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COLLOCATION FLUTTER ANALYSIS STUDY

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VOLUME III.

AICs - COMPUTER PROGRAM TO CALCULATE UNSTEADY AERODYNAMIC
INFLUENCE COEFFICIENTS FOR SUBSONIC, TRANSONIC AND SUPERSONIC FLIGHT

APRIL 1969



SEP 25 1969

MISSILE SYSTEMS DIVISION

HUGHES

HUGHES AIRCRAFT COMPANY

COFA

COLLOCATION FLUTTER ANALYSIS STUDY

VOLUME III

AICs - COMPUTER PROGRAM TO CALCULATE
UNSTEADY AERODYNAMIC INFLUENCE COEFFICIENTS FOR
SUBSONIC, TRANSONIC, AND SUPERSONIC FLIGHT

Prepared by Dynamics & Environments Section Personnel
Hughes Aircraft Company, Missile Systems Division
Contract No.00019-68-C-0247

APRIL 1969

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ABSTRACT

Subsonic Kernel function, transonic box, and supersonic box methods for computing unsteady aerodynamics are applied to the problem of interaction of a general trapezoidal wing with a downstream rectangular control surface lying in the wake of the wing. The unsteady aerodynamic forces are related to a set of collocation stations through a series of matrix transformations, interpolations, and differentiations. The resulting matrix is a set of aerodynamic influence coefficients (AICs) that are directly applicable to flutter analysis.

The transformation of the unsteady aerodynamics into AICs is presented as a separate discussion; followed by discussions for the developments of analytical techniques for each flight regime. The analytical developments and a discussion of the basic single-planar-surface are presented, followed by the complete two-surface solutions for the general aerodynamic forces. Each of the three numerical methods is developed by detailing the complete set of equations necessary to compute airloads on the configurations considered. A computer program to determine the AIC matrix for each flight regime is presented with a complete discussion of usage and logical flow. Also included are program listings, flow charts and sample input and output problems.

PART I - INTRODUCTION

The requirements for determination of flutter margins of safety for the lifting surfaces of advanced guided missiles have precipitated a need for accurate methods of analysis of unsteady aerodynamic loading in the high subsonic, transonic, and supersonic flight regimes. These methods must not only account for the high degree of chordwise and spanwise deformation of the surfaces, but also include the interference effects between tandem lifting surfaces. Recent developments in lifting surface theory in the three Mach number regimes have permitted extensions (Refs. 2 and 3) to determine airloads on typical missile wings with downstream control surfaces. These extensions account for the interaction and wake effects as well as for the three-dimensionality of the flow for a trapezoidal wing planform and a coplanar rectangular control surface placed at an arbitrary distance downstream of the unswept trailing edge of the wing. An underlying assumption in these methods is that the missile body diameter is large enough compared to the spans of the surfaces that the body surface acts as a reflection plane for disturbances at the line of its intersection with the lifting surfaces.

The present study extends the methods of Ref. 3 to obtain aerodynamic influence coefficients (AIC's) that relate the forces on the surfaces at a discrete set of points (control or collocation points) to the transverse deflections of the same set of points. Subsonic kernel function, transonic box, and supersonic box methods for computing the oscillatory AIC's are applied to the interference problem of a general trapezoidal wing with a downstream rectangular control surface lying in the wake of the wing. Highly efficient numerical methods for computation by the kernel function and Mach box techniques have been employed, along with the techniques for the newly developed transonic box method, to obtain AIC's which account for all interference effects within the framework of linearized theory.

Discussion of the derivation of the AIC's is given in Part III for the three Mach number regimes. The analytical basis of the theories are outlined in Appendices to Part III. Each of the three numerical methods is discussed and the basic equations necessary to compute airloads on the configurations considered are summarized.

The three computer programs are presented in Parts IV, V, and VI, for the subsonic, sonic, and supersonic cases, respectively. In addition to a technical outline of the methods employed, each Part is a manual containing a complete discussion of usage and logical flow accompanied by program listings, flow charts and sample input and output. Each Part also presents results computed by operation of the program for typical planforms.

PART II - NOMENCLATURE

a	Free-stream acoustic velocity
$a_{n,m}$	Coefficients of Kernel function pressure series
b	Local semi-chord
b_r	Reference semi-chord
C_h	Element of dimensionless AIC matrix
C_p	Pressure coefficient
$D_{n,m}$	Element of Kernel function matrix
G	Supersonic source influence function
h	AIC control point displacement.
K	Kernel function
k	Local reduced frequency $\sim \frac{\omega b}{U}$
k_r	Reference reduced frequency $\sim \frac{\omega b_r}{U}$
M	Mach number
p	Complex amplitude of pressure
S	Planform area
s	Semi-span
U	Free-stream fluid velocity
U_k	Chebyshev polynomial

$[W]$	Substantial derivative matrix
w	Complex amplitude of downwash
X, Y, Z	Cartesian coordinate system
β^2	$1-M^2$ for $M < 1$; M^2-1 for $M > 1$
Δ	Box length
ξ, η, ζ	Cartesian coordinate system variables
$\tilde{\xi}, \eta$	Special coordinates for collocation and integration points
ϕ	Complex amplitude of velocity potential
ψ	Transonic doublet influence function
ρ	Atmospheric density
ω	Angular frequency of harmonic oscillation $\sim$ rad/sec
AR	Aspect ratio $\sim 2s^2/s$

PART III

DISCUSSION OF THE DERIVATION OF AERODYNAMIC INFLUENCE COEFFICIENTS

DERIVATION OF SUBSONIC AERODYNAMIC INFLUENCE COEFFICIENTS

The subsonic kernel function procedure was developed by Watkins, Woolston and Cunningham,¹ extended to a wing-tail combination by Moore and Park,² and refined by Andrew.³ The present study extends the method of Ref. 3 to obtain aerodynamic influence coefficients (AICs). Oscillatory AICs have been defined in Ref. 4 to relate control point forces to control point deflections through the matrix equation.

$$\{F\} = \rho \omega^2 b_r^2 s [C_h] \{h\} \quad (3.1)$$

The derivation of the AICs requires a review of the technique of Refs. 1 - 3. (NOTE: These references are outlined in Part IV, Section A). The starting point is an assumed series for the lifting pressure distribution. It is chosen in the form³

$$C_p(\xi, \eta) = \frac{\sqrt{s^2 - \eta^2}}{b(\eta)} \sum_{n=0}^N \sum_{m=0}^M a_{nm} P_m(\eta) f_n(\xi) \quad (3.2)$$

where the chordwise pressure functions are

$$f_0(\xi) = \sqrt{(1 - \xi)/(1 + \xi)} \quad (3.3a)$$

$$f_n(\xi) = \sqrt{1 - \xi^2} U_{n-1}(\xi), \quad 1 \leq n \quad (3.3b)$$

the spanwise pressure functions are

$$P_0(\eta) = 1.0 \quad (3.4a)$$

$$P_m(\eta) = \eta^2 U_{m-1}(\eta), \quad 1 \leq m \quad (3.4b)$$

and the Chebyshev polynomial recurrence relation is

$$U_k(x) = 2x U_{k-1}(x) - U_{k-2}(x) \quad (3.5)$$

when $U_0(x) = 1.0$ and $U_1(x) = 2x$. The numerical procedures of Refs. 1 - 3 lead to a matrix formulation of the aerodynamic lifting surface integral equation as an equation between the control point downwashes and the amplitudes of the assumed pressure modes

$$\{w/U\} = [D_{nm}] \{a_{nm}\} \quad (3.6)$$

The solution of Eq. 3.6 by least-squares methods is given by Ref. 3 which we write in the form

$$\{a_{nm}\} = [A_{M<1}] \{w/U\} \quad (3.7)$$

In order to find the AICs it is necessary to define a grid of control points. We find it convenient to divide the surface into NS strips and to locate the control points on the centerline of each strip. We further choose NC control points on each strip located at the same fractional chord location on each strip. A typical distribution of control points is shown in Figure 3.1 for a wing-tail combination.

The downwashes required in Eq. 3.7 are obtained by a substantial differentiation of the AIC control point deflections

$$\{w/U\} = [W] \{h\} \quad (3.8)$$

Since the downwashes required in Ref. 3 are at an optimum set of points different from the AIC control points, the matrix $[W]$ is seen to be an interpolation as well as a substantial differentiation matrix.

TYPICAL DISTRIBUTION OF CONTROL POINTS

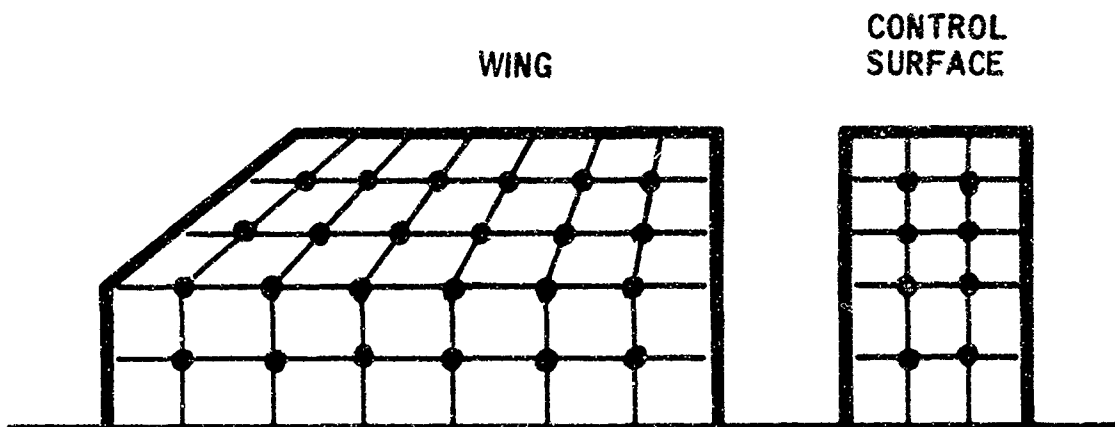


Figure 3.1

From the pressure modes and their amplitudes the forces may be found by an integration procedure. The NC forces on each strip may be found by integration of the pressure on the strip in the region of each of the NC forces to obtain equivalent concentrated forces. This leads to a relationship between the forces and the pressure mode amplitudes

$$\{F\} = qs^2 [B] \{a_{nm}\} \quad (3.9)$$

We designate the matrix $[B]$ as the integration matrix.

Combining Eqs. 3.7, 3.8 and 3.9, and identifying the result with Eq. 3.1 leads to the subsonic oscillatory AICs.

$$[C_h] = (s/2k_r^2) [B] [A_{M<1}] [W] \quad (3.10)$$

Ref. 3 provides $[A_{M<1}]$; the extension to obtain AICs requires the development of the matrices $[W]$ and $[B]$. These are discussed next.

THE SUBSTANTIAL DIFFERENTIATION MATRIX $[W]$

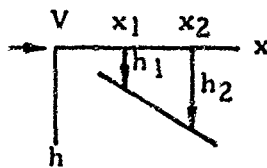
The substantial differentiation matrix is derived by surface fitting techniques. For maximum accuracy we fit the surface "in-the-small," i.e., locally. Rather than use a surface fit per se, we shall fit curves in the chordwise direction and then fit similar curves spanwise along lines of constant chord fraction. A higher order polynomial is not well behaved between points, so we choose to connect a series of parabolas. A number of options exists as the number of points is increased so it is well to develop the equations systematically.

With two control points the curve, of course, is a straight line. Its equation may be written in matrix form.

$$h(x) = \begin{bmatrix} 1 & x \end{bmatrix} \begin{bmatrix} 1 & x_1 \\ 1 & x_2 \end{bmatrix}^{-1} \begin{bmatrix} h_1 \\ h_2 \end{bmatrix} \quad (3.11)$$

With three control points the parabola is given by

$$h(x) = \begin{bmatrix} 1 & x & x^2 \end{bmatrix} \begin{bmatrix} 1 & x_1 & x_1^2 \\ 1 & x_2 & x_2^2 \\ 1 & x_3 & x_3^2 \end{bmatrix}^{-1} \begin{Bmatrix} h_1 \\ h_2 \\ h_3 \end{Bmatrix} \quad (3.12)$$



In the case of four points we fit two parabolas that are tangent half-way between the second and third points. For $x < x_{2-3} = (x_2 + x_3)/2$ we write

$$h(x) = a_0 + a_1x + a_2x^2 \quad (3.13)$$

and for $x > x_{2-3}$

$$h(x) = b_0 + b_1x + b_2x^2 \quad (3.14)$$

At $x = x_{2-3}$ the deflections and slopes must be equal.

$$a_0 + a_1x_{2-3} + a_2x_{2-3}^2 = b_0 + b_1x_{2-3} + b_2x_{2-3}^2 \quad (3.15)$$

$$a_1 + 2a_2x_{2-3} = b_1 + 2b_2x_{2-3} \quad (3.16)$$

The unknown coefficients are determined by the solution of the matrix equation

$$\begin{bmatrix} 1 & x_1 & x_1^2 & 0 & 0 & 0 \\ 1 & x_2 & x_2^2 & 0 & 0 & 0 \\ 1 & x_{2-3} & x_{2-3}^2 & -1 & -x_{2-3} & -x_{2-3}^2 \\ 0 & 1 & 2x_{2-3} & 0 & -1 & -2x_{2-3} \\ 0 & 0 & 0 & 0 & x_3 & x_3^2 \\ 0 & 0 & 0 & 0 & x_4 & x_4^2 \end{bmatrix} \begin{Bmatrix} a_0 \\ a_1 \\ a_2 \\ b_0 \\ b_1 \\ b_2 \end{Bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{Bmatrix} h_1 \\ h_2 \\ h_3 \\ h_4 \end{Bmatrix} \quad (3.17)$$

Solving for the coefficients leads to the equations for the curve.

$$h(x) = \begin{bmatrix} 1 & x & x^2 & 0 & 0 & 0 \end{bmatrix} \begin{Bmatrix} a_0 \\ a_1 \\ a_2 \\ b_0 \\ b_1 \\ b_2 \end{Bmatrix} \text{ for } x \leq x_{2-3} \quad (3.18a)$$

$$= \begin{bmatrix} 0 & 0 & 0 & 1 & x & x^2 \end{bmatrix} \begin{Bmatrix} a_0 \\ a_1 \\ a_2 \\ b_0 \\ b_1 \\ b_2 \end{Bmatrix} \text{ for } x \geq x_{2-3} \quad (3.18b)$$

The case of five points leads to the general pattern. We use two parabolas at the ends as in the four point case and one intermediate parabola that goes through one point and is tangent to the other parabolas.

For $x < x_{2-3} = (x_2 + x_3)/2$

$$h(x) = a_0 + a_1 x + a_2 x^2 \quad (3.19)$$

$$h'(x) = a_1 + 2a_2 x \quad (3.20)$$

For $x_{2-3} < x < x_{3-4} = (x_3 + x_4)/2$

$$h(x) = b_0 + b_1 x + b_2 x^2 \quad (3.21)$$

$$h'(x) = b_1 + 2b_2 x \quad (3.22)$$

Finally, for $x > x_{3-4}$

$$h(x) = c_0 + c_1 x + c_2 x^2 \quad (3.23)$$

$$h'(x) = c_1 + 2c_2 x \quad (3.24)$$

The nine coefficients are found from the solution of

$$\begin{bmatrix} 1 & x_1 & x_1^2 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & x_2 & x_2^2 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & x_{2-3} & x_{2-3}^2 & -1 & -x_{2-3} & -x_{2-3}^2 & 0 & 0 & 0 \\ 0 & 1 & 2x_{2-3} & 0 & -1 & -2x_{2-3} & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & x_3 & x_3^2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & x_{3-4} & x_{3-4}^2 & -1 & -x_{3-4} & -x_{3-4}^2 \\ 0 & 0 & 0 & 0 & 1 & 2x_{3-4} & 0 & -1 & -2x_{3-4} \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & x_4 & x_4^2 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & x_5 & x_5^2 \end{bmatrix} \begin{Bmatrix} a_0 \\ a_1 \\ a_2 \\ b_0 \\ b_1 \\ b_2 \\ c_0 \\ c_1 \\ c_2 \end{Bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{Bmatrix} h_1 \\ h_2 \\ h_3 \\ h_4 \\ h_5 \end{Bmatrix} \quad (3.25)$$

The general pattern is indicated by the partitioning. The equations for six or more points may be written by inspection. The equation for the curve may be written in the form

$$\left\{ \begin{array}{l} h(x < x_{2-3}) \\ h(x_{2-3} < x < x_{3-4}) \\ h(x \geq x_{3-4}) \end{array} \right\} = \left[\begin{array}{ccccccccc} 1 & x & x^2 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & x & x^2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & x & x^2 \end{array} \right] \left\{ \begin{array}{l} a_0 \\ a_1 \\ a_2 \\ b_1 \\ b_2 \\ b_3 \\ c_0 \\ c_1 \\ c_2 \end{array} \right\} \quad (3.26)$$

The curves that are obtained from this procedure resemble the deflection curve of a beam over multiple deflected supports. If only one support is deflected the curve damps out as the distance from the deflected support is increased. Some examples of the surface fits are shown in Figures 3.2 - 3.4.

The foregoing procedure may be summarized formally by re-writing Eq. 3.25 as

$$[T(x_a)] \{a_n\} = [B(x_a)] \{h_a\} \quad (3.27)$$

and Eq. 3.26 as

$$\{h(x)\} = [C(x)] \{a_n\} \quad (3.28)$$

The deflection at an arbitrary location is found in terms of the AIC control point deflections by combining Eqs. 3.27 and 3.28.

TYPICAL (W) MATRIX DEFLECTION PATTERN
FOR A UNIT DISPLACEMENT AT A

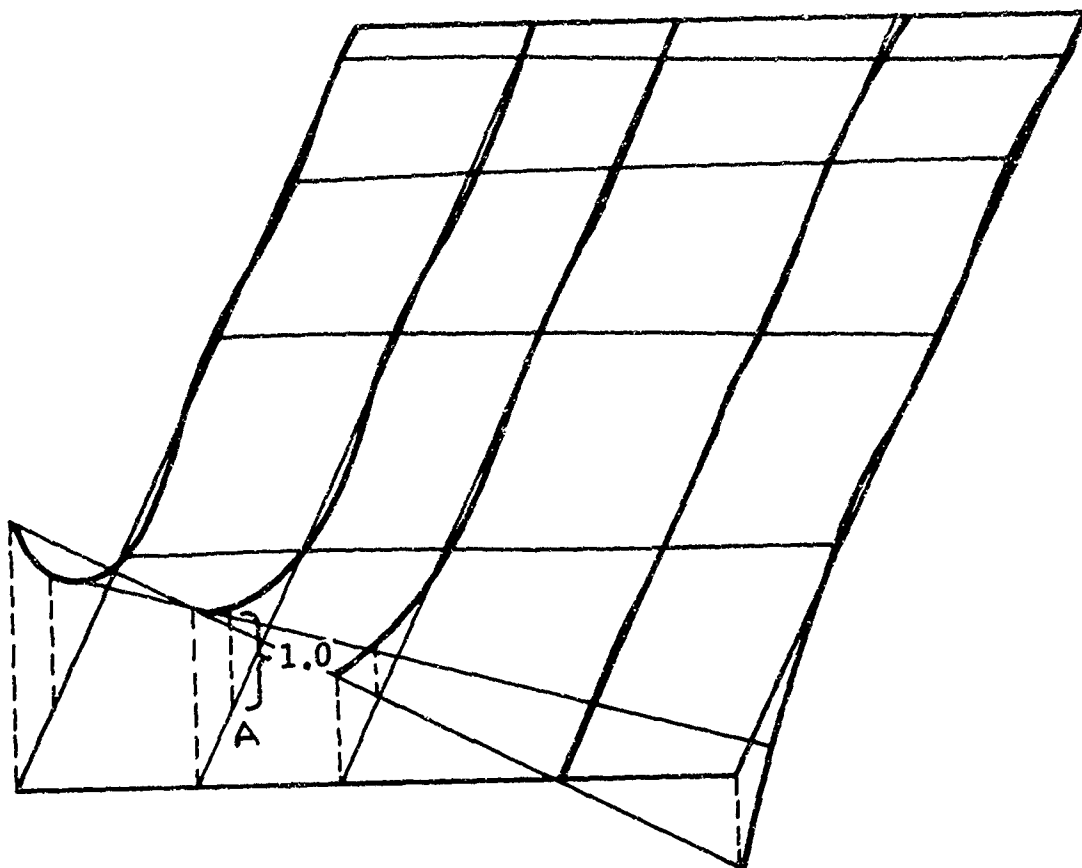


Figure 3.2

TYPICAL (W) MATRIX DEFLECTION PATTERN
FOR A UNIT DISPLACEMENT AT B

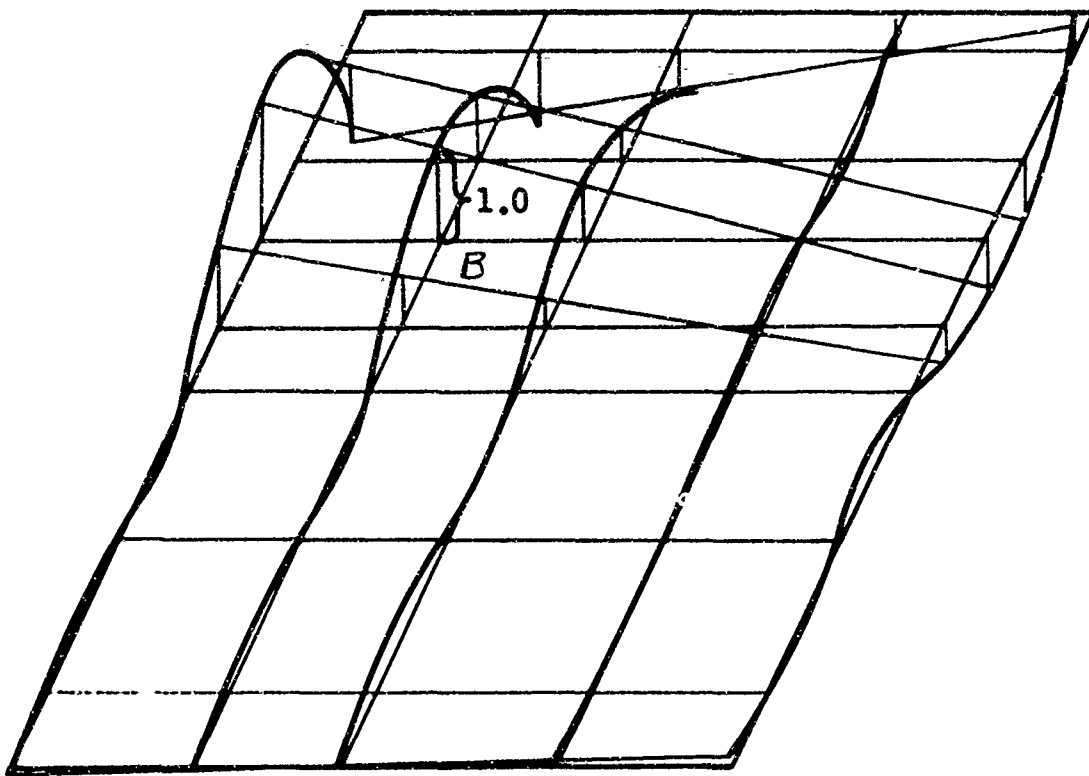


Figure 3.3

TYPICAL (W) MATRIX DEFLECTION PATTERN

FOR A UNIT DISPLACEMENT AT C

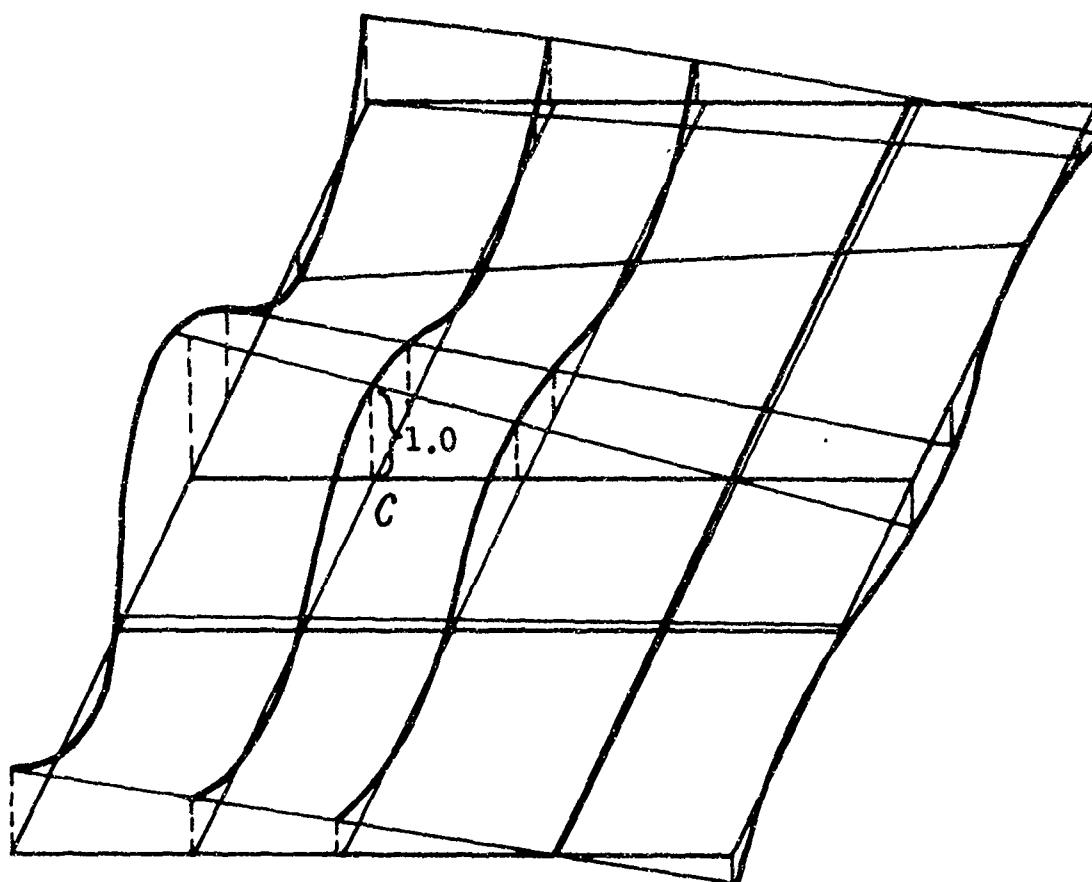


Figure 3.4

$$\{h(x)\} = [C(x)] [T(x_a)]^{-1} [B(x_a)] \{h_a\} \quad (3.29)$$

The downwash is the substantial derivative of Eq. 3.29.

$$\left\{ \frac{w(x)}{U} \right\} = \frac{\partial}{\partial x} \{h(x)\} + i \frac{\omega}{U} \{h(x)\} \quad (3.30a)$$

$$= \frac{\partial}{\partial x} \{h(x)\} + i \frac{k_r}{b_r} \{h(x)\} \quad (3.30b)$$

The derivative of Eq. 3.29 is

$$\frac{\partial}{\partial x} \{h(x)\} = [C'(x)] [T(x_a)]^{-1} [B(x_a)] \{h_a\} \quad (3.31)$$

where $[C'(x)]$ is the matrix of derivatives of $C(x)$.

We next consider the interpolation in the spanwise direction. We have already defined $\{h_a\}$ as the set of AIC control point deflections. Since the collocation points in the lifting surface theory have different chordwise and spanwise locations, we introduce the matrix $\{h_b\}$ of deflections on the AIC strip centerline at the fractional chord locations of the lifting surface theory collocation points. Interpolation among the $\{h_b\}$ on all of the strips then leads to the lifting surface theory collocation point deflections $\{h_c\}$. The substantial derivative matrix is then defined by

$$[W] \{h_a\} = \frac{\partial}{\partial x} \{h_c\} + i \frac{k_r}{b_r} \{h_c\} \quad (3.32)$$

The chordwise interpolation leads to

$$\{h_b\} = [C(x_b)] [T(x_a)]^{-1} [B(x_a)] \{h_a\} \quad (3.33)$$

and

$$\frac{\partial}{\partial x} \{h_b\} = [C'(x_b)] [T(x_a)]^{-1} [B(x_a)] \{h_a\} \quad (3.34)$$

Then the spanwise interpolation leads to

$$\{h_c\} = [C(y_c)] [T(y_a)]^{-1} [B(y_a)] \{h_b\} \quad (3.35)$$

and

$$\frac{\partial}{\partial x} \{h_c\} = [C(y_c)] [T(y_a)]^{-1} [B(y_a)] \frac{\partial}{\partial x} \{h_b\} \quad (3.36)$$

The required matrix $[W] = [W_R] + i [W_I]$ is found by combining Eqs. 3.32 - 3.36. The real and imaginary parts appear formally as

$$[W_R] = [C(y_c)] [T(y_a)]^{-1} [B(y_a)] [C'(x_b)] [T(x_a)]^{-1} [B(x_a)] \quad (3.37)$$

and

$$[W_I] = (k_r/b_r) [C(y_c)] [T(y_a)]^{-1} [B(y_a)] [C(x_b)] [T(x_a)]^{-1} [B(x_a)] \quad (3.38)$$

The formalism may be illustrated simply by considering two strips with 4 AIC points and 4 aerodynamic collocation points as shown in Figure 3.5.

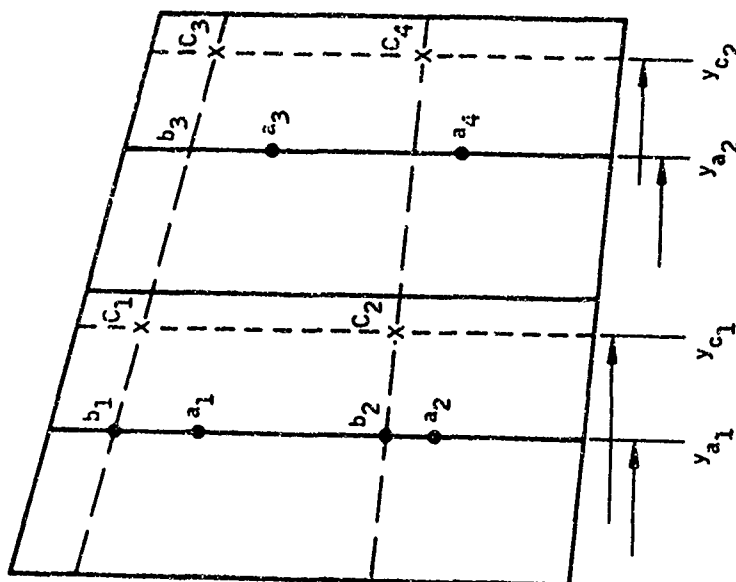


Figure 3.5

On the two strips

$$\begin{aligned} \begin{Bmatrix} h_{b_1} \\ h_{b_2} \end{Bmatrix} &= \begin{bmatrix} 1 & x_{b_1} \\ 1 & x_{b_2} \end{bmatrix} \begin{bmatrix} 1 & x_{a_1} \\ 1 & x_{a_2} \end{bmatrix}^{-1} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{Bmatrix} h_{a_1} \\ h_{a_2} \end{Bmatrix} \\ &= \begin{bmatrix} X_{12} \end{bmatrix} \begin{Bmatrix} h_{a_1} \\ h_{a_2} \end{Bmatrix} \end{aligned}$$

$$\begin{aligned} \begin{Bmatrix} h_{b_3} \\ h_{b_4} \end{Bmatrix} &= \begin{bmatrix} 1 & x_{b_3} \\ 1 & x_{b_4} \end{bmatrix} \begin{bmatrix} 1 & x_{a_3} \\ 1 & x_{a_4} \end{bmatrix}^{-1} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{Bmatrix} h_{a_3} \\ h_{a_4} \end{Bmatrix} \\ &= \begin{bmatrix} X_{34} \end{bmatrix} \begin{Bmatrix} h_{a_3} \\ h_{a_4} \end{Bmatrix} \end{aligned}$$

The slopes on the two strips are

$$\begin{aligned} \frac{\partial}{\partial x} \begin{Bmatrix} h_{b_1} \\ h_{b_2} \end{Bmatrix} &= \begin{bmatrix} 0 & 1 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & x_{a_1} \\ 1 & x_{a_2} \end{bmatrix}^{-1} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{Bmatrix} h_{a_1} \\ h_{a_2} \end{Bmatrix} \\ \frac{\partial}{\partial x} \begin{Bmatrix} h_{b_3} \\ h_{b_4} \end{Bmatrix} &= \begin{bmatrix} 0 & 1 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & x_{a_3} \\ 1 & x_{a_4} \end{bmatrix}^{-1} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{Bmatrix} h_{a_3} \\ h_{a_4} \end{Bmatrix} \end{aligned}$$

Combining the deflections yields a partitioned form

$$\begin{Bmatrix} h_{b_1} \\ h_{b_2} \\ h_{b_3} \\ h_{b_4} \end{Bmatrix} = \begin{bmatrix} \bar{X}_{12} & | & 0 \\ \hline & & \\ 0 & | & X_{34} \end{bmatrix} \begin{Bmatrix} h_{a_1} \\ h_{a_2} \\ h_{a_3} \\ h_{a_4} \end{Bmatrix}$$

The spanwise interpolation on the two spanwise lines gives

$$\begin{Bmatrix} h_{c_1} \\ h_{c_3} \end{Bmatrix} = \begin{bmatrix} 1 & y_{c_1} \\ 1 & y_{c_2} \end{bmatrix} \begin{bmatrix} 1 & y_{a_1} \\ 1 & y_{a_2} \end{bmatrix}^{-1} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{Bmatrix} h_{b_1} \\ h_{b_3} \end{Bmatrix}$$

$$= \begin{bmatrix} Y_{13} \end{bmatrix} \begin{Bmatrix} h_{b_1} \\ h_{b_3} \end{Bmatrix}$$

on the forward line and

$$\begin{Bmatrix} h_{c_2} \\ h_{c_4} \end{Bmatrix} = \begin{bmatrix} Y_{13} \end{bmatrix} \begin{Bmatrix} h_{b_2} \\ h_{b_4} \end{Bmatrix}$$

on the aft line. Combining the deflections leads to another partitioned form but also requires a row rearrangement matrix to order the $\{h_b\}$ properly

$$\begin{Bmatrix} h_{c1} \\ h_{c2} \\ h_{c3} \\ h_{c4} \end{Bmatrix} = \begin{bmatrix} \bar{Y}_{13} & | & 0 \\ \hline 0 & | & Y_{13} \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{Bmatrix} h_{b1} \\ h_{b2} \\ h_{b3} \\ h_{b4} \end{Bmatrix}$$

$$= \begin{bmatrix} Y \\ R \end{bmatrix} \begin{Bmatrix} h_{b1} \\ h_{b2} \\ h_{b3} \\ h_{b4} \end{Bmatrix}$$

The same procedure is used for the slopes. We note that Eqs. 3.37 and 3.38 must be generalized to include the row rearrangement matrix, and the formal equations for the real and imaginary parts of the substantial differentiation matrix become

$$[W_R] = [C(y_c)] [T(y_a)]^{-1} [B(y_a)] [R] [C'(x_b)] [T(x_a)]^{-1} [B(x_a)]$$

and

$$[W_I] = (k_r/b_r) [C(y_c)] [T(y_a)]^{-1} [B(y_a)] [R] [C(x_b)] [T(x_a)]^{-1} [B(x_a)]$$

where the format of each factor is illustrated in the above example.

THE INTEGRATION MATRIX [B]

The integration matrix converts the pressure distribution on each strip into an equivalent system of concentrated forces at the AIC control points by integrating the pressure spanwise and chordwise in the region of each AIC control point.

The integration of the pressure coefficient, Eq. 3.2 in the region of the AIC point leads to the force

$$F_n = q \iint C_p(\xi, \eta) d\xi d\eta \quad (3.39)$$

Letting $\eta = \cos \phi$ and $\xi = \cos \theta$ in Eqn. 3.2 and 3.7 we obtain

$$F_n = q \sum_m \sum_n a_{nm} \int_{\theta_f}^{\theta_a} \int_{\phi_i}^{\phi_o} \sin^2 \phi \sin \theta P_m(\eta) f_n(\xi) d\phi d\theta \quad (3.39A)$$

where θ_f and θ_a denote the chordwise angular measure of the forward and aft locations, respectively, of the pressure region, and ϕ_i and ϕ_o denote the spanwise angular measure of the inboard and outboard end, respectively, of the strip. If we define the spanwise integral

$$I_m(\eta_i, \eta_o) = \int_{\phi_i}^{\phi_o} \sin^2 \phi P_m(\eta) d\phi \quad (3.39B)$$

and the chordwise integral

$$J_n(\xi_f, \xi_a) = \int_{\theta_f}^{\theta_a} \sin \theta f_n(\xi) d\theta \quad (3.39C)$$

then the force from the nm mode is

$$F_{n_{nm}} = q \sum_m \sum_n a_{nm} I_m J_n \quad (3.39D)$$

and in matrix form

$$F_n = q \sum_m \sum_n \left[I_m J_n \right] \left\{ a_{nm} \right\} \quad (3.39E)$$

so that the integration matrix $[B]$ is given by

$$[B] = \left[I_m(\eta_i, \eta_o) J_n(\xi_f, \xi_a) \right] \quad (3.39F)$$

The integrals are easily evaluated. Consider first the spanwise integration. In terms of the spanwise angular coordinate ϕ we note

$$P_0(\eta) = 1.0 \quad (3.40)$$

$$\begin{aligned} P_m(\eta) &= \eta^2 U_{m-1}(\eta) \\ &= \cos^2 \phi \sin m \phi / \sin \phi, \quad 1 \leq m \end{aligned} \quad (3.40A)$$

Then

$$\begin{aligned} I_0(\eta_i, \eta_o) &= \int_{\phi_i}^{\phi_o} \sin^2 \phi \, d\phi \\ &= \frac{1}{2} (\cos^{-1} \eta_o - \cos^{-1} \eta_i - \eta_o \sqrt{1 - \eta_o^2} + \eta_i \sqrt{1 - \eta_i^2}) \end{aligned} \quad (3.40B)$$

For $m \geq 1$

$$I_m = \int_{\phi_i}^{\phi_o} \sin \phi \cos^2 \phi \sin m \phi \, d\phi \quad (3.40C)$$

from which

$$\begin{aligned} I_1 &= \int_{\phi_i}^{\phi_o} \sin^2 \phi \cos^2 \phi \, d\phi \\ &= \frac{1}{4} \left[\eta_o (1 - \eta_o^2)^{3/2} - \eta_i (1 - \eta_i^2)^{3/2} + I_0 \right] \end{aligned} \quad (3.40C)$$

and for $m \neq 1, 3$,

$$\begin{aligned} I_m &= \frac{1}{4} \left\{ \frac{1}{m-1} \left[\sin(m-1)\phi_o - \sin(m-1)\phi_i \right] \right. \\ &\quad - \frac{1}{m+1} \left[\sin(m+1)\phi_o - \sin(m+1)\phi_i \right] \\ &\quad + \frac{1}{m-3} \left[\sin(m-3)\phi_o - \sin(m-3)\phi_i \right] \\ &\quad \left. - \frac{1}{m+3} \left[\sin(m+3)\phi_o - \sin(m+3)\phi_i \right] \right\} \end{aligned} \quad (3.40D)$$

$$\text{NOTE: } \sin n\phi = 2 \cos \phi \sin (n-1) \phi - \sin (n-2) \phi \quad (3.40E)$$

$$\text{so that } \sin n\phi_o = 2 \eta_o \sin (n-1) \phi_o - \sin (n-2) \phi_o$$

$$\text{and } \sin n\phi_i = 2 \eta_i \sin (n-1) \phi_i - \sin (n-2) \phi_i$$

Finally,

$$\begin{aligned} I_3 = 3I_1 - \frac{2}{3} & \left[\eta_o (1 - \eta_o^2)^{5/2} - \eta_i (1 - \eta_i^2)^{5/2} \right] \\ & - \left\{ \frac{1}{4} \cos^{-1} \eta_o - \frac{1}{4} \cos^{-1} \eta_i - \frac{1}{4} \left(\eta_o \sqrt{1 - \eta_o^2} - \eta_i \sqrt{1 - \eta_i^2} \right) \right. \\ & \left. - \frac{1}{6} \left[\eta_o (1 - \eta_o^2)^{3/2} - \eta_i (1 - \eta_i^2)^{3/2} \right] \right\} \end{aligned} \quad (3.40D)$$

Consider next the chordwise integral. In terms of the chordwise angular coordinate ϕ we note

$$r_o(\tilde{\xi}) = \frac{1 - \cos \phi}{\sin \phi} \quad (3.41)$$

$$r_n(\tilde{\xi}) = \sin n\phi, \quad n \geq 1 \quad (3.42)$$

$$\begin{aligned} J_o(\tilde{\xi}_f, \tilde{\xi}_a) &= \int_{\phi_f}^{\phi_a} (1 - \cos \phi) d\phi \\ &= \cos^{-1} \tilde{\xi}_a - \cos^{-1} \tilde{\xi}_f - \sqrt{1 - \tilde{\xi}_a^2} + \sqrt{1 - \tilde{\xi}_f^2} \end{aligned} \quad (3.43)$$

For $n \geq 1$

$$\begin{aligned} J_n &= \frac{1}{2(n-1)} \left[\sin (n-1) \phi_a - \sin (n-1) \phi_f \right] \\ &= \frac{1}{2(n+1)} \left[\sin (n+1) \phi_a - \sin (n+1) \phi_f \right] \end{aligned} \quad (3.44)$$

and for $n = 1$

$$J_1 = \frac{1}{2} \left[\cos^{-1} \tilde{\xi}_a - \cos^{-1} \tilde{\xi}_f - \tilde{\xi}_a \sqrt{1 - \tilde{\xi}_a^2} + \tilde{\xi}_f \sqrt{1 - \tilde{\xi}_f^2} \right] \quad (3.45)$$

To illustrate the format of $[B]$ consider the s^{th} strip

$$[B_s] = \begin{bmatrix} I_m(\eta_s) J_n(\tilde{\xi}_1) \\ I_m(\eta_s) J_n(\tilde{\xi}_2) \\ \vdots \\ I_m(\eta_s) J_n(\tilde{\xi}_{NC}) \end{bmatrix} \quad (3.46)$$

where η_s denotes the midpoint of the s^{th} strip, and $\tilde{\xi}_1, \tilde{\xi}_2, \dots, \tilde{\xi}_{NC}$ denote the first through NC chordwise forces on the strip. Generalizing to NS strips and illustrating the dependence on n and m we have

$$[B] = \begin{bmatrix} I_0(\eta_1) J_0(\tilde{\xi}_1) & I_1(\eta_1) J_1(\tilde{\xi}_1) & \dots & I_{NS}(\eta_1) J_{NS}(\tilde{\xi}_1) \\ I_0(\eta_1) J_0(\tilde{\xi}_2) & I_1(\eta_1) J_1(\tilde{\xi}_2) & \dots & I_{NS}(\eta_1) J_{NS}(\tilde{\xi}_2) \\ \vdots & \vdots & \ddots & \vdots \\ I_0(\eta_1) J_0(\tilde{\xi}_{NC}) & I_1(\eta_1) J_1(\tilde{\xi}_{NC}) & \dots & I_{NS}(\eta_1) J_{NS}(\tilde{\xi}_{NC}) \\ I_0(\eta_2) J_0(\tilde{\xi}_1) & I_1(\eta_2) J_1(\tilde{\xi}_1) & \dots & I_{NS}(\eta_2) J_{NS}(\tilde{\xi}_1) \\ \vdots & \vdots & \ddots & \vdots \\ I_0(\eta_2) J_0(\tilde{\xi}_{NC}) & I_1(\eta_2) J_1(\tilde{\xi}_{NC}) & \dots & I_{NS}(\eta_2) J_{NS}(\tilde{\xi}_{NC}) \\ \vdots & \vdots & \ddots & \vdots \\ I_0(\eta_{NS}) J_0(\tilde{\xi}_1) & I_1(\eta_{NS}) J_1(\tilde{\xi}_1) & \dots & I_{NS}(\eta_{NS}) J_{NS}(\tilde{\xi}_1) \\ \vdots & \vdots & \ddots & \vdots \\ I_0(\eta_{NS}) J_0(\tilde{\xi}_{NC}) & I_1(\eta_{NS}) J_1(\tilde{\xi}_{NC}) & \dots & I_{NS}(\eta_{NS}) J_{NS}(\tilde{\xi}_{NC}) \end{bmatrix} \quad (3.47)$$

DERIVATION OF SONIC AND SUPERSONIC AERODYNAMIC INFLUENCE COEFFICIENTS

The supersonic Mach box method was developed by Zartarian and Hsu⁴ and extended to intersecting planar lifting surfaces by Moore and Andrew⁵. The sonic box method was developed by Rodemich and Andrew⁶. A further extension to the wing-tail combination was made by Moore and Park² and refined by Andrew³. (NOTE: These references are outlined in Part I, Section A for the sonic case, and in Part VI, Section A for the supersonic case.

The box methods lead to the velocity potentials whose streamwise substantial derivative gives the pressure coefficient. The solution for the velocity potentials may be written [cf. Eq. (7)]

$$\{\phi\} = [A_{M \geq 1}] \{w/V\} \quad (3.48)$$

The pressure coefficients are given by

$$\{C_p\} = (2/a M) [W_a] \{\phi\} \quad (3.49)$$

where $[W_a]$ is the substantial derivative evaluated at the box centers. Since the boxes are all small the aerodynamic force on the boxes are approximately given by the product of the box pressure and its area. The forces on a strip (assumed to be narrow) are regarded as acting at the strip centerline and at the chordwise centerline of each spanwise line of boxes, and are found by summing spanwise the contribution of each box to the strip.

$$\{F_a\} = q [A] \{C_p\} \quad (3.50)$$

The elements of the diagonal area matrix $[A]$ consist of the appropriate box area or fractions thereof lying on the strip from each spanwise line of boxes.

The box forces are converted into AIC control point forces by the static equivalence of the box forces in the region of each control point, i.e., the control points are assumed to be connected by a series of simple beams, hinged at each control point, so that the AIC control point forces are the reactions to the box forces distributed along the series of beams. This leads to approximate generalized forces since this method of representing the chordwise deflections is not consistent with that used in the $[W]$ matrix. However, it leads to a more physically meaningful distribution of AIC forces, and the resulting approximation to the generalized forces in an arbitrary vibration mode is sufficiently accurate. Denoting the statically equivalent transformation matrix by $[T]$ we have the AIC forces

$$\{F\} = [T] \{F_a\} \quad (3.51a)$$

$$= q [T] [A] \{C_p\} \quad (3.51b)$$

If the foregoing equations are combined, including Eq. 3.8, the AIC control forces are related to the control point deflections through

$$\{F\} = (2q/a M) [T] [A] [W_a] [A_{M \geq 1}] [W] \{h\} \quad (3.52)$$

and leads to the AIC's by comparison with Eq. 3.1.

$$[C_h] = (1/a M k_r^2 s) [T] [A] [W_a] [A_{M \geq 1}] [W] \quad (3.53)$$

PART IV - SECTION A

TECHNICAL DISCUSSION OF THE SUBSONIC
KERNEL FUNCTION METHOD

INTRODUCTION

In defining aerodynamic influence coefficients, the aerodynamic loads are first derived by the well documented "Kernel function" method, and the resulting loads are then converted to aerodynamic influence coefficients. The procedure followed uses results from any of the pertinent papers, and extends the analysis to cover the problem of tandem surfaces.

The first published numerical procedure for solving the subsonic pressure distribution problem for isolated planar lifting surfaces undergoing simple harmonic motion was developed at NASA's Langley Research Center by Watkins, Runyan, and Woolston (Reference 1). Hsu (Reference 7) significantly advanced the logical development of the method when he established an optimum set of collocation and integration points. Rodemich (Reference 8), and later Landahl (Reference 9), have presented expressions for the kernel that are very much simpler than those previously used, and they take less time to evaluate. A further advance was made by Rodden and Revell (Reference 10), who described the matching of the boundary conditions with the least squared error. Rowe (Reference 11) has shown that to obtain sufficiently accurate results using Hsu's procedure, an extremely large number of collocation points must be used and when this is done, using the spanwise pressure function that Hsu and Watkins used, the downwash matrix becomes ill-conditioned. Rowe overcame this problem by using a Fourier series for the spanwise pressure function.

The present method uses Hsu's set of collocation points, Rodemich's expression for the kernel, Rodden and Revell's idea for matching the boundary conditions, and, like Rowe does, it uses an orthogonal set of functions for the spanwise pressure function. However, the present method utilizes these developments in a way that has not been previously published. The techniques employed result in speeds and accuracy not previously attained.

TANDEM SURFACE VIBRATION IN SUBSONIC FLOW

The method presented herein was developed for application to a missile with a very low aspect ratio, trapezoidal wing and a downstream rectangular control surface lying in the wake of the wing. The diameter of the body of the missile is considered large enough to act as a reflection plane for acoustic signals that emanate from points on the lifting surfaces.

