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RESISTANCE TESTS OF MODELS OF THREE FLYING-BOAT HULLS WITH A LENGTH-BEAM RATIO OF 10.5

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NACA

WASHINGTON

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ADVANCE RESTRICTED REPORT

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SUMMARY

Models of three flying-boat hulls, each with a length-beam ratio of 10.5, were tested at the Langley tank no. 1. The lines of these models were derived from the Deutsche Versuchsanstalt für Luftfahrt (DVL) standard series. The three models permitted tests with two depths of step and two angles of dead rise. Resistance, trimming-moment, and wetted-length data were obtained from general fixed-trim and free-to-trim tests at load coefficients ranging up to 4.0.

The results showed that these three models had low hydrodynamic resistance at high load coefficients. At the free-to-trim hump, load-resistance ratios of 4.5 and 3.9 were attained at load coefficients of 1.5 and 3.5, respectively. Increasing the angle of dead rise, excluding chine flare, from 20° to 24.5° tended to increase the resistance and trimming moments at planing speeds. Changing the depth of step from 5 to 10 percent beam had little effect on the resistance. With conventional nacelle locations, excessive spray would enter the propellers at load coefficients over 3.0.

INTRODUCTION

The effect of length-beam ratio on the water resistance of a flying-boat hull has been the subject of many investigations. Three independent studies (references 1 to 3) have indicated that, within the range of the investigations, increasing the length-beam ratio results in lowering the water resistance. Lines of the Deutsche Versuchsanstalt für Luftfahrt (DVL) standard series (reference 1) were used in the development of three models, each with a length-beam ratio of 10.5. Two of these models differed only in angle of dead rise; the third model was similar to the model with the higher dead rise but had a depth of step twice as great.

The models used were furnished to the NACA by Consolidated Vultee Aircraft Corporation.

MODELS

The models, designated in the Langley tanks as models 184, 185, and 185-A, were derived from the DVL series by increasing the station spacing along the forebody and afterbody keels and keeping the beam the same as that of the DVL models (11.81 in.). Two of these models differed only in angle of dead rise (defined herein as angle of dead rise excluding chine flare); the angle of dead rise was 20° for model 184 and 24.5° for model 185. The sections of the model with the higher angle of dead rise were formed by multiplying the ordinates of the lower angle of dead rise by 25/20. Use of this factor yields a dead-rise angle of 24.5° and a slightly different radius of curvature for the chine flare than that of model 184. Lines of model 185 are given in figure 1. The third model (model 185-A) was similar to model 185 except that the depth of step was doubled by raising the whole afterbody vertically. Sections of the three models at the step are shown in figure 2.

APPARATUS AND PROCEDURE

The tests were made in Langley tank no. 1, which is described in reference 4.

General fixed-trim tests were made by following the procedure described in reference 4. In addition to the usual measurements, wetted lengths of both forebody and afterbody were observed. General free-to-trim tests were also made at speed coefficients up to 5.3 (30 fps) or slightly over the hump speed. The schedule of loads and speeds used for the fixed-trim tests is given in figure 3 and the free-to-trim schedule is the same except for the elimination of all speed coefficients above 5.3. Limitations in the capacity of the test equipment made it necessary to drop some points from the schedule. These limitations were the resistance (approx. 60 lb) and the trimming moment (approx. 180 lb-ft).

RESULTS

The results of the tests were reduced to the usual coefficients based on Froude's law to make them independent of size. The nondimensional coefficients are defined as follows:

C_Δ load coefficient $\left(\Delta/wb^3\right)$

C_R resistance coefficient $\left(R/wb^3\right)$

C_V speed coefficient $\left(V/\sqrt{gb}\right)$

C_M trimming-moment coefficient $\left(M/wb^4\right)$

$C_{W.L.}$ wetted-length coefficient (l/b)

C_d draft coefficient (d/b)

where

Δ load on water, pounds

w specific weight of water, pounds per cubic foot (63.4 for these tests; usually taken as 64 for sea water)

b beam (0.985 ft)

R resistance, pounds

V speed, feet per second

g acceleration of gravity (32.2 ft/sec^2)

M trimming moment, pound-feet (positive moments tend to increase trim)

l wetted-length, feet

d draft at main step, feet

Any consistent system of units may be used. The moment data are referred to the center of moments shown in figure 1. Trim τ is the angle between the base line of the model and the horizontal.

The data obtained from tests of model 185 are given in figures 4 to 8. Resistance and trimming-moment data from fixed-trim tests are presented in figures 4 and 5, respectively. The trimming-moment data are arranged in a form unlike that used in previous NACA reports. Because of the large number of load parameters used, the usual method of presentation would result in a confusing intermingling of the curves at low speeds. In figure 5, therefore, trim τ is the parameter instead of the conventional load coefficient C_{Δ}. Data from the free-to-trim test on this model are given in figure 6. The static properties are shown in figure 7. Similar data for models 184 and 185-A are not given because these data differ only slightly from those for model 185.

Wetted-length data for model 185 are given in figure 8. Corresponding data for model 184 were obtained but are not presented herein. No data on wetted lengths were obtained for model 185-A. Observations of wetted lengths were made whenever practicable but, because of the heavy spray, the data at heavy loads are not complete. No wetted lengths on the afterbody keel are given because of the difficulty of observing them.

Best-trim curves derived from fixed-trim data for model 185 are given in figure 9. The best-trim data for models 184 and 185-A are given in figures 10 and 11, respectively. Photographs of the forebody spray of model 185 are shown in figure 12.

DISCUSSION

The spray and resistance characteristics observed were similar on all three models. Some relatively minor effects on the resistance were produced by the change in angle of dead rise and depth of step. Relatively high load-resistance ratios were maintained at very high-load coefficients by each of the three models.

Effect of angle of dead rise.- The effect of changing the angle of dead rise from 20° to 24.5° on the load-resistance ratio at hump speed and at high speeds is shown in figure 13. The model with the lower angle of dead rise shows slightly lower resistance at both hump and high speeds. Trimming moments are less positive for the model with the lower angle of dead rise at best trim beyond the hump. Below hump speed the effect of the change in angle of dead rise was negligible. These results are in agreement with those for conventional length-beam ratios reported in reference 5.

Effect of depth of step.- The effect on the resistance of changing the depth of step from 5 to 10 percent beam is indicated in figure 14 by a comparison of load-resistance ratios under several conditions of trim and speed. The effect is small, the trend for the model with the deeper step being toward higher resistance at hump speed and lower resistance at high speed and light loads. Greater positive trimming moments were observed on the model with the deep step than on the model with the shallow step. These results are similar to those for conventional length-beam ratios of reference 6. On a hull of the form of model 185, if a step as deep as 10 percent beam is required to attain good landing stability, no marked increase in take-off time may be expected over that for a hull with a shallow step.

Forebody spray.- Photographs of the forebody spray of model 185 are given in figure 12. The model is shown running free to trim at several load coefficients and at several speeds. The effect of the change in angle of dead rise on the spray was imperceptible, and therefore no photographs of the model with low angle of dead rise are given. The criterion for forebody loading (reference 7) is given as $C_{\Delta_0} = k\left(\frac{L_f}{b}\right)^2$, where L_f is the length of the forebody and k is an empirical coefficient. The following C_{Δ_0} values have been computed for this model having a forebody length-beam ratio of 5.8:

k	C_{Δ_o}
0.119	4.0
.0975 (excessive)	3.28
.0825 (heavy)	2.77
.0675 (satisfactory)	2.27
.0525 (light)	1.76

From this table, model 185 would be expected to produce extremely heavy forebody spray at a load coefficient of 4.0. The spray actually observed and shown in figure 12 verifies this expectation. With nacelles and wing located according to current design practice, a flying boat having a hull similar to model 184 or 185 would have an excessive amount of spray in its propellers when operating at load coefficients over 3.0.

CONCLUSIONS

1. The three models tested maintained relatively high load-resistance ratios to higher load coefficients than do models of conventional length-beam ratio. At the free-to-trim hump, load-resistance ratios of 4.5 and 3.9 were attained at load coefficients of 1.5 and 3.5, respectively.

2. Changing the angle of dead rise (excluding chine flare) and the depth of step on these models had the same effect on their resistance as similar changes made on models of conventional length-beam ratio.

3. Excessive spray was shown for the three models tested at conventional propeller locations with load coefficients greater than 3.0.

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5. Bell, Joe W., and Willis, John M., Jr.: The Effects of Angle of Dead Rise and Angle of Afterbody Keel on the Resistance of a Model of a Flying-Boat Hull. NACA ARR, Feb. 1943.

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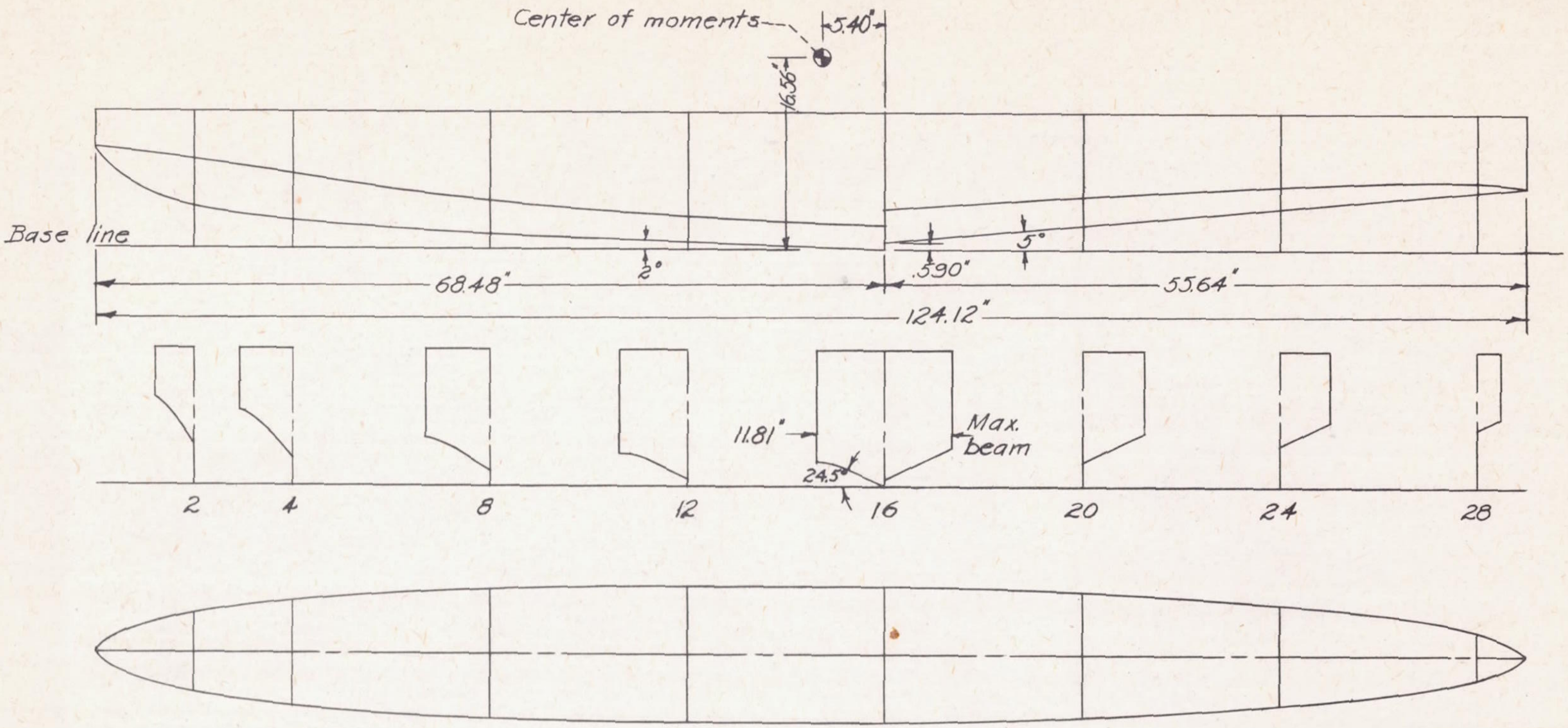

Figure 1.- Lines of model 185.

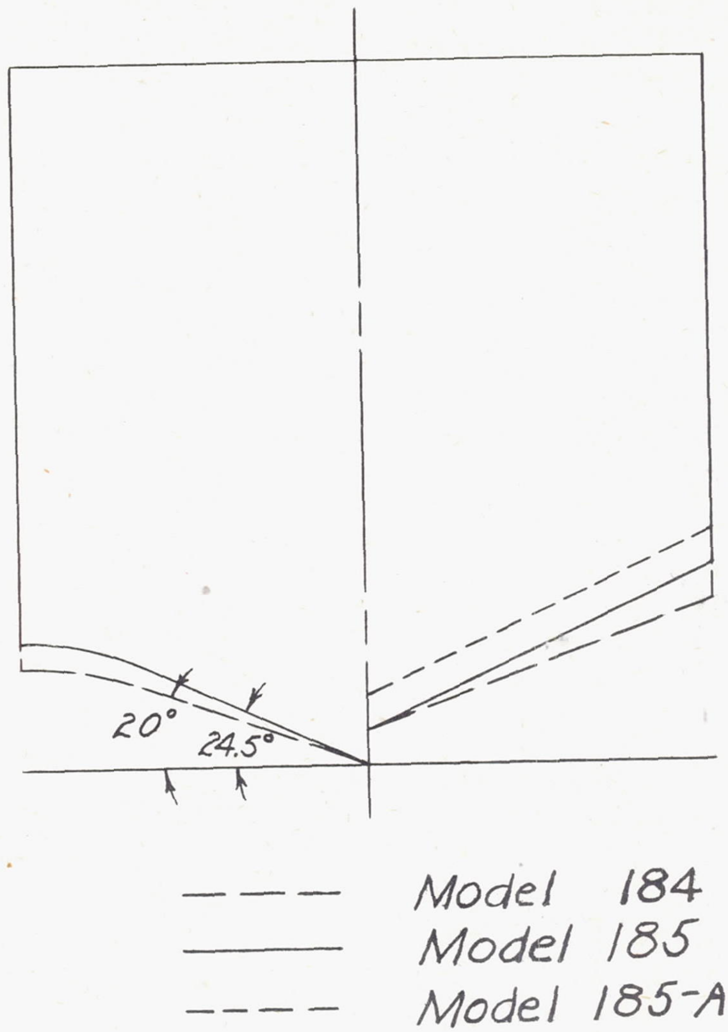

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Figure 2.- Comparison of hull sections at the step.

