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TECHNICAL MEMORANDUM
X-227

LOW-SUBSONIC-SPEED STATIC LONGITUDINAL STABILITY AND CONTROL CHARACTERISTICS OF A WINGED REENTRY-VEHICLE CONFIGURATION HAVING WINGTIP PANELS THAT FOLD UP FOR HIGH-DRAG REENTRY

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SUMMARY

An investigation of the low-subsonic-speed static longitudinal stability and control characteristics of a model of a manned reentry-vehicle configuration capable of high-drag reentry and glide landing has been made in the Langley free-flight tunnel. The model had a modified 63° delta plan-form wing with a fuselage on the upper surface. This configuation had wingtip panels designed to fold up 90° for the high-drag reentry phase of the flight and to extend horizontally for the glide landing.

Data for the basic configurations and modifications to determine the effects of plan form, wingtip panel incidence, dihedral, and vertical position of the wingtip panels are presented without analysis.

INTRODUCTION

An investigation is being conducted by the National Aeronautics and Space Administration to provide information on the stability and control characteristics of winged configurations designed for controlled reentry from satellite orbit. This type of configuration utilizes high-angle-of-attack reentry as a means of deceleration and after completion of the reentry phase employs normal values of angle of attack for a controlled glide flight to the desired point of landing.

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*Title, Unclassified.

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(See ref. 1.) Existing data on several delta plan-form configurations considered for possible reentry configurations are presented in references 2 to 4.

Winged vehicles considered suitable as reentry configurations must possess adequate stability throughout the expected Mach number and the angle-of-attack ranges. The purpose of the present investigation is to provide some information at low-subsonic speeds on the static longitudinal stability and control characteristics of a model having a 63° swept delta wing with a fuselage on the upper surface. This configuration had wingtip panels which were folded up 90° for the reentry condition and then folded down (extended) in an effort to provide static longitudinal stability and lift-drag ratios sufficient to perform a glide landing.

This study included static force tests at angles of attack from 0° to 90° to provide static longitudinal stability information with the wingtip panels either extended, folded 90°, or removed. Tests were made up to 45° angle of attack to determine the effects on the static longitudinal stability and control characteristics of the glide configuration of changing the vertical position, plan form, incidence, or dihedral of the wingtip panels. The effect of combining some of the geometric changes was investigated on a swept and an unswept flat-plate wingtip panel with wingtip rudders removed. Also studied was the effect of leading-edge flaps on the swept wingtip panels. The data are presented without analysis.

SYMBOLS

The longitudinal data are referred to the stability system of axes. (See fig. 1.) The origin of the axes was located to correspond to a longitudinal center-of-gravity position of about 63 percent wing root chord, which corresponds to $0.40\bar{c}$ for the model with the swept wingtip panels extended, $0.50\bar{c}$ with panels folded up 90° or removed, and $0.43\bar{c}$ with the unswept panels extended. (See table I.) The coefficients of each configuration are based on the area and mean aerodynamic chord of that particular configuration except where otherwise noted.

C_D	drag coefficient, F_D/qS
C_L	lift coefficient, F_L/qS
C_m	pitching-moment coefficient, $M_Y/qS\bar{c}$
$\bar{c}$	wing mean aerodynamic chord, ft

F_D drag force, lb

F_L lift force, lb

h vertical position of wingtip panel above wing mean chord plane, in.

i_t incidence of wingtip panel, negative when trailing edge is up, deg

M_Y pitching moment, ft-lb

q dynamic pressure, $\frac{\rho V^2}{2}$, lb/sq ft

S wing area, sq ft

V airspeed, ft/sec

X longitudinal body axis

Z vertical body axis

α angle of attack, deg

β angle of sideslip, deg

Γ dihedral angle of wingtip panel, deg

ρ air density, slugs/cu ft

APPARATUS AND MODEL

The moded was tested in the Langley free-flight tunnel, which is a low-speed tunnel with a 12-foot octagonal test section. A sting type of support system and an internally mounted three-component strain-gage balance were used.

The investigation was made with a 1/8-scale model of a design similar to the one used in reference 1. This model, which was constructed at the Langley Research Center, had a modified 63° delta plan-form wing with a fuselage on the upper surface and wingtip panels designed to fold up 90° for the high-drag reentry phase of the flight and to extend horizontally for the glide landing. Three-view drawings are presented in figures 2(a) and 2(b) for the model in the original and modified configurations, respectively, and some pertinent dimensions are given in table I. The folding wing panels could be set at dihedral angles from 0° to 90° and the incidence of the panels could be varied from 0° to -30°. End plates having a height of approximately one-half the semispan of the fixed wing were added at the tips of the fixed wing to allow the vertical height of the swept and unswept flat-plate folding wing panels to be varied. (See fig. 2(b).) The model also was equipped with flaps that could be extended from the leading edge of the swept wingtip panels.

TESTS

Force tests were made to determine the static longitudinal stability and control characteristics of the model over an angle-of-attack range from 0° to 90° with wingtip-panel dihedral angles of 6.5° and 90° measured from the horizontal and with panels removed. Tests were conducted over an angle-of-attack range of 0° to 45° with panel incidence of 0° to -30°, panel dihedral of 6.5° to 40°, and panel heights of 0, 3.06, and 5.37 inches above the normal position (wing mean chord plane). For these tests and the remaining tests, the model was tested with the wingtip rudders removed. Various combinations of panel height and incidence were also studied for the swept panels with and without leading-edge flaps and for unswept flat-plate panels. The tests were conducted at a dynamic pressure of 4.14 pounds per square foot which corresponds to an airspeed of 59 feet per second, and a Reynolds number of 377,000 per foot.

