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Theoretical and Experimental Investigation of Supersonic Aerodynamic Characteristics of a Twin-Fuselage Concept

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SUMMARY

A theoretical and experimental investigation has been conducted to evaluate the fundamental supersonic aerodynamic characteristics of a generic twin-body wind-tunnel model. The experimental testing was performed in the Langley Unitary Plan Wind Tunnel at a Mach number of 2.70. Experimental data were obtained on a simple rectangular-wing twin-body wind-tunnel model; these data were used to evaluate prediction methods and to investigate interference effects. Results show that existing aerodynamic prediction methods are adequate for making preliminary aerodynamic estimates. Theoretical and experimental results also indicate that significant variations in zero-lift wave drag are possible by varying body positioning; however, configuration optimization should not be concentrated only at the zero-lift condition because of the existence of strong interactions between lifting and thickness effects.

INTRODUCTION

Recent studies of advanced aircraft concepts indicate that significant aerodynamic performance and structural weight-reduction benefits may be realized for supersonic aircraft with two fuselages rather than a traditional single fuselage. In reference 1, it is stated that twin-fuselage supersonic transport aircraft could have levels of aerodynamic performance which equal or exceed that of a single-fuselage configuration having only one-half the passenger capacity. In reference 2, it is estimated that up to a 30-percent reduction in structural weight could be obtained for twin-fuselage aircraft compared with single-fuselage aircraft. Although this latter study was conducted for subsonic aircraft, the weight reduction appears to be independent of operating conditions and could be equally applicable to supersonic as well as subsonic aircraft. The combination of both aerodynamic performance and weight-reduction benefits makes the twin-fuselage concept look very promising; however, many questions remain to be answered on the ability of existing analysis methods to predict the aerodynamic characteristics of twin-fuselage configurations.

Previous work in the area of supersonic interference concentrated on complete configuration integration of conventional components (refs. 3 and 4) or was limited to mutual interference of isolated components such as wings and bodies (refs. 5 and 6). Despite the abundance of experimental data on near-field interference effects and the proven capability of methods to predict many of these effects, it was found that the capability to compute the supersonic aerodynamic characteristics of twin-fuselage lifting configurations had yet to be demonstrated.

The purpose of this report is to evaluate the supersonic aerodynamics of a generic twin-body model and assess the ability of existing supersonic methods to provide estimates of aerodynamic performance. Assessment of the methods is made by comparing the predicted results with existing wind-tunnel data and with data obtained for a generic twin-body model constructed specifically for this purpose. The generic model configurations consisted of two axisymmetric bodies of revolution incorporating a rectangular planform wing at various body lateral and longitudinal spacings. Tests were made at a Mach number of 2.70 in the Langley Unitary Plan Wind Tunnel.

The measurements and calculations of this investigation were made in U.S. Customary Units. Results are presented in both SI and U.S. Customary Units. Dimensions included in the definitions of the symbols are for the twin-body model.

b wing span, 50.800 cm (20.000 in.)

C_A axial-force coefficient, $\dfrac{\text{Axial force}}{qS}$

C_D drag coefficient, $\dfrac{\text{Drag}}{qS}$

ΔC_D incremental change in drag coefficient, $C_D - C_{D,o}\big|_{C_{L=0.15}}$

$C_{D,F}$ friction drag coefficient

$C_{D,o}$ zero-lift drag coefficient

$\Delta C_{D,o}$ incremental change in zero-lift drag coefficient from noninterference condition, $(C_{D,o})_{WOI} - (C_{D,o})_{WI}$

$C_{D,W}$ wave-drag coefficient

C_L lift coefficient, $\dfrac{\text{Lift}}{qS}$

C_m pitching-moment coefficient, $\dfrac{\text{Pitching moment}}{qS\bar{c}}$

C_N normal-force coefficient, $\dfrac{\text{Normal force}}{qS}$

C_n yawing-moment coefficient, $\dfrac{\text{Yawing moment}}{qSb}$

C_p pressure coefficient, $\dfrac{p_\ell - p_\infty}{q}$

C_Y side-force coefficient, $\dfrac{\text{Side force}}{qS}$

$\bar{c}$ wing mean aerodynamic chord, 28.095 cm (11.061 in.)

ι body or fuselage length, m (in.)

L/D lift-drag ratio

M free-stream Mach number

p_ℓ local total pressure, Pa (lb/ft^2)

p_∞ free-stream total pressure, Pa (lb/ft^2)

q free-stream dynamic pressure, Pa (lb/ft^2)

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S	wing reference area, 1427.223 cm^2 (221.220 in^2)
U	free-stream speed, m/sec (in/sec)
x	Cartesian coordinate in streamwise direction, m (in.)
Δx	incremental change in x-coordinate, m (in.)
y	Cartesian coordinate in spanwise direction, m (in.)
Δy	incremental change in y-coordinate, m (in.)
α	angle of attack, deg
θ	body polar angle, deg

Subscripts:

WI	with interference
WOI	without interference

PRELIMINARY THEORETICAL INVESTIGATION

The concept of employing two fuselages to improve supersonic performance creates new opportunities for those who work in technical fields such as aerodynamics, stability and control, and structures. However, as with any new concept, the development process begins by theoretically and experimentally assessing the merits and applications of the concept. Because of the increased number of possible geometric variations associated with the twin-fuselage concept, the capabilities of adequate aerodynamic prediction techniques become increasingly important.

Several linearized-theory prediction techniques for supersonic aerodynamics capable of analyzing the unique symmetric and asymmetric twin-fuselage geometries were selected for theoretical analysis. The methods chosen for making the zero-lift drag calculations were the PAN AIR pilot code and a modified version of the far-field wave-drag (FFWD) code.

The PAN AIR code (ref. 7) is an advanced panel method that employs surface distributions of quadratically varying doublet and linearly varying source distributions for computing the surface flow properties and resultant forces and moments at both lifting and nonlifting conditions. This code has a completely arbitrary geometry definition scheme; however, considerable attention must be paid to the details of the intersection of component boundaries, which results in a complicated geometry modeling process. The PAN AIR solution provides extensive surface flow properties and interference information in addition to the configuration forces and moments. The second method is a modified version of the far-field wave-drag code that employs the same supersonic area-rule solution technique as that of reference 8. This new code was developed specifically for the analysis of the twin-fuselage concept; the major modification to the code was the change in geometry input definition from a component-dependent scheme (e.g., wings, fuselage, and nacelle) to an arbitrary component-independent format. Also, the latter geometry definition does not require the matching of component boundaries, such as wing-fuselage intersections. Having the ability to model arbitrary geometries without imposing stringent modeling

requirements, the far-field solution technique is well suited for the analysis of the twin-fuselage concept and its multitude of possible configurations. The major drawbacks of far-field methods are the limited amount of aerodynamic interference information and the lack of surface flow properties they provide.

To evaluate the PAN AIR and far-field wave-drag code capabilities to make drag calculations at the zero-lift condition, a theoretical/experimental comparison was first performed with existing experimental data. Shown in figure 1 are the results in which theoretical and experimental data are presented for a reflection plane simulation of two interfering bodies (ref. 9). In the left portion of the figure, PAN AIR and experimental pressures are shown along two streamwise strips of a body of revolution in the vicinity of a reflection plane. At both separation distances, excellent agreement was obtained between the theory and experiment. Especially notice that for the separation distance y/ι of 0.10, the nose shock at $x/\iota = 0.33$ and the reflected shock at $x/\iota = 0.50$ are both well predicted by the PAN AIR code; the different character of the pressure distributions for $\theta = 0°$ and $\theta = 180°$ is also well predicted. The incremental change in zero-lift drag caused by varying the body position is presented in the right portion of figure 1. This figure shows that an optimum (minimum drag) body position does exist and that both the PAN AIR and the FFWD codes predict similar drag trends and drag levels.

Based upon this preliminary investigation, it was concluded that both methods are capable of predicting the zero-lift drag characteristics of interfering bodies of revolution and that the PAN AIR code provides a good estimate of the surface pressures; however, an assessment of the capabilities of the methods when applied to a twin-fuselage lifting configuration still needed to be made.

MODEL DESCRIPTION

An experimental test program was initiated to generate an initial set of twin-fuselage data which would be used in the theoretical method assessment. A sketch of the generic twin-body wind-tunnel model, fuselage details, and wing details are presented in figures 2(a), 2(b), and 2(c), respectively. The model consisted of two identical axisymmetric bodies of revolution with an effective fineness ratio of 10, and a rectangular planform wing having an aspect ratio of 1.8. Figure 3 is a photographic layout of all model parts showing their respective relationship during wind-tunnel testing. Figure 4 graphically depicts the wind-tunnel model test matrix where Δy denotes the distance between body center lines and Δx denotes the longitudinal distance between the aft end points of the bodies. A photograph of the model installed in the wind tunnel is represented in figure 5.

DISCUSSION OF RESULTS

Theoretical results were obtained on the generic twin-body model by using the method of reference 10 to calculate the skin-friction drag and either PAN AIR or a combination of the FFWD and lift analysis method of reference 11 to calculate the inviscid forces. Tests and calculations were performed at a Mach number of 2.70; a brief description showing how the theoretical methods were applied is presented in appendix A, and a description of the test conditions and a tabulation of the experimental data are given in appendix B.

Theoretical and experimental zero-lift wave-drag values for various longitudinal ($\Delta x/b$) and lateral ($\Delta y/b$) separations of the bodies are presented in figure 6. Com-

paring theory with experiment for the two cases of varying Δy reveals that both theoretical methods do an adequate job of predicting the trends, but the FFWD code does better at predicting the drag levels. Experimental results for both values of $\Delta x/b$, 0 and 0.50, show that an 18-percent variation (maximum to minimum drag value) in wave drag can be obtained when separating the bodies by varying Δy. However, because of the nature of the generic twin-body model, which has a large value of skin-friction drag ($C_{D,F}$), the total zero-lift drag variation is only 6 percent. The change in zero-lift wave drag caused by variations in the longitudinal separation distance ($\Delta x/b$) at a constant spanwise separation ($\Delta y/b = 0.25$) is also shown in figure 6. For this situation, experimental results show that the minimum zero-lift wave drag occurs at zero longitudinal separation. Both theories underpredicted the wave drag for the maximum longitudinal separation distance. From these results, it may be concluded that significant variations in wave drag are achievable with optimum body positioning and that the application of the twin-body concept to configurations with large zero-lift drag penalties could result in greater aerodynamic benefits.

Theoretical and experimental longitudinal force and moment results for symmetric configurations are presented in figure 7. Wing-alone theoretical and experimental comparisons are shown in figure 7(a), and a typical set of symmetric twin-fuselage characteristics is shown in figure 7(b). Theoretical predicted results from PAN AIR and the lift analysis method of reference 11, as implemented in the codes of references 12 and 13, are presented. The wing-alone configuration is the only one which may be accurately and completely modeled by the lift analysis method of reference 10. The results indicate that the PAN AIR code and the lift analysis method can be used to predict the lift and drag forces of symmetric twin-fuselage configurations and that only the PAN AIR code predicted the pitching-moment with consistent acceptability.

A summary of the longitudinal aerodynamic characteristics of all tested symmetric twin-body configurations is shown in figure 8. Presented in figure 8 are experimentally measured and theoretically predicted drag at zero lift, lift-drag ratio, and drag due-to-lift factor for various lateral body positionings. The results indicate that for drag minimization the optimum separation is $\Delta y/b = 0.85$, whereas a separation of 0.35 results in the highest lift-drag ratio. Comparing theoretical results reveals that both the PAN AIR and FFWD codes predict about the same minimum drag configuration; additionally, the PAN AIR code adequately predicts the variation in lift-drag ratio but overpredicts the levels of lift-drag ratio with body spacing. The overprediction of the levels of lift-drag ratio by the PAN AIR code can be explained by its underprediction of the minimum drag levels. A review of the variation in drag due-to-lift factor for various lateral body positionings reveals that the PAN AIR code does predict both the levels and trend. These results indicate that strong interactions exist between lifting and thickness effects for twin-body configurations and that configuration optimization should not be limited to the zero-lift conditions.

Presented in figure 9 are selected theoretical and experimental force and moment results for several asymmetric configurations. Theoretical analysis of the configurations was limited to the PAN AIR code because of the asymmetric geometries. In general, as with the symmetric configurations, the PAN AIR code adequately predicted the longitudinal force and moment coefficients except for the configuration with the maximum longitudinal spacing ($\Delta x/b = 1.00$).

Typical side-force and yawing-moment coefficients are presented in figure 10 as a function of angle of attack. The results on the left side of the figure show that the effect of skewing the fuselages from $\Delta x/b = 0$ to $\Delta x/b = 1.00$ produces a

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negative yawing moment and positive side force whose magnitude increases with angle of attack; the results in the right side of the figure show these effects to be enhanced with increased spanwise separation distance. A review of the theoretical results shows that the PAN AIR code overpredicted the directional aerodynamic coefficients for this asymmetric twin-fuselage configuration and indicates that the yawing moment is a net result of asymmetric interference effects. These large differences between theory and experiment could be caused by the observed flow separation on the aft portion of the bodies. Flow separation on the aft portion of the bodies would create a forward shift in the side-force center of pressure and result in the experimentally lower value of yawing moment. Two observations may be made from the directional data: first, the asymmetric twin-body configuration does not seem to be a viable option because of the severe directional characteristics seen on this model at zero sideslip, and second, the PAN AIR code does predict the proper trend in the directional instability of the asymmetric configurations.

SUMMARY OF RESULTS

A theoretical and experimental investigation was conducted at a Mach number of 2.70 to evaluate the aerodynamic characteristics of a generic twin-body wind-tunnel model and to assess the ability of existing theoretical methods to predict the aerodynamic characteristics. The results of this investigation are as follows:

1. Existing theoretical methods are adequate for making preliminary aerodynamic estimates; the far-field wave drag code provides the best estimate of zero-lift wave drag and the PAN AIR code provides the best estimate of lifting characteristics.

2. Both theoretical and experimental results show that the zero-lift wave drag of the twin-body model varies with body positioning; therefore, the application of the twin-fuselage concept to configurations with large zero-lift wave-drag penalties could result in greater aerodynamic benefits.

3. Strong interactions exist between thickness and lift; as a result, twin-fuselage configuration optimization should not be limited to the zero-lift condition.

4. Experimental results show that asymmetric arrangements of the bodies produce directionally unstable configurations. Theoretical PAN AIR results predict the correct trend but overpredict the level of side force and yawing moment for these asymmetric body arrangements.

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APPENDIX A

APPLICATION OF THEORETICAL METHODS

Several supersonic aerodynamic prediction methods are available for estimating
lift, drag, and moment coefficients of wings and wing-body configurations. However,
because of the geometric nature of the twin-fuselage concept, many of these methods
are not applicable, and with methods that are applicable, a variety of geometric
models can be constructed and analyzed. In order to clarify the theoretical/
experimental comparisons in this report, a brief description of the methods and the
geometric models used to analyze the twin-body model are presented.

