NASA
Technical
Paper
2133

March 1983

Aeropropulsive Characteristics of Twin Single-Expansion-Ramp Vectoring Nozzles Installed With Forward-Swept Wings and Canards

Mary L. Mason
and Francis J. Capone

NASA

NASA
Technical
Paper
2133

1983

Aeropropulsive Characteristics of Twin Single-Expansion-Ramp Vectoring Nozzles Installed With Forward-Swept Wings and Canards

Mary L. Mason
and Francis J. Capone
Langley Research Center
Hampton, Virginia

National Aeronautics
and Space Administration

**Scientific and Technical
Information Branch**

SUMMARY

An investigation has been conducted in the Langley 16-Foot Transonic Tunnel to determine the aeropropulsive characteristics of twin single-expansion-ramp nozzles installed in a wing-body configuration with forward-swept wings. The configuration was tested with and without canards. The test conditions included free-stream Mach numbers of 0.60, 0.90, and 1.20, an angle-of-attack range from -2° to 14°, and a nozzle-pressure-ratio range from 1.0 (jet off) to 9.0. The Reynolds number based on the wing mean aerodynamic chord varied from 3.0×10^6 to 4.8×10^6, depending on Mach number.

Aerodynamic characteristics for the wing-afterbody-nozzle and the wing-afterbody portions of the model were analyzed to determine the effects of thrust vectoring and the effects of the canard. Results indicate that thrust vectoring had a favorable effect at all test conditions on the wing-afterbody-nozzle lift but was less favorable on the wing-afterbody lift. Thrust vectoring had no effect on the angle of attack for the onset of inboard flow separation, which occurs for forward-swept wings. The canard was found to have little effect on the thrust-induced lift resulting from thrust vectoring.

INTRODUCTION

The mission requirements for the next generation of fighter aircraft imply a highly versatile vehicle capable of operating over a wide range of flight conditions. This aircraft will most likely be designed for high maneuverability and agility, be required to operate in an extremely hostile environment, and possess STOL capabilities necessary for operation from bomb-damaged airfields. The fighter aircraft of the future may be designed for supersonic cruise in order to maximize attack options and minimize exposure to hostile action. To provide such multimission capabilities, new technology concepts such as thrust vectoring, thrust reversing, forward wing sweep, vortex flow control, and close-coupled canards for favorable canard-wing interactions must be considered in the fighter aircraft design. Consequently, NASA has contributed considerable research effort to the development of these technologies (refs. 1 to 8).

This paper presents the results of an experimental investigation of a model which utilized three advanced technology concepts: forward wing sweep, nonaxisymmetric nozzles with thrust vectoring, and close-coupled canards. The effects of thrust vectoring with twin single-expansion-ramp nozzles were determined for a wing-body model with forward-swept wings. The configuration was tested with and without fixed canards. The wing used in this investigation was highly cambered and twisted for maneuver conditions and had a design lift coefficient of 0.90. This investigation is a continuation of an earlier study of the effects of nonaxisymmetric nozzles with thrust vectoring on a wing-body configuration with uncambered forward-swept and aft-swept wings (ref. 8). The combination of a forward-swept wing with nonaxisymmetric nozzle thrust vectoring may have a favorable effect by reducing the inboard flow separation phenomenon, which is typical of a forward-swept wing flow field.

The current investigation was conducted in the Langley 16-Foot Transonic Tunnel. The test conditions included free-stream Mach numbers of 0.60, 0.90, and 1.20, an angle-of-attack range from -2° to 14°, and a nozzle-pressure-ratio range from 1.0 (jet off) to 9.0. Reynolds number based on the wing mean geometric chord varied from 3.0×10^6 to 4.8×10^6, depending on Mach number.

SYMBOLS

Model forces and moments are referred to the stability-axis system with the model moment reference center located at FS 96.86. The symbols used in the computer-generated tables are given in parentheses in the second column. A discussion of the data reduction procedure and definitions of the aerodynamic force and moment terms and propulsion relationships used herein are given in the appendix.

$A_{mb,1}$		model cross-sectional area at FS 99.06, cm^2
$A_{mb,2}$		model cross-sectional area at FS 132.08, cm^2
$A_{seal,1}$		cross-sectional area enclosed by seal strip at FS 99.06, cm^2
$A_{seal,2}$		cross-sectional area enclosed by seal strip at FS 132.08, cm^2
C_D	(CDAERO)	wing-afterbody-nozzle thrust-removed drag coefficient, $\frac{D}{q_\infty S}$
$C_{D,a}$	(CDA)	wing-afterbody thrust-removed drag coefficient, $\frac{D_a}{q_\infty S}$
$C_{(D-F)}$	(C(D-F))	drag-minus-thrust coefficient (net force), $\frac{D - F}{q_\infty S}$, $C_{(D-F)} \equiv C_D$ at NPR = 1.0
$C_{(D_n-F)}$	(C(DN-F))	nozzle drag-minus-thrust coefficient, $\frac{D_n - F}{q_\infty S}$
$C_{D,0}$		C_D at $C_L = 0$ and NPR = 1.0
C_L	(CL)	total wing-afterbody-nozzle lift coefficient (including thrust component), $\frac{\text{Lift}}{q_\infty S}$, $C_L \equiv C_{L,aero}$ at NPR = 1.0
$C_{L,a}$	(CLA)	wing-afterbody thrust-removed lift coefficient
$C_{L,aero}$	(CLAERO)	wing-afterbody-nozzle thrust-removed lift coefficient
$C_{L,n}$	(CLN)	nozzle lift coefficient (including thrust component), $\frac{\text{Nozzle lift}}{q_\infty S}$

$C_{L,0}$		C_L at $\alpha = 0°$ and NPR = 1.0
C_m	(CM)	total pitching moment coefficient (including thrust component), $\frac{\text{Total pitching moment}}{q_\infty S\bar{c}}$
$C_{m,a}$	(CMA)	wing-afterbody thrust-removed aerodynamic pitching moment coefficient
	(CMAERO)	wing-afterbody-nozzle thrust-removed pitching moment coefficient
$C_{m,n}$	(CMN)	nozzle pitching moment coefficient (including thrust component), $\frac{\text{Nozzle pitching moment}}{q_\infty S\bar{c}}$
$\bar{c}$		wing mean geometric chord, 18.707 cm
D		wing-afterbody-nozzle drag, N
D_a		wing-afterbody drag, N
D_n		nozzle drag, N
F		thrust along stability axis, N
F_A		wing-afterbody-nozzle axial force, N
$F_{A,Mbal}$		axial force measured by main balance, N
$F_{A,mom}$		momentum tare axial force due to bellows, N
$F_{A,n}$		nozzle axial force, N
$F_{A,Tbal}$		axial force measured by thrust balance, N
F_j		thrust along body axis, N
M	(MACH)	free-stream Mach number
$\bar{p}_{es,1}$		average static pressure at external seal at FS 99.06, Pa
$\bar{p}_{es,2}$		average static pressure at external seal at FS 132.08, Pa
$\bar{p}_i$		average internal static pressure, Pa
$p_{t,j}$		average jet total pressure, Pa
p_∞		free-stream static pressure, Pa
q_∞		free-stream dynamic pressure, Pa

S		wing reference area, 1241.65 cm^2
x_e, y_e		coordinates of nozzle exit, cm
α	(ALPHA)	angle of attack, deg
Δ		increment
δ_v	(VEER)	geometric turning angle (positive direction deflects jet flow downward), deg

Subscripts:

c	canard
int	lift interference due to canard
p	potential flow
vle	vortex effect at leading edge
vse	vortex effect at side edge
w	wing

Abbreviations:

A/B		afterburner
ADEN		augmented deflector exhaust nozzle
ASME		American Society of Mechanical Engineers
BL		butt line, cm
FS		fuselage station (location described by distance in centimeters from model nose)
NPR	(NPR)	nozzle pressure ratio, $p_{t,j}/p_\infty$
SERN		single-expansion-ramp nozzle
STOL		short-field take-off and landing
WL		water line, cm

APPARATUS AND PROCEDURE

Model

General arrangement.- Photographs of the model are shown in figure 1. The overall external geometry of the model is presented in figure 2.

The fuselage had rectangular cross sections with rounded corners. The body lines were chosen to enclose the internal propulsion system and to fair into the afterbody enclosing the nozzles. The maximum width and height of the body were 22.86 cm and 12.70 cm, respectively, and the maximum body cross-sectional area was 284.78 cm^2. That portion of the configuration aft of the metric break at fuselage station 99.06 (afterbody, wing, and nozzle) was supported by the model main balance. A 0.16-cm gap between the nonmetric forebody and the metric afterbody (that portion of the model on which forces and moments are measured) was required to prevent fouling of the main balance. A flexible strip of DuPont Teflon inserted into slots was used as a seal to prevent flow into or out of the model. The low coefficient of friction of Teflon minimized restraints between the metric and nonmetric portions of the model. A metric break for a second balance (thrust balance), which supported nozzle hardware downstream of FS 132.08, is shown in figure 2 and was sealed in a manner similar to that for the main balance. In this report, that section of the model between the metric breaks (between FS 99.06 and FS 132.08), including the wing, will be referred to as the wing-afterbody. That section of the model from the first metric break (FS 99.06) to the end of the model (FS 154.40), including the wing, will be referred to as the wing-afterbody-nozzle.

Forward-swept wing.- The planform of the forward-swept wing is shown in figure 3. The reference-wing planform is also given in the figure. The reference wing is representative of a 0.10-scale tactical fighter and is the forward-swept wing described in reference 9. The reference wing had an area of 1241.65 cm^2, a leading-edge sweep of 40°, an aspect ratio of 4.0, and a taper ratio of 0.40. Other dimensions are given in figure 3. The forward-swept wing had both camber and twist, and a dihedral angle of 6°, as shown in figure 2. The design lift coefficient of the wing was 0.90.

The forward-swept wing was sized to the specifications of reference 9 and was used with the fuselage of reference 8. Consequently, the exposed wing area was small relative to the body maximum cross-sectional area. The wing was located longitudinally to align the nominal exit plane of the propulsion nozzle lower flap with the wing trailing edge (see fig. 2). The vertical location of the wing was at the model center line. This wing location was selected to maximize interactions between the wing and the nozzle within constraints of the model geometry.

Canard.- The canard, installed on the wing-body model, is shown in figure 2. The canard was cambered and had a leading-edge sweep of 48°, an aspect ratio of 1.284, a taper ratio of 0.40, and a dihedral angle of 13° when mounted on the model. The exposed root chord of the canard was 14.63 cm, and the exposed tip chord was 5.87 cm. The ratio of the exposed canard area to the wing reference area was 0.109. The canard was located upstream of the main balance metric break (FS 99.06) on the nonmetric part of the model.

Twin-Jet Propulsion Simulation System

A sketch of the twin-jet propulsion simulation system is presented in figure 4. This propulsion simulation system was also used for the investigation of reference 8. An external high-pressure air system provides a continuous flow of clean, dry air at a controlled temperature of about 306 K at the nozzle. This high-pressure air is brought through the support strut by six tubes into a high-pressure chamber. (See fig. 4.) Here the air is divided into two separate flows and is passed through flow-control valves. These manually operated valves are used to balance the exhaust nozzle total pressure in each duct. As shown in figure 5, the air in each supply pipe is then discharged perpendicularly to the model axis through eight sonic nozzles equally spaced around the supply pipe. This method is designed to eliminate any transfer of axial momentum as the air is passed from the nonmetric to the metric portion of the model. Two flexible metal bellows are used as seals and serve to compensate for the axial forces caused by pressurization. The cavity between the supply pipe and bellows is vented to model internal pressure. (See fig. 5.) The tailpipes are connected to the thrust balance whose loads are then transmitted to the main balance through the wing and thrust-balance support block.

The air is then passed through the tailpipes to the exhaust nozzles, as shown in figure 4. A transition, instrumentation, and choke plate section common to all nozzles was attached to the tailpipes at FS 122.44 with FS 132.08 being the nozzle connect station. The nozzles had square corners in the duct downstream of the choke plate. The interfairing between the nozzles was required to house the actuator for the remotely-controlled variable external expansion ramps used for thrust vectoring.

The single-expansion-ramp-nozzle (SERN) concept has a two-dimensional upper expansion ramp, which results in a combined internal/external expansion. This concept is a derivative of the augmented deflector exhaust nozzle (ADEN) of reference 10 and features elliptical throat and expansion surface contours. The nozzle tested is shown in the sketches of figure 6 and the photographs of figure 7. Static performance data for this nozzle configuration are presented in reference 11.

In the model, the elliptical contours have been approximated by a flow path formed by semicircular and straight line segments. The nozzle throat area and internal-area ratio (exit-area-to-throat-area ratio) are set by an adjustable lower surface flap and spacers to simulate rotation of the throat area control flap. Two nozzle power settings were tested and represented a dry or cruise power setting with a model throat area of 15.677 cm^2 and an afterburning (A/B) power setting with a model throat area of 27.032 cm^2. The internal-area ratio was 1.15 for the dry power setting and 1.21 for the A/B power setting.

Nozzle thrust vectoring was accomplished by deflection of the variable external expansion ramp. In the model, the variable external expansion ramp was remotely actuated.

Wind Tunnel and Support System

This investigation was conducted in the Langley 16-Foot Transonic Tunnel, a single-return, atmospheric wind tunnel with a slotted, octagonal test section and continuous air exchange. The wind tunnel has continuously variable airspeed up to a Mach number of 1.30. Test-section plenum suction is used for speeds above a Mach number of 1.10. From the calibration of the wind tunnel, the test-section wall divergence is adjusted as a function of the airstream dew point and Mach number. The adjustment eliminates any longitudinal static-pressure gradients in the test section. A complete description of this facility and operating characteristics can be found in reference 12.

The model was supported by a sting strut with the model center of rotation indicated in figure 8. The strut had a 45° leading-edge sweep, a 50.8-cm chord, and a 5-percent-thick hexagonal airfoil in the streamwise direction. The model blockage ratio was 0.0015 (ratio of model cross-sectional area to test-section area), and the maximum blockage ratio including the support system was 0.0020. Strut interference effects were considered to be small.

Instrumentation

The main balance measured forces and moments resulting from the nozzle gross thrust and the external flow field over that portion of the model aft of FS 99.06. (See fig. 2.) The thrust balance measured forces and moments resulting from the nozzle thrust and the external flow field over the nozzle boattail and interfairing aft of FS 132.08. (See appendix.) Five pressure orifices located in each metric break (FS 99.06 and FS 132.08) were used to measure pressures for tare corrections to each balance. Internal cavity pressures were measured at four locations and were also used for these tares. Forebody attitude relative to the horizontal center line of the test section was measured by a calibrated attitude indicator mounted in the nose. Angle of attack α, which is the angle between the afterbody center line and the relative wind, was determined by applying terms for afterbody deflection caused by model and balance bending under aerodynamic loads and a flow angularity term to the angle measured by the attitude indicator. The flow angularity adjustment was 0.1°, which is the average angularity measured in the 16-Foot Transonic Tunnel.

Flow conditions in each nozzle were determined from four total pressure probes and one total temperature probe located at FS 129.5 in the instrumentation section aft of the transition section and choke plate. All pressures were measured with individual pressure transducers, and temperatures were measured with iron-constantan thermocouples. Since the choke plate and nozzle flow instrumentation were downstream of the round-to-square duct transition section (see fig. 4), nozzle performance parameters were independent of duct transition effects.

As a check on the adequacy of the flow instrumentation, nozzle total pressure surveys were made (ref. 11) by translating a shielded total pressure probe (Kiel tube) across the flow duct in the instrumentation sections. These surveys were made at approximately the same fuselage station as the total pressure probes that were installed in the instrumentation sections. Surveys were made along the nozzle horizontal and vertical planes. The nozzles were surveyed at each power setting in each duct in order to determine the effects of any geometrical differences on the total pressure profiles at the measuring station. The numerically averaged total pressure from the total pressure tubes in the instrumentation section was within 0.2 percent of the integrated value from the Kiel tube surveys.

All data for both the model and the wind tunnel facility were recorded simultaneously on magnetic tape. Approximately 50 frames of data, taken at a rate of 10 frames per second, were used for each data point. Average values of the recorded data were used to compute standard force and moment coefficients based on wing area and mean geometric chord for reference area and length, respectively.

Tests

This investigation was conducted in the Langley 16-Foot Transonic Tunnel at Mach numbers from 0.60 to 1.20. Angle of attack was varied from -2° to 14°, depending upon Mach number; nozzle pressure ratio was varied from 1.0 (jet off) to 9.0, depending upon Mach number and nozzle power setting. Basic data were obtained by holding nozzle-pressure-ratio constant and varying angle of attack. Maximum allowable load limits on the wing restricted the maximum angle of attack at Mach numbers of 0.90 to 1.20. Reynolds number based on the wing mean geometric chord varied from about 3.0×10^6 to 4.8×10^6 at Mach numbers of 0.60 and 1.20, respectively.

All tests were conducted with 0.26-cm-wide boundary-layer transition strips consisting of No. 100 silicon carbide grit sparsely distributed in a thin film of lacquer (ref. 13). These strips were located 2.54 cm from the tip of the forebody nose and on both the upper and lower surfaces of the wings at 5 percent of the wing chord at the wing-fuselage juncture to 10 percent of the local streamwise chord at the wing tip.

RESULTS AND DISCUSSION

The results of this investigation are presented in both data plots and tables. Selected cases of basic aerodynamic data are presented in figures 9 to 17. Complete results for the entire investigation are presented in table I for the dry power configuration with canard on, in table II for the dry power configuration, canard off, in table III for the A/B power configuration with canard on, and in table IV for the A/B power configuration, canard off.

Effect of Thrust Vectoring

The effects of thrust vectoring on the aerodynamic characteristics for the dry power configuration with canard on are presented in figures 9 through 11. Results for the A/B power configuration with canard on are similar to the dry power results and are not presented graphically. The effect of the canard is discussed later in the text. Note that at jet-off conditions, the thrust is equal to zero, and the drag-minus-thrust term $C_{(D-F)}$ is equivalent to the total drag term C_D.

The lift curves in figures 9 through 11 are nearly linear up to an angle of attack near 8°, where a break in the lift curve slope occurs. This is most evident at $M = 0.90$ for each figure. The break in the lift curve slope indicates the onset of flow separation on the wing. Flow separation on a forward-swept wing most likely occurs initially at the wing root rather than at the tip, where it would occur for an aft-swept wing. Thrust vectoring has no effect on the onset of flow separation on the forward-swept wing. (See, for example, fig. 9(b) or 10(c).) Although thrust vectoring does affect the magnitude of the lift curves, the angle of attack at which the break in the lift curve slope occurs does not vary with thrust vector angle δ_v.

As thrust vector angle increases, there is the typical "crossover" of the individual drag-minus-thrust polars, with each crossover occurring at successively higher lift coefficients. (See fig. 9(a) or 10(b).) At maneuver conditions (high angles of attack), this crossover effect results in definite improvement in the subsonic drag-minus-thrust polars with increasing vector angle. This reduction in drag with increase in vector angle is particularly significant at angle-of-attack values above that required for the onset of flow separation on the wing. At supersonic conditions ($M = 1.20$), increases in vector angle result in small increases in lift but have little effect on the polars over the angle-of-attack range tested. (See figs. 9(c) and 10(f).)

Incremental thrust-removed lift characteristics for both the dry and A/B power configurations with canard on are given in figure 12. Incremental lift is the difference between jet-on and jet-off thrust-removed lift and generally represents jet-induced supercirculation lift. Increments are presented in figure 12 for both the wing-afterbody-nozzle thrust-removed lift coefficient $C_{L,aero}$ and the wing-afterbody thrust-removed lift coefficient $C_{L,a}$. (Note the difference in vertical scales between fig. 11 and fig. 12.) Results are shown for two values of angle of attack at each of the test Mach numbers.

The total wing-afterbody-nozzle incremental lift is generally much higher than the wing-afterbody incremental lift in all six cases of figure 12. This indicates that most of the jet-induced lift on the configuration occurs on the aft part of the wing-afterbody-nozzle section (nozzle and interfairing) and not on the wing-body alone. Previous studies have indicated that almost half of the induced lift occurs in the vicinity of the nozzle (ref. 14). The small magnitude of $\Delta C_{L,a}$ may be due to the small size of the wing relative to the afterbody. Since most of the jet-induced lift occurs on the nozzle and interfairing, the effects of vectoring should be more apparent on $\Delta C_{L,aero}$, which includes forces on this portion of the model. In fact, thrust vectoring has a favorable effect on $\Delta C_{L,aero}$ at all conditions given in figure 12, particularly at $M = 0.60$. The effect of thrust vectoring on $\Delta C_{L,a}$ is much smaller than on $\Delta C_{L,aero}$ and is favorable only at $M = 0.60$. It is not fully understood why vectoring has unfavorable results on the wing-afterbody lift $C_{L,a}$ at $M = 0.90$ and 1.20.

Figure 12 summarizes the effects of a number of aerodynamic parameters on the incremental lift data. The wing-afterbody-nozzle incremental lift (jet-induced lift) $\Delta C_{L,aero}$ tends to increase with increasing nozzle pressure ratio, angle of attack, and/or nozzle power setting at all Mach numbers tested. However, the effect of these parameters on wing-afterbody incremental lift $\Delta C_{L,a}$ appears to be Mach number dependent, and no general trends were observed for induced lift on the wing alone.

To show the effect of thrust vectoring on the nozzle pitching moment coefficient $C_{m,n}$, incremental pitch characteristics are given in figure 13 for both the dry power configuration and the A/B power configuration with canards on. The canard-off $C_{m,n}$ data showed similar trends and, thus, are presented only in the tables. Incremental pitching moment data ($\Delta C_{m,n}$) are presented as functions of thrust vector angle for an angle of attack of 0° and Mach numbers of 0.60, 0.90, and 1.20. Incremental pitch is the computed difference between the nozzle pitching moment coefficient at a particular nozzle pressure ratio and the nozzle pitching moment coefficient at jet-off conditions, and is essentially the pitching moment due to vectored jet operation.

Effect of Canards

Jet-off characteristics.- The effect of fixed canards on the thrust-removed wing-afterbody-nozzle lift and drag data at jet-off conditions is presented in figure 14. Only the dry power results are plotted, since data for the A/B power configuration showed similar canard effects. Note that these results were measured on the wing-afterbody-nozzle and reflect only the aerodynamic interference effect of the nonmetric part of the model (forebody plus fixed canard), since the exhaust jet is off. There is a loss in wing-afterbody-nozzle lift when the canard is installed due to the canard downwash flow field on the wing. For a more realistic fuselage-wing-canard configuration with a variable-incidence canard, this loss in wing lift would be compensated for by a comparable increase in canard lift at low angles of attack. Results similar to those of figure 14 are presented in figure 15 for the thrust-removed wing-afterbody characteristics and indicate that the interference effects for a fixed canard are felt primarily on the wing (for example, compare figs. 14(a) and 15(a)).

Comparison with theory.- A comparison of the jet-off wing-afterbody-nozzle experimental lift ($C_L = C_{L,aero}$ at jet off) with theoretical wing-afterbody-nozzle lift at $M = 0.60$ and $\delta_v = 0°$ is presented in figure 16. Drag polars are also compared in this figure. The lift curve for potential flow on the wing-afterbody-nozzle ($C_{L,p,w}$) was predicted by the method of reference 15. The lift curves for vortex-lift theory were computed by the method of reference 16. A description of the computational procedure used in this comparison is given in reference 17. This method has the capability of computing lift for a multiplanform configuration. Consequently, the complete model geometry, including both metric and nonmetric sections, was used in the lift computation. The first planform included that part of the model from the nose (FS 0.00) to the first metric break (FS 99.06); the second planform consisted of that part of the model from the first metric break to the end of the nozzle. In this comparison, only the theoretical results on the wing-afterbody-nozzle are discussed.

The lift curves in figure 16 show good agreement between experimental data and theory up to an angle of attack of about 10° for the canard-on case. The comparison between the theoretical and experimental results for the canard-off case probably indicates that there is little or no vortex lift being developed on the wing. This result is probably due to the camber, twist, and leading-edge sweep of the wing and to the leading-edge radius. However, the theory does predict the loss in wing lift due to the addition of the canard.

The comparison between experimental and theoretical drag curves is not as good as the lift curve comparisons. Theoretical drag polars were computed for both zero and full leading-edge suction. The experimental drag polars should be similar to the theoretical drag polars for zero leading-edge suction if the wing has a sharp leading edge and is uncambered. However, in this case, the wing has a small leading-edge radius, camber, and twist so that a suction distribution is produced, but it is below the level of full leading-edge suction. Thus, the experimental drag polar data lie in between the theoretical predictions for zero and full leading-edge suction.

Jet-on characteristics.- Selected cases of jet-on data are presented in figure 17 to show the effects of canards and thrust vectoring on the thrust-removed wing-afterbody aerodynamic data. These cases are typical of the experimental results at other Mach numbers and nozzle pressure ratios. The lift curves show the same canard effect discussed previously, that is, a reduction in wing-body lift when the canard is installed.

To summarize the effects of the fixed canard installation on thrust vectoring, incremental lift characteristics are presented in figure 18 for both the dry power and A/B power configurations. In this case, incremental lift is the difference between lift at $\delta_v > 0°$ and lift at $\delta_v = 0°$ for the wing-afterbody. The results indicate that installing the canard had only small effects on the incremental lift due to thrust vectoring. These results are consistent with the results presented in reference 14 for a configuration with an aft-swept wing. Reference 14 also indicated little or no effect on incremental lift for an aft-swept wing-body configuration with the nonmetric canard at deflections of $\pm 5°$.

CONCLUDING REMARKS

An investigation has been conducted in the Langley 16-Foot Transonic Tunnel to determine the aeropropulsive characteristics of twin single-expansion-ramp nozzles installed in a wing-body configuration with forward-swept wings. The configuration was tested with and without canards. The test conditions included free-stream Mach numbers of 0.60, 0.90, and 1.20, an angle-of-attack range from -2° to 14°, and a nozzle-pressure-ratio range from 1.0 (jet off) to 9.0. The Reynolds number based on the wing mean aerodynamic chord varied from 3.0×10^6 to 4.8×10^6, depending on Mach number.

The aerodynamic data were analyzed to determine the effects of thrust vectoring and the effects of the canard. Thrust vectoring had no effect on the angle of attack for the onset of flow separation on the wing but resulted in reduced drag at angle-of-attack values above that required for wing flow separation. Results indicate that thrust vectoring had a favorable effect at all test conditions on the wing-afterbody-nozzle lift but was less favorable on the wing-afterbody lift. Most of the induced lift due to vectoring occurred on the nozzle and interfairing, not on the wing. Finally, the canard was found to have little effect on the thrust-induced lift resulting from vectoring, since canard effects occurred primarily on the wing.

Langley Research Center
National Aeronautics and Space Administration
Hampton, VA 23665
February 10, 1983

APPENDIX

DATA REDUCTION AND CALIBRATION PROCEDURE

Calibration Procedure

The main balance measured the combined forces and moments due to nozzle gross thrust and the external flow field of that portion of the model aft of FS 99.06. The thrust balance measured forces and moments due to the nozzle gross thrust and the external flow field exerted over the nozzle boattail and interfairing aft of FS 132.08. Because the center lines of the force balances are located above and below the jet center line (fig. 4), force and moment interactions exist between the bellows-flow transfer system (fig. 5) and the force balances.

Consequently, single and combined calibration loadings of normal and axial force and pitching moment were made with the completely assembled model installed in the tunnel. In addition, with wedge nozzle 1 of reference 11 installed, loads were applied to the model with the jet operating. This wedge nozzle was used instead of the ASME-type calibration nozzles used previously (ref. 11) because of the availability of a calibration fixture upon which loadings could be made separately to each balance with the model fully assembled. Use of the ASME-type nozzles would have necessitated complete disassembly of the model, which could have altered some of the calibration results. The calibration results with the wedge nozzle agreed with previous data within 1/2 percent on sonic nozzle discharge coefficient, and within force balance accuracy on forces and moments.

The calibrations were performed with the jets operating because this condition gives a more realistic effect of pressurizing the bellows than does capping off the nozzles and pressurizing the flow system. However, loadings were also done in the axial-force direction with the flow system capped off and pressurized, and this method indicated no effect on the axial force measured by the main balance. Thus, in addition to the usual balance interaction corrections applied for a single force balance under combined loads, another set of interactions were made to the data from this investigation to account for the combined loading effect of the balance with the bellows system. These calibrations were performed over a range of expected normal forces and pitching moments. The interactions can be determined by either single or combined loadings.

Data Adjustments

In order to achieve desired axial-force-minus-thrust terms, the axial forces measured by both force balances must also be corrected for pressure-area tare forces acting on the model and for momentum tare forces caused by flow in the bellows. The external seal and internal pressure forces on the model were obtained by multiplying the difference between the average pressure (external seal or internal pressures) and free-stream static pressure by the affected projected area normal to the model axis. The momentum tare force was determined from calibrations using the wedge nozzle prior to the wind tunnel investigation.

Axial force minus thrust was computed from the main balance axial force from the following relationship:

$$F_A - F_j = F_{A,Mbal} + (\bar{p}_{es,1} - p_\infty)(A_{mb,1} - A_{seal,1}) + (\bar{p}_i - p_\infty)A_{seal,1} - F_{A,mom}$$

where $F_{A,Mbal}$ includes all pressure and viscous forces, internal and external, on both the afterbody and thrust system. The second and third terms account for the forward seal rim and interior pressure forces, respectively. In terms of an axial-force coefficient, the second term ranges from -0.0001 to -0.0007, and the third term varies ±0.0075, depending upon Mach number and pressure ratio. The internal pressure at any given set of test conditions was uniform throughout the inside of the model, thus indicating no cavity flow. The momentum tare force $F_{A,mom}$ is a momentum tare correction with jets operating and is a function of the average bellows internal pressure, which is a function of the internal chamber pressure in the supply pipes just ahead of the sonic nozzles (fig. 5). Although the bellows were designed to minimize momentum and pressurization tares, small bellows tares still exist with the jet on. These tares result from small pressure differences between the ends of the bellows when internal velocities are high and also from small differences in the forward and aft bellows spring constants when the bellows are pressurized.

Nozzle axial force minus thrust is computed from a similar relationship:

$$F_{A,n} - F_j = F_{A,Tbal} + (\bar{p}_{es,2} - p_\infty)(A_{mb,2} - A_{seal,2}) + (\bar{p}_i - p_\infty)A_{seal,2} + F_{A,mom}$$

where $F_{A,Tbal}$ includes nozzle thrust and the internal pressure forces acting on the thrust system.

Since both balances are offset from the model center line, similar adjustments are made to the pitching moments measured by both balances. These adjustments are necessary because both the pressure area and bellows momentum tare forces are assumed to act along the model center line. The pitching-moment tare is determined by multiplying the tare force by the appropriate moment arm and substracting the value from the measured pitching moments.

Thrust-Removed Characteristics

The resulting force and moment coefficients from the main balance include total lift coefficient C_L, drag-minus-thrust coefficient $C_{(D-F)}$, and total pitching moment coefficient C_m. Force and moment coefficients from the thrust balance are nozzle lift coefficient including thrust component $C_{L,n}$, nozzle drag-minus-thrust coefficient, $C_{(D_n-F)}$, and nozzle pitching moment coefficient $C_{m,n}$.

Thrust-removed aerodynamic force and moment coefficients for the entire model were obtained by determining the components of thrust in axial force, normal force, and pitching moment, and substracting these values from the measured total (aerodynamic-plus-thrust) forces and moments. These thrust components at forward speeds were determined from measured static data and were a function of the free-stream static and dynamic pressures. This procedure retains external flow effects on thrust in the thrust-removed aerodynamic coefficients. These effects can be large for SERN-type configurations. Thrust-removed aerodynamic coefficients are

$$C_{L,aero} = C_L - \text{Jet lift coefficient}$$

$$C_D = C_{(D-F)} + \text{Thrust coefficient}$$

APPENDIX

Thrust-removed coefficients for the wing body are obtained by simply combining the measured results from both force balances as follows:

$$C_{L,a} = C_L - C_{L,n}$$

$$C_{D,a} = C_{(D-F)} - C_{(D_n-F)}$$

$$C_{m,a} = C_m - C_{m,n}$$

It should be noted that the external aerodynamic forces on the nozzle (aft of FS 132.08) are also removed by this method.

REFERENCES

1. Tactical Aircraft Research and Technology - Volume I. NASA CP-2162, 1981.

2. Henderson, William P.; and Leavitt, Laurence D.: Stability and Control Characteristics of a Three-Surface Advanced Fighter Configuration at Angles of Attack up to 45°. NASA TM-83171, 1981.

3. Gloss, Blair B.; and McKinney, Linwood W.: Canard-Wing Lift Interference Related to Maneuvering Aircraft at Subsonic Speeds. NASA TM X-2897, 1973.

4. Re, Richard J.; and Capone, Francis J.: Longitudinal Aerodynamic Characteristics of a Fighter Model With a Close-Coupled Canard at Mach Numbers From 0.40 to 1.20. NASA TP-1206, 1978.

5. Capone, Francis J.: The Nonaxisymmetric Nozzle - It Is for Real. AIAA Paper 79-1810, Aug. 1979.

6. Huffman, Jarrett K.; and Fox, Charles H., Jr.: Subsonic Longitudinal and Lateral-Directional Static Aerodynamic Characteristics for a Model With Swept Back and Swept Forward Wings. NASA TM-74093, 1978.

7. Huffman, Jarrett K.; and Fox, Charles H., Jr.: The Effect of Canard Relative Size and Vertical Location on the Subsonic Longitudinal and Lateral-Directional Static Aerodynamic Characteristics for a Model With a Swept Forward Wing. NASA TM-78739, 1979.

8. Capone, Francis J.: Aeropropulsive Characteristics of Twin Nonaxisymmetric Vectoring Nozzles Installed With Forward-Swept and Aft-Swept Wings. NASA TP-1778, 1981.

9. Robinson, Michael R.; and Robinson, Douglas A.: Forward Swept Wing (FSW) Designs: A High Payoff Through Technology Integration. AIAA-80-1884, Aug. 1980.

10. Lander, J. A.; Nash, D. O.; and Palcza, J. Lawrence: Augmented Deflector Exhaust Nozzle (ADEN) Design for Future Fighters. AIAA Paper No. 75-1318, Sept.-Oct. 1975.

11. Capone, Francis J.: Static Performance of Five Twin-Engine Nonaxisymmetric Nozzles With Vectoring and Reversing Capability. NASA TP-1224, 1978.

12. Peddrew, Kathryn H., compiler: A User's Guide to the Langley 16-Foot Transonic Tunnel. NASA TM-83186, 1981.

13. Braslow, Albert L.; Hicks, Raymond M.; and Harris, Roy V., Jr.: Use of Grit-Type Boundary-Layer-Transition Trips on Wind-Tunnel Models. NASA TN D-3579, 1966.

14. Capone, Francis J.: Summary of Propulsive-Lift Research in the Langley 16-Ft. Transonic Tunnel. J. Aircr., vol. 13, no. 10, Oct. 1976, pp. 803-808.

15. Lamar, John E.: A Modified Multihopp Approach for Predicting Lifting Pressures and Camber Shape for Composite Planforms in Subsonic Flow. NASA TN-4427, 1968.

16. Lamar, John E.: Some Recent Applications of the Suction Analogy to Vortex-Lift Estimates. Aerodynamic Analyses Requiring Advanced Computers, Part II, NASA SP-347, 1975, pp. 985-1011.

17. Lamar, John E.; and Herbert, Henry E.: Production Version of the Extended NASA-Langley Vortex Lattice FORTRAN Computer Program - Volume I - User's Guide. NASA TM-83303, 1982.