The problem to be considered is that of determining the air loads on the wing and control surface which are induced by a simple harmonic motion. The surrounding fluid is assumed to be compressible, inviscid isentropic, and irrotational. The perturbation potential is used, and the problem is further linearized by applying boundary conditions at the mean ($z = 0$) surface. Thickness effects are ignored. With these hypothesis, it is well known that an integral relation exists between the pressure discontinuity over the surface $z = 0$ and the downwash over the same plane. If the downwash and pressure difference are representable in the form

$$\begin{aligned} W_1(x, y, 0, t) &= W(x, y)e^{i\omega t} \\ \Delta P_1(x, y, 0, t) &= \Delta P(x, y)e^{i\omega t} \end{aligned} \quad (4.1)$$

The integral relation becomes

$$\frac{W(x, y)}{U} = -\frac{1}{8\pi} \iint \frac{\Delta P(\xi, \eta)}{\frac{1}{2}\rho U^2} K\left(\frac{\omega}{U}, M, x - \xi, y - \eta\right) d\xi d\eta \quad (4.2)$$

The integral extends over the plane $z = 0$, but the integrand is zero except over the wing and control surface. The kernel function K is strongly singular and integration in a spanwise direction requires the use of the finite part concept. This is indicated by the cross on the integration sign. Equation (4.2) then represents the integral equation of the system wherein, given $W(x, y)$ over the wing and control surface, ΔP must then be determined.

The function $K(k, M, x-\xi, y-\eta)$ is represented here in the form

$$K\left(\frac{\omega}{U}, M, x-\xi, y-\eta\right) = e^{-i \frac{\omega}{U} (x-\xi)} \frac{K_1}{(y-\eta)^2} \quad (4.3)$$

where

$$K_1 = -k_1 K_1(k_1) - \frac{(x-\xi)}{R} e^{-i k_1 u_1} + i k_1 \int_0^1 \frac{W e^{-k_1 W}}{\sqrt{1-W^2}} dW + i k_1 \int_0^{u_1} \frac{u e^{-i k_1 u}}{\sqrt{1+u^2}} du \quad (4.4)$$

$$\text{and } R = \sqrt{(x-\xi)^2 + \beta^2 r_1^2}$$

$$r_1 = |y-\eta|$$

$$k_1 = \frac{\omega r_1}{U}$$

$$u_1 = \frac{MR - (x-\xi)}{\beta^2 r_1}$$

$$M = \text{Mach number}$$

$$\beta^2 = 1 - M^2$$

$K_1(k_1)$ is the modified Bessel function of the second kind of order one and argument k_1 .

This form for the kernel function has been used in References 8 and 9. While it is not identical to that of Reference 1, it may be obtained directly from that equation by substitution of the integral representation of the modified Bessel and Struve functions. The second order singularity in the spanwise variable in Equation(4.3) requires the use of the "finite part" technique of Hadamard.

PRESSURE DISTRIBUTION

As in many earlier studies, the pressure distribution is approximated as the sum of a series of functions which have the proper behavior as inferred from steady state and two-dimensional solutions. This behavior includes a Kutta condition at the trailing edge, a square root singularity at the leading edge, and a half ordered zero at the top for each surface. The pressure distribution on each surface is then approximated in the form

$$\frac{\Delta p(\xi, \eta)}{\frac{1}{2} \rho U^2} = \frac{\sqrt{s^2 - \eta^2}}{b(\eta)} \sum_{n=0}^N \sum_{m=0}^M a_{nm} P_m(\eta) f_n(\xi) \quad (4.5)$$

where

$$\begin{aligned} f_0(\xi) &= \sqrt{\frac{1 - \xi}{1 + \xi}} & f_n(\xi) &= \sqrt{1 - \xi^2} U_{n-1}(\xi); \quad 1 \leq n \\ P_0(\eta) &= 1.0 & P_m(\eta) &= \eta^2 U_{m-1}(\eta); \quad 1 \leq m \\ U_0(x) &= 1.0 \\ U_1(x) &= 2x & (4.6) \\ U_k(x) &= 2xU_{k-1}(x) - U_{k-2}(x); \quad 2 \leq k \\ \tilde{\xi} &= \frac{\xi - \bar{\xi}}{b(\eta)} & \text{and} & \quad \bar{\xi} = \frac{1}{2}(\xi_{l.e.} + \xi_{t.e.}) \\ \eta &= \frac{\eta}{s} \end{aligned}$$

The functions U_n are Chebyshev Polynomials and are introduced for purposes of convenience.

For a trapezoidal wing, the lines $\xi = \text{constant}$ and $\eta = \text{constant}$ are not orthogonal. This transformation maps each surface into a square in its (ξ, η) plane.

The fundamental integral Equation (4.2) is inverted by substituting Equation (4.5) into Equation (4.1), and determining the coefficient a_{nm} so that Equation (4.2) is equilibrated at a designated set of collocation points. This equilibrium is represented schematically in the form

$$\begin{Bmatrix} \left\{ \frac{W}{U} \right\} \\ \left\{ \frac{C}{U} \right\} \end{Bmatrix} = \begin{bmatrix} D_{nm}^{ww} & D_{nm}^{wc} \\ D_{nm}^{cw} & D_{nm}^{cc} \end{bmatrix} \begin{Bmatrix} \left\{ a_{nm}^{(w)} \right\} \\ \left\{ a_{nm}^c \right\} \end{Bmatrix} \quad (4.7)$$

The left hand side of Equation (4.7) represents the prescribed downwash at the chosen set of collocation points. $D_{nm} a_{nm}$ is the effect on downwash of the corresponding term in the pressure series expansion. The superscripts W and C designate wing and control surface, respectively. The left superscript on the D's indicate the surface on which the collocation point is located, the right superscript, the surface over which the integral is taken. Then $D_{nm}(x, y)$ is given by

$$D_{nm}(x, y) = -\frac{S^2}{8\pi} \int_{-1}^1 \sqrt{1-\eta^2} P_m(\eta) \int_{-1}^1 f_n(\xi) \frac{K_1(x-\xi, y-\eta)}{(y-\eta)^2} d\xi d\eta \quad (4.8)$$

The integrals involved in Equation (4.8) are evaluated by following the methods of Hsu. In this procedure, the Gauss-Mehler quadrature is used, and the collocation points are selected by a method which is analogous to using the Gauss-Mehler quadrature on the inverse problem.

In brief, this technique is concerned with a numerical evaluation of an integral in the form

$$\int_a^b W(x) f(x) dx \approx \sum_{j=1}^n H_j f(x_j)$$

Where $W(x)$ is a given weighting function, $f(x)$ an arbitrary function, and H_j are weighting numbers. The first choice of points x_j is taken to be that corresponding to which the approximate integration would be exact for a polynomial of degree less than or equal to $2n-1$. The integration points and weighting numbers are listed in Kopel (Reference 12) page 283. They are; for

$$\begin{aligned} W(x) &= (1-x)^\alpha (1+x)^\beta & (\alpha, \beta) &= \left(\pm \frac{1}{2}\right) \\ & & (a, b) &= (-1, +1) \\ \alpha = \beta = \frac{1}{2} & \quad x_j = \cos \left(\frac{\pi j}{n+1} \right), & H_j &= \frac{\pi(1-x_j^2)}{n+1} \\ \alpha = \beta = -\frac{1}{2} & \quad x_j = \cos \left(\frac{(2j-1)\pi}{2n} \right), & H_j &= \frac{\pi}{n} \\ \alpha = -\beta = \frac{1}{2} & \quad x_j = \cos \frac{2\pi j}{2n+1}, & H_j &= \frac{2\pi(1-x_j)}{2n+1} \\ \alpha = -\beta = -\frac{1}{2} & \quad x_j = \cos \frac{(2j-1)\pi}{2n+1}, & H_j &= \frac{2\pi(1+x_j)}{2n+1} \end{aligned} \quad (4.9)$$

where $j = 1, 2, \dots, n$

The inner integral of Equation (4.8) is then evaluated by using the third of Equation (4.9), With the previously defined notation then

$$\int_{-1}^{+1} \sqrt{\frac{1-\tilde{\xi}}{1+\tilde{\xi}}} F_n(\tilde{\xi}) d\tilde{\xi} = \frac{2\pi}{2L+1} \sum_{k=1}^L H_k F_n(\tilde{\xi}_k) \quad (4.10)$$

where $H_k = 1 - \tilde{\xi}_k$

$$\tilde{\xi}_k = -\cos \left(\frac{2k-1}{2L+1} \pi \right)$$

Hsu pointed out that if the collocation points are interdigitated according to the formula

$$\tilde{x}_j = -\cos \left(\frac{2j}{2L+1} \pi \right)$$

the inner integral is evaluated with the least squared error by Equation (4.10).

This minimization was of course achieved for a single surface, but the convention was retained for the tandem surface model.

Hsu did not take advantage of the fact that the number of collocation points does not need to be as great as the number of integration points. In the present method the computer program user may specify the number of integration points to be any positive integer times the number of chordwise collocation points, so long as the number of integration points is 40 or less. Sixteen, or more, chordwise integration points are recommended. Accurate results can be assured only if the user specified a sufficient number of quadrature points for the integral.

Substitution of Equation (4.10) into Equation (4.8) gives

$$D_{nm} = \frac{-s^2}{8\pi} \int_{-1}^{+1} \frac{\sqrt{1-\eta^2}}{(y-\eta)^2} G_{nm}(x, y-\eta) d\eta \quad (4.11)$$

where

$$G_{nm} = \frac{2\pi}{2L+1} P_n(\eta) \sum_{k=1}^L (1-\xi_k^2) U_{n-1}(\xi_k) K_1(x-\xi_k, y-\eta); \quad 1 \leq n$$

The integral for D_{nm} is singular. The Gauss-Mehler technique is again followed. This time the first of Equations (4.9) is used to perform the integration, and the finite part modification is introduced. With these constraints, Hsu has shown that the evaluation for D_{nm} becomes

$$D_{nm} = -\frac{1}{8\pi} \left\{ \frac{\pi s^2}{M+1} \sum_{p=1}^{M+1} \frac{(1-\eta_p)^2}{(y-\eta_p)^2} G_{nm}(x, y-\eta_p) - \pi (M+1) G_{nm}(x, 0) \right\}$$

and

$$G_{nm}(x, 0) = -2 \int_{-1}^x P_m(\tilde{\xi}) f_n(\tilde{\xi}) e^{-i \frac{\omega}{U}(x - \tilde{\xi})} d\tilde{\xi}$$

When the collocation point lies on the control surface this integral is taken over the wing, from the leading edge ($\tilde{\xi} = -1$) to the trailing edge ($\tilde{\xi} = +1$), and over the control surface, from the leading edge to the collocation point ($\tilde{\xi} = x$). The integrand of this expression does not vary widely over the region of integration and is evaluated with sufficient accuracy by a six-point quadrature formula. It has been made a part of the computer program and may not be controlled by the user.

PART IV - SECTION B
SUBSONIC AIC COMPUTER PROGRAM DESCRIPTION

A FORTRAN IV computer program is presented which computes subsonic unsteady aerodynamic influence coefficients for a variety of tandem coplanar lifting surface configurations. The computer solution is based on a kernel function formulation which satisfies the linearized equations of motion of an inviscid, isentropic, compressible and irrotational fluid. The analysis is extended to include interaction effects between tandem surfaces and wake effects on the trailing surface.

The various configurations which can be analyzed are shown in Figure 4.1. The vehicle body is considered as a reflection plane for acoustic signals emanating from the aerodynamic surfaces thereby giving the surfaces a plane of symmetry, parallel to the free-stream flow. The upstream surface (wing) must have an unswept trailing edge and the rectangular trailing surface must have the same spanwise dimension as the trailing edge of the wing. The downstream surface lies in the wake of the wing; any non-negative value may be used for the gap dimension. A single surface cannot be analyzed, however, an option is provided which eliminates interaction effects. Thus it is possible to generate AIC's for individual surfaces isolated from disturbances in the flow field.

The program allows up to 40 AIC control points, 20 per surface. The AIC stations must satisfy the following requirements:

- (1) Both surfaces must have the same number of spanwise rows of control points. The chordwise location of respective rows on the surfaces need not be the same.
- (2) The chordwise rows must be parallel to the flow stream.
- (3) The chordwise rows on a surface must have the same number of control points.
- (4) The control points in each spanwise row must have the same fractional chord location.
- (5) The minimum number of chordwise or spanwise control points for a surface is two and the maximum number is ten.
- (6) The origin for the AIC station coordinates and the geometric coordinates for the planform must be at the leading edge root of the wing.

Examples of acceptable AIC control point patterns for the subsonic program are illustrated in Figure 4.2.

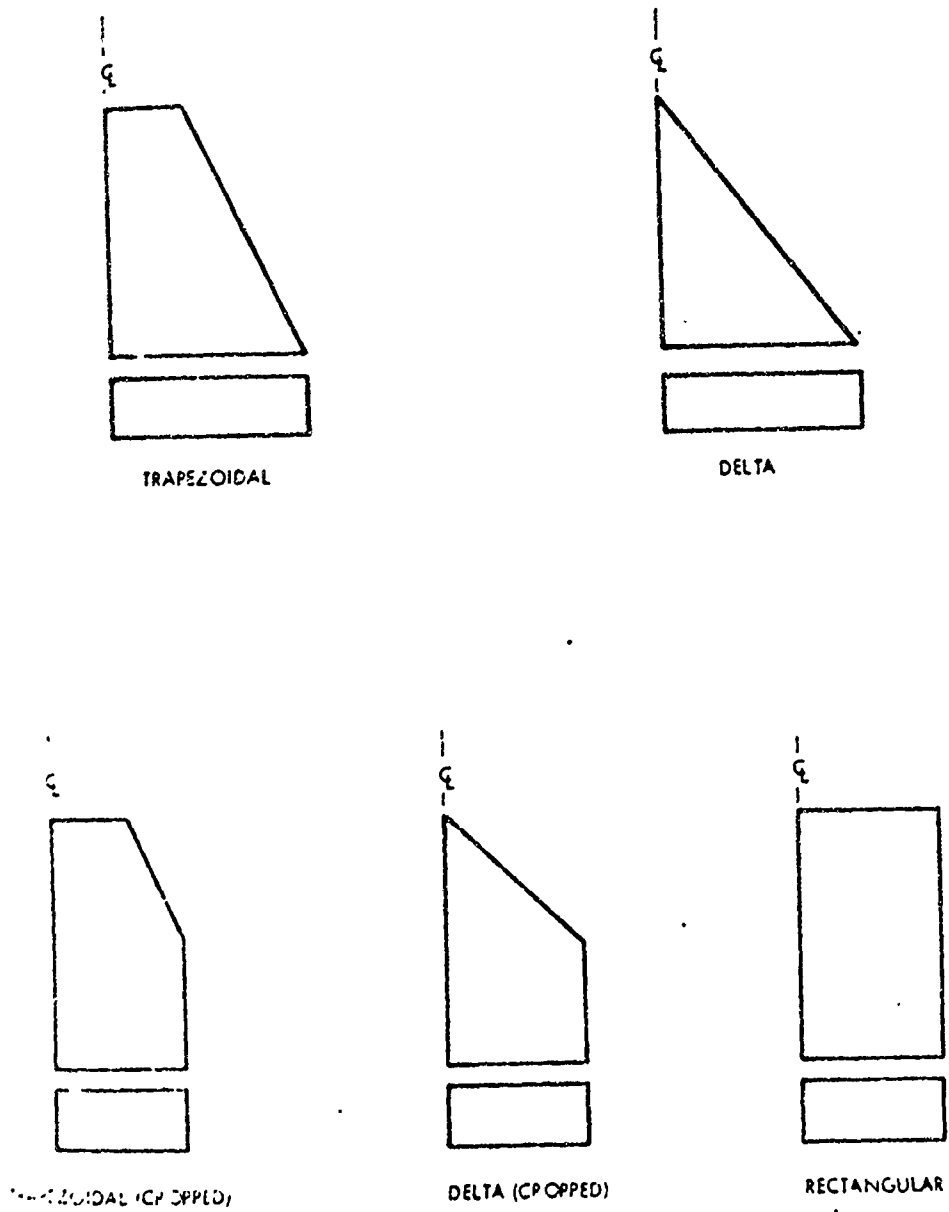


FIGURE 4.1 - TANDEM COPLANAR CONFIGURATIONS AT SUBSONIC MACH NUMBER

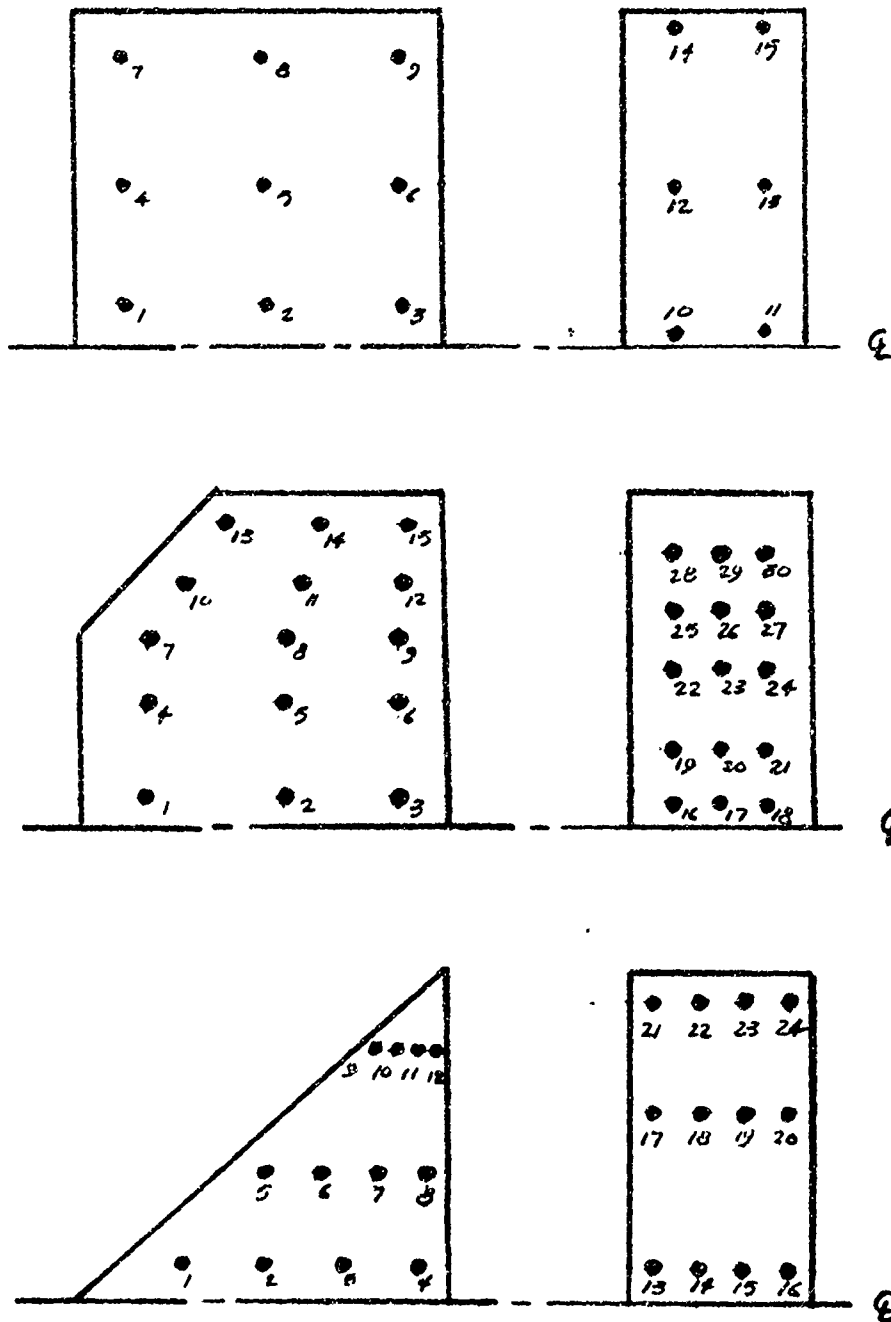


FIGURE 4.2 - EXAMPLES OF ACCEPTABLE AIC CONTROL POINT PATTERNS FOR THE SIRSONIC PROGRAM

The computer program consists of a main program (MAIN) and 24 subroutines and functions subprograms. Execution begins with MAIN calling KFPA which reads input data and stores this information in core. The program then calls TRAMP which generates the substantial derivative matrix, $[W]$. The $[W]$ matrix serves two functions. It relates the collocation stations of the unsteady aerodynamics to the control stations of the AIC matrix and it serves as a substantial derivative operator. Subroutines called by TRAMP are CMAT, SMAT, TMAT, BMAT, RMAT and MINV.

The next item computed is the kernel function matrix, $[D]$. The subroutine CORD is called for each unsteady aerodynamic collocation station and constructs the kernel function matrix which is dependent only on the relative location of the collocation stations and the Mach number-reduced frequency combination.

The pressure coefficients $\{a_{nm}\}$ are found from the relation

$$\{a_{nm}\} = [D]^{-1} [W]$$

The program has been written such that the number of spanwise and chordwise pressure coefficient terms and the number of spanwise and chordwise collocation stations for the unsteady aerodynamics matches the respective number of AIC control points on each surface. Thus the Kernel function matrix is square and its inverse is computed directly. The subroutines employed for this operation are CGRED and XLSQ.

After deriving the pressure coefficients, the pressure terms are integrated spanwise and chordwise to obtain the force acting at each AIC control station. The resulting matrix, after it is multiplied by a non-dimensionalizing factor, is the final AIC matrix, $[C_h]$. By definition, the AIC matrix relates forces to displacements through the equation

$$\{F\} = \rho \omega^2 b_r^2 s [C_h] \{h\}$$

The semi-chord of the wing root is used as the reference chord, b_r . s is the semi-span of the wing (and tail) and ω is the oscillatory frequency in radians/sec. This final phase of the subsonic AIC development uses the subroutines AICS, FORCE, ARCCOS, MINTS, and MINTC.

1.0 PROCESSING REQUIREMENTS

The input and output files used by the program are 05 and 06, respectively. All read and write statements are contained in the main program (MAIN) and the subroutines KFDA and KOUT. Peripheral tape and disc units are not used by the program. Approximately 40,000 cells of core storage is required. A standard input form of six 12-column fields per card is used by the program. Floating point numbers (6E12.5 format) may lie anywhere within the appropriate field, but fixed point numbers (6I12 format) must be right adjusted. Detailed instructions for data input are given and listings of data for sample problems are provided.

2.0 INPUT INSTRUCTIONS

Instructions for preparing input data for the subsonic AIC computer program are presented here. The field location and format for each input quantity is specified. Any set of units may be used for geometric dimensions and acoustic velocity as long as they are consistent, e.g., if feet is used for length then the acoustic velocity must have dimensions of feet per second.

1. Streamwise Coordinates (6E12.5 format)

Column	1-12	13-24	25-36	37-48	49-60	61-72
Name	X(1)	X(2)	X(3)	X(4)	X(5)	
Item	(1)	(2)	(3)	(4)	(5)	

- (1) X(1) Wing root leading edge streamwise coordinate
- (2) X(2) Wing tip leading edge streamwise coordinate
- (3) X(3) Wing trailing edge streamwise coordinate
- (4) X(4) Control surface leading edge streamwise coordinate
- (5) X(5) Control surface trailing edge streamwise coordinate

The technique for generating various configurations is shown in Table 4.1.

The origin for the planform and AIC station coordinates must be at the leading edge root of the wing therefore X(1) and Y(1), described below, must always be 0.0.

2. Spanwise Coordinates and Acoustic Velocity (6E12.5 format)

Column	1-12	13-24	25-36	37-48	49-60	61-72
Name	Y(1)	Y(2)	Y(3)	SOUND		
Item	(1)	(2)	(3)	(4)		

- (1) Y(1) Wing root spanwise coordinate
- (2) Y(2) Wing leading edge spanwise coordinate
- (3) Y(3) Wing (and control surface) tip spanwise coordinate
- (4) SOUND Acoustic velocity for altitude at which analysis is performed

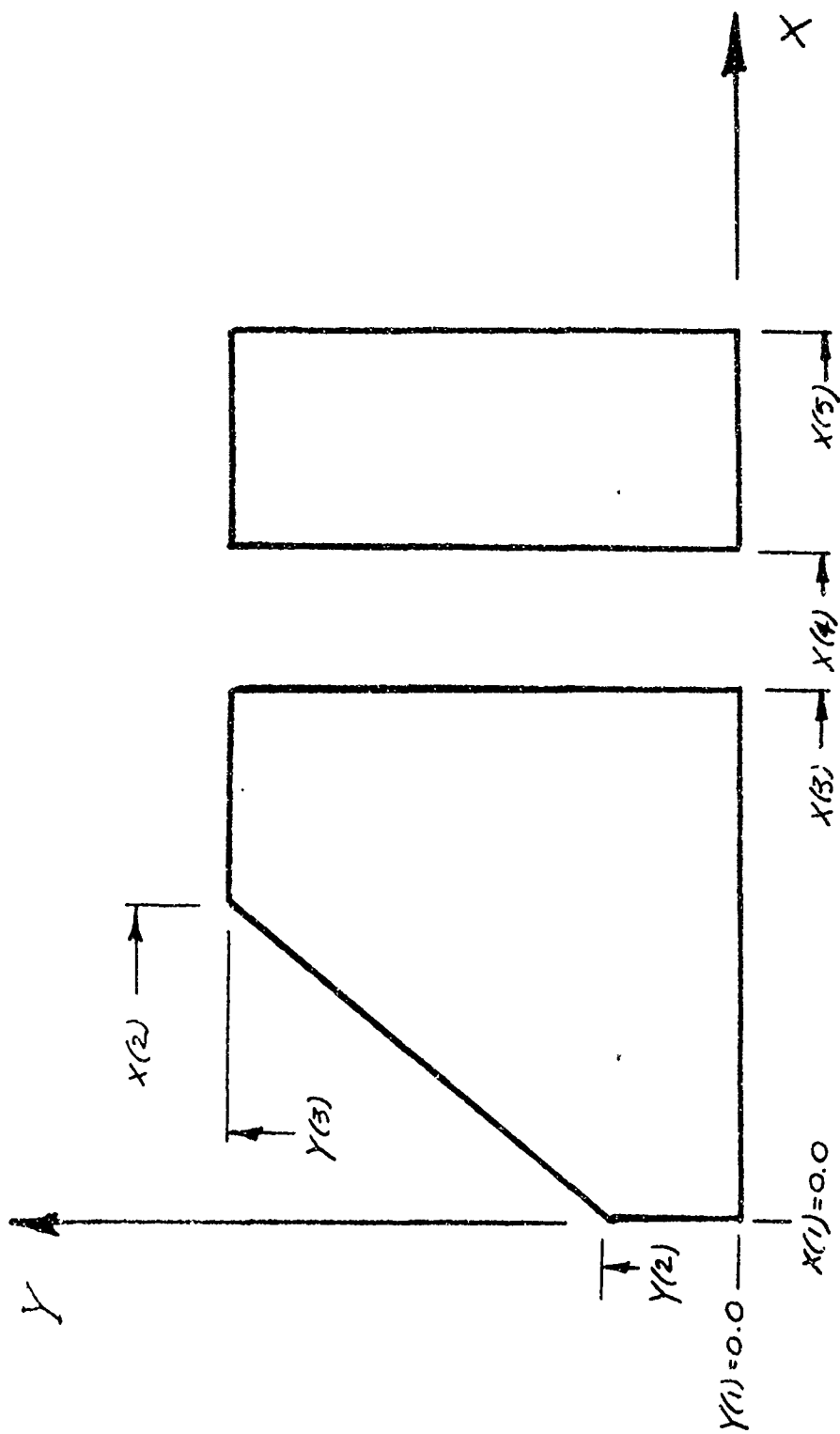


FIGURE 1.3 - GEOMETRY DESCRIPTION

TABLE 4.1 - OPTIONAL CONFIGURATIONS

Configuration	Chordwise Coordinates	Spanwise Coordinates
Rectangular	$X(1) = 0.0$ $X(2) = 0.0$ $X(3) > 0.0$ $X(4) > X(3)$ $X(5) > X(4)$	$Y(1) = 0.0$ $Y(2) = 0.0$ $Y(3) > 0.0$
Delta	$X(1) = 0.0$ $X(2) > 0.0$ $X(3) = X(2)$ $X(4) > X(3)$ $X(5) > X(4)$	$Y(1) = 0.0$ $Y(2) = 0.0$ $Y(3) > 0.0$
Trapezoidal	$X(1) = 0.0$ $X(2) > 0.0$ $X(3) = X(2)$ $X(4) > X(3)$ $X(5) > X(4)$	$Y(1) = 0.0$ $Y(2) > 0.0$ $Y(3) > Y(2)$
Trapezoidal (Cropped)	$X(1) = 0.0$ $X(2) > X(1)$ $X(3) > X(2)$ $X(4) > X(3)$ $X(5) > X(4)$	$Y(1) = 0.0$ $Y(2) > 0.0$ $Y(3) > Y(2)$
Delta (Cropped)	$X(1) = 0.0$ $X(2) > 0.0$ $X(3) > X(2)$ $X(4) > X(3)$ $X(5) > X(4)$	$Y(1) = 0.0$ $Y(2) = 0.0$ $Y(3) > Y(2)$

3. General Information (6I12 format)

Column	1-12	13-24	25-36	37-48	49-60	61-72
Name	NMACH	KF	NFREQ	LCOLL	LPUNCH	
Item	(1)	(2)	(3)	(4)	(5)	

- (1) NMACH Number of Mach numbers (max. 6)
- (2) KF Option to input either frequencies or reduced frequencies:
 KF = 0 frequencies
 KF = 1 reduced frequencies
- (3) NFREQ Number of frequencies or reduced frequencies at each Mach
 number (max. 10)
- (4) LCOLL Option to print aerodynamic and AIC collocation station
 coordinates:
 LCOLL = 0 do not print
 LCOLL = 1 print collocation station coordinates
- (5) LPUNCH Option to punch AIC matrix on cards:
 LPUNCH = 0 do not punch
 LPUNCH = 1 punch AIC matrix for wing only
 LPUNCH = 2 punch AIC matrix for control surface only
 LPUNCH = 3 punch individual AIC matrix for wing and
 control surface
 LPUNCH = 4 punch total AIC matrix of combined wing and
 control surface

The AIC matrix is punched by rows with a 1P6E12.5 format. Each row of the matrix begins on a new card.

4. General Information (6I12 format)

Column	1-12	13-24	25-36	37-48	49-60	61-72
Name	NWCX	NCCX	NIONCX	NIY	ISOLAT	
Item	(1)	(2)	(3)	(4)	(5)	

- (1) NWCX Number of chordwise collocation stations on wing ($2 \leq \text{NWCX} \leq 10$)
- (2) NCCX Number of chordwise collocation stations on control surface ($2 \leq \text{NCCX} \leq 10$)
- (3) NIONCX Factor for number of chordwise integration stations. Set NIONCX such that $\text{NIONCX} \times \text{NWCX}$ and $\text{NIONCX} \times \text{NCCX}$ are greater than 15 (but less than 40) to insure sufficient quadrature points for accurate integration of the Kernel function. If AIC's are desired for, say, the wing only, set NIONCX such that $\text{NIONCX} \times \text{NWCX}$ is greater than 15 and set NCCX equal to 2 to minimize computing time.
- (4) NIY Number of spanwise collocation stations (wing and control surface)
- (5) ISOLAT Option to isolate wing and control surface:
 ISOLAT = 0 interference and gap effects considered
 ISOLAT = 1 surfaces are isolated. AIC's will be for individual surfaces with no coupling effects.

5. Mach Numbers (6E12.5 format)

Column	1-12	13-24	25-36	37-48	49-60	61-72
Name	FMACH(1)	FMACH(2)	FMACH(3)	FMACH(4)	FMACH(5)	FMACH(6)
Item	(1)	(2)	(3)	(4)	(5)	(6)

- (1) FMACH (1) Mach number
- (2) FMACH (2) Mach number

· · · ·
 · · · ·
 · · · ·

(NMACH) FMACH(NMACH) Mach number

NMACH values of Mach number must be input (see Part 3, Item 1). Mach numbers must be greater than zero and less than 0.95.

6. Frequencies or Reduced Frequencies (6E12.5 format)

Column	1-12	13-24	25-36	37-48	49-60	61-72
Name	FREQ(1)	FREQ(2)	FREQ(3)	FREQ(4)	FREQ(5)	FREQ(6)
Item	(1)	(2)	(3)	(4)	(5)	(6)

If KF=0, input NFREQ values of frequency (cps). If KF=1, input NFREQ values of reduced frequency ($k_r = \omega b_r / U$ where b_r = semi-chord of wing root, U = free stream velocity, and ω = oscillatory angular frequency in radians/sec). Frequencies (and reduced frequencies) may not be zero.

(1) FREQ(1) f(cps) or k_r

(2) FREQ(2) "

. . . "

. . . "

. . . "

. . . "

(NFREQ) FREQ(NFREQ)

For NFREQ > 6, continue input on new card.

7. Spanwise Location of AIC Stations on Wing (6E12.5 format)

Column	1-12	13-24	25-36	37-48	49-60	61-72
Name	YAIC(1,W)	YAIC(2,W)	YAIC(3,W)	YAIC(4,W)	YAIC(5,W)	YAIC(6,W)
Item	(1)	(2)	(3)	(4)	(5)	(6)

(1) YAIC(1,W) Spanwise coordinate of first row of AIC collocation stations on wing.

(2) YAIC(2,W) Spanwise coordinate of second row of AIC collocation stations on wing.

.

.

.

.

(NIY) YAIC(NIY,W) Spanwise coordinate of last row of AIC collocation stations on wing

Collocation station rows are numbered from root to tip. For NIY > 6, continue input of YAIC (7,W) to YAIC(NIY,W) on new card(s).

8. Spanwise Location of AIC Stations on Control Surface (6E12.5 format)

Column	1-12	13-24	25-36	37-48	49-60	61-72
Name	YAIC(1,CS)	YAIC(2,CS)	YAIC(3,CS)	YAIC(4,CS)	YAIC(5,CS)	YAIC(6,CS)
Item	(1)	(2)	(3)	(4)	(5)	(6)

(1) YAIC(1,CS) Spanwise coordinate of first row of AIC collocation stations on control surface.

(2) YAIC(2,CS) second.....

.

(NIY) YAIC(NIY,CS) last.....

Collocation station rows are numbered from root to tip. If NIY > 6, continue input of YAIC(7,CS) to YAIC(NIY,CS) on new card(s).

9. Streamwise Location of AIC Stations on Wing (6E12.5 format)

Column	1-12	13-24	25-36	37-48	49-60	61-72
Name	XAIC(W,1,1)	XAIC(W,1,2)	XAIC(W,1,3)	...	...	...
Item	(1)	(2)	(3)	(4)	(5)	(6)

(1) XAIC(W,1,1) Streamwise coordinate of first AIC collocation station in first row on wing.

(2) XAIC(W,1,2) second.....

.

(NXWING*NYWING)

XAIC(W,NYWING,NXWING) last.....last row.....

Streamwise numbering sequence if from leading edge to trailing (see Figure 4.2). Continue input of values for each row immediately after the last value of the preceding row, do not begin input of each new row on new card.

10. Chordwise Location of AIC Stations on Control Surface (6E12.5 format)

Column	1-12	13-24	25-36	37-48	49-60	61-72
Name	XAIC(CS,1,1)	XAIC(CS,1,2)	XAIC(CS,1,3)	...	...	...
Item	(1)	(2)	(3)	(4)	(5)	(6)

Procedure to input streamwise coordinate location of AIC stations on control surface is the same as wing.

3.0 Sample Problems

Three sample problems are given to demonstrate the operation of the subsonic AIC program and to illustrate the options available. Trapezoidal, cropped trapezoidal, and delta configurations are analyzed. Explanation of input parameters and computer listings of input data cards and computer output are given for each problem.

Sample Problem 1

A cropped Delta wing-rectangular control surface combination is analyzed for $M = 0.5$ and $k_r = 0.10$. The planform geometry and AIC control station locations are shown in Figure 4.4. The dimensional unit used for length is feet for this particular case, therefore the acoustic velocity is entered with units of feet per second. NIONCX is set equal to 8 which makes NIONCX*NWCX and NIONCX*NCCX greater than 15, thereby insuring sufficient chordwise quadrature points for accurate chordwise integration of the kernel function.

The surfaces have 5 spanwise collocation stations and the wing has 3 chordwise stations while the control surface has 2 chordwise stations. Summarized below are input parameters. A listing of the data input cards and computer output follows.

X(1) = 0.0'	X(2) = 1.0'	X(3) = 2.0'	X(4) = 3.0'	X(5) = 4.0'
Y(1) = 0.0'	Y(2) = 0.0'	Y(3) = 2.0'		
SOUND = 1116.87 ft/sec (analysis for sea level)				
NMACH = 1	number of Mach numbers			
KF = 1	Input reduced frequency			
NFREQ = 1	Number of reduced frequencies			
LCOLL = 1	Print collocation station coordinates			
LPUNCH = 4	Punch total AIC matrix on cards			
NWCX = 3	Number of chordwise AIC collocation stations on wing			
NCCX = 2	Number of chordwise AIC collocation stations on control surface			
NIONCX = 8	Factor for determining number of chordwise integration stations			
NIY = 5	Number of spanwise AIC collocation stations			
ISOLAT = 0	Surfaces are not isolated			
FMACH(1) = 0.5	Mach number			
FREQ(1) = 0.1	Reduced frequency			

$$YAIC(1,W) = 0.2'$$

$$YAIC(4,W) = 1.4'$$

$$YAIC(2,W) = 0.6'$$

$$YAIC(5,W) = 1.8'$$

$$YAIC(3,W) = 1.0'$$

$$YAIC(1,CS) = 0.1'$$

$$YAIC(4,CS) = 1.5'$$

$$YAIC(2,CS) = 0.5'$$

$$YAIC(5,CS) = 1.9'$$

$$YAIC(3,CS) = 1.0'$$

$$XAIC(1,1,W) = 0.575'$$

$$XAIC(2,1,W) = 0.725'$$

$$XAIC(3,1,W) = 0.875'$$

$$XAIC(4,1,W) = 1.025'$$

$$XAIC(5,1,W) = 1.175'$$

$$XAIC(1,2,W) = 1.050'$$

$$XAIC(2,2,W) = 1.150'$$

$$XAIC(3,2,W) = 1.250'$$

$$XAIC(4,2,W) = 1.350'$$

$$XAIC(5,2,W) = 1.450'$$

$$XAIC(1,3,W) = 1.525'$$

$$XAIC(2,3,W) = 1.575'$$

$$XAIC(3,3,W) = 1.625'$$

$$XAIC(4,3,W) = 1.675'$$

$$XAIC(5,3,W) = 1.725'$$

$$XAIC(1,1,CS) = 3.25'$$

$$XAIC(2,1,CS) = 3.25'$$

$$XAIC(3,1,CS) = 3.25'$$

$$XAIC(4,1,CS) = 3.25'$$

$$XAIC(5,1,CS) = 3.25'$$

$$XAIC(1,2,CS) = 3.75'$$

$$XAIC(2,2,CS) = 3.75'$$

$$XAIC(3,2,CS) = 3.75'$$

$$XAIC(4,2,CS) = 3.75'$$

$$XAIC(5,2,CS) = 3.75'$$

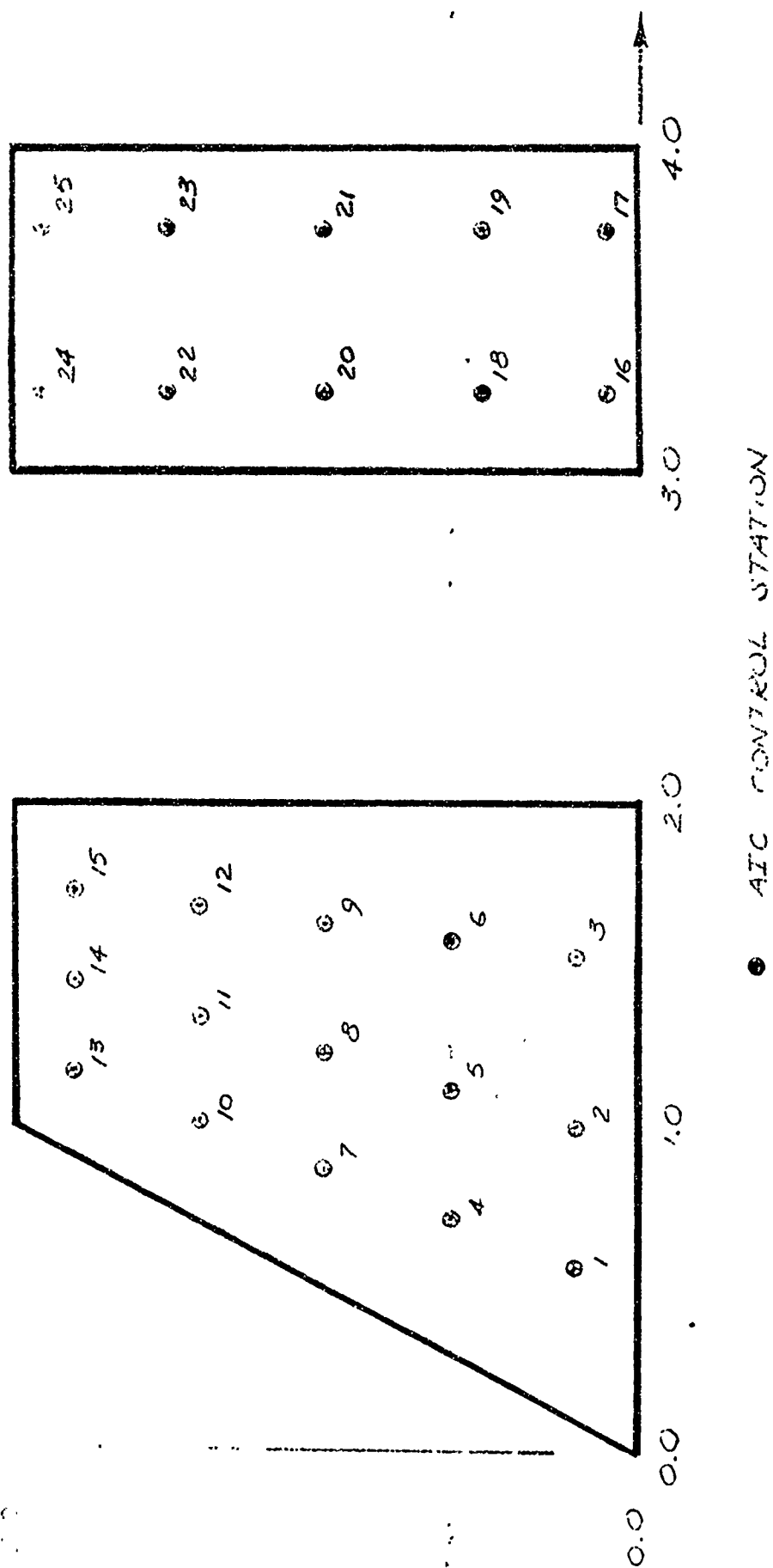


FIGURE 4.4 - SUBSONIC SAMPLE PROBLEM 1.

