NACA

RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

HYDRODYNAMIC INVESTIGATION OF THE TAKE-OFF CHARACTERISTICS OF A 1/10-SCALE DYNAMIC MODEL OF THE CONVAIR XF2Y-1 AIRPLANE

TED NO. NACA DE 372

By Ellis E. McBride and Lloyd J. Fisher

Langley Aeronautical Laboratory
Langley Field, Va.

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

WASHINGTON

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SUMMARY

An investigation was made of the take-off characteristics of a 1/10-scale dynamic model of the Convair XF2Y-1 airplane. This airplane is a water-based, jet-propelled, delta-wing fighter incorporating a hydro-ski landing gear. Tests were made with the original configuration, with the beaching wheels removed, and with the wheels installed and fairings added in front of the wheels. Each configuration was tested at weight and balance conditions simulating 17,000 pounds gross weight with the moment due to 7,600 pounds of thrust, 17,500 pounds gross weight with a 9,500-pound thrust condition, and 23,000 pounds gross weight with a 9,500-pound thrust condition.

Constant-speed runs were made at various elevon settings and vertical ski-strut positions; and trim, rise, and resistance were measured. Accelerated runs were made with controlled elevons and scale shock struts which could be extended as desired, and the longitudinal stability and spray characteristics were observed and photographed.

INTRODUCTION

The XF2Y-1 airplane is the prototype of a jet-propelled, delta-wing, supersonic, water-based fighter built by Convair. It is the first airplane incorporating a hydro-ski landing gear in the original design.

Investigations of the take-off characteristics of a 1/10-scale dynamic model of the airplane were conducted in the Langley tank no. 2 at the request of the Bureau of Aeronautics, Department of the Navy. Investigations were made with the original configuration, with the beaching wheels removed, and with the wheels installed and fairings added in front of the wheels. Three combinations of thrust and gross weight were included in the investigations. The data from these investigations are presented without analysis in this paper.

SYMBOLS

$\bar{c}$	mean aerodynamic chord
R	resistance, water and air, lb
r	rise of center of gravity from static condition, in.
T	rated thrust, lb
T_V	vertical component of thrust, lb
V	speed, knots
Y	vertical position of ski trailing edge, in. below keel
δ_e	elevon deflection, deg
Δ_o	gross load, lb
τ	angle of trim (angle between keel of hull and horizontal), deg

APPARATUS AND PROCEDURE

Description of Model

Photographs of the 1/10-scale dynamic model of the Convair XF2Y-1 airplane are shown in figure 1. Figure 2 is a three-view general-arrangement drawing of the airplane. The 1/10-scale model and pertinent information were furnished by the manufacturer. The model was constructed principally of balsa wood and was ballasted internally to obtain the desired gross weights and a pitching moment of inertia of 50,000 slug-feet^2 (full scale). As the tests progressed the original balsa-wood hull deteriorated

and a new hull of molded fiber glass and plastic was constructed. Pertinent data on the model and full-scale airplane are given in table I.

Bench tests of the model shock struts indicated a reasonable approximation of the full-scale characteristics. Pertinent data on the shock struts are listed in table I. The strut could be locked inoperative so that tests at various fixed strut positions could be made or could be fully extended automatically when desired.

The model was constructed so that a fairing could be added in front of the beaching wheels or the wheels could be removed and the wheel slots filled. Figure 3 is a drawing of the rear portion of the ski showing the installation of the beaching wheel and its fairing.

Test Methods and Equipment

The model was tested in the Langley tank no. 2. A photograph of the model attached to the towing apparatus is shown in figure 4. The model was free to trim about a pivot located at its center of gravity and was free to move vertically, but was restrained with respect to the towing carriage both longitudinally and laterally and in roll and yaw. The tests were made with the original configuration (beaching wheels installed, fig. 2), with the wheels removed, and with the wheels installed and fairings added in front of the wheels (figs. 1 and 3). Each configuration was tested at weight and balance conditions simulating 17,000 pounds gross weight with the moment due to 7,600 pounds of thrust, 17,500 pounds gross weight with a 9,500-pound thrust condition, and 23,000 pounds gross weight with a 9,500-pound thrust condition. The center of gravity was located at 28.8 percent mean aerodynamic chord $\bar{c}$ and 46 inches (full scale) above the keel of the hull. Trim was measured visually from a trim scale attached to the towing staff. Rise was measured visually from a scale at the top of the towing staff. The resistance was measured by a strain-gage beam in the towing staff.

An attempt was made to supply the model with scale jet thrust by using compressed air. This was unsatisfactory because of the stiffness of the hose required to supply the high air pressure needed. However, the pitching moment applied by the thrust was simulated by shifting a ballast weight to simulate a power-on condition. The use of an unbalanced pitching moment to simulate that applied by the thrust neglects the reduction in gross load caused by the vertical component of the thrust when the airplane is at a positive trim. Therefore, the model in the original configuration was tested at gross load conditions from 14,500 pounds to 17,000 pounds by 500-pound increments and resistance was measured in order to determine the effect of small load changes on the relationship Δ_0/R. All resistance data in this paper have been corrected accordingly.

Stability was observed in constant-acceleration runs at 3 ft/sec^2 with controllable elevons and actuating ski shock struts duplicating the take-off procedure for minimum resistance as close as possible. While at rest, the skis were set at the position, Y = 35 inches (recommended by the manufacturer, fig. 2), and were fully extended when the model had accelerated to forward speeds corresponding to about 50, 65, 85, and 103 knots. Tests were made at three longitudinal center-of-gravity positions: 30, 28.8, and 27 percent mean aerodynamic chord. Motion pictures and sequence photographs were made of these tests.

The aerodynamic tests were made at constant speeds. Trim and drag were measured. The model was fixed vertically so that at the highest trim the lowest part of the model was about 1/2 inch above the water. Both the power-off and power-on moment conditions were simulated.

RESULTS

For convenience, the data obtained are presented as converted to full-scale values according to Froude's law.

Aerodynamics

The variation of trim with elevon deflection is shown in figure 5. The aerodynamic drag measured at various trims and speeds is plotted in figure 6.

Correction for Vertical Component of Thrust

When the model was tested at various reduced gross loads the resulting Δ_o/R was found to remain constant as load was decreased. Only the values of Δ_o/R for the 14,500-pound and the 17,000-pound weight conditions are shown in figure 7. The results from tests at the intermediate weight conditions fall between these limits. The other curves used in correcting the measured resistance for the reduction in gross load due to the vertical component of thrust are also shown in figure 7. The curves for vertical component of thrust are based on the expression

$$T_V = T \sin \tau$$

Curves for the ratio of the corrected resistance to measured resistance are based on the expressions

$$\frac{\Delta_o}{R_{measured}} = \text{Constant} = \frac{\Delta_o - T_V}{R_{corrected}}$$

$$\frac{R_{corrected}}{R_{measured}} = \frac{\Delta_o - T_V}{\Delta_o}$$

Trim, Rise, and Resistance

Trim, rise, and resistance obtained with the original configuration at 17,000 pounds gross weight and a 7,600-pound thrust condition are shown in figure 8 for various ski positions and elevon deflections. Trim and rise at minimum resistance are shown in figure 9.

Figure 10 shows the trim, rise, and resistance for the no-wheel configuration at 17,000 pounds gross weight and a 7,600-pound thrust condition obtained at two vertical ski positions of Y = 55 and 35 inches at various elevon deflections. Figure 11 shows the trim and rise at minimum resistance for this configuration.

Figure 12 shows the trim, rise, and resistance for the wheel-and-fairing configuration at 17,000 pounds gross weight and a 7,600-pound thrust condition obtained at two vertical ski positions of Y = 55 and 35 inches at various elevon deflections. Figure 13 shows the trim and rise at minimum resistance for this configuration.

Figures 14 to 19 show the trim, rise, and resistance obtained at 17,500 pounds gross weight with a 9,500-pound thrust condition for the various wheel conditions, ski positions, and elevon deflections tested.

Figures 20 to 24 show the trim, rise, and resistance obtained at 23,000 pounds gross weight and a 9,500-pound thrust condition for the various wheel conditions, ski positions, and elevon deflections tested. The investigation of the original configuration was limited to one vertical ski position, Y = 35 inches, because of the high resistance obtained.

Stability and Spray

The behavior of the model was satisfactory when the skis were extended in tests at forward speeds corresponding to 50, 65, 85,

and 103 knots. When the skis were extended, the rise of the model increased and some change in trim was noted. This change in trim was steady and no oscillation of more than 1 cycle was apparent.

Stable take-offs were made at all three center-of-gravity positions tested. At the position of 30 percent mean aerodynamic chord the model was very sensitive to elevon control and it was easy to over-control. Figure 25 shows some typical spray photographs taken during these tests for the original configuration, the no-wheel configuration, and the wheel-and-fairing configuration at a center-of-gravity position of 28.8 percent mean aerodynamic chord and 17,000 pounds gross weight with a 7,600-pound thrust condition. Under the conditions tested (smooth water with no wind and no scale air inflow into the intake ducts), the jet intake ducts were well shielded from spray by the wing root. Heavy spray impinged on the under surface of the wing, and, at speeds below about 50 knots, a large quantity of water was dumped on top of the wing. In the original configuration (fig. 25(a)), a jet of spray originating at the slot around the wheel impinged on the under side of the wing at speeds above 50 knots. Removing the wheels (fig. 25(b)) or adding a fairing in front of the wheel (fig. 25(c)) eliminated this jet of spray and considerably improved the spray at high speeds.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., June 22, 1954.

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John B. Parkinson
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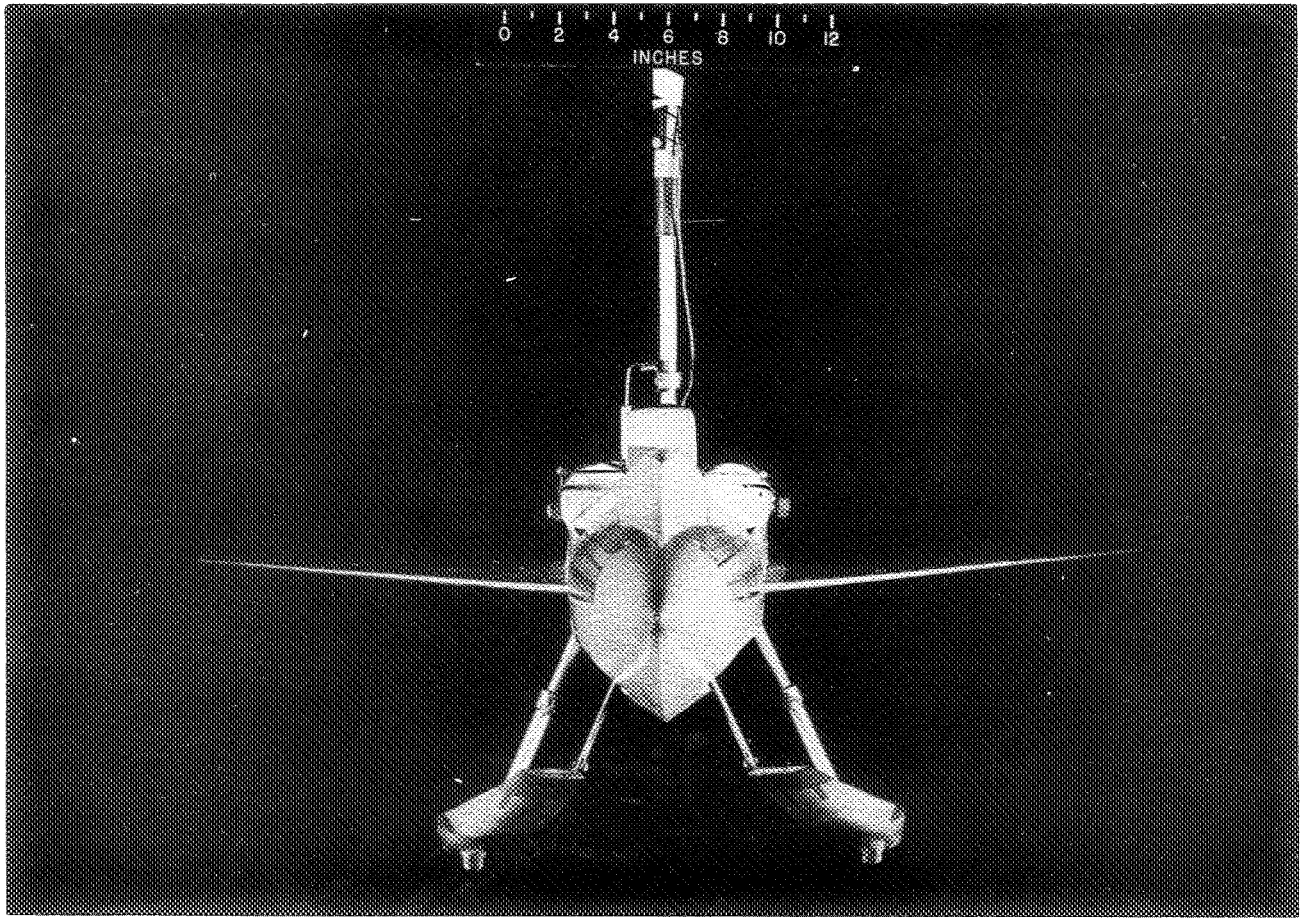
TABLE I

PERTINENT DATA OF THE CONVAIR XF2Y-1 AIRPLANE

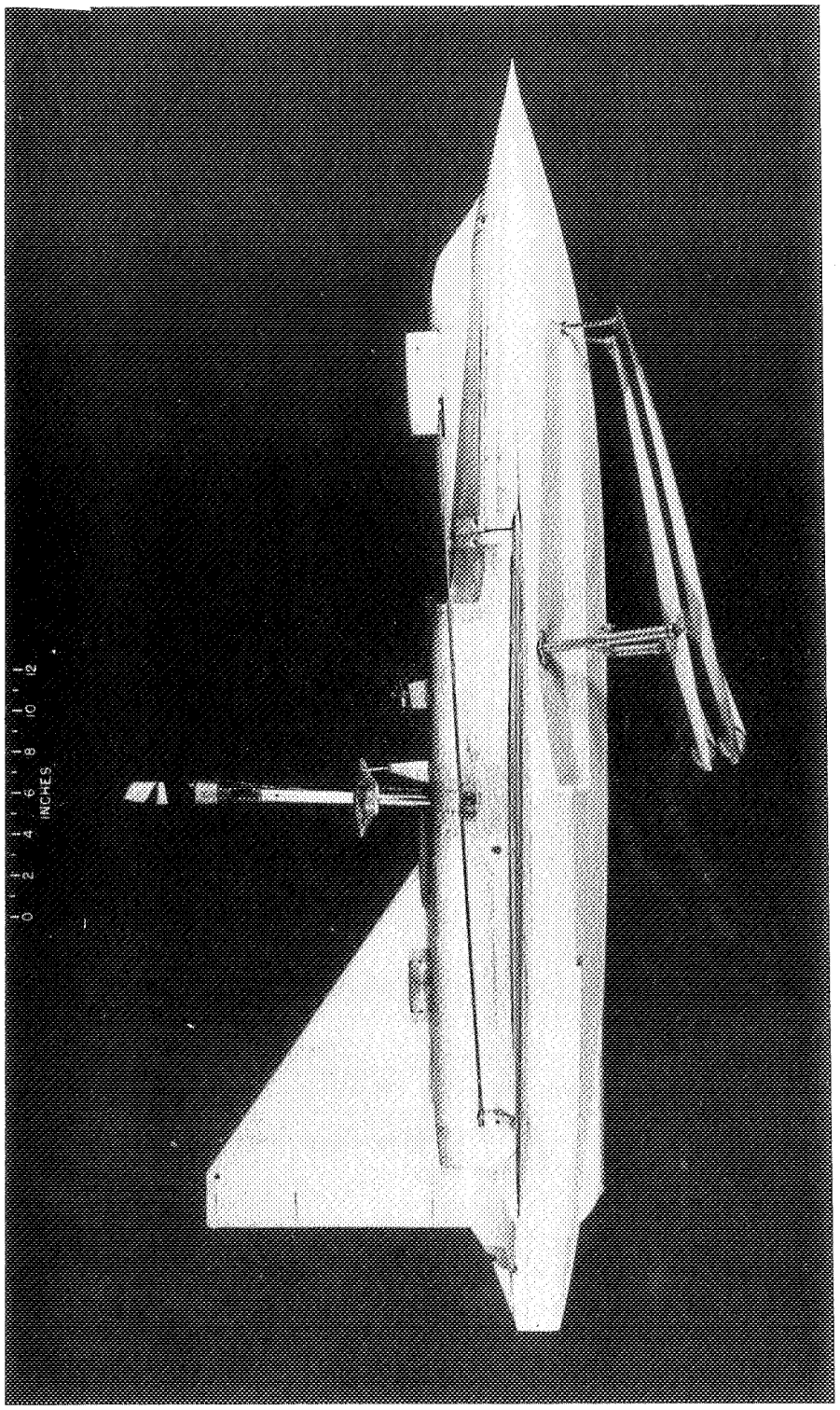
AND THE 1/10-SCALE DYNAMIC MODEL

	Model	Full scale
Wing:		
Area, sq ft	5.63	563
Span, ft	3.367	33.67
Sweepback (leading edge), deg	60	60
Mean aerodynamic chord, ft	2.1408	21.408
Hull:		
Overall length, ft	5.283	52.83
Maximum beam, ft	0.417	4.17
Dead-rise angle, deg	35	35
Hydro-ski:		
Overall length, in.	22.5	225
Maximum beam, in.	2.9	29
Shock strut:		
Maximum load absorption (each strut), lb	33	33,000
Stroke, in.	2.7	27
Piston diameter, in.	0.45	4.5
Ratio of extended to compressed-air volume	3	3
Initial air pressure, lb/sq in.	36	360
Extension time, sec	0.0316	0.10



(a) Front view. L-74796

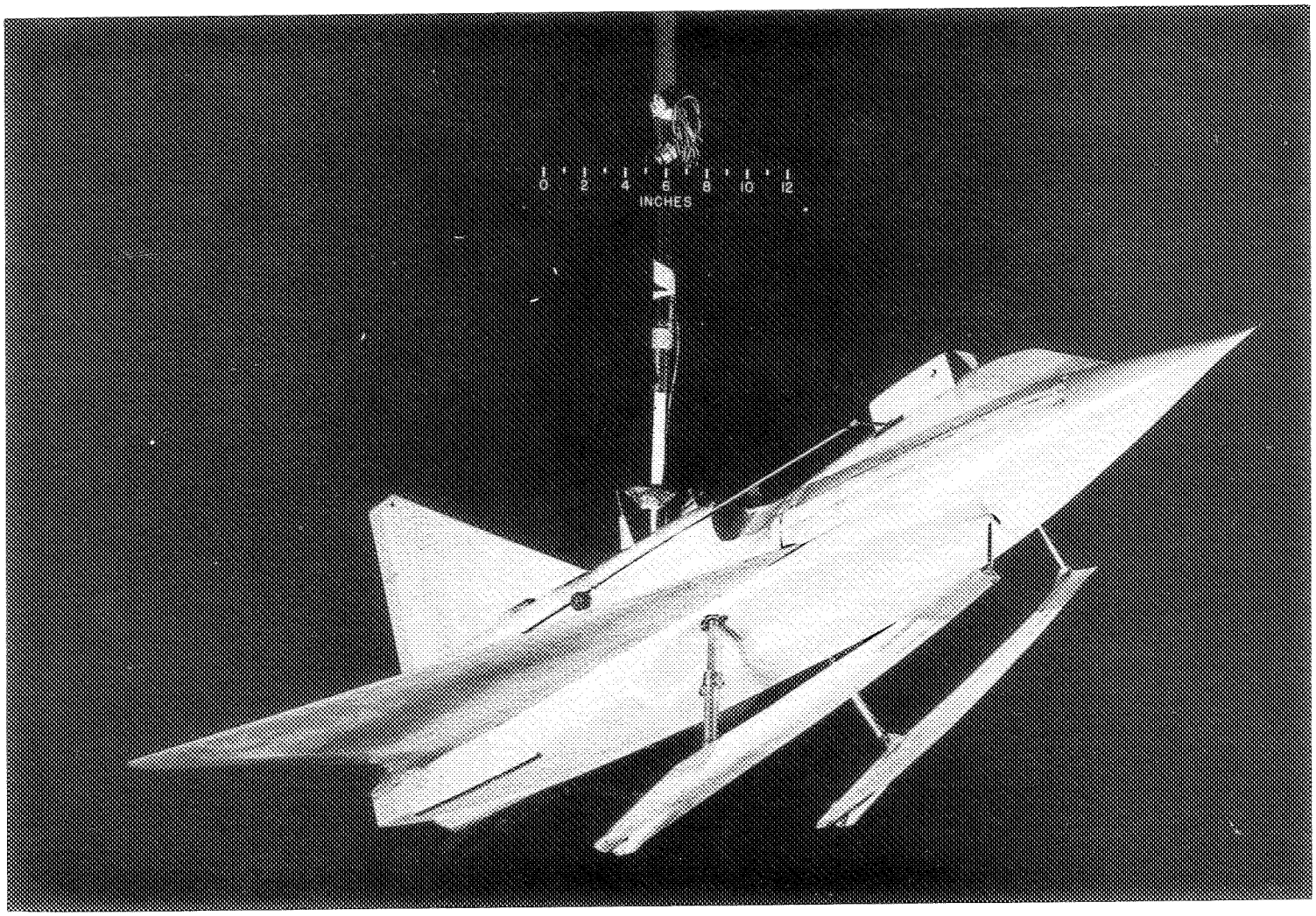
Figure 1.- Photographs of 1/10-scale dynamic model of the Convair XF2Y-1 airplane.



