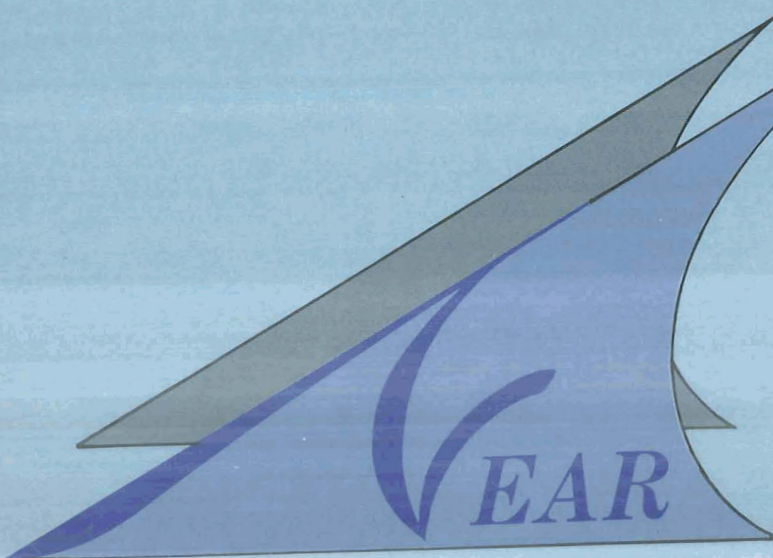


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COMPUTER PROGRAMS FOR CALCULATION OF
AERODYNAMIC INTERFERENCE BETWEEN
LIFTING SURFACES AND LIFT AND
CRUISE FANS

By M. F. E. Dillenius, M. R. Mendenhall,
and S. B. Spangler



**NIELSEN ENGINEERING
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COMPUTER PROGRAMS FOR CALCULATION OF AERODYNAMIC INTERFERENCE
BETWEEN LIFTING SURFACES AND LIFT AND CRUISE FANS

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- (1) p. 80 The right side of eq. (99) should read as follows:

$$= \alpha_{t_v} \cos \phi_v + \frac{v_{i,v}}{V} \sin \phi_v - \left(\frac{u_{i,v}}{V} \alpha_{\ell_v} + \frac{w_{i,v}}{V} \right) \cos \phi_v \quad (99)$$

$v=1,2,\dots,M$

- (2) p. 159 Figure 15(a) should be Figure 15(b) and page number should be 163.
- (3) p. 163 Figure 15(b) should be Figure 15(a) and page number should be 159.

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SUMMARY

This document is a user's manual for a series of three computer programs developed to predict aerodynamic interference in transport-type aircraft. The cases considered are interference between a high-bypass-ratio turbofan engine and a wing-pylon-tail configuration and interference between a fuselage-mounted lift fan and a wing-tail configuration. The methods are applicable to all speeds up to the critical speed of the configuration. The first program calculates the singularity distributions representing the flow model of a high-bypass-ratio turbofan engine and computes the velocity field induced by the singularities. The second program computes the singularity distributions representing the wake of a lift fan exhausting in a crossflow. The path of the jet is predicted and the velocity field induced by the jet is computed. The third program is a vortex lattice lifting surface method which can accommodate a wing with a single pylon per panel and a horizontal tail surface. This program can accept externally induced velocities such as those obtained from the turbofan engine program or the lift-fan program. The information obtained from the program is the detailed loading distributions on the wing, pylon, and tail at any angle of attack. The gross lift and pitching moment coefficients are computed. Included in this manual are a brief description of the theory and the calculation procedure, descriptions of input and output, program listings, and sample cases from each program. A description of a complete interference calculation for a turbofan engine adjacent to a wing-pylon-tail configuration is included to indicate how the programs can be used in sequence to calculate loadings with interference for a complete configuration.

INTRODUCTION

This report is the second of two reports prepared under Contract NAS2-5247 for the Ames Research Center, NASA. The work on this contract is concerned with the development of analytical methods for predicting the aerodynamic interference effects between fan engines and transport-type airframes. This document is a user's manual for the computer programs developed under the contract. The first document (ref. 1) describes the theoretical analysis on which the programs are based and some results and data comparisons.

The principal airframe components that were investigated are a wing with pylon, horizontal tail, high-bypass-ratio turbofan engine, and a lift fan mounted adjacent to the wing. Angle of attack with zero sideslip was considered. The speed range is subsonic, with a Prandtl-Glauert correction used to account for compressibility effects. The basic approach consists of constructing potential flow singularity models for each component, in which the boundary conditions include not only self-induced velocities but velocities induced by other adjacent airframe components. No frictional effects are considered. For purposes of computing engine or fan interference on the airframe, the flow blockage effect of the cowlings and the induction effect and wake are modeled; the details of the flow within the engine and fan are not considered.

Three programs are described herein. The first program computes the flow model and the induced velocity field due to a high-bypass-ratio turbofan engine. The second program performs the same operations for a lift fan exhausting normal to the free stream. The third program is a vortex lattice lifting-surface method for a wing with a single pylon per panel and a horizontal tail. The vortex lattice program includes interference effects from fans in the vicinity of the airframe by accepting externally induced velocities in the boundary conditions which are satisfied.

This report includes a brief discussion of the theoretical approach and the assumed flow models with a summary of the equations used in the program. No detailed derivations are included, but references are given to all the derivations of interest. The operation of the program is discussed along with descriptions of input and output. Program listings and sample cases are also included. A brief description of the use of the three programs in a complete interference calculation is presented.

LIST OF SYMBOLS

a	local speed of sound
b	wing span
B_{en}	Fourier series coefficients for the radial velocity induced on the core engine reference cylinder by the vortex cylinder trailing from the engine duct
B_{en}^*	Fourier series coefficients for the axial velocity induced on the core engine reference cylinder by the vortex cylinder trailing from the engine duct
$\tilde{B}_{en}$	Fourier series coefficients for the radial velocity induced on the core engine reference cylinder by the vortex cylinder trailing from the fan duct
$\tilde{B}_{en}^*$	Fourier series coefficients for the axial velocity induced on the core engine reference cylinder by the vortex cylinder trailing from the fan duct
B_{fn}	Fourier series coefficients for the radial velocity induced on the fan reference cylinder by the vortex cylinder trailing from the fan duct, eq. (25)
B_{fn}^*	Fourier series coefficients for the axial velocity induced on the fan reference cylinder by the vortex cylinder trailing from the fan duct, eq. (26)
$\tilde{B}_{fn}$	Fourier series coefficients for the radial velocity induced on the fan reference cylinder by the vortex cylinder trailing from the core engine duct, eq. (27)
$\tilde{B}_{fn}^*$	Fourier series coefficients for the axial velocity induced on the fan reference cylinder by the vortex cylinder trailing from the core engine duct, eq. (28)
c	local wing or duct chord, ft.
c_{ave}	average wing chord, S_{ref}/b
c_{en}	Glauert series coefficients for γ_{α_e} , eq. (38)
c_{fn}	Glauert series coefficients for γ_{α_f} , eq. (36)
c_l	section lift coefficient, based on local chord
C_{en}	Glauert series coefficients for γ_{D_e} , eq. (16)

C_{f_n}	Glauert series coefficients for γ_{D_f} , eq. (15)
C_L	lift coefficient, based on S_{ref}
C_m	pitching-moment coefficient, based on S_{ref} and wing average chord
d_o	lift fan wake initial diameter
D	duct diameter
$F_{e_n}^*$	Fourier series coefficients for the axial velocity induced on the core engine reference cylinder by the bound vorticity on the engine duct
$\tilde{F}_{e_n}$	Fourier series coefficients for the radial velocity induced on the core engine reference cylinder by the bound vorticity on the fan duct
$\tilde{F}_{e_n}^*$	Fourier series coefficients for the axial velocity induced on the core engine reference cylinder by the bound vorticity on the fan duct
$F_{f_n}^*$	Fourier series coefficients for the axial velocity induced on the fan reference cylinder by the bound vorticity on the fan duct, eq. (23)
$\tilde{F}_{f_n}$	Fourier series coefficients for the radial velocity induced on the fan reference cylinder by the bound vorticity on the core engine duct, eq. (30)
$\tilde{F}_{f_n}^*$	Fourier series coefficients for the axial velocity induced on the fan reference cylinder by the bound vorticity on the core engine duct, eq. (29)
F_{iu}	backwash velocity influence coefficient for a pylon image horse-shoe, length^{-1}
F_{iv}	sidewash velocity influence coefficient for a pylon image horse-shoe, length^{-1}
F_{iw}	downwash velocity influence coefficient for a pylon image horse-shoe, length^{-1}
F_u	backwash velocity influence coefficient for a wing, pylon, or tail horseshoe vortex, length^{-1} , eq. (102)
F_v	sidewash velocity influence coefficient for a wing, pylon, or tail horseshoe vortex, length^{-1} , eq. (102)
F_w	downwash velocity influence coefficient for a wing, pylon, or tail horseshoe vortex, length^{-1} , eq. (102)

i	pylon root chord angle of incidence, positive for toe-in, fig. 11
i_ℓ	angle between tangent to pylon camberline and pylon root-chord direction, fig. 11
i_t	$i + i_\ell$, fig. 11
M	number of control points on a wing panel
M_∞	free-stream Mach number
MP	number of control points on pylon
MT	number of control points on one horizontal tail panel
N	total number of vortices (including images) on the wing panel, pylon, and tail panel, $N = M + MP + MT$
$P_{k,\ell}$	influence coefficients for radial velocity induced on a cylindrical duct by the bound vorticity on that duct, eq. (24)
p_t	total pressure
p_o	free-stream static pressure
q	free-stream dynamic pressure, $\frac{1}{2} \rho_\infty V^2$
r_e	radius measured from duct centerline to effective camberline of core engine duct, eq. (18)
r_f	radius measured from duct centerline to effective camberline of fan duct, eq. (17)
R	radius of lift-fan wake
R_{en}^*	Fourier series coefficients of the core engine duct effective camberline, eq. (18)
R_{fn}^*	Fourier series coefficients of the fan-duct effective camberline, eq. (17)
s	semiwidth of horseshoe vortex measured in chordal plane; or distance along jet wake centerline
S_{ref}	planform wing area
T_t	total temperature
T_o	free-stream static temperature
u, v, w	perturbation velocities in x , y , and z directions, respectively

u_i, v_i, w_i perturbation velocities in the x, y, and z directions, respectively, induced on the wing-pylon-tail by external components

$\left. \begin{array}{l} u_{\gamma_D(e,e)} \\ \text{and} \\ v_{\gamma_D(e,e)} \end{array} \right\}$ velocities induced on the core engine duct by the core engine duct-bound vorticity, γ_{D_e}

$\left. \begin{array}{l} u_{\gamma_D(e,f)} \\ \text{and} \\ v_{\gamma_D(e,f)} \end{array} \right\}$ velocities induced on the fan duct by the core engine duct-bound vorticity, γ_{D_e} , eqs. (29) and (30)

$\left. \begin{array}{l} u_{\gamma_D(f,e)} \\ \text{and} \\ v_{\gamma_D(f,e)} \end{array} \right\}$ velocities induced on the core engine duct by the fan duct-bound vorticity, γ_{D_f}

$\left. \begin{array}{l} u_{\gamma_D(f,f)} \\ \text{and} \\ v_{\gamma_D(f,f)} \end{array} \right\}$ velocities induced on the fan duct by the fan duct-bound vorticity, γ_{D_f} , eqs. (23) and (24)

$\left. \begin{array}{l} u_{\gamma(e,e)} \\ \text{and} \\ v_{\gamma(e,e)} \end{array} \right\}$ velocities induced on the core engine duct by the trailing vorticity, γ_e

$\left. \begin{array}{l} u_{\gamma(e,f)} \\ \text{and} \\ v_{\gamma(e,f)} \end{array} \right\}$ velocities induced on the fan duct by the trailing vorticity, γ_e , eqs. (27) and (28)

$\left. \begin{array}{l} u_{\gamma(f,e)} \\ \text{and} \\ v_{\gamma(f,e)} \end{array} \right\}$ velocities induced on the core engine duct by the trailing vorticity, γ_f

$u_{\gamma(f,f)}$ and $v_{\gamma(f,f)}$	} velocities induced on the fan duct by the trailing vorticity, γ_f , eqs. (25) and (26)
u_{γ_α}	axial velocity induced by a nonaxisymmetric vorticity, γ_α , eq. (52)
$v_{r_{\gamma_\alpha}}$	radial velocity induced by a nonaxisymmetric vorticity, γ_α , eqs. (55) and (56)
$v_{\phi_{\gamma_\alpha}}$	tangential velocity induced by a nonaxisymmetric vorticity, γ_α , eqs. (59) and (60)
$v_{\gamma_\alpha(e,e)}$	radial velocity induced on the core engine duct by the bound and trailing vorticity associated with γ_{α_e} , eq. (42)
$v_{\gamma_\alpha(f,f)}$	radial velocity induced on the fan duct by the bound and trailing vorticity associated with γ_{α_f} , eq. (40)
$v_{\gamma_B(e,e)}$	radial velocity induced on the core engine duct by the bound and trailing vorticity associated with γ_{B_e} , eq. (43)
$v_{\gamma_B(f,f)}$	radial velocity induced on the fan duct by the bound and trailing vorticity associated with γ_{B_f} , eq. (41)
V	free-stream velocity
V_j	jet velocity at fan or engine exit
x,y,z	coordinates with origin located at the midspan of a horseshoe vortex and with same directions as X,Y,Z coordinate system, fig. 11; also, coordinate system fixed in lift-fan exit, fig. 7
X,Y,Z	coordinates with origin located at the wing root chord nose (fig. 11). X axis coincident with wing root chord, positive in forward direction, Y axis positive in starboard direction, Z axis positive in downward direction
α	angle of attack of wing root chord relative to free stream, fig. 11
α_ℓ	angle between streamwise tangent to wing camberline and the X - Z plane, fig. 11
α_t	$\alpha + \alpha_\ell$, fig. 11

α_{ti}	horizontal tail angle of incidence relative to X-Z plane, fig. 11
$\alpha_{t\ell}$	angle between streamwise tangent to tail camberline and tail root chord, fig. 11
$\alpha_{t\ell i}$	$\alpha_{t\ell} + \alpha_{ti}$, fig. 11(a)
α_{tt}	$\alpha_{t\ell} + \alpha_{ti} + \alpha$, fig. 11(a)
β	compressibility factor, $\sqrt{1 - M_\infty^2}$; or angle of sidewash, degrees
γ	strength of trailing wake vortex cylinder; also, ratio of specific heats
γ_D	axially symmetric component of duct-bound vorticity, eqs. (15) and (16)
γ_α	duct-bound vorticity component due to angle of attack
γ_B	duct-bound vorticity component due to angle of sidewash
Γ	vortex strength
δ_j	deflection angle of jet-exit centerline, degrees, fig. 7
η	nondimensional wing spanwise coordinate, $Y/(b/2)$
θ	transformed axial distance along duct, $x = (c/2)(1 - \cos \theta)$; or local angle of jet centerline, fig. 7
ξ, ζ, η	coordinate system in lift fan wake, fig. 7
ρ_∞	free-stream density
ϕ	dihedral of wing; or azimuthal angle on the engine, degrees
ϕ_t	dihedral angle of horizontal tail
ψ	sweep angle measured in the plane of the wing planform, degrees
ψ_c	sweep angle measured in the plane of the wing panel, degrees

Subscripts

e	core engine
f	fan

LE	leading edge
p	pylon
r	radial
t	total or tail
TE	trailing edge
w	wing
x	component in x direction
y	component in y direction
ϕ	tangential

TURBOFAN ENGINE PROGRAM

The purposes of the turbofan engine program are to calculate the singularity distributions representing the engine flow model and then to calculate the velocity field induced in the vicinity of the engine. The engines of interest are high-bypass-ratio turbofan engines which consist basically of a high-pressure-ratio, single-stage fan driven by a core engine. Since the purpose for which the program was developed is the calculation of interference between the engine and an adjacent wing-pylon, the computer program is oriented principally to use in such interference calculations.

Theoretical Analysis

For purposes of modeling the interference induced by a turbofan engine, the engine model must represent the fan and core engine ducts, the fan and core engine thrusts, and the resulting wake. The details of the flow within the engine need not be considered except insofar as they determine the wake velocity profile. The following analysis is the same as that described in reference 1. The approach is based on the ducted fan theory presented in reference 2.

Wake model.— The core engine and fan wakes are represented by semi-infinite, concentric, constant-diameter vortex cylinders extending downstream coaxial with the engine centerline (fig. 1(a)). The constant-diameter assumption is consistent with the results of reference 3, which indicate

wake spreading angles of 2° to 3° for a turbulent jet in a coflowing stream where the jet velocity is 50 percent greater than the free stream. This wake model assumes that the fan and engine thrust are produced by uniformly loaded actuator disks within the ducts. Thus, the performance of the engine determines the strengths of the trailing vortex cylinders, γ_f and γ_e . The velocity profile in the engine wake is given by the asymptotic velocity distribution inside a vortex cylinder and is shown in figure 1(b). The wake velocity distribution is written as

$$V_{j_f} = V + \gamma_f \quad (1)$$

$$V_{j_e} = V + \gamma_f + \gamma_e \quad (2)$$

Therefore, if the wake velocities V_{j_f} and V_{j_e} are known, the strengths of the trailing vortex cylinders, γ_f and γ_e , are

$$\frac{\gamma_e}{V} = \frac{V_{j_e}}{V} - \frac{V_{j_f}}{V} \quad (3)$$

$$\frac{\gamma_f}{V} = \frac{V_{j_f}}{V} - 1 \quad (4)$$

A second method may be used if engine performance tables are available. For example, in reference 4, predicted performance tables for an advanced turbofan engine are presented. For a specified flight Mach number and altitude, the tables include bypass ratio, mass flow rate of air, total temperature and total pressure in the fan exhaust, and total temperature and total pressure in the core engine exhaust as a function of total engine thrust. Assuming that the static pressure in the wake is equal to the free-stream static pressure, the information in these tables is adequate to compute the unknown wake velocities V_{j_f} and V_{j_e} using isentropic relations.

The fan and engine exit pressure ratios are

$$\frac{p_o}{p_{t_f}} = \frac{p_o}{p_{t_2}} \frac{p_{t_2}}{p_{t_f}} \quad (5)$$

$$\frac{p_o}{p_{t_e}} = \frac{p_o}{p_{t_2}} \frac{p_{t_2}}{p_{t_e}} \quad (6)$$

where the subscript 2 refers to inlet conditions. The exit Mach numbers are

$$M_f = \sqrt{\frac{2}{\gamma - 1}} \left[\left(\frac{p_{t_f}}{p_o} \right)^{\left(\frac{\gamma - 1}{\gamma} \right)} - 1 \right]^{1/2} \quad (7)$$

$$M_e = \sqrt{\frac{2}{\gamma - 1}} \left[\left(\frac{p_{t_e}}{p_o} \right)^{\left(\frac{\gamma - 1}{\gamma} \right)} - 1 \right]^{1/2} \quad (8)$$

The total temperature in the wake is

$$T_{t_f} = \frac{T_{t_f}}{T_{t_2}} \frac{T_{t_2}}{T_o} T_o \quad (9)$$

$$T_{t_e} = \frac{T_{t_e}}{T_{t_2}} \frac{T_{t_2}}{T_o} T_o \quad (10)$$

which leads to the static temperature

$$T_f = T_{t_f} \left(1 + \frac{\gamma - 1}{2} M_f^2 \right)^{-1} \quad (11)$$

$$T_e = T_{t_e} \left(1 + \frac{\gamma - 1}{2} M_e^2 \right)^{-1} \quad (12)$$

The local speeds of sound are

$$a_f = \sqrt{\gamma g R T_f} \quad (13)$$

$$a_e = \sqrt{\gamma g R T_e} \quad (14)$$

which when combined with equations (7) and (8) give the velocities in the wake. The trailing vortex cylinder strengths are then easily computed using equations (3) and (4).

Turbofan engine flow model.— When the trailing vortex cylinder strengths are known, the basic turbofan engine model can be determined. The flow model is considered in two parts: the axial flow portion which imposes boundary conditions on the engine ducts due to the actuator disk and wake, and a crossflow portion which imposes duct boundary conditions due to angle of attack and sidewash on the engine. These two portions are combined by superposition since both properly satisfy the boundary condition of flow tangency to the duct.

Axial flow solution: The axial flow model is determined by satisfying the boundary conditions of flow tangency to the mean lines of both the fan duct and the core engine duct. The flow tangency condition on both ducts is satisfied in a manner analogous to the method used for a single duct in reference 2. A bound vorticity of the form

$$\frac{\gamma_{Df}}{V} = C_{f_o} \cot \frac{\theta_f}{2} + \sum_{n=1}^5 C_{f_n} \sin (n\theta_f) \quad (15)$$

is placed on the fan duct reference cylinder and a similar bound vorticity

$$\frac{\gamma_{De}}{V} = C_{e_o} \cot \frac{\theta_e}{2} + \sum_{n=1}^5 C_{e_n} \sin (n\theta_e) \quad (16)$$

is placed on the core engine duct reference cylinder.

The fan duct has an effective camber distribution given by

$$\frac{dr_f}{dx_f} = \sum_{n=0}^3 R_{f_n}^* \cos (n\theta_f) \quad (17)$$

and similarly the core engine duct has an effective camber distribution given by

$$\frac{dr_e}{dx_e} = \sum_{n=0}^3 R_{e_n}^* \cos (n\theta_e) \quad (18)$$

The effective camber is made up of a geometric camber and an induced camber, as discussed in detail in section 2.3 of reference 5 (also ref. 11).

The two boundary conditions which must be satisfied are the flow tangency relations on the surface of the fan duct and the core engine duct.

$$v_f = \frac{dr_f}{dx_f} (u_f) \quad (19)$$

$$v_e = \frac{dr_e}{dx_e} (u_e) \quad (20)$$

The left sides of equations (19) and (20) represent the sum of the axisymmetric radial velocities induced by the two wake vortex cylinders and the two duct-bound vortex ring distributions. The corresponding axial velocity sums appear on the right sides of both equations. These equations are solved on the duct reference cylinder, which is defined as a constant-diameter cylinder passing through the trailing edge of the actual duct and having the same chord-to-diameter ratio as the actual duct. Expanding equations (19) and (20) into their components results in the following. From equation (19), for the fan duct

$$\begin{aligned} & v_{\gamma_D}(f,f) + v_{\gamma}(f,f) + v_{\gamma_D}(e,f) + v_{\gamma}(e,f) \\ &= \frac{dr_f}{dx_f} \left[u_{\gamma_D}(f,f) + u_{\gamma}(f,f) + u_{\gamma_D}(e,f) + u_{\gamma}(e,f) + v \right] \end{aligned} \quad (21)$$

and from equation (20) for the engine duct

$$\begin{aligned} & v_{\gamma_D}(e,e) + v_{\gamma}(e,e) + v_{\gamma_D}(f,e) + v_{\gamma}(f,e) \\ &= \frac{dr_e}{dx_e} \left[u_{\gamma_D}(e,e) + u_{\gamma}(e,e) + u_{\gamma_D}(f,e) + u_{\gamma}(f,e) + v \right] \end{aligned} \quad (22)$$

where the induced v velocities are normal to the duct reference cylinder and the induced u velocities are in the axial direction on the reference cylinder.

The velocities in equation (21) induced on the fan reference cylinder are described as follows. From equations (15) and (16) of reference 2, the velocities induced on the fan duct by the fan duct-bound vorticity γ_{Df} are

$$\begin{aligned} \frac{4D_f}{c_f} \frac{u_{\gamma_D(f,f)}}{V} &= \left(\ln \frac{16D_f}{c_f} - 1 \right) \left(c_{f_0} + \frac{c_{f_1}}{2} \right) + \left(c_{f_0} + \frac{c_{f_2}}{2} \right) \cos \theta_f \\ &+ \left(\frac{c_{f_3} - c_{f_1}}{4} \right) \cos 2\theta_f + \left(\frac{c_{f_4} - c_{f_2}}{6} \right) \cos 3\theta_f \\ &+ \left(\frac{c_{f_5} - c_{f_3}}{8} \right) \cos 4\theta_f - \frac{c_{f_4}}{10} \cos 5\theta_f \\ &= \sum_{n=0}^5 F_{fn}^* \cos n\theta_f \end{aligned} \quad (23)$$

and

$$\frac{v_{\gamma_D(f,f)}}{V} = \frac{c_{f_0}}{2} - \sum_{\ell=0}^5 \frac{c_{f_\ell}}{2} P_{0,\ell} + \sum_{k=1}^5 \cos k\theta_f \left(-\frac{c_{f_k}}{2} + \sum_{\ell=0}^5 \frac{c_{f_\ell}}{2} P_{k,\ell} \right) \quad (24)$$

The $P_{k,\ell}$ coefficients are described in Appendix B of reference 1.

The velocities induced on the fan duct by the vortex cylinder trailing from the fan duct are given by equation (C-3) of reference 6 and equation (23) of reference 7. These velocities are expressed in nondimensional form by six-term Fourier cosine series as

$$v_{\gamma(f,f)} = \gamma_f \sum_{n=0}^5 B_{fn} \cos n\theta_f \quad (25)$$

and

$$u_{\gamma(f,f)} = \gamma_f \sum_{n=0}^5 B_{fn}^* \cos n\theta_f \quad (26)$$

These equations are analogous to equations (8) and (9) of reference 2; that is, the coefficients B_{fn} and B_{fn}^* are a function only of the fan duct chord-to-diameter ratio.

The velocities induced on the fan duct by the vortex cylinder γ_e trailing from the engine duct are given by equations (13) and (20) of reference 7. These velocities are expressed in nondimensional form by a similar six-term Fourier series as

$$v_{\gamma(e,f)} = \gamma_e \sum_{n=0}^5 \tilde{B}_{fn} \cos n\theta_f \quad (27)$$

$$u_{\gamma(e,f)} = \gamma_e \sum_{n=0}^5 \tilde{B}_{fn}^* \cos n\theta_f \quad (28)$$

where, as before, the $\tilde{B}_{fn}$ and $\tilde{B}_{fn}^*$ coefficients are a function only of the geometry of the turbofan engine.

The velocities induced on the fan duct by the vortex ring distribution bound to the engine duct γ_{De} are functions of the unknown coefficients C_{en} . The axial velocity is computed using equation (A-9) of reference 6 and is then expressed as a six-term Fourier series as before. Thus,

$$u_{\gamma_D(e,f)} = v \sum_{n=0}^5 \tilde{F}_{fn}^* \cos n\theta_f \quad (29)$$

The radial velocity induced by γ_{De} is computed in exactly the same manner as the axial velocity except that equation (A-8) in the above reference is replaced by equation (27) on page 307 of reference 8. This velocity is also expressed in a Fourier series as

$$v_{\gamma_D(e,f)} = v \sum_{n=0}^5 \tilde{F}_{f_n} \cos n\theta_f \quad (30)$$

The velocities in equation (22) induced on the core engine reference cylinder are the same as equations (23) through (30) with the subscripts f and e interchanged everywhere.

Substituting equations (17) and (23) through (30) into equation (21) results in the following equation which is analogous to equation (17) of reference 2.

$$\begin{aligned} & \frac{C_{f_0}}{2} - \sum_{\ell=0}^5 \frac{C_{f_\ell}}{2} P_{0,\ell} + \sum_{k=1}^5 \left(-\frac{C_{f_k}}{2} + \sum_{\ell=0}^5 \frac{C_{f_\ell}}{2} P_{k,\ell} \right) \cos k\theta_f \\ & + \sum_{n=0}^5 \left(\frac{\gamma_f}{V} B_{f_n} + \tilde{F}_{f_n} + \frac{\gamma_e}{V} \tilde{B}_{f_n} \right) \cos n\theta_f \\ & = \sum_{m=0}^3 R_{f_m}^* \cos m\theta_f \left[\sum_{n=0}^5 \left(\frac{C_f}{4D_f} F_{f_n}^* + \frac{\gamma_f}{V} B_{f_n}^* \right. \right. \\ & \quad \left. \left. + \tilde{F}_{f_n}^* + \frac{\gamma_e}{V} \tilde{B}_{f_n}^* \right) \cos n\theta_f \right] \quad (31) \end{aligned}$$

A similar equation is obtained from equation (22) by interchanging subscripts f and e in the above equation, with the following result

$$\begin{aligned} & \frac{C_{e_0}}{2} - \sum_{\ell=0}^5 \frac{C_{e_\ell}}{2} P_{0,\ell} + \sum_{k=1}^5 \left(-\frac{C_{e_k}}{2} + \sum_{\ell=0}^5 \frac{C_{e_\ell}}{2} P_{k,\ell} \right) \cos k\theta_e \\ & + \sum_{n=0}^5 \left(\frac{\gamma_e}{V} B_{e_n} + \tilde{F}_{e_n} + \frac{\gamma_f}{V} \tilde{B}_{e_n} \right) \cos n\theta_e \end{aligned}$$

(continued on next page)

$$= \sum_{m=0}^3 R_{e_m}^* \cos m\theta_e \left[\sum_{n=0}^5 \left(\frac{c_e}{4D_e} F_{e_n}^* + \frac{\gamma_e}{V} B_{e_n}^* + \tilde{F}_{e_n}^* + \frac{\gamma_f}{V} \tilde{B}_{e_n}^* \right) \cos n\theta_e \right] \quad (32)$$

Expanding both sides of equation (31) into Fourier cosine series and equating harmonics on both sides results in six linear algebraic equations in terms of the six unknowns C_{f_n} . These equations are considerably simplified if we define the following coefficients.

$$E_{f_n} \equiv \frac{\gamma_f}{V} B_{f_n} + \tilde{F}_{f_n} + \frac{\gamma_e}{V} \tilde{B}_{f_n} \quad n = 0, 1, \dots, 5 \quad (33)$$

$$\left. \begin{aligned} E_{f_n}^* &\equiv \frac{\gamma_f}{V} B_{f_n}^* + F_{f_n}^* + \frac{\gamma_e}{V} \tilde{B}_{f_n}^* \quad n = 1, 2, \dots, 5 \\ E_{f_0}^* &\equiv \frac{\gamma_f}{V} B_{f_0}^* + \tilde{F}_{f_0}^* + \frac{\gamma_e}{V} \tilde{B}_{f_0}^* + 1 \end{aligned} \right\} \quad (34)$$

The first set of six equations is as follows:

Zeroth harmonic:

$$\begin{aligned} &C_{f_0} \left[\frac{1}{2} - \frac{P_{00}}{2} - \frac{c_f}{4D_f} R_{f_0}^* \left(\ln \frac{16D_f}{c_f} - 1 \right) - \frac{c_f}{4D_f} \left(\frac{R_{f_1}^*}{2} \right) \right] \\ &+ C_{f_1} \left[-\frac{P_{01}}{2} - \frac{c_f}{4D_f} \frac{R_{f_0}^*}{2} \left(\ln \frac{16D_f}{c_f} - 1 \right) + \frac{c_f}{4D_f} \left(\frac{R_{f_2}^*}{8} \right) \right] \\ &+ C_{f_2} \left[-\frac{P_{02}}{2} + \frac{c_f}{4D_f} \left(\frac{R_{f_3}^*}{12} \right) - \frac{c_f}{4D_f} \frac{R_{f_1}^*}{4} \right] \\ &+ C_{f_3} \left[-\frac{P_{03}}{2} - \frac{c_f}{4D_f} \left(\frac{R_{f_2}^*}{8} \right) \right] \end{aligned}$$

(continued on next page)

$$\begin{aligned}
& + C_{f_4} \left[-\frac{P_{O4}}{2} - \frac{c_f}{4D_f} \left(\frac{R_{f_3}^*}{12} \right) \right] \\
& + C_{f_5} \left[-\frac{P_{O5}}{2} \right] = R_{f_O}^* E_{f_O}^* + \frac{1}{2} \sum_{n=1}^3 R_{f_n}^* E_{f_n}^* - E_{f_O}
\end{aligned} \tag{35a}$$

First harmonic:

$$\begin{aligned}
& C_{f_O} \left[\frac{P_{1O}}{2} - \frac{c_f}{4D_f} \left(R_{f_O}^* + \frac{R_{f_2}^*}{2} \right) - \frac{c_f}{4D_f} \left(\ln \frac{16D_f}{c_f} - 1 \right) R_{f_1}^* \right] \\
& + C_{f_1} \left[-\frac{1}{2} + \frac{P_{11}}{2} - \frac{c_f}{4D_f} \left\{ \frac{R_{f_1}^*}{2} \left(\ln \frac{16D_f}{c_f} - 1 \right) - \left(\frac{R_{f_1}^* + R_{f_3}^*}{8} \right) \right\} \right] \\
& + C_{f_2} \left[\frac{P_{12}}{2} + \frac{c_f}{4D_f} \left(\frac{R_{f_2}^*}{12} \right) - \frac{c_f}{4D_f} \left(\frac{1}{2} \right) \left(R_{f_O}^* + \frac{R_{f_2}^*}{2} \right) \right] \\
& + C_{f_3} \left[\frac{P_{13}}{2} - \frac{c_f}{4D_f} \left\{ \left(\frac{R_{f_1}^* + R_{f_3}^*}{8} \right) - \frac{R_{f_3}^*}{16} \right\} \right] \\
& + C_{f_4} \left[\frac{P_{14}}{2} - \frac{c_f}{4D_f} \left(\frac{R_{f_2}^*}{12} \right) \right] + C_{f_5} \left[\frac{P_{15}}{2} - \frac{c_f}{4D_f} \left(\frac{R_{f_3}^*}{16} \right) \right] \\
& = R_{f_O}^* E_{f_1}^* + R_{f_1}^* E_{f_O}^* + \frac{1}{2} \sum_{n=1}^3 R_{f_n}^* E_{f_{n+1}}^* + \frac{1}{2} \sum_{n=2}^3 R_{f_n}^* E_{f_{n-1}}^* - E_{f_1}
\end{aligned} \tag{35b}$$

Second harmonic:

$$\begin{aligned}
& C_{f_O} \left[\frac{P_{2O}}{2} - \frac{c_f}{4D_f} \left\{ R_{f_2}^* \left(\ln \frac{16D_f}{c_f} - 1 \right) + \left(\frac{R_{f_1}^* + R_{f_3}^*}{2} \right) \right\} \right] \\
& + C_{f_1} \left[\frac{P_{21}}{2} - \frac{c_f}{4D_f} \left\{ \frac{R_{f_2}^*}{2} \left(\ln \frac{16D_f}{c_f} - 1 \right) - \frac{R_{f_O}^*}{4} \right\} \right]
\end{aligned} \tag{continued on next page}$$

$$\begin{aligned}
& + C_{f_2} \left[-\frac{1}{2} + \frac{P_{22}}{2} - \frac{c_f}{4D_f} \left(\frac{R_{f_1}^* + R_{f_3}^*}{4} - \frac{R_{f_1}^*}{12} \right) \right] \\
& + C_{f_3} \left[\frac{P_{23}}{2} - \frac{c_f}{4D_f} \left\{ \frac{R_{f_0}^*}{4} - \frac{R_{f_2}^*}{16} \right\} \right] \\
& + C_{f_4} \left[\frac{P_{24}}{2} - \frac{c_f}{4D_f} \left\{ \frac{R_{f_1}^*}{12} - \frac{R_{f_3}^*}{20} \right\} \right] + C_{f_5} \left[\frac{P_{25}}{2} - \frac{c_f}{4D_f} \left(\frac{R_{f_2}^*}{16} \right) \right] \\
& = R_{f_0}^* E_{f_2}^* + R_{f_2}^* E_{f_0}^* + \frac{1}{2} \left[R_{f_1}^* (E_{f_1}^* + E_{f_3}^*) + R_{f_3}^* (E_{f_1}^* + E_{f_5}^*) \right. \\
& \quad \left. + R_{f_2}^* E_{f_4}^* \right] - E_{f_2}
\end{aligned} \tag{35c}$$

Third harmonic:

$$\begin{aligned}
& C_{f_0} \left[\frac{P_{30}}{2} - \frac{c_f}{4D_f} \left\{ R_{f_3}^* \left(\ln \frac{16D_f}{c_f} - 1 \right) + \frac{R_{f_2}^*}{2} \right\} \right] \\
& + C_{f_1} \left[\frac{P_{31}}{2} - \frac{c_f}{4D_f} \left\{ \frac{R_{f_3}^*}{2} \left(\ln \frac{16D_f}{c_f} - 1 \right) - \frac{R_{f_1}^*}{8} \right\} \right] \\
& + C_{f_2} \left[\frac{P_{32}}{2} + \frac{c_f}{4D_f} \left(\frac{R_{f_0}^*}{6} - \frac{R_{f_2}^*}{4} \right) \right] + C_{f_3} \left[-\frac{1}{2} + \frac{P_{33}}{2} - \frac{c_f}{4D_f} \left\{ \frac{R_{f_1}^*}{16} \right\} \right] \\
& + C_{f_4} \left[\frac{P_{34}}{2} - \frac{c_f}{4D_f} \left\{ \frac{R_{f_0}^*}{6} - \frac{R_{f_2}^*}{20} \right\} \right] + C_{f_5} \left[\frac{P_{35}}{2} - \frac{c_f}{4D_f} \left(\frac{R_{f_1}^*}{16} \right) \right] \\
& = R_{f_0}^* E_{f_3}^* + R_{f_3}^* E_{f_0}^* + \frac{1}{2} \left[R_{f_1}^* (E_{f_2}^* + E_{f_4}^*) + R_{f_2}^* (E_{f_1}^* + E_{f_5}^*) \right] - E_{f_3}
\end{aligned} \tag{35d}$$

Fourth harmonic:

$$C_{f_0} \left[\frac{P_{40}}{2} - \frac{c_f}{4D_f} \left(\frac{R_{f_3}^*}{2} \right) \right] + C_{f_1} \left[\frac{P_{41}}{2} + \frac{c_f}{4D_f} \left(\frac{R_{f_2}^*}{8} \right) \right] \quad (\text{continued on next page})$$

$$\begin{aligned}
& + C_{f_2} \left[\frac{P_{42}}{2} + \frac{C_f}{4D_f} \left(\frac{R_{f_1}^*}{12} - \frac{R_{f_3}^*}{4} \right) \right] + C_{f_3} \left[\frac{P_{43}}{2} - \frac{C_f}{4D_f} \left(\frac{R_{f_2}^*}{8} - \frac{R_{f_0}^*}{8} \right) \right] \\
& + C_{f_4} \left[-\frac{1}{2} + \frac{P_{44}}{2} - \frac{C_f}{4D_f} \left(\frac{R_{f_1}^*}{30} \right) \right] + C_{f_5} \left[\frac{P_{45}}{2} - \frac{C_f}{4D_f} \left(\frac{R_{f_0}^*}{8} \right) \right] \\
& = R_{f_0}^* E_{f_4}^* + \frac{1}{2} \left[R_{f_1}^* \left(E_{f_3}^* + E_{f_5}^* \right) + R_{f_2}^* E_{f_2}^* + R_{f_3}^* E_{f_1}^* \right] - E_{f_4} \quad (35e)
\end{aligned}$$

Fifth harmonic:

$$\begin{aligned}
& C_{f_0} \left[\frac{P_{50}}{2} \right] + C_{f_1} \left[\frac{P_{51}}{2} + \frac{C_f}{4D_f} \left(\frac{R_{f_3}^*}{8} \right) \right] + C_{f_2} \left[\frac{P_{52}}{2} + \frac{C_f}{4D_f} \left(\frac{R_{f_2}^*}{12} \right) \right] \\
& + C_{f_3} \left[\frac{P_{53}}{2} - \frac{C_f}{4D_f} \left(\frac{R_{f_3}^*}{8} - \frac{R_{f_1}^*}{16} \right) \right] + C_{f_4} \left[\frac{P_{54}}{2} - \frac{C_f}{4D_f} \left(\frac{R_{f_2}^*}{12} - \frac{R_{f_0}^*}{10} \right) \right] \\
& + C_{f_5} \left[-\frac{1}{2} + \frac{P_{55}}{2} - \frac{C_f}{4D_f} \left(\frac{R_{f_1}^*}{16} \right) \right] \\
& = R_{f_0}^* E_{f_5}^* + \frac{1}{2} \sum_{n=1}^3 R_{f_n}^* E_{f_{5-n}}^* - E_{f_5} \quad (35f)
\end{aligned}$$

These equations are linear in terms of the unknown C_{f_n} coefficients, but because of the terms $\tilde{F}_{f_n}$ and $\tilde{F}_{f_n}^*$, the coefficients are implicit functions of the six unknowns, C_{e_n} . Equation (32) can be expanded into Fourier cosine series and like harmonics equated as before. The six equations obtained in this manner are linear algebraic equations in terms of the unknown coefficients C_{e_n} and implicit functions of the C_{f_n} coefficients because of the terms $\tilde{F}_{e_n}$ and $\tilde{F}_{e_n}^*$. These equations are identical to equations (35) with f and e interchanged everywhere. Thus, there exists a set of twelve equations and twelve unknowns, C_{f_n} and C_{e_n} . The solution is obtained by iteration.

For the case where the Mach number is not zero, the Prandtl-Glauert compressibility transformation discussed subsequently in connection with the wing model is employed (eqs. 5 to 7 of ref. 1). Accordingly, the engine and fan chord-to-diameter ratios are increased by the factor β and the duct camberline slopes remain the same at a given percent chord station.

Angle of attack solution: A turbofan engine mounted on a pylon beneath a swept wing is subjected to nonuniform wing-induced downwash and sidewash fields as well as a uniform downwash (or upwash) due to wing angle of attack. For most configurations, the angles and their spatial variation are small enough that they may be averaged axially and circumferentially over the fan duct and the engine duct. This approximation allows the use of an existing solution for a thin cylindrical duct in a uniform crossflow (ref. 9).

The procedure using the averaged crossflow velocities is to place a nonaxisymmetric bound vorticity distribution on each duct to cancel the appropriate crossflow through the duct reference cylinder (fig. 1(c)). Assuming that α_f and β_f are the average induced angles of upwash and sidewash on the fan duct, the two components of bound vorticity on the fan reference cylinder have the form

$$\frac{\gamma_{\alpha_f}}{V} = \sin \alpha_f \cos \phi \left[c_{f_o} \cot \frac{\theta_f}{2} + \sum_{n=1}^5 c_{f_n} \sin n\theta_f \right] \quad (36)$$

and

$$\frac{\gamma_{\beta_f}}{V} = \sin \beta_f \sin \phi \left[c_{f_o} \cot \frac{\theta_f}{2} + \sum_{n=1}^5 c_{f_n} \sin n\theta_f \right] \quad (37)$$

Similarly, the two components of bound vorticity on the engine duct are

$$\frac{\gamma_{\alpha_e}}{V} = \sin \alpha_e \cos \phi \left[c_{e_o} \cot \frac{\theta_e}{2} + \sum_{n=1}^5 c_{e_n} \sin n\theta_e \right] \quad (38)$$

and

$$\frac{\gamma_{\beta e}}{V} = \sin \beta_e \sin \phi \left[c_{e_0} \cot \frac{\theta_e}{2} + \sum_{n=1}^5 c_{e_n} \sin n\theta_e \right] \quad (39)$$

The c_{f_n} and c_{e_n} coefficients are functions only of the respective duct chord-to-diameter ratios and are tabulated in Table I of reference 10. In addition to the bound vorticity, there is a distribution of free axial trailing vortex filaments associated with each bound ring caused by the variation of strength around the γ_{α} or γ_{β} rings. Equations (36) through (39) are used to satisfy the following boundary conditions on the fan and engine ducts. On the reference cylinder representing the fan duct

$$v_{\gamma_{\alpha}}(f,f) - V \sin \alpha_f \cos \phi = 0 \quad (40)$$

$$v_{\gamma_{\beta}}(f,f) + V \sin \beta_f \sin \phi = 0 \quad (41)$$

and on the reference cylinder representing the engine duct

$$v_{\gamma_{\alpha}}(e,e) - V \sin \alpha_e \cos \phi = 0 \quad (42)$$

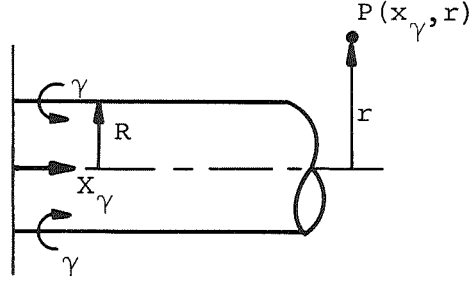
$$v_{\gamma_{\beta}}(e,e) + V \sin \beta_e \sin \phi = 0 \quad (43)$$

It is apparent from these boundary conditions that the mutual interference between the bound γ_{α} and γ_{β} vorticity of the two ducts is not considered. Since the induced crossflow is small, the strength of the bound vorticity is small and the velocities induced by the bound vorticities on each other is neglected as a second-order effect.

The above theory for the crossflow solution is applied to the engine transformed according to the Prandtl-Glauert rule in the event a compressibility correction is required.

Induced velocities.— Once the strength of the trailing vorticity is known and the coefficients for the bound vortex strength are computed, the velocity field induced by the engine may be calculated. The velocity at a field point is the sum of the velocities induced by each of the singularity distributions making up the engine model.

The velocity induced at a field point P by a constant strength vortex cylinder illustrated in the following sketch is computed as follows.



$$\left. \begin{aligned}
 x_\gamma < 0; \frac{r}{R} \leq 1 & \quad \frac{u_\gamma}{\gamma} = \frac{\left(\frac{x_\gamma}{R}\right)K}{2\pi \left[\left(\frac{x_\gamma}{R}\right)^2 + \left(\frac{r}{R} + 1\right)^2 \right]^{1/2}} + \frac{\Lambda_0}{4} + \frac{1}{2} \\
 x_\gamma < 0; \frac{r}{R} > 1 & \quad \frac{u_\gamma}{\gamma} = \frac{\left(\frac{x_\gamma}{R}\right)K}{2\pi \left[\left(\frac{x_\gamma}{R}\right)^2 + \left(\frac{r}{R} + 1\right)^2 \right]^{1/2}} - \frac{\Lambda_0}{4} \\
 x_\gamma = 0; \frac{r}{R} < 1 & \quad \frac{u_\gamma}{\gamma} = \frac{1}{2} \\
 x_\gamma = 0; \frac{r}{R} = 1 & \quad \frac{u_\gamma}{\gamma} = \frac{1}{4} \\
 x_\gamma = 0; \frac{r}{R} > 1 & \quad \frac{u_\gamma}{\gamma} = 0 \\
 x_\gamma > 0; \frac{r}{R} < 1 & \quad \frac{u_\gamma}{\gamma} = 1 - \left(\frac{u_\gamma}{\gamma}\right)_{(-x_\gamma, r/R)} \\
 x_\gamma > 0; \frac{r}{R} = 1 & \quad \frac{u_\gamma}{\gamma} = \frac{1}{2} - \left(\frac{u_\gamma}{\gamma}\right)_{(-x_\gamma, r/R)} \\
 x_\gamma > 0; \frac{r}{R} > 1 & \quad \frac{u_\gamma}{\gamma} = -\left(\frac{u_\gamma}{\gamma}\right)_{(-x_\gamma, r/R)}
 \end{aligned} \right\} \quad (44)$$

where the argument of the elliptic integrals K and E is

$$k_o^2 = \frac{4\left(\frac{r}{R}\right)}{\left(\frac{x\gamma}{R}\right)^2 + \left(\frac{r}{R} + 1\right)^2} \quad (45)$$

and the first argument of the Heuman Lambda Function $\Lambda_o(\beta, k_o)$ is

$$\beta = \sin^{-1} \left\{ \frac{\frac{x\gamma}{R}}{\left[\left(\frac{x\gamma}{R}\right)^2 + \left(\frac{r}{R} - 1\right)^2 \right]^{1/2}} \right\} \quad (46)$$

The radial velocity induced by the constant strength vortex cylinder is given by equation (C-3) of reference 6.

$$\frac{v_\gamma}{\gamma} = \frac{E - K}{2\pi\left(\frac{r}{R}\right)} \left[\frac{x\gamma}{R} + \left(\frac{r}{R} + 1\right)^2 \right]^{1/2} + \frac{K}{\pi \left[\left(\frac{x\gamma}{R}\right)^2 + \left(\frac{r}{R} + 1\right)^2 \right]^{1/2}} \quad (47)$$

The velocity induced by the duct-bound vorticity described by equations (15) or (16) is computed as follows. When the point P is on the duct surface, the approximate induced axial velocity on the surface of the duct is given by equation (23), and the radial velocity is given by equation (24). When the point P is not on the surface of the duct, the induced velocities must be obtained by numerically integrating over the vortex distribution bound to the duct. The axial velocities are computed using equation (A-9) of reference 6.

$$\frac{u_{\gamma_D}}{V} = \frac{c}{4\pi R} \int_0^\pi \frac{\frac{\gamma_D}{V} \sin \theta}{\left[\left(\frac{\xi}{R}\right)^2 + \left(\frac{r}{R} + 1\right)^2 \right]^{1/2}} \left[K - E - \frac{2\left(\frac{r}{R} - 1\right)E}{\left(\frac{\xi}{R}\right)^2 + \left(\frac{r}{R} - 1\right)^2} \right] d\theta \quad (48)$$

where

$$\frac{\xi}{R} = \frac{c}{D} \left(\cos \theta - \cos \theta_P \right) \quad (49)$$

and the argument of the elliptic integrals is

$$k^2 = \frac{4\left(\frac{r}{R}\right)}{\left(\frac{r}{R}\right)^2 + \left(\frac{r}{R} + 1\right)^2} \quad (50)$$

The radial velocity at point P is

$$\frac{v \gamma_D}{V} = \frac{c}{4\pi R} \int_0^\pi \frac{-\left(\frac{r}{R}\right) \frac{\gamma_D}{V} \sin \theta}{\frac{r}{R} \left[\left(\frac{r}{R}\right)^2 + \left(\frac{r}{R} + 1\right)^2 \right]^{1/2}} \left\{ K - \left[1 + \frac{2\left(\frac{r}{R}\right)}{\left(\frac{r}{R}\right)^2 + \left(\frac{r}{R} - 1\right)^2} \right] E \right\} d\theta \quad (51)$$

The velocity induced by the bound nonaxisymmetric vorticity, γ_α , described by equation (36) or (38) and its associated trailing vortex filaments is given as follows. The axial velocity is induced only by the bound vorticity and it is given by the following.

$$\begin{aligned} \frac{u \gamma_\alpha}{V \sin \alpha \cos \phi} = \frac{c}{D} \int_0^\pi \frac{g(\theta)}{2\pi \left[\left(\frac{r}{R}\right)^2 + \left(1 + \frac{r}{R}\right)^2 \right]^{3/2}} & \left\{ \frac{2}{1 - k^2} \left(1 - \frac{r}{R}\right) E \right. \\ & \left. + \frac{4}{k^2} \left[1 - \frac{4\left(\frac{r}{R}\right)}{k^2} \right] E + \frac{4}{k^4} \left[4\left(\frac{r}{R}\right) - k^2 \left(1 + 2 \frac{r}{R}\right) \right] K \right\} d\theta \end{aligned} \quad (52)$$

where

$$g(\theta) = \sin \theta \left[c_0 \cot \frac{\theta}{2} + \sum_{n=1}^5 c_n \sin n\theta \right] \quad (53)$$

and

$$k^2 = \frac{4\left(\frac{r}{R}\right)}{\left(\frac{r}{R}\right)^2 + \left(1 + \frac{r}{R}\right)^2} \quad (54)$$

The radial velocity component induced by the bound vorticity is

$$\left(\frac{v_r \gamma_\alpha}{V \sin \alpha \cos \phi} \right)_{\text{bound}} = \frac{c}{D} \int_0^\pi \frac{g(\theta) \frac{\xi}{R}}{8\pi \left(\frac{r}{R} \right)^{3/2}} \left[\frac{k^3 E}{1 - k^2} + \frac{8E}{k} - 4 \left(\frac{2 - k^2}{k} \right) K \right] d\theta \quad (55)$$

and the component induced by the trailing filaments is

$$\begin{aligned} \left(\frac{v_r \gamma_\alpha}{V \sin \alpha \cos \phi} \right)_{\text{trailing}} = \frac{c}{D} \int_0^\pi g(\theta) \left\{ \frac{\epsilon_r}{4} + \frac{\frac{\xi}{R}}{8\pi \left(\frac{r}{R} \right)^{3/2}} \left[\frac{4}{k} (K - E) \right. \right. \\ \left. \left. + 2\pi \frac{k}{k_0} \sqrt{\frac{1 - k_0^2}{k_0^2 - k^2}} (1 - \Lambda) \right] \right\} d\theta \quad (56) \end{aligned}$$

where

$$k_0^2 = \frac{4 \left(\frac{r}{R} \right)}{\left(1 + \frac{r}{R} \right)^2} \quad (57)$$

and

$$\Lambda = \Lambda(\beta, k)$$

$$\beta = \sin^{-1} \sqrt{\frac{1 - k_0^2}{1 - k^2}} \quad (58)$$

$$\epsilon_r = 1 \quad \text{when} \quad \frac{r}{R} \leq 1$$

$$\epsilon_r = \frac{1}{\left(\frac{r}{R} \right)^2} \quad \text{when} \quad \frac{r}{R} > 1$$

The tangential velocity component induced by the bound vorticity is

$$\left(\frac{v_{\phi} \gamma_{\alpha}}{v \sin \alpha \sin \phi} \right)_{\text{bound}} = \frac{c}{D} \int_0^{\pi} \frac{g(\theta) \frac{r}{R}}{8\pi \left(\frac{r}{R} \right)^{3/2}} \left[\frac{8E}{k} - 4K \left(\frac{2 - k^2}{k} \right) \right] d\theta \quad (59)$$

and the component due to the trailing filaments is

$$\begin{aligned} \left(\frac{v_{\phi} \gamma_{\alpha}}{v \sin \alpha \sin \phi} \right)_{\text{trailing}} = \frac{c}{D} \int_0^{\pi} g(\theta) \left\{ \frac{-\epsilon \phi}{4} - \frac{\frac{r}{R}}{8\pi \left(\frac{r}{R} \right)^{3/2}} \left[k k_0^2 K \left(1 + \frac{r}{R} \right) - \frac{4}{k} (K - E) \right. \right. \\ \left. \left. + \pi k k_0^2 \frac{\left[1 - \frac{r}{R} \right]^4}{8 \left(\frac{r}{R} \right)^2} \frac{(1 - \Lambda)}{\sqrt{(k_0^2 - k^2)(1 - k_0^2)}} \right] \right\} d\theta \end{aligned} \quad (60)$$

where

$$\left. \begin{aligned} \epsilon &= 1 & \text{when} & \quad \frac{r}{R} < 1 \\ \epsilon &= \frac{-1}{\rho^2} & \text{when} & \quad \frac{r}{R} > 1 \\ \epsilon &= 0 & \text{when} & \quad \frac{r}{R} = 1 \end{aligned} \right\} \quad (61)$$

The above equations for the velocity induced by γ_{α} type vorticity can be used for the velocity induced by γ_{β} type vorticity. The only change that should be made is that the azimuth angle ϕ should be replaced with $\phi' = \phi - 90^{\circ}$.

Program Description

Calculation procedure.— The computation is considered in two parts and proceeds as follows. Upon input, the main program immediately calls subroutine MODEL and the singularity distributions making up the axial flow model of the turbofan engine are calculated. These results are output and control returns to the main program. If the flow field induced

by the turbofan engine is to be computed, the local angles of attack and sidewash, the engine location relative to the wing, and the coordinates of the field points to be considered are input. MAIN then calls subroutine VELCTY where the total velocity induced at the field points by the axisymmetric and the nonaxisymmetric loadings on the engine are computed. These velocities are output and control returns to MAIN where a new case may be input.

Program use.— The program is written in Fortran IV for the IBM 7094 computer. No tapes other than the standard input and output tapes are required. Typical execution time for the complete program is approximately 6 minutes for a case with 100 field points. Since the engine model solution is obtained by iteration, the time estimate is strongly dependent on the the number of iterations (9 iterations for the above example). The program is built around three basic options. The complete program calculates the flow model for a high-bypass-ratio turbofan engine and then computes the velocity field induced by the engine. The program may be used just to calculate the engine flow model, or if the flow model is known a priori, the program may be used to compute the induced velocity at specified field points. A complete description of the input and output is presented in the following sections.

Description of Input

This section contains a description of input for the turbofan engine program. The relationship between the turbofan engine and the wing is shown in figure 2 for purposes of illustrating the geometry of the configuration which must be input.

A sample input form is presented in figure 3(a) for a normal run. All variables shown on the input forms in figure 3 are defined in the table at the end of this section. The first card contains identification information to be printed at the top of the output. The second card contains the geometry specification of the fan duct CDF, CHF, TCF, and RF(n). The third card contains similar information for the core engine duct. The fourth card contains more geometric information, RFRE and XECF; the free stream Mach number, EMZ; and the fan and engine wake velocity ratios, VFVZ and VEVZ. The fifth card is made up of four indices, NTYPE, MMP, NPRNT, and NCALC which specify the type of engine calculation required, the number of field points, the output options,

and the manner in which the program is to be used respectively. These first five cards appear as described in any input deck prepared for this program. The subsequent cards are dependent on the program options specified.

If the program is only to compute the turbofan engine flow model using the known values of jet wake velocities ($NTYPE = 1$) and no induced velocity field is wanted ($NCALC < 0$), the input deck is complete with the first five cards and items 6, 7, and 8 are omitted. If multiple cases are to be run, additional input decks following the first start with item 1 immediately after the last card of the previous deck. Any following cases are independent of the previous sets of input; therefore, they must specify the desired options.

When $NCALC = 0$, the induced velocity field is to be computed and items 6, 7, and 8 follow item 5 as shown in figure 3(a). Card 6 contains the combined geometric and induced angles of attack and sidewash on the fan and engine ducts. These are handled as the sum of two parts. The first consists of the flow and incidence effects on the engine at zero wing angle of attack and constitutes the engine-wing interaction effects not proportional to wing angle of attack. Thus $ALPF$ and $ALPHE$ are made up of the engine incidence angle with respect to the wing root-chord and any upwash induced on the engine due to the wing camber and twist at zero wing angle of attack. $BETAF$ and $BETAE$ include any geometric toe-in of the turbofan engine with respect to the wing root chord and any induced sidewash at zero wing angle. The second part consists of the flow and incidence effects on the engine which are proportional to wing angle of attack. For this purpose, the engine axis is assumed parallel to the root chord of the (uncambered and untwisted) wing. The fan and engine angles of attack $ADALF$ and $ADALE$ are made up of the geometrical angle of attack plus the wing-induced upwash due to angle of attack. The fan and engine angles of sidewash, $ADBTF$ and $ADBTE$, are those induced by the wing due to angle of attack.

Card 7 contains the coordinates (XQ, YQ, ZQ) of the center of the fan inlet in the wing coordinate system as shown in figure 2. Item 8 is a deck of MMP cards; each card contains the coordinates (XW, YW, ZW) of a field point at which induced velocities are to be calculated. These coordinates are also in the wing coordinate system. If the turbofan

engine program is used to compute externally induced velocities for input into the vortex lattice program, the order of the cards in item 8 should be the same as the order of the control points in that program. This use of the program is illustrated in the final section of this manual describing a sample interference calculation. If an engine-alone calculation is made, then XZ, YZ, and ZQ can be set equal to zero, and the field point coordinates XW, YW, and ZW would then be specified relative to a coordinate system with its origin at the center of the fan duct inlet face.

As an alternate method of calculating the engine vorticity, isentropic equations can be used to determine the wake characteristics if certain temperature and pressure ratios in the wake are known. This particular option is specified by the index $NTYPE = 0$ on card 5, and the changes in the input are shown in figure 3(b). Items 1 through 5 in figure 3(a) are unchanged. The two cards denoted as item 5(a) in figure 3(b) are inserted after item 5. The first card contains the ambient conditions, altitude, pressure, temperature, density, and the ratio of specific heats (the altitude is for information purposes only and is usually input in feet). The second card is the engine information obtained from some source similar to reference 4. The presence of items 6, 7, and 8 is determined by the index $NCALC$ as discussed above.

The final option available to this program is the calculation of the induced velocity field using a known turbofan engine flow model. This option can be used to avoid recomputing the turbofan singularity distributions for cases when the only changes in the input are the angles of attack and sidewash. The appropriate input is shown in figure 3(c). The first five cards are the same as shown in figure 3(a), and when the index $NCALC > 0$ on card 5, the two cards identified as item 5(a) in figure 3(c) are inserted after item 5 of the normal input. The first card contains the six coefficients of the fan duct-bound vorticity, C_{f_n} . The second card contains the coefficients for the engine duct-bound vorticity, C_{e_n} . Items 6, 7, and 8 are the same as shown previously.

The input program variables are defined as follows:

<u>Program Variable</u>	<u>Algebraic Symbol (if applicable)</u>	<u>Comments</u>
CDF	$(c/D)_{fan}$	fan duct chord-to-diameter ratio
CHF	C_f	fan duct chord

(Input program variables cont.)

<u>Program Variable</u>	<u>Algebraic Symbol (if applicable)</u>	<u>Comments</u>
TCF	$(t/c)_{fan}$	fan duct section thickness ratio
RF(N)	R_{fn}	fan duct geometric camberline coefficients
CDE	$(c/D)_{engine}$	engine duct chord-to-diameter ratio
CHE	c_e	engine duct chord
TCE	$(t/c)_{engine}$	engine duct section thickness ratio
RE(N)	R_{en}	engine duct geometric camberline coefficients
RFRE	R_f/R_e	ratio of fan duct radius to engine duct radius
XECF	x_e/c_f	location of engine duct leading edge relative to the fan inlet face
EMZ	M_o	Mach number
VFVZ	V_f/V	fan wake velocity ratio
VEVZ	V_e/V	core engine wake velocity ratio
NTYPE		index specifying type of engine calculation NTYPE = 0 - compute turbofan engine model using known engine thermodynamic characteristics NTYPE > 0 - compute turbofan engine model using known wake velocities
MMP		number of field points at which induced velocities are to be computed; MMP $\leq$ 150
NPRNT		index controlling optional output NPRNT = 0 for normal output NPRNT = 1 for expanded output
NCALC		index controlling use of program NCALC < 0 - calculate engine model only

(Input program variables cont.)

<u>Program Variable</u>	<u>Algebraic Symbol (if applicable)</u>	<u>Comments</u>
NCALC (cont.)		NCALC = 0 - calculate engine model and induced velocity field NCALC > 0 - calculate induced velocity field only
ALT		altitude (information only)
PZ	P_o	ambient pressure (psf)
TZ	T_o	ambient temperature ($^{\circ}$ R)
RZ	ρ_o	ambient density (slugs/ft ³)
GAMMA	γ	ratio of specific heats
FNT	F_T	total turbofan engine thrust (lbs)
WAT2	W_2	fuel consumption (lb/sec)
BPR		bypass ratio
PFPZ	P_f/P_o	total pressure ratio in fan wake
TFTZ	T_f/T_o	total temperature ratio in fan wake
PEPZ	P_e/P_o	total pressure ratio in engine wake
TETZ	T_e/T_o	total temperature ratio in engine wake
ALPHF	α_f	average angle of attack of fan duct, including engine incidence, for $\alpha = 0$, degrees
ALPHE	α_e	average angle of attack of engine duct, including engine incidence, for $\alpha = 0$, degrees
BETAF	β_f	average angle of sidewash of fan duct including engine toe-in angle, for $\alpha = 0$, degrees
BETAE	β_e	average angle of sidewash of engine duct, including engine toe-in angle, for $\alpha = 0$, degrees

(Input program variables cont.)

<u>Program Variable</u>	<u>Algebraic Symbol (if applicable)</u>	<u>Comments</u>
ADALF	α_f	average angle of attack of fan duct for additional loading, degrees
ADALE	α_e	average angle of attack of engine duct for additional loading, degrees
ADBTF	β_f	average angle of sidewash of fan duct for additional loading, degrees
ADBTE	β_e	average angle of sidewash of engine duct for additional loading, degrees
XQ,YZ,ZQ	x_Q, y_Q, z_Q	coordinates of center of turbofan inlet in wing coordinate system
XW(J),YW(J), ZW(J)	x_w, y_w, z_w	coordinates of field points in wing coordinate system

Samples of input decks are shown in figure 4 illustrating all of the options discussed previously. In figure 4(a), the input deck is shown for a normal run in which the engine flow model is computed using known wake velocities, and the induced velocity field is calculated at a number of field points. An input deck for computing only the turbofan flow model using known wake velocities is shown in figure 4(b). The input deck for computing only the velocity field induced by a known engine flow model is shown in figure 4(c). An input deck to compute the flow model when engine characteristics are known is shown in figure 4(d).

Input limitations.— Some care must be used in the specification of input variables. The calculation of the camber coefficients $RF(N)$ and $RE(N)$ on cards 2 and 3 respectively must be carried out with some care; therefore, the procedure is considered in detail in the following section. The chord-to-diameter ratio may be any number greater than zero. The duct chords, the coordinates of the engine location, and the coordinates of the control points are dimensioned variables, and they should have consistent units. All angles are input in degrees. Angles of attack are positive in the usual sense, and angles of sidewash are positive if their lateral component is directed in the +y direction (fig. 2).

The values assigned to R_f/R_e and x_e/c_f to determine the relative positions of the fan and core engine ducts are important. If the core

engine duct extends inside the fan duct ($x_e/c_f < 1$), the value of R_f/R_e should be greater than 3. This limitation occurs because the turbofan engine flow model will not converge on a solution if the ducts are too close together. If $R_f/R_e < 3$, convergence may be obtained if $x_e/c_f > 0.5$, although convergence is highly dependent on flow conditions. Good results have always been attained when $x_e/c_f = 1$.

The free-stream Mach number may be any value less than 1.0 for most calculations. One exception is when the turbofan model is to be computed from known engine thermodynamic characteristics (NTYPE = 0), as illustrated in figure 3(b). For this calculation, the Mach number should not equal zero.

Camber coefficients.— The geometric camber coefficients $RF(N)$ and $RE(N)$ are computed according to methods described in reference 2. These methods are repeated herein for convenience. The following equations are written in terms of the fan duct but they apply equally to the core engine duct by simply changing the subscripts.

The slope of the camberline is described with a Fourier series as

$$\frac{dr_f}{dx_f} = \sum_{n=0}^3 R_{f_n} \cos(n\theta_f) \quad (62)$$

where

$$\cos \theta_f = 1 - 2\left(\frac{x_f}{c_f}\right) \quad (63)$$

This can be integrated to give the camberline slope as

$$\begin{aligned} \frac{r_f - R_{f_0}}{c_f} = & -R_{f_0} \left(\frac{1 + \cos \theta_f}{2} \right) + R_{f_1} \left(\frac{1 - \cos^2 \theta_f}{4} \right) \\ & + R_{f_2} \left(\frac{1}{6} + \frac{1}{2} \cos \theta_f - \frac{1}{3} \cos^3 \theta_f \right) \\ & + R_{f_3} \left(-\frac{1}{4} + \frac{3}{4} \cos^2 \theta_f - \frac{1}{2} \cos^4 \theta_f \right) \end{aligned} \quad (64)$$

Note that the camberline radius at the trailing edge is identically that of the fan duct reference cylinder, which, by definition, passes through the trailing-edge radius. Four other points along the camberline must be selected and their corresponding θ_f and r_f values put into the above equation to obtain four simultaneous equations for the four R_{f_n} coefficients. It is suggested on the basis of past experience that these points be equally spaced for best results; that is, at $x_f/c_f = 0, 1/4, 1/2$, and $3/4$. If these four points are chosen, the R_{f_n} coefficients are obtained from the following equations.

$$\begin{bmatrix} R_{f_0} \\ R_{f_1} \\ R_{f_2} \\ R_{f_3} \end{bmatrix} = \begin{bmatrix} (-1 \frac{2}{3}) & (1 \frac{1}{3}) & (0) & (-1 \frac{1}{3}) \\ (-3 \frac{1}{3}) & (5 \frac{1}{3}) & (-4) & (5 \frac{1}{3}) \\ (-2) & (4) & (0) & (-4) \\ (-1 \frac{1}{3}) & (5 \frac{1}{3}) & (-8) & (5 \frac{1}{3}) \end{bmatrix} \times \begin{bmatrix} \left(\frac{r_f - R_f}{c_f} \right)_0 \\ \left(\frac{r_f - R_f}{c_f} \right)_{\frac{1}{4}} \\ \left(\frac{r_f - R_f}{c_f} \right)_{\frac{1}{2}} \\ \left(\frac{r_f - R_f}{c_f} \right)_{\frac{3}{4}} \end{bmatrix} \quad (65)$$

If the camberline is not well behaved, four other values of x_f/c_f may be necessary to give the best overall fit to the actual camberline. A word of caution is necessary here. Once the four values of R_f are computed, equation (64) should be used to compute the duct radius at various points other than those used to obtain the R_{f_n} coefficients. Comparison between these computed radii and the actual shape may dictate another choice of x_f/c_f values and a recalculation of R_{f_n} . It is absolutely necessary to check the computed camberline shape because the character of equation (62) is such that if the chosen values of x_f/c_f are not nearly equally spaced, large undulations in the camberline will appear.

The above values of R_{f_n} and R_{e_n} describing the geometric camberline are corrected in Subroutine CAMBER to include induced camber coefficients. The concept of induced camber is discussed in references 5 and 11. Suffice it to say here that these induced camber coefficients

are known only for $c/D \leq 1.0$ and values corresponding to $c/D > 1$ are obtained by extrapolation. This method is adequate for $c/D \approx 2$ because the coefficients are nearly linear functions of c/D ; however, for very large c/D values extrapolation can lead to erroneous results. For a typical duct camberline shape described in reference 2, the induced camber coefficients vary from a few percent of coefficients R_{f_0} and R_{f_3} to nearly 50 percent of R_{f_1} .

The effect of the induced camber coefficients can be removed from the program in the following manner. These coefficients are proportional to the duct thickness-to-chord ratio; therefore, the induced camber can be removed from consideration by setting $t/c = 0$ on cards 2 and 3 in the input deck. This change will not alter any other part of the program.

Description of Output

A sample set of output for a normal run is shown in figure 5. This set of output was generated from the input deck illustrated in figure 4(a). The entire set of optional output has been obtained for this case.

The pages are numbered and each page features the identification information from the first card of the input deck. At the top of page 1, the input turbofan geometric characteristics are output followed by the transformed geometric characteristics if $M \neq 0$. Under the major heading WAKE CHARACTERISTICS, the computed values of the strengths of the trailing vortex cylinders associated with the fan, $G(F)/V$, and the core engine, $G(E)/V$, are printed along with the input wake velocity ratios. The following information is the coefficients of the fan duct-bound vorticity, C_{f_n} , and the core engine duct-bound vorticity, C_{e_n} . The next line labeled CONVERGENCE indicates the number of iterations (9) and the convergence criterion (0.001). The maximum number of iterations allowable is 20 and the convergence criterion is a built-in constant and means that each of the C_n coefficients has converged within 0.1 percent.

The remainder of the output on this page is optional (NPRNT = 1). The first block of data is the Fourier coefficients of the induced velocities on the fan duct (eqs. (25) through (30)). The next block is the corresponding set of coefficients for the core engine duct. This page completes the turbofan engine flow model.

The output from the induced velocity portion of the program starts with page 2. This page contains the turbofan geometry and the coefficients of the bound vorticity repeated from the first page and the coordinates of the field points at which induced velocities are to be computed. The field points are output in several forms. The first three columns (XW, YW, ZW) are the coordinates in the wing system as input. The next three columns (X, Y, Z) are the coordinates transformed to the engine system, and the last two columns (R, PHI) are cylindrical coordinates in an engine-based reference system (fig. 2).

The next page (page 3) of output is optional (NPRNT = 1). This page lists the engine-induced velocity components at the field points in the engine velocity reference system (radial, tangential and axial). Note that the axial velocity, U/V , is positive aft, the radial velocity is positive in the direction of increasing radius, and the tangential velocity is positive in the direction of increasing azimuthal angle ϕ . These velocities are those induced by the turbofan engine model when the wing root chord is at zero angle of attack. Engine incidence angle and toe-in angle relative to the wing root chord are included at this time, as are any flow angles induced by wing camber and twist.

Page 4 contains the engine-induced velocity components for zero wing angle transformed to the wing reference system. The coordinates of each point (XW, YW, ZW) are output with the velocity components at that point. The velocities are positive in the positive coordinate direction as shown in figure 2.

The final page of output, page 5, contains the engine-induced velocities proportional to wing angle of attack. The angles of attack and sideslip at the fan and engine ducts are printed at the top of the page. The angle of attack includes both the geometric angle and the wing-induced upwash. The angle of sideslip is the wing-induced sidewash due to α . If these angles are zero, no further output is printed, since the engine-induced velocities are zero. If the angles are not zero, the three components of induced velocity at each field point (in the wing coordinate system) are printed. This concludes the output listing.

