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AIR AUGMENTED ROCKET POWER PLANT DESIGN PROGRAM (PLUMED MIX-MASTER)

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AERO-SPACE DIVISION
THE BOEING COMPANY

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Design Program (Plumed Mix-Master)

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PREPARED BY	Larry E. Savage Larry E. Savage by HHK **Esko G. Cate** Esko G. Cate by HHK
CHECKED BY	Loren R. Anderson Loren R. Anderson
APPROVED BY	H. James Kuhls H. James Kuhls Fred B. Lavering F.B. Lavering by HHK
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* In this document the modified version of AS 0317 will be referred to as "Plume"

** In this document the modified version of AS 1311 will be referred to as "Mix-Master"

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ABSTRACT

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The Air Augmented Rocket Power Plant Design Program calculates the thrust (as a function of downstream distance) obtained by enclosing a rocket exhaust within a duct. Additional values calculated are the velocity vector, temperature, density, the species concentrations of H_2O, H_2, O_2, CO_2, CO and N_2, and the Mach number throughout the mixing region of the exhaust as a function of downstream distance.

Author

1.0 GENERAL INFORMATION

Two versions of this program exist, a FORTRAN II program to be run on the IBM 7094 computer, and a FORTRAN IV program to be run on the SRU 1107 computer.

1.1 Purpose

The Air Augmented Rocket Power Plant Design Program is intended to solve the problem area illustrated in Figure 1. The fuel-rich exhaust from the rocket nozzle mixes with the secondary stream (air entering through the duct) and combusts. The resulting duct radius and thrust are computed vs. X; and the temperature, density, Mach number, and species concentration are computed vs. X and Y.

Two problems which arise in the design of a motor are: 1) Off-Design, and 2) Design Point. This program is used in the solution of both of these problems as described below.

Off Design:

In this problem it is assumed that the duct shape is known. It is desired to calculate the thrust of this duct for various flight conditions, i.e., altitude, air speed and rocket power level.

For the off-design problem the program does not perform an inlet calculation. The effects of altitude and air speed are introduced through the mass flow rate and total temperature and pressure of the secondary stream at the nozzle exit plane.

Assuming these secondary stream conditions are known the thrust on the duct can be calculated as follows.

1) Approximate the effective duct shape (there is some duct shape which when input to the Air Augmented program produces the desired duct shape as output. It is assumed that the user has through experience a reasonable guess as to what this "effective" duct shape is.)

2) Run the Air Augmented program to compute the resulting duct shape and the corresponding thrust.

3) Check that the resulting duct shape coincides with the known duct shape.

If not to the accuracy required then alter the effective duct shape and repeat steps 2 and 3. Once the resulting duct shape corresponds to the known duct shape the analysis is complete.

The most efficient operation of this motor occurs when the secondary stream goes supersonic. Unfortunately the secondary stream conditions at the nozzle exit plane which produce this type of flow are not independent of the rocket exhaust conditions. To determine the most optimum performance, step 2) above would be broken down as follows:

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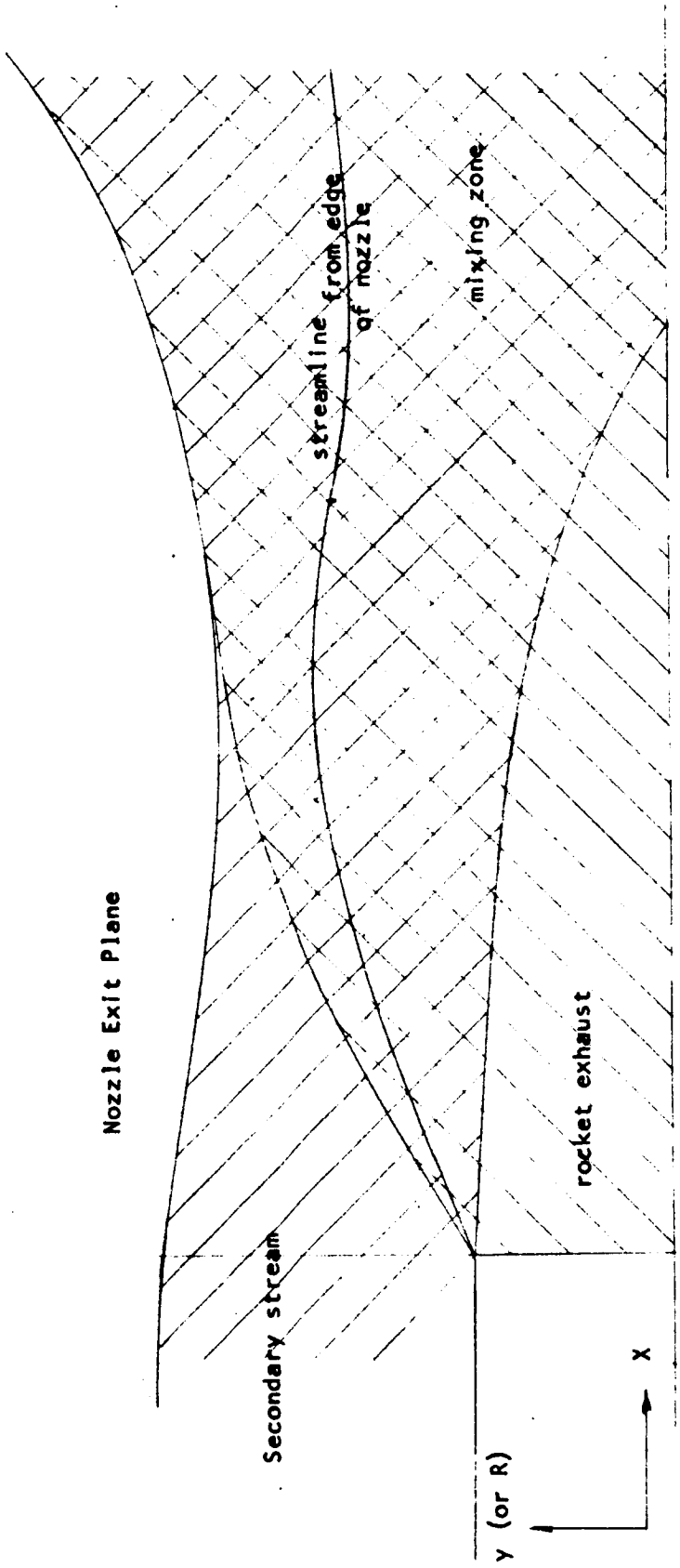
Nozzle Exit Plane
Secondary stream
streamline from edge of nozzle
mixing zone
rocket exhaust
y (or R)
x

Figure One

1.1 Purpose (Continued)

2.1) Estimate the secondary stream conditions ($\dot{w}$, P_T, T_T). Again it is assumed that reasonable engineering guesses can be made.

2.2) Calculate the pressure distribution and plume shape using the separate Plume Program.

2.3) Check to see if choked flow occurred. If not vary the estimates in step 2.1) and repeat step 2.2). If the flow is satisfactory, proceed to step 2.4).

2.4) Input the pressure distribution and plume shape from the Plume calculation into the separate Mix-Master program to calculate the output duct shape and thrust. Continue to step 3).

Design Point:

In this problem it is desired to determine the duct shape for specific flight conditions. This may be accomplished as follows:

1) Estimate the pressure distribution and initial stream conditions.

2) Use these in the combined Plume-Mix-Master program to compute duct shape and resulting thrust.

Estimates in step 1) may be varied in an attempt to maximize thrust.

1.2 Assumptions

The analysis performed is a two-dimensional analysis assuming the model is either axisymmetric or two-dimensional (see references 1 and 2).

1.3 Limitations

1.3.1 Limitations in the Plume Program

The Plume Program assumes nothing about what species are being used. It merely knows the specific heat ratios and gas constant and assumes these are constant.

The user generally desires a choked flow condition in the secondary stream when using option 2) (see section 1.1). It was quite difficult for him to determine the total conditions in the secondary stream which would produce the desired choked conditions.

In the production cases run, we experienced a shock wave reflecting off the axis of the motor. The program cannot handle this situation.

1.3.2 Limitations in Mix-Master

Temperature (T) must be in the range $450^{\circ}R \leq T \leq 9950^{\circ}R$.

This program is limited to the six species H_2O, H_2, O_2, CO_2, CO and N_2.

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1.3.2 Limitations in Mix-Master (Continued)

The time required to run a case increases exponentially as Δx^* decreases.

1.4 Recommendations

1.4.1 Recommendations for the Plume Program

As mentioned in 1.3.1 the user has some difficulty in determing the total condition in the secondary stream. An iteration process could be set up to find these conditions.

1.4.2 Recommendations for Mix-Master

1) It is recommended that the user input Δx in the range .03 to .05 feet.

2) If species other than those mentioned in section 1.3.2 are to be used, the following is recommended:

   **a. Write new versions of the subroutines NONEQ1 and NONEQ3 for each group of species under consideration.

   b. Write a general version of the Mix-Master main program.

      i) Increase the dimension statements to accomodate more than six species.

      ii) Read in a variable corresponding to the number of species used. Use this variable in the appropriate DO statements.

      iii) Read in a code to indicate whcih species are to be used to determine the extent of the mixing zone. (See Appendix A, Section 6.6.3). Add this code to the calling sequence for NONEQ3 or store it in common.

      iv) Read in the species name using an A format for variable output (H20, O2, etc.).

      v) Modify the output to print the maximum number of possible species.

      vi) If the species continuity, momentum or energy equation is modified in the subroutine NONEQ3 then the criteria for stability will have to be re-analysed (see section 6.1.8).

---

* Δx is the fixed interval between fronts (ft.).

** New routines are recommended due to the unique manner of calculating the concentrations of the present six species.

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1.5 Options

* 1) Plume as a distinct program.

a. Ambient pressure is input.

b. Duct radius is input.

* 2) Mix-Master is a distinct program.

a. Jet and secondary stream conditions are input.

b. An arbitrary profile of the mixing region conditions are input.

** 3) Plume and Mix-Master as a chain program.

a. Ambient pressure is input.

b. Duct radius is input.

c. Jet and secondary stream conditions are input.

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* See Appendix B.

** See sections 1.0 through Appendix A.

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2.0 PROCEDURE

2.1 Input Nomenclature

Since the Air Augmented Rocket Power Plant Design Program is the linking of two existing programs,* the input nomenclature will be divided into two sections. The first section will consist of the nomenclature used in the Plume Program and the second section will contain the nomenclature used in the Mix-Master Program.

2.1.1 Plume Input Symbols Definition

Program Symbol	Math Symbol	Definition
ALT		Altitude (this value is read in and printed out for reference information only) (feet)
BB		An array for inputting either pressure or effective duct shape (see NPORA below). The input may be either as coefficients of a polynomial or in tabular form (see INDP below). If a polynomial is used give the high order terms first. As an example, if INDP = 0, NPP = 3 then the polynomial used is $BB(1)\ X^2 + BB(2)\ X + BB(3)$. If tabular input is used then the independent and dependent variables should be alternately placed in the BB array. For example the following table:

X	Y
0	100.0
1.0	150.0
2.0	140.0

(i.e. Y = f(X) would produce:)

INDP = 1
NPP = 6
BB(1) = 0.0
BB(2) = 100.0
BB(3) = 1.0
BB(4) = 150.0
BB(5) = 2.0
BB(6) = 140.0

The following restrictions should be noted for tabular input.

1. BB(1) ≤ 0.0
2. The independent variably (X) must be increasing.
3. NPP must be an even number.

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* Modified version of AS 0317 and AS 1311.

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2.1.1 Plume Input Symbols Definition (Continued)

Program Symbol	Math Symbol	Definition
CPH		CPH = 1 indicates axisymmetric flow. CPH = 0 indicates two-dimensional flow.
DBFL		Degrees between fan lines in the Prandtl-Meyer expansion (> 0.1) (angular degrees).
GAMJ	γ_J	Gamma of the rocket exhaust. (Ratio of specific heats)
GMN	M	Mach number of the rocket exhaust.
GSEC	γ_{SEC}	Gamma in secondary stream. (Ratio of specific heats)
INDP		Indicator to describe the form of the data in the BB array: INDP = 0 BB are coefficients of a $(NPP-1)^{th}$ order polynomial in X. INDP ≠ 0 BB is tabular input with X as the independent variable.
ISTS		An indicator used only when NPORA ≠ 0. If: ISTS = 0 The flow in the secondary stream is assumed to be subsonic at the nozzle exit plane. ISTS ≠ 0 The flow in the secondary stream is assumed to be supersonic at the nozzle exit plane.
LSTART		An indicator and count for the variable properties input: LSTART = 0 No variable properties. The variables TZ, TR, THET, TXMN, TPRESS should not be input. LSTART > 0 The properties at the exit plane are variable and must be read as input (TZ, TR, ...). LSTART gives number of points to be input.
NPORA		Indicator to describe use of BB array: NPORA = 0 BB gives the ambient pressure distribution of the secondary stream. NPORA ≠ 0 BB gives the Y coordinate of the effective duct shape.
NPP		The number of values to be read into the BB array.

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2.1.1 Plume Input Symbols Definition (Continued)

Program Symbol	Math Symbol	Definition
PSEC	P_{SEC}	Static pressure in secondary stream. (lb/ft^2)
PJ	P_J	Static pressure of the rocket exhaust. (lb/ft^2)
PTSEC	P_{TSEC}	Total pressure in secondary stream. (lb/ft^2)
RGCJ	R_J	Gas constant of the rocket exhaust. ($\frac{ft\ lbs}{lb\ mass\ ^oR}$)
RN	R_N	Nozzle radius. (ft)
RSEC	R_{SEC}	Gas constant in secondary stream. ($\frac{ft\ lbs}{lb\ mass\ ^oR}$)
TEMPJ	T_J	Static temperature of the rocket exhaust. (^oR)
TPRESS	P	This is an array to read in static pressure (lb/ft^2) at the nozzle exit if the conditions are not constant (i.e. LSTART > 0). Note TPRESS(1) = PJ.
TTHET	θ	This is an array to read in the flow angle (in degrees - measured from the axis of symmetry) at the nozzle exit if the exit conditions are not constant (i.e. LSTART > 0).
TTSEC	T_{TSEC}	Total temperature in secondary stream. (^oR)
TR	Y	An array to read in the Y coordinate (ft) of the nozzle exit conditions, specified by TTHET, TXMN and TPRESS, when the exit conditions are not constant (i.e. LSTART > 0). The following restrictions hold: 1. TR(1) = RN 2. TR(i) ≥ 0 for all i. 3. TR must be decreasing.
TXD		Maximum X value which will be attained by a point on the axis of the plume. (ft)
TXMN	M	An array to read in the Mach number at the nozzle exit if the end conditions are not constant (i.e. LSTART > 0). TXMN(1) = GMN.
TZ	X	An array to input the X coordinate (ft) of the nozzle exit conditions, specified by TTHET, TXMN, and TPRESS, when the exit conditions are not constant (i.e. LSTART > 0). The following restrictions hold:

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2.1.1 Plume Input Symbols Definition (Continued)

Program Symbol	Math Symbol	Definition
		1. TZ(1) = 0.0 2. TZ must be increasing.
WSEC	$\dot{W}_{SEC}$	Total mass flow in secondary stream. (lb/sec)
X	X	the X coordinate is measured in feet along the axis of symmetry from the nozzle exit plane. The program was originally written using Z instead of X.
Y	Y	The Y coordinate is measured in feet perpendicular to the axis of symmetry. The axis of symmetry has the Y coordinate value of zero. The program was originally written using R instead of Y.

2.1.2 Mix-Master Input Symbols Definition

Program Symbol	Math Symbol	Definition
AAA		The name of the array that stores the input case identification. Starts in col. 2 and ends in col. 72.
A		Exponent in turbulent layer growth law.
C2(1,1)	C_{1e}	The jet side (ψ_0) boundary value of H_2O species concentration (lb. of H_2O/lb. of total mixture)
C2(2,1)	C_{2e}	The jet side (ψ_0) boundary value of H_2 species concentration. (lb. of H_2/lb of total mixture)
C2(3,1)	C_{3e}	The jet side (ψ_0) boundary value of O_2 species concentration. (lb. of O_2/lb. of total mixture)
C2(4,1)	C_{4e}	The jet side (ψ_0) boundary value of CO_2 species concentration. (lb. of CO_2/lb. of total mixture)
C2(5,1)	C_{5e}	The jet side (ψ_0) boundary value of CO species concentration. (lb. of CO/lb. of total mixture)
C2(6,1)	C_{6e}	The jet side (ψ_0) boundary value of N_2 species concentration. (lb. of N_2/lb. of total mixture)

2.1.2 Mix-Master Input Symbols Definition (Continued)

Program Symbol	Math Symbol	Definition
C2(1,NMAX)	C_{1S}	The secondary stream (ψ_{NMAX}) boundary value of H_2O species concentration. (lb. of H_2O/lb. of total mixture)
C2(2,NMAX)	C_{2S}	The secondary stream (ψ_{NMAX}) boundary value of H_2 species concentration. (lb. of H_2/lb. of total mixture)
C2(3,NMAX)	C_{3S}	The secondary stream (ψ_{NMAX}) boundary value of O_2 species concentration. (lb. of O_2/lb. of total mixture)
C2(4,NMAX)	C_{4S}	The secondary stream (ψ_{NMAX}) boundary value of CO_2 species concentration. (lb. of CO_2/lb. of total mixture)
C2(5,NMAX)	C_{5S}	The secondary stream (ψ_{NMAX}) boundary value of CO species concentration. (lb. of CO/lb. of total mixture)
C2(6,NMAX)	C_{6S}	The secondary stream (ψ_{NMAX}) boundary value of N_2 species concentration. (lb. of N_2/lb. of total mixture)
DELTA	δ	$\delta = 1$ indicates axisymmetric flow. $\delta \geq 0$ indicates two-dimensional flow.
DX	ΔX	Fixed interval between fronts. (ft)
EPSON	ϵ_0	Reichards exchange coefficient.
FCON	C	Viscosity constant.
FL	L	Reference length. (ft)
FLET	L_{e_t}	Turbulent Lewis number.
KSLIP		The psi line that corresponds to the radius of slipline (RE) at the initial front.

2.1.2 Mix-Master Input Symbols Definition (Continued)

Program Symbol	Math Symbol	Definition
LFRONT		The front interval for which printout is to occur. i.e. every LFRONT fronts a printout is produced.
MMAX		The maximum number of fronts for which calculations are to be performed.
NMAX		The maximum number of desired grid points at the initial front.
NMIN		NMIN = 0 indicates the properties in the jet and secondary streams are constant but not necessarily equal. (See page 18). X is internally set to zero and NMIN is then internally set to one. NMIN ≥ 1 indicates an arbitrary profile is input. The value of NMIN being the first psi line for which input is given. (See section 3.1, page 18 and Appendix A, page 27).
NS		The number of points on either side of the KSLIP psi line for which a smooth curve is desired. i.e. between (KSLIP and KSLIP-NS) and (KSLIP and KSLIP+NS). This curve fit is only obtained at the initial front to insure a smooth transition of properties between the jet and secondary stream.
NXTAB		The number of points in the axial coordinate, radius and pressure table. (Input only if Mix-Master is to be run as a non-chain job.) See Appendix A and section 7.2 page 55 . (NXTAB ≥ 3)
PRT	P_{r_t}	Turbulent Prandtl number
PTAB		The name of the pressure array. (lb/ft^2) (Input only if Mix-Master is to be run as a non-chain job.) See Appendix A and Section 7.2, page 55.
RDZERO	r_{D_0}	The radius of the duct at the initial front. (ft)
RE	r_e	The radius of the slip line at the initial front. (ft)
RTAB		The name of the radius array (radius to the slipline) (ft) (Input only if Mix-Master is to be run as a non-chain job.) See Appendix A and Section 7.2, page 55 .

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2.1.2 Mix-Master Input Symbols Definition (Continued)

Program Symbol	Math Symbol	Definition
RZERO1	R_{0_1}	The radius to the reference psi line, ψ_1. See figure 2, page 13 . (ft)
T2(1)	T_e	The initial value of temperature in the jet. (^oR)
T2(NMAX)	T_S	The initial value of temperature in the secondary stream. (^oR)
TESMAX		The test value to determine when the mixing region has expanded to the secondary stream. (See Appendix B, page 55).
TESMIN		The test value to determine when the mixing region has expanded to the jet stream. (See Appendix B, page 55).
V2(1)	U_e	The initial value of the axial velocity component in the jet. (ft/sec)
V2(NMAX	U_S	The initial value of the axial velocity component in the secondary stream. (ft/sec)
X	X	Input only if NMIN ≥ 1. The distance downstream for which the arbitrary profile is given. (ft)
XTAB		The name of the downstream distance array. (ft) (Input only if Mix-Master is to be run as a non-chain job.) See Appendix A and Section 7.2 page 55.

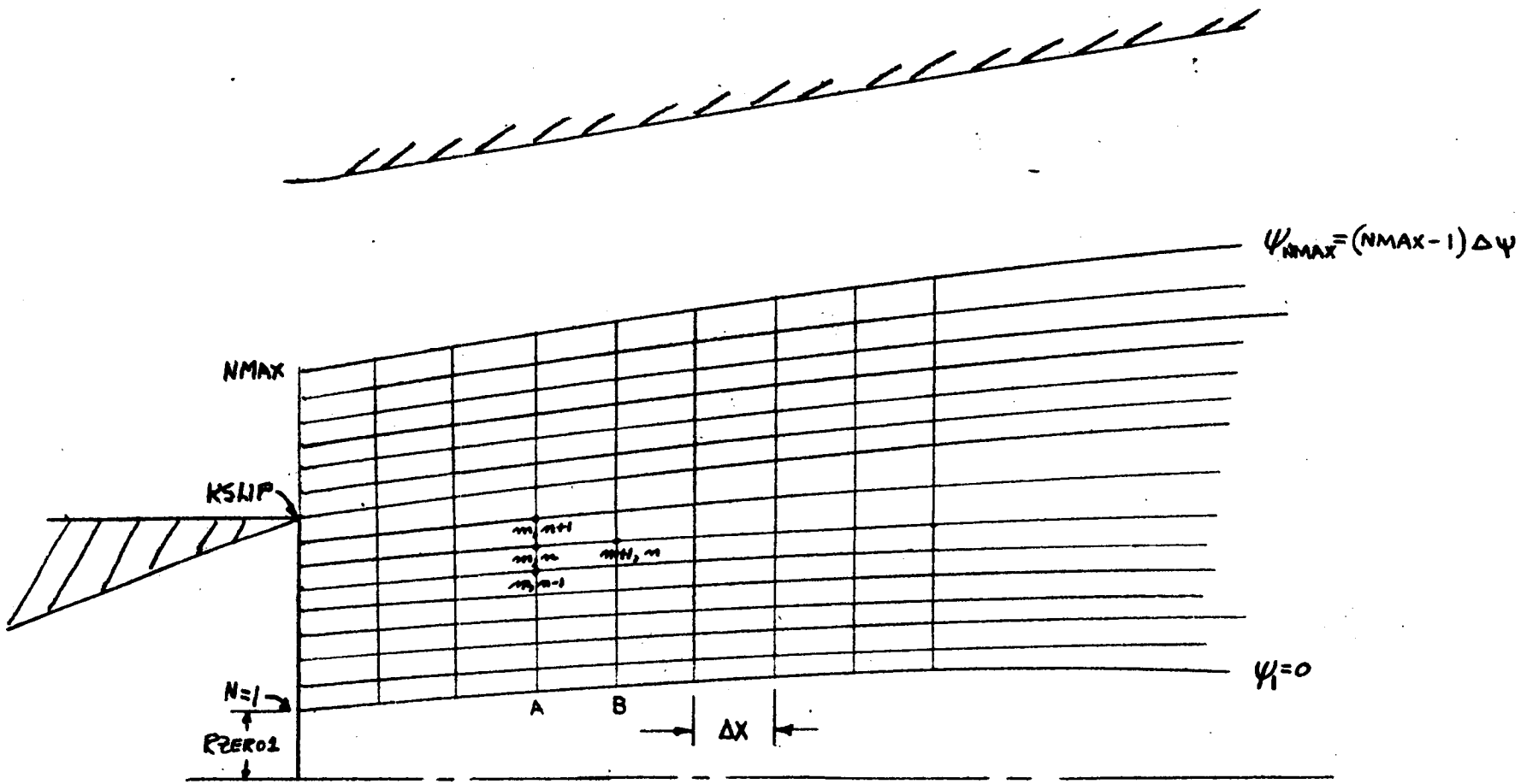

FIG. 2. FINITE DIFFERENCE GRID SYSTEM.

THE PROPERTIES OF THE POINT AT FRONT B ARE CALCULATED FROM THE PROPERTIES OF THE 3 POINTS AT FRONT A

2.2 Method

As observations are made farther and farther downstream from a rocket nozzle it is noted that the mixing area expands. It is also noted that the stream line, eminating at the nozzle exit and corresponding to the nozzle radius, changes shape (see figure 1, page 2). (NOTE: The rate the mixing area expands and the shape the stream line assumes is dependent to a large degree on the type and quantity of the gases in the exhaust.) Basically, the problem for finding this streamline shape (plume shape) and the species concentrations, temperatures, densities and velocities throughout the mixing area at various distances from the rocket nozzle is solved in the following manner.

The Plume program creates a table of radii*. This table produces the effective plume shape. The Mix-Master program calculates the turbulent exchange coefficient (ϵ_V) from the expression

$$\epsilon_V = \epsilon_0 \frac{X}{L} \tag{1}$$

which can also be expressed

$$\epsilon_V = \frac{\bar{U}L}{2\sigma^2} \tag{2}$$

where

ϵ_0 = Reichardt's coefficient

$\bar{U}$ = average velocity between the inner and outer streams (ft/sec)

L = reference length (ft)

σ = proportionality constant (or jet spread factor)

The parameter σ is an empirical parameter which must be determined experimentally. Reichardt's coefficient is defined as

$$\epsilon_0 = \frac{\bar{U}L}{2\sigma^2} \tag{3}$$

$\therefore$ knowledge of σ for given $\bar{U}$ permits calculation of ϵ_0 (reference 4).

---

* These radii have a one to one correspondence to stream lines and pressures as a function of distances (downstream) and are calculated by the method of characteristics.

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2.2 Method (Continued)

It is convenient to utilize the von Mises transformation with the stream function defined by:

$$\left(\frac{\partial \psi}{\partial r}\right)_X = \rho U r^{\delta} \tag{4}$$

This transformation is performed in order to solve the following equations more conveniently by the finite difference method.

- Global Continuity Equation:

$$\frac{\partial(\rho U r^{\delta})}{\partial X} + \frac{\partial(\rho V r^{\delta})}{\partial r} = 0 \tag{5}$$

Species Continuity Equation:

$$\rho U \frac{\partial C_K}{\partial X} + \rho V \frac{\partial C_K}{\partial r} = \frac{1}{r^{\delta}} \frac{\partial}{\partial r}\left[\frac{r^{\delta} \epsilon_V L_{et}}{P_{r_t}}\right] + \dot{w}_K \tag{6}*$$

Momentum Equation:

$$\rho U \frac{\partial U}{\partial X} + \rho V \frac{\partial U}{\partial r} = -\frac{\partial P}{\partial X} + \frac{1}{r^{\delta}}\left(\epsilon_V r^{\delta} \frac{\partial U}{\partial r}\right) \tag{7}*$$

Energy Equation:

$$C_{P_K}\left(\rho U \frac{\partial T}{\partial X} + \rho V \frac{\partial T}{\partial r}\right) = U \frac{\partial U}{\partial X} + \epsilon_V \left(\frac{\partial U}{\partial r}\right)^2 + \frac{1}{r^{\delta}} \frac{\partial}{\partial r}\left[C_{P_K} r^{\delta} \frac{\epsilon_V}{P_{r_t}} \frac{\partial T}{\partial r}\right]$$
$$+ \epsilon_V \frac{L_{et}}{P_{r_t}} \sum_K C_{P_K} \frac{\partial T}{\partial r} \frac{\partial C_K}{\partial r} - \sum_K \dot{w}_K h_K \tag{8}*$$

where

K = the Kth species

C_K = the concentration of the Kth species. (lb. of species/lb. of total mixture)

C_{P_K} = the specific heat of the Kth species (BTU/lb-$^{\circ}$R)

P = pressure (lb/ft^2)

* See Appendix A, page 30 and 31 for the finite difference form of these equations.

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2.2 Method (Continued)

T = temperature (^{o}R)

V = the radial velocity component (ft/sec)

$\dot{W}_K$ = the net rate of production of the Kth species ($lbm/ft^3 sec$)

2.3 References

1. Radtke, Leonard P., Rocket Exhaust Plume Program, Applied Math Write-up No. AS 0317, The Boeing Company, not yet released

2. Stewart, John M., Rocket Exhaust Mixing Program, Applied Math Write-up No. AS 1311, The Boeing Company, not yet released

3. Emmons, D. L., and Fitch, R. E., Investigation of Vehicle-Integrated Rocket Power Plants with Air Augmentation, D2-23217-1 (confidential), The Boeing Company, not yet released

4. Miles, I. B., Stanton Number for Separated Turbulent Flow Past Relatively Deep Cavities, PhD Thesis, University of Illinois, 1963

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3.0 INPUT PREPARATION AND OUTPUT DESCRIPTION

3.1 Input Data Preparation

The input is from cards set up in the following manner:

See Appendix C for sample input listing. Forms illustrating this input may be found on pages 20.1, 20.2, and 20.3.

The definitions, units and explanations of all items of input are listed in section 2.1 of this document. The order and method of input follows.

3.1.1 Case Cards

There are two types of cases that can be input. These are:

1. The input of ambient pressure.
2. The input of a duct shape.

3.1.2 The Input of Ambient Pressure

Card One -

TITLE Format (12A6)

72 alpha numeric characters

Card Two -

LSTART, INDP, NPP, NPORA Format (4I4)

4 fixed point quantities

NOTE: NPORA = 0

Card Three -

ALT, GMN, GAMJ, TEMPJ, PJ, RGCJ, RN, CPH Format (8F10.0)

8 floating point quantities

Card Four -

TXD, DBFL Format (8F10.0)

2 floating point quantities.

---

* Page 19 is used for ambient pressure input.
Page 19 is used for duct shape input.

3.1.2 The Input of Ambient Pressure (Continued)

Card Five represents an array. Repeat this card until NPP values have been produced.

Card Five -

BB_1, BB_2, BB_3, BB_4, . . . , BB_{NPP} Format (8F10.0)

8 floating point quantities per card.

Card Six represents an array of 5 variables. Repeat this card LSTART times.

I = 1, LSTART

Card Six -

TZ_I, TR_I, $TTHET_I$, $TXMIN_I$, $TPRESS_I$ Format (5F10.0)

5 floating point quantities.

Card Seven -

AAA Format (12A6)

71 alpha numeric characters starting in column two.

Card Eight -

NMAX, MMAX, NS, LFRONT, KSLIP, NMIN Format (15I4)

6 fixed point quantities.

Card Nine -

A, FL, EPSON, FLET, PRT, DELTA Format (6E12.5)

6 floating point quantities.

Card Ten -

DX, FCON, RZERO1, RE, RDZERO, TESMAX Format (6E12.5)

6 floating point quantities.

Card Eleven -

TESMIN Format (6E12.5)

1 floating point quantity.

3.1.2 The Input of Ambient Pressure (Continued)

Card Twelve - *

$C2_{1,e}$, $C2_{2,e}$, $C2_{3,e}$, $C2_{4,e}$, $C2_{5,e}$, $C2_{6,e}$ Format (6E12.5)

6 floating point quantities.

Card Thirteen - *

$C2_{1,s}$, $C2_{2,s}$, $C2_{3,s}$, $C2_{4,s}$, $C2_{5,s}$, $C2_{6,s}$ Format (6E12.5)

6 floating point quantities.

Card Fourteen -

$T2_e$, $T2_s$, $U2_e$, $U2_s$ Format (6E12.5)

4 floating point quantities.

3.1.3 The Input of a Duct Shape

Card One -

TITLE Format (12A6)

72 alpha numeric characters.

Card Two -

LSTART, INDP, NPP, NPORA, ISTS Format (5I4)

5 fixed point quantities.

NOTE: NPORA = 1

Card Three -

ALT, GMN, GAMJ, TEMPJ, PJ, RGCJ, RN, CPH Format (8F10.0)

8 floating point quantities.

Card Four -

TXD, DBFL Format (8F10.0)

2 floating point quantities.

Card Five -

WSEC, PTSEC, TTSEC, GSEC, RSEC Format (8F10.0)

5 floating point quantities.

* Card twelve and thirteen are to be used only if an arbitrary profile is to be input (NMIN ≥ 1).

3.1.3 The Input of a Duct Shape (Continued)

Card five through fourteen of section 3.1.2 of this document constitute the remainder of input for the duct shape.

3.2 Output Data

There is only one type of output and it is in the form of listings. Each item of output is defined in the listing. See Appendix C for sample output. See reference 3 for accuracy.

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1st CARD	AMBIENT PRESSURE DISTRIBUTION										(12A6
2nd CARD	LSTART	INDP	NPP	NPORA							(4I4)
				0							
3rd CARD	ALT	GMN	GAMI	TEMPI	PI	RGCI	RN	CPH			(8F10.
4th CARD	TXD	DBFL									"
5th CARD	BB(1)										"
6th											"
7th											"
8th											"
9th											"
10th											"
11th											"
12th											"
13th											"
14th											"

THESE CARDS INCLUDE BB(I), I=1,NPP AND THE OPTIONAL INPUT TR(I), TR(I), TTHET(I), TMN(I), TPRESS(I), I=1,LSTART.

CALC				
CHECK				
APR				
APR				
		REVISED	DATE	

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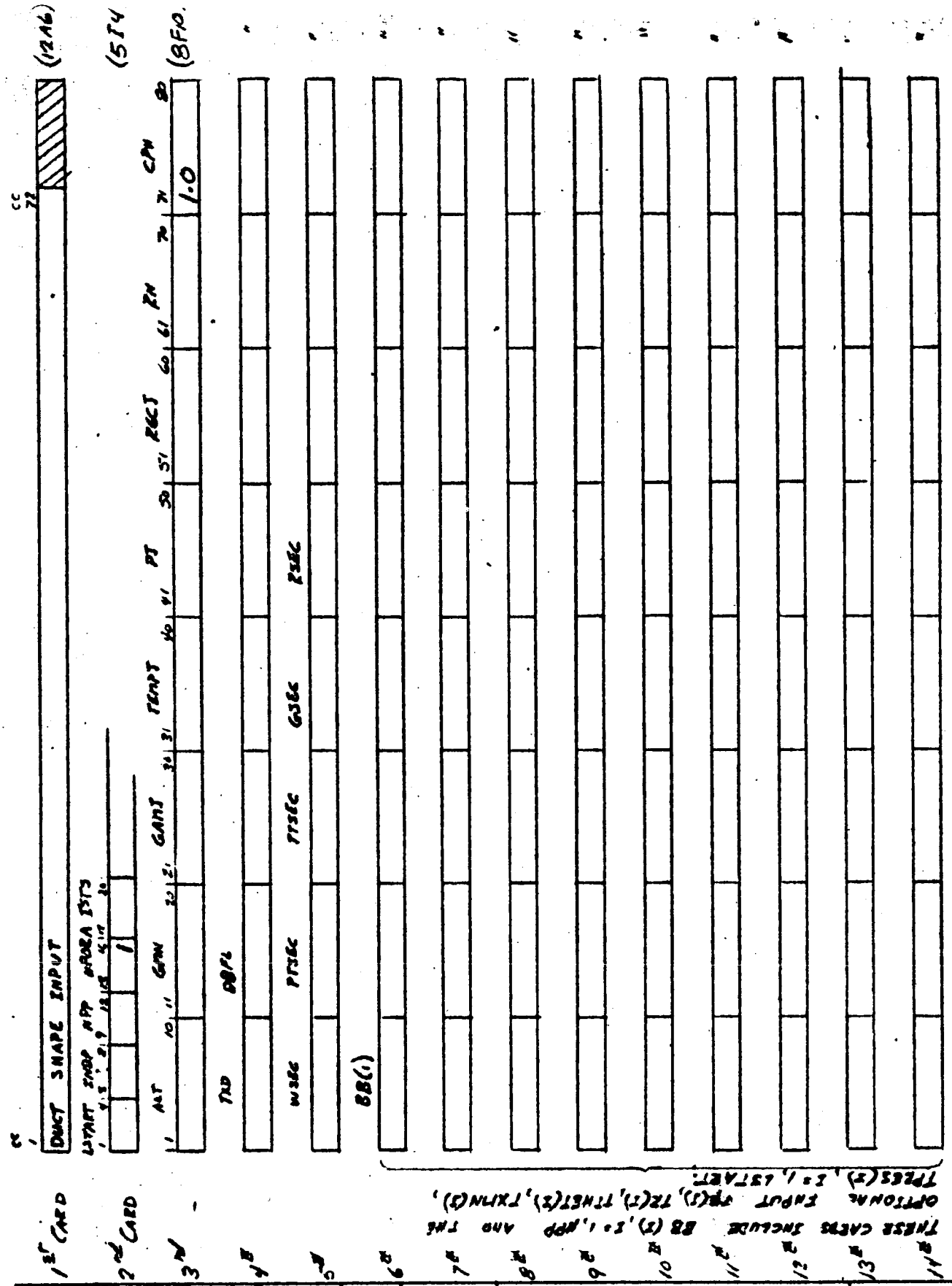

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APR						
APR					THE BOEING COMPANY	PAGE 20.2

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2 AAA 72	CASE	12A6
NMAX 4	MMAX 8	NS 12	LFRONT 16	KSLIP 20	NMIN 24	15I4
A 12	FL 24	EPSON 36	FLET 48	PRT 60	DELTA 72	6E12.5
DX 12	FCON 24	RZERO1 36	RE 48	RDZERO 60	TESMAX 72	6E12.5
TESMIN 12						6E12.5

FOR THE CHAIN VERSION OMIT NXTAB AND THE FOLLOWING XTAB, RTAB AND PTAB CARDS

NXTAB 4		15I4
$XTAB_I$ 16	$RTAB_I$ 32	$PTAB_I$ 48	3E16.7

REPEAT THE ABOVE CARD NXTAB TIMES
(I = 1, 2, 3, · · · , NXTAB)

IF NMIN ≥ 1 INPUT THE FOLLOWING CARDS

$C2_{1,N}$ 10	$C2_{2,N}$ 20	$C2_{3,N}$ 30	$C2_{4,N}$ 40	$C2_{5,N}$ 50	$C2_{6,N}$ 60	$T2_N$ 70	$U2_N$ 80	8E10.3

REPEAT THE ABOVE CARD NMAX-NMIN+1 TIMES
(N = NMIN, NMIN+1, NMIN+2, · · · · · , NMAX)

X 10	8E10.

IF NMIN = 0 INPUT THE FOLLOWING CARDS

$C2_{1,1}$ 12	$C2_{2,1}$ 24	$C2_{3,1}$ 36	$C2_{4,1}$ 48	$C2_{5,1}$ 60	$C2_{6,1}$ 72	6E12.5
$C2_{1,NMAX}$ 12	$C2_{2,NMAX}$ 24	$C2_{3,NMAX}$ 36	$C2_{4,NMAX}$ 48	$C2_{5,NMAX}$ 60	$C2_{6,NMAX}$ 72	6E12.5
$T2_1$ 12	$T2_{NMAX}$ 24	$U2_1$ 36	$U2_{NMAX}$ 48	6E12.5

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				REVISED
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MIX-MASTER

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4.0 OPERATING INFORMATION

4.1 Program and Data Set-Up

4.1.1 Program

The type of program input is binary or symbolic cards.

4.1.2 Data

The data is input in the form of punched cards and magnetic tape. (The input by magnetic tape is done by the program and should not concern the user.)

4.2 Machine Set-Up and Run Information

4.2.1 General Machine Operation

4.2.1.1 The sequence of control cards is as follows:

1. Job card
2. Account time card stating three tapes are used
3. Execute card
4. Print estimate card
5. A comment card indicating tapes B1, B2 and B3 will be used for scratch and chain
6. Chain (1, B2) card
7. The binary deck of Plume
8. Chain (2, B3) card
9. The binary deck of Mix-Master
10. Data card
11. The data deck

4.2.1.2 Run Time

The estimated running time to compute a case using H_2O, H_2, O_2, CO_2, CO and N_2 with a step size $\Delta X = .05$ from 0 to 10 feet is 2.38 minutes. The time to compute a case increases linearly as X increases. It also increases exponentially as ΔX decreases.

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4.2.1.3 Print Out

The estimated number of lines of print for the above case (printing every foot) is 803.

4.2.1.4 Tape Unit Requirements

1. Logical tape 5 for input.

2. Logical tape 6 for output.

3. B1, B2 and B3 for scratch and chain.

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5.0 PROGRAMMING INFORMATION

See Appendix D for listings and storage requirements.

This problem is written as a chain program. The Plume program is the first link (chain 1, B2) and Mix-Master is the second (chain 2, B3). Plume is executed and writes NXTAB, and ($XTAB_K$, $RTAB_K$, $PTAB_K$; K = 1,NXTAB) on logical tape 11 and then calls chain 2, B3. Mix-Master immediately reads logical tape 11 and proceeds with normal execution. When Mix-Master has completed all computations and printed the output, chain 1, B2 is called. This process is repeated until all input cases have been completed.

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6.0 APPENDIX A

Purpose

This appendix contains all of the modifications and additions made to AS 0317 and AS 1311 to produce the Air Augmented Rocket Power Plant Design Program.

It was compiled in order to make the differences between the programs readily available.

The paragraphs in this appendix are divided into two classifications as follows:

1. The paragraph number and the name of the routine where the modifications have occurred.

2. The paragraph subdivision numbers and the modifications that have occurred in the routine indicated by the paragraph number.

Appendix Symbol Definitions for Plume

Program Symbol	Math Symbol	Defintion	Units
A	A	the area of the secondary stream	ft^2
ASTAR	A_*	the critical area of the secondary stream	ft^2
GSEC	γ_{SEC}	gamma in secondary stream (ratio of specific heats)	
PSEC	P_{SEC}	static pressure in the secondary stream	lb/ft^2
PTSEC	P_{TSEC}	total pressure in the secondary stream	lb/ft^2
RSEC	R_{SEC}	gas constant in secondary stream	

Appendix Symbol Definitions for Mix-Master

Program Symbol	Math Symbol	Definition	Units
AD		the duct area at the current front.	
AMACH	V_N	the Mach number at the Nth psi line	
CI(I,N)	$CI_{i,N}$	the total concentration of the ith species at the previous front	$\frac{\text{lb. of species}}{\text{lb. total mix.}}$

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6.0 APPENDIX A (Continued)

Appendix Symbol Definitions for Mix-Master (Continued)

Program Symbol	Math Symbol	Definition	Units
C2(I,N)	$C2_{i,N}$	The concentration of the ith species at the Nth psi line. $i = 1, 2, 3, 4, 5, 6$ (H_2O, H_2, O_2, CO_2, CO, and N_2 respectively).	lb. of species / lb. of total mix.
CBAR(I,N)	$\bar{C}_{i,N}$	The concentration of the ith species at the Nth psi line of the current front due to mixing.	lb. of species / lb. of total mix.
CHAT(I,N)	$\tilde{C}_{i,N}$	The concentration of the ith species at the Nth psi line of the current front as established by an atom balance equation.	lb. of species / lb. of total mix.
CP(I,N)	$C_{P_{i,N}}$	The specific heat of the ith species at the Nth psi line.	BTU/lb
CP2(N)	C_{P_N}	The specific heat of the mixture at the Nth psi line.	BTU/lb
CUR		Expression used in defining the stability criteria of Ψ.	
D2MAX		The value of the expression $TESMAX-C2_{2,NMAX}$.	lb. of species / lb. of total mix.
DEL	δ'	Error in $\tilde{C}_{3,N}$.	
DERIV	δ''	The derivative of δ with respect to $C2_{2,N}$.	
DPDX	dP/dX	The derivative of pressure with respect to the axial coordinate.	
DPSI	$\Delta\Psi$	The step size of the stream function.	none
DTESMN		The value of the expression $TESMIN-C2_{6,1}$.	lb. of species / lb. of total mix.
DTESMX		The value of the expression $TESMAX-C2_{1,NMAX}$.	lb. of species / lb. of total mix.

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6.0 APPENDIX A (Continued)

Appendix Symbol Definitions for Mix-Master (Continued)

Program Symbol	Math Symbol	Definition	Units
DX	ΔX	The step size of the axial coordinate.	ft
EVN	ϵ_{V_N}	Turbulent exchange coefficient at the Nth psi line.	lb/ft-sec
EVNM1	$\epsilon_{V_{N-1}}$	Turbulent exchange coefficient at the N-1 psi line.	lb/ft-sec
EVNMP1	$\epsilon_{V_{N+1}}$	Turbulent exchange coefficient at the N+1 psi line.	lb/ft-sec
FKC		Parameter used in the calculation of non-equilibrium net rate of production.	none
FKP		Equilibrium constant calculated as a function of temperature.	
FLE	L_e	Laminar Lewis number.	none
FLET	L_{e_t}	Turbulent Lewis number.	none
FMU	μ	Viscosity	lb/ft-sec
H(I,N)	$h_{i,N}$	Enthalpy of the ith species at the Nth psi line.	BTU/lb
ICHECK		ICHECK = 0; a code indicating that the current front is to be printed and the case terminated. ICHECK = 1; indicates the case will be allowed to continue. (See paragraph 6.6.9)	
K(subscript)	i(subscript)	Corresponds to the ith species.	
KSLIP		The number of the psi line corresponding to the radius of the nozzle.	
M(subscript)	M(subscript)	The number corresponding to the Mth front.	
N(subscript)	N(subscript)	The number corresponding to the Nth psi line.	

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6.0 APPENDIX A (Continued)

Appendix Symbol Definitions for Mix-Master (Continued)

Program Symbol	Math Symbol	Definition	Units
NMAX		The maximum value of N for which calculations are performed.	
NMIN		The minimum value of N for which printout is produced (lower bound such that for all calculations at N, N is greater or equal to NMIN)	
NXTAB		The number of values in XTAB, PTAB, and PTAB arrays.	
P	P	Pressure.	lb/ft^2
PR	P_r	Laminar Prandtl number.	none
PRT	P_{r_t}	Turbulent Prandtl number.	none
PTAB		The name of the array that stores the P table.	
RDZERO	r_{D_0}	The radius of the duct at X = 0.	ft
RE	r_e	The radius of the nozzle.	ft
RHO2	ρ	Density.	lb/ft^3
RRR	r	Radius.	ft
RTAB		The name of the array that stores the r table.	
RZERO1	r_{0_1}	The radius to the reference stream line.	ft
T2	T2	Temperature.	^oR
THRUST	T_{h_M}	Thrust.	lb
U2	U	Axial velocity.	ft/sec
W(I)	$\dot{w}_i$	Net rate of production of the ith species.	lbM/ft^3sec

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6.0 APPENDIX A (Continued)

Appendix Symbol Definitions for Mix-Master (Continued)

Program Symbol	Math Symbol	Definition	Units
X	X	Axial distance to the current front.	ft
XINGRL(N)	I_N	The value of the integral $\int_{\psi_1}^{\psi_N} \frac{\partial \psi}{\partial U}$	
XTAB		The name of the array that stores the X table.	
	ψD_0	The value of psi corresponding to r_{D_0}.	
	r_{D_M}	The radius of the duct.	ft
	W, y	The independent and dependent variables in the cubic equation $aW^3 + bW^2 + cW + d = y$.	
WDOTST	$\dot{W}_{ST}$	The initial flow rate in the stream tube, defined by r_{0_1} and the streamline (r_0) corresponding to the XTAB, RTAB and PTAB tables.	lb/sec

6.1 Mix-Master (Main Program)

6.1.1 Chain Plume and Mix-Master Programs

The Plume Program is the first chain link and writes the value of J, (XTAB(K), RTAB(K), PTAB(K), K = 1, J) on logical tape 11. When this has been completed the second chain link (Mix-Master) is called. Link two immediately reads from logical tape 11 what link one has written and proceeds to normal input reading to conclude the case at hand. When this case is completed control is transferred to link 1 which reads in the next case.

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6.1.2 Case Termination

- When X becomes greater than $XTAB_{NXTAB}$, the current case is terminated and a new case is begun.

6.1.3 CURV1

At the initial front there is an abrupt change between the values of:

1) axial velocity between the jet and secondary stream
2) temperature between the jet and secondary stream
3) density between the jet and secondary stream
4) species composition between the jet and secondary stream

CURV1 was written to replace this abrupt change with a smooth transition. This transition is produced by fitting a cubic equation from the jet to the secondary stream through an even (2NS) number of intervals centered about the KSLIP streamline. The user may over-ride this curve fit by giving the input variable, NS, a value of zero. For a more detailed explanation see paragraph 6.4 of this appendix.

6.1.4 The $\Delta\psi$ Calculation (Spacing of Psi-Lines)

Given r_{0_1}, r_e and KSLIP the following equation

$$\frac{r_e^{\delta+1} - r_{0_1}^{\delta+1}}{\delta + 1} = \int_{\rho_1 U_1}^{\rho_{KSLIP} U_{KSLIP}} \frac{d\psi}{\rho U}$$

may be solved for $\Delta\psi$ where

$$X = \sum_{K=2}^{KSLIP} \left(\frac{1}{\rho_{K-1} U_{K-1}} + \frac{1}{\rho_K U_K} \right) \frac{\Delta\psi}{2} \approx \int_{\rho_1 U_1}^{\rho_{KSLIP} U_{KSLIP}} \frac{d\psi}{\rho U}$$

yielding

$$\Delta\psi = \left[\frac{(r_e^{\delta+1} - r_{0_1}^{\delta+1})/(\delta+1)}{X} \right] \Delta\psi$$

- r_e, r_{0_1} and KSLIP - Input to Mix-Master

6.1.5 The Print of the Initial Input

All values that the Mix-Master Program reads in are printed under the heading "INITIAL INPUT" followed by six blank lines.

6.1.6 DUCT

Given the radius of the duct at the initial front it was desired to know what effect the mixing would have on this radius. In order to determine this, the DUCT subroutine calculates the value of psi corresponding to the radius of the duct at the initial front. Since this psi line remains constant, DUCT can calculate the new duct radius (to this psi line) at each subsequent front. DUCT also calculates the thrust at each front. For a more detailed explanation see paragraph 6.2 of this appendix.

6.1.7 Arbitrary Profile Input

If after studying the data produced by a case 1, the user wishes to extend the case farther out along the axial coordinate he may input an arbitrary profile. In the new case 1A, NMIN will be the second value of N produced by the last printout of the case 1 run. NMAX will be the last value of N and NS = 0. KSLIP will be the third value of N. RZERO1 will be the first value of Y produced by the last printout of case 1. RE will be the value of Y at KSLIP. RDZERO will be the radius of the duct indicated on the last printout. The profile values will be H_2O, H_2, O_2, CO_2, CO, N_2, T2 and U2 at each value of N. (N = NMIN, NMIN + 1, NMIN + 2, . . ., NMAX). Finally, X will be the value indicated by the print statement "DISTANCE DOWNSTREAM = XXX FEET".

6.1.8 Stability Criteria

Statement of Karplus stability:

Given a function of the form

$$a(\Phi_{m,n+1} - \Phi_{m,n}) + b(\Phi_{m,n-1} - \Phi_{m,n}) + c(\Phi_{m+1,m} - \Phi_{m,n}) + d(\Phi_{m-1,n} - \Phi_{m,n}) = 0$$

where $a > 0$ stability exists if andonly if a, b, c, d ≥ 0 or $a + b + c + d < 0$.

Applying the above to the species continuity, momentum and energy equations respectively, (section 6.6.2), we have:

1) $$a = K_{1,N} + K_{2,N} + \frac{K_{1,N+1} - K_{1,N-1}}{4}$$

$$b = K_{1,N} - K_{2,N} - \frac{K_{1,N+1} - K_{1,N-1}}{4}$$

6.1.8 Stability Criteria (Continued)

$c = -1$

$d = 0$

where

$$K_{1,i} = \frac{r_i^{2\delta_{\Delta X}}}{\Delta\psi^2} \rho_i U l_i \left(\frac{\mu_i L_{e_i}}{P_{r_i}} + \frac{\epsilon_{V_i} L_{e_{t_i}}}{P_{r_{t_i}}} \right) \quad ; \quad i = N,\ N+1,\ N-1$$

$$K_2 = \frac{r_N^{2\delta_{\Delta X}}}{4\Delta\psi^2} \left(\frac{\mu_N L_{e_N}}{P_{r_N}} + \frac{\epsilon_{V_N} L_{e_{t_N}}}{P_{r_{t_N}}} \right)$$

substituting in the expression for a it is verified that $a > 0$.

$a + b + c + d = 2K_{1,N} - 1$

implies that for stability

$$\Delta\psi > \left[2r_N^{2\delta} \rho_N U l_N \Delta X \left(\frac{\mu_N L_{e_N}}{P_{r_N}} + \frac{\epsilon_{V_N} L_{e_{t_N}}}{P_{r_{t_N}}} \right) \right]^{1/2}$$

(2) $$a = K_{1,N,i} + \frac{K_{1,N+1,i} - K_{1,N-1,i}}{4} + \frac{K_{1,N,i+1} - K_{1,N,i-1}}{4}$$

$$b = K_{1,N,i} - \frac{K_{1,N+1,i} - K_{1,N-1,i}}{4} - \frac{K_{1,N,i+1} - K_{1,N,i-1}}{4}$$

$c = -1$

$d = 0$

where

$$K_{1,N,i} = \frac{r_N^{2\delta_{\Delta X}}}{\Delta\psi^2} \rho_N U l_N (\mu_i + \epsilon_{V_i}) \quad ; \quad i = N$$

Again it is verified that $a > 0$ hence $a + b + c + d = 2K_{1,N,i} - 1$

6.1.8 Stability Criteria (Continued)

implies that for stability

$$\Delta\psi > \left[2r_N^{2\delta} \rho_N U l_N \Delta X (\mu_N + \epsilon_{V_N}) \right]^{1/2}$$

(3) $$a = K_{2,N,i} + \frac{K_{2,N+1,i} - K_{2,N-1,i}}{4} + \frac{K_{2,N,i+1} - K_{2,N,i-1}}{4} + \frac{K_2}{C_{P_N}}$$

$$b = K_{2,N,i} - \frac{K_{2,N+1,i} - K_{2,N-1,i}}{4} - \frac{K_{2,N,i+1} - K_{2,N,i-1}}{4} - \frac{K_2}{C_{P_N}}$$

$c = -1$

$d = 0$

where

$$K_{2,N,i} = \frac{r_N^{2\delta} \Delta X}{\Delta\psi^2} \rho_N U l_N \left(\frac{\mu_i}{P_{r_i}} + \frac{\epsilon_{V_i}}{P_{r_{t_i}}} \right) \quad ; \quad i = N$$

It can be verified that $a > 0$ hence $a + b + c + d = 2K_{2,N,i} - 1$ implies that for stability

$$\Delta\psi > \left[2r_N^{2\delta} \rho_N U l_N \Delta X \left(\frac{\mu_N}{P_{r_N}} + \frac{\epsilon_{V_N}}{P_{r_{t_N}}} \right) \right]^{1/2}$$

Since $P_{r_t} < 1$ and $L_{e_t} > 1$ (input) it is seen that the stability criteria applied to the species continuity equation is the most demanding for the value of $\Delta\psi$.

To insure stability the maximum value of

$$2r_N^{2\delta} \rho_N U l_N \left(\frac{\mu_N L_{e_N}}{P_{r_N}} + \frac{\epsilon_{V_N} L_{e_{t_N}}}{P_{r_{t_N}}} \right) \quad ; \quad N = 2, 3, \ldots, NMAX$$

6.1.8 Stability Criteria (Continued)

is stored in CUR. The minimum value (DPSIM) that $\Delta\psi$ can be is

$$DPSIM = \sqrt{CUR \cdot \Delta X}$$

If $\Delta\psi < DPSIM$, $\Delta\psi$ is doubled until $\Delta\psi > DPSIM$.

NMAX, δ, ΔX, L_e, L_{e_t}, P_r, P_{r_t} - input to Mix-Master.

6.1.9 Restoration of Calculations when $\Delta\psi$ is Doubled

$\Delta\psi$ is doubled when NMAX > 197 (NMAX is then calculated as NMAX/2 + 2 and $NMIN = \frac{NMIN + 1}{2} - 1$) or when $\Delta\psi < DPSIM$. When this occurs, the values stored at location 2N-1 are re-stored at location N. (N = 1, NMAX) In effect NMIN and NMAX are halved. The doubling of $\Delta\psi$ ensures:

1) Stability 2) Storage allocations are not exceeded.

6.1.10 Mach Number Calculation

Prior to the printout at X determined by LFRONT given in the input, the Mach number is calculated at every psi line from NMIN to NMAX inclusive. The Mach number is calculated as follows.

$$(1) \quad V_N = \frac{U_N}{\sqrt{\frac{C_{P_N} \cdot J}{C_{P_N} \cdot J - R_N} \left(\frac{G \cdot P}{\rho_N}\right)}}$$

$$\text{since } R_N = \frac{P}{\rho_N \cdot T2_N}$$

If we substitute for R_N, divide numerator and denominator by J and expand we have the Mach number in its final form.

$$(2) \quad V_N = \frac{U_N}{\sqrt{\frac{C_{P_N} \cdot G \cdot \left(\frac{P}{\rho_N}\right)}{C_{P_N} - \frac{(P/\rho_N \cdot T2_N)}{J}}}}$$

6.1.10 Mach Number Calculation (Continued)

where

G = gravitational constant $(32.2 \frac{\text{lbm ft}}{\text{lbf-sec}^2})$

J = conversion factor $(778 \frac{\text{ft lbf}}{\text{BTU}})$

R = the gas constant of the mixture $(\frac{\text{ft-lbf}}{\text{lbm}^{\circ}\text{R}})$

6.2 DUCT (Subroutine)

The DUCT subroutine calculates the duct radius (r_{D_M}) and the thrust (T_{h_M}) at every front M given the following:

1. Axial distance (X) to front M.
2. The radius ($r_{N,M}$) to some streamline outside the mixing region.
3. The value of psi ($\psi_{N,M}$) at $r_{N,M}$.
4. The density ($\rho_{N,M}$) at $r_{N,M}$.
5. The axial velocity ($U_{N,M}$) at $r_{N,M}$
6. The pressure (P_M) at front M.
7. The radius of the duct (r_{D_0}) at X = 0.

Initially, at X = 0, subroutine DUCT calculates the value of ψ (ψ_{D_0}) at the given duct radius r_{D_0} by

$$(1) \quad \frac{r_{D_0}^{\delta+1} - r_{N,1}^{\delta+1}}{\delta + 1} = \int_{\psi_{N,1}}^{\psi_{D_0}} \frac{d\psi}{\rho U} = \frac{1}{\rho_{N,1} U_{N,1}} (\psi_{D_0} - \psi_{N,1})$$

$$(2) \quad \psi_{D_0} = \frac{\rho_{N,1} U_{N,1}}{\delta + 1} (r_{D_0}^{\delta+1} - r_{N,1}^{\delta+1}) + \psi_{N,1}$$

This determines the value of psi that corresponds to the duct radius (r_{D_M}) at any front M.

6.2 DUCT (Subroutine) (Continued)

Initially r_{D_M} is set equal to r_{D_0} and T_{h_M} is set equal to 0.

When $X > 0$ (corresponding to $M > 1$) the duct radius (r_{D_M}) at front M is calculated by the following form of (1):

$$(3) \quad r_{D_M} = \left[r_{N,M}^{\delta+1} + \frac{(\delta + 1)(\psi_{D_0} - \psi_{N,M})}{\rho_{N,M} U_{N,M}} \right]^{\frac{1}{\delta+1}}$$

The thrust over the interval $[0, X_i]$ is defined by

$$(4) \quad T_{h_i} = 2\pi \int_0^{X_i} r_D^{\delta}(X) \cdot P(X) \cdot \tan \alpha(X) \, dX$$

Hence for any interval $[X_{K-1}, X_K]$ the thrust can be written as

$$(5) \quad T_{h_{(K-1,K)}} = 2\pi \int_{X_{K-1}}^{X_K} r^{\delta}(X) \cdot P(X) \cdot \tan \alpha(X) \, dX$$

$$= 2\pi \int_{X_{K-1}}^{X_K} r^{\delta}(X) \cdot P(X) \cdot \frac{dr_0}{dX} \, dX$$

$$(6) \quad = 2\pi \int_{r_{D_{K-1}}}^{r_{D_K}} r^{\delta} \cdot P(r) \, dr_0$$

where $\alpha(X)$ is the angle the duct makes with the X axis and

$$\tan \alpha(X) = \frac{dr_0}{dX}$$

Since the radius of the duct may not be monotonic over the whole range of X, the total thrust can not be written directly. It is reasonable to assume however that the duct radius is monotonic over $[X_{K-1}, X_K]$. With this assumption we can calculate the total thrust to front M as a summation of the form

6.2 DUCT (Subroutine) (Continued)

$$(7)\quad T_{h_M} = \sum_{K=2}^{M} 2\pi \int_{r_{D_{K-1}}}^{r_{D_K}} r^{\delta} \cdot P(r)\, dr$$

Using trapezoidal approximation we obtain the final form

$$(8)\quad T_{h_M} = \sum_{K=2}^{M} 2\pi^{\delta} \frac{(r^{\delta}_{D_{K-1}} P_{K-1} + r^{\delta}_{D_K})(r_{D_K} - r_{D_{K-1}})}{2^{2-\delta}}$$

$$(9)\quad T_{h_M} = T_{h_{M-1}} + \pi^{\delta} (r^{\delta}_{D_{K-1}} P_{K-1} + r^{\delta}_{D_K} P_K)(r_{D_K} - r_{D_{K-1}}) \quad 2^{1-\delta}$$

(program equation)

Basically then, when DUCT is called it saves the duct radius, pressure and thrust from the previous time it was called (previous front). It then calculates the current duct radius (3), does the appropriate calculations using the duct radius and pressure of the previous and current fronts and finally adds the saved value of thrust to these calculations to obtain the current thrust, (9).

The calling sequence is:

CALL DUCT $(X, r_{N_M}, \Psi_{N_M}, r_{D_M}, T_{h_M}, \rho_{N_M}, U_{N_M}, P_M, r_{D_0}, \Psi_{D_0}, \delta)$

where:

X = the axial distanct to front M. ft. (input)

r_{N_M} = the radius to a psi line outside the mix region. ft. (input)

Ψ_{N_M} = the value of psi that corresponds to r_{N_M}. (input)

r_{D_M} = the radius of the duct at front M. ft. (output)

T_{h_M} = the thrust of the duct at front M. lbs. (output)

6.2 DUCT (Subroutine) (Continued)

ρ_{N_M} = the density corresponding to r_{N_M}. lbs/ft^3. (input)

U_{N_M} = the axial velocity corresponding to r_{N_M}. ft/sec. (input)

P_M = the pressure at front M. lbs/ft^2. (input)

r_{D_0} = the radius of the duct at front 1 (X = 0). ft. (input)

ψ_{D_0} = the value of the psi line with which the duct radius corresponds. (output)

δ = 1 or 2 (axisymmetric or two-dimensional flow) (input)

6.3 INGRAT (Subroutine)

Subroutine INGRAT calculates the radius of every psi line, at each front, from the basic equation

$$\frac{r_N^{\delta+1} - r_0^{\delta+1}}{\delta + 1} = \int_{\psi_1}^{\psi_N} \frac{d\psi}{\rho U}$$

$$(1) \quad r_N = \left[r_0^{\delta+1} + (\delta + 1) \int_{\psi_1}^{\psi_N} \frac{d\psi}{\rho U} \right]^{\frac{1}{\delta+1}}$$

where

r_N = the radius to the ψ_N streamline. ft.

r_0 = the radius to the ψ_1 streamline. ft. (given)

ρ_N = the density at the ψ_N streamline. lbs/ft^3. ($\rho = f(\psi)$)

U_N = the axial velocity at the ψ_N streamline. ft/sec. ($U = g(\psi)$)

A combination of the trapezoidal and Simpson's rule is used to evaluate the integral of (1) in the following way

When N = 2 the integral

6.3 INGRAT (Subroutine) (Continued)

$$I_N = \int_{\psi_1}^{\psi_N} \frac{d\psi}{\rho U} \approx \frac{1}{2}\left(\frac{1}{\rho_N U_N} - \frac{1}{\rho_1 U_1}\right)(\psi_N - \psi_1) = \frac{1}{2}\left(\frac{1}{\rho_N U_N} - \frac{1}{\rho_1 U_1}\right)\Delta\psi$$

(trapezoidal)

and (1) is then evaluated for r_N.

When N = 3 the integral

$$I_N = \int_{\psi_1}^{\psi_N} \frac{d\psi}{\rho U} \approx \frac{1}{3}\left(\frac{1}{\rho_{N-2} U_{N-2}} + \frac{1}{\rho_N U_N} + \frac{4}{\rho_{N-1} U_{N-1}}\right)\Delta\psi \qquad \text{(Simpson's)}$$

and (1) is evaluated for r_N.

When $N \geq 4$ the integral

$$IN = I_{N-2} + \int_{\psi_{N-2}}^{\psi_N} \frac{d\psi}{\rho_N U_N} = I_{N-2} + \frac{1}{3}\left(\frac{1}{\rho_{N-2} U_{N-2}} + \frac{1}{\rho_N U_N} + \frac{4}{\rho_{N-1} U_{N-1}}\right)\Delta\psi$$

and (1) is evaluated for r_N. This process is repeated for all I_N and r_N, N = 2, . . ., NMAX where NMAX is the maximum number of psi lines at the particular front under consideration.

The calling sequence is

CALL INGRAT; The arguments being transferred via common.

6.4 CURV1 (Subroutine)

Subroutine CURV1 fits a cubic equation of the form

(1) $aW^3 + bW^2 + cW + d = y$

Through an arbitrary even number of intervals (K). CURV1 calculates the K-1 intermediate points and stores these in the output array. The output is stored in a manner which is convenient for transfer to the storage arrays used in the finite difference calculations (see the calling sequence for particulars).

6.4 CURV1 (Subroutine)

The necessary inputs are:

1. The number of intervals (K).

2. The value y assumes at the end points of the interval (y_M and y_N).

3. The location (M) of the lower boundary point in the output array (ANS).

Note that K = N - M. In this routine it is assumed that dy/dW = 0 at the end points. Since the interval used in W has no effect we chose $\Delta W = 1$.

Consider the translation of axes.

(2) $W' = (W - W_M)$ to $y' = (y - y_M)$

Thus at $(W, y) = (W_M, y_M)$, $W' = 0$ and $y' = 0$.

Rewriting (1) in the new coordinate system we have

(3) $a'W'^3 + b'W'^2 + c'W' + d' = y'$

And differentiating with respect to W' we have

(4) $3a'W'^2 + 2b'W' + c' = \frac{dy'}{dW'}$

At $W' = 0$, $y' = 0$ so (3) implies that $d' = 0$. Since the translation was linear

(5) $\frac{dy'}{dW'} = \frac{dy}{dW} = 0$

for $W' = 0$. Looking at (4) this implies $c' = 0$.

At $(W, y) = (W_N, y_N)$ solving (3) and (4) for a and b we have

(6) $a' = -\frac{dy'}{W'^3} = -\frac{2(y_N - y_M)}{(W_N - W_M)^3}$ (from the translation of axes)

(7) $b' = \frac{3y'}{W'^2} = \frac{3(y_N - y_M)}{(W_N - W_M)^2}$

(It should be noted that since $\Delta W = 1$, $W_N - W_M = N - M$)

Substituting (6) and (7) into (3) we have

6.4 CURV1 (Subroutine) (Continued)

$$\frac{3(y_N - y_M)}{(W_N - W_M)^2} W'^2 - \frac{2(y_N - y_M)}{(W_N - W_M)^3} W'^3 = y'$$

or

$$\frac{3(y_N - y_M)}{K^2} (W_J - W_M)^2 - \frac{2(y_N - y_M)}{K^3} (W_J - W_M)^3 = y_J - y_M$$

$J = M+1, M+2, \ldots, N-1$

$K = N - M$

or

$$\frac{3(y_N - y_M)}{K^2} L^2 - \frac{2(y_N - y_M)}{K^3} L^3 + y_M = y_J$$

$(L,J) = (1, M+1), (2, M+2), \ldots, (K-1, N-1)$

The calling sequence is:

CALL CURV1 (y_M, y_N, ANS, M, K)

where

y_M = the left most dependent variable of the intervals over which the routine is to curve fit.

y_N = the right most dependent variable of the intervals over which the routine is to curve fit.

ANS = the name of the array where the K-1 values of y_J are stored. (y_J is stored in ANS(M), J = 1, 2, ..., K-1).

M = the subscript of the left most variable in the interval.

K = the number of intervals (ΔW's) over which the routine is to curve fit.

6.5 NONEQ1 (Subroutine)

Since the Mix-Master uses an equilibrium chemistry, the order of computation for FKP_i and $\dot{w}_K$ have been changed. The computation of FKC_i has been eliminated. ($i = 1$ and 4; $K = 1, 2, \ldots, 6$)

The changes that were made are:

6.5.1 FKP_i and $\dot{w}_i$ ($i = 1$ and 4) are now computed in subroutine NONEQ3.

6.5.2 The computations for FKC_i ($i = 1$ and 4) have been eliminated.

6.5.3 C_{P_N}, the specific heat of the mixture, now reads as

$$C_{P_N} = \sum_{i=1}^{6} C_{P_{i,N}} \, C2_{i,N}$$

$C_{P_{i,N}}$ the specific heat of the ith species. BTU/lbs^{o}R at the Nth psi line.

where

$$C_{P_{1,N}} = 1.102 - \frac{33.14}{T2_N^{1/2}} + \frac{416.3}{T2_N}$$

$$C_{P_{2,N}} = 2.857 + .2867 \times 10^{-3} \cdot T2_N + \frac{9.921}{T2_N^{1/2}}$$

$$C_{P_{3,N}} = .3598 - \frac{5.375}{T2_N^{1/2}} + \frac{47.81}{T2_N}$$

$$C_{P_{4,N}} = .368 - \frac{148}{T2_N} + \frac{.032 \times 10^6}{T2_N^2}$$

$$C_{P_{5,N}} = .338 - \frac{117}{T2_N} + \frac{.038 \times 10^6}{T2_N^2}$$

$$C_{P_{6,N}} = .338 - \frac{124}{T2_N} + \frac{.0414 \times 10^6}{T2_N^2}$$

6.5.4 $h_{i,N}$, the enthalpy of the ith species, at the nth psi line. BTU/lb. now reads as

$$h_{1,N} = 1.102\ T2_N - 66.3\ T2_N^{1/2} + 416.3 \ln T2_N - 1439 - \frac{104000}{18}$$

6.5 NONEQ1 (Subroutine) (Continued)

$$h_{2,N} = 2.857\ T2_N + .143 \times 10^{-3}\ T2_N^{\ 2} + 19.84\ T2_N^{\ 1/2} - 230$$

$$h_{3,N} = .3598\ T2_N - 10.75\ T2_N^{\ 1/2} + 47.8\ \ln T2_N - 128.3$$

$$h_{4,N} = .368\ T2_N - 148\ \ln T2_N - \frac{.032 \times 10^6}{T2_N} + 887 - \frac{169300}{44}$$

$$h_{5,N} = .338\ T2_N - 113\ \ln T2_N - \frac{.038 \times 10^6}{T2_N} + 762 - \frac{47700}{28}$$

$$h_{6,N} = .338\ T2_N - 124\ \ln T2_N - \frac{.0414 \times 10^6}{T2_N} + 815$$

The calling sequence is

CALL NONEQ1 where all arguments are transferred via common.

6.6 NONEQ3 (Subroutine)

The following changes were made in NONEQ3:

6.6.1 $FKP_{1,N}$ and $FKP_{4,N}$ are now calculated in NONEQ3 by

$$FKP_{1,N} = 4.72\times10^{-4}\left[10^{10^{(.8974-.8946T_0+.3963T_0^{\ 2}-.4501T_0^{\ 3}+.2858T_0^{\ 4}-.1139T_0^{\ 5})}}\right]^2$$

$$FKP_{4,N} = 4.72\times10^{-4}\left[10^{10^{(.8879-.9653T_0-.2969T_0^2+1.445T_0^3-2.07T_0^4+6697T_0^5)}}\right]^2$$

where $T_0 = \frac{1}{1800}\left(\frac{T2_N}{1.8} - 1200\right)$

and $T2_N$ is the temperature (^oR) for the Nth psi line at the current front.

6.6.2 The momentum equation now reads as

$$U2_N = U1_N - \frac{\Delta X\ GC}{\rho_N U1_N}\left(\frac{dP}{dX}\right)_N + \frac{\Delta X}{\Delta\psi^2}\rho_N U1_N r_N^{\ 2\delta}(\mu_N + \epsilon_{V_N})(U1_{N+1} - 2U1_N + U1_{N-1})$$

$$+ \frac{\Delta X}{\Delta\psi^2}(\mu_N + \epsilon_{V_N})(\rho_{N+1}U1_{N+1}r_{N+1}^{2\delta} - \rho_{N-1}U1_{N-1}r_{N-1}^{2\delta})(U1_{N+1} - U1_{N-1})$$

$$+ \frac{\Delta X}{4\Delta\psi^2}\rho_N U1_N r_N^{\ 2\delta}\left[(\mu_{N+1} - \mu_{N-1}) + (\epsilon_{V_{N+1}} - \epsilon_{V_{N-1}})\right](U1_{N+1} - U1_{N-1})$$

6.6 NONEQ3 (Subroutine) (Continued)

where

$U1_N$ is the axial velocity at the previous front

$U2_N$ is the axial velocity at the current front.

GC is the gravitational constant.

$\left(\frac{dP}{dX}\right)_N$ is the derivative of pressure with respect to X.

6.6.3 The species continuity equation now reads as

$$\bar{C}_{i,N} = C1_{i,N} + \frac{\Delta X\, \rho_N\, U1_N\, r_N^{2\delta}}{\Delta\psi^2}\left(\mu_N \frac{L_{e_N}}{P_{r_N}} + \frac{\epsilon_{V_N} L_{e_{t_N}}}{P_{r_{t_N}}}\right)(C1_{i,N+1} - 2C1_{i,N} + C1_{i,N-1})$$

$$+ \frac{\Delta X}{4\Delta\psi^2}\left(\mu_N \frac{L_{e_N}}{P_{r_N}} + \frac{\epsilon_{V_N} L_{e_{t_N}}}{P_{r_{t_N}}}\right)(\rho_{N+1}\, U1_{N+1} r_{N+1}^{2\delta} - \rho_{N-1} U1_{N-1} r_{N-1}^{2\delta})(C1_{i,N+1}$$

$$- C1_{i,N-1}) + \frac{\Delta X}{4\Delta\psi^2}\rho_N U1_N r_N^{2\delta}\left[\left(\frac{\mu_{N+1} L_{e_{N+1}}}{P_{r_{N+1}}} - \frac{\mu_{N-1} L_{e_{t_{N-1}}}}{P_{r_{N-1}}}\right.\right.$$

$$\left.\left. + \left(\frac{\epsilon_{V_{N+1}} L_{e_{t_{N+1}}}}{P_{r_{t_{N+1}}}} - \frac{\epsilon_{V_{N-1}} L_{e_{t_{N-1}}}}{P_{r_{t_{N-1}}}}\right)\right](C1_{i,N+1} - C1_{i,N-1})$$

where

Subscript N corresponds to the psi line referenced from the axial coordinate.

$\bar{C}_{i,N}$ is the concentration of the ith species at the current front. (This concentration is due to mixing only.)

$C1_{i,N}$ is the total concentration of the ith species at the previous front.

μ_N is the laminar viscosity at the current front.

L_{e_N} is the laminar Lewis number at the current front.

6.6 NONEQ3 (Subroutine) (Continued)

P_{r_N} is the laminar Prandtl number at the current front.

ϵ_{V_N} is the turbulent eddy viscosity at the current front.

$L_{e_{t_N}}$ is the turbulent Lewis number at the current front.

$P_{r_{t_N}}$ is the turbulent Prandtl number at the current front.

6.6.4 Atom balance equations have been incorporated to read

$$\tilde{C}_{2,N} = \bar{C}_{2,N} + \frac{W_2}{W_1}\bar{C}_{1,N}$$

$$\tilde{C}_{3,N} = \bar{C}_{3,N} + \frac{W_3}{2W_1}\bar{C}_{1,N} + \frac{W_3}{W_4}\bar{C}_{4,N} + \frac{W_3}{2W_5}\bar{C}_{5,N}$$

$$\tilde{C}_{4,N} + \frac{W_4}{W_5}\bar{C}_{5,N} = \bar{C}_{4,N} + \frac{W_4}{W_5}\bar{C}_{5,N}$$

$$\tilde{C}_6 = \bar{C}_6$$

W_i = the molecular weight of the ith species.

6.6.5 The total species concentrations are calculated by the following process

$$1.\quad \delta' = \frac{W_3}{FKP_1\, P\, W_M}\left(\frac{\tilde{C}_{2,N} - C2_{2,N}}{C2_{2,N}}\right)^2 + \frac{W_3}{2W_2}\left(\tilde{C}_{2,N} - C2_{2,N}\right.$$

$$+ \frac{\left(\frac{\tilde{C}_{2,N} - C2_{2,N}}{C2_{2,N}}\right)\left[\frac{W_3}{W_4}\left(\frac{FKP_4}{FKP_1}\right)^{1/2}\left(\tilde{C}_{4,N} + \frac{W_4}{W_5}\tilde{C}_{5,N}\right)\right]}{\left[1 + \left(\frac{FKP_4}{FKP_1}\right)^{1/2}\left(\frac{\tilde{C}_{2,N} - C2_{2,N}}{C2_{2,N}}\right)\right.} + \frac{W_3}{2W_2}\left[\tilde{C}_{4,N}\right.$$

$$\left.\left. + \frac{W_4}{W_5}\tilde{C}_{5,N} - \frac{\left(\frac{FKP_4}{FKP_1}\right)^{1/2}\left(\frac{\tilde{C}_{2,N} - C2_{2,N}}{C2_{2,N}}\right)\left(\tilde{C}_{4,N} + \frac{W_4}{W_5}\tilde{C}_{5,N}\right)}{1 + \left(\frac{FKP_4}{FKP_1}\right)^{1/2}\left(\tilde{C}_{4,N} + \frac{W_4}{W_5}\tilde{C}_{5,N}\right)}\right]\right. - \tilde{C}_{3,N}$$

where

δ' is the error function of $\tilde{C}_{3,N}$

6.6 NONEQ3 (Subroutine) (Continued)

An iteration for $C2_{2,N}$ is made and when

2. $$\left| \frac{\delta'}{\tilde{C}_{3,N}} \right| \leq .0005$$

equations 4 through 8 are evaluated for the total species concentrations. If $C2_{2,N}$ becomes less than $\frac{\tilde{C}_{2,N}}{1000}$ before inequality 2 is satisfied, then

3. $$C2_{2,N} = \sqrt{\frac{W_3}{FKP_1 \; P \; W_M}} \left[\frac{\tilde{C}_{2,N}}{\sqrt{\tilde{C}_{3,N} - \frac{W_3}{2W_2} \tilde{C}_{2,N} - \frac{W_3}{W_4} \left(\tilde{C}_{4,N} + \frac{W_4}{W_5} \tilde{C}_{5,N}\right)}} \right]$$

W_M = the average molecular weight of the mixture.

and

4. $$C2_{1,N} = \frac{W_1}{W_2} \left(\tilde{C}_{2,N} - C2_{2,N}\right)$$

5. $$C2_{3,N} = \frac{W_2^2 \; C2_{1,N}^2}{W_1^2 \; C2_{2,N}^2 \; FKP_1 \; P \; W_M}$$

6. $$C2_{4,N} = \left(\frac{FKP_4}{FKP_1}\right)^{1/2} \left[\frac{\tilde{C}_{2,N} - C2_{2,N}}{C2_{2,N}} \; \frac{\tilde{C}_{4,N} + \frac{W_4}{W_5} \tilde{C}_{5,N}}{1 + \left(\frac{FKP_4}{FKP_1}\right)^{1/2} \left(\frac{C_{2,N} - C2_{2,N}}{C2_{2,N}}\right)} \right]$$

7. $$C2_{5,N} = \frac{W_5}{W_4} \left(\tilde{C}_{4,N} + \frac{W_4}{W_5} \tilde{C}_{5,N} - C2_{4,N}\right)$$

8. $$C2_{6,N} = \tilde{C}_{6,N}$$

The net rate of production is then calculated for each species by

9. $$\dot{w}_{K,N} = \left(C2_{K,N} - \bar{C}_{K,N}\right) \rho_1 U_1 / \Delta X \qquad K = 1, 2, 3, 4, 5, 6$$

6.6 NONEQ3 (Subroutine) (Continued)

6.6.6 The energy equation now reads

$$T2_N = T1_N + \frac{\Delta X}{\rho_N\ J\ CP2_N}\left(\frac{dP}{dX}\right)_N + (\mu_N + \epsilon_{V_N})\frac{\rho_N\ U1_N\ r_N^{2\delta}\ \Delta X}{4\ GC\ J\ CP2_N\ \Delta\psi^2}(U1_{N+1} - U1_{N-1})^2$$

$$+ \frac{\Delta X}{\Delta\psi^2}\rho_N\ U1_N\ r_N^{2\delta}\left(\frac{\mu_N}{P_{r_N}} + \frac{\epsilon_{V_N}}{P_{r_{t_N}}}\right)(T1_{N+1} - 2T1_N + T1_{N-1})$$

$$+ \frac{\Delta X}{4\Delta\psi^2}\rho_N\ U1_N\ r_N^{2\delta}\left(\frac{\mu_{N+1}}{P_{r_{N+1}}} - \frac{\mu_{N-1}}{P_{r_{t_{N-1}}}}\right) + \left(\frac{\epsilon_{V_{N+1}}}{P_{r_{t_{N+1}}}} - \frac{\epsilon_{V_{N-1}}}{P_{r_{t_{N-1}}}}\right)\Bigg](T1_{N+1} - T1_{N-1})$$

$$+ \frac{\Delta X}{4\Delta\psi^2\ CP2_N}\left(\frac{\mu_N}{P_{r_N}} + \frac{\epsilon_{V_N}}{P_{r_{t_N}}}\right)(\rho_{N+1}\ U1_{N+1}\ r_{N+1}^{2\delta}\ CP2_{N+1}$$

$$- \rho_{N-1}\ U1_{N-1}\ r_{N-1}^{2\delta}\ CP2_{N-1})(T1_{N+1} - T1_{N-1}) + \frac{\Delta X\ \rho_N\ U1_N\ r_N^{2\delta}}{4\ CP2_N\ \Delta\psi^2}\left(\frac{\mu_N\ L_{e_N}}{P_{r_N}}\right.$$

$$\left. + \frac{\epsilon_{V_N}\ L_{e_{t_N}}}{P_{r_{t_N}}}\right)\sum_{i=1}^{6}\left[CP_{i,N}(T1_{N+1} - T1_{N-1})(C1_{i,N+1} - C1_{i,N-1})\right]$$

$$- \frac{\Delta X}{\rho_N\ CP2_N\ U1_N}\sum_{i=1}^{6}\dot{w}_{i,N}\ h_{i,N}$$

where $T1_N$ is the temperature of the previous front.

6.6.7 Limiting the calculations in NONEQ3 to the mixing zone and termination of the case.

At the beginning of a case the mixing zone is very small compared to the total region considered. Since the regions on either side of the mixing zone are assumed to have one dimensional flow the calculations in these regions have been reduced. Three points in either direction outside of the mixing zone are maintained. Any concentration less than TESMAX and TESMIN was assumed to be round-off in our calculations and H_2O, H_2, and N_2 was set to TESMAX - DTESMX, TESMAX - D2MAX and TESMIN - DTESMN respectively.

6.6 NONEQ3 (Subroutine) (Continued)

6.6.8 Expansion outwardly to the duct wall and inwardly to the reference psi line (ψ_1)

If uncontrolled, the mixing region will very often expand outwardly past the duct wall. To prevent this the following analysis has been incorporated: Psi corresponding to the last point in the mixing region PSINM3 (at NMAX-3) is compared with the value of psi at the duct wall (PSID). If PSINM3 ≥ PSID, the largest value of 'psi' is found such that

'psi' ≤ PSID ≤ PSINM3

NMAX is then set equal to the value of "n" that corresponds to 'psi'. All values at NMAX-1 are set equal to the corresponding values at NMAX. NMAX then remains constant until $\Delta\psi$ is doubled. When $\Delta\psi$ is doubled the above analysis is again initiated.

Since negative subscripts cannot be allowed, two checks are made to determine if the case being run has expanded inwardly to the reference psi line (ψ_1) and will be terminated. If NMIN > 2 and $r_1 \equiv r_{0_1} = 0$ ($r_{0_1} = 0$ signifies that the reference psi line (ψ_o) is the axis of symmetry), NMIN is set to one, ICHECK is set to one, the values at NMIN are set equal to the corresponding values at NMIN + 1 and the case is allowed to run out to the number of fronts specified by MMAX. For the remainder of the case NMIN remains constant.

If NMIN < 2 and $r_{0_1} \neq 0$, NMIN is set to one, ICHECK is set to zero, and the statement "THE MINIMUM SUBSCRIPT = 1" is printed. Control is returned to the main program where the current front is printed and the case terminated.

The calling sequence is:

CALL NONEQ3 (IDUCT, PSID, TESMAX, TESMIN, DTESMX, DTESMN, D2MAX)

where -

IDUCT = IDUCT ≠ 0 indicates the mixing region has expanded to the duct wall.

IDUCT = 0 indicates the mixing region has not expanded to the duct wall. (Internally determined)

PSID = The value of psi corresponding to the radius of the duct at the current front.

TESMAX = Input to Mix-Master

TESMIN = Input to Mix-Master

6.6 NONEQ3 (Subroutine) (Continued)

DTESMX = TESMAX - C2(1, NMAX)

DTESMN = TESMIN - C2(6, 1)

D2MAX = TESMAX - C2(2, NMAX)

6.7 PRESS (Subroutine)

Subroutine PRESS does a table look up for r_1 and P_M given X at front M and evaluates dP/dX.

Given XTAB, RTAB, PTAB (Input to Mix-Master) and X, PRESS uses the TAB function (SHARE Routine GMTABF) to interpolate for r_1 and P_M using second order polynomial interpolation. Then using XTAB, PTAB, X + .1 and X - .1 the TAB function interpolates the P1 and P2. PRESS then uses these values to calculate dP/dX.

$$\frac{dP}{dX} = \frac{P1 - P2}{.2}$$

The calling sequence is

CALL PRESS, the arguments being transferred via common.

6.8 Changes to Plume Program

The input form was rearranged and put into the form given in section 3.1. The output was changed so that the coordinates have dimensions rather than assuming the nozzle has unit radius. Subroutine PAMBPT was altered slightly so that it recognized when an iteration failed to converge. Subroutine PSEC was added (see section 6.8.1) and is called by PAMBPT. Subroutine STORE was written (see section 6.8.2) and is called by the chain version of the main program.

6.8.1 PSEC

Subroutine to compute static pressure in secondary stream for the Plume Program.

6.8.1.1 Introduction

The user requested the ability of either inputting the static pressure distribution of the secondary stream or the effective duct shape and the total conditions in the secondary stream. He also requested the option of either using polynomial input or tabular input. These requests have been implemented in the Plume Program by the addition of several items to the input list and by writing subroutine PSEC.

6.8.1.2 Nomenclature

The inputs are described in Input Symbols Definition (Section 2.1).

6.8.1.2 Nomenclature (Continued)

Specifically, the inputs which were added are:

$$(INDP, NPP, NPORA, ISTS, \dot{W}_{SEC}, P_{TSEC}, T_{TSEC}, \gamma_{SEC}, R_{SEC}, BB)$$

The array BB is used for all functions of X (either static pressure or effective duct in either polynomial or tabular form).

6.8.1.3 Method

If BB is given as a polynomial in X (INDP = 0) then the functional value at any X is defined as:

$$f(X) = BB(1)X^{NPP-1} + BB(2)X^{NPP-2} + \ldots, BB(NPP-1)X + BB(NPP)$$

If BB is given as a set of tabular data (INDP ≠ 0) then the functional value at any X is found by a linear table lookup. The table is to be stored in the BB array by alternately giving the independent and dependent variables. As an example, the table:

X	f(X)
0	100.0
1.0	150.0
2.0	140.0

would be input as,

BB(1) = 0.0
BB(2) = 100.0
BB(3) = 1.0
BB(4) = 150.0
BB(5) = 2.0
BB(6) = 140.0

The first value of the independent variable must be less than or equal to zero and the independent variable must be strictly increasing.

If the static pressure is being input, subroutine PSEC merely sets the pressure (P) equal to the functional value (f(X)) as defined above.

If the effective duct shape is being input then the static pressure is defined as a root of the following equation:

6.8.1.3 Method (Continued)

$$\left(\frac{P_{SEC}}{P_{TSEC}}\right)^{\frac{2}{\gamma_{SEC}}} - \left(\frac{P_{SEC}}{P_{TSEC}}\right)^{\frac{1+\gamma_{SEC}}{\gamma_{SEC}}} = \left(\frac{A_*}{A}\right)^2 \frac{\gamma_{SEC} - 1}{2}\left(\frac{\gamma_{SEC} + 1}{2}\right)^{\frac{1+\gamma_{SEC}}{1-\gamma_{SEC}}} \quad (1)$$

where A is the area of the secondary stream and A_* is the critical area of the secondary stream. Then A_* is given by:

$$A_* = \frac{0.1762\ \dot{w}_{SEC}}{P_{TSEC}\left[\frac{\gamma_{SEC}}{R_{SEC}T_{TSEC}}\left(\frac{2}{\rho_{SEC} + 1}\right)^{\frac{\gamma_{SEC}+1}{\gamma_{SEC}-1}}\right]^{1/2}}$$

and A is biven by

$$A = \pi\left[f(X)^2 - y_{SL}^{\ 2}\right]$$

where f(X) is defined by the BB array and y_{SL} is the y coordinate of the inviscid slip line. Thus given (X, y_{SL}) the subroutine finds f(X), A_*, A and then iterates to find P. Unfortunately there are two solutions to equation (1). These represent the supersonic and subsonic flow conditions. The program input ISTS determines whether the flow is initially supersonic or subsonic. If ISTS $\neq$ 0 then the flow is assumed to be initially supersonic and it is assumed that the flow will remain supersonic throughout the duct. If ISTS = 0 then the flow is assumed to start subsonic. The subroutine will attempt to determine which solution to take by extrapolating the last two pressures to see which way the pressures were heading. Equation (1) is solved using Newton's iteration scheme. The iteration variable is $\left(\frac{P_{SEC}}{P_{TSEC}}\right)$ rather than P_{SEC}. Thus given an estimate at the above ratio $\left(\frac{P_{SEC}}{P_{TSEC}}\right)_1$ and the error (E) given by

6.8.1.3 Method (Continued)

$$E = \left(\frac{P_{SEC}}{P_{TSEC}}\right)_1^{\frac{2}{\gamma_{SEC}}} - \left(\frac{P_{SEC}}{P_{TSEC}}\right)_1^{\frac{1+\gamma_{SEC}}{\gamma_{SEC}}} - \left(\frac{A^*}{A}\right)^2 \frac{\gamma_{SEC} - 1}{2}\left(\frac{\gamma_{SEC} + 1}{2}\right)^{\frac{1+\gamma_{SEC}}{1-\gamma_{SEC}}}$$

Then the next estimate for the pressure ratio $\left(\frac{P_{SEC}}{P_{TSEC}}\right)_2$ is given by:

$$\left(\frac{P_{SEC}}{P_{TSEC}}\right)_2' = \left(\frac{P_{SEC}}{P_{TSEC}}\right)_1 - E \frac{\partial E}{\partial\left(\frac{P_{SEC}}{P_{TSEC}}\right)_1}$$

where

$$\frac{\partial E}{\partial\left(\frac{P_{SEC}}{P_{TSEC}}\right)_1} = \frac{2}{\gamma_{SEC}}\left(\frac{P_{SEC}}{P_{TSEC}}\right)_1^{\frac{2-\gamma_{SEC}}{\gamma_{SEC}}} - \frac{1 + \gamma_{SEC}}{\gamma_{SEC}}\left(\frac{P_{SEC}}{P_{TSEC}}\right)_1^{\frac{1}{\gamma_{SEC}}}$$

The two solutions can be identified by the sign of $\frac{\partial E}{\partial\left(\frac{P_{SEC}}{P_{TSEC}}\right)_1}$.

If $\frac{\partial E}{\partial\left(\frac{P_{SEC}}{P_{TSEC}}\right)_1} < 0$ when (1) is satisfied, then we have found the subsonic solution. If $\frac{\partial E}{\partial\left(\frac{P_{SEC}}{P_{TSEC}}\right)_1} > 0$ when (1) is satisfied, then we have found the supersonic solution. By testing this partial derivative, the program is able to find the desired solution.

6.8.2 Subroutine STORE

Subroutine STORE was written to save the values of X, y and P_{SEC} at the boundary points of the plume. This is done only in the chain version. Once a case is completed subroutine STORE writes this information on logical tape 11.

APPENDIX B

Independent Plume and Mix-Master Input

7.0 PURPOSE (APPENDIX B)

This appendix states the method of input for Plume and Mix-Master when they are used as independent programs.*

The input for Plume will be given first followed by the input for Mix-Master.

7.1 Plume Data Configuration

Two types of input may be used for Plume. They are given in 7.1.1 and 7.1.2.

7.1.1 Ambient Pressure Input

Card one -

TITLE Format (12A6)

72 alpha numeric characters.

Card two -

LSTART, INDP, NPP, NPORA Format (4I4)

4 fixed point quantities.

Card three -

ALT, GMN, GAMJ, TEMPJ, PJ, RGCJ, RN, CPH Format (8F10.0)

8 floating point quantities.

Card four -

TXD, DBFL Format (8F10.0)

2 floating point quantities.

Repeat the next card for NPP values. Read BB_1, BB_2, BB_3, ..., BB_{NPP} inclusive.

Card five -

BB_1, BB_2, BB_3, ..., BB_{NPP} Format (8F10.0)

8 floating point quantities per card.

---

* The independent version of Plume and Mix-Master contain the modifications and/or additions given in appendix A with the exception of the linkage. All nomenclature used in this appendix may be found in the Air Augmented Rocket Power Plant Design Program input nomenclature lists.

7.1.1 Ambient Pressure Input (Continued)

The next card represents an array of variables.

DO I = 1, 2, 3, ..., LSTART

Card six -

TZ_I, TR_I, $TTHET_I$, $TXMN_I$, $TPRESS_I$ Format (8F10.0)

5 floating point quantities.

7.1.2 Duct Shape Input

Card one -

TITLE Format (12A6)

72 alpha numeric characters.

Card two -

LSTART, INDP, NPP, NPORA Format (4I4)

4 fixed point quantities.

Card three -

ALT, GMN, GAMJ, TEMPJ, PJ, RGCJ, RN, CPH Format (8F10.0)

8 floating point quantities.

Card four -

TXD, DBFL Format 8F10.0)

2 floating point quantities.

Card five -

WSEC, PTSEC, TTSEC, GSEC, RSEC Format (8F10.0)

5 floating point quantities.

Repeat the next card for NPP values. Read BB_1, BB_2, ..., BB_{NPP} inclusive.

Card six -

BB_1, BB_2, BB_3, ..., BB_{NPP} Format (8F10.0)

8 floating point quantities per card.

The next card represents an array of 5 variables.

DO I = 1, 2, 3, ..., LSTART

7.1.2 Duct Shape Input (Continued)

Card seven -

TZ_I, TR_I, $TTHET_I$, $TXMN_I$, $TPRESS_I$ Format (8F10.0)

5 floating point quantities.

7.2 Mix-Master Data Configuration

Card one -

AAA Format (12A6)

71 alpha numeric characters beginning in column 2 and ending in column 72.

Card two -

NMAX, MMAX, NS, LFRONT, KSLIP, NMIN Format (15I4)

6 fixed point quantities.

Card three -

A, FL, EPSON, FLET, PRT, DELTA Format (6E12.5)

6 floating point quantities.

Card four -

DX, FCON, RZERO1, RE, RDZERO, TESMAX Format (6E12.5)

6 floating point quantities.

Card five -

TESMIN Format (6E12.5)

1 floating point quantity.

Card six -

NXTAB Format (15I4)

1 fixed point quantity.

The next card represents an array of 3 variables.

I = 1, NXTAB

Card seven -

$XTAB_I$, $RTAB_I$, $PTAB_I$ Format (3E16.7)

3 floating point quantities.

7.2 Mix-Master Data Configuration (Continued)

The next card represents an array of 8 variables.

I = NMIN, NMAX

*Card eight -

$C2_{1,I}$, $C2_{2,I}$, $C2_{3,I}$, $C2_{4,I}$, $C2_{5,I}$, $C2_{6,I}$, $T2_I$, $U2_I$ Format (8E10.3)

8 floating point quantities.

Card nine -

X Format (8E10.3)

1 floating point quantity.

Card ten -

$C2_{1,e}$, $C2_{2,e}$, $C2_{3,e}$, $C2_{4,e}$, $C2_{5,e}$, $C2_{6,e}$ Format (6E12.5)

6 floating point quantities.

Card eleven -

$C2_{1,S}$, $C2_{2,S}$, $C2_{3,S}$, $C2_{4,S}$, $C2_{5,S}$, $C2_{6,S}$ Format (6E12.5)

6 floating point quantities.

Card twelve -

$T2_e$, $T2_S$, $U2_e$, $U2_S$ Format (6E12.5)

4 floating point quantities.

* Card eight and nine are to be used only if an arbitrary profile is to be input.

APPENDIX C

Sample Input and Output

INPUT AND OUTPUT FOR

AIR-AUGMENTED ROCKET

POWER PLANT DESIGN PROGRAM

Explanation of physical quantities used for the Air Augmented Rocket Power Plant Design Program in the order they are input.

Case identification = CASE 76-P4

Code indicating there will be no variable properties input = 0

Code indicating tabular values of ambient pressure or duct radius will be used = 1

Number of tabular values = 4

Code designating ambient pressure is input = 0

Code for indicating the flow in the secondary stream is subsonic or supersonic at the nozzle exit plane is not used when ambient pressure is input. Hence, this code can have any value. (Set = 0)

Altitude = 0.0 ft.

Mach number of the rocket exhaust = 3.17

Ratio of specific heats of the rocket exhaust = 1.22

Static temperature of the rocket exhaust = 3681.0°R

Static pressure of the rocket exhaust = 1899.0 lb/ft

Gas constant of the rocket exhaust = $65.1 \frac{\text{ft. lbs.}}{\text{lb. mass } ^{\circ}\text{R}}$

Nozzle radius = 1.833 feet

Code indicating the flow is axisymmetric = 1.0

Maximum axial distance the Plume Program will reach = 10.0 feet

Number of degrees between fan lines in the Prandtl-Meyer expansion = 0.1 angular degrees

Table of ambient pressure as a function of axial distance =

X (feet)	P(lb/ft^2)
0.0	1600.0
10.0	1475.0

Case identification = CASE 76-P4

Number of grid points at the initial front = 196

Number of fronts for which properties are to be evaluated = 200

Number of points to curve fit between the jet and secondary stream = 3

Print interval = 20 fronts

Number of the ψ line that corresponds to the radius of the slipline at the initial front = 129

Exponent in the turbulent layer growth law = 1.0

Reference length = 1.0 foot

Reichard's exchange coefficient = 3.0

Turbulent Lewis number = 1.2

Turbulent Prandtl number = 0.8

Code indicating the flow is axisymmetric = 1.0

Axial step size = 0.05 foot

Viscosity constant = 0.0

Radius to ψ_1 = 0.0 foot

Radius to the slip line at the initial front = 1.833 feet

Radius of the duct at the initial front = 4.0 feet

Value used to determine when the mixing region has expanded outwardly to the secondary stream = .00001 $\frac{\text{lb. of } H_2O}{\text{lb of mixture}}$

Value used to determine when the mixing region has expanded inwardly to the jet stream = .00001 $\frac{\text{lb. of } N_2}{\text{lb. of mixture}}$

Jet stream values of H_2O, H_2, O_2, CO_2, CO and N_2 = 0.2585, 0.01179, 0.0, 0.324, 0.405, and 0.0 $\frac{\text{lb. of species}}{\text{lb. of mixture}}$

Secondary stream values of H_2O, H_2, O_2, CO_2, CO and N_2 = 0.0, 0.0, 0.2, 0.0, 0.0 and 0.8 $\frac{\text{lb. of species}}{\text{lb. of mixture}}$

Jet and secondary stream values of temperature = 6381.0 and 704.0°R

Jet and secondary stream values of axial velocity = 9734.0 and 748.0 ft/sec

```
CASE 76-P4
   0   1   4   0   0
0.0        3.17       1.22       3681.0     1899.4     65.1       1.833      1.0
10.0       0.1
0.0        1600.0     10.0       1475.0
 CASE 76-P4
 196 200   3  20 129
1.0          1.0          3.0          1.2          0.8          1.0
0.05                                   1.833        4.4          1.0       E-05
1.0      E-05
0.2585       0.01179                   0.324        0.405
                          0.2                                    0.8
3681.0       704.0        9734.0       748.0
```

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SPURT-A

METHOD OF CHARACTERISTICS PROGRAM FOR THE SUPERSONIC
FLOW FIELD IN THE AIR-AUGMENTED ROCKET DUCT.

AXISYMMETRIC FLOW

UNITS

TEMPERATURE.....DEGREES RANKINE
PRESSURE.....LBS./SQ.FT.
MACH NUMBER.....DIMENSIONLESS
GAMMA.....DIMENSIONLESS
GAS CONSTANT.....FT.LBS./LB.MASS--DEGREE RANKINE
FLOW ANGLE (THETA)....DEGREES-MEASURED WITH RESPECT TO AXIS OF SYMMETRY
SHOCK ANGLE.....DEGREES-MEASURED WITH RESPECT TO AXIS OF SYMMETRY
DENSITY.....SLUGS/CUBIC FT.
VELOCITY.....FT./SEC.

NOTE

INTERSECTION OF JET EXIT PLANE AND JET AXIS OF SYMMETRY TAKEN AS ORIGIN OF COORDINATE SYSTEM
X=ABSCISSA
Y=ORDINATE
BOTH X AND Y ARE MEASURED IN FEET.

IDENTIFICATION OF POINTS ALONG A LEFT RUNNING CHARACTERISTIC WITHIN THE EXHAUST PLUME

IDENT. NATURE OF POINT

0.....POINT ON THE AXIS OF SYMMETRY
2.....INTERIOR POINT
3.....UPSTREAM AND DOWNSTREAM INTERIOR SHOCK POINTS
4.....CONSTANT PRESSURE BOUNDARY POINT INSIDE PLUME

AMBIENT PRESSURE = 1600.0000 ALTITUDE = 0. FT.

JET EXIT CONDITIONS (CONSTANT ACROSS EXIT PLANE)

MACH NUMBER = 3.1700
GAMMA = 1.2200
TEMPERATURE = 3681.0000
PRESSURE = 1899.4000
GAS CONSTANT = 65.1000
FLOW ANGLE = 0.
NOZZLE RADIUS = 1.8330

PROGRAM CONTROLS
CPH 1.0000
TXD 10.0000
DBFL 0.1000

CASE 76-P4
0. 0.16000E 04 0.10000E 02 0.14750E 04

PRANDTL-MEYER

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
	0.	0.18330E 01	0.31700E 01	0.	0.24616E-03	0.18994E 04	0.36840E 04	
	0.	0.18330E 01	0.31739E 01	1.00000E-01	0.24473E-03	0.18859E 04	0.36792E 04	
	0.	0.18330E 01	0.31778E 01	0.20000E-00	0.24330E-03	0.18725E 04	0.36745E 04	
	0.	0.18330E 01	0.31816E 01	0.30000E-00	0.24188E-03	0.18592E 04	0.36698E 04	
	0.	0.18330E 01	0.31855E 01	0.40000E-00	0.24047E-03	0.18460E 04	0.36651E 04	
	0.	0.18330E 01	0.31894E 01	0.50000E-00	0.23907E-03	0.18329E 04	0.36604E 04	
	0.	0.18330E 01	0.31933E 01	0.60000E 00	0.23767E-03	0.18198E 04	0.36556E 04	
	0.	0.18330E 01	0.31972E 01	0.70000E 00	0.23628E-03	0.18068E 04	0.36509E 04	
	0.	0.18330E 01	0.32011E 01	0.80000E 00	0.23489E-03	0.17939E 04	0.36462E 04	
	0.	0.18330E 01	0.32050E 01	0.90000E 00	0.23351E-03	0.17811E 04	0.36415E 04	
	0.	0.18330E 01	0.32089E 01	1.00000E 00	0.23214E-03	0.17683E 04	0.36368E 04	
	0.	0.18330E 01	0.32129E 01	0.11000E 01	0.23078E-03	0.17556E 04	0.36321E 04	
	0.	0.18330E 01	0.32168E 01	0.12000E 01	0.22942E-03	0.17430E 04	0.36273E 04	
	0.	0.18330E 01	0.32207E 01	0.13000E 01	0.22807E-03	0.17305E 04	0.36226E 04	
	0.	0.18330E 01	0.32247E 01	0.14000E 01	0.22672E-03	0.17181E 04	0.36179E 04	
	0.	0.18330E 01	0.32286E 01	0.15000E 01	0.22538E-03	0.17057E 04	0.36132E 04	
	0.	0.18330E 01	0.32325E 01	0.16000E 01	0.22405E-03	0.16934E 04	0.36085E 04	
	0.	0.18330E 01	0.32365E 01	0.17000E 01	0.22272E-03	0.16812E 04	0.36038E 04	
	0.	0.18330E 01	0.32404E 01	0.18000E 01	0.22140E-03	0.16690E 04	0.35991E 04	
	0.	0.18330E 01	0.32444E 01	0.19000E 01	0.22009E-03	0.16570E 04	0.35944E 04	
	0.	0.18330E 01	0.32484E 01	0.20000E 01	0.21878E-03	0.16450E 04	0.35897E 04	
	0.	0.18330E 01	0.32523E 01	0.21000E 01	0.21748E-03	0.16330E 04	0.35850E 04	
	0.	0.18330E 01	0.32563E 01	0.22000E 01	0.21619E-03	0.16212E 04	0.35802E 04	
	0.	0.18330E 01	0.32603E 01	0.23000E 01	0.21490E-03	0.16094E 04	0.35755E 04	
	0.	0.18330E 01	0.32635E 01	0.23805E 01	0.21387E-03	0.16000E 04	0.35718E 04	

JET VELOCITY AT THE SLIP LINE = 0.98677E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
1 4	0.23176E-02	0.18331E 01	0.32635E 01	0.23802E 01	0.21387E-03	0.16000E 04	0.35718E 04	

JET VELOCITY AT THE SLIP LINE = 0.98678E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
2 4	0.46322E-02	0.18332E 01	0.32635E 01	0.23799E 01	0.21386E-03	0.15999E 04	0.35717E 04	

JET VELOCITY AT THE SLIP LINE = 0.98678E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
3 4	0.92612E-02	0.18334E 01	0.32635E 01	0.23794E 01	0.21386E-03	0.15999E 04	0.35717E 04	

JET VELOCITY AT THE SLIP LINE = 0.98678E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
4 4	0.18519E-01	0.18338E 01	0.32635E 01	0.23784E 01	0.21385E-03	0.15998E 04	0.35717E 04	

JET VELOCITY AT THE SLIP LINE = 0.98678E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
5 4	0.37033E-01	0.18345E 01	0.32636E 01	0.23763E 01	0.21382E-03	0.15995E 04	0.35716E 04	

JET VELOCITY AT THE SLIP LINE = 0.98679E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
6 4	0.74057E-01	0.18361E 01	0.32638E 01	0.23722E 01	0.21377E-03	0.15991E 04	0.35714E 04	

JET VELOCITY AT THE SLIP LINE = 0.98681E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
7 4	0.14809E-00	0.18391E 01	0.32641E 01	0.23639E 01	0.21367E-03	0.15981E 04	0.35710E 04	

JET VELOCITY AT THE SLIP LINE = 0.98685E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
8 4	0.29608E-00	0.18452E 01	0.32647E 01	0.23471E 01	0.21347E-03	0.15963E 04	0.35703E 04	

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JET VELOCITY AT THE SLIP LINE =  0.98693E 04  FT/SEC.

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
   9  4  0.59179E 00   0.18573E 01   0.32660E 01   0.23129E 01   0.21306E-03   0.15926E 04   0.35688E 04
JET VELOCITY AT THE SLIP LINE =  0.98708E 04  FT/SEC.

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  10  4  0.11821E 01   0.18807E 01   0.32685E 01   0.22415E 01   0.21225E-03   0.15852E 04   0.35658E 04
JET VELOCITY AT THE SLIP LINE =  0.98738E 04  FT/SEC.

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  11  4  0.23583E 01   0.19252E 01   0.32736E 01   0.20847E 01   0.21064E-03   0.15705E 04   0.35598E 04
JET VELOCITY AT THE SLIP LINE =  0.98798E 04  FT/SEC.

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  12  4  0.35294E 01   0.19660E 01   0.32787E 01   0.19067E 01   0.20902E-03   0.15559E 04   0.35538E 04
JET VELOCITY AT THE SLIP LINE =  0.98858E 04  FT/SEC.

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  13  4  0.46964E 01   0.20027E 01   0.32839E 01   0.17012E 01   0.20742E-03   0.15413E 04   0.35478E 04
JET VELOCITY AT THE SLIP LINE =  0.98918E 04  FT/SEC.

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  14  4  0.58610E 01   0.20348E 01   0.32890E 01   0.14588E 01   0.20581E-03   0.15267E 04   0.35417E 04
JET VELOCITY AT THE SLIP LINE =  0.98978E 04  FT/SEC.

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  15  4  0.70265E 01   0.20615E 01   0.32943E 01   0.11649E 01   0.20420E-03   0.15122E 04   0.35356E 04
JET VELOCITY AT THE SLIP LINE =  0.99038E 04  FT/SEC.

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  16  4  0.81994E 01   0.20816E 01   0.32996E 01   0.79417E 00   0.20257E-03   0.14975E 04   0.35294E 04
JET VELOCITY AT THE SLIP LINE =  0.99100E 04  FT/SEC.

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  17  4  0.93951E 01   0.20930E 01   0.33051E 01   0.29702E-00   0.20092E-03   0.14826E 04   0.35230E 04
JET VELOCITY AT THE SLIP LINE =  0.99166E 04  FT/SEC.