L-74797

(b) Profile view.

Figure 1.- Continued.



L-74798

(c) Three-quarter bottom view.

Figure 1.- Concluded.

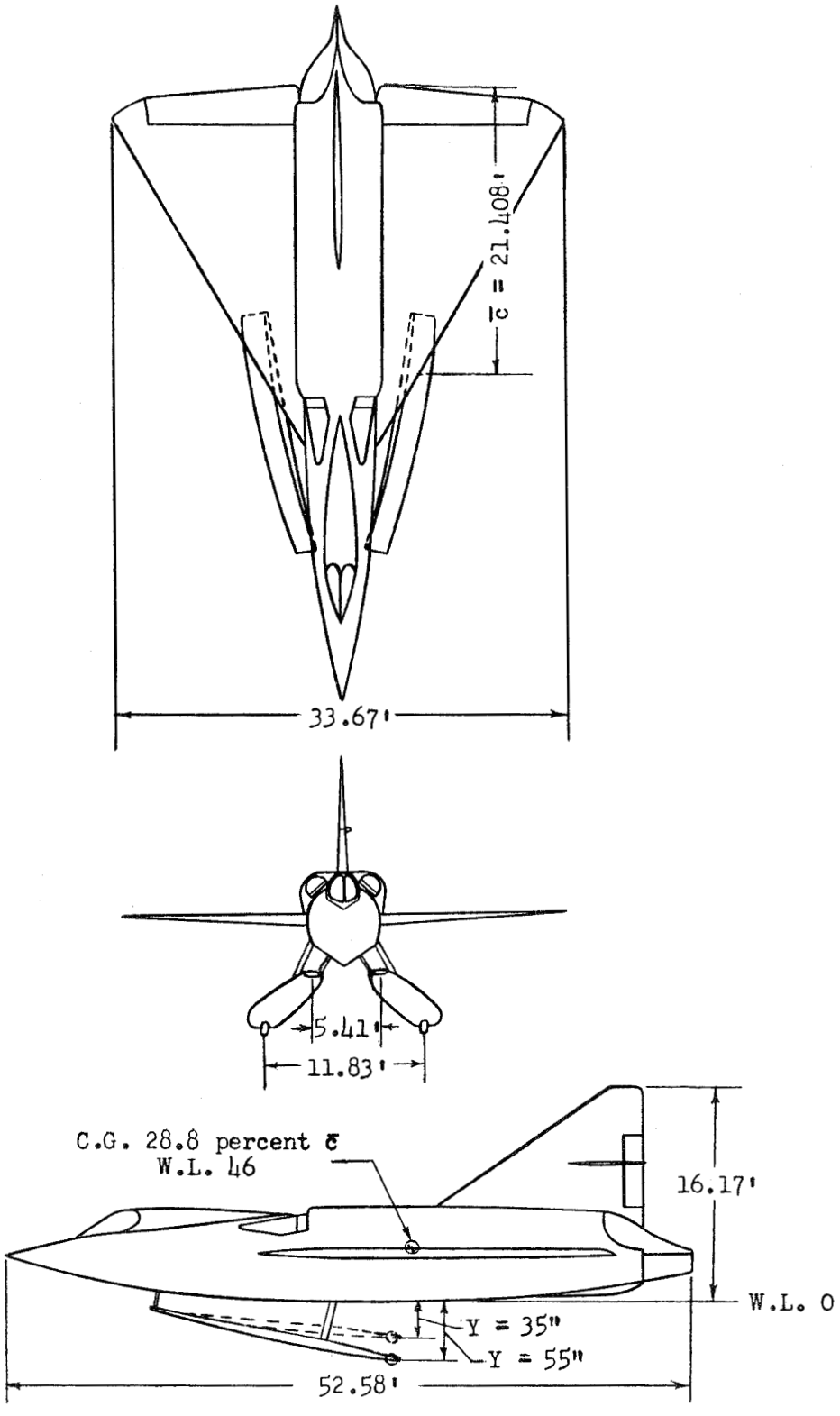


Figure 2.- General arrangement of Convair XF2Y-1 airplane.

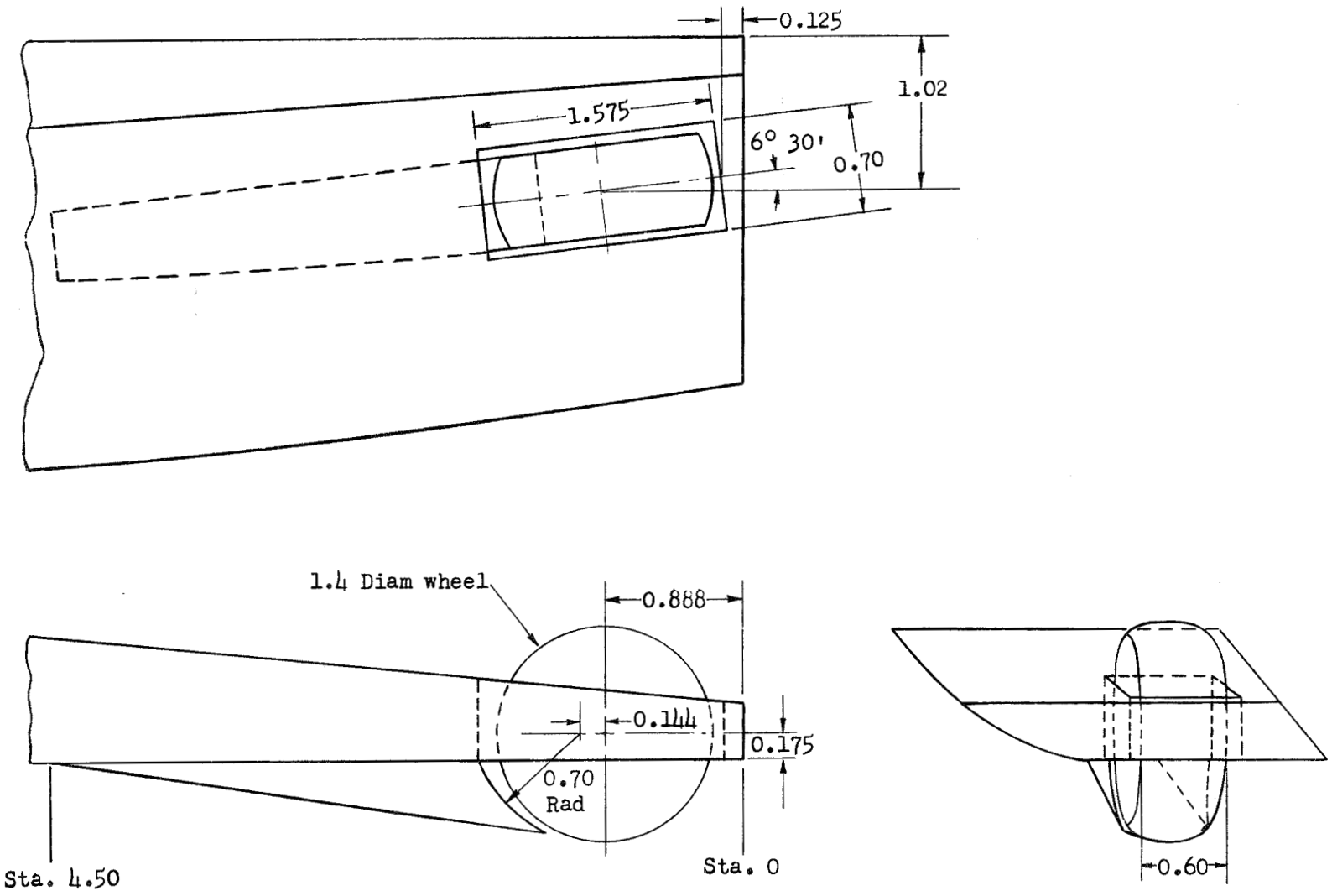
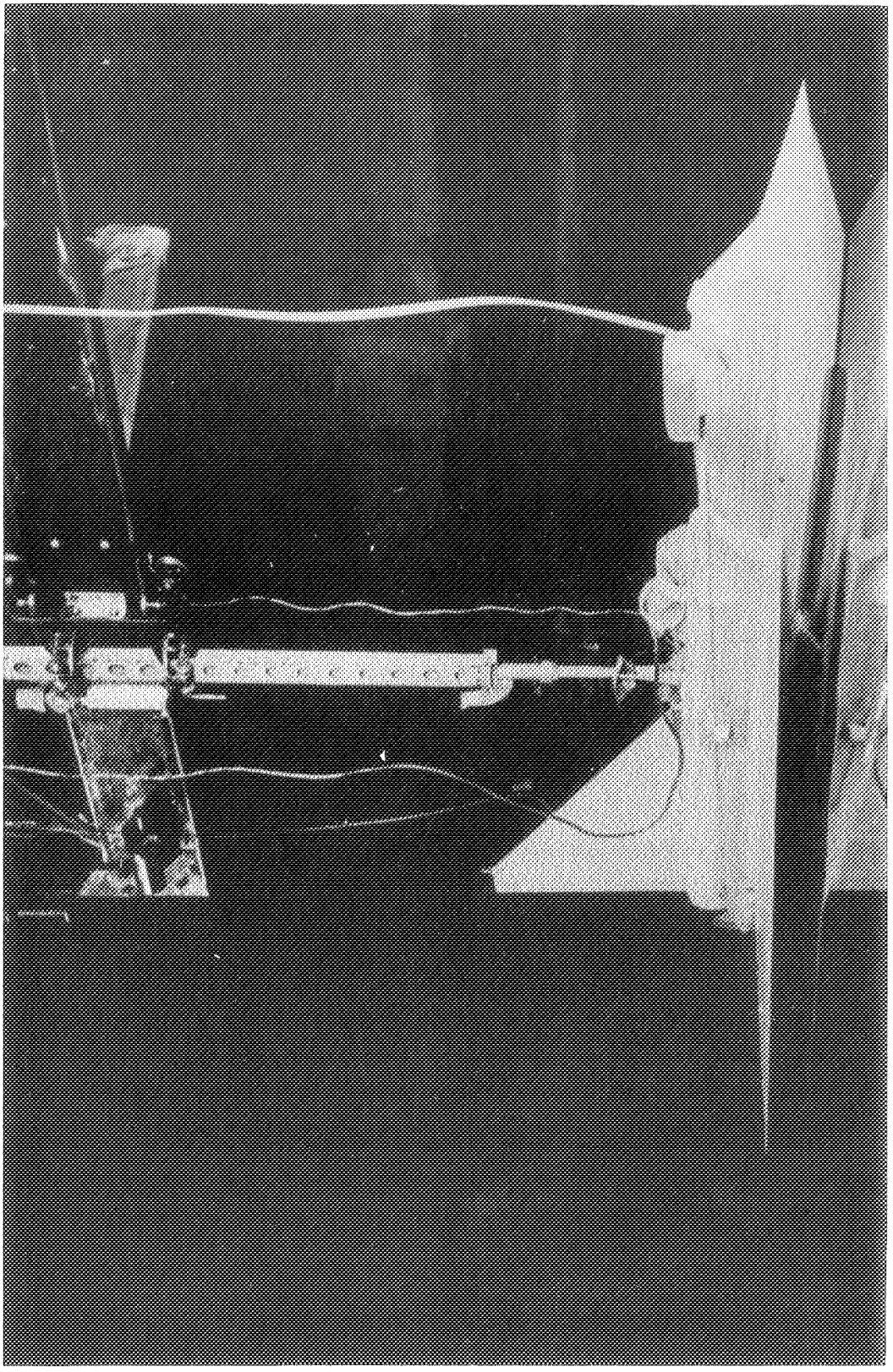


Figure 3.- Installation of beaching wheel and fairing on 1/10-scale model of Convair XF2Y-1 airplane. All dimensions are in inches.



L-84909

Figure 4.- Setup of model on towing apparatus.

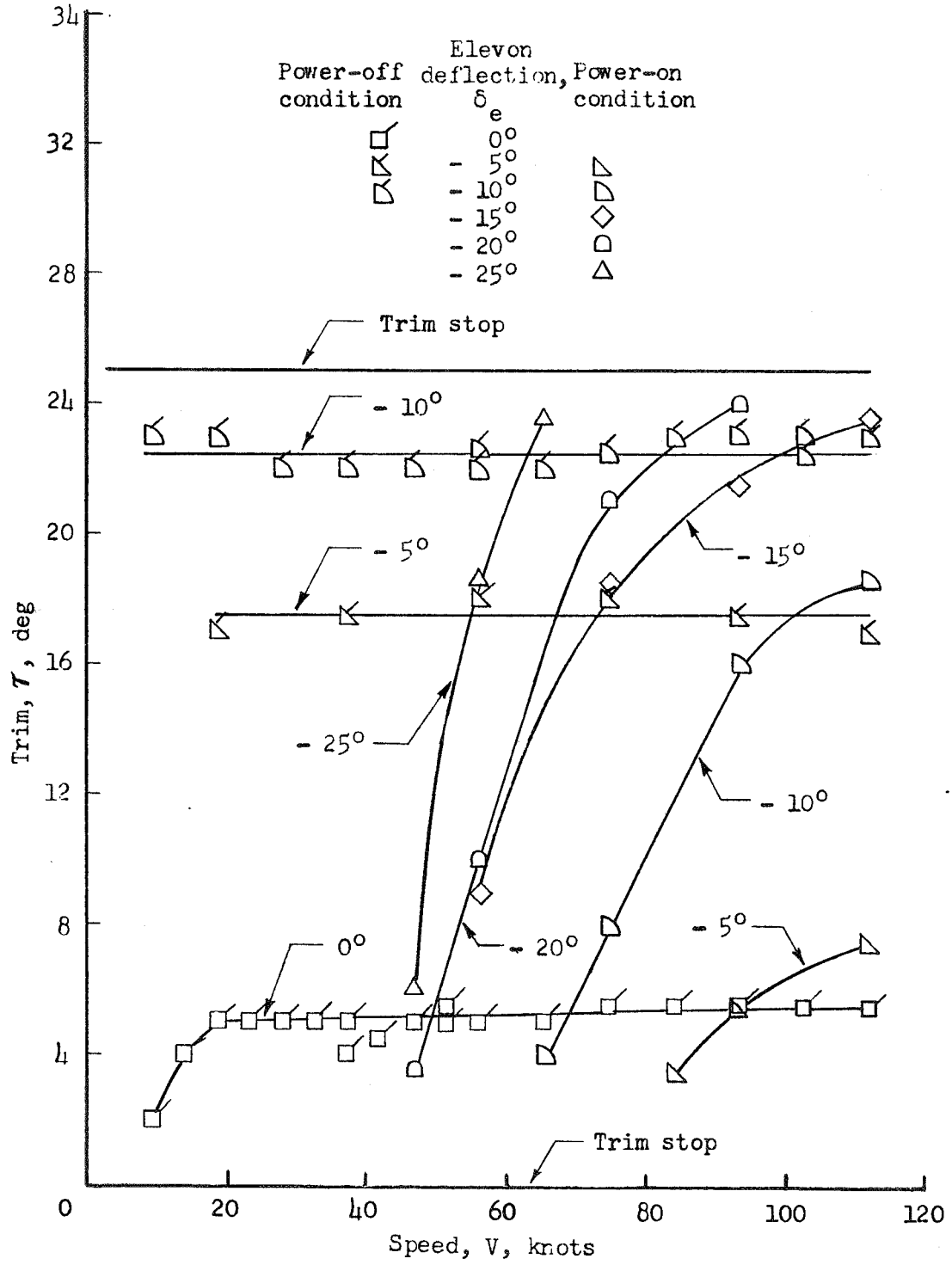


Figure 5.- Variation of trim with elevon deflection. Center-of-gravity location, 28.8 percent mean aerodynamic chord; gross weight, 17,000 pounds; thrust condition, 7,600 pounds.

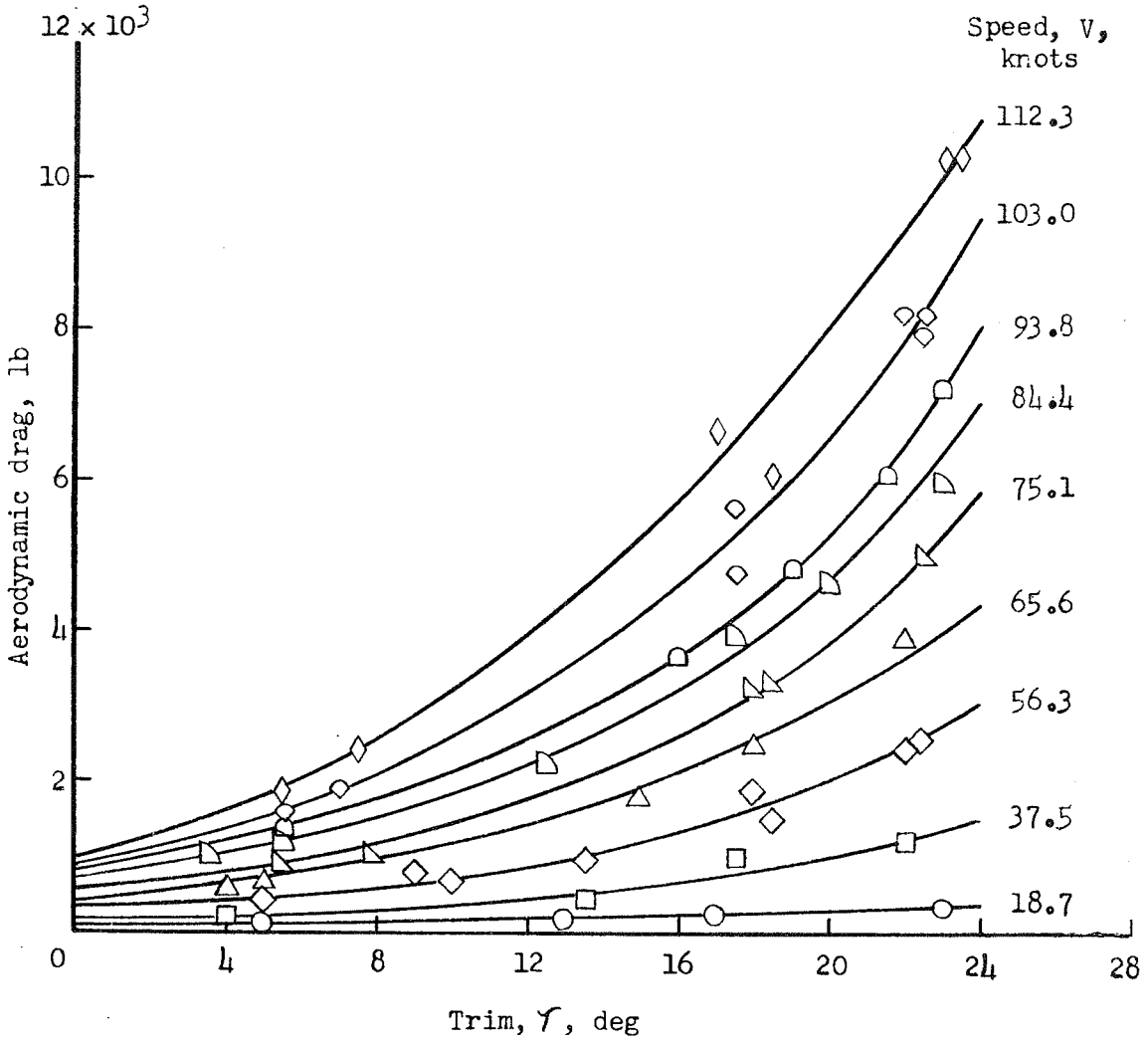


Figure 6.- Aerodynamic drag of model in original configuration. Values are full scale.