RESULTS

The results of the investigation are presented herein without analysis. The static longitudinal stability characteristics are presented in figure 3 for the basic model with wingtip panels extended, folded 90°, and removed. The effect of wingtip-panel incidence and dihedral on the longitudinal stability characteristics of the model are given in figures 4 and 5, respectively. The effect of vertical position of wingtip panels on the longitudinal stability characteristics of the model is presented in figure 6, and the effect of combining vertical position with wingtip-panel incidence and leading-edge flaps is presented in figure 7. Figure 8 indicates the effect of vertical position and incidence of unswept flat-plate wingtip panels on the longitudinal stability characteristics of the model.

Langley Research Center,
National Aeronautics and Space Administration,
Langley Field, Va., October 19, 1959.

REFERENCES

1. Staff of Langley Flight Research Division (Compiled by Donald C. Cheatham): A Concept of a Manned Satellite Reentry Which is Completed With a Glide Landing. NASA TM X-226, 1959.

2. Spencer, Bernard, Jr.: High-Subsonic-Speed Investigation of the Static Longitudinal Aerodynamic Characteristics of Several Delta-Wing Configurations for Angles of Attack From 0° to 90°. NASA TM X-168, 1959.

3. Fournier, Paul G.: Wind-Tunnel Investigation at High Subsonic Speed of the Static Longitudinal Stability Characteristics of a Winged Reentry Vehicle Having a Large Negatively Deflected Flap-Type Control Surface. NASA TM X-179, 1959.

4. Foster, Gerald V.: Exploratory Investigation at Mach Number of 2.01 of the Longitudinal Stability and Control Characteristics of a Winged Reentry Configuration. NASA TM X-178, 1959.

TABLE I.- DIMENSIONS OF MODEL CONFIGURATIONS

	Tip panels folded 90°	Swept tip panels extended	Unswept tip panels extended
Area, sq ft	3.17	4.11	4.30
Span, ft	1.88	3.38	3.38
Aspect ratio	1.11	2.77	2.69
Root chord, ft	2.50	2.50	2.50
Tip chord, ft	0.75	0.50	0.75
Mean aerodynamic chord, ft	1.86	1.55	1.61
Distance from nose to L.E. of M.A.C., ft	0.64	0.95	0.89
Distance from nose to c.g., ft	1.58	1.58	1.58
Airfoil thickness-chord ratio	0.06	0.06	[a]0.014

[a]For 0.125-inch flat-plate unswept wingtip panel.