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  18  4  0.10660E 02   0.20913E 01   0.33109E 01  -0.45152E-00   0.19916E-03   0.14668E 04   0.35162E 04
JET VELOCITY AT THE SLIP LINE =  0.99248E 04  FT/SEC.

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  19  4  0.12360E 02   0.20523E 01   0.33189E 01  -0.21716E 01   0.19679E-03   0.14455E 04   0.35070E 04
JET VELOCITY AT THE SLIP LINE =  0.99424E 04  FT/SEC.

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  20  4  0.12611E 02   0.20421E 01   0.33201E 01  -0.25136E 01   0.19644E-03   0.14424E 04   0.35056E 04
JET VELOCITY AT THE SLIP LINE =  0.99465E 04  FT/SEC.

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  21  3  0.57162E 01   0.26187E-01   0.36834E 01   0.35996E 01   0.11431E-03   0.74510E 03   0.31119E 04  -0.12153E 02
  21  4  0.12950E 02   0.20259E 01   0.33217E 01  -0.29588E 01   0.19597E-03   0.14381E 04   0.35037E 04
JET VELOCITY AT THE SLIP LINE =  0.99523E 04  FT/SEC.

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  22  4  0.13118E 02   0.20170E 01   0.33225E 01  -0.30658E 01   0.19573E-03   0.14360E 04   0.35028E 04
JET VELOCITY AT THE SLIP LINE =  0.99544E 04  FT/SEC.
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IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
23 •	0.57906E 01	0.92288E-02	0.39003E 01	0.12142E 01	0.83124E-04	0.50513E 03	0.29013E 04	

INTERIOR SHOCK IS NOW GOING NORMAL TO AXIS OF SYMMETRY

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
24 •	0.58276E 01	0.	0.40231E 01	0.	0.69541E-04	0.40632E 03	0.27874E 04	

END OF COMPUTATION FOR THIS CASE

CASE 76-P4

INITIAL INPUT

NMAX	MMAX	NS	LFRONT	KSLIP	NMIN
196	200	3	20	129	1

A	L	REICHARTS COEF.	LEWIS NO.	PRANDTL NO.	DELTA
1.000E 00	1.000E 00	3.000E 00	1.200E 00	8.000E-01	1.000E 00

DX	VISCOSITY CONST.	DELTA-PSI (NOT INPUT)
5.000E-02	-0.	8.533E-01

RZERO1	RE	RDZERO
-0.	1.833E 00	4.400E 00

TESMAX	TESMIN	NXTAB
10.000E-06	10.000E-06	23

XTAB	RTAB	PTAB	XTAB	RTAB	PTAB	XTAB	RTAB	PTAB
0.	1.833E 00	1.600E 03	2.318E-03	1.833E 00	1.600E 03	4.632E-03	1.833E 00	1.600E 03
9.261E-03	1.833E 00	1.600E 03	1.852E-02	1.834E 00	1.600E 03	3.703E-02	1.835E 00	1.600E 03
7.406E-02	1.836E 00	1.599E 03	1.481E-01	1.839E 00	1.598E 03	2.961E-01	1.845E 00	1.596E 03
5.918E-01	1.857E 00	1.593E 03	1.182E 00	1.881E 00	1.585E 03	2.358E 00	1.925E 00	1.571E 03
3.529E 00	1.966E 00	1.556E 03	4.696E 00	2.003E 00	1.541E 03	5.861E 00	2.035E 00	1.527E 03
7.027E 00	2.062E 00	1.512E 03	8.199E 00	2.082E 00	1.498E 03	9.395E 00	2.093E 00	1.483E 03
1.066E 01	2.091E 00	1.467E 03	1.236E 01	2.052E 00	1.445E 03	1.261E 01	2.042E 00	1.442E 03
1.295E 01	2.026E 00	1.438E 03	1.312E 01	2.017E 00	1.436E 03			

C211	C221	C231	C241	C251	C261	C21NMAX	C22NMAX	C23NMAX	C24NMAX
2.585E-01	1.179E-02	-0.	3.240E-01	4.050E-01	-0.	-0.	-0.	2.000E-01	-0.

C25NMAX	C26NMAX
-0.	8.000E-01

T21	T2NMAX	U21	U2NMAX
3.681E 03	7.340E 02	9.734E 03	7.480E 02

PROPERTIES GIVEN BELOW ARE AT FRONT 1 DISTANCE DOWNSTREAM = 0. FEET PRESSURE= 1600.0000PSF

INITIAL FLOW IN SECONDARY STREAM = 1593.3593 LBS/SEC
RADIUS OF DUCT = 4.4000 FT. THRUST = 0. LB. DUCT AREA = 60.8212 SQ FT.

N	Y	X-COMP VELOCITY	TEMPERATURE	DENSITY	----------CONCENTRATION OF SPECIES------- H2O	H2	O2	CO2	CO	N2	MACH
1	-0	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165

1	-0	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
2	.16202	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
3	.22913	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
4	.28063	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
5	.32404	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
6	.36229	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
7	.39687	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
8	.42866	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
9	.45826	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
10	.48606	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
11	.51235	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
12	.53736	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
13	.56125	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
14	.58417	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
15	.60622	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
16	.62750	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
17	.64808	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
18	.66802	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
19	.68739	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
20	.70623	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
21	.72457	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
22	.74247	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
23	.75994	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
24	.77702	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
25	.79373	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
26	.81010	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
27	.82614	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
28	.84188	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
29	.85733	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
30	.87250	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
31	.88742	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
32	.90209	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
33	.91652	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
34	.93073	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
35	.94473	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
36	.95852	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
37	.97212	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
38	.98553	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
39	.99876	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
40	1.0118	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
41	1.0247	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
42	1.0374	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
43	1.0500	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
44	1.0624	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
45	1.0747	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
46	1.0869	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
47	1.0989	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
48	1.1108	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
49	1.1225	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
50	1.1341	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
51	1.1457	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
52	1.1571	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
53	1.1683	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
54	1.1795	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
55	1.1906	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
56	1.2016	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
57	1.2124	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
58	1.2232	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165

59	1.2339	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
60	1.2445	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
61	1.2550	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
62	1.2654	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
63	1.2757	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
64	1.2860	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
65	1.2962	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
66	1.3062	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
67	1.3163	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
68	1.3262	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
69	1.3360	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
70	1.3458	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
71	1.3556	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
72	1.3652	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
73	1.3748	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
74	1.3843	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
75	1.3937	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
76	1.4031	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
77	1.4125	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
78	1.4217	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
79	1.4309	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
80	1.4401	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
81	1.4491	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
82	1.4582	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
83	1.4672	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
84	1.4761	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
85	1.4849	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
86	1.4937	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
87	1.5025	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
88	1.5112	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
89	1.5199	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
90	1.5285	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
91	1.5371	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
92	1.5456	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
93	1.5540	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
94	1.5625	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
95	1.5708	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
96	1.5792	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
97	1.5875	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
98	1.5957	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
99	1.6039	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
100	1.6121	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
101	1.6202	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
102	1.6283	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
103	1.6363	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
104	1.6442	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
105	1.6523	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
106	1.6602	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
107	1.6681	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
108	1.6759	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
109	1.6838	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
110	1.6915	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
111	1.6994	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
112	1.7072	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
113	1.7147	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
114	1.7223	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
115	1.7299	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
116	1.7375	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165

117	1.7450	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
118	1.7525	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
119	1.7600	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
120	1.7674	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
121	1.7748	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
122	1.7822	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
123	1.7896	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
124	1.7969	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
125	1.8042	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
126	1.8114	9734.0	3681.0	0.6679E-02	.25850	0.1179E-01	-0	.32400	.40500	-0	3.165
127	1.8187	9068.4	3460.5	0.7197E-02	.25935	0.1092E-01	0.1481E-01	.30000	.37500	0.5926E-01	3.053
128	1.8258	7404.3	2909.2	0.8849E-02	.19148	0.8733E-02	0.5185E-01	.24000	.30000	.20741	2.744
129	1.8330	5241.0	2192.5	0.1228E-01	.12925	0.5895E-02	1.0000E-01	.16200	.20250	.40000	2.261
130	1.8405	3077.7	1475.8	0.1911E-01	0.6702E-01	0.3057E-02	.14815	0.8400E-01	.10500	.59259	1.629
131	1.8493	1413.6	924.52	0.3167E-01	0.1915E-01	0.8733E-03	.18519	0.2400E-01	0.3000E-01	.74074	0.944
132	1.8617	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
133	1.8769	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
134	1.8905	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
135	1.9055	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
136	1.9168	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
137	1.9336	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
138	1.9469	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
139	1.9614	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
140	1.9744	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
141	1.9887	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
142	2.0015	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
143	2.0157	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
144	2.0283	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
145	2.0423	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
146	2.0548	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
147	2.0686	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
148	2.0809	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
149	2.0946	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
150	2.1067	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
151	2.1202	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
152	2.1322	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
153	2.1456	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
154	2.1574	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
155	2.1706	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
156	2.1823	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
157	2.1953	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
158	2.2069	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
159	2.2198	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
160	2.2313	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
161	2.2440	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
162	2.2554	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
163	2.2680	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
164	2.2792	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
165	2.2917	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
166	2.3028	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
167	2.3151	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
168	2.3261	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
169	2.3383	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
170	2.3492	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
171	2.3613	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
172	2.3721	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
173	2.3841	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
174	2.3948	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572

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175	2.4067	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
176	2.4173	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
177	2.4290	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
178	2.4395	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
179	2.4512	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
180	2.4616	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
181	2.4731	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
182	2.4834	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
183	2.4949	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
184	2.5051	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
185	2.5164	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
186	2.5265	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
187	2.5378	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
188	2.5478	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
189	2.5590	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
190	2.5690	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
191	2.5800	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
192	2.5899	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
193	2.6009	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
194	2.6107	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
195	2.6216	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572
196	2.6313	748.00	704.00	0.4223E-01	-0	-0	.20000	-0	-0	.80000	0.572

DELTA PSI WAS SET = 1.7066

PROPERTIES GIVEN BELOW ARE AT FRONT 21 DISTANCE DOWNSTREAM = 1.0000FEET PRESSURE= 1587.5000PSF

RADIUS OF DUCT = 4.4154 FT. THRUST = 681.8113 LB. DUCT AREA = 61.2483 SQ FT.

N	Y	X-COMP VELOCITY	TEMPERATURE	DENSITY	----------CONCENTRATION OF SPECIES-------- H2O	H2	O2	CO2	CO	N2	MACH
1	-0	9740.2	3675.7	0.6636E-02	.25850	0.1179E-01	0.2182E-09	.32400	.40500	0	3.169
55	1.6886	9740.2	3675.7	0.6636E-02	.25850	0.1179E-01	0.2182E-09	.32400	.40500	0	3.169
56	1.7042	9740.2	3675.7	0.6636E-02	.25850	0.1179E-01	0.2182E-09	.32400	.40500	0	3.169
57	1.7196	9740.2	3675.7	0.6636E-02	.25850	0.1179E-01	0.3480E-09	.32400	.40500	0	3.169
58	1.7349	9740.2	3675.7	0.6637E-02	.25849	0.1179E-01	0.2697E-08	.32400	.40498	0.1453E-04	3.169
59	1.7500	9739.8	3675.9	0.6637E-02	.25845	0.1178E-01	0.2356E-07	.32400	.40482	0.2192E-03	3.169
60	1.7651	9736.2	3677.3	0.6637E-02	.25821	0.1175E-01	0.1640E-06	.32398	.40391	0.1435E-02	3.168
61	1.7800	9711.7	3685.9	0.6637E-02	.25714	0.1159E-01	0.8425E-06	.32380	.39978	0.7002E-02	3.160
62	1.7949	9588.8	3725.6	0.6617E-02	.25356	0.1101E-01	0.2998E-05	.32285	.38567	0.2626E-01	3.116
63	1.8102	9144.2	3863.2	0.6516E-02	.24445	0.9439E-02	0.8643E-05	.31936	.34894	0.7724E-01	2.951
64	1.8273	7531.2	4224.2	0.6245E-02	.22449	0.6050E-02	0.1839E-03	.31175	.26919	.18796	2.509
65	1.8501	5260.4	4639.3	0.6187E-02	.16685	0.1613E-02	0.1516E-01	.30359	.11083	.40206	1.656
66	1.8863	2186.3	3252.4	0.9209E-02	0.6742E-01	0.1049E-05	.10275	.17753	0.6054E-04	.65204	0.826
67	1.9331	1202.8	1669.0	0.1777E-01	0.2485E-01	0.1505E-06	.16419	0.6544E-01	0.8965E-05	.74548	0.617
68	1.9682	928.03	1114.2	0.2654E-01	0.1118E-01	0.7455E-07	.18389	0.2944E-01	0.4926E-05	.77547	0.573
69	2.0041	830.27	891.46	0.3313E-01	0.5572E-02	0.5092E-07	.19196	0.1468E-01	0.3485E-05	.78776	0.568
70	2.0308	789.80	790.20	0.3735E-01	0.2850E-02	0.3427E-07	.19588	0.7522E-02	0.2371E-05	.79373	0.572
71	2.0613	772.29	741.91	0.3977E-01	0.1428E-02	0.2139E-07	.19793	0.3785E-02	0.1487E-05	.79685	0.576
72	2.0849	764.93	719.10	0.4103E-01	0.6775E-03	0.1211E-07	.19900	0.1818E-02	0.8478E-06	.79848	0.579

73	2.1135	762.08	708.93	0.4161E-01	0.2977E-03	0.6139E-08	.19955	0.8259E-03	0.4364E-06	.79931	0.581
74	2.1360	761.10	704.80	0.4185E-01	0.1171E-03	0.2700E-08	.19980	0.3605E-03	0.2028E-06	.79970	0.582
75	2.1636	760.81	703.32	0.4194E-01	0.3853E-04	0.9622E-09	.19991	0.1661E-03	0.9001E-07	.79986	0.582
76	2.1855	760.74	702.89	0.4197E-01	0.1128E-04	0.3001E-09	.19995	0.9878E-04	0.4666E-07	.79992	0.582
77	2.2125	760.73	702.78	0.4197E-01	0	0	.19996	0.7799E-04	0.3206E-07	.79993	0.582
78	2.2339	760.73	702.78	0.4197E-01	0	0	.19996	0.7799E-04	0.3206E-07	.79993	0.582
79	2.2603	760.73	702.78	0.4197E-01	0	0	.19996	0.7799E-04	0.3206E-07	.79993	0.582

DELTA PSI WAS SET = 3.4132

PROPERTIES GIVEN BELOW ARE AT FRONT 41 DISTANCE DOWNSTREAM = 2.0000FEET PRESSURE= 1574.9999PSF

RADIUS OF DUCT = 4.4266 FT. THRUST = 1173.3735 LB. DUCT AREA = 61.5592 SQ FT.

N	Y	X-COMP VELOCITY	TEMPERATURE	DENSITY	CONCENTRATION OF SPECIES H2O	H2	O2	CO2	CO	N2	MACH
1	-0	9746.4	3670.3	0.6594E-02	.25850	0.1179E-01	0.5844E-09	.32400	.40500	0	3.173
24	1.5630	9746.4	3670.3	0.6594E-02	.25850	0.1179E-01	0.5844E-09	.32400	.40500	0	3.173
25	1.5967	9746.4	3670.3	0.6594E-02	.25850	0.1179E-01	0.5844E-09	.32400	.40500	0	3.173
26	1.6296	9746.4	3670.3	0.6594E-02	.25850	0.1179E-01	0.1480E-08	.32400	.40499	0	3.173
27	1.6619	9746.3	3670.4	0.6594E-02	.25849	0.1179E-01	0.1255E-07	.32400	.40494	0.5706E-04	3.173
28	1.6935	9745.2	3671.2	0.6594E-02	.25839	0.1177E-01	0.1014E-06	.32397	.40456	0.5807E-03	3.173
29	1.7246	9735.3	3677.1	0.6591E-02	.25784	0.1168E-01	0.6157E-06	.32380	.40238	0.3583E-02	3.169
30	1.7553	9669.6	3710.6	0.6566E-02	.25548	0.1128E-01	0.2576E-05	.32302	.39291	0.1663E-01	3.142
31	1.7863	9357.3	3849.7	0.6439E-02	.24809	0.9953E-02	0.7827E-05	.31984	.36249	0.5911E-01	3.013
32	1.8203	8254.4	4278.6	0.6065E-02	.22970	0.6442E-02	0.2588E-03	.30951	.28526	.16880	2.584
33	1.8667	5181.5	4832.7	0.5911E-02	.16298	0.1460E-02	0.1783E-01	.30293	.10246	.41356	1.601
34	1.9438	1543.6	2936.7	0.1007E-01	0.5463E-01	0.1466E-06	.12154	.14392	0.6997E-05	.68011	0.729
35	2.0384	1070.0	1474.8	0.1993E-01	0.1890E-01	0.2465E-07	.17281	0.4982E-01	0.1402E-05	.75850	0.581
36	2.1018	851.47	1021.4	0.2871E-01	0.8426E-02	0.1521E-07	.18785	0.2224E-01	0.1009E-05	.78147	0.566
37	2.1684	817.45	846.31	0.3461E-01	0.4196E-02	0.1128E-07	.19392	0.1112E-01	0.7872E-06	.79074	0.573
38	2.2146	791.55	768.02	0.3812E-01	0.2141E-02	0.7935E-08	.19687	0.5731E-02	0.5777E-06	.79523	0.581
39	2.2700	780.60	731.36	0.4003E-01	0.1074E-02	0.5137E-08	.19839	0.2945E-02	0.4004E-06	.79755	0.586
40	2.3115	776.04	714.26	0.4098E-01	0.5137E-03	0.3021E-08	.19918	0.1495E-02	0.2682E-06	.79875	0.589
41	2.3637	774.27	706.71	0.4142E-01	0.2292E-03	0.1590E-08	.19958	0.7720E-03	0.1816E-06	.79936	0.591
42	2.4012	773.64	703.61	0.4160E-01	0.9184E-04	0.7241E-09	.19976	0.4357E-03	0.1320E-06	.79964	0.592
43	2.4518	773.44	702.48	0.4166E-01	0.3008E-04	0.2592E-09	.19984	0.2966E-03	0.1081E-06	.79975	0.592
44	2.4885	773.40	702.15	0.4169E-01	0	0	.19986	0.2499E-03	0.9919E-07	.79979	0.592
45	2.5367	773.40	702.15	0.4169E-01	0	0	.19986	0.2499E-03	0.9919E-07	.79979	0.592
46	2.5722	773.40	702.15	0.4169E-01	0	0	.19986	0.2499E-03	0.9919E-07	.79979	0.592

DELTA PSI WAS SET = 6.8265

PROPERTIES GIVEN BELOW ARE AT FRONT 61 DISTANCE DOWNSTREAM = 3.0000FEET PRESSURE= 1562.5000PSF

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RADIUS OF DUCT = 4.4321 FT. THRUST = 1414.3533 LB. DUCT AREA = 61.7120 SQ FT.

N	Y	X-COMP VELOCITY	TEMPERATURE	DENSITY	CONCENTRATION OF SPECIES H2O	H2	O2	CO2	CO	N2	MACH
1	-0	9752.7	3664.9	0.6551E-02	.25850	0.1179E-01	0.1481E-08	.32400	.40499	0	3.178
10	1.3868	9752.7	3664.9	0.6551E-02	.25850	0.1179E-01	0.1481E-08	.32400	.40499	0	3.178
11	1.4618	9752.7	3664.9	0.6551E-02	.25850	0.1179E-01	0.1481E-08	.32400	.40499	0	3.178
12	1.5332	9752.7	3664.9	0.6551E-02	.25850	0.1179E-01	0.2911E-08	.32400	.40499	0	3.178
13	1.6013	9752.4	3665.2	0.6551E-02	.25846	0.1178E-01	0.3634E-07	.32399	.40485	0.1773E-03	3.177
14	1.6668	9745.2	3670.5	0.6549E-02	.25803	0.1171E-01	0.5472E-06	.32380	.40308	0.2660E-02	3.174
15	1.7301	9645.1	3726.2	0.6502E-02	.25467	0.1109E-01	0.5853E-05	.32220	.38909	0.2231E-01	3.131
16	1.7951	8855.4	4052.4	0.6213E-02	.23893	0.8106E-02	0.4613E-04	.31400	.32298	.11568	2.815
17	1.8814	5156.5	4646.1	0.6168E-02	.16315	0.1198E-02	0.7666E-02	.32732	0.8327E-01	.41835	1.636
18	2.0285	1397.4	2134.0	0.1371E-01	0.3458E-01	0.7401E-10	.15027	0.9113E-01	0.1778E-08	.72409	0.640
19	2.1954	918.54	1097.2	0.2652E-01	0.1005E-01	0.2639E-07	.18549	0.2657E-01	0.1623E-05	.77787	0.571
20	2.2932	825.16	837.86	0.3468E-01	0.3900E-02	0.1412E-07	.19431	0.1041E-01	0.9170E-06	.79133	0.581
21	2.4063	798.35	751.02	0.3868E-01	0.1638E-02	0.6065E-08	.19754	0.4497E-02	0.4510E-06	.79625	0.592
22	2.4799	789.61	718.41	0.4042E-01	0.6689E-03	0.2442E-08	.19891	0.1989E-02	0.2432E-06	.79834	0.598
23	2.5785	786.88	706.54	0.4110E-01	0.2543E-03	0.9557E-09	.19949	0.9386E-03	0.1605E-06	.79922	0.601
24	2.6449	786.10	702.54	0.4133E-01	0.8086E-04	0.3223E-09	.19971	0.5283E-03	0.1284E-06	.79956	0.602
25	2.7367	785.92	701.43	0.4140E-01	0.1005E-04	0.4117E-10	.19978	0.3972E-03	0.1177E-06	.79967	0.602
26	2.7990	785.91	701.32	0.4141E-01	0	0	.19979	0.3808E-03	0.1163E-06	.79968	0.602
27	2.8859	785.91	701.32	0.4141E-01	0	0	.19979	0.3808E-03	0.1163E-06	.79968	0.602
28	2.9451	785.91	701.32	0.4141E-01	0	0	.19979	0.3808E-03	0.1163E-06	.79968	0.602

PROPERTIES GIVEN BELOW ARE AT FRONT 81 DISTANCE DOWNSTREAM = 4.0000FEET PRESSURE= 1549.9999PSF

RADIUS OF DUCT = 4.4568 FT. THRUST = 2485.4014 LB. DUCT AREA = 62.4006 SQ FT.

N	Y	X-COMP VELOCITY	TEMPERATURE	DENSITY	CONCENTRATION OF SPECIES H2O	H2	O2	CO2	CO	N2	MACH
1	-0	9759.0	3659.5	0.6508E-02	.25850	0.1179E-01	0.2274E-08	.32400	.40499	0	3.182
9	1.3113	9759.0	3659.5	0.6508E-02	.25850	0.1179E-01	0.2274E-08	.32400	.40499	0	3.182
10	1.3909	9759.0	3659.5	0.6508E-02	.25850	0.1179E-01	0.2274E-08	.32400	.40499	0	3.182
11	1.4661	9759.0	3659.5	0.6509E-02	.25849	0.1179E-01	0.7135E-08	.32400	.40497	0	3.182
12	1.5377	9758.6	3659.9	0.6509E-02	.25845	0.1178E-01	0.6140E-07	.32398	.40479	0.2416E-03	3.182
13	1.6061	9753.4	3664.0	0.6506E-02	.25810	0.1172E-01	0.4518E-06	.32387	.40341	0.2165E-02	3.180
14	1.6719	9709.1	3690.9	0.6485E-02	.25624	0.1141E-01	0.2240E-05	.32330	.39593	0.1243E-01	3.160
15	1.7366	9448.2	3814.9	0.6376E-02	.24921	0.1020E-01	0.9234E-05	.32083	.36745	0.5178E-01	3.051
16	1.8054	8369.2	4204.9	0.6063E-02	.23002	0.6630E-02	0.1694E-03	.31109	.28763	.16438	2.640
17	1.8967	5119.3	4713.8	0.6036E-02	.16098	0.1153E-02	0.9779E-02	.32361	0.8131E-01	.42402	1.612
18	2.0446	1750.4	2713.2	0.1073E-01	0.4962E-01	0.3249E-07	.12870	.13077	0.1286E-05	.69107	0.718
19	2.2186	1057.3	1400.9	0.2064E-01	0.1708E-01	0.1353E-07	.17539	0.4511E-01	0.7925E-06	.76242	0.587
20	2.3309	893.81	998.24	0.2890E-01	0.7742E-02	0.1049E-07	.18878	0.2056E-01	0.6871E-06	.78287	0.580
21	2.4482	838.63	840.86	0.3429E-01	0.3976E-02	0.7567E-08	.19417	0.1068E-01	0.5346E-06	.79110	0.590
22	2.5281	815.91	768.42	0.3750E-01	0.2123E-02	0.5044E-08	.19681	0.5839E-02	0.3952E-06	.79514	0.598
23	2.6250	805.93	733.06	0.3930E-01	0.1137E-02	0.3134E-08	.19821	0.3283E-02	0.2889E-06	.79726	0.605
24	2.6936	801.47	715.46	0.4027E-01	0.5941E-03	0.1811E-08	.19897	0.1894E-02	0.2162E-06	.79842	0.608

25	2.7817	798.53	706.94	0.4075E-01	0.2972E-03	0.9701E-09	.19937	0.1155E-02	0.1712E-06	.79904	0.610
26	2.8450	798.74	702.98	0.4099E-01	0.1373E-03	0.4686E-09	.19958	0.7767E-03	0.1458E-06	.79935	0.611
27	2.9277	798.40	701.29	0.4108E-01	0.5216E-04	0.1826E-09	.19967	0.5995E-03	0.1332E-06	.79950	0.612
28	2.9878	798.34	700.70	0.4112E-01	0.1045E-04	0.3701E-10	.19971	0.5316E-03	0.1282E-06	.79956	0.612
29	3.0657	798.33	700.60	0.4112E-01	0	0	.19972	0.5178E-03	0.1271E-06	.79957	0.612
30	3.1249	798.33	700.60	0.4112E-01	0	0	.19972	0.5178E-03	0.1271E-06	.79957	0.612
31	3.1994	798.33	700.60	0.4112E-01	0	0	.19972	0.5178E-03	0.1271E-06	.79957	0.612

PROPERTIES GIVEN BELOW ARE AT FRONT 101 DISTANCE DOWNSTREAM = 5.0000FEET PRESSURE= 1537.5000PSF

RADIUS OF DUCT = 4.4658 FT. THRUST = 2878.0658 LB. DUCT AREA = 62.6552 SQ FT.

N	Y	X-COMP VELOCITY	TEMPERATURE	DENSITY	CONCENTRATION OF SPECIES H2O	H2	O2	CO2	CO	N2	MACH
1	[illegible]	3765.4	3654.0	0.6466E-02	.25850	0.1179E-01	0.3710E-08	.32400	.40498	0	3.186
8	1.2507	3765.4	3654.0	0.6466E-02	.25850	0.1179E-01	0.3710E-08	.32400	.40498	0	3.186
9	1.3152	3765.4	3654.0	0.6466E-02	.25850	0.1179E-01	0.3710E-08	.32400	.40498	0	3.186
10	1.3950	3765.3	3654.1	0.6466E-02	.25849	0.1179E-01	0.9318E-08	.32400	.40496	0	3.186
11	1.4705	3765.0	3654.5	0.6466E-02	.25845	0.1178E-01	0.5528E-07	.32398	.40479	0.2302E-03	3.186
12	1.5423	3761.6	3657.3	0.6464E-02	.25819	0.1174E-01	0.3019E-06	.32389	.40376	0.1662E-02	3.185
13	1.6115	3738.4	3672.5	0.6454E-02	.25709	0.1155E-01	0.1296E-05	.32349	.39926	0.7900E-02	3.175
14	1.6779	3625.2	3737.0	0.6403E-02	.25344	0.1090E-01	0.4587E-05	.32202	.38430	0.2872E-01	3.126
15	1.7442	3231.4	3915.0	0.6243E-02	.24413	0.9178E-02	0.1525E-04	.31768	.34553	0.8309E-01	2.954
16	1.8162	2565.2	4321.0	0.5949E-02	.22265	0.5546E-02	0.4617E-03	.31023	.25948	.20194	2.499
17	1.9115	1524.1	4687.5	0.6036E-02	.16156	0.1062E-02	0.7301E-02	.33366	0.7452E-01	.42453	1.621
18	2.0555	2274.2	3159.5	0.9170E-02	0.6253E-01	0.8173E-06	.11001	.16475	0.4645E-04	.66271	0.794
19	2.2415	1204.2	1697.5	0.1692E-01	0.2409E-01	0.1075E-06	.16531	0.6359E-01	0.5813E-05	.74702	0.615
20	2.3549	975.48	1175.4	0.2437E-01	0.1186E-01	0.2700E-07	.18286	0.3142E-01	0.1492E-05	.77383	0.588
21	2.4775	950.61	953.63	0.3001E-01	0.6697E-02	0.1133E-07	.19025	0.1787E-01	0.6953E-06	.78511	0.591
22	2.5643	852.02	842.55	0.3394E-01	0.4030E-02	0.6441E-08	.19406	0.1089E-01	0.4540E-06	.79093	0.598
23	2.6622	832.65	781.87	0.3657E-01	0.2497E-02	0.4214E-08	.19624	0.6886E-02	0.3431E-06	.79426	0.606
24	2.7341	822.34	746.91	0.3827E-01	0.1557E-02	0.2876E-08	.19757	0.4449E-02	0.2750E-06	.79629	0.611
25	2.8208	816.77	726.47	0.3934E-01	0.9660E-03	0.1963E-08	.19840	0.2932E-02	0.2278E-06	.79756	0.615
26	2.8855	813.79	714.46	0.4000E-01	0.5898E-03	0.1308E-08	.19892	0.1979E-02	0.1942E-06	.79835	0.618
27	2.9654	812.15	707.53	0.4039E-01	0.3516E-03	0.8399E-09	.19924	0.1390E-02	0.1707E-06	.79884	0.620
28	3.0264	811.34	703.61	0.4062E-01	0.2015E-03	0.5117E-09	.19944	0.1033E-02	0.1548E-06	.79914	0.621
29	3.1024	810.92	701.50	0.4074E-01	0.1085E-03	0.2889E-09	.19955	0.8260E-03	0.1449E-06	.79931	0.621
30	3.1602	810.73	700.43	0.4080E-01	0.5247E-04	0.1445E-09	.19961	0.7132E-03	0.1391E-06	.79940	0.622
31	3.2328	810.65	699.95	0.4083E-01	0.2022E-04	0.5693E-10	.19964	0.6586E-03	0.1362E-06	.79945	0.622
32	3.2862	810.63	699.77	0.4084E-01	0	0	.19965	0.6374E-03	0.1350E-06	.79947	0.622
33	3.3579	810.63	699.77	0.4084E-01	0	0	.19965	0.6374E-03	0.1350E-06	.79947	0.622
34	3.4111	810.63	699.77	0.4084E-01	0	0	.19965	0.6374E-03	0.1350E-06	.79947	0.622

DELTA PSI WAS SET = 13.653

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PROPERTIES GIVEN BELOW ARE AT FRONT 121 DISTANCE DOWNSTREAM = 6.0000FEET PRESSURE= 1525.0000PSF

RADIUS OF DUCT = 4.4726 FT. THRUST = 3168.9700 LB. DUCT AREA = 62.8441 SQ FT.

N	Y	X-COMP VELOCITY	TEMPERATURE	DENSITY	CONCENTRATION OF SPECIES H2O	H2	O2	CO2	CO	N2	MACH
1	-0	9771.7	3648.5	0.6423E-02	.25849	0.1179E-01	0.5102E-08	.32400	.40498	0	3.191
3	.93281	9771.7	3648.5	0.6423E-02	.25849	0.1179E-01	0.5102E-08	.32400	.40498	0	3.191
4	1.1425	9771.7	3648.5	0.6423E-02	.25849	0.1179E-01	0.5102E-08	.32400	.40498	0	3.191
5	1.3192	9771.7	3648.6	0.6423E-02	.25849	0.1179E-01	0.1179E-07	.32400	.40495	0	3.191
6	1.4749	9768.9	3651.1	0.6422E-02	.25825	0.1175E-01	0.2469E-06	.32391	.40399	0.1334E-02	3.190
7	1.6163	9697.4	3694.4	0.6389E-02	.25536	0.1123E-01	0.3586E-05	.32271	.39208	0.1795E-01	3.159
8	1.7534	8939.6	4010.1	0.6120E-02	.23920	0.8231E-02	0.3535E-04	.31535	.32447	.11260	2.854
9	1.9293	5121.9	4693.5	0.5980E-02	.16090	0.1052E-02	0.7896E-02	.33232	0.7414E-01	.42614	1.619
10	2.2113	1381.8	1993.2	0.1431E-01	0.3158E-01	0.7958E-05	.15494	0.8264E-01	0.5667E-03	.73042	0.653
11	2.4948	953.27	1082.8	0.2623E-01	0.9758E-02	0.2308E-06	.18585	0.2594E-01	0.1558E-04	.77837	0.596
12	2.6682	866.18	845.94	0.3353E-01	0.4134E-02	0.2424E-07	.19388	0.1122E-01	0.1580E-05	.79065	0.607
13	2.8518	838.69	759.66	0.3733E-01	0.1930E-02	0.5059E-08	.19700	0.5492E-02	0.3964E-06	.79542	0.619
14	2.9793	828.54	723.58	0.3918E-01	0.9065E-03	0.1927E-08	.19844	0.2865E-02	0.2292E-06	.79761	0.625
15	3.1338	824.75	708.26	0.4003E-01	0.4113E-03	0.8392E-09	.19911	0.1630E-02	0.1749E-06	.79864	0.629
16	3.2455	823.39	701.96	0.4038E-01	0.1719E-03	0.3597E-09	.19942	0.1064E-02	0.1527E-06	.79911	0.631
17	3.3859	822.95	699.63	0.4052E-01	0.5941E-04	0.1287E-09	.19955	0.8309E-03	0.1436E-06	.79931	0.631
18	3.4888	822.83	698.93	0.4056E-01	0	0	.19959	0.7533E-03	0.1405E-06	.79937	0.632
19	3.6195	822.83	698.93	0.4056E-01	0	0	.19959	0.7533E-03	0.1405E-06	.79937	0.632
20	3.7159	822.83	698.93	0.4056E-01	0	0	.19959	0.7533E-03	0.1405E-06	.79937	0.632

PROPERTIES GIVEN BELOW ARE AT FRONT 141 DISTANCE DOWNSTREAM = 7.0000FEET PRESSURE= 1512.5000PSF

RADIUS OF DUCT = 4.4925 FT. THRUST = 4021.8303 LB. DUCT AREA = 63.4045 SQ FT.

N	Y	X-COMP VELOCITY	TEMPERATURE	DENSITY	CONCENTRATION OF SPECIES H2O	H2	O2	CO2	CO	N2	MACH
1	-0	9778.2	3643.0	0.6380E-02	.25849	0.1179E-01	0.5312E-08	.32400	.40498	0	3.195
2	.66160	9778.2	3643.0	0.6380E-02	.25849	0.1179E-01	0.5312E-08	.32400	.40498	0	3.195
3	.93564	9778.2	3643.0	0.6380E-02	.25849	0.1179E-01	0.5312E-08	.32400	.40498	0	3.195
4	1.1459	9778.2	3643.0	0.6380E-02	.25849	0.1179E-01	0.7881E-08	.32400	.40497	0	3.195
5	1.3232	9777.6	3643.6	0.6380E-02	.25843	0.1178E-01	0.7579E-07	.32397	.40473	0.2742E-03	3.195
6	1.4795	9765.2	3652.5	0.6375E-02	.25774	0.1165E-01	0.1062E-05	.32369	.40186	0.4307E-02	3.190
7	1.6222	9620.1	3730.5	0.6310E-02	.25218	0.1089E-01	0.3035E-05	.32379	.38098	0.3158E-01	3.128
8	1.7632	8676.3	4086.5	0.6026E-02	.23428	0.7374E-02	0.7074E-04	.31420	.30402	.14032	2.761
9	1.9422	5064.6	4570.2	0.6105E-02	.15820	0.9451E-03	0.9789E-02	.33247	0.6791E-01	.43417	1.624
10	2.2204	1580.9	2311.7	0.1226E-01	0.3967E-01	0.6732E-05	.14350	.10406	0.4905E-03	.71268	0.698
11	2.5165	1033.6	1240.1	0.2273E-01	0.1346E-01	0.9249E-06	.18059	0.3566E-01	0.6636E-04	.77021	0.607
12	2.6980	908.36	927.10	0.3036E-01	0.6131E-02	0.3026E-06	.19102	0.1648E-01	0.2153E-04	.78624	0.610
13	2.8881	866.02	805.72	0.3491E-01	0.3160E-02	0.1004E-06	.19523	0.8744E-02	0.7127E-05	.79271	0.621
14	3.0165	848.51	749.87	0.3750E-01	0.1690E-02	0.3309E-07	.19730	0.4946E-02	0.2396E-05	.79588	0.630
15	3.1725	840.82	722.73	0.3891E-01	0.9073E-03	0.1083E-07	.19839	0.2955E-02	0.8560E-06	.79754	0.635
16	3.2822	837.37	709.25	0.3965E-01	0.4736E-03	0.3513E-08	.19897	0.1883E-02	0.3619E-06	.79843	0.638

17	3.4222	835.87	702.76	0.4001E-01	0.2330E-03	0.1156E-08	.19928	0.1322E-02	0.2098E-06	.79890	0.640
18	3.5223	835.26	699.80	0.4019E-01	0.9941E-04	0.3696E-09	.19943	0.1045E-02	0.1636E-06	.79913	0.641
19	3.6523	835.04	698.64	0.4025E-01	0.3107E-04	0.9845E-10	.19949	0.9271E-03	0.1503E-06	.79925	0.641
20	3.7459	834.99	698.32	0.4027E-01	0	0	.19951	0.8903E-03	0.1470E-06	.79926	0.641
21	3.8683	834.99	698.32	0.4027E-01	0	0	.19951	0.8903E-03	0.1470E-06	.79926	0.641
22	3.9568	834.99	698.32	0.4027E-01	0	0	.19951	0.8903E-03	0.1470E-06	.79926	0.641

PROPERTIES GIVEN BELOW ARE AT FRONT 161 DISTANCE DOWNSTREAM = 8.0000FEET PRESSURE= 1500.0000PSF

RADIUS OF DUCT = 4.5155 FT. THRUST = 5005.9911 LB. DUCT AREA = 64.0568 SQ FT.

N	Y	X-COMP VELOCITY	TEMPERATURE	DENSITY	CONCENTRATION OF SPECIES H2O	H2	O2	CO2	CO	N2	MACH
1	-0	9784.6	3637.4	0.6337E-02	.25849	0.1179E-01	0.5932E-08	.32400	.40497	0	3.200
2	.56442	9784.6	3637.4	0.6337E-02	.25849	0.1179E-01	0.5932E-08	.32400	.40497	0	3.200
3	.93850	9784.6	3637.4	0.6337E-02	.25849	0.1179E-01	0.5932E-08	.32400	.40497	0	3.200
4	1.1494	9784.5	3637.5	0.6337E-02	.25848	0.1179E-01	0.2195E-07	.32399	.40492	0	3.200
5	1.3272	9782.2	3639.5	0.6336E-02	.25829	0.1176E-01	0.2338E-06	.32394	.40417	0.1043E-02	3.199
6	1.4842	[illegible]	3658.7	[illegible]	.25681	0.1152E-01	0.1718E-05	.32362	.39828	0.9045E-02	3.186
7	[illegible]	[illegible]	3770.5	[illegible]	.24971	[illegible]	[illegible]	.32235	.37015	[illegible]	[illegible]
8	1.7757	4428.5	4156.0	0.5940E-02	.22957	0.6621E-02	0.1318E-03	.31353	.28520	.16551	2.675
9	1.9577	5033.7	4589.9	0.6035E-02	.15641	0.9107E-03	0.1115E-01	.32993	0.6600E-01	.43878	1.611
10	2.2354	1762.1	2564.9	0.1097E-01	0.4659E-01	0.7170E-05	.13376	.12225	0.5247E-03	.69748	0.741
11	2.5557	1117.5	1392.0	0.2310E-01	0.1705E-01	0.1215E-05	.17551	0.4511E-01	0.8808E-04	.76231	0.623
12	2.7267	936.04	1015.5	0.2750E-01	0.8245E-02	0.5305E-06	.18800	0.2206E-01	0.3826E-04	.78157	0.616
13	2.9194	897.91	860.51	0.3243E-01	0.4549E-02	0.2469E-06	.19324	0.1242E-01	0.1776E-04	.78963	0.625
14	3.0557	872.06	784.65	0.3555E-01	0.2646E-02	0.1179E-06	.19592	0.7483E-02	0.8491E-05	.79375	0.633
15	3.2052	859.55	744.62	0.3746E-01	0.1571E-02	0.5641E-07	.19742	0.4724E-02	0.4107E-05	.79606	0.640
16	3.3205	853.21	722.57	0.3860E-01	0.9298E-03	0.2652E-07	.19831	0.3105E-02	0.1990E-05	.79741	0.645
17	3.4574	849.97	710.40	0.3926E-01	0.5415E-03	0.1222E-07	.19883	0.2150E-02	0.9869E-06	.79821	0.647
18	3.5587	848.35	703.75	0.3963E-01	0.3038E-03	0.5453E-08	.19913	0.1591E-02	0.5189E-06	.79867	0.649
19	3.6850	847.57	700.26	0.3983E-01	0.1590E-03	0.2331E-08	.19930	0.1278E-02	0.3090E-06	.79893	0.650
20	3.7740	847.22	698.54	0.3992E-01	0.7125E-04	0.8930E-09	.19939	0.1113E-02	0.2190E-06	.79907	0.651
21	3.8979	847.08	697.83	0.3997E-01	0.2320E-04	0.2637E-09	.19943	0.1040E-02	0.1847E-06	.79913	0.651
22	3.9870	847.05	697.62	0.3998E-01	0	0	.19944	0.1016E-02	0.1746E-06	.79915	0.651
23	4.0396	847.05	697.62	0.3998E-01	0	0	.19944	0.1016E-02	0.1746E-06	.79915	0.651
24	4.1843	847.05	697.62	0.3998E-01	0	0	.19944	0.1016E-02	0.1746E-06	.79915	0.651

PROPERTIES GIVEN BELOW ARE AT FRONT 181 DISTANCE DOWNSTREAM = 9.0000FEET PRESSURE= 1487.5000PSF

RADIUS OF DUCT = 4.5379 FT. THRUST = 5958.1719 LB. DUCT AREA = 64.6936 SQ FT.

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N	Y	X-COMP VELOCITY	TEMPERATURE	DENSITY	CONCENTRATION OF SPECIES H2O	H2	O2	CO2	CO	N2	MACH
1	-0	9791.1	3631.8	0.6294E-02	.25849	0.1179E-01	0.6895E-08	.32400	.40497	0.1692E-07	3.204
1	-0	9791.1	3631.8	0.6294E-02	.25849	0.1179E-01	0.6895E-08	.32400	.40497	0.1692E-07	3.204
2	.66566	9791.1	3631.8	0.6294E-02	.25849	0.1179E-01	0.6895E-08	.32400	.40497	0.1692E-07	3.204
3	.94139	9791.1	3631.8	0.6294E-02	.25849	0.1179E-01	0.8591E-08	.32400	.40497	0.2373E-05	3.204
4	1.1530	9790.7	3632.2	0.6294E-02	.25845	0.1178E-01	0.5750E-07	.32398	.40478	0.1244E-03	3.204
5	1.3314	9784.6	3636.9	0.6292E-02	.25802	0.1171E-01	0.4735E-06	.32388	.40310	0.2496E-02	3.201
6	1.4892	9728.6	3670.0	0.6268E-02	.25563	0.1132E-01	0.2467E-05	.32334	.39350	0.1554E-01	3.178
7	1.6355	9409.0	3814.5	0.6149E-02	.24704	0.9855E-02	0.9005E-05	.32095	.35855	0.6330E-01	3.046
8	1.7849	8200.4	4218.9	0.5859E-02	.22520	0.5969E-02	0.2320E-03	.31323	.26822	.18798	2.596
9	1.9729	5016.7	4592.1	0.6000E-02	.15582	0.8271E-03	0.9331E-02	.33617	0.5980E-01	.44170	1.608
10	2.2480	1932.8	2781.4	0.1005E-01	0.5285E-01	0.7862E-05	.12493	.13870	0.5765E-03	.68371	0.784
11	2.5473	1204.2	1538.8	0.1804E-01	0.2058E-01	0.1480E-05	.17051	0.5440E-01	0.1078E-03	.75454	0.641
12	2.7493	1007.5	1106.5	0.2504E-01	0.1040E-01	0.7189E-06	.18493	0.2775E-01	0.5218E-04	.77681	0.624
13	2.9453	933.35	920.43	0.3008E-01	0.6022E-02	0.3825E-06	.19113	0.1631E-01	0.2770E-04	.78637	0.629
14	3.0852	898.74	825.39	0.3352E-01	0.3708E-02	0.2138E-06	.19440	0.1030E-01	0.1548E-04	.79140	0.637
15	3.2398	880.89	772.52	0.3581E-01	0.2354E-02	0.1221E-06	.19629	0.6808E-02	0.8870E-05	.79432	0.645
16	3.3549	871.10	741.44	0.3731E-01	0.1509E-02	0.6985E-07	.19747	0.4650E-02	0.5115E-05	.79612	0.650
17	3.4900	865.63	722.83	0.3826E-01	0.9666E-03	0.3973E-07	.19821	0.3287E-02	0.2964E-05	.79726	0.654
18	3.5925	862.54	711.57	0.3887E-01	0.6115E-03	0.2226E-07	.19868	0.2415E-02	0.1725E-05	.79798	0.656
19	3.7162	860.82	704.86	0.3924E-01	0.3787E-03	0.1225E-07	.19898	0.1864E-02	0.1023E-05	.79844	0.658
20	3.8110	859.88	700.91	0.3946E-01	0.2257E-03	0.6535E-08	.19917	0.1522E-02	0.6308E-06	.79873	0.659
21	3.9268	859.39	698.69	0.3959E-01	0.1259E-03	0.3318E-08	.19928	0.1318E-02	0.4197E-06	.79890	0.660
22	4.0161	859.15	697.52	0.3965E-01	0.6233E-04	0.1526E-08	.19934	0.1204E-02	0.3115E-06	.79899	0.660
23	4.1259	859.05	696.98	0.3968E-01	0.2415E-04	0.5637E-09	.19937	0.1148E-02	0.2618E-06	.79904	0.660
24	4.2108	859.01	696.79	0.3970E-01	0	0	.19938	0.1127E-02	0.2434E-06	.79906	0.660
25	4.3157	859.01	696.79	0.3970E-01	0	0	.19938	0.1127E-02	0.2434E-06	.79906	0.660
26	4.3969	859.01	696.79	0.3970E-01	0	0	.19938	0.1127E-02	0.2434E-06	.79906	0.660

PROPERTIES GIVEN BELOW ARE AT FRONT 201 DISTANCE DOWNSTREAM = 10.0000FEET PRESSURE= 1475.0000PSF

RADIUS OF DUCT = 4.5598 FT. THRUST = 6886.4007 LB. DUCT AREA = 65.3197 SQ FT.

N	Y	X-COMP VELOCITY	TEMPERATURE	DENSITY	CONCENTRATION OF SPECIES H2O	H2	O2	CO2	CO	N2	MACH
1	-0	9797.7	3626.1	0.6251E-02	.25849	0.1179E-01	0.7165E-08	.32400	.40497	0.7580E-06	3.209
1	-0	9797.7	3626.1	0.6251E-02	.25849	0.1179E-01	0.7165E-08	.32400	.40497	0.7580E-06	3.209
2	.66773	9797.7	3626.1	0.6251E-02	.25849	0.1179E-01	0.7165E-08	.32400	.40497	0.7580E-06	3.209
3	.94431	9797.6	3626.2	0.6251E-02	.25848	0.1179E-01	0.1576E-07	.32399	.40494	0.3057E-04	3.209
4	1.1565	9796.5	3627.2	0.6251E-02	.25837	0.1177E-01	0.1242E-06	.32397	.40449	0.5443E-03	3.208
5	1.3356	9783.5	3636.5	0.6245E-02	.25760	0.1164E-01	0.7949E-06	.32378	.40138	0.4835E-02	3.203
6	1.4944	9693.3	3686.0	0.6208E-02	.25421	0.1107E-01	0.3321E-05	.32288	.38765	0.2358E-01	3.165
7	1.6430	9285.3	3860.1	0.6066E-02	.24431	0.9321E-02	0.1058E-04	.31967	.34673	0.7984E-01	2.999
8	1.7966	7691.0	4269.2	0.5791E-02	.22108	0.5408E-02	0.3710E-03	.31353	.25268	.20808	2.526
9	1.9878	5006.9	4560.6	0.5991E-02	.15500	0.8100E-03	0.1037E-01	.33499	0.5893E-01	.44383	1.610
10	2.2588	2096.6	2966.2	0.9352E-02	0.5869E-01	0.8329E-05	.11667	.15406	0.6098E-03	.67087	0.825
11	2.5574	1295.8	1680.5	0.1639E-01	0.2410E-01	0.1716E-05	.16552	0.6368E-01	0.1248E-03	.74679	0.661
12	2.7671	1062.2	1198.7	0.2293E-01	0.1260E-01	0.8905E-06	.18181	0.3355E-01	0.6478E-04	.77196	0.634
13	2.9665	971.63	983.44	0.2792E-01	0.7548E-02	0.5100E-06	.18895	0.2035E-01	0.3707E-04	.78300	0.635

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14	3.1115	824.07	870.13	0.3154E-01	0.4837E-02	0.3100E-06	.19278	0.1330E-01	0.2253E-04	.78889	0.642
15	3.2672	804.54	804.83	0.3409E-01	0.3217E-02	0.1945E-06	.19505	0.9101E-02	0.1415E-04	.79240	0.649
16	3.3450	791.01	764.78	0.3587E-01	0.2177E-02	0.1235E-06	.19650	0.6428E-02	0.9021E-05	.79463	0.655
17	3.5195	762.96	739.50	0.3709E-01	0.1484E-02	0.7878E-07	.19746	0.4666E-02	0.5801E-05	.79610	0.660
18	3.6255	778.06	723.23	0.3792E-01	0.1010E-02	0.5006E-07	.19810	0.3478E-02	0.3743E-05	.79710	0.663
19	3.7454	775.09	712.74	0.3848E-01	0.6826E-03	0.3159E-07	.19854	0.2675E-02	0.2429E-05	.79777	0.665
20	3.8409	773.27	705.99	0.3885E-01	0.4550E-03	0.1968E-07	.19884	0.2132E-02	0.1590E-05	.79822	0.667
21	3.9546	772.14	701.71	0.3909E-01	0.2969E-03	0.1205E-07	.19903	0.1770E-02	0.1063E-05	.79852	0.668
22	4.0441	771.56	699.04	0.3924E-01	0.1872E-03	0.7168E-08	.19916	0.1534E-02	0.7367E-06	.79872	0.669
23	4.1516	771.20	697.44	0.3933E-01	0.1120E-03	0.4082E-08	.19924	0.1385E-02	0.5412E-06	.79884	0.670
24	4.2366	771.01	696.53	0.3938E-01	0.6108E-04	0.2141E-08	.19929	0.1296E-02	0.4292E-06	.79892	0.670
25	4.3392	770.92	696.06	0.3941E-01	0.2633E-04	0.8999E-09	.19932	0.1248E-02	0.3705E-06	.79896	0.670
26	4.4204	770.89	695.87	0.3942E-01	0	0	.19933	0.1227E-02	0.3459E-06	.79898	0.670
27	4.5188	770.89	695.87	0.3942E-01	0	0	.19933	0.1227E-02	0.3459E-06	.79898	0.670
28	4.5969	770.89	695.87	0.3942E-01	0	0	.19933	0.1227E-02	0.3459E-06	.79898	0.670

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INPUT AND OUTPUT

FOR

PLUME (AMBIENT PRESSURE)

Explanation of physical quantities used for the Plume Program in the order they are input.

Case identification = SAMPLE CASE AMBIENT PRESSURE INPUT

Code indicating there will be no variable properties input = 0

Code indicating tabular values of ambient pressure or duct radius will be used = 1

Number of tabular values = 14

Code designating ambient pressure is input = 0

Code for indicating the flow in the secondary stream is subsonic or supersonic at the nozzle exit plane is not used when ambient pressure is input. Hence, this code can have any value. (Set = 0)

Altitude = 0.0 feet

Mach number of the rocket exhaust = 3.05

Ratio of specific heats of the rocket exhaust = 1.2

Static temperature of the rocket exhaust = 2970.0°R

Static pressure of the rocket exhaust = 1540.0 lb/ft^2

Gas constant of the rocket = $65.2 \frac{ft.\ lbs.}{lb.\ mass\,^{o}R}$

Nozzle radius = .207 foot

Code indicating the flow is axisymmetric = 1.0

Maximum axial distance (X) the Plume Program will reach = 10.0 feet

Number of degrees between fan lines in the Prandtl-Meyer expansion = 0.5 angular degrees

Table of ambient pressure as a function of axial distance =

X (feet)	P ($lb./ft^2$)
0.0	985.0
0.417	750.0
1.0	495.0
1.25	452.0
1.46	444.0
1.875	379.0
2.21	328.0

SAMPLE CASE AMBIENT PRESSURE INPUT

```
   0    1   14    0    0
0.0        3.05       1.2        2970.0     1540.0     65.2       0.207      1.0
10.0       0.5
0.0        285.0      0.417      750.0      1.0        495.0      1.25       452.0
1.46       444.0      1.875      379.0      2.21       328.0
```

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SPURT-A 03-20-64

METHOD OF CHARACTERISTICS PROGRAM FOR THE SUPERSONIC
FLOW FIELD IN THE AIR-AUGMENTED ROCKET DUCT.

AXISYMMETRIC FLOW

UNITS

TEMPERATURE.....DEGREES RANKINE
PRESSURE.....LBS./SQ.FT.
MACH NUMBER.....DIMENSIONLESS
GAMMA.....DIMENSIONLESS
GAS CONSTANT.....FT.LBS./LB.MASS--DEGREE RANKINE
FLOW ANGLE (THETA)....DEGREES-MEASURED WITH RESPECT TO AXIS OF SYMMETRY
SHOCK ANGLE.....DEGREES-MEASURED WITH RESPECT TO AXIS OF SYMMETRY
DENSITY.....SLUGS/CUBIC FT.
VELOCITY.....FT./SEC.

NOTE

INTERSECTION OF JET EXIT PLANE AND JET AXIS OF SYMMETRY TAKEN AS ORIGIN OF COORDINATE SYSTEM
X=ABSCISSA
Y=ORDINATE
BOTH X AND Y ARE MEASURED IN FEET.

IDENTIFICATION OF POINTS ALONG A LEFT RUNNING CHARACTERISTIC WITHIN THE EXHAUST PLUME

IDENT. NATURE OF POINT

0.....POINT ON THE AXIS OF SYMMETRY
2.....INTERIOR POINT
3.....UPSTREAM AND DOWNSTREAM INTERIOR SHOCK POINTS
4.....CONSTANT PRESSURE BOUNDARY POINT INSIDE PLUME

AMBIENT PRESSURE = 985.0000 ALTITUDE = 0. FT.

JET EXIT CONDITIONS (CONSTANT ACROSS EXIT PLANE)

MACH NUMBER = 3.0500
GAMMA = 1.2000
TEMPERATURE = 2970.0000
PRESSURE = 1540.0000
GAS CONSTANT = 65.2000
FLOW ANGLE = 0.
NOZZLE RADIUS = 0.2070

PROGRAM CONTROLS
CPH 1.0000
TXD 10.0000
DDEL 0.5000

SAMPLE CASE AMBIENT PRESSURE INPUT-

0.	0.98500E 03	0.41700E-00	0.75000E 03	0.10000E 01	0.49500E 03	0.12500E 01
0.45200E 03	0.14600E 01	0.44400E 03	0.18750E 01	0.37900E 03	0.22100E 01	0.32800E 03

PRANDTL-MEYER

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
	0.	0.20700E-00	0.30500E 01	0.	0.24698E-03	0.15400E 04	0.29724E 04	
	0.	0.20700E-00	0.30679E 01	0.50000E-00	0.24010E-03	0.14887E 04	0.29557E 04	
	0.	0.20700E-00	0.30859E 01	1.00000E 00	0.23338E-03	0.14388E 04	0.29389E 04	
	0.	0.20700E-00	0.31039E 01	0.15000E 01	0.22681E-03	0.13904E 04	0.29222E 04	
	0.	0.20700E-00	0.31220E 01	0.20000E 01	0.22040E-03	0.13433E 04	0.29055E 04	
	0.	0.20700E-00	0.31403E 01	0.25000E 01	0.21414E-03	0.12976E 04	0.28888E 04	
	0.	0.20700E-00	0.31586E 01	0.30000E 01	0.20802E-03	0.12533E 04	0.28721E 04	
	0.	0.20700E-00	0.31770E 01	0.35000E 01	0.20204E-03	0.12102E 04	0.28554E 04	
	0.	0.20700E-00	0.31956E 01	0.40000E 01	0.19621E-03	0.11684E 04	0.28387E 04	
	0.	0.20700E-00	0.32142E 01	0.45000E 01	0.19052E-03	0.11279E 04	0.28220E 04	
	0.	0.20700E-00	0.32329E 01	0.50000E 01	0.18497E-03	0.10885E 04	0.28054E 04	
	0.	0.20700E-00	0.32517E 01	0.55000E 01	0.17955E-03	0.10504E 04	0.27888E 04	
	0.	0.20700E-00	0.32706E 01	0.60000E 01	0.17426E-03	0.10133E 04	0.27721E 04	
	0.	0.20700E-00	0.32856E 01	0.63935E 01	0.17019E-03	0.98500E 03	0.27591E 04	

JET VELOCITY AT THE SLIP LINE - 0.86588E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
1 4	0.28148E-03	0.20703E-00	0.32857E 01	0.63943E 01	0.17016E-03	0.98484E 03	0.27590E 04	

JET VELOCITY AT THE SLIP LINE = 0.86590E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
2 4	0.56160E-03	0.20706E-00	0.32858E 01	0.63949E 01	0.17014E-03	0.98468E 03	0.27589E 04	

JET VELOCITY AT THE SLIP LINE = 0.86591E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
3 4	0.11218E-02	0.20713E-00	0.32859E 01	0.63963E 01	0.17009E-03	0.98437E 03	0.27588E 04	

JET VELOCITY AT THE SLIP LINE = 0.86593E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
4 4	0.22423E-02	0.20725E-00	0.32863E 01	0.63990E 01	0.17000E-03	0.98374E 03	0.27585E 04	

JET VELOCITY AT THE SLIP LINE = 0.86597E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
5 4	0.44835E-02	0.20750E-00	0.32869E 01	0.64044E 01	0.16982E-03	0.98247E 03	0.27579E 04	

JET VELOCITY AT THE SLIP LINE = 0.86606E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
6 4	0.89667E-02	0.20801E-00	0.32883E 01	0.64152E 01	0.16946E-03	0.97995E 03	0.27567E 04	

JET VELOCITY AT THE SLIP LINE = 0.86623E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
7 4	0.17936E-01	0.20902E-00	0.32910E 01	0.64369E 01	0.16873E-03	0.97489E 03	0.27543E 04	

JET VELOCITY AT THE SLIP LINE = 0.86657E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
8 4	0.35888E-01	0.21105E-00	0.32965E 01	0.64803E 01	0.16727E-03	0.96478E 03	0.27495E 04	

JET VELOCITY AT THE SLIP LINE = 0.86727E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
9 4	0.71844E-01	0.21516E-00	0.33077E 01	0.65673E 01	0.16434E-03	0.94451E 03	0.27398E 04	

JET VELOCITY AT THE SLIP LINE = 0.86868E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
10 4	0.14399E-00	0.22358E-00	0.33309E 01	0.67427E 01	0.15842E-03	0.90386E 03	0.27198E 04	

JET VELOCITY AT THE SLIP LINE = 0.87157E 04 FT/SEC.

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE

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  11  4  0.28935E-00   0.24123E-00   0.33811E 01   0.71042E 01   0.14636E-03   0.82194E 03   0.26771E 04
JET VELOCITY AT THE SLIP LINE =  0.87772E 04  FT/SEC.

IDENT.        X              Y            MACH NO.        THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE
  12  4  0.43661E-00   0.26004E-00   0.34356E 01   0.74547E 01   0.13431E-03   0.74142E 03   0.26315E 04
JET VELOCITY AT THE SLIP LINE =  0.88424E 04  FT/SEC.

IDENT.        X              Y            MACH NO.        THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE
  13  4  0.58581E 00   0.27968E-00   0.34844E 01   0.75428E 01   0.12439E-03   0.67616E 03   0.25914E 04
JET VELOCITY AT THE SLIP LINE =  0.88993E 04  FT/SEC.

IDENT.        X              Y            MACH NO.        THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE
  14  4  0.73739E 00   0.29990E-00   0.35390E 01   0.76512E 01   0.11414E-03   0.60986E 03   0.25472E 04
JET VELOCITY AT THE SLIP LINE =  0.89615E 04  FT/SEC.

IDENT.        X              Y            MACH NO.        THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE
  15  4  0.89300E 00   0.32099E-00   0.36019E 01   0.77854E 01   0.10342E-03   0.54180E 03   0.24974E 04
JET VELOCITY AT THE SLIP LINE =  0.90311E 04  FT/SEC.

IDENT.        X              Y            MACH NO.        THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE
  16  4  0.10546E 01   0.34279E-00   0.36601E 01   0.75880E 01   0.94399E-04   0.48561E 03   0.24523E 04
JET VELOCITY AT THE SLIP LINE =  0.90939E 04  FT/SEC.

IDENT.        X              Y            MACH NO.        THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE
  17  4  0.12242E 01   0.36378E-00   0.36932E 01   0.65218E 01   0.89649E-04   0.45644E 03   0.24271E 04
JET VELOCITY AT THE SLIP LINE =  0.91287E 04  FT/SEC.

IDENT.        X              Y            MACH NO.        THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE
  18  4  0.14094E 01   0.38167E-00   0.37056E 01   0.45087E 01   0.87925E-04   0.44593E 03   0.24177E 04
JET VELOCITY AT THE SLIP LINE =  0.91416E 04  FT/SEC.

VALUES ALONG INSERTED CHARACTERISTIC

IDENT.        X              Y            MACH NO.        THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE
  19  4  0.15301E 01   0.38963E-00   0.37213E 01   0.30389E 01   0.85799E-04   0.43302E 03   0.24059E 04
JET VELOCITY AT THE SLIP LINE =  0.91579E 04  FT/SEC.

IDENT.        X              Y            MACH NO.        THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE
  19  4  0.16515E 01   0.39483E-00   0.37453E 01   0.18624E 01   0.82647E-04   0.41400E 03   0.23879E 04
JET VELOCITY AT THE SLIP LINE =  0.91825E 04  FT/SEC.

IDENT.        X              Y            MACH NO.        THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE
  20  4  0.17530E 01   0.39701E-00   0.37662E 01   0.59863E 00   0.79995E-04   0.39811E 03   0.23724E 04
JET VELOCITY AT THE SLIP LINE =  0.92037E 04  FT/SEC.

IDENT.        X              Y            MACH NO.        THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE
  21  4  0.18301E 01   0.39731E-00   0.37827E 01  -0.14842E-00   0.77968E-04   0.38604E 03   0.23603E 04
JET VELOCITY AT THE SLIP LINE =  0.92203E 04  FT/SEC.

IDENT.        X              Y            MACH NO.        THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE
  22  4  0.19447E 01   0.39605E-00   0.38078E 01  -0.11141E 01   0.74986E-04   0.36839E 03   0.23419E 04
JET VELOCITY AT THE SLIP LINE =  0.92453E 04  FT/SEC.

IDENT.        X              Y            MACH NO.        THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE
  23  4  0.20340E 01   0.39392E-00   0.38279E 01  -0.16151E 01   0.72672E-04   0.35479E 03   0.23273E 04
JET VELOCITY AT THE SLIP LINE =  0.92652E 04  FT/SEC.

IDENT.        X              Y            MACH NO.        THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE
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  24  4  0.20844E 01   0.39248E-00   0.38397E 01  -0.16485E 01   0.71360E-04   0.34711E 03   0.23188E 04
JET VELOCITY AT THE SLIP LINE =  0.92767E 04  FT/SEC.

IDENT.        X              Y            MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  25  4  0.22136E 01   0.38833E-00   0.38710E 01  -0.20357E 01   0.67976E-04   0.32746E 03   0.22964E 04
JET VELOCITY AT THE SLIP LINE =  0.93071E 04  FT/SEC.

IDENT.        X              Y            MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  26  4  0.23277E 01   0.38421E-00   0.39003E 01  -0.21004E 01   0.64958E-04   0.31009E 03   0.22756E 04
JET VELOCITY AT THE SLIP LINE =  0.93351E 04  FT/SEC.

IDENT.        X              Y            MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  27  4  0.24397E 01   0.38024E-00   0.39309E 01  -0.19594E 01   0.61966E-04   0.29303E 03   0.22543E 04
JET VELOCITY AT THE SLIP LINE =  0.93639E 04  FT/SEC.

IDENT.        X              Y            MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  28  3  0.10799E 01   0.47325E-01   0.43516E 01   0.32398E 01   0.32623E-04   0.13569E 03   0.19828E 04  -0.10046E 02
  28  4  0.25517E 01   0.37674E-00   0.39632E 01  -0.16222E 01   0.58947E-04   0.27598E 03   0.22319E 04
JET VELOCITY AT THE SLIP LINE =  0.93940E 04  FT/SEC.

END OF COMPUTATION FOR THIS CASE
```

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INPUT AND OUTPUT

FOR

PLUME (DUCT SHAPE)

Explanation of physical quantities used for the Plume Program in the order they are input.

Case identification = SAMPLE CASE DUCT SHAPE INPUT

Code indicating there will be no variable properties input = 0

Code indicating tabular values of ambient pressure or duct radius will be used = 1

Number of tabular values = 4

Code designating duct radius is input = 1

Code for indicating the flow in the secondary stream is subsonic at the nozzle exit plane = 0

Altitude = 0.0 feet

Mach number of the rocket exhaust = 3.05

Ratio of specific heats of the rocket exhaust = 1.2

Static temperature of the rocket exhaust = 2970.0^{o}R

Static pressure of the rocket exhaust = 1540.0 lb/ft^2

Gas constant of the rocket exhaust = 65.2 $\frac{\text{ft. lbs.}}{\text{lb. mass}^{o}\text{R}}$

Nozzle radius = .207 foot

Code indicating the flow is axisymmetric = 1.0

Maximum axial distance (X) the Plume Program will reach = 10.0 feet

Number of degrees between fan lines in the Prandtl-Meyer expansion = 0.5 angular degrees

Total mass flow in the secondary stream = 22.33 lb/sec

Total pressure in the secondary stream = 1457.0 lb/ft^2

Total temperature in the secondary stream = 707.0^{o}R

Ratio of specific heats in the secondary stream = 1.4

Gas constant in the secondary stream = 53.3 $\frac{\text{ft. lbs.}}{\text{lb. mass}^{o}\text{R}}$

Table of duct radius as a function of axial distance =

X (feet)	r (feet)
0.0	0.562
2.28	0.743

```
SAMPLE CASE   DUCT SHAPE INPUT
  0    1    4    1    0
0.0        3.05       1.2        2970.0     1540.0     65.2       0.207      1.0
10.0       0.5
22.33      1457.0     707.0      1.4        53.3
0.0        0.562      2.28       0.743
```

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METHOD OF CHARACTERISTICS PROGRAM FOR THE SUPERSONIC
FLOW FIELD IN THE AIR-AUGMENTED ROCKET DUCT.

AXISYMMETRIC FLOW

UNITS

```
TEMPERATURE............DEGREES RANKINE
PRESSURE...............LBS./SQ.FT.
MACH NUMBER............DIMENSIONLESS
GAMMA..................DIMENSIONLESS
GAS CONSTANT...........FT.LBS./LB.MASS--DEGREE RANKINE
FLOW ANGLE (THETA)....DEGREES-MEASURED WITH RESPECT TO AXIS OF SYMMETRY
SHOCK ANGLE............DEGREES-MEASURED WITH RESPECT TO AXIS OF SYMMETRY
DENSITY................SLUGS/CUBIC FT.
VELOCITY...............FT./SEC.
```

NOTE

INTERSECTION OF JET EXIT PLANE AND JET AXIS OF SYMMETRY TAKEN AS ORIGIN OF COORDINATE SYSTEM
X=ABSCISSA
Y=ORDINATE
BOTH X AND Y ARE MEASURED IN FEET.

IDENTIFICATION OF POINTS ALONG A LEFT RUNNING CHARACTERISTIC WITHIN THE EXHAUST PLUME

```
IDENT.        NATURE OF POINT

  0.....POINT ON THE AXIS OF SYMMETRY
  2.....INTERIOR POINT
  3.....UPSTREAM AND DOWNSTREAM INTERIOR SHOCK POINTS
  4.....CONSTANT PRESSURE BOUNDARY POINT INSIDE PLUME
```

AMBIENT PRESSURE = 1080.9679 ALTITUDE = 0. FT.

JET EXIT CONDITIONS (CONSTANT ACROSS EXIT PLANE)

```
MACH NUMBER =      3.0500
GAMMA =      1.2000
TEMPERATURE =  2970.0000
PRESSURE =  1540.0000
GAS CONSTANT =    65.2000
FLOW ANGLE =      0.
NOZZLE RADIUS =      0.2070
PROGRAM CONTROLS
CPH      1.0000
TXD     10.0000
DBFL     0.5000
```

```
SAMPLE CASE   DUCT SHAPE INPUT
  0.            0.56200E 00   0.22800E 01   0.74300E 00
```

FOR THE SECONDARY STREAM

MASS FLOW = 22.3300
TOTAL PRESSURE = 1457.0000
TOTAL TEMPERATURE = 707.0000
GAMA = 1.4000
GAS CONSTANT = 53.3000
A STAR = 0.7656

PRANDTL-MEYER

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
	0.	0.20700E-00	0.30500E 01	0.	0.24698E-03	0.15400E 04	0.29724E 04	
	0.	0.20700E-00	0.30679E 01	0.50000E-00	0.24010E-03	0.14887E 04	0.29557E 04	
	0.	0.20700E-00	0.30858E 01	1.00000E 00	0.23338E-03	0.14388E 04	0.29389E 04	
	0.	0.20700E-00	0.31039E 01	0.15000E 01	0.22681E-03	0.13904E 04	0.29222E 04	
	0.	0.20700E-00	0.31220E 01	0.20000E 01	0.22040E-03	0.13433E 04	0.29055E 04	
	0.	0.20700E-00	0.31403E 01	0.25000E 01	0.21414E-03	0.12976E 04	0.28888E 04	
	0.	0.20700E-00	0.31586E 01	0.30000E 01	0.20802E-03	0.12533E 04	0.28721E 04	
	0.	0.20700E-00	0.31770E 01	0.35000E 01	0.20204E-03	0.12102E 04	0.28554E 04	
	0.	0.20700E-00	0.31956E 01	0.40000E 01	0.19621E-03	0.11684E 04	0.28387E 04	
	0.	0.20700E-00	0.32142E 01	0.45000E 01	0.19052E-03	0.11279E 04	0.28220E 04	
	0.	0.20700E-00	0.32329E 01	0.50000E 01	0.18497E-03	0.10885E 04	0.28054E 04	
	0.	0.20700E-00	0.32366E 01	0.50978E 01	0.18390E-03	0.10810E 04	0.28021E 04	

JET VELOCITY AT THE SLIP LINE = 0.85960E 04 FT/SEC.
SECONDARY STREAM, AREA = 0.8576, MACH NO. = 0.6672

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
1 4	0.27015E-03	0.20702E-00	0.32365E 01	0.50959E 01	0.18390E-03	0.10810E 04	0.28022E 04	

JET VELOCITY AT THE SLIP LINE = 0.85960E 04 FT/SEC.
SECONDARY STREAM, AREA = 0.8577, MACH NO. = 0.6671

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
2 4	0.53992E-03	0.20705E-00	0.32365E 01	0.50939E 01	0.18391E-03	0.10811E 04	0.28022E 04	

JET VELOCITY AT THE SLIP LINE = 0.85959E 04 FT/SEC.
SECONDARY STREAM, AREA = 0.8577, MACH NO. = 0.6671

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
3 4	0.10794E-02	0.20710E-00	0.32364E 01	0.50899E 01	0.18393E-03	0.10812E 04	0.28022E 04	

JET VELOCITY AT THE SLIP LINE = 0.85958E 04 FT/SEC.
SECONDARY STREAM, AREA = 0.8578, MACH NO. = 0.6669

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
4 4	0.21582E-02	0.20719E-00	0.32363E 01	0.50820E 01	0.18397E-03	0.10815E 04	0.28024E 04	

JET VELOCITY AT THE SLIP LINE = 0.85957E 04 FT/SEC.
SECONDARY STREAM, AREA = 0.8580, MACH NO. = 0.6667

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
5 4	0.43150E-02	0.20738E-00	0.32361E 01	0.50661E 01	0.18404E-03	0.10820E 04	0.28026E 04	

JET VELOCITY AT THE SLIP LINE = 0.85954E 04 FT/SEC.
SECONDARY STREAM, AREA = 0.8583, MACH NO. = 0.6661

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
6 4	0.86254E-02	0.20776E-00	0.32356E 01	0.50344E 01	0.18418E-03	0.10830E 04	0.28030E 04	

JET VELOCITY AT THE SLIP LINE = 0.85947E 04 FT/SEC.
SECONDARY STREAM, AREA = 0.8591, MACH NO. = 0.6651

IDENT.	X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
7 4	0.17234E-01	0.20852E-00	0.32346E 01	0.49715E 01	0.18446E-03	0.10850E 04	0.28039E 04	

JET VELOCITY AT THE SLIP LINE = 0.85935E 04 FT/SEC.

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SECONDARY STREAM, AREA =      0.8605, MACH NO. =      0.6629

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
   8  4  0.34400E-01   0.20999E-00   0.32327E 01   0.48473E 01   0.18502E-03   0.10889E 04   0.28056E 04
JET VELOCITY AT THE SLIP LINE =  0.85910E 04  FT/SEC.
SECONDARY STREAM, AREA =      0.8634, MACH NO. =      0.6586

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
   9  4  0.68540E-01   0.21282E-00   0.32289E 01   0.46048E 01   0.18612E-03   0.10967E 04   0.28089E 04
JET VELOCITY AT THE SLIP LINE =  0.85861E 04  FT/SEC.
SECONDARY STREAM, AREA =      0.8693, MACH NO. =      0.6502

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  10  4  0.13609E-00   0.21798E-00   0.32217E 01   0.41411E 01   0.18826E-03   0.11118E 04   0.28153E 04
JET VELOCITY AT THE SLIP LINE =  0.85767E 04  FT/SEC.
SECONDARY STREAM, AREA =      0.8815, MACH NO. =      0.6337

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  11  4  0.26856E-00   0.22657E-00   0.32084E 01   0.32815E 01   0.19227E-03   0.11403E 04   0.28272E 04
JET VELOCITY AT THE SLIP LINE =  0.85592E 04  FT/SEC.
SECONDARY STREAM, AREA =      0.9077, MACH NO. =      0.6022

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  12  4  0.39808E-00   0.23310E-00   0.31963E 01   0.24917E 01   0.19597E-03   0.11667E 04   0.28380E 04
JET VELOCITY AT THE SLIP LINE =  0.85433E 04  FT/SEC.
SECONDARY STREAM, AREA =      0.9363, MACH NO. =      0.5725

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  13  4  0.52524E 00   0.23781E-00   0.31854E 01   0.17462E 01   0.19937E-03   0.11911E 04   0.28478E 04
JET VELOCITY AT THE SLIP LINE =  0.85289E 04  FT/SEC.
SECONDARY STREAM, AREA =      0.9673, MACH NO. =      0.5444

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  14  4  0.65060E 00   0.24084E-00   0.31756E 01   0.10204E 01   0.20251E-03   0.12136E 04   0.28567E 04
JET VELOCITY AT THE SLIP LINE =  0.85157E 04  FT/SEC.
SECONDARY STREAM, AREA =      1.0008, MACH NO. =      0.5178

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  15  4  0.77487E 00   0.24225E-00   0.31666E 01   0.28696E-00   0.20540E-03   0.12344E 04   0.28648E 04
JET VELOCITY AT THE SLIP LINE =  0.85037E 04  FT/SEC.
SECONDARY STREAM, AREA =      1.0370, MACH NO. =      0.4925

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  16  4  0.89908E 00   0.24203E-00   0.31584E 01  -0.49185E-00   0.20809E-03   0.12538E 04   0.28723E 04
JET VELOCITY AT THE SLIP LINE =  0.84927E 04  FT/SEC.
SECONDARY STREAM, AREA =      1.0763, MACH NO. =      0.4682

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  17  4  0.10253E 01   0.23997E-00   0.31507E 01  -0.13802E 01   0.21063E-03   0.12722E 04   0.28792E 04
JET VELOCITY AT THE SLIP LINE =  0.84823E 04  FT/SEC.
SECONDARY STREAM, AREA =      1.1196, MACH NO. =      0.4445

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
  18  4  0.11590E 01   0.23541E-00   0.31433E 01  -0.25254E 01   0.21311E-03   0.12902E 04   0.28860E 04
JET VELOCITY AT THE SLIP LINE =  0.84723E 04  FT/SEC.
SECONDARY STREAM, AREA =      1.1697, MACH NO. =      0.4204

IDENT.        X              Y          MACH NO.        THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE
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19	3	0.76299E 00	0.67495E-01	0.36839E 01	0.78546E 01	0.90949E-04	0.46439E 03	0.24341E 04	-0.78959E 01
19	4	0.13225E 01	0.22563E-00	0.31351E 01	-0.43219E 01	0.21591E-03	0.13105E 04	0.28935E 04	

JET VELOCITY AT THE SLIP LINE = 0.84611E 04 FT/SEC.
SECONDARY STREAM, AREA = 1.2377, MACH NO. = 0.3920

IDENT.		X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
20	3	0.78407E 00	0.64157E-01	0.37535E 01	0.68528E 01	0.81592E-04	0.40767E 03	0.23818E 04	-0.10095E 02
20	3	0.78407E 00	0.64157E-01	0.36491E 01	0.44319E 01	0.95957E-04	0.49534E 03	0.24608E 04	-0.10095E 02
20	4	0.13835E 01	0.22052E-00	0.31322E 01	-0.52469E 01	0.21689E-03	0.13177E 04	0.28962E 04	

JET VELOCITY AT THE SLIP LINE = 0.84572E 04 FT/SEC.
SECONDARY STREAM, AREA = 1.2652, MACH NO. = 0.3817

IDENT.		X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
21	3	0.80149E 00	0.60946E-01	0.38015E 01	0.61968E 01	0.75719E-04	0.37272E 03	0.23465E 04	-0.10793E 02
21	3	0.80149E 00	0.60946E-01	0.36793E 01	0.33989E 01	0.91483E-04	0.46781E 03	0.24377E 04	-0.10793E 02
21	4	0.14291E 01	0.21617E-00	0.31301E 01	-0.56685E 01	0.21759E-03	0.13228E 04	0.28980E 04	

JET VELOCITY AT THE SLIP LINE = 0.84544E 04 FT/SEC.
SECONDARY STREAM, AREA = 1.2865, MACH NO. = 0.3741

IDENT.		X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
22	3	0.82468E 00	0.56290E-01	0.38724E 01	0.51254E 01	0.67829E-04	0.32661E 03	0.22954E 04	-0.11915E 02
22	3	0.82468E 00	0.56290E-01	0.37247E 01	0.18092E 01	0.85122E-04	0.42915E 03	0.24033E 04	-0.11915E 02
22	4	0.14336E 01	0.20953E-00	0.31274E 01	-0.60713E 01	0.21854E-03	0.13297E 04	0.29005E 04	

JET VELOCITY AT THE SLIP LINE = 0.84507E 04 FT/SEC.
SECONDARY STREAM, AREA = 1.3172, MACH NO. = 0.3638

IDENT.		X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
23	3	0.84525E 00	0.51795E-01	0.39216E 01	0.44314E 01	0.62874E-04	0.29821E 03	0.22610E 04	-0.12736E 02
23	3	0.84525E 00	0.51795E-01	0.37501E 01	0.63486E 00	0.81716E-04	0.40875E 03	0.23845E 04	-0.12736E 02
23	4	0.15419E 01	0.20442E-00	0.31255E 01	-0.60203E 01	0.21920E-03	0.13345E 04	0.29023E 04	

JET VELOCITY AT THE SLIP LINE = 0.84481E 04 FT/SEC.
SECONDARY STREAM, AREA = 1.3403, MACH NO. = 0.3564

IDENT.		X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
24	3	0.86423E 00	0.47451E-01	0.39386E 01	0.44092E 01	0.61238E-04	0.28892E 03	0.22491E 04	-0.13043E 02
24	3	0.86423E 00	0.47451E-01	0.37429E 01	0.95028E-01	0.82484E-04	0.41351E 03	0.23898E 04	-0.13043E 02
24	4	0.15694E 01	0.20162E-00	0.31245E 01	-0.56070E 01	0.21955E-03	0.13371E 04	0.29032E 04	

JET VELOCITY AT THE SLIP LINE = 0.84467E 04 FT/SEC.
SECONDARY STREAM, AREA = 1.3532, MACH NO. = 0.3524

IDENT.		X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
25	3	0.88323E 00	0.40373E-01	0.40061E 01	0.34726E 01	0.55201E-04	0.25510E 03	0.22029E 04	-0.14387E 02
25	3	0.88323E 00	0.40373E-01	0.37622E 01	-0.17973E 01	0.79639E-04	0.39687E 03	0.23756E 04	-0.14387E 02
25	4	0.16299E 01	0.19597E-00	0.31224E 01	-0.50508E 01	0.22027E-03	0.13424E 04	0.29051E 04	

JET VELOCITY AT THE SLIP LINE = 0.84438E 04 FT/SEC.
SECONDARY STREAM, AREA = 1.3811, MACH NO. = 0.3441

IDENT.		X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
26	3	0.92061E 00	0.33182E-01	0.40600E 01	0.27593E 01	0.50809E-04	0.23094E 03	0.21667E 04	-0.15278E 02
26	3	0.92061E 00	0.33182E-01	0.37873E 01	-0.30384E 01	0.76272E-04	0.37712E 03	0.23570E 04	-0.15278E 02
26	4	0.16744E 01	0.19239E-00	0.31210E 01	-0.41636E 01	0.22075E-03	0.13459E 04	0.29064E 04	

JET VELOCITY AT THE SLIP LINE = 0.84419E 04 FT/SEC.
SECONDARY STREAM, AREA = 1.4009, MACH NO. = 0.3385

IDENT.		X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
27	3	0.94766E 00	0.25493E-01	0.41114E 01	0.20846E 01	0.46965E-04	0.21013E 03	0.21328E 04	-0.16217E 02
27	3	0.94766E 00	0.25493E-01	0.38047E 01	-0.43322E 01	0.73810E-04	0.36298E 03	0.23443E 04	-0.16217E 02
27	4	0.17052E 01	0.19046E-00	0.31201E 01	-0.30181E 01	0.22106E-03	0.13481E 04	0.29072E 04	

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JET VELOCITY AT THE SLIP LINE = 0.84407E 04 FT/SEC.
SECONDARY STREAM, AREA = 1.4139, MACH NO. = 0.3349

IDENT.		X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
-28	3	0.97476E 00	0.17325E-01	0.41628E 01	0.14049E 01	0.43422E-04	0.19125E 03	0.20996E 04	-0.17329E 02
28	3	0.97476E 00	0.17325E-01	0.38106E 01	-0.58370E 01	0.72433E-04	0.35554E 03	0.23399E 04	-0.17329E 02
28	4	0.17154E 01	0.19005E-00	0.31199E 01	-0.15699E 01	0.22115E-03	0.13488E 04	0.29075E 04	

JET VELOCITY AT THE SLIP LINE = 0.84404E 04 FT/SEC.
SECONDARY STREAM, AREA = 1.4179, MACH NO. = 0.3338

IDENT.		X	Y	MACH NO.	THETA	DENSITY	PRESSURE	TEMPERATURE	SHOCK ANGLE
29	3	0.10014E 01	0.86378E-02	0.42092E 01	0.73808E 00	0.40459E-04	0.17570E 03	0.20701E 04	-0.18839E 02

END OF COMPUTATION FOR THIS CASE

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INPUT AND OUTPUT

FOR

MIX-MASTER

Explanation of physical quantities used for the Mix-Master Program in the order they are input.

Case identification = CASE B5-1

Number of grid points at the initial front = 196

Number of fronts for which properties are to be evaluated = 400

Number of points to curve fit between the jet and secondary stream = 3

Print interval = 100 fronts

Number of the Ψ line that corresponds to the radius of the slip line at the initial front = 129

Exponent in the turbulent layer growth law = 1.0

Reference length = 1.0 foot

Reichard's exchange coefficient = 3.62

Turbulent Lewis number = 1.2

Turbulent Prandtl number = 0.8

Code indicating the flow is axisymmetric = 1.0

Axial step size = 0.05 foot

Viscosity constant = 0.0

Radius to Ψ_1 = 0.0 feet

Radius to the slip line at the initial front = 1.833 feet

Radius of the duct at the initial front = 4.4 feet

Value used to determine when the mixing region has expanded outwardly to the secondary stream = $.00001 \frac{\text{lb. of } H_2O}{\text{lb. of mixture}}$

Value used to determine when the mixing region has expanded inwardly to the jet stream = $.00001 \frac{\text{lb. of } N_2}{\text{lb. of mixture}}$

Number of points of axial distance (X), radius (r) and pressure (P) in the table = 3

Table of X, r and P =

X (feet)	r (feet)	P (lb/ft^2)
0.0	1.833	2145.0
10.0	1.833	2145.0
20.0	1.833	2145.0

Jet stream values of H_2O, H_2, O_2, CO_2, CO and N_2 = 0.2585, 0.01179, 0.0, 0.324, 0.405 and 0.0 $\frac{\text{lb. Of species}}{\text{lb. Of mixture}}$

Secondary stream values of H_2O, H_2, O_2, CO_2, CO and N_2 = 0.0, 0.0, 0.233, 0.0, 0.0 and 0.767 $\frac{\text{lb. of species}}{\text{lb. of mixture}}$

Jet and secondary values of temperature = 3681.0 and 809.0°R

Jet and secondary values of axial velocity = 9734.0 and 489.0 ft/sec

```
CASE  B5-1
196 400    3 100 120
1.0          1.0          3.62         1.3          0.8          1.0
0.05         0.0          0.0          1.833        04.4         0.00001
.00001
   3
0.0                 1.833               2145.0
10.0                1.833               2145.0
20.0                1.833               2145.0
0.2585       0.01179      0.0          0.324        0.405
0.0          0.0          0.233        0.0          0.0          0.767
3681.0       809.0        9734.0       489.0
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INITIAL INPUT

CASE B5-1

NMAX	MMAX	NS	LFRONT	KSLIP	NMIN
196	400	3	100	129	1

A	L	REICHARTS COEF.	LEWIS NO.	PRANDTL NO.	DELTA
1.000E 00	1.000E 00	3.670E 00	1.200E 00	8.000E-01	1.000E 00

DX	VISCOSITY CONST.	DELTA-PSI (NOT INPUT)
5.000E-02	0.	1.144E 00

PZERO1	RE	RDZERO
0.	1.833E 00	4.400E 00

TESMAX	TESMIN	NXTAB
10.000E-06	10.000E-06	3

XTAB	RTAB	PTAB	XTAB	RTAB	PTAB	XTAB	RTAB	PTAB
0.	1.833E 00	2.145E 03	1.000E 01	1.833E 00	2.145E 03	2.000E 01	1.833E 00	2.145E 03

C211	C221	C231	C241	C251	C261	C21NMAX	C22NMAX	C23NMAX	C24NMAX
2.585E-01	1.179E-02	0.	3.240E-01	4.050E-01	-0.	0.	0.	2.330E-01	0.

C25NMAX	C26NMAX
0.	7.670E-01

T21	T2NMAX	U21	U2NMAX
3.681E 03	8.090E 02	9.734E 03	4.890E 02

PROPERTIES GIVEN BELOW ARE AT FRONT 1 DISTANCE DOWNSTREAM = 0. FEET PRESSURE= 2145.0000PSF
INITIAL FLOW IN SECONDARY STREAM = 1227.4645 LBS/SEC
RADIUS OF DUCT = 4.4000 FT. THRUST = 0. LB. DUCT AREA = 60.8212 SQ FT.

N	Y	X-COMP VELOCITY	TEMPERATURE	DENSITY	CONCENTRATION OF SPECIES H2O	H2	O2	CO2	CO	N2	MACH
1	0	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
1	0	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
2	.16199	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
3	.22909	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
4	.28058	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
5	.32398	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
6	.36222	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
7	.39679	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
8	.42859	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
9	.45818	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165

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10	.48597	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
11	.51226	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
12	.53726	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
13	.56115	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
14	.58407	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
15	.60611	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
16	.62739	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
17	.64796	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
18	.66791	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
19	.68727	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
20	.70610	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
21	.72445	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
22	.74234	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
23	.75980	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
24	.77688	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
25	.79359	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
26	.80995	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
27	.82599	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
28	.84173	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
29	.85718	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
30	.87235	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
31	.88726	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
32	.90193	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
33	.91636	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
34	.93057	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
35	.94456	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
36	.95835	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
37	.97195	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
38	.98535	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
39	.99858	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
40	1.0116	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
41	1.0245	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
42	1.0372	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
43	1.0498	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
44	1.0622	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
45	1.0745	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
46	1.0867	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
47	1.0987	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
48	1.1106	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
49	1.1223	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
50	1.1339	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
51	1.1454	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
52	1.1568	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
53	1.1681	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
54	1.1793	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
55	1.1904	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
56	1.2014	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
57	1.2122	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
58	1.2230	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
59	1.2337	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
60	1.2443	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
61	1.2548	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
62	1.2652	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
63	1.2755	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
64	1.2858	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
65	1.2959	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
66	1.3060	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
67	1.3160	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165

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68	1.3260	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
69	1.3358	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
70	1.3456	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
71	1.3553	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
72	1.3650	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
73	1.3745	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
74	1.3841	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
75	1.3935	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
76	1.4029	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
77	1.4122	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
78	1.4215	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
79	1.4307	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
80	1.4398	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
81	1.4489	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
82	1.4579	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
83	1.4669	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
84	1.4758	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
85	1.4847	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
86	1.4935	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
87	1.5022	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
88	1.5110	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
89	1.5196	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
90	1.5282	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
91	1.5368	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
92	1.5453	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
93	1.5538	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
94	1.5622	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
95	1.5706	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
96	1.5789	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
97	1.5872	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
98	1.5954	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
99	1.6036	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
100	1.6118	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
101	1.6199	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
102	1.6280	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
103	1.6360	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
104	1.6440	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
105	1.6520	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
106	1.6599	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
107	1.6678	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
108	1.6756	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
109	1.6835	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
110	1.6912	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
111	1.6990	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
112	1.7067	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
113	1.7143	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
114	1.7220	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
115	1.7296	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
116	1.7372	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
117	1.7447	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
118	1.7522	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
119	1.7597	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
120	1.7671	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
121	1.7745	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
122	1.7819	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
123	1.7892	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
124	1.7966	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
125	1.8039	9734.0	3681.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165

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126	1.8111	9734.0	3581.0	0.8954E-02	.25850	0.1179E-01	0	.32400	.40500	-0	3.165
127	1.8183	9049.2	3489.3	0.9629E-02	.23935	0.1092E-01	0.1726E-01	.30000	.37500	0.5691E-01	3.043
128	1.8256	7337.1	2335.4	0.1176E-01	.19148	0.8733E-02	0.6041E-01	.24000	.30000	.19985	2.708
129	1.8330	5111.5	2245.0	0.1610E-01	.12925	0.5895E-02	.11650	.16200	.20250	.38350	2.183
130	1.8410	2885.3	1553.6	0.2441E-01	0.6702E-01	0.3057E-02	.17259	0.8400E-01	.10500	.56815	1.493
131	1.8518	1173.8	1021.7	0.3856E-01	0.1915E-01	0.8733E-03	.21574	0.2400E-01	0.3000E-01	.71019	0.749
132	1.8706	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
133	1.8983	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
134	1.9225	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
135	1.9475	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
136	1.9631	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
137	1.9754	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
138	2.0165	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
139	2.0422	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
140	2.0629	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
141	2.0880	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
142	2.1082	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
143	2.1328	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
144	2.1526	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
145	2.1767	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
146	2.1961	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
147	2.2197	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
148	2.2387	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
149	2.2619	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
150	2.2805	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
151	2.3033	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
152	2.3216	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
153	2.3440	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
154	2.3620	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
155	2.3840	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
156	2.4017	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
157	2.4233	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
158	2.4407	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
159	2.4620	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
160	2.4791	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
161	2.5001	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
162	2.5170	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
163	2.5376	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
164	2.5543	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
165	2.5746	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
166	2.5910	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
167	2.6111	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
168	2.6273	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
169	2.6470	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
170	2.6630	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
171	2.6825	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
172	2.6983	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
173	2.7175	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
174	2.7331	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
175	2.7521	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
176	2.7674	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
177	2.7862	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
178	2.8014	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
179	2.8200	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
180	2.8349	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
181	2.8533	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
182	2.8681	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
183	2.8862	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351

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184	2.9009	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
185	2.9188	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
186	2.9333	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
187	2.9510	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
188	2.9653	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
189	2.9829	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
190	2.9970	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
191	3.0144	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
192	3.0284	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
193	3.0456	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
194	3.0595	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
195	3.0765	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351
196	3.0902	489.00	809.00	0.4947E-01	0	0	.23300	0	0	.76700	0.351

DELTA PSI WAS SET = 2.2871

DELTA PSI WAS SET = 4.5742

DELTA PSI WAS SET = 9.1485

PROPERTIES GIVEN BELOW ARE AT FRONT 101 DISTANCE DOWNSTREAM = 5.0000FEET PRESSURE= 2144.9999PSF
RADIUS OF DUCT = 4.4799 FT. THRUST = 4782.5892 LB. DUCT AREA = 63.0509 SQ FT.

N	Y	X-COMP VELOCITY	TEMPERATURE	DENSITY	----------CONCENTRATION OF SPECIES------- H2O	H2	O2	CO2	CO	N2	MACH
1	0	9734.0	3681.0	0.8954E-02	.25849	0.1179E-01	0.4572E-08	.32400	.40498	0	3.165
7	1.1223	9734.0	3681.0	0.8954E-02	.25849	0.1179E-01	0.4572E-08	.32400	.40498	0	3.165
8	1.2122	9734.0	3681.0	0.8954E-02	.25849	0.1179E-01	0.4572E-08	.32400	.40498	0	3.165
9	1.2959	9734.0	3681.0	0.8954E-02	.25849	0.1179E-01	0.5230E-08	.32400	.40497	0	3.165
10	1.3745	9733.9	3691.2	0.8955E-02	.25848	0.1179E-01	0.1790E-07	.32400	.40491	0.3245E-04	3.165
11	1.4489	9733.0	3682.1	0.8954E-02	.25841	0.1177E-01	0.9844E-07	.32399	.40453	0.5438E-03	3.164
12	1.5196	9726.5	3687.8	0.8950E-02	.25804	0.1169E-01	0.4841E-06	.32393	.40271	0.2890E-02	3.162
13	1.5874	9689.6	3712.9	0.8924E-02	.25674	0.1138E-01	0.1980E-05	.32370	.39610	0.1138E-01	3.146
14	1.6535	9535.1	3795.9	0.8825E-02	.25309	0.1052E-01	0.7086E-05	.32298	.37747	0.3535E-01	3.080
15	1.7202	9040.4	4098.1	0.8575E-02	.24480	0.8546E-02	0.2399E-04	.32119	.33489	0.9022E-01	2.882
16	1.7936	7759.9	4416.8	0.8203E-02	.22535	0.4929E-02	0.7464E-03	.32310	.24649	.19963	2.424
17	1.8851	5104.8	4338.5	0.9004E-02	.16705	0.1371E-02	0.2845E-01	.31350	.10123	.38959	1.667
18	2.0260	1980.3	3449.4	0.1178E-01	0.7401E-01	0.3430E-05	.12012	.19477	0.2224E-03	.61118	0.730
19	2.2444	918.45	1853.8	0.2172E-01	0.2752E-01	0.6263E-06	.19086	0.7261E-01	0.4077E-04	.70896	0.450
20	2.4265	640.46	1257.8	0.3191E-01	0.1222E-01	0.2696E-06	.21421	0.3238E-01	0.1851E-04	.74112	0.375
21	2.6114	550.88	1022.1	0.3922E-01	0.6166E-02	0.1604E-06	.22343	0.1649E-01	0.1142E-04	.75382	0.354
22	2.7542	516.04	915.64	0.4375E-01	0.3302E-02	0.1004E-06	.22778	0.8999E-02	0.7349E-05	.75980	0.349
23	2.9060	501.17	863.88	0.4636E-01	0.1808E-02	0.6170E-07	.23003	0.5117E-02	0.4679E-05	.76291	0.348
24	3.0271	494.53	837.72	0.4780E-01	0.9873E-03	0.3645E-07	.23125	0.3006E-02	0.2937E-05	.76459	0.349
25	3.1614	491.57	824.50	0.4856E-01	0.5294E-03	0.2054E-07	.23193	0.1850E-02	0.1852E-05	.76552	0.349
26	3.2707	490.26	817.92	0.4895E-01	0.2734E-03	0.1092E-07	.23229	0.1224E-02	0.1213E-05	.76602	0.350
27	3.3941	489.71	814.77	0.4914E-01	0.1319E-03	0.5343E-08	.23248	0.8989E-03	0.8620E-06	.76628	0.350
28	3.4955	489.50	813.37	0.4923E-01	0.5455E-04	0.2222E-08	.23257	0.7412E-03	0.6867E-06	.76641	0.350
29	3.6109	489.42	812.83	0.4926E-01	0.1641E-04	0.6699E-09	.23261	0.6762E-03	0.6132E-06	.76646	0.350
30	3.7063	489.41	812.69	0.4927E-01	0	0	.23262	0.6565E-03	0.5908E-06	.76647	0.350

31	3.8153	489.41	812.69	0.4927E-01	0	0	.23262	0.6565E-03	0.5908E-06	.76647	0.350
32	3.9056	489.41	812.69	0.4927E-01	0	0	.23262	0.6565E-03	0.5908E-06	.76647	0.350

DELTA PSI WAS SET = 18.297

PROPERTIES GIVEN BELOW ARE AT FRONT 201 DISTANCE DOWNSTREAM = 10.0000FEET PRESSURE= 2144.9999PSF
RADIUS OF DUCT = 4.5648 FT. THRUST = 9957.8525 LB. DUCT AREA = 65.4636 SQ FT.

N	Y	X-COMP VELOCITY	TEMPERATURE	DENSITY	CONCENTRATION OF SPECIES H2O	H2	O2	CO2	CO	N2	MACH
1	0	9733.9	3681.1	0.8955E-02	.25849	0.1179E-01	0.9148E-08	.32400	.40495	0.5341E-05	3.165
1	0	9733.9	3681.1	0.8955E-02	.25849	0.1179E-01	0.9148E-08	.32400	.40495	0.5341E-05	3.165
2	.64735	9733.9	3681.1	0.8955E-02	.25849	0.1179E-01	0.9148E-08	.32400	.40495	0.5341E-05	3.165
3	.91634	9733.7	3681.3	0.8955E-02	.25847	0.1178E-01	0.3028E-07	.32400	.40485	0.1199E-03	3.165
4	1.1223	9731.0	3683.9	0.8954E-02	.25828	0.1174E-01	0.2274E-06	.32397	.40389	0.1300E-02	3.164
5	1.2962	9706.5	3701.3	0.8938E-02	.25724	0.1150E-01	0.1321E-05	.32394	.39866	0.8002E-02	3.153
6	1.4511	9569.9	3775.2	0.8858E-02	.25361	0.1066E-01	0.5677E-05	.32334	.38025	0.3153E-01	3.097
7	1.5976	9064.0	3996.3	0.8624E-02	.24460	0.8556E-02	0.2097E-04	.32201	.33417	0.9044E-01	2.897
8	1.7509	7694.7	4398.7	0.8276E-02	.22310	0.4681E-02	0.7334E-03	.32612	.23708	.20901	2.414
9	1.9352	4929.5	4310.8	0.9155E-02	.16200	0.1035E-02	0.2726E-01	.32672	0.7932E-01	.40653	1.624
10	2.2015	1957.7	3305.0	0.1229E-01	0.7113E-01	0.8212E-05	.12502	.18687	0.5930E-03	.61702	0.734
11	2.5783	949.05	1875.6	0.2147E-01	0.2834E-01	0.1724E-05	.18969	0.7487E-01	0.1237E-03	.70705	0.462
12	2.8890	668.40	1312.5	0.3059E-01	0.1362E-01	0.8415E-06	.21201	0.3627E-01	0.6099E-04	.73795	0.383
13	3.1945	571.02	1074.6	0.3732E-01	0.7494E-02	0.4686E-06	.22127	0.2025E-01	0.3423E-04	.75078	0.359
14	3.4327	529.92	959.41	0.4177E-01	0.4453E-02	0.2795E-06	.22586	0.1232E-01	0.2065E-04	.75713	0.351
15	3.6766	510.60	898.86	0.4457E-01	0.2792E-02	0.1738E-06	.22836	0.8008E-02	0.1307E-04	.76059	0.349
16	3.8736	500.98	865.84	0.4627E-01	0.1849E-02	0.1129E-06	.22977	0.5567E-02	0.8714E-05	.76254	0.348
17	4.0840	496.29	848.56	0.4720E-01	0.1339E-02	0.7969E-07	.23054	0.4251E-02	0.6346E-05	.76360	0.348
18	4.2582	494.39	841.26	0.4761E-01	0.1119E-02	0.6530E-07	.23086	0.3684E-02	0.5323E-05	.76405	0.348
19	4.4487	494.39	841.26	0.4761E-01	0.1119E-02	0.6530E-07	.23086	0.3684E-02	0.5323E-05	.76405	0.348

PROPERTIES GIVEN BELOW ARE AT FRONT 301 DISTANCE DOWNSTREAM = 15.0000FEET PRESSURE= 2144.9999PSF

RADIUS OF DUCT = 4.6486 FT. THRUST = 15157.1337 LB. DUCT AREA = 67.8875 SQ FT.

N	Y	X-COMP VELOCITY	TEMPERATURE	DENSITY	CONCENTRATION OF SPECIES H2O	H2	O2	CO2	CO	N2	MACH
1	0	9732.8	3682.3	0.8954E-02	.25838	0.1176E-01	0.1248E-06	.32399	.40440	0.6965E-03	3.164
1	0	9732.8	3682.3	0.8954E-02	.25838	0.1176E-01	0.1248E-06	.32399	.40440	0.6965E-03	3.164
2	.64798	9732.8	3682.3	0.8954E-02	.25838	0.1176E-01	0.1248E-06	.32399	.40440	0.6965E-03	3.164
3	.91651	9723.0	3690.3	0.8950E-02	.25782	0.1164E-01	0.7081E-06	.32393	.40156	0.4292E-02	3.161
4	1.1234	9672.6	3722.2	0.8921E-02	.25599	0.1122E-01	0.2614E-05	.32375	.39233	0.1602E-01	3.140

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5	1.3004	9503.6	3806.9	0.8930E-02	.25187	0.1027E-01	0.7510E-05	.32331	.37143	0.4261E-01	3.071
6	1.4629	9086.6	3977.1	0.8645E-02	.24448	0.8553E-02	0.1978E-04	.32242	.33367	0.9072E-01	2.908
7	1.6229	8250.4	4251.7	0.8389E-02	.23155	0.5958E-02	0.2095E-03	.32336	.27229	.16701	2.605
8	1.7935	6812.9	4546.2	0.8276E-02	.20571	0.2979E-02	0.3388E-02	.33387	.17737	.27776	2.139
9	1.9870	4815.3	4272.3	0.9279E-02	.15811	0.9296E-03	0.2853E-01	.32537	0.7212E-01	.41663	1.597
10	2.2265	2728.1	3942.2	0.1034E-01	0.9735E-01	0.4188E-04	0.8642E-01	.25274	0.3178E-02	.56116	0.948
11	2.5468	1504.8	2673.4	0.1514E-01	0.5200E-01	0.9233E-05	.15361	.13654	0.6921E-03	.65708	0.623
12	2.8492	988.31	1913.0	0.2106E-01	0.2997E-01	0.3560E-05	.18689	0.7912E-01	0.2603E-03	.70348	0.477
13	3.1567	763.54	1506.9	0.2668E-01	0.1916E-01	0.2063E-05	.20334	0.5086E-01	0.1487E-03	.72620	0.411
14	3.4197	655.16	1283.8	0.3128E-01	0.1344E-01	0.1339E-05	.21209	0.3587E-01	0.9600E-04	.73823	0.380
15	3.6785	598.47	1156.3	0.3470E-01	0.1022E-01	0.9255E-06	.21702	0.2744E-01	0.6628E-04	.74500	0.364
16	3.9011	567.58	1082.6	0.3705E-01	0.8363E-02	0.6897E-06	.21985	0.2260E-01	0.4946E-04	.74889	0.356
17	4.1248	551.34	1042.4	0.3847E-01	0.7353E-02	0.5644E-06	.22140	0.1996E-01	0.4056E-04	.75101	0.352
18	4.3211	544.47	1025.0	0.3912E-01	0.6917E-02	0.5116E-06	.22207	0.1882E-01	0.3691E-04	.75192	0.350
19	4.5224	544.47	1025.0	0.3912E-01	0.6917E-02	0.5116E-06	.22207	0.1882E-01	0.3681E-04	.75192	0.350

PROPERTIES GIVEN BELOW ARE AT FRONT 401 DISTANCE DOWNSTREAM = 20.0000FEET PRESSURE= 2144.9999PSF

RADIUS OF DUCT = 4.6846 FT. THRUST = 17425.0564 LB. DUCT AREA = 68.9448 SQ FT.