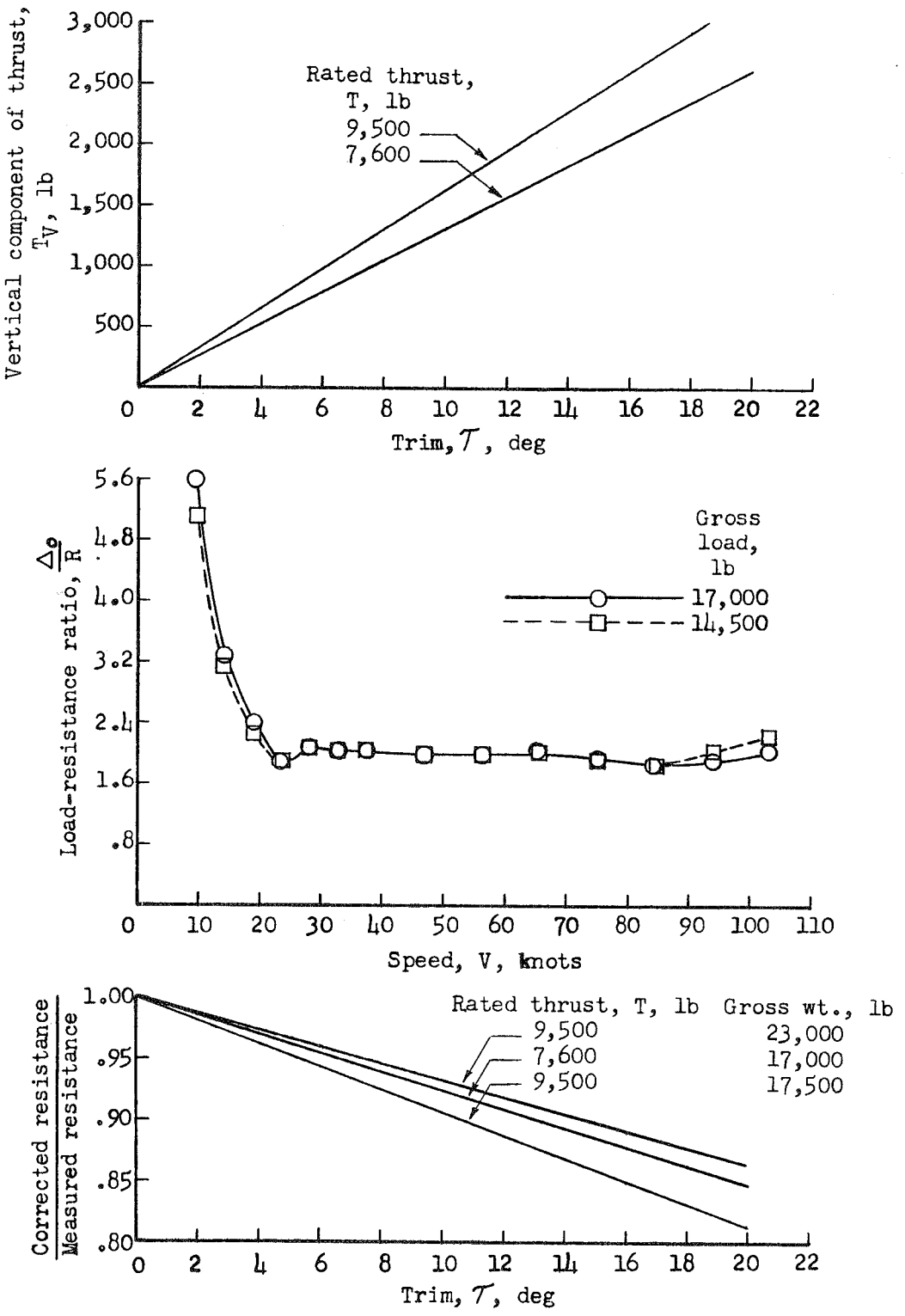
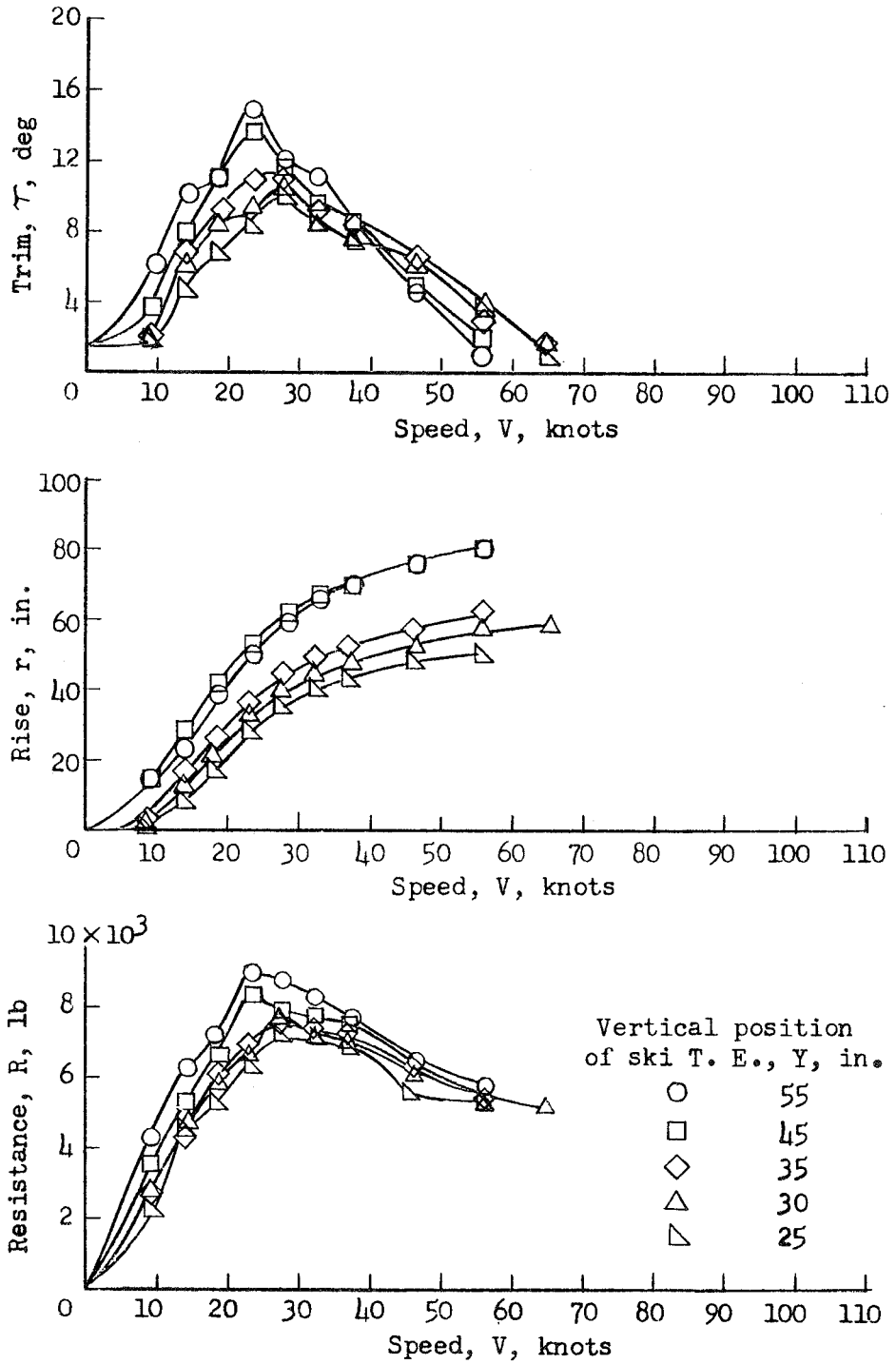
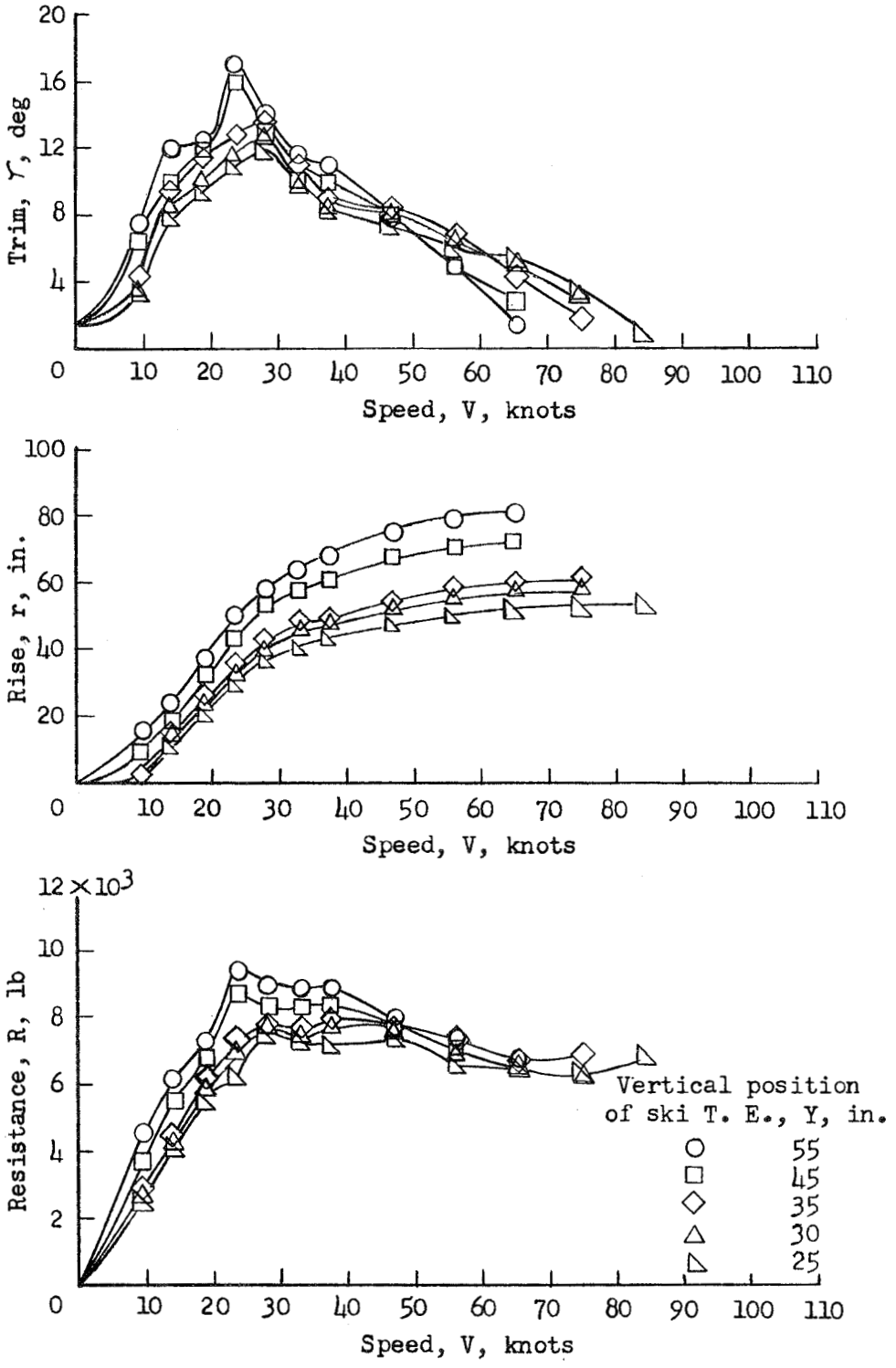


Figure 7.- Curves used in correcting resistance for reduction in gross load due to vertical component of thrust.



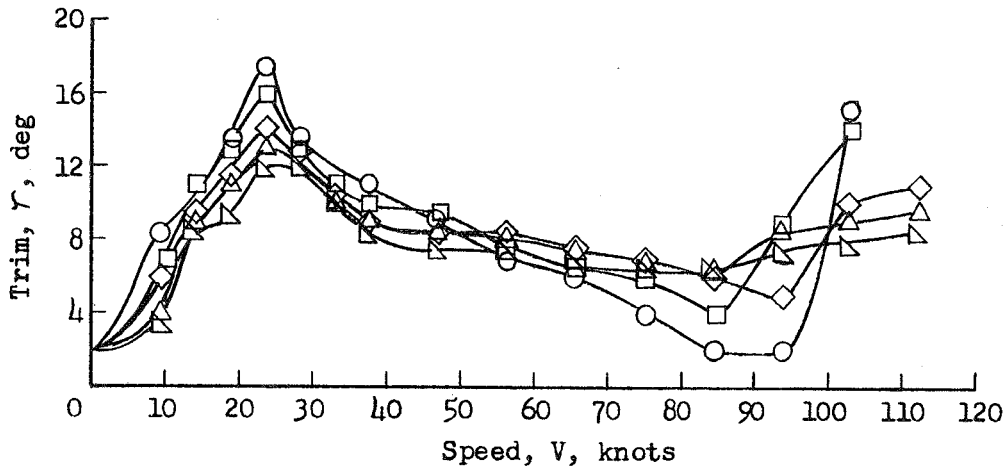
(a) Elevons, 15°.

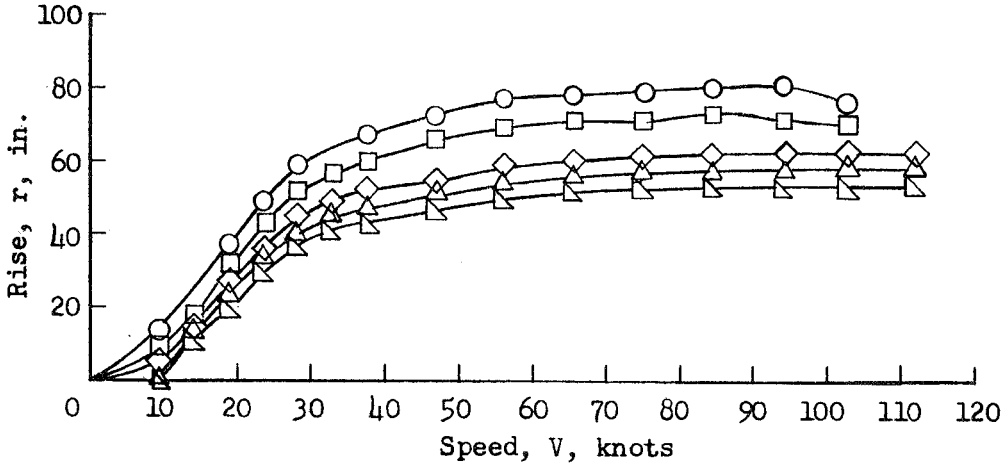
Figure 8.- Trim, rise, and resistance for original configuration. Gross weight, 17,000 pounds; thrust condition, 7,600 pounds.

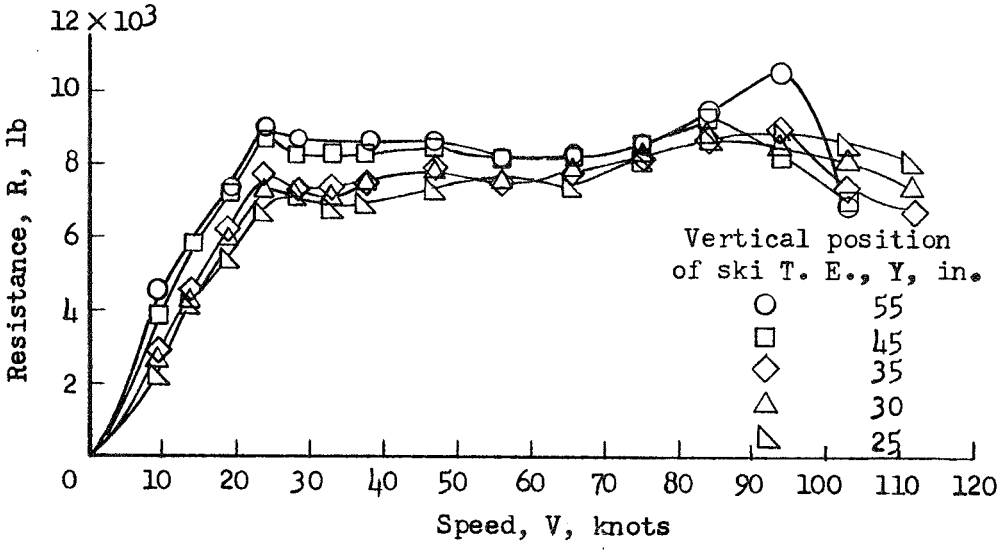


(b) Elevons, 0°.

Figure 8.- Continued.

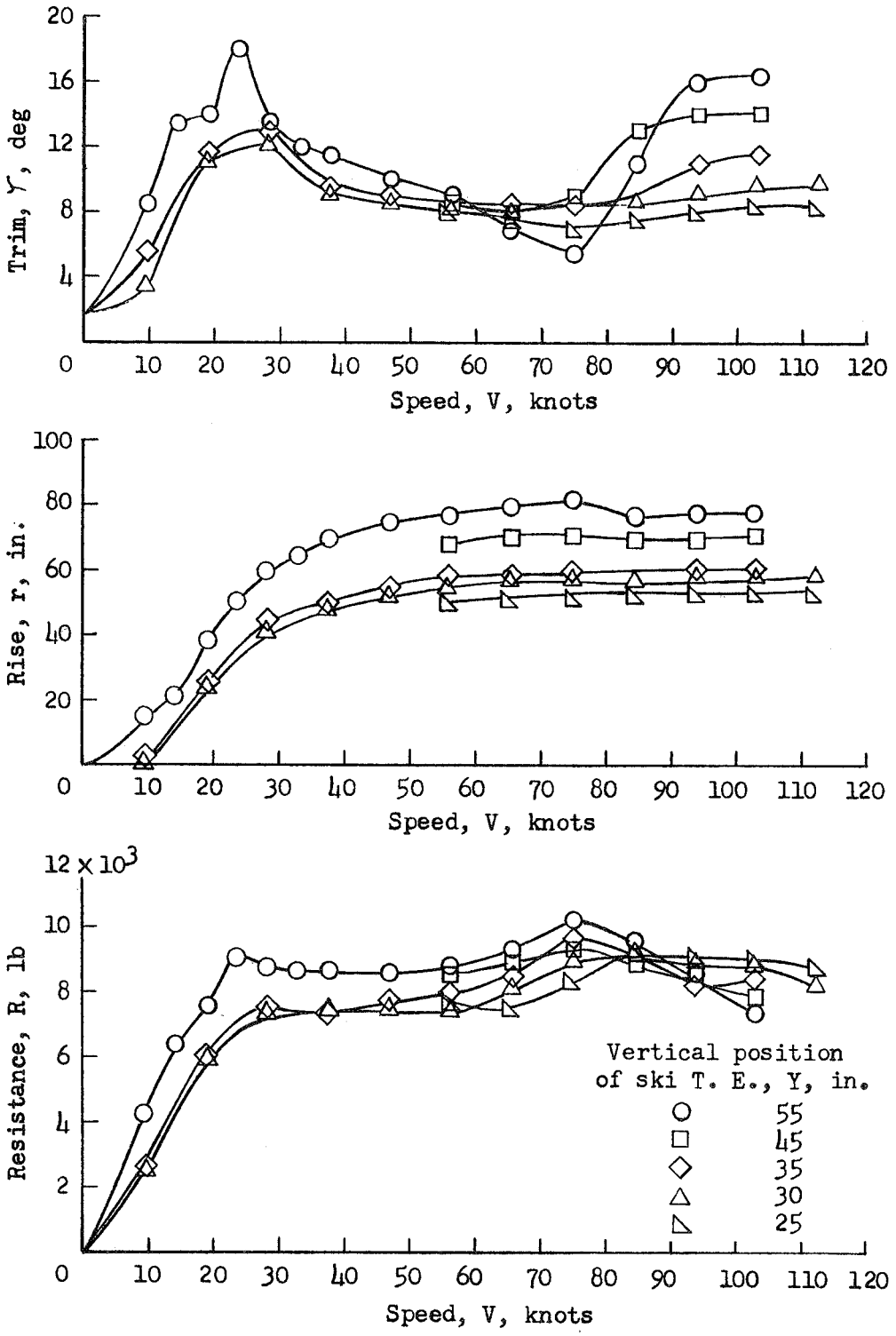






(c) Elevons, -15°.

Figure 8.- Continued.



(d) Elevons, -25°.

Figure 8.- Concluded.

