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# RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

## WIND-TUNNEL INVESTIGATION AT LOW SPEED OF THE ROLLING STABILITY DERIVATIVES OF A 1/9-SCALE POWERED MODEL OF THE CONVAIR XFY-1 VERTICALLY RISING AIRPLANE

TED NO. NACA DE 373

By M. J. Queijo, Walter D. Wolhart,
and H. S. Fletcher

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Langley Field, Va.



NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

WASHINGTON



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## SUMMARY

An experimental investigation has been conducted in the Langley stability tunnel at low speed to determine the rolling stability derivatives of a 1/9-scale powered model of the Convair XFY-1 vertically rising airplane. Effects of thrust coefficient were investigated for the complete model and for certain components of the model. Effects of control deflections and of propeller blade angle were investigated for the complete model. Most of the tests were made through an angle-of-attack range from about -4° to 29°, and the thrust coefficient range was from 0 to 0.7.

In order to expedite distribution of these data, no analysis of the data has been prepared for this paper.

## INTRODUCTION

Various investigations have shown that the dynamic stability characteristics of high-speed aircraft are critically dependent on certain mass and aerodynamic parameters and, hence, that reliable estimates of the dynamic stability of such aircraft can be made only if these parameters are determined accurately. The purpose of the present investigation was to determine the rolling stability derivatives of a powered model of the Convair XFY-1 vertically rising airplane from a series of low-speed tests in the Langley stability tunnel. These tests were made at the request of the Bureau of Aeronautics to aid in the development of the XFY-1 airplane. The results of previous investigations to determine the static longitudinal and lateral stability derivatives and the yawing stability derivatives of the same model are given in references 1 and 2, respectively.

## SYMBOLS AND COEFFICIENTS

The data presented herein are in the form of standard NACA coefficients of forces and moments which are referred to the system of stability axes (fig. 1) with the origin at the projection of the 14-percent wing mean aerodynamic chord on the plane of symmetry. This system of axes is defined as an orthogonal system having the origin at the assumed center of gravity and in which the Z-axis is in the plane of symmetry and perpendicular to the relative wind, the X-axis is in the plane of symmetry and perpendicular to the Z-axis, and Y-axis is perpendicular to the plane of symmetry. Positive directions of forces, moments, and displacements are shown in figure 1.

$b$ theoretical wing span, 2.86 ft

$d$ local propeller blade chord, ft

$h$ maximum blade thickness at local chord, ft

$D$ propeller diameter, ft

$q$ dynamic pressure, $\frac{1}{2}\rho V^2$, lb/sq ft

$r_O$ radial distance from propeller hub center line, ft

$p$ rolling angular velocity, radians/sec

$R$ propeller radius, 0.889 ft

$S$ area of theoretical wing, 4.27 sq ft

$V$ free-stream velocity, ft/sec

$\alpha$ wing angle of attack, deg

$\beta$ sideslip angle, radians

$(\beta_o)_F$ front propeller blade angle measured at 0.75R, deg

$\gamma$ angle of climb, deg

$\delta_e$ elevator deflection, positive trailing edge down, deg

$\delta_R$ rudder deflection, positive trailing edge to left, deg

$\psi$ angle of yaw, deg

$\theta$ local blade angle, deg

$\phi$ angle of roll, deg

$\rho$ mass density of air, slugs/cu ft

L lift, lb

X longitudinal force, lb

Y side force, lb

T thrust, lb $\left(T = X_{\text{propellers on}} - X_{\text{propellers off}}\right.$, for complete model at $\left.\alpha = 0^\circ\right)$

N yawing moment, ft-lb

$l$ rolling moment, ft-lb

$C_L$ lift coefficient, $L/qS$

$C_Y$ side-force coefficient, $Y/qS$

$T_c{}'$ thrust coefficient, $T/qS$

$C_n$ yawing-moment coefficient, $N/qSb$

$C_l$ rolling-moment coefficient, $l/qSb$

$\frac{pb}{2V}$ rolling velocity parameter

$$C_{y_p} = \frac{\partial C_y}{\partial \frac{pb}{2V}}$$

$$C_{l_p} = \frac{\partial C_l}{\partial \frac{pb}{2V}}$$

$$C_{n_p} = \frac{\partial C_n}{\partial \frac{pb}{2V}}$$

Abbreviations:

| | |
|---|---|
| W | wing |
| $T_u$ | upper tail |
| $T_L$ | lower tail |
| F | fuselage |
| P | propeller |

Subscripts:

| | |
|---|---|
| F | front |
| L | left |
| R | right |

## MODEL AND APPARATUS

The model used in this investigation was a 1/9-scale powered model of the Convair XFY-1 vertically rising airplane. Pertinent geometric characteristics of the model are given in figure 2. The wing was built around a core made from 1/2-inch-thick duralumin sheet and was built up to the proper contour with laminated mahogany. The fuselage and fins were constructed of laminated mahogany. All control surfaces were made of solid duralumin. The wing and fins had modified NACA 63-009 airfoil contours parallel to the model thrust line.

The propeller blades, for which the geometric characteristics are given in figure 3, were constructed of heat-treated duralumin and were driven by a 50-horsepower water-cooled motor. The motor was equipped with a dual-rotating gear box. Power for the model motor was supplied by a 75-kilowatt motor-generator set, which is part of the equipment of the Langley stability tunnel. Propeller speeds were measured by means of a Stroboconn unit in conjunction with an alternator driven directly by the model motor.

A two-strut support system was used to attach the model to a six-component balance system. Photographs of the model mounted on the struts are given as figure 4. All tests were made in the Langley stability tunnel in which rolling flow is simulated by curving the air stream about a stationary model (ref. 3).

## TESTS

Most of the tests of the present investigation were made at a dynamic pressure of 16 lb/sq ft, which corresponds to a Mach number of about 0.11 and a Reynolds number of $1.28 \times 10^6$ based on the wing mean aerodynamic chord of 1.73 feet. Tests at a thrust coefficient of 0.7 and angles of attack greater than about $8^\circ$ were made at a dynamic pressure of 8 lb/sq ft to minimize the danger of breaking propeller blades and the resulting damage to the model. Propeller blades had been broken on this model in two previous instances while conducting the tests of reference 2. In both cases the accidents had occurred at a dynamic pressure of 16 lb/sq ft and at an angle of attack of about $20^\circ$.

Most tests of the present investigation were made with controls in the neutral position and with the front blades set at $\left(\beta_o\right)_F = 25^\circ$. A few tests were made to determine effects of blade angle on the yawing stability derivatives. In all cases the rear blades were set at $1^\circ$ less than the front blades. Effects of control deflections also were investigated.

The rolling stability derivatives of three basic model configurations were investigated; these configurations were as follows:

Wing with fuselage and propellers . . . . . . . . . . . . . . $W + F + P$
Wing with fuselage, upper tail, and propeller . . . . . $W + F + T_u + P$
Complete model (wing with fuselage, upper tail, lower
tail, and propeller) . . . . . . . . . . . . . . $W + F + T_u + T_L + P$

The characteristics of these configurations with propellers removed also were investigated.

Tests were made at values of $\frac{pb}{2V}$ of about 0, $\pm 0.045$, and $\pm 0.073$.

Power-on data were obtained for several thrust coefficients from 0 to 0.7. The thrust coefficient was held constant for any particular test by holding the propeller speed constant while varying the angle of attack. The scope of this investigation is indicated in table I.

## CORRECTIONS

Approximate corrections for jet-boundary effects were applied to the angle of attack by the methods of reference 4. Blockage corrections were determined and applied by the methods of reference 5. Strut-tare corrections were determined experimentally and applied to all data.

## PRESENTATION OF RESULTS

The results of the investigation are presented in figures 5 to 8. The data, model configuration, and figure in which the data are shown are indicated in table I for convenience in locating desired information. All moment data are referred to the system of stability axes with the origin at the projection of the 14-percent wing mean aerodynamic chord on the plane of symmetry.

## CONCLUDING REMARKS

An experimental investigation has been made in the Langley stability tunnel at low speed to determine the rolling stability derivatives of a 1/9-scale powered model of the Convair XFY-1 vertically rising airplane. Effects of thrust coefficient were investigated for the complete model and for certain components of the model. Effects of control deflection and of propeller blade angle were investigated for the complete model. Most of the tests were made through an angle-of-attack range from about $-4^{\circ}$ to $29^{\circ}$, and the thrust-coefficient range was from 0 to 0.7.

In order to expedite distribution of these data, no analysis of the data has been prepared for this paper.

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## REFERENCES

1. Queijo, M. J., Wolhart, W. D., and Fletcher, H. S.: Wind-Tunnel Investigation at Low Speed of the Static Longitudinal and Lateral Stability Characteristics of a 1/9-Scale Powered Model of the Convair XFY-1 Vertically Rising Airplane - TED No. NACA DE 373. NACA RM SL53B20, Bur. Aero., 1953.

2. Queijo, M. J., Wolhart, W. D., and Fletcher, H. S.: Wind-Tunnel Investigation at Low Speed of the Yawing Stability Derivatives of a 1/9-Scale Powered Model of the Convair XFY-1 Vertically Rising Airplane - TED No. NACA DE 373. NACA RM SL53D01, Bur. Aero., 1953.

3. MacLachlan, Robert, and Letko, William: Correlation of Two Experimental Methods of Determining the Rolling Characteristics of Unswept Wings. NACA TN 1309, 1947.

