NACA

RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

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

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

Langley Aeronautical Laboratory
Langley Field, Va.

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS
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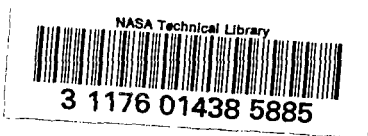
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SUMMARY

An experimental investigation has been conducted in the Langley
stability tunnel at low speed to determine the yawing stability deriva-
tives 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 deflec-
tions 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.

INTRODUCTION

Various investigations have shown that the dynamic stability char-
acteristics 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 param-
eters are determined accurately. The purpose of the present investigation
was to determine the yawing 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 a previous investigation to determine
the static longitudinal and lateral stability derivatives of the same
model are given in reference 1.

SYMBOLS AND COEFFICIENTS

The data presented herein are in the form of standard NACA coef-
ficients of forces and moments which are referred to the system of
stability axes (fig. 1) with the origin at the projection on the plane
of symmetry of the 14-percent point of the wing mean aerodynamic chord.
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 the 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

r yawing angular velocity, radians per second

R propeller radius, 0.889 ft

S area of theoretical wing, 4.27 sq ft

V free-stream velocity, ft/sec

α wing angle of attack, deg

β sideslip angle, rad

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

γ angle of climb, deg

δ_e elevator deflection, positive trailing edge up, deg

δ_R rudder deflection, positive trailing edge to right, deg

ψ angle of yaw, deg

θ local blade angle, deg

ϕ angle of roll, deg

ρ mass density of air, slugs/cu ft

L lift, lb

X longitudinal force, lb

Y side force, lb

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

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

$\dfrac{rb}{2V}$ yawing velocity parameter

C_l rolling-moment coefficient, l/qSb

$$C_{y_r} = \frac{\partial C_y}{\partial \frac{rb}{2V}}$$

$$C_{l_r} = \frac{\partial C_l}{\partial \frac{rb}{2V}}$$

$$C_{n_r} = \frac{\partial C_n}{\partial \frac{rb}{2V}}$$

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 yawing flow is simulated by curving the air stream about a stationary model (ref. 2).

TESTS

All tests of this investigation were made at a dynamic pressure of 16 pounds per square foot, which corresponds to a Mach number of about 0.11 and a Reynolds number of 1.28×10^6 based on the wing mean aerodynamic chord of 1.73 feet. Most of the tests were made with controls in the neutral position and with the front blades set at $(\beta_0)_F = 25^0$. 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 1^0 less than the front blades. Effects of control deflections also were investigated.

The yawing stability derivatives of three basic model configurations were investigated, and 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.

The angle-of-attack range for all tests was from about -4^0 to 29^0. Tests were made at values of rb/2V of 0, -0.0281, -0.0581, and -0.0814.

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 3. Blockage corrections were determined and applied by the methods of reference 4. 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 9. The data, model configuration, and figure on 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 yawing 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° 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.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va.

M. J. Queijo
Aeronautical Research Scientist

W. D. Wolhart
Aeronautical Research Scientist

H. S. Fletcher
Aeronautical Research Scientist

Approved: Thomas A. Harris
Thomas A. Harris
Chief of Stability Research Division

vr

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. Bird, John D., Jaquet, Byron M., and Cowan, John W.: Effect of Fuselage and Tail Surfaces on Low-Speed Yawing Characteristics of a Swept-Wing Model as Determined in Curved-Flow Test Section of the Langley Stability Tunnel. NACA TN 2483, 1951. (Supersedes NACA RM L8G13.)

3. 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.

4. Herriot, John C.: Blockage Corrections for Three-Dimensional Closed-Throat Wind Tunnels, With Consideration of the Effects of Compressibility. NACA Rep. 995, 1950. (Supersedes NACA RM A7B28a.)

TABLE I

SUMMARY OF MODEL CONFIGURATIONS TESTED,

TEST VARIABLES, AND DATA PRESENTED

Model configuration	Data presented	Figure
$W + F + T_u + T_L + P$ $(\beta_0)_F = 25^\circ, 35^\circ, 50^\circ$	$T_c{}'$ against propeller speed	5
$W + F$ $W + F + P$, $(\beta_0)_F = 25^\circ$	C_{Y_r}, C_{l_r}, C_{n_r} against C_L for various thrust coefficients	6(a)
$W + F + T_u$ $W + F + T_u + P$, $(\beta_0)_F = 25^\circ$	C_{Y_r}, C_{l_r}, C_{n_r} against C_L for various thrust coefficients	6(b)
$W + F + T_u + T_L$ $W + F + T_u + T_L + P$, $(\beta_0)_F = 25^\circ$	C_{Y_r}, C_{l_r}, C_{n_r} against C_L for various thrust coefficients	6(c)
$W + F + T_u + T_L$ $W + F + T_u + T_L + P$, $(\beta_0)_F = 35^\circ$	C_{Y_r}, C_{l_r}, C_{n_r} against C_L for various thrust coefficients	7
$W + F + T_u + T_L$ $W + F + T_u + T_L + P$, $(\beta_0)_F = 50^\circ$	C_{Y_r}, C_{l_r}, C_{n_r} against C_L for various thrust coefficients	8
$W + F + T_u + T_L + P$, $(\beta_0)_F = 25^\circ$ $T_c{}' = 0$	C_{Y_r}, C_{l_r}, C_{n_r} against α for various control deflections	9(a)
$W + F + T_u + T_L + P$, $(\beta_0)_F = 25^\circ$ $T_c{}' = 0.2$	C_{Y_r}, C_{l_r}, C_{n_r} against α for various control deflections	9(b)
$W + F + T_u + T_L + P$, $(\beta_0)_F = 25^\circ$ $T_c{}' = 0.4$	C_{Y_r}, C_{l_r}, C_{n_r} against α for various control deflections	9(c)
$W + F + T_u + T_L + P$, $(\beta_0)_F = 25^\circ$ $T_c{}' = 0.7$	C_{Y_r}, C_{l_r}, C_{n_r} against α for various control deflections	9(d)

