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A TECHNIQUE USING A NONLINEAR HELICOPTER MODEL FOR DETERMINING TRIMS AND DERIVATIVES

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SUMMARY

This paper describes a technique for determining the trims and quasi-static derivatives of a flight vehicle for use in a linear perturbation model; both the coupled and uncoupled forms of the linear perturbation model are included. Since this technique requires a nonlinear vehicle model, detailed equations with constants and nonlinear functions for the CH-47B tandem rotor helicopter are presented. Tables of trims and derivatives are included for airspeeds between -40 and 160 knots and rates of descent between ±10.16 m/sec (±2000 ft/min). As a verification, the calculated and referenced values of comparable trims, derivatives, and linear model poles are shown to have acceptable agreement.

INTRODUCTION

Avionics research for helicopters is in progress at the Langley Research Center as part of the VTOL approach and landing technology (VALT) program (ref. 1). An NASA/Army/Boeing Vertol CH-47B helicopter will be used as a tool to evaluate advanced research concepts relating to navigation, guidance, control, and displays. In order to assist this effort, a mathematical model of the CH-47B is required. Although a nonlinear model is available from the TAGS program (ref. 2), the complications become immense when the development of a feedback controller for the vehicle is considered a prime goal. Furthermore, the computational time during simulation can become significant, especially if the model contains a large number of nonlinear functions.

An alternate approach is to represent the vehicle by a linear perturbation model consisting of trims and stability and control derivatives. Since data for the complete CH-47 flight regime are unavailable in the literature, a method to calculate the trims and derivatives is needed. This report, therefore, describes a general procedure, using a nonlinear model, that automatically determines the trim conditions and the stability and control derivatives for any vehicle. The data generated in this paper are specifically for the CH-47B and are compared with existing data (ref. 3) where available.

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This report is divided into three main sections. The first section describes the approach for calculating the trims and the stability and control derivatives. An iterative solution to the six steady-state equations of motion is used to balance the forces and moments in a body-axis reference frame. Six trim variables are calculated for various flight regimes; these are the pitch and roll attitudes relative to a level-heading frame and the four control stick positions. Quasi-static derivatives (ref. 4) are determined by calculating the changes in the forces and moments due to a small perturbation in each of the state and control variables. The second section describes the twin-engine, tandem-rotor helicopter model used to calculate the forces and moments. This model is essentially the large maneuver model used in reference 2, with modifications to give a better representation of the CH-47B. The equations are divided into major modules representing specific areas or major functions. A brief description of each module is presented in this section and the actual equations are given in an appendix. Trims and derivatives obtained by the methods described in this paper are discussed in the third section and are compared with data from reference 3; this section includes plots of selected derivatives and trims for zero rate of climb and a velocity range of -40 to 160 knots. The data are presented generally in both SI Units and U.S. Customary Units. Calculations were made in U.S. Customary Units. Five appendixes include a discussion of the sign convention and major coordinate frames used (appendix A), equations for the helicopter nonlinear mathematical model (appendix B), constants for the CH-47B (appendix C), a linear perturbation model (appendix D), and a set of tables (appendix E) containing the trims and derivatives for velocities ranging from -40 to 160 knots and rates of descent over a range of ± 10.16 m/sec (± 2000 ft/min).

SYMBOLS

[A]	stability derivative matrix
[B]	control derivative matrix
[C]	gradient matrix of $\vec{Y}$ with respect to $\vec{\delta}_T$, θ, and ϕ
$\vec{C}_j$	jth column vector of [C]
C_T	rotor thrust coefficient
dF_{FR}	interference factor of front rotor on rear rotor (see eqs. (B38) and (B41))
dF_{RF}	interference factor of rear rotor on front rotor (see eqs. (B39) and (B40))

$\vec{F}_T,\vec{M}_T$	vector of total force on vehicle, N, and vector of total moments on vehicle, N-m (see fig. D1)
F_X,F_Y,F_Z	summation of thrust and aerodynamic forces along body x-axis, y-axis, and z-axis, respectively, N (see fig. A1)
g	acceleration due to gravity, m/sec^2
H_f,H_r	drag force of front or rear rotor perpendicular to shaft in downwind direction, N (see fig. A2)
h_f,h_r	distance from center of gravity of helicopter to front or rear rotor hub, measured parallel to helicopter z-axis, m (see fig. A2)
I_{XX},I_{YY},I_{ZZ}	helicopter moments of inertia about X-axis, Y-axis, and Z-axis, respectively, kg-m^2
I_{XZ}	helicopter product of inertia in XZ-plane, kg-m^2
i	angle of incidence of rotor shaft, rad (see fig. A2)
i,j	dummy variables for counting
L,M,N	total rolling, pitching, and yawing moments about center of gravity of helicopter, N-m (see fig. A1)
l_f,l_r	distance from center of gravity of helicopter to projection of front or rear rotor hub on x-axis, m (see fig. A2)
m	helicopter mass, kg
P,Q,R	vehicle angular velocity about body x-axis, y-axis, and z-axis, respectively, rad/sec (see fig. A1)
$[S]$	6×10 stability derivative matrix defined by equation (15)
$\vec{S}_j$	jth column vector of $[S]$
T_f,T_r	thrust force of front or rear rotor parallel to shaft, N (see fig. A2)

U,V,W	velocity of vehicle along body x-axis, y-axis, and z-axis, respectively, m/sec (see fig. A3)
$\vec{V}_B,\vec{V}_L$	vector of vehicle velocities expressed in a body frame or a local level frame, m/sec
V_∞	free-stream velocity, m/sec
X,Y,Z	orthogonal coordinate system with X-axis parallel to Earth in direction of forward flight, Z-axis down toward center of Earth, and Y-axis completing a right-hand coordinate frame (see fig. A1)
x,y,z	orthogonal body-axis coordinate system with x-axis toward front of vehicle, z-axis pointing downward, and y-axis completing a right-hand coordinate frame (see fig. A1)
x',y',z'	rotor-hub axes, parallel to body axes but centered at rotor hub (see fig. A2)
x_S,y_S,z_S	rotor-shaft axes, centered at rotor hub with z_S-axis down along rotor shaft, y_S-axis coincident with y'-axis, and x_S-axis forward to complete a right-hand frame (see fig. A2)
x_W,y_W,z_W	rotor wind axes, related to rotor-shaft axes by rotor angle of sideslip (see fig. A2 and eq. (A3))
$\dot{X}$	vehicle horizontal airspeed, knots (see figs. 9 to 15)
X,Y,Z	summation in equation (6) of aerodynamic, thrust, and gravitational forces along body x-axis, y-axis, and z-axis, respectively, N
X_{fus},Y_{fus},Z_{fus}	fuselage aerodynamic force along body x-axis, y-axis, and z-axis, respectively, N
$\vec{X}$	general state vector (see appendix D)
$\vec{X}_N$	nominal state vector
$\dot{\vec{X}}_N$	derivative of nominal state vector

$\vec{X}_P$	perturbation state vector
$\dot{\vec{X}}_P$	derivative of perturbation state vector
$\vec{X}_T$	total state vector of vehicle
$\dot{\vec{X}}_T$	derivative of total state vector
$\vec{Y}$	output vector from HELICOP defined by equation (6)
Y_f, Y_r	side force of front or rear rotor perpendicular to shaft and directed 90° from downwind in direction of rotor rotation, N (see fig. A2)
$\dot{Z}$	vehicle vertical velocity, positive down toward Earth center, m/sec
α_{fus}	fuselage angle of attack, deg (see fig. A3)
β_{fus}	fuselage angle of sideslip, deg (see fig. A3)
β'	sideslip angle of rotor, rad (see fig. A2)
$\vec{\delta}$	general control vector (see appendix D)
δ_j	jth component of $\vec{\delta}_T$
$\Delta\vec{p}$	perturbation vector
Δp_j	jth component of $\Delta\vec{p}$
$\Delta\vec{\delta}_T, \Delta\theta, \Delta\phi$	correction terms to $\vec{\delta}_T$, θ, and ϕ for trim calculations (see fig. 2)
$\Delta\vec{\xi}$	perturbation vector in $\vec{\xi}$ (see fig. 4)
$\delta_B, \delta_C, \delta_S, \delta_R$	longitudinal, collective, lateral, and directional controls, cm
$\vec{\delta}_N, \vec{\delta}_P, \vec{\delta}_T$	nominal, perturbation, and total control vectors, m (see fig. D1)

$\vec{\epsilon}$	convergence tolerance vector for trim calculations (see fig. 2)
θ	pitch attitude of vehicle, deg (see fig. A1)
λ	rotor inflow ratio
λ'	component of inflow ratio due to free-stream velocity
μ	rotor advance ratio
ν	variable step parameter (see eq. (8))
$\vec{\xi}$	10 × 1 parameter vector defined by equation (14)
ρ	air density, kg/m^3
ϕ	roll attitude angle of vehicle, deg
Ω	rotor rotational speed, rad/sec
$\vec{\Omega}_B$	vector of vehicle angular velocity expressed in a body frame, rad/sec

Subscripts:

f	front
r	rear
N	nominal
P	perturbation

Stability derivative notation:

$B_A = \left.\frac{\partial B}{\partial A}\right|_{trim}$ where B can be X, Y, Z, L, M, N and A can be U, V, W, P, Q, R, δ_B, δ_C, δ_S, δ_R

CALCULATION OF TRIMS AND STABILITY DERIVATIVES

Background

The motion of a vehicle can be described by the general nonlinear vector differential equation

$$\dot{\vec{X}}_T = f(\vec{X}_T, \vec{\delta}_T) \tag{1}$$

where $\vec{X}_T$ is the total state vector and $\vec{\delta}_T$ is the total control vector. The vehicle motion can also be represented as the sum of a nominal trim motion $(\vec{X}_N, \vec{\delta}_N)$ and a perturbation $(\vec{X}_P, \vec{\delta}_P)$ about the nominal. With this approach, both the state vector and control input vector are given by

$$\vec{X}_T = \vec{X}_N + \vec{X}_P \tag{2}$$

$$\vec{\delta}_T = \vec{\delta}_N + \vec{\delta}_P \tag{3}$$

The nominal trim variables $\vec{X}_N$ and $\vec{\delta}_N$ are then chosen to satisfy

$$\dot{\vec{X}}_N = f(\vec{X}_N, \vec{\delta}_N) = 0 \tag{4}$$

Expanding equation (1) about the nominal trim values and retaining only first-order terms in $\vec{X}_P$ and $\vec{\delta}_P$ gives the linear vector differential equation

$$\dot{\vec{X}}_P = [A]\vec{X}_P + [B]\vec{\delta}_P \tag{5}$$

Equation (5) is a good representation of the motion of the vehicle near the trim $\vec{X}_N$, $\vec{\delta}_N$, i.e., for small $\vec{X}_P$ and $\vec{\delta}_P$. The matrices [A] and [B] are the stability and control derivatives of the vehicle. For convenience, matrices [A] and [B] are referred to as the stability derivative matrix. A detailed representation of equation (5) is given in appendix D.

Trims

The calculation of static trim conditions and associated stability derivatives makes repeated use of a large maneuver model of the CH-47B. The nonlinear model, discussed in a later section, is referred to as HELICOP. As shown in figure 1, inputs to HELICOP include constants such as air density ρ, distances of rotor hubs from center of gravity

l_f, l_r, h_f, h_r, and mass m and variables such as vehicle velocity $\vec{V}_L$ expressed in a local level frame, vehicle angular velocity $\vec{\Omega}_B$ expressed in the body frame, roll angle ϕ, pitch angle θ, and four control stick deflections $\vec{\delta}_T$.

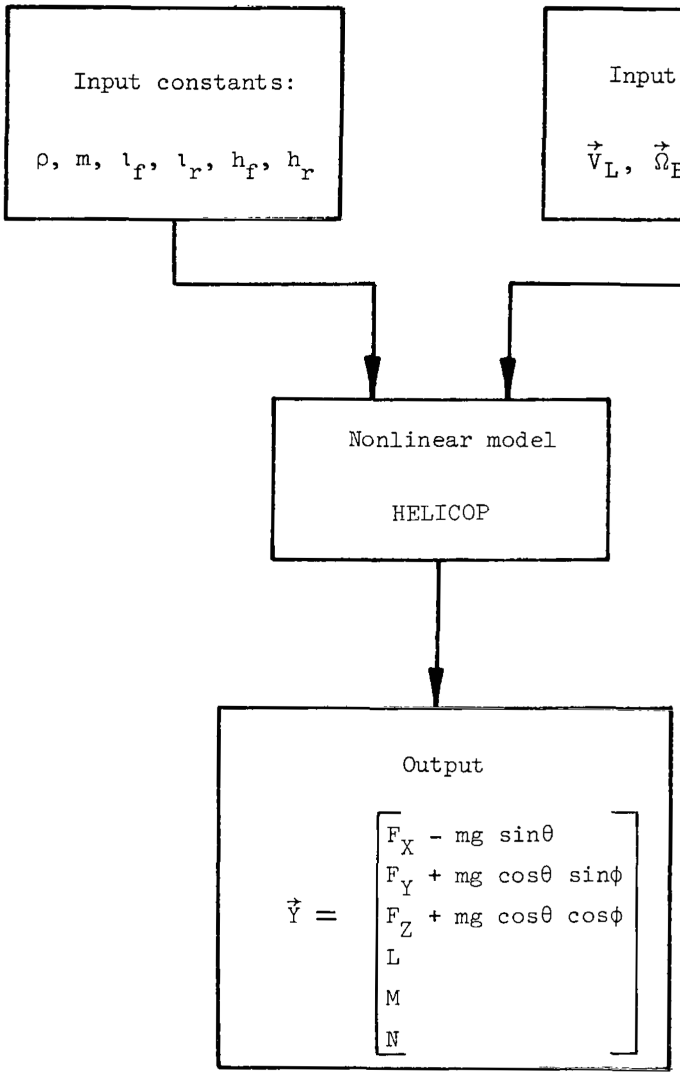


Figure 1.- Input-output definition for HELICOP.

The output from HELICOP is the 6 × 1 vector of forces and moments $\vec{Y}$. The first three components of $\vec{Y}$ (i.e., X, Y, Z) are the sum of the body-axes aerodynamic and thrust forces F_X, F_Y, F_Z and gravitational forces. The second three components of $\vec{Y}$ are the total moments L, M, N about the vehicle center of gravity expressed in body axes. Positive directions for the body-axes forces and moments are shown in appendix A, figure A1. The vector $\vec{Y}$ is given by

$$\vec{Y} = \begin{bmatrix} F_X - mg \sin\theta \\ F_Y + mg \cos\theta \sin\phi \\ F_Z + mg \cos\theta \cos\phi \\ L \\ M \\ N \end{bmatrix} = \begin{bmatrix} X \\ Y \\ Z \\ L \\ M \\ N \end{bmatrix} \tag{6}$$

where g is the acceleration due to gravity.

The trim condition implies a special set of the vehicle velocities, stick positions, and attitude angles that produce static equilibrium; i.e., the sum of the forces and moments equals zero $(\vec{Y} = 0)$. The trim conditions defined herein are calculated and tabulated for fixed values of ρ, m, l_f, l_r, h_f, h_r, and $\vec{\Omega}_B$ and discrete values of $\vec{V}_L$. For each $\vec{V}_L$, the program iterates on $\vec{\delta}_T$, θ, and ϕ.

As shown in figure 2, initial guesses are made for the stick positions $\vec{\delta}_T^{(0)}$ and attitudes $\theta^{(0)}$ and $\phi^{(0)}$. (The superscripts refer to the iteration number.) If $\vec{Y}^{(i)}$ is not within a predetermined convergence tolerance $\vec{\epsilon}$, then $\vec{\delta}_T$, θ, and ϕ are updated by increments $\Delta\vec{\delta}_T$, $\Delta\theta$, and $\Delta\phi$. These updates are calculated using the negative of the gradient of $\vec{Y}$ with respect to $\vec{\delta}_T$, θ, and ϕ (ref. 5). The approach for calculating the gradient matrix $[C]$ is described later in this section. A gradient step that would reduce $\vec{Y}^{(i)}$ to zero if the relation were linear is

$$\begin{bmatrix} \Delta\vec{\delta}_T \\ \Delta\theta \\ \Delta\phi \end{bmatrix} = -\left[C^{(i)}\right]^{-1} \vec{Y}^{(i)} \tag{7}$$

Since $\vec{Y}$ is a nonlinear function of $\vec{\delta}_T$, θ, and ϕ, the step given by equation (7) may be too large (linearity could be violated); consequently, a parameter ν is introduced so that the size of the gradient steps can be reduced to:

$$\begin{bmatrix} \Delta\vec{\delta}_T \\ \Delta\theta \\ \Delta\phi \end{bmatrix} = -\nu\left[C^{(i)}\right]^{-1} \vec{Y}^{(i)} \tag{8}$$

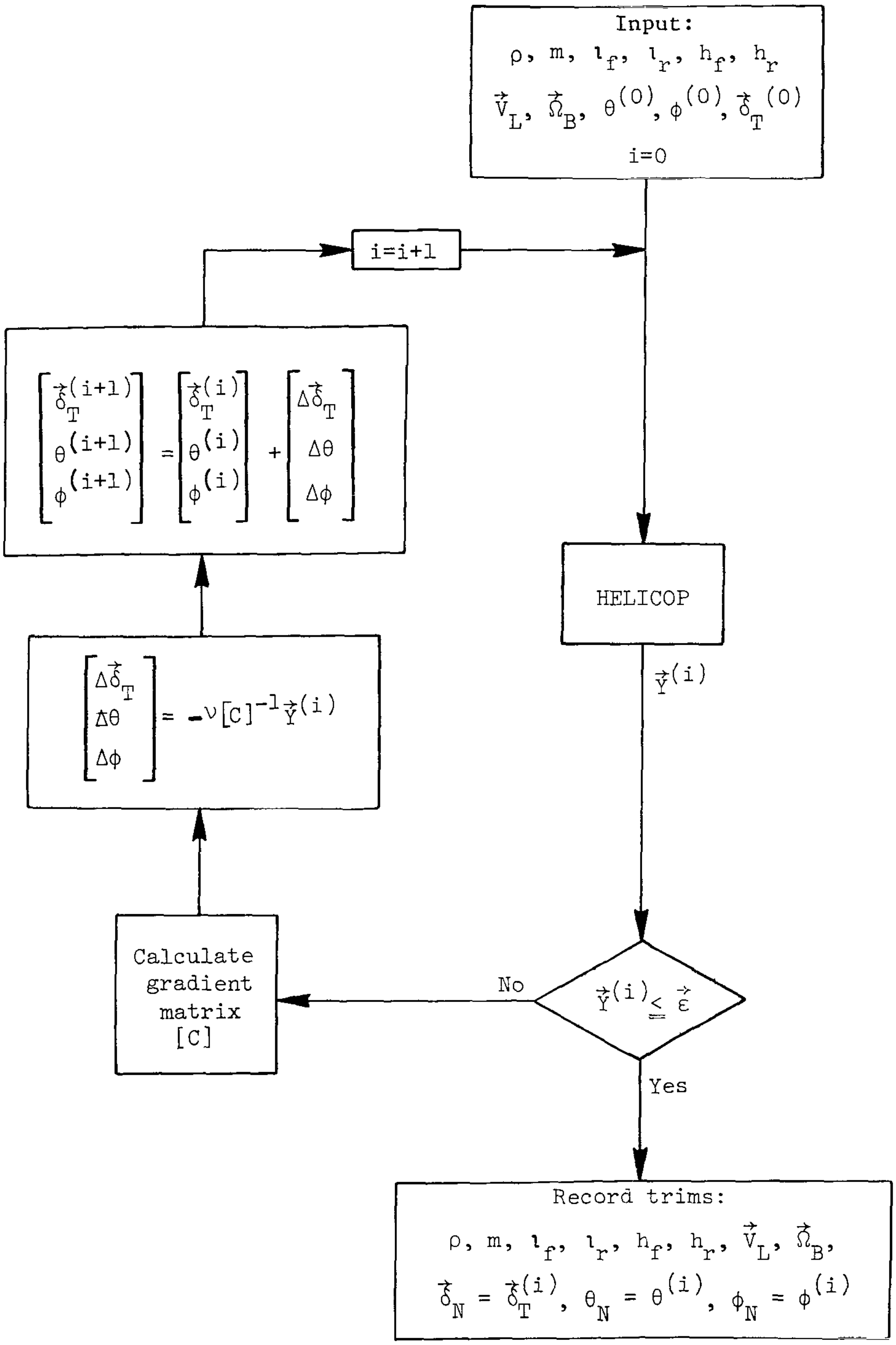


Figure 2.- Flow chart for trim calculations.

where $0 \leqq \nu \leqq 1$. A value of 0.1 for ν was found to give rapid convergence for all trim cases. The control sticks and attitude angles are updated by

$$\begin{bmatrix} \vec{\delta}_T^{(i+1)} \\ \theta^{(i+1)} \\ \phi^{(i+1)} \end{bmatrix} = \begin{bmatrix} \vec{\delta}_T^{(i)} \\ \theta^{(i)} \\ \phi^{(i)} \end{bmatrix} - \nu \left[C^{(i)}\right]^{-1} \vec{Y}^{(i)} \tag{9}$$

This process is iterated until all components of $\vec{Y}$ are sufficiently close to zero. Convergence tolerances of 0.04448 N (0.01 lb) for the force components and 0.00136 N-m (0.001 ft-lb) for the moment components were used. When convergence is reached, the trim condition defined by the constants $\vec{V}_L$, $\vec{\Omega}_B$, m, ρ, l_f, l_r, h_f, h_r, and the final values of the variables $\vec{\delta}_T$, θ, and ϕ is recorded. The trim values of $\vec{\delta}_T$, θ, and ϕ are designated $\vec{\delta}_N$, θ_N, and ϕ_N.

A flow chart illustrating the technique for calculating the gradient matrix [C] is shown in figure 3. Inputs include the final updated values $\vec{\delta}_T^{(i)}$, $\theta^{(i)}$, $\phi^{(i)}$, and $\vec{Y}^{(i)}$ and a control-stick perturbation vector $\Delta\vec{p}$. Also required are the other basic inputs to HELICOP $(\rho,\ m,\ l_f,\ l_r,\ h_f,\ h_r,\ \vec{V}_L,$ and $\vec{\Omega}_B)$. The approach is to estimate the first four columns of [C], relating to the four control channels, by using a perturbation approximation to the derivative and to estimate the last two columns, relating to the attitudes θ and ϕ, by using an analytic expression for the derivative. A new set of forces and moments $\vec{Y}_j$ are generated by separately applying a perturbation to each of the four control channels. Each of the first four columns of [C] are then approximated by calculating the change in $\vec{Y}$ due to the perturbation in control stick $\Delta\vec{p}_j$, as shown in

$$\frac{\partial \vec{Y}}{\partial \delta_j} \approx \frac{\vec{Y}^{(i)} - \vec{Y}_j}{\Delta \vec{p}_j} = \vec{C}_j \qquad (j = 1, \ldots, 4) \tag{10}$$

As an approximation to save computer time, the gradient of $\vec{Y}$ with respect to the attitude angles θ and ϕ is generated by performing the partial derivative operations on equation (6) and by assuming that F_X, F_Y, F_Z, L, M, and N are not functions of θ and ϕ. The last two columns of [C] are given by

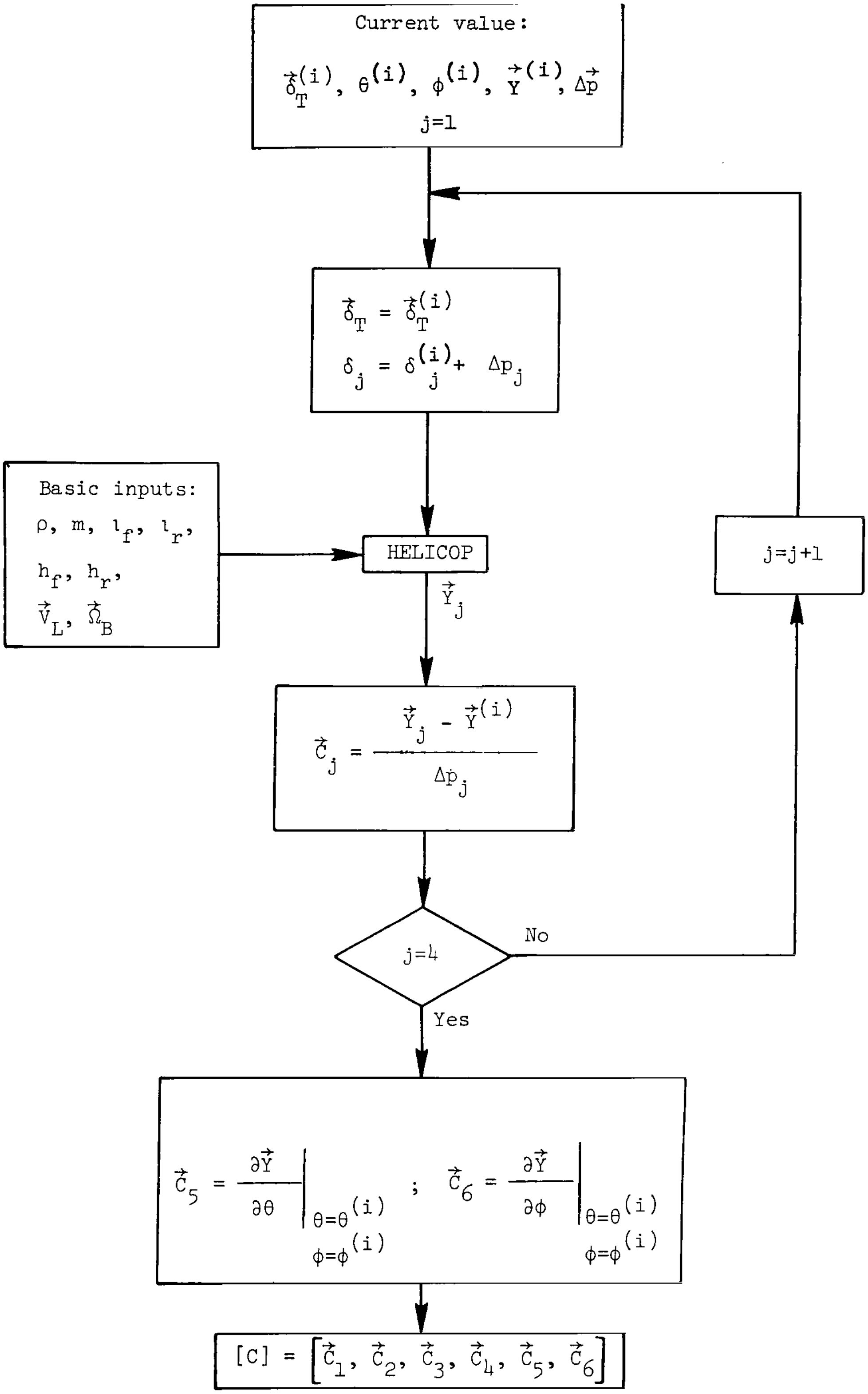


Figure 3.- Flow chart for calculation of gradient matrix [C].

$$\frac{\partial \vec{Y}}{\partial \theta} = \begin{bmatrix} -mg \cos \theta \\ -mg \sin \theta \sin \phi \\ -mg \sin \theta \cos \phi \\ 0 \\ 0 \\ 0 \end{bmatrix} \tag{11}$$

$$\frac{\partial \vec{Y}}{\partial \phi} = \begin{bmatrix} 0 \\ mg \cos \theta \cos \phi \\ -mg \cos \theta \sin \phi \\ 0 \\ 0 \\ 0 \end{bmatrix} \tag{12}$$

The fifth and sixth columns of [C] are then $\partial\vec{Y}/\partial\theta$ and $\partial\vec{Y}/\partial\phi$ evaluated at $\theta = \theta^{(i)}$ and $\phi = \phi^{(i)}$, i.e., the present estimates of the trim attitude angles.

The gradient matrix [C] is

$$\left[C^{(i)}\right] = \left[\vec{C}_1 \quad \vec{C}_2 \quad \vec{C}_3 \quad \vec{C}_4 \quad \frac{\partial \vec{Y}}{\partial \theta} \quad \frac{\partial \vec{Y}}{\partial \phi}\right]_{\substack{\theta=\theta^{(i)} \\ \phi=\phi^{(i)}}} \tag{13}$$

Stability Derivatives

The stability derivatives are used to approximate the behavior of the vehicle about a trim condition when subjected to small perturbations in $\vec{V}_B$, $\vec{\Omega}_B$, and $\vec{\delta}_T$. For convenience, define the 10 × 1 parameter vector $\vec{\xi}$ as

$$\vec{\xi} = \begin{bmatrix} \vec{V}_B \\ \vec{\Omega}_B \\ \vec{\delta}_T \end{bmatrix} \tag{14}$$

The 6 × 10 stability derivative matrix [S] is defined as the gradient of $\vec{Y}$ with respect to $\vec{\xi}$, evaluated at trim conditions, as shown in the following equation:

$$[S] = \left[\frac{\partial \vec{Y}}{\partial \vec{\xi}}\right]_{\substack{\vec{X}_T = \vec{X}_N \\ \vec{\delta}_T = \vec{\delta}_N}} \tag{15}$$

The stability derivatives, shown in figure 4, are calculated by changing one component of the parameter vector $\vec{\xi}_j$ by a small amount $\left(\Delta\vec{\xi}_j\right)$ and by leaving all other components at their trim values. (The subscript j refers to the element in $\vec{\xi}$.) This new set of inputs is then put into HELICOP, resulting in a changed output $\vec{Y}$. In order to get a reasonably good fit, both a positive and a negative perturbation are used to produce $\vec{Y}^{(1)}$ and $\vec{Y}^{(2)}$, respectively. The jth column of [S] is then approximated as

$$\vec{S}_j = \frac{\vec{Y}^{(1)} - \vec{Y}^{(2)}}{2\,\Delta\vec{\xi}_j} \tag{16}$$

The size of $\Delta\vec{\xi}_j$ was kept small to get a good approximation; 1 percent of the typical range of that variable was used. The perturbations are tabulated as follows:

ΔU, m/sec	0.792
ΔV, m/sec	0.152
ΔW, m/sec	0.152
ΔP, rad/sec	0.005
ΔQ, rad/sec	0.005
ΔR, rad/sec	0.005
$\Delta\delta_B$, cm	0.330
$\Delta\delta_C$, cm	0.229
$\Delta\delta_S$, cm	0.216
$\Delta\delta_R$, cm	0.190

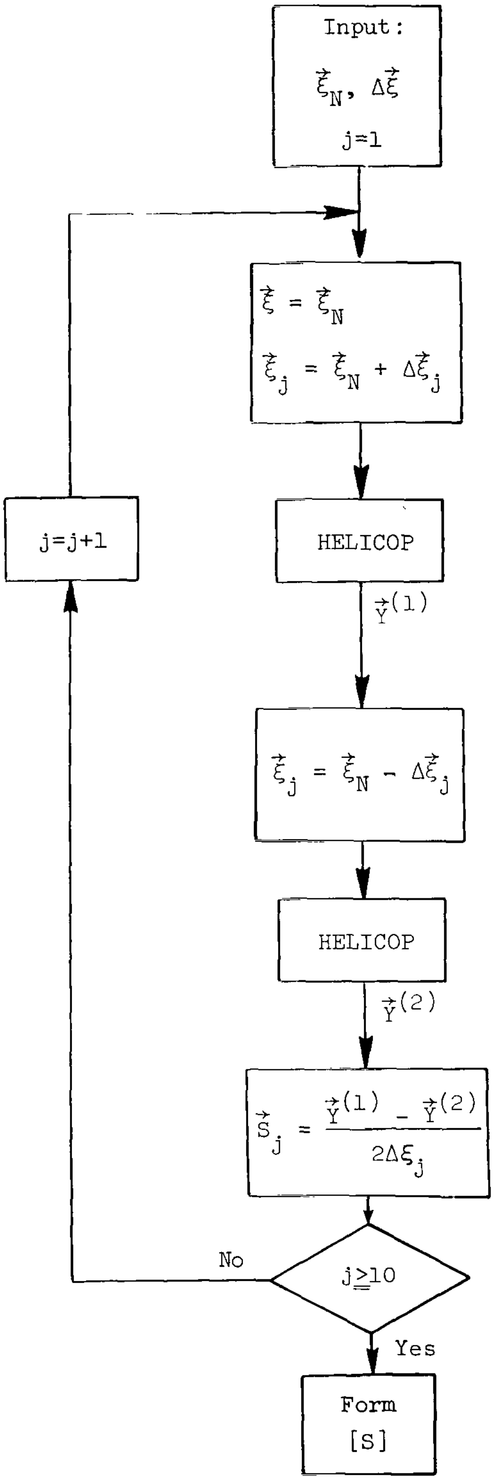


Figure 4.- Flow chart for stability derivatives.

HELICOPTER NONLINEAR MODEL

The CH-47 (Chinook) is a twin-engine tandem rotor helicopter (see fig. 5 taken from ref. 6) designed for all-weather, medium-sized transport type operations. The three bladed rotors are driven in opposite directions through interconnecting shafts which enable both rotors to be driven by either engine. The rotor heads are fully articulated, with pitch, flapping, and drag hinges.

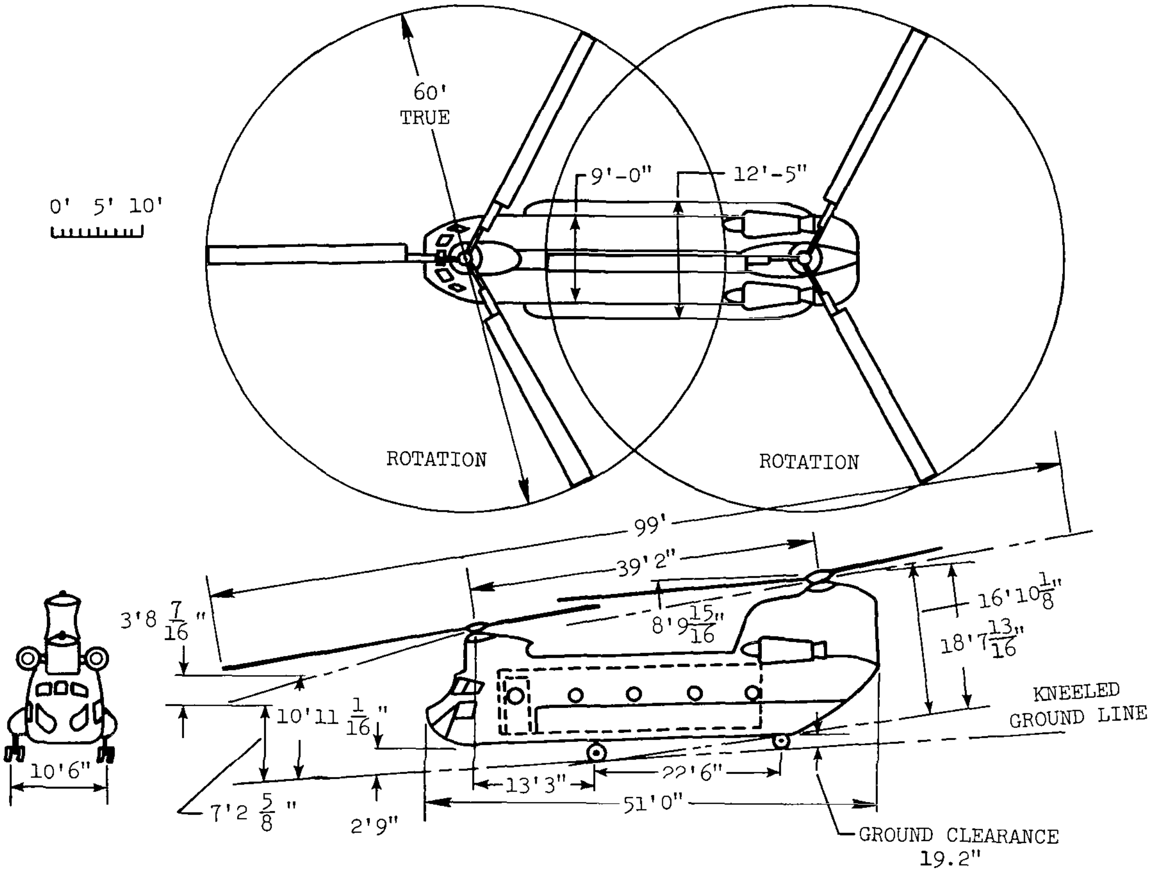


Figure 5.- Three-view drawing of the CH-47C helicopter taken from reference 6 (1 ft = 0.3048 m; 1 in. = 0.0254 m).

The equations describing the helicopter are taken from reference 2, with a few modifications to give a better representation of the CH-47B, and are shown in appendix B for completeness. Only steady-state equations are included since the desired purpose of this research is to calculate trims and quasi-static derivatives. The only two areas affected by this approach are control mixing and rotor inflow ratio. Since the helicopter model (HELICOP) has been developed in modular form for computer programing, the transient response dynamics can be easily added if desired.

A flow chart for HELICOP is shown in figure 6. Each box represents a major module that is described in the following sections in the order shown on the flow chart.

Although HELICOP has been specialized for the CH-47B, only minor variations would be required to represent other tandem rotor helicopters.

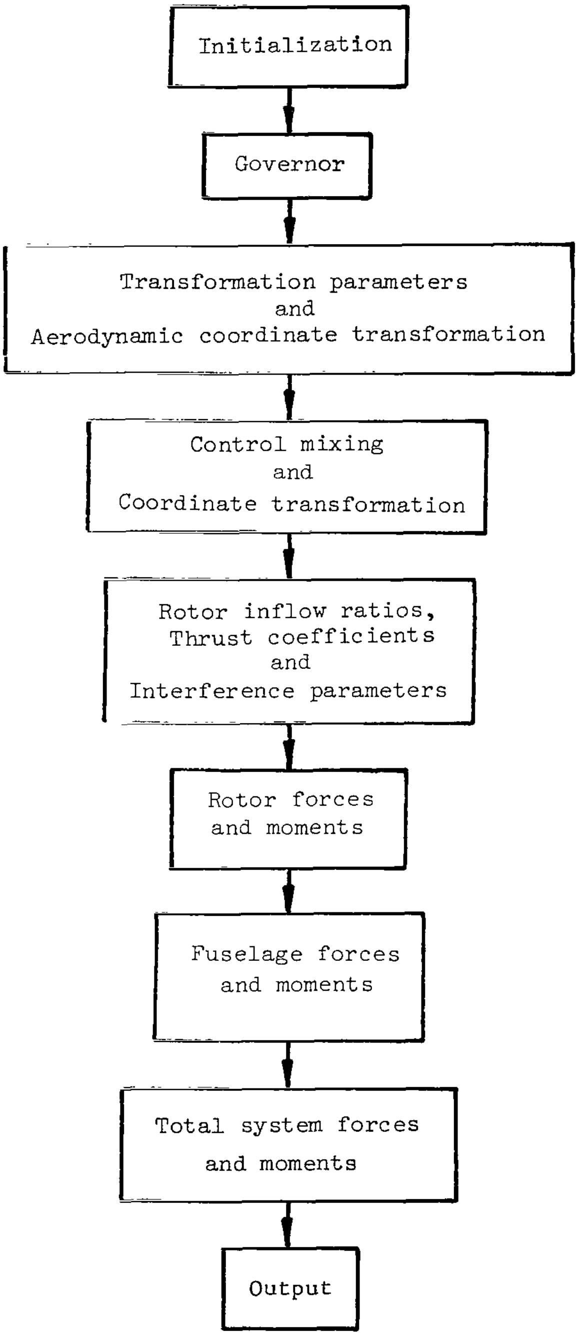


Figure 6.- Flow chart for HELICOP.

Governor

For the purpose of this program, the rotor rotational speed Ω is a constant. The model can be expanded in the future to include engine dynamics and to investigate the sensitivity of the trims and derivatives to changes in angular velocity.

Transformation Parameters and Aerodynamic Input

Coordinate Transformation

The linear velocities of each rotor referenced to their respective shaft incidence angles and the angular velocities referenced to the rotor wind axes are calculated (see appendix B, eqs. (B2) to (B9) for the front rotor and eqs. (B12) to (B19) for the rear rotor). The relationship of the rotor wind axes to the body axes is shown in figure A2 of appendix A. Normalizing the horizontal and vertical velocities of each rotor by the rotor tip speed allows calculation of the rotor advance ratio μ and the component of inflow ratio due to free-stream velocity λ' (eqs. (B10), (B11), (B20), and (B21)).

Control Mixing and Coordinate Transformation

Equations for first and second stage mixing are combined and shown in simplified form (eqs. (B22), (B23), (B25), and (B26)). This simplification is possible since only quasi-static derivatives are desired. For each trim condition, the final stick trim positions were checked to verify that physical limits are not exceeded.

The CH-47B and CH-47C models have actuators at both front and rear rotors to automatically introduce forward longitudinal cyclic pitch as a function of airspeed. These trim schedules (fig. B1) affect the trim values at higher airspeeds. Finally, the lateral and longitudinal cyclic pitch angles are transformed from the body axis coordinate frame to the rotor wind axis frame (eqs. (B24) and (B27)).

Rotor Inflow Ratios, Thrust Coefficients, and Interference Parameters

There are four nonlinear equations that contain terms for the rotor inflow ratios λ_f, λ_r and the thrust coefficients $C_{T,f}$, $C_{T,r}$. The problem is to find values that satisfy all equations. The approach used is to initially guess at two of the variables and then iterate until all four variables converge within a predefined tolerance. Figure 7 is a flow chart showing the major steps in calculating the four variables. Since trims are being calculated for flight conditions which differ by small steps in velocity, the past values of λ_f and λ_r are used as the initial guess for the new flight condition. By means of equations (B28) to (B35) and the initial guess, $C_{T,f}$ and $C_{T,r}$ are then calculated. A nonlinear function simulating rotor lift stall is included in the thrust coefficient calculations and is shown in figure B2.

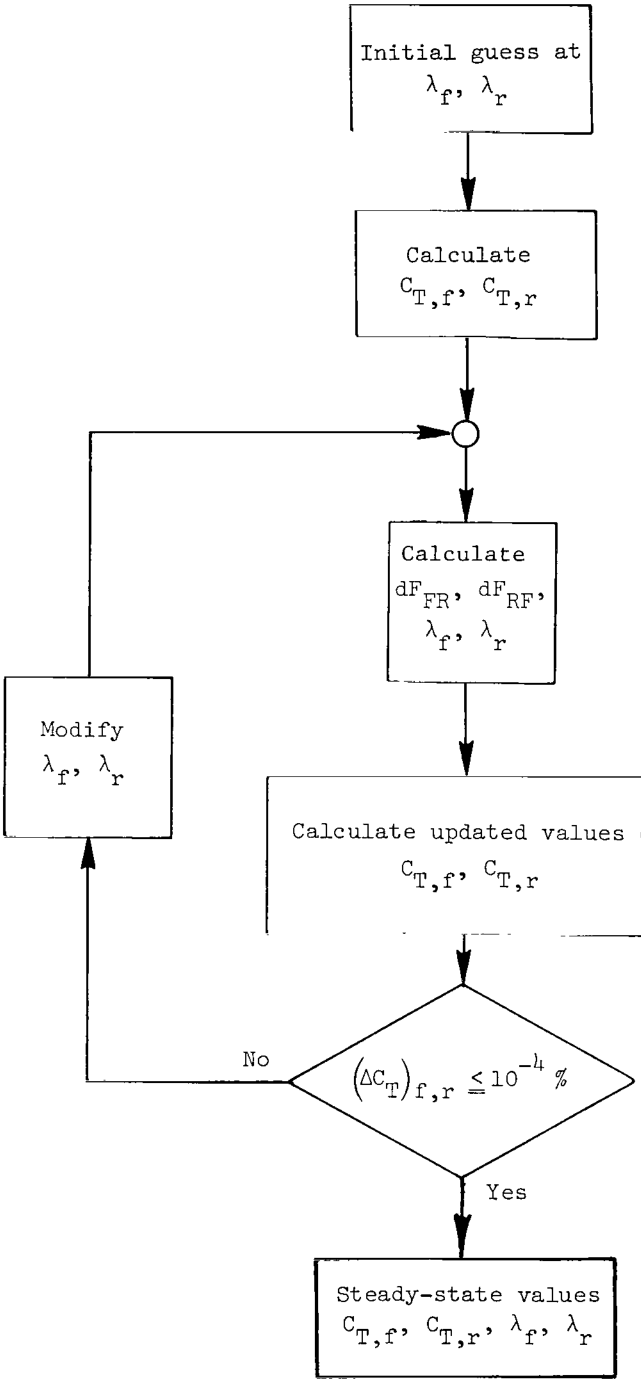


Figure 7.- Convergence loop for calculating rotor inflow ratios and thrust coefficients.

Interference parameters dF_{FR}, dF_{RF} between the two rotors are functions of the inflow ratio, advance ratio, and rotor sideslip angle (eqs. (B36) to (B41)). For backward flight, the interference parameters are interchanged; i.e., equations (B40) and (B41) are used in place of equations (B38) and (B39). New values for λ_f and λ_r are then calculated (eqs. (B41) and (B43)) by using the values obtained for the thrust coefficients, interference parameters, and components of inflow ratio due to the free-stream velocity.

The new values of λ_f and λ_r are then used to calculate new values for $C_{T,f}$ and $C_{T,r}$, as described previously. If $C_{T,f}$ and $C_{T,r}$ agree with the previous values within 0.0001 percent, the iteration is assumed complete. If the convergence tolerance is not met, λ_f and λ_r are modified by adding a fraction of the difference between the old and new inflow ratios to the previous values. The process is then repeated for another iteration. A number that works reasonably well for this fraction is 0.25.

Rotor Forces and Moments

Inputs to this module include rotor inflow and advance ratios, longitudinal and lateral cyclic pitch angles, collective pitch angles, blade twist, rotor angular velocities, and rotor parameters. These inputs are used to calculate thrust, coning angle, longitudinal and lateral flapping angles, horizontal and side forces, required torque, and both pitching and rolling hub moments. A correction factor to simulate stall at high airspeed is included by increasing the average rotor drag coefficient (δ_{FH} and δ_{RH} of appendix B). The force and moment calculations for the front and rear rotors are shown in equations (B44) to (B74).

Assumptions used in development of these equations include: (1) constant induced velocity through the rotor disk, (2) small flapping angle and inflow angle of attack, (3) negligible second and higher order harmonics for flapping, (4) negligible effect of the reverse flow region, and (5) infinitely rigid blades in all directions. The air density is assumed constant in all of these calculations. Provisions can be made to change air density as a function of altitude.

