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RESEARCH MEMORANDUM

EXPERIMENTAL INVESTIGATION OF VARIOUS EXTERNAL-STORE CONFIGURATIONS ON A MODEL OF A TAILLESS AIRPLANE WITH A SWEPTBACK WING

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EXPERIMENTAL INVESTIGATION OF VARIOUS EXTERNAL-STORE CONFIGURATIONS ON A MODEL OF A TAILLESS AIRPLANE WITH A SWEPTBACK WING

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SUMMARY

An experimental investigation of various external-store configurations on a model of a tailless airplane with a sweptback wing over a Mach number range from 0.40 to 0.91 was made in the Langley high-speed 7- by 10-foot tunnel.

The results indicate that wing-tip- and fuselage-mounted stores suspended on a swept pylon member that locates the external store away from adjacent parts of the model resulted in the most favorable combination of drag-break Mach number and drag at force break and also the highest lift-drag ratios. The largest effect of external stores on the aerodynamic-center location below force break was a forward shift of 2.5 percent. Except for the pylon-suspended tip-mounted external store which produced a change in the effective dihedral parameter that was approximately equal to an 8° reduction in dihedral, the effect of stores on the lateral stability of the test model was small. The effectiveness of the elevon was increased considerably by the addition of a tip store centrally mounted on the wing.

INTRODUCTION

The attachment of auxiliary equipment to the exterior of high-speed airplanes has introduced the problem of interference between these objects and supporting members of the airplane. The first consideration in the design of an external-store installation has been the drag produced by the installation, and, in the case of high-speed airplanes, the associated compressibility phenomenon. In order to provide the designer with some information relative to the high-speed interference effects of external stores, an investigation of a number of external-store configurations was undertaken by the National Advisory Committee for Aeronautics. The results of the studies pertaining to the mounting of stores on unswept wings are presented in references 1 to 4.

Presented in this paper are drag studies, longitudinal stability and control characteristics, and lateral stability characteristics of several external-store configurations on a model of a tailless sweptback-wing airplane. Two general locations of stores were chosen for this investigation: at the tip of the wing and on the fuselage in the plane of symmetry. For purposes of discussion, the installations are considered as either wing-tip or fuselage-mounted configurations.

Analysis of the results has been made by a comparison of the data obtained with the stores in place with those obtained on the basic model. Evaluation of the characteristics of the basic model has been reported previously and is presented in reference 5.

COEFFICIENTS AND SYMBOLS

The system of axes employed, together with an indication of the positive forces, moments, and angles, is presented in figure 1. Pertinent symbols and coefficients used in this paper are defined as follows:

C_L lift coefficient (Lift/qS)

C_D drag coefficient (Drag/qS)

C_m pitching-moment coefficient (Pitching moment/$qS\bar{c}$)

C_l rolling-moment coefficient (Rolling moment/qSb)

C_Y side-force coefficient (Side force/qS)

C_n yawing-moment coefficient (Yawing moment/qSb)

q free-stream dynamic pressure, pounds per square foot $(\rho V^2/2)$

S wing area, 3.174 square feet on model

$\bar{c}$	wing mean aerodynamic chord (M.A.C.) $\left(\frac{2}{S}\int_0^{b/2} c^2 dy\right)$
c	chord, parallel to plane of symmetry, feet
b	wing span, 3.09 feet on model
V	velocity of free-stream air, feet per second
a	speed of sound, feet per second
M	Mach number (V/a)
R	Reynolds number $(\rho V\bar{c}/\mu)$
μ	absolute viscosity, pounds-seconds per square foot
ρ	mass density of air, slugs per cubic foot
g	acceleration due to gravity, feet per second^2
α	angle of attack, degrees
α_{static}	angle of attack of model under no-load conditions, degrees
δ_e	control deflection, measured in plane parallel to plane of symmetry as the angle the chord line of control makes with fuselage reference line, degrees
δ_s	angle of center line of external store with respect to plane of symmetry, positive when nose of store is outboard of trailing edge of store, degrees
ψ	angle of yaw, degrees
L/D	lift-drag ratio (C_L/C_D)
W/S	wing loading (Weight/S)
M_d	Mach number for divergence of drag coefficient (see fig. 2)
C_{D_d}	drag coefficient at divergence Mach number (see fig. 2)

$C_{L_\alpha} = \left(\partial C_L/\partial \alpha\right)_M$

$C_{m_{C_L}} = \left(\partial C_m/\partial C_L\right)_M$

$C_{m_{\delta_e}} = \partial C_m/\partial \delta_e$

$C_{l_\psi} = \partial C_l/\partial \psi$

$C_{n_\psi} = \partial C_n/\partial \psi$

$C_{Y_\psi} = \partial C_Y/\partial \psi$

Note: Δ indicates an increment taken between data of the basic model and that of the model with stores in place. Example, $\Delta C_\psi = C_{\psi_{\text{model + store}}} - C_{\psi_{\text{model}}}$

MODELS AND APPARATUS

Tunnel

The tests were conducted in the Langley high-speed 7- by 10-foot tunnel, which is a closed-throat rectangular tunnel of the return-flow type with a contraction ratio of 15.7 to 1.

The sting support system which was used to suspend the model in the tunnel consisted of a horizontal member that extended from the rear of the fuselage to a vertical member that was located downstream of the test section. These struts were attached to the tunnel balance system and shielded from the air flow by streamline fairings.

Basic Model

The test model was a model of a tailless, jet-propelled, fighter airplane with a wing of 35° sweepback and aspect ratio of 3.01. The physical characteristics of the solid-steel model with typical external stores in test locations are presented in figure 3, and photographs of the model mounted on the sting support struts used for this investigation are presented in figure 4. For that portion of the analysis for which full-scale airplane dimensions were required, a model scale of 0.08 was assumed. The control surfaces, which are plain flaps with sealed gaps, are termed elevons and are intended to be used for both longitudinal and lateral control. Rudders were not simulated on the model. No restriction was placed on the air flow through the jet-intake ducts to permit a comparison with the results obtained on the basic model (reference 5). One of the intake ducts, together with its reflection on the fuselage, can be seen in figure 4(a).

External Stores

As previously noted, the external stores used in this investigation were mounted in two general locations: at the tip of each wing, tip-mounted configurations, and in the plane of symmetry, fuselage-mounted configurations. A drawing of the tip-mounted stores tested is presented in figure 5(a) and the fuselage-mounted stores in figure 5(b). The original tip-mounted external store was located forward of the wing tip in a plane parallel to the plane of symmetry of the model. Modifications to this configuration included moving the store rearward on the wing tip, skewing the store in the rearward location, and providing a fairing for the juncture of rearward-located, skewed, tip store. The body of revolution used in this investigation was an NACA 66_1-014 profile (table I) with an assumed volumetric displacement equivalent to approximately 200 gallons based on an assumed scale of 0.08. The pylon-suspension members were NACA 66_1-016 sections (table I) perpendicular to the leading edge.

The external-store configurations whose body members were not bodies of revolution were designed to have full-scale volumetric displacement of approximately twice the value of the body of revolution, that is, about 400 gallons.

Corrections

The test results have been corrected for all the tare forces and moments produced by the support system. The method by which the sting tares were determined is explained in detail in reference 5. There are small additional corrections to the pitching-moment and rolling-moment coefficients that were determined subsequent to the completion of the present investigation and have not been incorporated in the data.

These corrections, which are inherent in the balance system, can be made to the data of this paper by the following formulas:

$$\left(C_m\right)_{corrected} = \left(C_m\right)_{presented} - 0.003$$

$$\left(C_l\right)_{corrected} = \left(C_l\right)_{presented} - 0.0008$$

The jet-boundary corrections to the lift and drag were computed by the method of reference 6. The jet-boundary corrections to other components were considered negligible.

The drag coefficients have been corrected for the buoyance produced by the small longitudinal static-pressure gradient in the tunnel. All coefficients and Mach numbers were corrected for blocking by the model and its wake by the method of reference 7.

TESTS

The investigation was made over a Mach number range from 0.40 to 0.91. Aerodynamic characteristics in pitch were measured over an angle-of-attack range from 0° to 6°. Effect of a symmetrical deflection of the control surface for the complete model was determined for two configurations of tip-mounted stores (pylon-suspended and central-tip, $\delta_s = 10^{\circ}$, faired) throughout the angle-of-attack range. Control deflections investigated were $\pm 4.4^{\circ}$. Aerodynamic characteristics in yaw were measured with the model complete (fins on) and with the wing-fuselage combination (fins off) at approximately $\pm 4^{\circ}$ angle of yaw and 0° and 6° static angles of attack. Data were also obtained for some external-store configurations at $\pm 2^{\circ}$ angles of yaw.

The variation of test Reynolds number with Mach number for average test conditions is presented in figure 6. The size of the model used in the present investigation resulted in a tunnel choking Mach number of about 0.94. Experience has indicated that with this value of choking Mach number, the data can be considered reliable up to a Mach number of about 0.91.

RESULTS

An outline of the results of the wind-tunnel investigation is presented below. The effect of changes in the location of mass of the external store on the center-of-gravity position was not considered, and the aerodynamic-moment coefficients are presented about an assumed center-of-gravity location of 17 percent mean aerodynamic chord.

Presented in table II is a summation of the high-speed drag characteristics of the test model with tip- and fuselage-mounted external-store configurations. The method used to obtain the parameters is illustrated in figure 2.

Table III is a summary of the effects of the various external-store configurations on the lateral-stability parameters of the basic model. The values presented in table III were taken as representative of the effects produced by each external-store configuration below force-break Mach number. When the variation of a parameter is sufficiently large so as to invalidate a single representative value, a mean value is presented and designated as such.

DISCUSSION

Some results of a previous investigation (reference 5) of the basic model without external stores are presented in this paper for comparative purposes. These results are superimposed on the aerodynamic characteristics in pitch of the model with various external-store configurations and are presented separately for the aerodynamic characteristics in yaw.

Lift-Drag Ratios

Mounting external stores at the wing tips has proven to be desirable (reference 8) on airplanes with unswept wings because of the favorable end-plate effects on the lift-drag ratios and the mild effects of juncture interference on the lift-drag ratio. The results of the present investigation indicate that tip-mounted stores are equally effective on a model with a sweptback wing at low Mach numbers, but that end-plate effectiveness appears to be largely destroyed by juncture interference at the higher Mach numbers. This is illustrated in figure 9 where it is seen that the maximum lift-drag ratio of the tip-mounted stores is equal to or greater than that of the basic model at $M = 0.40$, but at $M = 0.80$ the highest maximum lift-drag ratio for a tip-mounted store was about 11.5 percent lower than that of the basic model.

Mach number, in general, has less influence on fuselage-mounted stores than on tip-mounted stores. The largest reduction in maximum lift-drag ratio is of the order of 10 percent at $M = 0.40$ and 15 percent at $M = 0.80$. As might be expected from consideration of interference, the external stores located away from the wing tip and the fuselage by swept pylon-suspension members gave the highest lift-drag ratios. The fuselage-mounted configuration (pylon-suspended, overhead) gave the largest value of $(L/D)_{max}$ at the higher Mach numbers. This may be attributed to the lower local velocities over the fuselage than over the wing at a given free-stream Mach number.

Drag Characteristics

Drag studies of the model with various external stores show that, in addition to the strong influence of Mach number on the drag coefficient as reflected in $(L/D)_{max}$, changes in lift coefficient have an appreciable effect on the drag characteristics of tip-mounted stores (fig. 9). The forward tip store increased the drag of the basic model only about 8 percent at $C_L = 0$, but at $C_L = 0.3$ and a Mach number of 0.80 the forward tip store was responsible for a 20-percent increase in drag. The modifications to this configuration included moving the store rearward on the wing tip (central-tip store), toeing it out ($\delta_s = 10^\circ$), and fairing the store-wing juncture ($\delta_s = 10^\circ$, faired); each modification was effective in reducing the drag at the higher lift coefficients. The lowest drag was obtained with the central-tip store, $\delta_s = 10^\circ$, faired.

The drag contribution of this configuration was approximately one-half that of the original forward tip store up to a Mach number of 0.80 and amounted to an increase in total drag of the model of about 11 percent at $C_L = 0.3$ and $M = 0.8$. However, the lowest drag coefficient measured on a tip-mounted store was with the pylon-suspended configuration. An increase of basic model drag of less than 9 percent was noted for this configuration at $C_L = 0.3$ and $M = 0.8$.

The drag of fuselage-mounted configurations, although higher than the drag of the tip-mounted stores at the lower Mach numbers, remained virtually constant to the force-break Mach numbers. The effect of lift coefficient on drag was much less pronounced for fuselage-mounted configurations than for tip-mounted configurations.

The lowest drag coefficients for each location of external stores at $C_L = 0.3$ were generally obtained with swept pylon-suspended configurations, and at the higher Mach numbers the fuselage mounted configuration (pylon-suspended, overhead) gave considerably lower drag coefficients than the tip-mounted configuration. At a Mach number of 0.80 the drag contribution of the fuselage-mounted store on a swept pylon was about 4.5 percent of the drag of the basic model.

Buffeting

To evaluate the performance of an external-store installation, it is of foremost importance to consider the Mach number at which the drag coefficient of the model diverges with the external store in place. The significance of this Mach number has previously been established (reference 3) as the speed at which buffeting of the airplane and its component parts may seriously impair its combat usefulness. A well-designed external-store configuration may be considered as one that does not lower the drag-divergence Mach number of the basic model.

The method used to establish the drag-break Mach number in this investigation is presented in figure 2. This method establishes M_d as the Mach number where a line 45° from the horizontal becomes tangent to the drag-coefficient curve when C_D is presented for a scale of 0.01 per inch and M is presented at 0.1 per inch. Thus the drag-break Mach number is assumed to be that corresponding to $\frac{dC_D}{dM} = 0.10$.

The most satisfactory combinations of M_d and C_{D_d}; that is, the highest Mach number for drag divergence with lowest values of drag coefficient at drag-divergence Mach number, were obtained with the external stores suspended from swept pylon members. (See table II.) The fuselage-mounted configuration gave the least reduction in M_d (0.042) and, with one exception, the smallest increase in C_{D_d} (0.0035) of any configuration tested.

Lift-Curve Slopes

Tip-mounted stores increase the lift-curve slope, with the largest increases being produced by the pylon-suspended configuration (fig. 9). The increases range from 10 percent at $M = 0.40$ to a maximum of about 15 percent at $M = 0.85$. The lift-curve slope was relatively unaffected by the fuselage-mounted external stores, the maximum change being less than 4 percent.

Longitudinal Stability Characteristics

Aerodynamic center.- The rate of change of pitching-moment coefficient with lift coefficient at a constant Mach number $C_{m_{C_L}}$ is a measure of the aerodynamic-center location relative to the assumed center-of-gravity position in percent of the mean aerodynamic chord. The effect of external stores on the aerodynamic-center location is presented in figure 9. It is seen that tip-mounted stores, in general, exert a small stabilizing influence. Below a Mach number of 0.80 the maximum increase of stability amounts to a rearward movement of the aerodynamic center of 2.5 percent mean aerodynamic chord. It may be noted that the forward tip store produces a small forward movement of the aerodynamic center (about 1.5 percent mean aerodynamic chord).

The effects of fuselage-mounted external stores are less consistent in that both stabilizing and destabilizing changes in $C_{m_{C_L}}$ are shown. However, the maximum change in the aerodynamic-center location is generally less than 2.5 percent below $M = 0.80$. Above a Mach number of 0.80 a rearward movement of the aerodynamic center or stabilizing trend is generally produced by both tip- and fuselage-mounted external stores.

Control effectiveness.- The control-effectiveness parameter $C_{m_{\delta_e}}$ as a function of Mach number is presented in figure 11 for the basic model and for two tip-mounted external stores: the pylon-suspended and the central-tip store, $\delta_s = 10^{\circ}$, faired. The greatest increases in effectiveness caused by the end-plate action of tip stores were given by the central-tip store faired at $\delta_s = 10^{\circ}$. For this configuration an average increase of 12 percent was noticed to a Mach number of 0.80 where $C_{m_{\delta_e}}$ increased sharply, reaching a maximum at $M = 0.85$ where it was 22 percent more than the basic model.

An investigation of the effects of tip-mounted external stores on the damping-in-roll characteristics of a model with a sweptback wing (reference 9) showed similarly large increases in the control effectiveness in roll.

Control position for trim.- Control position for longitudinal trim in both level and maneuvering flight as a function of Mach number is shown in figure 12 for an assumed wing loading of 34 pounds per square foot and altitudes of sea level and 40,000 feet. It appears that tip-mounted external stores do not produce any serious changes in control position for trim within the range of flight conditions covered in this investigation.

It should be pointed out that the control positions for trim were calculated on the basis of the pitching-moment coefficient which do not include a constant correction of 0.003 as previously mentioned. Including the correction would result in a small and approximately constant change in control position for trim.

The marginal longitudinal stability of the basic model in conjunction with the small changes in the untrimmed pitching moments produced by the stores result in relatively small changes in the control settings for trim in spite of the increase in the control effectiveness produced by the tip stores.

Directional Stability

The results presented in table III indicate that tip-mounted external stores increase slightly the directional stability of the test model; and, where comparisons are available, the stabilizing influence is, in general, more pronounced on the plain wing, that is, with tails off, than on the complete model. The central tip store faired with $\delta_s = 10^\circ$ produced, at $\alpha_{static} = 0^\circ$, the only destabilizing influence noted for tip stores.

Fuselage-mounted stores generally are slightly destabilizing. The exceptions wherein fuselage-mounted stores increased the directional stability of the basic model occurred for the single blister and the pylon-suspended (overhead) configurations with the fins of the model removed. The stability contributions of these configurations were, however, small.

Effective Dihedral

With the exception of the pylon-suspended, tip-mounted external store, the change in the effective dihedral parameter C_{l_ψ} produced by both tip- and fuselage-mounted external stores is small. (See table III.) The maximum change in C_{l_ψ} is -0.0005 which is equivalent to about 4° of effective dihedral. The relation between C_{l_ψ} and the effective dihedral angle established in reference 10 was used in this investigation. As might be expected (reference 11), the pylon-suspended, tip-mounted store reduced the effective dihedral of the basic model by about 8° at $\alpha_{static} = 0^\circ$ and 8.6° at $\alpha_{static} = 6^\circ$.

CONCLUSIONS

An experimental investigation of various external-store configurations on a model of a tailless airplane with a sweptback wing over a Mach number range from 0.40 to 0.91 indicates the following conclusions:

1. Tip- or fuselage-mounted stores suspended on a swept-pylon member that locates the external store away from adjacent parts of the

model resulted in the most favorable combination of drag-break Mach number and drag at force break and also the highest lift-drag ratios of the configurations investigated.

2. The largest effect of the external stores on the aerodynamic-center location, below force break, was a forward shift of 2.5 percent of the mean aerodynamic chord.

3. Except for the pylon-suspended, tip-mounted external store, which produced a change in the effective dihedral parameter that was approximately equal to an 8° reduction in dihedral, the effect of stores on the directional and the lateral stability of the test model was small.

4. The effectiveness of the elevon control was increased considerably by the addition of a tip store centrally mounted on the wing.

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TABLE I

ORDINATES FOR THE EXTERNAL STORE AND THE PYLON-SUSPENSION MEMBER

[Dimensions in inches]

External store	
NACA 66_1-014	
Station	Ordinate
0	0
.070	±.148
.105	±.177
.175	±.222
.350	±.295
.700	±.407
1.050	±.496
1.400	±.571
2.100	±.692
2.800	±.784
3.500	±.855
4.200	±.910
4.900	±.947
5.600	±.972
6.300	±.980
7.000	±.974
8.400	±.912
9.800	±.737
11.200	±.481
12.600	±.202
13.300	±.077
14.000	0
L. E. radius: 0.1332	

Pylon-suspension member	
NACA 66_1-016	
Station	Ordinate
0	0
.014	±.033
.020	±.039
.034	±.049
.068	±.066
.136	±.091
.204	±.110
.272	±.127
.408	±.154
.544	±.174
.680	±.190
.816	±.202
.952	±.210
1.088	±.216
1.224	±.218
1.360	±.216
1.632	±.203
1.904	±.164
2.176	±.107
2.448	±.045
2.584	±.017
2.720	0
L. E. radius: 0.0344	

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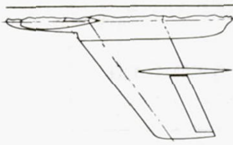
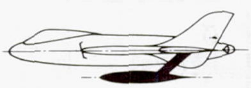
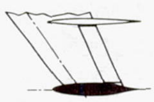
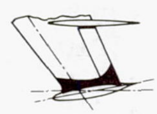
Table II

Summary of the High Speed Drag Characteristics at

C_L = .3 of the External Stores Installations Investigated

(a) Tip-mounted stores.

Configuration		M_d	ΔM_d	C_{D_d}	ΔC_{D_d}
	basic model	.897	—	.0292	—
	forward $\delta_s = 0^\circ$	.846	-.051	.0342	.0077
	pylon-suspended $\delta_s = 0^\circ$	.840	-.057	.0307	.0044
	central $\delta_s = 0^\circ$	.820	-.077	.0310	.0050
	central $\delta_s = 10^\circ$	.838	-.059	.0325	.0062
	central (faired) $\delta_s = 10^\circ$	.813	-.084	.0297	.0039

(b) Fuselage-mounted stores.

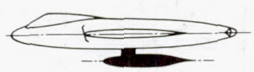
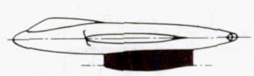
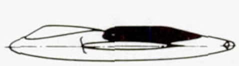
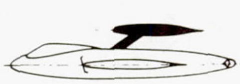
Configuration		M_d	ΔM_d	C_{D_d}	ΔC_{D_d}
	pylon-suspended	.825	-.072	.0287	.0035
	flush	.830	-.067	.0285	.0032
	twin blister	.835	-.062	.0322	.0068
	single blister	.850	-.047	.0310	.0054
	single blister (upper)	.820	-.077	.0303	.0051
	pylon-suspended (overhead)	.855	-.042	.0292	.0035

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TABLE III

SUMMARY OF THE EFFECTS OF THE EXTERNAL-STORE CONFIGURATIONS INVESTIGATED ON THE LATERAL STABILITY PARAMETERS OF THE BASIC MODEL

[All values presented represent average values between M = 0.60 and force-break Mach number except as noted]

Store configuration	Tail on				Tail off			
	$\alpha_{static} = 0^\circ$		$\alpha_{static} = 6^\circ$		$\alpha_{static} = 0^\circ$		$\alpha_{static} = 6^\circ$	
	ΔC_{n_ψ}	ΔC_{l_ψ}	ΔC_{n_ψ}	ΔC_{l_ψ}	ΔC_{n_ψ}	ΔC_{l_ψ}	ΔC_{n_ψ}	ΔC_{l_ψ}
(a) Tip-mounted stores								
Forward	[a]-0.00020	0.00025			0	0		
Pylon-suspended	[a]-.00030	-.00100	-0.0025	-0.00110	-.00060	-.00100	-0.00035	[a]-0.00110
Central					-.00010	.00010		
Central $\delta_s = 10^\circ$	-.00010	[a].00010	0	-.00040	-.00020	.00015	[a]-.00020	[a]-.00025
Central $\delta_s = 10^\circ$ (faired)	.00025	-.00015	[a]-.00020	[a]-.00025				
(b) Fuselage-mounted stores								
Pylon-suspended	0.00010	0.00010			0.00015	0.00020		
Flush	.00035	-.00050			.00035	.00035		
Twin blister	0	0	0.00010	-0.00010				
Single blister	.00010	[a]0	.00030	[a]-.00020	0	.00020	-0.00010	0
Single blister (upper)	.00010	-.00040	[a].00030	-.00035				
Pylon-suspended (overhead)	.00020	0	.00015	-.00040	-.00010	-.00015	[a]-.00015	-.00050

[a] Denotes a mean value below the force-break Mach number.