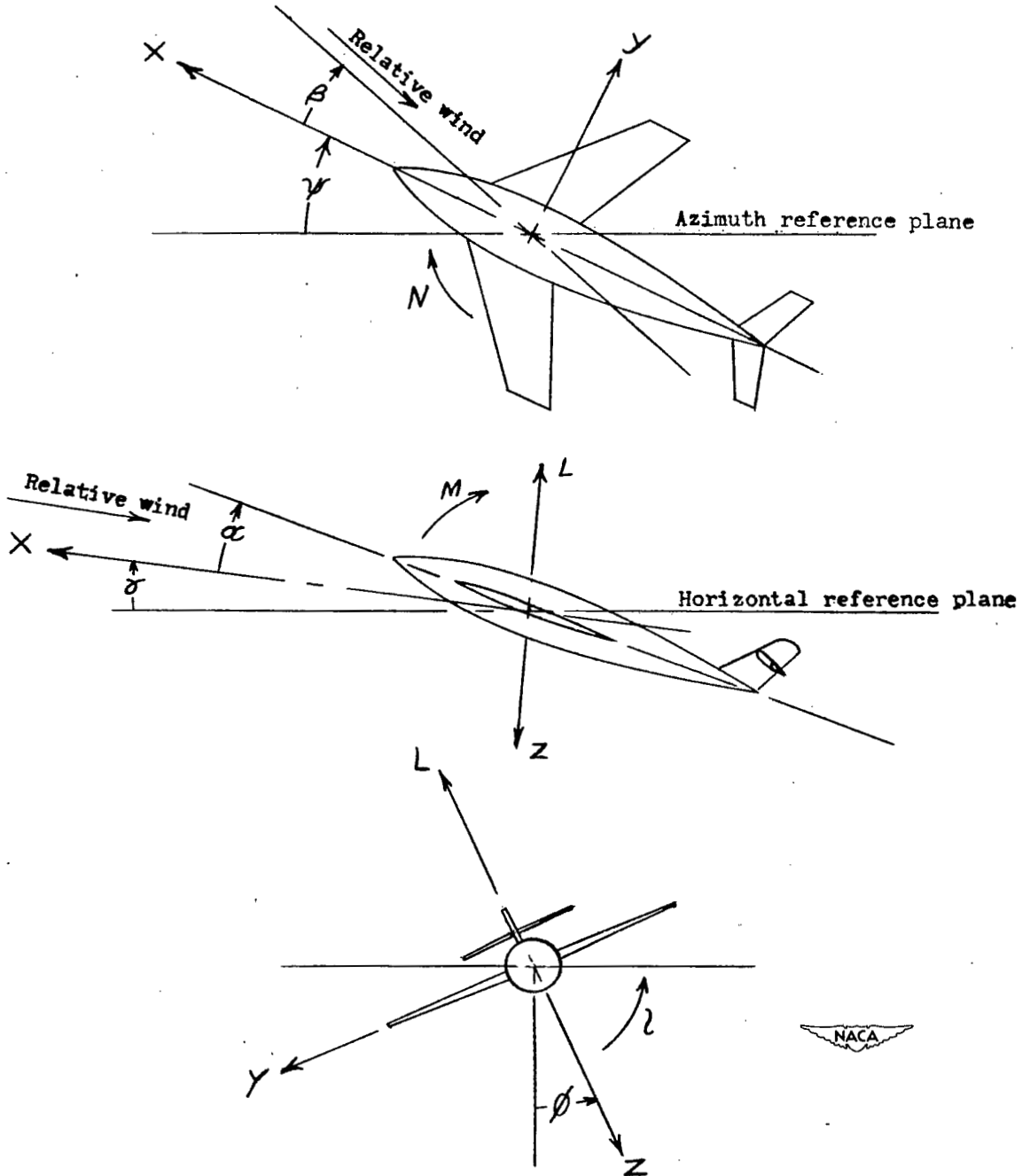Figure 1.- System of stability axes. Arrows indicate positive direction
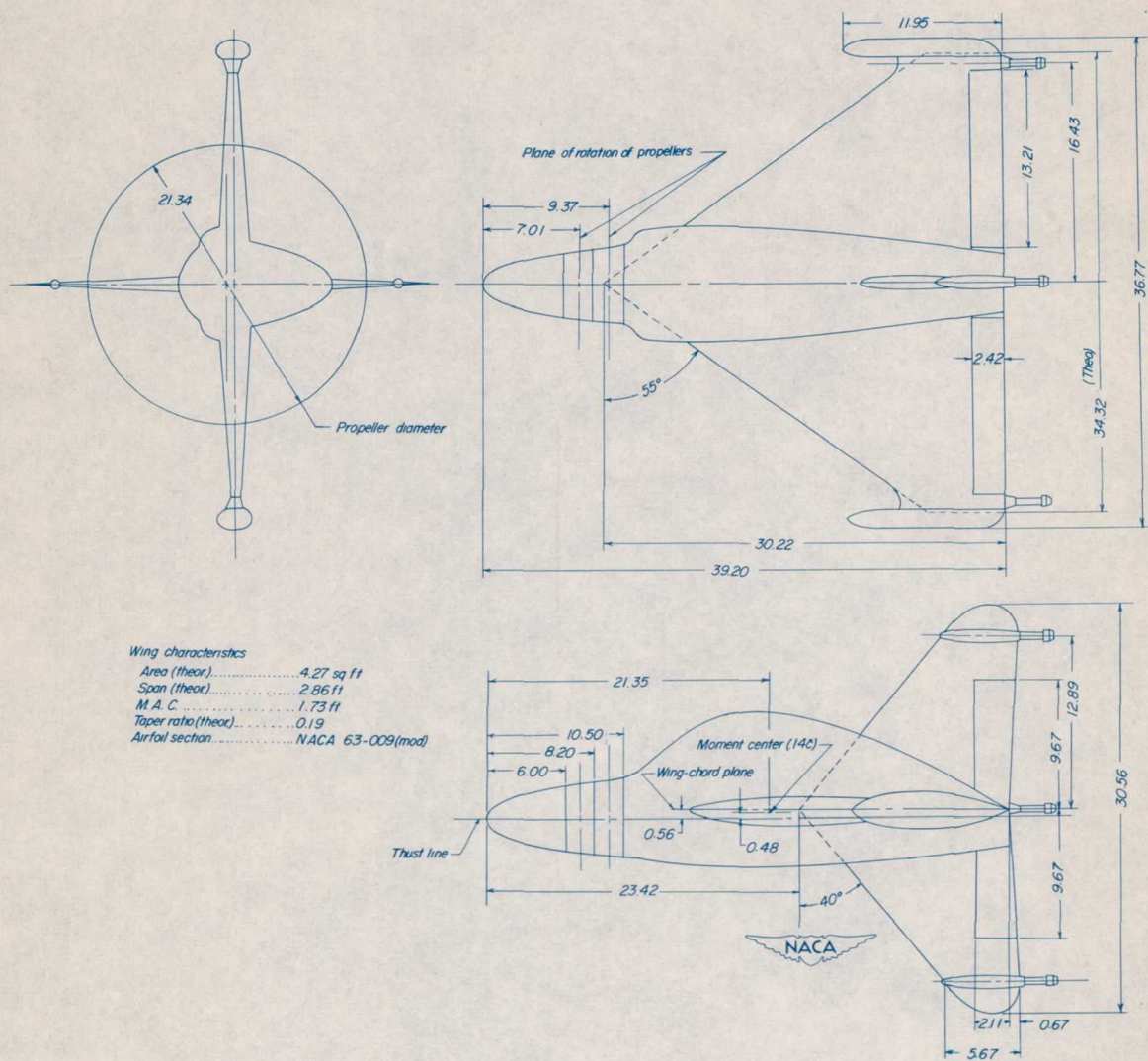of forces, moments, and displacements.

Wing characteristics
Area (theor.)..................4.27 sq ft
Span (theor.)..............2.86 ft
M.A.C.....................1.73 ft
Taper ratio (theor.)........0.19
Airfoil section..............NACA 63-009(mod)