N	Y	X-COMP VELOCITY	TEMPERATURE	DENSITY	----------CONCENTRATION OF SPECIES------- H2O	H2	O2	CO2	CO	N2	MACH
1	0	9717.5	3695.2	0.8948E-02	.25743	0.1155E-01	0.1079E-05	.32391	.39962	0.6759E-02	3.159
1	0	9717.5	3695.2	0.8948E-02	.25743	0.1155E-01	0.1079E-05	.32391	.39962	0.6759E-02	3.159
2	.64873	9717.5	3695.2	0.8948E-02	.25743	0.1155E-01	0.1079E-05	.32391	.39962	0.6759E-02	3.159
3	.91826	9653.6	3734.4	0.8912E-02	.25521	0.1104E-01	0.3324E-05	.32371	.38840	0.2099E-01	3.132
4	1.1288	9478.1	3921.0	0.8820E-02	.25100	0.1008E-01	0.8200E-05	.32331	.36710	0.4805E-01	3.061
5	1.3127	9118.8	3368.9	0.8660E-02	.24454	0.8587E-02	0.1861E-04	.32259	.33420	0.8992E-01	2.921
6	1.4859	8498.8	4182.9	0.8451E-02	.23489	0.6557E-02	0.1177E-03	.32279	.28729	.14862	2.692
7	1.6590	7544.4	4438.0	0.8272E-02	.21913	0.4211E-02	0.1085E-02	.32828	.22201	.22618	2.367
8	1.8421	6231.4	4588.2	0.8365E-02	.19248	0.2110E-02	0.7281E-02	.33933	.13866	.32197	1.967
9	2.0396	4713.3	4242.6	0.9374E-02	.15443	0.8211E-03	0.3090E-01	.32495	0.6462E-01	.42638	1.570
10	2.2629	3195.3	4147.2	0.9820E-02	.11134	0.1082E-03	0.6866E-01	.28261	0.9646E-02	.53044	1.085
11	2.5438	2047.3	3273.6	0.1241E-01	0.7261E-01	0.4498E-05	.12244	.19127	0.3328E-03	.61382	0.774
12	2.8233	1398.7	2512.0	0.1610E-01	0.4827E-01	0.3735E-05	.15937	.12728	0.2872E-03	.66499	0.596
13	3.1142	1055.5	2025.3	0.1991E-01	0.3434E-01	0.2813E-05	.18046	0.9071E-01	0.2120E-03	.69429	0.496
14	3.3817	869.55	1726.0	0.2332E-01	0.2627E-01	0.2247E-05	.19267	0.6955E-01	0.1684E-03	.71124	0.440
15	3.6464	765.47	1543.4	0.2606E-01	0.2152E-01	0.1903E-05	.19987	0.5709E-01	0.1417E-03	.72123	0.408
16	3.8858	706.66	1434.3	0.2803E-01	0.1874E-01	0.1692E-05	.20409	0.4978E-01	0.1254E-03	.72708	0.389
17	4.1218	675.14	1373.6	0.2925E-01	0.1721E-01	0.1574E-05	.20640	0.4577E-01	0.1161E-03	.73029	0.379
18	4.3363	661.73	1347.3	0.2982E-01	0.1655E-01	0.1522E-05	.20740	0.4404E-01	0.1121E-03	.73168	0.375
19	4.5494	661.73	1347.3	0.2982E-01	0.1655E-01	0.1522E-05	.20740	0.4404E-01	0.1121E-03	.73168	0.375

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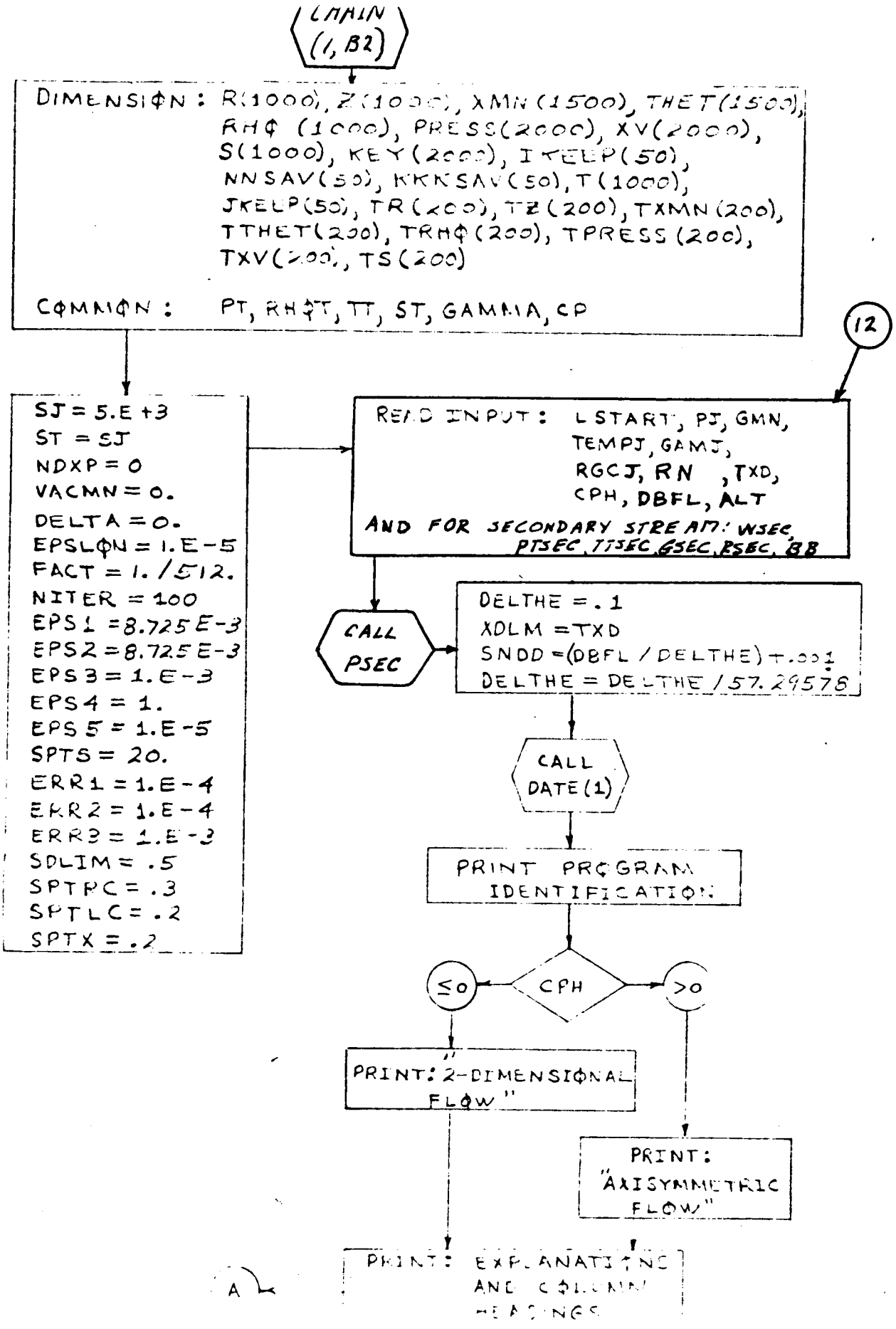

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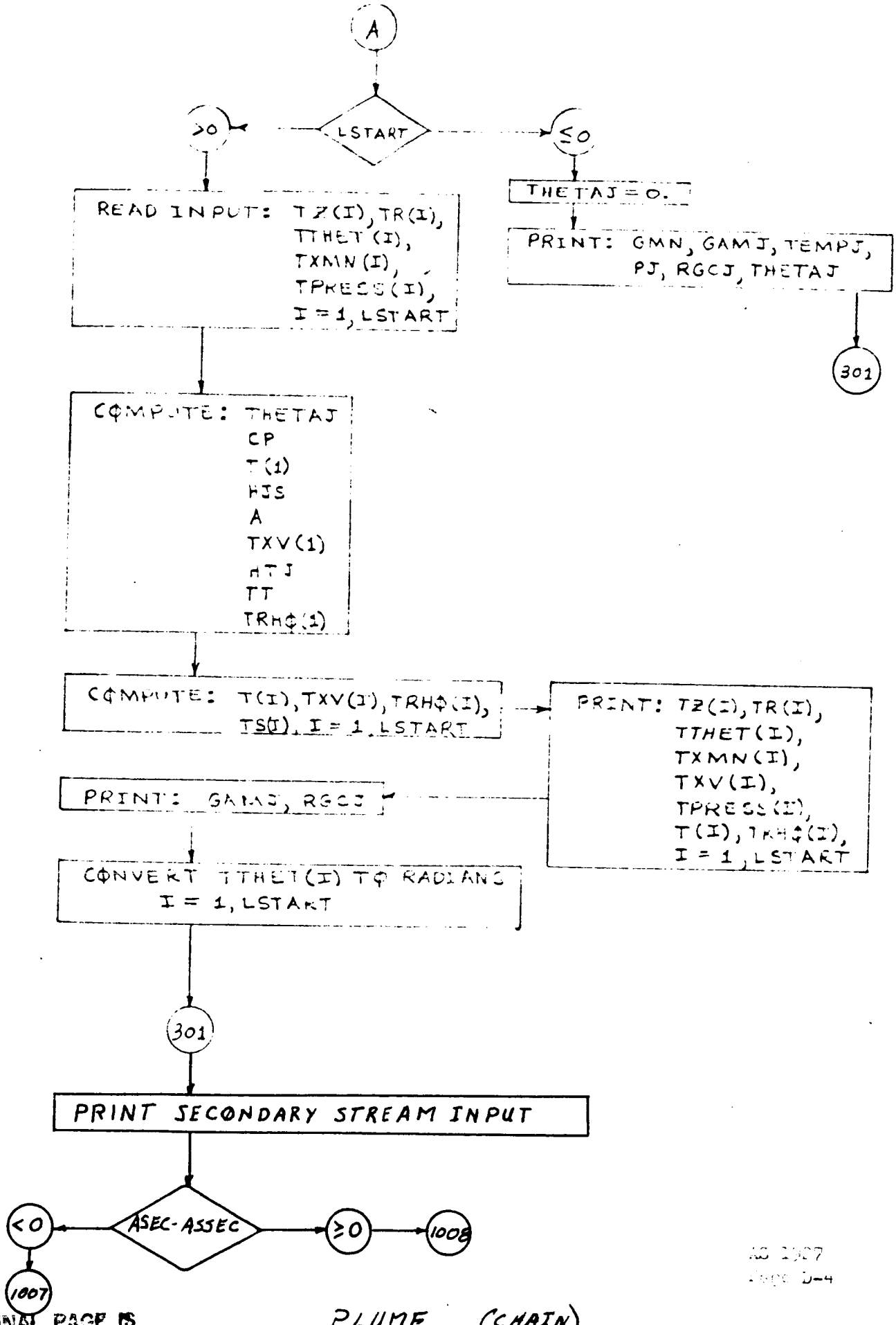

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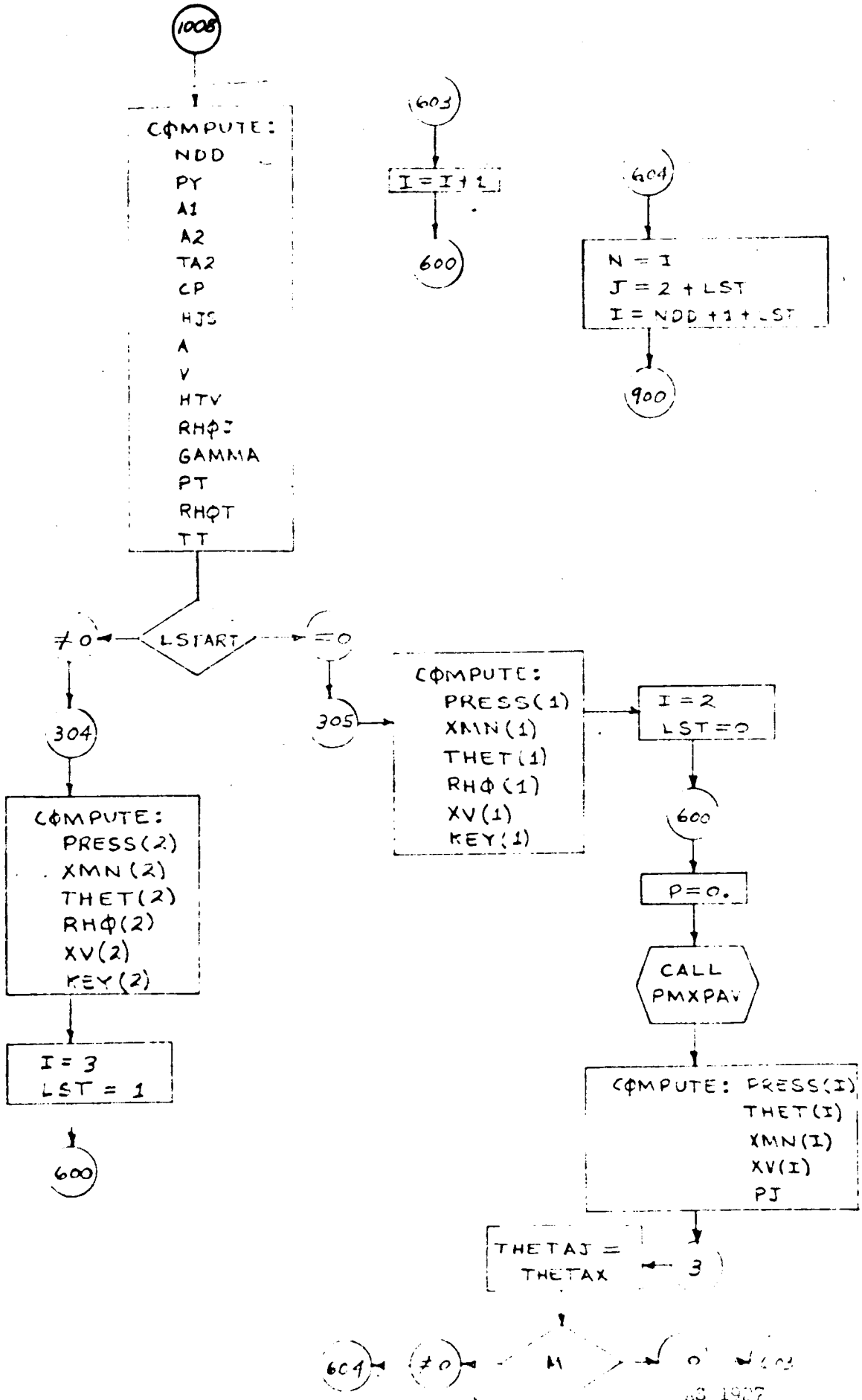

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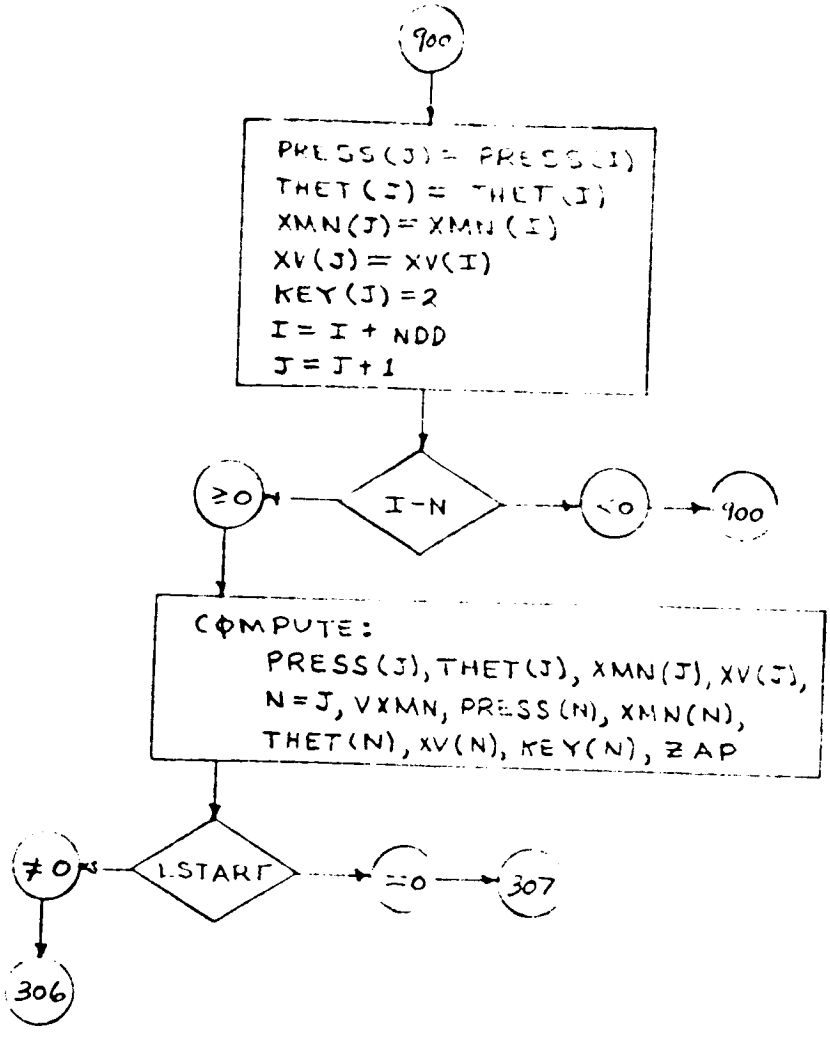

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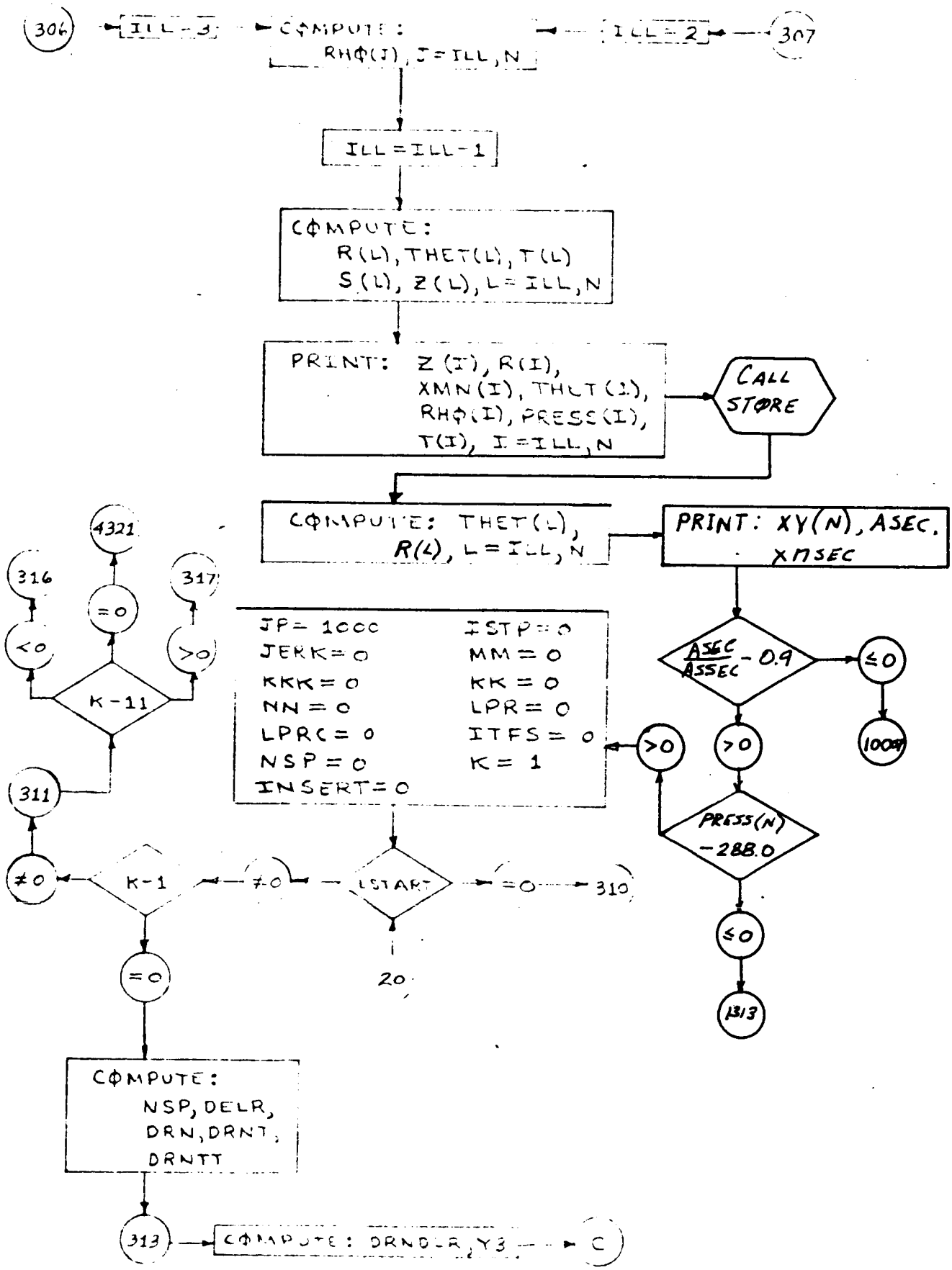

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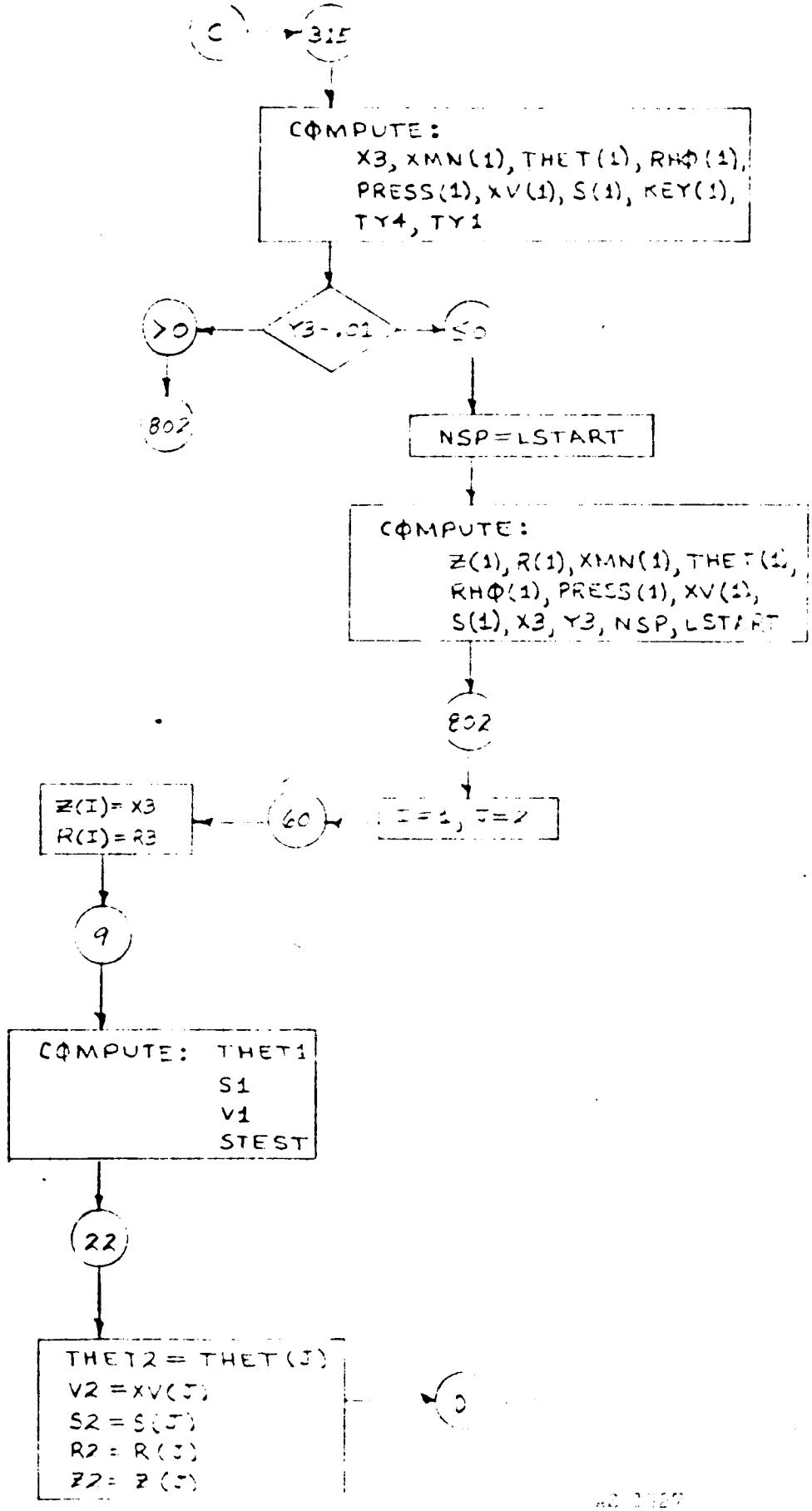

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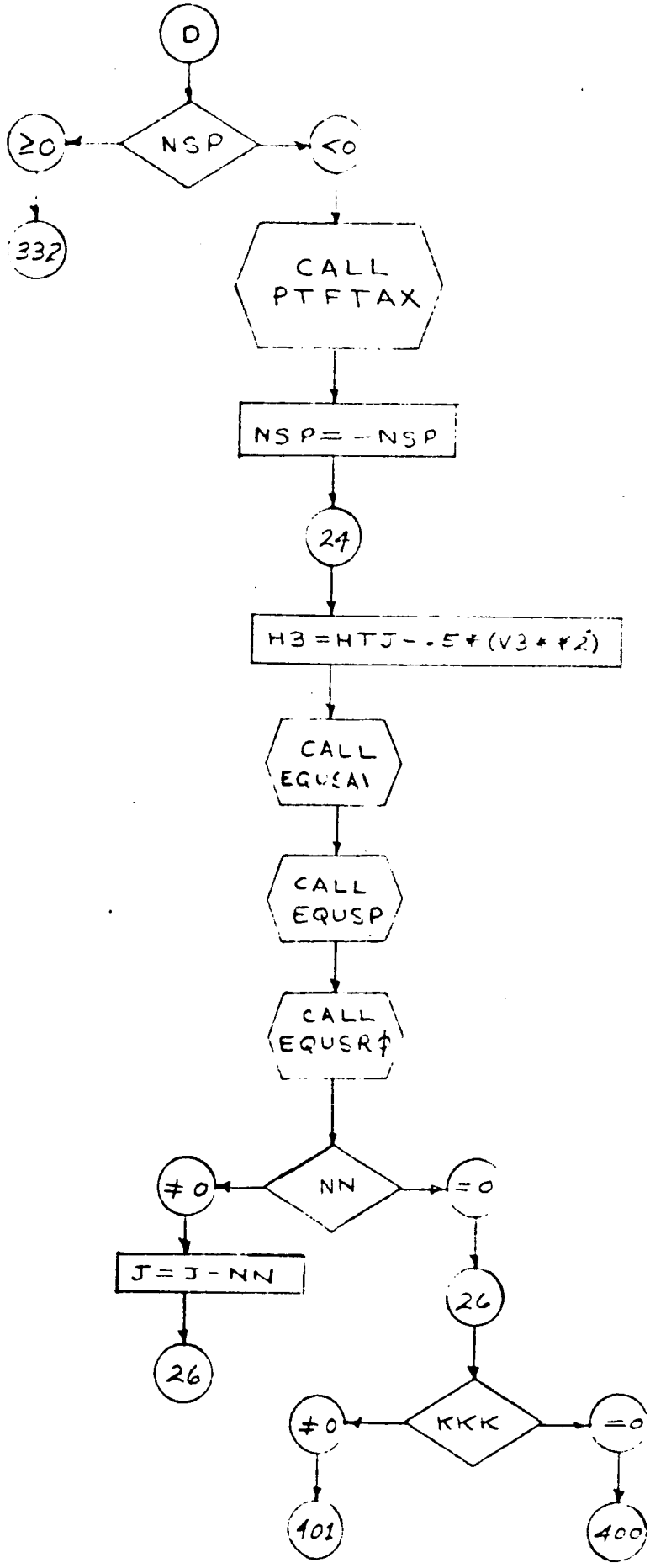
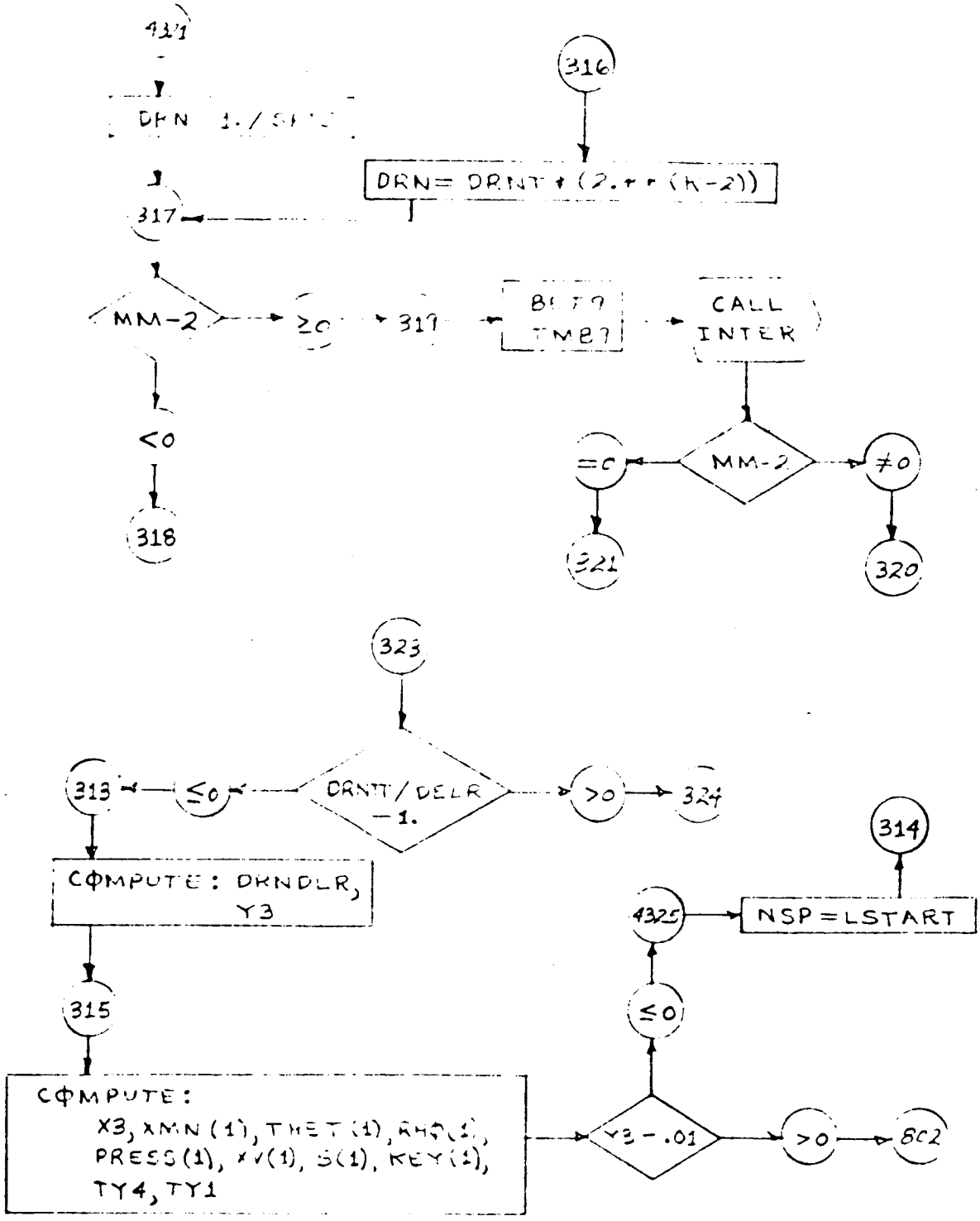

D
NSP
≥0
<0
332
CALL PTFTAX
NSP=-NSP
24
H3=HTJ-.5*(V3**2)
CALL EQUSAI
CALL EQUSP
CALL EQUSRP
NN
≠0
=0
J=J-NN
26
26
KKK
≠0
=0
401
400

PLUME (CHAIN)



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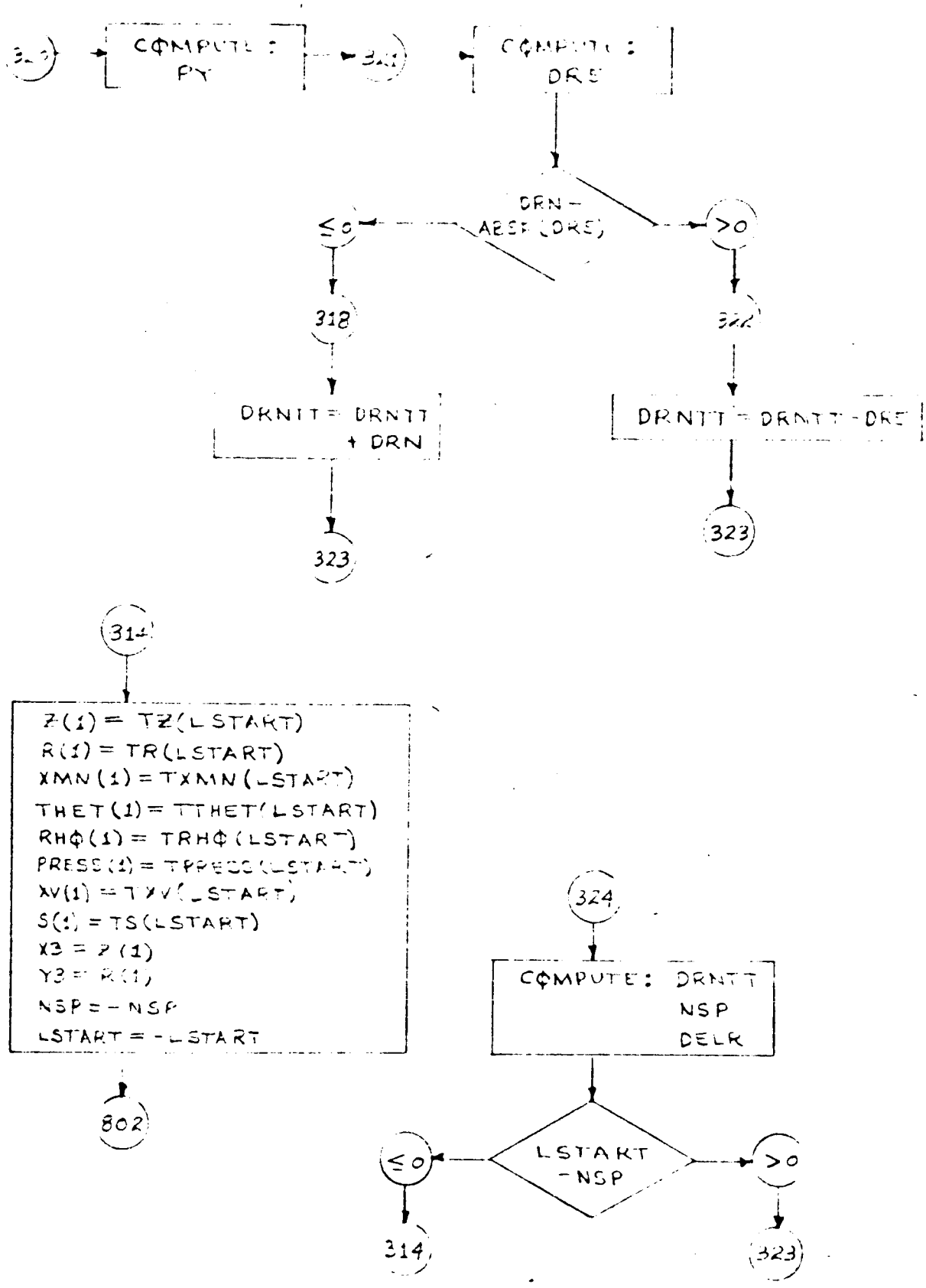

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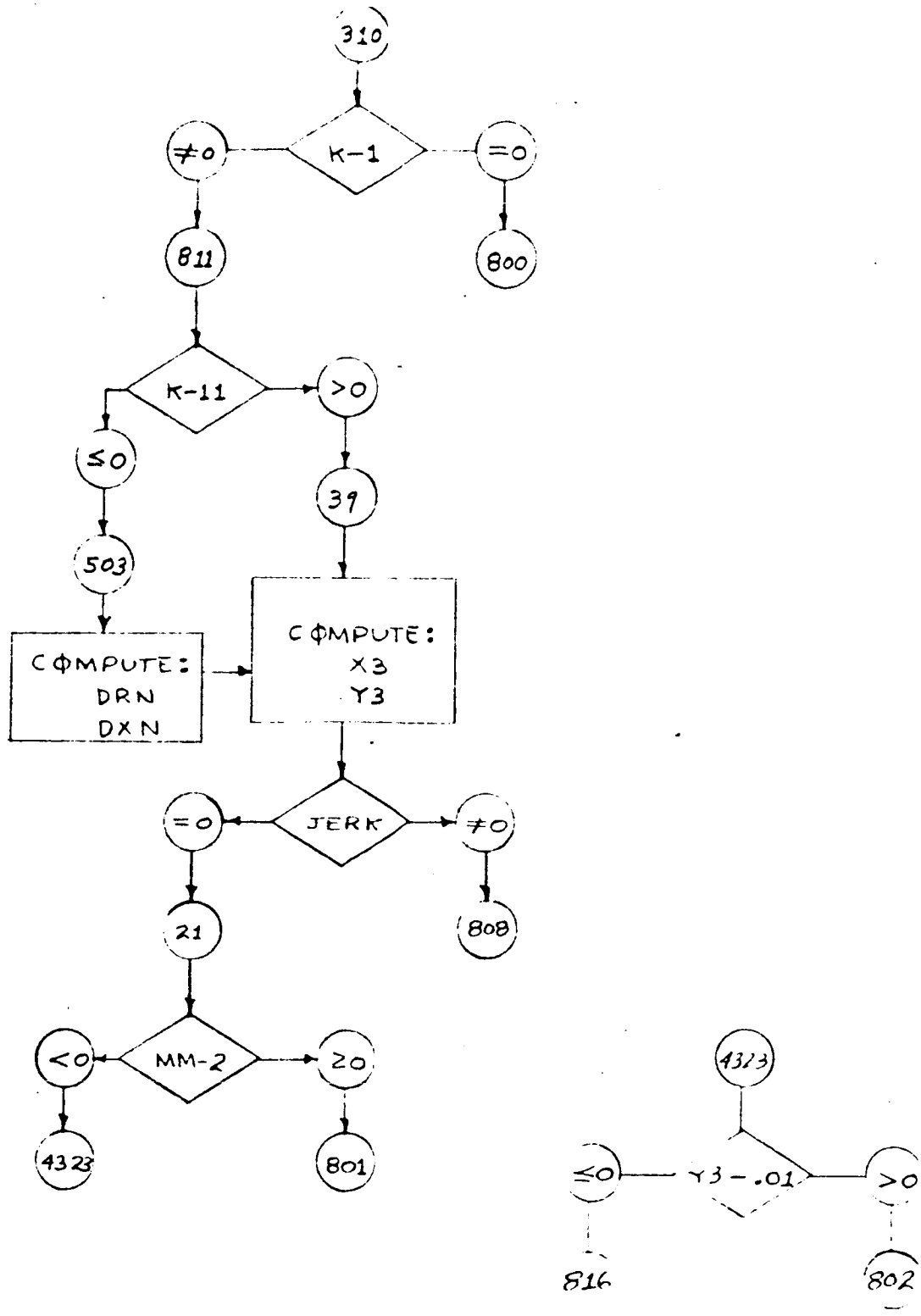
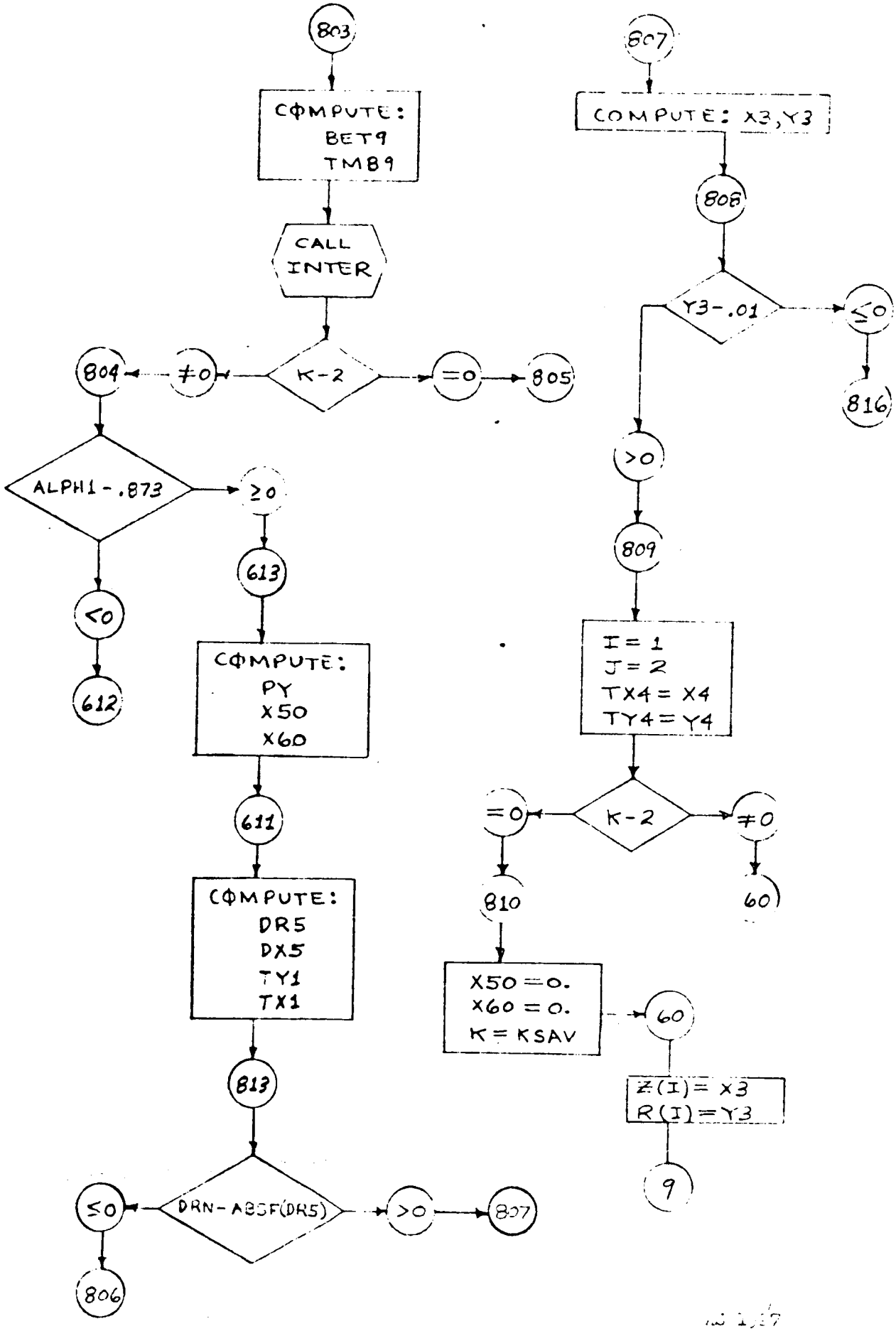
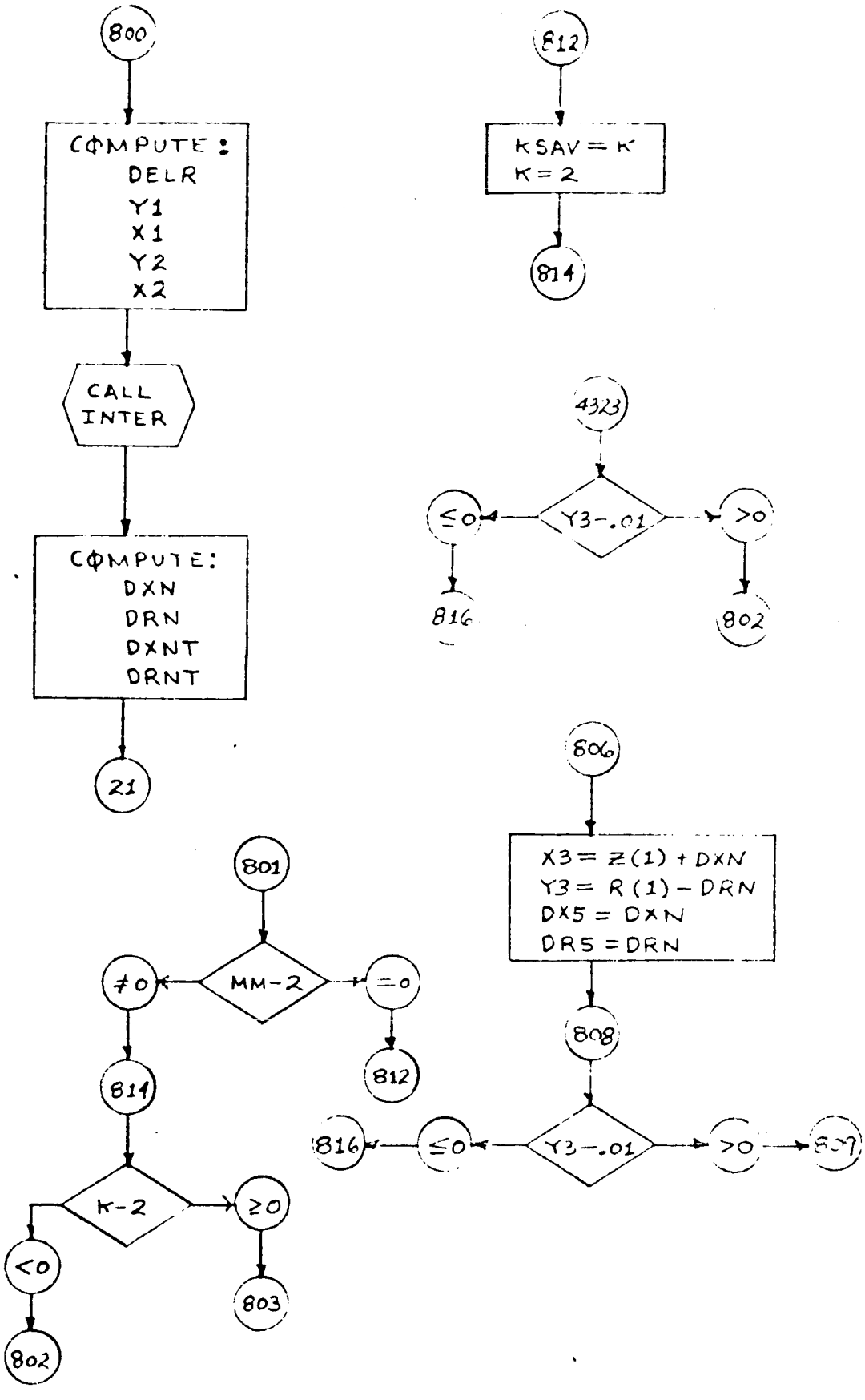

310
K-1
≠0
=0
811
800
K-11
>0
≤0
39
503
CΦMPUTE:
DRN
DXN
CΦMPUTE:
X3
Y3
JERK
=0
≠0
21
808
MM-2
<0
≥0
4323
801
4323
Y3 - .01
≤0
>0
816
802

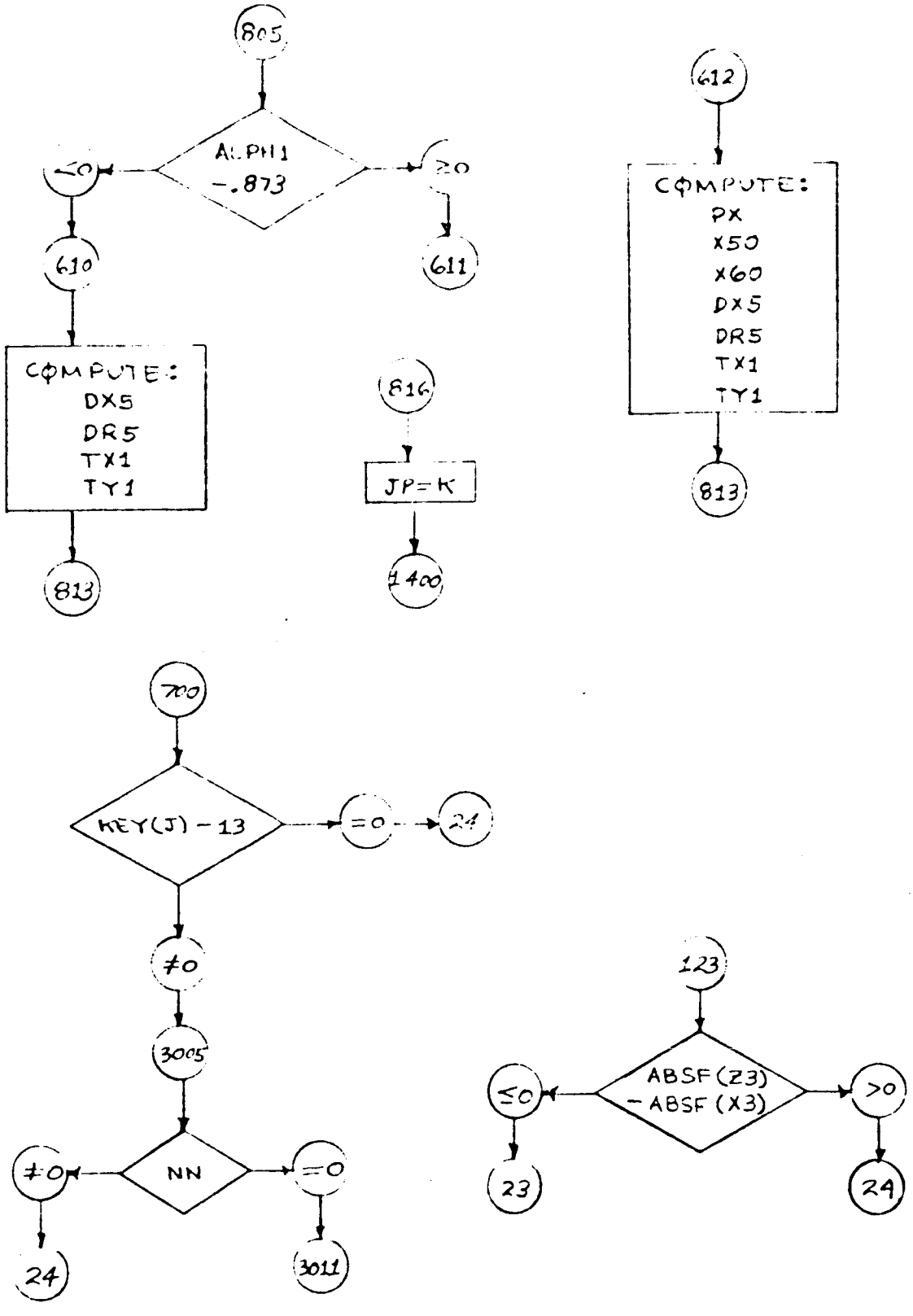
PLUME (CHAIN)


803
CΦMPUTE:
BET9
TMB9
CALL
INTER
K-2
≠0
=0
804
805
ALPHI-.873
≥0
<0
613
612
CΦMPUTE:
PY
X50
X60
611
CΦMPUTE:
DR5
DX5
TY1
TX1
813
DRN-ABSF(DR5)
≤0
>0
806
807
807
COMPUTE: X3,Y3
808
Y3-.01
≤0
816
>0
809
I=1
J=2
TX4=X4
TY4=Y4
K-2
=0
≠0
810
60
X50=0.
X60=0.
K=KSAV
60
Z(I)=X3
R(I)=Y3
9

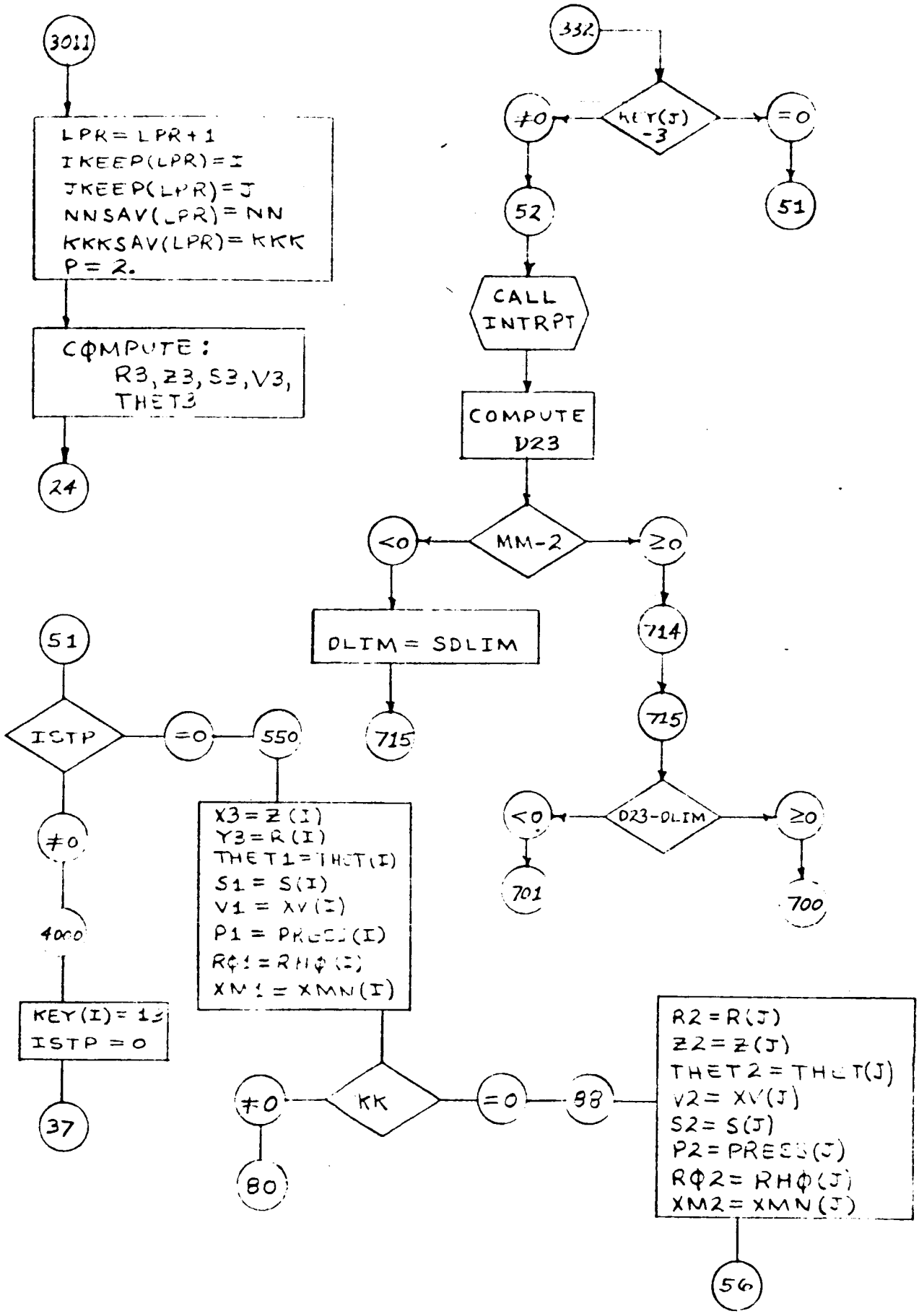
PLUME (CHAIN)


800
COMPUTE:
DELR
Y1
X1
Y2
X2
CALL INTER
COMPUTE:
DXN
DRN
DXNT
DRNT
21
812
KSAV = K
K = 2
814
4323
Y3-.01
≤0
>0
816
802
806
X3 = Z(1) + DXN
Y3 = R(1) - DRN
DX5 = DXN
DR5 = DRN
808
Y3-.01
≤0
>0
816
807
801
MM-2
≠0
=0
812
814
K-2
<0
≥0
802
803

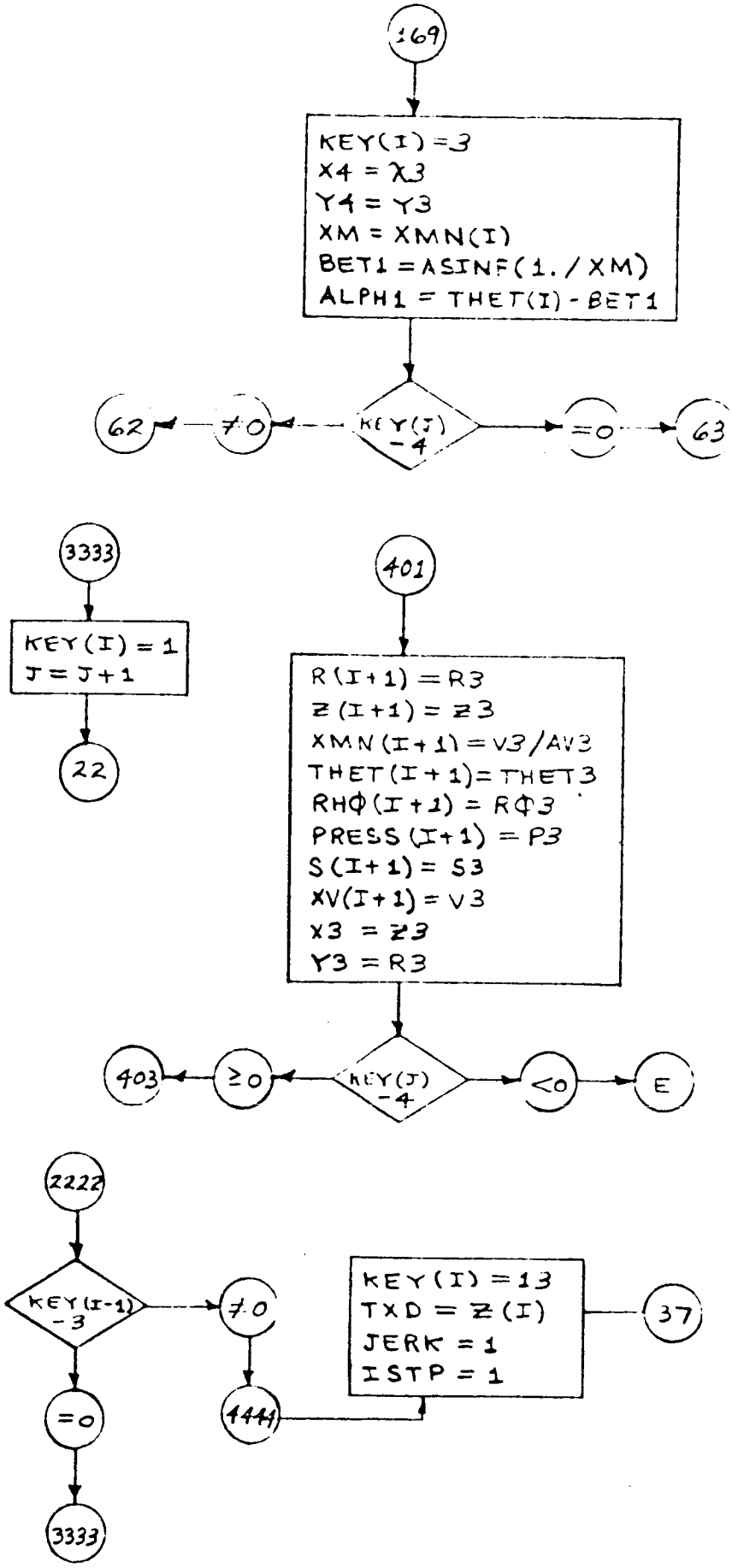
PLUME (CHAIN)


805
ALPH1
-.873
<0
≥0
610
611
COMPUTE:
DX5
DR5
TX1
TY1
813
816
JP=K
1400
612
COMPUTE:
PX
X50
X60
DX5
DR5
TX1
TY1
813
700
KEY(J) - 13
=0
24
≠0
3005
NN
≠0
=0
24
3011
123
ABSF(Z3)
- ABSF(X3)
≤0
>0
23
24

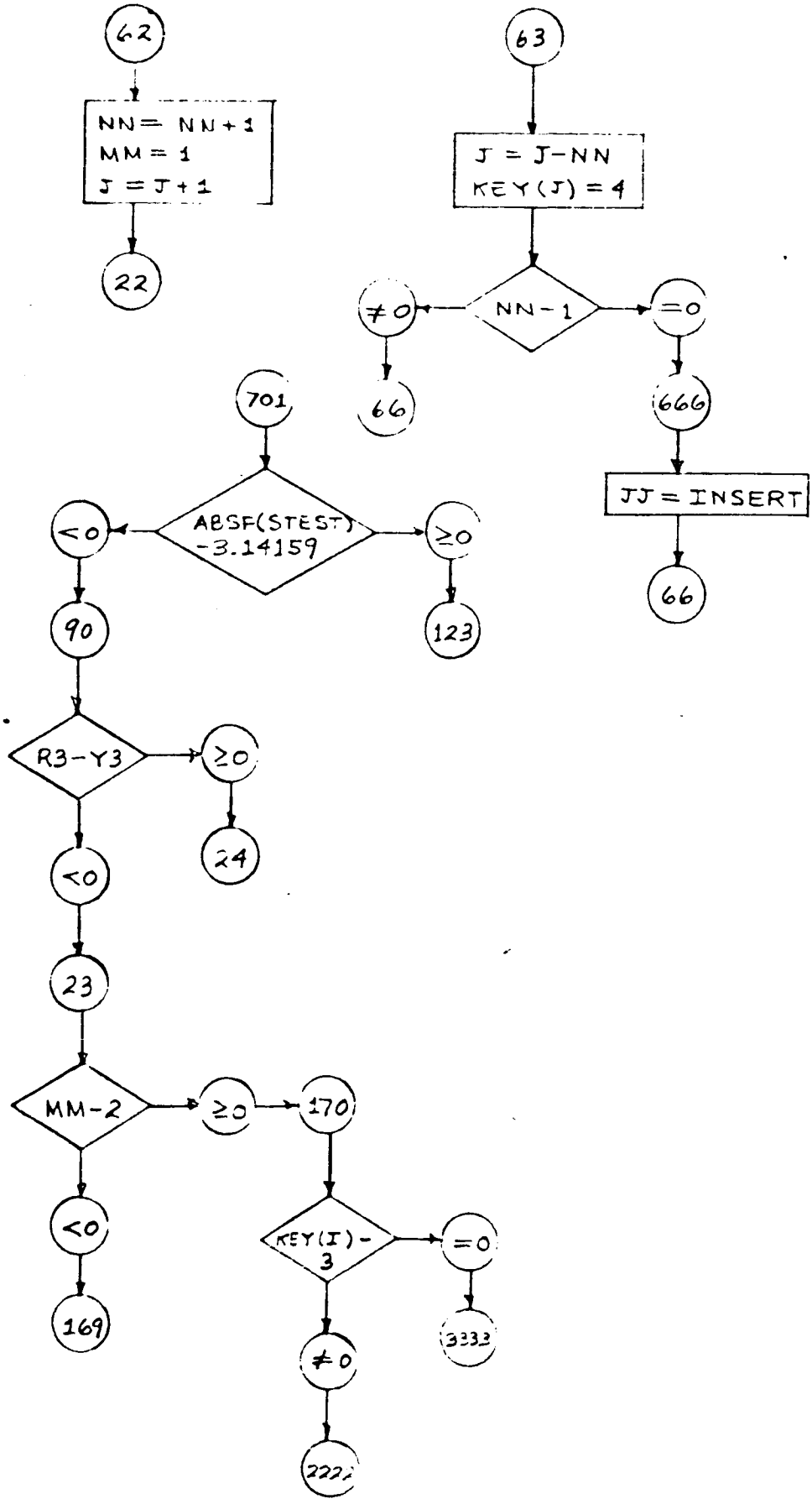
PLUME (CHAIN)


3011
LPR = LPR + 1
IKEEP(LPR) = I
JKEEP(LPR) = J
NNSAV(LPR) = NN
KKKSAV(LPR) = KKK
P = 2.
COMPUTE:
R3, Z3, S3, V3,
THET3
24
332
KEY(J) -3
≠0
=0
51
52
CALL INTRPT
COMPUTE D23
MM-2
<0
≥0
DLIM = SDLIM
715
714
715
D23-DLIM
<0
≥0
701
700
51
ISTP
=0
550
≠0
4000
KEY(I) = 13
ISTP = 0
37
X3 = Z(I)
Y3 = R(I)
THET1 = THET(I)
S1 = S(I)
V1 = XV(I)
P1 = PRESS(I)
RΦ1 = RHΦ(I)
XM1 = XMN(I)
KK
≠0
80
=0
88
R2 = R(J)
Z2 = Z(J)
THET2 = THET(J)
V2 = XV(J)
S2 = S(J)
P2 = PRESS(J)
RΦ2 = RHΦ(J)
XM2 = XMN(J)
56

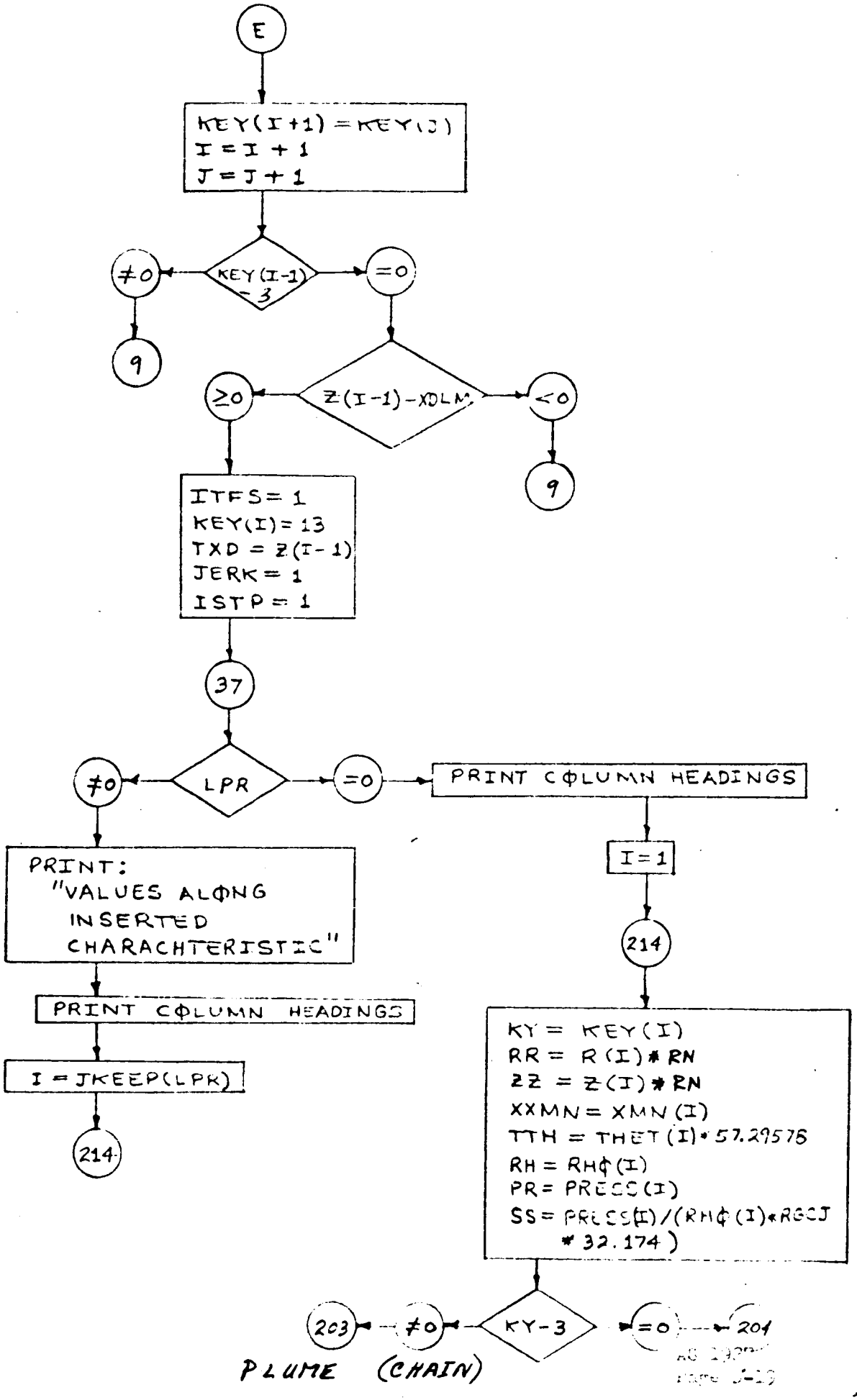
PLUME (CHAIN)


169
KEY(I) = 3
X4 = X3
Y4 = Y3
XM = XMN(I)
BET1 = ASINF(1./XM)
ALPH1 = THET(I) - BET1
KEY(J) - 4
≠0
62
=0
63
3333
KEY(I) = 1
J = J + 1
22
401
R(I+1) = R3
Z(I+1) = Z3
XMN(I+1) = V3/AV3
THET(I+1) = THET3
RHΦ(I+1) = RΦ3
PRESS(I+1) = P3
S(I+1) = S3
XV(I+1) = V3
X3 = Z3
Y3 = R3
KEY(J) - 4
≥0
403
<0
E
2222
KEY(I-1) - 3
≠0
=0
3333
1444
KEY(I) = 13
TXD = Z(I)
JERK = 1
ISTP = 1
37

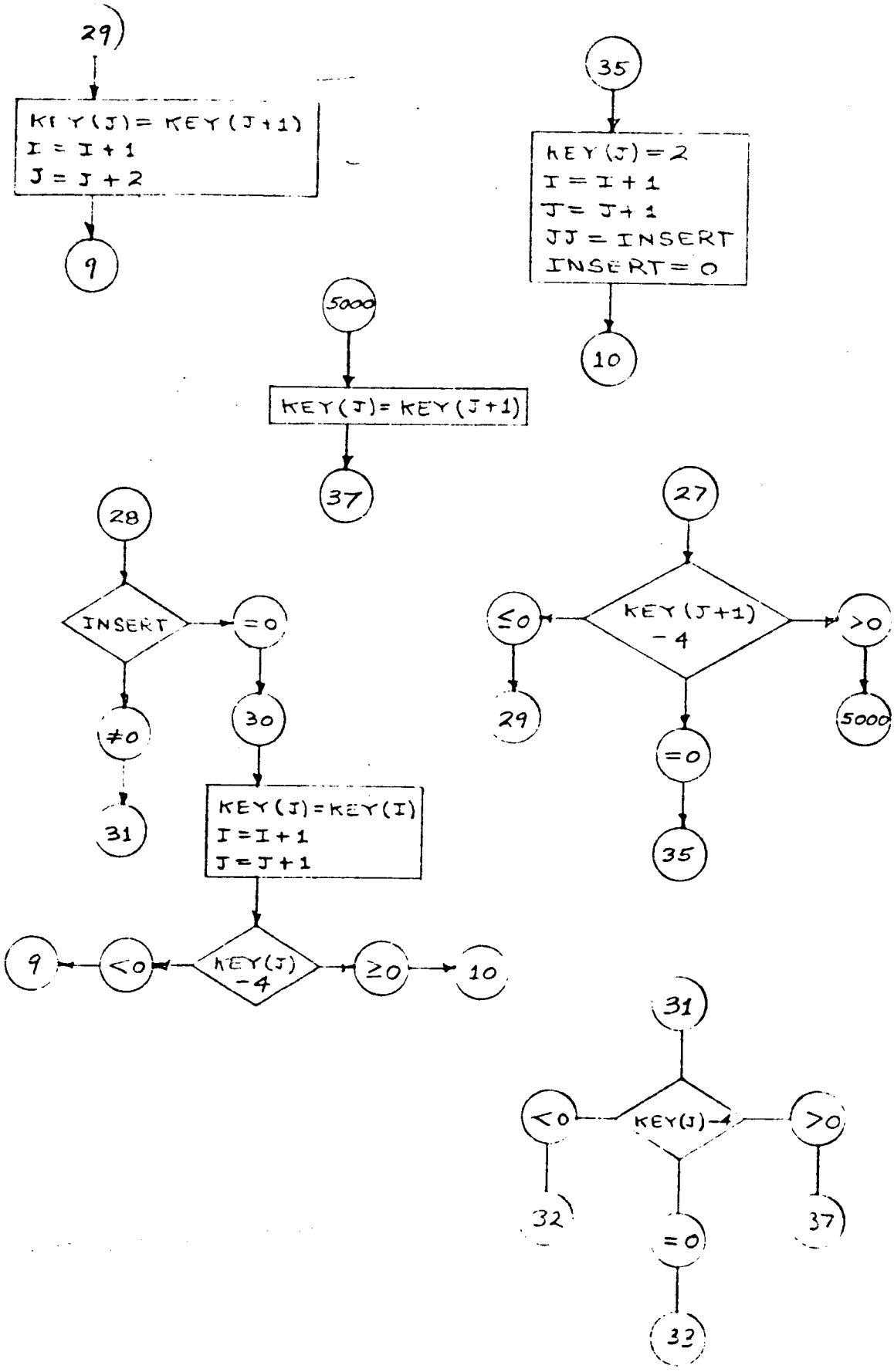
PLUME (CHAIN)


62
NN= NN+1
MM = 1
J = J+1
22
63
J = J-NN
KEY(J) = 4
NN-1
≠0
=0
66
666
JJ = INSERT
66
701
ABSF(STEST)
-3.14159
<0
≥0
90
123
R3-Y3
≥0
24
<0
23
MM-2
≥0
170
<0
169
KEY(I)-
3
=0
3333
≠0
2222

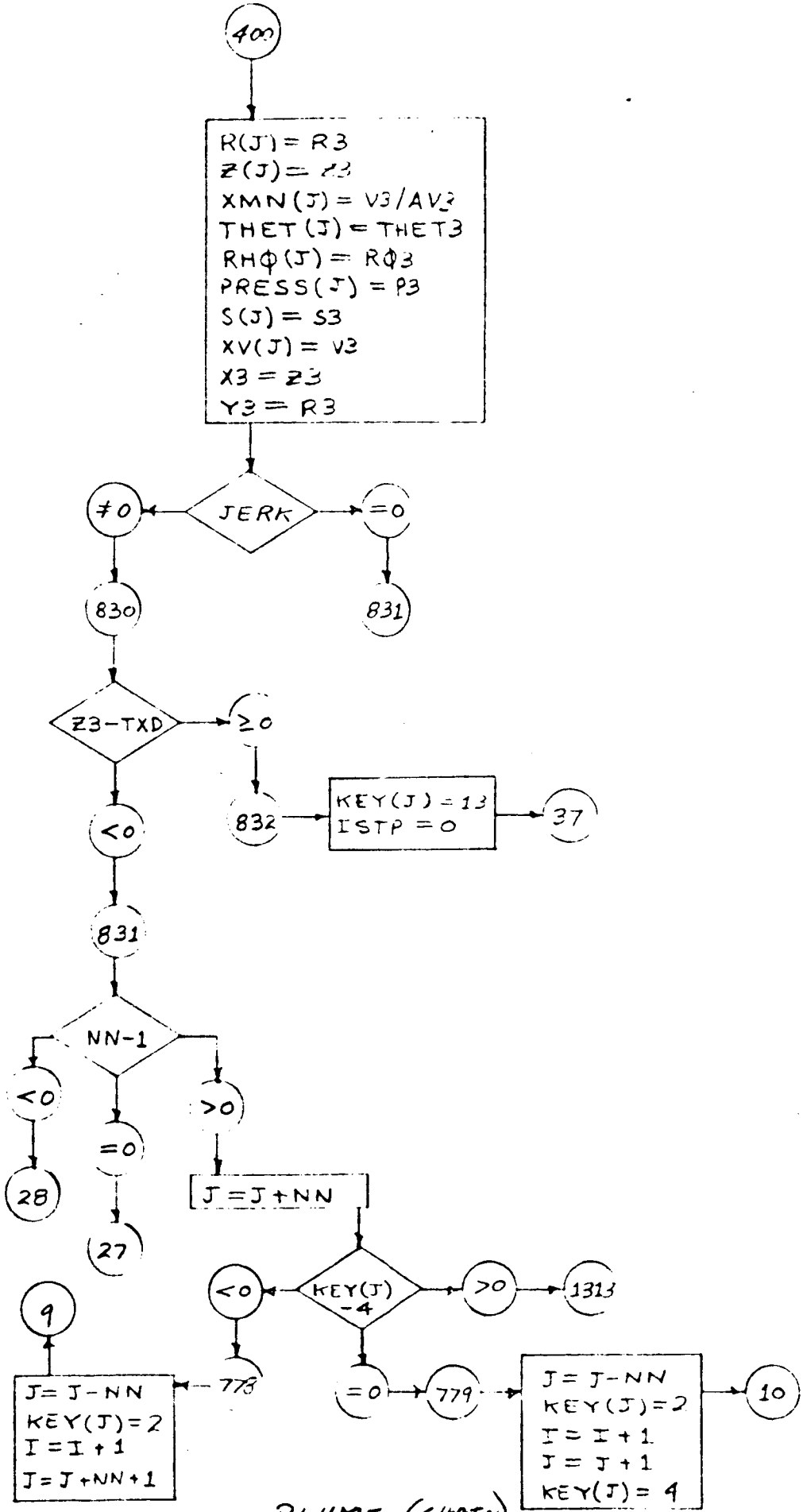
PLUME (CHAIN)


E
KEY(I+1) = KEY(J)
I = I + 1
J = J + 1
KEY(I-1) - 3
≠0
=0
9
Z(I-1) - XDLM
≥0
<0
9
ITFS = 1
KEY(I) = 13
TXD = Z(I-1)
JERK = 1
ISTP = 1
37
LPR
≠0
=0
PRINT COLUMN HEADINGS
PRINT:
"VALUES ALONG
INSERTED
CHARACHTERISTIC"
PRINT COLUMN HEADINGS
I = JKEEP(LPR)
214
I = 1
214
KY = KEY(I)
RR = R(I) * RN
ZZ = Z(I) * RN
XXMN = XMN(I)
TTH = THET(I) * 57.29578
RH = RHO(I)
PR = PRESS(I)
SS = PRESS(I)/(RHO(I) * RGCJ
* 32.174)
KY-3
≠0
=0
203
201

PLUME (CHAIN)


29
KEY(J)= KEY(J+1)
I = I + 1
J = J + 2
9
35
KEY(J) = 2
I = I + 1
J = J + 1
JJ = INSERT
INSERT = 0
10
5000
KEY(J)= KEY(J+1)
37
28
INSERT
=0
≠0
30
31
KEY(J)=KEY(I)
I = I + 1
J = J + 1
KEY(J) -4
<0
9
≥0
10
27
KEY(J+1) - 4
≤0
29
>0
5000
=0
35
31
KEY(J)-4
<0
32
>0
37
=0
33

PLUME (CHAIN)



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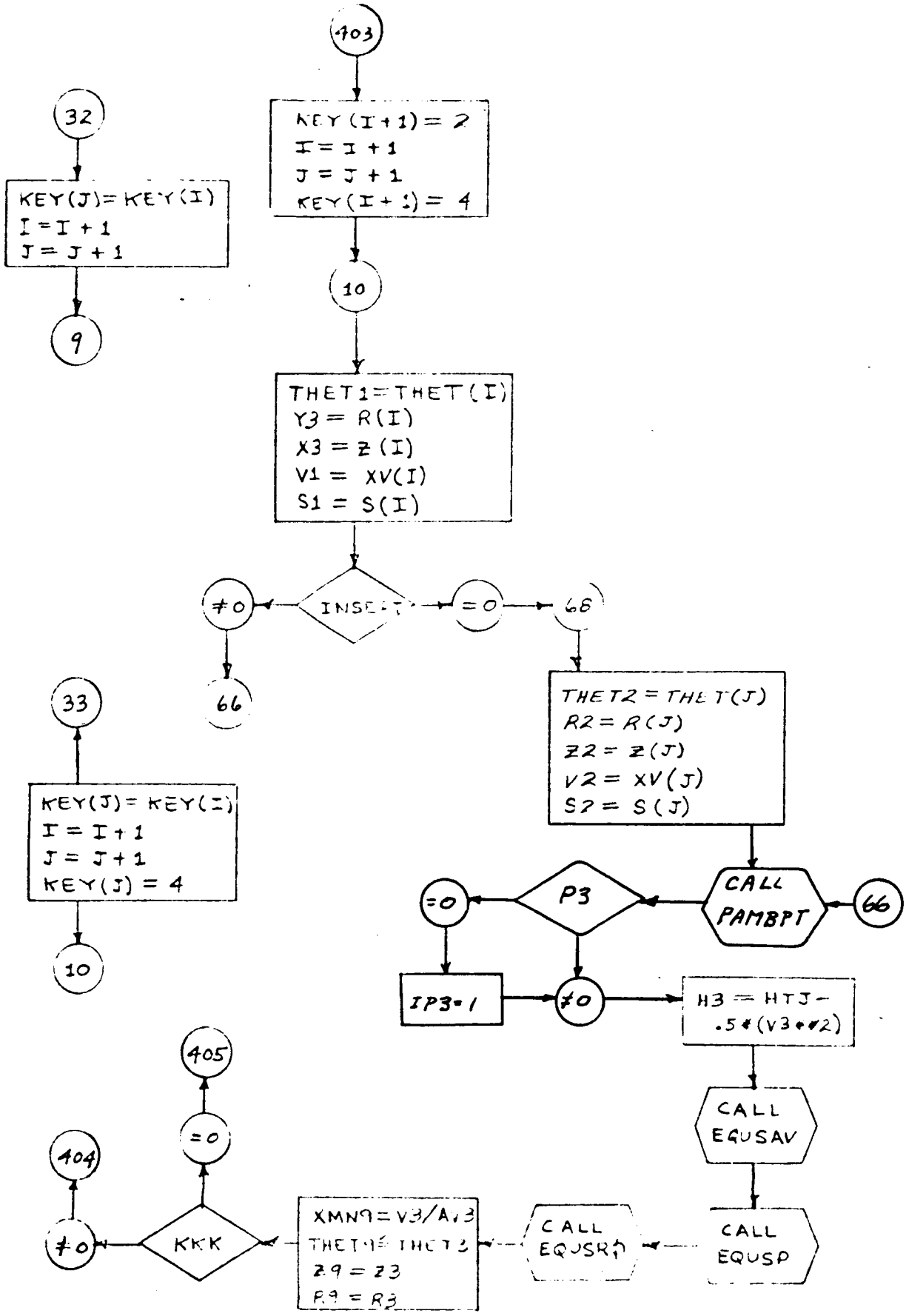

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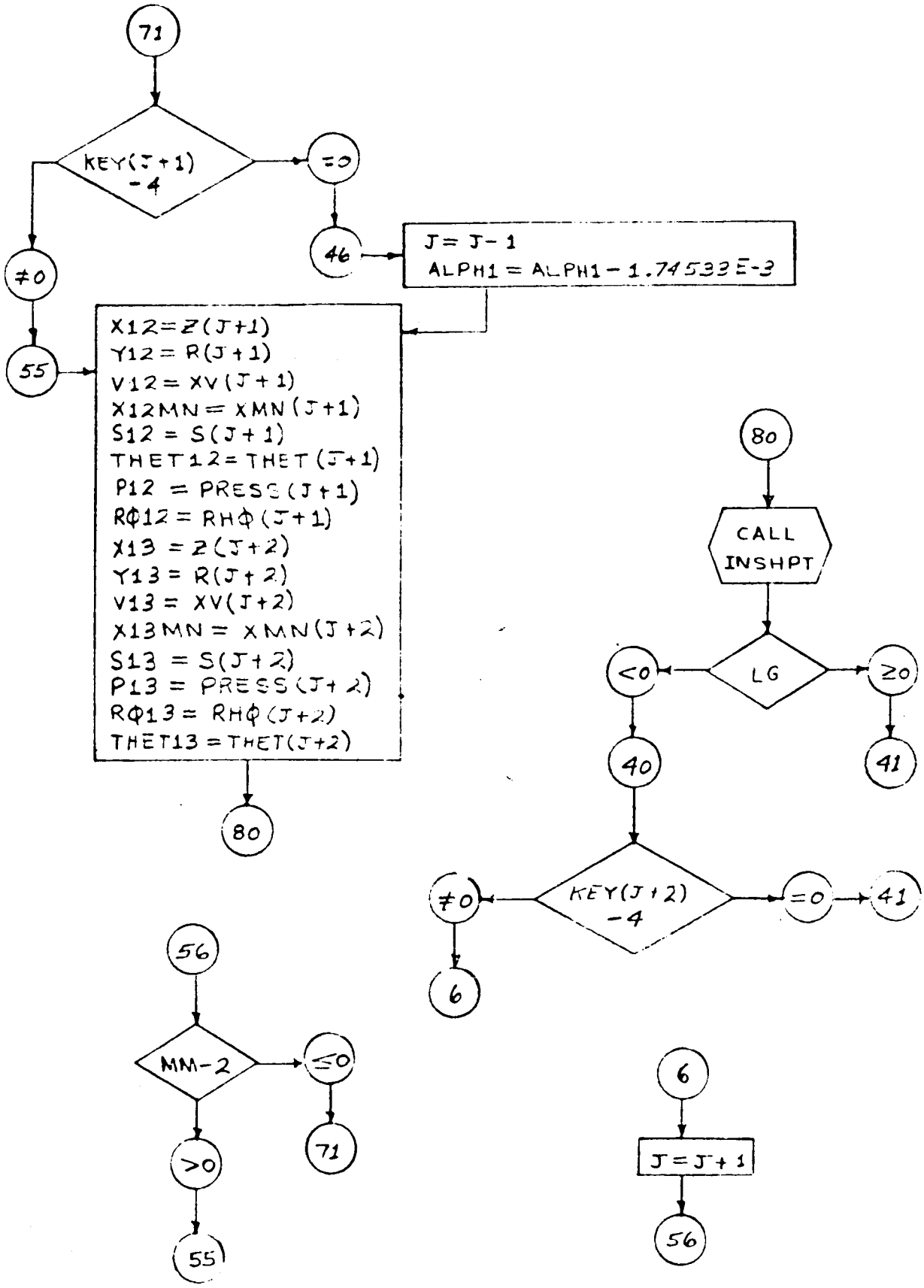

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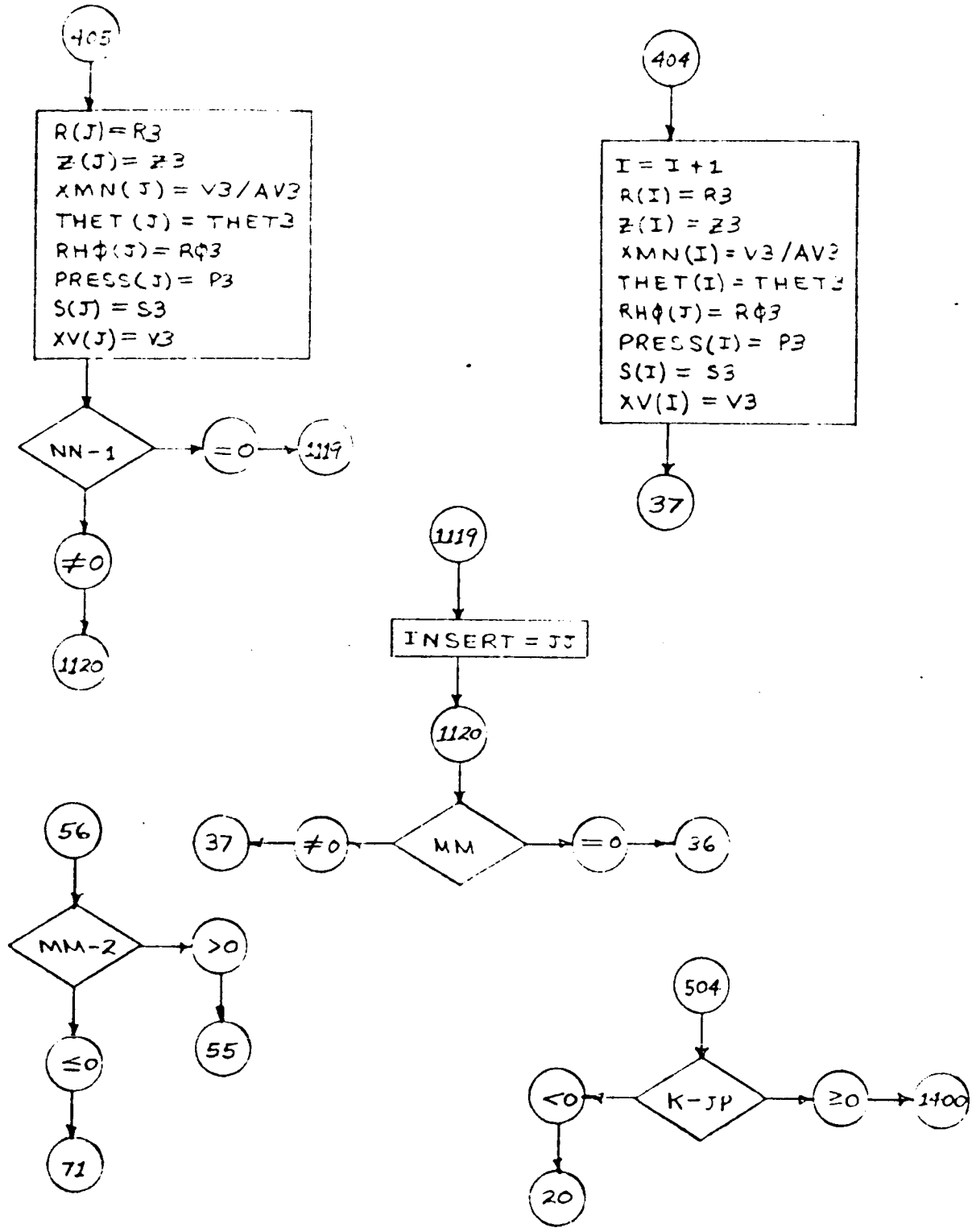
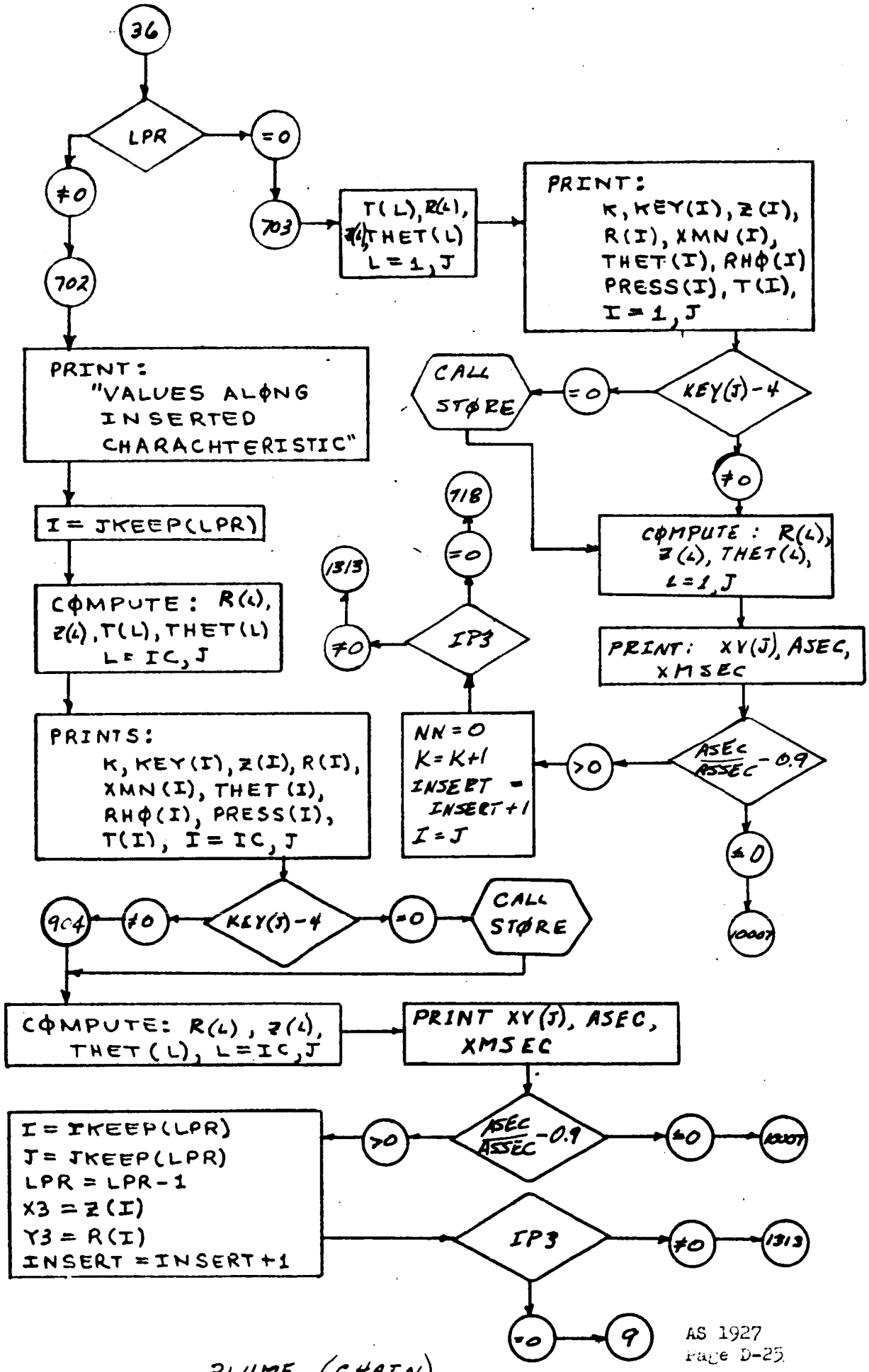
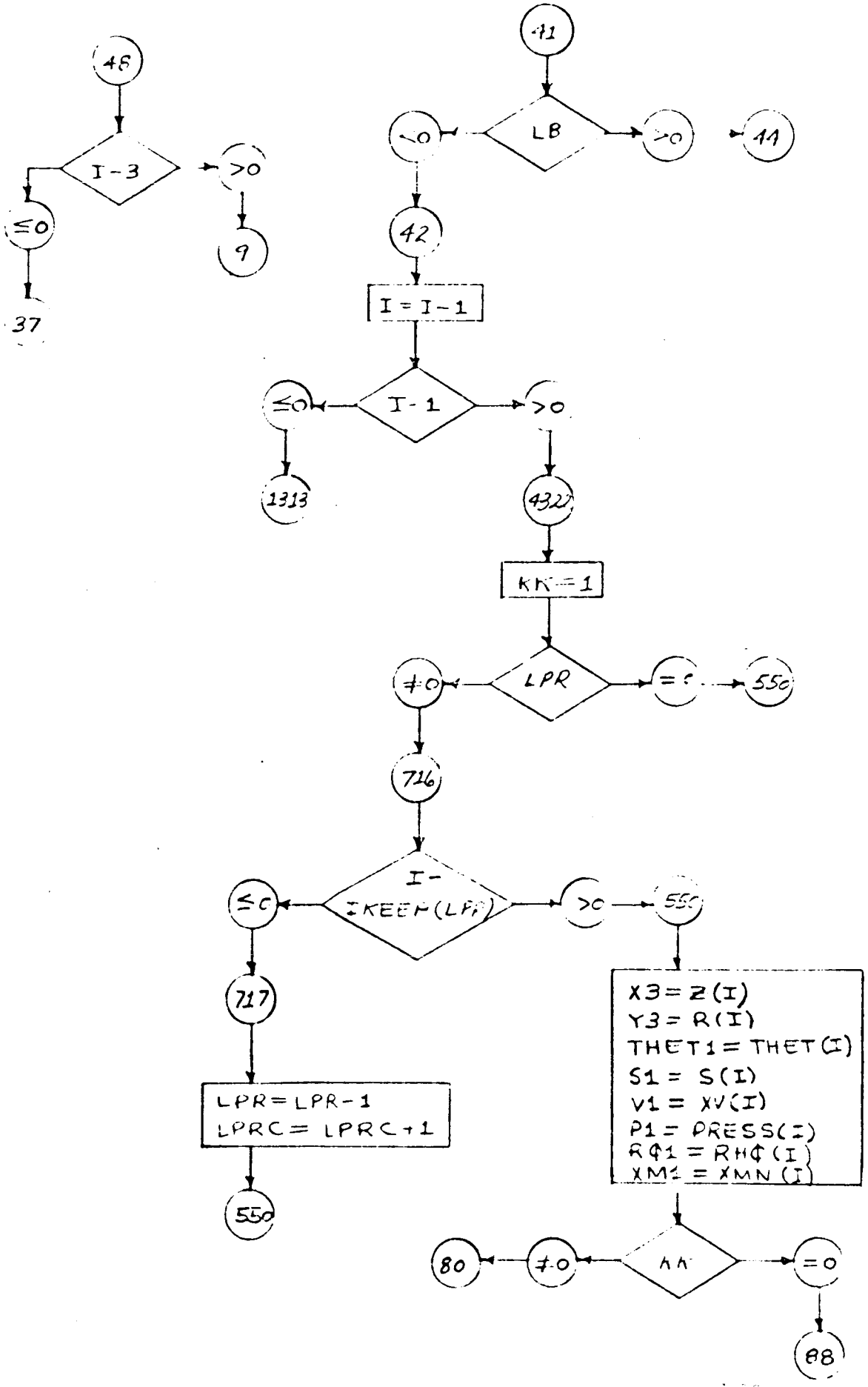

405
R(J) = R3
Z(J) = Z3
XMN(J) = V3/AV3
THET(J) = THET3
RHΦ(J) = RΦ3
PRESS(J) = P3
S(J) = S3
XV(J) = V3
NN - 1
= 0
1119
≠ 0
1120
404
I = I + 1
R(I) = R3
Z(I) = Z3
XMN(I) = V3/AV3
THET(I) = THET3
RHΦ(J) = RΦ3
PRESS(I) = P3
S(I) = S3
XV(I) = V3
37
1119
INSERT = JJ
1120
MM
≠ 0
37
= 0
36
56
MM-2
> 0
55
≤ 0
71
504
K-JP
< 0
20
≥ 0
1400

PLUME (CHAIN)


36
LPR
=0
≠0
703
702
T(L), R(L), Z(L), THET(L) L=1, J
PRINT: K, KEY(I), Z(I), R(I), XMN(I), THET(I), RHΦ(I) PRESS(I), T(I), I=1, J
PRINT: "VALUES ALΦNG INSERTED CHARACHTERISTIC"
CALL STØRE
=0
KEY(J)-4
≠0
I = JKEEP(LPR)
CØMPUTE: R(L), Z(L), THET(L), L=1, J
718
=0
1313
≠0
IP3
CØMPUTE: R(L), Z(L), T(L), THET(L) L=IC, J
PRINT: XY(J), ASEC, XMSEC
PRINTS: K, KEY(I), Z(I), R(I), XMN(I), THET(I), RHΦ(I), PRESS(I), T(I), I=IC, J
NN=0
K=K+1
INSERT = INSERT+1
I=J
>0
ASEC/ASSEC - 0.9
≤0
10007
904
≠0
KEY(J)-4
=0
CALL STØRE
CØMPUTE: R(L), Z(L), THET(L), L=IC, J
PRINT XY(J), ASEC, XMSEC
I = IKEEP(LPR)
J = JKEEP(LPR)
LPR = LPR-1
X3 = Z(I)
Y3 = R(I)
INSERT = INSERT+1
>0
ASEC/ASSEC - 0.9
≤0
10007
IP3
≠0
1313
=0
9

PLUME (CHAIN)



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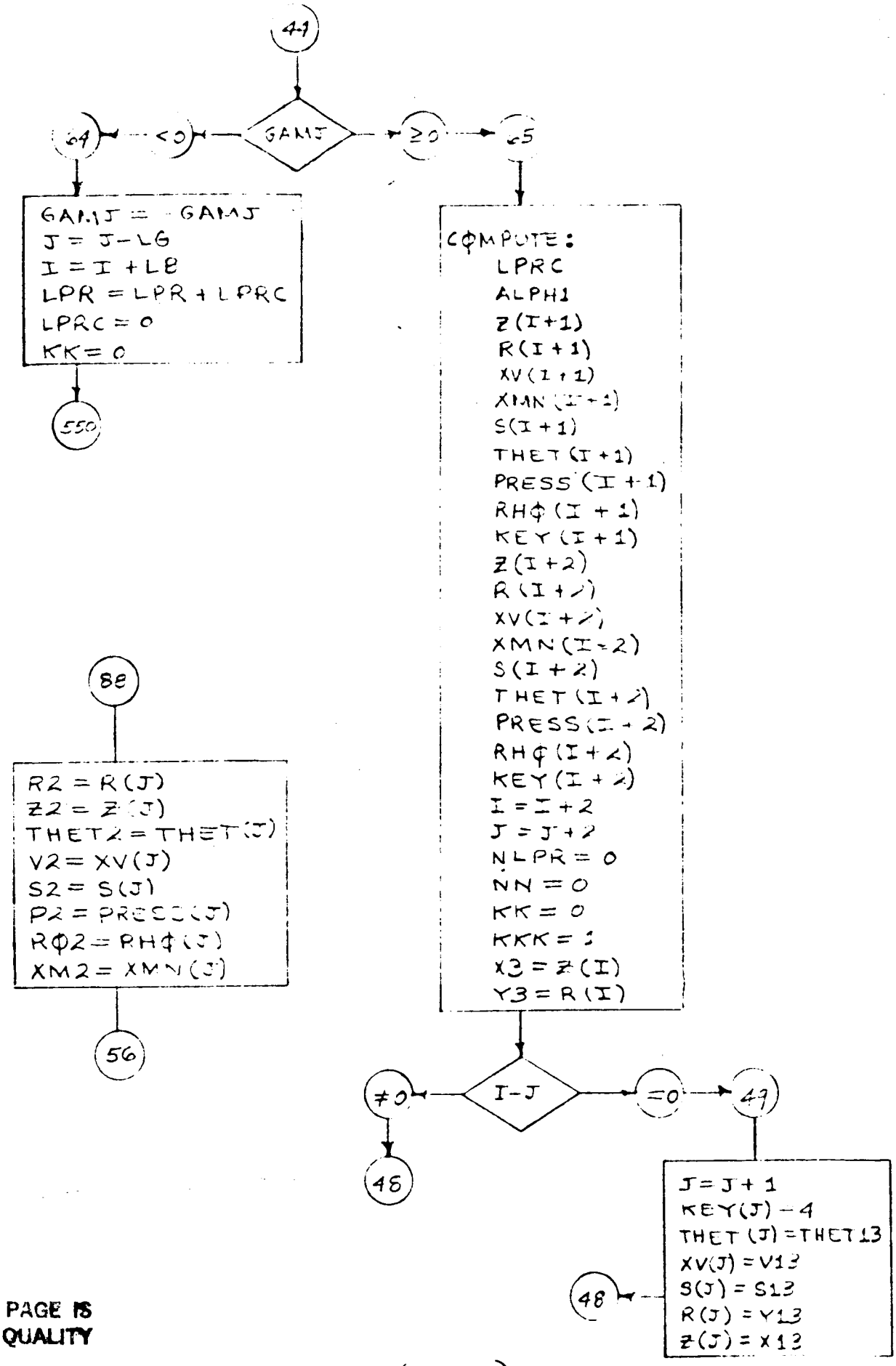

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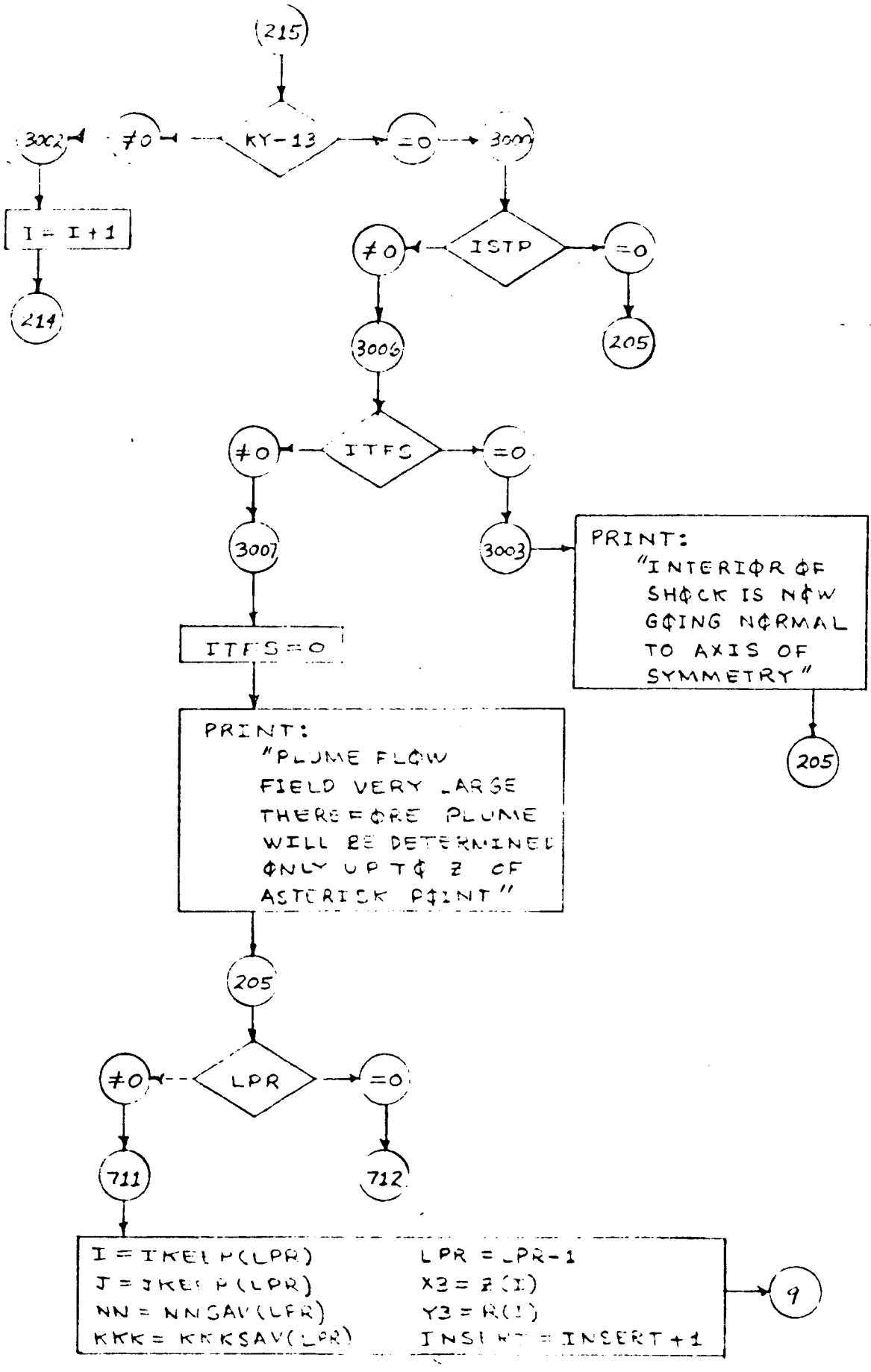

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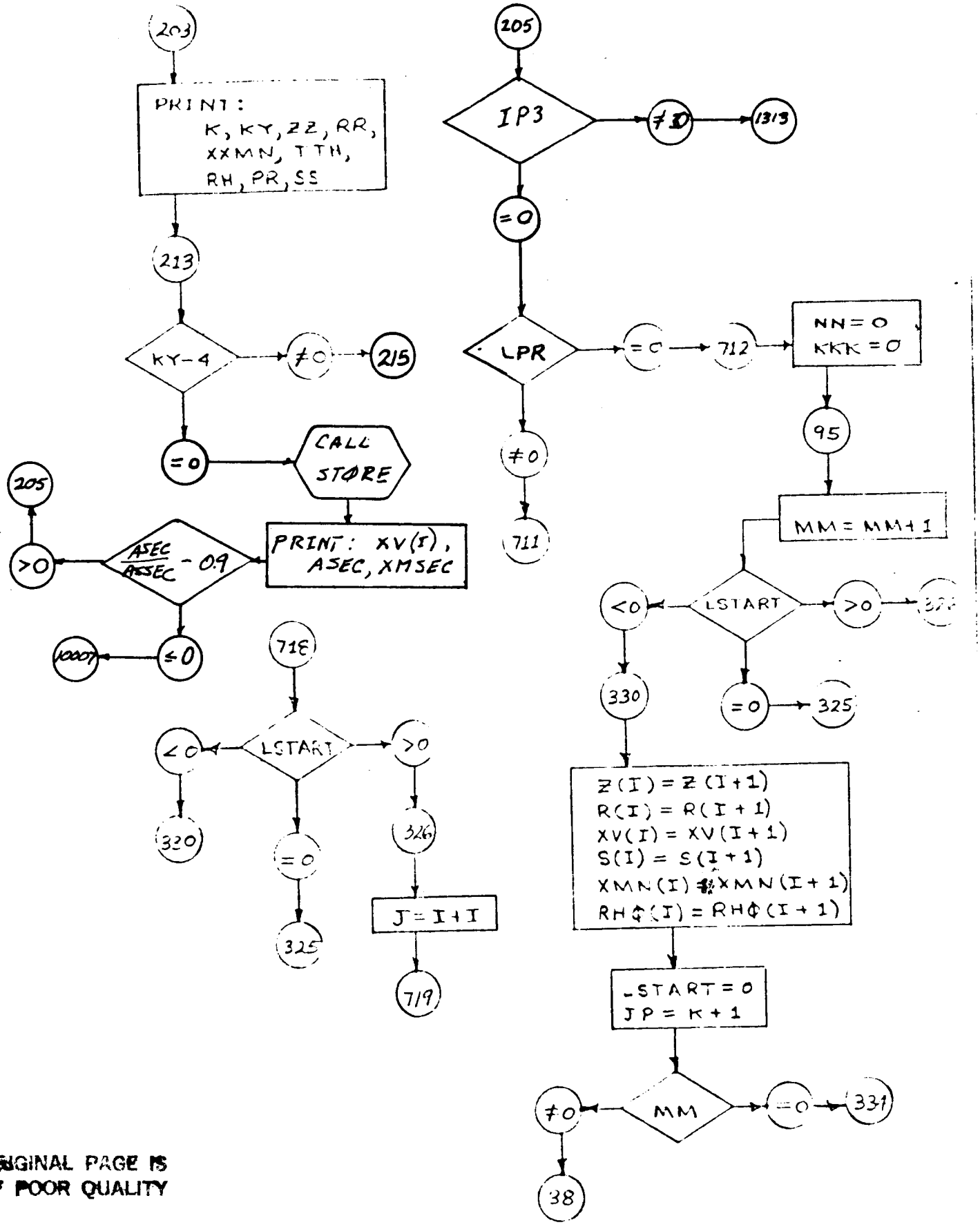

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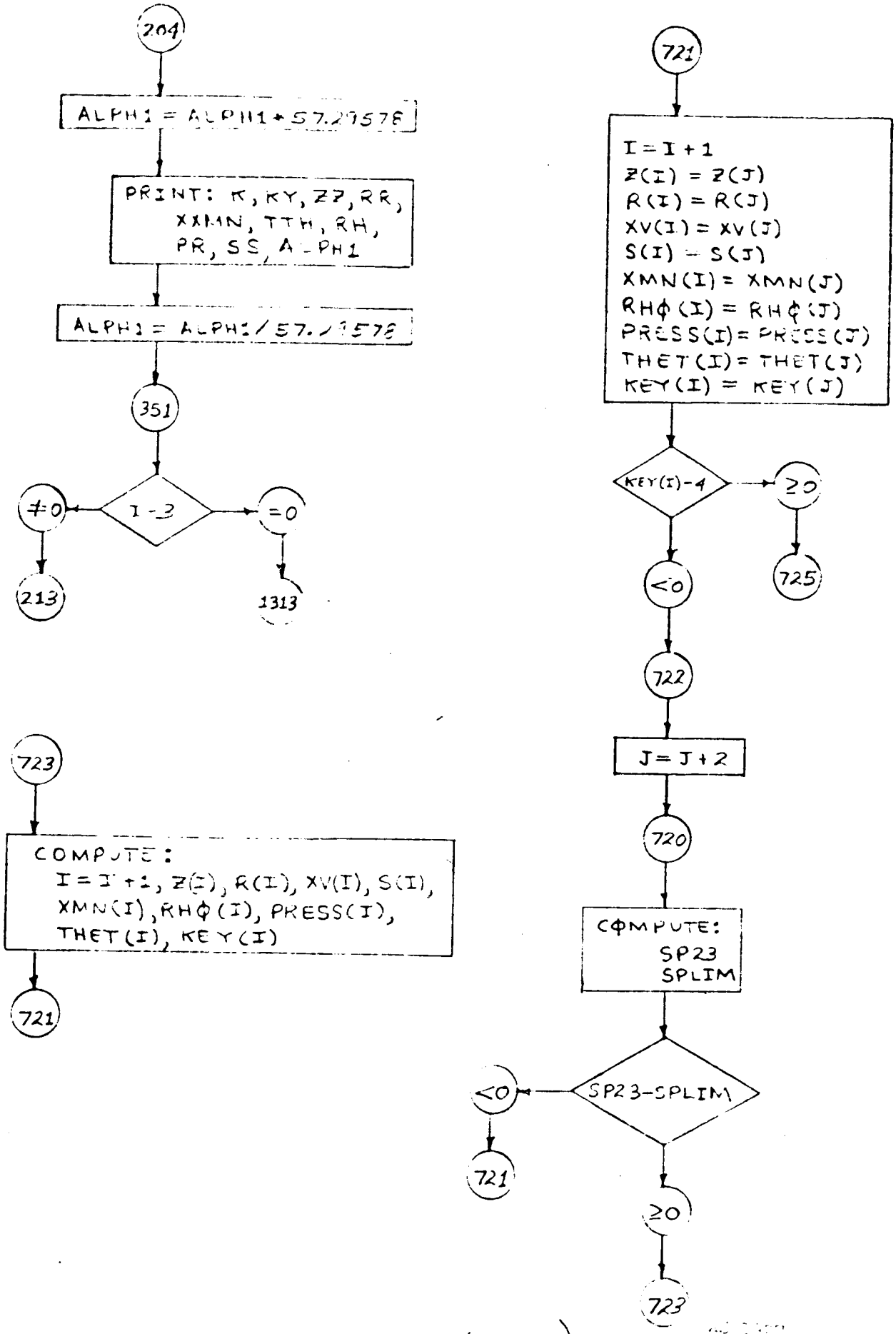
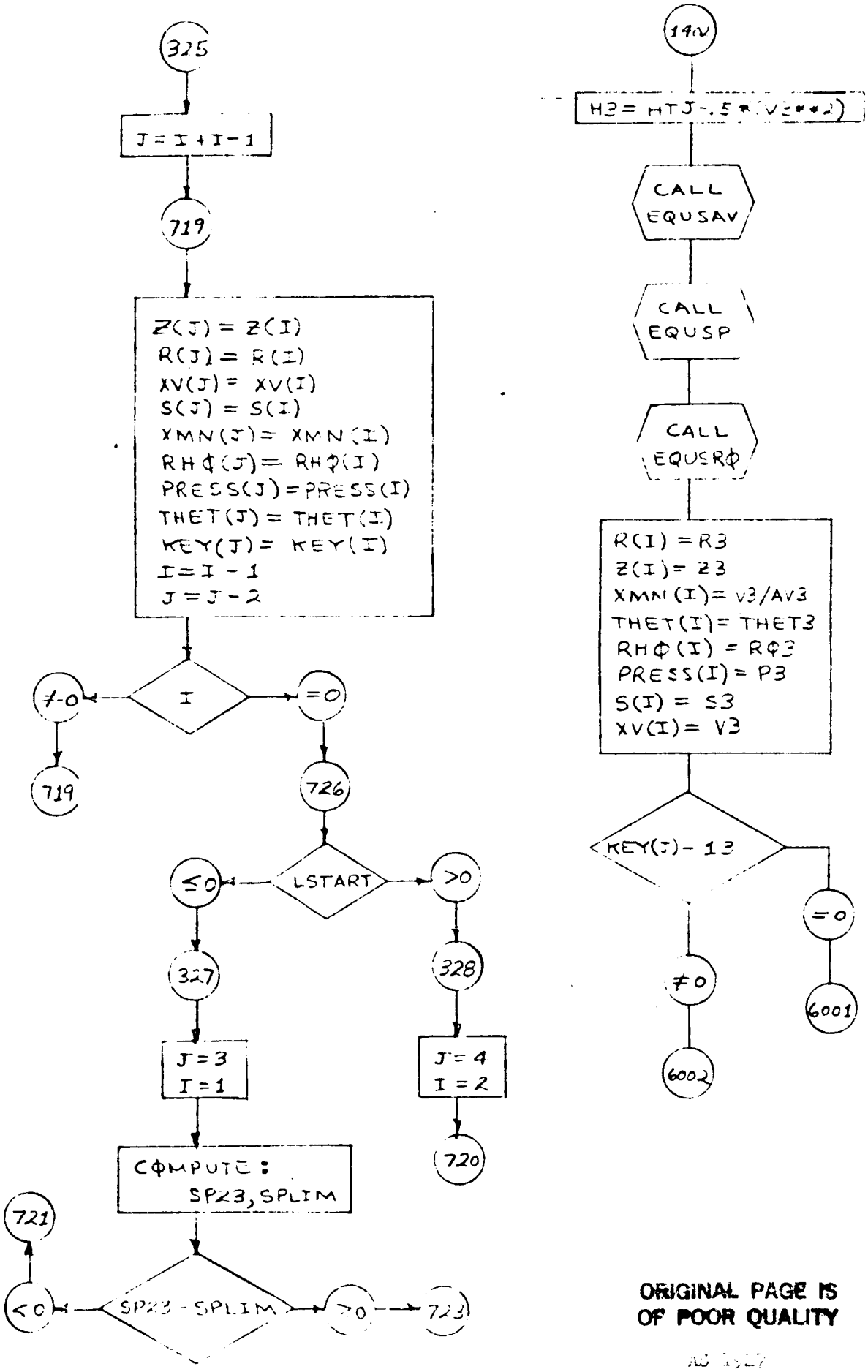