PAN AIR Code

The PAN AIR code (ref. 7) was used for making nonlifting and lifting inviscid
drag calculations on all symmetric and asymmetric configurations. The analysis of
symmetric configurations was performed by modeling half of the geometry and imposing
X-Z plane symmetry. Shown in figure A1 is a typical PAN AIR input geometry consist-
ing of 18 networks representing the model and 8 wake networks; all impermeable sur-
faces were represented by mass-flux-type boundary conditions except for the balance
housing where the surface panels are near Mach inclined boundary conditions and,
according to reference 3, velocity-type boundary conditions produce better solu-
tions. No attempt was made to model flow separation and the paneling arrangement was
kept constant for all configurations.

NETWORK PANELING

▨ SUBINCLINED
MASS FLUX BC

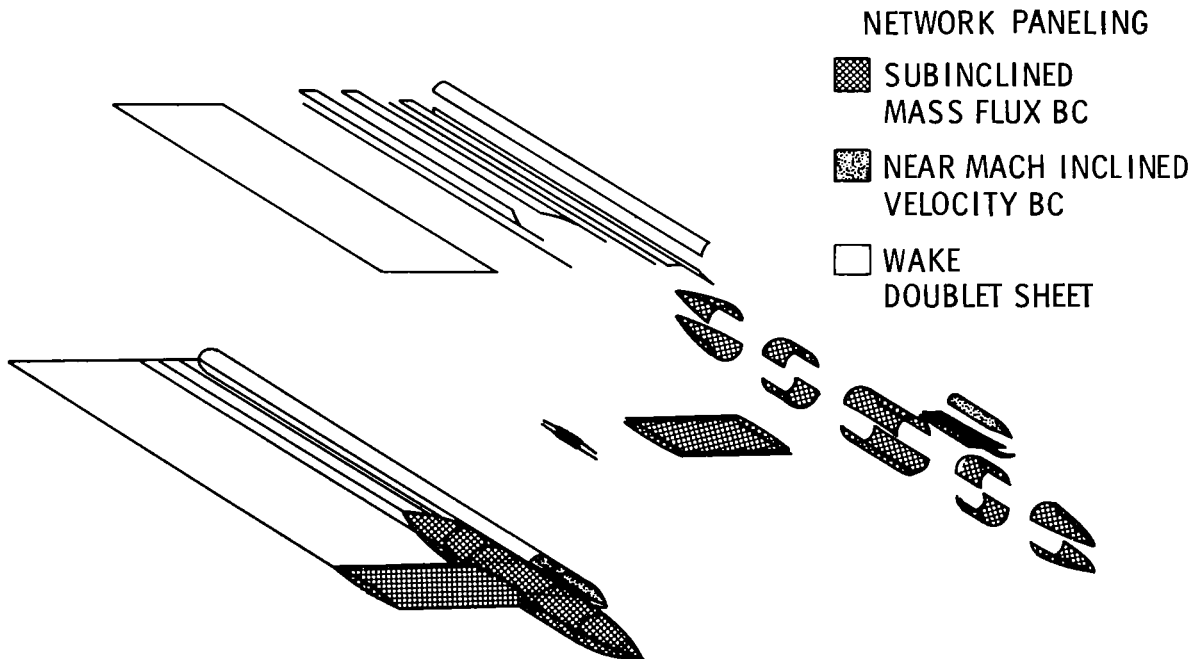▨ NEAR MACH INCLINED
VELOCITY BC

☐ WAKE
DOUBLET SHEET

Figure A1.- Typical PAN AIR input geometry and associated surface boundary
conditions (BC).

APPENDIX A

FFWD Code

The FFWD code (ref. 8) was used for making zero-lift wave-drag calculations on all symmetric and asymmetric configurations. Analysis of symmetric configurations with the FFWD code was again performed by modeling half of the geometry and imposing X-Z plane symmetry. Calculations were performed on all geometries by employing the same number of cutting planes (NX = 50) and the same number of configuration azimuth angles (Nθ = 36, 0° $\leqslant$ θ $\leqslant$ 360°).

Lift Analysis Code

Lifting characteristics computed with the lift analysis code of reference 11 were obtained by representing the model as a zero-thickness, uncambered surface having a planform which included both the rectangular wing and the two bodies. Because this code is limited to planforms which have X-Z plane of symmetry, this lift analysis could not be performed on asymmetric body arrangements.

Skin-Friction Drag Estimation

Wind-tunnel skin-friction drag coefficients were computed with the T' method of reference 10. Because of geometry restrictions, calculations were only performed on a representative symmetric configuration, with the results being applied to all symmetric and asymmetric geometries.

APPENDIX B

TEST DESCRIPTION

The wind-tunnel test program was conducted in test section 1 of the Unitary Plan Wind Tunnel (ref. 14) at a Mach number of 2.70 and a stagnation pressure of 85.059 kPa (1777 lb/ft^2). The Reynolds number for the test was 6.56×10^6/m (2.0×10^6/ft) and the stagnation temperature was held constant at 324.8 K (125°F). The dew point was maintained sufficiently low to prevent condensation shocks in the tunnel.

Strips of No. 60 sand grit were applied at 1.02 cm (0.4 in.) from the leading edge of the rectangular wing and 3.05 cm (1.2 in.) aft of the nose of each body to induce boundary-layer transition. The method of reference 15 was used to determine transition-strip size and location.

Forces and moments on the model were measured by means of a six-component electrical strain-gage balance which was contained within the model and connected through a supporting sting to the permanent model actuating system in the wind tunnel. The force and moment data have been corrected for balance-chamber pressure which was measured throughout the test. All angles of attack have been adjusted for tunnel flow misalignment and sting deflections.

Table BI gives the headings which appear on the tabulated data and their corresponding symbols. Table BII contains the tabulated data.

TABLE BI.- TABULATED DATA SYMBOLS

Headings	Definitions
ALPHA	α
CA	C_A
CD	C_D
CL	C_L
CM	C_m
CN	C_N
CNB	C_n
CYB	C_Y
LATERAL	$\Delta y/b$
LONGITUDINAL	$\Delta x/b$
L/D	L/D
MACH	M

APPENDIX B

TABLE BII.- TABULATED EXPERIMENTAL DATA

GENERIC TWIN BODY MODEL ; WING ONLY   MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-3.83450	-6.49553	-.09709	.01495	-.00201	-.09787	.00842	-.00003	.00029
-1.87009	-4.77028	-.04793	.01005	-.00100	-.04823	.00848	-.00005	.00015
-.91551	-2.98481	-.02663	.00892	-.00055	-.02677	.00850	-.00005	.00019
.07688	-.04766	-.00040	.00839	.00015	-.00039	.00839	-.00005	.00018
1.09053	2.86730	.02547	.00888	.00078	.02563	.00840	-.00004	.00009
2.04779	5.03249	.05154	.01024	.00146	.05187	.00839	-.00005	.00010
4.16505	6.60247	.10750	.01628	.00300	.10840	.00843	-.00008	.00003
6.18956	6.09195	.16106	.02644	.00454	.16297	.00892	-.00011	-.00011
8.15698	5.36904	.21244	.03957	.00593	.21590	.00902	-.00011	0.00000
10.18998	4.65579	.26857	.05768	.00720	.27454	.00926	-.00014	-.00010
12.16214	4.04051	.32451	.08031	.00843	.33414	.01014	-.00015	-.00038
.25513	1.15817	.00958	.00827	.00036	.00962	.00823	-.00005	.00020

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.25 , LATERAL 0.25 ;   MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-3.95101	-5.39420	-.11756	.02179	-.00815	-.11878	.01364	.00010	-.00063
-1.93839	-3.75170	-.05711	.01522	-.00433	-.05760	.01328	.00022	-.00019
-.84192	-1.85561	-.02522	.01359	-.00195	-.02541	.01322	.00025	.00017
-.02899	-.52437	-.00687	.01311	-.00062	-.00688	.01311	.00006	0.00000
.91135	1.46875	.01993	.01357	.00151	.02015	.01325	.00011	.00018
2.01396	3.63848	.05555	.01527	.00433	.05605	.01331	.00006	.00026
4.16132	5.39357	.11916	.02209	.00856	.12045	.01339	.00012	.00014
6.16848	5.37925	.18007	.03347	.01148	.18262	.01393	-.00017	.00064
7.83697	4.97174	.22641	.04554	.01299	.23051	.01424	-.00054	.00087
10.16849	4.37554	.30947	.07073	.01562	.31710	.01498	-.00136	.00274
12.07240	3.87387	.36855	.09514	.01751	.38030	.01595	-.00125	.00156
.01380	-.25589	-.00335	.01309	-.00027	-.00335	.01309	.00014	.00017

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 1.00 , LATERAL 0.25 ;   MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-4.04187	-5.13627	-.11577	.02254	-.00995	-.11707	.01432	-.00029	-.00137
-1.84139	-3.26338	-.05116	.01568	-.00478	-.05164	.01403	-.00033	-.00056
-1.16000	-2.65353	-.03870	.01458	-.00384	-.03899	.01380	-.00038	-.00032
.03235	-.07101	-.00097	.01372	-.00018	-.00097	.01372	-.00034	-.00005
.88268	1.36310	.01912	.01403	.00166	.01934	.01373	-.00035	.00002
2.02862	3.31512	.05213	.01573	.00472	.05266	.01387	-.00020	.00004
4.05267	5.00747	.11189	.02235	.00969	.11319	.01438	-.00021	.00036
6.05985	5.15777	.16864	.03270	.01370	.17114	.01471	-.00056	.00035
7.86536	4.82516	.21973	.04554	.01664	.22390	.01504	-.00052	.00012
10.06716	4.33980	.29611	.06823	.02044	.30347	.01542	-.00105	.00114
11.93113	3.88090	.35443	.09133	.02306	.36565	.01608	-.00255	.00099
.08040	.21029	.00293	.01393	.00030	.00295	.01393	-.00025	.00014

TABLE BII.- Continued

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.00 , LATERAL 0.165 ; MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-3.67988	-5.09963	-.10418	.02043	-.00700	-.10528	.01370	-.00060	-.00032
-1.96070	-3.81685	-.05848	.01532	-.00457	-.05897	.01331	-.00037	-.00019
-.89517	-1.93436	-.02654	.01372	-.00262	-.02675	.01330	-.00042	-.00007
-.06858	-.34059	-.00463	.01361	-.00068	-.00465	.01360	-.00063	-.00029
1.00840	1.76127	.02447	.01389	.00150	.02471	.01346	-.00047	.00009
2.12136	3.72632	.05766	.01547	.00387	.05819	.01333	-.00049	.00016
4.06336	5.34965	.11634	.02175	.00727	.11759	.01345	-.00098	.00073
5.86520	5.34966	.16668	.03116	.00934	.16899	.01396	-.00170	.00169
8.06124	4.94154	.23808	.04818	.01145	.24248	.01432	-.00323	.00236
10.07169	4.39473	.30533	.06948	.01412	.31278	.01501	-.00418	.00426
12.13877	3.87901	.37672	.09712	.01632	.38872	.01573	-.00517	.00614
.01899	.09913	.00132	.01334	-.00024	.00133	.01334	-.00050	.00003

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.00 , LATERAL 0.250 ; MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-3.97474	-5.41853	-.11707	.02160	-.00813	-.11828	.01344	-.00010	.00009
-1.93498	-3.81124	-.05703	.01496	-.00435	-.05750	.01303	.00008	.00051
-.80672	-1.78747	-.02376	.01329	-.00180	-.02394	.01295	.00008	.00050
.17215	.16617	.00215	.01296	.00016	.00219	.01295	-.00001	.00039
1.14143	2.15687	.02977	.01380	.00240	.03004	.01321	-.00004	.00038
1.92909	3.46370	.05200	.01501	.00409	.05248	.01325	.00005	.00052
3.94819	5.17727	.10896	.02105	.00790	.11015	.01349	.00002	.00036
5.98545	5.36869	.17168	.03198	.01116	.17408	.01390	-.00010	.00046
7.86146	4.88645	.22689	.04643	.01289	.23111	.01496	-.00017	.00057
9.72538	4.45353	.28728	.06451	.01497	.29405	.01505	-.00029	.00038
11.94414	3.90192	.36576	.09374	.01755	.37724	.01601	-.00037	.00081
.08451	.23035	.00296	.01284	.00021	.00298	.01284	.00012	.00066

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.00 , LATERAL 0.350 ; MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-4.11113	-5.58719	-.12717	.02276	-.00880	-.12848	.01359	-.00005	-.00023
-1.87810	-3.86617	-.05707	.01476	-.00413	-.05752	.01288	.00006	.00033
-1.01784	-2.49357	-.03342	.01340	-.00240	-.03366	.01281	-.00008	.00015
-.04685	-.50701	-.00659	.01300	-.00027	-.00660	.01299	-.00004	.00019
.92909	1.46408	.01931	.01319	.00171	.01952	.01288	-.00004	.00023
2.08050	3.64598	.05463	.01498	.00440	.05514	.01299	-.00005	.00020
4.01493	5.26483	.11192	.02126	.00830	.11313	.01337	-.00003	.00056
5.98367	5.33921	.17092	.03201	.01138	.17333	.01402	-.00020	.00030
7.82082	4.90508	.22442	.04575	.01374	.22856	.01479	-.00020	.00060
10.10473	4.32152	.30204	.06989	.01657	.30962	.01582	-.00036	.00058
12.12588	3.85076	.37040	.09619	.01920	.38234	.01624	-.00015	.00074
.10027	.05794	.00077	.01323	.00025	.00079	.01322	.00006	.00034

TABLE BII.- Continued

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.00 , LATERAL 0.450 ; MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-3.98863	-5.24586	-.11421	.02177	-.00841	-.11545	.01377	.00009	.00028
-1.76615	-3.45032	-.05113	.01482	-.00414	-.05156	.01324	.00005	.00032
-.84559	-1.73970	-.02340	.01345	-.00197	-.02360	.01311	.00005	.00037
.04745	-.11685	-.00154	.01314	-.00030	-.00152	.01314	.00001	.00029
1.10557	2.05392	.02790	.01358	.00208	.02815	.01304	0.00000	.00032
2.05188	3.62751	.05586	.01540	.00436	.05637	.01339	.00003	.00044
3.89517	5.00937	.10497	.02096	.00782	.10615	.01378	-.00017	.00023
6.10146	5.30250	.17453	.03291	.01161	.17704	.01418	-.00012	.00033
8.11975	4.83664	.23583	.04876	.01415	.24035	.01496	-.00015	.00030
10.18561	4.30977	.30118	.06988	.01717	.30879	.01552	-.00021	.00055
12.06719	3.83024	.35981	.09394	.01952	.37149	.01664	-.00029	-.00033
.18826	.41883	.00548	.01308	.00033	.00552	.01306	.00005	.00037