Figure 2.- Geometric characteristics of model.   All dimensions are in inches.
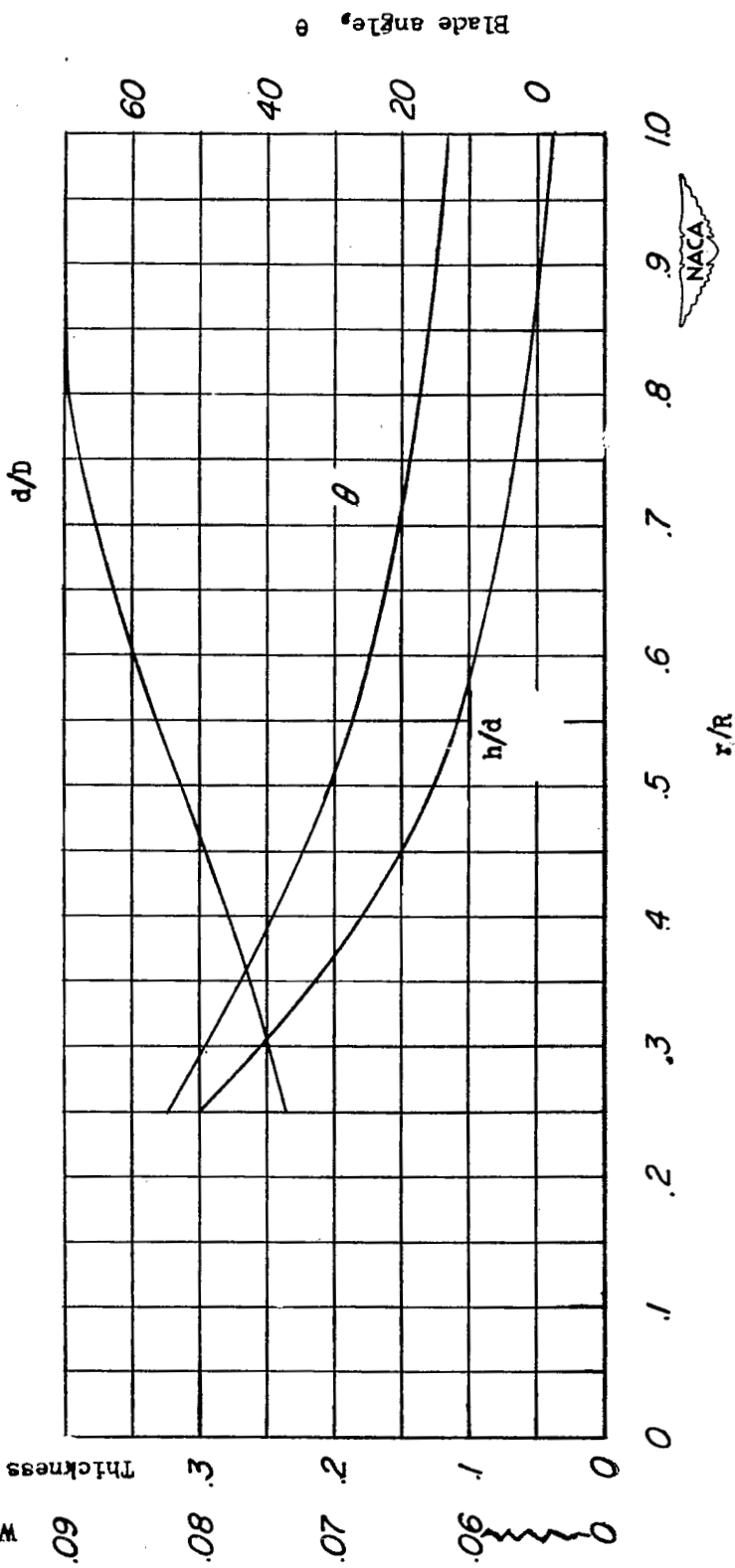
Figure 3.- Geometric characteristics of propeller blades used on a 1/9-scale model of the Convair XFY-1 vertically rising airplane. R = 0.889 feet.
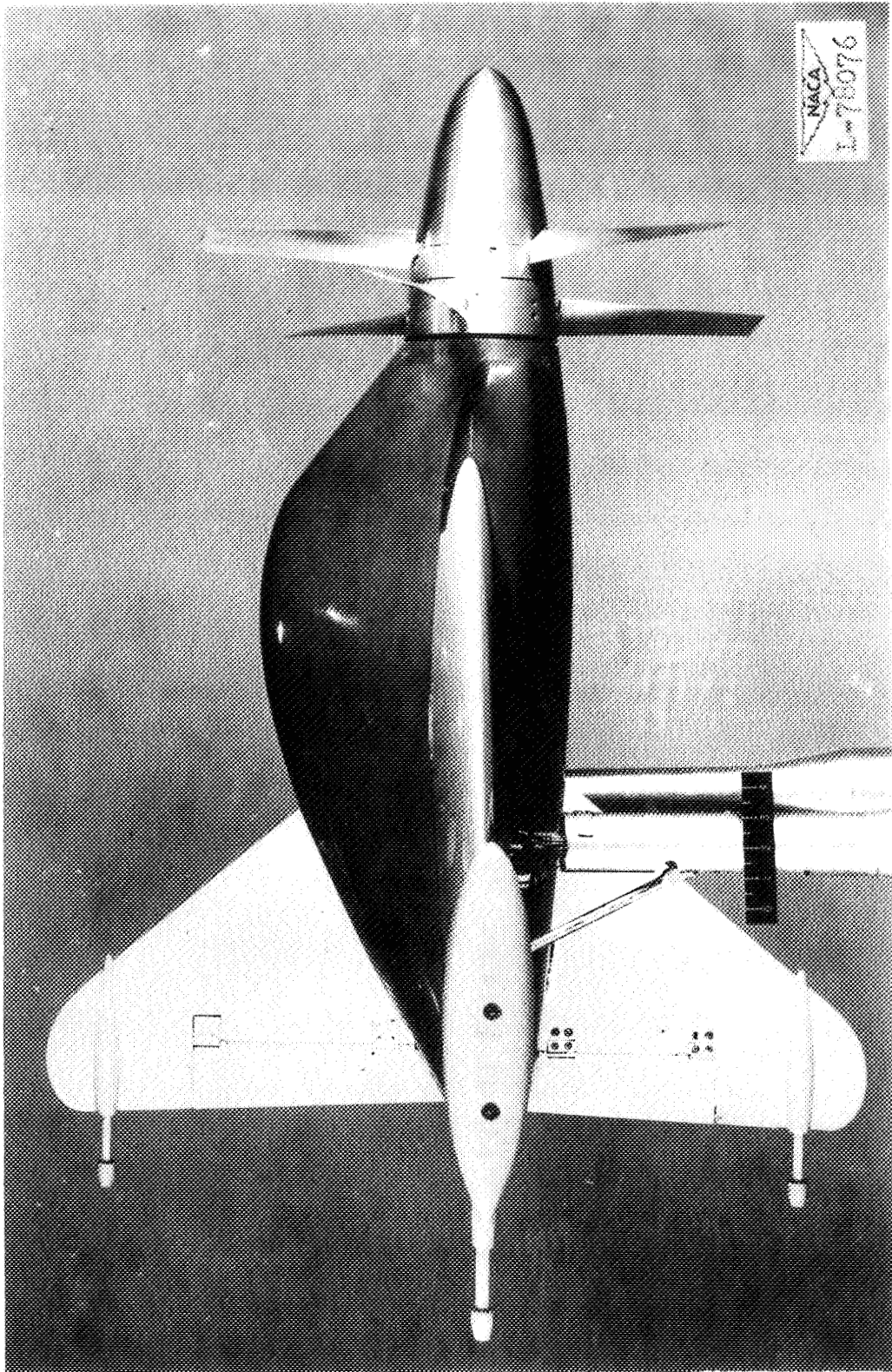
(a) Side view of model.

Figure 4.- Photographs of model used in investigation.
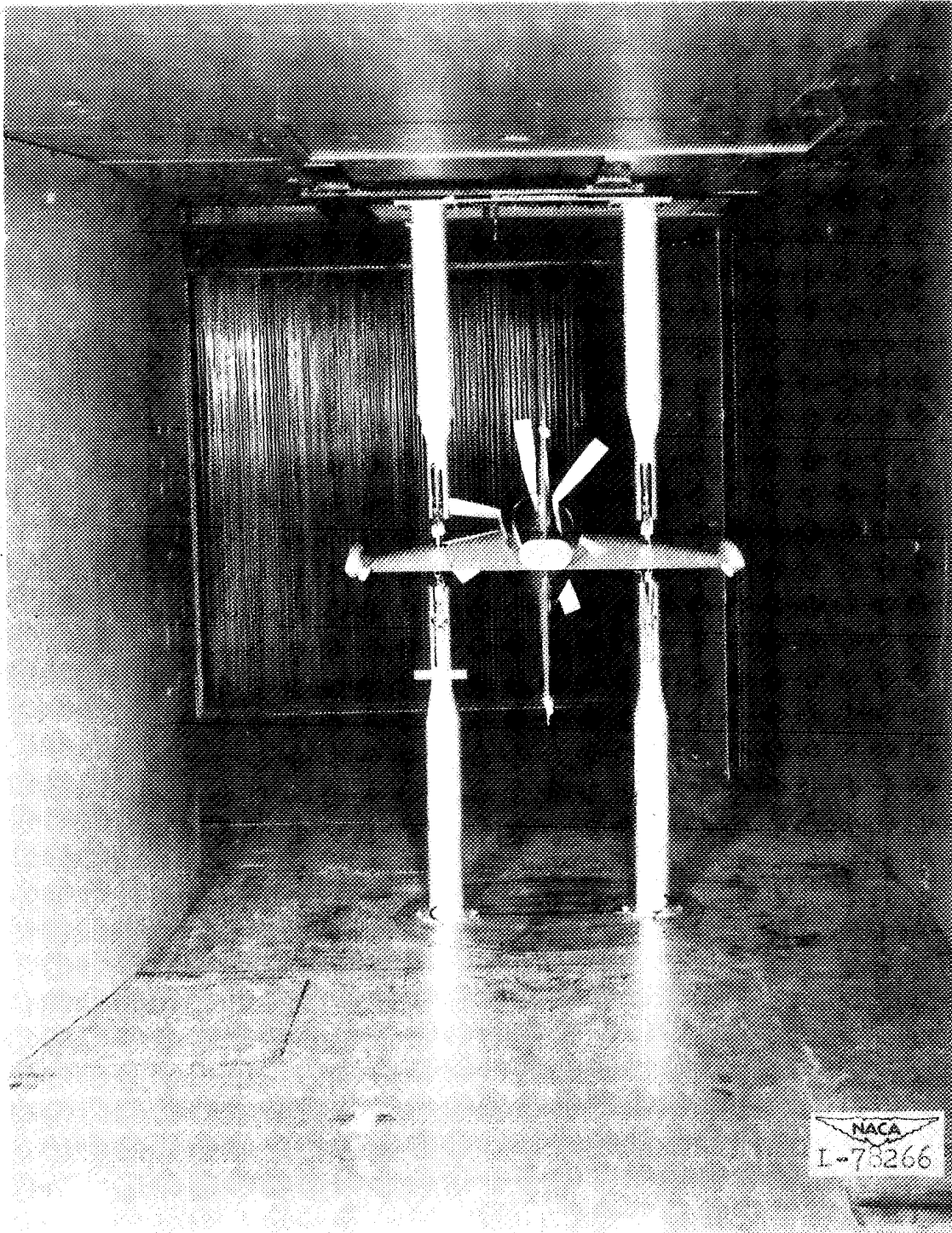
(b) Rear view of model with dummy struts used in tare tests.