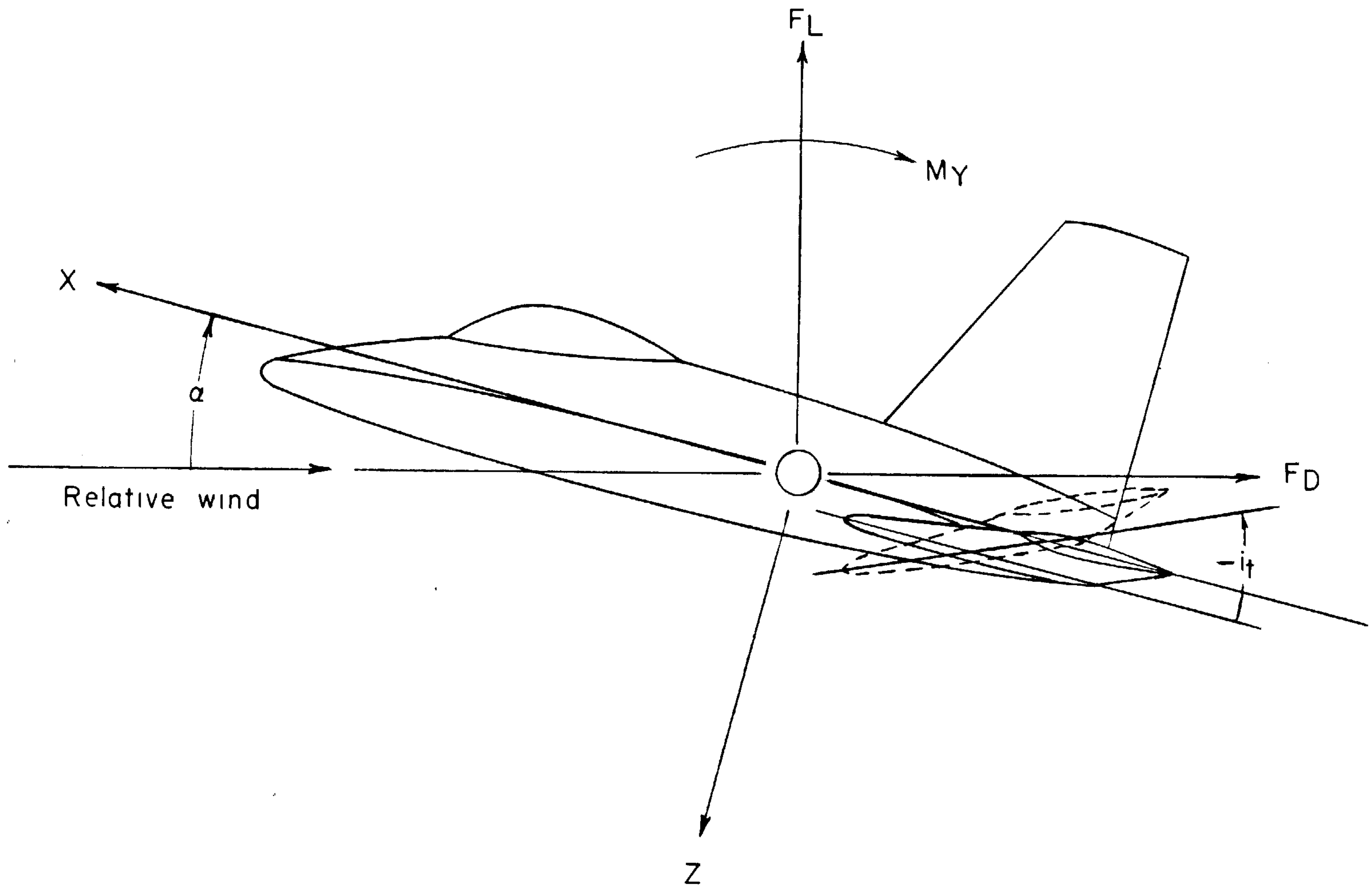
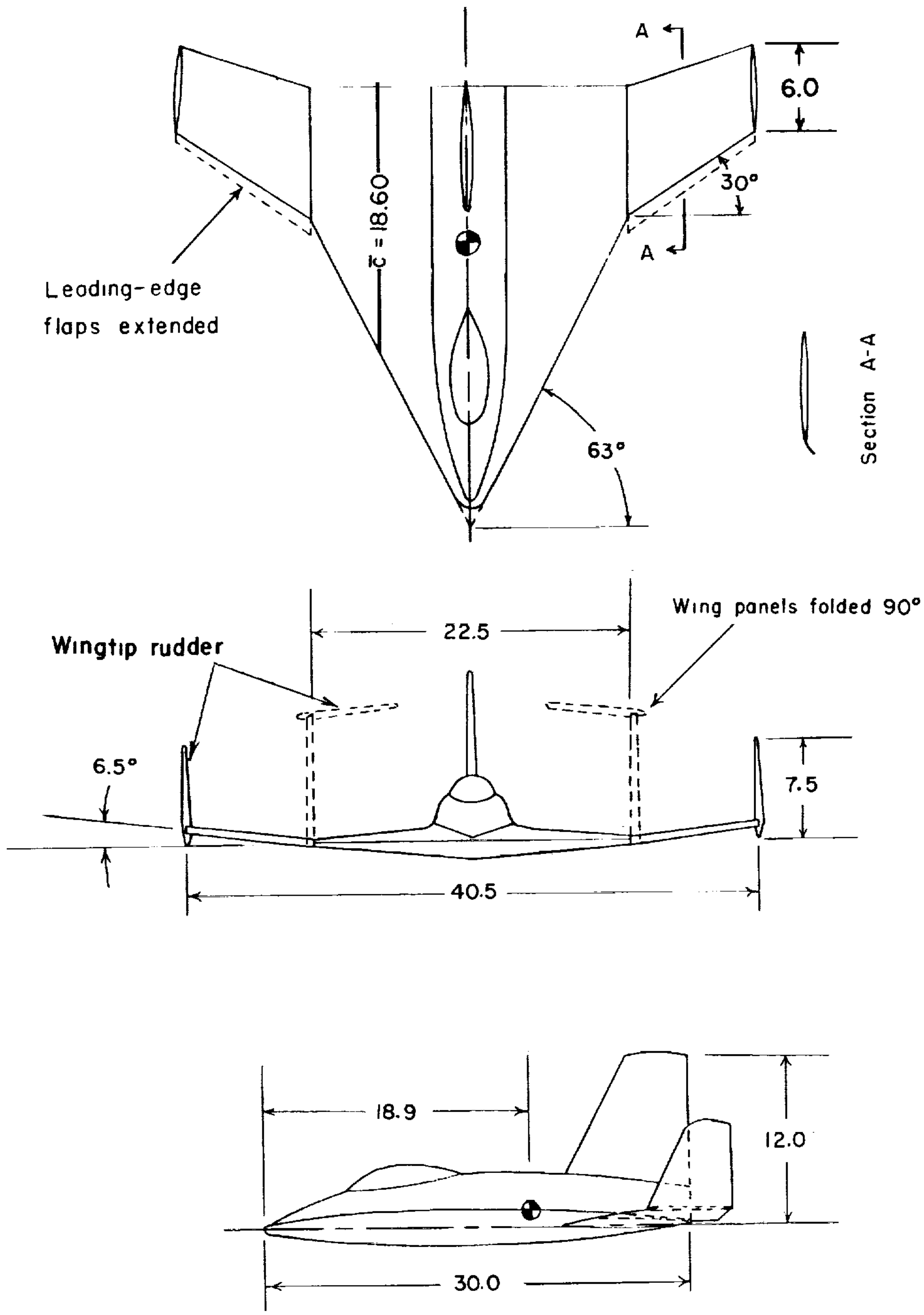