11111111 22222222333333334444444455555555666666667777777778888888899999999

	MACH NO.	RED FREQ	Y-WING	Y-TAIL	X-WING	X-WING	X-TAIL	X-TAIL
0.6	3.0	4.0						
0.0	116.87							
1	1							4
3	8							0
0.5								
0.1								
0.200			1.400		1.800			
0.100			1.500		1.900			
0.575			0.725		1.150			1.575
0.875			1.025		1.350			1.675
1.175								
3.250			3.750		3.250			3.750
3.250			3.75					

[illegible]

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DUJHES AIRCRAFT CO. SUBSONIC AIC PROGRAM

FLIGHT CONDITIONS AND GEOMETRY

MACH NUMBER = 0.50000 SPEED OF SOUND = 1116.870 L/T RHO=0.100000000E 01

L.E. STATION (L)	0.	TAIL
ROOT CHORD (L)	2.000	3.090
L.E. SPAN (L)	0.	1.090
T.E. SPAN (L)	2.000	2.090
TIP CHORD (L)	1.000	2.080
TOTAL AREA (L*L)	6.000	1.090
SPAN COLL. STA.	5	4.090
CHORD COLL. STA.	3	5
CHORD INTG. STA.	24	2
SPAN PRES MODES	5	14
CHORD PRES MODES	3	5
		2

HUGHES AIRCRAFT CO. SONARSONIC AIC PROGRAM (CONT-D)

UNSTEADY AERO COLLOCATION STATION COORDINATES ON THE WING

S STA NO	YC	XC VALUES--	
1	0.	0.481607E 00	0.146254E 01 0.199795E 01
2	0.618034E 00	0.716212E 00	0.153558E 01 0.199826E 01
3	0.117557E 01	0.927852E 00	0.167049E 01 0.199855E 01
4	0.161803E 01	0.109581E 01	0.167995E 01 0.199878E 01
5	0.190211E 01	0.120365E 01	0.171812E 01 0.199892E 01

INTEGRATION STATION COORDINATES ON THE WING

S STA NO	YI	XI VALUES--		
1	0.312869E 00	0.158328E 00	0.173433E 00	0.203394E 00 0.247720E 00
		0.305682E 00	0.37329E 00	0.458502E 00 0.550850E 00
		0.51857E 00	0.759866E 00	0.873101E 00 0.989705E 00
		0.110774E 01	0.123533E 01	0.134049E 01 0.145134E 01
		0.155606E 01	0.16294E 01	0.174038E 01 0.181693E 01
		0.189138E 01	0.193263E 01	0.196985E 01 0.199243E 01
2	0.907981E 00	0.435579E 00	0.46245E 00	0.493371E 00 0.530542E 00
		0.579149E 00	0.639394E 00	0.707303E 00 0.784746E 00
		0.860451E 00	0.96026E 00	0.105499E 01 0.115277E 01
		0.125177E 01	0.135037E 01	0.144694E 01 0.153989E 01
		0.162772E 01	0.176896E 01	0.178228E 01 0.184649E 01
		0.190053E 01	0.194351E 01	0.197472E 01 0.199365E 01
3	0.141421E 01	0.708435E 00	0.719028E 00	0.740039E 00 0.771125E 00
		0.811774E 00	0.86319E 00	0.918947E 00 0.983710E 00
		0.105455E 01	0.113029E 01	0.120971E 01 0.129148E 01
		0.137427E 01	0.148673E 01	0.153749E 01 0.161522E 01
		0.168867E 01	0.175661E 01	0.181793E 01 0.187162E 01
		0.191681E 01	0.198276E 01	0.197886E 01 0.199469E 01
4	0.178201E 01	0.892146E 00	0.901232E 00	0.919255E 00 0.945919E 00
		0.980786E 00	0.102328E 01	0.107271E 01 0.112827E 01
		0.118903E 01	0.125400E 01	0.132212E 01 0.139226E 01
		0.146328E 01	0.153400E 01	0.160327E 01 0.166995E 01
		0.173295E 01	0.179123E 01	0.184383E 01 0.186988E 01
		0.192865E 01	0.198948E 01	0.198187E 01 0.199545E 01
5	0.197534E 01	0.998728E 00	0.997922E 00	0.101347E 01 0.103781E 01
		0.106964E 01	0.112043E 01	0.115356E 01 0.120426E 01
		0.125973E 01	0.133904E 01	0.146121E 01 0.144524E 01
		0.151007E 01	0.157463E 01	0.163786E 01 0.169873E 01
		0.175623E 01	0.186943E 01	0.185744E 01 0.189948E 01
		0.19467E 01	0.196301E 01	0.198345E 01 0.199584E 01

HUGHES AIRCRAFT CO. SUBSONIC AIC PROGRAM (CONT'D)

UNSTEADY AERO COLLOCATION STATION COORDINATES ON THE TAIL

S STA NO	YC	XC VALUES--	
1	0.	0.347621E 01	0.396774E 01
2	0.618034E 00	0.347621E 01	0.396774E 01
3	0.117557E 01	0.347621E 01	0.396774E 01
4	0.161803E 01	0.347621E 01	0.396774E 01
5	0.190211E 01	0.347621E 01	0.396774E 01

S STA NO	YI	XI VALUES--	
1	0.312869E 00	0.300226E 01	0.302025E 01
		0.317257E 01	0.325000E 01
		0.352379E 01	0.361788E 01
		0.386187E 01	0.392063E 01
2	0.907981E 00	0.300226E 01	0.302025E 01
		0.317257E 01	0.325000E 01
		0.352379E 01	0.361788E 01
		0.386187E 01	0.392063E 01
3	0.141421E 01	0.300226E 01	0.302025E 01
		0.317257E 01	0.325000E 01
		0.352379E 01	0.361788E 01
		0.386187E 01	0.392063E 01
4	0.178201E 01	0.300226E 01	0.302025E 01
		0.317257E 01	0.325000E 01
		0.352379E 01	0.361788E 01
		0.386187E 01	0.392063E 01
5	0.197538E 01	0.300226E 01	0.302025E 01
		0.317257E 01	0.325000E 01
		0.352379E 01	0.361788E 01
		0.386187E 01	0.392063E 01

INTEGRATION STATION COORDINATES ON THE TAIL

S STA NO	YI	XI VALUES--	
1	0.312869E 00	0.305558E 01	0.310697E 01
		0.333647E 01	0.342884E 01
		0.370771E 01	0.379003E 01
		0.396418E 01	0.399096E 01
2	0.907981E 00	0.305558E 01	0.310697E 01
		0.333647E 01	0.342884E 01
		0.370771E 01	0.379003E 01
		0.396418E 01	0.399096E 01
3	0.141421E 01	0.305558E 01	0.310697E 01
		0.333647E 01	0.342884E 01
		0.370771E 01	0.379003E 01
		0.396418E 01	0.399096E 01
4	0.178201E 01	0.305558E 01	0.310697E 01
		0.333647E 01	0.342884E 01
		0.370771E 01	0.379003E 01
		0.396418E 01	0.399096E 01
5	0.197538E 01	0.305558E 01	0.310697E 01
		0.333647E 01	0.342884E 01
		0.370771E 01	0.379003E 01
		0.396418E 01	0.399096E 01

HUGHES AIRCRAFT CO. SUBSONIC AIC PROGRAM (CONT-D)

AIC COLLOCATION STATION COORDINATES ON THE WING			
YAIC	XAIC VALUES--		
0.200000E 00	0.575000E 00	0.105000E 01	0.152500E 01
0.600000E 00	0.725000E 00	0.115000E 01	0.157500E 01
0.100000E 01	0.875000E 00	0.125000E 01	0.162500E 01
0.140000E 01	0.102500E 01	0.135000E 01	0.167500E 01
0.180000E 01	0.117500E 01	0.145000E 01	0.172500E 01

HUGHES AIRCRAFT CO. SUBSONIC AIC PROGRAM (CONT-D)

AIG COLLOCATION STATION COORDINATES ON THE TAIL

YAIC	XAIC VALUES--	
0.100000E 00	0.325000E 01	0.375000E 01
0.500000E 00	0.325000E 01	0.375000E 01
0.100000E 01	0.325000E 01	0.375000E 01
0.150000E 01	0.325000E 01	0.375000E 01
0.190000E 01	0.325000E 01	0.375000E 01

HUGHES AIRCRAFT CO. SUBSONIC AIC PROGRAM (CONT-D)

OSCILLATORY FREQUENCY (CPS) 8.88777E 00

REFERENCE CHORD 1.00000E 00

REDUCED FREQUENCY (REF. CHORD) 1.00000E-01

REDUCED VELOCITY (REF. CHORD) 1.00000E 01

FREE STREAM MACH NUMBER 5.00000E-01

FREE STREAM VELOCITY 5.58435E 02

DENSITY 1.00

DYNAMIC PRESSURE (1/2* ρ *V²) 1.55925E 05

AERODYNAMIC INFLUENCE COEFFICIENTS

RL	IM	RL	IM	RL	IM	RL	IM	RL	IM
ROW = 1									
1.9737E 03	-6.28820E 01	-3.4937E 03	9.1008E 01	1.5227E 03	-4.3777E 01	-3.8532E 03	1.5955E 02	4.5738E 03	-1.4104E 02
-2.7240E 03	7.0267E 01	2.7537E 03	-8.3180E 01	-4.6233E 03	1.0553E 02	1.8718E 03	-5.5209E 01	-7.9200E 02	1.6388E 01
1.2630E 03	-8.0521E 00	-4.7241E 02	2.0849E 00	3.5502E 01	-2.1366E 00	-2.9963E 01	1.6790E 00	-5.5489E 00	-6.7135E-01
2.8760E 00	1.9945E-01	2.8647E 00	-3.4308E-01	2.1449E-01	-2.8742E 00	-2.8742E 00	-3.5866E-01	3.51920E 00	2.5799E-01
-3.1778E 00	-4.1736E-01	1.8022E 00	1.4465E-01	-1.7943E 00	-2.7458E-01	4.7383E-01	3.5344E-03	-4.7388E-01	-2.9033E-02
ROW = 2									
-8.2336E 02	2.5013E 00	1.6737E 03	5.5166E 01	-8.4930E 02	-5.8917E 01	1.5732E 03	5.9370E-01	-3.1007E 03	-1.0717E 02
1.5349E 02	-1.0498E 02	-1.1665E 03	-3.4436E-01	2.3154E 03	6.9444E 01	-1.1480E 03	-6.8425E 01	3.2088E 02	6.8855E-01
-6.0623E 02	1.6573E 01	2.8581E 02	4.9184E 01	-8.4283E 00	6.3100E-01	8.3867E 00	-2.0749E 00	7.0526E-03	1.6766E 00
4.7742E-01	-2.5529E-01	-4.9027E-01	2.3146E-01	5.5339E-01	-2.7463E-01	-5.8713E-01	2.4702E-01	7.6444E-01	-3.3831E-01
-7.8133E-01	3.0036E-01	5.3086E-01	-2.0854E-01	-5.4124E-01	1.8206E-01	1.5747E-01	-4.6454E-02	-1.5987E-01	3.8974E-02
ROW = 3									
-1.8133E 03	5.0187E 01	3.6031E 03	-5.5244E 00	-1.7894E 03	-4.3430E 01	3.5560E 03	-7.3664E 01	-6.8783E 03	-2.6882E 01
3.3164E 03	9.1841E 01	-2.5049E 03	4.9184E 01	5.0399E 03	1.5615E 01	-2.4305E 03	-5.8322E 01	7.4862E 02	-6.6297E 00
-1.3871E 03	-1.6990E 01	6.3851E 02	2.0048E 01	-3.5167E 01	3.9275E-01	4.4976E 01	-8.3796E-01	-9.8485E 00	1.1417E 00
6.5679E-01	5.5498E-01	-2.6895E-01	4.3076E-01	-7.7805E-01	-4.1873E-01	7.5660E-01	4.5766E-01	-6.8331E-01	-5.2022E-01
ROW = 4									
1.6134E 03	-5.6083E 01	-2.8560E 03	7.3909E 01	1.2448E 03	-3.5471E 01	-3.2326E 03	9.9479E 01	5.5235E 03	-1.1766E 02
-2.2921E 03	5.3317E 01	2.3850E 03	-7.1690E 01	-3.9981E 03	9.0136E 01	-1.6150E 03	-4.7412E 01	-6.7888E 02	1.3935E 01
1.0850E 03	-6.9647E 01	-0.0628E 02	1.4960E 01	2.7201E 01	-1.7250E 00	-1.8182E 01	1.1386E 00	-9.1375E 00	-4.4335E-01
2.5517E 00	9.7700E-02	-2.5461E 00	-2.1806E-01	2.6010E 00	9.7705E-02	-2.9528E 00	-2.2783E-01	2.9688E 00	1.1385E-01
-2.9549E 00	-2.5113E-01	1.7237E 00	5.2876E-02	-1.7204E 00	-1.3890E-01	4.6104E-01	-1.6972E-02	-4.6390E-01	-6.0227E-03
ROW = 5									
-6.7228E 02	2.1321E 01	1.3666E 03	4.4769E 01	-0.9350E 02	-4.7923E 01	1.3379E 03	3.5572E-01	-2.6034E 03	-4.9287E 01
1.2862E 03	5.7620E 01	-1.0127E 03	-4.2131E-01	2.0100E 03	6.8463E 01	-0.9553E 02	-5.9452E 01	2.7136E 02	5.4355E-01
-5.1290E 02	1.3812E 01	2.4083E 02	1.2273E 01	-6.6843E 00	9.3706E-01	4.2148E 00	-1.7449E 00	4.1580E-01	1.4887E 00
4.3617E-01	-2.1397E-01	-4.4692E-01	1.9219E-01	5.3314E-01	-2.3003E-01	-5.1468E-01	2.3833E-01	6.9002E-01	-2.8571E-01
-7.0424E-01	2.5128E-01	4.7625E-01	-1.7567E-01	-4.8488E-01	9.7191E-01	1.4083E-01	-3.5611E-02	-1.4234E-01	3.1564E-02

ROM = 6
-1.4817E 03 4.1122E 01 2.9401E 03 -4.8932E 00 -1.4631E 03 8.3217E 01 2.9799E 03 -6.3109E 01 -5.7633E 03 -2.2010E 01
-2.707E 03 7.6833E 01 -2.2600E 03 4.2107E 01 4.3693E 03 1.4695E 01 2.1098E 03 -5.110E 01 6.3798E 02 3.5341E 00
-1.1796E 03 -1.4943E 01 5.4166E 02 1.6994E 01 -2.8495E 01 2.7189E 01 3.9201E 01 4.0237E 01 -6.7335E 00 9.2933E 01
-6.657E 01 -3.1363E 01 6.5130E 01 3.4696E 01 -6.0738E 01 -8.3944E 01 5.9025E 01 3.6994E 01 -5.4696E 01 -4.2277E 01
5.2533E 01 4.5012E 01 -2.2531E 01 -2.6166E 01 2.1024E 01 2.7314E 01 -3.8836E 02 -5.3899E 02 3.6152E 02 5.5789E 02

ROM = 7
-1.0335E 03 -3.603E 01 1.8499E 03 4.7201E 01 8.0288E 02 -2.2694E 01 2.1633E 03 6.6322E 01 3.7090E 03 -7.6281E 01
-1.5998E 03 3.8571E 01 1.6399E 03 -4.9044E 01 -2.7297E 03 6.1132E 01 1.0933E 03 -3.231E 01 -4.1535E 02 8.2355E 00
6.656E 02 -2.2410E 00 -3.0699E 02 1.3211E 02 -1.3044E 01 2.1166E 00 -4.3361E 01 7.3891E 01 -2.5135E 01 -3.2598E 01
2.0235E 00 -6.1038E 02 -3.0236E 00 -2.0236E 00 -2.1135E 00 -6.6098E 02 2.1135E 00 -4.3361E 01 2.5135E 01 -6.8515E 01
-2.517E 00 -3.6908E 02 1.5355E 00 -7.1741E 02 -1.5375E 00 -4.6373E 03 4.2667E 01 -4.3219E 02 -4.2097E 01 2.1995E 02

ROM = 8
-4.358E 02 1.4336E 00 8.844E 02 2.8799E 01 -4.4907E 02 -3.0904E 01 8.7995E 02 1.2660E 01 -1.7390E 03 -5.9255E 01
8.5998E 02 5.820E 01 -6.9736E 02 -4.3477E 01 1.3844E 02 4.1935E 01 6.8698E 02 -4.1135E 01 1.6082E 02 2.3377E 01
-2.9846E 02 -7.7153E 00 1.3811E 02 6.7795E 00 -5.0035E 00 3.5630E 01 4.4908E 00 -1.1335E 00 -1.5083E 00 8.7388E 01
3.639E 01 -1.499E 01 3.708E 01 1.3126E 01 4.1505E 01 -1.6241E 01 -4.2308E 01 1.4170E 01 5.6245E 01 -2.0235E 01
-5.7271E 01 1.7443E 01 3.8535E 01 -1.2509E 01 -3.9135E 01 1.0586E 01 1.132E 01 -2.7935E 02 -1.1535E 01 2.2235E 02

ROM = 9
-9.5941E 02 2.6685E 01 1.9035E 03 -3.3825E 00 -9.4673E 02 -2.2646E 01 1.9975E 03 -4.2235E 01 -3.8498E 03 -1.4328E 01
1.896E 03 5.0937E 01 -1.5538E 03 2.8599E 01 3.0037E 03 1.1095E 01 -1.4408E 03 -3.5722E 01 3.8330E 02 -3.1044E 00
-7.027E 02 -9.8221E 00 3.1946E 02 1.0036E 01 -1.7516E 01 1.8666E 01 2.2303E 01 -4.8423E 01 -6.9801E 01 5.6188E 01
-3.8270E 01 -2.0151E 01 3.7299E 01 2.2024E 01 -3.5088E 01 -2.1837E 01 3.3933E 01 2.3428E 01 -8.2538E 01 -2.7333E 01
3.1150E 01 2.8942E 01 -1.3999E 01 -1.6899E 01 1.3132E 01 1.7600E 01 -2.5337E 02 -5.3986E 02 2.3667E 02 3.5288E 02

ROM = 10
-5.4317E 00 -6.1884E 02 2.4578E 01 4.7794E 02 -1.9166E 01 -6.3614E 01 -1.4059E 01 1.4333E 01 3.2398E 01 -2.5621E 01
1.8934E 01 -2.8535E 01 -1.2133E 01 -1.2133E 01 -2.5708E 01 1.6032E 00 -1.7603E 00 5.7277E 01 7.7277E 01 -2.2835E 00
-1.114E 02 2.3135E 00 3.392E 01 -1.940E 00 2.0303E 01 -5.9032E 01 2.6068E 01 8.8328E 01 6.6501E 01 -6.9801E 01
1.2317E 00 -3.1332E 01 -1.241E 00 2.5235E 01 1.3504E 00 -3.3899E 01 -1.3621E 00 2.7158E 01 1.7308E 00 -4.2335E 01
-1.7557E 00 3.361E 01 1.1537E 00 -2.7495E 01 -1.1671E 00 2.1698E 01 3.4238E 01 -8.0869E 02 -5.4682E 01 6.3790E 02

ROM = 11
-4.9440E 00 -1.3437E 01 1.172E 01 8.4277E 01 -6.7921E 00 -7.6600E 01 1.4398E 00 -1.0508E 01 -2.2921E 00 1.5682E 01
6.545E 01 -9.3742E 02 -2.2360E 01 -2.5882E 01 4.6977E 01 2.0811E 00 -2.4579E 01 -1.9095E 00 -4.4595E 01 -6.287E 01
9.182E 01 3.021E 00 -4.722E 01 -2.844E 00 -1.6339E 01 -5.3075E 02 3.5733E 01 9.4995E 01 -1.9388E 01 -9.8072E 01
2.6802E 01 -4.2711E 02 -2.6802E 01 2.9483E 02 2.8889E 01 4.6506E 02 -2.911E 01 3.2085E 02 3.4482E 01 -5.9079E 02
-3.6719E 01 4.0993E 02 3.3722E 01 -3.8385E 02 -2.3909E 01 2.6943E 02 6.9698E 02 -1.1097E 02 -7.0192E 02 7.5797E 03

ROM = 12
-6.6534E 00 -3.0131E 02 1.4099E 01 6.9080E 01 -7.3988E 00 -6.9651E 01 6.5407E 00 -2.4946E 01 -1.220E 01 3.3249E 01
5.683E 00 -1.2111E 01 -4.2377E 01 4.7897E 01 8.3673E 01 1.3473E 00 -4.1269E 01 -1.7846E 00 -0.9809E 01 1.1218E 00
1.771E 02 1.608E 00 -8.720E 01 -2.644E 00 -2.878E 01 4.3049E 01 6.0330E 01 2.5318E 01 -3.1583E 01 -7.5888E 01
6.6187E 02 -1.1688E 02 6.6702E 02 8.3946E 03 6.3270E 02 -1.2749E 02 -4.3899E 02 9.5835E 03 5.9385E 02 -1.6652E 02
-6.0207E 02 1.3690E 02 2.6443E 02 -1.0446E 02 -2.7000E 02 9.1219E 03 6.4941E 03 -2.7737E 03 -6.6476E 03 2.4482E 03

ROM = 13
-4.4838E 03 1.5130E 02 8.0255E 03 -1.9702E 02 -3.5589E 03 8.9764E 01 9.3031E 03 -2.9745E 02 -1.584E 04 3.3933E 02
6.567E 03 -1.4882E 02 -6.6640E 03 1.9836E 02 1.1233E 04 -2.4676E 02 -4.3740E 03 1.2704E 02 1.9168E 03 -4.0799E 01
-3.0149E 03 2.1190E 01 1.102E 03 -6.872E 00 -4.317E 00 3.020E 00 4.3855E 01 -8.2333E 01 4.8303E 01 -7.5014E 01
-1.1583E 00 -1.4415E 00 1.0849E 00 1.4994E 00 -4.9173E 01 -1.5546E 00 8.1351E 01 1.5994E 00 -5.304E 01 -1.9154E 00
4.356E 01 1.9421E 00 4.737E 03 -1.813E 00 -4.3852E 02 1.1806E 00 7.9348E 02 -2.5560E 01 -9.2083E 02 2.5144E 01

ROM = 14
1.8156E 03 -7.5304E 00 -3.0707E 03 -1.1555E 02 1.5609E 03 1.2537E 02 -3.8133E 03 -1.3374E 00 7.5471E 03 2.5874E 02
-3.7299E 03 -2.8335E 02 2.7884E 03 4.3072E 01 -5.9187E 03 -1.6386E 02 2.7253E 03 1.6085E 02 -7.9772E 02 -1.7790E 00
1.524E 03 4.1505E 01 -7.2435E 02 3.357E 01 -2.9287E 01 -1.5331E 00 8.5786E 01 7.6872E 01 -5.6082E 01 -4.779E 00
1.6086E 01 3.8481E 01 -1.4149E 01 -3.6226E 01 6.8000E 02 8.8371E 01 -4.8582E 02 -3.8722E 01 -1.2544E 01 4.7775E 01

1.4960E-01	-4.7150E-01	-1.9455E-01	2.8936E-01	2.0911E-01	-2.7969E-01	-6.6712E-02	5.0569E-02	6.9239E-02	-4.7189E-02
ROW = 15									
4.0330E 03	-1.1400E 02	-8.0169E 03	1.9959E 01	3.9772E 03	2.0880E 01	-6.6044E 03	1.8186E 02	1.6645E 04	5.4711E 01
-8.0386E 03	-2.2239E 02	6.2533E 03	-1.1677E 02	-1.2065E 04	-3.3997E 01	5.8186E 03	1.3906E 02	-1.8426E 03	1.6617E 01
3.4283E 03	-4.1152E 01	-1.5853E 03	-4.9407E 01	-1.2504E 01	9.5265E-01	8.6195E 01	-2.3810E 00	-7.5581E 00	-4.6680E 00
1.9330E 00	7.2871E-01	-1.6233E 00	-8.2541E-01	1.7871E 00	7.9096E-01	-1.7468E 00	-8.8041E-01	1.6943E 00	9.9026E-01
-1.6437E 00	-1.9750E 00	7.8592E-01	6.1426E-01	-7.5455E-01	-5.5358E-01	1.6842E-01	1.1769E-01	-1.6248E-01	-1.2602E-01
ROW = 16									
4.9351E 02	-4.1937E 01	-1.3211E 03	1.0776E 02	8.2945E 02	-5.0041E 01	-9.8790E 02	6.1179E 01	-2.4330E 03	-2.8705E 02
-1.1590E 02	9.7997E 01	3.6859E 02	-2.8531E 01	5.0303E 03	1.7752E 02	-1.2731E 03	-8.0871E 01	-2.2279E 02	1.8329E 01
5.9091E 02	-4.4446E 01	-3.6859E 02	2.3411E 01	5.0370E 00	-3.1670E-01	1.3328E 01	1.0358E 01	8.5041E 00	-6.2970E-01
2.6100E 02	3.4680E 00	-2.6131E 02	-1.6534E 01	-4.0131E 02	-6.1988E 00	4.0050E 02	2.6229E 01	2.8348E 02	3.6610E 00
-2.8296E 02	-1.7840E 01	-1.0703E 02	-1.8109E 00	1.0680E 02	7.1528E 00	2.2973E 01	2.5863E-01	-2.2301E 01	-1.4055E 00
ROW = 17									
8.7398E-01	-1.7967E-01	-3.0549E 00	6.6494E-01	2.1961E 00	-4.2336E-01	8.7348E 00	-1.6910E 00	-2.3657E 01	4.5021E 00
1.4980E 01	-2.5509E 00	1.5277E 00	5.5941E-02	-4.7914E 00	2.0521E-02	3.2698E 00	-1.1251E-02	3.6396E 00	-9.7271E-01
-1.5575E 01	2.1880E 00	9.9615E 00	-1.5760E 00	-3.2647E 00	1.1465E-01	8.3732E 00	-2.0608E-01	-5.1096E 00	4.0335E-02
9.2299E-01	2.5303E 01	-2.8589E-01	-2.5350E 01	5.9940E 00	-4.0392E 01	-7.0050E 01	4.0094E 01	3.6944E 00	2.6850E 01
-3.0160E 00	-2.7035E 01	2.5286E 00	-1.0883E 01	-2.8006E 00	1.0757E 01	-6.7581E-01	2.3514E 00	7.3384E-01	-2.3177E 00
ROW = 18									
6.2240E 02	-5.2976E 01	-1.6665E 03	1.3628E 02	1.0464E 03	-6.3378E 01	-1.2736E 03	1.0442E 02	3.3982E 03	-2.0627E 02
-2.1246E 03	1.2589E 02	-1.0151E 03	-9.1940E 01	-2.7145E 03	2.3827E 02	-1.7023E 03	-1.2076E 02	-2.9235E 02	2.3334E 01
7.7440E 02	-5.9664E 01	8.8273E 00	2.9891E 01	6.7044E 00	-5.6873E-01	1.6159E 02	1.8562E 00	-1.2335E 01	-1.1372E 00
3.3246E 02	-4.3487E 00	-3.3155E 02	-2.0928E 01	-5.2143E 02	-8.0973E 00	5.2037E 01	3.1233E-01	3.8748E 02	5.0179E 00
-3.8633E 02	-2.4336E 01	-1.4196E 02	-2.4361E 00	1.4165E 02	6.5215E 00	3.1284E 01	3.4523E-01	-8.3287E 01	-1.9067E 00
ROW = 19									
4.9964E-01	-2.5702E-01	-2.3430E 00	9.5634E-01	1.8642E 00	-6.3571E-01	1.2085E 01	-2.2692E 00	-3.2741E 01	6.0430E 00
2.0733E 01	3.6412E 00	2.9853E 00	-4.4185E-02	-8.9911E 00	3.8427E-01	6.0181E 00	-1.0679E-01	8.5941E 00	-1.4296E 00
-2.3730E 01	3.9476E 01	1.5240E 01	-2.3044E 01	-4.0579E 00	9.0879E-02	1.0309E 01	-1.1290E-01	-6.2534E 00	-3.7174E-02
1.0779E 00	3.2111E 01	-2.1015E-01	-3.2163E 01	8.1071E 00	-8.2558E 01	-9.4224E 00	5.2155E 01	5.7821E 00	3.6373E 01
-4.6532E 00	-3.6863E 01	3.8983E 00	-1.4541E 01	-4.2610E 00	3.4347E 01	-7.9375E-01	3.1770E 00	8.7160E-01	-3.1374E 00
ROW = 20									
4.1981E 02	-3.6167E 01	-1.1249E 03	9.3407E 01	7.0669E 02	-4.3764E 01	-8.9241E 02	7.2711E 01	2.3907E 03	-1.8526E 02
-1.4910E 03	8.7337E 01	7.4506E 02	-6.8394E 01	-1.9935E 03	1.7749E 02	1.2506E 03	-9.0338E 01	-1.7782E 02	1.2952E 01
4.6881E 02	-3.2098E 01	-2.9131E 02	1.5450E 01	7.1522E 00	-1.2235E 00	-2.0713E 01	3.7760E 00	1.3698E 01	-2.3748E 00
2.2722E 02	2.8563E 00	-2.2681E 02	-1.4198E 01	-3.6916E 02	-8.8523E 00	3.6840E 02	2.4278E 01	2.0657E 02	3.7170E 00
-2.9621E 02	-1.9528E 01	-6.8517E 01	-1.6593E 00	8.8313E 01	6.0772E 00	2.3488E 01	2.3241E-01	-2.3340E 01	-1.4048E 00
ROW = 21									
-1.4660E-01	-3.1455E-01	-5.2318E-01	1.0989E 00	6.9102E-01	-7.4583E-01	9.5759E 00	-1.7399E 00	-2.6082E 01	4.6454E 00
1.6487E 01	-2.5168E 00	4.1684E 00	-3.3627E-01	-1.2104E 01	1.1137E 00	7.9558E 00	-6.3592E-01	9.0881E 00	-1.3770E 00
-2.5007E 01	3.6045E 00	1.6004E 01	-2.2027E 00	-1.4079E 00	-1.4376E-01	3.1825E 00	5.1625E-01	-1.7693E 00	-3.821E-01
7.9284E-01	2.1940E 01	-2.4273E-01	-2.1940E 01	6.4420E 00	-8.7364E 01	-7.3774E 00	3.7064E 01	6.1085E 00	2.7644E 01
-5.4090E 00	-2.7950E 01	4.4347E 00	-9.4680E 00	-4.6684E 00	9.2469E 00	-1.1879E-01	2.2890E 00	1.7548E-01	-2.2831E 00
ROW = 22									
-1.1293E 02	7.9593E 00	2.9914E 02	-1.6859E 01	-1.8651E 02	6.3355E 00	2.6300E 02	-2.2614E 01	-7.0340E 02	5.8168E 01
4.4122E 02	-2.8050E 01	-1.7956E 02	1.3592E 01	4.7625E 02	-3.3906E 01	-2.9711E 02	1.5939E 01	1.0969E 02	-1.1846E 01
-2.9565E 02	3.1422E 01	1.8628E 02	-1.7138E 01	2.5128E 01	-3.9213E 00	-7.0134E 01	1.0922E 01	4.5102E 01	-6.4562E 00
-5.6761E 01	-1.1099E 00	5.6629E 01	3.9429E 00	1.1645E 02	1.3624E 00	-1.1624E 02	-7.1946E 00	-5.2904E 01	-1.1654E 00
5.2770E 01	3.9630E 00	5.8308E 01	5.2507E-01	-5.8215E 01	-3.6054E 00	7.6395E-01	-5.3144E-02	-7.6941E-01	1.9991E-02
ROW = 23									
3.6086E 00	-7.9885E-01	-1.0203E 01	2.2320E 00	6.6306E 00	-1.1020E 00	-4.5778E-01	1.1094E-01	9.6679E-01	-2.3390E-01
-5.1040E-01	1.2633E-01	4.4058E 00	-9.1483E-01	-1.2381E 01	2.5427E 00	5.0068E 00	-1.5049E 00	3.5843E 00	-5.2173E-01
-1.0131E 01	1.4928E 00	6.6634E 00	-8.7469E-01	4.3144E 00	-8.4441E-01	-1.1917E 01	1.3135E 00	7.6485E 00	-6.7982E-01

2.437E 00 -6.7080E 00 -2.5087E 00 5.9678E 00 1.5137E 00 1.9989E 01 -1.2362E 00 -1.1065E 01 3.6497E 00 -5.9342E 00
-3.7917E 00 5.7702E 00 2.0049E 00 5.0320E 00 -2.7547E 00 -5.1762E 00 -1.2694E 00 -1.9159E-01 -1.2724E 00 1.2821E-01

ROW =24

-1.3083E 03 1.79187E 02 3.4917E 03 -2.5788E 02 -2.1879E 03 1.1464E 02 2.9303E 03 -2.4337E 02 -7.8241E 03 6.2213E 02
4.9030E 03 -2.79571E 02 -2.2284E 03 1.0412E 02 5.9487E 03 -4.9910E 02 -3.7261E 03 2.4931E 02 6.7609E 02 -5.9982E 01
-1.8006E 03 1.5460E 02 1.1201E 03 -6.0189E 01 2.1598E 01 -5.0119E 00 -6.2097E 01 1.3021E 01 4.0612E 01 -4.2945E 00
-6.9467E 02 -1.0211E 01 6.9329E 02 4.4884E 01 1.2487E 03 1.8046E 01 -1.2463E 03 -6.0374E 01 -6.1698E 02 -1.2010E 01
8.1539E 02 5.2787E 01 3.4581E 02 4.9497E 00 -3.4514E 02 -2.2210E 01 -5.7624E 01 -6.3024E-01 5.7584E 01 3.7144E 00

ROW =25

1.7523E 01 -2.79877E 00 -4.7036E 01 6.7689E 00 2.9015E 01 -8.6364E 00 -2.1443E 01 4.1273E 00 3.7222E 01 -1.0823E 01
-3.5913E 01 6.70922E 00 7.0904E 00 -2.5525E 00 -1.9117E 01 6.8158E 00 1.2088E 01 -4.0813E 00 -1.0996E 01 1.4339E 00
2.9320E 01 -3.7204E 00 -1.8360E 01 2.0495E 01 1.3309E 01 -1.1700E 00 -3.5520E 01 3.0679E 00 2.2238E 01 -1.6538E 00
8.9594E 00 -6.79510E 01 -1.0697E 01 6.9065E 01 6.7407E 00 1.2315E 02 9.8341E 00 -1.2281E 02 -2.2663E-01 -7.9717E 01
-1.7855E 00 7.9731E 01 -1.8376E 00 3.3712E 01 2.6840E 00 -3.3621E 01 3.5945E 00 -6.3280E 00 -3.7477E 00 6.1486E 00

Sample Problem 2

A cropped trapezoidal wing is analyzed for $M = 0.5$ and $k_r = 0.10$. Since the subsonic AIC program requires a control surface, a dummy surface is added with a minimal number of chordwise collocation stations (2) to minimize computing time. The surfaces are isolated and the option LPUNCH is input as 1 to punch the AIC matrix for the wing only. The wing has 4 chordwise and 4 spanwise collocation stations. Planform geometry and AIC control station locations are shown in Figure 4.6. Summarized below are input parameters. A listing of the data input cards and computer output follows.

$X(1) = 0.0'$ $X(2) = 1.0'$ $X(3) = 2.0'$ $X(4) = 3.0'$ $X(5) = 4.0'$
 $Y(1) = 0.0'$ $Y(2) = 1.0'$ $Y(3) = 2.0'$

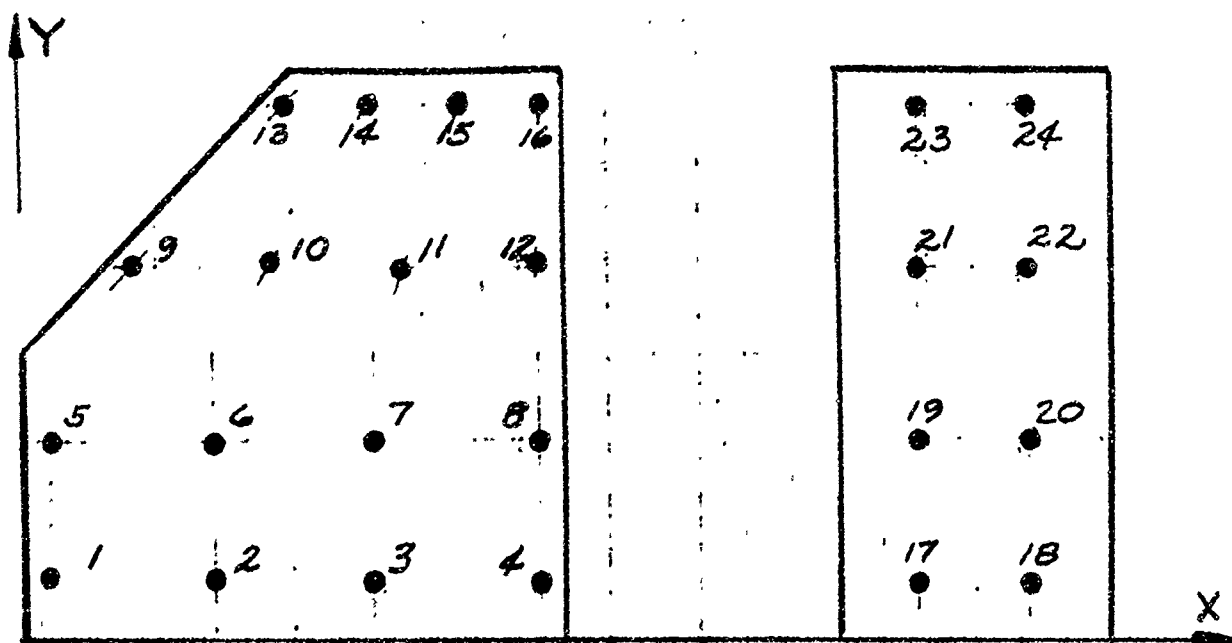
SOUND = 1116.87 ft/sec

NMACH = 1	Number of Mach numbers
KF = 1	Input reduced frequency
NFREQ = 1	Number of reduced frequencies
LCOLL = 1	Print collocation station coordinates
LPUNCH = 1	Punch AIC matrix for wing
NWCX = 4	Number of chordwise AIC collocation stations on wing
NCCX = 2	Number of chordwise AIC collocation stations on control surface
NIONCX = 4	Factor for determining number of chordwise integration stations
NIY = 4	Number of spanwise AIC collocation stations
ISOLAT = 1	Isolate wing and control surface
FMACH (1) = 0.5	Mach number
FREQ(1) = 0.10	Reduced frequency

$YAIC(1,W) = 0.2'$ $YAIC(2,W) = 0.7'$ $YAIC(3,W) = 1.3'$
 $YAIC(4,W) = 1.8'$

$YAIC(1,CS) = 0.2'$ $YAIC(2,CS) = 0.7'$ $YAIC(3,CS) = 1.3'$
 $YAIC(4,CS) = 1.8'$

$XAIC(1,1,W) = 0.10'$	$XAIC(1,2,W) = 0.70'$	$XAIC(1,3,W) = 1.30'$
$XAIC(1,4,W) = 1.90'$		
$XAIC(2,1,W) = 0.10'$	$XAIC(2,2,W) = 0.70'$	$XAIC(2,3,W) = 1.30'$
$XAIC(2,4,W) = 1.90'$		
$XAIC(3,1,W) = 0.38'$	$XAIC(3,2,W) = 0.90'$	$XAIC(3,3,W) = 1.405'$
$XAIC(3,4,W) = 1.915'$		
$XAIC(4,1,W) = 0.86'$	$XAIC(4,2,W) = 1.22'$	$XAIC(4,3,W) = 1.58'$
$XAIC(4,4,W) = 1.94'$		
$XAIC(1,1,CS) = 3.25'$	$XAIC(1,2,CS) = 3.75'$	
$XAIC(2,1,CS) = 3.25'$	$XAIC(2,2,CS) = 3.75'$	
$XAIC(3,1,CS) = 3.25'$	$XAIC(3,2,CS) = 3.75'$	
$XAIC(4,1,CS) = 3.25'$	$XAIC(4,2,CS) = 3.75'$	



• AIC CONTROL STATION

FIGURE 4.6
SUBSONIC SAMPLE PROBLEM #2

HUGHES AIRCRAFT CO. SUBSONIC AIC PROGRAM

FLIGHT CONDITIONS AND GEOMETRY

MACH NUMBER = 0.50000 SPEED OF SOUND = 1116.870 L/T $\rho = 0.100000000E 01$

	WING	TAIL
L.E. STATION (L)	0.	3.000
ROOT CHORD (L)	2.000	1.000
L.E. SPAN (L)	1.000	2.000
T.E. SPAN (L)	2.000	2.000
TIP CHORD (L)	1.000	1.000
TOTAL AREA (L*L)	7.000	4.000
SPAN COLL. STA.	4	4
CHORD COLL. STA.	4	2
CHORD INTG. STA.	16	8
SPAN PRES MODES	4	4
CHORD PRES MODES	4	2

WING AIRCRAFT C7. SUBSONIC AIC PROGRAM (CONT-D)

UNSTEADY AERO COLLOCATION STATION COORDINATES ON THE WING			
S STA NO	YC	XC VALUES--	
1	0.	0.276266E 00	0.952418E 00 0.165486E 01 0.199547E 01
2	.765367E 00	0.276266E 00	0.952418E 00 0.165486E 01 0.199547E 01
3	.141421E 00	0.633263E 00	0.116938E 01 0.172634E 01 0.199641E 01
4	0.184776E 01	0.100692E 01	0.139647E 01 0.180116E 01 0.199739E 01

INTEGRATION STATION COORDINATES ON THE WING			
S STA NO	YI	XI VALUES--	
1	0.390181E 00	0.452807E-02 0.345139E 00 0.104758E 01 0.172373E 01	0.405070E-01 0.500000E 00 0.123576E 01 0.184125E 01 0.111165E 00 0.672932E 00 0.141541E 01 0.192837E 01 0.213947E 00 0.857685E 00 0.158006E 01 0.198193E 01
2	.111114E 01	0.115417E 00 0.437100E 00 0.116051E 01 0.173909E 01	0.149396E 00 0.583355E 00 0.127823E 01 0.185008E 01 0.216128E 00 0.746677E 00 0.144790E 01 0.193235E 01 0.313198E 00 0.921164E 00 0.160339E 01 0.198293E 01
3	.166294E 1	0.665966E 00 0.893675E 00 0.136328E 01 0.181531E 01	0.690019E 00 0.997204E 00 0.148908E 01 0.189387E 01 0.737256E 00 0.111281E 01 0.160919E 01 0.195211E 01 0.805969E 00 0.123633E 01 0.171928E 01 0.198792E 01
4	.196157E 01	0.963922E 00 0.114077E 01 0.150549E 01 0.185656E 01	0.982602E 00 0.122118E 01 0.160319E 01 0.191758E 01 0.101929E 01 0.131097E 01 0.169647E 01 0.196281E 01 0.107265E 01 0.140689E 01 0.178196E 01 0.199062E 01

HIGHES AIRCRAFT CO. SURSONIC AIC PROGRAM (CONT-D)

UNSTEADY AERO COLLOCATION STATION COORDINATES ON THE TAIL

S STA	YD	YC	XC VALUES--	
1		6.	0.345387E 01	0.399149E 01
2		.755367E 00	0.345387E 01	0.399149E 01
3		0.141421E 01	0.345387E 01	0.399149E 01
4		0.184776E 01	0.345387E 01	0.399149E 01

INTERGRATION STATION COORDINATES ON THE TAIL

S STA	YD	YI	XI VALUES--	
1		0.390181E 00	0.300851E 01	0.307489E 01
			0.354613E 01	0.372287E 01
2		0.111114E 01	0.300851E 01	0.307489E 01
			0.354613E 01	0.372287E 01
3		0.166294E 01	0.300851E 01	0.307489E 01
			0.354613E 01	0.372287E 01
4		0.196157E 01	0.300851E 01	0.307489E 01
			0.354613E 01	0.372287E 01

0.336317E 01
0.396624E 01
0.336317E 01
0.396624E 01
0.336317E 01
0.396624E 01
0.336317E 01
0.396624E 01
0.336317E 01
0.396624E 01

HUGHES AIRCRAFT CO. SUBSONIC AIC PROGRAM (CONT-D)

AIC COLLOCATION STATION COORDINATES ON THE WING			
YAIC	XAIC VALUES--		
0.260000E 00	0.100000E 00	0.700000E 00	0.130000E 01
0.700000E 00	0.100000E 00	0.700000E 00	0.130000E 01
0.130000E 01	0.380000E 00	0.900000E 00	0.140500E 01
0.180000E 01	0.860000E 00	0.122000E 01	0.158000E 01
			0.190000E 01
			0.190000E 01
			0.191500E 01
			0.194000E 01

HUGHES AIRCRAFT CO. SURSONIC AIC PROGRAM (CONT-D)

AIC COLLOCATION STATION COORDINATES ON THE TAIL

YAIC	XAIC VALUES--	
0.200000E 00	0.325000E 01	0.375000E 01
0.700000E 00	0.325000E 01	0.375000E 01
0.130000E 01	0.325000E 01	0.375000E 01
0.180000E 01	0.325000E 01	0.375000E 01

HUGHES AIRCRAFT CO. SUBSONIC AIC PROGRAM (CONT-D)

OSCILLATORY FREQUENCY (CPS) 8.88777E 00
REFERENCE CHORD 1.00000E 00
REDUCED FREQUENCY (REF. CHORD) 1.00000E-01
REDUCED VELOCITY (REF. CHORD) 1.00000E 01
FREE STREAM MACH NUMBER 5.00000E-01
FREE STREAM VELOCITY 5.58435E 02
DENSITY 1.00
DYNAMIC PRESSURE (1/2*RH0*VEL**2) 1.55925E 05

AERODYNAMIC INFLUENCE COEFFICIENTS

	RL	IM	RL	IM	RL	IM	RL	IM
ROW = 1								
3.0277E 02	-6.6667E 00	-6.2017E 02	-1.1730E 01	4.9906E 02	2.2950E 01	-1.8156E 02	-1.4986E 01	-3.5214E 02
7.7999E 02	1.3377E 01	-6.4773E 02	-3.3088E 01	2.1963E 02	2.0672E 01	2.1610E 02	-4.3830E 00	-4.5127E 02
3.6769E 02	1.3491E 01	-1.3248E 02	-8.3362E 00	-1.0106E 02	1.2299E 00	1.6562E 02	2.3269E 00	-9.1648E 01
2.7054E 01	2.5499E 00	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW = 2								
8.9541E 01	-2.0789E 00	-3.6262E 02	2.5103E 00	5.0217E 02	1.1902E 01	-2.2870E 02	-1.5052E 01	-1.0511E 02
4.242E 02	-2.9028E 00	-5.8406E 02	-1.4747E 01	2.5633E 02	1.7098E 01	6.4340E 01	-1.3046E 00	-2.7653E 02
3.952E 02	7.4396E 00	-1.7812E 02	-9.7019E 00	-3.3853E 01	6.3348E-01	1.0687E 02	9.9410E-02	-1.2512E 02
5.272E 01	2.5888E 00	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW = 3								
-1.7729E 02	7.5105E 00	3.2225E 02	6.6806E 00	-1.4545E 02	-1.4634E 01	9.4712E-01	2.4717E 00	2.1005E 02
-4.374E 02	-6.3219E 00	2.5506E 02	1.7689E 01	-4.1797E 01	-5.1216E 00	-1.2602E 02	4.6707E 00	-6.5703E 00
-9.7456E 01	-9.3216E 00	-6.4797E 00	1.3600E 00	6.0737E 01	-1.1565E 00	-8.5944E 01	-1.4354E 00	2.3020E 02
7.7188E 00	1.5492E-01	0.	0.	0.	0.	0.	0.	1.7455E 01
0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW = 4								
-1.9852E 02	8.5586E 00	5.3919E 02	-1.3007E 00	-5.2016E 02	-1.3441E 01	1.7980E 02	8.4671E 00	2.3606E 02
-6.8085E 02	3.1092E 00	6.9193E 02	1.5837E 01	-2.4744E 02	-1.1339E 01	-1.4162E 02	5.2873E 00	4.0095E 02
-3.9420E 02	-8.5774E 00	1.3504E 02	5.3909E 00	7.2062E 01	-1.5670E 00	-1.5869E 02	-3.8219E-01	1.2770E 02
-4.095E 01	-1.1911E 00	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW = 5								
2.214E 02	-4.9079E 00	-4.5335E 02	-8.2165E 00	3.7130E 02	1.5819E 01	-1.3804E 02	-1.0203E 01	-2.5620E 02
5.8394E 02	9.3038E 00	-4.9522E 02	-2.4941E 01	1.6729E 02	1.5652E 01	2.1195E 02	-4.3845E 00	-4.4682E 02
3.697E 02	1.3363E 01	-1.3483E 02	-8.5730E 00	-9.8198E 01	1.1079E 00	1.5691E 02	2.8483E 00	-8.1314E 01
2.2574E 01	2.3012E 00	0.	0.	0.	0.	0.	0.	0.

ROW = 6
 6.479E 01 -1.4648E 02 -2.6468E 02 1.9922E 00 3.7066E 02 8.2695E 00 -1.7038E 02 -1.0905E 01 -7.5857E 01 1.9906E 00
 3.675E 02 -2.2438E 02 -4.202E 02 -1.0628E 01 1.8684E 02 1.2297E 01 6.2281E 01 -1.2306E 00 -2.7545E 02 1.9763E 00
 3.9519E 02 7.3449E 00 -1.8181E 02 -9.8388E 00 -3.3763E 01 6.6362E-01 1.0153E 02 1.7567E-01 -1.1483E 02 -2.7928E 00
 4.547E 01 2.3699E 02 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.

ROW = 7
 -1.2819E 02 5.5285E 01 2.3393E 02 4.8690E 00 -1.0440E 02 -1.0908E 01 -9.9578E-01 1.8222E 00 1.5333E 02 -6.3090E 00
 -3.776E 02 -4.1516E 02 2.0786E 02 1.3047E 01 -4.0722E 01 -4.2135E 00 -1.2313E 02 4.6603E 00 2.2623E 02 4.2515E 00
 -9.673E 01 -9.5611E 00 -9.1653E 00 1.3951E 00 5.9340E 01 -1.0576E 00 -8.1925E 01 -1.3560E 00 1.5280E 01 1.0896E 00
 7.2765E 00 2.6233E-01 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.

ROW = 8
 -1.4318E 02 6.2412E 00 5.9137E 02 -1.0005E 00 -3.7849E 02 -9.8672E 00 1.3054E 02 6.1771E 00 1.7172E 02 -7.2891E 00
 -5.7712E 02 2.7788E 00 5.2523E 02 1.1837E 01 -1.5005E 02 -8.5277E 00 -1.3744E 02 3.1974E 00 3.9474E 02 -9.6239E-01
 -3.9450E 02 -8.7469E 00 1.3338E 02 5.4807E 00 7.0677E 01 -1.4915E 00 -1.5213E 02 -4.3782E-01 1.1960E 02 1.9948E 00
 -3.8172E 01 -1.0529E 00 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.

ROW = 9
 4.6979E 01 -1.1843E 00 -1.0236E 02 -1.2399E 00 9.3337E 01 1.5185E 00 -4.0002E 01 -1.2296E 00 -5.6749E 01 1.2949E 00
 1.4682E 02 1.8743E 00 -1.3196E 02 -7.0504E 00 4.1825E 01 4.3984E 00 1.1167E 02 -2.4032E 00 -2.3048E 02 -3.2333E 00
 1.9391E 02 6.0459E 00 -7.5104E 01 -4.0479E 00 -1.8902E 01 1.7013E-01 1.3828E 01 7.4985E-01 1.6267E 01 -6.1641E-01
 -1.1207E 01 1.5619E-01 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.

ROW = 10
 1.5925E 01 -2.7235E-01 -5.9586E 01 6.8621E-01 8.8990E 01 1.1332E 00 -4.3271E 01 -2.2388E 00 -1.6181E 01 4.0905E-01
 7.255E 01 -5.9037E-01 -9.6177E 01 -2.3731E 00 4.0247E 01 2.5894E 00 3.2251E 01 -6.0941E-01 -1.4788E 02 1.1821E 00
 -1.892E 02 3.8027E 00 -1.0317E 02 -5.4764E 00 -8.3388E 00 0. 0. 0. 0. 0. 0. 0. 0.
 -7.2432E 00 -2.1546E-02 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.

ROW = 11
 -2.7412E 01 1.3036E 01 5.0347E 01 1.0829E 00 -1.9762E 01 -2.5424E 00 -2.7807E 00 2.8189E-01 3.4722E 01 -1.4636E 00
 -8.5732E 01 -4.6331E-01 7.0856E 01 3.2160E 00 -2.0795E 01 -1.5715E 00 -6.4063E 01 2.5212E 00 2.0235E 02 -3.9995E-01
 -3.5871E 01 -5.0829E 00 -1.2233E 01 4.1498E-01 1.2479E 01 1.1393E-02 -9.3474E 00 -1.8208E-01 -4.0810E 00 -6.4229E-01
 9.450E-01 2.8642E-01 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.

ROW = 12
 -3.261E 01 1.4017E 00 8.4463E 01 -2.8477E-01 -8.2248E 01 -2.1176E 00 2.8106E 01 1.2449E 00 3.8287E 01 -1.6621E 00
 -1.568E 02 1.1229E 00 1.4018E 02 2.5728E 00 -5.2752E 01 -2.7764E 00 -7.0847E 01 2.7464E 00 2.0235E 02 -3.9995E-01
 -1.7402E 02 -4.6879E 00 0.5604E 01 1.6746E 01 -1.9716E-01 -1.3933E-02 -9.3474E 00 -3.3236E-01 3.1910E 00 -1.4879E-03
 5.4792E-01 8.6263E-02 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.

ROW = 13
 -4.3238E 02 9.1045E 01 9.0371E 02 1.7560E 01 -7.1672E 02 -3.7351E 01 2.4511E 02 2.3084E 01 7.3188E 02 -1.6371E 01
 -1.378E 03 -2.6432E 01 1.3925E 03 6.5947E 01 -4.8621E 02 -4.1930E 01 -4.1622E 02 8.2079E 00 8.8129E 02 1.3887E 01
 -6.9764E 02 -3.1538E 01 2.3176E 02 1.9440E 01 2.6766E 02 -3.5799E 00 -4.5456E 02 -6.5103E 00 2.8251E 02 3.9503E 00
 -9.574E 01 -5.2163E 0 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.

ROW = 14
 -1.4151E 02 3.3710E 00 5.1639E 02 -2.8059E 00 -6.8630E 02 -1.8196E 01 3.0095E 02 2.0501E 01 2.1543E 02 -5.1456E 00
 -9.387E 02 0.9704E 00 -2.683E 03 2.9452E 01 -5.5610E 02 -3.6036E 01 -1.2577E 02 2.8289E 00 5.3123E 02 -2.7508E 00
 -7.4457E 02 -1.6183E 01 3.1676E 02 1.8436E 01 8.7939E 01 -1.5304E 00 -2.9530E 02 4.0006E-01 3.6949E 02 6.3263E 00

0.5643E 02 -3.1144E 00 -1.6762E 02 -3.3919E 00 1.6724E 02 1.1759E 01 3.0324E 02 4.1393E 00 -3.0267E 02 -1.9276E 01
 -1.5643E 02 -3.1144E 00 1.5607E 02 1.0923E 01 6.9669E 01 6.1505E-01 -6.9944E 01 -4.2933E 00
 ROM =24
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 4.0806E 00 -1.5706E 01 -4.4734E 00 1.5502E 01 -3.8450E-01 1.6647E 01 -1.6720E 00 2.8860E 01 2.3963E 00 -2.8774E 01
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.