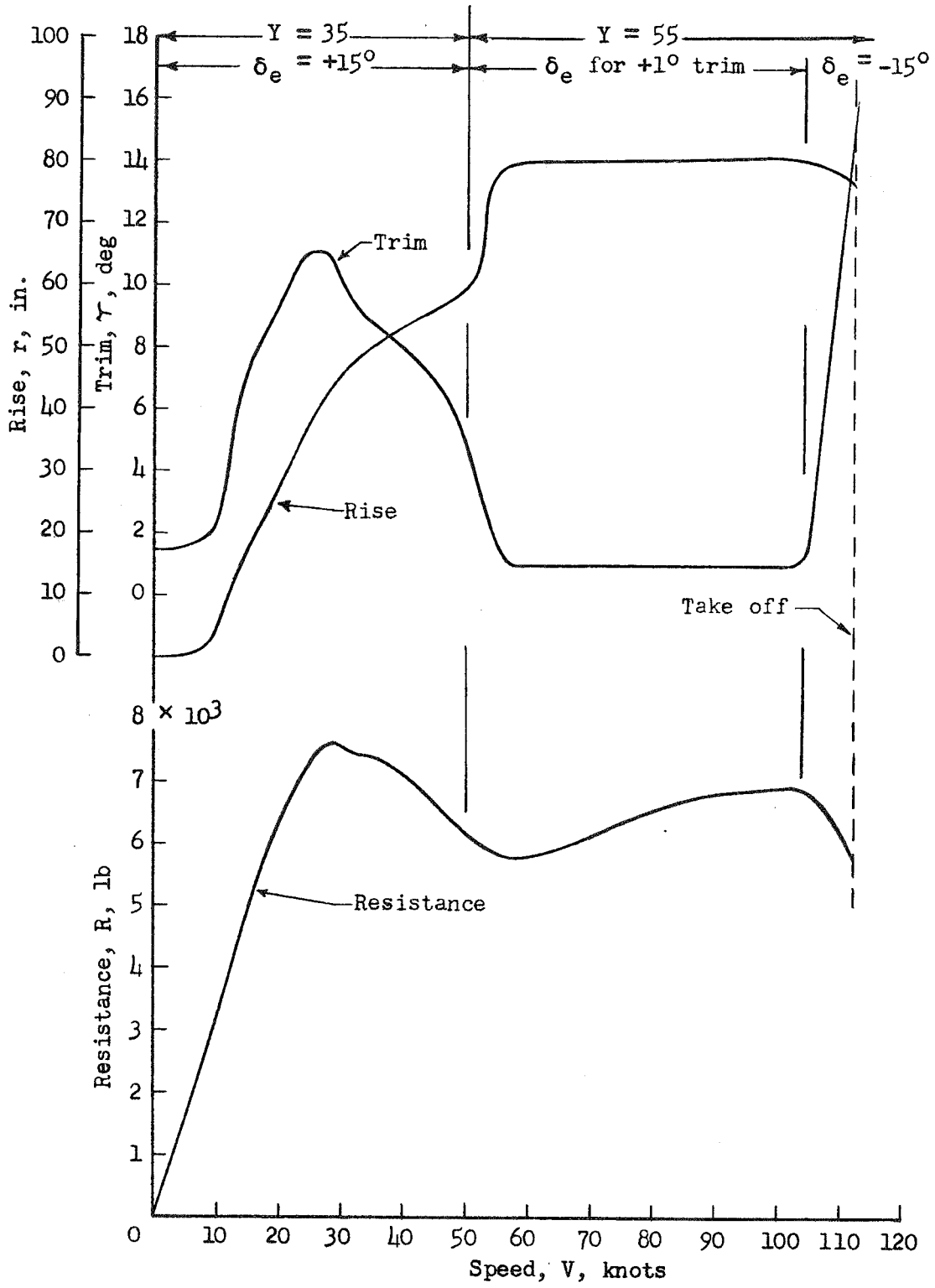
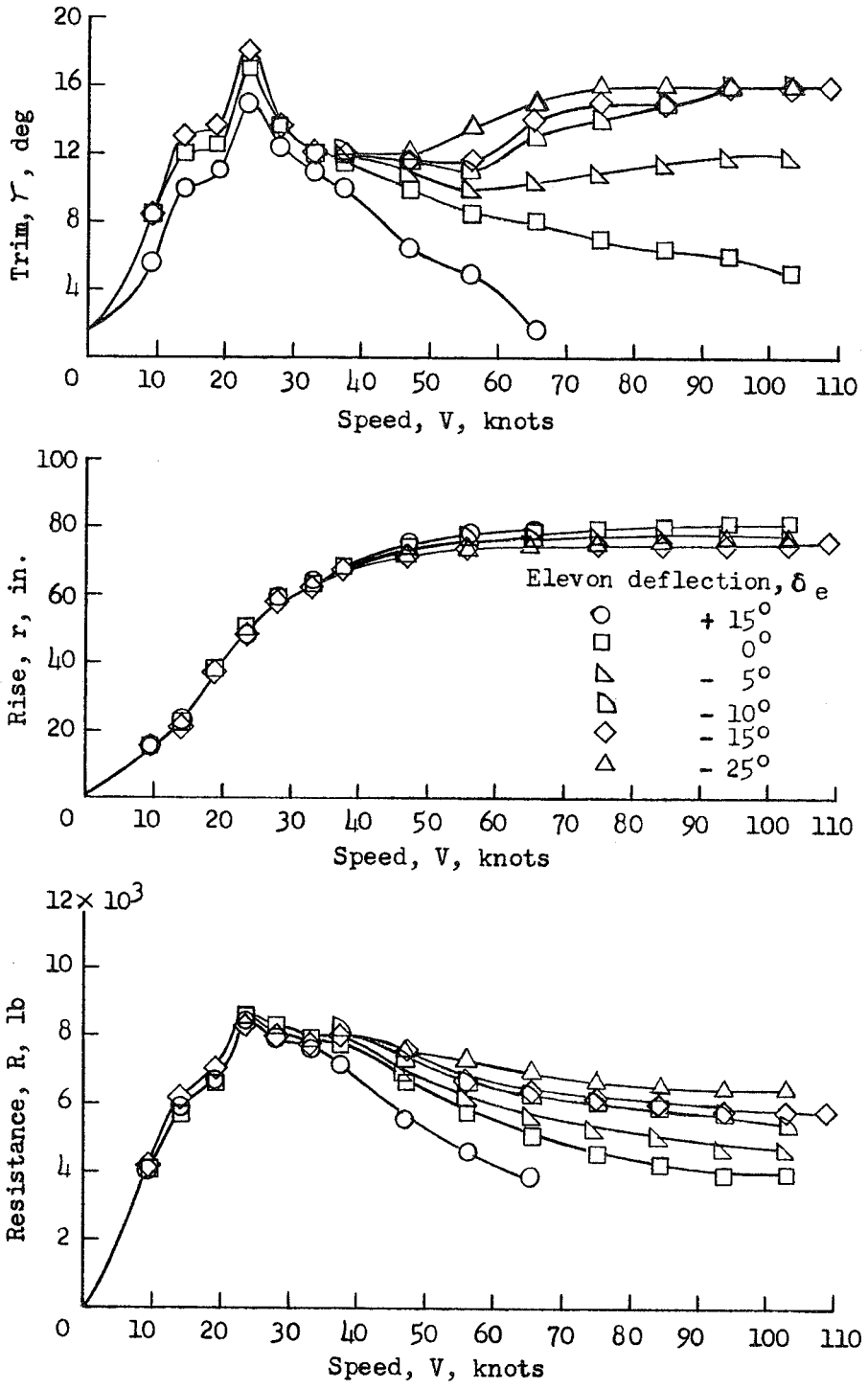
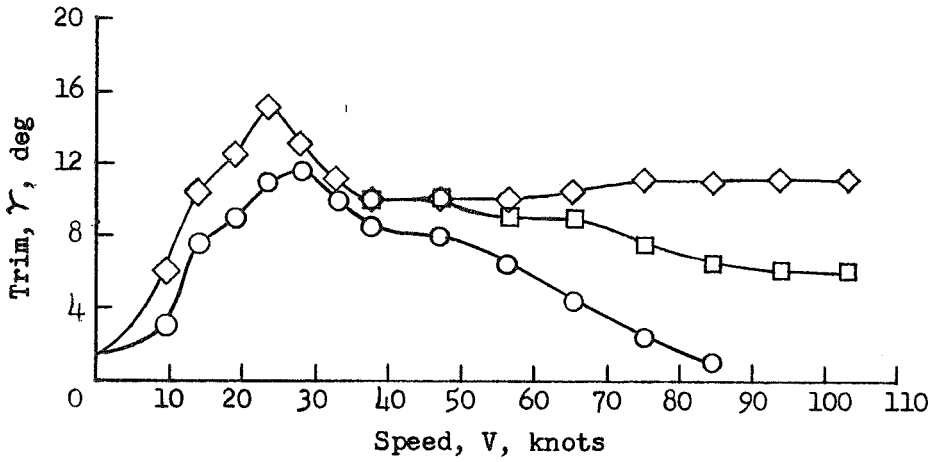


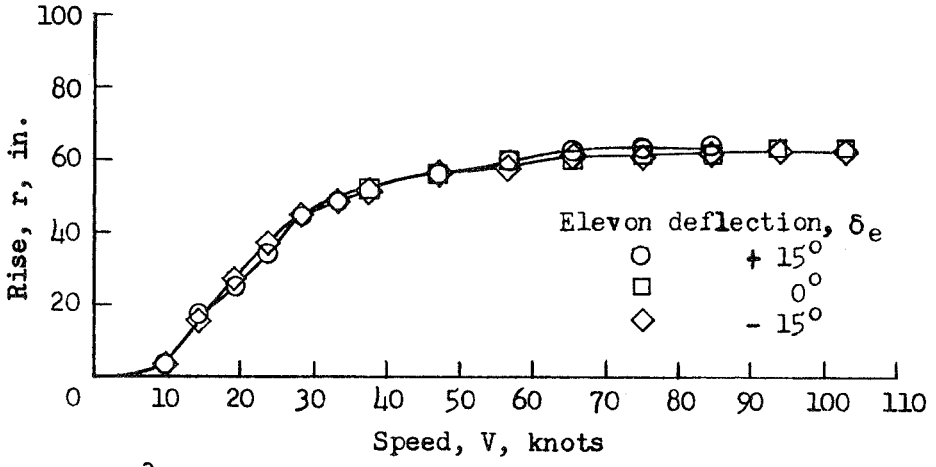
Figure 9.- Trim and rise at minimum resistance for original configuration. Gross weight, 17,000 pounds; thrust condition, 7,600 pounds.

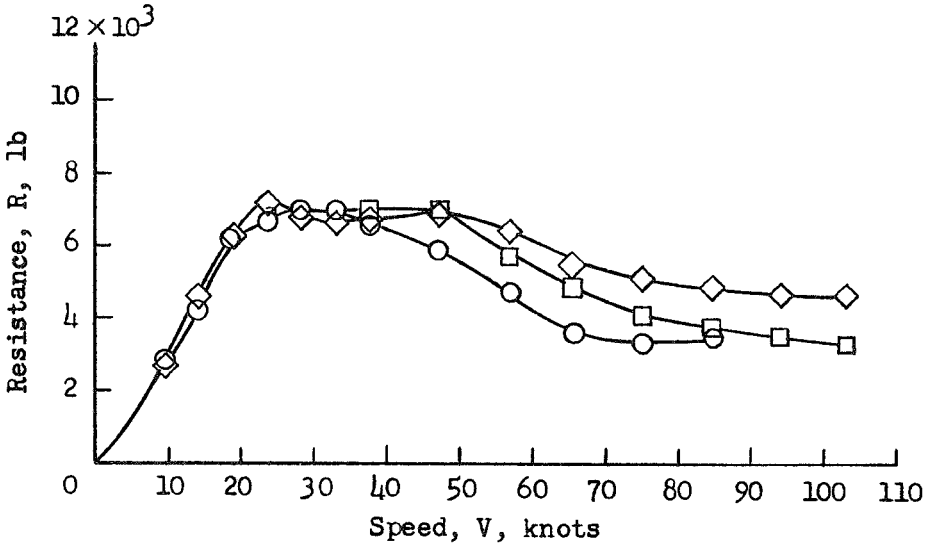


(a) Ski position, Y = 55 inches.

Figure 10.- Trim, rise, and resistance for no-wheel configuration. Gross weight, 17,000 pounds; thrust condition, 7,600 pounds.







(b) Ski position, Y = 35 inches.

Figure 10.- Concluded.

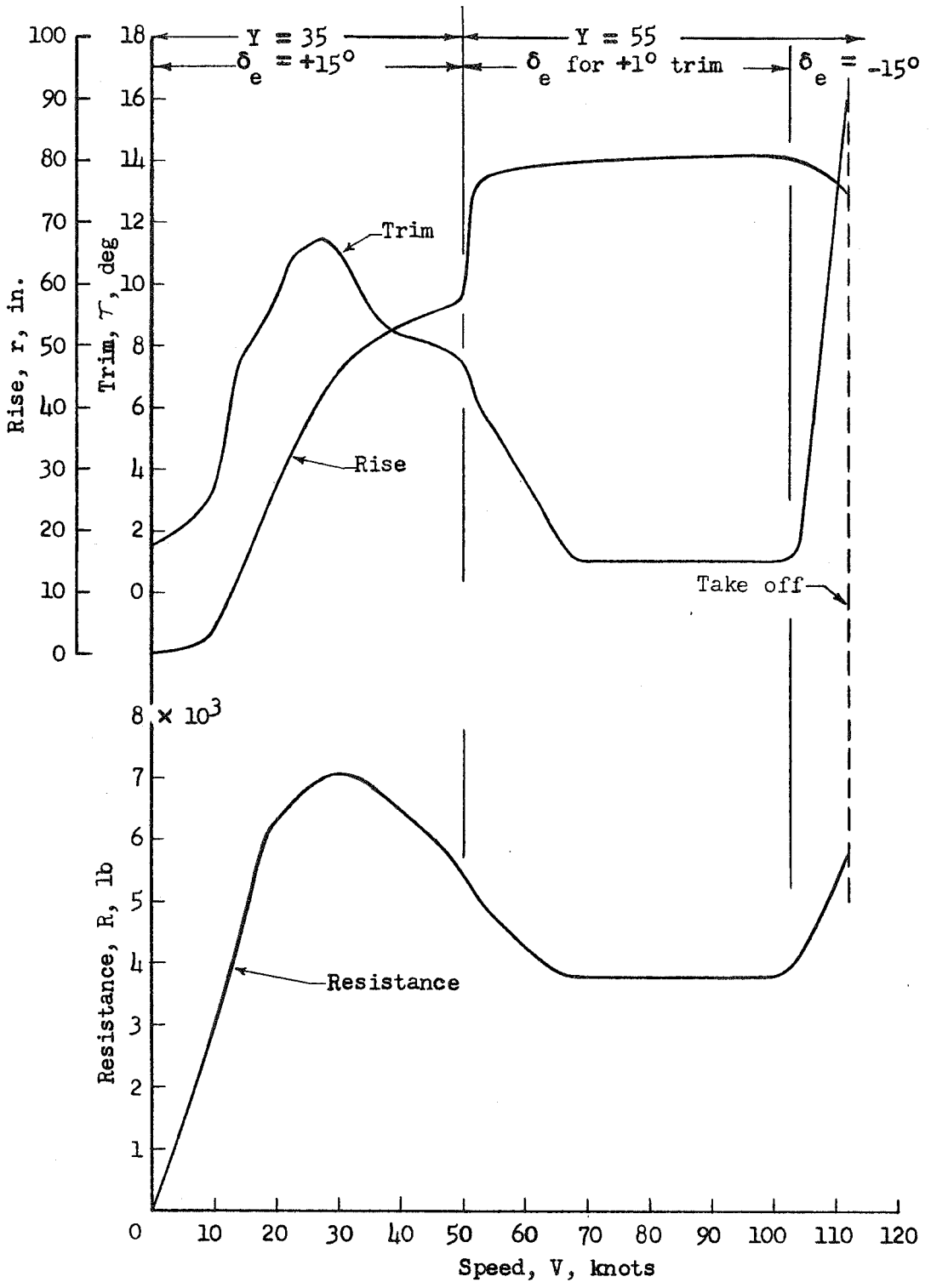
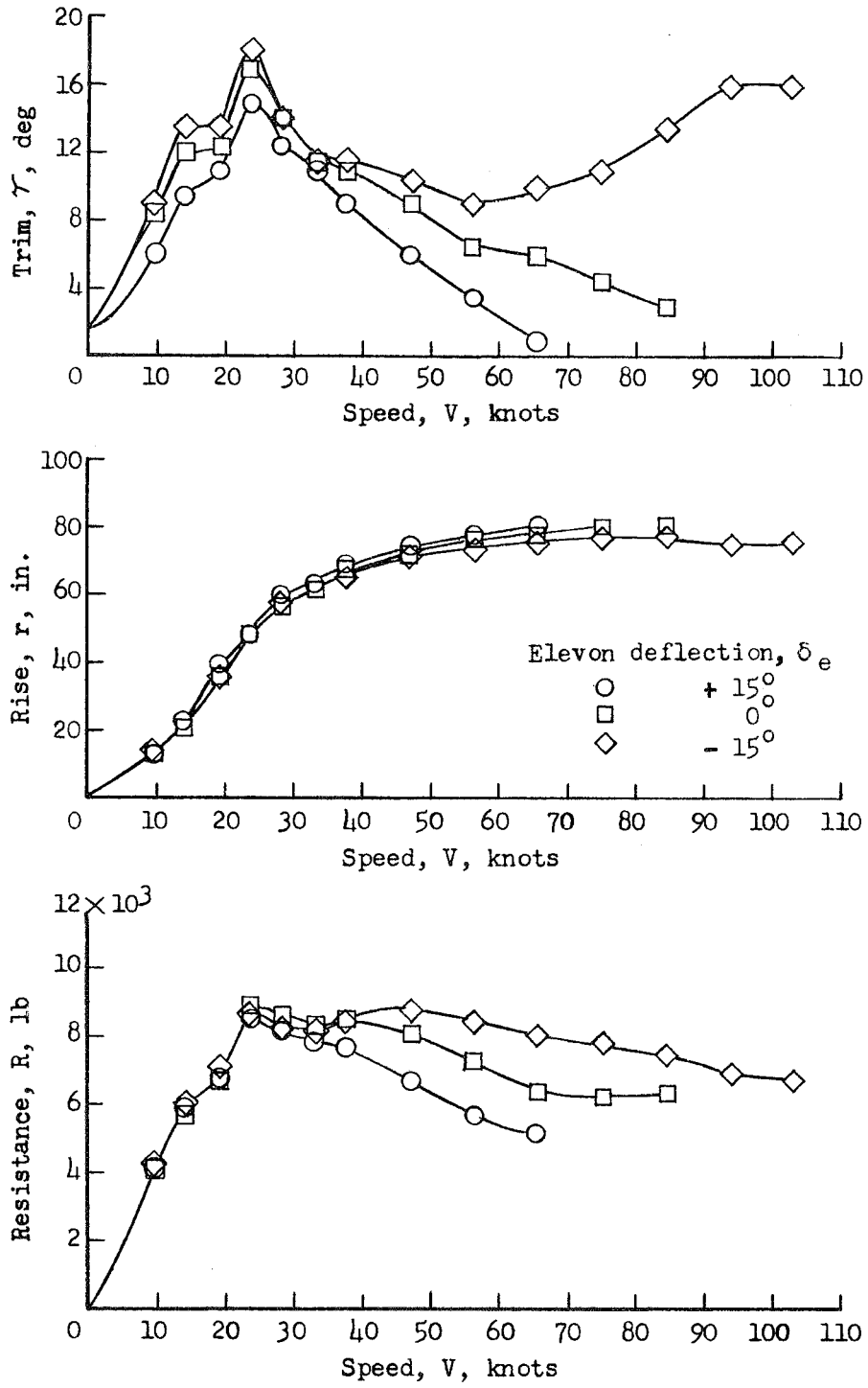
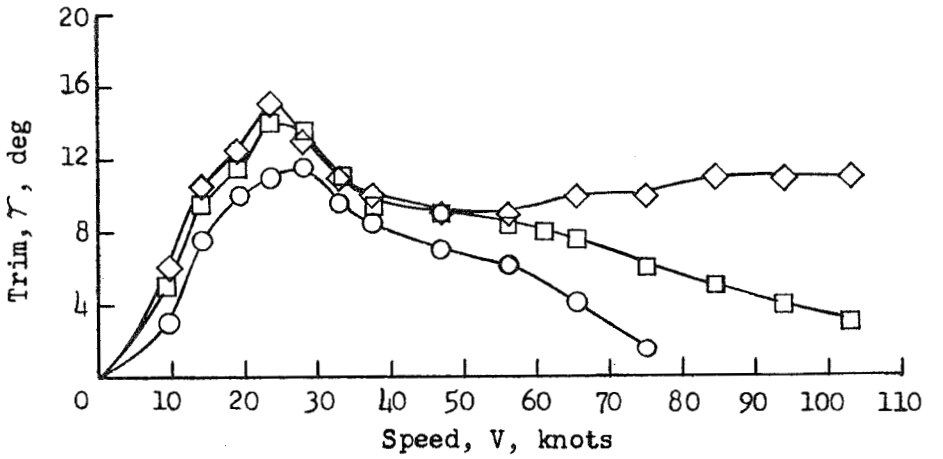


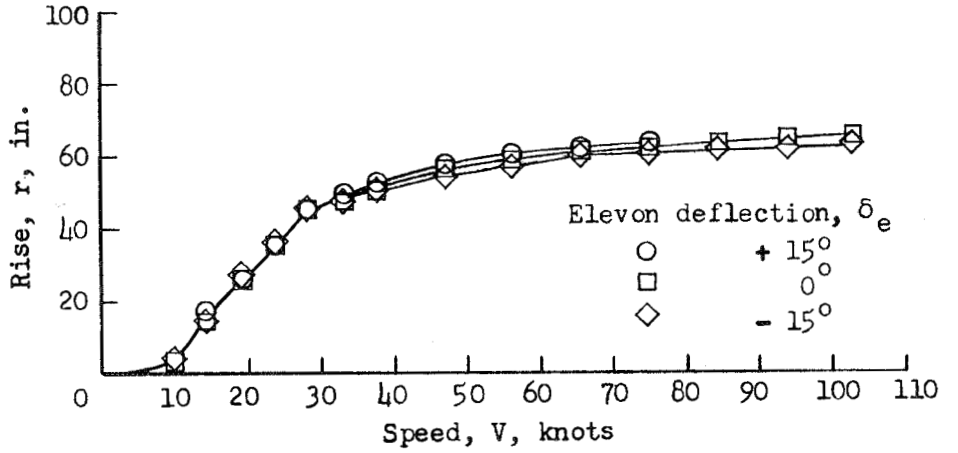
Figure 11.- Trim and rise at minimum resistance for no-wheel configuration. Gross weight, 17,000 pounds; thrust condition, 7,600 pounds.