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.00 , LATERAL 0.550 ; MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-4.04647	-5.39502	-.12048	.02233	-.00955	-.12175	.01377	-.00001	.00020
-2.01251	-3.71873	-.05787	.01556	-.00473	-.05838	.01352	-.00001	.00028
-.83067	-1.80883	-.02413	.01334	-.00192	-.02433	.01299	.00002	.00036
.03086	-.03320	-.00044	.01330	.00010	-.00043	.01330	.00009	.00048
.94038	1.55350	.02072	.01334	.00194	.02094	.01300	-.00003	.00023
1.79925	2.87916	.04249	.01476	.00381	.04294	.01342	-.00013	.00013
3.98476	5.12767	.10947	.02135	.00921	.11069	.01369	-.00007	.00018
5.88588	5.19574	.16185	.03115	.01294	.16419	.01439	0.00000	.00038
7.98085	4.85959	.22802	.04692	.01701	.23232	.01481	0.00000	.00039
9.90695	4.36369	.28650	.06566	.02035	.29352	.01538	-.00027	.00010
12.12306	3.81440	.35972	.09431	.02359	.37151	.01666	-.00040	-.00005
-.13141	-.55980	-.00752	.01344	-.00059	-.00755	.01342	-.00003	.00024

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.00 , LATERAL 0.650 ; MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-4.13776	-5.31923	-.12008	.02257	-.01067	-.12139	.01385	-.00013	.00044
-1.96491	-3.68375	-.05611	.01523	-.00529	-.05660	.01330	-.00012	.00017
-.74187	-1.55551	-.02066	.01328	-.00217	-.02083	.01301	-.00002	.00035
.13118	-.03297	-.00043	.01292	-.00022	-.00040	.01292	-.00005	.00026
.91429	1.43876	.01958	.01361	.00167	.01979	.01329	.00009	.00034
2.14080	3.57009	.05504	.01542	.00497	.05558	.01335	-.00003	.00026
4.06184	5.04369	.10613	.02104	.00961	.10735	.01347	-.00015	.00009
6.05315	5.23199	.16428	.03140	.01417	.16668	.01390	-.00017	.00017
7.97280	4.83495	.22022	.04555	.01761	.22441	.01456	-.00004	.00035
10.13572	4.31990	.29080	.06732	.02089	.29811	.01509	-.00013	.00029
11.91885	3.85780	.34890	.09044	.02242	.36005	.01643	-.00016	.00028
.01203	-.29986	-.00396	.01322	-.00058	-.00396	.01322	-.00001	.00019
-.87344	-3.67758	-.05489	.01493	.00045	-.05511	.01409	.00045	-.04980

TABLE BII.- Continued

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.00 , LATERAL 0.750 ; MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-3.89338	-5.20388	-.10770	.02070	-.00945	-.10886	.01334	.00001	.00053
-1.93909	-3.77053	-.05533	.01467	-.00491	-.05580	.01279	-.00001	.00047
-1.07560	-2.54643	-.03404	.01337	-.00292	-.03428	.01272	-.00006	.00043
.16644	.25410	.00323	.01270	.00039	.00326	.01269	.00009	.00037
1.16368	2.14650	.02856	.01331	.00295	.02883	.01272	.00002	.00014
2.15062	3.66477	.05516	.01505	.00536	.05568	.01297	.00024	.00032
4.01928	5.04490	.10488	.02079	.01005	.10608	.01339	.00007	-.00007
5.81994	5.23099	.15494	.02962	.01348	.15714	.01376	.00003	.00016
8.04778	4.82269	.22266	.04617	.01647	.22693	.01454	.00002	-.00002
10.20965	4.27596	.29351	.06864	.01841	.30103	.01553	-.00022	-.00006
12.05383	3.83432	.35325	.09213	.01923	.36470	.01633	-.00029	-.00003
.11609	.04167	.00053	.01273	.00024	.00056	.01273	.00004	.00032

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.00 , LATERAL 0.850 ; MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-3.85623	-5.12206	-.10572	.02064	-.00853	-.10687	.01348	-.00014	.00075
-2.03371	-3.87439	-.05910	.01526	-.00480	-.05961	.01315	-.00011	.00038
-.88448	-2.07196	-.02734	.01320	-.00229	-.02754	.01277	-.00007	.00020
.09617	-.11533	-.00145	.01258	-.00016	-.00143	.01258	.00004	.00018
1.19254	2.22374	.02930	.01318	.00269	.02957	.01257	.00005	-.00002
2.02961	3.20732	.04724	.01473	.00393	.04773	.01305	-.00003	-.00004
4.00342	5.04281	.10352	.02053	.00853	.10470	.01325	-.00005	-.00023
6.04448	5.23247	.16463	.03146	.01126	.16703	.01395	-.00003	-.00024
8.11002	4.80905	.22767	.04734	.01188	.23207	.01475	.00002	-.00046
10.08987	4.31342	.29090	.06744	.01241	.29822	.01543	-.00023	-.00011
12.04443	3.83352	.35502	.09261	.01502	.36653	.01649	-.00022	-.00040
.05535	-.02724	-.00035	.01278	-.00008	-.00034	.01278	.00003	.00030

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.00 , LATERAL 0.900 ; MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-3.93731	-5.20627	-.11225	.02156	-.00746	-.11347	.01380	-.00019	.00082
-1.95449	-3.70981	-.05624	.01516	-.00438	-.05672	.01323	-.00015	.00060
-1.05236	-2.47559	-.03422	.01382	-.00240	-.03447	.01319	-.00010	.00062
-.02056	-.41755	-.00541	.01296	-.00033	-.00541	.01295	.00012	.00028
1.15146	2.18541	.02945	.01347	.00242	.02971	.01288	.00008	.00008
2.03543	3.47809	.05156	.01482	.00408	.05205	.01298	.00009	-.00015
4.01877	5.03140	.10579	.02103	.00767	.10700	.01356	.00013	-.00023
6.02062	5.22867	.16509	.03157	.00886	.16749	.01408	.00013	-.00038
7.94601	4.83598	.22348	.04621	.00896	.22772	.01487	.00003	-.00068
10.01642	4.32353	.29155	.06743	.01033	.29883	.01570	-.00014	-.00056
12.03900	3.86044	.35840	.09284	.01446	.36988	.01604	-.00015	-.00116
.17872	.42125	.00547	.01299	.00013	.00551	.01298	.00015	.00023

TABLE BII.- Continued

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.50 , LATERAL 0.165 ; MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-3.90041	-5.35583	-.11811	.02205	-.00714	-.11934	.01397	.00001	-.00035
-2.02959	-3.94480	-.06215	.01576	-.00464	-.06267	.01354	.00007	-.00001
-1.07713	-2.48102	-.03471	.01399	-.00283	-.03497	.01334	.00009	.00014
.18963	.48918	.00652	.01332	.00061	.00656	.01330	.00007	.00031
1.08063	2.06047	.02857	.01387	.00202	.02883	.01333	.00017	.00056
2.18323	3.92535	.06213	.01583	.00426	.06269	.01345	.00003	.00054
3.96962	5.21705	.11189	.02145	.00651	.11311	.01365	-.00012	.00084
6.10848	5.39044	.18335	.03401	.00945	.18593	.01431	-.00006	.00163
7.96507	4.99195	.24042	.04816	.01110	.24477	.01438	-.00018	.00178
10.04653	4.40734	.31079	.07052	.01262	.31833	.01522	-.00031	.00220
11.84071	3.93776	.36742	.09331	.01352	.37875	.01593	-.00039	.00096
-.08153	-.41048	-.00545	.01327	-.00059	-.00547	.01327	0.00000	.00022

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.50 , LATERAL 0.250 ; MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-3.88758	-5.23118	-.11329	.02166	-.00822	-.11449	.01393	0.00000	-.00018
-1.99294	-3.90736	-.06054	.01549	-.00487	-.06104	.01338	.00006	-.00008
-.95812	-2.09594	-.02874	.01371	-.00236	-.02896	.01323	-.00001	-.00008
.17231	.31479	.00420	.01334	.00035	.00424	.01333	.00002	-.00001
1.05581	2.05696	.02848	.01384	.00231	.02873	.01332	0.00000	-.00009
2.11345	3.83527	.05987	.01561	.00481	.06041	.01339	0.00000	-.00026
3.90200	5.10102	.10753	.02108	.00794	.10872	.01371	-.00011	-.00064
6.08506	5.34374	.17400	.03256	.01166	.17647	.01393	-.00053	-.00017
8.13812	4.88834	.24059	.04922	.01412	.24513	.01466	-.00140	.00061
10.34434	4.30414	.31556	.07332	.01655	.32360	.01546	-.00179	.00174
12.20141	3.84843	.37485	.09740	.01829	.38697	.01598	-.00147	.00255
-.00789	-.15948	-.00212	.01328	-.00030	-.00212	.01328	-.00003	-.00006

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.50 , LATERAL 0.350 ; MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-3.92179	-5.21879	-.11521	.02208	-.00784	-.11645	.01414	.00039	.00052
-2.00305	-3.87501	-.06048	.01561	-.00447	-.06099	.01348	.00016	.00028
-.91299	-2.13914	-.03008	.01406	-.00217	-.03030	.01358	.00021	.00042
-.00039	-.07739	-.00104	.01340	.00024	-.00104	.01340	.00010	.00028
1.11259	2.18828	.03075	.01405	.00277	.03102	.01345	.00023	.00031
2.24111	3.81289	.06107	.01602	.00510	.06165	.01362	.00029	.00024
3.96295	5.11202	.11195	.02190	.00862	.11319	.01411	.00027	-.00010
5.97363	5.22992	.16741	.03201	.01179	.16984	.01441	.00041	-.00030
8.24524	4.83170	.24419	.05054	.01570	.24892	.01500	.00016	-.00023
10.15771	4.31649	.30234	.07004	.01820	.30995	.01563	-.00023	.00017
12.04592	3.84172	.36930	.09613	.02075	.38123	.01694	-.00063	.00102
.10615	.09167	.00124	.01353	.00042	.00127	.01352	0.00000	.00020

TABLE BII.- Continued

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.50 , LATERAL 0.450 ; MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-4.07276	-5.34452	-.11923	.02231	-.00894	-.12051	.01378	.00046	-.00039
-3.88814	-5.26487	-.11298	.02146	-.00860	-.11418	.01375	.00050	-.00034
-3.90793	-5.31210	-.11416	.02149	-.00858	-.11535	.01366	.00056	-.00024
-1.91164	-3.66654	-.05618	.01532	-.00448	-.05666	.01344	.00050	-.00020
-.84530	-1.90422	-.02571	.01350	-.00208	-.02591	.01312	.00034	-.00028
.05693	-.18292	-.00239	.01305	-.00021	-.00237	.01306	.00037	-.00025
1.08607	2.04159	.02791	.01367	.00234	.02817	.01314	.00046	-.00030
2.09769	3.80682	.05860	.01539	.00487	.05912	.01324	.00042	-.00038
3.05330	5.17829	.10885	.02102	.00865	.11004	.01347	.00055	-.00057
6.10064	5.32778	.17389	.03264	.01297	.17638	.01397	.00015	-.00093
7.87661	4.95703	.22561	.04551	.01563	.22972	.01417	-.00010	-.00064
9.95911	4.38848	.29202	.06654	.01889	.29913	.01504	-.00025	-.00004
11.89857	3.88614	.35724	.09193	.02156	.36852	.01630	-.00068	.00008
.06236	.00991	.00013	.01296	0.00000	.00014	.01296	.00049	-.00022

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.50 , LATERAL 0.550 ; MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-3.88592	-5.33488	-.11177	.02095	-.00903	-.11293	.01333	.00028	-.00053
-1.91077	-3.80394	-.05605	.01474	-.00466	-.05651	.01286	.00050	-.00037
-.90757	-2.05165	-.02715	.01324	-.00211	-.02736	.01280	.00045	-.00037
-.04406	-.52774	-.00680	.01289	-.00054	-.00681	.01288	.00042	-.00055
1.07519	1.98014	.02632	.01329	.00238	.02657	.01280	.00052	-.00041
2.06291	3.50830	.05105	.01455	.00434	.05154	.01270	.00044	-.00064
4.14932	5.31747	.11479	.02159	.00941	.11605	.01322	.00018	-.00066
6.10787	5.34564	.17560	.03285	.01353	.17812	.01370	-.00014	-.00036
7.92872	4.93816	.22338	.04524	.01621	.22748	.01399	-.00038	-.00018
10.09947	4.36119	.29535	.06772	.01994	.30264	.01488	-.00089	.00082
12.16651	3.85698	.36166	.09377	.02312	.37330	.01544	-.00101	.00078
.13162	.19964	.00256	.01283	.00027	.00259	.01283	.00042	-.00053
1.85744	3.26479	.04624	.01416	.00379	.04667	.01266	.00054	-.00059

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.50 , LATERAL 0.650 ; MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-3.80109	-5.13468	-.10595	.02063	-.00913	-.10709	.01357	.00010	.00052
-1.90909	-3.54582	-.05296	.01493	-.00477	-.05342	.01316	.00031	-.00023
-1.03710	-2.22745	-.03064	.01375	-.00302	-.03088	.01320	.00035	-.00056
.03143	-.24914	-.00330	.01326	-.00055	-.00330	.01327	.00050	-.00046
1.00573	1.70174	.02298	.01350	.00167	.02322	.01310	.00041	-.00067
1.90769	3.17644	.04755	.01497	.00382	.04802	.01338	.00024	-.00079
4.08775	5.19704	.11014	.02119	.00946	.11137	.01329	.00012	-.00026
5.95903	5.16083	.16004	.03101	.01321	.16240	.01423	-.00063	0.00000
8.10598	4.85302	.22560	.04649	.01791	.22991	.01421	-.00086	.00114
10.10773	4.32750	.28798	.06655	.02085	.29518	.01497	-.00133	.00175
12.12843	3.83526	.35478	.09250	.02343	.36629	.01590	-.00122	.00214
.10338	.18298	.00240	.01310	-.00017	.00242	.01309	.00056	-.00038

TABLE BII.- Concluded

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.50 , LATERAL 0.750 ; MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-3.83419	-5.18253	-.10630	.02051	-.00931	-.10743	.01336	-.00022	.00109
-2.01783	-3.80068	-.05666	.01491	-.00516	-.05715	.01290	.00003	.00002
-.99042	-2.22857	-.03000	.01346	-.00272	-.03023	.01294	.00036	-.00011
-.04569	-.59194	-.00761	.01285	-.00070	-.00762	.01284	.00041	-.00029
.96923	1.60886	.02104	.01308	.00182	.02126	.01272	.00030	-.00048
2.01294	3.43611	.05115	.01489	.00456	.05165	.01308	.00030	-.00022
4.07906	5.16980	.10814	.02092	.00965	.10936	.01317	-.00035	.00029
6.12525	5.27982	.16764	.03175	.01396	.17007	.01368	-.00099	.00146
8.07710	4.83567	.22411	.04635	.01646	.22840	.01440	-.00150	.00156
9.99836	4.37309	.28752	.06575	.01839	.29457	.01483	-.00163	.00273
12.31391	3.80507	.36401	.09566	.01951	.37604	.01583	-.00202	.00323
.21026	.50427	.00652	.01293	.00049	.00657	.01290	.00030	-.00043