Figure 4.- Concluded.
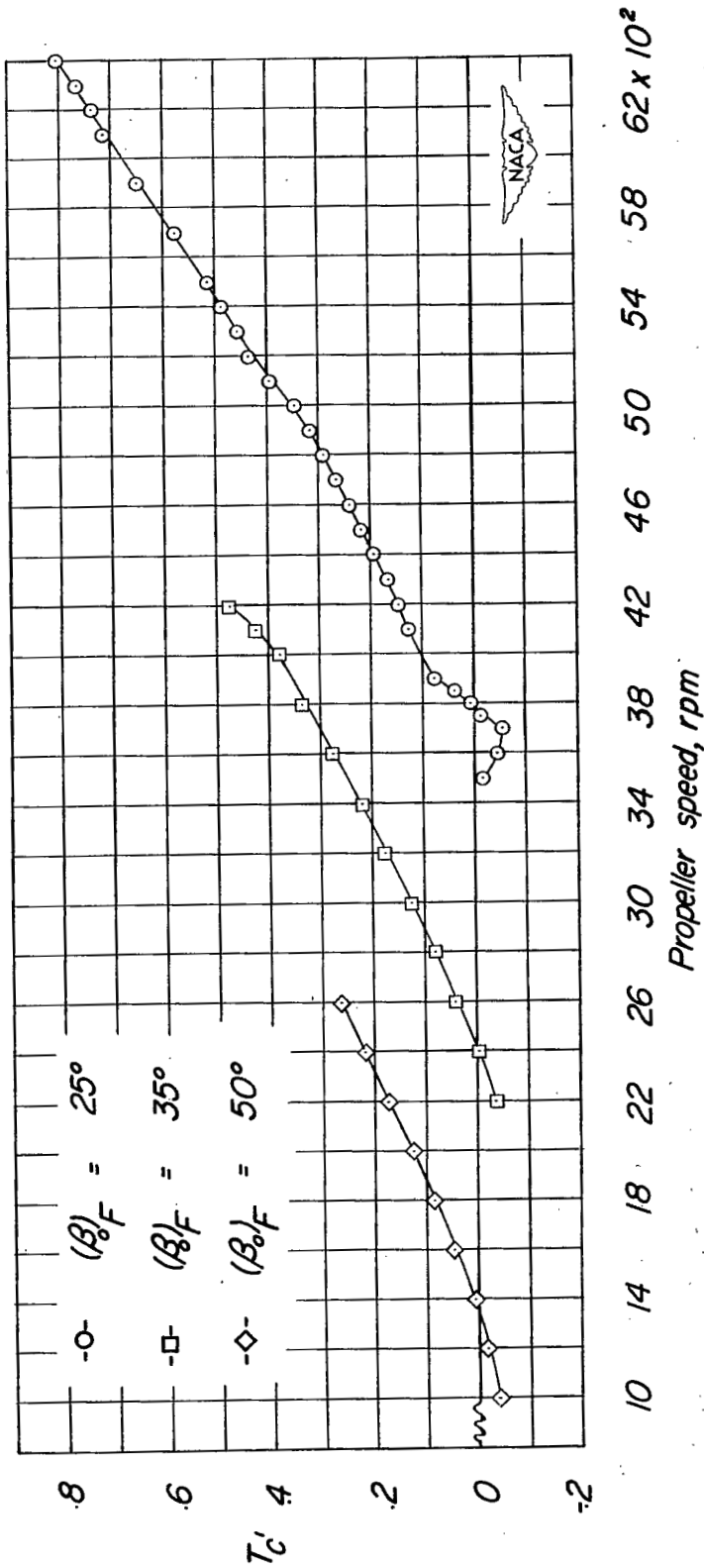
Figure 5.- Variation of thrust coefficient with propeller speed for various propeller-blade angles. $\alpha = 0°$; q = 16 pounds per square foot; complete model.
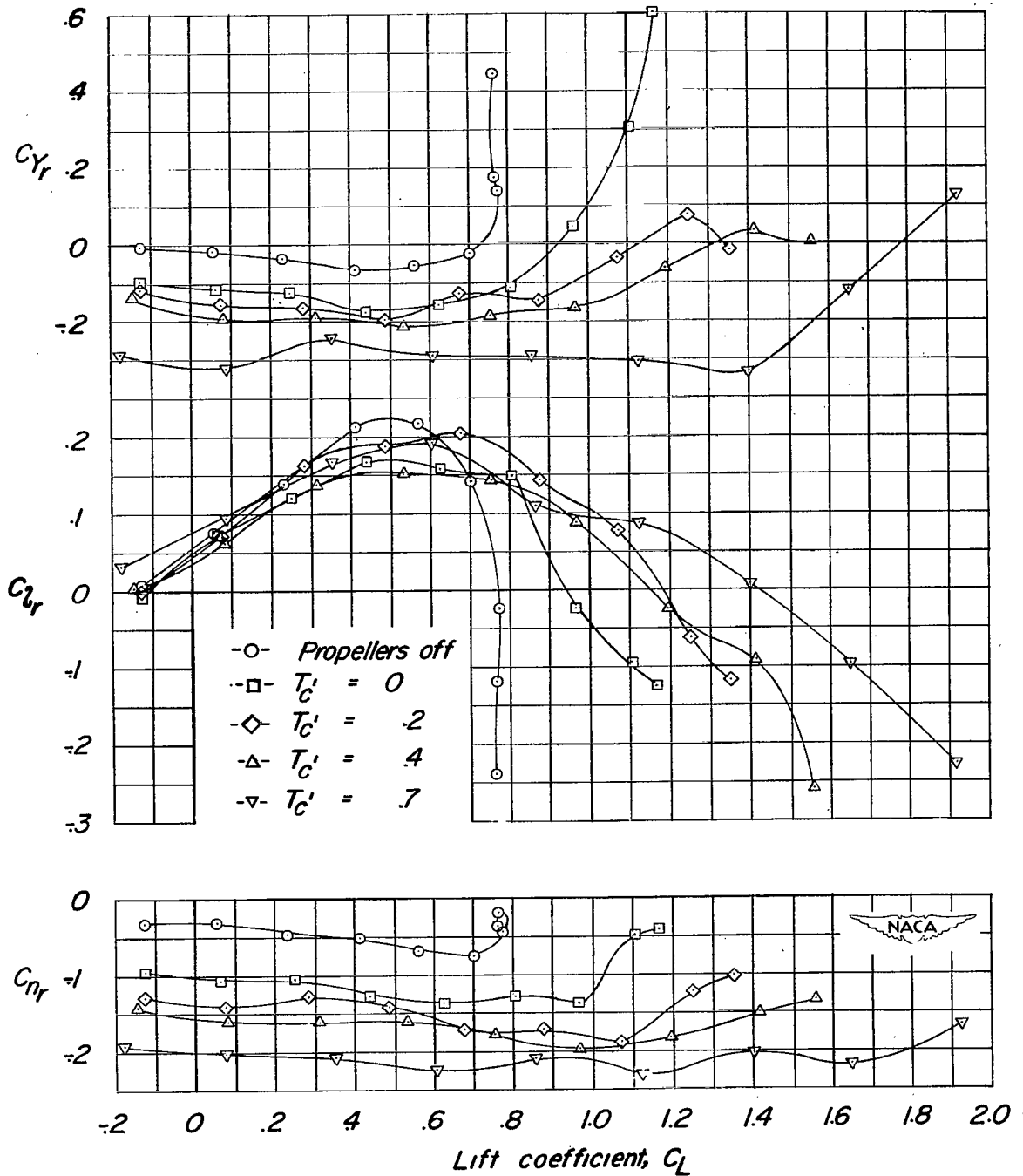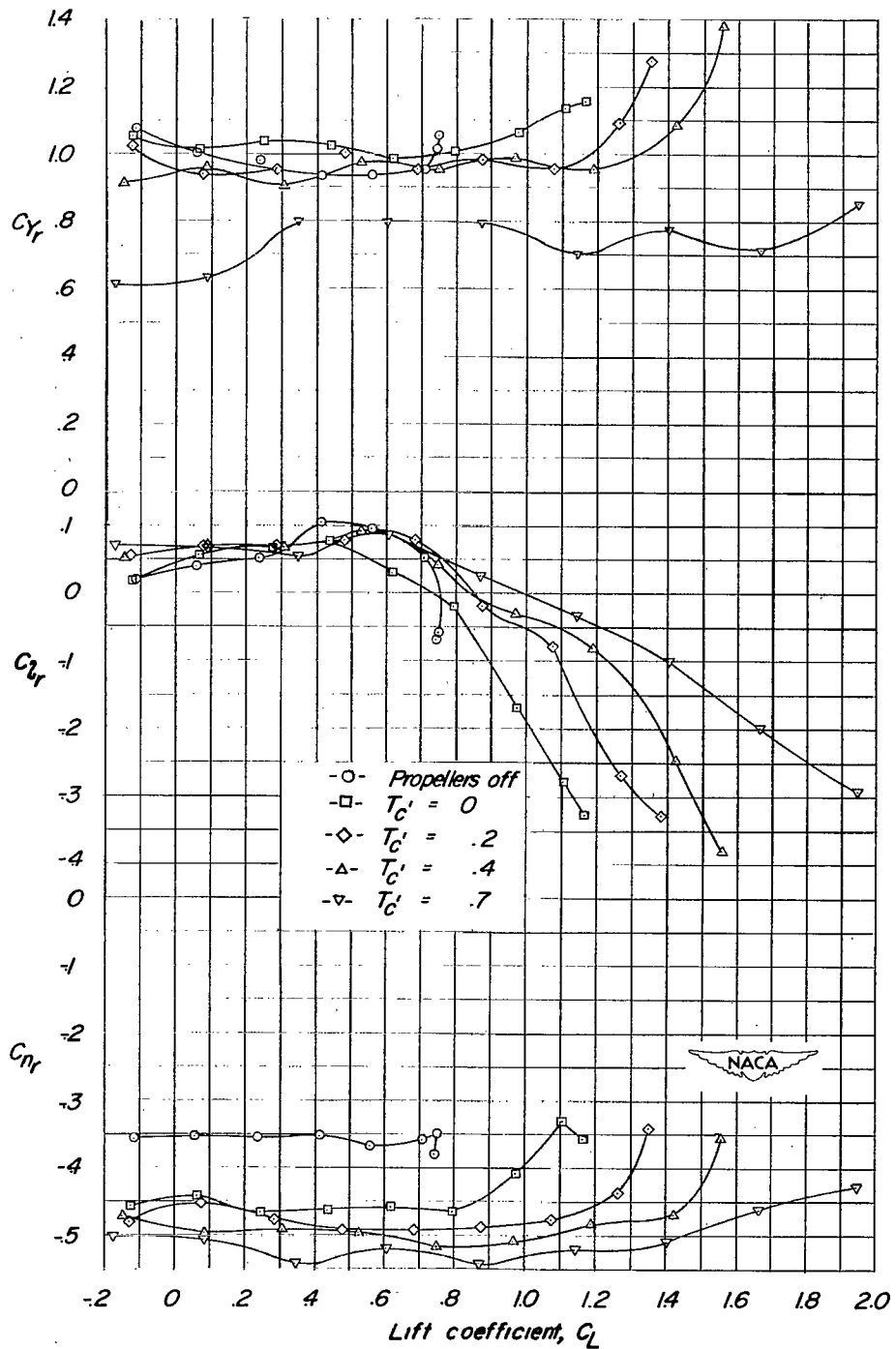
(a) Both fins off. Configurations W + F and W + F + P.

