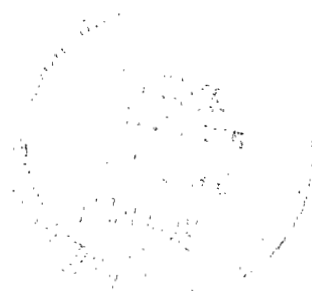# GROUND-EFFECTS INVESTIGATION OF A STOL AIR-SEA TRANSPORT MODEL WITH BLOWING OVER THE CANARD AND WING FLAPS

by Raymond D. Vogler

Langley Research Center

Hampton, Va. 23365

1. Report No. NASA TN D-5988	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle GROUND-EFFECTS INVESTIGATION OF A STOL AIR-SEA TRANSPORT MODEL WITH BLOWING OVER THE CANARD AND WING FLAPS		5. Report Date October 1970
		6. Performing Organization Code
7. Author(s) Raymond D. Vogler		8. Performing Organization Report No. L-7193
9. Performing Organization Name and Address NASA Langley Research Center Hampton, Va. 23365		10. Work Unit No. 126-63-11-27
		11. Contract or Grant No.
		13. Type of Report and Period Covered Technical Note
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546		
		14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Compressed air was used for blowing over the flaps of the canard and wing. The total mass flow over the flaps was varied as well as the distribution of the flow between the canard and wing. Data were obtained through an angle-of-attack range and an angle-of-sideslip range with the model at various heights above a moving ground plane. Interference effects between canard and wing were obtained by comparing complete model data with data for the wing alone and canard alone.

17. Key Words (Suggested by Author(s)) STOL air-sea model Canards Blowing flaps Interference effects Ground effects Moving-ground effects	18. Distribution Statement Unclassified – Unlimited		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 43	22. Price* $3.00

*For sale by the Clearinghouse for Federal Scientific and Technical Information
Springfield, Virginia 22151

GROUND-EFFECTS INVESTIGATION OF A
STOL AIR-SEA TRANSPORT MODEL WITH BLOWING
OVER THE CANARD AND WING FLAPS

By Raymond D. Vogler
Langley Research Center

SUMMARY

An investigation was made at low speeds to determine the aerodynamic characteristics of a jet STOL subsonic transport canard model influenced by ground proximity and jet interference. The model had provision for blowing over the flaps of the wing and canard. The jet deflection angle was usually 56° and the canard-wing blowing-thrust ratio, as well as the total blowing momentum, was varied.

Except for a reduction in maximum lift, ground proximity effects were small and differences between the effects of a moving and a stationary ground plane were insignificant. Varying the canard-wing blowing-thrust ratio gave large pitch control forces, as did varying the canard flap deflection. In sideslip, blowing increased the effective dihedral and reduced the yawing stability, as compared with results without blowing over the model. Interference between the canard and wing results in a lift-coefficient loss of about 10 percent, with or without blowing.

INTRODUCTION

The Office of Naval Research (ONR) contracted with the Lockheed-California Company to design and build a model of a jet-flap STOL air-sea transport. This configuration provides for internal-blowing jet flaps on the canard and the wing during take-off and landing. The model was used in the present NASA-ONR program to investigate the feasibility of such a canard airplane configuration to employ efficiently the jet-flap principle to attain short take-off and landing capability.

A jet sheet of air blowing over deflected flaps increases the circulation about the wing and produces very high lift coefficients which are required for STOL-type airplanes. As the high lifting force is generated by the jet sheet, the center of pressure of the wing moves rearward and results in large nose-down pitching moments. A jet-flap STOL airplane that uses a canard surface to trim these pitching moments looks attractive in that the trimming moment is provided by a positive lift on the canard which adds to the wing lift.

Some models using blowing over the flaps show large lift losses and moment changes due to ground effect. (See ref. 1.) Reference 2 indicates that a moving ground plane, as opposed to a fixed one, will result in more valid tunnel data for models that have blowing jets that impinge on the ground plane.

The purposes of this investigation were (1) to determine the aerodynamic characteristics of the air-sea transport model at low speed at various model heights above a moving ground plane for various ratios of blowing thrust between the canard and the wing, (2) to determine whether there are significant differences for this canard configuration between the data obtained with the model over a moving and over a stationary ground plane, and (3) to get an indication of the magnitude of interference effects between the canard and wing jets in ground effect.

SYMBOLS

The force and moment data are presented about the stability axes with the moment center located as shown in figure 1. The units of measurement used in this report are given both in the U.S. Customary Units and, parenthetically, in the International System of Units (SI). (See ref. 3.)

b wing span, inches (centimeters)

$\bar{c}$ wing mean aerodynamic chord, inches (centimeters)

$\bar{c}_c$ canard mean aerodynamic chord, inches (centimeters)

$\bar{c}_t$ vertical-tail mean aerodynamic chord, inches (centimeters)

C_L lift coefficient, $\dfrac{\text{Lift}}{q_\infty S}$

C_D drag coefficient, $\dfrac{\text{Drag}}{q_\infty S}$

C_m pitching-moment coefficient, $\dfrac{\text{Pitching moment}}{q_\infty S \bar{c}}$

C_n yawing-moment coefficient, $\dfrac{\text{Yawing moment}}{q_\infty S b}$

C_l rolling-moment coefficient, $\dfrac{\text{Rolling moment}}{q_\infty S b}$

C_Y side-force coefficient, $\dfrac{\text{Side force}}{q_\infty S}$

C_μ total momentum coefficient, $C_{\mu,w} + \dfrac{S_c}{S} C_{\mu,c}$

$C_{\mu,c}$ canard momentum coefficient, $\dfrac{\dot{m}V}{q_\infty S_c}$

$C_{\mu,w}$ wing momentum coefficient, $\dfrac{\dot{m}V}{q_\infty S}$

h   distance from ground plane to moment center, inches   (centimeters)

$\dot{m}$ mass rate of flow from jets in wing or canard, $\dfrac{lb\text{-}s}{ft}$ $\left(\dfrac{N\text{-}s}{m}\right)$

q_∞ free-stream dynamic pressure, lb/ft^2 (N/m^2)

S   wing area, ft^2 (m^2)

S_c canard area, ft^2 (m^2)

V   jet velocity, based on isentropic expansion from jet-exit total pressure to tunnel static pressure, ft/s   (m/s)

α wing angle of attack, deg

β model angle of sideslip, deg

τ canard-wing blowing-thrust ratio, $\dfrac{S_c C_{\mu,c}}{S C_{\mu,w}}$

δ wing jet deflection angle, deg

δ_a aileron jet deflection angle, deg   All jet deflection angles are 11° greater than the deflection of the chord of the control surface

δ_c canard jet deflection angle, deg

MODEL DESCRIPTION

A 1/30-scale model of a conceptual design of a medium-range subsonic jet air-sea transport with STOL capability was used in the investigation. The model is a canard configuration with provision for blowing over the trailing-edge flaps of both the wing and canard. The landing floats are retractable into fairings under the fuselage and outboard under the wing. A three-view drawing of the model with floats retracted, without engine nacelles, and with the large and small canards is shown in figure 1. Photographs of the model over the moving ground plane are shown in figure 2.

3

The wing and the canards are similar in construction. The large canard is one-third the wing area and the small canard is one-fourth the wing area. The wing and the canards have leading-edge slats of constant chord $\left(0.20\bar{c}\text{ and }0.20\bar{c}_c\text{, respectively}\right)$ and trailing-edge flaps hinged at the 0.80-chord line. The wing and the canards are swept 20° at the quarter-chord line with zero degrees of incidence and dihedral and have an NACA 64_2A215 airfoil section. They are made of aluminum and are hollow to provide a plenum chamber for supplying air to the jet-flap nozzles. The plenum chambers of the wing and the canards are provided with six static-pressure orifices and one thermocouple. That part of the wing flap outboard of the float fairing can be deflected independently of the inboard part of the flap for use as an aileron.

The vertical tail has the same airfoil section as the wing and has the quarter-chord line swept 45°.

The fuselage is made of 6-inch-diameter (15.24-cm) aluminum tubing with 0.25-inch-thick (0.63-cm) walls. The ellipsoidal nose is removable for ease in changing canards.

High-pressure air for operating the jet flaps is brought through the sting to a plenum chamber within the fuselage. Air from the fuselage plenum is carried to the wing and canard plenums through ducts. Interchangeable orifice plates are located in the ducts so that the flow distribution to the wing and canard may be varied. The total mass flow into the model is measured by a flowmeter in the air line outside the tunnel.

The model was sting supported over a moving ground plane in the 17-foot (5.18-meter) test section of the Langley 300-MPH 7- by 10-foot tunnel. The moving ground plane was obtained by means of a fabric belt between two rollers driven by an electric motor. (See ref. 2.) Boundary-layer buildup on the moving ground plane is prevented by operating the belt at a velocity approximately equal to the free-stream velocity.

TESTS AND PROCEDURES

Most of the tests were made over the moving ground plane at heights of 0.9, 1.2, 1.7, and 2.7 mean aerodynamic chords measured from the ground plane to the moment center of the model. The height of the model was adjusted for angle of attack and model forces to maintain a constant height during a run. For comparison, a few out-of-ground-effect tests were made at a height of 9 chords. A height of 1.2 chords is the height at which the floats touch the water, and 0.9 chord is the height with the model at rest on the water. All data were obtained with the floats retracted. At low heights, the angle of attack was limited by the ground plane.

Before testing began, the wing and the canard were calibrated for mass flow against the ratio of plenum chamber pressure to ambient static pressure. During runs, the plenum pressures were recorded and from the ratio of plenum pressure to tunnel static pressure, momentum coefficients for the wing and canard were obtained by using the earlier calibrations. The total mass flow was also obtained independently of the calibrations by means of a flowmeter in the air-supply line. The mass flow obtained by the two methods agreed very well. The total mass flow of air could be divided between the canard and wing in different proportions by changing the size of the orifices in the ducts between the fuselage plenum and the airfoil plenums. The mass flow of the wing or canard multiplied by the respective jet velocity is the blowing thrust. The canard-wing ratios of blowing thrusts (τ) investigated were 0 (no canard blowing), 0.5, 1.0, 1.7 (1.5 with small canard), and ∞ (no wing blowing).

Except for some tests to determine the effect of jet deflection angle, the data were obtained with a jet deflection angle of 56° which was obtained by deflecting the physical flap 45°. The tunnel dynamic pressure was 10 pounds per square foot (479 newtons per square meter) except at the higher lift coefficient where the dynamic pressure was reduced by as much as 50 percent in order to obtain high lift coefficients without increasing the pressure in the canard plenum sufficiently to cause jet-sheet separation.

Some sideslip tests were made with and without blowing to get the effect of sideslip with various ratios of canard-wing blowing thrust.

RESULTS AND DISCUSSION

This report presents the results of the in-ground-effect investigation. Reference 2 indicates that the data obtained with models developing large lift coefficients are more valid when the data are obtained over a moving ground plane than when obtained over a stationary one. Consequently, all the tests were made over the moving ground plane except a few for comparison with the moving ground plane and a few considered as in the out-of-ground-effect region ($h/\overline{c} = 9.0$).

Longitudinal Aerodynamic Characteristics

Effect of moving ground plane.- A comparison of the longitudinal aerodynamic characteristics obtained with and without the moving ground plane is shown in figure 3 for a momentum coefficient range at zero angle of attack and for various ground proximities. No significant differences between the data obtained with the moving and the stationary ground plane for the model are noted except possibly in drag, and this difference may be related to the lower accuracy of the balance in the axial direction caused by the attachment of the air line to the model. The advantage of blowing over the deflected flaps is

indicated by the large lift coefficients obtained, which are four or five times the values without blowing at zero angle of attack and at the same tunnel dynamic pressure. The airplane which the model simulated was designed to take off at a speed of 60 knots, requiring a lift coefficient of about 6. Some data points near $C_L = 5$ which do not fair were obtained by reducing both the tunnel dynamic pressure and the airfoil plenum pressures.

Effect of ground proximity.- The effects of ground proximity on the blowing model at $\alpha = 0^O$ and with the jets deflected 56° are shown in figure 4. The effects are small, but generally there is a decrease in drag, an increase in lift, and a more negative pitching moment as the model approaches the ground. Similar results are also shown in figure 5 through a model angle-of-attack range for constant high blowing momentum. Figure 5 also shows a considerable reduction in maximum lift as the ground is approached. Both figures show the large effects of canard-wing blowing-thrust ratio (τ) on the pitching moments and indicates that variation in blowing ratio may be used as an effective trimming device. Out-of-ground-effect maximum lift (fig. 5(c)) occurs at an angle of attack of 12°, accompanied by pitch-up as the wing stalls. Ground proximity reduces the angle of attack at which maximum lift and pitch-up tendency occur to as low as 5°. The effect of angle of attack on lift is small in comparison with the effect of momentum coefficient on lift (fig. 4).

Without blowing (fig. 6), ground proximity has little effect on the lift and pitching moments, but the presence of the ground reduces the drag.

Effect of jet deflection angle.- The effect of increasing the jet deflection angle of the wing and canard with the model in ground effect is shown in figure 7. Increasing the jet angle from 56° to 71° gives 15 to 20 percent increase in lift coefficient, a large increase in drag, and slightly more negative pitching moments. The jet deflection angle of 71° would be appropriate for landing, since the high drag would allow a steeper approach path and would also allow the airplane to approach at a thrust setting well above zero.

The effectiveness of the jet angle of the canard as a pitch control device is indicated in figure 8. The canard jet deflection angle and the canard-wing blowing-thrust ratio (fig. 5), which was shown to be an effective trim control, would correspond to the elevator and the stabilizer of a conventional airplane. The canard is effective after the wing stalls but the sustained lift of the canard is in the wrong direction to counteract the pitch-up due to wing stall, a fact which is not true with the conventional tail. If the canard stalls before the wing, the plane may go into a dive. The poor stalling characteristics are an inherent disadvantage of the canard-type airplane.

Figures 9, 10, and 11 present the aerodynamic characteristics of the model with the canard removed and with partial-span flaps, aileron deflection, and aileron droop for

obtaining full-span flap deflections. The indicated jet deflections of 56° and 11° correspond to physical control settings of 45° and 0°. Drooping the aileron with the partial-span flaps increases the lift coefficient of the model with partial-span flaps by about 20 percent without blowing (fig. 9) or with blowing (fig. 10). Aileron deflection produced large rolling moments which were lost with wing stall at approximately 10° angle of attack (fig. 10). The fact that the rolling moments are not zero when model configurations indicate they should be, with or without blowing, probably indicates some model asymmetry. There was no provision in the model for varying the blowing-thrust ratio between the flaps and ailerons; therefore, the rolling moments (fig. 11) increased linearly with lift coefficient as the blowing momentum was increased. As noted in the figures, these partial-span-flap data are for the model without the canard — hence the large diving moments.

Effect of small canard.- The characteristics of the model with the small canard are shown in figure 12. With the small canard, the pressures in the plenums were increased to maintain about the same momentum coefficients as with the large canard, and the canard-wing blowing-thrust ratio (τ) changed from 1.7 to 1.5. Flow separation on the canard is indicated by the one unfaired pitching-moment data point in figure 12(c). Figures 12(b) and 12(c) are comparable to figures 5(c) and 4(c), respectively, for the large canard. Under the noted conditions, the small canard did not trim the model.

Lateral Aerodynamic Characteristics

The characteristics of the model in sideslip in an out of ground effect are shown in figure 13 without blowing momentum and in figures 14 and 15 with blowing momentum. The effect of deflecting the ailerons (figs. 9 to 11) was discussed earlier. The model shows effective dihedral and stability in yaw without blowing (fig. 13). Blowing doubles the effective dihedral and reduces the yawing stability to almost zero (fig. 14). In ground effect, the model shows a negative shift in the rolling moments which is almost constant through the sideslip range, with or without blowing. This shift could indicate some asymmetry in tunnel flow near the ground plane as well as model asymmetry resulting from model changes between in- and out-of-ground-effect runs.

The effects of the ratio of canard-wing blowing thrust on the forces and moments of the model in sideslip near the ground are shown in figure 15. Except for rolling moments and side force, there is little variation with sideslip angle for any blowing ratio. Increasing the ratio of canard-wing blowing thrust produces large increments of pitching moment and small reductions in lift at all sideslip angles. Part of the lift reduction may be ascribed to the reduction in total momentum as the blowing ratio is increased, and part may result from increased interference as the blowing over the canard is increased.

Interference Effects

The interference effects between the canard and the wing are shown in figure 16 for two model heights in ground effect, with and without blowing. Data for the wing alone or canard alone were obtained with the other airfoil removed. Blowing momentum for the wing or canard alone was the same as the blowing momentum on each when tested as the complete model. The algebraic sum of the force and moment coefficients of the wing alone and canard alone is indicated in the figure by the curve without test-point symbols. The difference between these curves and the curves for the complete model shows the interference effect of the canard on the wing. This interference results in a lift-coefficient loss of about 10 percent at small angles of attack with or without blowing (fig. 16(a)). At higher angles of attack, the loss is greater, especially for the model nearer the ground plane. At the lower model heights, interference from the canard also causes earlier wing stall. The sustained lift of the canard after the wing stall, mentioned earlier, is shown by the wing-alone and canard-alone data. Aside from any interference effect, the indicated lift patterns of the wing and canard would be expected with blowing over the model in ground effect, since canard height increases and wing height decreases with increasing angle of attack. The lift loss from interference is reflected in the pitching-moment data presented in figure 16(b). The large negative moments of the wing are reduced by the interference effect of the canard jet so that the resulting moment of the model is more positive than the algebraic sum of the moments of the wing and canard.

SUMMARY OF RESULTS

An investigation was made at take-off and landing speeds over a moving ground plane of a model of a medium-range subsonic jet STOL air-sea transport. The model is a canard configuration with provision for blowing over the flaps of the wing and canard. Compressed air was used for blowing. Results are as follows:

1. Ground proximity effects are small at zero angle of attack, but generally there is a decrease in drag, an increase in lift, and more negative pitching moments. Ground proximity reduces maximum lift and lowers the angle of attack at which maximum lift and pitch-up tendency occur.

2. Increasing the jet deflection angle from 56° to 71° gives a substantial increase in lift and a large increase in drag.

3. Large variations in pitching moments could be obtained by varying the canard jet deflection angle or by varying the canard-wing blowing-thrust ratio.

4. In sideslip, the model shows effective dihedral and stability in yaw without blowing. Blowing doubles the effective dihedral and reduces the yawing stability.

5. For this canard model with the jets deflected 56°, there is no significant difference in data obtained over a still and over a moving ground plane.

6. The interference between the canard and wing results in a lift-coefficient loss of about 10 percent, with or without blowing, and an associated small increase in model pitching moments.

Langley Research Center,
    National Aeronautics and Space Administration,
        Hampton, Va., July 22, 1970.

REFERENCES

1. Vogler, Raymond D.: Investigation Over Moving Ground Plane of a Transport Airplane Model Using Blowing Over Flaps for Boundary-Layer Control. NASA TN D-4083, 1967.

2. Turner, Thomas R.: A Moving-Belt Ground Plane for Wind-Tunnel Ground Simulation and Results for Two Jet-Flap Configurations. NASA TN D-4228, 1967.