To obtain the total velocity induced by the engine at the field points, the $\alpha = 0$ velocities at a given field from page 4 are added

directly to the additional-type velocities from page 5. For purposes of computing engine-wing interference using the vortex-lattice program, these two sets of velocities are input as separate blocks of data

Description of Error Messages

The turbofan engine program has only one built-in error message to stop the computation. If the model calculation fails to converge on a solution in 20 iterations, the following message is printed in Subroutine MODEL:

SOLUTION HAS NOT CONVERGED IN 20 ITERATIONS

The program then outputs the solution from the last iteration including all the Fourier coefficients corresponding to the optional output discussed previously. Control is returned to the main program where execution is terminated at a STOP.

When the above problem occurs, first check the geometry of the turbofan engine. If the core engine duct is too near the fan duct ($x_e/c_f < 1$ and $R_f/R_e < 2$) there is a possibility that no solution can be obtained in the conventional manner used in this program. Generally, a solution may be obtained by setting $x_e/c_f = 1$, and the results will not be greatly different from those which would have been calculated with $x_e/c_f < 1$.

The variables controlling the convergence are $EPS = 0.001$ and $MAXIT = 20$ in Subroutine MODEL. These variables may be modified, but experience has shown that EPS should not be greater than 0.01 and in most cases that have converged solutions, convergence is obtained in less than 15 iterations.

Program Listing

The turbofan engine flow model program is written in Fortran IV for the IBM 7094 computer. The program consists of the main program and 17 subroutines. The table below will act as a table of contents for the program listing given on the following pages.

<u>Program</u>	<u>Identification</u>	<u>Page No.</u>
MAIN	TF 01	40
MODEL	TF 02	40
VELCTY	TF 03	42
ELLIPS	TF 04	44
LAMBDA	TF 05	45
PKL	TF 06	46
FOURCS	TF 07	47
MATRIX	TF 08	47
BNCOEF	TF 09	48
BSCOEF	TF 10	48
BTCOEF	TF 11	49
FTCOEF	TF 12	50
CNCOEF	TF 13	51
CAMBER	TF 14	52
ENGINE	TF 15	52
MMGAMD	TF 16	53
MMGAMC	TF 17	54
MMGAMA	TF 18	55

```

C MAIN PROGRAM TO CONTROL CALCULATION OF HIGH BYPASS RATIO
C TURBOFAN ENGINE MODEL AND INDUCED VELOCITY FLOW FIELD
C
DIMENSION TITLE(20),CF(6),CE(6),PF(6,6),PE(6,6)
DIMENSION RF(4),RE(4),XW(150),YW(150),ZW(150)
COMMON MZZZ
COMMON/FAN/ CDF,CHF,TCF,RFRE,VFVZ,RF
COMMON/ENG/ CDE,CHE,TCE,XECF,VEVZ,RE
COMMON/INDEX/ NTYPE,MMP,NPRNT,NCALC
COMMON/SAVE/ GVF,GVE,CF,CE,PF,PE
COMMON/HRM1A/ EMZ,PZ,TZ,RZ,GAMMA,FNT,WAT2,BPR,PPF2,TFT2,PEP2,TET2
COMMON/HRM2A/ ALPHF,BETAF,ALPHE,BETAE,ADALF,ADBT,ADALE,ADBT,
1 XQ,YQ,ZQ,XW,YW,ZW
COMMON/PAGE/ TITLE,NPAGE
702 FORMAT (8F10.0)
703 FORMAT (6E13.6)
704 FORMAT (5I5)
706 FORMAT (20A4)
10 READ (5,706) TITLE
MZZZ=1
NPAGE=0
READ (5,702) CDF,CHF,TCF,(RF(J),J=1,4)
READ (5,702) CDE,CHE,TCE,(RE(J),J=1,4)
READ (5,702) RFRE,XECF,EMZ,VFVZ,VEVZ
READ (5,704) NTYPE,MMP,NPRNT,NCALC
IF (NCALC .GT. 0) GO TO 19
IF (NTYPE .GT. 0) GO TO 15
READ (5,702) ALP,PZ,TZ,RZ,GAMMA
READ (5,702) FNT,WAT2,BPR,PPF2,TFT2,PEP2,TET2
15 CONTINUE
C
C CALCULATE HIGH BYPASS RATIO TURBOFAN ENGINE MODEL
C
CALL MODEL
IF (MZZZ .EQ. 10) STOP
IF (NCALC) 10,20,20
19 READ (5,703) (CF(N),N=1,6)
READ (5,703) (CE(N),N=1,6)
GVF=VFVZ-1.0
GVE=VEVZ-VFVZ
20 CONTINUE
READ (5,702) ALPHF,BETAF,ALPHE,BETAE,ADALF,ADBT,ADALE,ADBT,
READ (5,702) XQ,YQ,ZQ
DO 25 J=1,MMP
25 READ (5,702) XW(J),YW(J),ZW(J)
C
C CALCULATE VELOCITIES INDUCED BY A HIGH BYPASS RATIO TURBOFAN ENGINE
C
30 CONTINUE
CALL VELCTY
GO TO 10
END

```

```

TF01 001
TF01 002
TF01 003
TF01 004
TF01 005
TF01 006
TF01 007
TF01 008
TF01 009
TF01 010
TF01 011
TF01 012
TF01 013
TF01 014
TF01 015
TF01 016
TF01 017
TF01 018
TF01 019
TF01 020
TF01 021
TF01 022
TF01 023
TF01 024
TF01 025
TF01 026
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TF01 028
TF01 029
TF01 030
TF01 031
TF01 032
TF01 033
TF01 034
TF01 035
TF01 036
TF01 037
TF01 038
TF01 039
TF01 040
TF01 041
TF01 042
TF01 043
TF01 044
TF01 045
TF01 046
TF01 047
TF01 048
TF01 049
TF01 050
TF01 051
TF01 052

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SUBROUTINE MODEL
SUBPROGRAM TO CALCULATE A HIGH BYPASS RATIO
TURBOFAN ENGINE FLOW MODEL
C
DIMENSION RF(4),RE(4),RPF(4),RPE(4),TITLE(20)
DIMENSION PF(6,6),PE(6,6),BF(6),BE(6),RFS(6),BES(6),BET(6),BETS(6)
1 RFT(6),BFTS(6),FFT(6),FFT(6),FET(6),FEIS(6),EF(6),EE(6)
2 EFS(6),EES(6),CF(6),CE(6),CFS(6),CES(6),CESAV(6)
COMMON MZZZ
COMMON/FAN/ CDF,CHF,TCF,RFRE,VFVZ,RF
COMMON/ENG/ CDE,CHE,TCE,XECF,VEVZ,RE
COMMON/INDEX/ NTYPE,MMP,NPRNT,NCALC
COMMON/HRM1A/ EMZ,PZ,TZ,RZ,GAMMA,FNT,WAT2,BPR,PPF2,TFT2,PEP2,TET2
COMMON/SAVE/ GVF,GVE,CF,CE,PF,PE
COMMON/PAGE/ TITLE,NPAGE
C
701 FORMAT (1H1/5X,20A4,5X4HPAGE,I3//)
702 FORMAT (1H )
703 FORMAT ( 5X,6(1PE14.7))
710 FORMAT (8X3HFAN,9F10.5)
711 FORMAT ( 5X6HENGINE,7F10.5)
713 FORMAT (/5X,17HFLIGHT CONDITION5/17X,3HALT7X1HM5X6HP(PSF16X4HT(R),
1 4X3HRHO10X3HGAM/10X,F10.0,F10.3,2F10.2,F10.6,F10.2)
714 FORMAT (/5X,22HENGINE CHARACTERISTICS/14X,6HF(LBS)3X9HW(LB/SEC),
1 3X3HBP6X6HP(T/PT4X6HT(T/TT4X6HPT(PT4X6HT(T/TT3X8HF(FAN)/FT02 025
2 /10X2F10.1,6F10.4)
715 FORMAT (/5X,20HWAKE CHARACTERISTICS/15X,6HG(F)/V4X6HG(E)/V4X4HVF/VTF02 027
1 6X4HVE/V/11X,4F10.5)
716 FORMAT (/5X,31HCOEFFICIENTS OF BOUND VORTICITY,5X10HC(N),N=1,6)
717 FORMAT (8X,3HFAN,6(1PE15.7))
718 FORMAT (5X,6HENGINE,6(1PE15.7))
719 FORMAT (/5X,29HINDUCED VELOCITY COEFFICIENTS//)
720 FORMAT (/10X,12HCONVERGENCE,15,F10.4)
730 FORMAT (16X3HC/D7X1HC9X3HT/C7X2HR08X2HR18X2HR28X2HR37X5HRF/RE5X5HXTF02 034
1E/CF)
731 FORMAT (8X3HFAN)
732 FORMAT (8X6HENGINE)
740 FORMAT (5X25HGEOMETRIC CHARACTERISTICS)
741 FORMAT (/5X37HTRANSFORMED GEOMETRIC CHARACTERISTICS,5X,3HM =,F6.3)
742 FORMAT (14X7HFAN C/D3X7HENG C/D4X5HFAN C5X5HENG C/11X4F10.5)
750 FORMAT (5X,12HB(N) 6(1PE14.7))
751 FORMAT (5X,12HB*(N) 6(1PE14.7))
752 FORMAT (5X,12HB(N)-TILDE 6(1PE14.7))
753 FORMAT (5X,12HB*(N)-TILDE 6(1PE14.7))
754 FORMAT (5X,12HF(N)-TILDE 6(1PE14.7))
755 FORMAT (5X,12HF*(N)-TILDE 6(1PE14.7))
799 FORMAT (/10X35H*** SOLUTION HAS NOT CONVERGED IN ,I3,16H ITERATI
1ONS ***/)
EPS=0.001
MAXIT=20
C
C OUTPUT TURBOFAN ENGINE GEOMETRY
C
NPAGE=NPAGE+1
WRITE (6,701) TITLE,NPAGE
WRITE (6,740)
WRITE (6,730)
WRITE (6,710) CDF,CHF,TCF,(RF(J),J=1,4),RFRE,XECF
WRITE (6,711) CDE,CHE,TCE,(RE(J),J=1,4)
BETA=SQRT(1.0 - EMZ*EMZ)
IF (EMZ .LE. 0.0) GO TO 9
WRITE (6,741) EMZ
CDF=CDF/BETA
CDE=CDE/BETA
CHF=CHF/BETA
CHE=CHE/BETA
WRITE (6,742) CDF,CDE,CHF,CHE
C
9 CALL PKL (CDF,PF)
CALL PKL (CDE,PE)
CALL CAMBER (CDF,TCF,RPF)
CALL CAMBER (CDE,TCE,RPE)

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TF02 001
TF02 002
TF02 003
TF02 004
TF02 005
TF02 006
TF02 007
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TF02 071
TF02 072

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DO 11 J=1,4
RE(J)=RE(J)-RPF(J)
11 RF(J)=RF(J)-RPF(J)
IF (NTYPE) 12,12,15
C
C   OUTPUT FLIGHT CONDITIONS
C
12 WRITE (6,713) ALT,EMZ,PZ,TZ,RZ,GAMMA
C
C   CALL ENGINE (EME,EMF,VEVZ,VFVZ,FRAT)
C
C   OUTPUT TURBOFAN ENGINE CHARACTERISTICS
C
WRITE (6,714) FNT,WAT2,BPR,PPF2,TFT2,PEP2,TET2,FRAT
15 GVF = VFVZ - 1.0
GVE = VEVZ - VFVZ
WRITE (6,715) GVF,GVE,VFVZ,VEVZ
NTIME=0
C
C   COMPUTE THE B(N) FOURIER COEFFICIENTS
C
CRF=CDF*2.0
CRF=CDE*2.0
CALL BNCOE (CRF,BF)
CALL BNCOE (CRE,BE)
C
C   COMPUTE THE B*(N) FOURIER COEFFICIENTS
C
CALL BSCOE (CRF,BFS)
CALL BSCOE (CRE,BES)
C
C   COMPUTE THE B(N)-TILDE AND B*(N)-TILDE FOURIER COEFFICIENTS
C
XGECF=CDE/CDF/RFRE + XECF
XGFCE=(1.0-XECF)*CDF*RFRE/CDE
RERF=1.0/RFRE
CALL BTCOE (CRE,XGFCE,RFRE,BET,BETS)
CALL BTCOE (CRF,XGECF,RERF,BFT,BFTS)
20 DO 21 N=1,6
FFT(N)=0.0
FFTS(N)=0.0
FET(N)=0.0
FETS(N)=0.0
CFSAV(N)=0.0
21 CESAV(N)=0.0
C
C   DEFINE E(N) AND E*(N) FOURIER COEFFICIENTS
C
30 DO 31 N=1,6
EF(N)=GVF*BF(N)+FFT(N)+GVE*BFT(N)
EFS(N)=GVF*BFS(N)+FFTS(N)+GVE*BFTS(N)
EE(N)=GVE*BE(N)+FET(N)+GVF*BET(N)
31 EFS(N)=GVE*BES(N)+FETS(N)+GVF*BETS(N)
EFS(1)=EFS(1)+1.0
EFS(1)=EFS(1)+1.0
NTIME=NTIME+1
CALL CNCOE (CF,CDF,RF,PF,FF,EFS)
CALL CNCOE (CF,CDE,RE,PE,FE,EFS)
C
C   TEST CONVERGENCE OF CE(N) AND CF(N) COEFFICIENTS
C
NTEST=0
DO 32 N=1,6
TFST=(CF(N)-CFSAV(N))/CF(N)
IF (ABS(TFST).GT.EPS) NTEST=NTEST+1
TFST=(CF(N)-CESAV(N))/CE(N)
IF (ABS(TFST).GT.EPS) NTEST=NTEST+1
32 CONTINUE

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TF02 073
TF02 074
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TF02 135
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TF02 137
TF02 138
TF02 139
TF02 140

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IF (NTEST) 37,37,33
33 IF (NTIME-1) 134,134,35
134 DO 36 N=1,6
CFSAV(N)=CF(N)
CESAV(N)=CE(N)
GO TO 37
35 IF (NTIME-MAXIT) 38,99,99
38 DO 34 N=1,6
DUM=CFSAV(N)
CFSAV(N)=CF(N)
CF(N)=(CF(N)+DUM)/2.0
DUM=CESAV(N)
CESAV(N)=CE(N)
34 CF(N)=(CE(N)+DUM)/2.0
C
C   COMPUTE THE F(N)-TILDE AND F*(N)-TILDE FOURIER COEFFICIENTS
C
37 XGAMCE=-XECF*CDF*RFRE/CDE
CALL FTCOE (CDE,CDF,RFRE,CE,XGAMCE,FFT,FFTS)
CALL FTCOE (CDE,CDE,RERF,CF,XECF,FET,FETS)
IF (NTEST) 50,50,30
99 WRITE (6,799) NTIME
MZZZ=10
NPRNT=1
50 CONTINUE
WRITE (6,716)
WRITE (6,717) (CF(N),N=1,6)
WRITE (6,718) (CE(N),N=1,6)
WRITE (6,720) NTIME,EPS
IF (NPRNT) 10,10,51
51 WRITE (6,719)
WRITE (6,731)
WRITE (6,750) (BF(J),J=1,6)
WRITE (6,751) (BFS(J),J=1,6)
WRITE (6,752) (BFT(J),J=1,6)
WRITE (6,753) (BFTS(J),J=1,6)
WRITE (6,754) (FFT(J),J=1,6)
WRITE (6,755) (FFTS(J),J=1,6)
WRITE (6,702)
WRITE (6,732)
WRITE (6,750) (BE(J),J=1,6)
WRITE (6,751) (BES(J),J=1,6)
WRITE (6,752) (BET(J),J=1,6)
WRITE (6,753) (BETS(J),J=1,6)
WRITE (6,754) (FET(J),J=1,6)
WRITE (6,755) (FETS(J),J=1,6)
CDE=CDF*BETA
CDE=CDE*BETA
CHF=CHF*BETA
CHE=CHE*BETA
10 RETURN
END

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TF02 141
TF02 142
TF02 143
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TF02 145
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SUBROUTINE VELCTY
SUBPROGRAM TO CALCULATE THE VELOCITIES INDUCED AT SPECIFIED
CONTROL POINTS BY A HIGH BYPASS RATIO TURBOFAN ENGINE
DIMENSION XW(150),YW(150),ZW(150),X(150),Y(150),Z(150),R(150),
PHI(150)
DIMENSION U(150),VR(150),VP(150),UA(150),VRA(150),VPA(150),
AVRT(150),AVPT(150),AU(150),AVR(150),AVP(150),
UB(150),VRB(150),VPB(150),BU(150),BVR(150),BVP(150)
DIMENSION PF(6,6),PE(6,6),CF(6),CE(6),TITLE(20),RFDUM(4),REDUM(4)
COMMON MZZZ
COMMON/FAN/ CDF,CHF,TCF,RFRE,VFVZ,RFDUM
COMMON/ENG/ CDE,CHE,TCE,XECF,VEVZ,REDUM
COMMON/SAVE/ GVF,GVE,CF,CE,PF,PE
COMMON/INDEX/ NTYPE,MMP,NPRNT,NCALC
COMMON/MRM1A/ FMZ,PZ,TZ,RZ,GAMMA,FNT,WAT2,BPR,PPF2,TFT2,PEP2,TET2
COMMON/MRM2A/ ALPHF,BETAF,ALPHE,BETAE,ADALF,ADBTF,ADALE,ADBTE,
XO,YO,ZO,XW,YW,ZW
COMMON/PAGE/ TITLE,NPAGE
701 FORMAT (5I5)
702 FORMAT (6E12.5)
703 FORMAT (1H1/5X,20A4,5X,4HPAGE,I3)
704 FORMAT (8X,8F10.4)
705 FORMAT (9X6(1PE15.7))
706 FORMAT (5X,15+6(1PE15.7))
707 FORMAT (5X,15+3(1X,3(1PE12.4)))
708 FORMAT (/5X15)
709 FORMAT (/12X1H(6X22HWHING COORDINATE SYSTEM,5X1H),2X1H(5X24HENGINE
COORDINATE SYSTEM,4X1H))
710 FORMAT ( 9X1HN,6X2HXW,10X2HYW,10X2HZW,10X1HX,11X1HY,11X1HZ,12X1HR,
11X3HPHI)
711 FORMAT (/9X1HN,4X7H XW , 6X2HYW,10X2HZW,10X3HU/V,7X8HV(RAD)/V,
4X8HV(TAN)/V)
712 FORMAT (/9X1HN,4X7H XW , 6X2HYW,10X2HZW,10X3HU/V,9X3HW/V)
713 FORMAT (/12X1H(6X22HWHING COORDINATE SYSTEM,5X1H),2X1H(5X24HENGINE
COORDINATE SYSTEM,4X1H))
714 FORMAT (// 2X18H(ADDITIONAL LOADING,8X8HALPHA(F)3X7HBETA(F)2X8HALPH(T)
1A(E)3X7HBETA(E)/25X4F10.4//)
715 FORMAT (/5X,31HCoefficients of Bound Vorticity,5X10HC(N),N=1,6)
716 FORMAT (8X,3HFAN,6(1PE15.7))
717 FORMAT (8X,6HENGINE,6(1PE15.7))
718 FORMAT (/14X1HM9X4HBETA6X2HXQ8X2HYQ8X2HZQ)
719 FORMAT (// 2X42HBASIC TYPE LOADING, ALPHA(ROOT) = 0.0 DEG. ,
1 5X8HALPHA(F)2X7HBETA(F)3X8HALPHA(E)2X7HBETA(E)/46X4F10.4)
720 FORMAT (/13X3HC/D8X1HC7X5HGAM/V5X, 5HRF/RE5X5HXE/CF)
721 FORMAT (5X3HFAN,8F10.4)
722 FORMAT (2X6HENGINE,6F10.4)
723 FORMAT (/10X54HINDUCED VELOCITY COMPONENTS IN ENGINE REFERENCE SYSTEM,
ITEM)
724 FORMAT (/9X52HINDUCED VELOCITY COMPONENTS IN WING REFERENCE SYSTEM)
MZZZ=1
PI=3.1415926
RAD=180.0/PI
BETA=SQRT(1.0-FMZ*EMZ)
TRANSFORM CONTROL POINTS TO ENGINE COORDINATE SYSTEM
DO 12 N=1,MMP
X(N)=XO-XW(N)
Y(N)=YO-YW(N)
Z(N)=ZO-ZW(N)
PHI(N)=0.0
U(N)=0.0
VR(N)=0.0
VP(N)=0.0
NPAGE=NPAGE+1
WRITE (6,703) TITLE,NPAGE
WRITE (6,722)
WRITE (6,723) CDF,CHF,GVF,RFRE,XECF
WRITE (6,724) CDE,CHE,GVE

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WRITE (6,720)
WRITE (6,704) EMZ,BETA,XO,YO,ZO
WRITE (6,716)
WRITE (6,717) CF
WRITE (6,718) CE
WRITE (6,709)
WRITE (6,710)
COMPUTE RADIUS AND AZIMUTH ANGLE FOR EACH CONTROL POINT
DO 20 N=1,MMP
R(N)=SQRT(Y(N)*Y(N) + Z(N)*Z(N))
IF (Y(N)) 15,16,15
15 DUM=ATAN(Z(N)/Y(N))*RAD
IF (DUM) 17,18,19
18 IF (Y(N)) 17,20,19
17 PHI(N)= 90.0 - DUM
GO TO 20
19 PHI(N)= 270.0-DUM
GO TO 20
16 IF (Z(N)) 20,20,116
116 PHI(N)=180.0
20 WRITE(6,707) N,XW(N),YW(N),ZW(N),X(N),Y(N),Z(N),R(N),PHI(N)
APPLY COMPRESSIBILITY FACTOR - STRETCH X-COORDINATE
DO 70 N=1,MMP
70 X(N)=X(N)/BETA
CDF=CDF/BETA
CDE=CDE/BETA
XO=XO/BETA
CHF=CHF/BETA
CHE=CHE/BETA
IF (NCALC .EQ. 0) GO TO 321
CALL PKL (CDF,PF)
CALL PKL (CDE,PE)
321 CONTINUE
COMPUTE VELOCITY INDUCED BY FAN DUCT BOUND VORTICITY
RF=CHF/CDF/2.0
DO 21 N=1,MMP
X(N)=X(N)/CHF
21 R(N)=R(N)/RF
CALL MMGAMD (CDF,CF,MMP,X,R,AU,AVR,PF)
22 DO 22 N=1,MMP
U(N)=U(N)+AU(N)
22 VR(N)=VR(N)+AVR(N)
COMPUTE VELOCITY INDUCED BY FAN DUCT TRAILING VORTICITY
XCYL=1.0
CALL MMGAMC (CDF,XCYL,MMP,X,R,AU,AVR)
223 DO 23 N=1,MMP
U(N)=U(N)+AU(N)*GVF
23 VR(N)=VR(N)+AVR(N)*GVF
COMPUTE VELOCITY INDUCED BY ALPHA AND BETA VORTICITY
CALL MMGAMA (CDF,MMP,X,R,AU,AVR,AVP,AVPT)
DO 27 N=1,MMP
CSPHI=COS(PHI(N)/RAD)
SNPHI=SIN(PHI(N)/RAD)
UA(N)=AU(N)*CSPHI
VRA(N)=(AVR(N)+AVRT(N))*CSPHI
VPA(N)=(AVP(N)+AVPT(N))*SNPHI
PHIP=PHI(N)-90.0
CSPHI=COS(PHIP/RAD)
SNPHI=SIN(PHIP/RAD)
UB(N)=AU(N)*CSPHI
VRB(N)=(AVR(N)+AVRT(N))*CSPHI
27 VPB(N)=(AVP(N)+AVPT(N))*SNPHI

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IF (ALPHF.EQ.0.0.AND.BETAF.EQ.0.0) GO TO 26
SNALPH=SIN(ALPHF/RAD)
SNBETA=SIN(BETAF/RAD)
DO 24 N=1,MMP
  U(N)=U(N) + UA(N)*SNALPH
  VR(N)=VR(N) + VRA(N)*SNALPH
  VP(N)=VP(N) + VPA(N)*SNALPH
  U(N)=U(N) + UB(N)*SNBETA
  VR(N)=VR(N) + VRB(N)*SNBETA
  VP(N)=VP(N) + VPB(N)*SNBETA
26 CONTINUE

C
C      COMPUTE VELOCITY INDUCED BY ENGINE DUCT BOUND VORTICITY
C
DO 31 J=1,MMP
  X(J)=X(J)-XECF
  X(J)=X(J)*CHF/CHF
31 R(J)=R(J)*RFRE
CALL MMGAMD (CDE,CE,MMP,X,R,AU,AVR,PE)
232 DO 32 J=1,MMP
  U(J)=U(J)+AU(J)
  VR(J)=VR(J)+AVR(J)
32

C
C      COMPUTE VELOCITY INDUCED BY ENGINE DUCT TRAILING VORTICITY
C
XCYL=1.0
CALL MMGAMC (CDE,XCYL,MMP,X,R,AU,AVR)
233 DO 33 J=1,MMP
  U(J)=U(J)+AU(J)*GVE
  VR(J)=VR(J)+AVR(J)*GVE
33

C
C      COMPUTE VELOCITY INDUCED BY ALPHA AND BETA VORTICITY
C
CALL MMGAMA (CDE,MMP,X,R,AU,AVR,AVP,AVRT,AVPT)
DO 37 J=1,MMP
  DMA=AU(J)
  DMB=AVR(J)+AVRT(J)
  DMC=AVP(J)+AVPT(J)
  CSPHI=COS(PHI(J)/RAD)
  SNPHI=SIN(PHI(J)/RAD)
  AU(J)=DMA*CSPHI
  AVR(J)=DMB*CSPHI
  AVP(J)=DMC*SNPHI
  PHIP=PHI(J)-90.0
  CSPHI=COS(PHIP/RAD)
  SNPHI=SIN(PHIP/RAD)
  BU(J)=DMA*SNPHI
  BVR(J)=DMB*SNPHI
  BVP(J)=DMC*CSPHI
37 IF (ALPHE.EQ.0.0.AND.BETAE.EQ.0.0) GO TO 36
SNALPH=SIN(ALPHE/RAD)
SNBETA=SIN(BETAE/RAD)
DO 34 J=1,MMP
  U(J)=U(J) + AU(J)*SNALPH
  VR(J)=VR(J) + AVR(J)*SNALPH
  VP(J)=VP(J) + AVP(J)*SNALPH
  U(J)=U(J) + BU(J)*SNBETA
  VR(J)=VR(J) + BVR(J)*SNBETA
  VP(J)=VP(J) + BVP(J)*SNBETA
34 CONTINUE
36 CONTINUE
IF (NPRNT.LE.0) GO TO 236

C
C      OUTPUT ENGINE INDUCED VELOCITIES IN ENGINE COORDINATE SYSTEM
C
NPAGE=NPAGE+1
WRITE (6,703) TITLE,NPAGE
WRITE (6,721) ALPHF,BETAF,ALPHE,BETAE
WRITE (6,730)
WRITE (6,713)
DO 936 J=1,MMP
936 WRITE (6,707) J,XW(J),YW(J),ZW(J),U(J),VR(J),VP(J)

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TF03 215
TF03 216

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C
C      OUTPUT ENGINE INDUCED VELOCITIES IN WING COORDINATE SYSTEM
C
236 NPAGE=NPAGE+1
WRITE (6,703) TITLE,NPAGE
WRITE (6,721) ALPHF,BETAF,ALPHE,BETAE
WRITE (6,731)
WRITE (6,714)
DO 937 J=1,MMP
  U(J)=U(J)
  PHIP=PHI(J)-90.0
  CSPHI=COS(PHIP/RAD)
  SNPHI=SIN(PHIP/RAD)
  V=VP(J)*SNPHI - VR(J)*CSPHI
  W=-VP(J)*CSPHI - VR(J)*SNPHI
  WRITE (6,707) J,XW(J),YW(J),ZW(J),U(J),V,W
937 CONTINUE
NPAGE=NPAGE+1
WRITE (6,703) TITLE,NPAGE
WRITE (6,715) ADALF,ADBTF,ADALE,ADBTE
238 CONTINUE
IF (ADALF.EQ.0.0.AND.ADBTF.EQ.0.0.AND.ADALE.EQ.0.0.AND.
1 ADBTE.EQ.0.0) GO TO 10
SNALF=SIN(ADALF/RAD)
SNBTF=SIN(ADBTF/RAD)
SNALE=SIN(ADALE/RAD)
SNBTE=SIN(ADBTE/RAD)
WRITE (6,731)
WRITE (6,714)
DO 40 J=1,MMP
  U(J)= UA(J)*SNALF + UB(J)*SNBTF + AU(J)*SNALE + BU(J)*SNBTE
  VR(J)= VRA(J)*SNALF + VRB(J)*SNBTF + AVR(J)*SNALE + BVR(J)*SNBTE
  VP(J)= VPA(J)*SNALF + VPB(J)*SNBTF + AVP(J)*SNALE + BVP(J)*SNBTE
  PHIP=PHI(J)-90.0
  CSPHI=COS(PHIP/RAD)
  SNPHI=SIN(PHIP/RAD)
  V=VP(J)*SNPHI - VR(J)*CSPHI
  W=-VP(J)*CSPHI - VR(J)*SNPHI
  U(J)=U(J)
C
C      OUTPUT INDUCED ADDITIONAL VELOCITIES IN WING COORDINATE SYSTEM
C
WRITE (6,707) J,XW(J),YW(J),ZW(J),U(J),V,W
40 CONTINUE
10 RETURN
END

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TF03 217
TF03 218
TF03 219
TF03 220
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TF03 262

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SUBROUTINE ELLIPS (AKSQ,TK,TE)
-- TABLE LOOK-UP OF ELLIPTIC INTEGRALS --
DIMENSION CKK(100),CK(100),CE(100)
COMMON MZZZ
CKK = ARGUMENT OF ELLIPTIC INTEGRALS
DATA CKK/0.00,.01,.02,.03,.04,.05,.06,.07,.08,.09,.10,.11,.12,.13,
1 .14,.15,.16,.17,.18,.19,.20,.21,.22,.23,.24,.25,.26,.27,
2 .28,.29,.30,.31,.32,.33,.34,.35,.36,.37,.38,.39,.40,.41,
3 .42,.43,.44,.45,.46,.47,.48,.49,.50,.51,.52,.53,.54,.55,
4 .56,.57,.58,.59,.60,.61,.62,.63,.64,.65,.66,.67,.68,.69,
5 .70,.71,.72,.73,.74,.75,.76,.77,.78,.79,.80,.81,.82,.83,
6 .84,.85,.86,.87,.88,.89,.90,.91,.92,.93,.94,.95,.96,.97,
7 .98,.99/
CK = COMPLETE ELLIPTIC INTEGRALS OF FIRST KIND
DATA CK/1.570796,1.574746,1.578740,1.582780,1.586868,1.591003,
1 1.595188,1.599423,1.603710,1.608049,1.612441,1.616889,
2 1.621393,1.625955,1.630576,1.635257,1.640000,1.644806,
3 1.649678,1.654617,1.659624,1.664701,1.669850,1.675073,
4 1.680373,1.685750,1.691208,1.696749,1.702374,1.708087,
5 1.713889,1.719785,1.725776,1.731865,1.738055,1.744351,
6 1.750754,1.757269,1.763898,1.770647,1.777519,1.784519,
7 1.791650,1.798918,1.806328,1.813884,1.821593,1.829460,
8 1.837491,1.845694,1.854075,1.862641,1.871400,1.880361,
9 1.889533,1.898925,1.908547,1.918410,1.928526,1.938908,
A 1.949568,1.960521,1.971783,1.983371,1.995303,2.007598,
B 2.020279,2.033369,2.046894,2.060882,2.075363,2.090373,
C 2.105948,2.122132,2.138970,2.156516,2.174827,2.193971,
D 2.214022,2.235068,2.257205,2.280549,2.305232,2.331409,
E 2.359264,2.389016,2.420933,2.455338,2.492635,2.533335,
F 2.578092,2.627773,2.683551,2.747073,2.820752,2.908337,
G 3.016112,3.155875,3.354141,3.695637/
CE = COMPLETE ELLIPTIC INTEGRALS OF SECOND KIND
DATA CE/1.570796,1.566862,1.562913,1.558948,1.554969,1.550973,
1 1.546963,1.542936,1.538893,1.534833,1.530758,1.526665,
2 1.522555,1.518428,1.514284,1.510122,1.505942,1.501743,
3 1.497526,1.493290,1.489035,1.484761,1.480466,1.476152,
4 1.471818,1.467462,1.463086,1.458688,1.454269,1.449827,

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5 1.445363,1.440876,1.436366,1.431832,1.427274,1.422691,
6 1.418083,1.413450,1.408791,1.404105,1.399392,1.394652,
7 1.389883,1.385086,1.380259,1.375402,1.370515,1.365596,
8 1.360645,1.355661,1.350644,1.345592,1.340505,1.335382,
9 1.330223,1.325024,1.319788,1.314511,1.309192,1.303832,
A 1.298428,1.292979,1.287484,1.281942,1.276350,1.270707,
B 1.265013,1.259263,1.253458,1.247595,1.241671,1.235684,
C 1.229632,1.223512,1.217321,1.211056,1.204714,1.198290,
D 1.191781,1.185183,1.178490,1.171697,1.164798,1.157787,
E 1.150656,1.143396,1.135998,1.128451,1.120742,1.112856,
F 1.104775,1.096478,1.087938,1.079121,1.069986,1.060474,
G 1.050502,1.039947,1.028595,1.015994/
IF (MZZZ) 73,30,3
3 IF(AKSQ=.99120,20,21
21 PARA=0.25*(1.0-AKSQ)
700 TEST = 1.00E-07
IF(PARA-TEST)701,702,702
701 PARA=TEST
702 ZLP=ALOG(4./PARA)
TK=ZLP*0.5*(1.+PARA)-PARA
TE=1.0+(ZLP*PARA)-PARA
GO TO 30
20 JA=100.0*AKSQ
JA=1+JA
IF(CKK(JA)-AKSQ)22,23,22
23 TK=CK(JA)
TE=CE(JA)
GO TO 30
22 CON=(AKSQ-CKK(JA))/(CKK(JA+1)-CKK(JA))
TK=CK(JA)+CON*(CK(JA+1)-CK(JA))
TE=CE(JA)+CON*(CE(JA+1)-CE(JA))
GO TO 30
73 IF(AKSQ=.011721,721,720
721 PARA=.25*AKSQ
GO TO 700
720 AKSQ=1.-AKSQ
GO TO 20
30 CONTINUE
RETURN
END

```



```

C SUBROUTINE PKL (CD,P) TF06 001
C SUBROUTINE TO COMPUTE P(K,L) COEFFICIENTS FROM BTZ COEFFICIENTS TF06 002
C REF. THERM TAR-TR 613 (PAGE 22) TF06 003
C REF. BTZ DA-91-508-EUC-393 (TABLE 8) TF06 004
C DIMENSION B(8*8),FNU(100),THETA(100),P(6*6),UI(100) TF06 005
C COMMON MZZZ TF06 006
C PI=3.1415926 TF06 007
C IF (MZZZ.EQ. 0) RETURN TF06 008
C M=31 TF06 009
C IF (CD.GT. 5*0) M=63 TF06 010
C DO 11 NUP=1,8 TF06 011
C DO 11 MUP=1,8 TF06 012
11 B(NUP,MUP)=0.0 TF06 013
C MP=M+1 TF06 014
C MPP=MP+1 TF06 015
C EMP=MP TF06 016
C DTH=PI/EMP TF06 017
C DO 12 L=1,MPP TF06 018
C NL=L-1 TF06 019
C EL=NL TF06 020
12 THETA(L)=EL*DTH TF06 021
C DO 20 NUP=1,7 TF06 022
C NU=NUP-1 TF06 023
C MUPI=NUP+1 TF06 024
C DO 20 MUP=MUPI,8 TF06 025
C MU=MUP-1 TF06 026
C EMU=MU TF06 027
C SIGN=(-1.0)**MU TF06 028
C IF (MU.EQ. NU) GO TO 20 TF06 029
C NDEX=MU+NU TF06 030
C MDEX=NDEX/2 TF06 031
C MDEX=2*MDEX TF06 032
C IF (MDEX.EQ. NDEX) GO TO 20 TF06 033
C FSIGN=(-1.0)**NU TF06 034
C MPF=MPP-1 TF06 035
C EMPF=MPF TF06 036
C ENU=NU TF06 037
C DO 120 I=1,MPP TF06 038
C THI=THETA(I) TF06 039
C TF06 040
C TF06 041
C TF06 042
C TF06 043
C TF06 044
C TF06 045
C TF06 046

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CSTHI=COS(THI) TF06 047
DO 220 K=1,MPP TF06 048
THK=THETA(K) TF06 049
UI(K)=0.0 TF06 050
ETA=CD*(COS(THK)-CSTHI) TF06 051
IF (ETA.EQ.0.0) GO TO 220 TF06 052
AK2=4.0/(ETA*ETA+4.0) TF06 053
AK=SQRT(AK2) TF06 054
AKP2=1.0-AK2 TF06 055
CALL ELLIPS (AK2,ZK,ZE) TF06 056
W=((1.0+AKP2)*ZE - (2.0*AKP2*ZK))/AK TF06 057
UI(K)=(W-1.0)/ETA TF06 058
220 CONTINUE TF06 059
C FNU(I)=(UI(1)+FSIGN*UI(MPP))/2.0 TF06 060
C DO 110 K=2,MPP TF06 061
C THK=THETA(K) TF06 062
110 FNU(I)=FNU(I)+UI(K)*COS(ENU*THK) TF06 063
120 FNU(I)=PI/EMPF*FNU(I) TF06 064
C B(NUP,MUP)=(FNU(1)+SIGN*FNU(MPP))/2.0 TF06 065
C DO 15 I=2,MP TF06 066
C THI=THETA(I) TF06 067
15 B(NUP,MUP)=B(NUP,MUP)+FNU(I)*COS(EMU*THI) TF06 068
C B(NUP,MUP)=2.0/EMPF*B(NUP,MUP) TF06 069
20 B(MUP,NUP)=-B(NUP,MUP) TF06 070
C COMPUTE P(K,L) COEFFICIENTS FROM B(NU,MU) COEFFICIENTS TF06 071
C DO 13 K=1,8 TF06 072
C B(K,1)=B(K,1)/2.0 TF06 073
13 B(1,K)=B(1,K)/2.0 TF06 074
C B(1,1)=B(1,1)/4.0 TF06 075
C DO 14 K=1,6 TF06 076
C P(K,1)=CD/PI*(-B(K,2)-2.*B(K,1)) TF06 077
C P(K,2)=CD/PI*(2.*B(K,3)-2.*B(K,1)*TF) TF06 078
C DO 14 L=3,6 TF06 079
C P(K,L)=CD/PI/2.0*(B(K,L+1)-B(K,L-1)) TF06 080
14 CONTINUE TF06 081
C DO 16 L=1,6 TF06 082
16 P(1,L)=-P(1,L) TF06 083
C RETURN TF06 084
C END TF06 085
C TF06 086
C TF06 087
C TF06 088
C TF06 089

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SUBROUTINE FOURCS (F,B,N,NOUT,NPRINT)
C
C SUB. FOURCS -- FOURIER COSINE SERIES DETERMINATION
C FROM RALSTON AND WILF -- MATH. METHODS FOR DIGITAL COMPUTERS
C CHAPT. 24 BY G. GOERTZEL
C
  DIMENSION F(50),FF(50),B(50)
  COMMON MZZZ
700 FORMAT (1H /)
701 FORMAT (4E15.7)
702 FORMAT(5X5HTHETA6X10HFOURIER FN6X11HORIGINAL FN4X12HFOURIER COEF/)
  PI=3.1415927
  IF(NOUT-N)10,10,11
11 NOUT=N
10 ZRO=0.
  ONE=1.0
  TWO=2.0
  IZRO=0
  IONE=1
  ITWO=2
  MPI=1.5707963
  NH=N
  NS=ITWO*(NH-IONE)
  FNS=NS
  FR=TWO/FNS
  PIN=PI*FR
  DO 201 I=1,NH
  CJ=I-IONE
  CSI=COS (PIN*CJ)
  CCSI=CSI+CSI
  CA=ZRO
  CB=ZRO
  DO 202 J=2,NS
  JK=NS-J+ITWO
  IF(JK-NH) 220,220,221
221 JK=ITWO*NH-JK
220 CC=F(JK)+CA*CCSI-CB
  CB=CA
  CA=CC
  FF(I)=FR*(F(I)+CA*CSI-CB)
  IF(I-IONE) 290,291,290
291 FF(I)=FF(I)/TWO
290 JN=NS-I-1+IONE
  IF(JN) 203,204,204
203 FF(I)=FF(I)/TWO
204 CONTINUE
201 CONTINUE
  IF (NPRINT-1)2,6,7
6 M=N
  GO TO 1
7 M=NOUT
1 CN=N
  WRITE (6,700)
  WRITE (6,702)
  DTH=PI/(CN-1.0)
  TH=-DTH
  DO 3 I=1,N
  TH=TH+DTH
  SUM=0.0
  DO 4 J=1,M
  CJ=J-1
4 SUM=SUM+ FF(J)*COS (CJ*TH)
3 WRITE (6,701) TH, SUM,F(I), FF(I)
2 DO 8 K=1,NOUT
8 B(K)=FF(K)
  RETURN
  END

```

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TF07 001
TF07 002
TF07 003
TF07 004
TF07 005
TF07 006
TF07 007
TF07 008
TF07 009
TF07 010
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TF07 012
TF07 013
TF07 014
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TF07 062
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TF07 065
TF07 066
TF07 067

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SUBROUTINE MATRIX (A,NR)
  DIMENSION A( 6, 7),B( 7, 7),N( 7)
  NC=NR+1
  DO 1 J=1,NR
1 N(J)=0
  DO 2 I=1,NR
  CON=0.0
  II=I-1
  DO 3 J=1,NR
  JJ=J-1
  IF (II) 4,4,5
5 DO 6 K=1,II
  IF (J-N(K)) 6,3,6
6 CONTINUE
4 CONA=A(J,1)
  IF (CONA) 8,9,9
8 CONA=-CONA
9 IF (CONA-CON) 3,3,11
11 CON=CONA
  N(I)=J
3 CONTINUE
  IF(CON) 500,600,500
600 WRITE (6,601) I
601 FORMAT(13H SINGULAR, I=I3)
  STOP
500 NN=N(I)
  DO 12 J=1,NR
12 A(J,NC)=0.0
  A(NN,NC)=1.0
  DIV=A(NN,1)
  DO 13 L=1,NC
13 A(NN,L)=A(NN,L)/DIV
  DO 14 L=1,NR
  IF (L-NN) 15,14,15
15 CMULT=A(L,1)
  DO 16 J=1,NC
16 A(L,J)=A(L,J)-CMULT*A(NN,J)
14 CONTINUE
  DO 17 L=1,NR
  DO 18 J=1,NR
18 A(L,J)=A(L,J+1)
17 CONTINUE
2 CONTINUE
  DO 19 J=1,NR
  DO 20 L=1,NR
  NN=N(J)
20 B(J,L)=A(NN,L)
19 CONTINUE
  DO 21 J=1,NR
  DO 22 L=1,NR
  NN=N(J)
22 A(L,NN)=B(L,J)
21 CONTINUE
  RETURN
  END

```

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TF08 001
TF08 002
TF08 003
TF08 004
TF08 005
TF08 006
TF08 007
TF08 008
TF08 009
TF08 010
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TF08 054
TF08 055

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SUBROUTINE BNGCOF (C,BGI)

FOURIER ANALYSIS OF RADIAL VELOCITY INDUCED BY AN
ACTUATOR DISK IN THE EXIT PLANE -- B(N)

DIMENSION BG(6,2),BGI(6),BGO(6)

COMMON MZZZ

PI=3.1415927

MZZZ=-10

N=100

KMAX=6

DO 10 K=1,KMAX

10 BGI(K)=0.0

EPS=PI/180.

PIM=PI-EPS

CN=N

DELTH=.5*PIM/CN

NP=N+1

DO 6 I=1,NP

DO 3 J=1,2

F1=I-2

FJ=J

TH=F1*PIM/CN+FJ*DELTH

STH=SIN (TH)

CTH=COS (TH)

72 XG=-.5*C*(1.+CTH)

73 XGSQ=XG*XG

GK SQ=XGSQ/(4.+XGSQ)

GK=SQRT (4./(4.+XGSQ))

CALL ELLIPS (GK SQ,ZKG,ZCG)

BGC=.5/PI*((GK-2./GK)*ZKG+2./GK*ZCG)

STHK=0.

CTHK=1.

DO 2 K=1,KMAX

BG(K,J)=BGC*CTHK

CON=STHK*CTH+CTHK*STH

CTHK=CTHK*CTH-STHK*STH

2 STHK=CON

3 CONTINUE

DO 5 K=1,KMAX

IF (I-1) 4,5,4

4 BGI(K)=BGI(K)+DELTH*(BG(K,1)+(BGO(K)+BG(K,1)+BG(K,2))/3.)

5 BGO(K)=BG(K,2)

6 CONTINUE

EXTRA=-EPS/PI*ALOG(4./EPS*SQRT (2./C1))

SI=-1

DO 7 K=1,KMAX

SI=-SI

7 BGI(K)=2.*(BGI(K)+SI*EXTRA)/PI

BGI(1)=.5*BGI(1)

MZZZ=1

RETURN

END

TF09 001

TF09 002

TF09 003

TF09 004

TF09 005

TF09 006

TF09 007

TF09 008

TF09 009

TF09 010

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TF09 049

TF09 050

TF09 051

TF09 052

TF09 053

SUBROUTINE BSCOE (CR,BS)

DIMENSION BS(6),F(50)

COMMON MZZZ

PI=3.1415926

N=50

CN=N

DTH=PI/(CN-1.0)

TH=-DTH

22 DO 30 J=1,N

TH=TH+DTH

CSTH=COS(TH)

XG=-0.5*CR*(1.0+CSTH)

GK SQ=XG*XG

GK SQ=4.0+GK SQ

GK SQ=4.0/GK SQ

CALL ELLIPS (GK SQ,ZK,ZE)

GK=SQRT(GK SQ)

30 F(J)=0.25*(GK*XG/4.0*ZK/PI)

CALL FOURCS (F,F,N,6,0)

DO 31 J=1,6

31 BS(J)=F(J)

RETURN

END

TF10 001

TF10 002

TF10 003

TF10 004

TF10 005

TF10 006

TF10 007

TF10 008

TF10 009

TF10 010

TF10 011

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SUBROUTINE BTCOEF (CRV,XGAMCV,RGAMRV,BT,BTS)
C
C   DIMENSION BT(6),BTS(6),F(50),G(50)
C
COMMON MZZZ
C
CR=CRV
XCYL=XGAMCV
RCYLR=RGAMRV
N=50
CN=N
PI=3.1415926
DTH=PI/(CN-1.0)
RAD=180./PI
RRA=1.0/RCYLR
RRAP=(RRA+1.0)**2
RRA4=4.0*RRA
RASQT=SQRT(RRA)
TH=-DTH
DO 48 J=1,N
TH=TH+DTH
CSTH=COS(TH)
XR=CR*(1.-CSTH)/2.
XG=XR-XCYL*CR
XG=XG*RRA
XGSQ=XG*XG
GK=SQRT(RRA4/(RRAP+XGSQ))
GK=SQRT(GK*SQ)
CALL ELLIPS (GK*SQ,ZK,ZE)
F(J)=((ZE-ZK)/GK + (GK*ZK/2.))/PI/RASQT
NDEX=0
SNB=((RRA-1.0)**2)+XGSQ
SNB=XG/SQRT(SNB)
BETA=ASIN(SNB)*RAD
ASK=ASIN(GK)*RAD
XG=XG*RCYLR
IF (BETA) 62,63,63
62 BETA=-BETA
NDEX=-1
63 CALL LAMRDA (ASK,BETA,HLMB)
IF (NDEX) 64,65,65
64 HLMB=-HLMB
NDEX=0
BETA=-BETA
65 CONTINUE
IF (XG) 71,72,73

```

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TF11 001
TF11 002
TF11 003
TF11 004
TF11 005
TF11 006
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TF11 008
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72 IF (RCYLR-1.0) 74,75,76
74 G(J)=0.0
GO TO 48
75 G(J)=-0.25
GO TO 48
76 G(J)=-0.50
GO TO 48
73 NDEX=-1
HLMB=-HLMB
XG=-XG
71 IF (RCYLR-1.0) 77,78,78
77 G(J)=-GK*XG*ZK*RASQT/(4.*PI)
G(J)=G(J) + (.25*HLMB)
GO TO 79
78 G(J)=-GK*XG*ZK*RASQT/(4.*PI)
G(J)=G(J)-.5-(.25*HLMB)
79 IF (NDEX) 80,48,48
80 XG=-XG
NDEX=0
IF (RCYLR-1.0) 81,82,83
81 G(J)=-G(J)
GO TO 48
82 G(J)=-G(J)-0.5
GO TO 48
83 G(J)=-G(J)-1.0
48 G(J)=-G(J)
CALL FOURCS (F,F,N,6,0)
CALL FOURCS (G,G,N,6,0)
DO 20 J=1,6
RT(J)=F(J)
20 BTS(J)=G(J)
RETURN
END

```

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TF11 047
TF11 048
TF11 049
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TF11 077
TF11 078
TF11 079

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C	SUBROUTINE FTCOEF (CDGAM,CDV,RVRGAM,CN,XCGAM,FT,FTS)	TF12 001	51 DO 60 J=K,3	TF12 073
		TF12 002	STP=SIN (TP)	TF12 074
	DIMENSION TH(105),GD(105),DI(3),DJ(3)	TF12 003	CTP=COS (TP)	TF12 075
	DIMENSION CN(6),FU(50),FV(50),FT(6),FTS(6)	TF12 004	XS=-0.5*CTP	TF12 076
C		TF12 005	XI=(XSP-XS)*CD*2.0	TF12 077
	COMMON MZZZ	TF12 006	X2=X1*X1	TF12 078
C		TF12 007	RR=R+1.0	TF12 079
700	FORMAT (//5X77HSUBROUTINE FTCOEF DOES NOT ALLOW THE INTERSECTION	TF12 008	RM=R-1.0	TF12 080
1F THE FAN AND ENGINE DUCTS//10X20HEXECUTION TERMINATED)	TF12 009	PP=X2+RR*RR	TF12 081	
	CD=CDGAM	TF12 010	PM=X2+RM*RM	TF12 082
	C0=CN(1)	TF12 011	RTPP=SQRT(PP)	TF12 083
	C1=CN(2)	TF12 012	AK2=4.*R/PP	TF12 084
	C2=CN(3)	TF12 013	CALL ELLIPS (AK2,ZK,ZE)	TF12 085
	C3=CN(4)	TF12 014	DUM=ZK-ZE-2.0*RM/PM*ZE	TF12 086
	C4=CN(5)	TF12 015	U=DUM/RTPP	TF12 087
	C5=CN(6)	TF12 016	DUM=ZK-ZE-2.0*R/PM*ZE	TF12 088
C		TF12 017	V=DUM*X1/R/RTPP	TF12 089
C	SET UP A TABLE OF GAMMA D/VZERO * SIN(THETA) VERSUS THETA	TF12 018	52 IF (TP-TH(NT))55,54,53	TF12 090
		TF12 019	53 NT=NT+1	TF12 091
	DG=100.	TF12 020	GO TO 52	TF12 092
	PI=3.1415926	TF12 021	54 G=GD(NT)	TF12 093
13	DT=PI/DG	TF12 022	GO TO 56	TF12 094
	N=DG	TF12 023	55 G=GD(NT-1)+(TP-TH(NT-1))*(GD(NT)-GD(NT-1))/(TH(NT)-TH(NT-1))	TF12 095
	NM=N	TF12 024	56 DI(J)=G*U	TF12 096
	N=N+1	TF12 025	DJ(J)=-G*V	TF12 097
	K=N+4	TF12 026	60 TP=TP+DTP	TF12 098
	DO 12 J=1,K	TF12 027	K=2	TF12 099
	TH(J)=0.	TF12 028	UI=UI+H*(DI(1)+4.*DI(2)+DI(3))	TF12 100
	ST=0.0	TF12 029	VI=VI+H*(DJ(1)+4.*DJ(2)+DJ(3))	TF12 101
12	GD(J)=0.	TF12 030	DI(1)=DI(3)	TF12 102
	DO 19 J=2,N	TF12 031	DJ(1)=DJ(3)	TF12 103
	TH(J)=TH(J-1)+DT	TF12 032	IF (TP-PI)51,51,61	TF12 104
120	T=TH(J)	TF12 033	61 FU(JX)=CD/2./PI*UI	TF12 105
	CT=COS (T/2.)	TF12 034	FV(JX)=CD/2./PI*VI	TF12 106
	CT=CT/SIN (T/2.)	TF12 035	UI=0.	TF12 107
	A=C0*CT	TF12 036	VI=0.	TF12 108
	ST=SIN (T)	TF12 037	TP=0.	TF12 109
	B=C1*ST	TF12 038	99 CONTINUE	TF12 110
	C=C2*SIN (2.*T)	TF12 039	CALL FOURCS (FV,FV,NF,6,0)	TF12 111
	D=C3*SIN (3.*T)	TF12 040	CALL FOURCS (FU,FU,NF,6,0)	TF12 112
	E=C4*SIN (4.*T)	TF12 041	DO 70 J=1,6	TF12 113
	F=C5*SIN (5.*T)	TF12 042	FT(J)=FV(J)	TF12 114
	GD(J)=A+B+C+D+E+F	TF12 043	70 FTS(J)=FU(J)	TF12 115
	GD(J)=GD(J)+ST	TF12 044	999 RETURN	TF12 116
19	CONTINUE	TF12 045	998 WRITE (6,700)	TF12 117
	TH(N+1)=PI+1.	TF12 046	STOP	TF12 118
	GD(N+1)=GD(N)	TF12 047	END	TF12 119
22	GD(1)=2.*C0	TF12 048		
	TH(1)=0.	TF12 049		
C		TF12 050		
C	COMPUTE INDUCED RADIAL AND AXIAL VELOCITIES	TF12 051		
C		TF12 052		
	NF=50	TF12 053		
	CNF=NF	TF12 054		
	DTF=PI/(CNF-1.)	TF12 055		
	DTI=100.	TF12 056		
	DTP=PI/DTI	TF12 057		
	H=DTP/3.	TF12 058		
	TF=-DTF	TF12 059		
	R=RVRGAM	TF12 060		
C		TF12 061		
	DO 99 JX=1,NF	TF12 062		
	TF=TF+DTF	TF12 063		
	UI=0.	TF12 064		
	VI=0.	TF12 065		
	TP=0.	TF12 066		
	XSCV=-0.5*COS(TF)	TF12 067		
	XCV=XSCV+0.5	TF12 068		
	XSP= XCGAM - 0.5 + XCV*CDV*RVRGAM/CDGAM	TF12 069		
	IF (XSP*GE.-0.5.AND.XSP*LT.0.5.AND.R*EQ.1.0) GO TO 998	TF12 070		
50	K=1	TF12 071		
	NT=1	TF12 072		

C	SUBROUTINE CNCOEF (C,CD,R,P,E,ES)	TF13 001			
		TF13 002		Q(2,5)=Q(2,5) - C4D*(R(3)/12.0)	TF13 047
C	DIMENSION C(6),R(4),P(6,6),E(6),ES(6),Q(6,7),RHS(6)	TF13 003		Q(2,6)=Q(2,6) - C4D*(R(4)/16.0)	TF13 048
C		TF13 004	C	Q(3,1)=Q(3,1) - C4D*(R(3)*CLN + (R(2)+R(4))/2.0)	TF13 049
	C4D=CD/4.0	TF13 005		Q(3,2)=Q(3,2) - C4D*(R(3)*CLN/2.0 - R(1)/4.0)	TF13 050
	CLN=ALOG(16.0/CD) - 1.0	TF13 006		Q(3,3)=Q(3,3) - C4D*((R(2)+R(4))/4.0 - R(2)/12.0)	TF13 051
C		TF13 007		Q(3,4)=Q(3,4) - C4D*(R(1)/4.0 - R(3)/16.0)	TF13 052
C	COMPUTE RIGHT HAND SIDE	TF13 008		Q(3,5)=Q(3,5) - C4D*(R(2)/12.0 - R(4)/20.0)	TF13 053
C		TF13 009		Q(3,6)=Q(3,6) - C4D*(R(3)/16.0)	TF13 054
	DO 10 N=1,6	TF13 010	C		TF13 055
10	RHS(N)=0.0	TF13 011		Q(4,1)=Q(4,1) - C4D*(R(4)*CLN + R(3)/2.0)	TF13 056
	DO 12 J=2,4	TF13 012		Q(4,2)=Q(4,2) - C4D*(R(4)*CLN/2.0 - R(2)/8.0)	TF13 057
	K=7-J	TF13 013		Q(4,3)=Q(4,3) - C4D*(R(3)/4.0 - R(1)/6.0)	TF13 058
	RHS(1)=RHS(1) + 0.5*R(J)*ES(J)	TF13 014		Q(4,4)=Q(4,4) - C4D*(R(2)/16.0)	TF13 059
	RHS(2)=RHS(2) + 0.5*R(J)*ES(J+1)	TF13 015		Q(4,5)=Q(4,5) - C4D*(R(1)/6.0 - R(3)/20.0)	TF13 060
12	RHS(6)=RHS(6) + 0.5*R(J)*ES(K)	TF13 016	C	Q(4,6)=Q(4,6) - C4D*(R(2)/16.0)	TF13 061
	RHS(1)=RHS(1) + R(1)*ES(1) - E(1)	TF13 017			TF13 062
	RHS(2)=RHS(2) + R(1)*ES(2) + R(2)*ES(1) + 0.5*R(3)*ES(2)	TF13 018		Q(5,1)=Q(5,1) - C4D*(R(4)/2.0)	TF13 063
	+ 0.5*R(4)*ES(3) - E(2)	TF13 019		Q(5,2)=Q(5,2) + C4D*(R(3)/8.0)	TF13 064
1	RHS(3)= R(1)*ES(3) + R(3)*ES(1) + 0.5*(R(2)*(ES(2)+ES(4)) + R(4)*	TF13 020		Q(5,3)=Q(5,3) + C4D*(R(2)/12.0 - R(4)/4.0)	TF13 065
1	(ES(2)+ES(6)) + R(3)*ES(5) - E(3)	TF13 021		Q(5,4)=Q(5,4) - C4D*(R(3)/8.0 - R(1)/8.0)	TF13 066
	RHS(4)= R(1)*ES(4) + R(4)*ES(1) + 0.5*(R(2)*(ES(3)+ES(5)) + R(3)*	TF13 022		Q(5,5)=Q(5,5) - C4D*(R(2)/12.0 - R(2)/20.0)	TF13 067
1	(ES(2)+ES(6)) - E(4)	TF13 023		Q(5,6)=Q(5,6) - C4D*(R(1)/8.0)	TF13 068
	RHS(5)= R(1)*ES(5) + 0.5*(R(2)*(ES(4)+ES(6)) + R(3)*ES(3) + R(4)*	TF13 024	C		TF13 069
1	ES(2)) - E(5)	TF13 025		Q(6,2)=Q(6,2) + C4D*(R(4)/8.0)	TF13 070
	RHS(6)= RHS(6) + R(1)*ES(6) -E(6)	TF13 026		Q(6,3)=Q(6,3) + C4D*(R(3)/12.0)	TF13 071
C		TF13 027		Q(6,4)=Q(6,4) - C4D*(R(4)/8.0 - R(2)/16.0)	TF13 072
C	COMPUTE COEFFICIENT MATRIX	TF13 028		Q(6,5)=Q(6,5) - C4D*(R(3)/12.0 - R(1)/10.0)	TF13 073
C		TF13 029		Q(6,6)=Q(6,6) - C4D*(R(2)/16.0)	TF13 074
	DO 15 J=1,6	TF13 030	C		TF13 075
	DO 15 K=1,6	TF13 031		CALL MATRIX (0,6)	TF13 076
15	Q(J,K)=P(J,K)/2.0	TF13 032	59	DO 60 J=1,6	TF13 077
	DO 16 K=1,6	TF13 033	60	C(J)=0.0	TF13 078
	J=K	TF13 034		DO 61 J=1,6	TF13 079
	Q(K,J)=Q(K,J)-0.5	TF13 035		DO 61 K=1,6	TF13 080
16	Q(1,K)=-Q(1,K)	TF13 036	61	C(J)=C(J) + Q(J,K)*RHS(K)	TF13 081
	Q(1,1)=Q(1,1) - C4D*(R(1)*CLN + R(2)/2.0)	TF13 037		RETURN	TF13 082
	Q(1,2)=Q(1,2) - C4D*(R(1)*CLN/2.0 - R(3)/8.0)	TF13 038		END	TF13 083
	Q(1,3)=Q(1,3) + C4D*(R(4)/12.0 - R(2)/4.0)	TF13 039			TF13 084
	Q(1,4)=Q(1,4) - C4D*(R(3)/8.0)	TF13 040			
	Q(1,5)=Q(1,5) - C4D*(R(4)/12.0)	TF13 041			
C		TF13 042			
	Q(2,1)=Q(2,1) - C4D*(R(2)*CLN + R(1) + R(3)/2.0)	TF13 043			
	Q(2,2)=Q(2,2) - C4D*(R(2)*CLN/2.0 - (R(2)+R(4))/8.0)	TF13 044			
	Q(2,3)=Q(2,3) - C4D*((R(1)+R(3)/2.0)/2.0 - R(3)/12.0)	TF13 045			
	Q(2,4)=Q(2,4) - C4D*((R(2)+R(4))/8.0 - R(4)/16.0)	TF13 046			

```

SUBROUTINE CAMBER (CD,TC,RP)
C
C SUBROUTINE TO COMPUTE INDUCED CAMBER COEFFICIENTS
C
C DIMENSION CDRAT(5),DCD(4,5),RP(4)
C
DATA CDRAT(0,0,0.25,0.50,0.75,1.0)/
DATA (DCD(1,J),J=1,5)/0.0,0.00149,0.00316,0.00505,0.00696/
DATA (DCD(2,J),J=1,5)/0.0,0.10897,0.22236,0.33414,0.43940/
DATA (DCD(3,J),J=1,5)/0.0,0.03558,0.07223,0.11022,0.14928/
DATA (DCD(4,J),J=1,5)/0.0,-0.00203,-0.00539,-0.00948,-0.01375/
C
DO 2 J=1,5
N=J
IF (CDRAT(J)-CD) 2,3,4
2 CONTINUE
4-N=1-
DEL=CDRAT(N)-CDRAT(M)
DIF=CD-CDRAT(M)
DELTA=DIF/DEL
DO 10 K=1,4
RP(K)=DCD(K,M) + DELTA*(DCD(K,N)-DCD(K,M))
10 CONTINUE
GO TO 20
3 M=N
DO 6 K=1,4
6 RP(K)=DCD(K,M)
20 DO 21 K=1,4
21 RP(K)=RP(K)*TC
RETURN
END

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TF14 001
TF14 002
TF14 003
TF14 004
TF14 005
TF14 006
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TF14 029
TF14 030
TF14 031

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SUBROUTINE ENGINE (EME,EMF,VEVZ,VFVZ,FRAT)
C
COMMON/MRMA/ EMZ,PZ,TZ,RZ,GAMMA,FNT,WAT2,BPR,PPF2,TFT2,PEP2,TET2
C
CONSTANTS
C
G=32.174
PZSL=2116.0
TZSL=519.0
RAIR=53.3
GAM1=GAMMA-1.0
GAM2=GAMMA/GAM1
GAM3=GAM1/2.0
GAM4=SQRT(GAM3)
PZP2=(1.0+GAM3*EMZ*EMZ)**(-GAM2)
TZT2=1.0/(1.0+GAM3*EMZ*EMZ)
DELTA=PZ/PZP2/PZSL
THETA=TZ/TZT2/TZSL
RTGGR=SQRT(GAMMA*G*RAIR)
AZ=RTGGR*SQRT(TZ)
VZ=AZ*EMZ
W=WAT2*DELTA/SQRT(THETA)
PZPF=PZP2/PPF2
PZPE=PZP2/PEP2
EMF=SQRT((1./PZPF)**(1./GAM2) - 1.0) /GAM4
EME=SQRT((1./PZPE)**(1./GAM2) - 1.0) /GAM4
TTF=TFT2/TZT2*TZ
TTE=TET2/TZT2*TZ
TFTTF=1./((1.0+GAM3*EMF*EMF)
TETTE=1./((1.0+GAM3*EME*EME)
TF=TFTTF*TTF
TE=TETTE*TTE
AF=RTGGR*SQRT(TF)
AE=RTGGR*SQRT(TE)
VF=EMF*AF
VE=EME*AE
FNF=W/G*BPR/(BPR+1.0)*(VF-VZ)
FNE=W/G/(BPR+1.0)*(VE-VZ)
FNTP=FNF+FNE
FRAT=FNF/FNTP
VEVZ=VE/VZ
VFVZ=VF/VZ
RETURN
END

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TF15 001
TF15 002
TF15 003
TF15 004
TF15 005
TF15 006
TF15 007
TF15 008
TF15 009
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TF15 044

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SUBROUTINE MMGAMD (CD,CN,IX,XP,RP,UG,VG,VP)
  VELOCITY INDUCED AT A FIELD POINT BY A DISTRIBUTION OF
  GAMMA-D VORTEX RINGS

  DIMENSION CN(6),UG(150),VG(150),XP(150),RP(150),GDG(150),P(6,6)
  DIMENSION TH(105),GD(105),DI(3),DJ(3),CST(5),CV(6),CU(6)

  COMMON MZZZ

  C0=CN(1)
  C1=CN(2)
  C2=CN(3)
  C3=CN(4)
  C4=CN(5)
  C5=CN(6)

  SET UP A TABLE OF GAMMA D/GAMMA * SIN(THETA) VERSUS THETA

  DG=100.
  PI=3.1415926
  DT=PI/DG
  N=DG
  NM=N
  N=N+1
  K=N+4
  DO 12 J=1,K
    TH(J)=0.
    ST=0.0
  12 GD(J)=0.
  DO 19 J=2,N
    TH(J)=TH(J-1)+DT
  19 T=TH(J)
  CT=COS (T/2.)
  CT=CT/SIN (T/2.)
  A=C0*CT
  ST=SIN (T)
  B=C1*ST
  C=C2*SIN (2.*T)
  D=C3*SIN (3.*T)
  E=C4*SIN (4.*T)
  F=C5*SIN (5.*T)
  GD(J)=A+B+C+D+E+F
  GD(J)=GD(J)*ST
  19 CONTINUE
  TH(N+1)=PI+1.
  GD(N+1)=GD(N)
  22 GD(1)=2.*C0
  TH(1)=0.

  COMPUTE COEFFICIENTS FOR VELOCITIES INDUCED ON REF. CYLINDER

  DO 210 J=1,6
    CU(J)=0.
    CV(J)=0.0
    DUM=0.0
  210 DO 211 L=1,6
    DUM=DUM + CN(L)*P(1,L)
    CV(1)=(CN(1)-DUM)/2.0
    DO 212 K=2,6
    DO 213 L=1,6
    213 CV(K)=CV(K) + CN(L)*P(K,L)
    212 CV(K)=(CV(K)-CN(K))/2.0

  CU(1)=(ALOG(16./CD)-1.0)*(CN(1)+CN(2)/2.0)
  CU(2)=CN(1)+CN(3)/2.0
  DO 214 J=3,5
    L=2*(J-1)
    DUM=L
  214 CU(J)=(CN(J+1)-CN(J-1))/DUM
  CU(6)=-CN(5)/10.0
  DO 215 J=1,6
    DI(J)=CU(J)*CD/4.
    DTI=100.
  31 DTP=PI/DTI
  H=DTP/3.

  DO 99 JX=1,IX

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TF16 001
TF16 002
TF16 003
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TF16 077

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GDG(JX)=0.0
XSP=XP(JX)-0.5
UI=0.
VI=0.
TP=0.
R=RP(JX)
IF (XSP,GE,-0.5,AND,XSP,LE,0.5,AND,R,EQ,1.0) GO TO 70
50 K=1
NT=1
51 DO 60 J=K,3
  STP=SIN (TP)
  CTP=COS (TP)
  XS=-0.5*CTP
  XI=(XSP-XS)*CD*2.0
  X2=XI*XI
  RR=R+1.0
  RM=R-1.0
  PP=X2+RR*RR
  PM=X2+RM*RM
  RTPP=SQRT(PP)
  AK2=4.*R/PP
  CALL ELLIPS (AK2,ZK,ZE)
  DUM=ZK-ZE-2.0*RM/PM*ZE
  U=DUM/RTPP
  DUM=ZK-ZE-2.0*R/PM*ZE
  V=DUM*XI/R/RTPP
52 IF (TP-TH(NT))55,54,53
53 NT=NT+1
GO TO 52
54 G=GD(NT)
GO TO 56
55 G=GD(NT-1)+(TP-TH(NT-1))*(GD(NT)-GD(NT-1))/(TH(NT)-TH(NT-1))
56 DI(J)=G*U
DJ(J)=-G*V
60 TP=TP+DTP
K=2
UI=UI+H*(DI(1)+4.*DI(2)+DI(3))
VI=VI+H*(DJ(1)+4.*DJ(2)+DJ(3))
DI(1)=DI(3)
DJ(1)=DJ(3)
IF (TP-PI)51,51,61
61 UG(JX) = CD/2./PI*UI
VG(JX) = CD/2./PI*VI
TP=0.
UI=0.
VI=0.
GO TO 69
70 CST(1)=-2.*XSP
CST(2)=2.*CST(1)*CST(1)-1.0
DO 71 J=3,5
71 CST(J)=2.*CST(J-1)*CST(1)-CST(J-2)
UI=CU(1)
VI=CV(1)
DO 72 J=1,5
  UI=UI+CU(J+1)*CST(J)
  VI=VI+CV(J+1)*CST(J)
72 UG(JX) = UI
VG(JX) = VI

  COMPUTE GAMMA-D/(2 GAMMA)

  CTN=SQRT((1.+CST(1))/2.)
  IF (CTN,GE,1.) GO TO 69
  CTN=CTN/SQRT(1.-CTN*CTN)
  GDGAM=CN(1)*CTN
  DUM=CST(1)
  CST(1)=SQRT(1.-CST(1)*CST(1))
  CST(2)=2.*CST(1)*DUM
  DO 74 J=3,5
  74 CST(J)=2.*CST(J-1)*DUM-CST(J-2)
  DO 73 J=2,6
  73 GDGAM=GDGAM+CN(J)*CST(J-1)
  GDG(JX)=GDGAM/2.
69 CONTINUE
99 CONTINUE
999 RETURN
END

```

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TF16 078
TF16 079
TF16 080
TF16 081
TF16 082
TF16 083
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TF16 152
TF16 153
TF16 154

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SUBROUTINE MMGAMC (CD,XC,NX,XP,RP,UG,VG)
      VELOCITIES INDUCED BY A CONSTANT STRENGTH VORTEX CYLINDER
      DIMENSION XP(150),RP(150),UG(150),VG(150)
      COMMON MZ
      PI=3.1415926
      RAD=180./PI
      RA=1.0
      CR=CD*2.
      DO 160 J=1,NX
        RRG=RP(J)/RA
        RGR=RA*RP(J)
        RGP2=(RA+RP(J))**2
        RGM2=(RP(J)-RA)**2
        RTRRG=SQRT(RRG)
        X=XP(J)
        XG=X-XC
        XGR=XG*CR
        XGR2=XGR*XGR
        GK5Q=4.*RGR/(XGR2+RGP2)
        GK=SQRT(GK5Q)
        CALL ELLIPS (GK5Q,ZK,ZE)
        IF (XGR) 38,42,38
      42 IF (RRG-1.0) 342,242,142
      142 U=0.0
        GO TO 59
      242 U=0.25
        GO TO 59
      342 U=0.50
        V=0.0
        IF (RRG) 60,60,59
      38 CONTINUE
        NDEX=0
        SNB=XGR/SQRT(XGR2+RGM2)
        BETA=ASIN(SNB)*RAD
        ASK=ASIN(GK)*RAD
        IF (BETA) 34,35,35
      34 BETA=-BETA
        NDEX=-1
      35 CALL LAMBDA (ASK,BETA,HLMB)
        IF (NDEX) 36,37,37
      36 HLMB=-HLMB

```

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TF17 001
TF17 002
TF17 003
TF17 004
TF17 005
TF17 006
TF17 007
TF17 008
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TF17 010
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TF17 012
TF17 013
TF17 014
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TF17 044
TF17 045
TF17 046

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```

      BETA=-BETA
      NDEX=0
      37 CONTINUE
        IF (XGR) 41,42,43
      43 NDEX=-1
        HLMB=-HLMB
        XGR=-XGR
      41 IF (RRG-1.0) 241,241,141
      141 U=XGR*ZK/(2.*PI)/SQRT(XGR2+RGP2) - .25*HLMB
        GO TO 45
      241 U=XGR*ZK/(2.*PI)/SQRT(XGR2+RGP2) + .5 + .25*HLMB
      45 IF (NDEX) 46,59,59
      46 XGR=-XGR
        NDEX=0
        HLMB=-HLMB
      47 IF (RRG-1.0) 347,247,147
      147 U=-U
        GO TO 59
      247 U=-U + .5
        GO TO 59
      347 U=-U + 1.0
      COMPUTE RADIAL VELOCITY
      59 V=(ZE-ZK)/GK + GK*ZK/2.
        V=V/PI/RTRRG
      60 UG(J) = U
        VG(J) = V
      160 CONTINUE
      99 RETURN
      END

```

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TF17 047
TF17 048
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TF17 076
TF17 077

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SUBROUTINE MMGAMA (CD,IX,XP,RP,UG,VG,WG,VGT,WGT)
  VELOCITY INDUCED BY A DISTRIBUTION OF ALPHA VORTEX RINGS
  AND ASSOCIATED TRAILING VORTEX FILAMENTS

  DIMENSION DU(3),DV(3),DVT(3),DW(3),DWT(3)
  DIMENSION TCD(7),TSC(6,7),TH(205),GA(205),SC(6),ST(6)
  DIMENSION XP(150),RP(150),UG(150),VG(150),WG(150),VGT(150),
  WGT(150),GD2(150)
1
  COMMON MZZZ

  DATA TCD/ 0.,0.5,0.75,1.0,1.5,2.0,5.0/
  DATA (TSC(I,1),I=1,6)/1.7,0.,0.,0.,0.,0./
  DATA (TSC(I,2),I=1,6)/1.0978,-0.2382,-0.0175,0.,0.,0./
  DATA (TSC(I,3),I=1,6)/0.92,-0.345,-0.042,0.,0.,0./
  DATA (TSC(I,4),I=1,6)/0.7955,-0.4151,-0.0680,0.,0.,0./
  DATA (TSC(I,5),I=1,6)/0.5611,-0.4834,-0.1230,-0.0121,0.,0./
  DATA (TSC(I,6),I=1,6)/0.5640,-0.5045,-0.1666,-0.0317,0.0035,0./
  DATA (TSC(I,7),I=1,6)/0.3566,-0.4590,-0.2607,-0.1246,-0.0494,0./

1 CONTINUE

  COMPUTE SC(N) COEFFICIENTS

  DO 11 J=1,7
    JSC=J
    IF (CD-TCD(J)) 4,3,11
11 CONTINUE
  3 DO 5 N=1,6
    SC(N)=TSC(N,JSC)
    GO TO 10
  4 IF (JSC-1) 6,6,7
  6 RETURN
  7 DELSC=(TCD(JSC)-TCD(JSC-1))/(TCD(JSC)-CD)
  J=JSC
  DO 8 N=1,6
    SC(N)=(TSC(N,J-1)-TSC(N,J))/DELSC + TSC(N,J)
  8

  SET UP A TABLE OF GAMMA ALPHA/V*SIN(THETA) VERSUS THETA

10 PI=3.1415926
  RAD=57.2957795
  DG=100.
  DT=PI/DG
  DK=DG+1.0
  K=DK
  DO 12 J=1,K
    TH(J)=0.0
12 GA(J)=0.0
  DO 20 J=2,K
    TH(J)=TH(J-1)+DT
    T=TH(J)
    CTN=COS(T/2.)/SIN(T/2.)
    CT=COS(T)
    ST(1)=SIN(T)
    ST(2)=2.*ST(1)*CT
  DO 13 N=3,5
    NM=N-1
    NMM=N-2
13 ST(N)=2.*ST(NM)*CT-ST(NMM)
    GA(J)=SC(1)*CTN
  DO 14 N=2,6
14 GA(J)=GA(J)+SC(N)*ST(N-1)
    GA(J)=GA(J)*ST(1)
20 CONTINUE
  GA(1)=2.*SC(1)
  TH(K+1)=PI+1.
  GA(K+1)=GA(K)

  2 CONTINUE
  DTI=100.