204
ALPH1 = ALPH1 * 57.29578
PRINT: K, KY, ZZ, RR, XXMN, TTH, RH, PR, SS, ALPH1
ALPH1 = ALPH1 / 57.29578
351
I - 3
≠0
=0
213
1313
721
I = I + 1
Z(I) = Z(J)
R(I) = R(J)
XV(I) = XV(J)
S(I) = S(J)
XMN(I) = XMN(J)
RHΦ(I) = RHΦ(J)
PRESS(I) = PRESS(J)
THET(I) = THET(J)
KEY(I) = KEY(J)
KEY(I) - 4
≥0
725
<0
722
J = J + 2
720
CΦMPUTE: SP23 SPLIM
SP23-SPLIM
<0
721
≥0
723
723
COMPUTE: I = I + 1, Z(I), R(I), XV(I), S(I), XMN(I), RHΦ(I), PRESS(I), THET(I), KEY(I)
721

PLUME (CHAIN)



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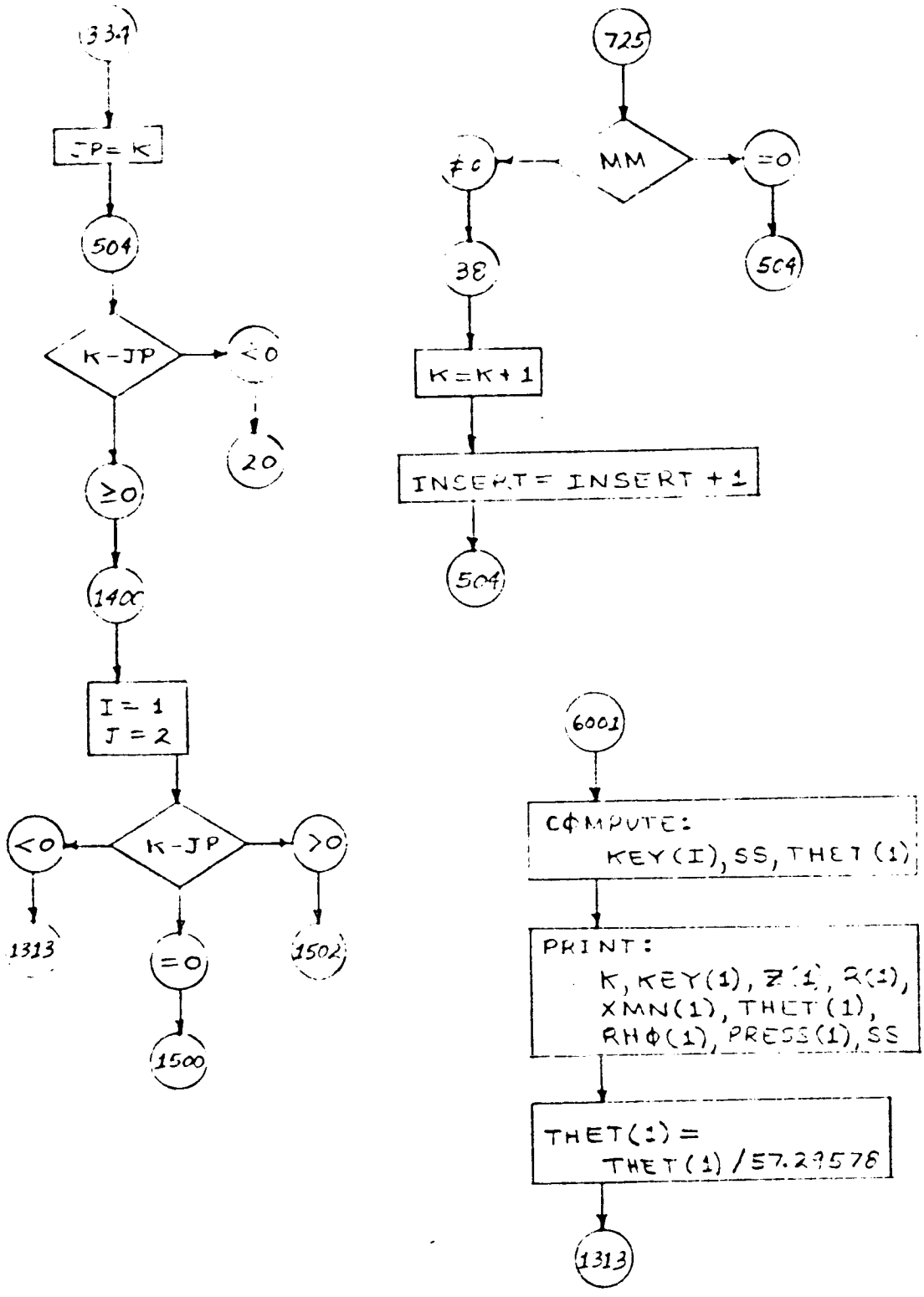

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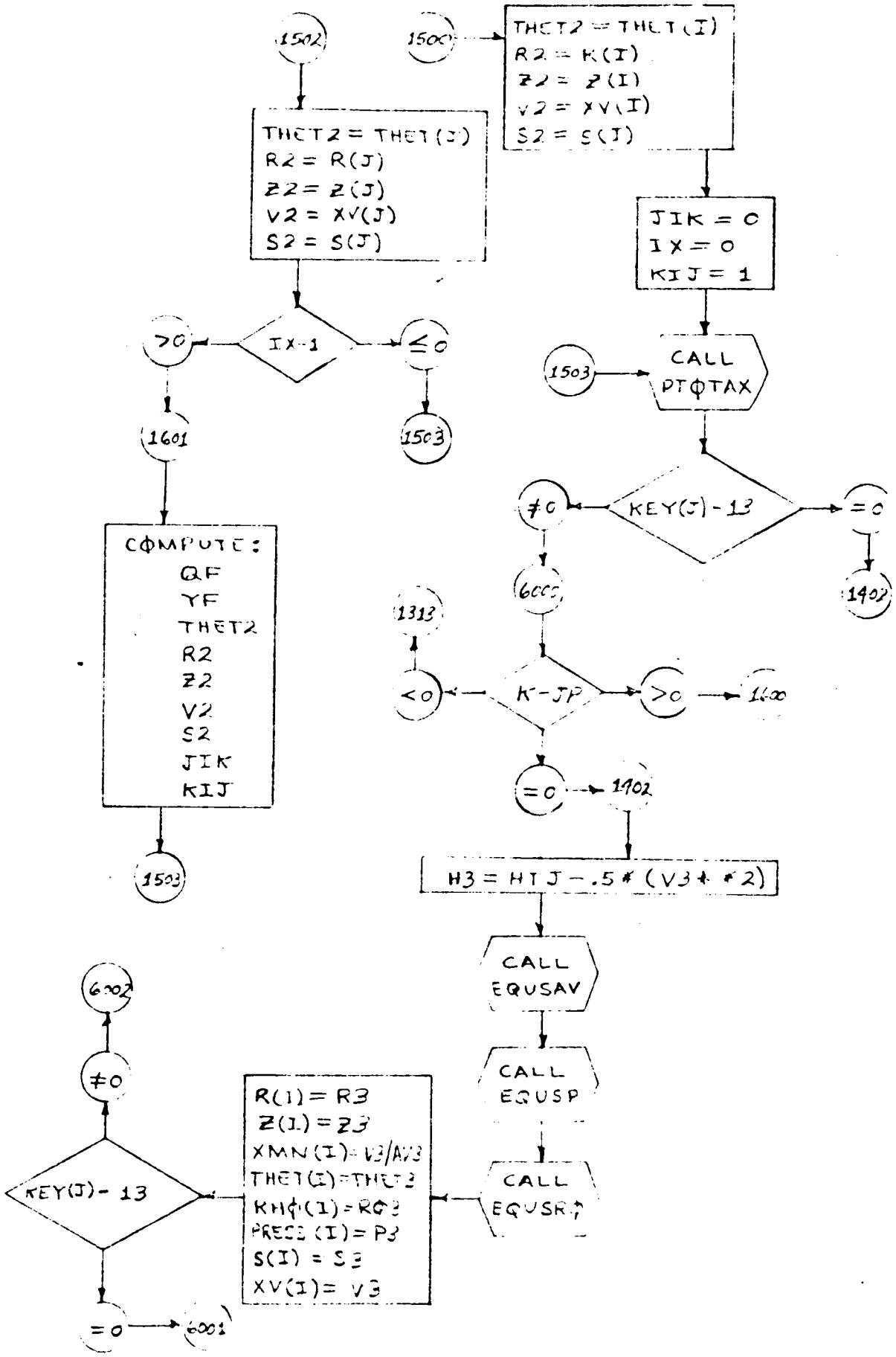
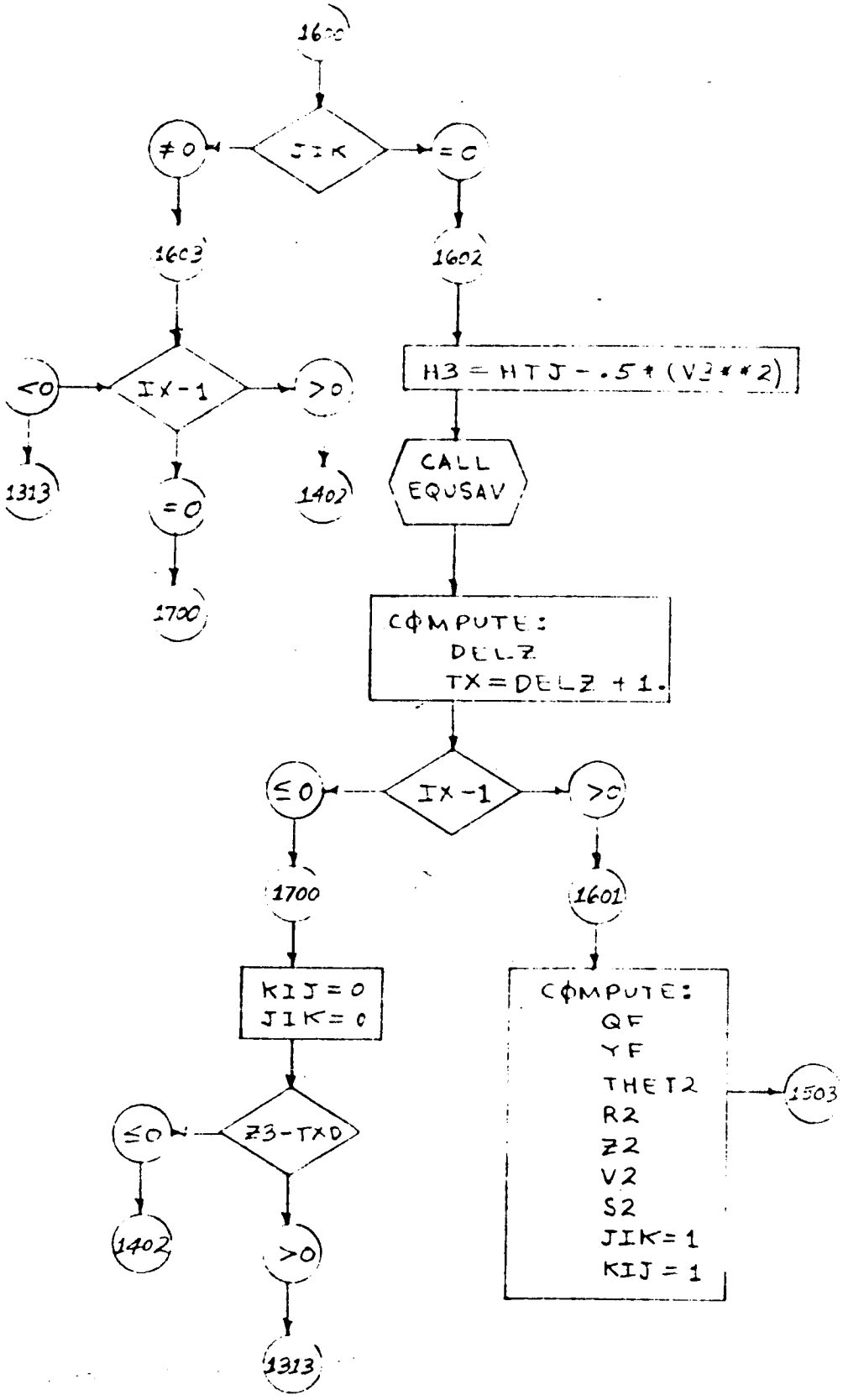
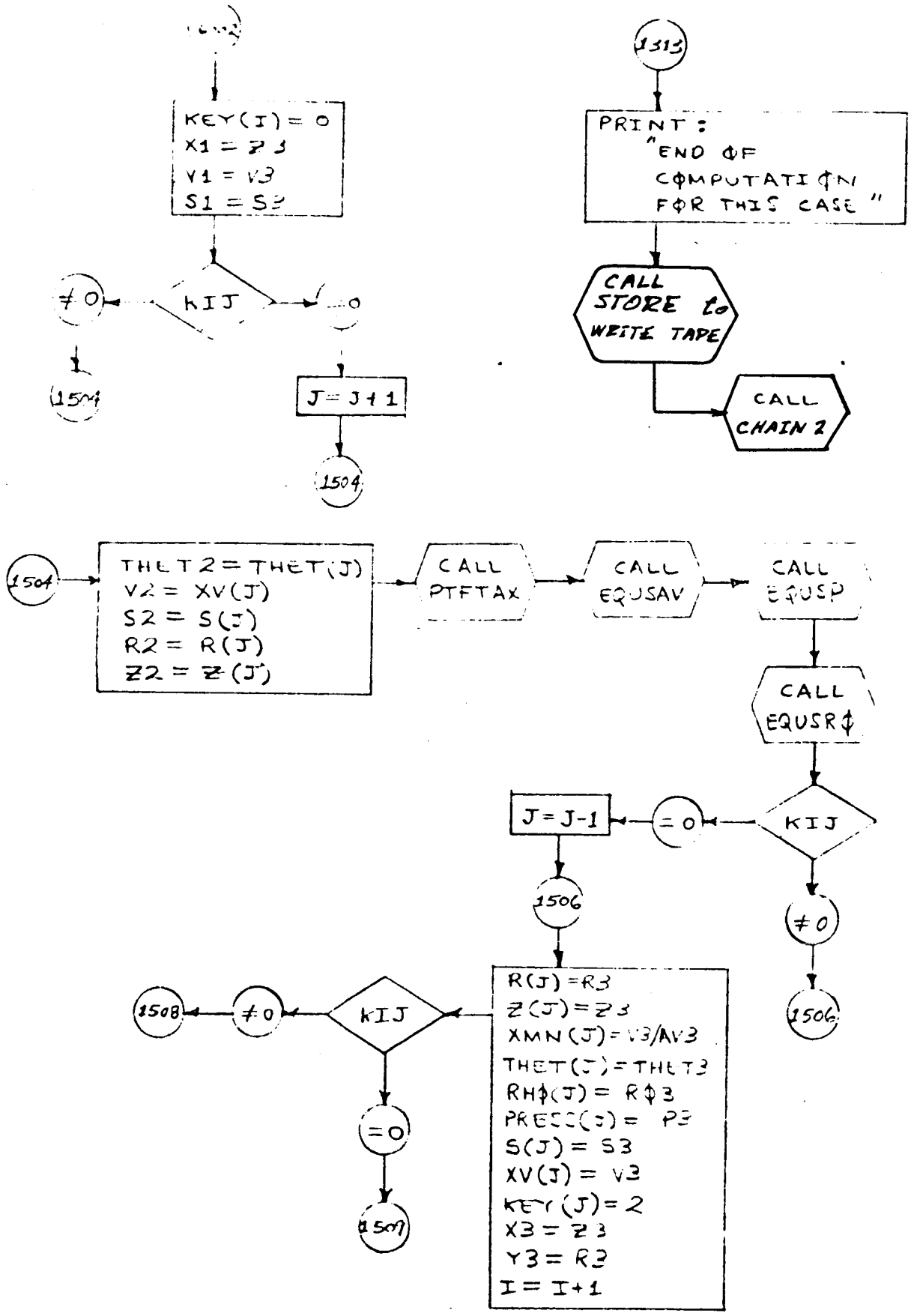

1500
THET2 = THET(I)
R2 = R(I)
Z2 = Z(I)
V2 = XV(I)
S2 = S(I)
JIK = 0
IX = 0
KIJ = 1
1503
CALL PTΦTAX
KEY(J) - 13
≠0
=0
1402
6000
K - JP
<0
1313
>0
1600
=0
1402
H3 = HTJ - .5 * (V3 * * 2)
CALL EQUSAV
CALL EQUSP
CALL EQUSR
R(I) = R3
Z(I) = Z3
XMN(I) = V3/AV3
THET(I) = THET3
RHΦ(I) = RΦ3
PRESS(I) = P3
S(I) = S3
XV(I) = V3
KEY(J) - 13
≠0
6002
=0
6001
1502
THET2 = THET(J)
R2 = R(J)
Z2 = Z(J)
V2 = XV(J)
S2 = S(J)
IX - 1
>0
≤0
1601
1503
CΦMPUTE:
QF
YF
THET2
R2
Z2
V2
S2
JIK
KIJ
1503

PLUME (CHAIN)


1600
JIK
≠0
=0
1603
1602
IX-1
<0
>0
1313
=0
1402
1700
H3 = HTJ - .5 * (V3**2)
CALL EQUSAV
CΦMPUTE:
DELZ
TX = DELZ + 1.
IX-1
≤0
>0
1700
1601
KIJ = 0
JIK = 0
CΦMPUTE:
QF
YF
THET2
R2
Z2
V2
S2
JIK = 1
KIJ = 1
1503
Z3-TXD
≤0
>0
1402
1313

PLUME (CHAIN)



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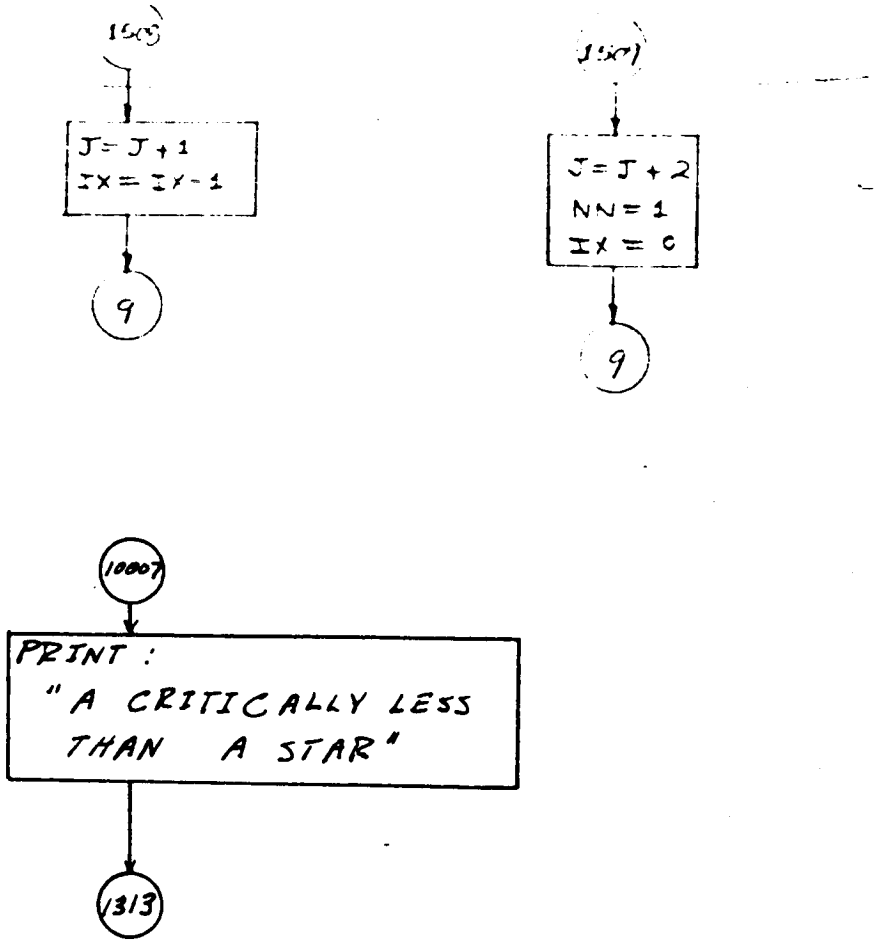

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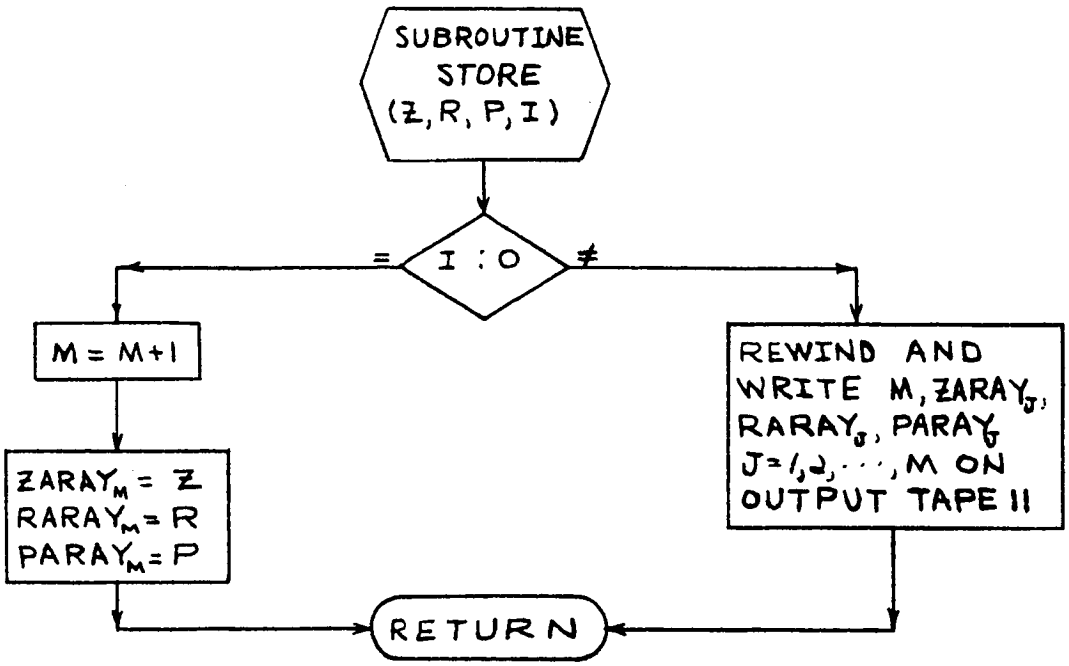
PLUME (CHAIN)



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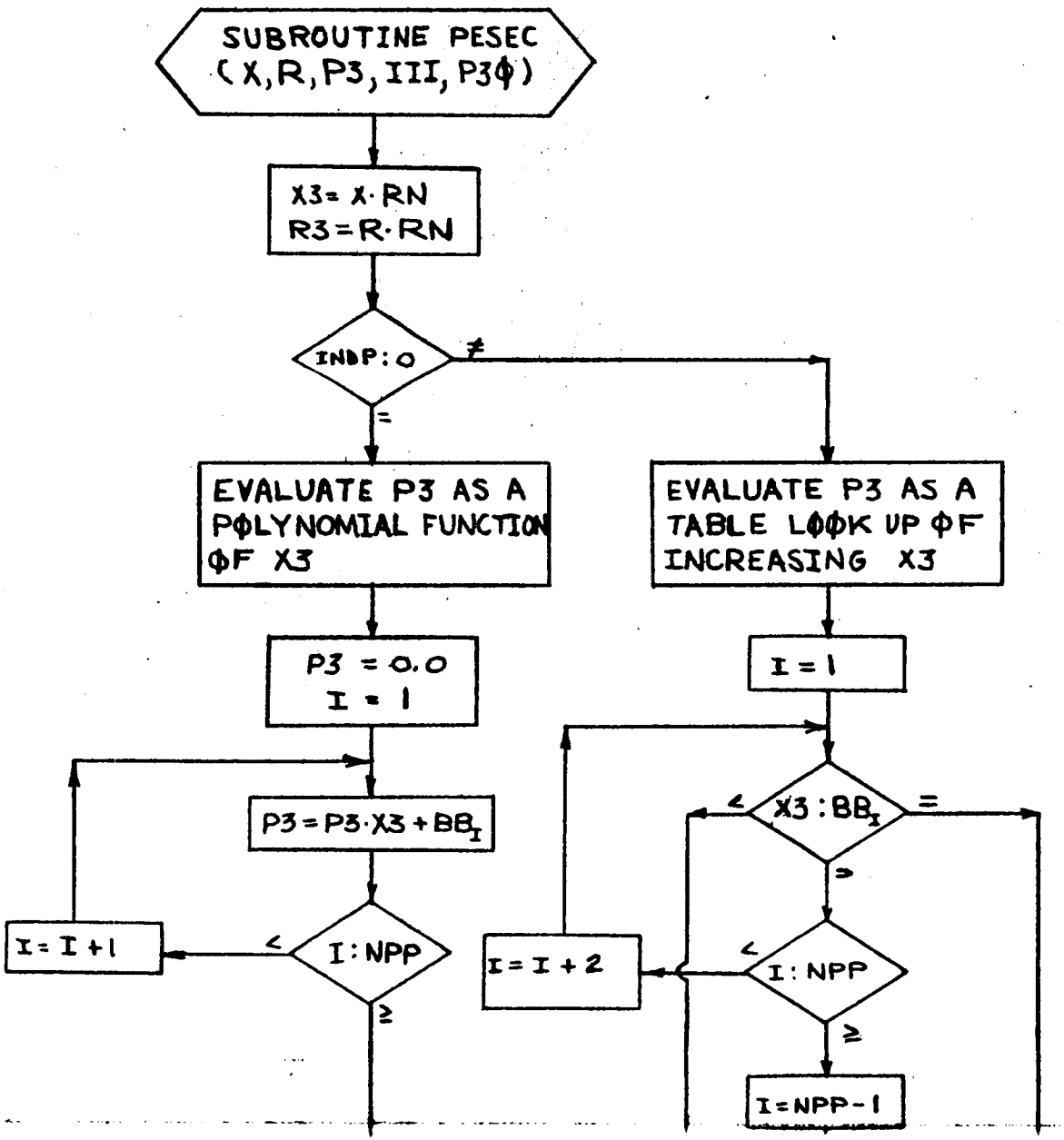
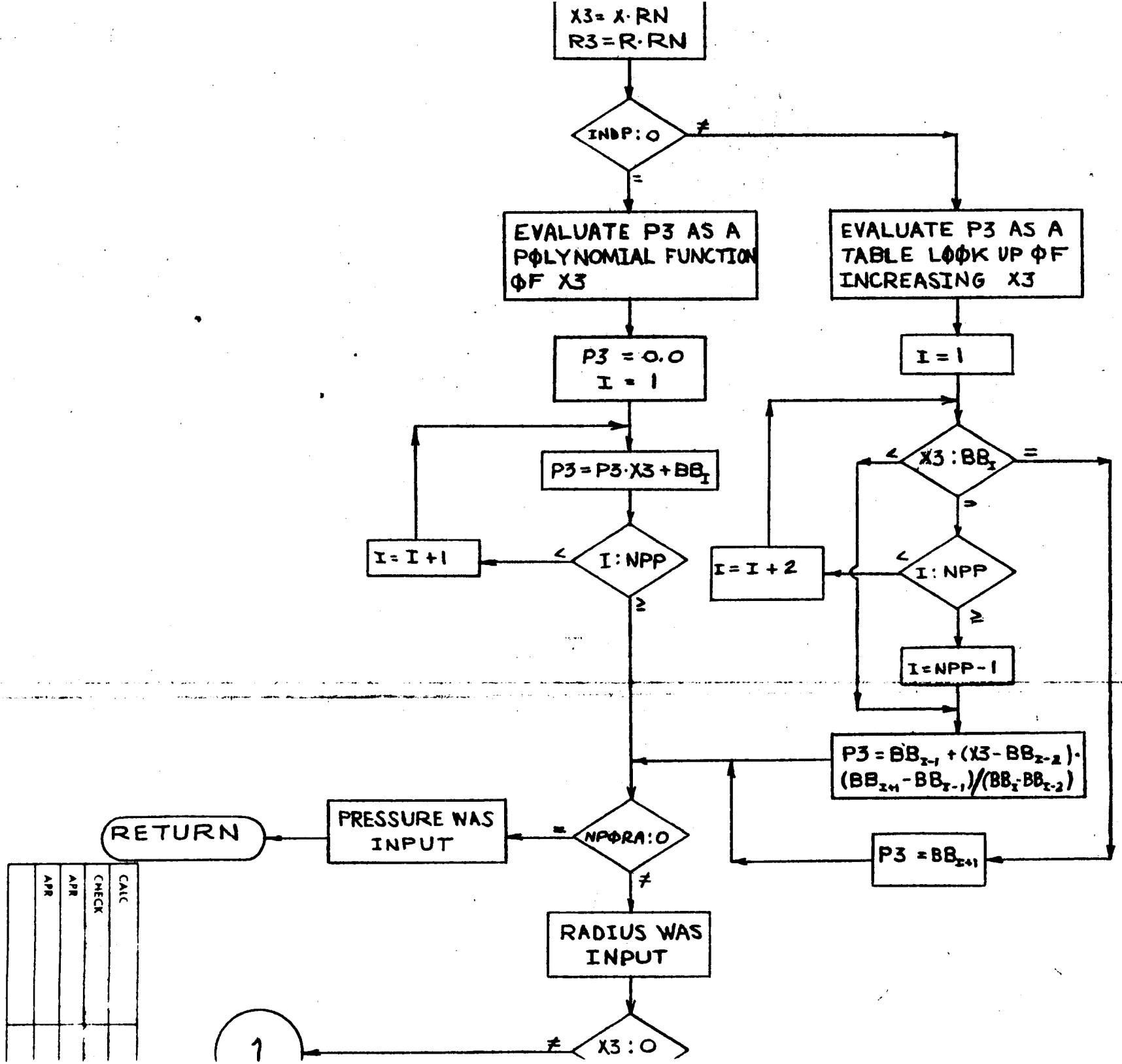
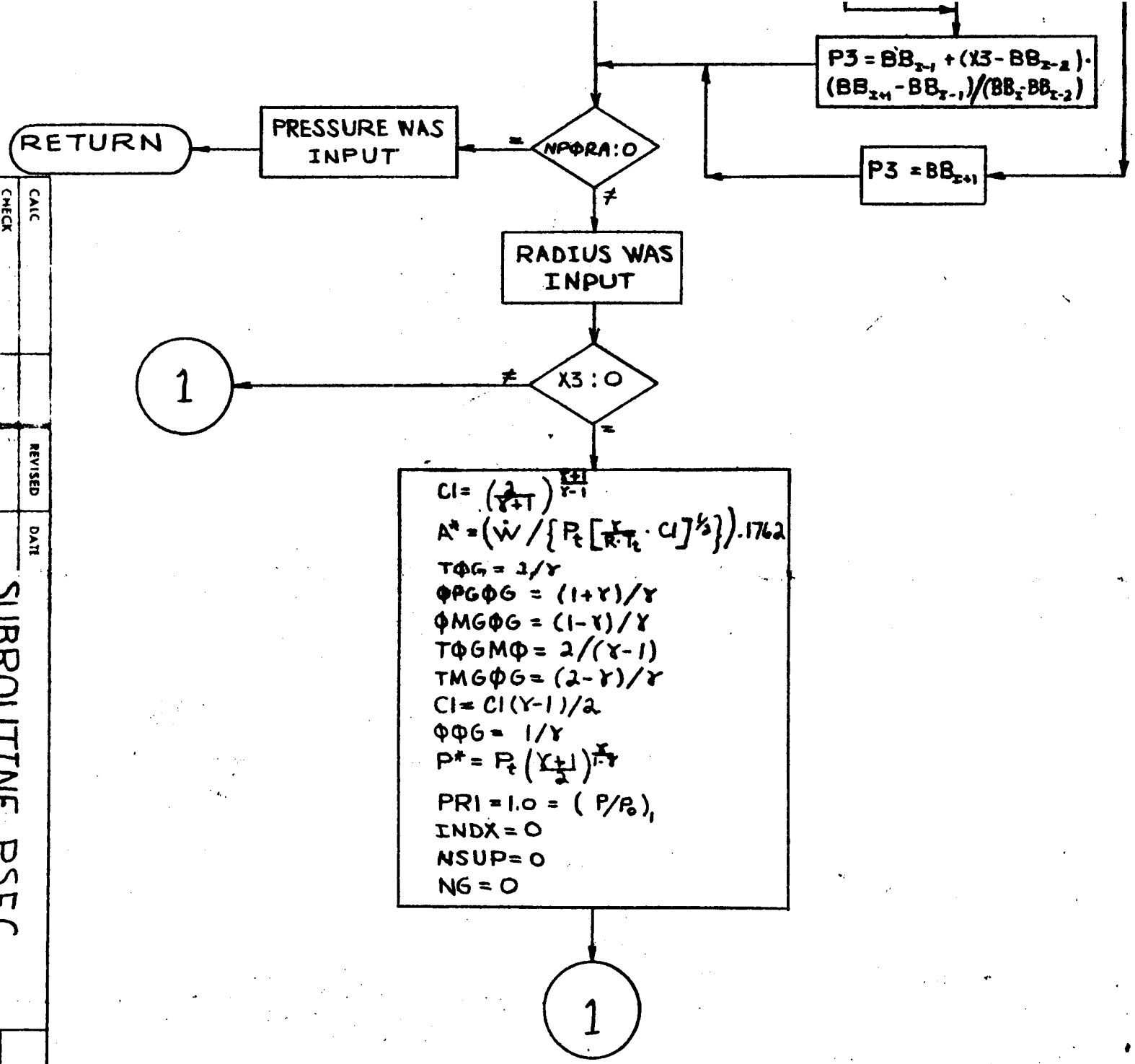

SUBROUTINE PESEC
(X,R,P3,III,P3Φ)
X3= X·RN
R3=R·RN
INDP:0
≠
=
EVALUATE P3 AS A
PΦLYNOMIAL FUNCTION
ΦF X3
EVALUATE P3 AS A
TABLE LΦΦK UP ΦF
INCREASING X3
P3 = 0.0
I = 1
I = 1
P3=P3·X3+BB_I
X3 : BB_I
<
=
>
I : NPP
<
≥
I = I + 1
I = I + 2
I : NPP
<
≥
I=NPP-1


X3 = X · RN
R3 = R · RN
INDP : 0
≠
=
EVALUATE P3 AS A POLYNOMIAL FUNCTION OF X3
EVALUATE P3 AS A TABLE LOOK UP OF INCREASING X3
P3 = 0.0
I = 1
P3 = P3 · X3 + BB_I
I = I + 1
<
I : NPP
≥
I = 1
X3 : BB_I
=
>
<
I : NPP
≥
I = I + 2
I = NPP - 1
P3 = BB_{I-1} + (X3 - BB_{I-2}) · (BB_{I+1} - BB_{I-1}) / (BB_I - BB_{I-2})
P3 = BB_{I+1}
NPORA : 0
=
≠
PRESSURE WAS INPUT
RETURN
RADIUS WAS INPUT
X3 : 0
≠
1
CALC
CHECK
APR
APR



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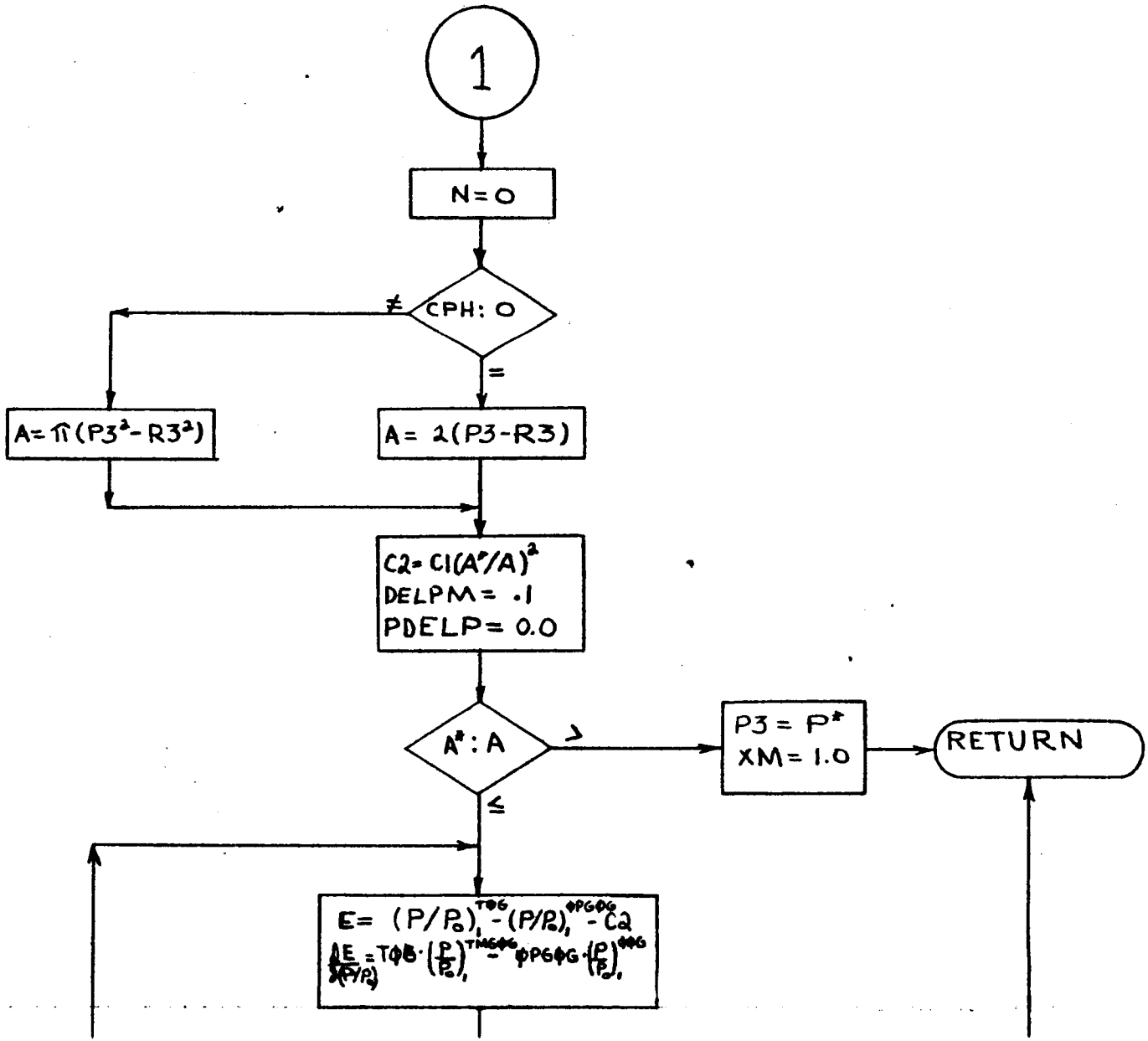
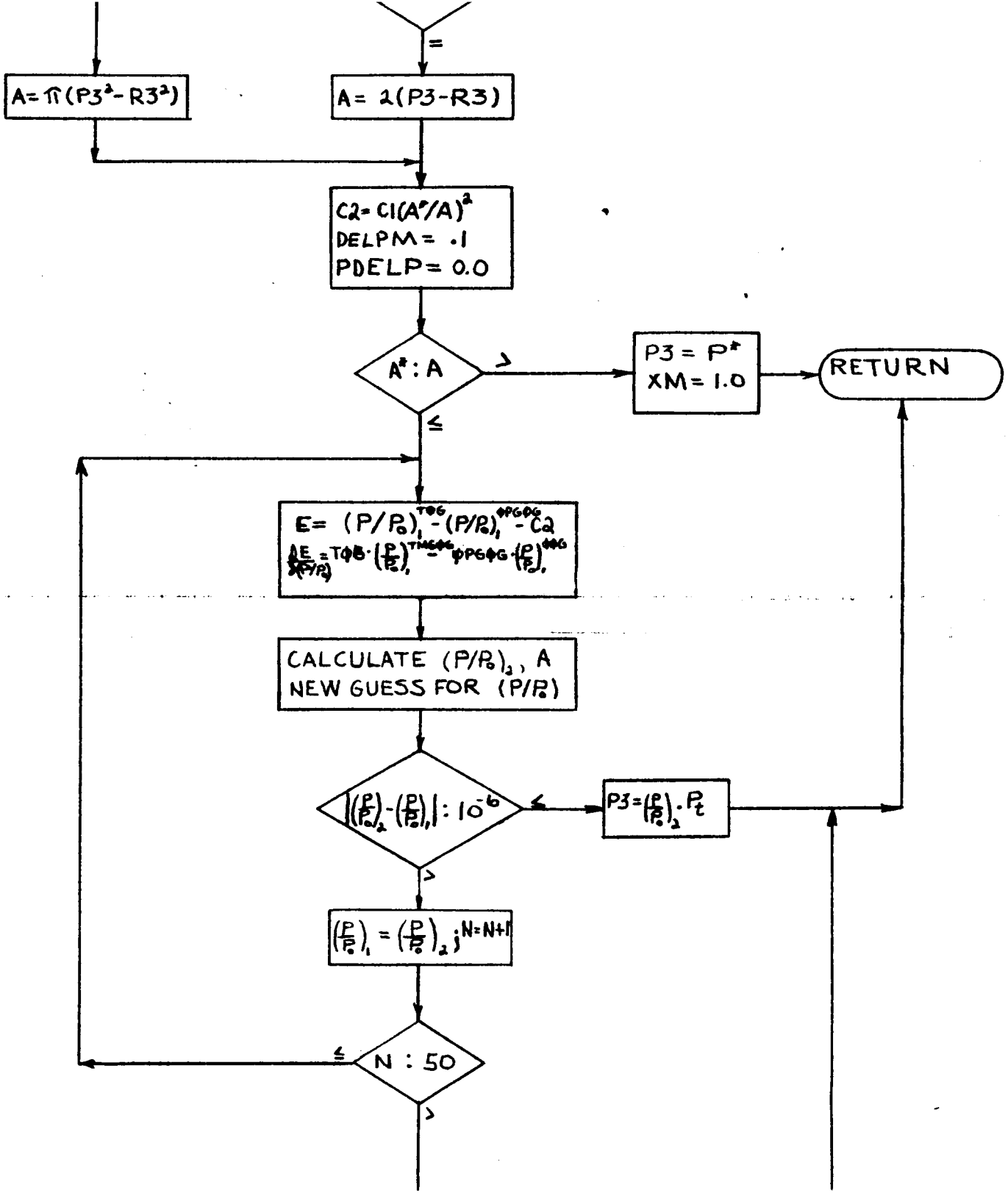
SUBROUTINE PSEC

THE BOEING COMPANY

AS 1927

PAGE


1
N=0
CPH: 0
≠
=
A= π(P3² - R3²)
A= 2(P3-R3)
C2= C1(A*/A)²
DELPM= .1
PDELP= 0.0
A*: A
>
≤
P3 = P*
XM= 1.0
RETURN
E= (P/P0)₁^TΦG - (P/P2)₁^ΦPGΦG - C2
ΔE/Δ(P/P2) = TΦB·(P/P2)₁^TMGΦG - ΦPGΦG·(P/P2)₁^ΦPG



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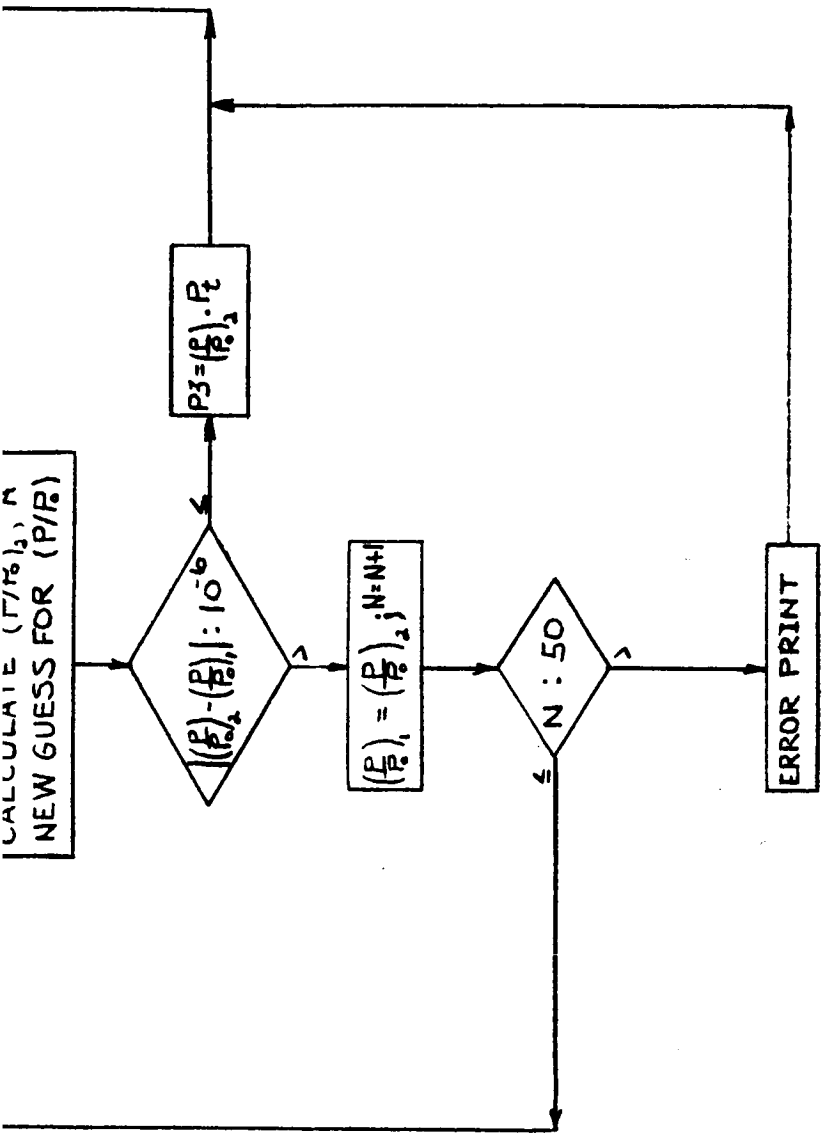

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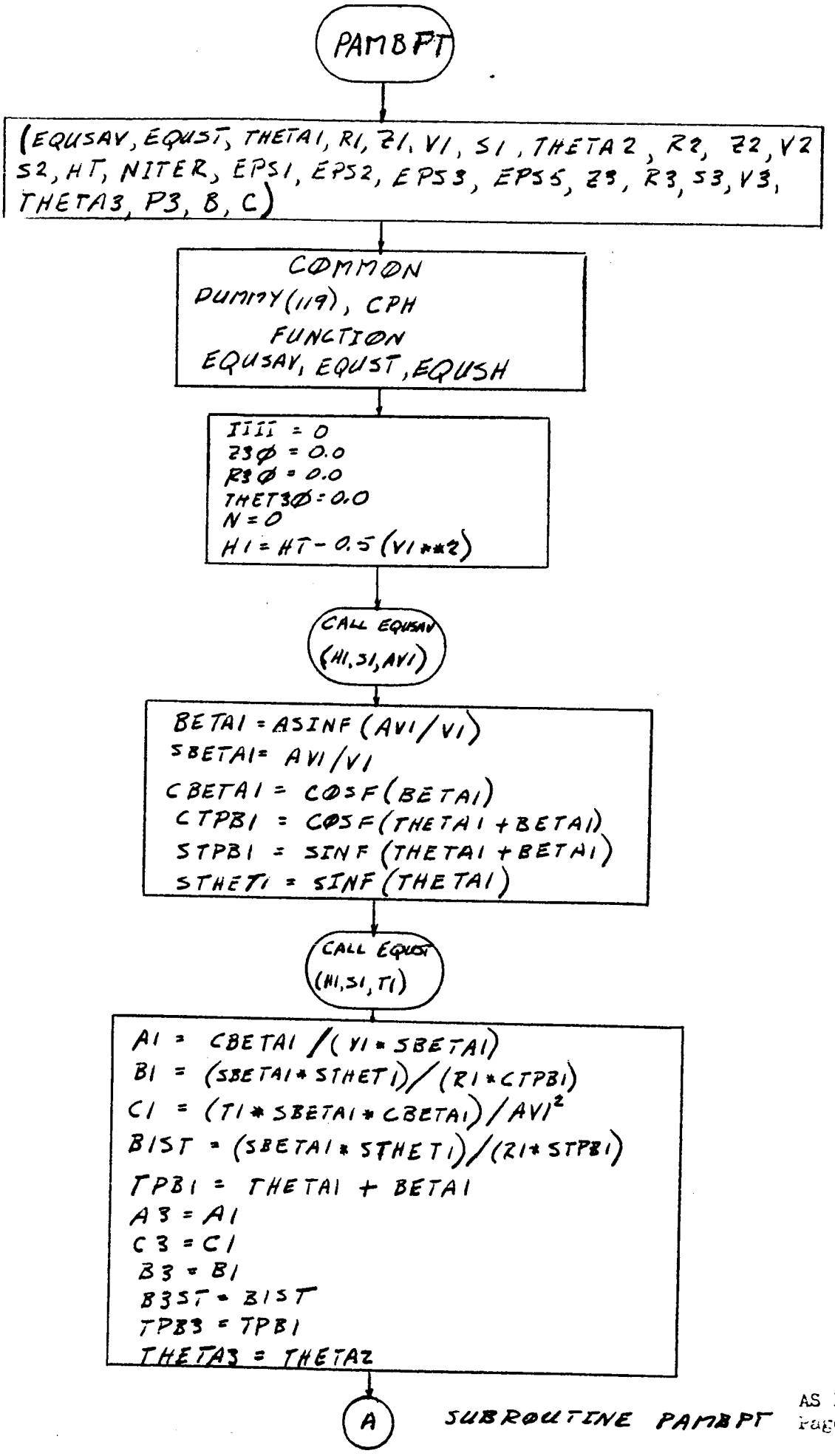
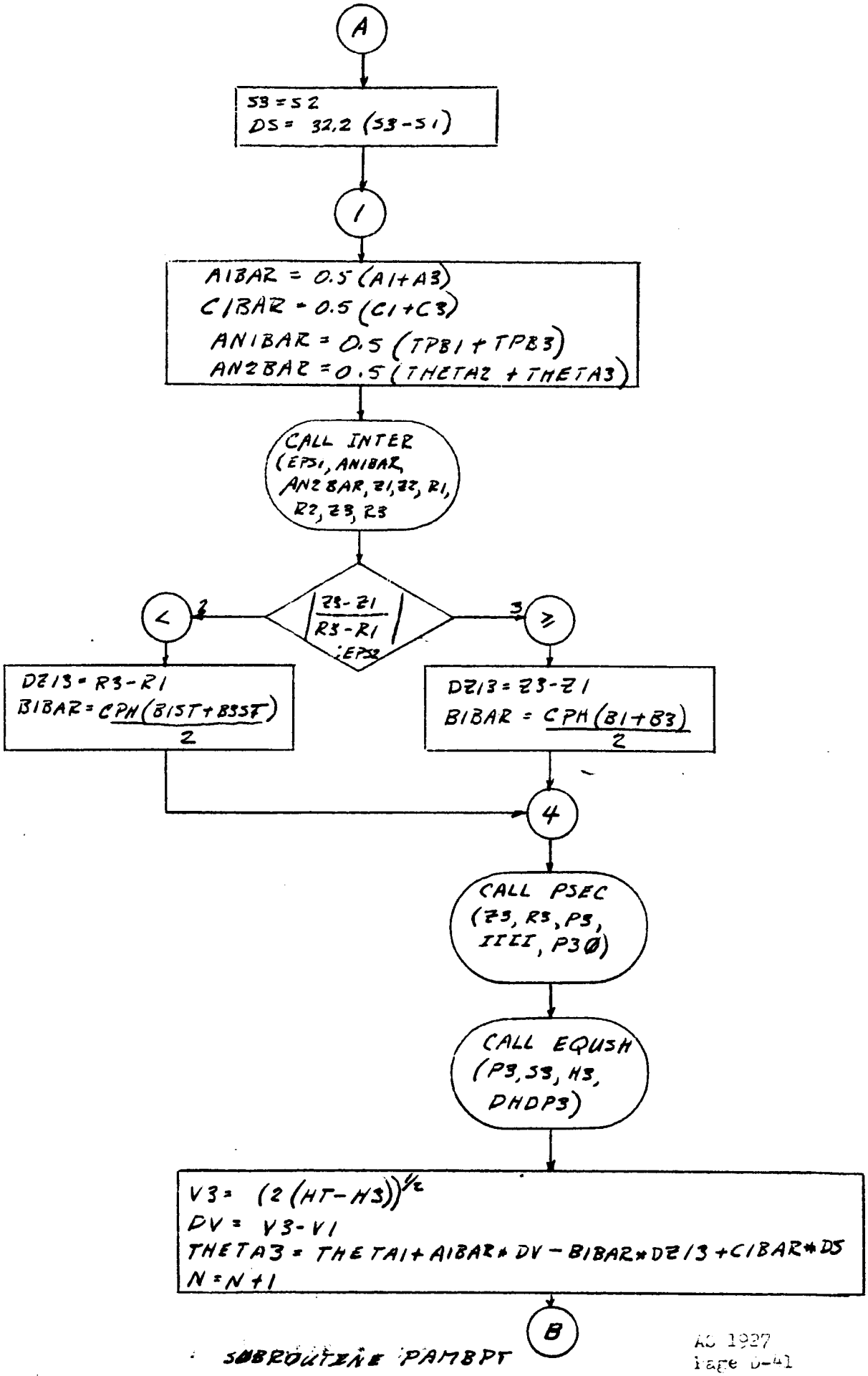
APR				THE BOEING COMPANY	PAGE D-39



SUBROUTINE PAMBPT



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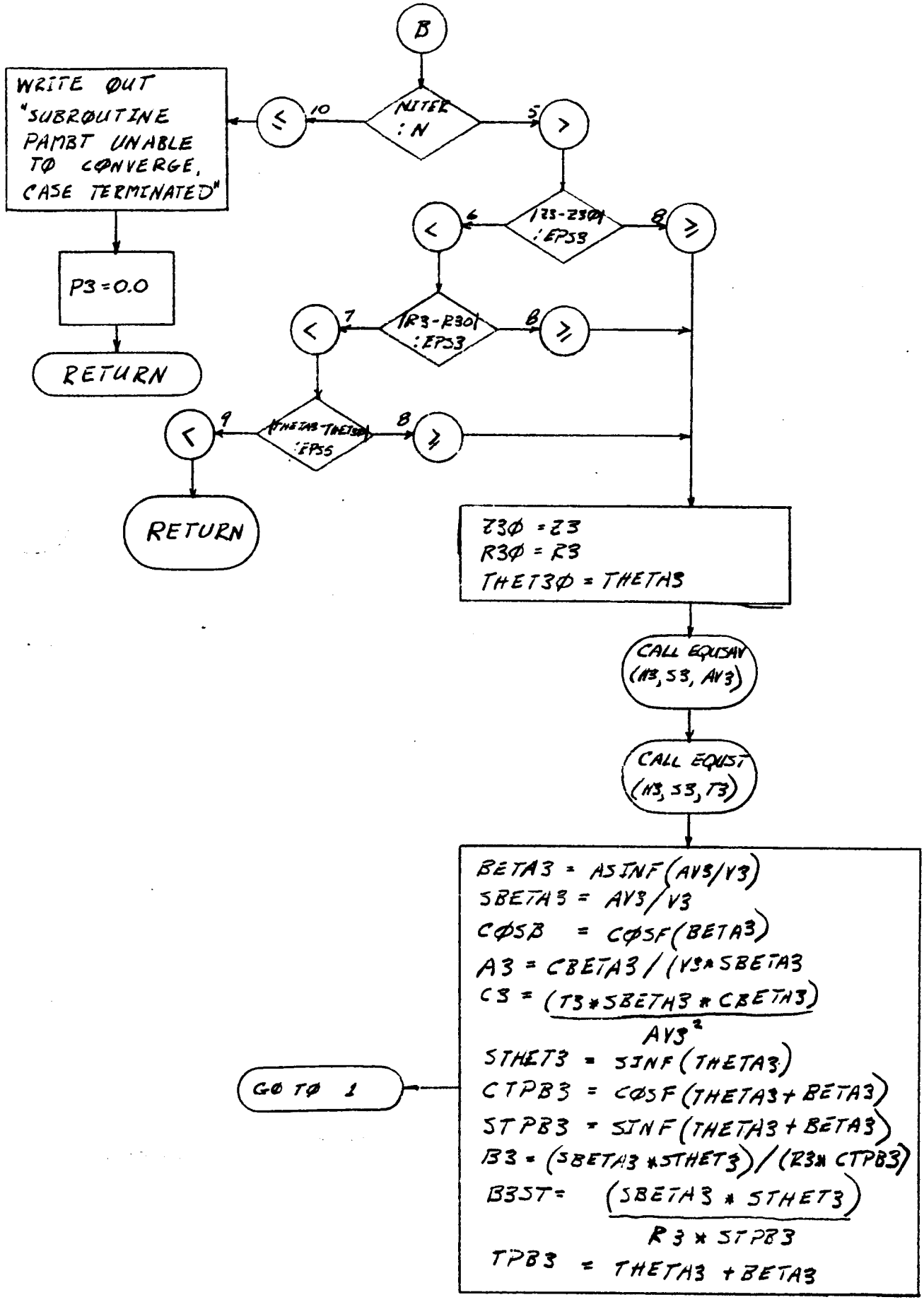

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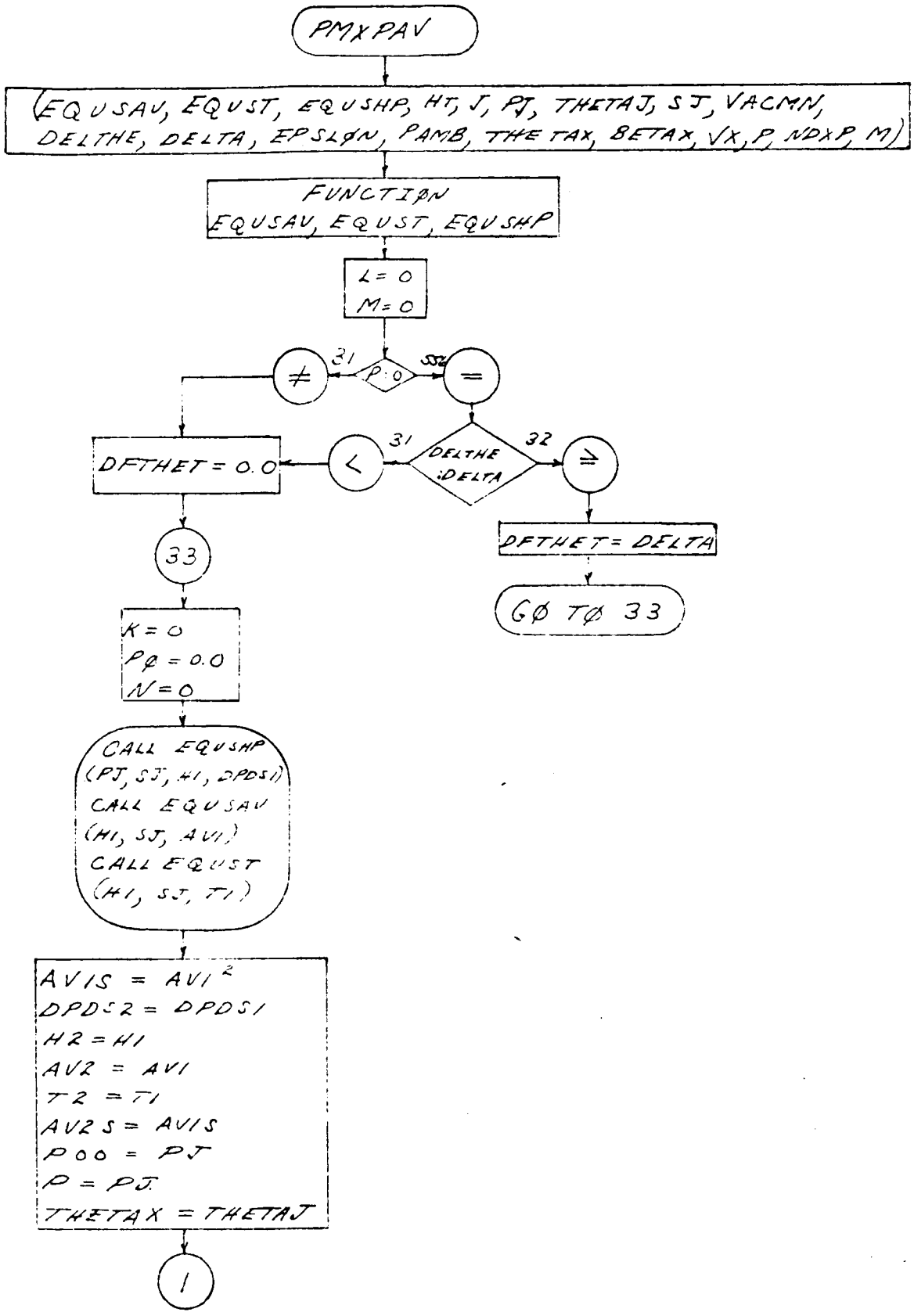

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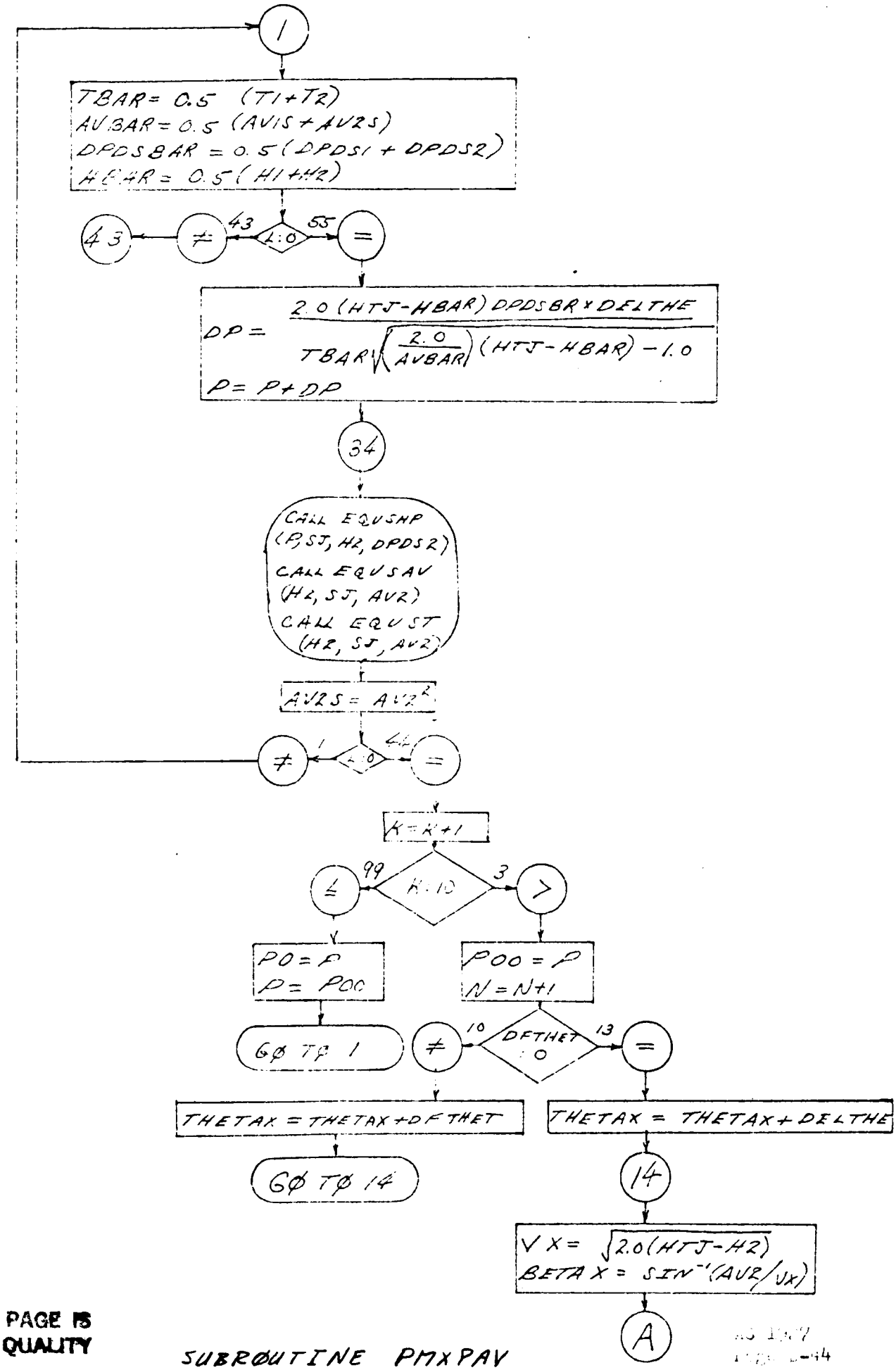
SUBROUTINE PMXPAV



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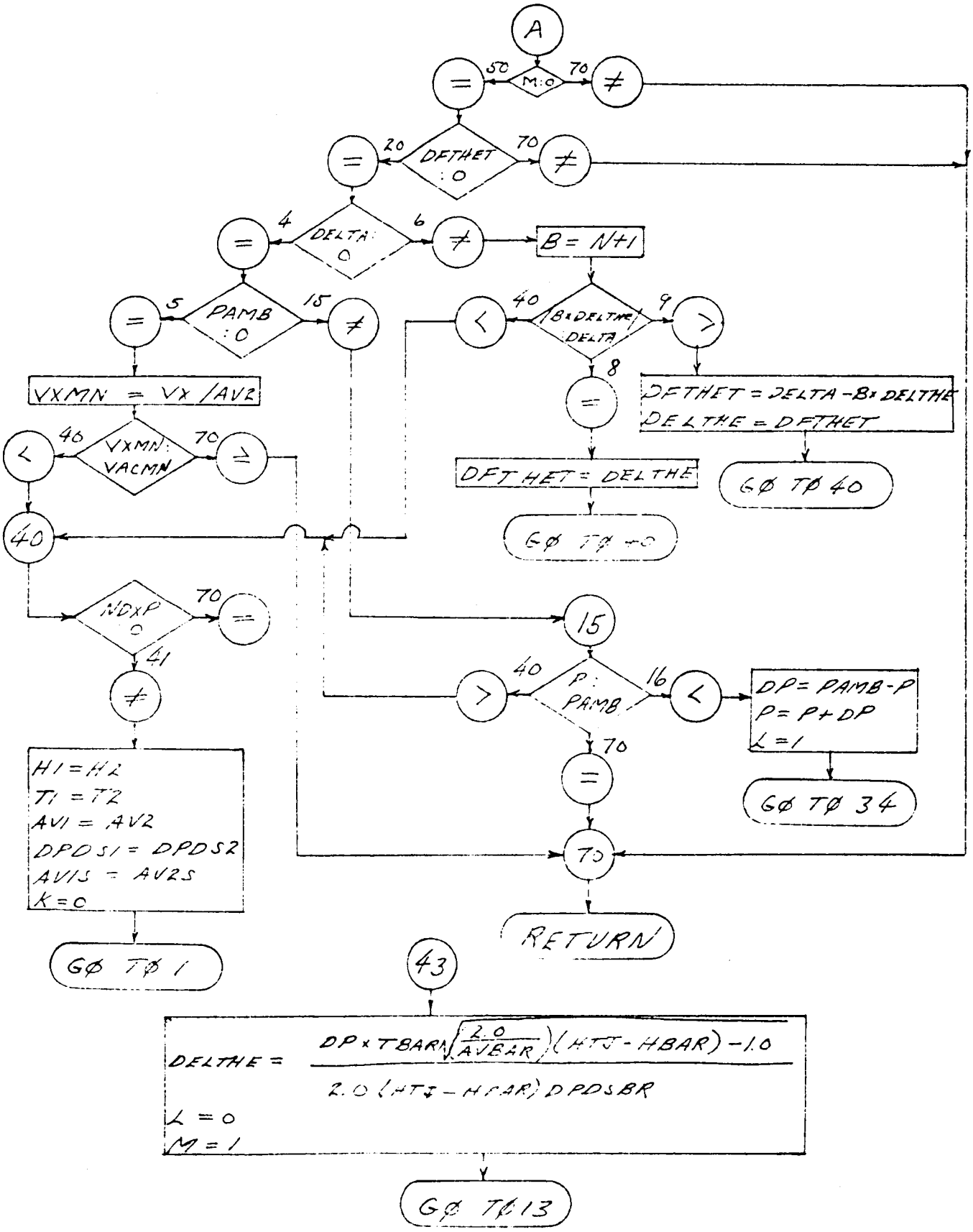
SUBRØUTINE PMXPAV



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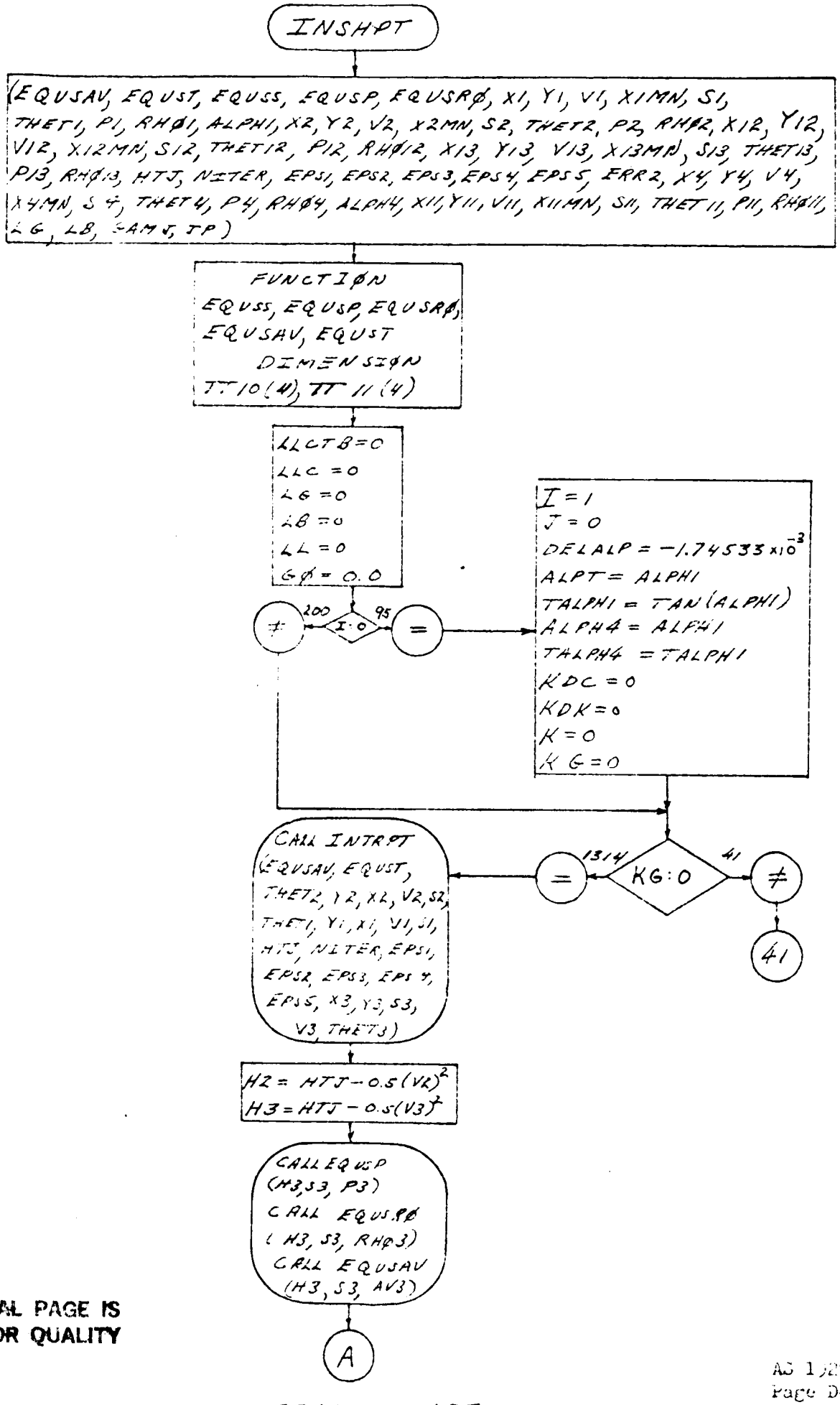
SUBROUTINE PMXPAV



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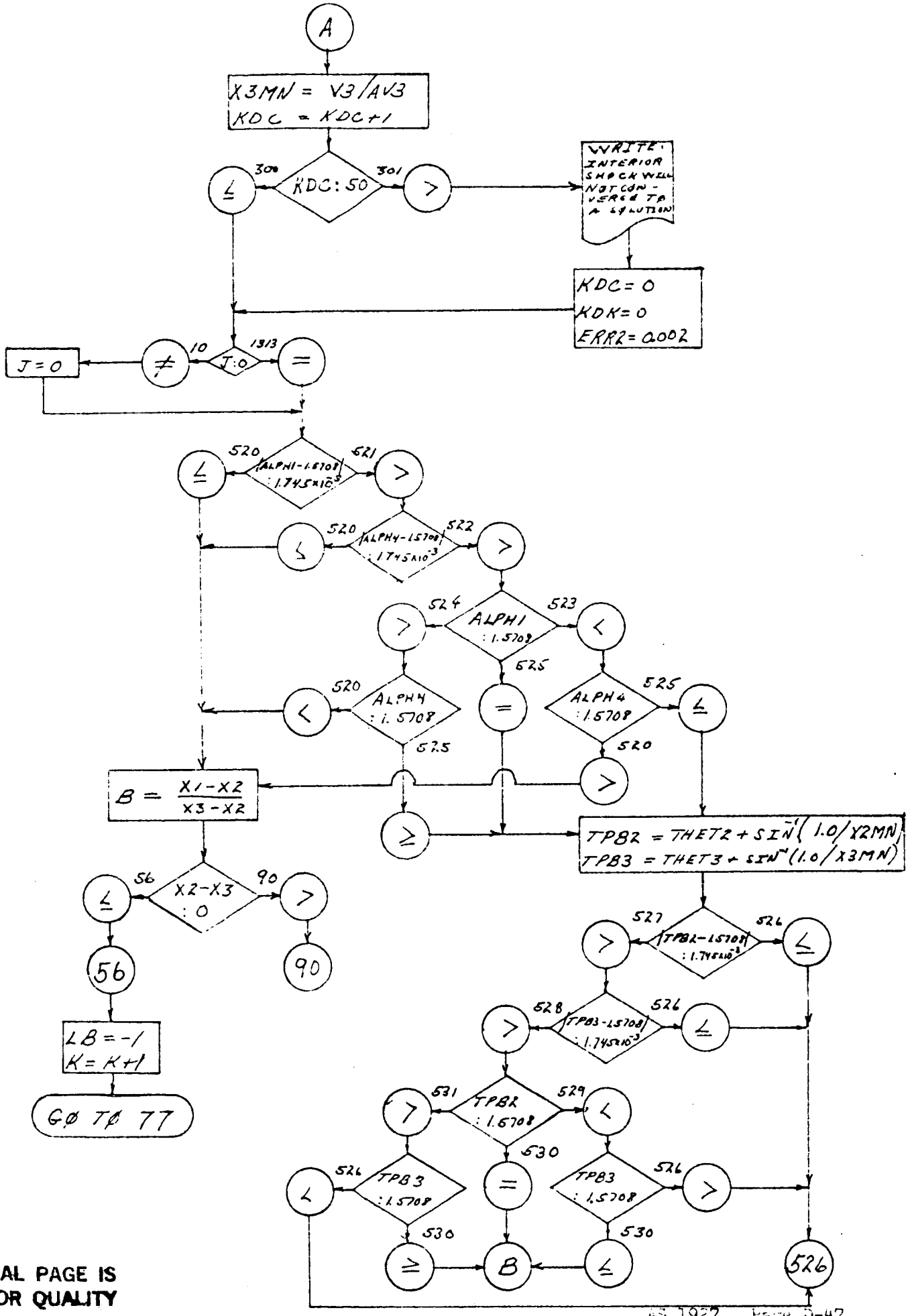
SUBROUTINE INSHPT



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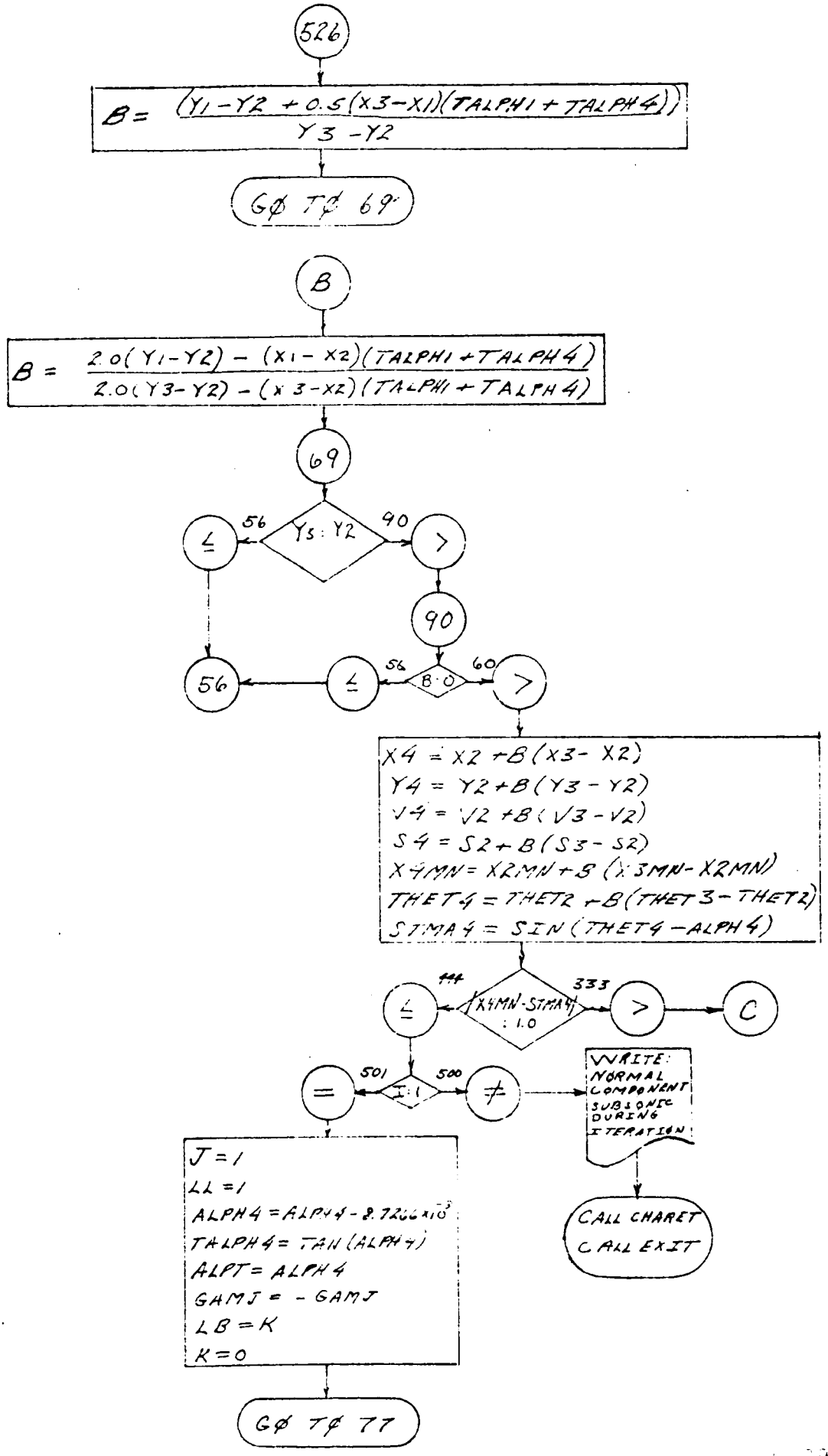


SUBROUTINE INSHPT

C

$P4 = P2 + B(P3 - P2)$
$RH\emptyset 4 = RH\emptyset 2 + B(RH\emptyset 3 - RH\emptyset 2)$
$H4 = H2 + B(H3 - H2)$
$SSTMA4 = STMA4^2$
$$E1 = \frac{(GAMJ - 1.0)(X4MN^2)\,SSTMA4 + 2.0}{(GAMJ + 1.0)(X4MN^2)\,SSTMA4}$$
$P11 = P4 + RH\emptyset 4(V4^2)\,SSTMA4\,(1.0 - E1)$
$H11 = H4 + 0.5(V4^2)\,SSTMA4\,(1.0 - E1^2)$

CALL EQUSS
(H11, P11, S11)

$RH\emptyset 11 = RH\emptyset 4 / E1$
$X11 = X4$
$Y11 = Y4$

CALL EQUSAV
(H11, S11, AV11)
CALL EQUST
(H11, S11, T11)

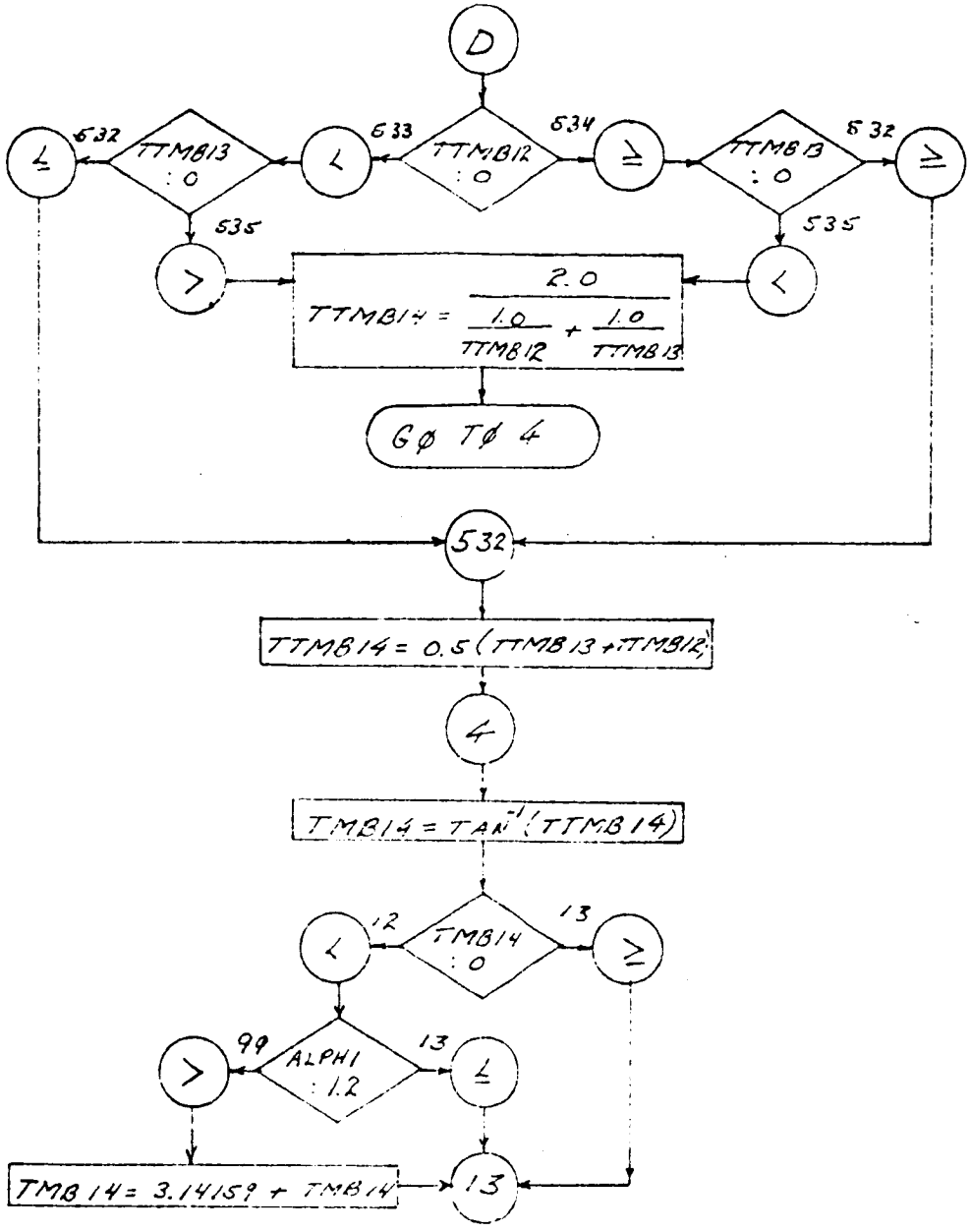
$VN11 = V4 \times E1 \times |SIN(THET4 - ALPH4)|$
$VT11 = V4 \times |COS(THET4 - ALPH4)|$
$V11 = \sqrt{VN11^2 + VT11^2}$
$X11MN = V11 / AV11$
$BETA11 = SIN^{-1}(AV11 / V11)$
$DEL11 = TAN^{-1}(VN11 / VT11)$
$THET11 = ALPH4 + DEL11$
$THET10 = THET11$
$LPR = I + 1$
$TT10(LPR) = THET11$
$TMB11 = THET11 - BETA11$
$TTMB11 = TAN(TMB11)$

41

$BETA12 = SIN^{-1}(1.0 / X12MN)$
$BETA13 = SIN^{-1}(1.0 / X13MN)$
$$TTMB12 = \frac{SIN(THET12 - BETA12)}{COS(THET12 - BETA12)}$$
$$TTMB13 = \frac{SIN(THET13 - BETA13)}{COS(THET13 - BETA13)}$$

D

SUBROUTINE INSHPT



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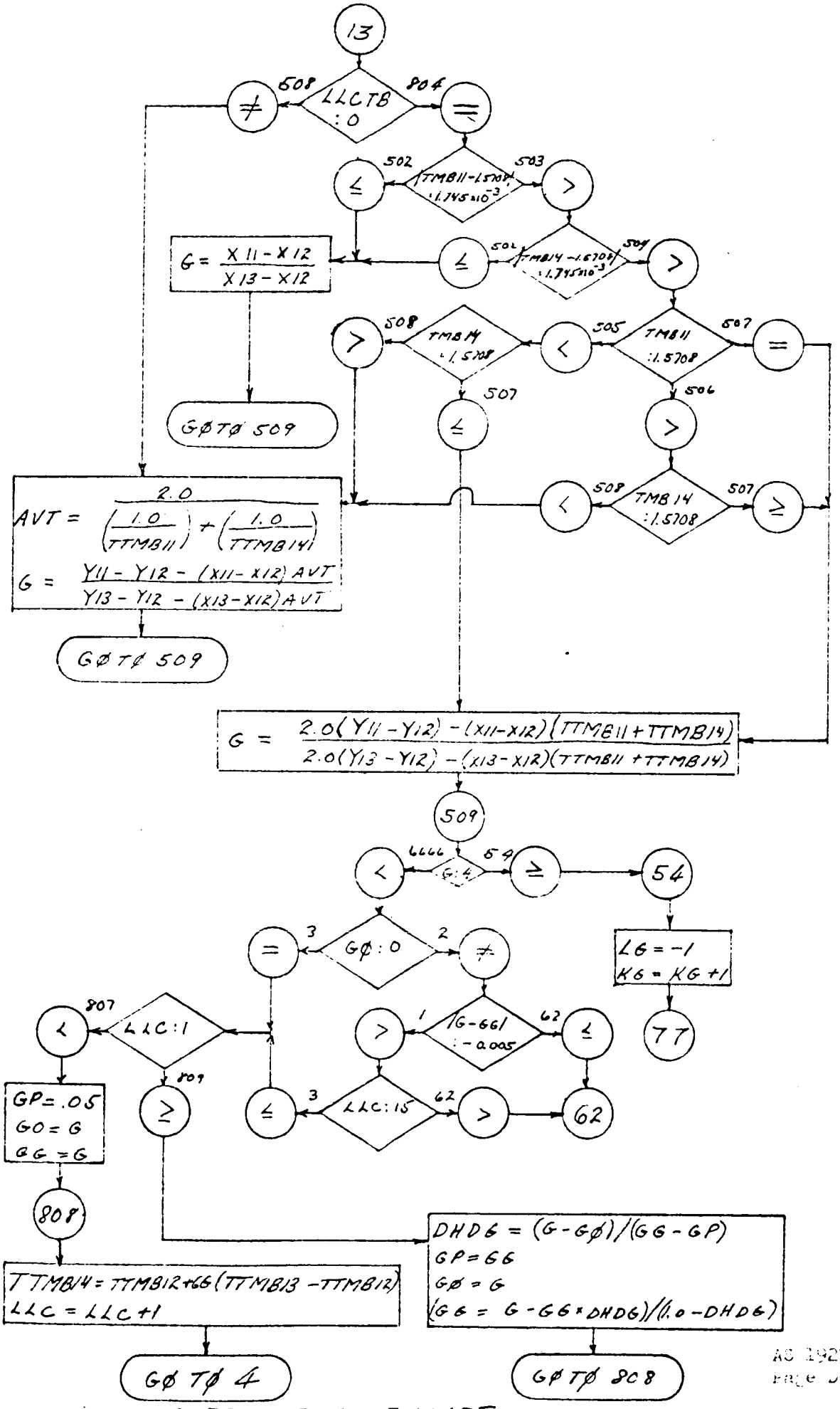

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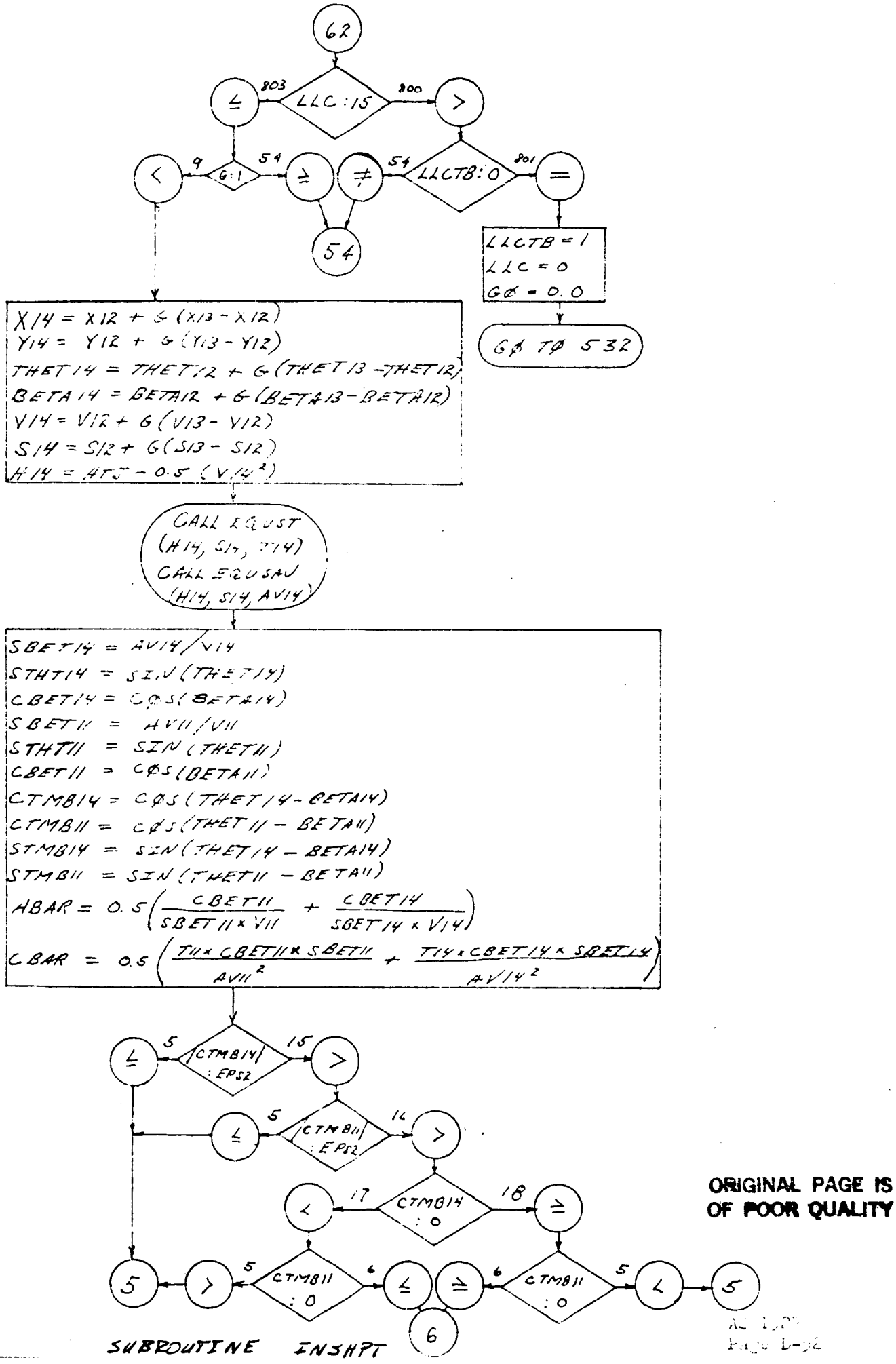

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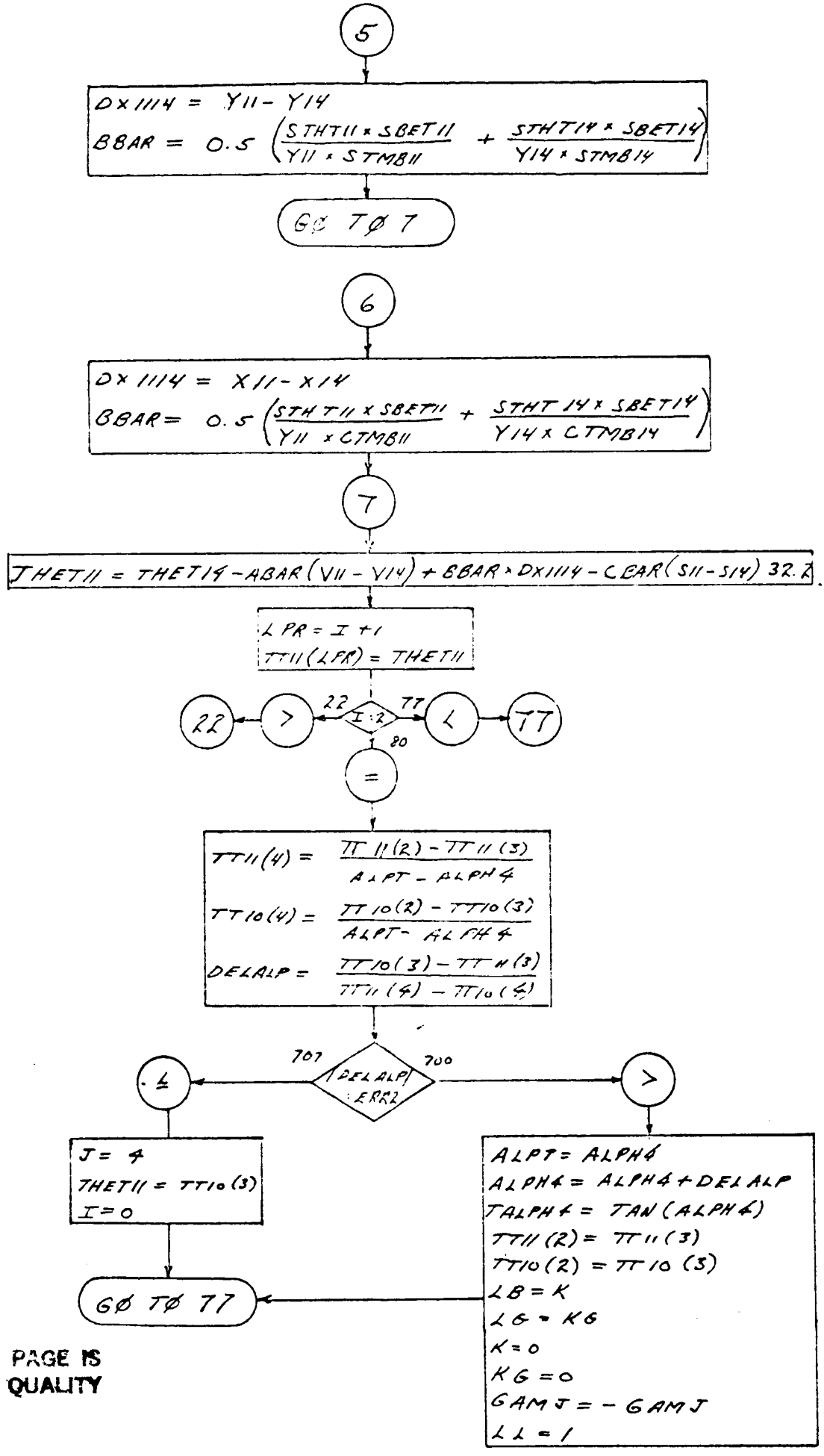

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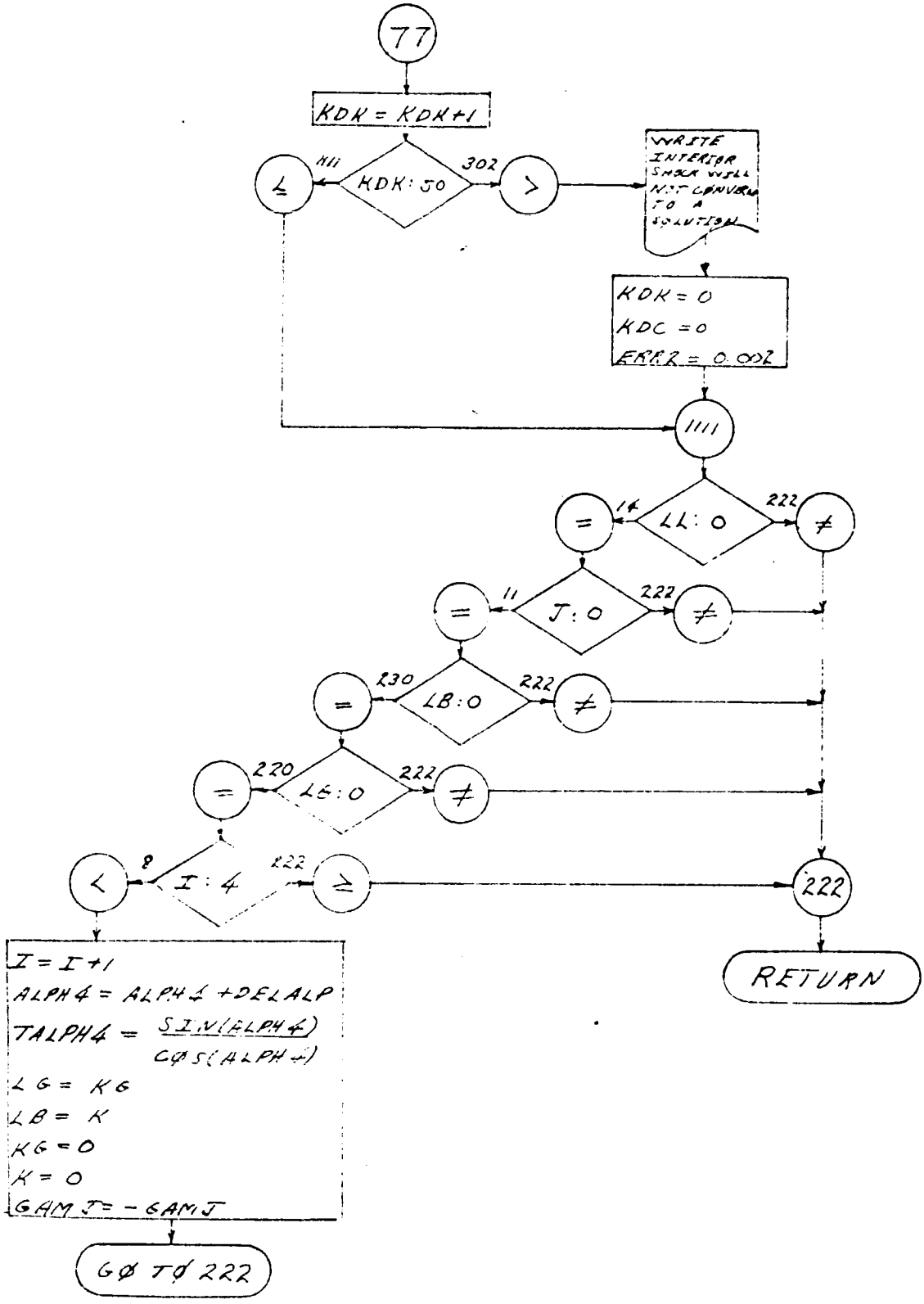
Page D-33

SUBROUTINE INSHPT



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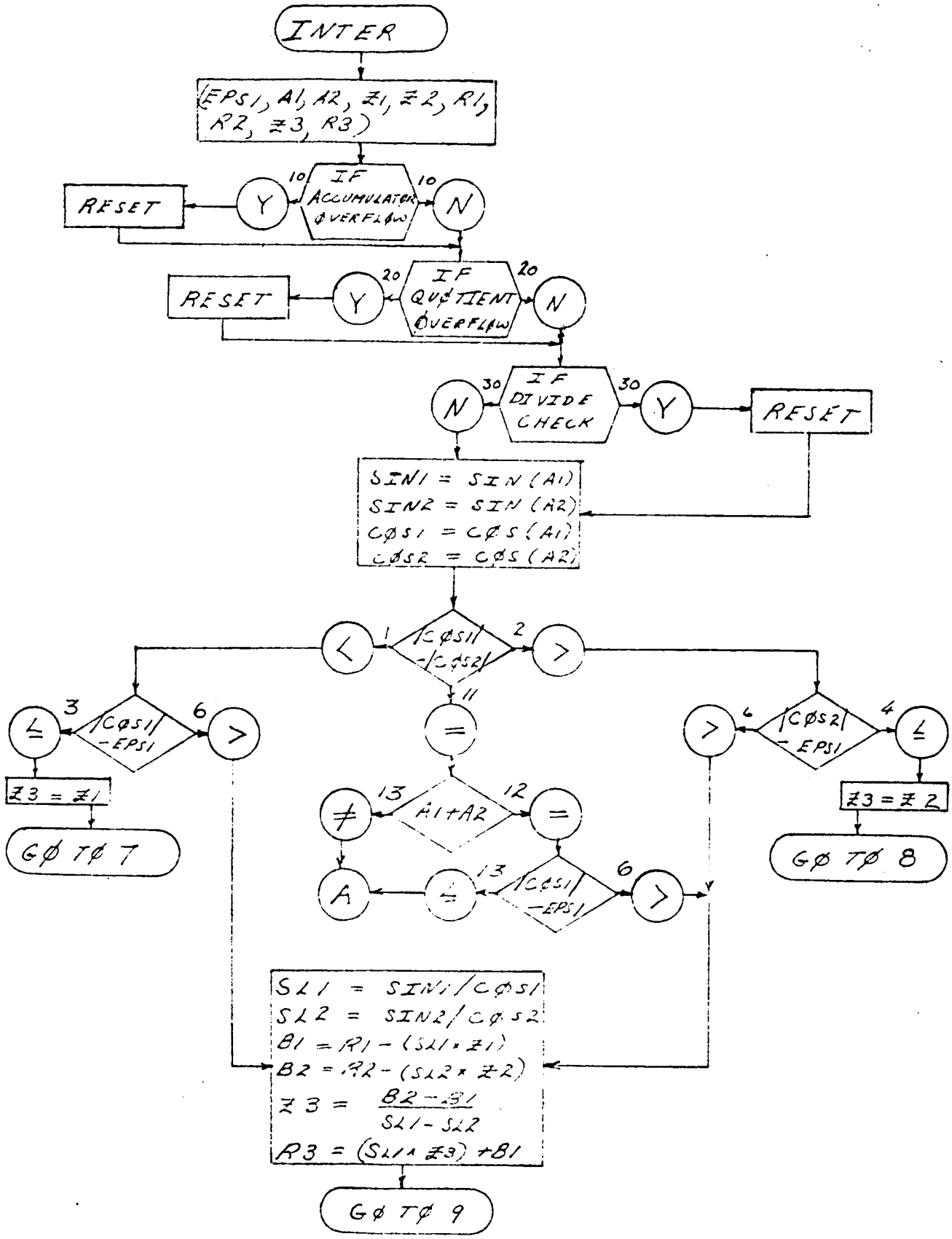