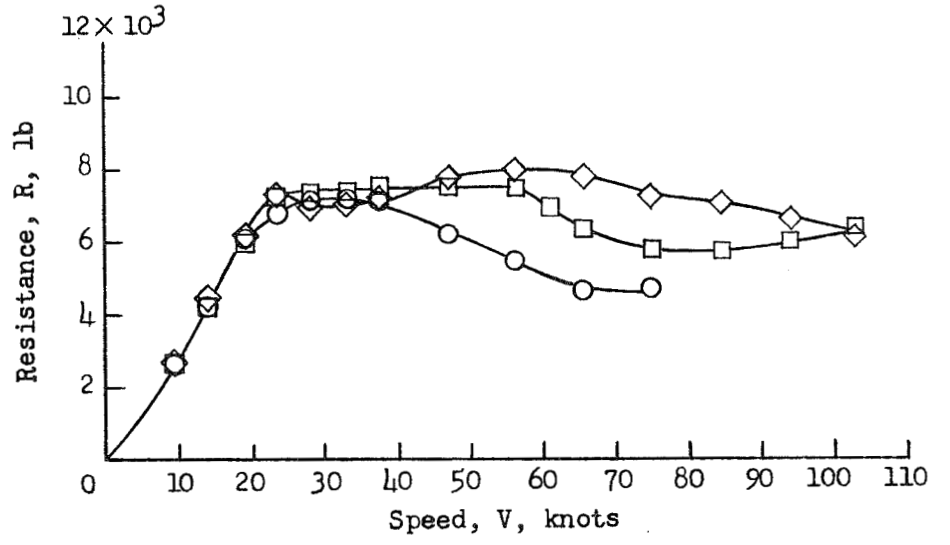


(a) Ski position, Y = 55 inches.

Figure 12.- Trim, rise, and resistance for wheel-and-fairing configuration. Gross weight, 17,000 pounds; thrust condition, 7,600 pounds.







(b) Ski position, Y = 35 inches.

Figure 12.- Concluded.

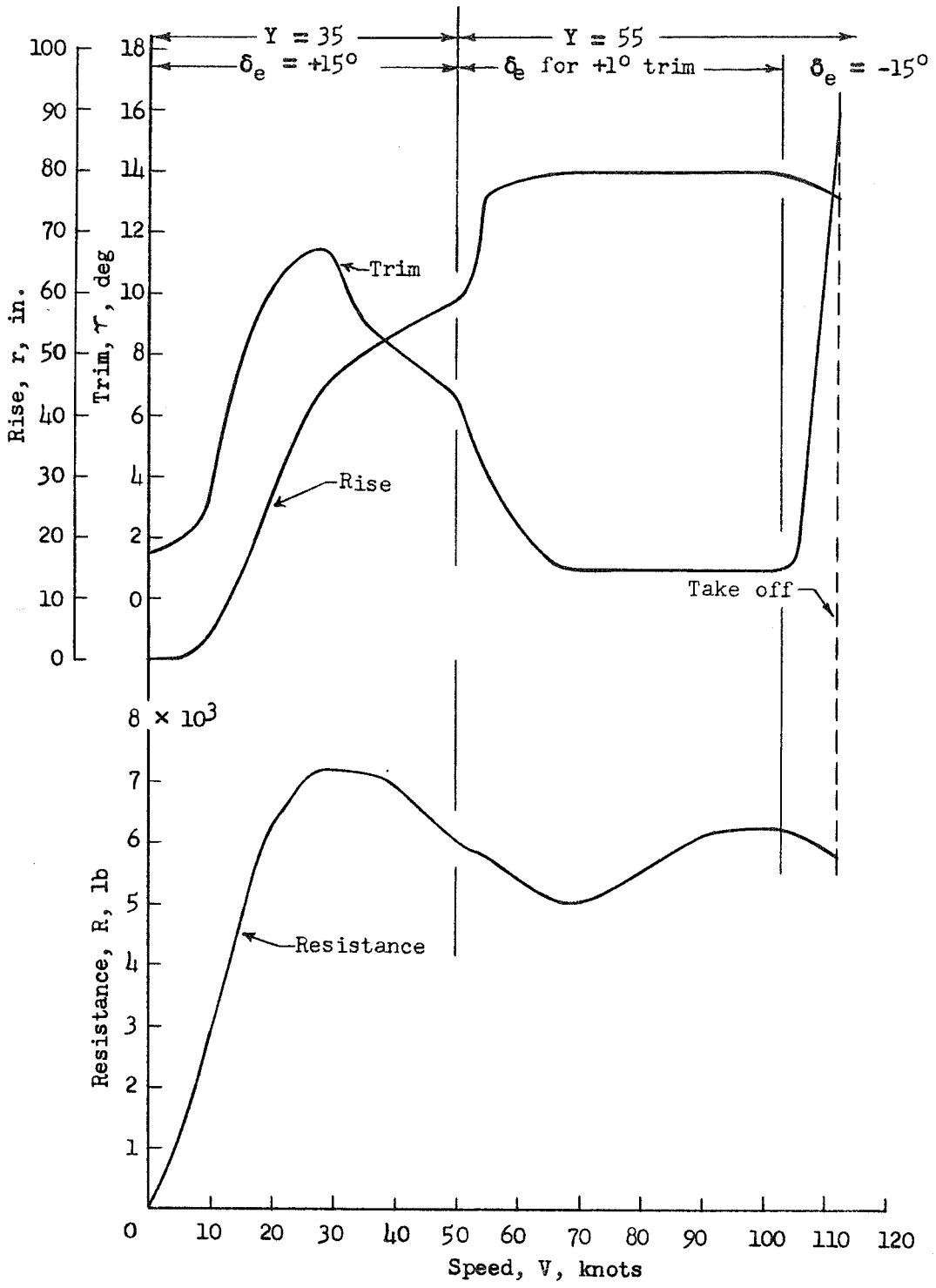
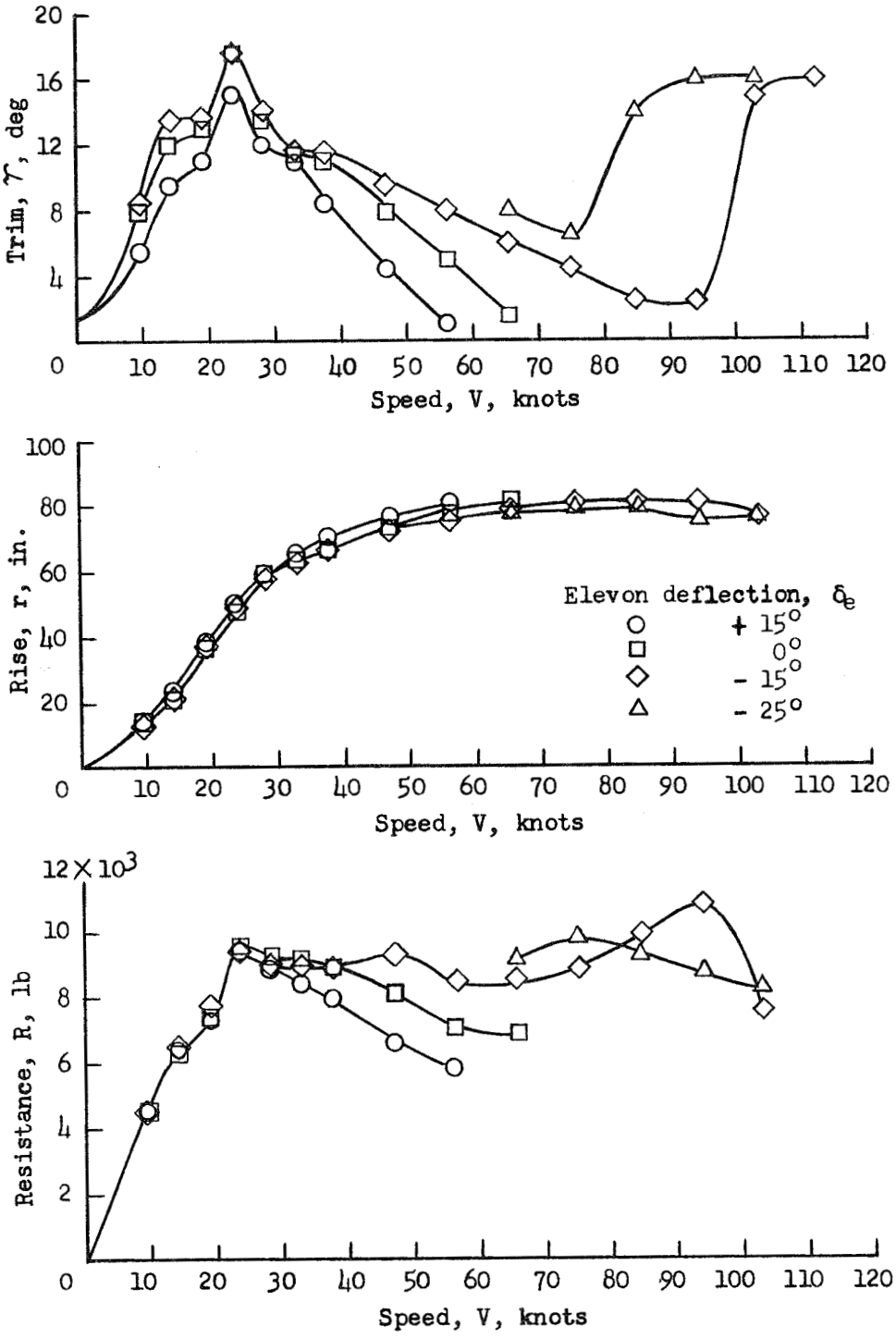
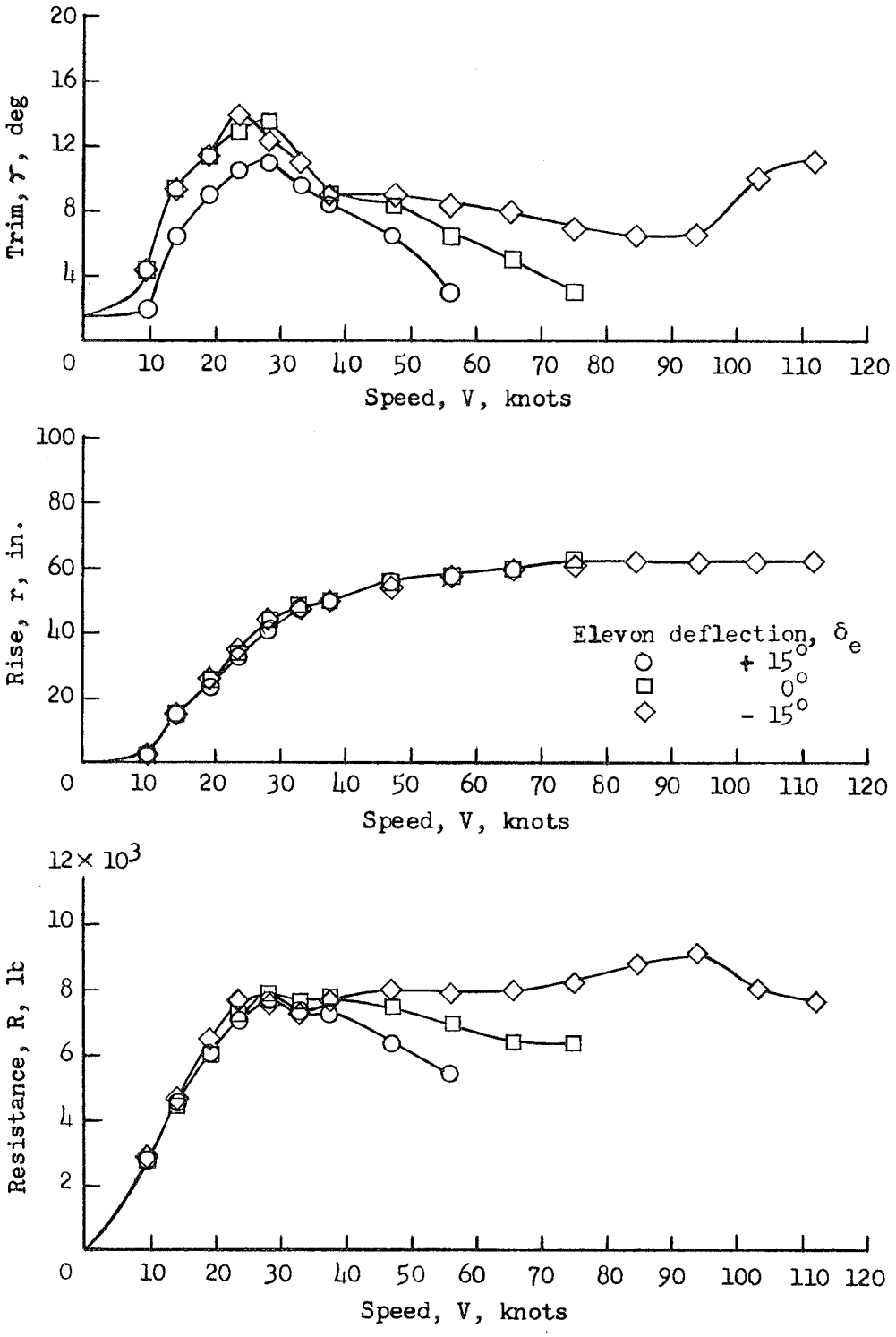


Figure 13.- Trim and rise at minimum resistance for wheel-and-fairing configuration. Gross weight, 17,000 pounds; thrust condition, 7,600 pounds.



(a) Ski position, Y = 55 inches.

Figure 14.- Trim, rise, and resistance for original configuration. Gross weight, 17,500 pounds; thrust condition, 9,500 pounds.



(b) Ski position, Y = 35 inches.

Figure 14.- Concluded.

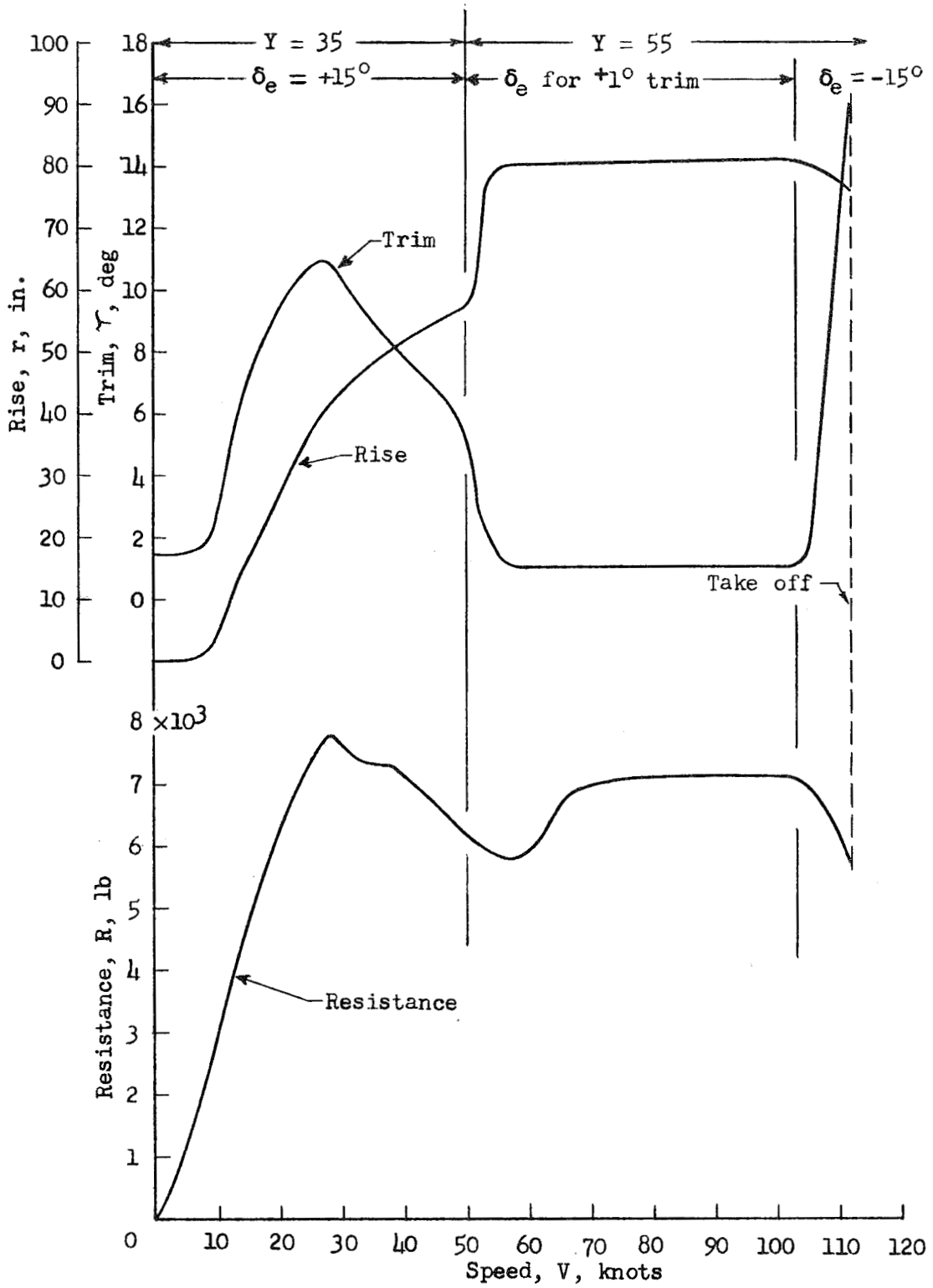
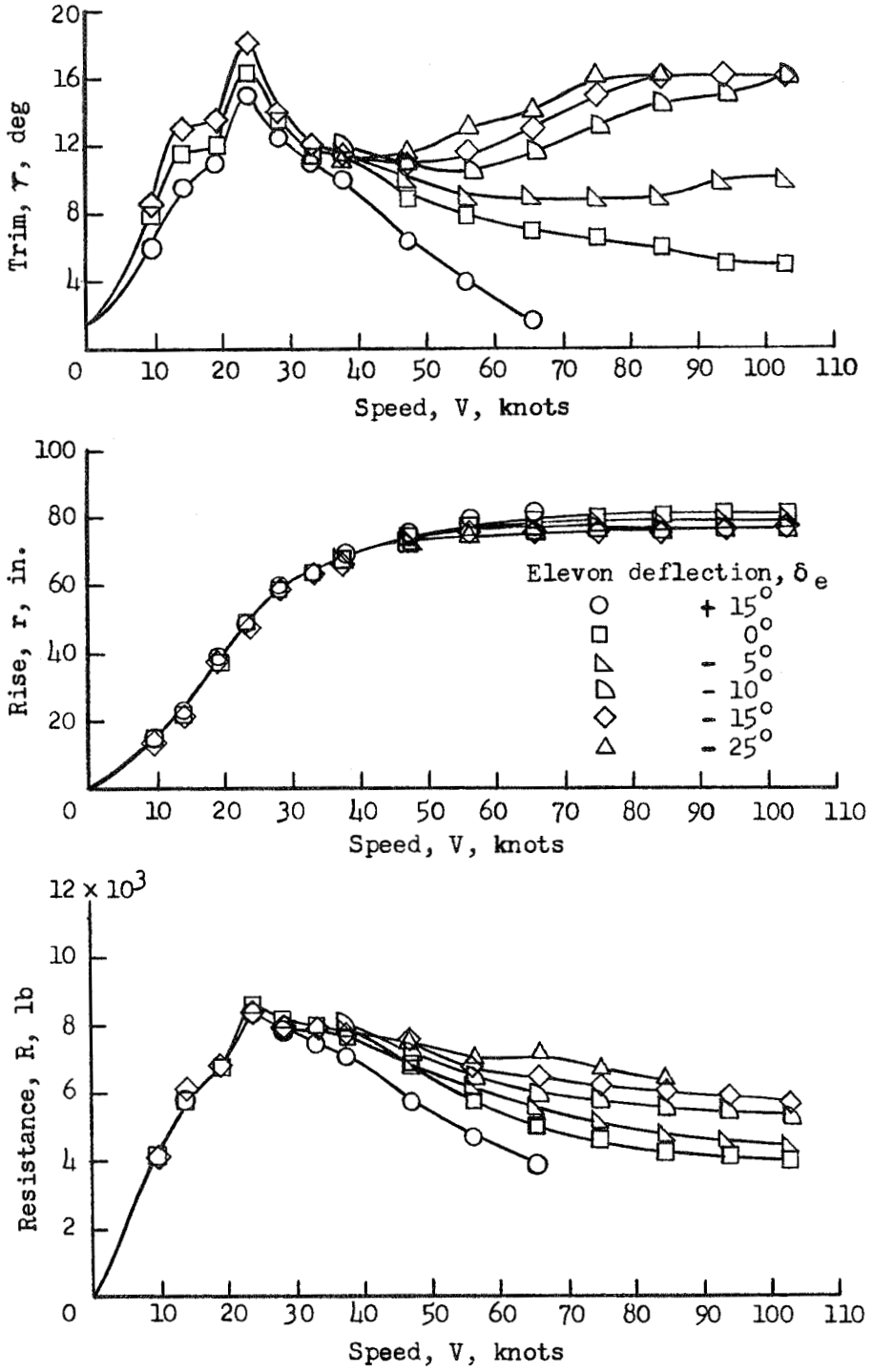
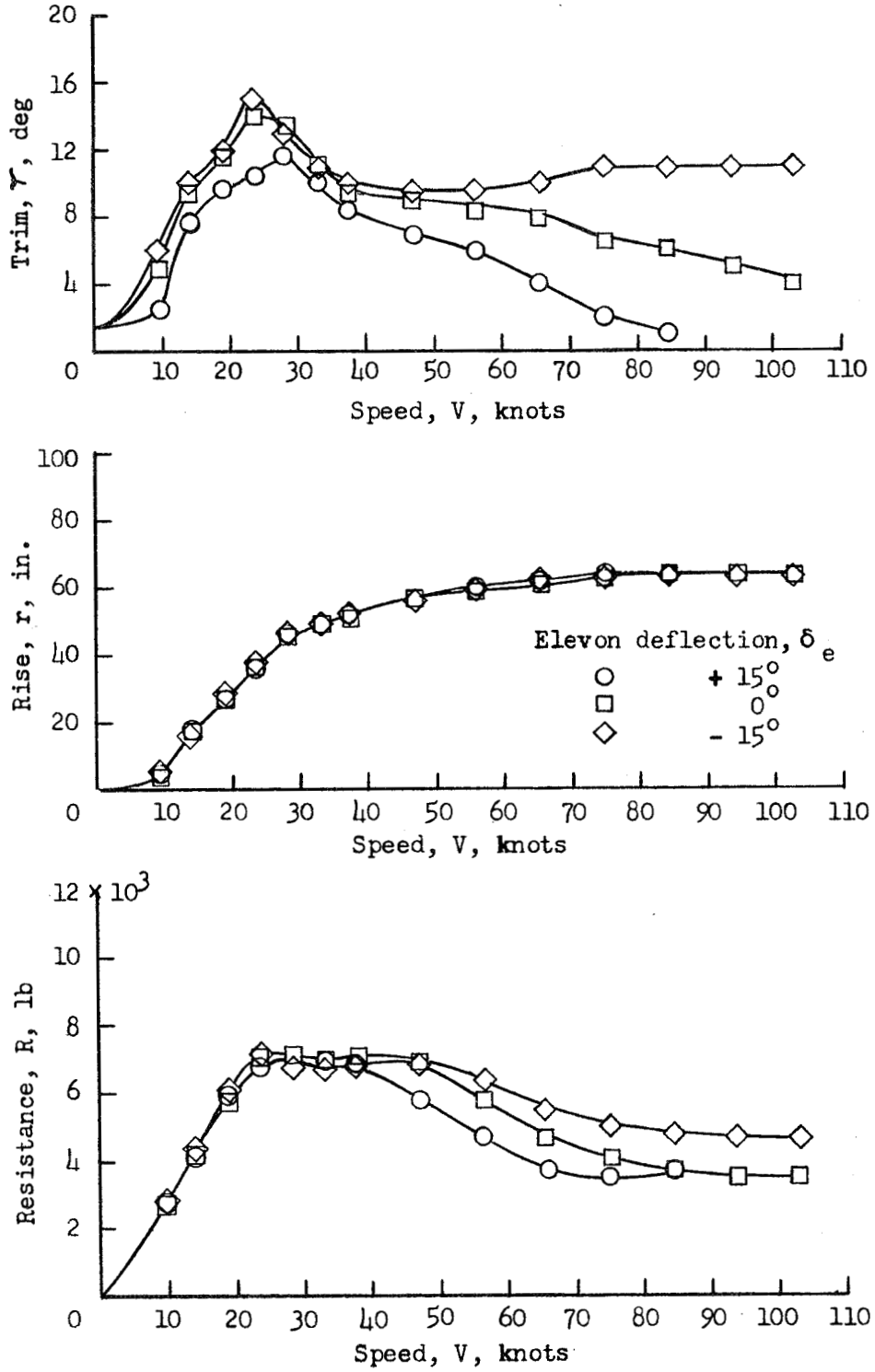