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.50 , LATERAL 0.850 ; MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-3.73855	-5.06502	-.10146	.02003	-.00792	-.10255	.01337	-.00123	.00157
-1.91799	-3.58720	-.05327	.01485	-.00463	-.05374	.01306	-.00030	.00036
-.80155	-2.06928	-.02773	.01340	-.00239	-.02793	.01297	-.00012	.00003
.15894	.24128	.00309	.01279	.00006	.00312	.01278	.00010	.00006
1.03038	1.65667	.02235	.01349	.00164	.02259	.01309	-.00004	.00006
1.93014	3.14826	.04591	.01458	.00373	.04638	.01303	-.00020	.00028
4.07263	5.11055	.10664	.02087	.00852	.10785	.01324	-.00102	.00162
6.13682	5.24361	.16753	.03195	.01111	.16999	.01386	-.00193	.00313
8.13252	4.86448	.22869	.04701	.01166	.23304	.01419	-.00298	.00406
10.32101	4.29104	.30044	.07002	.01253	.30813	.01506	-.00399	.00585
11.97302	3.87925	.35008	.09025	.01458	.36119	.01565	-.00421	.00688
.19507	.51103	.00657	.01285	.00034	.00661	.01283	.00012	.00005

GENERIC TWIN BODY MODEL ; BODY POSITION : LONGITUDINAL 0.50 , LATERAL 0.900 ; MACH 2.70

ALPHA	L/D	CL	CD	CM	CN	CA	CNB	CYB
-3.71838	-5.00740	-.10105	.02018	-.00683	-.10215	.01358	-.00176	.00233
-2.05074	-3.70030	-.05699	.01540	-.00427	-.05750	.01335	-.00084	.00103
-.90232	-1.95786	-.02639	.01348	-.00206	-.02659	.01306	-.00038	.00048
-.09699	-.46769	-.00606	.01295	-.00044	-.00608	.01294	-.00028	.00016
1.06670	2.01166	.02683	.01334	.00225	.02707	.01283	-.00031	.00025
2.13426	3.60851	.05449	.01510	.00426	.05501	.01306	-.00065	.00071
4.06195	5.15829	.10833	.02100	.00755	.10954	.01327	-.00148	.00197
6.30144	5.26230	.17566	.03338	.00876	.17826	.01390	-.00249	.00418
7.94410	4.89782	.22267	.04546	.00954	.22682	.01425	-.00327	.00550
10.09978	4.36051	.29277	.06714	.01139	.30000	.01476	-.00413	.00740
12.12068	3.85520	.35860	.09302	.01435	.37014	.01565	-.00454	.00736
.12831	.16971	.00221	.01305	.00022	.00224	.01304	-.00011	.00007

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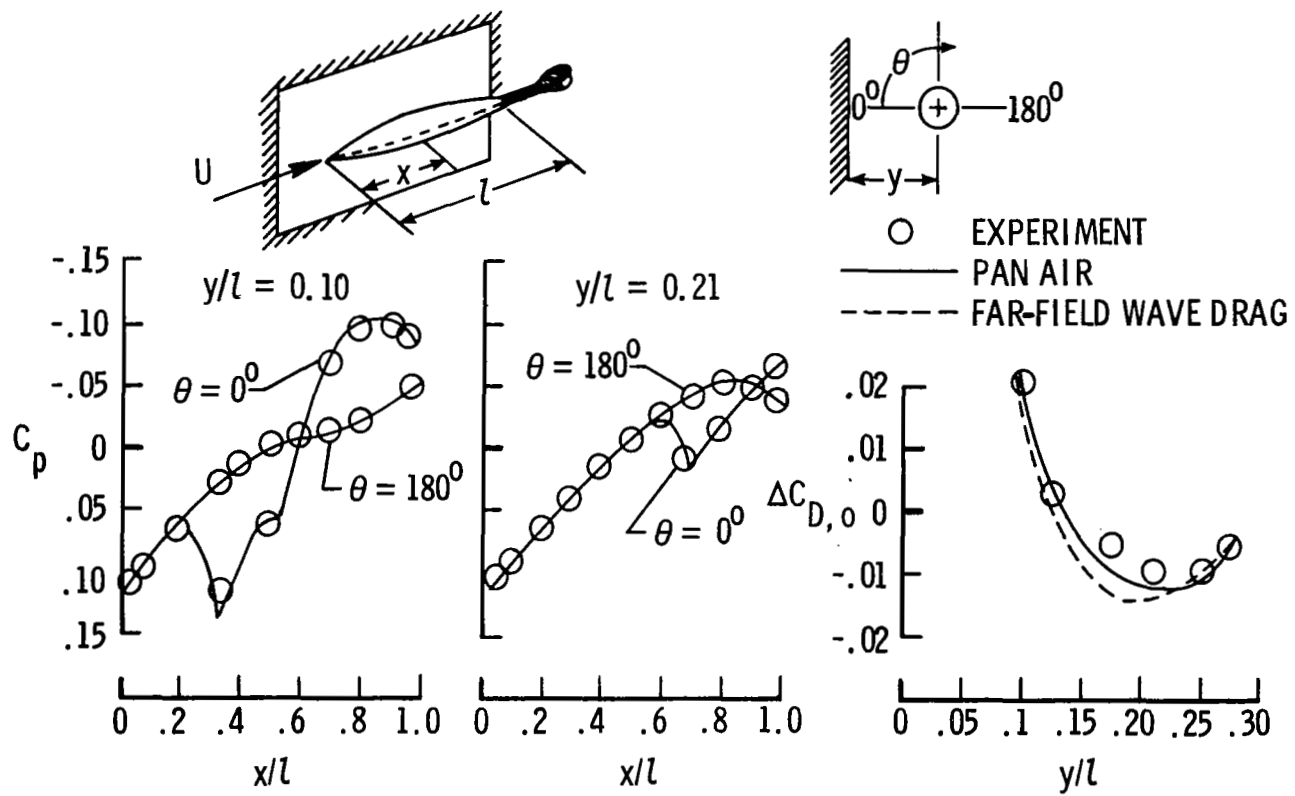
Figure 1.- Reflection plane simulation of two interfering bodies at M = 2.01.

13.51
(5.30)

Moment reference center

101.60
(40.00)

(11.06)
28.09

25.40
(10.00)

(0.72)
.84
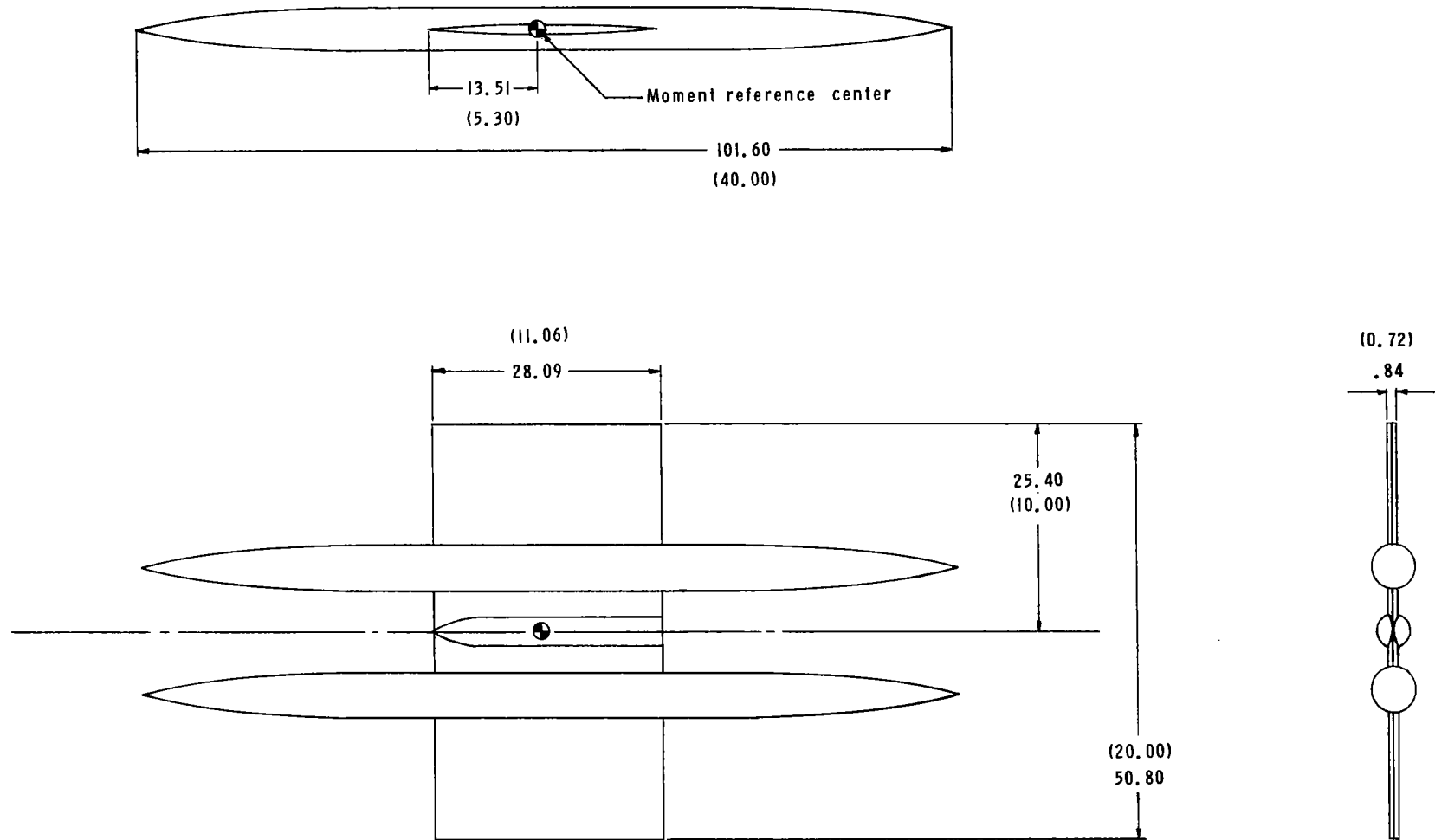
(20.00)
50.80

(a) Three-view sketch of twin-body model.

Figure 2.- Details of twin-body model. All linear dimensions are in centimeters (inches).

101.60
(40.00)
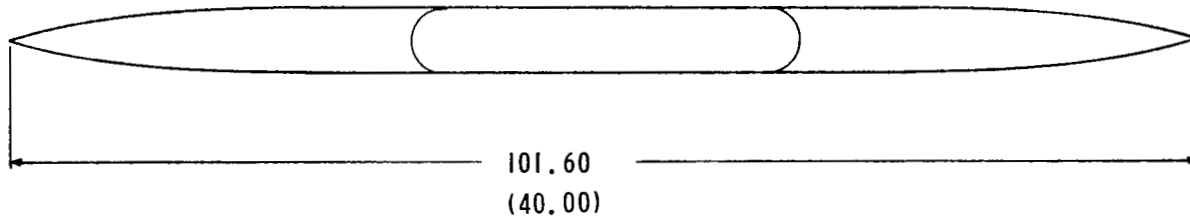
Four body pairs were constructed
with the following values of x:

x   Body Orientation

50.80(20.00)   Symmetric
44.45(17.50)   Asymmetric
38.10(15.00)   Asymmetric
25.40(10.00)   Asymmetric

Forebody and afterbodies are five
caliber circular arcs

5.08 (2.00)

(10.00)
25.40

X

Reference at 50 % chord
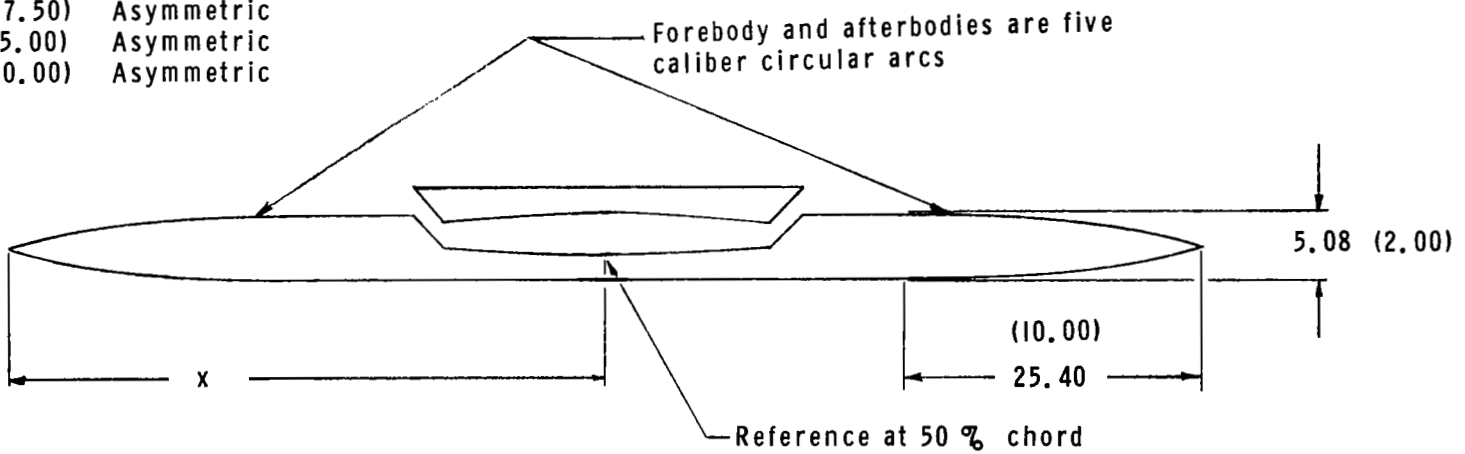
(b) Sketch of fusiform bodies.