3. Mechtly, E. A.: The International System of Units — Physical Constants and Conversion Factors. NASA SP-7012, 1964.

ITEM	WING	LARGE CANARD	SMALL CANARD	VERTICAL TAIL
Area	3.703 ft² (.3440 m²)	1.234 ft² (.1146 m²)	0.926 ft² (.0860 m²)	1.028 ft² (.0955 m²)
Span	61.09 in. (155.4 cm)	29.81 in. (75.8 cm)	25.82 in. (65.6 cm)	15.10 in. (38.4 cm)
$\bar{c}$, $\bar{c}_c$, or $\bar{c}_t$	9.26 in. (23.5 cm)	6.33 in. (16.1 cm)	5.48 in. (13.9 cm)	10.40 in. (26.4 cm)
Taper Ratio	0.4	0.4	0.4	0.4
Aspect Ratio	7.0	5.0	5.0	1.54
Root Chord	12.47 in. (31.7 cm)	8.52 in. (21.6 cm)	7.38 in. (18.7 cm)	14.00 in. (35.6 cm)
Tip Chord	4.99 in. (12.7 cm)	3.41 in. (8.7 cm)	2.95 in. (7.5 cm)	5.60 in. (14.2 cm)
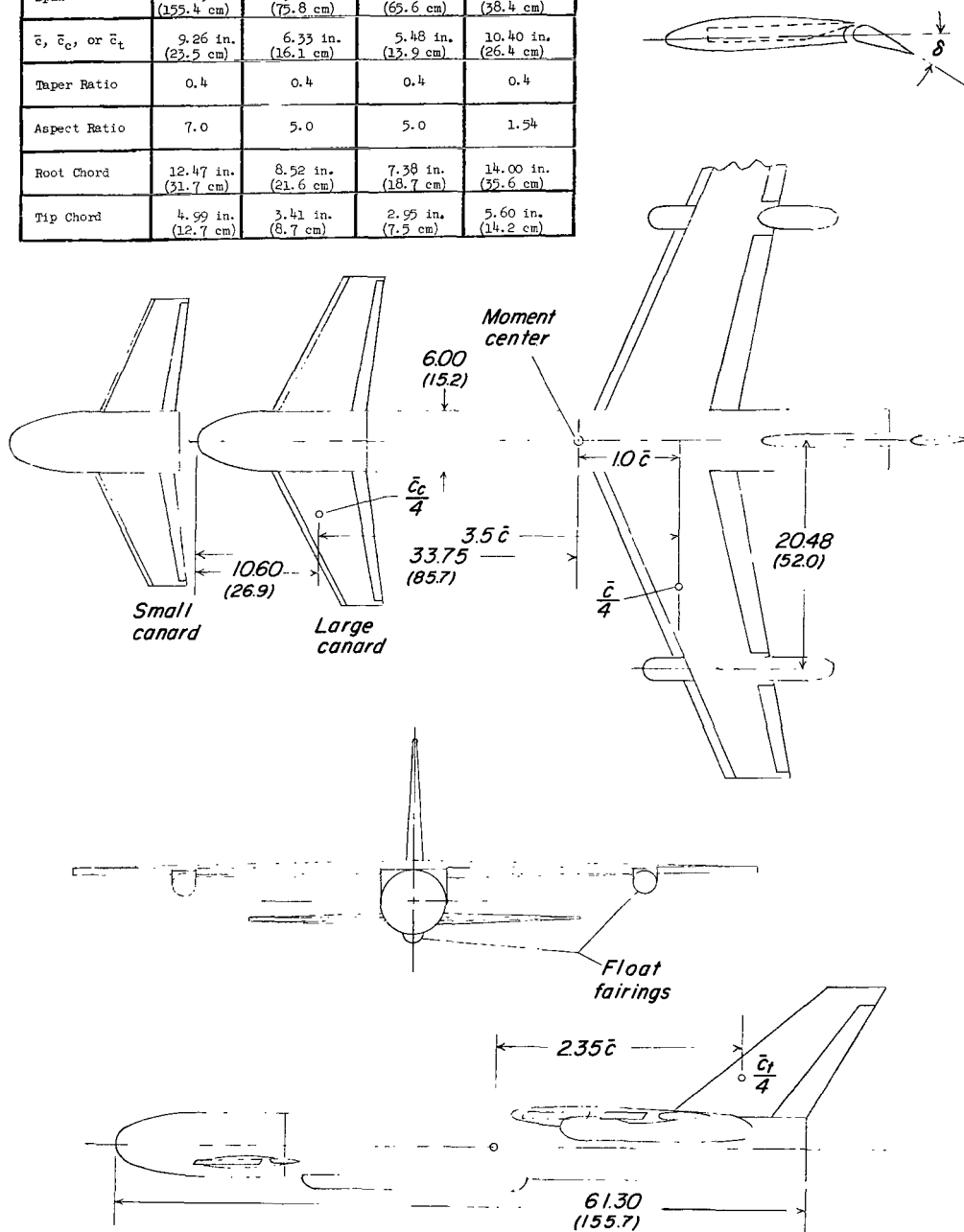
Figure 1.- Three-view drawing of model without engine nacelles and with floats retracted. All dimensions in inches (centimeters).
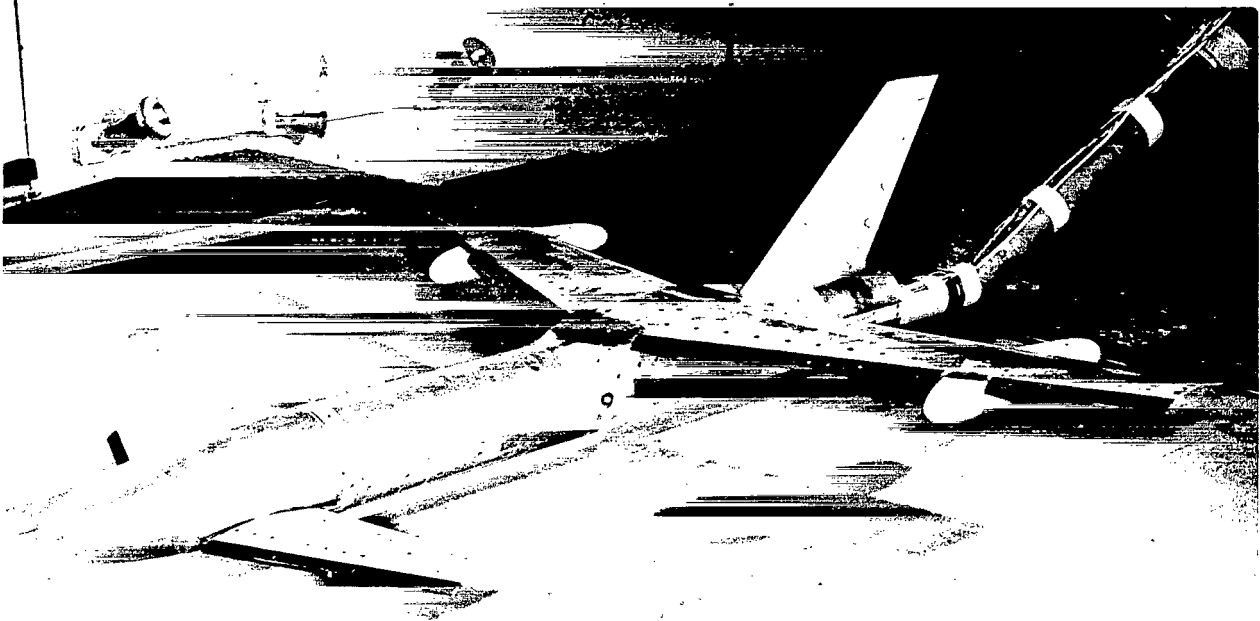
L-68-1018

(a) Three-quarter front view.

L-68-1020
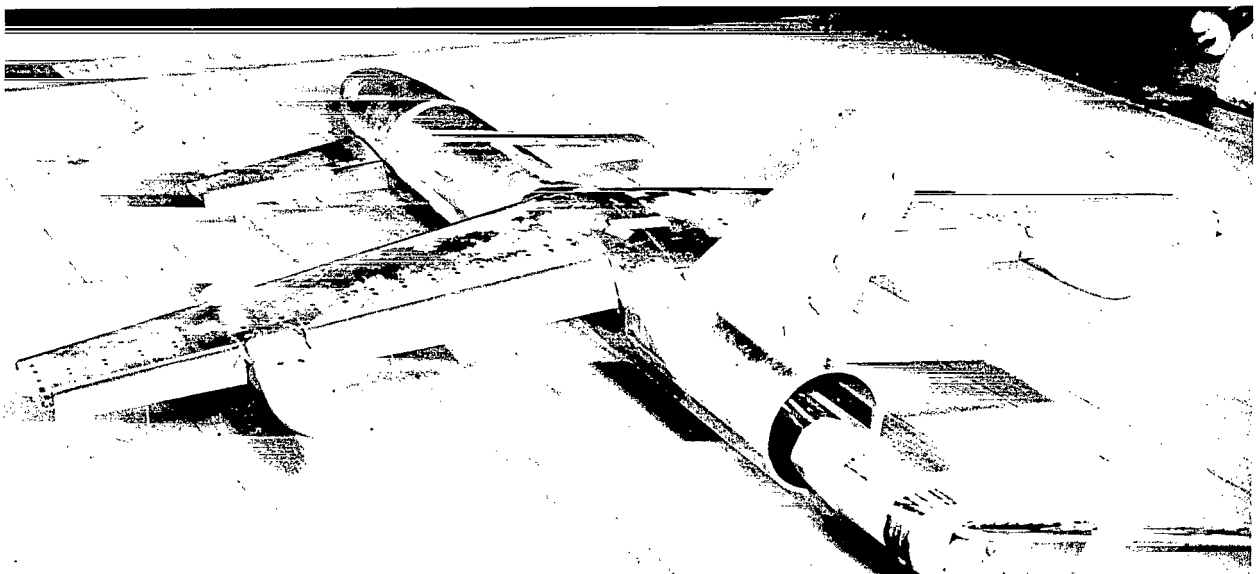
(b) Three-quarter rear view.

Figure 2.- Model over moving ground plane.
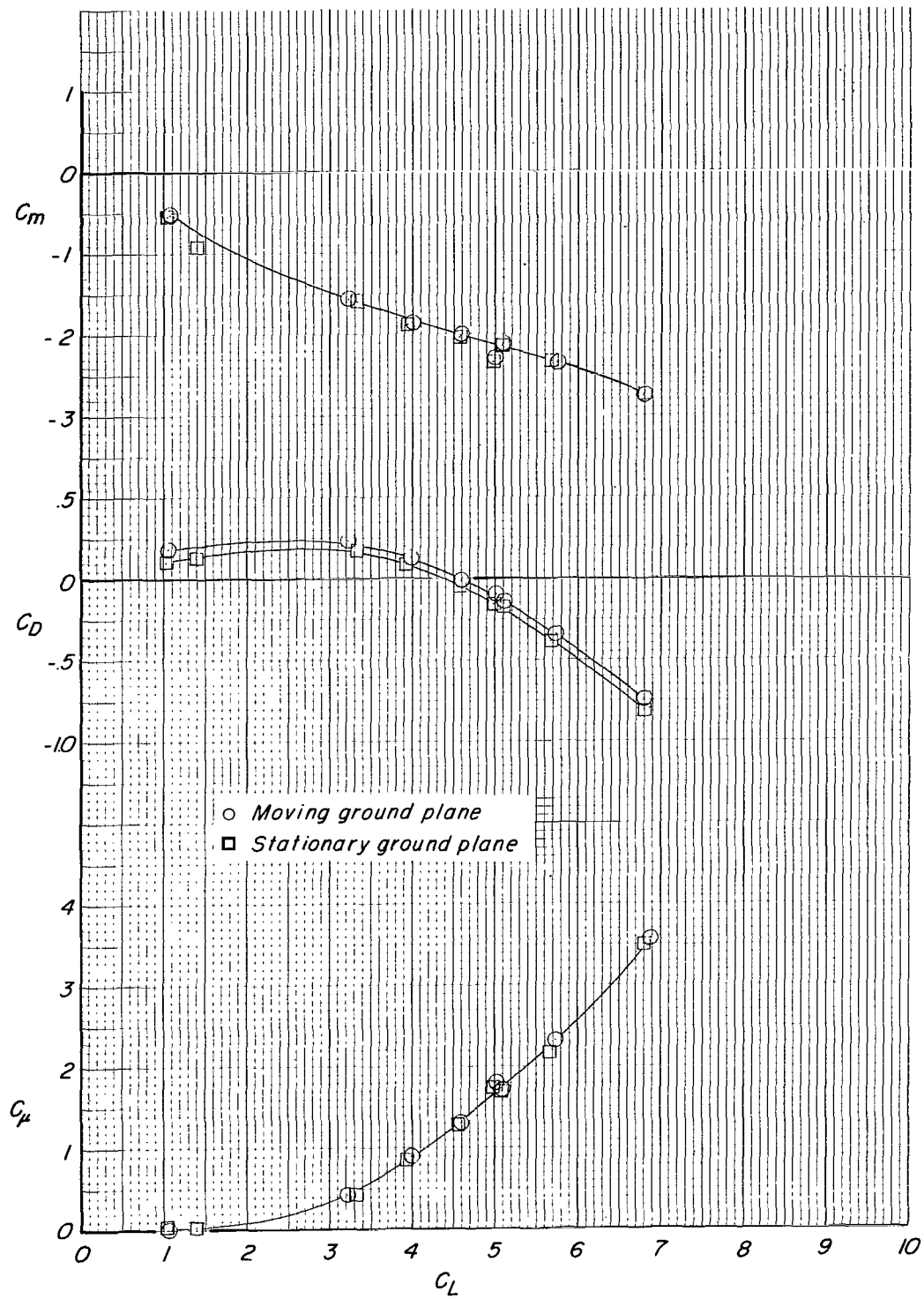
(a) $\tau = 0.5$; $h/\bar{c} = 1.7$.

Figure 3.- Effect of moving ground plane for various model heights
and ratios of canard-wing blowing thrust. Large canard; $\alpha = 0^{\circ}$;
$\delta_c = 56^{\circ}$; $\delta = 56^{\circ}$.
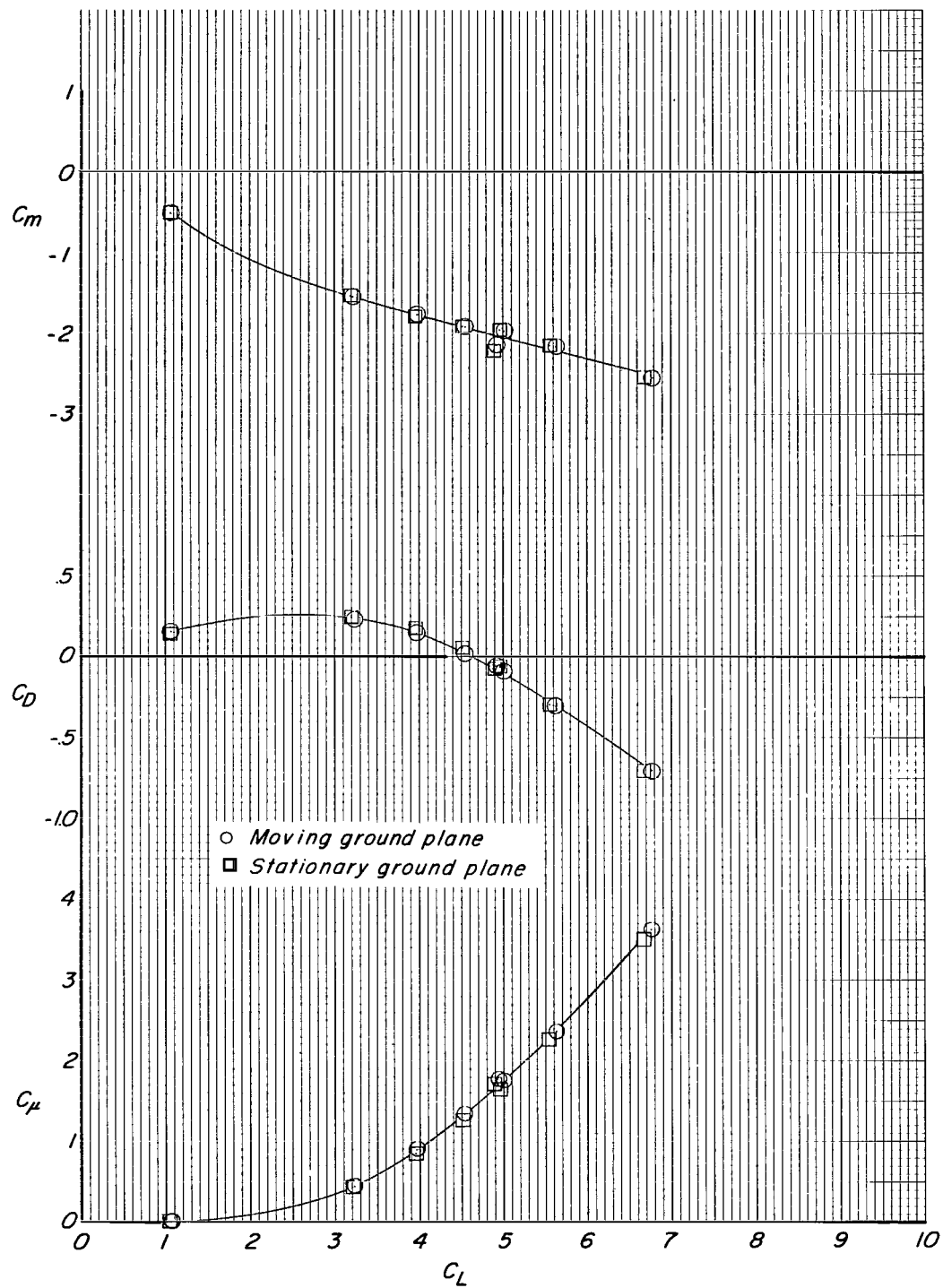
(b) $\tau = 0.5$; $h/\bar{c} = 2.7$.

Figure 3.- Continued.
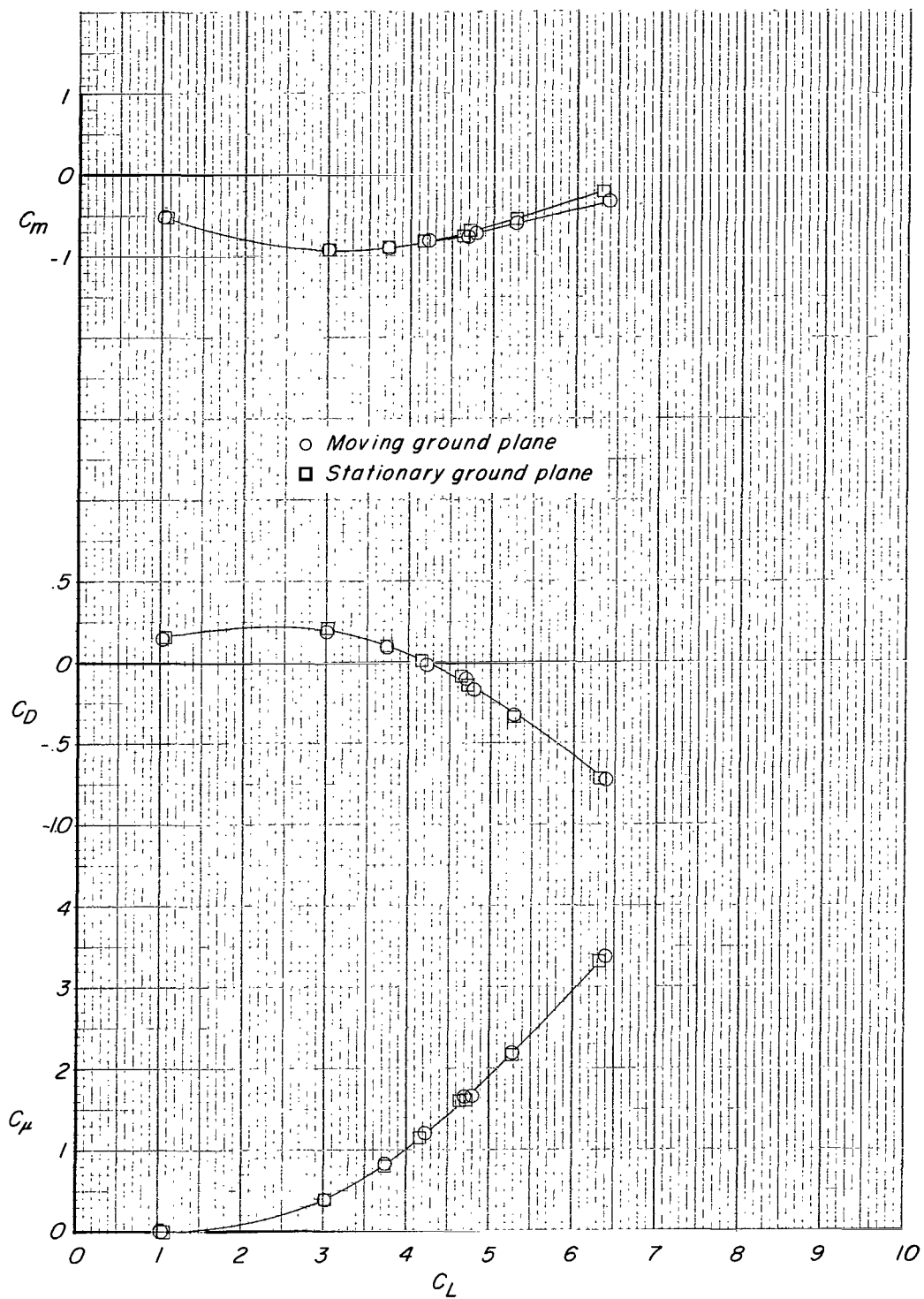
(c) $\tau = 1.0$; $h/\bar{c} = 1.7$.