Figure 15.- Trim and rise at minimum resistance for original configuration. Gross weight, 17,500 pounds; thrust condition, 9,500 pounds.



(a) Ski position, Y = 55 inches.

Figure 16.- Trim, rise, and resistance for no-wheel configuration. Gross weight, 17,500 pounds; thrust condition, 9,500 pounds.



(b) Ski position, Y = 35 inches.

Figure 16.- Concluded.

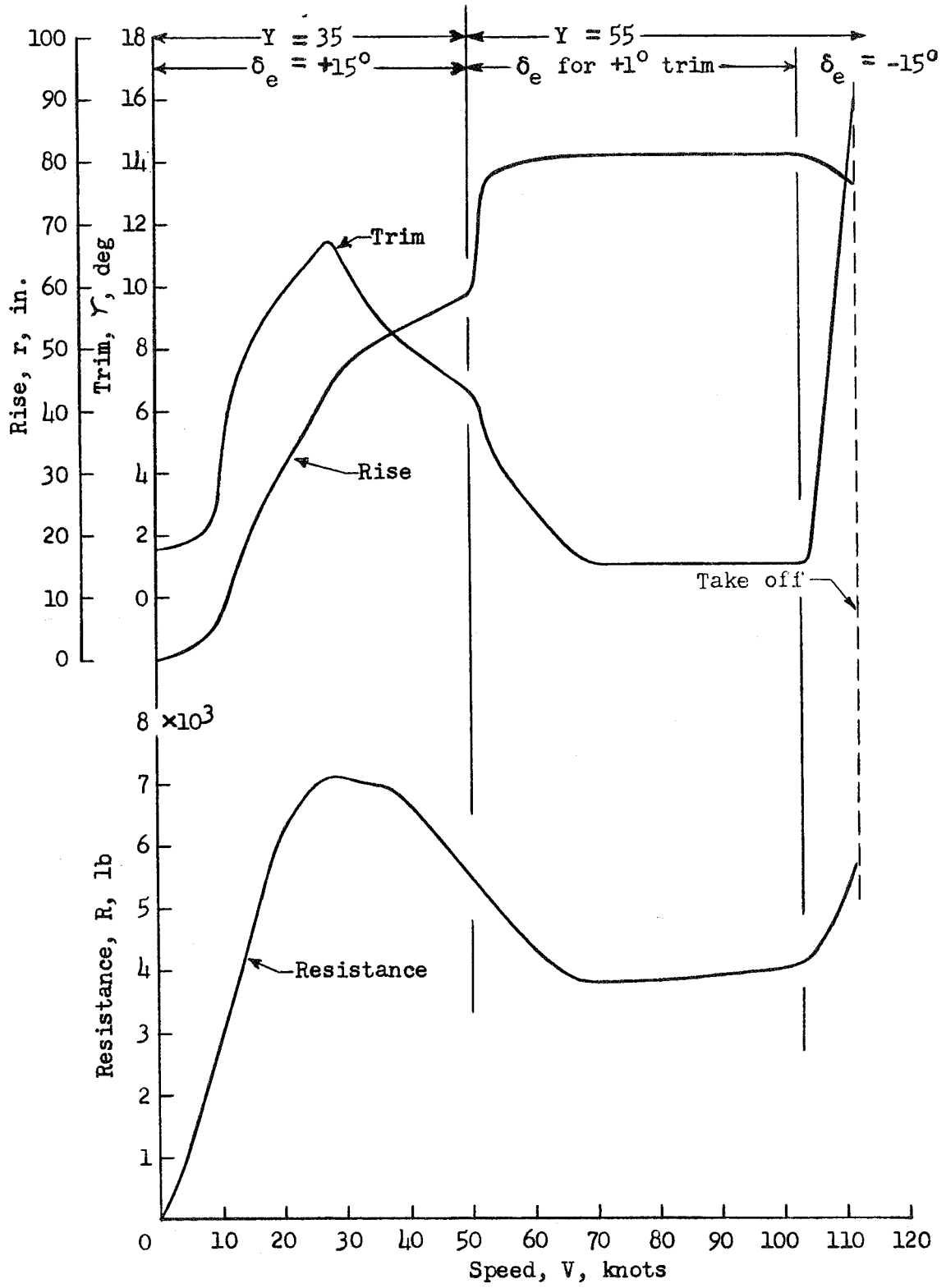
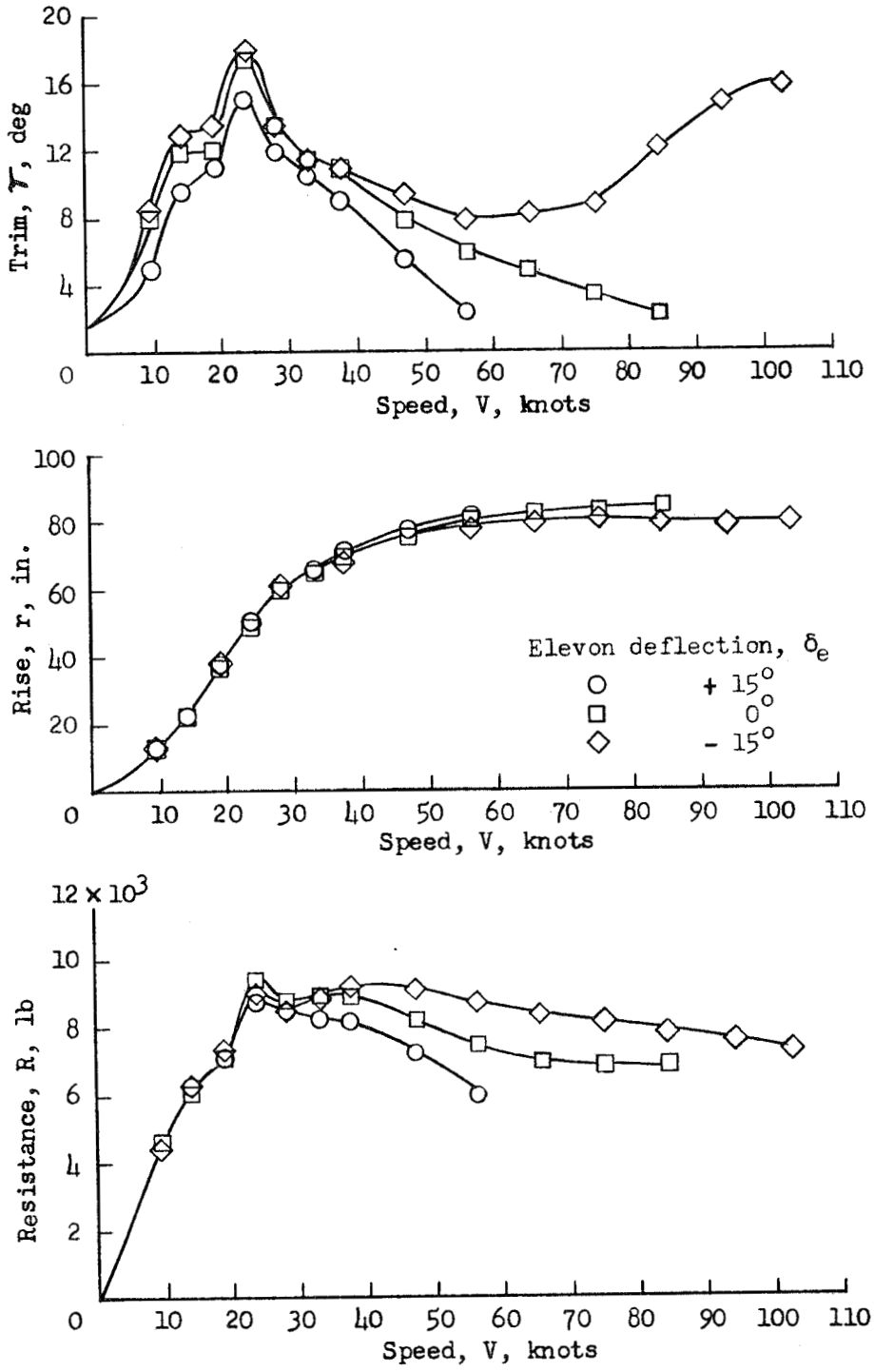
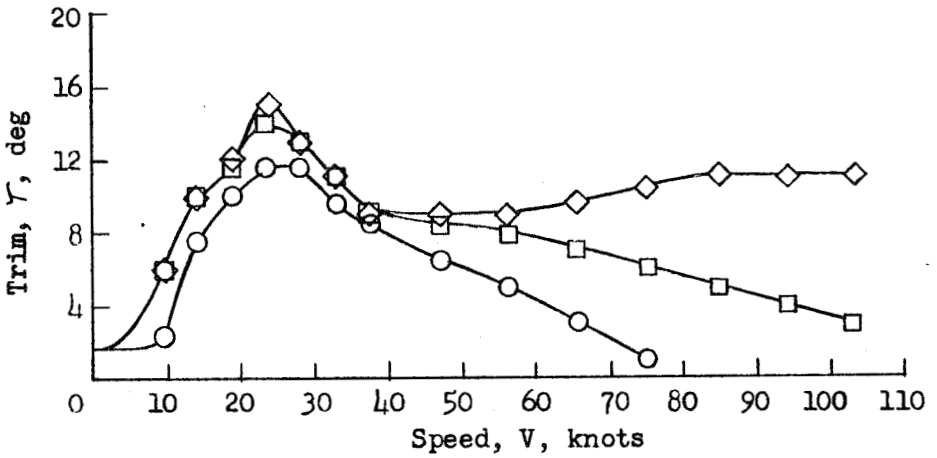


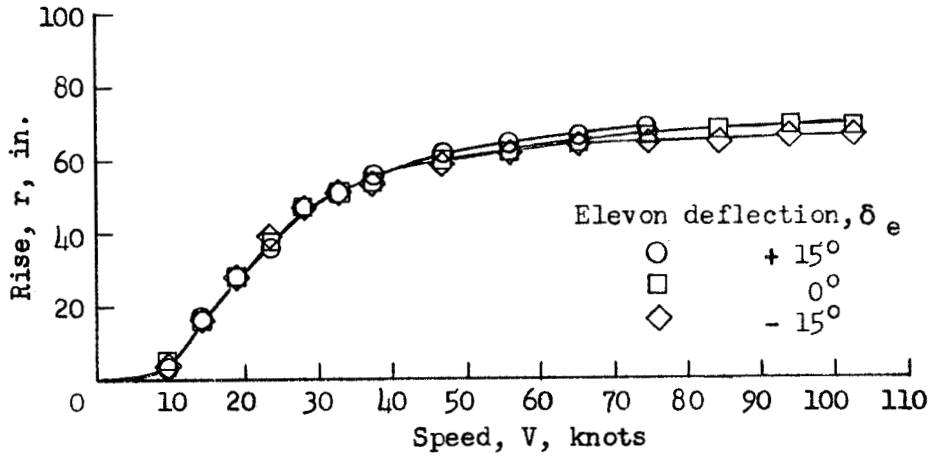
Figure 17.- Trim and rise at minimum resistance for no-wheel configuration. Gross weight, 17,500 pounds; thrust condition, 9,500 pounds.

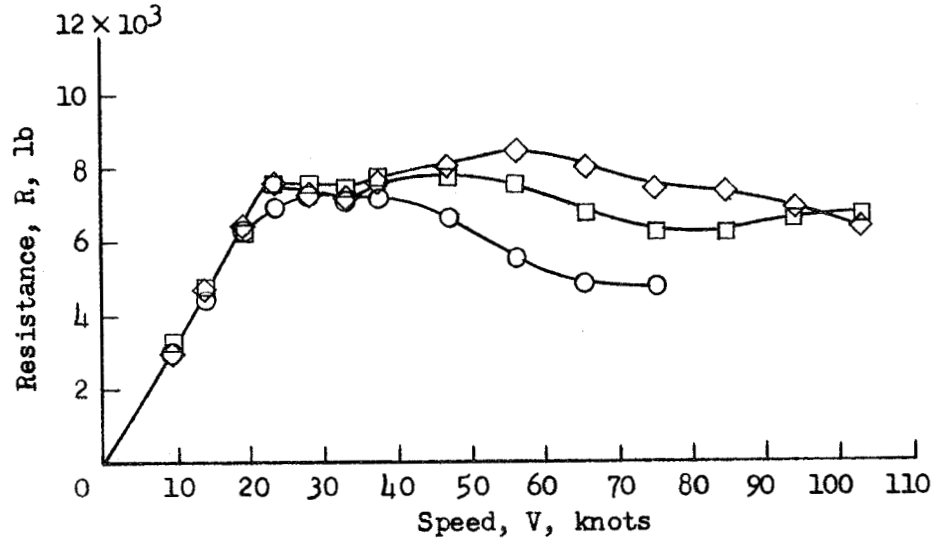


(a) Ski position, Y = 55 inches.

Figure 18.- Trim, rise, and resistance for wheel-and-fairing configuration. Gross weight, 17,500 pounds; thrust condition, 9,500 pounds.







(b) Ski position, Y = 35 inches.

Figure 18.- Concluded.

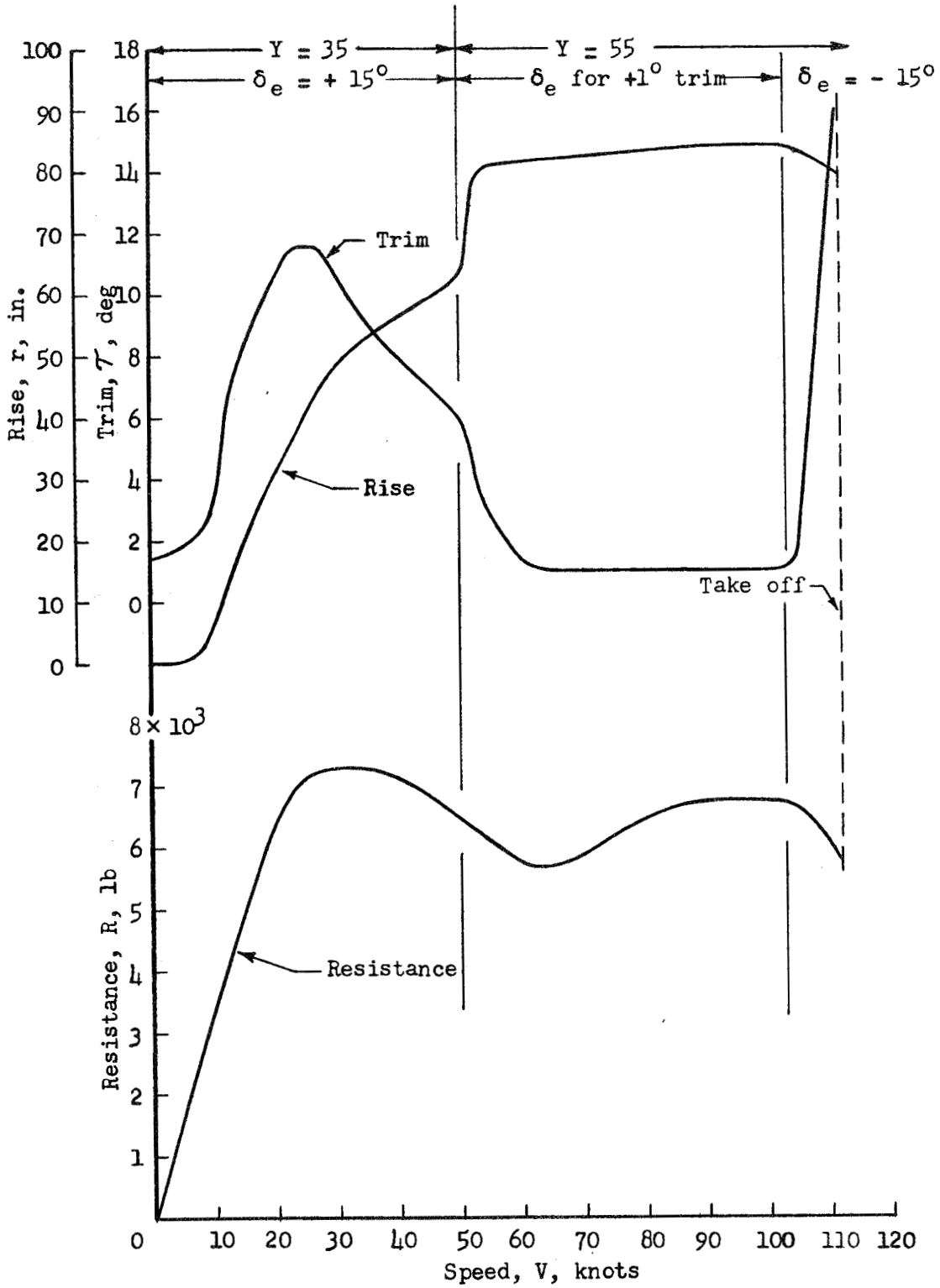


Figure 19.- Trim and rise at minimum resistance for wheel-and-fairing configuration. Gross weight, 17,500 pounds; thrust condition, 9,500 pounds.