Sample Problem 3

A 45° delta wing-control surface combination is analyzed for $M = 0.5$ and $f = 5.0$ cps. There are 4 spanwise and 4 chordwise AIC control stations for both the wing and control surface. The planform geometry and AIC control station locations are shown in Figure 4.8. The input parameters are summarized below and a listing of the data input cards and computer output follows.

$X(1) = 0.0'$ $X(2) = 2.0'$ $X(3) = 2.0'$ $X(4) = 3.0'$ $X(5) = 4.0'$
 $Y(1) = 0.0'$ $Y(2) = 0.0'$ $Y(3) = 2.0'$

SOUND = 1116.87 ft/sec

NMACH = 1	Number of Mach numbers
KF = 0	Input frequencies
NFREQ = 1	Number of frequencies
LCOLL = 1	Print collocation station coordinates
LPUNCH = 4	Punch cards for total AIC matrix
NWCX = 4	Number of chordwise AIC collocation stations on wing
NCCX = 4	Number of chordwise AIC collocation stations on control surface
NIONCX = 4	Factor for determining number of chordwise integration stations
NIY = 4	Number of spanwise AIC collocation stations
ISOLAT = 0	Surfaces are not isolated
FMACH(1) = 0.5	Mach number
FREQ(1) = 5.0	Frequency

$YAIC(1,W) = 0.2'$ $YAIC(2,W) = 0.6'$ $YAIC(3,W) = 1.0'$
 $YAIC(4,W) = 1.4'$

$YAIC(1,CS) = 0.25'$ $YAIC(2,CS) = 0.75'$ $YAIC(3,CS) = 1.25'$
 $YAIC(4,CS) = 1.75'$

XAIC(1,1,W) = 0.56'	XAIC(1,2,W) = 0.92'	XAIC(1,3,W) = 1.28'
XAIC(1,4,W) = 1.64'		
XAIC(2,1,W) = 0.88'	XAIC(2,2,W) = 1.16'	XAIC(2,3,W) = 1.44'
XAIC(2,4,W) = 1.72'		
XAIC(3,1,W) = 1.20'	XAIC(3,2,W) = 1.40'	XAIC(3,3,W) = 1.60'
XAIC(3,4,W) = 1.80'		
XAIC(4,1,W) = 1.52'	XAIC(4,2,W) = 1.64'	XAIC(4,3,W) = 1.76'
XAIC(4,4,W) = 1.88'		
XAIC(1,1,CS) = 3.125'	XAIC(1,2,CS) = 3.375'	XAIC(1,3,CS) = 3.625'
XAIC(1,4,CS) = 3.875'		
XAIC(2,1,CS) = 3.125'	XAIC(2,2,CS) = 3.375'	XAIC(2,3,CS) = 3.625'
XAIC(2,4,CS) = 3.875'		
XAIC(3,1,CS) = 3.125'	XAIC(3,2,CS) = 3.375'	XAIC(3,3,CS) = 3.625'
XAIC(3,4,CS) = 3.875'		
XAIC(4,1,CS) = 3.125'	XAIC(4,2,CS) = 3.375'	XAIC(4,3,CS) = 3.625'
XAIC(4,4,CS) = 3.875'		

77 A

20

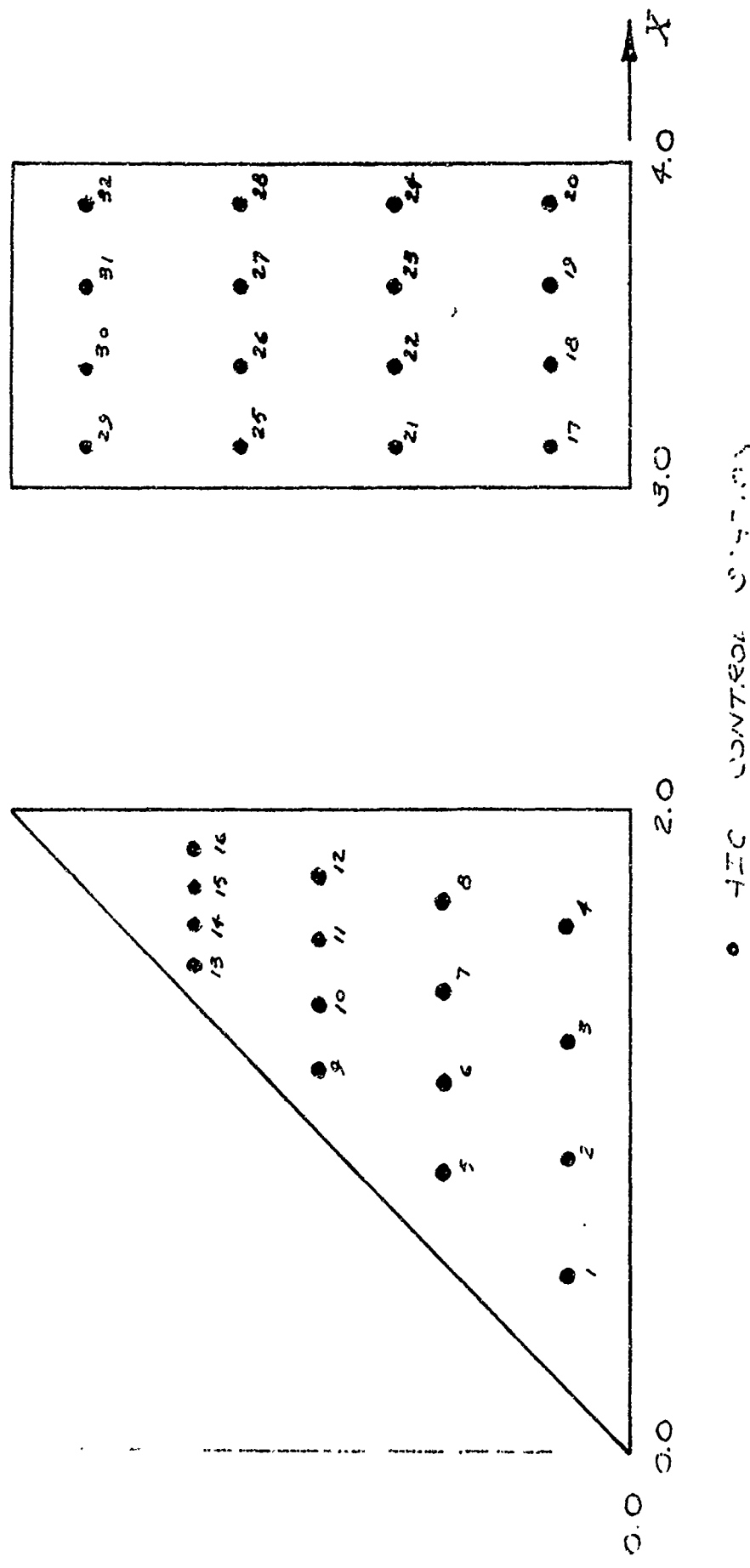


FIGURE 4.8 - VISUONIC SAMPLE PROBLEM

HUGHES AIRCRAFT CO. SUPRSONIC AIC PROGRAM

FLIGHT CONDITIONS AND GEOMETRY

MACH NUMBER = 0.50000 SPEED OF SOUND = 1116.870 L/T RHO=0.10000000E 01

	WING	TAIL
L.E. STATION (L)	0.	3.000
ROOT CHORD (L)	2.000	1.000
L.E. SPAN (L)	0.	2.000
T.E. SPAN (L)	2.000	2.000
TIP CHORD (L)	0.	1.000
TOTAL AREA (L* $\bar{L}$)	4.000	4.000
SPAN COLL. STA.	4	4
CHORD COLL. STA.	4	4
CHORD INTG. STA.	16	16
SPAN PRES MODES	4	4
CHORD PRES MODES	4	4

HUGHES AIRCRAFT CO. SUBSONIC AIC PROGRAM (CONT-D)

UNSTEADY AERO COLLOCATION STATION COORDINATES ON THE WING

S STA NO	YC	XC VALUES--	
1	0.	0.276266E 00	0.952418E 00 0.105486E 01 0.199547E 01
2	0.765367E 00	0.935910E 00	0.135331E 01 0.178694E 01 0.199720E 01
3	0.141421E 01	0.149513E 01	0.169317E 01 0.189891E 01 0.199847E 01
4	0.184776E 01	0.186879E 01	0.192026E 01 0.197373E 01 0.199946E 01

INTEGRATION STATION COORDINATES ON THE WING

S STA NO	YI	XI VALUES--	
1	0.390181E 00	0.393825E 00 0.667987E 00 0.123339E 01 0.177783E 01	0.422785E 00 0.792635E 00 0.138485E 01 0.187222E 01 0.479608E 00 0.931830E 00 0.152946E 01 0.194834E 01 0.562389E 00 0.108054E 01 0.106198E 01 0.108843E 01
2	0.111114E 01	0.111315E 01 0.126493E 01 0.157672E 01 0.187722E 01	0.112914E 01 0.133336E 01 0.166035E 01 0.192945E 01 0.116055E 01 0.141021E 01 0.174019E 01 0.196816E 01 0.120622E 01 0.149232E 01 0.181336E 01 0.190197E 01
3	0.166294E 01	0.166370E 01 0.172111E 01 0.183949E 01 0.195344E 01	0.166977E 01 0.174720E 01 0.187120E 01 0.197325E 01 0.168167E 01 0.177635E 01 0.190148E 01 0.198793E 01 0.169908E 01 0.180748E 01 0.192923E 01 0.199695E 01
4	0.196157E 01	0.196166E 01 0.196820E 01 0.198170E 01 0.199469E 01	0.196235E 01 0.197118E 01 0.198532E 01 0.199695F 01 0.196371E 01 0.197450E 01 0.198877E 01 0.199862E 01 0.196568E 01 0.197805E 01 0.199103E 01 0.199945E 01

WUGHES AIRCRAFT CO. SUBSONIC AIC PROGRAM (CONT-D)

UNSTEADY AERO COLLOCATION STATION COORDINATES ON THE TAIL			
S STA '10	YC	XC VALUES--	
1	0.	0.313813E 01	0.382743E 01 0.399774E 01
2	0.765367E 00	0.313813E 01	0.382743E 01 0.399774E 01
3	0.141421E 01	0.313813E 01	0.382743E 01 0.399774E 01
4	0.184776E 01	0.313813E 01	0.382743E 01 0.399774E 01

INTEGRATION STATION COORDINATES ON THE TAIL

S STA '10	YI	XI VALUES--	
1	0.390181E 00	0.300226E 01 0.317257E 01 0.352379E 01 0.386187E 01	0.309558E 01 0.333647E 01 0.370771E 01 0.396418E 01 0.310497E 01 0.342884E 01 0.379003E 01 0.399096E 01
2	0.111114E 01	0.300226E 01 0.317257E 01 0.352379E 01 0.386187E 01	0.309558E 01 0.333647E 01 0.370771E 01 0.396418E 01 0.310497E 01 0.342884E 01 0.379003E 01 0.399096E 01
3	0.166294E 01	0.300226E 01 0.317257E 01 0.352379E 01 0.386187E 01	0.309558E 01 0.333647E 01 0.370771E 01 0.396418E 01 0.310497E 01 0.342884E 01 0.379003E 01 0.399096E 01
4	0.196157E 01	0.300226E 01 0.317257E 01 0.352379E 01 0.386187E 01	0.309558E 01 0.333647E 01 0.370771E 01 0.396418E 01 0.310497E 01 0.342884E 01 0.379003E 01 0.399096E 01

HUGHES AIRCRAFT CO. SUBSONIC AIC PROGRAM (CONT-D)

AIC COLLOCATION STATION COORDINATES ON THE WING

YAIC	XAIC VALUES--		
0.20000E 00	0.56000E 00	0.92000E 00	0.12800E 01
0.60000E 00	0.88000E 00	0.11600E 01	0.14400E 01
0.10000E 01	0.12000E 01	0.14000E 01	0.16000E 01
0.14000E 01	0.15200E 01	0.16400E 01	0.17600E 01
			0.18800E 01

HUGHES AIRCRAFT CO. SUBSONIC AIC PROGRAM (CONT-D)

AIC COLLOCATION STATION COORDINATES ON THE TAIL				
YAIC	XAIC VALUES--			
0.25000E 00	0.31250E 01	0.33750E 01	0.36250E 01	0.38750E 01
0.75000E 00	0.31250E 01	0.33750E 01	0.36250E 01	0.38750E 01
0.12500E 01	0.31250E 01	0.33750E 01	0.36250E 01	0.38750E 01
0.17500E 01	0.31250E 01	0.33750E 01	0.36250E 01	0.38750E 01

HUGHES AIRCRAFT CO. SUBSONIC AIC PROGRAM (CONT-D)

OSCILLATORY FREQUENCY (CPS) 5.00000E 00
 REFERENCE CHORD 1.00000E 00
 REDUCED FREQUENCY (REF. CHORD) 5.62571E-02
 REDUCED VELOCITY (REF. CHORD) 1.77756E 01
 FREE STREAM MACH NUMBER 5.00000E-01
 FREE STREAM VELOCITY 5.58435E 02
 DENSITY 1.00
 DYNAMIC PRESSURE (1/2* ρ *V²) 1.55925E 05

AERODYNAMIC INFLUENCE COEFFICIENTS

	RL	IM	RL	IM	RL	IM	RL	IM
ROW = 1								
2.5673E 03	-2.9785E 01	-7.7904E 03	-4.5876E 01	9.4193E 03	2.0440E 02	-3.1958E 03	-1.3970E 02	-4.9141E 03
1.2869E 04	4.3412E 01	-1.2358E 04	-2.2343E 02	4.4032E 03	1.5022E 02	3.3245E 03	-2.6726E 01	-8.9088E 03
9.2355E 03	7.3226E 01	-3.6510E 03	-5.9477E 01	-8.1422E 02	1.0365E 01	2.6406E 03	-2.8112E 01	-3.4314E 03
1.651E 03	-1.4966E 01	4.4291E 00	-2.0918E-01	1.0595E 01	8.5137E-01	-3.0321E 00	-2.0327E 00	-1.4236E 01
7.2694E-01	-2.3879E-02	2.0411E 00	1.7339E-01	4.3454E 00	-4.7356E-01	-3.0321E 00	2.8997E-01	2.5813E 00
7.7138E 00	5.5841E-01	1.3635E 01	1.4009E 00	-9.5079E 00	8.4097E-01	7.6408E-01	-2.7000E-02	-2.3831E 00
5.7225E 03	-5.3522E-01	-3.6541E 00	3.2560E-01					
ROW = 2								
-3.2768E-02	7.5376E 00	-9.6302E 02	-5.0438E 00	2.0128E 03	2.0049E 01	-1.0495E 03	-2.4288E 01	-4.6365E 01
1.106E 03	5.5177E 00	-3.1298E 03	-2.9621E 01	1.5653E 03	3.1467E 01	6.4005E 01	3.7660E 00	-1.1280E 03
2.89E 03	1.1118E 01	-1.0448E 03	-1.2304E 01	1.3121E 01	-4.6586E-01	1.4578E 02	2.2442E 00	-2.3786E 02
7.4959E 01	1.6202E 03	1.2082E 00	-2.2042E-01	-4.2680E 00	5.2242E-01	9.8038E 00	-2.1423E 00	-6.7560E 00
5.165E-01	-4.9175E-02	1.2879E 00	2.0630E-01	2.4655E 00	-4.9277E-01	-1.6907E 00	3.1573E-01	1.1702E 00
-3.725E 03	6.4767E-01	7.2114E 00	-1.5131E 00	-4.9709E 00	9.6830E-01	5.5073E-01	-5.9023E-02	-1.5362E 00
3.593E 03	-6.5627E-01	-2.1776E 00	4.1625E-01					
ROW = 3								
-6.413E 02	2.2031E 01	1.4974E 03	-7.7901E 00	-9.1550E 02	-2.7591E 01	9.2526E 01	1.2217E 01	1.3025E 03
-2.414E 03	1.1957E 01	1.2856E 03	2.3651E 01	-5.5936E 01	-8.7148E 00	-8.5753E 02	1.3013E 01	1.6842E 03
-9.116E 01	-6.8127E 00	1.4563E 02	3.5957E 00	2.3793E 02	-1.4094E 00	-6.3986E 02	6.4704E 00	7.5844E 02
-3.552E 02	3.4903E 00	1.4641E 00	-2.0096E-01	-4.4114E 00	8.9416E-01	9.4105E 00	-2.1318E 00	-6.4762E 00
4.125E-01	-5.3721E-02	1.1241E 00	-2.1284E-01	2.5900E 00	-5.0107E-01	-1.5805E 00	3.2049E-01	1.1459E 00
-3.725E 03	6.4767E-01	7.2114E 00	-1.5131E 00	-4.9709E 00	9.6830E-01	5.5073E-01	-5.9023E-02	-1.5362E 00
2.0779E 03	-6.5366E-01	-2.0572E 00	4.3342E-01					
ROW = 4								
-2.55E 03	4.2827E 00	5.1618E 03	-5.3953E 01	-6.3603E 03	-6.4825E 01	2.4073E 03	5.5107E 01	3.4227E 03
-4.626E 03	2.4148E 01	2.4663E 03	2.4525E 01	5.7895E 02	-1.4506E 00	-2.0137E 03	7.0142E 00	6.5552E 03
-6.516E 03	-2.4148E 01	2.4663E 03	2.4525E 01	5.7895E 02	-1.4506E 00	-2.0137E 03	7.0142E 00	6.5552E 03
-1.76E 03	3.4903E 00	1.4641E 00	-2.0096E-01	-4.4114E 00	8.9416E-01	9.4105E 00	-2.1318E 00	-6.4762E 00
3.92E-01	-5.3721E-02	1.1241E 00	-2.1284E-01	2.5900E 00	-5.0107E-01	-1.5805E 00	3.2049E-01	1.1459E 00

NOT REPRODUCIBLE

NOT REPRODUCIBLE

4.3971E 00 -7.8007E-01 -3.0374E 00 4.8182E-01

ROW = 5

1.7828E 03 -2.0541E 01 -5.4233E 03 -3.0736E 01 5.9027E 03 1.3874E 02 -2.2619E 03 -9.8660E 01 -3.5440E 03 3.6887E 01
9.2700E 03 2.8965E 01 -8.9956E 03 -1.5604E 02 3.1685E 03 1.0372E 02 2.9038E 03 -2.3204E 01 -7.6201E 03 1.3228E-01
7.7711E 03 5.4610E 01 -3.0622E 03 -4.5654E 02 7.3925E 02 8.4810E 00 8.2235E 03 -2.1771E 01 -2.7335E 03 2.8077E 01
1.2566E 03 -1.1800E 01 5.2399E 00 -4.1110E-01 -1.3203E 01 1.6812E 00 2.6032E 01 -3.6492E 00 -1.8117E 01 2.4832E 00
9.9151E-01 -7.6519E-02 -2.7582E 00 3.7215E-01 1.7702E 00 -9.2799E-01 -4.0118E 00 5.8688E-01 3.2677E 00 -2.5983E-01
-8.7190E 00 1.1579E 00 1.7826E 01 -2.7946E 00 -1.2389E 01 1.7525E 00 1.0872E 00 -9.0474E-02 3.2999E 00 -6.6801E-01
7.1522E 00 -1.1618E 00 -4.9460E 00 7.3066E-01

ROW = 6

1.1920E 00 5.2419E 00 -6.6942E 02 -3.5302E 00 1.3979E 03 1.3820E 01 -7.2939E 02 -1.4790E 01 -3.4796E 01 -4.6330E 00
1.1546E 03 4.0555E 00 -2.2355E 03 -2.1204E 01 1.1155E 03 2.2304E 01 5.4777E 01 2.7035E 00 -9.6806E 02 -2.6737E 00
1.8222E 03 1.0213E 01 -8.8861E 02 -1.0883E 01 8.0612E 00 -3.0581E-02 1.2056E 02 1.6942E 00 -1.7288E 02 -3.5335E 00
4.4174E 01 1.2465E 00 1.2411E 00 -1.8274E-01 -3.9101E 00 7.7147E-01 8.7121E 00 -1.8030E 00 -6.0132E 00 1.1511E 00
4.4798E-01 -4.1164E-02 -3.1245E 00 1.7462E-01 2.1634E 00 -4.1820E-01 -1.4883E 00 2.6714E-01 1.0785E 00 -1.2543E-01
-3.0537E 00 5.3661E-01 6.3631E 00 1.2774E 00 -4.3951E 00 8.1538E-01 4.9377E-01 -4.8550E-02 1.3533E 00 2.3129E-01
2.7670E 00 -5.5415E-01 -1.9106E 00 3.5074E-01

ROW = 7

-4.6015E 02 1.5235E 01 1.0358E 03 -5.5881E 00 -6.3568E 02 -1.8617E 01 6.6242E 01 8.2244E 00 9.3998E 02 -2.0515E 01
-1.8313E 03 6.7439E 00 9.4260E 02 1.6269E 01 -5.1488E 01 -6.1016E 00 -7.3069E 02 1.0511E 01 1.4336E 03 -6.7567E 00
-7.8213E 02 3.5886E 00 9.9278E 01 1.7148E 00 2.1941E 02 -7.3018E-01 -5.6847E 02 4.7851E 00 6.4418E 02 -7.9895E 00
-3.0312E 02 2.7021E 00 1.1282E 00 1.3465E-01 -3.3320E 00 4.1255E-01 5.6822E 00 -1.4712E 00 -4.8680E 00 9.3988E-01
3.242E-01 -3.4203E-02 -8.6244E-01 1.7220E-01 1.7275E 00 -3.4842E-01 -1.1942E 00 2.2135E-01 9.0032E-01 -9.8372E-02
-2.4932E 00 4.4355E-01 5.1361E 00 1.8991E 00 -3.5502E 00 6.7572E-01 4.2134E-01 -4.2014E-02 -1.1208E 00 1.9884E-01
2.2496E 00 -4.7310E-01 -1.5531E 00 2.9838E-01

ROW = 8

-1.1832E 03 3.2339E 01 3.9887E 03 -2.3755E 01 -4.4091E 03 -1.6038E 03 3.7374E 01 2.4736E 03 -4.7571E 01
-7.1180E 03 3.2783E 01 7.0706E 03 5.3717E 01 -2.4254E 03 -4.2932E 01 1.6038E 03 2.3074E 01 5.6822E 03 -1.8528E 01
-5.7140E 03 -1.5501E 01 2.0450E 03 1.8646E 01 5.4538E 02 -4.2312E-01 -2.1769E 03 4.2178E 00 -2.1854E 03 -5.0728E 00
9.5988E 02 -6.0947E-01 3.0485E 00 5.3704E-02 -6.3083E 00 -4.3121E-01 1.0685E 01 -1.2178E 00 -7.4149E 00 7.4072E-01
-2.9747E-01 -2.0621E-02 8.5297E-01 1.2303E 00 3.3088E-01 -1.5425E 00 1.8187E-01 1.5071E 00 -3.1382E-02
-3.6330E 00 3.4209E-01 7.0578E 00 -9.0191E-01 -4.9387E 00 5.5030E-01 5.4032E-01 -2.6091E-02 -1.4101E 00 1.7095E-01
2.8269E 00 -4.1985E-01 -1.9596E 00 2.5407E-01

ROW = 9

9.5645E 02 -1.1028E 01 -2.9560E 03 -1.4255E 01 3.2888E 03 4.9578E 01 -1.2891E 03 -4.9282E 01 -2.1012E 03 2.2135E 01
5.4931E 03 1.4455E 01 -5.2529E 03 -8.7349E 01 1.8608E 03 5.9755E 01 2.1345E 03 -1.7277E 01 -5.4401E 03 3.8145E 00
5.4405E 03 2.9088E 01 -2.1349E 03 -2.4469E 01 -2.0178E 02 4.3493E 00 6.4102E 02 -1.4115E 03 -8.5439E 02 2.0488E 01
4.1509E 02 -9.3236E 00 5.9732E 00 -6.3944E-01 -1.5818E 01 2.6066E 00 3.1944E 01 -6.1158E 00 -2.2117E 01 3.8917E 00
1.5179E 00 -1.3681E-01 3.5605E 00 5.9535E-01 7.3288E 00 -1.4335E 00 -5.0845E 00 9.1894E-01 -4.0118E 00 -1.2966E-01
-1.0079E 01 1.0255E 00 2.3288E 01 -4.3375E 00 -1.5487E 01 2.7643E 00 1.4943E 00 -1.6494E-01 -4.3606E 00 7.6843E-01
9.7413E 00 -1.8516E 00 -6.3858E 00 1.1777E 00

ROW = 10

1.7910E 00 2.7901E 00 -3.7519E 02 -1.7543E 00 7.4250E 02 4.8169E 00 -3.6800E 02 -6.5675E 00 -2.1692E 01 -2.5370E 00
6.772E 02 2.3095E 00 -1.2950E 03 -1.2112E 01 6.4288E 02 1.2582E 01 2.1345E 03 1.3732E 00 -8.8692E 02 -1.8066E 00
1.2505E 03 8.9553E 00 -6.1365E 02 -7.8991E 01 1.0768E 01 4.6670E-01 4.6670E-01 -1.1100E 01 8.5339E-01 1.5761E 02 -1.6493E 00
-1.2725E 02 3.8990E-01 1.0361E 00 -1.3484E-01 -3.1488E 01 5.7346E 00 6.8166E-02 -1.3491E 00 -4.7136E 00 8.5945E-01
3.5474E-01 -3.1021E-02 -8.7702E-01 1.3222E-01 1.6831E 00 -3.1710E-01 -1.1649E 00 2.0201E-01 8.8800E-01 -3.3704E-02
-2.4216E 00 4.0367E-01 4.9647E 00 -9.6149E-01 -3.4373E 00 6.1232E-01 4.0330E-01 -3.7577E-02 1.0679E 00 1.7400E-01
2.1520E 00 -4.1776E-01 -1.4898E 00 2.6401E-01

ROW = 11

-2.4824E 02 8.0778E 00 5.6376E 02 -3.2049E 00 -3.6977E 02 -9.6402E 00 5.0335E 01 4.4289E 00 9.5948E 02 -1.1745E 01
-1.1113E 03 5.2493E 00 5.9033E 02 9.1900E 00 -4.8320E 01 -3.7070E 00 -5.5475E 02 6.8748E 00 1.0296E 03 -4.9056E 00
-5.4277E 02 -3.9764E-01 6.7987E 01 9.3260E-02 8.2712E 01 7.2415E 01 2.2415E 02 2.3278E 00 4.3459E 02 -4.4082E 00
42.4658E 02 1.4012E 00 5.8338E-01 -4.9287E-02 1.6947E 00 2.4845E-01 3.5830E 00 -4.1294E-01 -2.4735E 00 3.6428E-02
1.1613E-01 -1.3689E-02 -4.7295E-01 6.2117E-02 9.0155E-01 -1.4914E-01 -6.2353E-01 9.3031E-02 5.1069E 00 -3.7831E-02

NOT REPRODUCIBLE

-1.244E 00 1.3244E-01 2.6478E 00 -4.4768E-01 -1.8369E 00 2.8151E-01 2.5584E-01 -1.7010E-02 -6.1630E-01 6.4056E-08
1.757E 00 -2.3277E-01 -8.1638E-01 1.2572E-01

ROW = 12

-6.455E 02 1.7122E 01 2.1526E 03 -1.3304E 01 -2.4085E 03 -2.3440E 01 8.8816E 02 1.9622E 01 1.4750E 03 -2.7310E 01
-4.492E 03 1.8771E 01 4.2308E 03 3.1599E 01 -1.4567E 03 -2.5555E 01 -1.4992E 03 1.9608E 01 4.0841E 03 -1.2223E 01
-4.23E 03 -1.2208E 01 1.4274E 03 2.2668E 01 1.9472E 02 2.2165E 00 -6.9105E 02 -2.1085E 02 9.8534E 00 -2.5979E 00
-4.808E 02 -6.7221E-01 1.0851E 00 6.9468E-02 1.8820E 00 1.5160E-01 2.8331E 00 2.2572E-01 -1.8844E 00 -1.7463E-01
5.494E-02 1.0554E-02 -1.7922E-01 1.7922E-01 -2.0789E-02 4.9762E-01 4.0246E-02 -3.7757E-02 5.2372E-01 4.0166E-02
-1.153E 00 -8.4554E-02 1.7189E 00 1.3494E-01 -1.2277E 00 -1.0841E-01 2.1811E-01 1.1577E-02 -4.1485E-01 -2.2629E-02
6.417E-01 4.3815E-02 -4.7705E-01 -3.6794E-02

ROW = 13

-4.228E 03 5.6687E 01 1.3184E 04 6.4762E 01 -1.4183E 04 -3.4484E 02 5.2211E 03 2.3301E 02 1.0798E 04 -1.2236E 02
-2.8314E 04 -6.0205E 01 2.7106E 04 4.3190E 02 -9.7895E 03 -2.9774E 02 -8.2285E 03 7.447E 01 2.1478E 04 -3.3629E 01
-2.672E 04 -1.0105E 02 8.422E 03 9.6452E 01 4.9774E 03 4.1204E 01 -1.4622E 04 9.6451E 01 1.6877E 04 -1.267E 02
-7.627E 03 4.9455E 01 1.4143E 01 -1.9295E 00 3.9119E 01 8.1451E 00 8.0000E 00 -1.0220E 01 -5.3280E 01 -1.2439E 01
3.792E 00 -4.8493E-01 -9.4176E 00 2.0005E 00 1.9255E 01 4.6676E 00 -1.3351E 01 2.9981E 00 1.0294E 01 -1.4057E 00
-2.153E 01 5.9176E 00 5.7702E 01 -1.3987E 01 -3.9935E 01 9.0199E 00 4.5863E 00 -6.1016E-01 -1.2399E 01 2.6735E 00
2.5133E 01 -6.2423E 00 -1.7358E 01 3.9805E 00

ROW = 14

7.933E 00 -1.1194E 01 1.5007E 03 4.4376E 00 -3.1304E 03 -2.4133E 01 1.6215E 03 3.3013E 01 1.1475E 02 1.2142E 01
-3.178E 03 -1.0137E 01 6.8081E 03 5.9955E 01 -3.4045E 03 -6.3737E 01 -1.8517E 02 -3.7158E 00 2.6479E 03 3.5437E 00
-4.867E 03 -2.2053E 01 2.3240E 03 7.1678E 01 1.2568E 00 1.2568E 00 2.7094E 03 -4.2915E 00 2.6784E 03 1.001E 01
-1.632E 03 -6.7399E 00 1.8057E 00 1.0618E-01 2.5961E 00 -3.5520E-01 2.8661E 00 6.9959E-01 -2.0732E 00 -4.9424E-01
-1.111E-01 2.4670E-02 9.9616E-02 -6.8280E-02 2.1133E-01 1.4632E-01 -1.9282E-01 -1.0385E-01 4.8233E-01 7.3410E-02
-7.679E-01 -2.3396E-01 1.2712E 00 4.8583E-01 -9.5484E-01 -3.4124E-01 -8.4124E-03 2.8200E-02 -3.5497E-02 -1.0290E-01
1.492E-01 2.2848E-01 -1.4958E-01 -1.5518E-01

ROW = 15

1.763E 03 -3.5887E 01 -2.737E 03 1.1241E 01 1.9651E 03 5.5479E 01 -3.6473E 02 -2.8835E 01 -2.8511E 03 6.0016E 01
5.044E 03 -2.6845E 01 -2.8733E 03 4.6935E 01 1.6016E 02 1.8463E 01 2.1346E 03 -2.4941E 01 -4.1731E 03 1.7917E 01
2.721E 03 7.6722E 03 -4.3473E 02 -6.6155E 00 -1.2718E 02 7.4944E 00 2.7094E 03 -1.8953E 01 -2.1437E 03 2.4856E 01
7.211E 02 -9.6715E 00 -7.4021E-01 3.2179E-01 3.3049E 00 -1.3240E 00 -7.9245E 00 3.0722E 00 5.3794E 00 -2.0202E 00
-4.35E-01 8.3988E-02 1.1119E 00 -3.2535E-01 2.1730E 00 7.4214E-01 1.4860E 00 -4.8362E-01 -9.3099E-01 2.3910E-01
-2.111E 00 -9.6785E-01 -6.235E 00 2.2454E 00 4.2394E 00 -1.4718E 00 -5.9007E-01 1.0470E-01 1.5351E 00 -4.4896E-01
-2.816E 03 1.9357E 00 2.4429E 00 -6.6775E-01

ROW = 16

2.4767E 03 -7.7505E 01 -1.0093E 04 5.7141E 01 1.1441E 04 1.2549E 02 -4.2243E 03 -1.0281E 02 -7.5185E 03 1.4046E 02
2.623E 02 -9.8371E 01 -2.1275E 04 -1.5772E 02 7.3722E 03 1.2804E 02 5.8412E 03 -5.7742E 01 -1.6278E 04 4.7005E 01
1.297E 04 5.2158E 01 -5.8612E 03 -5.5668E 01 -3.3468E 03 1.3469E 01 7.9232E 03 -2.8316E 01 -1.0927E 04 2.1124E 01
4.478E 03 1.2531E 01 -6.5479E 00 5.0583E-01 1.4622E 01 -2.2998E 00 -2.6248E 01 5.6489E 00 1.8106E 01 -3.6259E 00
-3.214E-01 1.3552E-01 2.0194E 00 -6.0403E-01 -5.5478E 00 1.4008E 00 3.9310E 00 -8.9352E-01 -3.2030E 00 3.8498E-01
8.226E 00 -1.7371E 01 -1.7861E 01 4.1747E 00 1.2404E 01 -2.6800E 00 -1.3418E 00 1.7793E-01 3.7144E 00 -8.2538E-01
-7.471E 00 1.9289E 01 5.1861E 00 -1.2231E 00

ROW = 17

-2.166E 02 1.7164E 01 1.3656E 03 -1.3206E 02 -5.3104E 03 2.7296E 02 2.9241E 03 -1.3558E 02 4.4566E 02 -2.3438E 01
-3.519E 01 1.9876E 01 3.5621E 03 -4.1074E 02 -4.8576E 03 2.0716E 02 -3.4383E 02 2.1404E 01 2.8840E 03 -1.6737E 02
-6.827E 03 3.4867E 01 3.246E 03 -1.8757E 02 6.9926E 01 7.8244E-01 -7.8320E 02 1.8608E 01 1.6728E 03 -4.1729E 01
-9.46E 02 2.0205E 01 3.4833E 03 -2.1451E 01 -7.6048E 03 2.7020E 01 6.3426E 03 7.3998E 01 -2.2430E 03 -4.8154E 01
-4.324E 01 2.9916E 01 1.0663E 04 4.4581E 01 -2.6131E 03 -1.2430E 02 2.8423E 03 7.7423E 01 2.9032E 03 -1.7963E 01
-6.824E 01 -2.3233E 03 5.275E 03 4.5451E 01 -1.6217E 03 -4.1240E 01 2.7029E 02 4.2435E 00 1.5375E 03 7.5715E 00
-3.154E 03 -2.1144E 01 3.074E 02 1.2847E 01

ROW = 18

-4.7206E 01 3.1764E 01 3.9558E 02 -2.3552E 01 -8.3832E 02 4.8799E 01 4.9024E 02 -2.4605E 01 6.3332E 01 -3.6674E 00
-6.807E 02 3.1902E 01 1.2386E 03 -6.4071E 01 -7.4020E 02 3.2399E 01 5.5649E 01 3.6730E 00 4.6035E 02 -2.8043E 01
-9.249E 02 5.8863E 01 5.6755E 02 -3.1714E 01 4.1626E 00 5.5048E-01 -8.3245E 01 -1.6746E 00 1.8166E 02 2.7728E 00

NOT REPRODUCIBLE

NOT REPRODUCIBLE

-9. 496E 02	5.4501E 00	4.1637E 03	-5.2199E-01	-5.8196E 03	-4.8602E 01	2.5906E 03	4.7850E 01	5.4909E 02	-2.8334E 00
-2. 937E 03	8.0441E-01	3.5495E 03	2.7242E 01	-1.6078E 03	-2.8248E 01	-1.3413E 02	5.5698E-01	5.9941E 02	1.8293E-01
-8. 741E 02	-7.8756E 0	3.6209E 02	7.2713E 00						
R04 = 19									
4. 13E 01	-2.1813E 00	-3.7455E 02	1.8540E 01	7.9232E 02	-3.8099E 01	-4.6042E 02	1.8291E 01	-8.2628E 01	4.3365E 00
7. 73E 02	-3.7501E 01	-1.5371E 03	7.6580E 01	8.9276E 02	-3.8656E 01	5.5182E 01	-3.1123E 00	-4.7595E 02	2.5782E 01
1. 24E 03	-5.3437E 01	-2.8174E 01	2.8339E 01	-2.2849E 01	1.3424E 00	1.9401E 02	-1.1212E 01	-4.0757E 02	2.3381E 01
2. 745E 02	-1.2917E 01	-3.205E 03	1.6849E 01	2.1047E 03	5.6222E 00	-4.7444E 02	-1.9436E 01	-3.0953E 02	1.5817E-01
1. 325E 03	-2.2201E 01	-3.0822E 03	-9.0241E 00	8.9286E 02	2.8745E 01	3.0661E 02	-2.8146E 00	-1.1060E 03	1.3695E 01
1. 869E 03	5.0765E 00	-4.4703E 02	-1.6805E-01	-2.3168E 02	8.1385E-01	2.7411E 02	-3.0786E 00	-4.5736E 02	-1.4536E 00
1. 986E 02	4.3495E 00	3.3357E 01	-6.2692E-01						
R04 = 20									
8. 71E 01	-4.7162E 00	-7.2823E 02	3.8361E 01	1.5413E 03	-7.9052E 01	-8.9719E 02	3.8612E 01	-1.5077E 02	8.0350E 00
1. 7312E 03	-6.8333E 01	-2.8148E 03	1.4134E 02	1.6349E 03	-7.1461E 01	1.0435E 02	-6.1964E 00	-8.9125E 02	5.8190E 01
1. 2451E 03	-1.3425E 02	-1.3915E 03	5.5666E 01	-3.2648E 01	1.3179E 00	3.0245E 02	-1.4259E 01	-6.3873E 02	3.0093E 01
3. 6897E 02	-1.6262E 01	-2.6067E 03	3.1754E 01	6.8721E 03	-1.0718E 01	-6.3885E 03	-4.1347E 01	-2.1229E 03	2.6833E 01
3. 352E 03	-4.3489E 01	-9.9321E 03	1.3163E 01	9.3094E 03	6.2797E 01	-3.1228E 03	-4.1858E 01	-2.1920E 03	2.6246E 01
5. 74E 03	-8.3538E 01	-5.4247E 03	-3.6060E 01	1.8095E 03	2.3601E 01	5.4268E 02	-6.1483E 00	-1.4529E 03	1.3706E 00
1. 729E 05	1.0263E 01	-4.6267E 02	-6.8235E 00						
R04 = 21									
-1. 463E 02	1.1155E 01	1.3866E 03	-8.1074E 01	-2.9355E 03	1.6735E 02	1.7146E 03	-8.4055E 01	2.7759E 02	-1.4588E 01
-2. 735E 02	1.2247E 02	5.2313E 03	-2.5227E 02	-3.0365E 03	1.2601E 02	-2.7208E 02	1.6705E 01	2.3107E 03	-1.3253E 02
-4. 131E 03	2.7563E 02	2.8453E 03	-1.4868E 01	2.9266E 01	3.6733E 00	-2.7076E 02	-1.4170E 01	1.0999E 03	1.2809E-01
-6. 153E 02	-3.5400E 00	2.0386E 03	-1.2580E 01	4.4601E 03	-1.4292E 01	3.7757E 03	3.9014E 01	-1.3541E 03	-2.5801E 01
-2. 379E 03	1.7897E 01	6.4777E 01	3.2700E 01	-5.1578E 03	-7.5374E 01	1.6879E 03	4.6730E 01	2.2048E 03	-1.3700E 01
-4. 92E 03	1.7185E 01	4.0207E 03	4.7641E 01	-1.4062E 03	-3.0775E 01	-5.3285E 02	3.2073E 00	1.1658E 03	5.9644E 00
-9. 35E 02	-1.6747E 01	2.7553E 02	1.0039E 01						
R04 = 22									
-2. 646E 01	2.1446E 01	2.3579E 02	-1.5065E 01	-4.9956E 02	3.1196E 01	2.9260E 02	-1.5971E 01	4.1775E 01	-2.2550E 00
-3. 574E 02	1.8841E 01	7.9554E 02	-3.8820E 01	-4.6174E 02	1.9568E 01	-4.3207E 01	2.8412E 00	3.6453E 02	-2.2008E 01
-7. 131E 02	4.6764E 01	4.5022E 03	-2.4969E 01	-4.1075E 01	1.4876E 00	-2.6701E 01	-5.4707E 00	6.3762E 01	1.0735E 01
-3. 226E 01	5.3386E 01	3.833E 02	-1.7022E 00	-1.7471E 03	8.0924E-01	2.5222E 03	1.7823E 01	-1.1583E 03	-1.9430E 01
-5. 565E 02	3.3985E 02	2.5001E 03	-3.1857E-01	-3.4744E 03	-2.9156E 01	1.5398E 03	2.8482E 01	4.1184E 02	-2.0035E 00
-1. 522E 03	6.3305E-01	2.7154E 03	3.2059E 01	-1.2379E 03	-2.1647E 01	-1.0260E 02	7.1216E-01	4.5302E 02	1.5586E-01
-6. 99E 02	-6.0408E 01	2.6453E 02	5.4552E 00						
R04 = 23									
2. 36E 01	-1.2149E 00	-2.1540E 02	1.0332E 01	4.5582E 02	-2.1143E 01	-2.6458E 02	1.0055E 01	-5.3377E 01	2.7796E 00
4. 374E 02	-2.3509E 01	-9.8981E 02	4.8588E 01	5.7465E 01	-2.4456E 01	4.4891E 01	-2.4809E 00	-3.8740E 02	2.0742E 01
3. 26E 02	-4.3755E 01	-4.7422E 02	2.2799E 01	-2.1084E 01	1.1375E 00	1.8246E 02	-9.8811E 00	-3.8421E 02	2.0638E 01
2. 286E 02	-1.1338E 01	-7.6773E 02	9.8946E 00	1.2205E 03	3.2072E 00	-2.6389E 02	-1.1276E 01	-1.8876E 02	-4.8823E-02
1. 719E 03	-1.3145E 01	-1.8634E 03	-5.5085E 00	5.6233E 02	1.7345E 01	1.6900E 02	-1.9500E 00	-8.3767E 02	1.0588E 01
1. 795E 03	3.7546E 00	-3.0841E 02	-1.2658E 01	-1.9333E 02	3.2097E-01	2.0916E 02	-2.2580E 00	-3.5316E 02	-1.1529E 00
1. 556E 02	3.3662E 00	1.8444E 01	-6.1247E-01						
R04 = 24									
4. 10E 01	-2.8246E 01	-4.2466E 02	2.2433E 01	8.9805E 02	-4.6108E 01	-5.2262E 02	2.2544E 01	-9.6253E 01	5.0930E 00
5. 499E 02	-4.3464E 01	-1.7959E 02	6.8837E 01	1.0428E 01	-4.4790E 01	8.3759E 01	-4.8898E 00	-7.1872E 02	4.0040E 01
1. 164E 03	-8.3294E 01	-8.5175E 02	4.4431E 01	-2.6492E 01	7.9830E-01	2.6097E 02	-1.0729E 01	-5.5326E 01	2.2757E 01
5. 861E 02	-1.2729E 01	-1.5192E 03	1.8572E 01	4.0048E 03	-6.4647E 00	-3.7209E 03	-2.3556E 01	1.2354E 03	1.5232E 01
2. 522E 03	-2.6147E 01	-5.9067E 03	7.7657E 00	5.6298E 03	3.7915E 01	-1.8924E 03	-2.5406E 01	-1.8496E 03	2.0032E 01
4. 849E 03	-6.4725E 01	-4.0671E 03	-2.7107E 03	1.3510E 03	1.7575E 01	4.1525E 02	-4.6122E 00	-1.1143E 03	9.5621E-01
1. 568E 03	7.9754E 01	-3.5774E 02	-5.3599E 00						
R04 = 25									
-4. 335E 01	4.2521E 00	5.7341E 02	-2.6615E 01	-7.8906E 02	5.4662E 01	4.6234E 02	-2.8633E 01	7.6665E 01	-3.7461E 00
-7. 324E-02	3.2508E 01	1.5311E 03	-6.4000E 01	-8.8384E 02	3.2494E 01	-8.327E 01	-5.0705E 00	7.9830E 02	-4.1423E 01

NOT REPRODUCIBLE

7.406 02 -8.1676 01 5.7182 02 -3.6491 00 -1.2681 03 -1.6459 00 1.1338 03 4.4608 00 -4.3757 02 -3.5638 00
 -9.407E 02 5.4868 00 1.9970 03 8.8250 00 -1.5819 03 -2.4717 01 4.9897 02 1.5050 01 1.1474 03 -7.2727 00
 -2.5 69E 03 -8.1815 00 2.1301 03 2.2380 01 -7.7055 02 -1.4880 01 -6.7949 01 4.3377 01 1.9429 02 1.7087 00
 -1.277E 02 -4.8718 00 0.4181 00 2.5612 00

ROW 26

-8.0 33E 01 9.6116E-11 0.8351 01 -5.7602 00 -1.4468 02 1.1907 01 8.5319 01 -6.4041 00 1.0211 01 -5.4684E-01
 -1. 89E 02 4.5689 00 2.1412 02 -9.2599 00 -1.2347 02 4.5518 00 -1.2296 01 8.8346E-01 1.1833 02 -7.3361 00
 -2.5396 02 1.5566 01 1.4797 02 -8.5044 00 -2.8065 01 2.8261 00 1.6006 02 -3.2922 02 -3.3230 01
 1.9728 02 -1.9257 01 1.1013 02 -4.1617E-01 4.9705 02 6.6486E-01 7.2970 02 3.5009 00 -3.4275 02 -4.6771 00
 -1.5 38E 02 1.2096 00 7.7671 02 -8.6070E-02 1.0559 03 -9.1239 00 4.5957 02 8.6143 00 2.0930 02 -8.5629E-01
 -9.565E 02 4.1279E-01 1.4486 03 1.0478 01 -6.7114 02 -1.1485 01 -2.1769 01 3.1282E-01 7.0896 01 9.7942E-02
 -6.766E 01 -1.2208 00 1.6641 01 6.3969E-01

ROW 27

5.752E 01 -2.1918E-01 -5.4193 01 2.0154 00 1.1411 02 -4.0063 00 -6.5774 01 1.7402 00 -1.8434 01 9.0384E-01
 1.226E 02 -7.7033E 00 -3.4337 02 1.5781 01 1.9899 02 7.8344 00 1.7471 01 -8.3420E-01 1.5870 02 7.6904 00
 3.555E 02 -1.5987 01 -1.9436 02 8.3331 00 3.6292 00 -8.2933E-03 4.3525 01 -9.2307 01 -9.2307 01 2.0473 00
 5.412E 01 -9.4397E-01 -2.0907 02 2.8245 00 3.2839 02 7.8340E-01 -5.6259 01 -3.0239 00 -6.3022 01 -2.0731E-01
 3.5437 02 -3.8694 00 -5.9496 02 -1.8343 00 2.0596 02 5.5222E 00 3.4592 01 -9.3292E-01 4.3254 02 5.7845 00
 6.695E 02 1.6778 00 -1.2002 02 -6.4395E 00 -1.2431 02 -2.5392E-01 3.7939 01 -9.8994E-02 -7.8973 01 -3.5088E-01
 6.930E 01 7.1402E-01 -2.0890 01 -5.3439E-01

ROW 28

1.2989E 01 -8.1266E-01 -1.1312 02 5.9237 00 2.3863 02 -1.2027 01 -1.3856 02 5.8772 00 -3.1400 01 1.5813 00
 2.8255 02 -1.3231 01 -5.9641 02 2.7484 01 3.4537 02 -1.3659 01 3.0844 01 -1.6448 00 -2.8252 02 1.4677 01
 5.9908 02 -3.0662 01 -3.4749 02 1.6207 00 8.0919 00 -1.3603 00 -1.3585 01 6.2712 00 2.3732 02 1.2846 01
 -1.347E 01 7.7929 00 -4.1899 02 5.2152 00 1.1039 03 -2.1141 00 -1.0231 03 -3.8867 00 3.3829 02 3.6049 00
 7.466E 02 -7.9693 00 -1.9032 03 2.2354 00 1.7971 03 1.2104 01 -6.0866 02 -8.2671 00 -8.4332 02 1.0611 01
 2.253E 01 -3.0716 00 -2.0608 03 -1.3696 01 6.7895 02 8.6617 00 8.3177 01 -5.7338E-01 -2.2995 02 -9.3523E-02
 2.245E 02 1.7499 00 -8.3667 01 -1.4052 00

