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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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EFFECT OF INCREASE IN AFTERBODY LENGTH ON THE HYDRODYNAMIC QUALITIES OF A FLYING-BOAT HULL OF HIGH LENGTH-BEAM RATIO

By Walter J. Kapryan and Eugene P. Clement

Langley Aeronautical Laboratory
Langley Air Force Base, Va.

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SUMMARY

An investigation has been made to determine the effects of increased afterbody length on the hydrodynamic qualities of a model of a flying boat with a hull having a basic length-beam ratio of 15. The basic afterbody length was increased from 6.37 to 9.24 beams so that the sternpost of the extended afterbody almost coincided with the tip of the tail extension. The flying boat was assumed to have a design gross weight of 75,000 pounds, a gross-load coefficient of 5.88, a wing loading of 41.1 pounds per square foot, and a power loading for take-off of 11.5 pounds per brake horsepower.

The stable range of trim between the upper and lower trim limits of stability was greater for the extended afterbody at low and intermediate speeds, because of the lower hump of the lower trim limit and the virtual elimination of the upper limit at these speeds, and was slightly less for the extended afterbody at high speeds. For take-off at constant elevator deflection, the range of center-of-gravity position for satisfactory stability was increased by the model with the extended afterbody. The landing stability of the extended-afterbody configuration in smooth water was satisfactory. The spray entering the propellers was heavier for the extended afterbody but the spray striking the flaps was lighter. The heavy spray striking the horizontal tail surfaces of the basic afterbody was almost completely eliminated with the extended afterbody. The maximum trim oscillations encountered by the hull with the extended afterbody, during landings in waves 4 feet high, were of several degrees lower amplitude than those with the basic afterbody. The maximum vertical and angular accelerations of 5.6g and 8.6 radians per second per second were approximately 35 percent and 30 percent lower, respectively, than those for the basic hull. The maximum rise above the water during these rough-water landings was considerably lowered by the extended afterbody.

INTRODUCTION

The results of wind-tunnel investigations of a series of related hulls of varying length-beam ratio (reference 1) showed that the minimum aerodynamic drag, with wing interference included, of a hull with the high length-beam ratio of 15 was 29 percent less than that of a hull with the more conventional length-beam ratio of 6. Furthermore, results of tank tests have shown that appreciable reductions in vertical accelerations during landings in waves were obtained by increasing the length-beam ratio from 6 to 15 (reference 2).

An increase in afterbody length would be expected to reduce the amplitude of the trim oscillation experienced during landings in waves and thereby reduce both the vertical motions and resulting accelerations. In an effort to obtain further improvement in the rough-water behavior of the hull with a high length-beam ratio, the investigation described in references 2 and 3 was therefore extended to include tests of a long afterbody on the hull having a basic length-beam ratio of 15.

The model was assumed to be a $\frac{1}{10}$-size powered dynamic model of a twin-engine propeller-driven flying boat having a gross weight of 75,000 pounds (gross-load coefficient, $C_{\Delta_o} = 5.88$), a wing loading of 41.1 pounds per square foot, and power loading for take-off of 11.5 pounds per brake horsepower. The characteristics determined were the trim limits of stability, the range of position of the center of gravity for take-off, the landing stability, the spray characteristics, the excess thrust for take-off, and the impact accelerations and behavior during landings in waves 4 feet high (full size). The qualities of the seaplane having an extended afterbody are compared with the same qualities of the seaplane having the basic afterbody as presented in references 2 and 3.

SYMBOLS

C_{Δ_o}	gross-load coefficient (Δ_o/wb^3)
Δ_o	gross load, pounds
b	maximum beam of hull, feet
g	acceleration due to gravity (32.2), feet per second per second
n_v	vertical acceleration, g units

α angular acceleration, radians per second per second

w specific weight of water (63.4 for these tests), pounds per cubic foot

V carriage speed (approx. 95 percent of airspeed), feet per second

V_v sinking speed, feet per second

γ flight-path angle, degrees

δ_e elevator deflection, degrees

τ trim (angle between forebody keel at step and horizontal), degrees

τ_L landing trim, degrees

MODEL

With the exception of the afterbody bottom, the model was the same as that having a basic length-beam ratio of 15 (Langley tank model 224) described in reference 3. The extended afterbody, which had a length of 9.24 beams as compared with 6.37 beams for the basic afterbody, was derived by a 45-percent increase in station spacing of the basic afterbody; however, the angle of afterbody keel was the same. With the increased afterbody length, the sternpost almost coincided with the tip of the tail extension.

An increase in afterbody length generally requires an increase in depth of step for a constant sternpost angle for similar landing stability. The depth of step was therefore increased from 16.5 to 24 percent of the beam, and the sternpost angle was 6.9° for the two afterbodies. This procedure appeared to be in agreement with the reasoning applied in the analysis of landing stability presented in reference 4 for hulls of low and intermediate length-beam ratios. The difference in depth of step used and the minimum that would be required for satisfactory landing characteristics is believed to be small, and this difference, therefore, would not have an appreciable effect on the hydrodynamic characteristics. The general arrangement of the flying boat with the extended afterbody (Langley tank model 224I) is shown in figure 1.

APPARATUS AND PROCEDURES

The apparatus and procedures were the same as used in reference 3 so that the results with the extended and basic afterbodies were directly comparable.

Langley tank no. 1 is described in reference 5. The setup of the model and towing gear is shown in figure 2. The model was free to trim about a pivot which coincided with its center of gravity. A roller cage and rectangular towing staff provided freedom in rise but restrained the model in roll and yaw. Limited fore-and-aft movement (approx. 2 ft) of the model was provided by mounting this roller cage on horizontal tracks. With the thrust adjusted so that the resultant horizontal force was zero, the model was actually landed in a self-propelled condition free of the fore-and-aft stops. Contact of the model with the water was electrically recorded through the use of contacts built into the planing bottom at the sternpost, step, and bow.

The hydrodynamic qualities were determined at a design gross load corresponding to 75,000 pounds, except for the spray investigation in which the gross loads corresponded to loads from 60,000 to 80,000 pounds. With the exception of the landing tests, which were made at half thrust, the hydrodynamic qualities were determined with full thrust. The flaps were deflected 20° for all the tests. The results have been converted to full-size units and all the data, with the exception of table I, are presented as full-size values. Data in table I were obtained from the landing records of the model and are included for detailed study and for comparison with similar data in reference 2.

Procedures for determining the trim limits of stability, center-of-gravity limits of stability, landing stability, spray characteristics, and excess thrust are described in references 3 and 6. The trim limits were determined at forward and after positions of the center of gravity and are therefore completely defined for take-off at the design gross load. The center-of-gravity limits of stability were determined at an acceleration of 1 foot per second per second.

The landings, both in smooth water and in waves, were made at a deceleration of 2 feet per second per second and with the center of gravity at 32 percent mean aerodynamic chord. For all landings the model was held in trim by the electrically actuated trim brake during the initial landing approach, and the elevators were set to give the proper trimming moments upon contact with the water. This procedure was used to overcome the tendency of the trim to change caused by ground effect on the aerodynamic moments during the approach to the water surface. The rough-water landings were made in oncoming waves 4 feet high (full size) of lengths from 130 to 360 feet (full size), and at an initial trim of approximately 8°. Flight-path angle, horizontal velocity, sinking speed, vertical and angular accelerations, and trim were determined for the instant of first impact and for the subsequent impacts which produced the maximum vertical and angular accelerations.

The spray investigation was conducted with the center of gravity at 32 percent mean aerodynamic chord. The spray diagrams and pictures were made during constant-speed runs. Spray photographs were taken with the models free to trim with constant elevator deflection of -10°.