Figure 6.- Effect of thrust coefficient on the yawing stability deriva-
tives of various components of a 1/9-scale powered model of the
Convair XFY-1 vertically rising airplane. $(\beta_0)_F = 25^o$.

Legend:
-O- Propellers off
-□- $T_c' = 0$
-◇- $T_c' = .2$
-△- $T_c' = .4$
-▽- $T_c' = .7$
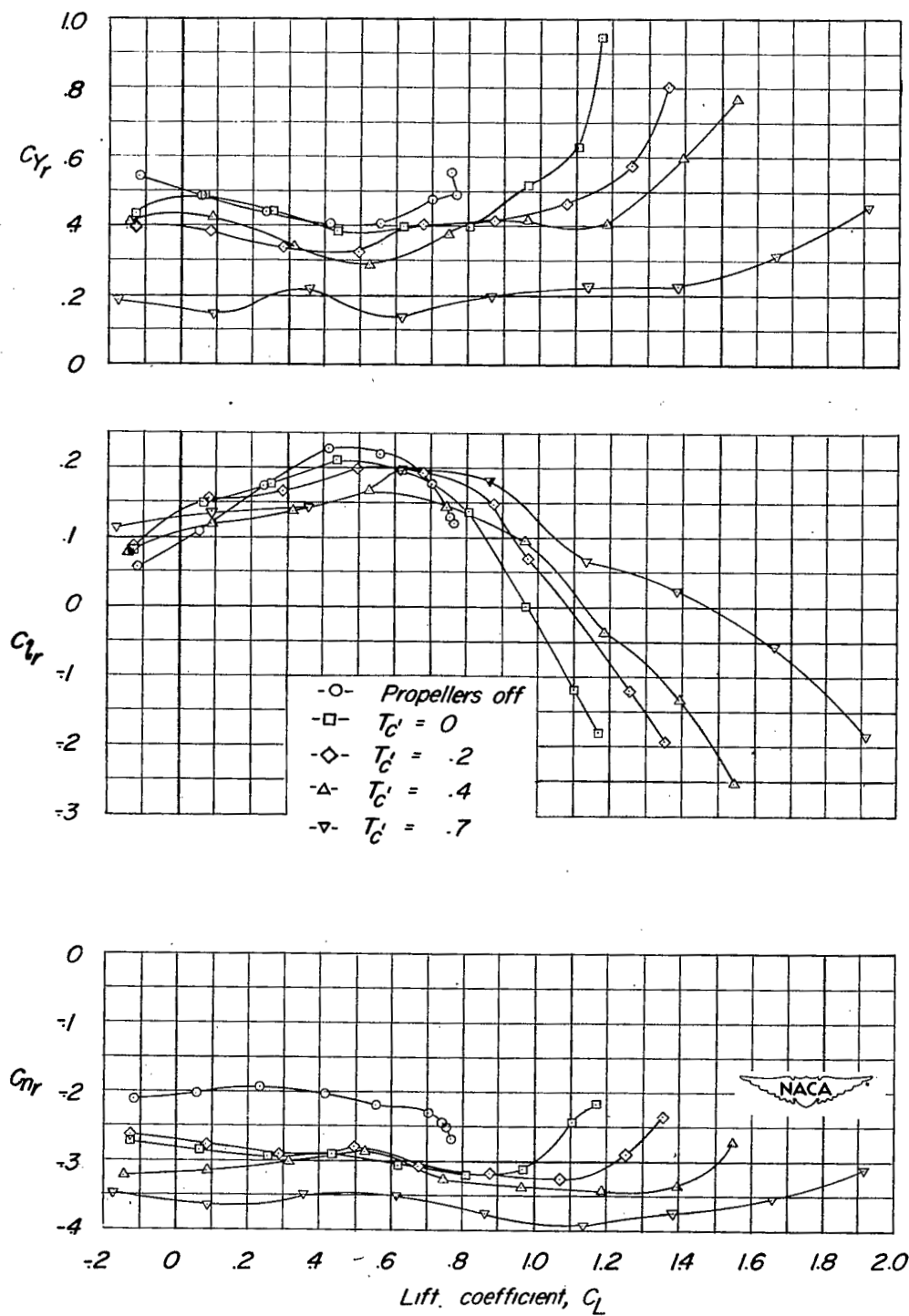
(b) Lower fin off.   Configurations $W + F + T_u$ and $W + F + T_u + P$.