86

ROW 29

3.7 46E 02 -1.7125E 01 -3.2874E 03 1.4814 02 6.9453 03 -3.0215 02 -4.0301 03 1.4116 02 -8.3892 02 4.3098 01
 7.482E 03 -3.6337E 02 -1.5516 04 7.4868 02 9.0099 03 -3.7590 02 6.7782 02 -3.6124 03 -5.8145 03 3.0102 02
 1.244E 04 -6.2325E 02 -7.1388 03 3.2858 02 2.2725 01 2.2725 01 3.1078 03 -1.8109 02 -6.5337 03 3.7705 02
 3.996E 03 -2.0898 02 -4.8347 03 2.9131 00 1.0538 04 4.5923 02 8.4763 03 -1.2740 02 2.7729 03 7.9139 01
 8.919E 03 -5.5086 01 -1.9617 04 -7.9469 01 1.5923 04 2.2150 02 -5.2981 03 -1.3850 02 -9.3059 03 3.2351 01
 1.575E 04 4.9659 01 -9.3370E 03 -1.3859 02 3.0670 03 8.6167 01 1.8045 03 -1.1105 01 -3.9625 03 -1.5767 01
 3.558E 03 4.4208 01 -1.0976 03 -2.7722 01

ROW 30

5.6677E 01 -2.4910E 01 -4.9859 02 2.2077 01 1.0533 03 -4.4995 01 -6.1080 02 2.0883 01 -1.2893 02 6.6986 00
 1.283E 03 -5.6254E 01 -2.3822 03 1.1594 02 1.3833 03 -5.8284 01 3.0168 02 -5.3931 00 -8.7417 02 4.5254 01
 1.413E 03 -9.3649 01 -1.0681 03 4.9323 01 -5.8890 01 3.7917 00 4.6262 02 -2.9371 01 -1.0135 03 6.1059 01
 5.634E 02 -3.3962 01 -2.2999 02 5.4953 00 4.1147 03 -2.8464E-01 -5.7229 03 -4.8531 01 2.5379 03 4.7325 01
 1.711E 03 -9.8874E 00 -7.6616 03 1.3821 00 1.0730 04 8.7834 01 -4.7880 03 -8.7301 01 -1.0109 03 5.9478 00
 4.228E 03 -4.0801E-01 -6.3203 03 -5.3595 01 2.8142 03 5.2462 01 3.3754 02 -1.8534 00 -1.5508 03 1.6672E-01
 2.46E 03 1.8341 01 -9.9129 02 -1.8280 01

ROW 31

-7.99E 01 3.6100E 01 2.5146 02 -3.0285 01 -1.3345 03 6.1938 01 7.7506 02 -2.9465 01 1.5455 02 -8.1112 00
 -5.98E 03 6.8518 01 2.8687 03 -1.4125 02 -1.6657 03 7.1152 01 -1.2133 02 6.6841 00 1.0436 03 -5.5557 01
 -2.76E 03 1.517E 01 1.2767 03 -6.0947 01 5.4776 01 3.0210 00 -4.7829 02 2.6067 01 1.0078 03 -5.4422 01
 5.42E 02 2.9923 01 1.6225 03 -2.1650 01 -3.0517 03 9.1385 02 2.9029 01 2.8509 02 -3.4468 00
 3.52E 03 4.1932 01 5.8259 03 1.6383 01 -1.0137 03 -5.2496 01 -5.7908 02 4.7577 00 2.0452 03 -2.4012 01
 -3.013E 03 -1.098E 01 9.7231 02 3.2027 01 3.3309 02 -3.5150 00 -6.9350 02 8.3838 00 1.1299 03 3.4134 00
 -3.25E 02 -1.1753 01 -1.3219 02 7.1500E-01

ROW 32

-1.4962E 04 6.4139E 00 1.1452 03 -5.4467 01 -2.4190 03 1.1134 02 1.4050 03 -5.2818 01 2.8230 02 -1.4873 01
 1.4962E 04 6.4139E 00 1.1452 03 -5.4467 01 -2.4190 03 1.1134 02 1.4050 03 -5.2818 01 2.8230 02 -1.4873 01
 1.4962E 04 6.4139E 00 1.1452 03 -5.4467 01 -2.4190 03 1.1134 02 1.4050 03 -5.2818 01 2.8230 02 -1.4873 01

-3.525E 07 2.0709E 02 2.2945E 03 -1.0953E 02 1.0152E 02 -5.8813E 00 -8.7547E 02 4.9387E 01 1.8428E 03 -1.0297E 02
 -1.59E 07 5.6700E 01 3.7169E 03 -4.2925E 01 -9.8610E 03 1.2447E 01 9.2502E 03 6.3215E 01 -3.1063E 03 -4.2203E 01
 -8.73E 03 8.0350E 01 1.8224E 04 -2.4602E 01 -1.7077E 04 -1.1418E 02 5.7265E 03 7.5999E 01 4.0589E 03 -4.7270E 01
 -1.784E 14 1.3519E 07 1.0117E 04 7.0204E 01 -3.3922E 03 -4.6667E 01 -1.3615E 03 1.6095E 01 3.6355E 03 -4.2501E 00
 -3.558E 07 -2.4606E 07 1.1419E 03 1.5998E 01

PART IV - SECTION B4.0

LISTING OF SUBSONIC AIC COMPUTER PROGRAM

```

CMAIN      MAIN
COMPLEX A,AA,ANM,CZERO,WASH,AIC
DIMENSION TEMP(40,40),AIC(40,80),WASH(40),FM(40,40)
COMMON/C1/A(80),AA(40,80),ANM(40,40),CZERO
COMMON/C2/HKFR(20),ZKER(20),FMACH(6),FREQ(10),NOM(5),IL(50),
1          HCOR(6),ZCOR(6),WXCHN(11),WBCN(11),WRIN(11),WT(90),
2          XE(5),YE(5),UX(10),UY(10),WXIMN(11),SIX(40,2),SCX(10,2),
3          ETA(1)
COMMON/C3/Y(11),XAIC(10,10,2),YAIC(10,2),B(40,40),R(40,40),
1          C(10,40),T(40,40),TH(40,40),TR(40,40),TI(40,40)
COMMON/C4/CLFN,NGSKRN,NPY,SOUND,NMACH,NFREQ,MAUG,NIONCX,RHO,
6          NMODES,LCOLL,LPRWSH,LPRCO,IIX,ISURF,ISOLAT,FM,FC,
7          NCOLS,NOMIT,MACH,XCOLL,YCOLL,PI,U,QWCX,CXHN,IMOD,IROW,
8          EM,FK,BZ,NWIX,NCIX,CHON,NWCY,IFR,E1,E2,QWY,QWXX,
9          SN,WRO,NIY,NWCX,NCCX,NWPX,NCPX,NXWING,NYWING,NXCS,NYCS
COMMON/C5/LPUNCH,KF
EQUIVALENCE (AA,AIC),(A,WASH),(FM,T)

C ***
C ***
      WRITE(6,66)
66 FORMAT(1H1)
1 CALL KFDA
  FW = 2*NWIX + 1
  FC = 2*NCIX + 1
  QWXX = 2.0*PI/FW
  QWCX = 2.0*PI/FC
  QWY = PI/FLOAT(2*NIY)
  CALL GEOM
  CALL TRAMP(NIY,NWCX,NCCX,NXWING,NYWING,NXCS,NYCS,2,WRO,SN)
  NRS=NIY*(NWCX+NCCX)
  NCS=NXWING*NYWING+NXCS*NYCS
  DO 100 MIT=1,NRS
  DO 200 MIT=1,NCS
200 TEMP(MIT,MIT)=TR(MIT,MIT)
  CALL TRAMP(NIY,NWCX,NCCX,NXWING,NYWING,NXCS,NYCS,1,WRO,SN)
  DO 201 MIT=1,NRS
  DO 201 MIT=1,NCS
201 TR(MIT,MIT)=TEMP(MIT,MIT)
  DO 100 MACH=1,NMACH
    MACH = MACH
    EM = FMACH(MACH)
    U = FM*SOUND
    WRO = WRO/U
    RZ = 1.0 - EM*FM
    CALL KOUT(1)
    IF (LCOLL.NE.0) CALL KOUT(2)
    DO 100 IFR=1,NFREQ
      IFR = IFR
      IF (KF.EQ.1) FREQ(IFR)=FREQ(IFR)*U/(WRO*2.0*PI)
      FK=2.0*PI*FREQ(IFR)*WRO/U
      NSURF = 1 (WING) OR 2 (CONTROL SURFACE)
      NCX = NWCX
      NOMIT = 1
      NMODES = NXWING*NYWING + NXCS*NYCS
      MAUG = NCOLS + NMODES
      DO 4 J=1,NCOLS
        TI(J) = 0
      DO 4 K=1,MAUG
        AA(J,K) = CZERO
        IROW = 1
      DO 15 NSURF=1,

```

```

NSURF = NSURF
DO 14 IY=1,NIY
  IY = IY
  IF(MOMIT-MOMIT.LT.0) GO TO 7
  IF(IY-NOM(MOMIT).EQ.0) GO TO 15
7   YCOLL = SN*Y(IY)
  DO 12 IX=L,NCX
    IIX = IX
    XCOLL = XS(1,NSURF,IX,IY)
    CALL CORD
    DO 10 M=1,NMODFS
      SR = IR(IROW,M)
      SI = II(IROW,M)*FK/WBO
      MNC = NCOLS + M
50  WASH(MNC) = CMPLX(SR,SI)
      DO 20 N=1,NCOIS
60  CALL CGRFD(A,N,N)
        IROW = IROW + 1
12  CONTINUE
        GO TO 14
13  MOMIT = MOMIT + 1
14  CONTINUE
      NCX = NCCX
15  CONTINUE
      CALL XLSQ
      CALL AICS
      CALL KOUT(6)
      IF (LPUNCH .NE. 0) CALL KOUT(7)
150 CONTINUE
      GO TO 1
END

```

CKFDA

KFDA

```

SURROUTINE KFDA
COMPLEX A,AA,ANN,CZERO,WASH,AIC
DIMENSION AIC(40,40),WASH(40)
COMMON/C1/A(80),AA(40,80),ANN(40,40),CZERO
COMMON/C2/HKFR(20),ZKER(20),FMACH(6),FRFQ(10),NOM(5),IL(50),
1      HCOR(6),ZCOR(6),WXCHN(11),WBCN(11),WBIN(11),WT(40),
2      XF(5),YE(5),UX(10),UY(10),WXIMN(11),SIX(40,2),SCX(2,2),
3      ETA(11)
COMMON/C3/Y(1),XAIC(10,10,2),YAIC(10,2),H(40,40),R(40,40),
1      C(10,40),T(40,40),TH(40,40),TR(40,40),TI(40,40)
COMMON/C4/CLFN,NGSKRN,NPY,SOUND,NMACH,NFREQ,HAUG,NIONCX,RHO,
6      NHODFS,LCOLL,LPRWSH,IPRCD,IY,IIX,NSURF,ISOLAT,FW,FC,
7      NCOLS,NOMIT,MACH,XCOLL,YCOLL,P1,U,QWCX,CXMN,IMOD,IROW,
8      EM,EK,R,NWIX,NCIX,CRON,NWCY,IFR,E1,F2,QWY,QWXX,
9      SN,WRO,NIY,NWCX,NCCX,NWPX,NCPX,NXWING,NYWING,NXCS,NYCS
COMMON/C5/LPUNCH,KF
EQUIVALENCE (AA,AIC),(A,WASH)
11 FORMAT(6F12.8)
12 FORMAT(6I12)
READ(5,11)(XF(I),I=1,5)
READ(5,11)(YE(I),I=1,3),SOUND
RHO=1.0
READ(5,12) NMACH,KF,NFREQ,LCOLL,LPUNCH
READ(5,12) NWCX,NCCX,NIONCX,NIY,ISOLAT
INWTS=0
NWPX=NWCX
NXWING=NWCX
NCPX=NCCX
NXCS=NCCX
NWCY=NIY
NPY=NIY
NYWING=NIY
NYCS=NIY
NCOLS=NPY*(NWPX+NCPX)
NCIX=NCCX*NIONCX
NWIX=NWCX*NIONCX
NWTS = NWCY*NWCX + NIY*NCCX
DO 40 I=1,NWTS
40 WT(I) = 1.0
IF(INWTS.NE.0) READ(5,11)(WT(I),I=1,NWTS)
NCOLS = NPY * (NWPX + NCPX)
NCIX = NCCX*NIONCX
NWIX = NWCX*NIONCX
NOMIT = 0
DO 4 I=1,5
4 NOM(I) = 0
II(NWCY,0,NIY) GO TO 5
NOMIT = NIY-NWCY
READ(5,12)(NOM(I),I=1,NOMIT)
6 READ(5,11)(FMACH(I),I=1,NMACH)
DO 7 I=1,NMACH
7 IF(FMACH(I).LE.0.99) GO TO 7
WRITE(6,13)
14 FORMAT(/1H A MACH NUMBER GREATER THAN 0.99 HAS BEEN READ IN----
1 CASE TERMINATED)
CALL EXIT
/ CONTINUE
READ(5,11)(FRFQ(I),I=1,NFREQ)
READ(5,11)(YAIC(1,1),I=1,NYWING)
READ(5,11)(YAIC(1,2),I=1,NYCS)

```

```

READ(5,11) ((XAIC(I,J,1),I=1,NXWING),J=1,NYWING)
READ(5,11) ((XAIC(I,J,2),I=1,NXCS),J=1,NYCS)
IF(NCIX.GT.40.OR.NWIX.GT.40) GO TO 86
IF(NWCX+NWCY+NCCX+NIY.GT.90) GO TO 86
IF(NPY+(NWPX+NCPX).GT.50) GO TO 86
IF(NWPX.GT.10.OR.NCPX.GT.10.OR.NPY.GT.10) GO TO 86
RETURN
86 FM = FMACH(1)
CALL KOUT(1)
CALL KOUT(5)
RETURN
END

```

```

CKOUT      KOUT
SUBROUTINE KOUT(IND)
COMPLEX A,AA,ANH,CZERO,WASH,AIC
DIMENSION SURF(2,2),XPR(50),AIC(40,80),WASH(40)
COMMON/C1/A(80),AA(40,80),ANH(40,40),CZERO
COMMON/C2/HKFR(20),ZKER(20),FMACH(6),FREQ(10),NOM(5),IL(50),
1      HGOR(6),ZCOR(6),WXCMN(11),WBCN(11),WBIN(11),WT(90),
2      XE(5),YE(3),UX(10),UY(10),WXINN(11),SIX(40,2),SCX(10,2),
3      ETA(11)
COMMON/C3/Y(11),XAIC(10,10,2),YAIC(10,2),B(40,40),R(40,40),
1      C(40,40),T(40,40),TH(40,40),TR(40,40),TI(40,40)
COMMON/C4/CLFN,NGSKRN,NPY,SOUND,NHACH,NFREQ,MAUG,NIOACX,RHO,
6      NMOIFS,LCELL,LPRWSH,LPRCO,IY,IY,NSURF,ISOLAT,FW,FC,
7      NCOIS,NOMIT,MACH,XCOLL,YCOLL,P1,U,QWCX,CXMN,IMOD,IROW,
8      EM,FK,B?,NWIX,NCIX,CBON,NWCY,IFR,E1,E2,QWY,QWXX,
9      SN,WRO,NIY,NWCX,NCCX,NWPX,NCPX,NXWING,NYWING,NXCS,NYCS
COMMON/C5/LPUNCH,KF
EQUIVALENCE (AA,AIC),(A,WASH),(XPR,IL)
DATA (SURF(1,1),I=1,2)/8HWING ,8HTAIL /
GO TO (10,20,30,40,50,60,70), IND
C *****
10 XV=XE(5)-XE(4)
   XX=XE(3)-XE(2)
   AW=2.0*(XE(5)*YE(3)-0.5*XE(2)*(YE(3)-YE(2)))
   AT=2.0*XV*YE(3)
   WRITE(6,11)EM,SOUND,RHO,XE(1),XE(4),XE(3),XV,YE(2),YE(3),YE(3),
11 YE(3),XX,XV,AW,AT,NWCY,NIY,NWCX,NCCX,NWIX,NCIX,NPY,NPY,NWPX,NCPX
11 FORMAT(1H1///// 32X,41HHUGHES AIRCRAFT CO. SUBSONIC AIC PROGRAM
1  ///3/X,30HFLIGHT CONDITIONS AND GEOMETRY/1H0//15X, 13HMACH NUMBER
2  =.F8.5,4X,16HSPEED OF SOUND =F10.3,4H L/T,4X,4HRHO=.E14.8//1H0/
354X,4HWING,18X,
3  4HTAIL///22X,16HL.E. STATION (L),2F22.3//22X,16HROOT CHORD (L),
4  2F22.3// 22X,16HL.F. SPAN (L),2F22.3//22X,16HT.E. SPAN (L),
5  2F22.3// 22X,16HTIP CHORD (L),2F22.3//22X,16HTOTAL AREA (L*L)
6  2F22.3//22X,16HSPAN COLL. STA.,I19,I22,//22X,16HCHORD COLL. STA.
7  I19,I22//22X,16HCHORD INTG. STA.,I19,I22//22X,16HSPAN PRES MODES
8  I19,I22//22X,16HCHORD PRES MODES,I19,I22)
   IF(FMACH(MACH).LE.0.95) GO TO 15
   WRITE(6,14)
14 FORMAT(92H A MACH NUMBER GREATER THAN 0.95 HAS BEEN USED-----
1USE CAUTION IN APPLYING CASE RESULTS)
15 IF(NOMIT.EQ.0) RETURN
   WRITE(6,12)(NOM(I),I=1,NOMIT)
12 FORMAT(1H0,15X,51HTHE SPANWISE COLLOCATION STATION(S) OMITTED ON W
1ING,915)
   RETURN
C *****
20 NCX=NWCX
   NIX=NWIX
   DO 150 NS=1,2
     WRITE(6,22)(SURF(I,NS),I=1,2)
22 FORMAT(1H1,////30X,50HHUGHES AIRCRAFT CO. SUBSONIC AIC PROGRAM (CO
INT-D) //)
220X,53HUNSTEADY AERO COLLOCATION STATION COORDINATES ON THE 2A6/1H
30,12H S STA NO,7X,2HYC,8X,7X,11HXC VALUES--)
   DO 123 IY=1,NIY
     YC=WRO*SN*Y(IY)
   DO 120 IX=1,NCX
120 XPR(IX)=WRO*XS(1,NS,IX,IY)
123 WRITE(6,124) IY,YC,(XPR(IX),IX=1,NCX)

```

```

124 FORMAT(1H0,112.5E17.6/(1H ,29X.4E17.6))
WRITE(6,105) (SURF(I,NS),I=1,2)
105 FORMAT(1H0,24X.39HINTEGRATION STATION COORDINATES ON THE 2A6/1H0,
112H S STA NO,7X,2HY1,8X,7X,11HXI VALUES--)
DO 106 IY=1,NIY
YI=WBO*SN*ETA(IY)
DO 126 IX=1,NIX
126 XPR(IX)=WBO*XS(2,NS,IX,IY)
106 WRITE(6,124) IY,YI,(XPR(IX),IX=1,NIX)
NCX=NCCX
NIX=NCIX
150 CONTINUE
NXS=MXWING
NYS=NYWING
DO 200 NS=1,2
WRITE (6,201) (SURF(I,NS),I=1,2)
201 FORMAT(1H1,////30X,50HHUGHES AIRCRAFT CO. SUBSONIC AIC PROGRAM (CO
1NT-D) //)
228X,43HAIC COLLOCATION STATION COORDINATES ON THE 2A6/1H0,
319X, 4HYAIC,13X,13HXAIC VALUES--)
DO 202 IY=1,NYS
YC=YAIC(IY,NS)
202 WRITE(6,203) YC,(XAIC(IX,IY,NS),IX=1,NXS)
NYS=NYCS
200 NXS=NXCS
293 FORMAT(1H0,12X.5E17.6/(1H ,29X.4E17.6))
RETURN

```

C *****

```

10 DO 34 NS = 1.2
WRITE(6,21)FREQ(IFR),NMODES,EK,EM
21 FORMAT(1H1,31X,42HMISSILE SUBSONIC AIRLOADS PROGRAM (CONT-D)//1H /
1 9X,27HOSCILLATORY FREQUENCY (CPS),F12.5,14X,12,15H COLL. STATIONS
2 /1H0,8X,30HREDUCED FREQUENCY (SEMI-CHORD),F9.5,14X,23HFREE STREA
3H MACH NUMBER,F9.3/1H )
WRITE(6,31) IMOD
31 FORMAT(31X,40HPRESSURE COEFFICIENTS FOR COLL. STA. NO.13//19X,1H11
21X,10HR COEFF(1)12X,10H1 COEFF(1) 9X,9HSPAN MODE 3X,10HCHORD MODE)
WRITE(6,32)(SURF(KI,NS),KI=1,2)
32 FORMAT(1H0,9X,2A6//)
GO TO(2,3),NS
2 NL = NWPX
ML = NPY
IK = 1
GO TO 4
3 NL = NCPX
ML = NPY
IK = NWPX*NPY+1
4 DO 6 IMM=1,ML
DO 6 INN=1,NI
WRITE(6,33)IK,ANN(IK,IMOD),IMM,INN
33 FORMAT(1H0,119.1P/E22.5,2I13)
6 IK = IK + 1
34 CONTINUE
RETURN

```

C *****

```

40 WRITE(6,41)
41 FORMAT(1H0,20X.38HERROR IN INPUT DATA (NO TAIL) REQUIRES//,21X,19H
1TERMINATION OF CASE)
CALL EXIT

```

C *****

```

50 WRITE(6,51)

```

```

51 FORMAT(1H0,/,0X,63HNUMBER OF COLLOCATION OR INTEGRATION STATIONS OR
1 PRESSURE TERMS///1X,25HEXCEEDS ALLOWABLE MAXIMUM///15X,10HCASE IS
2 TERMINATED)

```

```

CALL EXIT

```

```

C *****

```

```

60 VEL=FM*SOUND
Q=0.5*RHO*VEL**2
EK1=1.0/EK
REFC=(XE(3)-XE(1))/2.0
WRITE (6,220) FREQ(IFR),REFC,EK,EK1,EM,U,RHO,Q
220 FORMAT (1H1,11X,50H HUGHES AIRCRAFT CO. SUBSONIC AIC PROGRAM (CONT
1-D)///9X,20H OSCILLATORY FREQUENCY (CPS),4X,1PE12.5,/,1H0,9X,15HRE
2 FERENCE CHORD,4X,1PE12.5,/,1H0,9X,30HREDUCED FREQUENCY (REF. CHORD)
3,4X,1PE12.5,/,1H0,9X,29HREDUCED VELOCITY (REF. CHORD),4X,1PE12.5,
4/,1H0,9X,23HFREE STREAM MACH NUMBER,4X,1PE12.5,/,1H0,9X,20HFREE STRE
5AM VELOCITY,4X,1PE12.5,/,1H0,9X,7H DENSITY,4X,0PF5.2,/,1H0,9X,33HDYNA
6MIC PRESSURE (1/2*RHO*VEL**2),4X,1PE12.5,////)
WRITE(6,221)

```

```

221 FORMAT(///35X,14HAERODYNAMIC INFLUENCE COEFFICIENTS,/,4X,2HRL,10X,
12HIM,10X,2HRL,10X,2HIM,10X,2HRL,10X,2HIM,10X,2HRL,10X,2HIM,10X,2HR
2L,10X,2HIM,/)

```

```

NROWS=NYWING*NXWING+NXCS*NYCS

```

```

DO 222 NROW=1,NROWS

```

```

WRITE(6,223)NROW

```

```

WRITE(6,224) (AIC(NROW,NCOL),NCOL=1,NROWS)

```

```

223 FORMAT(/ 5HROW = 12)

```

```

224 FORMAT(1P10E12.4)

```

```

222 CONTINUE

```

```

RETURN

```

```

C *****

```

```

70 NW=NXWING*NYWING

```

```

NC=NXCS*NYCS

```

```

NT=NW+NC

```

```

NW1=NW+1

```

```

GO TO (81,82,83,84),LPUNCH

```

```

81 CONTINUE

```

```

DO 301 I=1,NW

```

```

PUNCH 85, (AIC(I,J),J=1,NW)

```

```

301 CONTINUE

```

```

85 FORMAT (1P6F12.5)

```

```

RETURN

```

```

82 CONTINUE

```

```

DO 302 J=NW1,NT

```

```

PUNCH 85, (AIC(I,J),J=NW1,NT)

```

```

302 CONTINUE

```

```

RETURN

```

```

83 CONTINUE

```

```

DO 303 I=1,NW

```

```

PUNCH 85, (AIC(I,J),J=1,NW)

```

```

303 CONTINUE

```

```

DO 304 I=NW1,NT

```

```

PUNCH 85, (AIC(I,J),J=NW1,NT)

```

```

304 CONTINUE

```

```

RETURN

```

```

84 CONTINUE

```

```

DO 305 J=1,NT

```

```

PUNCH 85, (AIC(I,J),J=1,NT)

```

```

305 CONTINUE

```

```

1000 RETURN

```

```

END

```

GAICS

```

SURROUTINE AICS
COMPLEX A,AA,ANH,CZERO,WASH,AIC
DIMENSION AIC(40,80),WASH(40),FM(40,40)
COMMON/C1/A(80),AA(40,80),ANH(40,40),CZERO
COMMON/C2/HKER(20),ZKER(20),FMACH(4),FREQ(10),NOM(5),IL(50),
1      HCOR(6),ZCOR(6),WXCMN(11),WBCN(11),WRIN(11),WT(90),
2      XF(5),YE(5),UX(10),UY(10),WXIMN(11),SIX(40,2),SCX(10,2),
3      ETA(11)
COMMON/C3/Y(11),XAIC(10,10,2),YAIC(10,2),B(40,40),R(40,40),
1      C(40,40),T(40,40),TH(40,40),TR(40,40),TI(40,40)
COMMON/C4/CLFN,NGSKRM,NPY,SOUND,NMACH,NFREQ,HAUG,NIOX,CMX,RHO,
4      NMDFS,LCOLL,LPRNSH,LPRCO,IY,IIX,NSURF,ISOLAT,FW,FC,
5      NCOLS,NOMIT,MACH,XCOLL,YCOLL,PI,U,QWCX,CXMN,IMOD,IROW,
6      EM,EK,R2,NWIX,NCIX,CHON,NWCY,IFR,E1,E2,QWY,QWIX,
7      SN,WRO,NIY,NWCX,NCCX,NWPX,NCPX,NXWING,NYWING,NXCS,NYCS
EQUIVALENCE (AA,AIC),(A,WASH),(FM,T)
NCOLS=NPY*(NWPX+NCPX)
NROWS=NXWING+NYWING+NYCS+NXCS
CALL FORCE
DO 200 I=1,NROWS
DO 200 J=1,NCOLS
SR=FM(I,J)
SI=0.0
200 AA(I,J)=CMPLX(SR,SI)
DO 300 I=1,NROWS
DO 300 J=1,NCOLS
A(J)=(0.0,0.0)
DO 300 K=1,NCOLS
200 A(J)=A(J)-AA(I,K)*ANH(K,J)
DO 225 I=1,NROWS
225 AIC(I,I)=(YE(5)-YE(1))*A(I)/(7.0*EK**2)
300 CONTINUE
RETURN
END

```

```

CCGRFD      CGRED
SUBROUTINE CGRFD(V,IR,IC)
COMPLEX ANH,CZERO,AIC,WASH
DIMENSION AIC(40,80),WASH(40),V(2,1)
COMMON/C1/A(2,80),AA(2,40,80),ANH(40,40),CZERO
COMMON/C2/HKFR(20),ZKER(20),FMACH(6),FREQ(10),NOM(5),IL(50),
1      HCOR(6),ZCOR(6),WXCHN(11),WBCN(11),WBIN(11),WT(90),
2      XE(5),YE(3),UX(10),UY(10),WXIMN(11),SIX(40,2),SCX(10,2),
3      ETA(11)
COMMON/C3/Y(11),XAIC(10,10,2),YAIC(10,2),B(40,40),R(40,40),
1      C(40,40),T(40,40),TH(40,40),TR(40,40),TI(40,40)
COMMON/C4/CLFN,NGSKRN,NPY,SOUND,NMACH,NFREQ,MAUG,NIONCX,RHO,
6      NMDFS,LCOLL,LPRWSH,LPRCO,IY,IIX,NSURF,ISLAT,FW,FC,
7      NCOLS,NOMIT,MACH,XCOLL,YCOLL,P1,U,QWCX,CXMY,IMOD,IROW,
8      FM,FK,R,NWIX,NCIX,CRON,NWCY,IFR,E1,E2,QWY,QWXX,
9      SN,WRO,NIY,NWCX,NCCX,NWPX,NCPX,NXWING,NYWING,NXCS,NYCS
EQUIVALENCE (AA,AIC),(A,WASH)
RMN = SORT(AA(1,IR,IC)**2 + AA(2,IR,IC)**2)
IF(AA(2,IR,IC).LE.E2) GO TO 30
CR = AA(1,IR,IC)/RMN
CI = AA(2,IR,IC)/RMN
DO 10 N=IC,MAUG
TI = CR*AA(1,IR,N) + CI*AA(2,IR,N)
AA(2,IR,N) = CR*AA(2,IR,N) - CI*AA(1,IR,N)
20 AA(1,IR,N) = TI
30 RAN = SORT(V(1,IC)**2 + V(2,IC)**2)
IF(RAN.LE.E2) GO TO 60
RAN = SORT(RAN**2 + RMN**2)
CR = V(1,IC)/RAN
CI = V(2,IC)/RAN
RMN = RMN/RAN
DO 40 N=IC,MAUG
AIR = RMN*AA(1,IR,N) + CR*V(1,N) + CI*V(2,N)
AII = RMN*AA(2,IR,N) + CR*V(2,N) - CI*V(1,N)
VR = RMN*V(1,N) - CR*AA(1,IR,N) + CI*AA(2,IR,N)
VI = RMN*V(2,N) - CR*AA(2,IR,N) - CI*AA(1,IR,N)
AA(1,IR,N) = AIR
AA(2,IR,N) = AII
V(1,N) = VR
50 V(2,N) = VI
60 RETURN
END

```

CFORCF

```

SUBROUTINE FORCE
  DIMENSION FM(40,40)
  COMMON/C3/Y(11),XAIC(10,10.2),YAIC(10,2),B(40,40),R(10,40),
1    C(40,40),T(40,40),TH(40,40),TR(40,40),TI(40,40)
  COMMON/C2/HKER(20),ZKER(20),FMACH(6),FREQ(10),NOM(5),IL(50),
1    HCOR(6),ZCOR(6),WXCEN(11),WBCN(11),WRIN(11),WT(90),
2    XF(5),YE(3),UX(10),UY(10),WXIMN(11),SIX(40.2),SCX(10.2),
3    ETA(11)
  COMMON/C4/CLFN,NGSKRN,NPY,SOUND,NMACH,NFREQ,MAUG,NIONCX,RHO,
6    NMDFS,LCOLL,LPRWSH,LPRCO,IYY,IIX,NSURF,ISGLAT,FW,FC,
7    NCOLS,NOMIT,MACH,XCOLL,YCOLL,PI,U,OWCX,CXMM,IMOD,IROW,
8    EM,EK,B2,NWIX,NCIX,CRON,NWCY,IFR,E1,E2,OWY,OWWX,
9    SN,WRO,NIY,NWCX,NCCX,NWPX,NCPX,NXWING,NYWING,NXCS,NYCS
  EQUIVALENCE (FM,T)
  MROWS=NIY*(NWCX+NCCX)
  MCOLS=NPY*(NWPX+NCPX)
  DO 100 I=1,MROWS
  DO 100 J=1,MCOLS
100  FM(I,J)=0.0
C *** BEGIN TO ASSEMBLE FM(IROW,ICOL) MATRIX STARTING WITH WING
  IROW=1
  DO 300 I=1,NIY
    IF (I.EQ. 1) GO TO 105
    IF (I.EQ. NIY) GO TO 110
    SNL=(0.5*(YAIC(I-1,1)+YAIC(I,1))-YE(1))/(YE(3)-YE(1))
    SNU=(0.5*(YAIC(I,1)+YAIC(I+1,1))-YE(1))/(YE(3)-YE(1))
    GO TO 115
105  SNL=0.0
    SNU=(0.5*(YAIC(1,1)+YAIC(2,1))-YE(1))/(YE(3)-YE(1))
    GO TO 115
110  SNL=(0.5*(YAIC(NIY-1,1)+YAIC(NIY,1))-YE(1))/(YE(3)-YE(1))
    SNU=1.0
115  CONTINUE
    DO 400 J=1,NWCX
      IF (J.EQ. 1) GO TO 120
      IF (J.EQ. NWCX) GO TO 125
      CNI=(0.5*(XAIC(J,1,1)+XAIC(J-1,1,1))-XE(1)-0.5*(XE(3)-XE(1)))/
1(0.5*(XE(3)-XE(1)))
      CNU=(0.5*(XAIC(J+1,1,1)+XAIC(J,1,1))-XE(1)-0.5*(XE(3)-XE(1)))/
1(0.5*(XE(3)-XE(1)))
      GO TO 130
120  CNI=-1.0
      CNU=(0.5*(XAIC(1,1,1)+XAIC(2,1,1))-XE(1)-0.5*(XE(3)-XE(1)))/
1(0.5*(XE(3)-XE(1)))
      GO TO 130
125  CNI=(0.5*(XAIC(NWCX-1,1,1)+XAIC(NWCX,1,1))-XE(1)-0.5*(XE(3)-XE(1)))/
1(0.5*(XE(3)-XE(1)))
      CNU=1.0
130  CONTINUE
      ICOL=1
      DO 200 K=1,NPY
        CALL MINTS(K,SNL,SNU,FS)
        DO 200 L=1,NWPX
          CALL MINTC(L,CNI,CNU,FC)
          FM(IROW,ICOL)=FS*FC
        200  ICOL=ICOL+1
      300  IROW=IROW+1
C *** ASSEMBLE CONTROL SURFACE CONTRIBUTION
    DO 400 J=1,NIY
      IF (I.EQ. 1) GO TO 505

```

```

      IF (I .EQ. NIY) GO TO 510
      SNL=(0.5*(YAIC(I-1,2)+YAIC(I,2))-YE(1))/(YE(3)-YE(1))
      SNU=(0.5*(YAIC(I,2)+YAIC(I+1,2))-YE(1))/(YE(3)-YE(1))
      GO TO 515
505  SNL=0.0
      SNU=(0.5*(YAIC(1,2)+YAIC(2,2))-YE(1))/(YE(3)-YE(1))
      GO TO 515
510  SNL=(0.5*(YAIC(NIY-1,2)+YAIC(NIY,2))-YE(1))/(YE(3)-YE(1))
      SNU=1.0
515  CONTINUE
      DO 600 J=1,NCCX
      IF (J .EQ. 1) GO TO 720
      IF (J .EQ. NCCX) GO TO 725
      CNL=(0.5*(XAIC(J,1,2)+XAIC(J-1,1,2))-XE(4)-0.5*(XE(5)-XE(4)))/
      1(0.5*(XF(5)-XF(4)))
      CNU=(0.5*(XAIC(J+1,1,2)+XAIC(J,1,2))-XE(4)-0.5*(XE(5)-XE(4)))/
      1(0.5*(XF(5)-XF(4)))
      GO TO 730
720  CNL=-1.0
      CNU=(0.5*(XAIC(1,1,2)+XAIC(2,1,2))-XE(4)-0.5*(XE(5)-XE(4)))/
      1(0.5*(XF(5)-XF(4)))
      GO TO 730
725  CNL=(0.5*(XAIC(NCCX-1,1,2)+XAIC(NCCX,1,2))-XF(4)-0.5*(XE(5)-XE(4))
      1)/(0.5*(XE(5)-XE(4)))
      CNU=1.0
730  CONTINUE
      ICOL=NPY*NWPX+1
      DO 800 K=1,NPY
      CALL MINTS(K,SNL,SNU,FS)
      DO 600 L=1,NCPX
      CALL MINTC(L,CNL,CNU,FC)
      FM(IROW,ICOL)=FS*FC
800  ICOL=ICOL+1
600  IROW=IROW+1
      RETURN
      END

```

```

CCORD      CORD
SURROUTINE CORD
COMPLEX A,AA,ANH,CZERO,WASH,AIC,AK,H2,TRM,D1,CRNL
DIMENSION AIC(40,80),WASH(40)
COMMON/C1/A(80),AA(40,80),ANH(40,40),CZERO
COMMON/C2/HKFR(20),ZKER(20),FMACH(6),FREQ(10),NOM(5),IL(50),
1      HCOR(6),ZCOR(6),WXCHN(11),WBCN(11),WBIN(11),WT(90),
2      XE(5),YE(3),UX(10),UY(10),WXIMN(11),SIX(40,2),SCX(10,2),
3      ETA(11)
COMMON/C3/Y(11),XAIC(10,10,2),YAIC(10,2),B(40,40),R(40,40),
1      C(40,40),T(40,40),TH(40,40),TR(40,40),TI(40,40)
COMMON/C4/CLFN,NSKRN,NPY,SOUND,NMACH,NFREQ,MAUG,NIONCX,RHO,
6      NMODES,LCOLL,LPRWSH,LPRCO,IY,IIX,NSURF,ISOLAT,FW,FC,
7      NCOLS,NOMIT,MACH,XCOLL,YCOLL,PI,U,QWCX,CXMN,IMOD,IROW,
8      EM,EK,B2,NWIX,NCIX,CRON,NWCY,IFR,E1,E2,QWY,QWXX,
9      SN,WRO,NIY,NWCX,NCCX,NWPX,NCPX,NXWING,NYWING,NXCS,NYCS
EQUIVALENCE (AA,AIC),(A,WASH)
C      THIS SUBROUTINE CONSTRUCTS A ROW OF THE DOWNWASH MATRIX
C      THE PRESSURE SERIES IS A PRODUCT OF CHEBYSHEV POLYNOMIALS IN THE
C      NEGATIVE OF PERCENT SEMI-CHORD FROM THE MID-CHORD AND PERCENT
C      SEMI-SPAN FROM THE ROOT.
DO 6 JC=1,NCOLS
6 A(JC) = CZERO
IC1 = 0
NIX = NWIX
QWX = -QWXX*SN**2/(8.0*PI)
NPX = NWPX
C      THE DO 14 LOOP COMPUTES THE NON-SINGULAR PORTION OF n(N,M)
C      DUE TO BOTH SURFACES
DO 14 MSURF=1,2
IF(MSURF.NE.NSURF.AND.ISOLAT.NF.0) GO TO 13
DO 12 IY=1,NIY
ETA1 = SN*ETA(IY)
ET2 = ETA(IY)**2
IF(NPY.GT.1) CALL CHEB(NPY-1,ETA(IY),UY(2))
UY(1) = 1.0 -ET2
DO 5 K=2,NPY
3 UY(K) = ET2*UY(1)*UY(K)
DO 10 IX=1,NIX
XI = XS(2,MSURF,IX,IY)
XID = XCOLL -XI
AK = CRNL(EK,XID,YCOLL-ETA1,EM,B2) + CRNL(EK,XID,YCOLL+ETA1,EM,B2)
IC = IC1 +1
H2 = AK*QWX*QWY
IF(NPX.GT.1) CALL CHEB(NPX-1,-SIX(IX,MSURF),UX(2))
UX(1) = 1.0 -SIX(IX,MSURF)
DO 4 K=2,NPX
4 UX(K) = (1.0 +SIX(IX,MSURF))*UX(1)*UX(K)
C      ** ADD AN INCREMENT TO EACH ELEMENT OF THE ROW FOR (YI,ETA1) **
DO 10 NY=1,NPY
TRM = H2 * UY(NY)
DO 10 NX=1,NPX
A(IC) = A(IC) +TRM*UX(NX)
10 IC = IC+1
C      ** IC EQUALS NPY*NWPX+1 AT THE END OF THE FIRST PASS **
12 CONTINUE
13 NIX = NCIX
QWX = -QWCX*SN**2/(8.0*PI)
NPX = NCPX
14 IC1 = NPY*NWPX
IC1 = 0

```

```

      NPX = NWPX
      XCOLS = XS(1,NSURF,IIX,IY)
      Y2 = Y(IY)**2
      CALL CHEB(NPY-1,Y(IY),UY(2))
      UY(1) = -2.0
      DO 15 K=2,NPY
15    UY(K) = -2.0*Y2*UY(K)
      DO 40 MSURF=1,NSURF
C      ** THIS LOOP ADDS THE CONTRIBUTION OF THE SINGULAR INTEGRAL
C      ALONG THE LINE FROM THE WING L.F. TO THE COLLOCATION POINT
      IF(MSURF.NE.NSURF.AND.ISOLAT.NE.0) GO TO 23
      IF(NSURF.LE.MSURF) GO TO 16
      UPLIM = PI
      GO TO 18
16    XT = SCX(IIX,NSURF)
      UPLIM = -ATAN(SQRT(1.0-XT**2)/XT)
      IF(UPLIM.LT.0.0) UPLIM=UPLIM+PI
18    QWSNG = FLOAT(2*NIY)*UPLIM/8.0
      DO 22 N=1,6
      IC = IC+1
C      ** THIS LOOP CONSTRUCTS D(0,M) ,M=0,1,....NPX-1
      VINT = UPLIM*ZCOR(N)
      C = COS(VINT)
      CALL CHEB(NPX-1,C,UX(2))
      UX(1) = 1.0 +C
      DO 19 K=2,NPX
19    UX(K) = (1.0 -C)*UX(1)*UX(K)
      ARG = EK*(XCOLS -WXCHN(IY) +C*WRCN(IY))
      IF(MSURF.EQ.2) ARG=EK*(XCOLS-CXHN+C*CBON)
      C1 = COS(ARG)
      S1 = SQRT(1.0 -C1**2)
      D1 = CMPLX(C1,-S1)*HCOR(N)
      DO 22 NY=1,NPY
      TRM = QWSNG*UY(NY)*D1
      DO 22 NX=1,NPX
      A(IC) = A(IC) +TRM*UX(NX)
22    IC = IC+1
23    IC1 = NPY*NWPX
40    NPX = NCPX
      RETURN
      END

```

```

CCRN1      CRNL
COMPLEX FUNCTION CRNL(CK,X,Y,CH,R2)
COMMON/C2/HKER(20),ZKER(20),FMACH(4),FREO(10),NOM(5),IL(50),
1      HCOR(4),ZCOR(6),WXCKN(11),WBCN(11),WBIN(11),WT(90),
2      XF(10),YF(10),UX(10),UY(10),WXIMN(11),SIX(40,2),SCX(10,2),
3      FTA(11)
COMMON/C4/CLFN,NGSKRN,NPY,SOUND,NMACH,NFREO,MAUG,NIU,CX,RHO,
4      NMDFS,LCOLL,LPRWSH,LPRCO,IY,IX,NSURF,ISLAT,FW,FC,
5      NCOLS,NOMIT,MACH,XCOLL,YCOLL,P1,U,QWCX,CXMN,IMOD,IROW,
6      EM,EK,R2,NWIX,NCIX,CRON,NWCY,IFR,F1,E2,QWY,QWXX,
7      SN,WRO,NIY,NWCX,NCCX,NWPX,NCPX,NXWING,NYWING,NXCS,NYCS
8
9      R=A+S(Y)
R=R*R
CK1 = CK*R
R1 = 0.0
R2 = 0.0
R3 = 0.0
R4 = 0.0
5      S2 = X*X + R1*R1
S = SQRT(S2)
U1 = (CM*S-X)/(R1*R)
UK = CK1*U1
DO 10 I = 1,NGSKRN
U2 = U1*ZKER(I)
U22 = U2*U2
R=U1*ZKER(I)
F = HKER(I)*SQRT(1.0+U22)*U2*U1
R1=1.4*F*COS(R)
R2=1.4*F*SIN(R)
V = 1.0 - ZKER(I)**
F = HKER(I)*V*V*EXP(-CK1*V)*SQRT(1.0+V)
10 G1=1.4*F
G2 = G1 + G1
XS = X/S
IF(CK.NE.0.0) GO TO 20
F14 = 1.0
GO TO 20
20 F14 = CK1*BI SI(CK)
21 G1=1.4*G1-F14-XS*COS(UK)
G2=-CK1*G2+XS*SIN(UK)
XK = CK*X
CO = COS(XK)
SI = SIN(XK)
CCRN1 = CMPLX((CO*G1+SI*G2)/R2,(CO*G2-SI*G1)/R2)
RETURN
END

```

```

CRFSI      RESL
            FUNCTION BESL(X)
            IF(X.GT.2.0) GO TO 50
            T=X/3.75
            T=T*T
            RS11=0.5+T*(0.87890594+T*(0.51498869+T*(0.15084934+T*(0.02658745+T
1*(0.00301532+T*(0.00032411))))))
            RS11=RS11*X
            Y=Y/2.0
            RSK1=X*ALOG(Y)*RS11+1.0
            Y=Y*Y
            RSK1=RSK1+Y*(0.15443144+Y*(-0.67278579+Y*(-0.18156897+Y*
1*(-0.01919402+Y*(-0.00110404+Y*(-0.00004686))))))
            RESI =RSK1/X
            GO TO 60
50          Y=2.0/X
            RSK1=1.25331414+Y*(0.23498619+Y*(-0.03655620+Y*(0.01504268+Y*
1*(-0.00780353+Y*(0.00325614+Y*(-0.00068245))))))
            RESI =RSK1/(SORT(X)*EXP(X))
50          RETURN
            END

```

```

CCHER      CHEB
SUBROUTINE CHEB(N1,X,UX)
  DIMENSION UX(1)
  DO 10 I=1,N1
10  UX(I) = 0.0
    UX(1) = 1.0
    UX(2) = 2.0*X
    IF(N1.LT.3) RETURN
    DO 20 I=3,N1
20  UX(I) = 2.0*X*UX(I-1) -UX(I-2)
    RETURN
  END

```

CCONS1 CONS1

BLOCK DATA

COMPLEX A,AA,ANM,CZERO,WASH,AIC

DIMENSION AIC(40,60),WASH(40)

COMMON/C1/A(80),AA(40,80),ANM(40,40),CZERO

COMMON/C2/HKER(20),ZKER(20),FMACH(6),FREQ(10),NOM(5),IL(50),

1 HCOR(6),ZCOR(6),WXCHN(11),WBCN(11),WBIN(11),WT(90),

2 XE(5),YE(3),UX(10),UY(10),WXIMN(11),SIX(40,2),SCX(10,2),

3 ETA(11)

COMMON/C4/CLEN,NGSKRN,NPY,SOUND,NHACH,NFREQ,HAUG,NIDWCX,RHO,

6 NMODFS,LCOLL,LPRWSH,LPRCO,IYY,IIX,NSURF,ISOLAT,FW,FC,

7 NCOLS,NOMIT,MACH,XCOLL,YCOLL,PI,U,OWCX,CXMN,IMOD,IROW,

8 EM,EK,B2,NWIX,NCIX,CRON,NWCY,IFR,E1,E2,OWY,OWWX,

9 SN,WRO,NIY,NWCX,NCCX,NWPX,NCPX,NXWING,NYWING,NXCS,NYCS

EQUIVALENCE (AA,AIC),(A,WASH)

DATA PI/3.14159267/

DATA HCOR/0.08566225,0.18038079,0.23395697,0.23395697,0.18038079,
10.08566225/

DATA ZCOR/0.03376524,0.16939531,0.38069041,0.61930959,0.83060469,
10.06623476/

C *****

C NGSKRN SHOULD BE COMPATIBLE WITH HKER AND ZKER LISTS

DATA NGSKRN/R/

DATA (HKER(I),I=1,8)/0.05061427,0.11119052,0.15685332,0.18134189
X,0.;8134189,0.15685332,0.11119052,0.05061427/

DATA (ZKER(I),I=1,8)/0.01985507,0.10166676,0.23723380,0.40828266
X,0.59171732,0.76276620,0.89833424,0.98014493/

C *****

DATA E1/0.0000001/,E2/0.0000001/,CZERO/(0.0,0.0)/

END

CXS

XS

```

FUNCTION XS(L,NS,I3,J3)
COMMON/C2/HKER(20),ZKER(20),FMACH(6),FREQ(10),NOM(5),IL(50),
1      HCOR(6),ZCOR(6),WXCMN(11),WBCN(11),WBIN(11),WT(90),
2      XF(5),YE(3),UX(10),UY(10),WXIMN(11),SIX(40,2),SCX(10,2),
3      ETA(11)
COMMON/C4/CLFN,NBSKRN,NPY,SOUND,NHACH,NFREQ,MAUG,NIONCX,RHO,
6      NMODFS,LCOLL,LPRWSH,LPRCO,IIY,IIY,NSURF,ISALAT,FW,FC,
7      NCOLS,NOMIT,MACH,XCOLL,YCOLL,PI,U,QWCX,CXMN,IMOD,IROW,
8      EM,EK,BZ,NWIX,NCIX,CRON,NWCY,IFR,E1,E2,QWY,QWXX,
9      SN,WRO,NIY,NWCX,NCCX,NWPX,NCPX,NXWING,NYWING,NXCS,NYCS
GO TO (10,40),I
10 GO TO (20,30),NS
20 XS = WXCMN(J3) + WBCN(J3) * SCX(I3,1)
RETURN
30 XS = CXMN + CRON * SCX(I3,2)
RETURN
40 GO TO (50,60),NS
50 XS = WXIMN(J3) + WBIN(J3) * SIX(I3,1)
RETURN
60 XS = CXMN + CRON * SIX(I3,2)
RETURN
END