TABLE I.- AERODYNAMIC CHARACTERISTICS FOR SERN, DRY POWER, CANARD ON

MACH	VEFR	NPR	ALPHA	CL	C(D-F)	CM	CLN	C(DN-F)	CMN	CLAERO	CDAERO	CMAERO	CLA	CDA	CMA
.601	.07	1.00	-2.02	.0566	.0380	-.0943	-.0024	.0071	.0027	.0566	.0380	-.0943	.0590	.0309	-.0970
.597	.03	1.00	-.02	.1619	.0370	-.1456	-.0058	.0071	.0072	.1619	.0370	-.1456	.1677	.0299	-.1528
.603	.06	1.00	1.98	.2809	.0425	-.2069	-.0065	.0073	.0065	.2809	.0425	-.2069	.2874	.0353	-.2134
.603	.07	1.00	3.98	.4053	.0538	-.2742	-.0056	.0074	.0022	.4053	.0538	-.2742	.4108	.0463	-.2764
.601	.07	1.00	5.97	.5281	.0704	-.3382	-.0064	.0077	.0010	.5281	.0704	-.3382	.5345	.0627	-.3392
.600	.09	1.00	7.98	.6577	.0965	-.4069	-.0057	.0088	-.0038	.6577	.0965	-.4069	.6633	.0877	-.4032
.598	.08	1.00	11.99	.8721	.1854	-.5366	-.0012	.0116	-.0221	.8721	.1854	-.5366	.8733	.1738	-.5145
.603	.08	1.00	14.54	.9818	.2599	-.6189	.0031	.0147	-.0376	.9818	.2599	-.6189	.9787	.2452	-.5813
.601	.12	2.01	-.03	.1655	-.1019	-.1809	.0031	-.1261	-.0275	.1719	.0346	-.1835	.1625	.0242	-.1534
.601	.09	2.01	3.99	.4247	-.0844	-.3184	.0151	-.1254	-.0392	.4216	.0514	-.3210	.4096	.0410	-.2792
.601	.09	2.02	7.98	.6975	-.0397	-.4659	.0305	-.1231	-.0585	.6847	.0971	-.4685	.6670	.0835	-.4074
.599	.09	2.02	11.99	.9240	.0524	-.6007	.0471	-.1152	-.0824	.9015	.1890	-.6032	.8770	.1676	-.5183
.597	.09	2.01	14.51	1.0470	.1293	-.6915	.0589	-.1111	-.1016	1.0186	.2648	-.6941	.9881	.2405	-.5899
.599	.10	3.51	-2.03	.0566	-.3029	-.1472	.0039	-.3192	-.0443	.0719	.0397	-.1367	.0527	.0163	-.1029
.599	.09	3.52	-.02	.1788	-.3050	-.2093	.0145	-.3221	-.0479	.1821	.0392	-.1987	.1643	.0171	-.1614
.598	.09	3.52	1.99	.3109	-.2998	-.2734	.0263	-.3226	-.0521	.3021	.0453	-.2628	.2846	.0228	-.2213
.600	.07	3.51	3.98	.4483	-.2858	-.3418	.0375	-.3199	-.0561	.4276	.0567	-.3312	.4108	.0341	-.2857
.598	.05	3.51	6.00	.5901	-.2675	-.4149	.0501	-.3201	-.0633	.5572	.0752	-.4043	.5399	.0526	-.3516
.598	.02	3.50	8.00	.7325	-.2387	-.4887	.0642	-.3168	-.0744	.6878	.1024	-.4781	.6683	.0782	-.4142
.596	.02	3.51	11.99	.9759	-.1457	-.6272	.0939	-.3088	-.0994	.9070	.1939	-.6165	.8820	.1631	-.5278
.600	.01	3.52	14.48	1.1082	-.0621	-.7204	.1131	-.2991	-.1197	1.0255	.2707	-.7098	.9951	.2370	-.6007
.604	-.11	5.01	-.05	.1751	-.5043	-.2042	.0122	-.5155	-.0389	.1851	.0367	-.2040	.1629	.0112	-.1653
.603	-.13	5.00	4.00	.4650	-.4844	-.3450	.0485	-.5155	-.0502	.4368	.0554	-.3447	.4165	.0311	-.2948
.604	-.15	5.01	7.99	.7624	-.4354	-.4910	.0879	-.5093	-.0692	.6967	.1013	-.4907	.6746	.0739	-.4218
.598	-.20	5.01	11.99	1.0190	-.3484	-.6281	.1310	-.5105	-.0908	.9138	.1936	-.6279	.8879	.1620	-.5374
.599	-.20	5.02	14.50	1.1565	-.2661	-.7180	.1593	-.5006	-.1110	1.0280	.2693	-.7178	.9973	.2345	-.6070
.600	10.01	1.02	-2.00	.0806	.0362	-.1570	.0261	.0092	-.0619	.0806	.0362	-.1570	.0545	.0270	-.0951
.601	9.99	1.02	-.00	.1883	.0366	-.2125	.0233	.0105	-.0611	.1883	.0366	-.2125	.1649	.0261	-.1514
.601	9.99	1.02	2.00	.3047	.0430	-.2732	.0214	.0122	-.0627	.3047	.0430	-.2732	.2833	.0308	-.2105
.602	10.01	1.02	4.01	.4350	.0560	-.3473	.0230	.0138	-.0712	.4350	.0560	-.3473	.4120	.0423	-.2761
.602	10.00	1.02	6.01	.5616	.0747	-.4166	.0236	.0156	-.0775	.5616	.0747	-.4166	.5379	.0591	-.3391
.601	10.00	1.02	8.00	.6921	.1019	-.4887	.0256	.0178	-.0867	.6921	.1019	-.4887	.6664	.0841	-.4020
.601	10.00	1.02	12.02	.9054	.1956	-.6173	.0302	.0249	-.1054	.9054	.1956	-.6173	.8752	.1707	-.5119
.599	9.99	1.02	14.50	1.0167	.2715	-.7016	.0343	.0304	-.1207	1.0167	.2715	-.7016	.9824	.2411	-.5808
.603	10.11	1.99	.02	.2611	-.0860	-.3738	.0828	-.1082	-.2155	.2417	.0420	-.3149	.1783	.0222	-.1583
.600	10.14	2.03	4.01	.5136	-.0682	-.5149	.0944	-.1089	-.2335	.4835	.0647	-.4525	.4192	.0407	-.2814
.599	10.13	1.99	8.00	.7818	-.0121	-.6628	.1064	-.0955	-.2559	.7442	.1138	-.6030	.6754	.0834	-.4069
.600	10.09	2.00	12.02	1.0136	.0873	-.8057	.1217	-.0835	-.2846	.9668	.2111	-.7453	.8919	.1707	-.5211
.600	10.05	2.00	14.52	1.1322	.1688	-.8974	.1325	-.0747	-.3066	1.0799	.2909	-.8369	.9997	.2436	-.5908
.602	10.06	3.49	-1.99	.2033	-.2807	-.4684	.1340	-.3028	-.3602	.1526	.0441	-.3070	.0694	.0221	-.1082

TABLE I.- Continued

MACH	VEFR	NPR	ALPHA	CL	C(D-F)	CM	CLN	C(DN-F)	CMN	CLAERO	CDAERO	CMAERO	CLA	CDA	CMA
.602	9.97	3.50	.01	.3275	-.2765	-.5333	.1452	-.2992	-.3674	.2653	.0470	-.3716	.1823	.0227	-.1659
.600	10.00	3.51	2.02	.4577	-.2691	-.6023	.1573	-.2974	-.3765	.3832	.0562	-.4384	.3004	.0284	-.2259
.599	9.98	3.49	4.02	.5964	-.2489	-.6748	.1683	-.2901	-.3851	.5111	.0719	-.5118	.4281	.0412	-.2897
.602	9.96	3.50	6.03	.7326	-.2224	-.7452	.1787	-.2801	-.3936	.6368	.0928	-.5835	.5539	.0577	-.3517
.600	9.99	3.50	8.00	.8734	-.1914	-.8242	.1920	-.2757	-.4086	.7658	.1233	-.6609	.6814	.0843	-.4156
.598	9.94	3.50	12.01	1.1208	-.0853	-.9692	.2195	-.2567	-.4401	.9911	.2218	-.8055	.9012	.1714	-.5292
.598	9.95	3.50	14.50	1.2479	.0015	-1.0618	.2369	-.2433	-.4607	1.1049	.3030	-.8980	1.0110	.2448	-.6012
.603	9.93	5.02	.02	.4421	-.4512	-.8023	.2547	-.4715	-.6316	.2839	.0669	-.4170	.1875	.0203	-.1707
.600	9.92	5.00	4.02	.7179	-.4162	-.9385	.2879	-.4573	-.6447	.5229	.0934	-.5512	.4300	.0411	-.2938
.600	9.92	5.00	8.02	1.0114	-.3467	-1.0872	.3208	-.4324	-.6643	.7819	.1470	-.7009	.6907	.0857	-.4229
.599	9.92	5.00	12.02	1.2632	-.2342	-1.2270	.3570	-.4051	-.6941	.9988	.2441	-.8391	.9062	.1709	-.5329
.600	9.92	5.00	14.54	1.4044	-.1379	-1.3261	.3800	-.3848	-.7160	1.1191	.3283	-.9380	1.0244	.2470	-.6101
.601	20.25	1.03	-2.00	.1083	.0391	-.2090	.0465	.0124	-.1117	.1083	.0391	-.2090	.0618	.0267	-.0973
.602	20.25	1.03	.01	.2174	.0407	-.2683	.0460	.0142	-.1149	.2174	.0407	-.2683	.1714	.0264	-.1534
.597	20.01	1.03	1.99	.3331	.0486	-.3297	.0446	.0171	-.1182	.3331	.0486	-.3297	.2886	.0316	-.2116
.600	20.05	1.03	3.99	.4617	.0633	-.4033	.0465	.0204	-.1278	.4617	.0633	-.4033	.4152	.0429	-.2756
.601	20.01	1.04	6.00	.5926	.0839	-.4776	.0480	.0233	-.1370	.5926	.0839	-.4776	.5446	.0605	-.3405
.602	20.06	1.04	8.00	.7221	.1129	-.5519	.0513	.0274	-.1496	.7221	.1129	-.5519	.6708	.0855	-.4023
.600	20.06	1.04	12.00	.9312	.2055	-.6718	.0517	.0343	-.1609	.9312	.2055	-.6718	.8796	.1712	-.5109
.599	20.00	1.04	14.52	1.0441	.2846	-.7568	.0543	.0404	-.1739	1.0441	.2846	-.7568	.9898	.2442	-.5829
.602	20.01	2.03	.03	.3393	-.0692	-.5518	.1524	-.0928	-.3903	.2954	.0601	-.4285	.1869	.0235	-.1615
.601	20.00	2.00	4.02	.5868	-.0373	-.6850	.1604	-.0803	-.4026	.5354	.0864	-.5648	.4264	.0430	-.2824
.600	19.99	2.00	8.01	.8544	.0208	-.8399	.1725	-.0649	-.4303	.7944	.1409	-.7193	.6820	.0857	-.4096
.599	20.03	2.00	12.01	1.0807	.1251	-.9797	.1838	-.0462	-.4589	1.0126	.2407	-.8594	.8970	.1713	-.5208
.602	19.99	2.01	14.52	1.2014	.2115	-1.0745	.1927	-.0348	-.4811	1.1275	.3246	-.9529	1.0087	.2463	-.5934
.602	20.02	3.50	-1.99	.3227	-.2452	-.7505	.2494	-.2677	-.6429	.1997	.0622	-.4172	.0733	.0225	-.1076
.601	20.02	3.52	.01	.4485	-.2389	-.8198	.2610	-.2612	-.6512	.3135	.0665	-.4835	.1874	.0223	-.1686
.601	20.02	3.52	2.03	.5755	-.2222	-.8827	.2700	-.2513	-.6567	.4304	.0774	-.5475	.3055	.0290	-.2259
.599	20.02	3.51	4.02	.7129	-.2004	-.9564	.2802	-.2423	-.6653	.5566	.0949	-.6201	.4324	.0419	-.2910
.600	20.02	3.51	6.03	.8499	-.1708	-1.0305	.2900	-.2304	-.6754	.6839	.1187	-.6946	.5598	.0596	-.3551
.603	20.01	3.52	8.03	.9910	-.1297	-1.1070	.3003	-.2160	-.6872	.8161	.1519	-.7732	.6907	.0862	-.4197
.602	20.01	3.51	12.01	1.2309	-.0158	-1.2504	.3212	-.1878	-.7186	1.0369	.2531	-.9166	.9097	.1720	-.5318
.601	20.02	3.51	14.52	1.3588	.0789	-1.3493	.3356	-.1692	-.7424	1.1530	.3392	-1.0152	1.0232	.2482	-.6069
.600	20.03	5.01	.03	.5929	-.3944	-1.1484	.3957	-.4076	-.9706	.3348	.0663	-.5399	.1972	.0132	-.1778
.600	20.04	4.99	4.03	.8676	-.3432	-1.2849	.4223	-.3755	-.9816	.5793	.0967	-.6791	.4453	.0323	-.3033
.600	20.01	5.01	8.04	1.1580	-.2645	-1.4439	.4551	-.3418	-1.0125	.8383	.1558	-.8355	.7030	.0773	-.4314
.600	20.02	5.02	12.03	1.4083	-.1401	-1.5909	.4844	-.3046	-1.0440	1.0586	.2583	-.9799	.9239	.1645	-.5469
.599	20.00	5.01	14.54	1.5461	-.0377	-1.6904	.5066	-.2794	-1.0725	1.1793	.3451	-1.0795	1.0395	.2418	-.6179
.903	.04	1.02	-2.01	.0299	.0490	-.1227	-.0012	.0026	.0058	.0299	.0490	-.1227	.0311	.0465	-.1285
.800	.04	1.02	.02	.1565	.0453	-.1924	-.0089	.0034	.0190	.1565	.0453	-.1924	.1653	.0419	-.2114

TABLE I.- Continued

MACH	VEFR	NPR	ALPHA	CL	C(D-F)	CM	CLN	C(DN-F)	CMN	CLAERO	CDAERO	CMAERO	CLA	CDA	CMA
.800	.01	1.02	4.01	.4511	.0679	-.3597	-.0186	.0026	.0314	.4511	.0679	-.3597	.4697	.0653	-.3911
.898	.04	1.02	6.01	.6266	.0972	-.4560	-.0198	.0045	.0301	.6266	.0972	-.4560	.6464	.0927	-.4861
.904	.05	1.00	8.00	.7589	.1470	-.5297	-.0207	.0097	.0255	.7589	.1470	-.5297	.7795	.1372	-.5552
.901	-.04	.98	12.00	.8690	.2454	-.5333	-.0322	.0205	.0406	.8690	.2454	-.5333	.9011	.2248	-.5739
.904	-.05	.96	14.50	.9760	.3256	-.6142	-.0362	.0259	.0415	.9760	.3256	-.6142	1.0122	.2998	-.6558
.899	-.08	3.53	.02	.1733	-.1054	-.2256	.0036	-.1447	-.0112	.1746	.0481	-.2209	.1697	.0394	-.2144
.901	.02	3.51	4.03	.4845	-.0796	-.4059	.0088	-.1427	-.0103	.4752	.0722	-.4012	.4757	.0631	-.3956
.899	-.13	3.51	8.01	.8074	-.0010	-.5859	.0232	-.1345	-.0345	.7875	.1500	-.5812	.7842	.1335	-.5514
.898	-.06	3.50	12.02	.9383	.1016	-.6117	.0274	-.1218	-.0339	.9079	.2512	-.6071	.9109	.2235	-.5778
.900	-.09	3.51	14.51	1.0557	.1856	-.7016	.0338	-.1138	-.0432	1.0189	.3332	-.6969	1.0219	.2994	-.6584
.903	-.10	5.00	-1.98	.0470	-.1912	-.1714	.0116	-.2312	-.0403	.0595	.0495	-.1713	.0354	.0400	-.1311
.903	.06	5.03	.00	.1848	-.1957	-.2585	.0176	-.2324	-.0421	.1891	.0473	-.2584	.1672	.0367	-.2164
.905	.09	5.06	2.01	.3333	-.1890	-.3436	.0208	-.2317	-.0377	.3290	.0547	-.3436	.3125	.0427	-.3058
.901	.03	4.96	4.01	.5064	-.1661	-.4464	.0322	-.2234	-.0550	.4938	.0730	-.4462	.4742	.0573	-.3914
.902	.08	5.07	6.01	.6838	-.1437	-.5345	.0336	-.2302	-.0440	.6623	.1018	-.5346	.6502	.0865	-.4904
.800	.00	5.01	8.01	.8310	-.0902	-.6187	.0478	-.2199	-.0692	.8014	.1510	-.6186	.7832	.1297	-.5495
.899	.08	5.00	12.03	.9647	.0134	-.6313	.0508	-.2047	-.0551	.9182	.2521	-.6312	.9139	.2181	-.5782
.900	-.05	5.00	14.52	1.0836	.0967	-.7152	.0577	-.2012	-.0519	1.0269	.3327	-.7151	1.0259	.2979	-.6633
.898	.07	7.03	.00	.1766	-.3256	-.2214	.0033	-.3597	.0027	.1835	.0423	-.2295	.1733	.0341	-.2241
.900	.05	7.03	4.01	.5032	-.2987	-.4036	.0236	-.3555	-.0017	.4845	.0667	-.4117	.4796	.0568	-.4019
.900	.04	7.00	8.02	.8398	-.2146	-.5846	.0493	-.3432	-.0228	.7958	.1467	-.5926	.7905	.1285	-.5618
.898	.05	7.01	12.01	.9889	-.1123	-.6141	.0688	-.3298	-.0275	.9194	.2473	-.6221	.9201	.2175	-.5866
.898	.05	6.99	14.51	1.1206	-.0263	-.7124	.0864	-.3222	-.0429	1.0355	.3299	-.7204	1.0342	.2958	-.6694
.900	9.98	1.05	-1.80	.0704	.0499	-.1797	.0205	.0029	-.0478	.0704	.0499	-.1797	.0498	.0470	-.1319
.898	9.99	1.05	.01	.1808	.0477	-.2432	.0139	.0032	-.0367	.1808	.0477	-.2432	.1668	.0445	-.2065
.900	9.99	1.05	2.05	.3221	.0550	-.3255	.0084	.0038	-.0291	.3221	.0550	-.3255	.3137	.0512	-.2964
.899	9.99	1.06	4.10	.4833	.0732	-.4198	.0076	.0052	-.0334	.4833	.0732	-.4198	.4757	.0679	-.3863
.898	10.00	1.05	6.02	.6453	.1020	-.5096	.0074	.0071	-.0378	.6453	.1020	-.5096	.6379	.0949	-.4717
.902	10.00	1.03	8.10	.7835	.1533	-.5816	.0005	.0125	-.0285	.7835	.1533	-.5816	.7830	.1408	-.5532
.902	9.99	1.02	12.05	.8809	.2502	-.5734	-.0147	.0241	-.0069	.8809	.2502	-.5734	.8956	.2261	-.5665
.899	10.00	1.00	14.58	.9907	.3322	-.6627	-.0147	.0307	-.0171	.9907	.3322	-.6627	1.0054	.3015	-.6456
.905	10.05	3.52	-.01	.2470	-.0866	-.4228	.0905	-.1306	-.2201	.2191	.0581	-.3504	.1565	.0439	-.2027
.899	9.99	3.52	4.03	.5547	-.0602	-.5935	.0929	-.1254	-.2167	.5163	.0838	-.5203	.4617	.0652	-.3769
.897	9.97	3.54	8.04	.8707	.0167	-.7604	.0992	-.1163	-.2268	.8217	.1595	-.6862	.7716	.1330	-.5337
.899	9.97	3.54	12.02	.9980	.1251	-.7775	.0959	-.0992	-.2133	.9395	.2635	-.7036	.9021	.2243	-.5642
.900	9.95	3.54	14.52	1.1074	.2093	-.8626	.0994	-.0896	-.2200	1.0431	.3446	-.7890	1.0081	.2988	-.6426
.900	9.93	5.02	-2.00	.1617	-.1675	-.4623	.1420	-.2118	-.3562	.0988	.0678	-.2891	.0197	.0443	-.1061
.901	9.92	5.00	.02	.2931	-.1644	-.5395	.1431	-.2061	-.3449	.2228	.0667	-.3680	.1500	.0417	-.1946
.902	9.93	5.00	2.05	.4405	-.1545	-.6181	.1440	-.2010	-.3344	.3620	.0740	-.4467	.2965	.0466	-.2837
.901	9.92	5.00	4.03	.5988	-.1340	-.7045	.1461	-.1960	-.3309	.5123	.0920	-.5327	.4527	.0620	-.3736

TABLE I.- Continued

MACH	VEFR	NPR	ALPHA	CL	C(D-F)	CM	CLN	C(DN-F)	CMN	CLAERO	CDAERO	CMAERO	CLA	CDA	CMA
.904	9.93	5.01	6.03	.7740	-.1000	-.7977	.1470	-.1904	-.3274	.6797	.1222	-.6261	.6270	.0904	-.4703
.900	9.93	5.00	8.01	.9222	-.0519	-.8715	.1914	-.1836	-.3301	.8202	.1678	-.6997	.7709	.1317	-.5415
.903	9.94	5.02	12.03	1.0520	.0581	-.8788	.1513	-.1637	-.3143	.9349	.2695	-.7070	.9007	.2218	-.5645
.899	9.94	4.99	14.52	1.1695	.1428	-.9683	.1617	-.1526	-.3302	1.0431	.3497	-.7963	1.0078	.2954	-.6381
.899	9.94	7.02	.02	.3011	-.2952	-.5436	.1511	-.3316	-.3515	.2295	.0541	-.3788	.1500	.0363	-.1921
.898	9.93	7.01	4.03	.6243	-.2613	-.7315	.1718	-.3135	-.3657	.5283	.0823	-.5663	.4525	.0523	-.3658
.899	9.93	6.98	8.02	.9581	-.1727	-.9068	.1847	-.2900	-.3706	.8388	.1611	-.7417	.7734	.1173	-.5362
.901	9.93	7.01	12.02	1.0937	-.0629	-.9111	.1899	-.2697	-.3501	.9517	.2618	-.7469	.9038	.2068	-.5611
.900	9.94	7.01	14.53	1.2112	.0238	-.9949	.2031	-.2692	-.3536	1.0548	.3427	-.8304	1.0081	.2930	-.6413
.892	20.05	1.06	-2.00	.0672	.0520	-.1984	.0371	.0070	-.0841	.0672	.0520	-.1984	.0301	.0450	-.1142
.901	20.02	1.07	-.01	.1933	.0495	-.2787	.0313	.0068	-.0746	.1933	.0495	-.2787	.1620	.0426	-.2041
.902	20.03	1.07	2.00	.3359	.0568	-.3638	.0289	.0085	-.0729	.3359	.0568	-.3638	.3071	.0483	-.2909
.900	20.03	1.07	4.00	.4960	.0757	-.4605	.0304	.0113	-.0821	.4960	.0757	-.4605	.4656	.0644	-.3784
.900	20.03	1.07	6.00	.6647	.1066	-.5557	.0290	.0143	-.0868	.6647	.1066	-.5557	.6357	.0923	-.4689
.900	20.04	1.06	8.01	.7974	.1559	-.6148	.0199	.0192	-.0747	.7974	.1559	-.6148	.7775	.1367	-.5401
.900	20.02	1.04	12.02	.9080	.2550	-.6208	.0079	.0305	-.0572	.9080	.2550	-.6208	.9001	.2244	-.5636
.901	19.97	1.02	14.51	1.0178	.3367	-.7093	.0076	.0374	-.0660	1.0178	.3367	-.7093	1.0102	.2993	-.6433
.901	19.99	3.54	.04	.3066	-.0680	-.5725	.1576	-.1084	-.3859	.2459	.0691	-.4214	.1490	.0404	-.1865
.900	19.99	3.49	4.02	.6002	-.0347	-.7354	.1559	-.0964	-.3745	.5316	.0955	-.5873	.4443	.0617	-.3609
.899	19.99	3.51	8.03	.9256	.0473	-.9073	.1550	-.0843	-.3716	.8473	.1733	-.7579	.7705	.1315	-.5358
.900	20.00	3.51	12.02	1.0576	.1563	-.9245	.1492	-.0666	-.3573	.9707	.2765	-.7751	.9084	.2228	-.5672
.901	19.97	3.52	14.52	1.1669	.2431	-1.0073	.1529	-.0543	-.3679	1.0748	.3596	-.8579	1.0139	.2974	-.6395
.901	19.97	5.01	-1.98	.2350	-.1380	-.6522	.2281	-.1771	-.5615	.1276	.0706	-.3819	.0069	.0391	-.0908
.901	19.98	5.00	.02	.3679	-.1346	-.7307	.2301	-.1694	-.5549	.2538	.0693	-.4616	.1379	.0348	-.1758
.903	19.99	5.01	2.05	.5086	-.1220	-.8111	.2295	-.1607	-.5453	.3876	.0771	-.5426	.2791	.0387	-.2658
.900	19.97	4.99	4.02	.6641	-.1006	-.8956	.2321	-.1560	-.5436	.5358	.0951	-.6260	.4320	.0554	-.3520
.901	19.97	5.00	6.03	.8353	-.0655	-.9846	.2313	-.1476	-.5392	.7005	.1252	-.7156	.6039	.0821	-.4455
.900	19.97	5.01	8.02	.9950	-.0154	-1.0653	.2300	-.1415	-.5307	.8529	.1714	-.7948	.7650	.1260	-.5346
.897	19.98	4.99	12.03	1.1413	.0981	-1.0846	.2279	-.1181	-.5179	.9863	.2749	-.8137	.9134	.2162	-.5667
.900	19.98	5.01	14.54	1.2436	.1882	-1.1566	.2311	-.1010	-.5227	1.0811	.3578	-.8859	1.0125	.2892	-.6339
1.202	-.10	.77	-2.01	-.0291	.1151	-.0657	.0119	.0515	-.0199	-.0291	.1151	-.0657	-.0410	.0636	-.0458
1.202	-.10	.77	.01	.0894	.1103	-.1505	.0067	.0506	-.0117	.0894	.1103	-.1505	.0827	.0597	-.1388
1.200	-.11	.78	2.00	.2235	.1146	-.2515	.0041	.0496	-.0107	.2235	.1146	-.2515	.2193	.0650	-.2408
1.201	-.11	.80	4.01	.3672	.1311	-.3733	.0071	.0495	-.0231	.3672	.1311	-.3733	.3600	.0816	-.3502
1.201	-.11	.80	6.03	.5099	.1595	-.4937	.0097	.0513	-.0325	.5099	.1595	-.4937	.5002	.1082	-.4611
1.200	-.11	.80	8.01	.6379	.1976	-.5986	.0090	.0537	-.0389	.6379	.1976	-.5986	.6289	.1439	-.5597
1.199	-.11	.77	12.02	.8692	.2986	-.7618	-.0003	.0579	-.0321	.8692	.2986	-.7618	.8695	.2407	-.7297
1.201	-.14	5.01	.01	.0950	-.0322	-.1759	.0185	-.0892	-.0364	.0973	.1044	-.1759	.0764	.0570	-.1396
1.201	-.08	4.99	4.02	.3918	-.0080	-.4185	.0369	-.0868	-.0694	.3846	.1278	-.4184	.3549	.0789	-.3491
1.201	-.15	5.03	8.02	.6809	.0606	-.6607	.0519	-.0810	-.0985	.6642	.1970	-.6607	.6290	.1416	-.5623

TABLE I.- Concluded

MACH	VEFR	NPR	ALPHA	CL	C(D-F)	CM	CLN	C(DN-F)	CMN	CLAERO	CDAERO	CMAERO	CLA	CDA	CMA
1.197	-.16	4.99	12.03	.9320	.1674	-.8480	.0603	-.0712	-.1166	.9058	.3019	-.8479	.8717	.2386	-.7314
1.200	.07	7.01	-1.99	-.0177	-.1002	-.1284	.0385	-.1601	-.0875	-.0067	.1050	-.1329	-.0563	.0599	-.0408
1.202	.04	6.98	.01	.1130	-.1035	-.2238	.0434	-.1583	-.0889	.1169	.1001	-.2282	.0696	.0548	-.1349
1.202	.04	7.00	2.02	.2619	-.0979	-.3361	.0507	-.1579	-.0961	.2586	.1063	-.3406	.2112	.0600	-.2401
1.202	.04	7.00	4.02	.4136	-.0797	-.4582	.0601	-.1554	-.1098	.4031	.1246	-.4627	.3534	.0757	-.3484
1.202	.04	7.00	6.02	.5622	-.0497	-.5802	.0697	-.1463	-.1260	.5446	.1539	-.5847	.4925	.0966	-.4542
1.201	.02	7.01	8.04	.7096	-.0078	-.7019	.0785	-.1464	-.1380	.6848	.1957	-.7064	.6311	.1386	-.5639
1.202	.02	7.02	12.03	.9602	.0993	-.8887	.0929	-.1367	-.1587	.9212	.3006	-.8932	.8673	.2360	-.7300
1.200	.10	9.01	.01	.1468	-.1750	-.3103	.0832	-.2309	-.1804	.1255	.0986	-.2698	.0636	.0559	-.1299
1.200	-.01	8.97	4.04	.4506	-.1474	-.5367	.1007	-.2255	-.1907	.4106	.1230	-.4969	.3499	.0781	-.3460
1.199	-.06	9.00	8.03	.7468	-.0746	-.7741	.1217	-.2157	-.2143	.6876	.1935	-.7337	.6252	.1410	-.5598
1.198	-.09	9.00	12.03	1.0043	.0351	-.9623	.1391	-.2016	-.2340	.9264	.2989	-.9219	.8652	.2367	-.7283
1.199	10.06	.81	-2.00	-.0093	.1212	-.1263	.0380	.0550	-.0899	-.0093	.1212	-.1263	-.0474	.0662	-.0364
1.199	10.07	.81	.02	.1139	.1165	-.2153	.0326	.0549	-.0807	.1139	.1165	-.2153	.0813	.0616	-.1346
1.199	10.07	.82	1.99	.2470	.1209	-.3132	.0287	.0542	-.0751	.2470	.1209	-.3132	.2183	.0668	-.2381
1.199	10.07	.85	4.02	.3903	.1372	-.4285	.0284	.0533	-.0785	.3903	.1372	-.4285	.3619	.0839	-.3501
1.199	10.07	.86	6.01	.5321	.1658	-.5462	.0284	.0545	-.0838	.5321	.1658	-.5462	.5036	.1112	-.4624
1.199	10.09	.86	8.01	.6680	.2065	-.6559	.0266	.0580	-.0867	.6680	.2065	-.6559	.6414	.1485	-.5693
1.199	9.90	5.00	.03	.1865	-.0108	-.4323	.1307	-.0721	-.3222	.1467	.1199	-.3354	.0558	.0613	-.1101
1.200	9.97	4.99	4.02	.4818	.0174	-.6663	.1431	-.0647	-.3411	.4333	.1444	-.5699	.3387	.0821	-.3251
1.200	9.98	5.01	8.03	.7673	.0908	-.8969	.1499	-.0534	-.3532	.7095	.2149	-.7995	.6174	.1441	-.5436
1.200	10.00	7.01	-2.00	.0495	-.0854	-.3124	.1193	-.1509	-.2906	.0162	.1118	-.2198	-.0698	.0655	-.0218
1.198	9.97	7.00	.01	.1874	-.0877	-.4265	.1315	-.1474	-.3100	.1470	.1087	-.3335	.0559	.0597	-.1164
1.199	9.97	7.00	2.01	.3331	-.0783	-.5435	.1431	-.1429	-.3272	.2860	.1163	-.4506	.1900	.0645	-.2162
1.198	9.98	7.00	4.03	.4927	-.0571	-.6752	.1543	-.1373	-.3457	.4388	.1359	-.5823	.3385	.0802	-.3295
1.198	9.97	7.00	6.03	.6409	-.0248	-.7949	.1610	-.1310	-.3537	.5802	.1663	-.7019	.4799	.1063	-.4411
1.198	9.97	7.01	8.05	.7867	.0196	-.9122	.1660	-.1212	-.3617	.7193	.2085	-.8192	.6207	.1408	-.5505
1.200	9.99	9.00	.03	.2128	-.1568	-.4851	.1613	-.2141	-.3705	.1461	.1037	-.3399	.0515	.0572	-.1146
1.201	9.97	9.02	4.02	.5145	-.1269	-.7149	.1818	-.2028	-.3891	.4294	.1288	-.5692	.3327	.0758	-.3258

TABLE II.- AERODYNAMIC CHARACTERISTICS FOR SERN, DRY POWER, CANARD OFF

MACH	VEER	NPR	ALPHA	CL	C(D-F)	CM	CLN	C(DN-F)	CMN	CLAERO	CDAERO	CMAERO	CLA	CDA	CMA
.597	.08	1.00	-2.00	.0373	.0407	-.0894	-.0006	.0084	-.0054	.0373	.0407	-.0894	.0380	.0323	-.0840
.597	.07	1.00	-.01	.1670	.0370	-.1535	-.0064	.0086	.0055	.1670	.0370	-.1535	.1733	.0284	-.1590
.599	.07	1.00	1.99	.3010	.0413	-.2233	-.0075	.0090	.0062	.3010	.0413	-.2233	.3085	.0323	-.2295
.598	.07	1.00	4.00	.4532	.0508	-.3112	-.0049	.0086	-.0021	.4532	.0508	-.3112	.4580	.0423	-.3091
.599	.06	1.00	6.00	.6060	.0663	-.4000	-.0013	.0090	-.0121	.6060	.0663	-.4000	.6074	.0572	-.3878
.598	.07	1.00	7.99	.7519	.0913	-.4797	.0035	.0111	-.0256	.7519	.0913	-.4797	.7484	.0802	-.4541
.601	.06	1.00	11.99	.9702	.1964	-.6228	.0099	.0187	-.0500	.9702	.1964	-.6228	.9603	.1777	-.5728
.597	.06	.99	14.50	1.0342	.2845	-.6871	.0008	.0203	-.0314	1.0342	.2845	-.6871	1.0335	.2642	-.6557
.599	.05	3.49	-.02	.1927	-.2995	-.2234	.0147	-.3210	-.0511	.1960	.0403	-.2131	.1780	.0214	-.1724
.600	.04	3.51	-2.00	.0474	-.2982	-.1480	.0059	-.3251	-.0517	.0625	.0439	-.1375	.0415	.0268	-.0963
.600	.03	3.51	1.99	.3536	-.2965	-.3094	.0294	-.3244	-.0610	.3448	.0456	-.2989	.3242	.0279	-.2484
.601	.02	3.51	3.99	.5098	-.2847	-.3912	.0417	-.3222	-.0670	.4891	.0559	-.3807	.4681	.0375	-.3242
.600	.02	3.50	5.98	.6736	-.2678	-.4792	.0558	-.3200	-.0760	.6412	.0719	-.4687	.6178	.0521	-.4032
.600	.02	3.49	7.99	.8353	-.2384	-.5604	.0721	-.3144	-.0901	.7912	.0985	-.5501	.7632	.0761	-.4703
.599	.02	3.49	12.00	1.0788	-.1284	-.7163	.1053	-.3016	-.1260	1.0110	.2060	-.7059	.9736	.1732	-.5903
.603	.03	3.50	14.51	1.1713	-.0303	-.8024	.1153	-.2924	-.1223	1.0896	.2978	-.7921	1.0560	.2621	-.6801
.600	10.00	1.01	-2.00	.0681	.0410	-.1505	.0232	.0065	-.0648	.0681	.0410	-.1505	.0449	.0345	-.0857
.600	10.00	1.02	-.01	.1997	.0384	-.2227	.0208	.0077	-.0621	.1997	.0384	-.2227	.1789	.0307	-.1606
.600	9.99	1.02	2.00	.3350	.0442	-.2942	.0197	.0089	-.0629	.3350	.0442	-.2942	.3152	.0352	-.2313
.601	9.99	1.02	4.01	.4876	.0545	-.3846	.0235	.0110	-.0748	.4876	.0545	-.3846	.4641	.0435	-.3098
.602	10.00	1.02	5.98	.6401	.0722	-.4742	.0269	.0138	-.0855	.6401	.0722	-.4742	.6132	.0585	-.3887
.600	10.00	1.01	8.00	.7879	.1001	-.5506	.0311	.0177	-.0962	.7879	.1001	-.5506	.7568	.0825	-.4544
.600	10.00	1.01	12.00	.9956	.2052	-.6793	.0331	.0276	-.1099	.9956	.2052	-.6793	.9625	.1776	-.5694
.597	10.01	1.00	14.50	1.0657	.2942	-.7526	.0250	.0295	-.0964	1.0657	.2942	-.7526	1.0407	.2647	-.6562
.600	10.00	3.51	-2.01	.1769	-.2797	-.4478	.1275	-.3012	-.3515	.1256	.0487	-.2845	.0494	.0215	-.0963
.600	9.98	3.52	.01	.3308	-.2811	-.5390	.1419	-.2992	-.3640	.2675	.0475	-.3747	.1889	.0181	-.1750
.600	9.98	3.51	2.01	.4843	-.2689	-.6218	.1535	-.2927	-.3719	.4100	.0556	-.4583	.3308	.0238	-.2499
.599	9.97	3.51	4.00	.6404	-.2533	-.7081	.1670	-.2858	-.3839	.5545	.0698	-.5439	.4734	.0325	-.3242
.600	9.97	3.50	6.04	.8054	-.2284	-.7973	.1786	-.2774	-.3919	.7085	.0899	-.6340	.6268	.0491	-.4055
.599	9.98	3.51	8.00	.9563	-.1989	-.8730	.1928	-.2743	-.4065	.8480	.1176	-.7087	.7635	.0753	-.4665
.598	9.97	3.50	12.02	1.2076	-.0821	-1.0204	.2145	-.2535	-.4237	1.0775	.2260	-.8561	.9931	.1714	-.5967
.599	9.97	3.51	14.51	1.2958	.0153	-1.0995	.2231	-.2471	-.4183	1.1522	.3179	-.9350	1.0728	.2624	-.6812
.601	20.00	1.03	-2.02	.0736	.0421	-.1817	.0430	.0108	-.1058	.0736	.0421	-.1817	.0306	.0313	-.0759
.602	20.00	1.04	.00	.2149	.0398	-.2699	.0459	.0136	-.1173	.2149	.0398	-.2699	.1689	.0262	-.1527
.599	19.99	1.04	2.00	.3535	.0461	-.3457	.0459	.0157	-.1215	.3535	.0461	-.3457	.3077	.0304	-.2242
.602	20.00	1.04	3.99	.5035	.0590	-.4374	.0500	.0194	-.1360	.5035	.0590	-.4374	.4535	.0397	-.3014
.603	20.00	1.04	5.99	.6521	.0768	-.5202	.0504	.0231	-.1419	.6521	.0768	-.5202	.6017	.0537	-.3783
.601	20.00	1.03	7.99	.7933	.1037	-.5897	.0507	.0269	-.1457	.7933	.1037	-.5897	.7427	.0768	-.4439
.602	20.00	1.03	11.99	1.0043	.2085	-.7170	.0504	.0361	-.1556	1.0043	.2085	-.7170	.9539	.1724	-.5614
.602	20.00	1.03	14.51	1.0773	.2993	-.8001	.0467	.0403	-.1538	1.0773	.2993	-.8001	1.0306	.2591	-.6464