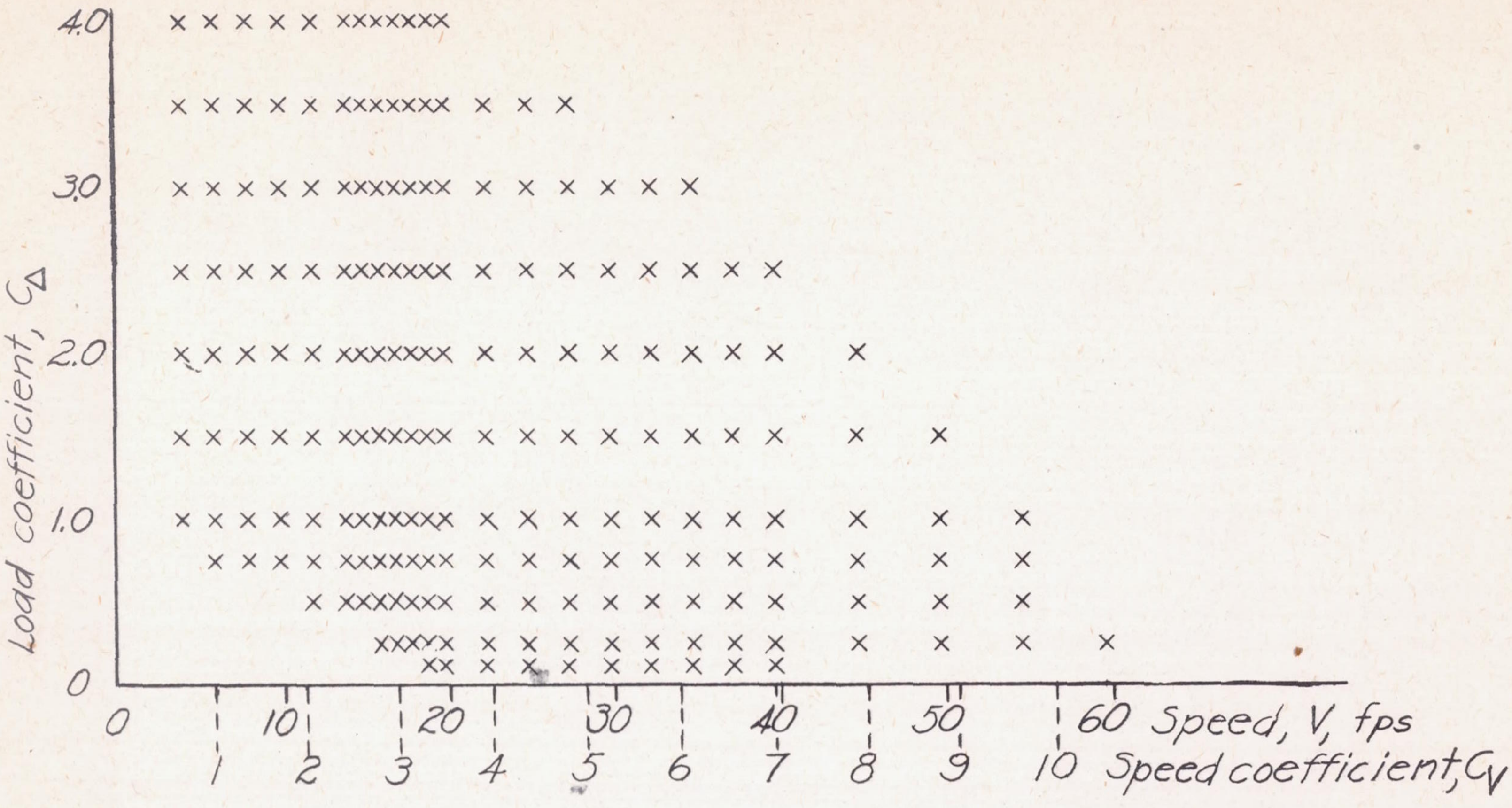

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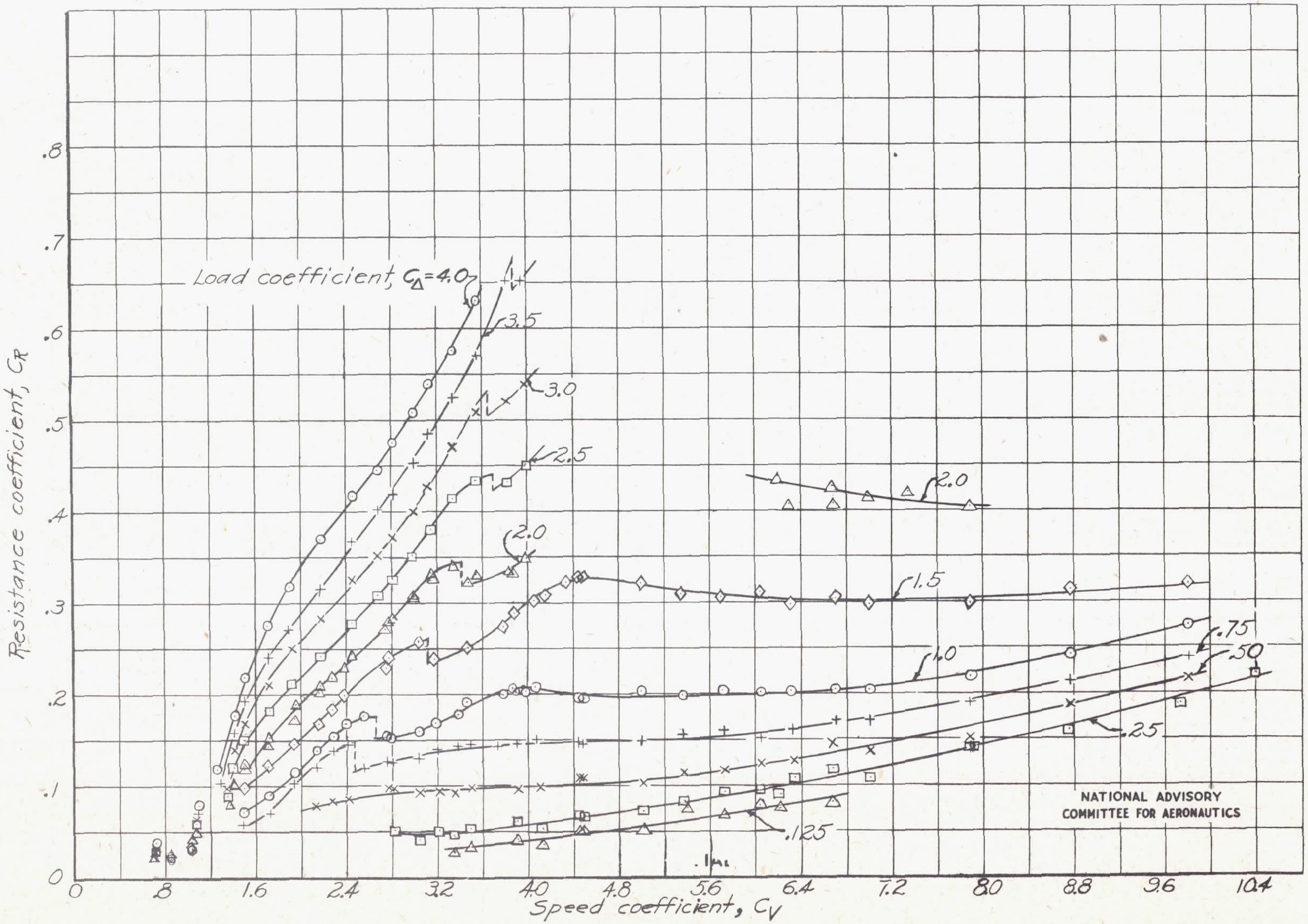
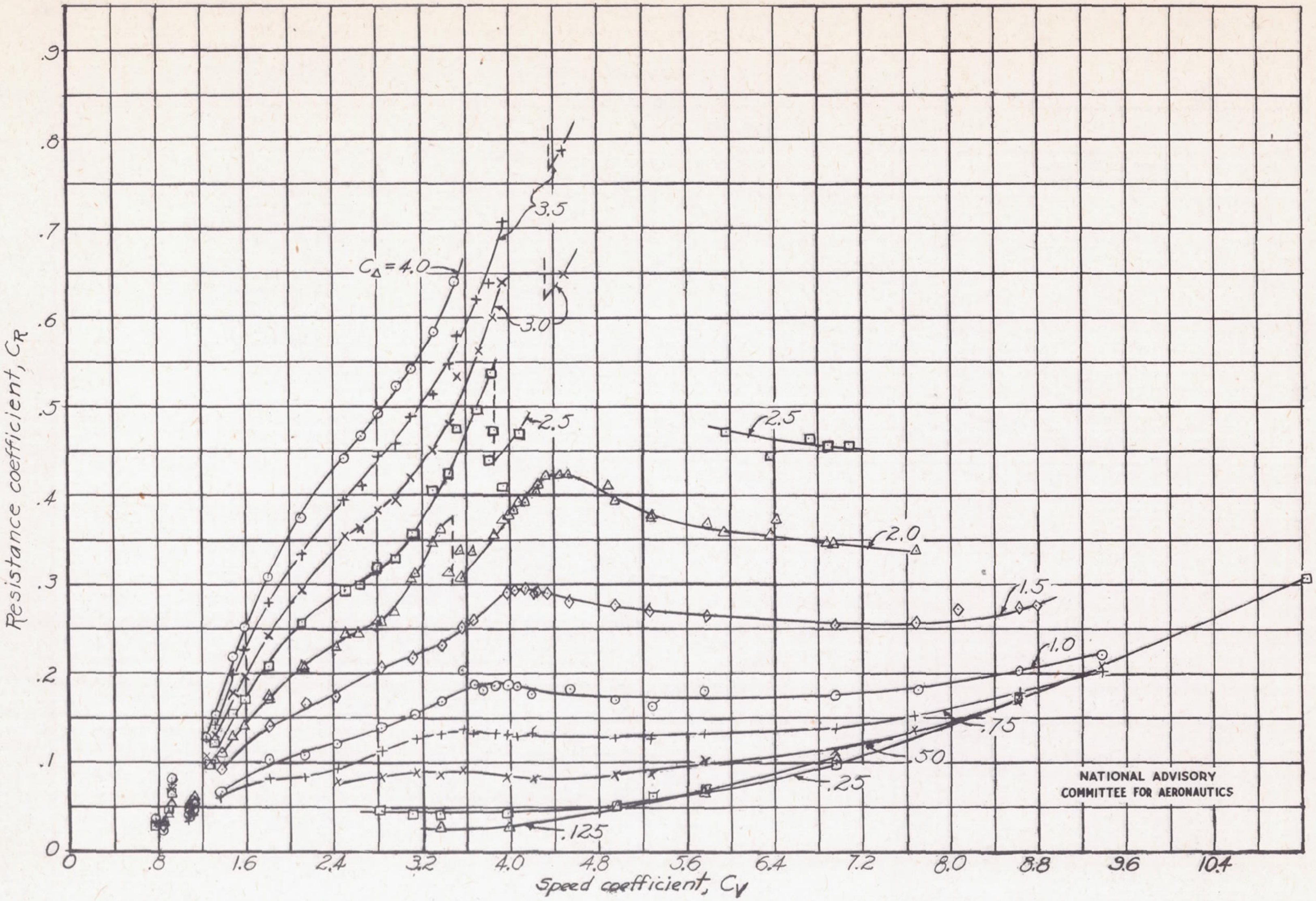
Figure 3.- Test schedule of model loads and speeds.
$C_V = 0.177V$.

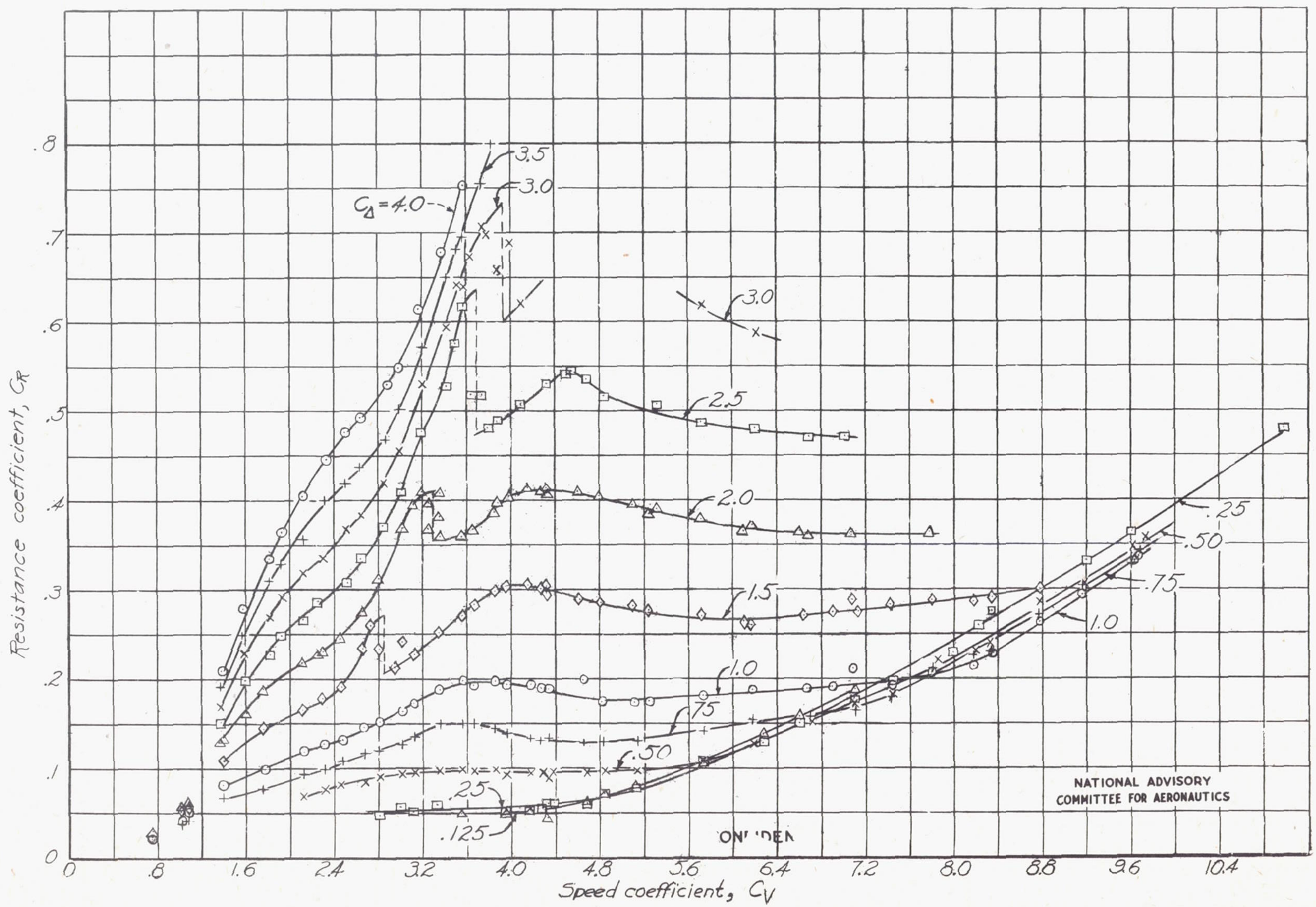


(a) τ, 2°.

Figure 4.- Model 185. Resistance characteristics.

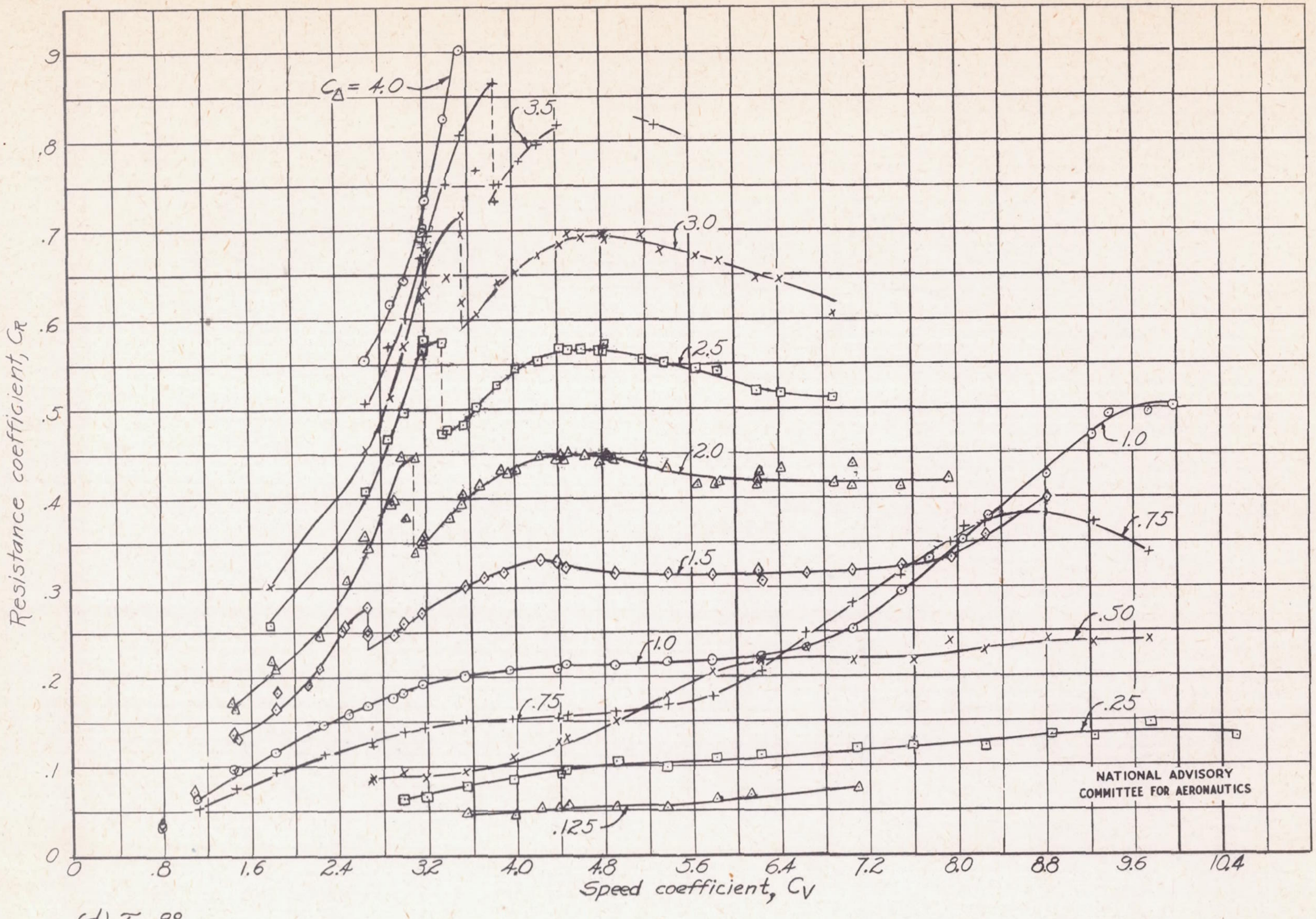


(b) τ, 4°.
Figure 4.- Continued.