RESULTS AND DISCUSSION

Longitudinal Stability

Trim limits of stability.- The trim limits of stability for the model with the extended afterbody are compared with those for the model with the basic afterbody in figure 3. The increase in afterbody length decreased the low-speed peak of the lower trim limit and lowered both branches of the upper limit at high speeds. The available aerodynamic moment was not great enough to trim the model to the upper trim limit at speeds below 65 miles per hour. For practical operation, the upper trim limit may therefore be considered as not existing below this speed. Above 65 miles per hour the range of stable trim was slightly less for the hull with the extended afterbody.

Center-of-gravity limits of stability.- Trim tracks for typical take-offs for the hull with the extended afterbody are presented in figure 4(a) for several positions of the center of gravity and elevator deflections. Comparable trim tracks for the hull with the basic afterbody are presented in figure 4(b). From these and similar data, the maximum amplitudes of porpoising that occurred during take-off were determined and are plotted against center-of-gravity position in figure 5. The maximum amplitude is defined as the difference between the maximum and minimum trims during the greatest porpoising cycle that occurred during the take-off.

The maximum amplitudes for the long afterbody are compared in figure 6 with those for the basic afterbody. With the extended afterbody, the rate of increase in amplitude of lower-limit porpoising with forward movement of the center of gravity was less than that with the basic afterbody. At after positions of the center of gravity the amplitude of upper-limit porpoising for the extended afterbody did not exceed 1°. This small amplitude was attributed to the effectiveness of the extended afterbody in damping the oscillation in trim. The greatest amplitude of upper-limit porpoising for the basic afterbody was about 2.5°.

For a given elevator deflection, the practical center-of-gravity limit is usually defined as that position of the center of gravity at which the amplitude of porpoising becomes 2°. A plot of elevator deflection against center-of-gravity position at which the maximum amplitude of porpoising was 2° is presented in figure 7. The forward center-of-gravity limit for the extended afterbody was only slightly forward of that for the basic afterbody; therefore, an increase in afterbody length did not appreciably change the step position required for stability during take-off at forward positions of the center of gravity. Since the maximum amplitude of upper-limit porpoising for the extended afterbody was 1°, no after limit existed within the range of center-of-gravity position tested. The hull with the extended afterbody was therefore slightly more stable during take-off at after positions of the center of gravity than the hull with the basic afterbody.

Landing stability.- Several typical time histories of trim, speed, and rise during landings in smooth water of the models with the extended and basic afterbodies are presented in figure 8. The time histories were used to determine the maximum and minimum values of the trim and rise of the flying boat at the greatest cycles of oscillation during the landing run as shown in figure 9.

The depth of step used with each of the afterbodies was adequate to prevent skipping. The hull with the extended afterbody encountered some lower-limit porpoising during almost all the landings. The extended afterbody had slightly greater trim and rise amplitudes for landing trims up to about 10°. At landing trims above 10°, however, the longer afterbody was effective in damping the trim oscillations and both the trim and rise amplitudes were less for the extended afterbody than for the basic afterbody.

Spray Characteristics

The range of speed over which spray entered the propellers and struck the flaps is plotted against gross load in figure 10. The speed ranges over which spray entered the propellers were almost the same for both afterbodies. Observations indicated, however, that the volume of heavy blister spray striking the propellers was greater for the extended afterbody. These observations are substantiated by the photographs of figure 11 which show that the propeller spray was heavier for the model with the extended afterbody. The heavier spray was attributed to the fact that the trim of the hull with the extended afterbody was almost 2° lower than the trim of the hull with the basic afterbody for this region of the take-off run.

Lengthening the afterbody greatly reduced the amount of spray striking the flaps. No blister spray struck the flaps at the design gross load, as indicated in figure 10. Loose spray on the flaps was comparable for both afterbodies, as shown in the photographs of figure 12.

During take-off (full thrust) the horizontal tail surfaces were relatively clear of spray. During landings (one-half take-off thrust), the heavy spray from the forebody striking the tail of the hull with the basic afterbody was almost completely eliminated with the extended afterbody, as can be seen in the photographs of figure 13.

Excess Thrust for Take-Off

Brief tests with the extended afterbody indicated no appreciable changes in excess thrust available for take-off when compared with the excess thrust obtained with the basic afterbody. These tests therefore indicated that the increase in afterbody length caused no significant change in take-off time and distance.

Landings in Waves

The results of the landings in waves are presented as model-size values in table I, which contains all the pertinent information regarding the initial impact and the subsequent impacts producing the maximum vertical and angular accelerations. During each of the rough-water landings the model bounced clear of the water after the initial contact, and a series of impacts of varying magnitude then took place with the maximum vertical and angular accelerations occurring during these subsequent impacts.

The maximum vertical and angular accelerations are plotted against wave length in figure 14. The maximum vertical acceleration of 5.6g for the hull with the extended afterbody during landings in waves 4 feet high was about 35 percent less than the maximum vertical acceleration for the hull with the basic afterbody. The maximum angular acceleration of 8.6 radians per second per second encountered by the hull with the extended afterbody was 30 percent less than the maximum angular acceleration encountered by the hull with the basic afterbody. The peak of the maximum impact accelerations occurred in waves approximately 190 feet long for both afterbodies. For waves shorter or longer than 190 feet the vertical and angular accelerations were decreased. The maximum negative angular acceleration encountered during these landings was approximately 4 radians per second per second. These accelerations are also plotted in figure 14.

The maximum and minimum values of the trim and rise of the flying boat at the greatest cycle of oscillation during each landing in waves are plotted against wave length in figure 15. The maximum and minimum trims attained were 14° and 0°, respectively, for the hull with the extended afterbody, compared with the maximum and minimum trims of 20° and 2°, respectively, for the hull with the basic afterbody. At no trims did the bow of the hull with either afterbody tend to dig in. The maximum rise was approximately 10 feet compared with a maximum rise of approximately 19 feet for the hull with the basic afterbody. The minimum rise of the hulls with the extended and basic afterbodies was approximately the same. The maximum trim oscillations and rise cycles therefore were reduced by extending the afterbody of the hull having a high length-beam ratio.

Summary Chart

The hydrodynamic qualities in smooth water of a flying boat with a hull of high length-beam ratio and having an extended afterbody, as determined by the powered dynamic model tests, are summarized in figure 16. This chart gives an over-all picture of the hydrodynamic characteristics in terms of full-scale operational parameters and is therefore useful for comparisons with similar data regarding other seaplanes for which operating experience is available.

CONCLUSIONS

The effects of an increase in the length of the afterbody (from 6.37 to 9.24 beams) on the hydrodynamic qualities of a flying boat with basic length-beam ratio of 15 are as follows:

1. The stable range of trim between the upper and lower trim limits of stability was greater for the extended afterbody at low and intermediate speeds, because of the lower hump of the lower trim limit and the virtual elimination of the upper limit at these speeds, and was slightly less for the extended afterbody at high speeds.

2. The center-of-gravity limits of stability were improved by the extended afterbody. This improvement was attributed chiefly to the effectiveness of the increased bow-down moments of the extended afterbody in limiting the maximum amplitude of upper-limit porpoising during take-off to 1°.

3. The landing stability in smooth water was satisfactory for the extended afterbody. At contact trims below 10° the trim and rise amplitudes for the extended afterbody were greater than for the basic afterbody; however, at contact trims above 10° the trim and rise amplitudes were lower.

4. The spray striking the propellers was heavier with the extended afterbody but the spray striking the flaps was lighter. The heavy spray

striking the horizontal tail of the hull with the basic afterbody was almost completely eliminated with the extended afterbody.