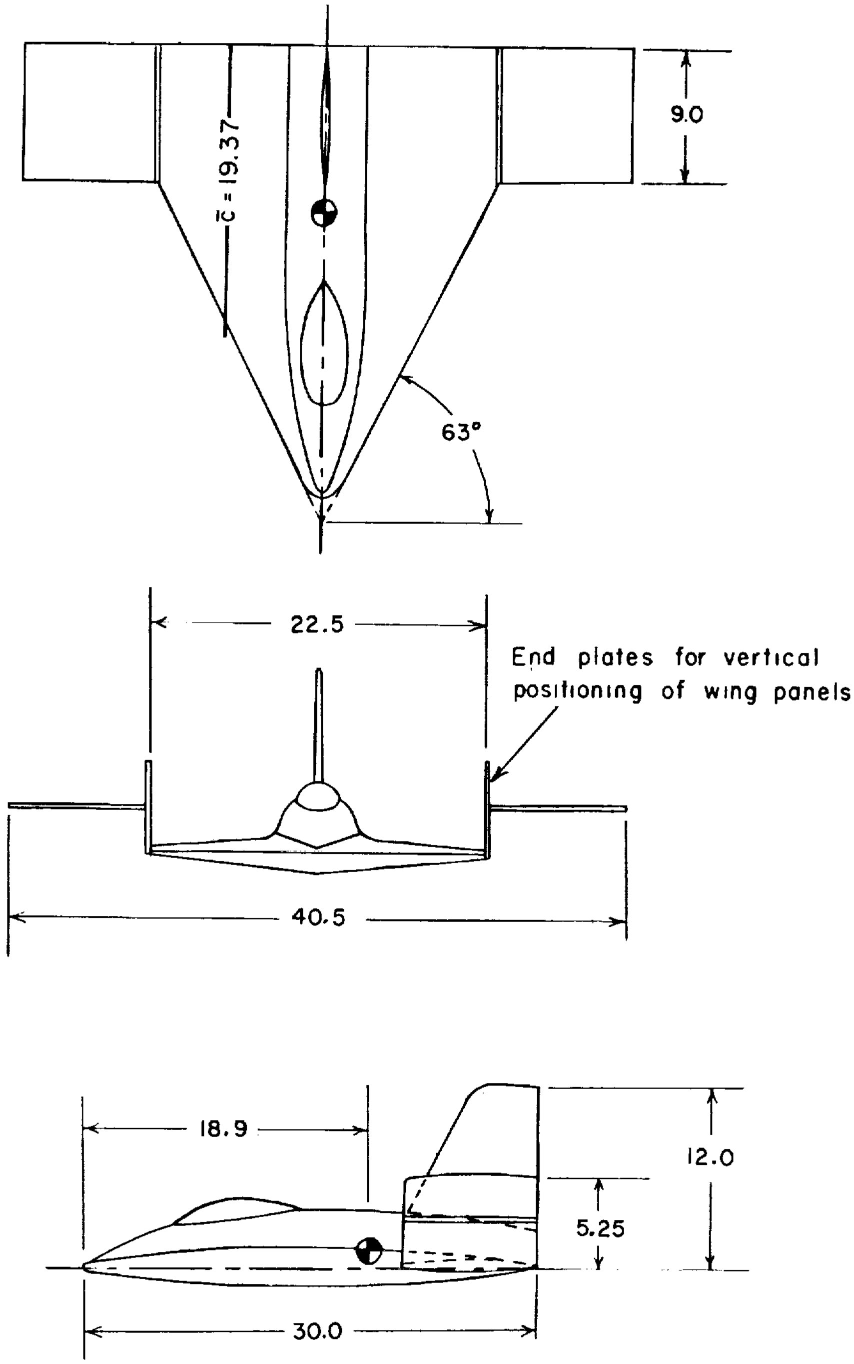