Fuselage Forces and Moments

Equations (B75) to (B90) show the approach for calculating the fuselage parasitic drag forces and moments. Analytical expressions relating the fuselage forces and moments to angle of attack α_{fus} and sideslip angle β_{fus} are taken from reference 2. Figure A3 of appendix A illustrates the sign convention for α_{fus} and β_{fus}. A different approach was used to calculate the fuselage aerodynamic force along the body x-axis X_{fus} since a numerical value for the flat-plate drag area was not available. A figure plotting the quotient of the drag to dynamic pressure as a function of α_{fus} and β_{fus}

can be found in reference 3 and is shown in figure B3. Interpolation is then used to obtain the flat-plate drag area.

Total System Forces and Moments

Equations (B91) to (B96) show the summation of the total aerodynamic forces and moments acting on the helicopter. The rotor forces and moments are transformed from the rotor wind axes to the aircraft body axes and are then summed with the fuselage forces and moments. The rotor forces also contribute aerodynamic moments about the helicopter center of gravity. As shown in figure A2, the positive directions for the front and rear rotor side forces are opposite each other.

RESULTS AND DISCUSSION

Using the techniques and the nonlinear model (HELICOP) described earlier, a set of trims and stability derivatives for the entire flight envelope was generated for the CH-47B. These data are presented in appendix E and are sufficient to allow the CH-47B to be represented by either the linear coupled model or the linear uncoupled model discussed in appendix D.

A major factor that impacts the validity of these trims and derivatives is the completeness of HELICOP. In order to establish confidence in HELICOP, a comparison is made with referenced data. The most complete set of data available in the literature is for level flight ($\dot{Z} = 0$) at horizontal velocities of $\dot{X} = 0$, 40, 80, 120, 140, and 160 knots (ref. 3). These data include 2 angle trims, 4 control-stick trims, and 30 stability derivatives required in the uncoupled linear model. Since both the nonlinear model and the technique used to generate the referenced data are not documented, the cause of any difference between referenced and calculated data cannot always be determined. As shown in figure 8, the linear-model analysis consists of comparing the calculated and referenced values of trims, stability derivatives, and poles of the linear model.

The calculated and referenced values of the stick and attitude trims are shown in figure 9. Additional calculated values are included to better define the shape of the trims. Both the shapes and magnitudes of the two sets of trim data agree very closely for all compared velocities. The maximum error in θ_N is at 80 knots and is less than 0.7°; the maximum error in ϕ_N is less than 0.4° at 160 knots. The stick trims show excellent agreement with a slight divergence between the calculated and referenced values in high-speed flight. The maximum errors occur at 160 knots and are 1.09 cm (0.43 in.) for $\delta_{B,N}$, 1.01 cm (0.4 in.) for $\delta_{C,N}$, 0.23 cm (0.09 in.) for $\delta_{S,N}$, and 0.94 cm (0.37 in.) for $\delta_{R,N}$.

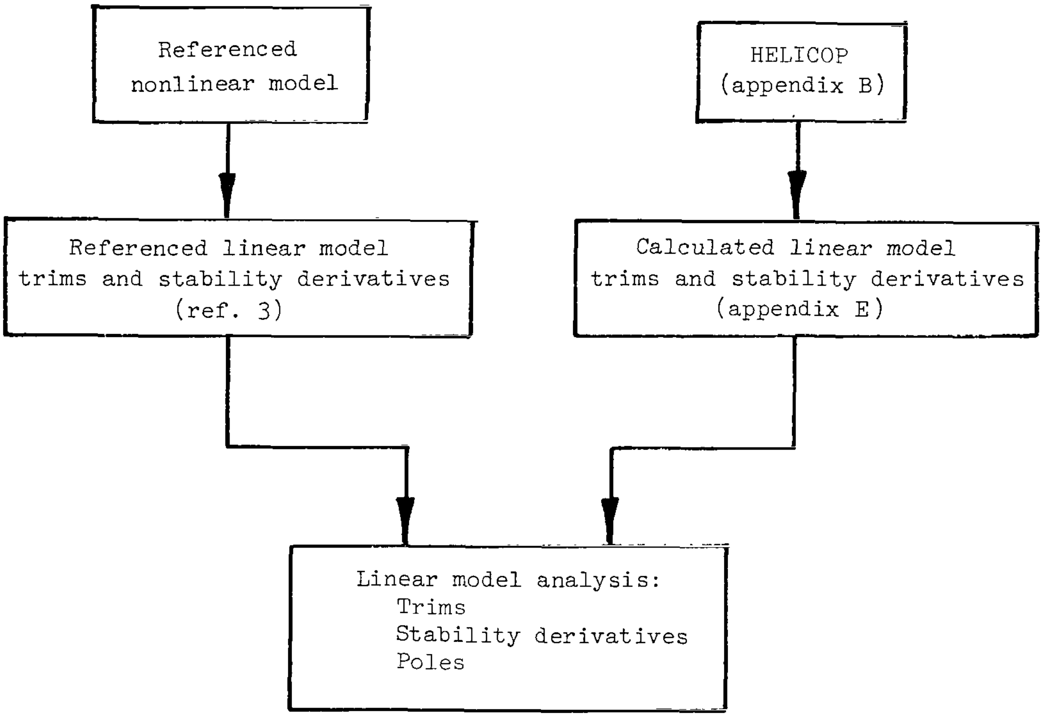


Figure 8.- Model verification.

Plots of the referenced and calculated stability derivatives are presented in figures 10 to 15. Approximately two-thirds of the 30 stability derivatives show excellent agreement for all velocities. The remainder of the derivatives have some differences in magnitude, although the shapes generally agree quite well. An exception occurs at hover ($\dot{X} = 0$). For this velocity the calculated values of several derivatives, e.g., Y_V and N_V, were found to be larger in order of magnitude than the referenced values. This would imply a radical change in the behavior of the vehicle in the vicinity of hover. Such behavior is not observed in the actual vehicle; it is concluded therefore that HELICOP and the calculated derivatives do not adequately describe the CH-47B at $\dot{X} = 0$. The nonlinear model representation (HELICOP) at hover is the suspected source of this anomaly. So as to generate reasonable values of calculated derivatives at $\dot{X} = 0$, a third-order curve was fitted through the calculated values at $\dot{X} = -40$, -20, 20, and 40 knots. This function was evaluated at $\dot{X} = 0$ to generate the values shown in figures 10 to 15 and in the tables of appendix E.

Approximately one-third of the stability derivatives exhibit some differences in magnitude between the two sets of data. A comparison of the linear-model poles for both referenced and calculated data (table I) shows the stability-derivative magnitude differences to be acceptable. Zeros of the models have also been calculated but are not included in table I since there is no simple and meaningful criterion for evaluating the effects of the zeros in a multi-input multi-output system.

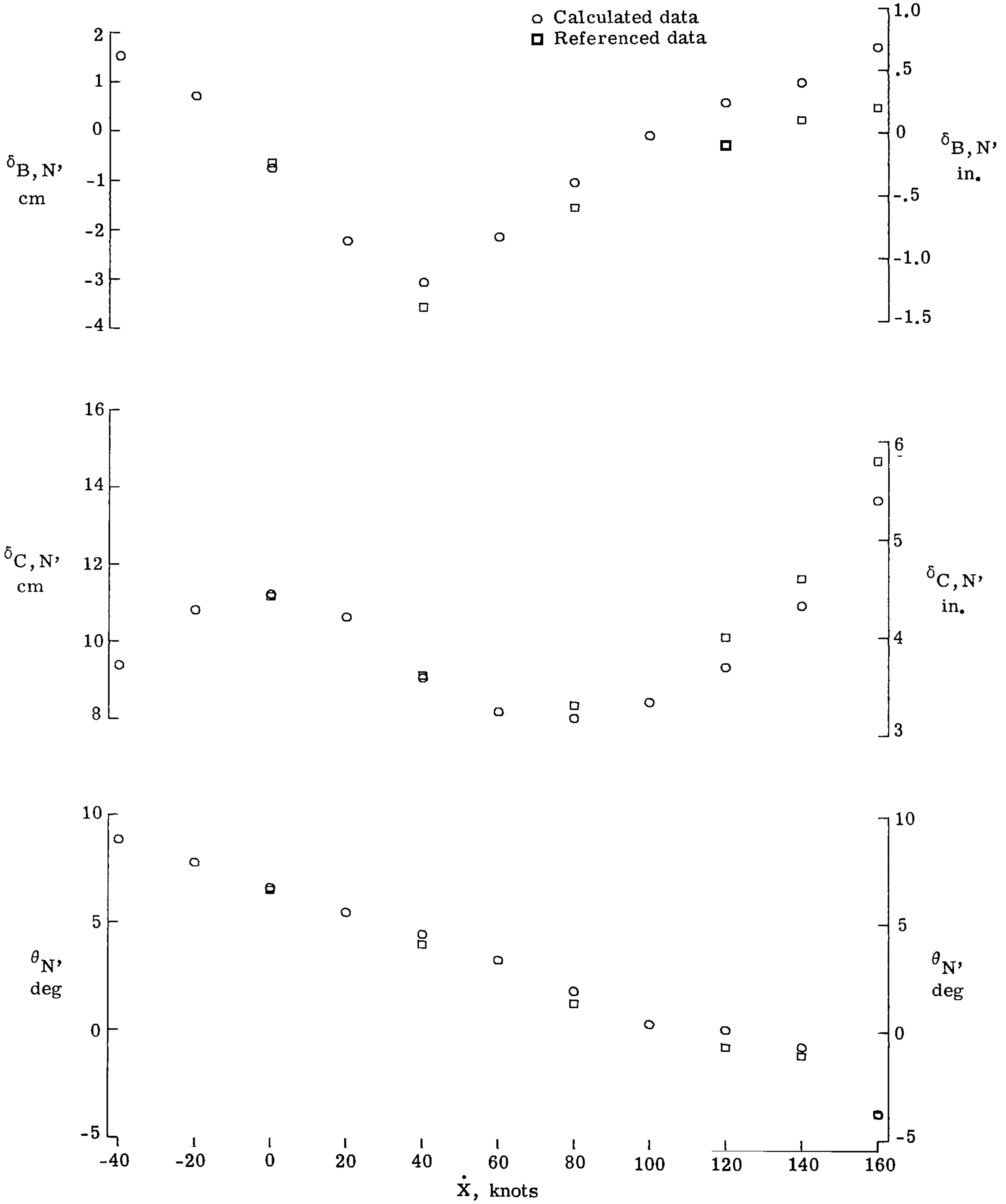


Figure 9.- Control-stick and attitude-angle trims of vehicle.

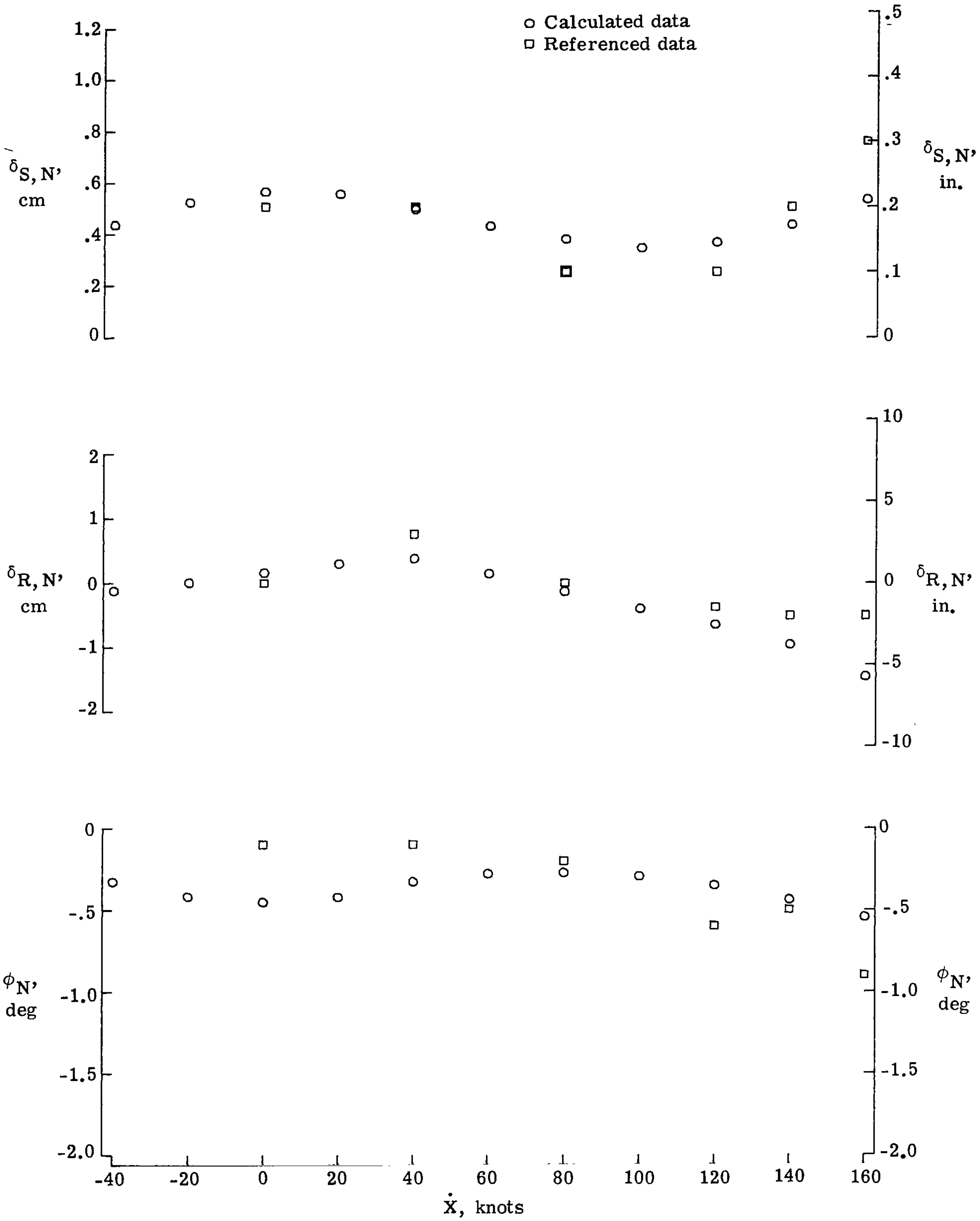


Figure 9.- Concluded.

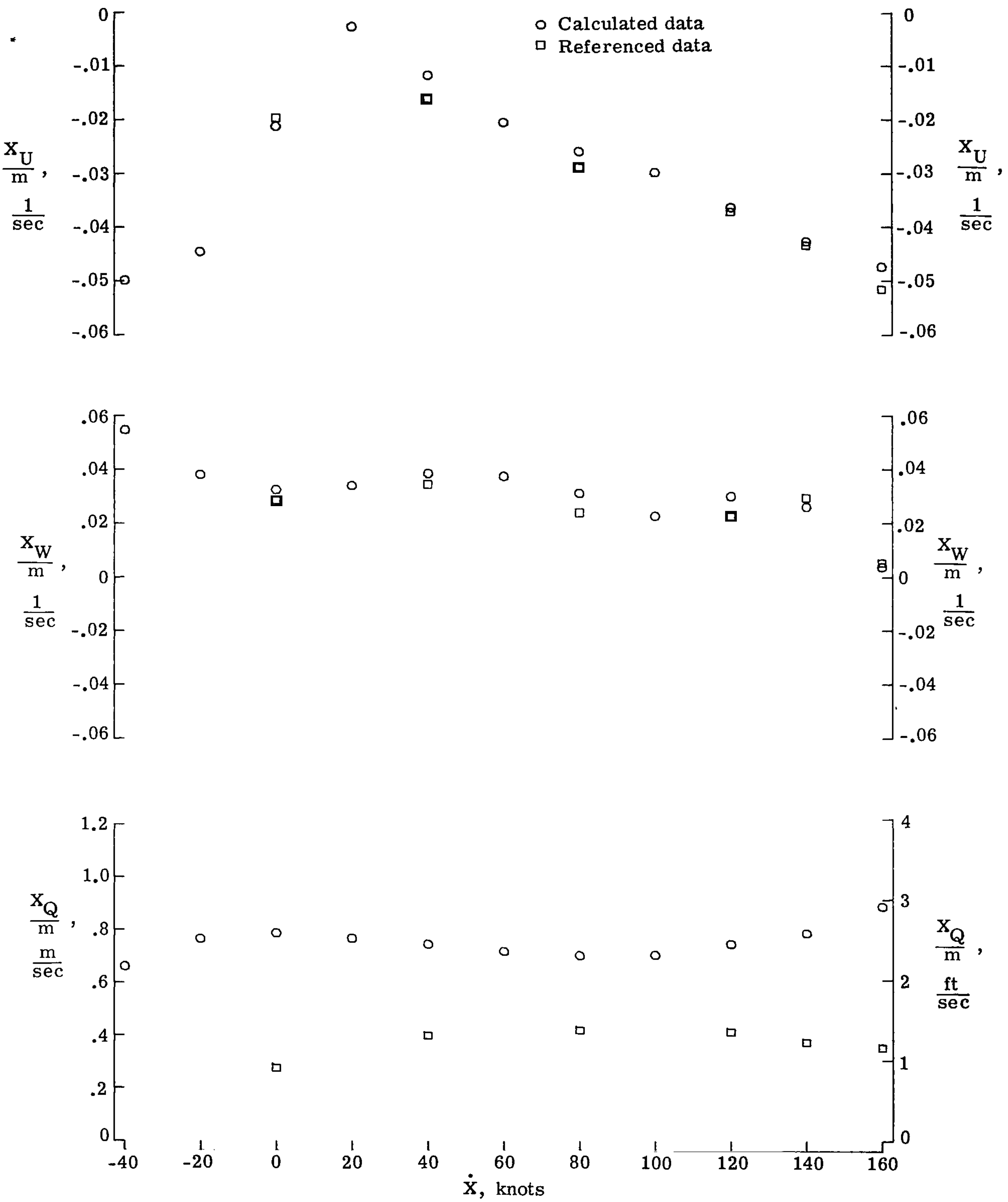


Figure 10.- Longitudinal-force stability and control derivatives.

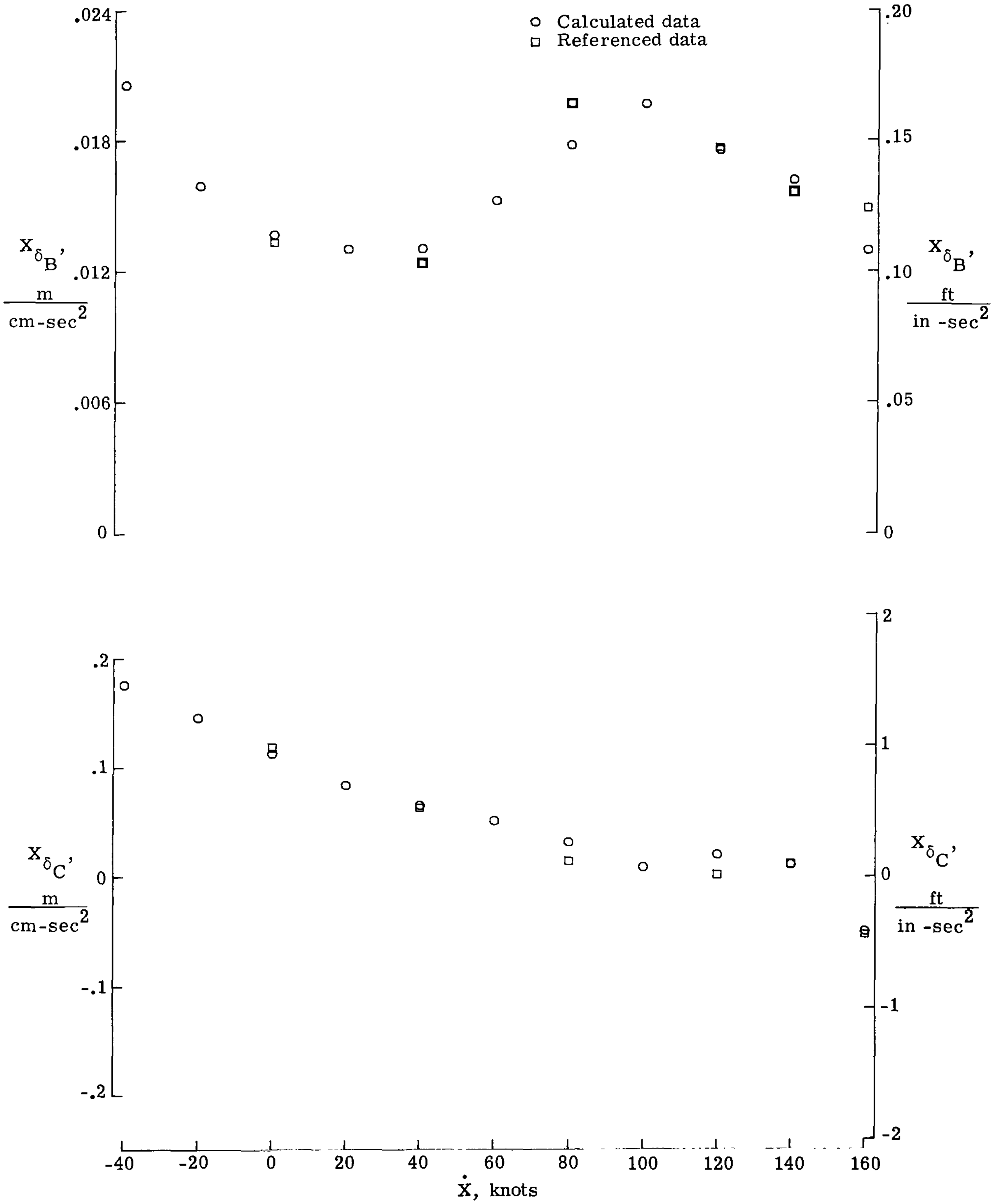


Figure 10.- Concluded.

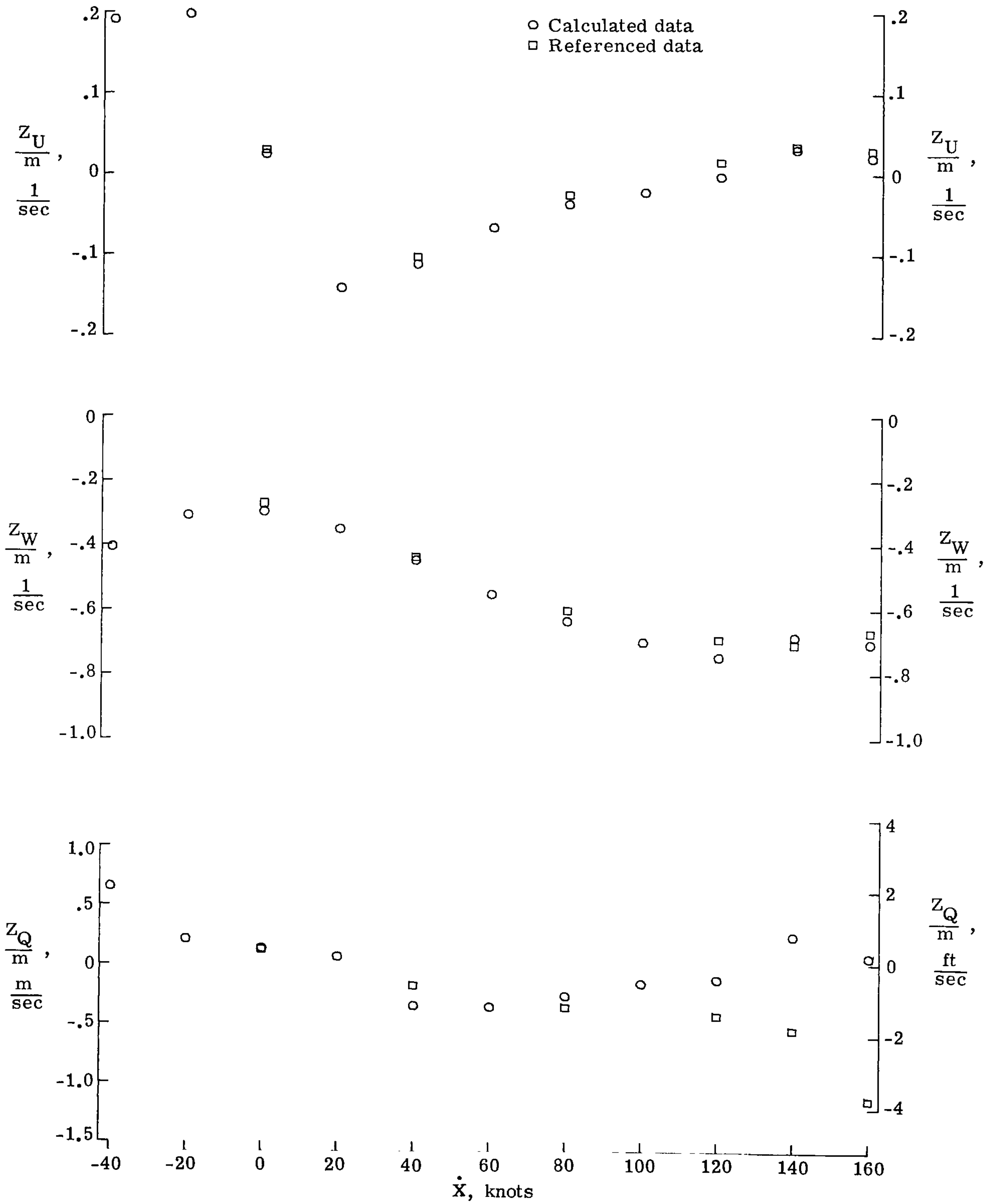


Figure 11.- Normal-force stability and control derivatives.

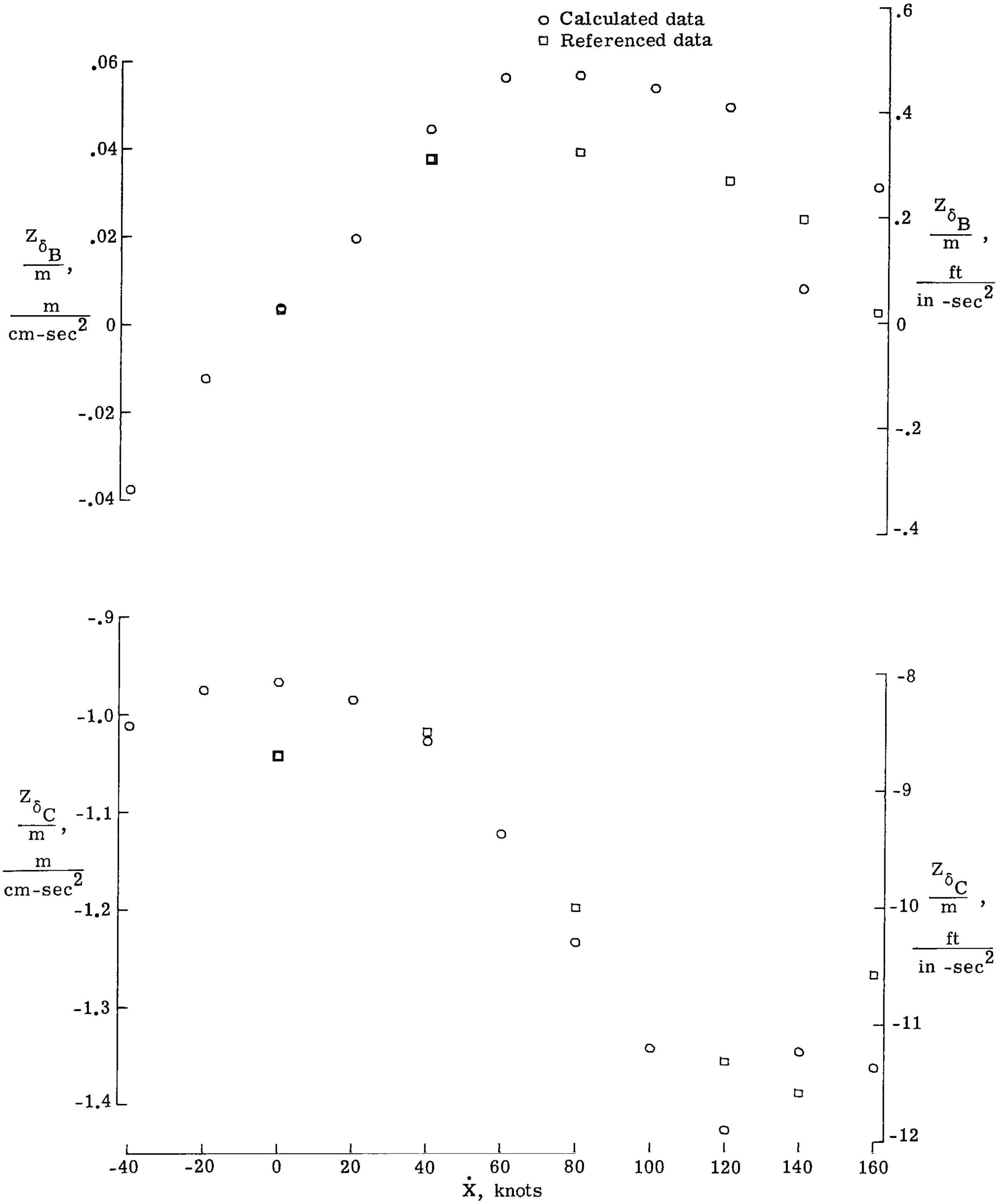


Figure 11.- Concluded.

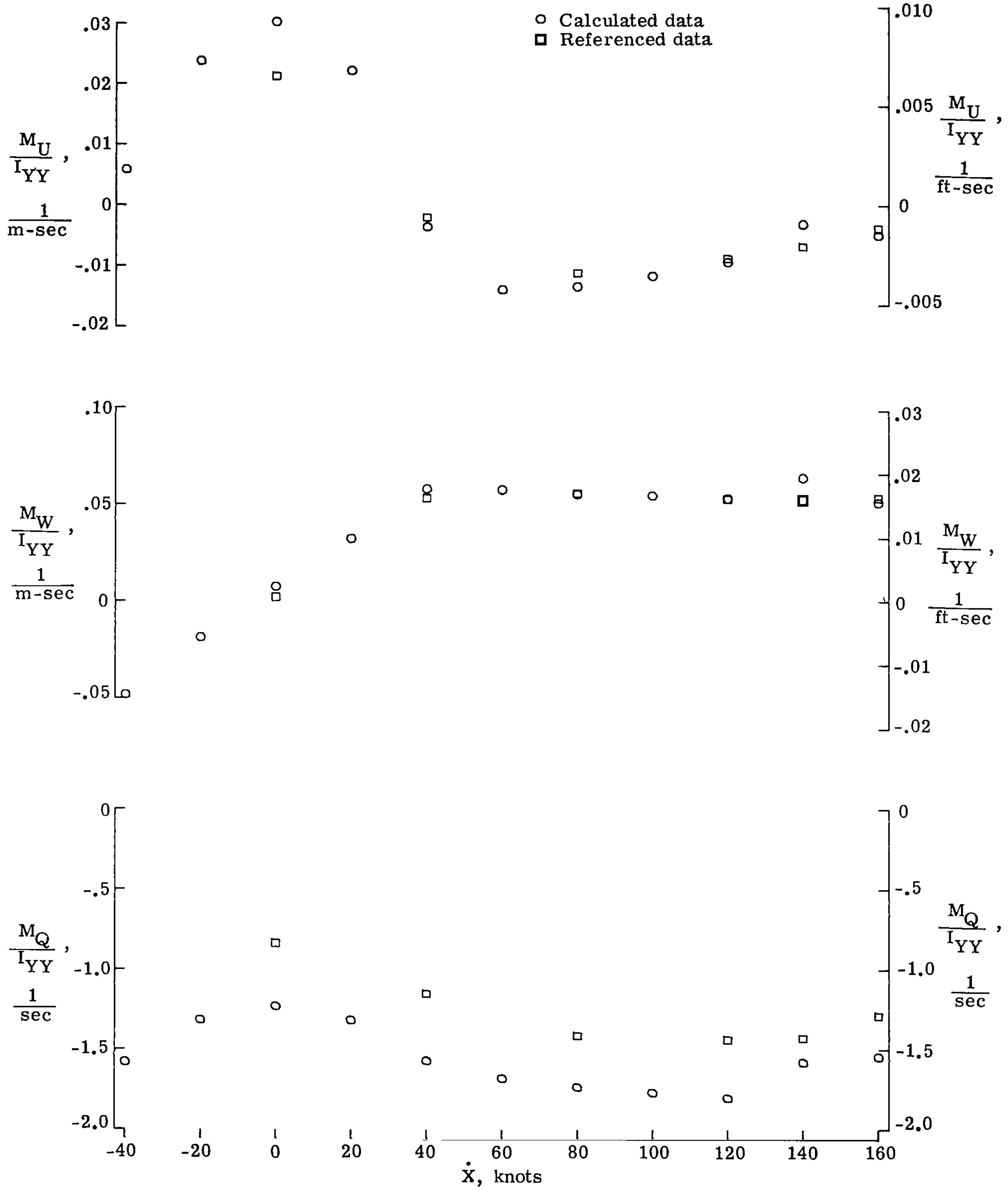


Figure 12.- Pitching-moment stability and control derivatives.

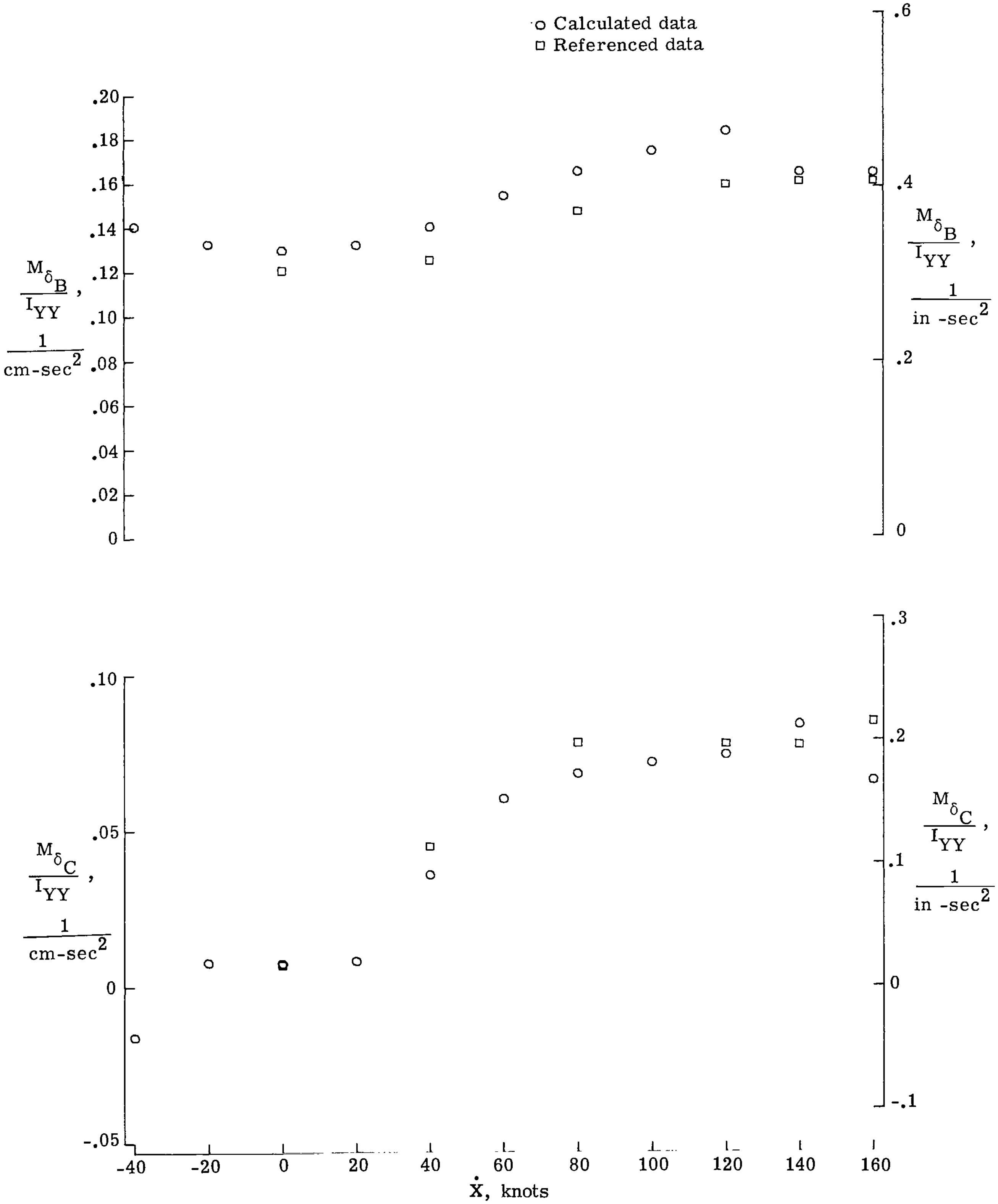


Figure 12.- Concluded.

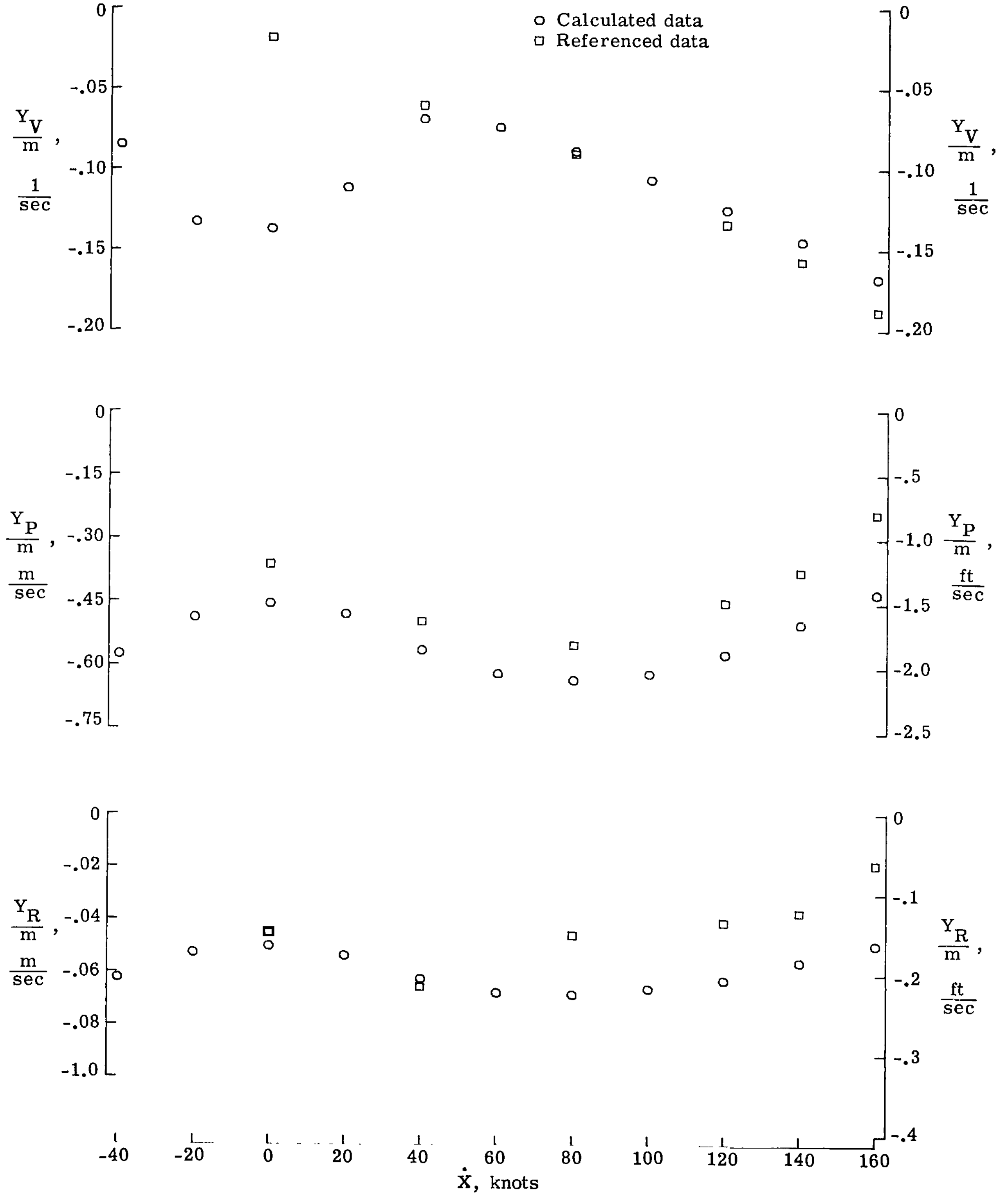


Figure 13.- Lateral-force stability and control derivatives.

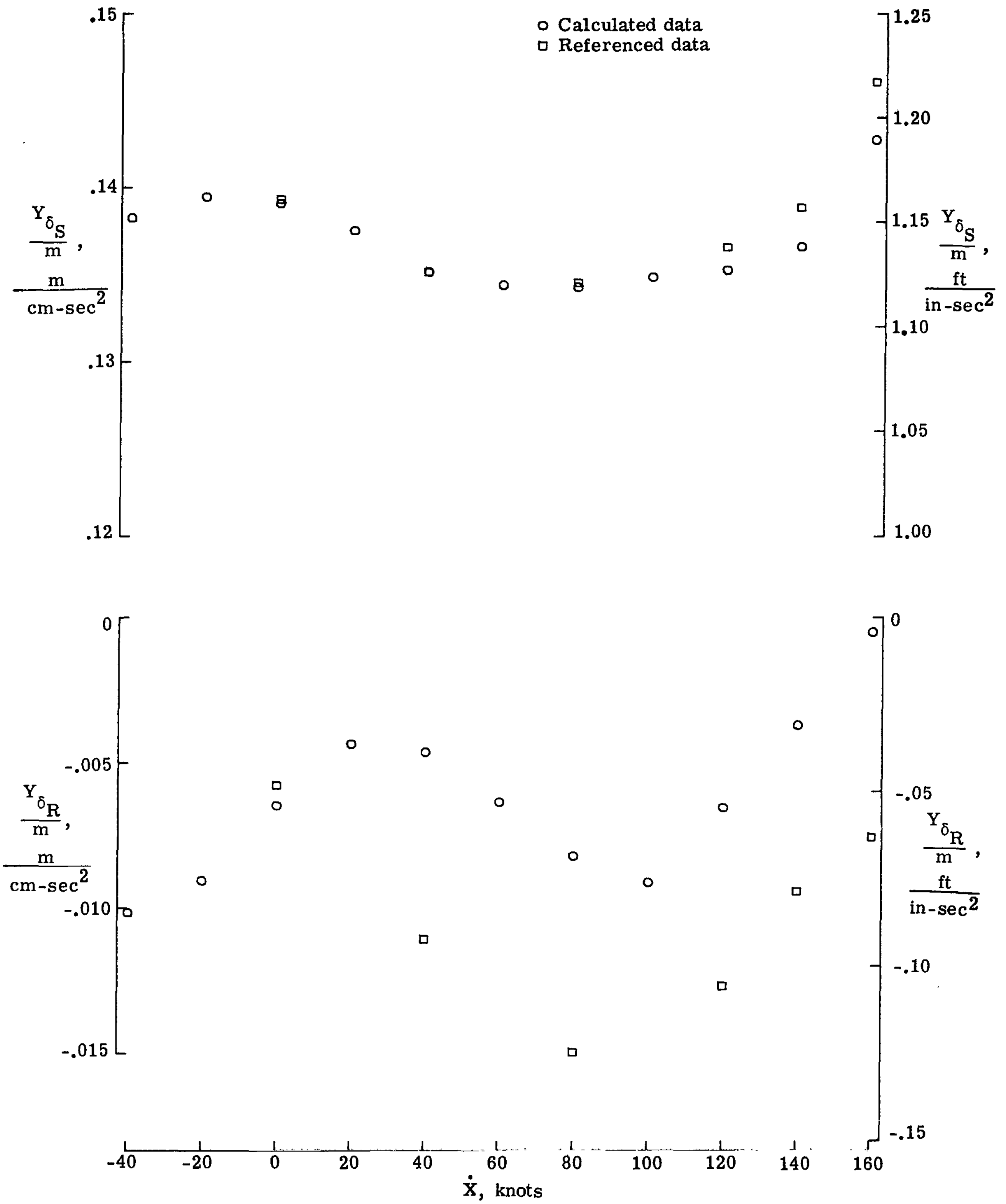


Figure 13.- Concluded.

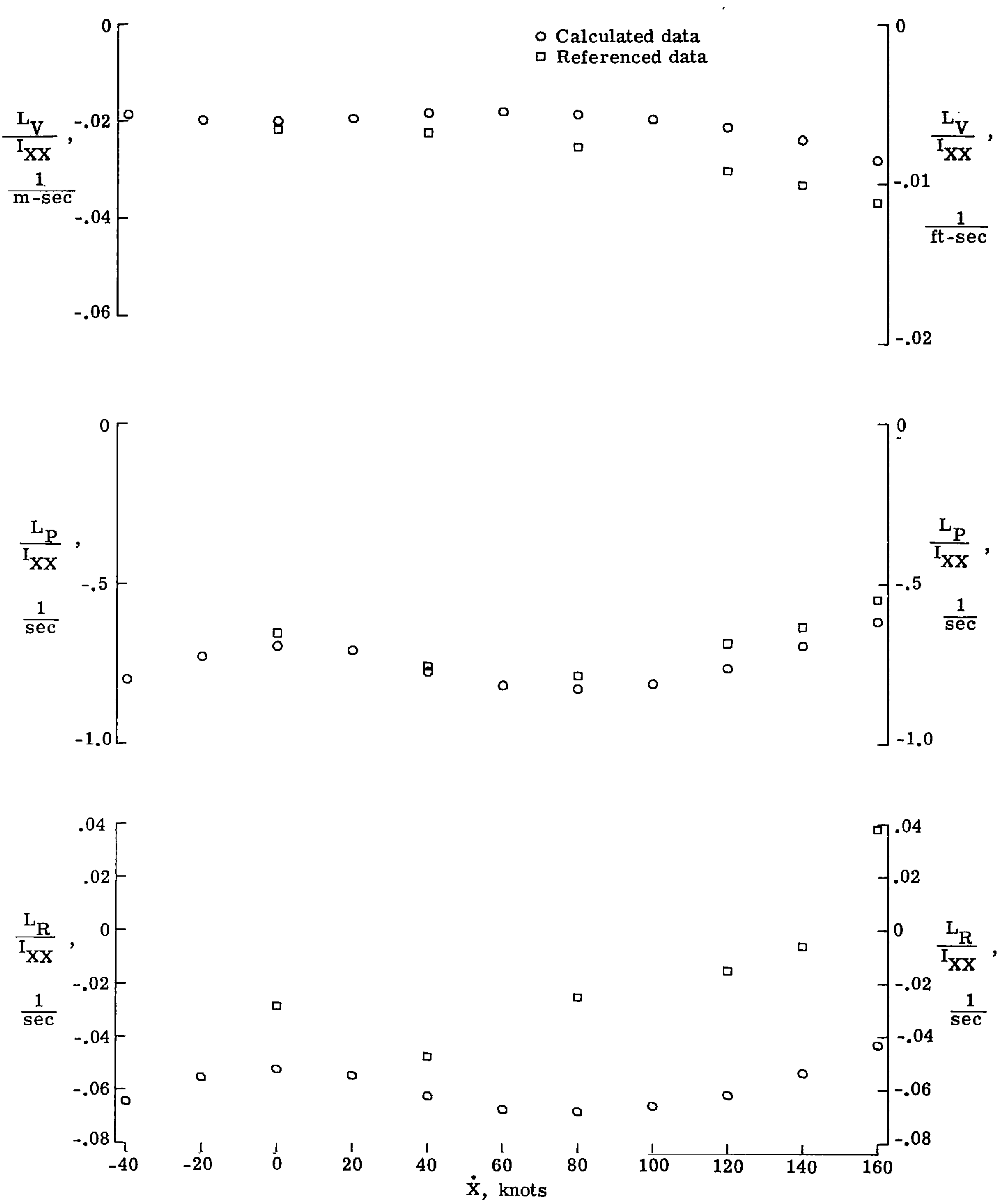


Figure 14.- Rolling-moment stability and control derivatives.