Figure 6.- Continued.

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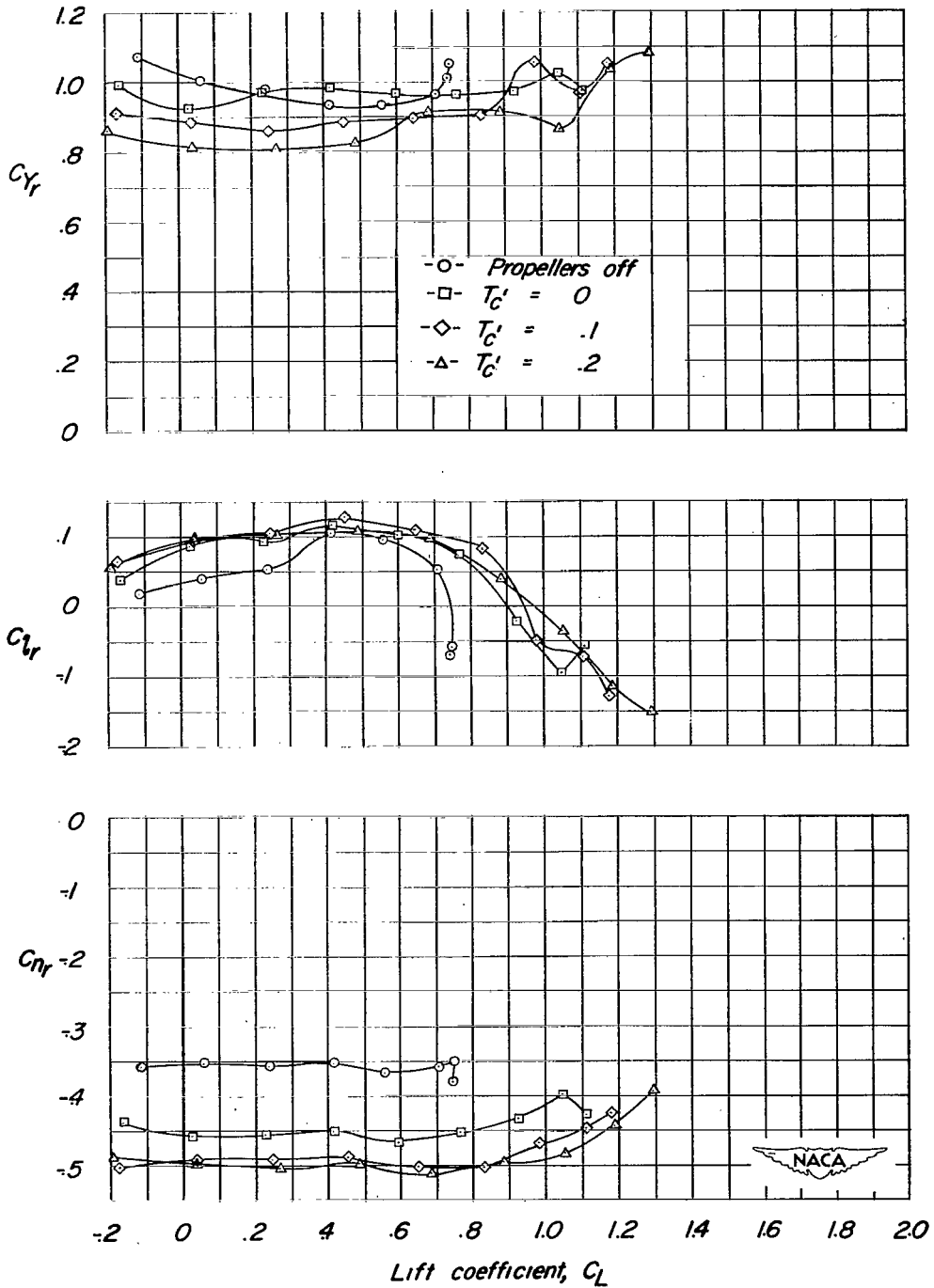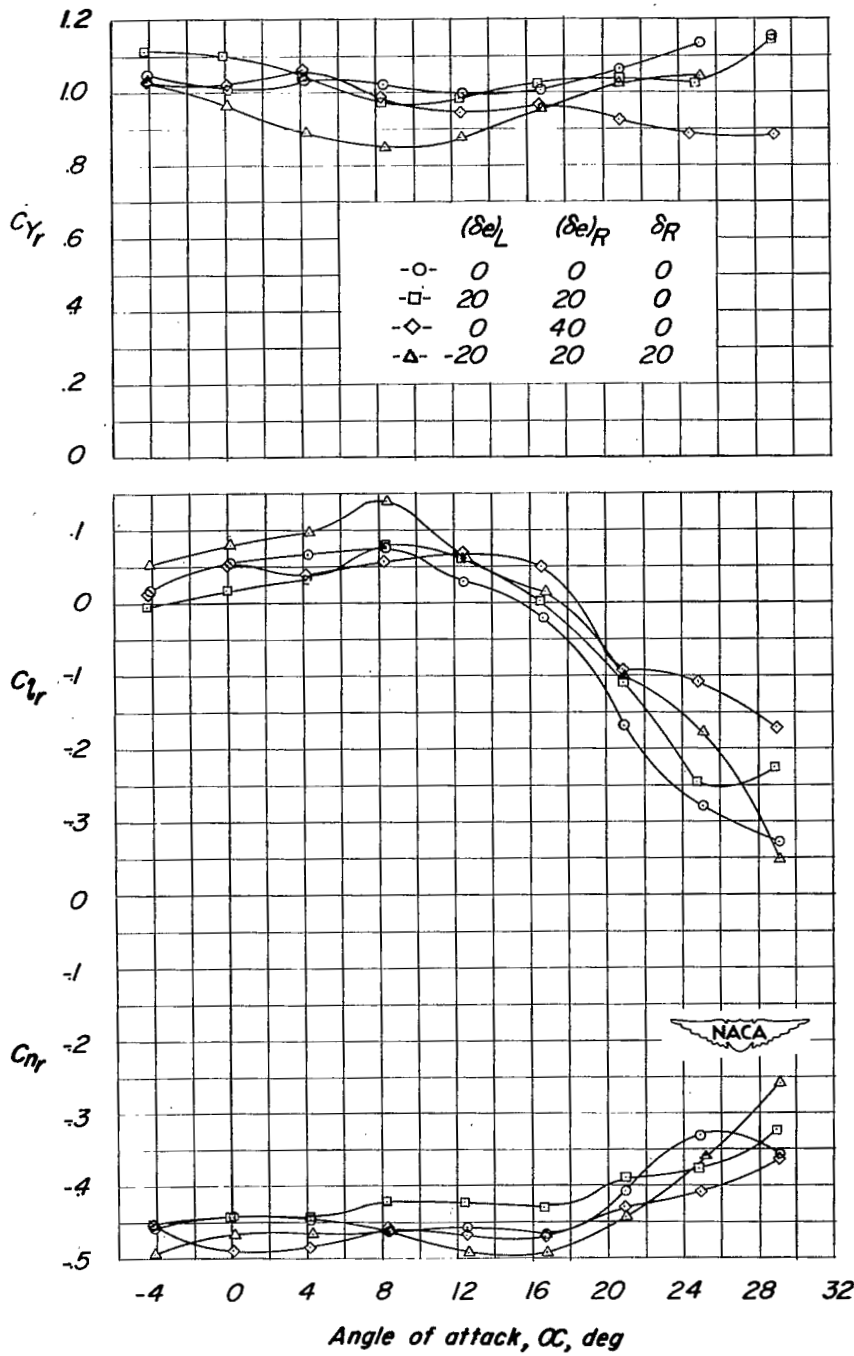$W + F + T_u + T_L + P.$