4. Silverstein, Abe, and White, James A.: Wind-Tunnel Interference With Particular Reference to Off-Center Positions of the Wing and to the Downwash at the Tail. NACA Rep. 547, 1936.

5. Herriot, John C.: Blockage Corrections for Three-Dimensional-Flow Closed-Throat Wind Tunnels, With Consideration of the Effect of Compressibility. NACA Rep. 995, 1950. (Supersedes NACA RM A7B28.)

TABLE I

SUMMARY OF MODEL CONFIGURATIONS TESTED,

TEST VARIABLES, AND DATA PRESENTED

| Model configuration | Data presented | Figure |
| --- | --- | --- |
| $W + F + T_u + T_L + P$<br>$(\beta_o)_F = 25^\circ, 35^\circ, 50^\circ$ | $T_c'$ against propeller speed | 5 |
| $W + F$<br>$W + F + P$, $(\beta_o)_F = 25^\circ$ | $C_{Y_p}$, $C_{l_p}$, $C_{n_p}$ against $C_L$ for various thrust coefficients | 6(a) |
| $W + F + T_u$<br>$W + F + T_u + P$, $(\beta_o)_F = 25^\circ$ | $C_{Y_p}$, $C_{l_p}$, $C_{n_p}$ against $C_L$ for various thrust coefficients | 6(b) |
| $W + F + T_u + T_L$<br>$W + F + T_u + T_L + P$, $(\beta_o)_F = 25^\circ$ | $C_{Y_p}$, $C_{l_p}$, $C_{n_p}$ against $C_L$ for various thrust coefficients | 6(c) |
| $W + F + T_u + T_L + P$, $T_c' = 0$ | $C_{Y_p}$, $C_{l_p}$, $C_{n_p}$ against $C_L$ for $(\beta_o)_F = 25^\circ, 35^\circ, 50^\circ$ | 7(a) |
| $W + F + T_u + T_L + P$, $T_c' = 0.2$ | $C_{Y_p}$, $C_{l_p}$, $C_{n_p}$ against $C_L$ for $(\beta_o)_F = 25^\circ, 35^\circ, 50^\circ$ | 7(b) |
| $W + F + T_u + T_L + P$, $T_c' = 0.4$ | $C_{Y_p}$, $C_{l_p}$, $C_{n_p}$ against $C_L$ for $(\beta_o)_F = 25^\circ, 35^\circ$ | 7(c) |
| $W + F + T_u + T_L + P$, $(\beta_o)_F = 25^\circ$<br>$T_c' = 0$ | $C_{Y_p}$, $C_{l_p}$, $C_{n_p}$ against $\alpha$ for various control deflections | 8(a) |
| $W + F + T_u + T_L + P$, $(\beta_o)_F = 25^\circ$<br>$T_c' = 0.2$ | $C_{Y_p}$, $C_{l_p}$, $C_{n_p}$ against $\alpha$ for various control deflections | 8(b) |
| $W + F + T_u + T_L + P$, $(\beta_o)_F = 25^\circ$<br>$T_c' = 0.4$ | $C_{Y_p}$, $C_{l_p}$, $C_{n_p}$ against $\alpha$ for various control deflections | 8(c) |
| $W + F + T_u + T_L + P$, $(\beta_o)_F = 25^\circ$<br>$T_c' = 0.7$ | $C_{Y_p}$, $C_{l_p}$, $C_{n_p}$ against $\alpha$ for various control deflections | 8(d) |

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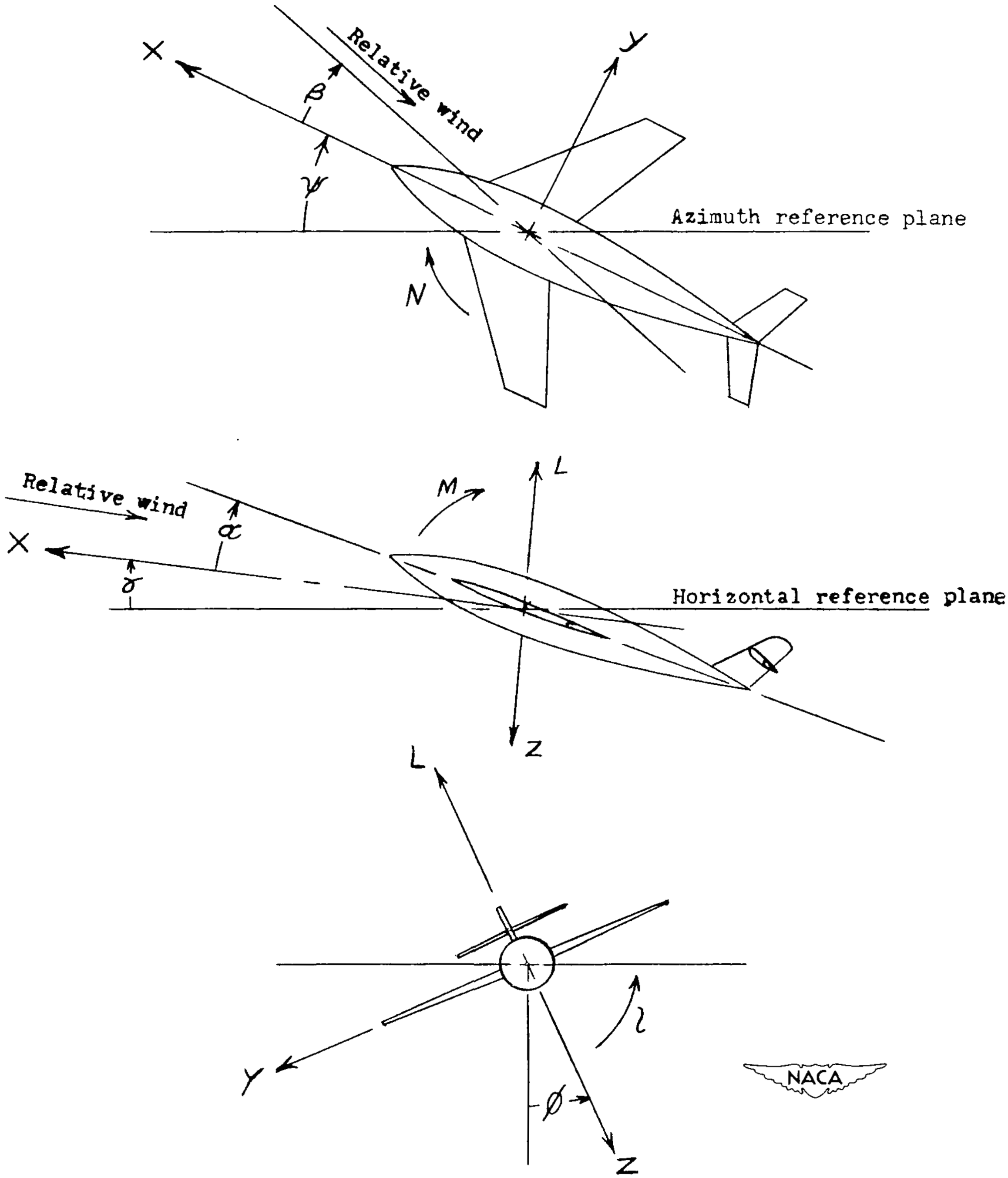



Figure 1.- System of stability axes. Arrows indicate positive direction of forces, moments, and displacements.

[redacted]