TABLE II.- Continued

MACH	VEER	NPR	ALPHA	CL	C(D-F)	CM	CLN	C(DN-F)	CMN	CLAERO	CDAERO	CMAERO	CLA	CDA	CMA
.599	19.96	3.49	-1.99	.2934	-.2431	-.7262	.2424	-.2605	-.6286	.1704	.0647	-.3926	.0510	.0174	-.0976
.601	19.99	3.52	.02	.4498	-.2398	-.8237	.2586	-.2554	-.6480	.3149	.0655	-.4875	.1912	.0156	-.1756
.600	19.99	3.50	2.01	.6036	-.2230	-.9023	.2682	-.2471	-.6538	.4592	.0758	-.5683	.3354	.0241	-.2485
.600	19.99	3.50	4.00	.7557	-.2018	-.9872	.2781	-.2364	-.6621	.6009	.0918	-.6531	.4776	.0346	-.3251
.601	19.97	3.50	6.00	.9152	-.1734	-1.0776	.2912	-.2244	-.6787	.7506	.1141	-.7441	.6240	.0510	-.3989
.600	19.97	3.49	8.01	1.0704	-.1376	-1.1530	.2992	-.2127	-.6850	.8956	.1444	-.8190	.7712	.0750	-.4680
.600	19.98	3.50	12.01	1.3175	-.0173	-1.2926	.3138	-.1893	-.6950	1.1236	.2516	-.9590	1.0037	.1720	-.5976
.601	19.98	3.51	14.53	1.4027	.0840	-1.3707	.3172	-.1779	-.6840	1.1965	.3447	-1.0360	1.0855	.2619	-.6867
.902	-.04	1.03	-2.01	.0025	.0533	-.1068	.0014	.0015	-.0023	.0025	.0533	-.1068	.0011	.0519	-.1045
.905	-.03	1.03	-.00	.1497	.0465	-.1945	-.0114	.0015	.0246	.1497	.0465	-.1945	.1611	.0450	-.2191
.899	-.06	1.02	2.01	.3192	.0490	-.2809	-.0192	.0025	.0374	.3192	.0490	-.2809	.3384	.0464	-.3183
.899	-.07	1.03	4.00	.4983	.0644	-.3841	-.0193	.0020	.0341	.4983	.0644	-.3841	.5176	.0624	-.4181
.898	-.06	1.03	6.01	.6849	.0946	-.5001	-.0128	.0033	.0168	.6849	.0946	-.5001	.6977	.0914	-.5168
.903	-.08	1.03	8.02	.8289	.1453	-.6048	.0007	.0109	-.0167	.8289	.1453	-.6048	.8283	.1343	-.5882
.902	.10	4.99	-2.01	.0205	-.1844	-.1648	.0171	-.2284	-.0561	.0331	.0562	-.1647	.0033	.0440	-.1088
.895	.06	4.96	.01	.1928	-.1947	-.2746	.0258	-.2282	-.0622	.1970	.0484	-.2744	.1670	.0335	-.2124
.899	.06	5.01	2.02	.3697	-.1900	-.3798	.0277	-.2301	-.0541	.3654	.0539	-.3797	.3420	.0401	-.3256
.897	.04	4.99	4.01	.5569	-.1734	-.4861	.0392	-.2260	-.0681	.5441	.0702	-.4859	.5177	.0525	-.4180
.904	.05	5.04	6.03	.7497	-.1389	-.6030	.0468	-.2245	-.0720	.7284	.1035	-.6030	.7029	.0856	-.5310
.900	.06	5.00	8.02	.9057	-.0870	-.7056	.0649	-.2118	-.1025	.8761	.1536	-.7054	.8408	.1248	-.6030
.902	10.03	1.04	-2.00	.0295	.0569	-.1534	.0208	.0035	-.0497	.0295	.0569	-.1534	.0088	.0534	-.1037
.900	10.02	1.05	-.00	.1843	.0493	-.2487	.0127	.0037	-.0344	.1843	.0493	-.2487	.1715	.0456	-.2143
.899	10.02	1.06	1.99	.3473	.0537	-.3428	.0070	.0036	-.0247	.3473	.0537	-.3428	.3403	.0501	-.3181
.900	10.03	1.06	3.99	.5265	.0701	-.4476	.0079	.0042	-.0292	.5265	.0701	-.4476	.5186	.0659	-.4184
.899	10.04	1.06	6.00	.7079	.1003	-.5516	.0096	.0061	-.0365	.7079	.1003	-.5516	.6983	.0942	-.5151
.898	10.04	1.05	7.98	.8546	.1488	-.6491	.0203	.0125	-.0623	.8546	.1488	-.6491	.8342	.1362	-.5868
.898	10.04	1.05	8.54	.8809	.1637	-.6614	.0207	.0151	-.0641	.8809	.1637	-.6614	.8602	.1486	-.5972
.900	9.96	5.02	-1.98	.1315	-.1631	-.4379	.1388	-.2094	-.3504	.0685	.0724	-.2644	-.0073	.0463	-.0875
.899	9.96	5.00	.01	.2920	-.1656	-.5383	.1431	-.2055	-.3444	.2212	.0669	-.3657	.1489	.0398	-.1939
.899	9.96	5.02	2.01	.4653	-.1590	-.6392	.1450	-.2019	-.3363	.3860	.0716	-.4657	.3202	.0429	-.3029
.901	9.96	5.01	4.01	.6461	-.1368	-.7365	.1458	-.1971	-.3289	.5594	.0895	-.5643	.5002	.0603	-.4076
.900	9.95	5.00	6.01	.8361	-.1041	-.8372	.1489	-.1912	-.3268	.7417	.1191	-.6651	.6872	.0871	-.5104
.901	9.96	5.01	7.10	.9208	-.0775	-.8890	.1542	-.1864	-.3341	.8223	.1435	-.7172	.7667	.1089	-.5549
.901	20.01	1.06	-2.03	.0295	.0583	-.1714	.0326	.0052	-.0766	.0295	.0583	-.1714	-.0031	.0531	-.0948
.902	20.03	1.07	-.00	.1883	.0511	-.2786	.0294	.0059	-.0718	.1883	.0511	-.2786	.1588	.0452	-.2068
.902	20.02	1.07	1.98	.3589	.0560	-.3850	.0281	.0076	-.0712	.3589	.0560	-.3850	.3308	.0484	-.3138
.900	20.02	1.07	3.99	.5374	.0733	-.4877	.0285	.0093	-.0759	.5374	.0733	-.4877	.5090	.0640	-.4118
.901	20.02	1.07	6.00	.7207	.1032	-.5917	.0283	.0114	-.0800	.7207	.1032	-.5917	.6924	.0918	-.5117
.900	20.02	1.07	8.00	.8622	.1512	-.6775	.0336	.0171	-.0947	.8622	.1512	-.6775	.8287	.1341	-.5828
.900	19.90	5.04	-1.97	.2043	-.1333	-.6238	.2225	-.1808	-.5521	.0958	.0771	-.3509	-.0182	.0475	-.0717

TABLE II.- Concluded

MACH	VEER	NPR	ALPHA	CL	C(D-F)	CM	CLN	C(DN-F)	CMN	CLAERO	CDAERO	CMAERO	CLA	CDA	CMA
.900	19.95	5.00	.04	.3638	-.1326	-.7298	.2255	-.1721	-.5466	.2494	.0716	-.4602	.1382	.0395	-.1832
.902	19.94	5.00	2.02	.5308	-.1229	-.8315	.2269	-.1663	-.5394	.4097	.0767	-.5624	.3039	.0434	-.2921
.901	19.93	5.00	4.01	.7124	-.1017	-.9296	.2302	-.1601	-.5379	.5845	.0935	-.6607	.4823	.0584	-.3917
.902	19.94	5.02	6.01	.9028	-.0685	-1.0303	.2306	-.1536	-.5325	.7673	.1231	-.7598	.6722	.0851	-.4979
1.200	-.07	.75	-2.00	-.0654	.1226	-.0192	.0040	.0549	-.0033	-.0654	.1226	-.0192	-.0694	.0681	-.0159
1.201	-.04	.75	-.00	.0722	.1146	-.1342	.0018	.0542	-.0021	.0722	.1146	-.1342	.0704	.0604	-.1321
1.201	-.09	.77	2.02	.2219	.1158	-.2598	.0027	.0528	-.0078	.2219	.1158	-.2598	.2192	.0630	-.2520
1.202	-.11	.78	4.01	.3706	.1298	-.3865	.0035	.0525	-.0134	.3706	.1298	-.3865	.3671	.0772	-.3731
1.201	-.09	.78	6.00	.5197	.1562	-.5130	.0023	.0539	-.0168	.5197	.1562	-.5130	.5174	.1023	-.4961
1.200	-.11	.78	8.00	.6714	.1952	-.6425	.0037	.0596	-.0254	.6714	.1952	-.6425	.6677	.1396	-.6171
1.201	.05	7.01	-1.99	-.0404	-.0946	-.0966	.0316	-.1543	-.0757	-.0294	.1104	-.1011	-.0720	.0597	-.0209
1.201	.04	7.01	.01	.1064	-.1026	-.2179	.0385	-.1536	-.0801	.1102	.1025	-.2224	.0679	.0510	-.1378
1.199	.03	7.00	2.02	.2631	-.1000	-.3453	.0462	-.1505	-.0867	.2597	.1056	-.3498	.2170	.0505	-.2586
1.199	.02	6.99	4.01	.4252	-.0832	-.4807	.0551	-.1487	-.0974	.4147	.1218	-.4852	.3701	.0655	-.3833
1.199	-.01	7.00	6.03	.5866	-.0539	-.6179	.0657	-.1460	-.1124	.5689	.1505	-.6224	.5209	.0920	-.5055
1.198	-.02	7.00	8.03	.7503	-.0121	-.7560	.0765	-.1431	-.1288	.7254	.1921	-.7605	.6738	.1311	-.6271
1.197	10.06	.82	-2.00	-.0303	.1233	-.0964	.0362	.0547	-.0859	-.0303	.1233	-.0964	-.0665	.0687	-.0104
1.200	10.00	.81	.01	.1056	.1167	-.2047	.0326	.0549	-.0794	.1056	.1167	-.2047	.0730	.0617	-.1253
1.199	10.00	.82	2.02	.2479	.1184	-.3175	.0297	.0538	-.0745	.2479	.1184	-.3175	.2182	.0646	-.2431
1.199	9.92	.85	4.02	.3998	.1325	-.4420	.0276	.0535	-.0726	.3998	.1325	-.4420	.3722	.0790	-.3694
1.199	9.90	.86	6.01	.5479	.1596	-.5680	.0265	.0547	-.0754	.5479	.1596	-.5680	.5215	.1049	-.4926
1.200	9.89	.87	8.01	.6935	.1986	-.6932	.0269	.0565	-.0824	.6935	.1986	-.6932	.6666	.1421	-.6108
1.198	10.02	6.98	-2.00	.0286	-.0812	-.2903	.1224	-.1486	-.3003	-.0048	.1158	-.1974	-.0937	.0674	.0100
1.200	10.02	7.00	.01	.1784	-.0850	-.4225	.1357	-.1443	-.3197	.1382	.1105	-.3299	.0427	.0593	-.1028
1.200	10.03	7.01	2.01	.3395	-.0790	-.5612	.1499	-.1394	-.3417	.2924	.1154	-.4685	.1896	.0603	-.2195
1.201	9.99	7.02	4.02	.5023	-.0599	-.7014	.1606	-.1333	-.3580	.4485	.1327	-.6090	.3417	.0734	-.3434
1.199	9.97	6.99	6.03	.6616	-.0282	-.8354	.1678	-.1259	-.3668	.6010	.1622	-.7426	.4938	.0977	-.4686

TABLE III.- AERODYNAMIC CHARACTERISTICS FOR SERN, A/B POWER, CANARD ON

MACH	VEFR	NPR	ALPHA	CL	C(D-F)	CM	CLN	C(DN-F)	CMN	CLAERO	CDAERO	CMAERO	CLA	CDA	CMA
.602	.08	.99	-2.00	.0470	.0385	-.0765	-.0062	.0146	.0245	.0470	.0385	-.0765	.0532	.0239	-.1010
.599	.09	.99	.00	.1557	.0368	-.1330	-.0087	.0142	.0261	.1557	.0368	-.1330	.1644	.0226	-.1591
.601	.10	.99	2.02	.2746	.0415	-.1971	-.0079	.0140	.0215	.2746	.0415	-.1971	.2825	.0275	-.2186
.600	.10	.99	4.02	.4058	.0524	-.2697	-.0066	.0136	.0164	.4058	.0524	-.2697	.4124	.0388	-.2860
.600	.10	.99	6.02	.5319	.0699	-.3334	-.0074	.0138	.0162	.5319	.0699	-.3334	.5393	.0561	-.3496
.600	.09	.99	7.99	.6570	.0967	-.3988	-.0072	.0150	.0136	.6570	.0967	-.3988	.6642	.0817	-.4123
.599	.10	.99	12.01	.8763	.1866	-.5336	-.0019	.0182	-.0057	.8763	.1866	-.5336	.8783	.1683	-.5279
.599	.10	.99	14.52	.9889	.2620	-.6233	.0041	.0226	-.0261	.9889	.2620	-.6233	.9848	.2394	-.5972
.601	.11	2.03	.01	.1619	-.1999	-.1631	-.0060	-.2234	.0080	.1812	.0365	-.1903	.1679	.0235	-.1711
.601	.08	2.00	4.03	.4304	-.1796	-.3001	.0109	-.2203	.0007	.4339	.0527	-.3283	.4195	.0407	-.3008
.600	.07	2.01	8.00	.7100	-.1354	-.4476	.0344	-.2197	-.0187	.6967	.1005	-.4754	.6756	.0843	-.4289
.598	.06	2.01	12.02	.9538	-.0407	-.5918	.0590	-.2136	-.0440	.9239	.1950	-.6198	.8948	.1728	-.5478
.598	.06	2.01	14.51	1.0731	.0373	-.6808	.0760	-.2059	-.0650	1.0331	.2708	-.7090	.9970	.2432	-.6158
.598	.07	3.50	-2.00	.0781	-.5179	-.1778	.0119	-.5393	-.0497	.0934	.0340	-.1605	.0663	.0215	-.1280
.601	.07	3.51	.02	.2087	-.5134	-.2388	.0303	-.5339	-.0538	.2044	.0336	-.2216	.1784	.0205	-.1850
.599	.06	3.50	2.02	.3474	-.5092	-.3030	.0487	-.5354	-.0566	.3241	.0399	-.2860	.2988	.0262	-.2464
.601	.05	3.50	4.02	.4967	-.4933	-.3756	.0675	-.5309	-.0618	.4543	.0524	-.3585	.4292	.0377	-.3138
.600	.05	3.50	6.02	.6453	-.4720	-.4470	.0864	-.5276	-.0681	.5839	.0719	-.4299	.5589	.0557	-.3789
.599	.05	3.50	8.01	.7948	-.4432	-.5229	.1078	-.5252	-.0807	.7144	.1001	-.5059	.6870	.0820	-.4422
.598	.04	3.50	12.02	1.0591	-.3434	-.6700	.1523	-.5151	-.1069	.9403	.1951	-.6529	.9068	.1717	-.5631
.601	.04	3.50	14.52	1.1906	-.2569	-.7596	.1807	-.5006	-.1287	1.0496	.2716	-.7425	1.0099	.2437	-.6308
.601	.02	5.02	.03	.1520	-.8442	-.0813	-.0354	-.8603	.1235	.2030	.0192	-.1940	.1874	.0161	-.2048
.597	-.03	5.00	4.03	.4659	-.8355	-.2195	.0254	-.8695	.1145	.4561	.0372	-.3324	.4406	.0340	-.3340
.600	-.02	5.01	8.03	.7903	-.7781	-.3677	.0870	-.8578	.0966	.7204	.0846	-.4801	.7033	.0796	-.4643
.601	-.08	5.01	12.01	1.0707	-.6764	-.5112	.1544	-.8456	.0689	.9411	.1787	-.6237	.9163	.1692	-.5801
.600	-.09	5.01	14.52	1.2225	-.5934	-.6068	.1993	-.8361	.0456	1.0553	.2566	-.7192	1.0232	.2427	-.6524
.599	10.60	1.00	-1.90	.0899	.0391	-.1450	.0163	.0126	-.0330	.0899	.0391	-.1450	.0736	.0265	-.1121
.600	10.60	1.00	.09	.1950	.0389	-.1969	.0125	.0134	-.0277	.1950	.0389	-.1969	.1825	.0255	-.1691
.600	10.60	1.00	2.11	.3146	.0458	-.2605	.0110	.0142	-.0283	.3146	.0458	-.2605	.3036	.0315	-.2322
.602	10.61	1.00	4.10	.4450	.0585	-.3349	.0142	.0153	-.0385	.4450	.0585	-.3349	.4308	.0432	-.2963
.600	10.60	1.00	6.11	.5739	.0773	-.4037	.0158	.0167	-.0447	.5739	.0773	-.4037	.5581	.0606	-.3590
.600	10.60	1.00	8.12	.7044	.1064	-.4752	.0169	.0187	-.0511	.7044	.1064	-.4752	.6875	.0877	-.4241
.599	10.15	1.00	12.12	.9168	.2002	-.6030	.0199	.0244	-.0659	.9168	.2002	-.6030	.8970	.1758	-.5371
.600	10.14	1.00	14.59	1.0226	.2756	-.6848	.0242	.0281	-.0813	1.0226	.2756	-.6848	.9984	.2475	-.6035
.601	10.14	2.04	.10	.2789	-.1859	-.3934	.0869	-.2110	-.2113	.2594	.0483	-.3282	.1920	.0251	-.1821
.602	10.14	2.02	4.12	.5465	-.1562	-.5332	.1030	-.1999	-.2225	.5120	.0715	-.4701	.4434	.0436	-.3107
.599	10.12	2.00	8.12	.8240	-.0997	-.6835	.1229	-.1903	-.2445	.7741	.1250	-.6211	.7011	.0906	-.4390
.603	10.11	2.02	12.12	1.0603	.0041	-.8289	.1453	-.1773	-.2753	.9942	.2249	-.7656	.9150	.1814	-.5535
.603	10.12	2.02	14.63	1.1781	.0865	-.9182	.1602	-.1679	-.2963	1.1021	.3050	-.8546	1.0179	.2545	-.6219
.599	9.87	3.52	-1.88	.2455	-.4984	-.5312	.1562	-.5236	-.3941	.1714	.0403	-.3104	.0893	.0252	-.1371

TABLE III.- Continued

MACH	VEFR	NPR	ALPHA	CL	C(D-F)	CM	CLN	C(DN-F)	CMN	CL AERO	CDAERO	CMAERO	CLA	CDA	CMA
.602	9.87	3.52	.13	.3692	-.4890	-.5843	.1712	-.5142	-.3917	.2771	.0425	-.3652	.1980	.0252	-.1926
.599	10.11	3.51	2.13	.5201	-.4773	-.6709	.1954	-.5093	-.4139	.4088	.0539	-.4505	.3246	.0320	-.2570
.599	10.12	3.51	4.13	.6647	-.4576	-.7421	.2126	-.5028	-.4191	.5349	.0699	-.5216	.4522	.0452	-.3229
.599	10.12	3.52	6.13	.8114	-.4313	-.8178	.2314	-.4948	-.4304	.6628	.0925	-.5966	.5800	.0635	-.3873
.600	10.12	3.52	8.12	.9646	-.3914	-.8974	.2513	-.4828	-.4432	.7985	.1248	-.6771	.7133	.0914	-.4543
.599	10.11	3.51	12.13	1.2210	-.2800	-1.0440	.2923	-.4614	-.4724	1.0186	.2253	-.8230	.9287	.1814	-.5716
.600	10.11	3.52	14.61	1.3582	-.1881	-1.1383	.3203	-.4434	-.4976	1.1344	.3071	-.9175	1.0379	.2553	-.6407
.600	10.12	5.02	.12	.4257	-.8067	-.6843	.2211	-.8294	-.4816	.3047	.0312	-.4211	.2045	.0227	-.2028
.600	10.08	5.02	4.13	.7280	-.7713	-.8183	.2741	-.8131	-.4871	.5485	.0573	-.5548	.4539	.0418	-.3312
.599	10.08	5.02	8.13	1.0522	-.7024	-.9752	.3333	-.7911	-.5108	.8149	.1132	-.7111	.7189	.0887	-.4644
.601	10.06	5.01	12.14	1.3317	-.5750	-1.1235	.3928	-.7555	-.5395	1.0402	.2155	-.8612	.9388	.1805	-.5840
.598	10.01	5.00	14.64	1.4822	-.4834	-1.2181	.4336	-.7390	-.5639	1.1546	.2984	-.9539	1.0486	.2557	-.6542
.600	20.03	1.00	-1.91	.1026	.0426	-.1692	.0252	.0147	-.0562	.1026	.0426	-.1692	.0775	.0279	-.1130
.601	20.04	1.00	.12	.2102	.0424	-.2229	.0219	.0156	-.0513	.2102	.0424	-.2229	.1883	.0268	-.1715
.601	20.04	.99	2.12	.3283	.0493	-.2821	.0193	.0165	-.0488	.3283	.0493	-.2821	.3091	.0328	-.2333
.601	20.04	1.00	4.11	.4583	.0630	-.3575	.0227	.0184	-.0603	.4583	.0630	-.3575	.4356	.0446	-.2972
.601	20.04	1.00	6.11	.5845	.0823	-.4266	.0244	.0203	-.0670	.5845	.0823	-.4266	.5601	.0621	-.3595
.601	20.05	1.00	8.12	.7222	.1130	-.5020	.0261	.0230	-.0744	.7222	.1130	-.5020	.6960	.0899	-.4276
.598	20.04	1.00	12.11	.9269	.2050	-.6211	.0270	.0285	-.0841	.9269	.2050	-.6211	.8998	.1765	-.5370
.598	20.03	1.00	14.62	1.0352	.2818	-.7037	.0311	.0327	-.0995	1.0352	.2818	-.7037	1.0041	.2491	-.6042
.601	20.05	2.01	.11	.3736	-.1536	-.5993	.1694	-.1797	-.4123	.3158	.0638	-.4520	.2041	.0262	-.1869
.601	20.02	2.02	4.10	.6361	-.1216	-.7410	.1852	-.1682	-.4274	.5628	.0921	-.5029	.4509	.0466	-.3136
.600	20.02	2.02	8.14	.9150	-.0587	-.8983	.2016	-.1525	-.4524	.8266	.1500	-.7497	.7134	.0937	-.4459
.598	20.02	2.01	12.13	1.1498	.0501	-1.0435	.2200	-.1333	-.4813	1.0468	.2531	-.8044	.9298	.1834	-.5622
.601	20.03	2.02	14.62	1.2600	.1359	-1.1252	.2312	-.1192	-.4996	1.1485	.3332	-.9765	1.0287	.2550	-.6256
.602	20.01	3.52	-1.88	.4005	-.4496	-.8808	.2993	-.4738	-.7354	.2342	.0571	-.4649	.1012	.0242	-.1454
.602	19.99	3.51	.14	.5269	-.4365	-.9431	.3151	-.4613	-.7395	.3435	.0622	-.5288	.2118	.0247	-.2036
.600	20.00	3.51	2.11	.6655	-.4208	-1.0149	.3325	-.4527	-.7479	.4641	.0739	-.5985	.3330	.0319	-.2670
.601	19.97	3.51	4.12	.8095	-.3944	-1.0877	.3494	-.4398	-.7566	.5908	.0930	-.6710	.4601	.0453	-.3311
.601	19.94	3.52	6.12	.9556	-.3612	-1.1624	.3643	-.4264	-.7641	.7200	.1182	-.7457	.5912	.0652	-.3983
.599	19.93	3.51	8.14	1.1106	-.3204	-1.2498	.3843	-.4135	-.7819	.8568	.1532	-.8308	.7263	.0931	-.4679
.603	19.98	3.52	12.13	1.3610	-.1920	-1.3925	.4146	-.3746	-.8086	1.0779	.2579	-.9780	.9464	.1827	-.5840
.601	19.99	3.52	14.64	1.4956	-.0958	-1.4893	.4379	-.3545	-.8329	1.1912	.3438	-1.0723	1.0577	.2587	-.6565
.598	20.00	5.02	.15	.7066	-.7118	-1.3355	.4416	-.7283	-1.0322	.3966	.0803	-.6726	.2650	.0165	-.3034
.599	20.00	4.71	4.12	.9737	-.5966	-1.4166	.4765	-.6380	-1.0175	.6395	.1141	-.8045	.4973	.0414	-.3990
.600	20.00	4.50	8.14	1.2537	-.4719	-1.5231	.5027	-.5638	-1.0066	.8942	.1748	-.9464	.7510	.0919	-.5165
.598	20.00	4.33	12.16	1.5048	-.3121	-1.6377	.5281	-.4969	-1.0076	1.1200	.2809	-1.0866	.9767	.1848	-.6301
.601	20.01	4.18	14.64	1.6117	-.1842	-1.6854	.5324	-.4448	-.9943	1.2233	.3636	-1.1619	1.0793	.2606	-.6911
.898	-.08	1.01	.03	.1809	.0485	-.2074	-.0036	.0056	.0160	.1809	.0485	-.2074	.1844	.0429	-.2234
.899	-.08	1.01	-2.01	.0520	.0514	-.1252	-.0007	.0058	.0111	.0520	.0514	-.1252	.0527	.0456	-.1362

TABLE III.- Continued

MACH	VEFR	NPR	ALPHA	CL	C(D-F)	CM	CLN	C(DN-F)	CMN	CLAERO	CDAERO	CMAERO	CLA	CDA	CMA
.900	-.08	1.01	-.00	.1782	.0483	-.2051	-.0038	.0060	.0172	.1782	.0483	-.2051	.1820	.0424	-.2223
.901	-.08	1.01	2.01	.3206	.0553	-.2908	-.0075	.0054	.0222	.3206	.0553	-.2908	.3280	.0499	-.3129
.901	-.08	1.02	4.02	.4760	.0715	-.3787	-.0085	.0049	.0219	.4760	.0715	-.3787	.4845	.0666	-.4005
.899	-.06	1.03	6.02	.6505	.1006	-.4834	-.0054	.0046	.0119	.6505	.1006	-.4834	.6559	.0960	-.4953
.800	-.06	1.02	8.01	.7933	.1482	-.5749	-.0011	.0090	-.0032	.7933	.1482	-.5749	.7943	.1391	-.5717
.898	-.07	1.00	12.02	.9288	.2512	-.6142	.0019	.0218	-.0173	.9288	.2512	-.6142	.9270	.2294	-.5969
.895	-.06	.98	14.51	1.0338	.3312	-.6948	-.0008	.0299	-.0190	1.0338	.3312	-.6948	1.0346	.3013	-.6758
.901	-.14	3.51	.02	.1921	-.1989	-.2456	.0152	-.2394	-.0225	.1901	.0451	-.2380	.1769	.0405	-.2232
.898	-.08	3.51	4.02	.5079	-.1765	-.4217	.0290	-.2392	-.0262	.4889	.0680	-.4140	.4789	.0628	-.3955
.898	-.10	3.50	8.04	.8428	-.0952	-.6133	.0501	-.2317	-.0487	.8067	.1469	-.6056	.7927	.1365	-.5646
.902	-.17	3.52	12.03	.9870	.0087	-.6567	.0668	-.2175	-.0620	.9341	.2478	-.6488	.9202	.2262	-.5947
.900	-.25	3.51	14.50	1.0996	.0888	-.7441	.0799	-.2079	-.0798	1.0366	.3250	-.7364	1.0198	.2968	-.6643
.900	-.11	5.01	-1.99	.0252	-.3476	-.0899	-.0277	-.3880	.0653	.0613	.0351	-.1398	.0529	.0404	-.1552
.899	-.12	5.01	.02	.1719	-.3539	-.1746	-.0173	-.3908	.0660	.1946	.0317	-.2249	.1891	.0369	-.2406
.899	-.11	5.02	2.02	.3276	-.3483	-.2606	-.0042	-.3908	.0617	.3370	.0385	-.3111	.3318	.0424	-.3223
.901	-.11	5.01	4.03	.5003	-.3276	-.3600	.0094	-.3882	.0547	.4960	.0565	-.4099	.4909	.0605	-.4148
.899	-.12	5.02	6.01	.6914	-.2998	-.4648	.0231	-.3902	.0474	.6738	.0871	-.5154	.6683	.0904	-.5123
.900	-.12	5.02	8.02	.8404	-.2488	-.5514	.0432	-.3831	.0241	.8094	.1357	-.6018	.7972	.1343	-.5755
.898	-.14	5.01	12.02	1.0065	-.1451	-.6065	.0750	-.3703	.0010	.9484	.2374	-.6567	.9315	.2252	-.6075
.899	-.14	5.00	14.52	1.1284	-.0608	-.6971	.0939	-.3585	-.0156	1.0540	.3169	-.7469	1.0344	.2978	-.6815
.901	-.08	7.03	.01	.2187	-.5442	-.2806	.0383	-.5761	-.0499	.2167	.0284	-.2846	.1804	.0319	-.2307
.898	-.11	7.01	4.03	.5624	-.5198	-.4617	.0747	-.5739	-.0574	.5202	.0537	-.4661	.4877	.0541	-.4043
.901	-.11	6.98	8.03	.9132	-.4271	-.6521	.1152	-.5542	-.0816	.8325	.1348	-.6571	.7980	.1271	-.5705
.898	-.11	6.99	12.05	1.0966	-.3207	-.7130	.1620	-.5468	-.1078	.9758	.2387	-.7179	.9346	.2262	-.6052
.900	-.13	7.03	14.52	1.2298	-.2352	-.8104	.1918	-.5310	-.1322	1.0843	.3189	-.8144	1.0380	.2958	-.6782
.898	9.90	1.03	-1.88	.0697	.0523	-.1732	.0180	.0060	-.0370	.0697	.0523	-.1732	.0517	.0463	-.1362
.900	9.90	1.03	.12	.1941	.0503	-.2499	.0130	.0061	-.0265	.1941	.0503	-.2499	.1812	.0442	-.2234
.898	9.91	1.03	2.11	.3367	.0574	-.3290	.0075	.0063	-.0169	.3367	.0574	-.3290	.3292	.0511	-.3121
.900	9.91	1.03	4.12	.4946	.0749	-.4181	.0047	.0059	-.0139	.4946	.0749	-.4181	.4899	.0690	-.4042
.898	9.92	1.04	6.10	.6678	.1046	-.5177	.0075	.0071	-.0234	.6678	.1046	-.5177	.6603	.0975	-.4942
.898	9.92	1.04	8.10	.8125	.1537	-.6064	.0098	.0104	-.0332	.8125	.1537	-.6064	.8026	.1432	-.5733
.898	9.93	1.01	12.11	.9418	.2572	-.6322	.0061	.0217	-.0331	.9418	.2572	-.6322	.9356	.2355	-.5991
.899	9.92	.99	14.61	1.0356	.3362	-.7025	.0030	.0296	-.0349	1.0356	.3362	-.7025	1.0326	.3066	-.6676
.902	9.87	3.53	.13	.2806	-.1837	-.4546	.1057	-.2275	-.2382	.2394	.0540	-.3565	.1750	.0438	-.2165
.803	9.87	3.51	4.13	.5945	-.1513	-.6325	.1163	-.2189	-.2400	.5373	.0811	-.5353	.4782	.0676	-.3925
.899	9.87	3.53	8.15	.9276	-.0694	-.8169	.1319	-.2108	-.2549	.8533	.1612	-.7184	.7957	.1414	-.5619
.898	9.87	3.52	12.13	1.0775	.0394	-.8550	.1430	-.1941	-.2587	.9872	.2646	-.7564	.9345	.2335	-.5963
.897	9.87	3.52	14.63	1.1851	.1225	-.9318	.1513	-.1824	-.2680	1.0850	.3438	-.8331	1.0338	.3050	-.6638
.901	9.42	5.03	-1.86	.1619	-.3321	-.4139	.1186	-.3751	-.2791	.1211	.0422	-.2970	.0433	.0429	-.1348
.900	9.40	5.03	.12	.3068	-.3310	-.5052	.1328	-.3710	-.2889	.2530	.0423	-.3880	.1740	.0401	-.2164

TABLE III.- Continued

MACH	VEFR	NPR	ALPHA	CL	C(D-F)	CM	CLN	C(DN-F)	CMN	CLAERO	CDAERO	CMAERO	CLA	CDA	CMA
.898	10.08	5.02	2.11	.4777	-.3159	-.6364	.1605	-.3623	-.3332	.4108	.0555	-.5190	.3172	.0464	-.3032
.900	10.07	5.01	4.12	.6442	-.2910	-.7322	.1701	-.3550	-.3369	.5647	.0764	-.6152	.4740	.0639	-.3954
.901	10.04	5.02	6.13	.8260	-.2564	-.8267	.1794	-.3488	-.3402	.7337	.1079	-.7098	.6466	.0924	-.4865
.897	10.06	5.01	8.15	.9902	-.2049	-.9139	.1907	-.3424	-.3461	.8845	.1580	-.7962	.7995	.1375	-.5678
.899	10.12	5.02	12.14	1.1449	-.0928	-.9409	.2063	-.3239	-.3389	1.0144	.2614	-.8236	.9386	.2311	-.6020
.901	10.14	5.03	14.62	1.2586	-.0059	-1.0153	.2155	-.3104	-.3355	1.1133	.3416	-.8983	1.0431	.3045	-.6798
.800	10.11	7.02	.12	.3580	-.5157	-.6128	.1899	-.5538	-.3953	.2680	.0366	-.4337	.1682	.0381	-.2174
.899	10.11	7.01	4.15	.6969	-.4803	-.7940	.2193	-.5417	-.3947	.5681	.0652	-.6148	.4775	.0614	-.3994
.900	10.10	7.03	8.14	1.0507	-.3871	-.9796	.2505	-.5235	-.4042	.8845	.1472	-.8006	.8002	.1364	-.5754
.896	10.11	6.99	12.14	1.2387	-.2695	-1.0355	.2876	-.5006	-.4207	1.0347	.2545	-.8556	.9510	.2311	-.6148
.900	10.09	7.01	14.63	1.3591	-.1751	-1.1168	.3109	-.4792	-.4352	1.1338	.3365	-.9380	1.0482	.3041	-.6816
.899	20.02	1.01	-1.88	.0783	.0545	-.1866	.0237	.0090	-.0506	.0783	.0545	-.1866	.0547	.0455	-.1361
.902	20.03	1.00	.11	.2029	.0523	-.2637	.0185	.0097	-.0398	.2029	.0523	-.2637	.1843	.0427	-.2239
.901	20.04	1.00	2.10	.3452	.0592	-.3419	.0125	.0102	-.0289	.3452	.0592	-.3419	.3327	.0490	-.3130
.899	20.04	1.01	4.09	.5001	.0762	-.4292	.0116	.0105	-.0296	.5001	.0762	-.4292	.4885	.0658	-.3997
.899	20.05	1.01	6.12	.6731	.1072	-.5305	.0132	.0112	-.0368	.6731	.1072	-.5305	.6598	.0960	-.4936
.900	20.06	1.00	8.11	.8127	.1562	-.6098	.0128	.0151	-.0397	.8127	.1562	-.6098	.7999	.1410	-.5701
.900	20.06	.99	10.11	.8674	.2020	-.5938	.0092	.0213	-.0354	.8674	.2020	-.5938	.8583	.1807	-.5584
.898	20.05	.97	12.11	.9465	.2587	-.6386	.0076	.0266	-.0349	.9465	.2587	-.6386	.9389	.2321	-.6036
.897	20.06	.95	14.63	1.0411	.3388	-.7038	.0041	.0355	-.0349	1.0411	.3388	-.7038	1.0371	.3033	-.6690
.900	20.04	3.51	.13	.3587	-.1581	-.6539	.1948	-.2003	-.4533	.2768	.0649	-.4687	.1640	.0422	-.2005
.902	20.03	3.53	4.12	.6677	-.1227	-.8363	.2050	-.1879	-.4573	.5703	.0944	-.6507	.4628	.0652	-.3790
.900	20.02	3.52	8.14	.9989	-.0355	-1.0139	.2115	-.1741	-.4592	.8862	.1746	-.8279	.7874	.1386	-.5547
.898	20.02	3.51	12.13	1.1580	.0791	-1.0588	.2177	-.1529	-.4599	1.0310	.2811	-.8727	.9403	.2320	-.5988
.899	20.00	3.51	14.65	1.2652	.1672	-1.1370	.2277	-.1359	-.4767	1.1295	.3633	-.9510	1.0376	.3031	-.6603
.902	19.36	5.00	-1.98	.2794	-.2841	-.7281	.2667	-.3245	-.6257	.1565	.0681	-.4373	.0128	.0404	-.1024
.898	19.38	5.01	.03	.4210	-.2828	-.8196	.2785	-.3199	-.6316	.2845	.0681	-.5262	.1425	.0371	-.1880
.901	20.05	5.01	2.03	.5715	-.2642	-.9210	.2907	-.3064	-.6420	.4237	.0799	-.6291	.2809	.0422	-.2790
.901	20.03	5.01	4.03	.7357	-.2392	-1.0124	.2989	-.2969	-.6447	.5758	.0998	-.7203	.4368	.0577	-.3677
.900	20.04	5.01	6.05	.9089	-.2024	-1.1006	.3038	-.2859	-.6430	.7370	.1310	-.8082	.6050	.0835	-.4576
.898	20.05	5.01	8.06	1.0769	-.1495	-1.1892	.3077	-.2772	-.6392	.8928	.1790	-.8957	.7693	.1278	-.5500
.898	20.05	5.00	12.03	1.2428	-.0294	-1.2253	.3151	-.2513	-.6286	1.0367	.2849	-.9324	.9277	.2219	-.5967
.899	20.05	5.00	14.55	1.3560	.0635	-1.3055	.3267	-.2309	-.6390	1.1369	.3678	-1.0133	1.0294	.2945	-.6665
1.199	-.13	.77	-2.02	-.0137	.1170	-.0968	.0331	.0507	-.0614	-.0137	.1170	-.0968	-.0468	.0663	-.0353
1.199	-.12	.77	-.01	.1124	.1111	-.1922	.0309	.0497	-.0583	.1124	.1111	-.1922	.0815	.0614	-.1339
1.199	-.13	.78	2.00	.2512	.1164	-.3034	.0333	.0497	-.0668	.2512	.1164	-.3034	.2180	.0667	-.2365
1.201	-.10	.79	3.98	.3974	.1335	-.4283	.0376	.0504	-.0803	.3974	.1335	-.4283	.3598	.0831	-.3480
1.200	-.10	.79	5.99	.5408	.1628	-.5506	.0394	.0525	-.0894	.5408	.1628	-.5506	.5014	.1103	-.4611
1.199	-.09	.78	8.01	.6749	.2038	-.6597	.0379	.0568	-.0927	.6749	.2038	-.6597	.6370	.1470	-.5671
1.203	-.11	.74	12.00	.9013	.3048	-.8218	.0306	.0640	-.0901	.9013	.3048	-.8218	.8707	.2408	-.7317