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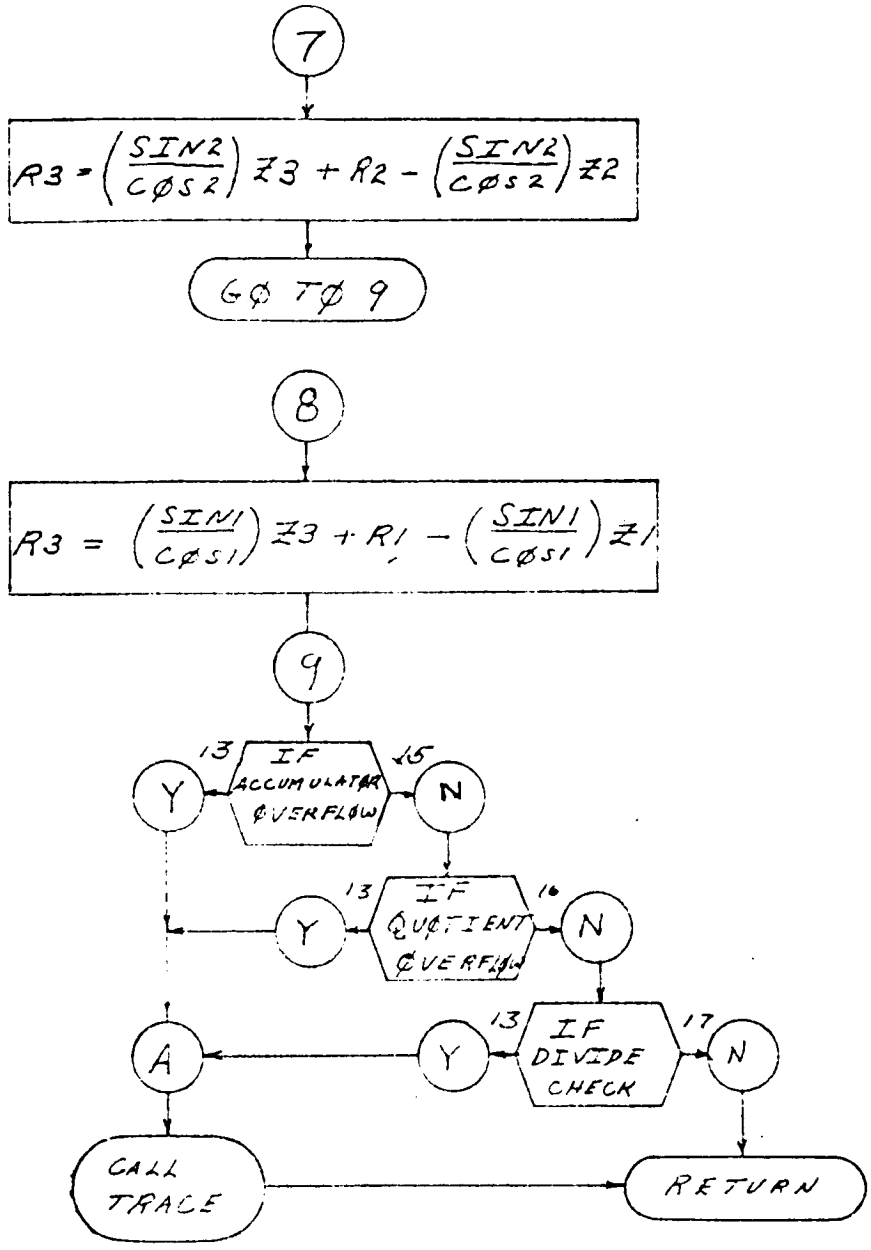
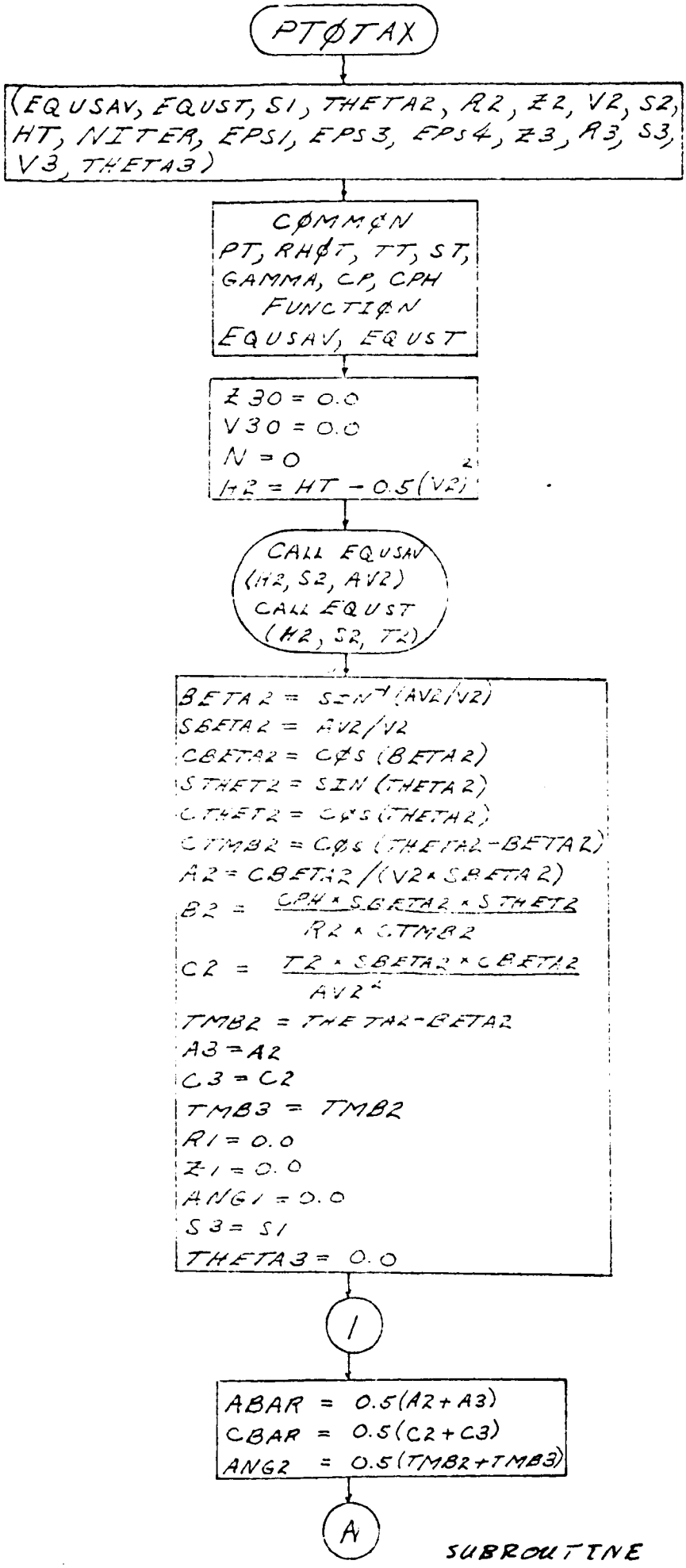
SUBROUTINE INTER



SUBROUTINE INTER



SUBROUTINE PTØTAX

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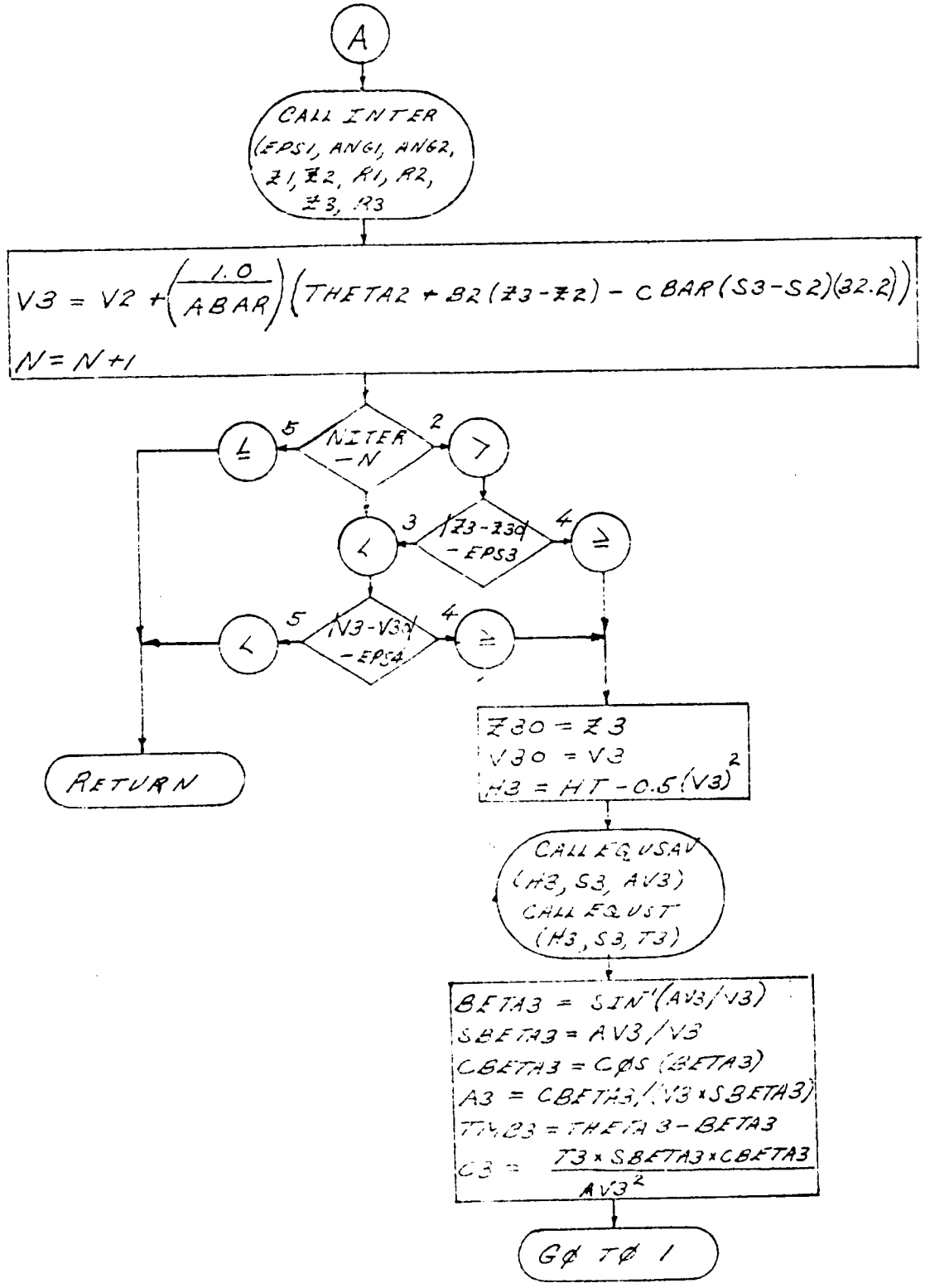

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PTFTAX

(EQUSAV, EQUST, Z1, V1, S1, THETA2, R2, Z2, V2, S2, HT, NITER, EPS1, EPS3, EPS4, EPS5, Z3, R3, S3, V3, THETA3)

COMMON
PT, RHOT, TT, ST,
GAMMA, CP, CPH
FUNCTION
EQUSAV, EQUST

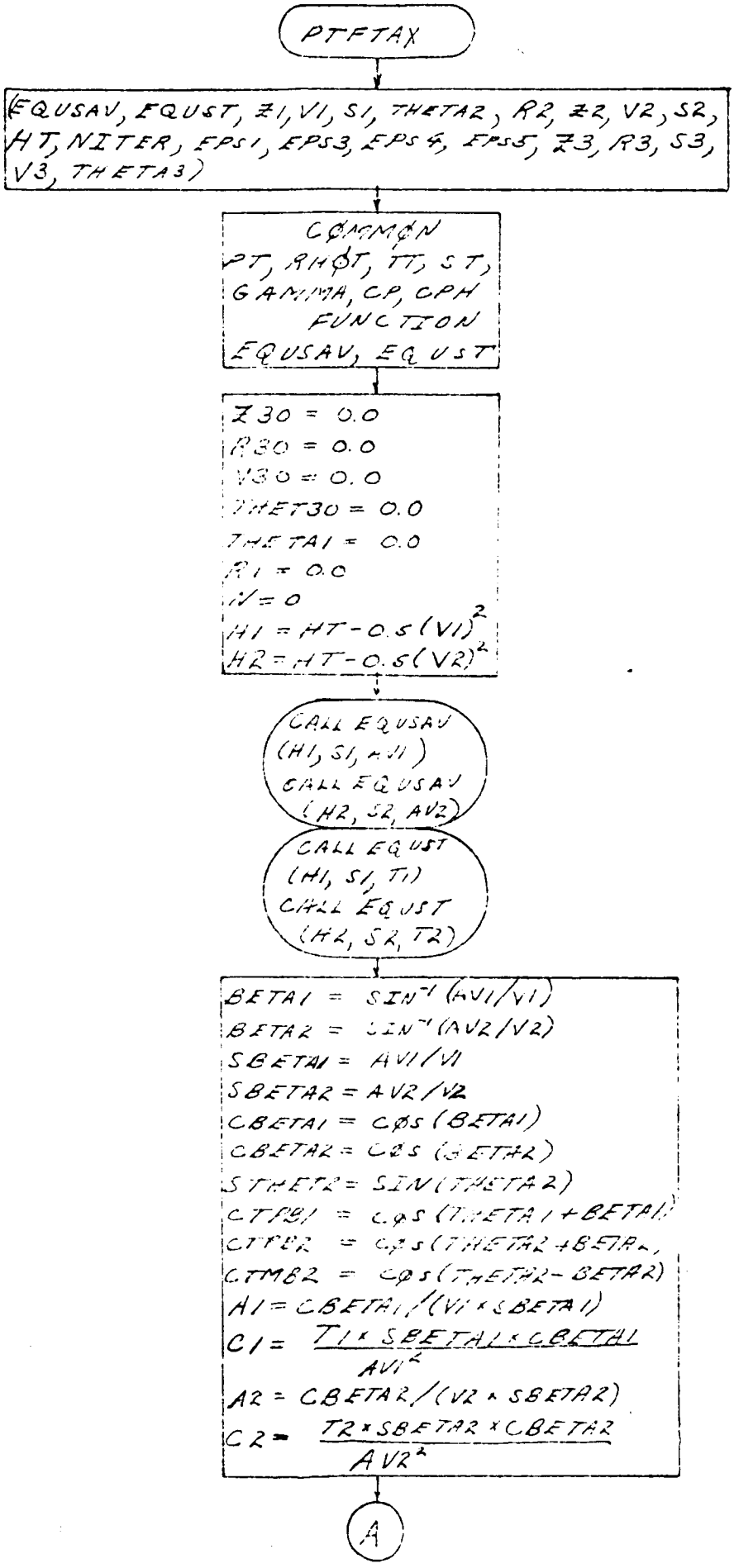
Z30 = 0.0
R30 = 0.0
V30 = 0.0
THET30 = 0.0
THETA1 = 0.0
R1 = 0.0
N = 0
$H1 = HT - 0.5(V1)^2$
$H2 = HT - 0.5(V2)^2$

CALL EQUSAV (H1, S1, AV1)
CALL EQUSAV (H2, S2, AV2)

CALL EQUST (H1, S1, T1)
CALL EQUST (H2, S2, T2)

$BETA1 = SIN^{-1}(AV1/V1)$
$BETA2 = SIN^{-1}(AV2/V2)$
SBETA1 = AV1/V1
SBETA2 = AV2/V2
CBETA1 = COS(BETA1)
CBETA2 = COS(BETA2)
STHET2 = SIN(THETA2)
CTPB1 = COS(THETA1 + BETA1)
CTPB2 = COS(THETA2 + BETA2)
CTMB2 = COS(THETA2 - BETA2)
A1 = CBETA1/(V1 × SBETA1)
$C1 = \frac{T1 \times SBETA1 \times CBETA1}{AV1^2}$
A2 = CBETA2/(V2 × SBETA2)
$C2 = \frac{T2 \times SBETA2 \times CBETA2}{AV2^2}$

A



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SUBROUTINE PTFTAX

A

$$B2 = \frac{CPH \times SBETA2 \times STHET2}{R2 \times CTMB2}$$

$B1 = (B2 \times CTMB2)/CTPB2$

$G1 = SBETA1/CTPB1$

$HH2 = SBETA2/CTMB2$

$TPB1 = THETA1 + BETA1$

$TMB2 = THETA2 - BETA2$

$BA3 = A1$

$BC3 = C1$

$SA3 = A2$

$SC3 = C2$

$SB3 = B2$

$G3 = G1$

$HH3 = HH2$

$TPB3 = TPB1$

$TMB3 = TMB2$

$B3 = 0.0$

1

$A1BAR = 0.5(A1 + BA3)$

$A2BAR = 0.5(A2 + SA3)$

$C1BAR = 0.5(C1 + BC3)$

$C2BAR = 0.5(C2 + SC3)$

$B2BAR = 0.5(B2 + SB3)$

$GBAR = 0.5(G1 + G3)$

$HBAR = 0.5(HH2 + HH3)$

$ANIBAR = 0.5(TPB1 + TPB3)$

$AN2BAR = 0.5(TMB2 + TMB3)$

CALL INTER (EPSI, ANIBAR, AN2BAR, Z1, Z2, R1, R2, Z3, R3)

$$S3 = S1 + \left(\frac{S2 - S1}{1.0 + \left(\frac{HBAR(Z3 - Z2)}{GBAR(Z3 - Z1)}\right)}\right)$$

$$V3 = \left(\frac{1.0}{A1BAR + A2BAR}\right)\Big(THETA2 + (A1BAR \times V1) + (A2BAR \times V2)$$

$$+ B3 \times (Z3 - Z1) + B2BAR(Z3 - Z2) - C1BAR(S3 - S1) \times 32.2$$

$$- C2BAR(S3 - S2) \times 32.2\Big)$$

$THETA3 = THETA2 - A2BAR(V3 - V2) + B2BAR(Z3 - Z2) - C2BAR(S3 - S2)32.2$

$N = N + 1$

B

SUBROUTINE PTFTAX

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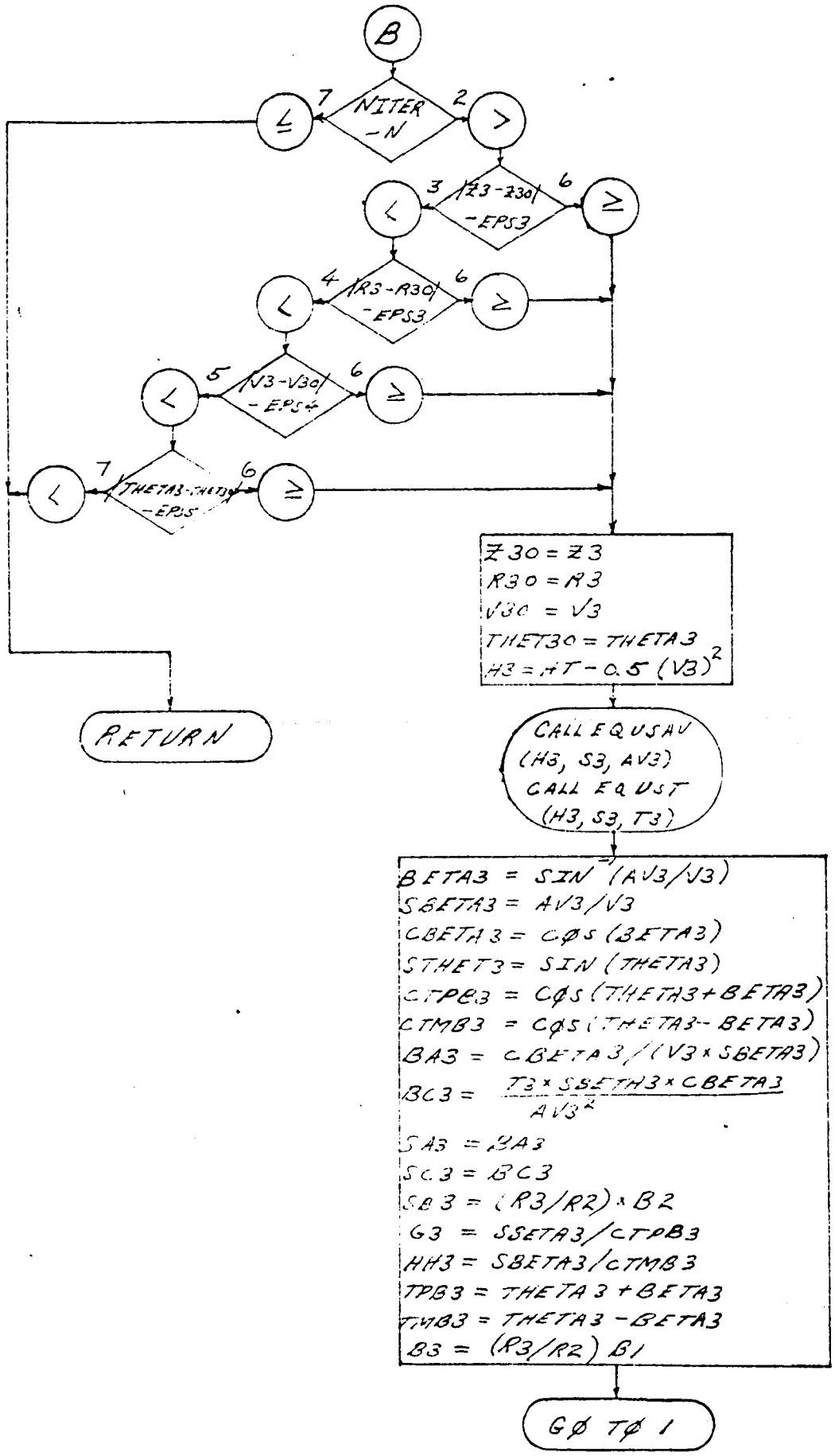

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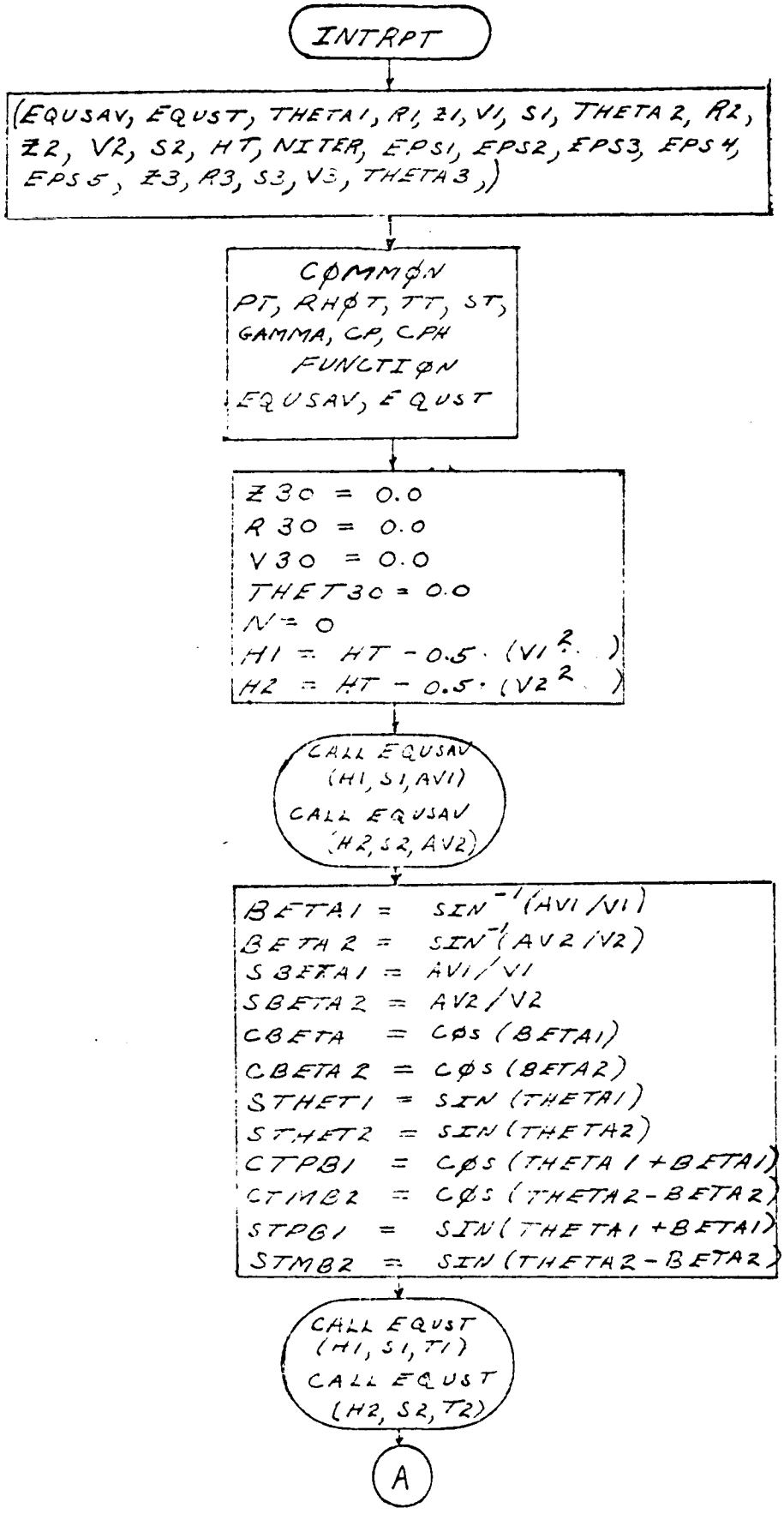
SUBROUTINE PTFTAX



SUBROUTINE INTRPT

(A)

$A1 = CBETA1 / (V1 \times SBETA1)$

$B1 = \dfrac{CPH \times SBETA1 \times STHET1}{R1 \times CTPB1}$

$C1 = \dfrac{T1 \times SBETA1 \times CBETA1}{AV1^2}$

$A2 = CBETA2 / (V2 \times SBETA2)$

$B2 = \dfrac{CPH \times SBETA2 \times STHET2}{R2 \times CTMB2}$

$C2 = \dfrac{T2 \times SBETA2 \times CBETA2}{AV2^2}$

$G1 = SBETA1 / CTPB1$

$HH2 = SBETA2 / CTMB2$

$G1ST = SBETA1 / STPB1$

$H2ST = SBETA2 / STMB2$

$B1ST = \dfrac{CPH \times SBETA1 \times STHET1}{R1 \times STPB1}$

$B2ST = \dfrac{CPH \times SBETA2 \times STHET2}{R2 \times STMB2}$

$TPB1 = THETA1 + BETA1$

$TMB2 = THETA2 - BETA2$

$BA3 = A1$

$BB3 = B1$

$BC3 = C1$

$SA3 = A2$

$SB3 = B2$

$SC3 = C2$

$G3 = G1$

$HH3 = HH2$

$G3ST = G1ST$

$H3ST = H2ST$

$BB3ST = B1ST$

$SB3ST = B2ST$

$TPB3 = TPB1$

$TMB3 = TMB2$

(1)

$A1BAR = 0.5(A1 + BA3)$

$C1BAR = 0.5(C1 + BC3)$

$A2BAR = 0.5(A2 + SA3)$

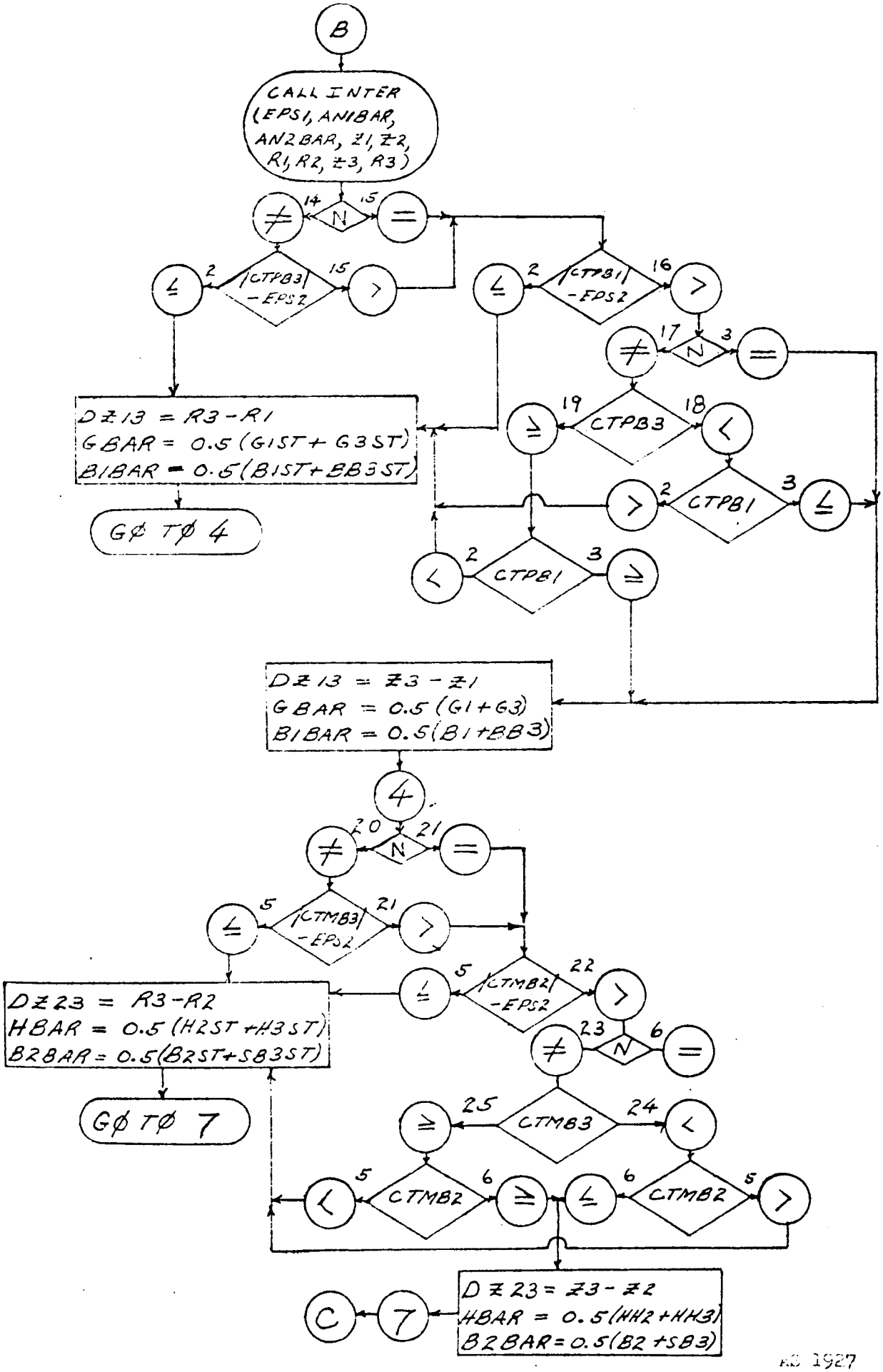
$C2BAR = 0.5(C2 + SC3)$

$AN1BAR = 0.5(TPB1 + TPB3)$

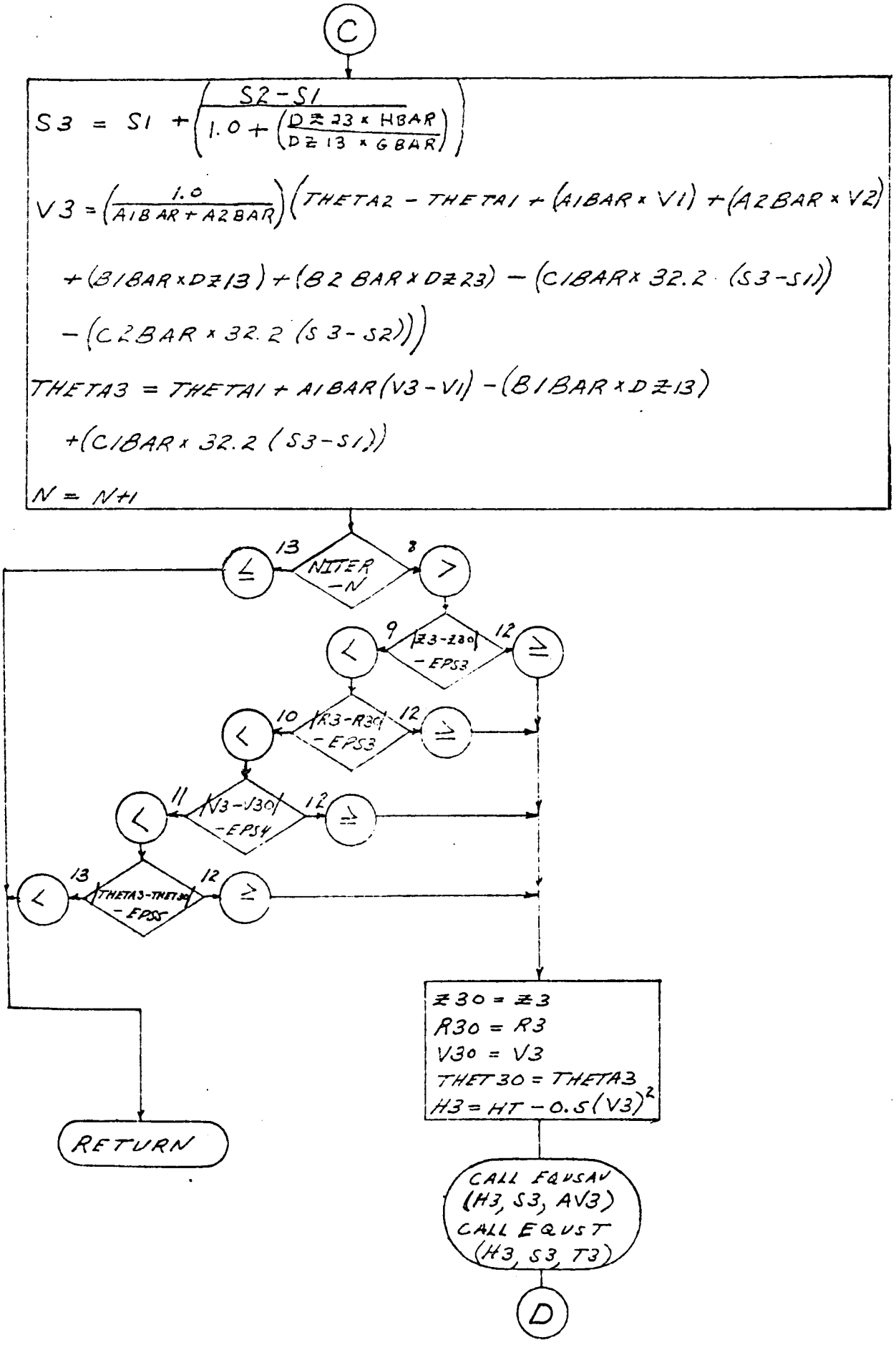
$AN2BAR = 0.5(TMB2 + TMB3)$

(B)

SUBROUTINE INTRPT



SUBROUTINE INTRPT



SUBROUTINE INTRPT

D

$BETA3 = SIN^{-1}(AV3/V3)$

$SBETA3 = AV3/V3$

$CBETA3 = CØS(BETA3)$

$STHET3 = SIN(THETA3)$

$CTPB3 = CØS(THETA3 + BETA3)$

$CTMB3 = CØS(THETA3 - BETA3)$

$STPB3 = SIN(THETA3 + BETA3)$

$STMB3 = SIN(THETA3 - BETA3)$

$BA3 = CBETA3/(V3 \times SBETA3)$

$$BB3 = \frac{(CPH \times SBETA3 \times STHET3)}{R3 \times CTPB3}$$

$$BC3 = \frac{(T3 \times SBETA3 \times CBETA3)}{AV3^2}$$

$SA3 = BA3$

$$SB3 = \frac{(CPH \times SBETA3 \times STHET3)}{R3 \times CTMB3}$$

$SC3 = BC3$

$G3 = SBETA3/CTPB3$

$HH3 = SBETA3/CTMB3$

$G3ST = SBETA3/STPB3$

$H3ST = SBETA3/STMB3$

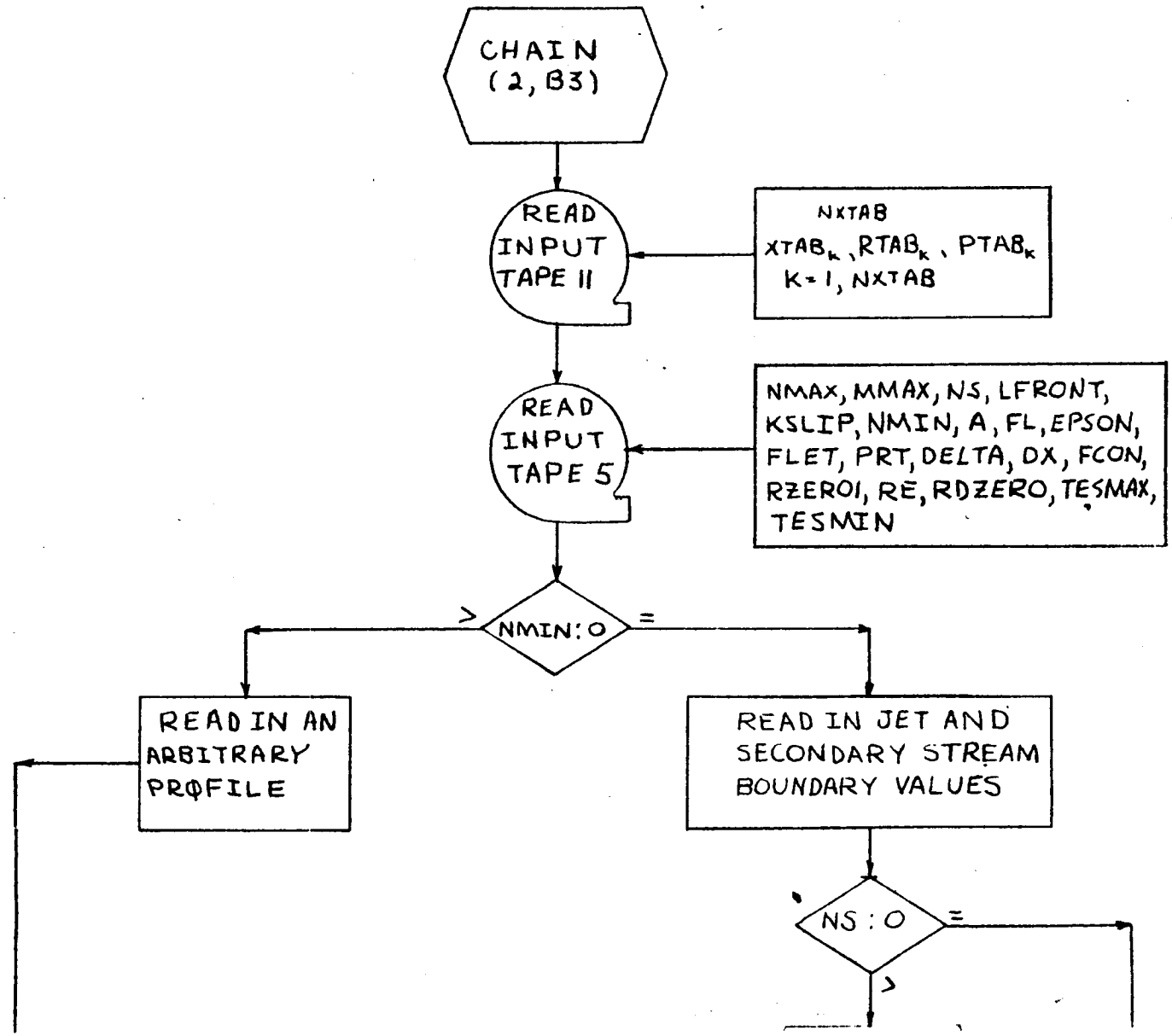
$$BB3ST = \frac{(CPH \times SBETA3 \times STHET3)}{R3 \times STPB3}$$

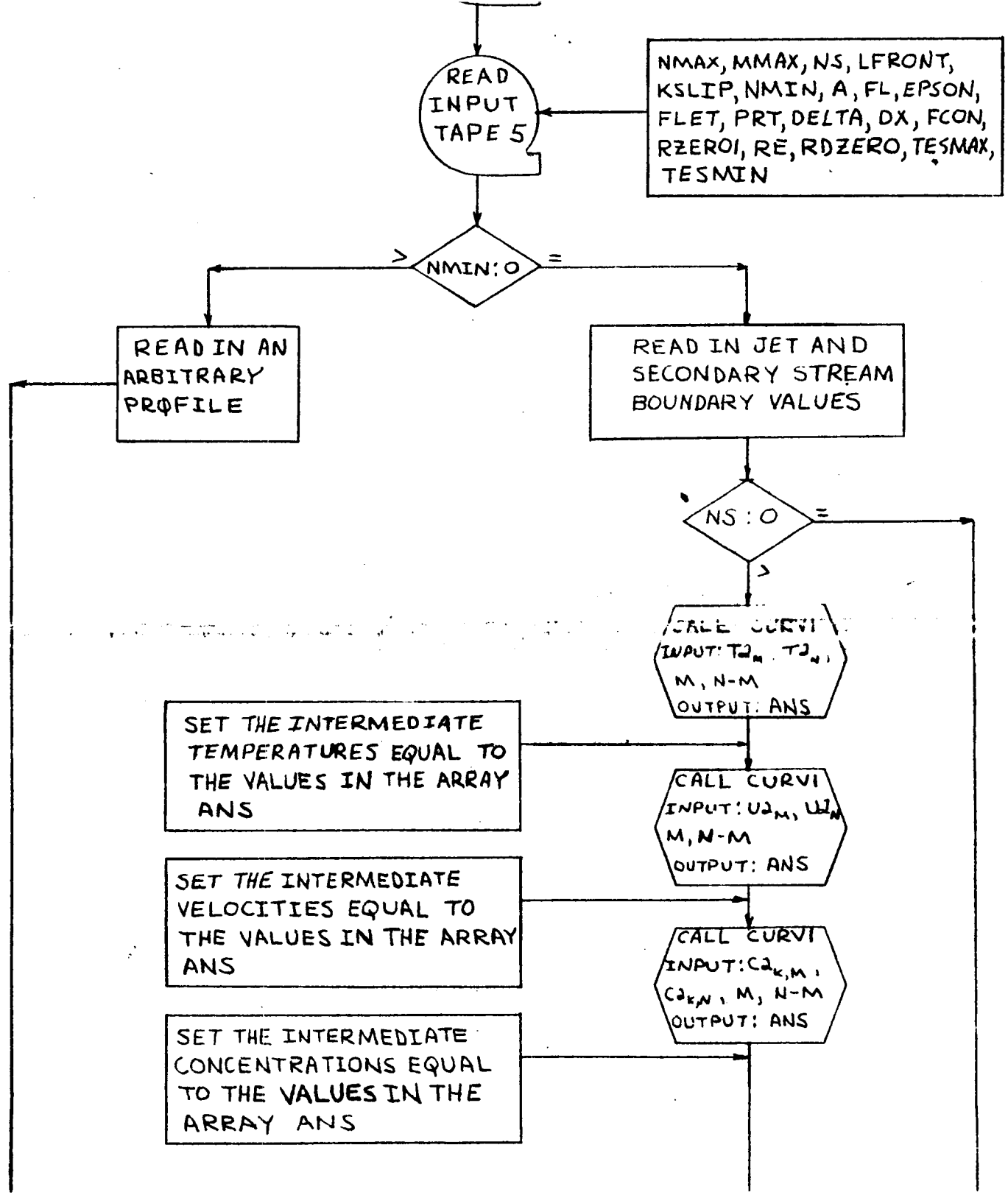
$$SB3ST = \frac{(CPH \times SBETA3 \times STHET3)}{R3 \times STMB3}$$

$TPB3 = THETA3 + BETA3$

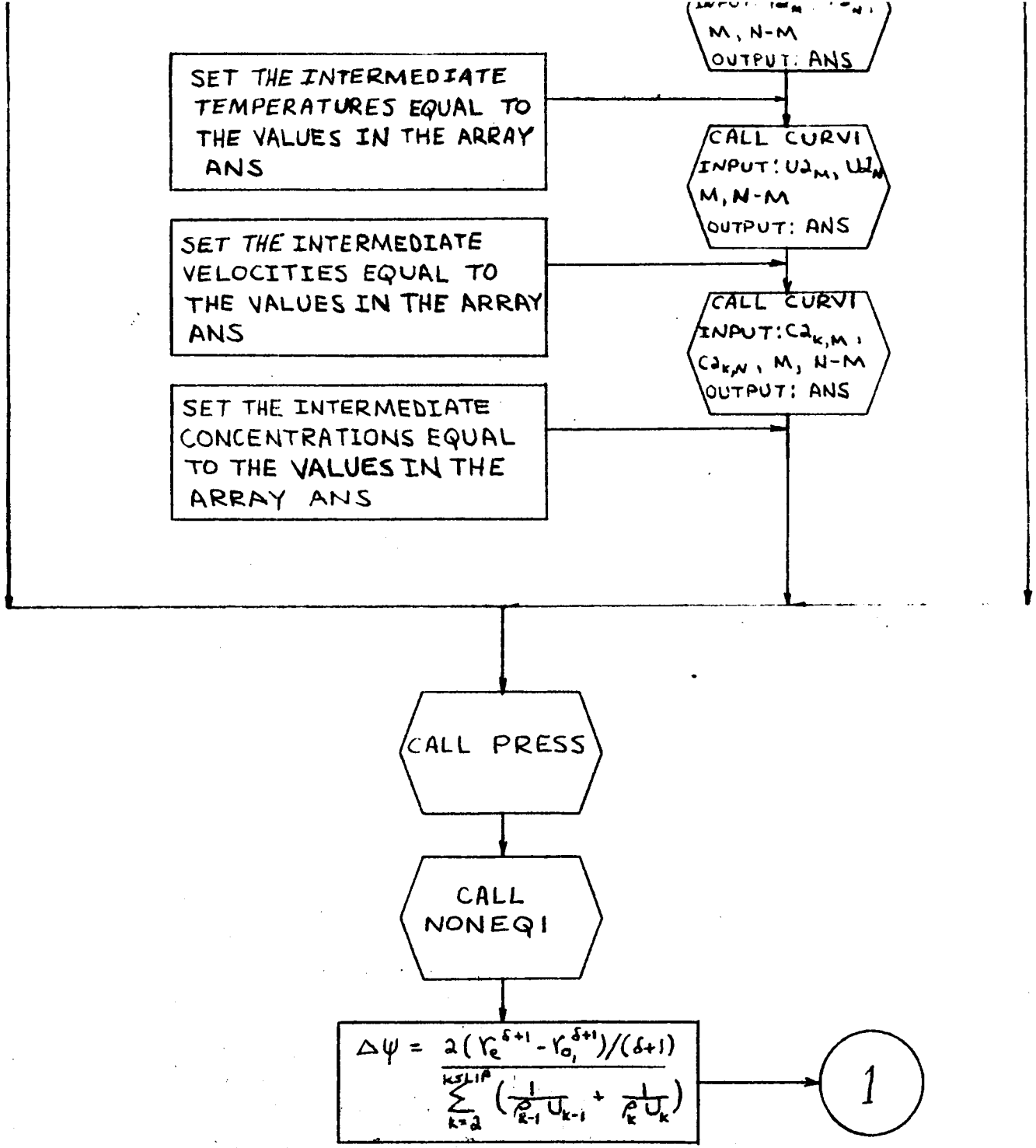
$TMB3 = THETA3 - BETA3$

GØ TØ 1


CHAIN (2, B3)
READ INPUT TAPE 11
NXTAB
XTAB_K, RTAB_K, PTAB_K
K=1, NXTAB
READ INPUT TAPE 5
NMAX, MMAX, NS, LFRONT, KSLIP, NMIN, A, FL, EPSON, FLET, PRT, DELTA, DX, FCON, RZEROI, RE, RDZERO, TESMAX, TESMIN
NMIN:0
>
=
READ IN AN ARBITRARY PROFILE
READ IN JET AND SECONDARY STREAM BOUNDARY VALUES
NS:0
=
>



			CHECK	CALC
			APR	
				REVISED
				DA



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MIX-MASTER (CHAIN)

THE BOEING COMPANY

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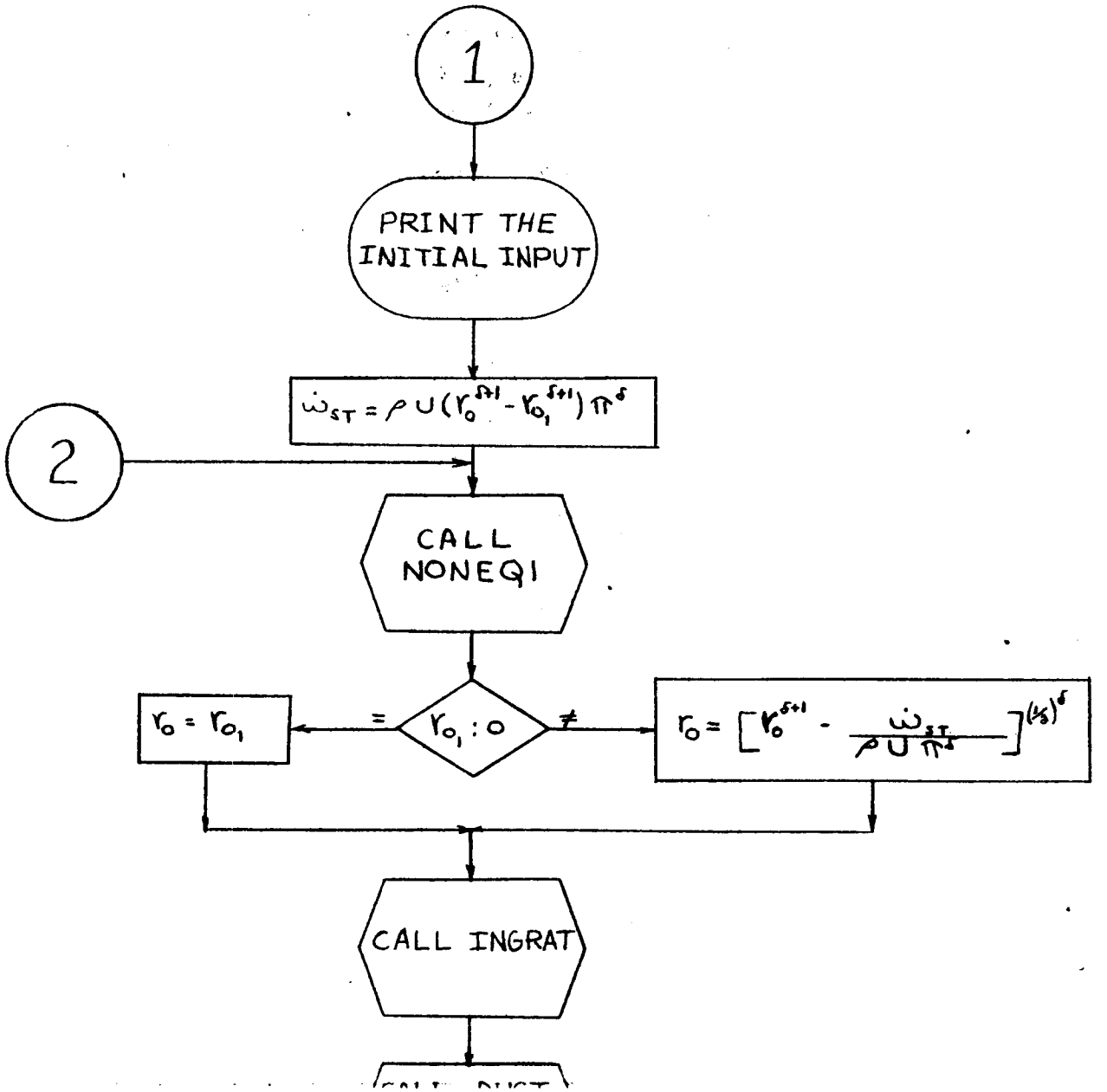
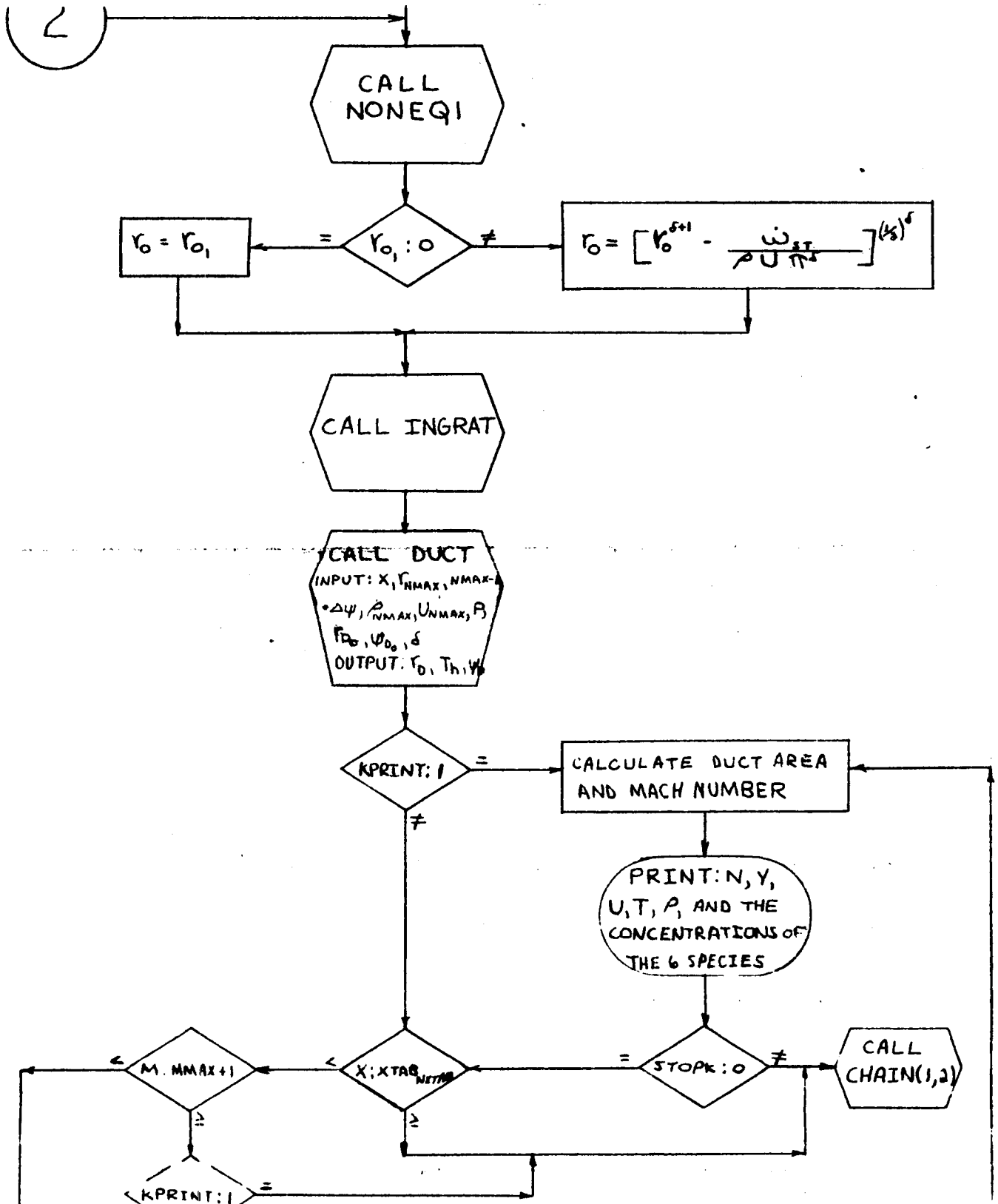

1
PRINT THE INITIAL INPUT
$\dot{\omega}_{ST} = \rho U (r_o^{\delta+1} - r_{o_1}^{\delta+1}) \pi^{\delta}$
2
CALL NONEQI
$r_{o_1} : o$
=
$r_o = r_{o_1}$
≠
$r_o = \left[r_o^{\delta+1} - \frac{\dot{\omega}_{ST}}{\rho U \pi^{\delta}} \right]^{(1/\delta)^{\delta}}$
CALL INGRAT



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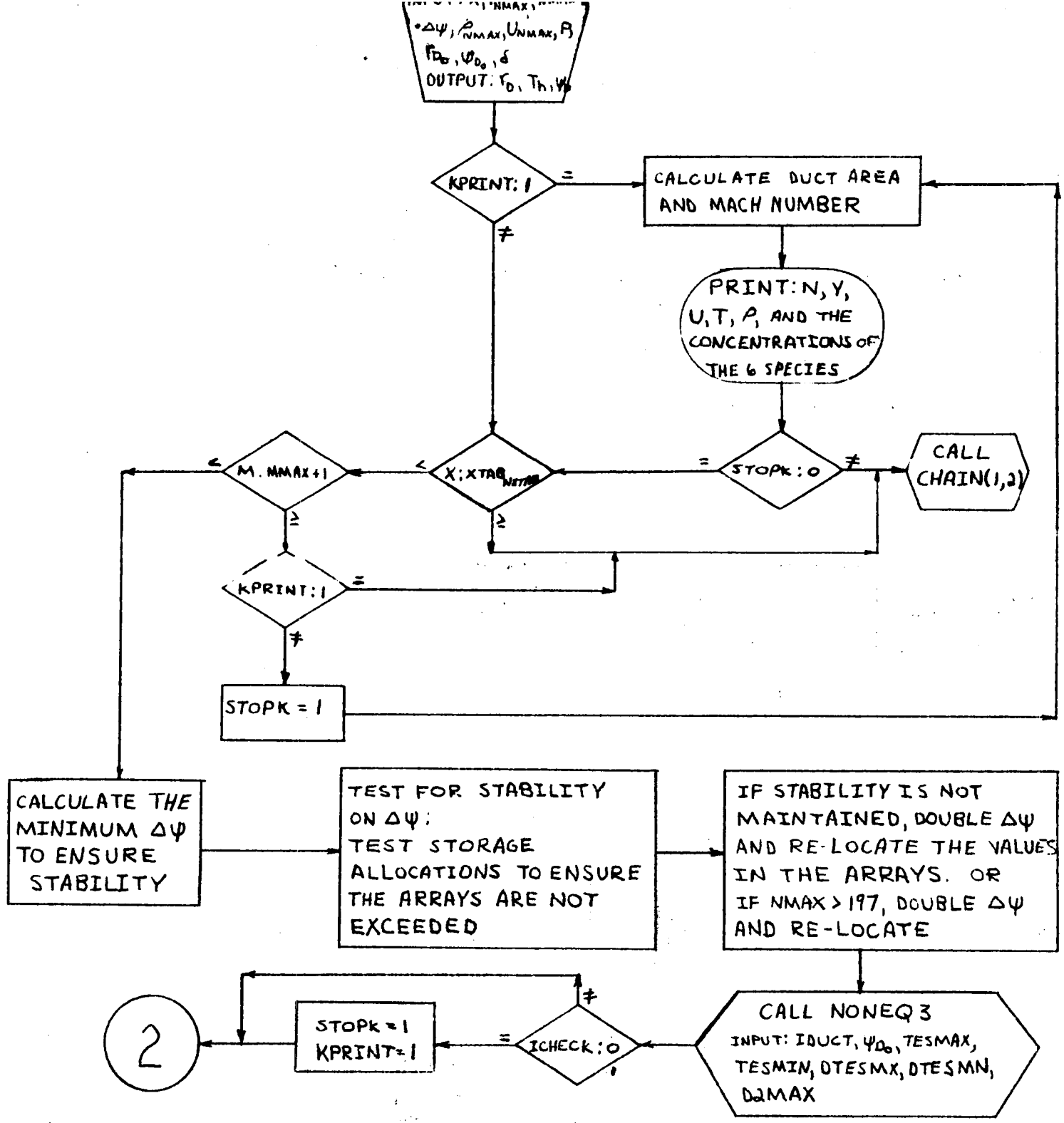
APR			DATE
APR			



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	DATE		

MIX-MASTER (CHAIN)

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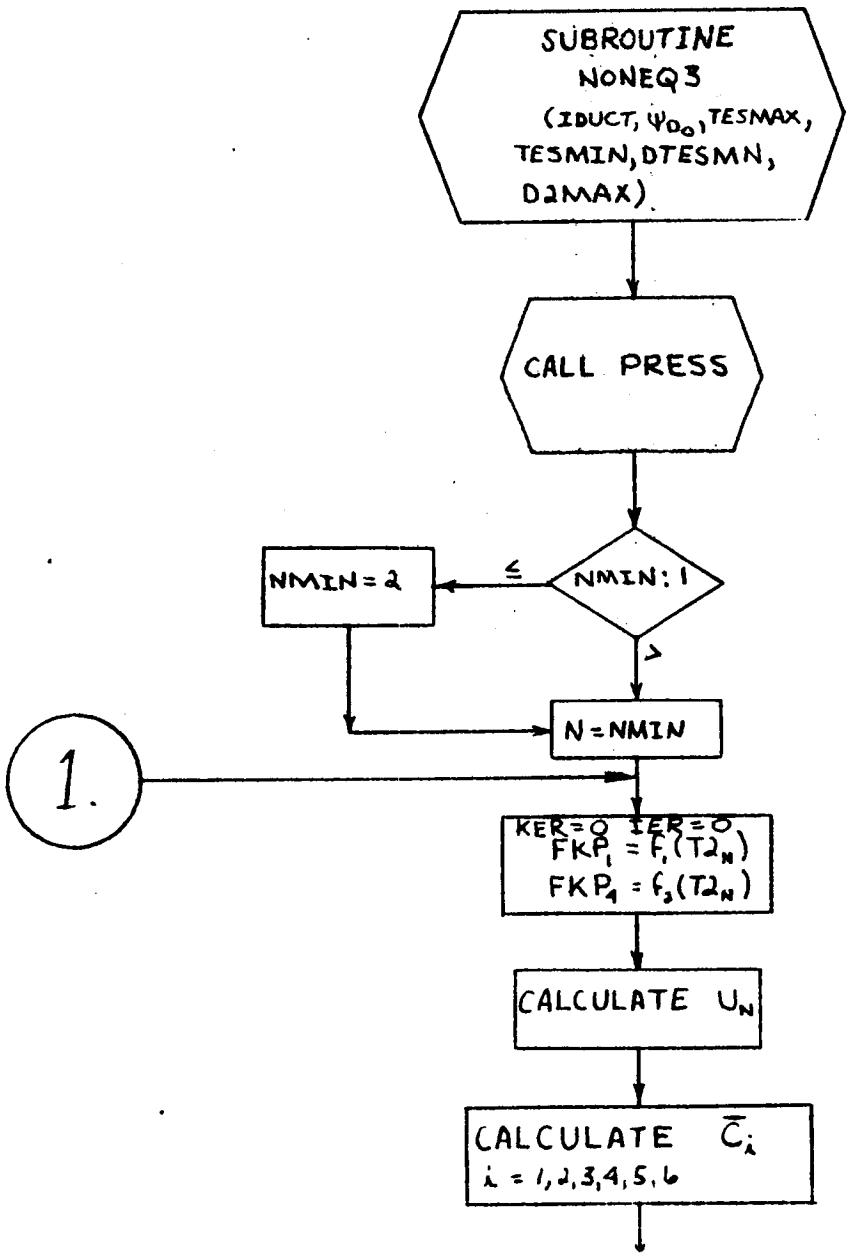
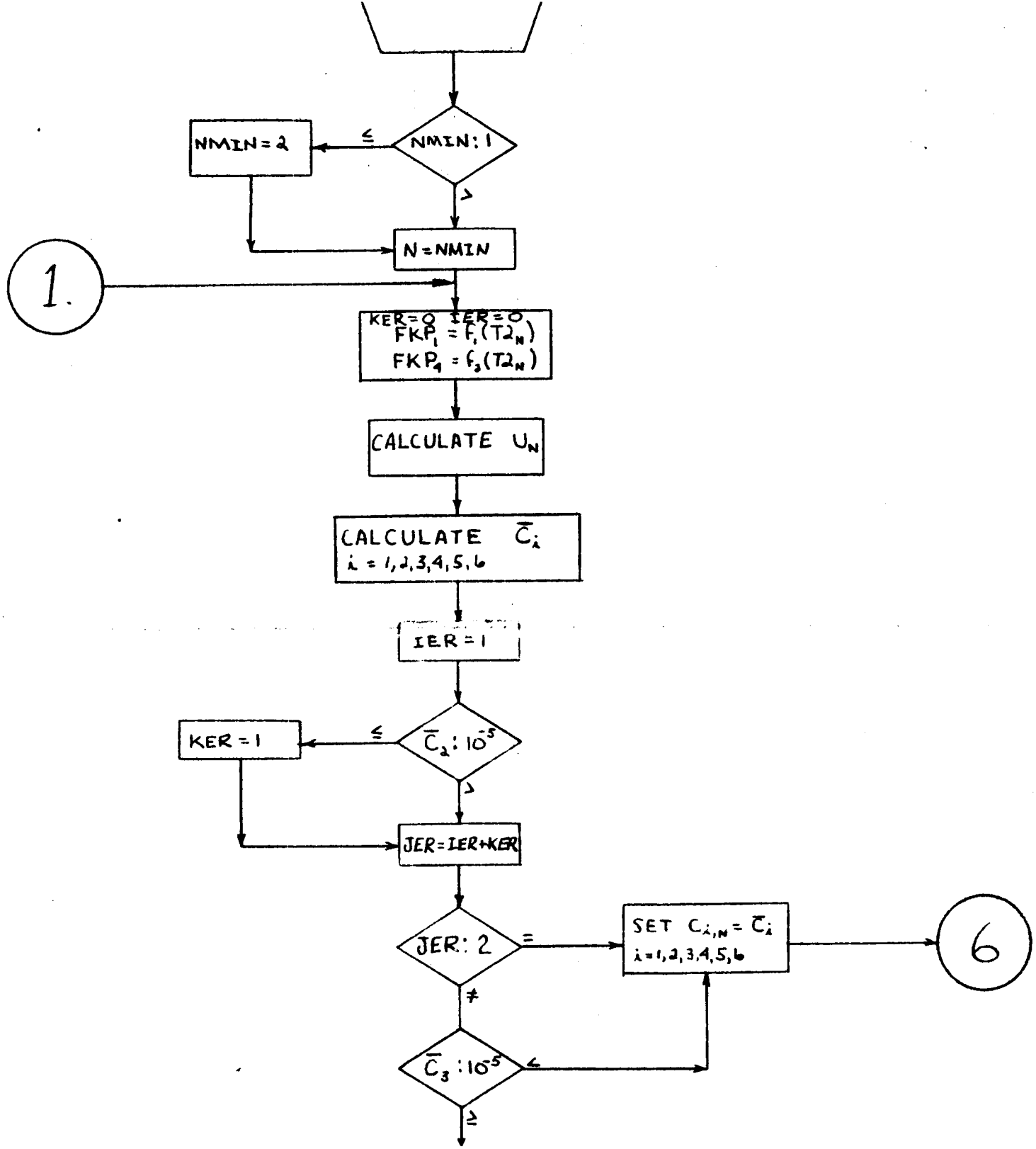
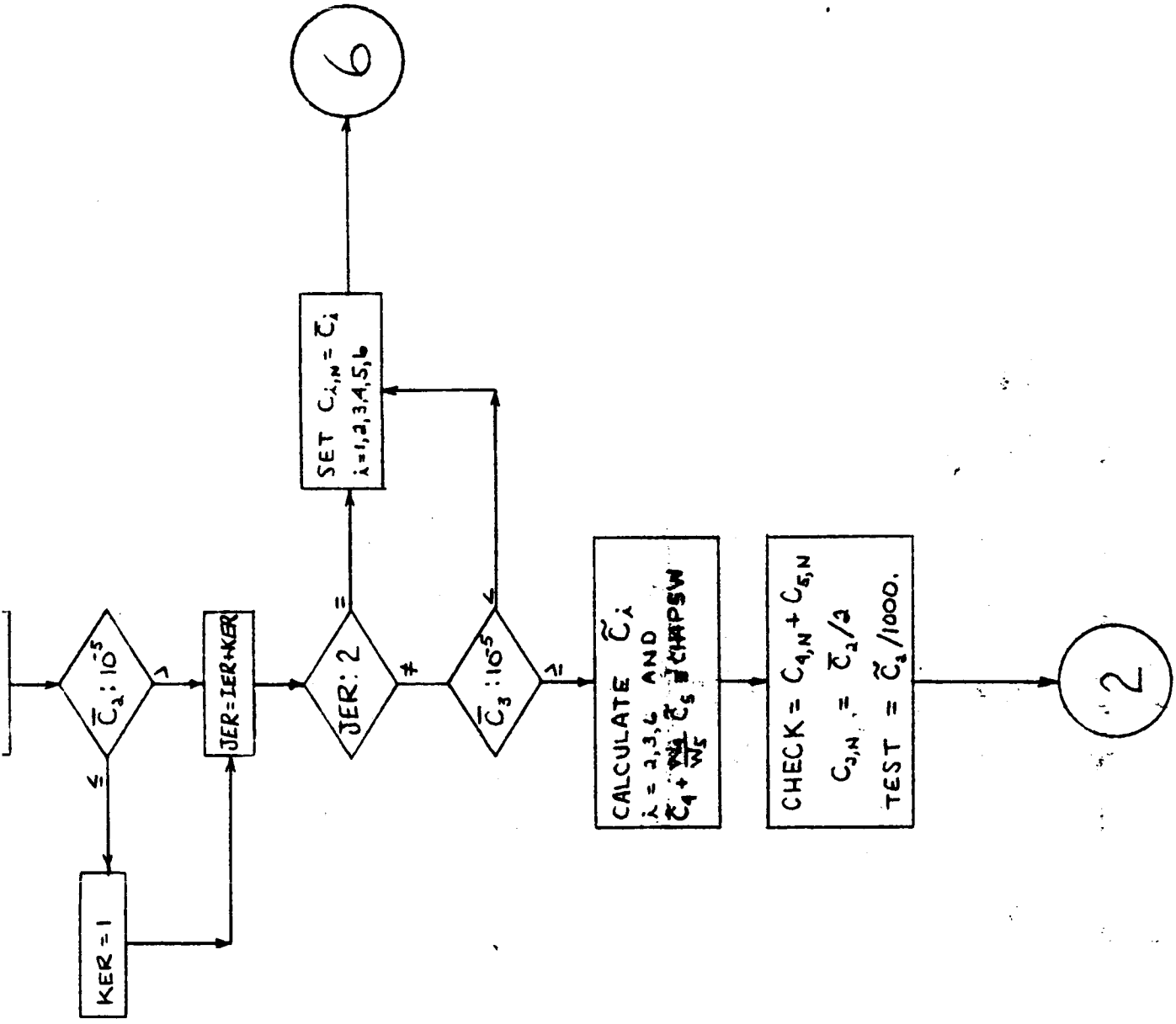
JUL 1967


SUBROUTINE
NONEQ3
(IDUCT, ψ_{D_0}, TESMAX,
TESMIN, DTESMN,
D2MAX)
CALL PRESS
NMIN : 1
≤
NMIN = 2
>
N = NMIN
1.
KER = 0 IER = 0
$FKP_1 = f_1(T2_N)$
$FKP_4 = f_3(T2_N)$
CALCULATE U_N
CALCULATE $\bar{C}_i$
$i = 1,2,3,4,5,6$

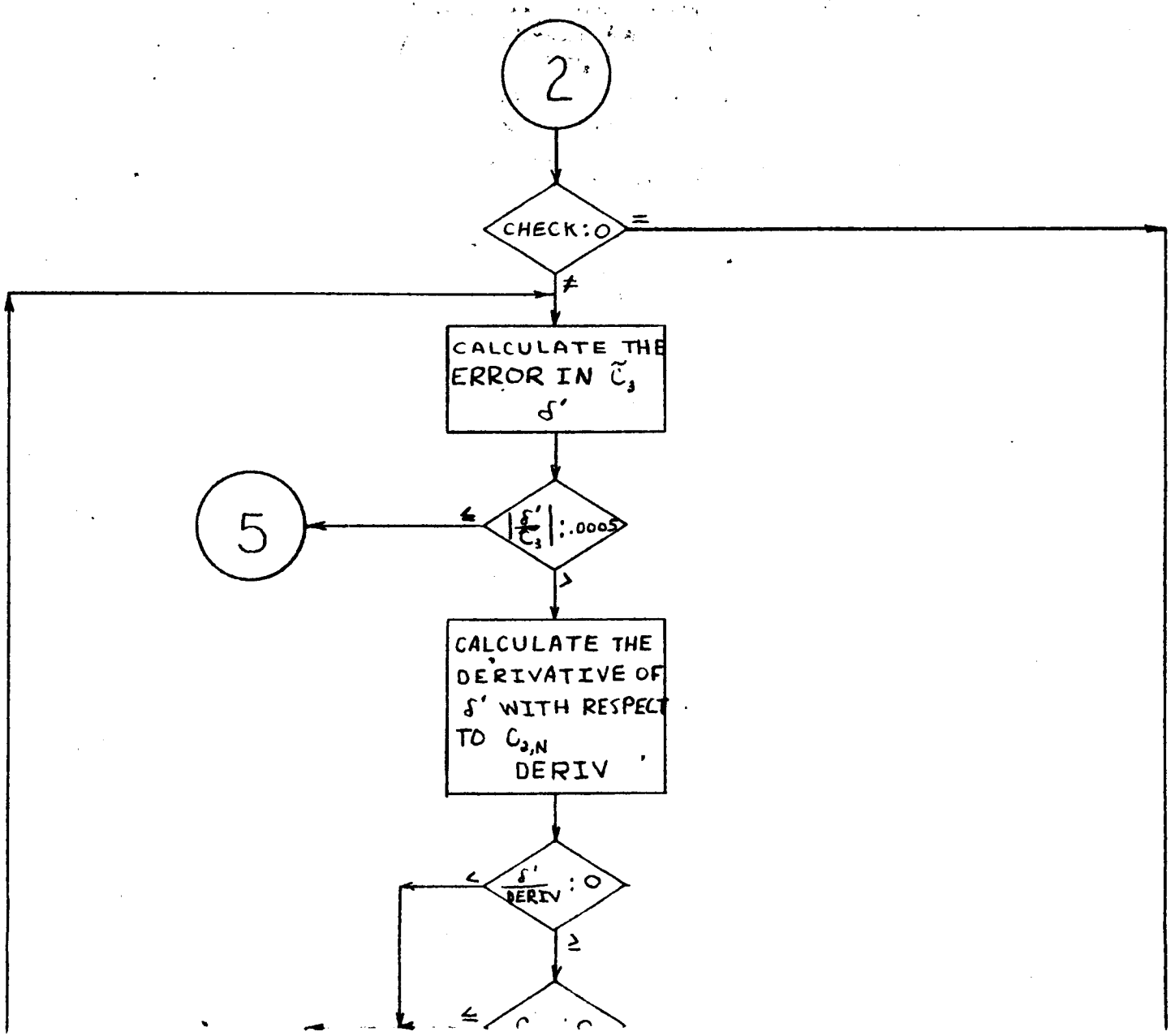
C3.

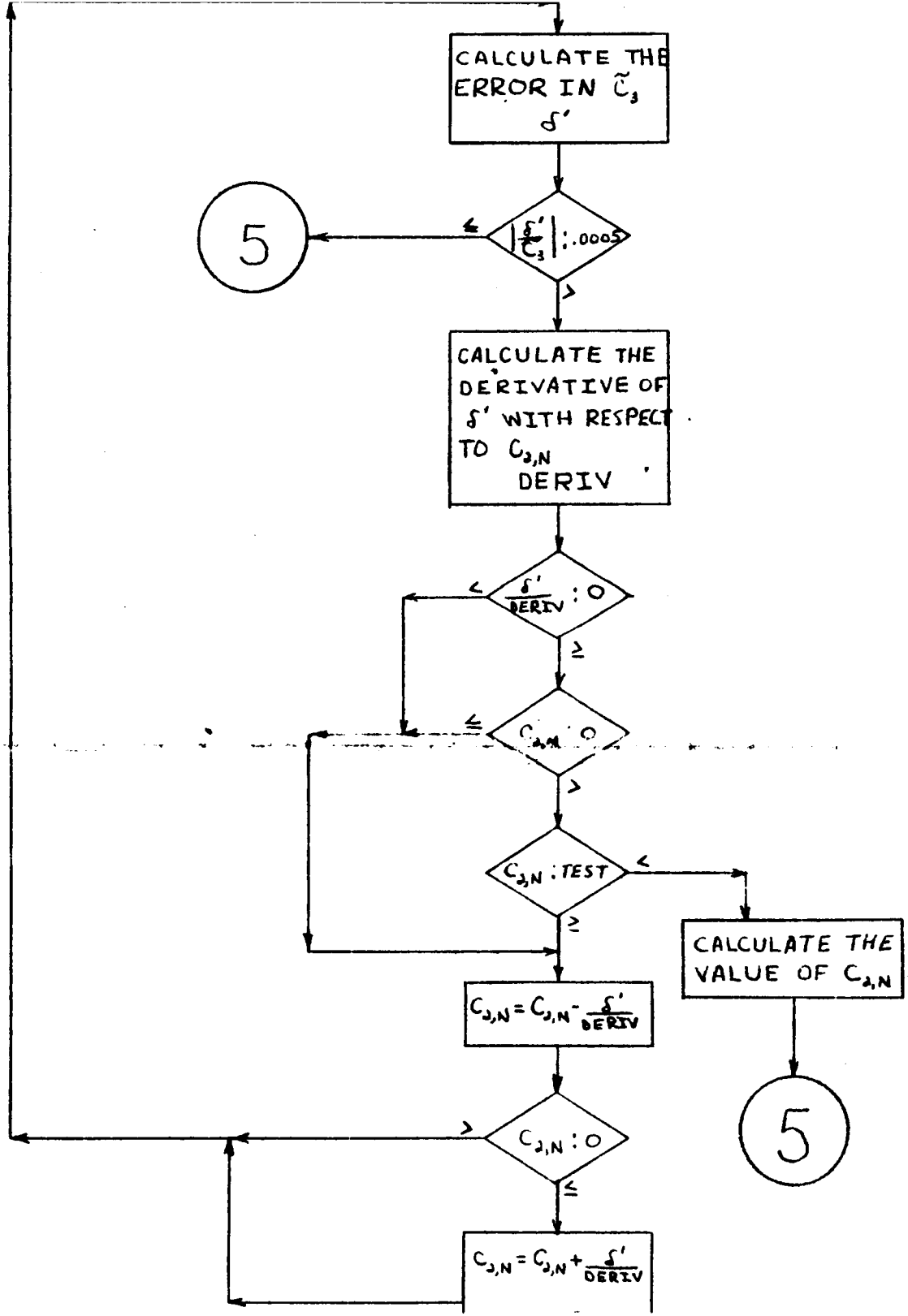


				CALC
				CHECK
				APR
				APR
				REVISED



CALC		REVISED	DATE	NONEQ3	
CHECK					AS 1927
APR					
APR				THE BOEING COMPANY	PAGE D-69


2
CHECK: 0
=
≠
CALCULATE THE ERROR IN $\tilde{C}_3$ δ'
5
≤
$\left|\frac{\delta'}{\tilde{C}_3}\right|$: .0005
>
CALCULATE THE DERIVATIVE OF δ' WITH RESPECT TO $C_{3,N}$ DERIV
<
$\frac{\delta'}{DERIV}$: 0
≥
≤



CALC		REVISE.
CHECK		
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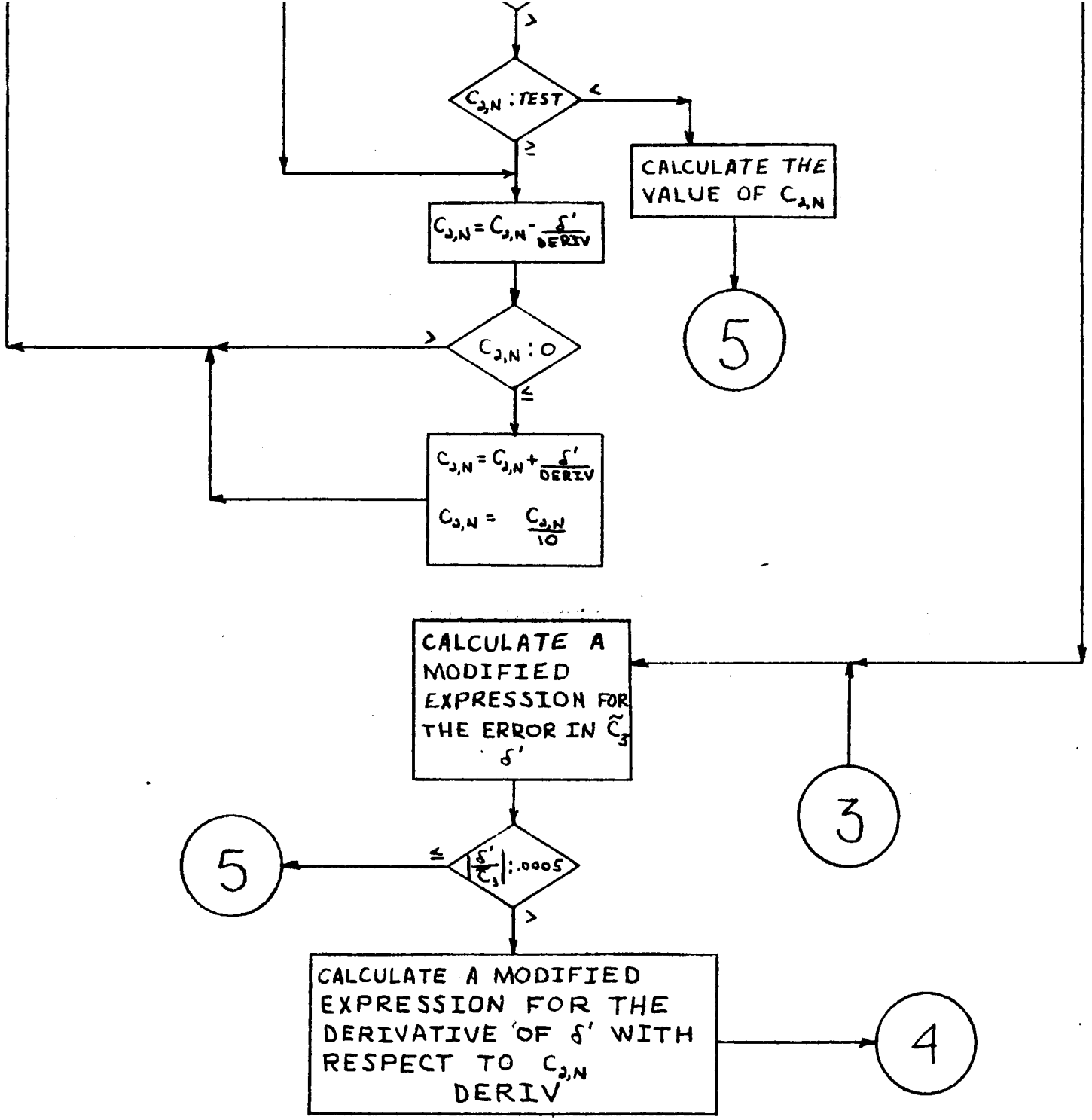
APR		



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THE BOEING COMPANY

NONEQ3

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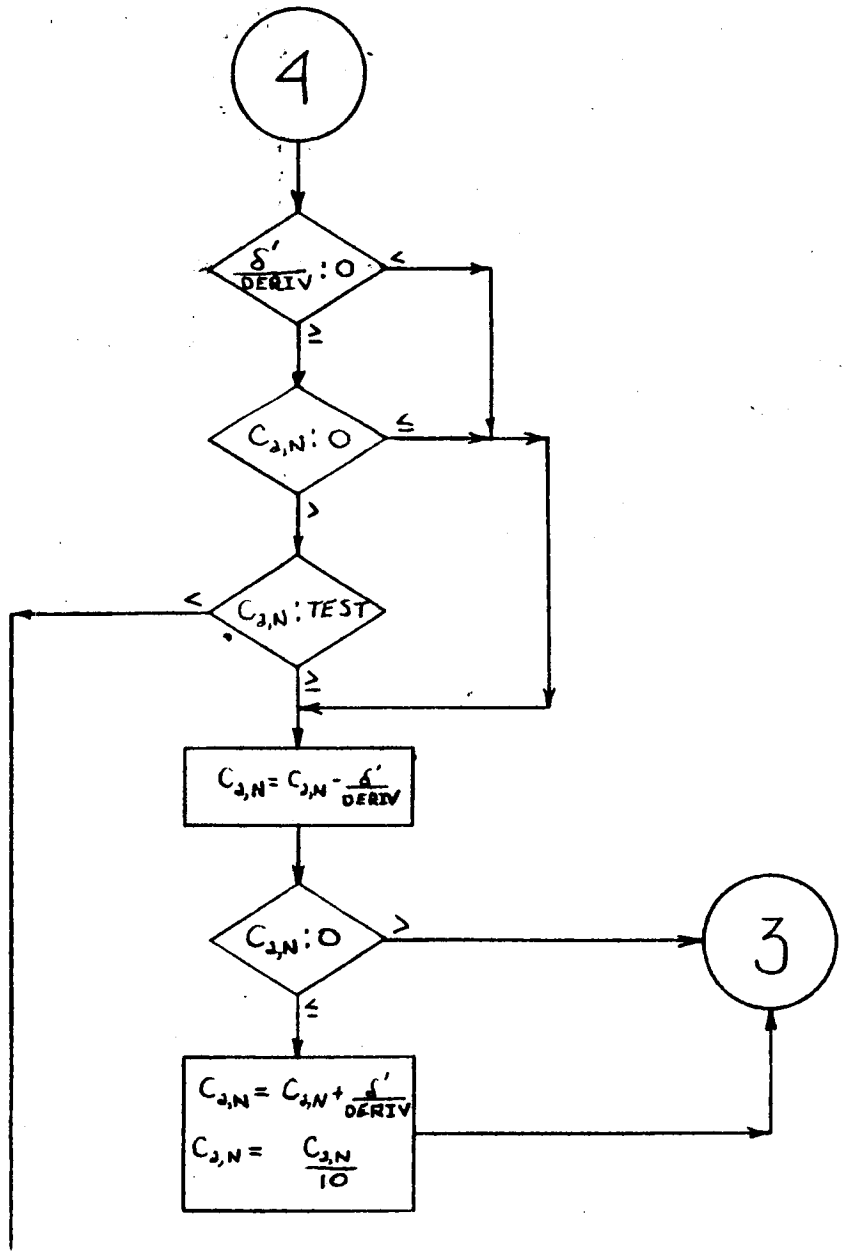
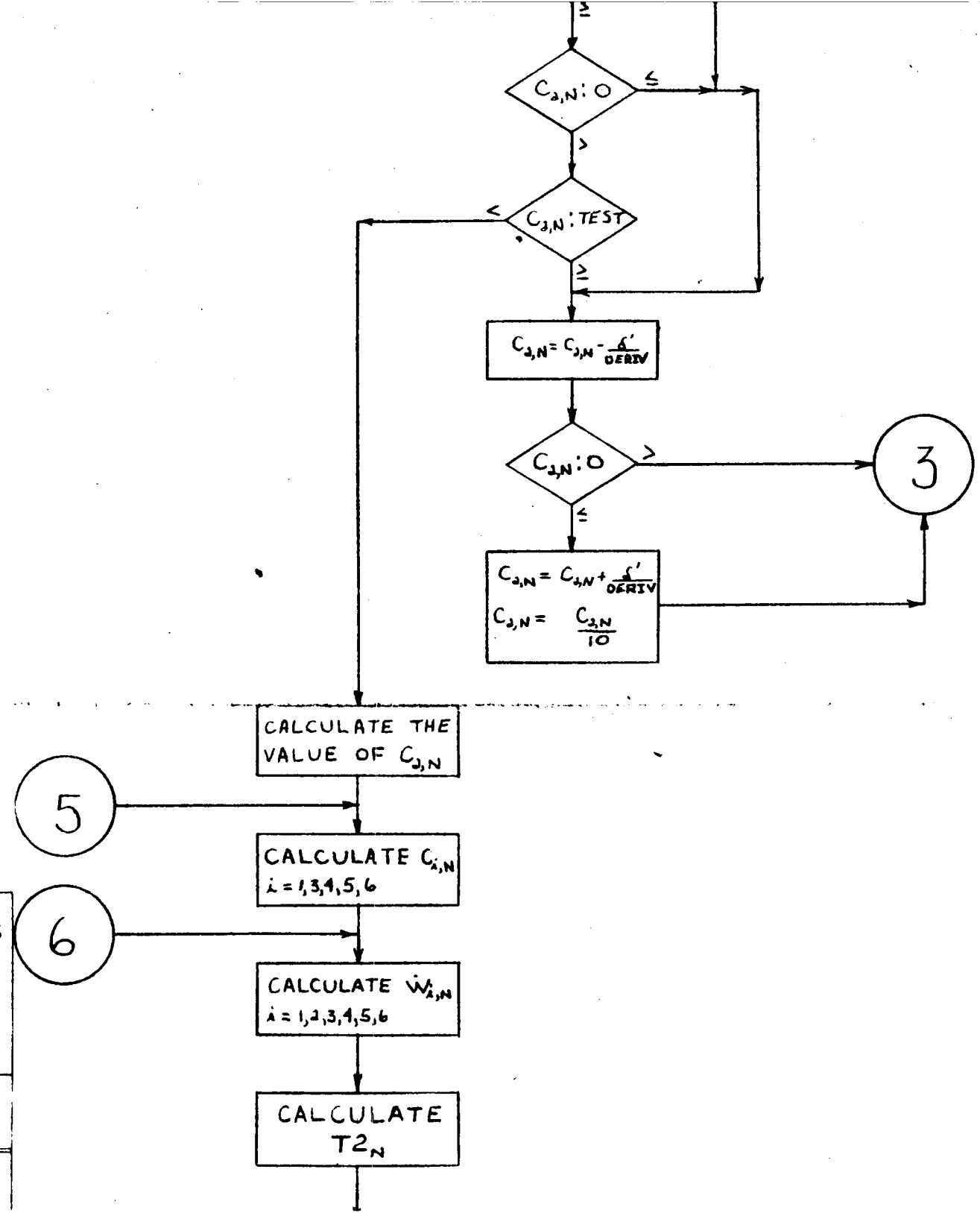

4
δ'/DERIV : 0
<
≥
C_{J,N} : 0
≤
>
C_{J,N} : TEST
<
≥
C_{J,N} = C_{J,N} - δ'/DERIV
C_{J,N} : 0
>
≤
C_{J,N} = C_{J,N} + δ'/DERIV
C_{J,N} = C_{J,N}/10
3



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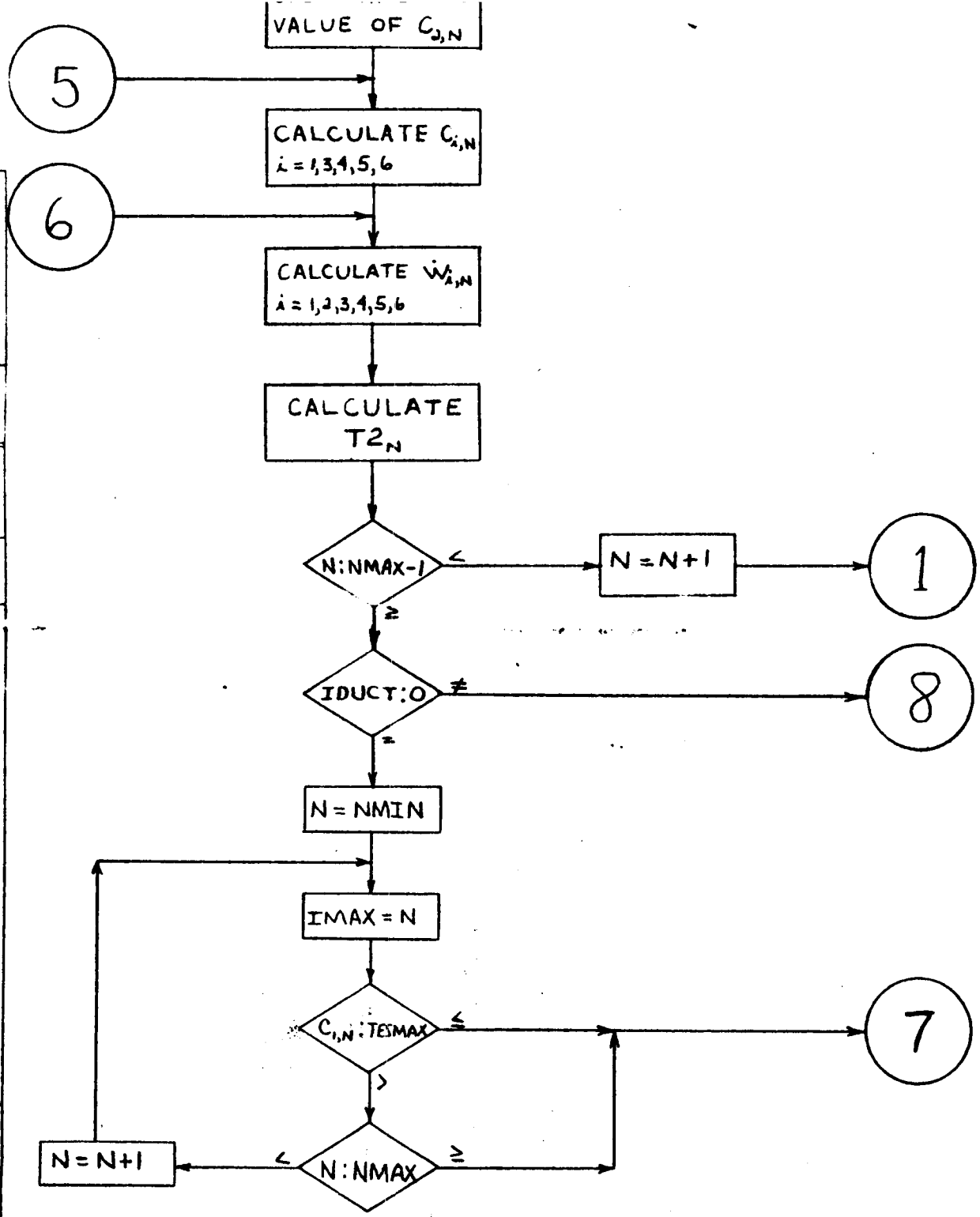

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APR		DATE	

THE BOEING COMPANY

NONEQ3

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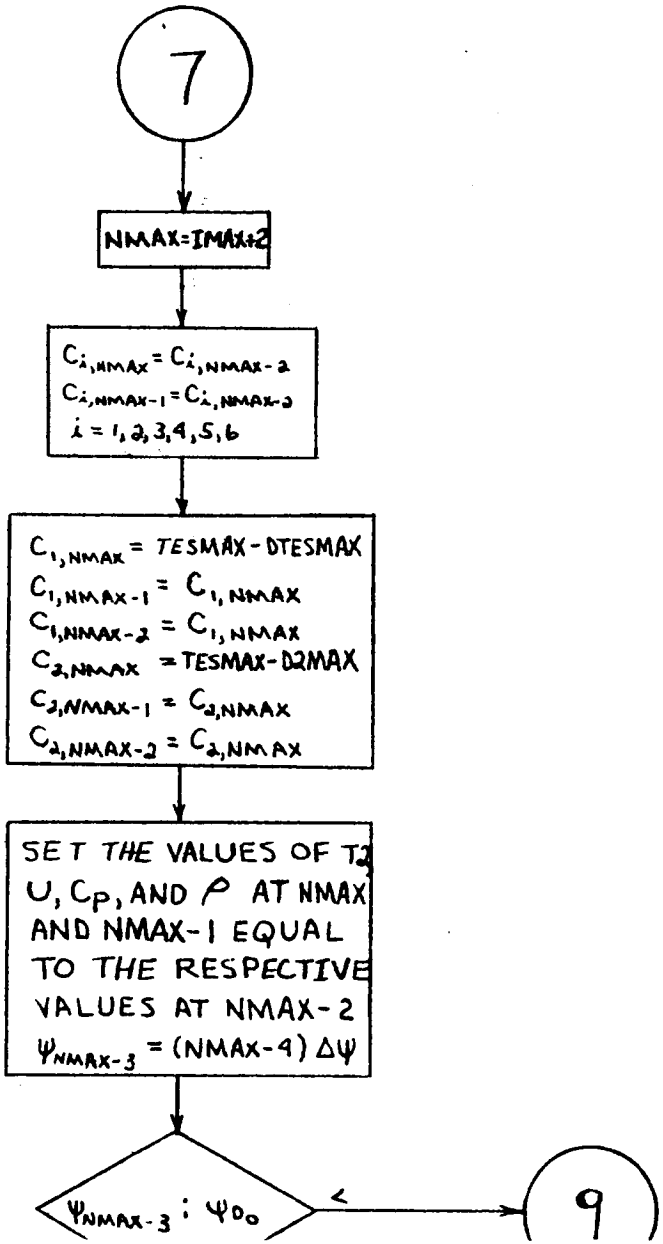
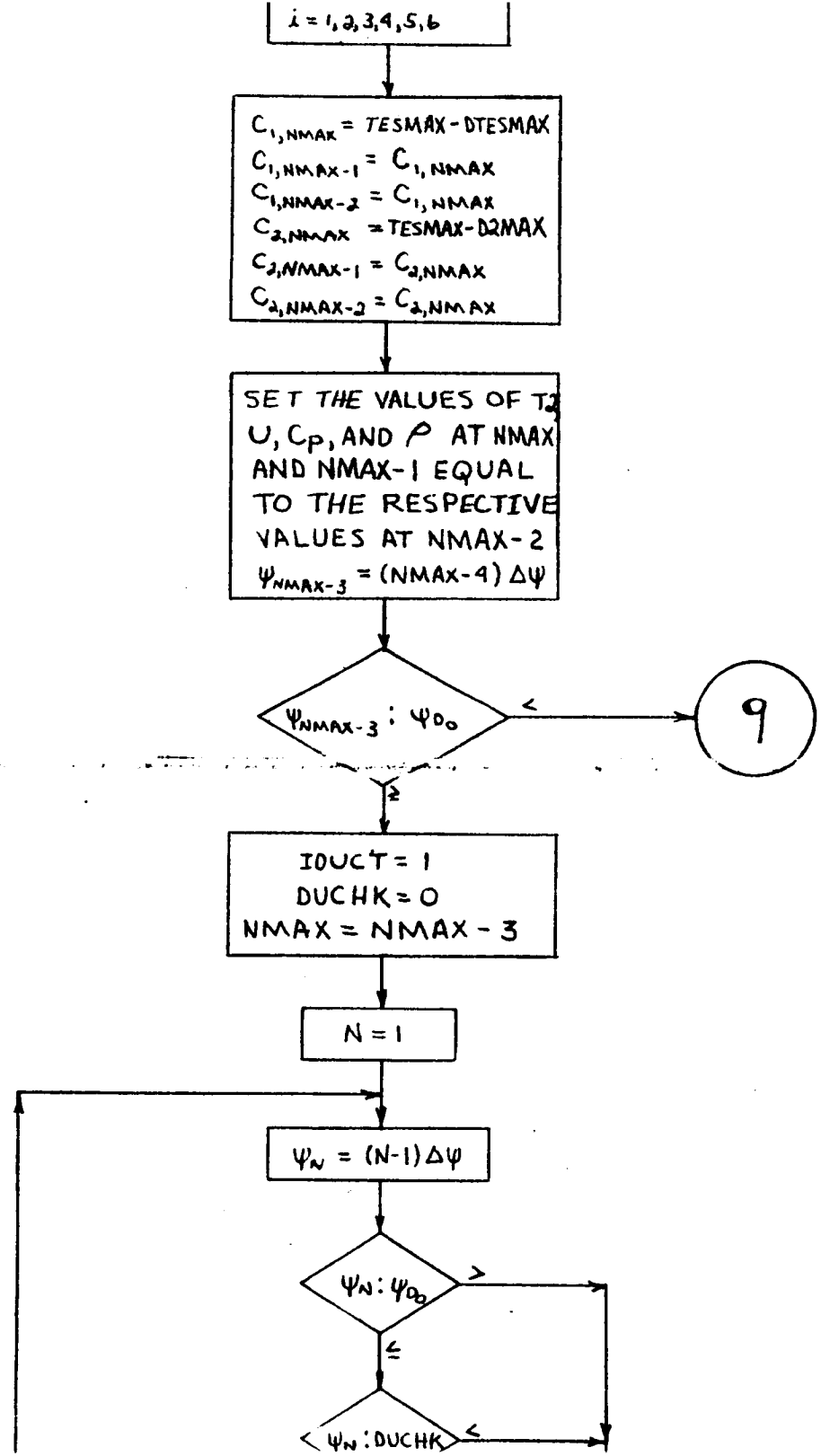

7
NMAX=IMAX+2
$C_{i,NMAX} = C_{i,NMAX-2}$
$C_{i,NMAX-1} = C_{i,NMAX-2}$
$i = 1,2,3,4,5,6$
$C_{1,NMAX} = TESMAX - DTESMAX$
$C_{1,NMAX-1} = C_{1,NMAX}$
$C_{1,NMAX-2} = C_{1,NMAX}$
$C_{2,NMAX} = TESMAX - D2MAX$
$C_{2,NMAX-1} = C_{2,NMAX}$
$C_{2,NMAX-2} = C_{2,NMAX}$
SET THE VALUES OF T2, U, Cp, AND ρ AT NMAX AND NMAX-1 EQUAL TO THE RESPECTIVE VALUES AT NMAX-2
$\psi_{NMAX-3} = (NMAX-4)\,\Delta\psi$
$\psi_{NMAX-3} : \psi_{D_0}$
<
9



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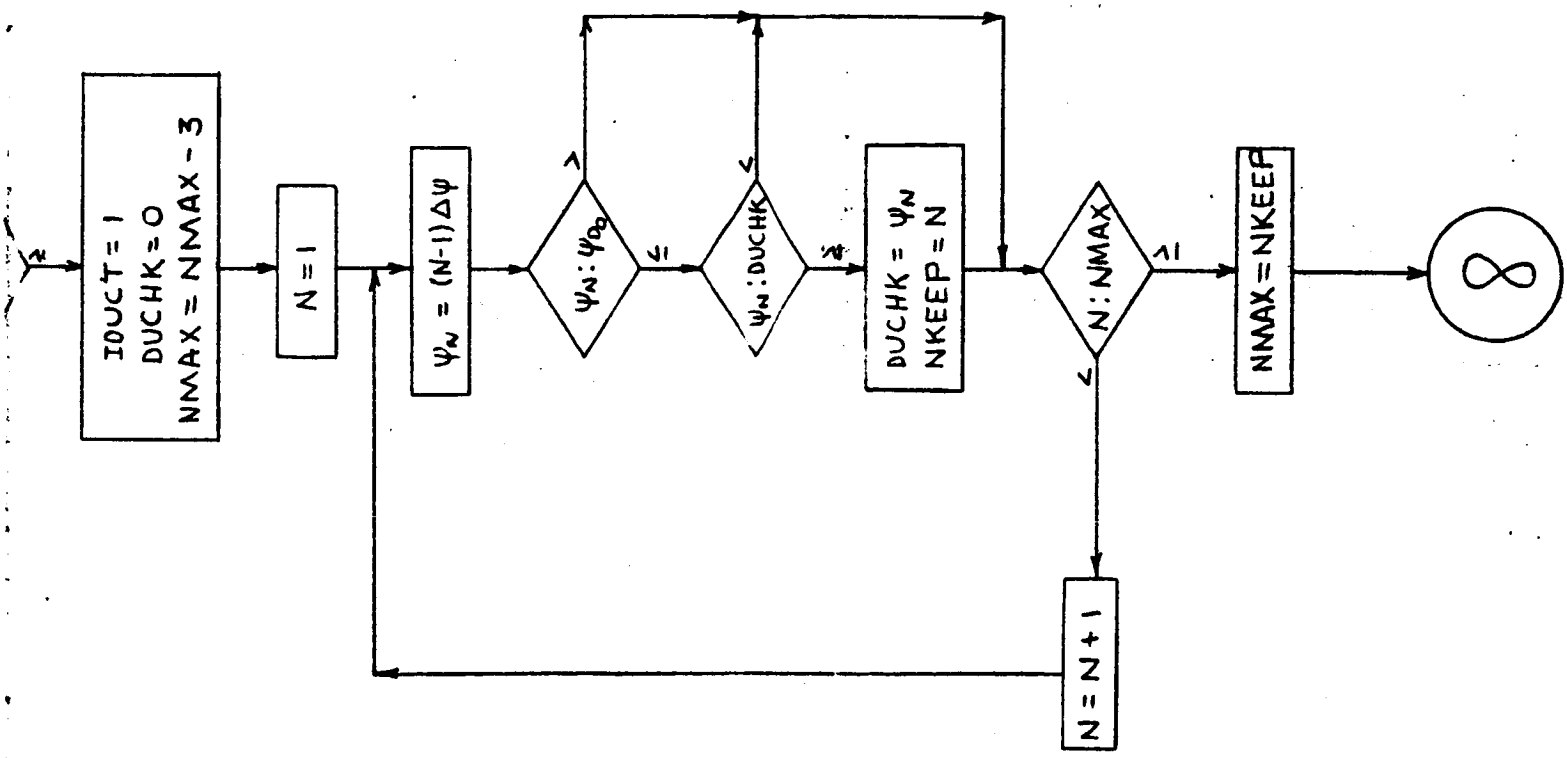
					REVISE
					DAT
	APR	APR	CHECK		



CALC		REVISE	DATE	NONEQ3	
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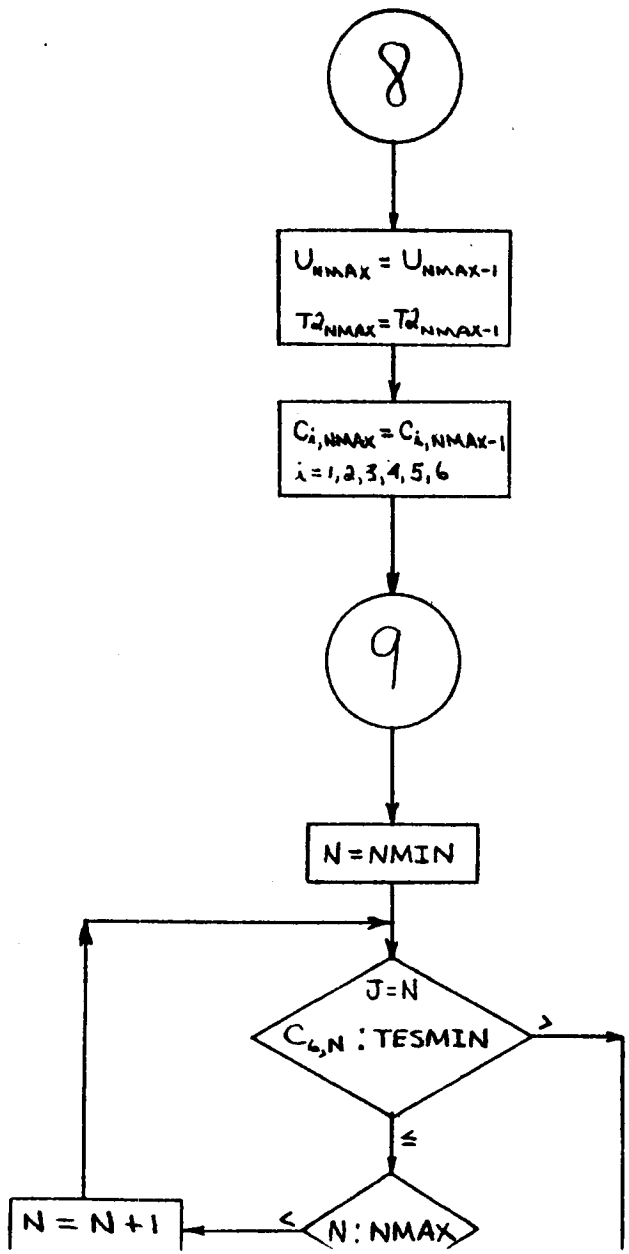
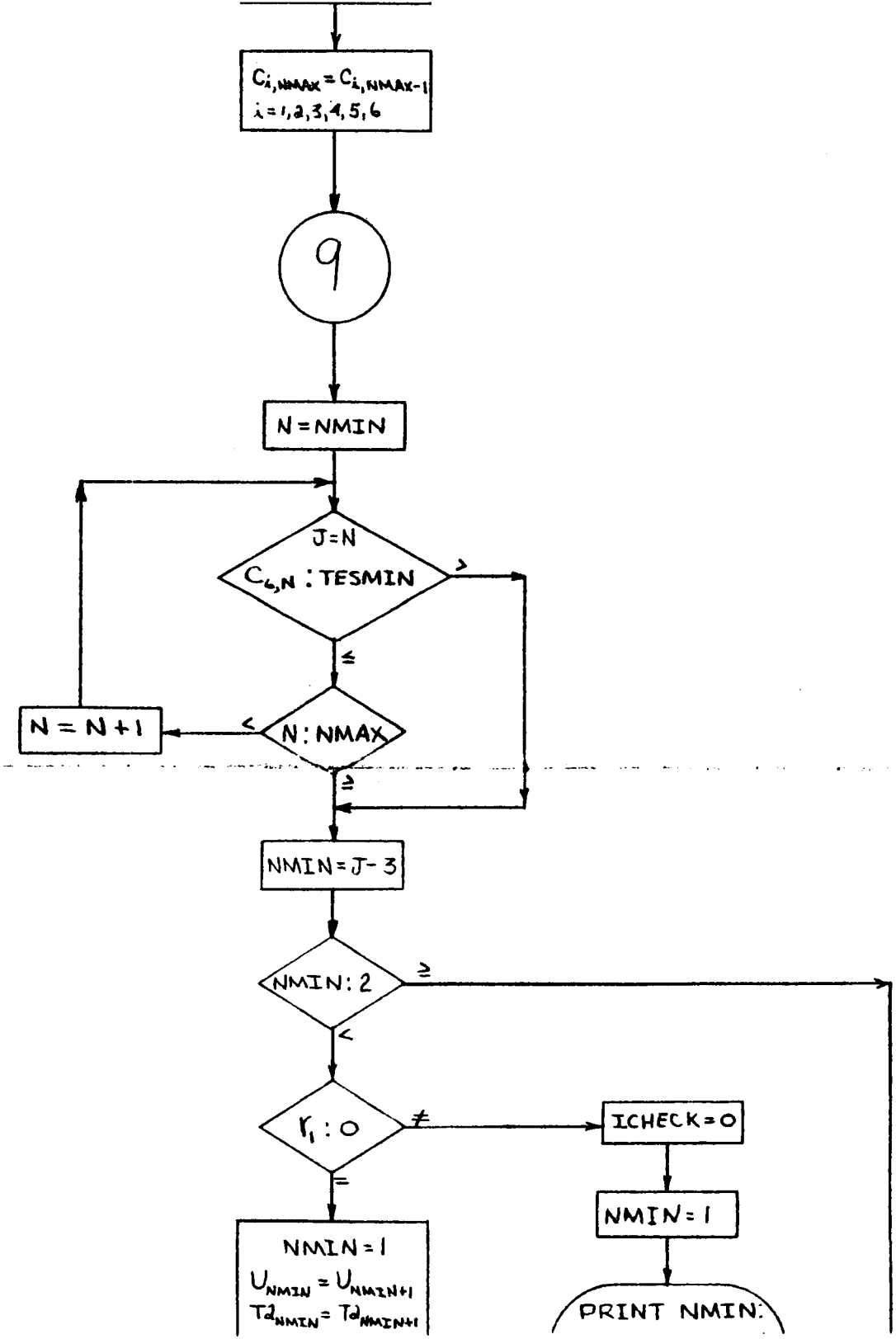
APR				THE BOEING COMPANY	PAGE D-72


8
$U_{NMAX} = U_{NMAX-1}$
$T2_{NMAX} = T2_{NMAX-1}$
$C_{i,NMAX} = C_{i,NMAX-1}$
$i = 1,2,3,4,5,6$
9
N = NMIN
J = N
$C_{6,N}$: TESMIN
>
≤
N : NMAX
<
N = N + 1