```

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TF18 001
TF18 002
TF18 003
TF18 004
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TF18 072

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DTP=PI/DTI
H=DTP/3.
70 DO 99 JX=1,IX
  TP=0.
  UU=0.
  UI=0.
  VI=0.
  VIT=0.
  WI=0.
  WIT=0.
  X=XP(JX)
  XS=X-.5
  CST=-2.*XS
  R=RP(JX)
  R32=R**1.5
  RP2=(R+1.)*.5
  K=1
  NT=1
77 DO 71 J=K,3
  CTP=COS(TP)
  XI=(CTP-CST)*CD
  X2=XI*X1
  DEN=X2+RP2
  AK2=4.*R/DEN
  CALL ELLIPS (AK2,ZK,ZE)
  AK=SQRT(AK2)
  AKZ=4.*R/RP2
  SBETA=SQRT((1.-AKZ)/(1.-AK2))
  BETA=ASIN(SBETA)*RAD
  ASK=ASIN(AK)*RAD

  CALL LAMBDA (ASK,BETA,HLMB)

  AU=2.*(1.-R)*ZE/(1.-AK2) + 4.*(1.-4.*R/AK2)*ZE/AK2
  AU=AU + 4.*(4.*R-AK2*(1.+2.*R))*ZK/AK2/AK2
  AU=AU/2./PI/(DEN**1.5)
  EPSP=1.
  EPSR=1.
  IF (R-1.) 41,43,42
42 EPSR=1./R/R
  EPSP=-EPSR
  GO TO 41
43 EPSP=0.0
  IF (X.LT.0.0.OR.X.GT.1.0) GO TO 41
  AV=0.0
  GO TO 141
41 CONTINUE
  AV=AK2*AK*ZE/(1.-AK2) + 8.*ZE/AK - 4.*(2.-AK2)*ZK/AK
  AV=AV*X1/(8.*PI*R32)
141 AVT=4.*(ZK-ZE)/AK+2.*PI*AK/SQRT(AK2)*(1.-HLMB)*SQRT((1.-AKZ)/(AKZ
  -AK2))
  AVT=AVT*X1/(8.*PI*R32) + EPSR/4.
  AW=(8.*ZE/AK-4.*ZK/AK*(2.-AK2))*X1/(8.*PI*R32)
  AWT=AK*AK2*ZK*(1.+R)-4./AK*(ZK-ZE)+PI*AK*AKZ*(1.-(R**4))/8./((R*R)*
  (1.-HLMB)/SQRT((AKZ-AK2)*(1.-AKZ)))
  AWT=AWT*X1/(8.*PI*R32)
  AWT=-EPSP/4.-AWT
72 IF (TP-TH(NT)) 75,74,73
73 NT=NT+1
  GO TO 72
74 G=GA(NT)
  GO TO 76
75 G=GA(NT-1)+(TP-TH(NT-1))*(GA(NT)-GA(NT-1))/(TH(NT)-TH(NT-1))
76 DU(J)=G*AU
  DV(J)=G*AV
  DW(J)=G*AW
  DVT(J)=G*AVT
  DWT(J)=G*AWT
71 TP=TP+DTP
  K=2
  VI=VI+H*(DV(1)+4.*DV(2)+DV(3))

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      UI=UI+H*(DU(1)+4.*DU(2)+DU(3))
      WI=WI+H*(DW(1)+4.*DW(2)+DW(3))
      VIT=VIT+H*(DVT(1)+4.*DVT(2)+DVT(3))
      WIT=WIT+H*(DWT(1)+4.*DWT(2)+DWT(3))
      DU(1)=DU(3)
      DV(1)=DV(3)
      DW(1)=DW(3)
      DVT(1)=DVT(3)
      DWT(1)=DWT(3)
      IF (TP-PI) 77,77,78
78  UG(JX) = CD*UI
      VG(JX) = CD*VI
      WG(JX) = CD*WI
      VGT(JX) = CD*VIT
      WGT(JX) = CD*WIT
      IF (AV.EQ.0.) VG(JX) = 1.0-VGT(JX)
      TP=0.0
      UI=0.0
      VI=0.0
      VIT=0.0
      WI=0.0
      WIT=0.0
99  CONTINUE
C
C      COMPUTE GAMMA=A/( 2*V*COS(PHI)*SIN(ALPHA) )
C
      DO 55 M=1,IX
      GD2(M)=0.0
      IF (XP(M).LE.0.0.OR.XP(M).GT.1.0) GO TO 55
      CST=-2.*(XP(M)-.5)
      ST(1)=SQRT(1.-CST*CST)
      CTN=SQRT((1.+CST)/2.)
      CTN=CTN/SQRT(1.-CTN*CTN)
      ST(2)=2.*ST(1)*CST
      DO 54 K=3,5
84  ST(K)=2.*ST(K-1)*CST-ST(K-2)
      GDA=SC(1)*CTN
      DO 53 L=1,5
93  GDA=GDA+SC(L+1)*ST(L)
      GD2(M)=GDA/2.
      55 CONTINUE
999 RETURN
      END

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TF18 145
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LIFT FAN PROGRAM

The purpose of the lift-fan program is to calculate the induced velocity field due to the presence of a lift fan exhausting into a crossflow. The model is that of a lift fan alone in the presence of a uniform stream, and is thus most applicable to fuselage mounted lift fans such as those described in reference 12. A schematic of a typical configuration showing coordinate systems and sign conventions is shown in figure 6.

Theoretical Analysis

Lift-fan model.- The lift-fan model on which the program is based is the same as that described in reference 1. The lift fan is replaced with a uniformly loaded actuator disk. The known solution for an actuator disk with no crossflow is a straight vortex cylinder trailing from the fan (ref. 8). Since the wake is bent due to the action of the free stream, it is assumed that the strength of the trailing vorticity can be determined as if the wake were straight. This vorticity is then superimposed on a circular cylinder lying along a curved path.

A model of a jet exhausting into a crossflow should include effects of entrainment of the free stream and the blockage effect of the wake (ref. 13). In reference 13, a distribution of sinks is placed on the jet centerline to represent the entrainment of the free stream. The blockage effect is calculated by assuming that the jet behaves locally as a solid cylinder with an elliptical cross section. Also, assuming that the flow past an elliptic cylinder can be reduced to the flow past an equivalent cylinder, a doublet distribution is used to represent the blockage effect of the jet. The entire set of equations to predict the velocity induced by each component of the lift-fan model is presented below.

The velocity induced by a curved vortex cylinder is determined by breaking the curved cylinder into many straight segments, each of which is then represented by a vortex ring. The jet-induced velocity is obtained by summing the velocities induced by each vortex ring. The number of segments used depends on the rapidity of the convergence of the induced velocities.

The incremental velocities induced by a single element of the vortex cylinder are

$$d\left(\frac{u_c}{V_j}\right) = \left\{ K - E - \frac{2\left(\frac{r_p}{R} - 1\right)E}{\left(\frac{\xi}{R}\right)^2 + \left(\frac{r_p}{R} - 1\right)^2} \right\} \frac{\frac{\gamma}{V_j} d\left(\frac{s}{d}\right)}{\pi \left[\left(\frac{\xi}{R}\right)^2 + \left(\frac{r_p}{R} + 1\right)^2 \right]^{1/2}} \quad (66)$$

and

$$d\left(\frac{v_c}{V_j}\right) = \left\{ K - E - \frac{2\left(\frac{r_p}{R}\right)E}{\left(\frac{\xi}{R}\right)^2 + \left(\frac{r_p}{R} - 1\right)^2} \right\} \frac{\left(-\frac{\gamma}{V_j} \frac{\xi}{R}\right) d\left(\frac{s}{d}\right)}{\pi \left(\frac{r_p}{R}\right) \left[\left(\frac{\xi}{R}\right)^2 + \left(\frac{r_p}{R} + 1\right)^2 \right]^{1/2}} \quad (67)$$

where

$$r_p = \sqrt{\eta^2 + \zeta^2} \quad (68)$$

and K and E are complete elliptic integrals with argument

$$k^2 = \frac{4\left(\frac{r_p}{R}\right)}{\left(\frac{\xi}{R}\right)^2 + \left(\frac{r_p}{R} + 1\right)^2} \quad (69)$$

These velocities are referenced to the ξ, η, ζ coordinate system defined in figure 7. The coordinate transformations are

$$\left. \begin{aligned} \xi &= (x_p - x_s) \sin \theta + (z_p - z_s) \cos \theta \\ \eta &= -y_p \\ \zeta &= (x_p - x_s) \cos \theta - (z_p - z_s) \sin \theta \end{aligned} \right\} \quad (70)$$

The velocity transformations to the x, y, z coordinate system are:

$$d\left(\frac{u}{V_j}\right) = d\left(\frac{u_c}{V_j}\right) \sin \theta + d\left(\frac{v_c}{V_j}\right) \frac{\zeta}{r_p} \cos \theta \quad (71)$$

$$d \left(\frac{v}{v_j} \right) = - \frac{\eta}{r_p} d \left(\frac{v_c}{v_j} \right) \quad (72)$$

$$d \left(\frac{w}{v_j} \right) = d \left(\frac{u_c}{v_j} \right) \cos \theta - d \left(\frac{v_c}{v_j} \right) \frac{z}{r_p} \sin \theta \quad (73)$$

The velocity field induced by the sink distribution is obtained from reference 13. The incremental velocities are given as follows, where the prime denotes quantities nondimensionalized by the initial wake diameter, d_o .

$$d \left(\frac{u_s}{v_j} \right) = \frac{-\bar{m}}{4\pi V_j d_o} \frac{(x' - x'_p)}{(z' - z'_p)^2 + (x' - x'_p)^2} \times \left\{ \begin{aligned} & \frac{y'_p - \frac{1}{2} d'}{\left[(z' - z'_p)^2 + (x' - x'_p)^2 + \left(y'_p - \frac{1}{2} d' \right)^2 \right]^{1/2}} \\ & - \frac{y'_p + \frac{1}{2} d'}{\left[(z' - z'_p)^2 + (x' - x'_p)^2 + \left(y'_p + \frac{1}{2} d' \right)^2 \right]^{1/2}} \end{aligned} \right\} \quad (74)$$

$$d \left(\frac{v_s}{v_j} \right) = \frac{-\bar{m}}{4\pi V_j d_o} \left\{ \begin{aligned} & \frac{1}{\left[(z' - z'_p)^2 + (x' - x'_p)^2 + \left(y'_p - \frac{1}{2} d' \right)^2 \right]^{1/2}} \\ & - \frac{1}{\left[(z' - z'_p)^2 + (x' - x'_p)^2 + \left(y'_p + \frac{1}{2} d' \right)^2 \right]^{1/2}} \end{aligned} \right\} \quad (75)$$

$$d \left(\frac{w_s}{v_j} \right) = \frac{-\bar{m}}{4\pi V_j d_o} \frac{z' - z'_p}{\left[(z' - z'_p)^2 + (x' - x'_p)^2 \right]}$$

(continued on next page)

$$\times \left\{ \frac{y'_p - \frac{1}{2} d'}{\left[\left(z' - z'_p \right)^2 + \left(x' - x'_p \right)^2 + \left(y'_p - \frac{1}{2} d' \right)^2 \right]^{1/2}} - \frac{y'_p + \frac{1}{2} d'}{\left[\left(z' - z'_p \right)^2 + \left(x' - x'_p \right)^2 + \left(y'_p + \frac{1}{2} d' \right)^2 \right]^{1/2}} \right\} \quad (76)$$

where

$$\frac{\bar{m}}{V_j d_o} = \left[E_1 \frac{V}{V_j} \cos \theta + \frac{E_2 \frac{C}{d}}{1 + E_3 \frac{V}{V_j} \cos \theta} \left(1 - \frac{V}{V_j} \sin \theta \right) \right] ds' \quad (77)$$

The E_1 , E_2 , and E_3 are empirical constants evaluated in reference 13 from data correlations and have the values

$$\left. \begin{aligned} E_1 &= 0.35 \\ E_2 &= 0.08 \\ E_3 &= 30.0 \end{aligned} \right\} \quad (78)$$

Other variables in the above equations are a function of the geometry of the jet, which is considered in two regions. The first region is from the jet exit with a circular cross section to some point down-stream where the cross section is a 1:4 ellipse. Therefore, in the first region,

$$0 \leq \left(z' \frac{V}{V_j} \right) \leq 0.3 \quad (79)$$

$$\frac{r_o}{d} = 1 - \frac{5}{2} z' \left(\frac{V}{V_j} \right) \quad (80)$$

$$\frac{c}{d} = \pi \left[\frac{1 + \left(1 - \frac{5}{2} z' \frac{v}{v_j}\right)^2}{2} \right]^{1/2} \quad (81)$$

In the second region the jet retains a similar elliptical cross section; therefore,

$$\left(z' \frac{v}{v_j}\right) > 0.3 \quad (82)$$

$$\frac{d_o}{d} = \frac{1}{4} \quad (83)$$

$$\frac{c}{d} = 2.24 \quad (84)$$

The velocity components induced by the doublet distribution are

$$d \left(\frac{u_1}{v_j} \right) = \left(-\frac{3}{8} K_D \right) \frac{\frac{v}{v_j} \xi' \zeta' (d')^2 \cos \theta}{\left[(\xi')^2 + (\eta')^2 + (\zeta')^2 \right]^{5/2}} ds' \quad (85)$$

$$d \left(\frac{v_1}{v_j} \right) = \left(-\frac{3}{8} K_D \right) \frac{\frac{v}{v_j} \zeta' \eta' (d')^2 \cos \theta}{\left[(\xi')^2 + (\eta')^2 + (\zeta')^2 \right]^{5/2}} ds' \quad (86)$$

$$d \left(\frac{w_1}{v_j} \right) = \frac{K_D}{8} \frac{\frac{v}{v_j} (d')^2 \cos \theta}{\left[(\xi')^2 + (\eta')^2 + (\zeta')^2 \right]^{3/2}} \left[1 - \frac{3 (\zeta')^2}{(\xi')^2 + (\eta')^2 + (\zeta')^2} \right] ds' \quad (87)$$

where K_D must be evaluated in the two regions of the jet.

$$K_D = 1 - \frac{5}{4} \left(z' \frac{v}{v_j} \right) \text{ when } 0 \leq \left(z' \frac{v}{v_j} \right) \leq 0.3 \quad (88)$$

and

$$K_D = \frac{5}{8} \text{ when } \left(z' \frac{v}{v_j} \right) > 0.3 \quad (89)$$

These velocities are relative to the local doublets; therefore, they must be transformed to the free-stream coordinate system as follows.

$$d \left(\frac{u_D}{V_j} \right) = d \left(\frac{u_1}{V_j} \right) \sin \theta + d \left(\frac{w_1}{V_j} \right) \cos \theta \quad (90)$$

$$d \left(\frac{v_D}{V_j} \right) = d \left(\frac{v_1}{V_j} \right) \quad (91)$$

$$d \left(\frac{w_D}{V_j} \right) = d \left(\frac{u_1}{V_j} \right) \cos \theta - d \left(\frac{w_1}{V_j} \right) \sin \theta \quad (92)$$

The total velocity induced by the lift-fan model is given by the sum of equations (71), (72), (73), (74), (75), (76), (90), (91), and (92).

Jet path.— The above jet wake model assumes the path of the jet centerline to be known a priori. Several different methods for computing the path of the centerline of the jet are available. The computer program offers an option of selecting either of two of these methods. The first, developed by Wooler (ref. 14), is based on a jet issuing perpendicular ($\delta_j = 90^\circ$) to the free stream. The centerline of the jet is described as

$$\frac{x}{d} = \sqrt{7} \left(\frac{V}{V_j} \frac{z}{d_o} \right)^{5/2} \quad (93)$$

and the distance along the path can be obtained as follows:

$$\frac{s}{d_o} = \int_0^{z/d_o} \left[1 + \frac{175}{4} \left(\frac{V}{V_j} \right)^5 \left(\frac{z}{d_o} \right)^3 \right]^{1/2} d \left(\frac{z}{d_o} \right) \quad (94)$$

The local angle of the centerline of the jet is

$$\tan \theta = \frac{5}{2} \sqrt{7} \left(\frac{V}{V_j} \right)^{5/2} \left(\frac{z}{d_o} \right)^{3/2} \quad (95)$$

The second method, developed by Margason (ref. 15), is applicable to a jet entering the crossflow over a range of angles ($\delta_j \neq 90^\circ$). The centerline is described by the following.

$$\frac{x}{d_o} = \frac{1}{4 \sin^2 \delta_j} \left(\frac{V}{V_j} \right)^2 \left(\frac{z}{d_o} \right)^3 + \frac{z}{d_o} \cot \delta_j \quad (96)$$

$$\tan \theta = \frac{3}{4 \sin^2 \delta_j} \left(\frac{V}{V_j} \right)^2 \left(\frac{z}{d_o} \right)^2 + \cot \delta_j \quad (97)$$

$$\frac{s}{d_o} = \int_0^{z/d_o} \left\{ 1 + \left[\frac{3}{4 \sin^2 \delta_j} \left(\frac{V}{V_j} \right)^2 \left(\frac{z}{d_o} \right)^2 + \cot \delta_j \right]^2 \right\}^{1/2} d \left(\frac{z}{d_o} \right) \quad (98)$$

These two methods can be compared for $\delta_j = 90^\circ$ for any V/V_j ratio. The results indicate considerable disagreement between the methods. This is not unexpected as there is much scatter in measured results on which the empirical centerline equations are based (ref. 15). If $\delta_j = 90^\circ$, the authors suggest that Wooller's method be used to compute the path taken by the jet because the entrainment and blockage effects are obtained from an analysis by Wooller. If the program user has some a priori knowledge of the jet centerline path, he should either use the method which most correctly represents the known path, or input the known path parameters directly. This latter option is discussed in more detail in the section describing preparation of input.

Program Description

Calculation procedure.— The computation proceeds as follows. Immediately upon input and initialization, the program computes the path of the jet centerline by either Wooller's method or Margason's method, or there is the option of reading in a different centerline path. The next step is to calculate the velocity components induced at the field points of interest by the sink and doublet distributions. These velocity components are computed by integrating over a specified number of jet diameters along the centerline path. Whether or not these individual components are printed is optional.

Inclusion of the curved vortex cylinder is optional. If it is included, the program computes the velocity components induced by the vortex cylinder at the field points.

The total induced velocity at each field point is computed by summing the above velocity components, and then the total velocity field induced by a single lift fan is output.

The program is capable of considering a second lift fan at this time although no interference between the two fan wakes is considered. The above procedure is repeated for the second fan and the total velocity induced by the pair of fans is output.

After the final output, the program returns to the beginning to read in another case.

Program use.— The program is written in Fortran IV for the IBM 7094 computer. No tapes other than the standard input and output tapes are required. Typical execution times are approximately 0.5 minutes for a case with one lift fan and 12 field points. A complete description of the input and output is presented in the following sections.

Description of Input

This section contains a description of the input for the lift-fan computer program. A sample input form is presented in figure 8. The input for a normal run is made up of a deck of $3 + NP$ cards as shown in figure 8(a). The first card is identification information to be printed at the top of the output. The second card contains information on the jet velocity, angle, size, and the location of the fan with respect to the wing coordinate system. The quantities called for in figure 8(a) are defined on the following pages. The second card also contains the location of a second jet in the wing coordinate system. If this second jet is included, its V/V_j , δ_j , and d_o are assumed to be the same as those of the first jet. If the second jet is not included, the last three quantities on card 2 may be left blank.

The third card contains additional information on the number of field points to be considered, the jet path description to be used, the number of fans, an optional output code, and several values which control the integration along the jet path. These latter values are defined in the following table and comments on selecting magnitudes of the values are given following the table.

The fourth and following cards, NP in number, are coordinates of the field points at which velocities are to be computed in the wing

coordinate system. If no wing is present, the "wing" coordinate system can be made to coincide with the jet coordinate system by specifying that XQ, YZ, and ZQ in card 1 are zero. It should be noted that the jet flow models were developed to permit prediction of wake-induced velocities adjacent to the wake; consequently, the model does not predict realistic velocity profiles within the wake and, in fact, there is a singularity at the wake center. Therefore, the field point location would generally lie outside the wake.

One program option (NPATH < 0) offers the ability to input a table of variables defining the path of the jet centerline. The set of cards described in figure 8(b) must be added in order to use this option. The number of points in the table is determined by the magnitude of NPATH ($NPS = |NPATH| < 40$). The next set of cards (item no. 5) is the location of the tabular points along the path in a jet coordinate system (fig. 7). With a maximum of eight points per card, there may be a total of five cards for this variable. Items 6 and 7 are the x/d_o and z/d_o coordinates respectively of the points defining the centerline path. The last item of input is the angle of the centerline, θ , at the specified points. Note that the angle θ is measured from the vertical. A sample set of input illustrating the various options is presented later.

The input program variables are defined as follows:

<u>Program Variable</u>	<u>Algebraic Symbol (if applicable)</u>	<u>Comments</u>
VVJ	V/V_j	jet velocity ratio, $V/V_j \neq 0$
DEL TJ	δ_j	jet exit angle measured from the horizontal, $\delta_j \neq 0^\circ$
D	d_o	jet exit diameter, ft.
XQ	X_Q	X-coordinate of center of first jet exit in wing coordinate system, ft.
YQ	Y_Q	Y-coordinate of center of first jet exit in wing coordinate system, ft.
ZQ	Z_Q	Z-coordinate of center of first jet exit in wing coordinate system, ft.
XQ2	X_Q	X-coordinate of center of second jet exit in wing coordinate system, ft.

(Input program variables cont.)

<u>Program Variable</u>	<u>Algebraic Symbol (if applicable)</u>	<u>Comments</u>
YQ2	Y_Q	Y-coordinate of center of second jet exit in wing coordinate system, ft.
ZQ2	Z_Q	Z-coordinate of center of second jet exit in wing coordinate system, ft.
NP		number of field points ($0 < NP \leq 200$), if $NP = 0$, no induced velocities are computed
NPATH		index defining type of centerline path = 1 Wooler's path = 2 Margason's path < 0 input table of path variables where NPATH = number of points in table ≤ 40
NFAN		number of fans ($NFAN \leq 2$)
NPRNT		index controlling optional output = 0 for normal output = 1 for expanded output
DZD	$d(z/d_o)$	integration interval for centerline path calculation
DS	$d(s/d_o)$	integration interval for sink-doublet calculation
DSV	$d(s/d_o)$	integration interval for curved vortex cylinder calculation
ENDS	$(s/d_o)_{end}$	length of jet wake for integration purposes. If $(s/d) = 0$, only the jet centerline coordinates are computed and output
CYL		index to determine presence of curved vortex cylinder = 0.0 no vortex cylinder = 1.0 curved vortex cylinder included in wake model
XW(J)	X_w	X-coordinate of field point in wing coordinate system, ft.
YW(J)	Y_w	Y-coordinate of field point in wing coordinate system, ft.

(Input program variables cont.)

<u>Program Variable</u>	<u>Algebraic Symbol (if applicable)</u>	<u>Comments</u>
ZW(J)	Z_w	Z-coordinate of field point in wing coordinate system, ft.
SD(J)	s/d_o	distance along centerline path in number of jet diameters
XD(J)	X/d_o	X-coordinate of centerline points in jet coordinate system
ZD(J)	Z/d_o	Z-coordinate of centerline points in jet coordinate system
THETA(J)	θ	angle of path at points defining jet path ($\tan \theta = dx/dz$), degrees

Samples of input decks are shown in figure 9 illustrating all of the discussed options. The first input deck shown is for a case with one lift fan where the fan wake at the exit is normal to the free stream. The path is to be computed using Wooler's method and the induced velocity field is to be computed at the specified field points. The complete set of output is required. The second set of cards illustrates the input for computing only the centerline path of a fan wake in an initial exit angle of 60° . Margason's method of calculation is specified, and no induced velocity field is requested. The last set of input is for two lift fans. The centerline path is specified and the complete velocity field is to be computed. No optional output is required for this case.

Limitations of Input

There are certain limits placed on some of the input variables. The jet velocity ratio should not equal zero because parts of the output are normalized on the free-stream velocity. The jet exit angle must be greater than zero; however, it may be greater than 90° . Margason's method (ref. 15) is always used for the centerline path if $\delta_j \neq 90^\circ$.

A consistent set of units must be used for the fan diameter, location, and field points since these variables have dimensions. When a table of centerline path variables is to be input, the index NPATH is specified as a negative number, the magnitude of which is the number of points in the table (≤ 40). The variable ENDS specifies the length of the centerline path used for the velocity integration. If $ENDS = 0.0$,

no induced velocity calculations are made. If ENDS is input greater than the length of the centerline path to which Wooler's or Margason's methods are applicable ($s/d_o \leq 50$), the value of ENDS is changed to equal the maximum length in the table. The maximum length which should be input is dependent on the location of the points where induced velocities are computed. If all points are forward of the jet, an input value of ENDS of the order of 10 should be adequate. If velocities are to be computed at points downstream of the jet, it is necessary to increase the input value of ENDS such that the jet extends downstream of the points in question. Generally, the author has found it necessary to run the program with different jet lengths and compare the final results to determine an appropriate length. One must remember that the execution time is directly proportional to the jet length.

Three different integration intervals are input in this program. All three have been investigated, and the values shown in the sample input should be considered as upper limits for most cases. Values larger than those shown can lead to noticeable variations in the results, and smaller values lead to excessive computer running time. The least critical is the value of DZD, the integration interval for the centerline path calculation. It has only a small effect on the final results and the total run time. The most critical is the value of DSV, the integration interval for the velocities induced by the curved vortex cylinder. Values smaller than that illustrated (0.2) can lead to large changes in computer execution time. If all field points at which induced velocities are to be computed are far removed from the jet centerline, the value of DSV will have a small effect on the final results; however, the value of DSV has a large effect on the results at field points very near the jet wake. The value of DS, the integration interval for the sink-doublet contribution to the induced velocity field, should not be larger than the illustrated value (0.1) to avoid excessive error. Intervals smaller than the above will not change the final results appreciably unless a field point is very near the jet centerline. If the user has some question about the above interval sizes, the best procedure is to choose several representative field points and run the program with various intervals.

The control points at which induced velocities are to be computed may be located anywhere in the flow field; however, the results are best

if the points do not fall inside the wake or too near the jet centerline.

A word of caution is necessary if several sets of runs are to be stacked. All runs specifying the jet centerline path ($NPATH < 0$) should follow any runs in which the path is computed. This is because the data block which specifies the array $SD(J)$ for a computed path is destroyed when a path is input.

Discussion of Output

A sample set of output for a normal run is shown in figure 10. This set of output was generated from the first input deck illustrated in figure 9. The entire set of optional output has been obtained for this case.

The pages are numbered and each page features the identification information from the first card of the input deck. At the top of page 1, the jet velocity ratio, the jet exit angle, and the integration interval are printed. This information is followed by a statement of the method used to compute the centerline parameters. The following four columns contain the coordinates and the angle of the path of the jet centerline.

Page 2 is the first of three pages of optional output. The first line contains the identification information and it is followed by a statement of the source of the induced velocities. This is followed by the jet velocity ratio (V/VJ), the initial diameter of the jet (D), the coordinates of the center of the jet exit in a wing-based coordinate system (XQ, YQ, ZQ), the assumed length of the jet (S/D), and the integration interval ($D(S/D)$). The velocity components induced by the sink distribution representing the entrainment of the jet are presented in a right-handed, fan-based coordinate system centered in the fan exit (figure 6). The coordinates of the field points are referenced to the fan exit diameter ($X/D, Y/D, Z/D$). The velocity components are referenced to the jet velocity, and the induced axial velocity (U/VJ) is positive aft, the induced lateral velocity (V/VJ) is positive left and the induced downwash is positive downward (fig. 6). The last column contains the total induced velocity due to the sink distribution.

Similar velocity components induced by the doublet distribution representing the blockage effect of the wake are presented on page 3.

Velocity components induced by the curved vortex cylinder are on page 4. Pages 3 and 4 are also optional.

The total velocity components induced by the fan wake are shown on page 5. The field point coordinates (XW,YW,ZW) are those input. The velocity components induced by the sink and doublet distributions are printed in the next three columns. The last three columns contain the velocity components induced by the sink and doublet distributions and the curved vortex cylinder. These velocities are referenced to the free-stream velocity and the wing coordinate system (figure 6). The axial velocity (U/V) is positive forward, the lateral velocity (V/V) is positive right, and the downwash (W/V) is positive downward. This page concludes the output when there is one lift fan. If a second lift fan is specified, pages 2 through 5 are repeated for the second fan and then one additional page is printed with the total velocities from both lift fans summed at each control point.

Error Messages and Stops

The lift-fan program has only one error message. If one set of input is executed in which the jet centerline path is specified through input, any following cases that are stacked must also have the path input. This is necessary because once a path is input the data block specifying the array SD(J) is changed and there is no simple way to initialize it again. If a following set of input specifies that the path be computed, the message

****EXECUTION TERMINATED - JET CENTERLINE PATH MUST BE INPUT****

is printed and execution terminates in a STOP statement. The above situation is avoided by proper stacking of input. All cases in which the path is computed (NPATH = 1 or 2) should be run before any cases in which the path is input (NPATH < 0).

Program Listing

The lift-fan flow model program is written in Fortran IV for the IBM 7094 computer. The program consists of the main program and two subroutines.

<u>Program</u>	<u>Identification</u>	<u>Page No.</u>
MAIN	LF01	72
INTERP	LF02	76
ELLIPS	LF03	77

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PROGRAM TO CALCULATE THE VELOCITIES INDUCED AT SPECIFIED
CONTROL POINTS BY A LIFT FAN
C
DIMENSION XD(40),ZD(40),SD(40),HFTA(40),vS1(3),T1LE(20)
DIMENSION XP(20),XP(20),ZP(20),vS(200),vS(200),vS(200)
DIMENSION FU(200),FV(200),FW(200),FV(200),FV(200),FV(200),FV(200)
DIMENSION DUS(3),DVS(3),DWS(3),DCT(3),DCT(3)
DIMENSION USV(200),VSV(200),WSV(200),XV(200),YV(200),ZV(200)
DIMENSION DUD(3),DVD(3),DWD(3),UD(200),VD(200),WD(200)
COMMON MZ
C
DATA SD/0.0,0.05,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0,1.5,2.0,
1 2.5,3.0,3.5,4.0,4.5,5.0,6.0,7.0,8.0,9.0,10.0,11.0,12.0,
2 14.0,16.0,18.0,20.0,22.0,24.0,26.0,28.0,30.0,35.0,40.0,
3 45.0,50.0/
C
699 FORMAT (9F8.0)
700 FORMAT (8F10.4)
701 FORMAT (1H1,5X20A4,20X4HPAGE,I3//)
702 FORMAT (10X,3F10.4//)
703 FORMAT (5X,4(1PE13.5))
704 FORMAT (415.6F10.5)
705 FORMAT (1X,14, 3F10.3+6(1PE12.4))
706 FORMAT (10X,6F10.4//)
707 FORMAT (10X,7F10.4//)
710 FORMAT (15X,4HV/VJ,4X5DELTA,6X6HD(Z/D))
711 FORMAT (10X3HX/D,10X3HZ/D,10X3HS/D, 9X5HTHEA)
712 FORMAT (15X4HV/VJ,7X1HDBX2HXQX2HYQX2HZQ,8X3HS/D)
713 FORMAT (10X3HX/D,7X3HY/D,7X3HZ/D,7X4HU/VJ,8X4HV/VJ,8X4HW/VJ,7X5HVT/VJ)
716 FORMAT (5X4HVFLOCIITY INDUCED BY ENTRAINMENT SINK DISTRIBUTION,2X
1 6H- FAN,I2,18H COORDINATE SYSTEM//)
718 FORMAT (5X4HVFLOCIITY INDUCED BY CURVED VORTEX CYLINDER,2X6H- FAN,I2,18H COORDINATE SYSTEM//)
719 FORMAT (5X22HTOTAL INDUCED VELOCITY,5X3HFAN,I2,25H - WING COORDINATE SYSTEM//)
720 FORMAT (10X3HX/D,7X3HY/D,7X3HZ/D,7X4HU/VJ,8X4HV/VJ,8X4HW/VJ,7X5HVT/VJ)
721 FORMAT (5X4HVFLOCIITY INDUCED BY DOUBLET DISTRIBUTION,2X6H- FAN, I2,18H COORDINATE SYSTEM//)
722 FORMAT (10X6H XW 6X4H YW 6X4H ZW 6X3HU/VV,9X3HV/V,9X3HW/V)
723 FORMAT (15X4HV/VJ,7X1HDBX2HXQX2HYQX2HZQ,8X3HS/D,6X6HD(S/D))
724 FORMAT (10X6H XW 6X4H YW 6X4H ZW 6X3HU/VV,9X3HV/V,9X3HW/V,9X3HU/V,9X3HVL/V)
725 FORMAT (20A6)
726 FORMAT (5X37HTOTAL INDUCED VELOCITY, TWO LIFT FANS,25H - WING COORDINATE SYSTEM//)
727 FORMAT (35X1H(9X)16HSINKS + DOUBLETS,59X1H(1X)36HSINKS + DOUBLETS + VLF,10X46H VORTEX CYLINDER//)
728 FORMAT (41X1H(9X)16HSINKS + DOUBLETS,59X1H(1X)36HSINKS + DOUBLETS + VLF,10X46H VORTEX CYLINDER//)
729 FORMAT (15X4HV/VJ,7X1HDBX2HXQX2HYQX2HZQ,8X3HV/V,9X3HW/V)
730 FORMAT (/47X7HD(S/D)=F5,3,34X7HD(S/D)=F5,3)
731 FORMAT (8X31HJET CENTERLINE PARAMETERS INPUT//)
732 FORMAT (8X58HJET CENTERLINE PARAMETERS COMPUTED USING MARGASON-S MLF,10X55H JET METHOD//)
733 FORMAT (8X56HJET CENTERLINE PARAMETERS COMPUTED USING WOOLER-S METL,10X55H JET METHOD//)
734 FORMAT (10X,9F10.4//)
735 FORMAT (15X4HV/VJ,7X1HDBX3HXQ17X3HYQ17X3HZQ17X3HXQ27X3HYQ27X3HZQ27X3HXQ37X3HYQ37X3HZQ37X3HXQ47X3HYQ47X3HZQ47X3HXQ57X3HYQ57X3HZQ57X3HXQ67X3HYQ67X3HZQ67X3HXQ77X3HYQ77X3HZQ77X3HXQ87X3HYQ87X3HZQ87X3HXQ97X3HYQ97X3HZQ97X3HXQ107X3HYQ107X3HZQ107X3HXQ117X3HYQ117X3HZQ117X3HXQ127X3HYQ127X3HZQ127X3HXQ137X3HYQ137X3HZQ137X3HXQ147X3HYQ147X3HZQ147X3HXQ157X3HYQ157X3HZQ157X3HXQ167X3HYQ167X3HZQ167X3HXQ177X3HYQ177X3HZQ177X3HXQ187X3HYQ187X3HZQ187X3HXQ197X3HYQ197X3HZQ197X3HXQ207X3HYQ207X3HZQ207X3HXQ217X3HYQ217X3HZQ217X3HXQ227X3HYQ227X3HZQ227X3HXQ237X3HYQ237X3HZQ237X3HXQ247X3HYQ247X3HZQ247X3HXQ257X3HYQ257X3HZQ257X3HXQ267X3HYQ267X3HZQ267X3HXQ277X3HYQ277X3HZQ277X3HXQ287X3HYQ287X3HZQ287X3HXQ297X3HYQ297X3HZQ297X3HXQ307X3HYQ307X3HZQ307X3HXQ317X3HYQ317X3HZQ317X3HXQ327X3HYQ327X3HZQ327X3HXQ337X3HYQ337X3HZQ337X3HXQ347X3HYQ347X3HZQ347X3HXQ357X3HYQ357X3HZQ357X3HXQ367X3HYQ367X3HZQ367X3HXQ377X3HYQ377X3HZQ377X3HXQ387X3HYQ387X3HZQ387X3HXQ397X3HYQ397X3HZQ397X3HXQ407X3HYQ407X3HZQ407X3HXQ417X3HYQ417X3HZQ417X3HXQ427X3HYQ427X3HZQ427X3HXQ437X3HYQ437X3HZQ437X3HXQ447X3HYQ447X3HZQ447X3HXQ457X3HYQ457X3HZQ457X3HXQ467X3HYQ467X3HZQ467X3HXQ477X3HYQ477X3HZQ477X3HXQ487X3HYQ487X3HZQ487X3HXQ497X3HYQ497X3HZQ497X3HXQ507X3HYQ507X3HZQ507X3HXQ517X3HYQ517X3HZQ517X3HXQ527X3HYQ527X3HZQ527X3HXQ537X3HYQ537X3HZQ537X3HXQ547X3HYQ547X3HZQ547X3HXQ557X3HYQ557X3HZQ557X3HXQ567X3HYQ567X3HZQ567X3HXQ577X3HYQ577X3HZQ577X3HXQ587X3HYQ587X3HZQ587X3HXQ597X3HYQ597X3HZQ597X3HXQ607X3HYQ607X3HZQ607X3HXQ617X3HYQ617XHZQ617X3HXQ627X3HYQ627X3HZQ627X3HXQ637X3HYQ637XHZQ637X3HXQ647X3HYQ647X3HZQ647X3HXQ657X3HYQ657X3HZQ657X3HXQ667X3HYQ667X3HZQ667X3HXQ677X3HYQ677X3HZQ677X3HXQ687X3HYQ687X3HZQ687X3HXQ697X3HYQ697X3HZQ697X3HXQ707X3HYQ707X3HZQ707X3HXQ717X3HYQ717X3HZQ717X3HXQ727X3HYQ727X3HZQ727X3HXQ737X3HYQ737X3HZQ737X3HXQ747X3HYQ747X3HZQ747X3HXQ757X3HYQ757X3HZQ757X3HXQ767X3HYQ767X3HZQ767X3HXQ777X3HYQ777X3HZQ777X3HXQ787X3HYQ787X3HZQ787X3HXQ797X3HYQ797X3HZQ797X3HXQ807X3HYQ807X3HZQ807X3HXQ817X3HYQ817X3HZQ817X3HXQ827X3HYQ827X3HZQ827X3HXQ837X3HYQ837X3HZQ837X3HXQ847X3HYQ847X3HZQ847X3HXQ857X3HYQ857X3HZQ857X3HXQ867X3HYQ867X3HZQ867X3HXQ877X3HYQ877X3HZQ877X3HXQ887X3HYQ887X3HZQ887X3HXQ897X3HYQ897X3HZQ897X3HXQ907X3HYQ907X3HZQ907X3HXQ917X3HYQ917X3HZQ917X3HXQ927X3HYQ927X3HZQ927X3HXQ937X3HYQ937X3HZQ937X3HXQ947X3HYQ947X3HZQ947X3HXQ957X3HYQ957X3HZQ957X3HXQ967X3HYQ967X3HZQ967X3HXQ977X3HYQ977X3HZQ977X3HXQ987X3HYQ987X3HZQ987X3HXQ997X3HYQ997X3HZQ997X3HXQ1007X3HYQ1007X3HZQ1007X3HXQ1017X3HYQ1017X3HZQ1017X3HXQ1027X3HYQ1027X3HZQ1027X3HXQ1037X3HYQ1037X3HZQ1037X3HXQ1047X3HYQ1047X3HZQ1047X3HXQ1057X3HYQ1057X3HZQ1057X3HXQ1067X3HYQ1067X3HZQ1067X3HXQ1077X3HYQ1077X3HZQ1077X3HXQ1087X3HYQ1087X3HZQ1087X3HXQ1097X3HYQ1097X3HZQ1097X3HXQ1107X3HYQ1107X3HZQ1107X3HXQ1117X3HYQ1117X3HZQ1117X3HXQ1127X3HYQ1127X3HZQ1127X3HXQ1137X3HYQ1137X3HZQ1137X3HXQ1147X3HYQ1147X3HZQ1147X3HXQ1157X3HYQ1157X3HZQ1157X3HXQ1167X3HYQ1167X3HZQ1167X3HXQ1177X3HYQ1177X3HZQ1177X3HXQ1187X3HYQ1187X3HZQ1187X3HXQ1197X3HYQ1197X3HZQ1197X3HXQ1207X3HYQ120
```

```

        NCYL=CYL
        NPAGE=1
        NPS=40
        IF (NP,LE,0 .OR. ENDS,LE,0.0) GO TO 111

        INPUT CONTROL POINTS IN WING COORDINATE SYSTEM

        DO 12 J=1,NP
        READ (5,700) XW(J),YW(J),ZW(J)

        TRANSFORM FIELD POINTS TO LIFT FAN COORDINATE SYSTEM

        XP(J)=(XQ-XW(J))/D
        YP(J)=(YQ-YW(J))/D
12  ZP(J)=(ZW(J)-ZQ)/D

        INITIALIZE INDUCED VELOCITY ARRAYS

        DO 11 J=1,NP
        FU(J)=0.
        FV(J)=0.
        FW(J)=0.
        FU1(J)=0.
        FV1(J)=0.
11  FW1(J)=0.
111 WRITE (6,701) TITLE,NPAGE
        NPAGE=NPAGE+1
        WRITE (6,710)
        WRITE (6,702) VVJ,DELTJ,DZD
        IF (MNPS .GT. 0 .AND. NPATH .GE. 0) GO TO 999

        COMPUTE THE PATH OF THE JET CENTERLINE

        IF (VVJ) 19,15,19
15  SNDJ=SIN(DELTJ/RAD)
        CSDJ=COS(DELTJ/RAD)
        NTYPE=0
        DO 16 J=1,40
        XD(J)=SD(J)*CSDJ
        THETA(J)=90.0-DELTJ
16  ZD(J)=SD(J)*SNDJ
        NPATH=0
        GO TO 40
19  IF (NPATH) 13,10,18

        INPUT THE PATH OF THE JET CENTERLINE

13  NPS=-NPATH
        MNPS=NPS
        READ (5,700) (SD(J),J=1,NPS)
        READ (5,700) (XD(J),J=1,NPS)
        READ (5,700) (ZD(J),J=1,NPS)
        READ (5,700) (THETA(J),J=1,NPS)
        WRITE (6,731)
        GO TO 40
18  IF (NPATH-1) 10,20,30

        (1) MARGASON'S METHOD - REF. NASA TN D-4919

20  CSDELJ=COS(DELTJ/RAD)
        SNDELJ=SIN(DELTJ/RAD)
        CTDELJ=CSDELJ/SNDELJ
        CON=(VVJ/SNDELJ)**2
        AM=9./16.*(CON**2)
        BM=1.5*CTDELJ*CON
        CM=1.0 + CTDELJ*CTDELJ
        WRITE (6,732)
        XD(1)=0.0
        ZD(1)=0.0
        THETA(1)=0.0
        SDT(1)=0.0
        SDT(2)=0.0

```

```

SDT(3)=0.0
ZDT(1)=0.0
ZDT(2)=0.0
ZDT(3)=0.0
S=0.0
J=2
K=1
M=3
Z=ZD(1)
H=DZD/3.0
21 DO 25 I=K,3
  DSI(I)=AM*(Z**4) + BM*(Z**2) + CM
  DSI(I)=SQRT(DSI(I))
25 Z=Z+DZD
  K=2
  MM=1
  S=S + H*(DSI(1) + 4.*DSI(2) + DSI(3))
  DSI(1)=DSI(3)
  SDT(1)=SDT(2)
  SDT(2)=SDT(3)
  SDT(3)=S
  ZDT(1)=ZDT(2)
  ZDT(2)=ZDT(3)
  ZDT(3)=Z-DZD
27 SL=SD(J)
  IF (S-SL) 21,26,28
28 IF (ZDT(1).EQ.ZDT(2)) MM=0
  CALL INTERP (M,MM,SDT,ZDT,SL,ZL)
  ZD(J)=ZL
  GO TO 29
26 SD(J)=S
  ZD(J)=Z-DZD
29 XD(J)=CON/4.0*(ZD(J)**3) + ZD(J)*CTDELJ
  TTH=0.75*CON*(ZD(J)**2) + CTDELJ
  TH=ATAN(TTH)
  THETA(J)=TH*RAD
  J=J+1
  IF (J-40) 27,27,40
  (2) WOOLER-S METHOD - REF. J. OF AIRCRAFT, MAY-JUNE 1969, P.283
30 XD(1)=0.0
  IF (DELTA.NE.90.) GO TO 20
  WRITE (6,733)
  ZD(1)=0.0
  THETA(1)=0.0
  SDT(1)=0.0
  SDT(2)=0.0
  SDT(3)=0.0
  ZDT(1)=0.0
  ZDT(2)=0.0
  ZDT(3)=0.0
  S=0.0
  H=DZD/3.0
  K=1
  J=2
  M=3
  Z=ZD(1)
  CON=175./4.*(VVJ**5)
31 DO 35 I=K,3
  DSI(I)=1.0 + CON*(Z**3)
  DSI(I)=SQRT(DSI(I))
35 Z=Z+DZD
  K=2
  MM=1
  S=S + H*(DSI(1) + 4.*DSI(2) + DSI(3))
  DSI(1)=DSI(3)
  SDT(1)=SDT(2)
  SDT(2)=SDT(3)
  SDT(3)=S
  ZDT(1)=ZDT(2)
  ZDT(2)=ZDT(3)

```

```

LF010145
LF010146
LF010147
LF010148
LF010149
LF010150
LF010151
LF010152
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LF010198
LF010199
LF010200
LF010201
LF010202
LF010203
LF010204
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LF010206
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LF010208
LF010209
LF010210
LF010211
LF010212
LF010213
LF010214
LF010215
LF010216

```

```

ZDT(3)=Z-DZD
37 SL=SD(J)
  IF (S-SL) 31,36,38
38 IF (ZDT(1).EQ.ZDT(2)) MM=0
  CALL INTERP (M,MM,SDT,ZDT,SL,ZL)
  ZD(J)=ZL
  GO TO 39
36 SD(J)=S
  ZD(J)=Z-DZD
39 XD(J)=SQRT(7.0)*((VVJ*ZD(J))**2.5)
  TTH=2.5*XD(J)/ZD(J)
  THETA(J)=ATAN(TTH)*RAD
  J=J+1
  IF (J-40) 37,37,40
40 CONTINUE
  WRITE (6,711)
  DO 41 J=1,NPS
41 WRITE (6,703) XD(J),ZD(J),SD(J),THETA(J)
  IF (NP.EQ.0 .OR. ENDS.LE.0.0) GO TO 10
  IF (ENDS.GT. SD(NPS)) ENDS=SD(NPS)
  MFAN=0
C
C COMPUTE WAKE ENTRAINMENT AND BLOCKAGE EFFECT
C WOOLER-S METHOD - REF. JOUR.OF AIRCRAFT, NOV-DEC 1967, P.537
C
MFANP=MFAN+1
42 IF (NPRNT.EQ.0) GO TO 45
  WRITE (6,701) TITLE,NPAGE
  NPAGE=NPAGE+1
  WRITE (6,716) MFANP
  WRITE (6,723)
  WRITE (6,707) VVJ,D,XQ,YQ,ZQ,ENDS,DS
  WRITE (6,713)
45 E1=0.35
  E2=0.08
  E3=30.0
  DO 50 J=1,NP
  MJ=J
  RS2=XP(J)*XP(J) + YP(J)*YP(J) + ZP(J)*ZP(J)
  US(J)=0.0
  VS(J)=0.0
  WS(J)=0.0
  UD(J)=0.0
  VD(J)=0.0
  WD(J)=0.0
  K=1
  S=0.0
  H=DS/3.0
  VSAV=0.0
  VT=0.0
  NTR=1
51 DO 55 I=K,3
C
C LOOK UP X, Z, AND THETA
C
DO 151 JN=NTR,NPS
  KJN=JN
  IF (S-SD(JN)) 153,152,151
151 CONTINUE
153 NTR=KJN-1
  MNT=KJN
  LNT=NTR
  DELTA=(S-SD(LNT))/(SD(MNT)-SD(LNT))
  X=XD(LNT) + (XD(MNT)-XD(LNT))*DELTA
  Z=ZD(LNT) + (ZD(MNT)-ZD(LNT))*DELTA
  TH=THETA(LNT) + (THETA(MNT)-THETA(LNT))*DELTA
  GO TO 154
152 NTR=KJN
  X=XD(NTR)
  Z=ZD(NTR)
  TH=THETA(NTR)
154 CONTINUE
LF010217
LF010218
LF010219
LF010220
LF010221
LF010222
LF010223
LF010224
LF010225
LF010226
LF010227
LF010228
LF010229
LF010230
LF010231
LF010232
LF010233
LF010234
LF010235
LF010236
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LF010250
LF010251
LF010252
LF010253
LF010254
LF010255
LF010256
LF010257
LF010258
LF010259
LF010260
LF010261
LF010262
LF010263
LF010264
LF010265
LF010266
LF010267
LF010268
LF010269
LF010270
LF010271
LF010272
LF010273
LF010274
LF010275
LF010276
LF010277
LF010278
LF010279
LF010280
LF010281
LF010282
LF010283
LF010284
LF010285
LF010286
LF010287
LF010288

```

```

WRITE (6,706) VVJ,D,XQ,YQ,ZQ,ENDS
WRITE (6,728)
WRITE (6,722)
DO 65 J=1,NP
U=US(J)+UD(J)
V=VS(J)+VD(J)
W=WS(J)+WD(J)
U=U/VVJ
V=V/VVJ
65 WRITE (6,705) J,XW(J),YW(J),ZW(J),U,V,W
GO TO 10

C
C
C
COMPUTE VELOCITY INDUCED BY A CONSTANT STRENGTH VORTEX
CYLINDER LYING ALONG THE JET CENTERLINE
62 IF (NPRNT.EQ.0) GO TO 66
WRITE (6,701) TITLE,NPAGE
NPAGE=NPAGE+1
WRITE (6,718) MFANP
WRITE (6,723)
WRITE (6,707) VVJ,D,XQ,YQ,ZQ,ENDS,DSV
WRITE (6,713)
66 DO 70 J=1,NP
MJ=J
GAMVJ=1.0
S=DSV/2.
H=DSV/3.
VSAV=0.0
VT=0.
USV(J)=0.0
VSV(J)=0.0
WSV(J)=0.0
RS2=XP(J)**2 + YP(J)**2 + ZP(J)**2
K=1
NTR=1
71 DO 75 I=K,3
LOOK UP LOCAL X, Z, AND THETA
DO 171 JN=NTR,NPS
KJN=JN
IF (S-SD(JN)) 173,172,171
171 CONTINUE
173 NTR=KJN-1
MNT=KJN
LNT=NTR
DELTA=(S-SD(LNT))/(SD(MNT)-SD(LNT))
X=XD(LNT) + (XD(MNT)-XD(LNT))*DELTA
Z=ZD(LNT) + (ZD(MNT)-ZD(LNT))*DELTA
TH=THETA(LNT) + (THETA(MNT)-THETA(LNT))*DELTA
GO TO 174
172 NTR=KJN
X=XD(NTR)
Z=ZD(NTR)
TH=THETA(NTR)
174 CONTINUE
C
C
C
CSTH=COS(TH/RAD)
SNTH=SIN(TH/RAD)
XID=(XP(J)-X)*SNTH + (ZP(J)-Z)*CSTH
ETAD=-YP(J)
ZETAD=(XP(J)-X)*CSTH - (ZP(J)-Z)*SNTH
XIR=XID*2.
ETAR=ETAD*2.
ZETAR=ZETAD*2.
RPR=SQRT(ETAR**2 + ZETAR**2)
DENM=XIR**2 + (RPR-1.0)**2
DENP=XIR**2 + (RPR+1.0)**2
AK2=4.*RPR/DENP
CALL ELLIPS (AK2,ZK,ZE)
DUMV=GAMVJ/PI/SQRT(DENP)*(ZK-ZE-2.*(RPR-1.)*ZE/DENM)
DUMV=GAMVJ/PI/RPR*XIR/SQRT(DENP)*(ZK-ZE-2.*RPR*ZE/DENM)

```

```

DUS(I)=DUMU*SNTH + DUMV*ZETAR*CSH/RPR
DVS(I)=-DUMV*ETAR/RPR
DWS(I)=DUMU*CSH - DUMV*ZETAR/RPR*SNTH
75 S=S+DSV
K=2
USV(J)=USV(J) + H*(DUS(1) + 4.*DUS(2) + DUS(3))
VSV(J)=VSV(J) + H*(DVS(1) + 4.*DVS(2) + DVS(3))
WSV(J)=WSV(J) + H*(DWS(1) + 4.*DWS(2) + DWS(3))
DUS(1)=DUS(3)
DVS(1)=DVS(3)
DWS(1)=DWS(3)
570 IF (S=ENDS) 71,71,78
78 SDEND=S+DSV
IF (NPRNT.EQ.0) GO TO 70
VSAV=SQRT(USV(J)**2 + VSV(J)**2 + WSV(J)**2)
WRITE (6,705)MJ,XP(J),YP(J),ZP(J),USV(J),VSV(J),WSV(J),VSAV
70 CONTINUE

```

C
C
C

OUTPUT TOTAL INDUCED VELOCITY COMPONENTS IN WING COORD. SYSTEM

```

WRITE (6,701) TITLE,NPAGE
NPAGE=NPAGE+1
MFAN=MFAN+1
WRITE (6,719) MFAN
WRITE (6,712)
WRITE (6,706) VVJ,D,XQ,YQ,ZQ,ENDS
WRITE (6,730) DS,DSV
WRITE (6,727)
WRITE (6,724)
DO 80 J=1,NP
U=US(J)+UD(J)
V=VS(J)+VD(J)
W=WS(J)+WD(J)
U1=U+USV(J)
V1=V+VSV(J)
W1=W+WSV(J)
U=-U/VVJ
V=-V/VVJ
U1=-U1/VVJ
V1=-V1/VVJ
W=W/VVJ
W1=W1/VVJ
FU(J)=FU(J)+U
FV(J)=FV(J)+V
FW(J)=FW(J)+W
FU1(J)=FU1(J)+U1
FV1(J)=FV1(J)+V1
FW1(J)=FW1(J)+W1
80 WRITE (6,705) J,XW(J),YW(J),ZW(J),U,V,W,U1,V1,W1
IF (NFAN=2) 10,81,83
81 NFAN=NFAN+1
MFANP=MFANP+1
DUM=YQ
YQ=YQ2
YQ2=DUM
DUM=XQ
XQ=XQ2
XQ2=DUM
DUM=ZQ
ZQ=ZQ2
ZQ2=DUM
DO 82 J=1,NP
XP(J)=(XQ-XW(J))/D
ZP(J)=(ZW(J)-ZQ)/D
82 YP(J)=(YQ-YW(J))/D
GO TO 42

```

C
C
C

OUTPUT TOTAL VELOCITY INDUCED BY TWO LIFT FANS

```

83 WRITE (6,701) TITLE,NPAGE
WRITE (6,726)
WRITE (6,735)

```

LF010433
LF010434
LF010435
LF010436
LF010437
LF010438
LF010439
LF010440
LF010441
LF010442
LF010443
LF010444
LF010445
LF010446
LF010447
LF010448
LF010449
LF010450
LF010451
LF010452
LF010453
LF010454
LF010455
LF010456
LF010457
LF010458
LF010459
LF010460
LF010461
LF010462
LF010463
LF010464
LF010465
LF010466
LF010467
LF010468
LF010469
LF010470
LF010471
LF010472
LF010473
LF010474
LF010475
LF010476
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LF010478
LF010479
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LF010481
LF010482
LF010483
LF010484
LF010485
LF010486
LF010487
LF010488
LF010489
LF010490
LF010491
LF010492
LF010493
LF010494
LF010495
LF010496
LF010497
LF010498
LF010499
LF010500
LF010501
LF010502
LF010503
LF010504