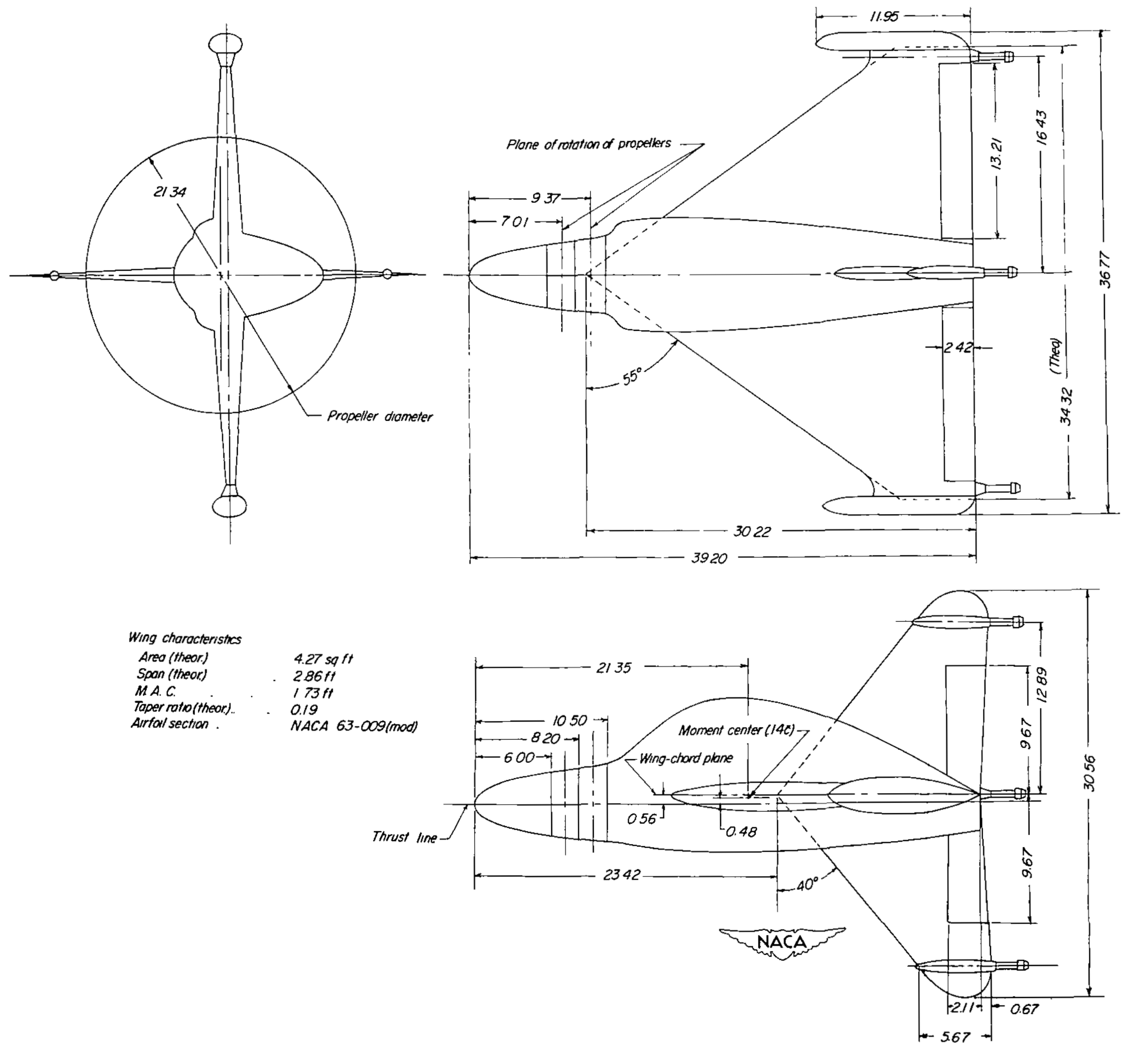



Figure 2.- Geometric characteristics of model. All dimensions are in inches.

[redacted]

[redacted]

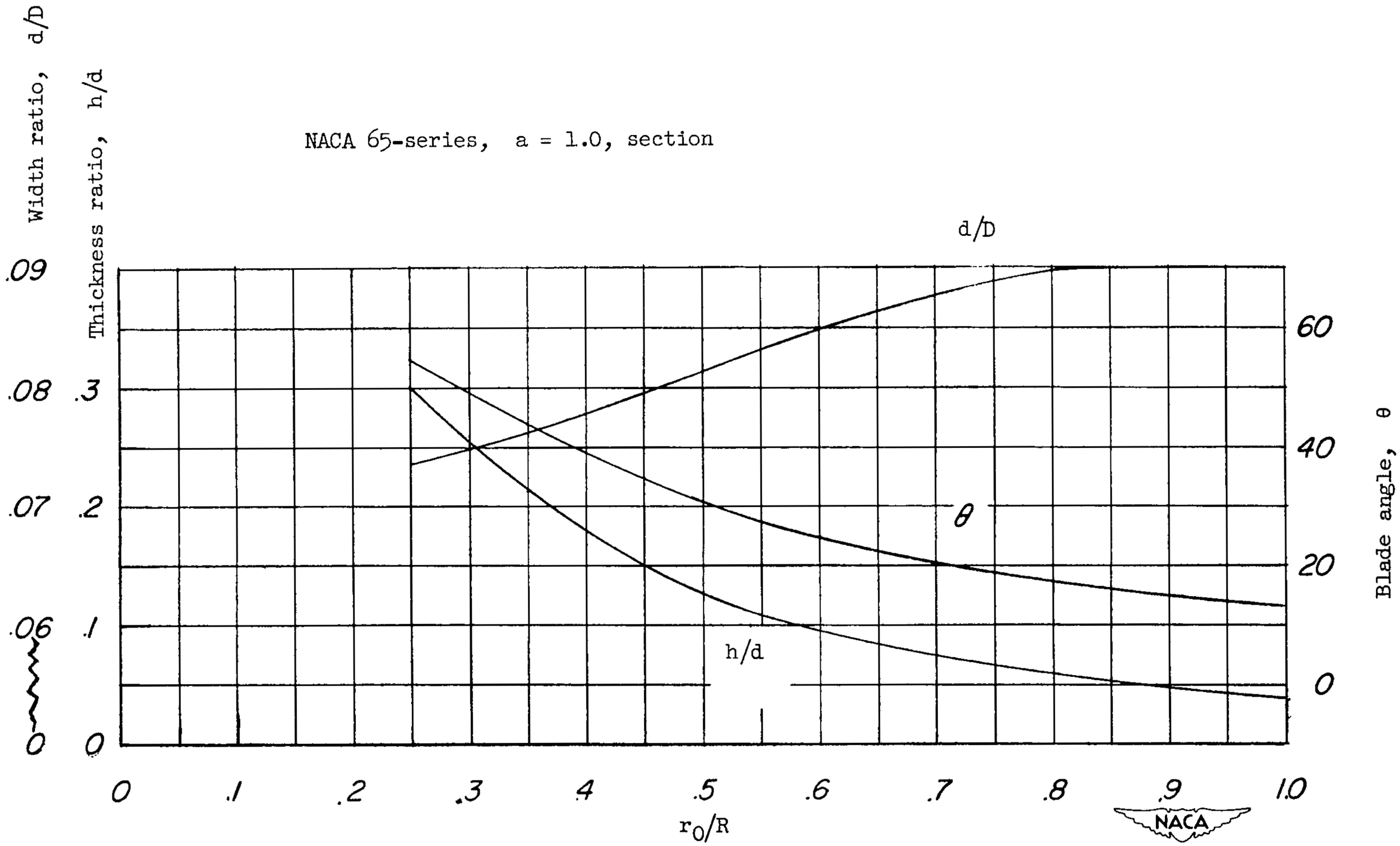
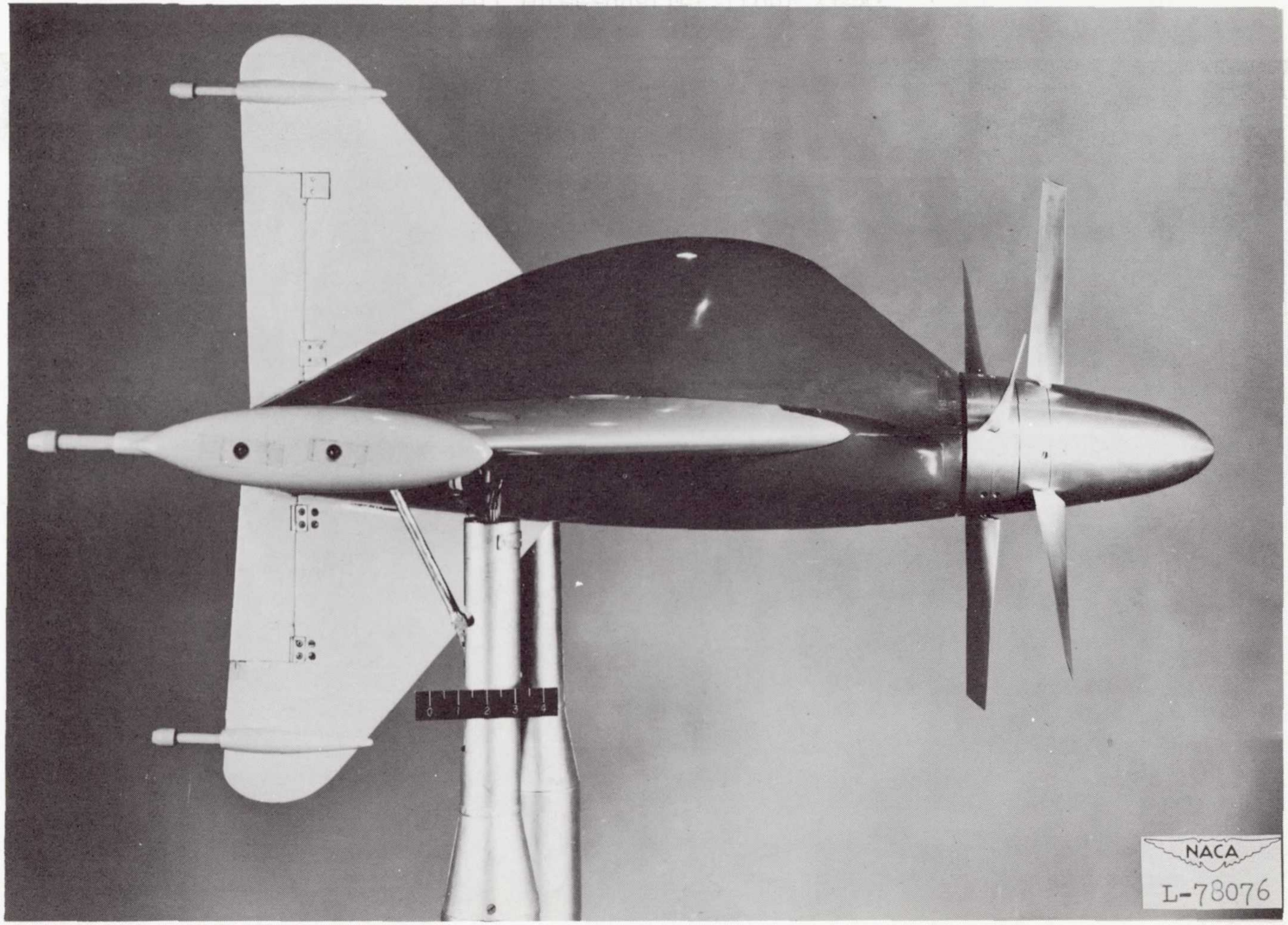