TABLE III.- Concluded

MACH	VEFR	NPR	ALPHA	CL	C(D-F)	CM	CLN	C(DN-F)	CMN	CLAERO	CDAERO	CMAERO	CLA	CDA	CMA
1.198	-.11	.72	14.50	1.0389	.3868	-.9438	.0353	.0728	-.1129	1.0389	.3868	-.9438	1.0037	.3140	-.8308
1.200	.03	5.00	.01	.1239	-.1277	-.2154	.0437	-.1897	-.0708	.1366	.0882	-.2433	.0801	.0620	-.1446
1.201	.00	5.02	4.00	.4266	-.1036	-.4552	.0651	-.1876	-.0952	.4244	.1137	-.4836	.3616	.0840	-.3600
1.199	.02	5.02	8.03	.7265	-.0300	-.6970	.0845	-.1786	-.1183	.7090	.1867	-.7254	.6420	.1485	-.5788
1.198	-.01	5.00	12.03	.9853	.0789	-.8896	.1022	-.1659	-.1434	.9526	.2937	-.9177	.8831	.2448	-.7462
1.200	.02	7.02	-2.00	.0276	-.2384	-.2219	.0867	-.3052	-.1850	.0378	.0834	-.2243	-.0590	.0667	-.0369
1.199	.01	7.00	.01	.1620	-.2409	-.3171	.0956	-.3024	-.1833	.1611	.0806	-.3197	.0664	.0616	-.1338
1.201	.01	7.01	2.00	.3146	-.2333	-.4262	.1052	-.2998	-.1856	.3024	.0875	-.4287	.2094	.0666	-.2406
1.200	-.01	7.01	4.03	.4731	-.2136	-.5472	.1175	-.2962	-.1931	.4496	.1069	-.5496	.3556	.0825	-.3541
1.200	-.02	7.01	6.03	.6287	-.1817	-.6704	.1295	-.2913	-.2022	.5940	.1379	-.6729	.4993	.1096	-.4681
1.199	-.04	7.01	8.03	.7758	-.1381	-.7850	.1420	-.2834	-.2137	.7300	.1804	-.7876	.6339	.1453	-.5714
1.197	-.05	6.99	12.04	1.0446	-.0253	-.9784	.1647	-.2683	-.2342	.9766	.2895	-.9811	.8799	.2429	-.7442
1.201	-.17	9.02	.01	.2036	-.3512	-.4121	.1444	-.4116	-.2848	.1889	.0749	-.3890	.0593	.0605	-.1273
1.201	-.20	9.04	4.02	.5218	-.3224	-.6415	.1731	-.4039	-.2936	.4770	.1032	-.6180	.3488	.0816	-.3478
1.200	-.21	9.00	8.05	.8316	-.2420	-.8755	.2011	-.3870	-.3079	.7575	.1781	-.8525	.6305	.1450	-.5676
1.197	-.22	8.99	12.05	1.1057	-.1265	-1.0662	.2292	-.3683	-.3258	1.0021	.2887	-1.0432	.8764	.2418	-.7404
1.198	9.92	.76	-2.00	-.0146	.1190	-.1112	.0407	.0548	-.0809	-.0146	.1190	-.1112	-.0553	.0642	-.0302
1.198	9.92	.75	-.00	.1064	.1124	-.1985	.0356	.0535	-.0705	.1064	.1124	-.1985	.0709	.0588	-.1279
1.200	9.93	.76	2.02	.2478	.1167	-.3078	.0353	.0529	-.0733	.2478	.1167	-.3078	.2124	.0639	-.2345
1.199	9.93	.77	3.99	.3908	.1332	-.4285	.0386	.0531	-.0844	.3908	.1332	-.4285	.3522	.0801	-.3440
1.200	9.93	.77	6.02	.5373	.1624	-.5529	.0405	.0554	-.0942	.5373	.1624	-.5529	.4968	.1070	-.4587
1.198	9.93	.75	8.01	.6679	.2032	-.6557	.0358	.0595	-.0918	.6679	.2032	-.6557	.6320	.1437	-.5639
1.196	9.95	.72	12.02	.9040	.3055	-.8235	.0284	.0654	-.0913	.9040	.3055	-.8235	.8756	.2401	-.7321
1.200	9.96	4.99	.01	.1888	-.1127	-.4095	.1331	-.1754	-.2948	.1590	.0957	-.3438	.0556	.0627	-.1146
1.200	9.93	5.01	4.01	.4875	-.0852	-.6397	.1503	-.1679	-.3102	.4432	.1212	-.5740	.3372	.0827	-.3294
1.198	9.92	5.00	8.04	.7819	-.0096	-.8686	.1603	-.1551	-.3149	.7231	.1935	-.8027	.6217	.1455	-.5537
1.196	9.92	5.01	12.04	1.0350	.0998	-1.0445	.1674	-.1422	-.3181	.9617	.2996	-.9783	.8676	.2420	-.7264
1.200	9.93	7.03	-2.00	.0886	-.2236	-.3865	.1645	-.2908	-.3706	.0494	.0890	-.2857	-.0758	.0672	-.0158
1.200	9.90	7.01	.02	.2273	-.2235	-.4944	.1790	-.2859	-.3838	.1773	.0869	-.3938	.0483	.0624	-.1106
1.200	9.90	7.00	2.02	.3766	-.2134	-.6036	.1900	-.2794	-.3903	.3159	.0945	-.5032	.1866	.0660	-.2132
1.200	9.90	7.00	4.03	.5337	-.1920	-.7224	.2003	-.2737	-.3950	.4622	.1136	-.6220	.3334	.0816	-.3274
1.200	9.90	7.01	6.01	.6847	-.1592	-.8376	.2084	-.2665	-.3964	.6027	.1438	-.7373	.4763	.1074	-.4413
1.198	9.89	7.00	8.04	.8358	-.1140	-.9535	.2171	-.2581	-.4018	.7429	.1868	-.8528	.6187	.1441	-.5517
1.199	9.90	7.03	12.05	1.0940	.0003	-1.1327	.2313	-.2395	-.4085	.9800	.2945	-1.0317	.8627	.2399	-.7242
1.200	9.91	9.04	.03	.2824	-.3307	-.6127	.2389	-.3910	-.5027	.2118	.0821	-.4769	.0435	.0604	-.1100
1.200	9.90	9.03	4.04	.5955	-.2938	-.8404	.2681	-.3738	-.5182	.4965	.1120	-.7050	.3274	.0800	-.3222
1.198	9.89	8.98	8.03	.9043	-.2103	-1.0726	.2933	-.3509	-.5287	.7776	.1870	-.9374	.6111	.1406	-.5439
1.198	9.90	8.99	12.06	1.1685	-.0910	-1.2490	.3083	-.3286	-.5277	1.0142	.2965	-1.1139	.8602	.2376	-.7213

TABLE IV.- AERODYNAMIC CHARACTERISTICS FOR SERN, A/B POWER, CANARD OFF

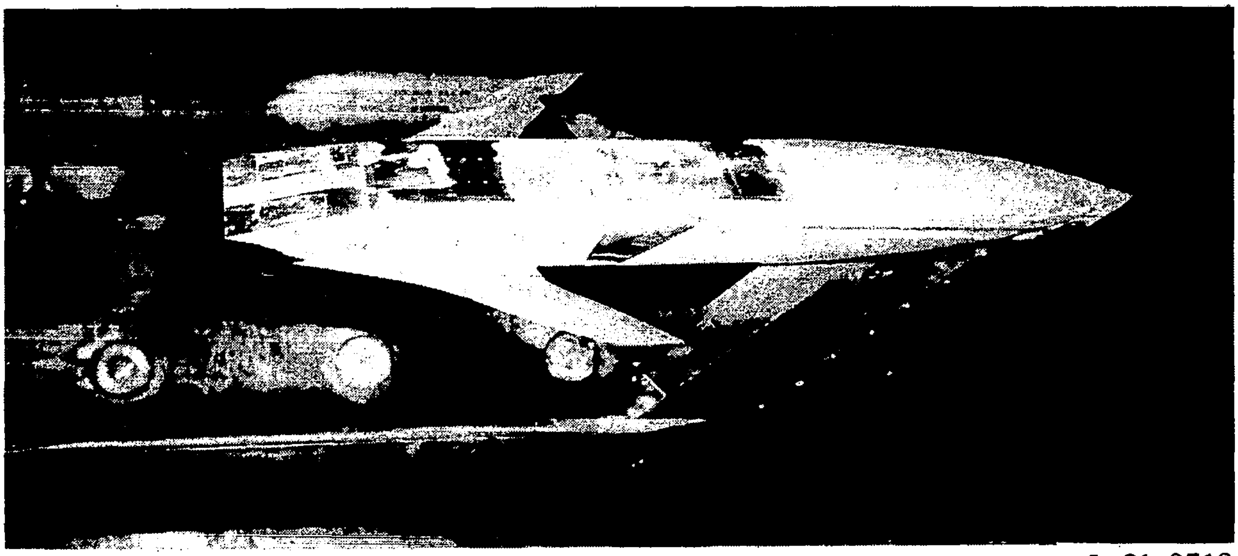
MACH	VEFR	NPR	ALPHA	CL	C(D-F)	CM	CLN	C(DN-F)	CMN	CLAERO	CDAERO	CMAERO	CLA	CDA	CMA
.600	-.03	.99	-2.02	.0478	.0443	-.0772	-.0055	.0105	.0217	.0478	.0443	-.0772	.0533	.0338	-.0989
.599	-.02	.99	-.01	.1790	.0407	-.1465	-.0081	.0104	.0272	.1790	.0407	-.1465	.1871	.0303	-.1737
.600	-.02	.99	2.00	.3185	.0452	-.2228	-.0078	.0099	.0250	.3185	.0452	-.2228	.3264	.0353	-.2479
.599	-.03	1.00	4.00	.4657	.0547	-.3077	-.0048	.0100	.0163	.4657	.0547	-.3077	.4704	.0447	-.3240
.603	-.02	1.00	6.00	.6163	.0703	-.3958	-.0021	.0104	.0071	.6163	.0703	-.3958	.6184	.0600	-.4029
.602	-.02	1.00	7.99	.7650	.0959	-.4787	.0036	.0119	-.0086	.7650	.0959	-.4787	.7614	.0840	-.4701
.602	-.03	1.00	11.98	.9871	.2014	-.6327	.0141	.0197	-.0414	.9871	.2014	-.6327	.9731	.1816	-.5913
.599	-.04	.98	14.50	1.0521	.2903	-.6914	.0014	.0217	-.0131	1.0521	.2903	-.6914	1.0507	.2686	-.6782
.599	-.18	3.51	-2.01	.0634	-.5249	-.1672	.0124	-.5539	-.0496	.0785	.0277	-.1496	.0509	.0291	-.1176
.599	-.22	3.51	.00	.2217	-.5256	-.2483	.0325	-.5513	-.0537	.2175	.0249	-.2310	.1892	.0257	-.1947
.599	-.25	3.51	2.01	.3840	-.5206	-.3289	.0527	-.5516	-.0599	.3605	.0309	-.3115	.3313	.0310	-.2690
.599	-.05	3.52	4.00	.5511	-.5105	-.4170	.0746	-.5513	-.0711	.5081	.0420	-.3992	.4765	.0408	-.3459
.597	-.14	3.47	6.02	.7230	-.4845	-.5061	.0956	-.5410	-.0798	.6619	.0599	-.4896	.6273	.0565	-.4263
.597	-.15	3.51	8.00	.8956	-.4619	-.5944	.1215	-.5432	-.0995	.8143	.0869	-.5769	.7741	.0814	-.4949
.603	-.13	3.48	12.00	1.1628	-.3281	-.7651	.1691	-.5104	-.1408	1.0470	.1988	-.7486	.9937	.1823	-.6242
.601	-.17	3.51	14.50	1.2650	-.2399	-.8486	.1905	-.5097	-.1356	1.1240	.2888	-.8314	1.0744	.2698	-.7130
.601	9.98	.99	-2.02	.0594	.0425	-.1285	.0155	.0128	-.0337	.0594	.0425	-.1285	.0439	.0297	-.0949
.601	9.96	.99	.01	.1915	.0387	-.1922	.0103	.0133	-.0206	.1915	.0387	-.1922	.1812	.0254	-.1716
.601	9.98	.99	2.03	.3306	.0442	-.2665	.0090	.0138	-.0206	.3306	.0442	-.2665	.3216	.0304	-.2459
.601	9.97	1.00	3.97	.4744	.0544	-.3522	.0124	.0148	-.0316	.4744	.0544	-.3522	.4620	.0396	-.3206
.601	9.95	1.00	6.01	.6351	.0711	-.4478	.0169	.0162	-.0453	.6351	.0711	-.4478	.6182	.0549	-.4025
.601	10.16	1.00	8.00	.7833	.0980	-.5274	.0211	.0190	-.0577	.7833	.0980	-.5274	.7622	.0790	-.4697
.599	10.09	.99	12.01	1.0003	.2033	-.6700	.0257	.0275	-.0770	1.0003	.2033	-.6700	.9746	.1759	-.5930
.600	10.12	.98	14.53	1.0707	.2941	-.7393	.0171	.0290	-.0589	1.0707	.2941	-.7393	1.0535	.2650	-.6805
.602	9.96	3.49	-2.00	.1952	-.4956	-.5122				.1239	.0341	-.2957			
.603	10.02	3.51	-.00	.3539	-.4946	-.6021				.2638	.0335	-.3846			
.601	10.04	3.51	2.03	.5157	-.4850	-.6859				.4065	.0418	-.4676			
.602	10.03	3.51	4.03	.6837	-.4665	-.7729				.5563	.0553	-.5548			
.602	10.07	3.51	6.03	.8523	-.4430	-.8633				.7065	.0748	-.6449			
.601	10.02	3.51	8.03	1.0218	-.4097	-.9460				.8578	.1039	-.7273			
.599	10.01	3.51	12.03	1.2885	-.2895	-1.1029				1.0883	.2131	-.8834			
.598	10.02	3.50	14.54	1.3946	-.1876	-1.1894				1.1720	.3073	-.9692			
.600	20.07	.99	-2.03	.0655	.0447	-.1463	.0245	.0148	-.0572	.0655	.0447	-.1463	.0410	.0298	-.0892
.601	20.05	.99	-.00	.2017	.0415	-.2200	.0214	.0161	-.0506	.2017	.0415	-.2200	.1803	.0254	-.1694
.601	20.09	.99	1.98	.3385	.0467	-.2913	.0195	.0164	-.0482	.3385	.0467	-.2913	.3190	.0303	-.2431
.602	20.03	1.00	3.99	.4895	.0579	-.3813	.0226	.0179	-.0603	.4895	.0579	-.3813	.4669	.0400	-.3210
.602	20.04	1.00	6.00	.6409	.0749	-.4681	.0252	.0199	-.0690	.6409	.0749	-.4681	.6157	.0549	-.3991
.601	20.02	1.00	8.00	.7877	.1015	-.5434	.0274	.0226	-.0766	.7877	.1015	-.5434	.7603	.0790	-.4668
.600	19.93	1.00	12.01	1.0051	.2066	-.6864	.0337	.0304	-.0987	1.0051	.2066	-.6864	.9714	.1762	-.5877
.600	19.94	.99	14.50	1.0775	.2970	-.7628	.0265	.0332	-.0860	1.0775	.2970	-.7628	1.0510	.2637	-.6768

TABLE IV.- Continued

MACH	VEER	NPR	ALPHA	CL	C(D-F)	CM	CLN	C(DN-F)	CMN	CLAERO	CDAERO	CMAERO	CLA	CDA	CMA
.601	20.00	3.43	-1.97	.3418	-.4441	-.8408				.1823	.0482	-.4388			
.601	19.99	3.52	.01	.5068	-.4517	-.9558				.3237	.0497	-.5395			
.600	19.96	3.51	2.03	.6676	-.4349	-1.0402				.4666	.0606	-.6232			
.600	19.98	3.51	4.01	.8350	-.4113	-1.1310				.6168	.0775	-.7136			
.601	19.98	3.51	6.01	.9999	-.3796	-1.2200				.7655	.0999	-.8038			
.601	19.98	3.51	8.01	1.1637	-.3414	-1.2979				.9125	.1300	-.8814			
.598	19.98	3.51	12.04	1.4348	-.2155	-1.4533				1.1492	.2403	-1.0340			
.601	19.98	3.51	14.53	1.5301	-.1071	-1.5268				1.2268	.3330	-1.1099			
.901	-.11	1.02	-2.00	.0141	.0576	-.1075	-.0009	.0040	.0080	.0141	.0576	-.1075	.0150	.0537	-.1155
.901	-.07	1.01	-.00	.1683	.0509	-.2068	-.0065	.0044	.0218	.1683	.0509	-.2068	.1748	.0464	-.2285
.897	-.01	1.01	2.00	.3398	.0545	-.3059	-.0085	.0050	.0244	.3398	.0545	-.3059	.3483	.0495	-.3303
.902	-.01	1.02	4.00	.5134	.0702	-.4093	-.0092	.0037	.0232	.5134	.0702	-.4093	.5227	.0666	-.4325
.900	-.01	1.03	5.99	.6963	.0986	-.5213	-.0025	.0043	.0048	.6963	.0986	-.5213	.6988	.0943	-.5261
.899	-.00	1.02	8.01	.8460	.1472	-.6274	.0116	.0099	-.0297	.8460	.1472	-.6274	.8344	.1373	-.5977
.898	-.01	1.01	9.98	.9275	.2010	-.6564	.0103	.0175	-.0302	.9275	.2010	-.6564	.9172	.1835	-.6262
.897	-.04	4.99	-2.02	-.0025	-.3495	-.0708	-.0274	-.3967	.0647	.0337	.0350	-.1205	.0248	.0472	-.1355
.901	-.05	5.02	-.00	.1704	-.3558	-.1852	-.0153	-.3973	.0642	.1933	.0287	-.2355	.1857	.0415	-.2494
.901	-.09	5.01	2.01	.3551	-.3515	-.2905	-.0023	-.3972	.0596	.3644	.0333	-.3406	.3574	.0457	-.3502
.899	-.10	5.00	4.01	.5544	-.3350	-.4034	.0144	-.3963	.0474	.5501	.0505	-.4534	.5399	.0613	-.4508
.902	-.07	5.03	6.02	.7457	-.3027	-.5185	.0338	-.3932	.0295	.7282	.0827	-.5691	.7119	.0906	-.5479
.901	-.10	5.03	8.01	.9063	-.2524	-.6222	.0613	-.3833	-.0050	.8754	.1326	-.6729	.8449	.1310	-.6172
.899	-.10	5.01	10.08	.9967	-.1973	-.6444	.0711	-.3779	-.0030	.9517	.1862	-.6946	.9256	.1806	-.6415
.897	9.97	1.02	-2.02	.0235	.0574	-.1424	.0173	.0063	-.0363	.0235	.0574	-.1424	.0061	.0512	-.1061
.898	9.93	1.01	.01	.1757	.0506	-.2400	.0104	.0072	-.0209	.1757	.0506	-.2400	.1653	.0434	-.2191
.903	10.10	1.02	2.01	.3403	.0551	-.3340	.0029	.0068	-.0055	.3403	.0551	-.3340	.3374	.0483	-.3286
.901	10.11	1.02	3.99	.5176	.0701	-.4305	.0009	.0061	-.0033	.5176	.0701	-.4305	.5167	.0639	-.4272
.898	10.09	1.03	5.99	.7009	.0982	-.5377	.0058	.0072	-.0171	.7009	.0982	-.5377	.6951	.0910	-.5206
.898	10.07	1.02	8.01	.8523	.1471	-.6442	.0201	.0131	-.0509	.8523	.1471	-.6442	.8322	.1340	-.5932
.899	10.12	1.01	10.01	.9334	.2025	-.6725	.0170	.0208	-.0482	.9334	.2025	-.6725	.9164	.1817	-.6243
.903	10.11	5.02	-1.99	.1148	-.3259	-.3854	.1221	-.3750	-.2859	.0751	.0454	-.2693	-.0074	.0491	-.0995
.903	10.02	5.02	.03	.2916	-.3296	-.5112	.1399	-.3705	-.3020	.2388	.0406	-.3950	.1517	.0409	-.2093
.903	9.92	5.01	2.01	.4758	-.3190	-.6337	.1568	-.3637	-.3196	.4104	.0479	-.5176	.3191	.0447	-.3141
.900	9.92	5.01	4.02	.6731	-.2999	-.7468	.1713	-.3601	-.3318	.5943	.0671	-.6299	.5017	.0602	-.4150
.899	9.90	5.00	6.03	.8633	-.2662	-.8483	.1840	-.3530	-.3400	.7717	.0979	-.7313	.6793	.0869	-.5083
.896	9.92	4.99	7.61	.9995	-.2269	-.9335	.1998	-.3455	-.3582	.8974	.1358	-.8159	.7997	.1186	-.5753
.901	19.91	1.02	-2.01	.0326	.0594	-.1552	.0209	.0081	-.0460	.0326	.0594	-.1552	.0118	.0513	-.1092
.899	20.00	1.01	-.01	.1867	.0532	-.2564	.0166	.0092	-.0364	.1867	.0532	-.2564	.1701	.0440	-.2200
.899	20.00	1.01	2.00	.3517	.0572	-.3492	.0108	.0091	-.0245	.3517	.0572	-.3492	.3409	.0481	-.3247
.898	20.00	1.01	4.01	.5280	.0722	-.4422	.0077	.0088	-.0206	.5280	.0722	-.4422	.5203	.0634	-.4217
.904	20.00	1.02	5.99	.7057	.1017	-.5534	.0095	.0088	-.0270	.7057	.1017	-.5534	.6963	.0929	-.5264

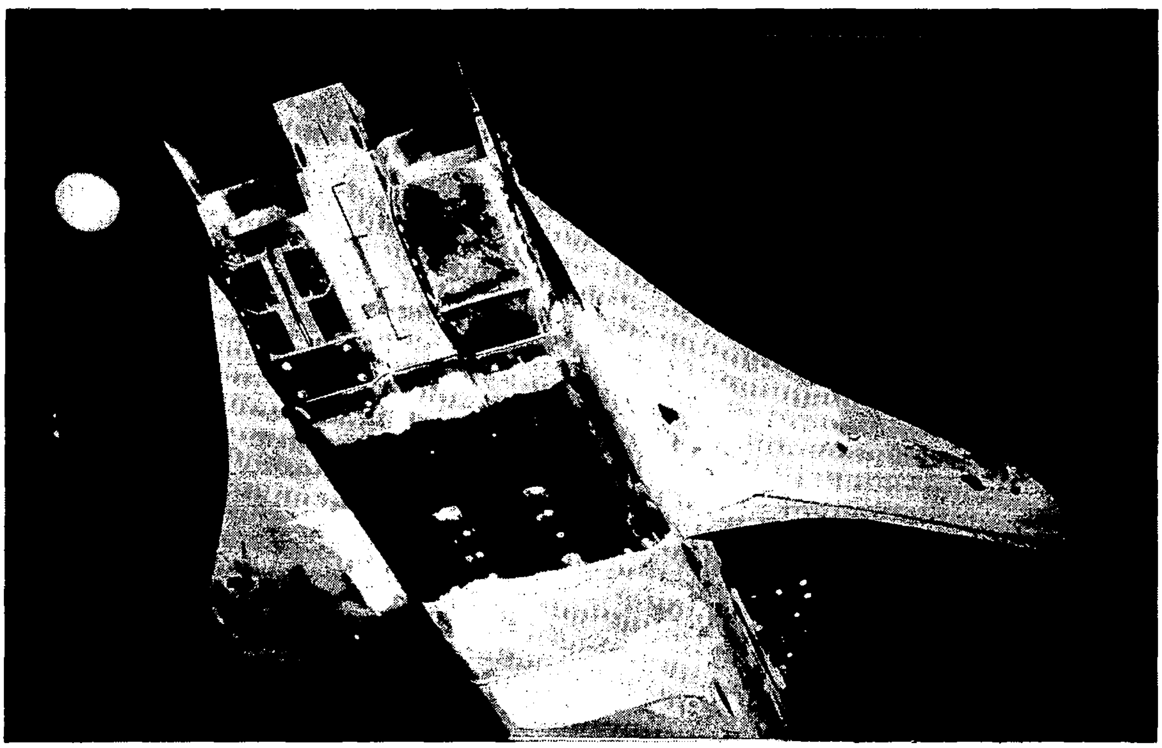
TABLE IV.- Concluded

MACH	VEER	NPR	ALPHA	CL	C(D-F)	CM	CLN	C(DN-F)	CMN	CLAERO	CDAERO	CMAERO	CLA	CDA	CMA
.901	20.00	1.02	7.99	.8547	.1499	-.6536	.0240	.0158	-.0608	.8547	.1499	-.6536	.8307	.1341	-.5928
.897	20.00	1.01	9.49	.9304	.1910	-.6880	.0245	.0213	-.0641	.9304	.1910	-.6880	.9059	.1697	-.6239
.897	19.99	5.00	-1.96	.2556	-.2842	-.7194	.2695	-.3123	-.6294	.1316	.0708	-.4264	-.0139	.0281	-.0900
.897	19.97	5.00	.04	.4269	-.2830	-.8416	.2854	-.3074	-.6432	.2903	.0681	-.5479	.1414	.0244	-.1984
.899	19.97	5.04	2.04	.6057	-.2719	-.9568	.2976	-.3016	-.6517	.4564	.0754	-.6622	.3082	.0298	-.3052
.896	19.98	5.00	4.03	.7915	-.2463	-1.0583	.3065	-.2921	-.6544	.6306	.0950	-.7642	.4850	.0458	-.4039
.899	19.90	5.03	6.05	.9813	-.2091	-1.1561	.3123	-.2833	-.6522	.8086	.1260	-.8623	.6691	.0743	-.5039
1.199	.00	.77	-2.02	-.0388	.1188	-.0689	.0315	.0506	-.0591	-.0388	.1188	-.0689	-.0703	.0682	-.0098
1.201	.01	.78	.00	.1017	.1105	-.1865	.0329	.0499	-.0622	.1017	.1105	-.1865	.0687	.0606	-.1243
1.201	-.00	.79	2.01	.2510	.1126	-.3146	.0369	.0492	-.0747	.2510	.1126	-.3146	.2140	.0634	-.2399
1.202	.00	.80	4.01	.4027	.1279	-.4478	.0410	.0503	-.0881	.4027	.1279	-.4478	.3617	.0776	-.3597
1.202	.00	.80	6.00	.5497	.1550	-.5717	.0402	.0524	-.0907	.5497	.1550	-.5717	.5095	.1026	-.4810
1.199	.00	.80	8.01	.7037	.1957	-.7095	.0451	.0564	-.1080	.7037	.1957	-.7095	.6586	.1394	-.6015
1.199	.00	.78	8.77	.7540	.2139	-.7460	.0424	.0571	-.1038	.7540	.2139	-.7460	.7116	.1568	-.6421
1.200	-.02	7.02	-1.99	.0074	-.2393	-.2010	.0859	-.3037	-.1836	.0176	.0825	-.2034	-.0785	.0644	-.0174
1.200	-.05	7.02	.00	.1555	-.2453	-.3150	.0978	-.3038	-.1863	.1545	.0767	-.3173	.0577	.0584	-.1287
1.199	-.04	7.02	2.02	.3169	-.2406	-.4385	.1080	-.3016	-.1877	.3046	.0818	-.4409	.2090	.0611	-.2507
1.200	-.04	7.03	4.03	.4801	-.2222	-.5669	.1201	-.2979	-.1938	.4564	.0997	-.5691	.3601	.0756	-.3731
1.200	-.05	7.01	6.01	.6404	-.1911	-.6955	.1312	-.2912	-.2012	.6058	.1287	-.6980	.5092	.1002	-.4944
1.201	-.05	7.03	8.03	.8051	-.1469	-.8325	.1464	-.2840	-.2159	.7592	.1713	-.8348	.6587	.1371	-.6166
1.199	10.06	.77	-2.01	-.0385	.1215	-.0883	.0410	.0536	-.0841	-.0385	.1215	-.0883	-.0796	.0679	-.0041
1.198	9.98	.76	-.00	.0997	.1121	-.1977	.0387	.0521	-.0777	.0997	.1121	-.1977	.0610	.0600	-.1201
1.198	9.97	.78	1.97	.2442	.1133	-.3177	.0400	.0517	-.0833	.2442	.1133	-.3177	.2042	.0616	-.2344
1.198	9.99	.78	4.02	.4006	.1281	-.4488	.0399	.0533	-.0865	.4006	.1281	-.4488	.3607	.0748	-.3623
1.199	9.98	.77	6.01	.5462	.1555	-.5724	.0378	.0589	-.0880	.5462	.1555	-.5724	.5084	.0966	-.4844
1.198	10.01	.75	8.03	.6939	.1957	-.6926	.0351	.0575	-.0879	.6939	.1957	-.6926	.6589	.1382	-.6047
1.201	9.96	.73	9.07	.7623	.2208	-.7470	.0336	.0590	-.0882	.7623	.2208	-.7470	.7287	.1618	-.6588
1.201	9.94	7.02	-1.98	.0632	-.2234	-.3578	.1606	-.2881	-.3627	.0240	.0887	-.2572	-.0974	.0647	.0049
1.203	9.95	7.02	.01	.2174	-.2254	-.4814	.1769	-.2831	-.3789	.1627	.0837	-.3813	.0355	.0578	-.1025
1.200	9.98	7.02	2.02	.3724	-.2194	-.6085	.1906	-.2781	-.3883	.3116	.0891	-.5080	.1818	.0588	-.2202
1.200	9.93	7.01	4.11	.5439	-.1982	-.7429	.2032	-.2732	-.3956	.4719	.1075	-.6425	.3407	.0750	-.3474
1.200	9.93	7.01	4.03	.5374	-.1989	-.7376	.2024	-.2739	-.3941	.4659	.1066	-.6373	.3350	.0749	-.3435
1.201	10.03	7.03	6.03	.6991	-.1679	-.8641	.2096	-.2664	-.3927	.6169	.1356	-.7635	.4895	.0984	-.4714
1.200	9.96	7.01	7.48	.8140	-.1367	-.9547	.2158	-.2596	-.3945	.7243	.1642	-.8543	.5982	.1229	-.5602



L-81-9718

(a) Top view.



L-81-9717

(b) Bottom view.

Figure 1.- Photographs of model.

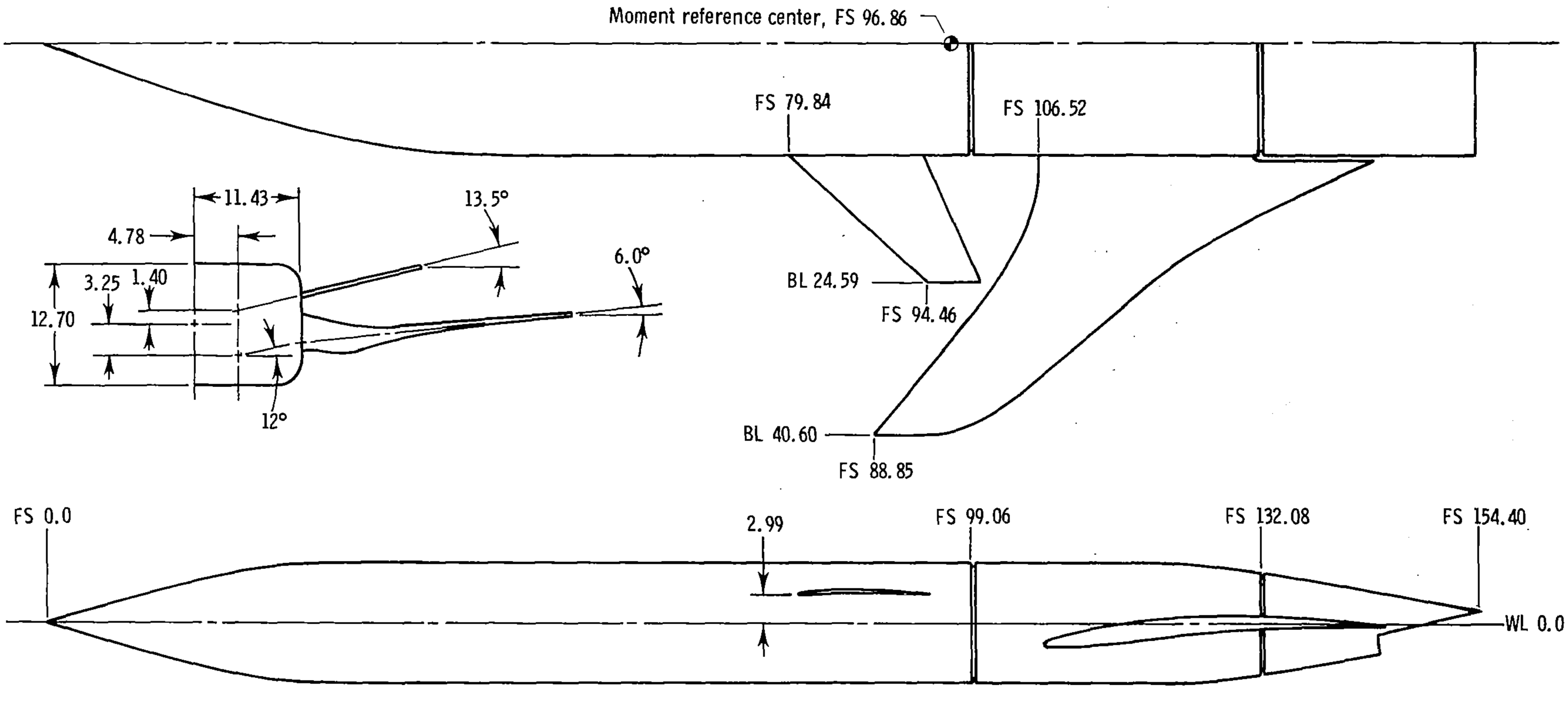


Figure 2.- General arrangement of model. All linear dimensions in centimeters.