NACA

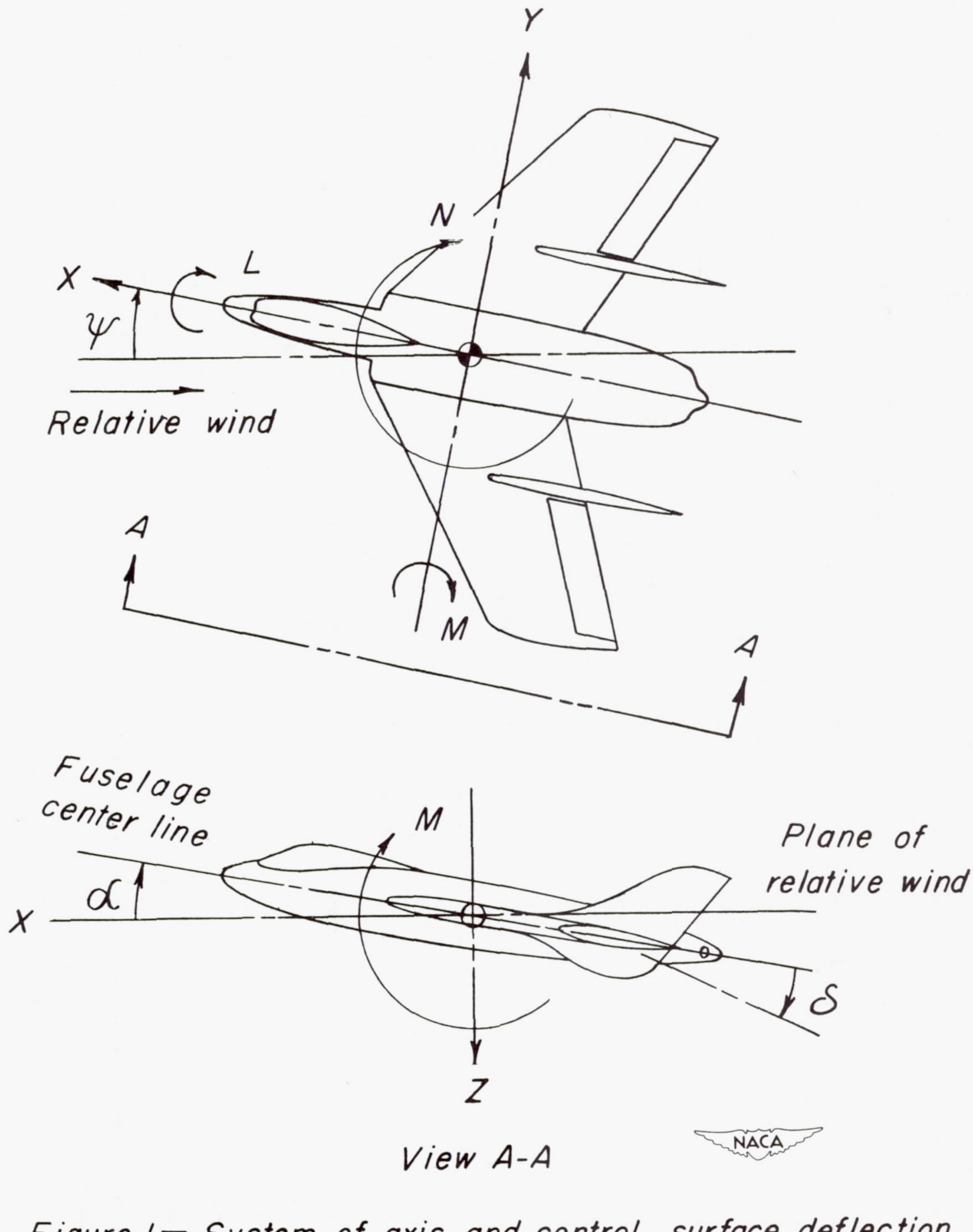


Figure 1.— System of axis and control- surface deflection. Positive values of forces, moments, and angles are indicated by arrows.

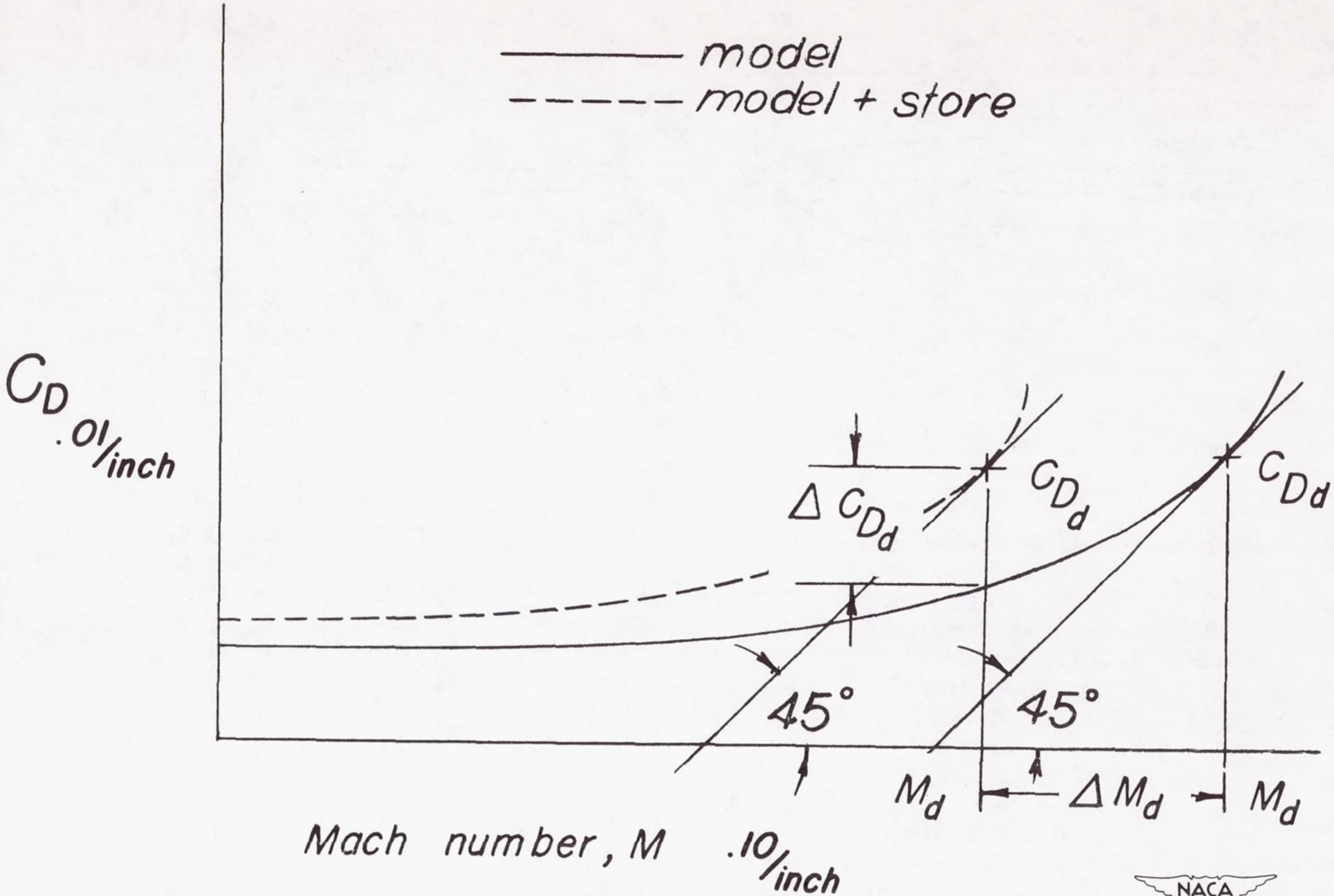
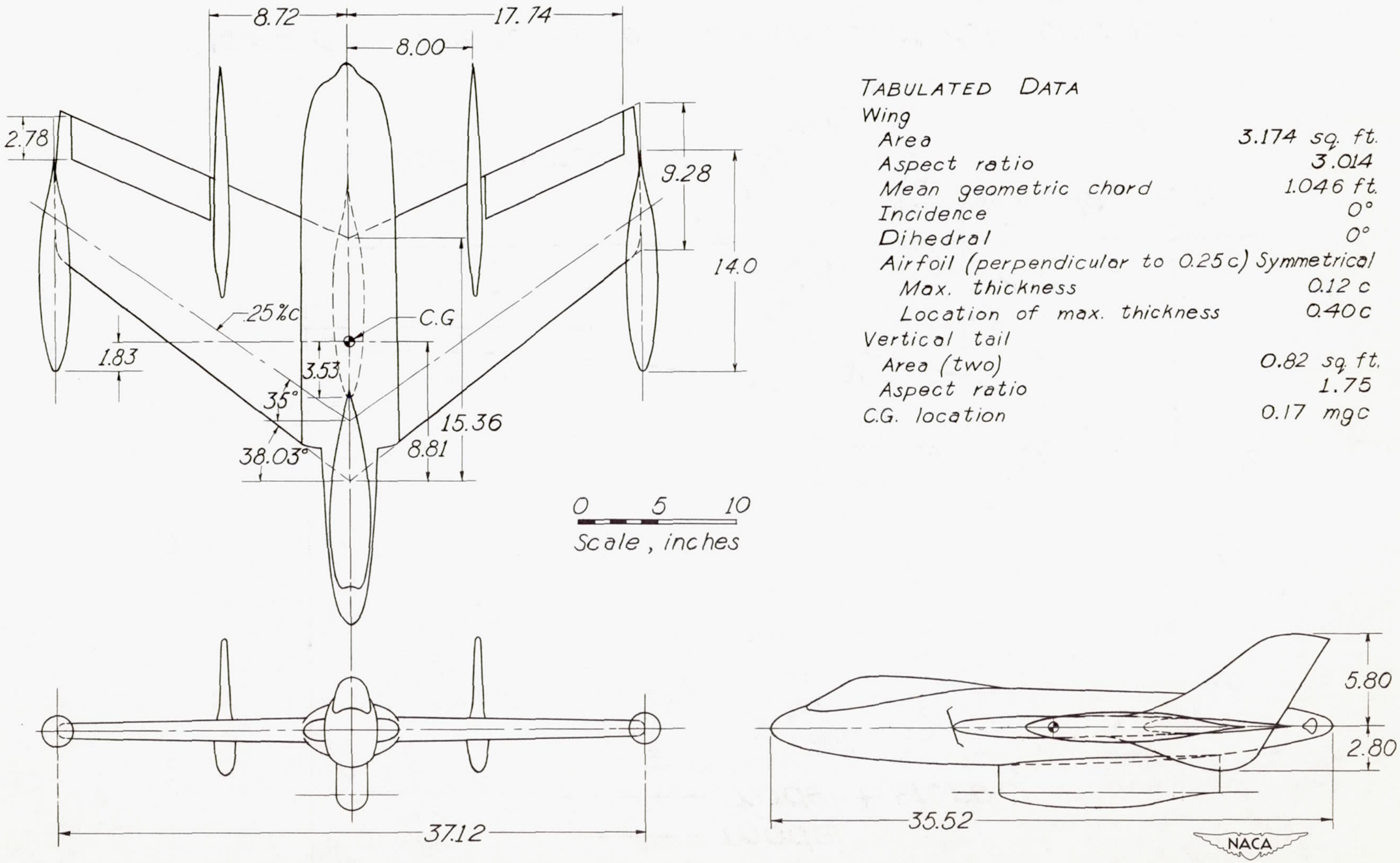


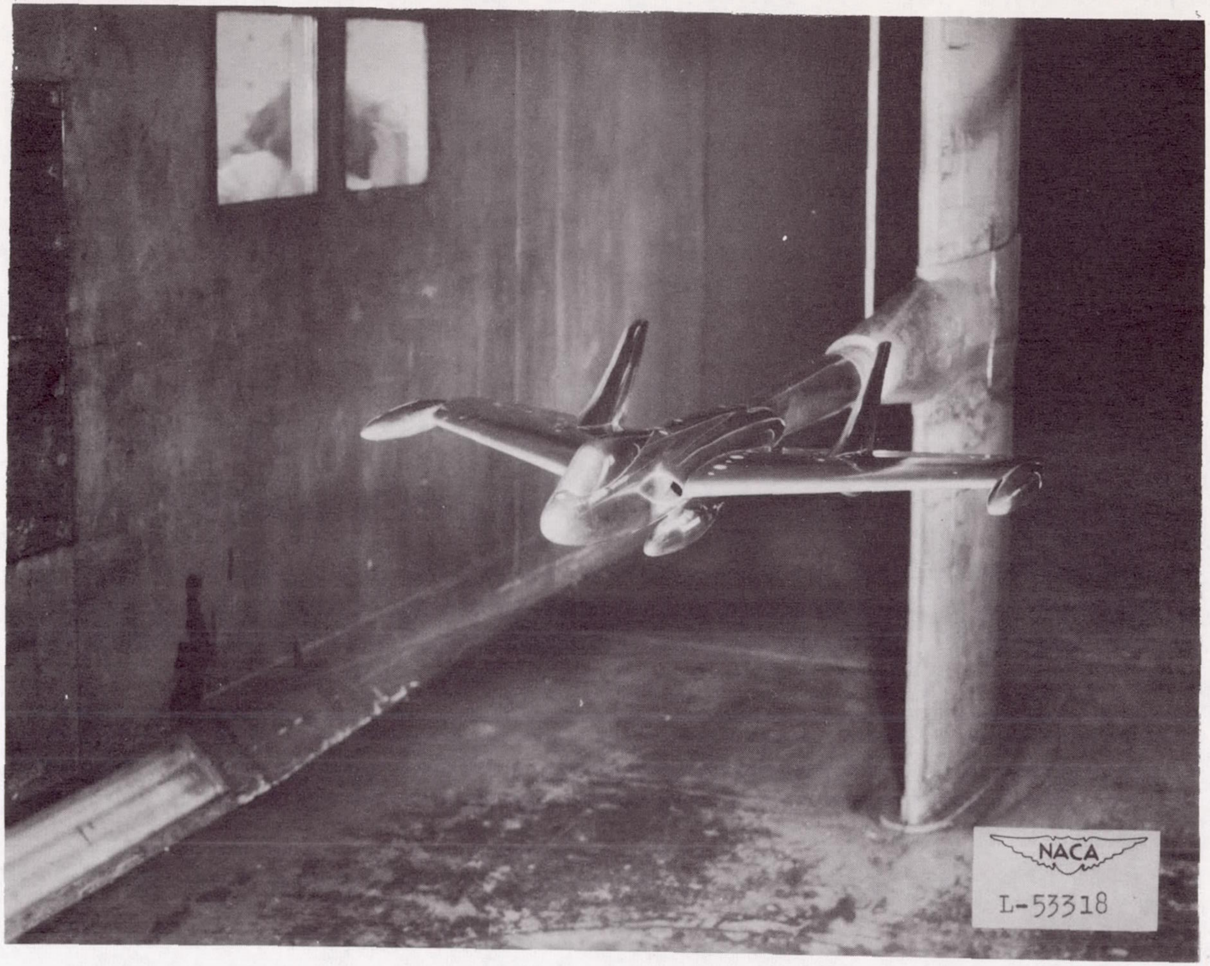
Figure 2.— Illustration of the method of determining the high-speed drag parameters of the test model with external stores.



TABULATED DATA

Wing	
Area	3.174 sq. ft.
Aspect ratio	3.014
Mean geometric chord	1.046 ft.
Incidence	0°
Dihedral	0°
Airfoil (perpendicular to 0.25 c)	Symmetrical
Max. thickness	0.12 c
Location of max. thickness	0.40 c
Vertical tail	
Area (two)	0.82 sq. ft.
Aspect ratio	1.75
C.G. location	0.17 mgc

Figure 3.— Three-view drawing of the test model with the forward tip-mounted and flush fuselage-mounted external-store configurations.

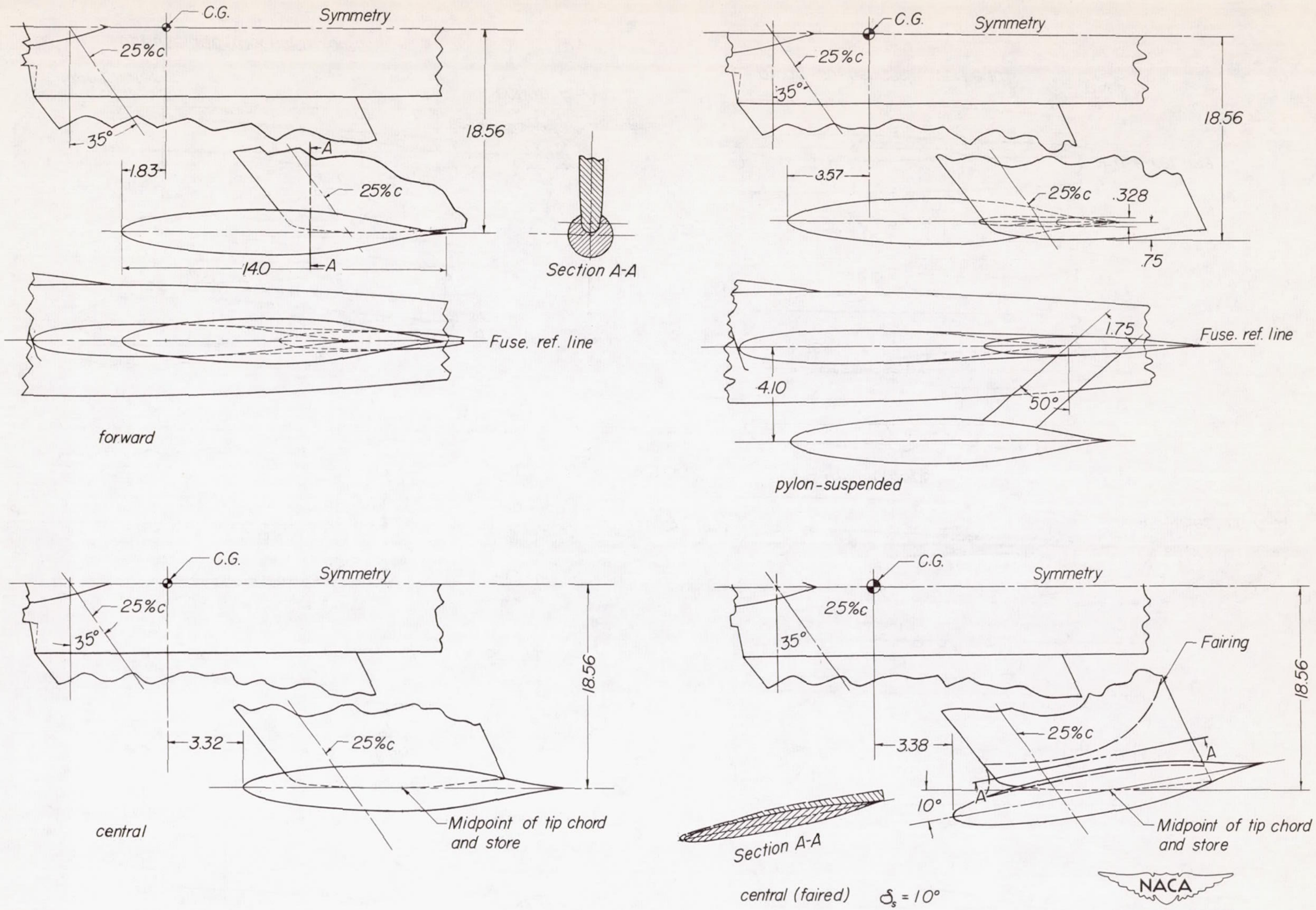


(a) Three-quarter front view.

Figure 4.- Photograph of the test model with the forward tip-mounted and pylon fuselage-mounted external-store configuration mounted in the Langley high-speed 7- by 10-foot tunnel.

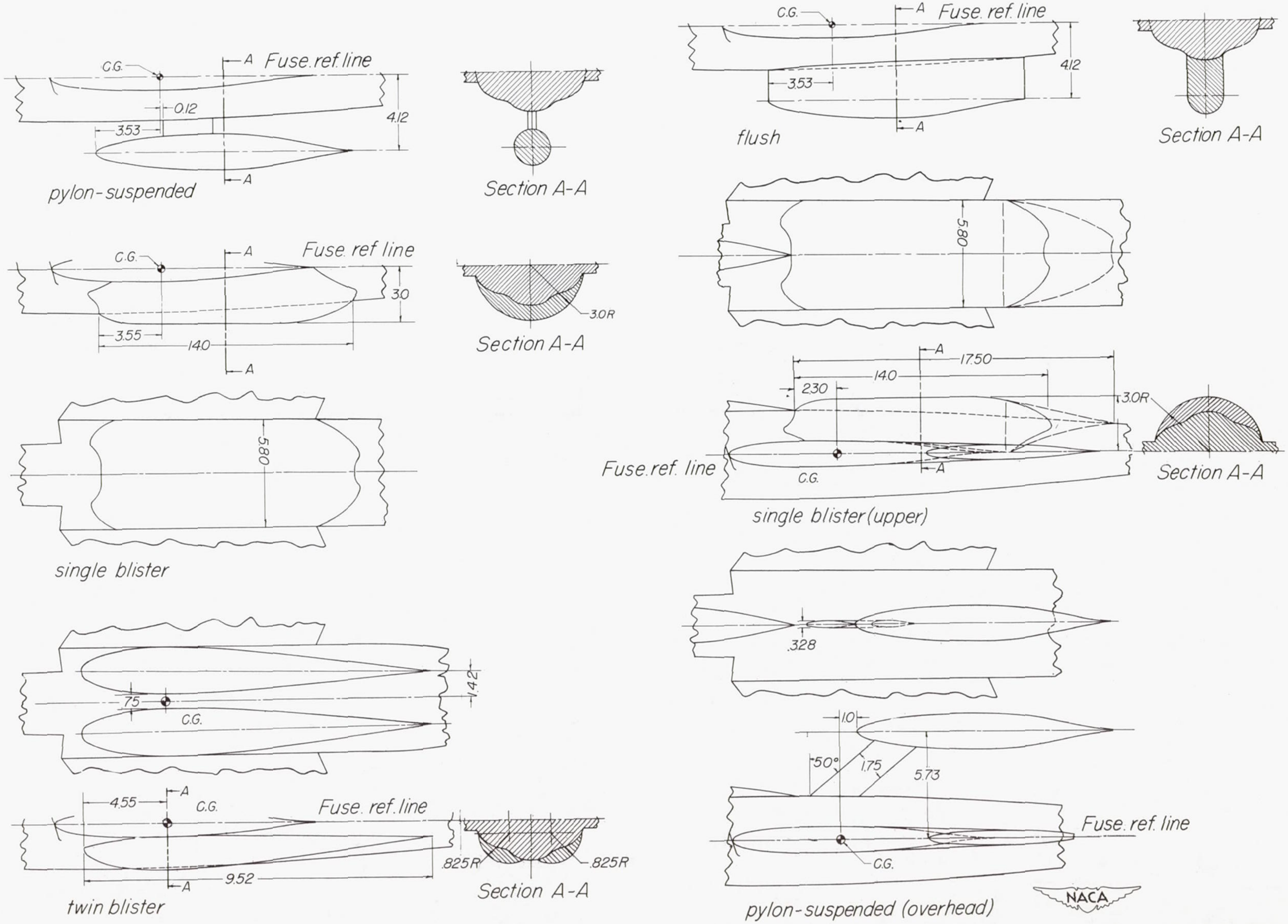
(b) Three-quarter rear view.

Figure 4.- Concluded.



(a) Tip-mounted stores.

Figure 5. – Drawings of the external store configurations showing the locations on the test model.