```

WRITE (6,734) VVJ,D,XQ2,YQ2,ZQ2,XQ,YQ,ZQ,ENDS
WRITE (6,730) DS,DSV
WRITE (6,727)
WRITE (6,724)
DO 84 J=1,NP
84 WRITE (6,705) J,XW(J),YW(J),ZW(J),FU(J),FV(J),FW(J),FU1(J),FV1(J),FW1(J)
1
GO TO 10
C
C
C
ERROR STOP
999 WRITE (6,799)
STOP
END
LF010505
LF010506
LF010507
LF010508
LF010509
LF010510
LF010511
LF010512
LF010513
LF010514
LF010515
LF010516
LF010517
LF010518

```

C INTERPOLATION SUBROUTINE WITH LINEAR OR PARABOLIC OPTION

C NTYPE = 0 : LINEAR INTERPOLATION
C NTYPE = 1 : PARABOLIC INTERPOLATION
C N = NUMBER OF TABLE ENTRIES
C X = INDEPENDENT VARIABLE
C F = F(X)
C VALUE = F(ARG)

C SUBROUTINE INTERP (N,NTYPE,X,F,ARG,VALUE)
C DIMENSION X(1),F(1)
C IF(N-1)1,10,20

C NO ENTRIES IN TABLE. SET VALUE TO ZERO.

C 1 VALUE=0.0
C RETURN

C ONE ENTRY. USE THIS VALUE.

C 10 VALUE=F(1)
C RETURN

C CHECK FOR ARG BEING LESS THAN X(1)

C 20 IF (ARG-X(1))21,21,22

C SET VALUE EQUAL TO FIRST ENTRY.

C 21 VALUE=F(1)
C RETURN

C CHECK FOR ARG BEING GREATER THAN X(N)

C 22 IF(ARG-X(N))24,23,23

C EXTRAPOLATE LINEARLY FROM LAST TWO ENTRIES

C 23 M=N
C L=N-1
C GO TO 31

C TWO OR MORE ENTRIES IN TABLE

C 24 IF(N-2)30,30,25

LF020001
LF020002
LF020003
LF020004
LF020005
LF020006
LF020007
LF020008
LF020009
LF020010
LF020011
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LF020013
LF020014
LF020015
LF020016
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LF020020
LF020021
LF020022
LF020023
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LF020030
LF020031
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LF020040
LF020041
LF020042
LF020043
LF020044
LF020045
LF020046

C CHECK TYPE OF INTERPOLATION SCHEME REQUESTED

C 25 IF (NTYPE-1) 26,40,40
C 26 DO 27 J=2,N
C IF (ARG-X(J)) 28,43,27
C 27 CONTINUE
C 28 M=J
C L=J-1
C GO TO 31

C LINEAR INTERPOLATION

C 30 L=1
C M=2
C 31 SLOPE=(F(M)-F(L))/(X(M)-X(L))
C VALUE=F(L)+(ARG-X(L))*SLOPE
C RETURN

C PARABOLIC INTERPOLATION

C 40 J=1
C 42 J=J+1
C IF(J+1-N)41,50,50
C 41 IF(ARG-X(J))50,43,42
C 43 VALUE=F(J)
C RETURN
C 50 VALUE=0.0
C ML=J-1
C MU=J+1
C DO 51 M=ML,MU
C PROD=F(M)
C DO 52 L=ML,MU
C IF(M-L)53,52,53
C 53 PROD=PROD*(ARG-X(L))/(X(M)-X(L))
C 52 CONTINUE
C 51 VALUE=VALUE+PROD

C 61 RETURN
C END

LF020047
LF020048
LF020049
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LF020056
LF020057
LF020058
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LF020083
LF020084
LF020085

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SUBROUTINE ELLIPS (AKSQ+TK+TE)
-- TABLE LOOK-UP OF ELLIPTIC INTEGRALS --
DIMENSION CKK(100),CK(100),CE(100)
COMMON MZZZ
CKK = ARGUMENT OF ELLIPTIC INTEGRALS
DATA CKK/0.00,.01,.02,.03,.04,.05,.06,.07,.08,.09,.10,.11,.12,.13,
1 .14,.15,.16,.17,.18,.19,.20,.21,.22,.23,.24,.25,.26,.27,
2 .28,.29,.30,.31,.32,.33,.34,.35,.36,.37,.38,.39,.40,.41,
3 .42,.43,.44,.45,.46,.47,.48,.49,.50,.51,.52,.53,.54,.55,
4 .56,.57,.58,.59,.60,.61,.62,.63,.64,.65,.66,.67,.68,.69,
5 .70,.71,.72,.73,.74,.75,.76,.77,.78,.79,.80,.81,.82,.83,
6 .84,.85,.86,.87,.88,.89,.90,.91,.92,.93,.94,.95,.96,.97,
7 .98,.99/
CK = COMPLETE ELLIPTIC INTEGRALS OF FIRST KIND
DATA CK/1.570796,1.574746,1.578740,1.582780,1.586868,1.591003,
1 1.595188,1.599423,1.603710,1.608049,1.612441,1.616889,
2 1.621393,1.625955,1.630576,1.635257,1.640000,1.644806,
3 1.649678,1.654617,1.659624,1.664701,1.669850,1.675073,
4 1.680373,1.685750,1.691208,1.696749,1.702374,1.708087,
5 1.713889,1.719785,1.725776,1.731865,1.738055,1.744351,
6 1.750754,1.757269,1.763898,1.770647,1.777519,1.784519,
7 1.791650,1.798918,1.806328,1.813884,1.821593,1.829460,
8 1.837491,1.845694,1.854075,1.862641,1.871400,1.880361,
9 1.889533,1.898925,1.908547,1.918410,1.928526,1.938908,
A 1.949568,1.960521,1.971783,1.983371,1.995303,2.007598,
B 2.020279,2.033369,2.046894,2.060882,2.075363,2.090373,
C 2.105948,2.122132,2.138970,2.156516,2.174827,2.193971,
D 2.214022,2.235068,2.257205,2.280549,2.305232,2.331409,
E 2.359264,2.389016,2.420933,2.455338,2.492635,2.533335,
F 2.578092,2.627773,2.683551,2.747073,2.820752,2.908337,
G 3.016112,3.155875,3.354141,3.695637/
CE = COMPLETE ELLIPTIC INTEGRALS OF SECOND KIND
DATA CE/1.570796,1.566862,1.562913,1.558948,1.554969,1.550973,
1 1.546963,1.542936,1.538893,1.534833,1.530758,1.526665,
2 1.522555,1.518428,1.514284,1.510122,1.505942,1.501743,
3 1.497526,1.493290,1.489035,1.484761,1.480466,1.476152,
4 1.471818,1.467462,1.463086,1.458688,1.454269,1.449827,

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LF030001
LF030002
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LF030038
LF030039
LF030040
LF030041
LF030042
LF030043
LF030044
LF030045
LF030046

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5 1.445363,1.440876,1.436366,1.431832,1.427274,1.422691,
6 1.418083,1.413450,1.408791,1.404105,1.399392,1.394652,
7 1.389883,1.385086,1.380259,1.375402,1.370515,1.365596,
8 1.360645,1.355661,1.350644,1.345592,1.340505,1.335382,
9 1.330223,1.325024,1.319788,1.314511,1.309192,1.303832,
A 1.298428,1.292979,1.287484,1.281942,1.276350,1.270707,
B 1.265013,1.259263,1.253458,1.247595,1.241671,1.235684,
C 1.229632,1.223512,1.217321,1.211056,1.204714,1.198290,
D 1.191781,1.185183,1.178490,1.171697,1.164798,1.157787,
E 1.150656,1.143396,1.135998,1.128451,1.120742,1.112856,
F 1.104775,1.096478,1.087938,1.079121,1.069986,1.060474,
G 1.050502,1.039947,1.028595,1.015994/
IF (MZZZ) 73,30,3
3 IF(AKSQ-.99)20,20,21
21 PARA=0.25*(1.0-AKSQ)
700 TEST = 1.00E-07
IF(PARA-TEST)701,702,702
701 PARA=TEST
702 ZLP=ALOG(4./PARA)
TK=ZLP*0.5*(1.+PARA)-PARA
TE=1.0+(ZLP*PARA)-PARA
GO TO 30
20 JA=100.0*AKSQ
JA=1+JA
IF(CKK(JA)-AKSQ)22,23,22
23 TK=CK(JA)
TE=CE(JA)
GO TO 30
22 CON=(AKSQ-CKK(JA))/(CKK(JA+1)-CKK(JA))
TK=CK(JA)+CON*(CK(JA+1)-CK(JA))
TE=CE(JA)+CON*(CE(JA+1)-CE(JA))
GO TO 30
73 IF(AKSQ-.01)721,721,720
721 PARA=.25*AKSQ
GO TO 700
720 AKSQ=1.-AKSQ
GO TO 20
30 CONTINUE
RETURN
END

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LF030047
LF030048
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LF030080
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LF030086
LF030087

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WING-PYLON-TAIL PROGRAM

This program computes span loadings, and lift and pitching coefficients for a configuration comprising a wing and a tail with a vertical pylon under or above each wing panel. The wing is considered the main planform while the pylon and tail are optional items. Sample cases described at the end of this section illustrate how the program handles the full wing-pylon-tail combination.

All three components may have sweep, taper, camber, and twist. Furthermore, the wing and tail may exhibit dihedral and the tail can have incidence relative to the wing root chord. The pylon is considered to lie in a vertical plane but there is allowance for pylon incidence with respect to the free stream (toe-in). The program cannot handle breaks in sweep or dihedral, nor yaw flight angle.

Fundamentally, the program is based on representing the surfaces of the wing, pylon, and tail by horseshoe vortices whose circulation strengths are determined from the flow tangency boundary conditions linearized in terms of angle of attack. This approach was also followed by Margason and Lamar at the Langley Research Center, NASA¹. The flow tangency formulations feature the optional inclusion of interference velocities induced by an external component such as a turbofan engine or a lift fan for purposes of computing interference wing loadings. Finally, a Prandtl-Glauert correction is used to account for compressibility effects at speeds up to the critical speed.

Theoretical Analysis

The requirements on the selected flow model are explained in detail in reference 1. The analysis makes use of a vortex lattice which models the wing-pylon-tail mean surface. The surfaces are divided into trapezoidal shaped elemental panels with one horseshoe vortex assigned to a panel. Such a vortex consists of three parts: a bound leg along the area element quarter chord, and two trailing legs along the sides of the element extending downstream to infinity parallel to the X axis (see figure 11).

¹R. J. Margason and J. E. Lamar have developed a planar vortex lattice analysis and computer program applicable to wing alone, including the effect of dihedral.

In the chordwise direction, the elements have equal dimensions and the same number of elements is used on both wing and pylon. The pylon root chord must equal the local wing chord where they join. In the spanwise direction, the area element widths may be varied to allow for closer spacing where large spanwise loading gradients exist. Furthermore, if a pylon is present, the trailing legs of two spanwise adjacent vortices and the upper vortex on the pylon must coincide at the wing-pylon intersection (see sample case 1). The horizontal tail is treated as a wing.

The flow tangency boundary condition states that there is no flow through the wing, pylon, and tail camber surfaces at control points. These points are actually located in the chordal planes at the midpoints of the three-quarter chord line of each area element. In the case of the wing and the tail, the chordal plane is the plane containing the respective root chord and making an angle equal to the respective dihedral with the $z = 0$ plane. For the pylon, the chordal plane is the vertical plane containing the pylon root chord.

The velocities normal to the wing consist of a component of the free stream, (optional) interference velocities u_i, v_i, w_i induced by an external component adjacent to the wing-pylon-tail airframe, and perturbation velocities u, v, w induced by the vortex lattice itself. With M control points on the left wing panel, MP on the pylon, and MT on the left horizontal tail panel, the boundary condition on the left wing panel at small angle of attack is given by:

$$\begin{aligned} & \left\{ \sum_{n=1}^M \frac{\Gamma_n}{4\pi V} \left(F_{w_{v,n}} \cos \phi_v - F_{v_{v,n}} \sin \phi_v \right) \right. \\ & + \sum_{n=M+1}^{M+MP} \frac{\Gamma_n}{4\pi V} \left[\left(F_{w_{v,n}} + F_{iw_{v,n}} \right) \cos \phi_v - \left(F_{v_{v,n}} + F_{iv_{v,n}} \right) \sin \phi_v \right] \\ & + \sum_{n=M+MP+1}^N \frac{\Gamma_n}{4\pi V} \left(F_{w_{v,n}} \cos \phi_v - F_{v_{v,n}} \sin \phi_v \right) \end{aligned}$$

(continued on next page)

$$= \alpha_{t_v} \cos \phi_v + \frac{v_{i,v}}{V} \sin \phi_v - \frac{u_{i,v}}{V} \alpha_{\ell_v} + \frac{w_{i,v}}{V} \cos \phi_v \quad v=1,2,\dots,M \quad (99)$$

where $N = M + MP + MT$ and $\alpha_t = \alpha + \alpha_{\ell_v}$ radians. The configuration and coordinate system pertaining to all formulations of this section are shown in figure 11(a) and 11(b).

With the pylon at small angle of incidence i (toe-in is positive), the pylon boundary condition is written for MP control points as:

$$\left\{ \sum_{n=1}^M \frac{\Gamma_n}{4\pi V} \left(-F_{v,n} \right) + \sum_{n=M+1}^{M+MP} \frac{\Gamma_n}{4\pi V} \left(-F_{v,n} - F_{iv,n} \right) + \sum_{n=M+MP+1}^N \frac{\Gamma_n}{4\pi V} \left(-F_{v,n} \right) \right. \\ \left. = i_{t_v} - \frac{u_{i,v}}{V} i_{t_v} + \frac{v_{i,v}}{V} \right\}_{v=M+1, M+2, \dots, M+MP} \quad (100)$$

where $i_t = i + i_{\ell}$ radians. Finally, with MT control points on the left panel of the horizontal tail at small angle of incidence α_{ti} relative to the wing root chord, the tail boundary conditions is specified as

$$\left\{ \sum_{n=1}^M \frac{\Gamma_n}{4\pi V} \left(F_{w,n} \cos \phi_{t_v} - F_{v,n} \sin \phi_{t_v} \right) \right. \\ + \sum_{n=M+1}^{M+MP} \frac{\Gamma_n}{4\pi V} \left[\left(F_{w,n} + F_{iw,n} \right) \cos \phi_{t_v} - \left(F_{v,n} + F_{iv,n} \right) \sin \phi_{t_v} \right] \\ + \sum_{n=M+MP+1}^N \frac{\Gamma_n}{4\pi V} \left(F_{w,n} \cos \phi_{t_v} - F_{v,n} \sin \phi_{t_v} \right) \\ \left. = \alpha_{tt} \cos \phi_{t_v} + \frac{v_{i,v}}{V} \sin \phi_{t_v} \right.$$

(continued on next page)

$$- \left(\frac{u_{i,v}}{V} \alpha_{t\ell_i} + \frac{w_{i,v}}{V} \right) \cos \phi_{t_v} \Bigg\}_{v=M+MP+1, \dots, N} \quad (101)$$

where $\alpha_{tt} = \alpha_{t\ell_v} + \alpha_{ti} + \alpha$ radians and $\alpha_{t\ell_i} = \alpha_{t\ell_v} + \alpha_{ti}$ radians.

Equations (99) and (100) are expanded versions of the boundary conditions described in reference 1. The additions are due to the horizontal tail contributions represented by the third summation term of the expressions (99) and (100). The functions F_u , F_v , F_w are influence functions obtained from the Biot-Savart law. Therefore, the perturbation velocities at a point (x,y,z) induced by a horseshoe vortex on the wing are

$$\begin{aligned} u(x,y,z) &= \frac{\Gamma}{4\pi} F_u(x,y,z,s,\psi_c,\phi) \\ v(x,y,z) &= \frac{\Gamma}{4\pi} F_v(x,y,z,s,\psi_c,\phi) \\ w(x,y,z) &= \frac{\Gamma}{4\pi} F_w(x,y,z,s,\psi_c,\phi) \end{aligned} \quad (102)$$

The functions F_{iv} and F_{iw} in equations (99) through (101) are influence functions associated with an (optional) pylon tip vortex image system which accounts for a portion of the interference caused by the presence of an engine at the pylon tip. The scheme, described in detail in reference 1 and shown in figure 12, consists of treating the engine as a cylindrical duct and imaging within the cylinder the horseshoe vortices present on the pylon. In this manner, the pylon-induced flow through the cylinder is approximately cancelled, the infinite sidewash velocity over the pylon tip is cancelled, and a lift carryover effect from the pylon to the engine is obtained. Since the vortices added in this scheme are images of pylon vortices, their location is known and no new unknown vortex strengths are added.

Equations (99), (100), and (101) represent a set of $M + MP + MT$ equations with $M + MP + MT$ unknown circulation strengths which can be computed through a matrix solution. Two sets of results are calculated: one at zero wing angle of attack which determines the circulations not dependent on α and one with circulations proportional to α , called the additional solution. Addition of these two sets of results

with the latter scaled to the appropriate α yields the total wing-pylon tail circulations at any angle of attack.

For the zero angle solution, the effects of wing camber and twist, pylon camber, twist and incidence, and tail camber, twist and incidence are obtained. If any externally-induced velocities are present, only that part of the velocities which are caused at zero wing angle of attack is to be included. For instance, in the case of an engine beneath the pylon, the zero angle solution should contain the engine-induced velocities caused by engine incidence relative to the wing root chord, the engine operating in the wing-induced sidewash and upwash at zero wing angle, and the flow acceleration (thrust) produced by the engine.

For the additional solution, the physical model is one of an untwisted, uncambered wing at angle of attack, a pylon with no twist, camber and incidence, and a tail with no incidence, twist, and camber. If any externally-induced velocities are present, only that part which is due to wing angle of attack should be included. For instance, in the case of an engine beneath the pylon, the engine is considered an open duct, with no thrust (or drag), aligned with the wing root chord direction and only engine-induced velocities due to engine operation in the α induced wing sidewash and upwash are considered. A proper test of the model for the additional solution is that all calculated loadings go to zero as α goes to zero.

Once the circulations are determined, the load distribution on the wing and tail can be obtained as follows. The force per unit length on the vortex filament is calculated as the product of density, velocity normal to the filament, and circulation strength.

The lift on an element is determined as the sum of two contributions: lift acting on the spanwise leg of the horseshoe vortex and the lift acting on that portion of the trailing legs within the planform. The first is calculated using the velocity at the midpoint of the element quarter chord, the vorticity strength of the bound leg, and the span of the elemental area. The second depends on the values of the velocity at the three-quarter chord of the area element, the net circulation $\Delta\Gamma$ of the coincident legs along the sides of the area element, and the appropriate length of the trailing legs. Because of symmetry, the net strength of the coincident trailing legs and the sidewash velocity

along the wing and tail root chords are zero, consequently no lift is computed along the root chords.

The expression for the elemental lift coefficient is (ref. 1, eq. (4)).

$$\begin{aligned} \left. \frac{L}{qS_{\text{ref}}} \right|_{\text{area element}} &= \frac{2}{S_{\text{ref}}} \frac{\Gamma}{V} 2s \left[\left(1 - \frac{u}{V}\right) \cos \phi + \frac{v}{V} \tan \psi_c \right] \\ &+ \frac{2}{S_{\text{ref}}} c \frac{\Delta \Gamma}{V} \frac{v}{V} \end{aligned} \quad (103)$$

These lifts are summed over the chord to obtain section lift. Summing up the lifts over the wing and tail yields the overall lift coefficient and the summing of elemental lifts multiplied by their respective moment arms gives the pitching moment.

To account for compressibility effects, a version of the Prandtl-Glauert rule is used. The flow is transformed into an equivalent, incompressible flow according to the following relations.

$$\begin{aligned} X' &= X/\beta, \quad Y' = Y, \quad Z' = Z \\ \beta &= \sqrt{1-M_\infty^2} \end{aligned} \quad (104)$$

where the primed quantities are the transformed values. The transformation on the velocity potential

$$\phi'(X', Y', Z') = \phi(X, Y, Z) \quad (105)$$

yields the incompressible form of the linearized differential equation for the velocity potential. Accordingly, the perturbation velocities are related as follows.

$$\begin{aligned} u'(X', Y', Z') &= \beta u(X, Y, Z) \\ v'(X', Y', Z') &= v(X, Y, Z) \\ w'(X', Y', Z') &= w(X, Y, Z) \end{aligned} \quad (106)$$

Since the v and w velocities remain unchanged in the transformation, the boundary condition requires that the actual and transformed slopes

of the wing-pylon camber surface remain the same at given percent chord stations which are equivalent points in the transformation.

Program Description

Calculation procedure.— The computer program proceeds through various stages as follows. The airframe geometry is first read in. This includes information such as leading and trailing edge sweeps, dihedrals, root chords, pylon height, horizontal tail location relative to the wing, and engine cowl radius when appropriate. Then the number of spanwise and chordwise vortices to be laid out on the wing, pylon, and tail are specified through input. Associated with the spanwise specification are spanwise coordinates of the left trailing legs of the horseshoe vortices. The distances from the root chord to the left legs are predetermined by the user and read in separately for the wing, pylon, and tail, respectively.

With the flow conditions, i.e., angle of attack and Mach number, specified through input, the program transforms the airframe according to the compressibility rule described above. It then proceeds to lay out trapezoidal shaped elemental panels in the chordal planes of the wing, pylon, and tail with one horseshoe assigned to a panel. The bound leg is made to coincide with the elemental panel quarter chord while the tails extend chordwise (parallel to the elemental panel side) downstream to infinity. This section of the program also locates the control points at which the boundary conditions are to be satisfied.

After completion of the various coordinate computations, Subroutine INFVW calculates the influence coefficients required by the main program to determine the elements of the influence coefficient matrix. The matrix is defined by the left-hand side of equations (99), (100), and (101). The next step is to build up the array defined by the right-hand side of the equations. At this stage, all local angles of attack and externally induced velocities are read in after which two single column arrays are computed: one for the zero angle case and one for the additional loading case. Subroutine MATINV inverts the matrix and solves for the unknown circulation strengths.

As a next stage, the program calls on Subroutine LOAD to calculate spanwise loadings on the wing and tail as well as the overall lift and

pitching moment coefficients. This calculation is based on the elemental lift expression given by equation (103). The last stage of the program prints out the spanwise loadings on wing and tail together with the overall lift and pitch coefficients.

As an option and after the circulations are known, wing-pylon-tail induced velocities at field points determined by the user can be computed and printed. The program is arranged to handle cases consecutively.

Program operation.- The computer program is written in Fortran IV and has been run on two machines: IBM 360-67 and Univac 1108. For the IBM 360/67, a maximum of 200 control points can be used. No tapes are required other than the standard input and output. For a configuration employing 120 control points, the running time to calculate loadings is about six minutes. For the Univac 1108, which has a somewhat smaller core, the maximum number of control points is limited to 170. The time requirement on this machine for the 120 control point case is about 2 minutes. In connection with the use of the Univac machine, it should be noted that the program as listed herein is dimensioned for 200 control points, and the dimension statements would have to be changed to permit operation on the Univac machine.

Program limitations and precautions.- There are problems that could arise in the use of the program. The first has to do with the layout of the vortices. The velocity induced at a point by a vortex filament becomes singular as the point approaches the filament. For each influence function, Subroutine INFWW avoids the singularity by examining a function which contains the distance between the point and the filament. If the value of this function is less than 10^{-5} (an absolute value independent of the dimensions of the wing and/or horse-shoe vortex), that influence coefficient is set equal to zero. Consequently, it is desirable to maintain a minimum value for the input semispan dimension. It is recommended that the semispan be made equal to or greater than 1.

Some care must be taken in selecting the spanwise widths of adjacent area elements and selecting field point locations for calculating off-wing velocities. As a general rule, the spanwise widths of two adjacent area elements should not differ by more than half of the smaller width. For the case where a pylon is present, the upper

area element on the pylon should have approximately the same spanwise width as the two adjacent elements on the wing. Also, the area elements should be laid out on the wing so that the common streamwise sides of two adjacent elements have the same spanwise coordinate as the pylon. Finally, use of the program has indicated that off-wing velocities can be computed at locations as close to the wing as one-half of the width of the nearest horseshoe vortex. At smaller distances, the influence of the nearest bound vortex filament is unduly large, and unrealistic velocities are computed.

A similar kind of problem can arise in the calculation of tail loads, in the event that a wing-tail combination is calculated. The wing vortex trailing legs extend downstream in the plane of the wing panel (the chordal plane). If the wing has no dihedral and the tail lies in the $Z = 0$ plane, the wing vortex trailing legs will lie in the tail plane. In this event, one of two courses is suggested. First, the spanwise spacing of the elements on the tail can be made the same as those on the wing so that the wing and tail vortex trailing legs coincide. This arrangement will not produce any unrealistic induced velocities on the tail due to the wing wake. Alternately, one can recognize that the wing wake will, in fact, be deflected downward at some angle to the $Z = 0$ plane. As a first approximation, this angle could be taken as $2\alpha/R$ on the basis of lifting line theory. Knowing the axial separation of wing and tail, the distance of the tail plane above the deflected wake can be calculated, and the tail can then be given this vertical offset above the $Z = 0$ plane. The latter method is probably the most realistic in terms of accuracy of the wing-induced interference.

The program contains an error message, "DETERMINANT IS ZERO," which is printed if the influence coefficient matrix is improperly defined. This condition should arise only if there is an error in the input or if the vortex layout is improper, according to the discussion either above or in the following section. The calculation will proceed, however, but an incorrect solution will be generated.

The one other circumstance that will cause the error message to be printed is if the dimensions of IPIVOT and INDEX do not equal NMAX. If the size of the program is reduced to enable the program to be run on a smaller machine than the IBM 360/67, the dimensions of the three variables noted above must be reduced to the same value.

Description of Input

This section describes the input for the computer program. In the following discussion, the content of all input cards is described and, where appropriate, instructions on generating the input quantities are given. All input variables are listed at the end of this section in the order of appearance in the input deck except that the first three variables listed do not appear in the input deck but are needed for program input preparation. The input format for all cards is shown in figure 13, and the item numbers refer to figure 13.

Item 1.- The first card serves as identification and may contain any alphanumeric information desired.

Item 2.- The second card specifies the number of chordwise vortices on the wing panel, pylon, and tail panel (NCW, NCP, and NCT) and the number of spanwise vortices on these components (MSW, MSP, and MST). The remaining variable is the number of image vortices MSPI used to represent the lift carryover due to an engine at the pylon tip. The presence of the pylon is indicated by a non-zero value of MSP. The presence of the tail is indicated by a non-zero value of NCT. If the vortex image is to be used, MSPI must equal MSP. For no image vortices, MSPI = 0.

The accuracy of the predicted lift and moment depends on the number of vortices used. In reference 16, it is suggested that a minimum of 20 vortices be used on the wing semispan (MSW) to obtain accurate lift coefficients. The pitching moment is sensitive to the chordwise number of vortices. For high aspect ratio wings, NCW = 2 may be adequate. In general, it is suggested that NCW = 4. For low aspect ratio wings, larger values may be necessary. For wing-pylon combinations, NCP should equal NCW although it is not required by the program (the program however requires the pylon root chord to be equal to the local wing chord). Reference 16 gives additional insight into the selection of numbers of wing vortices.

Finally, the number of vortices is affected to some extent by the considerations noted under Program Limitations and Precautions.

Item 3.- The three cards described as Item 3 contain data specifying the configuration and the flow condition. The first card contains wing

data, the engine radius, and angle of attack at which the additional loading is to be computed, and the Mach number. The wing chord and semi-span and engine radius are dimensional quantities and should have consistent units. The engine radius need be specified only if the vortex image scheme is used ($MSPI \neq 0$). The sign conventions for the sweep, incidence, and dihedral angles is shown in figure 11 and follows the usual convention wherein positive sweep is sweep aft, positive dihedral corresponds to wing tip above the root chord, positive tail incidence is such as to increase the angle of attack of the tail, and positive pylon incidence is toe-in.

The second and third cards contain the pylon and tail characteristics, respectively. Again, some of this input is dimensional and should have units consistent with the wing dimensions. The pylon may be either above or below the wing, but may not extend both above and below the wing. If the pylon is below the wing, the dihedral angle PHIP is specified as -90° and H is positive. If the pylon is above the wing, PHIP is specified as $+90^\circ$ and H is a negative number. No dihedral angles other than these two are permitted. The pylon may be located at any spanwise station on the wing, including the tip ($FRAC = 1.0$). If neither the pylon nor the tail, nor both, are present, the appropriate card(s) would have all zeros; i.e., a blank card can be used.

Item 4.— The sixth card, described as Item 4, contains the coordinates of the center of moments. These are dimensional quantities, whose units should be consistent with those of the wing, and whose signs must be consistent with the wing coordinate system. The Y coordinate, YM , must be zero.

Item 5.— The seventh card contains several indices which govern the input and output options, as indicated in the table at the end of this section.

Item 6.— The eighth and following cards comprising Item 6 list the spanwise location $Y(I)$ of the outboard trailing legs of each streamwise row of vortices on the wing. The input quantities are dimensional spanwise distances which should have the same units as the wing span and chord input values. All distances are input as positive quantities. The input starts at the root chord and proceeds outward towards the tip, according to the index I . A value of $I = 1$ is assigned to the trailing

legs on the root chord ($Y = 0$). Thus, $Y(1)$ is not input. The first quantity is $Y(2)$, which is the spanwise coordinate of the outboard trailing leg of the innermost horseshoe vortex.

If a pylon is present, one value of $Y(I)$, say $Y(I_{\text{pylon}})$, must be that spanwise coordinate at which the pylon is located; that is, $Y(I_{\text{pylon}}) = \text{SSPAN} \times \text{FRAC}$.

Since there are MSW vortices, spanwise, on the wing, the maximum value of I (which is IMAX) is $\text{MSW} + 1$. IMAX is limited to 50 in the program, so the maximum number of vortices, spanwise, on the wing is limited to 49. The last value of Y to be entered, $Y(\text{IMAX})$, must equal the value of the semispan; that is $Y(\text{IMAX}) = \text{SSPAN}$.

These six items comprise the minimum amount of input data required if the configuration consists only of an uncambered and untwisted wing. The remainder of the input is optional and is governed by the option card, Item 5, and the pylon and tail vortex specifications, MSP and NCT, Item 2.

Item 7.— The first optional set of input is necessary only if a pylon is present ($\text{MSP} \neq 0$). The quantities required are the vertical distances $Z(K)$ from the pylon root chord (the wing-pylon intersection) to the outboard trailing legs of each streamwise row of horseshoe vortices. The distances are all dimensional quantities, which should have the same units as the wing dimensions. As in the wing case, $Z(1)$ is associated with the trailing leg along the wing-pylon junction and is not input. The first quantity entered is $Z(2)$, the location of the outboard leg of the vortex on the pylon nearest the wing. K is limited to 9 ($\text{KMAX} \leq 9$). Consequently the spanwise number of vortices on the pylon, MSP, is limited to 8. The last value of $Z(K)$, $Z(\text{KMAX})$, must equal the pylon span, H , exactly.

For a pylon below the wing, the $Z(K)$ values are positive. For a pylon above the wing, the $Z(K)$ values are negative.

Item 8.— This set of input is necessary only if a tail is present ($\text{NCT} \neq 0$). The three quantities on this card are the X , Y , and Z coordinates of the leading edge of the tail root chord. These are dimensional quantities and must have signs according to the axis system of the wing. The Y coordinate, TNY, must be zero.

Item 9.- This set in input is necessary only if a tail is present (NCT $\neq$ 0). The quantities on these cards are the spanwise distances YT(K) from the tail root chord to the outboard leg of each streamwise row of horseshoe vortices. The procedure for obtaining the input is the same as that for the wing. The layout of the tail vortices should be governed by the comments made under Program Limitations and Precautions. The final value of YT must be equal to the tail semispan TSSPAN. The maximum value of K permitted is 15, which limits the spanwise number of vortices on the tail semispan to 14.

Item 10.- This set of input is necessary only if the wing has camber and twist (ALPHLC = 1.0). The quantities specified in this set of cards are the tangents of the local angles of attack, ALPHAL, of the cambered and twisted lifting surface at each control point for zero wing angle of attack. The first card in this item contains these values for the chordwise row of elemental panels nearest the root chord, starting with the panel nearest the leading edge. In the event that there are more than eight chordwise panels on the wing, the second card would have the values for the ninth, tenth, etc., panels in that first row. Otherwise, the second card has the values for the chordwise row next outboard of the first row, and so on. Thus, there are MSW (or possibly 2 MSW) cards in this item.

The values of ALPHAL are obtained as follows. Consider the upper sketch in figure 11(b), which shows the cambered and twisted section of the lifting surface at some spanwise station η , for zero wing angle of attack. At the control point P, a tangent to the surface is constructed, which makes an angle α_ℓ with the root chord (the X axis). The positive sense of α_ℓ is shown. The input value required is $\text{ALPHAL} = \tan \alpha_\ell$.

Items 11 and 12.- The input quantities in these two items are externally induced velocities at the wing control points. Cards with this input are required only if EI of item 5 is 1.0. Each card has the index number JN of control point and three velocities: u/V , v/V , and w/V . The velocities are those induced at the control points on the left wing panel and must have signs consistent with the wing coordinate system. The control points are considered in the following order: the first is nearest the leading edge and root chord, and the succeeding points proceed aft chordwise to the trailing edge, then from the leading edge

of the next outboard chordwise row aft towards the trailing edge of this row, and so on, ending with the chordwise row at the tip and the control point nearest the tip and trailing edge. There are M cards in each of these two items, where $M = MSW \times NCW$.

The induced velocities in item 11 are those that are present on the wing when the wing angle of attack is zero. The induced velocities in item 12 are those that are proportional to wing angle of attack and have magnitudes associated with the wing angle of attack, $ALPHA$, input in item 3.

Items 13 and 14.— The input quantities in these two items are externally induced velocities at the pylon control points. Cards with this input are required only if EI of item 5 is 1.0 and $MSP \neq 0$ in item 2. The input is determined in much the same manner as items 11 and 12. The order of control points is as follows: the first is nearest the pylon-wing intersection at the leading edge and succeeding points proceed aft in a chordwise direction to the trailing edge, then from the leading edge of the next outboard chordwise row aft to the trailing edge, and so on. There are MP cards, where $MP = MSP \times NCP$. The control point index JN in each card ranges from a value of $M + 1$ for the first card in the item to $M + MP$ in the last card of the item. Item 13 contains velocities present for $\alpha = 0$, and item 14 contains velocities proportional to α .

Items 15 and 16.— The input quantities in these items are externally induced velocities at the tail control points. Cards with this input are required only if EI of item 5 is 1.0 and $NCT \neq 0$ in item 2. The input is determined in much the same manner as in items 11 and 12. There are MT cards, where $MT = MST \times NCT$. The control point index JN ranges from $M + MP + 1$ to $M + MP + MT$. Item 15 contains $\alpha = 0$ velocities and item 16 contains velocities proportional to α .

Item 17.— This set of data is required if a pylon is present ($MSP \neq 0$) and if the pylon has camber and/or twist ($PINCLC = 1.0$ in item 5). The quantities specified are the tangents of the local angles of attack, $PINCL$, of the cambered, twisted pylon mean surface at each control point for zero pylon root chord incidence (toe-in) and zero wing angle of attack. As in the wing case, item 10, the first card contains values for the control points in the chordwise row of panels

nearest the wing-pylon junction, and each succeeding card covers the entire next outboard chordwise row. There are MSP cards in this item.

The values of PINCL are obtained as follows. Consider the middle sketch of figure 11(b), which shows a section of a pylon under the left wing panel. The pylon root chord has toe-in, so that it makes an angle i with the X direction. Due to a combination of twist and camber, the tangent to the pylon mean surface at control point P makes an angle i_ℓ with the pylon root chord direction, positive as shown. Then $PINCL = \tan i_\ell$.

Item 18.— This set of data is required only if a tail is present ($NCT \neq 0$) and the tail has camber and/or twist ($TLPHAC = 1.0$ in item 5). The quantities specified are the tangents of the local angles of attack, $TLPHAL$, of the cambered and/or twisted lifting tail surface for zero wing angle of attack and for zero tail incidence angle. The order of points and card arrangement follows those of items 10 and 17. There are MST cards in this item.

The values of $TLPHAL$ are obtained as follows. Consider the lower sketch of figure 11(b), which shows a tail whose root chord is located above the wing a distance TNZ and makes a positive incidence angle α_{ti} with respect to the X axis. At some spanwise station, the tangent to the mean surface at control point P makes an angle $\alpha_{t\ell}$ with the tail root chord direction, due to camber and twist, where $\alpha_{t\ell}$ is positive as shown. Then $TLPHAL = \tan \alpha_{t\ell}$.

Item 19.— This set of data is required only if induced velocities are to be computed at field points adjacent to the wing-pylon-tail ($MMM \neq 0$ in item 5). The number of cards in this item is MMM . Each card has X , Y , and Z coordinates of a point where the induced velocities are desired. The points need not be in any particular order, although an order might be dictated by the subsequent use of the output as, for instance, an engine-wing interference calculation.

This completes the description of the input and its preparation. The program variables with algebraic symbol and comments are listed below in the order in which they appear in the input deck.

<u>Program Variable</u>	<u>Algebraic Symbol (if applicable)</u>	<u>Comment</u>
M	M	number of control points on wing semispan $M = NCW \times MSW$
MP	MP	number of control points on pylon $MP = MCP \times MSP$
MT	MT	number of control points on tail semispan $MT = NCT \times MST$
JN		running index of control points $1 < JN < (M + MP + MT)$
<u>Item 2</u>		
NCW		number of chordwise vortices on wing
NCP		number of chordwise vortices on the pylon, $NCP = NCW$
MSW		number of spanwise vortices on left wing panel, $1 \leq MSW \leq 49$
MSP		number of spanwise vortices on the pylon. If $MSP = 0$, no pylon is present, $MSP \leq 8$
MSPI		number of spanwise image vortices, $MSPI = MSP$. If $MSPI = 0$, image vortex scheme is not included (also see RAD).
NCT		number of chordwise vortices on the horizontal tail. If $NCT = 0$, no tail is present.
MST		number of spanwise vortices on left tail panel, $1 \leq MST \leq 14$
<u>Item 3</u>		
PSIWLI	ψ_{wLE}	wing leading-edge sweep angle measured in the wing planform, positive for sweep back, deg.
PSIWTI	ψ_{wTE}	wing trailing-edge sweep angle measured in the wing planform, positive for sweep back, deg.
CRWI	c	wing root chord, dimensional
SSPAN	b/2	wing semispan, dimensional
PHI	ϕ	wing dihedral, positive for tips above root chord, deg.

(Input program variables, cont.)

<u>Program Variable</u>	<u>Algebraic Symbol (if applicable)</u>	<u>Comments</u>
RAD		engine radius, dimensional: RAD = 0.0 corresponds to the case of MSPI = 0; if MSPI = 1, a non-zero value of RAD must be specified
ALPHA	α	wing root chord angle of attack relative to free stream, deg.
MACH	M_{∞}	free-stream Mach number
PSIPLI	$\psi_{p_{LE}}$	pylon leading-edge sweep angle, positive for sweep back, deg.
PSIPTI	$\psi_{p_{TE}}$	pylon trailing-edge sweep angle, positive for sweep back, deg.
CRPI		pylon root chord, dimensional
H		pylon height (span), dimensional value is positive for pylon below wing and negative for pylon above wing
PHIP		pylon dihedral angle: -90.0 for pylon below wing and +90.0 for pylon above wing, deg.
FRAC	$Y_{PYL}/(b/2)$	spanwise pylon location, fraction of semispan
PINC	i	pylon incidence relative to X direction, toe-in positive, deg.
PSITLI	$\psi_{t_{LE}}$	horizontal tail leading-edge sweep angle measured in tail planform, positive for sweep back, deg.
PSITTI	$\psi_{t_{TE}}$	horizontal tail trailing-edge sweep angle measured in tail planform, positive for sweep back, deg.
CRTI		tail root chord, dimensional
TSSPAN	$b_t/2$	tail semispan, dimensional
PHIT	ϕ_t	tail dihedral, positive for tip above root chord, deg.
TLINC	α_{ti}	horizontal tail angle of incidence with respect to wing root chord, positive for upward induced face, deg.

(Input program variables, cont.)

<u>Program Variable</u>	<u>Algebraic Symbol (if applicable)</u>	<u>Comments</u>
<u>Item 4</u>		
XM YM ZM	}	coordinates of pitching-moment center in wing coordinate system, dimensional
<u>Item 5</u>		
MMM		number of locations in vicinity of wing-pylon-tail at which wing-pylon-tail induced velocities are determined ($MMM < 50$). If $MMM = 0$, induced velocities are not calculated
ALPHLC		ALPHLC = 0.0: wing without camber and twist ALPHLC = 1.0: wing with camber and twist. (ALPHAL(J) must be read in item 10)
PINCLC		PINCLC = 0.0: pylon without camber and twist PINCLC = 1.0: pylon with camber and twist (PINCL(J) must be read in item 17)
TLPHAC		TLPHAC = 0.0: tail without camber and twist TLPHAC = 1.0: tail with camber and twist (TLPHAL(J) must be read in item 18)
EI		EI = 0.0: no externally induced velocities EI = 1.0: externally induced velocities included (All cards described in items 11-16 must be included in input deck even though some may be blank)
CIRCP		CIRCP = 0.0: horseshoe vortex characteristics not printed CIRCP = 1.0: horseshoe vortex characteristics printed in output
<u>Item 6</u>		
Y(I)	Y(2),Y(3),..., Y(IMAX)	distance from wing root chord to outboard trailing leg of Ith wing horseshoe vortex, dimensional ($2 < I < IMAX$, $IMAX \leq 50$). One value must equal $FRAC*SSPAN$ if a

(Input program variables, cont.)

<u>Program Variable</u>	<u>Algebraic Symbol (If applicable)</u>	<u>Comments</u>
Y(I) cont.		pylon is present, and the last value must equal SSPAN, identically
<u>Item 7</u>		
Z(K)	Z(2), Z(3), ..., Z(KMAX)	distance from pylon root chord to outboard trailing leg of Kth pylon horseshoe vortex, dimensional $2 \leq K \leq KMAX$. Z(K) are positive for pylon below wing and negative for pylon above wing. Last value must equal H identically. If MSP = 0, no input cards are necessary
<u>Item 8</u>		
TNX TNY TNZ }		horizontal tail root chord nose coordinates, dimensional. If NCT = 0, no input cards are necessary
<u>Item 9</u>		
YT(IT)	YT(2), YT(3), ..., YT(ITMAX)	distance from horizontal tail root chord to outboard trailing leg of ITth tail horseshoe vortex, dimensional ($2 \leq IT \leq ITMAX$, $ITMAX < 15$). The last value must equal TSSPAN, identically. If NCT = 0, no input cards are necessary
<u>Item 10</u>		
ALPHAL(J)	$\tan \alpha_{\ell}(1), \tan \alpha_{\ell}(2), \dots, \tan \alpha_{\ell}(M)$	tangent of local angle of attack of wing mean surface at J'th control point due to wing twist and camber. See figure 11 for sign convention. $1 \leq J \leq M$, $M \leq 125$. (If ALPHLC = 0.0, no input cards are necessary)
<u>Item 11</u>		
UEI(JN,1)	$\frac{u_i}{V} (1,1), \frac{u_i}{V} (2,1),$ $\dots, \frac{u_i}{V} (M,1)$	

(continued on next page)

(Input program variables, cont.)

<u>Program Variable</u>	<u>Algebraic Symbol (if applicable)</u>	<u>Comments</u>
VEI (JN,1)	$\frac{v_i}{V} (1,1), \frac{v_i}{V} (2,1),$ $\dots, \frac{v_i}{V} (M,1)$	externally induced velocity components at JN'th wing control points for zero angle case. $1 \leq JN \leq M, M \leq 125$. (If EI = 0.0, no input cards are necessary)
WEI (JN,1)	$\frac{w_i}{V} (1,1), \frac{w_i}{V} (2,1)$ $\dots, \frac{w_i}{V} (M,1)$	
<u>Item 12</u>		
VEI (JN,2)	$\frac{v_i}{V} (1,2), \frac{v_i}{V} (2,2),$ $\dots, \frac{v_i}{V} (M,2)$	externally induced velocity components at JN'th wing control point for additional loading case. $1 \leq JN \leq M, M \leq 125$. (If EI = 0.0, no input cards are necessary)