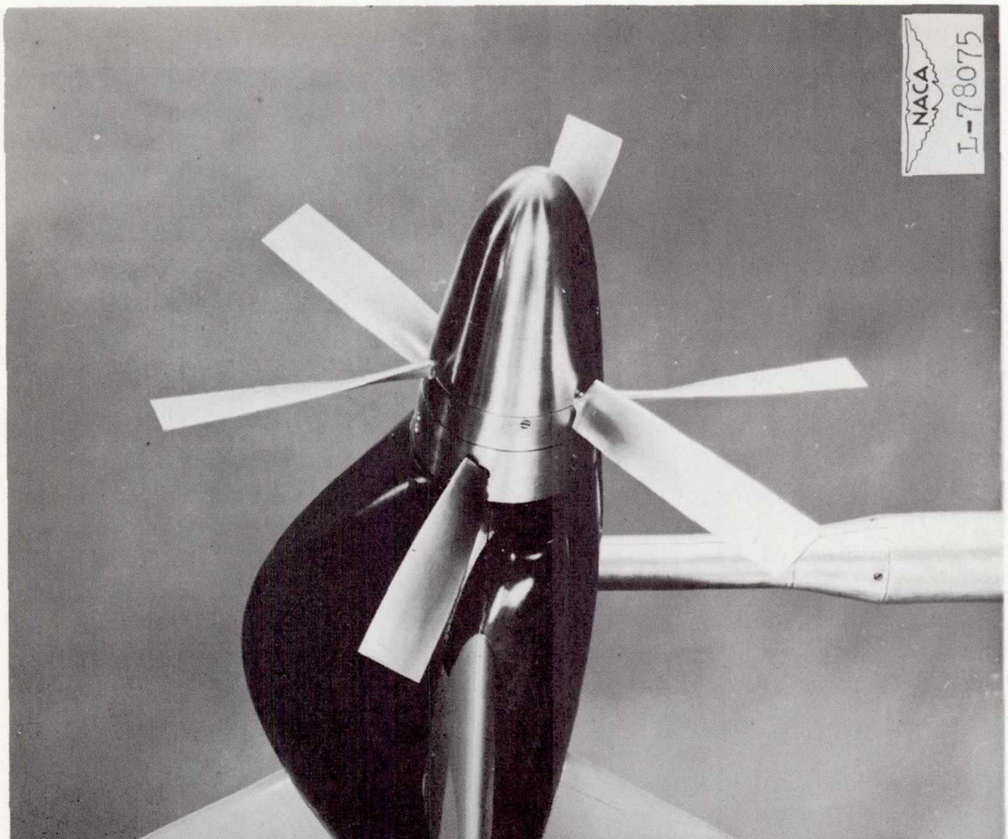

Figure 3.- Geometric characteristics of propeller blades used on a 1/9-scale model of the Convair XFY-1 vertically rising airplane. R = 0.889 foot.

[redacted]




(a) Side view.

Figure 4.- Photographs of model used in investigation.




(b) Three-quarter front view.

Figure 4.- Concluded.

[redacted]

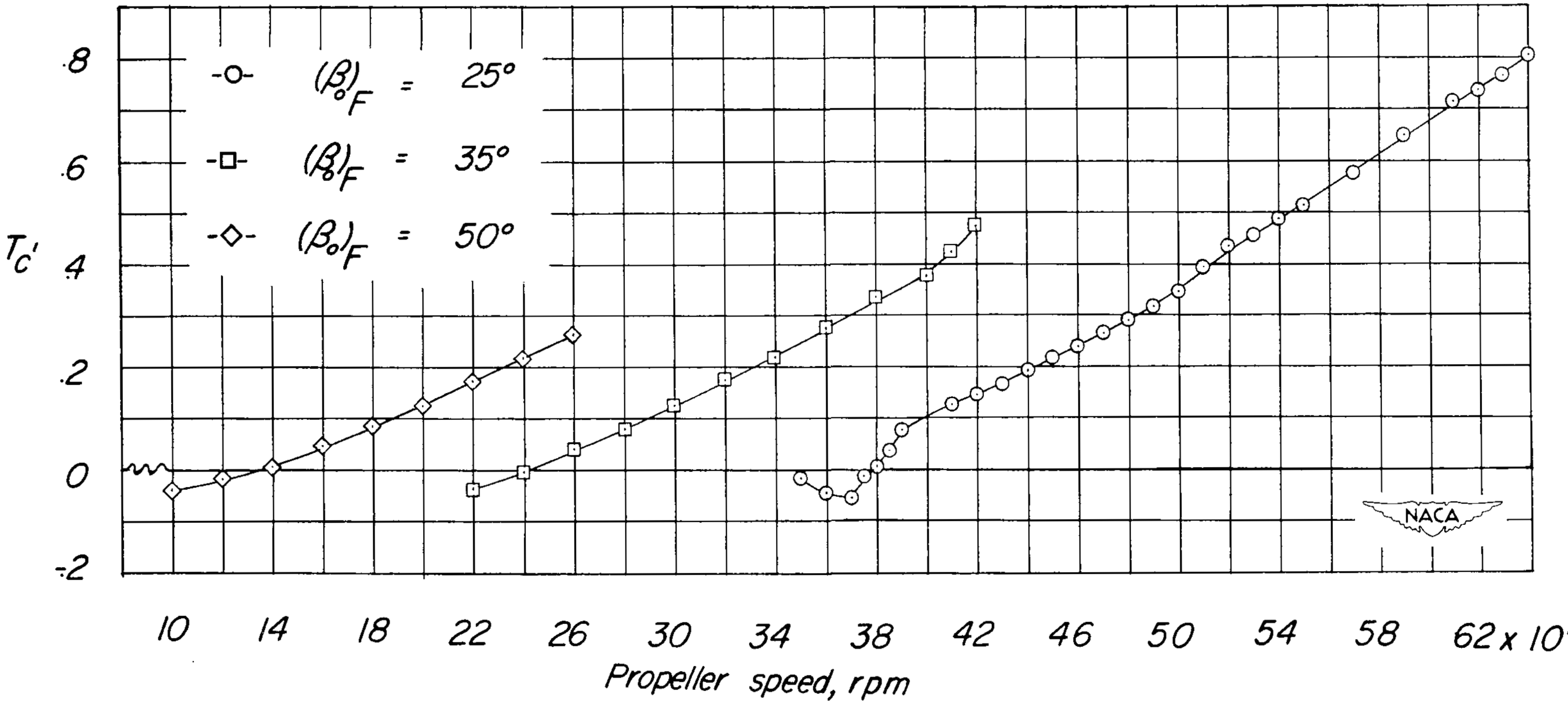
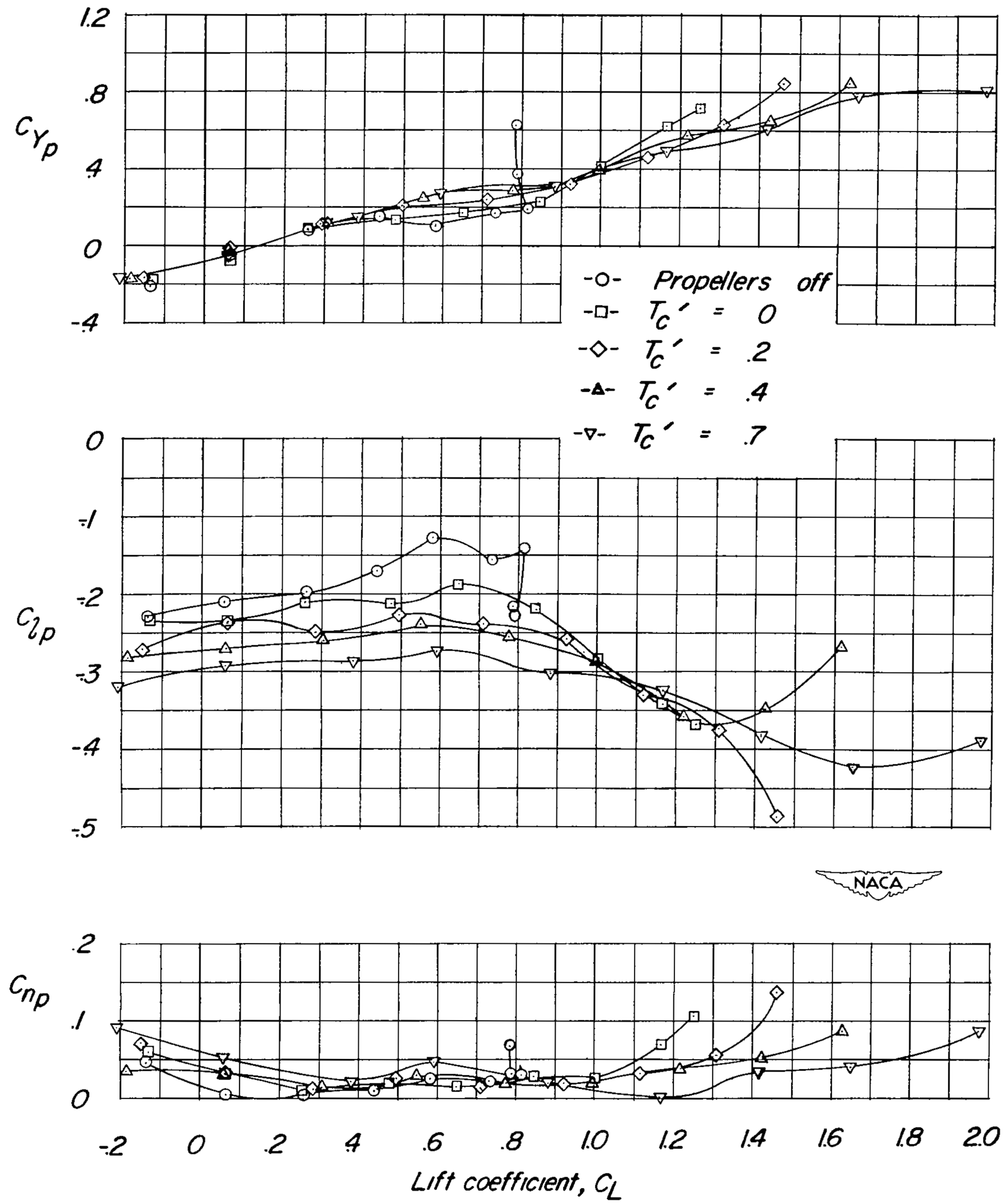