(b) Fuselage-mounted stores.

Figure 5.— Concluded.

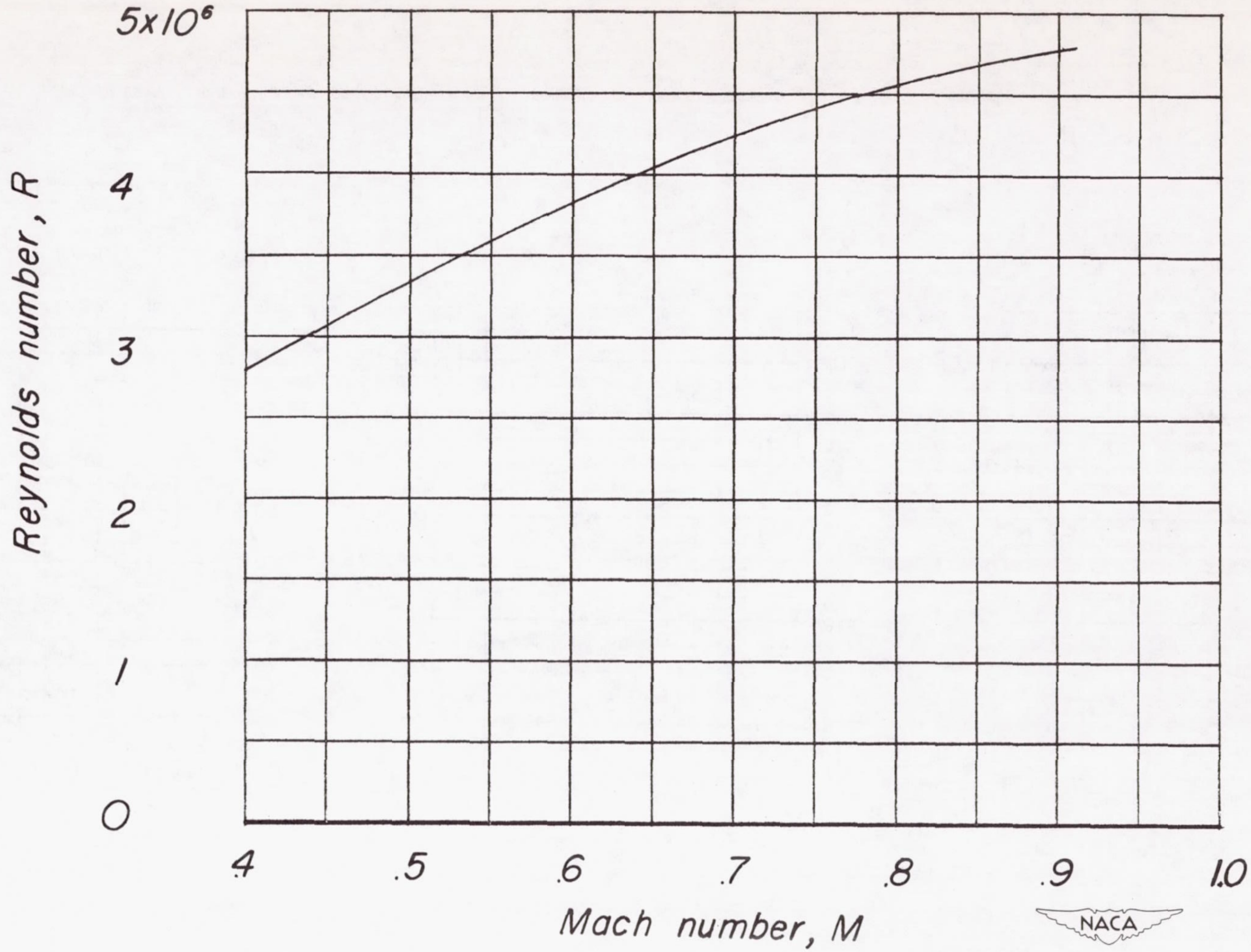
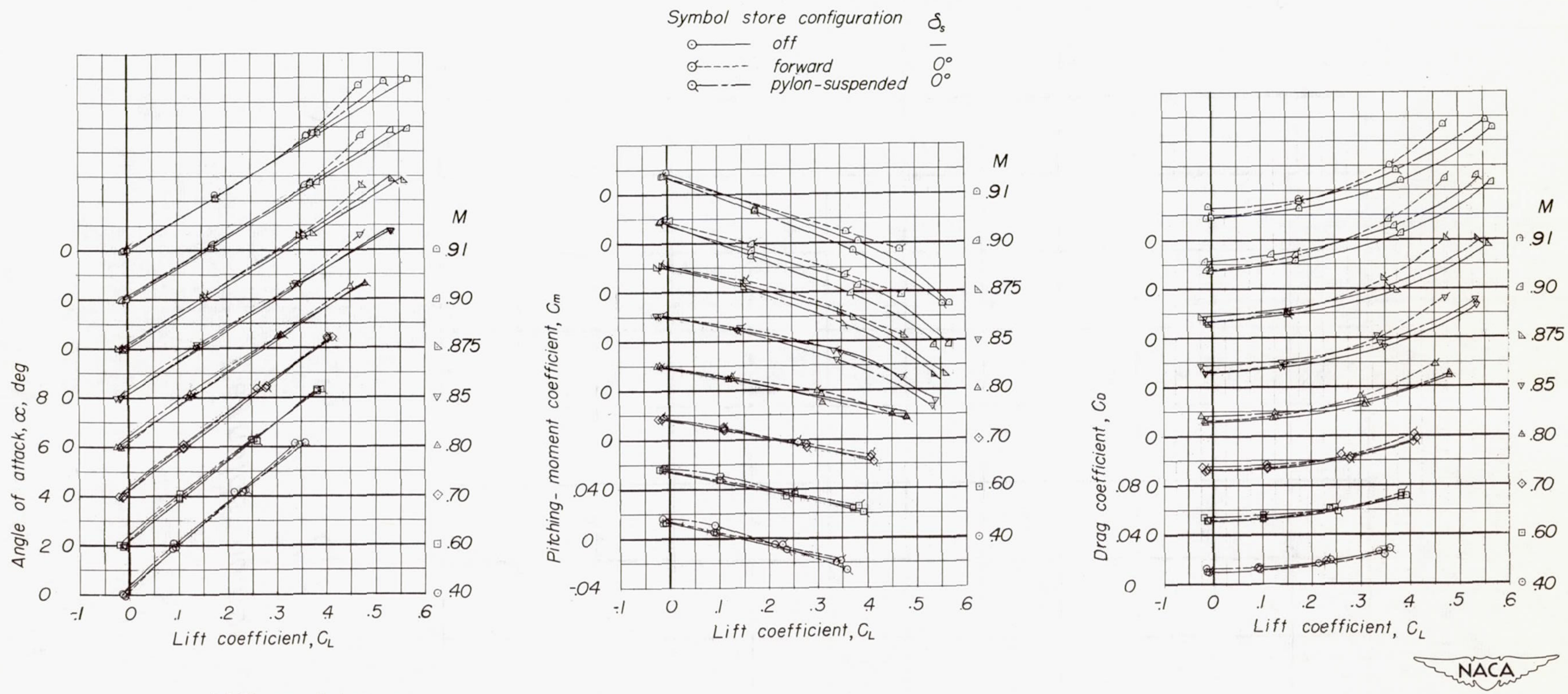
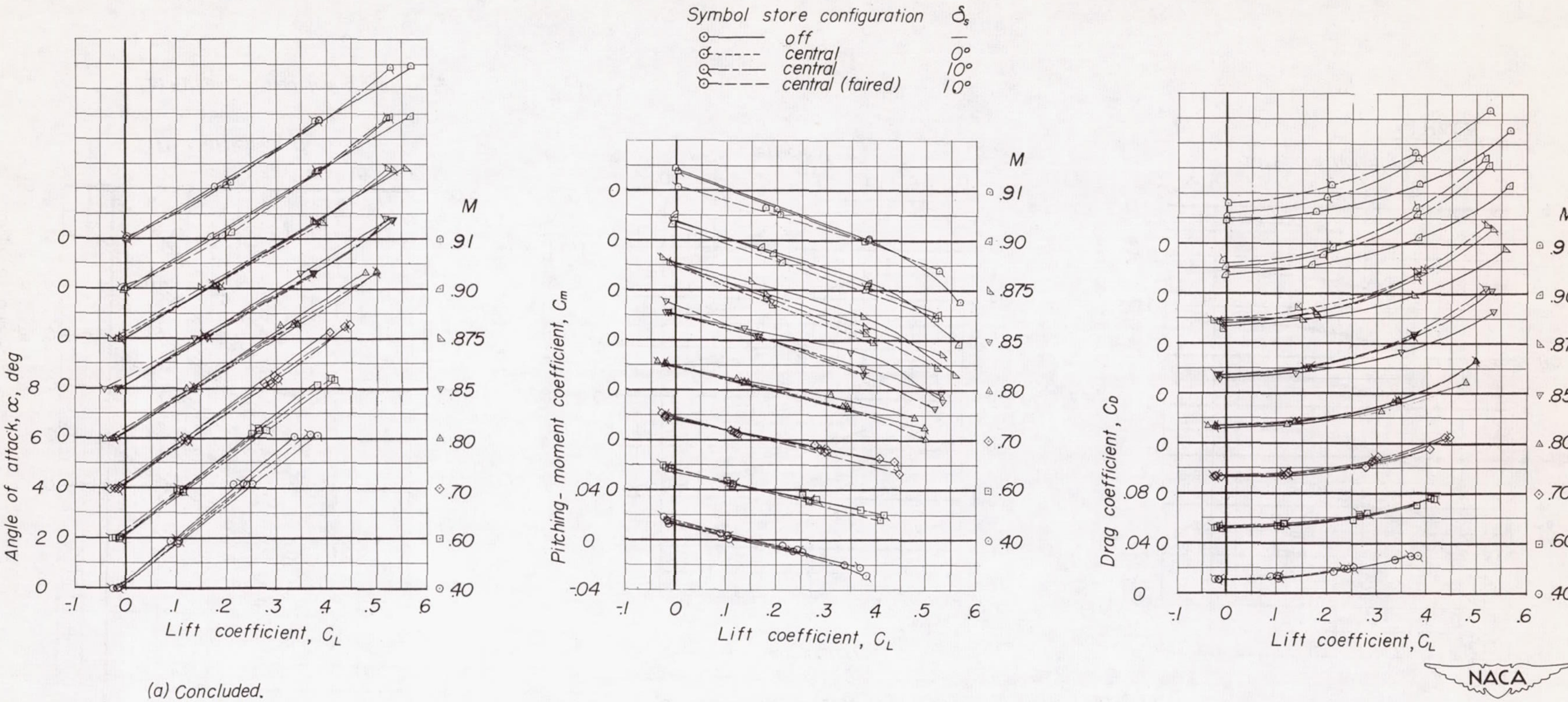


Figure 6.— Variation of Reynolds number with Mach number for the test model.



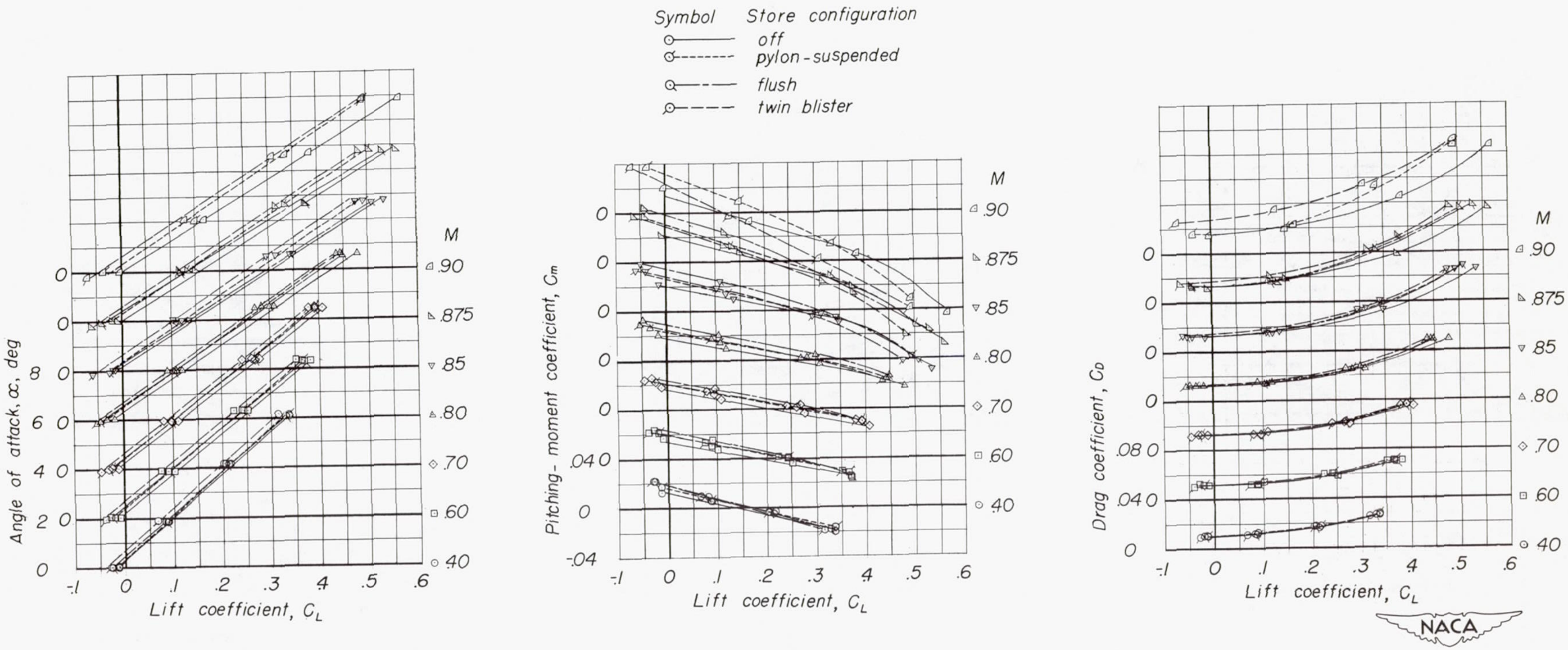
(a) Tip-mounted stores.

Figure 7. — Effect of several external store configurations on the aerodynamic characteristics in pitch of the test model.



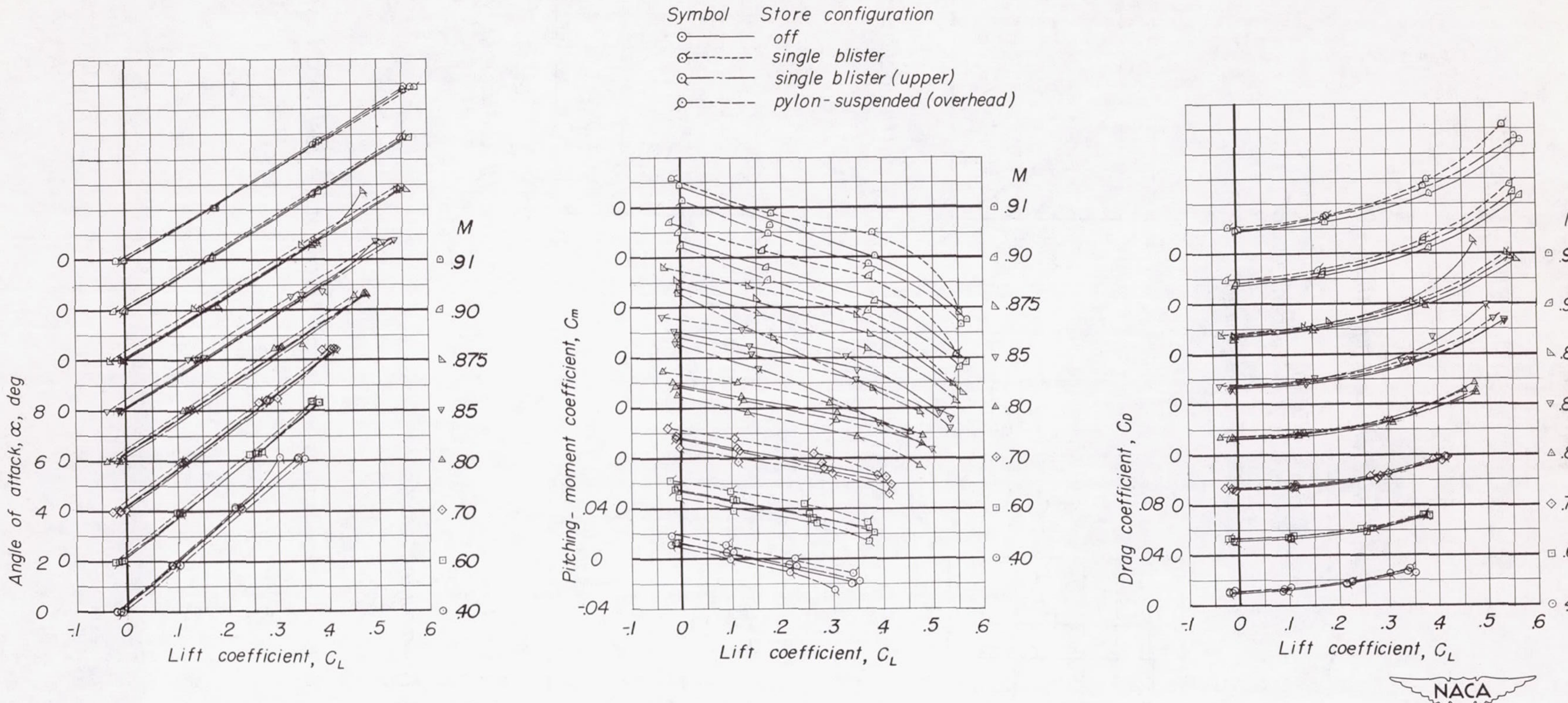
(a) Concluded.

Figure 7.— Continued.



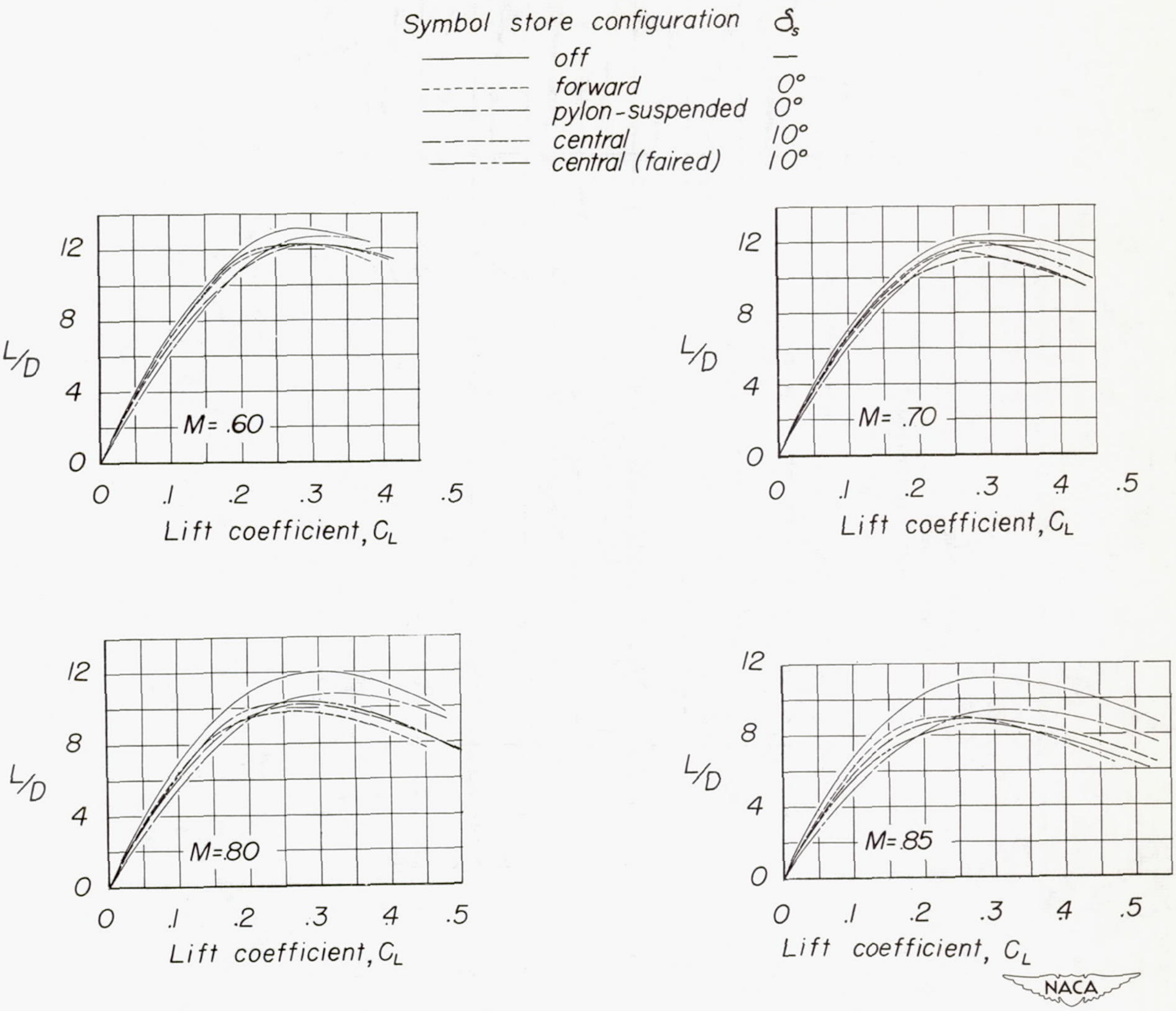
(b) Fuselage-mounted stores.

Figure 7.— Continued.



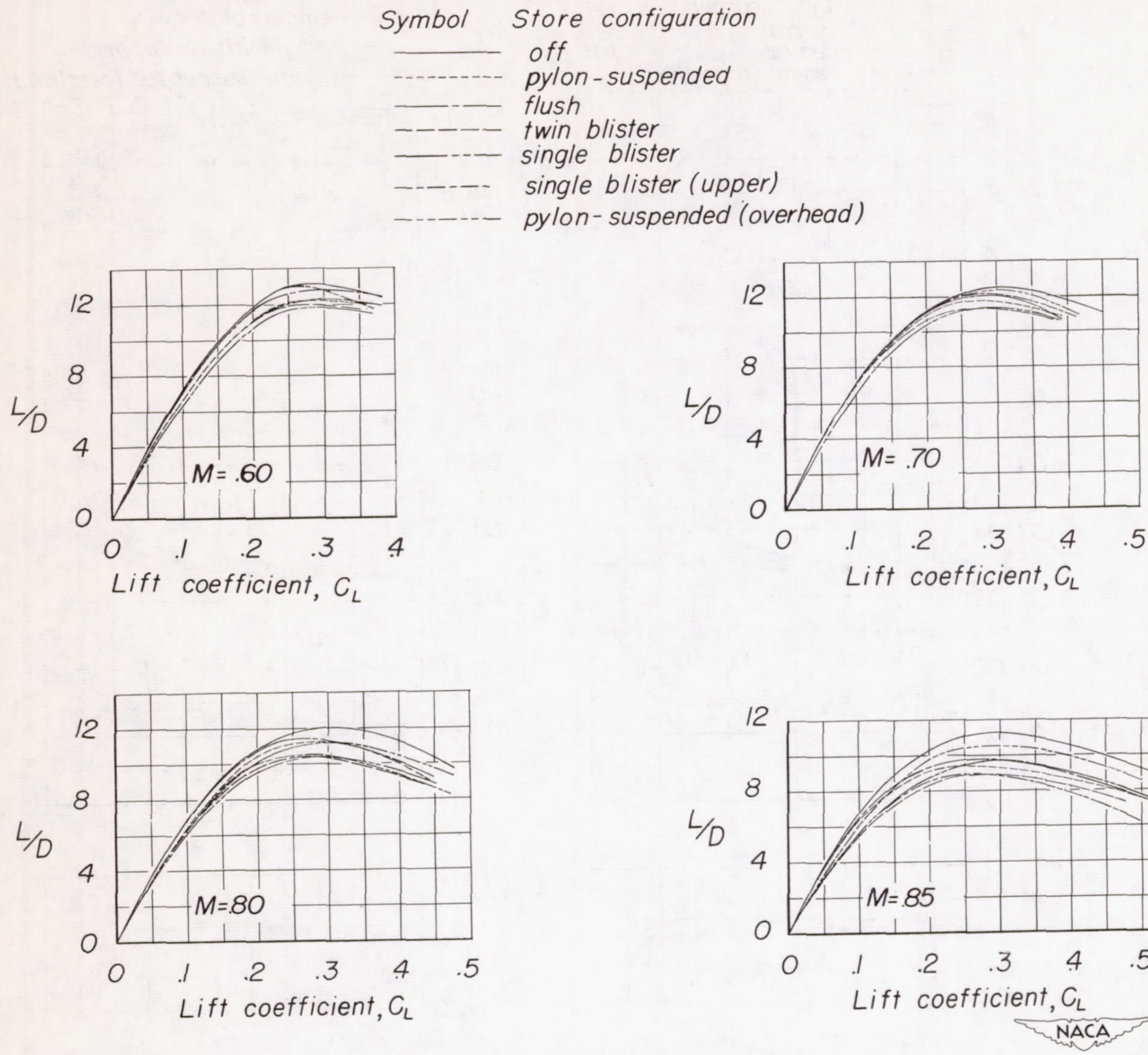
(b) Concluded.