WEI (JN,2)	$\frac{w_i}{V} (1,2), \frac{w_i}{V} (2,2),$ $\dots, \frac{w_i}{V} (M,2)$	
<u>Item 13</u>		
UEI (JN,1)	$\frac{u_i}{V} (M+1,1), \frac{u_i}{V} (M+2,1),$ $\dots, \frac{u_i}{V} (M+MP,1)$	externally induced velocity components at JN'th pylon control point for zero angle case. $M + 1 \leq JN \leq M + MP, M \leq 125, MP \leq 25$. (If EI = 0.0, no input cards are necessary)
VEI (JN,1)	$\frac{v_i}{V} (M+1,1), \frac{v_i}{V} (M+2,1),$ $\dots, \frac{v_i}{V} (M+MP,1)$	
<u>Item 14</u>		
VEI (JN,2)	$\frac{v_i}{V} (M+1,2), \frac{v_i}{V} (M+2,2),$ $\dots, \frac{v_i}{V} (M+MP,2)$	externally induced velocity components at JN'th pylon control point for additional loading case. $M + 1 \leq JN \leq M + MP, M \leq 125, MP \leq 25$. (If EI = 0.0, no input cards are necessary)

(Input program variables, cont.)

<u>Program Variable</u>	<u>Algebraic Symbol (if applicable)</u>	<u>Comments</u>
<u>Item 15</u>		
UEI (JN,1)	$\frac{u_i}{V} (M+MP+1,1),$	externally induced velocity components at JN'th tail control point for zero angle case. $M + MP + 1 \leq JN \leq M + MP + MT,$ $M \leq 125, MP \leq 25, MT \leq 50.$ (If EI = 0.0, no input cards are necessary)
	$\frac{u_i}{V} (M+MP+2,1),$	
	$\dots, \frac{u_i}{V} (M+MP+MT,1)$	
VEI (JN,1)	$\frac{v_i}{V} (M+MP+1,1),$	
	$\frac{v_i}{V} (M+MP+2,1),$	
	$\dots, \frac{v_i}{V} (M+MP+MT,1)$	
WEI (JN,1)	$\frac{w_i}{V} (M+MP+1,1),$	
	$\frac{w_i}{V} (M+MP+2,1),$	
	$\dots, \frac{w_i}{V} (M+MP+MT,1)$	
<u>Item 16</u>		
VEI (JN,2)	$\frac{v_i}{V} (M+MP+1,2),$	externally induced velocity components at JN'th tail control points for additional loading case. $M + MP + 1 \leq JN \leq M + MP + MT,$ $M \leq 125, MP \leq 25, MT \leq 50.$ (If EI = 0.0, no input cards are necessary)
	$\frac{v_i}{V} (M+MP+2,2),$	
	$\dots, \frac{v_i}{V} (M+MP+MT,2)$	
WEI (JN,2)	$\frac{w_i}{V} (M+MP+1,2),$	
	$\frac{w_i}{V} (M+MP+2,2),$	
	$\dots, \frac{w_i}{V} (M+MP+MT,2)$	

(Input program variables, cont.)

<u>Program Variable</u>	<u>Algebraic Symbol (if applicable)</u>	<u>Comments</u>
<u>Item 17</u>		
PINCL(J)	$\tan i_{\ell}(1), \tan i_{\ell}(2), \dots, \tan i_{\ell}(MP)$	tangent of angle between pylon mean surface tangent at J'th control point and pylon root chord direction, due to camber and twist of the pylon. See figure 11 for sign convention. $1 \leq J \leq MP$. (If PINCLC = 0.0, no input cards are necessary)
<u>Item 18</u>		
TLPHAL(J)	$\tan \alpha_{t\ell}(1), \tan \alpha_{t\ell}(2), \dots, \tan \alpha_{t\ell}(MT)$	tangent of angle of attack of tail mean surface at J'th control point relative to wing root chord plane, due to tail camber and twist. See figure 11 for sign convention. $1 \leq J \leq MT$. If TLPHAC = 0.0, no input cards are necessary.
<u>Item 19</u>		
PMX (MM) PMY (MM) PMZ (MM)		coordinates of locations at which wing-pylon-tail induced velocities are computed. $1 \leq MM \leq MMM$ If MMM = 0, no input cards are required

Samples of two input decks are shown in figure 14 illustrating the previously discussed options. The first input deck shown is for a wing-pylon-tail configuration with no externally induced velocities. The image vortex scheme is included. The vortex lattice is made up of 20 spanwise rows and 4 chordwise rows of vortices on the left wing panel, 10 spanwise rows and 2 chordwise rows of vortices on the left tail panel, and 2 spanwise rows and 4 chordwise rows of vortices on the left pylon. The airframe configuration is that shown in figure 16 and the flow conditions are specified by a free stream Mach number of 0.7 and angle of attack of 2.5° . The induced velocity field in the vicinity of a turbofan engine is required.

The second input deck shown in figure 14 concerns the same configuration, but includes velocities induced by a high bypass ratio turbofan engine. The preparation of input for this case is discussed in detail in the section entitled "Sample Interference Calculation."

Description of Output

This section describes the output from the wing-pylon-tail program. In the following, all items of output are enumerated and the contents briefly described. Two sample outputs are shown in figure 15.

The first page identifies the run and prints the geometry data, vortex distributions, and flow conditions as specified in the input. The wing root chord angle of attack, $\alpha = \text{ALPHA}$, is given in degrees on this page. In all following items ALPHA is specified in radians. On the next pages, program-computed control point coordinates are listed together with the mean surface slopes specified in the input as tangents. This part of the output also prints the externally induced velocities corresponding to the zero angle and additional loading cases. In the first sample case, figure 15(a), these velocities appear as zeroes. Whereas in the second case, figure 15(b), non-zero values were read in. The next item is optional, called for by $\text{CIRCP} = 1.0$ in the input, and provides information concerning the computed horseshoe vortex characteristics. This output starts on a new page and includes bound leg midpoint coordinates, bound leg sweep angles and vortex half widths. The calculated vortex strengths for the zero angle and additional cases are also listed in this option. The following new page contains the aerodynamic performance parameters computed by the program. All force and moment coefficients are referenced with respect to wing (planform) area and wing average chord, which are listed. Results are computed for the zero angle and additional cases. In the case of the span load coefficients, $c_{c_l}/C_L C_{av}$, the wing lift coefficient C_L is that for the loading case being considered. All length dimensions are the same as in the input and the coordinate system associated with the control points, etc., is shown in figure 11. The last and optional item is called by $\text{MMM} \neq 0$ in the input and starts on a new page. This output includes coordinates of the locations at which wing-pylon-tail induced velocities are calculated and the induced velocity components at these locations for both the zero angle and additional loading cases.

Program Listing

The wing-pylon-tail vortex lattice program is written in Fortran IV for the IBM 360/67 computer. The program consists of the main program and three subroutines.

<u>Program</u>	<u>Identification</u>	<u>Page No.</u>
MAIN	VL01	102
LOAD	VL02	110
INFWW	VL03	115
MATINV	VL04	115

C WING-PYLON-TAIL VORTEX LATTICE PROGRAM
C THIS PROGRAM CONSISTS OF
C MAIN PROGRAM
C SUBROUTINE LOAD
C SUBROUTINE INIW
C SUBROUTINE MATINV

C THIS PROGRAM IS ARRANGED TO LAY-OUT MAXIMUM OF 125 VORTICES ON
C THE LEFT WING PANEL, 25 ON THE LEFT PYLON, 50 ON THE LEFT HORIZON-
C TAL TAIL PANEL, TOTAL NUMBER OF VORTICES MUST NOT EXCEED 200

C MAXIMUM 49 SPANWISE ROWS ON LEFT HALF WING, 9 ON PYLON, 14 ON LEFT
C TAIL

C DIMENSION STATEMENTS

C DIMENSION Y(50),Z(9),SUMY(50),SUMZ(9),SWPVI(125),SWPC(9),PVX(125),
C 1PVY(125),PVZ(125),PCX(125),SW(125),SP(25),SWPCP(9),PVPX(25),
C 2PVPY(25),PVPZ(25),PCPX(25),FVW(2),FVW(2),FVW(2),FVW(2),
C 3FVW(2),FVW(2),CIR(200,2),YWP(2),YWP(2),YWP(2),YWP(2),FVN(200,200),
C 41PVT(200),INDEX(200,2),PVPXBE(125),PVPXBE(125),TALK(20),
C 5PCXBE(125),SWPVP(125),SWPVP(25),PCPXBE(25),ZI(9),SPI(25),
C 6SUMZI(9),SWPVP(25),SWPCP(9),PVPX(25),PVPY(25),PVPZ(25),
C 7PCPX(25),YWP(2),PTLX(125),PTLY(125),PTLZ(125),CHLOC(50),
C 8YRTW(2),YRT(2),YRT(2),YRT(2),YRT(2),YRT(2),V(125,2),U(125,2),
C 9V(125,2),T(125),SUMLI(2) , TLLIFT(125,2),PLIFT(125,2),YMPI(2)

C DIMENSION
C 1CHLIFT(50,2),SLOC(50,2),SLOC(50,2),ELPANL(125),FUPT(2),FVPI(2),
C 2FWPI(2),VLOC(50),UF(50,2),VE(50,2),PMX(50),PMY(50),
C 3PMZ(50),YWM(2),YPM(2),YPM(2),ALPHA(125),PINCL(25),UF(200,2),
C 4VE(200,2),WFI(200,2),BLIFR(125,2),SECLIF(50,2),SUNCIR(200),
C 5CHLOC(50),YT(15),SUMYT(15),
C 6TYLOC(15),ST(50),SWPT(9),SWPTV(50),SWPTV(50),PVTV(50),
C 7PVTV(50),PCTX(50),PTLX(50),PTLY(50),PTLZ(50),PCTXBE(50),
C 8YRTW(2),FUT(2),FVT(2),FVT(2),TUMLI(2),TCHLIF(15,2),YTT(2),
C 9YRTW(2),YRT(2),TCHLOC(15),TSLOC(15,2),TECLIF(15,2),TSLOC(15,2),
C 1YRTW(2),TMMOM(2),TMMOM(2),TMMOM(2),FVNT(200,25),CIRI(25,2),
C 2SUMCII(25),TLPHAL(50),VETOT(30),WETOT(50),
C 3YRT(2),YPT(2),YPT(2),YTM(2),YRTPI(2),YRTPI(2),TT(50),TLPANL(50),
C 4TLLIFT(50,2),RLIFT(50,2),VT(50,2),UT(50,2),VRT(50,2),CLTOT(2)

C COMMON CRWI,SSPAN,SWPVI,SWPVI,SRFF,CAVE,SUMLI,CHLIFT,NCW,V,M,
C 1YTH,PTLX,PTLY,PTLZ,PVX,PVY,PVZ,SWPVP,PHI,SW,FVW,FVW,CIP,MSP,
C 2MPI,MMP,YTP,PVPX,PVPY,PVPZ,SWPVP,PHIP,SP,FUP,FVP,FWP,MSP,MPI,
C 3NMMP,MP,YTP,PVPX,PVPY,PVPZ,SWPVP,PHI,FUPI,FVPI,FWPI,CIRI,
C 4NCT,MT,PVTX,PVTY,PVTZ,SWPTV,PHI,YTT,ST,FUT,FVT,FWT,U,V,W,YRW,
C 5YRPI,YRT,CHLOC,Y,SWPWF,SWPWF,T,CSPI,FRAC,IMAX,ELPANL,TLLIFT,
C 6BLIFR,BLLIFT,SLOC(1),SECLIF,SLOC(1),BETA,CRW,CPT,XMC,YRP,
C 7CWT,SSPAN,SWPTI,SWPTI,TSREF,TCAVE,TUMLI,TCHLIF, VT,YTTW,
C 8PTLX,PTLY,PTLZ,UT,VRT,YRTW,YRT,YRT,YRTI,TCHLOC,YT,SWPTI
C COMMON SWPTT,T,CSPI,ITMAX,TLPANL,TLLIFT,BLLIFT,TSLOC,
C 1TECLIF,TSLOC,TMMOM,TMMOM,TMMOM,CLTOT,UEI,VEI,WFI

C NMAX=200

C PEAL MACH

C 1 FORMAT (1H1,2TX,32HUNIFORM VORTEX CHARACTERISTICS//10X,17HUNIFORM VORTEX
C 1FG MIDPOINT,35X,24HUNIFORM STRENGTHS,GAMMA/V/13X,11HCOORDINATES// 3XVLOC(100,65
C 2,1HJ,5X,1HX,9X,1HY,5X,1HZ,5X,1HWSWEEP(100,65),1X,9HSEMIWIDTH,7X,7HALPHAL(100,65
C 3HA=0,6X,17HADDITIONAL,ALPHA=,F9.4/2X,13HUNIFORM VORTICES//
C 4 FORMAT (7I5)
C 7 FORMAT (8F10.5)
C 9 FORMAT (4X,23HSEMI SWEEP,DEG. , F9.4,2X,F9.4,2X,F9.4)
C 9 FORMAT (3X,1HJ,5X,1HX,9X,1HY,5X,1HZ,5X,1HWSWEEP,12X,
C 1,7X,3HV/V,7X,3HW/V,17X,3HV/V,7X,3HW/V)

10 FORMAT (4X,23HPYLON INCIDENCE,DEG. , 8H-----,2X,F9.4,2X,8H-----VLOC(100,65
C 1-----)
C 11 FORMAT (2F18.4, 1F24.4, 1F9.4, 1F13.4)
C 12 FORMAT(14H CIRC/CHORD, 14H CIRC/CHORD, 14H VOR SEMIWIDTH, 14H VOR SEMIWIDTH,
C 112H VOR SWEEP, 15H X,UNSTRETCHED,13H Y , 13H Z VLOC(100,65
C 2 , 13HSUM CIRC/CHORD / 4X, 10H ALPHA=0,4X,10HADDITIONAL,17X, VLOC(100,65
C 311HUNSTRETCHED)
C 13 FORMAT (14,1X,F9.4,2X,F9.4,2X,F9.4,2X,F9.4,2X,F9.4,7X,F9.4,7X, VLOC(100,65
C 1F8.4)
C 14 FORMAT (1H1, 20A4//)
C 15 FORMAT (20A4)
C 17 FORMAT (1H1, 25H DETERMINANT IS ZERO)
C 18 FORMAT (9X,22HTOTAL LIFT COEFFICIENT,19X,24HTOTAL MOMENT COEFFICIENT,19X,24HTOTAL
C INT)
C 19 FORMAT (5X,F9.4,5X,F9.4,2X,F9.4,5X,F9.4)
C 21 FORMAT (4X,23HDIHEDRAL,DEG. , F9.4,2X,F9.4 ,2X,F9.4) VLOC(100,65
C 22 FORMAT (4X,23HROOT CHORD , F9.4,2X,F9.4,2X,F9.4) VLOC(100,65
C 23 FORMAT (3X,13,7X,F9.4,6X,F9.4,6X,F9.4,6X,F9.4,3X,F9.4,7X,F9.4) VLOC(100,65
C 24 FORMAT (3X,4HWING//)
C 25 FORMAT (4X,23HSEMI SPAN , F9.4,2X,8H-----,2X,F9.4) VLOC(100,65
C 26 FORMAT (4X,23HPYLON LOC./WING SEMISP. , 8H-----,2X,F9.4,2X,8H-----VLOC(100,65
C 1-----)
C 27 FORMAT (4X,23HPYLON HEIGHT , 8H-----,2X,F9.4,2X,8H-----VLOC(100,65
C 1-----)
C 28 FORMAT (/24X,20HREFERENCE QUANTITIES//5X,11HWING SPAN,8,4X,23HWING VLOC(100,65
C 1 PLANFORM AREA,SREF,4X,10HWING AVE.CHORD,CAVE)
C 29 FORMAT (7X,F9.4,11X,F9.4,14X,F9.4) VLOC(100,65
C 30 FORMAT (4X,23HLE SWEEP,DEG. , F9.4,2X,F9.4,2X,F9.4) VLOC(100,65
C 31 FORMAT (10F8.5) VLOC(100,65
C 32 FORMAT (115,5F5.1) VLOC(100,65
C 33 FORMAT (3F10.3) VLOC(100,65
C 34 FORMAT (1H1,4X,36HCONTROL POINT COORDINATES AND SLOPES,15X, VLOC(100,65
C 129HEXTREMALLY INDUCED VELOCITIES)
C 35 FORMAT (14,1X,F9.4,2X,F9.4,2X,F9.4,2X,F9.4,6X,F9.5,1X,F9.5,1X,F9.5 VLOC(100,65
C 1,11X,F9.5,1X,F9.5)
C 36 FORMAT (1H1,9X,66HVELOCITIES INDUCED AT SPECIFIED POINTS IN THE VLOC(100,65
C 1CINITY OF THE WING// 41X,1H(,9X,7HALPHA=0,12X,1H),5X,1H(3X,17HADDITIONAL
C 2TIONAL,ALPHA=,F9.4,1H), VLOC(100,65
C 37 FORMAT (114,8F13.6) VLOC(100,65
C 38 FORMAT (4X,30HPITCHING MOMENT CENTER ,2X,F9.4,2X,F9.4,2X,F9.4 VLOC(100,65
C 1.4)
C 39 FORMAT (2X,12,3X,F9.4,2X,F9.4,2X,F9.4,7X,F9.5,2X,F9.5,2X,F9.5,7X, VLOC(100,65
C 1F8.5,2X,F9.5,2X,F9.5)
C 40 FORMAT (3X,1HJ,6X,1HX,9X,1HY,9X,1HZ,13X,3HV/V,7X,3HW/V, VLOC(100,65
C 112X,3HV/V,7X,3HW/V,7X,3HW/V//)
C 41 FORMAT (114,6F15.6) VLOC(100,65
C 43 FORMAT (15, 3F12.4) VLOC(100,65
C 45 FORMAT (15,3F25.6) VLOC(100,65
C 46 FORMAT (4X,30HTAIL PT.CHORD NOSE COORDINATES,2X,F9.4,2X,F9.4,2X,F9.4 VLOC(100,65
C 1.4)
C 47 FORMAT (/2X,10HWING CONTROL POINTS//)
C 48 FORMAT (14,2X,F9.4,2X,F9.4,2X,F9.4,2X,F9.4,6X,F9.5,1X,F9.5,1X, VLOC(100,65
C 10H-----,11X,F9.5,1X,9H-----)
C 49 FORMAT (4X,23HTAIL INCIDENCE,DEG. , 8H-----,2X,8H-----,2X VLOC(100,65
C 1,F9.4)
C 50 FORMAT (/22X, 9HVEI,ADTL)
C 51 FORMAT (/51X,1H(,4X,7HALPHA=0,16X,1H),1X,1H(2X,17HADDITIONAL,ALP VLOC(100,65
C 1HA=,F9.4,1H)/34X,12HMEAN SURFACE)
C 53 FORMAT (1F31.4, 2I29) VLOC(100,65
C 54 FORMAT (1F23.4, 2F18.4, 1F25.4, 1F13.4,2F14.4) VLOC(100,65
C 55 FORMAT (1F17.4, 3I29) VLOC(100,65
C 56 FORMAT (/30X, 12H MACH NUMBER) VLOC(100,65
C 57 FORMAT (1F38.4, 1F12.4) VLOC(100,65
C 58 FORMAT (4X,23HCHORDWISE VORTICES ,2X,13,7X,13,7X,13) VLOC(100,65
C 59 FORMAT (/34X,13HGEOMETRY DATA//22X, 4HWING,6X, 5HPYLON,5X, 4HTAIL VLOC(100,65
C 1//)
C 60 FORMAT (4X,23HSPANWISE VORTICES ,2X,13,7X,13,7X,13) VLOC(100,65
C 61 FORMAT (15X,44HENGINE INDUCED VELOCITIES ON HORIZONTAL TAIL/22X,9H VLOC(100,65
C 10,ALPHA=0,17X,9HV,ALPHA=0,17X,9HV,ALPHA=0) VLOC(100,65
C 62 FORMAT (4X,16HTURBULENCE RADIUS=,4X,F9.4) VLOC(100,65
C 63 FORMAT (2F18.4,1F24.4,1F14.4,3F18.4) VLOC(100,65
C 64 FORMAT (/3X,4HTAIL//) VLOC(100,65

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65 FORMAT(/24X,26HSPANWISE LOAD DISTRIBUTION//2X, 7HSTATION,5X, 7HY/(VLO10145
1R/2),5X,13HLOCAL CHORD,C,6X,12HCL*G/CL*CAVE,14X,10HCL*G/(2R)//42XVLO10146
2,7HALPHA=0,2X,10HADDITIONAL,7X,7HALPHA=0,2X,10HADDITIONAL/51X, 6HAVLO10147
3LPHA=F,4,12X, 6HALPHA=F,4) VLO10148
66 FORMAT (4X,26HANGLE OF ATTACK,ALPHA,DEG.,7X,F8.4) VLO10149
67 FORMAT(43X, 112,27X, 112) VLO10150
68 FORMAT (/2X,13HTAIL VORTICES) VLO10151
69 FORMAT (3F10.5) VLO10152
70 FORMAT (4X,20HMACH NUMBER ,13X,F8.4) VLO10153
71 FORMAT (/5X,7HALPHA=0,5X,17HADDITIONAL,ALPHA=F,4,5X,7HALPHA=0, VLO10154
14X,17HADDITIONAL,ALPHA=F,4) VLO10155
72 FORMAT (1H1,33X,27HAERODYNAMIC LOADING RESULTS//9X,21HWING LIFT CVLO10156
10EFFICIENT,20X,21HTAIL LIFT COEFFICIENT) VLO10157
73 FORMAT (/39X,21HX Y Z) VLO10158
74 FORMAT (/2X,20HPYLON CONTROL POINTS/) VLO10159
75 FORMAT (/2X,19HTAIL CONTROL POINTS/) VLO10160
76 FORMAT (/2X,14HPYLON VORTICES/) VLO10161
77 FORMAT (/2X,20HPYLON IMAGE VORTICES) VLO10162
78 FORMAT (/34X,15HFLOW CONDITIONS//) VLO10163
VLO10164
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VLO10216

1000 READ(5,15) TALK
C
C
C INITIALIZE TERMS
C
DO 3007 K=1,NMAX
DO 3311 J=1,NMAX
3311 FVN(J,K)=0.0
CIR(K,1)=0.0
CIR(K,2)=0.0
UEI(K,1)=0.0
UEI(K,2)=0.0
VEI(K,1)=0.0
VEI(K,2)=0.0
WEI(K,1)=0.0
WEI(K,2)=0.0
3007 DO 3008 J=1,125
ALPHA(J)=0.0
U(J,1)=0.0
U(J,2)=0.0
V(J,1)=0.0
V(J,2)=0.0
WB(J,1)=0.0
WB(J,2)=0.0
SW(J)=0.0
ELPANL(J)=0.0
BLLIFT(J,1)=0.0
BLLIFT(J,2)=0.0
TLLIFT(J,1)=0.0
TLLIFT(J,2)=0.0
BLLIFR(J,1)=0.0
3008 BLLIFR(J,2)=0.0
C
DO 3241 J=1,25
DO 3215 K=1,NMAX
3215 FVNI(J,K)=0.0
PINCL(J)=0.0
CIRI(J,1)=0.0
3241 CIRI(J,2)=0.0
C
DO 3218 J=1,50
TLPAL(J)=0.0
UT(J,1)=0.0
UT(J,2)=0.0
VT(J,1)=0.0
VT(J,2)=0.0
VBT(J,1)=0.0
VBT(J,2)=0.0
TLPANL(J)=0.0
YTLEFT(J,1)=0.0
TTLIFT(J,2)=0.0

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BTLIFT(J,1)=0.0 VLO10217
3218 BTLIFT(J,2)=0.0 VLO10218
C VLO10219
C VLO10220
C WRITE (6,14) TALK VLO10221
C VLO10222
C READ IN NUMBER OF CHORDWISE VORTICES ON WING AND PYLON, SPANWISE VLO10223
VORTICES ON WING AND PYLON, SPANWISE ON IMAGE PYLON, CHORDWISE AND VLO10224
SPANWISE ON HORIZONTAL TAIL VLO10225
C VLO10226
C READ (5,6) NCW,NCP,MSW,MSP,MSP1,NCT,MST VLO10227
C VLO10228
C READ IN WING L.E. AND T.E. SWEEP ANGLES,WING ROOT CHORD, VLO10229
WING SEMISPAN,WING DIHEDRAL,TURBOFAN RADIUS,WING ROOT CHORD VLO10230
C ANGLE OF ATTACK, FREE STREAM MACH NUMBER. VLO10231
C READ IN PYLON L.E. AND T.E. SWEEP ANGLES,PYLON ROOTCHORD, VLO10232
PYLON HEIGHT,PYLON DIHEDRAL,PYLON LOCATION,PYLON INCIDENCE. VLO10233
C READ IN TAIL L.E. AND T.E. SWEEP ANGLES,TAIL ROOTCHORD, VLO10234
C TAIL SEMISPAN,TAIL DIHEDRAL,TAIL INCIDENCE. VLO10235
C VLO10236
C READ (5,7) PSIWLI,PSIWTI,CRWI,SSPAN,PHI,RAD,ALPHA,MACH VLO10237
READ (5,7) PSIPLI,PSIPTI,CRPI,H,PHIP,FRAC,PINC VLO10238
READ (5,7) PSITLI,PSITTI,CPTI,TSSPAN,PHIT,TLINC VLO10239
TALPHA=ALPHA VLO10240
SWPWL1 =TAN ((PSIWLI/180.0)*3.1416) VLO10241
SWPWT1 =TAN ((PSIWTI/180.0)*3.1416) VLO10242
SWPPL1 =TAN ((PSIPLI/180.0)*3.1416) VLO10243
SWPPT1 =TAN ((PSIPTI/180.0)*3.1416) VLO10244
TANPHI =TAN ((PHI/180.0)*3.1416) VLO10245
TTNPHI =TAN ((PHIT/180.0)*3.1416) VLO10246
SWPTLI =TAN ((PSITLI/180.0)*3.1416) VLO10247
SWPTTI =TAN ((PSITTI/180.0)*3.1416) VLO10248
C VLO10249
C READ IN MOMENT CENTER VLO10250
C VLO10251
C READ (5,7 ) XM,YM,ZM VLO10252
C VLO10253
C CONTROL CARD-MMM IS NUMBER OF POINTS ON TURBOFAN WHERE VELOCITIES VLO10254
INDUCED BY WING-PYLON-TAIL ARE TO BE COMPUTED, ALPHLC=0 INDICATES VLO10255
NO WING CAMBER AND TWIST, 1.0 INDICATES WITH CAMBER AND TWIST, VLO10256
PINCLC INDICATES SAME FOR PYLON, TLPHAC FOR TAIL, EI=0.0 INDICATES VLO10257
NO EXTERNALLY INDUCED VELOCITIES TO BE READ IN AND INCLUDED IN VLO10258
THE CALCULATION, EI=1.0 READ AND INCLUDE EXTERNALLY INDUCED VELO- VLO10259
TIES, CIRCP=0.0 BYPASSES PRINTOUT OF VORTEX CHARACTERISTICS, VLO10260
CIRCP=1.0 OUTPUT SHOWS VORTEX CHARACTERISTICS VLO10261
C VLO10262
C READ (5,32) MMM,ALPHLC,PINCLC,TLPHAC,EI,CIRCP VLO10263
C VLO10264
C IMAX=MSW+1 VLO10265
C VLO10266
C LAY-OUT LEFT TAIL LEGS OF THE HORSESHOE VORTICES ON THE WING VLO10267
C VLO10268
C READ(5,7) (Y(I),I=2,IMAX) VLO10269
C VLO10270
C IF (MSP.EQ.0) GO TO 2205 VLO10271
KMAX=MSP+1 VLO10272
C VLO10273
C LAY-OUT LOWER TAIL LEGS OF THE HORSESHOE VORTICES ON THE PYLON VLO10274
C VLO10275
C READ(5,7) (Z(K),K=2,KMAX) VLO10276
C VLO10277
C 2205 CONTINUE VLO10278
IF (NCT.EQ.0) GO TO 1100 VLO10279
C VLO10280
C READ IN HORIZONTAL TAIL ROOT CHORD NOSE COORDINATES, TNX,TNY,TNZ VLO10281
C VLO10282
C READ (5,7 ) TNX,TNY,TNZ VLO10283
C VLO10284
C LAY-OUT LEFT TAIL LEGS OF HORSESHOE VORTICES ON THE TAIL VLO10285
C VLO10286
C ITMAX=MST+1 VLO10287
READ (5,7 ) (YT(IT),IT=2,ITMAX) VLO10288

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C
C
C      COMPRESSIBILITY RULE
1100  BFTA=SORT(1.-MACH*MACH)
      SWPWLE=SWPWLI/BETA
      SWPWTE=SWPWTI/BETA
      CRW=CRWI/BETA
      SWPPLE=SWPPLI/BETA
      SWPPTTE=SWPPTTI/BETA
      CRP=CRPI/BETA
      SWPTLE=SWPTLI/BETA
      SWPTTE=SWPTTI/BETA
      CRT=CRTI/BETA
      XMC=XM/BETA
      IF (NCT.NE.0) TNXC=TNX/BETA
C
C
C      WING-PYLON-TAIL GEOMETRY AND NUMBER OF VORTICES IN CHORDWISE AND
      SPANWISE DIRECTIONS OUTPUT
C
      WRITE (6,59)
      WRITE (6,30)  PSIWLI,PSIPLI,PSITLI
      WRITE (6,8 )  PSIWTI,PSIPTI,PSITTI
      WRITE (6,21)  PHI,PHIP,PHIT
      WRITE (6,22)  CRWI,CRPI,CRTI
      WRITE (6,25)  SSPAN,TSSPAN
      WRITE (6,26)  FRAC
      WRITE (6,27)  H
      WRITE (6,10)  PINC
      WRITE (6,49)  TLINC
      WRITE (6,58)  NCW,NCP,NCT
      WRITE (6,60)  MSW,MSP,MST
      WRITE (6,73)
      IF (NCT.EQ.0) GO TO 3182
      WRITE (6,46)  TNX,TNY,TNZ
3182  CONTINUE
      WRITE (6,38)  XM,YM,ZM
      WRITE (6,62)  RAD
      WRITE (6,78)
      WRITE (6,66)  ALPHA
      WRITE (6,70)  MACH
C
C
C      CHANGE ANGLES TO RADIANS
C
      ALPHA= (ALPHA/180.0)*3.1416
      TALPHA= (TALPHA/180.0)*3.1416
      PINC= (PINC/180.0)*3.1416
      TLINC= (TLINC/180.0)*3.1416
      PHI= (PHI/180.0)*3.1416
      PHIT= (PHIT/180.0)*3.1416
      PHIP= (PHIP/180.0)*3.1416
C
C      CALCULATE VORTEX AND CONTROL POINTS COORDINATES ON THE WING
C
      CSPHI=COS(ATAN(TANPHI))
      SPHI=SIN(ATAN(TANPHI))
      D=NCW
      I=1
      Y(I)=0.0
701  I=I+1
      SUMY(I)=(Y(I)+Y(I-1))/2.0
      YLOC(I)=SUMY(I)/SSPAN
      DO 720 JCW=1,NCW
      A=JCW
      SWPC(JCW)=SWPWLE-((A-0.25)/D)*(SWPWLE-SWPWTE)
      J=(I-2)*NCW+JCW
      SWPV(J)= SWPWLE-((A-0.75)/D)*(SWPWLE-SWPWTE)
C
C
C      DISTINCTION BETWEEN SWEEP IN CHORDAL(SWPVVP) AND PLANFORM(SWPV)
      PLANE
C
      SWPVVP(J)=SWPV(J)*CSPHI

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VL010289
VL010290
VL010291
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VL010300
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C WING VORTEX HALFWIDTH=SW VL010361
C SW(J)=(Y(I)-Y(I-1))/(2.0*CSPHI) VL010362
C PVX(J)=-((A-0.75)*(CRW/D))-(SUMY(I)*SWPV(J)) VI010363
C PVY(J)=-SUMY(I) VL010364
C PVZ(J)=-SUMY(I)*TANPHI VL010365
C PCX(J)=-((A-0.75)*(CRW/D))-(SUMY(I)*SWPC(JCW)) VL010366
C VL010367
C COORDINATES OF 3/4 CHORD ELEMENTAL PANEL LEFT SIDE POINT,PTL VL010368
C VL010369
C PTLX(J)=-((A-0.25)*(CRW/D))-(Y(I)*SWPC(JCW)) VL010370
C PTLY(J)=-Y(I) VL010371
C PTLZ(J)=-Y(I)*TANPHI VL010372
720 CONTINUE VL010373
C IF (Y(I).LT.SSPAN) GO TO 701 VL010374
C M=NCW*MSW VL010375
C IF (MSP.EQ.0) GO TO 1101 VL010376
C VL010377
C VL010378
C CALCULATE REAL AND IMAGE VORTEX POINTS AND CONTROL POINTS ON THE PYLON VL010379
C VL010380
C E=NCP VL010381
C K=1 VL010382
C Z(K)=0.0 VL010383
C VL010384
C THE FOLLOWING COORDINATES LOCATE THE PYLON ROOTCHORD NOSE VL010385
C VL010386
C PX=-FRAC*SSPAN*SWPPLF VL010387
C PY=-FRAC*SSPAN VL010388
C PZ=-FRAC*SSPAN*TANPHI VL010389
C VL010390
C THE FOLLOWING COORDINATES LOCATE PYLON-ENGINE CHORD NOSE AND TAIL VL010391
C VL010392
C PEX=PX-H*SWPPLF VL010393
C PEY=PY VL010394
C PEZ=H+PZ VL010395
C PEXT=PX-CRP-H*SWPPTF VL010396
C VL010397
C PYLON-ENGINE CHORD=CRPE VL010398
C VL010399
C CRPF=PEX-PEXT VL010400
801 K=K+1 VL010401
C SUM7(K)=(Z(K)+7*(K-1))/2.0 VL010402
C VL010403
C PYLON VORTEX HALFWIDTH=SP VL010404
C VL010405
C DO 820 JRP=1,NCP VL010406
C R=JRP VL010407
C SWPCP(JRP)=SWPPLF-((B-0.25)/F)*(SWPPLF-SWPPTF) VL010408
C JP=(K-2)*NCP+JRP+M VL010409
C JPP=JP-M VL010410
C SWPVP(JPP)=SWPPLF-((R-0.75)/C)*(SWPPLF-SWPPTF) VL010411
C SP(JPP)=(Z(K)-7*(K-1))/2.0 VL010412
C PVPY(JPP)=PX-((R-0.75)*(CRP/F))-SUM7(K)*SWPVP(JPP) VL010413
C PVPY(JPP)=PY VL010414
C PVPZ(JPP)=SUMZ(K)+P7 VL010415
C PCPX(JPP)=PX-((R-0.75)*(CRP/E))-SUMZ(K)*SWPCP(JRP) VL010416
C KMAX=K VL010417
C CONTINUE VL010418
820 IF (Z(K).NE.H) GO TO 801 VL010419
C KPI=KMAX+1 VL010420
C MP=MSP+NCP VL010421
C IF (MSP.EQ.0) GO TO 1203 VL010422
C VL010423
C VL010424
C PYLON VORTEX IMAGES ARE LAID OUT NEXT,NOTE ADDITION I REFERS TO IMAGE VL010425
C VL010426
C VL010427
C KI=KMAX VL010428
C ZI(KI)=0.0 VL010429
901 KI=KI+1 VL010430
C ISUB=2*KMAX-KI VL010431
C ZI(KI)=RAD-((PAD*RAD)/(RAD+H-ZI(SUB))) VL010432

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SUMZI(KI)=(ZI(KI)+ZI(KI-1))/2.0
IMAGINARY VORTEX WIDTH=SPI
DO 920 JRPI=1,NCP
C=JRPI
SWPCPI(JRPI)=-SWPCP(JRPI)
JPI=(KI-(KMAX+1))*NCP+JRPI+M+MP
JPI=JPI-(M+MP)
IMAG=JPI-((2*KI)-(3*KMAX))*NCP-MP
IMAGP=IMAG-M
SWPVP(JPI)=-SWPVP(IMAGP)
SPI(JPI)=(ZI(KI)-ZI(KI-1))/2.0
PVPI(JPI)=PEX-((C-0.75)*CRPE/E)-SUMZI(KI)*SWPVP(JPI)
PVPI(JPI)=PY
PVPZ(JPI)=SUMZI(KI)+H+PZ
PCPX(JPI)=PEX-((C-0.25)*CRPE/E)-SUMZI(KI)*SWPCPI(JRPI)
920 CONTINUE
DP=RAD-((RAD*RAD)/(RAD+H))
KIMAX=KI
IF (ZI(KI).LT.DP) GO TO 901
MPI=MSP1*NCP
GO TO 1102
1101 MP=0
1203 MPI=0
1102 CONTINUE
MPI=M+1
MMP=M+MP
MMP1=M+MP+1
NMTP1=M+MP+MPI+1
MT=NCT*MT
N=M+MP+MPI+MT
NMMT=M+MP+MPI
NMMP1=M+MP+MT

BUILD UP L.H.S. OF BOUNDARY CONDITION, THE COEFFICIENT MATRIX
CONTROL POINTS ON WING, VORTICES ON WING
DO 212 JC=1,M
DO 212 JV=1,M
XW=PCX(JC)-PVX(JV)
YW(1)=PVY(JC)-PVY(JV)
YW(2)=PVY(JC)+PVY(JV)
ZW=PVZ(JC)-PVZ(JV)
DO 261 I=1,2
CALL INFW(SWPVVP(JV),PHI,XW,YW(1),ZW,SW(JV),FVW(1),FVW(1),
1FWW(1))
SWPVVP(JV)=-SWPVVP(JV)
PHI=-PHI
261 CONTINUE
FVN(JC,JV)=(FVW(1)+FVW(2))*CSPHI-(FVW(1)+FVW(2))*SPHI
212 CONTINUE

CONTROL POINTS ON WING, VORTICES ON PYLON
IF (MSP1.EQ.0) GO TO 1103
DO 312 JC=1,M
DO 312 JV=MPI,MMP
JVP=JV-M
XW=PCX(JC)-PVX(JVP)
YW(1)=PVY(JC)-PVY(JVP)
YW(2)=PVY(JC)+PVY(JVP)
ZW=PVZ(JC)-PVZ(JVP)
DO 262 I=1,2
CALL INFW(SWPVP(JVP),PHI,XW,YW(1),ZW,SP(JVP),FUP(1),FVP(1),
1FWP(1))
PHI=-PHI
SWVP(JVP)=-SWVP(JVP)
262 CONTINUE
FVN(JC,JV)=(FWP(1)+FWP(2))*CSPHI-(FWP(1)+FWP(2))*SPHI
312 CONTINUE

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CONTROL POINTS ON WING, PYLON IMAGE VORTICES
FVNI WILL BE ADDED TO FVN OF PYLON ACCORDING TO IMAGE PRINCIPLE
IF (MSP1.EQ.0) GO TO 1204
DO 313 JC=1,M
DO 313 JV=MPP1,NMHT
JI=JV-(M+MP)
JVP=JV-(M+MP)
XWPI=PCX(JC)-PVPXI(JVP)
YWPI(1)=PVY(JC)-PVPYI(JVP)
YWPI(2)=PVY(JC)+PVPYI(JVP)
ZWPI=PVZ(JC)-PVPZI(JVP)
DO 265 I=1,2
CALL INFW(SWPVP(JVP),PHI,XWPI,YWPI(1),ZWPI,SPI(JVP),FUPI(1),
1FWPI(1),FWPI(1))
PHI=-PHI
SWVP(JVP)=-SWVP(JVP)
265 CONTINUE
FVNI(JC,JI)=(FWPI(1)+FWPI(2))*CSPHI-(FWPI(1)+FWPI(2))*SPHI
313 CONTINUE
1204 CONTINUE

CONTROL POINTS ON PYLON, WING VORTICES
DO 412 JC=MPI,MMP
JCP=JC-M
DO 412 JV=1,M
XPW=PCPX(JCP)-PVX(JV)
YPW(1)=PVPY(JCP)-PVY(JV)
YPW(2)=PVPY(JCP)+PVY(JV)
ZPW=PVPZ(JCP)-PVZ(JV)
DO 263 I=1,2
CALL INFW(SWPVVP(JV),PHI,XPW,YPW(1),ZPW,SW(JV),FVW(1),FVW(1),
1FWW(1))
SWPVVP(JV)=-SWPVVP(JV)
PHI=-PHI
263 CONTINUE
FVN(JC,JV)=-((FVW(1)+FVW(2)))
412 CONTINUE

CONTROL POINTS ON PYLON, VORTICES ON PYLON
DO 512 JC=MPI,MMP
JCP=JC-M
DO 512 JV=MPI,MMP
JVP=JV-M
XPP=PCPX(JCP)-PVPX(JVP)
YPP(1)=0.0
YPP(2)=FRAC*SSPAN*2.0
ZPP=PVPZ(JCP)-PVPZ(JVP)
DO 264 I=1,2
CALL INFW(SWPVP(JVP),PHI,XPP,YPP(1),ZPP,SP(JVP),FUP(1),FVP(1),
1FWP(1))
PHI=-PHI
SWVP(JVP)=-SWVP(JVP)
264 CONTINUE
FVN(JC,JV)=-((FVP(1)+FVP(2)))
512 CONTINUE

CONTROL POINTS ON PYLON, PYLON-IMAGE VORTICES
FVNI WILL BE ADDED TO FVN OF PYLON ACCORDING TO IMAGE PRINCIPLE
IF (MSP1.EQ.0) GO TO 1103
DO 513 JC=MPI,MMP
JCP=JC-M
DO 513 JV=MPP1,NMHT
JVP=JV-(M+MP)
JI=JV-(M+MP)
XPP1=PCPX(JCP)-PVPXI(JVP)
YPP1(1)=0.0
YPP1(2)=FRAC*SSPAN*2.0
ZPP1=PVPZ(JCP)-PVPZI(JVP)

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DO 267 I=1,2
CALL INFWW(SWPVP(JVP),PHIP,XPPI,YPP(I),ZPP(SPI(JVP),FUPI(I),
1 FVPI(I),FWPI(I))
PHIP=-PHIP
SWPVP(JVP)=-SWPVP(JVP)
267 CONTINUE
FVNI(JC,JV)=-FVPI(1)+FVPI(2)
513 CONTINUE
C
C VORTEX IMAGING SCHEME IN ACTION FOR WING AND PYLON CONTROL POINTS
C
DO 713 KI=KPI,KIMAX
DO 713 JRPI=1,NCP
JV= (KI-(KMAX+1))*NCP+JRPI+M+MP
JVP=JV-(M+MP)
IMAG=JV-(((2*KI)-(3*KMAX))*NCP)-MP
DO 713 JC=1,MMP
FVNI(JC,IMAG)=FVNI(JC,IMAG)+FVNI(JC,JVP)
713 CONTINUE
C
1103 CONTINUE
C
C CALCULATE MIDSPAN VORTEX ROUND LEG POINTS AND CONTROL POINTS
C COORDINATES ON THE HORIZONTAL TAIL
C
IF (NCT.EQ.0) GO TO 1205
TCSPHI=COS(ATAN(TTNPHI))
TSPHI=SIN(ATAN(TTNPHI))
DT=NCT
IT=1
YT(IT)=0.0
703 IT=IT+1
SUMYT(IT)=(YT(IT)+YT(IT-1))/2.0
TYLOC(IT)=SUMYT(IT)/TSSPAN
DO 721 JCT=1,NCT
AT=JCT
SWPTC(JCT)=SWPTLE-((AT-0.25)/DT)*(SWPTLE-SWPTTE)
JT=((IT-2)*NCT+JCT+M+MP+MPI)
JTT=JT-(M+MP+MPI)
SWPTV(JTT)=SWPTLE-((AT-0.75)/DT)*(SWPTLE-SWPTTE)
SWPTVV(JTT)=SWPTV(JTT)*TCSPHI
C
C TAIL VORTEX HALFWIDTH=ST
C
ST(JTT)=(YT(IT)-YT(IT-1))/(2.0*TCSPHI)
C
C PVTX(JTT)=((AT-0.75)*(CRT/DT))-(SUMYT(IT)*SWPTV(JTT))+TNXC
C PVTY(JTT)=-SUMYT(IT)
C PVTZ(JTT)=-SUMYT(IT)*TTNPHI+TNZ
C PCTX(JTT)=((AT-0.25)*(CRT/DT))-(SUMYT(IT)*SWPTC(JCT))+TNXC
C
C COORDINATES OF 3/4 CHORD ELEMENTAL PANEL LEFT SIDE POINT ON TAIL,
C PTTL
C
PTTLX(JTT)=((AT-0.25)*(CRT/DT))-(YT(IT)*SWPTC(JCT))+TNXC
PTTLY(JTT)=-YT(IT)
PTTLZ(JTT)=-YT(IT)*TTNPHI
721 CONTINUE
IF (YT(IT)+LT*TSSPAN) GO TO 703
C
C CONTROL POINTS ON TAIL, VORTICES ON TAIL
C
DO 523 JCT=1,MT
JC=JCT+M+MP
DO 523 JVT=1,MT
JV=JVT+M+MP
XTT=PCTX(JCT)-PVTX(JVT)
YTT(1)=PVTY(JCT)-PVTY(JVT)

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YTT(2)=PVTY(JCT)+PVTY(JVT)
ZTT=PVTZ(JCT)-PVTZ(JVT)
DO 278 I=1,2
CALL INFWW(SWPVV(JVT),PHIT,XTT,YTT(I),ZTT,ST(JVT),FUT(I),FVT(I),
1 FWT(I))
SWPTVV(JVT)=-SWPTVV(JVT)
PHIT=-PHIT
278 CONTINUE
FVNI(JC,JV)=(FWT(1)+FWT(2))*TCSPHI-(FVT(1)+FVT(2))*TSPHI
523 CONTINUE
C
C CONTROL POINTS ON WING, VORTICES ON TAIL
C
DO 524 JC=1,M
DO 524 JTT=1,MT
JV=JTT+M+MP
XWT=PCX(JC)-PVTX(JTT)
YWT(1)=PVTY(JC)-PVTY(JTT)
YWT(2)=PVTY(JC)+PVTY(JTT)
ZWT=PVZ(JC)-PVTZ(JTT)
DO 276 I=1,2
CALL INFWW(SWPVV(JTT),PHIT,XWT,YWT(I),ZWT,ST(JTT),FUT(I),FVT(I),
1 FWT(I))
SWPTVV(JTT)=-SWPTVV(JTT)
PHIT=-PHIT
276 CONTINUE
FVNI(JC,JV)=(FWT(1)+FWT(2))*TCSPHI-(FVT(1)+FVT(2))*TSPHI
524 CONTINUE
C
C CONTROL POINTS ON TAIL, VORTICES ON WING
C
DO 521 JCT=1,MT
JC=JCT+M+MP
DO 521 JV=1,M
XTW=PCTX(JCT)-PVX(JV)
YTW(1)=PVTY(JCT)-PVY(JV)
YTW(2)=PVTY(JCT)+PVY(JV)
ZTW=PVTZ(JCT)-PVZ(JV)
DO 277 I=1,2
CALL INFWW(SWPVVP(JV),PHI,XTW,YTW(I),ZTW,SW(JV),FUW(I),FVW(I),FWW
1 (I))
SWPVVP(JV)=-SWPVVP(JV)
PHI=-PHI
277 CONTINUE
FVNI(JC,JV)=(FWW(1)+FWW(2))*TCSPHI-(FVW(1)+FVW(2))*TSPHI
521 CONTINUE
C
C CONTROL POINTS ON TAIL, VORTICES ON PYLON
C
IF (MSP.EQ.0) GO TO 1525
DO 522 JCT=1,MT
JC=JCT+M+MP
DO 522 JV=MP1,MMP
JVP=JV-M
XPT=PCTX(JCT)-PVPX(JVP)
YPT(1)=PVTY(JCT)-PVPY(JVP)
YPT(2)=PVTY(JCT)+PVPY(JVP)
ZPT=PVTZ(JCT)-PVPZ(JVP)
DO 279 I=1,2
CALL INFWW(SWPVP(JVP),PHIP,XPT,YPT(I),ZPT,SP(JVP),FUP(I),FVP(I),
1 FWP(I))
PHIP=-PHIP
SWPVP(JVP)=-SWPVP(JVP)
279 CONTINUE
FVNI(JC,JV)=(FWP(1)+FWP(2))*TCSPHI-(FVP(1)+FVP(2))*TSPHI
522 CONTINUE
1525 CONTINUE
C
C CONTROL POINTS ON TAIL, PYLON IMAGE VORTICES
C FVNI WILL BE ADDED TO FVN OF PYLON ACCORDING TO IMAGE PRINCIPLE
C
IF (MSP.EQ.0) GO TO 1526

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DO 1524 JCT=1,MT
JC=JCT+M+MP
DO 1524 JV=MPP1,NMMP
JVP=JV-(M+MP)
XIPT=PCTX(JCT)-PVPXI(JVP)
YIPT(1)=PVTY(JCT)-PVPYI(JVP)
YIPT(2)=PVTY(JCT)+PVPYI(JVP)
ZIPT=PVTZ(JCT)-PVPZI(JVP)
DO 280 I=1,2
CALL INFW(SWPVPI(JVP),PHIP,XIPT,YIPT(I),ZIPT,SPI(JVP),FUPI(I),
FVPI(I),FWPI(I))
PHIP=-PHIP
SWPVPI(JVP)=-SWPVPI(JVP)
280 CONTINUE
FVNI(JC,JVP)=(FWPI(1)+FWPI(2))*TCSPI-(FVPI(1)+FVPI(2))*TSPHI
1524 CONTINUE
1526 CONTINUE
C
C CONTROL POINTS ON PYLON, VORTICES ON TAIL
C
IF (MSP.EQ.0) GO TO 1527
DO 525 JC=MPI,MMP
JCP=JC-M
DO 525 JTT=1,MT
JV=JTT+M+MP
XTP=PCTX(JCP)-PVTX(JTT)
YTP(1)=PVPY(JCP)-PVTY(JTT)
YTP(2)=PVPY(JCP)+PVTY(JTT)
ZTP=PVPZ(JCP)-PVTZ(JTT)
DO 281 I=1,2
CALL INFW(SWPTVV(JTT),PHIT,XTP,YTP(I),ZTP,ST(JTT),FUT(I),FVT(I),
1FVT(I))
SWPTVV(JTT)=-SWPTVV(JTT)
PHIT=-PHIT
281 CONTINUE
FVN(JC,JV)=-FVT(1)+FVT(2)
525 CONTINUE
1527 CONTINUE
C
C VORTEX IMAGING SCHEME IN ACTION FOR TAIL CONTROL POINTS
C
IF (MSP1.EQ.0) GO TO 9908
DO 4714 KI=KPI,KIMAX
DO 4714 JRPI=1,NCP
JV=(KI-(KMAX+1))*NCP+JRPI+M+MP
JVP=JV-(M+MP)
IMAG=JV-(((2*KI)-(3*KMAX))*NCP)-MCP
DO 4714 JC=MPP1,NMMP
FVN(JC,IMAG)=FVN(JC,IMAG)+FVNI(JC,JVP)
4714 CONTINUE
9908 CONTINUE
1205 CONTINUE
C
C LOCAL WING ANGLES OF ATTACK INPUT
C
IF (ALPHLC.EQ.0.0) GO TO 1612
MN=0
DO 9910 JNW=1,M+NCW
MN=MN+NCW
9910 READ (5,7) (ALPHAL(J),J=JNW,MN)
1612 CONTINUE
C
C READ IN SUM OF ENGINE AND THICKNESS INDUCED VELOCITIES, THICKNESS
C VEL. TO BE INCLUDED IN ZERO ANGLE KIND, VEI(J,1),VEI(J,1),
C WEI(J,1), VEI(J,2),WEI(J,2) ARE ADDITIONAL KIND.
C
IF (FI.EQ.0.0) GO TO 2256
DO 7001 J=1,M

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7001 READ (5,43) JN,UEI(JN,1),VEI(JN,1),WEI(JN,1)
DO 7002 J=1,M
7002 READ (5,43) JN,VEI(JN,2),WEI(JN,2)
IF (MP.EQ.0) GO TO 2275
DO 7003 J=MPI,MMP
7003 READ (5,43) JN,UEI(JN,1),VEI(JN,1)
DO 7004 J=MPI,MMP
7004 READ (5,43) JN,VEI(JN,2)
2275 CONTINUE
IF (NCT.EQ.0) GO TO 2256
DO 7005 J=MPP1,NMMP
7005 READ (5,43) JN,UEI(JN,1),VEI(JN,1),WEI(JN,1)
DO 7006 J=MPP1,NMMP
7006 READ (5,43) JN,VEI(JN,2),WEI(JN,2)
2256 CONTINUE
C
C BUILD UP SINGLE COLUMN MATRIX
C
C CONTROL POINTS ON WING
C
IF (ALPHLC.EQ.0.0.AND.EI.EQ.0.0) GO TO 1611
IF (ALPHLC.NE.0.0.AND.EI.EQ.0.0) GO TO 3612
IF (ALPHLC.EQ.0.0.AND.EI.NE.0.0) GO TO 2611
C
DO 2612 JC=1,M
CIR(JC,1)=12.566371*(ALPHAL(JC)*CSPHI+VEI(JC,1)*SPHI-(UEI(JC,1)*
1ALPHAL(JC)+WEI(JC,1))*CSPHI)
2612 CIR(JC,2)=12.566371*(ALPHA*CSPHI+VEI(JC,2)*SPHI-WEI(JC,2)*CSPHI)
GO TO 1614
3612 DO 612 JC=1,M
CIR(JC,1)=12.566371*ALPHAL(JC)*CSPHI
612 CIR(JC,2)=12.566371*ALPHA*CSPHI
GO TO 1614
1611 DO 1613 JC=1,M
CIR(JC,1)=0.0
1613 CIR(JC,2)=12.566371*ALPHA*CSPHI
GO TO 1614
2611 DO 2613 JC=1,M
CIR(JC,1)=12.566371*(VEI(JC,1)*SPHI-WEI(JC,1)*CSPHI)
2613 CIR(JC,2)=12.566371*(ALPHA*CSPHI+VEI(JC,2)*SPHI-WEI(JC,2)*CSPHI)
1614 CONTINUE
C
IF (MSP.EQ.0) GO TO 2710
C
C READ IN LOCAL PYLON ANGLES OF ATTACK
C
IF (PINCLC.EQ.0.0) GO TO 2711
MNP=0
DO 9912 JNP=1,M+MNP
MNP=MNP+NCP
9912 READ (5,7) (PINCL(JP),JP=JNP,MNP)
2711 CONTINUE
C
C CONTROL POINTS ON PYLON
C
IF (PINCLC.EQ.0.0.AND.EI.EQ.0.0) GO TO 1711
IF (PINCLC.NE.0.0.AND.EI.EQ.0.0) GO TO 1712
IF (PINCLC.EQ.0.0.AND.EI.NE.0.0) GO TO 1713
DO 1717 JC=MPI,MMP
JCC=JC-M
CIR(JC,1)=12.566371*(PINCL(JCC)+PINC-UEI(JC,1)*(PINCL(JCC)+PINC)
1+VEI(JC,1))
1717 CIR(JC,2)=12.566371*VEI(JC,2)
GO TO 2710
1711 DO 1714 JC=MPI,MMP
CIR(JC,1)=12.566371*PINC
1714 CIR(JC,2)=0.0
GO TO 2710

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1712 DO 1715 JC=MPI,MMP
      JCC=JC-M
      CIR(JC,1)=12.566371*(PINCL(JCC)+PINC)
1715 CIR(JC,2)=0.0
      GO TO 2710
1713 DO 1716 JC=MPI,MMP
      CIR(JC,1)=12.566371*(PINC-UEI(JC,1)*PINC+VEI(JC,1))
1716 CIR(JC,2)=12.566371*VEI(JC,2)
2710 CONTINUE
C
      IF (NCT.EQ.0) GO TO 1104
C
      READ IN LOCAL HORIZONTAL TAIL ANGLES OF ATTACK
C
      IF (TLPHAC.EQ.0.0) GO TO 4610
      MNT=0
      DO 9911 JNT=1,MT,NCT
      MNT=MNT+NCT
9911 READ (5,7) (TLPHAL(JT), JT=JNT,MNT)
4610 CONTINUE
C
      CONTROL POINTS ON HORIZONTAL TAIL
C
      IF (TLPHAC.EQ.0.0.AND.EI.EQ.0.0) GO TO 1811
      IF (TLPHAC.NE.0.0.AND.EI.EQ.0.0) GO TO 1812
      IF (TLPHAC.EQ.0.0.AND.EI.NE.0.0) GO TO 1813
      DO 4713 JC=MPP1,NMMP1
      JCC=JC-(M+MP)
      CIR(JC,1)=12.566371*((TLPHAL(JCC)+TLINC)*TCSPHI+VEI(JC,1)*TSPIH-
      1*(UEI(JC,1)*(TLPHAL(JCC)+TLINC)+WEI(JC,1))*TCSPHI)
4713 CIR(JC,2)=12.566371*(ALPHA*TCSPHI+VEI(JC,2)*TSPIH-WEI(JC,2)*
      1*TCSPHI)
      GO TO 1104
1811 DO 1814 JC=MPP1,NMMP1
      CIR(JC,1)=12.566371*TLINC*TCSPHI
1814 CIR(JC,2)=12.566371*ALPHA*TCSPHI
      GO TO 1104
1812 DO 2815 JC=MPP1,NMMP1
      JCC=JC-(M+MP)
      CIR(JC,1)=12.566371*(TLPHAL(JCC)+TLINC)*TCSPHI
2815 CIR(JC,2)=12.566371*ALPHA*TCSPHI
      GO TO 1104
1813 DO 1816 JC=MPP1,NMMP1
      CIR(JC,1)=12.566371*(TLINC*TCSPHI+VEI(JC,1)*TSPIH-(UEI(JC,1)*TLINC
      1+WEI(JC,1))*TCSPHI)
1816 CIR(JC,2)=12.566371*(ALPHA*TCSPHI+VEI(JC,2)*TSPIH-WEI(JC,2)*
      1*TCSPHI)
C
      1104 CONTINUE
      CALL MATINV(FVN,NMMP1,CIR,2,DETERM,IPIVOT,INDEX,NMAX,ISCALE)
C
      IF DETERMINANT OF THE COEFFICIENT MATRIX IS ZERO CHECK CALL
      ESPECIALLY NMMP1,IPIVOT,INDEX,NMAX
      DIMENSION OF IPIVOT AND INDEX MUST EQUAL NMAX, NMMP1 EQUALS
      NUMBER OF CONTROL POINTS IE. UNKNOWN
C
      IF (DETERM) 3004,3005,3004
C
      3005 WRITE (6,17)
C
      3004 CONTINUE
C
      IMAGE VORTEX STRENGTHS RELATED TO PYLON VORTEX STRENGTHS
C
      IF (MSPI.EQ.0) GO TO 9714
      DO 714 KI=KPI,KIMAX
      DO 714 JRPI=1,NCP
      JC=(KI-(KMAX+1))*NCP+JRPI+M+MP

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      JI=JC-MMP
      IMAG=JC-(((2*KI)-(3*KMAX))*NCP)-MP
      CIRI(JI,1)=CIR(IMAG,1)
      CIRI(JI,2)=CIR(IMAG,2)
714 CONTINUE
9714 CONTINUE
C
      CALCULATE VELOCITIES INDUCED ON ENGINE
C
      COORDINATES OF POINTS ON ENGINE ARE READ IN NEXT
C
      IF (MMM.EQ.0) GO TO 4000
      READ (5,33) (PMX(MM),PMY(MM),PMZ(MM),MM=1,MMM)
      DO 3112 MM=1,MMM
3112 PMX(MM)=PMX(MM)/BETA
C
      CALCULATE INDUCED VELOCITIES U,V,W AT POINTS ON ENGINE DUE TO WING
      VORTICES
C
      DO 5000 JV=1,MMM
      UE(JV,1)=0.0
      VE(JV,1)=0.0
      WE(JV,1)=0.0
      UE(JV,2)=0.0
      VE(JV,2)=0.0
      WE(JV,2)=0.0
      DO 5000 JC=1,M
      XWM = PMX(JV)-PVX(JC)
      YWM(1) = PMY(JV)-PVY(JC)
      YWM(2) = PMY(JV)+PVY(JC)
      ZWM = PMZ(JV)-PVZ(JC)
      DO 1261 I=1,2
      CALL INFVW (SWPVVP(JC),PHI,XWM,YWM(1),ZWM,SW(JC),FUW(1),FVW(1),
      1FWW(1))
      SWPVVP(JC)=-SWPVVP(JC)
      PHI=-PHI
1261 CONTINUE
      DO 1809 IXX=1,2
      UE(JV,IXX)=UE(JV,IXX)+((FUW(1)+FUW(2))*CIR(JC,IXX))/12.566371
      VE(JV,IXX)=VE(JV,IXX)+((FVW(1)+FVW(2))*CIR(JC,IXX))/12.566371
      WE(JV,IXX)=WE(JV,IXX)+((FWW(1)+FWW(2))*CIR(JC,IXX))/12.566371
1809 WE(JV,IXX)=WE(JV,IXX)+((FWW(1)+FWW(2))*CIR(JC,IXX))/12.566371
5000 CONTINUE
C
      CALCULATE VELOCITIES U,V,W AT POINTS ON ENGINE DUE TO PYLON VORTI-
      CES
C
      IF (MSP.EQ.0) GO TO 5036
      DO 5010 JV=1,MMM
      DO 5010 JC=MPI,MMP
      JCP=JC-M
      XPM= PMX(JV)-PVPX(JCP)
      YPM(1) = PMY(JV)-PVPY(JCP)
      YPM(2) = PMY(JV)+PVPY(JCP)
      ZPM = PMZ(JV)-PVPZ(JCP)
      DO 1271 I=1,2
      CALL INFVW(SWPVP(JCP),PHIP,XPM,YPM(1),ZPM,SP(JCP),FUP(1),FVP(1),
      1FWP(1))
      PHIP=-PHIP
      SWPVP(JCP)=-SWPVP(JCP)
1271 CONTINUE
      DO 1819 IXX=1,2
      UE(JV,IXX)=UE(JV,IXX)+((FUP(1)+FUP(2))*CIR(JC,IXX))/12.566371
      VE(JV,IXX)=VE(JV,IXX)+((FVP(1)+FVP(2))*CIR(JC,IXX))/12.566371
1819 WE(JV,IXX)=WE(JV,IXX)+((FWP(1)+FWP(2))*CIR(JC,IXX))/12.566371
5010 CONTINUE
C
      CALCULATE VELOCITIES U,V,W AT POINTS ON ENGINE DUE TO PYLON-IMAGE
      VORTICES
C
      IF (MSPI.EQ.0) GO TO 5036
      DO 5020 JV=1,MMM
      DO 5020 JC=MPP1,NMMP

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JI=JC-MMP
JCP=JC-(M+MP)
XPIM=PMX(JV)-PVPXI(JCP)
YPIM(1)=PMY(JV)-PVPYI(JCP)
YPIM(2)=PMY(JV)+PVPYI(JCP)
ZPIM=PMZ(JV)-PVPZI(JCP)
DO 1281 I=1,2
CALL INFW (SWPVP(JCP),PHIP,XPIM,YPIM(1),ZPIM,SP(JCP),FUPI(1),
1 FVPI(1),FVPI(1))
PHIP=-PHIP
SWPVP(JCP)=-SWPVP(JCP)
1281 CONTINUE
DO 1829 IXX=1,2
UE(JV,IXX)=UE(JV,IXX)+((FUPI(1)+FUPI(2))*CIRI(JI,IXX))/12.566371
VE(JV,IXX)=VE(JV,IXX)+((FVPI(1)+FVPI(2))*CIRI(JI,IXX))/12.566371
1829 WE(JV,IXX)=WE(JV,IXX)+((FWPI(1)+FWPI(2))*CIRI(JI,IXX))/12.566371
5020 CONTINUE
5036 CONTINUE
C
C CALCULATE VELOCITIES U, V, W AT POINTS ON ENGINE DUE TO
C HOR. TAIL VORTICES
C
IF (NCT.EQ.0) GO TO 5035
DO 5030 JV=1,MMM
DO 5030 JCC=1,MT
JC=JCC+M+MP
XTM=PMX(JV)-PVTX(JCC)
YTM(1)=PMY(JV)-PVTY(JCC)
YTM(2)=PMY(JV)+PVTY(JCC)
ZTM=PMZ(JV)-PVTZ(JCC)
DO 1291 I=1,2
CALL INFW (SWPTVV(JCC),PHIT,XTM,YTM(1),ZTM,ST(JCC),FUT(1),FVT(1),
1 FWT(1))
SWPTVV(JCC)=-SWPTVV(JCC)
PHIT=-PHIT
1291 CONTINUE
DO 1839 IXX=1,2
UF(JV,IXX)=UE(JV,IXX)+((FUT(1)+FUT(2))*CIR(JC,IXX))/12.566371
VF(JV,IXX)=VE(JV,IXX)+((FVT(1)+FVT(2))*CIR(JC,IXX))/12.566371
1839 WF(JV,IXX)=WE(JV,IXX)+((FWT(1)+FWT(2))*CIR(JC,IXX))/12.566371
5030 CONTINUE
5035 CONTINUE
C
4000 CONTINUE
C
C CONTROL POINT COORDINATES AND MEAN SURFACE SLOPES AND EXTERNALLY
C INDUCED VELOCITIES OUTPUT
C
WRITE (6,34)
WRITE (6,51) ALPHA
WRITE (6,9)
WRITE (6,47)
C
DO 6001 J=1,M
PCXBET(J)=PCX(J)*BETA
6001 WRITE (6,35) J,PCXBET(J),PVPY(J),PVZ(J),ALPHAL(J),UEI(J,1),VEI(J,1),
1 WEI(J,1),VEI(J,2),WEI(J,2)
IF (MSP.EQ.0) GO TO 6003
WRITE (6,74)
C
DO 6002 J=MPI,MMP
JCC=J-M
PCPXBE(JCC)=PCPX(JCC)*BETA
6002 WRITE (6,48) J,PCPXBE(JCC),PVPY(JCC),PVPZ(JCC),PINCL(JCC),UEI(J,1),
1 VEI(J,1),VEI(J,2)
6003 CONTINUE
C
IF (NCT.EQ.0) GO TO 6005
WRITE (6,75)

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DO 6004 J=1,MT
JTT=J+(M+MP)
PCTXBE(J)=PCTX(J)*BETA
6004 WRITE (6,35) JTT,PCTXBE(J),PVTY(J),PVTZ(J),TLPHAL(J),UEI(JTT,1),
1 VEI(JTT,1),WEI(JTT,1),VEI(JTT,2),WEI(JTT,2)
6005 CONTINUE
C
C CIRCULATION VALUES AND VORTEX BOUND LEG MIDPOINT COORDINATES OUT
C
IF (CIRCP.EQ.0) GO TO 3001
WRITE (6,1) ALPHA
DO 550 J=1,M
SWPVP(J)=(ATAN(SWPVP(J)*BETA))*(57.29578)
PVBRET(J)=PVB(J)*BETA
550 WRITE (6,13) J,PVBRET(J),PVPY(J),PVZ(J),SWPVP(J),SW(J),CIR(J,1),
1 CIR(J,2)
DO 150 J=1,M
150 SWPVP(J)=TAN(SWPVP(J)/57.29578)/BETA
C
IF (MSP.EQ.0) GO TO 2998
WRITE (6,76)
DO 551 J=MPI,MMP
JP=J-M
SWPVP(JP)=(ATAN(SWPVP(JP)*BETA))*(57.29578)
PVPXBE(JP)=PVPX(JP)*BETA
551 WRITE (6,13) J,PVPXBE(JP),PVPY(JP),PVPZ(JP),SWPVP(JP),SP(JP),
1 CIR(J,1),CIR(J,2)
DO 151 JP=1,MPI
151 SWPVP(JP)=TAN(SWPVP(JP)/57.29578)/BETA
C
IF (MSPI.EQ.0) GO TO 2998
WRITE (6,77)
DO 552 J=MPP1,NMMP
JI=J-(M+MP)
SWPVP(JI)=(ATAN(SWPVP(JI)*BETA))*(57.29578)
PVPXI(JI)=PVPXI(JI)*BETA
552 WRITE (6,13) J,PVPXI(JI),PVPYI(JI),PVPZI(JI),SWPVP(JI),SPI(JI),
1 CIRI(JI,1),CIRI(JI,2)
DO 152 JPI=1,MPI
152 SWPVP(JPI)=TAN(SWPVP(JPI)/57.29578)/BETA
2998 CONTINUE
C
IF (NCT.EQ.0) GO TO 3001
WRITE (6,68)
DO 153 JT=1,MT
J=JT+(M+MP+MPI)
JCS=J-MPI
SWPTVV(JT)=(ATAN(SWPTVV(JT)*BETA))*(57.29578)
PVTX(JT)=PVTX(JT)*BETA
153 WRITE (6,13) J,PVTX(JT),PVTY(JT),PVTZ(JT),SWPTVV(JT),ST(JT),
1 CIR(JCS,1),CIR(JCS,2)
DO 154 J=1,MT
SWPTVV(J)=TAN(SWPTVV(J)/57.29578)/BETA
154 PVTX(J)=PVTX(J)/BETA
3001 CONTINUE
C
SPAN= 2.0*SSPAN
C
WING LOADING CALCULATIONS FOLLOW
C
CALL LOAD
CONTINUE
C
OVERALL LIFT AND MOMENT COEFFICIENT,REFERENCE QUANTITIES,SPANWISE
LOADINGS OUTPUT
C
WRITE (6,72)
WRITE (6,71) ALPHA,ALPHA
WRITE (6,19) SUMLIF(1),SUMLIF(2),TUMLIF(1),TUMLIF(2)

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WRITE (6,18)
WRITE (6,71) ALPHA, ALPHA
WRITE (6,19) CLTOT(1), CLTOT(2), TOTMOM(1), TOTMOM(2)
WRITE (6,28)
WRITE (6,29) SPAN, SREF, CAVE
WRITE (6,65) ALPHA, ALPHA

C
WRITE (6,24)
DO 3000 I=2, IMAX
  IM1=I-1
  CHLOCB(I)=CRWI-SUMY(I)*(SWPWL1-SWPWTI)
3000 WRITE (6,23) IM1, YLOC(I), CHLOCB(I), SLDCO(I,1), SLDCO(I,2), SECLIF(I,1), SECLIF(I,2)

C
IF (NCT.EQ.0) GO TO 9121
WRITE (6,64)
DO 3100 IT=2, ITMAX
  ITM1=IT-1
  TCHLOC(IT)=CRTI-SUMY(IT)*(SWPTL1-SWPTTI)
3100 WRITE (6,23) ITM1, TYLOC(IT), TCHLOC(IT), TSLDCO(IT,1), TSLDCO(IT,2),
  1TECLIF(IT,1), TECLIF(IT,2)
9121 CONTINUE
IF (MMH.EQ.0) GO TO 9100
WRITE (6,36) ALPHA
WRITE (6,40)
DO 4001 J=1, MMH
  PMX(J)=PMX(J)*BETA
  UE(J,1)=UE(J,1)/BETA
  UE(J,2)=UE(J,2)/BETA
4001 WRITE (6,39) J, PMX(J), PMY(J), PMZ(J), UE(J,1), VE(J,1), WE(J,1), UE(J,2),
  1, VE(J,2), WE(J,2)
9100 GO TO 1000
FND

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SUBROUTINE LOAD
DIMENSION SUMLIF(2), CHLIFT(50,2), V(125,2), YTW(2), PTLY(125),
1PTLY(125), PTLZ(125), PVX(125), PVY(125), PVZ(125), SWPVVP(125),
2SW(125), FUW(2), FVW(2), FWH(2), CIR(200,2), YTP(2), PVPX(25), PVPY(25),
3PVPZ(25), SWPVP(25), SPI(25), FUP(2), FVP(2), FWP(2), YTP(2), PVPX(25),
4PVPY(25), PVPZ(25), SWPVP(25), SPI(25), FUPI(2), FVPI(2), FUPI(2),
5CIR(25,2), PVTX(50), PVTY(50), PVTZ(50), YTT(2), SWPTVV(50), ST(50),
6FUT(2), FVT(2), FWT(2), U(125,2), VB(125,2), YBW(2), YBP(2), YBPI(2),
7YBT(2), CHLOC(50), Y(50), T(125), ELPANL(125), TLLIFT(125,2),
8BLLIFB(125,2), BLLIFT(125,2), SLDCO1(50,2), SLDCO(50,2), SECLIF(50,2)

C
DIMENSION TUMLIF(2), TCHLIF(15,2), PTTX(50), PTTY(50), PTTZ(50),
1YTTW(2), VT(50,2), UT(50,2), VRT(50,2), YBTW(2), YBTT(2), YBTP(2),
2YBTPI(2), TCHLOC(15), YT(15), TT(50), TLPANL(50), TTLIFT(50,2),
3BTLIFT(50,2), TSLDCO1(15,2), TECLIF(15,2), TSLDCO(15,2), WMOM(2),
4TMOM(2), TOTMOM(2), CLTOT(2), UEI(200,2), VEI(200,2), WEI(200,2)

C
COMMON CRWI, SSPAN, SWPWL1, SWPWTI, SREF, CAVE, SUMLIF, CHLIFT, NCW, V, M,
1YTW, PTLX, PTLY, PTLZ, PVX, PVY, PVZ, SWPVVP, PHI, SW, FUW, FVW, FWH, CIR, MSP,
2MPI, MMP, YTP, PVPX, PVPY, PVPZ, SWPVP, PHIP, SP, FUP, FVP, FWP, MSP1, MPP1,
3NMMT, MP, YTP1, PVPX1, PVPY1, PVPZ1, SWPVP1, SPI, FUPI, FVPI, FUPI, CIR1,
4NCT, HT, PVTX, PVTY, PVTZ, SWPTVV, PHIT, YTT, ST, FUT, FVT, FWT, U, VB, YBW,
5YBPI, YBT, CHLOC, Y, SWPHLE, SWPTE, T, CSPHI, FRAC, IMAX, ELPANL, TLLIFT,
6BLLIFB, BLLIFT, SLDCO1, SECLIF, SLDCO, BETA, CRW, CRT, XMC, YBP,
7CRTI, TSSPAN, SWPTL1, SWPTTI, TSREF, TCARE, TUMLIF, TCHLIF, VT, YTTW,
8PTTX, PTTY, PTLZ, UT, VBT, YRTW, YBTT, YBTP, YBTP1, TCHLOC, YT, SWPTLE
COMMON SWPTE, TT, TCSPI, ITMAX, TLPANL, TTLIFT, BTLIFT, TSLDCO1,
1TECLIF, TSLDCO, WMOM, TMOM, TOTMOM, CLTOT, UEI, VEI, WEI

C
CALCULATE REFERENCE WING AREA=PLANFORM WING AREA, UNSTRETCHED, SREF
CTWI=WING TIPCHORD UNSTRETCHED

C
D=NCW
CTWI=CRWI-SSPAN*(SWPWL1-SWPWTI)
SREF=(CRWI+CTWI)*SSPAN
CAVE=AVERAGE CHORD
CAVE=SREF/(2.0*SSPAN)
I=1
SUMLIF(1)=0.0
SUMLIF(2)=0.0
702 I=I+1
CHLIFT(1,1)=0.0
CHLIFT(1,2)=0.0

C
THE FOLLOWING VELOCITIES ARE NEEDED FOR THE LOADING CALCULATIONS
C
CALCULATE SIDEWASH VELOCITY V AT THE 3/4 CHORD OF THE LEFT
C
TRAILING VORTEX LEGS ON THE WING INDUCED BY WING VORTICES
C
DO 823 NV=1, NCW
  JT=(I-2)*NCW+NV
  V(JT,1)=VEI(JT,1)
  V(JT,2)=VEI(JT,2)
  DO 823 NN=1, M
    XTW=PTLY(JT)-PVX(NN)
    YTW(1)=PTLY(JT)-PVY(NN)
    YTW(2)=PTLY(JT)+PVY(NN)
    ZTW=PTLZ(JT)-PVZ(NN)
  DO 271 L=1,2
    CALL INFWH(SWPVVP(NN), PHI, XTW, YTW(1), ZTW, SW(NN), FUW(L), FVW(L),
    1FVW(L))
    SWPVVP(NN)=-SWPVVP(NN)
    PHI=-PHI
271 CONTINUE
DO 809 IXX=1,2
809 V(JT, IXX)=V(JT, IXX)+((FVW(1)+FVW(2))*CIR(NN, IXX))/12.56637
823 CONTINUE

C
CALCULATE SIDEWASH VELOCITY V AT THE 3/4 CHORD OF THE LEFT
C
TRAILING VORTEX LEGS ON THE WING INDUCED BY PYLON VORTICES
C
IF (MSP.EQ.0) GO TO 3030
DO 824 NV=1, NCW

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DO 824 NN=MP1,MMP
NNP=NN-M
JT=(I-2)*NCW+NV
XTP=PTLX(JT)-PVPX(NNP)
YTP(1)=PTLY(JT)-PVPY(NNP)
YTP(2)=PTLY(JT)+PVPY(NNP)
ZTP=PTLZ(JT)-PVPZ(NNP)
DO 266 L=1,2
CALL INFHW(SWPVP(NNP),PHIP,XTP,YTP(L),ZTP,SP(NNP),FUP(L),FVP(L),
IFWP(L))
SWPVP(NNP)=-SWPVP(NNP)
PHIP=-PHIP
266 CONTINUE
DO 810 IXX=1,2
810 V(JT,IXX)=V(JT,IXX)+((FVP(1)+FVP(2))*CIR(NN,IXX))/12.566371
824 CONTINUE
C
C CALCULATE SIDEWASH VELOCITY V AT THE 3/4 CHORD OF THE LEFT
C TRAILING VORTEX LEGS ON THE WING INDUCED BY PYLON IMAGE VORTICES
C
IF (MSPI.EQ.0) GO TO 3030
DO 825 NV=1,NCW
DO 825 NN=MP1,NMMP
NNPI=NN-(M+MP)
JI=NN-MMP
JT=(I-2)*NCW+NV
XTP=PTLX(JT)-PVPX(NNP)
YTP(1)=PTLY(JT)-PVPY(NNP)
YTP(2)=PTLY(JT)+PVPY(NNP)
ZTP=PTLZ(JT)-PVPZ(NNP)
DO 272 L=1,2
CALL INFHW(SWPVP(NNP),PHIP,XTP,YTP(L),ZTP,SP(NNP),FUP(L),FVP(L),
IFWP(L),FWPI(L))
SWPVP(NNP)=-SWPVP(NNP)
PHIP=-PHIP
272 CONTINUE
DO 811 IXX=1,2
811 V(JT,IXX)=V(JT,IXX)+((FVPI(1)+FVPI(2))*CIRI(JI,IXX))/12.566371
825 CONTINUE
3030 CONTINUE
C
C CALCULATE SIDEWASH VELOCITY V AT THE 3/4 CHORD OF THE
C LEFT TRAILING VORTEX LEGS ON WING INDUCED BY HOR. TAIL VORTICES
C
IF (NCT.EQ.0) GO TO 3002
DO 830 NV=1,NCW
JT=(I-2)*NCW+NV
DO 830 NN=1,MT
JIT=NN+(M+MP)
XTT=PTLX(JT)-PVTX(NNP)
YTT(1)=PTLY(JT)-PVTY(NNP)
YTT(2)=PTLY(JT)+PVTY(NNP)
ZTT=PTLZ(JT)-PVTZ(NNP)
DO 275 L=1,2
CALL INFHW(SWPTVV(NN),PHIT,XTT,YTT(L),ZTT,ST(NN),FUT(L),FVT(L),
IFWT(L))
SWPTVV(NN)=-SWPTVV(NN)
PHIT=-PHIT
275 CONTINUE
DO 815 IXX=1,2
815 V(JT,IXX)=V(JT,IXX)+((FVT(1)+FVT(2))*CIP(JIT,IXX))/12.566371
830 CONTINUE
C
C CALCULATE VELOCITY U AND V AT WING VORTEX ROUND LEG MIDPOINT
C INDUCED BY WING VORTICES
C
3002 CONTINUE
DO 826 NV=1,NCW
JB=(I-2)*NCW+NV
U(JB,1)=UEI(JB,1)

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U(JB,2)=UEI(JB,2)
VB(JB,1)=VEI(JB,1)
VB(JB,2)=VEI(JB,2)
DO 826 NN=1,M
XBW=PVB(JB)-PVX(NN)
YBW(1)=PVY(JB)-PVY(NN)
YBW(2)=PVY(JB)+PVY(NN)
ZBW=PVZ(JB)-PVZ(NN)
DO 268 L=1,2
CALL INFHW(SWPVVP(NN),PHI,XBW,YBW(L),ZBW,SW(NN),FUW(L),FVW(L),
IFW(L))
SWPVVP(NN)=-SWPVVP(NN)
PHI=-PHI
268 CONTINUE
DO 812 IXX=1,2