Figure 3.- Continued.
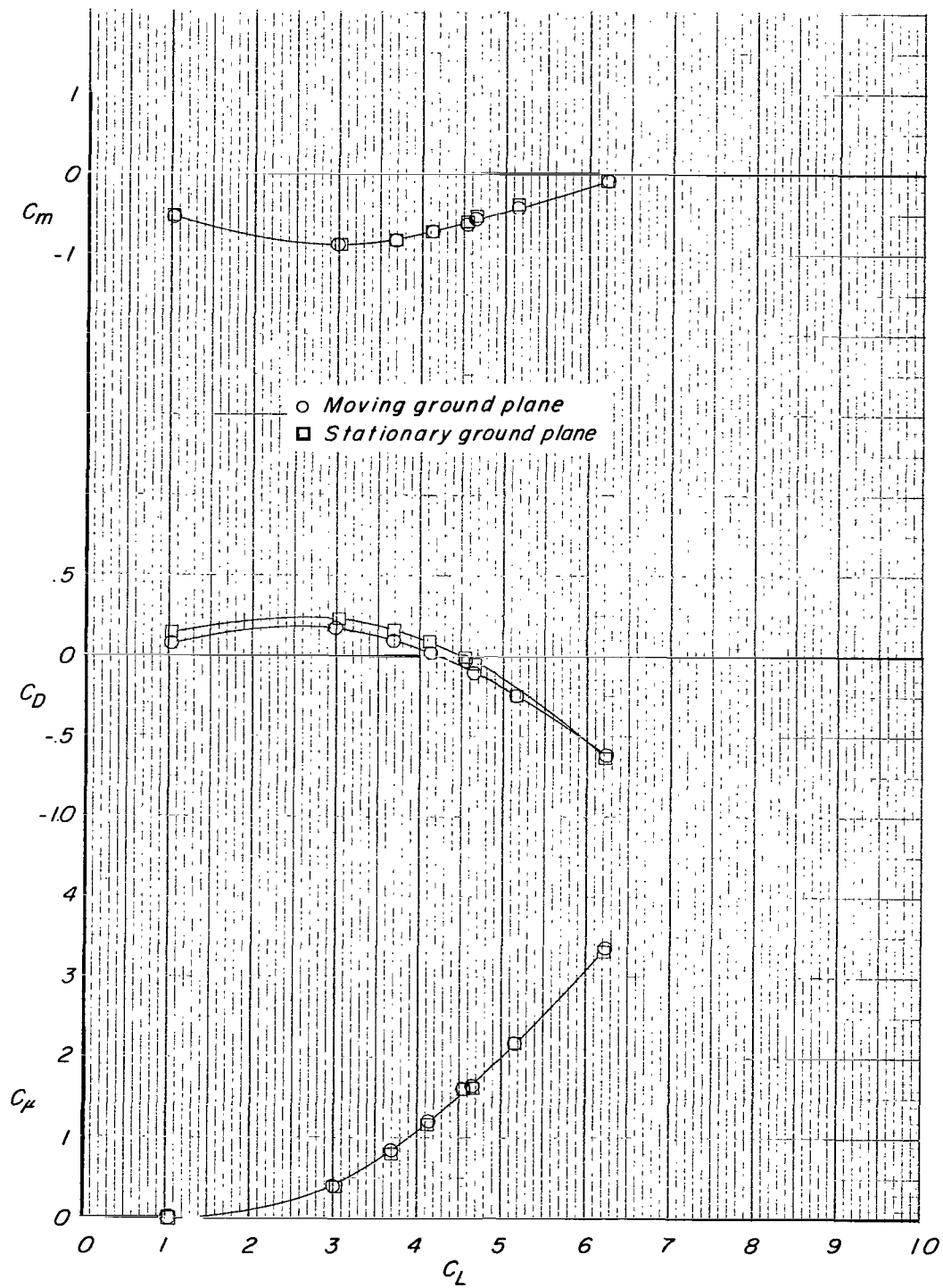
(d) $\tau = 1.0$; $h/\bar{c} = 2.7$.

Figure 3.- Continued.
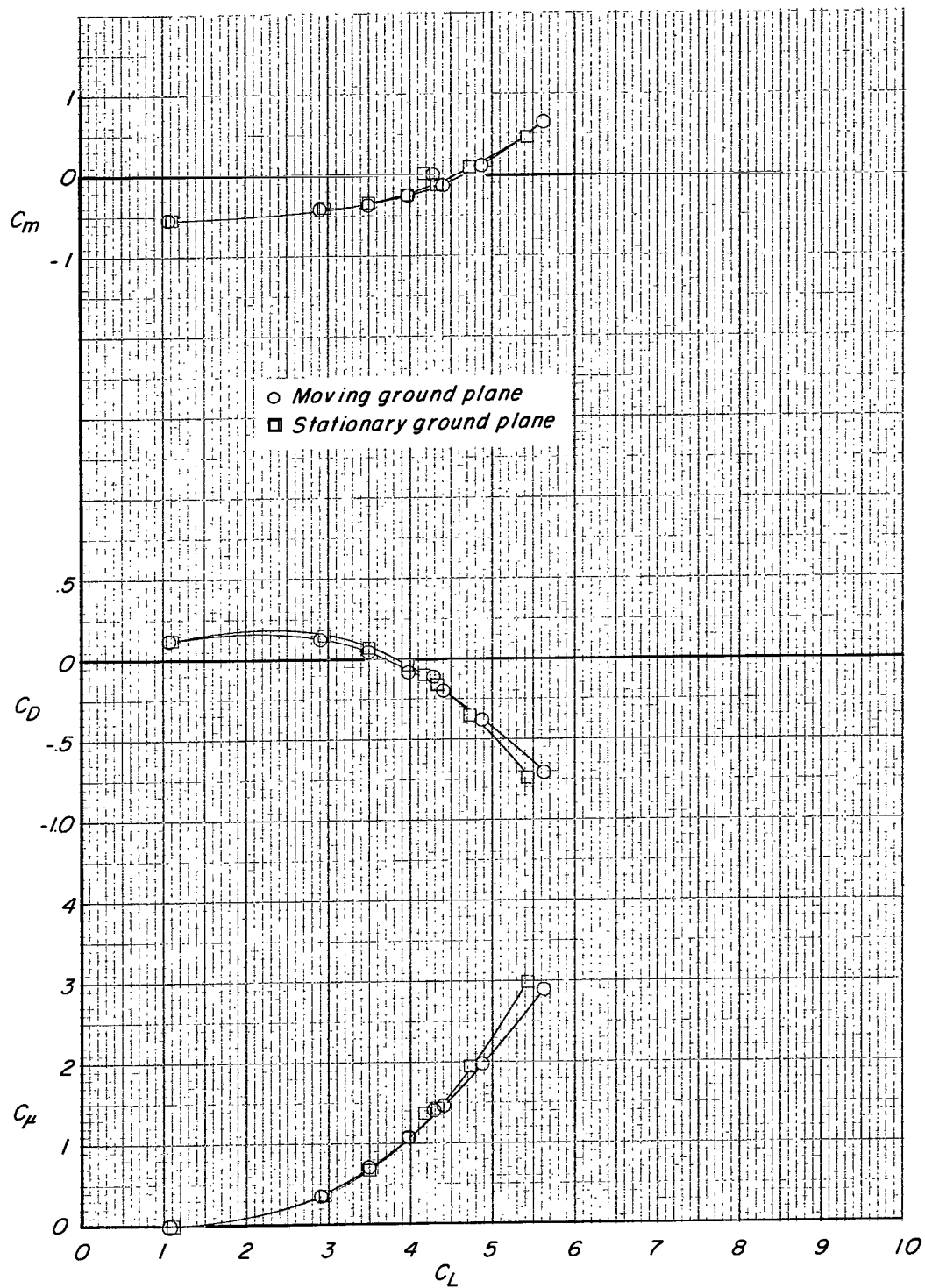
(e) $\tau = 1.7$; $h/\overline{c} = 0.9$.

Figure 3.- Continued.
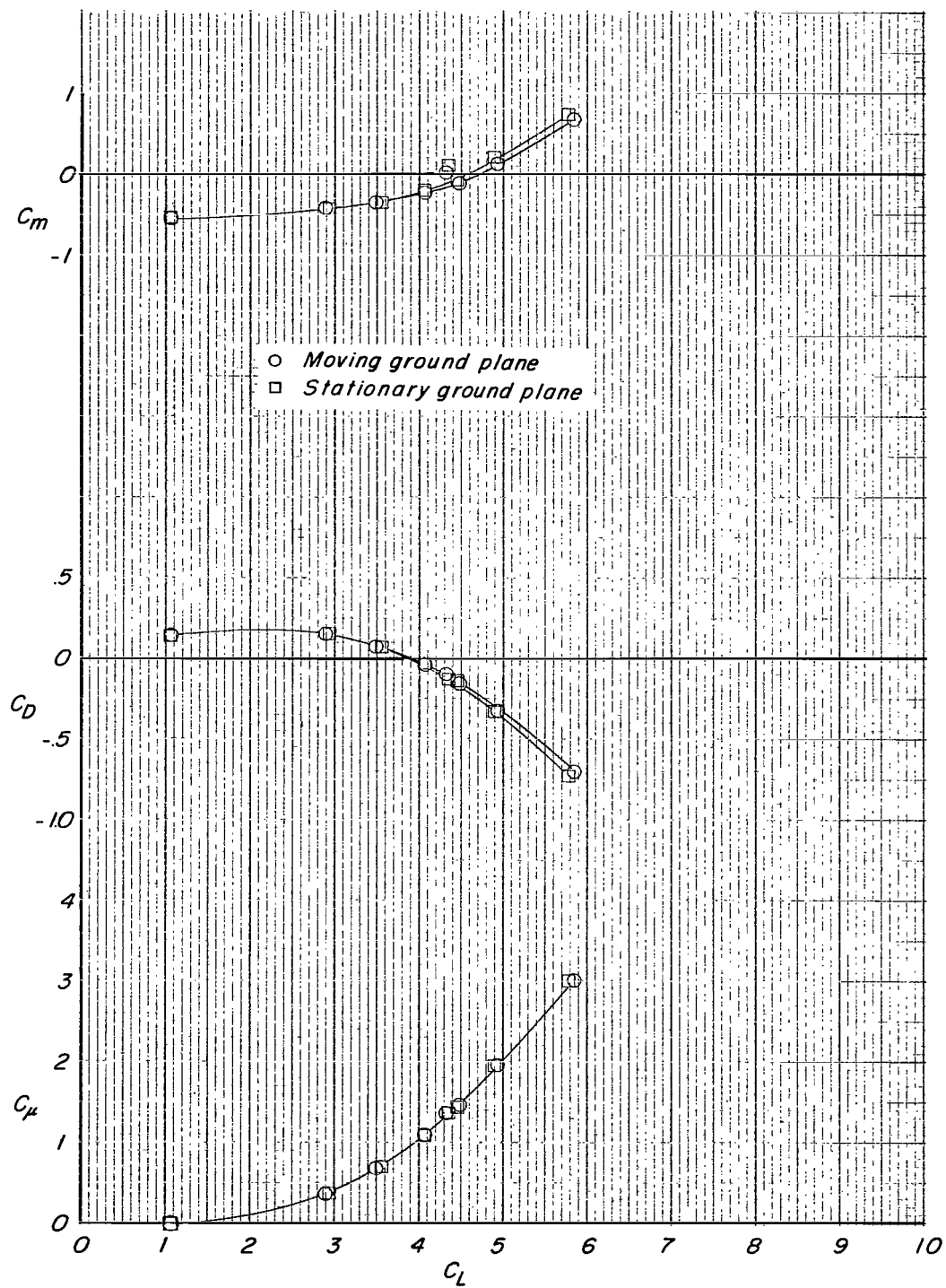
(f) $\tau = 1.7$; $h/\overline{c} = 1.2$.

Figure 3.- Continued.
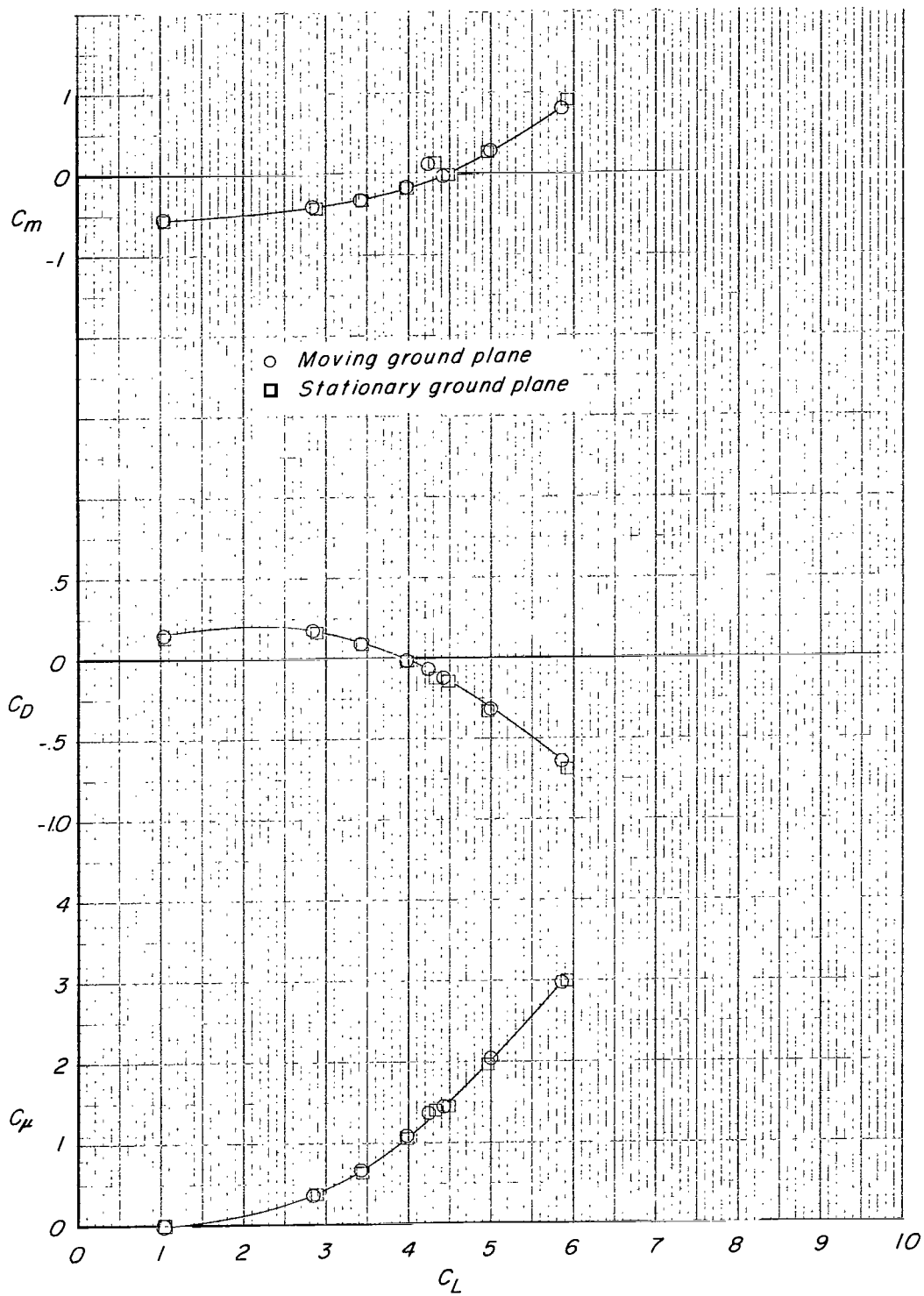
(g) τ = 1.7; h/c̄ = 1.7.

Figure 3.- Continued.
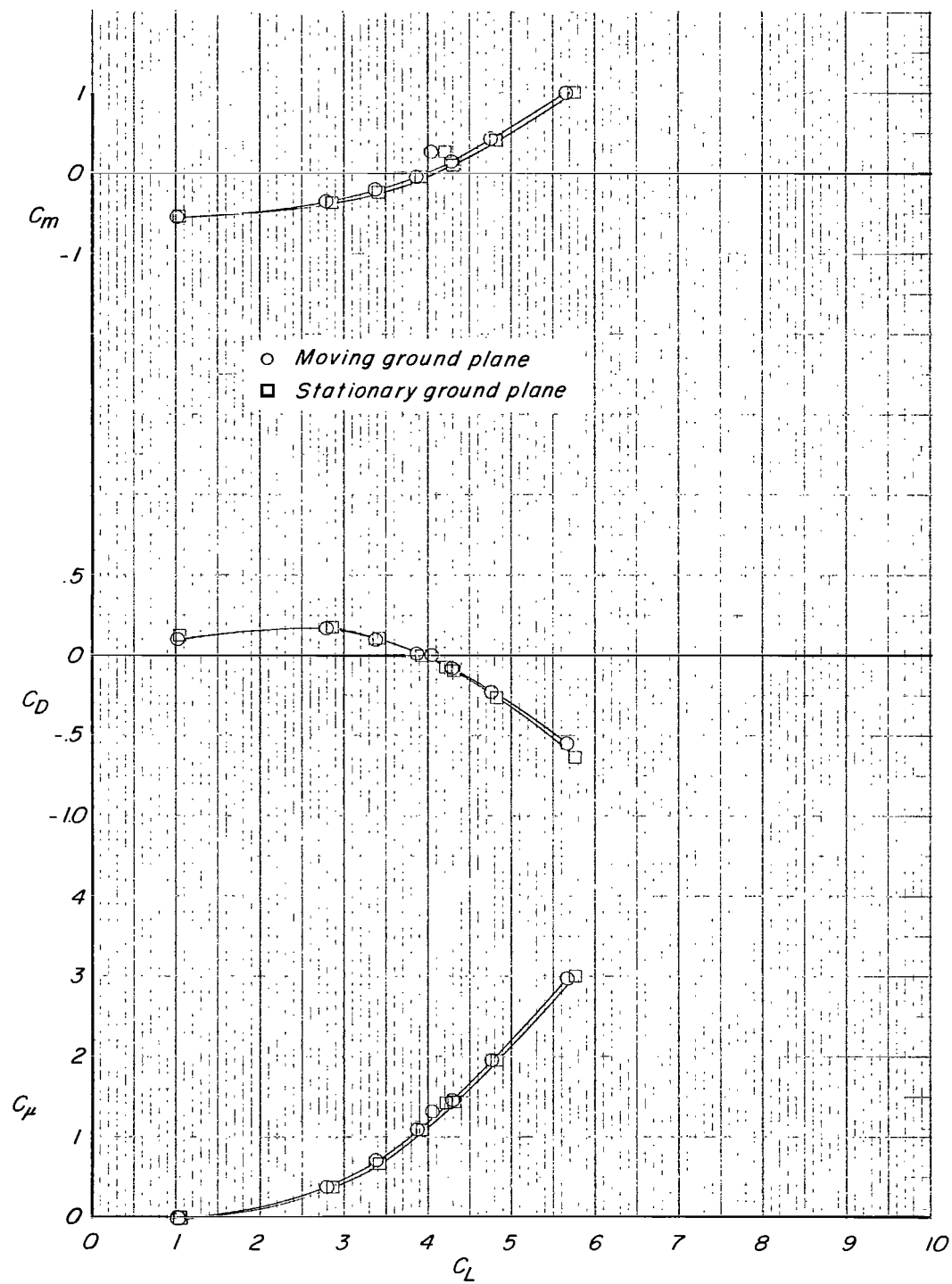
(h) $\tau = 1.7$; $h/\bar{c} = 2.7$.