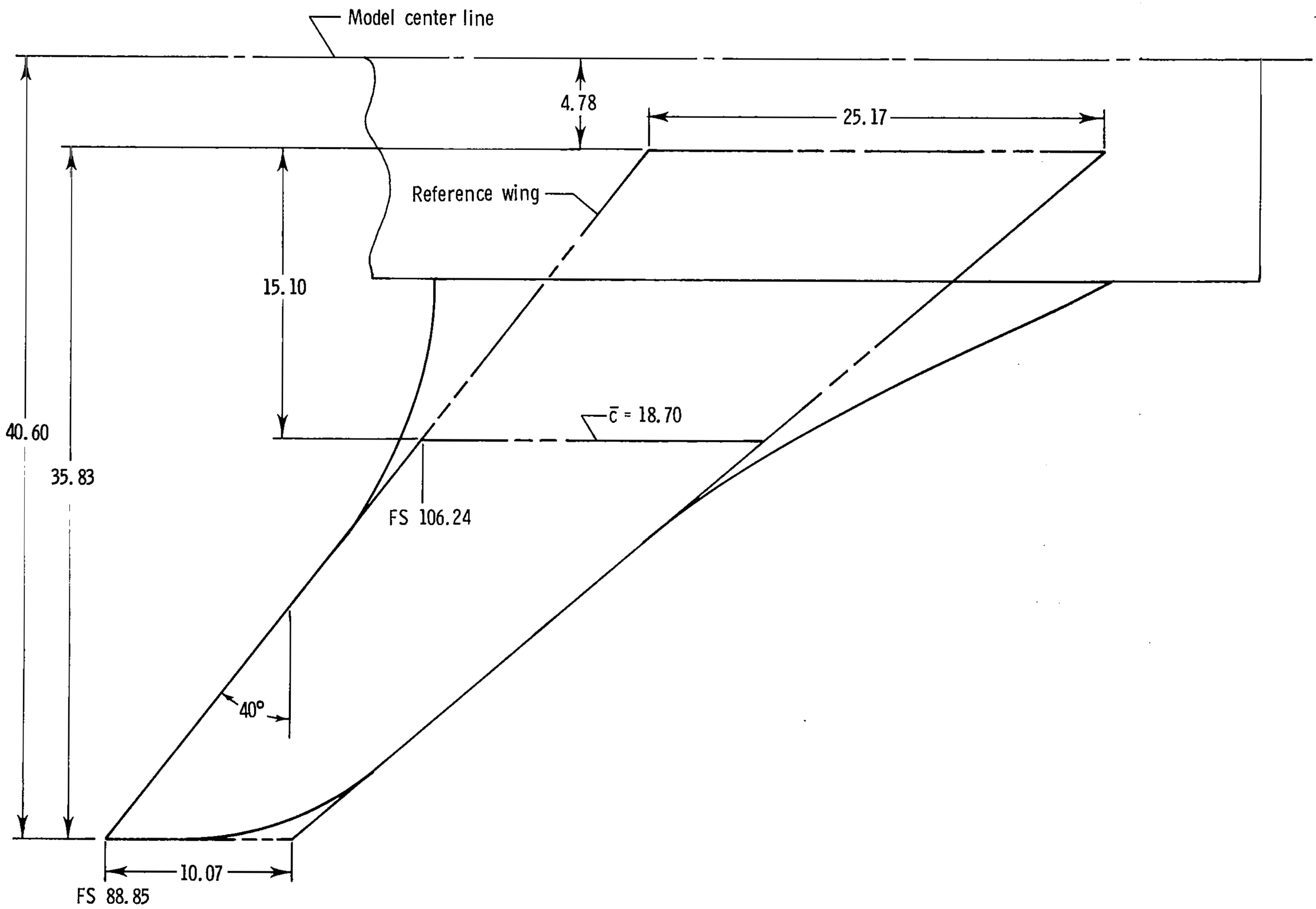


Figure 3.- Definition of wing reference area. All linear dimensions in centimeters.

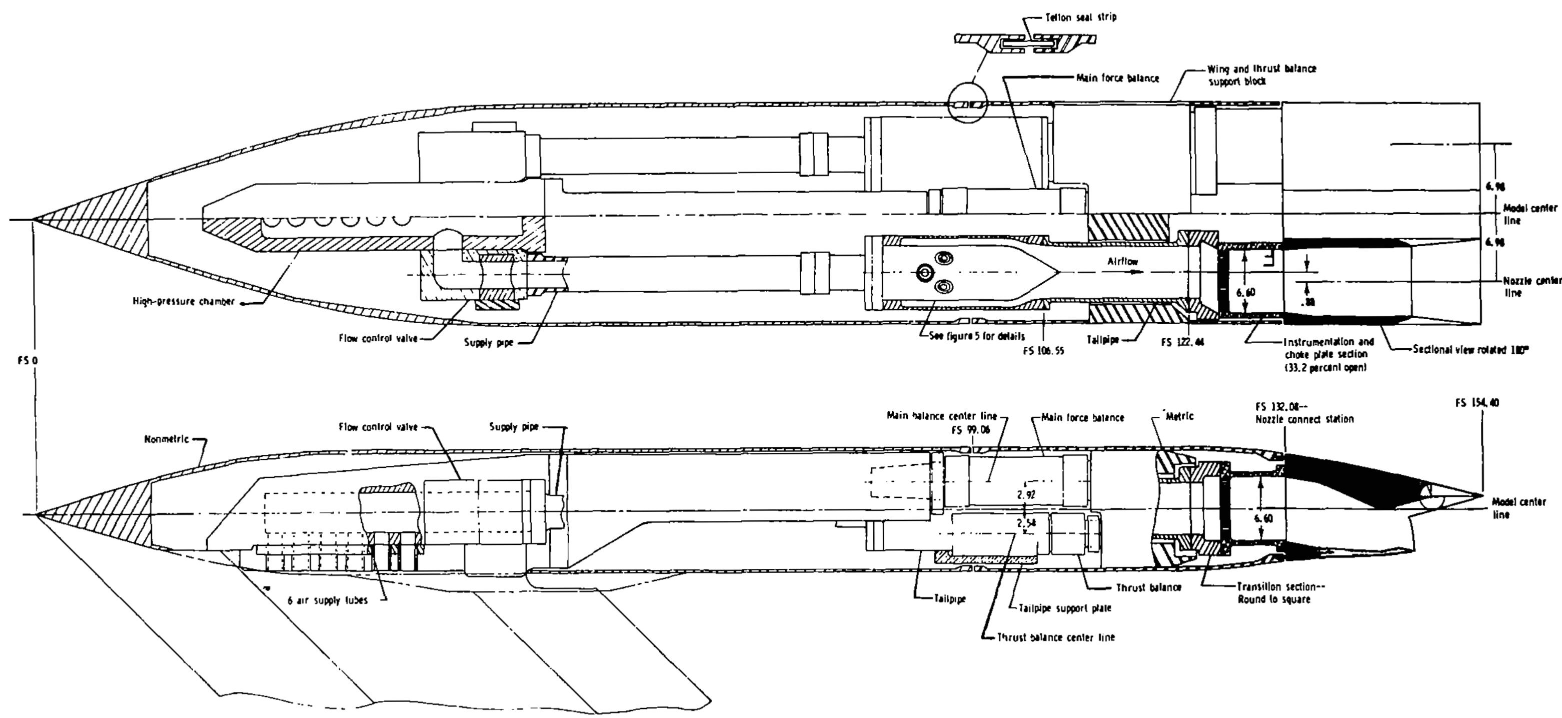


Figure 4.- Sketch of twin-jet propulsion simulation system with upright SERN. All dimensions are in centimeters unless otherwise noted.

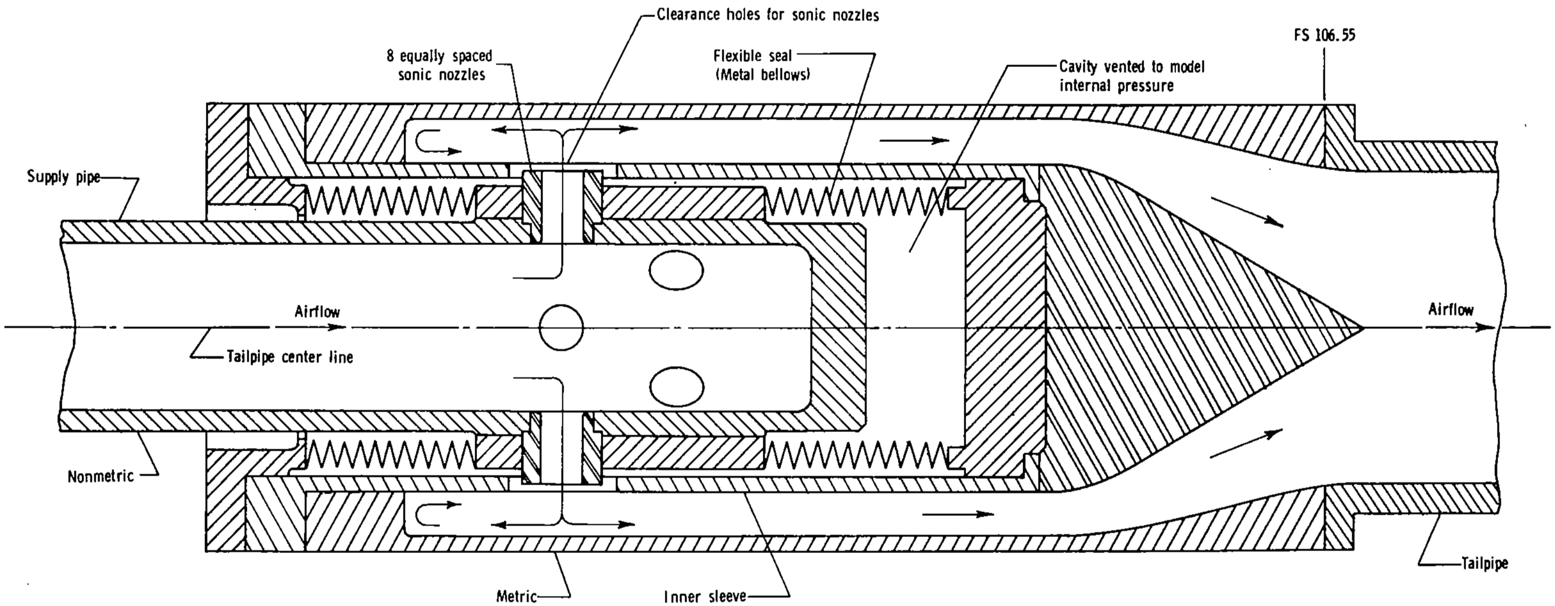
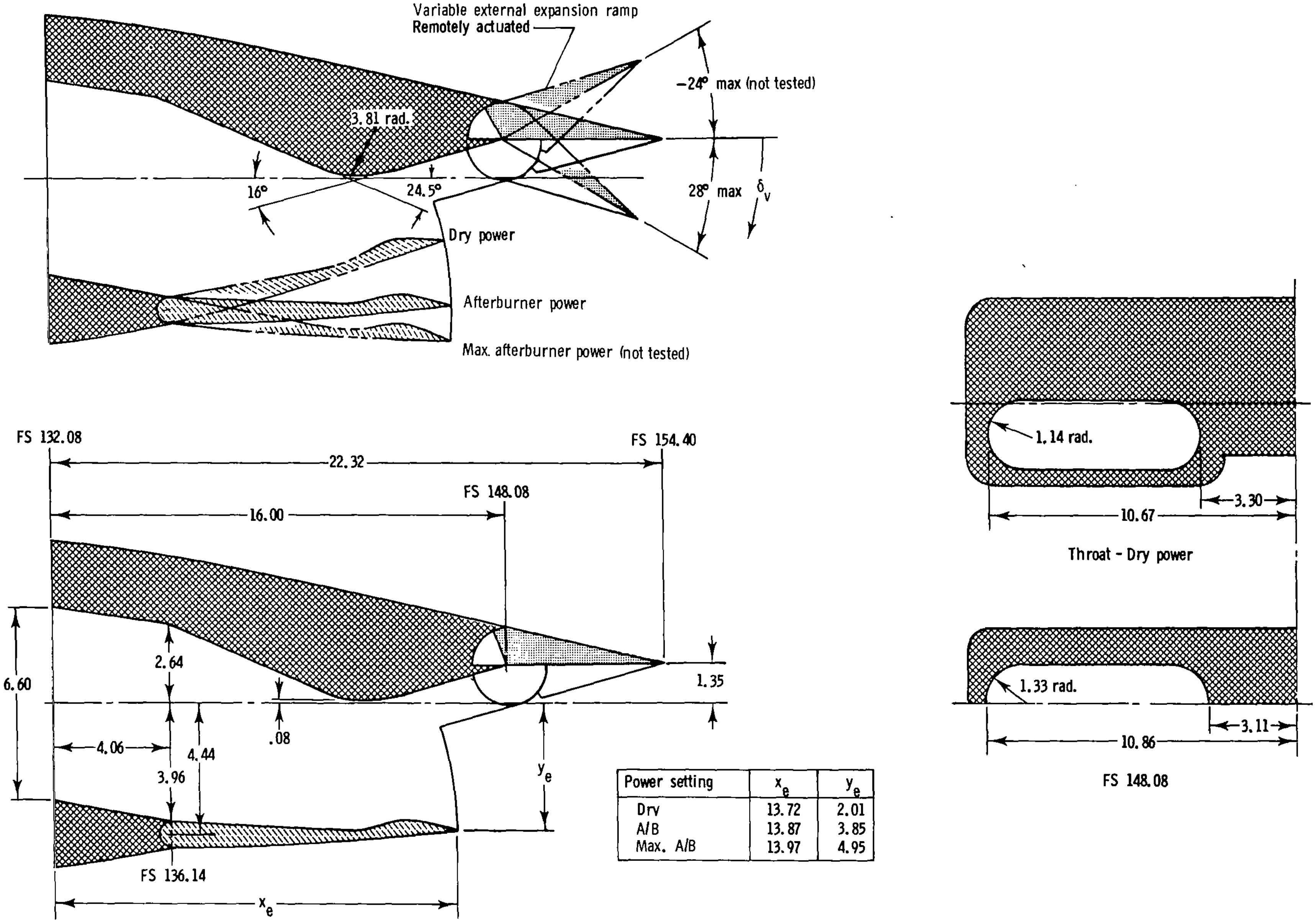
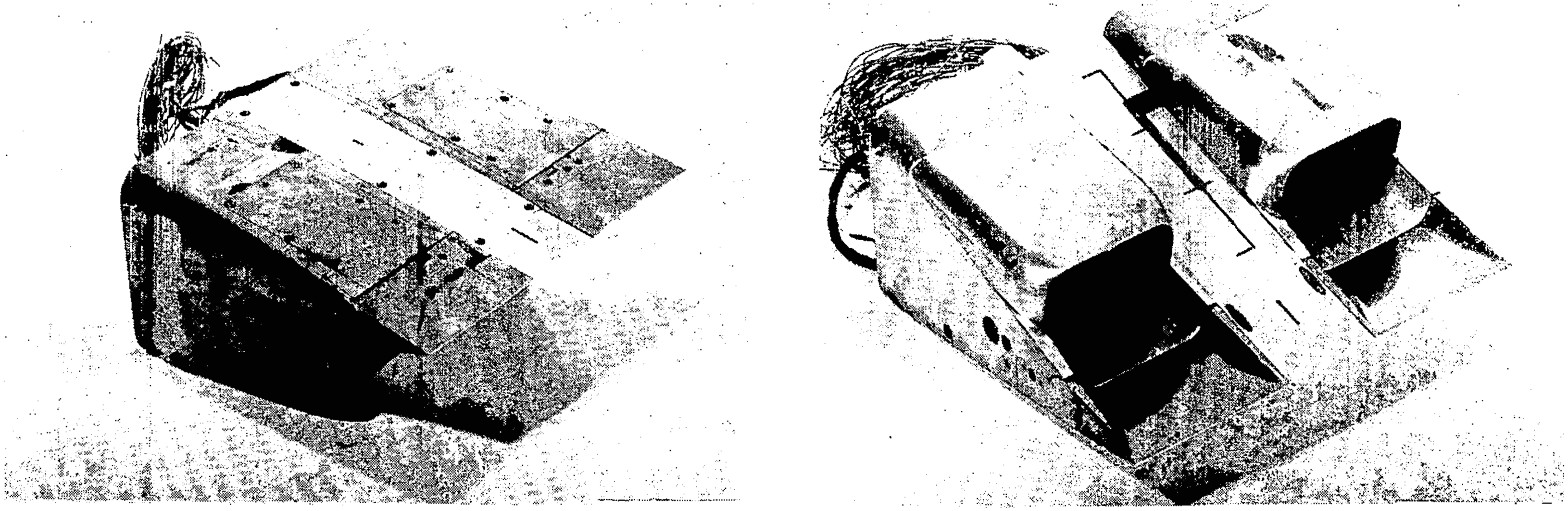


Figure 5.- Details of bellows arrangement used to transfer air from the nonmetric to metric portions of the model.



Power setting	x_e	y_e
Dry	13.72	2.01
A/B	13.87	3.85
Max. A/B	13.97	4.95

Figure 6.- Details of the single-expansion-ramp nozzle (SERN) (maximum vectoring range indicated). All dimensions are in centimeters unless otherwise noted.



L-77-1120

(a) Top view.

L-77-1124

(b) Bottom view.

Figure 7.- Photographs of the single-expansion-ramp nozzle.

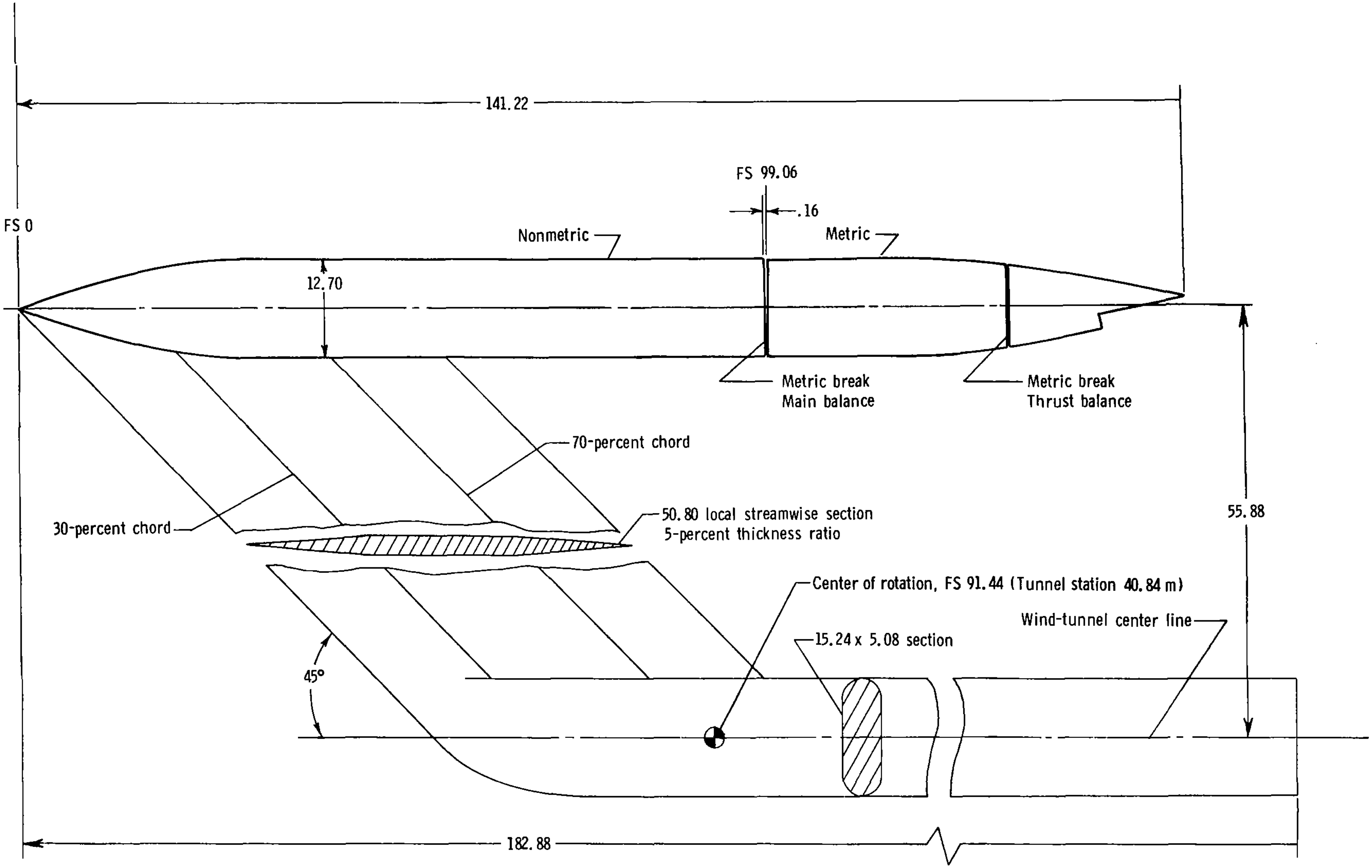
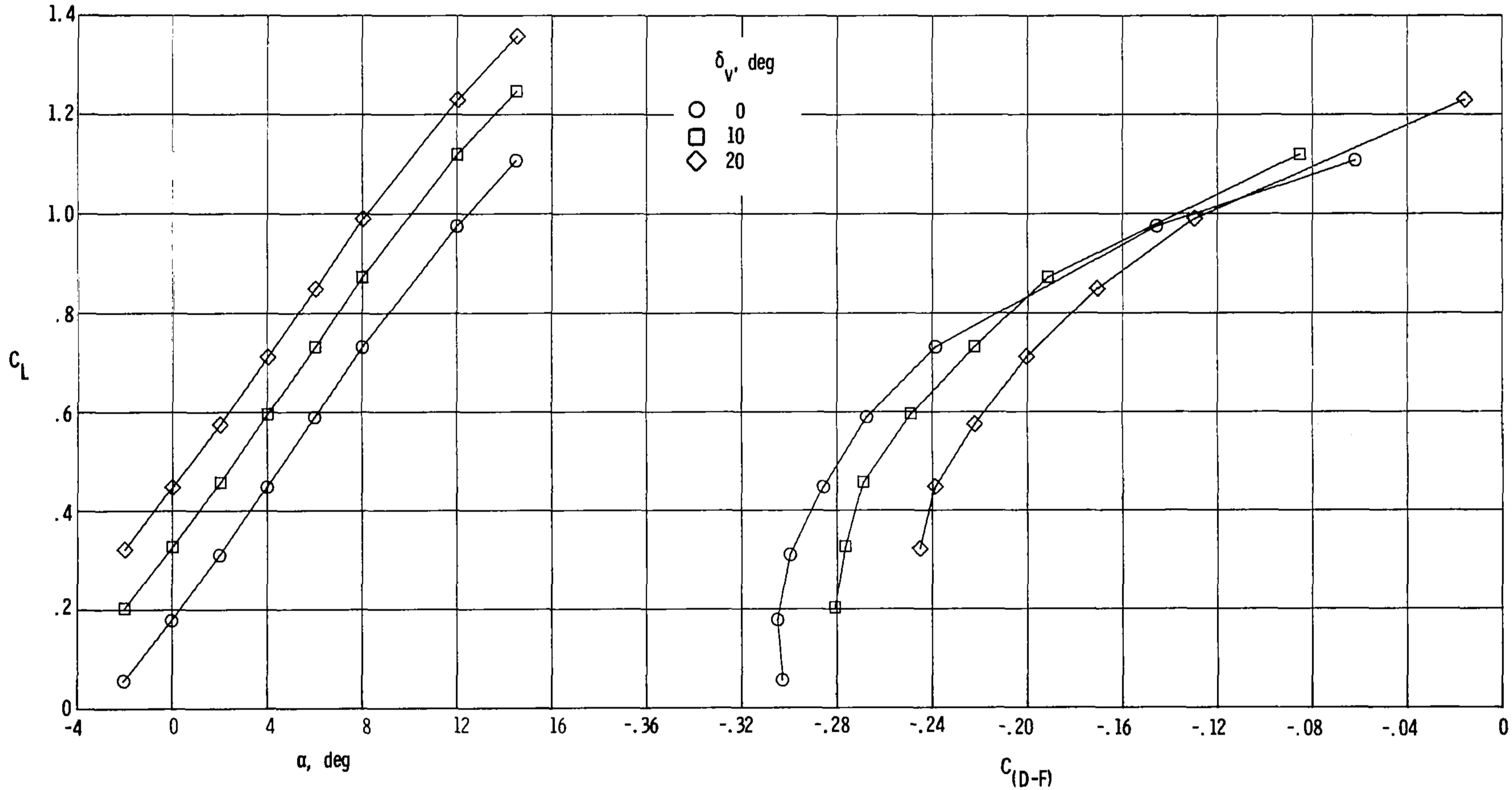
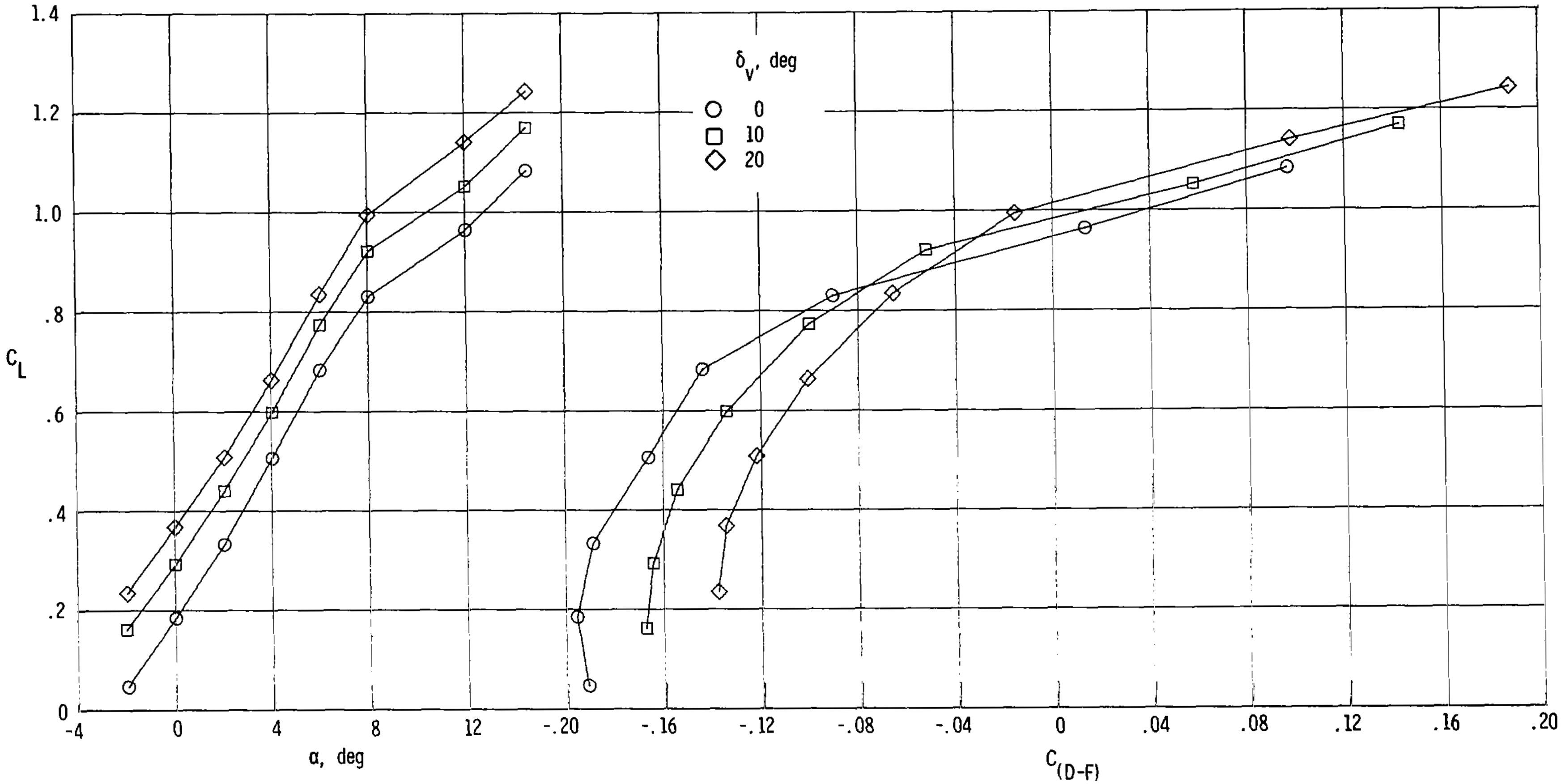


Figure 8.- General arrangement of model. All dimensions are in centimeters unless otherwise noted.



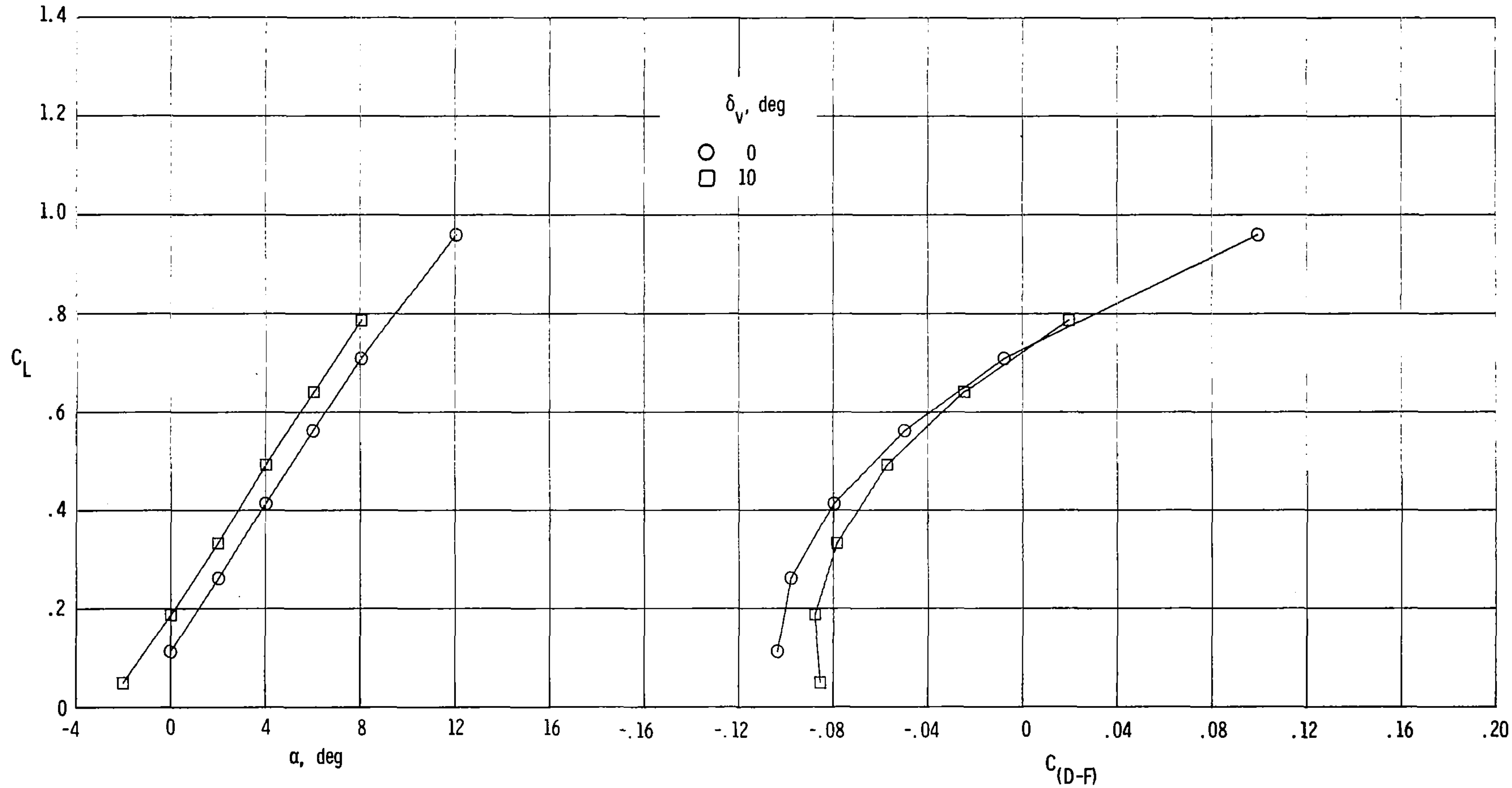
(a) M = 0.60; NPR = 3.5.

Figure 9.- Effect of thrust vector angle on total wing-afterbody-nozzle aerodynamic characteristics. Canard on; dry power.



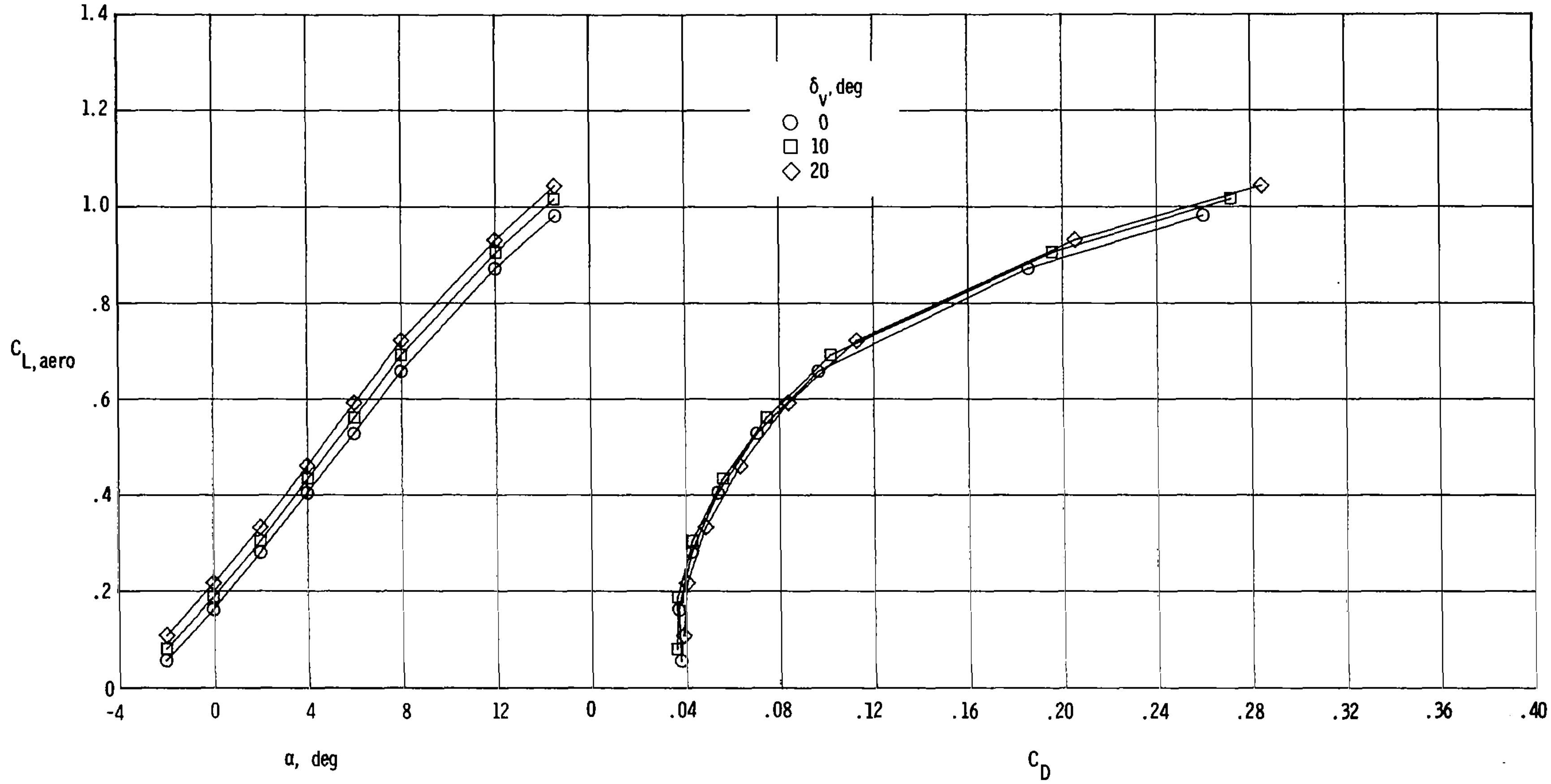
(b) M = 0.90; NPR = 5.0.

Figure 9.- Continued.