Figure 2.- Continued.
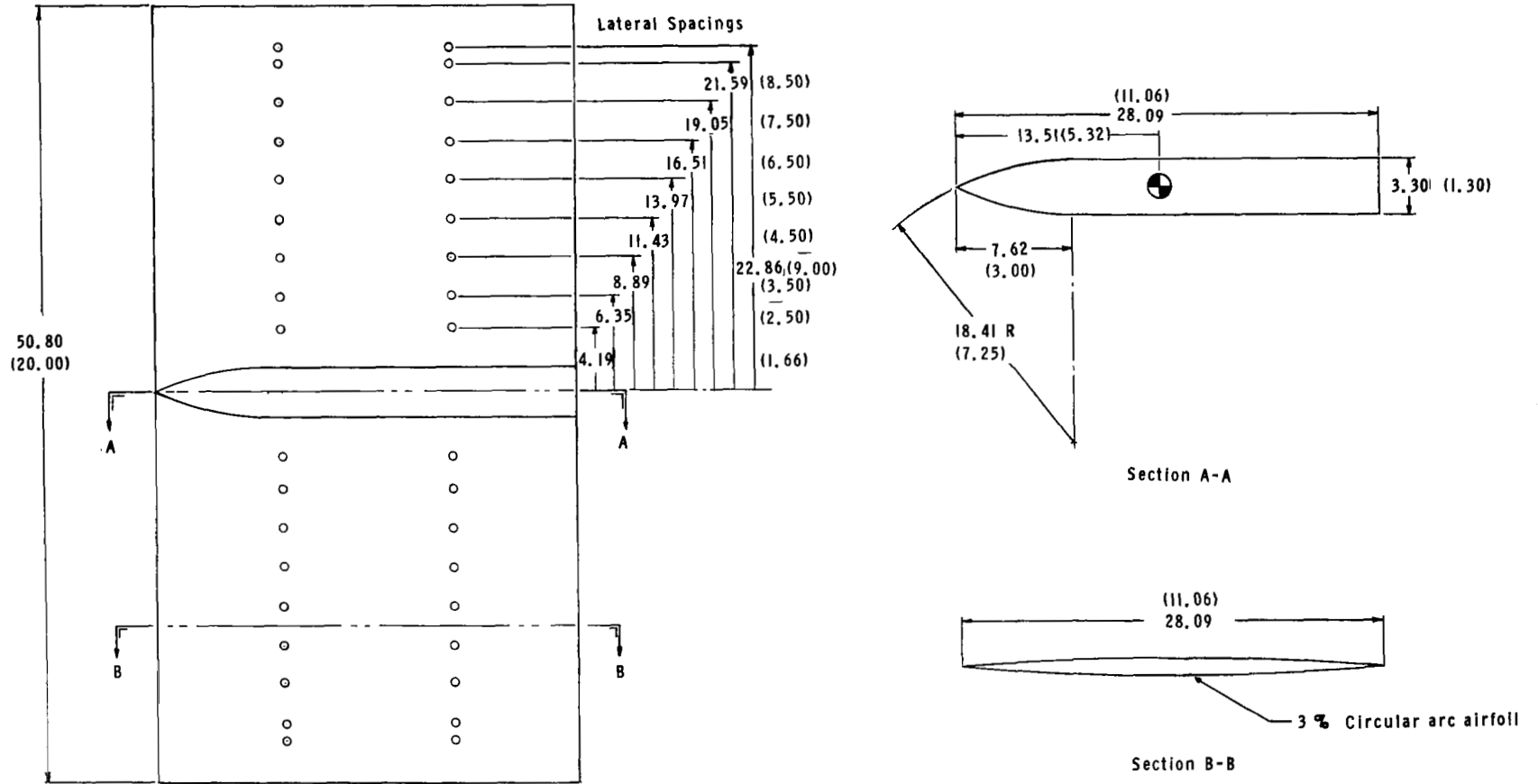
(c) Sketch of wing and balance housing.

Figure 2.- Concluded.

L-82-1391

Figure 3.- Photographic layout of model parts.

$\Delta x/b = 0$
$\Delta y/b$ VARIATION

$\Delta x/b = 0.25$

$\Delta x/b = 0.50$
$\Delta y/b$ VARIATION

$\Delta x/b = 1.00$
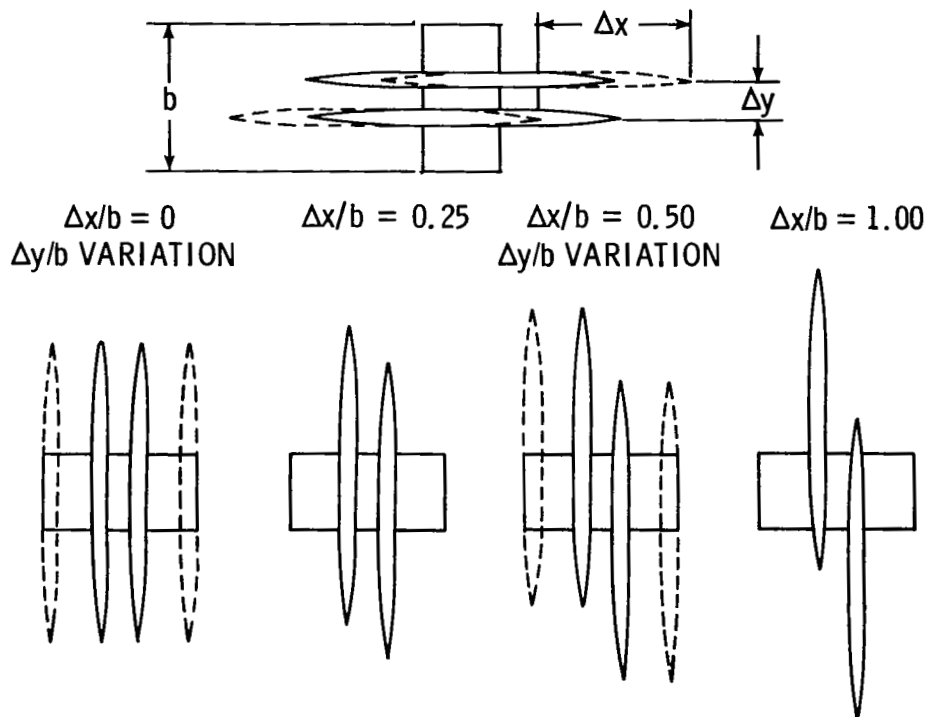
Figure 4.- Sketch showing parametric variation of test geometries.
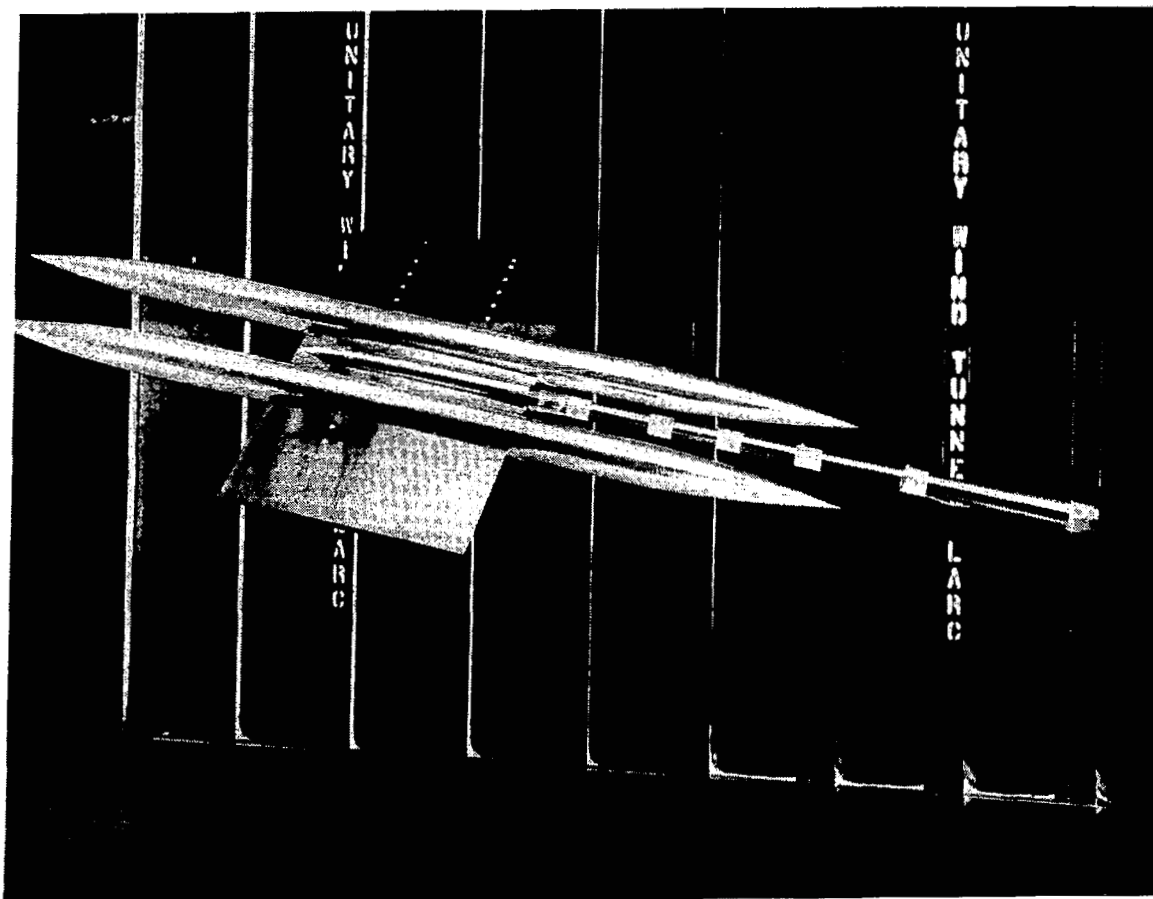
L-82-1282

Figure 5.- Twin-body model in wind-tunnel.
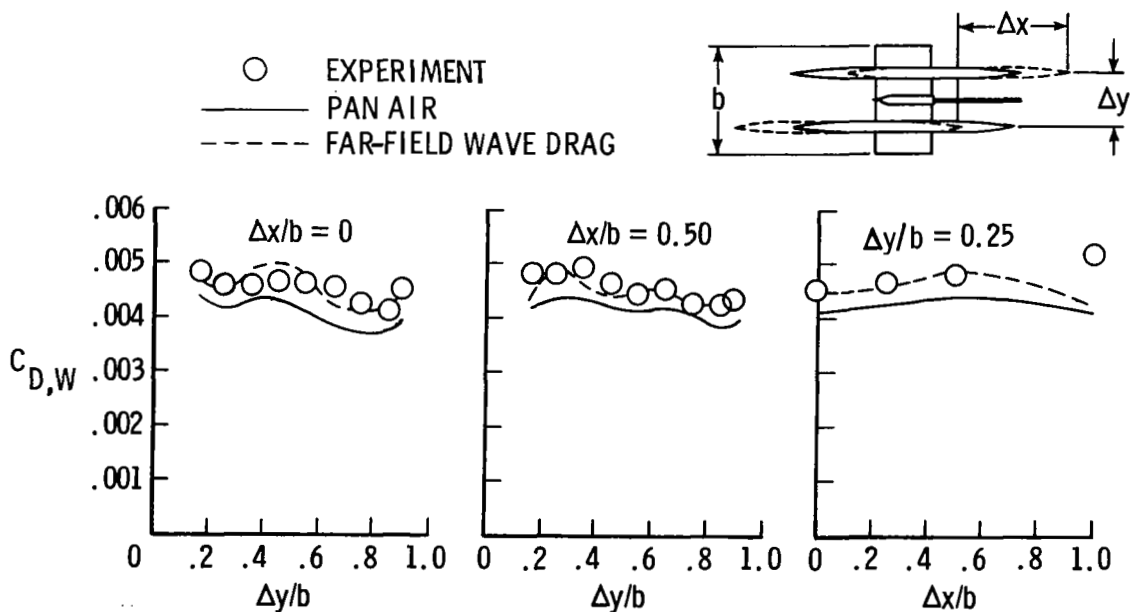
Figure 6.- Experimental and theoretical variations in zero-lift wave drag
with body positioning at M = 2.7.
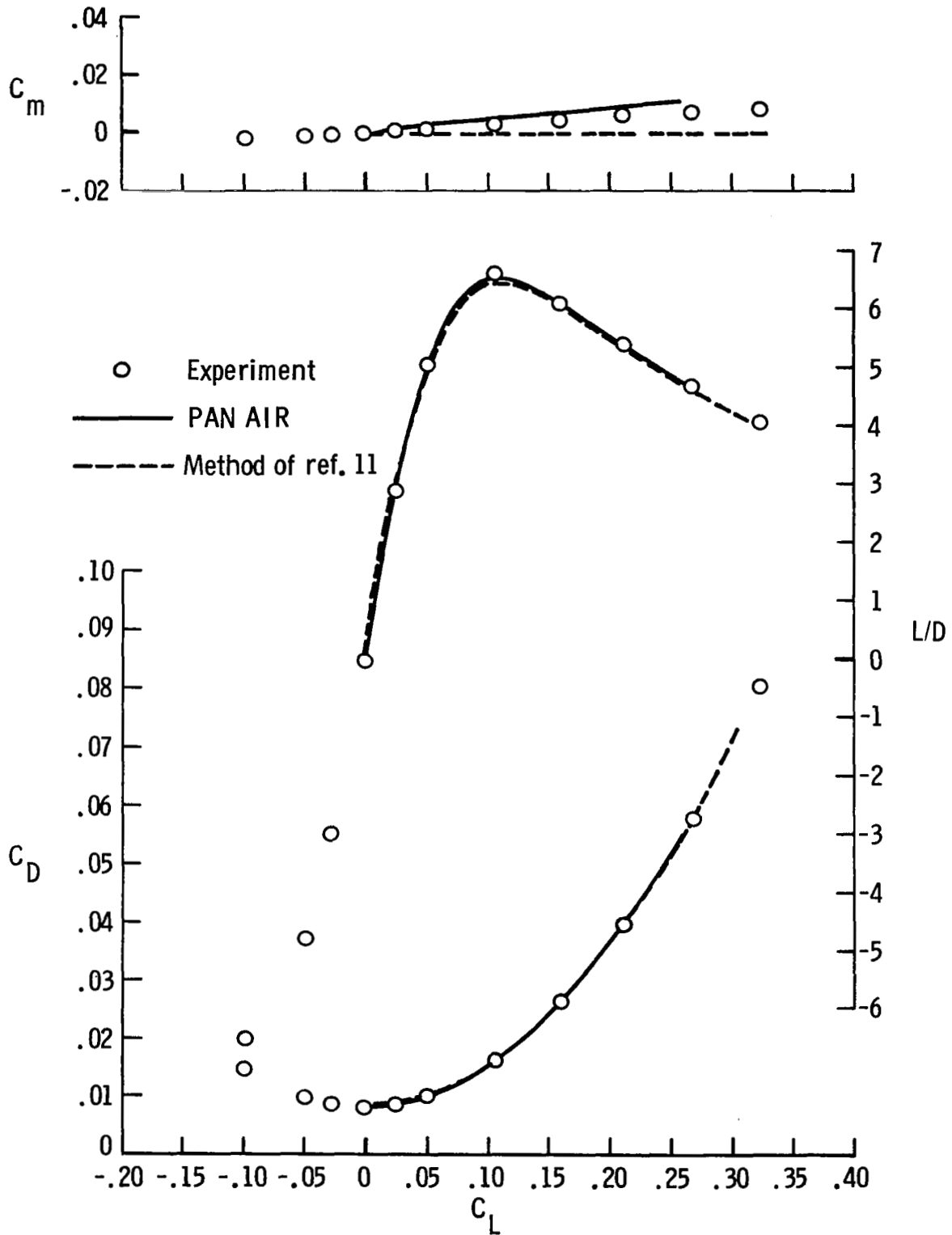
(a) Wing only.