U3 4038 8000



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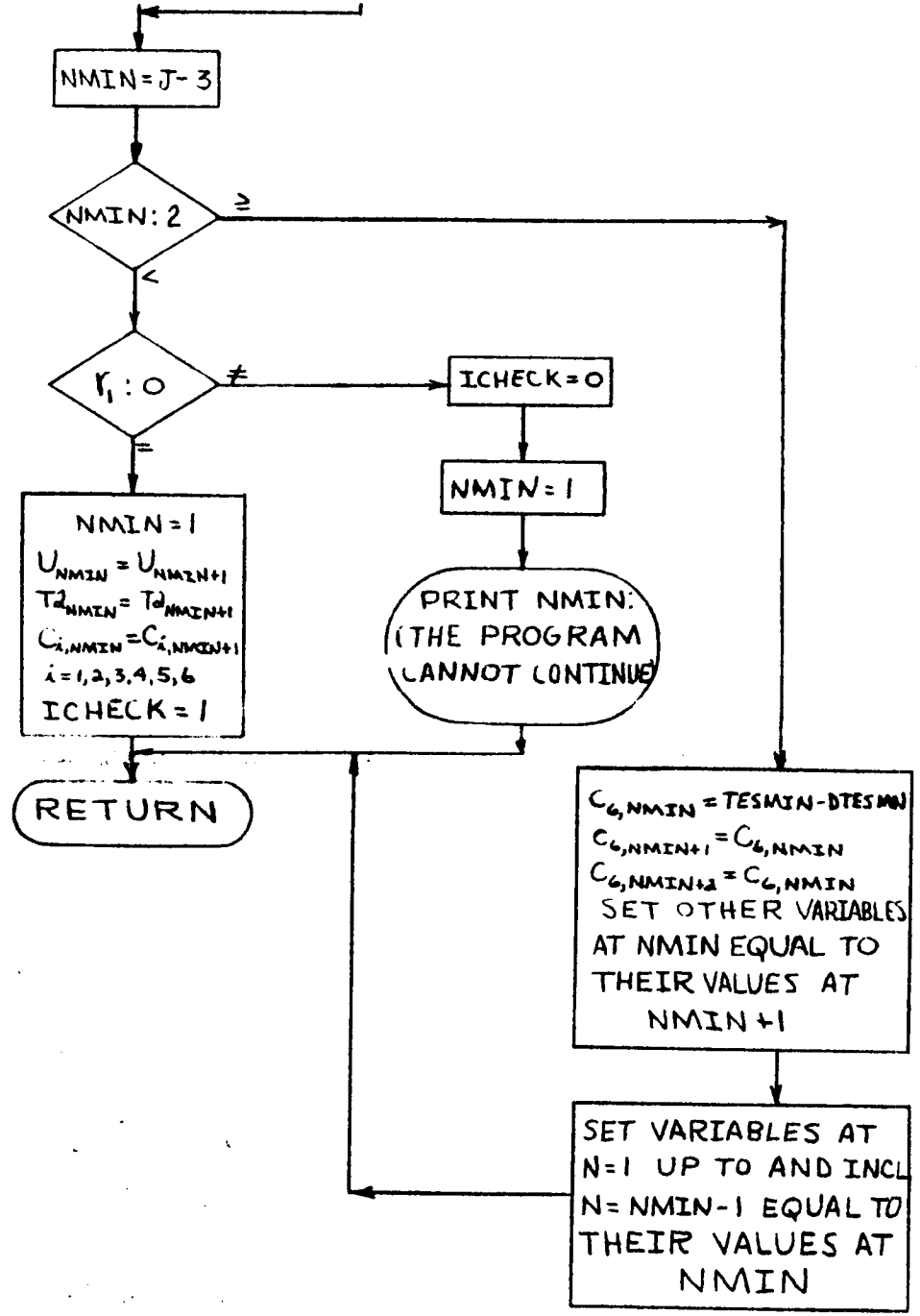
				APR
				REVISED



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NONEQ3

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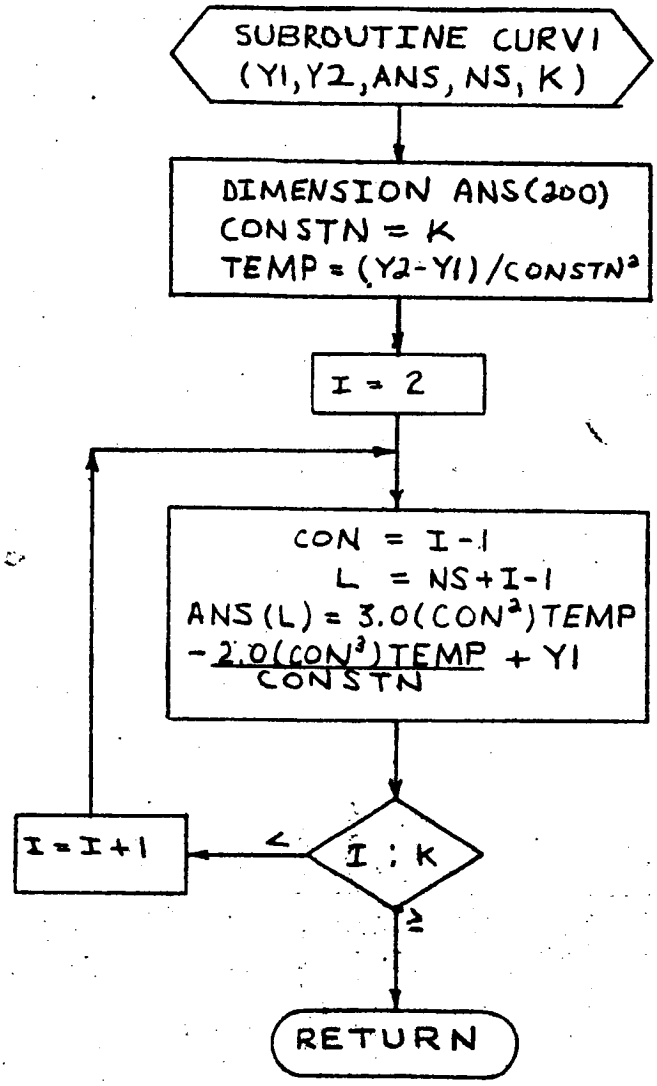

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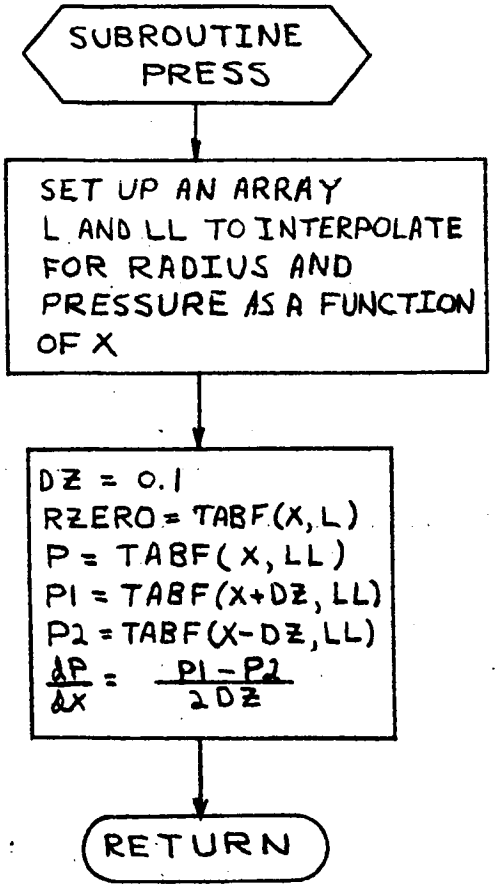
CHECK						AS 1927
APR						
APR					BOEING AIRPLANE COMPANY	PAGE D-74

U3 4038 8000 (WAS BAC 1017 R5)

2-7000



CALC			REVISED	DATE	PRESS	
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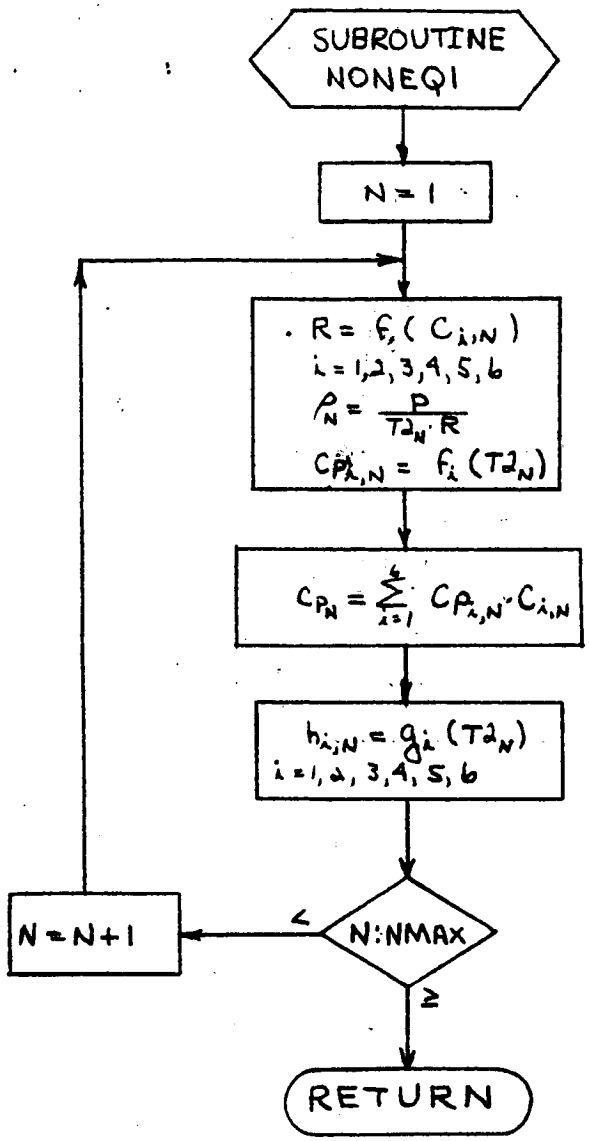
APR						
APR					BOEING AIRPLANE COMPANY	PAGE D-75

U3 4038 8000 (WAS BAC 1017 R5)

2-7000



CALC			REVISED	DATE	NONEQI	
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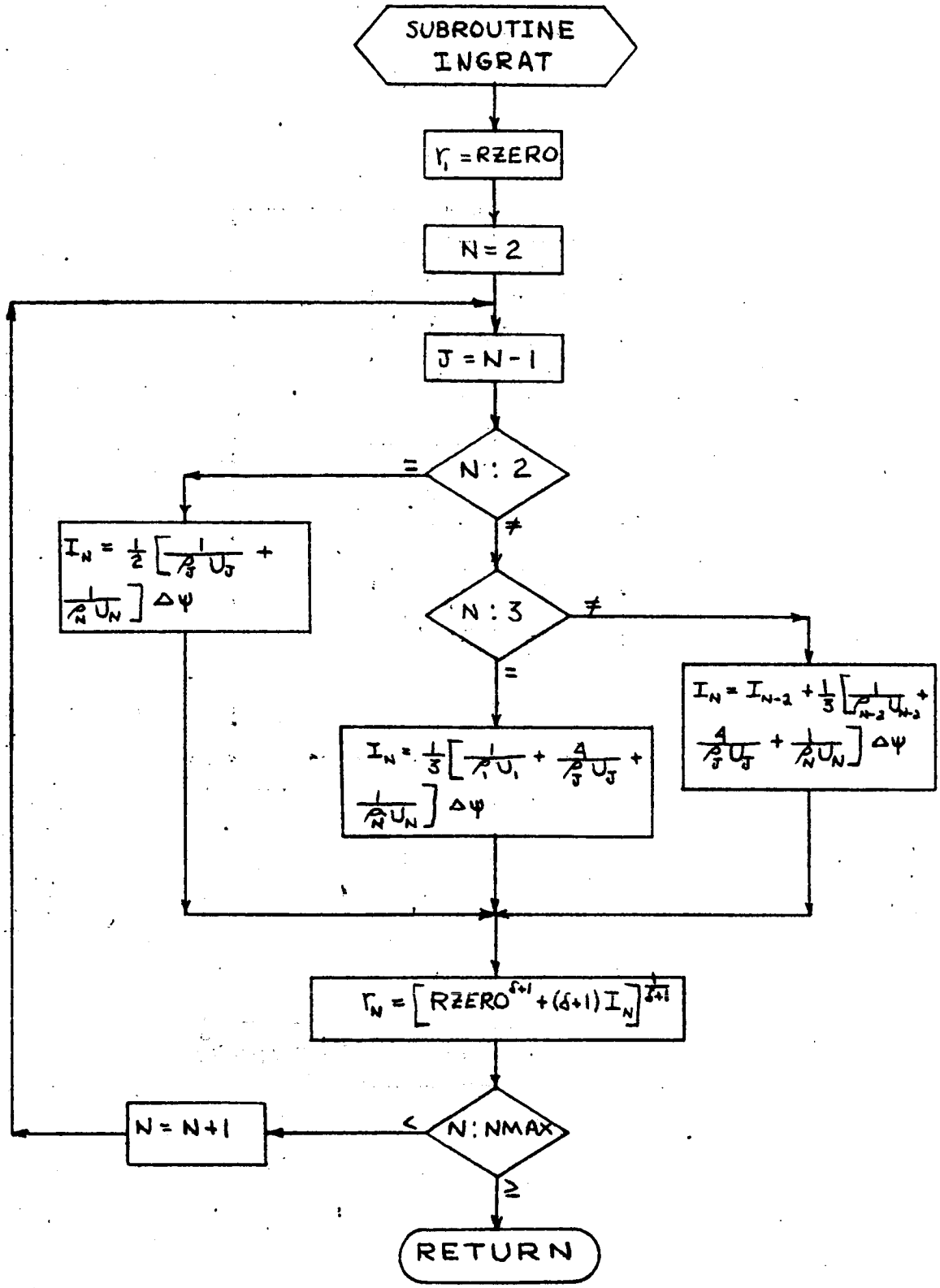
APR						
APR					BOEING AIRPLANE COMPANY	PAGE D-76



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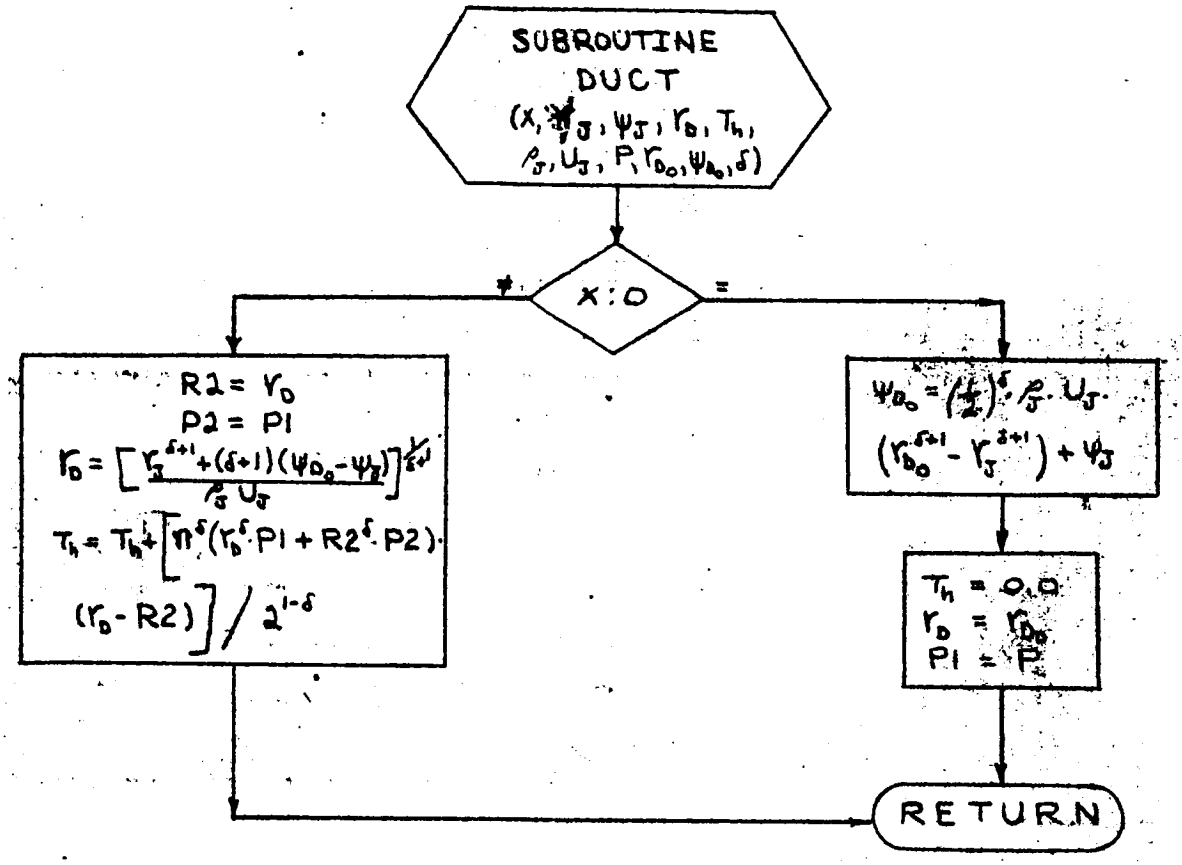
APR					BOEING AIRPLANE COMPANY	PAGE D-77

U3 4038 8000 (WAS BAC 1017 R5) 2-7000



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APR						AS 1927
APR					BOEING AIRPLANE COMPANY	PAGE D-78

U3 4038 8000 (WAS BAC 1017 R5)

2-7000

SYMBOLIC DECK SEQUENCE NUMBERS

PROGRAM NAME	SEQUENCE NUMBERS
PLUME (Chain version)	19270001 - 19271012
EQUSS	19271013 - 19271024
EQUSP	19271025 - 19271036
EQUSRO	19271037 - 19271050
EQUSH	19271051 - 19271063
EQUSAV	19271064 - 19271071
EQUST	19271072 - 19271079
EQUSHP	19271080 - 19271091
PSEC	19271092 - 19271229
DATE	19271230 - 19271256
PRIDAT	19271257 - 19271264
PMXPAV	19271265 - 19271351
STORE	19271352 - 19271374
INTER	19271375 - 19271410
PTFTAX	19271411 - 19271508
INTRPT	19271509 - 19271645
PAMBPT	19271646 - 19271726
INSHPT	19271727 - 19271962
PTOTAX	19271963 - 19272018
MIX-MASTER (chain version)	19272019 - 19272365
CURV1	19272366 - 19272379
PRESS	19272380 - 19272442
NONEQ1	19272443 - 19272492
INGRAT	19272493 - 19272534
DUCT	19272535 - 19272556
NONEQ3	19272557 - 19272808
PLUME(non-chain version)	19272809 - 19273811
MIX-MASTER (non-chain version)	19273812 - 19274148

BINARY DECK SEQUENCE NUMBERS

PROGRAM NAME	SEQUENCE NUMBERS
PLUME (chain version)	19270001 - 19270231
EQUSS	19270232 - 19270236
EQUSP	19270237 - 19270241
EQUSRO	19270242 - 19270246
EQUSH	19270247 - 19270252
EQUSAV	19270253 - 19270255
EQUST	19270256 - 19270258
EQUSHP	19270259 - 19270263
PSEC	19270264 - 19270294
DATE	19270295 - 19270297
PRIDAT	19270298 - 19270300
PMXPAV	19270301 - 19270321
STORE	19270322 - 19270327
INTER	19270328 - 19270338
PTFTAX	19270339 - 19270371
INTRPT	19270372 - 19270412
PAMBT	19270413 - 19270438
INSHPT	19270439 - 19270515
PTOTAX	19270516 - 19270533
MIX-MASTER (chain version)	19270534 - 19270635
CURV1	19270636 - 19270641
PRESS	19270642 - 19270651
NONEQ1	19270652 - 19270671
INGRAT	19270672 - 19270680
DUCT	19270681 - 19270691
NONEQ3	19270692 - 19270775
PLUME (non-chain version)	19270776 - 19271003
MIX-MASTER (non-chain version)	19271004 - 19271104

```
C     PLUME MAIN PROGRAM                                                19270001
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS   19270002
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN    19270003
* * * *     CONSENT OF THE BOEING COMPANY.                              19270004
C**** PLUME IS A CHAIN PROGRAM ****                                     19270005
      DIMENSION R(1000), Z(1000), XMN(1000), THET(1000), RHO(1000),     19270006
     1PRESS(1000), XV(1000), S(1000), KEY(1000), IKEEP(50), NNSAV(50),  19270007
     2KKKSAV(50), T(1000), JKEEP(50), TR(200), TZ(200), TXMN(200),      19270008
     3TTHET(200), TRHO(200), TPRESS(200), TXV(200), TS(200)             19270009
F     EQUSS, EQUSP, EQUSRO, EQUSAV, EQUST, EQUSHP                       19270010
      COMMON PT, RHOT, TT, ST, GAMMA, CP                                19270011
      DIMENSION BB(100), TITLE(12)                                      19270012
      COMMON NPORA, INDP, NPP, WSEC, PTSEC, TTSEC, GSEC, RSEC, RN, BB   19270013
      COMMON ASEC, XMSEC, ASSEC, ISTS                                   19270014
      COMMON CPH                                                        19270015
      SJ=5.0E+3                                                         19270016
      ST = SJ                                                           19270017
      NDXP = 0                                                          19270018
      VACMN = 0.0                                                       19270019
      DELTA = 0.0                                                       19270020
      EPSLON = 1.0E-5                                                   19270021
      FACT = 1.0/512.0                                                  19270022
      NITER=100                                                         19270023
      EPS1=8.725E-3                                                     19270024
      EPS2=8.725E-3                                                     19270025
      EPS3=1.0E-3                                                       19270026
      EPS4=1.0                                                          19270027
      EPS5=1.0E-5                                                       19270028
      SPTS=10.0                                                         19270029
      ERR1=1.0E-4                                                       19270030
      ERR2=1.0E-4                                                       19270031
      ERR3=1.0E-3                                                       19270032
      SDLIM=0.50                                                        19270033
      SPTRC=0.30                                                        19270034
      SPTLC=0.20                                                        19270035
      SPTX=0.20                                                         19270036
   12 CONTINUE                                                          19270037
      READ INPUT TAPE 5, 7002, TITLE                                    19270038
 7002 FORMAT(12A6)                                                      19270039
      READ INPUT TAPE 5, 10000, LSTART, INDP, NPP, NPORA,ISTS           19270040
```

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```
      READ INPUT TAPE 5, 10001, ALT, GMN, GAMJ, TEMPJ, PJ, RGCJ, RN,
     1CPH, TXD, DBFL
      IF (NPORA) 10002, 10003, 10002
10002 READ INPUT TAPE 5, 10001, WSEC, PTSEC, TTSEC, GSEC, RSEC
10003 READ INPUT TAPE 5, 10001, (BB(I),I=1,NPP)
10000 FORMAT(6I4)
10001 FORMAT(8F10.0)
      CALL PSEC(0.0,1.0,PAMB,0.0,0.0)
      DELTHE=0.10
      XDLM=TXD
      SNDD=DBFL/DELTHE +0.001
      DELTHE=DELTHE/57.29578
      CALL DATE(1)
      WRITE OUTPUT TAPE 6,8000
 8000 FORMAT(1H ,55X,7HSPURT-A)
      WRITE OUTPUT TAPE 6,8001
 8001 FORMAT(1H0,30X52HMETHOD OF CHARACTERISTICS PROGRAM FOR THE SUPERSO
     1NIC/1H 34X44HFLOW FIELD IN THE AIR-AUGMENTED ROCKET DUCT.)
      IF(CPH)8002,8002,8004
 8002 WRITE OUTPUT TAPE 6,8003
 8003 FORMAT(1H0,50X,18H2-DIMENSIONAL FLOW)
      GO TO 8006
 8004 WRITE OUTPUT TAPE 6,8005
 8005 FORMAT(1H0,50X,17HAXISYMMETRIC FLOW)
 8006 WRITE OUTPUT TAPE 6,8007
 8007 FORMAT(1H0,3X,5HUNITS//1H ,7X,37HTEMPERATURE.............DEGREES RAN
     1KINE/1H ,7X,33HPRESSURE................LBS./SQ.FT./1H ,7X,35HMACH NU
     2MBER............DIMENSIONLESS/1H ,7X,35HGAMMA....................DIMEN
     3SIONLESS/1H ,7X,53HGAS CONSTANT..........FT.LBS./LB.MASS--DEGREE R
     4ANKINE/1H ,7X,71HFLOW ANGLE (THETA)....DEGREES-MEASURED WITH RESPE
     5CT TO AXIS OF SYMMETRY/1H ,7X,71HSHOCK ANGLE............DEGREES-MEA
     6SURED WITH RESPECT TO AXIS OF SYMMETRY/1H ,7X,37HDENSITY..........
     7.....SLUGS/CUBIC FT./1H ,7X,30HVELOCITY................FT./SEC.)
      WRITE OUTPUT TAPE 6,8008
 8008 FORMAT(1H0,4X,4HNOTE//1H ,6X,92HINTERSECTION OF JET EXIT PLANE AND
     1 JET AXIS OF SYMMETRY TAKEN AS ORIGIN OF COORDINATE SYSTEM/1H ,11X
     2,10HX=ABSCISSA/12X,10HY=ORDINATE/8X,34HBOTH X AND Y ARE MEASURED I
     3N FEET.)
      WRITE OUTPUT TAPE 6,8009,PAMB,ALT
 8009 FORMAT(1H0,3X,85HIDENTIFICATION OF POINTS ALONG A LEFT RUNNING CHA
```

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```
     1RACTERISTIC WITHIN THE EXHAUST PLUME//1H ,11X,6HIDENT.,8X,15HNATUR19270081
     2E OF POINT//1H ,13X,35H0.....POINT ON THE AXIS OF SYMMETRY/1H ,13X19270082
     3,20H2.....INTERIOR POINT/1H ,13X51H3.....UPSTREAM AND DOWNSTREAM I19270083
     4NTERIOR SHOCK POINTS/1H ,13X,51H4.....CONSTANT PRESSURE BOUNDARY P19270084
     5OINT INSIDE PLUME///1H ,3X,19HAMBIENT PRESSURE = F10.4,21X,11HALTI19270085
     6TUDE = F10.2,4H FT.//)                                            19270086
      IF(LSTART)8010,8010,300                                           19270087
 8010 THETAJ=0.0                                                        19270088
      WRITE OUTPUT TAPE 6,8011,GMN,GAMJ,TEMPJ,PJ,RGCJ,THETAJ            19270089
 8011 FORMAT(1H0,3X,50HJET EXIT CONDITIONS ( CONSTANT ACROSS EXIT PLANE 19270090
     1)//1H ,6X,14HMACH NUMBER = F10.4/1H ,6X,8HGAMMA = F10.4/1H ,6X,14H19270091
     2TEMPERATURE = F10.4/1H ,6X,11HPRESSURE = F10.4/1H ,6X,15HGAS CONST19270092
     3ANT = F10.4/1H ,6X,13HFLOW ANGLE = F10.4)                         19270093
      WRITE OUTPUT TAPE 6, 7000, RN                                     19270094
 7000 FORMAT(7X,16HNOZZLE RADIUS = F10.4)                               19270095
      GO TO 301                                                         19270096
  300 READ INPUT TAPE 5,302,(TZ(I),TR(I),TTHET(I),TXMN(I),TPRESS(I),    19270097
     1I=1,LSTART)                                                       19270098
  302 FORMAT(5F10.0)                                                    19270099
      THETAJ=TTHET(1)/57.29578                                          19270100
      CP=(GAMJ*RGCJ)/(GAMJ-1.0)                                         19270101
      T(1)=TEMPJ                                                        19270102
      HJS=CP*TEMPJ*32.2                                                 19270103
      A=SQRTF((GAMJ-1.0)*HJS)                                           19270104
      TXV(1)=A*TXMN(1)                                                  19270105
      HTJ=0.5*(TXV(1)**2)+HJS                                           19270106
      TT=HTJ/(CP*32.2)                                                  19270107
      TRHO(1)=TPRESS(1)/(RGCJ*T(1)*32.2)                                19270108
      DO 303 I=2,LSTART                                                 19270109
      T(I)=TT*(2.0/(2.0+(GAMJ-1.0)*(TXMN(I)**2)))                       19270110
      HJS=T(I)*CP*32.2                                                  19270111
      TXV(I)=SQRTF(2.0*(HTJ-HJS))                                       19270112
      TRHO(I)=TPRESS(I)/(RGCJ*T(I)*32.2)                                19270113
  303 TS(I)=SJ                                                          19270114
      WRITE OUTPUT TAPE 6,8012,(TZ(I),TR(I),TTHET(I),TXMN(I),           19270115
     1TXV(I),TPRESS(I),T(I),TRHO(I),I=1,LSTART)                         19270116
 8012 FORMAT(1H0,35X,48HDISTRIBUTION OF CONDITIONS ACROSS JET EXIT PLANE19270117
     1 //1H ,7X,1HX,13X,1HY,12X,5HTHETA,9X,8HMACH NO.,7X,8HVELOCITY,7X,819270118
     2HPRESSURE,5X,11HTEMPERATURE,6X,7HDENSITY//(1H ,2X,F10.4,5X,F10.4,519270119
     3X,F10.4,5X,F10.4,5X,F10.4,5X,F10.4,5X,F10.4,5X,F10.4))            19270120
```

```
      WRITE OUTPUT TAPE 6,8013,GAMJ,RGCJ                                19270121
 8013 FORMAT(1H0,6X,8HGAMMA = F10.4,7X,15HGAS CONSTANT = F10.4,7X,40HTHE19270122
     1SE ARE CONSTANT ACROSS JET EXIT PLANE)                            19270123
      DO 7999 I=1,LSTART                                                19270124
      TZ(I) = TZ(I)/RN                                                  19270125
      TR(I) = TR(I)/RN                                                  19270126
 7999 TTHET(I)=TTHET(I)/57.29578                                        19270127
      WRITE OUTPUT TAPE 6, 7000, RN                                     19270128
  301 CONTINUE                                                          19270129
      WRITE OUTPUT TAPE 6, 7001, CPH, TXD, DBFL                         19270130
 7001 FORMAT(4X,16HPROGRAM CONTROLS/7X,3HCPHF11.4/7X,3HTXDF11.4/7X,4HDBF19270131
     1LF10.4)                                                           19270132
      WRITE OUTPUT TAPE 6, 7004, TITLE                                  19270133
 7004 FORMAT(1H012A6)                                                   19270134
      WRITE OUTPUT TAPE 6, 7003, (BB(I),I=1,NPP)                        19270135
 7003 FORMAT(1X7F14.5)                                                  19270136
      IF (NPORA) 10004, 10005, 10004                                    19270137
10004 WRITE OUTPUT TAPE 6, 7005, WSEC, PTSEC, TTSEC, GSEC, RSEC, ASSEC 19270138
 7005 FORMAT(25HOFOR THE SECONDARY STREAM/7X12HMASS FLOW = F10.4/7X17HTO19270139
     1TAL PRESSURE = F10.4/7X20HTOTAL TEMPERATURE = F10.4/7X7HGAMA = F1019270140
     2.4/7X15HGAS CONSTANT = F10.4/7X9HA STAR = F10.4)                  19270141
10005 CONTINUE                                                          19270142
      IF (ASEC-ASSEC) 10007, 10008, 10008                               19270143
10008 INDINS = 0                                                        19270144
      TXD = TXD/RN                                                      19270145
      NDD = SNDD                                                        19270146
      PY = 0.1                                                          19270147
      A1 = THETAJ                                                       19270148
      A2 = THETAJ-ASINF(1.0/GMN)                                        19270149
      TA2 = TANF(A2)                                                    19270150
      CP = (GAMJ*RGCJ)/(GAMJ-1.0)                                       19270151
      HJS = CP*TEMPJ*32.2                                               19270152
      A = SQRTF((GAMJ-1.0)*HJS)                                         19270153
      V = A*GMN                                                         19270154
      HTJ = HJS+0.5*(V**2)                                              19270155
      RHOJ = PJ/(RGCJ*TEMPJ*32.2)                                       19270156
      GAMMA = GAMJ                                                      19270157
      PT = PJ                                                           19270158
      RHOT = RHOJ                                                       19270159
      TT = TEMPJ                                                        19270160
```

```
      IF (LSTART) 304, 305, 304
  304 PRESS(2) = TPRESS(1)
      XMN(2) = TXMN(1)
      THET(2) = TTHET(1)
      RHO(2) = TRHO(1)
      XV(2) = TXV(1)
      KEY(2) = 2
      I = 3
      LST = 1
      GO TO 600
  305 PRESS(1) = PJ
      XMN(1) = GMN
      THET(1) = THETAJ
      RHO(1) = RHOJ
      XV(1) = V
      KEY(1) = 2
      I = 2
      LST = 0
  600 P = 0.0
      CALL PMXPAV (EQUSAV,EQUST,EQUSHP,HTJ,PJ,THETAJ,SJ,VACMN,DELTHE,
     1DELTA,EPSLON,PAMB,THETAX,BETAX,VX,P,NDXP,M)
      PRESS(I) = P
      THET(I) = THETAX
      XMN(I) = 1.0/(SINF(BETAX))
      XV(I) = VX
      PJ = P
    3 THETAJ = THETAX
      IF (M) 604, 603, 604
  603 I = I+1
      GO TO 600
  604 N = I
      J = 2+LST
      I = NDD+1+LST
  900 PRESS(J) = PRESS(I)
      THET(J) = THET(I)
      XMN(J) = XMN(I)
      XV(J) = XV(I)
      KEY(J)=2
      I = I+NDD
      J = J+1
```

```
      IF (I-N) 900, 901, 901
  901 PRESS(J) = PRESS(N)
      THET(J) = THET(N)
      XMN(J) = XMN(N)
      XV(J) = XV(N)
      N = J
      VXMN = 1.0/(SINF(BETAX))
      PRESS(N) = P
      XMN(N) = VXMN
      THET(N) = THETAX
      XV(N) = VX
      KEY(N) = 4
      ZAP = 1.0/GAMJ
      IF (LSTART) 306, 307, 306
  306 ILL = 3
      GO TO 308
  307 ILL = 2
  308 DO 4 J=ILL, N
    4 RHO(J) = RHO(J-1)/((PRESS(J-1)/PRESS(J))**ZAP)
      ILL = ILL-1
      DO 5 L=ILL, N
      R(L) = 1.0
      THET(L) = THET(L)*57.29578
      T(L) = (PRESS(L))/(RHO(L)*RGCJ*32.174)
      S(L) = SJ
      R(L) = R(L)*RN
    5 Z(L) = 0.0
      WRITE OUTPUT TAPE 6, 7, (Z(I),R(I),XMN(I),THET(I),RHO(I),PRESS(I),
     1T(I),I=ILL,N)
    7 FORMAT(14H0PRANDTL-MEYER//119H IDENT.        X                Y
     1   MACH NO.          THETA          DENSITY       PRESSURE      TEMPERAT
     2URE    SHOCK ANGLE/(9H          E12.5,2H  E12.5,2H  F12.5,2H  E12.5,
     32H  E12.5,2H  F12.5,2H  E12.5))
      CALL STORE(Z(N),R(N),PRESS(N),0)
      DO 902 L=ILL, N
      R(L) = R(L)/RN
  902 THET(L) = THET(L)/57.29578
      VVV= XV(N)
      WRITE OUTPUT TAPE 6, 7006, VVV
 7006 FORMAT(33H JET VELOCITY AT THE SLIP LINE = E12.5,9H  FT/SEC.)
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      IF (NPORA) 7601, 7603, 7601                                       19270241
 7601 WRITE OUTPUT TAPE 6, 7602, ASEC, XMSEC                            19270242
 7602 FORMAT(26H SECONDARY STREAM, AREA = F10.4,13H, MACH NO. = F10.4)  19270243
      IF (ASEC/ASSEC-0.9) 10007, 10007, 7603                            19270244
 7603 CONTINUE                                                          19270245
      IF (PRESS(N)-288.0) 1313, 1313, 7604                              19270246
 7604 CONTINUE                                                          19270247
      IP3=0                                                             19270248
      JP = 1000                                                         19270249
      ISTP = 0                                                          19270250
      JERK = 0                                                          19270251
      MM = 0                                                            19270252
      KKK = 0                                                           19270253
      KK = 0                                                            19270254
      NN = 0                                                            19270255
      LPR = 0                                                           19270256
      LPRC = 0                                                          19270257
      ITES = 0                                                          19270258
      NSP = 0                                                           19270259
      K = 1                                                             19270260
      INSERT = 0                                                        19270261
   20 IF (LSTART) 309, 310, 309                                         19270262
  309 IF (K-1) 311, 312, 311                                            19270263
  312 NSP = 1                                                           19270264
      DELR = TR(NSP)-TR(NSP+1)                                          19270265
      DRN = FACT*DELR                                                   19270266
      DRNT = DRN                                                        19270267
      DRNTT = DRN                                                       19270268
  313 DRNDLR = DRNTT/DELR                                               19270269
      Y3 = TR(NSP)+DRNDLR*(TR(NSP+1)-TR(NSP))                           19270270
  315 X3 = TZ(NSP)+DRNDLR*(TZ(NSP+1)-TZ(NSP))                           19270271
      XMN(1) = TXMN(NSP)+DRNDLR*(TXMN(NSP+1)-TXMN(NSP))                 19270272
      THET(1) = TTHET(NSP)+DRNDLR*(TTHET(NSP+1)-TTHET(NSP))             19270273
      RHO(1) = TRHO(NSP)+DRNDLR*(TRHO(NSP+1)-TRHO(NSP))                 19270274
      PRESS(1) = TPRESS(NSP)+DRNDLR*(TPRESS(NSP+1)-TPRESS(NSP))         19270275
      XV(1) = TXV(NSP)+DRNDLR*(TXV(NSP+1)-TXV(NSP))                     19270276
      S(1) = 5.0E+3                                                     19270277
      KEY(1) = 2                                                        19270278
      TY4 = Y4                                                          19270279
      TY1 = R(2)                                                        19270280
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      IF (Y3-0.01) 4325, 4325, 802                                      19270281
 4325 NSP = LSTART                                                      19270282
      GO TO 314                                                         19270283
  311 IF (K-11) 316, 4321, 317                                          19270284
 4321 DRN = 1.0/SPTS                                                    19270285
      GO TO 317                                                         19270286
  316 DRN = DRNT*(2.0**(K-2))                                           19270287
  317 IF (MM-2) 318, 319, 319                                           19270288
  319 BET9 = ASINF(1.0/XMN9)                                            19270289
      TMB9 = THET9-BET9                                                 19270290
      CALL INTER(EPS1,ALPH1,TMB9,X4,Z9,Y4,R9,Z15,R15)                   19270291
      IF (MM-2) 320, 321, 320                                           19270292
  320 PY = 0.75*((R(2)-TY1)/(1.0-TY1-((Y4-1.0)*(1.0-TY1))/(TY4-1.0)))   19270293
  321 DR5 = (1.0-R(2)-((R15-1.0)*(1.0-R(2)))/(Y4-1.0))*PY               19270294
      IF (DRN-ABSF(DR5)) 318, 318, 322                                  19270295
  318 DRNTT = DRNTT+DRN                                                 19270296
      GO TO 323                                                         19270297
  322 DRNTT = DRNTT-DR5                                                 19270298
  323 IF (DRNTT/DELR-1.0) 313, 313, 324                                 19270299
  324 DRNTT = DRNTT-DELR                                                19270300
      NSP = NSP+1                                                       19270301
      DELR = TR(NSP)-TR(NSP+1)                                          19270302
      IF (LSTART-NSP) 314, 314, 323                                     19270303
  314 Z(1) = TZ(LSTART)                                                 19270304
      R(1) = TR(LSTART)                                                 19270305
      XMN(1) = TXMN(LSTART)                                             19270306
      THET(1) = TTHET(LSTART)                                           19270307
      RHO(1) = TRHO(LSTART)                                             19270308
      PRESS(1) = TPRESS(LSTART)                                         19270309
      XV(1) = TXV(LSTART)                                               19270310
      S(1) = TS(LSTART)                                                 19270311
      X3 = Z(1)                                                         19270312
      Y3 = R(1)                                                         19270313
      NSP = -NSP                                                        19270314
      LSTART = -LSTART                                                  19270315
      GO TO 802                                                         19270316
  310 IF (K-1) 811, 800, 811                                            19270317
  811 IF (K-11) 503, 503, 39                                            19270318
  503 DRN = DRNT*(2.0**(K-2))                                           19270319
      DXN = DXNT*(2.0**(K-2))                                           19270320
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   39 X3 = Z(1)+DXN                                                    19270321
      Y3 = R(1)-DRN                                                    19270322
      IF(JERK) 808,21,808                                              19270323
  800 DELR = 1.0/SPTS                                                  19270324
      Y1 = 1.0-FACT*DELR                                               19270325
      X1 = 0.0                                                         19270326
      Y2 = 1.0                                                         19270327
      X2 = 0.0                                                         19270328
      CALL INTER(EPS1,A1,A2,X1,X2,Y1,Y2,X3,Y3)                         19270329
      DXN = X3-Z(1)                                                    19270330
      DRN = R(1)-Y3                                                    19270331
      DXNT = DXN                                                       19270332
      DRNT = DRN                                                       19270333
   21 IF (MM-2) 4323, 801, 801                                         19270334
 4323 IF (Y3-0.01) 816, 816, 802                                       19270335
  801 IF (MM-2) 814, 812, 814                                          19270336
  812 KSAV = K                                                         19270337
      K = 2                                                            19270338
  814 IF (K-2) 802, 803, 803                                           19270339
  803 BET9 = ASINF(1.0/XMN9)                                           19270340
      TMB9 = THET9-BET9                                                19270341
      CALL INTER(EPS1,ALPH1,TMB9,X4,Z9,Y4,R9,Z15,R15)                  19270342
      IF (K-2) 804, 805, 804                                           19270343
  805 IF (ALPH1-0.873) 610, 611, 611                                   19270344
  611 DR5 = (1.0-R(1)-((R15-1.0)*(1.0-R(1)))/(Y4-1.0))*PY              19270345
      DX5 = DR5/TA2                                                    19270346
      TY1 = R(1)                                                       19270347
      TX1 = Z(1)                                                       19270348
      GO TO 813                                                        19270349
  610 DX5 = (0.8*(Z15-X4)*Z(1))/X4                                     19270350
      DR5 = DX5*TA2                                                    19270351
      TX1 = Z(1)                                                       19270352
      TY1 = R(1)                                                       19270353
  813 IF (DRN-ABSF(DR5)) 806, 806, 807                                 19270354
  806 X3 = Z(1)+DXN                                                    19270355
      Y3 = R(1)-DRN                                                    19270356
      DX5 = DXN                                                        19270357
      DR5 = DRN                                                        19270358
      GO TO 808                                                        19270359
  807 X3 = Z(1)+DX5                                                    19270360
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      Y3 = R(1)+DR5                                                     19270361
  808 IF (Y3-0.01) 816, 816, 809                                        19270362
  809 I = 1                                                             19270363
      J = 2                                                             19270364
      TX4 = X4                                                          19270365
      TY4 = Y4                                                          19270366
      IF (K-2) 60, 810, 60                                              19270367
  810 X50 = 0.0                                                         19270368
      X60 = 0.0                                                         19270369
      K = KSAV                                                          19270370
      GO TO 60                                                          19270371
  804 IF (ALPH1-0.873) 612, 613, 613                                    19270372
  613 PY = 0.75*((1.0-R(1))*(TY4-1.0))/((Y4-1.0)*(1.0-TY1))             19270373
      X50 = TX1                                                         19270374
      X60 = TX4                                                         19270375
      GO TO 611                                                         19270376
  612 PX = (DX5*(TX4-X60))/((X4-TX4)*(TX1-X50))                         19270377
      X50 = TX1                                                         19270378
      X60 = TX4                                                         19270379
      DX5 = (0.9*PX*(Z15-X4)*(Z(1)-X50))/(X4-X60)                       19270380
      DR5 = DX5*TA2                                                     19270381
      TX1 = Z(1)                                                        19270382
      TY1 = R(1)                                                        19270383
      GO TO 813                                                         19270384
  816 JP = K                                                            19270385
      GO TO 1400                                                        19270386
  802 I = 1                                                             19270387
      J = 2                                                             19270388
   60 Z(I) = X3                                                         19270389
      R(I) = Y3                                                         19270390
    9 THET1 = THET(I)                                                   19270391
      S1 = S(I)                                                         19270392
      V1 = XV(I)                                                        19270393
      STEST = THET(I)+ASINF(1.0/XMN(I))                                 19270394
   22 THET2 = THET(J)                                                   19270395
      V2 = XV(J)                                                        19270396
      S2 = S(J)                                                         19270397
      R2 = R(J)                                                         19270398
      Z2 = Z(J)                                                         19270399
      IF (NSP) 331, 332, 332                                            19270400
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```
  331 CALL PTFTAX(EQUSAV,EQUST,X3,V1,S1,THFT2,R2,Z2,V2,S2,HTJ,NITFR,     19270401
     1EPS1,EPS3,EPS4,EPS5,Z3,R3,S3,V3,THFT3)                            19270402
      NSP = -NSP                                                        19270403
      GO TO 24                                                          19270404
  332 IF (KEY(J)-3) 52, 51, 52                                          19270405
   52 CALL INTRPT (EQUSAV,EQUST,THFT1,Y3,X3,V1,S1,THFT2,R2,Z2,V2,S2,HTJ,19270406
     XNITFR,EPS1,EPS2,EPS3,EPS4,EPS5,Z3,R3,S3,V3,THFT3)                 19270407
      D23 = SQRTF((Z3-Z2)**2+(R3-R2)**2)                                19270408
      IF (MM-2) 713, 714, 714                                           19270409
  713 DLIM = SDLIM                                                      19270410
      GO TO 715                                                         19270411
  714 DLIM = SDLIM+SPTRC*SQRTF(R3**2+Z3**2)                             19270412
  715 IF (D23-DLIM) 701, 700, 700                                       19270413
  700 IF (KEY(J)-13) 3005, 24, 3005                                     19270414
 3005 IF (NN) 24, 3011, 24                                              19270415
 3011 LPR = LPR+1                                                       19270416
      IKEEP(LPR) = I                                                    19270417
      JKEEP(LPR) = J                                                    19270418
      NNSAV(LPR) = NN                                                   19270419
      KKKSAV(LPR) = KKK                                                 19270420
      P = 2.0                                                           19270421
      R3 = R2+0.5*(R3-R2)                                               19270422
      Z3 = Z2+0.5*(Z3-Z2)                                               19270423
      S3 = S2+0.5*(S3-S2)                                               19270424
      V3 = V2+0.5*(V3-V2)                                               19270425
      THFT3 = THFT2+0.5*(THFT3-THFT2)                                   19270426
      GO TO 24                                                          19270427
  701 IF(ABSF(STEST)-3.14159)90,123,123                                 19270428
  123 IF(ABSF(Z3)-ABSF(X3))23,23,24                                     19270429
   90 IF(R3-Y3) 23,24,24                                                19270430
   23 IF (MM-2) 169, 170, 170                                           19270431
  170 IF (KEY(I)-3) 2222, 3333, 2222                                    19270432
 2222 IF (KEY(I-1)-3) 4444, 3333, 4444                                  19270433
 3333 KEY(I) = 1                                                        19270434
      J = J+1                                                           19270435
      GO TO 22                                                          19270436
 4444 KEY(I) = 13                                                       19270437
      IXD = Z(I)                                                        19270438
      JERK = 1                                                          19270439
      ISTP = 1                                                          19270440
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      GO TO 37                                                          19270441
  169 KEY(I) = 3                                                        19270442
      X4 = X3                                                           19270443
      Y4 = Y3                                                           19270444
      XM = XMN(I)                                                       19270445
      BET1 = ASINF(1.0/XM)                                              19270446
      ALPH1 = THET(I)-BET1                                              19270447
      IF (KEY(J)-4) 62, 63, 62                                          19270448
   63 J = J-NN                                                          19270449
      KEY(J) = 4                                                        19270450
      IF (NN-1) 66, 666, 66                                             19270451
  666 JJ = INSERT                                                       19270452
      GO TO 66                                                          19270453
   62 NN = NN+1                                                         19270454
      MM = 1                                                            19270455
      J = J+1                                                           19270456
      GO TO 22                                                          19270457
   24 H3 = HTJ-0.5*(V3**2)                                              19270458
      CALL EQUSAV (H3,S3,AV3)                                           19270459
      CALL EQUSP (H3,S3,P3)                                             19270460
      CALL EQUSRO (H3,S3,RO3)                                           19270461
      IF (NN) 25, 26, 25                                                19270462
   25 J = J-NN                                                          19270463
   26 IF (KKK) 401, 400, 401                                            19270464
  401 R(I+1) = R3                                                       19270465
      Z(I+1) = Z3                                                       19270466
      XMN(I+1) = V3/AV3                                                 19270467
      THET(I+1) = THET3                                                 19270468
      RHO(I+1) = RO3                                                    19270469
      PRESS(I+1) = P3                                                   19270470
      S(I+1) = S3                                                       19270471
      XV(I+1) = V3                                                      19270472
      X3 = Z3                                                           19270473
      Y3 = R3                                                           19270474
      IF (KEY(J)-4) 402, 403, 403                                       19270475
  402 KEY(I+1) = KEY(J)                                                 19270476
      I = I+1                                                           19270477
      J = J+1                                                           19270478
      IF (KEY(I-1)-3) 9, 3009, 9                                        19270479
 3009 IF (Z(I-1)-XDLM) 9, 3010, 3010                                    19270480
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3010 ITFS = 1                                                    19270481
     KEY(I) = 13                                                 19270482
     TXD = Z(I-1)                                                19270483
     JERK = 1                                                    19270484
     ISTP = 1                                                    19270485
     GO TO 37                                                    19270486
 403 KEY(I+1) = 2                                                19270487
     I = I+1                                                     19270488
     J = J+1                                                     19270489
     KEY(I+1) = 4                                                19270490
     GO TO 10                                                    19270491
 400 R(J) = R3                                                   19270492
     Z(J) = Z3                                                   19270493
     XMN(J) = V3/AV3                                             19270494
     THFT(J) = THFT3                                             19270495
     RHO(J) = RO3                                                19270496
     PRESS(J) = P3                                               19270497
     S(J) = S3                                                   19270498
     XV(J) = V3                                                  19270499
     X3 = Z3                                                     19270500
     Y3 = R3                                                     19270501
     IF (JERK) 830, 831, 830                                     19270502
 830 IF (Z3-TXD) 831, 832, 832                                   19270503
 832 KEY(J) = 13                                                 19270504
     ISTP = 0                                                    19270505
     GO TO 37                                                    19270506
 831 IF (NN-1) 28, 27, 777                                       19270507
 777 J = J+NN                                                    19270508
     IF (KEY(J)-4) 778, 779, 1313                                19270509
 778 J = J-NN                                                    19270510
     KEY(J) = 2                                                  19270511
     I = I+1                                                     19270512
     J = J+NN+1                                                  19270513
     GO TO 9                                                     19270514
 779 J = J-NN                                                    19270515
     KEY(J) = 2                                                  19270516
     I = I+1                                                     19270517
     J = J+1                                                     19270518
     KEY(J) = 4                                                  19270519
     GO TO 10                                                    19270520
```

```
   27 IF (KEY(J+1)-4) 29, 35, 5000                                      19270521
 5000 KEY(J) = KEY(J+1)                                                 19270522
      GO TO 37                                                          19270523
   29 KEY(J) = KEY(J+1)                                                 19270524
      I = I+1                                                           19270525
      J = J+2                                                           19270526
      GO TO 9                                                           19270527
   35 KEY(J) = 2                                                        19270528
      I = I+1                                                           19270529
      J = J+1                                                           19270530
      JJ = INSERT                                                       19270531
      INSERT = 0                                                        19270532
      GO TO 10                                                          19270533
   28 IF (INSERT) 31, 30, 31                                            19270534
   30 KEY(J) = KEY(I)                                                   19270535
      I = I+1                                                           19270536
      J = J+1                                                           19270537
      IF (KEY(J)-4) 9, 10, 10                                           19270538
   31 IF (KEY(J)-4) 32, 33, 37                                          19270539
   32 KEY(J) = KEY(I)                                                   19270540
      I = I+1                                                           19270541
      J = J+1                                                           19270542
      GO TO 9                                                           19270543
   33 KEY(J) = KEY(I)                                                   19270544
      I = I+1                                                           19270545
      J = J+1                                                           19270546
      KEY(J) = 4                                                        19270547
   10 THET1 = THET(I)                                                   19270548
      Y3 = R(I)                                                         19270549
      X3 = Z(I)                                                         19270550
      V1 = XV(I)                                                        19270551
      S1 = S(I)                                                         19270552
      IF (INSERT) 66, 68, 66                                            19270553
   68 THET2 = THET(J)                                                   19270554
      R2 = R(J)                                                         19270555
      Z2 = Z(J)                                                         19270556
      V2 = XV(J)                                                        19270557
      S2 = S(J)                                                         19270558
   66 CALL PAMBPT(EQUSAV,EQUST,THET1,Y3,X3,V1,S1,THET2,R2,Z2,V2,S2,HTJ, 19270559
     1NITER,EPS1,EPS2,EPS3,EPS5,Z3,R3,S3,V3,THET3,P3,BP,CC)             19270560
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      IF (P3) 662, 661, 662                                          19270561
  661 IP3 = 1                                                        19270562
  662 CONTINUE                                                       19270563
      H3 = HTJ-0.5*(V3**2)                                           19270564
      CALL EQUSAV(H3,S3,AV3)                                         19270565
      CALL EQUSRO(H3,S3,RO3)                                         19270566
      XMN9 = V3/AV3                                                  19270567
      THET9 = THET3                                                  19270568
      IF(P3-288.0)7777,7777,8888                                     19270569
 7777 IP3=1                                                          19270570
 8888 Z9=Z3                                                          19270571
      R9 = R3                                                        19270572
      IF (KKK) 404, 405, 404                                         19270573
  404 I = I+1                                                        19270574
      R(I) = R3                                                      19270575
      Z(I) = Z3                                                      19270576
      XMN(I) = V3/AV3                                                19270577
      THET(I) = THET3                                                19270578
      RHO(I) = RO3                                                   19270579
      PRESS(I) = P3                                                  19270580
      S(I) = S3                                                      19270581
      XV(I) = V3                                                     19270582
      GO TO 37                                                       19270583
  405 R(J) = R3                                                      19270584
      Z(J) = Z3                                                      19270585
      XMN(J) = V3/AV3                                                19270586
      THET(J) = THET3                                                19270587
      RHO(J) = RO3                                                   19270588
      PRESS(J) = P3                                                  19270589
      S(J) = S3                                                      19270590
      XV(J) = V3                                                     19270591
      IF (NN-1) 1120, 1119, 1120                                     19270592
 1119 INSERT = JJ                                                    19270593
 1120 IF (MM) 37, 36, 37                                             19270594
   38 K = K+1                                                        19270595
      INSERT = INSERT+1                                              19270596
  504 IF (K-JP) 20, 1400, 1400                                       19270597
   51 IF (ISTP) 4000, 550, 4000                                      19270598
 4000 KEY(I) = 13                                                    19270599
      ISTP = 0                                                       19270600
```

```
      GO TO 37                                                          19270601
  550 X3 = Z(I)                                                         19270602
      Y3 = R(I)                                                         19270603
      THFT1 = THFT(I)                                                   19270604
      S1 = S(I)                                                         19270605
      V1 = XV(I)                                                        19270606
      P1 = PRESS(I)                                                     19270607
      RO1 = RHO(I)                                                      19270608
      XM1 = XMN(I)                                                      19270609
      IF (KK) 80, 88, 80                                                19270610
   88 R2 = R(J)                                                         19270611
      Z2 = Z(J)                                                         19270612
      THFT2 = THFT(J)                                                   19270613
      V2 = XV(J)                                                        19270614
      S2 = S(J)                                                         19270615
      P2 = PRESS(J)                                                     19270616
      RO2 = RHO(J)                                                      19270617
      XM2 = XMN(J)                                                      19270618
   56 IF (MM-2) 71, 71, 55                                              19270619
   71 IF(KEY(J+1)-4) 55, 46, 55                                         19270620
   46 J = J-1                                                           19270621
      ALPH1 = ALPH1-1.74533E-3                                          19270622
   55 X12 = Z(J+1)                                                      19270623
      Y12 = R(J+1)                                                      19270624
      V12 = XV(J+1)                                                     19270625
      X12MN = XMN(J+1)                                                  19270626
      S12 = S(J+1)                                                      19270627
      THFT12 = THFT(J+1)                                                19270628
      P12 = PRESS(J+1)                                                  19270629
      RO12 = RHO(J+1)                                                   19270630
      X13 = Z(J+2)                                                      19270631
      Y13 = R(J+2)                                                      19270632
      V13 = XV(J+2)                                                     19270633
      X13MN = XMN(J+2)                                                  19270634
      S13 = S(J+2)                                                      19270635
      P13 = PRESS(J+2)                                                  19270636
      RO13 = RHO(J+2)                                                   19270637
      THFT13 = THFT(J+2)                                                19270638
   80 CALL INSHPT(EQUSAV,EQUST,EQUSS,EQUSP,EQUSRO,Z2,R2,V2,XM2,         19270639
     1S2,THFT2,P2,RO2,ALPH1,X3,Y3,V1,XM1,S1,THFT1,P1,RO1,X12,Y12,       19270640
```

```
     2V12,X12MN,S12,THET12,P12,RO12,X13,Y13,V13,X13MN,S13,THET13,        19270641
     3P13,RO13,HTJ,NITER,EPS1,EPS2,EPS3,EPS4,EPS5,ERR2,                  19270642
     4X4,Y4,V4,X4MN,S4,THET4,P4,RO4,ALPH4,X11,Y11,V11,X11MN,             19270643
     5S11, THET11, P11, RO11, LG, LB, GAMJ, INDINS)                      19270644
      IF (INDINS) 1313, 10009, 1313                                      19270644
10009 IF (LG) 40, 41, 41                                                 19270645
   40 IF (KEY(J+2)-4) 6, 41, 6                                           19270646
    6 J = J+1                                                            19270647
      GO TO 56                                                           19270648
   41 IF (LB) 42, 44, 44                                                 19270649
   42 I = I-1                                                            19270650
      IF (I-1) 1313, 1313, 4322                                          19270651
 4322 KK = 1                                                             19270652
      IF (LPR) 716, 550, 716                                             19270653
  716 IF (I-IKEEP(LPR)) 717, 717, 550                                    19270654
  717 LPR = LPR-1                                                        19270655
      LPRC = LPRC+1                                                      19270656
      GO TO 550                                                          19270657
   44 IF (GAMJ) 64, 65, 65                                               19270658
   64 GAMJ = -GAMJ                                                       19270659
      J = J-LG                                                           19270660
      I = I+LB                                                           19270661
      LPR = LPR+LPRC                                                     19270662
      LPRC = 0                                                           19270663
      KK = 0                                                             19270664
      GO TO 550                                                          19270665
   65 LPRC = 0                                                           19270666
      ALPH1 = ALPH4                                                      19270667
      Z(I+1) = X4                                                        19270668
      R(I+1) = Y4                                                        19270669
      XV(I+1) = V4                                                       19270670
      XMN(I+1) = X4MN                                                    19270671
      S(I+1) = S4                                                        19270672
      THET(I+1) = THET4                                                  19270673
      PRESS(I+1) = P4                                                    19270674
      RHO(I+1) = RO4                                                     19270675
      KEY(I+1) = 3                                                       19270676
      Z(I+2) = X11                                                       19270677
      R(I+2) = Y11                                                       19270678
      XV(I+2) = V11                                                      19270679
```

```
      XMN(I+2) = X11MN
      S(I+2) = S11
      THET(I+2) = THET11
      PRESS(I+2) = P11
      RHO(I+2) = RO11
      KEY(I+2) = 3
      I = I+2
      J = J+2
      NLPR = 0
      NN = 0
      KK = 0
      KKK = 1
      X3 = Z(I)
      Y3 = R(I)
      IF (I-J) 48, 49, 48
   49 J = J+1
      KEY(J) = 4
      THET(J) = THET13
      XV(J) = V13
      S(J) = S13
      R(J) = Y13
      Z(J) = X13
   48 IF (I-3) 37, 37, 9
   36 IF (LPR) 702, 703, 702
  702 WRITE OUTPUT TAPE 6, 704
  704 FORMAT(37H0VALUES ALONG INSERTED CHARACTERISTIC)
      IC = JKEEP(LPR)
      DO 903 L=IC, J
      T(L) = (PRESS(L))/(RHO(L)*RGCJ*32.174)
      Z(L) = Z(L)*RN
      R(L) = R(L)*RN
  903 THET(L) = THET(L)*57.29578
      WRITE OUTPUT TAPE 6, 705, (K,KEY(I),Z(I),R(I),XMN(I),THET(I),
     1RHO(I),PRESS(I),T(I),I=J ,J)
  705 FORMAT(119H0IDENT.        X                Y          MACH NO.
     1THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE/(
     21H I4,2H  I1,1H E12.5,2H  E12.5,2H  E12.5,2H  E12.5,2H  E12.5,2H
     3E12.5,2H  E12.5))
      IF (KEY(J)-4) 9042, 9041, 9042
 9041 CALL STORE(Z(J),R(J),PRESS(J),0)
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 9042 CONTINUE
      DO 904 L=IC, J
      Z(L) = Z(L)/RN
      R(L) = R(L)/RN
  904 THET(L) = THET(L)/57.29578
      VVV = XV(J)
      WRITE OUTPUT TAPE 6, 7006, VVV
      IF (NPORA) 19041, 19042, 19041
19041 WRITE OUTPUT TAPE 6, 7602, ASEC, XMSEC
      IF (ASEC/ASSEC-0.9) 10007, 10007, 19042
19042 CONTINUE
      I = IKEEP(LPR)
      J = JKEEP(LPR)
      LPR = LPR-1
      X3 = Z(I)
      Y3 = R(I)
      INSERT = INSERT+1
      IF(IP3)1313,9,1313
  703 DO 905 L=1, J
      T(L) = (PRESS(L))/(RHO(L)*RGCJ*32.174)
      Z(L) = Z(L)*RN
      R(L) = R(L)*RN
  905 THET(L) = THET(L)*57.29578
      WRITE OUTPUT TAPE 6, 200, (K,KEY(I),Z(I),R(I),XMN(I),THET(I),
     1RHO(I),PRESS(I),T(I),I=J,J)
  200 FORMAT(119H0IDENT.        X                Y          MACH NO.
     1THETA         DENSITY       PRESSURE      TEMPERATURE   SHOCK ANGLE/(
     21H I4,2H  I1,1H E12.5,2H  E12.5,2H  E12.5,2H  E12.5,2H  E12.5,2H
     3E12.5,2H  E12.5))
      IF (KEY(J)-4) 9062, 9061, 9062
 9061 CALL STORE(Z(J),R(J),PRESS(J),0)
 9062 CONTINUE
      DO 906 L=1, J
      Z(L) = Z(L)/RN
      R(L) = R(L)/RN
  906 THET(L) = THET(L)/57.29578
      VVV = XV(J)
      WRITE OUTPUT TAPE 6, 7006, VVV
      IF (NPORA) 19061, 19062, 19061
19061 WRITE OUTPUT TAPE 6, 7602, ASEC, XMSEC
```

```
      IF (ASEC/ASSEC-0.9) 10007, 10007, 19062
19062 CONTINUE
      NN = 0
      K = K+1
      INSERT = INSERT+1
      I = J
      IF(IP3)1313,718,1313
   37 IF (LPR) 706, 707, 706
  706 WRITE OUTPUT TAPE 6, 704
      WRITE OUTPUT TAPE 6, 708
  708 FORMAT(119H0IDENT.          X                 Y          MACH NO.
     1THETA          DENSITY        PRESSURE       TEMPERATURE   SHOCK ANGLE)
      I = JKEEP(LPR)
      GO TO 214
  707 WRITE OUTPUT TAPE 6, 202
  202 FORMAT(119H0IDENT.          X                 Y          MACH NO.
     1THETA          DENSITY        PRESSURE       TEMPERATURE   SHOCK ANGLE)
      I = 1
  214 KY = KEY(I)
      RR = R(I)*RN
      ZZ = Z(I)*RN
      XXMN = XMN(I)
      TTH = THET(I)*57.29578
      RH = RHO(I)
      PR = PRESS(I)
      SS = (PRESS(I))/(RHO(I)*RGCJ*32.174)
      IF (KY-3) 213, 204, 203
  203 WRITE OUTPUT TAPE 6, 210, K, KY, ZZ, RR, XXMN, TTH, RH, PR, SS
  210 FORMAT(1H I4,2H  I1,1H E12.5,2H  E12.5,2H  E12.5,2H  E12.5,2H  E12
     1.5,2H  E12.5,2H  E12.5)
      GO TO 213
  204 ALPH1 = ALPH1*57.29578
      WRITE OUTPUT TAPE 6, 211, K, KY, ZZ, RR, XXMN, TTH, RH, PR, SS,
     1ALPH1
  211 FORMAT(1H I4,2H  I1,1H E12.5,2H  E12.5,2H  E12.5,2H  E12.5,2H  E12
     1.5,2H  E12.5,2H  E12.5,2H  E12.5)
      ALPH1 = ALPH1/57.29578
  351 IF(I-3) 213, 1313, 213
  213 IF (KY-4) 215, 2131, 215
 2131 VVV = XV(I)
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      CALL STORE(ZZ,PR,PR,0)                                            19270800
      WRITE OUTPUT TAPE 6, 7006, VVV                                    19270801
      IF (NPORA) 2132, 205, 2132                                        19270802
 2132 WRITE OUTPUT TAPE 6, 7602, ASEC, XMSEC                            19270803
      IF (ASEC/ASSEC-0.9) 10007, 10007, 205                             19270804
  215 IF (KY-13) 3002, 3000, 3002                                       19270805
 3002 I = I+1                                                           19270806
      GO TO 214                                                         19270807
 3000 IF (ISTP) 3006, 205, 3006                                         19270808
 3006 IF (ITES) 3007, 3003, 3007                                        19270809
 3007 ITES = 0                                                          19270810
      WRITE OUTPUT TAPE 6, 3008                                         19270811
 3008 FORMAT(94H0PLUME FLOW FIELD VERY LARGE THEREFORE PLUME WILL BE DET19270812
     1ERMINED ONLY UP TO Z OF ASTERISK POINT)                           19270813
      GO TO 205                                                         19270814
 3003 WRITE OUTPUT TAPE 6, 3001                                         19270815
 3001 FORMAT(55H0INTERIOR SHOCK IS NOW GOING NORMAL TO AXIS OF SYMMETRY)19270816
  205 IF(IP3)1313,20005,1313                                            19270817
20005 IF(LPR)711,712,711                                                19270818
  711 I = IKEEP(LPR)                                                    19270819
      J = JKEEP(LPR)                                                    19270820
      NN = NNSAV(LPR)                                                   19270821
      KKK = KKKSAV(LPR)                                                 19270822
      LPR = LPR-1                                                       19270823
      X3 = Z(I)                                                         19270824
      Y3 = R(I)                                                         19270825
      INSERT = INSERT+1                                                 19270826
      GO TO 9                                                           19270827
  712 NN = 0                                                            19270828
      KKK = 0                                                           19270829
   95 MM = MM+1                                                         19270830
  718 IF (LSTART) 330, 325, 326                                         19270831
  330 J = I-1                                                           19270832
      DO 329 I=1, J                                                     19270833
      Z(I) = Z(I+1)                                                     19270834
      R(I) = R(I+1)                                                     19270835
      XV(I) = XV(I+1)                                                   19270836
      S(I) = S(I+1)                                                     19270837
      XMN(I) = XMN(I+1)                                                 19270838
      RHO(I) = RHO(I+1)                                                 19270839
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      PRESS(I) = PRESS(I+1)                                             19270840
      THET(I) = THET(I+1)                                               19270841
  329 KEY(I) = KEY(I+1)                                                 19270842
      LSTART = 0                                                        19270843
      JP = K+1                                                          19270844
      IF (MM) 38, 334, 38                                               19270845
  334 JP = K                                                            19270846
      GO TO 504                                                         19270847
  326 J = I+I                                                           19270848
      GO TO 719                                                         19270849
  325 J = I+I-1                                                         19270850
  719 Z(J) = Z(I)                                                       19270851
      R(J) = R(I)                                                       19270852
      XV(J) = XV(I)                                                     19270853
      S(J) = S(I)                                                       19270854
      XMN(J) = XMN(I)                                                   19270855
      RHO(J) = RHO(I)                                                   19270856
      PRESS(J) = PRESS(I)                                               19270857
      THET(J) = THET(I)                                                 19270858
      KEY(J) = KEY(I)                                                   19270859
      I = I-1                                                           19270860
      J = J-2                                                           19270861
      IF (I) 719, 726, 719                                              19270862
  726 IF (LSTART) 327, 327, 328                                         19270863
  327 J = 3                                                             19270864
      I = 1                                                             19270865
      GO TO 720                                                         19270866
  328 J = 4                                                             19270867
      I = 2                                                             19270868
  720 SP23 = SQRTF((Z(J)-Z(I))**2+(R(J)-R(I))**2)                       19270869
      SPLIM = 0.75+SPTLC*SQRTF(R(I)**2+Z(I)**2)                         19270870
      IF (SP23-SPLIM) 721, 723, 723                                     19270871
  721 I = I+1                                                           19270872
      Z(I) = Z(J)                                                       19270873
      R(I) = R(J)                                                       19270874
      XV(I) = XV(J)                                                     19270875
      S(I) = S(J)                                                       19270876
      XMN(I) = XMN(J)                                                   19270877
      RHO(I) = RHO(J)                                                   19270878
      PRESS(I) = PRESS(J)                                               19270879
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      THET(I) = THET(J)                                                 19270880
      KEY(I) = KEY(J)                                                   19270881
      IF(KEY(I)-4) 722, 725, 725                                        19270882
  722 J = J+2                                                           19270883
      GO TO 720                                                         19270884
  723 I = I+1                                                           19270885
      Z(I) = Z(I-1)+0.5*(Z(J)-Z(I-1))                                   19270886
      R(I) = R(I-1)+0.5*(R(J)-R(I-1))                                   19270887
      XV(I) = XV(I-1)+0.5*(XV(J)-XV(I-1))                               19270888
      S(I) = S(I-1)+0.5*(S(J)-S(I-1))                                   19270889
      XMN(I) = XMN(I-1)+0.5*(XMN(J)-XMN(I-1))                           19270890
      RHO(I) = RHO(I-1)+0.5*(RHO(J)-RHO(I-1))                           19270891
      PRESS(I) = PRESS(I-1)+0.5*(PRESS(J)-PRESS(I-1))                   19270892
      THET(I) = THET(I-1)+0.5*(THET(J)-THET(I-1))                       19270893
      KEY(I) = 2                                                        19270894
      GO TO 721                                                         19270895
  725 IF (MM) 38, 504, 38                                               19270896
 1400 I = 1                                                             19270897
      J = 2                                                             19270898
      IF (K-JP) 1313, 1500, 1502                                        19270899
 1502 THET2 = THET(J)                                                   19270900
      R2 = R(J)                                                         19270901
      Z2 = Z(J)                                                         19270902
      V2 = XV(J)                                                        19270903
      S2 = S(J)                                                         19270904
      IF (IX-1) 1503, 1503, 1601                                        19270905
 1500 THET2 = THET(I)                                                   19270906
      R2 = R(I)                                                         19270907
      Z2 = Z(I)                                                         19270908
      V2 = XV(I)                                                        19270909
      S2 = S(I)                                                         19270910
      JIK = 0                                                           19270911
      IX = 0                                                            19270912
      KIJ  =1                                                           19270913
 1503 CALL PTOTAX(EQUSAV,EQUST,SJ,THET2,R2,Z2,V2,S2,HTJ,NITER,EPS1,EPS3,19270914
     1EPS4,Z3,R3,S3,V3,THET3)                                           19270915
      IF (KEY(J)-13) 6000, 1402, 6000                                   19270916
 6000 IF (K-JP) 1313, 1402, 1600                                        19270917
 1600 IF (JIK) 1603, 1602, 1603                                         19270918
 1603 IF (IX-1) 1313, 1700, 1402                                        19270919
```

```
1602 H3 = HTJ-0.5*(V3**2)
     CALL EQUSAV(H3,S3,AV3)
     DELZ = 57.29578*(ASINF(1.0/XMN(1))-ASINF(AV3/V3))
     IX = DELZ+1.0
     IF (IX-1) 1700, 1700, 1601
1601 QF = IX
     YF = 1.0/QF
     THET2 = THET(I)+(THET2-THET(I))*YF
     R2 = R(I)+(R2-R(I))*YF
     Z2 = Z(I)+(Z2-Z(I))*YF
     V2 = XV(I)+(V2-XV(I))*YF
     S2 = S(I)+(S2-S(I))*YF
     JIK = 1
     KIJ = 1
     GO TO 1503
1700 KIJ = 0
     JIK = 0
     IF (Z3-TXD) 1402, 1402, 1313
1402 H3 = HTJ-0.5*(V3**2)
     CALL EQUSAV(H3,S3,AV3)
     CALL EQUSP(H3,S3,P3)
     CALL EQUSRO(H3,S3,RO3)
     R(I) = R3
     Z(I) = Z3
     XMN(I) = V3/AV3
     THET(I) = THET3
     RHO(I) = RO3
     PRESS(I) = P3
     S(I) = S3
     XV(I) = V3
     IF (KEY(J)-13) 6002, 6001, 6002
6001 KEY(I) = 13
     SS=(PRESS(1))/(RHO(1)*RGCJ*32.2)
     THET(1) = THET(1)*57.29578
     Z(1) = Z(1)*RN
     R(1) = R(1)*RN
     WRITE OUTPUT TAPE 6, 6005, (K,KEY(1),Z(1),R(1),XMN(1),THET(1),
    1RHO(1),PRESS(1),SS)
6005 FORMAT(119H0IDENT.        X              Y          MACH NO.
    1THETA        DENSITY      PRESSURE     TEMPERATURE   SHOCK ANGLE/(
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
     21H I4,2H  I1,1H E12.5,2H  E12.5,2H  E12.5,2H  E12.5,2H  E12.5,2H  19270960
     3E12.5),2H  E12.5)                                                 19270961
      THET(1) = THET(1)/57.29578                                        19270962
      Z(1) = Z(1)/RN                                                    19270963
      R(1) = R(1)/RN                                                    19270964
      GO TO 1313                                                        19270965
 6002 KEY(I) = 0                                                        19270966
      X1 = Z3                                                           19270967
      V1 = V3                                                           19270968
      S1 = S3                                                           19270969
      IF (KIJ) 1504, 1505, 1504                                         19270970
 1505 J = J+1                                                           19270971
 1504 THET2 = THET(J)                                                   19270972
      V2 = XV(J)                                                        19270973
      S2 = S(J)                                                         19270974
      R2 = R(J)                                                         19270975
      Z2 = Z(J)                                                         19270976
      CALL RTETAX(EQUSAV,EQUST,X1,V1,S1,THET2,R2,Z2,V2,S2,HTJ,NITER,    19270977
     1EPS1,EPS3,EPS4,EPS5,Z3,R3,S3,V3,THET3)                            19270978
      H3 = HTJ-0.5*(V3**2)                                              19270979
      CALL EQUSAV(H3,S3,AV3)                                            19270980
      CALL EQUSP(H3,S3,P3)                                              19270981
      CALL EQUSRO(H3,S3,RO3)                                            19270982
      IF (KIJ) 1506, 1507, 1506                                         19270983
 1507 J = J-1                                                           19270984
 1506 R(J) = R3                                                         19270985
      Z(J) = Z3                                                         19270986
      XMN(J) = V3/AV3                                                   19270987
      THET(J) = THET3                                                   19270988
      RHO(J) = RO3                                                      19270989
      PRESS(J) = P3                                                     19270990
      S(J) = S3                                                         19270991
      XV(J) = V3                                                        19270992
      KEY(J) = 2                                                        19270993
      X3 = Z3                                                           19270994
      Y3 = R3                                                           19270995
      I = I+1                                                           19270996
      IF (KIJ) 1508, 1509, 1508                                         19270997
 1509 J = J+2                                                           19270998
      NN = 1                                                            19270999
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
      IX = 0                                                            19271000
      GO TO 9                                                           19271001
 1508 J = J+1                                                           19271002
      IX = IX-1                                                         19271003
      GO TO 9                                                           19271004
10006 FORMAT(30H0A CRITICALLY LESS THAN A STAR)                         19271005
10007 WRITE OUTPUT TAPE 6, 10006                                        19271006
 1313 WRITE OUTPUT TAPE 6, 11                                           19271007
   11 FORMAT(33H0END OF COMPUTATION FOR THIS CASE)                      19271008
   13 CONTINUE                                                          19271009
      CALL STORE(0,0,0,1)                                               19271010
      CALL CHAIN(2,3)                                                   19271011
       END                                                              19271012
```

ORIGINAL PAGE IS
OF POOR QUALITY

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
16595	40323	32441	77271

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ASEC	32446	77276	ASSEC	32444	77274	BB	32546	77442	CPH	32442	77272	CP	32556	77454
GAMMA	32557	77455	GSEC	32549	77445	INDP	32554	77452	ISTS	32443	77273	NPURA	32555	77453
NPP	32553	77451	PT	32561	77461	PTSEC	32551	77447	RHOT	32560	77460	RN	32547	77443
RSEC	32548	77444	ST	32558	77456	TT	32559	77457	TTSEC	32550	77446	WSEC	32552	77450
XMSEC	32445	77275												

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
IKEEP	7594	16652	JKEEP	6444	14454	KEY	8594	20622	KKKSAV	7494	16506	NNSAV	7544	16570
PRESS	11594	26512	RHO	12594	30462	R	16594	40322	S	9594	22572	THET	13594	32432
TITLE	4794	11272	TPRESS	5394	12422	TRHO	5594	12732	TR	6394	14372	T	7444	16424
TS	4994	11602	TTHET	5794	13242	TXMN	5994	13552	TXV	5194	12112	TZ	6194	14067
XMN	14594	34402	XV	10594	24542	Z	15594	36352						

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A1	4782	11256	A2	4781	11255	ALPH1	4780	11254	ALPH4	4779	11253	ALT	4778	11252
A	4777	11251	AV3	4776	11250	BET1	4775	11247	BET9	4774	11246	BETAX	4773	11245
CC	4772	11244	D23	4771	11243	DBFL	4770	11242	DELR	4769	11241	DELTA	4768	11240
DELTHE	4767	11237	DELZ	4766	11236	DLIM	4765	11235	DR5	4764	11234	DRNDLR	4763	11233
DRN	4762	11232	DRNT	4761	11231	DRNTT	4760	11230	DX5	4759	11227	DXN	4758	11226
DXNT	4757	11225	EPS1	4756	11224	EPS2	4755	11223	EPS3	4754	11222	EPS4	4753	11221
EPS5	4752	11220	EPSLON	4751	11217	ERR1	4750	11216	ERR2	4749	11215	ERR3	4748	11214
FACT	4747	11213	GAMJ	4746	11212	GMN	4745	11211	H3	4744	11210	HJS	4743	11207
HTJ	4742	11206	IC	4741	11205	ILL	4740	11204	INDINS	4739	11203	INSERT	4738	11202
IP1	4737	11201	I	4736	11200	ISTP	4735	11177	ITFS	4734	11176	IX	4733	11175
JERK	4732	11174	JIK	4731	11173	JJ	4730	11172	JP	4729	11171	J	4728	11170
KIJ	4727	11167	KKK	4726	11166	KK	4725	11165	K	4724	11164	KSAV	4723	11163
KY	4722	11162	LB	4721	11161	LG	4720	11160	LPRC	4719	11157	LPR	4718	11156
LSTART	4717	11155	LST	4716	11154	MM	4715	11153	M	4714	11152	NDD	4713	11151
NDXP	4712	11150	NITER	4711	11147	NLPR	4710	11146	NN	4709	11145	N	4708	11144
NSP	4707	11143	P11	4706	11142	P12	4705	11141	P13	4704	11140	P1	4703	11137
P2	4702	11136	P3	4701	11135	P4	4700	11134	PAMB	4699	11133	PJ	4698	11132
PR	4697	11131	P	4696	11130	PX	4695	11127	PY	4694	11126	QP	4693	11125
R15	4692	11124	R2	4691	11123	R3	4690	11122	R9	4689	11121	RGCJ	4688	11120
RHOJ	4687	11117	RH	4686	11116	RO11	4685	11115	RO12	4684	11114	RO13	4683	11113
RO1	4682	11112	RO2	4681	11111	RO3	4680	11110	RO4	4679	11107	RR	4678	11106
S11	4677	11105	S12	4676	11104	S13	4675	11103	S1	4674	11102	S2	4673	11101
S3	4672	11100	S4	4671	11077	SDLIM	4670	11076	SJ	4669	11075	SNDU	4668	11074
SP23	4667	11073	SPLIM	4666	11072	SPTLC	4665	11071	SPTRC	4664	11070	SPTS	4663	11067
SPTX	4662	11066	SS	4661	11065	STEST	4660	11064	TA2	4659	11063	TEMPJ	4658	11062
THET11	4657	11061	THET12	4656	11060	THET13	4655	11057	THET1	4654	11056	THET2	4653	11055
THET3	4652	11054	THET4	4651	11053	THET9	4650	11052	THETAJ	4649	11051	THETAX	4648	11050
TM89	4647	11047	TTH	4646	11046	TX1	4645	11045	TX4	4644	11044	TXD	4643	11043

TY1	4642	11042	TY4	4641	11041	V11	4640	11040	V12	4639	11037	V13	4638	11036
V1	4637	11035	V2	4636	11034	V3	4635	11033	V4	4634	11032	VACMN	4633	11031
V	4632	11030	VVV	4631	11027	VXMN	4630	11026	VX	4629	11025	X11MN	4628	11024
X11	4627	11023	X12MN	4626	11022	X12	4625	11021	X13MN	4624	11020	X13	4623	11017
X1	4622	11016	X2	4621	11015	X3	4620	11014	X4MN	4619	11013	X4	4618	11012
X50	4617	11011	X60	4616	11010	XDLM	4615	11007	XM1	4614	11006	XM2	4613	11005
XMN9	4612	11004	XM	4611	11003	XXMN	4610	11002	Y11	4609	11001	Y12	4608	11000
Y13	4607	10777	Y1	4606	10776	Y2	4605	10775	Y3	4604	10774	Y4	4603	10773
YF	4602	10772	Z15	4601	10771	Z2	4600	10770	Z3	4599	10767	Z9	4598	10766
ZAP	4597	10765	ZZ	4596	10764									

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)7	7	10155	8)8	11	07532	8)68	200	10011	8)6A	202	07721	8)6I	210	07674
8)6J	211	07656	8)9E	302	10326	8)MO	704	10053	8)M1	705	10054	8)M4	708	07746
8)2TP	3001	07615	8)2U0	3008	07636	8)5RL	6005	07603	8)6Q0	7000	10333	8)6QP	7001	10232
8)6QQ	7002	10747	8)6QR	7003	10214	8)6QS	7004	10216	8)6QT	7005	10212	8)6QU	7006	10107
8)7DI	7602	10075	8)7Q0	8000	10743	8)7Q1	8001	10737	8)7Q3	8003	10713	8)7Q5	8005	10705
8)7Q7	8007	10700	8)7Q8	8008	10551	8)7Q9	8009	10507	8)7QB	8011	10402	8)7QC	8012	10324
8)7QD	8013	10253	8)90G	10000	10746	8)90H	10001	10745	8)90M	10006	07540			

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	4584	10750	2)	3882	07452	3)	3893	07455	4)	32767	77777	6)	3918	07516
C)G0	4590	10756	C)G2	4591	10757	C)G3	4592	10760	C)G5	4593	10761	C)G6	4594	10762
C)G7	4595	10763	D)120	1539	03003	D)14I	2281	04351	D)14J	2291	04363	D)14M	2304	04400
D)170	3305	06351	D)176	3434	06552	D)177	3452	06574	D)320	1538	03002	D)34I	2280	04350
D)34J	2290	04362	D)41D	954	01672	D)41T	1177	02231	D)42N	1531	02773	D)43F	1836	03454
D)43H	1872	03520	D)464	2949	05605	D)46K	3159	06127	D)47N	3841	07401	D)47O	3852	07414
D)52N	1530	02772	D)564	2948	05604	D)56K	3158	06126	D)67O	3851	07413	D)72O	1537	03001
D)74I	2279	04347	D)74J	2289	04361	E)2	149	00225	E)6	213	00325	E)9	280	00430
E)M	525	01015	E)N	531	01023	E)P	636	01174	E)R	704	01300	E)T	724	01324
E)10	789	01425	E)1B	916	01624	E)1I	1044	02024	E)1U	1207	02267	E)3O	1970	03662
E)3U	2031	03757	E)44	2091	04053	E)48	2137	04131	E)4A	2183	04207	E)4D	2220	04254
E)4F	2250	04312	E)59	2618	05072	E)70	3304	06350	E)73	3401	06511	E)11B	916	01624
E)22M	1520	02760	E)77O	3849	07411									

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ASIN	16	00020	CHAIN	29	00035	DATE	11	00013	EQUSAV	4	00004	EQUSHP	6	00006
EQUSP	2	00002	EQUSRO	3	00003	EQUSS	1	00001	EQUST	5	00005	EXP(2	22	00026
EXP13	20	00024	INSHPT	27	00033	INTER	23	00027	INTRPT	25	00031	PAMBPT	26	00032
PMXPAV	18	00022	PSEC	10	00012	PTFTAX	24	00030	PTOTAX	28	00034	SIN	19	00023
SQRT	14	00016	STORE	21	00025	TAN	17	00021	(FIL)	13	00015	(FPT)	0	00000
(RTN)	9	00011	(SLI)	8	00010	(SLO)	15	00017	(STH)	12	00014	(TSH)	7	00007

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

ASIN	CHAIN	DATE	EQUSAV	EQUSHP	EQUSP	EQUSRO	EQUSS	EQUST	EXP(2
EXP(3	INSHPT	INTER	INTRPT	PAMBPT	PMXPAV	PSEC	PTFTAX	PTOTAX	SIN
SQRT	STORE	TAN	(FIL)	(FPT)	(RTN)	(SLI)	(SLO)	(STH)	(TSH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
12	63	00116	10002	71	00202	10003	73	00226	8002	89	00316	8004	91	00326
8006	92	00334	8010	97	00367	300	103	00431	303	122	00613	7999	133	00701
301	136	00720	10004	147	00770	10005	149	01016	10008	151	01024	304	169	01151
305	178	01175	600	186	01217	3	194	01272	603	196	01301	604	198	01307
900	201	01327	901	209	01356	306	222	01422	307	224	01430	308	225	01432
4	226	01435	5	234	01505	902	244	01556	7601	249	01605	7603	252	01625
7604	254	01632	20	269	01673	309	270	01675	312	271	01702	313	276	01717
315	278	01731	4325	289	02017	311	291	02025	4321	292	02032	316	294	02036
317	295	02054	319	296	02061	320	301	02117	321	302	02144	318	304	02174
322	306	02200	323	307	02203	324	308	02212	314	312	02232	310	325	02270
811	326	02273	503	327	02277	39	329	02333	800	332	02345	21	343	02413
4323	344	02417	801	345	02424	812	346	02431	814	348	02435	803	349	02442
805	354	02502	611	355	02507	610	360	02541	813	364	02561	806	365	02567
807	370	02602	808	372	02610	809	373	02615	810	378	02636	804	382	02645
613	383	02652	612	387	02701	816	395	02755	802	397	02761	60	399	02774
9	401	03004	22	405	03025	331	411	03042	332	415	03077	52	416	03102
713	420	03165	714	422	03170	715	423	03210	700	424	03215	3005	425	03220
3011	426	03224	701	438	03307	123	439	03315	90	440	03326	23	441	03332
170	442	03337	2222	443	03342	3333	444	03347	4444	447	03357	169	452	03370
63	459	03422	666	462	03436	62	464	03441	24	468	03455	25	476	03513
26	477	03521	401	478	03523	402	489	03554	3009	493	03575	3010	494	03602
404	500	03615	400	505	03633	830	516	03653	832	517	03670	831	520	03675
777	521	03702	778	523	03712	779	528	03734	27	534	03760	5000	535	03765
29	537	03770	35	541	04005	28	547	04026	30	548	04032	31	552	04054
32	553	04060	33	557	04075	10	561	04113	68	567	04132	66	572	04144
661	575	04210	662	576	04212	7777	585	04251	8888	586	04255	404	589	04263
405	599	04313	1119	608	04341	1120	609	04343	38	610	04352	504	612	04364
51	613	04371	4000	614	04373	550	617	04401	88	626	04425	56	634	04445
71	635	04451	46	636	04456	55	638	04456	80	654	04526	10009	657	04642
40	658	04645	6	659	04650	41	661	04656	42	662	04661	4322	664	04673
716	666	04677	717	667	04704	44	670	04715	64	671	04720	65	678	04746
49	707	05050	48	714	05073	36	715	05100	702	716	05102	903	722	05134
9041	729	05205	9042	731	05227	904	735	05240	19041	740	05263	19042	743	05306
703	751	05337	905	755	05360	9061	762	05431	9062	764	05453	906	768	05464
19061	773	05507	19062	776	05532	37	782	05552	706	783	05554	707	787	05572
214	789	05606	203	798	05644	204	801	05677	351	805	05741	213	806	05744
2131	807	05751	2132	813	06000	215	816	06023	3002	817	06026	3000	819	06034
3006	820	06036	3007	821	06040	3003	824	06051	205	825	06057	20005	826	06063
711	827	06065	712	836	06116	95	838	06122	718	839	06130	330	840	06133
329	850	06163	334	854	06202	326	856	06205	325	858	06213	719	859	06220
726	871	06256	327	872	06261	328	875	06272	720	877	06302	721	880	06352
722	891	06404	723	893	06412	725	904	06512	1400	905	06516	1502	908	06533
1500	914	06553	1503	922	06575	6000	925	06627	1600	926	06634	1603	927	06636
1602	928	06643	1601	934	06730	1700	944	07004	1402	947	07014	6001	963	07076
6002	977	07165	1505	982	07201	1504	983	07206	1507	998	07312	1506	999	07316
1509	1012	07356	1508	1016	07370	10007	1019	07432	1313	1020	07415	13	1021	07423

```
      SUBROUTINE EQUSS(H,P,S)                                           19271013
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS   19271014
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN    19271015
* * * *     CONSENT OF THE BOEING COMPANY.                              19271016
      COMMON PT, RHOT, TT, ST, GAMMA, CP                                19271017
    3 T = H/(CP*32.2)                                                   19271018
      A = T/TT                                                          19271019
      B = (GAMMA-1.0)/GAMMA                                             19271020
      C = (P/PT)**B                                                     19271021
      S = ST+CP*LOGF(A/C)                                               19271022
    4 RETURN                                                            19271023
       END                                                              19271024
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
70	00106	32555	77453

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CP	32556	77454	GAMMA	32557	77455	PT	32561	77461	RHOT	32560	77460	ST	32558	77456
TT	32559	77457												

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A	69	00105	B	68	00104	C	67	00103	T	66	00102			

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	63	00077	3)	55	00067	6)	57	00071						

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
EXP(3	0	00000	LOG	1	00001									

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP(3 LOG

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
3	4	00021	4	9	00063									

```
      SUBROUTINE EQUSP (H,S,P)                                          19271025
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS   19271026
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN    19271027
* * * *     CONSENT OF THE BOEING COMPANY.                              19271028
      COMMON PT, RHOT, TT, ST, GAMMA, CP                                19271029
    3 A = GAMMA/(GAMMA-1.0)                                             19271030
      B = EXPF((S-ST)/CP)                                               19271031
      T = H/(CP*32.2)                                                   19271032
      C = T/TT                                                          19271033
      P = PT*((C/B)**A)                                                 19271034
    4 RETURN                                                            19271035
       END                                                              19271036
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
72	00110	32559	77453

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CP	32559	77454	GAMMA	32557	77455	PT	32561	77461	RHOT	32560	77460	ST	32558	77456
TT	32554	77457												

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A	71	00107	B	70	00106	C	69	00105	T	68	00104			

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	65	00101	3)	57	00071	6)	59	00073						

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
EXP	0	00000	EXP(3	1	00001									

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP EXP(3

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
3	4	00021	4	9	00065									

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```
      SUBROUTINE EQUSRO(H,S,RO)                                         19271037
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS    19271038
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN     19271039
* * * *     CONSENT OF THE BOEING COMPANY.                               19271040
      COMMON PT, RHOT, TT, ST, GAMMA, CP                                19271041
    3 T = H/(CP*32.2)                                                   19271042
      A = T/TT                                                          19271043
      B = EXPF(((S-ST)*GAMMA)/CP)                                       19271044
      ZAP = 1.0/(GAMMA-1.0)                                             19271045
      RO = RHOT*((A/B)**ZAP)                                            19271046
    4 RETURN                                                            19271047
       END                                                              19271048
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
74	00112	32555	77453

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CP	32558	77454	GAMMA	32557	77455	PT	32561	77461	RHOT	32560	77460	ST	32559	77456
TI	32554	77457												

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
S	73	00111	B	72	00110	T	71	00107	ZAP	70	00106			

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
I1	67	00103	I1	59	00073	I1	61	00075						

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
EXP	0	00000	EXP13	1	00001									

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP EXP13

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
3	4	00021	4	7	00067									

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```
      SUBROUTINE EQUSH (P,S,H,DHDP)                                     19271051
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS    19271052
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN     19271053
* * * *     CONSENT OF THE BOEING COMPANY.                               19271054
      COMMON PT, RHOT, TT, ST, GAMMA, CP                                19271055
      A = (GAMMA-1.0)/GAMMA                                             19271056
      B = TT*((P/PT)**A)                                                19271057
      T = B*EXPF((S-ST)/CP)                                             19271058
      H = CP*T*32.2                                                     19271059
      C = (P/PT)**(1.0/GAMMA)                                           19271060
      DHDP = 1.0/(RHOT*C)                                               19271061
      RETURN                                                            19271062
       END                                                              19271063
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
90	00132	32555	77453

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CP	32556	77454	GAMMA	32557	77455	PT	32561	77461	RHOT	32560	77460	ST	32558	77456
TT	32559	77457												

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A	89	00131	B	88	00130	C	87	00127	T	86	00126			

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	83	00123	3)	75	00113	6)	77	00115						

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
EXP	1	00001	EXP(3	0	00000									

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP EXP(3

```
      SUBROUTINE EQUSAV (H,S,AV)                                        19271064
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS    19271065
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN     19271066
* * * *     CONSENT OF THE BOEING COMPANY.                               19271067
      COMMON PT, RHOT, TT, ST, GAMMA, CP                                19271068
    3 AV = SQRTF(H*(GAMMA-1.0))                                         19271069
    4 RETURN                                                            19271070
       END                                                              19271071
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
36	00044	32555	77453

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CP	32556	77454	GAMMA	32557	77455	PT	32561	77461	RHOT	32560	77460	ST	32558	77456
TT	32559	77457												

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	34	00042	3)	27	00033	6)	28	00034						

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
SQRT	0	00000												

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

SQRT

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
3	4	00016	4	5	00027									

```
      SUBROUTINE EQUST (H,S,T)
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN
* * * *     CONSENT OF THE BOEING COMPANY.
      COMMON PT, RHOT, TT, ST, GAMMA, CP
    3 T = H/(CP*32.2)
    4 RETURN
      END
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
32	00040	32555	77453

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CP	32556	77454	GAMMA	32557	77455	PT	32561	77461	RHOT	32560	77460	ST	32558	77456
TT	32559	77457												

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	30	00036	3)	23	00027	6)	24	00030						

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
3	4	00015	4	5	00023									

```
      SUBROUTINE EQUSHP (P,S,H,DPDS)                                    19271080
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS    19271081
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN     19271082
* * * *     CONSENT OF THE BOEING COMPANY.                               19271083
      COMMON PT, RHOT, TT, ST, GAMMA, CP                                19271084
    3 A = (GAMMA-1.0)/GAMMA                                             19271085
      B = TT*((P/PT)**A)                                                19271086
      T = B*EXPF((S-ST)/CP)                                             19271087
      H = CP*T*32.2                                                     19271088
      DPDS = -(P*GAMMA)/(CP*(GAMMA-1.0)*32.2)                           19271089
    4 RETURN                                                            19271090
       END                                                              19271091
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
85	00125	32555	77453

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CP	32556	77454	GAMMA	32557	77455	PT	32561	77461	RHOT	32560	77460	ST	32558	77456
TT	32559	77457												

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A	84	00124	B	83	00123	T	82	00122						

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	79	00117	3)	71	00107	6)	73	00111						

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
EXP	1	00001	EXP(3	0	00000									

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP EXP(3

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
3	4	00024	4	9	00103									

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```
      SUBROUTINE PSEC(Z,RR,P3,IIIII,P30)                                19271092
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS   19271093
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN    19271094
* * * *     CONSENT OF THE BOEING COMPANY.                              19271095
      DIMENSION DUMY(6), BB(100)                                        19271096
      COMMON DUMY, NPORA, INDP, NPP, W, PT, TT, G, R, RN, BB            19271097
      COMMON A, XM, ASTAR, ISTS                                         19271098
      DIMENSION PSAVE(60), ESAVE(60), DESAVE(60)                        19271099
      COMMON CPH                                                        19271100
C                           NPORA ZERO IMPLIES P INPUT                  19271101
C                           NPORA NONZERO IMPLIES Y INPUT               19271102
      Z3 = Z*RN                                                         19271103
      R3 = RR*RN                                                        19271104
      IF (INDP) 3, 1, 3                                                 19271105
C                           POLYNOMIAL OF DEGREE (NPP-1)                19271106
    1 P3 = 0                                                            19271107
      DO 2 I=1, NPP                                                     19271108
    2 P3 = P3*Z3+BB(I)                                                  19271109
      GO TO 8                                                           19271110
C                           P INPUT AS TABLE OF INCREASING Z            19271111
    3 IF (Z3-BB) 9, 4, 4                                                19271112
    4 DO 5 I=1, NPP, 2                                                  19271113
      IF (Z3-BB(I)) 6, 7, 5                                             19271114
    5 CONTINUE                                                          19271115
C                           EXTRAPOLATE BEYOND TABLE                    19271116
      I = NPP-1                                                         19271117
    6 P3 = BB(I-1)+(Z3-BB(I-2))*(BB(I+1)-BB(I-1))/(BB(I)-BB(I-2))       19271118
      GO TO 8                                                           19271119
    7 P3 = BB(I+1)                                                      19271120
    8 IF (NPORA) 1000, 10, 1000                                         19271121
   10 RETURN                                                            19271122
    9 WRITE OUTPUT TAPE 6, 100                                          19271123
  100 FORMAT(31HOX OUTSIDE OF INPUT TABLE FOR P)                        19271124
      CALL CHARET                                                       19271125
C                           Y (OR R) OF DUCT INPUT                      19271126
 1000 IF (Z3) 1002, 1001, 1002                                          19271127
 1001 C1 = (2.0/(G+1.0))**((G+1.0)/(G-1.0))                             19271128
      ASTAR = W/(PT*SQRTF(G/(R*TT)*C1))*0.1762                          19271129
      TOG = 2.0/G                                                       19271130
```

```
      OPGOG = (1.0+G)/G                                                 19271131
      OMGOG = (1.0-G)/G                                                 19271132
      TOGMO = 2.0/(G-1.0)                                               19271133
      TMGOG = (2.0-G)/G                                                 19271134
      C1 = 0.5(G-1.0)*C1                                                19271135
      OOG = 1.0/G                                                       19271136
      PSTAR = PT*((G+1.0)/2.0)**(G/(1.0-G))                             19271137
      PR1 = 1.0                                                         19271138
      INDX = 0                                                          19271139
      NSUP = 0                                                          19271140
      NG = 0                                                            19271141
C                                                                       19271142
 1002 CONTINUE                                                          19271143
      N = 0                                                             19271144
      IF (CPH) 10042, 10041, 10042                                      19271145
10041 A = 2.0*(P3-R3)                                                   19271146
      GO TO 10043                                                       19271147
10042 A = 3.14159*(P3**2-R3**2)                                         19271148
10043 CONTINUE                                                          19271149
      C2 = C1*(ASTAR/A)**2                                              19271150
      DELPM = 0.1                                                       19271151
      PDELP = 0.0                                                       19271152
      IF (ASTAR-A) 10222,10222,10221                                    19271153
10221 P3 = PSTAR                                                        19271154
      XM = 1.0                                                          19271155
      RETURN                                                            19271156
10222 IF (Z3) 10019, 10223, 10019                                       19271157
10223 IF (ISTS) 10024, 10022, 10024                                     19271158
C                                TEST FOR INDX = 0                      19271159
10019 IF (INDX) 10023, 10021, 10023                                     19271160
10021 INDX = 1                                                          19271161
      A2 = A3                                                           19271162
      X2 = X3                                                           19271163
C                                FIND SUBSONIC SOLUTION                 19271164
10022 PR1 = 1.0                                                         19271165
      SIGN = 1.0                                                        19271166
      GO TO 1003                                                        19271167
C                                IS SUPERSONIC SOLUTION DESIRED         19271168
10023 IF (NSUP) 10024, 10025, 10024                                     19271169
C                                FIND SUPERSONIC SOLUTION               19271170
```

```
10024 PR1 = 0.1                                                         19271171
      SIGN = -1.0                                                       19271172
      NSUP = 1                                                          19271173
      GO TO 1003                                                        19271174
C                           HAVE WE PASSED SONIC POINT                  19271175
10025 IF (IIIII) 10022, 10026, 10022                                    19271176
10026 IIIII = 1                                                         19271177
      A1 = A2                                                           19271178
      A2 = A3                                                           19271179
      X1 = X2                                                           19271180
      X2 = X3                                                           19271181
      XK1 = (A2-A1)/(X2-X1)                                             19271182
      IF (XK1) 10027, 10022, 10022                                      19271183
10027 APRIM = A2+XK1*(Z3-X2)                                            19271184
      IF (PSTAR-APRIM) 10022, 10022, 10024                              19271185
C                           COMPUTE ERROR AND PARTIAL                   19271186
 1003 E = PR1**TOG-PR1**OPGOG-C2                                        19271187
      DEDP = TOG*PR1**TMGOG-OPGOG*PR1**OOG                              19271188
      PSAVE(N+1) = PR1                                                  19271189
      ESAVE(N+1) = E                                                    19271190
      DESAVE(N+1) = DEDP                                                19271191
C                           TEST FOR SECOND ROOT                        19271192
      IF (SIGN*DEDP) 1032, 1031, 1031                                   19271193
 1031 NG = NG+1                                                         19271194
      PR1 = 0.5*(PSAVE(N)+PSAVE(N+1))                                   19271195
      N = N-1                                                           19271196
      IF (NG-20) 1003, 1003, 1005                                       19271197
 1032 CONTINUE                                                          19271198
C                           COMPUTE NEW GUESS                           19271199
      DELP = E/DEDP                                                     19271200
      IF (DELP*PDELP) 10031, 10032, 10032                               19271201
10031 DELPM = DELPM/2.0                                                 19271202
10032 IF (DELPM-ABSF(DELP)) 10033, 10034, 10034                         19271203
10033 DELP = SIGNF(DELPM,DELP)                                          19271204
10034 PR2 = PR1-DELP                                                    19271205
      PDELP = DELP                                                      19271206
C                           TEST TOLERANCE                              19271207
      IF (ABSF(PR2-PR1)-1.0E-5) 1006, 1006, 1004                        19271208
C                           TRY AGAIN                                   19271209
 1004 PR1 = PR2                                                         19271210
```

```
      N = N+1
      IF (N-50) 1003, 1003, 1005
 1005 WRITE OUTPUT TAPE 6, 10000, Z3, R3
10000 FORMAT(33H0ITERATION FOR P FAILED WHEN X = F10.4,9H AND Y = F10.4)
      WRITE OUTPUT TAPE 6, 10001, (PSAVE(I),ESAVE(I),DESAVE(I),I=1,N),
     1PR1, E, DEDP
10001 FORMAT(28H THE ITERATED VALUES WERE.../6H PS/PT10X5HERROR10X5HDE/
     1DP/(1X1P3E15.5))
      WRITE OUTPUT TAPE 6, 10002, ASTAR, A, C2
10002 FORMAT(9H ASTAR = 1PE15.5,8H,   A = 1PE15.5,9H,   C2 = 1PE15.5)
      P3 = 0.0
      RETURN
C
 1006 P3 = PR2*PT
      XM = SQRTF(TOGMO*(PR2**OMGOG-1.0))
      A3 = P3
      X3 = Z3
      RETURN
      END
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
816	01460	32441	77271

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A	32446	77276	ASTAR	32444	77274	BB	32546	77442	CPH	32442	77272	DUMY	32561	77461
G	32549	77445	INDP	32554	77452	ISTS	32443	77273	NPORA	32555	77453	NPP	32553	77451
PT	32551	77447	RN	32547	77443	R	32548	77444	TT	32550	77446	W	32552	77450
XY	32445	77275												

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
DESAVE	695	01267	ESAVE	755	01363	PSAVE	815	01457						

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A1	635	01173	A2	634	01172	A3	633	01171	APRIM	632	01170	C1	631	01167
C2	630	01166	DEDP	629	01165	DELPM	628	01164	DELP	627	01163	E	626	01162
INDX	625	01161	I	624	01160	NG	623	01157	N	622	01156	NSUP	621	01155
OMGOG	620	01154	OOG	619	01153	OPGOG	618	01152	PDELP	617	01151	PR1	616	01150
PR2	615	01147	PSTAR	614	01146	R3	613	01145	SIGN	612	01144	TMGOG	611	01143
TOSMU	610	01142	TUG	609	01141	X1	608	01140	X2	607	01137	X3	606	01136
XK1	605	01135	Z3	604	01134									

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)34	100	01124	8)90G	10000	01116	8)90H	10001	01104	8)90I	10002	01067			

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	597	01125	2)	538	01032	3)	544	01040	6)	552	01050	C)G0	602	01132
C)G1	603	01133	D)211	340	00524	D)415	418	00642	E)7	72	00110	E)F	110	00156
E)J	222	00336	E)O	269	00415	E)Q	279	00427	E)U	301	00455	E)11	339	00523
E)13	406	00626	E)14	414	00636	E)16	425	00651	E)211	342	00526			

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CHARET	2	00002	EXP(3	3	00003	SQRT	4	00004	(FIL)	1	00001	(STH)	0	00000

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

CHARET EXP(3 SQRT (FIL) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
1	15	00054	2	17	00064	3	19	00073	4	20	00100	5	22	00117
6	24	00127	7	26	00144	8	27	00146	10	28	00152	9	30	00157
1000	32	00166	1001	33	00172	1002	47	00327	10041	50	00337	10042	52	00346
10043	53	00360	10221	58	00401	10222	62	00411	10223	63	00417	10019	64	00423
10021	65	00431	10022	68	00437	10023	71	00444	10024	72	00446	10025	76	00457
10026	77	00463	10027	84	00507	1003	86	00530	1031	92	00604	1032	96	00627
10031	99	00637	10032	100	00643	10033	101	00652	10034	102	00656	1004	105	00672
1005	108	00705	1006	120	00776									

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        ENTRY   DATE                                                    19271230
* * * *      THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS  19271231
* * * *      NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN   19271232
* * * *      CONSENT OF THE BOEING COMPANY.                             19271233
 DATE   SXD     *-2,4                                                   19271234
        PXA             ZERO THE AC                                     19271235
        LDQ     DATEC  THE DATE IS PUT IN THE MQ (XXXXXX)               19271236
        LGL     12     THE MONTH IS PUT IN THE AC (XX     )             19271237
        ALS     6      SPACE IS MADE AVAILABLE IN THE AC FOR -         19271238
        ORA*    FORTY  THE - IS PUT IN THE AC (XX-    )                19271239
        LGL     12     THE DAY IS PUT IN THE AC (XX-XX )               19271240
        ALS     6      SPACE IS MADE AVAILABLE IN THE AC FOR -         19271241
        ORA*    FORTY  THE - IS PUT IN THE AC (XX-XX-)                 19271242
        STO     AMODAY THE MONTH AND DAY IS STORED (XX-XX-)            19271243
        PXA            ZERO THE AC                                     19271244
        LGL     36     THE YEAR IS PUT IN THE AC LEFT ADJUSTED         19271245
        ORA*    BLANK  THE REMAINDER OF THE AC IS BLANKED              19271246
        STO     YEAR   THE YEAR IS STORED (XX     )                    19271247
        CALL    PRIDAT,AMODAY,YEAR                                     19271248
        LXD     DATE-2,4  XR4 IS RE-STORED                             19271249
        TRA     2,4     .   RETURN                                     19271250
 DATEC  BOOL    64     THE LOCATION WHERE THE DATE IS FOUND            19271251
 FORTY          =0000000000040                                         19271252
 BLANK          =0000060606060                                         19271253
AMODAY  PZE                                                            19271254
 YEAR   PZE                                                            19271255
        END                                                            19271256
```

```
      SUBROUTINE PRIDAT(X,Y)                                            19271257
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS   19271258
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN    19271259
* * * *     CONSENT OF THE BOEING COMPANY.                              19271260
      WRITE OUTPUT TAPE 6, 1, X, Y                                      19271261
    1 FORMAT (1H1,109X,2A6)                                             19271262
      RETURN                                                            19271263
      END                                                               19271264
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
37	00045	32561	77461

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC	EFN	LOC	EFN	LOC	EFN	LOC
8)1	1	00044						

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
2)	27	00033	6)	28	00034									

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
(FIL)	1	00001	(STH)	0	00000									

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

(FIL) (STH)

ORIGINAL PAGE IS
OF POOR QUALITY

```
      SUBROUTINE PMXPAV(EQUSAV,EQUST,EQUSHP,HTJ,PJ,THETAJ,SJ,VACMN,
     1DELTHE,DELTA,EPSLON,PAMB,THETAX,BETAX,VX,P,NDXP,M)
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN
* * * *     CONSENT OF THE BOEING COMPANY.
F     EQUSAV, EQUST, EQUSHP
      L = 0
      M = 0
      IF (P) 31, 556, 31
  556 IF (DELTHE-DELTA) 31, 32, 32
   32 DFTHET = DELTA
      GO TO 33
   31 DFTHET = 0.0
   33 K = 0
      PO = 0.0
      N = 0
      CALL EQUSHP(PJ,SJ,H1,DPDS1)
      CALL EQUSAV(H1,SJ,AV1)
      CALL EQUST(H1,SJ,T1)
      AV1S = AV1**2
      DPDS2 = DPDS1
      H2 = H1
      AV2 = AV1
      T2 = T1
      AV2S = AV1S
      POO = PJ
      P = PJ
      THETAX = THETAJ
    1 TBAR = 0.5*(T1+T2)
      AVBAR = 0.5*(AV1S+AV2S)
      DPDSBR = 0.5*(DPDS1+DPDS2)
      HBAR = 0.5*(H1+H2)
      IF (L) 43, 55, 43
   55 DP = (2.0*(HTJ-HBAR)*DPDSBR*DELTHE)/(TBAR*(((2.0)/(AVBAR))*
     1(HTJ-HBAR)-1.0)**0.5)
   17 P = P+DP
   34 CALL EQUSHP(P,SJ,H2,DPDS2)
      CALL EQUSAV(H2,SJ,AV2)
      CALL EQUST(H2,SJ,T2)
```

```
      AV2S = AV2**2                                                     19271304
      IF (L) 1, 44, 1                                                   19271305
   44 K = K+1                                                           19271306
      IF (K-10) 99, 99, 3                                               19271307
   99 PO = P                                                            19271308
      P = POO                                                           19271309
      GO TO 1                                                           19271310
    3 POO = P                                                           19271311
      N = N+1                                                           19271312
      IF (DFTHET) 10, 13, 10                                            19271313
   10 THETAX = THETAX+DFTHET                                            19271314
      GO TO 14                                                          19271315
   13 THETAX = THETAX+DELTHE                                            19271316
   14 VX = (2.0*(HTJ-H2))**0.5                                          19271317
      BETAX = ASINF(AV2/VX)                                             19271318
      IF (M) 70, 50, 70                                                 19271319
   50 IF (DFTHET) 70, 20, 70                                            19271320
   20 IF (DELTA) 6, 4, 6                                                19271321
    4 IF (PAMB) 15, 5, 15                                               19271322
    5 VXMN = VX/AV2                                                     19271323
      IF (VXMN-VACMN) 40, 70, 70                                        19271324
   40 IF (NDXP) 41, 70, 41                                              19271325
   41 H1 = H2                                                           19271326
      T1 = T2                                                           19271327
      AV1 = AV2                                                         19271328
      DPDS1 = DPDS2                                                     19271329
      AV1S = AV2S                                                       19271330
      K = 0                                                             19271331
      GO TO 1                                                           19271332
    6 B = N+1                                                           19271333
      IF (ABSF(B*DELTHE)-ABSF(DELTA)) 40, 8, 9                          19271334
    8 DFTHET = DELTHE                                                   19271335
      GO TO 40                                                          19271336
    9 DFTHET = DELTA-B*DELTHE                                           19271337
      DELTHE = DFTHET                                                   19271338
      GO TO 40                                                          19271339
   15 IF (P-PAMB) 16, 70, 40                                            19271340
   16 DP = PAMB-P                                                       19271341
      P = P+DP                                                          19271342
      L = 1                                                             19271343
```