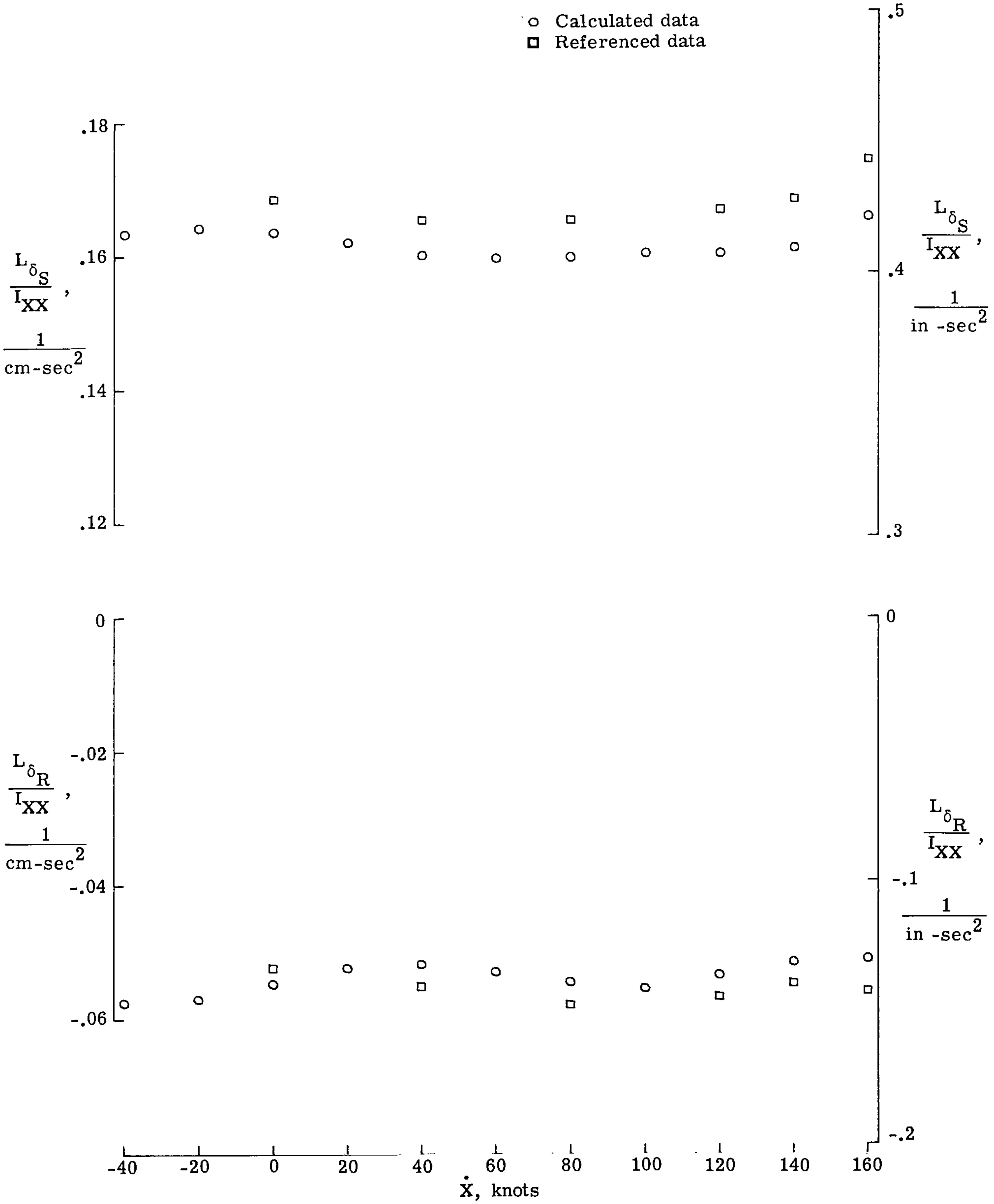


Figure 14.- Concluded.

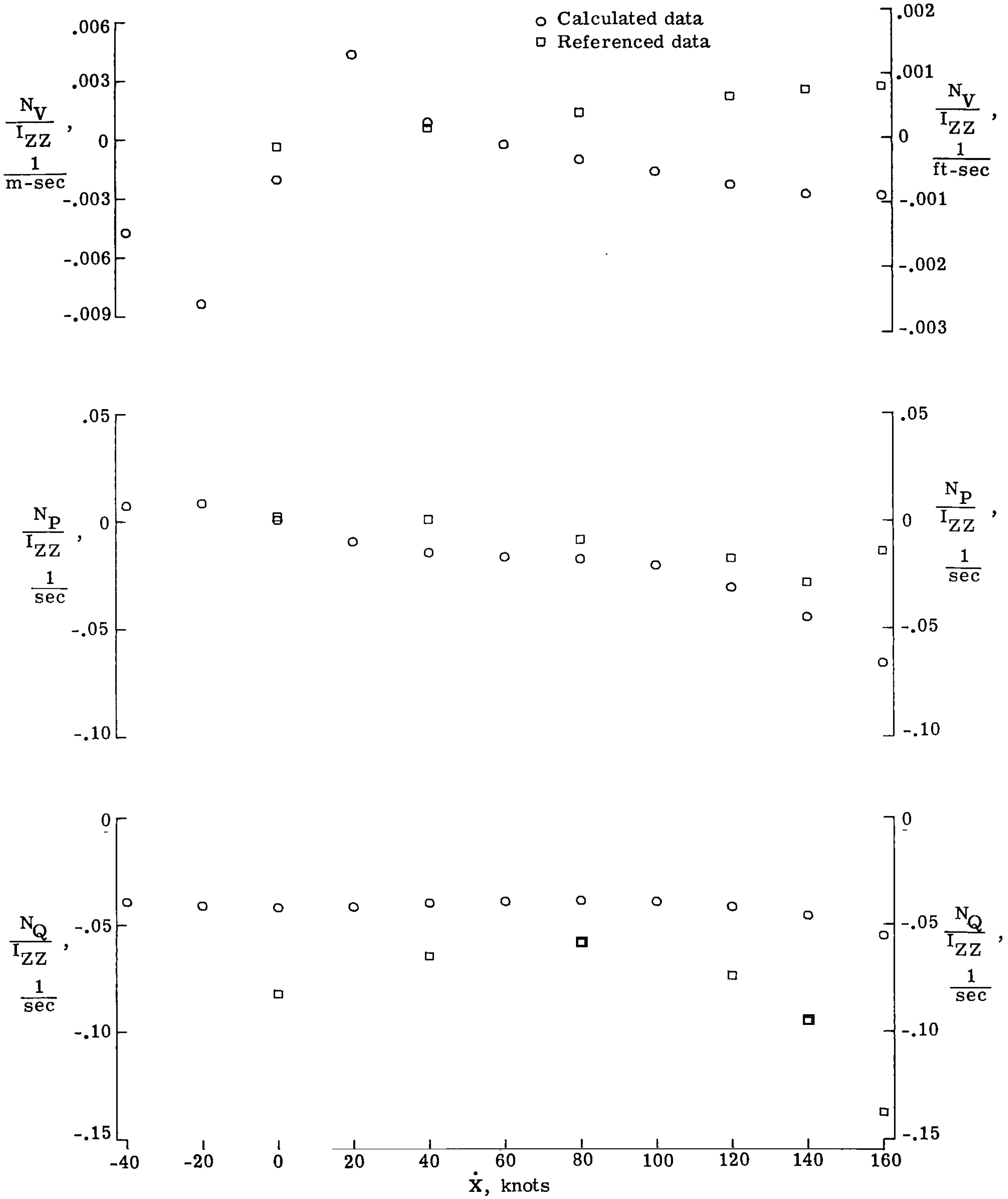


Figure 15.- Yawing-moment stability and control derivatives.

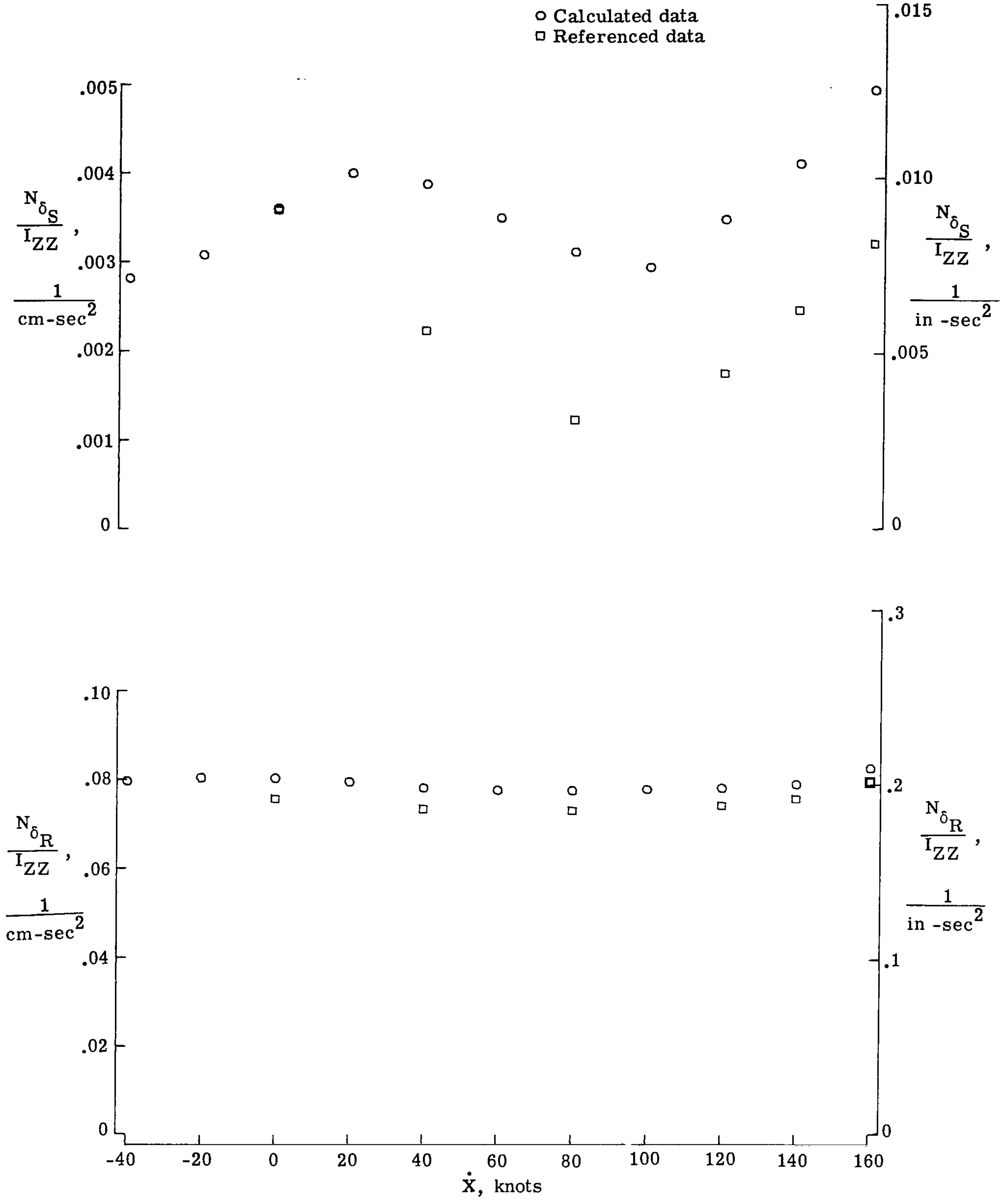


Figure 15.- Concluded.

TABLE I.- POLES OF REFERENCES AND CALCULATED LINEAR MODELS

(a) Longitudinal

$\dot{X}$, knots	Calculated poles	Referenced poles
0	-0.2977	-0.272
	-1.404	-1.040
	0.078 ± 0.459j	0.094 ± 0.440j
40	0.388	0.427
	-0.091 ± 0.286j	-0.064 ± 0.268j
	-2.23	-1.90
80	0.555	0.645
	-0.093 ± 0.242j	-0.067 ± 0.209j
	-2.77	-2.55
120	0.666	-0.803
	-0.053 ± 0.173j	-0.043 ± 0.142j
	-3.14	-2.88
140	1.056	0.911
	-0.050	-0.035 ± 0.096j
	-0.002	
	-3.31	-3.02
160	0.978	1.12
	-0.020	-0.019
	-0.053	-0.052
	-3.20	-3.06

(b) Lateral

$\dot{X}$, knots	Calculated poles	Referenced poles
0	-0.987	-0.942
	0.064 ± 0.459j	0.123 ± 0.469j
	-0.042	-0.082
40	-1.02	-1.03
	0.065 ± 0.440j	0.089 ± 0.469j
	-0.035	-0.062
80	-1.11	-1.11
	0.077 ± 0.386j	0.096 ± 0.515j
	-0.039	-0.049
120	-1.18	-1.13
	0.127 ± 0.350j	0.131 ± 0.600j
	-0.046	-0.053
140	-1.24	-1.17
	0.177 ± 0.365j	0.156 ± 0.640j
	-0.047	-0.063
160	-1.37	-1.21
	0.260 ± 0.402j	0.204 ± 0.623j
	-0.046	-0.098

The form of the referenced and calculated poles shown in table I agree at all velocities except for two longitudinal poles at 140 knots. This exception occurs at a transition point in the velocity sweep where a pair of complex roots at lower velocities become real roots at higher velocities.

Comparing poles near the origin (real parts less than 0.1 rad/sec) for both longitudinal and lateral cases shows that the real parts of all roots differ by less than 0.03 rad/sec, except for a pair of lateral roots at $\dot{X} = 0$ and a single lateral root at $\dot{X} = 160$ knots. For roots with real parts larger than 0.1 rad/sec, only a single longitudinal root at $\dot{X} = 0$ and a pair of lateral roots at $\dot{X} = 160$ knots have differences in their real parts greater than 20 percent. The majority of the imaginary part of the roots also exhibit similar close agreement.

The excellent agreement of the control-stick and attitude-angle trims, the shape and magnitude agreement of the majority of the stability derivatives, and the agreement of the pole location indicate that HELICOP and the referenced nonlinear model agree (except at $\dot{X} = 0$) with regard to the stability character and fundamental modes of response of the CH-47B. Exceptions do exist which produce differences in some zeros that could lead to different time responses.

CONCLUSIONS

This report contains a complete set of materials needed to mathematically describe the CH-47B helicopter. The material includes both a nonlinear model (HELICOP) and a linear coupled model with its 6 trims and 60 quasi-static stability derivatives covering the entire flight regime. The results from comparison with reference data show that the linear model and HELICOP are a good representation of the CH-47B, the exception being that HELICOP is questionable at zero airspeed. A comparison with data available in the literature was made for the trims, stability derivatives, and poles of the uncoupled linear model for positive velocities and zero rate of descent.

The two attitude-angle trims and four control-stick trims show excellent agreement at all velocities. The 30 stability derivatives comprising the uncoupled model show very good agreement regarding shapes, and the majority agree in magnitude. All but three of the poles of the linear model near the origin (real parts less than 0.1 rad/sec) agree within 0.03 rad/sec. Only three roots which have real parts greater than 0.1 rad/sec show differences in real parts greater than 20 percent. The majority of the imaginary parts also exhibit close agreement.

The technique used to generate the trims and stability derivatives is general and could be applied to other vehicles. All that is required is a nonlinear model of the vehicle, equivalent to HELICOP, which generates forces and moments from attitude angles and control-stick inputs.

Langley Research Center
National Aeronautics and Space Administration
Hampton, Va. 23665
March 25, 1976

APPENDIX A

SIGN CONVENTION AND COORDINATE FRAMES

This appendix defines the sign conventions, angles, and coordinate frames used in this paper. Figure A1 illustrates the relationship between the local level axes (X, Y, Z) and the body axes (x, y, z). The local level frame has its origin at the vehicle center of gravity. The Z-axis is down and coincident with the Earth vertical; the X-axis is the projection of the vehicle's longitudinal body axis along the Earth with positive direction defined in forward flight; and the Y-axis completes a right-hand coordinate frame.

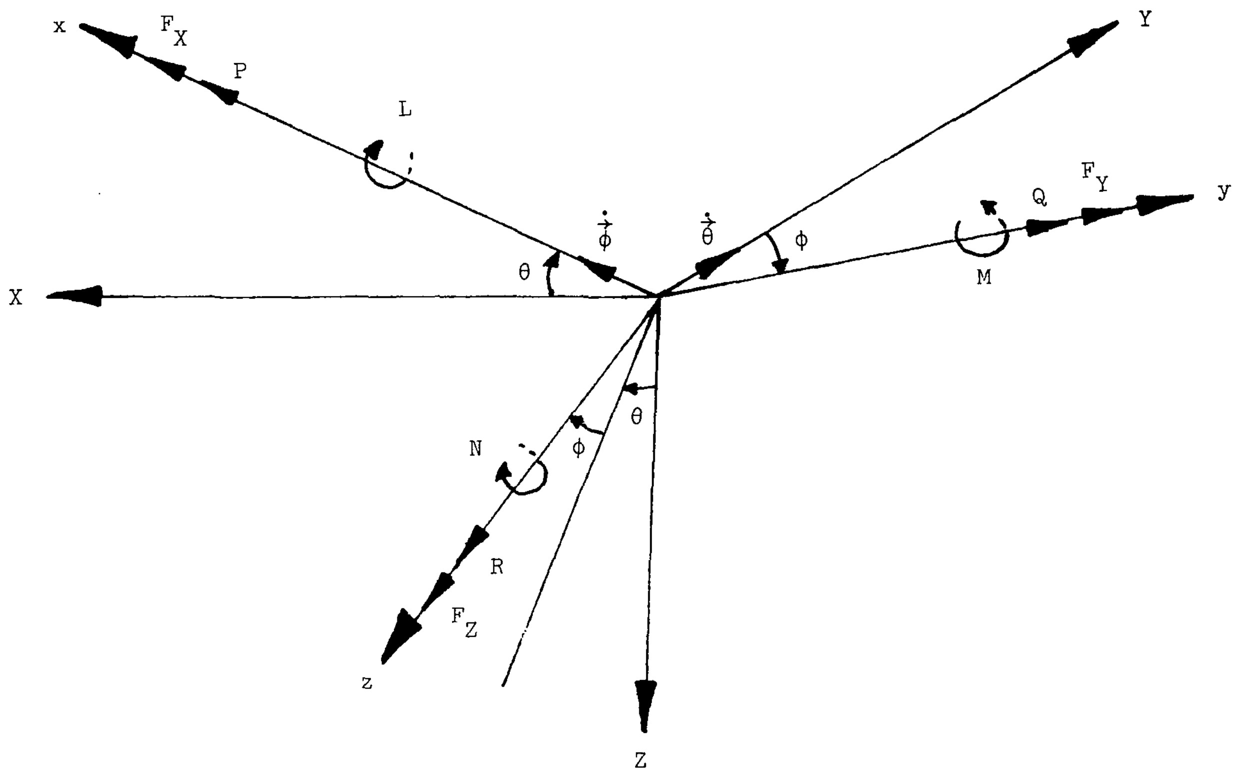


Figure A1.- Angular velocities, aerodynamic forces and moments, and relationships of local level axes and body axes with positive directions of vehicles.

The body frame has its origin at the vehicle center of gravity. The x-axis is along the reference longitudinal direction of the vehicle with the positive direction pointing forward; the z-axis is in the plane of symmetry of the fuselage with the positive direction through the floor; and the y-axis is positive to the right side, completing a right-hand coordinate frame. The transformation from the local level frame to the body frame is:

$$\begin{Bmatrix} x \\ y \\ z \end{Bmatrix} = \begin{bmatrix} \cos\theta & 0 & -\sin\theta \\ \sin\theta\sin\phi & \cos\phi & \cos\theta\sin\phi \\ \sin\theta\cos\phi & -\sin\phi & \cos\theta\cos\phi \end{bmatrix} \begin{Bmatrix} X \\ Y \\ Z \end{Bmatrix} \tag{A1}$$

where θ and ϕ are the pitch and roll attitude angles. Positive directions for the body forces and moments $(F_X,\ F_Y,\ F_Z$ and $L,\ M,\ N)$ and the body angular velocities (P, Q, R) are shown in figure A1.

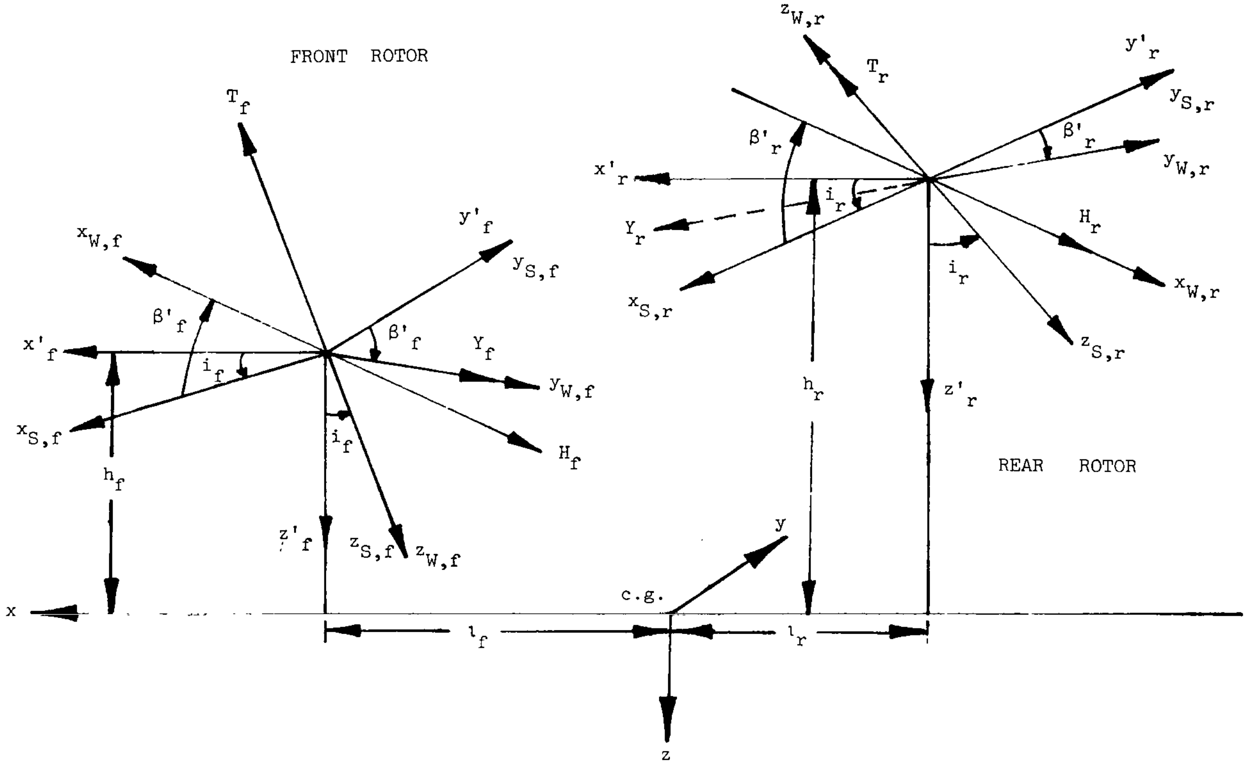


Figure A2.- Definition of rotor-shaft axes, wind axes, and rotor forces for front rotor and rear rotor.

Figure A2 defines the relationship of the body axes, rotor-shaft axes, and wind axes as used in the nonlinear model. (The subscripts f and r refer to the front rotor and the rear rotor.) Two rotor-hub axes (x', y', z') are defined parallel to the body axes, one centered at the front rotor hub and the second at the rear rotor hub. The locations of the two rotor hubs relative to the vehicle center of gravity are given by l_f, l_r, h_f, and h_r. The rotor-shaft axes $(x_S,\ y_S,\ z_S)$ are related to the body frame by

$$\begin{Bmatrix} x_S \\ y_S \\ z_S \end{Bmatrix} = \begin{bmatrix} \cos i & 0 & \sin i \\ 0 & 1 & 0 \\ -\sin i & 0 & \cos i \end{bmatrix} \begin{Bmatrix} x' \\ y' \\ z' \end{Bmatrix} \tag{A2}$$

where i is the shaft incidence angle.

The wind axes for each rotor is related to the respective shaft axes by the rotor sideslip angles β'_f and β'_r as follows:

$$\begin{Bmatrix} x_{W,f} \\ y_{W,f} \\ z_{W,f} \end{Bmatrix} = \begin{bmatrix} \cos \beta'_f & \sin \beta'_f & 0 \\ -\sin \beta'_f & \cos \beta'_f & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{Bmatrix} x_{S,f} \\ y_{S,f} \\ z_{S,f} \end{Bmatrix} \tag{A3a}$$

$$\begin{Bmatrix} x_{W,r} \\ y_{W,r} \\ z_{W,r} \end{Bmatrix} = \begin{bmatrix} -\cos \beta'_r & -\sin \beta'_r & 0 \\ -\sin \beta'_r & \cos \beta'_r & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{Bmatrix} x_{S,r} \\ y_{S,r} \\ z_{S,r} \end{Bmatrix} \tag{A3b}$$

Finally, the transformation from wind axes to rotor forces is:

$$\begin{Bmatrix} H_f \\ Y_f \\ T_f \end{Bmatrix} = \begin{bmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{bmatrix} \begin{Bmatrix} x_{W,f} \\ y_{W,f} \\ z_{W,f} \end{Bmatrix} \tag{A4a}$$

$$\begin{Bmatrix} H_r \\ Y_r \\ T_r \end{Bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{Bmatrix} x_{W,r} \\ y_{W,r} \\ z_{W,r} \end{Bmatrix} \tag{A4b}$$

where the rear rotor forces constitute a left-hand coordinate frame. The positive directions for all rotor forces are shown in figure A2.

The definition of fuselage angle of attack (α_{fus}) and angle of sideslip (β_{fus}) is shown in figure A3. The three linear velocities U, V, and W are defined along the x, y, and z body axes, respectively.

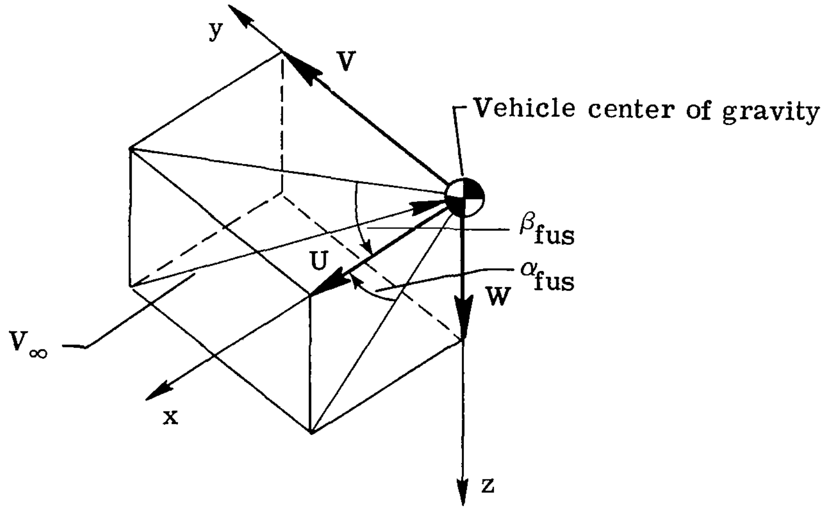


Figure A3.- Definition of fuselage angle of attack α_{fus} and angle of sideslip β_{fus}.

APPENDIX B

EQUATIONS FOR HELICOPTER NONLINEAR MODEL

The 10 inputs to the helicopter nonlinear model (HELICOP) are the three body-axes velocities U, V, and W, the three angular body rates P, Q, and R, and the four control stick positions δ_B, δ_C, δ_S, and δ_R. The six outputs are the three forces F_X, F_Y, and F_Z and the three moments L, M, and N. Constants for the model are presented in appendix C. A complete list of equations for each module (found mainly in ref. 2) are presented in this appendix. (Subscripts F and R refer to the front and rear rotors, respectively.) The equations in this appendix are essentially in modular form for use in a computer program.

Additional symbols applicable to this appendix are defined as follows:

A_{OF},A_{OR}	front/rear rotor coning angle, rad
A_{IF},A_{IR}	front/rear longitudinal flapping angle, rad
A_{ICF},A_{ICR}	front/rear lateral cyclic pitch angle in rotor-shaft axes, rad
A_{ICFDR},A_{ICRDR}	rate of change of front/rear lateral cyclic with direction control, rad/m
A_{ICFDS},A_{ICRDS}	rate of change of front/rear lateral cyclic with lateral control, rad/m
A_{ICFR},A_{ICRR}	front/rear lateral cyclic pitch angle in wind axes, rad
a_S	slope of rotor-blade lift curve per radian
B_{IF},B_{IR}	front/rear lateral flapping angle, rad
B_{ICF},B_{ICR}	front/rear longitudinal cyclic pitch angle in rotor-shaft axes, rad or deg
B_{ICFR},B_{ICRR}	front/rear longitudinal cyclic pitch angle in wind axes, rad
b_S	number of blades per rotor

C_{FE}	equivalent flat-plate drag area of fuselage, m^2
$C_{F1},\ldots,C_{F4}$	dummy variables in equations (B91a) to (B91d)
$C_{L\alpha}$	rate of change of fuselage lift force with α normalized by dynamic pressure, m^2/rad
$C_{L\beta}$	rate of change of fuselage rolling moment with β normalized by dynamic pressure, m^3/rad
$C_{M\alpha}$	rate of change of fuselage pitching moment with α normalized by dynamic pressure, m^3/rad
$C_{N\beta}$	rate of change of fuselage yawing moment with β normalized by dynamic pressure, m^3/rad
$C_{R1},\ldots,C_{R4}$	dummy variables in equations (B91e) to (B91h)
$C_{Y\beta}$	rate of change of fuselage side force with β normalized by dynamic pressure, m^2/rad
D_{FUS1}	body-axes velocity component in longitudinal plane, m/sec
D_{FUS2}	body-axes velocity component in lateral plane, m/sec
e_S	rotor flapping hinge offset, m
F_H	dummy variable, kg-m (see eq. (B44))
H_{CF},H_{CR}	front/rear rotor drag-force coefficient
L_{FUS}	aerodynamic rolling moment about helicopter center of gravity due to fuselage, N-m
L_{HF},L_{HR}	front/rear lateral hub moment, N-m

L_P	rolling moment about helicopter center of gravity due to rotor drag and side forces, N-m
M_D	Mach number above which a nonlinear compressibility term is added
M_{FUS}	aerodynamic pitching moment about helicopter center of gravity due to fuselage, N-m
M_{HF},M_{HR}	front/rear longitudinal rotor hub moment, N-m
M_P	pitching moment about helicopter center of gravity due to rotor thrust, drag, and side forces, N-m
M_{T90F},M_{T90R}	front/rear Mach number at rotor blade azimuth of 90°
M_W	mass moment of blade about flapping hinge, N-m
N_{FUS}	aerodynamic yawing moment about helicopter center of gravity due to fuselage, N-m
N_P	yawing moment about helicopter center of gravity due to rotor drag and side forces, N-m
P_F,P_R	front/rear components of vehicle rolling rate about rotor wind axes, rad/sec
Q_{AEROF},Q_{AEROR}	front/rear torque required, N-m
Q_{CF},Q_{CR}	front/rear rotor torque coefficient
Q_{DPRES}	dynamic pressure, N/m^2
Q_F,Q_R	front/rear components of vehicle pitching rate about rotor wind axes, rad/sec
R_B	rotor blade radius, m
R_F,R_R	front/rear components of vehicle yawing rate about rotor wind axes, rad/sec

R_{IF},R_{IR}	front/rear rotor wake angle, rad
T_C	dummy variable related to rotor thrust coefficients (see eqs. (B28) to (B35))
$(T_C)_{break}$	break point above which a nonlinear function simulating rotor lift stall is included
t_c	ratio of thickness to blade section chord
U_F,U_R	front/rear rotor relative wind velocity in rotor wind axes, m/sec
U_{F1},U_{R1}	longitudinal velocity of front/rear rotor along x-axis of body, m/sec
U_{F2},U_{R2}	longitudinal velocity of front/rear rotor in rotor-shaft axes, m/sec
V_{F1},V_{R1}	lateral velocity of front/rear rotor along y-axis of body, m/sec
W_{FUS}	vertical body axes velocity due to fuselage, m/sec
W_{F1},W_{R1}	vertical velocity of front/rear rotor along z-axis of body, m/sec
W_{F2},W_{R2}	vertical velocity of front/rear rotor in rotor wind axes, m/sec
Y_{CF},Y_{CR}	front/rear rotor side-force coefficient
γ	rotor blade lock number
$\Delta T_{CF},\Delta T_{CR}$	thrust limit nonlinear gain from reference 2 (see fig. B2)
δ_{FH},δ_{RH}	front/rear drag coefficient for rotor drag force and torque
δ_o	nominal average rotor drag coefficient without correction term
$\theta_{FDB},\theta_{RDB}$	rate of change of front/rear collective pitch with longitudinal stick, rad/m

$\theta_{FDC}, \theta_{RDC}$	rate of change of front/rear collective pitch with collective stick, rad/m
θ_{OF}, θ_{OR}	front/rear root collective pitch, rad
θ_T	rotor blade twist, rad
θ_{TF}, θ_{TR}	root collective pitch at full δ_C, rad
σ	rotor solidity ratio
Ω_O	nominal rotor rotational speed, rad/sec

I Governor

$$\Omega = \Omega_O \tag{B1}$$

II Transformation Parameters and Aerodynamic Coordinate Transformation

Front Rotor

Rotor velocities in body axes

$$U_{F1} = U - h_f Q \tag{B2}$$

$$V_{F1} = V + l_f R + h_f P \tag{B3}$$

$$W_{F1} = W - l_f Q \tag{B4}$$

Rotor velocities in rotor-shaft axes

$$\begin{Bmatrix} U_{F2} \\ W_{F2} \end{Bmatrix} = \begin{bmatrix} \cos i_F & \sin i_F \\ -\sin i_F & \cos i_F \end{bmatrix} \begin{Bmatrix} U_{F1} \\ W_{F1} \end{Bmatrix} \tag{B5}$$

Relative wind velocity in rotor wind axes

$$U_F = \left[\left(U_{F2}\right)^2 + \left(V_{F1}\right)^2 \right]^{1/2} \tag{B6}$$

APPENDIX B

Rotor sideslip angle

$$\sin \beta'_F = \begin{cases} \dfrac{V_{F1}}{U_F} & (U_F \neq 0) \\ 0 & (U_F = 0) \end{cases} \tag{B7}$$

$$\cos \beta'_F = \begin{cases} \dfrac{U_{F2}}{U_F} & (U_F \neq 0) \\ 1 & (U_F = 0) \end{cases} \tag{B8}$$

Angular velocities in rotor wind axes

$$\begin{Bmatrix} P_F \\ Q_F \\ R_F \end{Bmatrix} = \begin{bmatrix} \cos i_F \cos \beta'_F & \sin \beta'_F & \sin i_F \cos \beta'_F \\ -\cos i_F \sin \beta'_F & \cos \beta'_F & -\sin i_F \sin \beta'_F \\ -\sin i_F & 0 & \cos i_F \end{bmatrix} \begin{Bmatrix} P \\ Q \\ R \end{Bmatrix} \tag{B9}$$

Avance ratio

$$\mu_F = \frac{U_F}{\Omega R_B} \tag{B10}$$

Component of inflow ratio

$$\lambda'_F = \frac{W_{F2}}{\Omega R_B} \tag{B11}$$

Rear Rotor

Rotor velocities in body axes

$$U_{R1} = U - h_r Q \tag{B12}$$

$$V_{R1} = V - l_r R + h_r P \tag{B13}$$

$$W_{R1} = W + l_r Q \tag{B14}$$

Rotor velocities in rotor-shaft axes

$$\begin{Bmatrix} U_{R2} \\ W_{R2} \end{Bmatrix} = \begin{bmatrix} \cos i_R & \sin i_R \\ -\sin i_R & \cos i_R \end{bmatrix} \begin{Bmatrix} U_{R1} \\ W_{R1} \end{Bmatrix} \tag{B15}$$

Relative wind velocity in rotor wind axes

$$U_R = \left[\left(U_{R2}\right)^2 + \left(V_{R1}\right)^2 \right]^{1/2} \tag{B16}$$

Rotor sideslip angle

$$\sin \beta'_R = \begin{cases} \dfrac{V_{R1}}{U_R} & \left(U_R \neq 0\right) \\ 0 & \left(U_R = 0\right) \end{cases} \tag{B17}$$

$$\cos \beta'_R = \begin{cases} \dfrac{U_{R2}}{U_R} & \left(U_R \neq 0\right) \\ 1 & \left(U_R = 0\right) \end{cases} \tag{B18}$$

Angular velocities in rotor wind axes

$$\begin{Bmatrix} P_R \\ Q_R \\ R_R \end{Bmatrix} = \begin{bmatrix} -\cos i_R \cos \beta'_R & -\sin \beta'_R & -\sin i_R \cos \beta'_R \\ -\cos i_R \sin \beta'_R & \cos \beta'_R & -\sin i_R \sin \beta'_R \\ \sin i_R & 0 & -\cos i_R \end{bmatrix} \begin{Bmatrix} P \\ Q \\ R \end{Bmatrix} \tag{B19}$$

Advance ratio

$$\mu_R = \frac{U_R}{\Omega R_B} \tag{B20}$$

Component of inflow ratio

$$\lambda'_R = \frac{w_{R2}}{\Omega R_B} \tag{B21}$$

III Control Mixing and Coordinate Transformation

Front Rotor

$$\theta_{OF} = \theta_{TF} + \theta_{FDB}\delta_B + \theta_{FDC}\delta_C \tag{B22}$$

$$A_{ICF} = A_{ICFDS}\delta_S + A_{ICFDR}\delta_R \tag{B23}$$

$$\begin{Bmatrix} A_{ICFR} \\ B_{ICFR} \end{Bmatrix} = \begin{bmatrix} \cos\beta'_F & -\sin\beta'_F \\ \sin\beta'_F & \cos\beta'_F \end{bmatrix} \begin{Bmatrix} A_{ICF} \\ B_{ICF} \end{Bmatrix} \tag{B24}$$

Rear Rotor

$$\theta_{OR} = \theta_{TR} + \theta_{RDB}\delta_B + \theta_{RDC}\delta_C \tag{B25}$$

$$A_{ICR} = A_{ICRDS}\delta_S + A_{ICRDR}\delta_R \tag{B26}$$

$$\begin{Bmatrix} A_{ICRR} \\ B_{ICRR} \end{Bmatrix} = \begin{bmatrix} \cos\beta'_R & \sin\beta'_R \\ -\sin\beta'_R & \cos\beta'_R \end{bmatrix} \begin{Bmatrix} A_{ICR} \\ B_{ICR} \end{Bmatrix} \tag{B27}$$

The longitudinal cyclic trim terms $\left(B_{ICF},\ B_{ICR}\right)$ automatically introduce forward longitudinal cyclic pitch into both rotor systems as a function of airspeed, as shown in figure B1.

IV Thrust Coefficients

Front Rotor

$$T_{CF} = \frac{\lambda_F}{2} + \frac{\theta_{OF}}{3} + \frac{\theta_T}{4} + \mu_F\left[\mu_F\left(\frac{\theta_{OF}}{2} + \frac{\theta_T}{4}\right) - \frac{B_{ICFR}}{2}\right] \tag{B28}$$

$$(T_{CF})_{break} = \frac{0.288 - 0.48\mu_F}{a_S} \tag{B29}$$

$$T_{CF} = \begin{cases} T_{CF} & \left(T_{CF} \leqq (T_{CF})_{break}\right) \\ (T_{CF})_{break} + \Delta T_{CF} & \left(T_{CF} > (T_{CF})_{break}\right) \end{cases} \tag{B30}$$

where ΔT_{CF} is computed from figure B2.

$$C_{TF} = \frac{a_S \sigma}{2} T_{CF} \tag{B31}$$

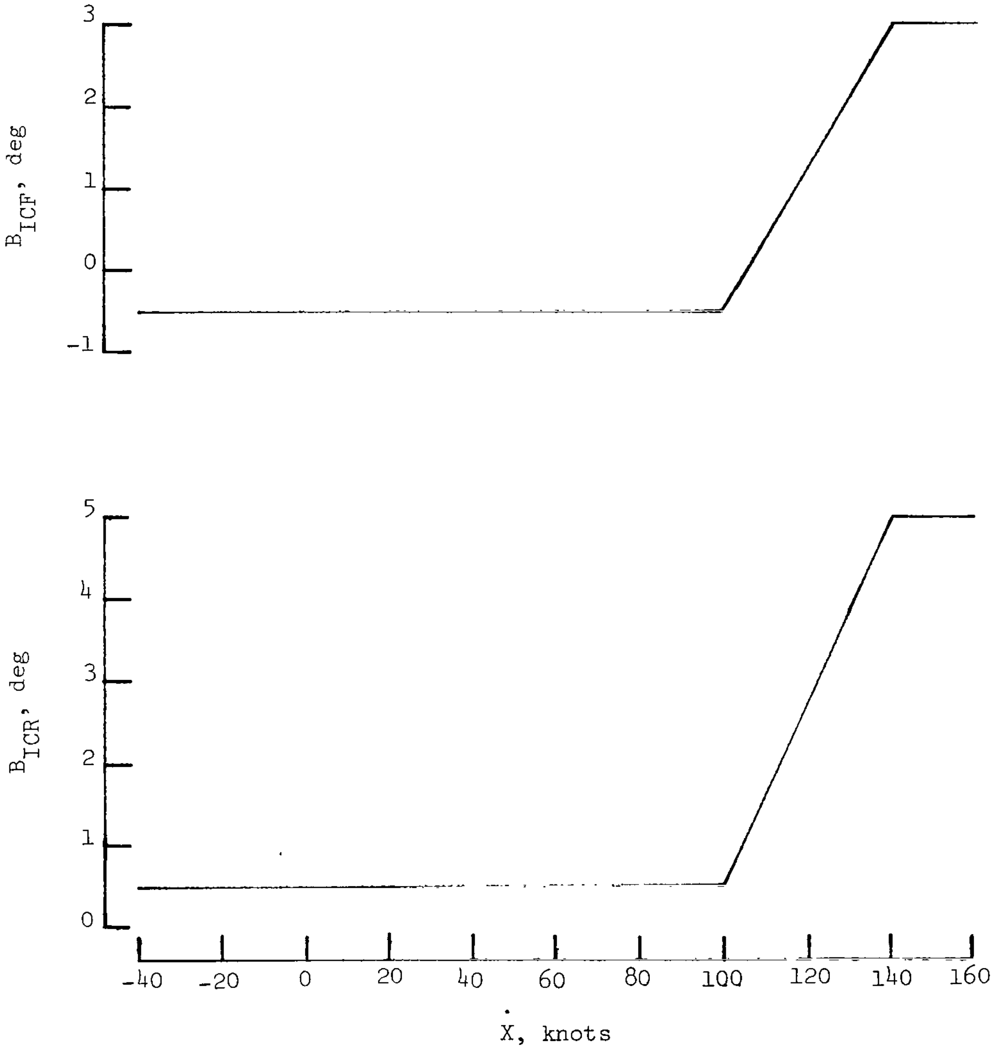


Figure B1.- Trim schedules of front and rear longitudinal cyclic pitch.

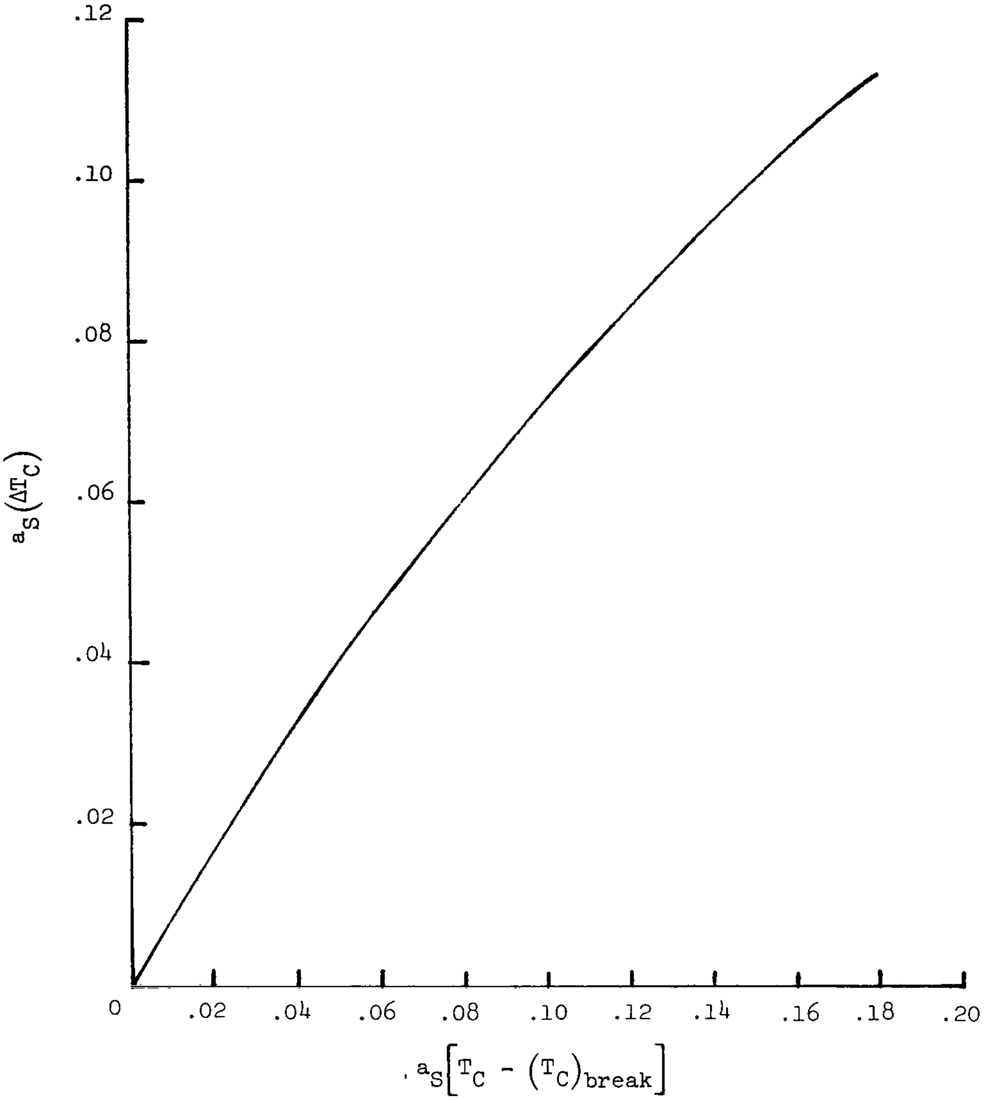


Figure B2.- Thrust limit nonlinear gain for both front and rear rotor.