Figure 7.- Comparison between experimental and theoretical longitudinal aerodynamic characteristics of symmetric configurations at M = 2.70.
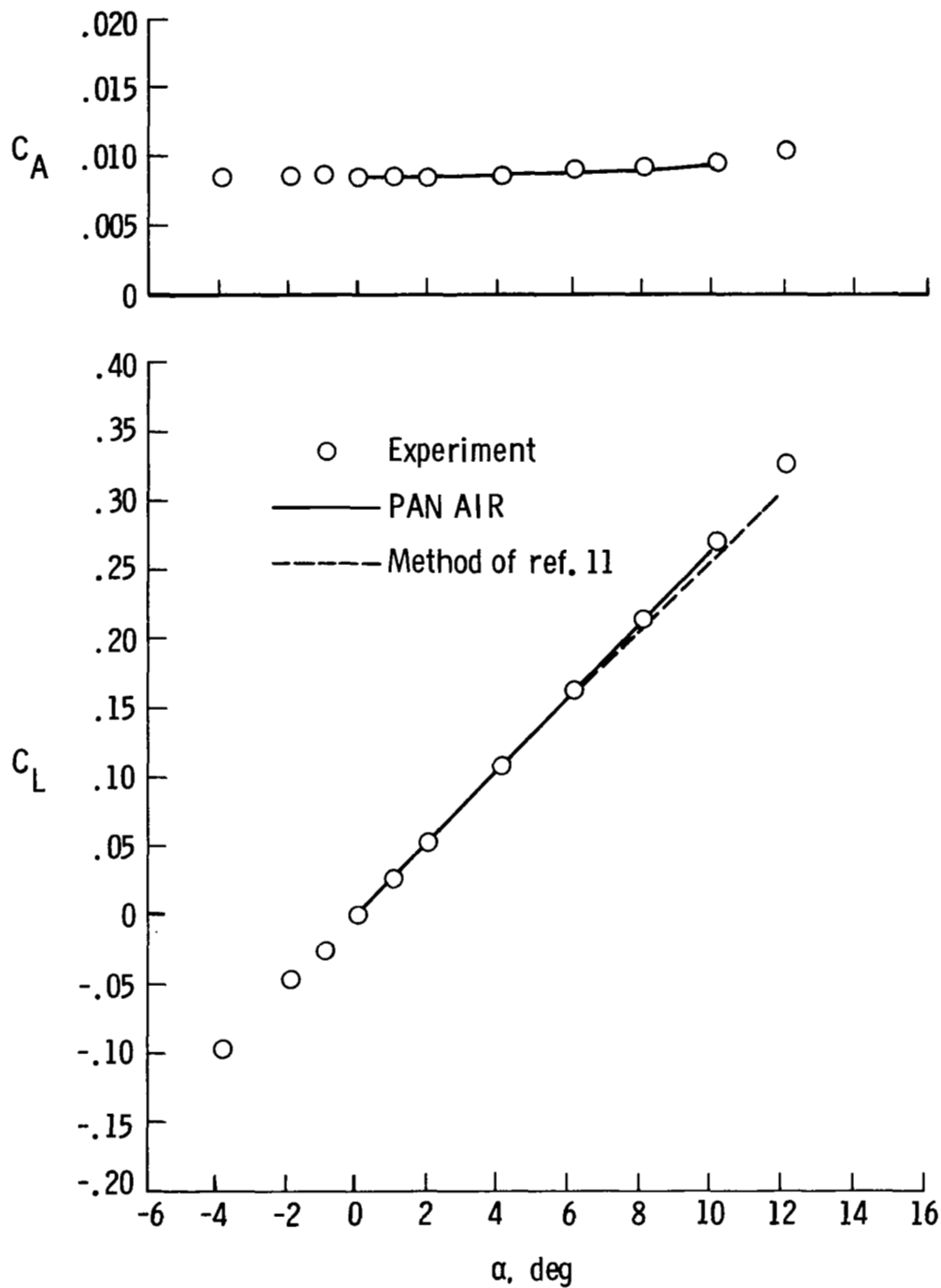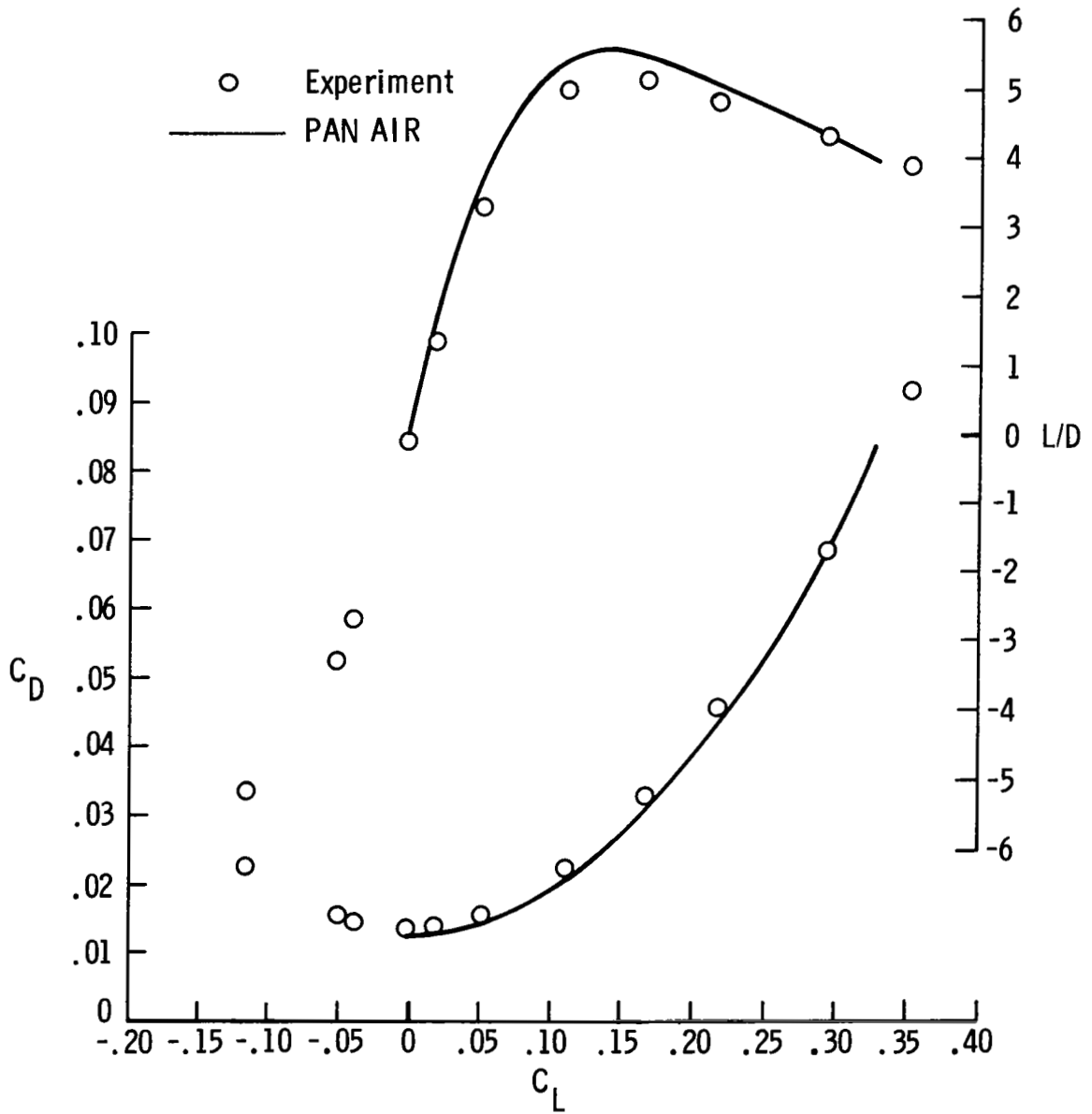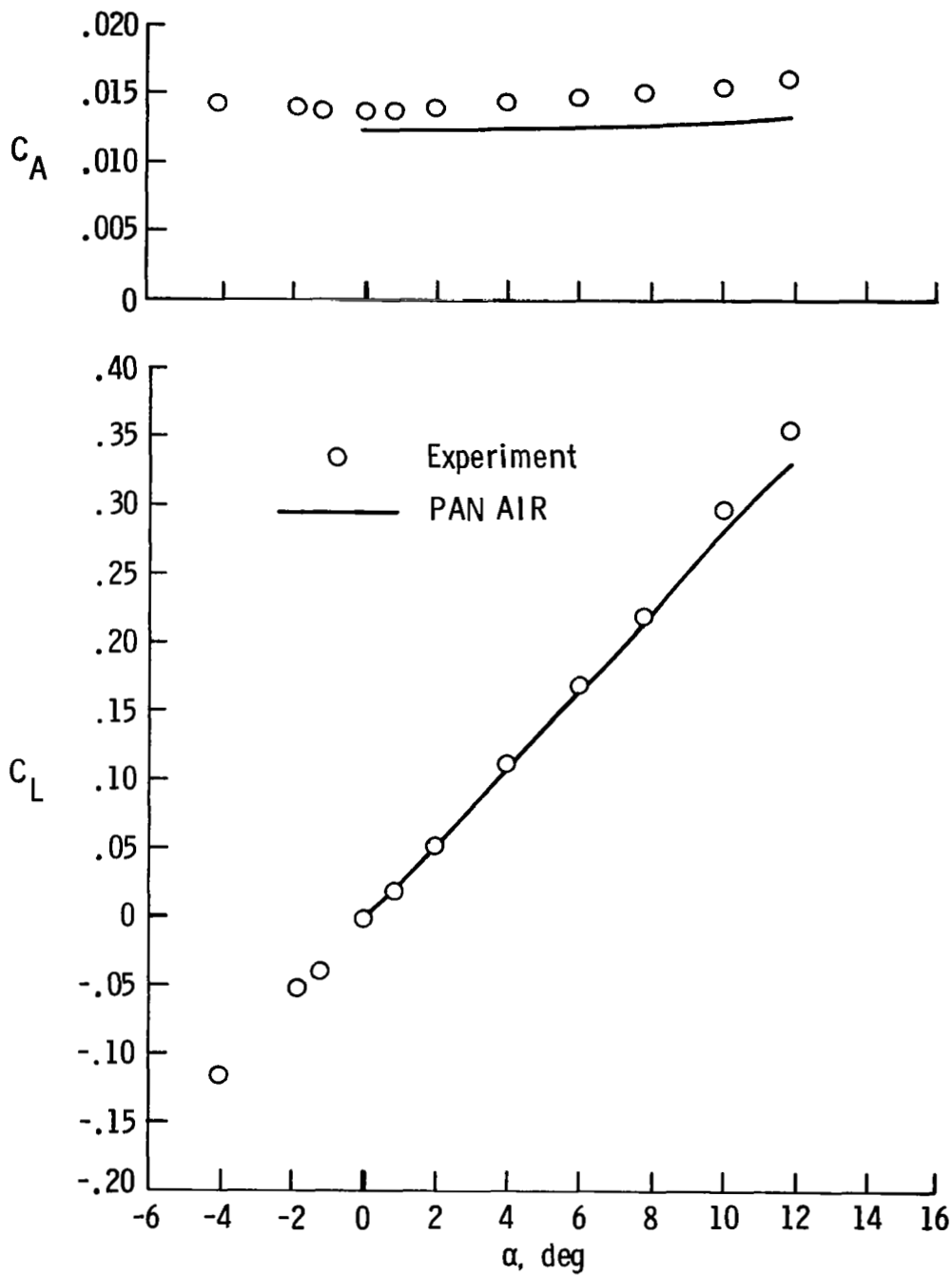
(a) Concluded.

Figure 7.- Continued.
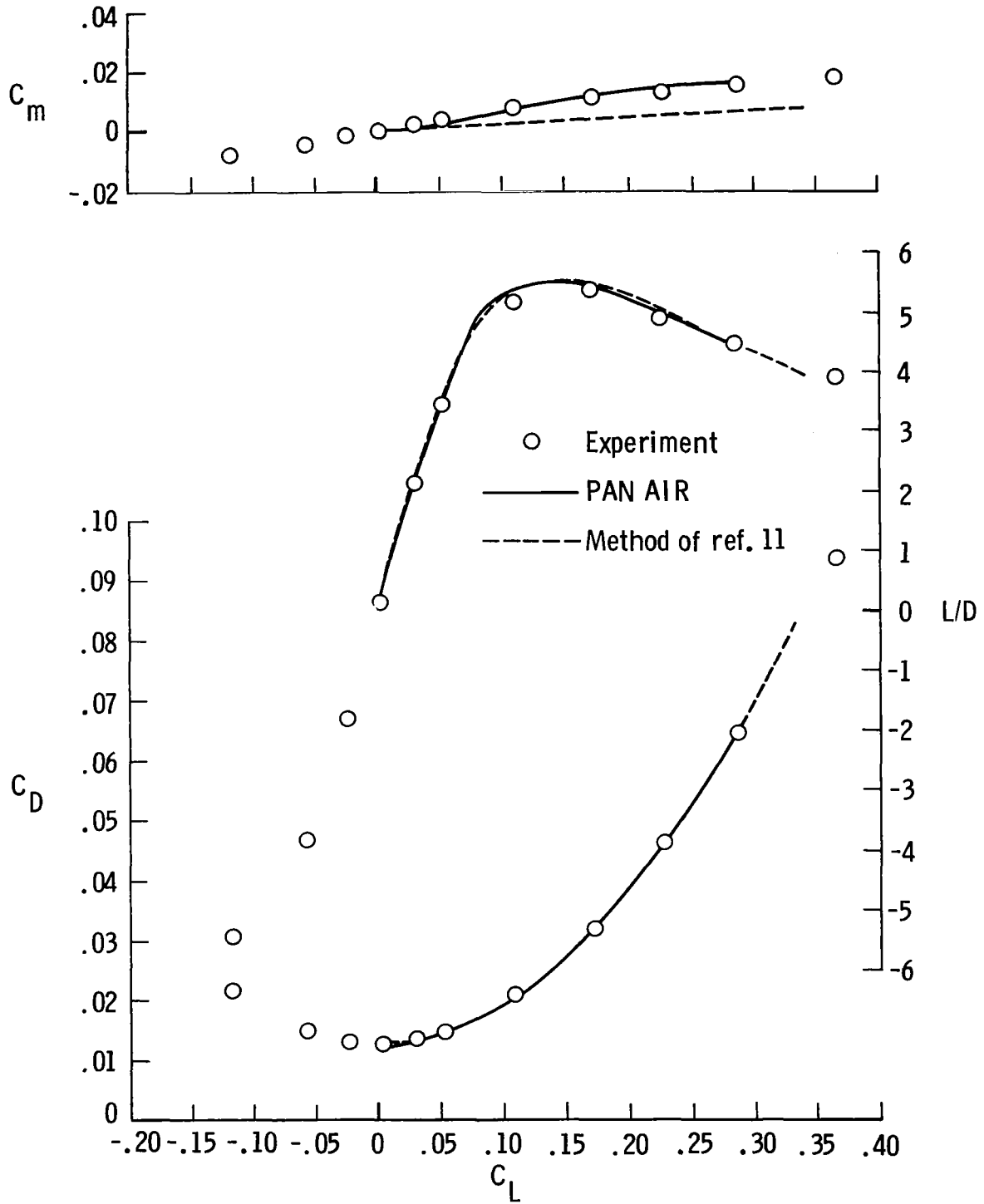
(b) Fuselage position: Δx/b = 0.0, Δy/b = 0.25.