Figure 3.- Concluded.

(a) $\tau = 0.5$.
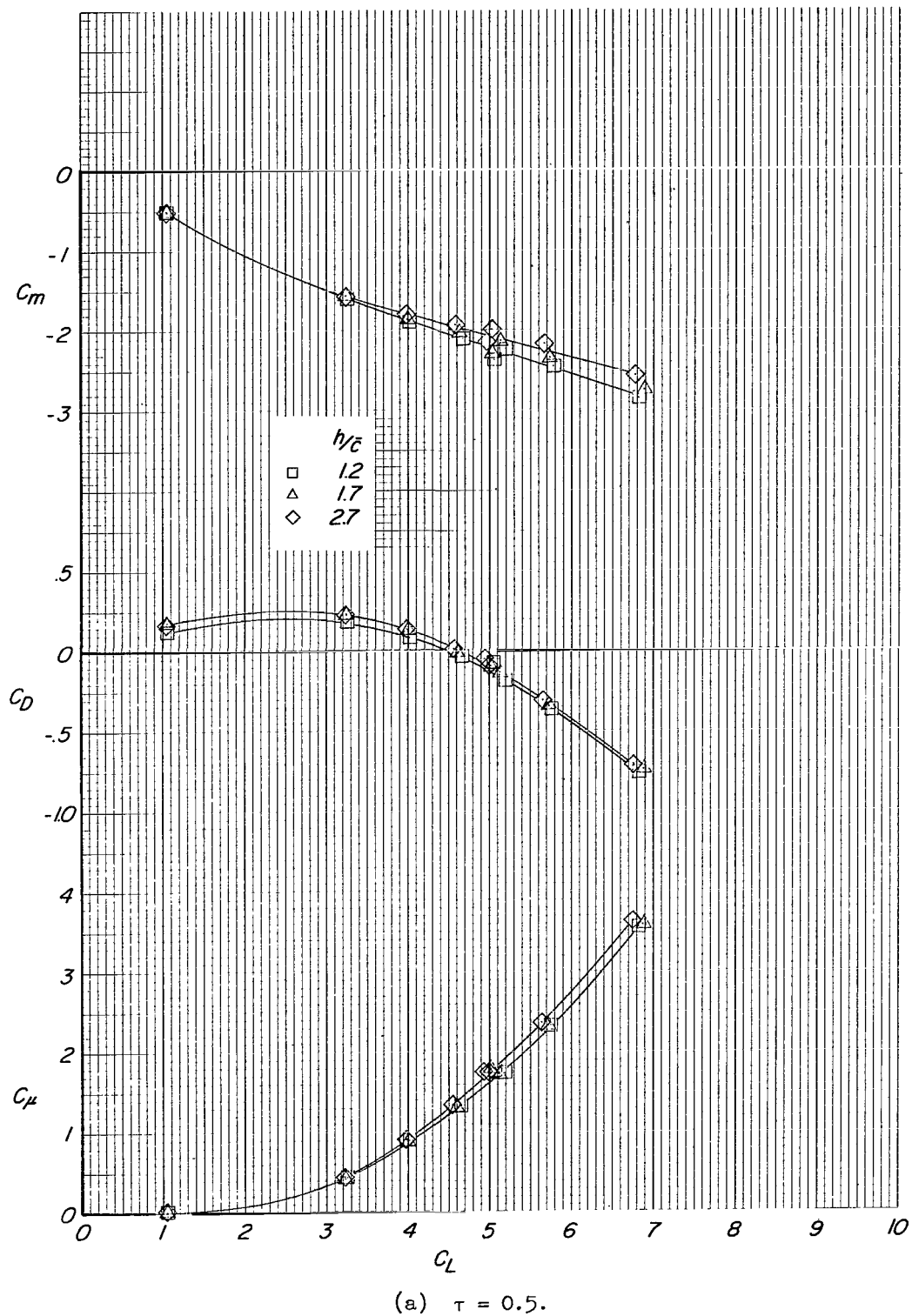
Figure 4.- Effect of model height through a range of blowing momentums for three ratios of canard-wing blowing thrust. Large canard; $\alpha = 0^\circ$; $\delta_c = 56^\circ$; $\delta = 56^\circ$.
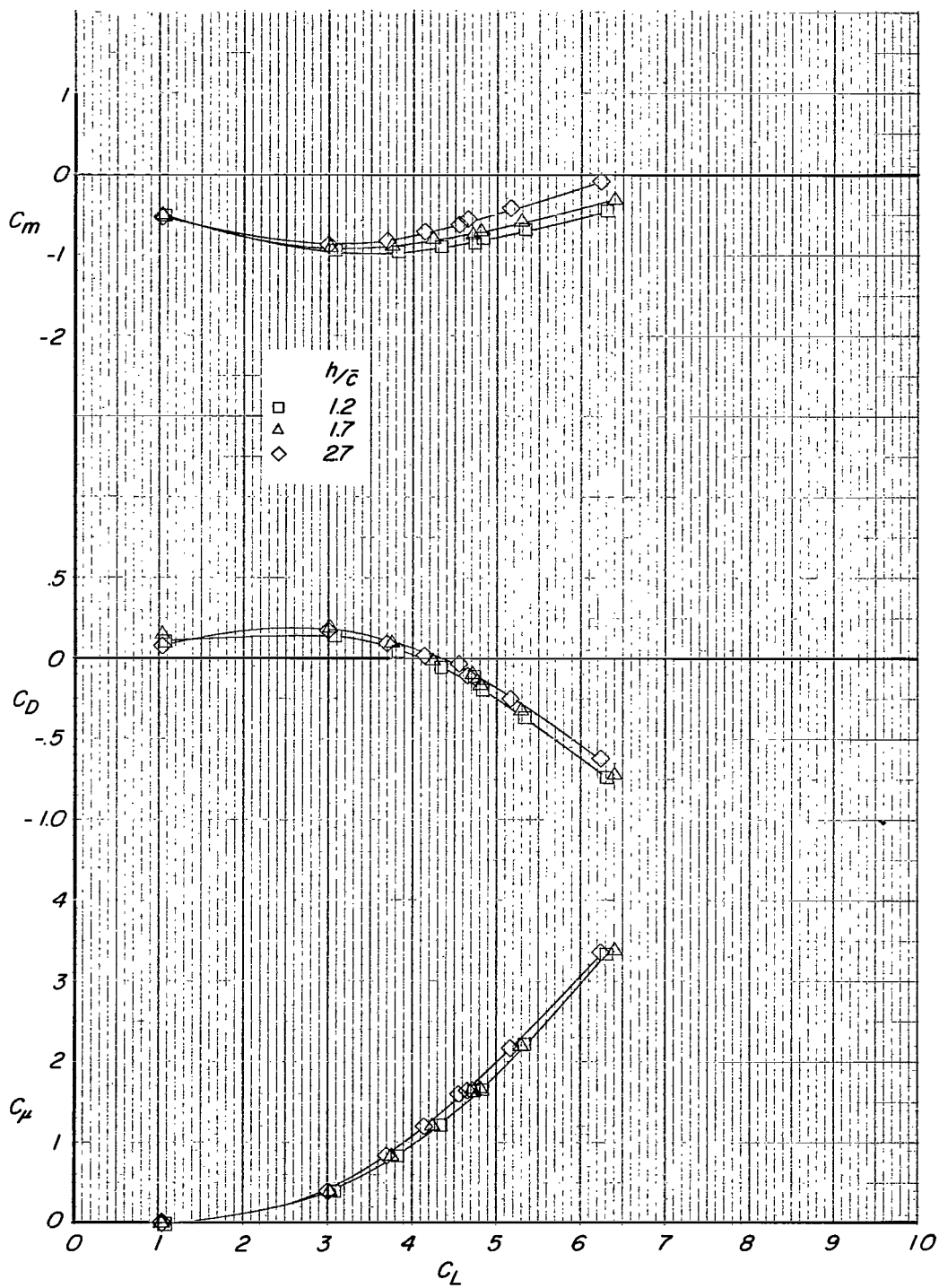
(b) $\tau = 1.0$.

Figure 4.- Continued.
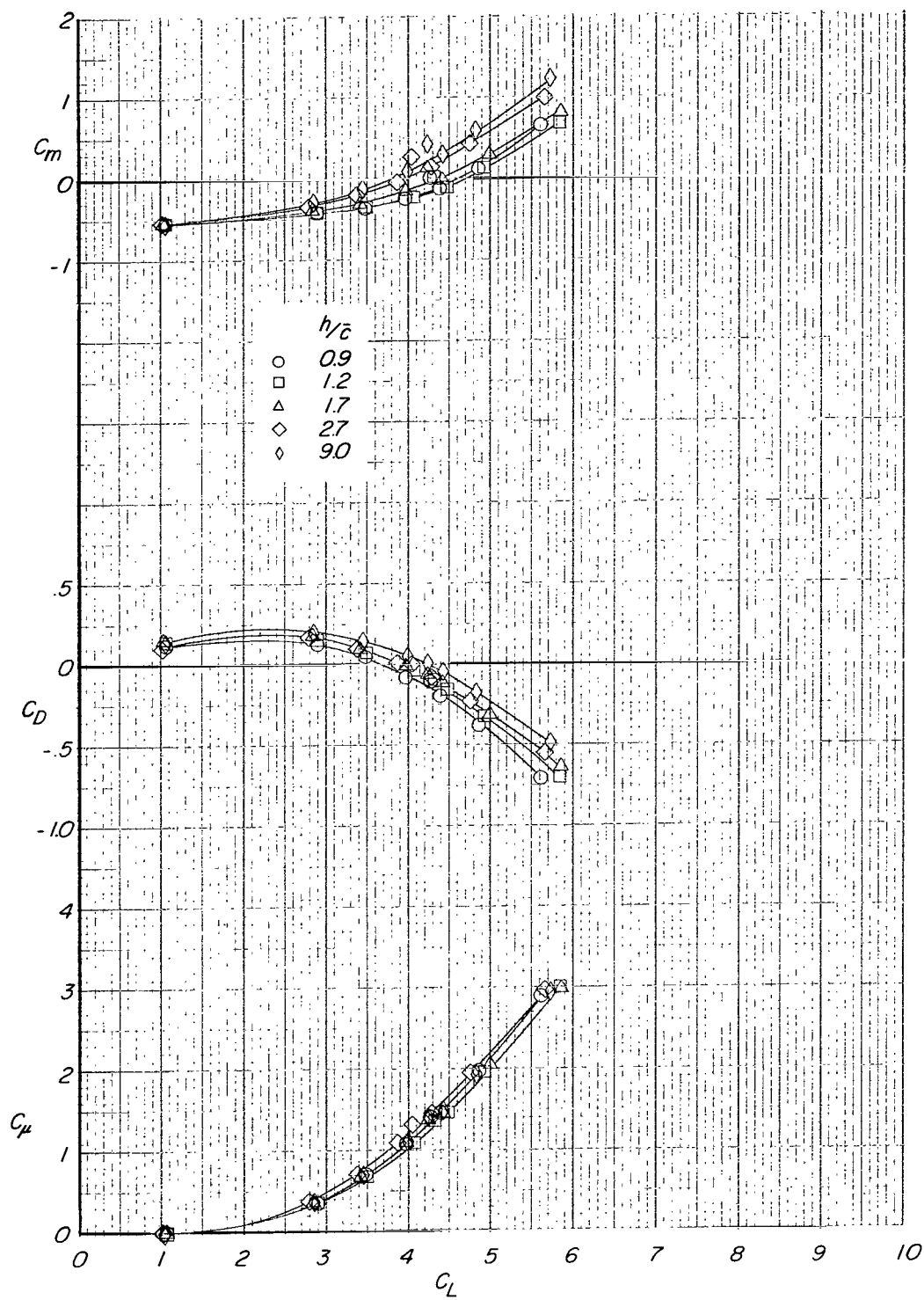
(c) $\tau = 1.7$.

Figure 4.- Concluded.
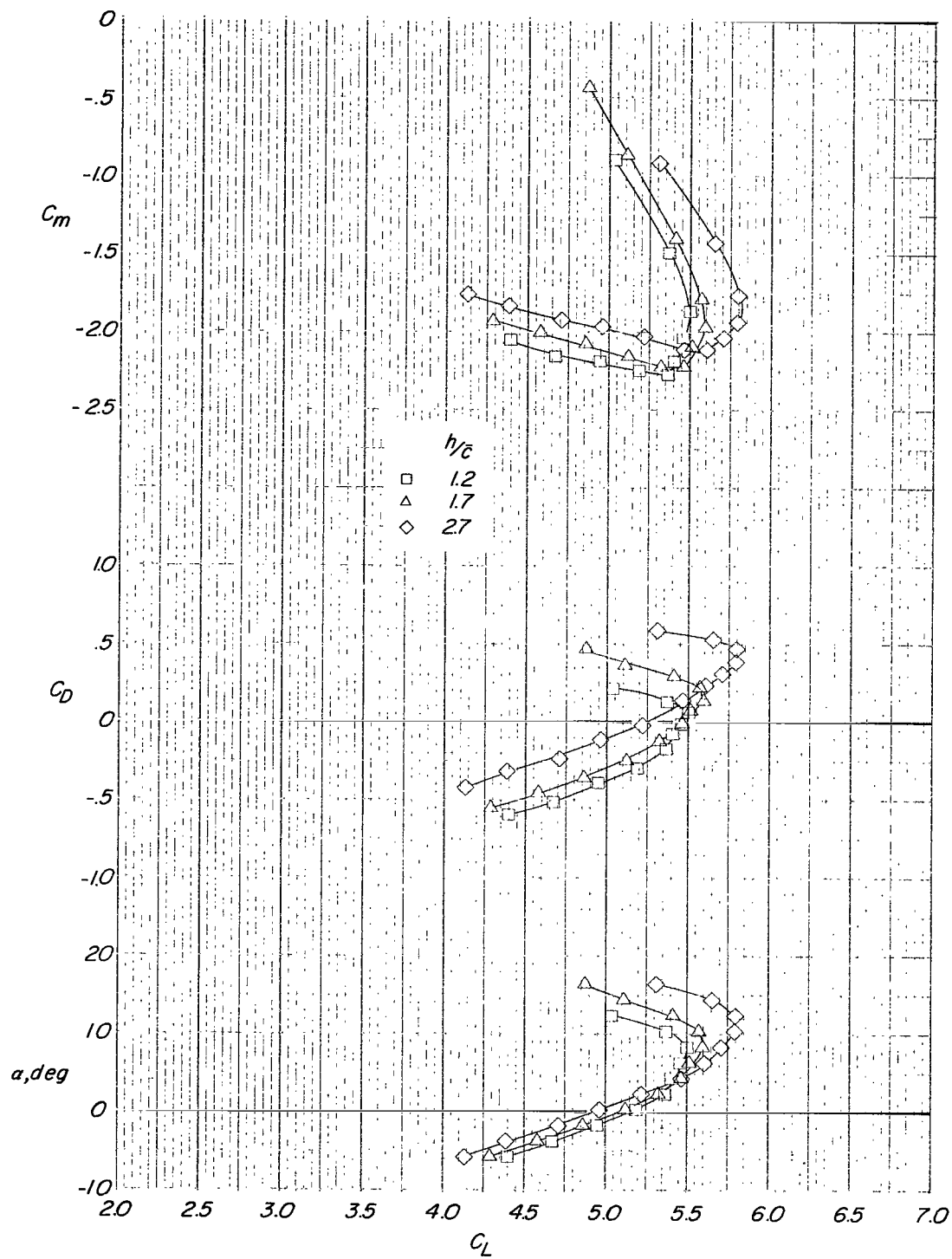
(a) $\tau = 0.5$; $C_\mu = 1.71$.

Figure 5.- Effect of model height at constant blowing momentum for three ratios of canard-wing blowing thrust. Large canard; $\delta_c = 56^o$; $\delta = 56^o$.
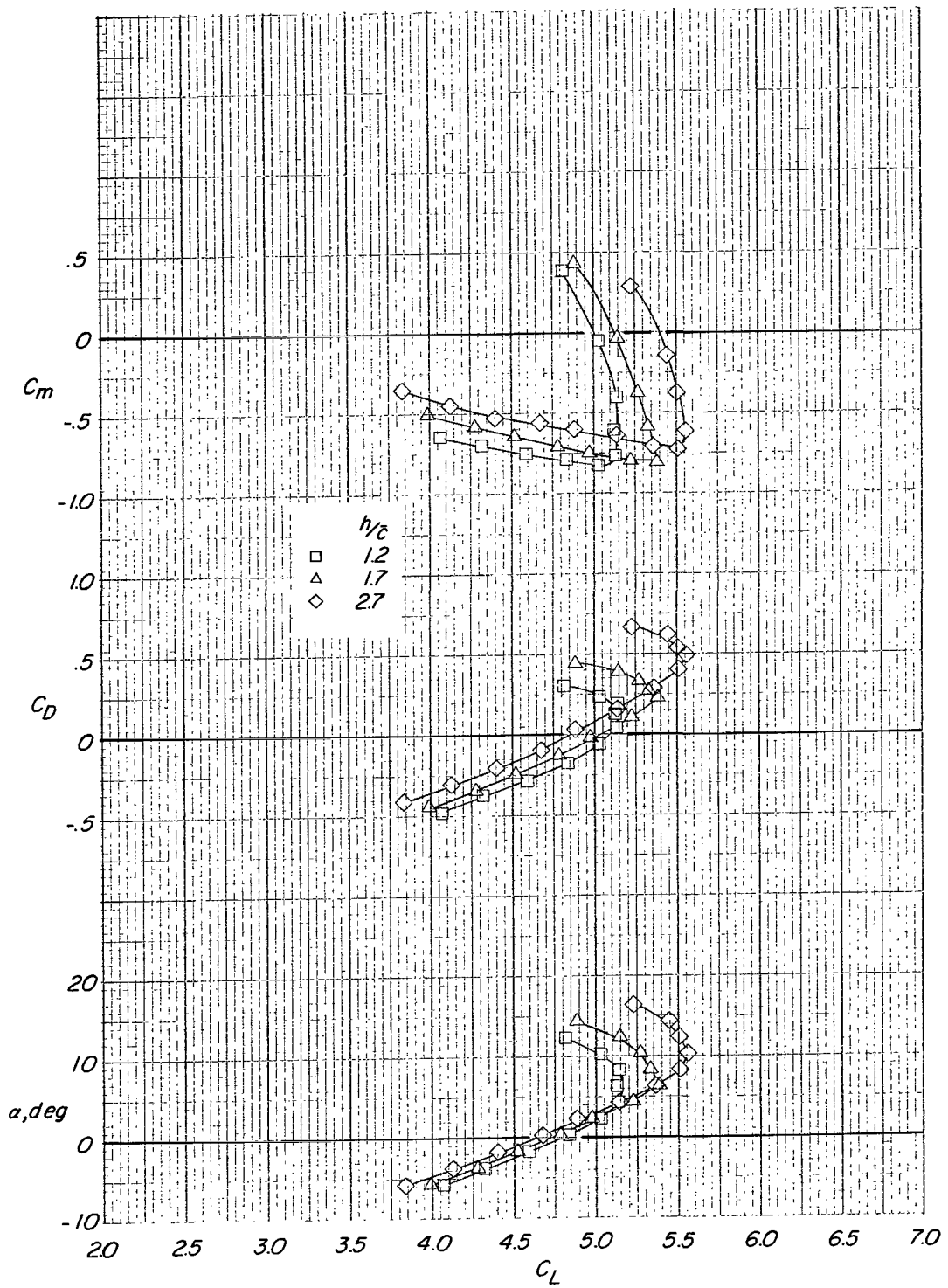
(b) $\tau = 1.0$; $C_\mu = 1.61$.