5. The maximum vertical and angular accelerations, encountered during rough-water landings, were reduced approximately 35 percent and 30 percent, respectively, to 5.6g and 8.6 radians per second per second by use of the extended afterbody.

6. During landings in waves the maximum trims attained during the high-speed portion of the runout were several degrees lower than those of the basic afterbody. The minimum trims were also slightly lower, but there was no tendency for the bow to dig in. The maximum rise above the water was considerably less for the hull with the extended afterbody.

Langley Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Air Force Base, Va., January 24, 1949

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TABLE I

DATA OBTAINED DURING LANDINGS IN WAVES OF LANGLEY TANK MODEL 224I

[All values are model size;
wave height = 0.4 foot for all landings]

Landing	Wave length (ft)	Initial impact τ_L (deg)	V_v (fps)	V (fps)	γ (deg)	n_v (g)	α $\left(\frac{\text{radians}}{\text{sec}^2}\right)$	Maximum acceleration Impact	τ (deg)	V_v (fps)	V (fps)	γ (deg)	n_v (g)	α $\left(\frac{\text{radians}}{\text{sec}^2}\right)$
1	13.0	7.6	0.99	38.2	1.5	2.3	18	5	5.0	1.79	31.5	3.2	4.0	44
								(a)	3.6	1.39	23.8	3.3	3.3	73
2	13.2	7.7	1.31	38.3	2.0	2.0	11	3	5.6	1.16	33.2	2.0	4.0	40
								(a)	4.4	1.96	24.5	4.6	2.7	52
3	13.4	7.7	.89	38.0	1.3	1.5	5	4	5.4	1.24	25.0	2.8	3.2	66
4	14.2	7.7	.95	37.9	1.4	0	-10	4	5.2	1.77	31.4	3.2	4.4	63
								(a)	4.4	1.65	25.2	3.7	4.0	67
5	15.6	8.2	.79	38.5	1.2	1.2	8	4	4.6	1.90	33.3	3.3	3.8	47
								(a)	3.9	1.31	25.0	3.0	2.5	61
6	15.6	8.2	1.15	38.0	1.7	.9	-18	3	5.0	2.78	34.0	4.7	3.8	52
								[b]5	3.0	1.63	23.7	3.9	2.7	67
7	15.9	8.3	1.06	37.4	1.6	1.8	12	4	4.1	2.21	31.8	4.0	3.8	55
								[b]7	4.4	1.74	25.0	4.0	3.4	65
8	16.2	8.2	.74	36.7	1.2	1.2	16	4	6.4	1.70	26.0	3.7	3.0	44
9	16.4	8.2	.96	37.6	1.5	.8	5	4	4.4	2.26	32.0	4.2	4.6	66
10	16.9	7.7	.94	36.5	1.5	.9	2	3	5.6	1.90	32.7	3.3	2.0	30
11	17.0	8.2	1.06	37.2	1.6	1.0	8	4	5.0	2.60	30.8	4.8	5.0	70
12	17.0	7.8	.88	37.0	1.4	1.9	13	3	3.8	2.04	33.1	3.5	4.1	54
								[b]4	4.0	2.20	25.8	4.9	3.3	61
13	17.0	7.7	.94	37.5	1.4	0	0	2	3.9	1.84	35.1	3.0	3.8	59
								[b]7	4.0	2.09	24.9	4.8	3.2	68
14	17.1	8.0	1.08	37.0	1.7	2.2	30	3	3.9	3.02	32.5	5.3	4.1	81
15	17.2	7.8	1.13	36.3	1.8	1.0	0	2	4.2	2.55	33.9	4.3	4.0	65
16	17.2	8.1	.78	37.2	1.2	.5	0	5	4.7	2.95	25.0	6.7	3.2	68
17	17.5	7.8	1.13	37.1	1.7	2.3	18	4	6.5	2.08	26.0	4.6	3.3	52
18	18.3	8.0	.69	36.2	1.1	.2	-10	4	4.1	2.82	30.5	5.3	5.5	86
19	19.3	7.2	1.20	36.6	1.9	.9	5	4	5.1	2.51	29.6	4.8	4.4	70
20	19.5	7.8	.96	37.0	1.5	3.6	40	6	5.7	2.32	27.2	4.8	5.6	55
21	19.6	7.8	1.26	36.6	2.0	1.0	0	8	3.9	2.28	25.5	5.0	4.1	66
22	19.7	8.1	1.01	36.8	1.6	1.1	8	6	3.5	3.53	29.0	6.9	4.5	82
23	19.7	8.1	.96	37.4	1.5	3.5	32	4	5.5	2.36	30.2	4.5	4.8	70
24	19.9	7.7	.91	36.8	1.4	.8	0	3	8.5	2.37	31.5	4.3	4.8	62
								[b]4	9.5	3.26	29.9	6.2	4.2	71
25	20.2	8.0	.97	37.6	1.5	1.6	12	8	3.6	2.67	25.7	5.9	5.1	77
26	20.3	7.6	.97	38.3	1.4	2.6	28	5	6.7	2.11	29.5	4.1	3.8	49
								[b]7	2.6	2.70	26.6	5.8	3.1	66
27	22.3	8.1	.77	37.9	1.2	.7	-9	4	5.0	3.78	31.2	6.9	4.3	50
28	22.3	8.2	1.02	37.8	1.5	1.3	7	7	1.3	4.22	25.1	9.5	2.1	54
29	22.6	8.0	1.06	37.4	1.6	1.4	11	3	5.2	3.35	31.7	6.0	4.0	57
30	22.9	7.9	.96	37.2	1.5	1.3	18	3	3.2	3.07	32.1	5.5	5.0	65
31	22.9	7.9	1.04	37.0	1.6	.9	-10	7	2.8	1.84	25.2	4.2	2.4	55
32	23.1	8.0	1.24	37.5	1.9	1.1	-13	5	5.6	3.94	31.0	7.2	5.3	69
33	23.2	8.2	1.06	36.8	1.6	.8	-11	4	5.9	3.68	30.0	7.0	4.0	59
34	23.3	8.1	1.04	37.0	1.6	1.3	10	3	10.1	3.37	31.7	6.1	3.2	-11
								[b]5	-.3	3.00	24.5	7.0	2.6	56
35	26.3	7.7	1.00	36.9	1.6	3.4	36	3	5.6	3.88	30.6	7.3	3.4	45
36	26.3	6.6	1.51	37.1	2.3	2.3	22	3	9.4	3.09	32.1	5.5	3.0	-15
								[b]9	-1.0	3.27	24.9	7.5	2.1	57
37	26.3	8.0	1.03	38.1	1.5	1.3	9	6	3.3	3.36	26.4	7.3	3.6	63
38	26.6	7.9	1.09	37.5	1.7	1.1	0	7	2.7	3.51	26.3	7.6	4.3	60
39	27.0	8.2	.96	37.5	1.5	1.3	12	7	.5	3.58	25.5	8.0	2.3	48
40	28.1	7.7	.95	37.9	1.5	1.2	-9	2	3.0	2.24	35.8	3.6	3.0	43
41	30.6	7.9	1.01	36.9	1.6	1.1	0	5	5.7	2.89	29.0	5.7	2.6	31
42	31.6	8.5	1.14	36.6	1.8	.9	-6	4	8.0	2.18	30.5	4.1	2.0	8
								[b]6	4.9	3.52	26.6	7.5	1.4	20
43	31.9	8.0	1.14	36.0	1.8	1.4	5	4	7.4	2.87	29.1	5.6	1.9	10
								[b]2	3.0	2.65	34.0	4.5	1.6	23
44	33.2	7.8	1.22	35.8	2.0	.9	9	3	6.6	2.42	29.5	4.7	2.0	20
45	34.5	8.0	1.51	37.0	2.3	1.6	0	6	6.8	2.93	28.2	5.9	1.9	14
46	35.6	7.5	1.42	35.8	2.3	1.1	8	2	8.3	2.28	32.9	4.0	1.8	14
47	35.9	8.5	1.06	36.5	1.7	1.0	-4	6	7.8	2.51	30.1	4.8	1.5	10

[a]Maximum angular acceleration resulted from model planing on waves rather than directly from an impact.