Figure 7.- Continued.
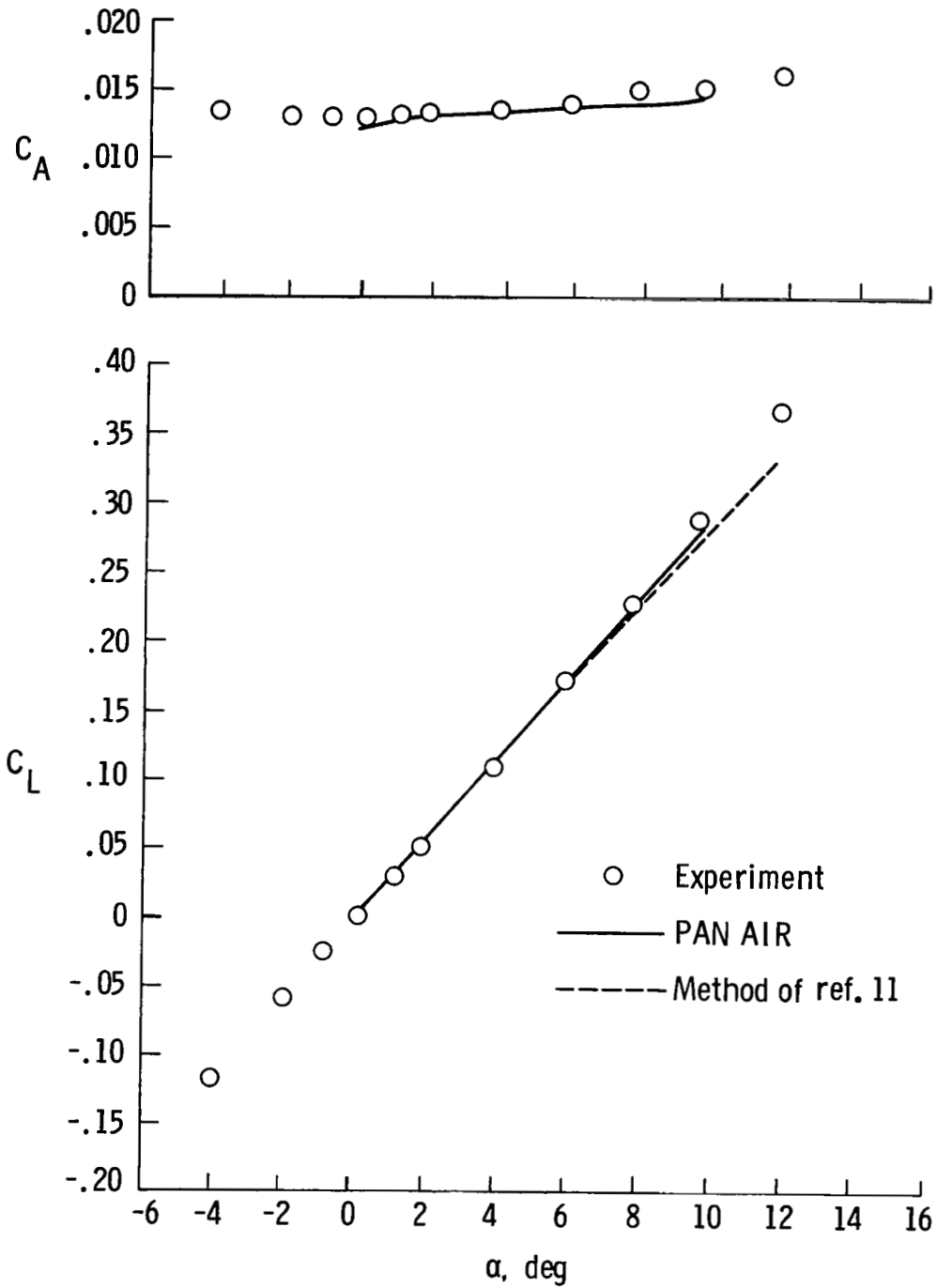
(b) Concluded.

Figure 7.- Concluded.
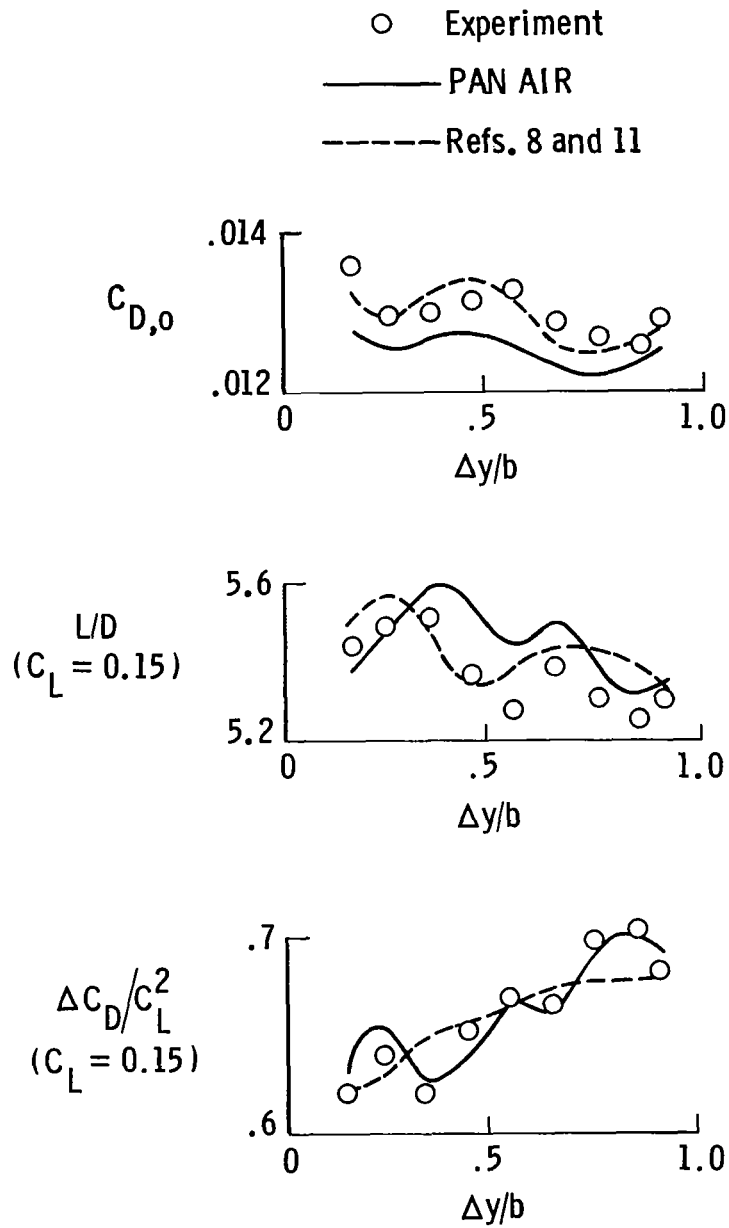
Figure 8.- Summary of longitudinal aerodynamic characteristics for all symmetric configurations at M = 2.70.
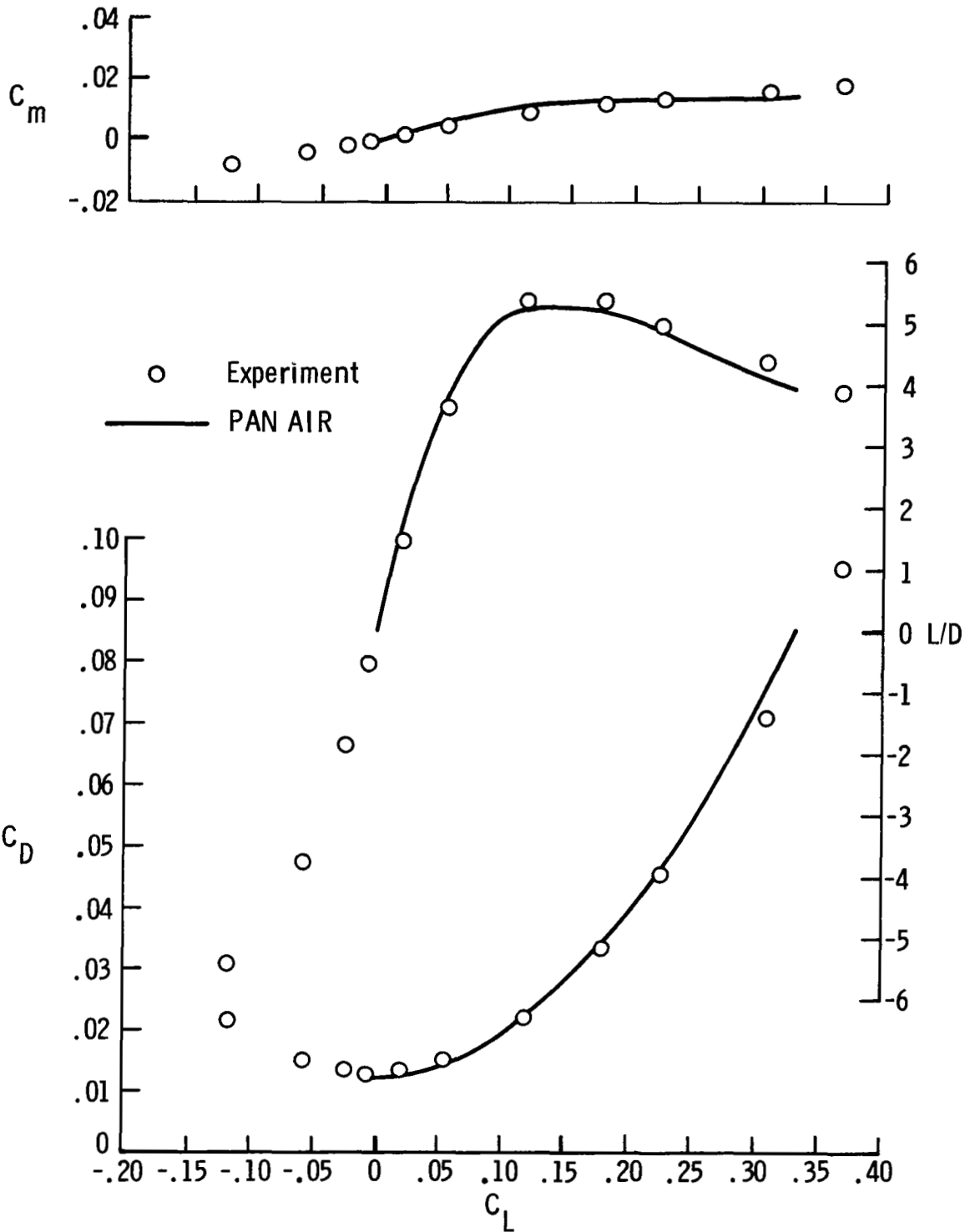
(a) Fuselage position: $\Delta x/b = 0.25$, $\Delta y/b = 0.25$.

Figure 9.- Comparison between experimental and theoretical longitudinal aerodynamic characteristics of asymmetric configurations.
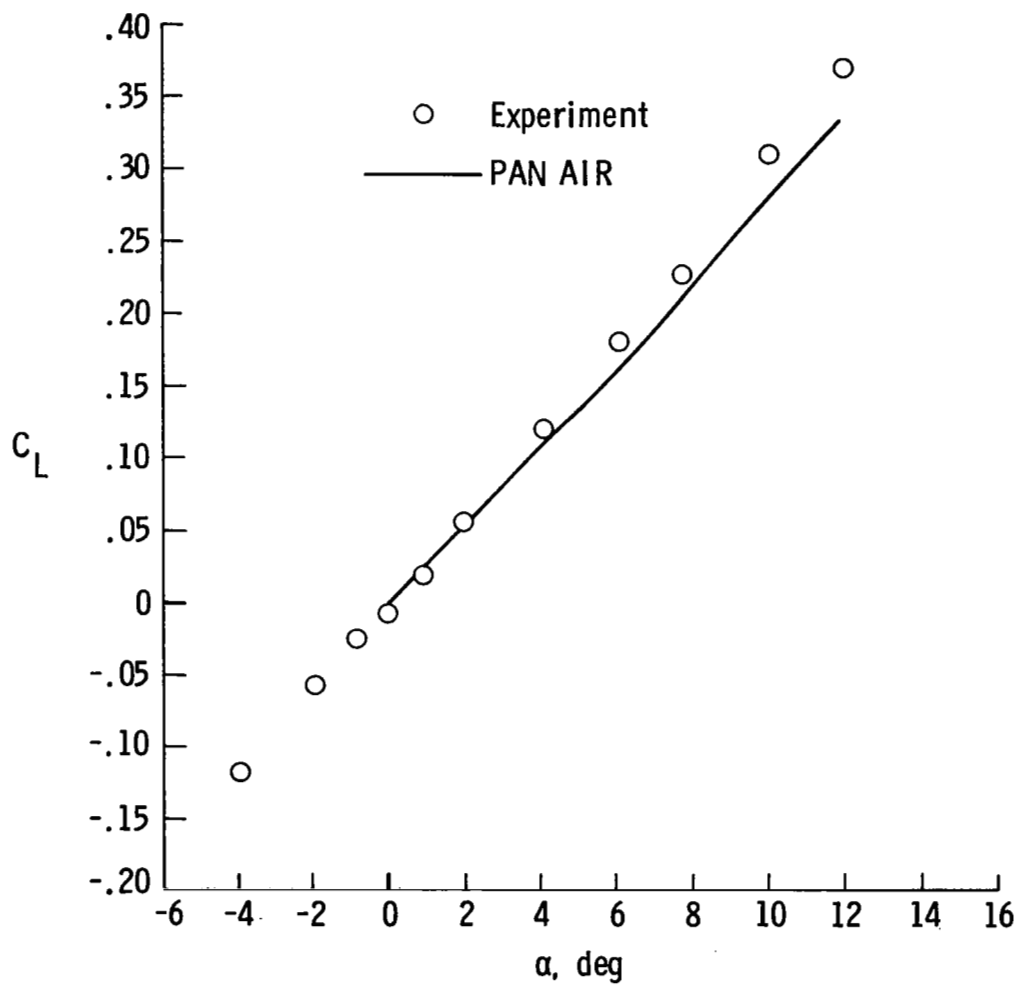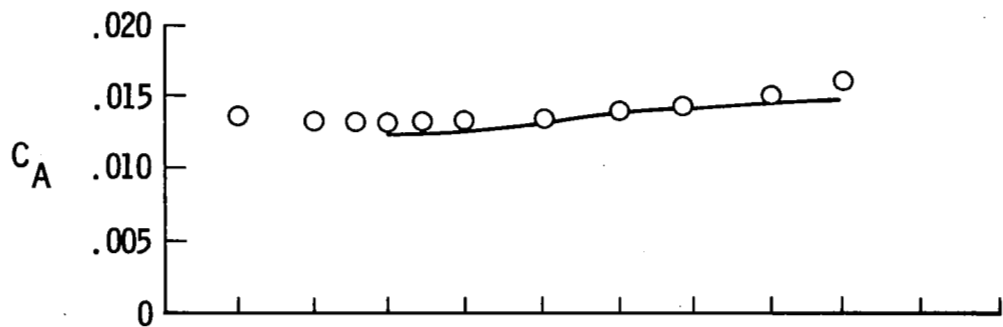
(a) Concluded.