Figure 7. —Concluded.



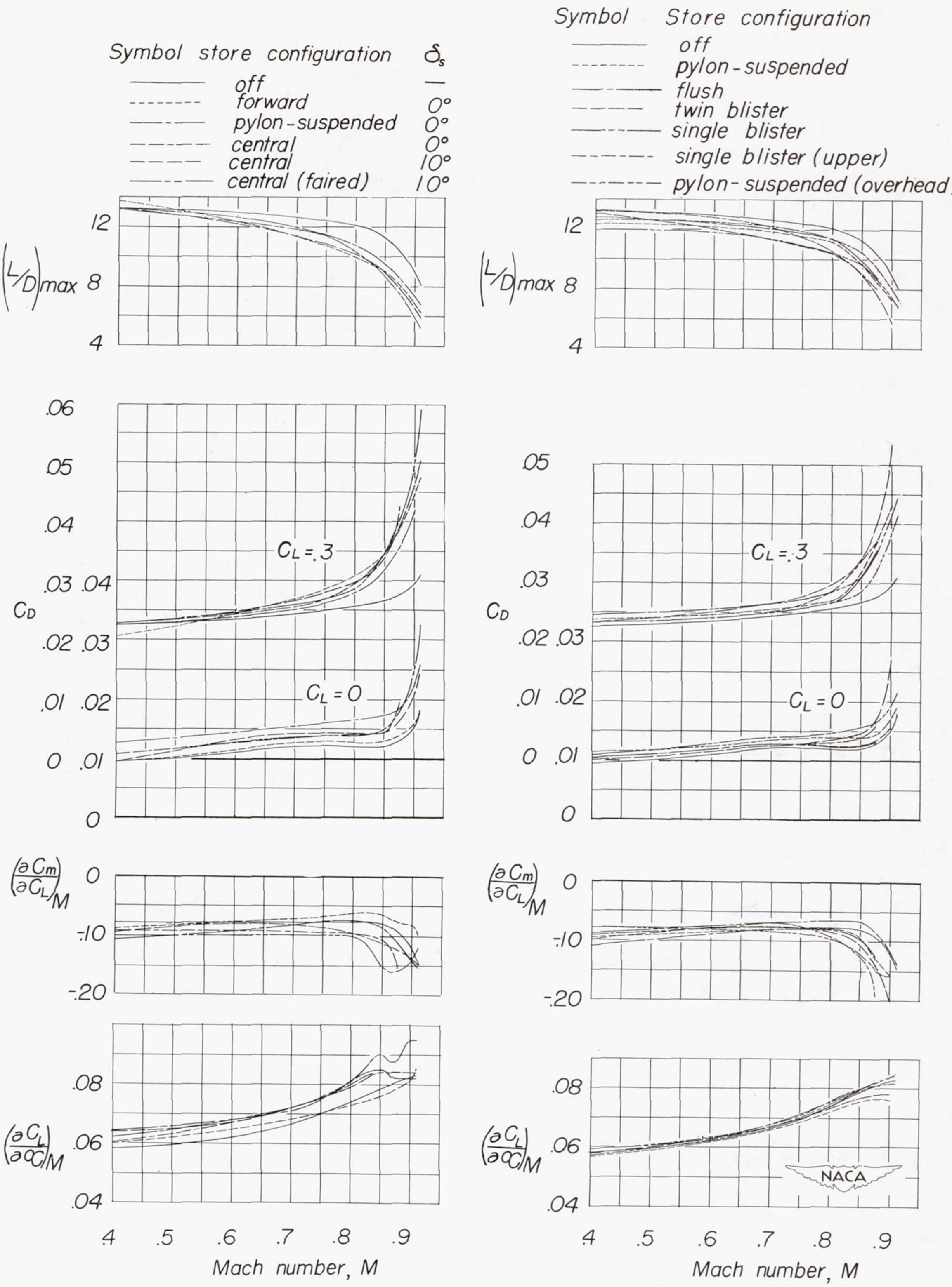
(a) Tip-mounted stores.

Figure 8.— Variation of the lift-drag ratio with lift coefficient of the test model with external stores.



(b) Fuselage-mounted stores.

Figure 8.— Concluded.



(a) Tip-mounted stores. (b) Fuselage-mounted stores.

Figure 9. — Effect of Mach number on the aerodynamic characteristics in pitch of the test model with external stores.

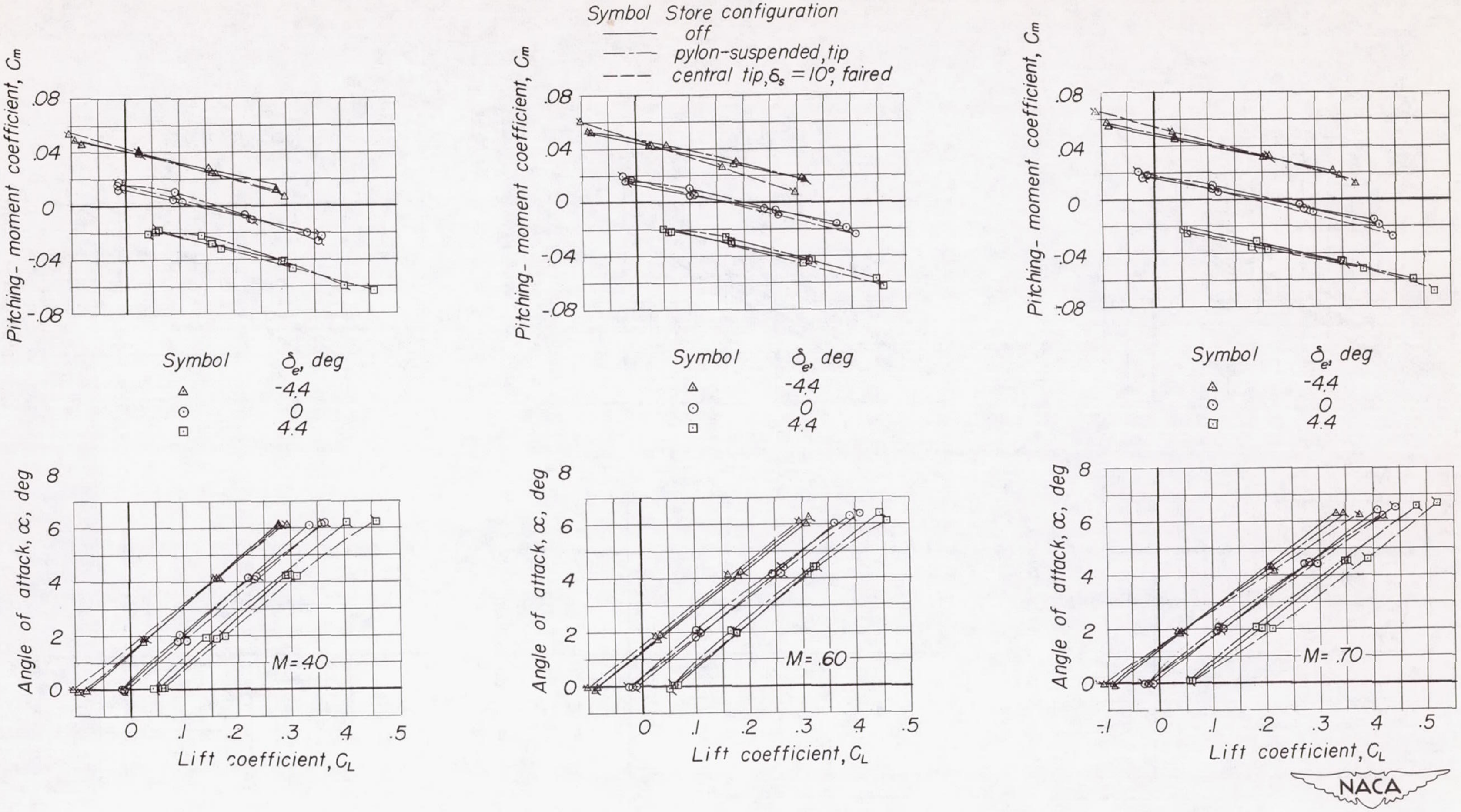


Figure 10. — Effect of control deflection on the aerodynamic characteristics in pitch of the test model with two wing-tip-mounted external-store configurations.

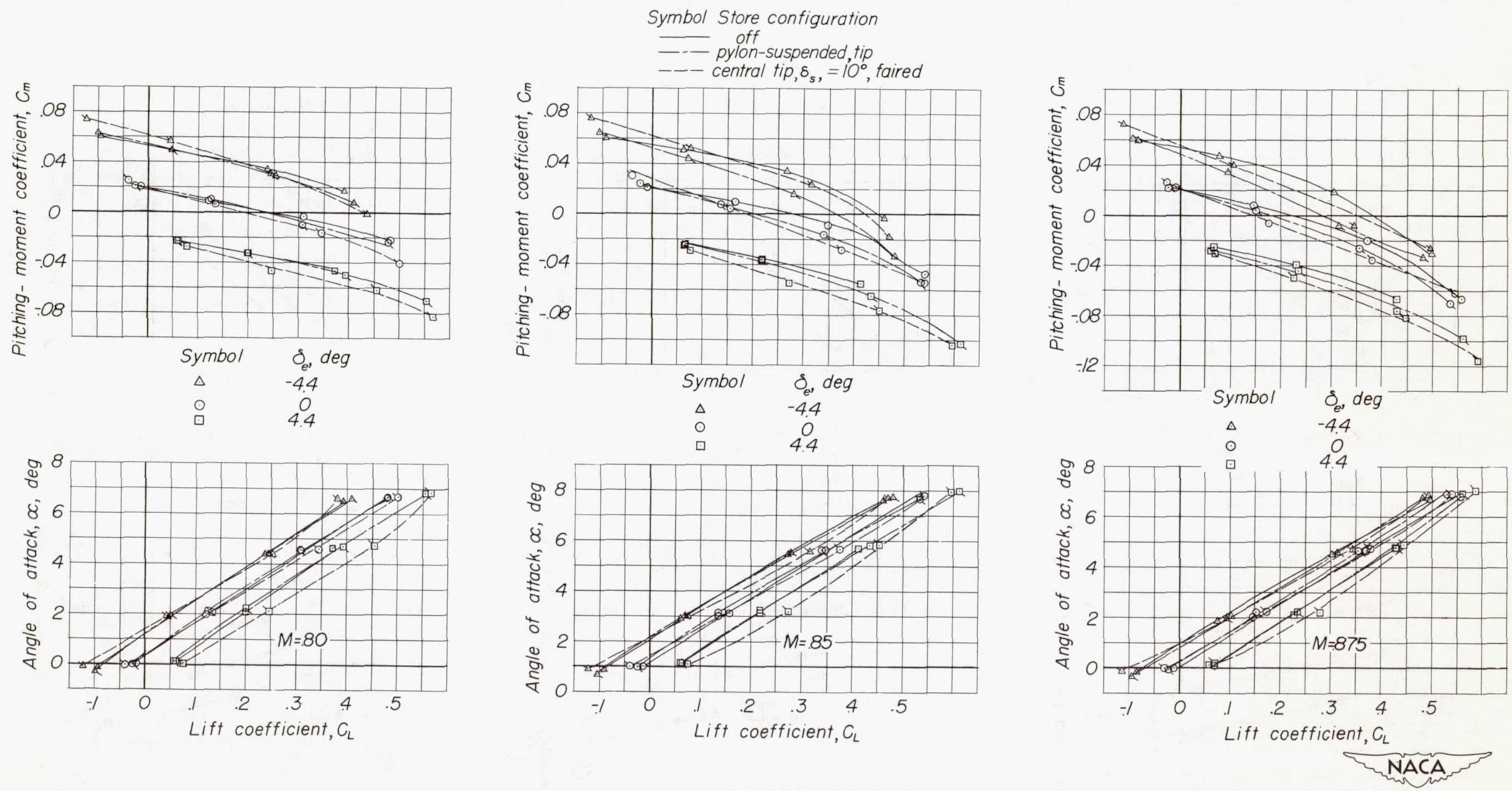


Figure 10.– Continued.

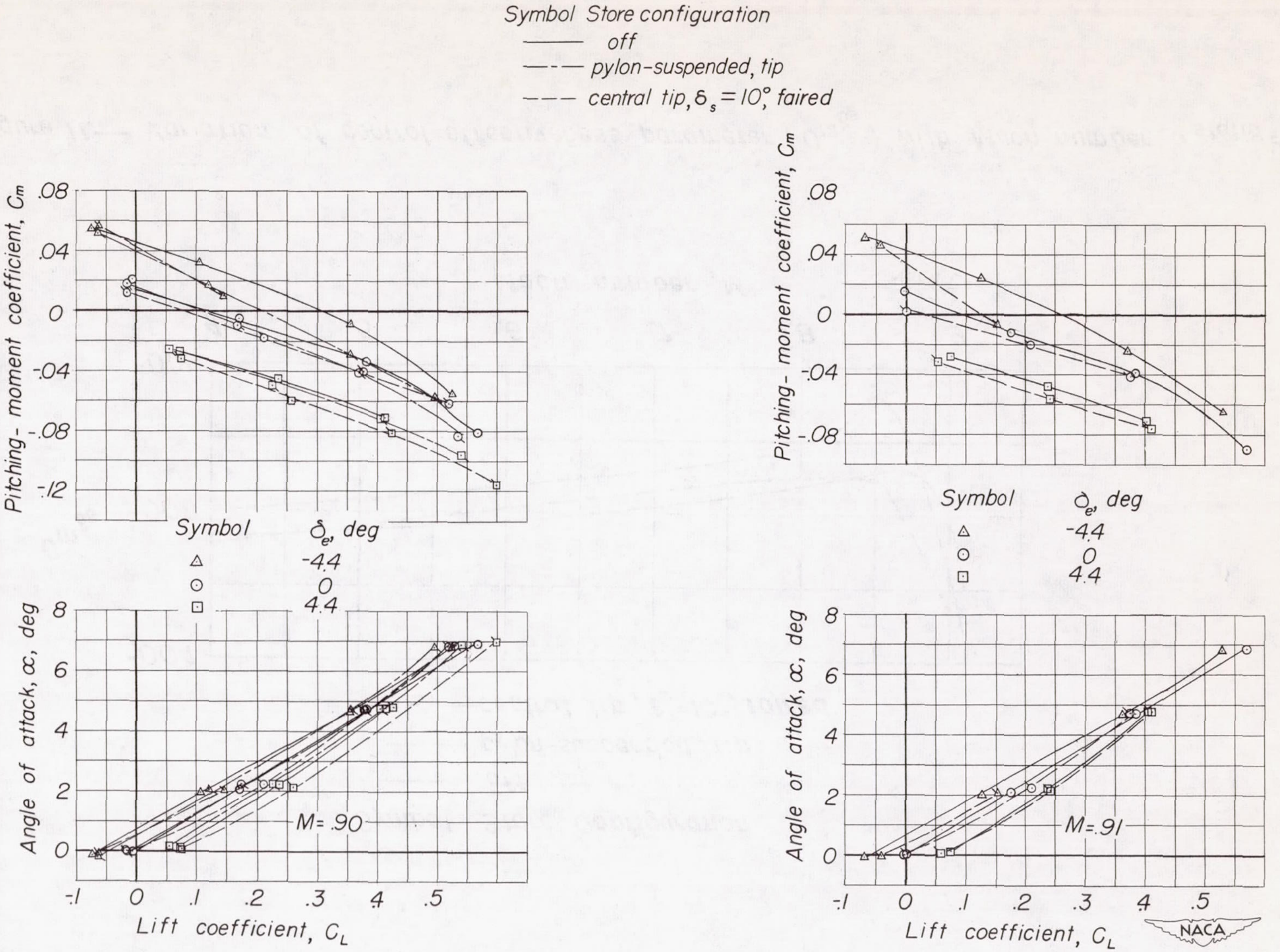


Figure 10.— Concluded.

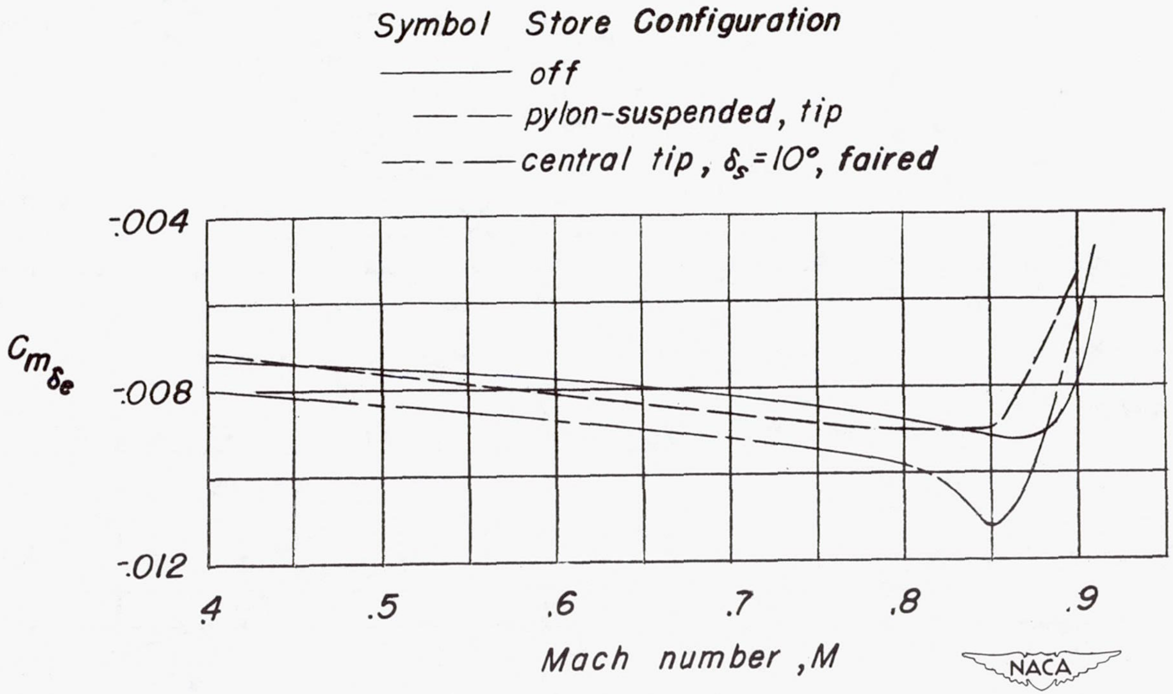
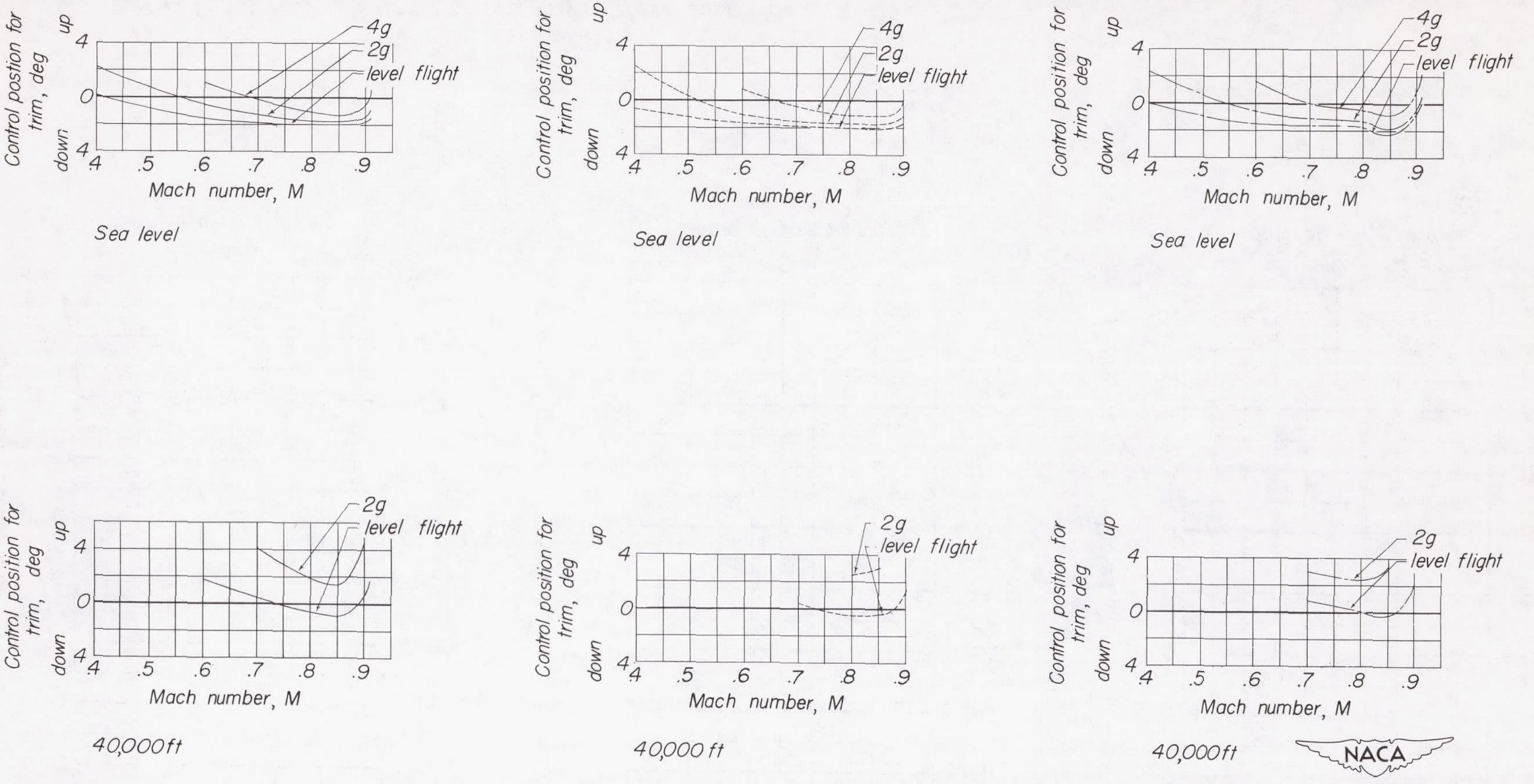


Figure 11.— Variation of control effectiveness parameter ($C_{m_{\delta_e}}$) with Mach number, α_{static} = 4°.