Rear Rotor

$$T_{CR} = \frac{\lambda_R}{2} + \frac{\theta_{OR}}{3} + \frac{\theta_T}{4} + \mu_R\left[\mu_R\left(\frac{\theta_{OR}}{2} + \frac{\theta_T}{4}\right) - \frac{B_{ICRR}}{2}\right] \tag{B32}$$

$$\left(T_{CR}\right)_{break} = \frac{0.288 - 0.48\mu_R}{a_S} \tag{B33}$$

$$T_{CR} = \begin{cases} T_{CR} & \left(T_{CR} \leqq (T_{CR})_{break}\right) \\ (T_{CR})_{break} + \Delta T_{CR} & \left(T_{CR} > (T_{CR})_{break}\right) \end{cases} \tag{B34}$$

where ΔT_{CR} is computed from figure B2.

$$C_{TR} = \frac{a_S \sigma}{2} T_{CR} \tag{B35}$$

V Rotor Inflow Ratios and Interference Parameters

$$R_{IF} = \tan^{-1}\left|\frac{\mu_F}{\lambda_F}\right| \tag{B36}$$

$$R_{IR} = \tan^{-1}\left|\frac{\mu_R}{\lambda_R}\right| \tag{B37}$$

For $U_X \geqq 0$:

$$dF_{FR} = \left[0.356 + 0.321R_{IF} - 0.368(R_{IF})^2 + 0.392(R_{IF})^3\right]\left(1 - \left|\sin \beta'_F\right|\right) + \left[0.356 + 0.0131R_{IF} - 0.0764(R_{IF})^2 - 0.0085(R_{IF})^3\right]\left|\sin \beta'_F\right| \tag{B38}$$

$$dF_{RF} = \left[0.356 - 0.151R_{IR} - 0.314(R_{IR})^2 + 0.164(R_{IR})^3\right]\left(1 - \left|\sin \beta'_R\right|\right) + \left[0.356 + 0.0131R_{IR} - 0.0764(R_{IR})^2 - 0.0085(R_{IR})^3\right]\left|\sin \beta'_R\right| \tag{B39}$$

For $U_X < 0$:

$$dF_{RF} = \left[0.356 + 0.321R_{IR} - 0.368(R_{IR})^2 + 0.392(R_{IR})^3\right]\left(1 - \left|\sin \beta'_R\right|\right) + \left[0.356 + 0.0131R_{IR} - 0.0764(R_{IR})^2 - 0.0085(R_{IR})^3\right]\left|\sin \beta'_R\right| \tag{B40}$$

$$dF_{FR} = \left[0.356 - 0.151R_{IF} - 0.314(R_{IF})^2 + 0.164(R_{IF})^3\right]\left(1 - |\sin\beta'_F|\right) + \left[0.356 + 0.0131R_{IF} - 0.0764(R_{IF})^2 - 0.0085(R_{IF})^3\right]|\sin\beta'_F| \tag{B41}$$

$$\lambda_F = \lambda'_F - \frac{C_{TF}}{2\left[(\lambda_F)^2 + (\mu_F)^2\right]^{1/2}} - dF_{RF}\frac{C_{TR}}{2\left[(\lambda_R)^2 + (\mu_R)^2\right]^{1/2}} \tag{B42}$$

$$\lambda_R = \lambda'_R - \frac{C_{TR}}{2\left[(\lambda_R)^2 + (\mu_R)^2\right]^{1/2}} - dF_{FR}\frac{C_{TF}}{2\left[(\lambda_F)^2 + (\mu_F)^2\right]^{1/2}} \tag{B43}$$

VI Rotor Forces and Moments

$$F_H = \pi\rho(R_B)^4 \tag{B44}$$

Front Rotor

Drag coefficient

For $M_{T90F} - M_D \leqq 0$,

$$\delta_{FH} = \delta_o + 2.07(T_{CF})^2 \tag{B45}$$

For $M_{T90F} - M_D > 0$,

$$\delta_{FH} = \delta_o + 2.07(T_{CF})^2 + 0.096\left(M_{T90F} - M_D\right) + 0.8\left(M_{T90F} - M_D\right)^3 \tag{B46}$$

where

$$M_D = 0.955 - 1.25t_c \tag{B47a}$$

and

$$M_{T90F} = \frac{\Omega R_B}{331.6}\left(1 + \sqrt{(\mu_F)^2 + (\lambda'_F)^2}\right) \tag{B47b}$$

Thrust

$$T_f = F_H C_{TF} \Omega^2 \tag{B48}$$

Coning angle

$$A_{OF} = \frac{\gamma}{12}\left[4T_{CF} + \frac{\theta_{OF}}{6} + \frac{\theta_T}{5} - \frac{(\mu_F)^2 \theta_{OF}}{2}\right] \tag{B49}$$

Longitudinal flapping angle

$$A_{IF} = \frac{4}{1 - \frac{(\mu_F)^2}{2}}\left[\mu_F\left(\frac{\lambda_F}{2} + \frac{2}{3}\theta_{OF} + \frac{\theta_T}{2} - \frac{3}{8}\mu_F B_{ICFR}\right) - \frac{B_{ICFR}}{4}\right] - \frac{16Q_F}{\gamma\Omega}\left[1 + \frac{(\mu_F)^2}{2}\right] \tag{B50}$$

Lateral flapping angle

$$B_{IF} = \frac{4}{3}\left[\frac{\mu_F}{1 + \frac{(\mu_F)^2}{2}}\right]A_{OF} + A_{ICFR} - \frac{16P_F}{\gamma\Omega}\left[1 - \frac{(\mu_F)^2}{2}\right] \tag{B51}$$

Side-force coefficient

$$\begin{aligned} Y_{CF} = {} & T_{CF}B_{IF} + \mu_F\left[A_{IF}\left(\frac{B_{IF}}{4} - \frac{A_{ICFR}}{4} - \mu_F A_{OF}\right) + A_{OF}\left(\frac{\mu_F B_{ICFR}}{2} - \frac{3}{4}\theta_{OF} - \frac{3}{2}\lambda_F - \frac{\theta_T}{2}\right)\right] \\ & + \lambda_F\left(\frac{B_{IF}}{4} - \frac{A_{ICFR}}{4}\right) + A_{OF}\left(\frac{B_{ICFR}}{6} + \frac{A_{IF}}{6}\right) \end{aligned} \tag{B52}$$

Side force

$$Y_f = \frac{a_s\sigma}{2} Y_{CF} F_H \Omega^2 \tag{B53}$$

Horizontal-force coefficient

$$H_{CF} = T_{CF}A_{IF} + \frac{\mu_F \delta_{FH}}{2a_S} \tag{B54}$$

Horizontal force

$$H_f = \frac{a_S \sigma}{2} H_{CF} F_H \Omega^2 \tag{B55}$$

Torque coefficient

$$Q_{CF} = \mu_F \left\{ \mu_F \left[\frac{\delta_{FH}}{4a_S} + \frac{B_{ICFR}A_{IF}}{16} - \frac{3}{16}\left(A_{IF}\right)^2 + \frac{A_{ICFR}B_{IF}}{16} - \frac{\left(B_{IF}\right)^2}{16} - \frac{\left(A_{OF}\right)^2}{4} \right] \right.$$

$$\left. + \lambda_F \left(\frac{B_{ICFR}}{4} - \frac{A_{IF}}{2} \right) - \frac{A_{OF}A_{ICFR}}{6} + \frac{A_{OF}B_{IF}}{3} \right\} + \frac{\delta_H}{4a_S} - \frac{\theta_{OF}\lambda_F}{3} - \frac{\theta_T \lambda_F}{4}$$

$$- \frac{B_{ICFR}A_{IF}}{8} + \frac{A_{ICFR}B_{IF}}{8} - \frac{\left(\lambda_F\right)^2}{2} - \frac{\left(A_{IF}\right)^2}{8} - \frac{\left(B_{IF}\right)^2}{8} \tag{B56}$$

Torque required

$$Q_{AEROF} = \frac{a_S \sigma}{2} Q_{CF} F_H \Omega^2 R_B \tag{B57}$$

Longitudinal hub moment

$$M_{HF} = \frac{e_S b_S}{2} M_W \Omega^2 A_{IF} \tag{B58}$$

Lateral hub moment

$$L_{HF} = \frac{e_S b_S}{2} M_W \Omega^2 B_{IF} \tag{B59}$$

Rear Rotor

Drag coefficient

For $M_{T90R} - M_D \leqq 0$,

$$\delta_{RH} = \delta_o + 2.07(T_{CR})^2 \tag{B60}$$

For $M_{T90R} - M_D > 0$,

$$\delta_{RH} = \delta_o + 2.07(T_{CR})^2 + 0.096(M_{T90R} - M_D) + 0.8(M_{T90R} - M_D)^3 \tag{B61}$$

where M_D is defined by equation (B47a) and where

$$M_{T90R} = \frac{\Omega R_B}{331.6}\left(1 + \sqrt{(\mu_R)^2 + (\lambda'_R)^2}\right) \tag{B62}$$

Thrust

$$T_r = C_{TR} F_H \Omega^2 \tag{B63}$$

Coning angle

$$A_{OR} = \frac{\gamma}{12}\left[4T_{CR} + \frac{\theta_{OR}}{6} + \frac{\theta_T}{5} - \frac{(\mu_R)^2 \theta_{OR}}{2}\right] \tag{B64}$$

Longitudinal flapping angle

$$A_{IR} = \frac{4}{1 - \frac{(\mu_R)^2}{2}}\left[\mu_R\left(\frac{\lambda_R}{2} + \frac{2}{3}\theta_{OR} + \frac{\theta_T}{2} - \frac{3}{8}\mu_R B_{ICRR}\right) - \frac{B_{ICRR}}{4}\right] - \frac{16Q_R}{\gamma\Omega}\left[1 + \frac{(\mu_R)^2}{2}\right] \tag{B65}$$

Lateral flapping angle

$$B_{IR} = \frac{4}{3}\left[\frac{\mu_R}{1 + \frac{(\mu_R)^2}{2}}\right] A_{OR} + A_{ICRR} - \frac{16P_R}{\gamma\Omega}\left[1 - \frac{(\mu_R)^2}{2}\right] \tag{B66}$$

Side-force coefficient

$$Y_{CR} = T_{CR}B_{IR} + \mu_R\left[A_{IR}\left(\frac{B_{IR}}{4} - \frac{A_{ICRR}}{4} - \mu_R A_{OR}\right) + A_{OR}\left(\frac{\mu_R B_{ICRR}}{2} - \frac{3}{4}\theta_{OR} - \frac{3}{2}\lambda_R - \frac{\theta_T}{2}\right)\right]$$

$$+ \lambda_R\left(\frac{B_{IR}}{4} - \frac{A_{ICRR}}{4}\right) + A_{OR}\left(\frac{B_{ICRR}}{6} + \frac{A_{IR}}{6}\right) \tag{B67}$$

Side force

$$Y_r = \frac{a_S\sigma}{2} Y_{CR}F_H\Omega^2 \tag{B68}$$

Horizontal-force coefficient

$$H_{CR} = T_{CR}A_{IR} + \frac{\mu_R\delta_R}{2a_S} \tag{B69}$$

Horizontal force

$$H_r = \frac{a_S\sigma}{2} H_{CR}F_H\Omega^2 \tag{B70}$$

Torque coefficient

$$Q_{CR} = \mu_R\left\{\mu_R\left[\frac{\delta_{RH}}{4a_S} + \frac{B_{ICRR}A_{IR}}{16} - \frac{3}{16}(A_{IR})^2 + \frac{A_{ICRR}B_{IR}}{16} - \frac{(B_{IR})^2}{16} - \frac{(A_{OR})^2}{4}\right]\right.$$

$$\left. + \lambda_R\left(\frac{B_{ICRR}}{4} - \frac{A_{IR}}{2}\right) - \frac{A_{OR}A_{ICRR}}{6} + \frac{A_{OR}B_{IR}}{3}\right\} + \frac{\delta_H}{4a_S} - \frac{\theta_{OR}\lambda_R}{3} - \frac{\theta_T\lambda_R}{4} - \frac{B_{ICRR}A_{IR}}{8}$$

$$+ \frac{A_{ICRR}B_{IR}}{8} - \frac{(\lambda_R)^2}{2} - \frac{(A_{IR})^2}{8} - \frac{(B_{IR})^2}{8} \tag{B71}$$

Torque required

$$Q_{AEROR} = \frac{a_S\sigma}{2}Q_{CR}F_H\Omega^2 R_B \tag{B72}$$

Longitudinal hub moment

$$M_{HR} = \frac{e_S b_S}{2} M_W \Omega^2 A_{IR} \qquad \text{(B73)}$$

Lateral hub moment

$$L_{HR} = \frac{e_S b_S}{2} M_W \Omega^2 B_{IR} \qquad \text{(B74)}$$

VII Fuselage Forces and Moments

Vertical velocity with downwash

$$W_{FUS} = W + \left[\left(\lambda_F - \lambda_F'\right) + \left(\lambda_R - \lambda_R'\right)\right]\Omega R_B \qquad \text{(B75)}$$

$$D_{FUS1} = \left[U^2 + \left(W_{FUS}\right)^2\right]^{1/2} \qquad \text{(B76)}$$

$$D_{FUS2} = \left(U^2 + V^2\right)^{1/2} \qquad \text{(B77)}$$

Fuselage angle of attack

$$\sin \alpha_{fus} = \begin{cases} \dfrac{W_{FUS}}{D_{FUS1}} & \left(D_{FUS1} \neq 0\right) \\ 0 & \left(D_{FUS1} = 0\right) \end{cases} \qquad \text{(B78)}$$

$$\cos \alpha_{fus} = \begin{cases} \dfrac{U}{D_{FUS1}} & \left(D_{FUS1} \neq 0\right) \\ 1 & \left(D_{FUS1} = 0\right) \end{cases} \qquad \text{(B79)}$$

$$\alpha_{fus} = \begin{cases} \tan^{-1}\left(\dfrac{W_{FUS}}{U}\right) & \left(D_{FUS1} \neq 0\right) \\ 0 & \left(D_{FUS1} = 0\right) \end{cases} \qquad \text{(B80)}$$

Fuselage angle of sideslip

$$\sin \beta_{fus} = \begin{cases} \dfrac{V}{D_{FUS2}} & (D_{FUS2} \neq 0) \\ 0 & (D_{FUS2} = 0) \end{cases} \tag{B81}$$

$$\cos \beta_{fus} = \begin{cases} \dfrac{U}{D_{FUS2}} & (D_{FUS2} \neq 0) \\ 1 & (D_{FUS2} = 0) \end{cases} \tag{B82}$$

$$\beta_{fus} = \begin{cases} \tan^{-1}\left(\dfrac{V}{U}\right) & (D_{FUS2} \neq 0) \\ 0 & (D_{FUS2} = 0) \end{cases} \tag{B83}$$

Dynamic pressure

$$Q_{DPRES} = \frac{1}{2} \rho \left(U^2 + V^2 + W_{FUS}^2\right) \tag{B84}$$

Fuselage forces

$$X_{fus} = \begin{cases} -C_{FE} Q_{DPRES} & (U \geqq 0) \\ C_{FE} Q_{DPRES} & (U < 0) \end{cases} \tag{B85}$$

where the flat-plate drag of the fuselage (C_{FE}) is found from figure B3 as a function of the angles of attack and sideslip.

$$Y_{fus} = -C_{Y\beta} Q_{DPRES} \sin \beta_{fus} \tag{B86}$$

$$Z_{fus} = -C_{L\alpha} Q_{DPRES} \sin \alpha_{fus} \tag{B87}$$

Fuselage moments

$$L_{FUS} = -C_{L\beta} Q_{DPRES} \sin \beta_{fus} \left|\cos \beta_{fus}\right| \left(1 - \left|\sin \alpha_{fus}\right|\right) \tag{B88}$$

$$M_{FUS} = C_{M\alpha}QDPRES \sin \alpha_{fus} \cos \alpha_{fus} \tag{B89}$$

$$N_{FUS} = -C_{N\beta}QDPRES \sin \beta_{fus} \cos \beta_{fus}(0.94 \sin \alpha_{fus} + 0.342 \cos \alpha_{fus}) \tag{B90}$$

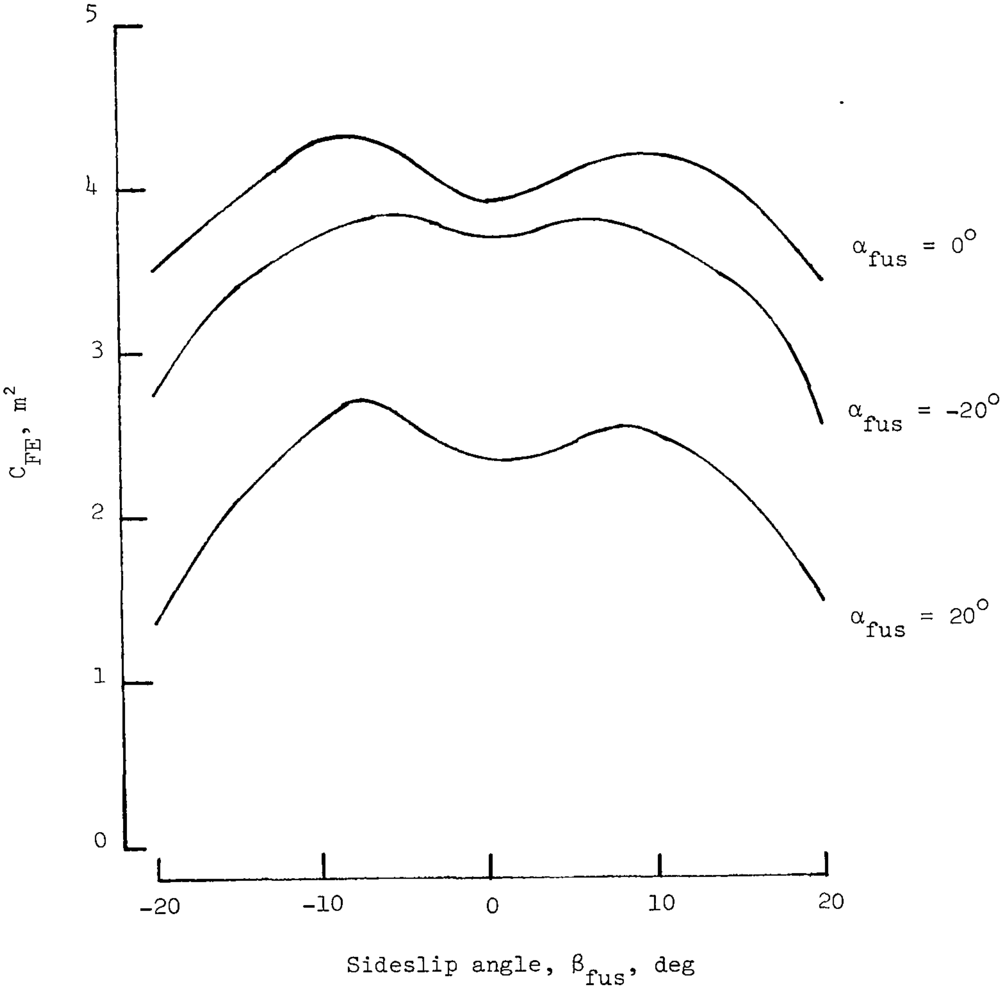


Figure B3.- Flat-plate drag area of fuselage as a function of angle of attack and sideslip angle.

VIII Total System Forces and Moments

Define the following:

$$C_{F1} = \sin \beta'_F \tag{B91a}$$

$$C_{F2} = \cos \beta'_F \tag{B91b}$$

$$C_{F3} = \sin i_F \tag{B91c}$$

$$C_{F4} = \cos i_F \tag{B91d}$$

$$C_{R1} = \sin \beta'_R \tag{B91e}$$

$$C_{R2} = \cos \beta'_R \tag{B91f}$$

$$C_{R3} = \sin i_R \tag{B91g}$$

$$C_{R4} = \cos i_R \tag{B91h}$$

Total forces

$$\begin{Bmatrix} F_X \\ F_Y \\ F_Z \end{Bmatrix} = \begin{Bmatrix} X_{fus} \\ Y_{fus} \\ Z_{fus} \end{Bmatrix} + \begin{bmatrix} -C_{F2}C_{F4} & -C_{F1}C_{F4} & C_{F3} \\ -C_{F1} & C_{F2} & 0 \\ -C_{F2}C_{F3} & -C_{F1}C_{F3} & -C_{F4} \end{bmatrix} \begin{Bmatrix} H_f \\ Y_f \\ T_f \end{Bmatrix}$$

$$+ \begin{bmatrix} -C_{R2}C_{R4} & C_{R1}C_{R4} & C_{R3} \\ -C_{R1} & -C_{R2} & 0 \\ -C_{R2}C_{R3} & C_{R1}C_{R3} & -C_{R4} \end{bmatrix} \begin{Bmatrix} H_r \\ Y_r \\ T_r \end{Bmatrix} \tag{B92}$$

Moments resulting from rotor forces

$$L_P = h_f(-C_{F1}H_f + C_{F2}Y_f) - h_r(C_{R1}H_r + C_{R2}Y_r) \tag{B93}$$

$$M_P = H_f(C_{F2}C_{F4}h_f + C_{F2}C_{F3}l_f) + H_r(C_{R2}C_{R4}h_r - C_{R2}C_{R3}l_r) + Y_f(C_{F1}C_{F4}h_f + C_{F1}C_{F3}l_f)$$

$$+ Y_r(-C_{R1}C_{R4}h_r + C_{R1}C_{R3}l_r) + T_f(-C_{F3}h_f + C_{F4}l_f) + T_r(-C_{R3}h_r - C_{R4}l_r) \tag{B94}$$

$$N_P = l_f(-C_{F1}H_f + C_{F2}Y_f) + l_r(C_{R1}H_r + C_{R2}Y_r) \tag{B95}$$

Total moments

$$\begin{Bmatrix} L \\ M \\ N \end{Bmatrix} = \begin{Bmatrix} L_{FUS} \\ M_{FUS} \\ N_{FUS} \end{Bmatrix} + \begin{Bmatrix} L_P \\ M_P \\ N_P \end{Bmatrix} + \begin{bmatrix} C_{F2}C_{F4} & -C_{F1}C_{F4} & -C_{F3} \\ C_{F1} & C_{F2} & 0 \\ C_{F2}C_{F3} & -C_{F1}C_{F3} & C_{F4} \end{bmatrix} \begin{Bmatrix} L_{HF} \\ M_{HF} \\ Q_{AEROF} \end{Bmatrix}$$

$$+ \begin{bmatrix} -C_{R2}C_{R4} & -C_{R1}C_{R4} & C_{R3} \\ -C_{R1} & C_{R2} & 0 \\ -C_{R2}C_{R3} & -C_{R1}C_{R3} & -C_{R4} \end{bmatrix} \begin{Bmatrix} L_{HR} \\ M_{HR} \\ Q_{AEROR} \end{Bmatrix} \qquad \text{(B96)}$$

APPENDIX C

CONSTANTS FOR CH-47B

Constants used in this report are for the center of gravity of the vehicle located at fuselage station line 338 (0.1778 m) aft and at water line 18.7 (1.309 m). Numerical values of these constants are as follows:

A_{ICFDR} = 125 deg/m (3.18 deg/in.)

A_{ICRDR} = 125 deg/m (3.18 deg/in.)

A_{ICFDS} = 75.2 deg/m (1.91 deg/in.)

A_{ICRDS} = -75.2 deg/m (-1.91 deg/in.)

$a_S = 5.75$

$b_S = 3$

$C_{L\alpha}$ = 32.5 m^2/rad (350 ft^2/rad)

$C_{L\beta}$ = 6.57 m^3/rad (232 ft^3/rad)

$C_{M\alpha}$ = 142 m^3/rad (5000 ft^3/rad)

$C_{N\beta}$ = 51.5 m^3/rad (1820 ft^3/rad)

$C_{Y\beta}$ = 43.4 m^2/rad (467 ft^2/rad)

e_S = 0.203 m (0.667 ft)

h_f = 2.093 m (6.867 ft)

h_r = 3.527 m (11.57 ft)

I_{XX} = 50 386.3 kg-m^2 (37 163 slug-ft^2)

I_{YY} = 273 536 kg-m^2 (201 750 slug-ft^2)

I_{ZZ} = 257 685 kg-m^2 (190 059 slug-ft^2)

I_{XZ} = 19 838.3 kg-m^2 (14 632 slug-ft^2)

$i_f = 9.0^\circ$

$i_r = 4.0^\circ$

l_f = 6.425 m (21.08 ft)

l_r = 5.450 m (17.88 ft)

M_W = 510.2 kg-m (114.7 slug-ft)

m = 14 968.6 kg (1 025.67 slug)

R_B = 9.144 m (30 ft)

$\gamma = 8.26$

$\delta_o = 0.0094$

θ_{FDB} = 24.2 deg/m (0.615 deg/in.)

θ_{RDB} = -24.2 deg/m (-0.615 deg/in.)

θ_{FDC} = 73.4 deg/m (1.864 deg/in.)

θ_{RDC} = 73.4 deg/m (1.864 deg/in.)

$\theta_T = -9.14^\circ$

$\theta_{TF} = 7.85^\circ$

$\theta_{TR} = 7.85^\circ$

$\rho = 1.227$ kg/m^3 (0.00238 slug/ft^3)

$\sigma = 0.067$

$\Omega_o = 24$ rad/sec

APPENDIX D

LINEAR PERTURBATION MODEL

This appendix presents the development of the linear perturbation model in both the coupled and uncoupled forms. For completeness, details are included which show the relationship of the nonlinear model and the perturbation linear model, the method of handling a general trim condition (nonstatic trim conditions), and the assumption required to arrive at the coupled and uncoupled models used in this report.

A nonlinear model of a vehicle can be considered as a transformation of the vehicle state $\vec{X}_T$ and control $\vec{\delta}_T$ into forces $\vec{F}_T$ and moments $\vec{M}_T$ applied to the vehicle (fig. D1(a)); that is,

$$\left.\begin{aligned} \vec{F}_T &= f_1\left(\vec{X}_T,\vec{\delta}_T\right) \\ \vec{M}_T &= f_2\left(\vec{X}_T,\vec{\delta}_T\right) \end{aligned}\right\} \tag{D1}$$

An equivalent representation of the vehicle motions, which is more convenient for control system design, is to have as outputs the rate of change of the state variables (see fig. D1(b)). The general nonlinear representation is

$$\dot{\vec{X}}_T = f\left(\vec{X}_T,\vec{\delta}_T\right) \tag{D2}$$

The transformation between equations (D1) and (D2) is given in reference 7. It is possible to represent equation (D2) by a series expanded about a nominal condition $\left(\vec{X}_N,\ \vec{\delta}_N\right)$ as

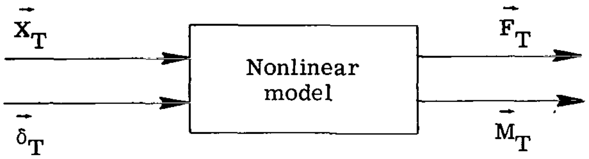
$$\dot{\vec{X}}_T = \dot{\vec{X}}_N + \left.\frac{\partial f}{\partial \vec{X}_T}\right|_{\substack{\vec{X}_T=\vec{X}_N \\ \vec{\delta}_T=\vec{\delta}_N}} \left(\vec{X}_T - \vec{X}_N\right) + \left.\frac{\partial f}{\partial \vec{\delta}_T}\right|_{\substack{\vec{X}_T=\vec{X}_N \\ \vec{\delta}_T=\vec{\delta}_N}} \left(\vec{\delta}_T - \vec{\delta}_N\right) + \text{Higher order terms} \tag{D3}$$

If the perturbations (fig. D1(c))

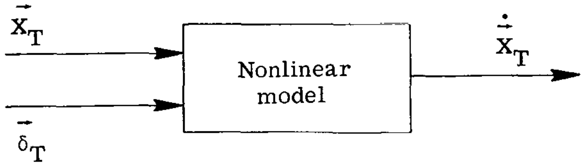
$$\vec{X}_P = \vec{X}_T - \vec{X}_N \tag{D4}$$

and

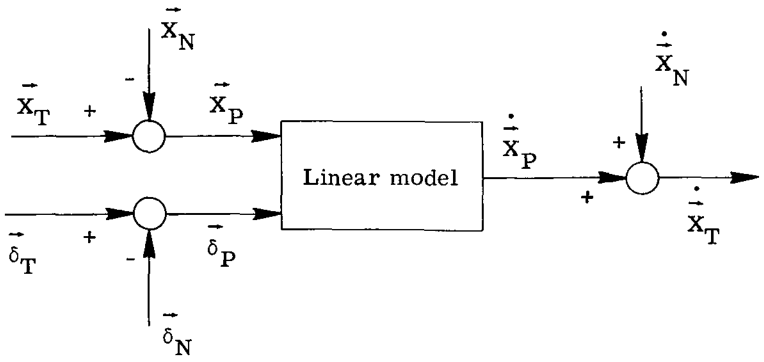
$$\vec{\delta}_P = \vec{\delta}_T - \vec{\delta}_N \tag{D5}$$



(a) Force and moment output of nonlinear model.



(b) Angular and linear acceleration output of nonlinear model.



(c) Angular and linear acceleration output of linear model.

Figure D1.- Nonlinear and linear representation of vehicle dynamics.

are sufficiently small, equation (D3) can be represented by

$$\dot{\vec{X}}_T = \dot{\vec{X}}_N + [A]\vec{X}_P + [B]\vec{\delta}_P \tag{D6}$$

where

$$[A] = \left.\frac{\partial f}{\partial \vec{X}_T}\right|_{\substack{\vec{X}_T=\vec{X}_N \\ \vec{\delta}_T=\vec{\delta}_N}} \tag{D7}$$

$$[B] = \left.\frac{\partial f}{\partial \vec{\delta}_T}\right|_{\substack{\vec{X}_T=\vec{X}_N \\ \vec{\delta}_T=\vec{\delta}_N}} \tag{D8}$$

In this report the state vector is defined by

$$\vec{X} = \begin{bmatrix} \vec{V}_B \\ \vec{\Omega}_B \\ \theta \\ \phi \end{bmatrix} \tag{D9}$$

where $\vec{V}_B = (U, \ V, \ W)^T$ is the vehicle linear velocity expressed in body coordinates, $\vec{\Omega}_B = (P, \ Q, \ R)^T$ is the vehicle body rate expressed in body coordinates, and θ and ϕ are the vehicle pitch and roll angles. The control vector $\vec{\delta}$ is given by

$$\vec{\delta} = \begin{bmatrix} \delta_B \\ \delta_C \\ \delta_S \\ \delta_R \end{bmatrix} \tag{D10}$$

where δ_B is differential collective stick, δ_C is collective stick, δ_S is cyclic stick, and δ_R is differential cyclic stick.

The nominal values $\vec{X}_N$, $\vec{\delta}_N$ and the coefficient matrices [A], [B] are functions of the flight condition. This report considers nonaccelerating and nonrotating flight paths, i.e., $\dot{\vec{X}}_N = 0$, for which the nominal state is given by

$$\vec{X}_N = \begin{bmatrix} U_N \\ V_N \\ W_N \\ 0 \\ 0 \\ 0 \\ \theta_N \\ \phi_N \end{bmatrix} \tag{D11}$$

For this condition, equation (D6) is given by

$$
\begin{bmatrix} \dot{U}_P \\ \dot{V}_P \\ \dot{W}_P \\ \dot{P}_P \\ \dot{Q}_P \\ \dot{R}_P \\ \dot{\theta}_P \\ \dot{\phi}_P \end{bmatrix}
=
\begin{bmatrix}
\frac{X_U}{m} & \frac{X_V}{m} & \frac{X_W}{m} & \frac{X_P}{m} & \left(\frac{X_Q}{m} - W_N\right) & \left(\frac{X_R}{m} + V_N\right) & -g \cos \theta_N & 0 \\
\frac{Y_U}{m} & \frac{Y_V}{m} & \frac{Y_W}{m} & \left(\frac{Y_P}{m} + W_N\right) & \frac{Y_Q}{m} & \left(\frac{Y_R}{m} - U_N\right) & -g \sin \theta_N \sin \phi_N & g \cos \phi_N \cos \theta_N \\
\frac{Z_U}{m} & \frac{Z_V}{m} & \frac{Z_W}{m} & \frac{Z_P}{m} & \left(\frac{Z_Q}{m} + U_N\right) & \frac{Z_R}{m} & -g \cos \theta_N & 0 \\
\left(\frac{I_1 L_U}{I_{XX}} + \frac{I_3 N_U}{I_{ZZ}}\right) & \left(\frac{I_1 L_V}{I_{XX}} + \frac{I_3 N_V}{I_{ZZ}}\right) & \left(\frac{I_1 L_W}{I_{XX}} + \frac{I_3 N_W}{I_{ZZ}}\right) & \left(\frac{I_1 L_P}{I_{XX}} + \frac{I_3 N_P}{I_{ZZ}}\right) & \left(\frac{I_1 L_Q}{I_{XX}} + \frac{I_3 N_Q}{I_{ZZ}}\right) & \left(\frac{I_1 L_R}{I_{XX}} + \frac{I_3 N_R}{I_{ZZ}}\right) & 0 & 0 \\
\frac{M_U}{I_{YY}} & \frac{M_V}{I_{YY}} & \frac{M_W}{I_{YY}} & \frac{M_P}{I_{YY}} & \frac{M_Q}{I_{YY}} & \frac{M_R}{I_{YY}} & 0 & 0 \\
\left(\frac{I_2 L_U}{I_{XX}} + \frac{I_1 N_U}{I_{ZZ}}\right) & \left(\frac{I_2 L_V}{I_{XX}} + \frac{I_1 N_V}{I_{ZZ}}\right) & \left(\frac{I_2 L_W}{I_{XX}} + \frac{I_1 N_W}{I_{ZZ}}\right) & \left(\frac{I_2 L_P}{I_{XX}} + \frac{I_1 N_P}{I_{ZZ}}\right) & \left(\frac{I_2 L_Q}{I_{XX}} + \frac{I_1 N_Q}{I_{ZZ}}\right) & \left(\frac{I_2 L_R}{I_{XX}} + \frac{I_1 N_R}{I_{ZZ}}\right) & 0 & 0 \\
0 & 0 & 0 & 0 & \cos \phi_N & -\sin \phi_N & 0 & 0 \\
0 & 0 & 0 & 1 & -\sin \phi_N \tan \theta_N & \cos \phi_N \tan \theta_N & 0 & 0
\end{bmatrix}
\begin{bmatrix} U_P \\ V_P \\ W_P \\ P_P \\ Q_P \\ R_P \\ \theta_P \\ \phi_P \end{bmatrix}
$$

$$+\begin{bmatrix} \frac{X_{\delta_B}}{m} & \frac{X_{\delta_C}}{m} & \frac{X_{\delta_S}}{m} & \frac{X_{\delta_R}}{m} \\ \frac{Y_{\delta_B}}{m} & \frac{Y_{\delta_C}}{m} & \frac{Y_{\delta_S}}{m} & \frac{Y_{\delta_R}}{m} \\ \frac{Z_{\delta_B}}{m} & \frac{Z_{\delta_C}}{m} & \frac{Z_{\delta_S}}{m} & \frac{Z_{\delta_R}}{m} \\ \left(\frac{I_1 L_{\delta_B}}{I_{XX}} + \frac{I_3 N_{\delta_B}}{I_{ZZ}}\right) & \left(\frac{I_1 L_{\delta_C}}{I_{XX}} + \frac{I_3 N_{\delta_C}}{I_{ZZ}}\right) & \left(\frac{I_1 L_{\delta_S}}{I_{XX}} + \frac{I_3 N_{\delta_S}}{I_{ZZ}}\right) & \left(\frac{I_1 L_{\delta_R}}{I_{XX}} + \frac{I_3 N_{\delta_R}}{I_{ZZ}}\right) \\ \frac{M_{\delta_B}}{I_{YY}} & \frac{M_{\delta_C}}{I_{YY}} & \frac{M_{\delta_S}}{I_{YY}} & \frac{M_{\delta_R}}{I_{YY}} \\ \left(\frac{I_2 L_{\delta_B}}{I_{XX}} + \frac{I_1 N_{\delta_B}}{I_{ZZ}}\right) & \left(\frac{I_2 L_{\delta_C}}{I_{XX}} + \frac{I_1 N_{\delta_C}}{I_{ZZ}}\right) & \left(\frac{I_2 L_{\delta_S}}{I_{XX}} + \frac{I_1 N_{\delta_S}}{I_{ZZ}}\right) & \left(\frac{I_2 L_{\delta_R}}{I_{XX}} + \frac{I_1 N_{\delta_R}}{I_{ZZ}}\right) \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \delta_{B,P} \\ \delta_{C,P} \\ \delta_{S,P} \\ \delta_{R,P} \end{bmatrix} \qquad \text{(D12)}$$

where

$$I_1 = \frac{I_{XX} I_{ZZ}}{I_{XX} I_{ZZ} - I_{XZ}^2} \qquad I_2 = \frac{I_{XX} I_{XZ}}{I_{XX} I_{ZZ} - I_{XZ}^2} \qquad I_3 = \frac{I_{ZZ} I_{XZ}}{I_{XX} I_{ZZ} - I_{XZ}^2}$$

Equation (D12) represents the coupled motion of the longitudinal variables (U, W, Q, θ) and the lateral variables (R, P, V, ϕ). Coupling refers to the fact that perturbations in longitudinal variables affect the rate of change of lateral variables and vice versa. For many vehicles this coupling is not strong enough to influence the motion of the vehicle. For these cases the cross derivatives and ϕ_N are assumed equal to zero, and the set of eight coupled equations can be written as two sets of four equations each. The longitudinal equations are

$$\begin{bmatrix} \dot{U}_P \\ \dot{W}_P \\ \dot{Q}_P \\ \dot{\theta}_P \end{bmatrix} = \begin{bmatrix} \frac{X_U}{m} & \frac{X_W}{m} & \left(\frac{X_Q}{m} - W_N\right) & -g \cos \theta_N \\ \frac{Z_U}{m} & \frac{Z_W}{m} & \left(U_N + \frac{Z_Q}{m}\right) & -g \sin \theta_N \\ \frac{M_U}{I_{YY}} & \frac{M_W}{I_{YY}} & \frac{M_Q}{I_{YY}} & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} U_P \\ W_P \\ Q_P \\ \theta_P \end{bmatrix} + \begin{bmatrix} \frac{X_{\delta_B}}{m} & \frac{X_{\delta_C}}{m} \\ \frac{Z_{\delta_B}}{m} & \frac{Z_{\delta_C}}{m} \\ \frac{M_{\delta_B}}{I_{YY}} & \frac{M_{\delta_C}}{I_{YY}} \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \delta_{B,P} \\ \delta_{C,P} \end{bmatrix} \tag{D13}$$

and the lateral equations are

$$\begin{bmatrix} \dot{P}_P \\ \dot{\phi}_P \\ \dot{R}_P \\ \dot{V}_P \end{bmatrix} = \begin{bmatrix} \left(\frac{I_1 L_P}{I_{XX}} + \frac{I_3 N_P}{I_{ZZ}}\right) & 0 & \left(\frac{I_1 L_R}{I_{XX}} + \frac{I_3 N_R}{I_{ZZ}}\right) & \left(\frac{I_1 L_V}{I_{XX}} + \frac{I_3 N_V}{I_{ZZ}}\right) \\ 1 & 0 & \tan \theta_N & 0 \\ \left(\frac{I_2 L_P}{I_{XX}} + \frac{I_1 N_P}{I_{ZZ}}\right) & 0 & \left(\frac{I_2 L_R}{I_{XX}} + \frac{I_1 N_R}{I_{ZZ}}\right) & \left(\frac{I_2 L_V}{I_{XX}} + \frac{I_1 N_V}{I_{ZZ}}\right) \\ \left(W_N + \frac{Y_P}{m}\right) & g \cos \theta_N & \left(\frac{Y_R}{m} - U_N\right) & \frac{Y_V}{m} \end{bmatrix} \begin{bmatrix} P_P \\ \phi_P \\ R_P \\ V_P \end{bmatrix}$$

$$+ \begin{bmatrix} \left(\frac{I_1 L_{\delta_S}}{I_{XX}} + \frac{I_3 N_{\delta_S}}{I_{ZZ}}\right) & \left(\frac{I_1 L_{\delta_R}}{I_{XX}} + \frac{I_3 N_{\delta_R}}{I_{ZZ}}\right) \\ 0 & 0 \\ \left(\frac{I_2 L_{\delta_S}}{I_{XX}} + \frac{I_1 N_{\delta_S}}{I_{ZZ}}\right) & \left(\frac{I_2 L_{\delta_R}}{I_{XX}} + \frac{I_1 N_{\delta_R}}{I_{ZZ}}\right) \\ Y_{\delta_S} & Y_{\delta_R} \end{bmatrix} \begin{bmatrix} \delta_{S,P} \\ \delta_{R,P} \end{bmatrix} \tag{D14}$$

APPENDIX E

TRIM AND DERIVATIVE DATA

A complete set of trims and derivatives are shown in tables E1 and E2 for sea-level conditions and for the flight envelope $-40 \leqq \dot{X} \leqq 160$ knots and $-10.16 \leqq \dot{Z} \leqq 10.16$ m/sec (±2000 ft/min). The trims and derivatives are given in the International System of Units (SI) in table E1 and in the U.S. Customary Units in table E2. These data are based upon a center of gravity of 0.1778 m (7 in.) aft of the vehicle reference point. All of the force derivatives are normalized by m, the rolling moments by I_{XX}, the pitching moments by I_{YY}, and the yawing moments by I_{ZZ}. Values for m, I_{XX}, I_{YY}, and I_{ZZ} are given in appendix C.