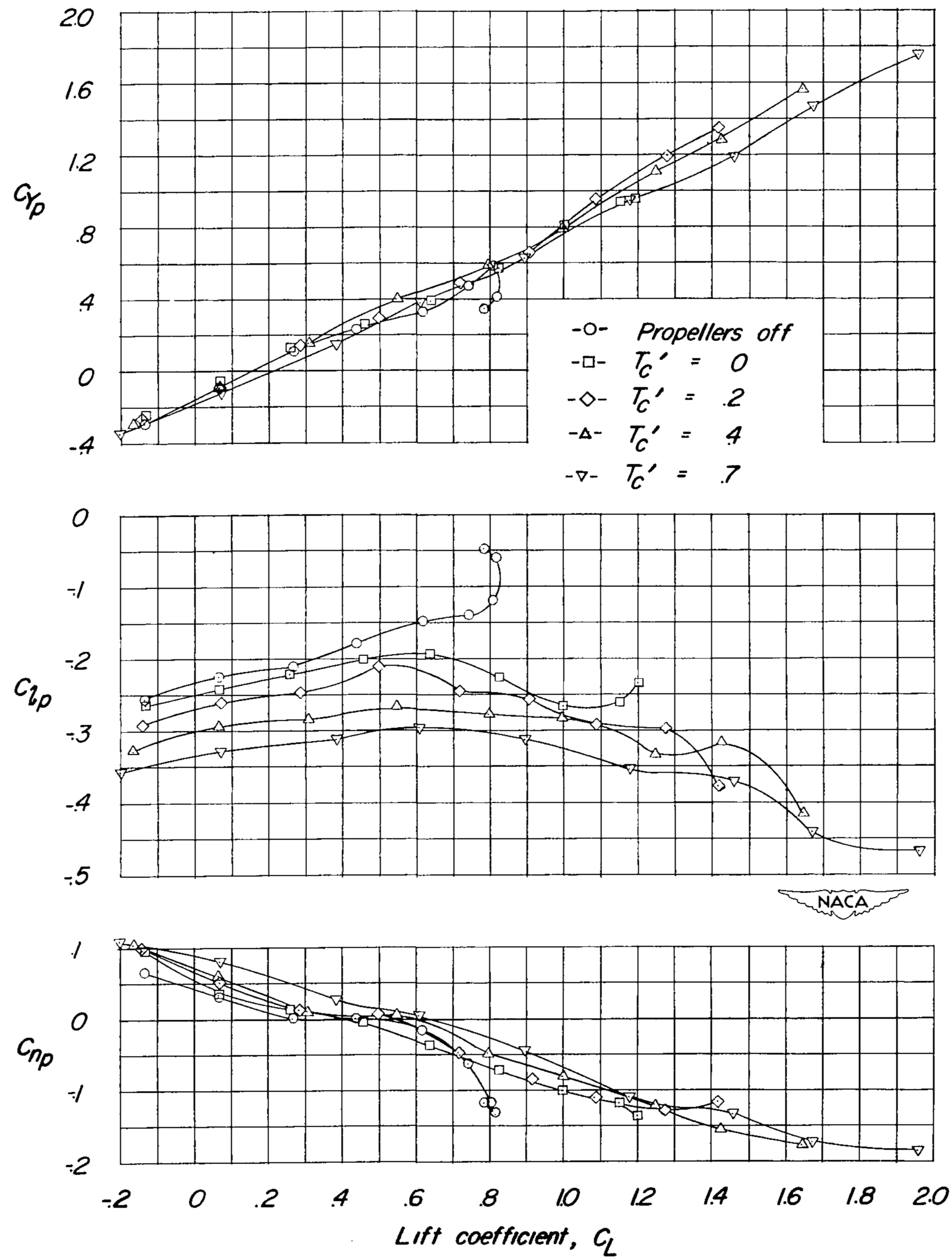

Figure 5.- Variation of thrust coefficient with propeller speed for various propeller blade angles. $\alpha = 0^{\circ}$. $q = 16$ lb/sq ft.

[redacted]



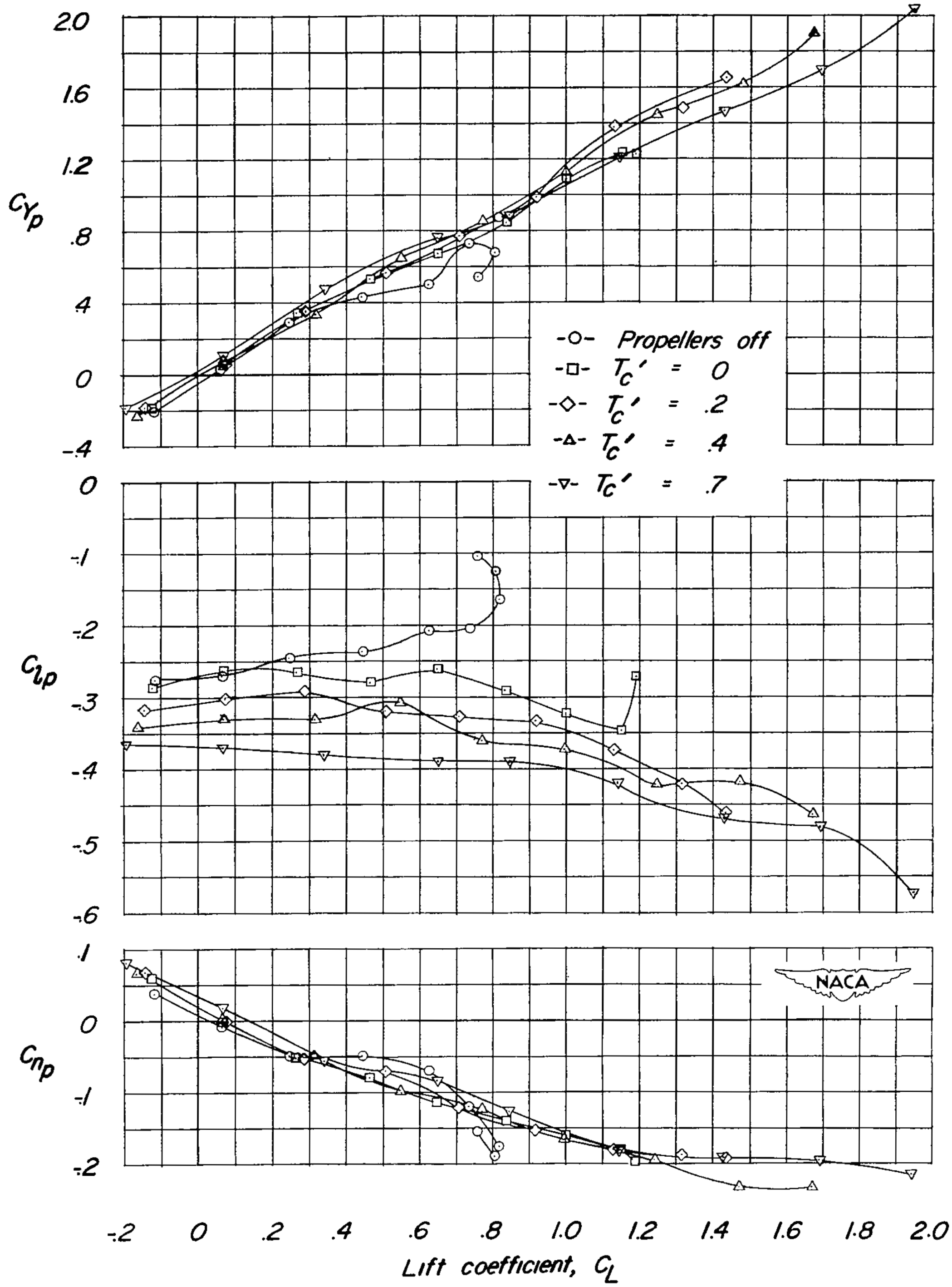

(a) Both fins off. Configurations W + F and W + F + P.

Figure 6.- Effect of thrust coefficient on the rolling stability derivatives of various components of a 1/9-scale powered model of the Convair XFY-1 vertically rising airplane. $(\beta_o)_F = 25^\circ$.