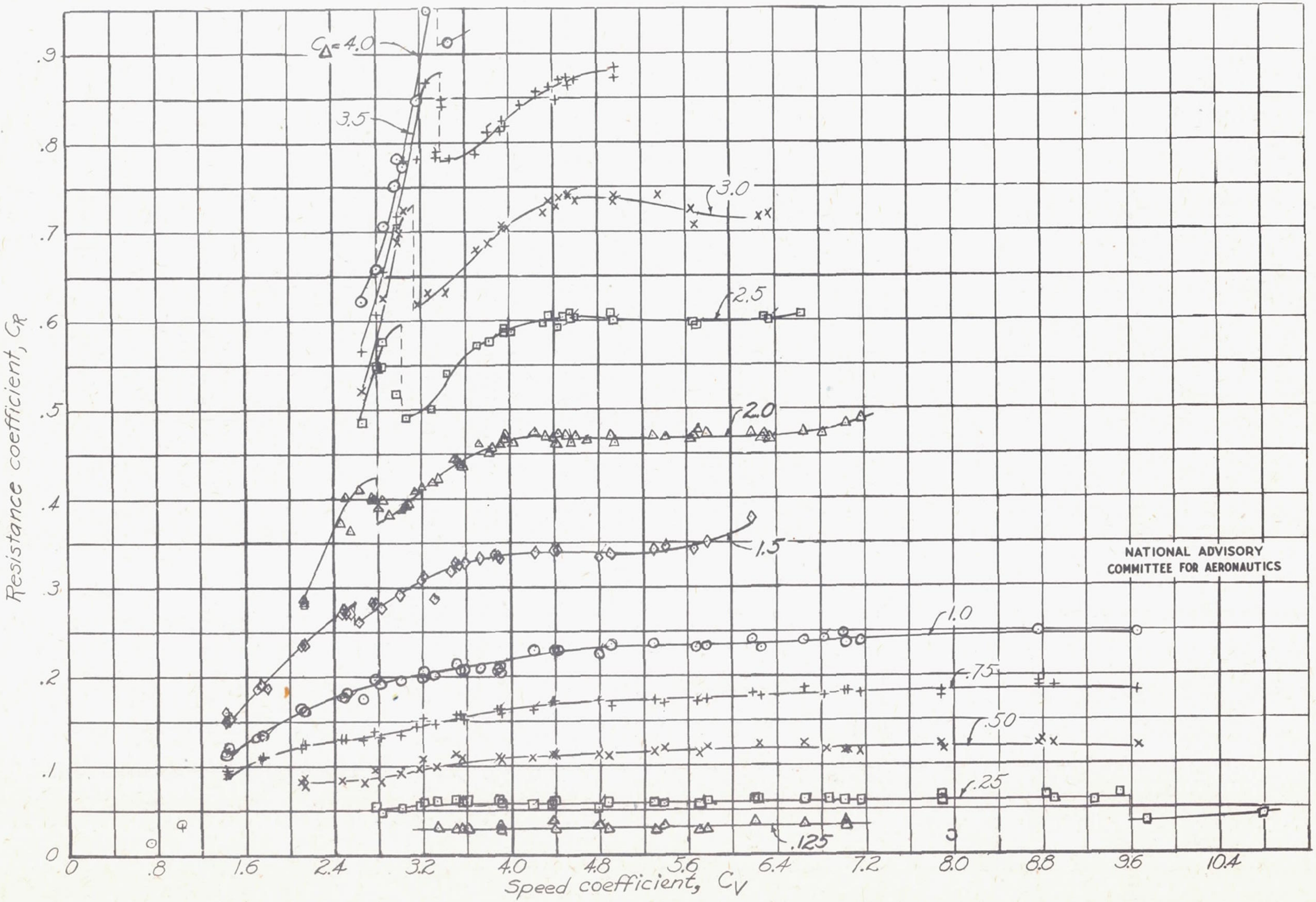
(c) τ, 6°.

Figure 4.- Continued.



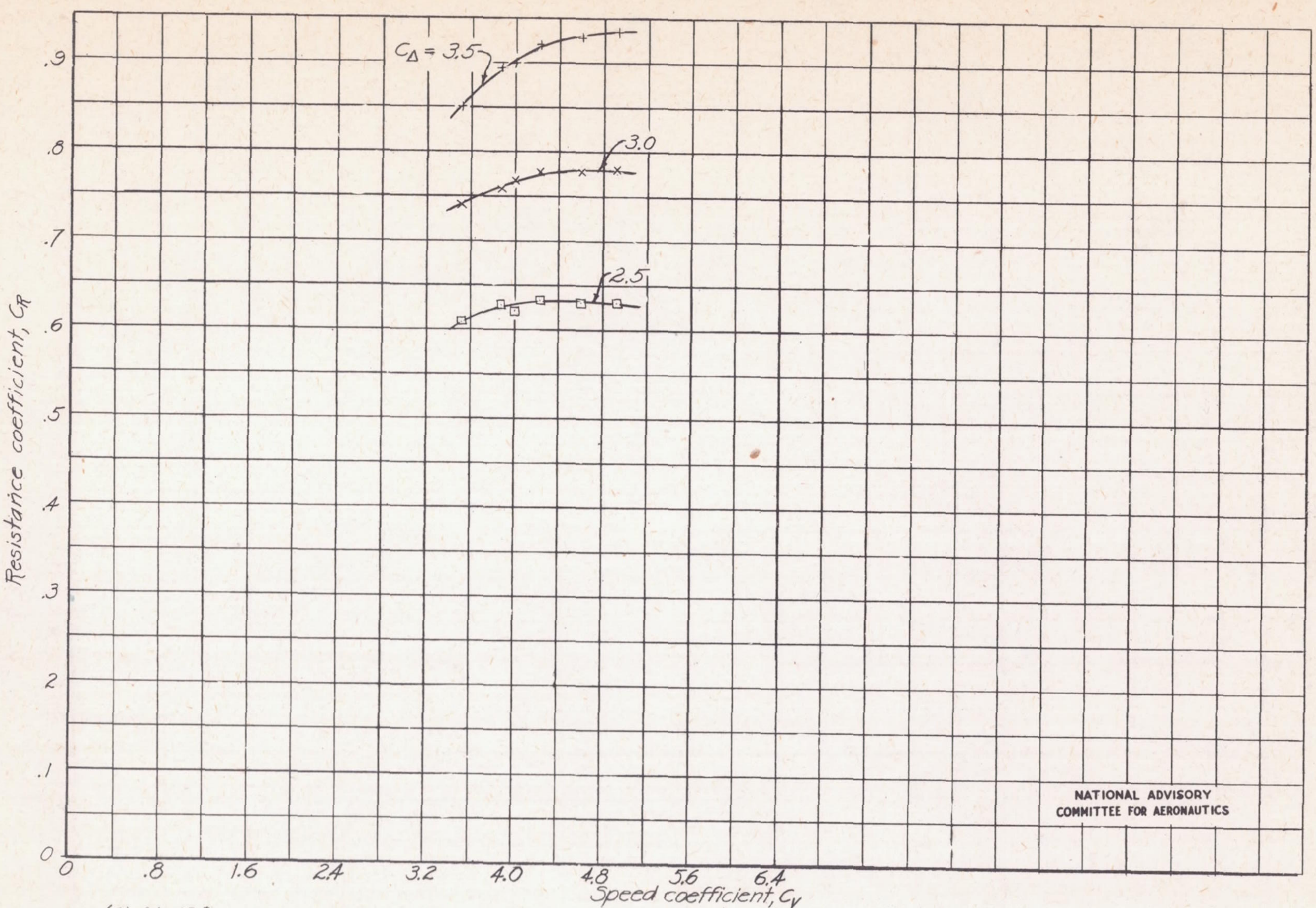
(d) τ, 8°.

Figure 4.- Continued.



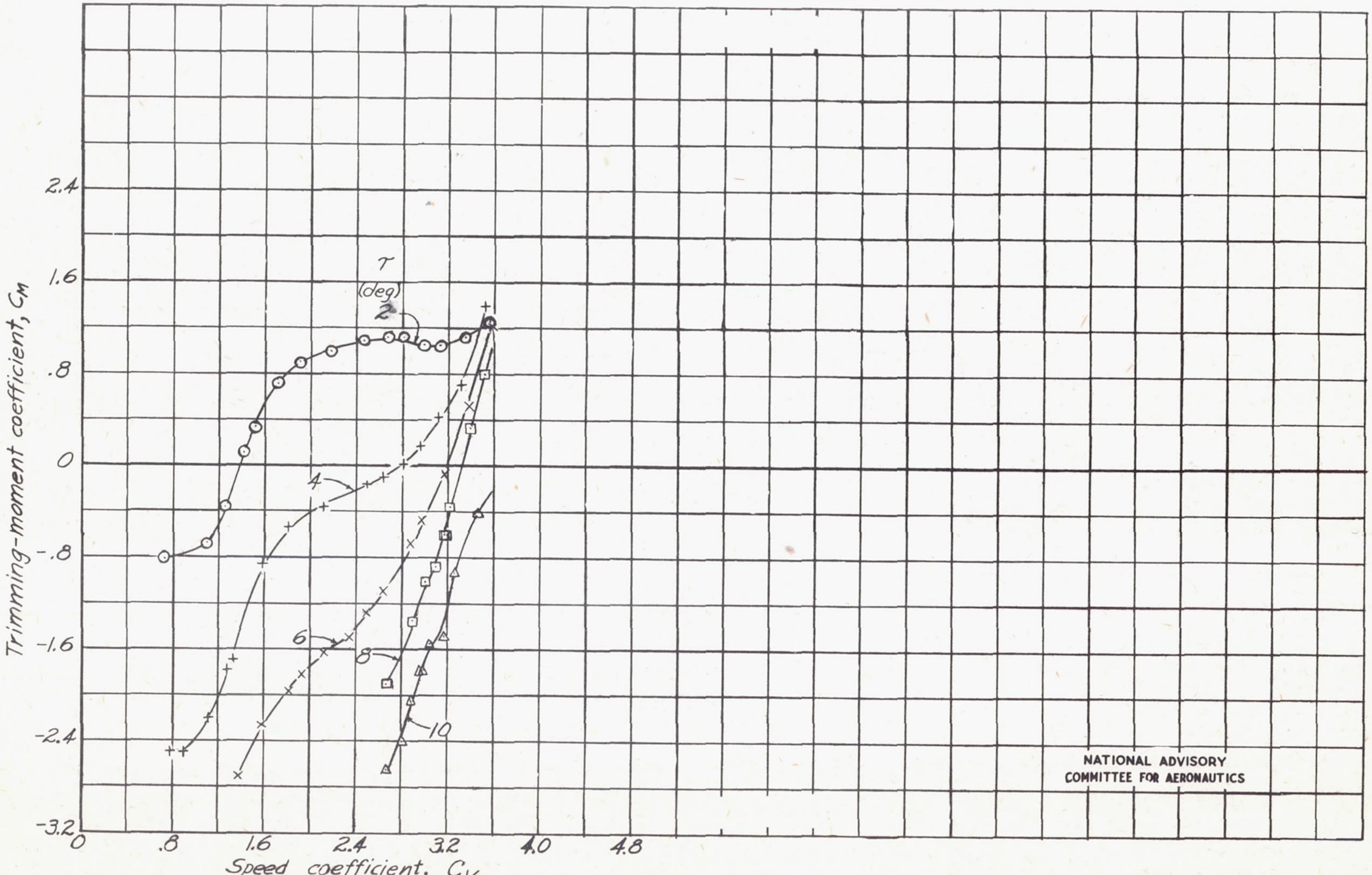
(e) τ, 10°.

Figure 4.- Continued.



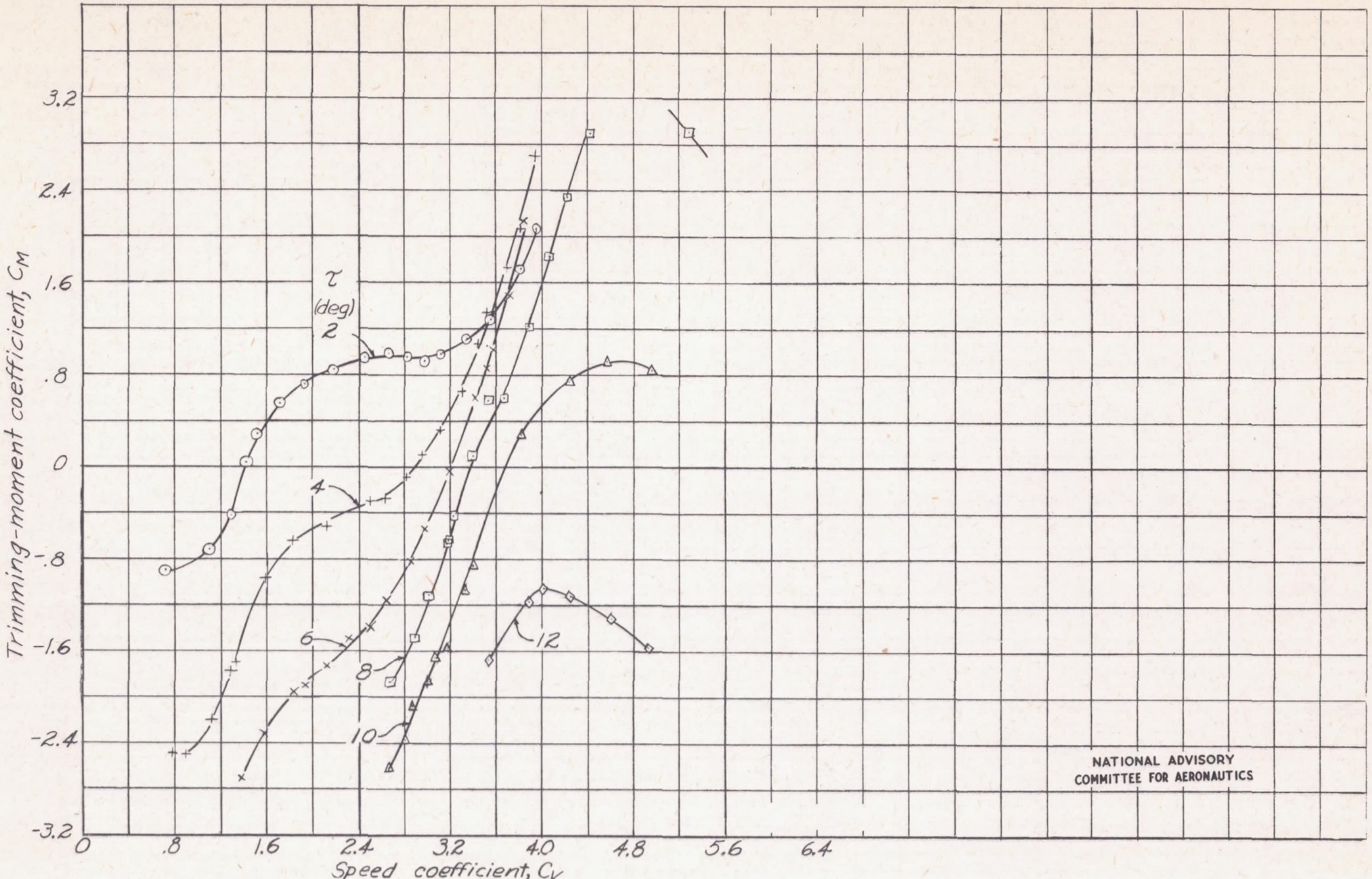
(f) τ, 12°.

Figure 4.- Concluded.

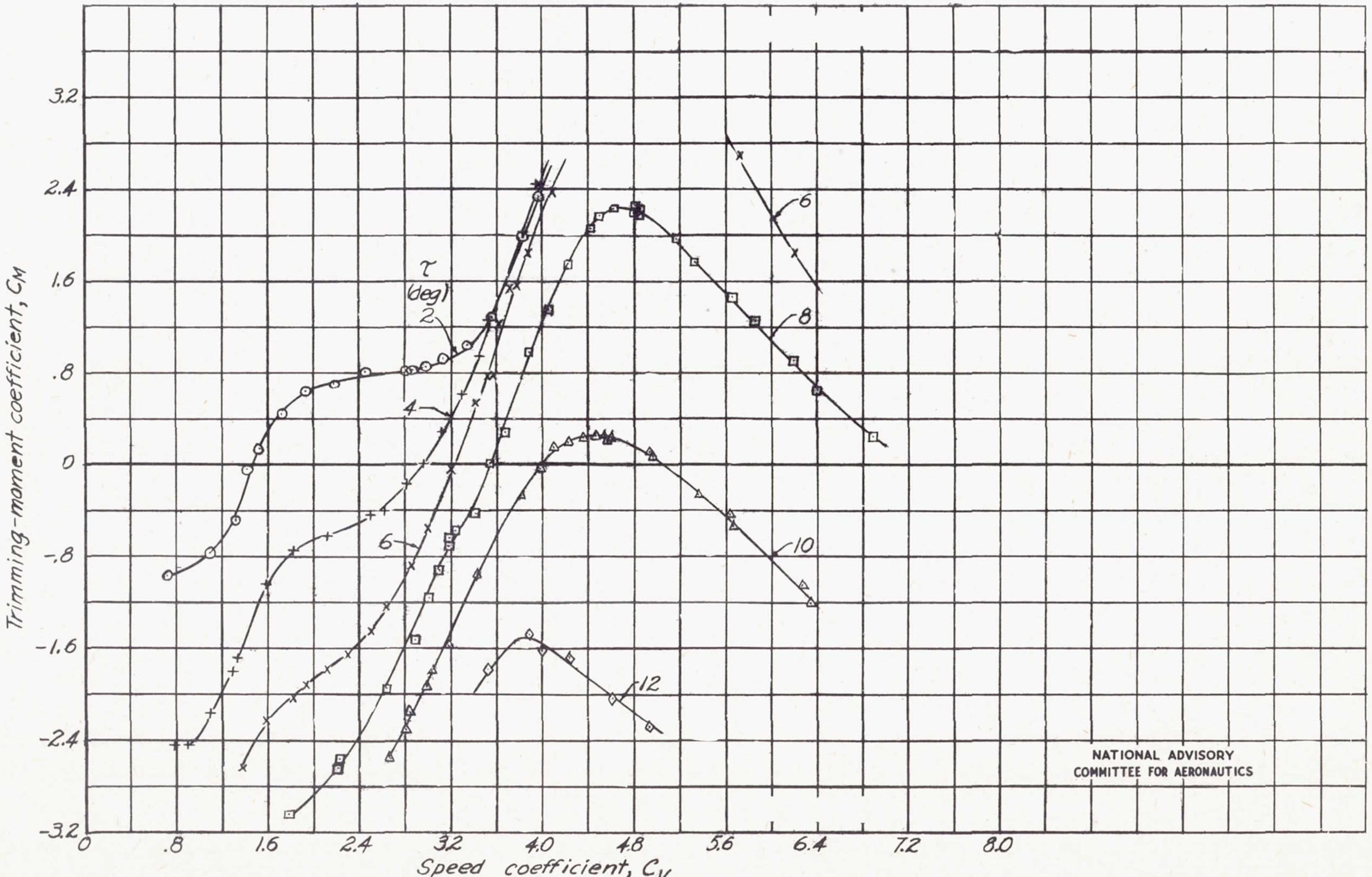


(a) Load coefficient, $C_\Delta = 4.0$.