APPENDIX E

TABLE E1.- STABILITY DERIVATIVES AND TRIMS IN SI UNITS

(a) $\dot{Z}$ = -10.16 m/sec

Parameter	Unit	Value of parameter at $\dot{X}$, knots, of										
		-40	-20	*0	20	40	60	80	100	120	140	160
XU/M	1/SEC	-.05118	-.04400	-.02862	-.01680	-.02032	-.02594	-.03059	-.03473	-.04149	-.04742	-.05539
XV/M	1/SEC	-.00316	-.01169	-.01371	.00564	.00121	-.00002	-.00079	-.00162	-.00288	-.00477	-.00513
XW/M	1/SEC	.07545	.05547	.04517	.04082	.03871	.03191	.02074	.00780	.00789	.00078	-.02732
XDB/M	M/SEC2-CM	.01918	.01697	.01553	.01487	.01500	.01626	.01791	.01900	.01482	.01011	.00564
XDC/M	M/SEC2-CM	.13678	.15531	.11862	.08708	.06104	.03524	.00431	-.02974	-.03572	-.05857	-.13284
XDS/M	M/SEC2-CM	-.00016	-.00011	-.00008	-.00006	-.00004	-.00003	-.00002	-.00001	-.00001	.00000	.00009
XDR/M	M/SEC2-CM	-.00008	-.00007	-.00005	-.00005	-.00004	-.00004	-.00005	-.00006	-.00005	-.00004	-.00004
XP/M	M/SEC	.01926	.02064	.00564	-.00799	-.00252	-.00020	.00109	.00231	.00278	.00309	.00463
XQ/M	M/SEC	.76153	.79626	.79645	.78184	.77235	.76694	.77209	.79581	.87197	.96536	1.10221
XR/M	M/SEC	-.07117	-.06570	-.03817	-.01258	-.01370	-.01822	-.02306	-.02841	-.03077	-.03737	-.05997
YU/M	1/SEC	-.00225	-.00344	-.00123	.00119	.00041	.00034	.00057	.00090	.00101	.00096	.00059
YV/M	1/SEC	-.11966	-.14226	-.18665	-.14146	-.09535	-.09455	-.10600	-.12218	-.13994	-.16058	-.18770
YW/M	1/SEC	.00450	.00418	.00458	.00500	.00532	.00530	.00527	.00536	.00493	.00431	.00217
YDB/M	M/SEC2-CM	.00051	.00094	.00180	.00272	.00353	.00330	.00220	.00044	-.00323	-.00895	-.01821
YDC/M	M/SEC2-CM	.01027	.00995	.01006	.01032	.01042	.01040	.01055	.01113	.01158	.01180	.00891
YDS/M	M/SEC2-CM	.14351	.14292	.14206	.14108	.14012	.14074	.14245	.14521	.14804	.15221	.16207
YDR/M	M/SEC2-CM	-.01111	-.00876	-.00595	-.00363	-.00272	-.00269	-.00269	-.00166	.00314	.00834	.01394
YP/M	M/SEC	-.30831	-.25760	-.23872	-.25198	-.29764	-.33275	-.34790	-.34348	-.31788	-.27377	-.22010
YQ/M	M/SEC	-.02122	-.01473	-.00350	.00682	.01063	.02620	.04924	.07640	.11715	.17723	.26581
YR/M	M/SEC	-.03134	-.02845	-.02546	-.02582	-.03196	-.03623	-.03820	-.03883	-.04011	-.04043	-.04252
ZU/M	1/SEC	.15413	.13780	.03773	-.05601	-.05338	-.03476	-.02517	-.02305	.00183	.02673	.03788
ZV/M	1/SEC	-.00626	-.00078	.00158	.00090	-.01156	-.00109	.00022	.00112	.00174	.00206	.00555
ZW/M	1/SEC	-.51[illegible]	-.42980	-.41575	-.45665	-.54146	-.61615	-.68038	-.73471	-.71791	-.66132	-.58574
ZDB/M	M/SEC2-CM	-.02214	-.00913	.00304	.01509	.02777	.03610	.03903	.03895	.03301	.01970	.04195
ZDC/M	M/SEC2-CM	-1.08496	-1.03300	-1.02115	-1.04593	-1.10786	-1.19634	-1.29057	-1.38496	-1.37363	-1.24820	-1.09836
ZDS/M	M/SEC2-CM	.00094	.00070	.00071	.00067	.00063	.00065	.00073	.00090	.00097	.00108	.00145
ZDR/M	M/SEC2-CM	.00014	.00003	-.00001	-.00004	-.00006	-.00009	-.00014	-.00014	-.00009	-.00013	-.00033
ZP/M	M/SEC	-.05598	-.03927	-.00398	.02114	.00735	.00459	.01102	.02000	.02502	.03973	.04311
ZQ/M	M/SEC	.33475	.15606	.15864	.16958	.00793	-.05761	-.01809	.06371	.07813	.09258	-.07103
ZR/M	M/SEC	.26132	.25663	.01013	-.23649	-.24156	-.22261	-.20842	-.21137	-.21852	-.22176	-.23920
LU/IXX	1/SEC-M	-.00188	-.00208	-.00175	-.00119	-.00067	-.00028	.00013	.00059	.00038	.00078	.00119
LV/IXX	1/SEC-M	-.02410	-.02431	-.02395	-.02340	-.02503	-.02335	-.02451	-.02586	-.02818	-.03199	-.03906
LW/IXX	1/SEC-M	.00121	.00135	.00151	.00173	.00229	.00285	.00330	.00372	.00452	.00573	.00604
LDB/IXX	1/SEC2-CM	-.01558	-.01509	-.01369	-.01167	-.00920	-.00803	-.00805	-.00913	-.01259	-.01890	-.02971
LDC/IXX	1/SEC2-CM	-.00459	-.00587	-.00677	-.00734	-.00761	-.00779	-.00794	-.00797	-.00710	-.00509	-.00609
LDS/IXX	1/SEC2-CM	.16768	.16708	.16601	.16490	.15399	.16449	.16592	.16810	.16985	.17266	.18019
LDR/IXX	1/SEC2-CM	-.06014	-.05704	-.05530	-.05303	-.05194	-.05213	-.05273	-.05285	-.04984	-.04696	-.04573
LP/IXX	1/SEC	-.59483	-.54596	-.51947	-.51926	-.54922	-.57182	-.57709	-.56336	-.52459	-.46679	-.39543
LQ/IXX	1/SEC	.15014	.14503	.14176	.13165	.10961	.09877	.09740	.10394	.13124	.17750	.24050
LR/IXX	1/SEC	-.03513	-.03152	-.02967	-.03047	-.03480	-.03759	-.03817	-.03692	-.03457	-.02936	-.02151
MU/IYY	1/SEC-M	.00089	.00342	.00454	.00513	-.00197	-.00765	-.00962	-.00966	-.00775	-.00531	-.00781
MV/IYY	1/SEC-M	.00722	.00865	-.00048	-.00842	-.00579	-.00254	.00045	.00325	.00588	.00773	.00992
MW/IYY	1/SEC-M	-.02318	-.00837	.00555	.01967	.03499	.04344	.04789	.05154	.04906	.04837	.03509
MDB/IYY	1/SEC2-CM	.14668	.14176	.13999	.14128	.14585	.15433	.16326	.17182	.16469	.14786	.12297
MDC/IYY	1/SEC2-CM	-.01194	.00341	.00876	.01763	.03145	.04666	.05773	.06581	.06222	.06228	.03008
MDS/IYY	1/SEC2-CM	.00001	-.00000	-.00001	-.00001	-.00002	-.00002	-.00003	-.00004	-.00004	-.00004	-.00003
MDR/IYY	1/SEC2-CM	-.00064	-.00054	-.00049	-.00045	-.00042	-.00042	-.00048	-.00057	-.00060	-.00064	-.00085
MP/IYY	1/SEC	.02734	.01360	-.00252	-.03813	-.03030	-.01752	-.00516	.00600	.01514	.02173	.02788
MQ/IYY	1/SEC	-1.52788	-1.39708	-1.35265	-1.39397	-1.52040	-1.63108	-1.70365	-1.75387	-1.65610	-1.46228	-1.23556
MR/IYY	1/SEC	-.00317	-.00371	-.00456	-.00908	-.01362	-.01562	-.01186	-.00608	-.00152	.00333	.00451
NU/IZZ	1/SEC-M	.00097	.00170	.00214	.00212	.00146	.00101	.00083	.00072	.00048	.00016	-.00083
NV/IZZ	1/SEC-M	-.00646	-.01164	-.00361	.00497	.00141	.00034	-.00026	-.00068	-.00121	-.00154	-.00113
NW/IZZ	1/SEC-M	.00117	.00113	.00115	.00128	.00122	.00067	-.00006	-.00103	-.00377	-.00823	-.01524
NDB/IZZ	1/SEC2-CM	.02428	.02565	.02604	.02543	.02383	.02289	.02270	.02340	.02488	.02766	.03215
NDC/IZZ	1/SEC2-CM	-.00165	-.00043	.00075	.00204	.00355	.00488	.00580	.00627	.00399	-.00199	-.01258
NDS/IZZ	1/SEC2-CM	.00276	.00324	.00379	.00424	.00440	.00443	.00448	.00476	.00584	.00703	-.00847
NDR/IZZ	1/SEC2-CM	.08262	.08235	.08194	.08144	.08093	.08128	.08226	.08387	.08562	.08813	.09388
NP/IZZ	1/SEC	.03740	.02549	.00744	-.01049	-.02254	-.03137	-.04039	-.05300	-.07687	-.10728	-.14998
NQ/IZZ	1/SEC	-.21913	-.23281	-.23718	-.23246	-.21888	-.20645	-.19817	-.19464	-.17704	-.16343	-.15835
NR/IZZ	1/SEC	-.04328	-.04433	-.04551	-.04667	-.04736	-.04848	-.05025	-.05339	-.05964	-.06983	-.08899
DB	CM	-.46739	-.41465	-.62476	-.86673	-.90896	-.46995	.23976	1.02924	1.69096	2.52938	3.41746
DC	CM	14.14760	14.79175	14.93655	14.63157	13.87630	13.55224	13.73655	14.42087	15.52704	17.46014	20.83610
DS	CM	.77156	.82217	.83481	.81430	.76557	.72156	.68374	.65429	.67236	.76897	.97146
DR	CM	.61770	.41501	.18876	-.03330	-.22140	-.47687	-.79275	-1.16655	-1.61519	-2.18413	-3.07758
THEN	DEG.	9.41930	7.96786	6.61948	5.30248	4.02516	2.59770	.91870	-.87356	-1.33030	-2.40688	-6.17521
PHIN	DEG.	-.53696	-.56449	-.56340	-.57188	-.54815	-.52384	-.51905	-.53071	-.56499	-.62282	-.70425

* DERIVED BY FITTING A THIRD ORDER CURVE THROUGH -40, -20, +20 AND +40 VALUES.

APPENDIX E

TABLE E1.- Continued

(b) $\dot{Z}$ = -7.62 m/sec

Parameter	Unit	Value of parameter at $\dot{X}$, knots, of										
		-40	-20	*0	20	40	60	80	100	120	140	160
XU/M	1/SEC	-.05033	-.04387	-.02686	-.01355	-.01818	-.02447	-.02928	-.03329	-.03977	-.04612	-.05283
XV/M	1/SEC	-.06115	-.00711	-.00238	.00340	.00060	-.00015	-.00064	-.00126	-.00216	-.00379	-.00591
XW/M	1/SEC	.07103	.05143	.04213	.03923	.03884	.03340	.02340	.01158	.01419	.00531	-.01981
XDB/M	M/SEC2-CM	.01934	.01672	.01510	.01440	.01453	.01599	.01785	.01914	.01618	.01039	.00775
XDC/M	M/SEC2-CM	.19172	.15236	.11679	.08636	.06240	.03930	.01106	-.02022	-.02101	-.04592	-.11329
XDS/M	M/SEC2-CM	-.00011	-.00008	-.00006	-.00004	-.00003	-.00002	-.00002	-.00001	-.00001	-.00001	.00005
XDR/M	M/SEC2-CM	-.00007	-.00005	-.00004	-.00003	-.00003	-.00003	-.00003	-.00004	-.00004	-.00003	-.00005
XP/M	M/SEC	.02092	.01995	.00589	-.00625	-.00149	.00010	.00095	.00190	.00241	.00271	.00418
XQ/M	M/SEC	.73977	.78983	.79333	.77614	.76412	.75377	.75361	.77163	.82287	.92910	1.04199
XR/M	M/SEC	-.06813	-.06460	-.03412	-.00550	-.00756	-.01297	-.01772	-.02228	-.02343	-.02942	-.04769
YU/M	1/SEC	-.00169	-.00265	-.00087	.00100	.00032	.00024	.00048	.00079	.00101	.00087	.00086
YV/M	1/SEC	-.19873	-.17212	-.16982	-.13168	-.08753	-.08844	-.10083	-.11743	-.13536	-.15579	-.18139
YW/M	1/SEC	.00380	.00379	.00403	.00440	.00476	.00467	.00457	.00464	.00504	.00371	.00331
YDB/M	M/SEC2-CM	-.00080	.00028	.00170	.00314	.00429	.00407	.00290	.00119	-.00165	-.00760	-.01475
YDC/M	M/SEC2-CM	.00914	.00926	.00946	.00956	.00938	.00918	.00916	.00963	.01084	.00999	.00960
YDS/M	M/SEC2-CM	.14194	.14176	.14102	.13991	.13863	.13894	.14024	.14248	.14469	.14813	.15697
YDR/M	M/SEC2-CM	-.01089	-.00880	-.00608	-.00386	-.00325	-.00363	-.00406	-.00550	.00075	.00537	.01041
YP/M	M/SEC	-.37556	-.31749	-.29619	-.31208	-.36558	-.40430	-.41941	-.41283	-.38257	-.33250	-.27528
YQ/M	M/SEC	-.01093	-.00672	-.00208	.00185	.00394	.01955	.04312	.06976	.10004	.16326	.23488
YR/M	M/SEC	-.03982	-.03503	-.03178	-.03239	-.03919	-.04362	-.04527	-.04525	-.04510	-.04394	-.04369
ZU/M	1/SEC	.16121	.15090	.03464	-.07480	-.06464	-.04075	-.02741	-.02259	-.00052	.03022	.03086
ZV/M	1/SEC	-.00716	-.00141	.00089	.00059	-.00144	-.00031	.00100	.00172	.00175	.00240	.00256
ZW/M	1/SEC	-.48786	-.40112	-.38687	-.43138	-.52093	-.60080	-.66904	-.72574	-.72914	-.65092	-.61676
ZDB/M	M/SEC2-CM	-.02511	-.01007	.00317	.01629	.03094	.04012	.04280	.04221	.02933	.02545	.02690
ZDC/M	M/SEC2-CM	-1.06861	-1.01756	-1.00459	-1.02904	-1.09026	-1.18098	-1.27864	-1.37613	-1.40014	-1.23035	-1.18302
ZDS/M	M/SEC2-CM	.00068	.00057	.00050	.00044	.00040	.00041	.00046	.00059	.00068	.00076	.00118
ZDR/M	M/SEC2-CM	.00009	.00003	-.00001	-.00003	-.00004	-.00005	-.00010	-.00008	-.00002	-.00010	-.00014
ZP/M	M/SEC	-.07680	-.05216	-.01030	.01553	-.00794	-.00702	.00237	.01234	.01842	.02429	.03256
ZQ/M	M/SEC	.39184	.15353	.15359	.16028	-.05816	-.12570	-.07760	.00925	.22471	.05161	.13783
ZR/M	M/SEC	.27983	.28051	.00861	-.26418	-.26616	-.23066	-.20348	-.19705	-.20261	-.19576	-.22072
LU/IXX	1/SEC-M	-.00172	-.00200	-.00161	-.00099	-.00057	-.00031	.00003	.00044	.00026	.00054	.00114
LV/IXX	1/SEC-M	-.02264	-.02301	-.02282	-.02232	-.02176	-.02193	-.02276	-.02414	-.02621	-.02964	-.03562
LW/IXX	1/SEC-M	.00163	.00152	.00153	.00183	.00261	.00326	.00368	.00402	.00529	.00555	.00691
LDB/IXX	1/SEC2-CM	-.01503	-.01429	-.01249	-.00995	-.00697	-.00559	-.00549	-.00636	-.00893	-.01542	-.02409
LDC/IXX	1/SEC2-CM	-.00402	-.00542	-.00636	-.00687	-.00695	-.00693	-.00698	-.00702	-.00576	-.00493	-.00474
LDS/IXX	1/SEC2-CM	.16654	.16612	.16516	.16395	.16281	.16312	.16425	.16605	.16736	.16964	.17638
LDR/IXX	1/SEC2-CM	-.05939	-.05758	-.05506	-.05282	-.05187	-.05229	-.05311	-.05343	-.05066	-.04802	-.04690
LP/IXX	1/SEC	-.64632	-.59328	-.56592	-.56888	-.60679	-.63365	-.64013	-.62600	-.58538	-.52507	-.45372
LQ/IXX	1/SEC	.14216	.13825	.12938	.11315	.08715	.07420	.07201	.07753	.09734	.14880	.20010
LR/IXX	1/SEC	-.04261	-.03797	-.03559	-.03646	-.04158	-.04487	-.04553	-.04410	-.04110	-.03545	-.02700
MU/IYY	1/SEC-M	.00268	.00667	.00837	.00625	-.00120	-.00831	-.01019	-.00999	-.00681	-.00558	-.00519
MV/IYY	1/SEC-M	.00656	.00708	-.00021	-.00692	-.00468	-.00189	.00063	.00299	.00540	.00669	.00876
MW/IYY	1/SEC-M	-.02711	-.00994	.00571	.02145	.03885	.04637	.04953	.05227	.05706	.04585	.04878
MDB/IYY	1/SEC2-CM	.14508	.13969	.13769	.13918	.14425	.15382	.16332	.17213	.17171	.14651	.13646
MDC/IYY	1/SEC2-CM	-.01251	.00102	.00851	.01661	.03198	.04884	.05965	.06690	.06948	.05518	.04323
MDS/IYY	1/SEC2-CM	.00001	-.00000	-.00000	-.00001	-.00001	-.00001	-.00002	-.00003	-.00004	-.00003	-.00005
MDR/IYY	1/SEC2-CM	-.00047	-.00040	-.00035	-.00038	-.00026	-.00026	-.00030	-.00038	-.00042	-.00045	-.00070
MP/IYY	1/SEC	.03643	.04190	-.00240	-.04582	-.03770	-.02255	-.00915	.00204	.01100	.01720	.02440
MQ/IYY	1/SEC	-1.52562	-1.36512	-1.31090	-1.36209	-1.51781	-1.63613	-1.70785	-1.75547	-1.74017	-1.45782	-1.32729
MR/IYY	1/SEC	-.01319	-.00270	-.00330	-.01025	-.01880	-.02036	-.01519	-.00863	-.00153	.00121	.00744
NU/IZZ	1/SEC-M	.00076	.00155	.00202	.00199	.00127	.00088	.00077	.00068	.00052	.00016	-.00049
NV/IZZ	1/SEC-M	-.00590	-.01050	-.00307	.00473	.00127	.00019	-.00046	-.00094	-.00152	-.00193	-.00174
NW/IZZ	1/SEC-M	.00137	.00098	.00105	.00121	.00109	.00051	-.00017	-.00086	-.00281	-.00709	-.01230
NDB/IZZ	1/SEC2-CM	.02153	.02331	.02385	.02314	.02117	.01989	.01939	.01980	.02127	.02358	.02831
NDC/IZZ	1/SEC2-CM	-.00184	-.00057	.00062	.00189	.00335	.00458	.00549	.00612	.00489	-.00095	-.00835
NDS/IZZ	1/SEC2-CM	.00277	.00319	.00373	.00416	.00425	.00419	.00413	.00431	.00525	.00630	.00759
NDR/IZZ	1/SEC2-CM	.08175	.08170	.08135	.08078	.08007	.08024	.08097	.08227	.08365	.08574	.09090
NP/IZZ	1/SEC	.03068	.02154	.00544	-.01082	-.02047	-.02704	-.03383	-.04389	-.06407	-.08988	-.12650
NQ/IZZ	1/SEC	-.19053	-.20835	-.21434	-.20859	-.19118	-.17488	-.16413	-.15930	-.14690	-.13211	-.13531
NR/IZZ	1/SEC	-.04228	-.04328	-.04432	-.04511	-.04536	-.04581	-.04696	-.04939	-.05442	-.06299	-.07875
DB	CM	-.12671	-.23046	-.65125	-1.10181	-1.29485	-.82341	-.05616	.76096	1.40680	1.98255	2.95622
DC	CM	12.94367	13.71754	13.92011	13.55557	12.62809	12.19190	12.29597	12.91102	13.95141	15.78485	18.93929
DS	CM	.68047	.74073	.75980	.74143	.68937	.64298	.60313	.57233	.58704	.67066	.83186
DR	CM	.45733	.32825	.18113	.03514	-.09058	-.31788	-.60984	-.94845	-1.33742	-1.82713	-2.60270
THEN	DEG.	9.26035	7.92430	6.61524	5.34968	4.14412	2.78578	1.17638	-.53930	-.92517	-1.90961	-5.45690
PHIN	DEG.	-.48783	-.51836	-.53898	-.55565	-.49431	-.46426	-.45899	-.47303	-.51179	-.57628	-.66222

* DERIVED BY FITTING A THIRD ORDER CURVE THROUGH -40, -20, +20 AND +40 VALUES.

APPENDIX E

TABLE E1.- Continued

(c) $\dot{Z}$ = -5.08 m/sec

Parameter	Unit	Value of parameter at $\dot{X}$, knots, of										
		-40	-20	*0	20	40	60	80	100	120	140	160
XU/M	1/SEC	-.04972	-.04402	-.02511	-.01009	-.01604	-.02307	-.02806	-.03200	-.03833	-.04501	-.05093
XV/M	1/SEC	.00001	-.00391	-.00149	.00175	.00026	-.00011	-.00037	-.00078	-.00138	-.00267	-.00576
XW/M	1/SEC	.06619	.04724	.03904	.03759	.03889	.03484	.02603	.01535	.02025	.01025	-.01344
XDB/M	M/SEC2-CM	.01960	.01647	.01466	.01393	.01405	.01573	.01781	.01930	.01720	.01105	.00828
XDC/M	M/SEC2-CM	.18657	.14963	.11510	.08556	.06361	.04331	.01783	-.01063	-.00611	-.03192	-.09554
XDS/M	M/SEC2-CM	-.00007	-.00005	-.00004	-.00002	-.00002	-.00001	-.00001	-.00001	-.00001	-.00001	.00003
XDR/M	M/SEC2-CM	-.00004	-.00003	-.00002	-.00002	-.00001	-.00001	-.00002	-.00002	-.00003	-.00002	-.00003
XP/M	M/SEC	.02401	.02065	.00662	-.00488	-.00063	.00029	.00072	.00142	.00198	.00227	.00337
XQ/M	M/SEC	.71614	.78342	.79144	.77187	.75721	.74147	.73600	.74840	.79452	.89413	1.00264
XR/M	M/SEC	-.06764	-.06472	-.03035	.00153	-.00300	-.00961	-.01295	-.01677	-.01745	-.02253	-.03727
YU/M	1/SEC	-.00139	-.00208	-.00060	.00090	.00024	.00013	.00039	.00071	.00094	.00084	.00071
YV/M	1/SEC	-.09938	-.15574	-.15610	-.12340	-.08054	-.08301	-.09629	-.11328	-.13143	-.15165	-.17610
YW/M	1/SEC	.00324	.00520	.00348	.00391	.00434	.00412	.00391	.00395	.00463	.00338	.00238
YDB/M	M/SEC2-CM	-.00202	-.00044	.00159	.00362	.00514	.00480	.00347	.00172	-.00047	-.00638	-.01247
YDC/M	M/SEC2-CM	.00804	.00857	.00886	.00883	.00839	.00800	.00779	.00814	.01007	.00892	.00842
YDS/M	M/SEC2-CM	.14055	.14080	.14018	.13893	.13731	.13730	.13815	.13985	.14146	.14418	.15206
YDR/M	M/SEC2-CM	-.01063	-.00896	-.00622	-.00406	-.00375	-.00455	-.00544	-.00535	-.00166	.00236	.00681
YP/M	M/SEC	-.44258	-.37598	-.35182	-.37074	-.43333	-.47619	-.49124	-.48224	-.44707	-.39057	-.32907
YQ/M	M/SEC	-.00118	.00082	-.00072	-.00277	-.00327	.01326	.03825	.06503	.09274	.15171	.21097
YR/M	M/SEC	-.04767	-.04160	-.03790	-.03882	-.04662	-.05145	-.05261	-.05174	-.05048	-.04753	-.04597
ZU/M	1/SEC	.16925	.16588	.03148	-.09572	-.07749	-.04789	-.03020	-.02241	-.00280	.03274	.02714
ZV/M	1/SEC	-.00722	-.00162	.00072	.00082	-.00032	.00107	.00206	.00242	.00244	.00281	.00464
ZW/M	1/SEC	-.46335	-.37131	-.35751	-.40558	-.49832	-.58473	-.65759	-.71686	-.74411	-.64564	-.64701
ZDB/M	M/SEC2-CM	-.02855	-.01098	.00333	.01749	.03463	.04474	.04696	.04573	.03110	.02726	.04565
ZDC/M	M/SEC2-CM	-1.05129	-1.00181	-.98931	-1.01285	-1.07150	-1.16389	-1.26538	-1.36624	-1.42338	-1.22658	-1.21618
ZDS/M	M/SEC2-CM	.00046	.00038	.00030	.00025	.00020	.00020	.00024	.00034	.00039	.00046	.00096
ZDR/M	M/SEC2-CM	.00007	.00002	-.00001	-.00003	-.00005	-.00004	-.00003	-.00004	-.00001	-.00009	-.00028
ZP/M	M/SEC	-.10367	-.07023	-.02112	.00611	-.02608	-.02036	-.00681	.00473	.01106	.01827	.03614
ZQ/M	M/SEC	.46499	.15855	.14755	.11410	-.13957	-.19959	-.13886	-.04646	.14322	.01063	-.19385
ZR/M	M/SEC	.30542	.31077	.00018	-.29995	-.26321	-.19440	-.18451	-.18470	-.18294	-.17223	-.21324
LU/IXX	1/SEC-M	-.00158	-.01194	-.00144	-.00073	-.00048	-.00039	-.00011	.00027	.00003	.00033	.00065
LV/IXX	1/SEC-M	-.02122	-.02182	-.02178	-.02129	-.02054	-.02057	-.02127	-.02252	-.02441	-.02750	-.03265
LW/IXX	1/SEC-M	.00185	.00158	.00154	.00197	.00311	.00382	.00416	.00443	.00558	.00565	.00554
LDB/IXX	1/SEC2-CM	-.01453	-.01363	-.01139	-.00827	-.00472	-.00320	-.00305	-.00379	-.00563	-.01210	-.01944
LDC/IXX	1/SEC2-CM	-.00351	-.00502	-.00609	-.00642	-.00625	-.00593	-.00587	-.00590	-.00426	-.00400	-.00483
LDS/IXX	1/SEC2-CM	.16534	.16532	.16447	.16316	.16177	.16186	.16268	.16409	.16496	.16672	.17273
LDR/IXX	1/SEC2-CM	-.05869	-.05730	-.05488	-.05264	-.05182	-.05248	-.05353	-.05405	-.05154	-.04914	-.04819
LP/IXX	1/SEC	-.69755	-.63945	-.61095	-.61745	-.66429	-.69571	-.70323	-.68840	-.64553	-.58229	-.50997
LQ/IXX	1/SEC	.13520	.13108	.11838	.09605	.06460	.04995	.04770	.05286	.07124	.12280	.16163
LR/IXX	1/SEC	-.05003	-.04422	-.04119	-.04217	-.04844	-.05242	-.05301	-.05123	-.04777	-.04132	-.03328
MU/IYY	1/SEC-M	.00436	.01984	.01345	.01020	-.00088	-.00948	-.01100	-.01041	-.00715	-.00551	-.00724
MV/IYY	1/SEC-M	.00573	.00573	.00004	-.00510	-.00342	-.00123	.00080	.00274	.00472	.00574	.00810
MW/IYY	1/SEC-M	-.03238	-.01196	.00605	.02391	.04387	.04977	.05132	.05304	.05808	.04529	.03672
MDB/IYY	1/SEC2-CM	.14351	.13751	.13529	.13697	.14268	.15354	.16358	.17258	.17779	.14685	.14237
MDC/IYY	1/SEC2-CM	-.01351	.00219	.00824	.01502	.03275	.05172	.06201	.06824	.07619	.05421	.03725
MDS/IYY	1/SEC2-CM	.00000	-.00000	-.00000	-.00000	-.00001	-.00001	-.00001	-.00001	-.00002	-.00002	-.00001
MDR/IYY	1/SEC2-CM	-.00031	-.00026	-.00022	-.00017	-.00014	-.00013	-.00015	-.00021	-.00025	-.00029	-.00056
MP/IYY	1/SEC	.04726	.05177	-.00231	-.05489	-.04588	-.02774	-.01296	-.00160	.00717	.01310	.02291
MQ/IYY	1/SEC	-1.53243	-1.33744	-1.27220	-1.33496	-1.52399	-1.64610	-1.71462	-1.75868	-1.74931	-1.45384	-1.41351
MR/IYY	1/SEC	-.01843	-.00283	-.00458	-.01302	-.01750	-.01806	-.01523	-.01126	-.00415	-.00077	-.00163
NU/IZZ	1/SEC-M	.00051	.00135	.00186	.00184	.00108	.00082	.00076	.00069	.00057	.00019	-.00031
NV/IZZ	1/SEC-M	-.00543	-.00959	-.00264	.00455	.00113	.00003	-.00066	-.00120	-.00182	-.00227	-.00224
NW/IZZ	1/SEC-M	.00138	.00088	.00095	.00110	.00082	.00016	-.00035	-.00087	-.00218	-.00600	-.01016
NDB/IZZ	1/SEC2-CM	.01888	.02112	.02183	.02099	.01861	.01692	.01608	.01622	.01761	.01966	.02397
NDC/IZZ	1/SEC2-CM	-.00194	-.00068	.00050	.00171	.00305	.00405	.00488	.00565	.00536	.00009	-.00560
NDS/IZZ	1/SEC2-CM	.00278	.00315	.00368	.00410	.00411	.00395	.00379	.00385	.00466	.00557	.00671
NDR/IZZ	1/SEC2-CM	.08096	.08115	.08087	.08022	.07930	.07928	.07974	.08071	.08174	.08340	.08802
NP/IZZ	1/SEC	.02324	.01752	.00351	-.01103	-.01831	-.02288	-.02765	-.03532	-.05220	-.07347	-.10472
NQ/IZZ	1/SEC	-.16279	-.18593	-.19391	-.18670	-.16426	-.14334	-.12999	-.12401	-.11246	-.10165	-.10566
NR/IZZ	1/SEC	-.04101	-.04249	-.04345	-.04383	-.04318	-.04306	-.04377	-.04566	-.04979	-.05676	-.06986
DB	CM	.30235	.00496	-.67895	-1.39898	-1.76470	-1.21604	-.36594	.48780	1.14263	1.63651	2.52175
DC	CM	11.72193	12.69453	12.96092	12.52988	11.41022	10.84909	10.86939	11.41712	12.40784	14.14235	17.12020
DS	CM	.59438	.66412	.68983	.67398	.61908	.56903	.52650	.49466	.51032	.58274	.71519
DR	CM	.28420	.23383	.17367	.11039	.05068	-.16101	-.43787	-.74712	-1.08583	-1.50138	-2.17506
THEN	DEG.	9.10901	7.86562	6.51257	5.39523	4.25894	2.96632	1.42181	-.22319	-.55312	-1.45296	-4.81367
PHIN	DEG.	-.43595	-.48764	-.51126	-.49798	-.43906	-.40330	-.39769	-.41428	-.45802	-.52990	-.62193

* DERIVED BY FITTING A THIRD ORDER CURVE THROUGH -40, -20, +20 AND +40 VALUES.

APPENDIX E

TABLE E1.- Continued

(d) $\dot{Z}$ = -2.54 m/sec

Parameter	Unit	Value of parameter at $\dot{X}$, knots, of										
		-40	-20	*0	20	40	60	80	100	120	140	160
XU/M	1/SEC	-.04948	-.04431	-.02325	-.00641	-.01387	-.02174	-.02695	-.03084	-.03724	-.04364	-.04851
XV/M	1/SEC	.00046	-.00184	-.00097	.00055	.00008	.00001	-.00006	-.00027	-.00062	-.00137	-.00421
XW/M	1/SEC	.06078	.04288	.03589	.03589	.03884	.03625	.02864	.01910	.02536	.01854	-.00254
XDB/M	M/SEC2-CM	.01999	.01621	.01420	.01347	.01355	.01547	.01779	.01947	.01740	.01400	.01141
XDC/M	M/SEC2-CM	.18128	.14723	.11364	.08471	.06465	.04726	.02461	-.00098	.00731	-.01061	-.07156
XDS/M	M/SEC2-CM	-.00004	-.00003	-.00002	-.00001	-.00000	-.00000	-.00000	-.00000	-.00001	-.00001	.00000
XDR/M	M/SEC2-CM	-.00003	-.00002	-.00001	-.00001	-.00000	-.00000	-.00000	-.00001	-.00001	-.00001	-.00003
XP/M	M/SEC	.02888	.02325	.00988	-.01058	.00252	.00174	.00125	.00101	.00145	.00195	.00292
XQ/M	M/SEC	.89024	.77651	.79005	.76898	.75145	.72987	.71912	.72602	.77279	.82647	.93003
XR/M	M/SEC	[illegible]	-.00636	-.03670	-.00913	-.01274	-.01216	-.01117	-.01213	-.01227	-.01571	-.02764
YU/M	1/SEC	-.00115	-.00170	-.00058	.00087	.00013	.00000	.00032	.00066	.00082	.00101	.00100
YV/M	1/SEC	-.09145	-.11266	-.14525	-.11666	-.07436	-.07822	-.09235	-.10972	-.12806	-.14811	-.17168
YW/M	1/SEC	.00288	.00272	.00301	.00354	.00412	.00366	.00328	.00328	.00374	.00426	.00419
YDB/M	M/SEC2-CM	-.00337	-.00125	.00150	.00418	.00612	.00552	.00390	.00203	.00014	-.00474	-.00914
YDC/M	M/SEC2-CM	.00892	.00789	.00826	.00811	.00746	.00688	.00641	.00662	.00859	.00975	.01031
YDS/M	M/SEC2-CM	.13933	.14003	.13953	.13813	.13615	.13579	.13617	.13731	.13832	.14033	.14730
YDR/M	M/SEC2-CM	-.01138	-.00804	-.00635	-.00423	-.00422	-.00546	-.00683	-.00723	-.00410	-.00066	.00316
YP/M	M/SEC	-.50912	-.43273	-.40513	-.42728	-.50015	-.54836	-.56344	-.55164	-.51122	-.44784	-.38161
YQ/M	M/SEC	.01177	.00816	.00014	-.00749	-.01173	.00713	.03466	.06229	.08444	.13129	.17920
YR/M	M/SEC	-.05537	-.04801	-.04419	-.04639	-.05494	-.05980	-.06068	-.05901	-.05668	-.05088	-.04740
ZU/M	1/SEC	.17843	.14208	.02826	-.11816	-.09269	-.05637	-.03356	-.02250	-.00324	.03104	.01630
ZV/M	1/SEC	-.00605	-.00104	.00135	.01208	.00212	.00290	.00319	.00316	.00384	.00238	.00318
ZW/M	1/SEC	-.43581	-.31017	-.32741	-.37819	-.47314	-.56806	-.64615	-.70814	-.74979	-.66803	-.70849
ZDB/M	M/SEC2-CM	-.05259	-.01179	.00349	.01863	.03902	.05004	.05154	.04951	.04014	.01115	.03197
ZDC/M	M/SEC2-CM	-1.03261	-.96736	-.97629	-.99801	-1.05111	-1.14474	-1.25069	-1.35527	-1.42844	-1.28676	-1.30750
ZDS/M	M/SEC2-CM	.00028	.00022	.00015	.00009	.00005	.00003	.00006	.00014	.00017	.00026	.00071
ZDR/M	M/SEC2-CM	.00004	[illegible]	-.00001	-.00000	.00001	-.00001	-.00002	-.00006	-.00007	-.00003	-.00012
ZP/M	M/SEC	-.13911	-.09706	-.05452	-.02866	-.03784	-.01627	-.01423	-.00414	.00615	.01140	.02583
ZQ/M	M/SEC	.55381	.17418	.14069	.11583	-.23791	-.27815	-.20254	-.10313	-.07222	.24309	.10619
ZR/M	M/SEC	[illegible]	.34717	.09500	-.13521	-.06228	-.04443	-.06907	-.11120	-.13884	-.15921	-.19525
LU/IXX	1/SEC-M	-.00114	-.00101	-.00122	-.00038	-.00041	-.00054	-.00027	.00010	-.00026	.00028	.00057
LV/IXX	1/SEC-M	-.01948	-.02072	-.02082	-.02032	-.01936	-.01926	-.01985	-.02098	-.02272	-.02552	-.03013
LW/IXX	1/SEC-M	[illegible]	.00161	.00155	.00219	.00385	.00454	.00475	.00492	.00552	.00685	.00686
LDB/IXX	1/SEC2-CM	-.01424	-.01314	-.01039	-.00660	-.00241	-.00085	-.00074	-.00142	-.00283	-.00846	-.01399
LDC/IXX	1/SEC2-CM	[illegible]	-.00467	-.00570	-.00602	-.00548	-.00477	-.00460	-.00461	-.00316	-.00145	-.00211
LDS/IXX	1/SEC2-CM	.16429	.16469	.16395	.16252	.16086	.16071	.16121	.16221	.16265	.16389	.16922
LDR/IXX	1/SEC2-CM	[illegible]	-.05710	-.05476	-.05250	-.05180	-.05271	-.05398	-.05472	-.05246	-.05031	-.04957
LP/IXX	1/SEC	[illegible]	-.68419	-.65429	-.66455	-.72095	-.75755	-.76621	-.75041	-.70501	-.63821	-.56471
LQ/IXX	1/SEC	.12968	.12586	.10871	.07991	.04113	.02570	.02439	.02997	.04291	.08984	.12142
LR/IXX	1/SEC	-.05736	-.05023	-.04691	-.04845	-.05584	-.06018	-.06082	-.05872	-.05499	-.04675	-.03801
MU/IYY	1/SEC-M	.00553	.01635	.02044	.01536	-.00142	-.01128	-.01203	-.01093	-.00822	-.00370	-.00490
MV/IYY	1/SEC-M	.00471	[illegible]	.00028	-.00290	-.00205	-.00063	.00090	.00248	.00431	.00524	.00747
MW/IYY	1/SEC-M	-.03923	-.01466	.00656	.02742	.05032	.05363	.05324	.05584	.05405	.05626	.05182
MDB/IYY	1/SEC2-CM	[illegible]	.13510	.13266	.13461	.14125	.15357	.16408	.17317	.18026	.15481	.15969
MDC/IYY	1/SEC2-CM	-.01437	.00928	.00791	.01248	.03394	.05544	.06485	.06982	.07619	.07106	.05840
MDS/IYY	1/SEC2-CM	-.00000	-.00000	-.00000	-.00000	-.00000	-.00001	-.00000	-.00001	-.00001	-.00002	-.00003
MDR/IYY	1/SEC2-CM	-.00018	-.00015	-.00010	-.00006	-.00003	-.00002	-.00004	-.00009	-.00011	-.00016	-.00042
MP/IYY	1/SEC	.06038	.06421	.00108	-.05462	-.02849	-.01296	-.00879	-.00409	.00392	.00992	.01915
MQ/IYY	1/SEC	-1.54982	-1.31840	-1.24188	-1.31713	-1.54105	-1.66128	-1.72433	-1.76349	-1.80237	-1.56573	-1.55061
MR/IYY	1/SEC	[illegible]	-.00735	-.00288	-.00624	-.01073	-.00915	-.00751	-.00622	-.00487	.00033	.00176
NU/IZZ	1/SEC-M	.00022	.00110	.00164	.00165	.00091	.00084	.00083	.00075	.00062	.00033	.00006
NV/IZZ	1/SEC-M	[illegible]	-.00888	-.00230	.00442	.00100	-.00013	-.00087	-.00144	-.00210	-.00256	-.00259
NW/IZZ	1/SEC-M	.00160	.00183	.00085	.00093	.00034	-.00040	-.00076	-.00104	-.00194	-.00449	-.00713
NDB/IZZ	1/SEC2-CM	.01635	.01909	.01998	.01901	.01617	.01399	.01277	.01263	.01381	.01617	.02044
NDC/IZZ	1/SEC2-CM	-.00195	-.00076	.00039	.00152	.00265	.00326	.00395	.00482	.00511	.00192	-.00179
NDS/IZZ	1/SEC2-CM	.00280	.00312	.00364	.00404	.00398	.00372	.00345	.00339	.00407	.00484	.00582
NDR/IZZ	1/SEC2-CM	.08028	.08072	.08050	.07976	.07863	.07838	.07857	.07921	.07987	.08112	.08521
NP/IZZ	1/SEC	.01552	.01341	.00184	-.01072	-.01580	-.01901	-.02199	-.02739	-.04104	-.05823	-.08419
NQ/IZZ	1/SEC	-.13552	-.15553	-.17600	-.16680	-.13782	-.11156	-.09560	-.08867	-.07781	-.07774	-.08692
NR/IZZ	1/SEC	-.04057	-.04199	-.04263	-.04239	-.04116	-.04068	-.04096	-.04221	-.04540	-.05098	-.06183
DB	CM	.84398	.31047	-.70919	-1.74888	-2.34249	-1.64918	-.68715	.21224	.87295	1.29682	2.09347
DC	CM	10.53696	11.72764	12.06419	11.55953	10.22659	9.52319	9.45564	9.93812	10.88875	12.53349	15.37478
DS	CM	.51328	.59239	.62512	.61242	.55526	.49932	.45307	.42023	.43822	.50393	.61515
DR	CM	.09399	.12859	.16681	.19681	.20679	-.00611	-.27792	-.56418	-.85640	-1.20986	-1.78995
THEN	DEG.	8.96607	7.81254	6.61169	5.43887	4.36941	3.13931	1.65473	.07423	-.21157	-1.03887	-4.24451
PHIN	DEG.	-.38226	-.45397	-.48161	-.45975	-.38300	-.34133	-.33547	-.35475	-.40420	-.48392	-.58388

* DERIVED BY FITTING A THIRD ORDER CURVE THROUGH -40, -20, +20 AND +40 VALUES.

APPENDIX E

TABLE E1.- Continued

(e) $\dot{Z}$ = 0 m/sec

Parameter	Unit	Value of parameter at $\dot{X}$, knots, of										
		-40	-20	*0	20	40	60	80	100	120	140	160
XU/M	1/SEC	[illegible]	-.01470	-.02114	-.02259	-.01164	-.02046	-.02592	-.02981	-.03632	-.04267	-.04737
XV/M	1/SEC	.00032	-.00075	-.00085	-.00046	-.00004	.00014	.00024	.00021	.00013	-.00020	-.00267
XW/M	1/SEC	.05470	.03611	.03259	.03417	.03870	.03764	.03122	.02283	.03014	.02613	.00375
XDB/M	M/SEC2-CM	.02056	.01591	.01369	.01302	.01304	.01523	.01778	.01966	.01753	.01616	.01295
XDC/M	M/SEC2-CM	.17572	.14540	.11254	.08386	.06549	.05117	.03141	.00871	.02026	.01114	-.04955
XDS/M	M/SEC2-CM	-.00002	-.00001	-.00000	.00000	.00001	.00000	.00000	.00000	.00000	-.00000	-.00000
XDR/M	M/SEC2-CM	-.00001	-.00001	-.00000	.00000	.00000	.00000	.00000	.00000	.00000	-.00000	-.00002
XP/M	M/SEC	.05617	.01612	.00625	.00239	.00037	.00116	.00157	.00154	.00136	.00169	.00228
XQ/M	M/SEC	.65225	.76665	.78797	.76765	.74632	.71869	.70283	.70439	.74685	.78684	.88757
XR/M	M/SEC	-.05245	-.03791	-.03216	-.02921	-.02313	-.01425	-.00956	-.00856	-.00902	-.01156	-.02044
YU/M	1/SEC	-.00093	-.00149	-.00019	.00095	-.00006	-.00017	.00026	.00063	.00074	.00108	.00098
YV/M	1/SEC	-.16460	-.15255	-.13712	-.11155	-.06893	-.07404	-.08899	-.10671	-.12526	-.14524	-.16813
YW/M	1/SEC	.01282	.01238	.00265	.00334	.00418	.00330	.00267	.00260	.00308	.00476	.00409
YDB/M	M/SEC2-CM	-.00493	-.00219	.00141	.00489	.00729	.00622	.00417	.00209	.00044	-.00347	-.00768
YDC/M	M/SEC2-CM	.00597	.00719	.00762	.00740	.00664	.00582	.00502	.00505	.00685	.01013	.01073
YDS/M	M/SEC2-CM	.13827	.13946	.13908	.13752	.13515	.13439	.13427	.13485	.13525	.13659	.14271
YDR/M	M/SEC2-CM	-.01015	-.00905	-.00647	-.00436	-.00464	-.00636	-.00821	-.00911	-.00659	-.00371	-.00052
YP/M	M/SEC	-.57438	-.46785	-.45532	-.48917	-.56495	-.62055	-.63622	-.62157	-.57561	-.50485	-.43311
YQ/M	M/SEC	.02502	.01543	.00126	-.01304	-.02235	.00104	.03240	.06168	.08239	.12475	.16819
YR/M	M/SEC	-.06216	-.05267	-.05014	-.05369	-.06242	-.06766	-.06844	-.06627	-.06295	-.05622	-.04976
ZU/M	1/SEC	.13119	.14617	.02434	-.10099	-.11142	-.06631	-.03744	-.02283	-.00337	.03061	.02053
ZV/M	1/SEC	-.00314	.00100	.00374	.00524	.00592	.00487	.00425	.00381	.00437	.00302	.00355
ZW/M	1/SEC	-.40474	-.33703	-.29557	-.34885	-.44538	-.55118	-.63488	-.69967	-.74553	-.68261	-.70389
ZDB/M	M/SEC2-CM	-.03750	-.01235	.00364	.01952	.04438	.05608	.05653	.05354	.04916	.00780	.03083
ZDC/M	M/SEC2-CM	-1.01177	-.97537	-.96713	-.95577	-1.02824	-1.12319	-1.23455	-1.34323	-1.42725	-1.34721	-1.36395
ZDS/M	M/SEC2-CM	.00013	.00006	-.00000	-.00005	-.00006	-.00005	-.00004	-.00002	-.00001	.00006	.00040
ZDR/M	M/SEC2-CM	.00003	.00002	.00001	.00001	.00002	.00001	.00004	.00000	.00000	.00001	-.00008
ZP/M	M/SEC	-.14721	-.06379	.01277	.05702	.09555	.06548	.03796	.02030	.02122	.00923	.01968
ZQ/M	M/SEC	.55592	.21388	.13261	.06490	-.34846	-.35941	-.26711	-.16038	-.12684	.23919	.05954
ZR/M	M/SEC	.24746	.11592	.11041	.12051	.14785	.08698	.02534	-.02846	-.05733	-.08739	-.16859
LU/IXX	1/SEC-M	-.00130	-.00193	-.00091	.00013	-.00045	-.00077	-.00046	-.00007	-.00053	.00012	.00031
LV/IXX	1/SEC-M	-.01862	-.01972	-.01993	-.01939	-.01821	-.01798	-.01849	-.01953	-.02118	-.02379	-.02800
LW/IXX	1/SEC-M	.00236	.00165	.00158	.00254	.00495	.00544	.00544	.00548	.00587	.00791	.00704
LDB/IXX	1/SEC2-CM	-.01119	-.01287	-.00949	-.00491	.00009	.00148	.00145	.00074	-.00030	-.00503	-.01035
LDC/IXX	1/SEC2-CM	-.00249	-.00430	-.00553	-.00572	-.00462	-.00340	-.00317	-.00318	-.00208	.00088	-.00030
LDS/IXX	1/SEC2-CM	.16538	.16423	.16359	.16202	.16008	.15966	.15980	.16059	.16040	.16116	.16586
LDR/IXX	1/SEC2-CM	-.05719	-.05699	-.05471	-.05240	-.05180	-.05296	-.05447	-.05542	-.05342	-.05153	-.05103
LP/IXX	1/SEC	-.79828	-.72706	-.69495	-.70862	-.77475	-.81835	-.82866	-.81192	-.76384	-.69295	-.61744
LQ/IXX	1/SEC	.12621	.12183	.11020	.06396	.01569	.00117	.00203	.00889	.02211	.06761	.09796
LR/IXX	1/SEC	-.06426	-.05550	-.05220	-.05466	-.06241	-.06732	-.06815	-.06596	-.06182	-.05353	-.04309
MU/IYY	1/SEC-M	.00595	.02587	.03034	.02228	-.00540	-.01377	-.01329	-.01153	-.00918	-.00293	-.00483
MV/IYY	1/SEC-M	.00356	.00176	.01055	-.00021	-.00066	-.00020	.00090	.00218	.00368	.00442	.00632
MW/IYY	1/SEC-M	-.00487	-.01844	.00769	.03254	.05835	.05786	.05524	.05466	.05327	.06399	.05105
MDB/IYY	1/SEC2-CM	.14178	.13264	.12961	.13200	.14010	.15399	.16484	.17394	.18278	.16423	.16393
MDC/IYY	1/SEC2-CM	-.01599	.00703	.00750	.00850	.03588	.06018	.06819	.07166	.07411	.08375	.06581
MDS/IYY	1/SEC2-CM	-.00000	.00000	-.00000	.00000	.00001	.00000	.00001	.00000	.00000	-.00000	-.00002
MDR/IYY	1/SEC2-CM	-.00009	-.00005	-.00000	.00003	.00005	.00005	.00004	.00001	.00000	-.00003	-.00025
MP/IYY	1/SEC	.07711	.05658	.04267	.03618	.03792	.02270	.01306	.00808	.01083	.00945	.01458
MQ/IYY	1/SEC	-1.57909	-1.31503	-1.22925	-1.31598	-1.56947	-1.68183	-1.73681	-1.76988	-1.80477	-1.57954	-1.54494
MR/IYY	1/SEC	-.03206	-.01058	-.00433	-.00294	.00397	.00267	.00052	-.00041	.00022	.00241	-.00032
NU/IZZ	1/SEC-M	-.00007	.00075	.00130	.00139	.00081	.00098	.00098	.00087	.00071	.00045	.00015
NV/IZZ	1/SEC-M	-.00472	-.00833	-.01203	.00433	.00086	-.00030	-.00107	-.00168	-.00236	-.00285	-.00293
NW/IZZ	1/SEC-M	.00210	.00085	.00074	.00068	-.00039	-.00119	-.00136	-.00140	-.00192	-.00351	-.00582
NDB/IZZ	1/SEC2-CM	.01393	.01722	.01853	.01721	.01584	.01107	.00945	.00903	.01003	.01259	.01652
NDC/IZZ	1/SEC2-CM	-.00185	-.00086	.00028	.00135	.00214	.00217	.00267	.00362	.00434	.00306	.00050
NDS/IZZ	1/SEC2-CM	.00282	.00308	.00360	.00399	.00387	.00349	.00311	.00294	.00348	.00410	.00493
NDR/IZZ	1/SEC2-CM	.07968	.08039	.08025	.07941	.07804	.07755	.07744	.07774	.07804	.07889	.08249
NP/IZZ	1/SEC	.01730	.00866	.00080	-.00921	-.01442	-.01663	-.01772	-.02065	-.03098	-.04472	-.06599
NQ/IZZ	1/SEC	-.14825	-.14697	-.16952	-.14872	-.11142	-.07923	-.06077	-.05316	-.04408	-.04746	-.05912
NR/IZZ	1/SEC	-.03924	-.04048	-.04172	-.04145	-.03979	-.03912	-.03890	-.03947	-.04173	-.04588	-.05523
DB	CM	1.52765	.71568	-.74294	-2.21129	-3.05239	-2.11981	-1.01549	-.06276	.60592	1.01690	1.73389
DC	CM	9.39351	10.82392	11.23771	10.65139	9.08028	8.21236	8.05312	8.47287	9.39059	10.98348	13.71524
DS	CM	.43721	.52556	.56609	.55748	.49841	.43325	.38194	.34789	.36953	.43802	.53622
DR	CM	-.11870	.03694	.16093	.30058	.38281	.14634	-.13126	-.40124	-.65256	-.95875	-1.45900
THEN	DEG.	8.84219	7.76600	6.61333	5.48094	4.47560	3.39464	1.87456	.35227	.09997	-.68214	-3.75758
PHIN	DEG.	-.52757	-.41888	-.45153	-.42196	-.32665	-.27858	-.27258	-.29476	-.35037	-.43798	-.54619

* DERIVED BY FITTING A THIRD ORDER CURVE THROUGH -40, -20, +20 AND +40 VALUES.