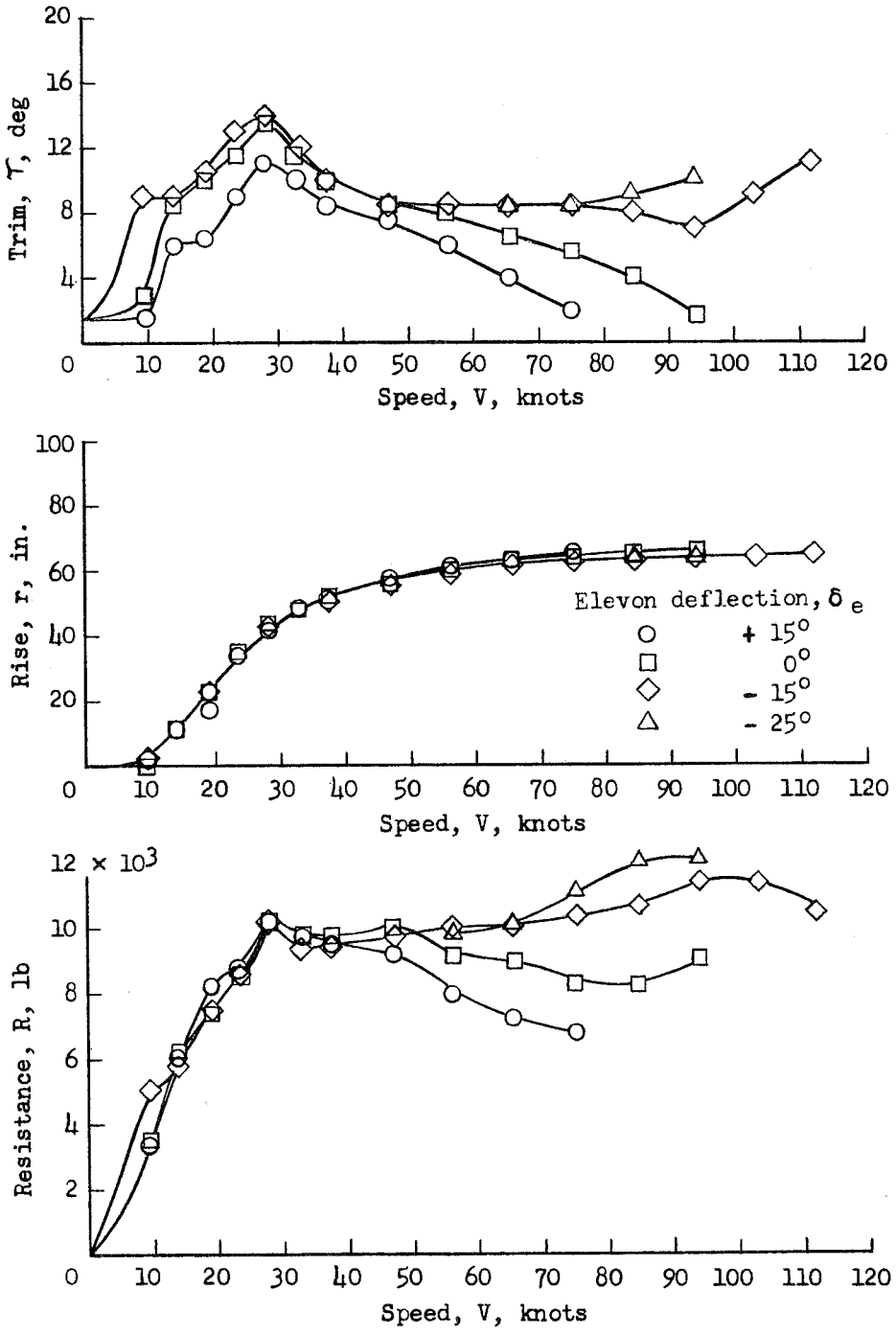
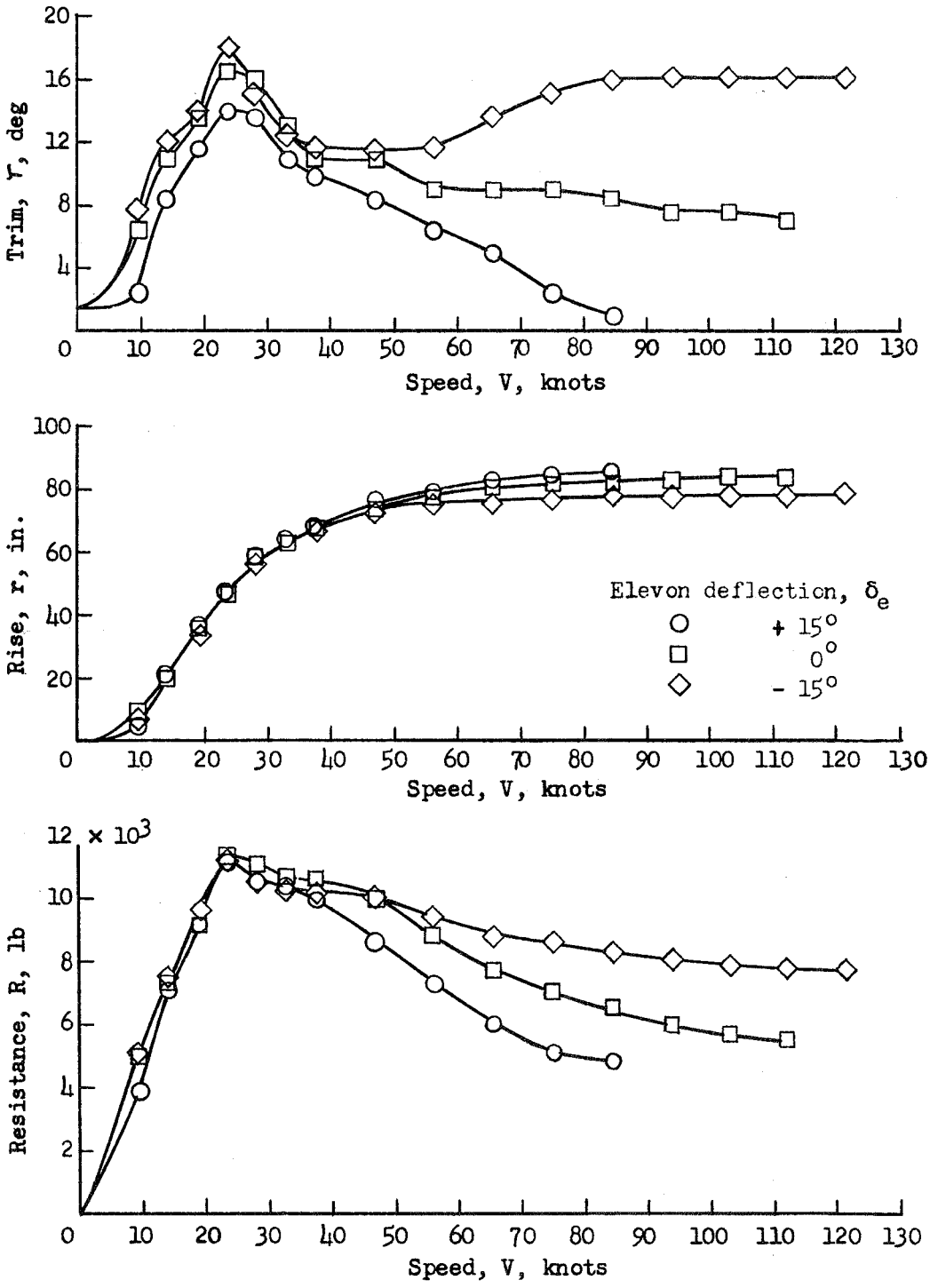
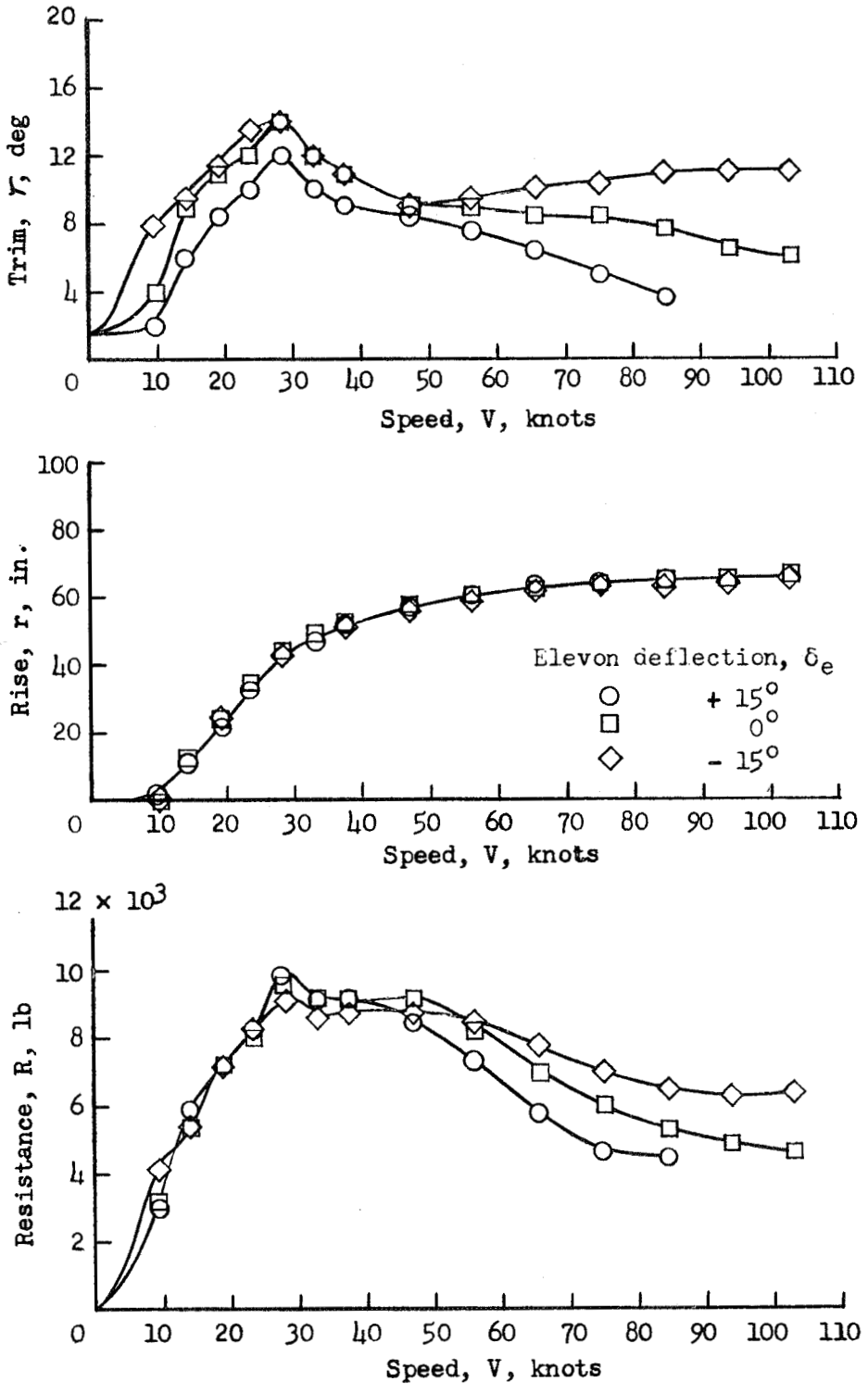


Figure 20.- Trim, rise, and resistance for original configuration. Gross weight, 23,000 pounds; thrust condition, 9,500 pounds; ski position, Y = 35 inches.



(a) Ski position, Y = 55 inches.

Figure 21.- Trim, rise, and resistance for no-wheel configuration. Gross weight, 23,000 pounds; thrust condition, 9,500 pounds.



(b) Ski position, Y = 35 inches.

Figure 21.- Concluded.

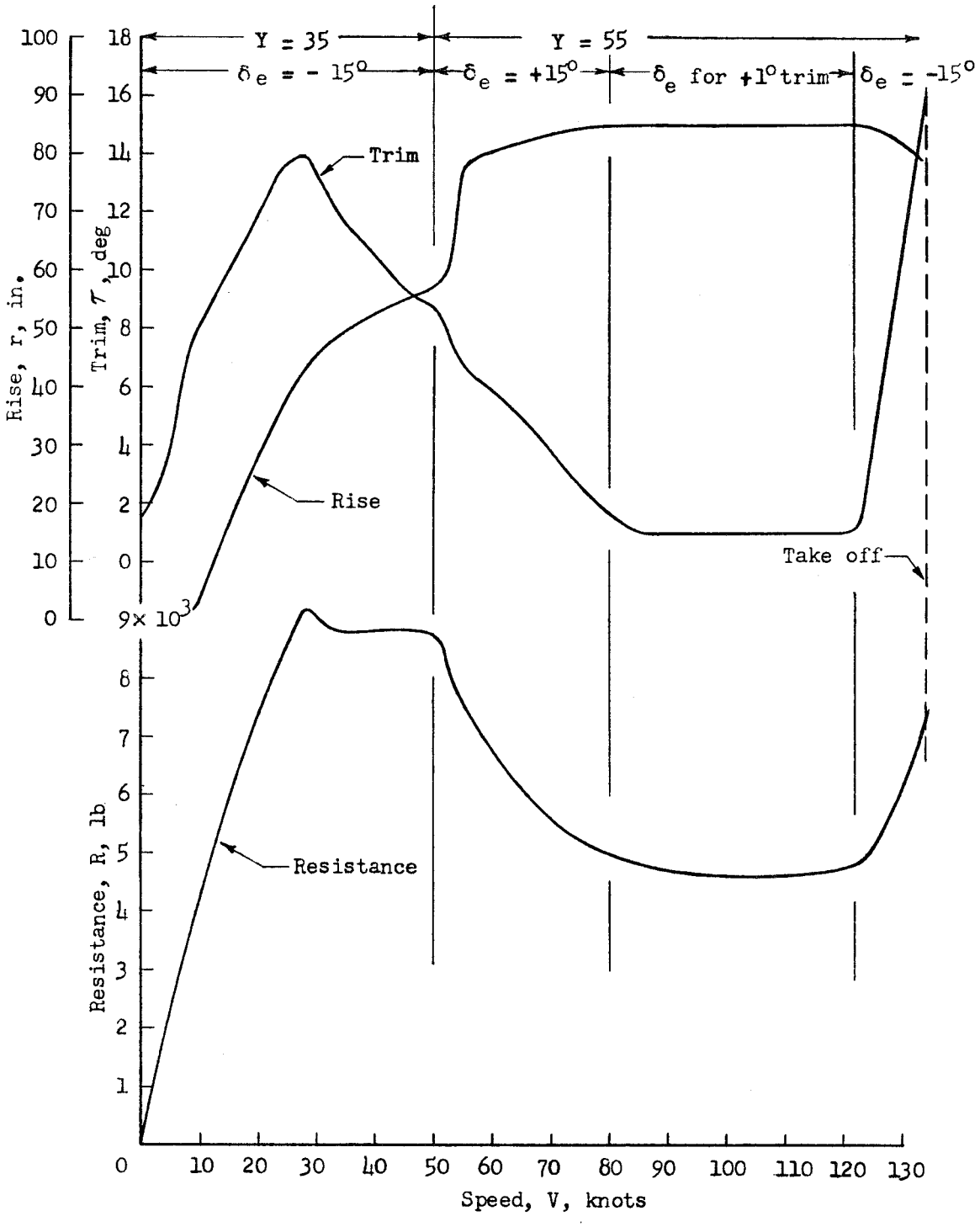
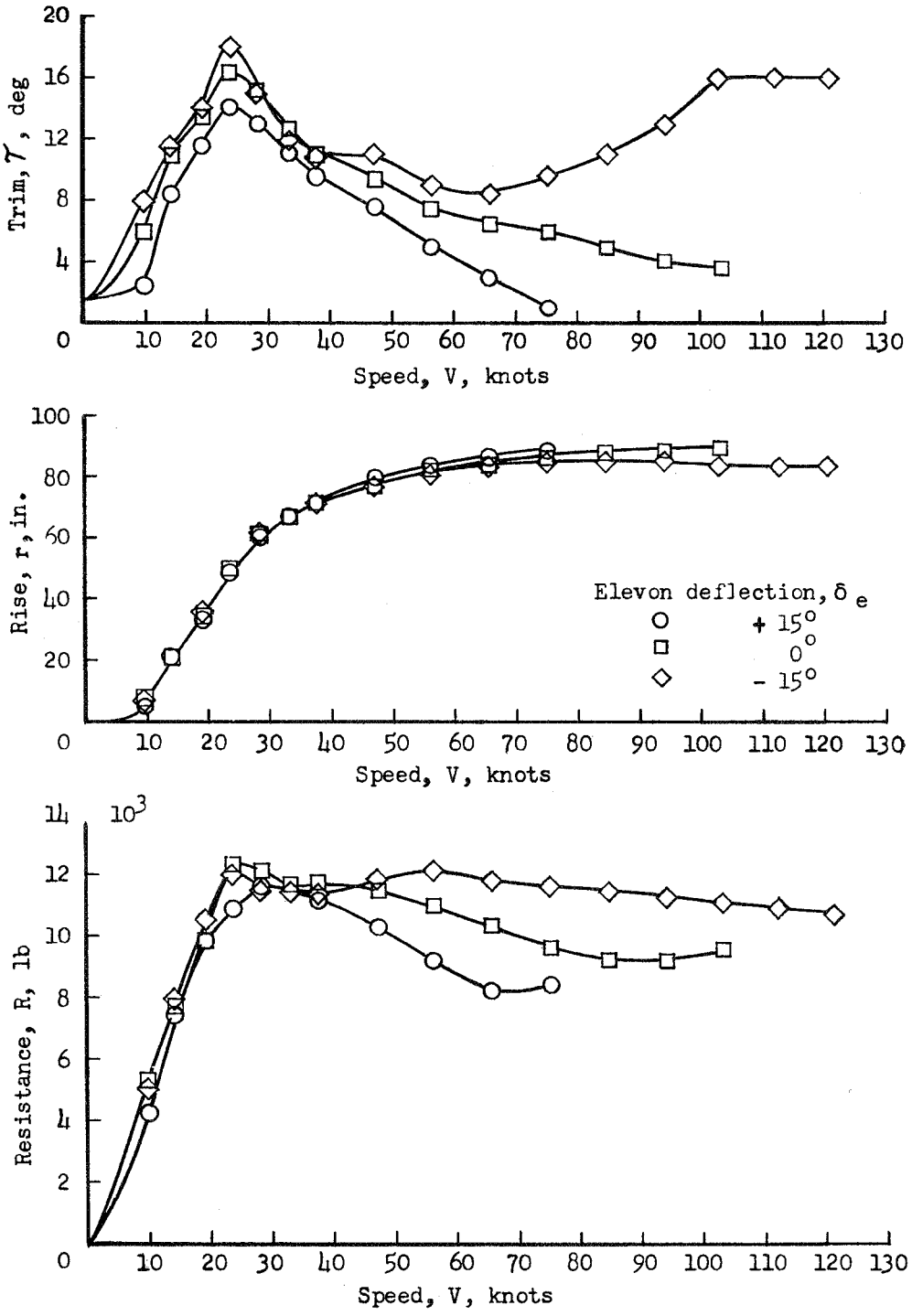
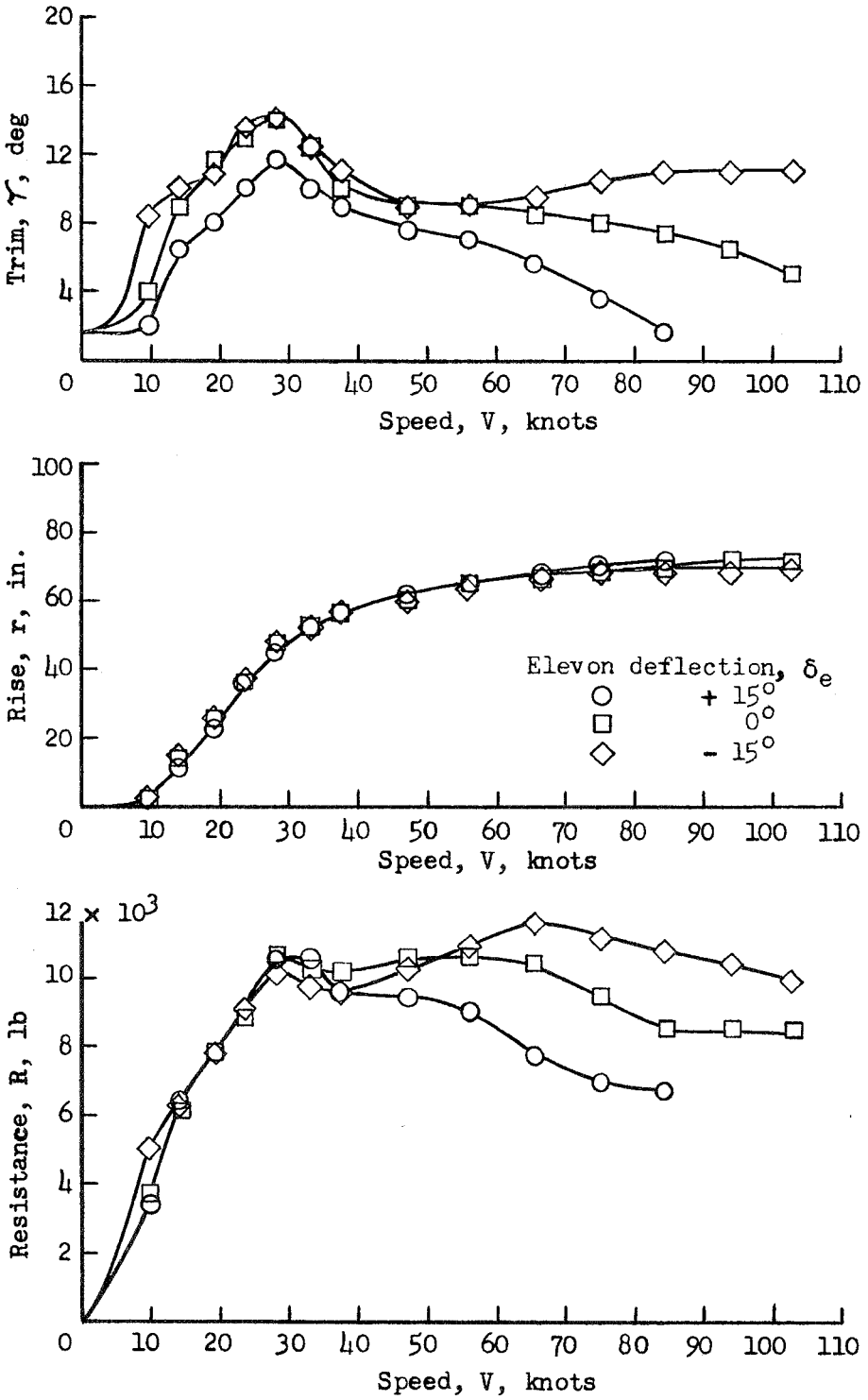