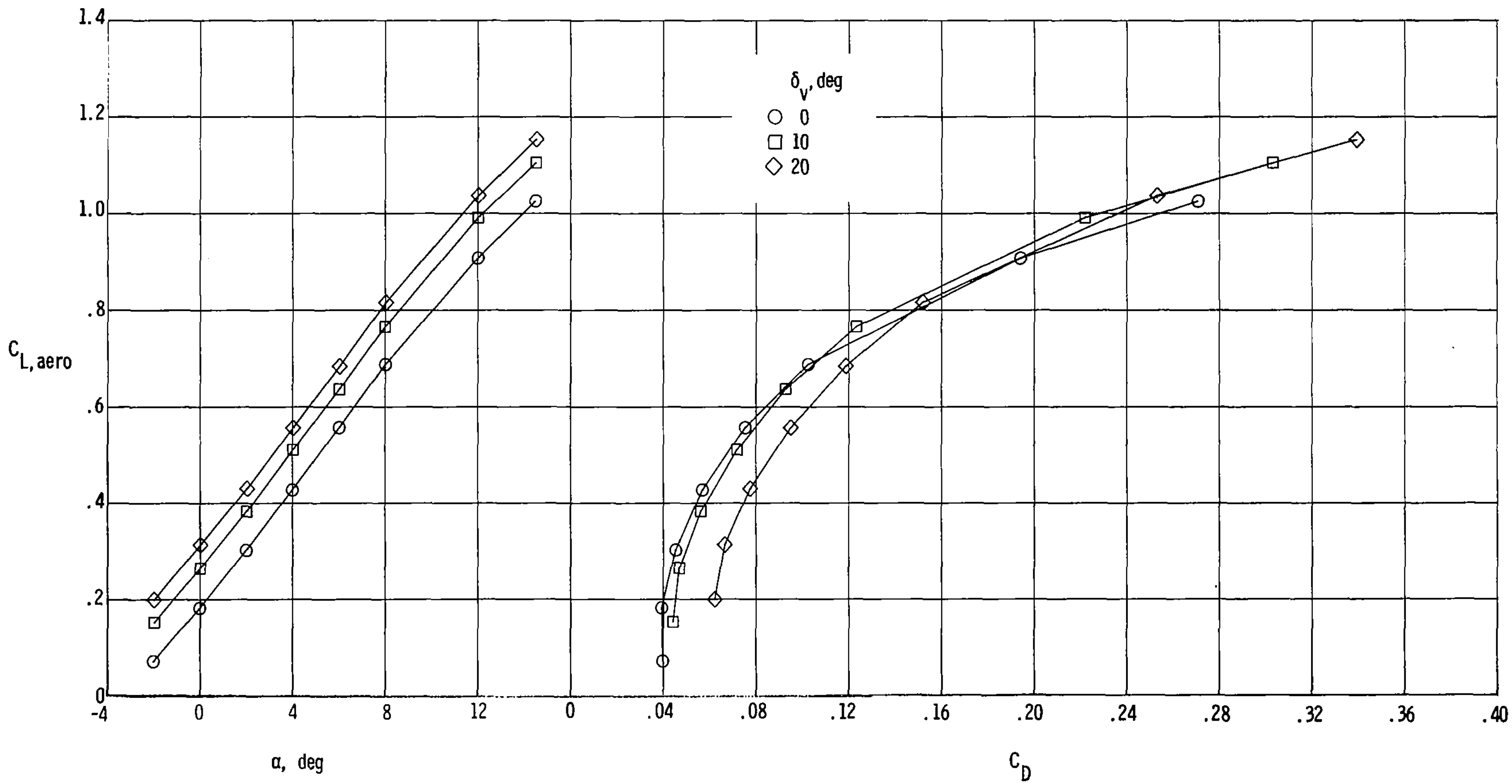
(c) M = 1.20; NPR = 7.0.

Figure 9.- Concluded.



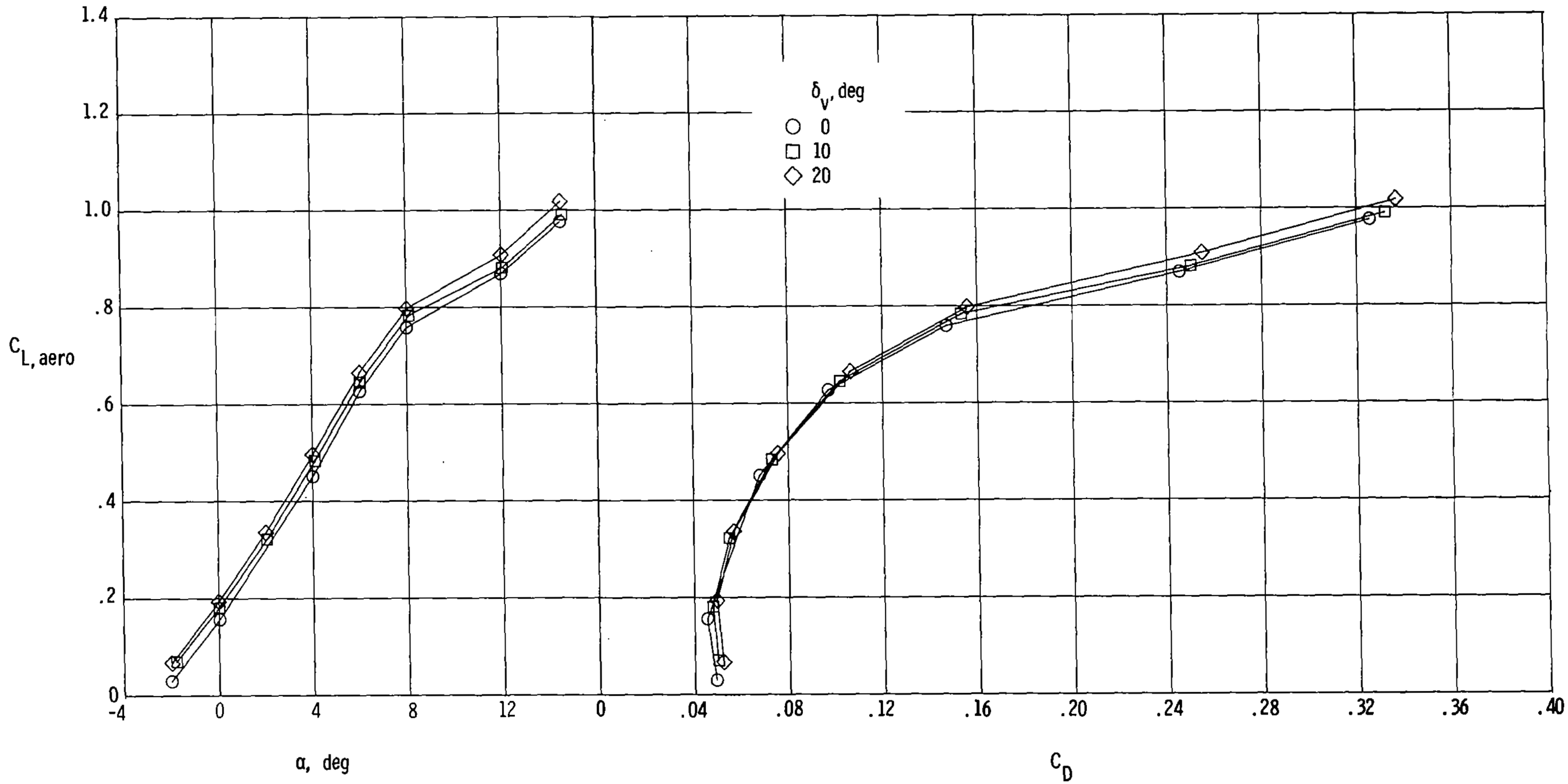
(a) M = 0.60; NPR = 1.0.

Figure 10.- Effect of thrust vectoring on thrust-removed wing-afterbody-nozzle aerodynamic characteristics. Canard on; dry power.



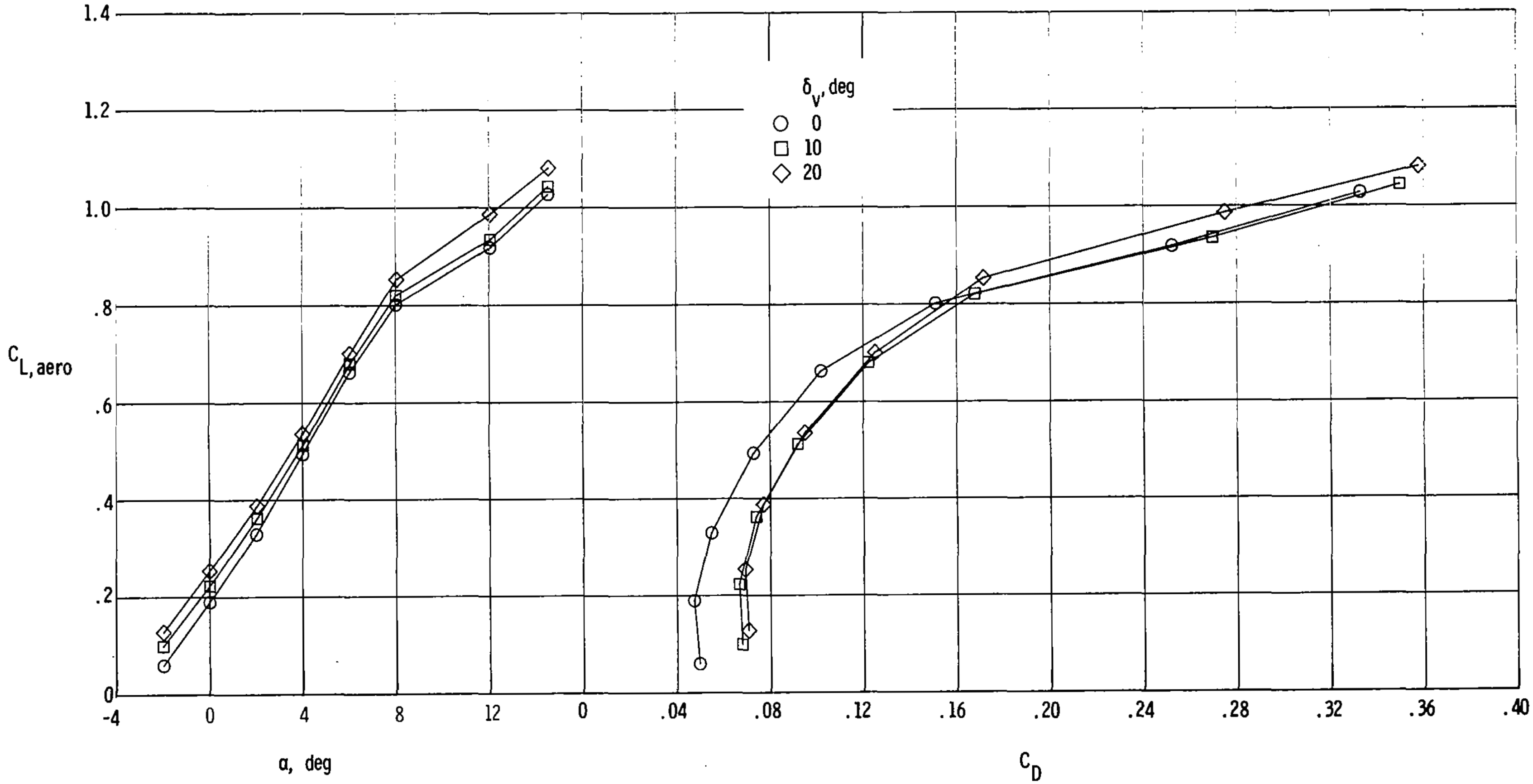
(b) M = 0.60; NPR = 3.5.

Figure 10.- Continued.



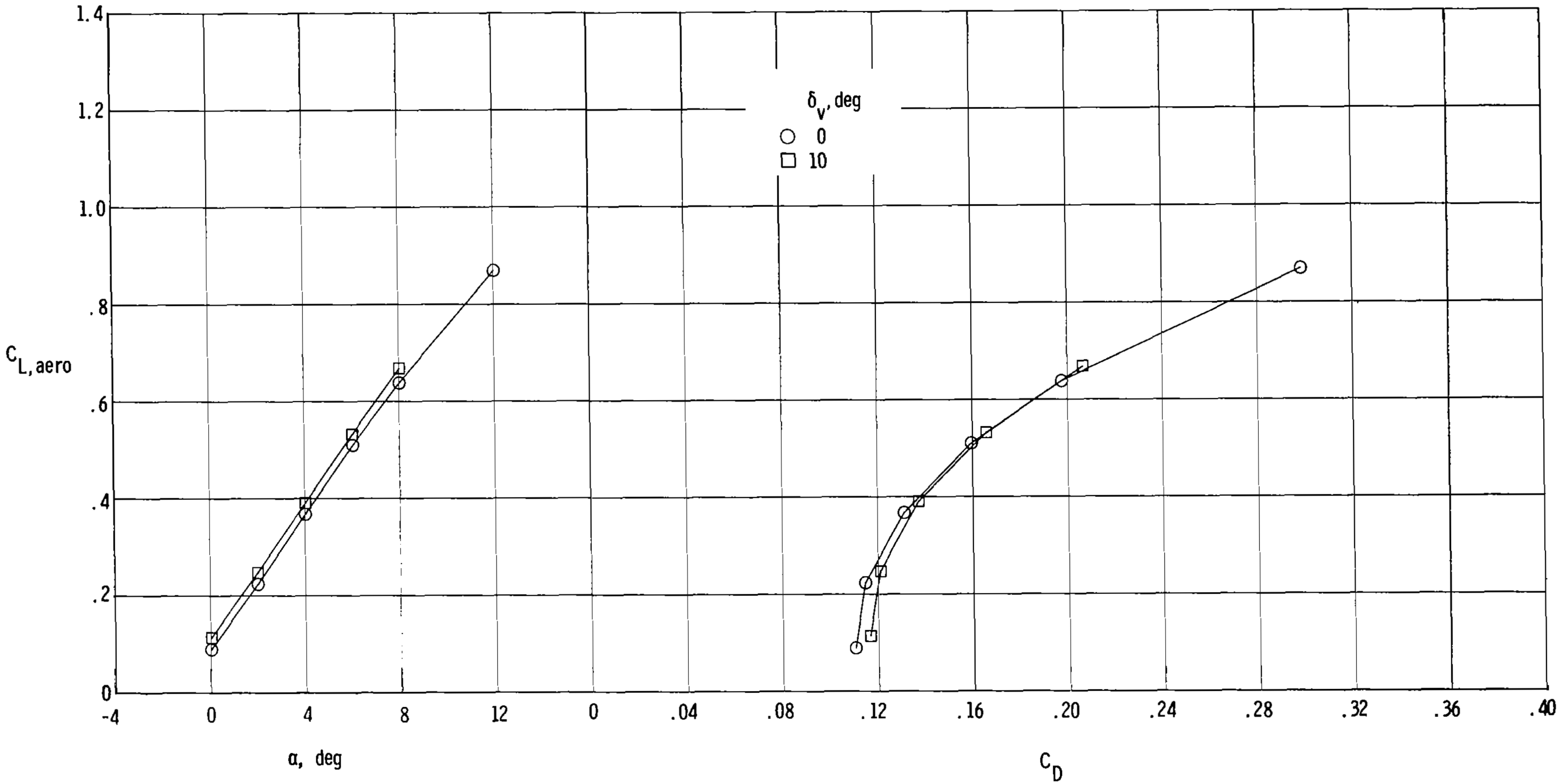
(c) M = 0.90; NPR = 1.0.

Figure 10.- Continued.



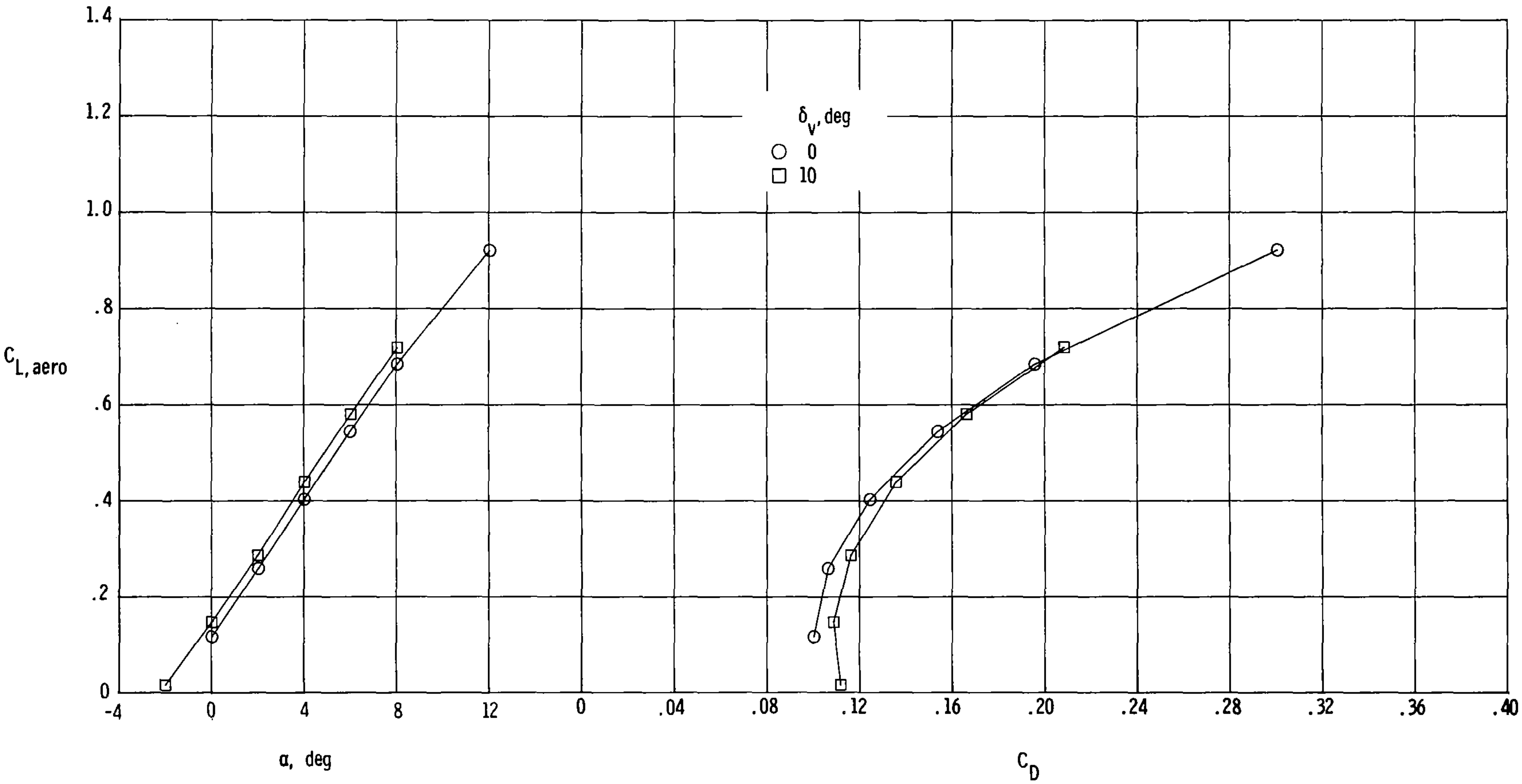
(d) M = 0.90; NPR = 5.0.

Figure 10.- Continued.



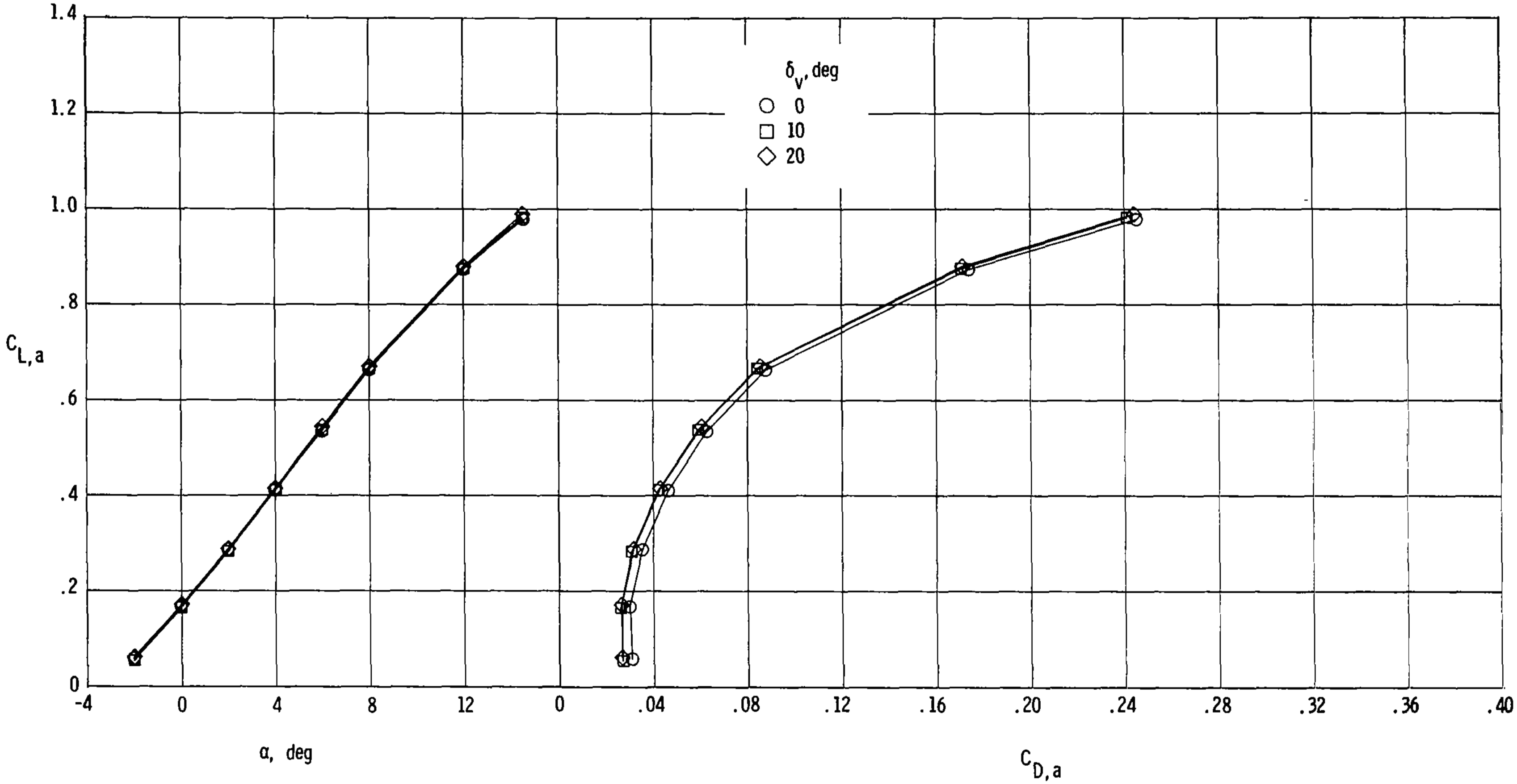
(e) M = 1.20; NPR = 1.0.

Figure 10.- Continued.



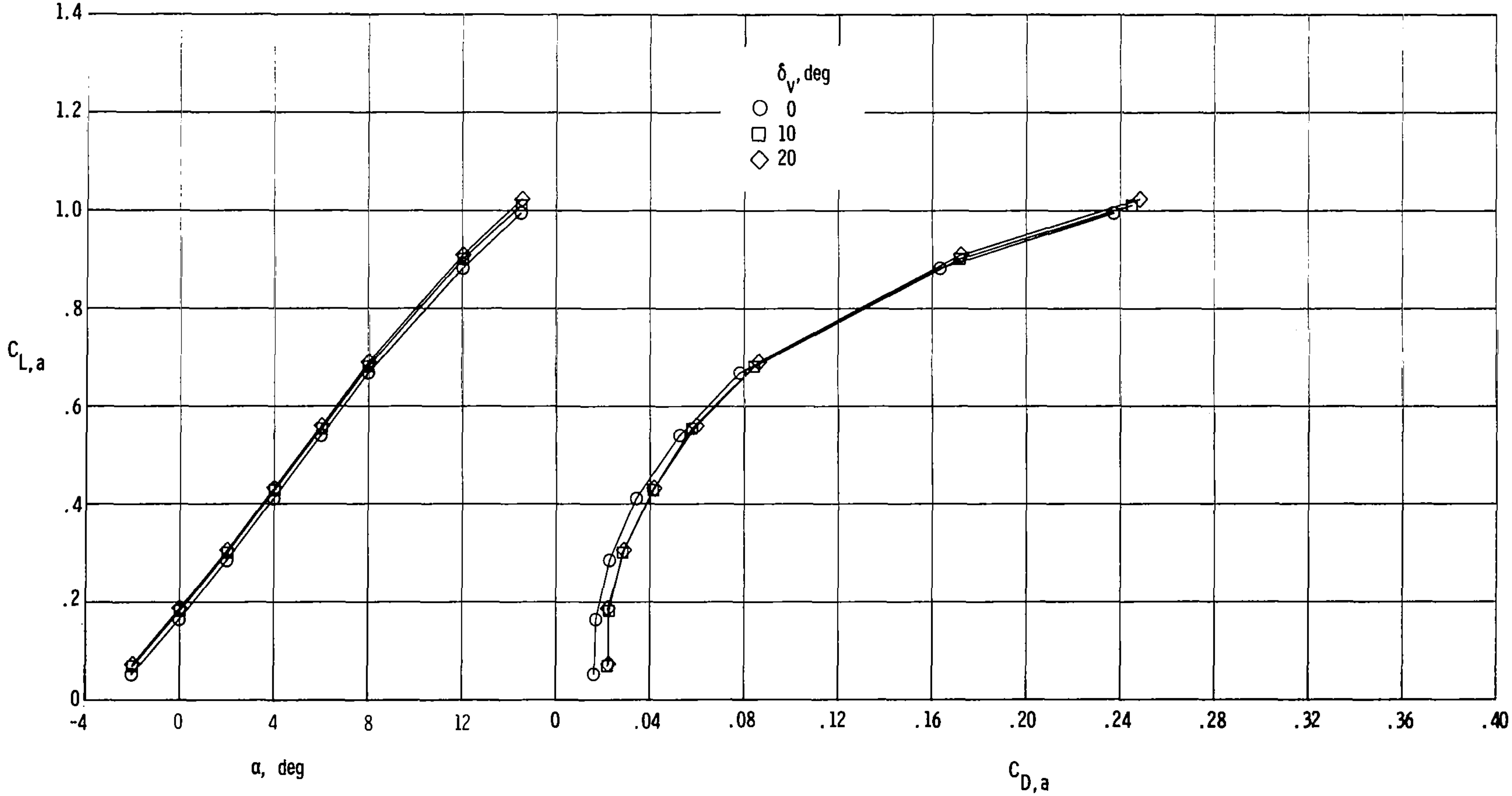
(f) M = 1.20; NPR = 7.0.

Figure 10.- Concluded.



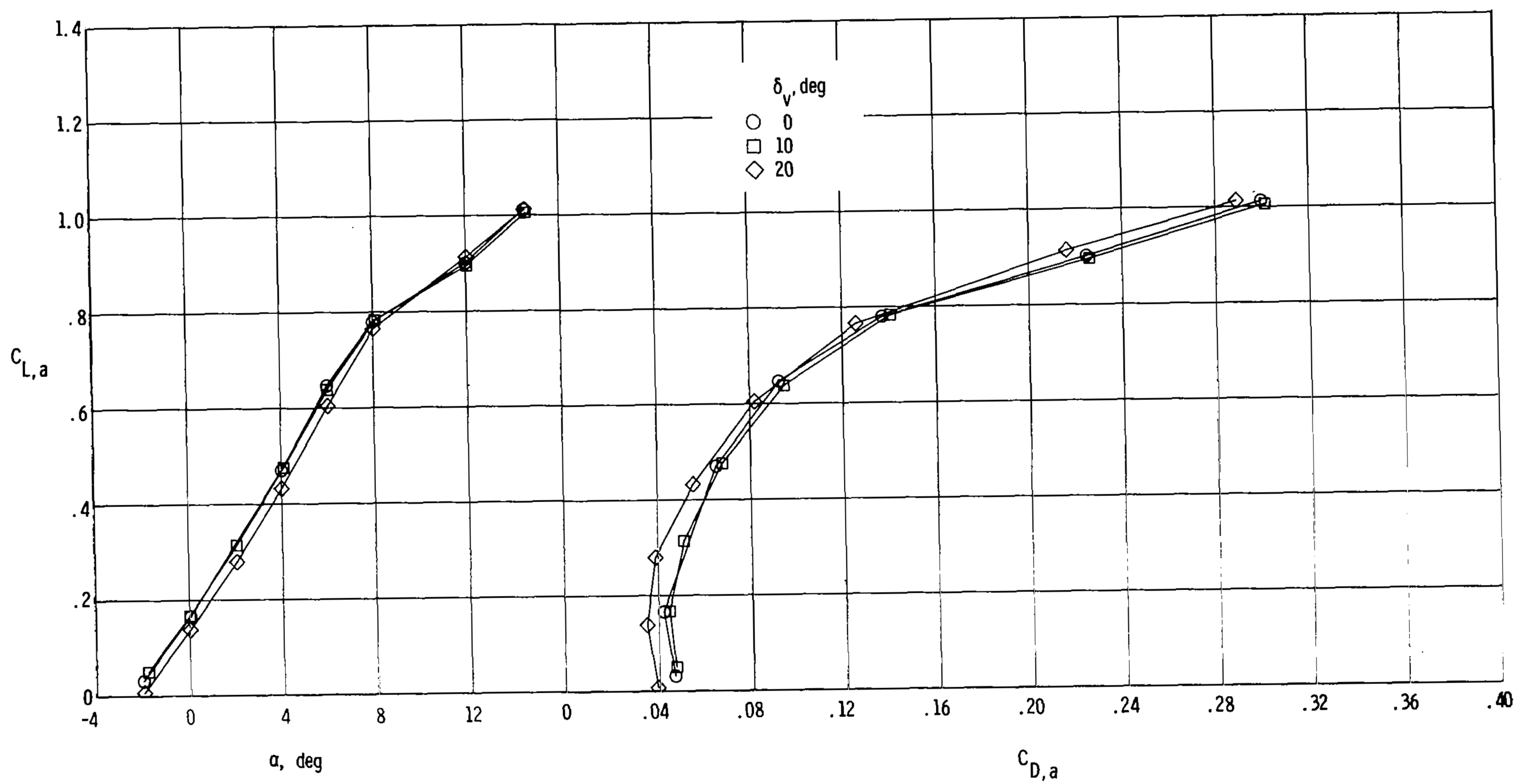
(a) M = 0.60; NPR = 1.0.

Figure 11.- Effect of thrust vectoring on thrust-removed wing-afterbody aerodynamic characteristics. Canard on; dry power.



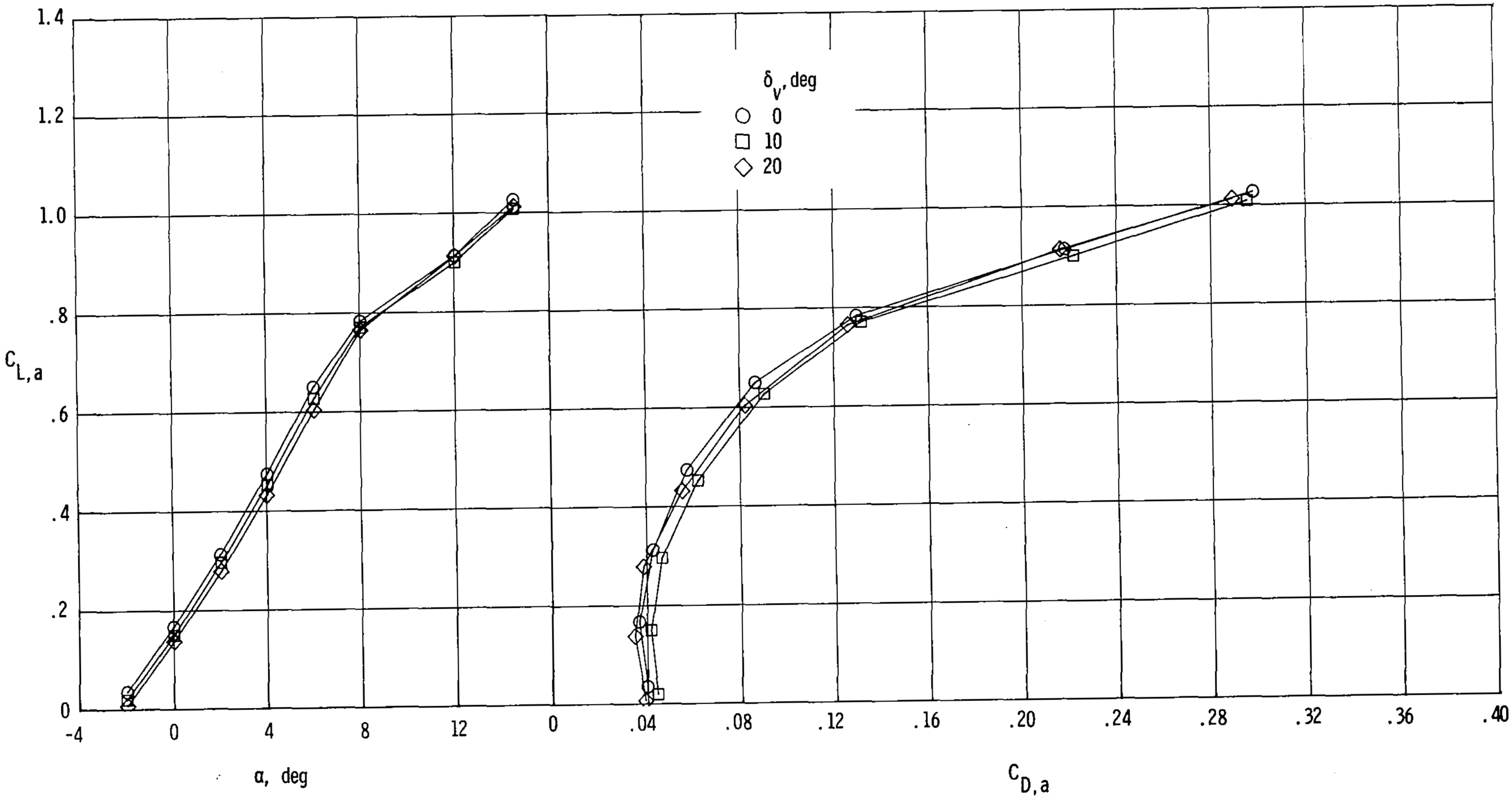
(b) M = 0.60; NPR = 3.5.

Figure 11.- Continued.



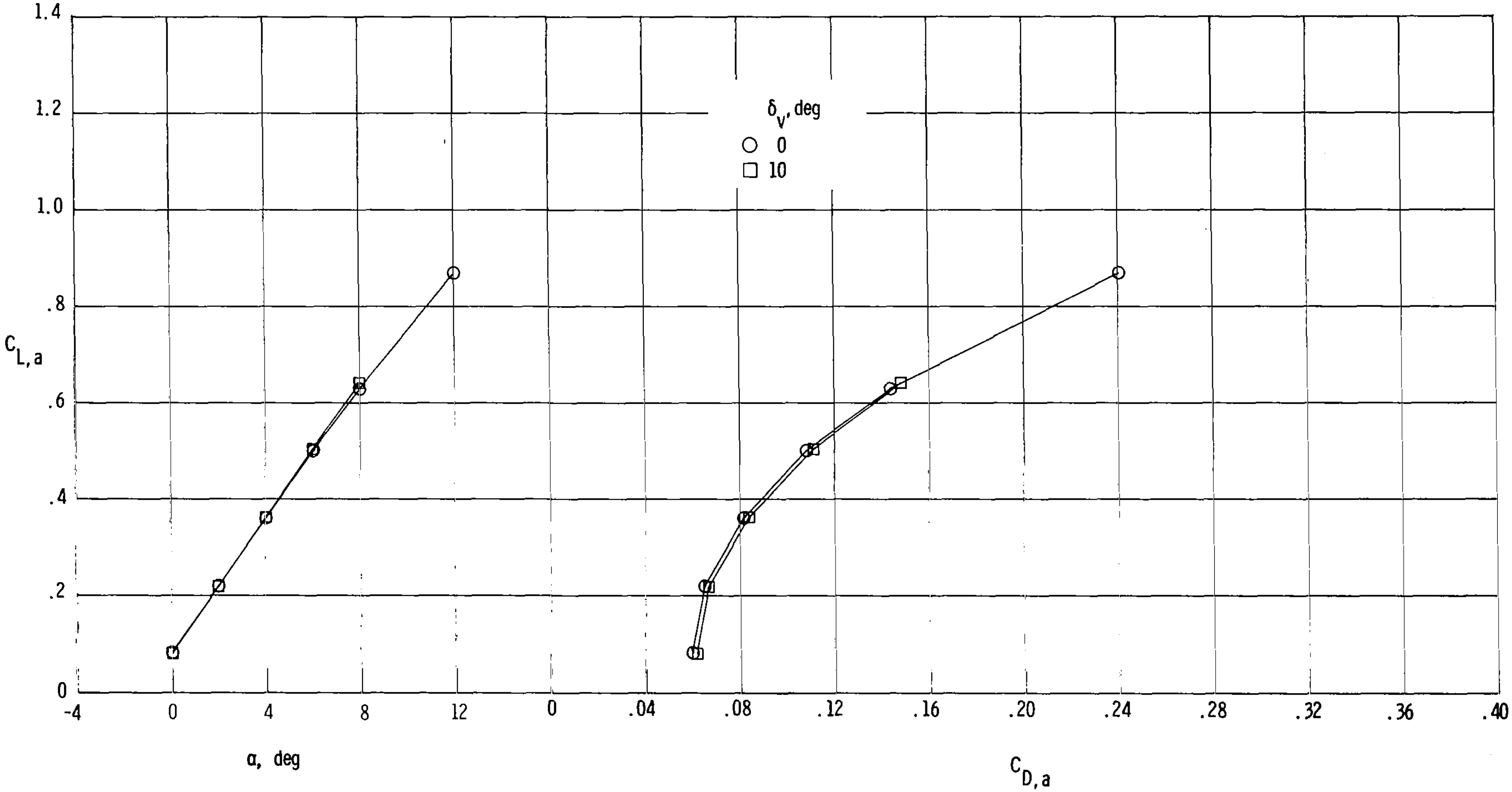
(c) M = 0.90; NPR = 1.0.

Figure 11.- Continued.