```

C

```

      XINT
      FUNCTION XINT (IY,IX,NIY,NS,WBO,SN)
      COMMON/C3/Y(11),XAIC(10,10,2),YAIC(10,2),B(40,40),R(40,40),
1      C(40,40),T(40,40),TH(40,40),TR(40,40),TI(40,40)
      COMMON/C2/HKFR(20),ZKER(20),FHACH(6),FREQ(10),NOH(5),IL(50),
1      HCOR(6),ZCOR(6),WXCMN(11),WBCN(11),WBIN(11),WT(90),
2      XE(5),YE(3),UX(10),UY(10),WXIMN(11),SIX(40,2),SCX(10,2),
3      ETA(11)
      IF (NS .EQ. 1) GO TO 200
      XINT=WBO*XS(1,2,IX,1)
      RETURN
200 IF (YAIC(IY,1) .GT. YE(2)) GO TO 300
      XINT=WBO*XS(1,1,IX,1)
      RETURN
300 SLOPE=(WBO*SN*Y(NIY)-YE(2))/(WBO*XS(1,1,IX,NIY)-WBO*YS(1,1,IX,1))
      XINT=WBO*XS(1,1,IX,1)+(YAIC(IY,1)-YE(2))/SLOPE
      RETURN
      END

```

CARCCOS

```
FUNCTION ARCCOS(X)
C *** DEFINE F(X)=A(0)+A(1)*X+A(2)*X**2+...+A(8)*X**8
C *** THEN ARCCOS(X)=F(X)*(1-X)**0.5 IF X.LT.1 AND .GT.0
C *** AND ARCCOS(X)=PI-(1-ABS(X))**0.5*F(ABS(X)) IF X.LT.0 AND .GT.-1
C *** ARCCOS(X) IN RADIANS *** VALID FOR 0 TO PI RADIANS
C *** ACCURATE TO AT LEAST 6 SIGNIFICANT FIGURES UNLESS X APPROACHES 1.0
  A0=1.57079633
  A1=-.21460184
  A2=0.08904567
  A3=-.05072733
  A4=0.03313246
  A5=-.02199838
  A6=0.01261235
  A7=-.00499706
  A8=0.00095128
  IF (X .GE. 0.0) GO TO 100
  Z=ABS(X)
  ARCCOS=3.1415927-(1.0-Z)**0.5*(A0+A1*Z+A2*Z**2+A3*Z**3+A4*Z**4
1+A5*Z**5+A6*Z**6+A7*Z**7+A8*Z**8)
  RETURN
100 ARCCOS=(1.0-X)**0.5*(A0+A1*X+A2*X**2+A3*X**3+A4*X**4+A5*X**5
1+A6*X**6+A7*X**7+A8*X**8)
  RETURN
END
```

CHINTC

SUBROUTINE MINTC(IS,CNL,CNU,FC)

C *** CHORDWISE PRESSURE INTEGRATION

C *** CNL=LOWER INTEGRATION LIMIT

C *** CNU=UPPER INTEGRATION LIMIT

CL=ARCCOS(CNL)

CU=ARCCOS(CNU)

SI=FLOAT(IS-1)

IF (IS .EQ. 1) GO TO 10

IF (IS .EQ. 2) GO TO 20

FC=(SIN((SI+1.0)*CU))/(2.0*(SI+1.0))-(SIN((SI-1.0)*CU))/(2.0*(SI-1.0))-

2 (SIN((SI+1.0)*CL))/(2.0*(SI+1.0))+(SIN((SI-1.0)*CL))/(2.0*(SI-1.0))

GO TO 100

10 FC=SIN(CU)-CU-SIN(CL)+CL

GO TO 100

20 FC=(SIN(2.0*CU))/4.0-CU/2.0-(SIN(2.0*CL))/4.0+CL/2.0

100 CONTINUE

RETURN

END

```

C MINTS
      SUBROUTINE MINTS(IS,SNL,SNU,FS)
C *** SPANWISE PRESSURE INTEGRATION
C *** SNI=LOWER INTEGRATION LIMIT
C *** SNU=UPPER INTEGRATION LIMIT
      SL=ARCCOS(SNI)
      SU=ARCCOS(SNU)
      IF (IS.EQ. 1) GO TO 10
      IF (IS.EQ. 2) GO TO 20
      IF (IS.EQ. 4) GO TO 40
      SI=FLOAT(IS-1)
      FS=(1.0/8.0)*((1.0/(SI-1.0))*(SIN((SI-1.0)*SU)-SIN((SI-1.0)*SL))
1          -(1.0/(SI+1.0))*(SIN((SI+1.0)*SU)-SIN((SI+1.0)*SL))
2          +(1.0/(SI-3.0))*(SIN((SI-3.0)*SU)-SIN((SI-3.0)*SL))
3          -(1.0/(SI+3.0))*(SIN((SI+3.0)*SU)-SIN((SI+3.0)*SL)))
      GO TO 100
10  FS=0.5*(SU-SL-SNU*(1.0-SNU**2)**0.5+SNL*(1.0-SNL**2)**0.5)
      GO TO 100
20  FS=0.25*(SNU*(1.0-SNU**2)**1.5-SNL*(1.0-SNL**2)**1.5
1      +0.5*(SU-SI-SNU*(1.0-SNU**2)**0.5+SNL*(1.0-SNL**2)**0.5))
      GO TO 100
40  FS=(1.0/8.0)*(SU-SL)+0.25*(SIN(SU)*COS(SU)-SIN(SL)*COS(SL))
1      +(11.0/12.0)*(COS(SU)*(SIN(SU)**3)-COS(SL)*(SIN(SL)**3))
2      -(2.0/3.0)*(COS(SU)*(SIN(SU)**5)-COS(SL)*(SIN(SL)**5))
100 CONTINUE
      RETURN
      END

```

```

CXLSQ      XLSQ
SURROUTINE XLSQ
COMPLEX A,AA,ANM,CZERO,WASH,AIC
DIMENSION AIC(40,40),WASH(40)
COMMON/C1/A(80),AA(40,80),ANM(40,40),CZERO
COMMON/C2/HKER(20),ZKER(20),FMACH(6),FREQ(10),NOM(5),IL(50),
1      HCOR(6),ZCOR(6),WXCMN(11),WBCN(11),WBIN(11),WT(90),
2      XF(5),YE(4),UX(10),UY(10),WXIMN(11),SIX(40,2),SCX(10,2),
3      EIA(11)
COMMON/C3/Y(11),XAIC(10,10,2),YAIC(10,2),B(40,40),R(40,40),
4      C(10,40),T(40,40),TM(40,40),TR(40,40),TI(40,40)
COMMON/C4/CIEN,NOSKRN,NPY,SGND,NMACH,NFREQ,MAUG,NIONCX,RHO,
5      NMODES,LCOLL,LPRWSH,LPRCO,IY,IX,NSURF,ISOLAT,FW,FC,
6      NCOLS,NOMIT,MACH,XCOLL,YCOLL,PI,U,QWCX,CXMN,IMOD,IROW,
7      EM,FK,R,NWIX,NCIX,CRON,NWCY,IFR,E1,E2,QWY,QMWX,
8      SN,WRO,NIY,NWCX,NCCX,NWPX,NCPX,NXWING,NYWING,NXCS,NYCS
EQUIVALENCE (AA,AIC),(A,WASH)
11 = 1
DO 135 I=1,NCOLS
RII = CABS(AA(I,1))
IF(RII.LE.E2) GO TO 135
IL(I) = I
II = II + 1
GO TO 136
135 IL(I) = -1
II2 = NCOLS - 1 - (I-II)
DO 135 II=II,II2
135 CALL CGRED(AA(II+1,1),II,I+1)
136 CONTINUE
C SOLVE FOR THE COEFFICIENTS BY BACK SUBSTITUTION
140 II = NCOLS
DO 150 I = 1,NCOLS
DO 150 L=1,NMODES
150 ANM(I,L) = CZERO
DO 160 J=1,NCOLS
IF(IL(J).LE.0) GO TO 210
JI = IL(J)
DO 160 I=1,NMODES
ML = NCOLS + L
IF(JI-NCOLS) 170,190,220
170 IK = JI + 1
DO 180 K=IK,NCOLS
180 ANM(JI,I) = ANM(JI,I) - AA(JI,K)*ANM(K,L)
190 ANM(JI,I) = (ANM(JI,L) + AA(JI,ML))/AA(JI,II)
200 CONTINUE
210 II = II - 1
220 RETURN
END

```

CGEOM

GEOM

SUBROUTINE GEOM

COMPLEX A,AA,ANH,CZERO,WASH,AIC

DIMENSION AIC(40,30),WASH(40)

COMMON/C1/A(80),AA(40,80),ANH(40,40),CZERO

COMMON/C2/HKER(20),ZKER(20),FHACH(6),FREQ(10),NOM(5),IL(50),

1 HCOR(6),ZCOR(6),WXCEN(11),WBCN(11),WBIN(11),WT(90),

2 XE(5),YE(3),UX(10),UY(10),WXIMN(11),SIX(40,2),SCX(10,2),

3 ETA(11)

COMMON/C3/Y(11),XAIC(10,10,2),YAIC(10,2),B(40,40),R(40,40),

1 C(40,40),T(40,40),TH(40,40),TR(40,40),TI(40,40)

COMMON/C4/CLFN,NGSKRN,NPY,SOUND,NHACH,NFREQ,MAUG,NIONCX,RHO,

6 NHODFS,LCOLL,LPRWSH,IPRCO,IY,IY,ISURF,ISOLAT,FW,FC,

7 NCOLS,NOMIT,MACH,XCOLL,YCOLL,PI,U,QWCX,CXMM,IMOD,IROW,

8 EH,FK,BZ,NWIX,NCIX,CHON,NWCY,IFR,E1,F2,QWY,QWXX,

9 SN,WRO,NIY,NWCX,NCCX,NWPX,NCPX,NXWING,NYWING,NXCS,NYCS

EQUIVALENCE (AA,AIC),(A,WASH)

C WRO = WING ROOT SEMI-CHORD

C S = SEMI-SPAN

C WTCN = WING TIP CHORD - NORMALIZED ON WRO

C WTLFN = WING TIP L.E. - NORMALIZED

C SN = SEMI-SPAN - NORMALIZED

C CRO = CONTROL SEMI-CHORD

C FW = 2*NWIX+1

C FC = 2*NCIX+1

WRO = XE(3)/2.0

CLFN = XE(4)/WRO

S = YE(3)

WTCN = (XE(3)-XE(2))/WRO

WTLFN = XE(2)/WRO

SN = S/WRO

CRO = (XE(5)-XE(4))/2.0

F1=FW

F2 = F1*PI/2.

J = NWIX

C COMPUTE CHORDWISE INTEGRATION AND COLLOCATION STATIONS

C FIRST ON THE WING SURFACE

DO 1 I=1,NWIX

F2 = F2 - 2.*PI

SIX(J,1) = SIN(F2/F1)

IL = FLOAT(I)/FLOAT(NIONCX) + 0.99

SCX(I,1) = -SIX(J,1)

5 J=J-1

F1=FC

F2 = F1*PI/2.

J = NCIX

C THEN ON THE CONTROL SURFACE

DO 1 I=1,NCIX

F2 = F2 - 2.*PI

SIX(J,2) = SIN(F2/F1)

IL = FLOAT(I)/FLOAT(NIONCX) + 0.99

SCX(I,2) = -SIX(J,2)

4 J=J-1

F1 = 4*NIY

F2 = 0.0

C COMPUTE SPANWISE INTEGRATION AND COLLOCATION STATIONS

DO 1 I=1,NIY

Y(I) = SIN(F2/F1)

F2 = F2 + PI

ETA(I) = SIN(F2/F1)

3 F2 = F2 + PI

```

C      COMPUTE WING SEMI-CHORDS AND MID-CHORD LOCATIONS AT THE
C      SPANWISE COLLOCATION AND INTEGRATION STATIONS
      PIR = YF(2)/YF(3)
      POR = 1.0-PIR
      CBON = (XE(5)-XE(1))/(2.0*WBO)
      CXMN = CBON +XF(4)/WBO
      DO 16 I=1,NIY
      IF(ETA(I).LE.PIR) GO TO 12
      F1 = WTLEN*(ETA(I)-PIR)/POR
      IF(Y(I).LE.PIR) GO TO 13
      F2 = WTLEN*(Y(I)-PIR)/POR
      GO TO 14
12 F1 = 0.0
13 F2 = 0.0
14 WRIN(I) = 0.5*(2.0-F1)
      WXIMN(I) = WRIN(I) +F1
      WRCN(I) = 0.5*(2.0-F2)
16 WXCIN(I) = WRCN(I) +F2
16 RETURN
      END

```

```

CTRAMP
  SUBROUTINE TRAMP(NIY,NWCX,NCCX,NXWING,NYWING,NXCS,NYCS,NIF,WBO,SN)
C *** TRANSFORMATION MATRIX PROGRAM
C *** TRANSFORMS AIC COLLOCATION STATIONS TO UNSTEADY AERO STATIONS
  COMMON/C3/Y(1),XAIC(10,10,2),YAIC(10,2),B(4,40),R(10,40),
  1 C(40,40),T(10,40),TM(40,40),TR(40,40),TI(4,40)
C *** ZERO (TM) MATRIX FOR CHORDWISE TRANSFORMATION
  KROWS=NXWING*NYWING+NXCS*NYCS
  KCOLS=KROWS
  DO 100 I=1,KROWS
  DO 100 J=1,KCOLS
    TM(I,J)=0.0
C *** CHORDWISE TRANSFORMATION (WING)
  IF (NXWING.EQ. 0) GO TO 1999
  DO 1000 I=1,NYWING
  CALL BMAT(NXWING,NRSB,NCSB)
  CALL TMAT(NXWING,1,MSIZE,1,1,WBO,SN)
  DO 1001 MR=1,MSIZE
  DO 1001 MC=1,NCSB
    TR(MR,MC)=0.0
  DO 1001 MRC=1,MSIZE
  1001 TR(MR,MC)=TR(MR,MC)+T(MR,MRC)*R(MRC,MC)
  CALL CMAT(NWCX,NIY,NXWING,NYWING,NIF,1,1,NRSC,NCSC,WBO,SN)
  DO 1002 MR=1,NRSC
  DO 1002 MC=1,NCSB
    T(MR,MC)=0.0
  DO 1002 MRC=1,NCSC
  1002 T(MR,MC)=T(MR,MC)+C(MR,MRC)*TR(MRC,MC)
  KROW=(I-1)*NXWING
  DO 1000 LR=1,NXWING
  LROW=KROW+LR
  KCOL=(I-1)*NXWING
  DO 1000 LC=1,NXWING
  LCOL=KCOL+LC
  1000 TM(LROW,LCOL)=T(LR,LC)
  1001 CONTINUE
  1000 CONTINUE
C *** CHORDWISE TRANSFORMATION (CONTROL SURFACE)
  IF (NXCS.EQ. 0) GO TO 2999
  DO 2000 I=1,NYCS
  CALL BMAT(NXCS,NRSB,NCSB)
  CALL TMAT(NXCS,1,MSIZE,2,1,WBO,SN)
  DO 2001 MR=1,MSIZE
  DO 2001 MC=1,NCSB
    TR(MR,MC)=0.0
  DO 2001 MRC=1,MSIZE
  2001 TR(MR,MC)=TR(MR,MC)+T(MR,MRC)*R(MRC,MC)
  CALL CMAT(NCCX,NIY,NXCS,NYCS,NIF,2,1,NRSC,NCSC,WBO,SN)
  DO 2002 MR=1,NRSC
  DO 2002 MC=1,NCSB
    T(MR,MC)=0.0
  DO 2002 MRC=1,NCSC
  2002 T(MR,MC)=T(MR,MC)+C(MR,MRC)*TR(MRC,MC)
  KROW=NXWING*NYWING+(I-1)*NXCS
  DO 2000 LR=1,NXCS
  LROW=KROW+LR
  KCOL=NXWING*NYWING+(I-1)*NXCS
  DO 2000 LC=1,NXCS
  LCOL=KCOL+LC
  2000 TM(LROW,LCOL)=T(LR,LC)
  2001 CONTINUE

```

```

2990 CONTINUE
C *** REARRANGE ROWS AND COLUMNS FOR SPANWISE TRANSFORMATION
CALL RMAT(NXWING,NYWING,NXCS,NYCS,MSIZE)
DO 2050 MR=1,MSIZE
DO 2050 MC=1,MSIZE
TI(MR,MC)=0.0
DO 3050 MRC=1,MSIZE
2070 TI(MR,MC)=TI(MR,MC)+R(MR,MRC)*TM(MRC,MC)
C *** ZF(R) (TM) MATRIX FOR SPANWISE TRANSFORMATION
KROWS=NIY*(NWCX+NCCX)
KCOLS=NXWING*NYWING+NXCS*NYCS
DO 70 I=1,KROWS
DO 70 J=1,KCOLS
60 TM(I,J)=0.0
C *** SPANWISE TRANSFORMATION (WING)
IF (NYWING.EQ.0) GO TO 3999
DO 3000 I=1,NWCX
CALL RMAT(NYWING,NRSB,NCSB)
CALL TMAT(NYWING,MSIZE,1,1,WRO,SN)
DO 3001 MR=1,MSIZE
DO 3001 MC=1,NCSB
TR(MR,MC)=0.0
DO 3001 MRC=1,MSIZE
3071 TR(MR,MC)=TR(MR,MC)+T(MR,MRC)*B(MRC,MC)
CALL SMAT(NIY,NYWING,1,NRSS,NCSS,WRO,SN)
DO 3002 MR=1,NRSS
DO 3002 MC=1,NCSB
T(MR,MC)=0.0
DO 3002 MRC=1,NCSS
3072 T(MR,MC)=T(MR,MC)+C(MR,MRC)*TR(MRC,MC)
KROW=(I-1)*NIY
DO 3080 LR=1,NIY
LROW=KROW+LR
NITR=NXWING-1
DO 3070 J=1,NITR
IF (WRO*XS(1,1,1,1).LT. .5*(XAIC(J,1,1)+XAIC(J+1,1,1)))GO TO 3050
3070 CONTINUE
KCOL=NYWING*(NXWING-1)
GO TO 3090
3080 KCOL=NYWING*(J-1)
3070 DO 3080 IC=1,NYWING
LCOL=KCOL+IC
3080 TM(LROW,LCOL)=T(LR,IC)
3080 CONTINUE
3090 CONTINUE
C *** SPANWISE TRANSFORMATION (CONTROL SURFACE)
IF (NYCS.EQ.0) GO TO 4999
DO 4000 I=1,NCCX
CALL RMAT(NYCS,NRSB,NCSB)
CALL TMAT(NYCS,MSIZE,2,1,WRO,SN)
DO 4001 MR=1,MSIZE
DO 4001 MC=1,NCSB
TR(MR,MC)=0.0
DO 4001 MRC=1,MSIZE
4071 TR(MR,MC)=TR(MR,MC)+T(MR,MRC)*B(MRC,MC)
CALL SMAT(NIY,NYCS,2,NRSS,NCSS,WRO,SN)
DO 4002 MR=1,NRSS
DO 4002 MC=1,NCSB
T(MR,MC)=0.0
DO 4002 MRC=1,NCSS
4072 T(MR,MC)=T(MR,MC)+C(MR,MRC)*TR(MRC,MC)

```

```

KROW=(I-1)*NIY+NWCX*NIY
DO 4080 LR=1,NIY
LROW=KROW+LR
NITR=NXCS-1
DO 4070 J=1,NITR
IF (WBO*XS(1,2,I,1) .LT. .5*(XAIC(J,1,2)+XAIC(J+1,1,2)))GO TO 4050
4070 CONTINUE
KCOL=NYWING*NXWING+NYCS*(NXCS-1)
GO TO 4090
4080 KCOL=NYWING*NXWING+NYCS*(J-1)
4090 DO 4080 LC=1,NYCS
LCOL=KCOL+LC
4080 TM(IROW,LCOL)=T(I,LC)
4090 CONTINUE
4990 CONTINUE
C *** REARRANGE ROWS AND COLUMNS SO STATIONS ARE STACKED ROWWISE
CALL RMAT(NIY,NWCX,NIY,NCCX,NSIZE)
DO 5001 MR=1,NSIZE
DO 5001 MC=1,KCOLS
TR(MR,MC)=0.0
DO 5001 MRC=1,NSIZE
5001 TR(MR,MC)=TR(MR,MC)+R(MR,MRC)*TM(MRC,MC)
DO 5002 MR=1,KROWS
DO 5002 MC=1,KCOLS
TM(MR,MC)=0.0
DO 5002 MRC=1,KCOLS
5002 TM(MR,MC)=TM(MR,MC)+TR(MR,MRC)*TI(MRC,MC)
DO 5003 I=1,KROWS
DO 5003 J=1,KCOLS
TR(I,J)=TM(I,J)
5003 TI(I,J)=TM(I,J)
RETURN
END

```

```

CTHAT  THAT
      SUBROUTINE THAT(NPTS,ND,MSIZE,NS,IY,WBO,SN)
      COMMON/C3/Y(1),XAIC(10,10,2),YAIC(10,2),B(40,40),R(40,40),
1      C(40,40),T(40,40),TH(40,40),TR(40,40),TI(40,40)
C *** GENERATES T**(-1) MATRIX
C *** NPTS = NUMBER OF AIC POINTS ALONG STRIP IN ND DIRECTION
C *** MSIZE = ORDER OF T MATRIX
C *** NS = SURFACE (1=WING AND 2=CONTROL SURFACE)
C *** ND = INTERPOLATION DIRECTION (1=CHORDWISE AND 2=SPANWISE)
      IF (NPTS .LT. 4) MSIZE=NPTS
      IF (NPTS .GT. 3) MSIZE=3*NPTS-6
      DO 1 J=1,MSIZE
      DO 1 K=1,MSIZE
1      T(J,K)=0.0
      IF (NPTS .GT. 4) GO TO 5000
      GO TO (2000,2100,3000,4000), NPTS
C *** NPTS=2 (TWO POINTS ALONG STRIP)
2000 T(1,1)=1.0
      T(2,1)=1.0
      IF (ND .EQ. 1) T(1,2)=XAIC(1,IY,NS)
      IF (ND .EQ. 1) T(2,2)=XAIC(2,IY,NS)
      IF (ND .EQ. 2) T(1,2)=YAIC(1,NS)
      IF (ND .EQ. 2) T(2,2)=YAIC(2,NS)
      GO TO 6000
C *** NPTS=3 (THREE POINTS ALONG STRIP)
3000 T(1,1)=1.0
      T(2,1)=1.0
      T(3,1)=1.0
      IF (ND .EQ. 2) GO TO 5010
C *** NPTS=3 CHORDWISE DIRECTION
      T(1,2)=XAIC(1,IY,NS)
      T(1,3)=T(1,2)**2
      T(2,2)=XAIC(2,IY,NS)
      T(2,3)=T(2,2)**2
      T(3,2)=XAIC(3,IY,NS)
      T(3,3)=T(3,2)**2
      GO TO 6000
C *** NPTS=3 SPANWISE DIRECTION
5000 T(1,2)=YAIC(1,NS)
      T(1,3)=T(1,2)**2
      T(2,2)=YAIC(2,NS)
      T(2,3)=T(2,2)**2
      T(3,2)=YAIC(3,NS)
      T(3,3)=T(3,2)**2
      GO TO 6000
C *** NPTS=4 (FOUR POINTS ALONG STRIP)
4000 T(1,1)=1.0
      T(2,1)=1.0
      T(3,1)=1.0
      T(4,1)=1.0
      T(5,1)=1.0
      T(6,1)=1.0
      T(3,4)=-1.0
      T(4,5)=-1.0
      IF (ND .EQ. 2) GO TO 4010
C *** NPTS=4 CHORDWISE DIRECTION
      T(1,2)=XAIC(1,IY,NS)
      T(1,3)=T(1,2)**2
      T(2,2)=XAIC(2,IY,NS)
      T(2,3)=T(2,2)**2
      T(3,2)=0.5*(XAIC(3,IY,NS)+XAIC(3,IY,NS))

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```

      T(3,3)=T(3,2)**2
      T(3,5)=-T(3,2)
      T(3,6)=-T(3,3)
      T(4,3)=2.0*T(3,2)
      T(4,6)=-T(4,3)
      T(5,5)=XAIC(3,1Y,NS)
      T(5,6)=T(5,5)**2
      T(6,5)=XAIC(4,1Y,NS)
      T(6,6)=T(6,5)**2
      GO TO 6000
C *** NPTS=4 SPANWISE DIRECTION
4010 T(1,2)=YAIC(1,NS)
      T(1,3)=T(1,2)**2
      T(2,2)=YAIC(2,NS)
      T(2,3)=T(2,2)**2
      T(3,2)=0.5*(YAIC(2,NS)+YAIC(3,NS))
      T(3,3)=T(3,2)**2
      T(3,5)=-T(3,2)
      T(3,6)=-T(3,3)
      T(4,3)=2.0*T(3,2)
      T(4,6)=-T(4,3)
      T(5,5)=YAIC(3,NS)
      T(5,6)=T(5,5)**2
      T(6,5)=YAIC(4,NS)
      T(6,6)=T(6,5)**2
      GO TO 6000
C *** NPTS .GT. 4
5000 IF (ND .EQ. 2) GO TO 5500
C *** NPTS .GT. 4 (CHORDWISE DIRECTION)
      T(1,1)=1.0
      T(1,2)=XAIC(1,1Y,NS)
      T(1,3)=T(1,2)**2
      T(2,1)=1.0
      T(2,2)=XAIC(2,1Y,NS)
      T(2,3)=T(2,2)**2
      T(MSIZE,MSIZE-2)=1.0
      T(MSIZE,MSIZE-1)=XAIC(NPTS,1Y,NS)
      T(MSIZE,MSIZE)=T(MSIZE,MSIZE-1)**2
      T(MSIZE-1,MSIZE-2)=1.0
      T(MSIZE-1,MSIZE-1)=XAIC(NPTS-1,1Y,NS)
      T(MSIZE-1,MSIZE)=T(MSIZE-1,MSIZE-1)**2
      NI=NPTS-4
      DO 5010 N=1,NI
        NR=2+5*N
        NC=3*N+1
        NP=N+2
        T(NR,NC)=1.0
        T(NR,NC+1)=XAIC(NP,1Y,NS)
5010 T(NR,NC+2)=T(NR,NC+1)**2
        NI=NPTS-3
        DO 5020 N=1,NI
          NR=3*N
          NC=3*N-2
          T(NR,NC)=1.0
          T(NR+1,NC+1)=1.0
          T(NR,NC+3)=-1.0
          T(NR+1,NC+4)=-1.0
          T(NR,NC+1)=0.5*(XAIC(N+1,1Y,NS)+XAIC(N+2,1Y,NS))
          T(NR,NC+2)=T(NR,NC+1)**2
          T(NR,NC+4)=-T(NR,NC+1)
          T(NR,NC+5)=-T(NR,NC+2)

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      T(NR+1,NC+2)=2.0*T(NR,NC+1)
5420  T(NR+1,NC+5)=-T(NR+1,NC+2)
      GO TO 6000
C *** NPTS .GT. 4 (SPANWISE DIRECTION)
5500  T(1,1)=1.0
      T(1,2)=YAIC(1,NS)
      T(1,3)=T(1,2)**2
      T(2,1)=1.0
      T(2,2)=YAIC(2,NS)
      T(2,3)=T(2,2)**2
      T(MSIZE,MSIZE-2)=1.0
      T(MSIZE,MSIZE-1)=YAIC(NPTS,NS)
      T(MSIZE,MSIZE)=T(MSIZE,MSIZE-1)**2
      T(MSIZE-1,MSIZE-2)=1.0
      T(MSIZE-1,MSIZE-1)=YAIC(NPTS-1,NS)
      T(MSIZE-1,MSIZE)=T(MSIZE-1,MSIZE-1)**2
      NT=NPTS-4
      DO 5510 N=1,NT
        NR=2+3*N
        NC=3*N+1
        NP=N+2
        T(NR,NC)=1.0
        T(NR,NC+1)=YAIC(NP,NS)
5510  T(NR,NC+2)=T(NR,NC+1)**2
        NT=NPTS-3
        DO 5520 N=1,NT
          NR=4*N
          NC=4*N-2
          T(NR,NC)=1.0
          T(NR+1,NC+1)=1.0
          T(NR,NC+3)=-1.0
          T(NR+1,NC+4)=-1.0
          T(NR,NC+1)=0.5*(YAIC(N+1,NS)+YAIC(N+2,NS))
          T(NR,NC+2)=T(NR,NC+1)**2
          T(NR,NC+4)=-T(NR,NC+1)
          T(NR,NC+5)=-T(NR,NC+2)
          T(NR+1,NC+2)=2.0*T(NR,NC+1)
5520  T(NR+1,NC+5)=-T(NR+1,NC+2)
C *** INVERT T MATRIX
6000  CONTINUE
      CALL MINV (MSIZE,T,C)
      RETURN
      END

```

```

CCMAT      1 MAT
      SURROUTINE CMAT(NPTS,NIY,NAICPX,NAICPY,NIF,NS,IY,NRS,NCS,WHO,SN)
C *** FOR CHORDWISE TRANSFORMATIONS
C *** NPTS = NUMBER OF CHORDWISE UNSTEADY AERO COLLOCATION STATIONS
C *** NIY = NUMBER OF SPANWISE UNSTEADY AERO COLLOCATION STATIONS
C *** NAICPX = NUMBER OF CHORDWISE AIC COLLOCATION STATIONS
C *** NAICPY = NUMBER OF SPANWISE AIC COLLOCATION STATIONS
C *** IY = SPAN NUMBER OF AIC STRIP BEING TRANSFORMED
C *** NIF = CODE FOR DIFFERENTIATION (1=NO DERIVATIVE AND 2=D( )/DX )
C *** MATRIX SIZE IS (NRS,NCS)
      COMMON/CS/Y(1),XAIC(10,10,2),YAIC(10,2),R(40,40),R(10,40),
1      C(10,40),T(40,40),TM(40,40),TR(40,40),TI(40,40)
      IF (NAICPX .GT. 5) GO TO 5
      NRS=NAICPX
      NCS=NAICPX
      DO 1 I=1,NRS
      DO 1 J=1,NCS
1      C(I,J)=0.0
      GO TO 100
4      NRS=NAICPX
      NCS=3*(NAICPX-2)
      DO 4 I=1,NRS
      DO 4 J=1,NCS
4      C(I,J)=0.0
100 IF (NCS .GT. 6) GO TO 500
      IF (NCS .EQ. 6) GO TO 400
      GO TO (200,200,300,300),NCS
C *** TWO POINTS
200 DO 10 I=1,NAICPX
      C(I,1)=1.0
      C(I,2)=XINT(IY,I,NIY,NS,WHO,SN)
      IF (NIF .EQ. 1) C(I,1)=0.0
      IF (NIF .EQ. 2) C(I,2)=1.0
210 CONTINUE
      RETURN
C *** THREE POINTS
300 DO 10 I=1,NAICPX
      C(I,1)=1.0
      IF (NIF .EQ. 2) C(I,1)=0.0
      C(I,2)=XINT(IY,I,NIY,NS,WHO,SN)
      IF (NIF .EQ. 1) C(I,2)=1.0
      C(I,3)=C(I,2)**2
      IF (NIF .EQ. 1) C(I,3)=2.0*XINT(IY,I,NIY,NS,WHO,SN)
310 CONTINUE
      RETURN
C *** FOUR POINTS
400 DO 10 I=1,NAICPX
      NX=NPTS-1
      DO 406 J=1,NX
      IF (0.5*(XAIC(J,IY,NS)+XAIC(J+1,IY,NS)).GT.XINT(IY,I,NIY,NS,WHO,SN)
1) GO TO 407
406 CONTINUE
      NX=NPTS
      GO TO 408
407 NX=J
408 KC=1
      IF (NX .GT. 2) KC=4
      C(I,KC)=1.0
      C(I,KC+1)=XINT(IY,I,NIY,NS,WHO,SN)
      C(I,KC+2)=C(I,KC+1)**2
      IF (NIF .EQ. 1) C(I,KC)=0.0

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      IF (NIF .EQ. 1) C(I,KC+1)=1.0
      IF (NIF .EQ. 2) C(I,KC+2)=2.0*XINT(IY,I,NIY,NS,WBO,SN)
410  CONTINUE
      RETURN
C *** .GT. FOUR POINTS
500  DO 510 I=1,NAICPX
      NX=NPTS-1
      DO 505 J=1,NX
        IF (0.5*(XAIC(J,IY,NS)+XAIC(J+1,IY,NS)).GT.XINT(IY,I,NIY,NS,WBO,SN)
1)) GO TO 507
506  CONTINUE
      NX=NPTS
      GO TO 508
507  NX=J
508  IF (NX .LT. 3) GO TO 550
      IF (NX .GT. NAICPX-2) GO TO 580
      KC=(NX-2)*3+1
      C(I,KC)=1.0
      C(I,KC+1)=XINT(IY,I,NIY,NS,WBO,SN)
      C(I,KC+2)=C(I,KC+1)**2
      IF (NIF .EQ. 1) C(I,KC+1)=1.0
      IF (NIF .EQ. 2) C(I,KC)=0.0
      IF (NIF .EQ. 2) C(I,KC+2)=2.0*XINT(IY,I,NIY,NS,WBO,SN)
      GO TO 510
510  C(I,1)=1.0
      C(I,2)=XINT(IY,I,NIY,NS,WBO,SN)
      C(I,3)=C(I,2)**2
      IF (NIF .EQ. 1) C(I,1)=0.0
      IF (NIF .EQ. 2) C(I,2)=1.0
      IF (NIF .EQ. 2) C(I,3)=2.0*XINT(IY,I,NIY,NS,WBO,SN)
      GO TO 510
520  C(I,NCS-2)=1.0
      C(I,NCS-1)=XINT(IY,I,NIY,NS,WBO,SN)
      C(I,NCS)=C(I,NCS-1)**2
      IF (NIF .EQ. 1) C(I,NCS-2)=0.0
      IF (NIF .EQ. 2) C(I,NCS-1)=1.0
      IF (NIF .EQ. 2) C(I,NCS)=2.0*XINT(IY,I,NIY,NS,WBO,SN)
530  CONTINUE
      RETURN
      END

```

```

C ***** SMAT
      SUBROUTINE SMAT(NIY,NAICPY,NS,NRS,NCS,WRO,SN)
C *** SPANWISE TRANSFORMATION
C *** NIY = NUMBER OF SPANWISE UNSTEADY AERO COLLOCATION STATIONS
C *** NAICPY = NUMBER OF SPANWISE AIC COLLOCATION STATIONS
C *** NS = SURFACE (1=WING AND 2=CONTROL SURFACE)
C *** MATRIX SIZE IS NRS BY NCS
      COMMON/CS/Y(1),XAIC(10,1,2),YAIC(10,2),B(40,40),R(10,40),
1      C(10,40),T(40,40),TH(40,40),TR(40,40),TI(40,40)
      IF (NAICPY .GT. 3) GO TO 8
      NRS=NIY
      NCS=NAICPY
      DO 4 J=1,NRS
      DO 6 J=1,NCS
4      C(1,J)=0.0
      GO TO 100
6      NRS=NIY
      NCS=3*(NAICPY-1)
      DO 5 J=1,NRS
      DO 6 J=1,NCS
5      C(1,J)=0.0
100  IF (NCS .GT. 1) GO TO 500
      IF (NCS .EQ. 1) GO TO 400
      GO TO (200,200,300),NCS
C *** TWO POINTS
200  DO 260 J=1,NIY
      C(1,1)=1.0
      C(1,2)=WRO*SN*Y(1)
260  CONTINUE
      RETURN
C *** THREE POINTS
300  DO 360 J=1,NIY
      C(1,1)=1.0
      C(1,2)=WRO*SN*Y(1)
      C(1,3)=C(1,2)**2
360  CONTINUE
      RETURN
C *** FOUR POINTS
400  DO 490 J=1,NIY
      IC=1
      IF (WRO*SN*Y(1) .LT. 0.5*(YAIC(2,NS)+YAIC(3,NS))) IC=1
      C(1,IC)=1.0
      C(1,IC+1)=WRO*SN*Y(1)
      C(1,IC+2)=C(1,IC+1)**2
490  CONTINUE
      RETURN
C *** .GT. FOUR POINTS
500  DO 520 J=1,NIY
      NI=NAICPY-2
      DO 525 J=1,NI
      IF (0.5*(YAIC(1,NS)+YAIC(J+1,NS)) .GT. WRO*SN*Y(1)) GO TO 523
525  CONTINUE
      IC=3*NAICPY-3
      GO TO 524
523  IC=(J-2)*3+3
      IF (J .LT. 3) IC=1
524  C(1,IC)=1.0
      C(1,IC+1)=WRO*SN*Y(1)
      C(1,IC+2)=C(1,IC+1)**2
525  CONTINUE
      RETURN
      END

```

```

CPMAT      RMAT
SUBROUTINE RMAT (NXWING,NYWING,NXCS,NYCS,MSIZE)
C *** REARRANGES AIC STATIONS INTO PROPER SEQUENCE FOR SPANWISE
C *** INTERPOLATION
C *** MATRIX SIZE IS MSIZE=NXWING*NYWING*NXCS*NYCS (SQUARE)
COMMON/C3/Y(1),XAIC(10,1+2),YAIC(10,2),B(40,40),R(10,40),
1      C(40,40),T(40,40),TM(40,40),TR(40,40),TI(40,40)
CZERO=0.0
MSIZE=NXWING*NYWING*NXCS*NYCS
DO 100 J=1,MSIZE
DO 100 I=1,MSIZE
100 R(I,J)=CZERO
IF (NXWING.EQ.0) GO TO 250
K=1
KK=
II=NYWING*NXWING
DO 100 I=1,II
R(I,K)=1.0
K=K+NXWING
IF (K.GT. II) KK=KK+1
IF (K.GT. II) K=KK
200 CONTINUE
250 CONTINUE
IF (NXCS.EQ.0) GO TO 350
II=NXCS*NYCS
K=NYWING*NYWING+1
KK=NXWING*NYWING+1
DO 300 I=1,II
IK=I+NXWING*NYWING
R(I,K)=1.0
K=K+NXCS
IF (K.GT. MSIZE) KK=KK+1
IF (K.GT. MSIZE) K=KK
300 CONTINUE
350 CONTINUE
RETURN
END

```

```

CHMAT      BHAT
SUBROUTINE BHAT(NPTS,IRS,ICS)
COMMON/C3/Y(1),XAIC(10,10,2),YAIC(10,2),B(40,40),R(10,40),
1          C(10,40),T(10,40),TH(40,40),TR(40,40),TI(40,40)
C *** R - R(IRS,ICS) MATRIX
C *** NPTS = NUMBER OF AIC STATION ALONG STRIP (EITHER CHORDWISE OR
C *** SPANWISE)
      ICS=NPTS
      IF (NPTS .GT. 4) GO TO 200
      IRS=NPTS
      DO 10 I=1,IRS
      DO 10 J=1,ICS
      R(I,J)=0.0
      IF (I .EQ. J) R(I,J)=1.0
10  CONTINUE
      RETURN
200  IRS=6+(NPTS-1)*3
      DO 100 I=1,IRS
      DO 100 J=1,ICS
300  R(I,J)=0.0
      R(1,1)=1.0
      R(2,2)=1.0
      R(IRS,ICS)=1
      R(IRS-1,ICS-1)=1.0
      IF (NPTS .EQ. 1) GO TO 400
      K=NPTS-4
      DO 150 I=1,K
      NR=2+3*I
      NC=1+I
350  R(NR,NC)=1.0
400  RETURN
      END

```

```

CMINV      MINV
SUBROUTINE MINV (NM,A,U)
  DIMENSION A(40,40),U(40,40)
  DO 1001 I=1,NM
  DO 1001 J=1,NM
    U(I,J)=0.0
    IF (1.E0.J) U(I,J)=1.0
1001 CONTINUE
  EPS=0.000000001
  DO 1015 I=1,NM
    K=1
    IF (1-NM) 1002,10017,10021
1002 IF (A(I,I)-EPS) 10004,10006,10007
1003 IF (-A(I,I)-EPS) 10006,10006,10007
1004 K=K+1
    DO 1024 J=1,NM
      U(I,J)=U(I,J)+U(K,J)
      A(I,J)=A(I,J)+A(K,J)
    GO TO 10021
1007 DIV=A(I,I)
    DO 1009 J=1,NM
      U(I,J)=U(I,J)/DIV
1009 A(I,J)=A(I,J)/DIV
    DO 1015 MM=1,NM
      DELT=A(MM,I)
      IF (ABS(DELT)-EPS) 10014,10015,10016
10016 IF (MM=1) 10010,10015,10010
10010 DO 1011 J=1,NM
      U(MM,J)=U(MM,J)-U(I,J)*DELT
10011 A(MM,J)=A(MM,J)-A(I,J)*DELT
10015 CONTINUE
    DO 1034 I=1,NM
    DO 1033 J=1,NM
10034 A(I,J)=U(I,J)
  RETURN
END

```

PART IV - SECTION B5.0

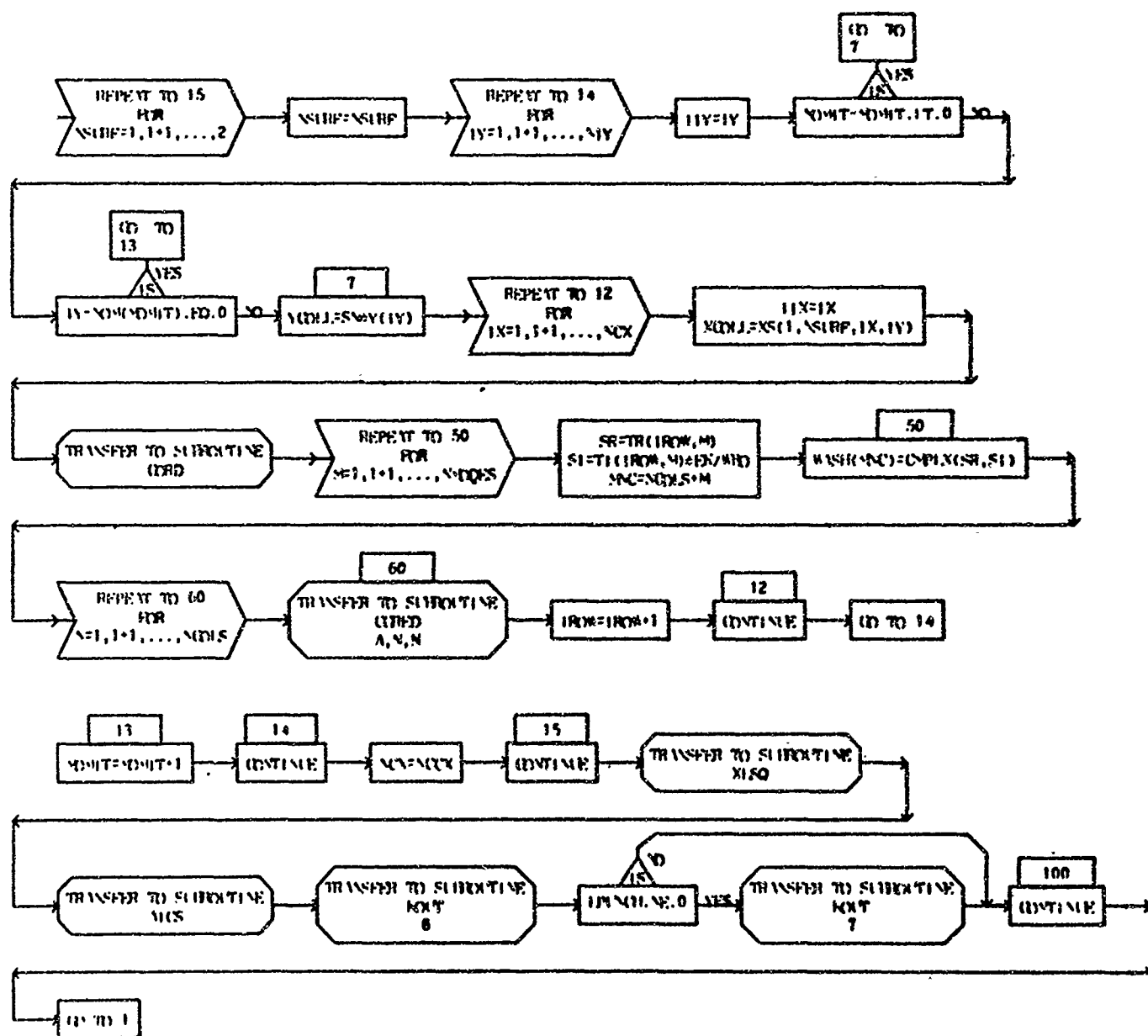
FLOW CHARTS FOR SUBSONIC
AIC COMPUTER PROGRAM

DIMENSIONED VARIABLES

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P45 2



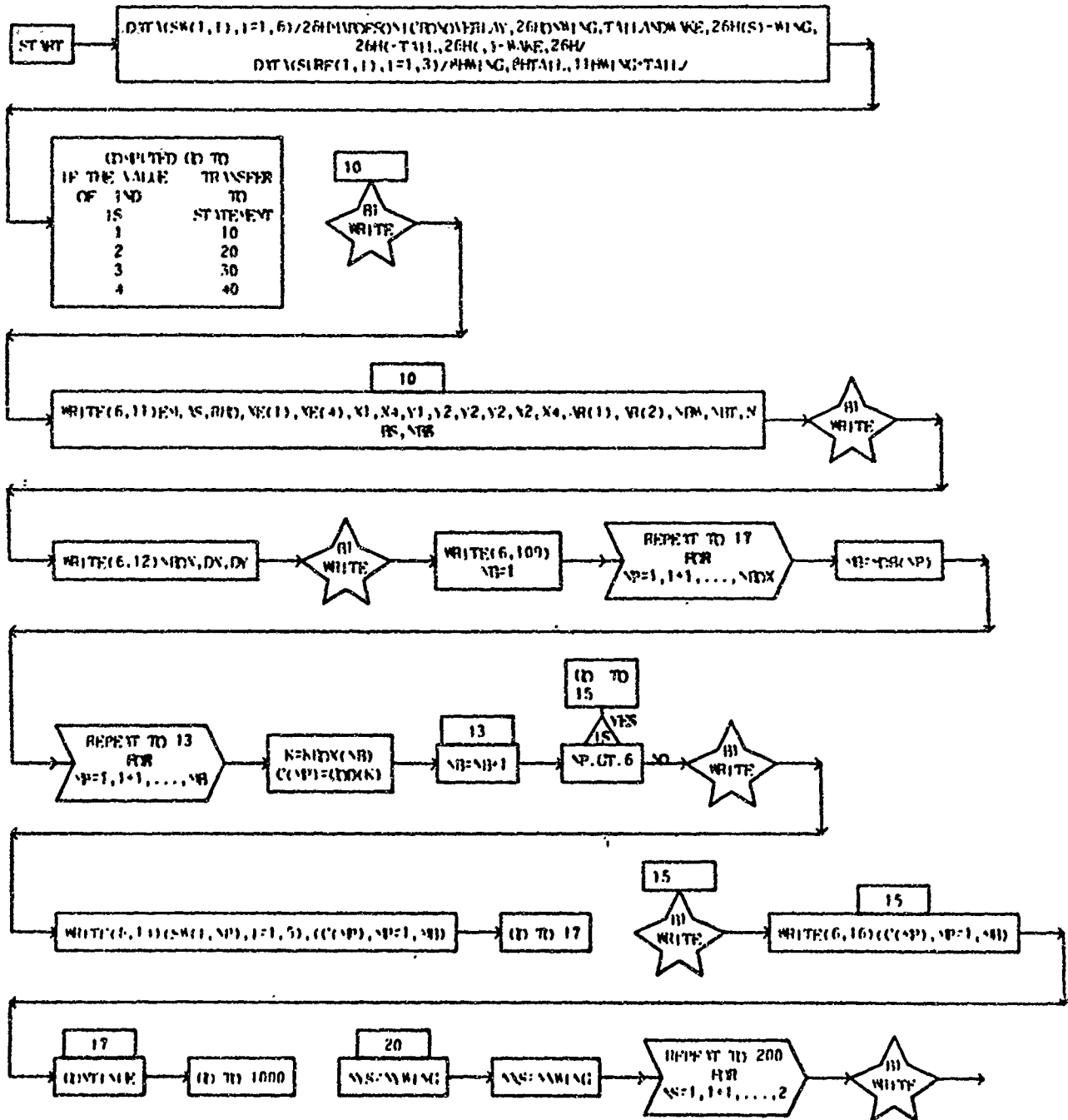
NOT NOT

DIMENSIONED VARIABLES

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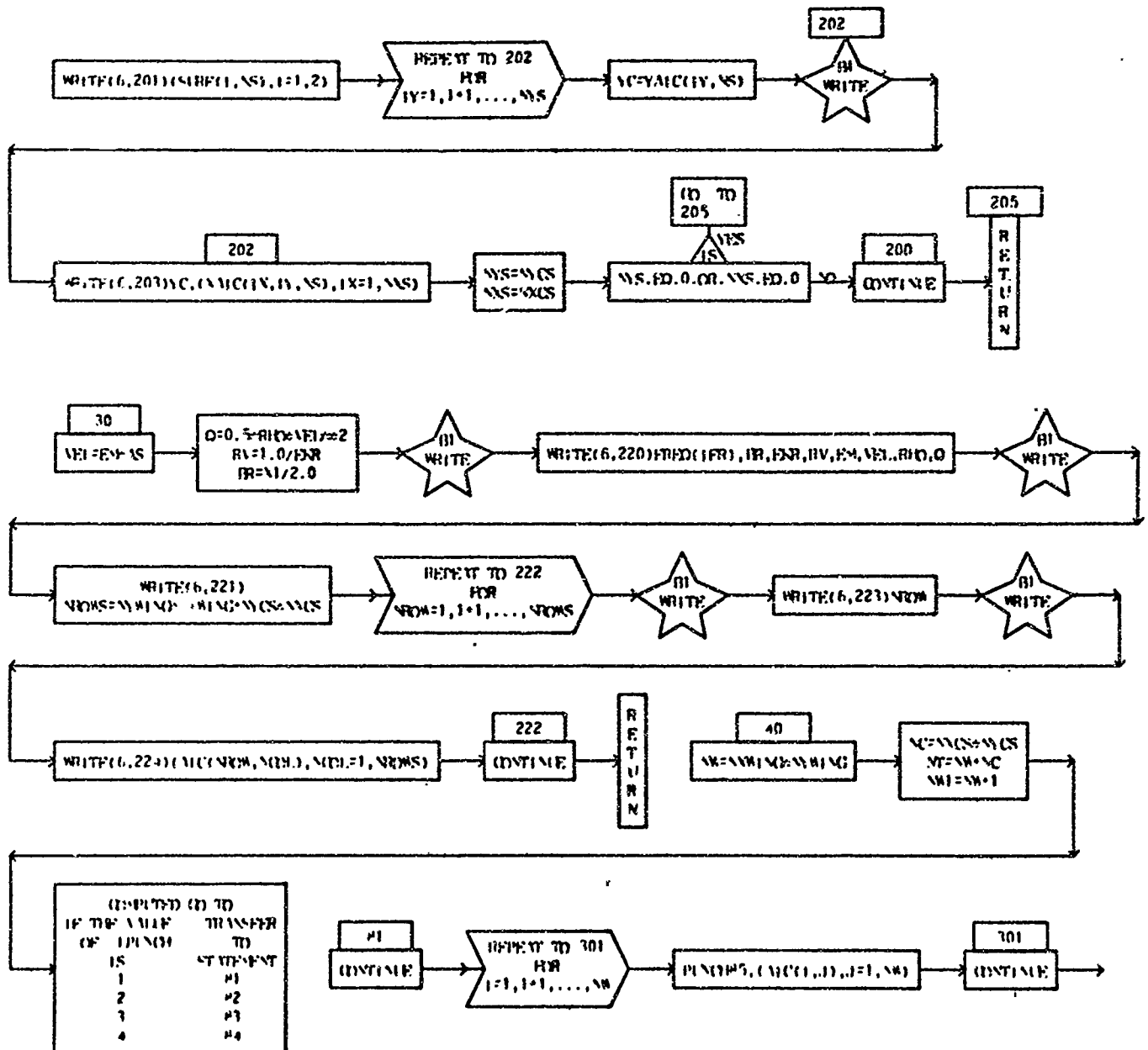
SUBROUTINE ROUT (END)