Figure 9.- Continued.
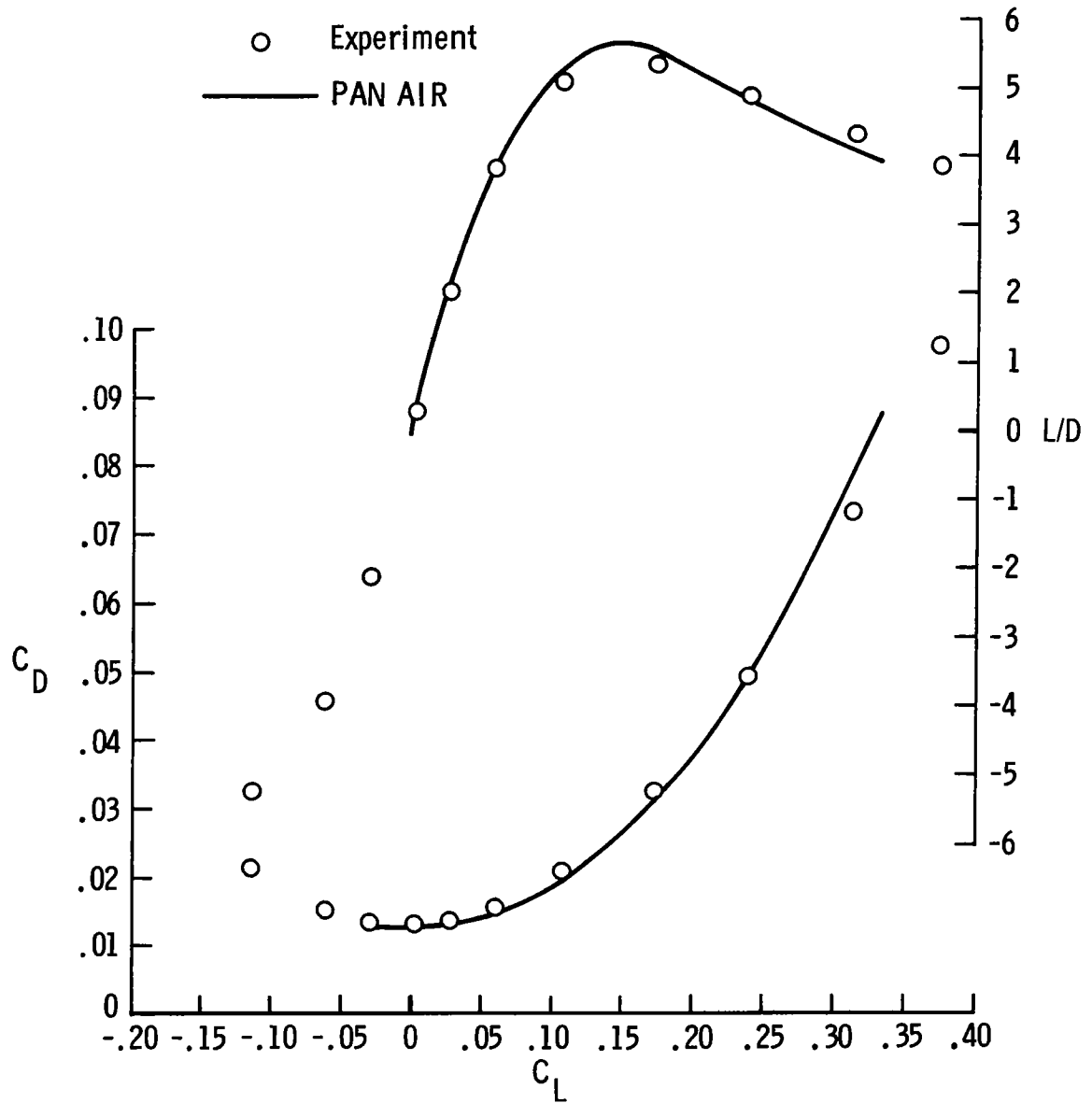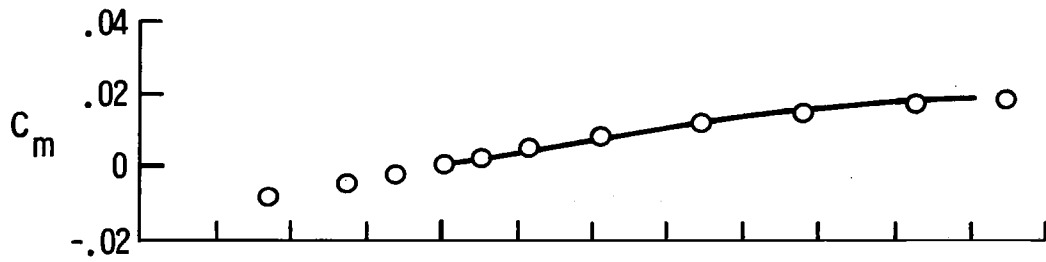
(b) Fuselage position: $\Delta x/b = 0.50$, $\Delta y/b = 0.25$.

Figure 9.- Continued.
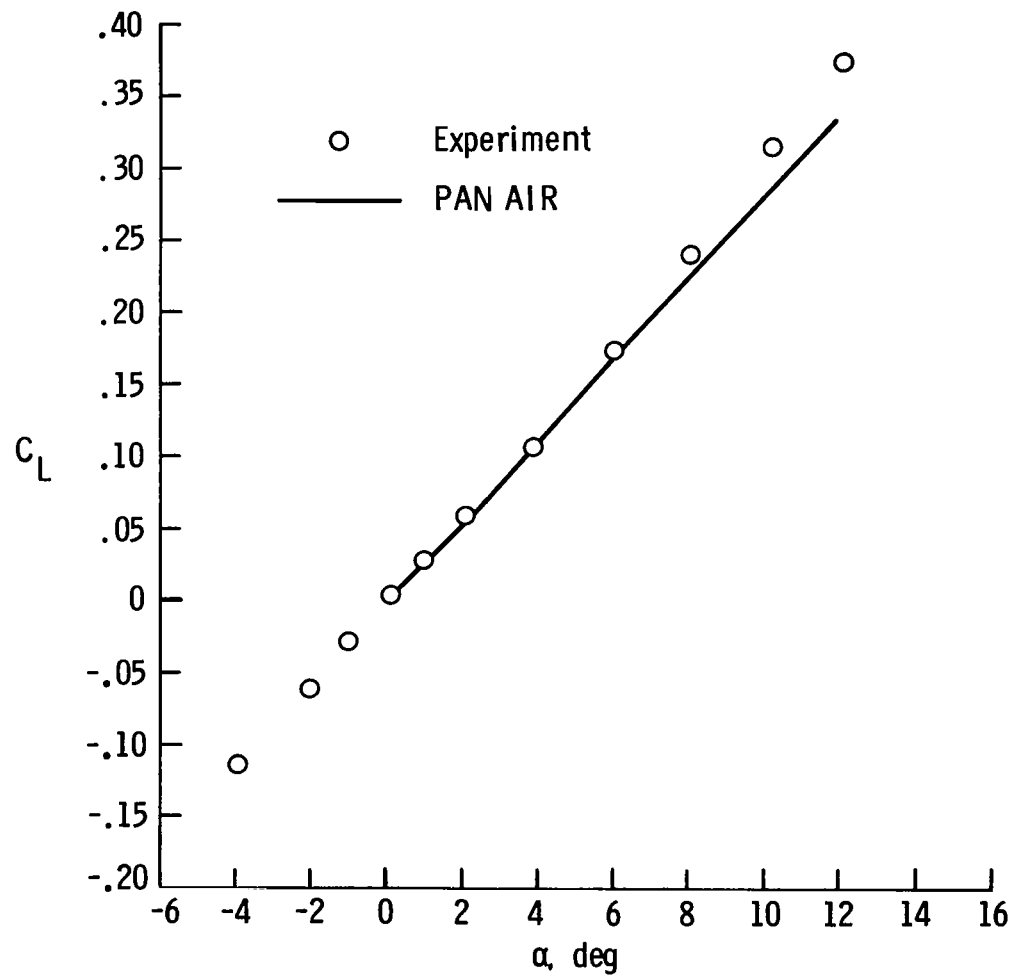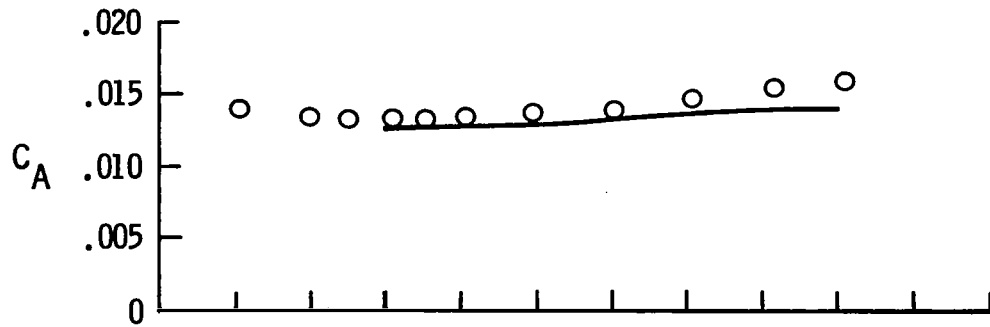
(b) Concluded.
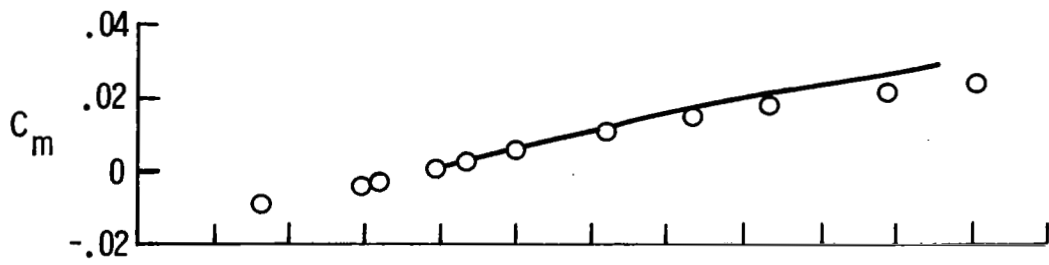
Figure 9.- Continued.

(c) Fuselage position: Δx/b = 1.00, Δy/b = 0.25.

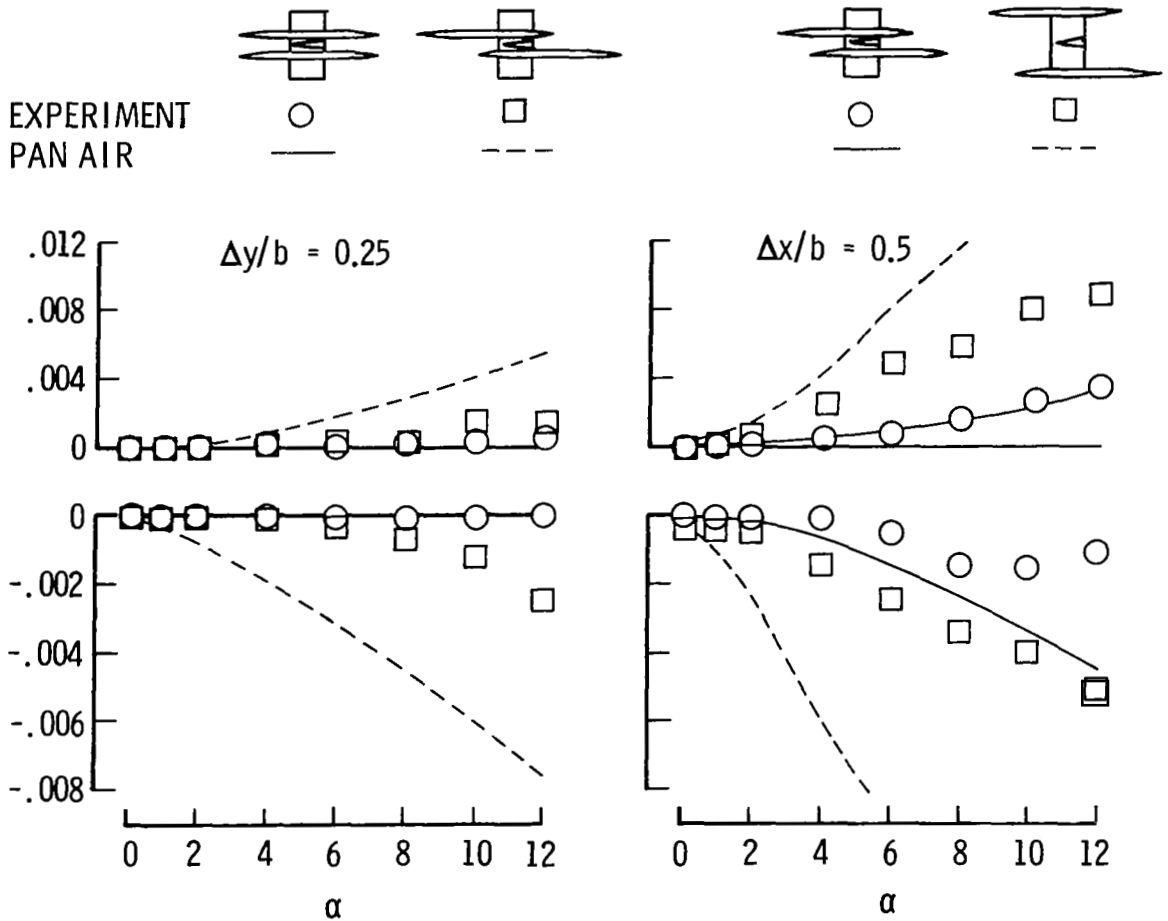Figure 9.- Continued.

(c) Concluded.

Figure 9.- Concluded.

Figure 10.- Typical experimental and theoretical directional characteristics associated with asymmetric twin-body geometries at M = 2.70.

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15. Supplementary Notes

16. Abstract

A theoretical and experimental investigation has been conducted to evaluate the fundamental supersonic aerodynamic characteristics of a generic twin-body model at a Mach number of 2.70. Results show that existing aerodynamic prediction methods are adequate for making preliminary aerodynamic estimates.

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