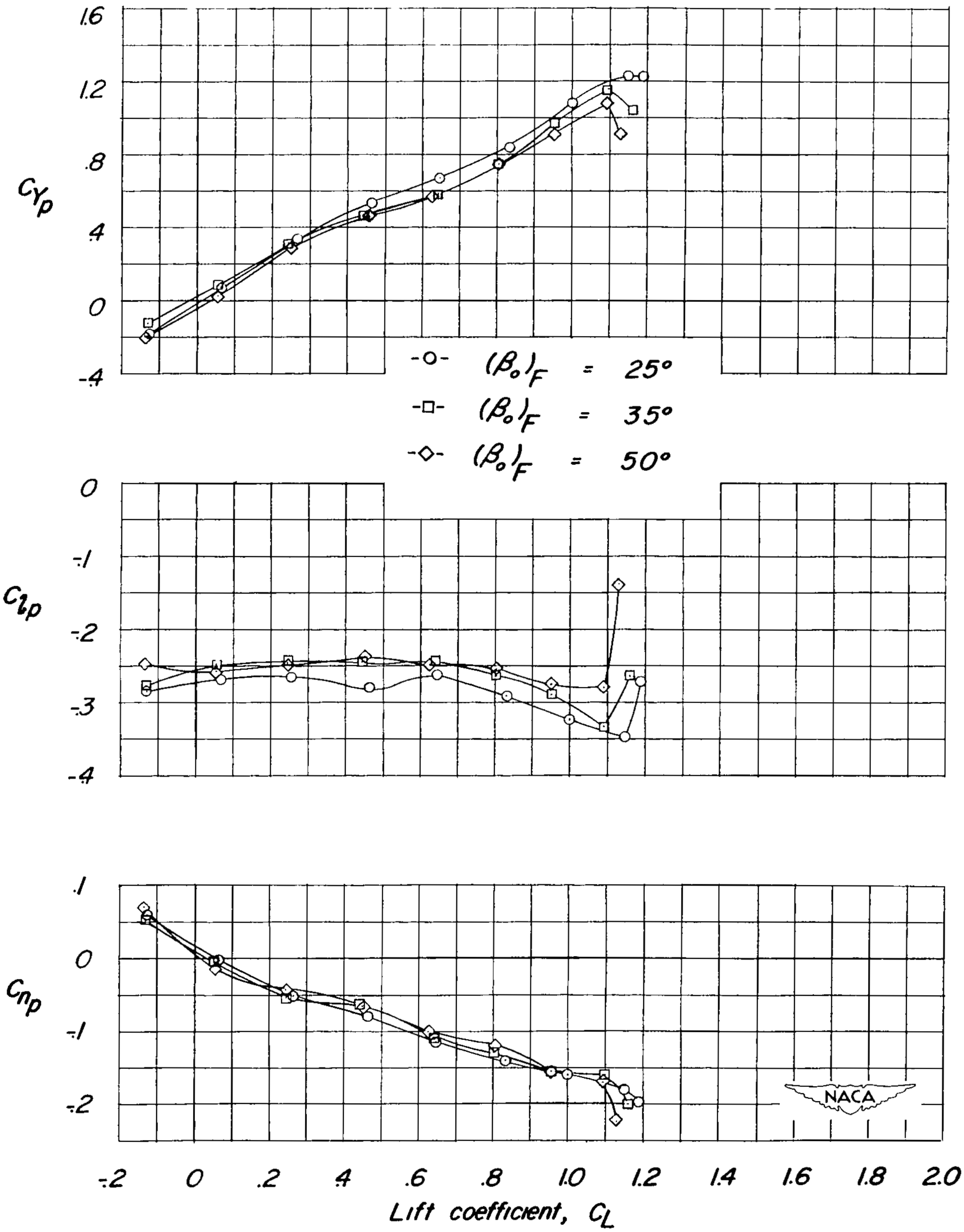

(b) Lower fin off. Configurations $W + F + T_u$ and $W + F + T_u + P$.

Figure 6.- Continued.



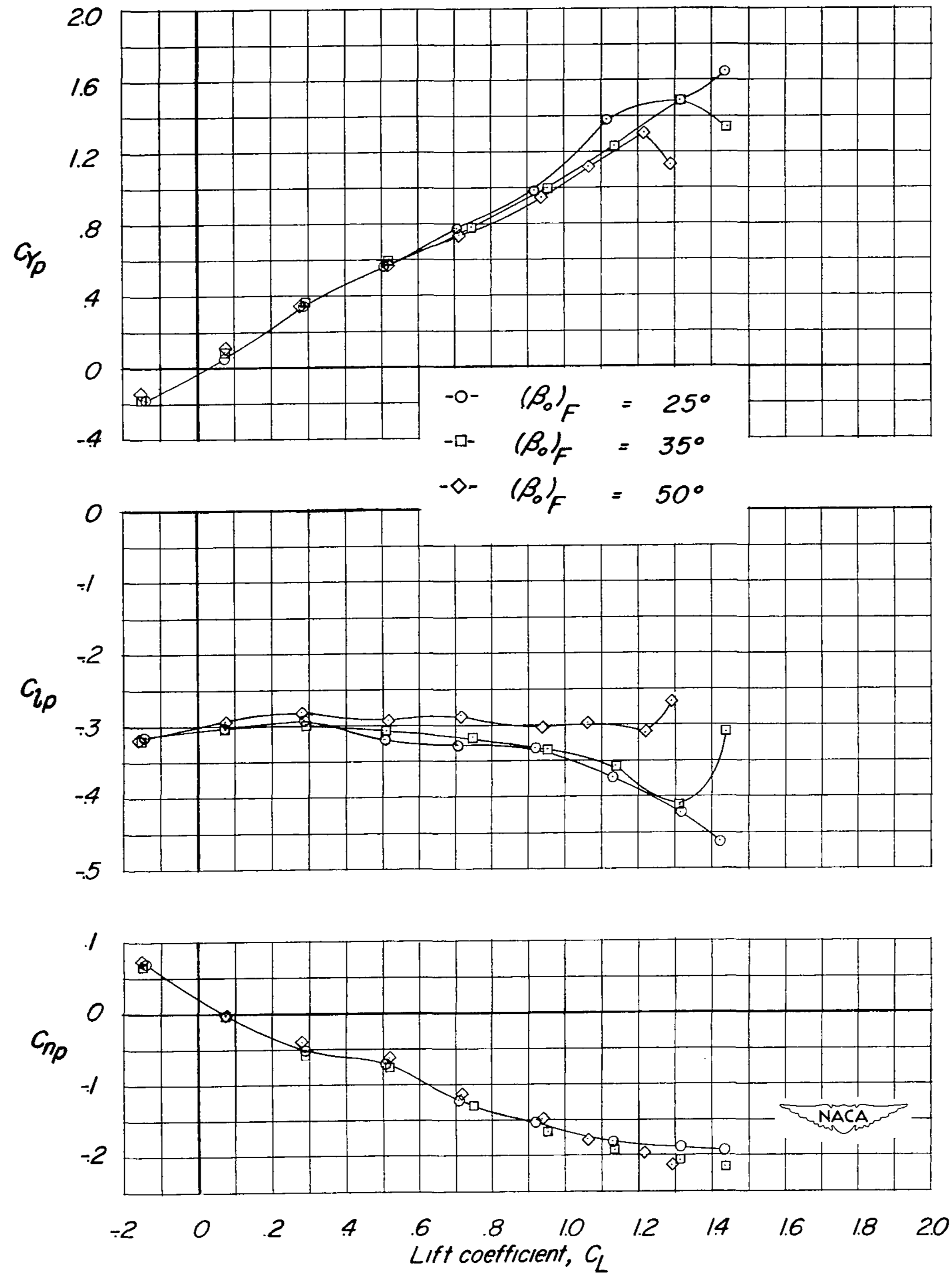

(c) Complete model. Configurations $W + F + T_u + T_L$ and $W + F + T_u + T_L + P$.

Figure 6.- Concluded.