[b]Impact for maximum angular acceleration.

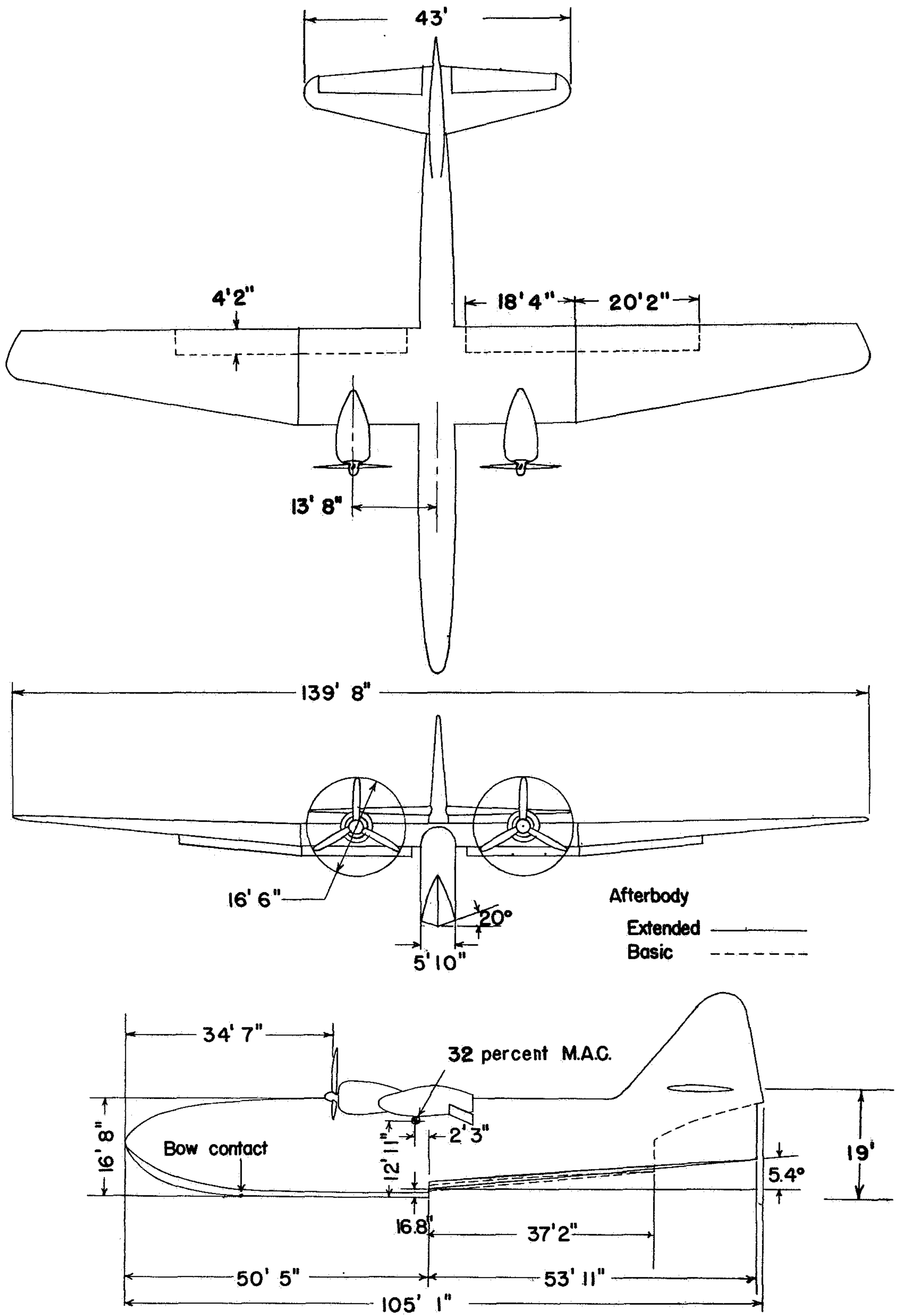
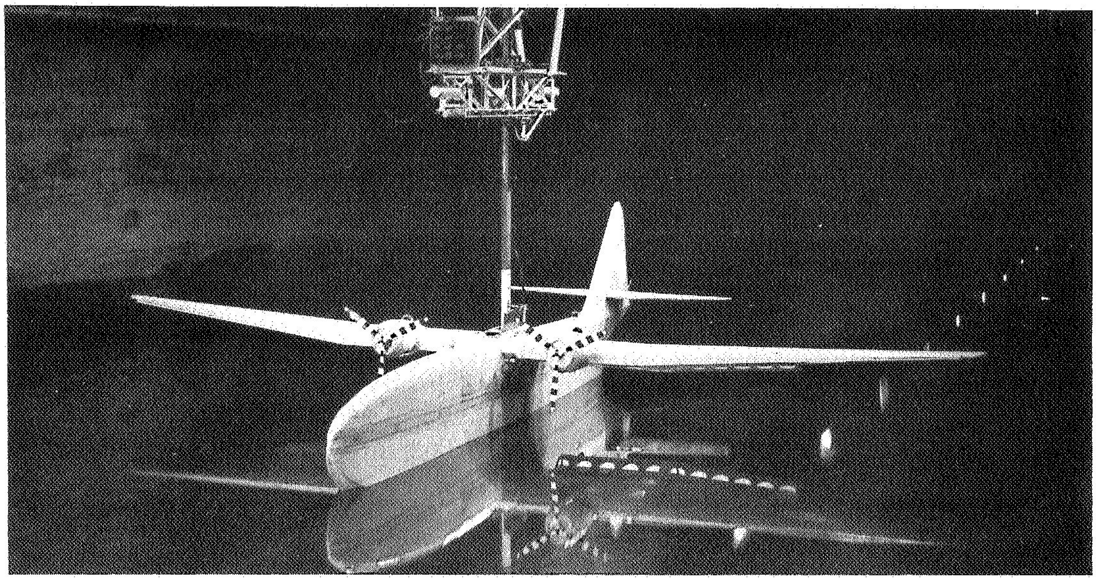
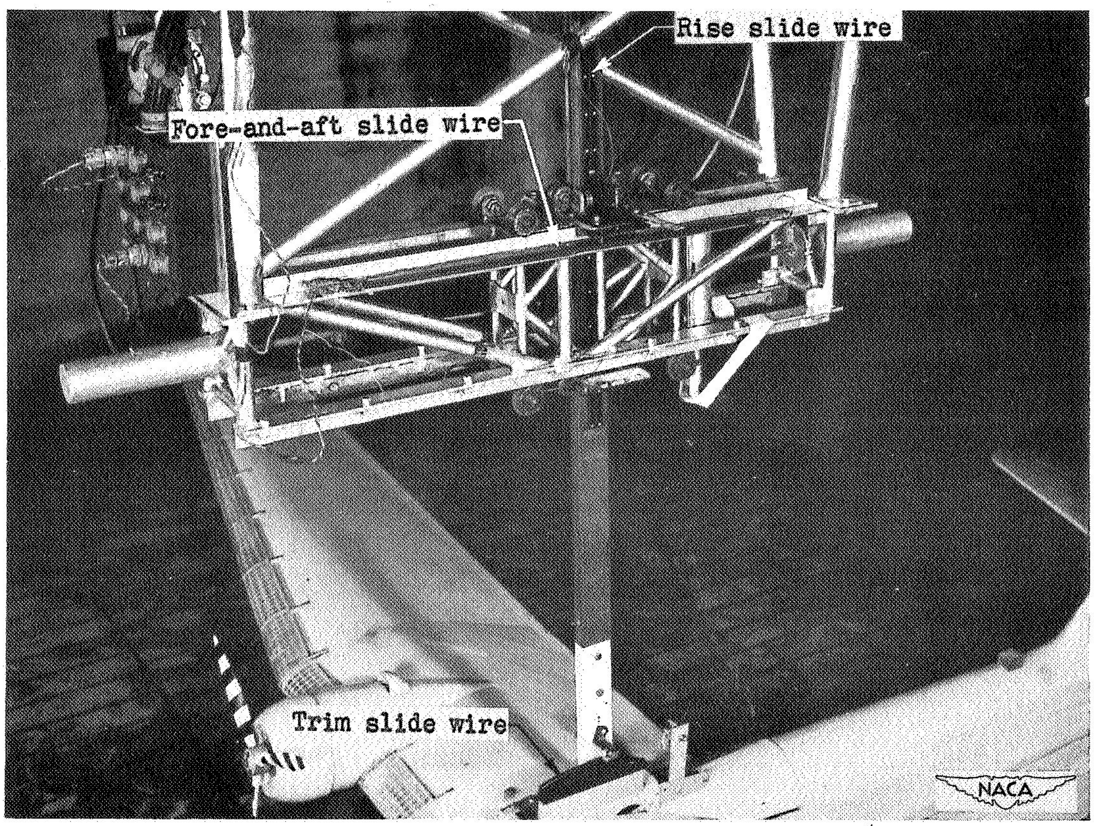