Figure 1.- Sketch of axis system showing forces, moments, and angles.



(a) Basic model.

Figure 2.- Three-view drawing of model used in investigation. All dimensions are in inches.



(b) Modifications to basic model.

Figure 2.- Concluded.

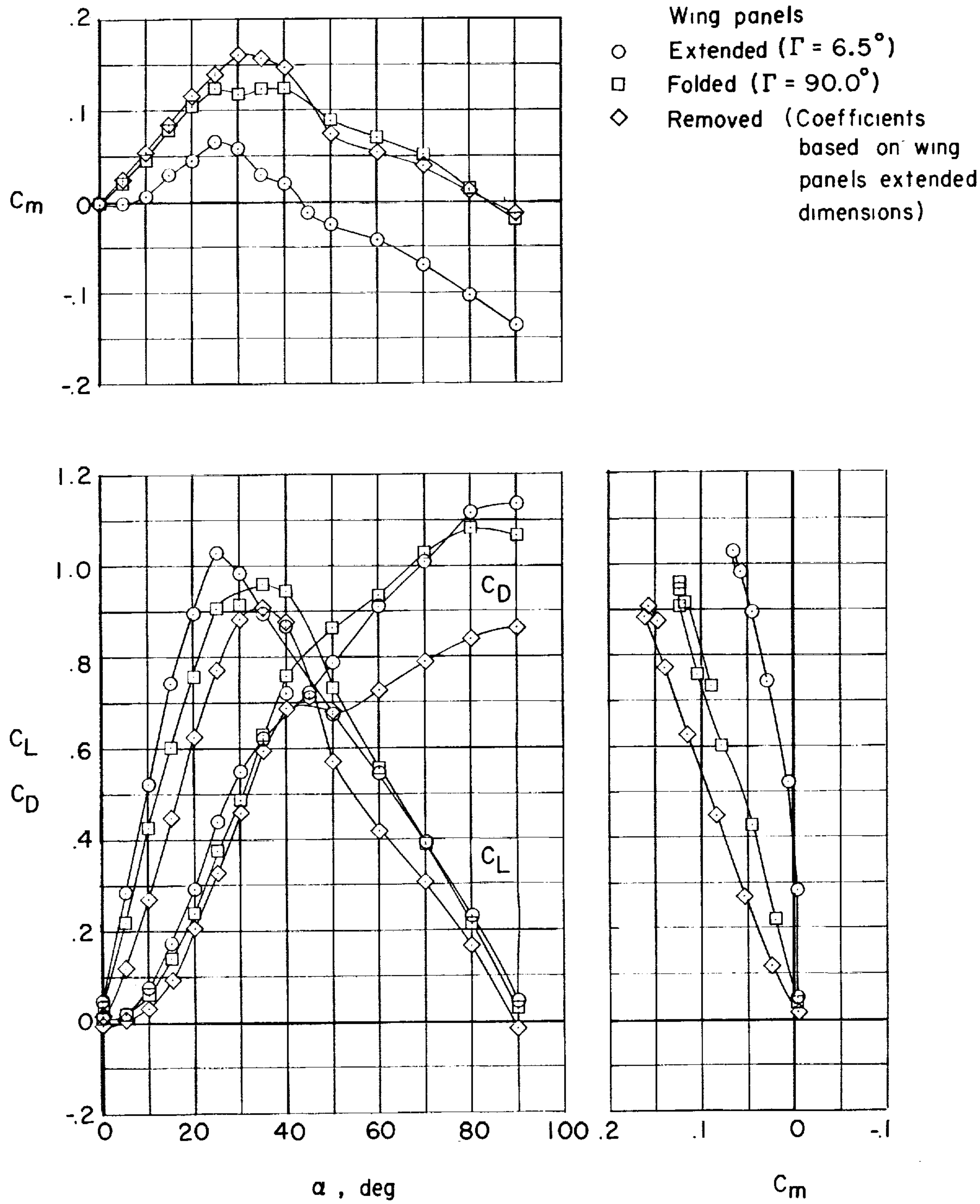


Figure 3.- Static longitudinal stability characteristics of basic model. $\beta = 0^{\circ}$.

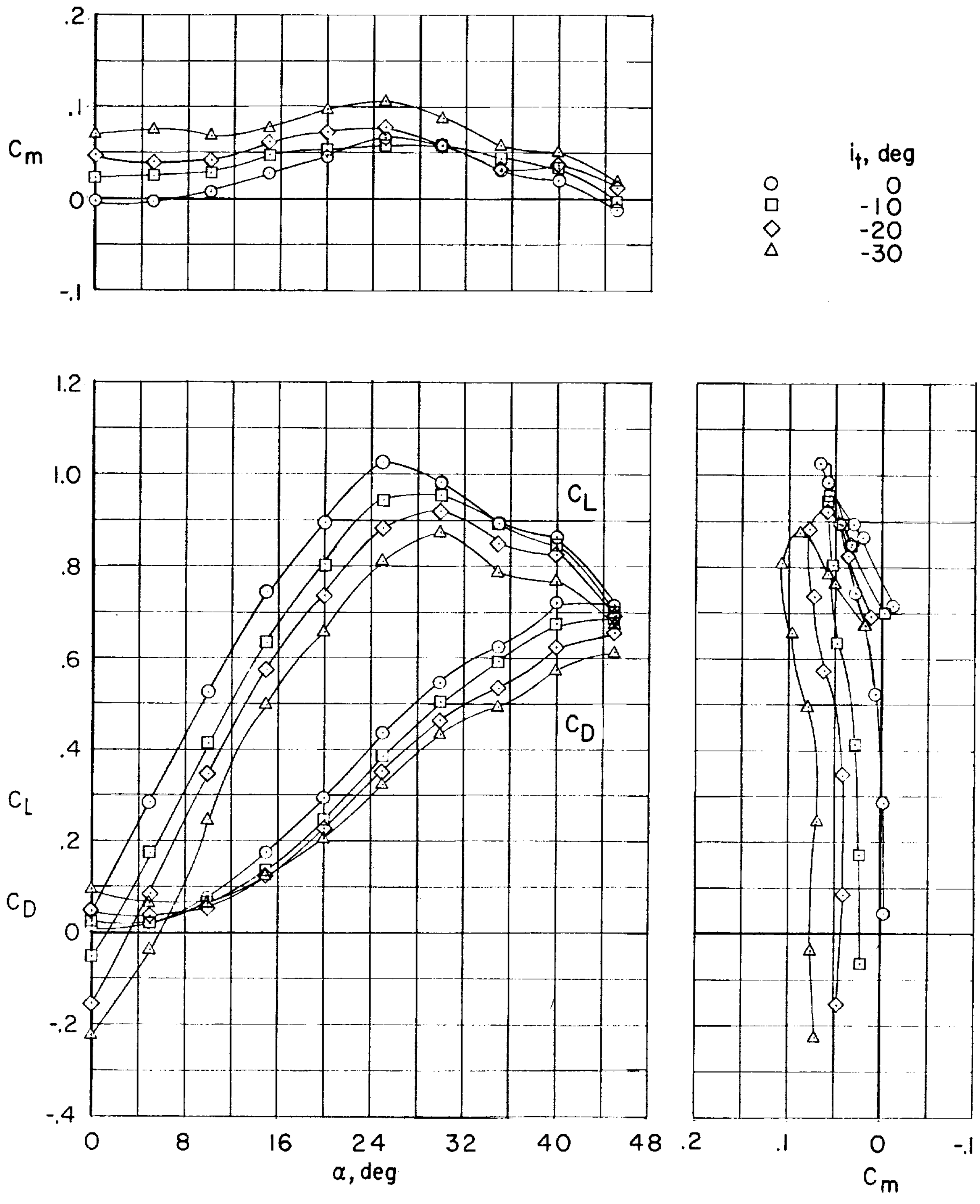


Figure 4.- Effect of wingtip-panel incidence on longitudinal stability characteristics of basic model. Tip rudders removed; $\beta = 0^{\circ}$; $\Gamma = 6.5^{\circ}$.