Figure 5.- Continued.
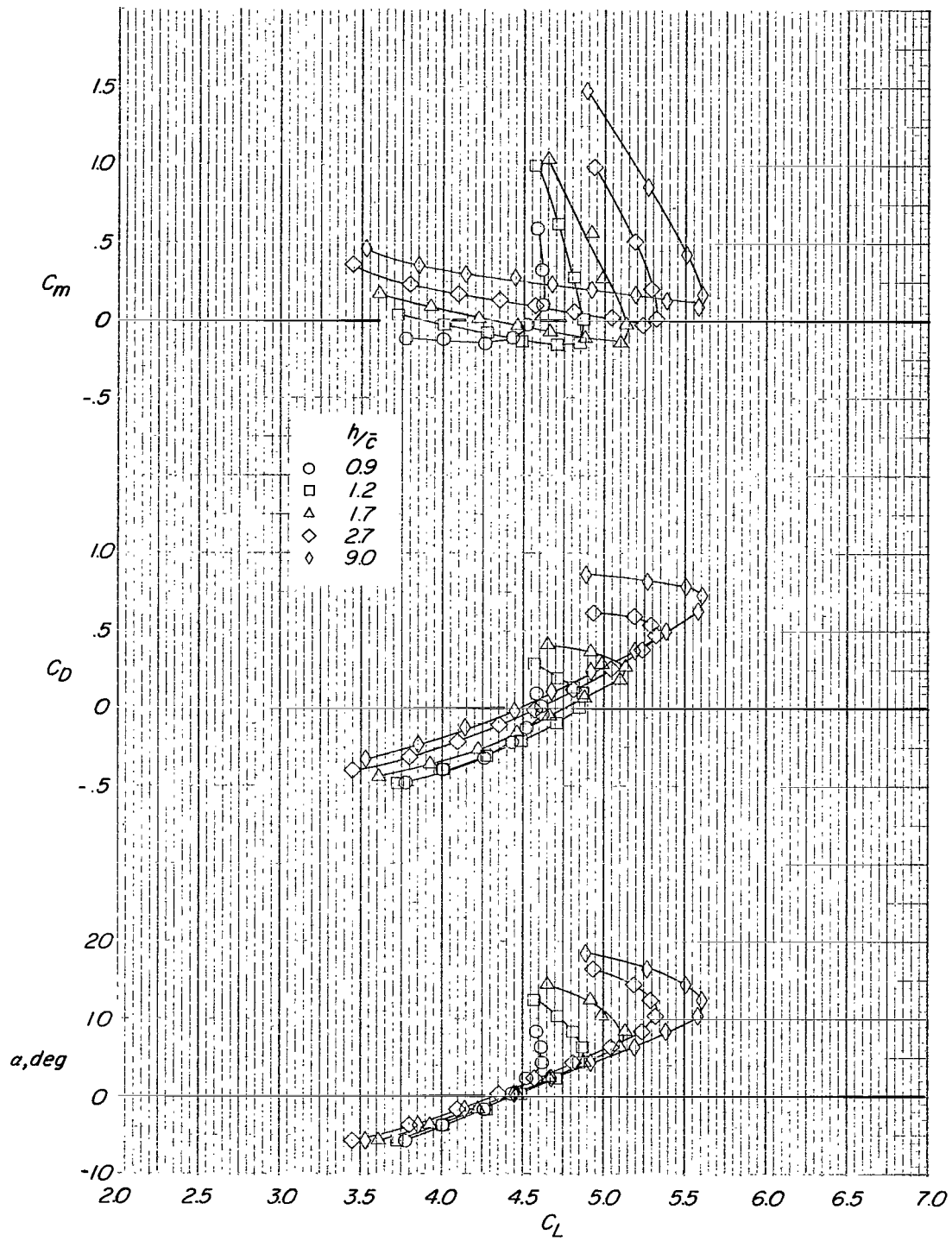
(c) $\tau = 1.7$; $C_\mu = 1.45$.

Figure 5.- Concluded.
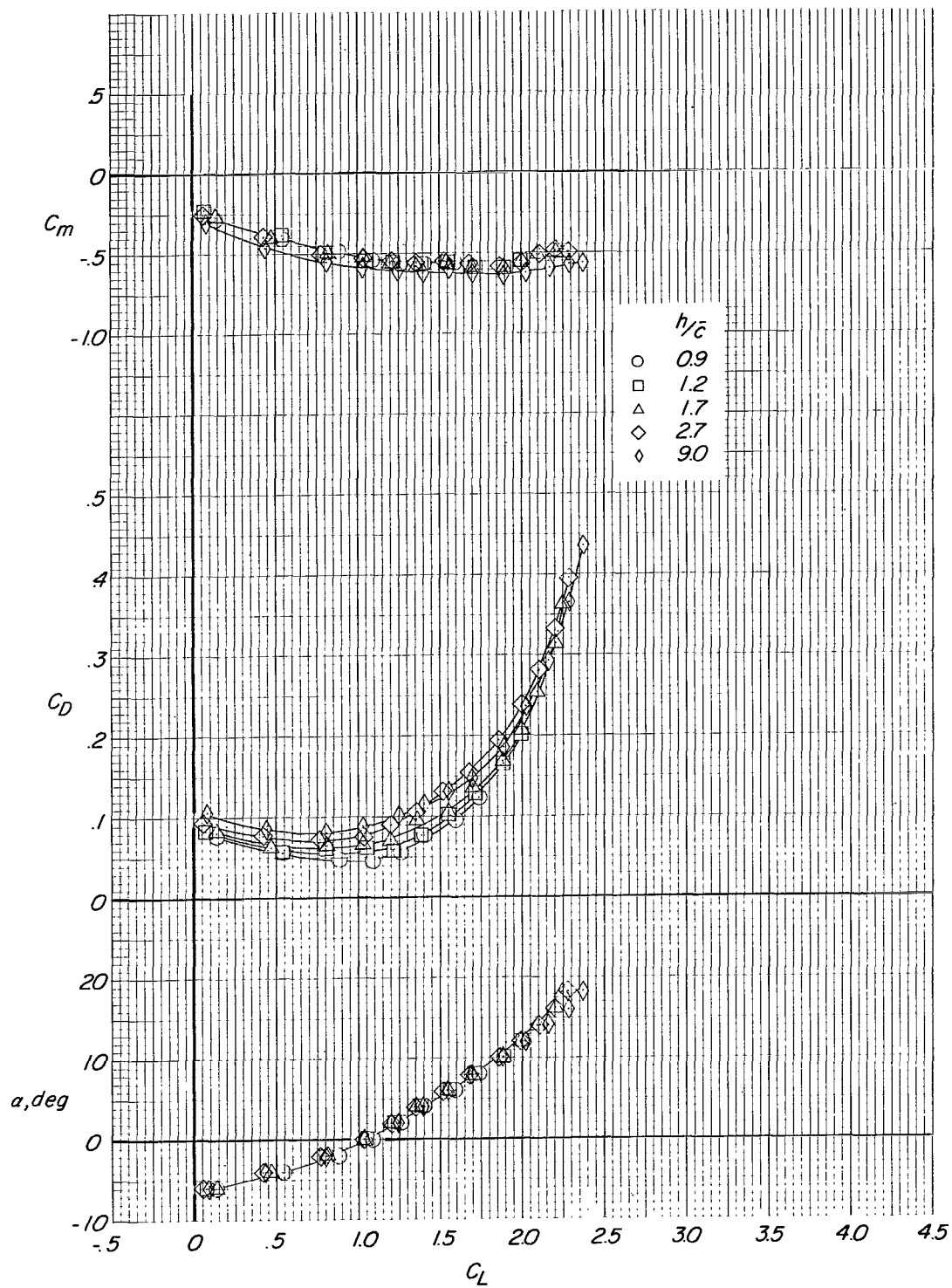
Figure 6.- Effect of model height without blowing on canard or wing.
Large canard; $\delta_c = 56^\circ$; $\delta = 56^\circ$.
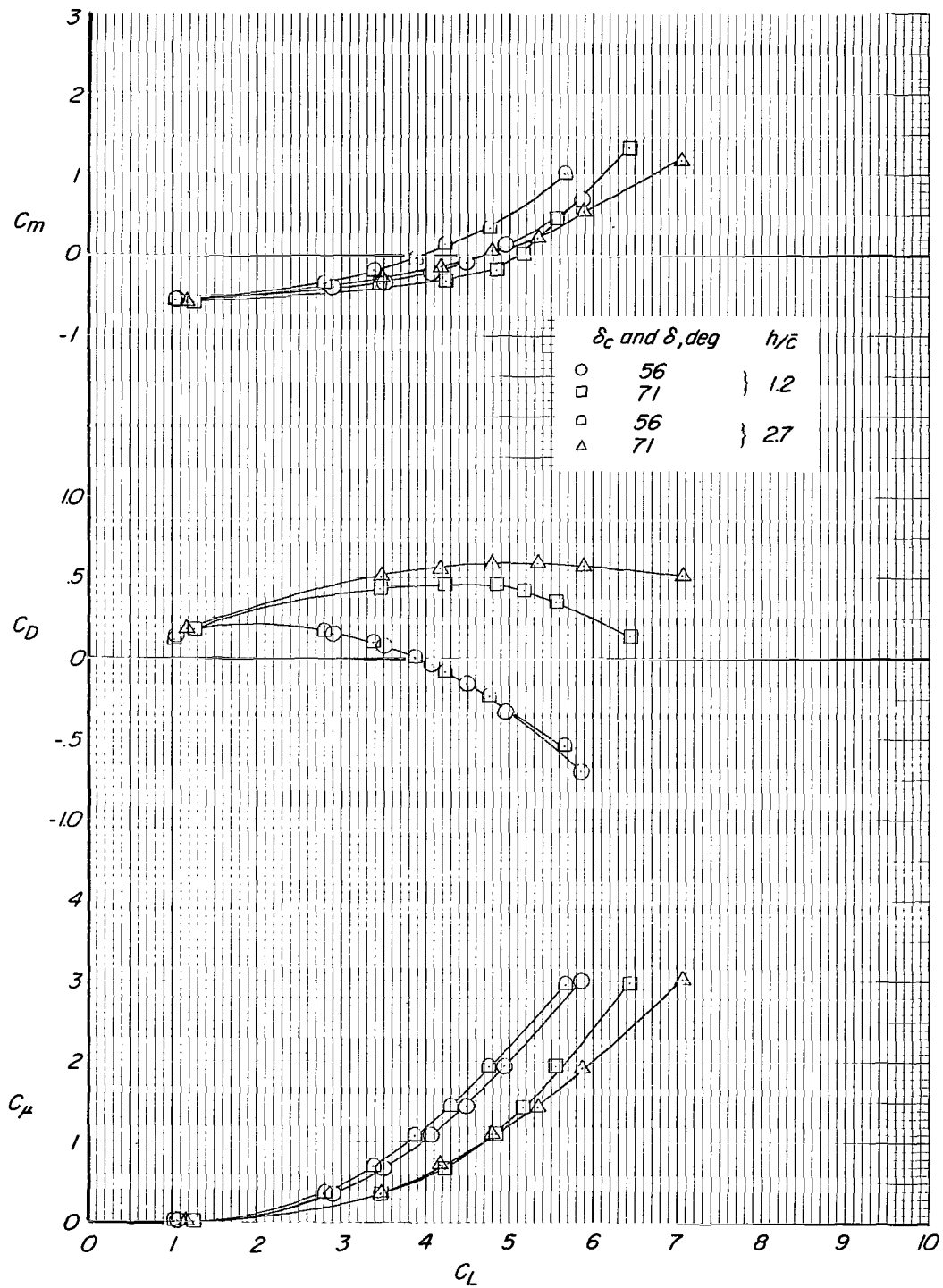
Figure 7.- Effect of increased deflection of wing and canard jet angles through a range of blowing momentums at two model heights. Large canard; $\alpha = 0^\circ$; $\tau = 1.7$.
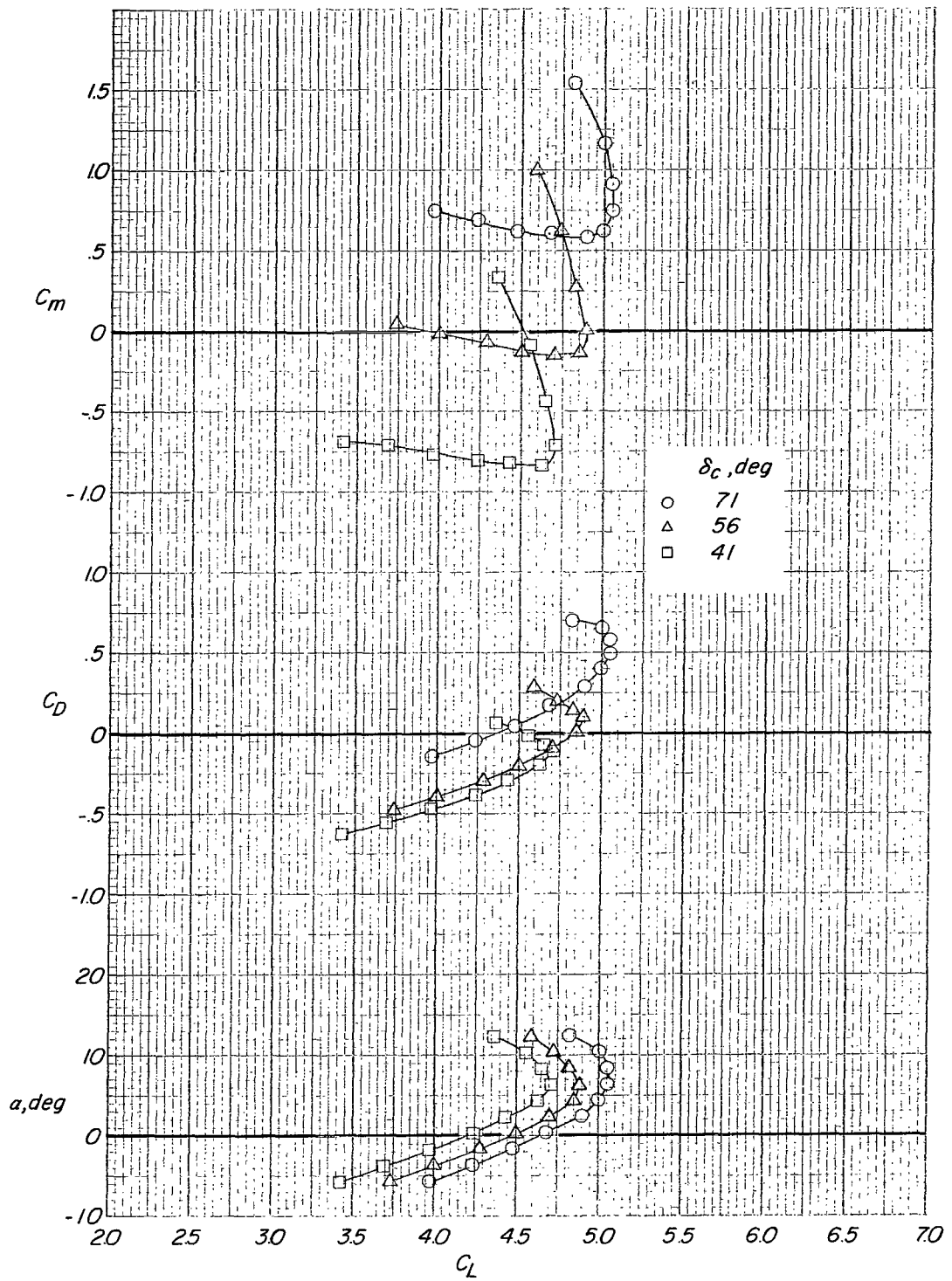
Figure 8.- Effect of canard jet angle on aerodynamic characteristics of model. Large canard; $\delta = 56°$; $C_\mu = 1.45$; $\tau = 1.7$; $h/\overline{c} = 1.2$.