Figure 5.- Model 185. Trimming-moment characteristics.

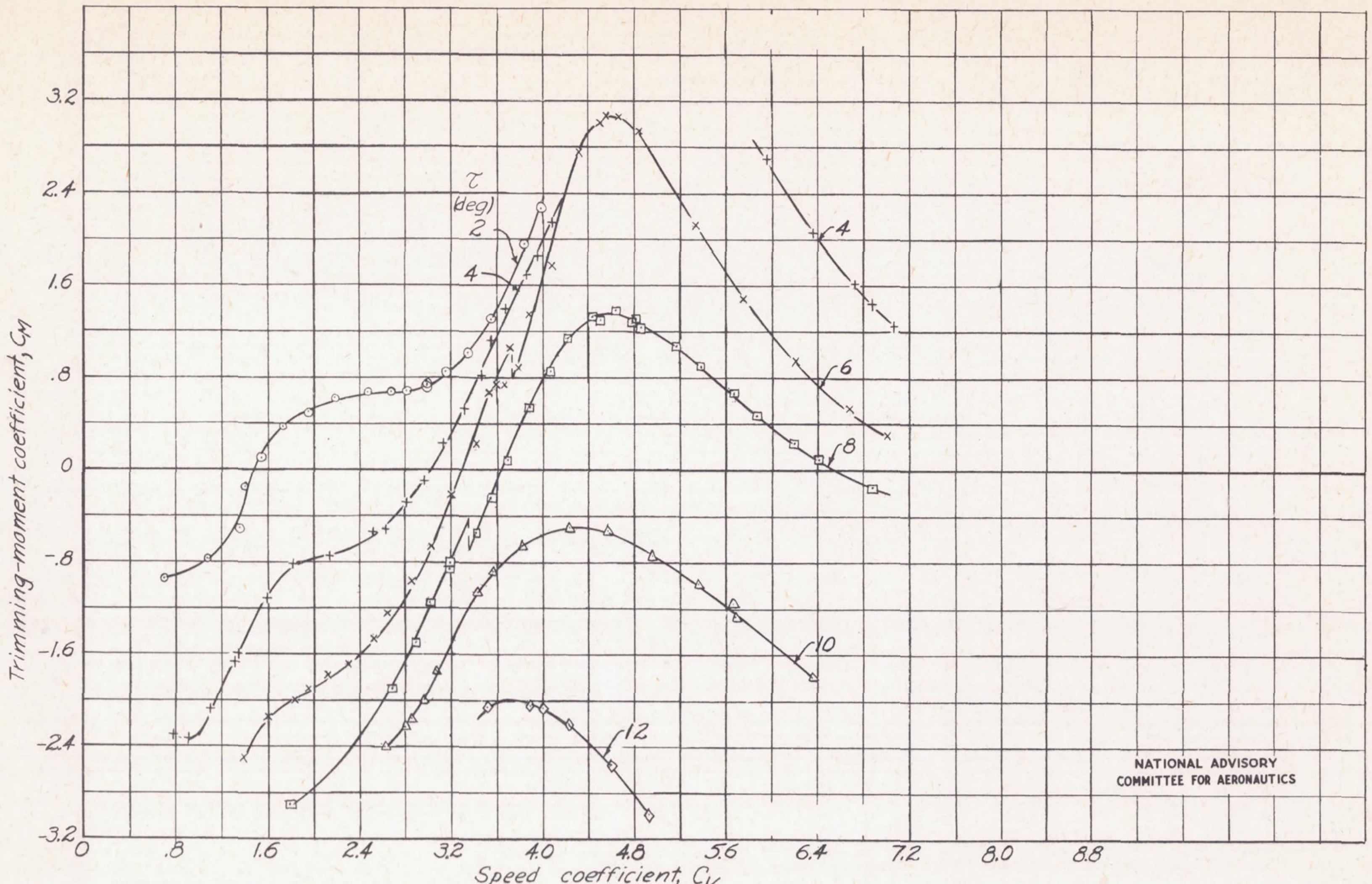


(b) $C_\Delta = 3.5$.
Figure 5.- Continued.

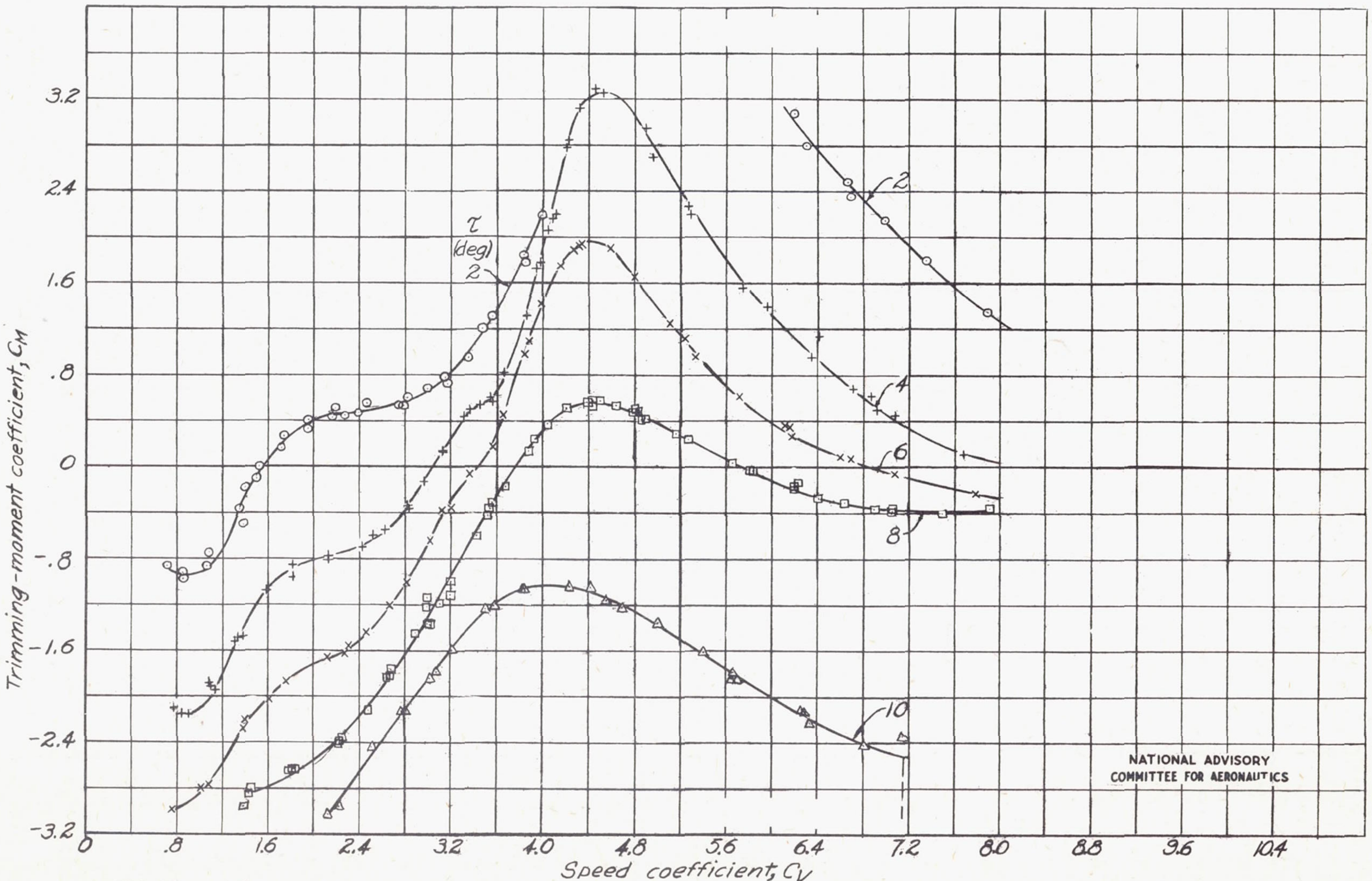


(c) $C_\Delta = 3.0$.

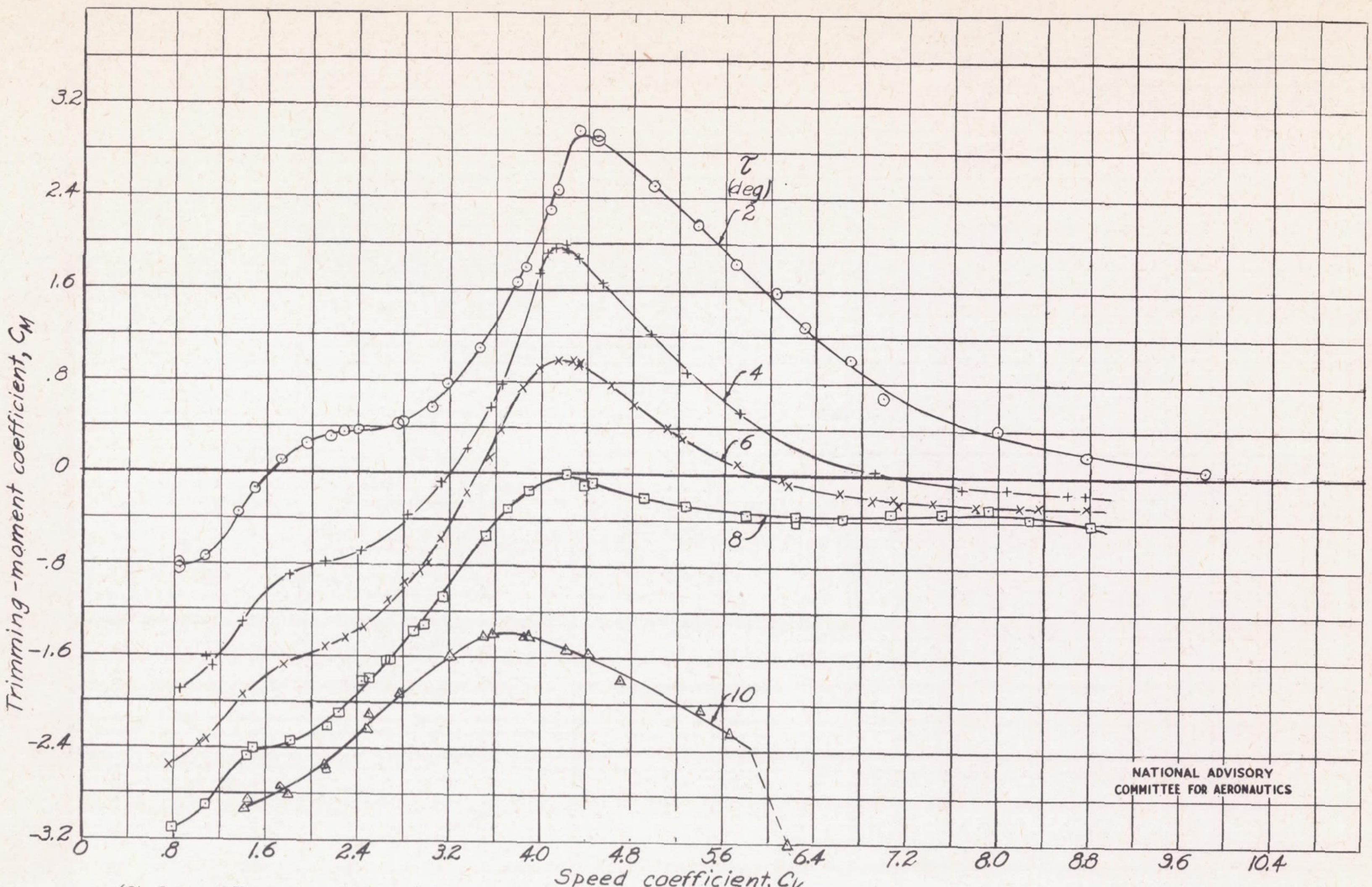
Figure 5.- Continued.



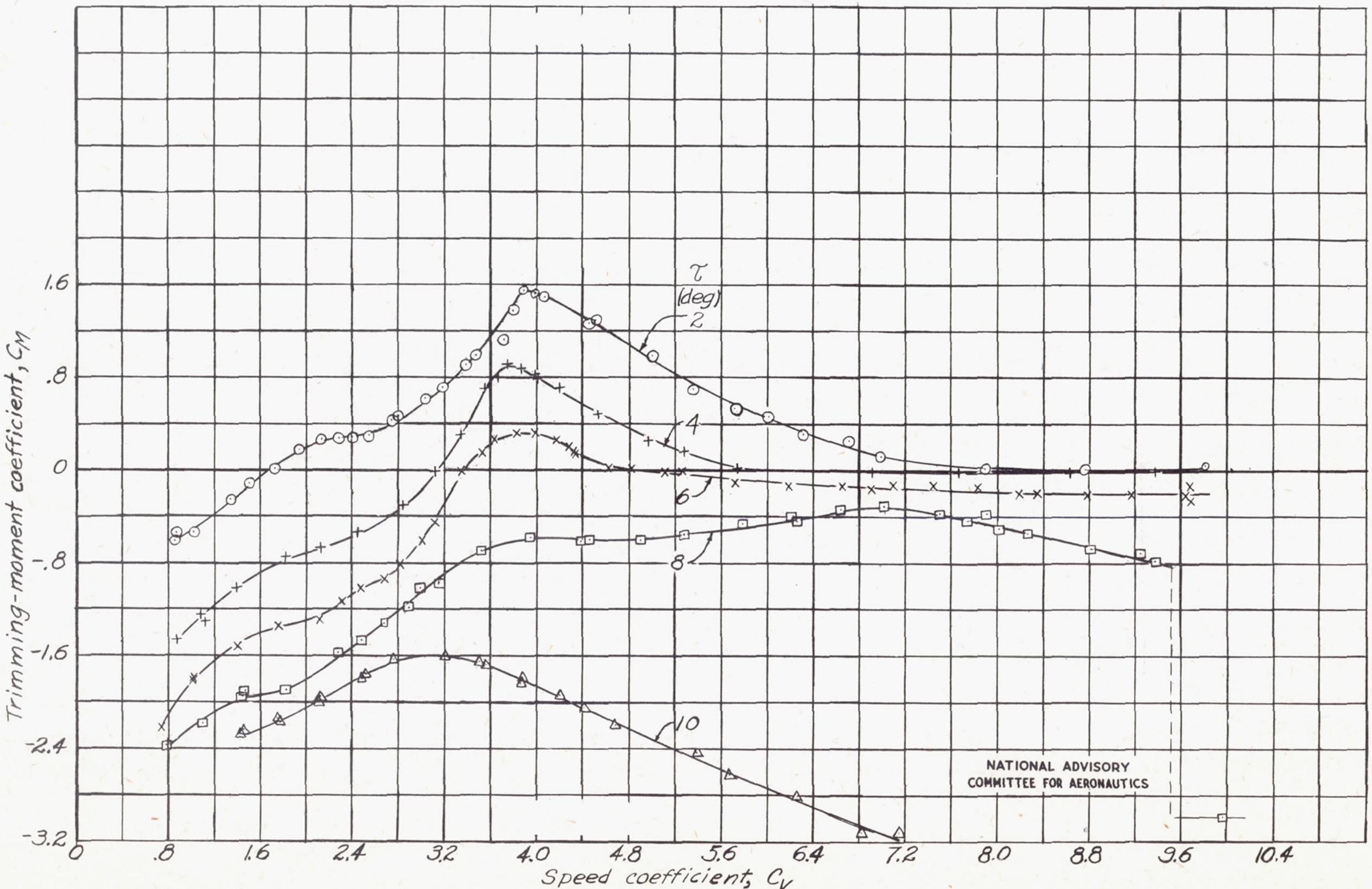
(d) $C_\Delta = 2.5$.
Figure 5.- Continued.