Figure 1.– General arrangement.



(a) Setup of model on towing apparatus.



(b) Details of fore-and-aft gear.

Figure 2.- Model and towing apparatus.

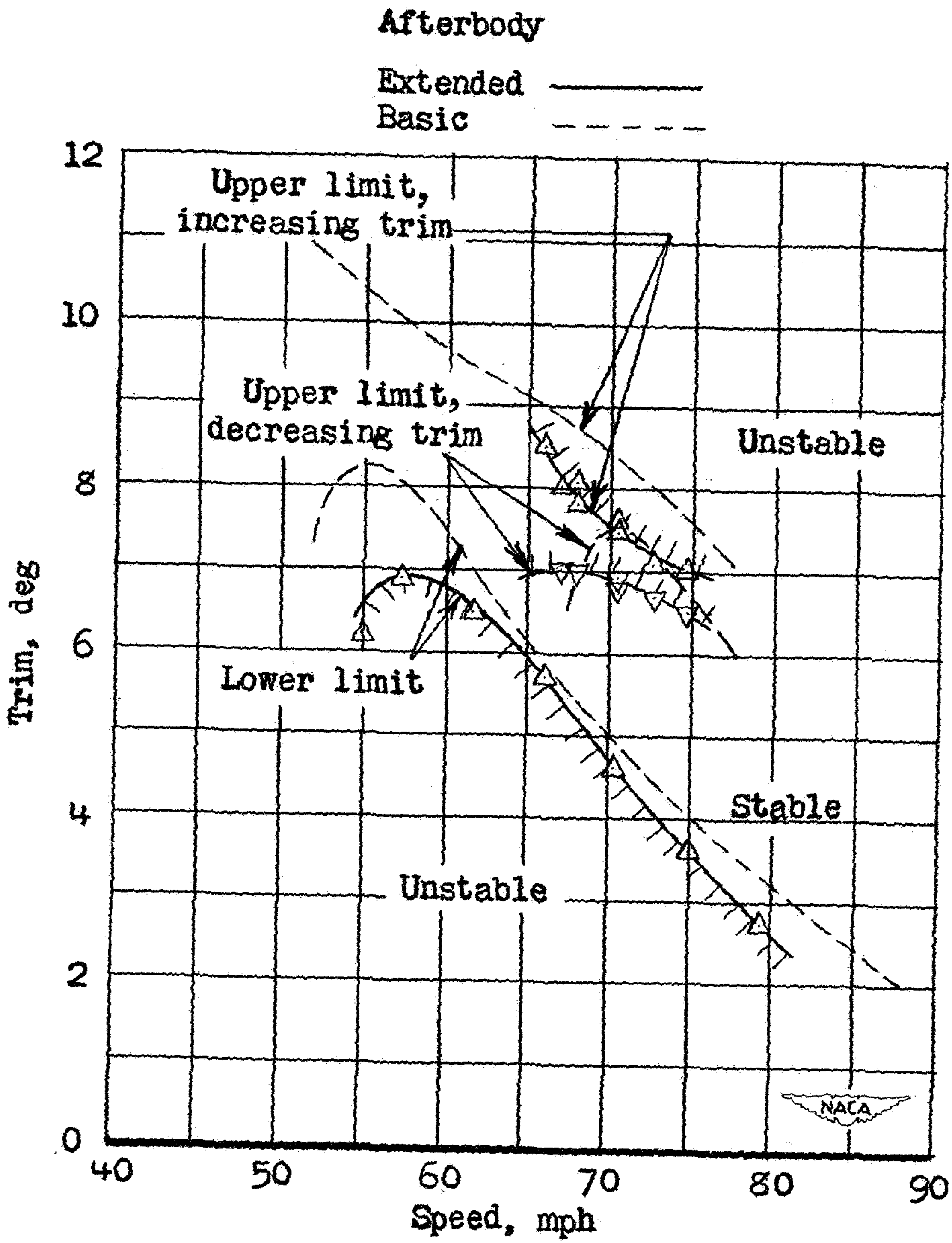
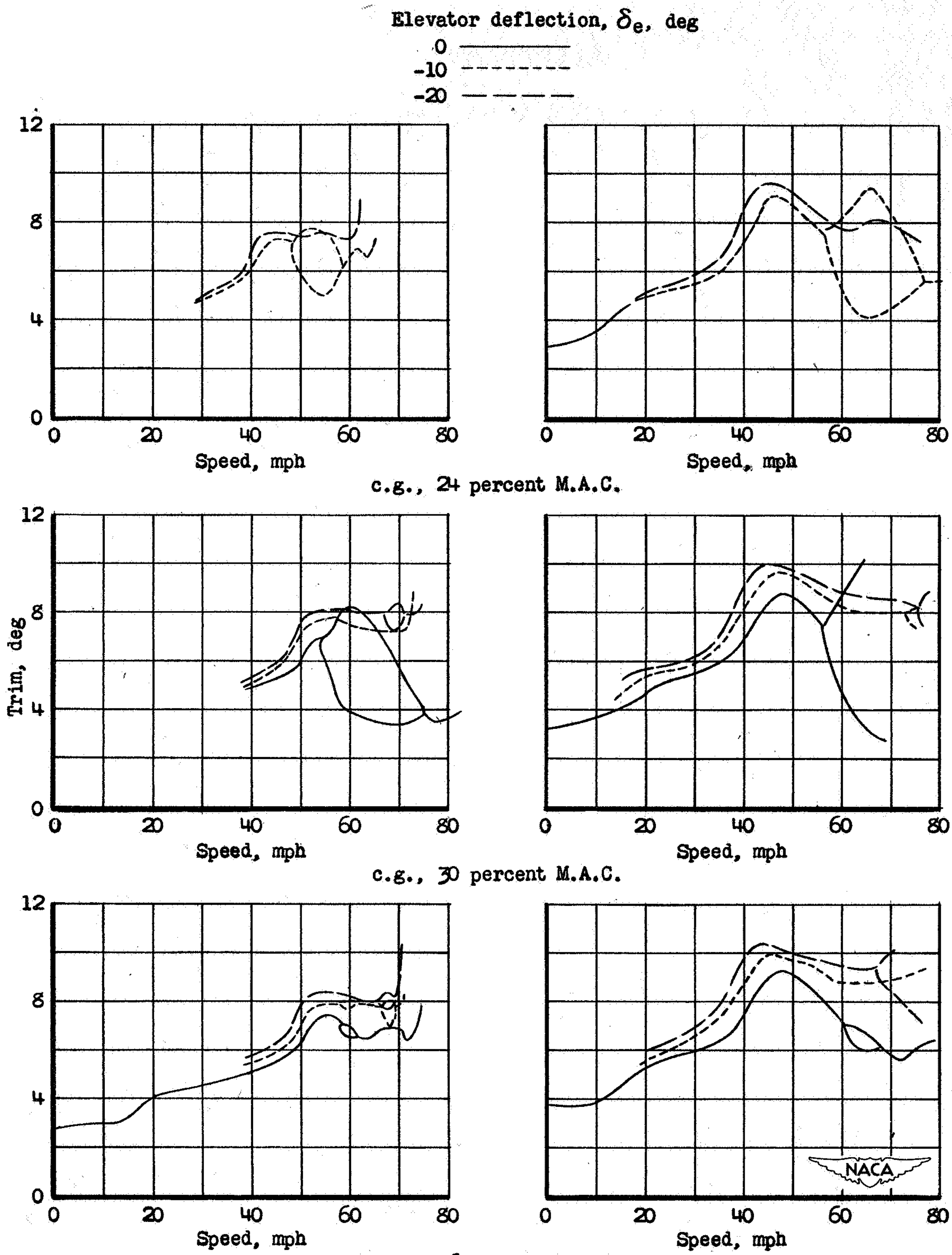
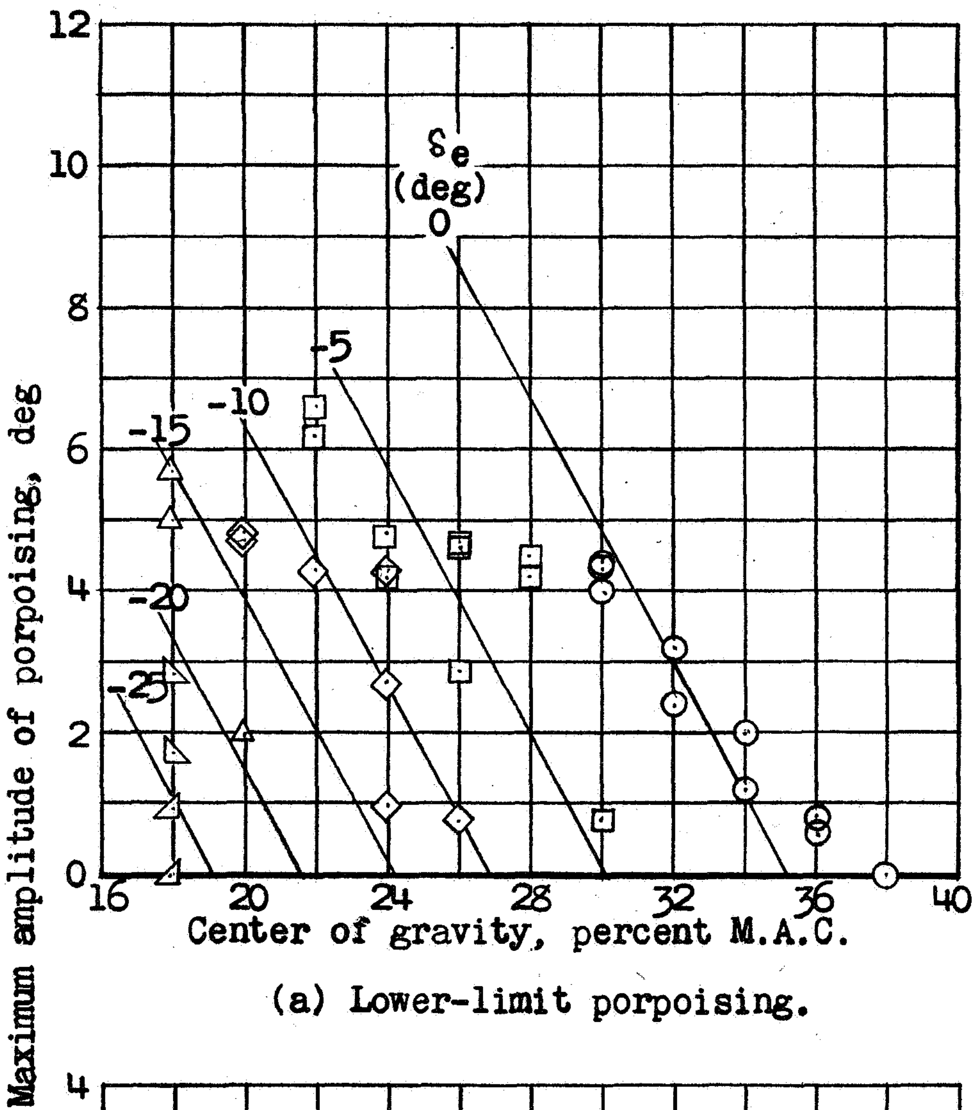