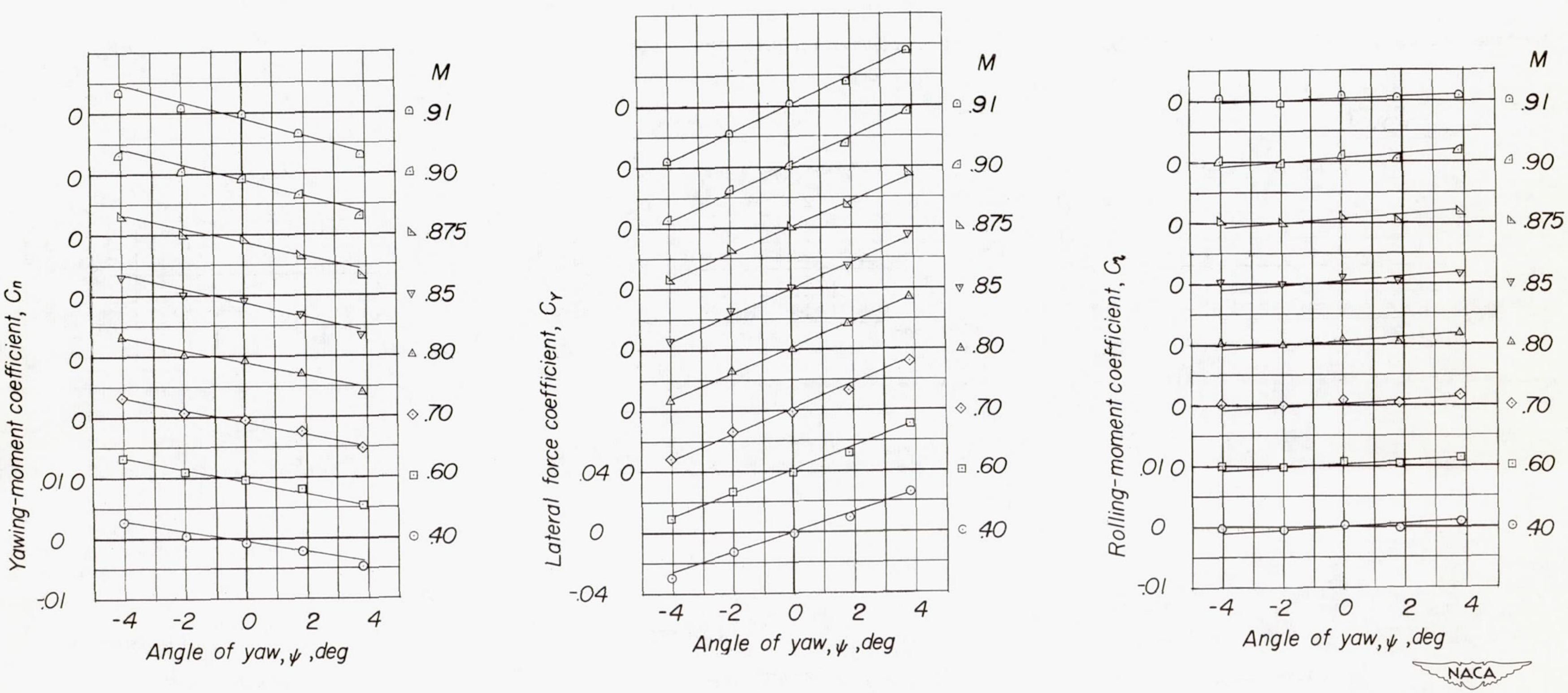


(a) Basic model.

(b) Pylon-suspended, tip-mounted store.

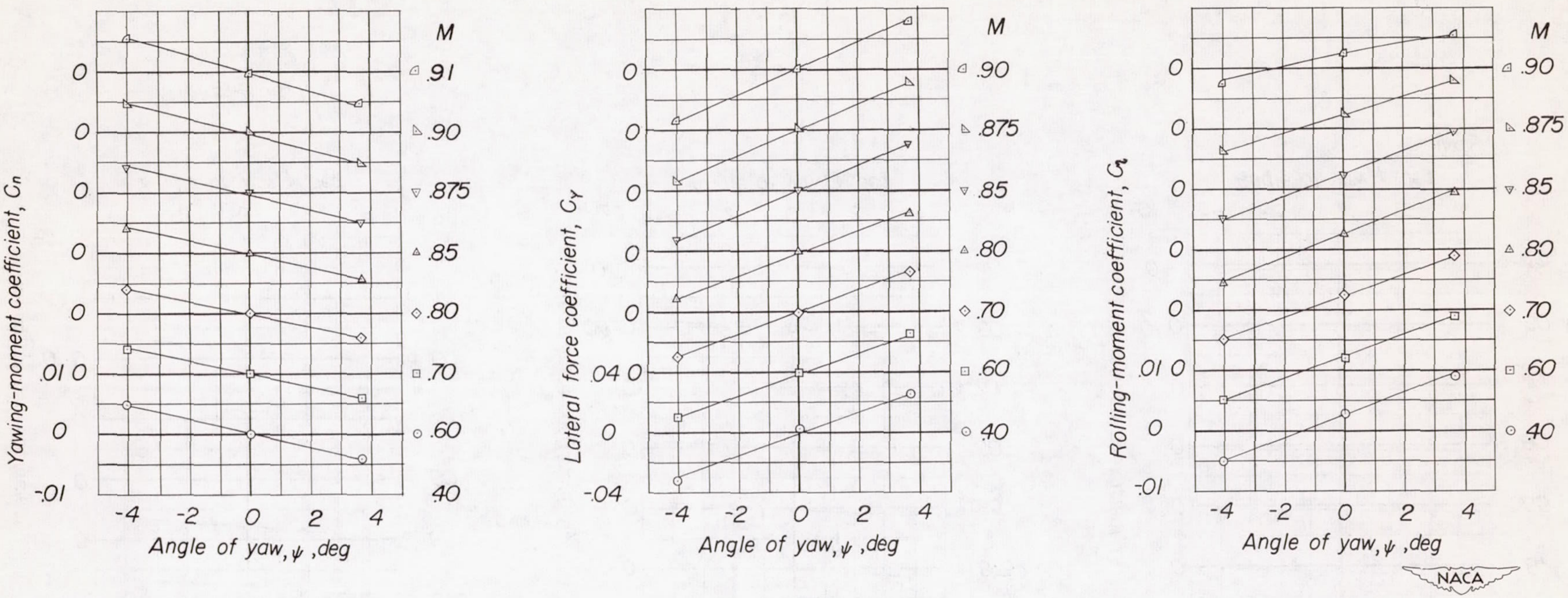
(c) Central (faired) $\delta_s = -10°$, tip-mounted store.

Figure 12.- Variation of control position for trim in level and accelerated flight for two altitudes at a wing loading of 34 pounds per square foot.



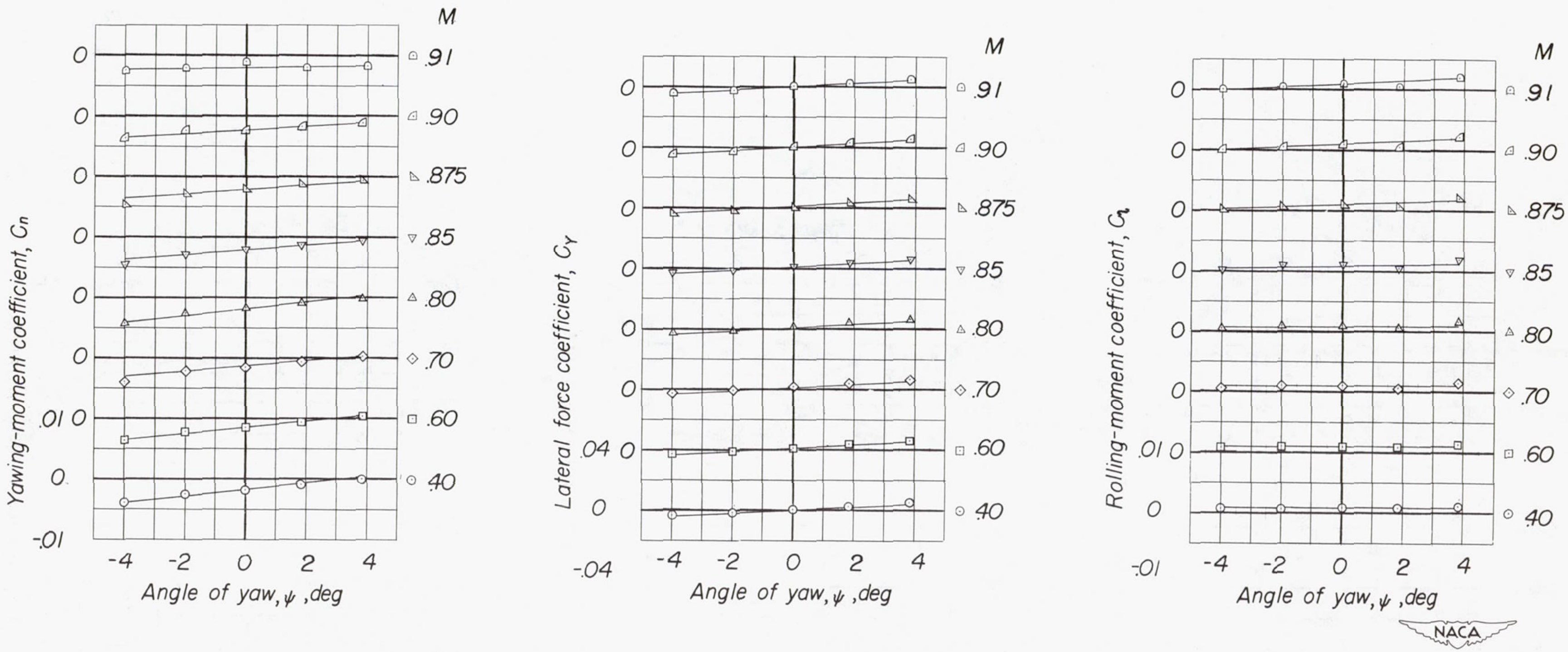
(a) $\alpha_{Static} = 0°$.

Figure 13. – Aerodynamic characteristics in yaw of the basic model, tail on.



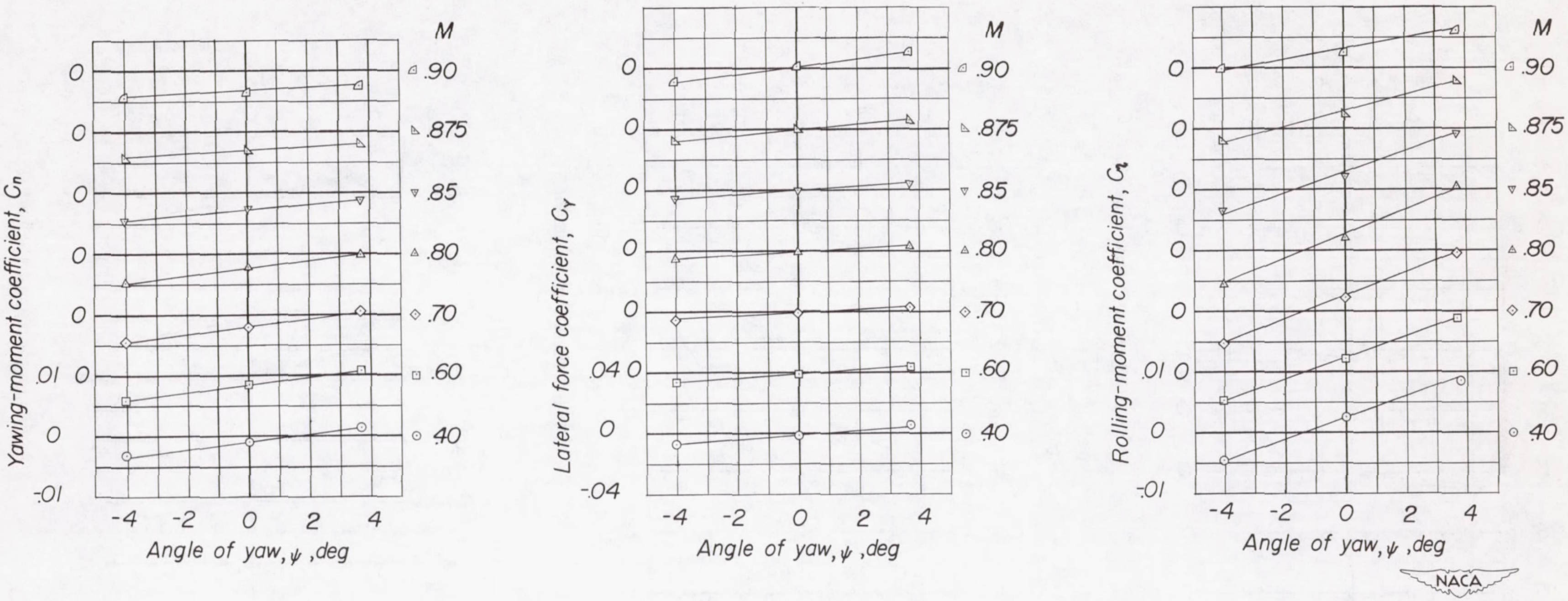
(b) $\alpha_{static} = 6°$.

Figure 13.— Concluded.



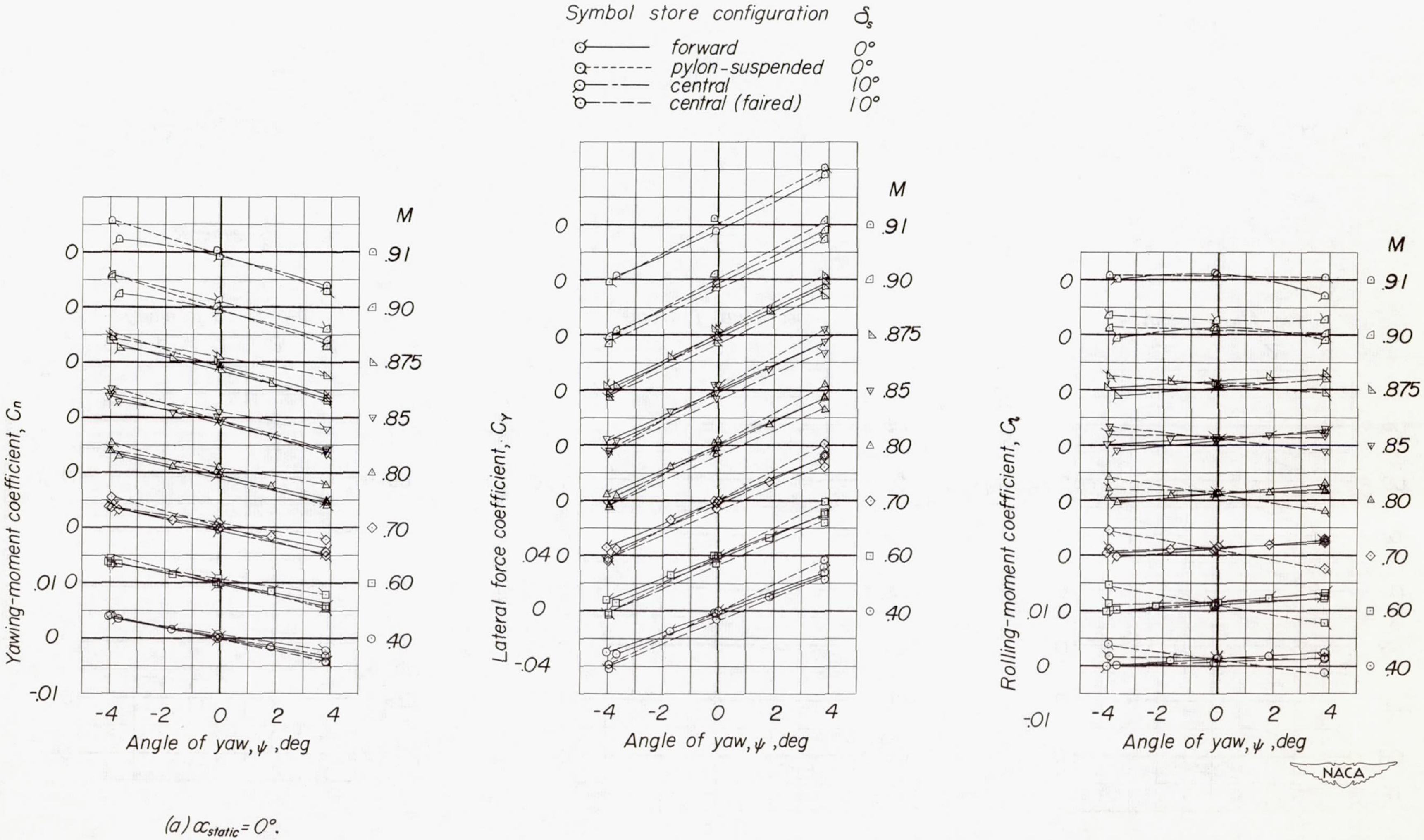
(a) $\alpha_{static} = 0°$.

Figure 14.– Aerodynamic characteristics in yaw of the basic model, tail off.



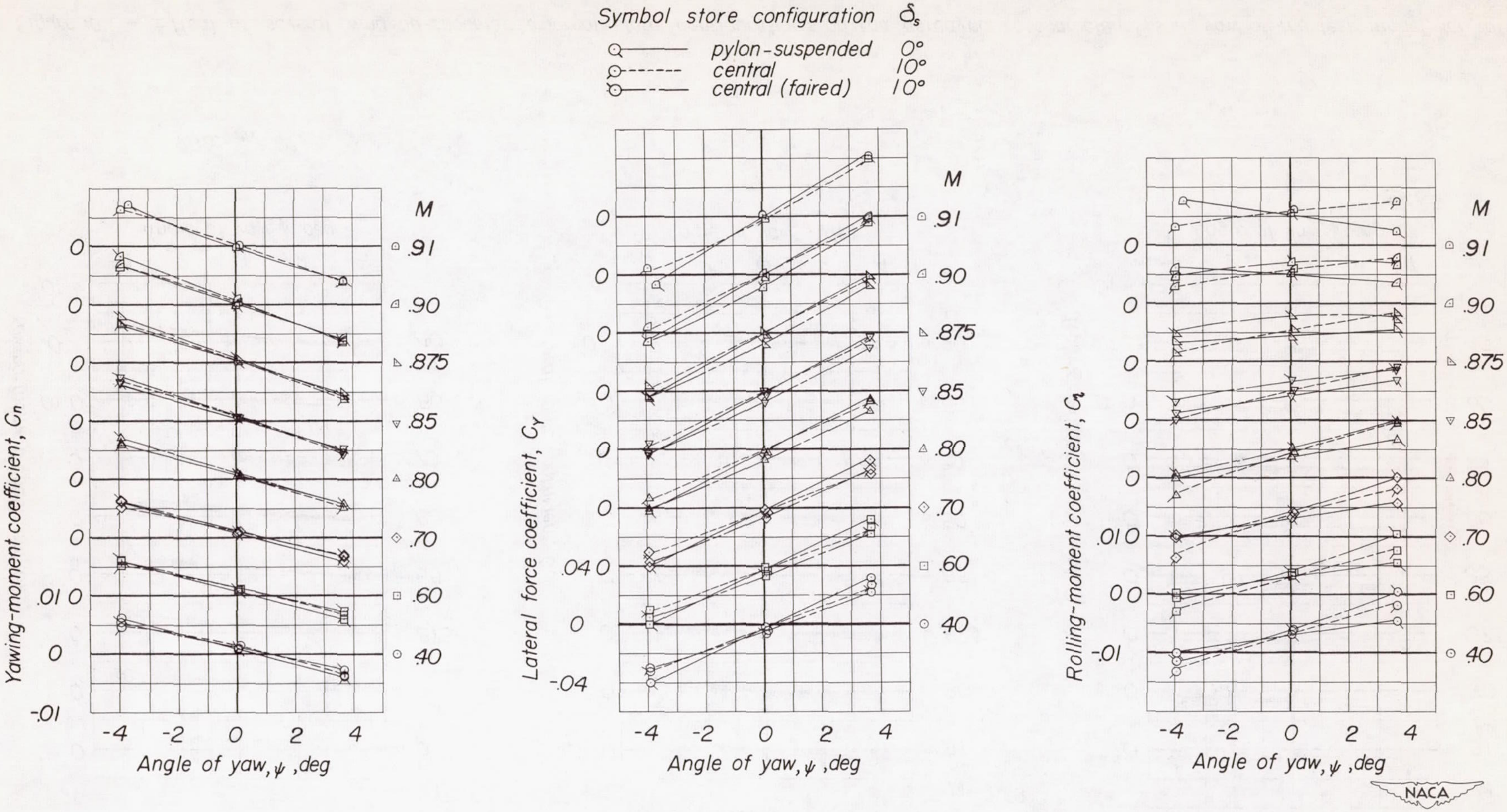
(b) $\alpha_{static} = 6°$.

Figure 14.— Concluded.



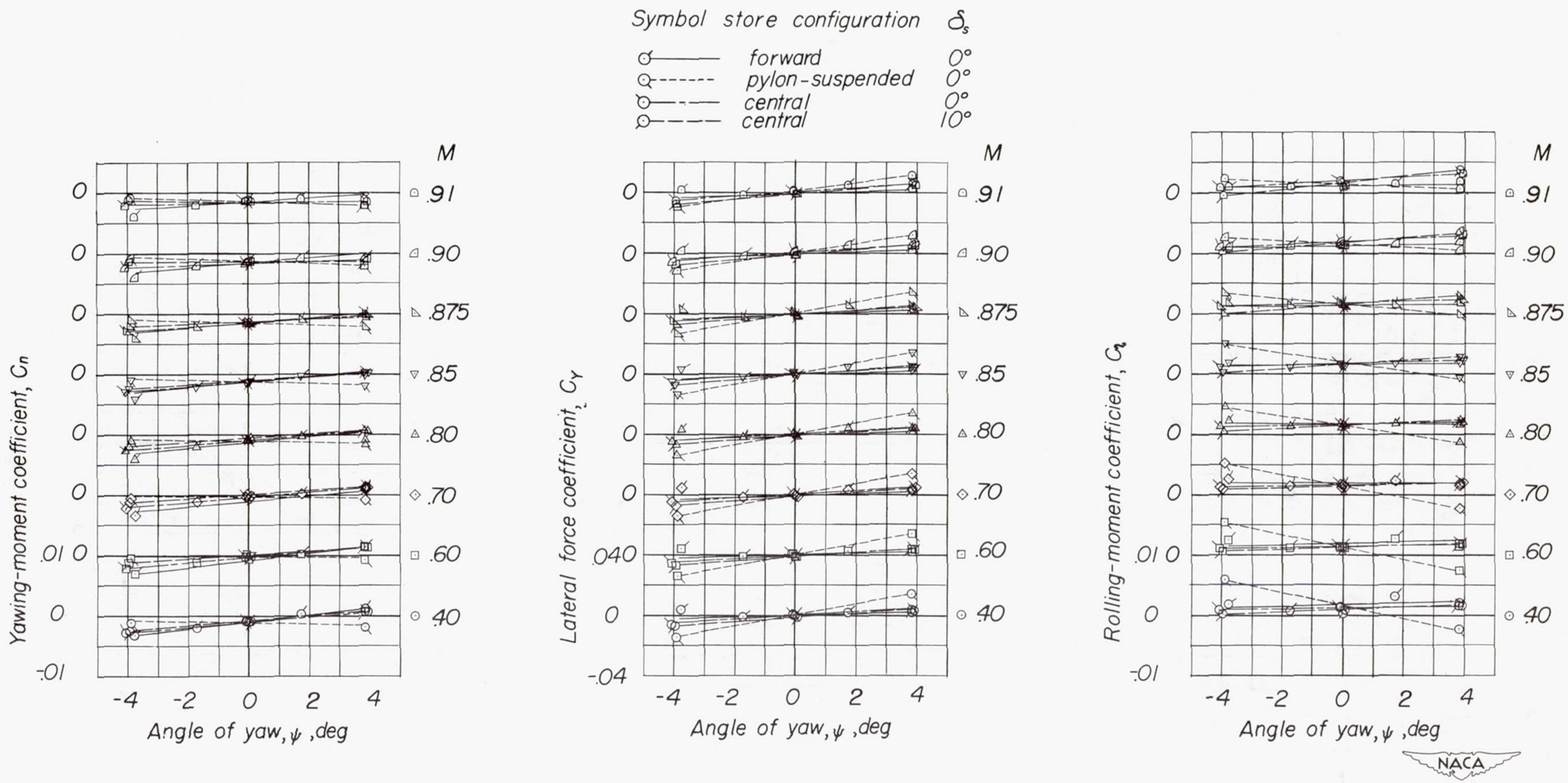
(a) $\alpha_{static} = 0°$.