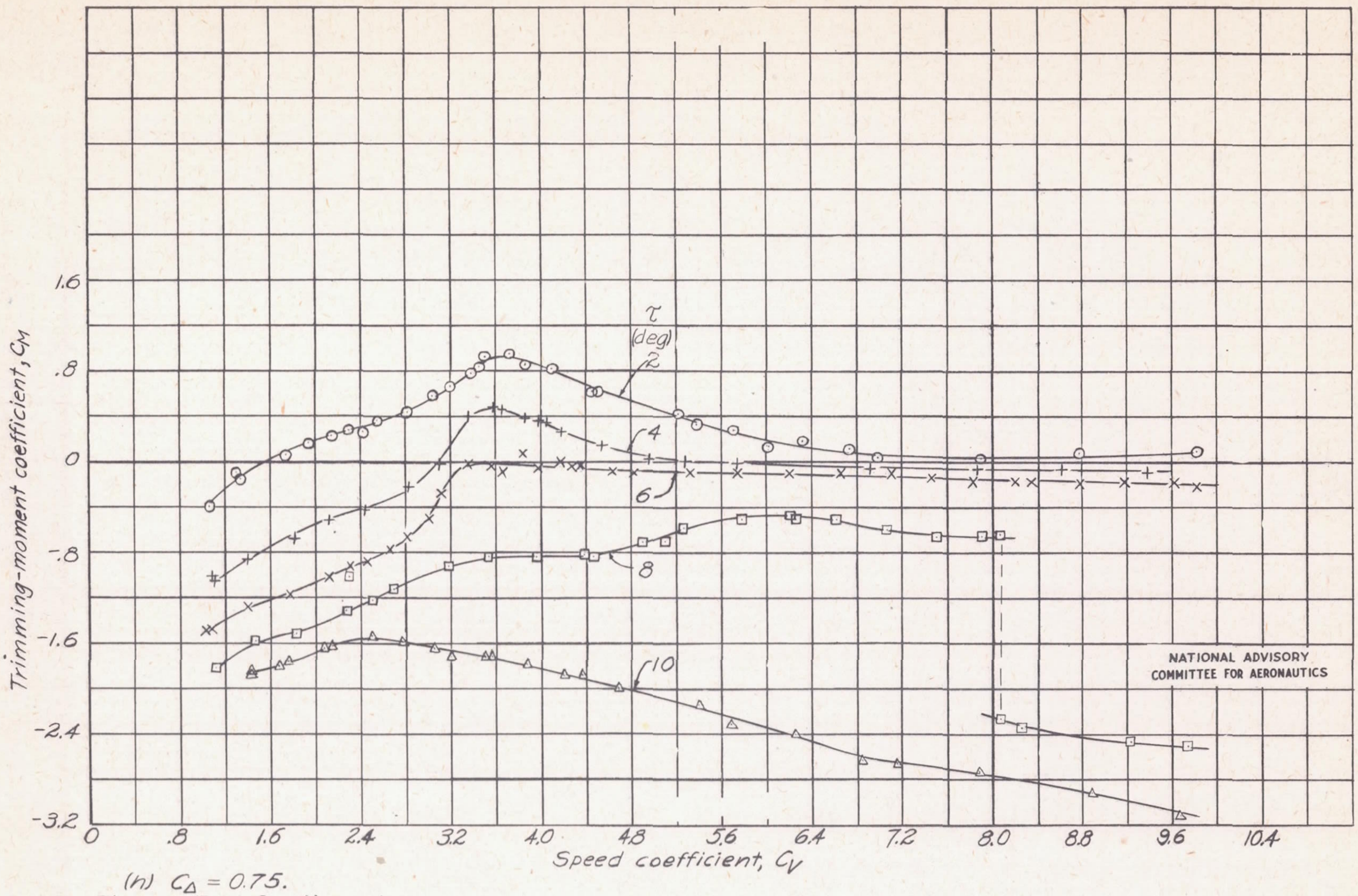
(e) $C_\Delta = 2.0$.
Figure 5. - Continued.



(f) $C_\Delta = 1.5$.
Figure 5.- Continued.

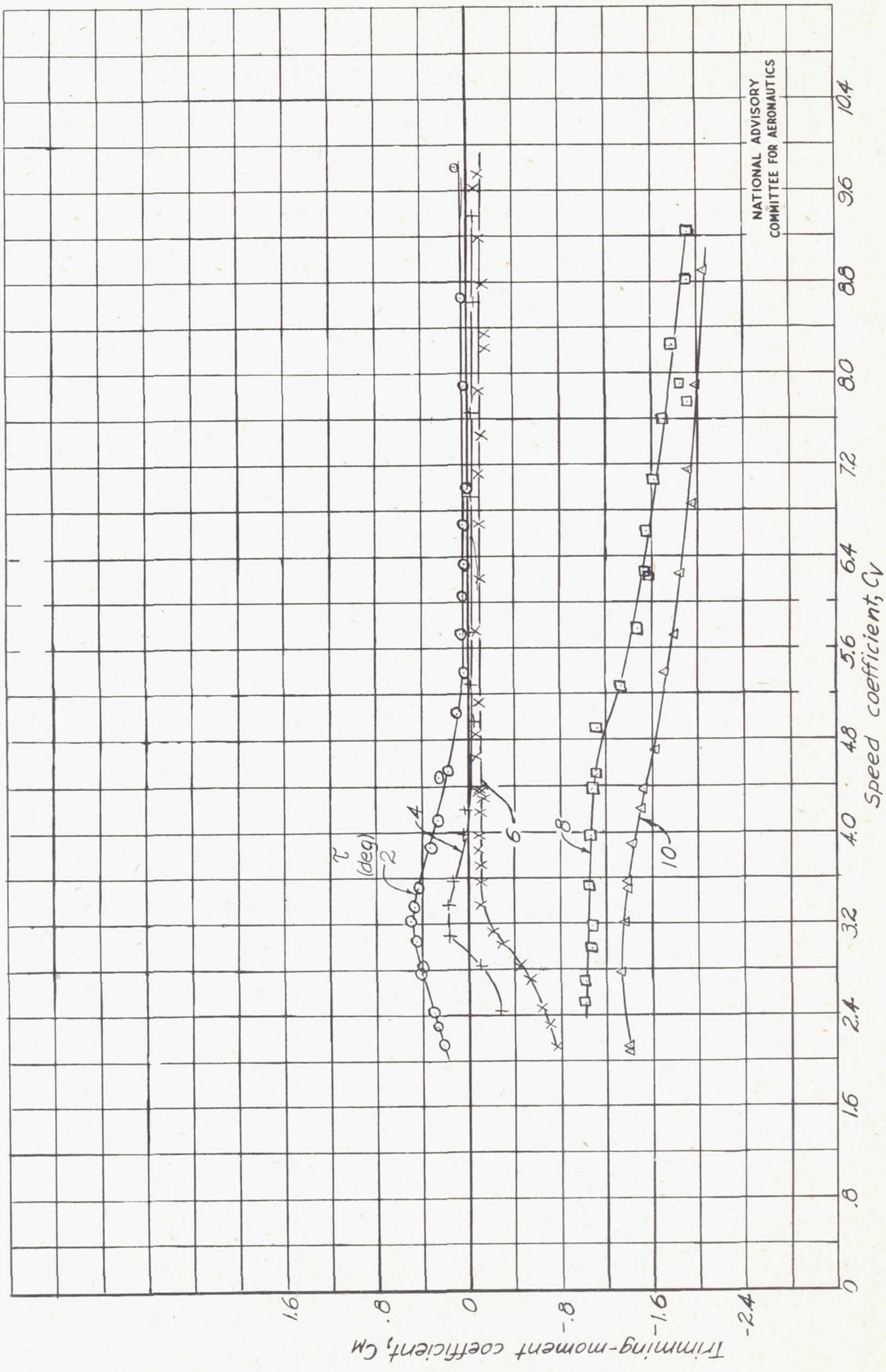


(g) $C_\Delta = 1.0$.
Figure 5.- Continued.

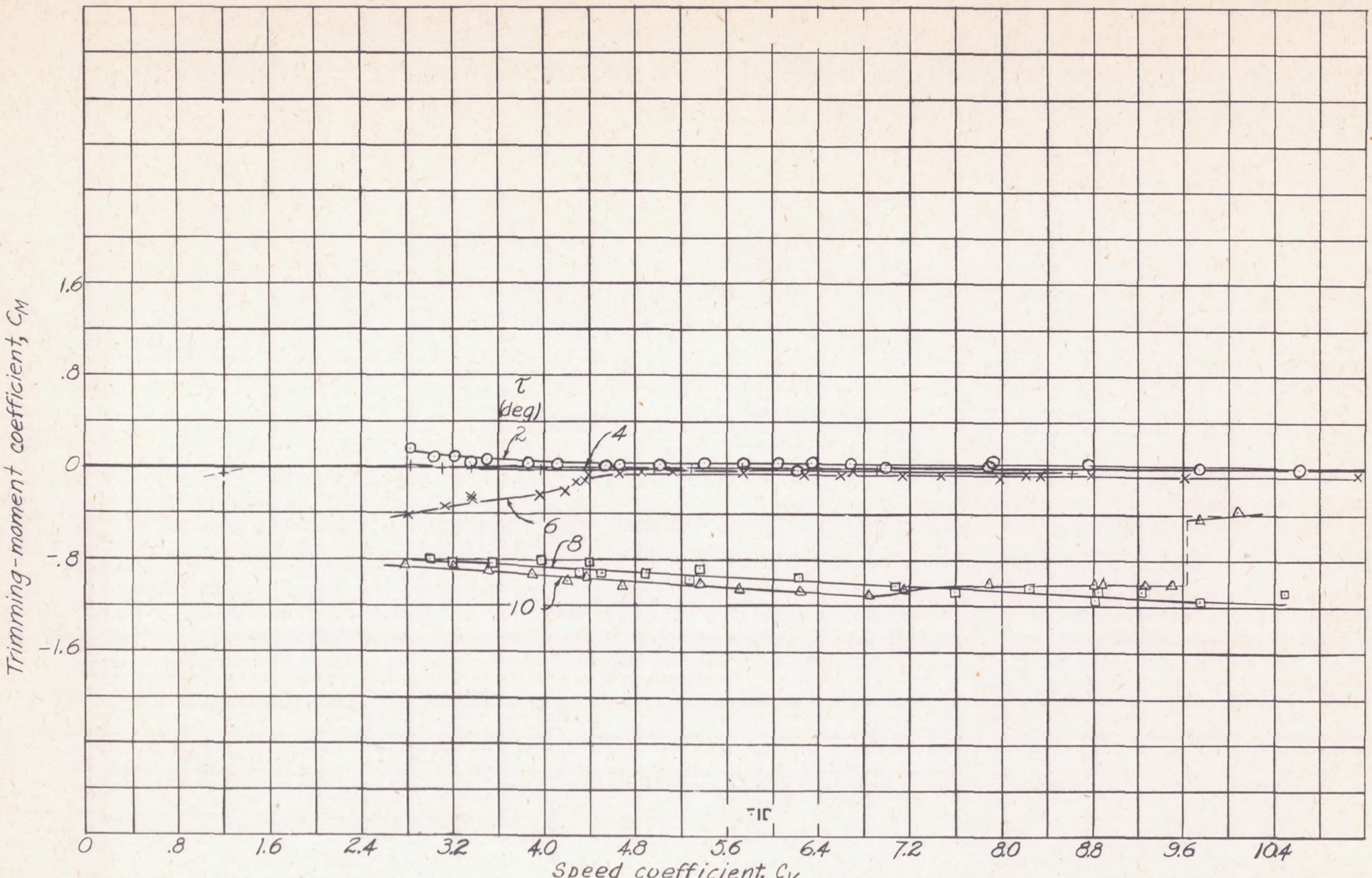


(h) $C_\Delta = 0.75$.

Figure 5. - Continued.



(i) $C_\Delta = 0.5$.
Figure 5.- Continued.



(j) $C_\Delta = 0.25$.
Figure 5.– Continued.

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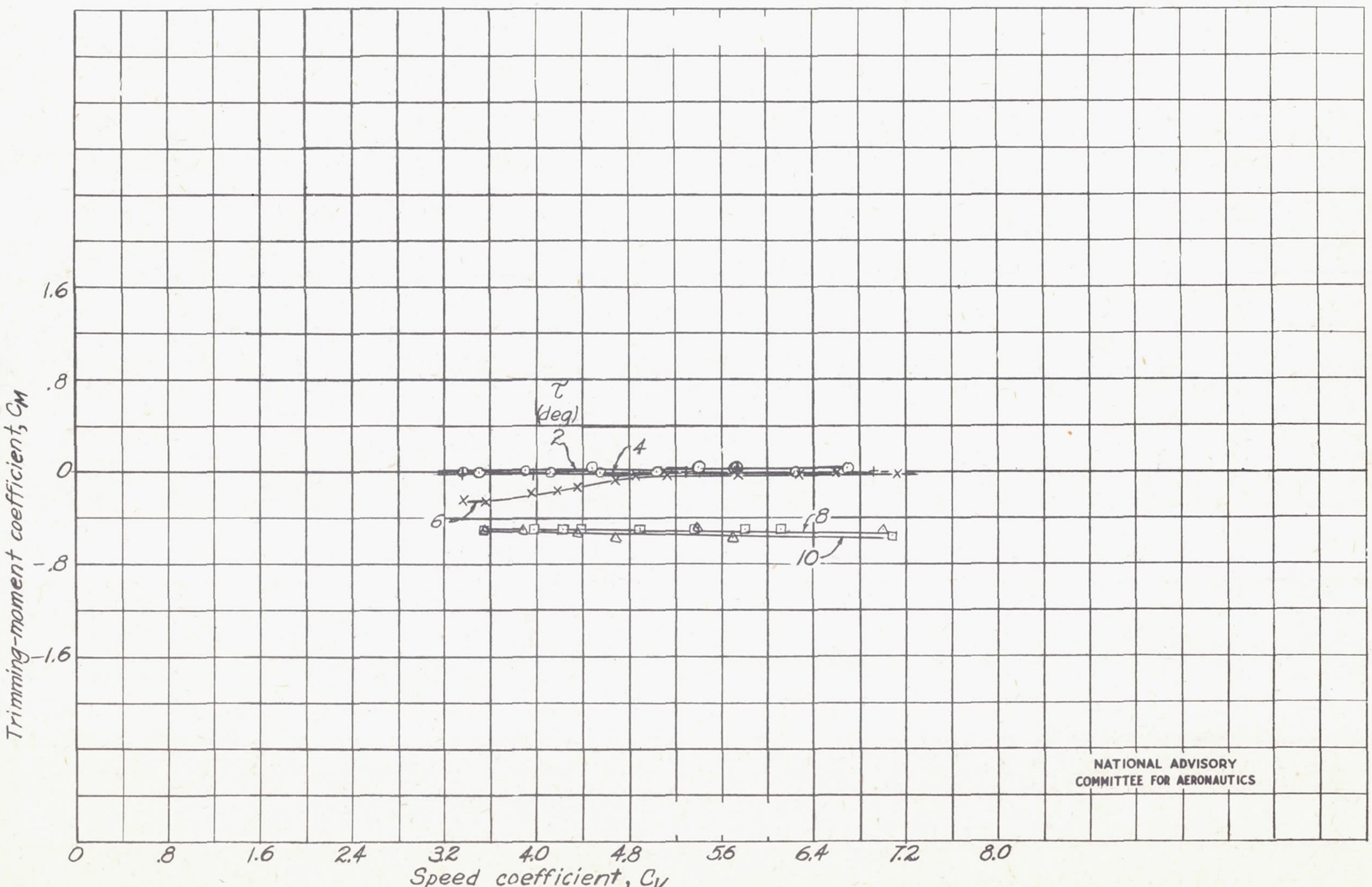

(k) $C_\Delta = 0.125$.
Figure 5.- Concluded.

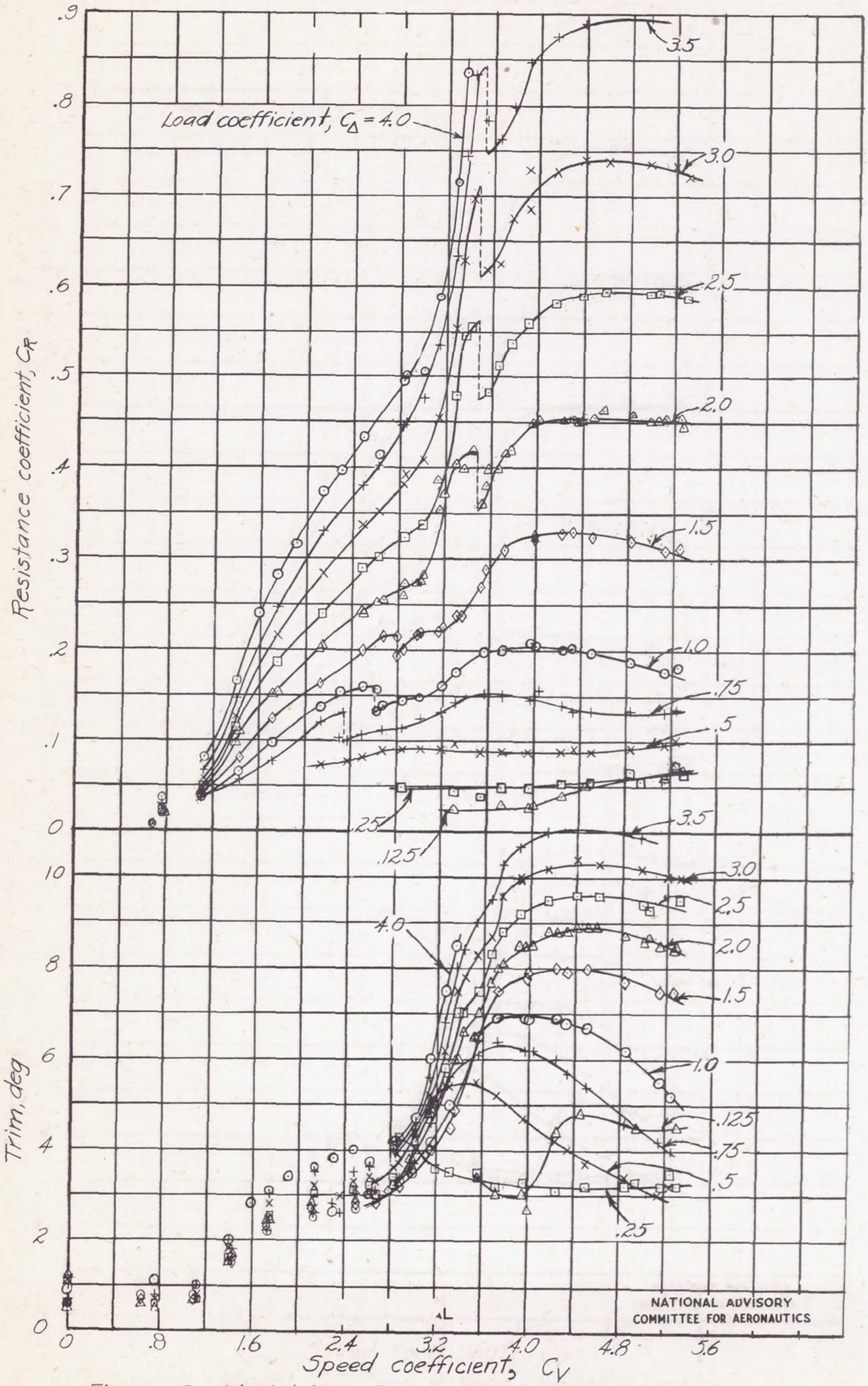

Figure 6.- Model 185. Free-to-trim characteristics.