	δ,deg	$\delta_{a_{left}}$,deg	$\delta_{a_{right}}$,deg
○	56	11	11
△	56	56	11
□	56	56	56
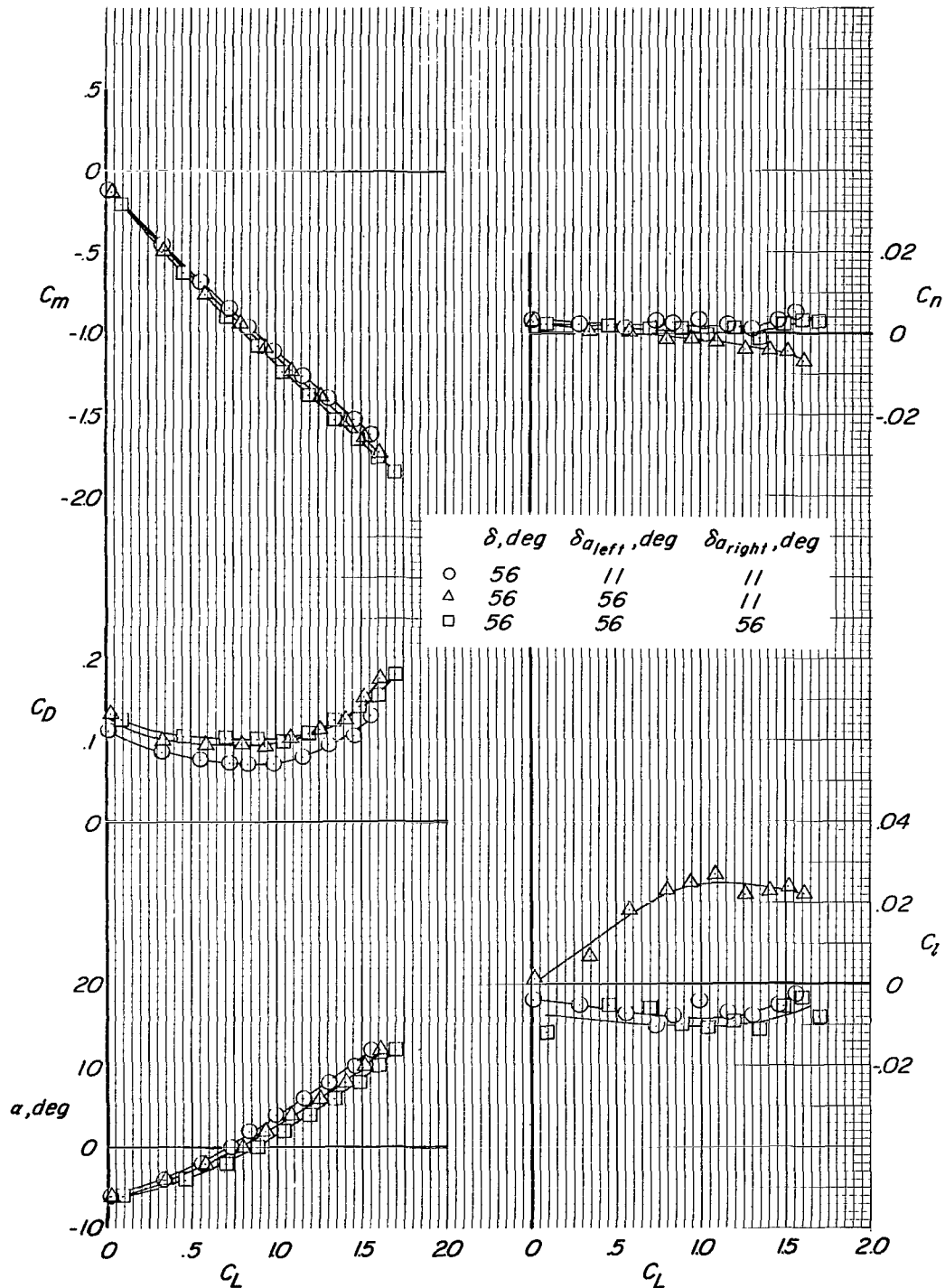
(a) h/c = 1.2.

Figure 9.- Effect of aileron deflection without blowing momentum.
Canard removed.
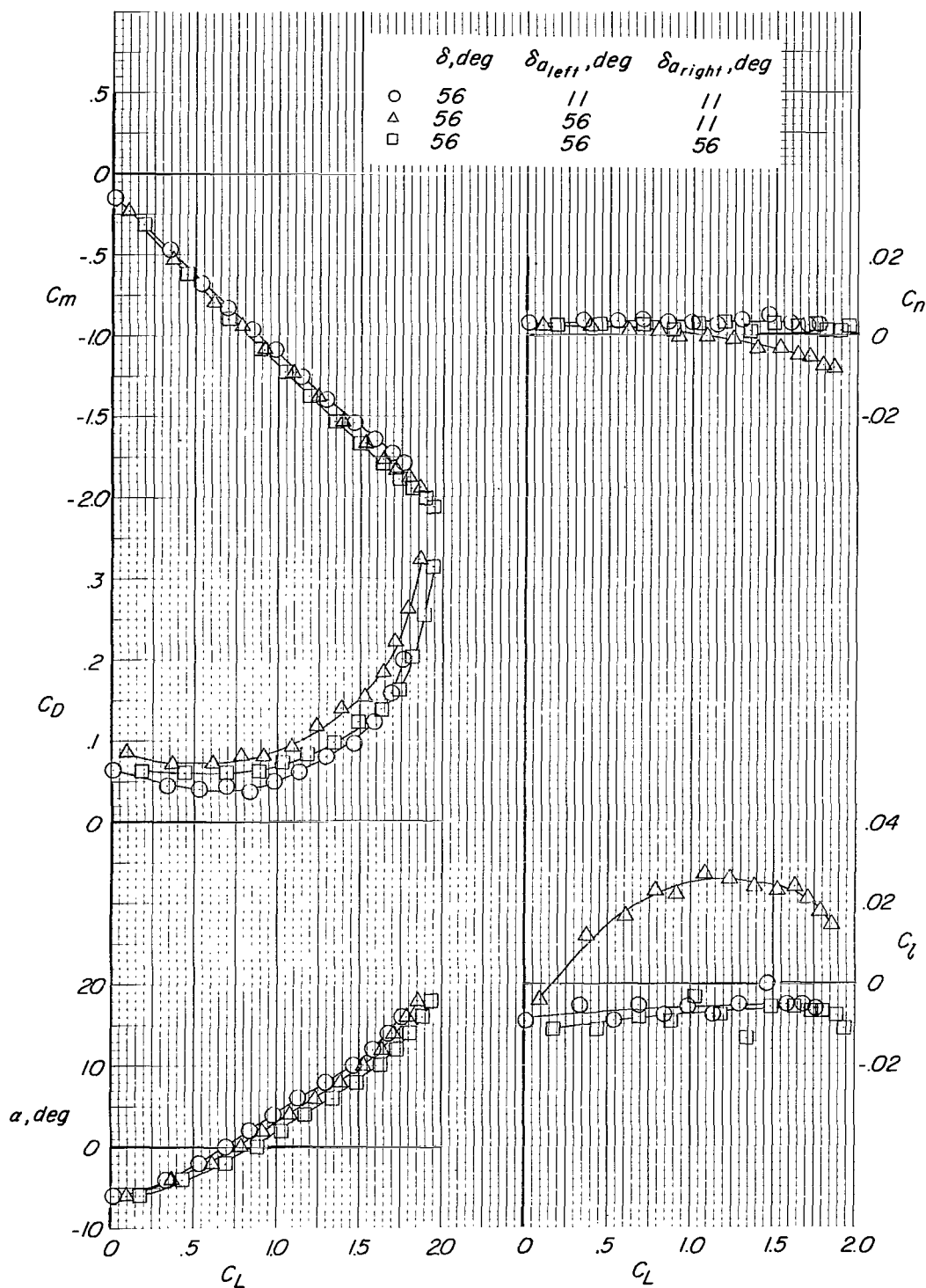
(b) h/$\overline{c}$ = 2.7.

Figure 9.- Concluded.

	δ,deg	$\delta_{a_{left}}$,deg	$\delta_{a_{right}}$,deg
○	56	11	11
△	56	56	11
□	56	56	56
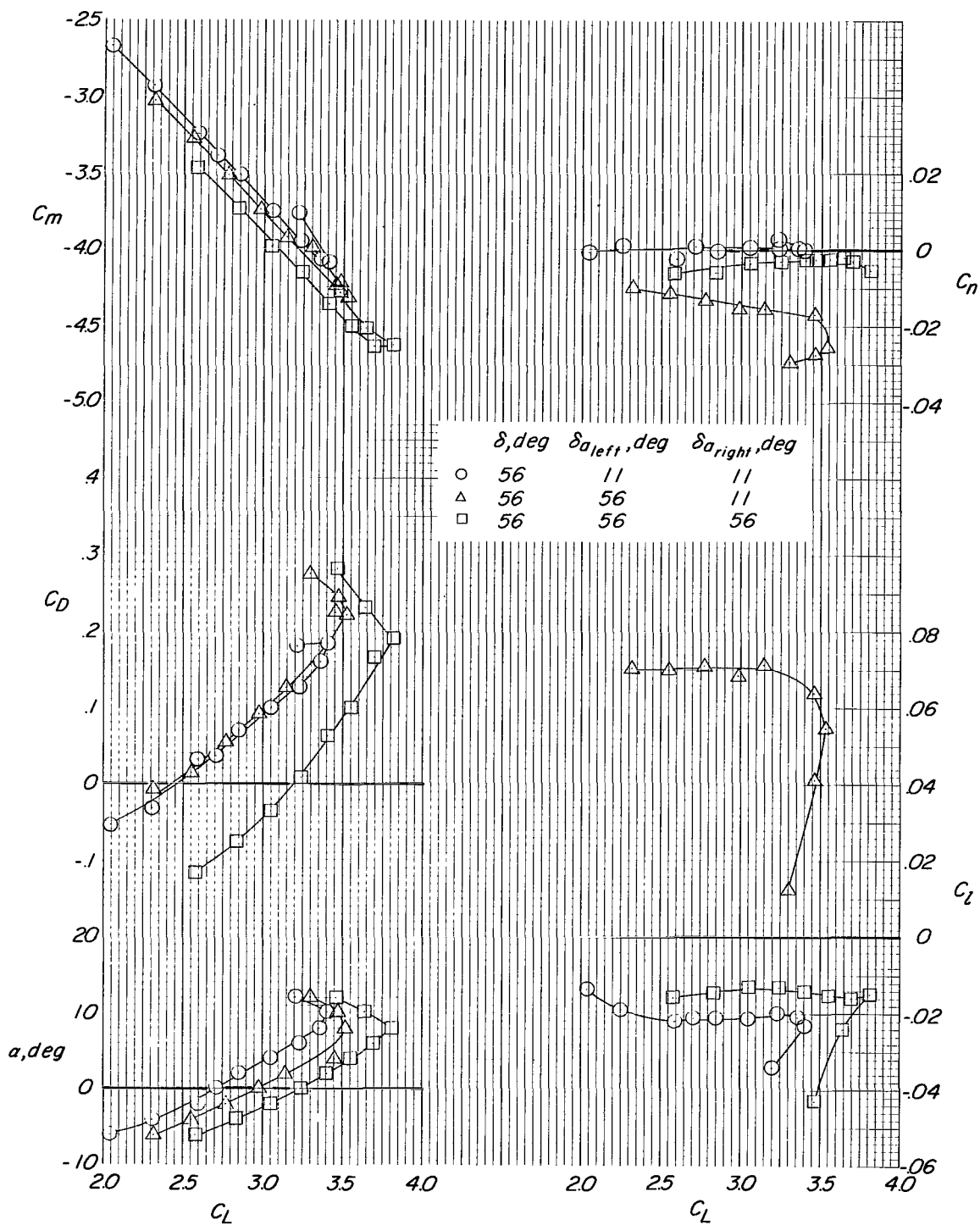
(a) $h/\overline{c}$ = 1.2; C_μ = 0.54.

Figure 10.- Effect of aileron jet angle with constant blowing momentum on wing. Canard removed.
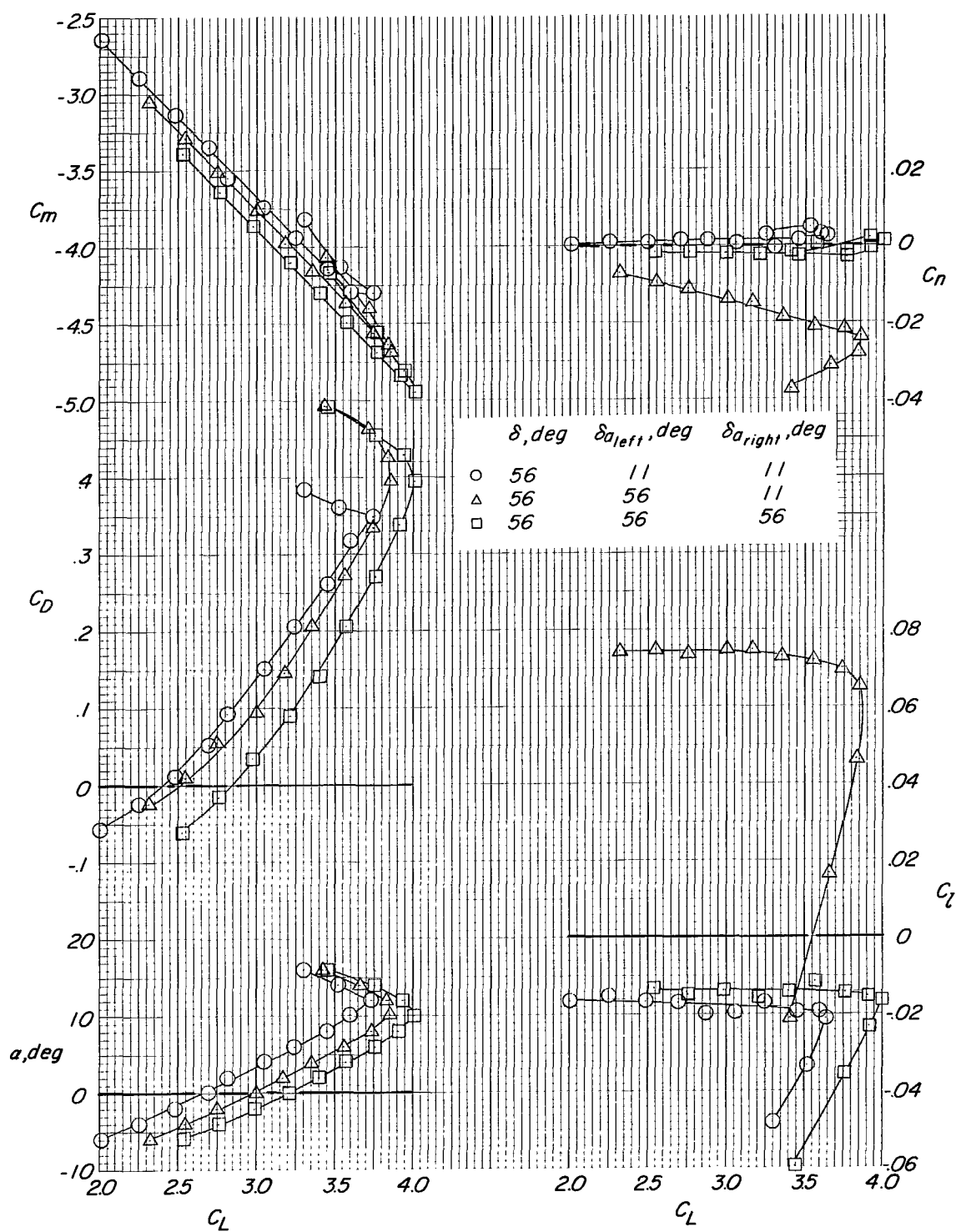
(b) $h/\overline{c} = 2.7$; $C_\mu = 0.56$.

Figure 10.- Concluded.
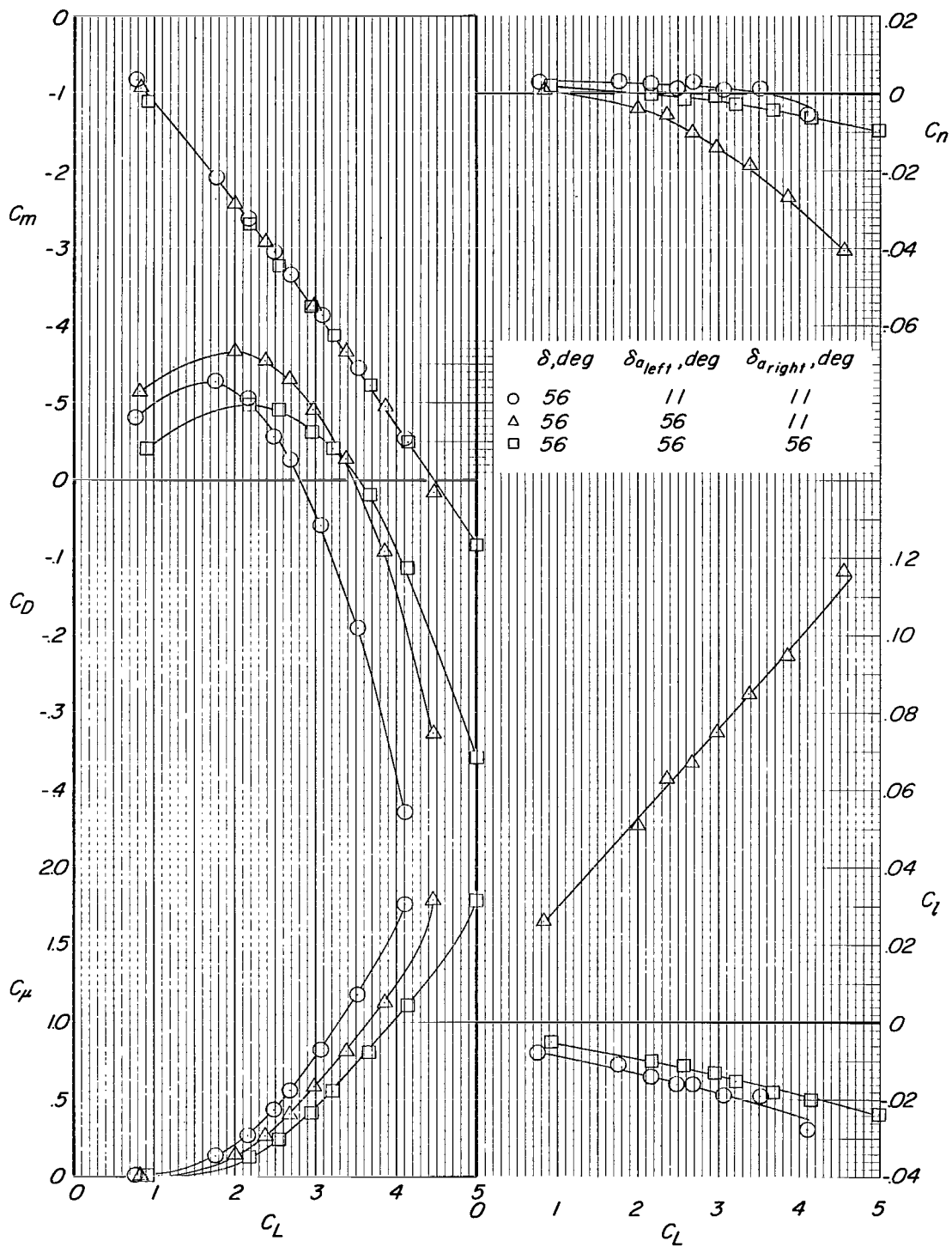
(a) h/$\bar{c}$ = 1.2.