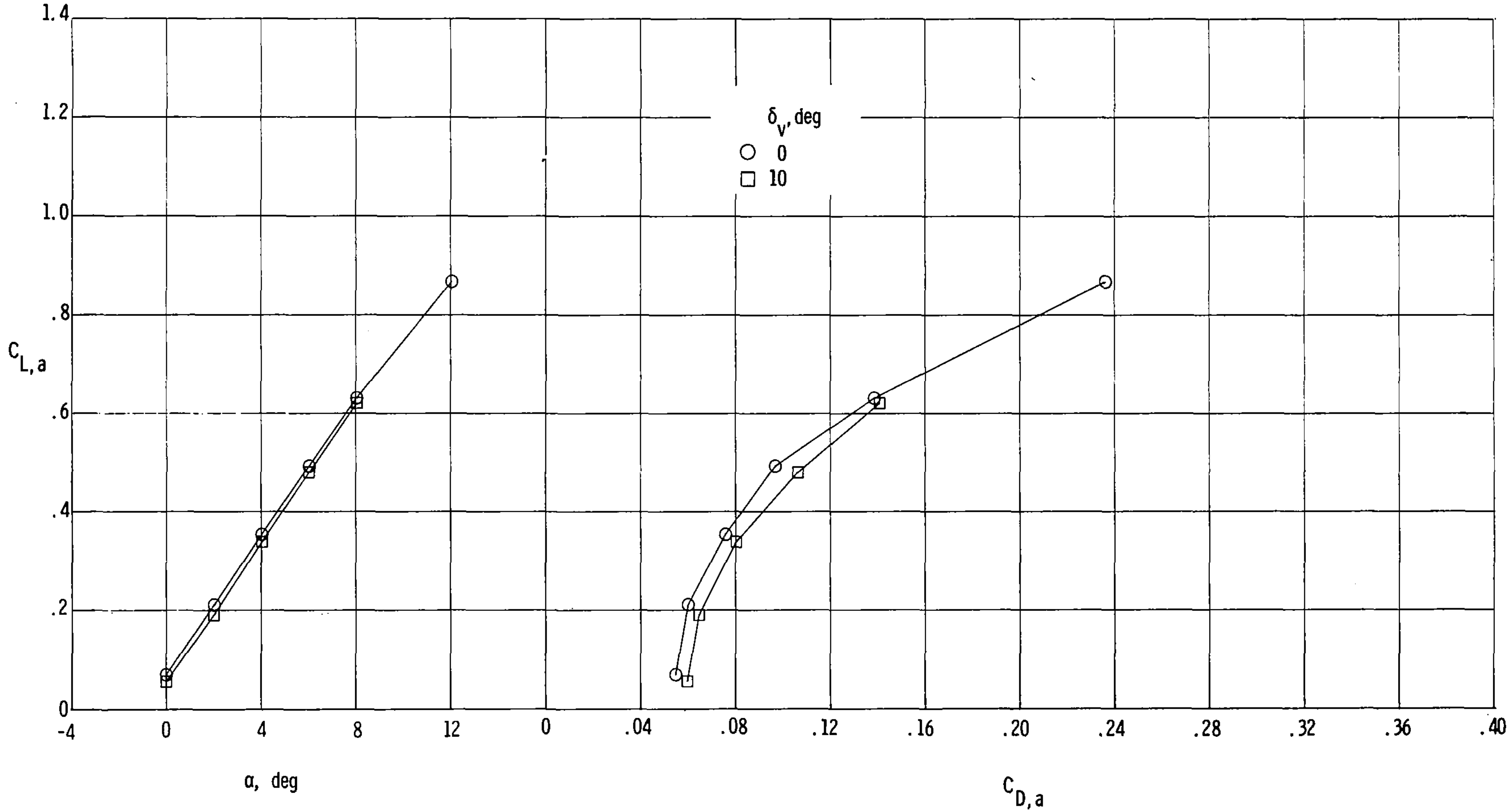
(d) M = 0.90; NPR = 5.0.

Figure 11.- Continued.



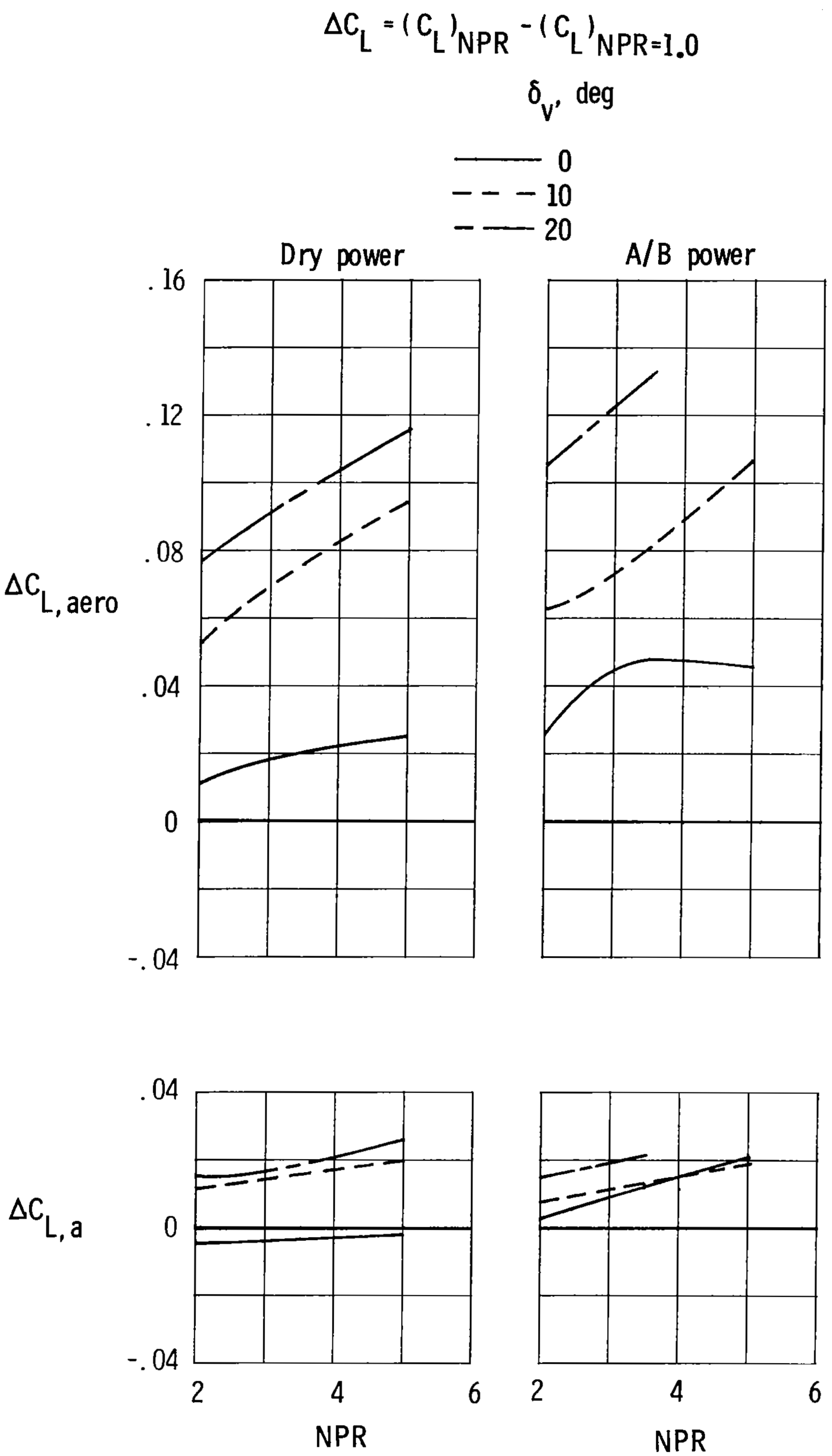
(e) M = 1.20; NPR = 1.0.

Figure 11.- Continued.



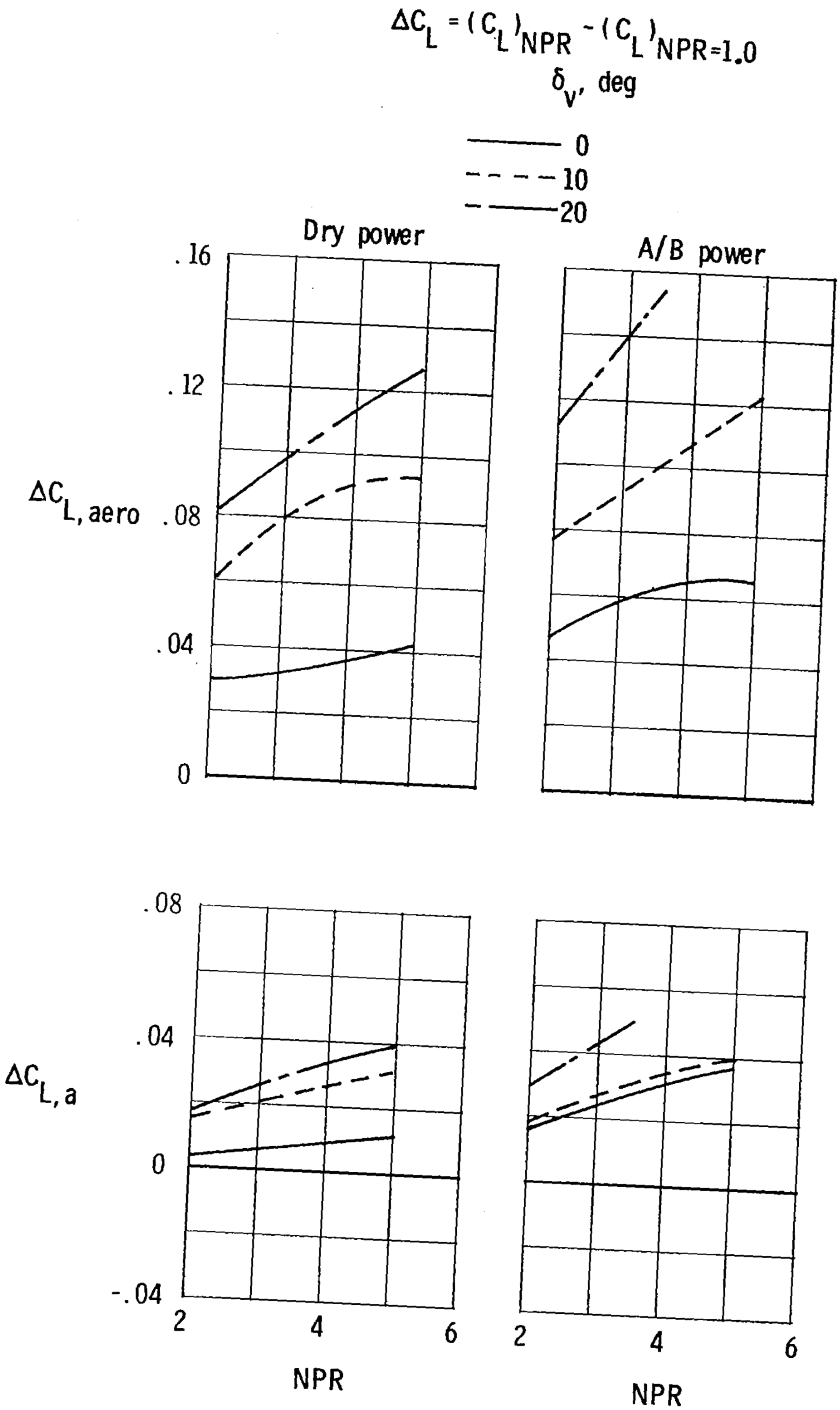
(f) M = 1.20; NPR = 7.0.

Figure 11.- Concluded.



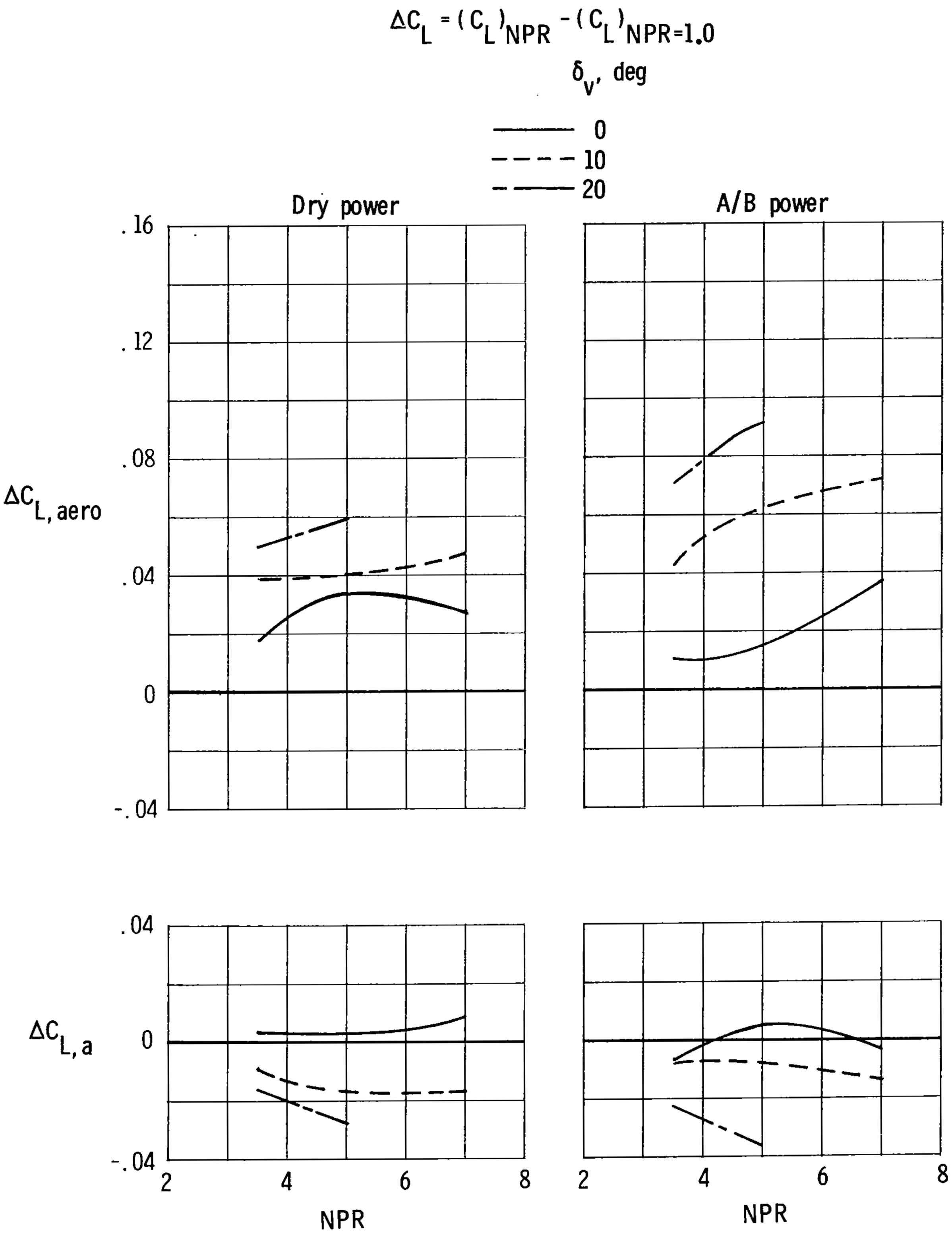
(a) M = 0.60; α = 0°.

Figure 12.- Effect of vectoring on thrust-removed incremental lift. Canard on.



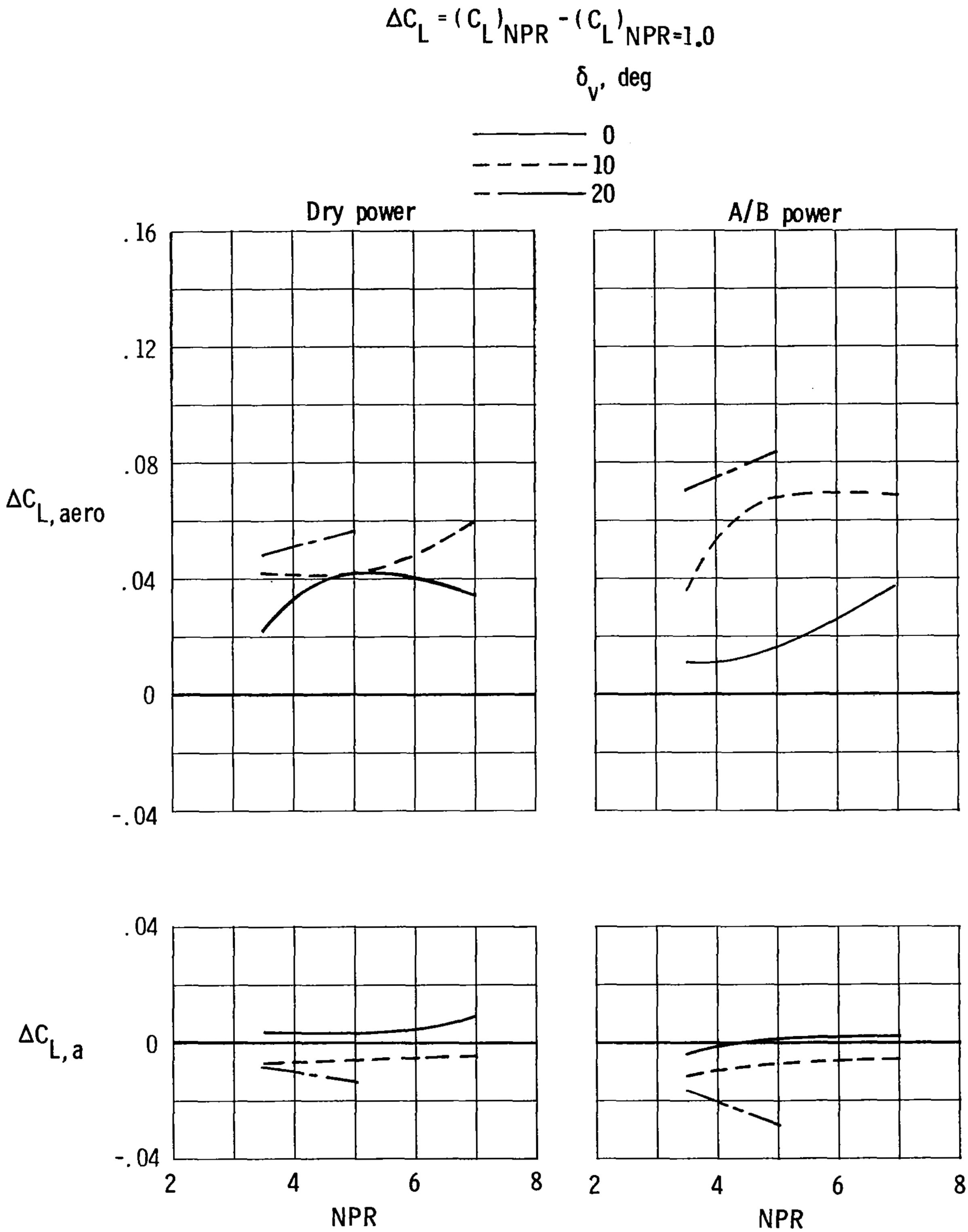
(b) $M = 0.60$; $\alpha = 12°$.

Figure 12.- Continued.



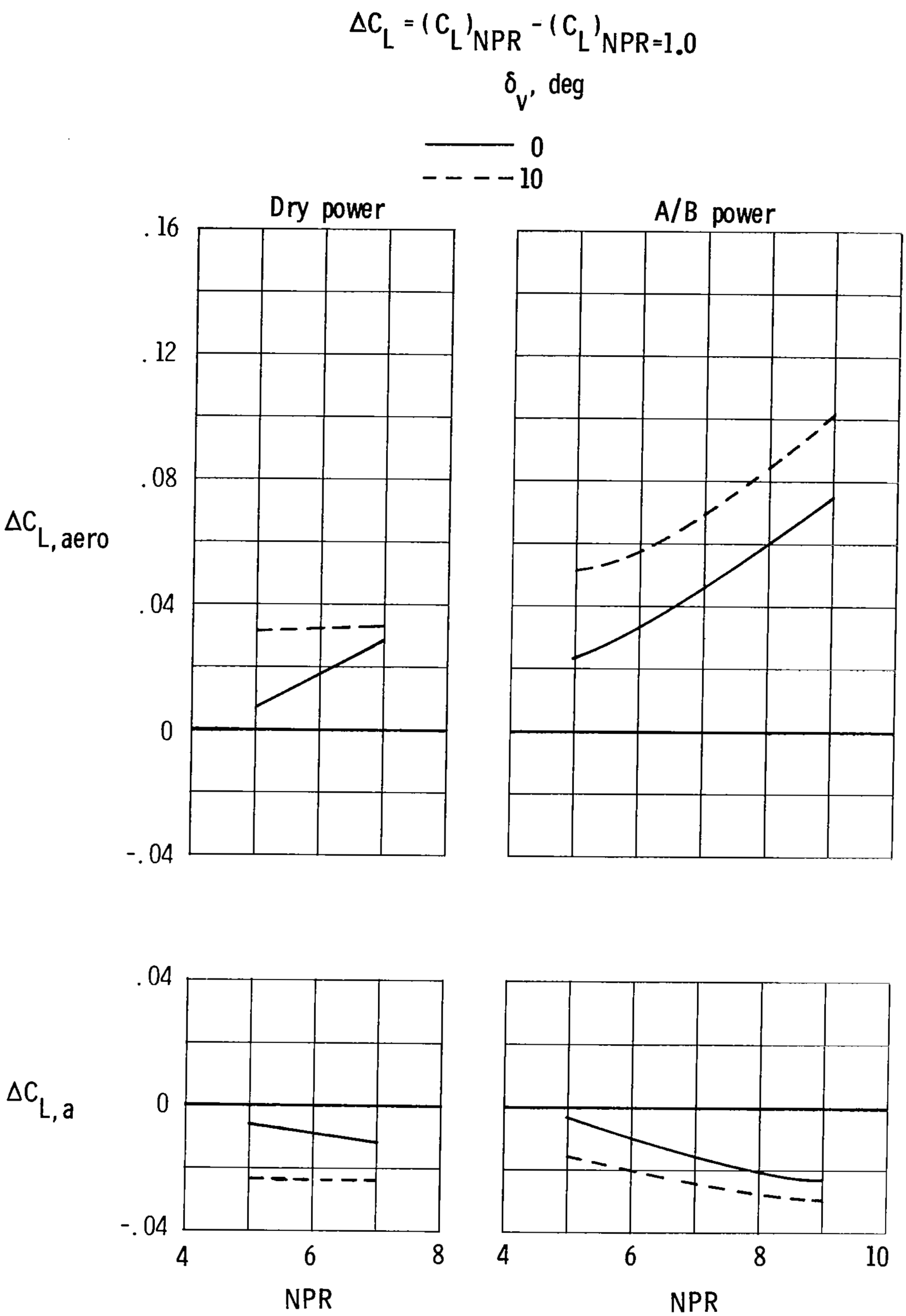
(c) $M = 0.90$; $\alpha = 0°$.

Figure 12.- Continued.



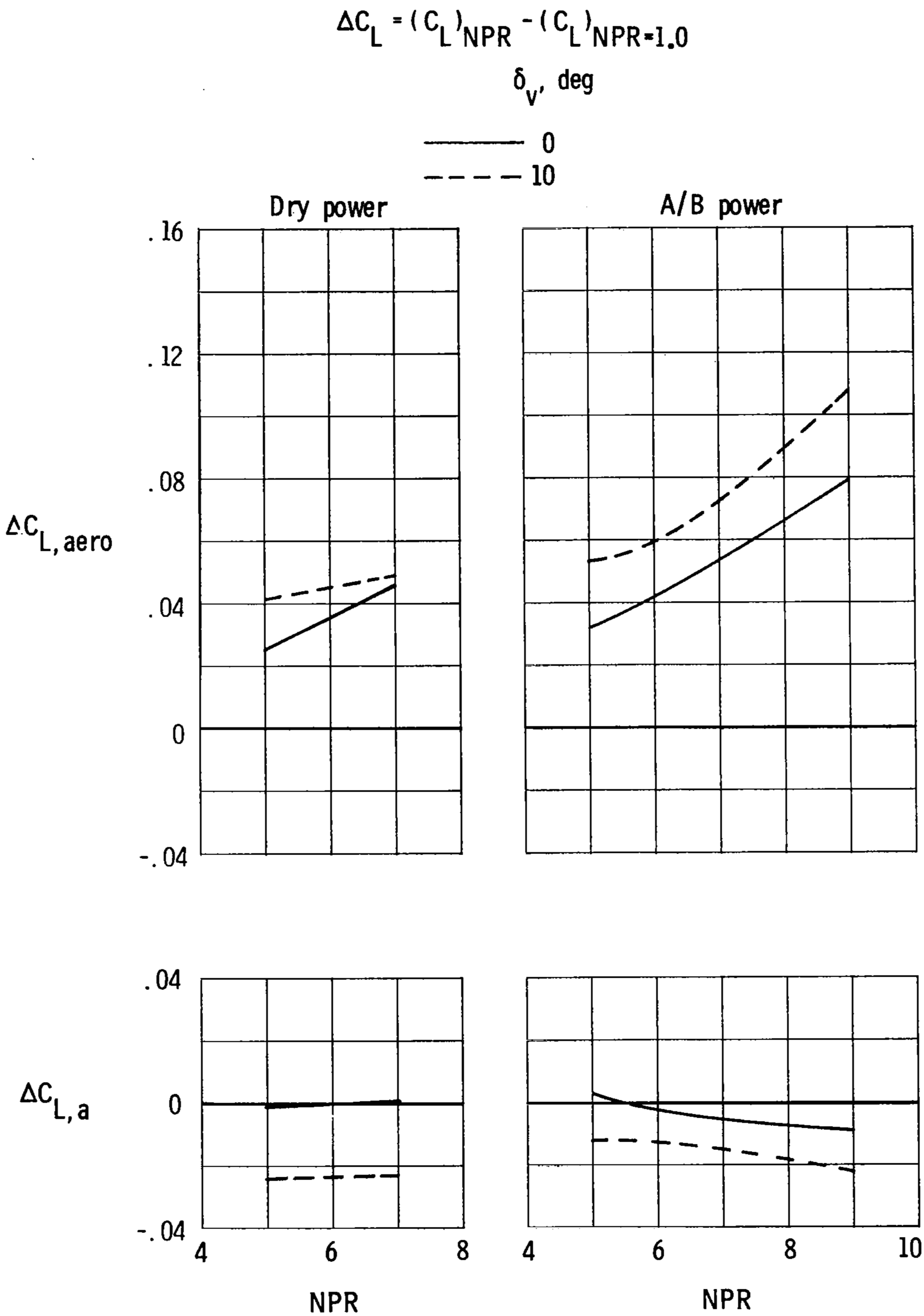
(d) M = 0.90; α = 12°.

Figure 12.- Continued.



(e) M = 1.20; α = 0°.

Figure 12.- Continued.



(f) M = 1.20; $\alpha = 8°$.

Figure 12.- Concluded.

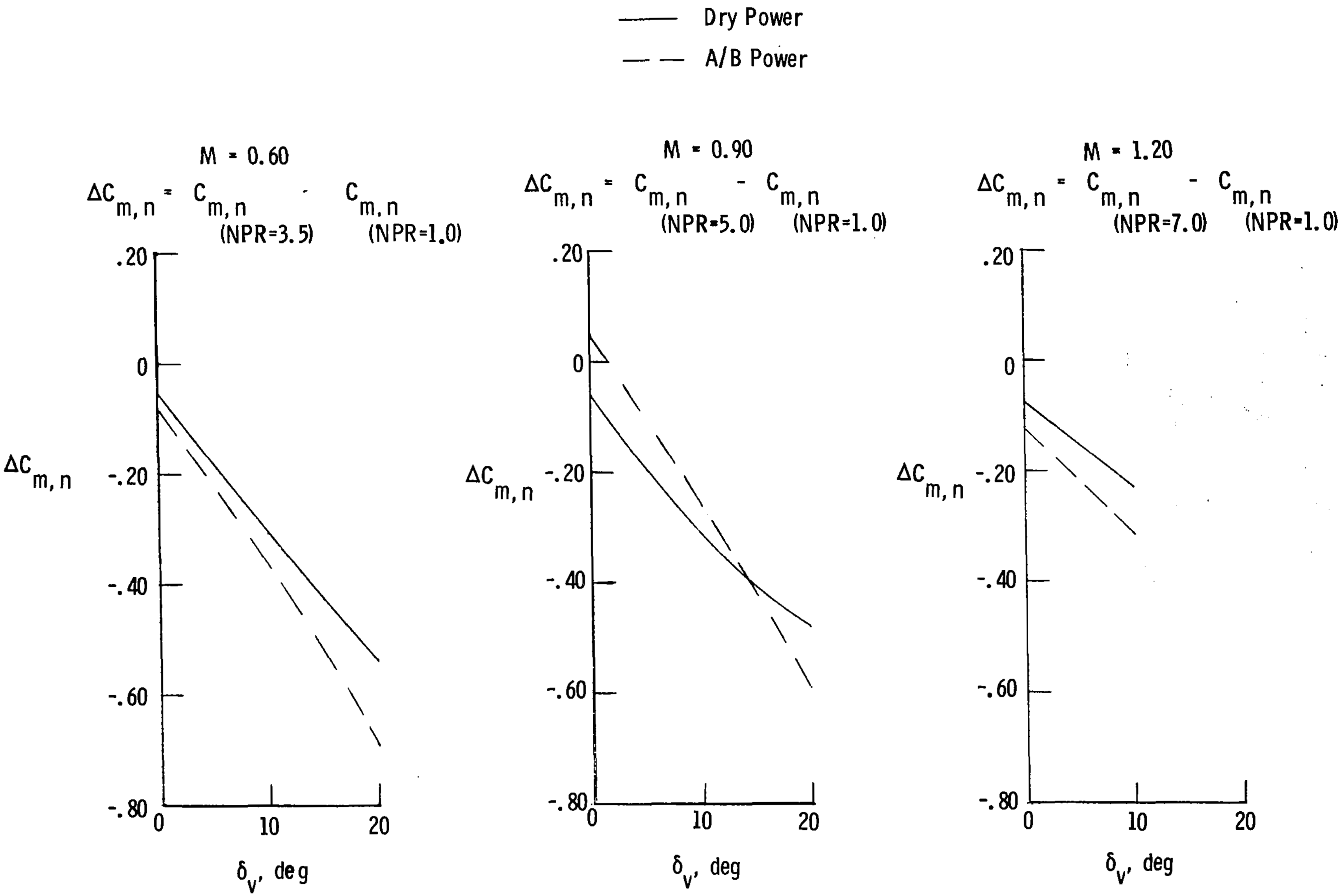
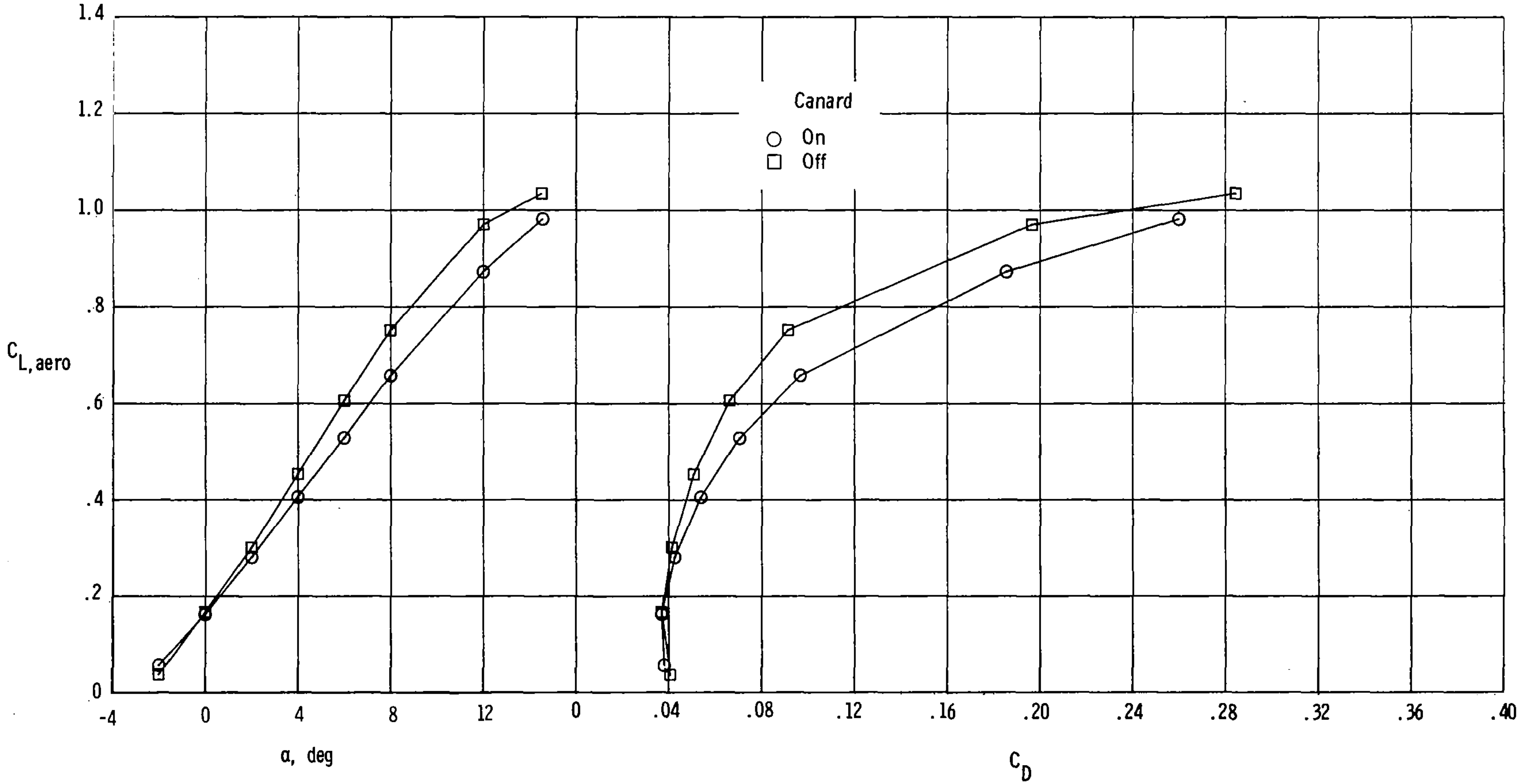
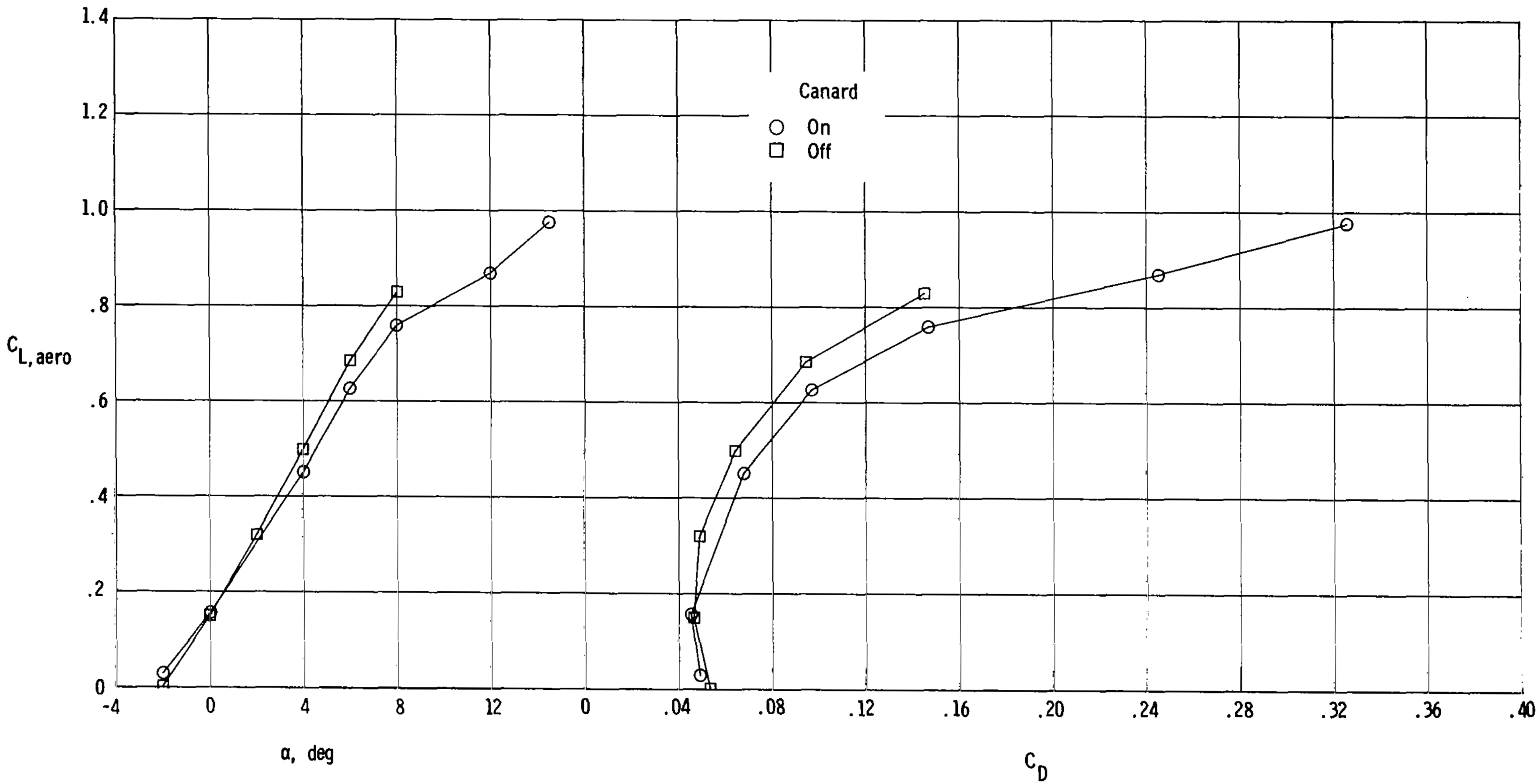


Figure 13.- Effect of thrust vector angle on incremental nozzle pitching moment. Canard on; $\alpha = 0°$.