Figure 15. – Effect of several wing tip-mounted external-store configurations on the aerodynamic characteristics in yaw of the test model, tail on.



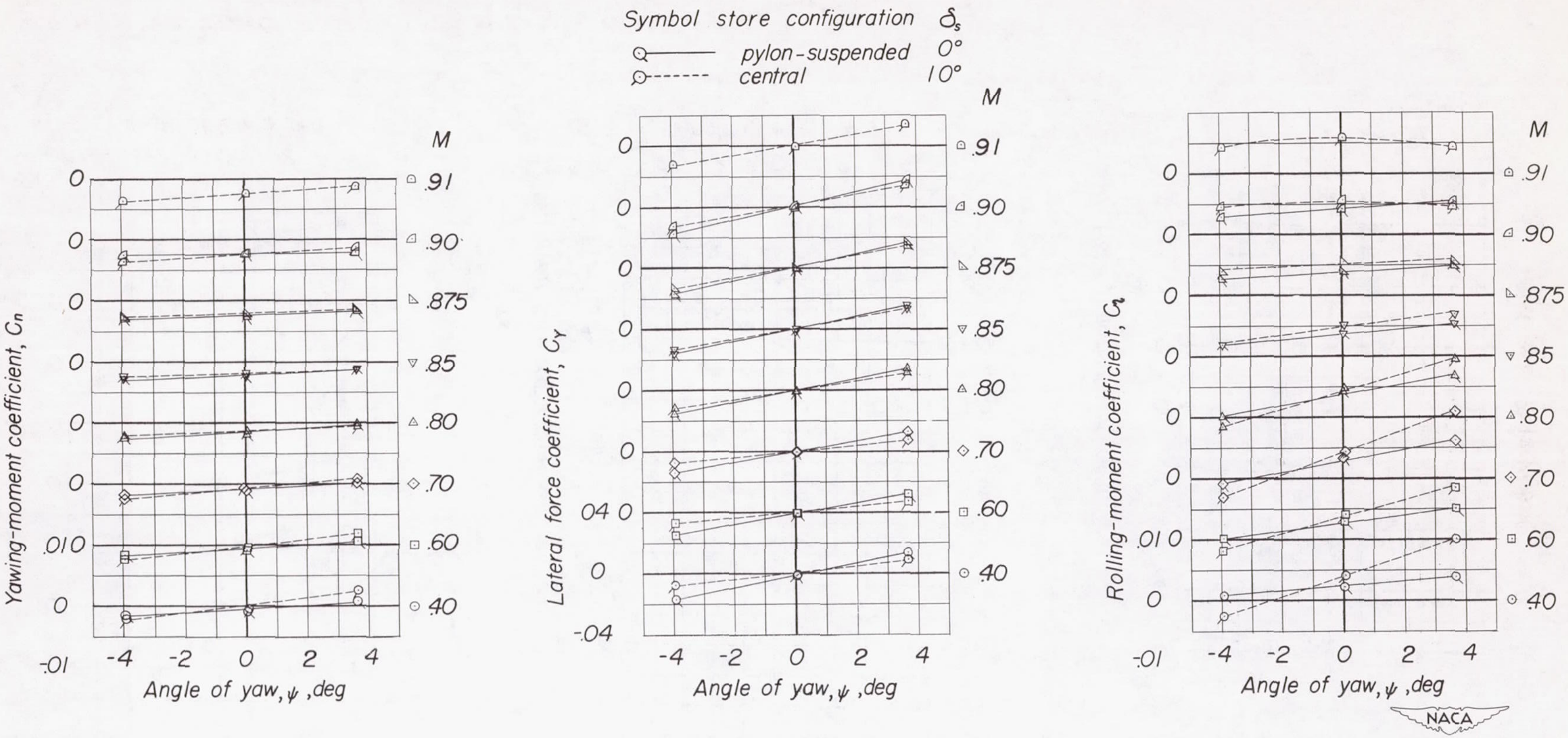
(b) $\alpha_{static} = 6°$.

Figure 15.— Concluded.



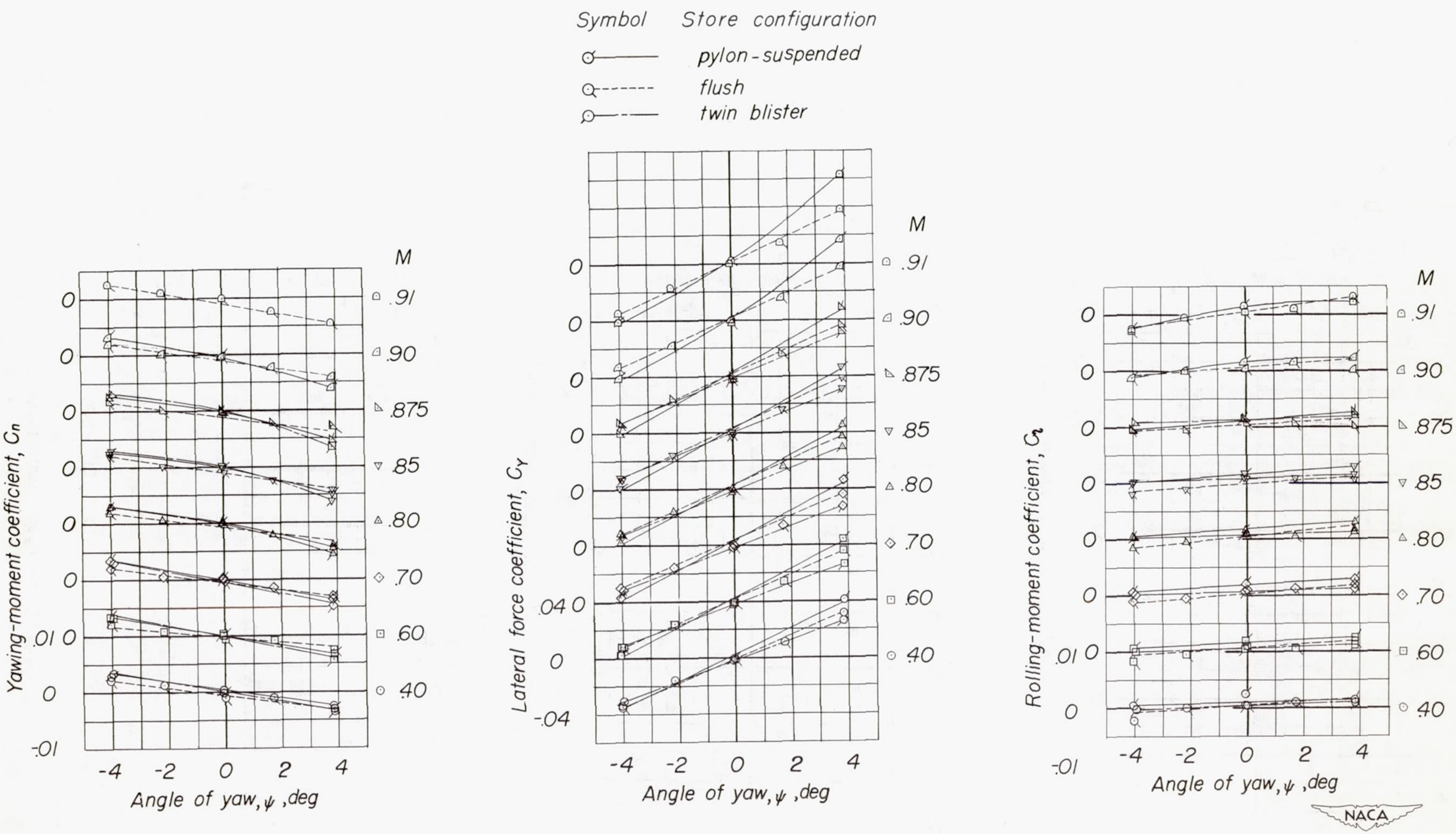
(a) $\alpha_{static} = 0°$.

Figure 16. — Effect of several wing-tip-mounted external-store configurations on the aerodynamic characteristics in yaw of the test model, tail off.



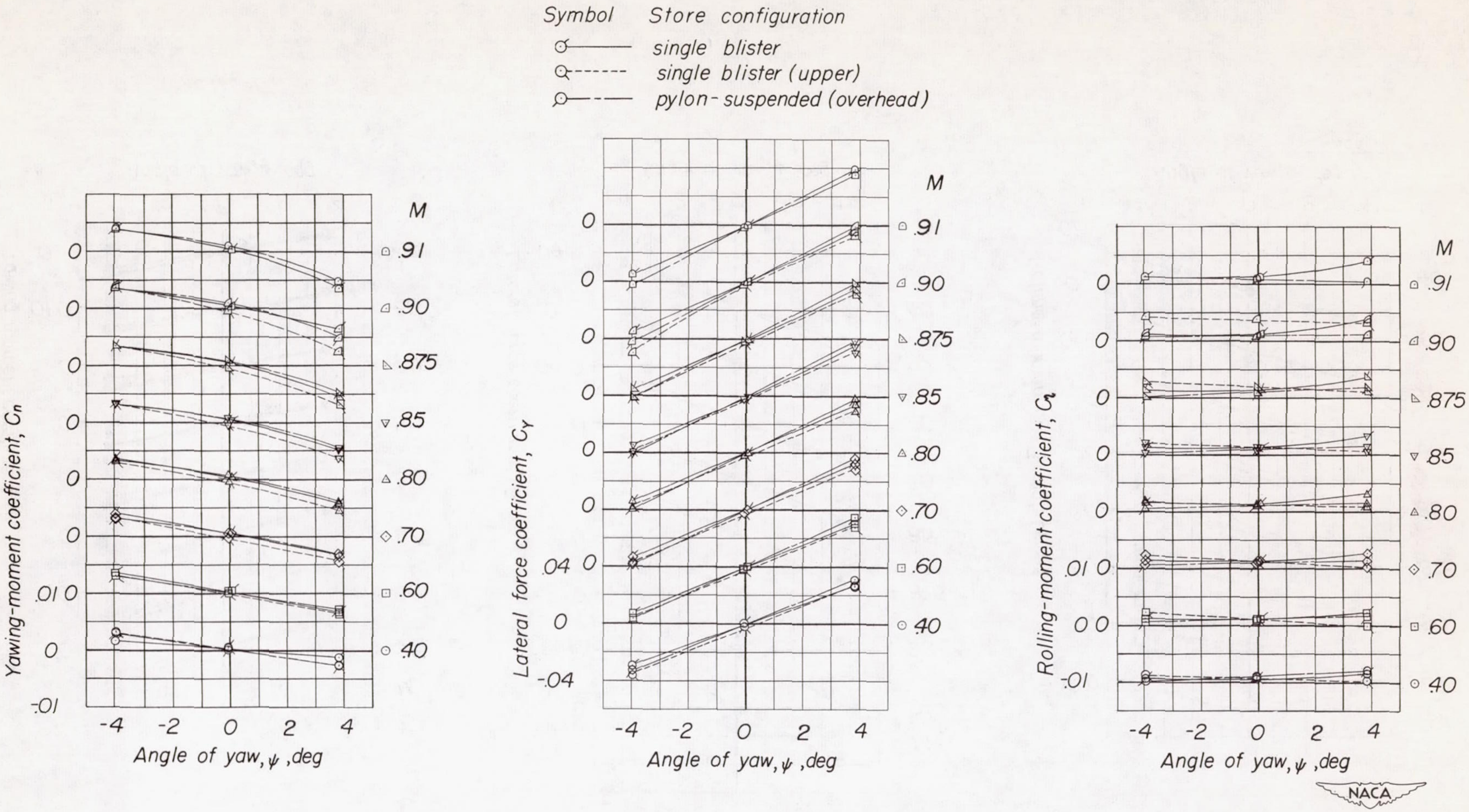
(b) $\alpha_{static} = 6°$.

Figure 16.— Concluded.



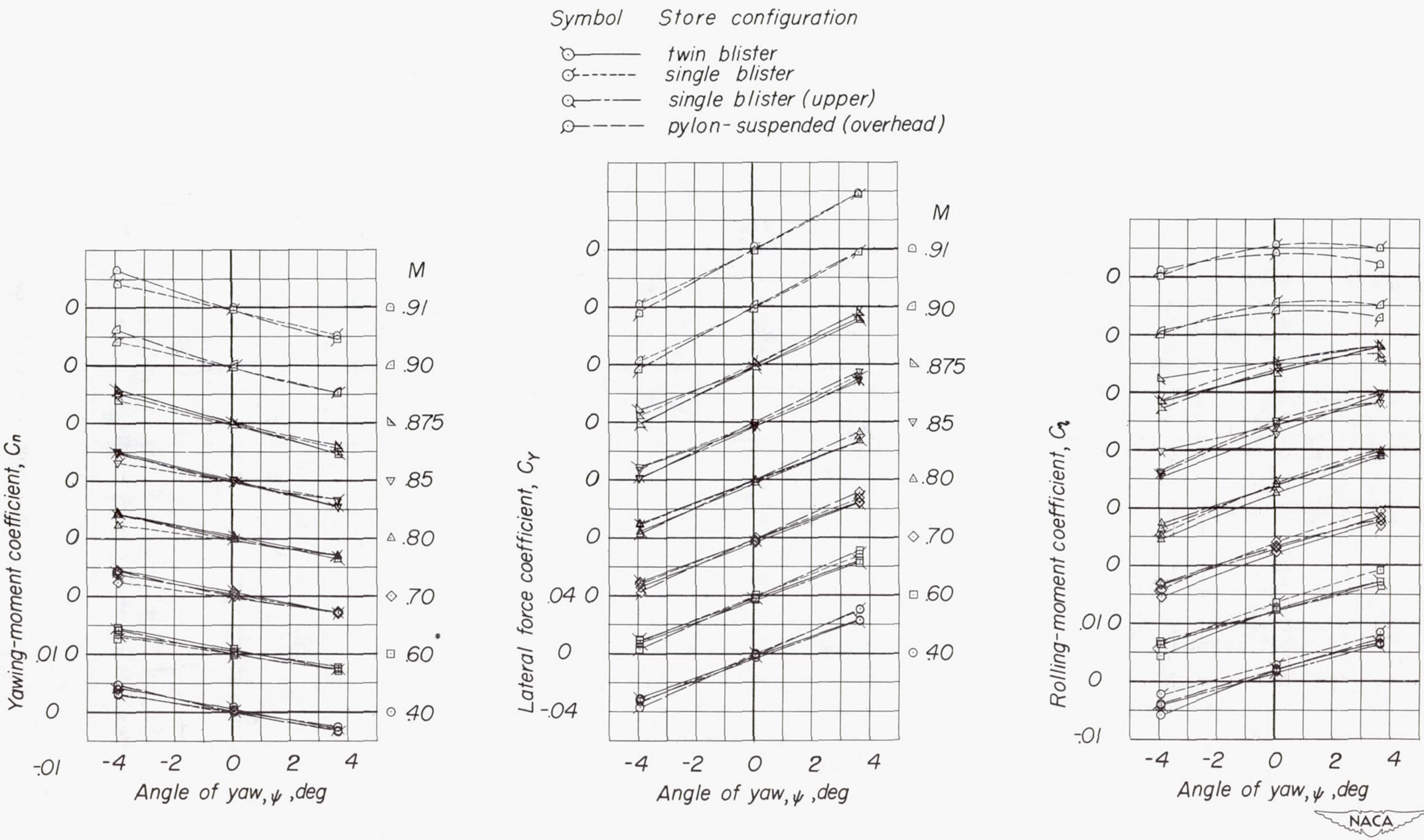
(a) $\alpha_{static} = 0°$.

Figure 17. — Effect of several fuselage-mounted external-store configurations on the aerodynamic characteristics in yaw of the test model, tail on.



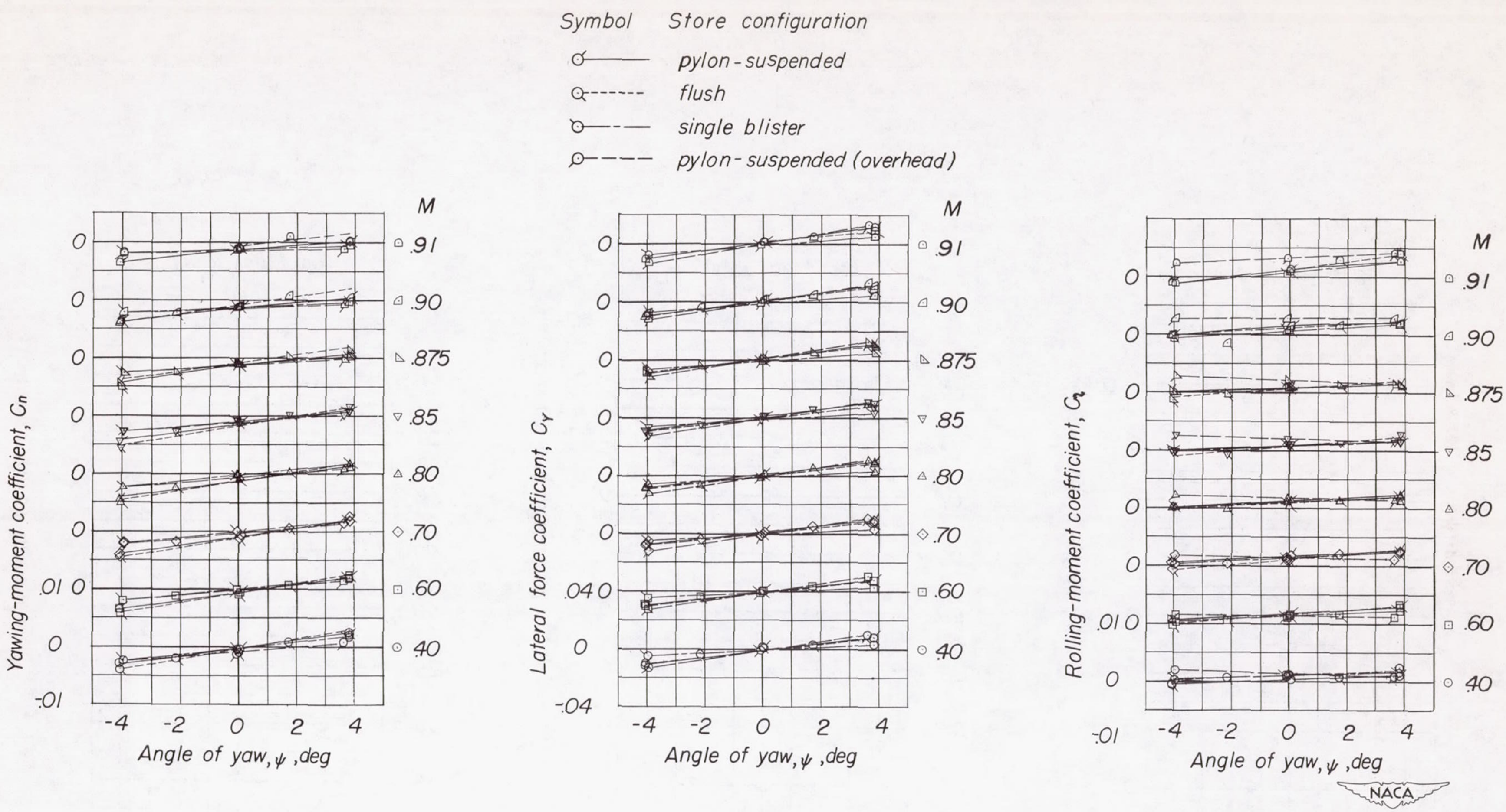
(a) Concluded.

Figure 17.- Continued.



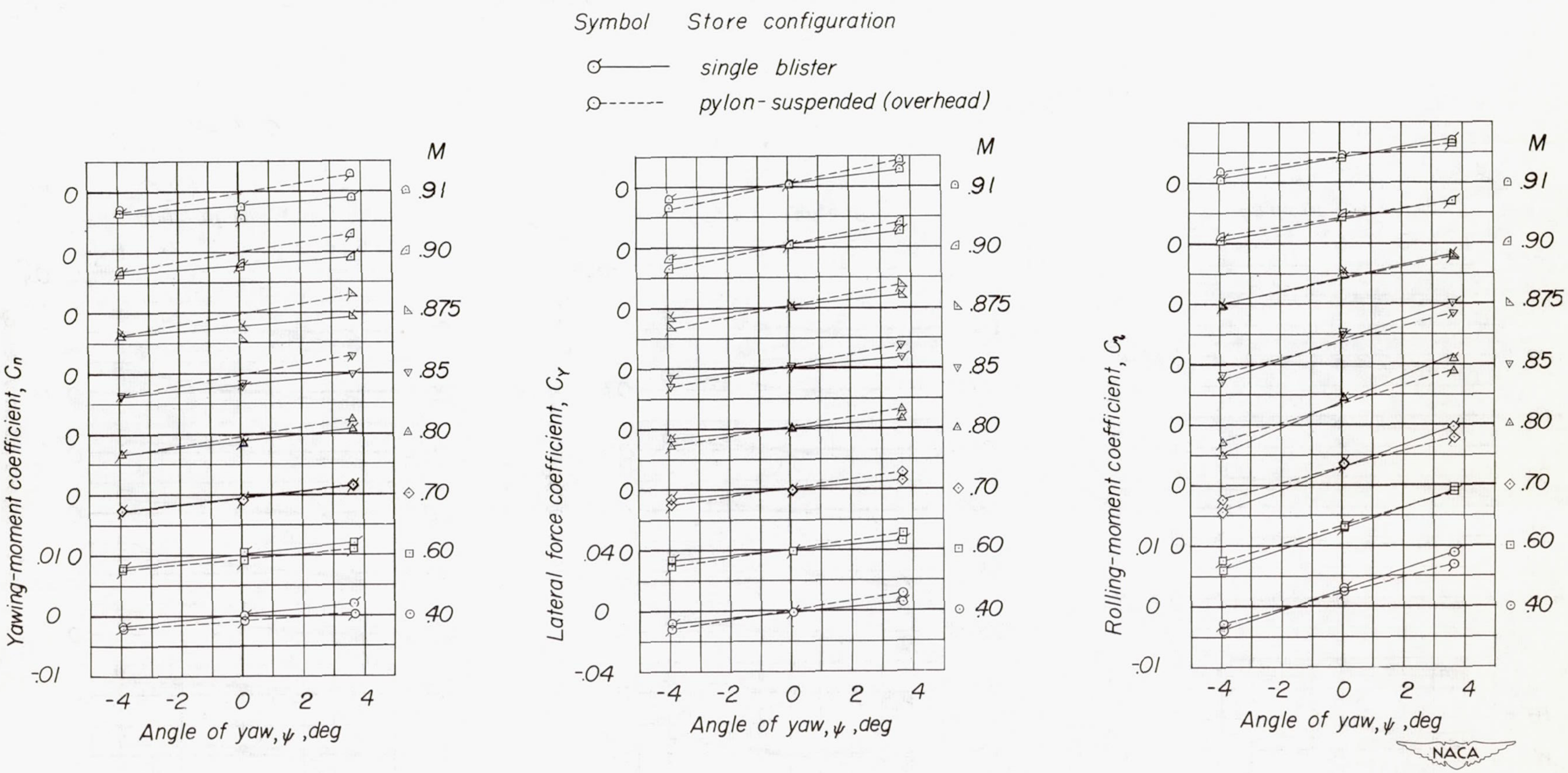
(b) $\alpha_{static} = 6°$.