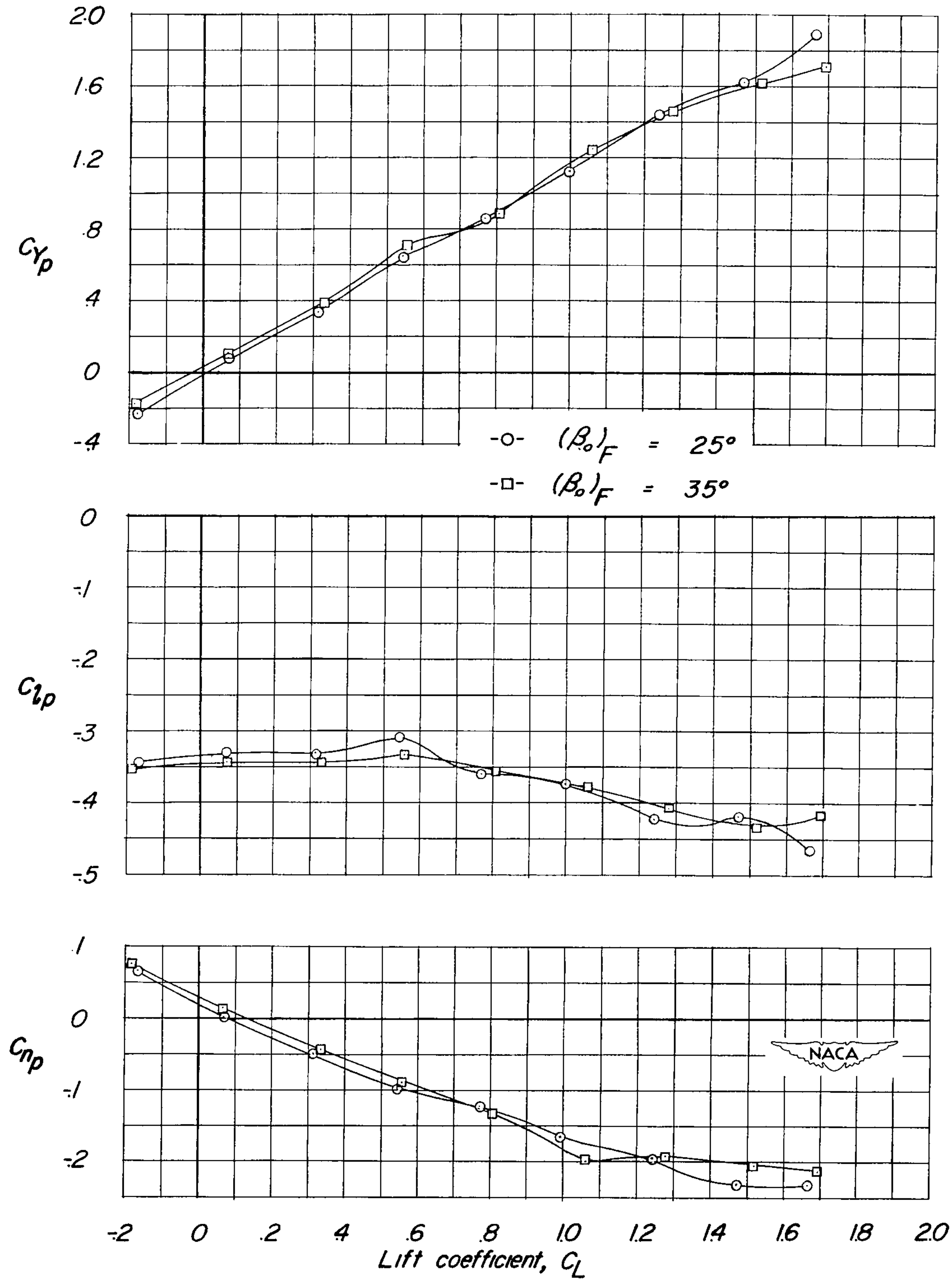

(a) $T_c' = 0$.

Figure 7.- Effect of propeller blade angle on the rolling stability derivatives of a 1/9-scale powered model of the Convair XFY-1 vertically rising airplane.



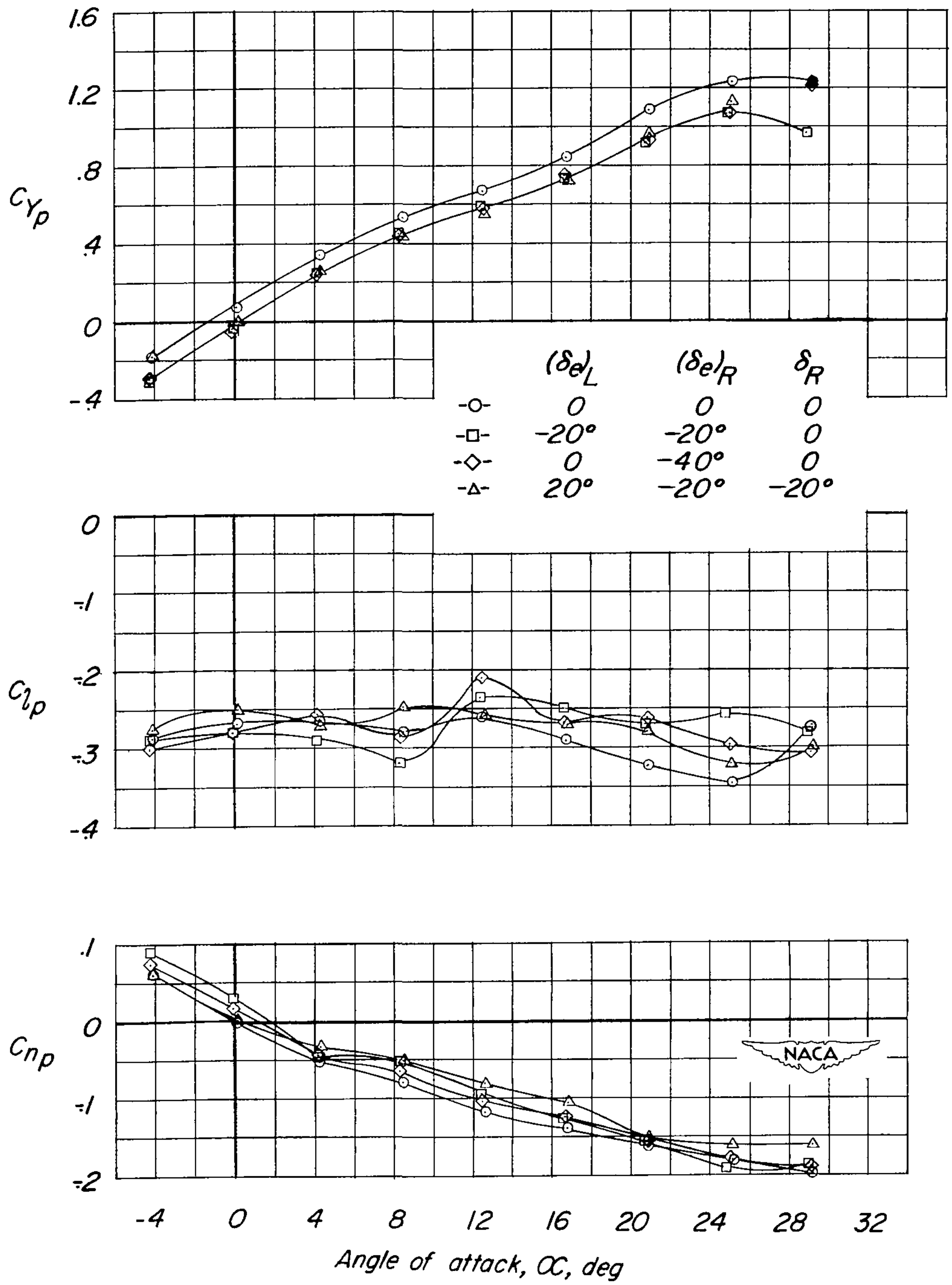

(b) $T_c' = 0.2$.

Figure 7.- Continued.



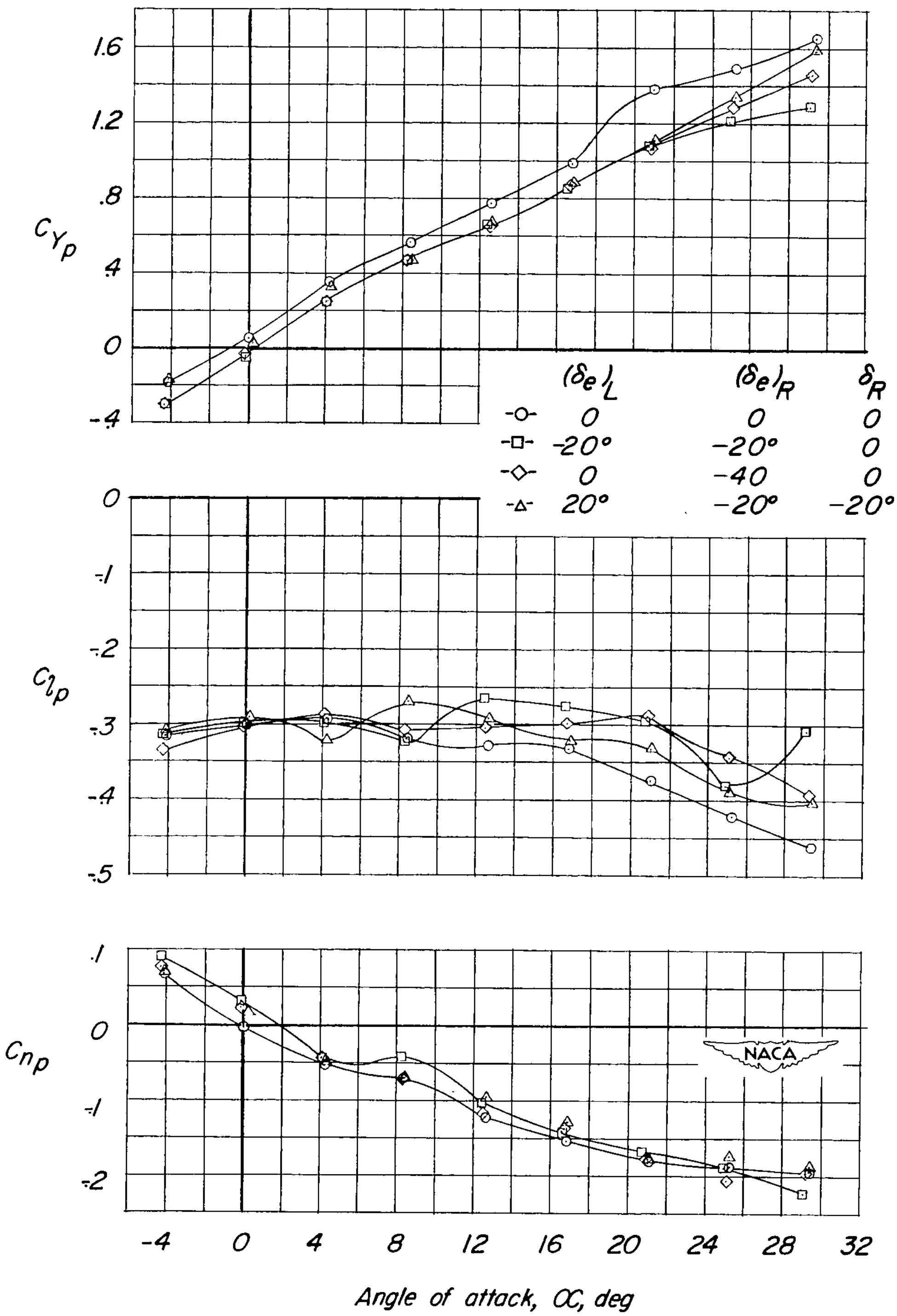

(c) $T_c' = 0.4$.