Figure 11.- Effect of aileron jet angle through a range of blowing
momentums on wing. Canard removed; α = 0°.
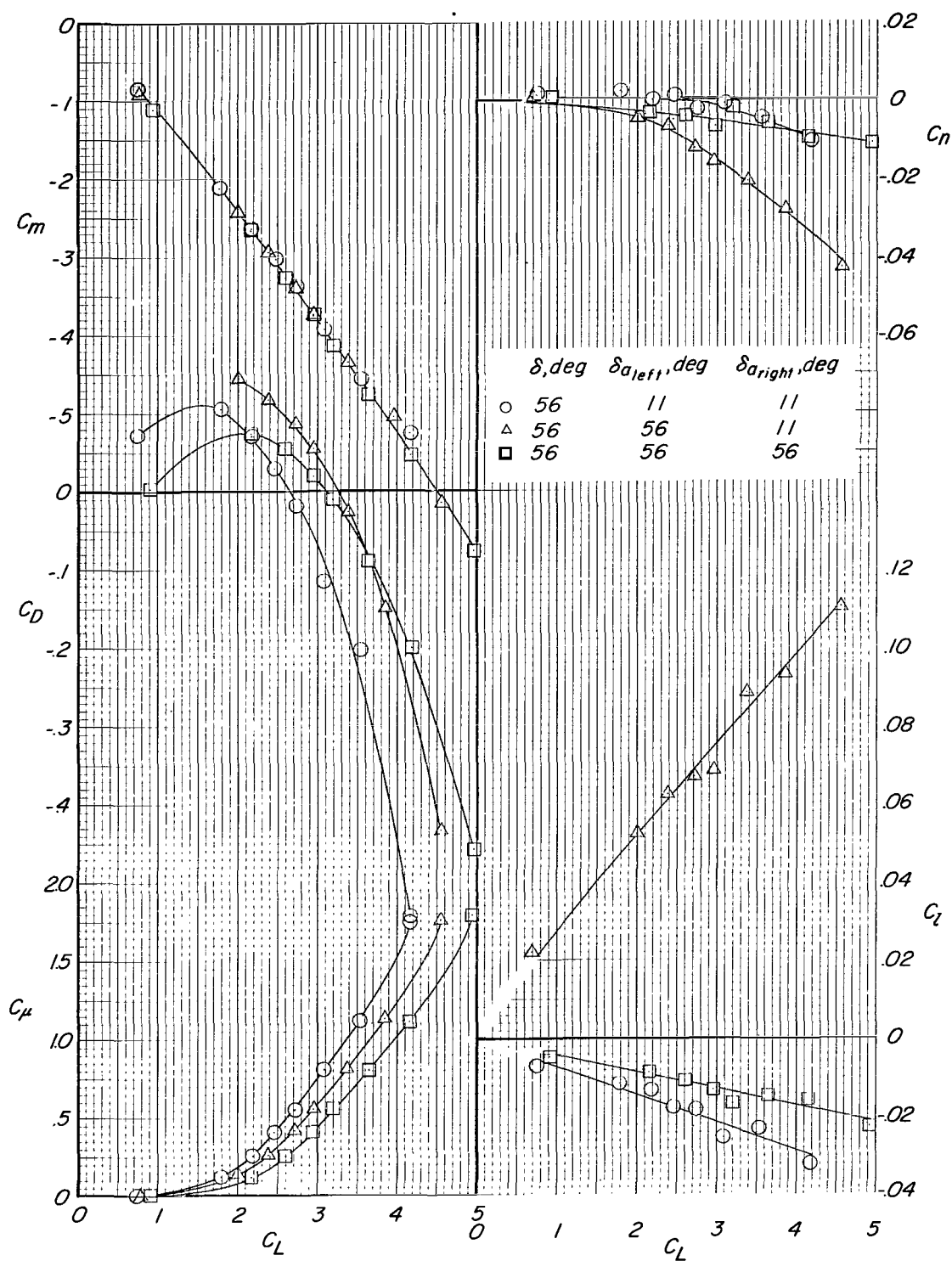
(b) h/$\bar{c}$ = 2.7.

Figure 11.- Concluded.
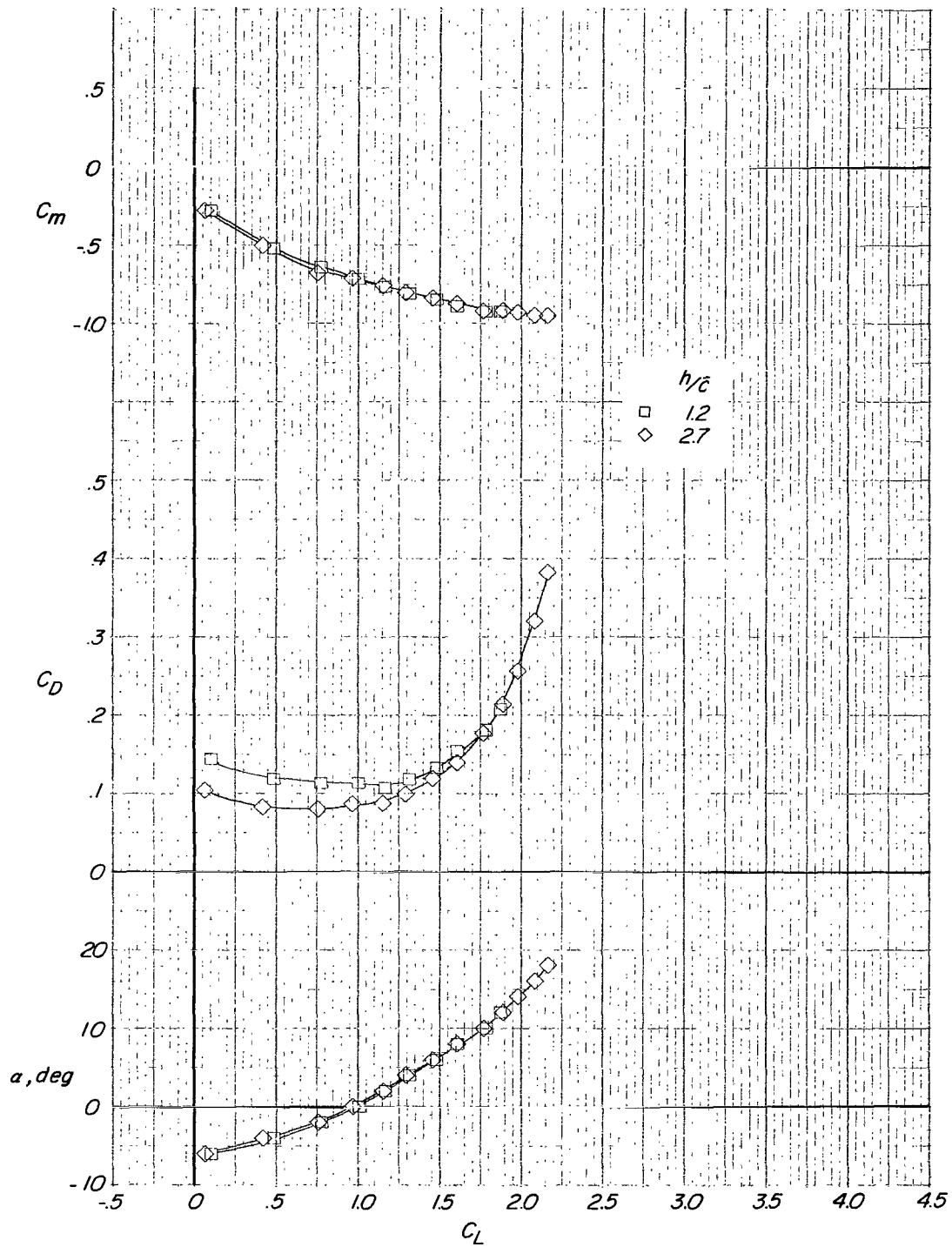
(a) $C_\mu = 0$.

Figure 12.- Aerodynamic characteristics of model with small canard.
$\delta_c = 56^\circ$; $\delta = 56^\circ$.
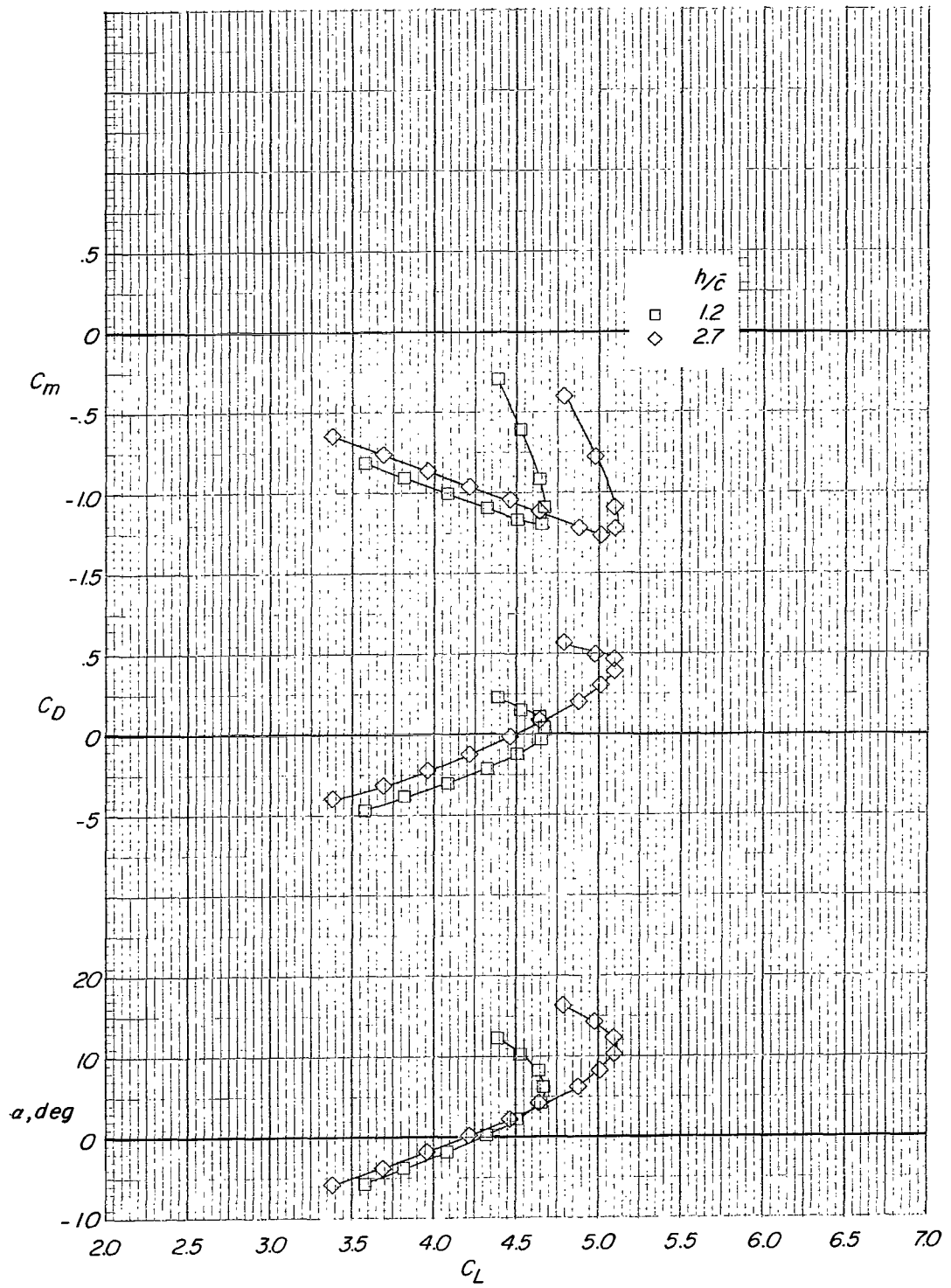
(b) $C_\mu = 1.5$; $\tau = 1.5$.

Figure 12.- Continued.
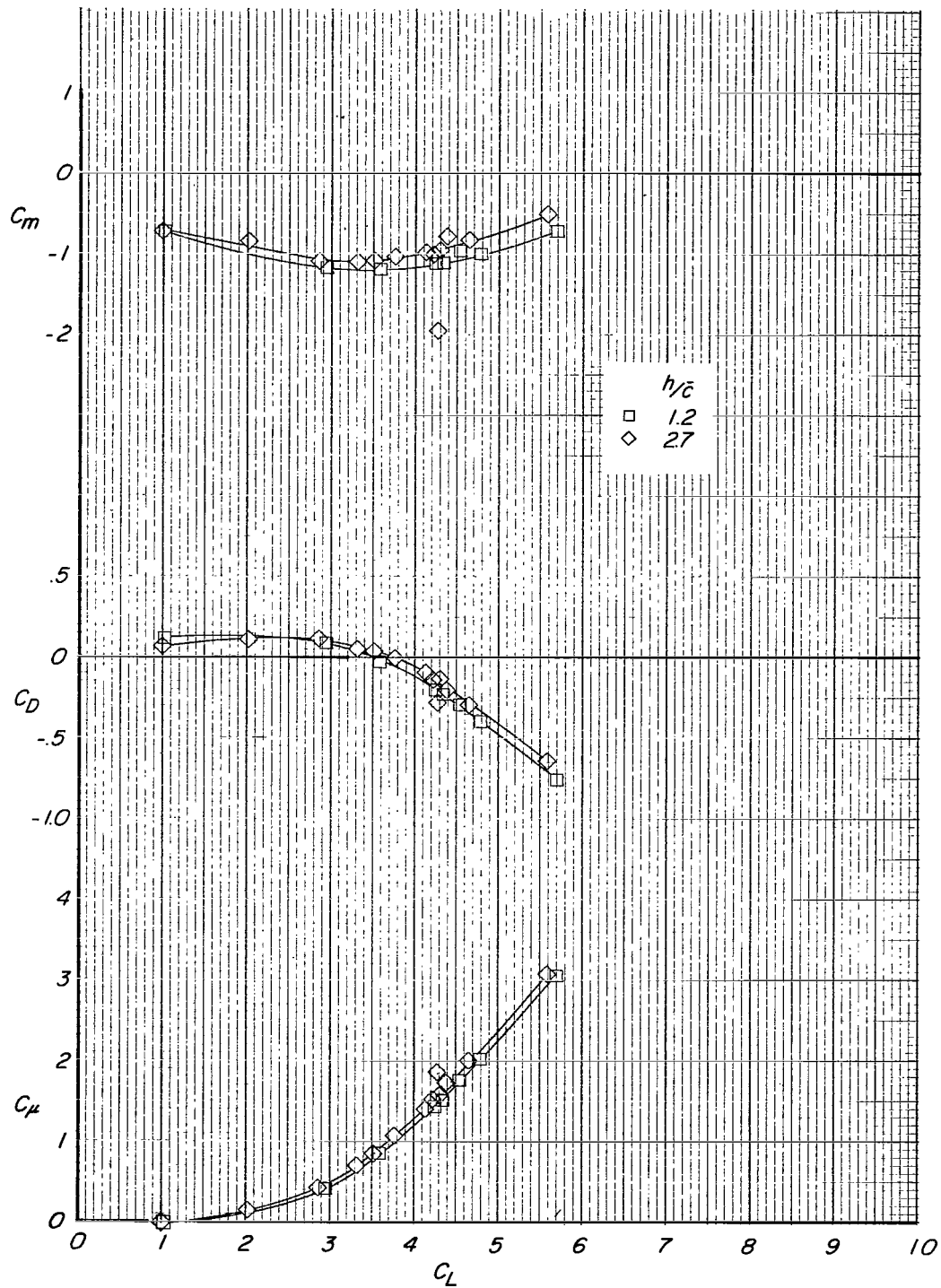
(c) C_μ = Range; τ = 1.5; α = 0°.