PAGE 1



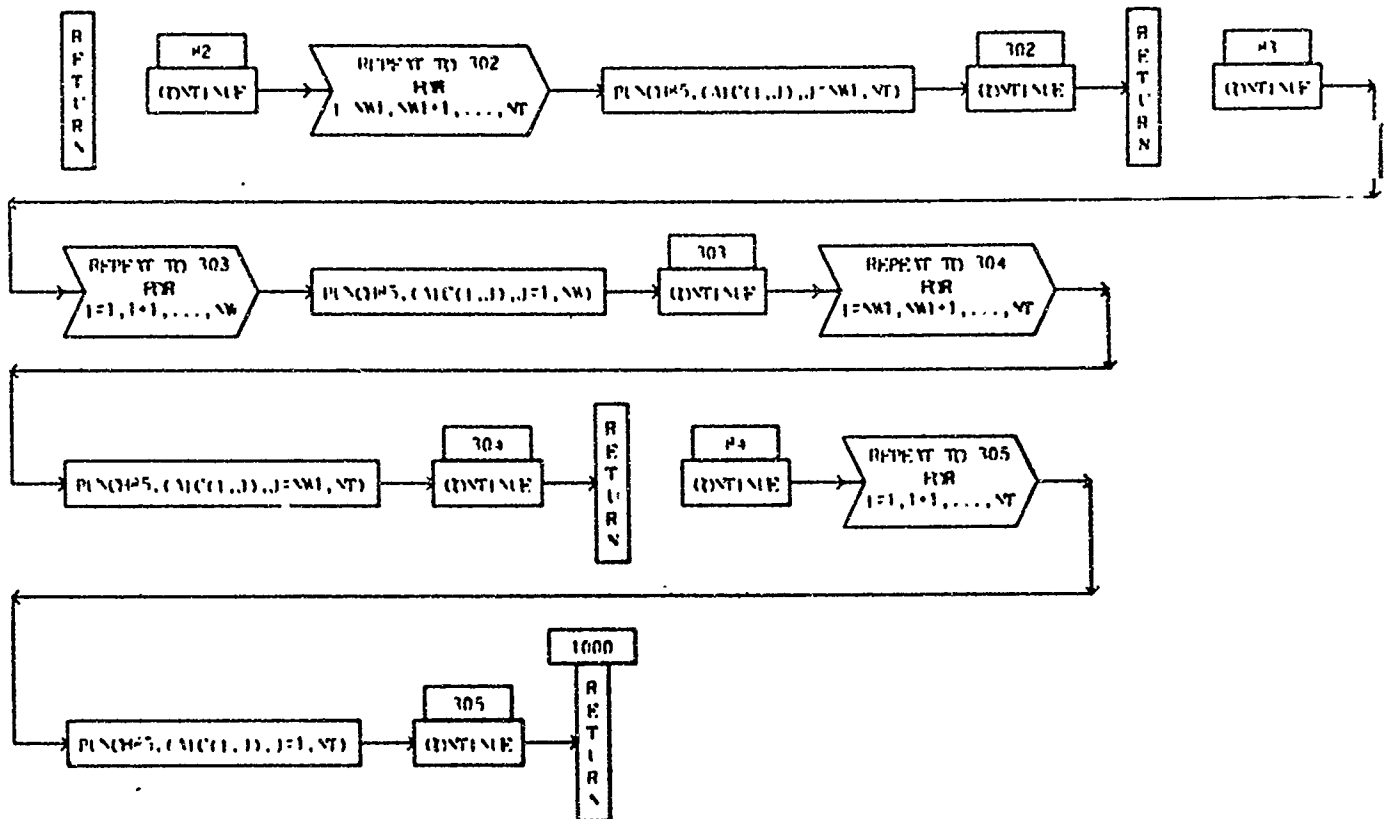
SUBROUTINE ROUT (1AD)

PAGE 2



SUBROUTINE ROOT (END)

PAGE 2



NDA NDA

D I M E N S I O N E D V A R I A B L E S

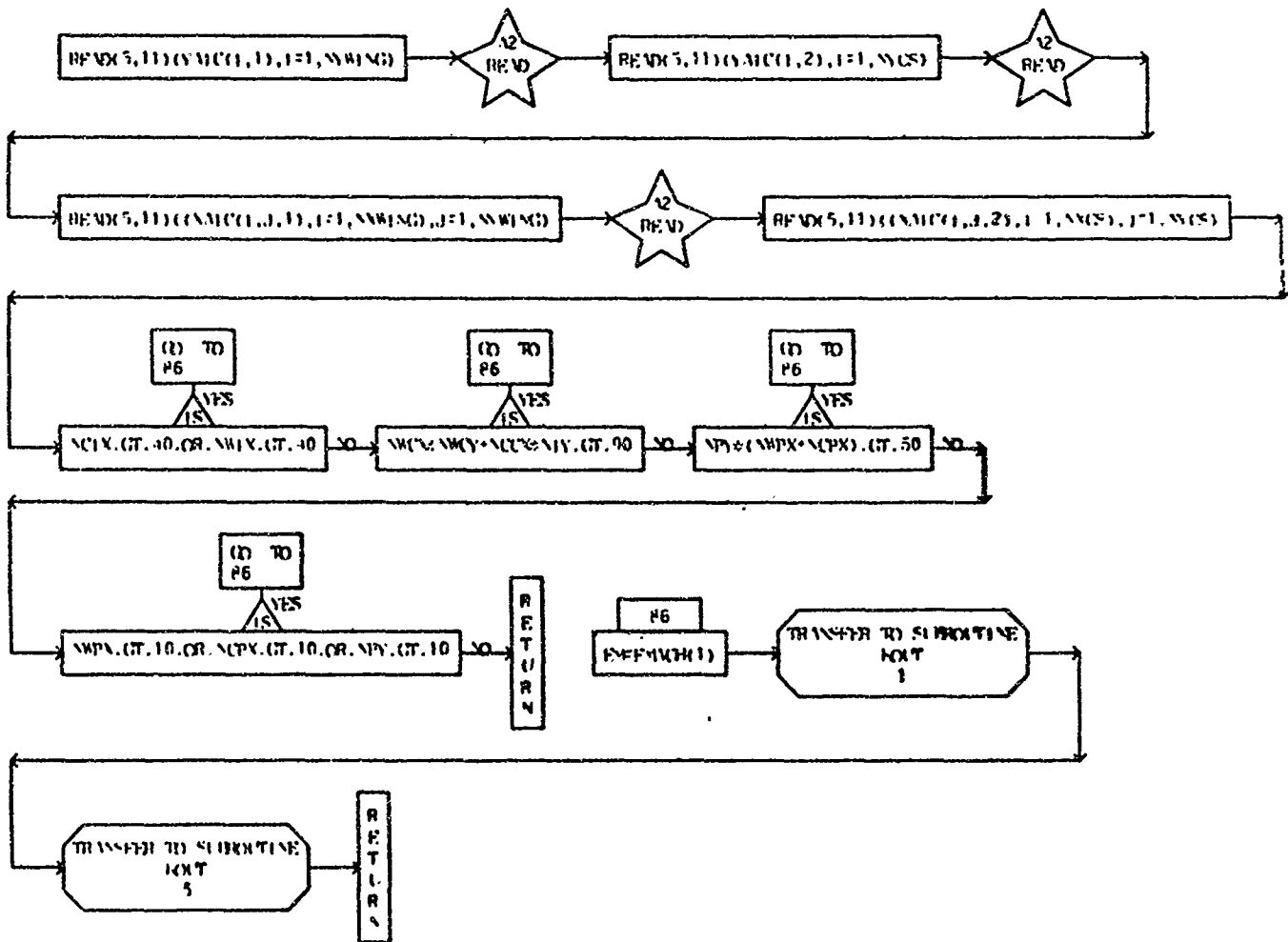
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M C	40, 20	M A S I	40						

PKA 1



SUBROUTINE WFDA

PAGE 2



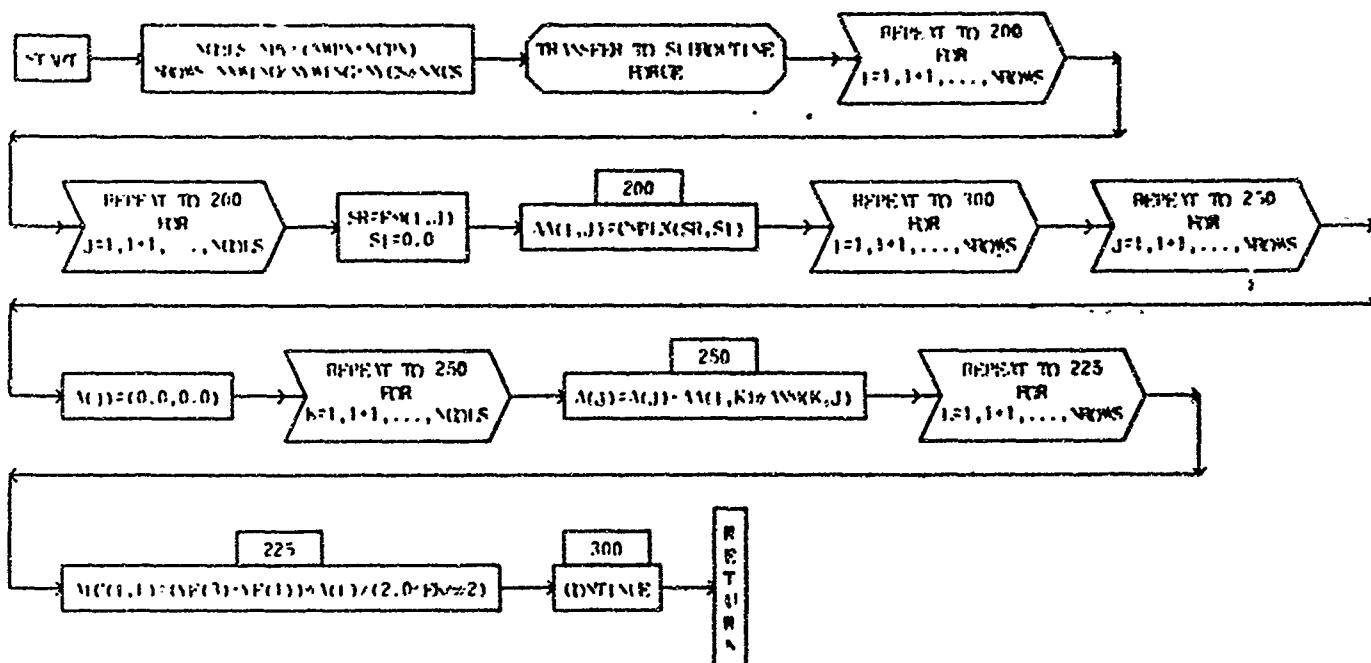
VCS

DIMENSIONED VARIABLES

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SUBROUTINE AICS

PGS 1 1



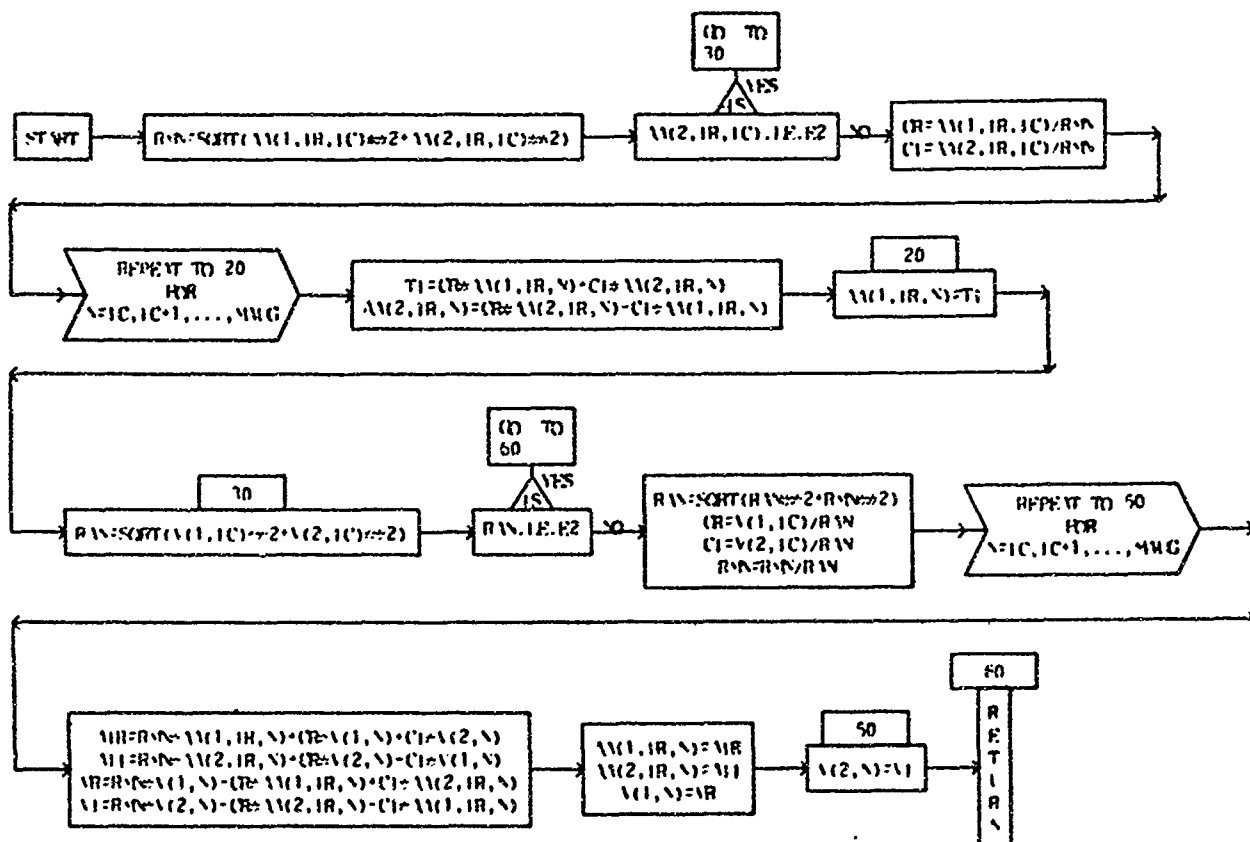
(177) (178)

DIMENSIONED VARIABLES

SYMBOL	STANDARD	SYMBOL	STANDARD	SYMBOL	STANDARD	SYMBOL	STANDARD	SYMBOL	STANDARD
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SUBROUTINE (RFDIV, IR, IC)

PAGE 1



HWI

D I M E N S I O N E D V A R I A B L E S

S Y M B	S T R U C T	S Y M B	S T R U C T	S Y M B	S T R U C T	S Y M B	S T R U C T	S Y M B	S T R U C T
P 4	10, 10								

PAGE 1

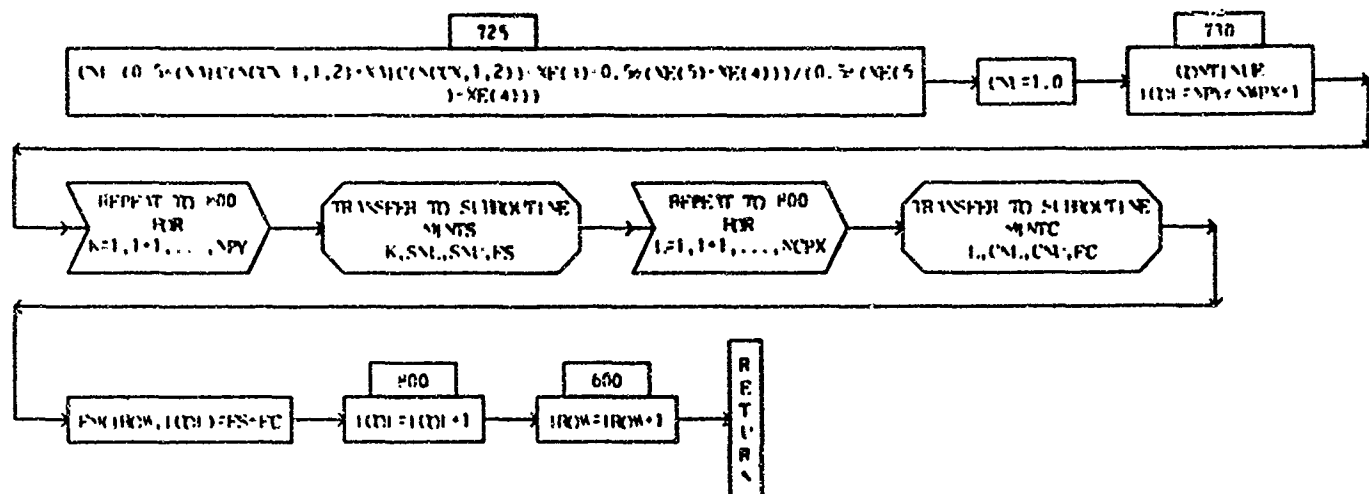


543 2



SUBROUTINE RSC02

PAGE 1



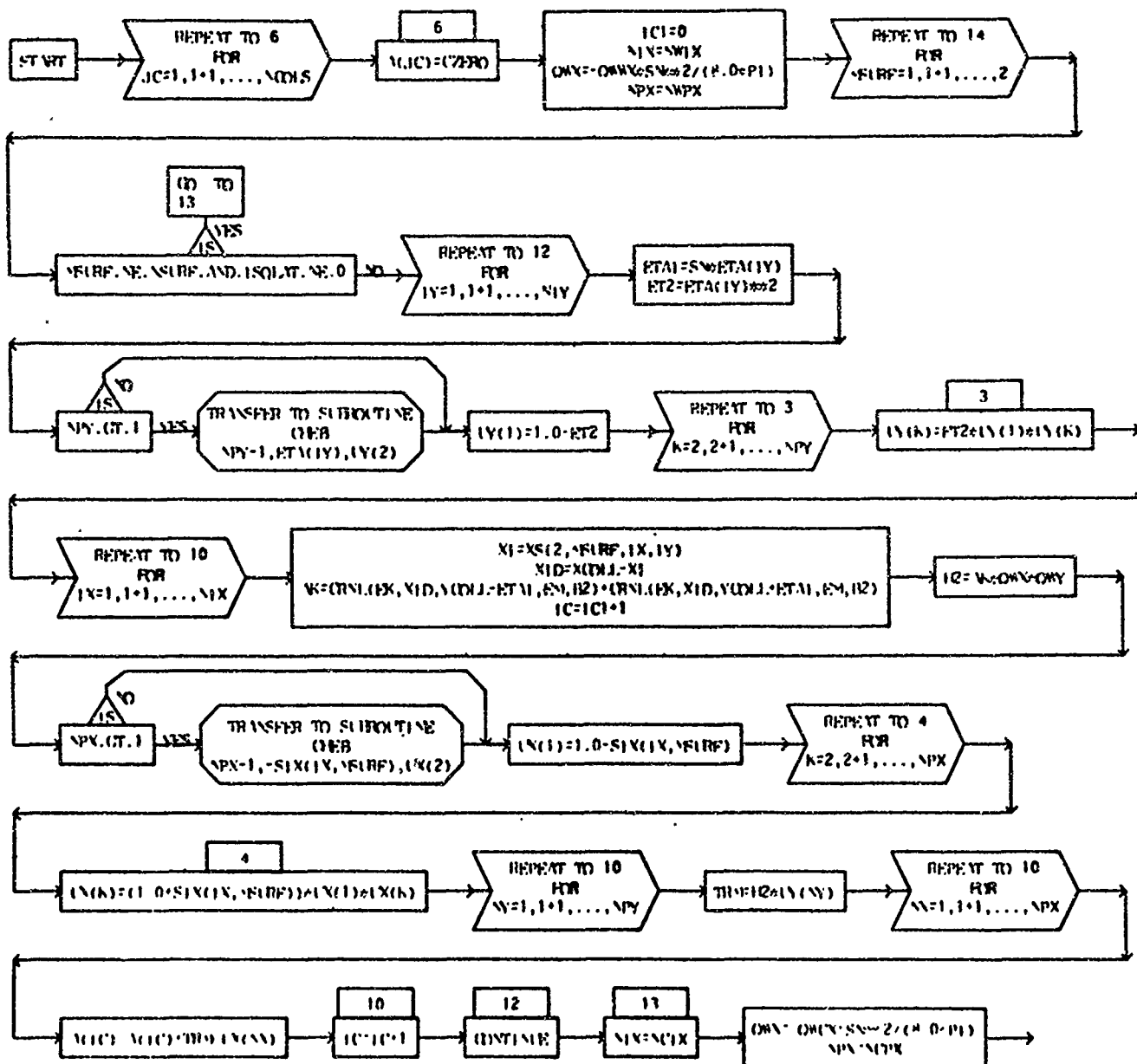
(GR) (GR)

D I M E N S I O N E D V A R I A B L E S

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W C	40, 20	W A H	40						

SUBROUTINE QRD

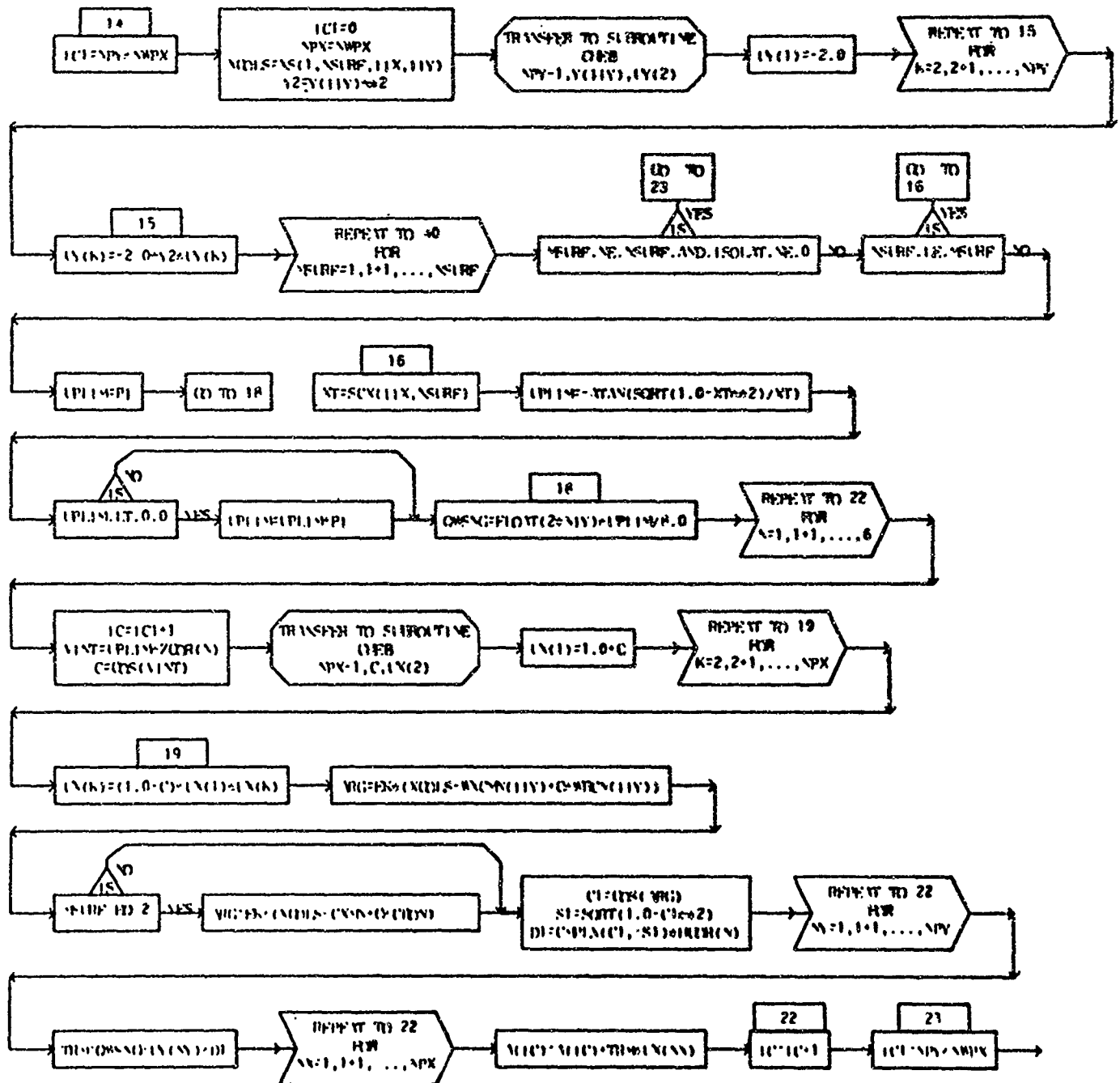
PAGE 1



NOT REPRODUCIBLE

ALGORITHM QND

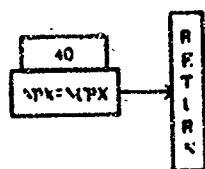
PAGE 2



SECRET

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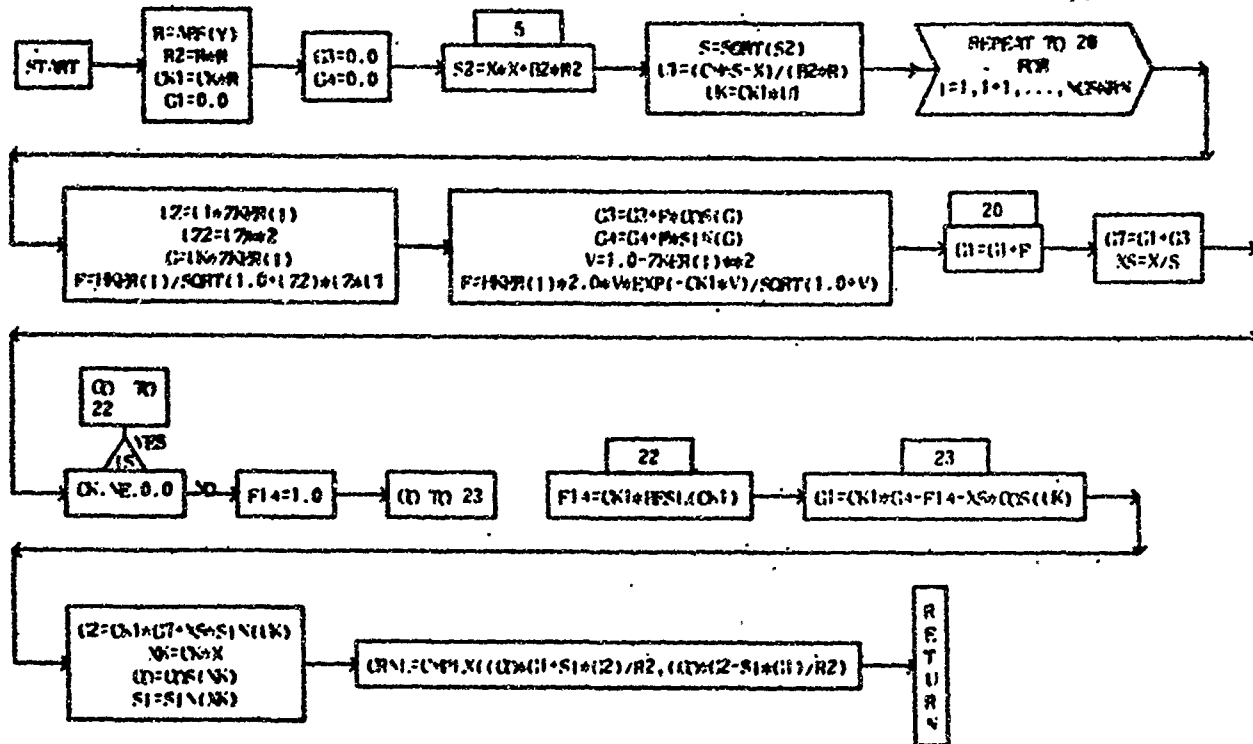
PAGE 1



CHN. CHN.

COMPLEX FUNCTION CRN(X,Y,C,R2)

PAGE 1

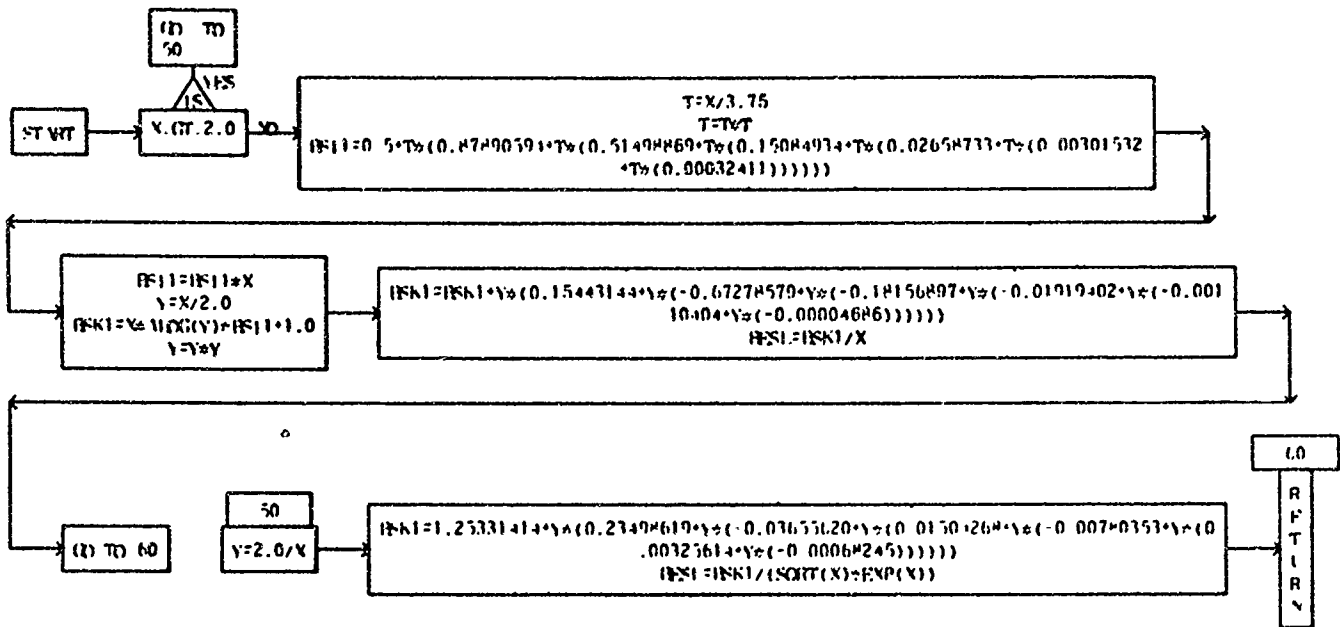


WPSI.

WPSL

FUNCTION PSI(X)

PAGE 1



048 048

DIMENSIONED VARIABLES

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1X	1								

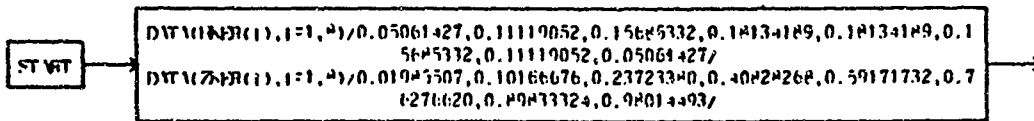
1540 1540

DIMENSIONED VARIABLES

SYM.	STORAGES	SYM.	STORAGES	SYM.	STORAGES	SYM.	STORAGES	SYM.	STORAGES
111	40, 40	112	40						

BLOCK DATA

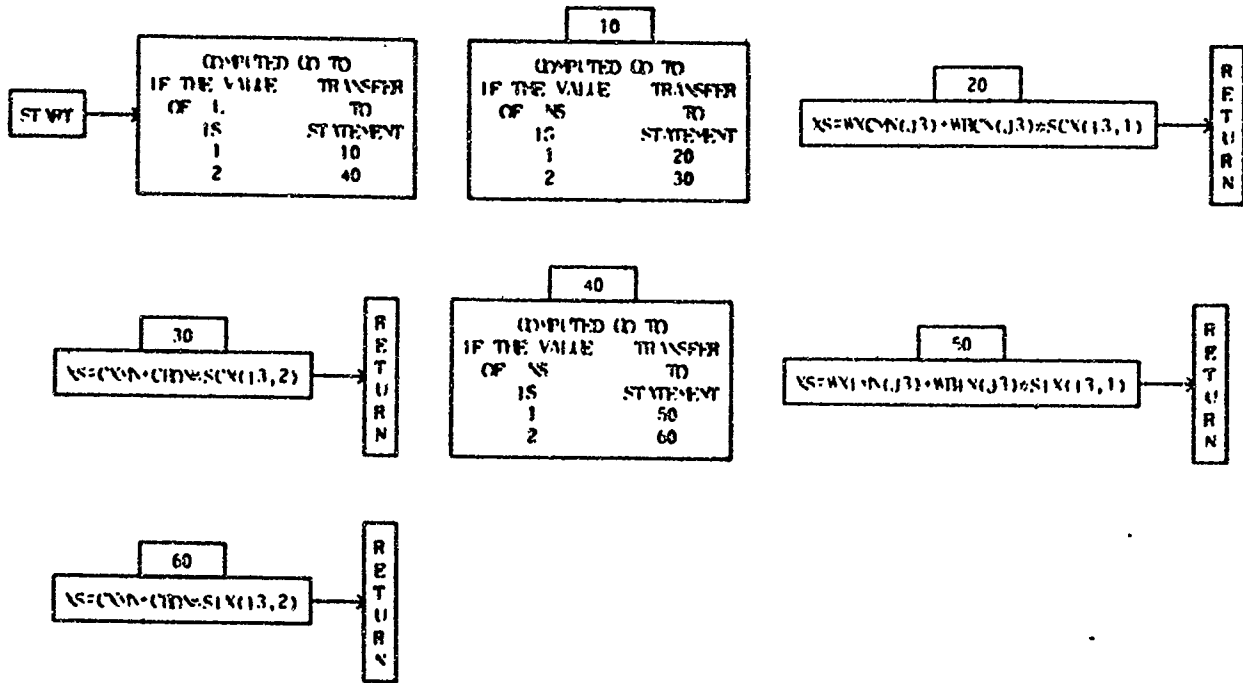
PAGE 1



" "

FUNCTION XS(L, NS, I3, J3)

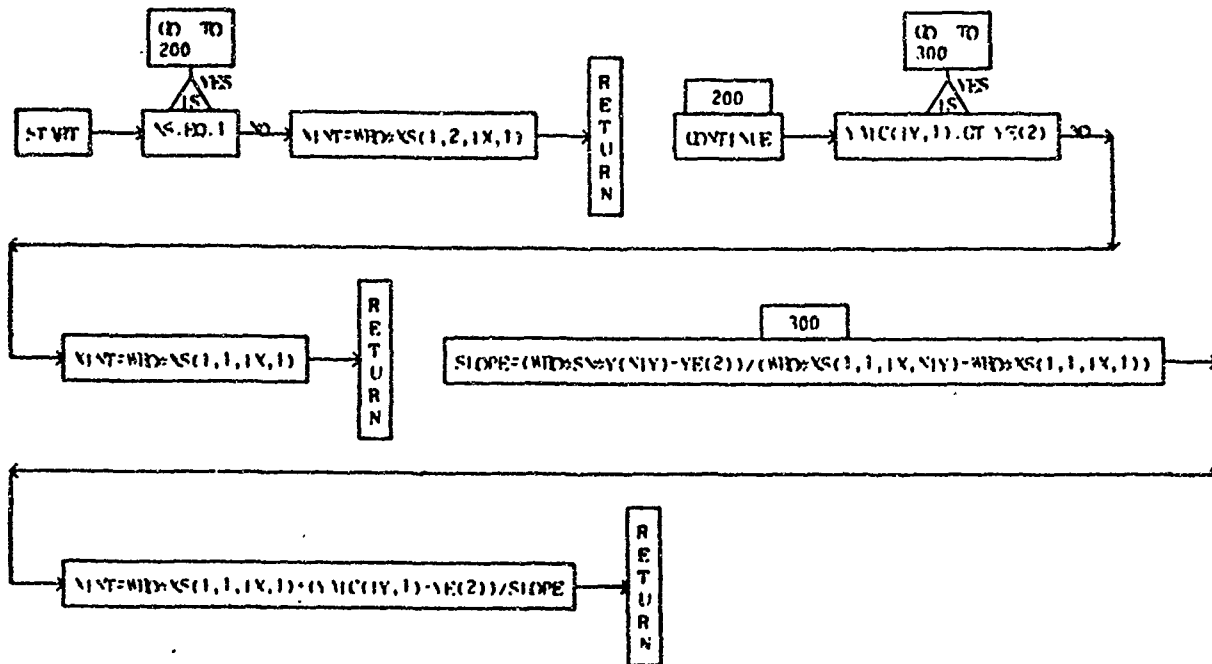
PAGE 1



417

FUNCTION NINT (IV,IX,NIV,NS,WID,SN)

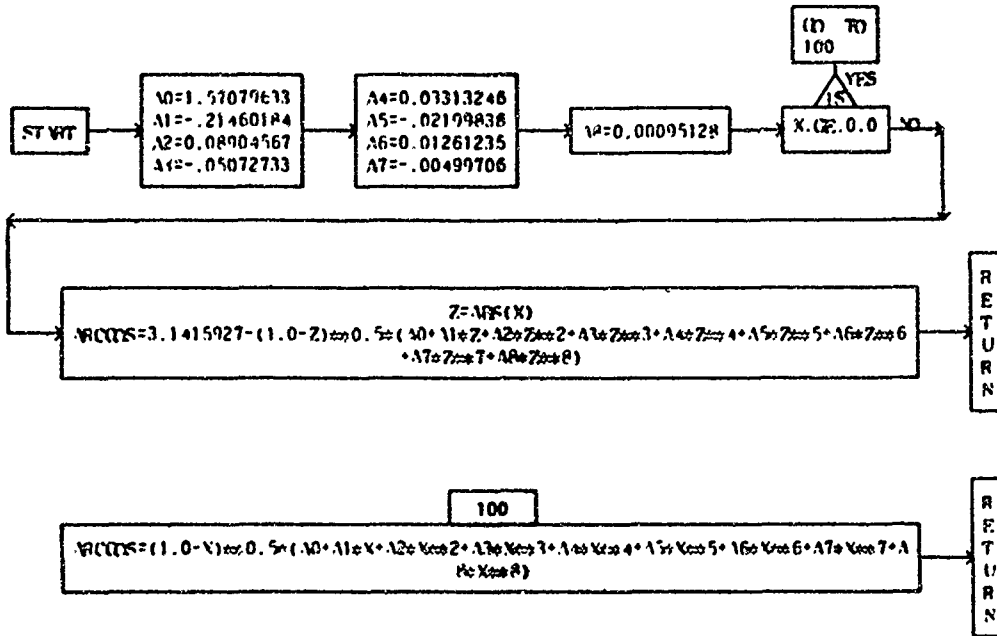
PAGE 1



WCUK

FUNCTION WCCUS(X)

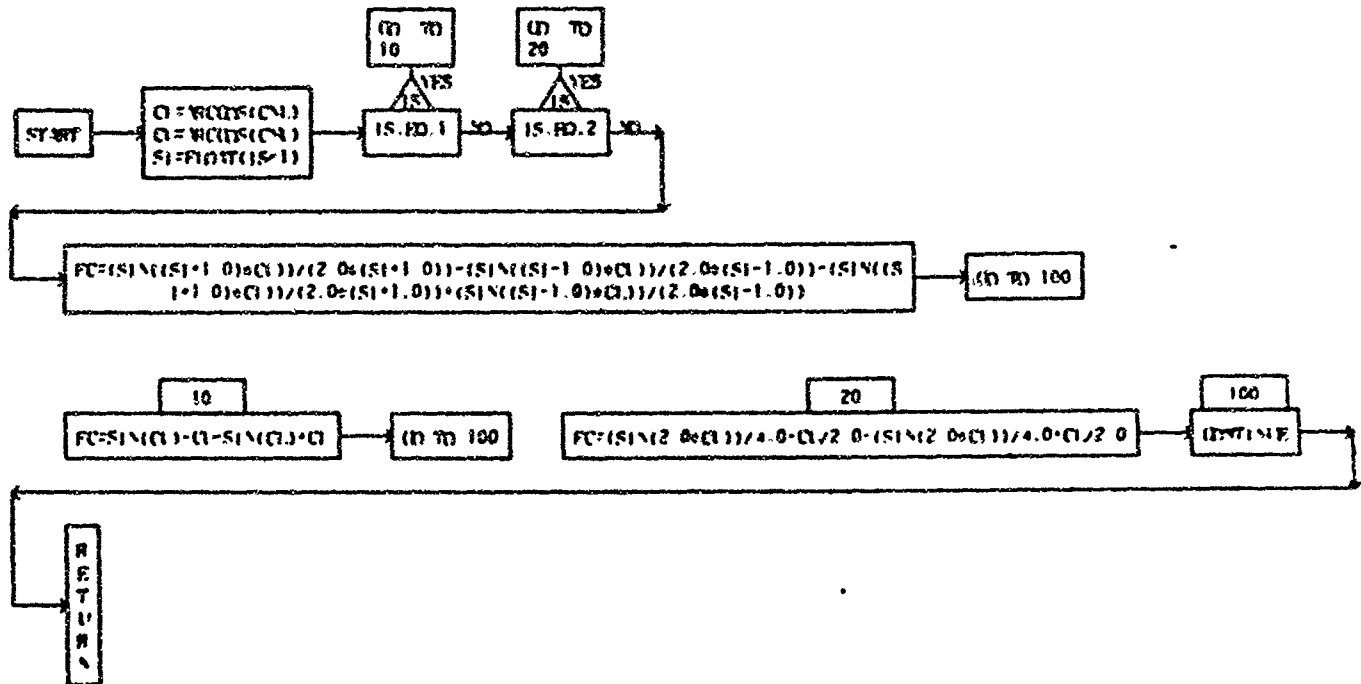
PAGE 1



4 17C

SUBROUTINE WNTC(IS,CN,CN',FC)

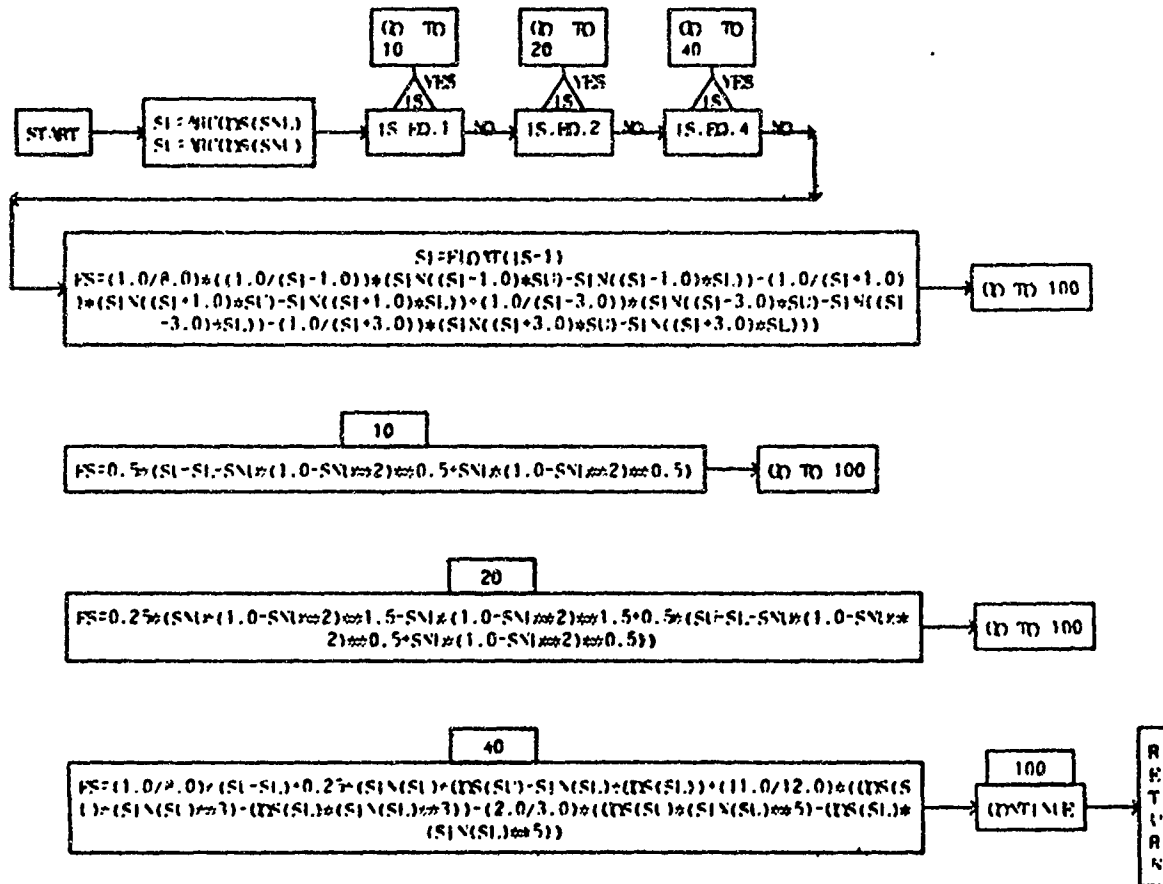
PAGE 1



19 575

SUBROUTINE MINTS(I5,SNL,SNL,FS)