812 U(JB,IXX)=U(JB,IXX)+((FUW(1)+FUW(2))*CIR(NN,IXX))/12.566371
812 VB(JB,IXX)=VB(JB,IXX)+((FVW(1)+FVW(2))*CIR(NN,IXX))/12.566371
826 CONTINUE
C
C CALCULATE VELOCITY U AND V AT WING VORTEX ROUND LEG MIDPOINT
C INDUCED BY PYLON VORTICES
C
IF (MSP.EQ.0) GO TO 3031
DO 827 NV=1,NCW
DO 827 NN=MP1,MMP
JB=(I-2)*NCW+NV
NNP=NN-M
XBP=PVB(JB)-PVPX(NNP)
YBP(1)=PVY(JB)-PVPY(NNP)
YBP(2)=PVY(JB)+PVPY(NNP)
ZBP=PVZ(JB)-PVPZ(NNP)
DO 269 L=1,2
CALL INFHW(SWPVP(NNP),PHIP,XBP,YBP(L),ZBP,SP(NNP),FUP(L),FVP(L),
IFWP(L))
SWPVP(NNP)=-SWPVP(NNP)
PHIP=-PHIP
269 CONTINUE
DO 813 IXX=1,2
813 U(JB,IXX)=U(JB,IXX)+((FUP(1)+FUP(2))*CIR(NN,IXX))/12.566371
813 VB(JB,IXX)=VB(JB,IXX)+((FVP(1)+FVP(2))*CIR(NN,IXX))/12.566371
827 CONTINUE
C
C CALCULATE VELOCITY U AND V AT WING VORTEX ROUND LEG MIDPOINT
C INDUCED BY PYLON IMAGE VORTICES
C
IF (MSPI.EQ.0) GO TO 3031
DO 828 NV=1,NCW
DO 828 NN=MP1,NMMP
JI=NN-MMP
NNPI=NN-(M+MP)
JB=(I-2)*NCW+NV
XBP=PVB(JB)-PVPX(NNP)
YBP(1)=PVY(JB)-PVPY(NNP)
YBP(2)=PVY(JB)+PVPY(NNP)
ZBP=PVZ(JB)-PVPZ(NNP)
DO 270 L=1,2
CALL INFHW(SWPVP(NNP),PHIP,XBP,YBP(L),ZBP,SP(NNP),FUP(L),FVP(L),
IFWP(L),FWPI(L))
SWPVP(NNP)=-SWPVP(NNP)
PHIP=-PHIP
270 CONTINUE
DO 814 IXX=1,2
814 U(JB,IXX)=U(JB,IXX)+((FUPI(1)+FUPI(2))*CIRI(JI,IXX))/12.566371
814 VB(JB,IXX)=VB(JB,IXX)+((FVPI(1)+FVPI(2))*CIRI(JI,IXX))/12.566371
828 CONTINUE
3031 CONTINUE
C
C CALCULATE VELOCITY U AND V AT WING VORTEX ROUNDLEG MIDPOINT
C INDUCED BY VORTICES ON HOR. TAIL
C
IF (NCT.EQ.0) GO TO 3132
DO 832 NV=1,NCW

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JB=(I-2)*NCW+NV
DO 832 NN=1,MT
NNT=NN+(M+MP)
XBT=PVX(JB)-PVTX(NN)
YBT(1)=PVY(JB)-PVTY(NN)
YBT(2)=PVY(JB)+PVTY(NN)
ZBT=PVZ(JB)-PVTZ(NN)
DO 289 L=1,2
CALL INFWH(SWPTVV(NN),PHIT,XBT,YBT(L),ZBT,ST(NN),FUT(L),FVT(L),
1FMT(L))
SWPTVV(NN)=SWPTVV(NN)
PHIT=-PHIT
289 CONTINUE
DO 816 IXX=1,2
U(JB,IXX)=U(JB,IXX)+((FUT(1)+FUT(2))*CIR(NNT,IXX))/12.566371
816 VB(JB,IXX)=VB(JB,IXX)+((FVT(1)+FVT(2))*CIR(NNT,IXX))/12.566371
832 CONTINUE
3132 CONTINUE
C
C CALCULATE LIFT ON CHORDWISE ROW OF ELEMENTAL PANELS
C
3003 CHLOC(I)=CRW-Y(I)*(SWPML-SWPWTE)
DO 1815 IXX=1,2
CIRNET=0.0
DO 829 KCW=1,NCW
JT=(I-2)*NCW+KCW
JS=(I-1)*NCW+KCW
T(JT)=SSPAN/(SW(JT)*CSPHI)
IF (MSP.EQ.0) GO TO 3012
DUM=Y(I)-(FRAC*SSPAN)
IF (ABS(DUM)-1.0E-05) 3011,3011,3012
3011 JP=M+KCW
CIRNET=CIRNET+CIR(JT,IXX)-CIR(JS,IXX)-CIR(JP,IXX)
GO TO 2011
3012 CONTINUE
IF (I.EQ.IMAX) GO TO 2010
CIRNET=CIRNET+CIR(JT,IXX)-CIR(JS,IXX)
GO TO 2011
2010 CIRNET=CIRNET+CIR(JT,IXX)
2011 FAC=1.0
IF (KCW.EQ.NCW) FAC=0.75
ELPANL(JT)=CHLOC(I)/O
C
C TLLIFT=LIFT ACTING ON LEFT LEG OF VORTEX TAIL AT THE 3/4 ELEMENTAL
C PANEL CHORD
C
TLLIFT(JT,IXX)=ELPANL(JT)*FAC*V(JT,IXX)*(2.0/SREF)*CIRNET
C
C BLLIFB IS PART OF RLLIFT
C
BLLIFB(JT,IXX)=(2.0/SREF)*2.0*SW(JT)*CIR(JT,IXX)*VB(JT,IXX)*
1SWPVVP(JT)
C
C RLLIFT=LIFT ACTING ON BOUND LEG OF THE VORTEX AT THE MIDPOINT
C
RLLIFT(JT,IXX)=(2.0/SREF)*2.0*SW(JT)*CIR(JT,IXX)*((1.0-U(JT,IXX))
1*CSPHI+VR(JT,IXX)*SWPVVP(JT))
IF (I.GT.2) GO TO 2007
CHLIFT(I,IXX)=CHLIFT(I,IXX)+(TLLIFT(JT,IXX)/2.0)+RLLIFT(JT,IXX)
GO TO 1832
2007 JU=(I-3)*NCW+KCW
CHLIFT(I,IXX)=CHLIFT(I,IXX)+((TLLIFT(JT,IXX)+TLLIFT(JU,IXX))/2.0)+
1BLLIFT(JT,IXX)
1832 SLDCO(I,IXX)=T(JT)*CHLIFT(I,IXX)
C
C SECLIF=(SECTIONLIFT*LOCAL CHORD)/2*SPAN
C
SECLIF(I,IXX)=CHLIFT(I,IXX)*(SREF/(2.0*SW(JT)*CSPHI*4.0*SSPAN))
C
829 CONTINUE
C
C SPANWISE SUMMING UP OF LIFTS ACTING ON CHORDWISE ROW OF ELEMENTAL

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C PANELS,SUMLIF=CL
C
SUMLIF(IXX)=SUMLIF(IXX)+2.0*CHLIFT(I,IXX)
1815 CONTINUE
IF (I.LT.IMAX) GO TO 702
C
C SLDCO=SPANLOAD COEFFICIENT CLC/CLCAVE FOR THE WING
C
DO 3010 IXX=1,2
DO 3010 I=2,IMAX
IF (SUMLIF(IXX).EQ.0.0) GO TO 3811
SLDCO(I,IXX)=SLDCO(I,IXX)/SUMLIF(IXX)
GO TO 3010
3811 SLDCO(I,IXX)=0.0
3010 CONTINUE
C
IF (INCT.EQ.0) GO TO 9120
C
HORIZONTAL TAIL LOADING CALCULATIONS FOLLOW
C
CTTI= TAIL TIPCHORD UNSTRETCHED
C
CTTI=CTTI-TSSPAN*(SWPTLI-SWPTTI)
TSREF=(CTTI+CTTI)*TSSPAN
TCAVE= TAIL AVERAGE CHORD
TCAVE=TSREF/(2.0*TSSPAN)
IT=1
TUMLIF(1)=0.0
TUMLIF(2)=0.0
7020 IT=IT+1
TCHLIF(IT,1)=0.0
TCHLIF(IT,2)=0.0
C
C THE FOLLOWING VELOCITIES ARE NEEDED FOR LOADING CALCULATIONS
C CALCULATE SIDEWASH VELOCITY V AT THE 3/4 CHORD OF THE LEFT
C TRAILING VORTEX LEGS ON THE HOR. TAIL INDUCED BY WING VORTICES
DO 8230 NV=1,NCT
JTT=(IT-2)*NCT+NV
JT=JTT+M+MP
VT(JTT,1)=VEI(JT,1)
VT(JTT,2)=VEI(JT,2)
DO 8230 NN=1,M
XTTW=PTTLX(JTT)-PVX(NN)
YTTW(1)=PTTLY(JTT)-PVY(NN)
YTTW(2)=PTTLY(JTT)+PVY(NN)
ZTTW=PTTLZ(JTT)-PVZ(NN)
DO 2715 L=1,2
CALL INFWH (SWPVVP(NN),PHI,XTTW,YTTW(L),ZTTW,SW(NN),FVW(L),FVW(L),
1FVW(L))
SWPVVP(NN)=SWPVVP(NN)
PHI=-PHI
2715 CONTINUE
DO 8090 IXX=1,2
8090 VT(JTT,IXX)=VT(JTT,IXX)+((FVW(1)+FVW(2))*CIR(NN,IXX))/12.56637
8230 CONTINUE
C
C CALCULATE SIDEWASH VELOCITY V AT THE 3/4 CHORD OF THE LEFT
C TRAILING VORTEX LEGS ON THE HOR. TAIL INDUCED BY HOR. TAIL VORTICES
C
DO 8240 NV=1,NCT
JTT=(IT-2)*NCT+NV
DO 8240 NN=1,M
NI=NN+(M+MP)
XTT=PTTLX(JTT)-PVTX(NN)
YTT(1)=PTTLY(JTT)-PVTY(NN)
YTT(2)=PTTLY(JTT)+PVTY(NN)
ZTT=PTTLZ(JTT)-PVTZ(NN)
DO 2660 L=1,2
CALL INFWH (SWPTVV(NN),PHIT,XTT,YTT(L),ZTT,ST(NN),FUT(L),FVT(L),
1FVT(L))
PHIT=-PHIT

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SWPTVV(NN)=-SWPTVV(NN)
2650 CONTINUE
DO 8100 IXX=1,2
8100 VT(JTT,IXX)=VT(JTT,IXX)+((FVT(1)+FVT(2))*CIR(NI,IXX))/12.566371
8240 CONTINUE
C
C CALCULATE SIDEWASH VELOCITY V AT 3/4 CHORD OF THE LEFT TRAILING
C VORTEX LEGS ON THE HOR. TAIL INDUCED BY PYLON VORTICES
C
IF (MSP.EQ.0) GO TO 8259
DO 8241 NV=1,NCT
JTT=(IT-2)*NCT+NV
DO 8241 NN=MPI,MMP
NNP=NN-M
XTP=PTTLX(JTT)-PVPX(NNP)
YTP(1)=PTTLX(JTT)-PVPY(NNP)
YTP(2)=PTTLX(JTT)+PVPY(NNP)
ZTP=PTTLZ(JTT)-PVPZ(NNP)
DO 2661 L=1,2
CALL INFWH(SWPVP(NNP),PHIP,YTP,YTP(L),ZTP,SP(NNP),FUP(L),FVP(L),
1FVP(L))
SWPVP(NNP)=-SWPVP(NNP)
PHIP=-PHIP
2661 CONTINUE
DO 8101 IXX=1,2
8101 VT(JTT,IXX)=VT(JTT,IXX)+((FVP(1)+FVP(2))*CIR(NN,IXX))/12.566371
8241 CONTINUE
C
C CALCULATE SIDEWASH VELOCITY V AT 3/4 CHORD OF THE LEFT
C TRAILING VORTEX LEGS ON THE HOR. TAIL INDUCED BY PYLON
C IMAGE VORTICES
C
IF (MSPI.EQ.0) GO TO 8259
DO 8242 NV=1,NCT
JTT=(IT-2)*NCT+NV
DO 8242 NN=MPI,MMP
NNP=NN-M
XTP=PTTLX(JTT)-PVPX(NNP)
YTP(1)=PTTLX(JTT)-PVPY(NNP)
YTP(2)=PTTLX(JTT)+PVPY(NNP)
ZTP=PTTLZ(JTT)-PVPZ(NNP)
DO 2662 L=1,2
CALL INFWH(SWPVP(NNP),PHIP,XTP,YTP(L),ZTP,SPI(NNP),FUPI(L),
1FUPI(L),FUPI(L))
2652 CONTINUE
DO 8102 IXX=1,2
8102 VT(JTT,IXX)=VT(JTT,IXX)+((FUPI(1)+FUPI(2))*CIR(NI,IXX))/12.566371
8242 CONTINUE
8259 CONTINUE
C
C CALCULATE VELOCITIES U AND V AT HOR. TAIL VORTEX BOUND LEG MID-
C POINT INDUCED BY WING VORTICES
C
DO 8260 NV=1,NCT
JTT=(IT-2)*NCT+NV
JT=JTT+M+MP
UT(JTT,1)=UEI(JT,1)
UT(JTT,2)=UEI(JT,2)
VBT(JTT,1)=VEI(JT,1)
VBT(JTT,2)=VEI(JT,2)
DO 8260 NN=1,M
XBTV=PVTX(JTT)-PVX(NN)
YBTW(1)=PVTY(JTT)-PVTY(NN)
YBTW(2)=PVTY(JTT)+PVTY(NN)
ZBTW=PVTZ(JTT)-PVTZ(NN)
DO 2690 L=1,2
CALL INFWH(SWPVP(NN),PHI,XBTW,YBTW(L),ZBTW,SW(NN),FUV(L),FVW(L),
1FVW(L))
SWPVP(NN)=-SWPVP(NN)
PHI=-PHI
2690 CONTINUE

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DO 8120 IXX=1,2
UT(JTT,IXX)=UT(JTT,IXX)+((FUV(1)+FUV(2))*CIR(NN,IXX))/12.566371
8120 VBT(JTT,IXX)=VBT(JTT,IXX)+((FVW(1)+FVW(2))*CIR(NN,IXX))/12.566371
8260 CONTINUE
C
C CALCULATE VELOCITIES U AND V AT HOR. TAIL VORTEX BOUNDLEG MID-
C POINT INDUCED BY TAIL VORTICES
C
DO 8270 NV=1,NCT
JTT=(IT-2)*NCT+NV
DO 8270 NN=1,MT
NI=NN+M+MP
XBTT=PVTX(JTT)-PVTX(NN)
YBTT(1)=PVTY(JTT)-PVTY(NN)
YBTT(2)=PVTY(JTT)+PVTY(NN)
ZBTT=PVTZ(JTT)-PVTZ(NN)
DO 2690 L=1,2
CALL INFWH(SWPTVV(NN),PHIT,XBTT,YBTT(L),ZBTT,ST(NN),FUT(L),FVT
1L),FWT(L))
SWPTVV(NN)=-SWPTVV(NN)
PHIT=-PHIT
2690 CONTINUE
DO 8130 IXX=1,2
8130 UT(JTT,IXX)=UT(JTT,IXX)+((FUT(1)+FUT(2))*CIR(NI,IXX))/12.566371
8270 VBT(JTT,IXX)=VBT(JTT,IXX)+((FVT(1)+FVT(2))*CIR(NI,IXX))/12.566371
8270 CONTINUE
C
C CALCULATE VELOCITIES U AND V AT HOR. TAIL VORTEX BOUNDLEG MIDPOINT
C INDUCED BY PYLON VORTICES
C
IF (MSP.EQ.0) GO TO 3113
DO 8271 NV=1,NCT
JTT=(IT-2)*NCT+NV
DO 8271 NN=MPI,MMP
NNP=NN-M
XBTP=PVTX(JTT)-PVPX(NNP)
YBTP(1)=PVTY(JTT)-PVPY(NNP)
YBTP(2)=PVTY(JTT)+PVPY(NNP)
ZBTP=PVTZ(JTT)-PVPZ(NNP)
DO 2691 L=1,2
CALL INFWH(SWPVP(NNP),PHIP,XBTP,YBTP(L),ZBTP,SP(NNP),FUP(L),
1FVP(L),FVP(L))
SWPVP(NNP)=-SWPVP(NNP)
PHIP=-PHIP
2691 CONTINUE
DO 8131 IXX=1,2
8131 UT(JTT,IXX)=UT(JTT,IXX)+((FUP(1)+FUP(2))*CIR(NN,IXX))/12.566371
8271 VBT(JTT,IXX)=VBT(JTT,IXX)+((FVP(1)+FVP(2))*CIR(NN,IXX))/12.566371
8271 CONTINUE
C
C CALCULATE VELOCITIES U AND V AT HOR. TAIL VORTEX BOUNDLEG MIDPOINT
C INDUCED BY PYLON IMAGE VORTICES
C
IF (MSPI.EQ.0) GO TO 3113
DO 8272 NV=1,NCT
JTT=(IT-2)*NCT+NV
DO 8272 NN=MPI,MMP
NNP=NN-M
XBTP=PVTX(JTT)-PVPX(NNP)
YBTP(1)=PVTY(JTT)-PVPY(NNP)
YBTP(2)=PVTY(JTT)+PVPY(NNP)
ZBTP=PVTZ(JTT)-PVPZ(NNP)
DO 2670 L=1,2
CALL INFWH(SWPVP(NNP),PHIP,XBTP,YBTP(L),ZBTP,SPI(NNP),FUPI(L),
1FUPI(L),FUPI(L))
2670 CONTINUE
DO 8132 IXX=1,2
8132 VBT(JTT,IXX)=VBT(JTT,IXX)+((FUPI(1)+FUPI(2))*CIR(NI,IXX))/12.566371
8272 VBT(JTT,IXX)=VBT(JTT,IXX)+((FVPI(1)+FVPI(2))*CIR(NI,IXX))/
112.566371
8272 CONTINUE
3113 CONTINUE
C

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C   CALCULATE LIFT ON CHORDWISE ROW OF ELEMENTAL PANELS ON THE
C   HORIZONTAL TAIL
C   WING SEMISPAN AND PLANFORM AREA SREF USED AS REFERENCE
C
3103 TCHLOC(IT)=CRT-YT(IT)*(SWPTLE-SWPTTE)
DO 8150 IXX=1,2
CIRNET=0.0
DO 8290 NT=1,NCT
JTT=(IT-2)*NCT+NT
NI=JTT+(M+MP)
JS=(IT-1)*NCT+NT
NS=JS+(M+MP)
TT(JTT)=SSPAN/(ST(JTT)*TCSPHI)
IF (IT.EQ.ITMAX) GO TO 2110
CIRNET=CIRNET+CIR(NI,IXX)-CIR(NS,IXX)
GO TO 2111
2110 CIRNET=CIRNET+CIR(NI,IXX)
2111 FAC=1.0
IF (NT.EQ.NCT) FAC=0.75
DT=NCT
TLPANL(JTT)=TCHLOC(IT)/DT
TTLIFT(JTT,IXX)=TLPANL(JTT)*FAC*VT(JTT,IXX)*(2.0/SREF)*CIRNET
RTLIFT(JTT,IXX)=(2.0/SREF)*2.0*ST(JTT)*CIR(NI,IXX)*((1.0-UT(JTT,
1XX))*TCSPHI+VRT(JTT,IXX)*SWPTVV(JTT))
IF (IT.GT.2) GO TO 2107
TCHLIF(IT,IXX)=TCHLIF(IT,IXX)+(TTLIFT(JTT,IXX)/2.0)+RTLIFT(JTT,
1XX)
GO TO 8320
2107 JU=(IT-3)*NCT+NT
TCHLIF(IT,IXX)=TCHLIF(IT,IXX)+((TTLIFT(JTT,IXX)+TTLIFT(JU,IXX))/
12.0)+RTLIFT(JTT,IXX)
8320 TSLDC1(IT,IXX)=TT(JTT)*TCHLIF(IT,IXX)
C
C   TAIL LOADING COEFFICIENTS ARE REFERENCED TO WING REF. AREA, SPAN,
C   AND AVERAGE CHORD AND LIFT COEFFICIENT
C
TECLIF=(SECTION LIFT*LOCAL CHORD)/(2.0*WING SPAN)
C
TECLIF(IT,IXX)=TCHLIF(IT,IXX)*SREF/(2.0*ST(JTT)*TCSPHI*4.0*SSPAV
1N))
8290 CONTINUE
C
C   SPANWISE SUMMING UP OF LIFTS ACTING ON CHORDWISE ROW OF
C   ELEMENTAL PANELS, TUMLIF=CL FOR HORIZONTAL TAIL
C
TUMLIF(IXX)=TUMLIF(IXX)+2.0*TCHLIF(IT,IXX)
8150 CONTINUE
IF (IT.LT.ITMAX) GO TO 7020
C
TSLDCO=SPANLOAD COEFFICIENT CLC/CLCAVE FOR THE HORIZONTAL TAIL
C
DO 3110 IXX=1,2
DO 3110 IT=2,ITMAX
IF (TUMLIF(IXX).EQ.0.0) GO TO 3821
TSLDCO(IT,IXX)=TSLDC1(IT,IXX)/SUMLIF(IXX)
GO TO 3110
3821 TSLDCO(IT,IXX)=0.0
3110 CONTINUE
GO TO 9131
9120 TSREF=0.0
TCAVE=0.0
TUMLIF(1)=0.0
TUMLIF(2)=0.0
9131 CONTINUE
CLTOT(1)=SUMLIF(1)+TUMLIF(1)
CLTOT(2)=SUMLIF(2)+TUMLIF(2)
C
C   PITCHING MOMENT CALCULATION FOLLOWS, SMALL ANGLES OF ATTACK ONLY,
C   WING AND TAIL LIFT FORCES TAKEN INTO ACCOUNT ONLY
C

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C   MOMENTS ARE TAKEN ABOUT POINT WITH COORDINATES XM, YM, ZM, AND ARE
C   DIVIDED BY Q*SREF*CAVE
C
C
C   WMOM(1)=0.0
C   WMOM(2)=0.0
C   TMOM(1)=0.0
C   TMOM(2)=0.0
C   DO 9108 IXX=1,2
C   DO 9109 JT=1,M
9109 WMOM(IXX)=WMOM(IXX)+(2.0*(BLLIFT(JT,IXX)*(PVX(JT)-XMC)+TLLIFT(JT,
1XX)*(PTLX(JT)-XMC))/CAVE)*BETA
DO 9110 JTT=1,MT
9110 TMOM(IXX)=TMOM(IXX)+(2.0*(BLLIFT(JTT,IXX)*(XMC-PVTX(JTT))+TTLIFT
1(JTT,IXX)*(XMC-PTTLX(JTT)))/CAVE)*BETA
9108 CONTINUE
C
TOTMOM(1)=WMOM(1)+TMOM(1)
TOTMOM(2)=WMOM(2)+TMOM(2)
C
RETURN
END

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      IF (ABS(PIVOTI)-R1) 320, 1080, 1080
1080 PIVOTI=PIVOTI/R1
      ISCALE=ISCALE+1
      GO TO 320
1090 IF (ABS(PIVOTI)-R2) 2000, 2000, 320
2000 PIVOTI=PIVOTI*R1
      ISCALE=ISCALE-1
      IF (ABS(PIVOTI)-R2) 2010, 2010, 320
2010 PIVOTI=PIVOTI*R1
      ISCALE=ISCALE-1
320 DETERM=DETERM*PIVOTI
C
C      DIVIDE PIVOT ROW BY PIVOT ELEMENT
C
330 A(ICOLUM, ICOLUM)=1.0
340 DO 350 L=1, N
350 A(ICOLUM, L)=A(ICOLUM, L)/PIVOT
355 IF (M) 380, 380, 360
360 DO 370 L=1, M
370 B(ICOLUM, L)=B(ICOLUM, L)/PIVOT
C
C      REDUCE NON-PIVOT ROWS
C
380 DO 550 L1=1, N
390 IF (L1-ICOLUM) 400, 550, 400
400 T=A(L1, ICOLUM)
420 A(L1, ICOLUM)=0.0
430 DO 450 L=1, N
450 A(L1, L)=A(L1, L)-A(ICOLUM, L)*T
455 IF (M) 550, 550, 460
460 DO 500 L=1, M
500 B(L1, L)=B(L1, L)-B(ICOLUM, L)*T
550 CONTINUE
C
C      INTERCHANGE COLUMNS
C
600 DO 710 I=1, N
610 L=N+1-I
620 IF (INDEX(L, 1)-INDEX(L, 2)) 630, 710, 630
630 JROW=INDEX(L, 1)
640 JCOLUM=INDEX(L, 2)
650 DO 705 K=1, N
660 SWAP=A(K, JROW)
670 A(K, JROW)=A(K, JCOLUM)
700 A(K, JCOLUM)=SWAP
705 CONTINUE
710 CONTINUE
740 RETURN
      END

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SAMPLE INTERFERENCE CALCULATION

In this section a sample case is set up to illustrate the use of the programs presented in this report to compute the interference of a high-bypass-ratio turbofan engine on a wing-pylon-tail configuration. Use of the lift-fan program to provide interference effects for the wing-pylon-tail program is also discussed.

Turbofan Engine-Airframe Interference

Calculation procedure.- The calculation of the interference of a high-bypass-ratio turbofan engine on a wing-pylon-tail configuration proceeds in the following manner. First, the vortex lattice program is used to compute the characteristics of the wing-pylon-tail configuration in a uniform flow at angle of attack (no interference from any external source). The flow field induced in the vicinity of the turbofan engine is computed at this time. From this flow field, average values of downwash and sidewash acting on the turbofan engine are obtained. These average values are made up of two components. The first is due to wing camber and twist, and pylon and tail camber, twist, and incidence, all at zero wing angle of attack. The second is due to the flat wing-pylon-tail at angle of attack (the additional loading case).

The turbofan engine characteristics and the components of the induced flow field at the engine are then input into the turbofan engine program. The singularity distribution representing the engine in the disturbed flow field is computed. From this singularity distribution, the flow field induced on the wing, pylon, and tail is obtained.

The engine-induced flow field is then input into the vortex lattice program in the form of perturbation velocities at the control points. A new wing-pylon-tail loading distribution is computed which includes the effect of the turbofan engine. Using the new loading, the induced flow field in the vicinity of the engine is recomputed and compared with the previous results. If the difference is sufficiently small, the interference calculation is complete. However, should the difference be large, a second iteration is necessary. A second iteration is carried out in exactly the same manner as the first. A specific case will be computed in the following section to further illustrate the above procedure.

Sample case.— An interference calculation such as that described in reference 1 using both the turbofan engine and the wing-pylon-tail vortex lattice programs proceeds as follows. For the illustrative sample case, the airframe configuration chosen is that of a wind tunnel model of a typical high-speed transport type aircraft (fig. 16). The wing has both camber and twist. The tip chord is twisted -3.5° with respect to the root chord and the twist distribution is assumed linear. The wing camber is defined by a NACA mean line $a = 0.4$ ($c_{\ell_i} = -0.02353$) at $\eta = 0.2$ and a NACA 63.25 mean line ($c_{\ell_i} = 0.1307$ at $\eta = 0.7$). Since four rows of vortices, chordwise, will be used on the wing, the wing mean surface slopes due to twist and camber are required at four chordwise stations over the wing semispan. The four slopes due to camber only at $\eta = 0.2$ and 0.7 are shown in figure 17, together with an assumed variation of these slopes over the remainder of the semispan. The mean surface slopes required as input to the vortex lattice program are the sum of those shown in figure 17 and the local twist angle.

The wing has a single pylon located at $\eta = 0.57$. The pylon is uncambered and untwisted, but it does have a 1° toe-in angle. The relationship between the pylon and wing is shown in figure 16.

The horizontal tail shown in figure 16 has basically the same planform as the wing except that it has no camber or twist. The tail has 0.5° incidence angle with respect to the wing root chord and is located 10 inches above the wing. The tail has a 1° positive dihedral angle.

The model turbofan engine is a single-stage fan driven by a turbine using an external cold gas supply, and is similar to that described in reference 17. A sketch of the engine is shown in figure 16 illustrating the relative size and location of the fan ducts and the core engine duct. Note that the engine has no toe-in angle and is at -4.5° incidence with respect to the wing root chord.

The conditions chosen for the sample calculation are the same as those presented in reference 1 with the exception that the results of reference 1 are for a wing-pylon-engine configuration with no horizontal tail present. The free stream Mach number is 0.7. The velocity ratios in the turbofan engine wake were measured during the wind tunnel tests described in reference 1 and the following representative values are used.

$$\frac{V_f}{V} = 1.473 \quad \frac{V_e}{V} = 0.8248$$

The unusual shape of the wake profile ($V_e < V$) and its effect is discussed in the above reference.

The first step in the calculation is to obtain the wing-pylon-tail characteristics with no external interference. The vortex lattice program is run with the first set of input shown in figure 14. The results of this run are presented in figure 15. Note that there are no externally induced velocities considered in this case. The flow field induced by the wing-pylon-tail loadings in the vicinity of the turbofan engine is calculated at points which correspond nearly to the engine centerline, the top and bottom of the engine ducts, and the inboard and outboard sides of the engine ducts.

The next step in the interference calculation is to compute the turbofan engine performance in the perturbed flow field. This requires knowledge of the average induced upwash and sidewash on both the fan and core engine ducts as was discussed previously. The wing-pylon-tail induced upwash in the vicinity of the engine is shown in figure 18 where the velocities induced by the $\alpha = 0^\circ$ loading and the additional loading at $\alpha = 2.5^\circ$ are both shown. The average induced upwash angles in the wing coordinate system are obtained from this figure, and the sidewash angles are obtained from similar curves. Noting that the engine is at -4.5° incidence with respect to the wing root chord and 0° toe-in, the following values are chosen.

		$\alpha = 0^\circ$			$\alpha = 2.5^\circ$		
		Incidence angle	Induced angle	Total angle	Incidence angle	Induced angle	Total angle
Fan	α_f	-4.5°	0.2°	$\approx -4.5^\circ$	2.5°	-1.0°	3.5°
	β_f	0°	0.05°	$\approx 0^\circ$	0°	-0.5°	-0.5°
Engine	α_e	-4.5°	-0.05°	$\approx -4.5^\circ$	2.5°	-0.9°	3.4°
	β_e	0°	0.3°	$\approx 0^\circ$	0°	-1.3°	-1.3°

Angles less than 0.5° are neglected in the above table because their effect is small.

Some care is required in determining the flow angles on the fan and core engine ducts such that certain incidence angles are not included twice in the calculation. The incidence and toe-in angles with respect to the wing root chord cause cross flow velocities on the engine at $\alpha = 0$ and therefore are included in the $\alpha = 0$ calculation. The flow angles induced by the $\alpha = 0$ loading on the wing-pylon-tail are superimposed on these incidence angles. For the additional loading case, the engine centerline must be aligned with the wing root chord, since the crossflow must go to zero as $\alpha \rightarrow 0$. Thus the engine has the same angle of attack as the wing root chord and the flow angles induced by the $\alpha \neq 0$ loading on the wing-pylon-tail are superimposed on these angles as shown in the above table. Some caution must be exercised in superimposing the above angles so that the signs are correct. Notice that a positive angle of attack exposes the bottom of the engine to the flow. However, because of the sign convention chosen for the induced velocities in the wing coordinate system, an induced downwash striking the top of the engine is taken as positive. The sign of the induced angles of attack must be changed before they are added to the geometric angle of attack. The signs of the induced sidewash are consistent as computed and therefore need not be changed. This is also illustrated in the above table.

The angles in the above table are included in the input to the turbofan engine program shown in figure 4. The output of the calculation is presented as figure 5. The important parts of the particular output are on pages 4 and 5 where the induced velocity components are listed for the $\alpha = 0^\circ$ and $\alpha = 2.5^\circ$ loading conditions, respectively. These externally induced velocities are included in the second set of input to the wing-pylon-tail program (fig. 14).

The wing-pylon-tail program is rerun with the engine interference included. This is considered the first iteration in the interference calculation. The induced flow field in the vicinity of the turbofan engine ducts is again computed. The new results (fig. 15(b)) are compared with the previous "no interference" case to determine if a second iteration is necessary. If the induced angles at the engine location have changed appreciably, the turbofan engine program should be rerun with the new induced angles to provide a new set of externally induced velocities for the vortex lattice program. The authors have found that for typical

transport type aircraft in a cruise configuration, the second iteration is unnecessary because the effect of the turbofan engine on the airframe is small. In the case of very closely coupled engines and wings, the interference effects could be large and additional iterations would be necessary. In this case the induced velocity field over the fan and engine ducts is even more nonuniform than that shown in figure 18; therefore, the assumption of a uniform upwash and sidewash may limit the reliability of the computed results.

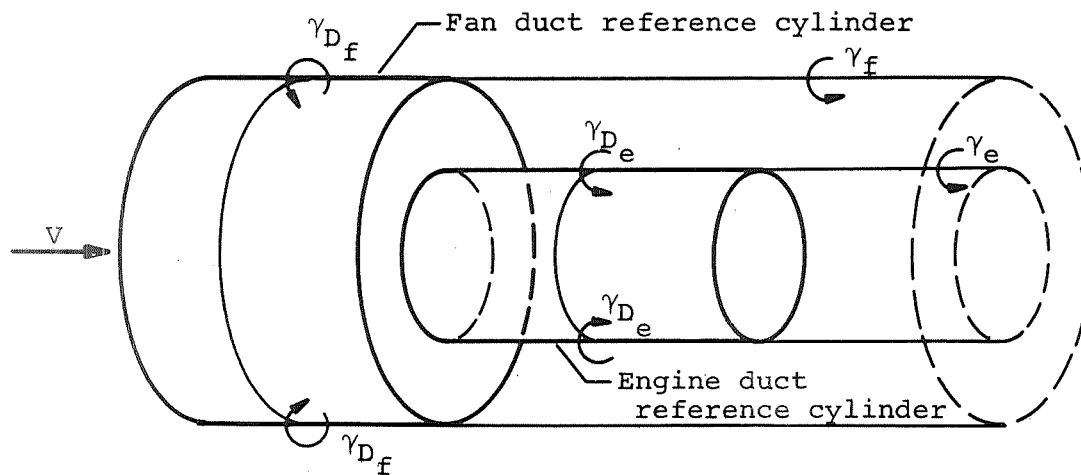
Lift-Fan Interference

The calculation of the interference of a lift fan on a wing-tail combination does not require iteration. The lift-fan model as described previously is not affected by interference velocity fields. Thus the fan wake calculation is made first and the velocities induced at the wing-tail control points is determined. These velocities are input as externally induced velocities on the wing and/or tail for the zero wing angle of attack loading case. The results from the vortex lattice program include the desired interference effects and no further iterations are necessary.

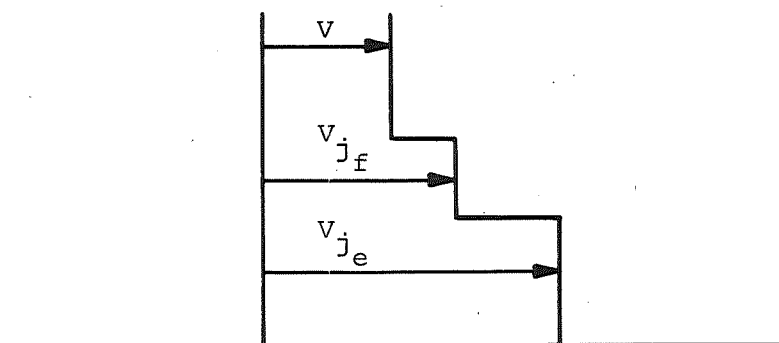
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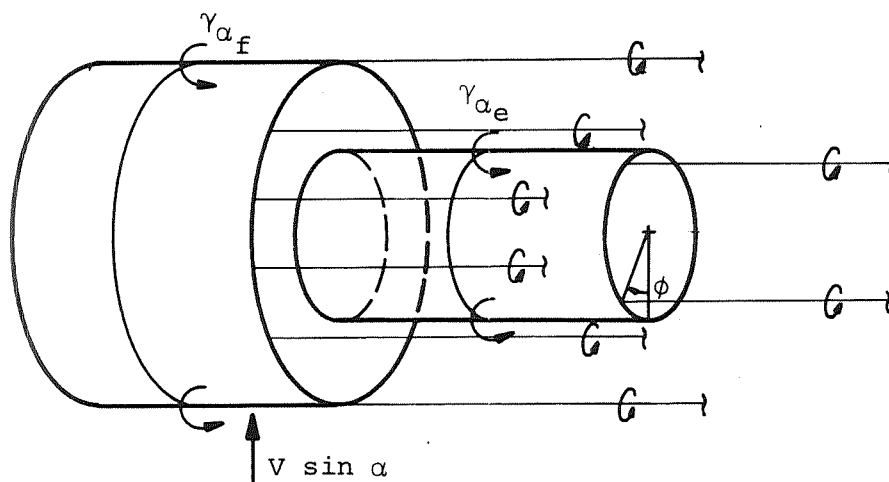
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15. Margason, R. J.: Path of a Jet Directed at Large Angles to a Subsonic Free Stream. NASA TN D-4919, Nov. 1968.
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(a) Axisymmetric vorticity distribution.



(b) Wake velocity profile.



(c) Angle of attack vorticity distribution.

Figure 1.- High-bypass-ratio turbofan engine model.

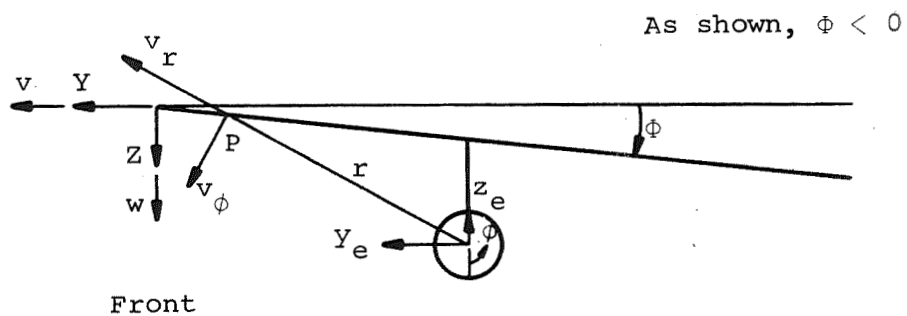
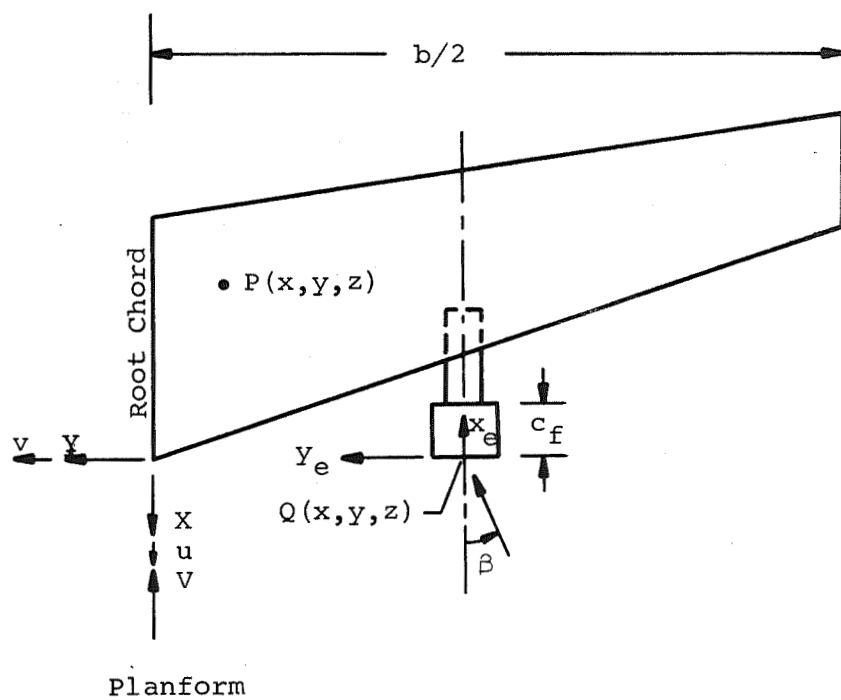


Figure 2.- Typical wing and high bypass ratio turbofan engine.

Item No. 1: Format (20A4), any alphabetic or numeric information
(1 card)

Column No.	1-80
Program Variable	TITLE
Data	

Item No. 2: Format (7F10.0), decimal point required
(1 card)

Column No.	10	20	30	40	50	60	70	80
Program Variable	CDF	CHF	TCF	RF(1)	RF(2)	RF(3)	RF(4)	
Data								

Item No. 3: Format (7F10.0), decimal point required
(1 card)

Column No.	10	20	30	40	50	60	70	80
Program Variable	CDE	CHE	TCE	RE(1)	RE(2)	RE(3)	RE(4)	
Data								

Item No. 4: Format (5F10.0), decimal point required
(1 card)

Column No.	10	20	30	40	50	60	70	80
Program Variable	RFRE	XECF	EMZ	VFVZ	VEVZ			
Data								

Item No. 5: Format (4I5)
(1 card)

Column No.	5	10	15	20	25	30	
Program Variable	NTYPE	MMP	NPRNT	NCALC			
Data							

Note: If NCALC < 0, Items 6, 7, and 8 are omitted and the program computes only the turbofan flow model.

Item No. 6: Format (8F10.0), decimal point required
(1 card)

Column No.	10	20	30	40	50	60	70	80
Program Variable	ALPHF	BETAF	ALPHE	BETAE	ADALF	ADBTF	ADALE	ADBTE
Data								

Item No. 7: Format (3F10.0), decimal point required
(1 card)

Column No.	10	20	30	40	
Program Variable	XQ	YQ	ZQ		
Data					

Item No. 8: Format (3F10.0), decimal point required
(MMP cards)

Column No.	10	20	30	40	
Program Variable	XW(J)	YW(J)	ZW(J)		
Data					

(J = 1, 2, ..., MMP)

(a) Normal input, NTYPE = 1, NCALC ≤ 0.

Figure 3.- Input forms for turbofan engine flow model program.

Item No. 1	}	Same as shown in figure 3(a).
Item No. 2		
Item No. 3		
Item No. 4		
Item No. 5		

If NTYPE = 0, insert the following two cards between Items 5 and 6.

Item No. 5(a): Format (7F10.0), decimal point required
(2 cards) (1)

Column No.	10	20	30	40	50	
Program Variable	ALT	PZ	TZ	RZ	GAMMA	
Data						

(2)

Column No.	10	20	30	40	50	60	70	80
Program Variable	FNT	WAT2	BPR	PFP2	TFT2	PEP2	TET2	
Data								

Note: If NCALC < 0, Items 6, 7, and 8 are omitted as before.

(b) Optional input, NTYPE = 0, NCALC ≤ 0.

Figure 3.- Continued.

Item No. 1
 Item No. 2
 Item No. 3
 Item No. 4
 Item No. 5

} Same as shown in figure 3(a).

If NCALC > 0, insert the following two cards between Items 5 and 6

Item No. 5(a): Format (6E13.6), decimal point required
 (2 cards) (1)

Column No.	13	26	39	52	65	78
Program Variable	CF(1)	CF(2)	CF(3)	CF(4)	CF(5)	CF(6)
Data						

(2)

Column No.	13	26	39	52	65	78
Program Variable	CE(1)	CE(2)	CE(3)	CE(4)	CE(5)	CE(6)
Data						

Item No. 6
 Item No. 7
 Item No. 8

} Same as shown in figure 3(a).

(c) Optional input, NCALC > 0.

Figure 3.- Concluded.

RUN 1-A , TURBOFAN INDUCED VELOCITIES AT WING-PYLON-TAIL FIELD POINTS, ALPHA=2.5

1.43	7.36	0.	0.	0.	0.	0.
2.92	7.94	0.	0.	0.	0.	0.
1.90	1.0	0.7	1.473	0.8248		
1	108	1	0			
-4.5	0.0	-4.5	0.0	3.5	-0.5	3.4
-9.16	-42.574	8.12				-1.3
-6.9048	-2.2865	0.1398				
-14.5511	-2.2865	0.1398				
-22.1973	-2.2865	0.1398				
-29.8436	-2.2865	0.1398				
-8.8881	-6.5730	0.4020				
-16.2542	-6.5730	0.4020				
-23.6203	-6.5730	0.4020				
-30.9864	-6.5730	0.4020				
-10.7389	-10.5730	0.6467				
-17.8435	-10.5730	0.6467				
-24.9482	-10.5730	0.6467				
-32.0528	-10.5730	0.6467				
-12.5897	-14.5730	0.8913				
-19.4329	-14.5730	0.8913				
-26.2760	-14.5730	0.8913				
-33.1192	-14.5730	0.8913				
-14.4405	-18.5730	1.1360				
-21.0222	-18.5730	1.1360				
-27.6039	-18.5730	1.1360				
-34.1855	-18.5730	1.1360				
-16.2913	-22.5730	1.3806				
-22.6115	-22.5730	1.3806				
-28.9317	-22.5730	1.3806				
-35.2519	-22.5730	1.3806				
-18.1422	-26.5730	1.6253				
-24.2009	-26.5730	1.6253				
-30.2596	-26.5730	1.6253				
-36.3183	-26.5730	1.6253				
-19.9930	-30.5730	1.8699				
-25.7902	-30.5730	1.8699				
-31.5875	-30.5730	1.8699				
-37.3847	-30.5730	1.8699				
-21.8438	-34.5730	2.1146				
-27.3795	-34.5730	2.1146				
-32.9153	-34.5730	2.1146				
-38.4511	-34.5730	2.1146				
-23.4632	-38.0730	2.3286				
-28.7702	-38.0730	2.3286				
-34.0772	-38.0730	2.3286				
-39.3842	-38.0730	2.3286				
-24.8513	-41.0730	2.5121				
-29.9622	-41.0730	2.5121				
-35.0731	-41.0730	2.5121				
-40.1840	-41.0730	2.5121				
-26.2394	-44.0730	2.6956				
-31.1542	-44.0730	2.6956				
-36.0690	-44.0730	2.6956				
-40.9838	-44.0730	2.6956				
-27.6275	-47.0730	2.8791				
-32.3462	-47.0730	2.8791				
-37.0649	-47.0730	2.8791				
-41.7836	-47.0730	2.8791				
-29.2470	-50.5730	3.0932				
-33.7369	-50.5730	3.0932				
-38.2268	-50.5730	3.0932				
-42.7167	-50.5730	3.0932				
-31.0978	-54.5730	3.3378				
-35.3262	-54.5730	3.3378				
-39.5546	-54.5730	3.3378				
-43.7831	-54.5730	3.3378				
-37.9486	-58.5730	3.5825				
-36.9155	-58.5730	3.5825				
-40.8825	-58.5730	3.5825				
-44.8494	-58.5730	3.5825				
-34.7994	-62.5730	3.8271				
-38.5049	-62.5730	3.8271				
-42.2104	-62.5730	3.8271				
-45.9158	-62.5730	3.8271				
-36.6502	-66.5730	4.0718				
-40.0942	-66.5730	4.0718				
-43.5382	-66.5730	4.0718				
-46.9822	-66.5730	4.0718				
-38.5010	-70.5730	4.3164				
-41.6835	-70.5730	4.3164				
-44.8661	-70.5730	4.3164				
-48.0486	-70.5730	4.3164				
-39.9804	-73.7702	4.5120				
-42.9539	-73.7702	4.5120				
-45.9274	-73.7702	4.5120				
-48.9010	-73.7702	4.5120				
-21.2770	-42.5740	3.6039				
-26.6123	-42.5740	3.6039				
-31.9476	-42.5740	3.6039				
-37.2829	-42.5740	3.6039				
-14.9890	-42.5740	5.0769				
-20.7994	-42.5740	5.0769				
-26.6098	-42.5740	5.0769				
-32.4202	-42.5740	5.0769				
-99.4148	-1.2500	-10.0218				
-104.4484	-1.2500	-10.0218				
-100.4490	-3.7500	-10.0655				
-105.1557	-3.7500	-10.0655				
-101.4832	-6.2500	-10.1091				
-105.8631	-6.2500	-10.1091				
-102.5174	-8.7500	-10.1527				
-106.5704	-8.7500	-10.1527				
-103.5516	-11.2500	-10.1964				
-107.2778	-11.2500	-10.1964				
-104.5858	-13.7500	-10.2400				
-107.9852	-13.7500	-10.2400				
-105.6199	-16.2500	-10.2836				
-108.6925	-16.2500	-10.2836				
-106.6541	-18.7500	-10.3273				
-109.3998	-18.7500	-10.3273				
-107.6883	-21.2500	-10.3709				
-110.1072	-21.2500	-10.3709				
-108.7225	-23.7500	-10.4146				
-110.8145	-23.7500	-10.4146				

(a) Input for normal run with known wake velocities.

Figure 4. Sample input to turbofan engine program.

RUN 1-B HIGH BYPASS RATIO TURBOFAN ENGINE FLOW MODEL

1.43	7.36	0.0	0.0	0.0	0.0	0.0
2.92	7.94	0.0	0.0	0.0	0.0	0.0
1.90	1.0	0.7	1.473	0.8248		
1	0	1	-1			

(b) Input for computing only turbofan engine flow model from known wake velocities.

RUN 1-C TURBOFAN ENGINE INDUCED FLOW FIELD

1.43	7.36	0.0	0.0	0.0	0.0	0.0
2.92	7.94	0.0	0.0	0.0	0.0	0.0
1.90	1.0	0.7	1.473	0.8248		
1	2	1	1			
8.763752E-02	2.913723E-01	-1.135658E-01	9.720423E-02	-7.968484E-02	6.441038E-02	
-1.130831E-01	-6.362226E-01	1.537594E-01	-1.500502E-01	1.077964E-01	-8.458991E-02	
-4.5	0.	-4.5	0.	3.5	-0.5	3.4
-9.16	-42.574	8.12				-1.3
-6.9048	-2.2865	0.1398				
-14.9048	-2.2865	0.1398				

(c) Input for computing induced flow field using known engine flow model.

RUN 1-D HIGH BYPASS RATIO TURBOFAN ENGINE FLOW MODEL

1.43	7.36	0.0	0.0	0.0	0.0	0.0
2.92	7.94	0.0	0.0	0.0	0.0	0.0
1.90	1.0	0.15				
0	0	1	-1			
0.	2116.2	519.0	0.002377	1.4		
29791.	1359.	5.18	1.43	1.12	1.35	2.45

(d) Input for computing turbofan engine flow model from known engine characteristics.

Figure 4.- Concluded.

GEOMETRIC CHARACTERISTICS

	C/L	C	T/C	RO	R1	R2	R3	RF/RE	XE/CF
FAN	1.43000	7.36000	0.00000	0.00000	0.00000	0.00000	0.00000	1.90000	1.00000
ENGINE	2.92000	7.94000	0.00000	0.00000	0.00000	0.00000	0.00000		

TRANSFORMED GEOMETRIC CHARACTERISTICS M = 0.700

FAN C/D	ENG C/D	FAN C	ENG C
2.00240	4.08882	10.30606	11.11822

WAKE CHARACTERISTICS

G(F)/V	G(E)/V	VF/V	VE/V
0.47300	-0.64820	1.47300	0.82480

COEFFICIENTS OF BOUND VORTICITY C(N), N=1,6

FAN	8.7637517E-02	2.9137233E-01	-1.1356583E-01	9.7204230E-02	-7.9684835E-02	6.4410385E-02
ENGINE	-1.1308311E-01	-8.3622263E-01	1.5375944E-01	-1.5005015E-01	1.0779640E-01	-8.4589913E-02

CONVERGENCE, 9 0.0010

INDUCED VELOCITY COEFFICIENTS

FAN						
B(N)	-1.2015707E-01	2.0620208E-01	-1.5292448E-01	1.0956105E-01	-8.1042063E-02	6.3364944E-02
B*(N)	7.9423047E-02	-9.6863886E-02	4.3263930E-02	-1.6487765E-02	6.1395433E-03	-2.6550736E-03
B(N)-TILDE	-2.5681575E-04	3.0929352E-04	-9.2657692E-05	2.5072053E-05	-3.7997941E-06	1.3736805E-06
B*(N)-TILDE	1.8640829E-03	-1.1753840E-03	2.3903069E-04	-3.4626800E-05	8.0334368E-06	-8.1719770E-06
F(N)-TILDE	1.7088685E-02	-2.5972144E-02	1.2753346E-02	-3.0932424E-03	1.3733308E-03	2.3423864E-03
F*(N)-TILDE	-5.2853798E-03	7.3891800E-04	6.5411990E-03	-7.2489797E-03	4.7631489E-03	-2.1164403E-03
ENGINE						
B(N)	-8.2562549E-02	1.5401602E-01	-1.3048751E-01	1.0490326E-01	-8.2957024E-02	6.6254978E-02
B*(N)	5.3701517E-02	-8.3366140E-02	5.2191042E-02	-2.8587647E-02	1.4340478E-02	-6.9101550E-03
B(N)-TILDE	-4.1757641E-02	-6.5296133E-02	-3.5901609E-02	1.3271094E-02	-1.3524362E-03	2.7822674E-03
B*(N)-TILDE	8.6896137E-01	-1.8885085E-01	-1.0359393E-01	-4.9729405E-02	-1.9951134E-02	-6.4165433E-03
F(N)-TILDE	1.5026586E-02	2.3737179E-02	1.3161314E-02	4.8902361E-03	4.8828295E-04	-1.0573893E-03
F*(N)-TILDE	4.4892641E-02	6.7203953E-02	3.8441345E-02	1.8414628E-02	7.5302963E-03	2.5036716E-03

Figure 5.- Sample output from turbofan engine program.

FAN C/C C GAM/V IF/KC AE/CF
ENGINE 1.4300 7.3600 0.4730 1.9000 1.0000
2.4200 7.9400 -0.0402

BETA XW YW ZW
C.7000 C.7141 -9.1800 -42.3740 8.1200

COEFFICIENTS OF ALL-D VORTICITY C(N),N=1,6
FAN 7.627517E-01 2.9137233E-01 -1.1356583E-01 9.7204230E-02 -7.9684835E-02 6.4410385E-02
ENGINE -1.1308311E-01 -0.3022263E-01 1.5375944E-01 -1.5005015E-01 1.0779640E-01 -8.4589913E-02

N	(WING COORDINATE SYSTEM)			(ENGINE COORDINATE SYSTEM)			PHI	
	XW	YW	ZW	X	Y	Z	R	
1	-0.9048E	CC -2.2385E	00 1.3980E-01	-2.2532E	00 4.0267E	01 7.9802E	00 4.1070E	01 2.5880E
2	-1.4551E	01 -2.2865E	00 1.3980E-01	5.3911E	00 4.0267E	01 7.9802E	00 4.1070E	01 2.5880E
3	-2.2197E	01 -2.2865E	00 1.3980E-01	1.3037E	01 4.0267E	01 7.9802E	00 4.1070E	01 2.5880E
4	-1.9844E	01 -2.2865E	00 1.3980E-01	2.0684E	01 4.0267E	01 7.9802E	00 4.1070E	01 2.5880E
5	-0.8861E	CC -0.5730E	00 4.0200E-01	-2.7195E	01 3.6001E	01 7.7180E	00 3.6819E	01 2.5790E
6	-1.6254E	01 -0.5730E	00 4.0200E-01	7.0942E	00 3.6001E	01 7.7180E	00 3.6819E	01 2.5790E
7	-2.3020E	01 -0.5730E	00 4.0200E-01	1.4460E	01 3.6001E	01 7.7180E	00 3.6819E	01 2.5790E
8	-3.0986E	01 -0.5730E	00 4.0200E-01	2.1826E	01 3.6001E	01 7.7180E	00 3.6819E	01 2.5790E
9	-1.0719E	01 -1.0573E	01 0.4670E-01	1.5789E	00 3.2001E	01 7.4733E	00 3.2862E	01 2.5686E
10	-1.7843E	01 -1.0573E	01 0.4670E-01	0.8683E	00 3.2001E	01 7.4733E	00 3.2862E	01 2.5686E
11	-2.4348E	01 -1.0573E	01 0.4670E-01	1.5789E	01 3.2001E	01 7.4733E	00 3.2862E	01 2.5686E
12	-3.2035E	01 -1.0573E	01 0.4670E-01	2.2893E	01 3.2001E	01 7.4733E	00 3.2862E	01 2.5686E
13	-1.2590E	01 -1.4573E	01 8.9130E-01	3.4297E	00 2.8001E	01 7.2287E	00 2.8919E	01 2.5552E
14	-1.7423E	01 -1.4573E	01 8.9130E-01	1.0273E	01 2.8001E	01 7.2287E	00 2.8919E	01 2.5552E
15	-2.6276E	01 -1.4573E	01 8.9130E-01	1.7140E	01 2.8001E	01 7.2287E	00 2.8919E	01 2.5552E
16	-3.1115E	01 -1.4573E	01 8.9130E-01	2.3594E	01 2.8001E	01 7.2287E	00 2.8919E	01 2.5552E
17	-1.4441E	01 -1.8573E	01 1.1306E	0.52805E	00 2.4001E	01 6.9840E	00 2.4996E	01 2.5378E
18	-2.1022E	01 -1.8573E	01 1.1306E	1.1862E	01 2.4001E	01 6.9840E	00 2.4996E	01 2.5378E
19	-2.7664E	01 -1.8573E	01 1.1306E	1.8444E	01 2.4001E	01 6.9840E	00 2.4996E	01 2.5378E
20	-3.4410E	01 -1.8573E	01 1.1306E	2.5026E	01 2.4001E	01 6.9840E	00 2.4996E	01 2.5378E
21	-1.0625E	01 -2.2573E	01 1.3806E	7.1313E	00 2.0001E	01 6.7394E	00 2.1106E	01 2.5138E
22	-2.2612E	01 -2.2573E	01 1.3806E	1.3452E	01 2.0001E	01 6.7394E	00 2.1106E	01 2.5138E
23	-2.8922E	01 -2.2573E	01 1.3806E	1.9772E	01 2.0001E	01 6.7394E	00 2.1106E	01 2.5138E
24	-3.5252E	01 -2.2573E	01 1.3806E	2.6092E	01 2.0001E	01 6.7394E	00 2.1106E	01 2.5138E
25	-1.0142E	01 -2.0573E	01 1.6253E	8.9822E	00 1.6001E	01 6.4947E	00 1.7269E	01 2.4791E
26	-2.4210E	01 -2.0573E	01 1.6253E	1.5041E	01 1.6001E	01 6.4947E	00 1.7269E	01 2.4791E
27	-3.0200E	01 -2.0573E	01 1.6253E	2.1100E	01 1.6001E	01 6.4947E	00 1.7269E	01 2.4791E
28	-3.6348E	01 -2.0573E	01 1.6253E	2.7158E	01 1.6001E	01 6.4947E	00 1.7269E	01 2.4791E
29	-1.9993E	01 -3.0573E	01 1.8699E	1.0833E	01 1.2001E	01 6.2501E	00 1.3531E	01 2.4249E
30	-2.7795E	01 -3.0573E	01 1.8699E	1.6820E	01 1.2001E	01 6.2501E	00 1.3531E	01 2.4249E
31	-3.5588E	01 -3.0573E	01 1.8699E	2.2807E	01 1.2001E	01 6.2501E	00 1.3531E	01 2.4249E
32	-1.7335E	01 -3.0573E	01 1.8699E	2.8235E	01 1.2001E	01 6.2501E	00 1.3531E	01 2.4249E
33	-1.1844E	01 -3.4573E	01 2.1146E	1.2594E	01 8.0010E	00 6.0054E	00 1.0004E	01 2.3311E
34	-2.7379E	01 -3.4573E	01 2.1146E	1.8219E	01 8.0010E	00 6.0054E	00 1.0004E	01 2.3311E
35	-3.2915E	01 -3.4573E	01 2.1146E	2.3755E	01 8.0010E	00 6.0054E	00 1.0004E	01 2.3311E
36	-1.4641E	01 -3.4573E	01 2.1146E	2.9291E	01 8.0010E	00 6.0054E	00 1.0004E	01 2.3311E
37	-2.3462E	01 -3.8073E	01 2.3286E	1.4303E	01 4.5010E	00 5.7914E	00 7.3348E	00 2.1785E
38	-3.7770E	01 -3.8073E	01 2.3286E	1.9810E	01 4.5010E	00 5.7914E	00 7.3348E	00 2.1785E
39	-4.6077E	01 -3.8073E	01 2.3286E	2.4917E	01 4.5010E	00 5.7914E	00 7.3348E	00 2.1785E
40	-5.4384E	01 -3.8073E	01 2.3286E	3.0224E	01 4.5010E	00 5.7914E	00 7.3348E	00 2.1785E
41	-2.4851E	01 -4.1073E	01 2.5121E	1.5691E	01 1.5010E	00 5.6079E	00 5.8053E	01 1.9498E
42	-3.4922E	01 -4.1073E	01 2.5121E	2.0802E	01 1.5010E	00 5.6079E	00 5.8053E	01 1.9498E
43	-3.5073E	01 -4.1073E	01 2.5121E	2.5913E	01 1.5010E	00 5.6079E	00 5.8053E	01 1.9498E
44	-4.0144E	01 -4.1073E	01 2.5121E	3.1024E	01 1.5010E	00 5.6079E	00 5.8053E	01 1.9498E
45	-2.6279E	01 -4.4073E	01 2.6956E	1.7075E	01 -1.4990E	00 5.4244E	00 5.6277E	01 1.6455E
46	-3.1114E	01 -4.4073E	01 2.6956E	2.2494E	01 -1.4990E	00 5.4244E	00 5.6277E	01 1.6455E
47	-3.6069E	01 -4.4073E	01 2.6956E	2.6903E	01 -1.4990E	00 5.4244E	00 5.6277E	01 1.6455E
48	-4.0994E	01 -4.4073E	01 2.6956E	3.1824E	01 -1.4990E	00 5.4244E	00 5.6277E	01 1.6455E
49	-2.7628E	01 -4.7073E	01 2.8791E	1.8467E	01 -4.4990E	00 5.2409E	00 6.9071E	00 1.3936E
50	-3.2346E	01 -4.7073E	01 2.8791E	2.3186E	01 -4.4990E	00 5.2409E	00 6.9071E	00 1.3936E
51	-3.7065E	01 -4.7073E	01 2.8791E	2.7905E	01 -4.4990E	00 5.2409E	00 6.9071E	00 1.3936E
52	-4.1784E	01 -4.7073E	01 2.8791E	3.2624E	01 -4.4990E	00 5.2409E	00 6.9071E	00 1.3936E
53	-4.6503E	01 -4.7073E	01 2.8791E	3.7343E	01 -4.4990E	00 5.2409E	00 6.9071E	00 1.3936E
54	-3.7376E	01 -5.0573E	01 3.0932E	2.4577E	01 -7.9990E	00 5.0268E	00 9.4474E	00 1.2215E
55	-3.8275E	01 -5.0573E	01 3.0932E	2.9067E	01 -7.9990E	00 5.0268E	00 9.4474E	00 1.2215E
56	-4.2717E	01 -5.0573E	01 3.0932E	3.3557E	01 -7.9990E	00 5.0268E	00 9.4474E	00 1.2215E
57	-4.1098E	01 -5.4573E	01 3.3379E	2.1938E	01 -1.1999E	01 4.7822E	00 1.2917E	01 1.1173E
58	-4.3320E	01 -5.4573E	01 3.3379E	2.6160E	01 -1.1999E	01 4.7822E	00 1.2917E	01 1.1173E
59	-3.9525E	01 -5.4573E	01 3.3379E	3.0395E	01 -1.1999E	01 4.7822E	00 1.2917E	01 1.1173E
60	-4.3733E	01 -5.4573E	01 3.3379E	3.4623E	01 -1.1999E	01 4.7822E	00 1.2917E	01 1.1173E
61	-3.7945E	01 -5.8573E	01 3.5825E	2.3784E	01 -1.5999E	01 4.5375E	00 1.6630E	01 1.0583E
62	-4.0161E	01 -5.8573E	01 3.5825E	2.7756E	01 -1.5999E	01 4.5375E	00 1.6630E	01 1.0583E
63	-4.3023E	01 -5.8573E	01 3.5825E	3.1723E	01 -1.5999E	01 4.5375E	00 1.6630E	01 1.0583E
64	-4.4849E	01 -5.8573E	01 3.5825E	3.5695E	01 -1.5999E	01 4.5375E	00 1.6630E	01 1.0583E
65	-3.4759E	01 -6.2573E	01 3.8271E	2.5635E	01 -1.9999E	01 4.2924E	00 2.0455E	01 1.0212E
66	-3.5503E	01 -6.2573E	01 3.8271E	2.9345E	01 -1.9999E	01 4.2924E	00 2.0455E	01 1.0212E
67	-4.2210E	01 -6.2573E	01 3.8271E	3.3055E	01 -1.9999E	01 4.2924E	00 2.0455E	01 1.0212E
68	-4.5916E	01 -6.2573E	01 3.8271E	3.6765E	01 -1.9999E	01 4.2924E	00 2.0455E	01 1.0212E
69	-3.6650E	01 -6.6573E	01 4.0718E	2.7406E	01 -2.3999E	01 4.0482E	00 2.4338E	01 0.9575E
70	-4.0094E	01 -6.6573E	01 4.0718E	3.0934E	01 -2.3999E	01 4.0482E	00 2.4338E	01 0.9575E
71	-4.3538E	01 -6.6573E	01 4.0718E	3.4462E	01 -2.3999E	01 4.0482E	00 2.4338E	01 0.9575E
72	-4.6982E	01 -6.6573E	01 4.0718E	3.7922E	01 -2.3999E	01 4.0482E	00 2.4338E	01 0.9575E
73	-3.8501E	01 -7.0573E	01 4.3164E	2.9341E	01 -2.7999E	01 3.8036E	00 2.8256E	01 0.7736E
74	-4.1693E	01 -7.0573E	01 4.3164E	3.2525E	01 -2.7999E	01 3.8036E	00 2.8256E	01 0.7736E
75	-4.4886E	01 -7.0573E	01 4.3164E	3.5709E	01 -2.7999E	01 3.8036E	00 2.8256E	01 0.7736E
76	-4.8079E	01 -7.0573E	01 4.3164E	3.8893E	01 -2.7999E	01 3.8036E	00 2.8256E	01 0.7736E
77	-3.9480E	01 -7.3770E	01 4.5120E	3.0820E	01 -3.1196E	01 3.6080E	00 3.1404E	01 0.6597E
78	-4.2494E	01 -7.3770E	01 4.5120E	3.3744E	01 -3.1196E	01 3.6080E	00 3.1404E	01 0.6597E
79	-4.5497E	01 -7.3770E	01 4.5120E	3.6767E	01 -3.1196E	01 3.6080E	00 3.1404E	01 0.6597E
80	-4.8901E	01 -7.3770E	01 4.5120E	3.9791E	01 -3.1196E	01 3.6080E	00 3.1404E	01 0.6597E
81	-3.1277E	01 -4.2574E	01 3.6039E	1.2117E	01 -0.0000E-39	4.5161E	00 4.5161E	01 1.8000E
82	-2.6612E	01 -4.2574E	01 3.6039E	1.7452E	01 -0.0000E-39	4.5161E	00 4.5161E	01 1.8000E
83	-1.1948E	01 -4.2574E	01 3.6039E	2.2787E	01 -0.0000E-39	4.5161E	00 4.5161E	01 1.8000E
84	-3.7283E	01 -4.2574E	01 3.6039E	2.8123E	01 -0.0000E-39	4.5161E	00 4.5161E	01 1.8000E
85	-1.4985E	01 -4.2574E	01 3.6039E	3.3459E	01 -0.0000E-39	4.5161E	00 4.5161E	01 1.8000E
86	-2.0794E	01 -4.2574E	01 3.6039E	3.8795E	01 -0.0000E-39	4.5161E	00 4.5161E	01 1.8000E
87	-2.5610E	01 -4.2574E	01 3.6039E	4.4131E	01 -0.0000E-39	4.5161E	00 4.5161E	01 1.8000E
88	-3.2420E	01 -4.2574E	01 3.6039E	4.9467E	01 -0.0000E-39	4.5161E	00 4.5161E	01 1.8000E
89	-0.9415E	01 -1.3900E	00 -1.0022E	0.0022E	01 4.1324E	01 1.8142E	01 4.5131E	01 2.4630E
90	-1.4445E	01 -1.5000E	00 -1.0022E	0.0022E	01 4.1324E	01 1.8142E	01 4.5131E	01 2.4630E
91	-1.0045E	01 -3.7300E	01 -					

BASIC TYPE LOADING, ALPHA(ROU) = 0.0 DEG. ALPHA(F) BETA(F) ALPHA(E) BETA(E)
-4.5000 0.0000 -4.5000 0.0000

INDUCED VELOCITY COMPONENTS IN ENGINE REFERENCE SYSTEM

N	XW	YW	ZW	U/V	V(RAD)/V	V(TAN)/V
1	-6.9048E-01	-2.2865E-01	1.3980E-01	4.7556E-05	-5.5351E-04	-1.0291E-03
2	-1.4551E-01	-2.2865E-01	1.3980E-01	-7.0441E-05	-1.3627E-04	3.6283E-04
3	-2.2197E-01	-2.2865E-01	1.3980E-01	-1.0520E-04	3.0115E-04	1.7273E-03
4	-2.9844E-01	-2.2865E-01	1.3980E-01	-1.1824E-04	6.6416E-04	2.8499E-03
5	-8.8881E-01	-6.5730E-01	4.0200E-01	-1.5619E-05	-5.7882E-04	-7.4711E-04
6	-1.6254E-01	-6.5730E-01	4.0200E-01	-1.0207E-04	-1.5509E-05	7.9683E-04
7	-2.3620E-01	-6.5730E-01	4.0200E-01	-1.4092E-04	5.3115E-04	2.2135E-03
8	-3.0986E-01	-6.5730E-01	4.0200E-01	-1.5075E-04	9.4826E-04	3.3121E-03
9	-1.0739E-01	-1.0573E-01	6.4870E-01	-7.0271E-05	-5.6567E-04	-3.8599E-04
10	-1.7843E-01	-1.0573E-01	6.4870E-01	-1.0433E-04	1.9331E-04	1.3018E-03
11	-2.4948E-01	-1.0573E-01	6.4870E-01	-1.9602E-04	8.6573E-04	2.7836E-03
12	-3.2053E-01	-1.0573E-01	6.4870E-01	-1.9854E-04	1.3361E-03	3.8482E-03
13	-1.2590E-01	-1.4573E-01	8.9130E-01	-1.8682E-04	-4.6510E-04	1.0484E-04
14	-1.9433E-01	-1.4573E-01	8.9130E-01	-2.6680E-04	5.6926E-04	1.9397E-03
15	-2.6276E-01	-1.4573E-01	8.9130E-01	-2.3324E-04	1.3603E-03	3.4135E-03
16	-3.3119E-01	-1.4573E-01	8.9130E-01	-2.1158E-04	1.8940E-03	4.3780E-03
17	-1.4441E-01	-1.8573E-01	1.1360E-01	-3.5272E-04	-1.6200E-04	7.7917E-04
18	-2.1022E-01	-1.8573E-01	1.1360E-01	-3.7165E-04	1.2457E-03	2.7527E-03
19	-2.7604E-01	-1.8573E-01	1.1360E-01	-3.2414E-04	2.1975E-03	4.1801E-03
20	-3.4186E-01	-1.8573E-01	1.1360E-01	-1.8963E-04	2.7435E-03	5.0463E-03
21	-1.6291E-01	-2.2573E-01	1.3806E-01	-5.5061E-04	6.0297E-04	1.7381E-03
22	-2.2612E-01	-2.2573E-01	1.3806E-01	-4.9444E-04	2.6544E-03	3.7796E-03
23	-2.8932E-01	-2.2573E-01	1.3806E-01	-3.6677E-04	5.5262E-03	5.0737E-03
24	-3.5252E-01	-2.2573E-01	1.3806E-01	-3.5374E-04	4.0737E-03	5.7738E-03
25	-1.8142E-01	-2.6573E-01	1.6253E-01	-8.8280E-04	2.3786E-03	3.0895E-03
26	-2.4201E-01	-2.6573E-01	1.6253E-01	-5.7578E-04	4.6947E-03	5.0802E-03
27	-3.0260E-01	-2.6573E-01	1.6253E-01	-3.9124E-04	5.7929E-03	6.1210E-03
28	-3.6319E-01	-2.6573E-01	1.6253E-01	-2.7192E-04	6.3034E-03	6.8222E-03
29	-1.9993E-01	-3.0573E-01	1.8699E-01	-1.1359E-03	6.3643E-03	5.0166E-03
30	-2.5790E-01	-3.0573E-01	1.8699E-01	-6.8452E-04	8.9562E-03	6.6820E-03
31	-3.1588E-01	-3.0573E-01	1.8699E-01	-3.8395E-04	9.9653E-03	7.3815E-03
32	-3.7385E-01	-3.0573E-01	1.8699E-01	-3.3310E-04	1.0405E-02	7.7010E-03
33	-2.1844E-01	-3.4573E-01	2.1146E-01	-1.2725E-03	1.5367E-02	7.6387E-03
34	-2.7379E-01	-3.4573E-01	2.1146E-01	-6.3808E-04	1.7792E-02	8.7135E-03
35	-3.2915E-01	-3.4573E-01	2.1146E-01	-4.1835E-04	1.8586E-02	9.0994E-03
36	-3.8451E-01	-3.4573E-01	2.1146E-01	-2.9881E-04	1.8911E-02	9.2561E-03
37	-2.3463E-01	-3.8073E-01	2.3286E-01	-1.1734E-03	3.1944E-02	9.6150E-03
38	-2.8770E-01	-3.8073E-01	2.3286E-01	-6.1349E-04	3.3713E-02	1.0102E-02
39	-3.4077E-01	-3.8073E-01	2.3286E-01	-4.2485E-04	3.4220E-02	1.0252E-02
40	-3.9384E-01	-3.8073E-01	2.3286E-01	-3.0012E-04	3.4438E-02	1.0327E-02
41	-2.4851E-01	-4.1073E-01	2.5121E-01	-1.0075E-03	5.2057E-02	5.9497E-03
42	-2.9962E-01	-4.1073E-01	2.5121E-01	-5.6876E-04	5.3084E-02	6.0738E-03
43	-3.5073E-01	-4.1073E-01	2.5121E-01	-3.9937E-04	5.3397E-02	6.1180E-03
44	-4.0184E-01	-4.1073E-01	2.5121E-01	-3.3103E-04	5.3527E-02	6.1375E-03
45	-2.6239E-01	-4.4073E-01	2.6956E-01	-8.0600E-04	5.4149E-02	6.5053E-03
46	-3.1154E-01	-4.4073E-01	2.6956E-01	-4.9421E-04	5.4802E-02	6.5913E-03
47	-3.6069E-01	-4.4073E-01	2.6956E-01	-3.1249E-04	5.5037E-02	6.6298E-03
48	-4.0984E-01	-4.4073E-01	2.6956E-01	-2.8872E-04	5.5135E-02	6.6456E-03
49	-2.7628E-01	-4.7073E-01	2.8791E-01	-7.2104E-04	3.4366E-02	-1.1628E-02
50	-3.2346E-01	-4.7073E-01	2.8791E-01	-5.0218E-04	3.4913E-02	-1.1809E-02
51	-3.7065E-01	-4.7073E-01	2.8791E-01	-3.8622E-04	3.5142E-02	-1.1902E-02
52	-4.1784E-01	-4.7073E-01	2.8791E-01	-2.8578E-04	3.5254E-02	-1.1942E-02
53	-2.9247E-01	-5.0573E-01	3.0932E-01	-5.1583E-04	1.7170E-02	-1.0060E-02
54	-3.3737E-01	-5.0573E-01	3.0932E-01	-4.2174E-04	1.7584E-02	-1.0295E-02
55	-3.8227E-01	-5.0573E-01	3.0932E-01	-3.2250E-04	1.7792E-02	-1.0406E-02
56	-4.2717E-01	-5.0573E-01	3.0932E-01	-2.9577E-04	1.7908E-02	-1.0470E-02
57	-3.1098E-01	-5.4573E-01	3.3378E-01	-3.9949E-04	6.3794E-03	-8.0230E-03
58	-3.5326E-01	-5.4573E-01	3.3378E-01	-3.5572E-04	8.6819E-03	-8.3154E-03