```
      GO TO 34                                                          19271344
   43 DELTHE = (DP*(TBAR*(((2.0)/(AVBAR))*(HTJ-HBAR)-1.0)**0.5))/(2.0   19271345
     1*(HTJ-HBAR)*DPDSBR)                                               19271346
      L = 0                                                             19271347
      M = 1                                                             19271348
      GO TO 13                                                          19271349
   70 RETURN                                                            19271350
       END                                                              19271351
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
428	00654	32561	77461

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
AV1	427	00653	AV1S	426	00652	AV2	425	00651	AV2S	424	00650	AVBAR	423	00647
B	422	00646	DFTHET	421	00645	DPDS1	420	00644	DPDS2	419	00643	DPDSBR	418	00642
DP	417	00641	H1	416	00640	H2	415	00637	HBAR	414	00636	K	413	00635
L	412	00634	N	411	00633	POO	410	00632	PO	409	00631	T1	408	00630
T2	407	00627	TBAR	406	00626	VXMN	405	00625						

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	400	00620	2)	386	00602	3)	390	00606	6)	394	00612			

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ASIN	1	00001	EXP(3	0	00000									

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

ASIN EXP(3

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
556	6	00141	32	7	00146	31	9	00151	33	10	00153	1	28	00227
55	33	00263	17	34	00312	34	35	00315	44	43	00347	99	45	00356
3	48	00363	10	51	00372	13	53	00376	14	54	00401	50	57	00427
20	58	00433	4	59	00437	5	60	00443	40	62	00452	41	63	00454
6	70	00471	8	72	00511	9	74	00514	15	77	00524	16	78	00530
43	82	00541	70	86	00576									

```
      SUBROUTINE STORE(Z,R,P,I)
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN
* * * *     CONSENT OF THE BOEING COMPANY.
      DIMENSION ZARAY(200), RARAY(200), PARAY(200)
      IF (I) 2, 1, 2
C                          STORE VALUES
    1 M = M+1
      ZARAY(M) = Z
      RARAY(M) = R
      PARAY(M) = P
      RETURN
C                          WRITE TAPE
    2 REWIND 11
      WRITE OUTPUT TAPE 11, 3, M
      WRITE OUTPUT TAPE 11, 4, (ZARAY(J),RARAY(J),PARAY(J),J=1,M)
      REWIND 11
      M = 0
      RETURN
C
    3 FORMAT(I4,80X)
    4 FORMAT(1P3E16.7)
      END
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
684	01254	32561	77461

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
PARAY	283	00433	RARAY	483	00743	ZARAY	683	01253						

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
M	83	00123												

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
813	3	00122	814	4	00120									

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
2)	70	00106	6)	73	00111									

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
(FIL)	2	00002	(RWT)	0	00000	(STH)	1	00001						

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

(FIL) (RWT) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
1	7	00030	2	13	00046									

```
      SUBROUTINE INTER (EPS1,A1,A2,Z1,Z2,R1,R2,Z3,R3)
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN
* * * *     CONSENT OF THE BOEING COMPANY.
      IF ACCUMULATOR OVERFLOW 10, 10
   10 IF QUOTIENT OVERFLOW 20, 20
   20 IF DIVIDE CHECK 30, 30
   30 SIN1 = SINF(A1)
      SIN2 = SINF(A2)
      COS1 = COSF(A1)
      COS2 = COSF(A2)
      IF (ABSF(COS1)-ABSF(COS2)) 1, 11, 2
   11 IF (A1+A2) 13, 12, 13
   12 IF (ABSF(COS1)-EPS1) 13, 13, 6
    1 IF (ABSF(COS1)-EPS1) 3, 3, 6
    3 Z3 = Z1
      GO TO 7
    2 IF (ABSF(COS2)-EPS1) 4, 4, 6
    4 Z3 = Z2
      GO TO 8
    6 SL1 = SIN1/COS1
      SL2 = SIN2/COS2
      B1 = R1-(SL1*Z1)
      B2 = R2-(SL2*Z2)
      Z3 = (B2-B1)/(SL1-SL2)
      R3 = SL1*Z3+B1
      GO TO 9
    7 R3 = (SIN2/COS2)*Z3+R2-((SIN2/COS2)*Z2)
      GO TO 9
    8 R3 = (SIN1/COS1)*Z3+R1-((SIN1/COS1)*Z1)
    9 IF ACCUMULATOR OVERFLOW 13, 15
   15 IF QUOTIENT OVERFLOW 13, 16
   16 IF DIVIDE CHECK 13, 17
   13 CALL TRACE
   17 RETURN
      END
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
195	00303	32561	77461

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
B1	194	00302	B2	193	00301	COS1	192	00300	COS2	191	00277	SIN1	190	00276
SIN2	189	00275	SL1	188	00274	SL2	187	00273						

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	184	00270	4)	32767	77777	6)	178	00262						

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
COS	1	00001	SIN	0	00000	TRACE	2	00002						

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

COS SIN TRACE

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
10	5	00064	20	7	00067	30	8	00071	11	13	00126	12	14	00133
1	15	00141	3	16	00146	2	18	00151	4	19	00156	6	21	00161
7	28	00215	8	30	00230	9	31	00242	15	33	00245	16	35	00250
13	36	00253	17	37	00256									

ORIGINAL PAGE IS OF POOR QUALITY

```
      SUBROUTINE PTFTAX (EQUSAV,EQUST,Z1,V1,S1,THETA2,R2,Z2,V2,S2,HT,
     1NITER,EPS1,EPS3,EPS4,EPS5,Z3,R3,S3,V3,THETA3)
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN
* * * *     CONSENT OF THE BOEING COMPANY.
      DIMENSION DUMMY(119)
      COMMON DUMMY
      COMMON CPH
F     EQUSAV, EQUST
      Z30 = 0.0
      R30 = 0.0
      V30 = 0.0
      THET30 = 0.0
      THETA1 = 0.0
      R1 = 0.0
      N = 0
      H1 = HT-0.5*(V1**2)
      H2 = HT-0.5*(V2**2)
      CALL EQUSAV(H1,S1,AV1)
      CALL EQUSAV(H2,S2,AV2)
      CALL EQUST(H1,S1,T1)
      CALL EQUST(H2,S2,T2)
      BETA1 = ASINF(AV1/V1)
      BETA2 = ASINF(AV2/V2)
      SBETA1 = AV1/V1
      SBETA2 = AV2/V2
      CBETA1 = COSF(BETA1)
      CBETA2 = COSF(BETA2)
      STHET2 = SINF(THETA2)
      CTPB1 = COSF(THETA1+BETA1)
      CTPB2=COSF(THETA2+BETA2)
      CTMB2 = COSF(THETA2-BETA2)
      A1 = CBETA1/(V1*SBETA1)
      C1 = (T1*SBETA1*CBETA1)/(AV1**2)
      A2 = CBETA2/(V2*SBETA2)
      C2 = (T2*SBETA2*CBETA2)/(AV2**2)
      B2 = (SBETA2*STHET2)/(R2*CTMB2)
      B1=B2*CTMB2/CTPB2
      G1 = SBETA1/CTPB1
```

```
      HH2 = SBETA2/CTMB2
      TPB1 = THETA1+BETA1
      TMB2 = THETA2-BETA2
      BA3 = A1
      BC3 = C1
      SA3 = A2
      SC3 = C2
      SB3 = B2
      G3 = G1
      HH3 = HH2
      TPB3 = TPB1
      TMB3 = TMB2
      B3 = 0.0
    1 A1BAR = 0.5*(A1+BA3)
      A2BAR = 0.5*(A2+SA3)
      C1BAR = 0.5*(C1+BC3)
      C2BAR = 0.5*(C2+SC3)
      B2BAR = CPH*0.5*(B2+SB3)
      GBAR = 0.5*(G1+G3)
      HBAR = 0.5*(HH2+HH3)
      AN1BAR = 0.5*(TPB1+TPB3)
      AN2BAR = 0.5*(TMB2+TMB3)
      CALL INTER (EPS1,AN1BAR,AN2BAR,Z1,Z2,R1,R2,Z3,R3)
      S3 = S1+((S2-S1)/(1.0+(HBAR*(Z3-Z2))/(GBAR*(Z3-Z1))))
      V3 = (1.0/(A1BAR+A2BAR))*(THETA2+A1BAR*V1+A2BAR*V2+B3*(Z3-Z1)
     1+B2BAR*(Z3-Z2)-C1BAR*(S3-S1)*32.2-C2BAR*(S3-S2)*32.2)
      THETA3 = THETA2-A2BAR*(V3-V2)+B2BAR*(Z3-Z2)-C2BAR*(S3-S2)*32.2
      N = N+1
      IF (NITER-N) 7, 7, 2
    2 IF (ABSF(Z3-Z30)-EPS3) 3, 6, 6
    3 IF (ABSF(R3-R30)-EPS3) 4, 6, 6
    4 IF (ABSF(V3-V30)-EPS4) 5, 6, 6
    5 IF (ABSF(THETA3-THET30)-EPS5) 7, 6, 6
    6 Z30 = Z3
      R30 = R3
      V30 = V3
      THET30 = THETA3
      H3 = HT-0.5*(V3**2)
      CALL EQUSAV(H3,S3,AV3)
      CALL EQUST(H3,S3,T3)
```

```
      BETA3 = ASINF(AV3/V3)                                             19271490
      SBETA3 = AV3/V3                                                   19271491
      CBETA3 = COSF(BETA3)                                              19271492
      STHET3 = SINF(THETA3)                                             19271493
      CTPB3 = COSF(THETA3+BETA3)                                        19271494
      CTMB3 = COSF(THETA3-BETA3)                                        19271495
      BA3 = CBETA3/(V3*SBETA3)                                          19271496
      BC3 = (T3*SBETA3*CBETA3)/(AV3**2)                                 19271497
      SA3 = BA3                                                         19271498
      SC3 = BC3                                                         19271499
      SB3=(R3/R2)*B2                                                    19271500
      G3 = SBETA3/CTPB3                                                 19271501
      HH3 = SBETA3/CTMB3                                                19271502
      TPB3 = THETA3+BETA3                                               19271503
      TMB3 = THETA3-BETA3                                               19271504
      B3 = CPH*(R3/R2)*B1                                               19271505
      GO TO 1                                                           19271506
    7 RETURN                                                            19271507
      END                                                               19271508
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
694	01266	32441	77271

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CPH	32442	77272	DUMMY	32561	77461									

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A1BAR	693	01265	A1	692	01264	A2BAR	691	01263	A2	690	01262	AN1BAR	689	01261
AN2BAR	688	01260	AV1	687	01257	AV2	686	01256	AV3	685	01255	B1	684	01254
B2BAR	683	01253	B2	682	01252	B3	681	01251	BA3	680	01250	BC3	679	01247
BETA1	678	01245	BETA2	677	01245	BETA3	676	01244	C1BAR	675	01243	C1	674	01242
C2BAR	673	01241	C2	672	01240	CBETA1	671	01237	CBETA2	670	01236	CBETA3	669	01235
CTMB2	668	01234	CTMB3	667	01233	CTPB1	666	01232	CTPB2	665	01231	CTPB3	664	01230
G1	663	01227	G3	662	01226	GBAR	661	01225	H1	660	01224	H2	659	01223
H3	658	01222	HBAR	657	01221	HH2	656	01220	HH3	655	01217	N	654	01216
R1	653	01215	R30	652	01214	SA3	651	01213	SB3	650	01212	SBETA1	649	01211
SBETA2	648	01210	SBETA3	647	01207	SC3	646	01206	STHET2	645	01205	STHET3	644	01204
T1	643	01203	T2	642	01202	T3	641	01201	THET30	640	01200	THETA1	639	01177
TMB2	638	01176	TMB3	637	01175	TPB1	636	01174	TPB3	635	01173	V30	634	01172
Z30	633	01171												

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	621	01155	2)	608	01140	3)	611	01143	6)	615	01147			

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ASIN	0	00000	COS	1	00001	INTER	3	00003	SIN	2	00002			

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

ASIN COS INTER SIN

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
1	53	00463	2	69	00734	3	70	00742	4	71	00750	5	72	00756
6	73	00765	7	99	01134									

```
      SUBROUTINE INTRPT (EQUSAV,EQUST,THETA1,R1,Z1,V1,S1,THETA2,R2,Z2,
     XV2,S2,HT,NITER,EPS1,EPS2,EPS3,EPS4,EPS5,Z3,R3,S3,V3,THETA3)
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN
* * * *     CONSENT OF THE BOEING COMPANY.
      DIMENSION DUMMY(119)
      COMMON DUMMY
      COMMON CPH
F     EQUSAV, EQUST
      Z30 = 0.0
      R30 = 0.0
      V30 = 0.0
      THET30 = 0.0
      N = 0
      H1 = HT-0.5*(V1**2)
      H2 = HT-0.5*(V2**2)
      CALL EQUSAV(H1,S1,AV1)
      CALL EQUSAV(H2,S2,AV2)
      BETA1 = ASINF(AV1/V1)
      BETA2 = ASINF(AV2/V2)
      SBETA1 = AV1/V1
      SBETA2 = AV2/V2
      CBETA1 = COSF(BETA1)
      CBETA2 = COSF(BETA2)
      STHET1 = SINF(THETA1)
      STHET2 = SINF(THETA2)
      CTPB1 = COSF(THETA1+BETA1)
      CTMB2 = COSF(THETA2-BETA2)
      STPB1 = SINF(THETA1+BETA1)
      STMB2 = SINF(THETA2-BETA2)
      CALL EQUST(H1,S1,T1)
      CALL EQUST(H2,S2,T2)
      A1 = CBETA1/(V1*SBETA1)
      B1 = (SBETA1*STHET1)/(R1*CTPB1)
      C1 = (T1*SBETA1*CBETA1)/(AV1**2)
      A2 = CBETA2/(V2*SBETA2)
      B2 = (SBETA2*STHET2)/(R2*CTMB2)
      C2 = (T2*SBETA2*CBETA2)/(AV2**2)
      G1 = SBETA1/CTPB1
```

```
      HH2 = SBETA2/CTMB2                                                19271548
      G1ST = SBETA1/STPB1                                               19271549
      H2ST = SBETA2/STMB2                                               19271550
      B1ST = (SBETA1*STHET1)/(R1*STPB1)                                 19271551
      B2ST = (SBETA2*STHET2)/(R2*STMB2)                                 19271552
      TPB1 = THETA1+BETA1                                               19271553
      TMB2 = THETA2-BETA2                                               19271554
      BA3 = A1                                                          19271555
      BB3 = B1                                                          19271556
      BC3 = C1                                                          19271557
      SA3 = A2                                                          19271558
      SB3 = B2                                                          19271559
      SC3 = C2                                                          19271560
      G3 = G1                                                           19271561
      HH3 = HH2                                                         19271562
      G3ST = G1ST                                                       19271563
      H3ST = H2ST                                                       19271564
      BB3ST = B1ST                                                      19271565
      SB3ST = B2ST                                                      19271566
      TPB3 = TPB1                                                       19271567
      TMB3 = TMB2                                                       19271568
    1 A1BAR = 0.5*(A1+BA3)                                              19271569
      C1BAR = 0.5*(C1+BC3)                                              19271570
      A2BAR = 0.5*(A2+SA3)                                              19271571
      C2BAR = 0.5*(C2+SC3)                                              19271572
      AN1BAR = 0.5*(TPB1+TPB3)                                          19271573
      AN2BAR = 0.5*(TMB2+TMB3)                                          19271574
      CALL INTER(EPS1,AN1BAR,AN2BAR,Z1,Z2,R1,R2,Z3,R3)                  19271575
      IF (N) 14, 15, 14                                                 19271576
   14 IF (ABSF(CTPB3)-EPS2) 2, 2, 15                                    19271577
   15 IF (ABSF(CTPB1)-EPS2) 2, 2, 16                                    19271578
   16 IF (N) 17, 3, 17                                                  19271579
   17 IF (CTPB3) 18, 19, 19                                             19271580
   18 IF (CTPB1) 3, 3, 2                                                19271581
   19 IF (CTPB1) 2, 3, 3                                                19271582
    2 DZ13 = R3-R1                                                      19271583
      GBAR = 0.5*(G1ST+G3ST)                                            19271584
      B1BAR = CPH*0.5*(B1ST+BB3ST)                                      19271585
      GO TO 4                                                           19271586
    3 DZ13 = Z3-Z1                                                      19271587
```

```
      GBAR = 0.5*(G1+G3)                                                19271588
      B1BAR = CPH*0.5*(B1+BB3)                                          19271589
    4 IF (N) 20, 21, 20                                                 19271590
   20 IF (ABSF(CTMB3)-EPS2) 5, 5, 21                                    19271591
   21 IF (ABSF(CTMB2)-EPS2) 5, 5, 22                                    19271592
   22 IF (N) 23, 6, 23                                                  19271593
   23 IF (CTMB3) 24, 25, 25                                             19271594
   24 IF (CTMB2) 6, 6, 5                                                19271595
   25 IF (CTMB2) 5, 6, 6                                                19271596
    5 DZ23 = R3-R2                                                      19271597
      HBAR = 0.5*(H2ST+H3ST)                                            19271598
      B2BAR = CPH*0.5*(B2ST+SB3ST)                                      19271599
      GO TO 7                                                           19271600
    6 DZ23 = Z3-Z2                                                      19271601
      HBAR = 0.5*(HH2+HH3)                                              19271602
      B2BAR = CPH*0.5*(B2+SB3)                                          19271603
    7 S3 = S1+((S2-S1)/(1.0+(DZ23*HBAR)/(DZ13*GBAR)))                   19271604
      V3 = (1.0/(A1BAR+A2BAR))*(THETA2-THETA1+A1BAR*V1+A2BAR*V2+B1BAR*DZ19271605
     113+B2BAR*DZ23-C1BAR*32.2*(S3-S1)-C2BAR*32.2*(S3-S2))              19271606
      THETA3 = THETA1+A1BAR*(V3-V1)-B1BAR*DZ13+C1BAR*32.2*(S3-S1)       19271607
      N = N+1                                                           19271608
      IF(NITER-N)13,13,8                                                19271609
    8 IF(ABSF(Z3-Z30)-EPS3)9,12,12                                      19271610
    9 IF(ABSF(R3-R30)-EPS3)10,12,12                                     19271611
   10 IF(ABSF(V3-V30)-EPS4)11,12,12                                     19271612
   11 IF(ABSF(THETA3-THET30)-EPS5)13,12,12                              19271613
   12 Z30 = Z3                                                          19271614
      R30 = R3                                                          19271615
      V30 = V3                                                          19271616
      THET30 = THETA3                                                   19271617
      H3 = HT-0.5*(V3**2)                                               19271618
      CALL EQUSAV(H3,S3,AV3)                                            19271619
      CALL EQUST(H3,S3,T3)                                              19271620
      BETA3 = ASINF(AV3/V3)                                             19271621
      SBETA3 = AV3/V3                                                   19271622
      CBETA3 = COSF(BETA3)                                              19271623
      STHET3 = SINF(THETA3)                                             19271624
      CTPB3 = COSF(THETA3+BETA3)                                        19271625
      CTMB3 = COSF(THETA3-BETA3)                                        19271626
      STPB3 = SINF(THETA3+BETA3)                                        19271627
```

```
      STMB3 = SINF(THETA3-BETA3)                                        19271628
      BA3 = CBETA3/(V3*SBETA3)                                          19271629
      BB3 = (SBETA3*STHET3)/(R3*CTPB3)                                  19271630
      BC3 = (T3*SBETA3*CBETA3)/(AV3**2)                                 19271631
      SA3 = BA3                                                         19271632
      SB3 = (SBETA3*STHET3)/(R3*CTMB3)                                  19271633
      SC3 = BC3                                                         19271634
      G3 = SBETA3/CTPB3                                                 19271635
      HH3 = SBETA3/CTMB3                                                19271636
      G3ST = SBETA3/STPB3                                               19271637
      H3ST = SBETA3/STMB3                                               19271638
      BB3ST = (SBETA3*STHET3)/(R3*STPB3)                                19271639
      SB3ST = (SBETA3*STHET3)/(R3*STMB3)                                19271640
      TPB3 = THETA3+BETA3                                               19271641
      TMB3 = THETA3-BETA3                                               19271642
      GO TO 1                                                           19271643
   13 RETURN                                                            19271644
       END                                                              19271645
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
876	01554	32441	77271

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CPH	32442	77272	DUMMY	32561	77461									

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A1BAR	875	01553	A1	874	01552	A2BAR	873	01551	A2	872	01550	AN1BAR	871	01547
AN2BAR	870	01546	AV1	869	01545	AV2	868	01544	AV3	867	01543	B1BAR	866	01542
B1	865	01541	B1ST	864	01540	B23AR	863	01537	B2	862	01536	B2ST	861	01535
BA3	860	01534	BB3	859	01533	BB3ST	858	01532	BC3	857	01531	BETA1	856	01530
BETA2	855	01527	BETA3	854	01526	C1BAR	853	01525	C1	852	01524	C2BAR	851	01523
C2	850	01522	CBETA1	849	01521	CBETA2	848	01520	CBETA3	847	01517	CTMB2	846	01516
CTMB3	845	01515	CTPB1	844	01514	CTPB3	843	01513	DZ13	842	01512	DZ23	841	01511
G1	840	01510	G1ST	839	01507	G3	838	01506	G3ST	837	01505	GBAR	836	01504
H1	835	01503	H2	834	01502	H2ST	833	01501	H3	832	01500	H3ST	831	01477
HBAR	830	01476	HH2	829	01475	HH3	828	01474	N	827	01473	R30	826	01472
SA3	825	01471	SB3	824	01470	SB3ST	823	01467	SBETA1	822	01466	SBETA2	821	01465
SBETA3	820	01464	SC3	819	01463	STHET1	818	01462	STHET2	817	01461	STHET3	816	01460
STMB2	815	01457	STMB3	814	01456	STPB1	813	01455	STPB3	812	01454	T1	811	01453
T2	810	01452	T3	809	01451	THET30	808	01450	TMB2	807	01447	TMB3	806	01446
TPB1	805	01445	TPB3	804	01444	V30	803	01443	Z30	802	01442			

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	792	01430	2)	779	01413	3)	782	01416	6)	786	01422			

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ASIN	0	00000	COS	1	00001	INTER	3	00003	SIN	2	00002			

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

ASIN COS INTER SIN

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
1	61	00551	14	70	00633	15	71	00641	16	72	00647	17	73	00651
18	74	00654	19	75	00660	2	76	00663	3	80	00704	4	83	00724
20	84	00726	21	85	00734	22	86	00742	23	87	00744	24	88	00747
25	89	00753	5	90	00756	6	94	00777	7	97	01017	8	102	01143
9	103	01151	10	104	01157	11	105	01165	12	106	01174	13	138	01407

```
      SUBROUTINE PAMBPT(EQUSAV,EQUST,THETA1,R1,Z1,V1,S1,THETA2,R2,Z2,V2,19271646
     1S2,HT,NITER,EPS1,EPS2,EPS3,EPS5,Z3,R3,S3,V3,THETA3,P3,B,C)         19271647
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS   19271648
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN    19271649
* * * *     CONSENT OF THE BOEING COMPANY.                              19271650
      DIMENSION DUMMY(119)                                              19271651
      COMMON DUMMY                                                      19271652
      COMMON CPH                                                        19271653
F     EQUSAV,EQUST,EQUSH                                                19271654
      IIIII = 0                                                         19271655
      Z30 = 0.0                                                         19271656
      R30 = 0.0                                                         19271657
      THET30 = 0.0                                                      19271658
      N = 0                                                             19271659
      H1 = HT-0.5*(V1**2)                                               19271660
      CALL EQUSAV(H1,S1,AV1)                                            19271661
      BETA1 = ASINF(AV1/V1)                                             19271662
      SBETA1 = AV1/V1                                                   19271663
      CBETA1 = COSF(BETA1)                                              19271664
      CTPB1 = COSF(THETA1+BETA1)                                        19271665
      STPB1 = SINF(THETA1+BETA1)                                        19271666
      STHET1 = SINF(THETA1)                                             19271667
      CALL EQUST(H1,S1,T1)                                              19271668
      A1 = CBETA1/(V1*SBETA1)                                           19271669
      B1 = (SBETA1*STHET1)/(R1*CTPB1)                                   19271670
      C1 = (T1*SBETA1*CBETA1)/(AV1**2)                                  19271671
      B1ST = (SBETA1*STHET1)/(R1*STPB1)                                 19271672
      TPB1 = THETA1+BETA1                                               19271673
      A3=A1                                                             19271674
      C3=C1                                                             19271675
      B3 = B1                                                           19271676
      B3ST = B1ST                                                       19271677
      TPB3 = TPB1                                                       19271678
      THETA3 = THETA2                                                   19271679
      S3 = S2                                                           19271680
      DS = 32.2*(S3-S1)                                                 19271681
    1 A1BAR = 0.5*(A1+A3)                                               19271682
      C1BAR = 0.5*(C1+C3)                                               19271683
      AN1BAR = 0.5*(TPB1+TPB3)                                          19271684
```

```
      AN2BAR = 0.5*(THETA2+THETA3)                                      19271685
      CALL INTER(EPS1,AN1BAR,AN2BAR,Z1,Z2,R1,R2,Z3,R3)                  19271686
      IF (ABSF((Z3-Z1)/(R3-R1))-EPS2) 2, 3, 3                           19271687
    2 DZ13 = R3-R1                                                      19271688
      B1BAR = CPH*0.5*(B1ST+B3ST)                                       19271689
      GO TO 4                                                           19271690
    3 DZ13 = Z3-Z1                                                      19271691
      B1BAR = CPH*0.5*(B1+B3)                                           19271692
    4 CALL PSEC(Z3,R3,P3,IIIII,P30)                                     19271693
      CALL EQUSH(P3,S3,H3,DHDP3)                                        19271694
      V3=SQRTF(2.0*(HT-H3))                                             19271695
      DV = V3-V1                                                        19271696
      THETA3 = THETA1+A1BAR*DV-B1BAR*DZ13+C1BAR*DS                      19271697
      N = N+1                                                           19271698
      IF (NITER-N) 10, 10, 5                                            19271699
    5 IF (ABSF(Z3-Z30)-EPS3) 6, 8, 8                                    19271700
    6 IF (ABSF(R3-R30)-EPS3) 7, 8, 8                                    19271701
    7 IF (ABSF(THETA3-THET30)-EPS5) 9, 8, 8                             19271702
    8 Z30 = Z3                                                          19271703
      R30 = R3                                                          19271704
      P30 = P3                                                          19271705
      THET30 = THETA3                                                   19271706
      CALL EQUSAV(H3,S3,AV3)                                            19271707
      CALL EQUST(H3,S3,T3)                                              19271708
      BETA3 = ASINF(AV3/V3)                                             19271709
      SBETA3 = AV3/V3                                                   19271710
      CBETA3 = COSF(BETA3)                                              19271711
      A3 = CBETA3/(V3*SBETA3)                                           19271712
      C3 = (T3*SBETA3*CBETA3)/(AV3**2)                                  19271713
      STHET3 = SINF(THETA3)                                             19271714
      CTPB3 = COSF(THETA3+BETA3)                                        19271715
      STPB3 = SINF(THETA3+BETA3)                                        19271716
      B3 = (SBETA3*STHET3)/(R3*CTPB3)                                   19271717
      B3ST = (SBETA3*STHET3)/(R3*STPB3)                                 19271718
      TPB3 = THETA3+BETA3                                               19271719
      GO TO 1                                                           19271720
    9 RETURN                                                            19271721
   10 WRITE OUTPUT TAPE 6, 11                                           19271722
   11 FORMAT(55HOSUBROUTINE PAMBT UNABLE TO CONVERGE   CASE TERMINATED.)19271723
      P3 = 0.0                                                          19271724
```

```
RETURN                                                    19271725
 END                                                      19271726
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
536	01030	32441	77271

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CPH	32442	77272	DUMMY	32561	77461									

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A1BAR	535	01027	A1	534	01026	A3	533	01025	AN1BAR	532	01024	AN2BAR	531	01023
AV1	530	01022	AV3	527	01021	B1BAR	526	01020	B1	527	01017	B1ST	526	01016
B3	525	01015	B3ST	524	01014	BETA1	523	01013	BETA3	522	01012	C1BAR	521	01011
C1	520	01010	C3	519	01007	CBETA1	516	01006	CBETA3	517	01005	CTPB1	516	01004
CTPB3	515	01003	EPOP3	514	01002	DS	513	01001	DV	512	01000	D713	511	00777
H1	510	00776	H3	509	00775	IIII	508	00774	N	507	00773	P30	506	00772
P30	505	00771	SBETA1	504	00770	SBETA3	503	00767	STHET1	502	00766	STHET3	501	00765
STPB1	500	00764	STPB3	499	00763	T1	498	00762	T3	497	00761	THET30	496	00760
TPB1	495	00757	TPB3	494	00756	Z30	493	00755						

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
918	11	00751												

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	490	00752	2)	466	00722	3)	470	00726	6)	474	00732			

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ASIN	1	00001	COS	2	00002	EQUSH	0	00000	INTER	4	00004	PSEC	5	00005
SIN	3	00003	SQRT	6	00006	(FIL)	8	00010	(STH)	7	00007			

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

ASIN COS EQUSH INTER PSEC SIN SQRT (FIL) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
1	36	00350	2	43	00427	3	46	00442	4	48	00454	5	57	00533
6	58	00541	7	59	00547	8	60	00556	9	80	00704	10	82	00710

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      SUBROUTINE INSHRT(EQUSAV,EQUST,EQUSS,EQUSP,EQUSRO,X1,Y1,V1,X1MN,
     1S1,THET1,P1,RHO1,ALPH1,X2,Y2,V2,X2MN,S2,THET2,P2,RHO2,X12,Y12,V12,
     2X12MN,S12,THET12,P12,RHO12,X13,Y13,V13,X13MN,S13,THET13,P13,RHO13,
     3HTJ,NITER,ERS1,ERS2,ERS3,ERS4,ERS5,ERR2,X4,Y4,V4,X4MN,
     4S4,THET4,P4,RHO4,ALPH4,X11,Y11,V11,X11MN,S11,THET11,P11,RHO11,LG,
     5LB,GAMJ,INDINS)
* * * *      THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS
* * * *      NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN
* * * *      CONSENT OF THE BOEING COMPANY.
      DIMENSION DUMMY(119)
      COMMON DUMMY
      COMMON CPH
E     EQUSS, EQUSP, EQUSRO, EQUSAV, EQUST
      DIMENSION TT10(4), TT11(4)
      LLC = 0
      LG = 0
      LB = 0
      LL = 0
      GO = 0.0
      IF (I) 200, 95, 200
   95 I = 1
      J = 0
      DELALP = -1.74533E-3
      ALPT = ALPH1
      TALPH1 = TANF(ALPH1)
      ALPH4 = ALPH1
      TALPH4 = TALPH1
      KDC = 0
      KDK = 0
      K = 0
      KG = 0
  200 IF (KG) 41, 1314, 41
 1314 CALL INTRPT(EQUSAV,EQUST,THET2,Y2,X2,V2,S2,THET1,Y1,X1,V1,S1,HTJ,
     1NITER, ERS1, ERS2, ERS3, ERS4, ERS5, X3, Y3, S3, V3, THET3)
      H2 = HTJ-0.5*(V2**2)
      H3 = HTJ-0.5*(V3**2)
      CALL EQUSP(H3,S3,P3)
      CALL EQUSRO(H3,S3,RHO3)
      CALL EQUSAV(H3,S3,AV3)
```

```
      X3MN = V3/AV3
      KDC = KDC+1
      IF (KDC-100) 300, 301, 301
  301 WRITE OUTPUT TAPE 6, 40
   40 FORMAT(47H0INTERIOR SHOCK WILL NOT CONVERGE TO A SOLUTION)
      GO TO 22
  300 IF (J) 10, 1313, 10
   10 J = 0
 1313 IF (ABSF(ALPH1-1.5708)-1.745E-3) 520, 520, 521
  521 IF (ABSF(ALPH4-1.5708)-1.745E-3) 520, 520, 522
  522 IF (ALPH1-1.5708) 523, 525, 524
  523 IF (ALPH4-1.5708) 525, 525, 520
  524 IF (ALPH4-1.5708) 520, 525, 525
  520 B = (X1-X2)/(X3-X2)
      IF (X2-X3) 56, 56, 90
  525 TPB2 = THET2+ASINF(1.0/X2MN)
      TPB3 = THET3+ASINF(1.0/X3MN)
      IF (ABSF(TPB2-1.5708)-1.745E-3) 526, 526, 527
  527 IF (ABSF(TPB3-1.5708)-1.745E-3) 526, 526, 528
  528 IF (TPB2-1.5708) 529, 530, 531
  529 IF (TPB3-1.5708) 530, 530, 526
  531 IF (TPB3-1.5708) 526, 530, 530
  526 B = (Y1-Y2+0.5*(X3-X1)*(TALPH1+TALPH4))/(Y3-Y2)
      GO TO 69
  530 B = (2.0*(Y1-Y2)-(X1-X2)*(TALPH1+TALPH4))/(2.0*(Y3-Y2)-(X3-X2)*
     1(TALPH1+TALPH4))
   69 IF (Y3-Y2) 56, 56, 90
   90 IF (B) 56, 56, 60
   60 X4 = X2+B*(X3-X2)
      Y4 = Y2+B*(Y3-Y2)
      V4 = V2+B*(V3-V2)
      S4 = S2+B*(S3-S2)
      X4MN = X2MN+B*(X3MN-X2MN)
      THET4 = THET2+B*(THET3-THET2)
      STMA4 = SINF(THET4-ALPH4)
      IF (ABSF(X4MN*STMA4)-1.0) 444, 444, 333
  444 IF (I-1) 500, 501, 500
  500 WRITE OUTPUT TAPE 6, 58
   58 FORMAT(43H0NORMAL COMPONENT SUBSONIC DURING ITERATION)
   22 INDINS = 1
```

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```
      I = 0                                                             19271806
      GO TO 222                                                         19271807
  501 J = 1                                                             19271808
      LL = 1                                                            19271809
      ALPH4 = ALPH4-8.7266E-3                                           19271810
      TALPH4 = TANF(ALPH4)                                              19271811
      ALPT = ALPH4                                                      19271812
      GAMJ = -GAMJ                                                      19271813
      LR = K                                                            19271814
      K = 0                                                             19271815
      GO TO 77                                                          19271816
  333 P4 = P2+B*(P3-P2)                                                 19271817
      RHO4 = RHO2+B*(RHO3-RHO2)                                         19271818
      H4 = H2+B*(H3-H2)                                                 19271819
      SSTMA4 = STMA4**2                                                 19271820
      E1 = ((GAMJ-1.0)*(X4MN**2)*SSTMA4+2.0)/((GAMJ+1.0)*(X4MN**2)      19271821
     1*SSTMA4)                                                          19271822
      P11 = P4+RHO4*(V4**2)*SSTMA4*(1.0-E1)                             19271823
      H11 = H4+0.5*(V4**2)*SSTMA4*(1.0-(E1**2))                         19271824
      CALL EQUSS(H11,P11,S11)                                           19271825
      RHO11 = RHO4/E1                                                   19271826
      X11 = X4                                                          19271827
      Y11 = Y4                                                          19271828
      CALL EQUSAV(H11,S11,AV11)                                         19271829
      CALL EQUST(H11,S11,T11)                                           19271830
      VN11 = V4*E1*ABSF(SINF(THET4-ALPH4))                              19271831
      VT11 = V4*ABSF(COSF(THET4-ALPH4))                                 19271832
      V11 = SQRTF(VN11**2+VT11**2)                                      19271833
      X11MN = V11/AV11                                                  19271834
      BETA11 = ASINF(AV11/V11)                                          19271835
      DEL11 = ATANF(VN11/VT11)                                          19271836
      THET11 = ALPH4+DEL11                                              19271837
      THET10 = THET11                                                   19271838
      LPR = I+1                                                         19271839
      TT10(LPR) = THET11                                                19271840
      TMB11 = THET11-BETA11                                             19271841
      TTMB11 = TANF(TMB11)                                              19271842
   41 BETA12 = ASINF(1.0/X12MN)                                         19271843
      BETA13 = ASINF(1.0/X13MN)                                         19271844
      TTMB12 = (SINF(THET12-BETA12))/(COSF(THET12-BETA12))              19271845
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```
      TTMB13 = (SINF(THET13-BETA13))/(COSF(THET13-BETA13))
      IF (TTMB12) 533, 534, 534
  533 IF (TTMB13) 532, 532, 535
  534 IF (TTMB13) 535, 532, 532
  535 TTMB14 = 2.0/((1.0/TTMB12)+(1.0/TTMB13))
      GO TO 4
  532 TTMB14 = 0.5*(TTMB13+TTMB12)
    4 TMB14 = ATANF(TTMB14)
      IF (TMB14) 12, 13, 13
   12 IF (ALPH1-1.2) 13, 13, 99
   99 TMB14 = 3.14159+TMB14
   13 CONTINUE
      IF (ABSF(TMB11-1.5708)-1.745E-3) 502, 502, 503
  503 IF (ABSF(TMB14-1.5708)-1.745E-3) 502, 502, 504
  504 IF (TMB11-1.5708) 505, 507, 506
  505 IF (TMB14-1.5708) 507, 507, 508
  506 IF (TMB14-1.5708) 508, 507, 507
  508 AVT = 2.0/((1.0/TTMB11)+(1.0/TTMB14))
      G = (Y11-Y12-(X11-X12)*AVT)/(Y13-Y12-(X13-X12)*AVT)
      GO TO 509
  502 G = (X11-X12)/(X13-X12)
      GO TO 509
  507 G = (2.0*(Y11-Y12)-(X11-X12)*(TTMB11+TTMB14))/(2.0*(Y13-Y12)-
     1(X13-X12)*(TTMB11+TTMB14))
  509 GG = G
      IF (GO) 2, 3, 2
    2 IF (ABSF(G-GO)-0.005) 62, 62, 1
    1 IF (LLC-15) 3, 3, 62
    3 TTMB14 = TTMB12+G*(TTMB13-TTMB12)
      GO = G
      LLC = LLC+1
      GO TO 4
   62 IF (G-1.0) 9, 54, 54
    9 X14 = X12+G*(X13-X12)
      Y14 = Y12+G*(Y13-Y12)
      THET14 = THET12+G*(THET13-THET12)
      BETA14 = BETA12+G*(BETA13-BETA12)
      V14 = V12+G*(V13-V12)
      S14 = S12+G*(S13-S12)
      H14 = HTJ-0.5*(V14**2)
```

```
      CALL EQUST(H14,S14,T14)                                           19271886
      CALL EQUSAV(H14,S14,AV14)                                         19271887
      SBET14 = AV14/V14                                                 19271888
      STHT14 = SINF(THET14)                                             19271889
      CBET14 = COSF(BETA14)                                             19271890
      SBET11 = AV11/V11                                                 19271891
      STHT11 = SINF(THET11)                                             19271892
      CBET11 = COSF(BETA11)                                             19271893
      CTMB14 = COSF(THET14-BETA14)                                      19271894
      CTMB11 = COSF(THET11-BETA11)                                      19271895
      STMB14 = SINF(THET14-BETA14)                                      19271896
      STMB11 = SINF(THET11-BETA11)                                      19271897
      ABAR = 0.5*(CBET11/(SBET11*V11)+CBET14/(SBET14*V14))              19271898
      CBAR = 0.5*((T11*CBET11*SBET11)/(AV11**2)+(T14*CBET14*SBET14)/    19271899
     1(AV14**2))                                                        19271900
      IF (CPH) 1000, 1001, 1000                                         19271901
 1000 BBAR = 0.0                                                        19271902
      GO TO 7                                                           19271903
 1001 IF (ABSF(CTMB14)-EPS2) 5, 5, 15                                   19271904
   15 IF (ABSF(CTMB11)-EPS2) 5, 5, 16                                   19271905
   16 IF (CTMB14) 17, 18, 18                                            19271906
   17 IF (CTMB11) 6, 6, 5                                               19271907
   18 IF (CTMB11) 5, 6, 6                                               19271908
    5 DX1114 = Y11-Y14                                                  19271909
      BBAR = 0.5*((STHT11*SBET11)/(Y11*STMB11)+(STHT14*SBET14)/         19271910
     1(Y14*STMB14))                                                     19271911
      GO TO 7                                                           19271912
    6 DX1114 = X11-X14                                                  19271913
      BBAR = 0.5*((STHT11*SBET11)/(Y11*CTMB11)+(STHT14*SBET14)/         19271914
     1(Y14*CTMB14))                                                     19271915
    7 THET11 = THET14-ABAR*(V11-V14)+BBAR*DX1114-CBAR*(S11-S14)*32.2    19271916
      LPR = I+1                                                         19271917
      TT11(LPR) = THET11                                                19271918
      IF (I-2) 77, 80, 22                                               19271919
   56 LR = -1                                                           19271920
      K = K+1                                                           19271921
      GO TO 77                                                          19271922
    8 I = I+1                                                           19271923
      ALPH4 = ALPH4+DELALP                                              19271924
      TALPH4 = (SINF(ALPH4))/(COSF(ALPH4))                              19271925
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```
      LG = KG                                                           19271926
      LB = K                                                            19271927
      KG = 0                                                            19271928
      K = 0                                                             19271929
      GAMJ = -GAMJ                                                      19271930
      GO TO 222                                                         19271931
   80 TT11(4) = (TT11(2)-TT11(3))/(ALPT-ALPH4)                          19271932
      TT10(4) = (TT10(2)-TT10(3))/(ALPT-ALPH4)                          19271933
      DELALP = (TT10(3)-TT11(3))/(TT11(4)-TT10(4))                      19271934
      IF (ABSF(DELALP)-ERR2) 707, 707, 700                              19271935
  700 ALPT = ALPH4                                                      19271936
      ALPH4 = ALPH4+DELALP                                              19271937
      TALPH4 = TANF(ALPH4)                                              19271938
      TT11(2) = TT11(3)                                                 19271939
      TT10(2) = TT10(3)                                                 19271940
      LB = K                                                            19271941
      LG = KG                                                           19271942
      K = 0                                                             19271943
      KG = 0                                                            19271944
      GAMJ = -GAMJ                                                      19271945
      LL = 1                                                            19271946
      GO TO 77                                                          19271947
  707 J = 4                                                             19271948
      THET11 = TT10(3)                                                  19271949
      I = 0                                                             19271950
      GO TO 77                                                          19271951
   54 LG = -1                                                           19271952
      KG = KG+1                                                         19271953
   77 KDK = KDK+1                                                       19271954
      IF (KDK-100) 1111, 301, 301                                       19271955
 1111 IF (LL) 222, 14, 222                                              19271956
   14 IF (J) 222, 11, 222                                               19271957
   11 IF (LB) 222, 230, 222                                             19271958
  230 IF (LG) 222, 220, 222                                             19271959
  220 IF (I-4) 8, 222, 222                                              19271960
  222 RETURN                                                            19271961
      END                                                               19271962
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STORAGE NOT USED BY PROGRAM

	DEC	OCT		DEC	OCT
	1612	03114		32441	77271

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CPH	32442	77272	DUMMY	32561	77461									

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
TT10	1611	03113	TT11	1607	03107									

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ABAR	1603	03103	ALPT	1602	03102	AV11	1601	03101	AV14	1600	03100	AV3	1599	03077
AVT	1598	03076	BBAR	1597	03075	BETA11	1596	03074	BETA12	1595	03073	BETA13	1594	03072
BETA14	1593	03071	B	1592	03070	CBAR	1591	03067	CBET11	1590	03066	CBET14	1589	03065
CTMB11	1588	03064	CTMP14	1587	03063	DEL11	1586	03062	DELALP	1585	03061	DX1114	1584	03060
E1	1583	03057	GG	1582	03056	GO	1581	03055	G	1580	03054	H11	1579	03053
H14	1578	03052	H2	1577	03051	H3	1576	03050	H4	1575	03047	I	1574	03046
J	1573	03045	KDC	1572	03044	KDK	1571	03043	KG	1570	03042	K	1569	03041
LLC	1568	03040	LL	1567	03037	LPR	1566	03036	P3	1565	03035	RHO3	1564	03034
S14	1563	03033	S3	1562	03032	SBET11	1561	03031	SBET14	1560	03030	SSTMA4	1559	03027
STHT11	1558	03026	STHT14	1557	03025	STMA4	1556	03024	STMB11	1555	03023	STMB14	1554	03022
T11	1553	03021	T14	1552	03020	TALPH1	1551	03017	TALPH4	1550	03016	THET10	1549	03015
THET14	1548	03014	THET3	1547	03013	TMB11	1546	03012	TMB14	1545	03011	TPB2	1544	03010
TPB3	1543	03007	TTMP11	1542	03006	TTMB12	1541	03005	TTMB13	1540	03004	TTMB14	1539	03003
V14	1538	03002	V3	1537	03001	VN11	1536	03000	VT11	1535	02777	X14	1534	02776
X3MN	1533	02775	X3	1532	02774	Y14	1531	02773	Y3	1530	02772			

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8118	40	02757	8110	58	02746									

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	1520	02760	2)	1478	02706	3)	1485	02715	6)	1497	02731	C)GO	1529	02771
D121J	1236	02324	E17	421	00645	E18	429	00655	E1V	897	01601	E117	952	01670
E118	958	01676	E11J	1235	02323	E11T	1374	02536	E122	1452	02654	E110L	562	01062
F1321	1444	02644												

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ASIN	4	00004	ATAN	8	00010	COS	6	00006	INTRPT	1	00001	SIN	5	00005
SQRT	7	00007	TAN	0	00000	(FIL)	3	00003	(STH)	2	00002			

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

ASIN ATAN COS INTRPT SIN SQRT TAN (FIL) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
95	15	00456	200	26	00511	1314	27	00515	301	40	00631	300	42	00640
10	43	00642	1313	44	00646	521	45	00656	522	46	00665	523	47	00671
524	48	00676	520	49	00702	525	51	00716	527	54	00753	528	55	00762
529	56	00766	531	57	00773	526	58	00777	530	60	01021	69	61	01055
90	62	01063	60	63	01067	444	71	01157	500	72	01162	22	73	01170
501	76	01175	333	85	01224	41	113	01500	533	118	01571	534	119	01575
535	120	01602	532	122	01616	4	123	01624	12	125	01636	99	126	01643
13	127	01646	503	129	01655	504	130	01664	505	131	01671	506	132	01677
508	133	01703	502	136	01740	507	138	01750	509	139	02004	2	141	02010
1	142	02017	3	143	02023	62	147	02040	9	148	02044	1000	172	02320
1001	174	02325	15	175	02333	16	176	02341	17	177	02344	18	178	02350
5	179	02353	6	182	02402	7	184	02430	56	188	02470	8	191	02476
80	200	02537	700	204	02572	707	216	02627	54	220	02636	77	222	02645
1111	224	02655	14	225	02661	11	226	02665	230	227	02671	220	228	02675
222	229	02702												

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      SUBROUTINE PTOTAX(EQUSAV,EQUST,S1,THETA2,R2,Z2,V2,S2,HT,NITER,
     1EPS1,EPS3,EPS4,Z3,R3,S3,V3,THETA3)
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN
* * * *     CONSENT OF THE BOEING COMPANY.
      DIMENSION DUMMY(119)
      COMMON DUMMY
      COMMON CPH
F     EQUSAV, EQUST
      Z30 = 0.0
      V30 = 0.0
      N = 0
      H2 = HT-0.5*(V2**2)
      CALL EQUSAV(H2,S2,AV2)
      CALL EQUST(H2,S2,T2)
      BETA2 = ASINF(AV2/V2)
      SBETA2 = AV2/V2
      CBETA2 = COSF(BETA2)
      STHET2 = SINF(THETA2)
      CTHET2 = COSF(THETA2)
      CTMB2 = COSF(THETA2-BETA2)
      A2 = CBETA2/(V2*SBETA2)
      B2 = (CPH*SBETA2*STHET2)/(R2*CTMB2)
      C2 = (T2*SBETA2*CBETA2)/(AV2**2)
      TMB2 = THETA2-BETA2
      A3 = A2
      C3 = C2
      TMB3 = TMB2
      R1 = 0.0
      Z1 = 0.0
      ANG1 = 0.0
      S3 = S1
      THETA3 = 0.0
    1 ABAR = 0.5*(A2+A3)
      CBAR = 0.5*(C2+C3)
      ANG2 = 0.5*(TMB2+TMB3)
      CALL INTER(EPS1,ANG1,ANG2,Z1,Z2,R1,R2,Z3,R3)
      V3 = V2+(1.0/ABAR)*(THETA2+B2*(Z3-Z2)-CBAR*(S3-S2)*32.2)
      N = N+1
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      IF (NITER-N) 5, 5, 2                                    19272002
    2 IF (ABSF(Z3-Z30)-EPS3) 3, 4, 4                          19272003
    3 IF (ABSF(V3-V30)-EPS4) 5, 4, 4                          19272004
    4 Z30 = Z3                                                19272005
      V30 = V3                                                19272006
      H3 = HT-0.5*(V3**2)                                     19272007
      CALL EQUSAV(H3,S3,AV3)                                  19272008
      CALL EQUST(H3,S3,T3)                                    19272009
      BETA3 = ASINF(AV3/V3)                                   19272010
      SBETA3 = AV3/V3                                         19272011
      CBETA3 = COSF(BETA3)                                    19272012
      A3 = CBETA3/(V3*SBETA3)                                 19272013
      TMB3 = THETA3-BETA3                                     19272014
      C3 = (T3*SBETA3*CBETA3)/(AV3**2)                        19272015
      GO TO 1                                                 19272016
    5 RETURN                                                  19272017
      END                                                     19272018
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STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
364	00554	32441	77271

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CPH	32442	77272	DUMMY	32561	77461									

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A2	363	00553	A3	362	00552	ABAR	361	00551	ANG1	360	00550	ANG2	359	00547
AV2	358	00546	AV3	357	00545	B2	356	00544	BETA2	355	00543	BETA3	354	00542
C2	353	00541	C3	352	00540	CBAR	351	00537	CBETA2	350	00536	CBETA3	349	00535
CTHET2	348	00534	CTMB2	347	00533	H2	346	00532	H3	345	00531	N	344	00530
R1	343	00527	SBETA2	342	00526	SBETA3	341	00525	STHET2	340	00524	T2	339	00523
T3	338	00522	TMB2	337	00521	TMB3	336	00520	V30	335	00517	Z1	334	00516
Z30	333	00515												

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	328	00510	2)	315	00473	3)	318	00476	6)	322	00502			

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ASIN	0	00000	COS	1	00001	INTER	3	00003	SIN	2	00002			

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

ASIN COS INTER SIN

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
1	32	00264	2	40	00357	3	41	00365	4	42	00374	5	56	00467

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C     MIX-MASTER MAIN PROGRAM                                           19272019
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS   19272020
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN    19272021
* * * *     CONSENT OF THE BOEING COMPANY.                              19272022
C**** MIX-MASTER IS A CHAIN PROGRAM ****                                19272023
      DIMENSION AAA(12)                                                 19272024
      DIMENSION C1(6,200), C2(6,200), T1(200), T2(200), RHO1(200),      19272025
     1RHO2(200), FKP(6), B(6), GAMMA(6), E(6), W(6,200),        DHF(6),  19272026
     2WW(6), H(8,200), U1(200), U2(200), V1(200), V2(200), XU(50),      19272027
     3YU(50), Z(200), CP2(200), FKC(6), YS(200), Y(200), FMU(200),      19272028
     4PR(200), FLE(200), ENERGY(200), FLET(200), PRT(200), XH(200),     19272029
     5CS(8,200), H2(200), H1(200), XTAB(100), RTAB(100), PTAB(100),     19272030
     6RRR(200), CP(6,200), CPN2(200)                                    19272031
      COMMON C1, C2, T1, T2, RHO1, RHO2                                 19272032
      COMMON FKP, FKC, B, GAMMA, E, W, CP, DHF, WW, CP2                 19272033
      COMMON H, U1, U2, V1, V2, YT, XU, YU, Z                           19272034
      COMMON P, MMAX, M, X, DX, DY, GC, FL, A, EPSON, FLET, PRT, FJ,    19272035
     1DELTA, NMAX, FCON, YS, DPDX                                       19272036
      COMMON DPSI, CONST, RZERO, Y, YZERO,KPRINT                        19272037
      COMMON FLE, PR, FMU, USUB11, ENERGY                               19272038
      COMMON XH, CS, H1, H2, NTCORE                                     19272039
      COMMON NXTAB, XTAB, RTAB, PTAB                                    19272040
      COMMON NMIN, ICHECK, CPN2                                         19272041
      EQUIVALENCE (FCON,CONST)                                          19272042
      EQUIVALENCE(Y,RRR)                                                19272043
C                                                                       19272044
      DIMENSION ANS(200)                                                19272045
      DIMENSION CBAR(6), CHAT(6)                                        19272046
      REWIND 11                                                         19272047
      READ INPUT TAPE 11, 500, NXTAB                                    19272048
      READ INPUT TAPE 11, 502, (XTAB(K),RTAB(K),PTAB(K),K=1,NXTAB)      19272049
      KODE = 1                                                          19272050
      ICHECK = 1                                                        19272051
      X=0.0                                                             19272052
      KPCODE = 1                                                        19272053
      KKODE = 1                                                         19272054
      IDUCT = 0                                                         19272055
      GC = 32.20                                                        19272056
      FJ = 778.0                                                        19272057
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      FMU(1) = 0.0                                                      19272058
      FLE(1) = 0.0                                                      19272059
      PR(1) = 0.0                                                       19272060
C-----. NMAX = THE NUMBER OF DESIRED GRID POINTS.                       19272061
      READ INPUT TAPE 5, 498, (AAA(I),I=1,12)                           19272062
      READ INPUT TAPE 5, 500, NMAX, MMAX, NS, LFRONT, KSLIP, NMIN       19272063
      READ INPUT TAPE 5, 501, A, FL, EPSON, FLET(1), PRT(1), DELTA,     19272064
     1DX, FCON, RZERO1, RE, RDZERO, TESMAX, TESMIN                      19272065
      NE1 = NPTS/3                                                      19272066
      IF (NMIN) 10, 5, 10                                               19272067
   10 DO 15 L=NMIN, NMAX                                                19272068
      READ INPUT TAPE 5, 499, C2(1,L), C2(2,L), C2(3,L), C2(4,L),       19272069
     1C2(5,L), C2(6,L), T2(L), U2(L)                                    19272070
   15 CONTINUE                                                          19272071
      READ INPUT TAPE 5, 499, X                                         19272072
      DTESMX = TESMAX - C2(1,NMAX)                                      19272073
      D2MAX = TESMAX -C2(2,NMAX)                                        19272074
      DTESMN = TESMIN - C2(6,NMIN)                                      19272075
      L = NMIN-1                                                        19272076
      DO 30 N=1, L                                                      19272077
      DO 25 K=1, 6                                                      19272078
      C2(K,N) = C2(K,NMIN)                                              19272079
   25 CONTINUE                                                          19272080
      T2(N) = T2(NMIN)                                                  19272081
      U2(N) = U2(NMIN)                                                  19272082
   30 CONTINUE                                                          19272083
      GO TO 170                                                         19272084
C-----SHEAR LAYER TYPE PROBLEM--ADDITIONAL INPUT--                      19272085
    5 READ INPUT TAPE 5, 501, (C2(K,1),K=1,6), (C2(K,NMAX),K=1,6),      19272086
     1T2(1), T2(NMAX), U2(1), U2(NMAX)                                  19272087
      NMIN = 1                                                          19272088
      DTESMX = TESMAX - C2(1,NMAX)                                      19272089
      D2MAX = TESMAX -C2(2,NMAX)                                        19272090
      DTESMN = TESMIN - C2(6,NMIN)                                      19272091
      GO TO 150                                                         19272092
C-----SHEAR LAYER TYPE PROBLEM---                                       19272093
C     GET BOUNDARY VALUES ON FIRST FRONT                                19272094
  150 IM = KSLIP                                                        19272095
      DO 160 I=1, IM                                                    19272096
      V2(I) = V2(1)                                                     19272097
```

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```
      U2(I) = U2(1)                                                     19272098
      T2(I) = T2(1)                                                     19272099
      DO 160 K=1, 6                                                     19272100
  160 C2(K,I) = C2(K,1)                                                 19272101
      IM = IM+1                                                         19272102
      DO 165 I=IM, NMAX                                                 19272103
      V2(I) = V2(1)                                                     19272104
      U2(I) = U2(NMAX)                                                  19272105
      T2(I) = T2(NMAX)                                                  19272106
      DO 165 K=1, 6                                                     19272107
  165 C2(K,I) = C2(K,NMAX)                                              19272108
      NE = KSLIP+NS                                                     19272109
      IF (NS) 176, 176, 1651                                            19272110
 1651 CONTINUE                                                          19272111
      NS1 = KSLIP-NS                                                    19272112
      NS2 = NS1+1                                                       19272113
      NE1 = NE-1                                                        19272114
      KK = NE-NS1                                                       19272115
      CALL CURV1(T2(NS1),T2(NE),ANS,NS1,KK)                             19272116
      DO 166 I=NS2, NE1                                                 19272117
  166 T2(I) = ANS(I)                                                    19272118
      CALL CURV1(U2(NS1),U2(NE),ANS,NS1,KK)                             19272119
      DO 167 I=NS2, NE1                                                 19272120
  167 U2(I) = ANS(I)                                                    19272121
      DO 168 K=1, 6                                                     19272122
      CALL CURV1(C2(K,NS1),C2(K,NE),ANS,NS1,KK)                         19272123
      DO 168 I=NS2, NE1                                                 19272124
  168 C2(K,I) = ANS(I)                                                  19272125
  176 CONTINUE                                                          19272126
      NE = NE+1                                                         19272127
  170 KFIRST = 1                                                        19272128
      KPRINT = 1                                                        19272129
      KOUNT = 0                                                         19272130
      M = 1                                                             19272131
      DO 180 I=1, 200                                                   19272132
      PRT(I) = PRT(1)                                                   19272133
      FLE(I) = FLE(1)                                                   19272134
      PR(I) = PR(1)                                                     19272135
      FMU(I) = FMU(1)                                                   19272136
  180 FLET(I) = FLET(1)                                                 19272137
```

```
      CALL PRESS
      CALL NONEQ1
      TEMP = 2.0*(RE**(DELTA+1.0)-RZERO1**(DELTA+1.0))/(DELTA+1.0)
      ATEMP = 0.
      DO 175 I=2, KSLIP
      ATEMP = ATEMP+1.0/(RHO2(I-1)*U2(I-1))+1.0/(RHO2(I)*U2(I))
  175 CONTINUE
      DPSI = TEMP/ATEMP
      WRITE OUTPUT TAPE 6, 514
      WRITE OUTPUT TAPE 6, 498, (AAA(I),I=1,12)
      WRITE OUTPUT TAPE 6, 535
      WRITE OUTPUT TAPE 6, 536, NMAX, MMAX, NS, LFRONT, KSLIP, NMIN
      WRITE OUTPUT TAPE 6, 515, A, FL, EPSON, FLET(1), PRT(1), DELTA
      WRITE OUTPUT TAPE 6, 516, DX, FCON, DPSI
      WRITE OUTPUT TAPE 6, 526
      WRITE OUTPUT TAPE 6, 527, RZERO1, RE, RDZERO
      WRITE OUTPUT TAPE 6, 537, TESMAX, TESMIN, NXTAB
  195 WRITE OUTPUT TAPE 6, 533
      WRITE OUTPUT TAPE 6, 534, (XTAB(K),RTAB(K),PTAB(K),K=1,NXTAB)
  190 WRITE OUTPUT TAPE 6, 530
      WRITE OUTPUT TAPE 6, 529, (C2(K,1),K=1,6),C2(1,NMAX),C2(2,NMAX),
     1C2(3,NMAX),C2(4,NMAX)
      WRITE OUTPUT TAPE 6, 531
      WRITE OUTPUT TAPE 6, 532, C2(5,NMAX), C2(6,NMAX)
      WRITE OUTPUT TAPE 6, 528, T2(1), T2(NMAX),U2(1),U2(NMAX)
      WDOTST = RHO2(1)*U2(1)*(RZERO**(DELTA+1.0)-RZERO1**(DELTA+1.0))*
     13.1415927**DELTA
      STOPK = 0.0
C
C     START OF LOOP
C
  200 CONTINUE
C
C
  229 DO 230 N=1, NMAX
  230 RHO1(N) = RHO2(N)
C
C
C     RHO2, CP2 FOR SHEAR LAYER
  295 CALL NONEQ1
```

```
      IF (RZERO1) 299, 298, 299                                         19272178
  298 RZERO = RZERO1                                                    19272179
      GO TO 301                                                         19272180
  299 RZERO = (RZERO**(DELTA+1.0)-WDOTST/(RHO2(1)*U2(1)*3.1415927**     19272181
     1DELTA))**(.50**DELTA)                                             19272182
  301 CALL INGRAT                                                       19272183
      IF (M-1) 3011, 3011, 3014                                         19272184
 3011 CALL DUCT(0.0,RRR(NMAX),FLOATF(NMAX-1)*DPSI,RD,THRUST,RHO2(NMAX), 19272185
     1U2(NMAX),P,RDZERO,PSID,DELTA)                                     19272186
      WDZS = RHO2(NE)*U2(NE)*(RD**(DELTA+1.0)-RRR(NE)**(DELTA+1.0))*    19272187
     13.1415927**DELTA                                                  19272188
      KK = KSLIP+1                                                      19272189
      IF (NE-KK-1) 3015, 3015, 3012                                     19272190
 3012 DO 3013  KKK=KK, NE                                               19272191
      WDZS = WDZS+0.5**DELTA*(RHO2(KKK-1)*U2(KKK-1)+RHO2(KKK)*U2(KKK))  19272192
     1*(RRR(KKK)**(DELTA+1.0)-RRR(KKK-1)**(DELTA+1.0))*3.1415927**DELTA 19272193
 3013 CONTINUE                                                          19272194
      GO TO 3015                                                        19272195
C                                                                       19272196
 3014 NMAX = NMAX                                                       19272197
      CALL DUCT(1.0,RRR(NMAX),FLOATF(NMAX-1)*DPSI,RD,THRUST,RHO2(NMAX), 19272198
     1U2(NMAX),P,RDZERO,PSID,DELTA)                                     19272199
 3015 CONTINUE                                                          19272200
      IF (KPRINT-1)  207, 302,  207                                     19272201
 3019 STOPK = 1.0                                                       19272202
  302 WRITE OUTPUT TAPE 6, 519, M, X, P                                 19272203
      AD = 2.0**(1.0-DELTA)*3.1415927**DELTA*RD**(DELTA+1.0)            19272204
      IF (X) 3022, 3021, 3022                                           19272205
 3021 WRITE OUTPUT TAPE 6, 524, WDZS, RD, THRUST, AD                    19272206
      GO TO 3023                                                        19272207
 3022 WRITE OUTPUT TAPE 6, 525, RD, THRUST, AD                          19272208
 3023 CONTINUE                                                          19272209
      WRITE OUTPUT TAPE 6, 520                                          19272210
      WRITE OUTPUT TAPE 6, 521                                          19272211
      N = 1                                                             19272212
      RSTART = P/RHO2(N)                                                19272213
      RCALCJ = (P/(RHO2(N)*T2(N)))/FJ                                   19272214
      AMACH = U2(N)/SQRTF((CP2(N)*GC*RSTART)/(CP2(N)-RCALCJ))           19272215
      WRITE OUTPUT TAPE 6, 522, N, Y(1), U2(1), T2(1), RHO2(1),         19272216
     1C2(1,1), C2(2,1), C2(3,1), C2(4,1), C2(5,1), C2(6,1),AMACH        19272217
```

```
      DO 305 N=NMIN, NMAX                                               19272218
      RSTART = P/RHO2(N)                                                19272219
      RCALCJ = (P/(RHO2(N)*T2(N)))/FJ                                   19272220
      AMACH = U2(N)/SQRTF((CP2(N)*GC*RSTART)/(CP2(N)-RCALCJ))           19272221
  305 WRITE OUTPUT TAPE 6, 522, N, Y(N), U2(N), T2(N),                  19272222
     1RHO2(N), C2(1,N), C2(2,N), C2(3,N), C2(4,N),C2(5,N),C2(6,N),AMACH 19272223
      IF (STOPK) 20, 207, 20                                            19272224
C                                                                       19272225
C                                                                       19272226
  207 IF (X-XTAB(NXTAB)) 208, 20, 20                                    19272227
  208 IF (M-MMAX-1) 220, 2071, 2071                                     19272228
 2071 IF (KPRINT-1) 3019, 20, 3019                                      19272229
C                                                                       19272230
C     CALCULATE MINIMUM DELTA PSI                                       19272231
C                                                                       19272232
  220 CONTINUE                                                          19272233
      DPSIM = 0.0                                                       19272234
      DO 2202 N=2,NMAX                                                  19272235
      CUR = 2.0*RRR(N)**(2.0*DELTA)*RHO2(N)*U2(N)*(FMU(N)*FLE(N)        19272236
     1/PR(N)+RHO2(N)*FPSON*(CONST+X/FL)**A*FLET(N)/PRT(N))              19272237
      IF (DPSIM-CUR) 2201, 2202, 2202                                   19272238
 2201 DPSIM = CUR                                                       19272239
 2202 CONTINUE                                                          19272240
      DPSIM = SQRTF(DX*DPSIM)                                           19272241
 2204 IF (DPSI-DPSIM) 307, 2205, 2205                                   19272242
 2205 CONTINUE                                                          19272243
      IF (NMAX-197) 361, 361, 307                                       19272244
C**** RE-STORE THE -FRONT- VALUES IN THE APPROPRIATE CELLS              19272245
C**** CORRESPONDING TO 2.*DPSI                                          19272246
  307 NMAX = NMAX/2+2                                                   19272247
      IDUCT = 0                                                         19272248
      IF (NMIN-2) 3072, 3072, 3071                                      19272249
 3071 NMIN = (NMIN+1)/2-1                                               19272250
 3072 CONTINUE                                                          19272251
      J = 1                                                             19272252
      JJ = NMAX-2                                                       19272253
      DO 311 N=2, JJ                                                    19272254
      K = N+J                                                           19272255
      U2(N) = U2(K)                                                     19272256
      T2(N) = T2(K)                                                     19272257
```

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```
      RHO2(N) = RHO2(K)
      RRR(N) = RRR(K)
      CP2(N) = CP2(K)
      FMU(N) = FMU(K)
      V2(N) = V2(K)
      H2(N) = H2(K)
      DO 313 L=1, 6
      C2(L,N) = C2(L,K)
      W(L,N) = W(L,K)
  313 CONTINUE
      J = J+1
  311 CONTINUE
      DO 314 L=1, 6
      C2(L,NMAX) = C2(L,NMAX-2)
      C2(L,NMAX-1) = C2(L,NMAX)
      W(L,NMAX) = W(L,NMAX-2)
      W(L,NMAX-1) = W(L,NMAX)
  314 CONTINUE
      U2(NMAX) = U2(NMAX-2)
      U2(NMAX-1) = U2(NMAX)
      T2(NMAX) = T2(NMAX-2)
      T2(NMAX-1) = T2(NMAX)
      RHO2(NMAX) = RHO2(NMAX-2)
      RHO2(NMAX-1) = RHO2(NMAX)
      RRR(NMAX) = RRR(NMAX-2)
      RRR(NMAX-1) = RRR(NMAX)
      CP2(NMAX) = CP2(NMAX-2)
      CP2(NMAX-1) = CP2(NMAX)
      FMU(NMAX) = FMU(NMAX-2)
      FMU(NMAX-1) = FMU(NMAX)
      V2(NMAX) = V2(NMAX-2)
      V2(NMAX-1) = V2(NMAX)
      H2(NMAX) = H2(NMAX-2)
      H2(NMAX-1) = H2(NMAX)
      DPSI = 2.0*DPSI
      IF (DPSI-DPSIM) 307, 3111, 3111
 3111 WRITE OUTPUT TAPE 6, 523, DPSI
      GO TO 361
  361 KPRINT = 0
      IF (LFRONT) 362, 369, 362
```

```
  362 KOUNT = KOUNT+1                                                   19272298
      IF (1-KOUNT/LFRONT) 430, 365, 430                                 19272299
  365 KOUNT = 0                                                         19272300
  369 KPRINT = 1                                                        19272301
C------SHEAR LAYER TYPE                                                19272302
  430 CALL NONEQ3(IDUCT,PSID,TESMAX,TESMIN,DTESMX,DTESMN,D2MAX)         19272303
      IF (ICHECK) 200, 431, 200                                         19272304
  431 STOPK = 1.0                                                       19272305
      KPRINT = 1                                                        19272306
      GO TO 200                                                         19272307
C                                                                       19272308
   20 CONTINUE                                                          19272309
      CALL CHAIN(1,B2)                                                  19272310
C                                                                       19272311
  498 FORMAT (12A6)                                                     19272312
  499 FORMAT (8E10.3)                                                   19272313
  500 FORMAT (15I4)                                                     19272314
  501 FORMAT(6E12.5)                                                    19272315
  502 FORMAT(3E16.7)                                                    19272316
  503 FORMAT(34H1ERROR IN THERMODYNAMIC SUBROUTINE3X,4HMAD=I4)          19272317
  504 FORMAT (20X,29HU,V,T VALUES ON INITIAL FRONT)                     19272318
  508 FORMAT(1X,19HERROR IN STEP SIZE,6G11.4/)                          19272319
  509 FORMAT(4X,20HYZERO AT X=0 EQUALS F14.5)                           19272320
  510 FORMAT(1X,7HYVALUE 10G11.4)                                       19272321
  512 FORMAT(11X,57HINITIAL VALUES FOR U2,C2,T2, FOR SHEAR LAYER TYPE PR19272322
     1OBLEM)                                                            19272323
  514 FORMAT(1H1,40X,13HINITIAL INPUT)                                  19272324
  515 FORMAT(1H0,6X,1HA,11X,1HL,11X,15HREICHARTS COEF.,4X,9HLEWIS NO.,6X19272325
     1,11HPRANDTL NO.,6X,5HDELTA/2X,1PE10.3,2X,1PE10.3,9X,1PE10.3,6X,1PE19272326
     210.3,6X,1PE10.3,4X,1PE10.3)                                       19272327
  516 FORMAT(1H0,5X,2HDX,7X,16HVISCOSITY CONST.,5X,21HDELTA-PSI (NOT INP19272328
     1UT)/2X,1PE10.3,6X,1PE10.3,8X,1PE10.3)                             19272329
  517 FORMAT(3X,51HNON-TURBULENT LEWIS NO.   NON-TURBULENT PRANDTL NO./519272330
     1X,G15.4,17X,G15.4)                                                19272331
  518 FORMAT(19X,26HINITIAL VALUES OF ENTHALPY///)                      19272332
  519 FORMAT(///////1X,36HPROPERTIES GIVEN BELOW ARE AT FRONT I5,7X,21HD19272333
     1ISTANCE DOWNSTREAM =F14.4,4HFEET,5X,9HPRESSURE=F14.4,3HPSF)       19272334
  520 FORMAT(///2X,1HN,6X,1HY,8X,28HX-COMP  TEMPERATURE  DENSITY,2X,43H-19272335
     1-----------CONCENTRATION OF SPECIES-------)                       19272336
  521 FORMAT(16X,8HVELOCITY,28X,3HH2O,8X,2HH2,9X,2HO2,8X,3HCO2,9X,2HCO ,19272337
```

```
   19X,2HN2,7X,4HMACH)
522 FORMAT(I4,10G11.4,F6.3)
523 FORMAT(21H0DELTA PSI WAS SET = G11.4)
524 FORMAT(36H0INITIAL FLOW IN SECONDARY STREAM = F14.4,8H LBS/SEC/ 18
   1H RADIUS OF DUCT = F14.4,17H FT.     THRUST = F14.4,20H LB.     DUCT
   2 AREA = F14.4,7H SQ FT.)
525 FORMAT(18H0RADIUS OF DUCT = F14.4,17H FT.     THRUST = F14.4,20H LB
   1.     DUCT AREA = F14.4,7H SQ FT.)
526 FORMAT(1H0,3X,6HRZERO1,8X,2HRE,8X,6HRDZERO)
527 FORMAT(2X,1PE10.3,2X,2(1PE10.3,2X))
528 FORMAT(1H0,4X,3HT21,8X,6HT2NMAX,7X,3HU21,8X,6HU2NMAX/1X,4(1PE10.3,
   12X)//////)
529 FORMAT(1X,10(1PE10.3,2X))
530 FORMAT(1H0,3X,4HC211,8X,4HC221,8X,4HC231,8X,4HC241,8X,4HC251,8X,4H
   1C261,6X,7HC21NMAX,5X,7HC22NMAX,5X,7HC23NMAX,5X,7HC24NMAX)
531 FORMAT(1H0,1X,7HC25NMAX,5X,7HC26NMAX)
532 FORMAT(1X,1PE10.3,2X,1PE10.3)
533 FORMAT(1H0,3X,4HXTAB,8X,4HRTAB,8X,4HPTAB,8X,4HXTAB,8X,4HRTAB,8X,4H
   1PTAB,8X,4HXTAB,8X,4HRTAB,8X,4HPTAB)
534 FORMAT(1X,9(1PE10.3,2X))
535 FORMAT(6H0 NMAX,3X,4HMMAX,3X,2HNS,3X,6HLFRONT,3X,5HKSLIP,3X,4HNMIN
   1)
536 FORMAT(2X,2(I4,3X),I2,3X,I6,3X,I5,3X,I4)
537 FORMAT(1H0,3X,6HTESMAX,6X,6HTESMIN,6X,5HNXTAB/2X,1PE10.3,2X,1PE10.
   13,4X,I3)
    END
```


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STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
2293	04365	19694	46356

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A	23809	56401	B	29148	70734	C1	32360	77150	C2	31160	74670	CONST	32561	77461
CPZ	26718	64136	CPN2	19894	46666	CP	27930	66432	CS	22198	53266	DELTA	23406	55556
DHF	26730	64152	DPDX	23204	55244	DPS1	23203	55243	DX	23813	56405	DY	23812	56404
ENERGY	22598	54106	EPSON	23808	56400	E	29136	70720	FCON	32561	77461	FJ	23407	55557
FKC	29154	70742	FKP	29160	70750	FLE	23199	55237	FLET	23807	56377	FL	23810	56402
FMU	22799	54417	GAMMA	29142	70726	GC	23811	56403	H1	20598	50166	H2	20398	47656
H	26518	63626	ICHECK	19895	46667	KPRINT	23200	55240	MMAX	23816	56410	M	23815	56407
NMAX	23405	55555	NMIN	19896	46670	NTCORE	20198	47346	NXTAB	20197	47345	PR	22999	54727
PRT	23607	56067	P	23817	56411	PTAB	19996	47034	RHO1	29560	71570	RHO2	29360	71260
RRR	32560	77460	RTAB	20096	47200	RZERO	23202	55242	T1	29960	72410	T2	29760	72100
U1	24918	60526	U2	24718	60216	USUB11	22599	54107	V1	24518	57706	V2	24318	57376
W	29130	70712	WW	26724	64144	XH	22398	53576	X	23814	56406	XTAB	20196	47344
XU	24117	57065	Y	32560	77460	YS	23404	55554	YT	24118	57066	YU	24067	57003
YZERO	23201	55241	Z	24017	56721									

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
AAA	2292	04364	ANS	2280	04350	CBAR	2080	04040	CHAT	2074	04032			

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
AD	2068	04024	AMACH	2067	04023	ATEMP	2066	04022	CUR	2065	04021	D2MAX	2064	04020
DPSIM	2063	04017	DTESMN	2062	04016	DTESMX	2061	04015	IDUCT	2060	04014	IM	2059	04013
JJ	2058	04012	J	2057	04011	KFIRST	2056	04010	KKODE	2055	04007	KK	2054	04006
KODE	2053	04005	KOUNT	2052	04004	KPCODE	2051	04003	K	2050	04002	KSLIP	2049	04001
LFRONT	2048	04000	L	2047	03777	NEI	2046	03776	NE	2045	03775	NPTS	2044	03774
N	2043	03773	NS1	2042	03772	NS2	2041	03771	NS	2040	03770	PSID	2039	03767
RCALCJ	2038	03766	RD	2037	03765	RDZERO	2036	03764	RE	2035	03763	RSTART	2034	03762
RZERO1	2033	03761	STOPK	2032	03760	TEMP	2031	03757	TESMAX	2030	03756	TESMIN	2029	03755
THRUST	2028	03754	WDOTST	2027	03753	WDZS	2026	03752						

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)FI	498	03721	8)FJ	499	03717	8)FK	500	03715	8)FL	501	03713	8)FM	502	03711
8)FN	503	03707	8)FO	504	03676	8)FS	508	03667	8)FT	509	03661	8)FU	510	03653
8)GO	512	03647	8)G2	514	03634	8)G3	515	03627	8)G4	516	03575	8)G5	517	03554
8)G6	518	03537	8)G7	519	03530	8)G8	520	03504	8)G9	521	03462	8)GA	522	03445
8)GB	523	03442	8)GC	524	03434	8)GD	525	03403	8)GE	526	03363	8)GF	527	03354
8)GG	528	03347	8)GH	529	03333	8)GI	530	03327	8)GJ	531	03303	8)GK	532	03275
8)GL	533	03271	8)GM	534	03251	8)GN	535	03246	8)GO	536	03233	8)GP	537	03225

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	2002	03722	2)	1651	03163	3)	1661	03175	4)	32767	77777	6)	1668	03204
A)101	1620	03124	A)102	1629	03135	A)108	1638	03146	C)G0	2010	03732	C)G2	2011	03733
C)G4	2012	03734	C)G5	2013	03735	C)G6	2014	03736	C)G7	2015	03737	C)G8	2016	03740
C)GA	2017	03741	C)101	2018	03742	C)102	2019	03743	C)103	2020	03744	C)107	2021	03745
C)108	2022	03746	C)109	2023	03747	C)10C	2024	03750	C)201	2025	03751	D)11F	816	01460
D)11S	1055	02037	D)12E	1442	02642	D)20B	231	00347	D)214	545	01041	D)222	1301	02425
D)22B	1392	02560	D)22L	1560	03030	D)22R	1603	03103	D)32B	1391	02557	D)32L	1559	03027
D)32R	1602	03102	D)40M	356	00544	D)40V	498	00762	D)41O	522	01012	D)41Q	1047	02027
D)50M	355	00543												

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CHAIN	14	00016	CURV1	4	00004	DUCT	11	00013	EXP13	7	00007	INGRAT	10	00012
NONEQ1	6	00006	NONEQ3	13	00015	PRESS	5	00005	SQRT	12	00014	(FIL)	9	00011
(FPT)	0	00000	(RTN)	3	00003	(RWT)	1	00001	(STH)	8	00010	(TSH)	2	00002

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

CHAIN (FPT) CURV1 (RTN) DUCT (RWT) EXP13 (STH) INGRAT (TSH) NONEQ1 NONEQ3 PRESS SQRT (FIL)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
10	82	00241	15	85	00305	25	95	00363	30	98	00374	5	100	00403
150	113	00466	160	119	00503	165	126	00565	1651	129	00611	166	137	00652
167	141	00703	168	146	01013	176	147	01034	170	149	01042	180	158	01063
175	165	01144	195	185	01274	190	191	01317	200	204	01461	229	205	01461
230	206	01464	295	207	01470	298	209	01477	299	211	01502	301	212	01543
3011	214	01552	3012	219	01664	3013	221	01752	3014	223	01755	3015	226	02030
3019	228	02035	302	229	02040	3021	233	02125	3022	236	02146	3023	238	02164
305	251	02355	207	254	02426	208	255	02433	2071	256	02441	220	257	02446
2201	262	02533	2202	263	02535	2204	265	02545	2205	266	02552	307	268	02561
3071	271	02606	3072	272	02623	313	288	02705	311	290	02714	314	296	02744
3111	315	03020	361	318	03031	362	320	03035	365	322	03053	369	323	03055
430	324	03057	431	327	03075	20	330	03104						

```
      SUBROUTINE CURV1(Y1,Y2,ANS,NS,K)                                  19272366
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS   19272367
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN    19272368
* * * *     CONSENT OF THE BOEING COMPANY.                              19272369
      DIMENSION ANS(200)                                                19272370
      CONSTN = K                                                        19272371
      TEMP = (Y2-Y1)/CONSTN**2                                          19272372
      DO 10 I=2, K                                                      19272373
      CON = I-1                                                         19272374
      L = NS+I-1                                                        19272375
      ANS(L) = 3.0*CON**2*TEMP-2.0*CON**3*TEMP/CONSTN+Y1                19272376
   10 CONTINUE                                                          19272377
      RETURN                                                            19272378
      END                                                               19272379
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
99	00143	32561	77461

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CON	98	00142	CONSTN	97	00141	I	96	00140	L	95	00137	TEMP	94	00136

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	89	00131	2)	77	00115	3)	80	00120	6)	82	00122	9)	88	00130
C)60	93	00135												

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
10	10	00106												

```
      SUBROUTINE PRESS                                                  19272380
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS   19272381
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN    19272382
* * * *     CONSENT OF THE BOEING COMPANY.                              19272383
      DIMENSION C1(6,200), C2(6,200), T1(200), T2(200), RHO1(200),      19272384
     1RHO2(200), FKP(6), B(6), GAMMA(6), E(6), W(6,200),        DHF(6),  19272385
     2WW(6), H(8,200), U1(200), U2(200), V1(200), V2(200), XU(50),      19272386
     3YU(50), Z(200), CP2(200), FKC(6), YS(200), Y(200), FMU(200),      19272387
     4PR(200), FLE(200), ENERGY(200), FLET(200), PRT(200), XH(200),     19272388
     5CS(8,200), H2(200), H1(200), XTAB(100), RTAB(100), PTAB(100),     19272389
     6RRR(200), CP(6,200), CPN2(200)                                    19272390
      COMMON C1, C2, T1, T2, RHO1, RHO2                                 19272391
      COMMON FKP, FKC, B, GAMMA, E, W, CP, DHF, WW, CP2                 19272392
      COMMON H, U1, U2, V1, V2, YT, XU, YU, Z                           19272393
      COMMON P, MMAX, M, X, DX, DY, GC, FL, A, EPSON, FLET, PRT, FJ,    19272394
     1DELTA, NMAX, FCON, YS, DPDX                                       19272395
      COMMON DPSI, CONST, RZERO, Y, YZERO,KPRINT                        19272396
      COMMON FLE, PR, FMU, USUB11, ENERGY                               19272397
      COMMON XH, CS, H1, H2, NTCORE                                     19272398
      COMMON NXTAB, XTAB, RTAB, PTAB                                    19272399
      COMMON NMIN, ICHECK, CPN2                                         19272400
      EQUIVALENCE (FCON,CONST)                                          19272401
      EQUIVALENCE(Y,RRR)                                                19272402
C                                                                       19272403
      DIMENSION L(8), LL(8)                                             19272404
      IF (M111) 2, 1, 2                                                 19272405
C                                SET UP                                 19272406
    1 M111 = 1                                                          19272407
      L(1) = XLOCF(L(1))                                                19272408
      L(2) = XLOCF(XTAB)                                                19272409
      L(3) = XLOCF(RTAB)                                                19272410
      L(4) = 1                                                          19272411
      L(5) = 1                                                          19272412
      L(6) = 2                                                          19272413
      LL(1) = XLOCF(LL(1))                                              19272414
      LL(2) = XLOCF(XTAB)                                               19272415
      LL(3) = XLOCF(PTAB)                                               19272416
      LL(4) = 1                                                         19272417
      LL(5) = 1                                                         19272418
```

```
      LL(6) = 2                                                         19272419
      DZ = 0.1                                                          19272420
C                                LOOK UP R AND P                        19272421
    2 L(7) = NXTAB                                                      19272422
      LL(7) = NXTAB                                                     19272423
      L(8) = 0                                                          19272424
      LL(8) = 0                                                         19272425
      RZERO = TABF(X,L)                                                 19272426
      IF (L(8)-1) 3, 3, 7                                               19272427
    3 P = TABF(X,LL)                                                    19272428
      IF (LL(8)-1) 4, 4, 7                                              19272429
C                                FIND DPDX                              19272430
    4 LL(8) = 0                                                         19272431
      P1 = TABF(X+DZ,LL)                                                19272432
      IF (LL(8)-1) 5, 5, 7                                              19272433
    5 LL(8) = 0                                                         19272434
      P2 = TABF(X-DZ,LL)                                                19272435
      IF (LL(8)-1) 6, 6, 7                                              19272436
    6 DPDX = (P1-P2)/(2.0*DZ)                                           19272437
      RETURN                                                            19272438
    7 WRITE OUTPUT TAPE 6, 100, X                                       19272439
  100 FORMAT(29H0TABLE LOOK-UP FAILED AT X = F10.4)                     19272440
      CALL EXIT                                                         19272441
      END                                                               19272442
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
188	00274	19694	46356

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A	23809	56401	B	29148	70734	C1	32360	77150	C2	31160	74670	CONST	32561	77461
CP2	26718	64136	CPN2	19894	46066	CP	27930	66432	CS	22198	53266	DELTA	23406	55556
DHF	25730	64152	DPDX	23204	55244	DPSI	23203	55243	DX	23813	56405	DY	23812	56404
ENERGY	22598	54106	EPSON	23808	56400	E	29136	70720	FCON	32561	77461	FJ	23407	55557
FKC	29154	70742	FKP	29160	70750	FLE	23199	55237	FLET	23807	56377	FL	23810	56402
FMU	22799	54417	GAMMA	29142	70726	GC	23811	56403	H1	20598	50166	H2	20398	47656
H	26514	63626	ICHECK	19895	46667	KPRINT	23200	55240	MMAX	23816	56410	M	23815	56407
NMAX	23405	55555	NMIN	19896	46670	NTCORE	20196	47346	NXTAB	20197	47345	PR	22999	54727
P21	23807	56067	P	23817	56411	PTAB	19996	47034	RHO1	29560	71570	RHO2	29360	71260
RTB	32560	77460	RTAB	20096	47200	RZERO	23202	55242	T1	29960	72410	T2	29760	72100
U1	24918	60526	U2	24718	60216	USUB11	22599	54107	V1	24518	57706	V2	24318	57376
W	29130	70712	WW	26724	64144	XH	22398	53576	X	23814	56406	XTAB	20196	47344
XU	24117	57065	Y	32560	77460	YS	23404	55554	YT	24118	57066	YU	24067	57003
YZERO	23201	55241	Z	24017	56721									

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
LL	179	00263	L	187	00273									

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
L2	171	00253	M111	170	00252	P1	169	00251	P2	168	00250			

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)34	100	00245									

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	166	00246	2)	147	00223	3)	151	00227	6)	153	00231			

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
EXIT	4	00004	TAB	1	00001	XLOC	0	00000	(FIL)	3	00003	(STH)	2	00002

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXIT TAB XLOC (FIL) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
1	18	00022	2	32	00100	3	38	00122	4	40	00134	5	43	00151
6	46	00166	7	49	00201									

```
      SUBROUTINE NONEQ1
* * * *    THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS
* * * *    NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN
* * * *    CONSENT OF THE BOEING COMPANY.
      DIMENSION C1(6,200), C2(6,200), T1(200), T2(200), RHO1(200),
     1RHO2(200), FKP(6), B(6), GAMMA(6), E(6), W(6,200),        DHF(6),
     2WW(6), H(8,200), U1(200), U2(200), V1(200), V2(200), XU(50),
     3YU(50), Z(200), CP2(200), FKC(6), YS(200), Y(200), FMU(200),
     4PR(200), FLE(200), ENERGY(200), FLET(200), PRT(200), XH(200),
     5CS(8,200), H2(200), H1(200), XTAB(100), RTAB(100), PTAB(100),
     6RRR(200), CP(6,200), CPN2(200)
      COMMON C1, C2, T1, T2, RHO1, RHO2
      COMMON FKP, FKC, B, GAMMA, E, W, CP, DHF, WW, CP2
      COMMON H, U1, U2, V1, V2, YT, XU, YU, Z
      COMMON P, MMAX, M, X, DX, DY, GC, FL, A, EPSON, FLET, PRT, FJ,
     1DELTA, NMAX, FCON, YS, DPDX
      COMMON DPSI, CONST, RZERO, Y, YZERO,KPRINT
      COMMON FLE, PR, FMU, USUB11, ENERGY
      COMMON XH, CS, H1, H2, NTCORE
      COMMON NXTAB, XTAB, RTAB, PTAB
      COMMON NMIN, ICHECK, CPN2
      EQUIVALENCE (FCON,CONST)
      EQUIVALENCE(Y,RRR)
      DO 40 N=1, NMAX
      SUM = 0.
      R     = 85.9*C2(1,N)+773.0*C2(2,N)+48.3*C2(3,N)+35.2*C2(4,N)+55.2*
     1C2(5,N)+55.2*C2(6,N)
      RHO2(N) = P/(R    *T2(N))
      CP(1,N) = 1.1020-33.140/(T2(N)**.50)+416.30/T2(N)
      CP(2,N) = 2.8570+.2867E-3*T2(N)+9.9210/(T2(N)**.50)
      CP(3,N) = .35980-5.3750/(T2(N)**.50)+47.810/T2(N)
      CP(4,N) = .3680-.1480E+3/T2(N)+.0320E+6/(T2(N)**2)
      CP(5,N) = .3380-.1170E+3/T2(N)+.0380E+6/(T2(N)**2)
      CP(6,N) = .3380-.1240E+3/T2(N)+.04140E+6/(T2(N)**2)
      DO 10 K=1, 6
      SUM = SUM+CP(K,N)*C2(K,N)
   10 CONTINUE
      CP2(N) = SUM
      H(1,N) = 1.102*T2(N)-66.3*T2(N)**.5+416.3*LOGF(T2(N))-1439.0
```

```
     1-104000./18.0                                                    19272482
      H(2,N) = 2.857*T2(N)+.143E-3*T2(N)**2+19.84*SQRTF(T2(N))-230.0   19272483
      H(3,N) = .3598*T2(N)-10.75*SQRTF(T2(N))+47.8*LOGF(T2(N))-128.3   19272484
      H(4,N) = .368*T2(N)-.148E3*LOGF(T2(N))-.032E6/T2(N)+887.0        19272485
     1-169300.0/44.0                                                   19272486
      H(5,N) = .338*T2(N)-.113E3*LOGF(T2(N))-.038E6/T2(N)+762.0        19272487
     1-47700.0/28.0                                                    19272488
      H(6,N) = .338*T2(N)-.124E3*LOGF(T2(N))-.0414E6/T2(N)+815.0       19272489
   40 CONTINUE                                                         19272490
      RETURN                                                           19272491
      END                                                              19272492
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
373	00565	19694	46356

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A	23809	56401	B	29148	70734	C1	32360	77150	C2	31160	74670	CONST	32561	77461
CP2	26718	64136	CPN2	19894	46666	CP	27930	66432	CS	22198	53266	DELTA	23406	55556
DHF	26730	64152	DPDX	23204	55244	DPSI	23203	55243	DX	23813	56405	DY	23812	56404
ENERGY	22598	54106	EPSON-	23808	56400	E	29136	70720	FCON	32561	77461	FJ	23407	55557
FKC	29154	70742	FKP	29160	70750	FLE	23199	55237	FLET	23807	56377	FL	23810	56402
FMU	22799	54417	GAMMA	29142	70726	GC	23811	56403	H1	20598	50166	H2	20398	47656
H	26518	63626	ICHECK	19895	46667	KPRINT	23200	55240	MMAX	23816	56410	M	23815	56407
NMAX	23405	55555	NMIN	19896	46670	NTCURE	20198	47346	NXTAB	20197	47345	PR	22999	54727
PRT	23607	56067	P	23817	56411	PTAB	19996	47034	RHO1	29560	71570	RHO2	29360	71260
RRR	32560	77460	RTAB	20096	47200	RZERO	23202	55242	T1	29960	72410	T2	29760	72100
U1	24918	60526	U2	24718	60216	USUB11	22599	54107	V1	24518	57706	V2	24318	57376
W	29130	70712	WW	26724	64144	XH	22398	53576	X	23814	56406	XTAB	20196	47344
XU	24117	57065	Y	32560	77460	YS	23404	55554	YT	24118	57066	YU	24067	57003
YZERO	23201	55241	Z	24017	56721									

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
R	372	00564	SUM	371	00563									

LOCATIONS FOR OTHER SYMBULS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	363	00553	2)	312	00470	3)	315	00473	6)	357	00545	C)100	369	00561
C)101	370	00562	D)202	144	00220									

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
EXP(3	0	00000	LOG	1	00001	SQRT	2	00002						

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP(3 LOG SQRT

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
10	27	00225	40	35	00452									

```
      SUBROUTINE INGRAT                                                 19272493
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS   19272494
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN    19272495
* * * *     CONSENT OF THE BOEING COMPANY.                              19272496
      DIMENSION C1(6,200), C2(6,200), T1(200), T2(200), RHO1(200),      19272497
     1RHO2(200), FKP(6), B(6), GAMMA(6), E(6), W(6,200),        DHF(6),  19272498
     2WW(6), H(8,200), U1(200), U2(200), V1(200), V2(200), XU(50),      19272499
     3YU(50), Z(200), CP2(200), FKC(6), YS(200), Y(200), FMU(200),      19272500
     4PR(200), FLE(200), ENERGY(200), FLET(200), PRT(200), XH(200),     19272501
     5CS(8,200), H2(200), H1(200), XTAB(100), RTAB(100), PTAB(100),     19272502
     6RRR(200), CP(6,200), CPN2(200)                                    19272503
      COMMON C1, C2, T1, T2, RHO1, RHO2                                 19272504
      COMMON FKP, FKC, B, GAMMA, E, W, CP, DHF, WW, CP2                 19272505
      COMMON H, U1, U2, V1, V2, YT, XU, YU, Z                           19272506
      COMMON P, MMAX, M, X, DX, DY, GC, FL, A, EPSON, FLET, PRT, FJ,    19272507
     1DELTA, NMAX, FCON, YS, DPDX                                       19272508
      COMMON DPSI, CONST, RZERO, Y, YZERO,KPRINT                        19272509
      COMMON FLE, PR, FMU, USUB11, ENERGY                               19272510
      COMMON XH, CS, H1, H2, NTCORE                                     19272511
      COMMON NXTAB, XTAB, RTAB, PTAB                                    19272512
      COMMON NMIN, ICHECK, CPN2                                         19272513
      EQUIVALENCE (FCON,CONST)                                          19272514
      EQUIVALENCE(Y,RRR)                                                19272515
C                                                                       19272516
      DIMENSION XINGRL(200)                                             19272517
      RRR(1) = RZERO                                                    19272518
      DO 30 N=2, NMAX                                                   19272519
      J = N-1                                                           19272520
      IF (N-2) 10, 5, 10                                                19272521
    5 XINGRL(N) = .50*(1.0/(RHO2(J)*U2(J))+1.0/(RHO2(N)*U2(N)))*DPSI    19272522
      GO TO 25                                                          19272523
   10 IF (N-3) 20, 15, 20                                               19272524
   15 XINGRL(N) = (1.0/3.0)*(1.0/(RHO2(1)*U2(1))+1.0/(RHO2(N)*U2(N))+   19272525
     14.0/(RHO2(J)*U2(J)))*DPSI                                         19272526
      GO TO 25                                                          19272527
   20 XINGRL(N) = XINGRL(N-2)+(1.0/3.0)*(1.0/(RHO2(N-2)*U2(N-2))+1.0/   19272528
     1(RHO2(N)*U2(N))+4.0/(RHO2(J)*U2(J)))*DPSI                         19272529
   25 RRR(N) = (RZERO**(DELTA+1.0)+(DELTA+1.0)*XINGRL(N))**(1.0/(DELTA  19272530
     1+1.0))                                                            19272531
```

```
30 CONTINUE                                                    19272532
   RETURN                                                      19272533
   END                                                         19272534
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
360	00550	19694	46356

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A	23809	56401	B	29148	70734	C1	32360	77150	C2	31160	74670	CONST	32561	77461
CP2	26718	64136	CPN2	19894	46666	CP	27930	66432	CS	22198	53266	DELTA	23406	55556
DHF	26730	64152	DPDX	23204	55244	DPSI	23203	55243	DX	23813	56405	DY	23812	56404
ENERGY	22598	54106	EPSUN	23808	56400	E	29136	70720	FCON	32561	77461	FJ	23407	55557
FKC	29154	70742	FKP	29160	70750	FLE	23199	55237	FLET	23807	56377	FL	23810	56402
FMU	22799	54417	GAMMA	29142	70726	GC	23811	56403	H1	20598	50166	H2	20398	47656
H	26518	63626	ICHECK	19895	46667	KPRINT	23200	55240	MMAX	23816	56410	M	23815	56407
NMAX	23405	55555	NMIN	19896	46670	NTCORE	20198	47346	NXTAB	20197	47345	PR	22999	54727
PRT	23607	56067	P	23817	56411	PTAB	19996	47034	RHO1	29560	71570	RHO2	29360	71260
RRR	32560	77460	RTAB	20096	47200	RZERO	23202	55242	T1	29960	72410	T2	29760	72100
U1	24918	60526	U2	24718	60216	USUB11	22599	54107	V1	24518	57706	V2	24318	57376
W	29130	70712	WW	26724	64144	XH	22398	53576	X	23814	56406	XTAB	20196	47344
XU	24117	57065	Y	32560	77460	YS	23404	55554	YT	24118	57066	YU	24067	57003
YZERO	23201	55241	Z	24017	56721									

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
XINGRL	359	00547												

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
J	159	00237	N	158	00236									

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	149	00225	2)	136	00210	3)	139	00213	6)	143	00217	C1G2	157	00235
E12	26	00032	E14	52	00064									

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
EXP13	0	00000												

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP13

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
5	20	00033	10	22	00057	15	23	00065	20	25	00121	25	26	00155
30	27	00201												

```
      SUBROUTINE DUCT(X,RJ,PSIJ,R1,THRUST,RHO,U,P,RDZERO,PSID,DELTA)
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN
* * * *     CONSENT OF THE BOEING COMPANY.
      IF (X) 2, 1, 2
    1 PSID = 0.5**DELTA*RHO*U*(RDZERO**(DELTA+1.0)-RJ**(DELTA+1.0))+
     1PSIJ
      THRUST = 0.0
      R1 = RDZERO
      P1 = P
      GO TO 3
C
    2 R2 = R1
      P2 = P1
      R1 = (RJ**(DELTA+1.0)+(DELTA+1.0)*(PSID-PSIJ)/(RHO*U))**(1.0/
     1(DELTA+1.0))
      P1 = P
      THRUST = THRUST+(3.1415927**DELTA*(R1**DELTA*P1+R2**DELTA*P2)
     1*(R1-R2))/(2.0**(1.0-DELTA))
C
    3 RETURN
      END
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
195	00303	32561	77461

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
P1	194	00302	P2	193	00301	R2	192	00300						

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	182	00266	3)	171	00253	6)	176	00260						