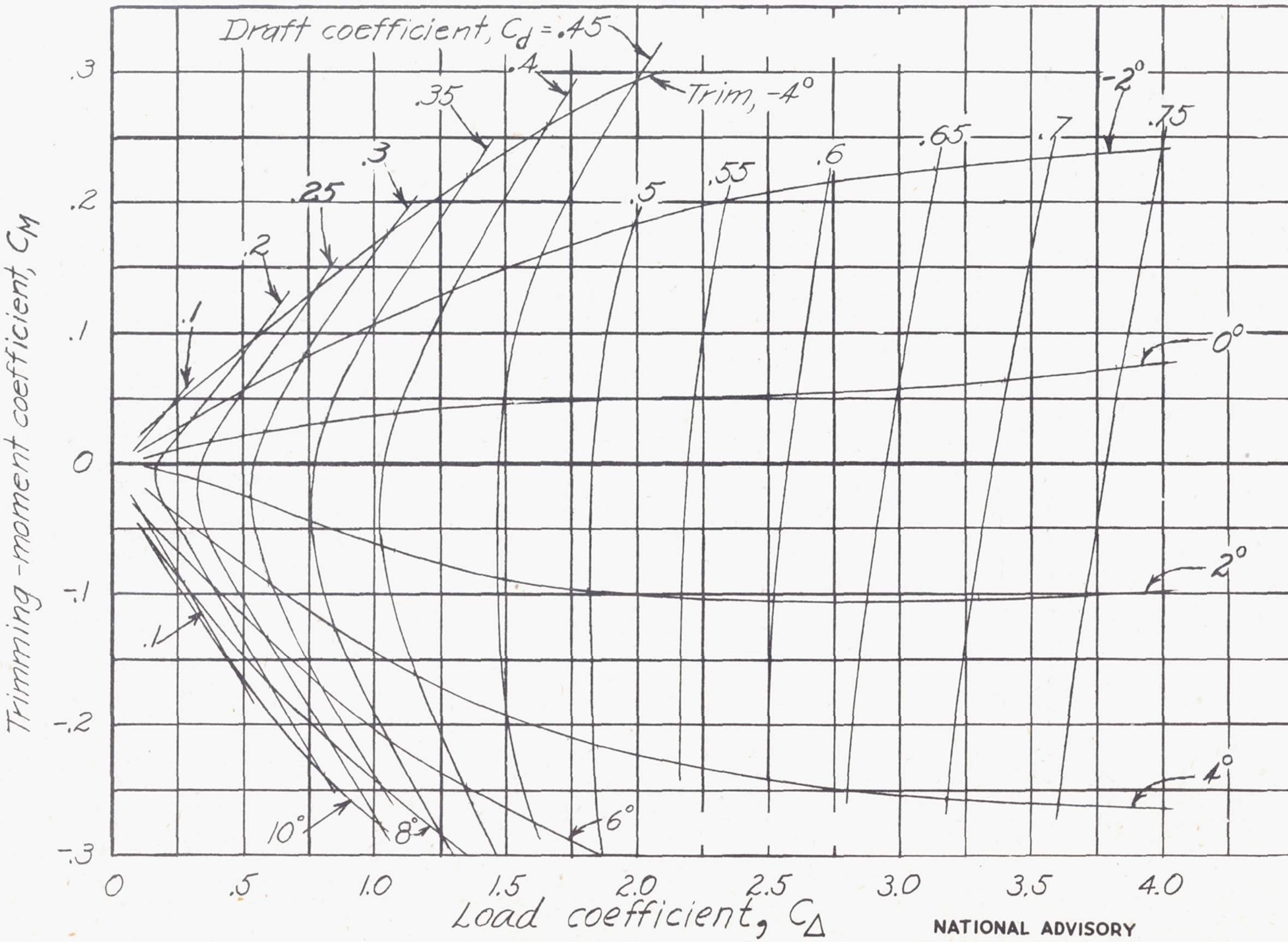

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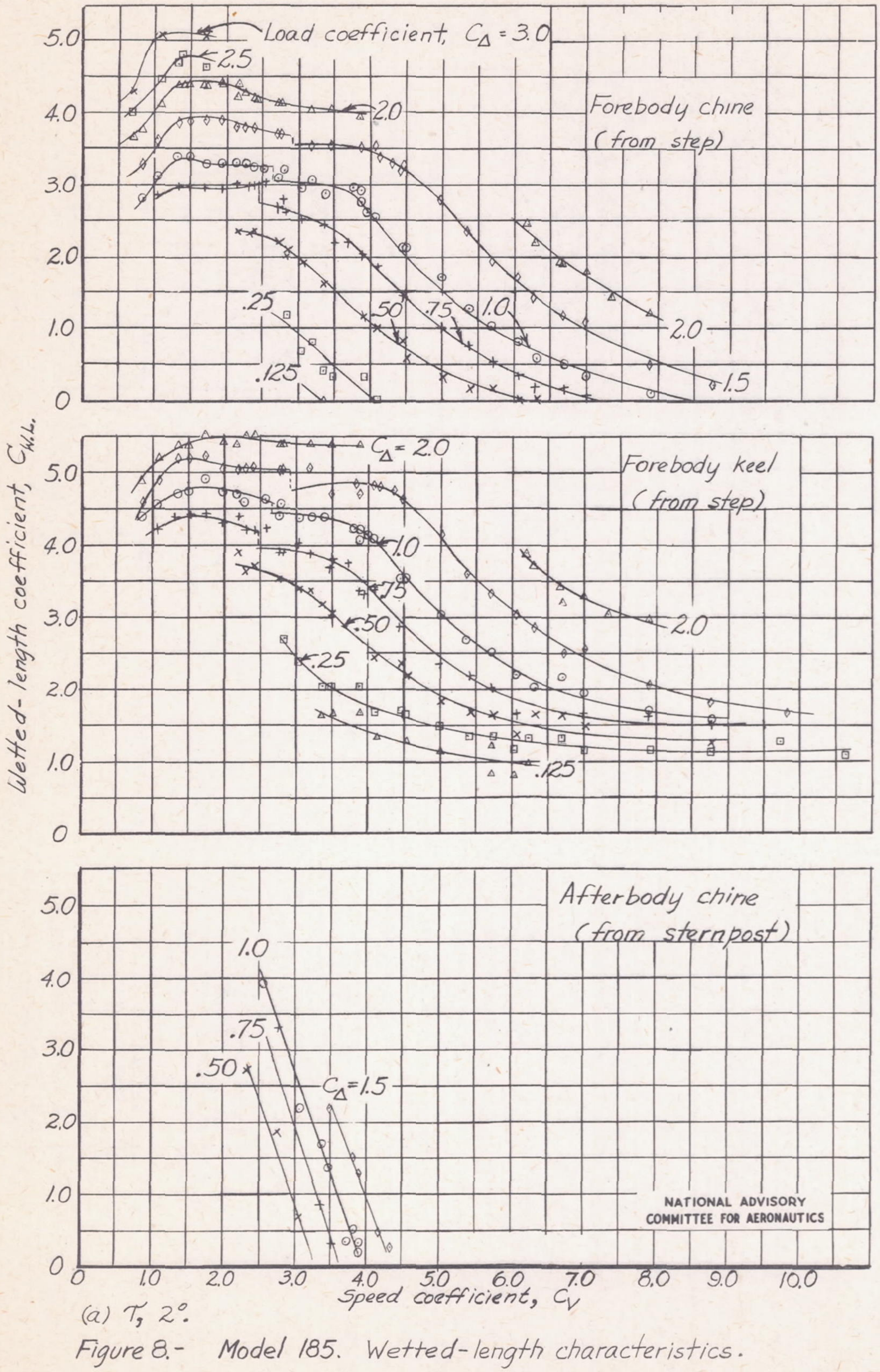
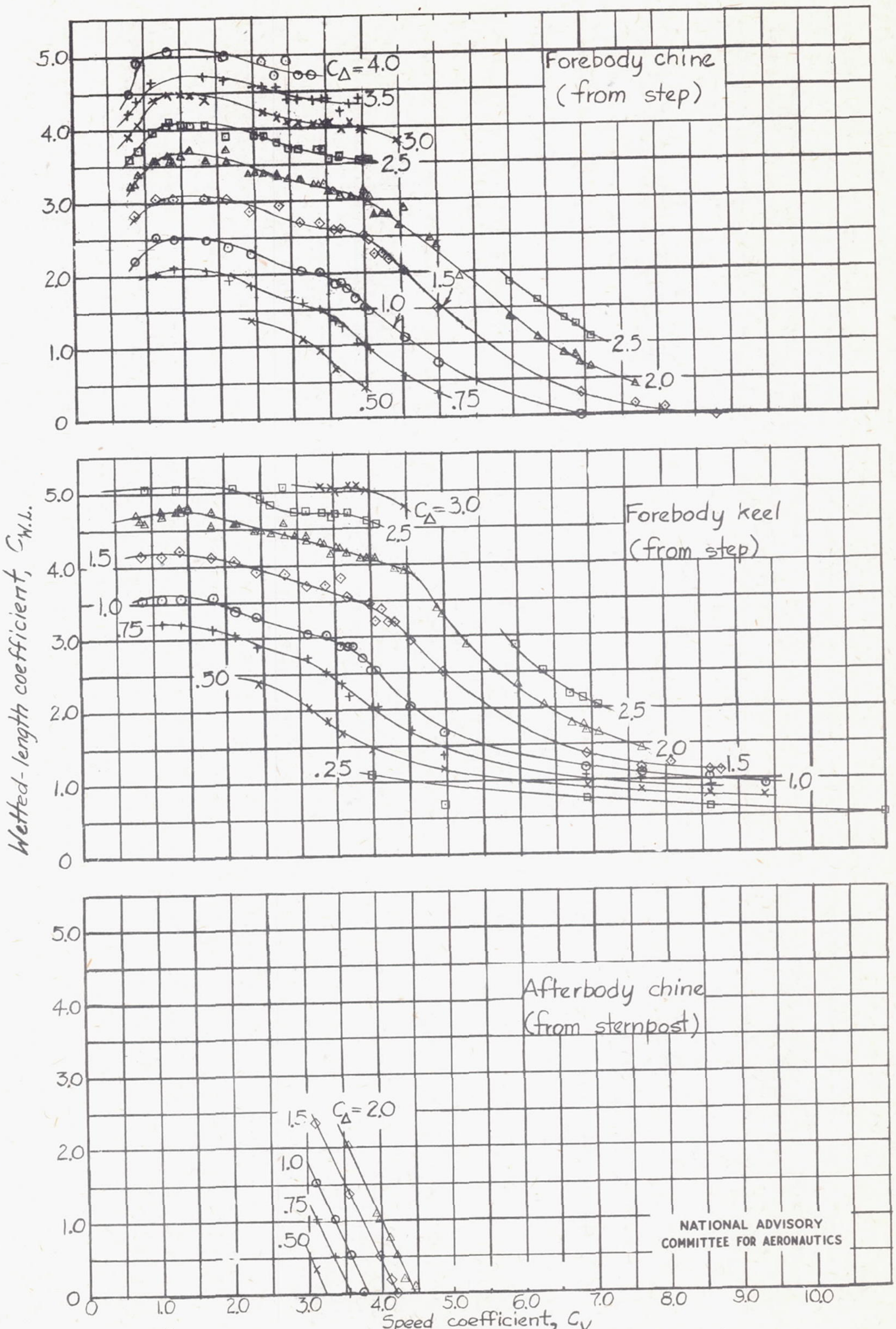
Figure 7.-Model 185. Static properties.



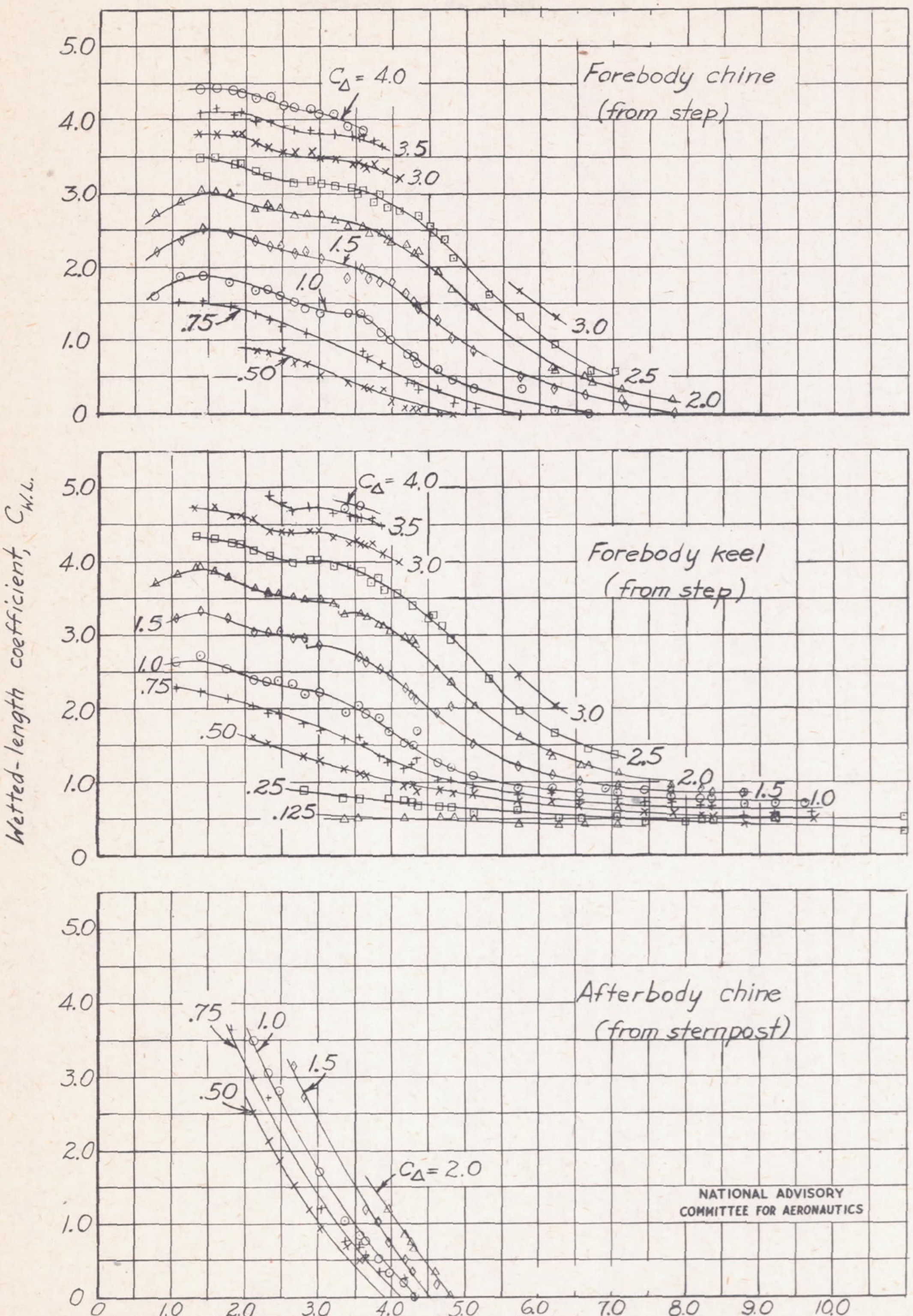
(a) τ, 2°.

Figure 8.- Model 185. Wetted-length characteristics.