59	-3.9555E-01	-5.4573E-01	3.3378E-01	-2.4604E-04	8.8528E-03	-8.4657E-03
60	-4.3783E-01	-5.4573E-01	3.3378E-01	-3.0367E-04	8.9626E-03	-8.5657E-03
61	-3.2949E-01	-5.8573E-01	3.5825E-01	-3.5032E-04	4.5839E-03	-6.8183E-03
62	-3.6916E-01	-5.8573E-01	3.5825E-01	-2.8657E-04	4.7880E-03	-7.0949E-03
63	-4.0883E-01	-5.8573E-01	3.5825E-01	-2.2281E-04	4.9161E-03	-7.2615E-03
64	-4.4849E-01	-5.8573E-01	3.5825E-01	-2.6124E-04	5.0056E-03	-7.3795E-03
65	-3.4799E-01	-6.2573E-01	3.8271E-01	-3.5826E-04	2.7337E-03	-6.0555E-03
66	-3.8505E-01	-6.2573E-01	3.8271E-01	-2.5198E-04	2.8710E-03	-6.2979E-03
67	-4.2210E-01	-6.2573E-01	3.8271E-01	-2.4707E-04	2.9670E-03	-6.4635E-03
68	-4.5916E-01	-6.2573E-01	3.8271E-01	-2.0302E-04	3.0392E-03	-6.6186E-03
69	-3.6650E-01	-6.6573E-01	4.0718E-01	-2.1084E-04	1.7326E-03	-5.4801E-03
70	-4.0094E-01	-6.6573E-01	4.0718E-01	-1.6039E-04	1.8324E-03	-5.7538E-03
71	-4.3538E-01	-6.6573E-01	4.0718E-01	-2.4304E-04	1.9043E-03	-5.9432E-03
72	-4.6982E-01	-6.6573E-01	4.0718E-01	-1.3678E-04	1.9582E-03	-6.0836E-03
73	-3.8501E-01	-7.0573E-01	4.3164E-01	-1.9736E-04	1.1541E-03	-5.1172E-03
74	-4.1683E-01	-7.0573E-01	4.3164E-01	-1.8565E-04	1.2197E-03	-5.3116E-03
75	-4.4866E-01	-7.0573E-01	4.3164E-01	-1.7780E-04	1.2691E-03	-5.4541E-03
76	-4.8049E-01	-7.0573E-01	4.3164E-01	-1.6766E-04	1.3123E-03	-5.6008E-03
77	-3.9980E-01	-7.3770E-01	4.5120E-01	-1.1578E-04	8.5176E-04	-4.8437E-03
78	-4.2954E-01	-7.3770E-01	4.5120E-01	-1.1089E-04	9.0282E-04	-5.0495E-03
79	-4.5927E-01	-7.3770E-01	4.5120E-01	-1.5717E-04	9.4321E-04	-5.2066E-03
80	-4.8901E-01	-7.3770E-01	4.5120E-01	-1.0632E-04	9.7649E-04	-5.3286E-03
81	-2.1277E-01	-4.2574E-01	3.6039E-01	-2.2663E-03	6.7721E-02	-2.1143E-09
82	-2.6612E-01	-4.2574E-01	3.6039E-01	-8.1250E-04	7.0894E-02	-2.1945E-09
83	-3.1948E-01	-4.2574E-01	3.6039E-01	-5.4323E-04	7.1282E-02	-2.2127E-09
84	-3.7283E-01	-4.2574E-01	3.6039E-01	-2.7225E-04	7.1390E-02	-2.2191E-09
85	-1.4989E-01	-4.2574E-01	5.0769E-01	-7.4795E-03	3.3729E-02	-3.3439E-09
86	-2.0799E-01	-4.2574E-01	5.0769E-01	-1.8757E-03	1.0157E-01	-4.4680E-09
87	-2.6610E-01	-4.2574E-01	5.0769E-01	-7.0427E-04	1.0618E-01	-4.5763E-09
88	-3.2420E-01	-4.2574E-01	5.0769E-01	-4.5232E-04	1.0617E-01	-4.5926E-09
89	-9.9413E-01	-1.2500E-01	-1.0022E-01	-2.1171E-04	2.7185E-03	4.8310E-03
90	-1.0445E-02	-1.2500E-01	-1.0022E-01	-1.1914E-04	2.7363E-03	4.8645E-03
91	-1.0045E-02	-3.7500E-01	-1.0066E-01	-1.1797E-04	3.0425E-03	4.8901E-03
92	-1.0516E-02	-3.7500E-01	-1.0066E-01	1.3012E-05	3.0588E-03	4.9153E-03
93	-1.0148E-02	-6.2500E-01	-1.0109E-01	2.6866E-05	3.4145E-03	4.9259E-03
94	-1.0586E-02	-6.2500E-01	-1.0109E-01	-4.1923E-05	3.4291E-03	4.9442E-03
95	-1.0252E-02	-8.7500E-01	-1.0153E-01	-7.3327E-05	3.8470E-03	4.9560E-03
96	-1.0657E-02	-8.7500E-01	-1.0153E-01	-1.2767E-04	3.8613E-03	4.9753E-03
97	-1.0355E-02	-1.1250E-01	-1.0196E-01	-1.6112E-04	4.3545E-03	4.9895E-03
98	-1.0728E-02	-1.1250E-01	-1.0196E-01	-1.6473E-04	4.3666E-03	5.0023E-03
99	-1.0459E-02	-1.3750E-01	-1.0240E-01	-1.1390E-04	4.9423E-03	4.9864E-03
100	-1.0799E-02	-1.3750E-01	-1.0240E-01	-3.4900E-05	4.9525E-03	4.9948E-03
101	-1.0562E-02	-1.6250E-01	-1.0284E-01	3.3286E-05	5.6356E-03	4.9732E-03
102	-1.0869E-02	-1.6250E-01	-1.0284E-01	3.6542E-05	5.6430E-03	4.9803E-03
103	-1.0665E-02	-1.8750E-01	-1.0327E-01	-1.3502E-05	6.4418E-03	4.9190E-03
104	-1.0940E-02	-1.8750E-01	-1.0327E-01	-3.9437E-05	6.4477E-03	4.9228E-03
105	-1.0769E-02	-2.1250E-01	-1.0371E-01	-8.0811E-05	7.3746E-03	4.8047E-03
106	-1.1011E-02	-2.1250E-01	-1.0371E-01	-9.3849E-05	7.3793E-03	4.8066E-03
107	-1.0872E-02	-2.3750E-01	-1.0415E-01	-1.2460E-04	8.4465E-03	4.6206E-03
108	-1.1081E-02	-2.3750E-01	-1.0415E-01	-1.2907E-04	8.4520E-03	4.6223E-03

Figure 5.- Continued.

BASIC TYPE LOADING, ALPHA(RUCT) = 0.0 DEG.

ALPHA(F) BETA(F) ALPHA(E) BETA(E)
-4.5000 0.0000 -4.5000 0.0000

INDUCED VELOCITY COMPONENTS IN WING REFERENCE SYSTEM

	XW	YW	ZW	U/V	V/V	W/V
1	-0.9046E-00	-2.2865E-00	1.3980E-01	-4.7556E-05	-7.4291E-04	-9.0189E-04
2	-1.4551E-01	-2.2865E-00	1.3930E-01	7.6441E-05	-6.3167E-05	3.6239E-04
3	-2.2197E-01	-2.2865E-00	1.3980E-01	1.0924E-04	6.3103E-04	1.6358E-03
4	-2.9844E-01	-2.2865E-00	1.3980E-01	1.1824E-04	1.2052E-03	2.6663E-03
5	-3.8881E-00	-6.2730E-00	4.0200E-01	1.6619E-05	-7.2257E-04	-6.0917E-04
6	-1.6254E-01	-6.2730E-00	4.0200E-01	1.0207E-04	1.5147E-04	7.6238E-04
7	-2.3620E-01	-6.2730E-00	4.0200E-01	1.4092E-04	9.8335E-04	2.0530E-03
8	-3.0966E-01	-6.2730E-00	4.0200E-01	1.5075E-04	1.6215E-03	3.0397E-03
9	-1.0739E-01	-1.0573E-01	6.4670E-01	7.0271E-05	-2.3863E-04	-2.4724E-04
10	-1.7843E-01	-1.0573E-01	6.4670E-01	1.6433E-04	4.8429E-04	1.2237E-03
11	-2.4948E-01	-1.0573E-01	6.4670E-01	1.9802E-04	1.4761E-03	2.5133E-03
12	-3.2053E-01	-1.0573E-01	6.4670E-01	1.9854E-04	2.1762E-03	3.4435E-03
13	-1.2590E-01	-1.4573E-01	8.9130E-01	1.8682E-04	-4.2413E-04	2.1777E-04
14	-1.9433E-01	-1.4573E-01	8.9130E-01	2.6680E-04	1.0361E-03	1.7359E-03
15	-2.6276E-01	-1.4573E-01	8.9130E-01	2.3324E-04	2.1898E-03	2.4601E-03
16	-3.3119E-01	-1.4573E-01	8.9130E-01	2.1158E-04	2.9282E-03	3.7656E-03
17	-1.4441E-01	-1.8573E-01	1.1350E-00	3.5272E-04	6.2149E-05	7.4341E-04
18	-2.1022E-01	-1.8573E-01	1.1360E-00	3.7166E-04	1.9652E-03	2.2950E-03
19	-2.7604E-01	-1.8573E-01	1.1360E-00	3.2416E-04	3.2779E-03	3.3996E-03
20	-3.4186E-01	-1.8573E-01	1.1350E-00	1.8963E-04	4.0442E-03	4.0788E-03
21	-1.6291E-01	-2.2573E-01	1.3806E-00	6.5061E-04	1.1264E-03	1.4546E-03
22	-2.2612E-01	-2.2573E-01	1.3806E-00	4.9444E-04	3.5413E-03	2.7951E-03
23	-2.8932E-01	-2.2573E-01	1.3806E-00	3.6677E-04	4.9617E-03	3.6822E-03
24	-3.5252E-01	-2.2573E-01	1.3806E-00	3.5374E-04	5.7041E-03	4.1708E-03
25	-1.8142E-01	-2.6573E-01	1.6253E-00	8.8280E-04	2.3659E-03	1.9681E-03
26	-2.4201E-01	-2.6573E-01	1.6253E-00	5.7578E-04	6.2606E-03	2.9416E-03
27	-3.0266E-01	-2.6573E-01	1.6253E-00	3.9124E-04	7.6696E-03	3.4930E-03
28	-3.6318E-01	-2.6573E-01	1.6253E-00	2.7192E-04	8.3312E-03	3.7653E-03
29	-1.9993E-01	-3.0573E-01	1.8699E-00	1.1359E-03	7.9619E-03	1.5096E-03
30	-2.5790E-01	-3.0573E-01	1.8699E-00	6.8452E-04	1.1030E-02	1.7895E-03
31	-3.1588E-01	-3.0573E-01	1.8699E-00	3.8395E-04	1.2248E-02	1.9437E-03
32	-3.7386E-01	-3.0573E-01	1.8699E-00	3.3310E-04	1.2785E-02	2.0242E-03
33	-2.1844E-01	-3.4573E-01	2.1146E-00	1.2725E-03	1.6875E-02	-3.1153E-03
34	-2.7375E-01	-3.4573E-01	2.1146E-00	6.3808E-04	1.9460E-02	-3.7115E-03
35	-3.2915E-01	-3.4573E-01	2.1146E-00	4.1835E-04	2.0327E-02	-3.8797E-03
36	-3.8451E-01	-3.4573E-01	2.1146E-00	2.9881E-04	2.0681E-02	-3.9496E-03
37	-2.3463E-01	-3.8073E-01	2.3286E-00	1.1734E-03	2.7225E-02	-1.9362E-02
38	-2.8770E-01	-3.8073E-01	2.3286E-00	6.1349E-04	2.8664E-02	-2.0420E-02
39	-3.4077E-01	-3.8073E-01	2.3286E-00	4.2485E-04	2.9094E-02	-2.0728E-02
40	-3.9384E-01	-3.8073E-01	2.3286E-00	3.0012E-04	2.9287E-02	-2.0855E-02
41	-2.4851E-01	-4.1073E-01	2.5121E-00	1.0075E-03	1.9207E-02	-4.8748E-02
42	-2.9962E-01	-4.1073E-01	2.5121E-00	5.6876E-04	1.9593E-02	-4.9709E-02
43	-3.5073E-01	-4.1073E-01	2.5121E-00	3.9937E-04	1.9716E-02	-4.9999E-02
44	-4.0184E-01	-4.1073E-01	2.5121E-00	3.3103E-04	1.9769E-02	-5.0120E-02
45	-2.6239E-01	-4.4073E-01	2.6956E-00	8.0600E-04	-2.0694E-02	-5.0460E-02
46	-3.1154E-01	-4.4073E-01	2.6956E-00	4.9421E-04	-2.0950E-02	-5.1067E-02
47	-3.6069E-01	-4.4073E-01	2.6956E-00	3.1249E-04	-2.1050E-02	-5.1283E-02
48	-4.0984E-01	-4.4073E-01	2.6956E-00	2.8872E-04	-2.1091E-02	-5.1373E-02
49	-2.7628E-01	-4.7073E-01	2.8791E-00	7.2104E-04	-3.1220E-02	-1.8517E-02
50	-3.2346E-01	-4.7073E-01	2.8791E-00	5.0218E-04	-3.1701E-02	-1.8799E-02
51	-3.7065E-01	-4.7073E-01	2.8791E-00	3.8622E-04	-3.1921E-02	-1.8912E-02
52	-4.1784E-01	-4.7073E-01	2.8791E-00	2.8578E-04	-3.2024E-02	-1.8971E-02
53	-2.9247E-01	-5.0573E-01	3.0932E-00	5.1583E-04	-1.9891E-02	-6.1805E-04
54	-3.3737E-01	-5.0573E-01	3.0932E-00	4.2174E-04	-2.0366E-02	-6.3915E-04
55	-3.8227E-01	-5.0573E-01	3.0932E-00	3.2250E-04	-2.0601E-02	-6.5649E-04
56	-4.2717E-01	-5.0573E-01	3.0932E-00	2.9577E-04	-2.0734E-02	-6.6360E-04
57	-3.1098E-01	-5.4573E-01	3.3378E-00	3.9949E-04	-1.0754E-02	4.3506E-03
58	-3.5326E-01	-5.4573E-01	3.3378E-00	3.5372E-04	-1.1144E-02	4.5102E-03
59	-3.9555E-01	-5.4573E-01	3.3378E-00	2.4604E-04	-1.1358E-02	4.5866E-03
60	-4.3782E-01	-5.4573E-01	3.3378E-00	3.0367E-04	-1.1497E-02	4.6388E-03
61	-3.2949E-01	-5.8573E-01	3.5825E-00	3.5032E-04	-6.2703E-03	5.3089E-03
62	-3.6916E-01	-5.8573E-01	3.5825E-00	2.8657E-04	-6.5434E-03	5.5236E-03
63	-4.0883E-01	-5.8573E-01	3.5825E-00	2.2611E-04	-6.7128E-03	5.6440E-03
64	-4.4849E-01	-5.8573E-01	3.5825E-00	2.6124E-04	-6.8292E-03	5.7337E-03
65	-3.4799E-01	-6.2573E-01	3.8271E-00	3.5825E-04	-3.9437E-03	5.3469E-03
66	-3.8505E-01	-6.2573E-01	3.8271E-00	2.5198E-04	-4.1288E-03	5.5550E-03
67	-4.2210E-01	-6.2573E-01	3.8271E-00	2.4707E-04	-4.2574E-03	5.6969E-03
68	-4.5915E-01	-6.2573E-01	3.8271E-00	2.0302E-04	-4.3606E-03	5.8333E-03
69	-3.6650E-01	-6.6573E-01	4.0718E-00	2.1084E-04	-2.6200E-03	5.1156E-03
70	-4.0054E-01	-6.6573E-01	4.0718E-00	1.6039E-04	-2.7639E-03	5.3689E-03
71	-4.3338E-01	-6.6573E-01	4.0718E-00	2.4304E-04	-2.8664E-03	5.5436E-03
72	-4.6942E-01	-6.6573E-01	4.0718E-00	1.3678E-04	-2.9428E-03	5.6731E-03
73	-3.6501E-01	-7.0573E-01	4.3164E-00	1.9736E-04	-1.8324E-03	4.9152E-03
74	-4.1582E-01	-7.0573E-01	4.3164E-00	1.6565E-04	-1.9236E-03	5.0991E-03
75	-4.4865E-01	-7.0573E-01	4.3164E-00	1.7780E-04	-1.9917E-03	5.2337E-03
76	-4.8049E-01	-7.0573E-01	4.3164E-00	1.0766E-04	-2.0542E-03	5.3732E-03
77	-3.9980E-01	-7.3770E-01	4.5120E-00	1.1578E-04	-1.4026E-03	4.7138E-03
78	-4.2954E-01	-7.3770E-01	4.5120E-00	1.1089E-04	-1.4770E-03	4.9123E-03
79	-4.5927E-01	-7.3770E-01	4.5120E-00	1.5717E-04	-1.5352E-03	5.0633E-03
80	-4.8901E-01	-7.3770E-01	4.5120E-00	1.0632E-04	-1.5822E-03	5.1812E-03
81	-2.1277E-01	-4.2574E-01	3.6039E-00	2.2663E-03	-4.1946E-04	-6.7721E-02
82	-2.6612E-01	-4.2574E-01	3.6039E-00	8.1230E-04	-4.3774E-04	-7.0894E-02
83	-3.1948E-01	-4.2574E-01	3.6039E-00	5.4323E-04	-4.4076E-04	-7.1282E-02
84	-3.7283E-01	-4.2574E-01	3.6039E-00	2.7225E-04	-4.4173E-04	-7.1390E-02
85	-1.4929E-01	-4.2574E-01	3.0769E-00	7.4752E-03	-4.3825E-04	-3.5729E-02
86	-2.0759E-01	-4.2574E-01	3.0769E-00	1.8757E-03	-7.5957E-04	-1.0157E-01
87	-2.6610E-01	-4.2574E-01	3.0769E-00	7.6427E-04	-7.8457E-04	-1.0618E-01
88	-3.2420E-01	-4.2574E-01	3.0769E-00	4.5232E-04	-7.8618E-04	-1.0617E-01
89	-3.8230E-01	-4.2574E-01	3.0769E-00	2.1171E-04	-4.4311E-03	3.3307E-03
90	-4.4040E-01	-4.2574E-01	3.0769E-00	1.1914E-04	-4.4609E-03	3.3542E-03
91	-1.0445E-02	-1.2900E-00	-1.0000E-01	1.1797E-04	4.8296E-03	3.1378E-03
92	-1.0045E-02	-1.2900E-00	-1.0000E-01	-1.3012E-05	4.8349E-03	3.1537E-03
93	-1.0516E-02	-1.2900E-00	-1.0000E-01	-2.6666E-05	5.2612E-03	2.8711E-03
94	-1.0536E-02	-1.2900E-00	-1.0109E-01	4.1923E-05	5.2825E-03	2.8809E-03
95	-1.0525E-02	-1.2900E-00	-1.0153E-01	7.3327E-05	5.7403E-03	2.5319E-03
96	-1.0657E-02	-1.2900E-00	-1.0153E-01	1.2767E-04	5.7621E-03	2.5420E-03
97	-1.0728E-02	-1.2900E-00	-1.0196E-01	1.5112E-04	6.2775E-03	2.1092E-03
98	-1.0748E-02	-1.2900E-00	-1.0196E-01	1.6473E-04	6.2945E-03	2.1141E-03
99	-1.0759E-02	-1.2900E-00	-1.0240E-01	1.1380E-04	6.8474E-03	1.5505E-03
100	-1.0799E-02	-1.2900E-00	-1.0240E-01	3.4900E-05	6.8605E-03	1.5521E-03
101	-1.0869E-02	-1.2900E-00	-1.0284E-01	-3.3286E-05	7.4633E-03	8.4683E-04
102	-1.0869E-02	-1.2900E-00	-1.0284E-01	-3.6542E-05	7.4784E-03	8.4838E-04
103	-1.0869E-02	-1.2900E-00	-1.0327E-01	1.3502E-05	8.1050E-03	-5.4578E-05
104	-1.0940E-02	-1.2900E-00	-1.0327E-01	3.9437E-05	8.1119E-03	-5.5144E-05
105	-1.0769E-02	-2.1250E-00	-1.0371E-01	8.0811E-05	8.7193E-03	-1.2014E-03
106	-1.1011E-02	-2.1250E-00	-1.0371E-01	9.3849E-05	8.7241E-03	-1.2030E-03
107	-1.0872E-02	-2.3750E-00	-1.0415E-01	1.2460E-04	9.2603E-03	-2.6337E-03
108	-1.1031E-02	-2.3750E-00	-1.0415E-01	1.2907E-04	9.2656E-03	-2.6362E-03

Figure 5.- Continued.

ADDITIONAL LOADING		ALPHA(F)	BETA(F)	ALPHA(E)	BETA(E)	
		3.5000	-0.5000	3.4000	-1.3000	
INDUCED VELOCITY COMPONENTS IN WING REFERENCE SYSTEM						
N	XW	YW	ZW	U/V	V/V	W/V
1	-6.9048E 00	-2.2865E 00	1.3980E-01	-5.0508E-07	4.6704E-05	8.4189E-04
2	-1.4551E 01	-2.2865E 00	1.3980E-01	6.1746E-07	-1.2430E-04	-2.6859E-04
3	-2.2197E 01	-2.2865E 00	1.3980E-01	1.5681E-06	-2.7786E-04	-1.3608E-03
4	-2.9844E 01	-2.2865E 00	1.3980E-01	1.6942E-06	-3.9440E-04	-2.2619E-03
5	-8.8881E 00	-6.5730E 00	4.0200E-01	-3.4926E-06	1.1905E-05	6.2341E-04
6	-1.6254E 01	-6.5730E 00	4.0200E-01	-1.6997E-06	-2.1968E-04	-6.0572E-04
7	-2.3620E 01	-6.5730E 00	4.0200E-01	-3.4301E-05	-4.1178E-04	-1.7392E-03
8	-3.0986E 01	-6.5730E 00	4.0200E-01	5.2796E-07	-5.5030E-04	-2.6210E-03
9	-1.0739E 01	-1.0573E 01	6.4670E-01	-8.5200E-06	-5.6602E-05	3.4599E-04
10	-1.7843E 01	-1.0573E 01	6.4670E-01	-5.2480E-06	-3.6629E-04	-9.9249E-04
11	-2.4494E 01	-1.0573E 01	6.4670E-01	-2.3428E-06	-6.1129E-04	-2.1757E-03
12	-3.2053E 01	-1.0573E 01	6.4670E-01	-1.0467E-06	-7.7536E-04	-3.0294E-03
13	-1.2590E 01	-1.4573E 01	8.9130E-01	-1.7344E-05	-1.9351E-04	-2.3732E-05
14	-1.9439E 01	-1.4573E 01	8.9130E-01	-1.0949E-05	-6.1411E-04	-1.4680E-03
15	-2.9274E 01	-1.4573E 01	8.9130E-01	-5.7005E-06	-9.1738E-04	-2.6395E-03
16	-3.3114E 01	-1.4573E 01	8.9130E-01	-3.1850E-05	-1.1041E-03	-3.4102E-03
17	-1.4441E 01	-1.8573E 01	1.1360E 00	-3.2622E-05	-4.6966E-04	-5.1032E-04
18	-2.1022E 01	-1.8573E 01	1.1360E 00	-1.9303E-05	-1.0472E-03	-2.0429E-03
19	-2.7604E 01	-1.8573E 01	1.1360E 00	-1.0379E-05	-1.4228E-03	-3.1665E-03
20	-3.4186E 01	-1.8573E 01	1.1360E 00	-5.9505E-06	-1.6418E-03	-3.8516E-03
21	-1.6291E 01	-2.2573E 01	1.3806E 00	-5.6113E-05	-1.0449E-03	-1.1433E-03
22	-2.2612E 01	-2.2573E 01	1.3806E 00	-1.1512E-05	-1.8304E-03	-2.6816E-03
23	-2.8932E 01	-2.2573E 01	1.3806E 00	-1.0546E-05	-2.2848E-03	-3.6820E-03
24	-3.5252E 01	-2.2573E 01	1.3806E 00	-9.2630E-06	-2.5262E-03	-4.2223E-03
25	-1.8142E 01	-2.6573E 01	1.6253E 00	-9.8063E-05	-2.2651E-03	-1.8533E-03
26	-2.4201E 01	-2.6573E 01	1.6253E 00	-4.8236E-05	-3.3171E-03	-3.2683E-03
27	-3.0260E 01	-2.6573E 01	1.6253E 00	-2.4047E-05	-3.8566E-03	-4.0227E-03
28	-3.6318E 01	-2.6573E 01	1.6253E 00	-1.2975E-05	-4.0863E-03	-4.3857E-03
29	-1.9999E 01	-3.0573E 01	1.8699E 00	-1.5781E-04	-4.9644E-03	-2.2491E-03
30	-2.5790E 01	-3.0573E 01	1.8699E 00	-6.8697E-05	-6.2747E-03	-3.2347E-03
31	-3.1588E 01	-3.0573E 01	1.8699E 00	-3.1930E-05	-6.8129E-03	-3.6558E-03
32	-3.7385E 01	-3.0573E 01	1.8699E 00	-1.6649E-05	-7.0544E-03	-3.8501E-03
33	-2.1844E 01	-3.4573E 01	2.1146E 00	-2.4022E-04	-1.1030E-02	-2.8720E-04
34	-2.7379E 01	-3.4573E 01	2.1146E 00	-8.8433E-05	-1.2417E-02	-5.2279E-04
35	-3.2915E 01	-3.4573E 01	2.1146E 00	-3.8450E-05	-1.2890E-02	-6.2235E-04
36	-3.8451E 01	-3.4573E 01	2.1146E 00	-1.9703E-05	-1.3084E-02	-6.6110E-04
37	-2.3463E 01	-3.8073E 01	2.3286E 00	-2.9906E-04	-2.0012E-02	1.0280E-02
38	-2.8770E 01	-3.8073E 01	2.3286E 00	-9.7143E-05	-2.1006E-02	1.0700E-02
39	-3.4077E 01	-3.8073E 01	2.3286E 00	-4.1824E-05	-2.1294E-02	1.0811E-02
40	-3.9384E 01	-3.8073E 01	2.3286E 00	-2.1524E-05	-2.1425E-02	1.0852E-02
41	-2.4851E 01	-4.1073E 01	2.5121E 00	-2.9374E-04	-1.7722E-02	3.4240E-02
42	-2.9942E 01	-4.1073E 01	2.5121E 00	-9.5066E-05	-1.8101E-02	3.4859E-02
43	-3.5073E 01	-4.1073E 01	2.5121E 00	-4.1897E-05	-1.8220E-02	3.5032E-02
44	-4.0184E 01	-4.1073E 01	2.5121E 00	-2.2102E-05	-1.8271E-02	3.5102E-02
45	-2.6239E 01	-4.4073E 01	2.6956E 00	-2.3883E-04	-1.2911E-02	4.2513E-02
46	-3.1154E 01	-4.4073E 01	2.6956E 00	-8.6622E-05	-1.3042E-02	4.3016E-02
47	-3.6069E 01	-4.4073E 01	2.6956E 00	-4.1177E-05	-1.3088E-02	4.3189E-02
48	-4.0984E 01	-4.4073E 01	2.6956E 00	-2.1950E-05	-1.3108E-02	4.3259E-02
49	-2.7628E 01	-4.7073E 01	2.8791E 00	-1.7732E-04	-2.5768E-02	1.9798E-02
50	-3.2346E 01	-4.7073E 01	2.8791E 00	-7.5603E-05	-2.6152E-02	2.0110E-02
51	-3.7064E 01	-4.7073E 01	2.8791E 00	-3.8405E-05	-2.6321E-02	2.0236E-02
52	-4.1784E 01	-4.7073E 01	2.8791E 00	-2.2137E-05	-2.6399E-02	2.0296E-02
53	-2.9247E 01	-5.0573E 01	3.0932E 00	-1.2427E-04	-1.8907E-02	4.0655E-03
54	-3.3737E 01	-5.0573E 01	3.0932E 00	-6.2524E-05	-1.9335E-02	4.1759E-03
55	-3.8227E 01	-5.0573E 01	3.0932E 00	-3.5929E-05	-1.9566E-02	4.2287E-03
56	-4.2717E 01	-5.0573E 01	3.0932E 00	-2.1494E-05	-1.9685E-02	4.2566E-03
57	-3.1056E 01	-5.4573E 01	3.3378E 00	-8.5517E-05	-1.1635E-02	1.3667E-03
58	-3.5246E 01	-5.4573E 01	3.3378E 00	-4.9804E-05	-1.2037E-02	1.4163E-03
59	-3.9555E 01	-5.4573E 01	3.3378E 00	-3.0982E-05	-1.2256E-02	1.4374E-03
60	-4.3783E 01	-5.4573E 01	3.3378E 00	-2.0515E-05	-1.2344E-02	1.4550E-03
61	-3.2945E 01	-5.8573E 01	3.5825E 00	-6.0843E-05	-7.6140E-03	1.9006E-03
62	-3.6916E 01	-5.8573E 01	3.5825E 00	-3.9847E-05	-7.9209E-03	3.0211E-03
63	-4.0883E 01	-5.8573E 01	3.5825E 00	-2.6773E-05	-8.1166E-03	3.0852E-03
64	-4.4849E 01	-5.8573E 01	3.5825E 00	-1.8853E-05	-8.2408E-03	3.1344E-03
65	-3.4759E 01	-6.2573E 01	3.8271E 00	-4.4856E-05	-9.3403E-03	3.3556E-03
66	-3.8505E 01	-6.2573E 01	3.8271E 00	-3.1762E-05	-9.5645E-03	3.4843E-03
67	-4.2210E 01	-6.2573E 01	3.8271E 00	-2.2976E-05	-9.7144E-03	3.5726E-03
68	-4.5916E 01	-6.2573E 01	3.8271E 00	-1.7001E-05	-9.8433E-03	3.6590E-03
69	-3.6650E 01	-6.6573E 01	4.0718E 00	-3.4017E-05	-9.9455E-03	3.7218E-03
70	-4.0094E 01	-6.6573E 01	4.0718E 00	-2.5718E-05	-1.0127E-02	3.7923E-03
71	-4.3535E 01	-6.6573E 01	4.0718E 00	-1.6993E-05	-1.0293E-02	3.7945E-03
72	-4.6982E 01	-6.6573E 01	4.0718E 00	-1.5293E-05	-1.0407E-02	3.7955E-03
73	-3.8501E 01	-7.0573E 01	4.3164E 00	-2.6502E-05	-1.0557E-02	3.8136E-03
74	-4.1623E 01	-7.0573E 01	4.3164E 00	-2.1098E-05	-1.1383E-02	3.8410E-03
75	-4.4868E 01	-7.0573E 01	4.3164E 00	-1.5890E-05	-1.1660E-02	3.8635E-03
76	-4.8049E 01	-7.0573E 01	4.3164E 00	-1.1362E-05	-1.1963E-02	3.8747E-03
77	-3.9980E 01	-7.3770E 01	4.5120E 00	-2.2134E-05	-1.2473E-02	3.9345E-03
78	-4.2954E 01	-7.3770E 01	4.5120E 00	-1.8239E-05	-1.2635E-02	3.9480E-03
79	-4.5927E 01	-7.3770E 01	4.5120E 00	-1.5026E-05	-1.2737E-02	3.9677E-03
80	-4.8901E 01	-7.3770E 01	4.5120E 00	-1.2465E-05	-1.2805E-02	3.9706E-03
81	-2.1277E 01	-4.2574E 01	3.6039E 00	-9.7101E-04	-5.4385E-03	5.2443E-02
82	-2.6612E 01	-4.2574E 01	3.6039E 00	-1.8122E-04	-5.7703E-03	5.4613E-02
83	-3.1948E 01	-4.2574E 01	3.6039E 00	-6.0008E-05	-5.8388E-03	5.4880E-02
84	-3.7223E 01	-4.2574E 01	3.6039E 00	-2.7473E-05	-5.9605E-03	5.4957E-02
85	-1.4985E 01	-4.2574E 01	5.0769E 00	-3.3838E-03	-6.2698E-03	3.7380E-02
86	-2.0799E 01	-4.2574E 01	5.0769E 00	-1.2295E-03	-1.1269E-02	8.0104E-02
87	-2.6610E 01	-4.2574E 01	5.0769E 00	-1.3317E-04	-1.1725E-02	8.1721E-02
88	-3.2420E 01	-4.2574E 01	5.0769E 00	-7.7665E-05	-1.1783E-02	8.1716E-02
89	-3.9415E 01	-4.2574E 01	5.0769E 00	-9.7540E-07	-2.5583E-03	3.5871E-03
90	-1.0445E 02	-1.1250E 01	-1.0022E 01	-8.2408E-07	-2.5752E-03	3.4107E-03
91	-1.0045E 02	-1.1250E 01	-1.0066E 01	-9.9370E-07	-2.8505E-03	3.3118E-03
92	-1.0516E 02	-1.1250E 01	-1.0066E 01	-8.7903E-07	-2.8648E-03	3.2388E-03
93	-1.0148E 02	-6.2500E 00	-1.0109E 01	-1.0323E-06	-3.1743E-03	3.1856E-03
94	-1.0586E 02	-6.2500E 00	-1.0109E 01	-9.5927E-07	-3.1662E-03	3.1497E-03
95	-1.0232E 02	-8.7500E 00	-1.0153E 01	-1.1043E-06	-3.5418E-03	3.0134E-03
96	-1.0657E 02	-8.7500E 00	-1.0153E 01	-1.0345E-06	-3.5546E-03	3.0257E-03
97	-1.0355E 02	-1.1250E 01	-1.0196E 01	-1.2017E-06	-3.9644E-03	2.7895E-03
98	-1.0728E 02	-1.1250E 01	-1.0196E 01	-1.0076E-06	-3.9742E-03	2.7970E-03
99	-1.0459E 02	-1.3750E 01	-1.0240E 01	-1.1527E-06	-4.4272E-03	2.4672E-03
100	-1.0799E 02	-1.3750E 01	-1.0240E 01	-9.7921E-07	-4.4349E-03	2.4713E-03
101	-1.0562E 02	-1.6250E 01	-1.0284E 01	-1.1010E-06	-4.9497E-03	2.0408E-03
102	-1.0369E 02	-1.6250E 01	-1.0284E 01	-9.6236E-07	-4.9599E-03	2.0437E-03
103	-1.0665E 02	-1.8750E 01	-1.0327E 01	-1.0539E-06	-5.5123E-03	1.4635E-03
104	-1.0946E 02	-1.8750E 01	-1.0327E 01	-8.8227E-07	-5.5172E-03	1.4644E-03
105	-1.0769E 02	-2.1250E 01	-1.0371E 01	-9.3393E-07	-6.0911E-03	6.9253E-04
106	-1.1011E 02	-2.1250E 01	-1.0371E 01	-7.9462E-07	-6.0945E-03	6.9185E-04
107	-1.0872E 02	-2.3750E 01	-1.0415E 01	-8.1709E-07	-6.6546E-03	3.1219E-04
108	-1.1081E 02	-2.3750E 01	-1.0415E 01	-7.1599E-07	-6.6577E-03	3.1288E-04

Figure 5.- Concluded.

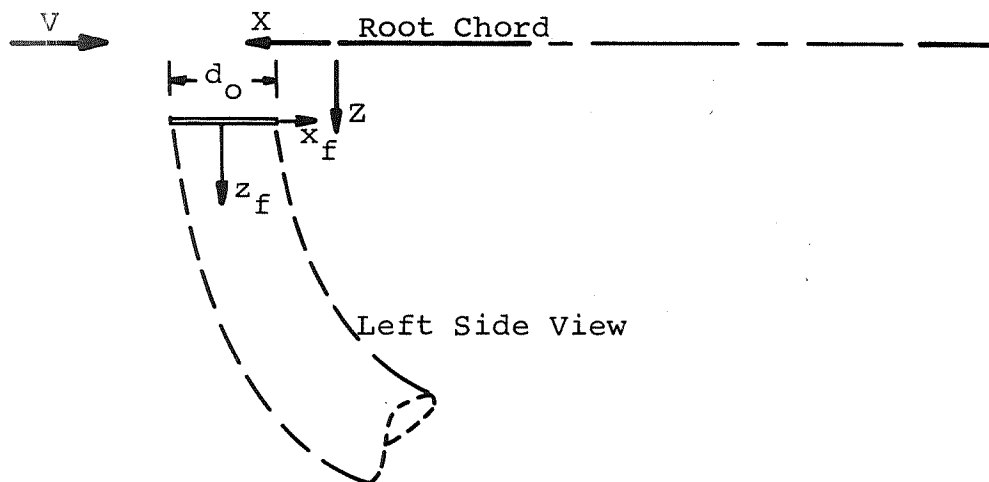
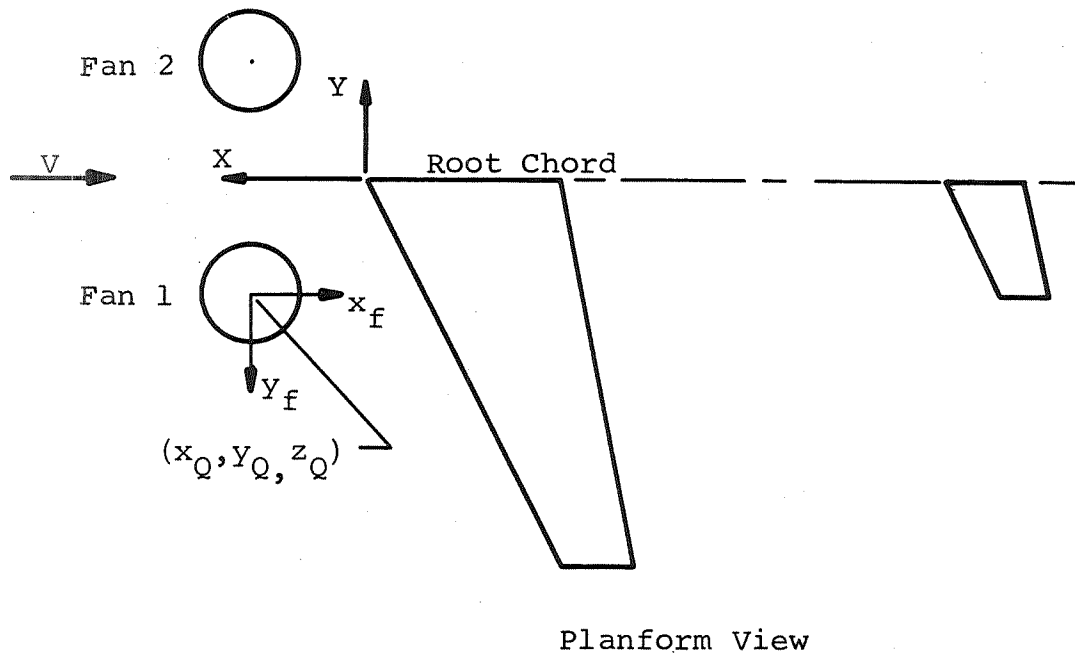


Figure 6.- Typical lift fan configuration.

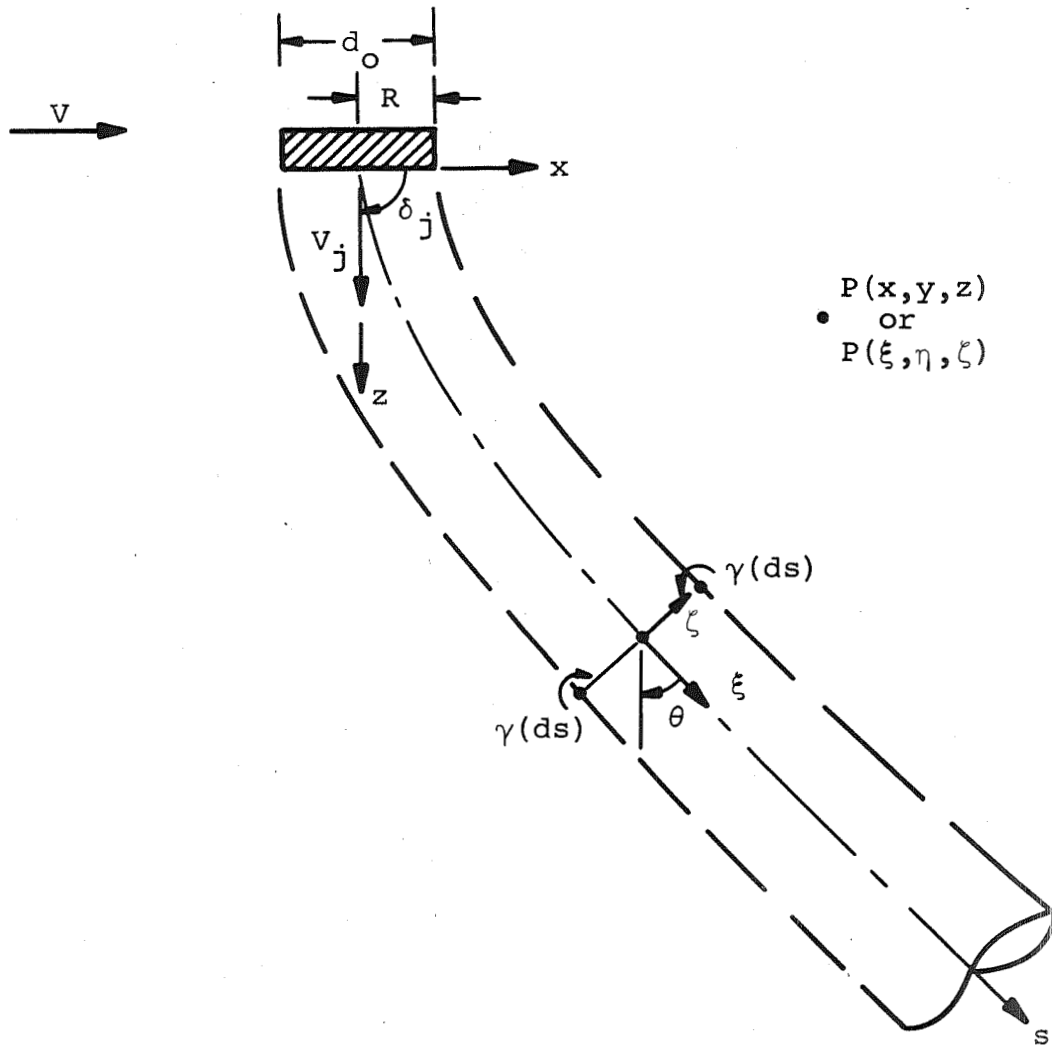


Figure 7.- Lift fan wake in a crossflow.

Item No. 1: Format (20A4), any alphabetic or numeric information
(1 card)

Column No.	1-80									
Program Variable	TITLE									
Data										

Item No. 2: Format (9F8.4), decimal point required
(1 card)

Column No.	8	16	24	32	40	48	56	64	72	80
Program Variable	VVJ	DELTJ	D	XQ	YQ	ZQ	XQ2	YQ2	ZQ2	
Data										

Item No. 3: Format (4I5, 5F10.5), decimal point required for last five variables
(1 card)

Column No.	5	10	15	20	30	40	50	60	70	80
Program Variable	NP	NPATH	NFAN	NPRNT	DZD	DS	DSV	ENDS	CYL	
Data										

Item No. 4: Format (3F10.5), decimal point required
(NP cards)

Column No.	10	20	30	40	
Program Variable	XW(J)	YW(J)	ZW(J)		
Data					

(J = 1, 2, ..., NP)

(a) Normal input, NPATH = 1 or 2.

Figure 8.- Input form for lift fan induced velocities program.

Note: $NPS = |NPATH| \leq 40$

Item No. 5: Format (8F10.5), decimal point required
(1 to 5 cards)

Column No.	10	20	30	40	50	60	70	80
Program Variable	SD(1)	SD(2)	SD(3)	...	SD(NPS)			
Data								

Item No. 6: Format (8F10.5), decimal point required
(1 to 5 cards)

Column No.	10	20	30	40	50	60	70	80
Program Variable	XD(1)	XD(2)	XD(3)	...	XD(NPS)			
Data								

Item No. 7: Format (8F10.5), decimal point required
(1 to 5 cards)

Column No.	10	20	30	40	50	60	70	80
Program Variable	ZD(1)	ZD(2)	ZD(3)	...	ZD(NPS)			
Data								

Item No. 8: Format (8F10.5), decimal point required
(1 to 5 cards)

Column No.	10	20	30	40	50	60	70	80
Program Variable	THETA(1)	THETA(2)	THETA(3)	...	THETA(NPS)			
Data								

(b) Optional input, $NPATH < 0$.

Figure 8.- Concluded.

SAMPLE CASE 1 - LIFT FAN INDUCED VELOCITIES

0.2	90.	3.0	6.66	-5.32	0.42		
12	2	1	1	.05	.10	.20	50.0 1.0
-2.140	-0.450	0.0					
-4.518	-0.450	0.0					
-6.896	-0.450	0.0					
-9.272	-0.450	0.0					
-7.994	-8.550	0.0					
-9.609	-8.550	0.0					
-11.225	-8.550	0.0					
-12.841	-8.550	0.0					
-14.581	-17.665	0.0					
-15.339	-17.665	0.0					
-16.097	-17.665	0.0					
-16.855	-17.665	0.0					

(a) Input for normal run.

SAMPLE CASE 2 - LIFT FAN WAKE CENTERLINE PATH CALCULATION

0.2	60.0	3.0	0.0	0.0	0.0		
0	1	1	0	.05	.10	.20	0. 0.

(b) Input for computing jet centerline path only.

SAMPLE CASE 3 - INPUT JET CENTERLINE PATH

0.4	90.	3.0	6.66	-5.32	0.42	6.66	5.32	0.42
12	-17	2	0	0.0	0.10	0.20	50.	1.0
-2.140	-0.450	0.0						
-4.518	-0.450	0.0						
-6.896	-0.450	0.0						
-9.272	-0.450	0.0						
-7.994	-8.550	0.0						
-9.609	-8.550	0.0						
-11.225	-8.550	0.0						
-12.841	-8.550	0.0						
-14.581	-17.665	0.0						
-15.339	-17.665	0.0						
-16.097	-17.665	0.0						
-16.855	-17.665	0.0						
0.	.5	1.0	1.5	2.0	3.0	4.0	5.0	
10.0	12.0	14.0	16.0	20.0	24.0	30.0	40.0	
50.0								
0.	.00836	.0471	.1286	.259	.668	1.245	1.941	
6.186	8.030	9.909	11.81	15.66	19.55	25.42	35.27	
45.16								
0.	.4999	.9983	1.491	1.974	2.884	3.699	4.417	
7.023	7.795	8.479	9.096	10.18	11.13	12.36	14.09	
15.55								
0.	2.395	6.730	12.16	18.16	30.09	40.09	47.68	
65.58	68.78	71.10	72.88	75.42	77.17	78.99	80.92	
82.16								

(c) Input for computing velocity field induced by two lift fans with specified jet path.

Figure 9.- Sample input to lift fan program.

V/VJ DELTA D(Z/D)
0.2000 90.0000 0.0500

JET CENTERLINE PARAMETERS COMPUTED USING WOOLER'S METHOD

X/D	Z/D	S/D	THETA
0.00000E-39	0.00000E-39	0.00000E-39	0.00000E-39
2.64574E-03	4.99999E-02	5.00000E-02	7.57949E-02
1.49666E-04	9.99998E-02	1.00000E-01	2.14380E-01
8.46611E-04	1.99997E-01	2.00000E-01	6.06326E-01
2.33279E-03	2.99986E-01	3.00000E-01	1.11374E 00
4.78798E-03	3.99935E-01	4.00000E-01	1.71425E 00
8.36203E-03	4.99891E-01	5.00000E-01	2.39467E 00
1.31854E-02	5.99774E-01	6.00000E-01	3.14580E 00
1.93740E-02	6.99581E-01	7.00000E-01	3.96051E 00
2.70321E-02	7.99286E-01	8.00000E-01	4.83291E 00
3.62538E-02	8.98859E-01	9.00000E-01	5.75783E 00
4.71237E-02	9.98265E-01	1.00000E 00	6.72056E 00
1.28560E-01	1.49140E 00	1.50000E 00	1.21614E 01
2.59058E-01	1.97333E 00	2.00000E 00	1.81655E 01
4.40005E-01	2.43983E 00	2.50000E 00	2.42698E 01
6.68593E-01	2.88412E 00	3.00000E 00	3.00942E 01
9.39326E-01	3.30428E 00	3.50000E 00	3.54010E 01
1.24569E 00	3.69925E 00	4.00000E 00	4.00924E 01
1.58135E 00	4.06969E 00	4.50000E 00	4.41694E 01
1.94079E 00	4.41715E 00	5.00000E 00	4.76809E 01
2.71373E 00	5.05100E 00	6.00000E 00	5.33320E 01
3.53821E 00	5.61648E 00	7.00000E 00	5.75865E 01
4.39791E 00	6.12701E 00	8.00000E 00	6.08706E 01
5.28256E 00	6.59308E 00	9.00000E 00	6.34701E 01
6.18553E 00	7.02265E 00	1.00000E 01	6.55756E 01
7.10236E 00	7.42184E 00	1.10000E 01	6.73154E 01
8.02995E 00	7.79535E 00	1.20000E 01	6.87781E 01
9.90919E 00	8.47941E 00	1.40000E 01	7.11047E 01
1.13115E 01	9.09647E 00	1.60000E 01	7.28783E 01
1.37302E 01	9.68097E 00	1.80000E 01	7.42806E 01
1.56608E 01	1.01830E 01	2.00000E 01	7.54210E 01
1.76006E 01	1.06699E 01	2.20000E 01	7.63694E 01
1.95476E 01	1.11272E 01	2.40000E 01	7.71727E 01
2.15004E 01	1.15502E 01	2.60000E 01	7.78633E 01
2.34579E 01	1.19692E 01	2.80000E 01	7.84645E 01
2.54193E 01	1.23599E 01	3.00000E 01	7.89936E 01
3.02365E 01	1.32659E 01	3.50000E 01	8.00784E 01
3.52681E 01	1.40897E 01	4.00000E 01	8.09208E 01
4.02102E 01	1.48486E 01	4.50000E 01	8.15976E 01
4.51601E 01	1.55544E 01	5.00000E 01	8.21557E 01

Figure 10.- Sample output from lift fan program.

SAMPLE CASE 1 - LIFT FAN INDUCED VELOCITIES

PAGE 2

VELOCITY INDUCED BY ENTRAINMENT SINK DISTRIBUTION - FAN 1 COORDINATE SYSTEM

	V/VJ	C	XQ	YQ	ZQ	S/D	U(S/D)
	0.2000	3.0000	6.6600	-5.3200	0.4200	50.0000	0.1000
	X/D	Y/D	Z/D	U/VJ	V/VJ	W/VJ	VT/VJ
1	2.933	-1.623	-0.140	-2.1429E-03	3.4778E-03	8.9479E-03	9.8363E-03
2	3.726	-1.623	-0.140	-1.9309E-03	3.7794E-03	7.9593E-03	8.6490E-03
3	4.519	-1.623	-0.140	-1.7022E-03	2.2986E-03	7.2299E-03	7.7751E-03
4	5.311	-1.623	-0.140	-1.4964E-03	1.9546E-03	6.6758E-03	7.1152E-03
5	6.104	1.077	-0.140	-1.8124E-03	-1.4782E-03	7.2486E-03	7.6166E-03
6	6.423	1.077	-0.140	-1.6386E-03	-1.3235E-03	6.8588E-03	7.1750E-03
7	6.962	1.077	-0.140	-1.4991E-03	-1.1981E-03	6.5314E-03	6.8053E-03
8	6.500	1.077	-0.140	-1.3608E-03	-1.0949E-03	6.2530E-03	6.4924E-03
9	7.080	4.115	-0.140	-4.7081E-04	-2.8334E-03	4.5396E-03	5.3719E-03
10	7.333	4.115	-0.140	-4.7450E-04	-2.7627E-03	4.5002E-03	5.3019E-03
11	7.586	4.115	-0.140	-4.7709E-04	-2.6958E-03	4.4622E-03	5.2351E-03
12	7.838	4.115	-0.140	-4.7879E-04	-2.6322E-03	4.4255E-03	5.1714E-03

SAMPLE CASE 1 - LIFT FAN INDUCED VELOCITIES

PAGE 3

VELOCITY INDUCED BY DOUBLET DISTRIBUTION - FAN 1 COORDINATE SYSTEM

	V/VJ	C	XQ	YQ	ZQ	S/D	U(S/D)
	0.2000	3.0000	6.6600	-5.3200	0.4200	50.0000	0.1000
	X/D	Y/D	Z/D	U/VJ	V/VJ	W/VJ	VT/VJ
1	2.933	-1.623	-0.140	-5.7551E-03	1.5678E-02	1.9435E-02	2.5624E-02
2	3.726	-1.623	-0.140	-6.8271E-03	1.0959E-02	1.5043E-02	1.9824E-02
3	4.519	-1.623	-0.140	-6.5618E-03	7.8273E-03	1.1701E-02	1.5532E-02
4	5.311	-1.623	-0.140	-5.8873E-03	5.7519E-03	9.2506E-03	1.2382E-02
5	6.104	1.077	-0.140	-7.6014E-03	-5.0480E-03	1.1946E-02	1.5032E-02
6	6.423	1.077	-0.140	-6.7933E-03	-4.0522E-03	1.0065E-02	1.2796E-02
7	6.962	1.077	-0.140	-6.0441E-03	-3.3063E-03	8.5811E-03	1.1004E-02
8	6.500	1.077	-0.140	-5.3905E-03	-2.7375E-03	7.3962E-03	9.5528E-03
9	7.080	4.115	-0.140	-1.6778E-03	-4.4826E-03	2.7466E-03	5.5184E-03
10	7.333	4.115	-0.140	-1.6948E-03	-4.2594E-03	2.6554E-03	5.2978E-03
11	7.586	4.115	-0.140	-1.7022E-03	-4.0489E-03	2.5669E-03	5.0872E-03
12	7.838	4.115	-0.140	-1.7017E-03	-3.8505E-03	2.4811E-03	4.8865E-03

Figure 10.- Continued.

SAMPLE CASE 1 - LIFT FAN INDUCED VELOCITIES

PAGE 4

VELOCITY INDUCED BY CURVED VORTEX CYLINDER - FAN 1 COORDINATE SYSTEM

	V/VJ	D	XQ	YQ	ZQ	S/D	D(S/D)
	0.2000	3.0000	6.6600	-5.3200	0.4200	50.0000	0.2000
	X/D	Y/D	Z/D	U/VJ	V/VJ	W/VJ	VT/VJ
1	2.933	-1.623	-0.140	-4.9340E-03	2.7270E-03	3.9940E-04	5.6516E-03
2	3.726	-1.623	-0.140	-3.5231E-03	1.5268E-03	2.1409E-04	3.8456E-03
3	4.519	-1.623	-0.140	-2.5965E-03	9.2361E-04	1.2190E-04	2.7586E-03
4	5.311	-1.623	-0.140	-1.9778E-03	3.9528E-04	7.2251E-05	2.0667E-03
5	4.895	1.077	-0.140	-2.4844E-03	-5.4154E-04	1.0543E-04	2.5450E-03
6	5.423	1.077	-0.140	-2.0463E-03	-4.0021E-04	7.3281E-05	2.0864E-03
7	5.962	1.077	-0.140	-1.7140E-03	-3.0361E-04	5.1370E-05	1.7414E-03
8	6.500	1.077	-0.140	-1.4569E-03	-2.3551E-04	3.5550E-05	1.4763E-03
9	7.080	4.115	-0.140	-8.3833E-04	-4.6576E-04	1.1689E-05	9.5909E-04
10	7.333	4.115	-0.140	-8.0381E-04	-4.2980E-04	9.0476E-06	9.1155E-04
11	7.586	4.115	-0.140	-7.7056E-04	-3.9717E-04	7.3923E-06	8.6692E-04
12	7.838	4.115	-0.140	-7.3915E-04	-3.6750E-04	5.4653E-06	8.2549E-04

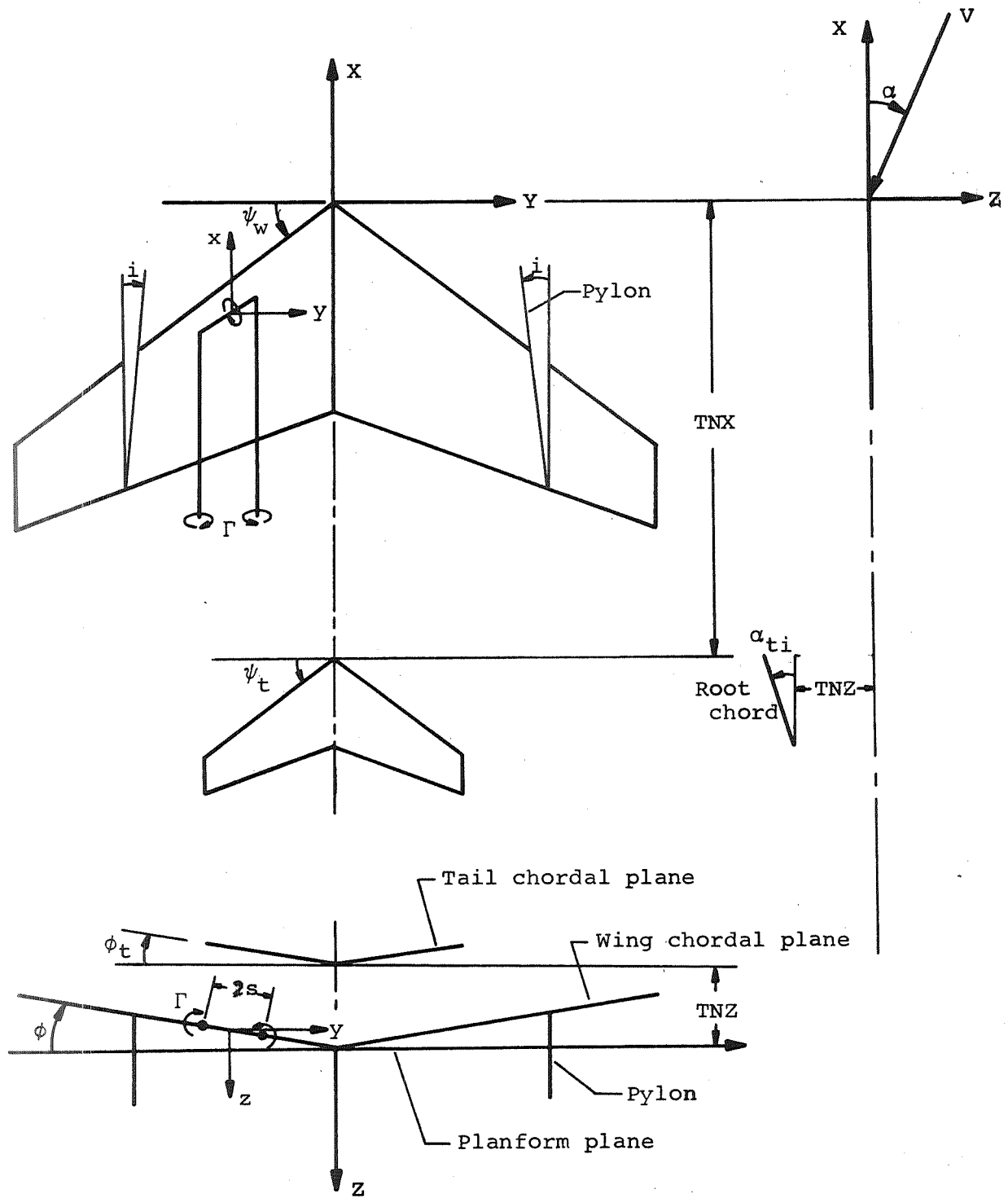
SAMPLE CASE 1 - LIFT FAN INDUCED VELOCITIES

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TOTAL INDUCED VELOCITY FAN 1 - WING COORDINATE SYSTEM

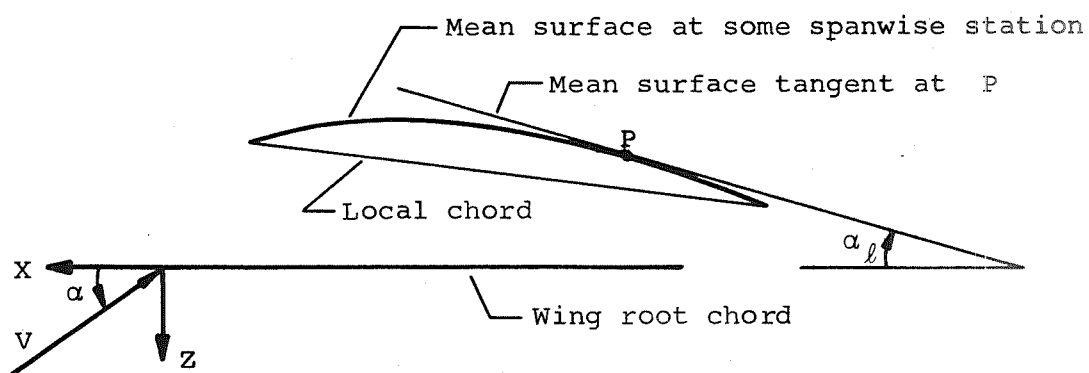
	V/VJ	D	XQ	YQ	ZQ	S/D	D(S/D)=0.100			D(S/D)=0.200		
	0.2000	3.0000	6.6600	-5.3200	0.4200	50.0000	(SINKS + DOUBLET)			(SINKS + DOUBLET + VORTEX CYLINDER)		
	XW	YW	ZW	U/V	V/V	W/V	U/V	V/V	W/V	U/V	V/V	W/V
1	-2.140	-0.450	0.000	3.9490E-02	-9.5777E-02	1.4191E-01	6.4160E-02	-1.0941E-01	1.4391E-01	6.4160E-02	-1.0941E-01	1.4391E-01
2	-4.518	-0.450	0.000	4.3790E-02	-6.8693E-02	1.1501E-01	6.1405E-02	-7.6327E-02	1.1608E-01	6.1405E-02	-7.6327E-02	1.1608E-01
3	-6.896	-0.450	0.000	4.1320E-02	-5.0630E-02	9.4655E-02	5.4303E-02	-5.5248E-02	9.5265E-02	5.4303E-02	-5.5248E-02	9.5265E-02
4	-9.273	-0.450	0.000	3.6918E-02	-3.8532E-02	7.9632E-02	4.6807E-02	-4.1509E-02	7.9994E-02	4.6807E-02	-4.1509E-02	7.9994E-02
5	-7.994	-8.550	0.000	4.7069E-02	3.2631E-02	9.5971E-02	5.9491E-02	3.5339E-02	9.6499E-02	5.9491E-02	3.5339E-02	9.6499E-02
6	-9.609	-8.550	0.000	4.2110E-02	2.6879E-02	8.4618E-02	5.2341E-02	2.8880E-02	8.4984E-02	5.2341E-02	2.8880E-02	8.4984E-02
7	-11.225	-8.550	0.000	3.7666E-02	2.2522E-02	7.5562E-02	4.6236E-02	2.4040E-02	7.5819E-02	4.6236E-02	2.4040E-02	7.5819E-02
8	-12.841	-8.550	0.000	3.3757E-02	1.9162E-02	6.8246E-02	4.1041E-02	2.0340E-02	6.8424E-02	4.1041E-02	2.0340E-02	6.8424E-02
9	-14.581	-17.665	0.000	1.0743E-02	3.6580E-02	3.6431E-02	1.4935E-02	3.8908E-02	3.6490E-02	1.4935E-02	3.8908E-02	3.6490E-02
10	-15.339	-17.665	0.000	1.0846E-02	3.5111E-02	3.5778E-02	1.4865E-02	3.7260E-02	3.5824E-02	1.4865E-02	3.7260E-02	3.5824E-02
11	-16.097	-17.665	0.000	1.0896E-02	3.3723E-02	3.5145E-02	1.4749E-02	3.5709E-02	3.5182E-02	1.4749E-02	3.5709E-02	3.5182E-02
12	-16.855	-17.665	0.000	1.0902E-02	3.2413E-02	3.4533E-02	1.4598E-02	3.4251E-02	3.4561E-02	1.4598E-02	3.4251E-02	3.4561E-02

Figure 10.- Concluded.

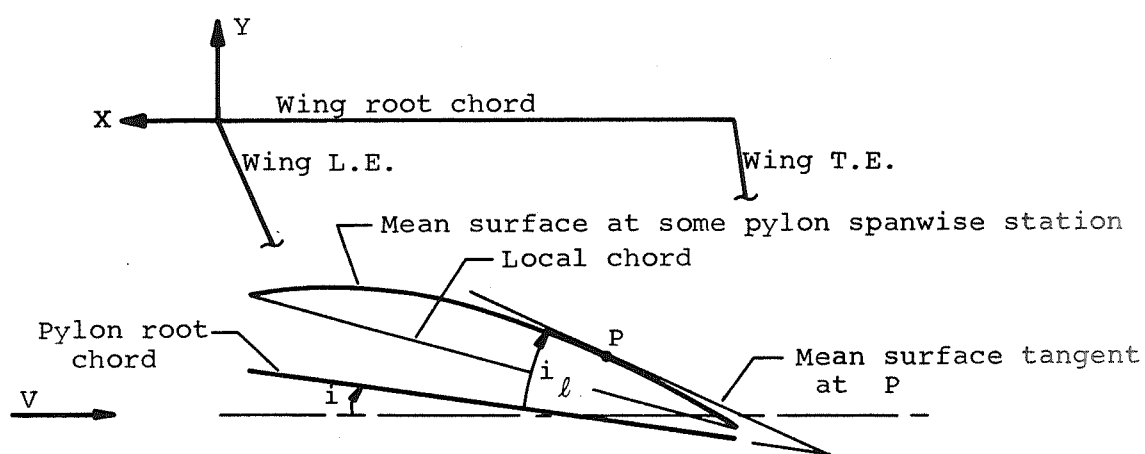


(a) Coordinate systems for wing-pylon-tail and horseshoe vortices.

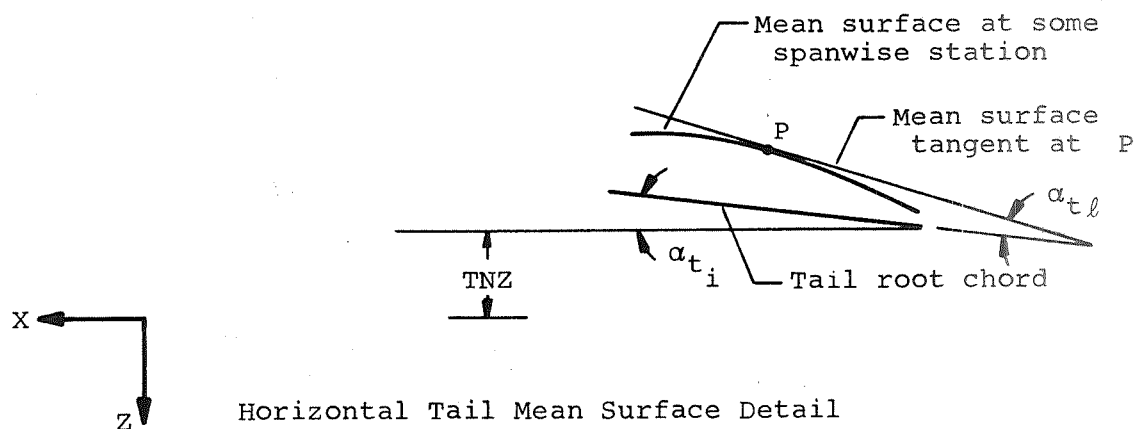
Figure 11.- Wing-pylon-tail nomenclature.



Wing Mean Surface Detail



Pylon Mean Surface Detail



Horizontal Tail Mean Surface Detail

(b) Angles of incidence and mean surface angles.

Figure 11.- Concluded.

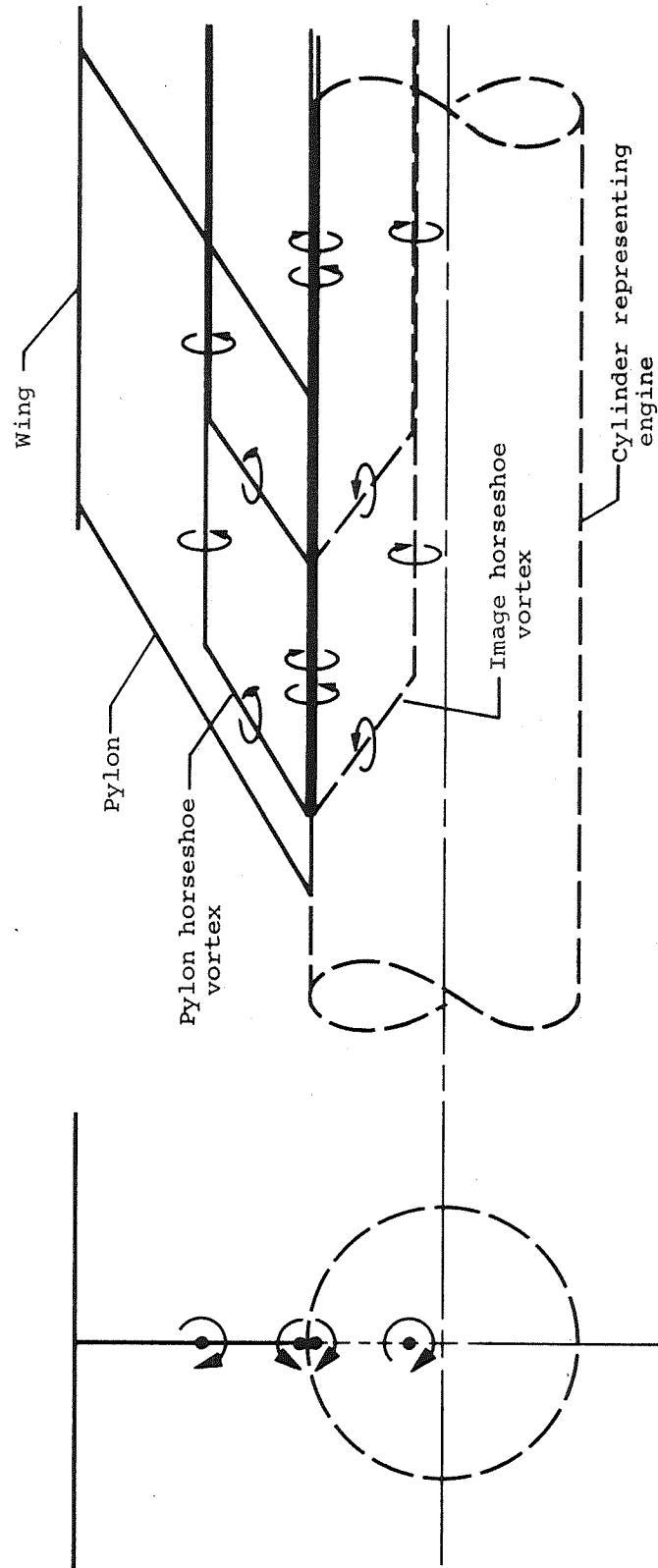


Figure 12.- Model of the image system used to represent the influence of the engine on the pylon span load distribution.

Item No. 1: Format (20A4), any alphabetic or numeric information
(1 card)

Column No.	1-80
Program Variable	TALK
Data	

Item No. 2: Format (7I5)
(1 card)

Column No.	5	10	15	20	25	30	35
Program Variable	NCW	NCP	MSW	MSP	MSPI	NCT	MST
Data							

Note: If $MSP \neq 0$, pylon is present; if $NCT \neq 0$, tail is present; if $MSPI \neq 0$, vortex imaging scheme is engaged.

Item No. 3: Format (8F10.5), decimal point required
(3 cards)

Column No.	10	20	30	40	50	60	70	80
Program Variable	PSIWLI	PSIWTI	CRWI	SSPAN	PHI	RAD	ALPHA	MACH
Data								

Note: If $MSPI \neq 0$, then RAD must be specified (non-zero).

(2)

Column No.	10	20	30	40	50	60	70	80
Program Variable	PSIPLI	PSIPTI	CRPI	H	PHIP	FRAC	PINC	
Data								

(3)

Column No.	10	20	30	40	50	60	70	80
Program Variable	PSITLI	PSITTI	CRTI	TSSPAN	PHIT	TLINC		
Data								

Figure 13.- Input form for vortex lattice program.

Item No. 4: Format (8F10.5), decimal point required
(1 card)

Column No.	10	20	30	40	50	60	70	80
Program Variable	XM	YM	ZM					
Data								

Item No. 5: Format (I5, 5F5.1), decimal point required in last five variables
(1 card)

Column No.	5	10	15	20	25	30	
Program Variable	MMM	ALPHLC	PINCLC	TLPHAC	EI	CIRCP	
Data							

Note: See listing of program variables for definition of option variables.

Item No. 6: Format (8F10.5), decimal point required
(≥ 1 card) (1)

Column No.	10	20	30	40	50	60	70	80
Program Variable	Y(2)	Y(3)	Y(4)	Y(5)	Y(6)	Y(7)	Y(8)	Y(9)
Data								

	(2)							
Column No.	10	20	30	40	50	60	70	80
Program Variable	Y(10)	Y(11)	Y(12)	...	Y(I _{wing tip})			
Data								

Note: Y(I_{wing tip}) = SSPAN identically
Y(I_{pylon}) = FRAC*SSPAN identically

Item No. 7 (option): Format (8F10.5), decimal point required
(≥ 1 card) (1)

Column No.	10	20	30	40	50	60	70	80
Program Variable	Z(2)	Z(3)	Z(4)	...	Z(K _{pylon tip})			
Data								

Note: Z(K_{pylon tip}) = H identically. These quantities are read in when MSP $\neq$ 0 (see Item 2);
if MSP = 0, omit Item 7.

Item No. 8 (option): Format (8F10.5), decimal point required
(1 card)

Column No.	10	20	30	40	50	60	70	80
Program Variable	TNX	TNY	TNZ					
Data								

Note: These quantities are read in when $NCT \neq 0$ (see Item 2); if $NCT = 0$, omit Item 8.

Item No. 9 (option): Format (8F10.5), decimal point required
(≥ 1 card) (1)

Column No.	10	20	30	40	50	60	70	80
Program Variable	YT(2)	YT(3)	YT(4)	YT(5)	YT(6)	YT(7)	YT(8)	YT(9)
Data								

(2)

Column No.	10	20	30	40	50	60	70	80
Program Variable	YT(10)	YT(11)	...	YT(IT _{tail tip})				
Data								

Note: These quantities are read in when $NCT \neq 0$ (see Item 2); if $NCT = 0$, omit Item 9.
 $YT(IT_{tip}) = TSSPAN$ identically.

Item No. 10 (option): Format (8F10.5), decimal point required
(MSW cards) (1)

Column No.	10	20	30	40	50	60	70	80
Program Variable	ALPHAL(1)	ALPHAL(2)	...	ALPHAL(NCW)				
Data								

Note: These quantities are read in when $ALPHLC = 1.0$ (see Item 5); if $ALPHLC = 0.0$, omit Item 10.
Number of data bits per card = number of chordwise wing vortices = NCW.

(2)

Column No.	10	20	30	40	50	60	70	80
Program Variable	ALPHAL(NCW+1)	ALPHAL(NCW+2)	...	ALPHAL(2NCW)				
Data								

(MSW)

Column No.	10	20	30	40	50	60	70	80
Program Variable	ALPHAL[M-(NCW-1)]	ALPHAL[M-(NCW-2)]	...	ALPHAL(MSW*NCW=M)				
Data								

Figure 13.- Continued.

Item No. 11 (option): Format (I5, 3E12.4), decimal point required in last three variables
(M cards) (1)

Column No.	5	17	29	41	
Program Variable	JN	UEI(1,1)	VEI(1,1)	WEI(1,1)	
Data	1				

Note: These quantities are read in when EI = 1.0 (see Item 5); if EI = 0.0, omit Item 11.

(2)

Column No.	5	17	29	41	
Program Variable	JN	UEI(2,1)	VEI(2,1)	WEI(2,1)	
Data	2				

(M)

Column No.	5	17	29	41	
Program Variable	JN	UEI(JN,1)	VEI(JN,1)	WEI(JN,1)	
Data	M				

Item No. 12 (option): Format (I5, 3E12.4), decimal point required in last two variables
(M cards) (1)

Column No.	5	17	29	41	
Program Variable	JN	VEI(1,2)	WEI(1,2)		
Data	1				

Note: These quantities are read in when EI = 1.0 (see Item 5); if EI = 0.0, omit Item 12.

(2)

Column No.	5	17	29	41	
Program Variable	JN	VEI(2,2)	WEI(2,2)		
Data	2				

(M)

Column No.	5	17	29	41	
Program Variable	JN	VEI(JN,2)	WEI(JN,2)		
Data	M				

Figure 13.- Continued.

Item No. 13 (option): Format (I5, 3E12.4), decimal point required in last two variables
(MP cards) (1)

Column No.	5	17	29	41	
Program Variable	JN	UEI(JN,1)	VEI(JN,1)		
Data	M+1				

Note: These quantities are read in when EI = 1.0 (see Item 5); if EI = 0.0, omit Item 13.

(MP)

Column No.	5	17	29	41	
Program Variable	JN	UEI(JN,1)	VEI(JN,1)		
Data	M+MP				

Item No. 14 (option): Format (I5, 3E12.4), decimal point required in second variable
(MP cards) (1)

Column No.	5	17	29	41	
Program Variable	JN	VEI(JN,2)			
Data	M+1				

Note: These quantities are read in when EI = 1.0 (see Item 5) and MSP $\neq$ 0 (see Item 2);
if EI = 0.0, omit Item 14.

(MP)

Column No.	5	17	29	41	
Program Variable	JN	VEI(JN,2)			
Data	M+MP				

Item No. 15 (option): Format (I5, 3E12.4), decimal point required in last three variables
(MT cards) (1)

Column No.	5	17	29	41	
Program Variable	JN	UEI(JN,1)	VEI(JN,1)	WEI(JN,1)	
Data	M+MP+1				

Note: These quantities are read in when EI = 1.0 (see Item 5) and NCT $\neq$ 0 (see Item 2);
if EI = 0.0, omit Item 15.

(MT)

Column No.	5	17	29	41	
Program Variable	JN	UEI(JN,1)	VEI(JN,1)	WEI(JN,1)	
Data	M+MP+MT				

Figure 13.- Continued.

Item No. 16 (option): Format (I5, 3E12.4), decimal point required in last two variables
(MT cards) (1)

Column No.	5	17	29	41	
Program Variable	JN	VEI(JN,2)	WEI(JN,2)		
Data	M+MP+1				

Note: These quantities are read in when EI = 1.0 (see Item 5) and NCT $\neq$ 0 (see Item 2);
if EI = 0.0, omit Item 16.

(MT)

Column No.	5	17	29	41	
Program Variable	JN	VEI(JN,2)	WEI(JN,2)		
Data	M+MP+MT				

Item No. 17 (option): Format (8F10.5), decimal point required
(MSP cards) (1)

Column No.	10	20	30	40	50	60	70	80
Program Variable	PINCL(1)	PINCL(2)	...	PINCL(NCP)				
Data								

Note: These quantities are read in when PINCLC = 1.0 (see Item 5); if PINCLC = 0.0, omit Item 17.

(MSP)

Column No.	10	20	30	40	50	60	70	80
Program Variable	PINCL MP-(NCP-1)	PINCL MP-(NCP-2)	...	PINCL(MSP*NCP=MP)				
Data								

Figure 13.- Continued.

Item No. 18 (option): Format (8F10.5), decimal points required
(MST cards) (1)

Column No.	10	20	30	40	50	60	70	80
Program Variable	TLPHAL (1)	TLPHAL (2)	...	TLPHAL (NCT)				
Data								

Note: These quantities are read in when TLPHAC = 1.0 (see Item 5); if TLPHAC = 0.0, omit Item 18.

	(MST)							
Column No.	10	20	30	40	50	60	70	80
Program Variable	TLPHAL MT- (NCT-1)	TLPHAL MT- (NCT-2)	...	TLPHAL (MST*NCT=MT)				
Data								

Item No. 19 (option): Format (3F10.3), decimal point required
(MMM cards) (1)

Column No.	10	20	30	
Program Variable	PMX (1)	PMY (1)	PMZ (1)	
Data				

Note: These quantities are read in when MMM $\neq$ 0 (see Item 5); if MMM = 0, omit Item 19.
One set of coordinates per card.

	(2)			
Column No.	10	20	30	
Program Variable	PMX (2)	PMY (2)	PMZ (2)	
Data				

	(MMM)			
Column No.	10	20	30	
Program Variable	PMX (MMM)	PMY (MMM)	PMZ (MMM)	
Data				

Figure 13.- Concluded.

SAMPLE CASE 1, WING-PYLON-TAIL CONFIGURATION, NO EXTERNAL INTERFERENCE									Item No.
4	4	20	2	2	2	10			1
27.10	14.05	31.183	74.9675	-3.50	2.57	2.50	0.70		2
-77.50	-72.75	20.051	2.946	-90.0	0.5679	1.0			3
27.10	14.05	10.394	25.0	1.0	0.5				4
-7.78	0.0	0.0							5
30 1.0	0.0 0.0	0.0 1.0							6
4.573	8.573	12.573	16.573	20.573	24.573	28.573	32.573		7
36.573	39.573	42.573	45.573	48.573	52.573	56.573	60.573		8
64.573	68.573	72.573	74.9675						9
2.90	2.946								10
-05.0	0.0	-10.0							11
2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00		12
22.50	25.00								13
-0.00785	0.02315	0.01815	0.00915						14
-0.01123	0.01967	0.01467	0.00567						15
-0.01512	0.01588	0.01088	0.00188						16
-0.01782	0.01318	0.00818	-0.00082						17
-0.02227	0.02227	0.02543	-0.00307						18
-0.02721	0.00669	0.02269	-0.00531						19
-0.03255	0.02225	0.00045	-0.00755						20
-0.03870	-0.00070	-0.00079	-0.00779						21
-0.04600	-0.00509	-0.00309	-0.00709						22
-0.05196	-0.00896	-0.00396	-0.00596						23
-0.05741	-0.01241	-0.00541	-0.00441						24
-0.06286	-0.01536	-0.00686	-0.00286						25
-0.06831	-0.01831	-0.00931	-0.00231						26
-0.07117	-0.02167	-0.01217	-0.00267						27
-0.07445	-0.02545	-0.01545	-0.00545						28
-0.07772	-0.02872	-0.01872	-0.00872						29
-0.08099	-0.03199	-0.02199	-0.01199						30
-0.08426	-0.03526	-0.02526	-0.01526						31
-0.08757	-0.03853	-0.02853	-0.01853						32
-0.09014	-0.04114	-0.03114	-0.02114						33
-9.158	-42.574	8.116							34
-12.840	-42.574	8.116							35
-16.520	-42.574	8.116							36
-20.490	-42.574	8.116							37
-22.480	-42.574	8.116							38
-24.460	-42.574	8.116							39
-26.440	-42.574	8.116							40
-9.158	-45.140	8.116							41
-12.840	-45.140	8.116							42
-16.520	-45.140	8.116							43
-20.490	-45.140	8.116							44
-22.480	-45.140	8.116							45
-24.460	-45.140	8.116							46
-26.440	-45.140	8.116							47
-9.158	-40.000	8.116							48
-12.840	-40.000	8.116							49
-16.520	-40.000	8.116							50
-20.490	-40.000	8.116							51
-22.480	-40.000	8.116							52
-24.460	-40.000	8.116							53
-26.440	-40.000	8.116							54
-9.160	-42.574	10.690							55
-12.840	-42.574	10.690							56
-16.520	-42.574	10.690							57
-20.490	-42.574	10.690							58
-22.480	-42.574	10.690							59
-24.460	-42.574	10.690							60
-26.440	-42.574	10.690							61
-28.430	-42.574	8.116							62
-30.420	-42.574	8.116							63

(a) No external interference.

Figure 14.- Sample input decks for wing-pylon-tail program.

SAMPLE CASE 2: WING-PYLON-TAIL CONFIGURATION, EXTERNAL INTERFERENCE INCLUDED										Item No.
4	20	2	2	10						1
27.10	14.05	31.183	74.9675	-3.50	2.57	2.50	0.70			2
-77.50	-72.75	20.051	2.946	-90.0	0.5679	1.0				3
-77.10	14.05	10.394	25.0	1.0	0.5					4
-77.78	0.0	0.0								5
30	1.0	0.0	1.0	1.0						6
4.573	0.573	12.573	16.573	20.573	24.573	28.573	32.573			7
36.573	39.573	42.573	45.573	48.573	52.573	56.573	60.573			8
64.573	68.573	72.573	74.9675							9
2.00	2.946									10
-95.0	0.0	-10.0								11
2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00			12
77.50	25.00									13
-0.00785	0.02315	0.01815	0.00915							14
-0.01133	0.01967	0.01467	0.00567							15
-0.01512	0.01588	0.01088	0.00188							16
-0.01787	0.01318	0.00818	-0.00082							17
-0.02207	0.00993	0.00543	-0.00307							18
-0.02731	0.00669	0.00269	-0.00531							19
-0.03255	0.00295	0.00045	-0.00755							20
-0.03879	-0.00079	-0.00079	-0.00779							21
-0.04509	-0.00509	-0.00309	-0.00709							22
-0.05196	-0.00896	-0.00396	-0.00596							23
-0.05741	-0.01241	-0.00541	-0.00441							24
-0.06286	-0.01536	-0.00686	-0.00286							25
-0.06831	-0.01831	-0.00931	-0.00231							26
-0.07117	-0.02167	-0.01217	-0.00267							27
-0.07445	-0.02545	-0.01545	-0.00545							28
-0.07772	-0.02872	-0.01872	-0.00872							29
-0.08099	-0.03199	-0.02199	-0.01199							30
-0.08426	-0.03526	-0.02526	-0.01526							31
-0.08757	-0.03853	-0.02853	-0.01853							32
-0.09014	-0.04114	-0.03114	-0.02114							33
1	-4.7556E-05	-7.4291E-04	-9.0189E-04							34
2	7.6441E-05	-6.3167E-05	3.6239E-04							35
3	1.0526E-04	6.3103E-04	1.6358E-03							36
4	1.1824E-04	1.2052E-03	2.6665E-03							37
5	1.6619E-05	-7.2257E-04	-6.0917E-04							38
6	1.0207E-04	1.5187E-04	7.8238E-04							39
7	1.4092E-04	9.8335E-04	2.0530E-03							40
8	1.5075E-04	1.6215E-03	3.0397E-03							41
9	7.0271E-05	-6.3863E-04	-2.4724E-04							42
10	1.6433E-04	4.8429E-04	1.2237E-03							43
11	1.9602E-04	1.4761E-03	2.5138E-03							44
12	1.9854E-04	2.1762E-03	3.4435E-03							45
13	1.8682E-04	-4.2413E-04	2.1777E-04							46
14	2.6680E-04	1.0361E-03	1.7359E-03							47
15	2.3324E-04	2.1898E-03	2.9601E-03							48
16	2.1158E-04	2.9282E-03	3.7656E-03							49
17	3.5272E-04	6.2149E-05	7.9341E-04							50
18	3.7165E-04	1.9652E-03	2.2950E-03							51
19	3.2416E-04	3.2779E-03	3.3996E-03							52
20	1.8963E-04	4.0442E-03	4.0788E-03							53
21	6.5061E-04	1.1264E-03	1.4546E-03							54
22	4.9444E-04	3.5413E-03	2.7951E-03							55
23	3.6677E-04	4.9617E-03	3.6822E-03							56
24	3.5374E-04	5.7041E-03	4.1708E-03							57
25	8.8280E-04	3.3659E-03	1.9681E-03							58
26	5.7578E-04	6.2606E-03	2.9416E-03							59
27	3.9124E-04	7.6696E-03	3.4930E-03							60
28	2.7192E-04	8.3312E-03	3.7653E-03							61
29	1.1359E-03	7.9619E-03	1.5096E-03							62
30	6.8452E-04	1.1030E-02	1.7895E-03							63
31	3.8395E-04	1.2248E-02	1.9437E-03							64
32	3.3310E-04	1.2785E-02	2.0242E-03							65
33	1.2725E-03	1.6875E-02	-3.1153E-03							66
34	6.3408E-04	1.9460E-02	-3.7115E-03							67
35	4.1835E-04	2.0327E-02	-3.6797E-03							68
36	2.9881E-04	2.0681E-02	-3.9496E-03							69
37	1.1734E-03	2.7225E-02	-1.9362E-02							70
38	6.1349E-04	2.8664E-02	-2.0420E-02							71
39	4.2485E-04	2.9094E-02	-2.0728E-02							72
40	3.0012E-04	2.9287E-02	-2.0855E-02							73
41	1.0075E-03	1.9207E-02	-4.8748E-02							74
42	5.6876E-04	1.9593E-02	-4.9709E-02							75
43	3.9937E-04	1.9716E-02	-4.9999E-02							76
44	3.7103E-04	1.9769E-02	-5.0120E-02							77
45	8.0660E-04	-2.0694E-02	-5.0460E-02							78
46	4.9421E-04	-2.0950E-02	-5.1067E-02							79
47	3.1249E-04	-2.1050E-02	-5.1283E-02							80
48	2.8872E-04	-2.1091E-02	-5.1373E-02							81
49	7.2104E-04	-3.1220E-02	-1.8517E-02							82
50	5.0218E-04	-3.1701E-02	-1.8799E-02							83
51	3.8622E-04	-3.1921E-02	-1.8912E-02							84
52	2.8578E-04	-3.2024E-02	-1.8971E-02							85
53	5.1583E-04	-1.9891E-02	-6.1805E-04							86
54	4.2174E-04	-2.0366E-02	-6.3915E-04							87
55	3.2250E-04	-2.0601E-02	-6.5640E-04							88
56	2.9577E-04	-2.0734E-02	-6.6360E-04							89
57	3.9949E-04	-1.0754E-02	4.3506E-03							90
58	3.5572E-04	-1.1144E-02	4.5102E-03							91
59	2.4604E-04	-1.1358E-02	4.5866E-03							92
60	3.0367E-04	-1.1497E-02	4.6388E-03							93
61	3.5032E-04	-6.2703E-03	5.3089E-03							94
62	2.8657E-04	-6.5434E-03	5.5236E-03							95
63	2.2281E-04	-6.7128E-03	5.6440E-03							96
64	2.6124E-04	-6.8292E-03	5.7337E-03							97
65	3.5826E-04	-3.9437E-03	5.3469E-03							98
66	2.5198E-04	-4.1288E-03	5.5550E-03							99
67	2.4707E-04	-4.2574E-03	5.6960E-03							100
68	2.0302E-04	-4.3606E-03	5.9333E-03							101
69	2.1084E-04	-2.6200E-03	5.1156E-03							102
70	1.6039E-04	-2.7639E-03	5.3689E-03							103
71	2.4304E-04	-2.8664E-03	5.5436E-03							104
72	1.3678E-04	-2.9428E-03	5.6731E-03							105
73	1.9736E-04	-1.8324E-03	4.9152E-03							106
74	1.8565E-04	-1.9236E-03	5.0991E-03							107