TABLE E1.- Continued

(f) $\dot{Z}$ = 2.54 m/sec

Parameter	Unit	Value of parameter at $\dot{X}$, knots, of -40	-20	*0	20	40	60	80	100	120	140	160
XU/M	1/SEC	-.05099	-.04422	-.01857	.00129	-.00932	-.01924	-.02498	-.02891	-.03565	-.04192	-.04656
XV/M	1/SEC	-.00027	-.00058	-.00127	-.00143	-.00016	.00023	.00044	.00058	.00078	.00080	-.00107
XW/M	1/SEC	.04792	.04283	.02894	.03219	.03852	.03901	.03377	.02653	.03475	.03293	.00993
XDB/M	M/SEC2-CM	.02140	.01553	.01309	.01259	.01251	.01499	.01778	.01986	.01776	.01608	.01405
XDC/M	M/SEC2-CM	.16964	.14452	.11245	.08305	.06607	.05503	.03822	.01844	.03330	.02739	-.03208
XDS/M	M/SEC2-CM	-.00001	.00001	.00001	.00002	.00001	.00001	.00001	.00000	.00001	.00001	-.00000
XDR/M	M/SEC2-CM	-.00010	.00000	.00001	.00001	.00001	.00001	.00001	.00001	.00001	.00001	-.00001
XP/M	M/SEC	.00705	-.01602	-.00874	.00488	.00085	.00131	.00141	.00153	.00101	.00092	.00166
XQ/M	M/SEC	.63271	.75036	.78355	.76851	.74145	.70773	.68700	.68340	.72175	.76915	.84664
XR/M	M/SEC	-.01473	.00237	-.02627	-.05381	-.03341	-.01527	-.00778	-.00548	-.00640	-.00825	-.01437
YU/M	1/SEC	-.00067	-.00151	-.00001	.00122	-.00042	-.00039	.00020	.00063	.00075	.00094	.00098
YV/M	1/SEC	-.07928	-.12523	-.13179	-.10831	-.06418	-.07043	-.08619	-.10425	-.12300	-.14289	-.16521
YW/M	1/SEC	.00321	.00221	.00244	.00341	.00463	.00301	.00206	.00189	.00246	.00376	.00403
YDB/M	M/SEC2-CM	-.00676	-.00332	.00134	.00581	.00872	.00691	.00429	.00188	.00033	-.00304	-.00703
YDC/M	M/SEC2-CM	.00558	.00641	.00683	.00661	.00600	.00486	.00361	.00341	.00503	.00840	.00940
YDS/M	M/SEC2-CM	.13757	.13910	.13846	.13710	.13428	.13308	.13245	.13244	.13224	.13293	.13824
YDR/M	M/SEC2-CM	-.00993	-.00920	-.00661	-.00445	-.00501	-.00724	-.00959	-.01100	-.00901	-.00677	-.00421
YP/M	M/SEC	-.63906	-.53933	-.50158	-.52953	-.62807	-.69246	-.70858	-.69102	-.63927	-.56153	-.48319
YQ/M	M/SEC	.04396	.02449	.00152	-.02078	-.03616	-.00512	.03155	.06333	.08319	.11681	.16047
YR/M	M/SEC	-.06921	-.05726	-.05522	-.06003	-.06863	-.07507	-.07597	-.07334	-.06903	-.06139	-.05278
ZU/M	1/SEC	.20766	.21206	.02097	-.16248	-.13514	-.07765	-.04175	-.02333	-.00153	.02798	.02465
ZV/M	1/SEC	.00055	.00570	.00975	.01176	.01077	.00650	.00487	.00415	.00468	.00487	.00389
ZW/M	1/SEC	-.37004	-.27069	-.25982	-.31546	-.41545	-.53448	-.62395	-.69155	-.73887	-.70234	-.69941
ZDB/M	M/SEC2-CM	-.04376	-.01240	.00378	.01992	.05120	.06299	.06194	.05779	.05521	.02373	.03277
ZDC/M	M/SEC2-CM	-.98734	-.96795	-.95612	-.97839	-1.00132	-1.09896	-1.21692	-1.33019	-1.42527	-1.35980	-1.36155
ZDS/M	M/SEC2-CM	.00003	-.00006	-.00013	-.00016	-.00014	-.00012	-.00012	-.00010	-.00012	-.00012	.00016
ZDR/M	M/SEC2-CM	-.00000	-.00000	.00001	.00002	.00004	.00004	.00001	.00003	.00006	.00004	-.00003
ZP/M	M/SEC	-.03191	.03174	.10912	.09661	.13062	.08073	.05534	.04260	.03739	.03500	.01449
ZQ/M	M/SEC	.76671	.29536	.12195	-.02747	-.46690	-.44102	-.33204	-.21771	-.18119	-.02794	.01342
ZR/M	M/SEC	.02528	-.14008	.13191	.43388	.35849	.18751	.09341	.03225	.00629	-.02894	-.12614
LU/IXX	1/SEC-M	-.00116	-.00205	-.00046	.00090	-.00071	-.00114	-.00070	-.00026	-.00073	-.00031	.00006
LV/IXX	1/SEC-M	-.01744	-.01882	-.01911	-.01848	-.01709	-.01676	-.01719	-.01815	-.01975	-.02216	-.02609
LW/IXX	1/SEC-M	.00278	.00173	.00169	.00514	.00654	.00653	.00621	.00611	.00637	.00744	.00731
LDB/IXX	1/SEC2-CM	-.01445	-.01280	-.00871	-.00514	.00259	.00382	.00352	.00268	.00182	-.00227	-.00753
LDC/IXX	1/SEC2-CM	-.00234	-.00422	-.00559	-.00565	-.00358	-.00178	-.00157	-.00161	-.00085	.00166	.00041
LDS/IXX	1/SEC2-CM	.16260	.16305	.16342	.16168	.15940	.15869	.15846	.15863	.15821	.15850	.16260
LDR/IXX	1/SEC2-CM	-.05699	-.05609	-.05474	-.05233	-.05180	-.05323	-.05497	-.05615	-.05441	-.05279	-.05253
LP/IXX	1/SEC	-.84669	-.76640	-.73128	-.74894	-.82699	-.87890	-.89052	-.87240	-.82127	-.74634	-.66812
LQ/IXX	1/SEC	.12560	.12011	.09244	.01674	-.01288	-.02389	-.01939	-.01031	.00393	.04144	.07813
LR/IXX	1/SEC	-.07108	-.06008	-.05704	-.06018	-.06756	-.07381	-.07507	-.07281	-.06821	-.05982	-.04836
MU/IYY	1/SEC-M	.00451	.03429	.04449	.03166	-.00761	-.01701	-.01075	-.01219	-.00949	-.00483	-.00474
MV/IYY	1/SEC-M	.00239	-.00109	.00090	.00519	.00061	-.00007	.00071	.00184	.00308	.00412	.00532
MW/IYY	1/SEC-M	-.05913	-.02597	.01935	.04021	.06803	.06235	.05727	.05546	.05335	.05539	.05014
MDB/IYY	1/SEC2-CM	.13929	.12965	.12582	.12894	.13946	.15490	.16591	.17487	.18442	.16914	.16440
MDC/IYY	1/SEC2-CM	-.01873	.01423	.00695	.00131	.03923	.06615	.07205	.07372	.07214	.07678	.05845
MDS/IYY	1/SEC2-CM	-.00010	.00000	.00000	-.00000	.00000	.00000	.00001	.00001	.00001	.00000	-.00001
MDR/IYY	1/SEC2-CM	-.00002	.00004	.00008	.00011	.00010	.00009	.00008	.00007	.00009	.00008	-.00010
MP/IYY	1/SEC	.02254	-.05053	.01003	.08761	.06559	.03469	.02152	.01685	.01716	.01719	.01084
MQ/IYY	1/SEC	-1.61906	-1.33744	-1.24855	-1.34224	-1.60835	-1.70716	-1.75196	-1.77776	-1.80805	-1.64924	-1.53966
MR/IYY	1/SEC	-.00867	.00643	.01044	.01388	.02728	.01524	.00831	.00505	.00514	.00362	-.00010
NU/IZZ	1/SEC-M	-.00031	.00025	.00075	.00102	.00086	.00128	.00122	.00105	.00083	.00057	.00026
NV/IZZ	1/SEC-M	-.00414	-.00793	-.00181	.00430	.00073	-.00046	-.00127	-.00192	-.00261	-.00313	-.00323
NW/IZZ	1/SEC-M	.00297	.00097	.00060	.00032	-.00144	-.00221	-.00216	-.00194	-.00210	-.00303	-.00469
NDB/IZZ	1/SEC2-CM	.01161	.01555	.01690	.01561	.01162	.00812	.00609	.00541	.00627	.00870	.01256
NDC/IZZ	1/SEC2-CM	-.00162	-.00101	.00020	.00128	.00147	.00071	.00101	.00202	.00313	.00275	.00122
NDS/IZZ	1/SEC2-CM	.00284	.00304	.00357	.00396	.00377	.00327	.00277	.00248	.00288	.00337	.00404
NDR/IZZ	1/SEC2-CM	.07917	.08018	.08011	.07916	.07753	.07678	.07635	.07630	.07625	.07671	.07983
NP/IZZ	1/SEC	.00013	.00403	-.00148	-.00977	-.01420	-.01495	-.01432	-.01522	-.02239	-.03273	-.04933
NQ/IZZ	1/SEC	-.08018	-.12984	-.14768	-.13206	-.09467	-.04605	-.02534	-.01740	-.01048	-.01590	-.03250
NR/IZZ	1/SEC	-.03842	-.03976	-.04078	-.04086	-.03938	-.03829	-.03747	-.03736	-.03883	-.04175	-.04924
DB	CM	2.38315	1.26420	-.78485	-2.82608	-3.92155	-2.62438	-1.34686	-.33354	.34583	.74352	1.38192
DC	CM	8.29473	9.99373	10.49561	9.81648	7.97326	6.91428	6.66011	7.02024	7.91239	9.46461	12.10222
DS	CM	.36603	.46373	.51350	.51042	.44898	.37014	.31222	.27641	.30279	.37604	.46536
DR	CM	-.35968	-.13978	.15721	.43181	.58454	.29581	.00093	-.25995	-.47649	-.74060	-1.17062
THEN	DEG.	8.73754	7.72698	6.61754	5.52108	4.57749	3.46245	2.08101	.60973	.37973	-.36946	-3.32911
PHIN	DEG.	-.27250	-.38399	-.42272	-.38580	-.27039	-.21527	-.20927	-.23465	-.29692	-.39304	-.50983

* DERIVED BY FITTING A THIRD ORDER CURVE THROUGH -40, -20, +20 AND +40 VALUES.

APPENDIX E

TABLE E1.- Continued

(g) $\dot{Z}$ = 5.08 m/sec

Parameter	Unit	Value of parameter at $\dot{X}$, knots, of -40	-20	*0	20	40	60	80	100	120	140	160
XU/M	1/SEC	-.05340	-.02396	-.01524	.00513	-.00690	-.01807	-.02411	-.02813	-.03516	-.04138	-.04634
XV/M	1/SEC	-.00119	-.00146	-.00252	-.00265	-.00028	.00026	.00052	.00079	.00127	.00179	.00049
XW/M	1/SEC	.03060	.02657	.02453	.02996	.03840	.04039	.03631	.03021	.03931	.03962	.01391
XDB/M	M/SEC2-CM	.02265	.01448	.01234	.01218	.01194	.01478	.01780	.02006	.01810	.01602	.01365
XDC/M	M/SEC2-CM	.16243	.14528	.11368	.08244	.06633	.05888	.04504	.02819	.04484	.04291	-.01704
XDS/M	M/SEC2-CM	.00001	.00002	.00003	.00002	.00001	.00001	.00001	.00001	.00001	.00002	.00000
XDR/M	M/SEC2-CM	.00000	.00001	.00002	.00002	.00001	.00001	.00001	.00001	.00001	.00001	.00000
XP/M	M/SEC	-.02575	-.05583	-.03074	.00099	-.00121	.00046	.00087	.00106	.00039	.00038	.00140
XQ/M	M/SEC	.60367	.72410	.77472	.77290	.73603	.69676	.67148	.66295	.69745	.74565	.82118
XR/M	M/SEC	.12225	.15455	-.00904	-.07506	-.04205	-.01446	-.00549	-.00265	-.00415	-.00609	-.00987
YU/M	1/SEC	-.00022	-.00193	.00017	.00184	-.00112	-.00068	.00016	.00067	.00080	.00086	.00093
YV/M	1/SEC	-.07469	-.12074	-.12961	-.10736	-.06003	-.06739	-.08394	-.10232	-.12126	-.14111	-.16269
YW/M	1/SEC	.00425	.00236	.00258	.00398	.00560	.00291	.00142	.00114	.00181	.00287	.00332
YDB/M	M/SEC2-CM	-.00893	-.00473	.00129	.00706	.01048	.00759	.00423	.00140	-.00020	-.00303	-.00729
YDC/M	M/SEC2-CM	.00441	.00541	.00563	.00555	.00567	.00401	.00215	.00166	.00319	.00711	.00780
YDS/M	M/SEC2-CM	.13661	.13900	.13892	.13691	.13354	.13186	.13067	.13007	.12927	.12934	.13387
YDR/M	M/SEC2-CM	-.00975	-.00910	-.00675	-.00950	-.00534	-.00810	-.01097	-.01290	-.01147	-.00982	-.00790
YP/M	M/SEC	-.63907	-.56515	-.54218	-.57509	-.69003	-.76459	-.78082	-.75977	-.70176	-.61637	-.53281
YQ/M	M/SEC	.06559	.05753	.00682	-.03306	-.05405	-.01131	.03221	.06738	.08699	.11535	.16056
YR/M	M/SEC	-.07767	-.06250	-.05874	-.05329	-.07328	-.08217	-.08331	-.08025	-.07499	-.06621	-.05644
ZU/M	1/SEC	.25135	.22150	.01617	-.18058	-.16505	-.09016	-.04638	-.02396	.00024	.02606	.03084
ZV/M	1/SEC	.00523	.01503	.02256	.02417	.01560	.00702	.00477	.00405	.00473	.00511	.00446
ZW/M	1/SEC	-.35238	-.22860	-.21585	-.27459	-.38494	-.51847	-.61350	-.68379	-.73257	-.71766	-.67921
ZDB/M	M/SEC2-CM	-.05169	-.01155	.00391	.01947	.06019	.07083	.06779	.06229	.05888	.03772	.04638
ZDC/M	M/SEC2-CM	-.95706	-.96860	-.97817	-.97982	-.96799	-1.07188	-1.19784	-1.31615	-1.41889	-1.38215	-1.33556
ZDS/M	M/SEC2-CM	-.00015	-.00015	-.00023	-.00025	-.00018	-.00013	-.00014	-.00016	-.00022	-.00024	-.00007
ZDR/M	M/SEC2-CM	-.00000	-.00001	.00000	.00003	.00006	.00003	.00002	.00005	.00006	.00008	.00000
ZP/M	M/SEC	.10205	.32039	.27305	.16755	.17100	.09233	.05645	.03941	.03449	.03104	.02873
ZQ/M	M/SEC	.87326	.42091	.10449	-.19123	-.58146	-.52178	-.39699	-.27523	-.23549	-.16598	-.13961
ZR/M	M/SEC	-.19177	-.50510	.08754	.72434	.54466	.24021	.12569	.06870	.05189	.02441	-.05976
LU/IXX	1/SEC-M	-.00097	-.00240	.00022	.00215	-.00144	-.00166	-.00097	-.00044	-.00092	-.00070	-.00026
LV/IXX	1/SEC-M	-.01632	-.01801	-.01835	-.01757	-.01603	-.01562	-.01597	-.01685	-.01841	-.02073	-.02438
LW/IXX	1/SEC-M	.00340	.00193	.00217	.00423	.00875	.00779	.00706	.00679	.00693	.00719	.00706
LDB/IXX	1/SEC2-CM	-.01505	-.01331	-.00809	-.00123	.00546	.00617	.00547	.00440	.00354	.00008	-.00558
LDC/IXX	1/SEC2-CM	-.00198	-.00420	-.00617	-.00605	-.00219	.00015	.00020	.00008	.00063	.00307	.00114
LDS/IXX	1/SEC2-CM	.16194	.16390	.16349	.16153	.15883	.15778	.15715	.15689	.15605	.15589	.15942
LDR/IXX	1/SEC2-CM	-.05657	-.05712	-.05088	-.05230	-.05181	-.05352	-.05550	-.05689	-.05542	-.05407	-.05406
LP/IXX	1/SEC	-.89327	-.83303	-.76413	-.78610	-.87850	-.95966	-.95215	-.93204	-.87733	-.79776	-.71720
LQ/IXX	1/SEC	.12854	.12220	.08461	.02537	-.04559	-.04961	-.03989	-.02756	-.01156	.02317	.06630
LR/IXX	1/SEC	-.07809	-.06075	-.06004	-.06255	-.07090	-.07989	-.08174	-.07937	-.07425	-.06532	-.05374
MU/IYY	1/SEC-M	.00037	.01878	.06443	.04424	-.01489	-.02096	-.01636	-.01289	-.00980	-.00648	-.00555
MV/IYY	1/SEC-M	.00140	-.00495	.00142	.00780	.00142	-.00043	.00029	.00141	.00251	.00344	.00437
MW/IYY	1/SEC-M	-.07226	-.05218	.01196	.05200	.07898	.06695	.05931	.05624	.05341	.04830	.04233
MDB/IYY	1/SEC2-CM	.13997	.12594	.12074	.12508	.13967	.15641	.16730	.17600	.18536	.17347	.15990
MDC/IYY	1/SEC2-CM	-.02354	.02502	.00614	-.01044	.04504	.07352	.07644	.07601	.07143	.07681	.04769
MDS/IYY	1/SEC2-CM	-.00000	.00000	.00000	-.00000	.00000	.00001	.00001	.00001	.00001	.00001	.00000
MDR/IYY	1/SEC2-CM	.00003	.00010	.00015	.00016	.00013	.00010	.00009	.00010	.00014	.00016	.00003
MP/IYY	1/SEC	-.04415	-.12549	-.01632	.10903	.07542	.03703	.02190	.01687	.01539	.01496	.01473
MQ/IYY	1/SEC	-1.66595	-1.39936	-1.32041	-1.41141	-1.65466	-1.73690	-1.76969	-1.78707	-1.81219	-1.67767	-1.48883
MR/IYY	1/SEC	.02160	.04525	.06124	.05574	.05494	.02445	.01313	.00922	.00950	.00799	.00146
NU/IZZ	1/SEC-M	-.00037	-.00049	-.00016	.00046	.00119	.00177	.00157	.00129	.00100	.00071	.00033
NV/IZZ	1/SEC-M	-.00421	-.00767	-.00163	.00432	.00061	-.00059	-.00146	-.00214	-.00286	-.00338	-.00351
NW/IZZ	1/SEC-M	.00450	.00124	.00043	-.00024	-.00285	-.00348	-.00314	-.00266	-.00246	-.00275	-.00404
NDB/IZZ	1/SEC2-CM	.00933	.01110	.01579	.01428	.00945	.00511	.00266	.00174	.00251	.00488	.00846
NDC/IZZ	1/SEC2-CM	-.00118	-.00132	.00015	.00139	.00055	-.00119	-.00106	.00000	.00147	.00223	.00122
NDS/IZZ	1/SEC2-CM	.00285	.00299	.00354	.00395	.00368	.00306	.00243	.00202	.00229	.00264	.00316
NDR/IZZ	1/SEC2-CM	.07873	.08011	.08014	.07905	.07709	.07605	.07529	.07499	.07447	.07456	.07721
NP/IZZ	1/SEC	-.00473	.00144	-.00315	-.01072	-.01405	-.01351	-.01136	-.01046	-.01481	-.02204	-.03446
NQ/IZZ	1/SEC	-.05141	-.11340	-.13490	-.11621	-.05725	-.01175	.01086	.01872	.02308	.01422	-.00523
NR/IZZ	1/SEC	-.03893	-.03937	-.04051	-.04114	-.04002	-.03787	-.03633	-.03567	-.03653	-.03850	-.04410
DB	CM	3.42790	2.02967	-.84572	-3.68309	-4.96724	-3.15433	-1.67674	-.59806	.09377	.46295	1.02751
DC	CM	7.23779	9.25533	9.86326	9.07475	6.90292	5.62542	5.27463	5.57875	6.45259	7.98268	10.52822
DS	CM	.23911	.40715	.46951	.47362	.40690	.30912	.24295	.20457	.23642	.31481	.39833
DR	CM	-.63283	-.32533	.15811	.60831	.81608	.44088	.11741	-.14162	-.32962	-.55625	-.92632
THEN	DEG.	8.59035	7.69638	6.62471	5.55735	4.67569	3.61291	2.27393	.84679	.62843	-.10420	-2.95613
PHIN	DEG.	-.21729	-.35113	-.39748	-.35299	-.21433	-.15149	-.14576	-.17474	-.24432	-.35026	-.47574

* DERIVED BY FITTING A THIRD ORDER CURVE THROUGH -40, -20, +20 AND +40 VALUES.

TABLE E1.- Continued

(h) $\dot{Z}$ = 7.62 m/sec

Parameter	Unit	Value of parameter at $\dot{X}$, knots, of -40	-20	*0	20	40	60	80	100	120	140	160
XU/M	1/SEC	-.06741	-.01060	-.00922	.00887	-.00417	-.01753	-.02172	-.02554	-.03268	-.03883	-.04612
XV/M	1/SEC	-.01111	-.00372	-.00533	-.00455	-.00001	.00024	.00038	.00065	.00124	.00224	.00205
XW/M	1/SEC	.07111	.01063	.01033	.02725	.05050	.04639	.04404	.03834	.05071	.05888	.01974
XDB/M	M/SEC2-CM	.03772	.00417	.00965	.01178	.03818	.01389	.01623	.01895	.01701	.01779	.01469
XDC/M	M/SEC2-CM	.12251	.10873	.12594	.08220	.05753	.06211	.04275	.02722	.04795	.05760	-.00043
XDS/M	M/SEC2-CM	.00001	.00003	.00004	.00003	.00001	.00001	.00001	.00001	.00002	.00003	.00001
XDR/M	M/SEC2-CM	.00002	.00002	.00002	.00012	.00001	.00001	.00001	.00001	.00002	.00002	.00001
XP/M	M/SEC	-.00669	-.07855	-.04847	-.00582	.00005	-.00063	-.00104	-.00039	-.00091	-.00066	.00087
XQ/M	M/SEC	.81660	.69000	.72555	.74259	.65441	.65739	.65202	.65619	.68733	.69631	.78385
XR/M	M/SEC	.15715	.09765	.00386	-.03817	-.04354	-.00903	-.00363	-.00138	-.00418	-.00557	-.00625
YU/M	1/SEC	.01166	-.00314	.00012	.00315	-.00224	-.00068	.00014	.00076	.00092	.00104	.00102
YV/M	1/SEC	-.07062	-.11938	-.13165	-.10916	-.05484	-.06448	-.08221	-.10085	-.11989	-.13964	-.16110
YW/M	1/SEC	.00242	.00514	.00489	.00556	.01283	.00157	.00101	.00029	.00100	.00327	.00338
YDB/M	M/SEC2-CM	-.01260	-.00656	.00149	.00476	.01246	.00718	.00373	.00258	-.00122	-.00302	-.00749
YDC/M	M/SEC2-CM	.00701	.00375	.00244	.00376	.00840	.00288	.00040	-.00030	.00118	.00582	.00694
YDS/M	M/SEC2-CM	.13548	.13922	.13943	.13702	.13251	.13033	.12885	.12764	.12606	.12532	.12958
YDR/M	M/SEC2-CM	-.00455	-.00970	-.01669	-.00449	-.00589	-.00929	-.01242	-.01485	-.01415	-.01328	-.01157
YP/M	M/SEC	-.75827	-.62476	-.57190	-.61362	-.75382	-.84657	-.85445	-.83025	-.76906	-.67749	-.57980
YQ/M	M/SEC	.06641	.05835	-.00268	-.05564	-.04395	-.00394	.03421	.07421	.09449	.11466	.15924
YR/M	M/SEC	-.06821	-.06995	-.06067	-.06533	-.07887	-.09066	-.09075	-.08727	-.08140	-.07119	-.05997
ZU/M	1/SEC	.32011	.22260	-.00071	-.10402	-.21513	-.08134	-.04012	-.02467	.00209	.02666	.03457
ZV/M	1/SEC	.00098	.03223	.05011	.04671	.01072	.00389	.00324	.00333	.00440	.00504	.00467
ZW/M	1/SEC	-.51071	-.17601	-.07810	-.22149	-.60347	-.64712	-.68914	-.67617	-.72710	-.74050	-.67573
ZDB/M	M/SEC2-CM	-.14157	-.00939	.00688	.01765	.13397	.09731	.08612	.06716	.06310	.03052	.04829
ZDC/M	M/SEC2-CM	-.7323	-.86313	-1.07569	-.99544	-.72743	-.99128	-1.14206	-1.30041	-1.40437	-1.42397	-1.32423
ZDS/M	M/SEC2-CM	-.00015	-.00021	-.00036	-.00034	-.00012	-.00008	-.00010	-.00015	-.00025	-.00039	-.00021
ZDR/M	M/SEC2-CM	-.00006	-.00011	.00011	.00004	.00013	.00002	.00005	.00003	.00005	.00003	.00006
ZP/M	M/SEC	.25921	.47554	.43978	.28266	.13487	.08169	.05785	.04007	.03286	.02768	.02786
ZQ/M	M/SEC	-.62965	.65702	.09146	-.16696	.84273	.26658	.06277	-.33467	-.30482	-.03659	-.18263
ZR/M	M/SEC	-.39241	-.80695	.06956	.96907	.62470	.18893	.11211	.07753	.08001	.04236	-.00585
LU/IXX	1/SEC-M	-.00631	-.00327	.00110	.00414	-.00283	-.01175	-.00112	-.00063	-.00111	-.00086	-.00046
LV/IXX	1/SEC-M	-.01524	-.01720	-.01747	-.01651	-.01495	-.01437	-.01475	-.01535	-.01659	-.01873	-.02282
LW/IXX	1/SEC-M	.00326	.00251	.00437	.00633	.00587	.00656	.00700	.00751	.00759	.00866	.00750
LDB/IXX	1/SEC2-CM	-.01627	-.01127	-.00774	.00092	.00929	.00807	.00728	.00592	.00505	.00271	-.00362
LDC/IXX	1/SEC2-CM	-.00156	-.00478	-.00889	-.00749	.00428	.00314	.00247	.00191	.00251	.00519	.00266
LDS/IXX	1/SEC2-CM	.16131	.16411	.16393	.16162	.15804	.15665	.15581	.15512	.15371	.15298	.15632
LDR/IXX	1/SEC2-CM	-.05615	-.05745	-.05518	-.05233	-.05191	-.05398	-.05606	-.05767	-.05652	-.05553	-.05561
LP/IXX	1/SEC	-.93946	-.83498	-.78825	-.81747	-.94006	-1.00854	-1.01475	-.99269	-.93696	-.85413	-.76306
LQ/IXX	1/SEC	.12561	.13200	.07050	-.00570	-.04341	-.05550	-.05265	-.04320	-.02504	.00411	.05431
LR/IXX	1/SEC	-.06679	-.06930	-.06083	-.06155	-.07505	-.08777	-.08864	-.08597	-.08055	-.07098	-.05851
MU/IYY	1/SEC-M	-.02358	.06833	.09420	.06015	-.02766	-.01959	-.01535	-.01363	-.01013	-.00535	-.00533
MV/IYY	1/SEC-M	.00224	-.01057	.00242	.01468	-.00033	-.00146	-.00044	.00089	.00194	.00290	.00372
MW/IYY	1/SEC-M	-.02693	-.04583	.01630	.07016	.02728	.03429	.04047	.05701	.05399	.06070	.04140
MDB/IYY	1/SEC2-CM	.16214	.12105	.11757	.12001	.15670	.16322	.17200	.17736	.18647	.18636	.16036
MDC/IYY	1/SEC2-CM	-.06148	.04310	.00465	-.02985	.10698	.09588	.08958	.07850	.07201	.08416	.04328
MDS/IYY	1/SEC2-CM	-.00001	.00001	-.00000	-.00001	.00001	.00001	.00001	.00001	.00001	.00002	.00001
MDR/IYY	1/SEC2-CM	.00007	.00015	.00020	.00021	.00014	.00008	.00008	.00010	.00017	.00024	.00014
MP/IYY	1/SEC	-.07911	-.15680	-.01533	.10070	.05665	.02884	.01873	.01548	.01339	.01278	.01407
MQ/IYY	1/SEC	-1.28579	-1.52095	-1.61079	-1.54482	-1.31252	-1.55120	-1.66254	-1.79803	-1.81249	-1.76339	-1.48440
MR/IYY	1/SEC	.05843	.07924	.10989	.11885	.07457	.01911	.01204	.01071	.01299	.00923	.00473
NU/IZZ	1/SEC-M	[illegible]	-.00156	-.00173	-.00030	.00215	.00202	.00176	.00162	.00125	.00094	.00048
NV/IZZ	1/SEC-M	-.00407	-.00757	-.00149	.00445	.00051	-.00075	-.00162	-.00236	-.00312	-.00367	-.00377
NW/IZZ	1/SEC-M	.00307	.00177	.00011	-.00107	-.00094	-.00173	-.00219	-.00358	-.00312	-.00235	-.00319
NDB/IZZ	1/SEC2-CM	.00589	.01294	.01553	.01328	.00578	.00111	-.00123	-.00209	-.00161	.00090	.00472
NDC/IZZ	1/SEC2-CM	.00229	-.00196	.00025	.00184	-.00426	-.00511	-.00447	-.00252	-.00083	.00120	.00116
NDS/IZZ	1/SEC2-CM	.00248	.00294	.00352	.00395	.00353	.00277	.00208	.00155	.00165	.00181	.00228
NDR/IZZ	1/SEC2-CM	.07852	.08023	.08043	.07912	.07648	.07514	.07420	.07344	.07255	.07215	.07465
NP/IZZ	1/SEC	-.00926	-.00028	-.00406	-.01155	-.01370	-.01204	-.00884	-.00651	-.00795	-.01178	-.02161
NQ/IZZ	1/SEC	-.03361	-.04659	-.11613	-.10038	-.04748	.00892	.03580	.05641	.05930	.04513	.01809
NR/IZZ	1/SEC	-.04104	-.04008	-.04133	-.04247	-.04118	-.03648	-.03487	-.03404	-.03449	-.03539	-.03996
DB	CM	4.61162	3.13556	-1.01372	-4.91758	-5.64742	-5.22440	-1.92866	-.86197	-.17193	.17177	.67258
DC	CM	6.18438	8.63796	9.42738	8.45673	5.63010	4.15117	3.86064	4.10154	4.87927	6.33776	8.99332
DS	CM	.23363	.35631	.44161	.45070	.34472	.22136	.16785	.12877	.16258	.24626	.33248
DR	CM	-.92874	-.57520	.18104	.85677	.97659	.48928	.20320	-.04502	-.20408	-.39149	-.72961
THEN	DEG.	8.47551	7.64041	6.63529	5.58860	4.78880	3.76925	2.46475	1.15994	1.07865	.41977	-2.64048
PHIN	DEG.	-.16059	-.32271	-.38098	-.32605	-.14862	-.08178	-.08156	-.11354	-.18845	-.30363	-.44497

* DERIVED BY FITTING A THIRD ORDER CURVE THROUGH -40, -20, +20 AND +40 VALUES.

APPENDIX E

TABLE E1.- Concluded

(i) $\dot{Z}$ = 10.16 m/sec

Parameter	Unit	Value of parameter at $\dot{X}$, knots, of										
		-40	-20	*0	20	40	60	80	100	120	140	160
XU/M	1/SEC	-.06263	-.03715	-.00486	.01280	-.00562	-.01522	-.02053	-.02449	-.03210	-.03842	-.04364
XV/M	1/SEC	-.00036	-.00813	-.01059	-.00780	.00018	.00001	-.00001	.00027	.00100	.00235	.00333
XW/M	1/SEC	.07681	.00783	-.00046	.02390	.05288	.05212	.04813	.04442	.05783	.06509	.04280
XDB/M	M/SEC2-CM	.03231	.01307	.00937	.01132	.00902	.01304	.01636	.01887	.01703	.01854	.01779
XDC/M	M/SEC2-CM	.11952	.15608	.12780	.08218	.06669	.06030	.05034	.03774	.06119	.07796	.01785
XDS/M	M/SEC2-CM	.00001	.00005	.00005	.00004	.00001	.00000	.00000	.00000	.00002	.00004	.00002
XDR/M	M/SEC2-CM	.00001	.00002	.00003	.00002	.00000	.00000	.00000	.00000	.00001	.00003	.00003
XP/M	M/SEC	-.02042	-.11682	-.08527	-.01653	-.00134	-.00051	-.00091	-.00133	-.00142	-.00128	-.00003
XQ/M	M/SEC	.81360	.61390	.70003	.79939	.63575	.64323	.63334	.62593	.65015	.66498	.70631
XR/M	M/SEC	.03259	.14286	.01734	-.11312	-.01765	.00085	.00320	.00274	-.00176	-.00322	-.00451
YU/M	1/SEC	.00173	-.00581	-.00019	.00551	-.00177	-.00041	.00033	.00084	.00101	.00118	.00130
YV/M	1/SEC	-.05914	-.12163	-.14042	-.11564	-.04739	-.06234	-.08100	-.09989	-.11907	-.13875	-.15958
YW/M	1/SEC	.00112	.00536	.00932	.00930	.00158	.00049	-.00005	-.00011	.00076	.00245	.00439
YDB/M	M/SEC2-CM	-.01042	-.00891	.00153	.01108	.00993	.00537	.00188	-.00114	-.00289	-.00456	-.00770
YDC/M	M/SEC2-CM	.00528	.00046	-.00139	.00014	.00545	.00050	-.00185	-.00279	-.00133	.00375	.00791
YDS/M	M/SEC2-CM	.13336	.13989	.14094	.13755	.13073	.12850	.12646	.12488	.12276	.12132	.12470
YDR/M	M/SEC2-CM	-.00796	-.01014	-.00719	-.00442	-.00714	-.01080	-.01436	-.01710	-.01691	-.01674	-.01583
YP/M	M/SEC	-.86995	-.65315	-.57260	-.64132	-.87236	-.93816	-.93879	-.90535	-.83647	-.73768	-.63279
YQ/M	M/SEC	.05747	.09684	-.00775	-.10177	-.03073	.01042	.04962	.08375	.10272	.12531	.15272
YR/M	M/SEC	-.09939	-.08070	-.05865	-.05549	-.09347	-.10072	-.09937	-.09463	-.08776	-.07634	-.06327
ZU/M	1/SEC	.30299	.21867	-.01843	-.21180	-.16494	-.06629	-.03036	-.01330	.01087	.03054	.03503
ZV/M	1/SEC	.00090	.06327	.10005	.08775	.00282	-.00013	.00037	.00150	.00342	.00489	.00442
ZW/M	1/SEC	-.56518	-.10912	.02341	-.15034	-.61310	-.66055	-.69979	-.73454	-.76482	-.73642	-.70289
ZDB/M	M/SEC2-CM	-.11240	-.00591	.02732	.01566	.10744	.08516	.07799	.07469	.07131	.03426	.03013
ZDC/M	M/SEC2-CM	-.75312	-1.01666	-1.10527	-1.02939	-.79955	-1.02189	-1.16492	-1.27755	-1.38020	-1.43782	-1.37438
ZDS/M	M/SEC2-CM	-.00004	-.00033	-.00048	-.00043	-.00008	-.00002	-.00003	-.00006	-.00024	-.00045	-.00042
ZDR/M	M/SEC2-CM	-.00003	-.00001	.00001	.00004	.00007	.00000	.00000	.00005	.00008	.00004	.00007
ZP/M	M/SEC	.10745	.71796	.75201	.46299	.10429	.00516	.00950	.03630	.02818	.02487	.02291
ZQ/M	M/SEC	-.57476	1.04091	.05095	-.90408	.81637	.24682	.05257	-.03104	-.10414	-.10410	.07534
ZR/M	M/SEC	-.20923	-1.03603	.16611	1.35996	.26664	.04400	.03111	.04755	.08698	.05478	.00880
LU/IXX	1/SEC-M	-.00105	-.00529	.00188	.00724	-.00242	-.00152	-.00105	-.00069	-.00127	-.00109	-.00056
LV/IXX	1/SEC-M	-.01317	-.01631	-.01639	-.01489	-.01334	-.01286	-.01283	-.01353	-.01480	-.01686	-.02069
LW/IXX	1/SEC-M	.00324	.00408	.00820	.01055	.00607	.00699	.00750	.00785	.00818	.00924	.00910
LDB/IXX	1/SEC2-CM	-.01171	-.01595	-.00793	.00338	.00901	.00850	.00785	.00687	.00609	.00387	-.00130
LDC/IXX	1/SEC2-CM	-.00212	-.00664	-.01235	-.01115	.00508	.00404	.00387	.00385	.00452	.00712	.00672
LDS/IXX	1/SEC2-CM	.15911	.16472	.16523	.16205	.15672	.15532	.15407	.15310	.15131	.15009	.15279
LDR/IXX	1/SEC2-CM	-.05394	-.05805	-.05596	-.05245	-.05232	-.05459	-.05685	-.05857	-.05766	-.05700	-.05743
LP/IXX	1/SEC	-1.02597	-.85822	-.78941	-.83989	-1.03004	-1.08668	-1.08656	-1.05662	-.99569	-.90851	-.81362
LQ/IXX	1/SEC	.09367	.15719	.06029	-.05739	-.05614	-.06492	-.06092	-.05097	-.03411	-.00484	.03533
LR/IXX	1/SEC	-.09530	-.07811	-.05610	-.05232	-.08980	-.09796	-.09727	-.09317	-.08681	-.07654	-.06304
MU/IYY	1/SEC-M	-.02509	.09250	.12110	.07691	-.02386	-.01620	-.01328	-.01161	-.00902	-.00552	-.00337
MV/IYY	1/SEC-M	.00307	-.01967	.00430	.02626	-.00249	-.00238	-.00098	.00041	.00148	.00243	.00340
MW/IYY	1/SEC-M	-.01793	-.06703	.01947	.09800	.02500	.03304	.03893	.04393	.04457	.06055	.05375
MDB/IYY	1/SEC2-CM	.15313	.11451	.10151	.11533	.14917	.16036	.17014	.17916	.18834	.18712	.16979
MDC/IYY	1/SEC2-CM	-.08747	.07215	.00584	-.06029	.09988	.08667	.08258	.08184	.07568	.08740	.06614
MDS/IYY	1/SEC2-CM	-.00000	.00003	-.00000	-.00003	.00000	.00000	.00000	.00001	.00001	.00002	.00002
MDR/IYY	1/SEC2-CM	.00004	.00018	.00026	.00024	.00006	.00001	.00002	.00006	.00016	.00029	.00027
MP/IYY	1/SEC	-.03520	-.23178	-.03066	.18870	.04683	-.00245	.00132	.01223	.01217	.01119	.01222
MQ/IYY	1/SEC	-1.32501	-1.72901	-1.88762	-1.77125	-1.34986	-1.55299	-1.65381	-1.71455	-1.75956	-1.75897	-1.61366
MR/IYY	1/SEC	.02571	.15217	.23723	.21576	.02264	-.00272	.00033	.00639	.01297	.00928	.00624
NU/IZZ	1/SEC-M	.00151	-.00301	-.00344	-.00116	.00244	.00206	.00185	.00168	.00140	.00118	.00074
NV/IZZ	1/SEC-M	-.00321	-.00761	-.00145	.00469	.00018	-.00097	-.00189	-.00263	-.00339	-.00397	-.00407
NW/IZZ	1/SEC-M	.00274	.00273	.00003	-.00231	-.00121	-.00218	-.00272	-.00295	-.00285	-.00282	-.00199
NDB/IZZ	1/SEC2-CM	.00196	.01215	.01591	.01271	.00206	-.00255	-.00514	-.00635	-.00591	-.00342	.00075
NDC/IZZ	1/SEC2-CM	.00543	-.00318	-.00001	.00281	-.00686	-.00699	-.00665	-.00586	-.00406	-.00093	.00146
NDS/IZZ	1/SEC2-CM	.00313	.00287	.00350	.00398	.00323	.00241	.00161	.00100	.00098	.00098	.00127
NDR/IZZ	1/SEC2-CM	.07692	.08060	.08128	.07942	.07543	.07406	.07278	.07180	.07058	.06975	.07172
NP/IZZ	1/SEC	-.02035	-.00103	-.00292	-.01209	-.01458	-.00874	-.00548	-.00338	-.00265	-.00357	-.00919
NQ/IZZ	1/SEC	-.00332	-.07806	-.10614	-.08390	-.00766	.04696	.07417	.08543	.08949	.07960	.03968
NR/IZZ	1/SEC	-.03942	-.04289	-.04631	-.04567	-.03701	-.03287	-.03191	-.03179	-.03253	-.03276	-.03595
DB	CM	3.67698	4.76246	-1.11595	-6.73442	-4.86914	-2.86325	-1.76608	-.97363	-.40221	-.09620	.27620
DC	CM	4.16392	8.18320	9.47243	8.00437	3.75176	2.48656	2.19566	2.50130	3.29269	4.72304	7.25064
DS	CM	.11084	.31152	.45187	.44684	.21139	.10631	.05640	.03311	.08130	.17523	.25527
DR	CM	-.85248	-.91782	.20013	1.21735	.84982	.43699	.18717	-.00509	-.12176	-.27258	-.56195
THEN	DEG.	8.21096	7.68382	6.67365	5.61325	4.93539	3.95243	2.81267	1.56647	1.51339	.89782	-2.04072
PHIN	DEG.	-.06388	-.31197	-.38678	-.30882	-.05863	-.00681	-.01180	-.05078	-.13447	-.25974	-.41379

* DERIVED BY FITTING A THIRD ORDER CURVE THROUGH -40, -20, +20 AND +40 VALUES.