Figure 6.- Concluded.
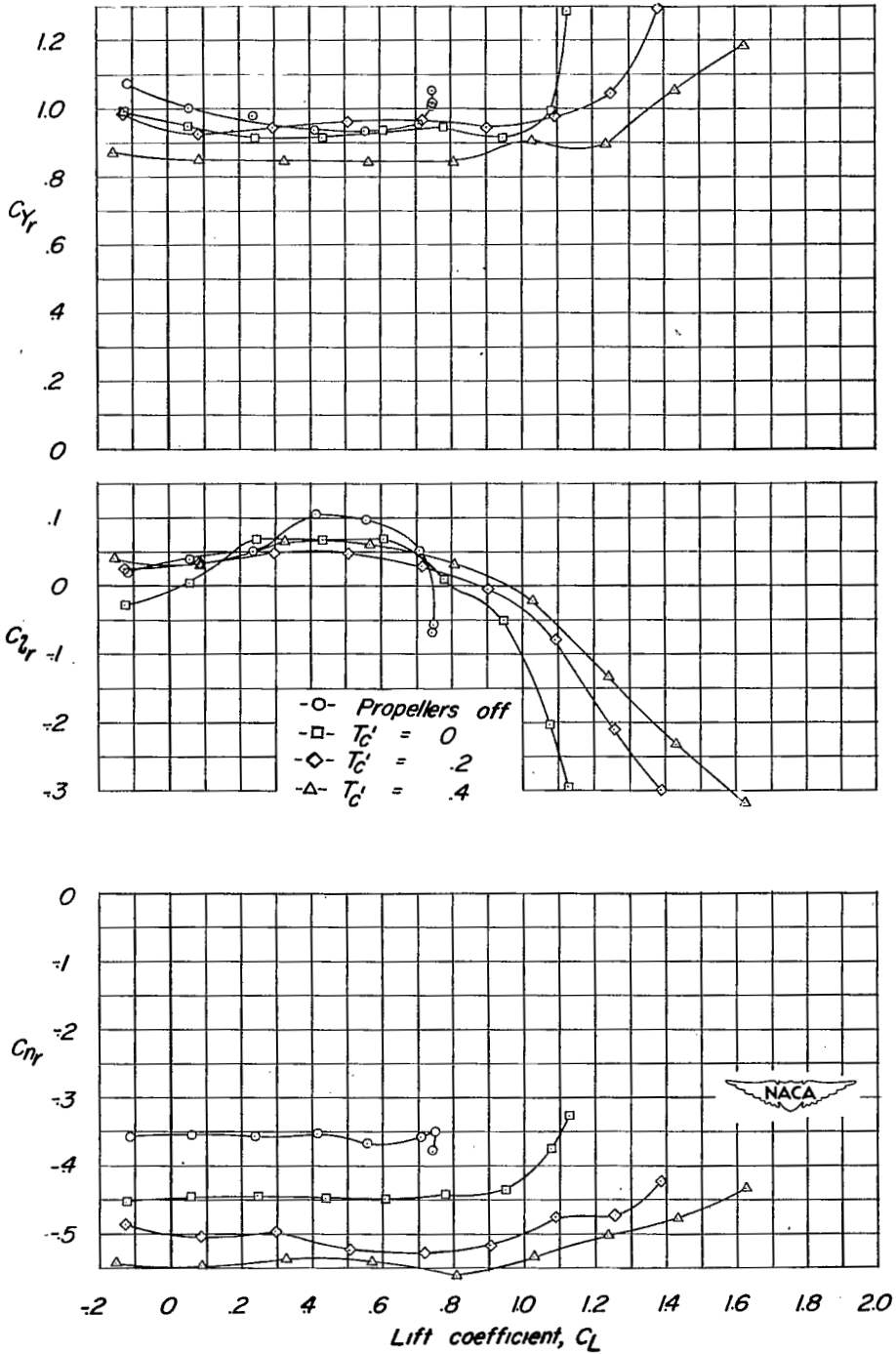
Figure 7.- Effect of thrust coefficient on the yawing stability derivatives of a 1/9-scale powered model of the Convair XFY-1 vertically rising airplane. $(\beta_o)_F = 35^o$; configurations $W + F + T_u + T_L$ and $W + F + T_u + T_L + P$.

Figure 8.- Effect of thrust coefficient on the yawing stability derivatives of a 1/9-scale powered model of the Convair XFY-1 vertically rising airplane. $(\beta_0)_F = 50^\circ$; configurations $W + F + T_u + T_L$ and $W + F + T_u + T_L + P$.
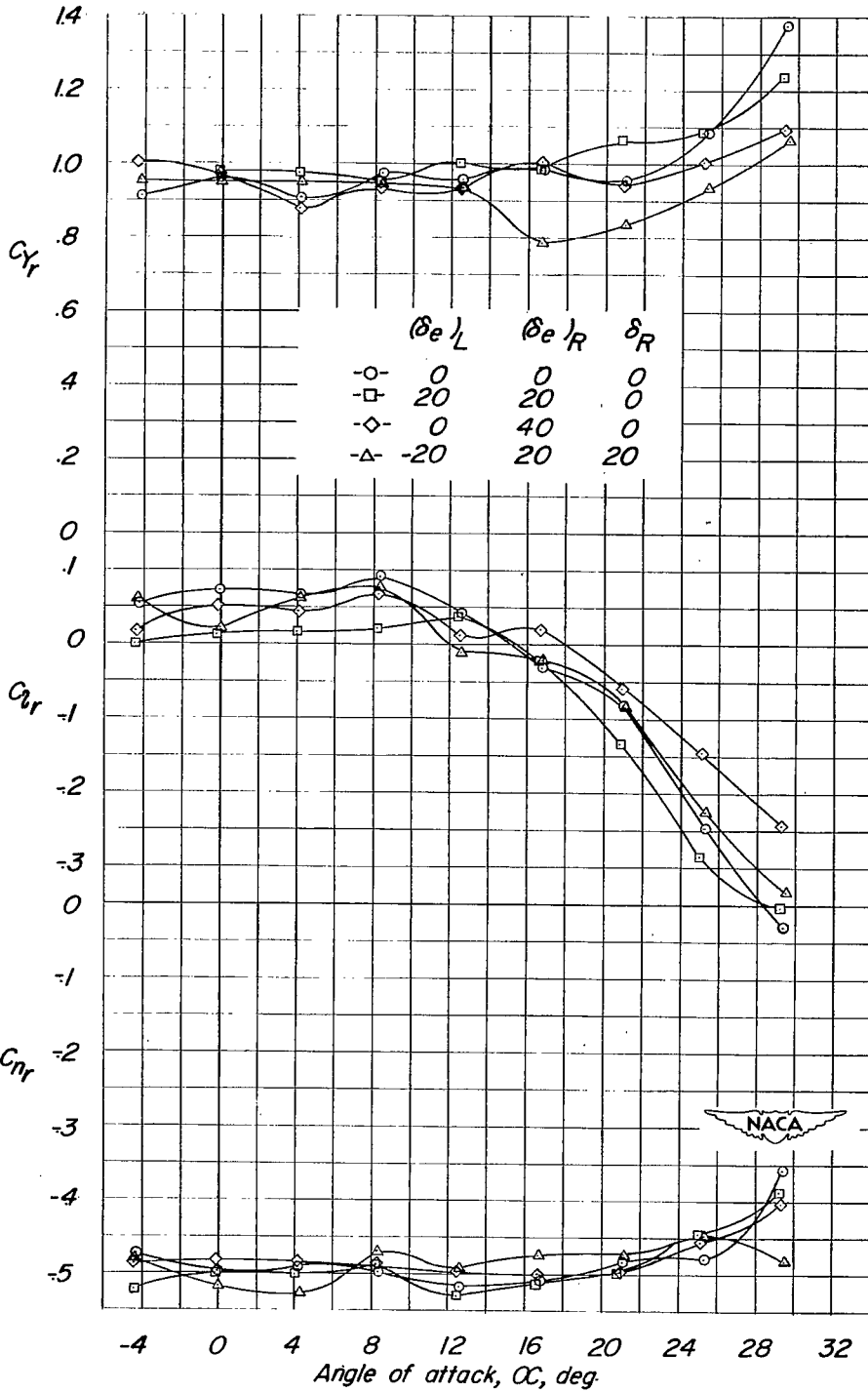
(a) $T_c' = 0$.