Figure 3.- Trim limits of stability.

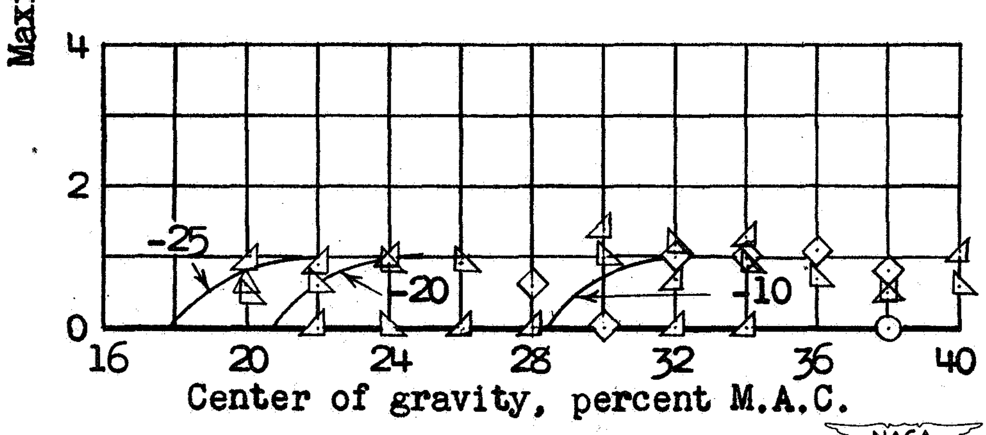


(a) Extended afterbody. (b) Basic afterbody.

Figure 4.- Variation of trim with speed during take-off.



(a) Lower-limit porpoising.



(b) Upper-limit porpoising.

Figure 5.- Maximum amplitude of porpoising at different positions of center of gravity.