TABLE E2.- STABILITY DERIVATIVES AND TRIMS IN U.S. CUSTOMARY UNITS

(a) $\dot{Z}$ = -2000 ft/min

Parameter	Unit	Value of parameter at $\dot{X}$, knots, of										
		-40	-20	*0	20	40	60	80	100	120	140	160
XU/M	1/SEC	-.05118	-.04400	-.02862	-.01680	-.02032	-.02594	-.03059	-.03473	-.04149	-.04742	-.05539
XV/M	1/SEC	-.00316	-.01169	-.00371	.00564	.00121	-.00002	-.00079	-.00162	-.00288	-.00477	-.00513
XW/M	1/SEC	.07545	.05547	.04517	.04082	.03871	.03191	.02074	.00780	.00789	.00078	-.02732
XDB/M	FT/SEC2-IN	.15981	.14142	.12940	.12388	.12502	.13553	.14923	.15833	.12347	.08429	.04701
XDC/M	FT/SEC2-IN	1.63981	1.29423	.98852	.72567	.50871	.29371	.05588	-.24779	-.29769	-.48805	-1.10702
XDS/M	FT/SEC2-IN	-.00130	-.00093	-.00068	-.00051	-.00037	-.00027	-.00017	-.00006	-.00007	.00003	.00079
XDR/M	FT/SEC2-IN	-.00070	-.00054	-.00045	-.00040	-.00036	-.00037	-.00042	-.00052	-.00045	-.00037	-.00037
XP/M	FT/SEC	.06319	.06770	.01851	-.02621	-.00825	-.00064	.00358	.00758	.00911	.01015	.01518
XQ/M	FT/SEC	2.49779	2.61239	2.61302	2.56508	2.55396	2.51622	2.53310	2.61093	2.86081	3.16720	3.61619
XR/M	FT/SEC	-.23021	-.21555	-.12490	-.04060	-.04496	-.05976	-.07565	-.09320	-.10096	-.12259	-.19675
YU/M	1/SEC	-.00205	-.00344	-.00123	.00118	.00041	.00034	.00057	.00090	.00101	.00096	.00059
YV/M	1/SEC	-.11966	-.19226	-.18665	-.14146	-.09535	-.09455	-.10600	-.12218	-.13994	-.16058	-.18770
YW/M	1/SEC	.00450	.00448	.00468	.00500	.00532	.00530	.00527	.00536	.00493	.00431	.00217
YDB/M	FT/SEC2-IN	.00255	.00783	.01503	.02270	.02942	.02752	.01832	.00366	-.02691	-.07455	-.15172
YDC/M	FT/SEC2-IN	.08559	.08289	.08387	.08603	.08687	.08665	.08790	.09272	.09646	.09836	.07427
YDS/M	FT/SEC2-IN	1.19595	1.19100	1.18384	1.17568	1.16770	1.17280	1.18709	1.21011	1.23366	1.26841	1.35059
YDR/M	FT/SEC2-IN	-.09284	-.07297	-.04955	-.03025	-.02271	-.02240	-.02238	-.01386	.02614	.06949	.11619
YP/M	FT/SEC	-1.01152	-.84513	-.78321	-.82669	-.97650	-1.09171	-1.14141	-1.12691	-1.04293	-.89819	-.72210
YQ/M	FT/SEC	-.06963	-.04832	-.01149	.02239	.03488	.08596	.16156	.25066	.38436	.58147	.87209
YR/M	FT/SEC	-.10480	-.09303	-.08354	-.08471	-.10487	-.11887	-.12534	-.12738	-.13159	-.13265	-.13951
ZU/M	1/SEC	.15413	.13780	.03773	-.05601	-.05338	-.03476	-.02517	-.02305	.00183	.02673	.03788
ZV/M	1/SEC	-.00626	-.00078	.00138	.00090	-.00156	-.00109	.00022	.00112	.00174	.00206	.00555
ZW/M	1/SEC	-.51004	-.42984	-.41575	-.45665	-.54146	-.61615	-.68038	-.73471	-.71791	-.66132	-.58574
ZDB/M	FT/SEC2-IN	-.18454	-.07609	.02530	.12574	.23139	.30079	.32528	.32456	.27510	.16413	.34962
ZDC/M	FT/SEC2-IN	-9.04134	-8.61662	-8.50956	-8.71609	-9.23216	-9.96946	-10.75477	-11.54134	-11.44694	-10.40171	-9.15297
ZDS/M	FT/SEC2-IN	.00783	.00656	.00589	.00555	.00528	.00545	.00609	.00749	.00812	.00900	.01211
ZDR/M	FT/SEC2-IN	.00082	.00029	-.00010	-.00037	-.00053	-.00075	-.00117	-.00119	-.00078	-.00105	-.00273
ZP/M	FT/SEC	-.18366	-.12884	-.01306	.06937	.02413	.01439	.03614	.06560	.08210	.10083	.14145
ZQ/M	FT/SEC	1.09826	.50543	.52048	.55636	.02603	-.18900	-.05936	.20901	.25632	.30375	-.23303
ZR/M	FT/SEC	.85735	.84197	.03325	-.77589	-.79252	-.73035	-.68379	-.69348	-.71694	-.72756	-.78478
LU/IXX	1/SEC-FT	-.00057	-.00063	-.00053	-.00036	-.00020	-.00008	.00004	.00018	.00012	.00024	.00036
LV/IXX	1/SEC-FT	-.00736	-.00741	-.00730	-.00713	-.00702	-.00712	-.00741	-.00788	-.00859	-.00975	-.01190
LW/IXX	1/SEC-FT	.00043	.00044	.00046	.00053	.00070	.00087	.00101	.00113	.00138	.00175	.00184
LDB/IXX	1/SEC2-IN	-.03983	-.03832	-.03477	-.02964	-.02337	-.02039	-.02045	-.02319	-.03197	-.04800	-.07546
LDC/IXX	1/SEC2-IN	-.01166	-.01491	-.01721	-.01865	-.01933	-.01978	-.02016	-.02025	-.01804	-.01292	-.01547
LDS/IXX	1/SEC2-IN	.42642	.42439	.42167	.41884	.41652	.41781	.42144	.42697	.43141	.43857	.45767
LDR/IXX	1/SEC2-IN	-.15274	-.14717	-.14046	-.13469	-.13194	-.13241	-.13395	-.13425	-.12660	-.11929	-.11616
LP/IXX	1/SEC	-.59483	-.54596	-.51947	-.51926	-.54922	-.57182	-.57709	-.56336	-.52459	-.46679	-.39543
LQ/IXX	1/SEC	.15014	.14593	.14176	.13165	.10961	.09877	.09740	.10394	.13124	.17750	.24050
LR/IXX	1/SEC	-.03513	-.03152	-.02967	-.03047	-.03480	-.03759	-.03817	-.03692	-.03457	-.02936	-.02151
MU/IYY	1/SEC-FT	.00027	.00104	.00138	.00095	-.00060	-.00233	-.00293	-.00295	-.00236	-.00162	-.00238
MV/IYY	1/SEC-FT	.00220	.00245	-.00015	-.00257	-.00176	-.00077	.00014	.00099	.00179	.00236	.00302
MW/IYY	1/SEC-FT	-.00703	-.00255	.00169	.00600	.01066	.01324	.01460	.01571	.01495	.01474	.01069
MDB/IYY	1/SEC2-IN	.37256	.36008	.35545	.35885	.37046	.39201	.41467	.43642	.41832	.37555	.31234
MDC/IYY	1/SEC2-IN	-.03008	.00104	.02225	.04478	.07988	.11852	.14663	.16715	.15803	.15819	.07641
MDS/IYY	1/SEC2-IN	.00002	-.00000	-.00002	-.00003	-.00004	-.00005	-.00008	-.00010	-.00010	-.00010	-.00007
MDR/IYY	1/SEC2-IN	-.00162	-.00138	-.00124	-.00115	-.00107	-.00107	-.00121	-.00145	-.00152	-.00162	-.00219
MP/IYY	1/SEC	.02734	.03360	-.00252	-.03813	-.03030	-.01752	-.00516	.00600	.01514	.02173	.02788
MQ/IYY	1/SEC	-1.52788	-1.39708	-1.35265	-1.39397	-1.52040	-1.63108	-1.70365	-1.75387	-1.65610	-1.46228	-1.23556
MR/IYY	1/SEC	-.01017	-.00371	-.00456	-.00908	-.01362	-.01562	-.01186	-.00608	-.00152	.00333	.00451
NU/IZZ	1/SEC-FT	.00030	.00052	.00065	.00065	.00044	.00031	.00025	.00022	.00015	.00005	-.00025
NV/IZZ	1/SEC-FT	-.00197	-.00355	-.00110	.00151	.00043	.00010	-.00008	-.00021	-.00037	-.00047	-.00034
NW/IZZ	1/SEC-FT	.00045	.00034	.00035	.00039	.00037	.00020	-.00002	-.00031	-.00115	-.00251	-.00464
NDB/IZZ	1/SEC2-IN	.06166	.06515	.06613	.06460	.06053	.05815	.05767	.05942	.06320	.07025	.08165
NDC/IZZ	1/SEC2-IN	-.00419	-.00110	.00191	.00518	.00902	.01239	.01474	.01592	.01013	-.00506	-.03196
NDS/IZZ	1/SEC2-IN	.00701	.00822	.00963	.01078	.01119	.01125	.01137	.01210	.01482	.01785	.02150
NDR/IZZ	1/SEC2-IN	.20987	.20917	.20812	.20687	.20556	.20646	.20895	.21303	.21747	.22385	.23844
NP/IZZ	1/SEC	.03790	.02549	.00744	-.01049	-.02254	-.03137	-.04039	-.05300	-.07687	-.10728	-.14998
NQ/IZZ	1/SEC	-.21913	-.23281	-.23718	-.23246	-.21888	-.20645	-.19817	-.19464	-.17704	-.16343	-.15835
NR/IZZ	1/SEC	-.04328	-.04433	-.04551	-.04660	-.04736	-.04848	-.05025	-.05339	-.05964	-.06983	-.08899
DB	IN	-.18425	-.16325	-.24597	-.34123	-.35786	-.18502	.09439	.40521	.66573	.91708	1.34546
DC	IN	5.58964	5.82353	5.88053	5.76046	5.46311	5.33553	5.40809	5.67751	6.11301	6.87407	8.20319
DS	IN	.30373	.32369	.32866	.32059	.30141	.28408	.26919	.25759	.26471	.30274	.38246
DR	IN	.24319	.16355	.07431	-.01311	-.08732	-.18775	-.31210	-.45927	-.63590	-.85990	-1.21164
THEN	DEG.	9.41930	7.98786	6.61948	5.30248	4.02516	2.59770	.91870	-.87356	-1.33030	-2.40688	-6.17521
PHIN	DEG.	-.53696	-.54449	-.56340	-.57188	-.54815	-.52384	-.51905	-.53071	-.56499	-.62282	-.70425

* DERIVED BY FITTING A THIRD ORDER CURVE THROUGH -40, -20, +20 AND +40 VALUES.

TABLE E2.- Continued

(b) $\dot{Z}$ = -1500 ft/min

Parameter	Unit	Value of parameter at $\dot{X}$, knots, of -40	-20	*0	20	40	60	80	100	120	140	160
XU/M	1/SEC	-.05033	-.04387	-.02686	-.01355	-.01818	-.02447	-.02928	-.03329	-.03977	-.04612	-.05283
XV/M	1/SEC	-.00115	-.00711	-.00238	.00340	.00060	-.00015	-.00064	-.00126	-.00216	-.00379	-.00591
XW/M	1/SEC	.07103	.05143	.04213	.03923	.03884	.03340	.02340	.01158	.01419	.00531	-.01981
XDB/M	FT/SEC2-IN	.16116	.13934	.12584	.11997	.12108	.13325	.14878	.15949	.13485	.08658	.06457
XDC/M	FT/SEC2-IN	1.59771	1.26970	.97328	.71964	.51999	.32753	.09215	-.16849	-.17508	-.38266	-.94407
XDS/M	FT/SEC2-IN	-.00093	-.00068	-.00048	-.00034	-.00024	-.00018	-.00013	-.00007	-.00011	-.00004	.00044
XDR/M	FT/SEC2-IN	-.00054	-.00040	-.00031	-.00026	-.00023	-.00023	-.00026	-.00034	-.00035	-.00027	-.00038
XP/M	FT/SEC	.06864	.06545	.01934	-.02051	-.00489	.00033	.00313	.00623	.00792	.00888	.01372
XQ/M	FT/SEC	2.42708	2.59131	2.60280	2.54639	2.50696	2.47299	2.47248	2.53161	2.69970	3.04823	3.41859
XR/M	FT/SEC	-.22351	-.21195	-.11195	-.01805	-.02481	-.04254	-.05814	-.07309	-.07686	-.09651	-.15647
YU/M	1/SEC	-.00169	-.00265	-.00087	.00100	.00032	.00024	.00048	.00079	.00101	.00087	.00086
YV/M	1/SEC	-.10873	-.17212	-.16982	-.13168	-.08753	-.08844	-.10083	-.11743	-.13536	-.15579	-.18139
YW/M	1/SEC	.00380	.00379	.00403	.00440	.00476	.00467	.00457	.00464	.00504	.00371	.00331
YDB/M	FT/SEC2-IN	-.00670	.00230	.01415	.02619	.03577	.03390	.02418	.00989	-.01374	-.06331	-.12291
YDC/M	FT/SEC2-IN	.07619	.07713	.07879	.07965	.07819	.07649	.07636	.08027	.09035	.08328	.07999
YDS/M	FT/SEC2-IN	1.18286	1.18133	1.17516	1.16595	1.15528	1.15787	1.16867	1.18731	1.20578	1.23445	1.30812
YDR/M	FT/SEC2-IN	-.09076	-.07337	-.05071	-.03216	-.02712	-.03021	-.03384	-.02915	.00628	.04473	.08679
YP/M	FT/SEC	-1.23216	-1.04164	-.97175	-1.02387	-1.19941	-1.32643	-1.37600	-1.35442	-1.25516	-1.09089	-.90315
YQ/M	FT/SEC	-.03586	-.02204	-.00682	.00608	.01291	.06414	.14147	.22889	.32821	.55562	.77059
YR/M	FT/SEC	-.13065	-.11491	-.10426	-.10628	-.12856	-.14311	-.14851	-.14845	-.14798	-.14418	-.14333
ZU/M	1/SEC	.16121	.15090	.03464	-.07480	-.06464	-.04075	-.02741	-.02259	-.00052	.03022	.03086
ZV/M	1/SEC	-.00716	-.00141	.00089	.00059	-.00144	-.00031	.00100	.00172	.00175	.00240	.00256
ZW/M	1/SEC	-.48786	-.40112	-.38687	-.43138	-.52093	-.60080	-.66904	-.72574	-.72914	-.65092	-.61676
ZDB/M	FT/SEC2-IN	-.20929	-.08395	.02643	.13573	.25785	.33436	.35668	.35174	.24441	.21211	.22413
ZDC/M	FT/SEC2-IN	-8.90506	-8.47970	-8.37162	-8.57537	-9.08549	-9.84153	-10.65535	-11.46771	-11.66779	-10.25289	-9.85852
ZDS/M	FT/SEC2-IN	.00566	.00479	.00416	.00369	.00330	.00342	.00380	.00490	.00563	.00632	.00985
ZDR/M	FT/SEC2-IN	.00079	.00024	-.00010	-.00028	-.00035	-.00041	-.00081	-.00065	-.00013	-.00080	-.00117
ZP/M	FT/SEC	-.25195	-.17114	-.03379	.05095	-.02604	-.02303	.00777	.04047	.06042	.07969	.10683
ZQ/M	FT/SEC	1.28556	.50370	.50391	.52584	-.19081	-.41239	-.25458	.03034	.73722	.16933	.45219
ZR/M	FT/SEC	.91806	.92030	.02824	-.86673	-.87324	-.75676	-.66760	-.64648	-.66472	-.64227	-.72414
LU/IXX	1/SEC-FT	-.00053	-.00061	-.00049	-.00030	-.00017	-.00010	.00001	.00013	.00008	.00016	.00035
LV/IXX	1/SEC-FT	-.00690	-.00701	-.00696	-.00680	-.00663	-.00669	-.00694	-.00736	-.00799	-.00904	-.01086
LW/IXX	1/SEC-FT	.00050	.00046	.00047	.00056	.00080	.00099	.00112	.00123	.00161	.00169	.00210
LDB/IXX	1/SEC2-IN	-.03817	-.03628	-.03173	-.02528	-.01769	-.01420	-.01394	-.01617	-.02269	-.03916	-.06119
LDC/IXX	1/SEC2-IN	-.01021	-.01376	-.01616	-.01744	-.01766	-.01759	-.01773	-.01782	-.01462	-.01252	-.01203
LDS/IXX	1/SEC2-IN	.42301	.42195	.41950	.41644	.41353	.41431	.41720	.42176	.42508	.43089	.44800
LDR/IXX	1/SEC2-IN	-.15084	-.14626	-.13985	-.13416	-.13174	-.13281	-.13489	-.13570	-.12868	-.12197	-.11913
LP/IXX	1/SEC	-.64632	-.59328	-.56592	-.56888	-.60679	-.63365	-.64013	-.62600	-.58538	-.52507	-.45372
LQ/IXX	1/SEC	.14216	.13825	.12938	.11315	.08715	.07420	.07201	.07753	.09734	.14880	.20010
LR/IXX	1/SEC	-.04261	-.03797	-.03559	-.03646	-.04158	-.04487	-.04553	-.04410	-.04110	-.03545	-.02700
MU/IYY	1/SEC-FT	.00082	.00203	.00255	.00190	-.00036	-.00253	-.00311	-.00304	-.00208	-.00170	-.00158
MV/IYY	1/SEC-FT	.00200	.00216	-.00006	-.00211	-.00143	-.00058	.00019	.00091	.00165	.00204	.00267
MW/IYY	1/SEC-FT	-.00826	-.00303	.00174	.00654	.01184	.01413	.01510	.01593	.01739	.01398	.01487
MDB/IYY	1/SEC2-IN	.36851	.35481	.34973	.35351	.36638	.39071	.41484	.43722	.43615	.37214	.34660
MDC/IYY	1/SEC2-IN	-.03176	.00260	.02162	.04220	.08124	.12407	.15151	.16993	.17649	.14017	.10979
MDS/IYY	1/SEC2-IN	.00001	-.00000	-.00001	-.00002	-.00003	-.00003	-.00005	-.00007	-.00010	-.00006	-.00013
MDR/IYY	1/SEC2-IN	-.00119	-.00101	-.00088	-.00077	-.00067	-.00066	-.00076	-.00096	-.00107	-.00114	-.00178
MP/IYY	1/SEC	.03643	.04190	-.00240	-.04582	-.03770	-.02255	-.00915	.00204	.01100	.01720	.02440
MQ/IYY	1/SEC	-1.52562	-1.36512	-1.31090	-1.36209	-1.51781	-1.63613	-1.70785	-1.75547	-1.74017	-1.45782	-1.32729
MR/IYY	1/SEC	-.01319	-.00270	-.00330	-.01025	-.01880	-.02036	-.01519	-.00863	-.00153	.00121	.00744
NU/IZZ	1/SEC-FT	.00023	.00047	.00062	.00061	.00039	.00027	.00023	.00021	.00016	.00005	-.00015
MV/IZZ	1/SEC-FT	-.00180	-.00320	-.00094	.00144	.00039	.00006	-.00014	-.00029	-.00046	-.00059	-.00053
NW/IZZ	1/SEC-FT	.00042	.00030	.00032	.00037	.00033	.00015	-.00004	-.00026	-.00086	-.00216	-.00375
NDB/IZZ	1/SEC2-IN	.05468	.05921	.06058	.05876	.05376	.05051	.04924	.05029	.05402	.05990	.07191
NDC/IZZ	1/SEC2-IN	-.00467	-.00146	.00158	.00479	.00851	.01163	.01394	.01556	.01243	-.00241	-.02121
NDS/IZZ	1/SEC2-IN	.00703	.00811	.00949	.01058	.01081	.01063	.01049	.01094	.01333	.01600	.01928
NDR/IZZ	1/SEC2-IN	.20764	.20751	.20663	.20519	.20338	.20381	.20567	.20896	.21247	.21778	.23089
NP/IZZ	1/SEC	.03068	.02154	.00544	-.01082	-.02047	-.02704	-.03383	-.04389	-.06407	-.08988	-.12650
NQ/IZZ	1/SEC	-.19053	-.20835	-.21434	-.20859	-.19118	-.17488	-.16413	-.15930	-.14690	-.13211	-.13531
NR/IZZ	1/SEC	-.04228	-.04328	-.04432	-.04511	-.04536	-.04581	-.04696	-.04939	-.05442	-.06299	-.07875
DB	IN	-.04989	-.09073	-.25640	-.43378	-.50978	-.32418	-.02211	.29959	.55386	.78053	1.16387
DC	IN	5.09593	5.40061	5.48036	5.33684	4.97169	4.79996	4.84093	5.08308	5.49268	6.21451	7.45641
DS	IN	.26790	.29183	.29913	.29190	.27140	.25314	.23745	.22533	.23112	.26404	.32750
DR	IN	.18005	.12923	.07131	.01383	-.03566	-.12515	-.24009	-.37341	-.52654	-.71934	-1.02469
THEN	DEG.	9.26035	7.92430	6.61524	5.34968	4.14412	2.78578	1.17638	-.53930	-.92517	-1.90961	-5.45690
PHIN	DEG.	-.48783	-.51836	-.53898	-.53565	-.49431	-.46426	-.45899	-.47303	-.51179	-.57628	-.66222

* DERIVED BY FITTING A THIRD ORDER CURVE THROUGH -40, -20, +20 AND +40 VALUES.

TABLE E2.- Continued

(c) $\dot{Z}$ = -1000 ft/min

Parameter	Unit	Value of parameter at $\dot{X}$, knots, of -40	-20	*0	20	40	60	80	100	120	140	160
XU/M	1/SEC	-.04972	-.04402	-.02511	-.01009	-.01604	-.02307	-.02806	-.03200	-.03833	-.04501	-.05093
XV/M	1/SEC	.00001	-.00391	-.00149	.00175	.00026	-.00011	-.00037	-.00078	-.00138	-.00267	-.00576
XW/M	1/SEC	.06619	.04724	.03904	.03759	.03889	.03484	.02603	.01535	.02025	.01025	-.01344
XDB/M	FT/SEC2-IN	.16333	.13727	.12217	.11608	.11705	.13105	.14845	.16082	.14331	.09211	.06900
XDC/M	FT/SEC2-IN	1.55478	1.24691	.95914	.71302	.53009	.36094	.14858	-.08856	-.05088	-.26597	-.79618
XDS/M	FT/SEC2-IN	-.00062	-.00044	-.00030	-.00019	-.00013	-.00009	-.00008	-.00006	-.00009	-.00007	.00021
XDR/M	FT/SEC2-IN	-.00036	-.00027	-.00019	-.00014	-.00010	-.00011	-.00014	-.00020	-.00021	-.00018	-.00026
XP/M	FT/SEC	.07878	.06776	.02172	-.01601	-.00205	.00096	.00235	.00465	.00651	.00746	.01105
XQ/M	FT/SEC	2.34955	2.57095	2.59658	2.53239	2.48428	2.43266	2.41469	2.45538	2.60669	2.93349	3.28950
XR/M	FT/SEC	-.22192	-.21234	-.09958	.00503	-.00983	-.03151	-.04247	-.05503	-.05724	-.07393	-.12226
YU/M	1/SEC	-.00139	-.00208	-.00060	.00090	.00024	.00013	.00039	.00071	.00094	.00084	.00071
YV/M	1/SEC	-.09938	-.15574	-.15610	-.12340	-.08054	-.08301	-.09629	-.11328	-.13143	-.15165	-.17610
YW/M	1/SEC	.00324	.00320	.00348	.00391	.00434	.00412	.00391	.00395	.00463	.00338	.00238
YDB/M	FT/SEC2-IN	-.01680	-.00370	.01329	.03014	.04281	.04004	.02892	.01435	-.00388	-.05315	-.10396
YDC/M	FT/SEC2-IN	.06701	.07144	.07384	.07355	.06990	.06667	.06490	.06780	.08390	.07431	.07018
YDS/M	FT/SEC2-IN	1.17124	1.17331	1.16814	1.15778	1.14427	1.14416	1.15126	1.16540	1.17883	1.20148	1.26714
YDR/M	FT/SEC2-IN	-.08862	-.07386	-.05181	-.03383	-.03128	-.03793	-.04536	-.04462	-.01384	.01970	.05677
YP/M	FT/SEC	-1.45203	-1.23353	-1.15428	-1.21632	-1.42169	-1.56230	-1.61167	-1.58215	-1.46677	-1.28139	-1.07961
YQ/M	FT/SEC	-.00060	.00269	-.00237	-.00908	-.01072	.04349	.12548	.21330	.30427	.49772	.69216
YR/M	FT/SEC	-.15641	-.13647	-.12434	-.12737	-.15294	-.16880	-.17261	-.16974	-.16560	-.15593	-.15084
ZU/M	1/SEC	.16925	.16588	.03148	-.09572	-.07749	-.04789	-.03020	-.02241	-.00280	.03274	.02714
ZV/M	1/SEC	-.00722	-.00162	.00072	.00082	-.00032	.00107	.00206	.00242	.00244	.00281	.00464
ZW/M	1/SEC	-.46335	-.37131	-.35751	-.40538	-.49832	-.58473	-.65759	-.71686	-.74411	-.64564	-.64701
ZDB/M	FT/SEC2-IN	-.23793	-.09152	.02774	.14579	.28857	.37286	.39135	.38110	.25913	.22713	.38045
ZDC/M	FT/SEC2-IN	-8.76072	-8.34844	-8.24424	-8.44039	-8.92918	-9.69911	-10.54486	-11.38530	-11.86153	-10.22149	-10.13481
ZDS/M	FT/SEC2-IN	.00387	.00314	.00253	.00205	.00170	.00165	.00196	.00287	.00325	.00385	.00801
ZDR/M	FT/SEC2-IN	.00055	.00019	-.00004	-.00022	-.00041	-.00037	-.00029	-.00030	-.00011	-.00076	-.00233
ZP/M	FT/SEC	-.34012	-.23042	-.06929	.02006	-.08558	-.06678	-.02233	.01553	.03630	.05994	.11857
ZQ/M	FT/SEC	1.52523	.52018	.48408	.47277	-.45790	-.65483	-.45558	-.15244	.46989	.03488	-.63600
ZR/M	FT/SEC	1.00204	1.01959	.00058	-.98409	-.86355	-.63779	-.60535	-.60597	-.60021	-.56505	-.69960
LU/IXX	1/SEC-FT	-.00048	-.00059	-.00044	-.00022	-.00014	-.00012	-.00003	.00008	.00001	.00010	.00020
LV/IXX	1/SEC-FT	-.00647	-.00665	-.00664	-.00649	-.00626	-.00627	-.00648	-.00686	-.00744	-.00838	-.00995
LW/IXX	1/SEC-FT	.00056	.00048	.00047	.00060	.00095	.00116	.00127	.00135	.00170	.00172	.00169
LDB/IXX	1/SEC2-IN	-.03692	-.03461	-.02893	-.02102	-.01198	-.00814	-.00774	-.00964	-.01429	-.03073	-.04938
LDC/IXX	1/SEC2-IN	-.00893	-.01275	-.01523	-.01630	-.01588	-.01506	-.01491	-.01497	-.01082	-.01017	-.01227
LDS/IXX	1/SEC2-IN	.41997	.41992	.41776	.41443	.41089	.41112	.41322	.41678	.41901	.42347	.43874
LDR/IXX	1/SEC2-IN	-.14907	-.14554	-.13939	-.13371	-.13162	-.13330	-.13596	-.13729	-.13090	-.12480	-.12241
LP/IXX	1/SEC	-.69755	-.63945	-.61095	-.61745	-.66429	-.69571	-.70323	-.68840	-.64553	-.58229	-.50997
LQ/IXX	1/SEC	.13520	.13148	.11838	.09605	.06460	.04995	.04770	.05286	.07124	.12280	.16163
LR/IXX	1/SEC	-.05003	-.04422	-.04119	-.04217	-.04844	-.05242	-.05301	-.05123	-.04777	-.04132	-.03328
MU/IYY	1/SEC-FT	.00133	.00330	.00410	.00311	-.00027	-.00289	-.00335	-.00317	-.00218	-.00168	-.00221
MV/IYY	1/SEC-FT	.00175	.00175	.00001	-.00155	-.00104	-.00037	.00024	.00083	.00144	.00175	.00247
MW/IYY	1/SEC-FT	-.00987	-.00365	.00184	.00729	.01337	.01517	.01564	.01617	.01770	.01380	.01119
MDB/IYY	1/SEC2-IN	.36452	.34928	.34363	.34790	.36241	.39000	.41550	.43835	.45158	.37301	.36161
MDC/IYY	1/SEC2-IN	-.03381	.00557	.02092	.03816	.08318	.13137	.15750	.17332	.19352	.13769	.09461
MDS/IYY	1/SEC2-IN	.00001	-.00000	-.00001	-.00001	-.00002	-.00001	-.00002	-.00004	-.00006	-.00004	-.00001
MDR/IYY	1/SEC2-IN	-.00079	-.00067	-.00055	-.00044	-.00035	-.00033	-.00039	-.00054	-.00063	-.00073	-.00144
MP/IYY	1/SEC	.04726	.05177	-.00231	-.05489	-.04588	-.02774	-.01296	-.00160	.00717	.01310	.02291
MQ/IYY	1/SEC	-1.53243	-1.33744	-1.27220	-1.33496	-1.52399	-1.64610	-1.71462	-1.75868	-1.74931	-1.45384	-1.41351
MR/IYY	1/SEC	-.01843	-.00283	-.00458	-.01302	-.01750	-.01806	-.01523	-.01126	-.00415	-.00077	-.00163
NU/IZZ	1/SEC-FT	.00015	.00041	.00057	.00056	.00033	.00025	.00023	.00021	.00017	.00006	-.00010
NV/IZZ	1/SEC-FT	-.00166	-.00292	-.00081	.00139	.00034	.00001	-.00020	-.00036	-.00055	-.00069	-.00068
NW/IZZ	1/SEC-FT	.00042	.00027	.00029	.00034	.00025	.00005	-.00011	-.00026	-.00067	-.00183	-.00310
NDB/IZZ	1/SEC2-IN	.04797	.05365	.05544	.05332	.04727	.04299	.04085	.04119	.04473	.04994	.06088
NDC/IZZ	1/SEC2-IN	-.00492	-.00173	.00127	.00434	.00775	.01029	.01239	.01436	.01360	.00023	-.01422
NDS/IZZ	1/SEC2-IN	.00706	.00801	.00936	.01040	.01045	.01003	.00962	.00978	.01184	.01415	.01704
NDR/IZZ	1/SEC2-IN	.20565	.20613	.20542	.20376	.20143	.20136	.20254	.20502	.20762	.21185	.22357
NP/IZZ	1/SEC	.02324	.01752	.00351	-.01103	-.01831	-.02288	-.02765	-.03532	-.05220	-.07347	-.10472
NQ/IZZ	1/SEC	-.16279	-.18593	-.19391	-.18670	-.16426	-.14334	-.12999	-.12401	-.11246	-.10165	-.10566
NR/IZZ	1/SEC	-.04141	-.04249	-.04345	-.04383	-.04318	-.04306	-.04377	-.04566	-.04979	-.05676	-.06986
DB	IN	.11903	.00195	-.26730	-.54684	-.69476	-.47876	-.14407	.19205	.44985	.64430	.99281
DC	IN	4.61493	4.99785	5.10272	4.93303	4.49221	4.27130	4.27929	4.49493	4.88498	5.56785	6.74024
DS	IN	.23401	.26147	.27159	.26535	.24373	.22403	.20728	.19475	.20091	.22942	.28157
DR	IN	.11189	.09206	.06837	.04346	.01995	-.06339	-.17239	-.29414	-.42749	-.59110	-.85632
THEN	DEG.	9.10901	7.86562	6.61257	5.39523	4.25894	2.96632	1.42181	-.22319	-.55312	-1.45296	-4.81367
PHIN	DEG.	-.43595	-.48766	-.51126	-.49798	-.43906	-.40330	-.39769	-.41428	-.45802	-.52990	-.62193

* DERIVED BY FITTING A THIRD ORDER CURVE THROUGH -40, -20, +20 AND +40 VALUES.

TABLE E2.- Continued

(d) $\dot{Z}$ = -500 ft/min

Parameter	Unit	Value of parameter at $\dot{X}$, knots, of										
		-40	-20	*0	20	40	60	80	100	120	140	160
XU/M	1/SEC	-.04948	-.04431	-.02325	-.00641	-.01387	-.02174	-.02695	-.03084	-.03724	-.04364	-.04851
XV/M	1/SEC	.00046	-.00184	-.00097	.00053	.00008	.00001	-.00006	-.00027	-.00062	-.00137	-.00421
XW/M	1/SEC	.06078	.04284	.03589	.03589	.03884	.03625	.02864	.01910	.02536	.01854	-.00254
XDB/M	FT/SEC2-IN	.16655	.13510	.11831	.11223	.11291	.12891	.14825	.16227	.14496	.11665	.09508
XDC/M	FT/SEC2-IN	1.51066	1.22694	.94701	.70594	.53876	.39387	.20511	-.00815	.06093	-.08844	-.59637
XDS/M	FT/SEC2-IN	-.00037	-.00025	-.00015	-.00007	-.00003	-.00002	-.00002	-.00003	-.00005	-.00008	.00003
XDR/M	FT/SEC2-IN	-.00021	-.00013	-.00008	-.00005	-.00003	-.00002	-.00004	-.00007	-.00008	-.00012	-.00026
XP/M	FT/SEC	.09475	.07629	.03242	-.00190	.00825	.00570	.00410	.00332	.00476	.00641	.00960
XQ/M	FT/SEC	2.26457	2.54761	2.59202	2.52291	2.46537	2.39457	2.35932	2.38195	2.53542	2.71152	3.05128
XR/M	FT/SEC	-.22649	-.21772	-.12040	-.02995	-.04178	-.03990	-.03665	-.03979	-.04027	-.05155	-.09068
YU/M	1/SEC	-.00115	-.00170	-.00038	.00087	.00013	.00000	.00032	.00066	.00082	.00101	.00100
YV/M	1/SEC	-.09145	-.14266	-.14525	-.11666	-.07436	-.07822	-.09235	-.10972	-.12806	-.14811	-.17168
YW/M	1/SEC	.00288	.00272	.00301	.00354	.00412	.00366	.00328	.00328	.00374	.00426	.00419
YDB/M	FT/SEC2-IN	-.02811	-.01042	.01249	.03487	.05098	.04601	.03248	.01689	.00117	-.03947	-.07617
YDC/M	FT/SEC2-IN	.05815	.06576	.06887	.06762	.06219	.05731	.05343	.05514	.07160	.08128	.08592
YDS/M	FT/SEC2-IN	1.16105	1.16691	1.16274	1.15112	1.13461	1.13154	1.13474	1.14425	1.15263	1.16939	1.22750
YDR/M	FT/SEC2-IN	-.08652	-.07451	-.05288	-.03522	-.03515	-.04552	-.05689	-.06022	-.03415	-.00552	.02634
YP/M	FT/SEC	-1.67033	-1.41972	-1.32917	-1.40184	-1.64092	-1.79907	-1.84855	-1.80984	-1.67724	-1.46929	-1.25200
YQ/M	FT/SEC	.03860	.02677	.00144	-.02457	-.03847	.02358	.11371	.20437	.27705	.43075	.58791
YR/M	FT/SEC	-.18165	-.15751	-.14595	-.15169	-.18026	-.19618	-.19909	-.19360	-.18595	-.16694	-.15551
ZU/M	1/SEC	.17883	.18208	.02826	-.11816	-.09269	-.05637	-.03356	-.02250	-.00324	.03104	.01650
ZV/M	1/SEC	-.00605	-.00104	.00135	.00208	.00212	.00290	.00319	.00316	.00384	.00238	.00318
ZW/M	1/SEC	-.43584	-.34017	-.32741	-.37819	-.47314	-.56806	-.64615	-.70814	-.74979	-.66803	-.70849
ZDB/M	FT/SEC2-IN	-.27161	-.09822	.02908	.15524	.32520	.41697	.42949	.41258	.33449	.09294	.26644
ZDC/M	FT/SEC2-IN	-8.60511	-8.22802	-8.13578	-8.31674	-8.75929	-9.53950	-10.42244	-11.29391	-11.90365	-10.72300	-10.89579
ZDS/M	FT/SEC2-IN	.00234	.00182	.00125	.00073	.00049	.00026	.00048	.00113	.00139	.00217	.00589
ZDR/M	FT/SEC2-IN	.00030	-.00001	-.00009	-.00002	.00008	-.00007	-.00013	-.00048	-.00055	-.00022	-.00099
ZP/M	FT/SEC	-.45639	-.31843	-.17822	-.09404	-.12415	-.05339	-.04668	-.01357	.02017	.03741	.08475
ZQ/M	FT/SEC	1.81696	.57144	.46157	.38001	-.78053	-.91256	-.66449	-.33834	-.23694	.79755	.34840
ZR/M	FT/SEC	1.11591	1.13901	.31169	-.44359	-.20434	-.14576	-.22661	-.36483	-.45551	-.52236	-.64057
LU/IXX	1/SEC-FT	-.00044	-.00058	-.00037	-.00012	-.00013	-.00016	-.00008	.00003	-.00008	.00008	.00017
LV/IXX	1/SEC-FT	-.00606	-.00631	-.00635	-.00619	-.00590	-.00587	-.00605	-.00640	-.00693	-.00778	-.00918
LW/IXX	1/SEC-FT	.00063	.00049	.00047	.00067	.00117	.00138	.00145	.00150	.00168	.00209	.00209
LDB/IXX	1/SEC2-IN	-.03616	-.03337	-.02638	-.01678	-.00612	-.00216	-.00187	-.00341	-.00718	-.02148	-.03553
LDC/IXX	1/SEC2-IN	-.00781	-.01187	-.01448	-.01528	-.01393	-.01211	-.01169	-.01171	-.00803	-.00569	-.00535
LDS/IXX	1/SEC2-IN	.41730	.41832	.41643	.41279	.40859	.40821	.40946	.41201	.41313	.41629	.42983
LDR/IXX	1/SEC2-IN	-.14745	-.14503	-.13909	-.13336	-.13157	-.13388	-.13711	-.13898	-.13326	-.12778	-.12591
LP/IXX	1/SEC	-.74828	-.68419	-.65429	-.66455	-.72095	-.75755	-.76621	-.75041	-.70501	-.63821	-.56471
LQ/IXX	1/SEC	.12968	.12586	.10871	.07991	.04113	.02570	.02439	.02997	.04291	.08984	.12142
LR/IXX	1/SEC	-.05736	-.05023	-.04691	-.04845	-.05584	-.06018	-.06082	-.05872	-.05499	-.04675	-.03801
MU/IYY	1/SEC-FT	.00172	.00498	.00623	.00468	-.00043	-.00344	-.00367	-.00335	-.00251	-.00113	-.00149
MV/IYY	1/SEC-FT	.00145	.00121	.00008	-.00088	-.00063	-.00019	.00027	.00075	.00131	.00160	.00228
MW/IYY	1/SEC-FT	-.01196	-.00447	.00203	.00836	.01534	.01635	.01623	.01641	.01647	.01715	.01580
MDB/IYY	1/SEC2-IN	.36076	.34340	.33695	.34191	.35878	.39006	.41676	.43986	.45786	.39321	.40560
MDC/IYY	1/SEC2-IN	-.03650	.01087	.02009	.03169	.08621	.14081	.16471	.17736	.19353	.18049	.14833
MDS/IYY	1/SEC2-IN	-.00000	-.00000	-.00000	-.00000	-.00000	-.00002	-.00001	-.00002	-.00002	-.00004	-.00007
MDR/IYY	1/SEC2-IN	-.00047	-.00037	-.00026	-.00015	-.00007	-.00006	-.00011	-.00022	-.00029	-.00040	-.00107
MP/IYY	1/SEC	.06038	.06421	.00108	-.05462	-.02849	-.01296	-.00879	-.00409	.00392	.00992	.01915
MQ/IYY	1/SEC	-1.54982	-1.31840	-1.24188	-1.31713	-1.54103	-1.66128	-1.72433	-1.76349	-1.80237	-1.56573	-1.55061
MR/IYY	1/SEC	-.02640	-.00735	-.00288	-.00624	-.01073	-.00915	-.00751	-.00622	-.00487	.00053	.00176
NU/IZZ	1/SEC-FT	.00007	.00033	.00050	.00050	.00028	.00026	.00025	.00023	.00019	.00010	.00002
MV/IZZ	1/SEC-FT	-.00154	-.00271	-.00070	.00135	.00030	-.00004	-.00026	-.00044	-.00064	-.00078	-.00079
NW/IZZ	1/SEC-FT	.00049	.00025	.00026	.00028	.00010	-.00012	-.00023	-.00032	-.00059	-.00137	-.00217
NDB/IZZ	1/SEC2-IN	.04154	.04849	.05075	.04829	.04107	.03554	.03245	.03208	.03508	.04108	.05191
NDC/IZZ	1/SEC2-IN	-.00494	-.00194	.00098	.00386	.00673	.00829	.01003	.01225	.01297	.00487	-.00455
NDS/IZZ	1/SEC2-IN	.00711	.00791	.00924	.01026	.01012	.00944	.00875	.00862	.01034	.01228	.01478
NDR/IZZ	1/SEC2-IN	.20390	.20502	.20448	.20260	.19972	.19909	.19956	.20119	.20288	.20604	.21643
NP/IZZ	1/SEC	.01552	.01341	.00184	-.01072	-.01580	-.01901	-.02199	-.02739	-.04104	-.05823	-.08419
NQ/IZZ	1/SEC	-.13552	-.16553	-.17600	-.16680	-.13782	-.11156	-.09560	-.08867	-.07781	-.07774	-.08692
NR/IZZ	1/SEC	-.04057	-.04199	-.04263	-.04239	-.04116	-.04068	-.04096	-.04221	-.04540	-.05098	-.06183
DB	IN	.33228	.12223	-.27921	-.68853	-.92224	-.64928	-.27053	.08356	.34368	.51056	.82420
DC	IN	4.14841	4.61718	4.74968	4.55100	4.02622	3.74929	3.72269	3.91265	4.28691	4.93444	6.05306
DS	IN	.20208	.23322	.24611	.24111	.21861	.19658	.17837	.16544	.17253	.19840	.24219
DR	IN	.03700	.05063	.06567	.07748	.08141	-.00240	-.10942	-.22212	-.33716	-.47632	-.70471
THEN	DEG.	8.96607	7.81254	6.61169	5.43887	4.36941	3.13931	1.65473	.07423	-.21157	-1.03887	-4.24451
PHIN	DEG.	-.38226	-.45397	-.48161	-.45975	-.35300	-.34133	-.33547	-.35475	-.40420	-.48392	-.58388

* DERIVED BY FITTING A THIRD ORDER CURVE THROUGH -40, -20, +20 AND +40 VALUES.

TABLE E2.- Continued

(e) $\dot{Z}$ = 0 ft/min

Parameter	Unit	Value of parameter at $\dot{X}$, knots, of										
		-40	-20	*0	20	40	60	80	100	120	140	160
XU/M	1/SEC	-.04980	-.04449	-.02114	-.00259	-.01164	-.02046	-.02592	-.02981	-.03632	-.04267	-.04737
XV/M	1/SEC	.00032	-.00075	-.00085	-.00046	-.00004	.00014	.00024	.00021	.00013	-.00020	-.00267
XW/M	1/SEC	.05470	.03811	.03259	.03412	.03870	.03764	.03122	.02283	.03014	.02613	.00375
XDB/M	FT/SEC2-IN	.17130	.13262	.11408	.10849	.10866	.12688	.14817	.16383	.14612	.13468	.10794
XDC/M	FT/SEC2-IN	1.46431	1.21170	.93867	.69883	.54575	.42640	.26174	.07262	.16882	.09284	-.41289
XDS/M	FT/SEC2-IN	-.00017	-.00007	-.00000	.00004	.00004	.00003	.00002	.00000	.00000	-.00002	-.00002
XDR/M	FT/SEC2-IN	-.00012	-.00006	-.00001	.00002	.00003	.00004	.00002	.00001	.00000	-.00003	-.00016
XP/M	FT/SEC	.11867	.05290	.02051	.00784	.00120	.00380	.00515	.00506	.00446	.00555	.00747
XQ/M	FT/SEC	2.17267	2.51458	2.58521	2.51853	2.44855	2.35790	2.30588	2.31099	2.45022	2.58151	2.91199
XR/M	FT/SEC	-.17177	-.12437	-.10552	-.09582	-.07589	-.04676	-.03138	-.02810	-.02961	-.03792	-.06707
YU/M	1/SEC	-.00093	-.00149	-.00019	.00095	-.00006	-.00017	.00026	.00063	.00074	.00108	.00098
YV/M	1/SEC	-.08480	-.13255	-.13712	-.11155	-.06893	-.07404	-.08899	-.10671	-.12526	-.14524	-.16813
YW/M	1/SEC	.00282	.00238	.00265	.00334	.00418	.00330	.00267	.00260	.00308	.00476	.00409
YDB/M	FT/SEC2-IN	-.04111	-.01824	.01175	.04076	.06073	.05185	.03478	.01739	.00369	-.02895	-.06397
YDC/M	FT/SEC2-IN	.04978	.05992	.06353	.06166	.05535	.04854	.04187	.04208	.05709	.08442	.08941
YDS/M	FT/SEC2-IN	1.15225	1.16217	1.15902	1.14599	1.12623	1.11989	1.11895	1.12371	1.12706	1.13824	1.18927
YDR/M	FT/SEC2-IN	-.08454	-.07540	-.05395	-.03632	-.03866	-.05298	-.06842	-.07593	-.05459	-.03095	-.00433
YP/M	FT/SEC	-1.88643	-1.60055	-1.49383	-1.57519	-1.85351	-2.03591	-2.08734	-2.03928	-1.88849	-1.65634	-1.42095
YQ/M	FT/SEC	.08504	.05194	.00414	-.04279	-.07332	.00340	.10630	.20236	.27032	.40930	.55181
YR/M	FT/SEC	-.20393	-.17280	-.16450	-.17614	-.20480	-.22199	-.22455	-.21743	-.20654	-.18446	-.16326
ZU/M	1/SEC	.19109	.19817	.02484	-.14099	-.11142	-.06631	-.03744	-.02283	-.00337	.03061	.02053
ZV/M	1/SEC	-.00344	.00100	.00374	.00524	.00592	.00487	.00425	.00381	.00437	.00302	.00355
ZW/M	1/SEC	-.40474	-.30703	-.29557	-.34885	-.44538	-.55118	-.63488	-.69967	-.74553	-.68261	-.70389
ZDB/M	FT/SEC2-IN	-.31253	-.10291	.03031	.16269	.36980	.46734	.47107	.44616	.40968	.06504	.25689
ZDC/M	FT/SEC2-IN	-8.43145	-8.12808	-8.06188	-8.21477	-8.56870	-9.35989	-10.28788	-11.19359	-11.89379	-11.22671	-11.36623
ZDS/M	FT/SEC2-IN	.00107	.00051	-.00002	-.00040	-.00050	-.00044	-.00032	-.00016	-.00007	.00054	.00333
ZDR/M	FT/SEC2-IN	.00027	.00014	.00011	.00012	.00014	.00008	.00034	.00000	.00000	.00008	-.00063
ZP/M	FT/SEC	-.61431	-.19944	.04190	.18709	.31348	.21481	.12453	.06661	.06962	.03030	.06456
ZQ/M	FT/SEC	2.15197	.69186	.43507	.21293	-1.14324	-1.17918	-.87636	-.52618	-.41613	.78476	.19533
ZR/M	FT/SEC	.81188	.47219	.36222	.39539	.48508	.28535	.08312	-.09338	-.18809	-.28671	-.55311
LU/IXX	1/SEC-FT	-.00040	-.00059	-.00028	.00004	-.00014	-.00024	-.00014	-.00002	-.00016	.00004	.00009
LV/IXX	1/SEC-FT	-.00568	-.00601	-.00608	-.00591	-.00555	-.00548	-.00564	-.00595	-.00646	-.00725	-.00853
LW/IXX	1/SEC-FT	.00072	.00050	.00048	.00077	.00151	.00166	.00166	.00167	.00179	.00241	.00214
LDB/IXX	1/SEC2-IN	-.03695	-.03269	-.02410	-.01247	.00000	.00376	.00369	.00188	-.00077	-.01278	-.02629
LDC/IXX	1/SEC2-IN	-.00683	-.01116	-.01403	-.01453	-.01174	-.00864	-.00804	-.00807	-.00528	.00225	-.00075
LDS/IXX	1/SEC2-IN	.41498	.41715	.41552	.41153	.40660	.40554	.40590	.40740	.40742	.40935	.42129
LDR/IXX	1/SEC2-IN	-.14601	-.14475	-.13896	-.13309	-.13156	-.13452	-.13834	-.14076	-.13570	-.13089	-.12961
LP/IXX	1/SEC	-.79828	-.72706	-.69495	-.70862	-.77476	-.81835	-.82866	-.81192	-.76384	-.69295	-.61744
LQ/IXX	1/SEC	.12624	.12183	.10020	.06396	.01569	.00117	.00203	.00889	.02211	.06761	.09796
LR/IXX	1/SEC	-.06426	-.05530	-.05220	-.05466	-.06241	-.06732	-.06815	-.06596	-.06182	-.05353	-.04309
MU/IYY	1/SEC-FT	.00181	.00727	.00925	.00679	-.00104	-.00420	-.00405	-.00351	-.00280	-.00089	-.00147
MV/IYY	1/SEC-FT	.00108	.00054	.00017	-.00006	-.00020	-.00006	.00027	.00067	.00112	.00135	.00193
MW/IYY	1/SEC-FT	-.01465	-.00562	.00234	.00992	.01778	.01764	.01684	.01666	.01624	.01950	.01556
MDB/IYY	1/SEC2-IN	.35758	.33689	.32921	.33528	.35584	.39113	.41870	.44180	.46426	.41714	.41639
MDC/IYY	1/SEC2-IN	-.04062	.02013	.01905	.02107	.09114	.15286	.17320	.18202	.18825	.21272	.16717
MDS/IYY	1/SEC2-IN	-.00000	.00000	-.00000	.00000	.00002	.00000	.00001	.00000	.00000	-.00001	-.00004
MDR/IYY	1/SEC2-IN	-.00024	-.00012	-.00000	.00009	.00011	.00011	.00009	.00003	.00001	-.00009	-.00063
MP/IYY	1/SEC	.07710	.05658	.04267	.03618	.03792	.02270	.01306	.00808	.01083	.00945	.01458
MQ/IYY	1/SEC	-1.57909	-1.31503	-1.22925	-1.31598	-1.56947	-1.68183	-1.73681	-1.76988	-1.80477	-1.57954	-1.54494
MR/IYY	1/SEC	-.03206	-.01058	-.00433	-.00294	.00397	.00267	.00052	-.00041	.00022	.00241	-.00032
NU/IZZ	1/SEC-FT	-.00002	.00023	.00040	.00042	.00025	.00030	.00030	.00027	.00022	.00014	.00005
NV/IZZ	1/SEC-FT	-.00144	-.00254	-.00062	.00132	.00026	-.00009	-.00033	-.00051	-.00072	-.00087	-.00089
NW/IZZ	1/SEC-FT	.00064	.00026	.00022	.00021	-.00012	-.00036	-.00042	-.00043	-.00058	-.00107	-.00177
NDB/IZZ	1/SEC2-IN	.03539	.04375	.04655	.04371	.03516	.02811	.02400	.02294	.02548	.03197	.04195
NDC/IZZ	1/SEC2-IN	-.00471	-.00218	.00072	.00344	.00543	.00552	.00677	.00919	.01102	.00778	.00128
NDS/IZZ	1/SEC2-IN	.00716	.00782	.00914	.01014	.00983	.00887	.00789	.00746	.00883	.01042	.01252
NDR/IZZ	1/SEC2-IN	.20238	.20419	.20382	.20170	.19822	.19699	.19669	.19746	.19823	.20039	.20952
NP/IZZ	1/SEC	.00740	.00866	.00080	-.00921	-.01442	-.01663	-.01772	-.02065	-.03098	-.04472	-.06599
NQ/IZZ	1/SEC	-.10825	-.14697	-.16052	-.14872	-.11142	-.07923	-.06077	-.05316	-.04408	-.04746	-.05912
NR/IZZ	1/SEC	-.03924	-.04088	-.04172	-.04145	-.03979	-.03912	-.03890	-.03947	-.04173	-.04588	-.05523
DB	IN	.60144	.28176	-.29250	-.87058	-1.20173	-.83457	-.39980	-.02471	.23855	.40035	.68263
DC	IN	3.69823	4.26139	4.42437	4.19346	3.57491	3.23321	3.17052	3.33578	3.69708	4.32420	5.39970
DS	IN	.17213	.20691	.22287	.21948	.19622	.17057	.15037	.13696	.14548	.17245	.21111
DR	IN	-.04673	.00269	.06336	.11834	.15071	.05761	-.05168	-.15797	-.25691	-.37746	-.57441
THEN	DEG.	8.83219	7.76600	6.61333	5.48094	4.47560	3.30464	1.87456	.35227	.09997	-.68214	-3.75758
PHIN	DEG.	-.32757	-.41888	-.45153	-.42196	-.32665	-.27858	-.27258	-.29476	-.35037	-.43798	-.54619

* DERIVED BY FITTING A THIRD ORDER CURVE THROUGH -40, -20, +20 AND +40 VALUES.