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
EXP13	0	00000												

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP13

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
1	4	00067	2	9	00134	3	14	00247						

```
      SUBROUTINE NONEQ3(IDUCT,PSID,TESMAX,TESMIN,DTESMX,DTESMN,D2MAX)
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN
* * * *     CONSENT OF THE BOEING COMPANY.
      DIMENSION C1(6,200), C2(6,200), T1(200), T2(200), RHO1(200),
     1RHO2(200), FKP(6), B(6), GAMMA(6), E(6), W(6,200),        DHF(6),
     2WW(6), H(8,200), U1(200), U2(200), V1(200), V2(200), XU(50),
     3YU(50), Z(200), CP2(200), FKC(6), YS(200), Y(200), FMU(200),
     4PR(200), FLE(200), ENERGY(200), FLET(200), PRT(200), XH(200),
     5CS(8,200), H2(200), H1(200), XTAB(100), RTAB(100), PTAB(100),
     6RRR(200), CP(6,200), CPN2(200)
      DIMENSION CBAR(6), CHAT(6)
      COMMON C1, C2, T1, T2, RHO1, RHO2
      COMMON FKP, FKC, B, GAMMA, E, W, CP, DHF, WW, CP2
      COMMON H, U1, U2, V1, V2, YT, XU, YU, Z
      COMMON P, MMAX, M, X, DX, DY, GC, FL, A, EPSON, FLET, PRT, FJ,
     1DELTA, NMAX, FCON, YS, DPDX
      COMMON DPSI, CONST, RZERO, Y, YZERO,KPRINT
      COMMON FLE, PR, FMU, USUB11, ENERGY
      COMMON XH, CS, H1, H2, NTCORE
      COMMON NXTAB, XTAB, RTAB, PTAB
      COMMON NMIN, ICHECK, CPN2
      EQUIVALENCE (FCON,CONST)
      EQUIVALENCE(Y,RRR)
      NMAX2 = NMAX-1
      M = M+1
      FFFM = M
C     SAVE M VALUES IN M-1
      DO 10 N=1, NMAX
      U1(N) = U2(N)
      T1(N) = T2(N)
      DO 10 K=1, 6
   10 C1(K,N) = C2(K,N)
      X = X+DX
      CALL PRESS
C
      PNON = EPSON*(CONST+FFFM*DX/FL)**A
      IF (NMIN-1) 25, 25, 30
   25 NMIN = 2
```

```
30 DO 100 N=NMIN, NMAX2                                                 19272596
   IF (N-2) 35, 35, 40                                                  19272597
35 RZNM1 = 0.0                                                          19272598
   GO TO 45                                                             19272599
40 RZNM1 = RRR(N-1)**(2.0*DELTA)                                        19272600
45 KER = 0                                                              19272601
   IER = 0                                                              19272602
   TO = 1.0/1800.*(T1(N)/1.8-1200.)                                     19272603
   FKP(1) = 4.72E-4*(10.0**(10.0**(.8974-.8946*TO+.3963*TO**2-          19272604
  1.4501*TO**3+.2858*TO**4-.1139*TO**5)))**2                            19272605
   FKP(4) = 4.72E-4*(10.0**(10.0**(.8879-.9653*TO-.2969*TO**2+          19272606
  11.445*TO**3-2.07*TO**4+.6697*TO**5)))**2                             19272607
15 EVN = RHO2(N)*PNON                                                   19272608
   EVNP1 = RHO2(N+1)*PNON                                               19272609
   EVNM1 = RHO2(N-1)*PNON                                               19272610
   TEMPRY = RHO2(N)*U1(N)*RRR(N)**(2.0*DELTA)*DX/DPSI**2                19272611
   U2(N) = U1(N)-DX*GC*DPDX/(RHO2(N)*U1(N))+TEMPRY*(FMU(N)+EVN)*        19272612
  1(U1(N+1)-2.0*U1(N)+U1(N-1))+.25*DX/DPSI**2*(FMU(N)+EVN)*             19272613
  2(RHO2(N+1)*U1(N+1)*RRR(N+1)**(2.0*DELTA)-RHO2(N-1)*U1(N-1)*          19272614
  3         RZNM1          )*(U1(N+1)-U1(N-1))+.25*TEMPRY*((FMU(N+1)-   19272615
  4FMU(N-1))+(EVNP1-EVNM1))*(U1(N+1)-U1(N-1))                           19272616
   DO 50 K=1, 6                                                         19272617
50 CBAR(K) = C1(K,N)+TEMPRY*(FMU(N)*FLE(N)/PR(N)+EVN*FLET(N)/PRT(N))*19272618
  1(C1(K,N+1)-2.0*C1(K,N)+C1(K,N-1))+.25*DX/DPSI**2*(FMU(N)*FLE(N)/PR19272619
  2(N)+EVN*FLET(N)/PRT(N))*(RHO2(N+1)*U1(N+1)*RRR(N+1)**(2.0*DELTA)- 19272620
  3RHO2(N-1)*U1(N-1)*          RZNM1          )*(C1(K,N+1)-C1(K,N-1))+  19272621
  4.25*TEMPRY*((FMU(N+1)*FLE(N+1)/PR(N+1)-FMU(N-1)*FLE(N-1)/PR(N-1))+19272622
  5(EVNP1*FLET(N+1)/PRT(N+1)-EVNM1*FLET(N-1)/PRT(N-1)))*                19272623
  6(C1(K,N+1)-C1(K,N-1))                                                19272624
17 CONTINUE                                                             19272625
66 IER = 1                                                              19272626
67 IF (CBAR(2)-1.0E-5) 71, 71, 69                                       19272627
71 KER = 1                                                              19272628
69 JER = IER+KER                                                        19272629
   IF (JER-2) 62, 64, 62                                                19272630
62 IF (CBAR(3)-1.0E-5) 64, 65, 65                                       19272631
64 C2(1,N) = CBAR(1)                                                    19272632
   C2(2,N) = CBAR(2)                                                    19272633
   C2(3,N) = CBAR(3)                                                    19272634
   C2(4,N) = CBAR(4)                                                    19272635
```

```
      C2(5,N) = CBAR(5)                                                 19272636
      C2(6,N) = CBAR(6)                                                 19272637
      GO TO 59                                                          19272638
   65 CHAT(2) = CBAR(2)+CBAR(1)*2.0/18.0                                19272639
      CHAT(3) = CBAR(3)+CBAR(1)*32.0/36.0+CBAR(4)*32.0/44.0+CBAR(5)     19272640
     1*32.0/56.0                                                        19272641
      CH4P5W = CBAR(4)+CBAR(5)*44.0/28.0                                19272642
      CHAT(6) = CBAR(6)                                                 19272643
      WM = CBAR(1)/18.0+CBAR(2)/2.0+CBAR(3)/32.0+CBAR(4)/44.0           19272644
     1+CBAR(5)/28.0+CBAR(6)/28.0                                        19272645
      WM = 1.0/WM                                                       19272646
      CHECK = C1(4,N)+C1(5,N)                                           19272647
      C2(2,N) = CBAR(2)/2.0                                             19272648
      TEST = CHAT(2)/1000.0                                             19272649
      IF (CHECK) 51, 53, 51                                             19272650
   51 DEL = 32.0/(FKP(1)*P*WM)*((CHAT(2)-C2(2,N))/C2(2,N))**2+8.00*     19272651
     1(CHAT(2)-C2(2,N))+(((CHAT(2)-C2(2,N))/C2(2,N))*(32.0/44.0*        19272652
     2(FKP(4)/FKP(1))**.5*CH4P5W))/(1.0+(FKP(4)/FKP(1))**.5*((CHAT(2)   19272653
     3-C2(2,N))/C2(2,N)))+32.0/88.0*(CH4P5W-((FKP(4)/FKP(1))**.5*       19272654
     4((CHAT(2)-C2(2,N))/C2(2,N))*CH4P5W)/(1.0+(FKP(4)/FKP(1))**.5*     19272655
     5((CHAT(2)-C2(2,N))/C2(2,N))))-CHAT(3)                             19272656
      IF (ABSF(DEL/CHAT(3))-.0005)55,55,52                              19272657
   52 DERIV = CHAT(2)/(C2(2,N)**2)*(-64.0/(FKP(1)*P*WM)*((CHAT(2)-C2    19272658
     1(2,N))/C2(2,N))-8.00*(C2(2,N)**2)/CHAT(2)+32.0/44.0*(FKP(4)/      19272659
     2FKP(1))**.5*CH4P5W/(1.0+(FKP(4)/FKP(1))**.5*((CHAT(2)-C2(2,N))    19272660
     3/C2(2,N)))*(-.5+(((CHAT(2)-C2(2,N))/C2(2,N))*(FKP(4)/FKP(1))**.5)/19272661
     4(2.0*(1.0+(FKP(4)/FKP(1))**.5*((CHAT(2)-C2(2,N))/C2(2,N))))))     19272662
      IF (DEL/DERIV) 75, 80, 80                                         19272663
   80 IF (C2(2,N)) 75, 75, 85                                           19272664
   85 IF (C2(2,N)-TEST) 102, 75, 75                                     19272665
   75 C2(2,N) = C2(2,N)-DEL/DERIV                                       19272666
      IF (C2(2,N)) 60, 60,  51                                          19272667
  102 C2(2,N) = (SQRTF(32.0)/(SQRTF(FKP(1))*SQRTF(P*WM)))*(CHAT(2)/     19272668
     1(SQRTF(CHAT(3)-8.0*CHAT(2)-32.0/44.0*CH4P5W)))                    19272669
      GO TO 55                                                          19272670
   60 C2(2,N) = C2(2,N)+DEL/DERIV                                       19272671
   61 C2(2,N) = C2(2,N)/10.0                                            19272672
      GO TO  51                                                         19272673
   53 DEL = 32.0/(FKP(1)*P*WM)*((CHAT(2)-C2(2,N))/C2(2,N))**2+8.00*     19272674
     1(CHAT(2)-C2(2,N))-CHAT(3)                                         19272675
```

```
      IF (ABSF(DEL/CHAT(3))-.0005)55,55,54
   54 DERIV = CHAT(2)/(C2(2,N)**2)*(-64.0/(FKP(1)*P*WM)*((CHAT(2)-C2
     1(2,N))/C2(2,N))-8.00*(C2(2,N)**2)/CHAT(2))
      IF (DEL/DERIV) 170, 175, 175
  175 IF (C2(2,N)) 170, 170, 180
  180 IF (C2(2,N)-TEST) 104, 170, 170
  170 C2(2,N) = C2(2,N)-DEL/DERIV
      IF (C2(2,N)) 57, 57,  53
  104 C2(2,N) = (SQRTF(32.0)/(SQRTF(FKP(1))*SQRTF(P*WM)))*(CHAT(2)/
     1(SQRTF(CHAT(3)-8.0*CHAT(2)-32.0/44.0*CH4P5W)))
      GO TO 55
   57 C2(2,N) = C2(2,N)+DEL/DERIV
   58 C2(2,N) = C2(2,N)/10.0
      GO TO  53
   55 C2(1,N) = (CHAT(2)-C2(2,N))*9.00
      C2(3,N) = C2(1,N)**2*128.0/(324.0*C2(2,N)*FKP(1)*C2(2,N)*P*WM)
      C2(4,N) = (FKP(4)/FKP(1))**.5*((CHAT(2)-C2(2,N))/C2(2,N))
     1*CH4P5W/(1.0+(FKP(4)/FKP(1))**.5*((CHAT(2)-C2(2,N))/C2(2,N)))
      C2(5,N) = (CH4P5W-C2(4,N))*28.0/44.0
      C2(6,N) = CHAT(6)
   59 DO 56 K=1, 6
      W(K,N) = (C2(K,N)-CBAR(K))*RHO1(N)*U1(N)/DX
   56 CONTINUE
   68 SUM1 = 0.
      SUM = 0.
      DO 70 K=1, 6
      SUM = SUM+W(K,N)*H(K,N)
      SUM1 = SUM1+CP(K,N)*(T1(N+1)-T1(N-1))*(C1(K,N+1)-C1(K,N-1))
   70 CONTINUE
   72 T2(N) = T1(N)+DX*DPDX/(RHO2(N)*CP2(N)*FJ)+(FMU(N)+EVN)*
     1TEMPRY/(4.0*CP2(N)*FJ*GC)*(U1(N+1)-U1(N-1))**2+TEMPRY*
     2(FMU(N)/PR(N)+EVN/PRT(N))*(T1(N+1)-2.0*T1(N)+T1(N-1))+
     3.25*TEMPRY*((FMU(N+1)/PR(N+1)-FMU(N-1)/PR(N-1))+(EVNP1/PRT(N+1)
     4-EVNM1/PRT(N-1)))*(T1(N+1)-T1(N-1))+DX/(4.0*DPSI**2*CP2(N))*
     5(FMU(N)/PR(N)+EVN/PRT(N))*(RHO2(N+1)*U1(N+1)*CP2(N+1)*RRR(N+1)**
     6(2.0*DELTA)-RHO2(N-1)*U1(N-1)*CP2(N-1)*          RZNM1          )*
     7(T1(N+1)-T1(N-1))+.25*TEMPRY/CP2(N)*(FMU(N)*FLE (N)/PR(N)+EVN*FLET
     8(N)/PRT(N))*SUM1-DX/(RHO2(N)*CP2(N)*U1(N))*SUM
  100 CONTINUE
      IF (IDUCT) 325, 105, 325
```

```
105 DO 110 N=NMIN, NMAX                                          19272716
    IMAX = N                                                     19272717
    IF (C2(1,N)-TESMAX) 120, 120, 110                            19272718
110 CONTINUE                                                     19272719
120 NMAX = IMAX+2                                                19272720
    DO 125 K=1, 6                                                19272721
    C2(K,NMAX) = C2(K,NMAX-2)                                    19272722
    C2(K,NMAX-1) = C2(K,NMAX)                                    19272723
125 CONTINUE                                                     19272724
    C2(1,NMAX) = TESMAX - DTESMX                                 19272725
    C2(1,NMAX-1) = C2(1,NMAX)                                    19272726
    C2(1,NMAX-2) = C2(1,NMAX)                                    19272727
    C2(2,NMAX) = TESMAX - D2MAX                                  19272728
    C2(2,NMAX-1) = C2(2,NMAX)                                    19272729
    C2(2,NMAX-2) = C2(2,NMAX)                                    19272730
    T2(NMAX) = T2(NMAX-2)                                        19272731
    T2(NMAX-1) = T2(NMAX)                                        19272732
    U2(NMAX) = U2(NMAX-2)                                        19272733
    U2(NMAX-1) = U2(NMAX)                                        19272734
    CP2(NMAX) = CP2(NMAX-2)                                      19272735
    CP2(NMAX-1) = CP2(NMAX)                                      19272736
    RHO2(NMAX) = RHO2(NMAX-2)                                    19272737
    RHO2(NMAX-1) = RHO2(NMAX)                                    19272738
    PSINM3 = FLOATF(NMAX-4)*DPSI                                 19272739
    IF (PSINM3-PSID) 128, 300, 300                               19272740
300 IDUCT = 1                                                    19272741
    DUCHK = 0.                                                   19272742
    NMAX = NMAX-3                                                19272743
    DO 320 N=1, NMAX                                             19272744
    PSIN = FLOATF(N-1)*DPSI                                      19272745
    IF (PSIN-PSID) 305, 305, 320                                 19272746
305 IF (PSIN-DUCHK) 320, 310, 310                                19272747
310 DUCHK = PSIN                                                 19272748
    NKEEP = N                                                    19272749
320 CONTINUE                                                     19272750
    NMAX = NKEEP                                                 19272751
325 U2(NMAX) = U2(NMAX-1)                                        19272752
    T2(NMAX) = T2(NMAX-1)                                        19272753
    DO 330 K=1, 6                                                19272754
    C2(K,NMAX) = C2(K,NMAX-1)                                    19272755
```

```
330 CONTINUE
128 DO 130 N=NMIN, NMAX
    J = N
    IF (C2(6,N)-TESMIN) 130, 130, 135
130 CONTINUE
135 NMIN = J-3
    IF (NMIN-2) 140, 145, 145
140 IF (RRR(1)) 143, 142, 143
142 NMIN = 1
340 U2(NMIN) = U2(NMIN+1)
    T2(NMIN) = T2(NMIN+1)
    DO 345 K=1, 6
    C2(K,NMIN) = C2(K,NMIN+1)
345 CONTINUE
350 ICHECK = 1
    RETURN
143 ICHECK = 0
    NMIN = 1
    WRITE OUTPUT TAPE 6, 200, NMIN
200 FORMAT(23HOTHE MINIMUM SUBSCRIPT=I2)
    RETURN
145 DO 150 K=1, 6
    C2(K,NMIN) = C2(K,NMIN+1)
    W(K,NMIN) = W(K,NMIN+1)
150 CONTINUE
    C2(6,NMIN) = TESMIN - DTESMN
    C2(6,NMIN+1) = C2(6,NMIN)
    C2(6,NMIN+2) = C2(6,NMIN)
    T2(NMIN) = T2(NMIN+1)
    V2(NMIN) = V2(NMIN+1)
    U2(NMIN) = U2(NMIN+1)
    H2(NMIN) = H2(NMIN+1)
    CP2(NMIN) = CP2(NMIN+1)
    FMU(NMIN) = FMU(NMIN+1)
    RHO2(NMIN) = RHO2(NMIN+1)
    RRR(NMIN) = RRR(NMIN+1)
    J = NMIN-1
    DO 160 N=1, J
    DO 155 K=1, 6
    C2(K,N) = C2(K,NMIN)
```

```
      W(K,N) = W(K,NMIN)                                                19272796
  155 CONTINUE                                                          19272797
      T2(N) = T2(NMIN)                                                  19272798
      V2(N) = V2(NMIN)                                                  19272799
      U2(N) = U2(NMIN)                                                  19272800
      H2(N) = H2(NMIN)                                                  19272801
      CP2(N) = CP2(NMIN)                                                19272802
      FMU(N) = FMU(NMIN)                                                19272803
      RHO2(N) = RHO2(NMIN)                                              19272804
      RRR(N) = RRR(NMIN)                                                19272805
  160 CONTINUE                                                          19272806
      RETURN                                                            19272807
      END                                                               19272808
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
1738	03312	19694	46356

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A	23809	56401	B	29148	70734	C1	32360	77150	C2	31160	74670	CONST	32561	77461
CP2	26718	64136	CPN2	19894	46666	CP	27930	66432	CS	22198	53266	DELTA	23406	55556
DHF	26730	64152	DPDX	23204	55244	DPSI	23203	55243	DX	23813	56405	DY	23812	56404
ENERGY	22598	54106	EPSON	23808	56400	E	29136	70720	FCON	32561	77461	FJ	23407	55557
FKC	29154	70742	FKP	29160	70750	FLE	23199	55237	FLET	23807	56377	FL	23810	56402
FMU	22799	54417	GAMMA	29142	70726	GC	23811	56403	H1	20598	50166	H2	20398	47656
H	26518	63626	ICHECK	19895	46667	KPRINT	23200	55240	MMAX	23816	56410	M	23815	56407
NMAX	23405	55555	NMIN	19896	46670	NTCORE	20198	47346	NXTAB	20197	47345	PR	22999	54727
PRT	23607	56067	P	23817	56411	PTAB	19996	47034	RHO1	29560	71570	RHO2	29360	71260
RRR	32560	77460	RTAB	20096	47200	RZERO	23202	55242	T1	29960	72410	T2	29760	72100
U1	24918	60526	U2	24718	60216	USUB11	22599	54107	V1	24518	57706	V2	24318	57376
W	29130	70712	WW	26724	64144	XH	22398	53576	X	23814	56406	XTAB	20196	47344
XU	24117	57065	Y	32560	77460	YS	23404	55554	YT	24118	57066	YU	24067	57003
YZERO	23201	55241	Z	24017	56721									

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CBAR	1737	03311	CHAT	1731	03303									

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CH4P5W	1725	03275	CHECK	1724	03274	DEL	1723	03273	DERIV	1722	03272	DUCHK	1721	03271
EVNM1	1720	03270	EVNP1	1719	03267	EVN	1718	03266	FFFM	1717	03265	IER	1716	03264
IMAX	1715	03263	JER	1714	03262	J	1713	03261	KER	1712	03260	NKEEP	1711	03257
NMAX2	1710	03256	N	1709	03255	PNON	1708	03254	PSINM3	1707	03253	PSIN	1706	03252
RZNM1	1705	03251	SUM1	1704	03250	SUM	1703	03247	TEMPRY	1702	03246	TEST	1701	03245
TO	1700	03244	WM	1699	03243									

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)68	200	03166												

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	1655	03167	2)	1598	03076	3)	1606	03106	6)	1644	03154	A)104	1580	03054
A)106	1589	03065	C)GO	1686	03226	C)G2	1687	03227	C)G3	1688	03230	C)G4	1689	03231
C)100	1690	03232	C)101	1691	03233	C)102	1692	03234	C)104	1693	03235	C)106	1694	03236
C)200	1695	03237	C)201	1696	03240	C)202	1697	03241	C)206	1698	03242	D)11K	1364	02524
D)21R	1408	02600	D)40B	434	00662	D)412	1014	01766	D)414	1032	02010	D)514	1031	02007
E)C	522	01012	E)I	622	01156	E)N	771	01403	E)13	1026	02002	E)15	1052	02034
E)11R	1410	02602	E)20M	760	01370	E)20P	827	01473	E)40M	760	01370			

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
EXP(3	1	00001	PRESS	0	00000	SQRT	2	00002	(FIL)	4	00004	(STH)	3	00003

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP(3 PRESS SQRT (FIL) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
10	24	00076	25	29	00136	30	30	00144	35	32	00247	40	34	00252
45	35	00265	15	40	00506	50	46	00663	17	47	01013	66	48	01013
67	49	01015	71	50	01021	69	51	01023	62	53	01031	64	54	01035
65	61	01053	51	71	01157	52	73	01262	80	75	01357	85	76	01363
75	77	01371	102	79	01404	60	81	01461	61	82	01467	53	84	01474
54	86	01532	175	88	01567	180	89	01573	170	90	01600	104	92	01612
57	94	01667	58	95	01675	55	97	01701	59	102	01765	56	104	01777
68	105	02003	70	110	02031	72	111	02036	100	112	02261	105	114	02277
110	117	02326	120	118	02334	125	122	02363	300	139	02442	305	145	02477
310	146	02504	320	148	02510	325	150	02525	330	154	02545	128	155	02550
130	158	02574	135	159	02604	140	161	02621	142	162	02625	340	163	02635
345	167	02655	350	168	02660	143	171	02666	145	177	02715	150	180	02733
155	197	03015	160	206	03042									

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ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,  CHAIN      1 ,  2
     (FPT)       (TSHM)      (SLI)       (RTN)       (STHM)      (RIL)       SQRT        (SLO)       ASIN        TAN
     SIN         EXP(3       EXP(2       CHAIN       LOG         EXP         CHARET      (RWT)       COS         TRACE
     ATAN

CORE UNUSED FROM  64354   TO  77271 (OCT)

 CORE LOADING MAP

PROG     *MAIN*     EQUSS      EQUSP      EQUSRO     EQUSH      EQUSAV     EQUST      EQUSHP     PSEC
ORIG      00144      40467      40573      40701      41011      41143      41205      41243      41366

PROG     DATE       PRIDAT     PMXPAV     STORE      INTER      PTFTAX     INTRPT     PAMBPT     INSHPT
ORIG      43046      43104      43151      44022      45276      45576      47064      50640      51670

PROG     PTOTAX     (FPT)      EXP(2      EXP(3      EXP        LOG        SIN        ASIN       SQRT
ORIG      55004      55560      55630      55715      55761      56050      56147      56336      56450

PROG     TAN        ATAN       (TSH)      (STH)      (RWT)      (SLO)      (SLI)      (WER)      (RER)
ORIG      56535      56711      57072      57142      57423      57432      57447      57464      57563

PROG     (IOH)      (IOS)      CHAIN      (EXE)      EXIT       CHARET     PRINTR     SDUMP      COMMON
ORIG      57640      61772      62140      62474      62670      62732      62742      63151      63501

PROG     (IOU)      (TES)      SYSCD      (CLOS)     TRACE      *OBUF*
ORIG      63504      63534      63535      63640      63643      64036
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ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,  CHAIN     2 ,  3
    (FPT)       (RWT)       (TSHM)      (RTN)       EXP(3       (STHM)      (FIL)       SQRT        CHAIN       XLOC
    TAB         EXIT        LOG

CORE UNUSED FROM  20334   TO  46356 (OCT)

 CORE LOADING MAP

PROG        *MAIN*      CURV1       PRESS       NONEQ1      INGRAT      DUCT        NONEQ3      (FPT)       EXP(3
ORIG         00144       04531       04674       05170       05755       06625       07030       12342       12412

PROG        EXP         LOG         SQRT        (TSH)       (STH)       (RWT)       (WER)       (RER)       (IOH)
ORIG         12456       12545       12644       12731       13001       13262       13271       13370       13445

PROG        (IOS)       CHAIN       (EXE)       EXIT        CHARET      PRINTR      SDUMP       COMMON      (IOU)
ORIG         15577       15745       16301       16475       16537       16647       16756       17306       17311

PROG        (TES)       SYSCD       (CLOS)      XLOC        TAB         *OBUF*
ORIG         17341       17342       17445       17450       17523       20016

      BEGIN EXECUTION                                       TIME 11.716
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C     PLUME MAIN PROGRAM                                                19272809
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS   19272810
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN    19272811
* * * *     CONSENT OF THE BOEING COMPANY.                              19272812
C**** PLUME IS A DISTINCT PROGRAM ****                                  19272813
      DIMENSION R(1000), Z(1000), XMN(1000), THET(1000), RHO(1000),     19272814
     1PRESS(1000), XV(1000), S(1000), KEY(1000), IKEEP(50), MNSAV(50),  19272815
     2KKKSAV(50), T(1000), JKEEP(50), TR(200), TZ(200), TXMN(200),      19272816
     3TTHET(200), TRHO(200), TPRESS(200), TXV(200), TS(200)             19272817
F     EQUSS, EQUSP, EQUSRO, EQUSAV, EQUST, EQUSHP                       19272818
      COMMON PT, RHOT, TT, ST, GAMMA, CP                                19272819
      DIMENSION BB(100), TITLE(12)                                      19272820
      COMMON NPORA, INDP, NPP, WSEC, PTSEC, TTSEC, GSEC, RSEC, RN, BB   19272821
      COMMON ASEC, XMSEC, ASSEC, ISTS                                   19272822
      COMMON CPH                                                        19272823
      SJ=5.0E+3                                                         19272824
      ST = SJ                                                           19272825
      NDXP = 0                                                          19272826
      VACMN = 0.0                                                       19272827
      DELTA = 0.0                                                       19272828
      EPSLON = 1.0E-5                                                   19272829
      FACT = 1.0/512.0                                                  19272830
      NITER=100                                                         19272831
      EPS1=8.725E-3                                                     19272832
      EPS2=8.725E-3                                                     19272833
      EPS3=1.0E-3                                                       19272834
      EPS4=1.0                                                          19272835
      EPS5=1.0E-5                                                       19272836
      SPTS=10.0                                                         19272837
      ERR1=1.0E-4                                                       19272838
      ERR2=1.0E-4                                                       19272839
      ERR3=1.0E-3                                                       19272840
      SDLIM=0.50                                                        19272841
      SPTRC=0.30                                                        19272842
      SPTLC=0.20                                                        19272843
      SPTX=0.20                                                         19272844
   12 CONTINUE                                                          19272845
      READ INPUT TAPE 5, 7002, TITLE                                    19272846
 7002 FORMAT(12A6)                                                      19272847
      READ INPUT TAPE 5, 10000, LSTART, INDP, NPP, NPORA,ISTS           19272848
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      READ INPUT TAPE 5, 10001, ALT, GMN, GAMJ, TEMPJ, PJ, RGCJ, PN,     19272849
     1CPH, TXD, DBEL                                                     19272850
      IF (NPOPA) 10002, 10003, 10002                                     19272851
10002 READ INPUT TAPE 5, 10001, WSEC, RTSEC, TTSEC, GSEC, RSEC           19272852
10003 READ INPUT TAPE 5, 10001, (PP(I),I=1,NPP)                          19272853
10000 FORMAT(6I4)                                                        19272854
10001 FORMAT(8F10.0)                                                     19272855
      CALL RSEC(0.0,1.0,PAMB,0.0,0.0)                                    19272856
      DELTHE=0.10                                                        19272857
      XDLM=TXD                                                           19272858
      SNDD=DBEL/DELTHE +0.001                                            19272859
      DELTHE=DELTHE/57.29578                                             19272860
      CALL DATE(1)                                                       19272861
      WRITE OUTPUT TAPE 6,8000                                           19272862
 8000 FORMAT(1H ,55X,7HSPURT-A)                                          19272863
      WRITE OUTPUT TAPE 6,8001                                           19272864
 8001 FORMAT(1H0,30X52HMETHOD OF CHARACTERISTICS PROGRAM FOR THE SUPERSO19272865
     1NIC/1H 34X44HFLOW FIELD IN THE AIR-AUGMENTED ROCKET DUCT.)         19272866
      IF(CPH)8002,8002,8004                                              19272867
 8002 WRITE OUTPUT TAPE 6,8003                                           19272868
 8003 FORMAT(1H0,50X,18H2-DIMENSIONAL FLOW)                              19272869
      GO TO 8006                                                         19272870
 8004 WRITE OUTPUT TAPE 6,8005                                           19272871
 8005 FORMAT(1H0,50X,17HAXISYMMETRIC FLOW)                               19272872
 8006 WRITE OUTPUT TAPE 6,8007                                           19272873
 8007 FORMAT(1H0,3X,5HUNITS//1H ,7X,37HTEMPERATURE.............DEGREES RAN19272874
     1KINE/1H ,7X,33HPRESSURE................LBS./SQ.FT./1H ,7X,35HMACH NU19272875
     2MBER............DIMENSIONLESS/1H ,7X,35HGAMMA.....................DIMEN19272876
     3SIONLESS/1H ,7X,53HGAS CONSTANT...........FT.LBS./LB.MASS--DEGREE R19272877
     4ANKINE/1H ,7X,71HFLOW ANGLE (THETA)....DEGREES-MEASURED WITH RESPE19272878
     5CT TO AXIS OF SYMMETRY/1H ,7X,71HSHOCK ANGLE.............DEGREES-MEA19272879
     6SURED WITH RESPECT TO AXIS OF SYMMETRY/1H ,7X,37HDENSITY...........19272880
     7.....SLUGS/CUBIC FT./1H ,7X,30HVELOCITY................FT./SEC.)   19272881
      WRITE OUTPUT TAPE 6,8008                                           19272882
 8008 FORMAT(1H0,4X,4HNOTE//1H ,6X,32HINTERSECTION OF JET EXIT PLANE AND19272883
     1 JET AXIS OF SYMMETRY TAKEN AS ORIGIN OF COORDINATE SYSTEM/1H ,11X19272884
     2,10HX=ABSCISSA/12X,10HY=ORDINATE/8X,34HBOTH X AND Y ARE MEASURED I19272885
     3N FEET.)                                                           19272886
      WRITE OUTPUT TAPE 6,8009,PAMB,ALT                                  19272887
 8009 FORMAT(1H0,3X,85HIDENTIFICATION OF POINTS ALONG A LEFT RUNNING CHA19272888
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     1RACTERISTIC WITHIN THE EXHAUST PLUME//1H ,11X,6HIDENT.,8X,15HNATUR
     2E OF POINT//1H ,13X,35H0.....POINT ON THE AXIS OF SYMMETRY/1H ,13X
     3,30H2.....INTERIOR POINT/1H ,13X51H3.....UPSTREAM AND DOWNSTREAM I
     4NTERIOR SHOCK POINTS/1H ,13X,51H4.....CONSTANT PRESSURE BOUNDARY P
     5OINT INSIDE PLUME///1H ,3X,19HAMBIENT PRESSURE = F10.4,21X,11HALTI
     6TUDE = F10.2,4H FT.//)
      IF(LSTART)3010,8010,300
 8010 THETAJ=0.0
      WRITE OUTPUT TAPE 6,8011,GMN,GAMJ,TEMPJ,PJ,RGCJ,THETAJ
 8011 FORMAT(1H0,3X,50HJET EXIT CONDITIONS ( CONSTANT ACROSS EXIT PLANE
     1)//1H ,6X,14HMACH NUMBER = F10.4/1H ,6X,8HGAMMA = F10.4/1H ,6X,14H
     2TEMPERATURE = F10.4/1H ,6X,11HPRESSURE = F10.4/1H ,6X,15HGAS CONST
     3ANT = F10.4/1H ,6X,13HFLOW ANGLE = F10.4)
      WRITE OUTPUT TAPE 6, 7000, RN
 7000 FORMAT(7X,16HNOZZLE RADIUS = F10.4)
      GO TO 301
  300 READ INPUT TAPE 5,302,(TZ(I),TR(I),TTHET(I),TXMN(I),TPRESS(I),
     1I=1,LSTART)
  302 FORMAT(5F10.0)
      THETAJ=TTHET(1)/57.29578
      CP=(GAMJ*RGCJ)/(GAMJ-1.0)
      T(1)=TEMPJ
      HJS=CP*TEMPJ*32.2
      A=SQRTE((GAMJ-1.0)*HJS)
      TXV(1)=A*TXMN(1)
      HTJ=0.5*(TXV(1)**2)+HJS
      TT=HTJ/(CP*32.2)
      TRHO(1)=TPRESS(1)/(RGCJ*T(1)*32.2)
      DO 303 I=2,LSTART
      T(I)=TT*(2.0/(2.0+(GAMJ-1.0)*(TXMN(I)**2)))
      HJS=T(I)*CP*32.2
      TXV(I)=SQRTE(2.0*(HTJ-HJS))
      TRHO(I)=TPRESS(I)/(RGCJ*T(I)*32.2)
  303 TS(I)=SJ
      WRITE OUTPUT TAPE 6,8012,(TZ(I),TR(I),TTHET(I),TXMN(I),
     1TXV(I),TPRESS(I),T(I),TRHO(I),I=1,LSTART)
 8012 FORMAT(1H0,35X,48HDISTRIBUTION OF CONDITIONS ACROSS JET EXIT PLANE
     1 //1H ,7X,1HX,13X,1HY,12X,5HTHETA,9X,8HMACH NO.,7X,8HVELOCITY,7X,8
     2HPRESSURE,5X,11HTEMPERATURE,6X,7HDENSITY//(1H ,2X,F10.4,5X,F10.4,5
     3X,F10.4,5X,F10.4,5X,F10.4,5X,F10.4,5X,F10.4,5X,F10.4))
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      WRITE OUTPUT TAPE 6,8013,GAMJ,RGCJ                                19272929
 8013 FORMAT(1H0,6X,8HGAMMA = F10.4,7X,15HGAS CONSTANT = F10.4,7X,40HTHE19272930
     1SE ARE CONSTANT ACROSS JET EXIT PLANE)                            19272931
      DO 7999 I=1,LSTART                                                19272932
      TZ(I) = TZ(I)/RN                                                  19272933
      TR(I) = TR(I)/RN                                                  19272934
 7999 TTHET(I)=TTHET(I)/57.29578                                        19272935
      WRITE OUTPUT TAPE 6, 7000, RN                                     19272936
  301 CONTINUE                                                          19272937
      WRITE OUTPUT TAPE 6, 7001, CPH, TXD, DBEL                         19272938
 7001 FORMAT(4X,16HPROGRAM CONTROLS/7X,3HCPHF11.4/7X,3HTXDF11.4/7X,4HDBF19272939
     1LF10.4)                                                           19272940
      WRITE OUTPUT TAPE 6, 7004, TITLE                                  19272941
 7004 FORMAT(1H012A6)                                                   19272942
      WRITE OUTPUT TAPE 6, 7003, (PR(I),I=1,NPR)                        19272943
 7003 FORMAT(1X7F14.5)                                                  19272944
      IF (NPORA) 10004, 10005, 10004                                    19272945
10004 WRITE OUTPUT TAPE 6, 7005, WSEC, PTSEC, TTSEC, GSEC, RSEC, ASSEC  19272946
 7005 FORMAT(25H0FOR THE SECONDARY STREAM/7X12HMASS FLOW = F10.4/7X17HTO19272947
     1TAL PRESSURE = F10.4/7X20HTOTAL TEMPERATURE = F10.4/7X7HGAMA = F10 19272948
     2.4/7X15HGAS CONSTANT = F10.4/7X9HA STAR = F10.4)                  19272949
10005 CONTINUE                                                          19272950
      IF (ASEC-ASSEC) 10007, 10008, 10008                               19272951
10008 INDINS = 0                                                        19272952
      TXD = TXD/RN                                                      19272953
      NDD = SNDD                                                        19272954
      PY = 0.1                                                          19272955
      A1 = THETAJ                                                       19272956
      A2 = THETAJ-ASINF(1.0/GMN)                                        19272957
      TA2 = TANF(A2)                                                    19272958
      CP = (GAMJ*RGCJ)/(GAMJ-1.0)                                       19272959
      HJS = CP*TEMPJ*32.2                                               19272960
      A = SQRTF((GAMJ-1.0)*HJS)                                         19272961
      V = A*GMN                                                         19272962
      HTJ = HJS+0.5*(V**2)                                              19272963
      RHOJ = PJ/(RGCJ*TEMPJ*32.2)                                       19272964
      GAMMA = GAMJ                                                      19272965
      PT = PJ                                                           19272966
      RHOT = RHOJ                                                       19272967
      TT = TEMPJ                                                        19272968
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      IF (LSTART) 304, 305, 304
  304 PRESS(2) = TPRESS(1)
      XMN(2) = TXMN(1)
      THET(2) = TTHET(1)
      RHO(2) = TRHO(1)
      XV(2) = TXV(1)
      KEY(2) = 2
      I = 3
      LST = 1
      GO TO 600
  305 PRESS(1) = PJ
      XMN(1) = GMN
      THET(1) = THETAJ
      RHO(1) = RHOJ
      XV(1) = V
      KEY(1) = 2
      I = 2
      LST = 0
  600 P = 0.0
      CALL PMXPAV (EOUSAV,EOUST,EOUSHP,HTJ,PJ,THETAJ,SJ,VACMN,DELTHE,
     1DELTA,EPSLON,PAMB,THETAX,BETAX,VX,P,NDXP,M)
      PRESS(I) = P
      THET(I) = THETAX
      XMN(I) = 1.0/(SINF(BETAX))
      XV(I) = VX
      PJ = P
    3 THETAJ = THETAX
      IF (M) 604, 603, 604
  603 I = I+1
      GO TO 600
  604 N = I
      J = 2+LST
      I = NDD+1+LST
  900 PRESS(J) = PRESS(I)
      THET(J) = THET(I)
      XMN(J) = XMN(I)
      XV(J) = XV(I)
      KEY(J)=2
      I = I+NDD
      J = J+1
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      IF (I-N) 900, 901, 901
  901 PRESS(J) = PRESS(N)
      THET(J) = THET(N)
      XMN(J) = XMN(N)
      XV(J) = XV(N)
      N = J
      VXMN = 1.0/(SINF(BETAX))
      PRESS(N) = P
      XMN(N) = VXMN
      THET(N) = THETAX
      XV(N) = VX
      KEY(N) = 4
      ZAP = 1.0/GAMJ
      IF (LSTART) 306, 307, 306
  306 ILL = 3
      GO TO 308
  307 ILL = 2
  308 DO 4 J=ILL, N
    4 RHO(J) = RHO(J-1)/((PRESS(J-1)/PRESS(J))**ZAP)
      ILL = ILL-1
      DO 5 L=ILL, N
      R(L) = 1.0
      THET(L) = THET(L)*57.29578
      T(L) = (PRESS(L))/(RHO(L)*RGCJ*32.174)
      S(L) = SJ
      R(L) = R(L)*RN
    5 Z(L) = 0.0
      WRITE OUTPUT TAPE 6, 7, (Z(I),R(I),XMN(I),THET(I),RHO(I),PRESS(I),
     1T(I),I=ILL,N)
    7 FORMAT(14H0PRANDTL-MEYER//119H IDENT.        X              Y
     1   MACH NO.        THETA        DENSITY       PRESSURE      TEMPERAT
     2URE    SHOCK ANGLE/(9H          F12.5,2H  F12.5,2H  F12.5,2H  F12.5,
     32H  F12.5,2H  F12.5,2H  F12.5))
      DO 902 L=ILL, N
      R(L) = R(L)/RN
  902 THET(L) = THET(L)/57.29578
      VVV= XV(N)
      WRITE OUTPUT TAPE 6, 7006, VVV
 7006 FORMAT(33H JET VELOCITY AT THE SLIP LINE = F12.5,9H  FT/SEC.)
      IF (NPORA) 7601, 7603, 7601
```

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```
7601 WRITE OUTPUT TAPE 6, 7602, ASEC, XMSEC                          19273049
7602 FORMAT(26H SECONDARY STREAM, AREA = F10.4,13H, MACH NO. = F10.4) 19273050
     IF (ASEC/ASSEC-0.9) 10007, 10007, 7603                          19273051
7603 CONTINUE                                                        19273052
     IF (PRESS(N)-288.0) 1313, 1313, 7604                            19273053
7604 CONTINUE                                                        19273054
     IP3=0                                                           19273055
     JP = 1000                                                       19273056
     ISTP = 0                                                        19273057
     JERK = 0                                                        19273058
     MM = 0                                                          19273059
     KKK = 0                                                         19273060
     KK = 0                                                          19273061
     NN = 0                                                          19273062
     LPP = 0                                                         19273063
     LPPC = 0                                                        19273064
     ITES = 0                                                        19273065
     NSP = 0                                                         19273066
     K = 1                                                           19273067
     INSERT = 0                                                      19273068
  20 IF (LSTART) 309, 310, 309                                       19273069
 309 IF (K-1) 311, 312, 311                                          19273070
 312 NSP = 1                                                         19273071
     DELR = TR(NSP)-TR(NSP+1)                                        19273072
     DRN = FACT*DELR                                                 19273073
     DRNT = DRN                                                      19273074
     DRNTT = DRN                                                     19273075
 313 DRNDLR = DRNTT/DELR                                             19273076
     Y3 = TR(NSP)+DRNDLR*(TR(NSP+1)-TR(NSP))                         19273077
 315 X3 = TZ(NSP)+DRNDLR*(TZ(NSP+1)-TZ(NSP))                         19273078
     XMN(1) = TXMN(NSP)+DRNDLR*(TXMN(NSP+1)-TXMN(NSP))               19273079
     THET(1) = TTHET(NSP)+DRNDLR*(TTHET(NSP+1)-TTHET(NSP))           19273080
     RHO(1) = TRHO(NSP)+DRNDLR*(TRHO(NSP+1)-TRHO(NSP))               19273081
     PRESS(1) = TPRESS(NSP)+DRNDLR*(TPRESS(NSP+1)-TPRESS(NSP))       19273082
     XV(1) = TXV(NSP)+DRNDLR*(TXV(NSP+1)-TXV(NSP))                   19273083
     S(1) = 5.0E+3                                                   19273084
     KEY(1) = 2                                                      19273085
     TY4 = Y4                                                        19273086
     TY1 = R(2)                                                      19273087
     IF (Y3-0.01) 4325, 4325, 802                                    19273088
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```
4325 NSP = LSTART                                                        19273089
     GO TO 314                                                           19273090
 311 IF (K-11) 316, 4321, 317                                            19273091
4321 DRN = 1.0/SPTS                                                      19273092
     GO TO 317                                                           19273093
 316 DRN = DRNT*(2.0**(K-2))                                             19273094
 317 IF (MM-2) 318, 319, 319                                             19273095
 319 BET9 = ASINF(1.0/XMN9)                                              19273096
     TMB9 = THET9-BET9                                                   19273097
     CALL INTER(EPS1,ALPH1,TMB9,X4,Z9,Y4,R9,Z15,R15)                     19273098
     IF (MM-2) 320, 321, 320                                             19273099
 320 DY = 0.75*((R(2)-TY1)/(1.0-TY1-((Y4-1.0)*(1.0-TY1))/(TY4-1.0)))     19273100
 321 DR5 = (1.0-R(2)-((R15-1.0)*(1.0-R(2)))/(Y4-1.0))*DY                 19273101
     IF (DRN-ABSF(DR5)) 318, 318, 322                                    19273102
 318 DRNTT = DRNTT+DRN                                                   19273103
     GO TO 323                                                           19273104
 322 DRNTT = DRNTT-DR5                                                   19273105
 323 IF (DRNTT/DELR-1.0) 313, 313, 324                                   19273106
 324 DRNTT = DRNTT-DELR                                                  19273107
     NSP = NSP+1                                                         19273108
     DELR = TR(NSP)-TR(NSP+1)                                            19273109
     IF (LSTART-NSP) 314, 314, 323                                       19273110
 314 Z(1) = TZ(LSTART)                                                   19273111
     R(1) = TR(LSTART)                                                   19273112
     XMN(1) = TXMN(LSTART)                                               19273113
     THET(1) = TTHET(LSTART)                                             19273114
     RHO(1) = TRHO(LSTART)                                               19273115
     PRESS(1) = TPRESS(LSTART)                                           19273116
     XV(1) = TXV(LSTART)                                                 19273117
     S(1) = TS(LSTART)                                                   19273118
     X3 = Z(1)                                                           19273119
     Y3 = R(1)                                                           19273120
     NSP = -NSP                                                          19273121
     LSTART = -LSTART                                                    19273122
     GO TO 802                                                           19273123
 310 IF (K-1) 811, 800, 811                                              19273124
 811 IF (K-11) 503, 503, 39                                              19273125
 503 DRN = DRNT*(2.0**(K-2))                                             19273126
     DXN = DXNT*(2.0**(K-2))                                             19273127
  39 X3 = Z(1)+DXN                                                       19273128
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```
      Y3 = R(1)-DRN                                                     19273129
      IF(JERK) 802,21,802                                               19273130
  800 DELR = 1.0/SPTS                                                   19273131
      Y1 = 1.0-FACT*DELR                                                19273132
      X1 = 0.0                                                          19273133
      Y2 = 1.0                                                          19273134
      X2 = 0.0                                                          19273135
      CALL INTER(EPS1,A1,A2,Y1,Y2,Y1,Y2,X3,Y3)                          19273136
      DXN = X3-Z(1)                                                     19273137
      DRN = R(1)-Y3                                                     19273138
      DXNT = DXN                                                        19273139
      DRNT = DRN                                                        19273140
   21 IF (MM-2) 4323, 801, 801                                          19273141
 4323 IF (Y3-0.01) 816, 816, 802                                        19273142
  801 IF (MM-2) 814, 812, 814                                           19273143
  812 KSAV = K                                                          19273144
      K = 2                                                             19273145
  814 IF (K-2) 802, 803, 803                                            19273146
  803 BETO = ASINF(1.0/XMNO)                                            19273147
      TMB9 = THETO-BETO                                                 19273148
      CALL INTER(EPS1,ALPH1,TMB9,X4,Z9,Y4,R9,Z15,R15)                   19273149
      IF (K-2) 804, 805, 804                                            19273150
  805 IF (ALPH1-0.873) 610, 611, 611                                    19273151
  611 DR5 = (1.0-R(1)-((R15-1.0)*(1.0-R(1)))/(Y4-1.0))*RY               19273152
      DX5 = DR5/TA2                                                     19273153
      TY1 = R(1)                                                        19273154
      TX1 = Z(1)                                                        19273155
      GO TO 813                                                         19273156
  610 DX5 = (0.8*(Z15-X4)*Z(1))/X4                                      19273157
      DR5 = DX5*TA2                                                     19273158
      TX1 = Z(1)                                                        19273159
      TY1 = R(1)                                                        19273160
  813 IF (DRN-ABSF(DR5)) 806, 806, 807                                  19273161
  806 X3 = Z(1)+DXN                                                     19273162
      Y3 = R(1)-DRN                                                     19273163
      DX5 = DXN                                                         19273164
      DR5 = DRN                                                         19273165
      GO TO 808                                                         19273166
  807 X3 = Z(1)+DX5                                                     19273167
      Y3 = R(1)+DR5                                                     19273168
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```
808 IF (Y3-0.01) 816, 816, 802
809 I = 1
    J = 2
    TX4 = X4
    TY4 = Y4
    IF (K-2) 60, 810, 60
810 X50 = 0.0
    X60 = 0.0
    K = KSAV
    GO TO 60
804 IF (ALPH1-0.873) 612, 612, 613
613 PY = 0.75*((1.0-R(1))*(TY4-1.0))/((Y4-1.0)*(1.0-TY1))
    X50 = TX1
    X60 = TX4
    GO TO 611
612 PX = (DX5*(TX4-X60))/((X4-TX4)*(TX1-X50))
    X50 = TX1
    X60 = TX4
    DX5 = (0.9*PX*(Z15-X4)*(Z(1)-X50))/(X4-X60)
    DR5 = DX5*TA2
    TX1 = Z(1)
    TY1 = R(1)
    GO TO 813
816 JP = K
    GO TO 1400
802 I = 1
    J = 2
 60 Z(I) = X3
    R(I) = Y3
  9 THET1 = THET(I)
    S1 = S(I)
    V1 = XV(I)
    STEST = THET(I)+ASINF(1.0/XMN(I))
 22 THET2 = THET(J)
    V2 = XV(J)
    S2 = S(J)
    R2 = R(J)
    Z2 = Z(J)
    IF (NSP) 331, 332, 332
331 CALL PTETAX(EQUSAV,EQUST,X3,V1,S1,THET2,R2,Z2,V2,S2,HTJ,NITER,
```

```
     1EPS1,EPS3,EPS4,EPS5,Z3,R3,S3,V3,THET3)
      NSP = -NSP
      GO TO 24
  332 IF (KEY(J)-3) 52, 51, 52
   52 CALL INTRPT (EQUSAV,EQUST,THET1,Y3,X3,V1,S1,THET2,R2,Z2,V2,S2,HTJ,
     XNITER,EPS1,EPS2,EPS3,EPS4,EPS5,Z3,R3,S3,V3,THET3)
      D23 = SQRTF((Z3-Z2)**2+(R3-R2)**2)
      IF (MM-2) 713, 714, 714
  713 DLIM = SDLIM
      GO TO 715
  714 DLIM = SDLIM+SPTRC*SQRTF(R3**2+Z3**2)
  715 IF (D23-DLIM) 701, 700, 700
  700 IF (KEY(J)-13) 3005, 24, 3005
 3005 IF (NN) 24, 3011, 24
 3011 LPR = LPR+1
      IKEEP(LPR) = I
      JKEEP(LPR) = J
      NNSAV(LPR) = NN
      KKKSAV(LPR) = KKK
      P = 2.0
      R3 = R2+0.5*(R3-R2)
      Z3 = Z2+0.5*(Z3-Z2)
      S3 = S2+0.5*(S3-S2)
      V3 = V2+0.5*(V3-V2)
      THET3 = THET2+0.5*(THET3-THET2)
      GO TO 24
  701 IF(ABSF(STEST)-3.14159)90,123,123
  123 IF(ABSF(Z3)-ABSF(X3))23,23,24
   90 IF(R3-Y3) 23,24,24
   23 IF (MM-2) 169, 170, 170
  170 IF (KEY(I)-3) 2222, 3333, 2222
 2222 IF (KEY(I-1)-3) 4444, 3333, 4444
 3333 KEY(I) = 1
      J = J+1
      GO TO 22
 4444 KEY(I) = 13
      TXD = Z(I)
      JERK = 1
      ISTP = 1
      GO TO 37
```

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```
  169 KEY(I) = 3                                                    19273249
      X4 = X3                                                       19273250
      Y4 = Y3                                                       19273251
      XM = XMN(I)                                                   19273252
      BET1 = ASINF(1.0/XM)                                          19273253
      ALPH1 = THET(I)-BET1                                          19273254
      IF (KEY(J)-4) 62, 63, 62                                      19273255
   63 J = J-NN                                                      19273256
      KEY(J) = 4                                                    19273257
      IF (NN-1) 66, 666, 66                                         19273258
  666 JJ = INSERT                                                   19273259
      GO TO 66                                                      19273260
   62 NN = NN+1                                                     19273261
      MM = 1                                                        19273262
      J = J+1                                                       19273263
      GO TO 22                                                      19273264
   24 H3 = HTJ-0.5*(V3**2)                                          19273265
      CALL EQUSAV (H3,S3,AV3)                                       19273266
      CALL EQUSP (H3,S3,P3)                                         19273267
      CALL EQUSRO (H3,S3,RO3)                                       19273268
      IF (NN) 25, 26, 25                                            19273269
   25 J = J-NN                                                      19273270
   26 IF (KKK) 401, 400, 401                                        19273271
  401 R(I+1) = R3                                                   19273272
      Z(I+1) = Z3                                                   19273273
      XMN(I+1) = V3/AV3                                             19273274
      THET(I+1) = THET3                                             19273275
      RHO(I+1) = RO3                                                19273276
      PRESS(I+1) = P3                                               19273277
      S(I+1) = S3                                                   19273278
      XV(I+1) = V3                                                  19273279
      X3 = Z3                                                       19273280
      Y3 = R3                                                       19273281
      IF (KEY(J)-4) 402, 403, 403                                   19273282
  402 KEY(I+1) = KEY(J)                                             19273283
      I = I+1                                                       19273284
      J = J+1                                                       19273285
      IF (KEY(I-1)-3) 9, 3009, 9                                    19273286
 3009 IF (Z(I-1)-XDLM) 9, 3010, 3010                                19273287
 3010 ITES = 1                                                      19273288
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```
      KEY(I) = 13                                                       19273289
      TXD = Z(I-1)                                                      19273290
      JERK = 1                                                          19273291
      ISTP = 1                                                          19273292
      GO TO 37                                                          19273293
  403 KEY(I+1) = 2                                                      19273294
      I = I+1                                                           19273295
      J = J+1                                                           19273296
      KEY(I+1) = 4                                                      19273297
      GO TO 10                                                          19273298
  400 R(J) = R3                                                         19273299
      Z(J) = Z3                                                         19273300
      XMN(J) = V3/AV3                                                   19273301
      THET(J) = THET3                                                   19273302
      RHO(J) = RO3                                                      19273303
      PRESS(J) = P3                                                     19273304
      S(J) = S3                                                         19273305
      XV(J) = V3                                                        19273306
      X3 = Z3                                                           19273307
      Y3 = R3                                                           19273308
      IF (JERK) 830, 831, 830                                           19273309
  830 IF (Z3-TXD) 831, 832, 832                                         19273310
  832 KEY(J) = 13                                                       19273311
      ISTP = 0                                                          19273312
      GO TO 37                                                          19273313
  831 IF (NN-1) 28, 27, 777                                             19273314
  777 J = J+NN                                                          19273315
      IF (KEY(J)-4) 778, 779, 1313                                      19273316
  778 J = J-NN                                                          19273317
      KEY(J) = 2                                                        19273318
      I = I+1                                                           19273319
      J = J+NN+1                                                        19273320
      GO TO 9                                                           19273321
  779 J = J-NN                                                          19273322
      KEY(J) = 2                                                        19273323
      I = I+1                                                           19273324
      J = J+1                                                           19273325
      KEY(J) = 4                                                        19273326
      GO TO 10                                                          19273327
   27 IF (KEY(J+1)-4) 29, 35, 5000                                      19273328
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```
5000 KEY(J) = KEY(J+1)                                                  19273329
     GO TO 37                                                           19273330
  29 KEY(J) = KEY(J+1)                                                  19273331
     I = I+1                                                            19273332
     J = J+2                                                            19273333
     GO TO 9                                                            19273334
  35 KEY(J) = 2                                                         19273335
     I = I+1                                                            19273336
     J = J+1                                                            19273337
     JJ = INSERT                                                        19273338
     INSERT = 0                                                         19273339
     GO TO 10                                                           19273340
  28 IF (INSERT) 31, 30, 31                                             19273341
  30 KEY(J) = KEY(I)                                                    19273342
     I = I+1                                                            19273343
     J = J+1                                                            19273344
     IF (KEY(J)-4) 9, 10, 10                                            19273345
  31 IF (KEY(J)-4) 32, 33, 37                                           19273346
  32 KEY(J) = KEY(I)                                                    19273347
     I = I+1                                                            19273348
     J = J+1                                                            19273349
     GO TO 9                                                            19273350
  33 KEY(J) = KEY(I)                                                    19273351
     I = I+1                                                            19273352
     J = J+1                                                            19273353
     KEY(J) = 4                                                         19273354
  10 THET1 = THET(I)                                                    19273355
     Y3 = R(I)                                                          19273356
     X3 = Z(I)                                                          19273357
     V1 = XV(I)                                                         19273358
     S1 = S(I)                                                          19273359
     IF (INSERT) 66, 68, 66                                             19273360
  68 THET2 = THET(J)                                                    19273361
     R2 = R(J)                                                          19273362
     Z2 = Z(J)                                                          19273363
     V2 = XV(J)                                                         19273364
     S2 = S(J)                                                          19273365
  66 CALL PAMBPT(EQUSAV,EQUST,THET1,Y3,X3,V1,S1,THET2,R2,Z2,V2,S2,HTJ,  19273366
    1INITER,EPS1,EPS2,EPS3,EPS5,Z3,R3,S3,V3,THET3,P3,BB,CC)             19273367
     IF (P3) 662, 661, 662                                              19273368
```

```
  661 IP3 = 1                                                          19273369
  662 CONTINUE                                                         19273370
      H3 = HTJ-0.5*(V3**2)                                             19273371
      CALL EQUSAV(H3,S3,AV3)                                           19273372
      CALL EQUSRO(H3,S3,RO3)                                           19273373
      XMN9 = V3/AV3                                                    19273374
      THET9 = THET3                                                    19273375
      IF(P3-288.0)7777,7777,8888                                       19273376
 7777 IP3=1                                                            19273377
 8888 Z9=Z3                                                            19273378
      R9 = R3                                                          19273379
      IF (KKK) 404, 405, 404                                           19273380
  404 I = I+1                                                          19273381
      R(I) = R3                                                        19273382
      Z(I) = Z3                                                        19273383
      XMN(I) = V3/AV3                                                  19273384
      THET(I) = THET3                                                  19273385
      RHO(I) = RO3                                                     19273386
      PRESS(I) = P3                                                    19273387
      S(I) = S3                                                        19273388
      XV(I) = V3                                                       19273389
      GO TO 37                                                         19273390
  405 R(J) = R3                                                        19273391
      Z(J) = Z3                                                        19273392
      XMN(J) = V3/AV3                                                  19273393
      THET(J) = THET3                                                  19273394
      RHO(J) = RO3                                                     19273395
      PRESS(J) = P3                                                    19273396
      S(J) = S3                                                        19273397
      XV(J) = V3                                                       19273398
      IF (NN-1) 1120, 1119, 1120                                       19273399
 1119 INSERT = JJ                                                      19273400
 1120 IF (MM) 37, 36, 37                                               19273401
   38 K = K+1                                                          19273402
      INSERT = INSERT+1                                                19273403
  504 IF (K-JP) 20, 1400, 1400                                         19273404
   51 IF (ISTP) 4000, 550, 4000                                        19273405
 4000 KEY(I) = 13                                                      19273406
      ISTP = 0                                                         19273407
      GO TO 37                                                         19273408
```

```
550 X3 = Z(I)
    Y3 = R(I)
    THET1 = THET(I)
    S1 = S(I)
    V1 = XV(I)
    P1 = PRESS(I)
    RO1 = RHO(I)
    XM1 = XMN(I)
    IF (KK) 80, 88, 80
 88 R2 = R(J)
    Z2 = Z(J)
    THET2 = THET(J)
    V2 = XV(J)
    S2 = S(J)
    P2 = PRESS(J)
    RO2 = RHO(J)
    XM2 = XMN(J)
 56 IF (MM-2) 71, 71, 55
 71 IF(KEY(J+1)-4) 55, 46, 55
 46 J = J-1
    ALPH1 = ALPH1-1.74533E-3
 55 X12 = Z(J+1)
    Y12 = R(J+1)
    V12 = XV(J+1)
    X12MN = XMN(J+1)
    S12 = S(J+1)
    THET12 = THET(J+1)
    P12 = PRESS(J+1)
    RO12 = RHO(J+1)
    X13 = Z(J+2)
    Y13 = R(J+2)
    V13 = XV(J+2)
    X13MN = XMN(J+2)
    S13 = S(J+2)
    P13 = PRESS(J+2)
    RO13 = RHO(J+2)
    THET13 = THET(J+2)
 80 CALL INSHPT(EQUSAV,EQUST,EQUSS,EQUSP,EQUSRO,Z2,R2,V2,XM2,
   1S2,THET2,P2,RO2,ALPH1,X3,Y3,V1,XM1,S1,THET1,P1,RO1,X12,Y12,
   2V12,X12MN,S12,THET12,P12,RO12,X13,Y13,V13,X13MN,S13,THET13,
```

```
     3P13,RO13,HTJ,NITER,EPS1,EPS2,EPS3,EPS4,EPS5,ERR2,                19273449
     4X4,Y4,V4,X4MN,S4,THET4,P4,RO4,ALPH4,X11,Y11,V11,X11MN,           19273450
     5S11, THET11, P11, RO11, LG, LB, GAMJ, INDINS)                    19273451
      IF (INDINS) 1313, 10000, 1313                                    19273451
10009 IF (LG) 40, 41, 41                                               19703452
   40 IF (KEY(J+2)-4) 6, 41, 6                                         19273453
    6 J = J+1                                                          19273454
      GO TO 56                                                         19273455
   41 IF (LB) 42, 44, 44                                               19273456
   42 I = I-1                                                          19273457
      IF (I-1) 1313, 1313, 4322                                        19273458
 4322 KK = 1                                                           19273459
      IF (LPR) 716, 550, 716                                           19273460
  716 IF (I-IKEEP(LPR)) 717, 717, 550                                  19273461
  717 LPR = LPR-1                                                      19273462
      LPRC = LPRC+1                                                    19273463
      GO TO 550                                                        19273464
   44 IF (GAMJ) 64, 65, 55                                             19273465
   64 GAMJ = -GAMJ                                                     19273466
      J = J-LG                                                         19273467
      I = I+LB                                                         19273468
      LPR = LPR+LPRC                                                   19273469
      LPRC = 0                                                         19273470
      KK = 0                                                           19273471
      GO TO 550                                                        19273472
   65 LPRC = 0                                                         19273473
      ALPH1 = ALPH4                                                    19273474
      Z(I+1) = X4                                                      19273475
      R(I+1) = Y4                                                      19273476
      XV(I+1) = V4                                                     19273477
      XMN(I+1) = X4MN                                                  19273478
      S(I+1) = S4                                                      19273479
      THET(I+1) = THET4                                                19273480
      PRESS(I+1) = P4                                                  19273481
      RHO(I+1) = RO4                                                   19273482
      KEY(I+1) = 3                                                     19273483
      Z(I+2) = X11                                                     19273484
      R(I+2) = Y11                                                     19273485
      XV(I+2) = V11                                                    19273486
      XMN(I+2) = X11MN                                                 19273487
```

```
      S(I+2) = S11
      THET(I+2) = THET11
      PRESS(I+2) = P11
      RHO(I+2) = RO11
      KEY(I+2) = 3
      I = I+2
      J = J+2
      NLPR = 0
      NN = 0
      KK = 0
      KKK = 1
      X3 = Z(I)
      Y3 = R(I)
      IF (I-J) 48, 49, 48
   49 J = J+1
      KEY(J) = 4
      THET(J) = THET13
      XV(J) = V13
      S(J) = S13
      R(J) = Y13
      Z(J) = X13
   48 IF (I-3) 37, 37, 9
   36 IF (LPR) 702, 703, 702
  702 WRITE OUTPUT TAPE 6, 704
  704 FORMAT(37H0VALUES ALONG INSERTED CHARACTERISTIC)
      IC = JKEEP(LPR)
      DO 903 L=IC, J
      T(L) = (PRESS(L))/(RHO(L)*RGCJ*32.174)
      Z(L) = Z(L)*RN
      R(L) = R(L)*RN
  903 THET(L) = THET(L)*57.29578
      WRITE OUTPUT TAPE 6, 705, (K,KEY(I),Z(I),R(I),XMN(I),THET(I),
     1RHO(I),PRESS(I),T(I),I=J ,J)
  705 FORMAT(119H0IDENT.        X                 Y          MACH NO.
     1THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE/(
     21H I4,2H  I1,1H E12.5,2H  E12.5,2H  E12.5,2H  E12.5,2H  E12.5,2H
     3E12.5,2H  E12.5))
      DO 904 L=IC, J
      Z(L) = Z(L)/RN
      R(L) = R(L)/RN
```

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```
  904 THET(L) = THET(L)/57.29578
      VVV = XV(J)
      WRITE OUTPUT TAPE 6, 7006, VVV
      IF (NPORA) 19041, 19042, 19041
19041 WRITE OUTPUT TAPE 6, 7602, ASEC, XMSEC
      IF (ASEC/ASSEC-0.9) 10007, 10007, 19042
19042 CONTINUE
      I = IKEEP(LPR)
      J = JKEEP(LPR)
      LPR = LPR-1
      X3 = Z(I)
      Y3 = R(I)
      INSERT = INSERT+1
      IF(IP3)1313,9,1313
  703 DO 905 L=1, J
      T(L) = (PRESS(L))/(RHO(L)*RGCJ*32.174)
      Z(L) = Z(L)*RN
      R(L) = R(L)*RN
  905 THET(L) = THET(L)*57.29578
      WRITE OUTPUT TAPE 6, 200, (K,KEY(I),Z(I),R(I),XMN(I),THET(I),
     1RHO(I),PRESS(I),T(I),I=J,J)
  200 FORMAT(119H0IDENT.        X                Y          MACH NO.
     1THETA         DENSITY       PRESSURE      TEMPERATURE   SHOCK ANGLE/(
     21H I4,2H  I1,1H E12.5,2H  E12.5,2H  E12.5,2H  E12.5,2H  E12.5,2H
     3E12.5,2H  E12.5))
      DO 906 L=1, J
      Z(L) = Z(L)/RN
      R(L) = R(L)/RN
  906 THET(L) = THET(L)/57.29578
      VVV = XV(J)
      WRITE OUTPUT TAPE 6, 7006, VVV
      IF (NPORA) 19061, 19062, 19061
19061 WRITE OUTPUT TAPE 6, 7602, ASEC, XMSEC
      IF (ASEC/ASSEC-0.9) 10007, 10007, 19062
19062 CONTINUE
      NN = 0
      K = K+1
      INSERT = INSERT+1
      I = J
      IF(IP3)1313,718,1313
```

```
   37 IF (LPR) 706, 707, 706
  706 WRITE OUTPUT TAPE 6, 704
      WRITE OUTPUT TAPE 6, 708
  708 FORMAT(119H0IDENT.        X                 Y          MACH NO.
     1THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE)
      I = JKEEP(LPR)
      GO TO 214
  707 WRITE OUTPUT TAPE 6, 202
  202 FORMAT(119H0IDENT.        X                 Y          MACH NO.
     1THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE)
      I = 1
  214 KY = KEY(I)
      RR = R(I)*RN
      ZZ = Z(I)*RN
      XXMN = XMN(I)
      TTH = THET(I)*57.29578
      RH = RHO(I)
      PR = PRESS(I)
      SS = (PRESS(I))/(RHO(I)*RGCJ*32.174)
      IF (KY-3) 213, 204, 203
  203 WRITE OUTPUT TAPE 6, 210, K, KY, ZZ, RR, XXMN, TTH, RH, PR, SS
  210 FORMAT(1H I4,2H  I1,1H E12.5,2H  E12.5,2H  E12.5,2H  E12.5,2H  E12
     1.5,2H  E12.5,2H  E12.5)
      GO TO 213
  204 ALPH1 = ALPH1*57.29578
      WRITE OUTPUT TAPE 6, 211, K, KY, ZZ, RR, XXMN, TTH, RH, PR, SS,
     1ALPH1
  211 FORMAT(1H I4,2H  I1,1H E12.5,2H  E12.5,2H  E12.5,2H  E12.5,2H  E12
     1.5,2H  E12.5,2H  E12.5,2H  E12.5)
      ALPH1 = ALPH1/57.29578
  351 IF(I-3) 213, 1313, 213
  213 IF (KY-4) 215, 2131, 215
 2131 VVV = XV(I)
      WRITE OUTPUT TAPE 6, 7006, VVV
      IF (NPORA) 2132, 205, 2132
 2132 WRITE OUTPUT TAPE 6, 7602, ASEC, XMSEC
      IF (ASEC/ASSEC-0.9) 10007, 10007, 205
  215 IF (KY-13) 3002, 3000, 3002
 3002 I = I+1
      GO TO 214
```

```
 3000 IF (ISTP) 3006, 205, 3006
 3006 IF (ITFS) 3007, 3003, 3007
 3007 ITFS = 0
      WRITE OUTPUT TAPE 6, 3008
 3008 FORMAT(94H0PLUME FLOW FIELD VERY LARGE THEREFORE PLUME WILL BE DET
     1ERMINED ONLY UP TO Z OF ASTERISK POINT)
      GO TO 205
 3003 WRITE OUTPUT TAPE 6, 3001
 3001 FORMAT(55H0INTERIOR SHOCK IS NOW GOING NORMAL TO AXIS OF SYMMETRY)
 205  IF(IP3)1313,20005,1313
20005 IF(LPR)711,712,711
  711 I = IKEEP(LPR)
      J = JKEEP(LPR)
      NN = NNSAV(LPR)
      KKK = KKKSAV(LPR)
      LPR = LPR-1
      X3 = Z(I)
      Y3 = R(I)
      INSERT = INSERT+1
      GO TO 9
  712 NN = 0
      KKK = 0
   95 MM = MM+1
  718 IF (LSTART) 330, 325, 326
  330 J = I-1
      DO 329 I=1, J
      Z(I) = Z(I+1)
      R(I) = R(I+1)
      XV(I) = XV(I+1)
      S(I) = S(I+1)
      XMN(I) = XMN(I+1)
      RHO(I) = RHO(I+1)
      PRESS(I) = PRESS(I+1)
      THET(I) = THET(I+1)
  329 KEY(I) = KEY(I+1)
      LSTART = 0
      JP = K+1
      IF (MM) 38, 334, 38
  334 JP = K
      GO TO 504
```

```
326 J = I+I                                                          19273648
    GO TO 719                                                        19273649
325 J = I+I-1                                                        19273650
719 Z(J) = Z(I)                                                      19273651
    R(J) = R(I)                                                      19273652
    XV(J) = XV(I)                                                    19273653
    S(J) = S(I)                                                      19273654
    XMN(J) = XMN(I)                                                  19273655
    RHO(J) = RHO(I)                                                  19273656
    PRESS(J) = PRESS(I)                                              19273657
    THET(J) = THET(I)                                                19273658
    KEY(J) = KEY(I)                                                  19273659
    I = I-1                                                          19273660
    J = J-2                                                          19273661
    IF (I) 719, 726, 719                                             19273662
726 IF (LSTART) 327, 327, 328                                        19273663
327 J = 3                                                            19273664
    I = 1                                                            19273665
    GO TO 720                                                        19273666
328 J = 4                                                            19273667
    I = 2                                                            19273668
720 SP23 = SQRTF((Z(J)-Z(I))**2+(R(J)-R(I))**2)                      19273669
    SPLIM = 0.75+SPTLC*SQRTF(R(I)**2+Z(I)**2)                        19273670
    IF (SP23-SPLIM) 721, 723, 723                                    19273671
721 I = I+1                                                          19273672
    Z(I) = Z(J)                                                      19273673
    R(I) = R(J)                                                      19273674
    XV(I) = XV(J)                                                    19273675
    S(I) = S(J)                                                      19273676
    XMN(I) = XMN(J)                                                  19273677
    RHO(I) = RHO(J)                                                  19273678
    PRESS(I) = PRESS(J)                                              19273679
    THET(I) = THET(J)                                                19273680
    KEY(I) = KEY(J)                                                  19273681
    IF(KEY(I)-4) 722, 725, 725                                       19273682
722 J = J+2                                                          19273683
    GO TO 720                                                        19273684
723 I = I+1                                                          19273685
    Z(I) = Z(I-1)+0.5*(Z(J)-Z(I-1))                                  19273686
    R(I) = R(I-1)+0.5*(R(J)-R(I-1))                                  19273687
```

```
      XV(I) = XV(I-1)+0.5*(XV(J)-XV(I-1))
      S(I) = S(I-1)+0.5*(S(J)-S(I-1))
      XMN(I) = XMN(I-1)+0.5*(XMN(J)-XMN(I-1))
      RHO(I) = RHO(I-1)+0.5*(RHO(J)-RHO(I-1))
      PRESS(I) = PRESS(I-1)+0.5*(PRESS(J)-PRESS(I-1))
      THET(I) = THET(I-1)+0.5*(THET(J)-THET(I-1))
      KEY(I) = 2
      GO TO 721
  725 IF (MM) 38, 504, 38
 1400 I = 1
      J = 2
      IF (K-JP) 1313, 1500, 1502
 1502 THET2 = THET(J)
      R2 = R(J)
      Z2 = Z(J)
      V2 = XV(J)
      S2 = S(J)
      IF (IX-1) 1503, 1503, 1601
 1500 THET2 = THET(I)
      R2 = R(I)
      Z2 = Z(I)
      V2 = XV(I)
      S2 = S(I)
      JIK = 0
      IX = 0
      KIJ  =1
 1503 CALL PTOTAX(EQUSAV,EQUST,SJ,THET2,R2,Z2,V2,S2,HTJ,NITER,EPS1,EPS3,
     1EPS4,Z3,R3,S3,V3,THET3)
      IF (KEY(J)-13) 6000, 1402, 6000
 6000 IF (K-JP) 1313, 1402, 1600
 1600 IF (JIK) 1603, 1602, 1603
 1603 IF (IX-1) 1313, 1700, 1402
 1602 H3 = HTJ-0.5*(V3**2)
      CALL EQUSAV(H3,S3,AV3)
      DELZ = 57.29578*(ASINF(1.0/XMN(1))-ASINF(AV3/V3))
      IX = DELZ+1.0
      IF (IX-1) 1700, 1700, 1601
 1601 QF = IX
      YF = 1.0/QF
      THET2 = THET(I)+(THET2-THET(I))*YF
```

```
      R2 = R(I)+(R2-R(I))*YF
      Z2 = Z(I)+(Z2-Z(I))*YF
      V2 = XV(I)+(V2-XV(I))*YF
      S2 = S(I)+(S2-S(I))*YF
      JIK = 1
      KIJ = 1
      GO TO 1503
 1700 KIJ = 0
      JIK = 0
      IF (Z3-TXD) 1402, 1402, 1313
 1402 H3 = HTJ-0.5*(V3**2)
      CALL EQUSAV(H3,S3,AV3)
      CALL EQUSP(H3,S3,P3)
      CALL EQUSRO(H3,S3,RO3)
      R(I) = R3
      Z(I) = Z3
      XMN(I) = V3/AV3
      THET(I) = THET3
      RHO(I) = RO3
      PRESS(I) = P3
      S(I) = S3
      XV(I) = V3
      IF (KEY(J)-13) 6002, 6001, 6002
 6001 KEY(I) = 13
      SS=(PRESS(1))/(RHO(1)*RGCJ*32.2)
      THET(1) = THET(1)*57.29578
      Z(1) = Z(1)*RN
      R(1) = R(1)*RN
      WRITE OUTPUT TAPE 6, 6005, (K,KEY(1),Z(1),R(1),XMN(1),THET(1),
     1RHO(1),PRESS(1),SS)
 6005 FORMAT(119H0IDENT.        X                 Y          MACH NO.
     1THETA          DENSITY       PRESSURE      TEMPERATURE    SHOCK ANGLE/(
     21H I4,2H  I1,1H E12.5,2H  E12.5,2H  E12.5,2H  E12.5,2H  E12.5,2H
     3E12.5),2H  E12.5)
      THET(1) = THET(1)/57.29578
      Z(1) = Z(1)/RN
      R(1) = R(1)/RN
      GO TO 1313
 6002 KEY(I) = 0
      X1 = Z3
```

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```
      V1 = V3                                                           19273768
      S1 = S3                                                           19273769
      IF (KIJ) 1504, 1505, 1504                                         19273770
 1505 J = J+1                                                           19273771
 1504 THET2 = THET(J)                                                   19273772
      V2 = XV(J)                                                        19273773
      S2 = S(J)                                                         19273774
      R2 = R(J)                                                         19273775
      Z2 = Z(J)                                                         19273776
      CALL PTFTAX(EQUSAV,EQUST,X1,V1,S1,THET2,R2,Z2,V2,S2,HTJ,NITER,    19273777
     1EPS1,EPS3,EPS4,EPS5,Z3,R3,S3,V3,THET3)                            19273778
      H3 = HTJ-0.5*(V3**2)                                              19273779
      CALL EQUSAV(H3,S3,AV3)                                            19273780
      CALL EQUSP(H3,S3,P3)                                              19273781
      CALL EQUSRO(H3,S3,RO3)                                            19273782
      IF (KIJ) 1506, 1507, 1506                                         19273783
 1507 J = J-1                                                           19273784
 1506 R(J) = R3                                                         19273785
      Z(J) = Z3                                                         19273786
      XMN(J) = V3/AV3                                                   19273787
      THET(J) = THET3                                                   19273788
      RHO(J) = RO3                                                      19273789
      PRESS(J) = P3                                                     19273790
      S(J) = S3                                                         19273791
      XV(J) = V3                                                        19273792
      KEY(J) = 2                                                        19273793
      X3 = Z3                                                           19273794
      Y3 = R3                                                           19273795
      I = I+1                                                           19273796
      IF (KIJ) 1508, 1509, 1508                                         19273797
 1509 J = J+2                                                           19273798
      NN = 1                                                            19273799
      IX = 0                                                            19273800
      GO TO 9                                                           19273801
 1508 J = J+1                                                           19273802
      IX = IX-1                                                         19273803
      GO TO 9                                                           19273804
10006 FORMAT(30H0A CRITICALLY LESS THAN A STAR)                         19273805
10007 WRITE OUTPUT TAPE 6, 10006                                        19273806
 1313 WRITE OUTPUT TAPE 6, 11                                           19273807
```

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```
11 FORMAT(33H0END OF COMPUTATION FOR THIS CASE)                19273808
   IF (NITER) 12, 13, 12                                       19273809
13 CALL EXIT                                                   19273810
   END                                                         19273811
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
16550	40246	32441	77271

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ASEC	32446	77276	ASSEC	32444	77274	BB	32546	77442	CPH	32442	77272	CP	32556	77454
GAMMA	32557	77455	GSEC	32549	77445	INDP	32554	77452	ISTS	32443	77273	NPORA	32555	77453
NPP	32553	77451	PT	32561	77461	PTSEC	32551	77447	RHOT	32560	77460	RN	32547	77443
RSEC	32548	77444	ST	32558	77456	TT	32559	77457	TTSEC	32550	77446	WSEC	32552	77450
XMSEC	32445	77275												

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
IKEEP	7549	16575	JKEEP	6399	14377	KEY	8549	20545	KKKSAV	7449	16431	NNSAV	7499	16513
PRESS	11549	26435	RHO	12549	30405	R	16549	40245	S	9549	22515	THET	13549	32355
TITLE	4749	11215	TPRESS	5349	12345	TRHO	5549	12655	TR	6349	14315	T	7399	16347
TS	4949	11525	TTHET	5749	13165	TXMN	5949	13475	TXV	5149	12035	TZ	6149	14005
XMN	14549	34325	XV	10549	24465	Z	15549	36275						

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A1	4737	11201	A2	4736	11200	ALPH1	4735	11177	ALPH4	4734	11176	ALT	4733	11175
A	4732	11174	AV3	4731	11173	BET1	4730	11172	BET9	4729	11171	BETAX	4728	11170
CC	4727	11167	F23	4726	11166	DBFL	4725	11165	DELR	4724	11164	DELTA	4723	11163
DELTHE	4722	11162	DEL7	4721	11161	DLIM	4720	11160	DR5	4719	11157	DRNDLR	4718	11156
DRN	4717	11155	DRNT	4716	11154	DRNTT	4715	11153	DX5	4714	11152	DXN	4713	11151
DXNT	4712	11150	EPS1	4711	11147	EPS2	4710	11146	EPS3	4709	11145	EPS4	4708	11144
EPS5	4707	11143	EPSLON	4706	11142	ERR1	4705	11141	ERR2	4704	11140	ERR3	4703	11137
FACT	4702	11136	GAM1	4701	11135	GMN	4700	11134	H3	4699	11133	HJS	4698	11132
HTJ	4697	11131	IC	4696	11130	ILL	4695	11127	INDINS	4694	11126	INSERT	4693	11125
IP3	4692	11124	I	4691	11123	ISTP	4690	11122	ITFS	4689	11121	IX	4688	11120
JFPK	4687	11117	JIK	4686	11116	JJ	4685	11115	JP	4684	11114	J	4683	11113
KIJ	4682	11112	KKK	4681	11111	KK	4680	11110	K	4679	11107	KSAV	4678	11106
KY	4677	11105	LD	4676	11104	LG	4675	11103	LPRC	4674	11102	LPR	4673	11101
LSTART	4672	11100	LST	4671	11077	MM	4670	11076	M	4669	11075	NDD	4668	11074
NDXP	4667	11073	NITER	4666	11072	NLPR	4665	11071	NN	4664	11070	N	4663	11067
NSP	4662	11066	P11	4661	11065	P12	4660	11064	P13	4659	11063	P1	4658	11062
P2	4657	11061	P3	4656	11060	P4	4655	11057	PAMB	4654	11056	PJ	4653	11055
PR	4652	11054	P	4651	11053	PX	4650	11052	PY	4649	11051	QF	4648	11050
P15	4647	11047	R2	4646	11046	R3	4645	11045	R9	4644	11044	RGCJ	4643	11043
RHOJ	4642	11042	RH	4641	11041	RO11	4640	11040	RO12	4639	11037	RO13	4638	11036
RO1	4637	11035	RO2	4636	11034	RO3	4635	11033	RO4	4634	11032	RR	4633	11031
S11	4632	11030	S12	4631	11027	S13	4630	11026	S1	4629	11025	S2	4628	11024
S3	4627	11023	S4	4626	11022	SDLIM	4625	11021	SJ	4624	11020	SNDD	4623	11017
SP23	4622	11016	SPLIM	4621	11015	SPTLC	4620	11014	SPTRC	4619	11013	SPTS	4618	11012
SPTX	4617	11011	SS	4616	11010	STEST	4615	11007	TA2	4614	11006	TEMPJ	4613	11005
THET11	4612	11004	THET12	4611	11003	THET13	4610	11002	THET1	4609	11001	THET2	4608	11000
THET3	4607	10777	THET4	4606	10776	THET9	4605	10775	THETAJ	4604	10774	THETAX	4603	10773
TMB9	4602	10772	TTH	4601	10771	TX1	4600	10770	TX4	4599	10767	TXD	4598	10766

TY1	4597	10765	TY4	4596	10764	V11	4595	10763	V12	4594	10762	V13	4593	10761
V1	4592	10760	V2	4591	10757	V3	4590	10756	V4	4589	10755	VACMN	4588	10754
V	4587	10753	VVV	4586	10752	VXMN	4585	10751	VX	4584	10750	X11MN	4583	10747
X11	4582	10746	X12MN	4581	10745	X12	4580	10744	X13MN	4579	10743	X13	4578	10742
X1	4577	10741	X2	4576	10740	X3	4575	10737	X4MN	4574	10736	X4	4573	10735
X50	4572	10734	X60	4571	10733	XDLM	4570	10732	XM1	4569	10731	XM2	4568	10730
XMN9	4567	10727	XM	4566	10726	XXMN	4565	10725	Y11	4564	10724	Y12	4563	10723
Y13	4562	10722	Y1	4561	10721	Y2	4560	10720	Y3	4559	10717	Y4	4558	10716
YF	4557	10715	Z15	4556	10714	Z2	4555	10713	Z3	4554	10712	Z9	4553	10711

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
B17	7	10100	B1B	11	07455	B168	200	07734	B16A	202	07644	B16I	210	07617
B1CJ	211	07601	B19F	302	10251	B1M0	704	10006	B1M1	705	07777	B1M4	708	07671
B12TP	3001	07540	B12U0	3008	07561	B15RL	6005	07526	B16Q0	7000	10256	B16QP	7001	10155
B16QC	7002	10677	B16QR	7003	10137	B16QS	7004	10141	B16QT	7005	10135	B16QU	7006	10032
B17Q1	7602	10020	B17Q0	8000	10666	B17Q1	8001	10662	B17Q3	8003	10636	B17Q5	8005	10630
B17Q7	8007	10623	B17Q8	8008	10474	B17Q9	8009	10432	B17QB	8011	10325	B17QC	8012	10247
B17QD	8013	10176	B190G	10000	10671	B190H	10001	10670	B190M	10006	07463			

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	4539	10673	2)	3837	07375	3)	3848	07410	4)	32767	77777	6)	3873	07441
C1G0	4545	10701	C1G2	4546	10702	C1G3	4547	10703	C1G5	4548	10704	C1G6	4549	10705
C1G7	4550	10706	D111F	960	01700	D112P	1543	03007	D113G	1855	03477	D114A	2167	04167
D115U	2892	05514	D117J	3396	06504	D117A	3413	06525	D117K	3802	07332	D117L	3812	07344
D121U	1183	02237	D131F	959	01677	D132P	1542	03006	D1401	77	00115	D1420	1535	02777
D142P	1546	03012	D144J	2301	04375	D144K	2309	04405	D1461	2920	05550	D146H	3121	06061
D1471	3367	06447	D154J	2300	04374	D154K	2308	04404	D1571	3366	06446	D157K	3801	07331
D157L	3811	07343	D162G	1534	02776	D162P	1545	03011	D1661	2919	05547	D166H	3120	06060
D171E	958	01676	D172P	1541	03005	E13	155	00233	E17	219	00333	E1A	286	00436
E1N	531	01023	E1O	538	01032	E1Q	643	01203	E1S	711	01307	E1U	731	01333
E111	796	01434	E118	900	01604	E11D	925	01635	E11J	1050	02032	E11V	1213	02275
E12U	1662	03176	E131	1688	03230	E136	1763	03343	E139	1777	03361	E13C	1800	03410
E13H	1886	03536	E13O	1966	03656	E149	2155	04153	E14C	2206	04236	E14E	2241	04301
E14G	2271	04337	E14L	2315	04413	E16T	3265	06301	E170	3361	06441	E122N	1526	02766
E123G	1853	03475	E187L	3810	07342									

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ASIN	16	00020	DATE	11	00013	EQUSAV	4	00004	EQUSHP	6	00006	EQUSP	2	00002
EQUSRC	3	00003	EQUSS	1	00001	EQUST	5	00005	EXIT	28	00034	EXP(2	21	00025
EXP(3	20	00024	INSHPT	26	00032	INTER	22	00026	INTRPT	24	00030	PAMBPT	25	00031
PMXPAV	18	00022	PSEC	10	00012	PTFTAX	23	00027	PTOTAX	27	00033	SIN	19	00023
SQRT	14	00016	TAN	17	00021	(FIL)	13	00015	(FPT)	0	00000	(RTN)	9	00011
(SLI)	8	00010	(SLO)	15	00017	(STH)	12	00014	(TSH)	7	00007			

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

ASIN	DATE	EQUSAV	EQUSHP	EQUSP	EQUSRO	EQUSS	EQUST	EXIT	EXP(2
EXP(3	INSHPT	INTER	INTRPT	PAMBPT	PMXPAV	PSLC	PTETAX	PTOTAX	SIN
SQRT	TAN	(FIL)	(FPT)	(RTN)	(SLI)	(SLO)	(STH)	(TSH)	

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
12	63	00116	10002	71	00210	10003	73	00234	8002	89	00324	8004	91	00334
8006	92	00342	8010	97	00375	300	103	00437	303	122	00621	7999	133	00707
301	136	00726	10004	147	00776	10005	149	01025	10008	151	01033	304	169	01160
305	178	01204	600	186	01226	3	194	01301	603	196	01310	604	198	01316
900	201	01336	901	209	01365	306	222	01431	307	224	01437	308	225	01441
4	226	01444	5	234	01514	902	242	01561	7601	247	01605	7603	250	01630
7604	252	01636	20	267	01701	309	268	01703	312	269	01710	313	274	01725
315	276	01737	4325	287	02025	311	289	02033	4321	290	02040	316	292	02044
317	293	02062	319	294	02067	320	299	02125	321	300	02152	318	302	02202
322	304	02206	323	305	02211	324	306	02220	314	310	02240	310	323	02276
811	324	02301	503	325	02305	39	327	02341	800	330	02353	21	341	02421
4323	342	02425	801	343	02432	812	344	02437	814	346	02443	803	347	02450
805	352	02510	611	353	02515	610	358	02547	813	362	02567	806	363	02575
807	368	02610	808	370	02616	809	371	02623	810	376	02644	804	380	02653
613	381	02660	613	385	02707	816	393	02763	802	395	02767	60	397	03000
9	399	03013	22	403	03034	331	409	03051	332	413	03110	52	414	03113
713	418	03200	714	420	03203	715	421	03223	700	422	03232	3005	423	03235
3011	424	03241	701	436	03324	123	437	03332	90	438	03345	23	439	03351
170	440	03356	2222	441	03363	3333	442	03370	4444	445	03377	169	450	03411
63	457	03443	666	460	03457	62	462	03462	24	466	03500	25	474	03537
26	475	03544	401	476	03546	402	487	03577	3009	491	03620	3010	492	03625
403	498	03640	400	503	03660	830	514	03707	832	515	03714	831	518	03721
777	519	03726	779	521	03736	779	526	03760	27	532	04003	5000	533	04010
29	535	04013	35	539	04030	28	545	04051	30	546	04055	31	550	04076
32	551	04102	33	555	04117	10	559	04135	68	565	04154	66	570	04170
661	573	04233	662	574	04237	7777	583	04276	8888	584	04302	404	587	04310
405	597	04340	1119	606	04366	1120	607	04370	38	608	04376	504	610	04406
51	611	04415	4000	612	04417	550	615	04424	88	624	04450	56	632	04470
71	633	04474	46	634	04501	55	636	04511	80	652	04551	10009	655	04665
40	656	04670	6	657	04673	41	659	04701	42	660	04704	4322	662	04716
716	664	04722	717	665	04726	44	668	04737	64	669	04742	65	676	04770
49	705	05073	49	712	05114	36	713	05121	702	714	05123	903	720	05155
904	729	05232	19041	734	05255	19042	737	05300	703	745	05330	905	749	05351
906	758	05426	19061	763	05451	19062	766	05474	37	772	05515	706	773	05517
707	777	05535	214	779	05551	203	788	05607	204	791	05642	351	795	05704
213	796	05707	2131	797	05714	2132	801	05732	215	804	05755	3002	805	05760
3000	807	05766	3006	808	05770	3007	809	05772	3003	812	06003	205	813	06011
20005	814	06015	711	815	06017	712	824	06050	95	826	06054	718	827	06062
330	828	06065	329	838	06115	334	842	06134	326	844	06137	325	846	06144
719	847	06152	726	859	06210	327	860	06213	328	863	06223	720	865	06233
721	868	06302	722	879	06334	723	881	06342	725	892	06442	1400	893	06450
1502	896	06465	1500	902	06505	1503	910	06526	6000	913	06560	1600	914	06565
1603	915	06567	1602	916	06574	1601	922	06661	1700	932	06735	1402	935	06745
6001	951	07026	6002	965	07115	1505	970	07131	1504	971	07136	1507	986	07242

AS 1927
1629 -230

```
1506   987 07246        1509  1000 07306        1508  1004 07320        10007  1007 07333        1313  1008 07345
  13  1010 07357
```

```
ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,
     EXP(3       LOG         EXP         SQRT        (STHM)      (FIL)       ASIN        (RWT)       SIN         COS
     TRACE       EXITX       EXIT        (FPT)       (TSHM)      (SLI)       (RTN)       (SLO)       TAN         EXP(2
     ATAN

CORE UNUSED FROM  63437   TO  77271 (OCT)

 CORE LOADING MAP

PROG        EQUSS       EQUSP       EQUSRO      EQUSH       EQUSAV      EQUST       EQUSHP      PSEC        DATE
ORIG         00144       00250       00356       00466       00620       00662       00720       01043       02523

PROG        PRIDAT      PMXPAV      STORE       INTER       PTFTAX      INTRPT      PAMBPT      PTOTAX      CHARET
ORIG         02561       02626       03477       04753       05253       06541       10315       11345       12121

PROG        *MAIN*      INSHPT      (FPT)       EXP(2       EXP(3       EXP         LOG         SIN         ASIN
ORIG         12200       52446       55562       55632       55717       55763       56052       56151       56340

PROG        SQRT        TAN         ATAN        (TSH)       (STH)       (RWT)       (SLO)       (SLI)       (WER)
ORIG         56452       56537       56713       57074       57124       57405       57414       57431       57446

PROG        (RER)       (IOH)       (IOS)       (EXE)       EXIT        PRINTR      (IOU)       (TES)       SYSCD
ORIG         57545       57622       61754       62122       62316       62360       62567       62617       62620

PROG        (CLCS)      TRACE       *CBUF*
ORIG         62723       62726       63121

     BEGIN EXECUTION                                        TIME 10.667
```

```
C     MIX-MASTER MAIN PROGRAM
* * * *     THIS PROGRAM IS THE PROPERTY OF THE BOEING COMPANY AND IS
* * * *     NOT TO BE RELEASED BY NASA TO ANYONE WITHOUT THE WRITTEN
* * * *     CONSENT OF THE BOEING COMPANY.
C**** MIX-MASTER IS A DISTINCT PROGRAM ****
      DIMENSION AAA(12)
      DIMENSION C1(6,200), C2(6,200), T1(200), T2(200), RHO1(200),
     1RHO2(200), FKP(6), B(6), GAMMA(6), E(6), W(6,200),        DHF(6),
     2WW(6), H(8,200), U1(200), U2(200), V1(200), V2(200), XU(50),
     3YU(50), Z(200), CP2(200), FKC(6), YS(200), Y(200), FMU(200),
     4PR(200), FLE(200), ENERGY(200), FLET(200), PRT(200), XH(200),
     5CS(8,200), H2(200), H1(200), XTAB(100), RTAB(100), PTAB(100),
     6RRR(200), CP(6,200), CPN2(200)
      COMMON C1, C2, T1, T2, RHO1, RHO2
      COMMON FKP, FKC, B, GAMMA, E, W, CP, DHF, WW, CP2
      COMMON H, U1, U2, V1, V2, YT, XU, YU, Z
      COMMON P, MMAX, M, X, DX, DY, GC, FL, A, EPSON, FLET, PRT, FJ,
     1DELTA, NMAX, FCON, YS, DPDX
      COMMON DPSI, CONST, RZERO, Y, YZERO,KPRINT
      COMMON FLE, PR, FMU, USUB11, ENERGY
      COMMON XH, CS, H1, H2, NTCORE
      COMMON NXTAB, XTAB, RTAB, PTAB
      COMMON NMIN, ICHECK, CPN2
      EQUIVALENCE (FCON,CONST)
      EQUIVALENCE(Y,RRR)
C
      DIMENSION ANS(200)
      DIMENSION CBAR(6), CHAT(6)
   20 KODE = 1
      ICHECK = 1
      X=0.0
      KPCODE = 1
      KKODE = 1
      IDUCT = 0
      GC = 32.20
      FJ = 778.0
C---- NMAX = THE NUMBER OF DESIRED GRID POINTS.
      READ INPUT TAPE 5, 498, (AAA(I),I=1,12)
      READ INPUT TAPE 5, 500, NMAX, MMAX, NS, LFRONT, KSLIP, NMIN
```

```
      READ INPUT TAPE 5, 501, A, FL, EPSON, FLET(1), PRT(1), DELTA,
     1DX, FCON, RZERO1, RE, RDZERO, TESMAX, TESMIN
      READ INPUT TAPE 5, 500, NXTAB
      READ INPUT TAPE 5, 502, (XTAB(K),RTAB(K),PTAB(K),K=1,NXTAB)
      NE1 = NPTS/3
      IF (NMIN) 10, 5, 10
   10 DO 15 L=NMIN, NMAX
      READ INPUT TAPE 5, 499, C2(1,L), C2(2,L), C2(3,L), C2(4,L),
     1C2(5,L), C2(6,L), T2(L), U2(L)
   15 CONTINUE
      READ INPUT TAPE 5, 499, X
      DTESMX = TESMAX - C2(1,NMAX)
      D2MAX = TESMAX -C2(2,NMAX)
      DTESMN = TESMIN - C2(6,NMIN)
      L = NMIN-1
      DO 30 N=1, L
      DO 25 K=1, 6
      C2(K,N) = C2(K,NMIN)
   25 CONTINUE
      T2(N) = T2(NMIN)
      U2(N) = U2(NMIN)
   30 CONTINUE
      GO TO 170
C-----SHEAR LAYER TYPE PROBLEM--ADDITIONAL INPUT--
    5 READ INPUT TAPE 5, 501, (C2(K,1),K=1,6), (C2(K,NMAX),K=1,6),
     1T2(1), T2(NMAX), U2(1), U2(NMAX)
      NMIN = 1
      DTESMX = TESMAX - C2(1,NMAX)
      D2MAX = TESMAX -C2(2,NMAX)
      DTESMN = TESMIN - C2(6,NMIN)
      GO TO 150
C-----SHEAR LAYER TYPE PROBLEM---
C     GET BOUNDARY VALUES ON FIRST FRONT
  150 IM = KSLIP
      DO 160 I=1, IM
      V2(I) = V2(1)
      U2(I) = U2(1)
      T2(I) = T2(1)
      DO 160 K=1, 6
  160 C2(K,I) = C2(K,1)
```

```
      IM = IM+1                                                         19273891
      DO 165 I=IM, NMAX                                                 19273892
      V2(I) = V2(1)                                                     19273893
      U2(I) = U2(NMAX)                                                  19273894
      T2(I) = T2(NMAX)                                                  19273895
      DO 165 K=1, 6                                                     19273896
  165 C2(K,I) = C2(K,NMAX)                                              19273897
      NE = KSLIP+NS                                                     19273898
      IF (NS) 176, 176, 1651                                            19273899
 1651 CONTINUE                                                          19273900
      NS1 = KSLIP-NS                                                    19273901
      NS2 = NS1+1                                                       19273902
      NE1 = NE-1                                                        19273903
      KK = NE-NS1                                                       19273904
      CALL CURV1(T2(NS1),T2(NE),ANS,NS1,KK)                             19273905
      DO 166 I=NS2, NE1                                                 19273906
  166 T2(I) = ANS(I)                                                    19273907
      CALL CURV1(U2(NS1),U2(NE),ANS,NS1,KK)                             19273908
      DO 167 I=NS2, NE1                                                 19273909
  167 U2(I) = ANS(I)                                                    19273910
      DO 168 K=1, 6                                                     19273911
      CALL CURV1(C2(K,NS1),C2(K,NE),ANS,NS1,KK)                         19273912
      DO 168 I=NS2, NE1                                                 19273913
  168 C2(K,I) = ANS(I)                                                  19273914
  176 CONTINUE                                                          19273915
      NE = NE+1                                                         19273916
  170 KFIRST = 1                                                        19273917
      KPRINT = 1                                                        19273918
      KOUNT = 0                                                         19273919
      M = 1                                                             19273920
      DO 180 I=1, 200                                                   19273921
      PRT(I) = PRT(1)                                                   19273922
      FLE(I) = FLE(1)                                                   19273923
      PR(I) = PR(1)                                                     19273924
  180 FLET(I) = FLET(1)                                                 19273925
      CALL PRESS                                                        19273926
      CALL NONEQ1                                                       19273927
      TEMP = 2.0*(RE**(DELTA+1.0)-RZERO1**(DELTA+1.0))/(DELTA+1.0)      19273928
      ATEMP = 0.                                                        19273929
      DO 175 I=2, KSLIP                                                 19273930
```

```
      ATEMP = ATEMP+1.0/(RHO2(I-1)*U2(I-1))+1.0/(RHO2(I)*U2(I))
  175 CONTINUE
      DPSI = TEMP/ATEMP
      WRITE OUTPUT TAPE 6, 514
      WRITE OUTPUT TAPE 6, 498, (AAA(I),I=1,12)
      WRITE OUTPUT TAPE 6, 535
      WRITE OUTPUT TAPE 6, 536, NMAX, MMAX, NS, LFRONT, KSLIP, NMIN
      WRITE OUTPUT TAPE 6, 515, A, FL, EPSON, FLET(1), PRT(1), DELTA
      WRITE OUTPUT TAPE 6, 516, DX, FCON, DPSI
      WRITE OUTPUT TAPE 6, 526
      WRITE OUTPUT TAPE 6, 527, RZERO1, RF, RDZERO
      WRITE OUTPUT TAPE 6, 537, TESMAX, TESMIN, NXTAB
  195 WRITE OUTPUT TAPE 6, 533
      WRITE OUTPUT TAPE 6, 534, (XTAB(K),RTAB(K),PTAB(K),K=1,NXTAB)
  190 WRITE OUTPUT TAPE 6, 530
      WRITE OUTPUT TAPE 6, 529, (C2(K,1),K=1,6),C2(1,NMAX),C2(2,NMAX),
     1C2(3,NMAX),C2(4,NMAX)
      WRITE OUTPUT TAPE 6, 531
      WRITE OUTPUT TAPE 6, 532, C2(5,NMAX), C2(6,NMAX)
      WRITE OUTPUT TAPE 6, 528, T2(1), T2(NMAX),U2(1),U2(NMAX)
      WDOTST = RHO2(1)*U2(1)*(RZERO**(DELTA+1.0)-RZERO1**(DELTA+1.0))*
     13.1415927**DELTA
      STOPK = 0.0
C
C     START OF LOOP
C
  200 CONTINUE
C
C
  229 DO 230 N=1, NMAX
  230 RHO1(N) = RHO2(N)
C
C
C     RHO2, CP2 FOR SHEAR LAYER
  295 CALL NONEQ1
      IF (RZERO1) 299, 298, 299
  298 RZERO = RZERO1
      GO TO 301
  299 RZERO = (RZERO**(DELTA+1.0)-WDOTST/(RHO2(1)*U2(1)*3.1415927**
     1DELTA))**(.50**DELTA)
```

```
  301 CALL INGRAT
      IF (M-1) 3011, 3011, 3014
 3011 CALL DUCT(0.0,RRR(NMAX),FLOATF(NMAX-1)*DPSI,RD,THRUST,RHO2(NMAX),
     1U2(NMAX),P,RDZERO,PSID,DELTA)
      WDZS = RHO2(NE)*U2(NE)*(RD**(DELTA+1.0)-RRR(NE)**(DELTA+1.0))*
     13.1415927**DELTA
      KK = KSLIP+1
      IF (NE-KK-1) 3015, 3015, 3012
 3012 DO 3013  KKK=KK, NE
      WDZS = WDZS+0.5**DELTA*(RHO2(KKK-1)*U2(KKK-1)+RHO2(KKK)*U2(KKK))
     1*(RRR(KKK)**(DELTA+1.0)-RRR(KKK-1)**(DELTA+1.0))*3.1415927**DELTA
 3013 CONTINUE
      GO TO 3015
C
 3014 NMAX = NMAX
      CALL DUCT(1.0,RRR(NMAX),FLOATF(NMAX-1)*DPSI,RD,THRUST,RHO2(NMAX),
     1U2(NMAX),P,RDZERO,PSID,DELTA)
 3015 CONTINUE
      IF (KPRINT-1)  207, 302,  207
 3019 STOPK = 1.0
  302 WRITE OUTPUT TAPE 6, 519, M, X, P
      AD = 2.0**(1.0-DELTA)*3.1415927**DELTA*RD**(DELTA+1.0)
      IF (X) 3022, 3021, 3022
 3021 WRITE OUTPUT TAPE 6, 524, WDZS, RD, THRUST, AD
      GO TO 3023
 3022 WRITE OUTPUT TAPE 6, 525, RD, THRUST, AD
 3023 CONTINUE
      WRITE OUTPUT TAPE 6, 520
      WRITE OUTPUT TAPE 6, 521
      N = 1
      RSTART = P/RHO2(N)
      RCALCJ = (P/(RHO2(N)*T2(N)))/FJ
      AMACH = U2(N)/SQRTF((CP2(N)*GC*RSTART)/(CP2(N)-RCALCJ))
      WRITE OUTPUT TAPE 6, 522, N, Y(1), U2(1), T2(1), RHO2(1),
     1C2(1,1), C2(2,1), C2(3,1), C2(4,1), C2(5,1), C2(6,1),AMACH
      DO 305 N=NMIN, NMAX
      RSTART = P/RHO2(N)
      RCALCJ = (P/(RHO2(N)*T2(N)))/FJ
      AMACH = U2(N)/SQRTF((CP2(N)*GC*RSTART)/(CP2(N)-RCALCJ))
  305 WRITE OUTPUT TAPE 6, 522, N, Y(N), U2(N), T2(N),
```

```
     1RHO2(N), C2(1,N), C2(2,N), C2(3,N), C2(4,N),C2(5,N),C2(6,N),AMACH 19274011
      IF (STOPK) 20, 207, 20                                            19274012
C                                                                       19274013
C                                                                       19274014
  207 IF (M-MMAX-1) 220, 2071, 2071                                     19274015
 2071 IF (KPRINT-1) 3019, 20, 3019                                      19274016
C                                                                       19274017
C     CALCULATE MINIMUM DELTA PSI                                       19274018
C                                                                       19274019
  220 CONTINUE                                                          19274020
      DPSIM = 0.0                                                       19274021
      DO 2202 N=2,NMAX                                                  19274022
      CUR = 2.0*RRR(N)**(2.0*DELTA)*RHO2(N)*U2(N)*(FMU(N)*FLE(N)        19274023
     1/PR(N)+RHO2(N)*EPSON*(CONST+X/FL)**A*FLET(N)/PRT(N))              19274024
      IF (DPSIM-CUR) 2201, 2202, 2202                                   19274025
 2201 DPSIM = CUR                                                       19274026
 2202 CONTINUE                                                          19274027
      DPSIM = SQRTF(DX*DPSIM)                                           19274028
 2204 IF (DPSI-DPSIM) 307, 2205, 2205                                   19274029
 2205 CONTINUE                                                          19274030
      IF (NMAX-197) 361, 361, 307                                       19274031
C**** RE-STORE THE -FRONT- VALUES IN THE APPROPRIATE CELLS              19274032
C**** CORRESPONDING TO 2.*DPSI                                          19274033
  307 NMAX = NMAX/2+2                                                   19274034
      IDUCT = 0                                                         19274035
      IF (NMIN-2) 3072, 3072, 3071                                      19274036
 3071 NMIN = (NMIN+1)/2-1                                               19274037
 3072 CONTINUE                                                          19274038
      J = 1                                                             19274039
      JJ = NMAX-2                                                       19274040
      DO 311 N=2, JJ                                                    19274041
      K = N+J                                                           19274042
      U2(N) = U2(K)                                                     19274043
      T2(N) = T2(K)                                                     19274044
      RHO2(N) = RHO2(K)                                                 19274045
      RRR(N) = RRR(K)                                                   19274046
      CP2(N) = CP2(K)                                                   19274047
      FMU(N) = FMU(K)                                                   19274048
      V2(N) = V2(K)                                                     19274049
      H2(N) = H2(K)                                                     19274050
```

```
      DO 313 L=1, 6
      C2(L,N) = C2(L,K)
      W(L,N) = W(L,K)
  313 CONTINUE
      J = J+1
  311 CONTINUE
      DO 314 L=1, 6
      C2(L,NMAX) = C2(L,NMAX-2)
      C2(L,NMAX-1) = C2(L,NMAX)
      W(L,NMAX) = W(L,NMAX-2)
      W(L,NMAX-1) = W(L,NMAX)
  314 CONTINUE
      U2(NMAX) = U2(NMAX-2)
      U2(NMAX-1) = U2(NMAX)
      T2(NMAX) = T2(NMAX-2)
      T2(NMAX-1) = T2(NMAX)
      RHO2(NMAX) = RHO2(NMAX-2)
      RHO2(NMAX-1) = RHO2(NMAX)
      RRR(NMAX) = RRR(NMAX-2)
      RRR(NMAX-1) = RRR(NMAX)
      CP2(NMAX) = CP2(NMAX-2)
      CP2(NMAX-1) = CP2(NMAX)
      FMU(NMAX) = FMU(NMAX-2)
      FMU(NMAX-1) = FMU(NMAX)
      V2(NMAX) = V2(NMAX-2)
      V2(NMAX-1) = V2(NMAX)
      H2(NMAX) = H2(NMAX-2)
      H2(NMAX-1) = H2(NMAX)
      DPSI = 2.0*DPSI
      IF (DPSI-DPSIM) 307, 3111, 3111
 3111 WRITE OUTPUT TAPE 6, 523, DPSI
      GO TO 361
  361 KPRINT = 0
      IF (LFRONT) 362, 369, 362
  362 KOUNT = KOUNT+1
      IF (1-KOUNT/LFRONT) 430, 365, 430
  365 KOUNT = 0
  369 KPRINT = 1
C------SHEAR LAYER TYPE
  430 CALL NONEQ3(IDUCT,PSID,TESMAX,TESMIN,DTESMX,DTESMN,D2MAX)
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
      IF (ICHECK) 200, 431, 200
  431 STOPK = 1.0
      KPRINT = 1
      GO TO 200
C
C
  498 FORMAT (12A6)
  499 FORMAT (8E10.3)
  500 FORMAT (15I4)
  501 FORMAT(6E12.5)
  502 FORMAT(3E16.7)
  503 FORMAT(34H1ERROR IN THERMODYNAMIC SUBROUTINE3X,4HMAD=I4)
  504 FORMAT (20X,29HU,V,T VALUES ON INITIAL FRONT)
  508 FORMAT(1X,19HERROR IN STEP SIZE,6G11.4/)
  509 FORMAT(4X,20HYZERO AT X=0 EQUALS F14.5)
  510 FORMAT(1X,7HYVALUE 10G11.4)
  512 FORMAT(11X,57HINITIAL VALUES FOR U2,C2,T2, FOR SHEAR LAYER TYPE PR
     1OBLEM)
  514 FORMAT(1H1,40X,13HINITIAL INPUT)
  515 FORMAT(1H0,6X,1HA,11X,1HL,11X,15HREICHARTS COEF.,4X,9HLEWIS NO.,6X
     1,11HPRANDTL NO.,6X,5HDELTA/2X,1PE10.3,2X,1PE10.3,9X,1PE10.3,6X,1PE
     210.3,6X,1PE10.3,4X,1PE10.3)
  516 FORMAT(1H0,5X,2HDX,7X,16HVISCOSITY CONST.,5X,21HDELTA-PSI (NOT INP
     1UT)/2X,1PE10.3,6X,1PE10.3,8X,1PE10.3)
  517 FORMAT(3X,51HNON-TURBULENT LEWIS NO.   NON-TURBULENT PRANDTL NO./5
     1X,G15.4,17X,G15.4)
  518 FORMAT(19X,26HINITIAL VALUES OF ENTHALPY///)
  519 FORMAT(///////1X,36HPROPERTIES GIVEN BELOW ARE AT FRONT I5,7X,21HD
     1ISTANCE DOWNSTREAM =F14.4,4HFEET,5X,9HPRESSURE=F14.4,3HPSF)
  520 FORMAT(///2X,1HN,6X,1HY,8X,28HX-COMP  TEMPERATURE  DENSITY,2X,43H-
     1----------CONCENTRATION OF SPECIES-------)
 521  FORMAT(16X,8HVELOCITY,28X,3HH2O,8X,2HH2,9X,2HO2,8X,3HCO2,9X,2HCO ,
     19X,2HN2,7X,4HMACH)
  522 FORMAT(I4,10G11.4,F6.3)
  523 FORMAT(21HODELTA PSI WAS SET = G11.4)
  524 FORMAT(36H0INITIAL FLOW IN SECONDARY STREAM = F14.4,8H LBS/SEC/ 18
     1H RADIUS OF DUCT = F14.4,17H FT.    THRUST = F14.4,20H LB.    DUCT
     2 AREA = F14.4,7H SQ FT.)
  525 FORMAT(18H0RADIUS OF DUCT = F14.4,17H FT.    THRUST = F14.4,20H LB
     1.    DUCT AREA = F14.4,7H SQ FT.)
```

```
526 FORMAT(1H0,3X,6HRZERO1,8X,2HRE,8X,6HRDZERO)                          19274131
527 FORMAT(2X,1PE10.3,2X,2(1PE10.3,2X))                                  19274132
528 FORMAT(1H0,4X,3HT21,8X,6HT2NMAX,7X,3HU21,8X,6HU2NMAX/1X,4(1PE10.3,19274133
   12X)//////)                                                           19274134
529 FORMAT(1X,10(1PE10.3,2X))                                            19274135
530 FORMAT(1H0,3X,4HC211,8X,4HC221,8X,4HC231,8X,4HC241,8X,4HC251,8X,4H19274136
   1C261,6X,7HC21NMAX,5X,7HC22NMAX,5X,7HC23NMAX,5X,7HC24NMAX)            19274137
531 FORMAT(1H0,1X,7HC25NMAX,5X,7HC26NMAX)                                19274138
532 FORMAT(1X,1PE10.3,2X,1PE10.3)                                        19274139
533 FORMAT(1H0,3X,4HXTAB,8X,4HRTAB,8X,4HPTAB,8X,4HXTAB,8X,4HRTAB,8X,4H19274140
   1PTAB,8X,4HXTAB,8X,4HRTAB,8X,4HPTAB)                                  19274141
534 FORMAT(1X,9(1PE10.3,2X))                                             19274142
535 FORMAT(6H0 NMAX,3X,4HMMAX,3X,2HNS,3X,6HLFRONT,3X,5HKSLIP,3X,4HNMIN19274143
   1)                                                                    19274144
536 FORMAT(2X,2(I4,3X),I2,3X,I6,3X,I5,3X,I4)                             19274145
537 FORMAT(1H0,3X,6HTESMAX,6X,6HTESMIN,6X,5HNXTAB/2X,1PE10.3,2X,1PE10.19274146
   13,4X,I3)                                                             19274147
    END                                                                  19274148
```


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STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
2271	04337	19694	46356

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A	23807	56401	H	29148	70734	C1	32360	77150	C2	31160	74670	CONST	32561	77461
CP2	26718	64136	CPN2	19894	46666	CP	27930	66432	CS	22198	53266	DELTA	23406	55556
DHF	26730	64152	DPDX	23204	55244	DPS1	23203	55243	DX	23813	56405	DY	23812	56404
ENERGY	22598	54106	EPSON	23808	56400	E	29136	70720	FCON	32561	77461	FJ	23407	55557
FKC	29154	70742	FKP	29160	70750	FLE	23199	55237	FLET	23807	56377	FL	23810	56402
FMU	22799	54417	GAMMA	29142	70726	GC	23811	56403	H1	20598	50166	H2	20398	47656
H	26510	63626	ICHECK	19895	46667	KPRINT	23700	55240	MMAX	23816	56410	M	23815	56407
NMAX	23405	55555	NMIN	19896	46670	NTCORE	20198	47346	NXTAB	20197	47345	PR	22999	54727
PRT	23607	56067	P	23817	56411	PTAB	19996	47034	RHO1	29560	71570	RHO2	29360	71260
RRR	32560	77460	RTAB	20096	47200	RZERO	23202	55242	T1	29960	72410	T2	29760	72100
U1	24716	60526	U2	24718	60216	USUB11	22599	54107	V1	24518	57706	V2	24318	57376
W	29130	70712	WW	26724	64144	XH	22398	53576	X	23814	56406	XTAB	20196	47344
XU	24117	57065	Y	32560	77460	YS	23404	55554	YT	24118	57066	YU	24067	57003
YZERO	23201	55241	Z	24017	56721									

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
AAA	2270	04336	ANS	2258	04322	CHAR	2058	04012	CHAT	2052	04004			

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
AC	2046	03776	AMACH	2045	03775	ATEMP	2044	03774	CUR	2043	03773	D2MAX	2042	03772
DPSIM	2041	03771	DTESMN	2040	03770	DTESMX	2039	03767	IDUCT	2038	03766	IM	2037	03765
JJ	2036	03764	J	2035	03763	KFIRST	2034	03762	KKODE	2033	03761	KK	2032	03760
KODE	2031	03757	KOUNT	2030	03756	KPCODE	2029	03755	K	2028	03754	KSLIP	2027	03753
LFRONT	2026	03752	L	2025	03751	NE1	2024	03750	NE	2023	03747	NPTS	2022	03746
N	2021	03745	NS1	2020	03744	NS2	2019	03743	NS	2018	03742	PSID	2017	03741
RCALCJ	2016	03740	RD	2015	03737	RDZERO	2014	03736	RE	2013	03735	RSTART	2012	03734
RZERO1	2011	03733	STOPK	2010	03732	TEMP	2009	03731	TESMAX	2008	03730	TESMIN	2007	03727
THRUST	2006	03726	WDOTST	2005	03725	WDZS	2004	03724						

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)FI	498	03675	8)FJ	499	03673	8)FK	500	03671	8)FL	501	03667	8)FM	502	03665
8)FN	503	03663	8)FO	504	03652	8)FS	508	03643	8)FT	509	03635	8)FU	510	03627
8)GC	512	03623	8)G2	514	03610	8)G3	515	03603	8)G4	516	03551	8)G5	517	03530
8)G6	518	03513	8)G7	519	03504	8)G8	520	03460	8)G9	521	03436	8)GA	522	03421
8)GB	523	03416	8)GC	524	03410	8)GD	525	03357	8)GE	526	03337	8)GF	527	03330
8)GG	528	03323	8)GH	529	03307	8)GI	530	03303	8)GJ	531	03257	8)GK	532	03251
8)GL	533	03245	8)GM	534	03225	8)GN	535	03222	8)GO	536	03207	8)GP	537	03201

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	1982	03676	2)	1632	03140	3)	1641	03151	4)	32767	77777	6)	1648	03160
A)101	1601	03101	A)102	1610	03112	A)108	1619	03123	C)G0	1990	03706	C)G2	1991	03707
C)G4	1992	03710	C)G5	1993	03711	C)G6	1994	03712	C)G7	1995	03713	C)G8	1996	03714
C)101	1997	03715	C)102	1998	03716	C)107	1999	03717	C)108	2000	03720	C)109	2001	03721
C)10C	2002	03722	C)201	2003	03723	D)10J	300	00454	D)110	481	00741	D)111	503	00767
D)209	213	00325	D)215	526	01016	D)21R	1040	02020	D)41G	794	01432	D)42E	1432	02630
E)1K	814	01456	E)1M	865	01541	E)1T	1049	02031	E)1U	1103	02117	E)20	1574	03046
E)2P	1578	03052	E)2Q	1595	03073	E)101	27	00033	E)12B	1382	02546	E)201	27	00033

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CURV1	3	00003	DUCT	10	00012	EXP(3	6	00006	INGRAT	9	00011	NONEQ1	5	00005
NONEQ3	12	00014	PRESS	4	00004	SQRT	11	00013	(FIL)	8	00010	(FPT)	0	00000
(RTN)	2	00002	(STH)	7	00007	(TSH)	1	00001						

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

CURV1	DUCT	EXP(3	INGRAT	NONEQ1	NONEQ3	PRESS	SQRT	(FIL)	(FPT)
(RTN)	(STH)	(TSH)							

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
20	52	00034	10	78	00224	15	81	00270	25	91	00341	30	94	00352
5	96	00361	150	109	00444	160	115	00464	165	122	00544	1651	125	00570
166	133	00631	167	137	00662	168	142	00770	176	143	01011	170	145	01017
180	153	01036	175	160	01117	195	180	01247	190	186	01272	200	199	01433
229	200	01433	230	201	01436	295	202	01442	298	204	01453	299	206	01457
301	207	01530	3011	209	01542	3012	214	01660	3013	216	01746	3014	218	01751
3015	221	02021	3019	223	02026	302	224	02032	3021	228	02120	3022	231	02141
3023	233	02157	305	246	02350	207	249	02420	2071	250	02426	220	251	02433
2201	256	02520	2202	257	02522	2204	259	02534	2205	260	02541	307	262	02547
3071	265	02572	3072	266	02611	313	282	02673	311	284	02702	314	290	02732
3111	309	03006	361	312	03021	362	314	03025	365	316	03043	369	317	03047
430	318	03053	431	321	03074									

```
ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,
    XLOC        TAB        (STHM)      (FIL)      EXIT       EXP(3      LOG        SQRT       (FPT)      (TSHM)
    (RTN)

CORE UNUSED FROM  17743   TO  46356 (OCT)

     BEGIN EXECUTION                                        TIME 19.736
```

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```
ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,
    (FPT)      (TSHM)      (RTN)      EXP(3      (STHM)      (FIL)      SQRT      XLOC      TAB      EXIT
    LOG

CORE UNUSED FROM  17723  TO  46356 (OCT)

 CORE LOADING MAP

PROG      *MAIN*     CURVI      PRESS      NONEQ1     INGRAT     DUCT       NONEQ3     (FPT)      EXP(3
ORIG       00144      04503      04646      05142      05727      06477      07002      12314      12364

PROG      EXP        LOG        SQRT       (TSH)      (STH)      (WER)      (RER)      (IOH)      (IOS)
ORIG       12430      12517      12616      12703      12733      13214      13313      13370      15522

PROG      (EXE)      EXIT       CHARET     PRINTR     SDUMP      COMMON     (IOU)      (TES)      SYSCO
ORIG       15670      16064      16126      16136      16345      16675      16700      16730      16731

PROG      (CLOS)     XLOC       TAB        *OBUF*
ORIG       17034      17037      17112      17405

     BEGIN EXECUTION                                   TIME 11.309
```