Figure 7.- Concluded.



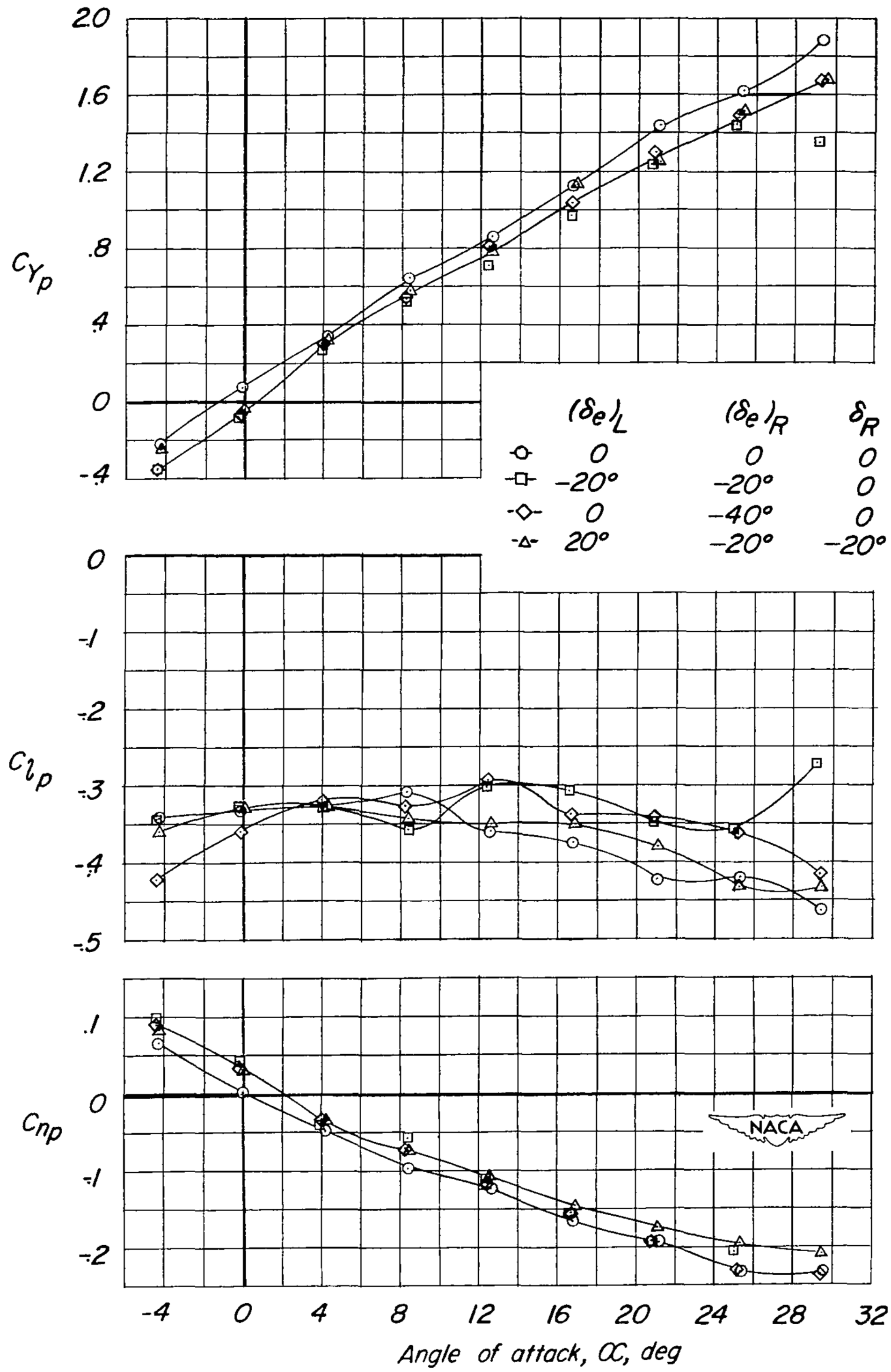

(a) $T_c' = 0$.

Figure 8.- Effect of control deflection on the rolling-stability derivatives of a 1/9-scale powered model of the Convair XFY-1 vertically rising airplane. $(\beta_o)_F = 25^{\circ}$; configuration $W + F + T_u + T_L + P$.



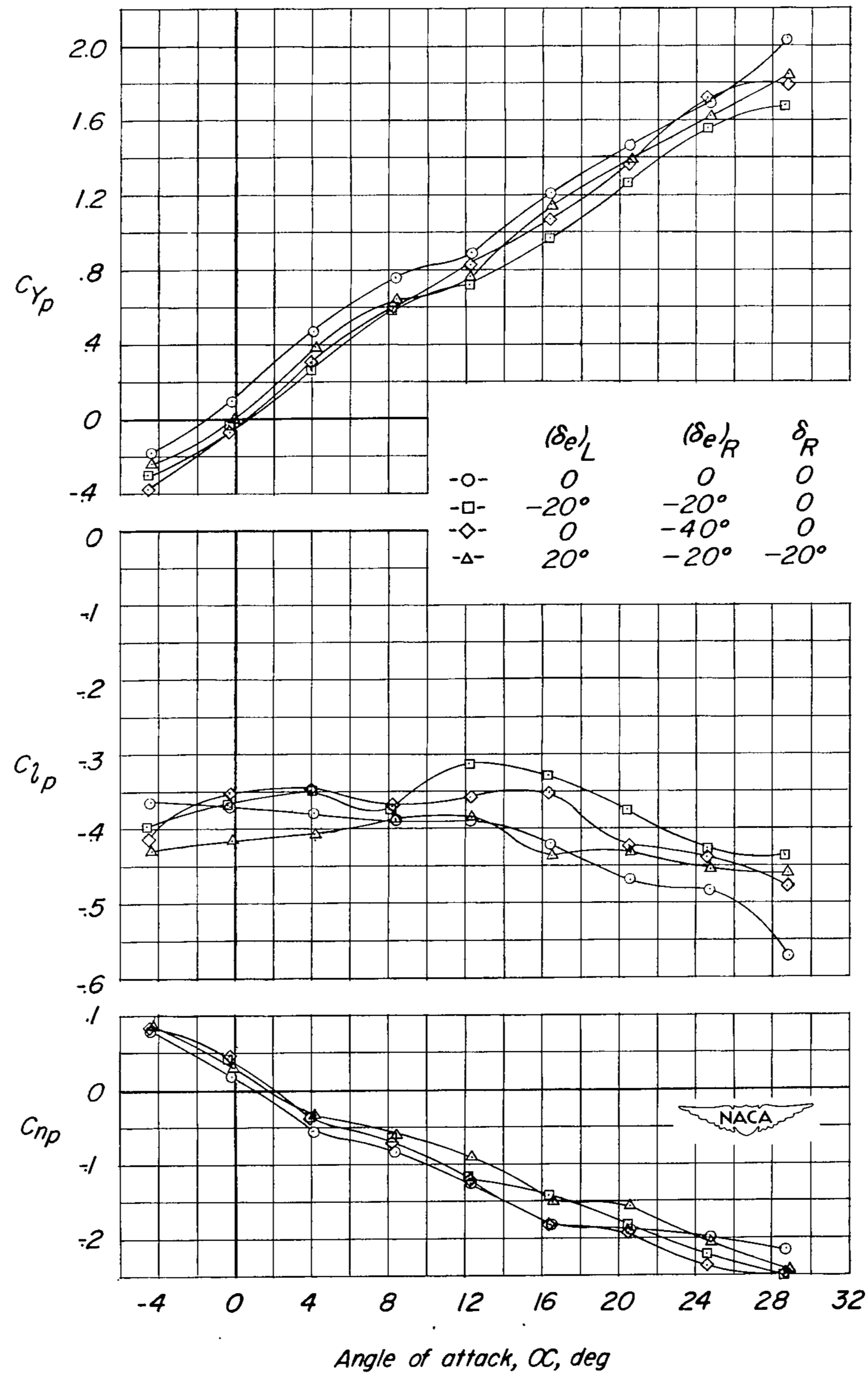

(b) $T_c' = 0.2$.

Figure 8.- Continued.




(c) $T_c' = 0.4$.

Figure 8.- Continued.




(d) $T_c' = 0.7$.

Figure 8.- Concluded.

[redacted]