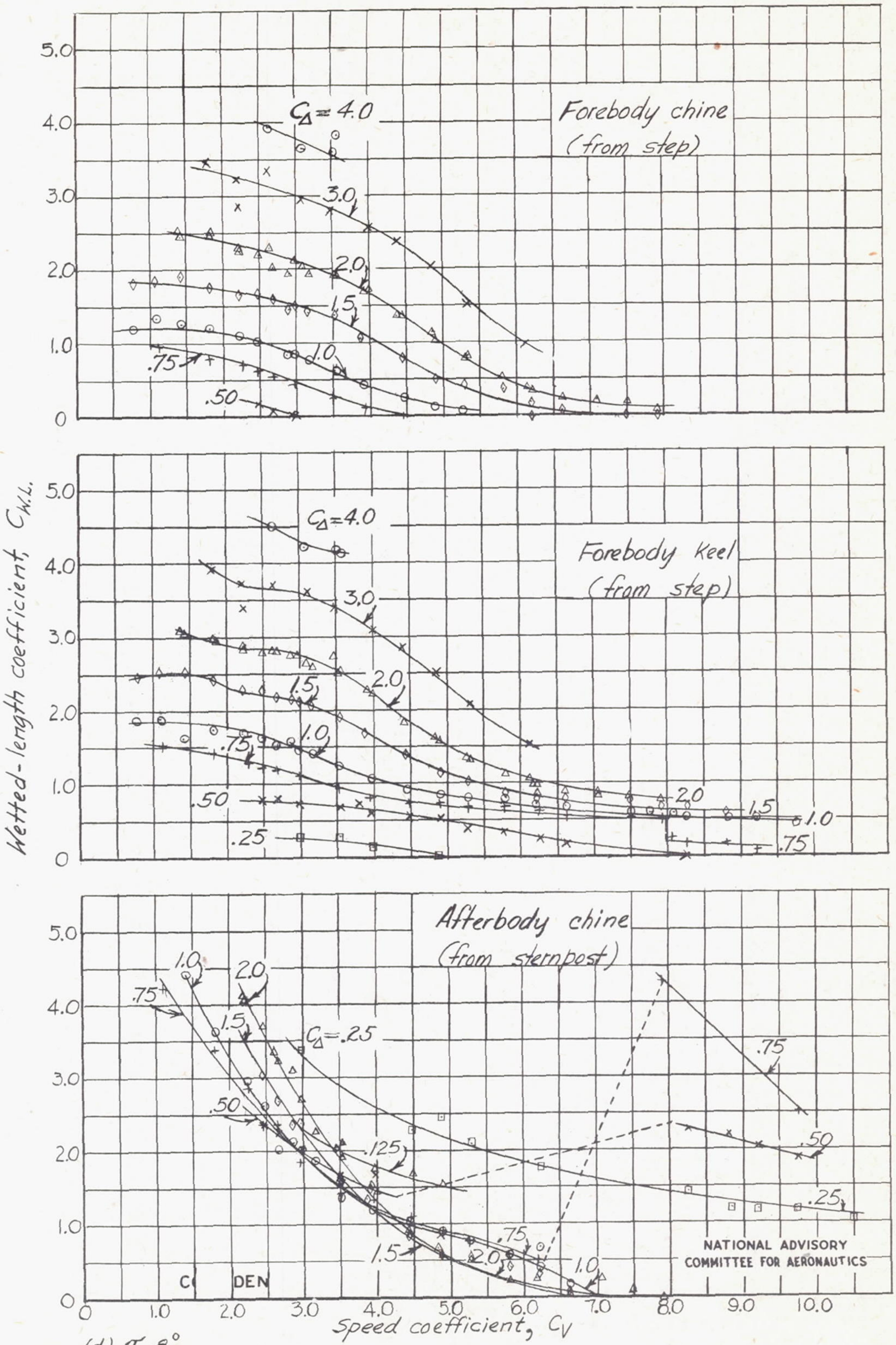
(b) τ, 4°.

Figure 8.- Continued.



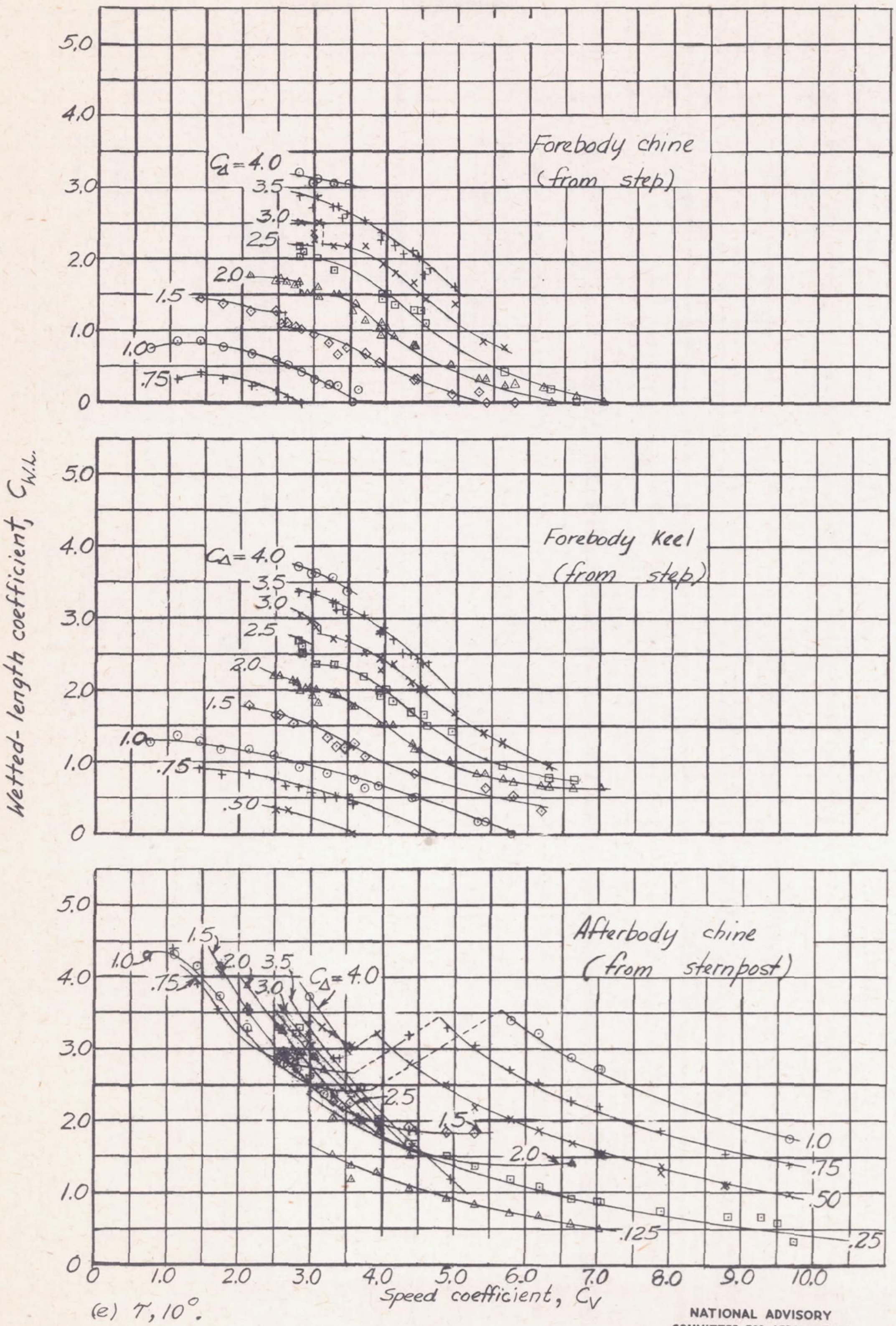
(c) τ, 6°.

Figure 8.- Continued.



(d) τ, 8°.

Figure 8.- Continued.



(e) τ, 10°.

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Figure 8.- Concluded.

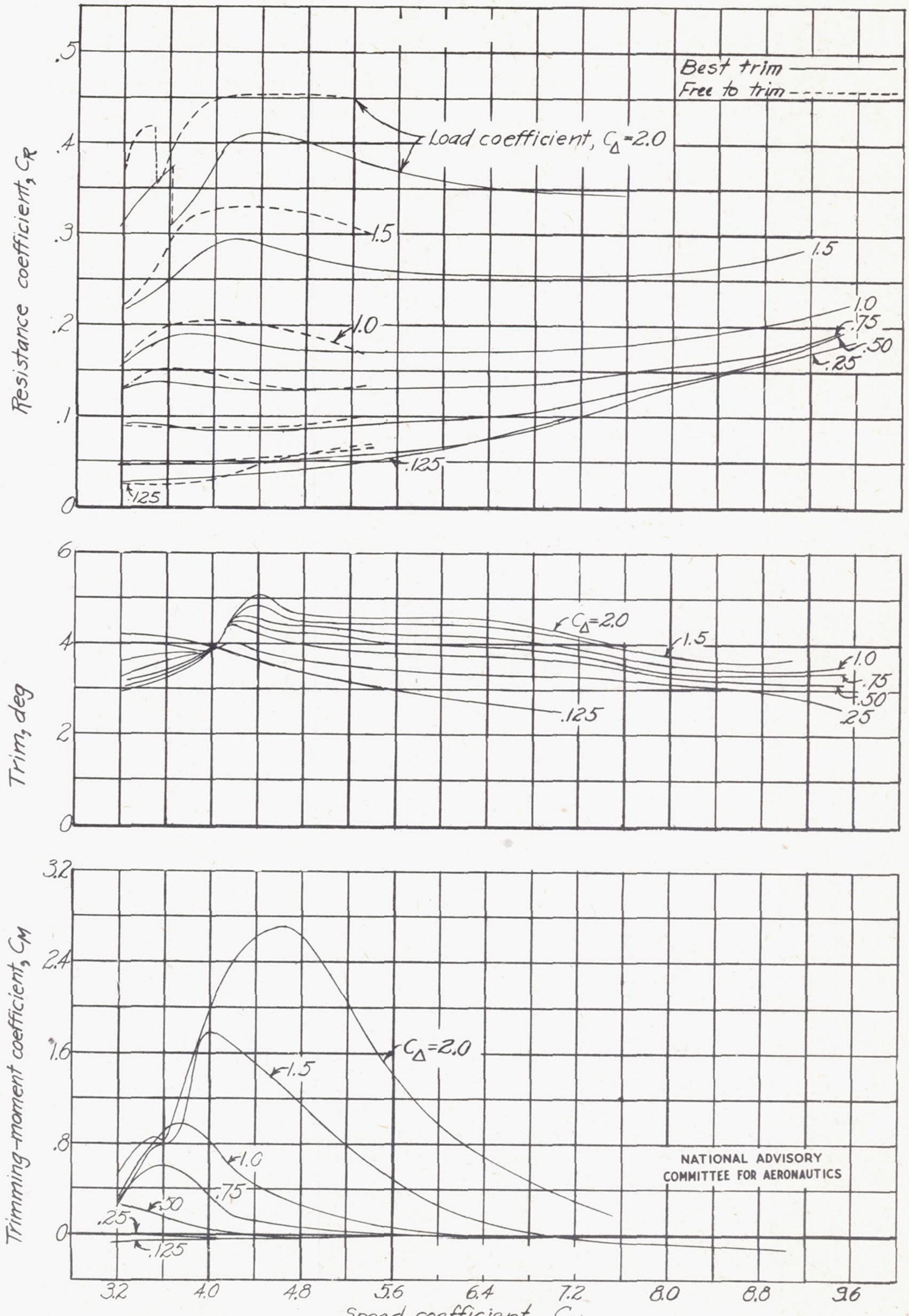


Figure 9.-Model 185. Best-trim characteristics.

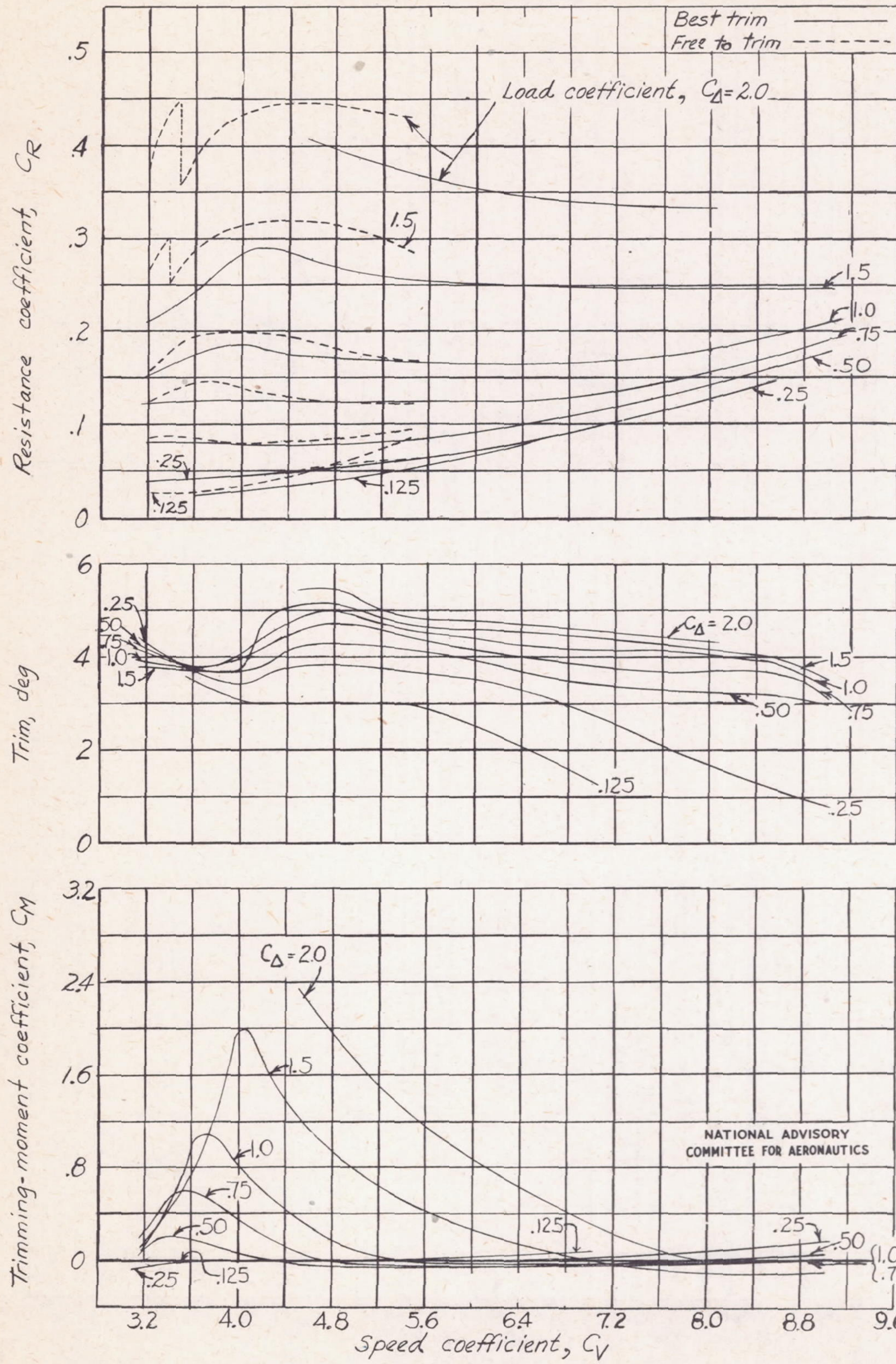


Figure 10.-Model 184. Best-trim characteristics.