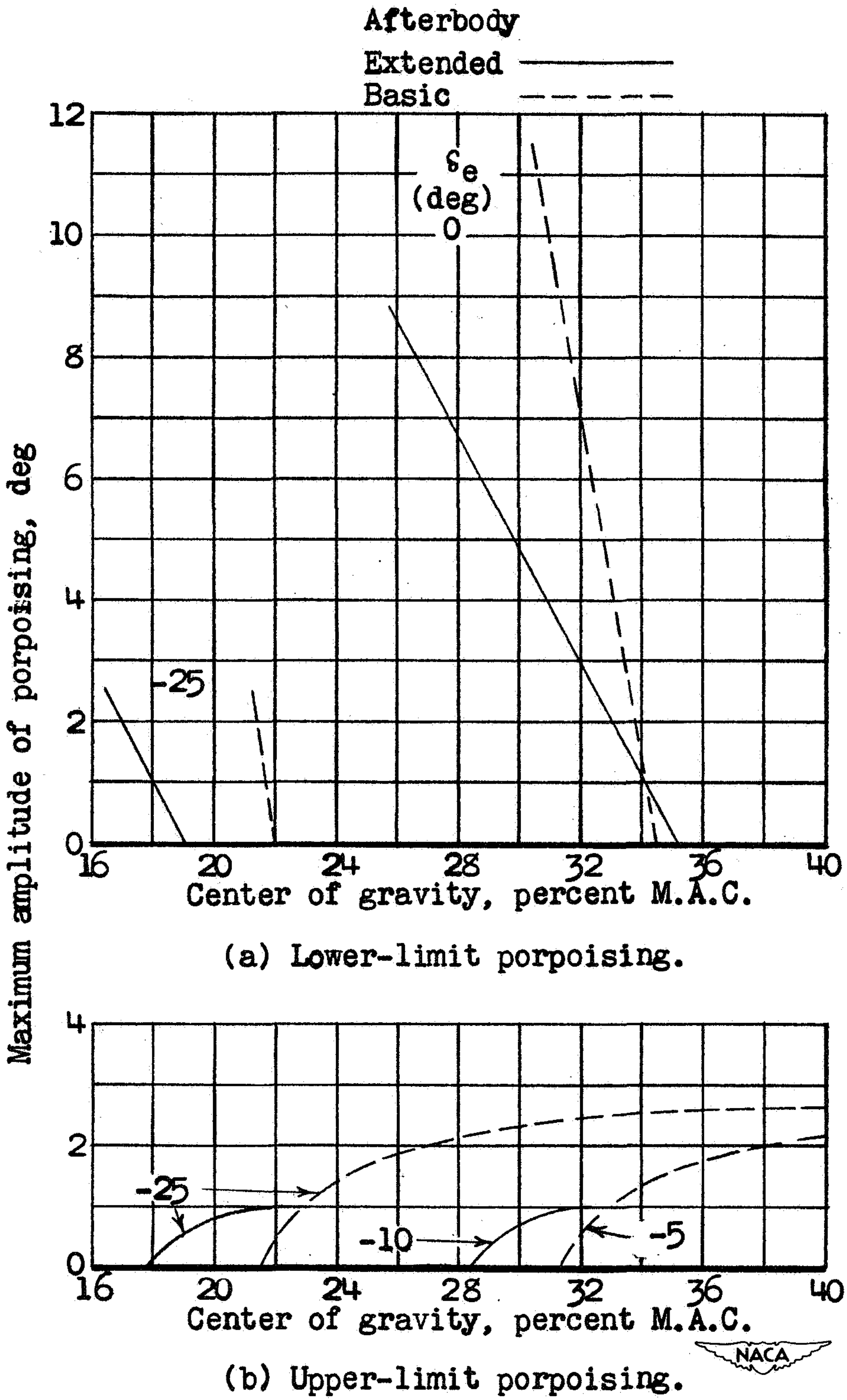


Figure 6.- Comparison of maximum amplitude of porpoising between extended and basic afterbodies.

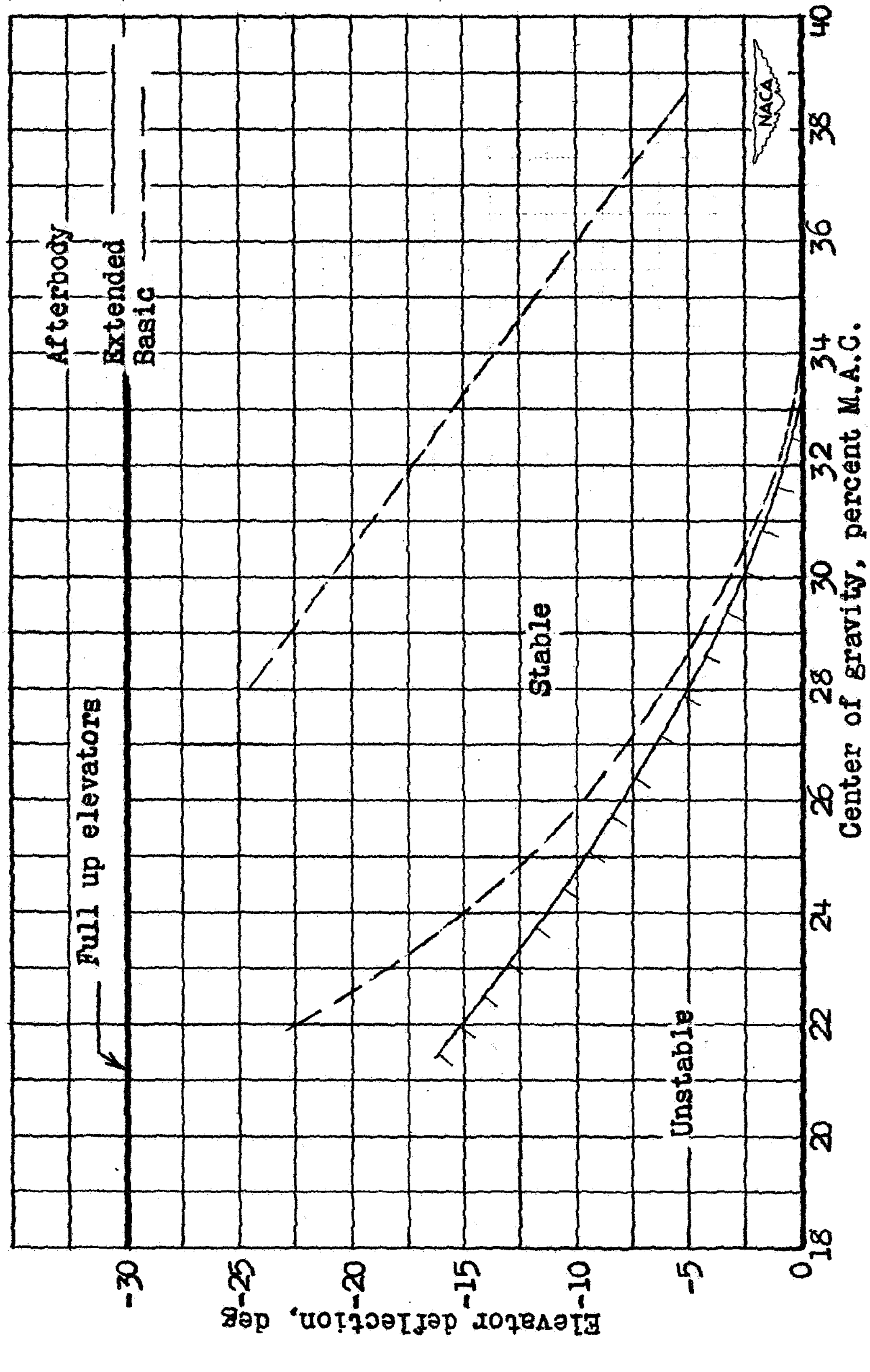
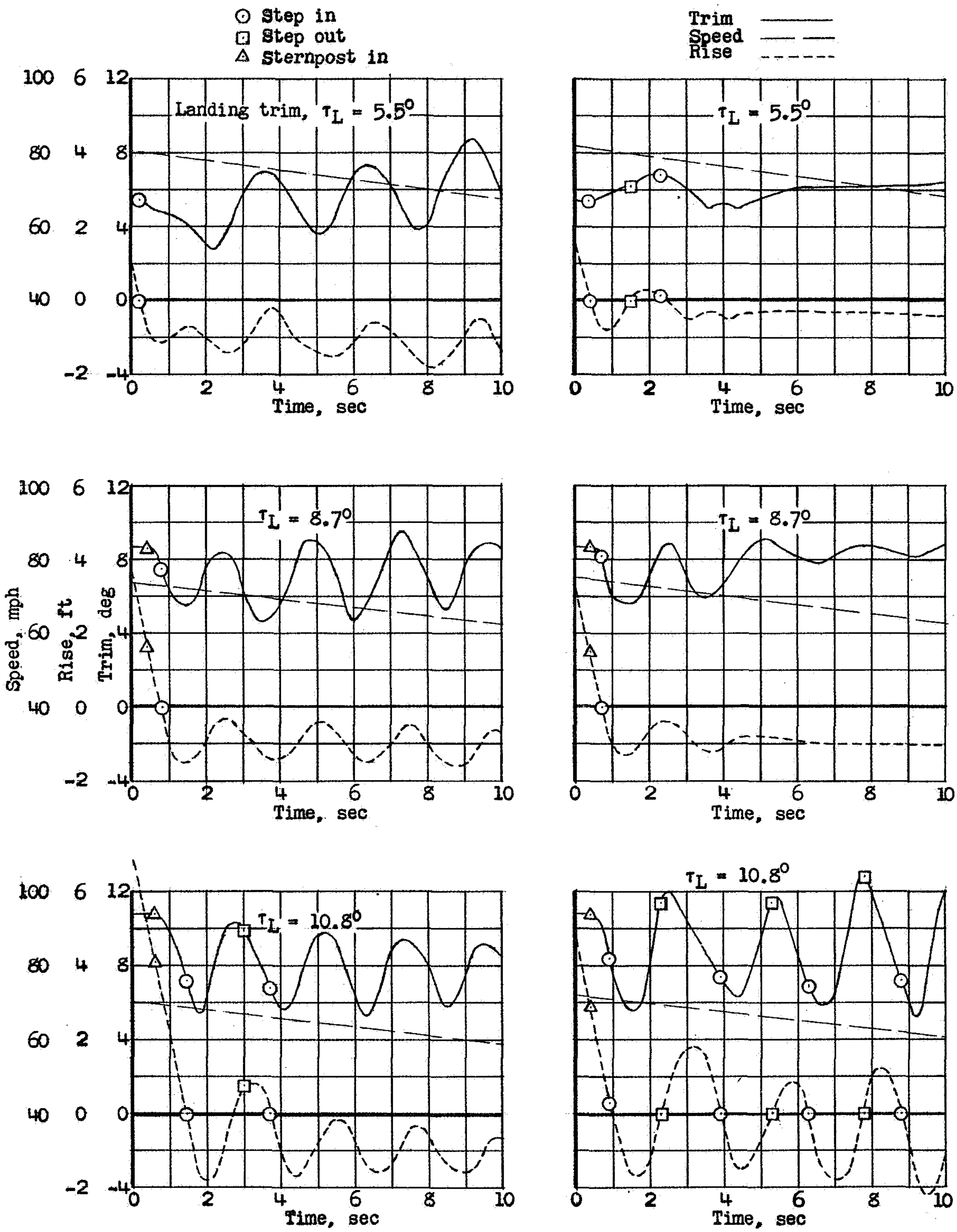