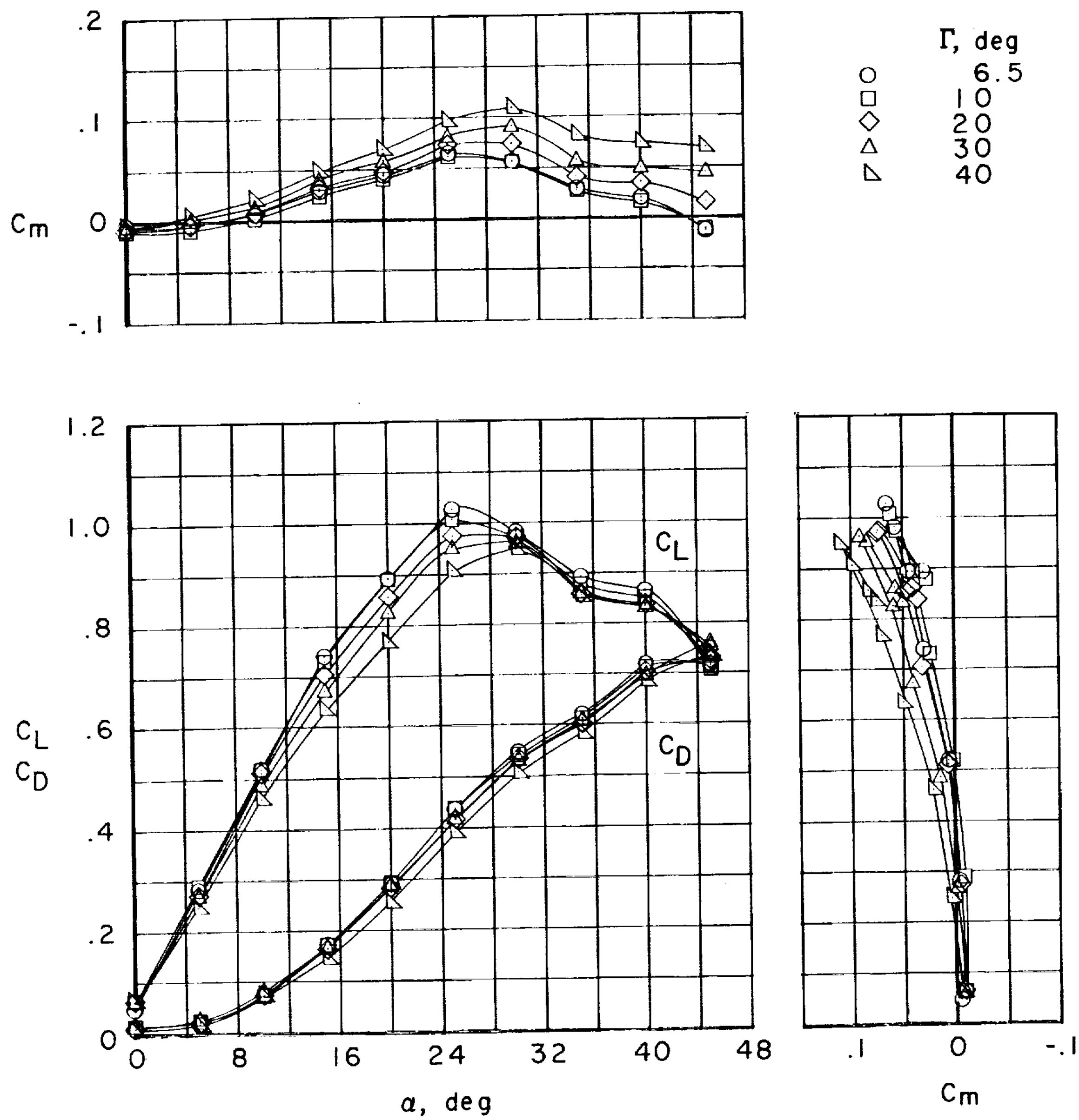


Figure 5.- Effect of wingtip-panel dihedral on the longitudinal stability characteristics of basic model. Tip rudders removed; $\beta = 0^{o}$.