Figure 17.—Concluded.



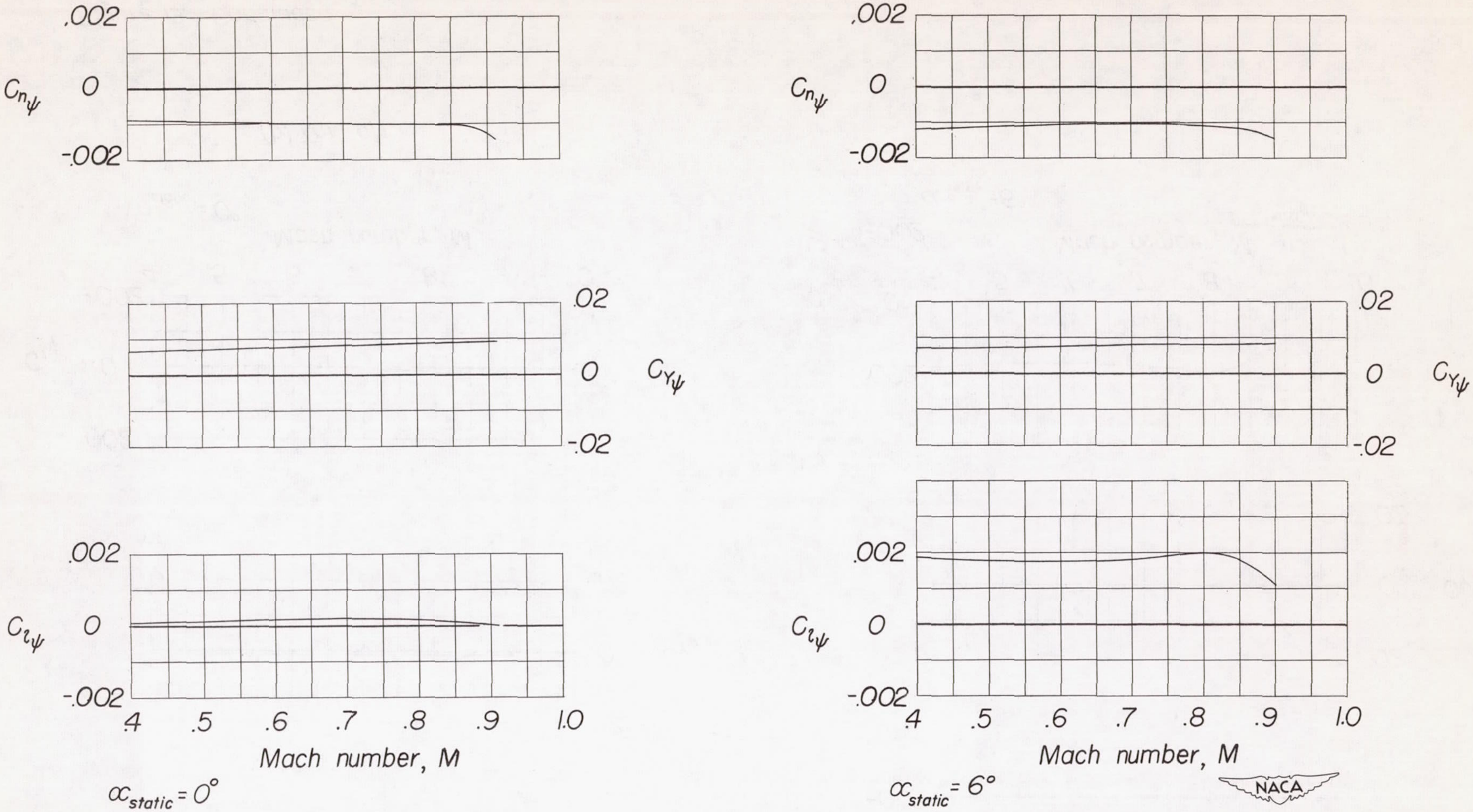
(a) $\alpha_{static} = 0°$.

Figure 18. — Effect of several fuselage-mounted external-store configurations on the aerodynamic characteristics in yaw of the test model, tail off.



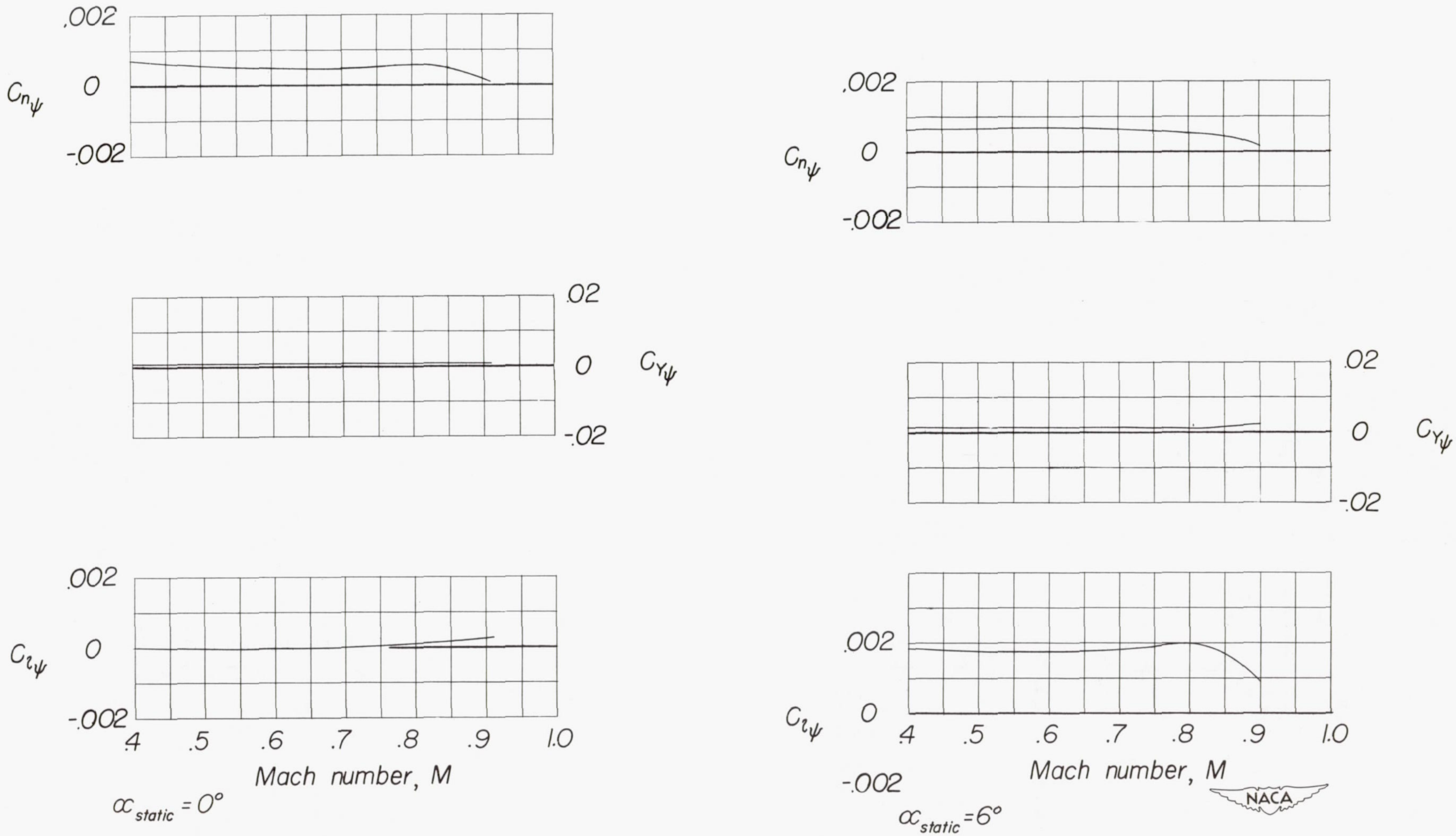
(b) $\alpha_{static} = 6°$.

Figure 18.—Concluded.



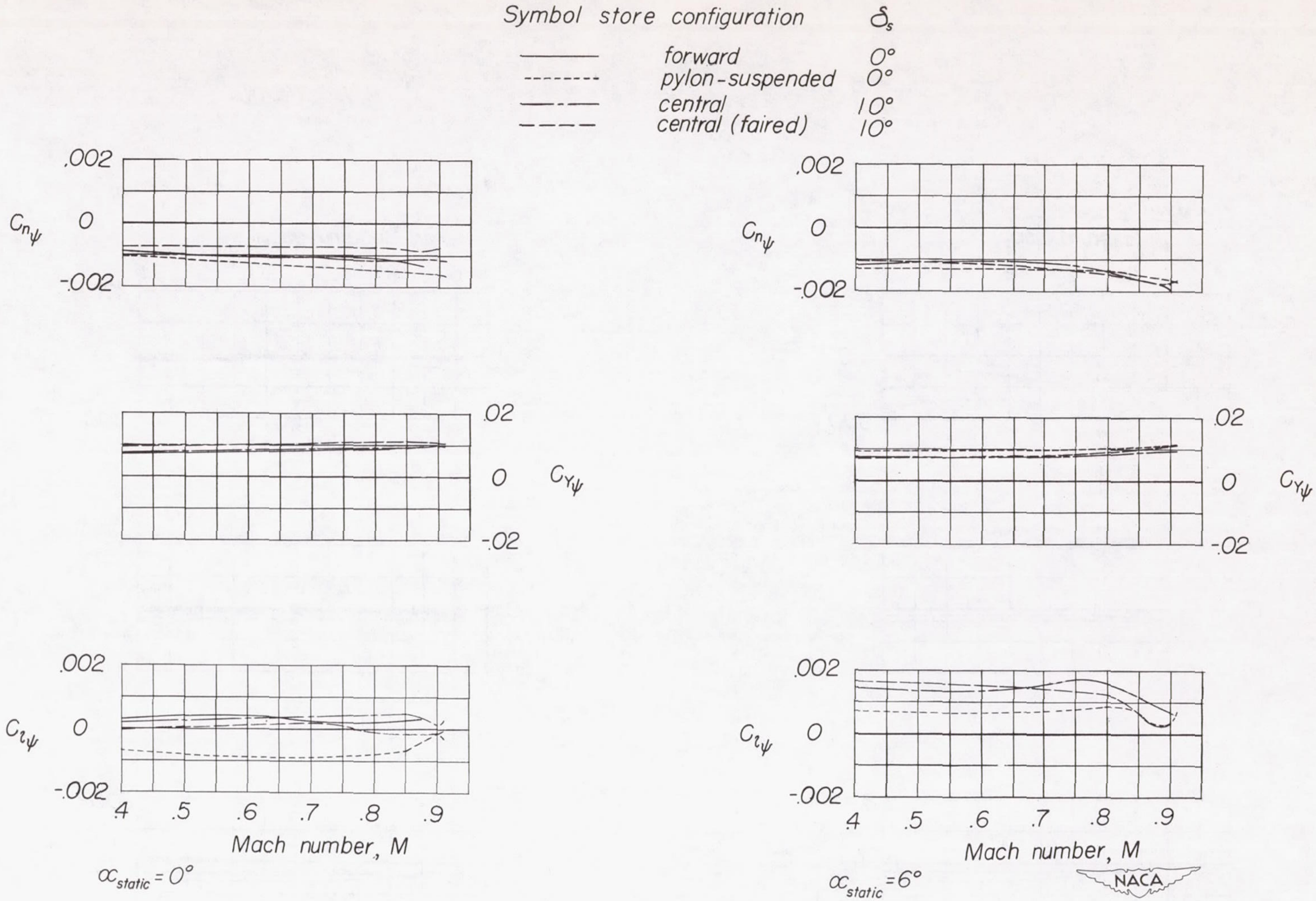
(a) Tail on.

Figure 19.- Variation of the lateral stability characteristics of the basic model with Mach number.



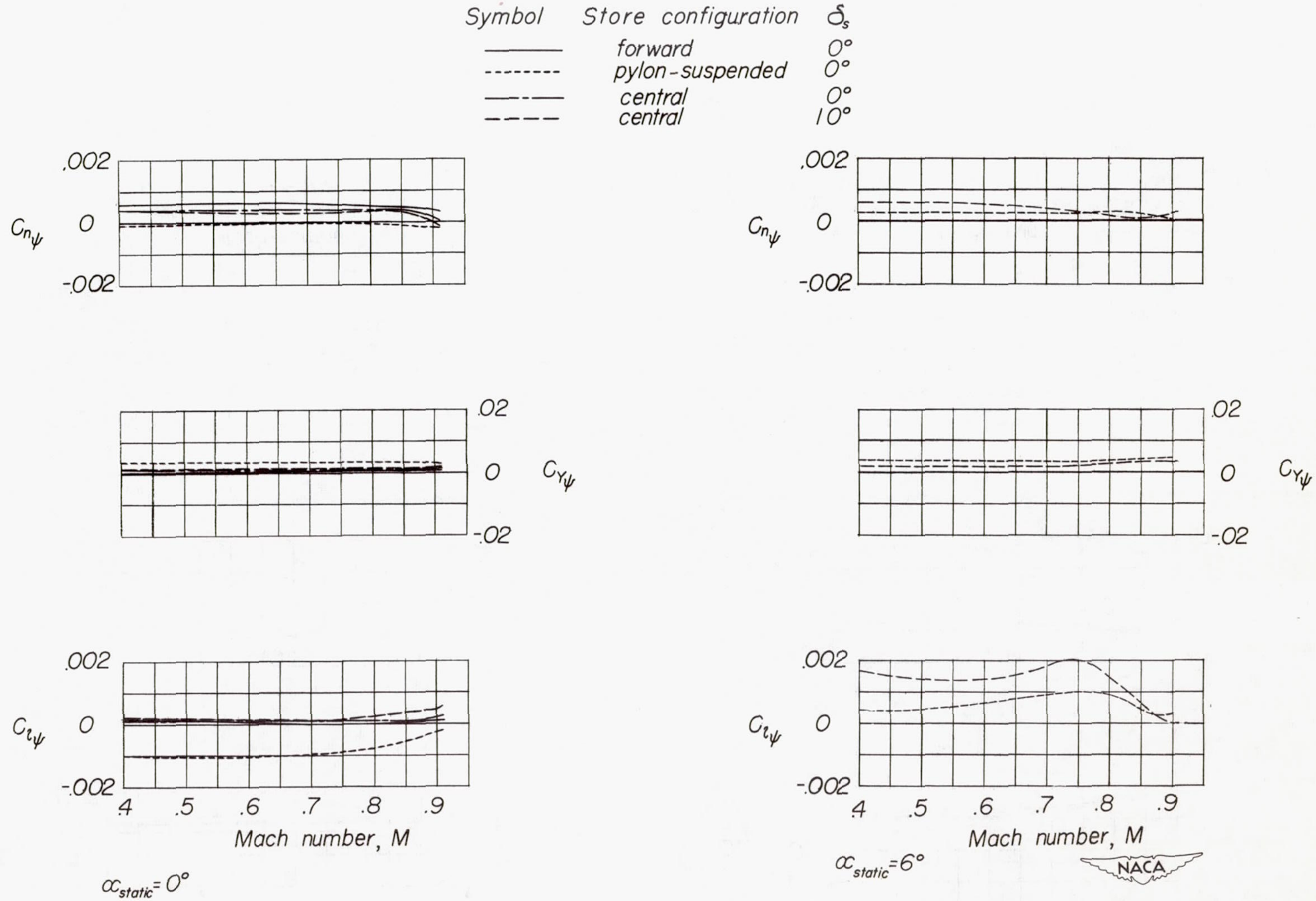
(b) Tail off.

Figure 19.—Concluded.



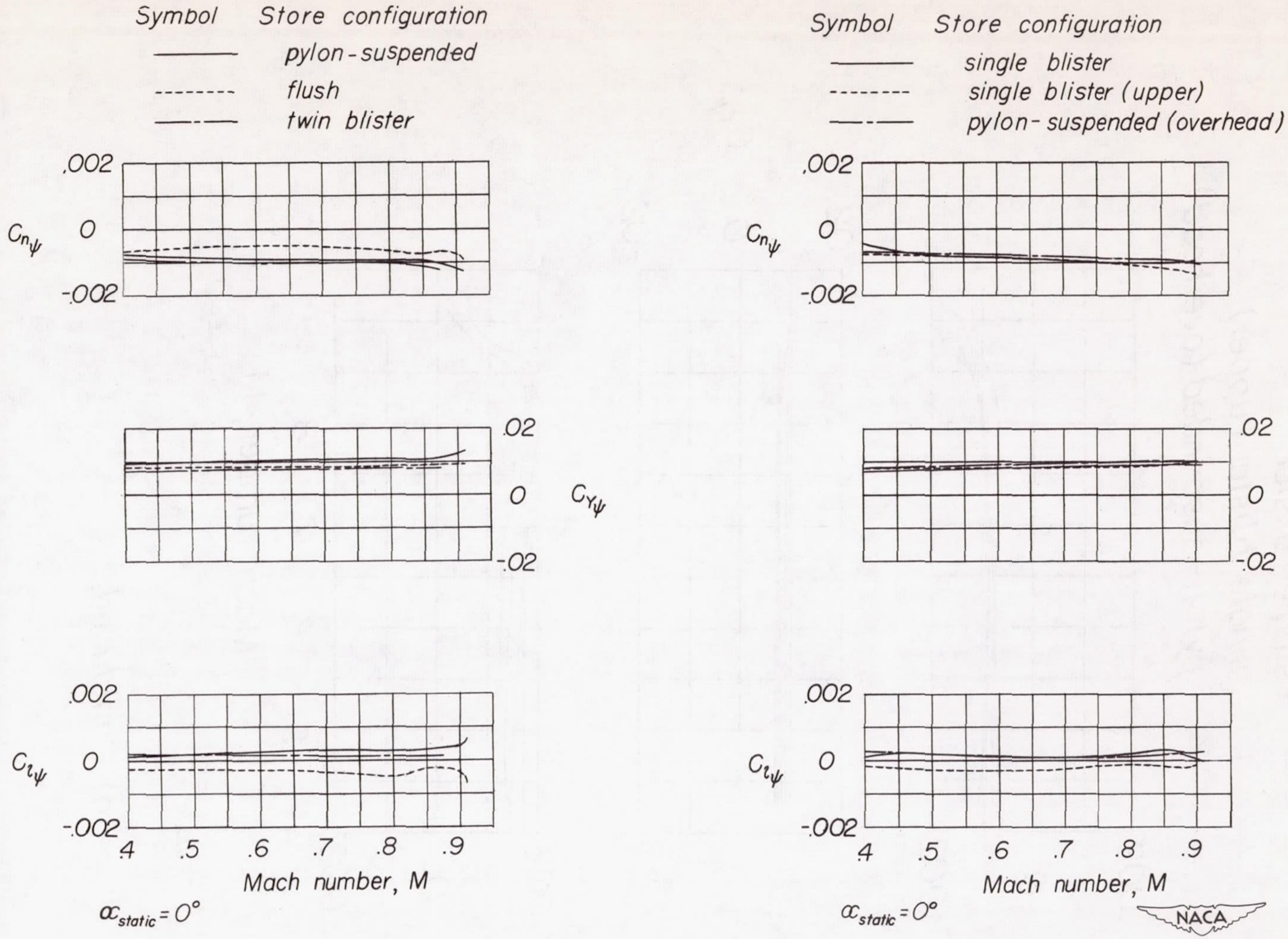
(a) Tail on.

Figure 20. — Variation with Mach number of the lateral stability parameters due to several tip-mounted external-store configurations.



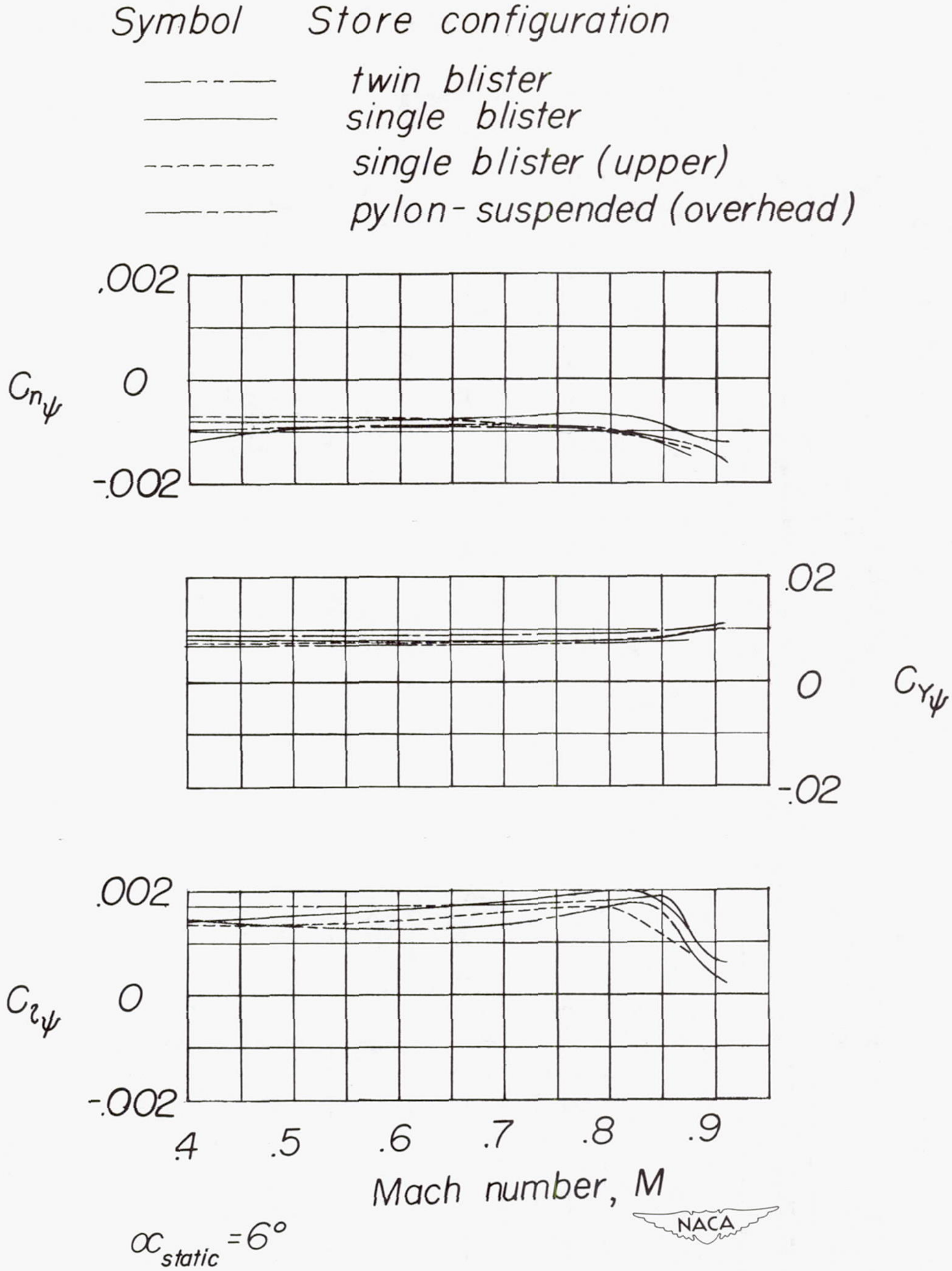
(b) Tail off.