Figure 22.- Trim and rise at minimum resistance for no-wheel configuration. Gross weight, 23,000 pounds; thrust condition, 9,500 pounds.



(a) Ski position, Y = 55 inches.

Figure 23.- Trim, rise, and resistance for wheel-and-fairing configuration. Gross weight, 23,000 pounds; thrust condition, 9,500 pounds.



(b) Ski position, Y = 35 inches.

Figure 23.- Concluded.

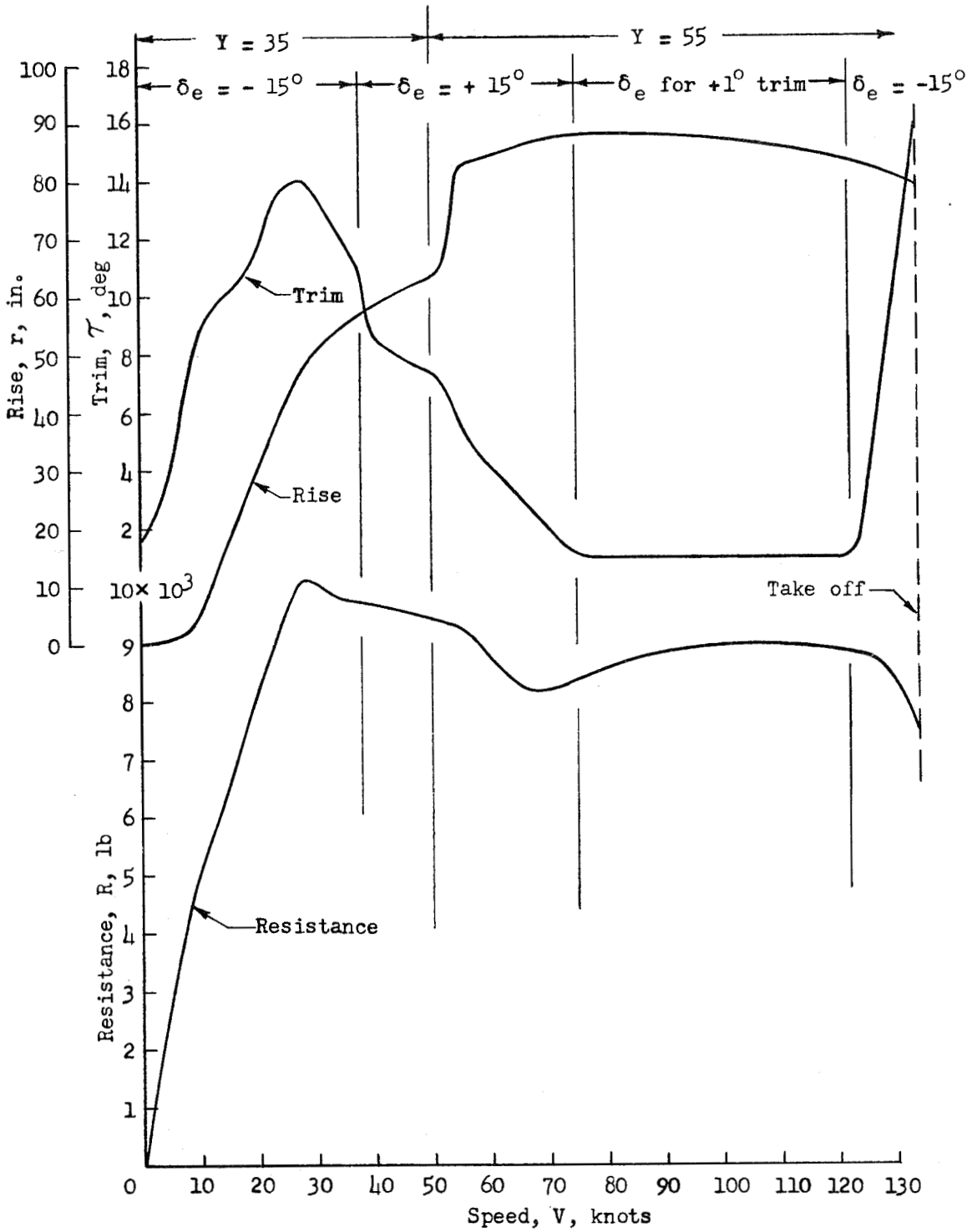
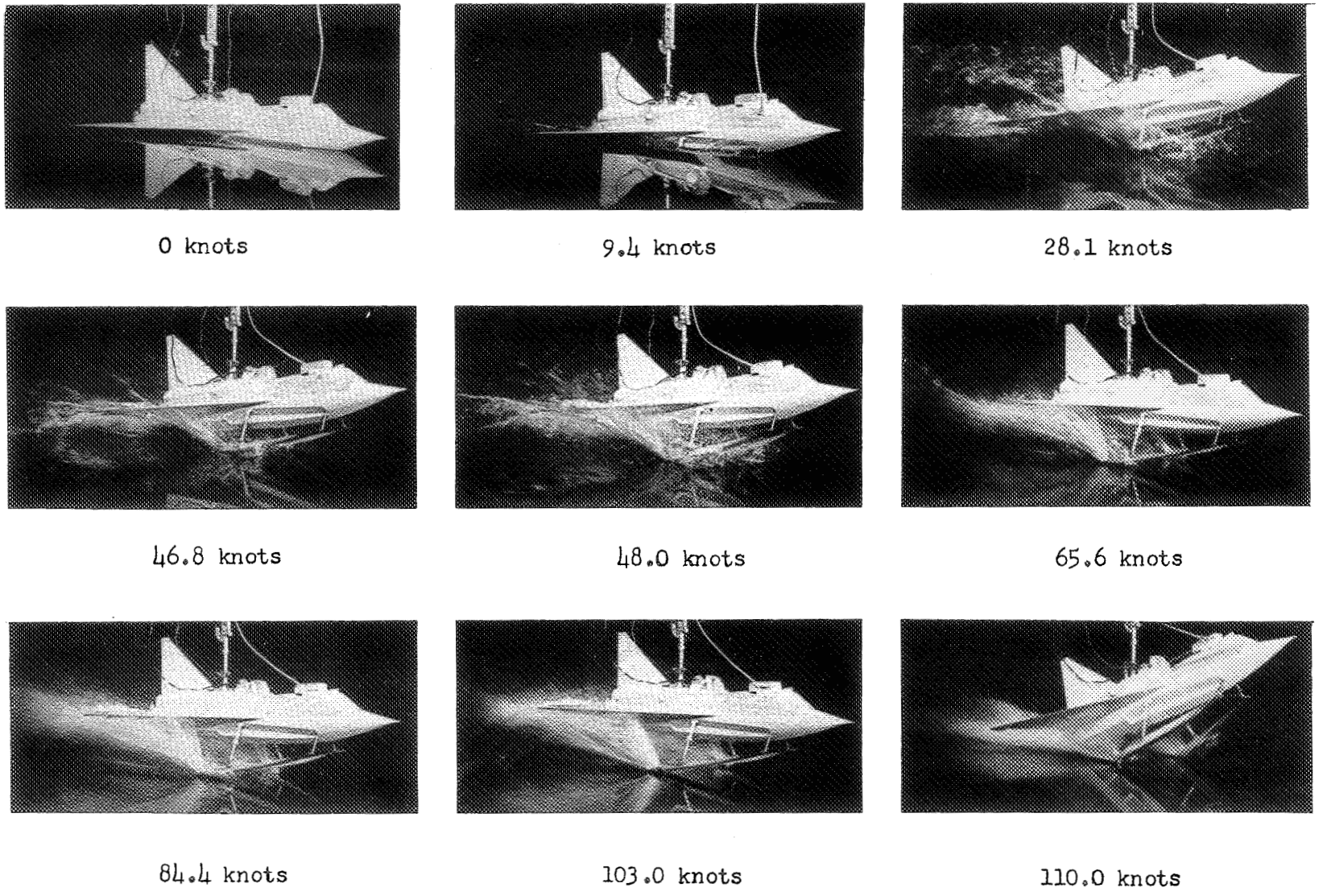
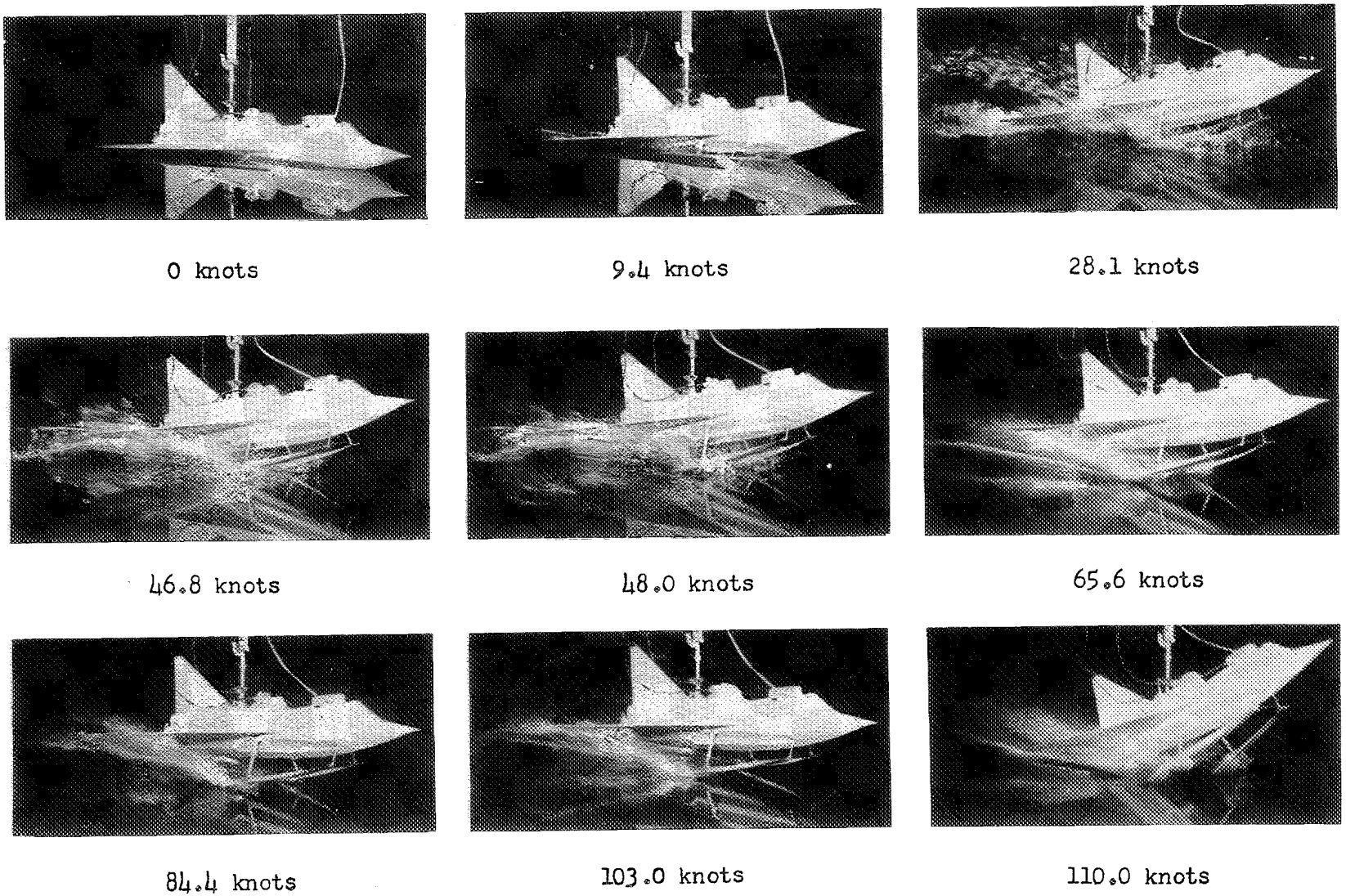


Figure 24.- Trim and rise at minimum resistance for wheel-and-fairing configuration. Gross weight, 23,000 pounds; thrust condition, 9,500 pounds.



(a) Original configuration. L-84910

Figure 25.- Typical spray photographs during take-off run. Constant acceleration, 3 ft/sec^2; gross weight, 17,000 pounds; thrust condition, 7,600 pounds; center-of-gravity position, 28.8 percent mean aerodynamic chord.



0 knots | 9.4 knots | 28.1 knots

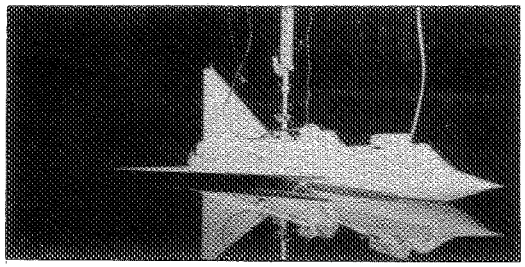
46.8 knots | 48.0 knots | 65.6 knots

84.4 knots | 103.0 knots | 110.0 knots

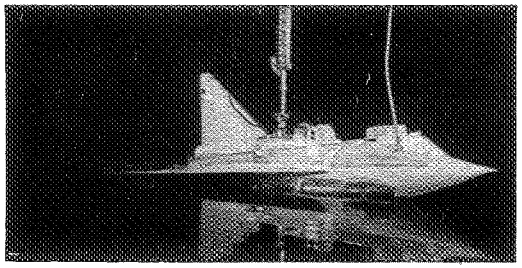
L-84911

(b) No-wheel configuration.

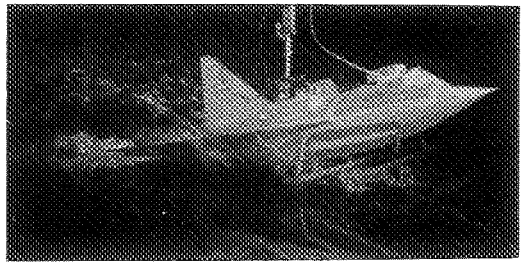
Figure 25.- Continued.



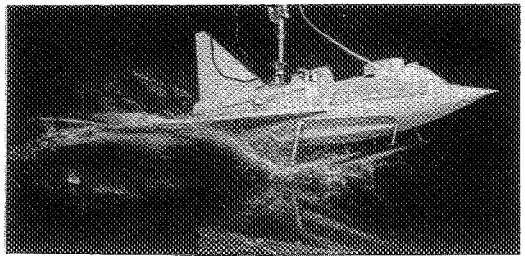
0 knots



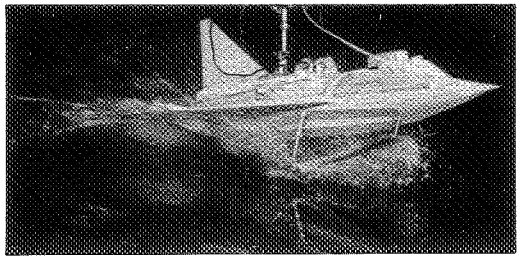
9.4 knots



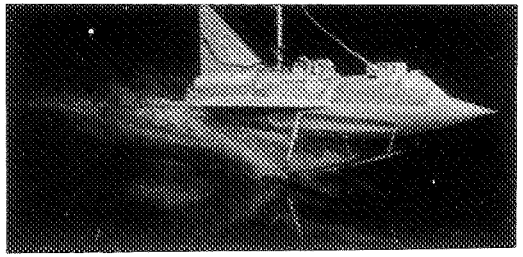
28.1 knots



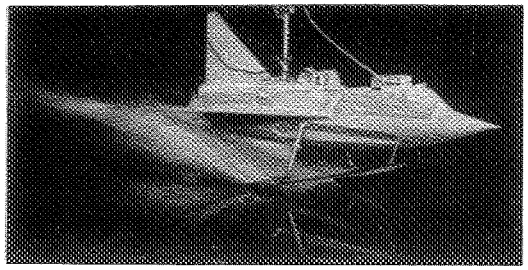
46.8 knots



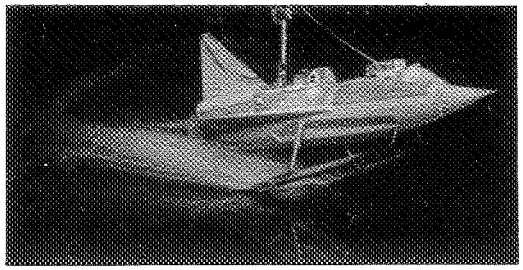
48.0 knots



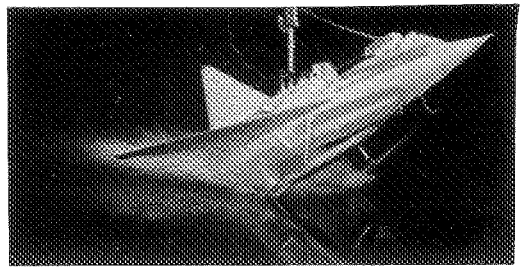
65.6 knots



84.4 knots



103.0 knots



110.0 knots

L-84912

(c) Wheel-and-fairing configuration.

Figure 25.- Concluded.