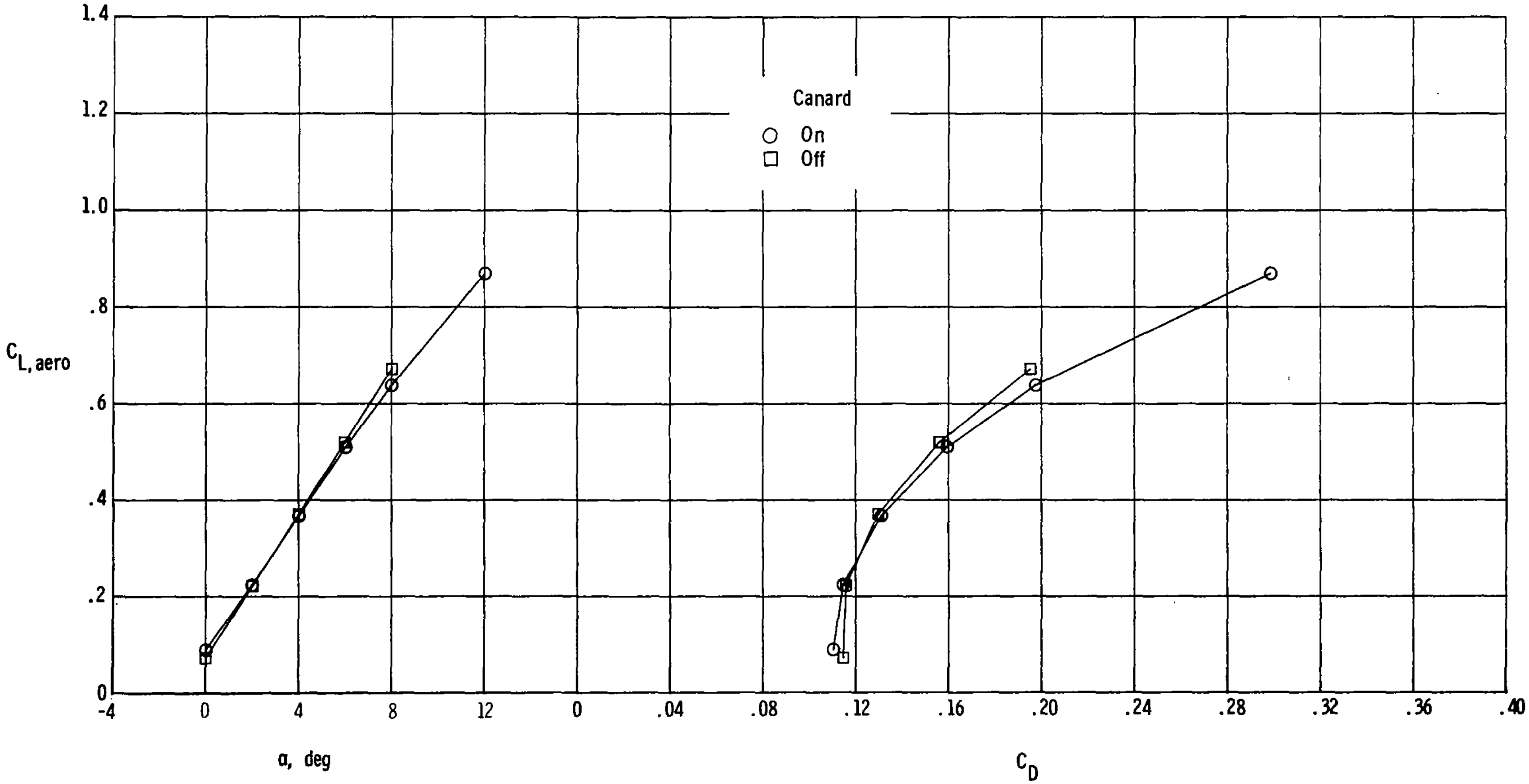
(a) M = 0.60.

Figure 14.- Effect of canard on thrust-removed wing-afterbody-nozzle aerodynamic characteristics. Dry power; $\delta_v = 0°$; NPR = 1.0.



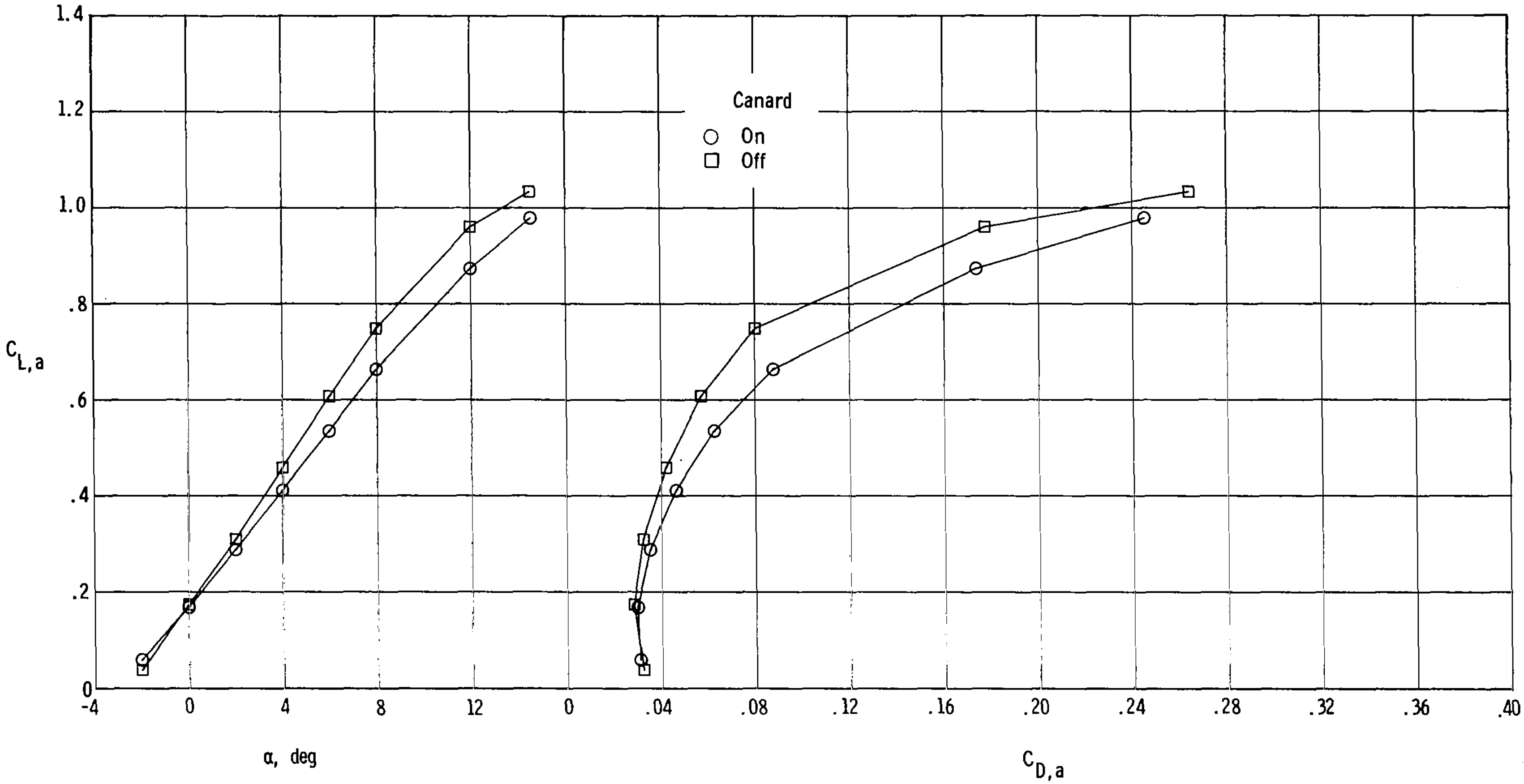
(b) M = 0.90.

Figure 14.- Continued.



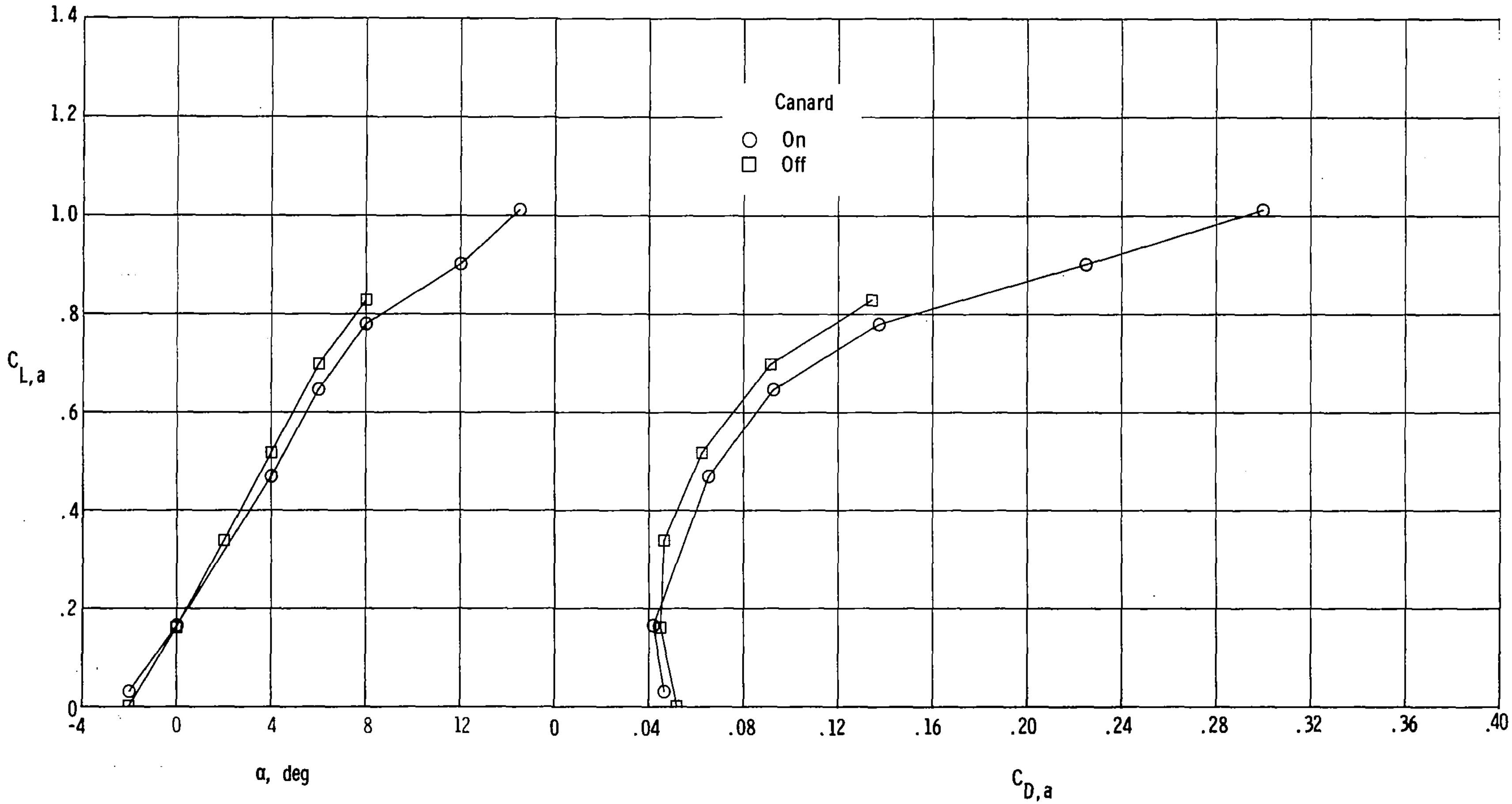
(c) M = 1.20.

Figure 14.- Concluded.



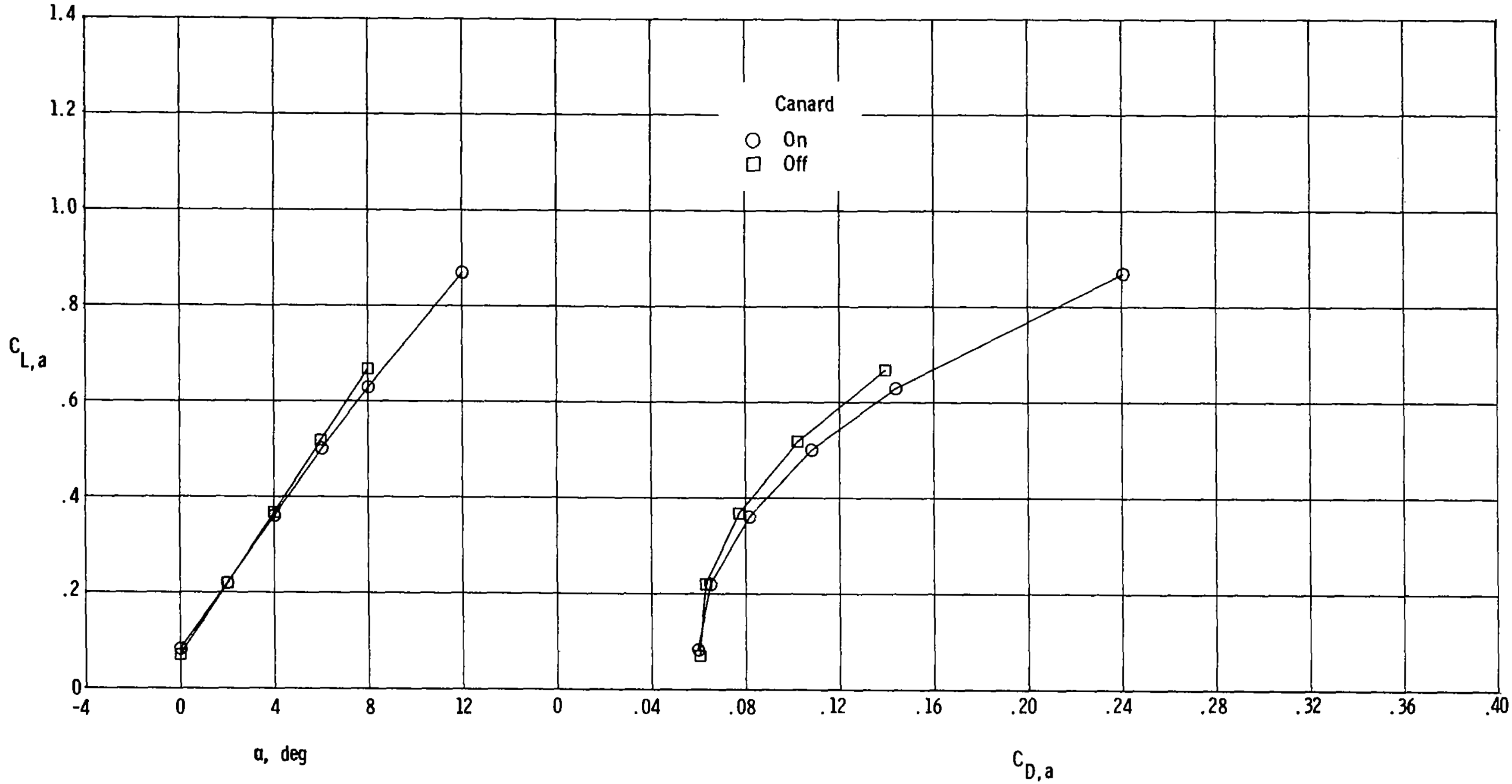
(a) M = 0.60.

Figure 15.- Effect of canard on thrust-removed wing-afterbody aerodynamic characteristics. Dry power; $\delta_v = 0°$; NPR = 1.0.



(b) M = 0.90.

Figure 15.- Continued.



(c) M = 1.20.

Figure 15.- Concluded.

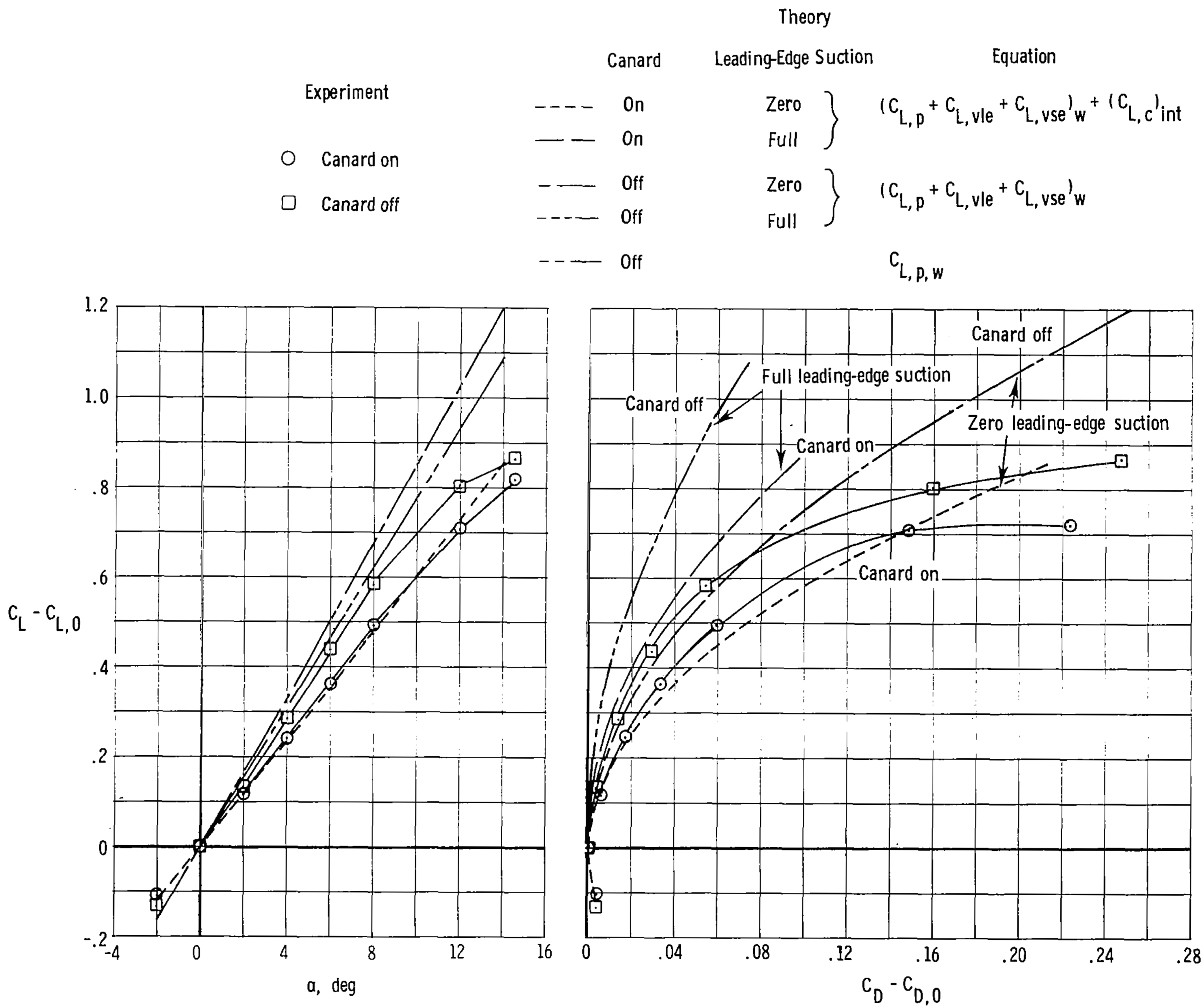
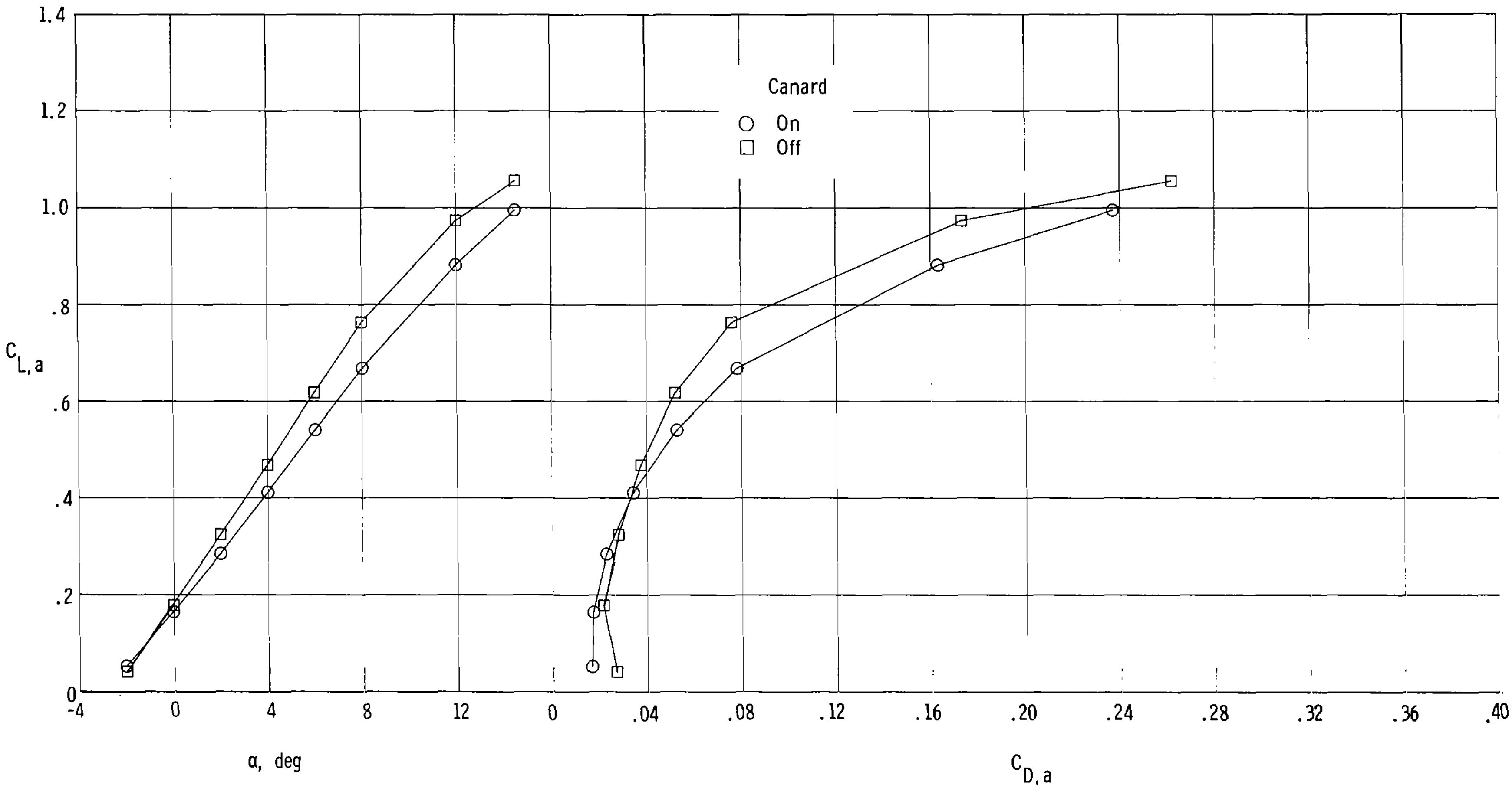
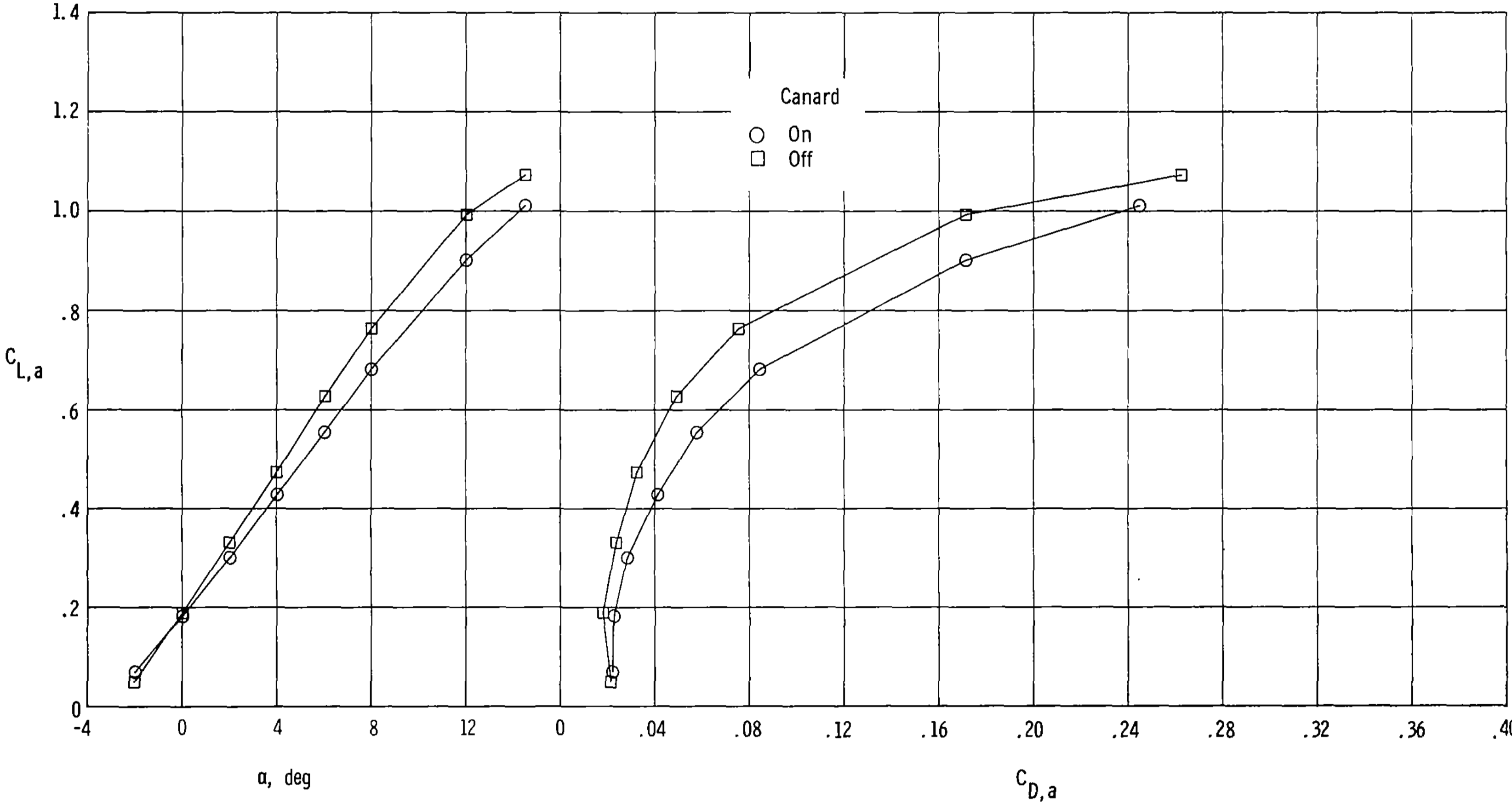


Figure 16.- Comparison of experimental and theoretical aerodynamic characteristics. Dry power; jet off; M = 0.60; $\delta_v = 0°$.



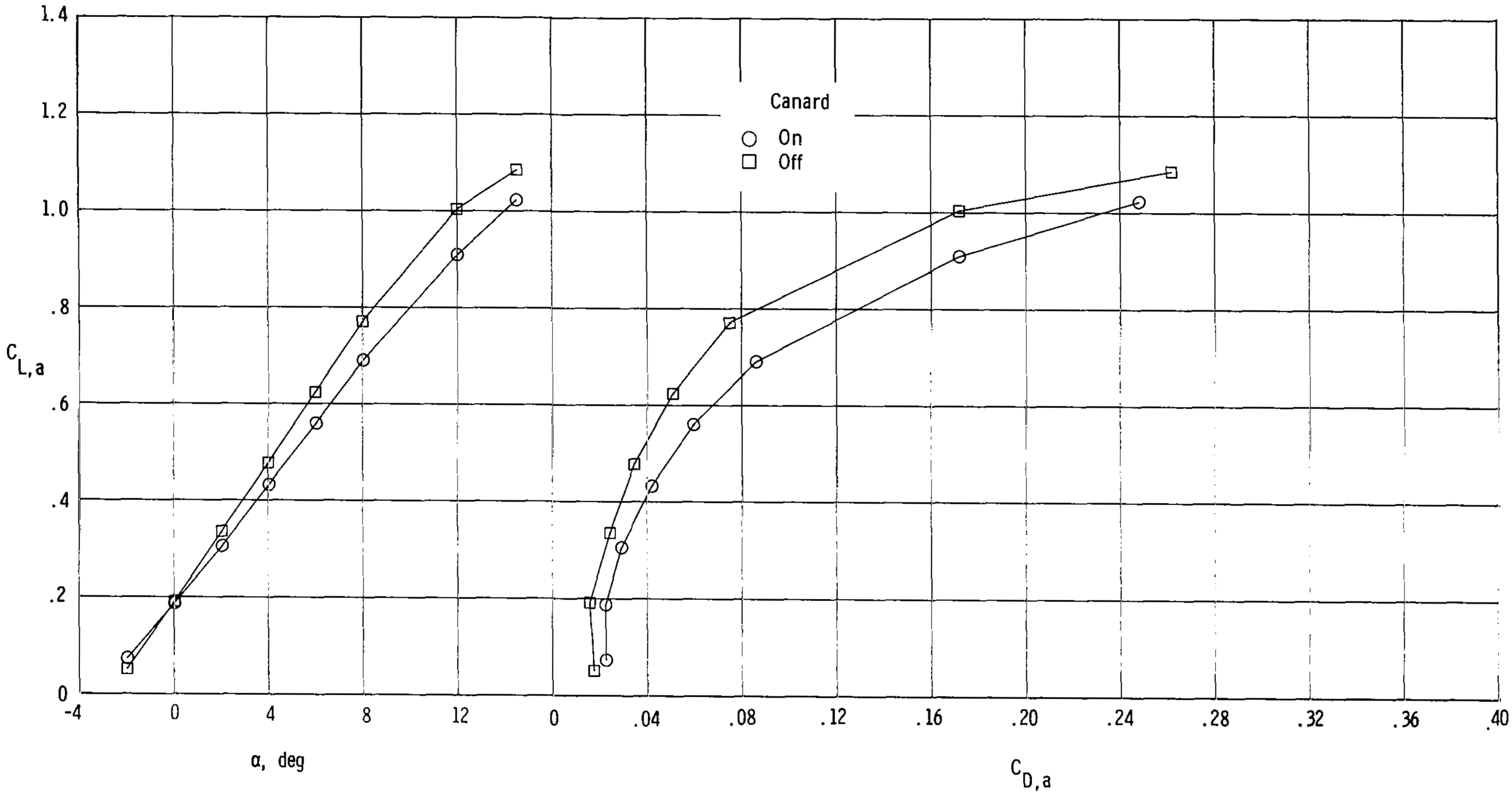
(a) $\delta_v = 0°$.

Figure 17.- Effect of canard and thrust vectoring on thrust-removed wing-afterbody aerodynamic characteristics. Dry power; M = 0.60; NPR = 3.5.



(b) $\delta_v = 10°$.

Figure 17.- Continued.



(c) $\delta_v = 20°$.

Figure 17.- Concluded.

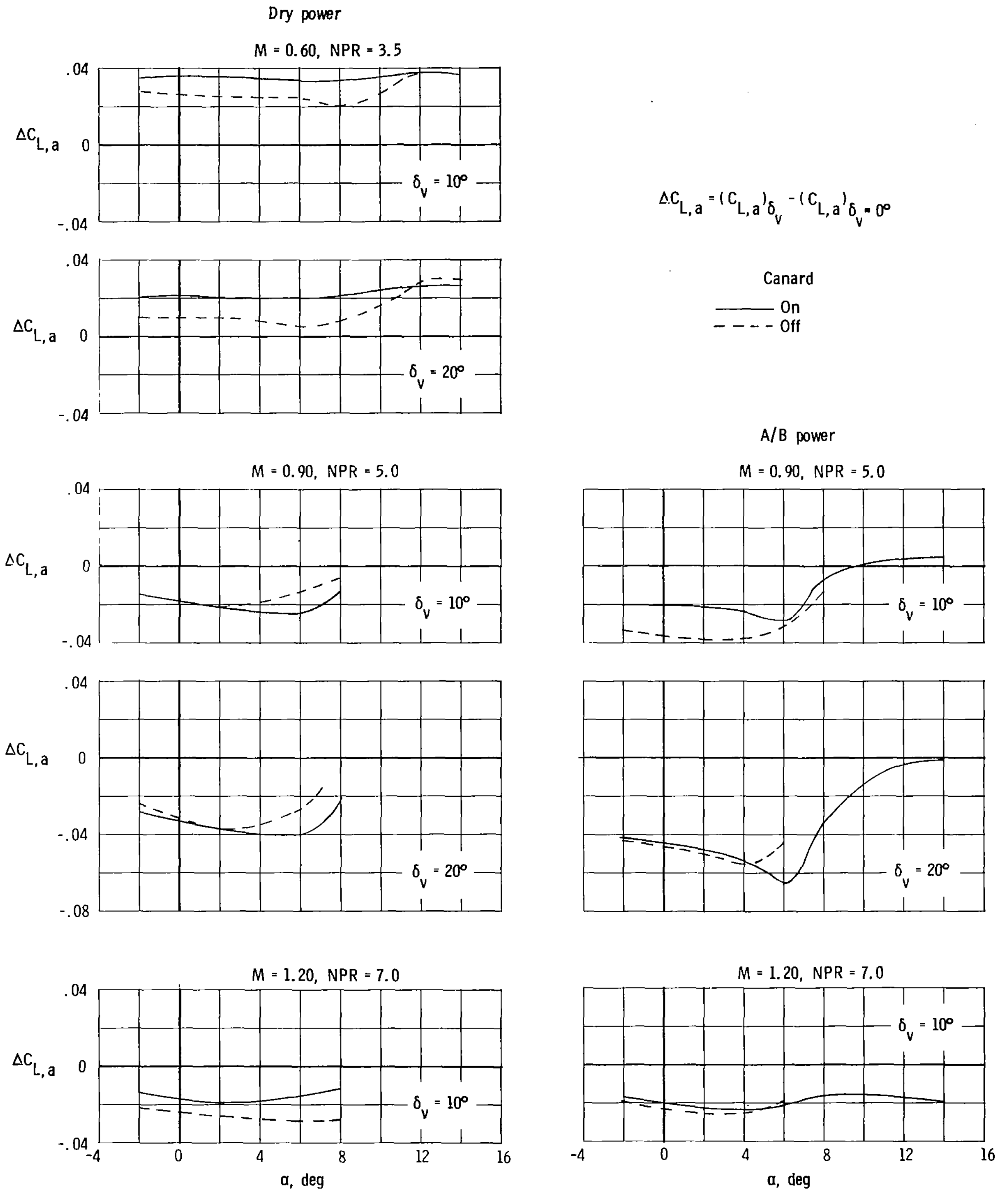


Figure 18.- Effect of canard on incremental wing-afterbody lift.

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TP-2133		

4. Title and Subtitle	5. Report Date
AEROPROPULSIVE CHARACTERISTICS OF TWIN SINGLE-EXPANSION-RAMP VECTORING NOZZLES INSTALLED WITH FORWARD-SWEPT WINGS AND CANARDS	March 1983
	6. Performing Organization Code 505-43-09-07
7. Author(s) Mary L. Mason and Francis J. Capone	8. Performing Organization Report No. L-15555
9. Performing Organization Name and Address NASA Langley Research Center Hampton, VA 23665	10. Work Unit No.
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546	13. Type of Report and Period Covered Technical Paper
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

An investigation was conducted in the Langley 16-Foot Transonic Tunnel to determine the aeropropulsive characteristics of twin single-expansion-ramp vectoring nozzles installed in a wing-body configuration with forward-swept wings. The configuration was tested with and without fixed canards. The test conditions included free-stream Mach numbers of 0.60, 0.90, and 1.20. The model angle of attack ranged from -2° to 14°; the nozzle pressure ratio ranged from 1.0 (jet off) to 9.0. The Reynolds number based on the wing mean aerodynamic chord varied from 3.0×10^6 to 4.8×10^6, depending on Mach number. Aerodynamic characteristics were analyzed to determine the effects of thrust vectoring and the canard effects on the wing-afterbody-nozzle and the wing-afterbody portions of the model. Thrust vectoring had no effect on the angle of attack for the onset of flow separation on the wing but resulted in reduced drag at angle-of-attack values above that required for wing flow separation. The canard was found to have little effect on the thrust-induced lift resulting from vectoring, since canard effects occurred primarily on the wing.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Forward-swept wing Close-coupled canards Nonaxisymmetric nozzles Thrust vectoring	Unclassified - Unlimited Subject Category 02

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	75	A04

For sale by the National Technical Information Service, Springfield, Virginia 22161

NASA-Langley, 1983