Figure 20.- Concluded.



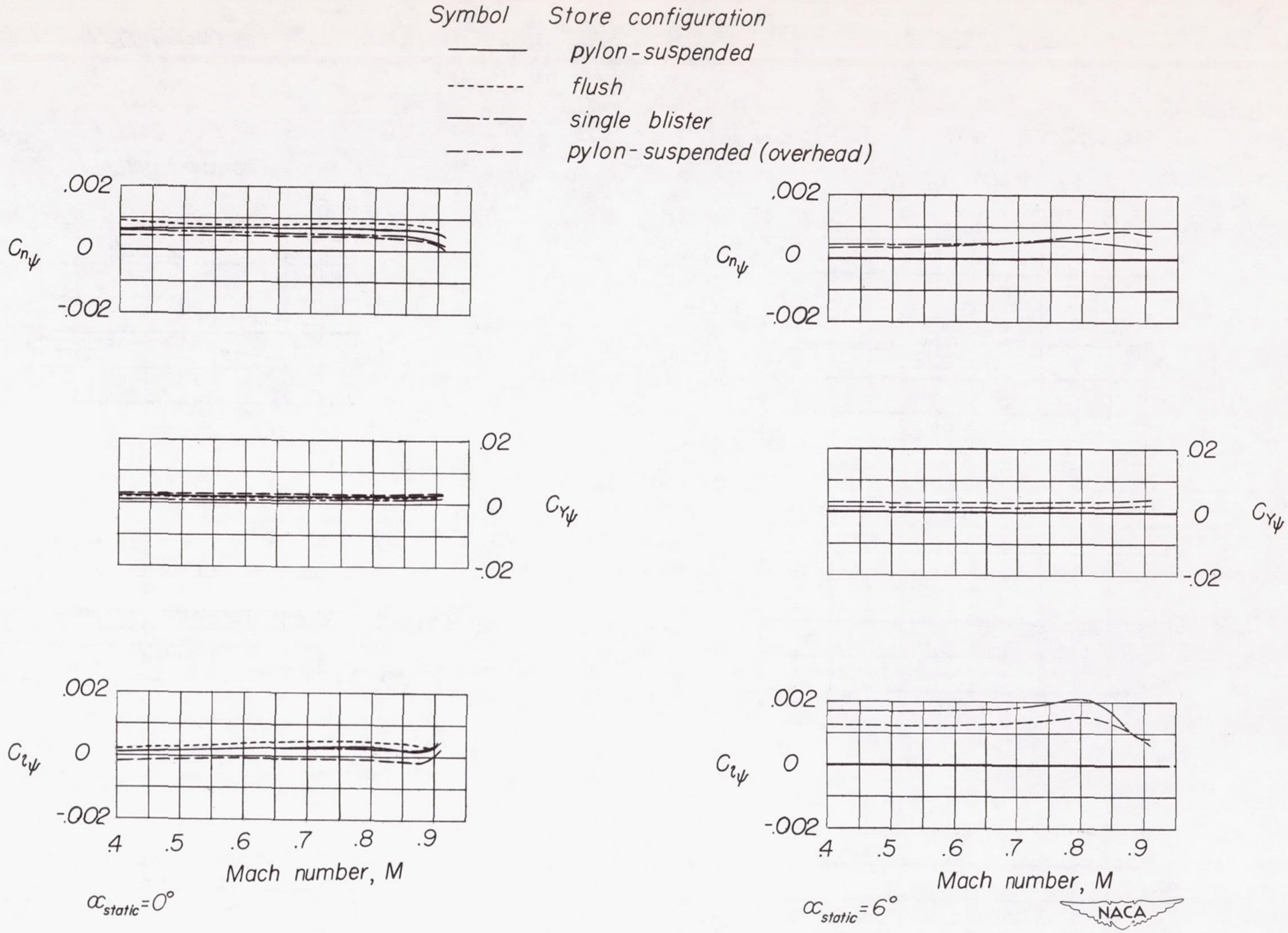
(a) Tail on.

Figure 21. — Variation with Mach number of the lateral stability parameters due to several fuselage-mounted external-store configurations.



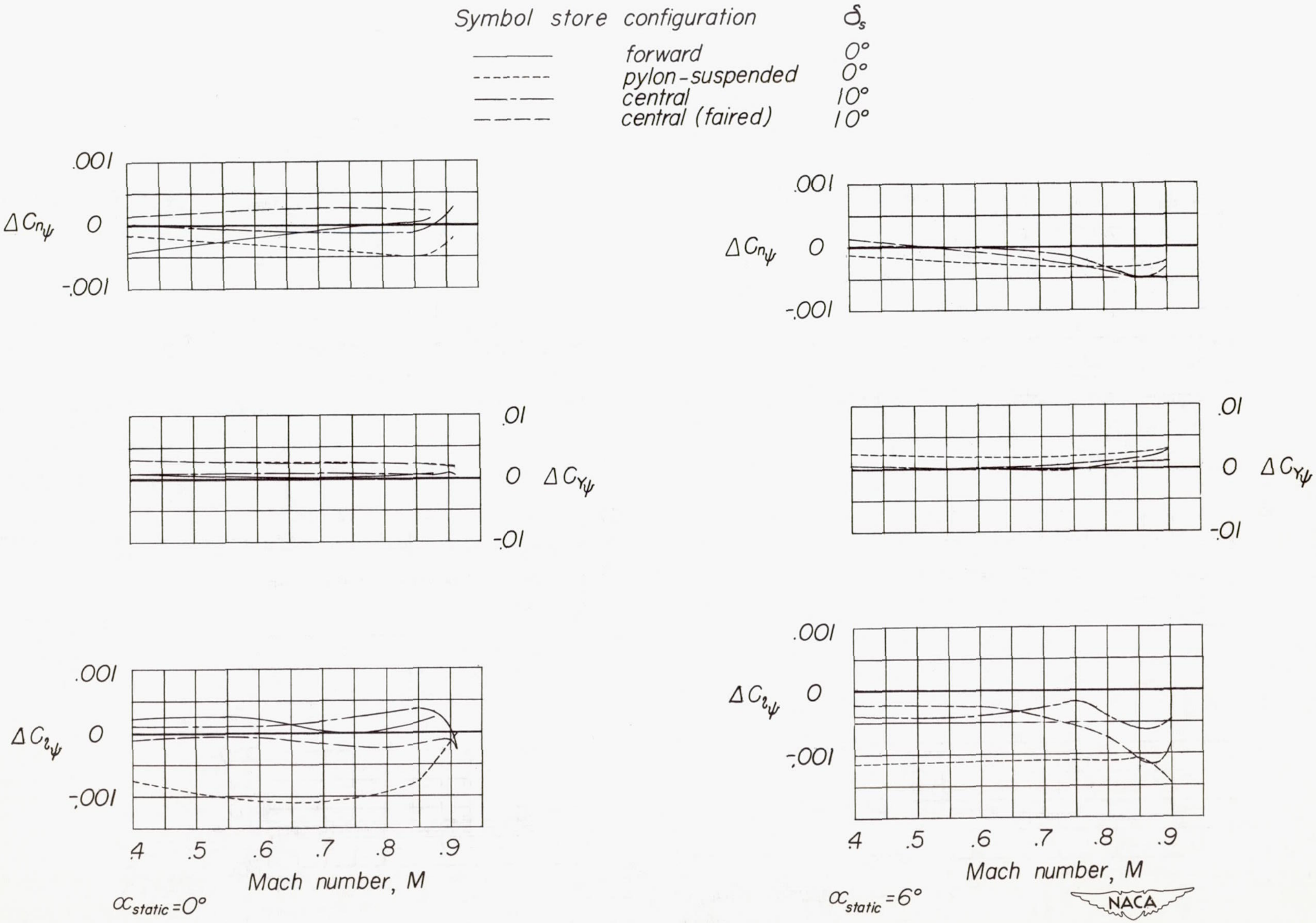
(a) Concluded.

Figure 21.– Continued.



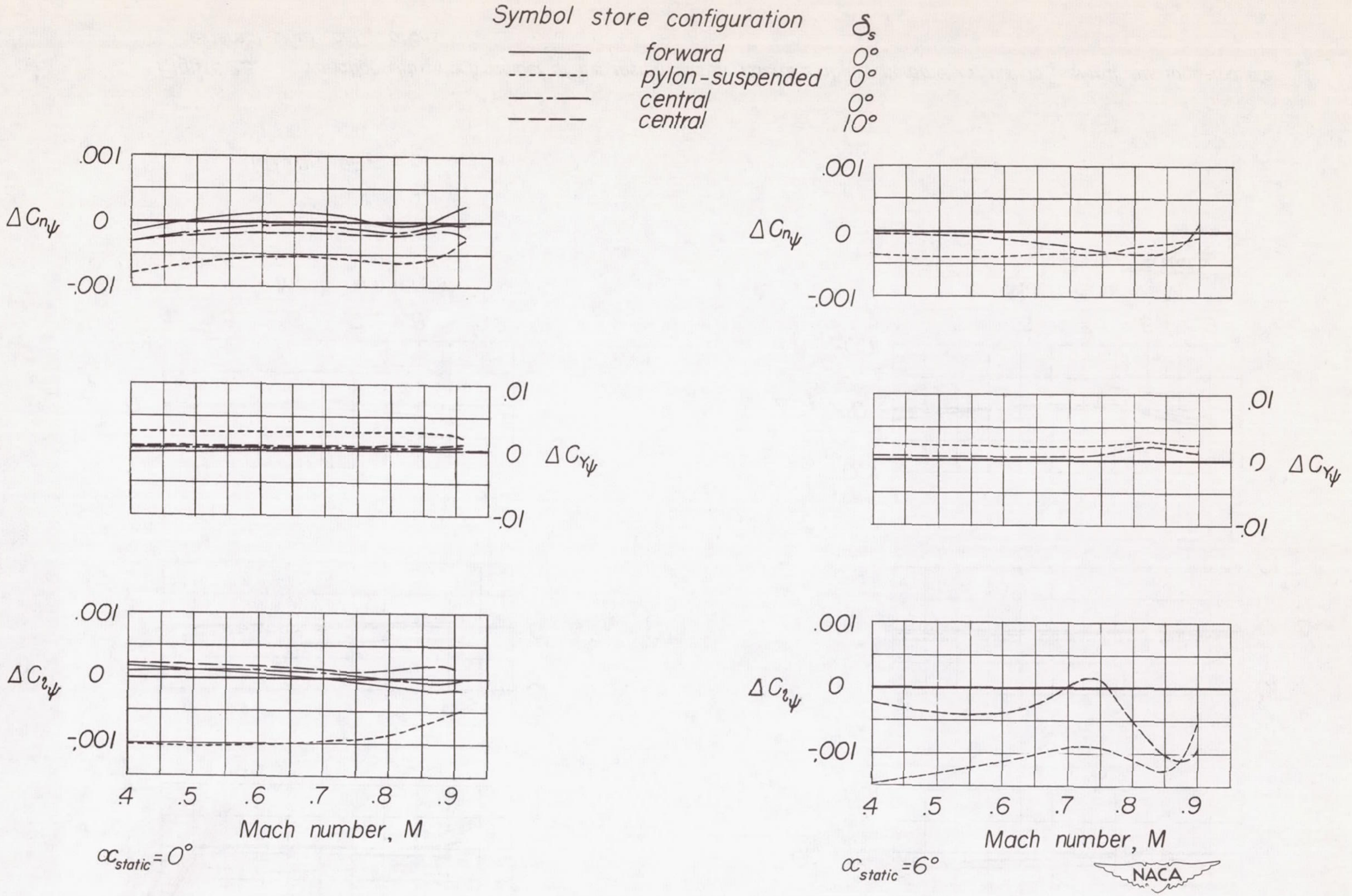
(b) Tail off.

Figure 21.—Concluded.



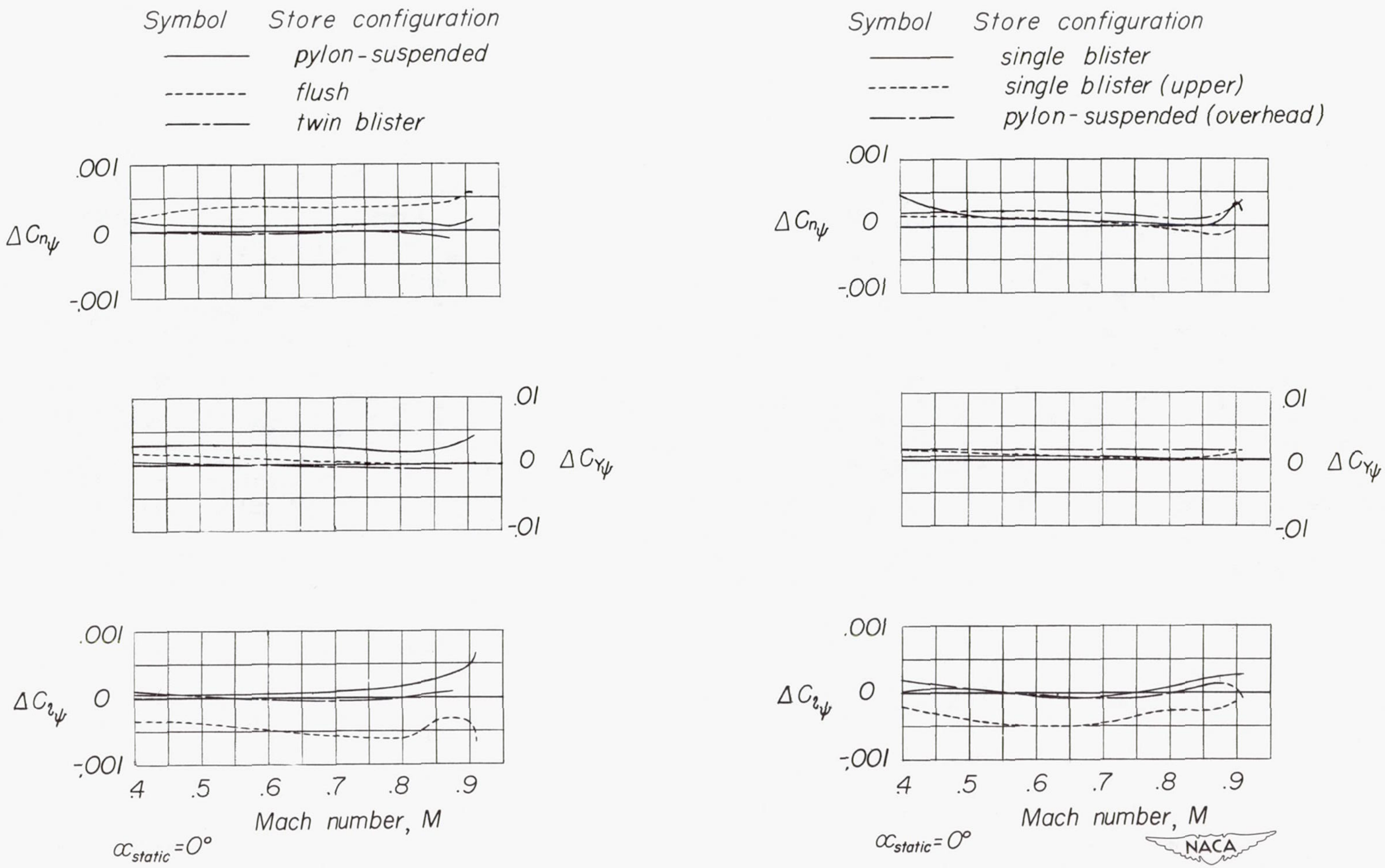
(a) Tail on.

Figure 22 — Variation with Mach number of the increments in lateral stability parameters due to several tip-mounted external-store configurations.



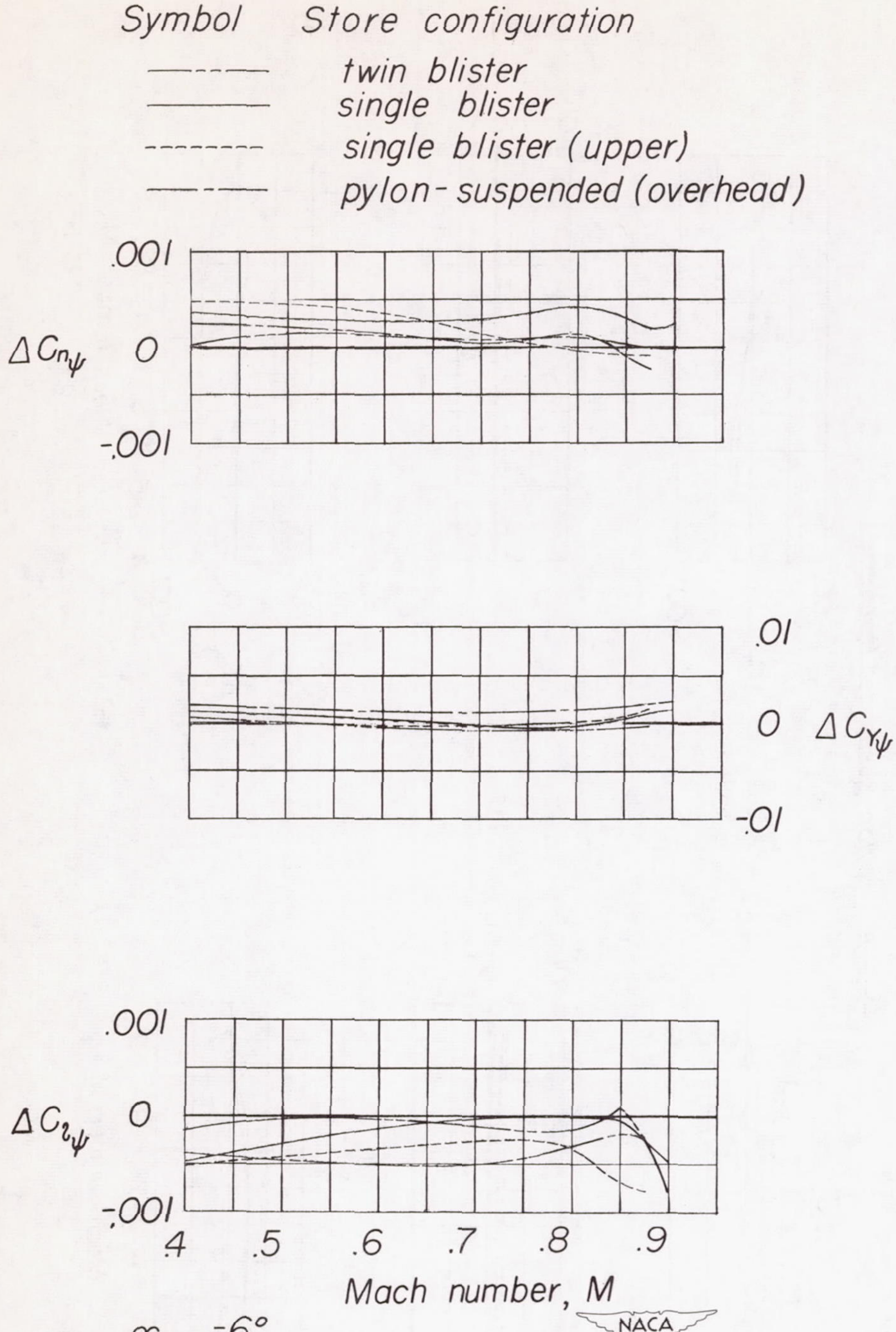
(b) Tail off.

Figure 22.- Concluded.



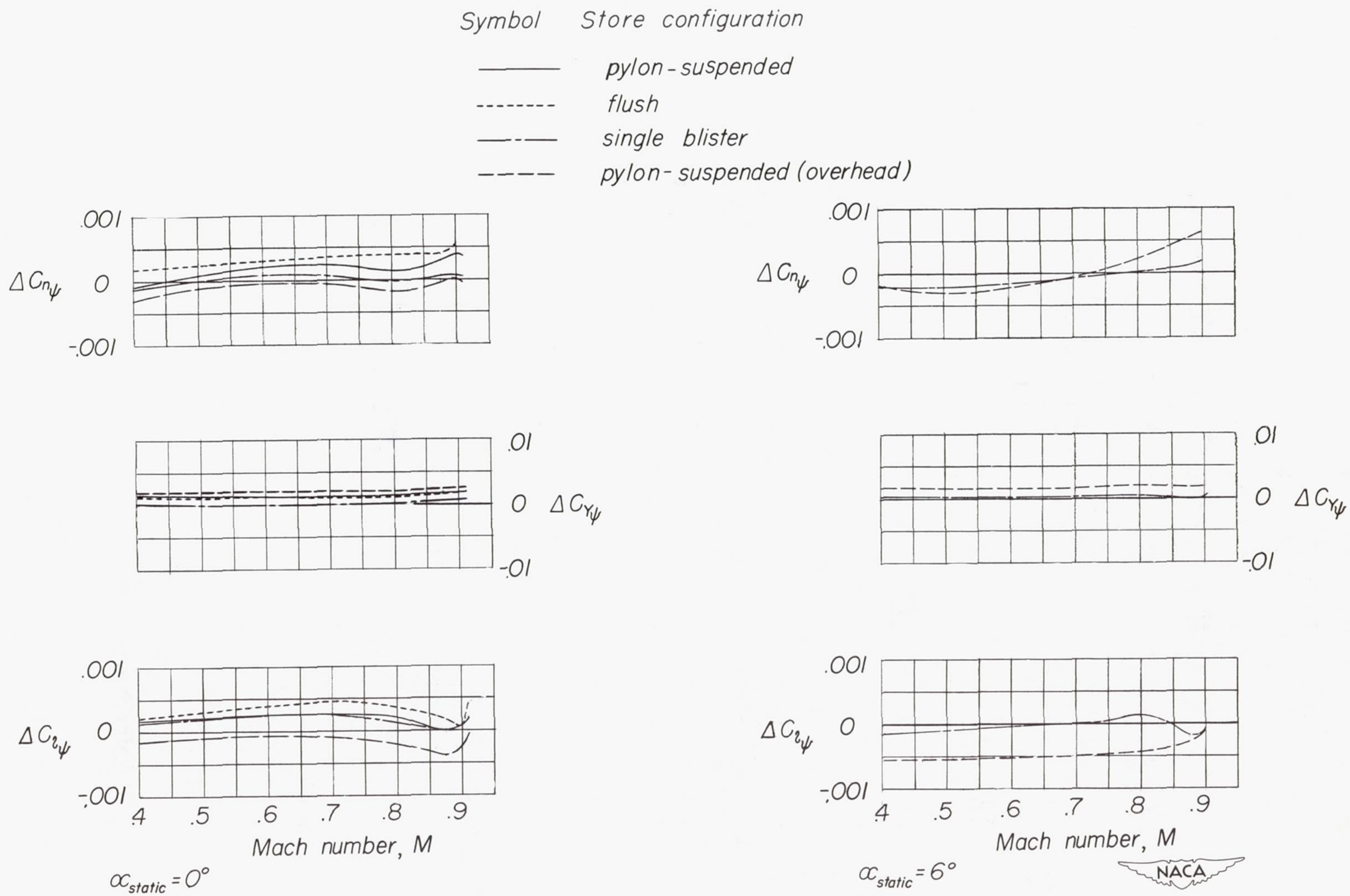
(a) Tail on.

Figure 23. — Variation with Mach number of the increments in lateral stability parameters due to several fuselage-mounted external-store configurations.



(a) Concluded.

Figure 23.- Continued.



(b) Tail off.

Figure 23.- Concluded.