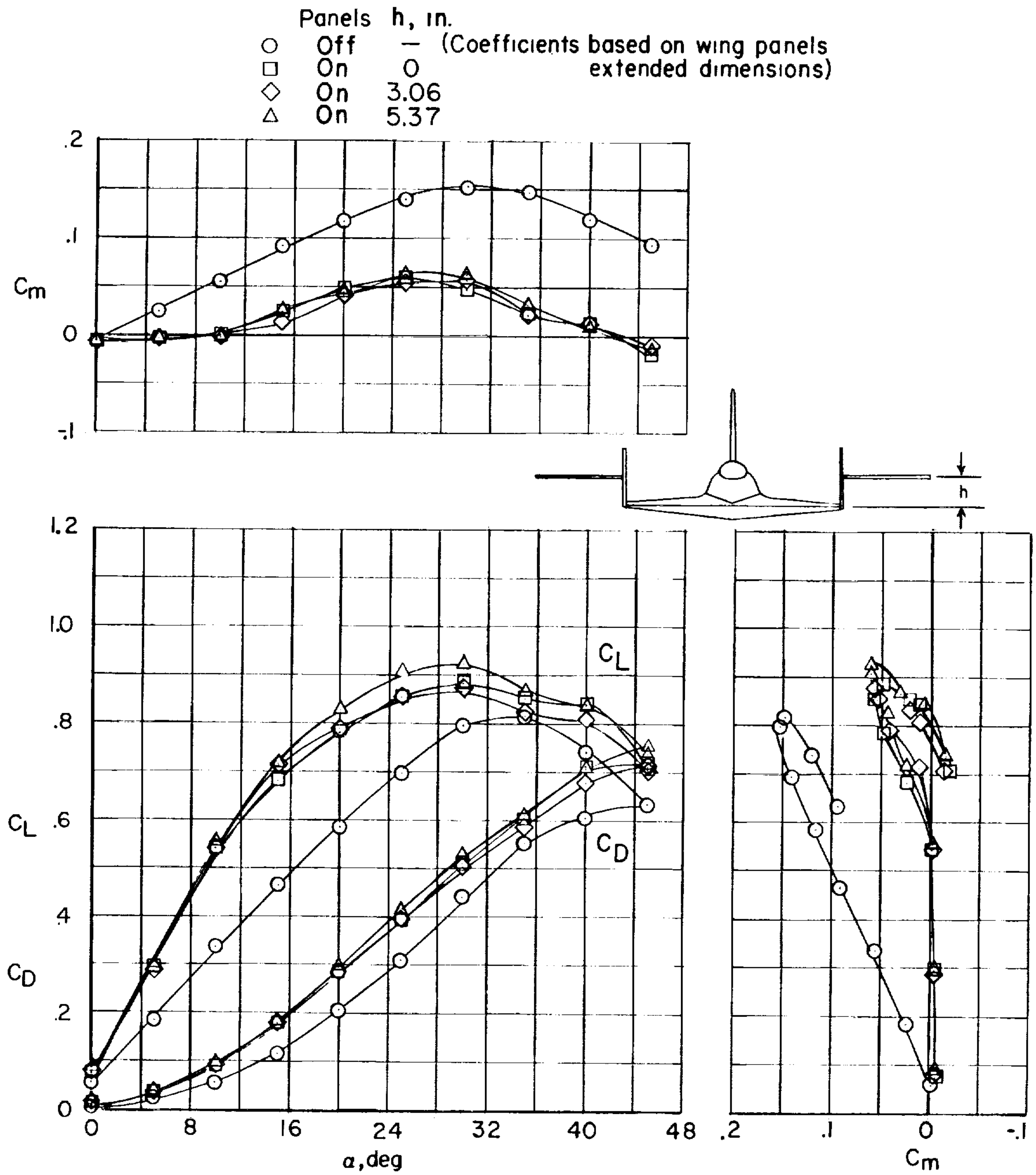


Figure 6.- Effect of vertical position of wingtip panel on longitudinal stability characteristics of basic model. End plates at tip of fixed wing; tip rudders removed; $\beta = 0^{\circ}$; $\Gamma = 0^{\circ}$.