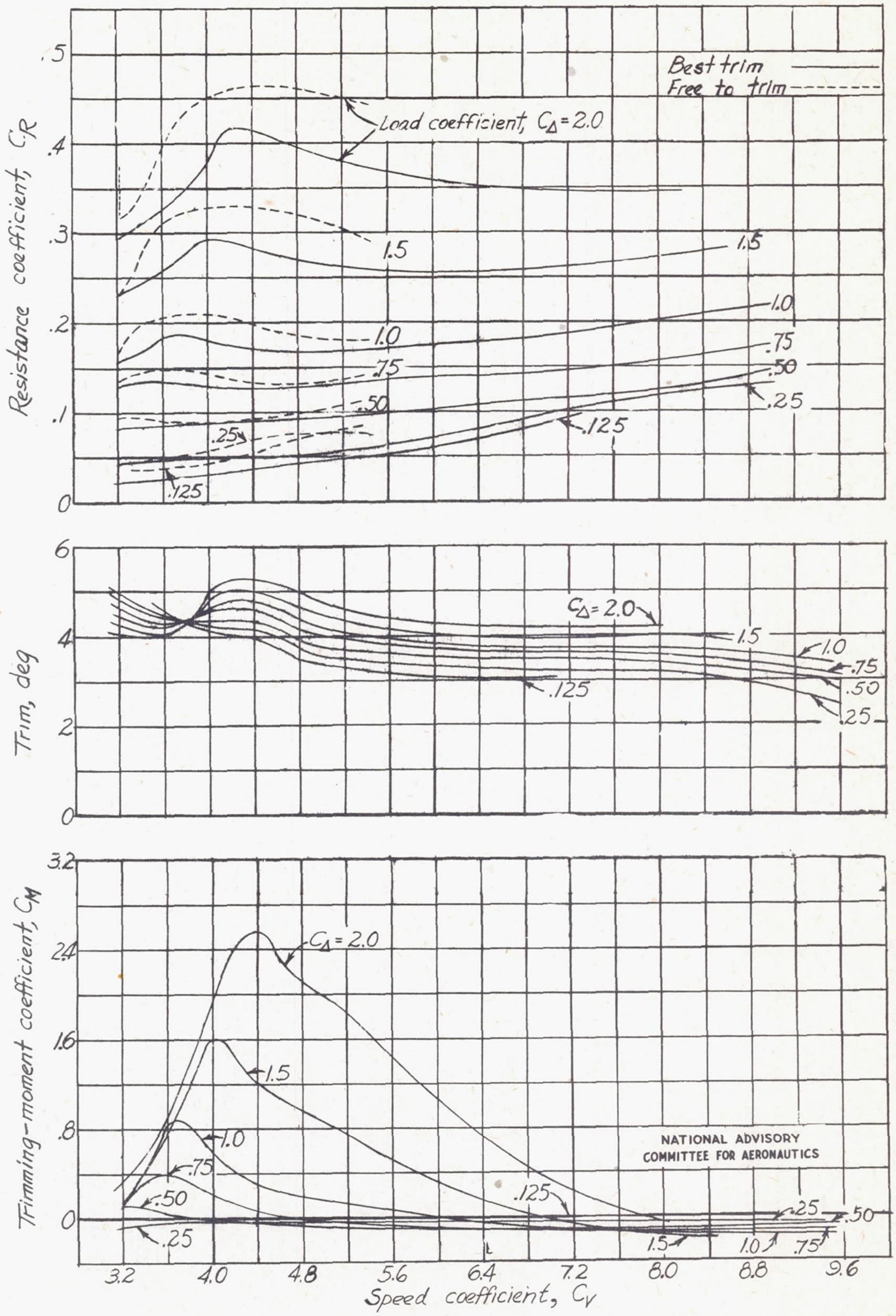
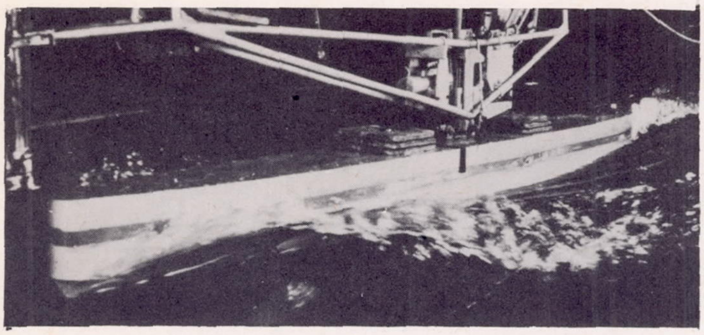
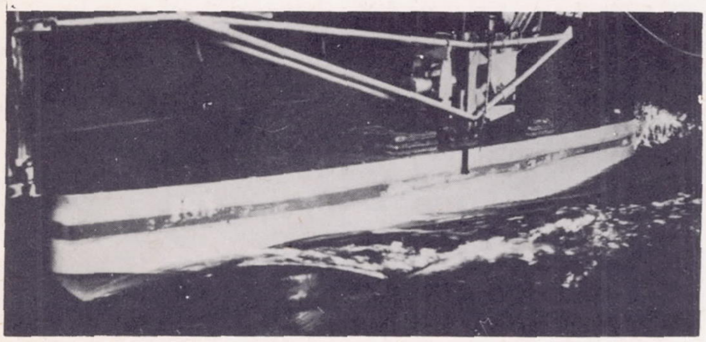


Figure 11.- Model 185-A. Best-trim characteristics.



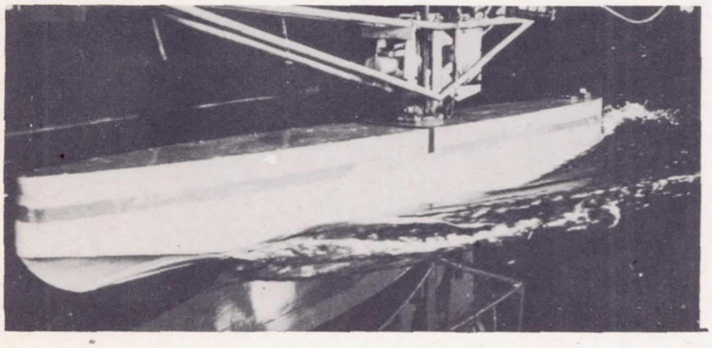
$\tau = 3.1^{\circ}$

$C_{\Delta} = 4.0$



$\tau = 2.6^{\circ}$

$C_{\Delta} = 3.0$

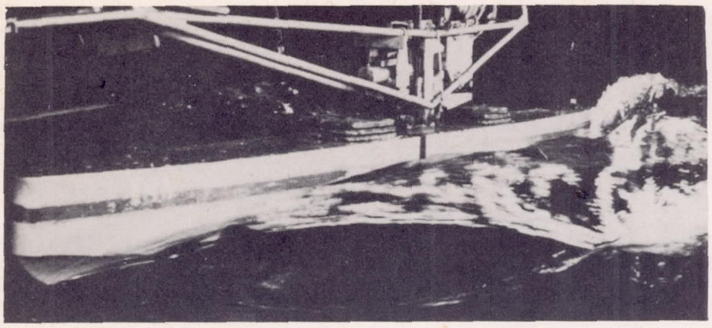


$\tau = 2.4^{\circ}$

$C_{\Delta} = 2.0$

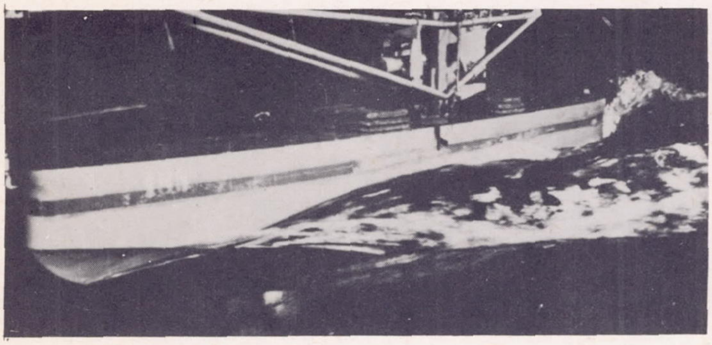
(a) Speed coefficient, $C_V = 1.77$.

Figure 12.- Model 185. Typical spray photographs, free to trim.



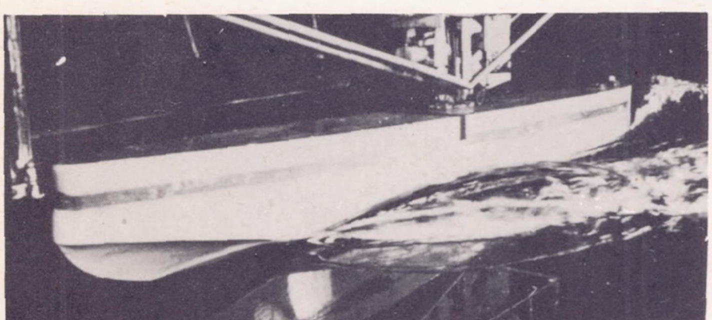
$\tau = 3.9^{\circ}$

$C_{\Delta} = 4.0$



$\tau = 3.4^{\circ}$

$C_{\Delta} = 3.0$

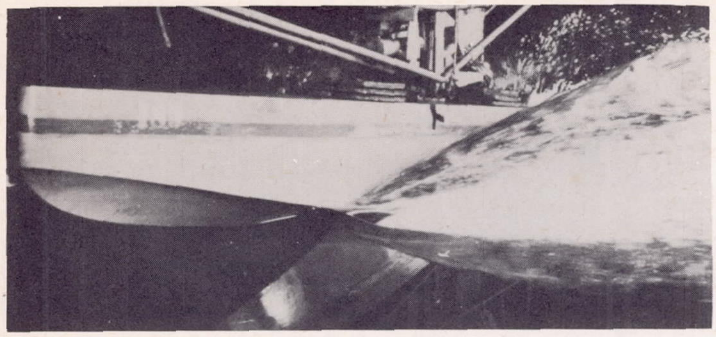


$\tau = 3.0^{\circ}$

$C_{\Delta} = 2.0$

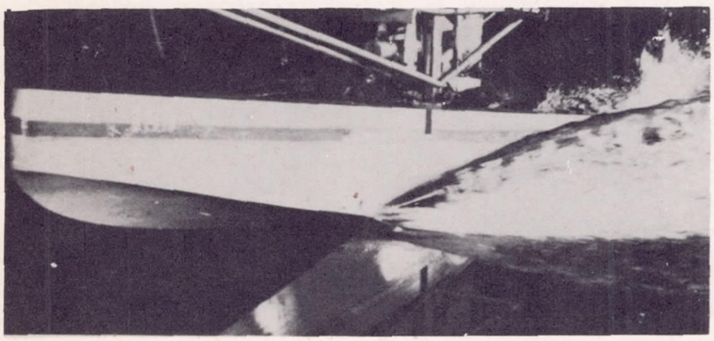
(b) Speed coefficient, C_V = 2.66.

Figure 12.- Continued.



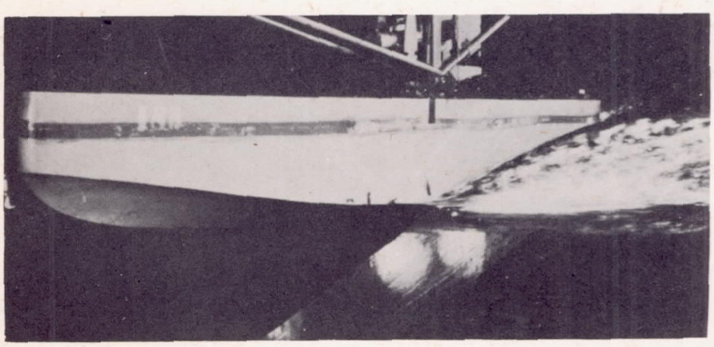
$\tau = 8.1^{\circ}$

$C_{\Delta} = 3.0$



$\tau = 6.7^{\circ}$

$C_{\Delta} = 2.0$



$\tau = 6.0^{\circ}$

$C_{\Delta} = 1.0$

(c) Speed coefficient, $C_V = 3.54$.

Figure 12.- Concluded.

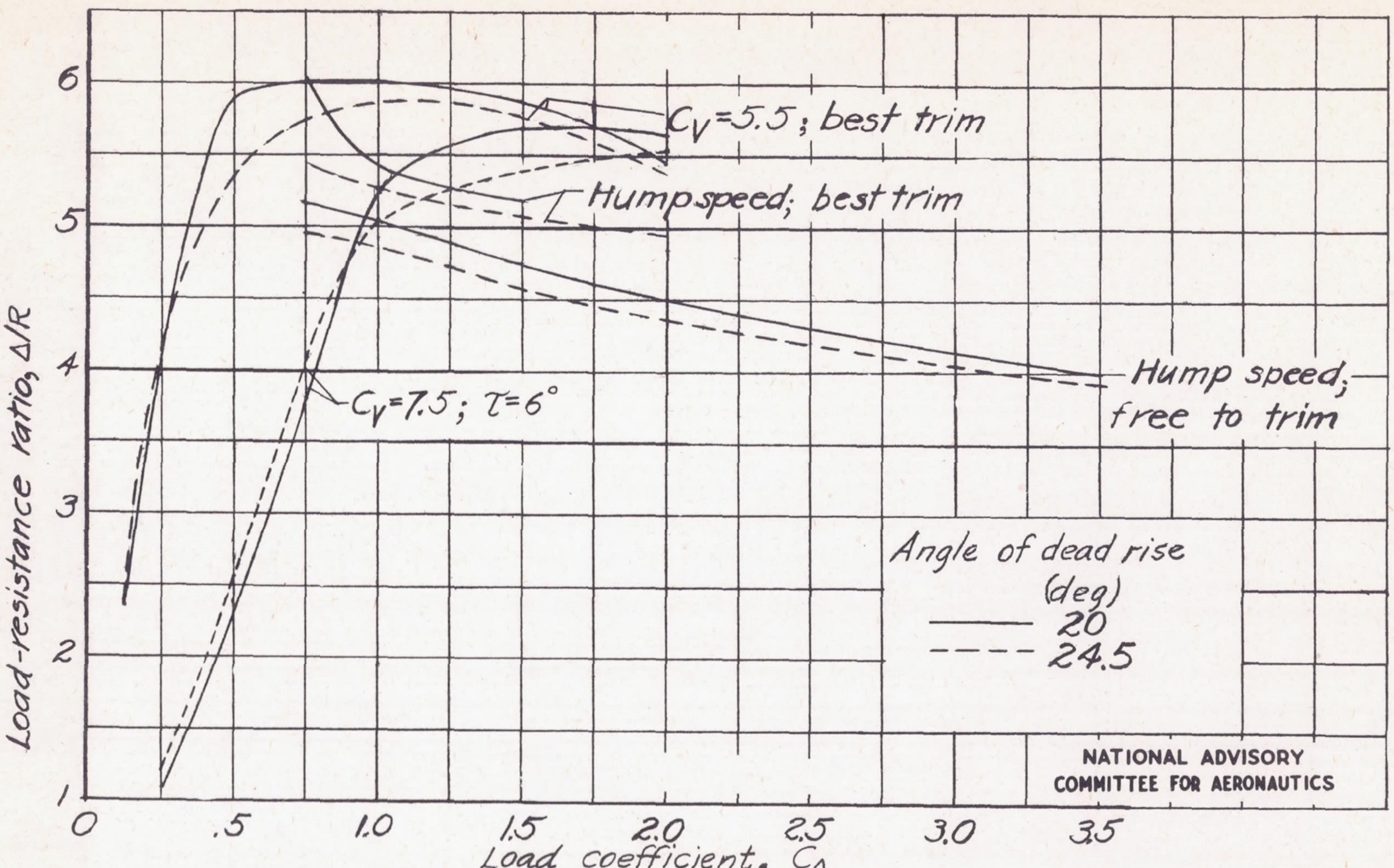


Figure 13.- Variation of load-resistance ratio with load for two angles of dead rise.

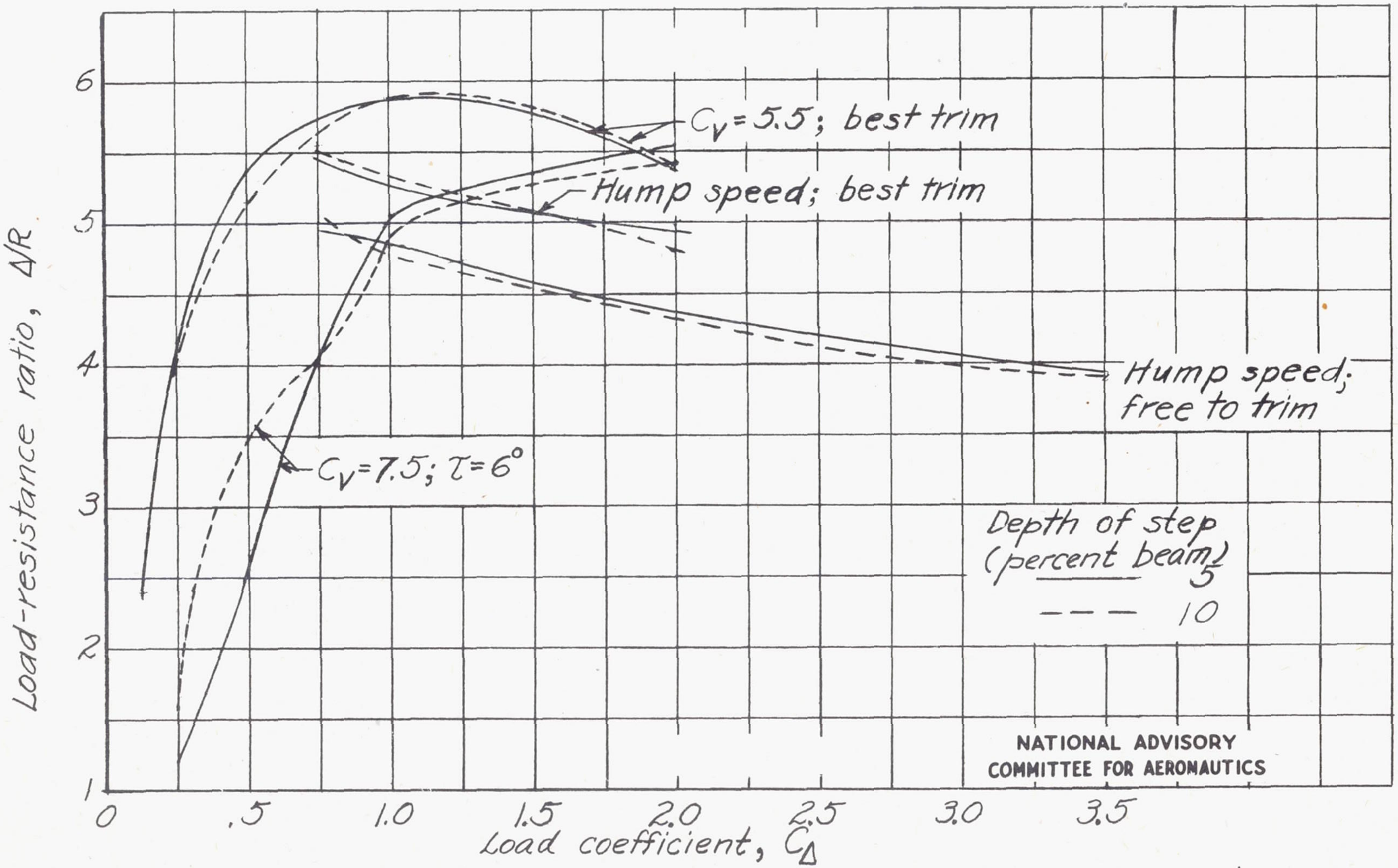


Figure 14.- Variation of load-resistance ratio with load for two depths of step.