Figure 12.- Concluded.
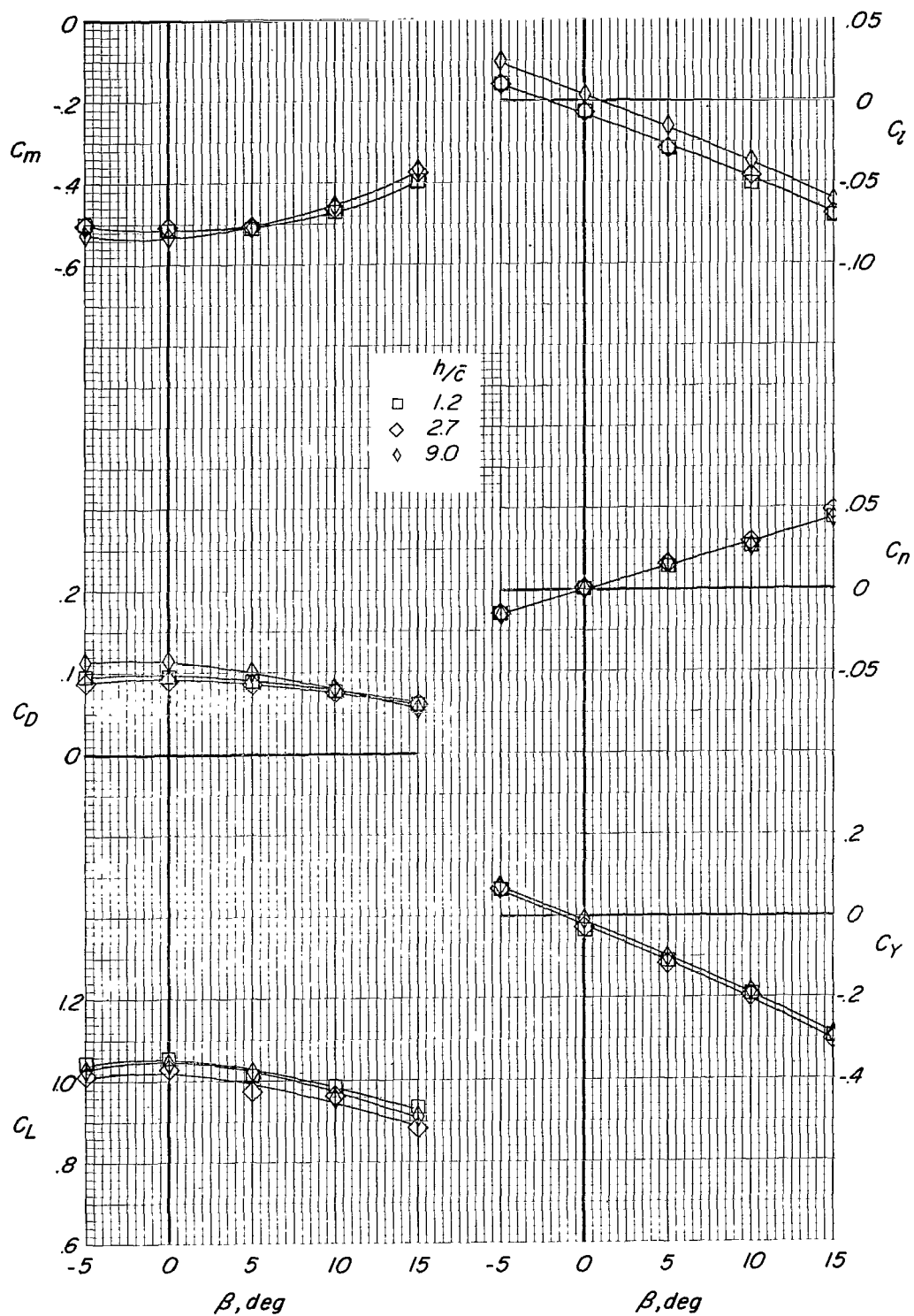
Figure 13.- Characteristics of model in sideslip at various model heights without blowing momentum. Large canard; $\delta_c = 56°$; $\delta = 56°$; $\alpha = 0°$.
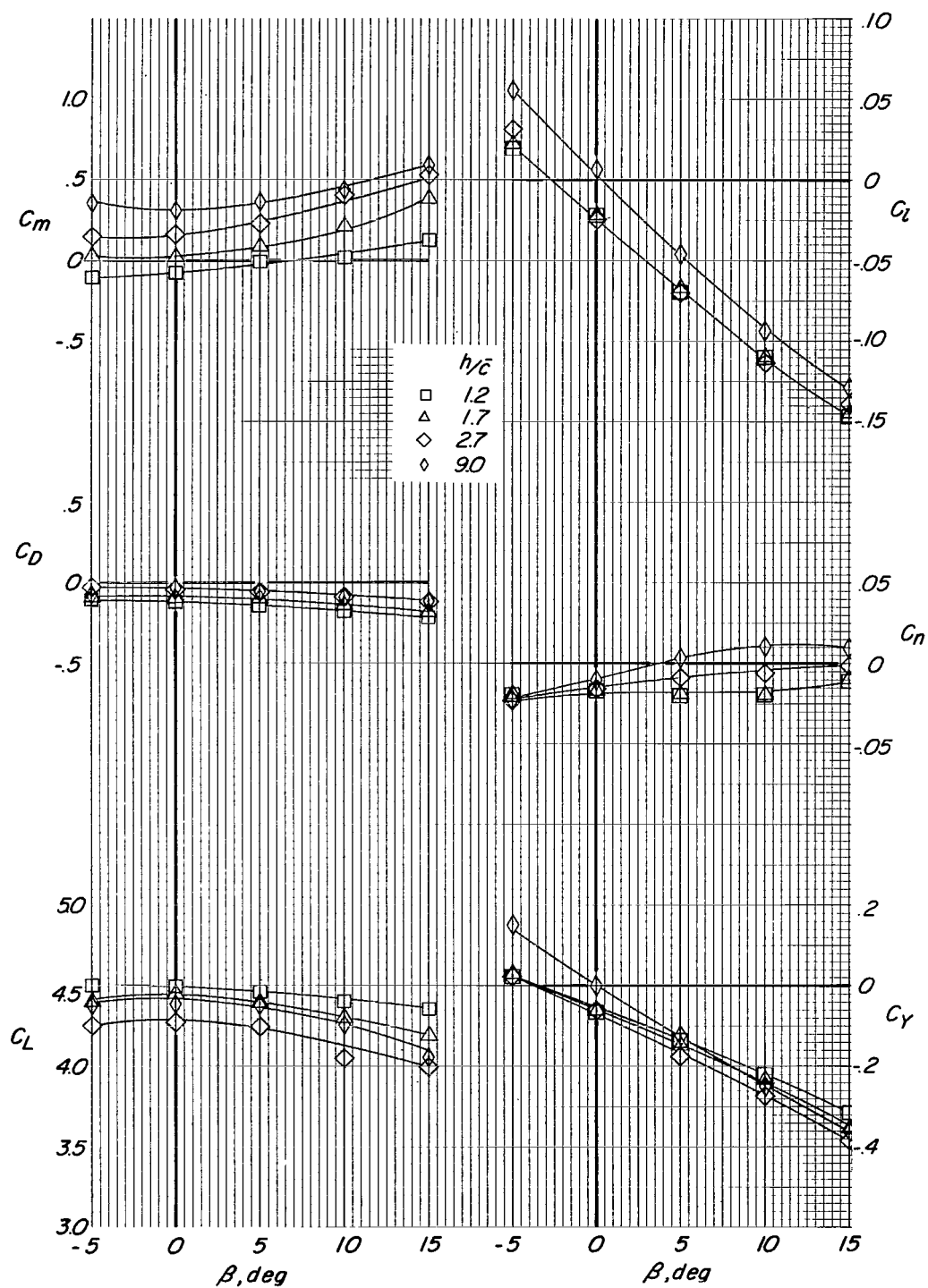
Figure 14.- Characteristics of model in sideslip at various model heights with blowing momentum on canard and wing. Large canard; $\delta_c = 56^\circ$; $\delta = 56^\circ$; $C_\mu = 1.45$; $\tau = 1.7$; $\alpha = 0^\circ$.
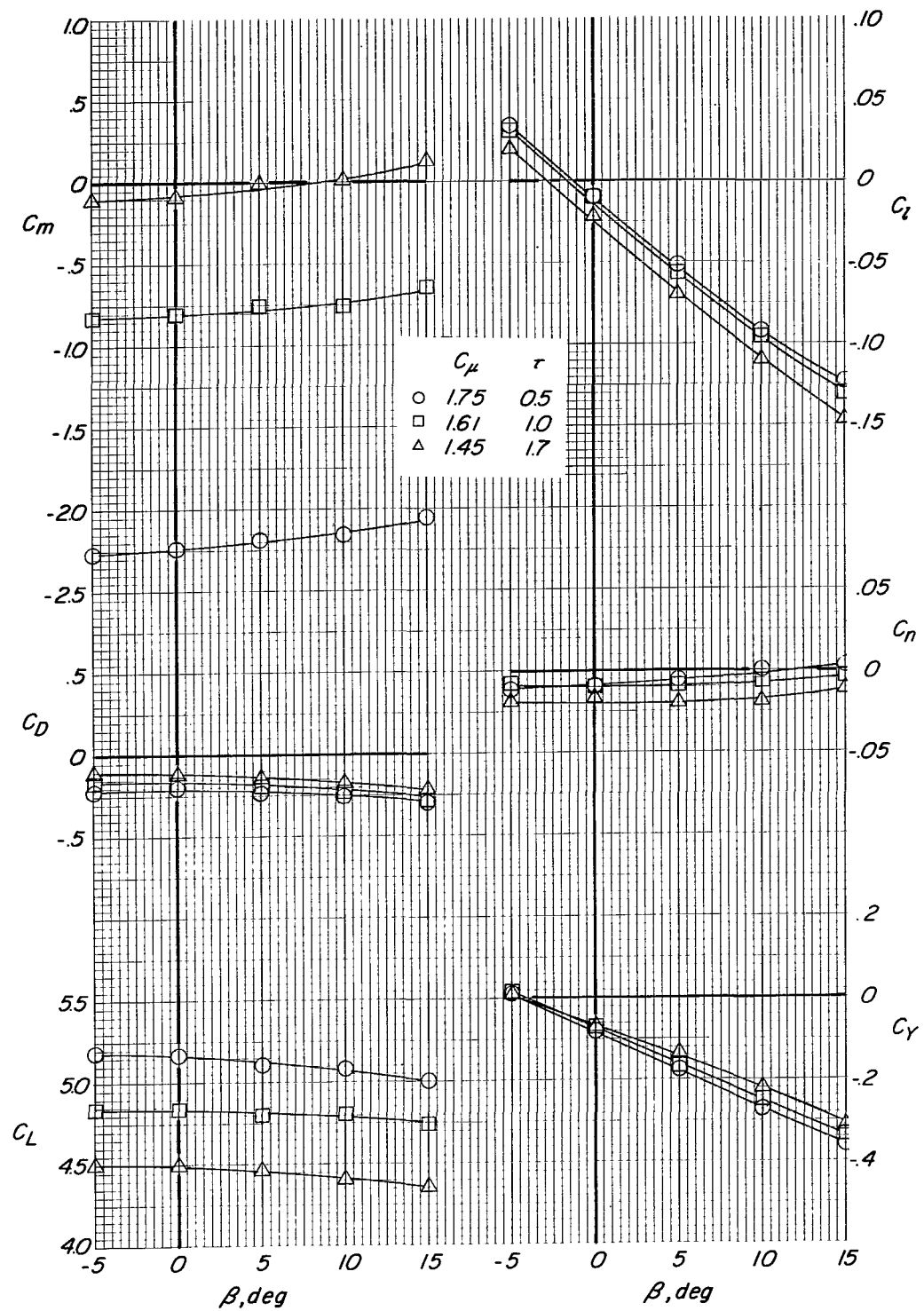
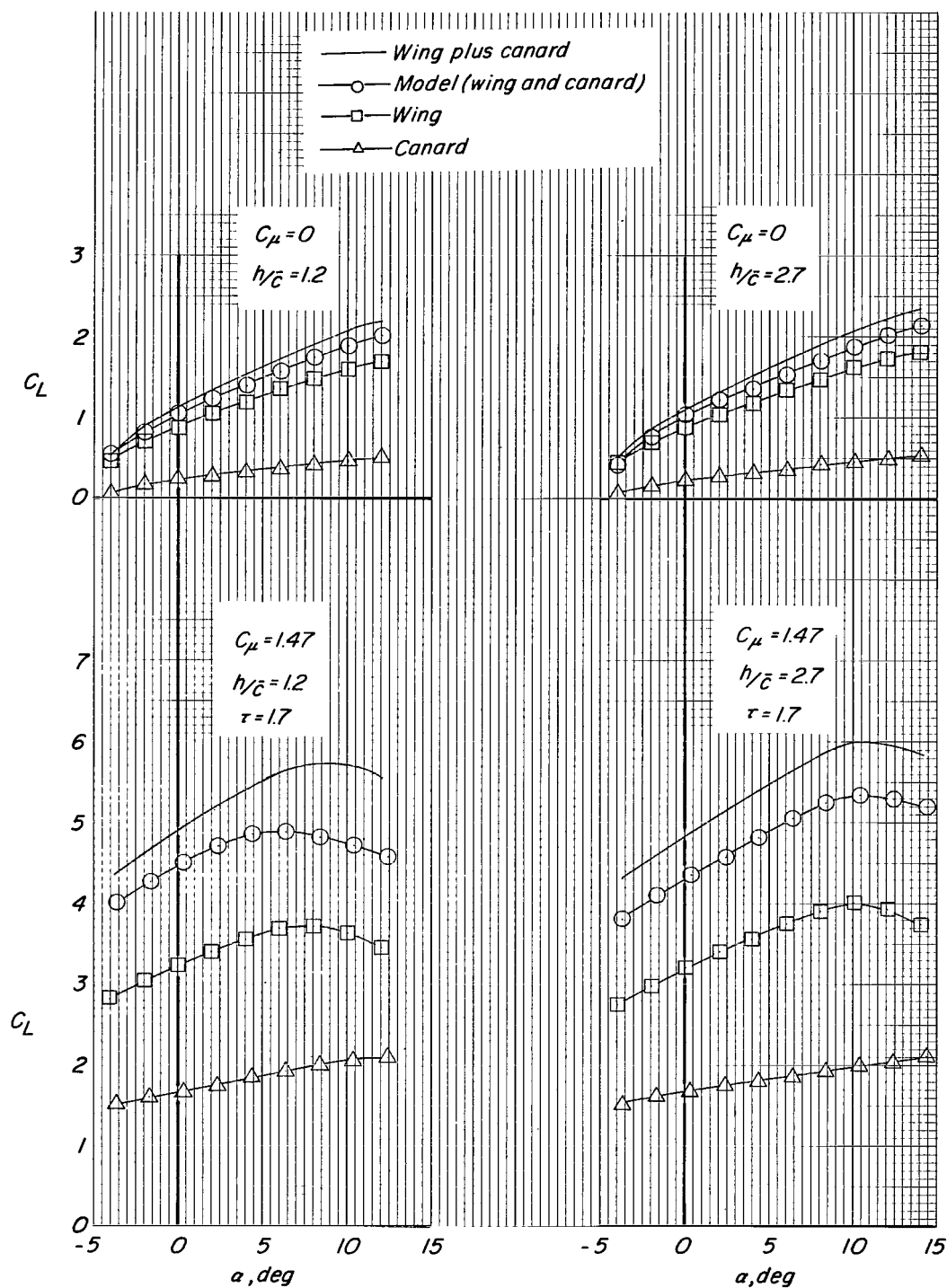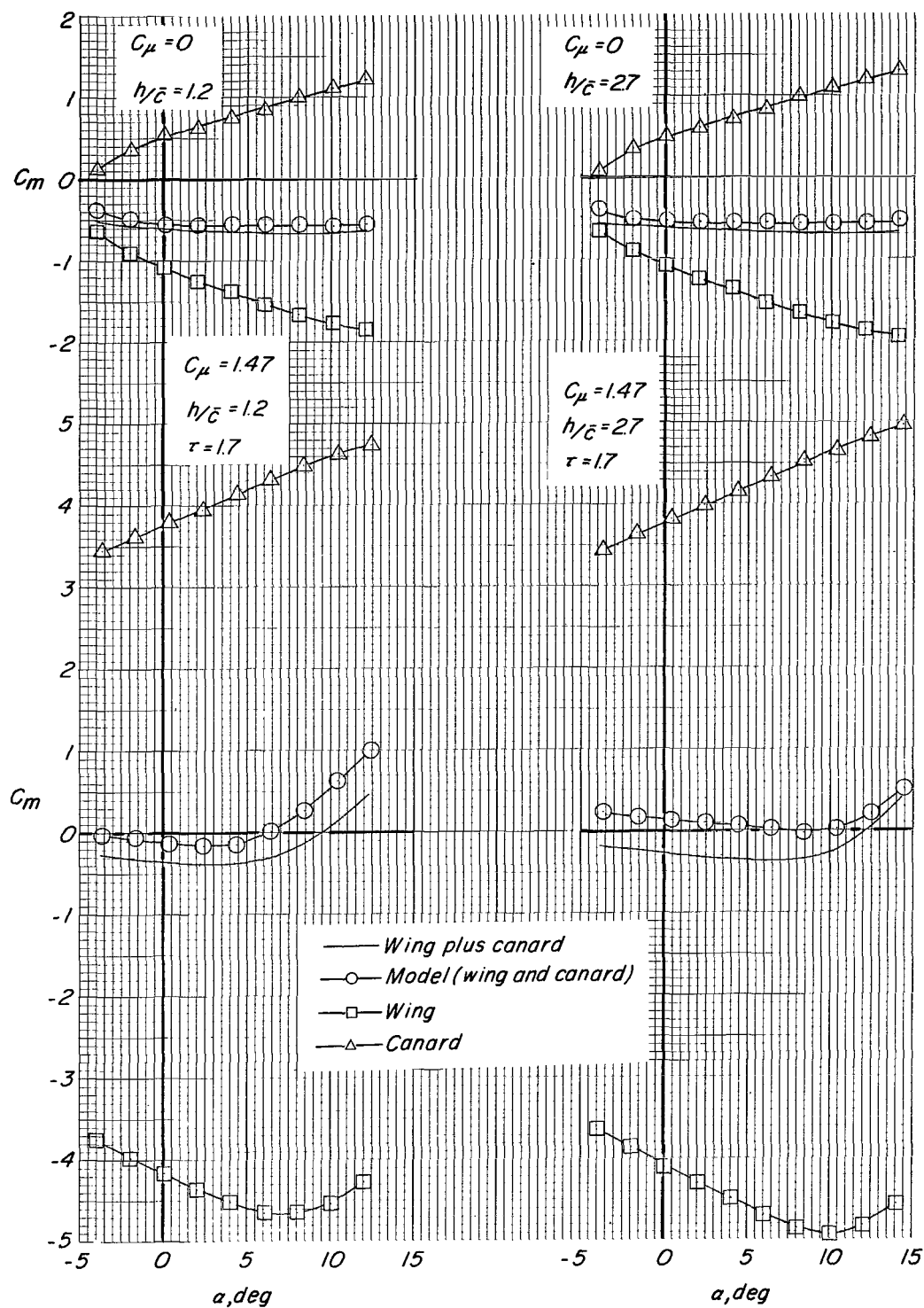Figure 15.- Effect of ratio of canard-wing blowing thrust on character-
istics of model in sideslip.   Large canard; $\delta_c = 56°$; $\delta = 56°$;
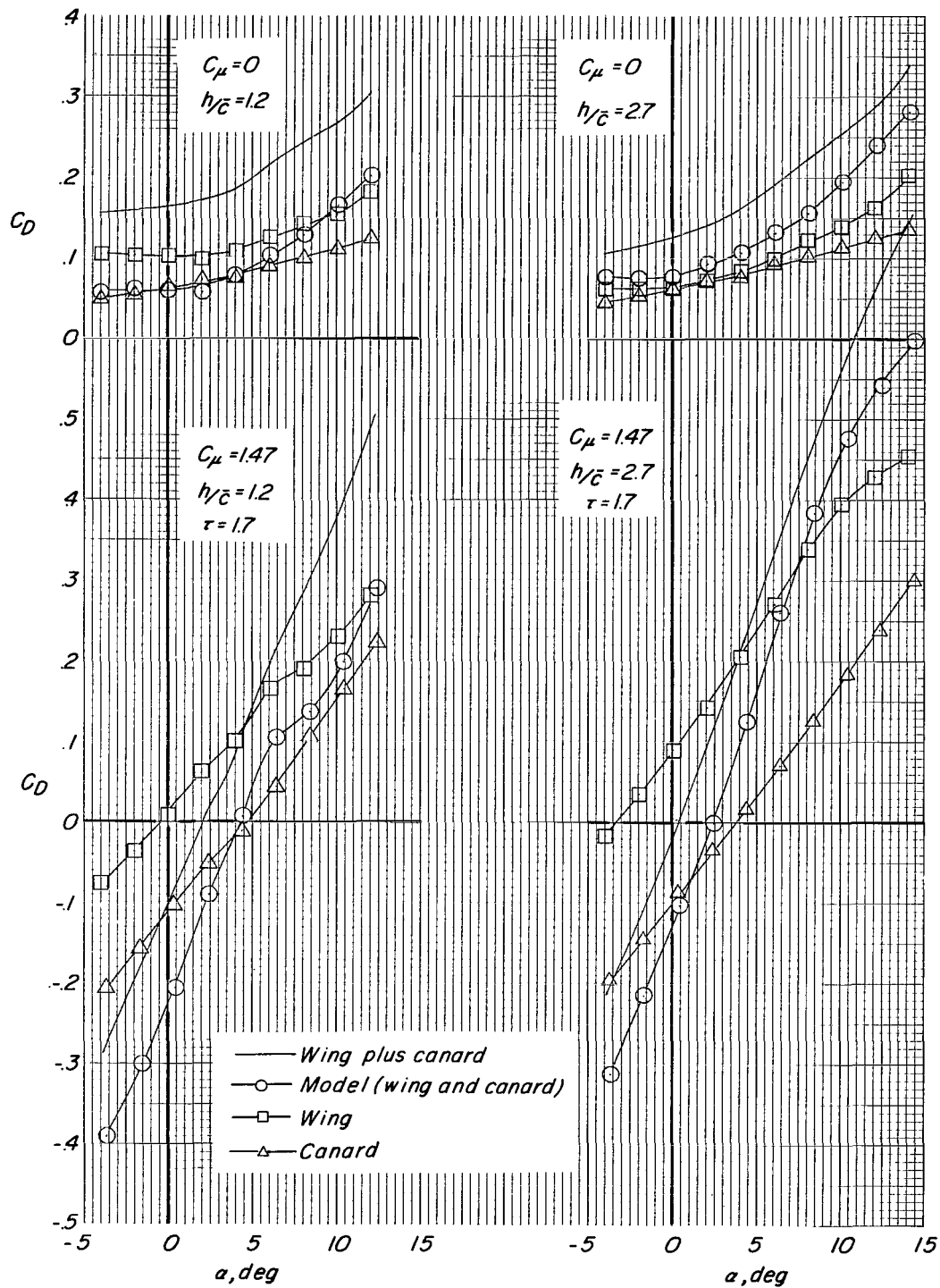$h/\bar{c} = 1.2$; $\alpha = 0°$.

(a) Lift coefficient.

Figure 16.- Interference effects between canard and wing as shown by a
comparison of data for model and summation of data for canard and
wing. Large canard; $\delta_c = 56°$; $\delta = 56°$.

(b) Pitching-moment coefficient.

Figure 16.- Continued.

(c) Drag coefficient.

Figure 16.- Concluded.

"The aeronautical and space activities of the United States shall be conducted so as to contribute . . . to the expansion of human knowledge of phenomena in the atmosphere and space. The Administration shall provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

— NATIONAL AERONAUTICS AND SPACE ACT OF 1958

NASA SCIENTIFIC AND TECHNICAL PUBLICATIONS

TECHNICAL REPORTS: Scientific and technical information considered important, complete, and a lasting contribution to existing knowledge.

TECHNICAL NOTES: Information less broad in scope but nevertheless of importance as a contribution to existing knowledge.

TECHNICAL MEMORANDUMS: Information receiving limited distribution because of preliminary data, security classification, or other reasons.

CONTRACTOR REPORTS: Scientific and technical information generated under a NASA contract or grant and considered an important contribution to existing knowledge.

TECHNICAL TRANSLATIONS: Information published in a foreign language considered to merit NASA distribution in English.

SPECIAL PUBLICATIONS: Information derived from or of value to NASA activities. Publications include conference proceedings, monographs, data compilations, handbooks, sourcebooks, and special bibliographies.

TECHNOLOGY UTILIZATION PUBLICATIONS: Information on technology used by NASA that may be of particular interest in commercial and other non-aerospace applications. Publications include Tech Briefs, Technology Utilization Reports and Notes, and Technology Surveys.

Details on the availability of these publications may be obtained from:

SCIENTIFIC AND TECHNICAL INFORMATION DIVISION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C. 20546