75	1.7780E-04	-1.9917E-03	5.2337E-03							108
76	1.6766E-04	-2.0542E-03	5.3732E-03							109
77	1.1578E-04	-1.4026E-03	4.7138E-03							110
78	1.1089E-04	-1.4770E-03	4.9123E-03							111
79	1.5717E-04	-1.5352E-03	5.0638E-03							112
80	1.0632E-04	-1.5822E-03	5.1812E-03							113

(b) With external interference.
Figure 14.- Continued.

			Item No.
1	4.6704E-05	8.4189E-04	12
2	-1.2430E-04	-2.6859E-04	
3	-2.7786E-04	-1.3608E-03	
4	-3.9440E-04	-2.2619E-03	
5	1.1905E-05	6.2341E-04	
6	-2.1966E-04	-6.0572E-04	
7	-4.1117E-04	-1.7392E-03	
8	-5.5030E-04	-2.6210E-03	
9	-5.6602E-05	3.4599E-04	
10	-3.6629E-04	-9.9249E-04	
11	-5.1129E-04	-2.1757E-03	
12	-7.7536E-04	-3.0294E-03	
13	-1.9351E-04	-2.3732E-05	
14	-6.1411E-04	-1.4682E-03	
15	-9.1738E-04	-2.6395E-03	
16	-1.1041E-03	-3.4102E-03	
17	-4.6986E-04	-5.1032E-04	
18	-1.0472E-03	-2.0429E-03	
19	-1.4228E-03	-3.1665E-03	
20	-1.6418E-03	-3.8516E-03	
21	-1.0449E-03	-1.1433E-03	
22	-1.8304E-03	-2.6861E-03	
23	-2.2848E-03	-3.6820E-03	
24	-2.5262E-03	-4.2223E-03	
25	-2.2651E-03	-1.8533E-03	
26	-3.3171E-03	-3.2683E-03	
27	-3.8366E-03	-4.0227E-03	
28	-4.0863E-03	-4.3857E-03	
29	-4.9644E-03	-2.2491E-03	
30	-6.2767E-03	-3.2347E-03	
31	-6.8129E-03	-3.6558E-03	
32	-7.0544E-03	-3.8501E-03	
33	-1.1030E-02	-2.8720E-04	
34	-1.2417E-02	-5.2279E-04	
35	-1.2890E-02	-6.2235E-04	
36	-1.3084E-02	-6.6110E-04	
37	-2.0012E-02	1.0280E-02	
38	-2.1006E-02	1.0700E-02	
39	-2.1294E-02	1.0811E-02	
40	-2.1425E-02	1.0852E-02	
41	-1.7722E-02	3.4240E-02	
42	-1.8101E-02	3.4859E-02	
43	-1.8220E-02	3.5032E-02	
44	-1.8271E-02	3.5102E-02	
45	1.2911E-02	4.2513E-02	
46	1.3042E-02	4.3016E-02	
47	1.3088E-02	4.3189E-02	
48	1.3108E-02	4.3259E-02	
49	2.5768E-02	1.9798E-02	
50	2.6152E-02	2.0110E-02	
51	2.6321E-02	2.0236E-02	
52	2.6399E-02	2.0296E-02	
53	1.8907E-02	4.0655E-03	
54	1.9353E-02	4.1759E-03	
55	1.9566E-02	4.2287E-03	
56	1.9685E-02	4.2566E-03	
57	1.1635E-02	-1.3667E-03	
58	1.2037E-02	-1.4163E-03	
59	1.2256E-02	-1.4374E-03	
60	1.2394E-02	-1.4550E-03	
61	7.6140E-03	-2.9060E-03	
62	7.9220E-03	-3.0212E-03	
63	8.1106E-03	-3.0852E-03	
64	8.2408E-03	-3.1343E-03	
65	5.3405E-03	-3.3556E-03	
66	5.5648E-03	-3.4843E-03	
67	5.7194E-03	-3.5728E-03	
68	5.8433E-03	-3.6590E-03	
69	3.9455E-03	-3.4218E-03	
70	4.1787E-03	-3.5923E-03	
71	4.2610E-03	-3.7092E-03	
72	4.3407E-03	-3.7955E-03	
73	3.0587E-03	-3.4138E-03	
74	3.1839E-03	-3.5410E-03	
75	3.2800E-03	-3.6335E-03	
76	3.3653E-03	-3.7297E-03	
77	2.5473E-03	-3.3395E-03	
78	2.6535E-03	-3.4804E-03	
79	2.7379E-03	-3.5877E-03	
80	2.8058E-03	-3.6706E-03	
81	2.2663E-03	-4.1996E-09	13
82	8.1250E-04	-4.3774E-09	
83	5.4323E-04	-4.4076E-09	
84	2.7225E-04	-4.4173E-09	
85	7.4795E-03	-4.3825E-09	14
86	1.8757E-03	-7.5957E-09	
87	7.6427E-04	-7.8457E-09	
88	4.5232E-04	-7.8618E-09	
81	-5.4385E-03		
82	-5.7703E-03		
83	-5.8388E-03		
84	-5.8605E-03		
85	-6.2998E-03		
86	-1.1269E-02		
87	-1.1725E-02		
88	-1.1783E-02		

(b) Continued.

Figure 14.- Continued.

89	2.1171E-04	4.4311E-03	3.3307E-03
90	1.1914E-04	4.4609E-03	3.3542E-03
91	1.1797E-04	4.8296E-03	3.1378E-03
92	-1.3012E-05	4.8549E-03	3.1537E-03
93	-2.6866E-05	5.2612E-03	2.8711E-03
94	4.1923E-05	5.2825E-03	2.8809E-03
95	7.3327E-05	5.7403E-03	2.5319E-03
96	1.2767E-04	5.7621E-03	2.5420E-03
97	1.6112E-04	6.2776E-03	2.1092E-03
98	1.6473E-04	6.2945E-03	2.1141E-03
99	1.1380E-04	6.8474E-03	1.5505E-03
100	3.4900E-05	6.8605E-03	1.5521E-03
101	-3.3286E-05	7.4683E-03	8.4683E-04
102	-3.6542E-05	7.4784E-03	8.4838E-04
103	1.3502E-05	8.1050E-03	-5.4578E-05
104	3.9437E-05	8.1119E-03	-5.5144E-05
105	8.0811E-05	8.7193E-03	-1.2014E-03
106	9.3849E-05	8.7241E-03	-1.2030E-03
107	1.2460E-04	9.2605E-03	-2.6337E-03
108	1.2907E-04	9.2656E-03	-2.6362E-03
89	-2.5583E-03	-3.3871E-03	
90	-2.5752E-03	-3.4107E-03	
91	-2.8505E-03	-3.3118E-03	
92	-2.8648E-03	-3.3288E-03	
93	-3.1743E-03	-3.1856E-03	
94	-3.1862E-03	-3.1972E-03	
95	-3.5418E-03	-3.0134E-03	
96	-3.5546E-03	-3.0257E-03	
97	-3.9644E-03	-2.7895E-03	
98	-3.9742E-03	-2.7970E-03	
99	-4.4272E-03	-2.4672E-03	
100	-4.4349E-03	-2.4713E-03	
101	-4.9497E-03	-2.0408E-03	
102	-4.9569E-03	-2.0437E-03	
103	-5.5123E-03	-1.4635E-03	
104	-5.5172E-03	-1.4641E-03	
105	-6.0911E-03	-6.9253E-04	
106	-6.0945E-03	-6.9185E-04	
107	-6.6546E-03	3.1219E-04	
108	-6.6577E-03	3.1288E-04	
	-9.158	-42.574	8.116
	-12.840	-42.574	8.116
	-16.520	-42.574	8.116
	-20.490	-42.574	8.116
	-22.480	-42.574	8.116
	-24.460	-42.574	8.116
	-26.440	-42.574	8.116
	-9.158	-45.140	8.116
	-12.840	-45.140	8.116
	-16.520	-45.140	8.116
	-20.490	-45.140	8.116
	-22.480	-45.140	8.116
	-24.460	-45.140	8.116
	-26.440	-45.140	8.116
	-9.158	-40.000	8.116
	-12.840	-40.000	8.116
	-16.520	-40.000	8.116
	-20.490	-40.000	8.116
	-22.480	-40.000	8.116
	-24.460	-40.000	8.116
	-26.440	-40.000	8.116
	-9.160	-42.574	10.690
	-12.840	-42.574	10.690
	-16.520	-42.574	10.690
	-20.490	-42.574	10.690
	-22.480	-42.574	10.690
	-24.460	-42.574	10.690
	-26.440	-42.574	10.690
	-28.430	-42.574	8.116
	-30.420	-42.574	8.116

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(b) Concluded.

Figure 14.- Concluded.

SAMPLE CASE 1, WING-PYLON-TAIL CONFIGURATION, NO EXTERNAL INTERFERENCE

GEOMETRY DATA

	WING	PYLON	TAIL
LE SWEEP, DEG.	27.1000	-77.5000	27.1000
TE SWEEP, DEG.	14.0500	-72.7500	14.0500
DIHEDRAL, DEG.	-3.5000	-90.0000	1.0000
ROOT CHORD	31.1830	20.0510	10.3940
SEMISPAN	74.9675	-----	25.0000
PYLON LOC./WING SEMISP.	-----	0.5679	-----
PYLON HEIGHT	-----	2.9460	-----
PYLON INCIDENCE, DEG.	-----	1.0000	-----
TAIL INCIDENCE, DEG.	-----	-----	0.5000
CHORDWISE VORTICES	4	4	2
SPANWISE VORTICES	20	2	10

	X	Y	Z
TAIL RT.CHORD NOSE COORDINATES	-95.0000	0.0000	-10.0000
PITCHING MOMENT CENTER	-7.7800	0.0000	0.0000
TURBOFAN RADIUS=	2.5700		

FLOW CONDITIONS

ANGLE OF ATTACK, ALPHA, DEG.	2.5000
MACH NUMBER	0.7000

(a) No external interference.

Figure 15.- Sample output from wing-pylon-tail program.

CONTROL POINT COORDINATES AND SLOPES

EXTERNALLY INDUCED VELOCITIES

				ALPHA=C		ADDITIONAL ALPHA=0.6761	
J	X	Y	Z	MEAN SURFACE SLOPE	U/V	V/V	W/V
WING CONTROL POINTS							
1	-4.9044	-2.2865	0.1398	-0.0078	-0.00005	-0.00074	-0.00030
2	-14.5511	-2.2865	0.1398	0.0231	0.00008	-0.00006	0.00038
3	-22.1973	-2.2865	0.1398	0.0181	0.00011	0.00063	0.00164
4	-29.8436	-2.2865	0.1398	0.0191	0.00012	0.00121	0.00267
5	-37.4899	-2.2865	0.1398	0.0202	0.00010	0.00015	0.00039
6	-45.1362	-2.2865	0.1398	0.0213	0.00010	0.00015	0.00039
7	-52.7825	-2.2865	0.1398	0.0224	0.00010	0.00015	0.00039
8	-60.4288	-2.2865	0.1398	0.0235	0.00010	0.00015	0.00039
9	-68.0751	-2.2865	0.1398	0.0246	0.00010	0.00015	0.00039
10	-75.7214	-2.2865	0.1398	0.0257	0.00010	0.00015	0.00039
11	-83.3677	-2.2865	0.1398	0.0268	0.00010	0.00015	0.00039
12	-91.0140	-2.2865	0.1398	0.0279	0.00010	0.00015	0.00039
13	-98.6603	-2.2865	0.1398	0.0290	0.00010	0.00015	0.00039
14	-106.3066	-2.2865	0.1398	0.0301	0.00010	0.00015	0.00039
15	-113.9529	-2.2865	0.1398	0.0312	0.00010	0.00015	0.00039
16	-121.5992	-2.2865	0.1398	0.0323	0.00010	0.00015	0.00039
17	-129.2455	-2.2865	0.1398	0.0334	0.00010	0.00015	0.00039
18	-136.8918	-2.2865	0.1398	0.0345	0.00010	0.00015	0.00039
19	-144.5381	-2.2865	0.1398	0.0356	0.00010	0.00015	0.00039
20	-152.1844	-2.2865	0.1398	0.0367	0.00010	0.00015	0.00039
21	-159.8307	-2.2865	0.1398	0.0378	0.00010	0.00015	0.00039
22	-167.4770	-2.2865	0.1398	0.0389	0.00010	0.00015	0.00039
23	-175.1233	-2.2865	0.1398	0.0400	0.00010	0.00015	0.00039
24	-182.7696	-2.2865	0.1398	0.0411	0.00010	0.00015	0.00039
25	-190.4159	-2.2865	0.1398	0.0422	0.00010	0.00015	0.00039
26	-198.0622	-2.2865	0.1398	0.0433	0.00010	0.00015	0.00039
27	-205.7085	-2.2865	0.1398	0.0444	0.00010	0.00015	0.00039
28	-213.3548	-2.2865	0.1398	0.0455	0.00010	0.00015	0.00039
29	-221.0011	-2.2865	0.1398	0.0466	0.00010	0.00015	0.00039
30	-228.6474	-2.2865	0.1398	0.0477	0.00010	0.00015	0.00039
31	-236.2937	-2.2865	0.1398	0.0488	0.00010	0.00015	0.00039
32	-243.9400	-2.2865	0.1398	0.0499	0.00010	0.00015	0.00039
33	-251.5863	-2.2865	0.1398	0.0510	0.00010	0.00015	0.00039
34	-259.2326	-2.2865	0.1398	0.0521	0.00010	0.00015	0.00039
35	-266.8789	-2.2865	0.1398	0.0532	0.00010	0.00015	0.00039
36	-274.5252	-2.2865	0.1398	0.0543	0.00010	0.00015	0.00039
37	-282.1715	-2.2865	0.1398	0.0554	0.00010	0.00015	0.00039
38	-289.8178	-2.2865	0.1398	0.0565	0.00010	0.00015	0.00039
39	-297.4641	-2.2865	0.1398	0.0576	0.00010	0.00015	0.00039
40	-305.1104	-2.2865	0.1398	0.0587	0.00010	0.00015	0.00039
41	-312.7567	-2.2865	0.1398	0.0598	0.00010	0.00015	0.00039
42	-320.4030	-2.2865	0.1398	0.0609	0.00010	0.00015	0.00039
43	-328.0493	-2.2865	0.1398	0.0620	0.00010	0.00015	0.00039
44	-335.6956	-2.2865	0.1398	0.0631	0.00010	0.00015	0.00039
45	-343.3419	-2.2865	0.1398	0.0642	0.00010	0.00015	0.00039
46	-350.9882	-2.2865	0.1398	0.0653	0.00010	0.00015	0.00039
47	-358.6345	-2.2865	0.1398	0.0664	0.00010	0.00015	0.00039
48	-366.2808	-2.2865	0.1398	0.0675	0.00010	0.00015	0.00039
49	-373.9271	-2.2865	0.1398	0.0686	0.00010	0.00015	0.00039
50	-381.5734	-2.2865	0.1398	0.0697	0.00010	0.00015	0.00039
51	-389.2197	-2.2865	0.1398	0.0708	0.00010	0.00015	0.00039
52	-396.8660	-2.2865	0.1398	0.0719	0.00010	0.00015	0.00039
53	-404.5123	-2.2865	0.1398	0.0730	0.00010	0.00015	0.00039
54	-412.1586	-2.2865	0.1398	0.0741	0.00010	0.00015	0.00039
55	-419.8049	-2.2865	0.1398	0.0752	0.00010	0.00015	0.00039
56	-427.4512	-2.2865	0.1398	0.0763	0.00010	0.00015	0.00039
57	-435.0975	-2.2865	0.1398	0.0774	0.00010	0.00015	0.00039
58	-442.7438	-2.2865	0.1398	0.0785	0.00010	0.00015	0.00039
59	-450.3901	-2.2865	0.1398	0.0796	0.00010	0.00015	0.00039
60	-458.0364	-2.2865	0.1398	0.0807	0.00010	0.00015	0.00039
61	-465.6827	-2.2865	0.1398	0.0818	0.00010	0.00015	0.00039
62	-473.3290	-2.2865	0.1398	0.0829	0.00010	0.00015	0.00039
63	-480.9753	-2.2865	0.1398	0.0840	0.00010	0.00015	0.00039
64	-488.6216	-2.2865	0.1398	0.0851	0.00010	0.00015	0.00039
65	-496.2679	-2.2865	0.1398	0.0862	0.00010	0.00015	0.00039
66	-503.9142	-2.2865	0.1398	0.0873	0.00010	0.00015	0.00039
67	-511.5605	-2.2865	0.1398	0.0884	0.00010	0.00015	0.00039
68	-519.2068	-2.2865	0.1398	0.0895	0.00010	0.00015	0.00039
69	-526.8531	-2.2865	0.1398	0.0906	0.00010	0.00015	0.00039
70	-534.4994	-2.2865	0.1398	0.0917	0.00010	0.00015	0.00039
71	-542.1457	-2.2865	0.1398	0.0928	0.00010	0.00015	0.00039
72	-549.7920	-2.2865	0.1398	0.0939	0.00010	0.00015	0.00039
73	-557.4383	-2.2865	0.1398	0.0950	0.00010	0.00015	0.00039
74	-565.0846	-2.2865	0.1398	0.0961	0.00010	0.00015	0.00039
75	-572.7309	-2.2865	0.1398	0.0972	0.00010	0.00015	0.00039
76	-580.3772	-2.2865	0.1398	0.0983	0.00010	0.00015	0.00039
77	-588.0235	-2.2865	0.1398	0.0994	0.00010	0.00015	0.00039
78	-595.6698	-2.2865	0.1398	0.1005	0.00010	0.00015	0.00039
79	-603.3161	-2.2865	0.1398	0.1016	0.00010	0.00015	0.00039
80	-610.9624	-2.2865	0.1398	0.1027	0.00010	0.00015	0.00039
81	-618.6087	-2.2865	0.1398	0.1038	0.00010	0.00015	0.00039
82	-626.2550	-2.2865	0.1398	0.1049	0.00010	0.00015	0.00039
83	-633.9013	-2.2865	0.1398	0.1060	0.00010	0.00015	0.00039
84	-641.5476	-2.2865	0.1398	0.1071	0.00010	0.00015	0.00039
85	-649.1939	-2.2865	0.1398	0.1082	0.00010	0.00015	0.00039
86	-656.8402	-2.2865	0.1398	0.1093	0.00010	0.00015	0.00039
87	-664.4865	-2.2865	0.1398	0.1104	0.00010	0.00015	0.00039
88	-672.1328	-2.2865	0.1398	0.1115	0.00010	0.00015	0.00039
89	-679.7791	-2.2865	0.1398	0.1126	0.00010	0.00015	0.00039
90	-687.4254	-2.2865	0.1398	0.1137	0.00010	0.00015	0.00039
91	-695.0717	-2.2865	0.1398	0.1148	0.00010	0.00015	0.00039
92	-702.7180	-2.2865	0.1398	0.1159	0.00010	0.00015	0.00039
93	-710.3643	-2.2865	0.1398	0.1170	0.00010	0.00015	0.00039
94	-718.0106	-2.2865	0.1398	0.1181	0.00010	0.00015	0.00039
95	-725.6569	-2.2865	0.1398	0.1192	0.00010	0.00015	0.00039
96	-733.3032	-2.2865	0.1398	0.1203	0.00010	0.00015	0.00039
97	-740.9495	-2.2865	0.1398	0.1214	0.00010	0.00015	0.00039
98	-748.5958	-2.2865	0.1398	0.1225	0.00010	0.00015	0.00039
99	-756.2421	-2.2865	0.1398	0.1236	0.00010	0.00015	0.00039
100	-763.8884	-2.2865	0.1398	0.1247	0.00010	0.00015	0.00039
101	-771.5347	-2.2865	0.1398	0.1258	0.00010	0.00015	0.00039
102	-779.1810	-2.2865	0.1398	0.1269	0.00010	0.00015	0.00039
103	-786.8273	-2.2865	0.1398	0.1280	0.00010	0.00015	0.00039
104	-794.4736	-2.2865	0.1398	0.1291	0.00010	0.00015	0.00039
105	-802.1199	-2.2865	0.1398	0.1302	0.00010	0.00015	0.00039
106	-809.7662	-2.2865	0.1398	0.1313	0.00010	0.00015	0.00039
107	-817.4125	-2.2865	0.1398	0.1324	0.00010	0.00015	0.00039
108	-825.0588	-2.2865	0.1398	0.1335	0.00010	0.00015	0.00039
109	-832.7051	-2.2865	0.1398	0.1346	0.00010	0.00015	0.00039
110	-840.3514	-2.2865	0.1398	0.1357	0.00010	0.00015	0.00039
111	-847.9977	-2.2865	0.1398	0.1368	0.00010	0.00015	0.00039
112	-855.6440	-2.2865	0.1398	0.1379	0.00010	0.00015	0.00039
113	-863.2903	-2.2865	0.1398	0.1390	0.00010	0.00015	0.00039
114	-870.9366	-2.2865	0.1398	0.1401	0.00010	0.00015	0.00039
115	-878.5829	-2.2865	0.1398	0.1412	0.00010	0.00015	0.00039
116	-886.2292	-2.2865	0.1398	0.1423	0.00010	0.00015	0.00039
117	-893.8755	-2.2865	0.1398	0.1434	0.00010	0.00015	0.00039
118	-901.5218	-2.2865	0.1398	0.1445	0.00010	0.00015	0.00039
119	-909.1681	-2.2865	0.1398	0.1456	0.00010	0.00015	0.00039
120	-916.8144	-2.2865	0.1398	0.1467	0.00010	0.00015	0.00039
121	-924.4607	-2.2865	0.1398	0.1478	0.00010	0.00015	0.00039
122	-932.1070	-2.2865	0.1398	0.1489	0.00010	0.00015	0.00039
123	-939.7533	-2.2865	0.1398	0.1500	0.00010	0.00015	0.00039
124	-947.3996	-2.2865	0.1398	0.1511	0.00010	0.00015	0.00039
125	-955.0459	-2.2865	0.1398	0.1522	0.00010	0.00015	0.00039
126	-962.6922	-2.2865	0.1398	0.1533	0.00010	0.00015	0.00039
127	-970.3385	-2.2865	0.1398	0.1544	0.00010	0.00015	0.00039
128	-977.9848	-2.2865	0.1398	0.1555	0.00010	0.00015	0.0

HORSESHOE VORTEX CHARACTERISTICS

ROUNDING MIDPOINT COORDINATES				VORTEX STRENGTHS, GAMMA/V			
J	X	Y	Z	SWEEP (DEG)	SEMIWIDTH	ALPHA=C	ADDITIONAL, ALPHA= C/0.436
WING VORTICES							
1	-3.0816	-2.2865	0.1398	26.3106	2.2908	-0.1703	1.4051
2	-17.7279	-2.2865	0.1398	23.2297	2.2908	0.3609	0.7005
3	-18.3742	-2.2865	0.1398	19.9999	2.2908	-0.0186	0.5549
4	-26.0205	-2.2865	0.1398	16.6321	2.2908	-0.1459	0.3415
5	-4.2051	-6.5730	0.4020	26.3106	2.0037	-0.0918	1.4994
6	-12.5712	-6.5730	0.4020	23.2297	2.0037	0.3383	0.7737
7	-19.9172	-6.5730	0.4020	19.9999	2.0037	-0.0311	0.5237
8	-27.3033	-6.5730	0.4020	16.6321	2.0037	-0.1418	0.3141
9	-7.1866	-10.5730	0.6467	26.3106	2.0037	-0.1360	1.5497
10	-14.2912	-10.5730	0.6467	23.2297	2.0037	0.3109	0.7589
11	-21.3958	-10.5730	0.6467	19.9999	2.0037	-0.0378	0.4980
12	-28.5005	-10.5730	0.6467	16.6321	2.0037	-0.1355	0.2921
13	-9.1682	-14.5730	0.8913	26.3106	2.0037	-0.1858	1.5946
14	-16.0113	-14.5730	0.8913	23.2297	2.0037	0.2818	0.7475
15	-22.8544	-14.5730	0.8913	19.9999	2.0037	-0.0983	0.4598
16	-29.6976	-14.5730	0.8913	16.6321	2.0037	-0.1259	0.2740
17	-11.1497	-18.5730	1.1360	26.3106	2.0037	-0.2508	1.6108
18	-17.7314	-18.5730	1.1360	23.2297	2.0037	0.2655	0.7350
19	-24.3130	-18.5730	1.1360	19.9999	2.0037	-0.0305	0.4580
20	-30.8947	-18.5730	1.1360	16.6321	2.0037	-0.1107	0.2581
21	-13.1313	-22.5730	1.3806	26.3106	2.0037	-0.3237	1.6114
22	-19.4516	-22.5730	1.3806	23.2297	2.0037	0.2589	0.7181
23	-25.7716	-22.5730	1.3806	19.9999	2.0037	-0.0140	0.4373
24	-32.0918	-22.5730	1.3806	16.6321	2.0037	-0.0921	0.2429
25	-15.1128	-26.5730	1.6253	26.3106	2.0037	-0.3913	1.5980
26	-21.1715	-26.5730	1.6253	23.2297	2.0037	0.2601	0.6941
27	-27.2302	-26.5730	1.6253	19.9999	2.0037	0.0145	0.4140
28	-33.2889	-26.5730	1.6253	16.6321	2.0037	-0.0723	0.2279
29	-17.0949	-30.5730	1.8699	26.3106	2.0037	-0.4383	1.5666
30	-22.8916	-30.5730	1.8699	23.2297	2.0037	0.2785	0.6508
31	-28.6888	-30.5730	1.8699	19.9999	2.0037	0.0529	0.3883
32	-34.4861	-30.5730	1.8699	16.6321	2.0037	-0.0446	0.2133
33	-19.0759	-34.5730	2.1146	26.3106	2.0037	-0.4508	1.4974
34	-24.6116	-34.5730	2.1146	23.2297	2.0037	0.3102	0.6143
35	-30.1474	-34.5730	2.1146	19.9999	2.0037	0.0491	0.3623
36	-35.6832	-34.5730	2.1146	16.6321	2.0037	-0.0608	0.1958
37	-20.8097	-38.0730	2.3286	26.3106	1.5028	-0.3689	1.3765
38	-26.1167	-38.0730	2.3286	23.2297	1.5028	0.3334	0.5653
39	-31.4237	-38.0730	2.3286	19.9999	1.5028	0.1200	0.3415
40	-36.7307	-38.0730	2.3286	16.6321	1.5028	-0.0230	0.1892
41	-22.2959	-41.0730	2.5121	26.3106	1.5028	-0.2531	1.2386
42	-27.4068	-41.0730	2.5121	23.2297	1.5028	0.3391	0.5407
43	-32.5177	-41.0730	2.5121	19.9999	1.5028	0.1372	0.3282
44	-37.6285	-41.0730	2.5121	16.6321	1.5028	-0.0511	0.1811
45	-23.7822	-44.0730	2.6956	26.3106	1.5028	-0.2021	0.8881
46	-28.6968	-44.0730	2.6956	23.2297	1.5028	0.3250	0.4774
47	-33.6116	-44.0730	2.6956	19.9999	1.5028	0.1497	0.3762
48	-38.5264	-44.0730	2.6956	16.6321	1.5028	0.0784	0.1726
49	-25.2682	-47.0730	2.8791	26.3106	1.5028	-0.4275	1.0032
50	-29.4869	-47.0730	2.8791	23.2297	1.5028	0.2891	0.4826
51	-34.7056	-47.0730	2.8791	19.9999	1.5028	0.1438	0.2904
52	-39.4242	-47.0730	2.8791	16.6321	1.5028	-0.0986	0.1661
53	-27.0027	-50.5730	3.0632	26.3106	2.0037	-0.6197	1.1094
54	-31.4919	-50.5730	3.0632	23.2297	2.0037	0.2338	0.4865
55	-35.9818	-50.5730	3.0632	19.9999	2.0037	0.1332	0.2916
56	-40.4717	-50.5730	3.0632	16.6321	2.0037	0.1116	0.1588
57	-28.9876	-54.5730	3.3378	26.3106	2.0037	-0.7415	1.1445
58	-33.2120	-54.5730	3.3378	23.2297	2.0037	0.1738	0.4816
59	-37.4404	-54.5730	3.3378	19.9999	2.0037	0.1179	0.2756
60	-41.6688	-54.5730	3.3378	16.6321	2.0037	0.1089	0.1487
61	-20.9651	-58.5730	3.5825	26.3106	2.0037	-0.8067	1.1329
62	-24.9321	-58.5730	3.5825	23.2297	2.0037	0.1336	0.4636
63	-28.8990	-58.5730	3.5825	19.9999	2.0037	0.1014	0.2659
64	-32.8660	-58.5730	3.5825	16.6321	2.0037	0.1009	0.1350
65	-17.9465	-62.5730	3.8271	26.3106	2.0037	-0.9084	1.0084
66	-21.6521	-62.5730	3.8271	23.2297	2.0037	0.1031	0.4373
67	-25.3576	-62.5730	3.8271	19.9999	2.0037	0.0895	0.2324
68	-29.0631	-62.5730	3.8271	16.6321	2.0037	0.0933	0.1160
69	-34.9282	-66.5730	4.0718	26.3106	2.0037	-0.4313	1.0041
70	-38.4722	-66.5730	4.0718	23.2297	2.0037	0.0893	0.3764
71	-41.8162	-66.5730	4.0718	19.9999	2.0037	0.0850	0.1901
72	-45.2602	-66.5730	4.0718	16.6321	2.0037	0.0871	0.0965
73	-36.0097	-70.5730	4.3164	26.3106	2.0037	-0.7800	0.8746
74	-40.0923	-70.5730	4.3164	23.2297	2.0037	0.1042	0.2951
75	-43.2748	-70.5730	4.3164	19.9999	2.0037	0.0852	0.1293
76	-46.4573	-70.5730	4.3164	16.6321	2.0037	0.0775	0.0793
77	-38.4936	-73.7702	4.5120	26.3106	1.1995	-0.6056	0.6376
78	-41.4671	-73.7702	4.5120	23.2297	1.1995	0.1363	0.1448
79	-44.4407	-73.7702	4.5120	19.9999	1.1995	-0.0339	0.0648
80	-47.4142	-73.7702	4.5120	16.6321	1.1995	0.0560	0.0353
PYLON VORTICES							
81	-18.6093	-42.5740	3.6039	-77.2799	1.0000	-0.0809	0.1858
82	-23.9446	-42.5740	3.6039	-76.3173	1.0000	-0.0850	0.1591
83	-29.2799	-42.5740	3.6039	-75.2006	1.0000	-0.0899	0.0654
84	-34.6152	-42.5740	3.6039	-73.8906	1.0000	-0.0929	0.0074
85	-12.0838	-42.5740	5.0769	-77.2799	0.4730	-0.0605	0.0801
86	-17.8942	-42.5740	5.0769	-76.3173	0.4730	-0.0608	0.1758
87	-23.7046	-42.5740	5.0769	-75.2006	0.4730	-0.0613	0.1146
88	-29.5150	-42.5740	5.0769	-73.8906	0.4730	-0.0628	0.0127
PYLON IMAGE VORTICES							
89	-11.5200	-42.5740	5.8957	77.2799	0.3457	-0.0605	0.0801
90	-17.3714	-42.5740	5.8957	76.3173	0.3457	-0.0608	0.1758
91	-23.2229	-42.5740	5.8957	75.2006	0.3457	-0.0613	0.1146
92	-29.0743	-42.5740	5.8957	73.8906	0.3457	-0.0628	0.0127
93	-14.5604	-42.5740	6.5820	77.2799	0.3406	-0.0809	0.1858
94	-20.1904	-42.5740	6.5820	76.3173	0.3406	-0.0850	0.1591
95	-25.8205	-42.5740	6.5820	75.2006	0.3406	-0.0899	0.0654
96	-31.4506	-42.5740	6.5820	73.8906	0.3406	-0.0929	0.0074
TAIL VORTICES							
97	-96.8080	-1.2500	-10.0218	25.5930	1.2502	0.0594	0.4565
98	-101.9316	-1.2500	-10.0218	19.2009	1.2502	0.0310	0.1941
99	-98.0956	-3.7500	-10.0655	25.5930	1.2502	0.0556	0.4704
100	-102.8024	-3.7500	-10.0655	19.2009	1.2502	0.0260	0.1702
101	-99.2932	-6.2500	-10.1091	25.5930	1.2502	0.0730	0.4714
102	-103.6731	-6.2500	-10.1091	19.2009	1.2502	0.0363	0.1678
103	-100.4909	-8.7500	-10.1527	25.5930	1.2502	0.0811	0.4415
104	-104.5439	-8.7500	-10.1527	19.2009	1.2502	0.0314	0.1582
105	-101.6885	-11.2500	-10.1964	25.5930	1.2502	0.0892	0.4442
106	-105.4147	-11.2500	-10.1964	19.2009	1.2502	0.0327	0.1484
107	-102.8861	-13.7500	-10.2400	25.5930	1.2502	0.0866	0.4150
108	-106.2854	-13.7500	-10.2400	19.2009	1.2502	0.0338	0.1374
109	-104.0837	-16.2500	-10.2836	25.5930	1.2502	0.1023	0.3843
110	-107.1562	-16.2500	-10.2836	19.2009	1.2502	0.0342	0.1250
111	-105.2813	-18.7500	-10.3273	25.5930	1.2502	0.1052	0.3517
112	-108.0270	-18.7500	-10.3273	19.2009	1.2502	0.0329	0.1046
113	-106.4789	-21.2500	-10.3709	25.5930	1.2502	0.1028	0.3836
114	-109.8978	-21.2500	-10.3709	19.2009	1.2502	0.0285	0.0950
115	-107.6765	-23.7500	-10.4146	25.5930	1.2502	0.0875	0.2370
116	-109.7685	-23.7500	-10.4146	19.2009	1.2502	0.0173	0.0685

(a) Continued.

Figure 15.- Continued.

AFRODYNAMIC LOADING RESULTS

WING LIFT COEFFICIENT			TAIL LIFT COEFFICIENT			
ALPHA=0 -0.0293	ADDITIONAL, ALPHA= 0.0436 0.2372		ALPHA=0 0.0035	ADDITIONAL, ALPHA= 0.0436 0.0162		
TOTAL LIFT COEFFICIENT		TOTAL MOMENT COEFFICIENT				
ALPHA=0 -0.0258	ADDITIONAL, ALPHA= 0.0436 0.2535		ALPHA=0 0.0077	ADDITIONAL, ALPHA= 0.0436 -0.2371		
REFERENCE QUANTITIES						
WING SPAN, R 149.9350	WING PLANFORM AREA, SREF 3205.9200	WING AVE. CHORD, CAVE 21.3921				
SPANWISE LOAD DISTRIBUTION						
STATION	Y/(P/2)	LOCAL CHORD, C	CL*C/CL*CAVE		CL*C/(2*S)	
			ALPHA=0	ADDITIONAL ALPHA= 0.0436	ALPHA=0	ADDITIONAL ALPHA= 0.0436
WING						
1	0.0305	30.5851	-0.4973	1.1904	0.0010	0.0203
2	0.0877	29.4643	-0.3224	1.2040	0.0007	0.0204
3	0.1410	28.4185	-0.0850	1.2038	0.0002	0.0204
4	0.1944	27.3726	0.1667	1.1994	-0.0003	0.0203
5	0.2477	26.3267	0.4229	1.1908	-0.0009	0.0201
6	0.3011	25.2808	0.6786	1.1781	-0.0014	0.0199
7	0.3545	24.2349	0.9199	1.1618	-0.0019	0.0197
8	0.4078	23.1890	1.1040	1.1423	-0.0023	0.0193
9	0.4612	22.1431	1.2455	1.1209	-0.0026	0.0190
10	0.5079	21.0972	1.3510	1.1023	-0.0028	0.0186
11	0.5479	20.0436	1.4412	1.0900	-0.0030	0.0184
12	0.5879	19.0592	1.5206	0.9969	-0.0028	0.0169
13	0.6279	18.8748	1.4320	0.9754	-0.0030	0.0165
14	0.6746	17.9596	1.5470	0.9421	-0.0032	0.0159
15	0.7280	16.9137	1.6965	0.8943	-0.0035	0.0151
16	0.7813	15.8678	1.8240	0.8355	-0.0038	0.0141
17	0.8347	14.8220	1.8867	0.7627	-0.0039	0.0129
18	0.8880	13.7761	1.8357	0.6684	-0.0038	0.0113
19	0.9414	12.7302	1.5934	0.5366	-0.0033	0.0091
20	0.9840	11.8942	1.0679	0.3452	-0.0022	0.0058
TAIL						
1	0.0500	10.0672	-0.3271	0.2452	0.0007	0.0041
2	0.1500	9.4135	-0.3375	0.2451	0.0007	0.0041
3	0.2500	8.7598	-0.3524	0.2419	0.0007	0.0041
4	0.3500	8.1061	-0.3692	0.2355	0.0008	0.0040
5	0.4500	7.4524	-0.3844	0.2264	0.0008	0.0038
6	0.5500	6.7988	-0.3952	0.2144	0.0008	0.0036
7	0.6500	6.1451	-0.3981	0.1992	0.0008	0.0034
8	0.7500	5.4914	-0.3878	0.1801	0.0008	0.0030
9	0.8500	4.8377	-0.3552	0.1540	0.0007	0.0026
10	0.9500	4.1841	-0.2750	0.1121	0.0006	0.0019

VELOCITIES INDUCED AT SPECIFIED POINTS IN THE VICINITY OF THE WING

N	X	Y	Z	ALPHA=0			ADDITIONAL, ALPHA= 0.0436		
				U/V	V/V	W/V	U/V	V/V	W/V
1	-9.1530	-42.5740	8.1160	-0.00145	0.00082	0.00198	0.00721	-0.00476	-0.01427
2	-12.8400	-42.5740	8.1160	-0.00282	0.00340	0.00287	0.01160	-0.00963	-0.01853
3	-16.5200	-42.5740	8.1160	-0.00626	0.00992	0.00396	0.02114	-0.02331	-0.02383
4	-20.4900	-42.5740	8.1160	-0.01577	0.01478	0.00192	0.04487	-0.04293	-0.02349
5	-24.4900	-42.5740	8.1160	-0.02074	0.01549	-0.00462	0.05837	-0.05307	-0.01230
6	-24.4600	-42.5740	8.1160	-0.01869	0.01264	-0.01323	0.06083	-0.05623	-0.00360
7	-26.4400	-42.5740	8.1160	-0.01080	0.00746	-0.01708	0.05564	-0.05489	-0.01449
8	-9.1530	-45.1400	8.1160	-0.00093	0.00059	0.00203	0.00568	-0.00399	-0.01333
9	-12.8400	-45.1400	8.1160	-0.00141	0.00088	0.00384	0.00812	-0.00609	-0.01814
10	-16.5200	-45.1400	8.1160	-0.00403	0.00140	0.00667	0.01432	-0.00949	-0.02593
11	-20.4900	-45.1400	8.1160	-0.01265	0.00466	0.00772	0.03300	-0.01944	-0.03312
12	-22.4800	-45.1400	8.1160	-0.01950	0.00735	0.00395	0.04839	-0.02755	-0.02056
13	-24.4600	-45.1400	8.1160	-0.02297	0.00796	-0.00505	0.05954	-0.03329	-0.01645
14	-26.4400	-45.1400	8.1160	-0.01745	0.00418	-0.01348	0.05857	-0.03272	-0.00210
15	-9.1530	-40.0000	8.1160	-0.00200	0.00064	0.00193	0.00903	-0.00527	-0.01530
16	-12.8400	-40.0000	8.1160	-0.00434	0.00111	0.00185	0.01573	-0.00962	-0.01894
17	-16.5200	-40.0000	8.1160	-0.00879	0.00216	0.00094	0.02946	-0.01495	-0.02110
18	-20.4900	-40.0000	8.1160	-0.01785	0.00532	-0.00530	0.05622	-0.02856	-0.00091
19	-22.4800	-40.0000	8.1160	-0.01857	0.00456	-0.01303	0.06299	-0.03203	-0.00645
20	-24.4600	-40.0000	8.1160	-0.01265	0.00074	-0.01834	0.05896	-0.03049	-0.00087
21	-26.4400	-40.0000	8.1160	-0.00555	-0.00319	-0.01832	0.05281	-0.02805	-0.00089
22	-9.1600	-42.5740	10.6900	-0.00184	0.00069	0.00162	0.00934	-0.00550	-0.01241
23	-12.8400	-42.5740	10.6900	-0.00331	0.00159	0.00204	0.01419	-0.00887	-0.01502
24	-16.5200	-42.5740	10.6900	-0.00624	0.00322	0.00204	0.02285	-0.01439	-0.01689
25	-20.4900	-42.5740	10.6900	-0.01136	0.00511	-0.00070	0.03751	-0.02419	-0.01209
26	-22.4800	-42.5740	10.6900	-0.01305	0.00520	-0.00417	0.04397	-0.02826	-0.00625
27	-24.4600	-42.5740	10.6900	-0.01224	0.00402	-0.00806	0.04654	-0.03024	-0.00227
28	-26.4400	-42.5740	10.6900	-0.00918	0.00189	-0.01056	0.04532	-0.03020	-0.00114
29	-28.4300	-42.5740	8.1160	-0.00397	0.00353	-0.01565	0.04948	-0.05251	-0.02200
30	-30.4200	-42.5740	8.1160	-0.00974	0.00182	-0.01281	0.04195	-0.04922	-0.02670

(a) Concluded.

Figure 15.- Continued.

SAMPLE CASE 2, WING-PYLON-TAIL CONFIGURATION, EXTERNAL INTERFERENCE INCLUDED

GEOMETRY DATA

	WING	PYLON	TAIL
LE SWEEP, DEG.	27.1000	-77.5000	27.1000
TE SWEEP, DEG.	14.0500	-72.7500	14.0500
DIHEDRAL, DEG.	-3.5000	-90.0000	1.0000
ROOT CHORD	31.1830	20.0510	10.3940
SEMISPAN	74.9675	-----	25.0000
PYLON LOC./WING SEMISP.	-----	0.5679	-----
PYLON HEIGHT	-----	2.9460	-----
PYLON INCIDENCE, DEG.	-----	1.0000	-----
TAIL INCIDENCE, DEG.	-----	-----	0.5000
CHORDWISE VORTICES	4	4	2
SPANWISE VORTICES	20	2	10

	X	Y	Z
TAIL RT.CHORD NOSE COORDINATES	-95.0000	0.0000	-10.0000
PITCHING MOMENT CENTER	-7.7800	0.0000	0.0000
TURBOFAN RADIUS=	2.5700		

FLOW CONDITIONS

ANGLE OF ATTACK, ALPHA, DEG.	2.5000
MACH NUMBER	0.7000

(b) With external interference.

Figure 15.- Continued.

				(ALPHA=0)		(ADDITIONAL ALPHA= 1.04761)			
J	X	Y	Z	MEAN SURFACE SLOPE	U/V	V/V	W/V	V/V	W/V
WING CONTROL POINTS									
1	-6.9044	-2.2865	0.1398	-0.0078	0.00000	0.00000	0.00000	0.00000	0.00000
2	-14.5511	-2.2865	0.1398	0.0231	0.00000	0.00000	0.00000	0.00000	0.00000
3	-22.1973	-2.2865	0.1398	0.0181	0.00000	0.00000	0.00000	0.00000	0.00000
4	-29.8436	-2.2865	0.1398	0.0091	0.00000	0.00000	0.00000	0.00000	0.00000
5	-37.4881	-6.5730	0.4020	-0.0113	0.00000	0.00000	0.00000	0.00000	0.00000
6	-16.2547	-6.5730	0.4020	0.0197	0.00000	0.00000	0.00000	0.00000	0.00000
7	-23.6293	-6.5730	0.4020	0.0147	0.00000	0.00000	0.00000	0.00000	0.00000
8	-30.9864	-6.5730	0.4020	0.0057	0.00000	0.00000	0.00000	0.00000	0.00000
9	-10.7389	-10.5730	0.6467	-0.0151	0.00000	0.00000	0.00000	0.00000	0.00000
10	-17.8435	-10.5730	0.6467	0.0159	0.00000	0.00000	0.00000	0.00000	0.00000
11	-24.9482	-10.5730	0.6467	0.0109	0.00000	0.00000	0.00000	0.00000	0.00000
12	-32.0529	-10.5730	0.6467	0.0019	0.00000	0.00000	0.00000	0.00000	0.00000
13	-12.5897	-14.5730	0.8913	-0.0178	0.00000	0.00000	0.00000	0.00000	0.00000
14	-19.6329	-14.5730	0.8913	0.0132	0.00000	0.00000	0.00000	0.00000	0.00000
15	-26.7260	-14.5730	0.8913	0.0082	0.00000	0.00000	0.00000	0.00000	0.00000
16	-33.8192	-14.5730	0.8913	-0.0008	0.00000	0.00000	0.00000	0.00000	0.00000
17	-14.4405	-18.5730	1.1360	-0.0221	0.00000	0.00000	0.00000	0.00000	0.00000
18	-21.0222	-18.5730	1.1360	0.0099	0.00000	0.00000	0.00000	0.00000	0.00000
19	-27.6039	-18.5730	1.1360	0.0054	0.00000	0.00000	0.00000	0.00000	0.00000
20	-34.1855	-18.5730	1.1360	-0.0031	0.00000	0.00000	0.00000	0.00000	0.00000
21	-16.2513	-22.5730	1.3806	-0.0273	0.00000	0.00000	0.00000	0.00000	0.00000
22	-22.6115	-22.5730	1.3806	0.0067	0.00000	0.00000	0.00000	0.00000	0.00000
23	-28.9317	-22.5730	1.3806	-0.0027	0.00000	0.00000	0.00000	0.00000	0.00000
24	-35.2519	-22.5730	1.3806	-0.0053	0.00000	0.00000	0.00000	0.00000	0.00000
25	-18.1422	-26.5730	1.6253	-0.0325	0.00000	0.00000	0.00000	0.00000	0.00000
26	-24.2009	-26.5730	1.6253	0.0029	0.00000	0.00000	0.00000	0.00000	0.00000
27	-30.2596	-26.5730	1.6253	0.0004	0.00000	0.00000	0.00000	0.00000	0.00000
28	-36.3183	-26.5730	1.6253	-0.0075	0.00000	0.00000	0.00000	0.00000	0.00000
29	-19.0933	-30.5730	1.8699	-0.0388	0.00000	0.00000	0.00000	0.00000	0.00000
30	-25.7603	-30.5730	1.8699	-0.0308	0.00000	0.00000	0.00000	0.00000	0.00000
31	-31.9875	-30.5730	1.8699	-0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
32	-37.3847	-30.5730	1.8699	-0.0078	0.00000	0.00000	0.00000	0.00000	0.00000
33	-21.8438	-34.5730	2.1146	-0.0461	0.00000	0.00000	0.00000	0.00000	0.00000
34	-27.3795	-34.5730	2.1146	-0.0051	0.00000	0.00000	0.00000	0.00000	0.00000
35	-32.9153	-34.5730	2.1146	-0.0031	0.00000	0.00000	0.00000	0.00000	0.00000
36	-38.4511	-34.5730	2.1146	-0.0071	0.00000	0.00000	0.00000	0.00000	0.00000
37	-23.4637	-38.0730	2.3286	-0.0520	0.00000	0.00000	0.00000	0.00000	0.00000
38	-29.7702	-38.0730	2.3286	-0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
39	-34.0772	-38.0730	2.3286	-0.0040	0.00000	0.00000	0.00000	0.00000	0.00000
40	-39.3842	-38.0730	2.3286	-0.0060	0.00000	0.00000	0.00000	0.00000	0.00000
41	-24.8513	-41.0730	2.5121	-0.0574	0.00000	0.00000	0.00000	0.00000	0.00000
42	-29.9622	-41.0730	2.5121	-0.0124	0.00000	0.00000	0.00000	0.00000	0.00000
43	-35.0731	-41.0730	2.5121	-0.0054	0.00000	0.00000	0.00000	0.00000	0.00000
44	-40.1840	-41.0730	2.5121	-0.0044	0.00000	0.00000	0.00000	0.00000	0.00000
45	-24.2384	-44.0730	2.6956	-0.0629	0.00000	0.00000	0.00000	0.00000	0.00000
46	-31.1542	-44.0730	2.6956	-0.0154	0.00000	0.00000	0.00000	0.00000	0.00000
47	-46.0697	-44.0730	2.6956	-0.0069	0.00000	0.00000	0.00000	0.00000	0.00000
48	-40.9838	-44.0730	2.6956	-0.0029	0.00000	0.00000	0.00000	0.00000	0.00000
49	-27.6275	-47.0730	2.8791	-0.0683	0.00000	0.00000	0.00000	0.00000	0.00000
50	-32.3462	-47.0730	2.8791	-0.0193	0.00000	0.00000	0.00000	0.00000	0.00000
51	-37.0649	-47.0730	2.8791	-0.0093	0.00000	0.00000	0.00000	0.00000	0.00000
52	-41.7836	-47.0730	2.8791	-0.0023	0.00000	0.00000	0.00000	0.00000	0.00000
53	-29.2473	-50.0730	3.0932	-0.0712	0.00000	0.00000	0.00000	0.00000	0.00000
54	-33.7369	-50.0730	3.0932	-0.0217	0.00000	0.00000	0.00000	0.00000	0.00000
55	-38.2268	-50.0730	3.0932	-0.0122	0.00000	0.00000	0.00000	0.00000	0.00000
56	-42.7167	-50.0730	3.0932	-0.0027	0.00000	0.00000	0.00000	0.00000	0.00000
57	-31.0078	-54.0730	3.3378	-0.0744	0.00000	0.00000	0.00000	0.00000	0.00000
58	-35.3262	-54.0730	3.3378	-0.0254	0.00000	0.00000	0.00000	0.00000	0.00000
59	-39.5545	-54.0730	3.3378	-0.0154	0.00000	0.00000	0.00000	0.00000	0.00000
60	-43.7831	-54.0730	3.3378	-0.0054	0.00000	0.00000	0.00000	0.00000	0.00000
61	-37.9486	-58.0730	3.5825	-0.0777	0.00000	0.00000	0.00000	0.00000	0.00000
62	-36.9155	-58.0730	3.5825	-0.0287	0.00000	0.00000	0.00000	0.00000	0.00000
63	-40.8825	-58.0730	3.5825	-0.0187	0.00000	0.00000	0.00000	0.00000	0.00000
64	-44.8494	-58.0730	3.5825	-0.0087	0.00000	0.00000	0.00000	0.00000	0.00000
65	-34.7094	-62.0730	3.8271	-0.0810	0.00000	0.00000	0.00000	0.00000	0.00000
66	-38.5049	-62.0730	3.8271	-0.0320	0.00000	0.00000	0.00000	0.00000	0.00000
67	-42.2104	-62.0730	3.8271	-0.0220	0.00000	0.00000	0.00000	0.00000	0.00000
68	-46.0158	-62.0730	3.8271	-0.0120	0.00000	0.00000	0.00000	0.00000	0.00000
69	-36.6502	-66.0730	4.0718	-0.0843	0.00000	0.00000	0.00000	0.00000	0.00000
70	-40.0942	-66.0730	4.0718	-0.0353	0.00000	0.00000	0.00000	0.00000	0.00000
71	-43.5382	-66.0730	4.0718	-0.0253	0.00000	0.00000	0.00000	0.00000	0.00000
72	-46.9822	-66.0730	4.0718	-0.0153	0.00000	0.00000	0.00000	0.00000	0.00000
73	-34.5010	-70.0730	4.3164	-0.0976	0.00000	0.00000	0.00000	0.00000	0.00000
74	-41.6830	-70.0730	4.3164	-0.0476	0.00000	0.00000	0.00000	0.00000	0.00000
75	-44.8661	-70.0730	4.3164	-0.0285	0.00000	0.00000	0.00000	0.00000	0.00000
76	-48.0486	-70.0730	4.3164	-0.0185	0.00000	0.00000	0.00000	0.00000	0.00000
77	-39.9804	-73.7702	4.5120	-0.0901	0.00000	0.00000	0.00000	0.00000	0.00000
78	-42.9539	-73.7702	4.5120	-0.0411	0.00000	0.00000	0.00000	0.00000	0.00000
79	-45.9274	-73.7702	4.5120	-0.0311	0.00000	0.00000	0.00000	0.00000	0.00000
80	-48.9010	-73.7702	4.5120	-0.0211	0.00000	0.00000	0.00000	0.00000	0.00000
PYTHON CONTROL POINTS									
81	-21.2770	-42.5740	3.6039	0.0000	0.00000	0.00000	-----	0.00000	-----
82	-26.6123	-42.5740	3.6039	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
83	-31.9475	-42.5740	3.6039	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
84	-37.2829	-42.5740	3.6039	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
85	-14.9890	-42.5740	5.0769	0.0000	0.00000	0.00000	-----	0.00000	-----
86	-20.7994	-42.5740	5.0769	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
87	-26.6098	-42.5740	5.0769	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
88	-32.4202	-42.5740	5.0769	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
TAIL CONTROL POINTS									
89	-98.4144	-1.2500	-10.0218	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
90	-104.4484	-1.2500	-10.0218	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
91	-100.4490	-3.7500	-10.0655	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
92	-105.1557	-3.7500	-10.0655	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
93	-101.4832	-6.2500	-10.1091	0.0000	0.00000	0.00000			

HOPSESHOF VORTEX CHARACTERISTICS

BOUNDLEG MIDPOINT COORDINATES				VORTEX STRENGTHS, GAMMA/V			
J	X	Y	Z	SWEEP (DEG)	SEMIWIDTH	ALPHA * C	ADDITIONAL ALPHA * C, C/636
WING VORTICES							
1	-2.0215	-2.7865	0.1398	26.3106	2.2008	-0.0901	1.4151
2	-10.7279	-2.2865	0.1398	23.2297	2.2908	0.3749	0.7805
3	-18.1742	-2.2865	0.1398	19.9999	2.2908	0.0016	0.5302
4	-26.0205	-2.2865	0.1398	16.6321	2.2908	-0.1305	0.3226
5	-34.0551	-6.5730	0.4020	26.3106	2.0037	-0.1109	1.5062
6	-12.5712	-6.5730	0.4020	23.2297	2.0037	0.3533	0.7531
7	-19.9377	-6.5730	0.4020	19.9999	2.0037	-0.1126	0.5007
8	-27.3033	-6.5730	0.4020	16.6321	2.0037	-0.1290	0.2973
9	-7.1866	-10.5730	0.6467	26.3106	2.0037	-0.1496	1.5624
10	-14.2912	-10.5730	0.6467	23.2297	2.0037	0.1253	0.7377
11	-21.3958	-10.5730	0.6467	19.9999	2.0037	-0.0227	0.4772
12	-28.5005	-10.5730	0.6467	16.6321	2.0037	-0.1265	0.2782
13	-9.1687	-14.5730	0.8913	26.3106	2.0037	-0.1965	1.5992
14	-16.0113	-14.5730	0.8913	23.2297	2.0037	0.2952	0.7266
15	-23.8564	-14.5730	0.8913	19.9999	2.0037	-0.0292	0.4598
16	-30.9974	-14.5730	0.8913	16.6321	2.0037	-0.1222	0.2647
17	-11.1497	-18.5730	1.1360	26.3106	2.0037	-0.2591	1.6052
18	-17.7314	-18.5730	1.1360	23.2297	2.0037	0.2701	0.7173
19	-24.3137	-18.5730	1.1360	19.9999	2.0037	-0.0299	0.4460
20	-30.8947	-18.5730	1.1360	16.6321	2.0037	-0.1134	0.2530
21	-13.1313	-22.5730	1.3806	26.3106	2.0037	-0.3344	1.6546
22	-19.4514	-22.5730	1.3806	23.2297	2.0037	0.2508	0.7072
23	-25.7714	-22.5730	1.3806	19.9999	2.0037	-0.0263	0.4340
24	-32.0918	-22.5730	1.3806	16.6321	2.0037	-0.1023	0.2418
25	-15.1128	-26.5730	1.6253	26.3106	2.0037	-0.4143	1.5930
26	-21.1715	-26.5730	1.6253	23.2297	2.0037	0.2308	0.6962
27	-27.2307	-26.5730	1.6253	19.9999	2.0037	-0.0135	0.4228
28	-33.2900	-26.5730	1.6253	16.6321	2.0037	-0.0903	0.2354
29	-17.0594	-30.5730	1.8699	26.3106	2.0037	-0.5009	1.5764
30	-23.8916	-30.5730	1.8699	23.2297	2.0037	0.2170	0.6840
31	-29.8888	-30.5730	1.8699	19.9999	2.0037	0.0080	0.4108
32	-34.4861	-30.5730	1.8699	16.6321	2.0037	-0.0693	0.2271
33	-19.0759	-34.5730	2.1146	26.3106	2.0037	-0.5917	1.5557
34	-24.6116	-34.5730	2.1146	23.2297	2.0037	0.2078	0.6700
35	-30.1474	-34.5730	2.1146	19.9999	2.0037	0.0304	0.3977
36	-35.6832	-34.5730	2.1146	16.6321	2.0037	-0.0358	0.2185
37	-20.8097	-38.0730	2.3286	26.3106	1.5028	-0.6708	1.5453
38	-26.1167	-38.0730	2.3286	23.2297	1.5028	0.1996	0.6534
39	-31.4237	-38.0730	2.3286	19.9999	1.5028	0.0561	0.3840
40	-36.7307	-38.0730	2.3286	16.6321	1.5028	-0.0068	0.2101
41	-22.2959	-41.0730	2.5121	26.3106	1.4028	-0.7465	1.4409
42	-27.4068	-41.0730	2.5121	23.2297	1.4028	0.1976	0.6354
43	-32.5177	-41.0730	2.5121	19.9999	1.4028	0.0754	0.3705
44	-37.6285	-41.0730	2.5121	16.6321	1.4028	-0.0228	0.2020
45	-23.7823	-44.0730	2.6956	26.3106	1.5028	-0.7444	1.3573
46	-28.6968	-44.0730	2.6956	23.2297	1.5028	0.1845	0.6010
47	-33.6116	-44.0730	2.6956	19.9999	1.5028	0.0909	0.3581
48	-38.5264	-44.0730	2.6956	16.6321	1.5028	-0.0526	0.1946
49	-25.2682	-47.0730	2.8791	26.3106	1.5028	-0.4017	1.3543
50	-29.9867	-47.0730	2.8791	23.2297	1.5028	0.1812	0.5827
51	-34.7055	-47.0730	2.8791	19.9999	1.5028	0.0957	0.3432
52	-39.4243	-47.0730	2.8791	16.6321	1.5028	-0.0749	0.1856
53	-27.0023	-50.5730	3.0932	26.3106	2.0037	-0.8359	1.3247
54	-31.4919	-50.5730	3.0932	23.2297	2.0037	0.1593	0.5593
55	-35.9814	-50.5730	3.0932	19.9999	2.0037	0.0974	0.3262
56	-40.4717	-50.5730	3.0932	16.6321	2.0037	-0.0949	0.1748
57	-28.9836	-54.5730	3.3378	26.3106	2.0037	-0.9557	1.2716
58	-33.2127	-54.5730	3.3378	23.2297	2.0037	0.1321	0.5295
59	-37.4404	-54.5730	3.3378	19.9999	2.0037	0.0946	0.3041
60	-41.6688	-54.5730	3.3378	16.6321	2.0037	-0.0577	0.1674
61	-30.9651	-58.5730	3.5825	26.3106	2.0037	-0.8630	1.2043
62	-34.9321	-58.5730	3.5825	23.2297	2.0037	0.1193	0.4931
63	-38.8990	-58.5730	3.5825	19.9999	2.0037	0.0880	0.2768
64	-42.8660	-58.5730	3.5825	16.6321	2.0037	-0.0463	0.1429
65	-27.9464	-62.5730	3.8271	26.3106	2.0037	-0.8570	1.1230
66	-31.6521	-62.5730	3.8271	23.2297	2.0037	0.0825	0.4470
67	-35.3576	-62.5730	3.8271	19.9999	2.0037	0.0832	0.2619
68	-39.0631	-62.5730	3.8271	16.6321	2.0037	-0.0902	0.1207
69	-32.9282	-66.5730	4.0718	26.3106	2.0037	-0.8320	1.0710
70	-36.3722	-66.5730	4.0718	23.2297	2.0037	0.0873	0.3844
71	-40.1867	-66.5730	4.0718	19.9999	2.0037	0.0832	0.1949
72	-43.9902	-66.5730	4.0718	16.6321	2.0037	-0.0860	0.0920
73	-36.9097	-70.5730	4.3164	26.3106	2.0037	-0.7491	0.8781
74	-40.0923	-70.5730	4.3164	23.2297	2.0037	0.1059	0.2881
75	-43.2748	-70.5730	4.3164	19.9999	2.0037	0.0852	0.1315
76	-46.4573	-70.5730	4.3164	16.6321	2.0037	-0.0775	0.0674
77	-38.4936	-73.7702	4.5120	26.3106	1.1995	-0.5934	0.6466
78	-41.4671	-73.7702	4.5120	23.2297	1.1995	-0.1378	0.1458
79	-44.4407	-73.7702	4.5120	19.9999	1.1995	0.0647	0.0656
80	-47.4142	-73.7702	4.5120	16.6321	1.1995	-0.0550	0.0307
PYLON VORTICES							
91	-18.6093	-42.5740	3.6039	-77.2790	1.0000	-0.0936	0.1454
92	-23.9446	-42.5740	3.6039	-76.3173	1.0000	0.3247	0.0759
93	-29.2799	-42.5740	3.6039	-75.2006	1.0000	0.0086	0.0074
94	-34.6152	-42.5740	3.6039	-73.8906	1.0000	-0.0694	-0.0046
95	-12.0838	-42.5740	5.0769	-77.2790	0.4730	-0.0650	0.0552
96	-17.8942	-42.5740	5.0769	-76.3173	0.4730	-0.0459	0.1300
97	-23.7046	-42.5740	5.0769	-75.2006	0.4730	0.0361	0.0513
98	-29.5150	-42.5740	5.0769	-73.8906	0.4730	0.0086	-0.0151
PYLON IMAGE VORTICES							
99	-11.5200	-42.5740	5.8957	77.2790	0.3457	-0.0640	0.0552
100	-17.3714	-42.5740	5.8957	76.3173	0.3457	-0.0459	0.1300
101	-23.2229	-42.5740	5.8957	75.2006	0.3457	0.0361	0.0513
102	-29.0743	-42.5740	5.8957	73.8906	0.3457	0.0086	-0.0151
103	-14.5604	-42.5740	6.5820	77.2790	0.3406	-0.0935	0.1454
104	-20.1904	-42.5740	6.5820	76.3173	0.3406	-0.0747	0.0759
105	-25.8205	-42.5740	6.5820	75.2006	0.3406	0.0086	0.0074
106	-31.4506	-42.5740	6.5820	73.8906	0.3406	-0.0694	-0.0046
TAIL VORTICES							
107	-94.8989	-1.2500	-10.0218	25.5930	1.2502	0.0692	0.4354
108	-101.9316	-1.2500	-10.0218	19.2009	1.2502	0.0312	0.1860
109	-98.0956	-3.7500	-10.0655	25.5930	1.2502	0.0761	0.4491
110	-102.8024	-3.7500	-10.0655	19.2009	1.2502	0.0316	0.1721
111	-99.2537	-6.2500	-10.1091	25.5930	1.2502	0.0793	0.4614
112	-103.6731	-6.2500	-10.1091	19.2009	1.2502	0.0310	0.1615
113	-100.4929	-8.7500	-10.1527	25.5930	1.2502	0.0843	0.4739
114	-104.5439	-8.7500	-10.1527	19.2009	1.2502	0.0312	0.1520
115	-101.6885	-11.2500	-10.1964	25.5930	1.2502	0.0814	0.4859
116	-105.4147	-11.2500	-10.1964	19.2009	1.2502	0.0314	0.1443
117	-102.8861	-13.7500	-10.2400	25.5930	1.2502	0.0921	0.4980
118	-106.2854	-13.7500	-10.2400	19.2009	1.2502	0.0314	0.1347
119	-104.0837	-16.2500	-10.2836	25.5930	1.2502	0.0936	0.5112
120	-107.1562	-16.2500	-10.2836	19.2009	1.2502	0.0307	0.1229
121	-105.2813	-18.7500	-10.3273	25.5930	1.2502	0.0924	0.5277
122	-108.0270	-18.7500	-10.3273	19.2009	1.2502	0.0306	0.1177
123	-106.4789	-21.2500	-10.3709	25.5930	1.2502	0.0967	0.5414
124	-109.4074	-21.2500	-10.3709	19.2009	1.2502	0.0307	0.1076
125	-107.6765	-23.7500	-10.4146	25.5930	1.2502	0.0970	0.5550
126	-109.7685	-23.7500	-10.4146	19.2009	1.2502	0.0309	0.1002

(b) Continued.

Figure 15.- Continued.

AERODYNAMIC LOADING RESULTS

WING LIFT COEFFICIENT			TAIL LIFT COEFFICIENT			
ALPHA=0 -0.0142	ADDITIONAL, ALPHA= 0.2257	0.0436	ALPHA=0 0.0036	ADDITIONAL, ALPHA= 0.0167	0.0436	
TOTAL LIFT COEFFICIENT			TOTAL MOMENT COEFFICIENT			
ALPHA=0 -0.0106	ADDITIONAL, ALPHA= 0.2424	0.0436	ALPHA=0 -0.0058	ADDITIONAL, ALPHA= -0.2280	0.0436	
REFERENCE QUANTITIES						
WING SPAN, B 149.9350	WING PLANFORM AREA, SREF 3205.9209	WING AVE. CHORD, CAVE 21.3821				
SPANWISE LOAD DISTRIBUTION						
STATION	Y/(B/2)	LOCAL CHORD, C	CL*C/CL*CAVE		CL*C/(1/2*B)	
			ALPHA=0	ADDITIONAL ALPHA= 0.0436	ALPHA=0	ADDITIONAL ALPHA= 0.0436
WING						
1	0.0305	30.5851	-0.8277	1.2824	0.0008	0.0206
2	0.0877	29.4643	-0.4725	1.2878	0.0005	0.0207
3	0.1410	28.4185	-0.0130	1.2875	0.0000	0.0207
4	0.1944	27.3726	0.4317	1.2811	-0.0004	0.0206
5	0.2477	26.3267	0.8229	1.2678	-0.0008	0.0204
6	0.3011	25.2808	1.1167	1.2459	-0.0011	0.0201
7	0.3545	24.2349	1.2383	1.2134	-0.0013	0.0195
8	0.4078	23.1890	1.0408	1.1663	-0.0011	0.0188
9	0.4612	22.1431	0.4497	1.0982	-0.0005	0.0177
10	0.5079	21.2280	-0.5346	1.0095	0.0005	0.0162
11	0.5479	20.4436	-1.6800	0.9208	0.0017	0.0148
12	0.5879	19.6592	-2.1021	0.7578	0.0021	0.0122
13	0.6279	18.8748	-0.3588	0.8149	0.0004	0.0131
14	0.6746	17.9596	1.1392	0.8551	-0.0012	0.0138
15	0.7280	16.9137	2.2921	0.8595	-0.0023	0.0138
16	0.7813	15.8678	3.1085	0.8320	-0.0032	0.0134
17	0.8347	14.8220	3.6053	0.7775	-0.0037	0.0125
18	0.8880	13.7761	3.7315	0.6979	-0.0038	0.0112
19	0.9414	12.7302	3.3500	0.5632	-0.0034	0.0091
20	0.9840	11.8942	2.2636	0.3681	-0.0023	0.0059
TAIL						
1	0.0500	10.0672	-0.5957	0.2696	0.0006	0.0043
2	0.1500	9.4135	-0.6283	0.2690	0.0006	0.0043
3	0.2500	8.7598	-0.6791	0.2646	0.0007	0.0043
4	0.3500	8.1061	-0.7406	0.2567	0.0008	0.0041
5	0.4500	7.4524	-0.8029	0.2455	0.0008	0.0040
6	0.5500	6.7988	-0.8600	0.2310	0.0009	0.0037
7	0.6500	6.1451	-0.9018	0.2130	0.0009	0.0034
8	0.7500	5.4914	-0.9136	0.1908	0.0009	0.0031
9	0.8500	4.8377	-0.8697	0.1614	0.0009	0.0026
10	0.9500	4.1841	-0.6996	0.1160	0.0007	0.0019

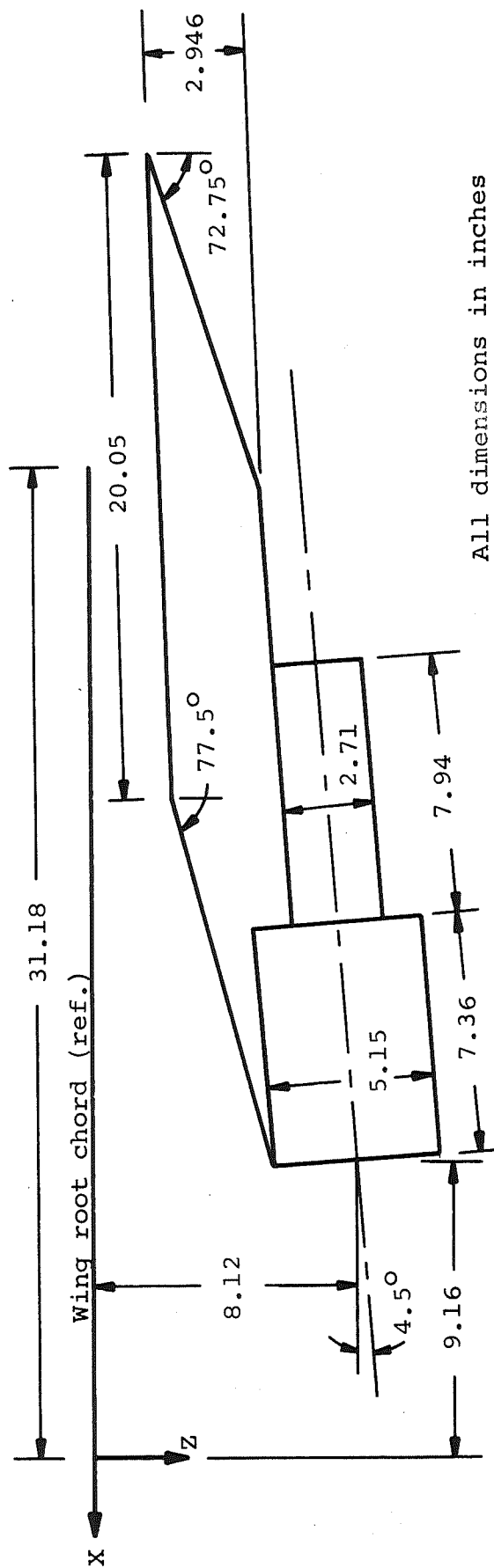
VELOCITIES INDUCED AT SPECIFIED POINTS IN THE VICINITY OF THE WING									
N	X	Y	Z	(ALPHA=0)			(ADDITIONAL, ALPHA= 0.0436)		
				U/V	V/V	W/V	U/V	V/V	W/V
1	-9.1580	-42.5740	8.1160	-0.00078	0.00067	0.00102	0.00680	-0.00495	-0.01267
2	-12.8400	-42.5740	8.1160	-0.00144	0.00294	0.00145	0.01072	-0.01067	-0.01763
3	-16.5200	-42.5740	8.1160	-0.00286	0.00829	0.00190	0.01889	-0.02677	-0.02249
4	-20.4900	-42.5740	8.1160	-0.00574	0.01210	0.00097	0.03778	-0.04958	-0.02276
5	-24.4800	-42.5740	8.1160	-0.00631	0.01268	-0.00133	0.04767	-0.06227	-0.01464
6	-28.4600	-42.5740	8.1160	-0.00376	0.01081	-0.00382	0.04927	-0.06824	-0.00344
7	-26.4400	-42.5740	8.1160	0.00156	0.00739	-0.00358	0.04588	-0.07021	0.00412
8	-9.1580	-45.1400	8.1160	-0.00034	0.00043	0.00108	0.00514	-0.00408	-0.01278
9	-12.8400	-45.1400	8.1160	-0.00029	0.00058	0.00237	0.00686	-0.00610	-0.01749
10	-16.5200	-45.1400	8.1160	-0.00129	0.00069	0.00434	0.01158	-0.00912	-0.02593
11	-20.4900	-45.1400	8.1160	-0.00440	0.00186	0.00545	0.02579	-0.01770	-0.02446
12	-24.4800	-45.1400	8.1160	-0.00669	0.00229	0.00433	0.03736	-0.02433	-0.03371
13	-28.4600	-45.1400	8.1160	-0.00761	0.00101	0.00112	0.04610	-0.02902	-0.02618
14	-26.4400	-45.1400	8.1160	-0.00401	-0.00309	-0.00195	0.04665	-0.02870	-0.01714
15	-9.1580	-40.0000	8.1160	-0.00125	0.00093	0.00096	0.00876	-0.00540	-0.01465
16	-12.8400	-40.0000	8.1160	-0.00272	0.00090	0.00051	0.01527	-0.00875	-0.01764
17	-16.5200	-40.0000	8.1160	-0.00483	0.00171	-0.00073	0.02783	-0.01491	-0.01859
18	-20.4900	-40.0000	8.1160	-0.00724	0.00412	-0.00471	0.05027	-0.02840	-0.00710
19	-24.4800	-40.0000	8.1160	-0.00529	0.00406	-0.00807	0.05478	-0.03273	0.00755
20	-28.4600	-40.0000	8.1160	-0.00020	0.00215	-0.00925	0.05083	-0.03304	0.01945
21	-26.4400	-40.0000	8.1160	0.00494	-0.00012	-0.00676	0.04575	-0.03232	0.02604
22	-9.1580	-42.5740	10.6900	-0.00097	0.00054	0.00079	0.00880	-0.00543	-0.01180
23	-12.8400	-42.5740	10.6900	-0.00164	0.00127	0.00097	0.01312	-0.00916	-0.01433
24	-16.5200	-42.5740	10.6900	-0.00277	0.00250	0.00089	0.02052	-0.01557	-0.01610
25	-20.4900	-42.5740	10.6900	-0.00405	0.00366	-0.00033	0.03228	-0.02534	-0.01318
26	-24.4800	-42.5740	10.6900	-0.00387	0.00354	-0.00148	0.03717	-0.02990	-0.00815
27	-28.4600	-42.5740	10.6900	-0.00250	0.00251	-0.00245	0.03909	-0.03263	-0.00134
28	-26.4400	-42.5740	10.6900	-0.00021	0.00093	-0.00239	0.03830	-0.03353	0.00297
29	-28.4300	-42.5740	8.1160	0.00584	0.00474	0.00021	0.04164	-0.02730	0.00672
30	-30.4200	-42.5740	8.1160	0.00670	0.00401	0.00442	0.03595	-0.02680	0.01321

(b) Concluded.

Figure 15.- Concluded.

(a) Wing-tail detail.

Figure 16.- Airframe configuration for sample case.



(b) Turbofan engine-pylon detail.

Figure 16.- Concluded.

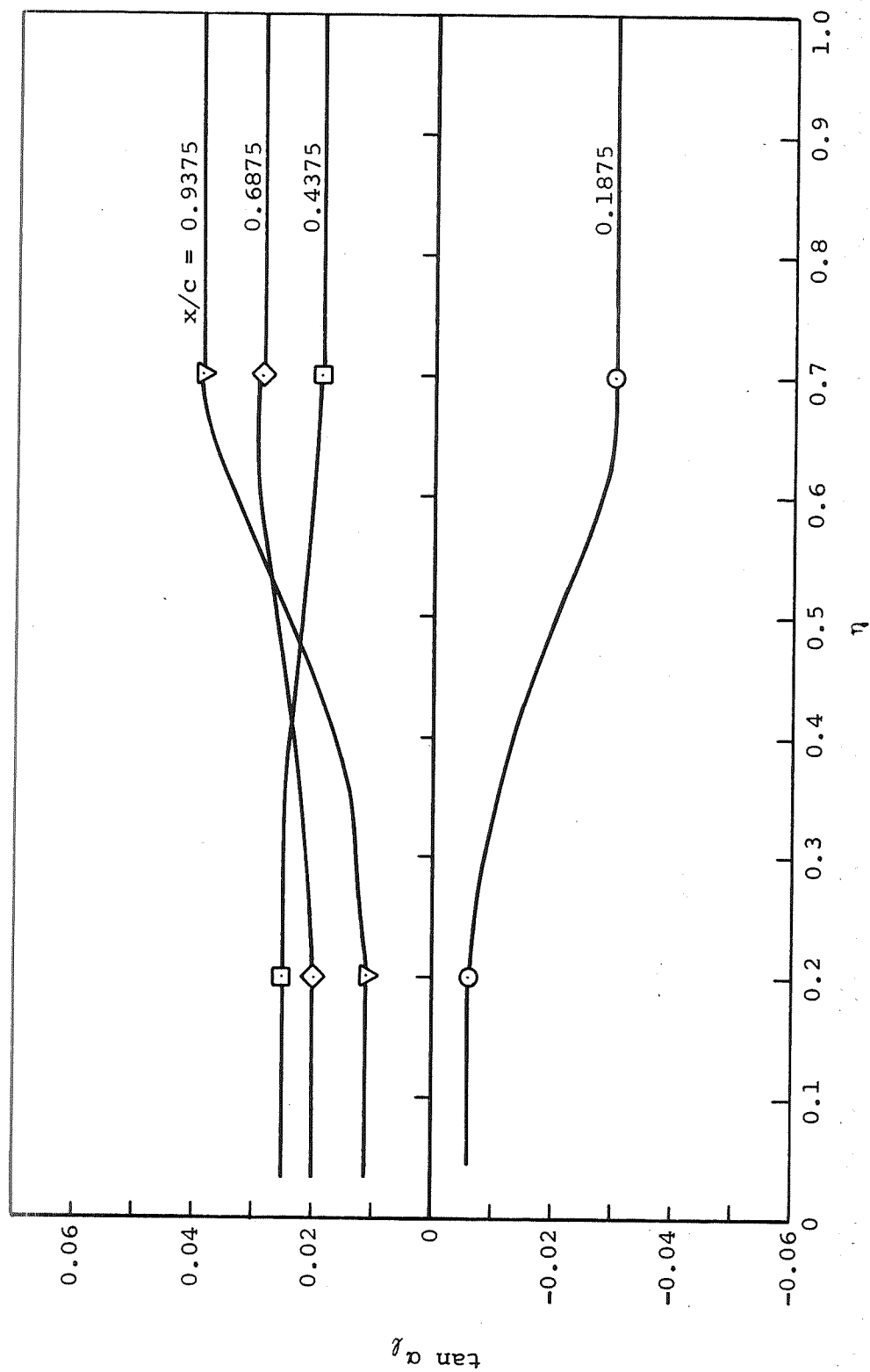


Figure 17.- Spanwise distribution of wing camberline slope at four chordwise stations.

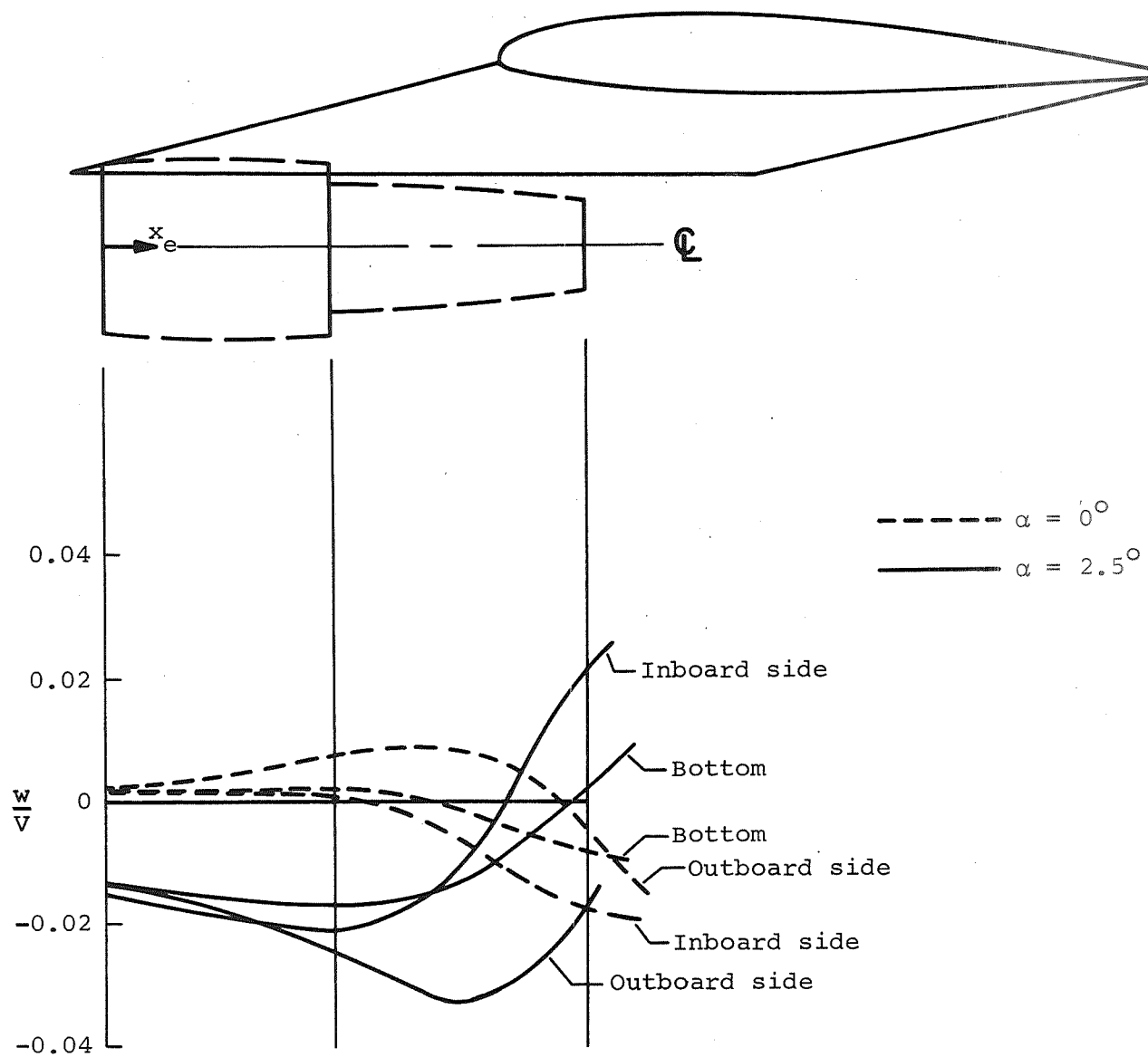


Figure 18.- Predicted axial variation of the wing-pylon-tail induced downwash at three locations relative to the turbofan engine.