PAGE 1



1120 1120

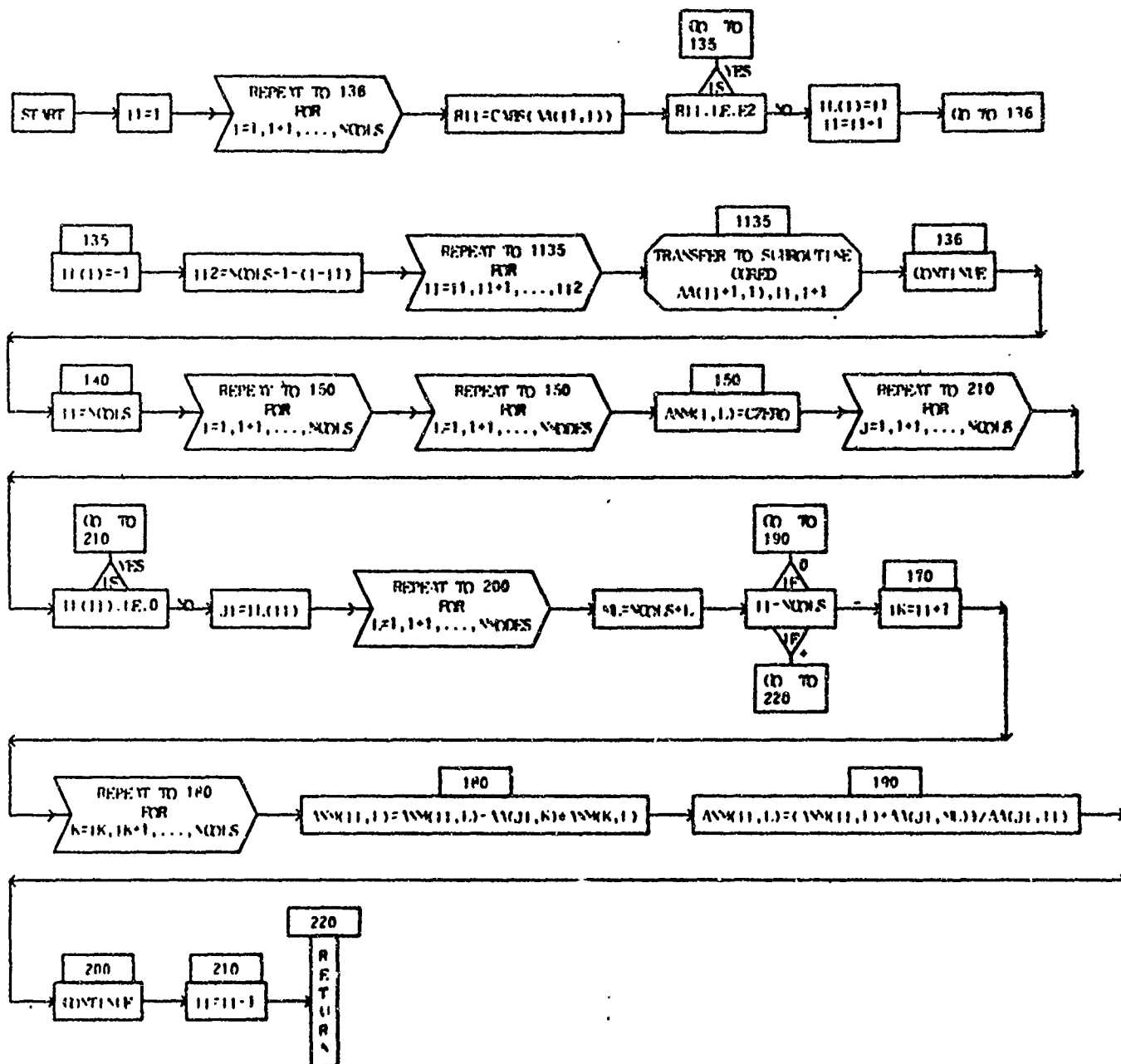
D I M E N S I O N E D V A R I A B L E S

SYMBOL	STORMS	SYMBOL	STORMS	SYMBOL	STORMS	SYMBOL	STORMS	SYMBOL	STORMS
MC	10, 20	WGH	40						

NOT REPRODUCIBLE

SUBROUTINE KIRO

PAGE

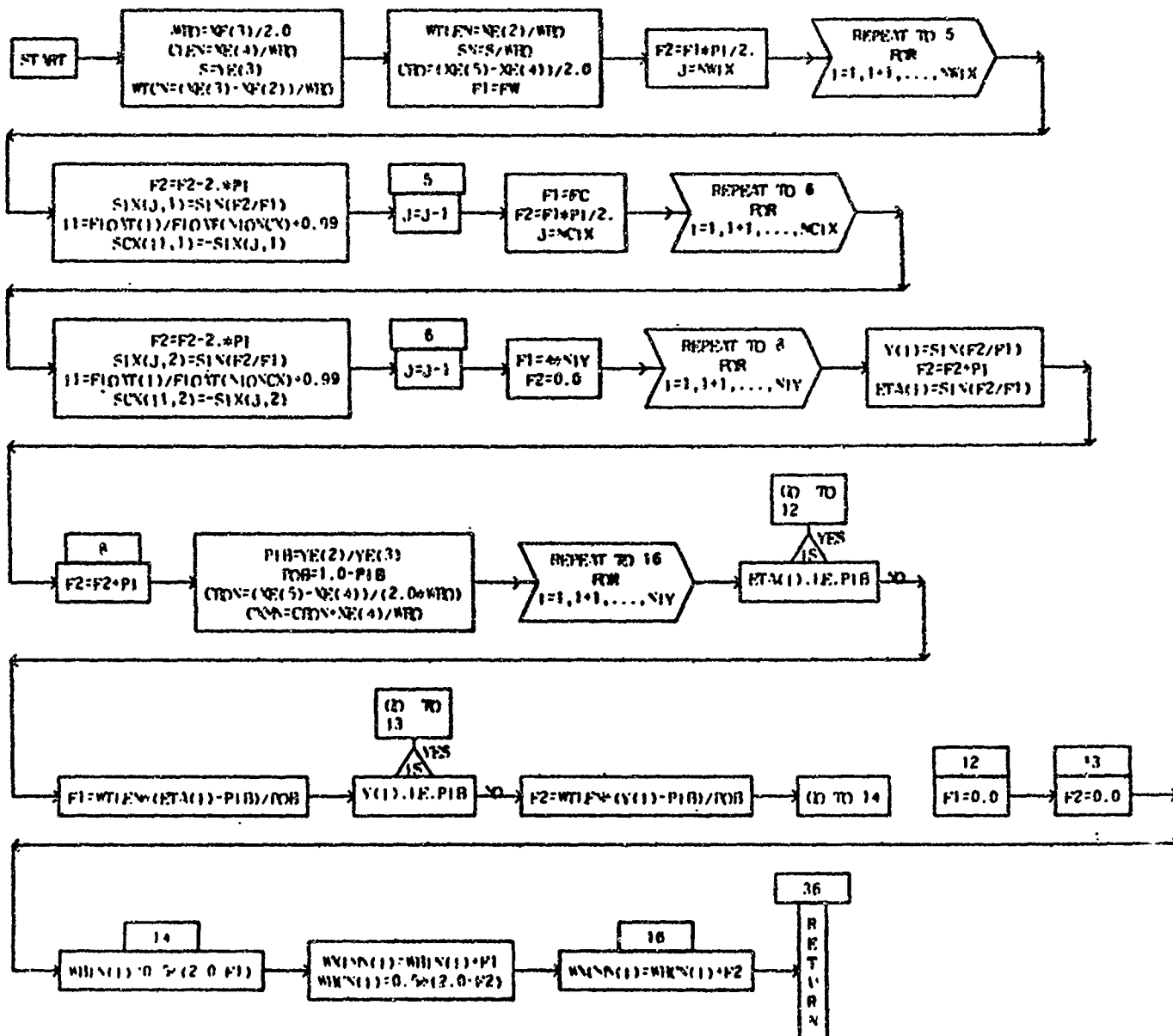


SECRET/NOFORN 104

CRM CRM

DIMENSIONED VARIABLES

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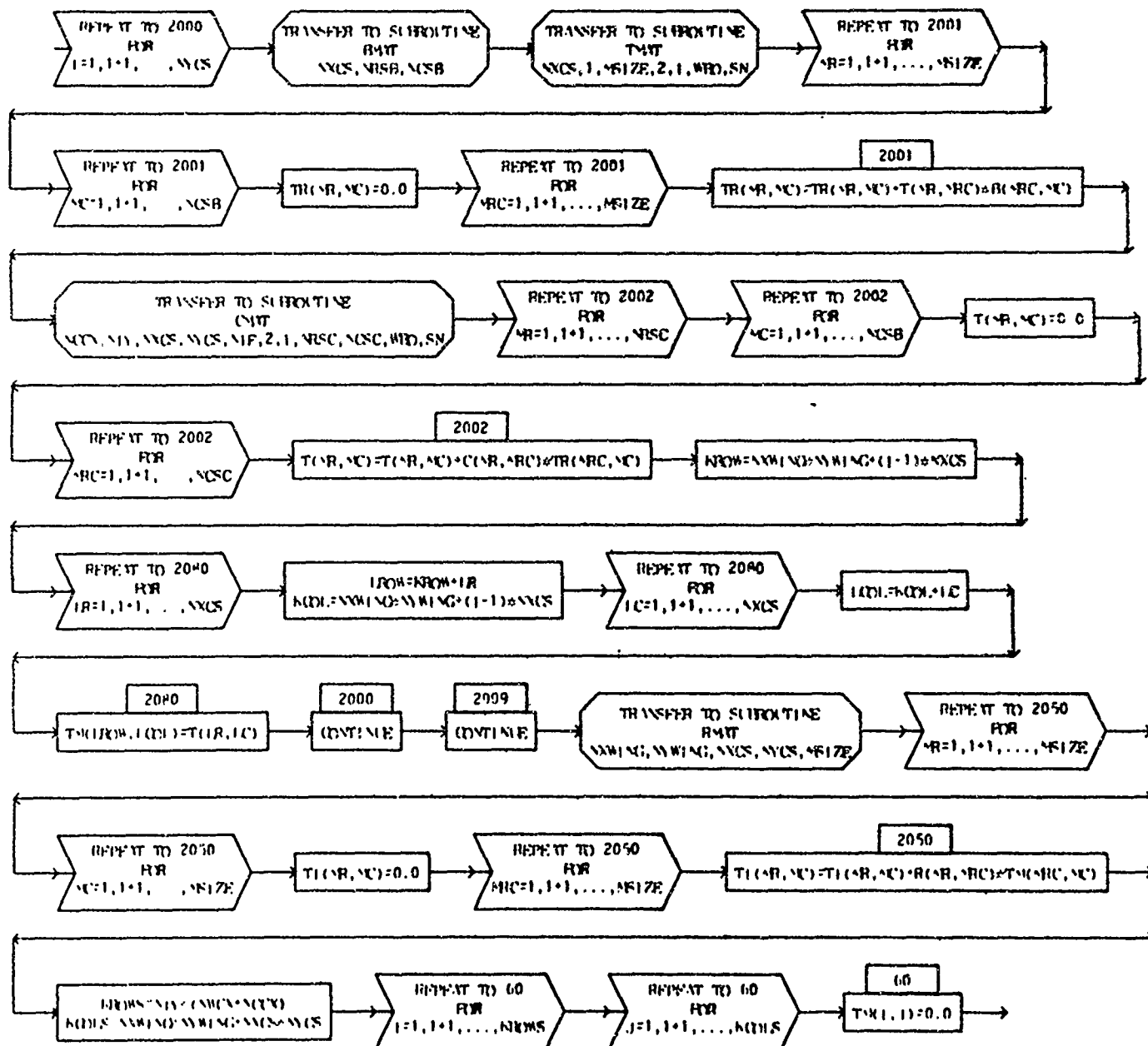


TRIP

NOT REPRODUCIBLE

[illegible]

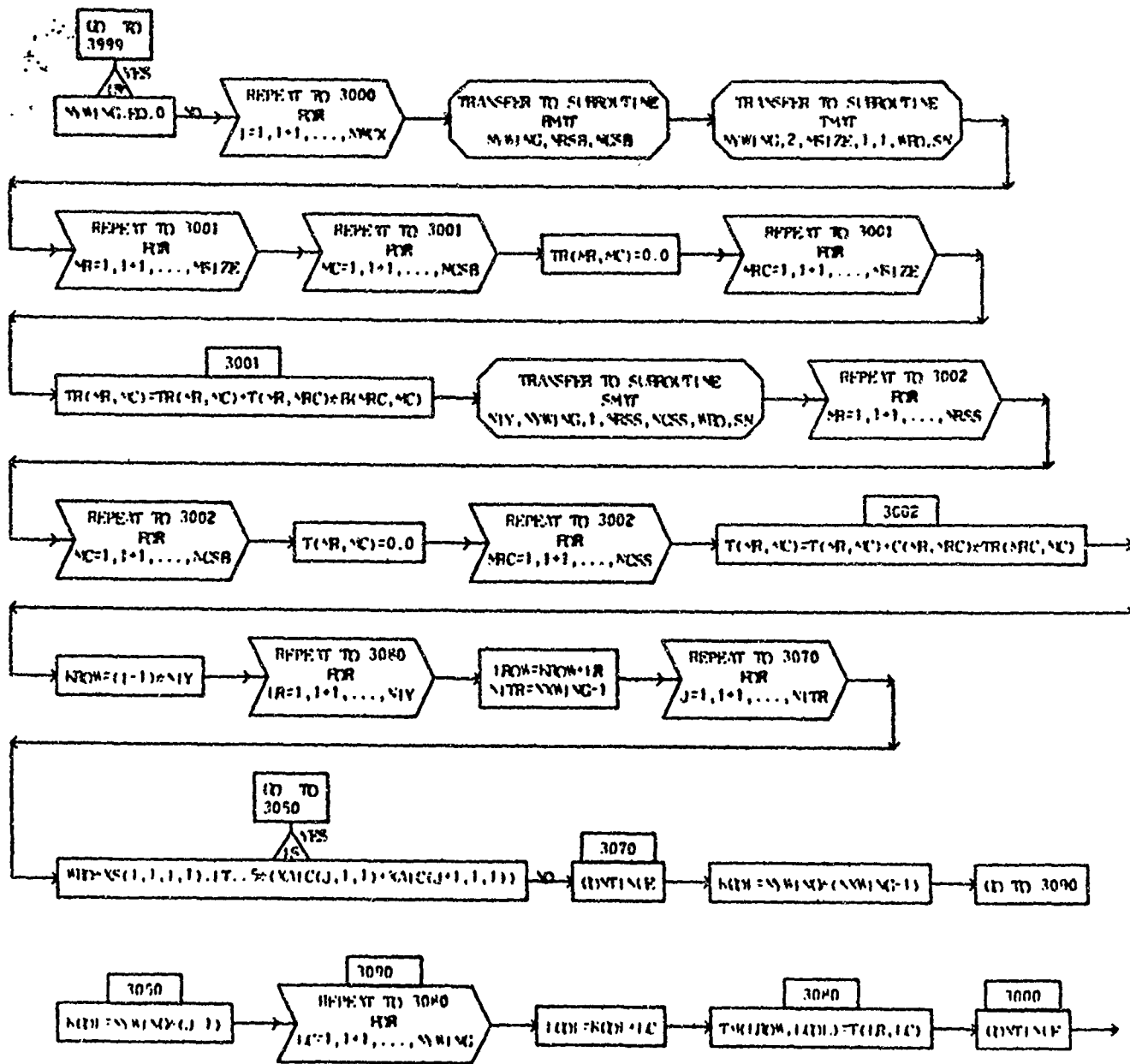
РКЗ 2



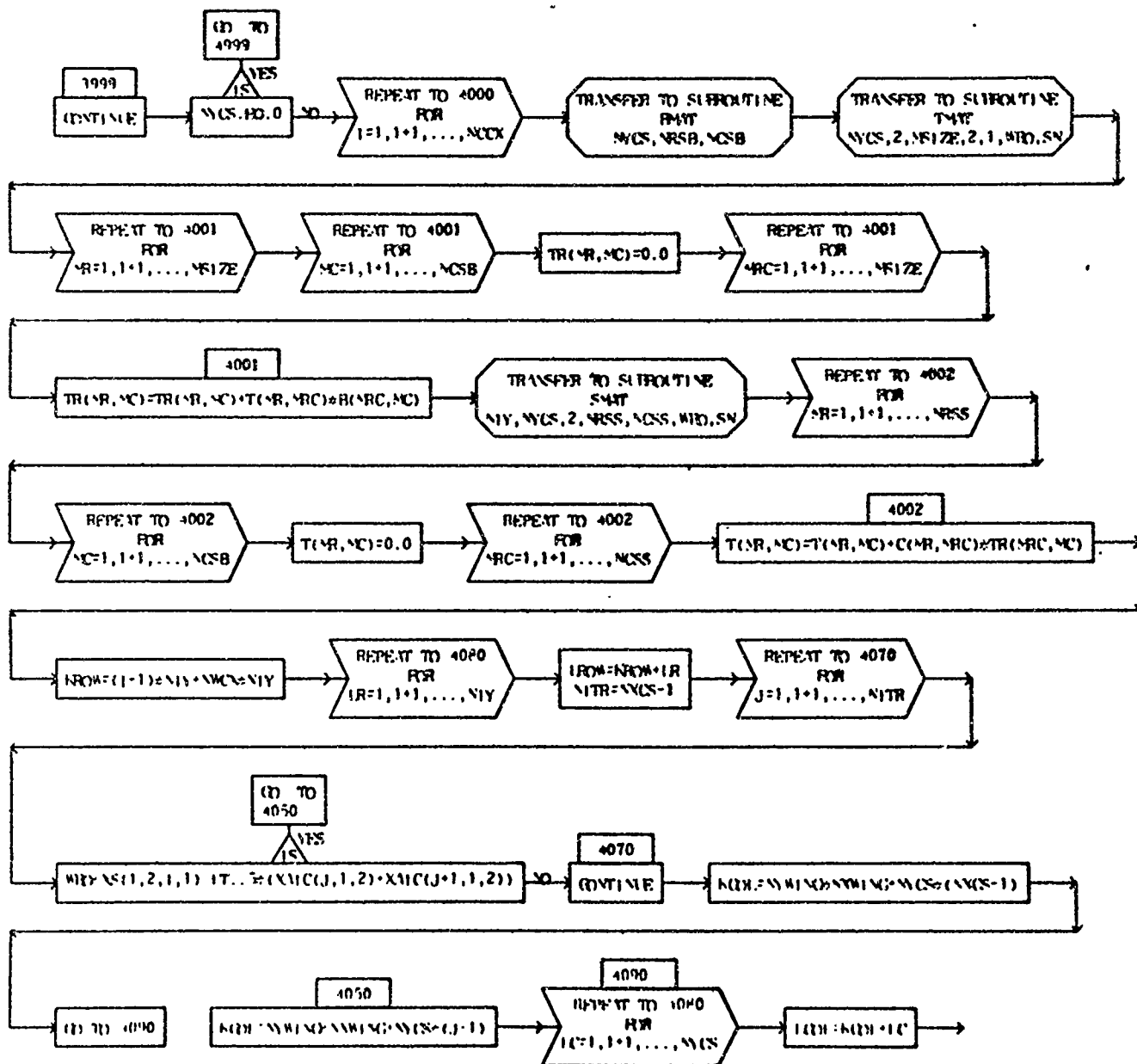
NOT REPRODUCIBLE

SUBROUTINE TRAPXNY, NWCY, NCXY, NWCYNG, NWCYNG, NWCY, NWCY, NWCY, NWCY, NWCY

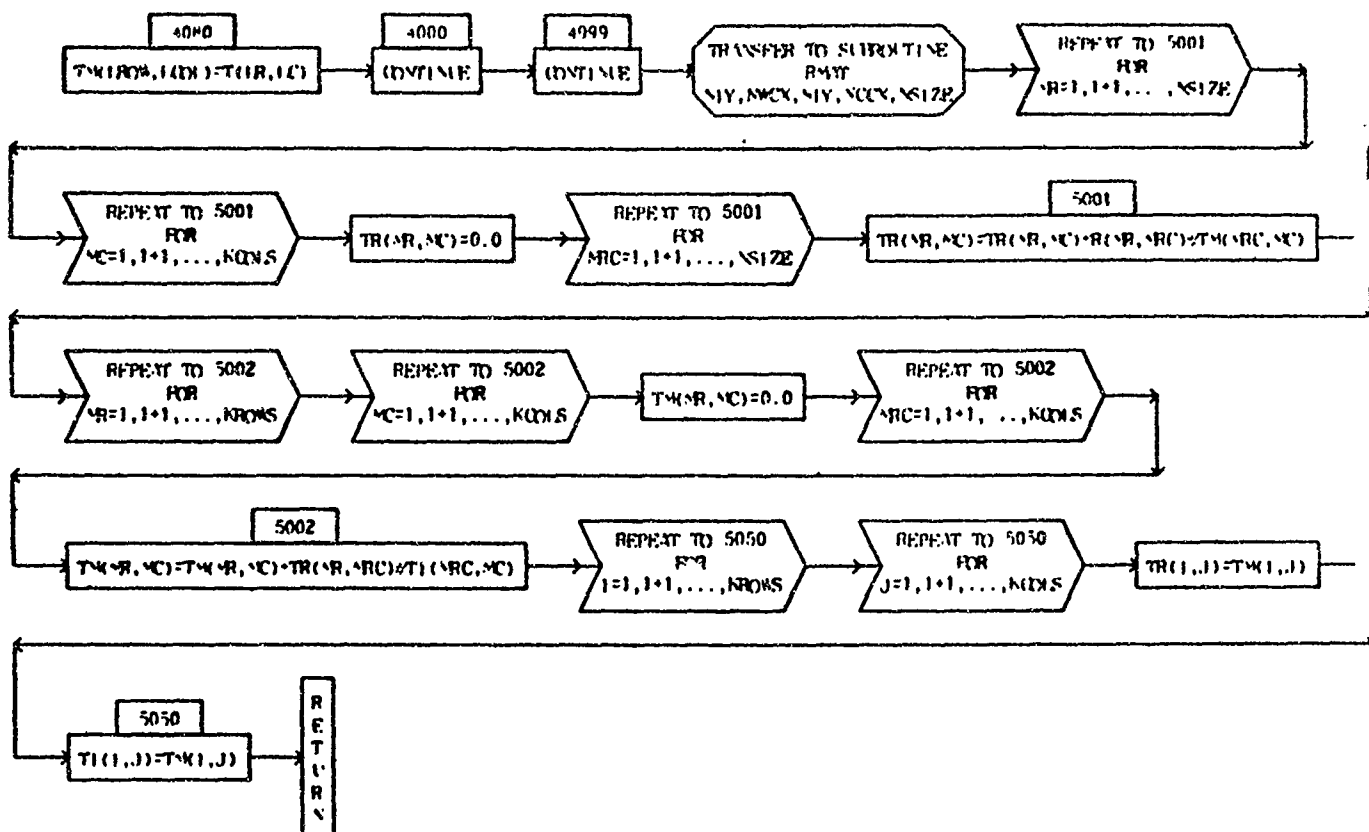
PAGE 3



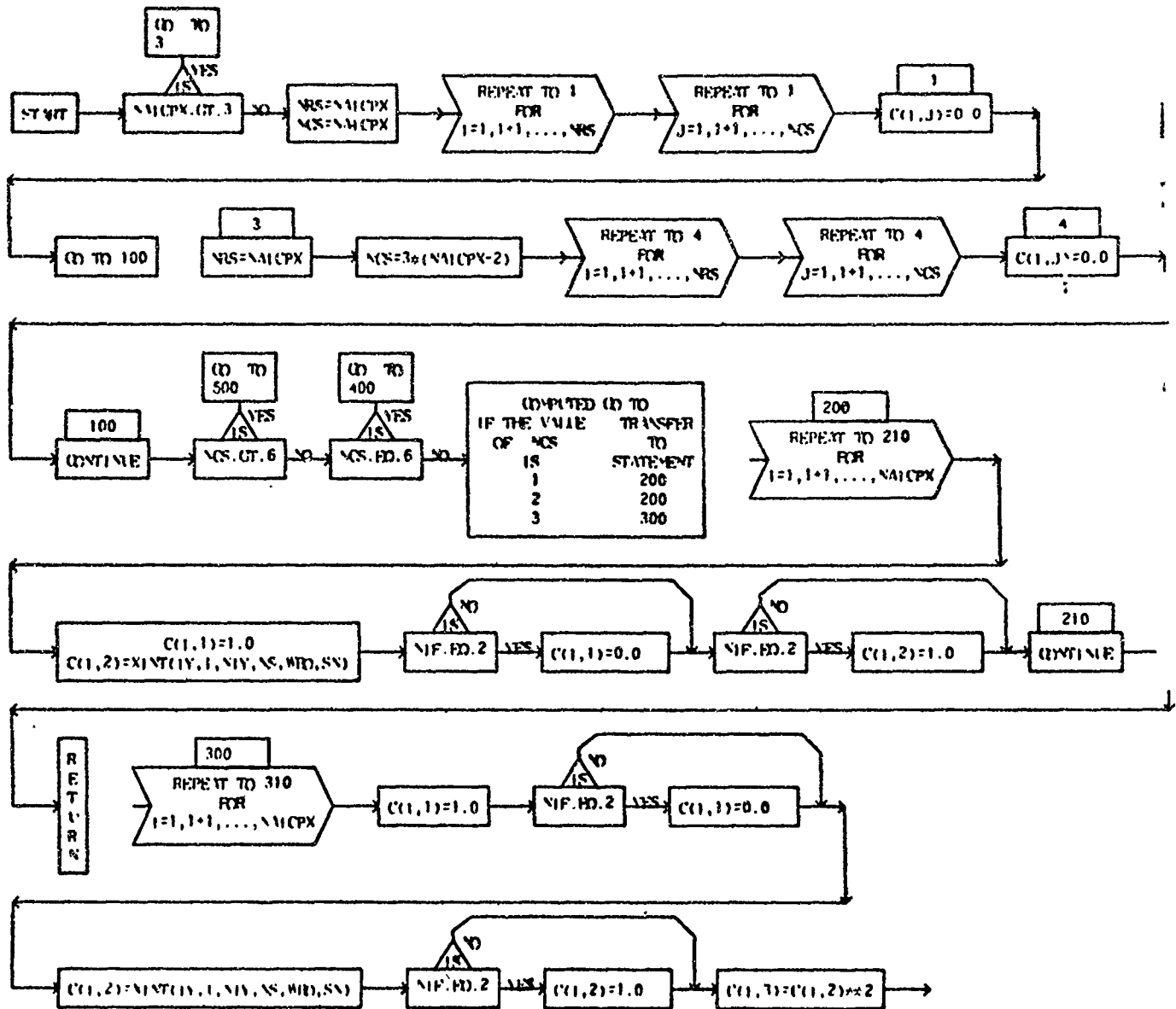
PAGE 4



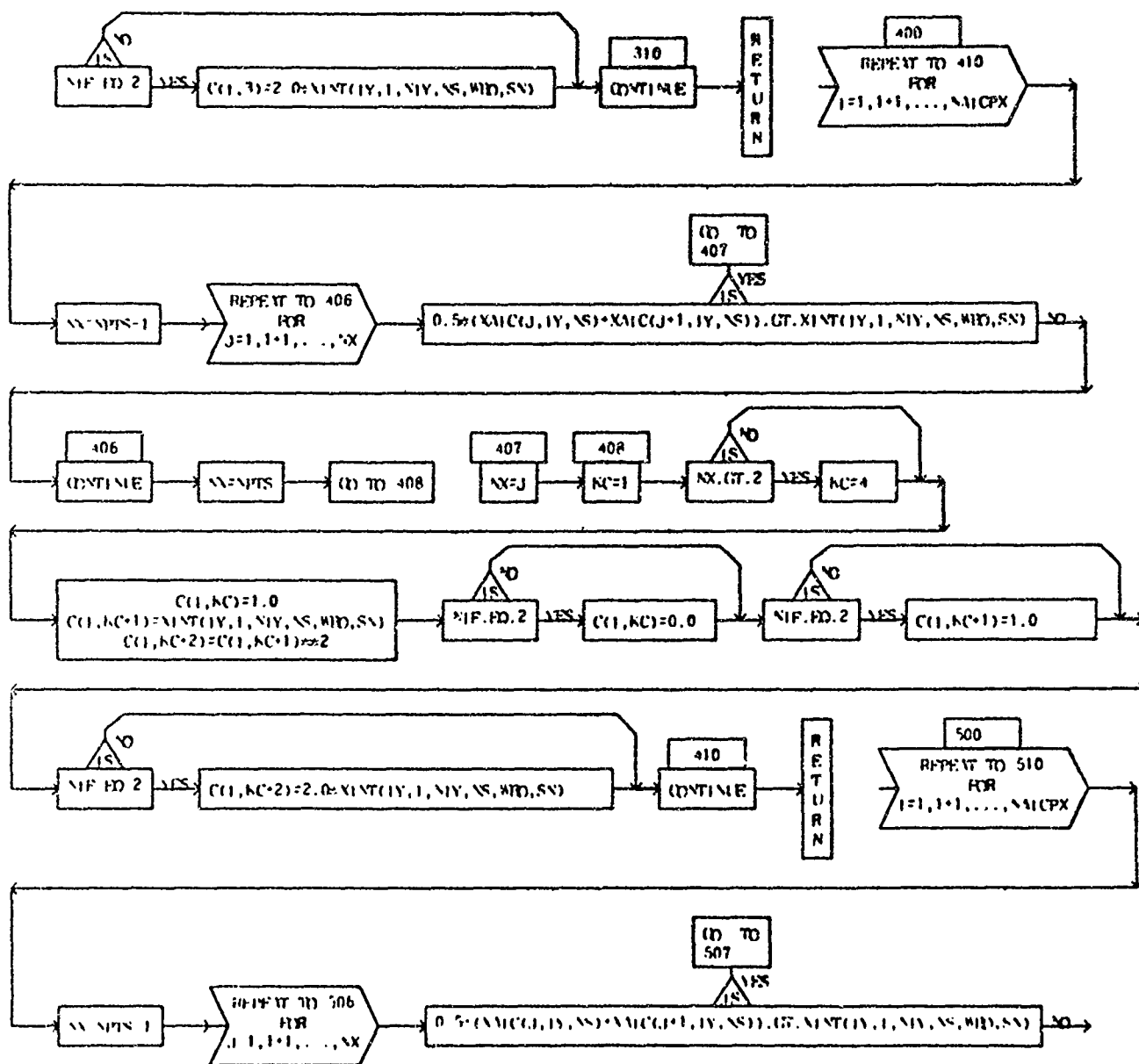
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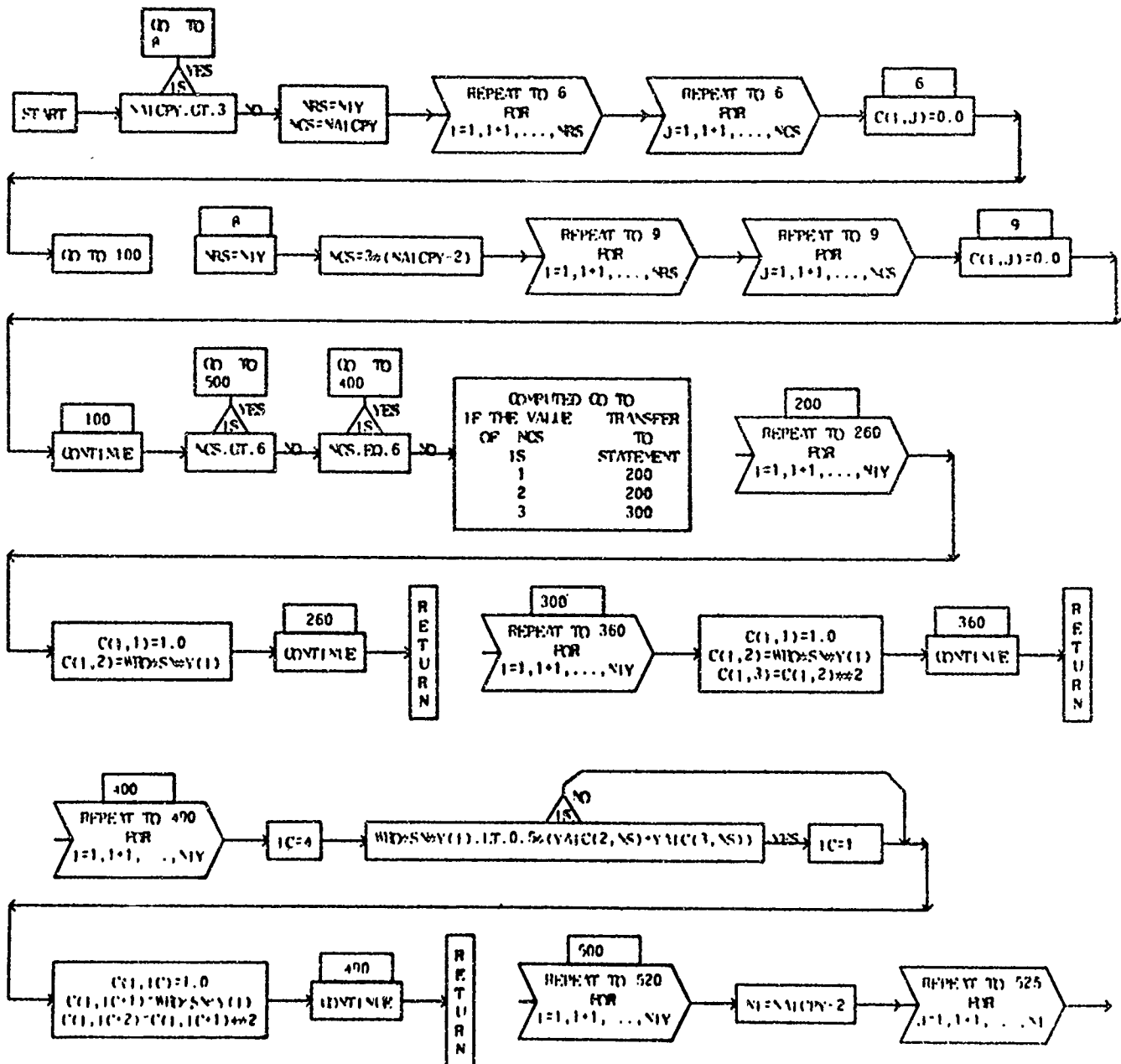


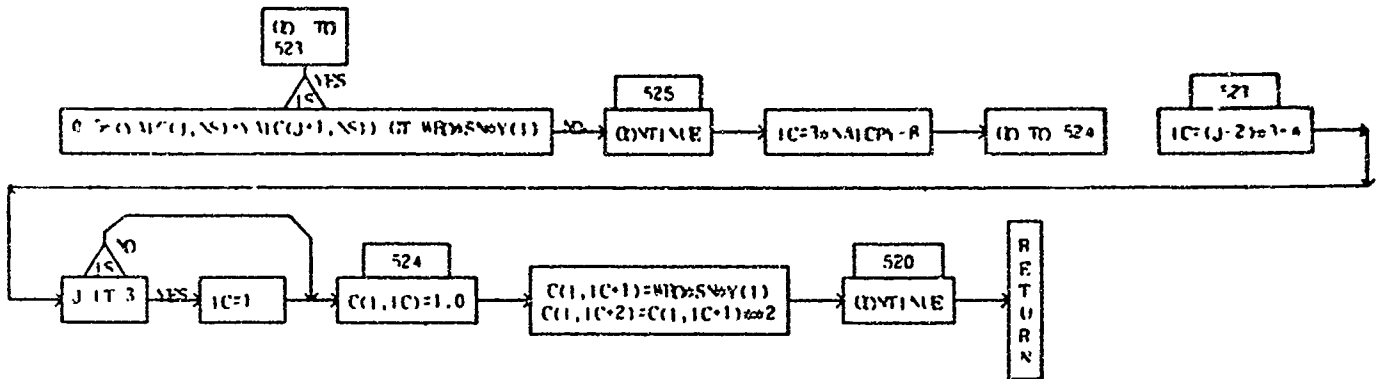
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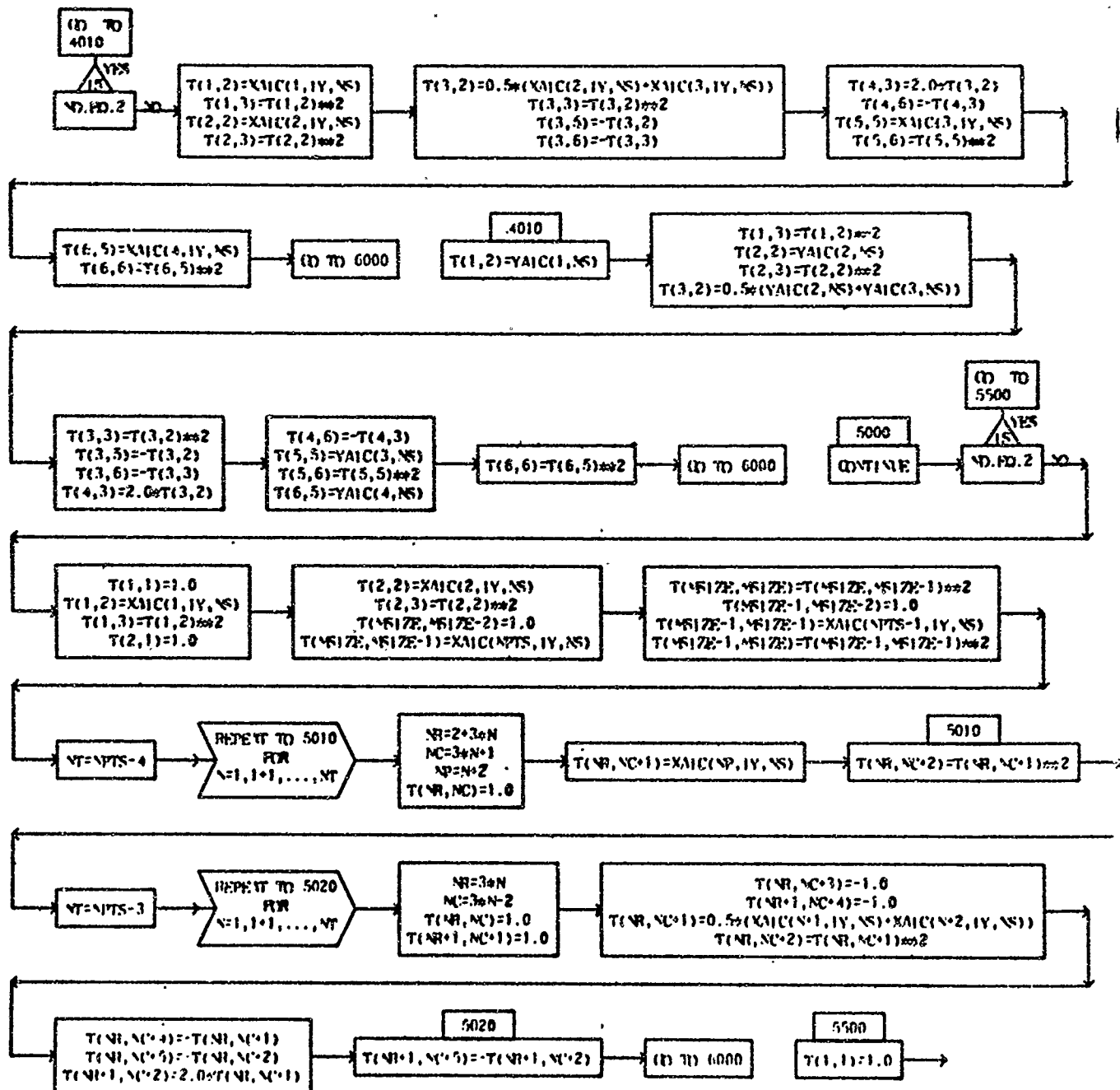
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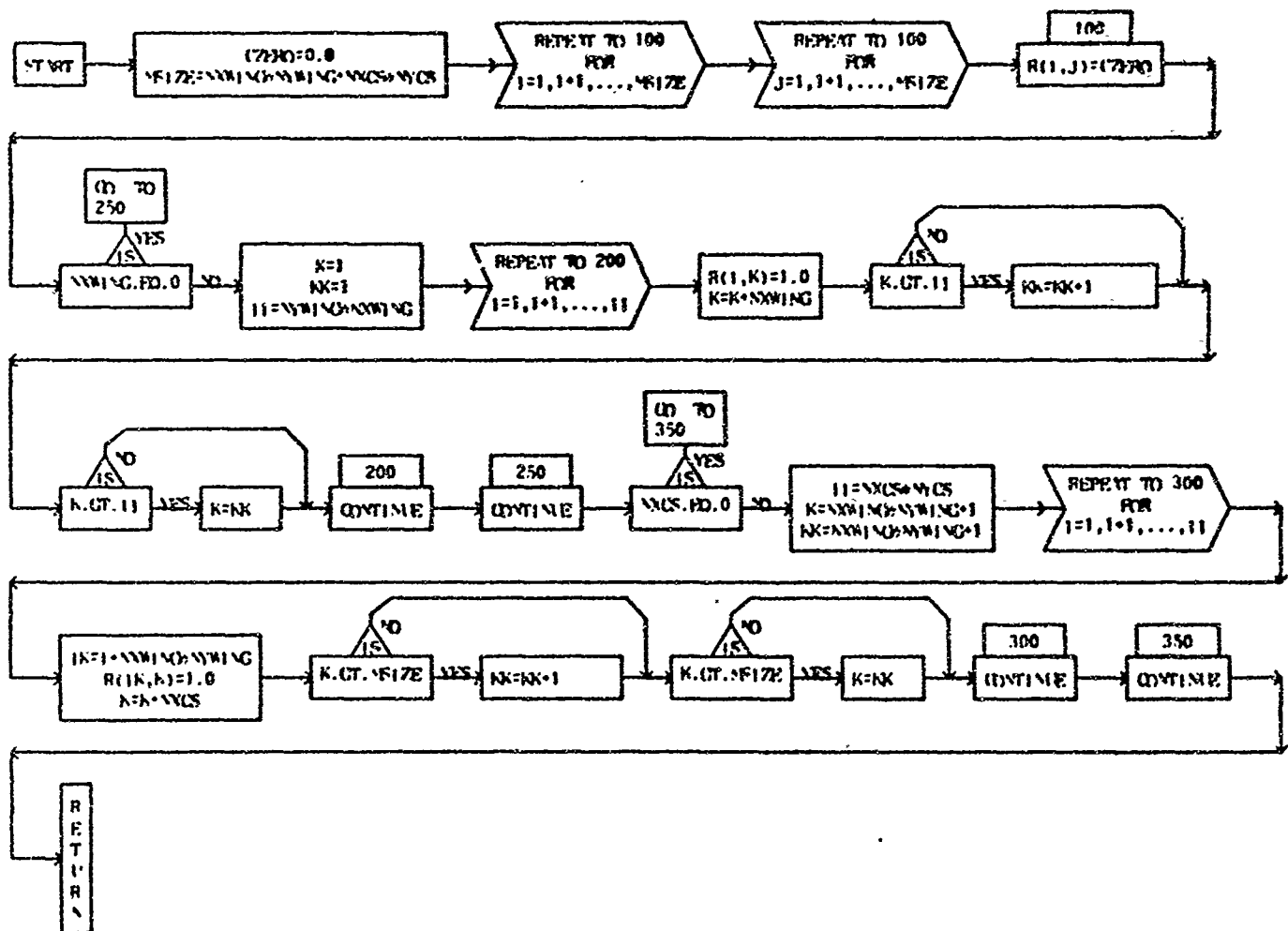
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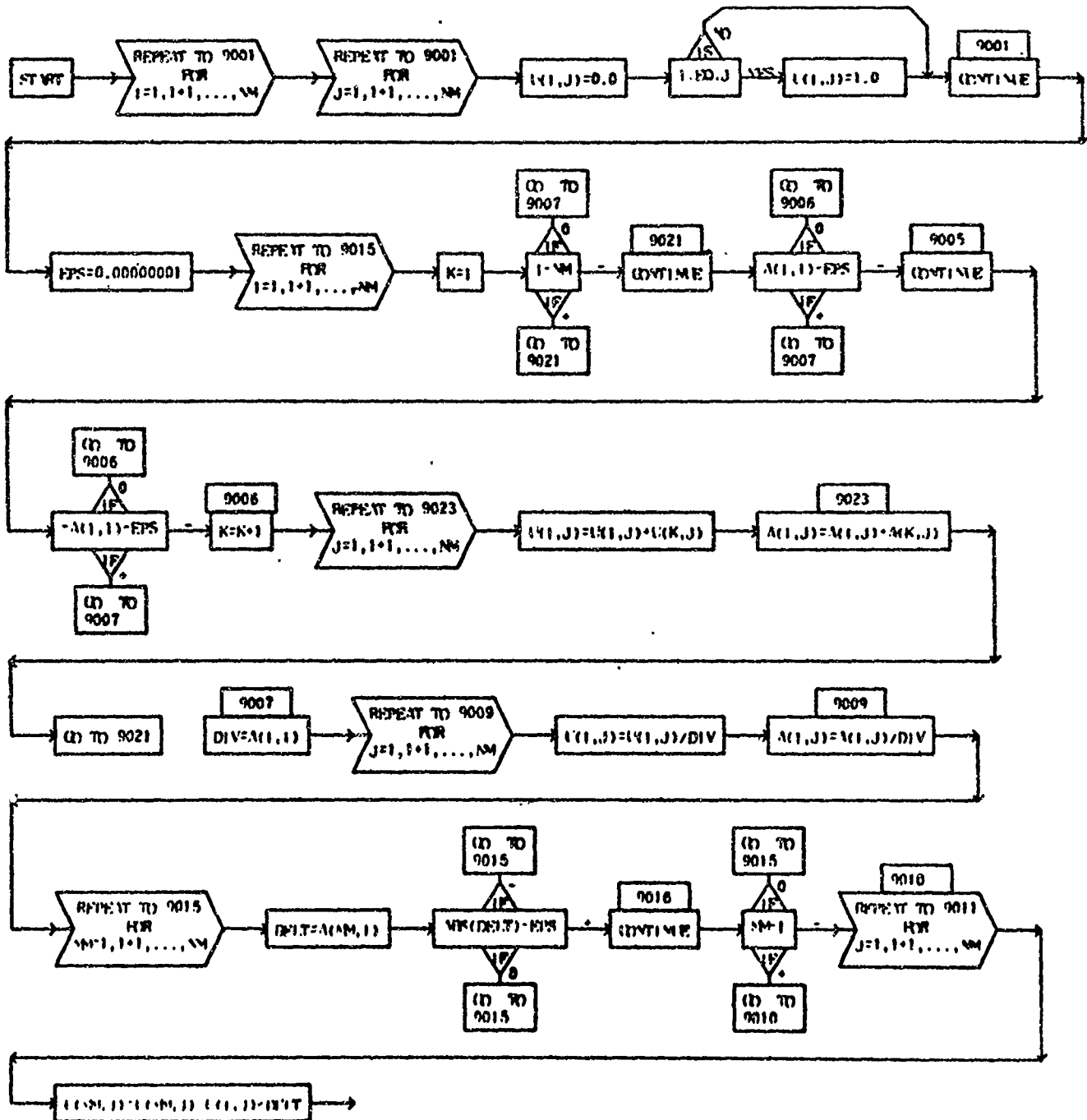
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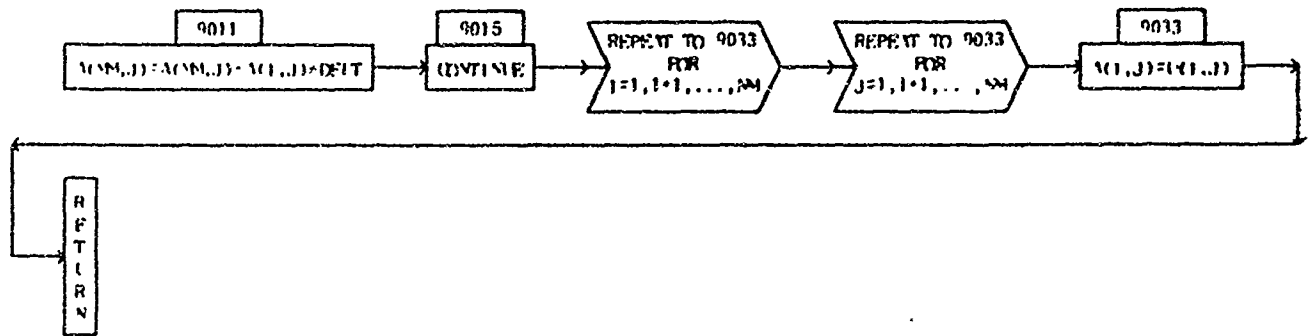
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13. ABSTRACT THIS STUDY COVERS THE DEVELOPMENT OF A SET OF COMPUTER PROGRAM TO PERFORM FLUTTER ANALYSIS BY THE COLLOCATION METHOD. WHILE THIS METHOD HAS BEEN KNOWN FOR SOME TIME, ONLY RECENTLY HAVE ADVANCES IN COMPUTER TECHNOLOGY MADE THE METHOD TECHNICALLY AND FINANCIALLY FEASIBLE. THE INGREDIENTS OF A COLLOCATION FLUTTER ANALYSIS ARE 1) A FLEXIBILITY MATRIX, 2) AERODYNAMIC INFLUENCE COEFFICIENT MATRIX, AND 3) AN EIGENVALUE SOLUTION. THIS STUDY IS PRESENTED IN FOUR VOLUMES. VOLUME I CONTAINS A GENERAL PROGRAM DISCUSSION. VOLUME II CONTAINS THE PROGRAM FINDER WHICH CALCULATES THE FLEXIBILITY MATRIX. VOLUME III CONTAINS A SET OF THREE PROGRAMS TO CALCULATE AERODYNAMIC INFLUENCE COEFFICIENTS FOR SUBSONIC, TRANSONIC, AND SUPERSONIC FLIGHT REGIMES. VOLUME IV CONTAINS THE PROGRAM CORA WHICH SETS UP AND SOLVES THE FLUTTER EIGENVALUE MATRIX.			

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