TABLE E2.- Continued

(f) $\dot{Z}$ = 500 ft/min

Parameter	Unit	Value of parameter at $\dot{X}$, knots, of										
		-40	-20	*0	20	40	60	80	100	120	140	160
XU/M	1/SEC	-.05099	-.04422	-.01857	.00129	-.00932	-.01924	-.02498	-.02891	-.03565	-.04192	-.04656
XV/M	1/SEC	-.00027	-.00058	-.00127	-.00143	-.00016	.00023	.00044	.00058	.00078	.00080	-.00107
XW/M	1/SEC	.04792	.03283	.02894	.03219	.03852	.03901	.03377	.02653	.03475	.03293	.00993
XDB/M	FT/SEC2-IN	.17836	.12940	.10910	.10490	.10425	.12496	.14820	.16547	.14802	.13403	.11707
XDC/M	FT/SEC2-IN	1.41369	1.20437	.93710	.69235	.55058	.45862	.31847	.15368	.27751	.22823	-.26731
XDS/M	FT/SEC2-IN	-.00004	.00007	.00012	.00013	.00009	.00007	.00006	.00004	.00006	.00006	-.00002
XDR/M	FT/SEC2-IN	-.00002	.00003	.00007	.00008	.00007	.00007	.00007	.00006	.00006	.00005	-.00006
XP/M	FT/SEC	.02312	-.05257	-.02869	.01602	.00280	.00430	.00462	.00503	.00330	.00301	.00545
XQ/M	FT/SEC	2.07584	2.46181	2.57072	2.52136	2.43256	2.32194	2.25393	2.24212	2.36793	2.52346	2.77769
XR/M	FT/SEC	-.04833	.00776	-.08620	-.17655	-.10961	-.05009	-.02551	-.01798	-.02101	-.02707	-.04715
YU/M	1/SEC	-.00067	-.00151	-.00001	.00122	-.00042	-.00039	.00020	.00063	.00075	.00094	.00098
YV/M	1/SEC	-.07928	-.12523	-.13179	-.10831	-.06418	-.07043	-.08619	-.10425	-.12300	-.14289	-.16521
YW/M	1/SEC	.00321	.00221	.00244	.00341	.00463	.00301	.00206	.00189	.00246	.00376	.00403
YDB/M	FT/SEC2-IN	-.05637	-.02766	.01113	.04843	.07265	.05759	.03573	.01569	.00277	-.02535	-.05856
YDC/M	FT/SEC2-IN	.04234	.05345	.05696	.05507	.04999	.04051	.03009	.02839	.04191	.07003	.07837
YDS/M	FT/SEC2-IN	1.14476	1.15921	1.15717	1.14249	1.11902	1.10903	1.10375	1.10365	1.10199	1.10775	1.15200
YDR/M	FT/SEC2-IN	-.08278	-.07663	-.05506	-.03710	-.04178	-.06031	-.07993	-.09170	-.07509	-.05639	-.03508
YP/M	FT/SEC	-2.09665	-1.76946	-1.64496	-1.73729	-2.06058	-2.27186	-2.32475	-2.26714	-2.09734	-1.84230	-1.58527
YQ/M	FT/SEC	.14258	.08166	.00500	-.06817	-.11863	-.01679	.10350	.20777	.27293	.38324	.52647
YR/M	FT/SEC	-.22708	-.18787	-.18117	-.19694	-.22517	-.24628	-.24924	-.24060	-.22649	-.20142	-.17316
ZU/M	1/SEC	.20766	.21206	.02097	-.16248	-.13514	-.07765	-.04175	-.02333	-.00153	.02798	.02465
ZV/M	1/SEC	.00055	.00570	.00975	.01176	.01077	.00650	.00487	.00415	.00468	.00487	.00389
ZW/M	1/SEC	-.37004	-.27064	-.25982	-.31546	-.41545	-.53448	-.62395	-.69153	-.73887	-.70234	-.69941
ZDB/M	FT/SEC2-IN	-.36464	-.10331	.03148	.16602	.42663	.52490	.51619	.48161	.46008	.19775	.27312
ZDC/M	FT/SEC2-IN	-8.22796	-8.06621	-8.05096	-8.15329	-8.34437	-9.15801	-10.14101	-11.08494	-11.87723	-11.53166	-11.34629
ZDS/M	FT/SEC2-IN	.00028	-.00050	-.00110	-.00136	-.00113	-.00102	-.00102	-.00082	-.00099	-.00098	.00131
ZDR/M	FT/SEC2-IN	-.00000	-.00001	.00005	.00018	.00037	.00034	.00011	.00025	.00049	.00029	-.00026
ZP/M	FT/SEC	-.10468	.30099	.35800	.31697	.42854	.26485	.18156	.13976	.12267	.11484	.04752
ZQ/M	FT/SEC	2.51557	.93621	.40010	-.09012	-1.53182	-1.44692	-1.08937	-.71426	-.59444	-.09167	.04404
ZR/M	FT/SEC	.08295	-.45957	.43277	1.42350	1.17616	.61518	.30646	.10581	.02065	-.09494	-.41384
LU/IXX	1/SEC-FT	-.00035	-.00063	-.00014	.00027	-.00022	-.00035	-.00021	-.00008	-.00022	-.00010	.00002
LV/IXX	1/SEC-FT	-.00532	-.00574	-.00583	-.00563	-.00521	-.00511	-.00524	-.00553	-.00602	-.00675	-.00795
LW/IXX	1/SEC-FT	.00085	.00053	.00052	.00096	.00199	.00199	.00189	.00186	.00194	.00227	.00223
LDB/IXX	1/SEC2-IN	-.03670	-.03274	-.02213	-.00798	.00659	.00969	.00894	.00681	.00462	-.00576	-.01912
LDC/IXX	1/SEC2-IN	-.00595	-.01071	-.01419	-.01434	-.00910	-.00452	-.00398	-.00408	-.00217	.00422	.00104
LDS/IXX	1/SEC2-IN	.41301	.41645	.41509	.41067	.40489	.40307	.40248	.40291	.40184	.40259	.41301
LDR/IXX	1/SEC2-IN	-.14476	-.14475	-.13905	-.13291	-.13158	-.13521	-.13965	-.14261	-.13821	-.13408	-.13342
LP/IXX	1/SEC	-.84669	-.76640	-.73128	-.74894	-.82699	-.87890	-.89052	-.87240	-.82127	-.74634	-.66812
LQ/IXX	1/SEC	.12564	.12011	.09244	.04674	-.01288	-.02389	-.01939	-.01031	.00393	.04144	.07813
LR/IXX	1/SEC	-.07108	-.06008	-.05704	-.06014	-.06756	-.07381	-.07507	-.07281	-.06821	-.05982	-.04836
MU/IYY	1/SEC-FT	.00138	.01045	.01356	.00965	-.00232	-.00518	-.00450	-.00371	-.00289	-.00147	-.00144
MV/IYY	1/SEC-FT	.00073	-.00033	.00027	.00097	.00018	-.00002	.00022	.00056	.00094	.00126	.00162
MW/IYY	1/SEC-FT	-.01802	-.00731	.00285	.01226	.02073	.01900	.01746	.01690	.01626	.01688	.01528
MDB/IYY	1/SEC2-IN	.35557	.32931	.31958	.32750	.35422	.39346	.42140	.44418	.46843	.42962	.41757
MDC/IYY	1/SEC2-IN	-.04758	.03615	.01764	.00333	.09965	.16803	.18301	.18725	.18323	.19501	.14846
MDS/IYY	1/SEC2-IN	-.00000	.00001	.00000	-.00000	.00001	.00001	.00002	.00001	.00002	.00001	-.00001
MDR/IYY	1/SEC2-IN	-.00005	.00009	.00021	.00027	.00025	.00022	.00020	.00018	.00023	.00020	-.00024
MP/IYY	1/SEC	.02254	-.05053	.01003	.08761	.06559	.03469	.02152	.01685	.01716	.01719	.01084
MQ/IYY	1/SEC	-1.61906	-1.33744	-1.24855	-1.34224	-1.60835	-1.70716	-1.75196	-1.77776	-1.80805	-1.64924	-1.53966
MR/IYY	1/SEC	-.00867	.00643	.01044	.01388	.02728	.01524	.00831	.00505	.00514	.00362	-.00010
NU/IZZ	1/SEC-FT	-.00009	.00008	.00023	.00031	.00026	.00039	.00037	.00032	.00025	.00017	.00008
MV/IZZ	1/SEC-FT	-.00135	-.00242	-.00055	.00131	.00022	-.00014	-.00039	-.00058	-.00080	-.00095	-.00098
NW/IZZ	1/SEC-FT	.00090	.00030	.00018	.00010	-.00044	-.00067	-.00066	-.00059	-.00064	-.00092	-.00143
NDB/IZZ	1/SEC2-IN	.02948	.03949	.04294	.03966	.02951	.02063	.01546	.01373	.01592	.02211	.03190
NDC/IZZ	1/SEC2-IN	-.00413	-.00256	.00052	.00324	.00373	.00181	.00256	.00513	.00796	.00697	.00311
NDS/IZZ	1/SEC2-IN	.00720	.00772	.00906	.01006	.00957	.00832	.00703	.00629	.00733	.00855	.01027
NDR/IZZ	1/SEC2-IN	.20109	.20366	.20349	.20108	.19693	.19502	.19393	.19381	.19366	.19484	.20276
NP/IZZ	1/SEC	.00013	.00403	-.00148	-.00977	-.01420	-.01495	-.01432	-.01522	-.02239	-.03273	-.04933
NQ/IZZ	1/SEC	-.08048	-.12984	-.14708	-.13206	-.08467	-.04605	-.02534	-.01740	-.01048	-.01590	-.03250
NR/IZZ	1/SEC	-.03842	-.03976	-.04078	-.04086	-.03938	-.03829	-.03747	-.03736	-.03883	-.04175	-.04924
DB	IN	.93825	.49772	-.30900	-1.11263	-1.54392	-1.03322	-.53026	-.13131	.13616	.29273	.54406
DC	IN	3.26564	3.93462	4.13213	3.86476	3.13908	2.72216	2.62209	2.76387	3.11511	3.72622	4.76465
DS	IN	.14411	.18257	.20220	.20095	.17677	.14572	.12292	.10882	.11921	.14805	.18321
DR	IN	-.14161	-.05503	.06189	.17000	.23013	.11646	.00037	-.10234	-.18760	-.29157	-.46088
THEN	DEG.	8.70754	7.72648	6.61754	5.52108	4.57749	3.46245	2.08101	.60973	.37973	-.36946	-3.32911
PHIN	DEG.	-.27250	-.38399	-.42272	-.38580	-.27039	-.21527	-.20927	-.23465	-.29692	-.39304	-.50983

* DERIVED BY FITTING A THIRD ORDER CURVE THROUGH -40, -20, +20 AND +40 VALUES.

TABLE E2.- Continued

(g) $\dot{Z}$ = 1000 ft/min

Parameter	Unit	Value of parameter at $\dot{X}$, knots, of										
		-40	-20	*0	20	40	60	80	100	120	140	160
XU/M	1/SEC	-.05340	-.04306	-.01524	.00513	-.00690	-.01807	-.02411	-.02813	-.03516	-.04138	-.04634
XV/M	1/SEC	-.00109	-.00146	-.00252	-.00265	-.00028	.00026	.00052	.00079	.00127	.00179	.00049
XW/M	1/SEC	.04060	.02657	.02453	.02996	.03840	.04039	.03631	.03021	.03931	.03962	.01391
XDB/M	FT/SEC2-IN	.18878	.12481	.10282	.10149	.09949	.12317	.14834	.16717	.15087	.13354	.11376
XDC/M	FT/SEC2-IN	1.35522	1.21065	.94734	.68735	.55274	.49068	.37530	.23495	.37365	.35756	-.14197
XDS/M	FT/SEC2-IN	.00007	.00018	.00022	.00019	.00012	.00008	.00007	.00006	.00011	.00014	.00001
XDR/M	FT/SEC2-IN	.00003	.00011	.00014	.00013	.00009	.00008	.00009	.00009	.00011	.00010	.00002
XP/M	FT/SEC	-.08448	-.17662	-.10085	.00324	-.00396	.00152	.00285	.00349	.00129	.00125	.00459
XQ/M	FT/SEC	1.98055	2.37567	2.54172	2.53575	2.41481	2.28595	2.20302	2.17502	2.28822	2.44636	2.69415
XR/M	FT/SEC	.07299	.17898	-.02965	-.23969	-.13796	-.04746	-.01801	-.00870	-.01362	-.01998	-.03240
YU/M	1/SEC	-.00022	-.00193	.00017	.00184	-.00112	-.00068	.00016	.00067	.00080	.00086	.00093
YV/M	1/SEC	-.07469	-.12074	-.12961	-.10736	-.06003	-.06739	-.08394	-.10232	-.12126	-.14111	-.16289
YW/M	1/SEC	.00425	.00236	.00258	.00398	.00560	.00281	.00142	.00114	.00181	.00287	.00332
YDB/M	FT/SEC2-IN	-.07445	-.03944	.01076	.05881	.08736	.06322	.03521	.01163	-.00171	-.02523	-.06078
YDC/M	FT/SEC2-IN	.03679	.04505	.04688	.04629	.04727	.03340	.01793	.01381	.02662	.05926	.06498
YDS/M	FT/SEC2-IN	1.13839	1.15833	1.15764	1.14093	1.11281	1.09883	1.08896	1.08391	1.07727	1.07783	1.11556
YDR/M	FT/SEC2-IN	-.08126	-.07837	-.05628	-.03750	-.04453	-.06752	-.09142	-.10750	-.09562	-.08185	-.06580
YP/M	FT/SEC	-2.29354	-1.92078	-1.77881	-1.88679	-2.26388	-2.50848	-2.56174	-2.49268	-2.30235	-2.02220	-1.74808
YQ/M	FT/SEC	.21454	.12312	.00268	-.10979	-.17733	-.03710	.10567	.22106	.28540	.37844	.52678
YR/M	FT/SEC	-.25481	-.20536	-.19279	-.20763	-.24042	-.26958	-.27334	-.26330	-.24603	-.21723	-.18518
ZU/M	1/SEC	.23030	.22100	.01607	-.18058	-.16505	-.09016	-.04638	-.02396	.00024	.02606	.03084
ZV/M	1/SEC	.00523	.01503	.02266	.02417	.01563	.00702	.00477	.00405	.00473	.00511	.00446
ZW/M	1/SEC	-.33298	-.22864	-.21583	-.27459	-.38494	-.51847	-.61350	-.68379	-.73257	-.71766	-.67921
ZDB/M	FT/SEC2-IN	-.43318	-.09623	.03261	.16224	.50157	.59022	.56493	.51907	.49070	.31436	.38649
ZDC/M	FT/SEC2-IN	-7.97548	-8.07244	-8.15139	-8.16516	-8.06660	-8.93235	-9.98202	-10.96791	-11.82412	-11.51790	-11.12967
ZDS/M	FT/SEC2-IN	-.00042	-.00129	-.00192	-.00208	-.00150	-.00105	-.00116	-.00133	-.00181	-.00204	-.00054
ZDR/M	FT/SEC2-IN	-.00002	-.00012	.00001	.00025	.00050	.00028	.00014	.00040	.00050	.00066	.00003
ZP/M	FT/SEC	.46737	1.05116	.89583	.54969	.56102	.30291	.18521	.12929	.11316	.10184	.09425
ZQ/M	FT/SEC	2.86504	1.38094	.34281	-.62739	-1.90768	-1.70958	-1.30247	-.90297	-.77260	-.54456	-.45804
ZR/M	FT/SEC	-.62915	-1.65715	.28656	2.37644	1.78694	.78808	.41237	.22539	.17024	.08010	-.19607
LU/IXX	1/SEC-FT	-.00029	-.00073	.00007	.00065	-.00044	-.00051	-.00030	-.00014	-.00028	-.00021	-.00008
LV/IXX	1/SEC-FT	-.00497	-.00549	-.00559	-.00535	-.00489	-.00476	-.00487	-.00514	-.00561	-.00632	-.00743
LW/IXX	1/SEC-FT	.00105	.00059	.00063	.00129	.00267	.00257	.00215	.00207	.00211	.00219	.00215
LDB/IXX	1/SEC2-IN	-.03822	-.03380	-.02055	-.00312	.01386	.01567	.01388	.01117	.00900	.00020	-.01416
LDC/IXX	1/SEC2-IN	-.00502	-.01078	-.01566	-.01535	-.00555	.00038	.00050	.00020	.00159	.00779	.00289
LDS/IXX	1/SEC2-IN	.41133	.41629	.41526	.41029	.40342	.40075	.39917	.39851	.39636	.39597	.40493
LDR/IXX	1/SEC2-IN	-.14369	-.14510	-.13941	-.13284	-.13160	-.13595	-.14096	-.14451	-.14077	-.13733	-.13731
LP/IXX	1/SEC	-.89327	-.80303	-.76413	-.78610	-.87850	-.93966	-.95215	-.93204	-.87753	-.79776	-.71720
LQ/IXX	1/SEC	.12854	.12229	.08461	.02537	-.04559	-.04961	-.03989	-.02756	-.01156	.02317	.06630
LR/IXX	1/SEC	-.07809	-.06475	-.06004	-.06255	-.07090	-.07989	-.08174	-.07937	-.07425	-.06532	-.05374
MU/IYY	1/SEC-FT	.00011	.01487	.01964	.01349	-.00454	-.00639	-.00499	-.00393	-.00299	-.00197	-.00169
MV/IYY	1/SEC-FT	.00044	-.00151	.00043	.00238	.00043	-.00013	.00009	.00043	.00077	.00105	.00133
MW/IYY	1/SEC-FT	-.02203	-.00987	.00365	.01585	.02407	.02041	.01808	.01714	.01628	.01472	.01290
MDB/IYY	1/SEC2-IN	.35553	.31988	.30668	.31771	.35475	.39728	.42495	.44704	.47082	.44061	.40616
MDC/IYY	1/SEC2-IN	-.05979	.06354	.01559	-.02651	.11441	.18675	.19415	.19307	.18144	.19509	.12114
MDS/IYY	1/SEC2-IN	-.00000	.00001	.00000	-.00001	.00000	.00003	.00002	.00002	.00002	.00002	.00000
MDR/IYY	1/SEC2-IN	.00008	.00025	.00038	.00042	.00032	.00025	.00024	.00026	.00036	.00042	.00009
MP/IYY	1/SEC	-.04415	-.12569	-.01632	.10903	.07542	.03703	.02190	.01687	.01539	.01496	.01473
MQ/IYY	1/SEC	-1.66595	-1.39936	-1.32041	-1.41141	-1.65466	-1.73690	-1.76969	-1.78707	-1.81219	-1.67767	-1.48883
MR/IYY	1/SEC	.02160	.04525	.06124	.06574	.05494	.02445	.01313	.00922	.00950	.00799	.00146
NU/IZZ	1/SEC-FT	-.00011	-.00015	-.00005	.00014	.00036	.00054	.00048	.00039	.00031	.00022	.00010
MV/IZZ	1/SEC-FT	-.00128	-.00234	-.00050	.00132	.00019	-.00018	-.00044	-.00065	-.00087	-.00103	-.00107
NW/IZZ	1/SEC-FT	.00131	.00038	.00013	-.00007	-.00087	-.00106	-.00096	-.00081	-.00075	-.00084	-.00123
NDB/IZZ	1/SEC2-IN	.02371	.03581	.04010	.03627	.02400	.01298	.00676	.00443	.00637	.01239	.02149
NDC/IZZ	1/SEC2-IN	-.00299	-.00336	.00037	.00352	.00140	-.00302	-.00270	.00001	.00374	.00566	.00310
NDS/IZZ	1/SEC2-IN	.00725	.00760	.00899	.01002	.00934	.00777	.00618	.00513	.00582	.00669	.00803
NDR/IZZ	1/SEC2-IN	.19998	.20349	.20356	.20080	.19581	.19317	.19124	.19022	.18916	.18937	.19612
NP/IZZ	1/SEC	-.00473	.00144	-.00305	-.01072	-.01405	-.01351	-.01136	-.01046	-.01481	-.02204	-.03446
NQ/IZZ	1/SEC	-.05180	-.11340	-.13490	-.11621	-.05725	-.01175	.01086	.01872	.02308	.01422	-.00523
NR/IZZ	1/SEC	-.03893	-.03937	-.04051	-.04114	-.04002	-.03787	-.03633	-.03567	-.03653	-.03850	-.04410
DB	IN	1.34957	.79908	-.33296	-1.45003	-1.95561	-1.24186	-.66014	-.23546	.03692	.18227	.40453
DC	IN	2.84952	3.64383	3.88318	3.57273	2.71768	2.21473	2.07662	2.19636	2.54039	3.14279	4.14497
DS	IN	.11776	.16030	.18485	.18646	.16020	.12170	.09565	.08054	.09308	.12394	.15682
DR	IN	-.24915	-.12808	.06225	.23949	.32129	.17357	.04623	-.05576	-.12977	-.21899	-.36469
THEN	DEG.	8.59095	7.69638	6.62471	5.55735	4.67569	3.61291	2.27393	.84679	.62843	-.10420	-2.95613
PHIN	DEG.	-.21729	-.35113	-.39748	-.35299	-.21433	-.15149	-.14576	-.17474	-.24432	-.35026	-.47574

* DERIVED BY FITTING A THIRD ORDER CURVE THROUGH -40, -20, +20 AND +40 VALUES.

TABLE E2. - Continued

(h) $\dot{Z}$ = 1500 ft/min

Parameter	Unit	Value of parameter at $\dot{X}$, knots, of										
		-40	-20	*0	20	40	60	80	100	120	140	160
XU/M	1/SEC	-.06741	-.04060	-.00922	.00887	-.00417	-.01753	-.02172	-.02554	-.03268	-.03883	-.04612
XV/M	1/SEC	-.00111	-.00372	-.00533	-.00455	-.00001	.00024	.00038	.00065	.00124	.00224	.00205
XW/M	1/SEC	.07101	.01863	.01033	.02725	.05050	.04639	.04404	.03834	.05071	.05888	.01974
XDB/M	FT/SEC2-IN	.31431	.11811	.08045	.09819	.06819	.11574	.13523	.15794	.14176	.14821	.12242
XDC/M	FT/SEC2-IN	1.02115	1.23941	1.03287	.68503	.47938	.51759	.35622	.22679	.39962	.48001	-.00359
XDS/M	FT/SEC2-IN	.00006	.00029	.00033	.00025	.00010	.00006	.00005	.00006	.00014	.00024	.00007
XDR/M	FT/SEC2-IN	.00014	.00014	.00018	.00017	.00005	.00006	.00005	.00009	.00013	.00019	.00010
XP/M	FT/SEC	-.15317	-.25770	-.15902	-.01909	.00015	-.00206	-.00342	-.00128	-.00299	-.00216	.00286
XQ/M	FT/SEC	2.77757	2.23421	2.38042	2.56756	2.14702	2.15680	2.13918	2.15284	2.25501	2.28450	2.57169
XR/M	FT/SEC	.18750	.32039	.01265	-.29025	-.14285	-.02961	-.01190	-.00454	-.01371	-.01828	-.02050
YU/M	1/SEC	.00156	-.00314	.00012	.00315	-.00224	-.00068	.00014	.00076	.00092	.00104	.00102
YV/M	1/SEC	-.07062	-.11938	-.13165	-.10946	-.05484	-.06448	-.08221	-.10085	-.11989	-.13964	-.16110
YW/M	1/SEC	.00262	.00314	.00489	.00556	.00283	.00157	.00101	.00029	.00100	.00327	.00338
YDB/M	FT/SEC2-IN	-.10498	-.05463	.01246	.07303	.10383	.05985	.03108	.00480	-.01019	-.02517	-.06241
YDC/M	FT/SEC2-IN	.05840	.03126	.02036	.03136	.06996	.02396	.00330	-.00246	.00983	.04853	.05780
YDS/M	FT/SEC2-IN	1.13235	1.16017	1.16192	1.14186	1.10425	1.08610	1.07374	1.06370	1.05052	1.04437	1.07986
YDR/M	FT/SEC2-IN	-.07958	-.08086	-.05742	-.03744	-.04912	-.07742	-.10347	-.12379	-.11795	-.11064	-.09638
YP/M	FT/SEC	-2.48777	-2.04972	-1.87631	-2.01318	-2.50597	-2.77681	-2.80331	-2.72393	-2.52316	-2.22275	-1.90222
YQ/M	FT/SEC	.21930	.19143	-.00879	-.18584	-.14420	-.01293	.11223	.24348	.31001	.37618	.52246
YR/M	FT/SEC	-.28939	-.22786	-.19906	-.20777	-.25876	-.29743	-.29775	-.28632	-.26705	-.23358	-.19674
ZU/M	1/SEC	.32011	.22260	-.00071	-.19492	-.20513	-.08104	-.04012	-.02467	.00209	.02666	.03457
ZV/M	1/SEC	.00498	.03223	.05001	.04671	.01072	.00389	.00324	.00333	.00440	.00504	.00467
ZW/M	1/SEC	-.51971	-.17691	-.07840	-.22149	-.60347	-.64712	-.68914	-.67617	-.72710	-.74050	-.67573
ZDB/M	FT/SEC2-IN	-1.17810	-.07824	.05732	.14879	1.11638	.81090	.71770	.55971	.52580	.25436	.40244
ZDC/M	FT/SEC2-IN	-6.10251	-8.19191	-8.96407	-8.29551	-6.06191	-8.26064	-9.51718	-10.83679	-11.70306	-11.86640	-11.03521
ZDS/M	FT/SEC2-IN	-.00041	-.00202	-.00298	-.00280	-.00101	-.00065	-.00085	-.00128	-.00212	-.00322	-.00178
ZDR/M	FT/SEC2-IN	-.00050	-.00008	.00005	.00029	.00109	.00019	.00040	.00021	.00038	.00025	.00049
ZP/M	FT/SEC	.85054	1.56017	1.44284	.92736	.44249	.26800	.18979	.13146	.10781	.09080	.09142
ZQ/M	FT/SEC	-2.06578	2.15689	.30006	-1.53202	2.76487	.87460	.20595	-1.09801	-1.00005	-.12005	-.59918
ZR/M	FT/SEC	-1.28744	-2.64746	.22757	3.17935	2.04955	.61984	.36781	.25436	.26251	.13899	-.01918
LU/IXX	1/SEC-FT	-.00010	-.00100	.00034	.00126	-.00086	-.00053	-.00034	-.00019	-.00034	-.00026	-.00014
LV/IXX	1/SEC-FT	-.00464	-.00525	-.00532	-.00503	-.00456	-.00438	-.00450	-.00468	-.00506	-.00571	-.00695
LW/IXX	1/SEC-FT	.00099	.00076	.00133	.00193	.00179	.00200	.00213	.00229	.00231	.00264	.00229
LDB/IXX	1/SEC2-IN	-.04132	-.03626	-.01966	.00234	.02361	.02049	.01850	.01503	.01283	.00689	-.00920
LDC/IXX	1/SEC2-IN	-.00141	-.01215	-.02236	-.01902	.01088	.00797	.00627	.00485	.00637	.01318	.00676
LDS/IXX	1/SEC2-IN	.40973	.41685	.41639	.41053	.40142	.39790	.39577	.39400	.39043	.38858	.39704
LDR/IXX	1/SEC2-IN	-.14261	-.14593	-.14015	-.13292	-.13185	-.13710	-.14239	-.14647	-.14357	-.14104	-.14124
LP/IXX	1/SEC	-.93986	-.83488	-.78825	-.81747	-.94006	-1.00854	-1.01475	-.99269	-.93696	-.85413	-.76306
LQ/IXX	1/SEC	.12561	.13200	.07050	-.00570	-.04341	-.05550	-.05265	-.04320	-.02504	.00411	.05431
LR/IXX	1/SEC	-.08579	-.06989	-.06083	-.06155	-.07505	-.08777	-.08864	-.08597	-.08055	-.07098	-.05851
MU/IYY	1/SEC-FT	-.00719	.02083	.02871	.01853	-.00843	-.00597	-.00468	-.00416	-.00309	-.00163	-.00162
MV/IYY	1/SEC-FT	.00068	-.00322	.00074	.00447	-.00010	-.00045	-.00013	.00027	.00059	.00088	.00113
MW/IYY	1/SEC-FT	-.00821	-.01391	.00497	.02138	.00831	.01045	.01233	.01738	.01646	.01850	.01262
MDB/IYY	1/SEC2-IN	.41184	.30747	.27322	.30482	.39801	.41458	.43688	.45049	.47363	.47336	.40732
MDC/IYY	1/SEC2-IN	-.20797	.10948	.01192	-.07582	.27172	.24353	.22754	.19940	.18292	.21377	.10994
MDS/IYY	1/SEC2-IN	-.00002	.00002	-.00001	-.00003	.00004	.00003	.00002	.00002	.00003	.00005	.00002
MDR/IYY	1/SEC2-IN	.00019	.00037	.00051	.00053	.00034	.00019	.00019	.00025	.00043	.00062	.00035
MP/IYY	1/SEC	-.07911	-.16680	-.01533	.14070	.06665	.02884	.01873	.01548	.01339	.01278	.01407
MQ/IYY	1/SEC	-1.28579	-1.52095	-1.61079	-1.54482	-1.31252	-1.55120	-1.66254	-1.79803	-1.81249	-1.76339	-1.48440
MR/IYY	1/SEC	.05843	.07924	.10989	.11885	.07457	.01911	.01204	.01071	.01299	.00923	.00473
NU/IZZ	1/SEC-FT	.00024	-.00048	-.00053	-.00009	.00066	.00062	.00054	.00049	.00038	.00029	.00015
NV/IZZ	1/SEC-FT	-.00124	-.00231	-.00045	.00136	.00015	-.00023	-.00049	-.00072	-.00095	-.00112	-.00115
NW/IZZ	1/SEC-FT	.00094	.00054	.00003	-.00033	-.00029	-.00053	-.00067	-.00109	-.00095	-.00072	-.00097
NDB/IZZ	1/SEC2-IN	.01497	.03286	.03945	.03373	.01468	.00283	-.00314	-.00530	-.00409	.00230	.01200
NDC/IZZ	1/SEC2-IN	.00583	-.00499	.00063	.00468	-.01083	-.01299	-.01136	-.00639	-.00211	.00304	.00296
NDS/IZZ	1/SEC2-IN	.00730	.00746	.00895	.01003	.00897	.00704	.00529	.00393	.00418	.00459	.00580
NDR/IZZ	1/SEC2-IN	.19893	.20378	.20429	.20095	.19427	.19086	.18848	.18654	.18428	.18326	.18961
NP/IZZ	1/SEC	-.00926	-.00028	-.00406	-.01155	-.01370	-.01204	-.00884	-.00651	-.00795	-.01178	-.02161
NQ/IZZ	1/SEC	-.04361	-.09659	-.11613	-.10038	-.04748	.00892	.03580	.05641	.05930	.04513	.01809
NR/IZZ	1/SEC	-.04104	-.04008	-.04133	-.04247	-.04118	-.03648	-.03487	-.03404	-.03449	-.03539	-.03996
DB	IN	1.81166	1.23447	-.39910	-1.93606	-2.22340	-1.26945	-.75931	-.33934	-.06769	.06762	.26479
DC	IN	2.43480	3.40077	3.71157	3.32942	2.21657	1.63432	1.51994	1.61478	1.92097	2.49518	3.54068
DS	IN	.09198	.14028	.17386	.17744	.13572	.08715	.06608	.05070	.06401	.09695	.13090
DR	IN	-.36565	-.22569	.07128	.33731	.38448	.19263	.08000	-.01772	-.08035	-.15413	-.28725
THEN	DEG.	8.47551	7.68041	6.63529	5.58860	4.78880	3.76925	2.46475	1.15994	1.07865	.41977	-2.64048
PHIN	DEG.	-.16059	-.32271	-.38098	-.32605	-.14862	-.08178	-.08156	-.11354	-.18845	-.30363	-.44497

* DERIVED BY FITTING A THIRD ORDER CURVE THROUGH -40, -20, +20 AND +40 VALUES.

APPENDIX E

TABLE E2.- Concluded

(i) $\dot{Z}$ = 2000 ft/min

Parameter	Unit	Value of parameter at $\dot{X}$, knots, of										
		-40	-20	*0	20	40	60	80	100	120	140	160
XU/M	1/SEC	-.06263	-.03715	-.00486	-.01280	-.00562	-.01522	-.02053	-.02449	-.03210	-.03842	-.04364
XV/M	1/SEC	-.00036	-.00813	-.01059	-.00780	.00018	.00001	-.00001	.00027	.00100	.00235	.00333
XW/M	1/SEC	.07681	.00783	-.00046	.02390	.05288	.05212	.04813	.04442	.05783	.06509	.04280
XDB/M	FT/SEC2-IN	.26925	.10894	.07809	.09430	.07518	.10865	.13635	.15723	.14189	.15454	.14826
XDC/M	FT/SEC2-IN	.99597	1.30066	1.06503	.68481	.55576	.50248	.41950	.31448	.50991	.64971	.14877
XDS/M	FT/SEC2-IN	.00005	.00040	.00046	.00031	.00006	.00001	.00002	.00003	.00015	.00032	.00019
XDR/M	FT/SEC2-IN	.00007	.00017	.00023	.00020	.00002	.00001	.00002	.00004	.00011	.00023	.00021
XP/M	FT/SEC	-.06699	-.38327	-.27977	-.05422	-.00439	-.00167	-.00299	-.00436	-.00466	-.00421	-.00011
XQ/M	FT/SEC	2.66929	2.01115	2.29670	2.62268	2.08579	2.11034	2.07789	2.05357	2.13303	2.18169	2.31730
XR/M	FT/SEC	.10693	.46870	.05689	-.37112	-.05791	.00279	.01049	.00899	-.00577	-.01057	-.01479
YU/M	1/SEC	.00173	-.00581	-.00019	.00551	-.00177	-.00041	.00033	.00084	.00101	.00118	.00130
YV/M	1/SEC	-.05914	-.12163	-.14042	-.11564	-.04739	-.06234	-.08100	-.09989	-.11907	-.13875	-.15958
YW/M	1/SEC	.00112	.00536	.00932	.00930	.00158	.00049	-.00005	-.00011	.00076	.00245	.00439
YDB/M	FT/SEC2-IN	-.08680	-.07426	.01272	.09234	.08278	.04478	.01565	-.00949	-.02409	-.03803	-.06418
YDC/M	FT/SEC2-IN	.04402	.00385	-.01157	.00115	.04540	.00417	-.01545	-.02325	-.01110	.03125	.06590
YDS/M	FT/SEC2-IN	1.11133	1.16572	1.17450	1.14623	1.08945	1.07086	1.05385	1.04068	1.02302	1.01103	1.03916
YDR/M	FT/SEC2-IN	-.06637	-.08447	-.05991	-.03686	-.05949	-.08998	-.11967	-.14250	-.14095	-.13950	-.13191
YP/M	FT/SEC	-2.85417	-2.14288	-1.87861	-2.10408	-2.86207	-3.07796	-3.08002	-2.97030	-2.74432	-2.42021	-2.07608
YQ/M	FT/SEC	.18856	.31771	-.02542	-.33390	-.10081	.03417	.16281	.27478	.33702	.41111	.50106
YR/M	FT/SEC	-.32607	-.26477	-.19242	-.18205	-.30665	-.33044	-.32602	-.31047	-.28792	-.25047	-.20757
ZU/M	1/SEC	.30299	.21867	-.01843	-.21180	-.16494	-.06629	-.03036	-.01330	.01087	.03054	.03503
ZV/M	1/SEC	.00090	.06327	.10005	.08775	.00282	-.00013	.00037	.00150	.00342	.00489	.00442
ZW/M	1/SEC	-.56518	-.10912	.02341	-.15034	-.61310	-.66055	-.69979	-.73454	-.76482	-.73642	-.70289
ZDB/M	FT/SEC2-IN	-.93664	-.04927	.06102	.13049	.89535	.70970	.64991	.62243	.59427	.28547	.25111
ZDC/M	FT/SEC2-IN	-6.27516	-8.47221	-9.21060	-8.57821	-6.66292	-8.51574	-9.70769	-10.64605	-11.50169	-11.98186	-11.45317
ZDS/M	FT/SEC2-IN	-.00033	-.00275	-.00403	-.00354	-.00066	-.00015	-.00025	-.00052	-.00199	-.00376	-.00351
ZDR/M	FT/SEC2-IN	-.00021	-.00004	.00012	.00051	.00056	.00000	.00000	.00043	.00064	.00034	.00056
ZP/M	FT/SEC	.55251	2.35551	2.46723	1.51900	.34216	.01693	.03118	.11910	.09247	.08160	.07518
ZQ/M	FT/SEC	-1.88570	3.41505	.16714	-2.96616	2.67839	.80977	.17249	-.10184	-.34166	-.34154	.24719
ZR/M	FT/SEC	-.68646	-3.59722	.54499	4.46180	.87482	.14437	.10206	.15601	.28536	.17974	.02887
LU/IXX	1/SEC-FT	-.00032	-.00161	.00057	.00221	-.00074	-.00046	-.00032	-.00021	-.00039	-.00033	-.00017
LV/IXX	1/SEC-FT	-.00402	-.00497	-.00499	-.00454	-.00407	-.00392	-.00391	-.00412	-.00451	-.00514	-.00631
LW/IXX	1/SEC-FT	.00099	.00124	.00250	.00322	.00185	.00213	.00229	.00239	.00249	.00282	.00277
LDB/IXX	1/SEC2-IN	-.02974	-.04052	-.02015	.00858	.02288	.02158	.01995	.01745	.01547	.00982	-.00329
LDC/IXX	1/SEC2-IN	-.00539	-.01686	-.03137	-.02832	.01290	.01027	.00982	.00979	.01148	.01810	.01706
LDS/IXX	1/SEC2-IN	.40388	.41840	.41969	.41161	.39806	.39451	.39134	.38887	.38433	.38123	.38808
LDR/IXX	1/SEC2-IN	-.13700	-.14744	-.14213	-.13323	-.13290	-.13867	-.14439	-.14877	-.14646	-.14478	-.14588
LP/IXX	1/SEC	-1.02597	-.85822	-.78941	-.83989	-1.03004	-1.08668	-1.08656	-1.05662	-.99569	-.90851	-.81362
LQ/IXX	1/SEC	.09367	.15719	.06028	-.05739	-.05614	-.06492	-.06092	-.05097	-.03411	-.00484	.03533
LR/IXX	1/SEC	-.09530	-.07811	-.05610	-.05232	-.08980	-.09796	-.09727	-.09317	-.08681	-.07654	-.06304
MU/IYY	1/SEC-FT	-.00765	.02819	.03691	.02344	-.00727	-.00494	-.00405	-.00354	-.00275	-.00168	-.00103
MV/IYY	1/SEC-FT	.00094	-.00599	.00131	.00801	-.00076	-.00072	-.00030	.00013	.00045	.00074	.00103
MW/IYY	1/SEC-FT	-.00547	-.02043	.00593	.02987	.00762	.01007	.01187	.01339	.01358	.01846	.01638
MDB/IYY	1/SEC2-IN	.38894	.29086	.25784	.28787	.37890	.40731	.43216	.45508	.47838	.47529	.43128
MDC/IYY	1/SEC2-IN	-.22218	.18325	.01483	-.15312	.25369	.22014	.20975	.20787	.19224	.22199	.16798
MDS/IYY	1/SEC2-IN	-.00001	.00006	-.00000	-.00006	.00001	.00000	.00000	.00002	.00003	.00006	.00006
MDR/IYY	1/SEC2-IN	.00011	.00046	.00067	.00061	.00016	.00002	.00004	.00016	.00042	.00074	.00068
MP/IYY	1/SEC	-.03520	-.23178	-.03066	.18870	.04683	-.00245	.00132	.01223	.01217	.01119	.01222
MQ/IYY	1/SEC	-1.32541	-1.72901	-1.88762	-1.77125	-1.34986	-1.55299	-1.65381	-1.71455	-1.75956	-1.75897	-1.61366
MR/IYY	1/SEC	.02571	.15217	.23723	.21576	.02264	-.00272	.00033	.00639	.01297	.00928	.00624
NU/IZZ	1/SEC-FT	.00046	-.00092	-.00105	-.00035	.00075	.00063	.00057	.00051	.00043	.00036	.00023
MV/IZZ	1/SEC-FT	-.00098	-.00232	-.00044	.00143	.00006	-.00030	-.00058	-.00080	-.00103	-.00121	-.00124
NW/IZZ	1/SEC-FT	.00083	.00083	.00001	-.00070	-.00037	-.00066	-.00083	-.00090	-.00087	-.00086	-.00061
NDB/IZZ	1/SEC2-IN	.00497	.03087	.04041	.03229	.00522	-.00649	-.01306	-.01614	-.01501	-.00869	.00192
NDC/IZZ	1/SEC2-IN	.01378	-.00807	-.00002	.00714	-.01742	-.01777	-.01689	-.01488	-.01032	-.00257	.00372
NDS/IZZ	1/SEC2-IN	.00796	.00728	.00890	.01010	.00820	.00612	.00410	.00255	.00250	.00249	.00322
NDR/IZZ	1/SEC2-IN	.19537	.20472	.20646	.20172	.19160	.18810	.18487	.18236	.17926	.17716	.18216
NP/IZZ	1/SEC	-.02035	-.00103	-.00292	-.01209	-.01458	-.00874	-.00548	-.00338	-.00265	-.00357	-.00919
NQ/IZZ	1/SEC	-.00332	-.07806	-.10614	-.08390	-.00766	.04696	.07417	.08543	.08949	.07960	.03968
NR/IZZ	1/SEC	-.03942	-.04289	-.04631	-.04567	-.03701	-.03287	-.03191	-.03179	-.03253	-.03276	-.03595
DB	IN	1.44763	1.87498	-.43935	-2.65135	-1.91699	-1.12726	-.69531	-.38332	-.15835	-.03787	.10874
DC	IN	1.63934	3.22173	3.72930	3.15133	1.47707	.97896	.86443	.98477	1.29634	1.85946	2.85458
DS	IN	.04364	.12265	.17790	.17592	.08323	.04185	.02220	.01304	.03201	.06899	.10050
DR	IN	-.33562	-.36135	.07879	.47927	.33457	.17204	.07369	-.00200	-.04794	-.10731	-.22124
THEN	DEG.	8.21096	7.68382	6.67365	5.61325	4.93539	3.95243	2.81267	1.56647	1.51339	.89782	-2.04072
PHIN	DEG.	-.06388	-.30197	-.38678	-.30882	-.05863	-.00681	-.01180	-.05078	-.13447	-.25974	-.41379

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