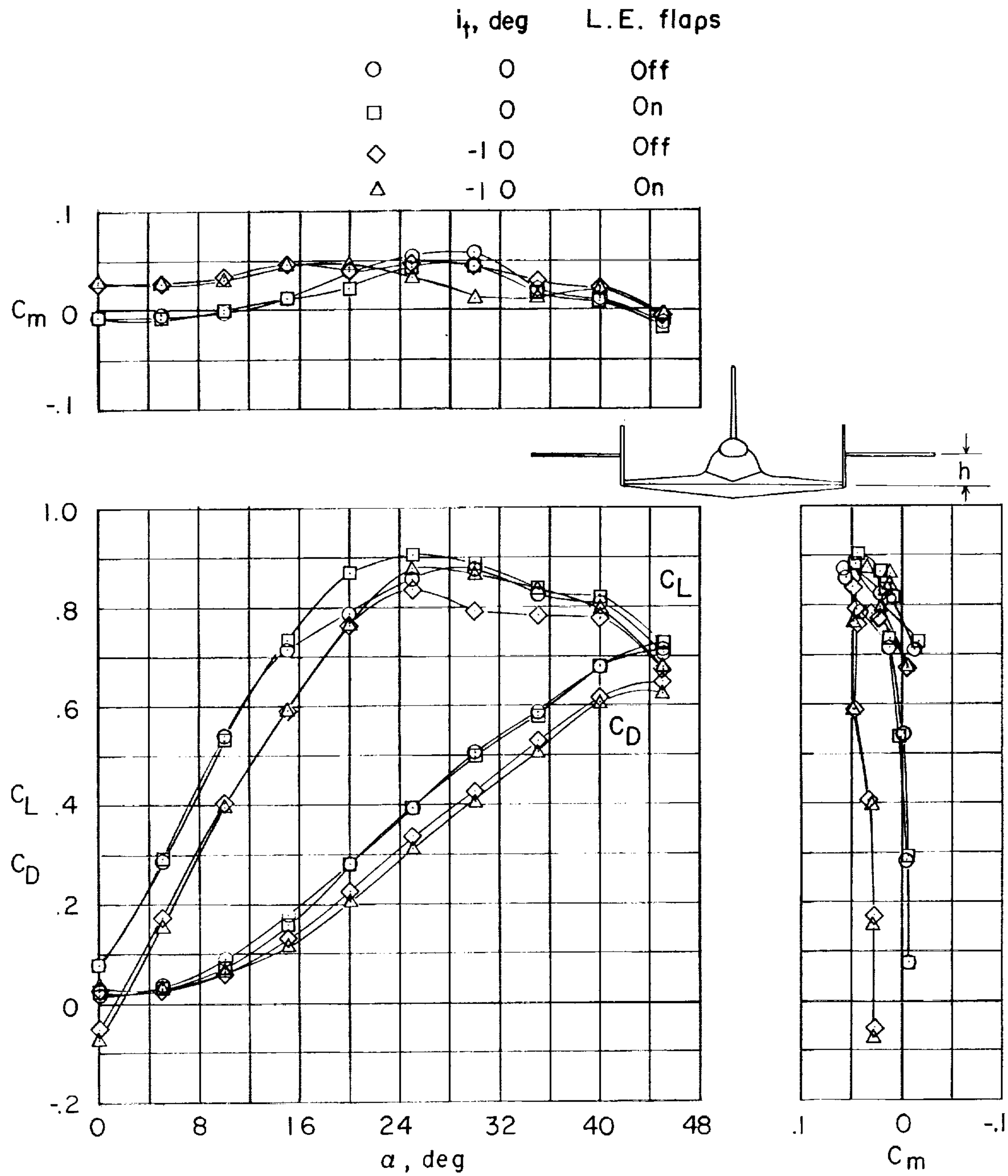


Figure 7.- Effect of wingtip-panel incidence and leading-edge flaps with h = 3.06 inches on longitudinal stability characteristics of basic model. End plates at tip of fixed wing; tip rudders removed; $\beta = 0^{\circ}$; $\Gamma = 0^{\circ}$.

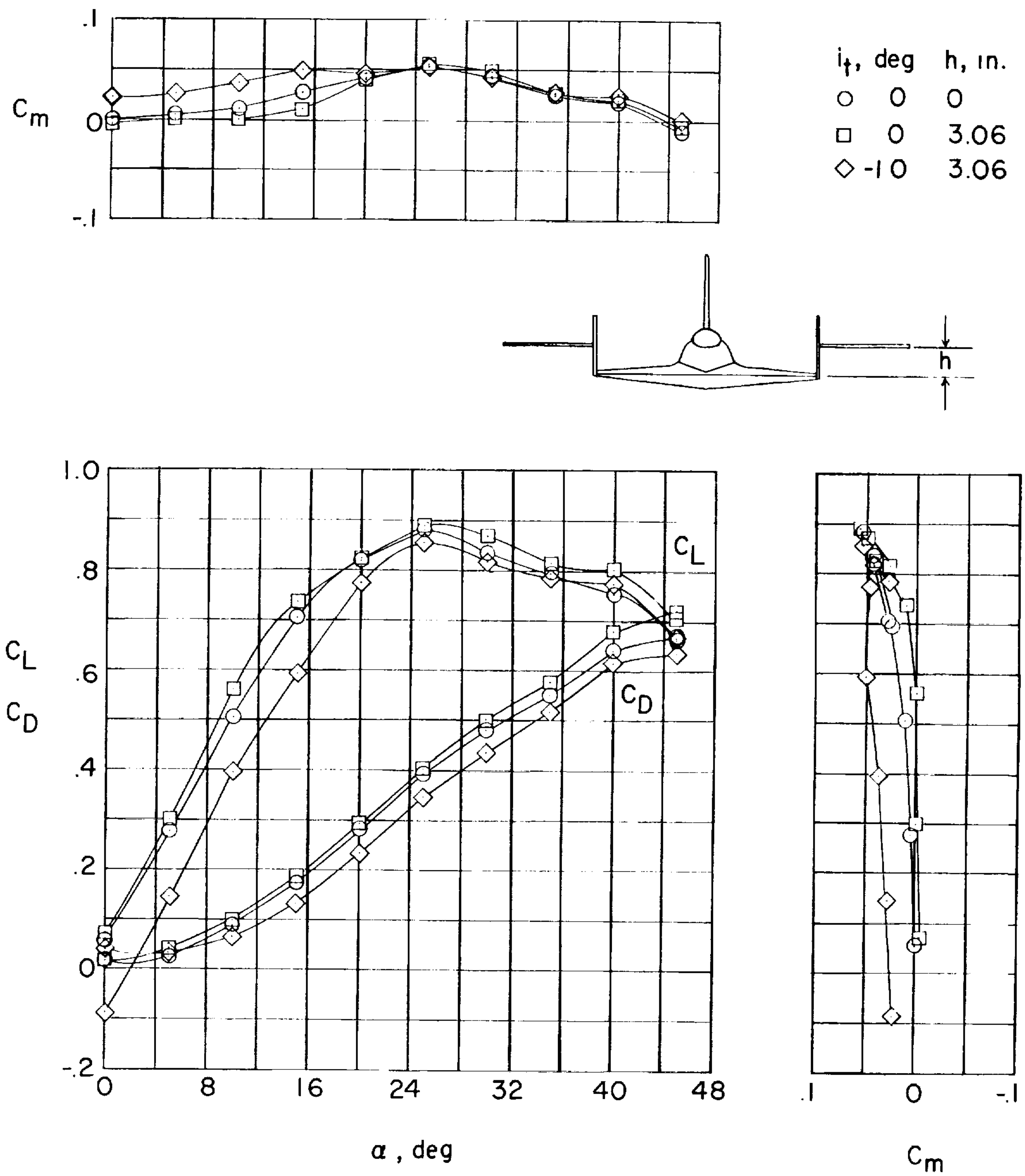


Figure 8.- Effect of vertical position and incidence of unswept flat-plate wingtip panels on longitudinal stability characteristics of model. End plates at tip of fixed wing; tip rudders removed; $\beta = 0^{\circ}$; $\Gamma = 0^{\circ}$.