Figure 9.- Effect of control deflection on the yawing stability derivatives of a 1/9-scale powered model of the Convair XFY-1 vertically rising airplane. $(\beta_0)_F = 25^\circ$; configuration W + F + T_u + T_L + P.
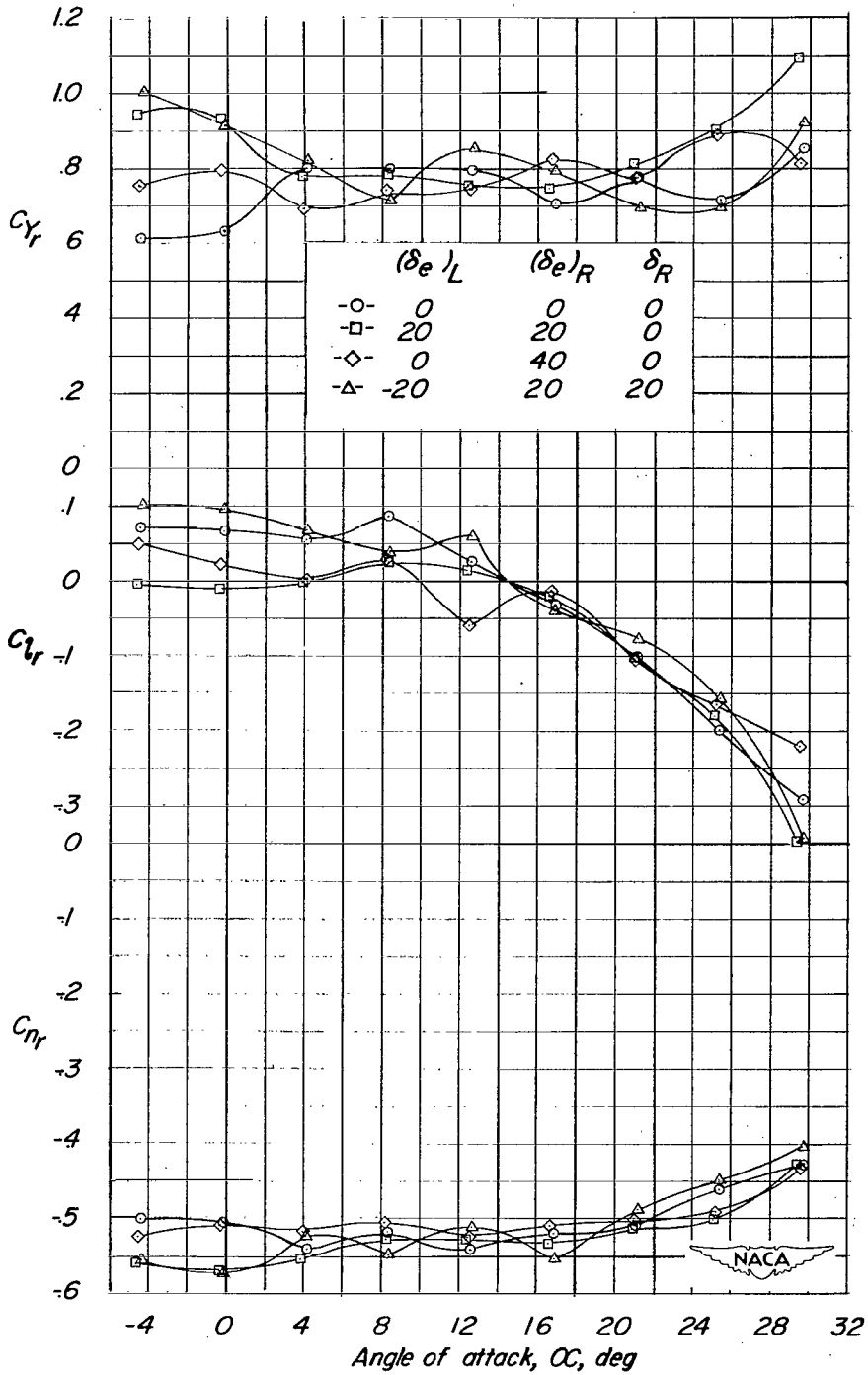
	$(\delta_e)_L$	$(\delta_e)_R$	δ_R
-o-	0	0	0
-□-	20	20	0
-◇-	0	40	0
-△-	-20	20	20
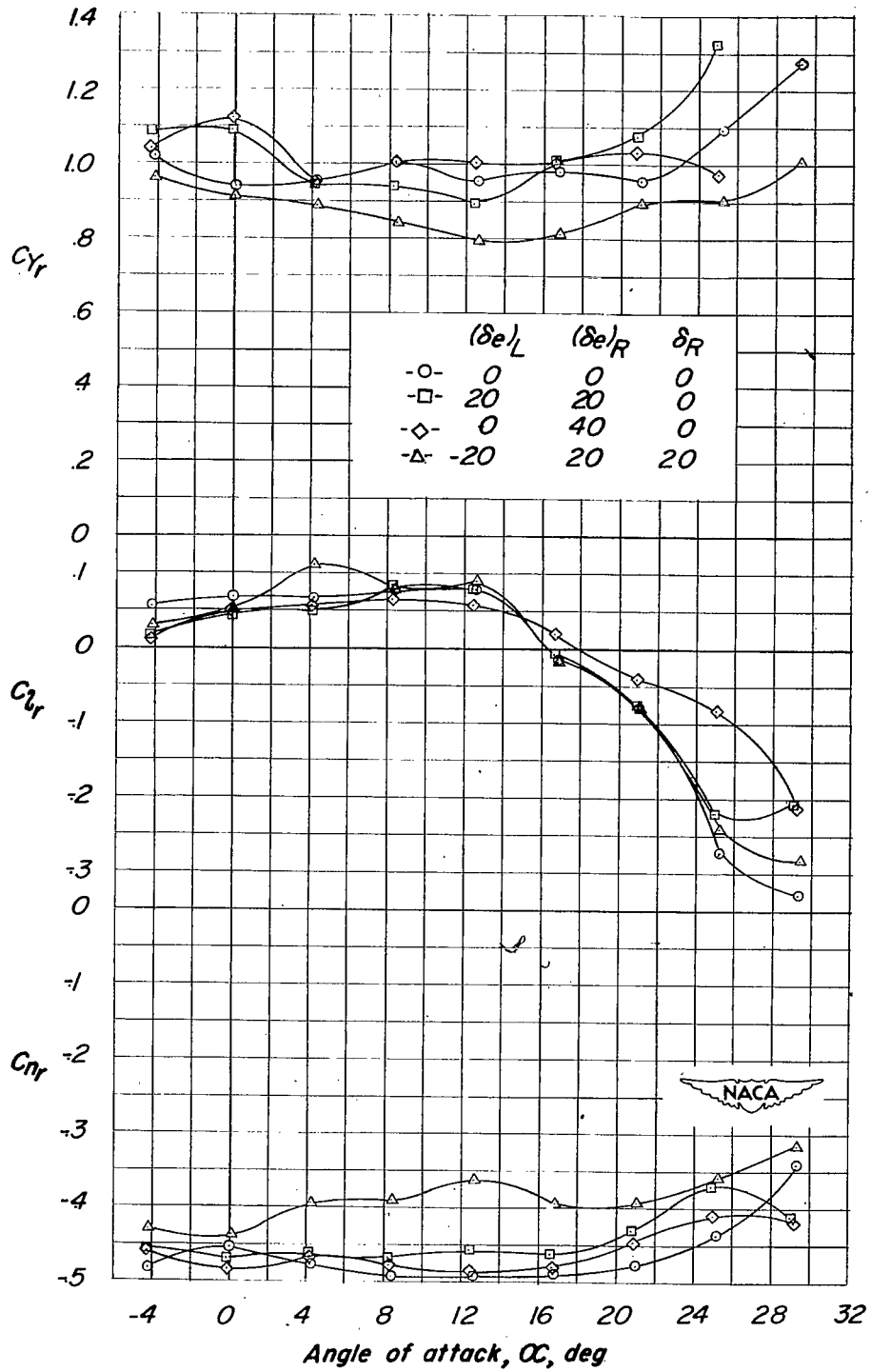
(b) $T_c' = 0.2$.

Figure 9.- Continued.

(c) $T_c' = 0.4$.

Figure 9.- Continued.

(d) $T_c' = 0.7$.

Figure 9.- Concluded.

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