Figure 7.- Variation of center-of-gravity limits of stability with elevator deflection for 2° amplitude of porpoising.



(a) Extended afterbody.

(b) Basic afterbody.

Figure 8.- Variation of trim, rise, and speed with time during landings in smooth water.

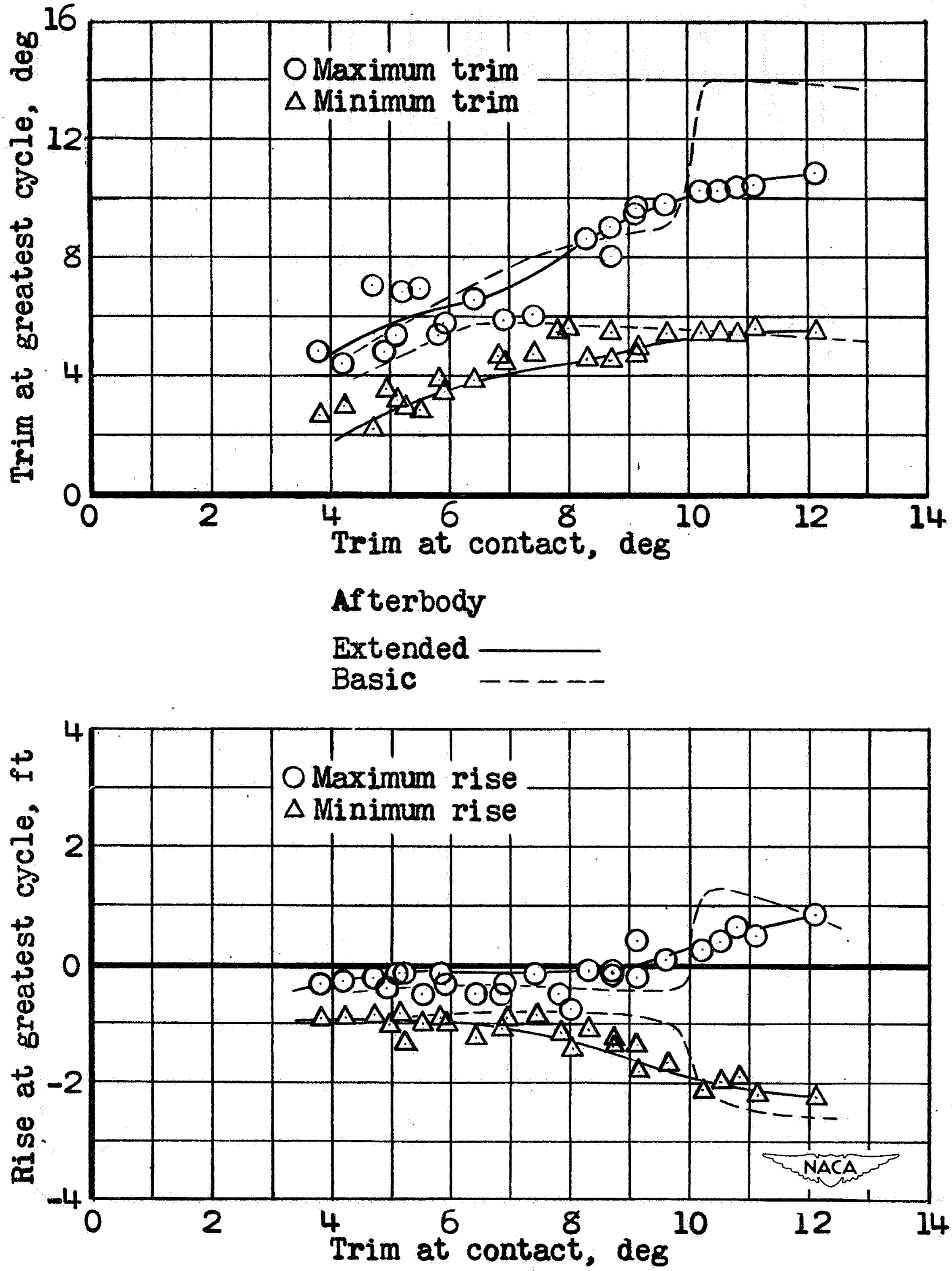


Figure 9.- Variation in maximum and minimum trim and rise with trim at contact, for landings in smooth water.

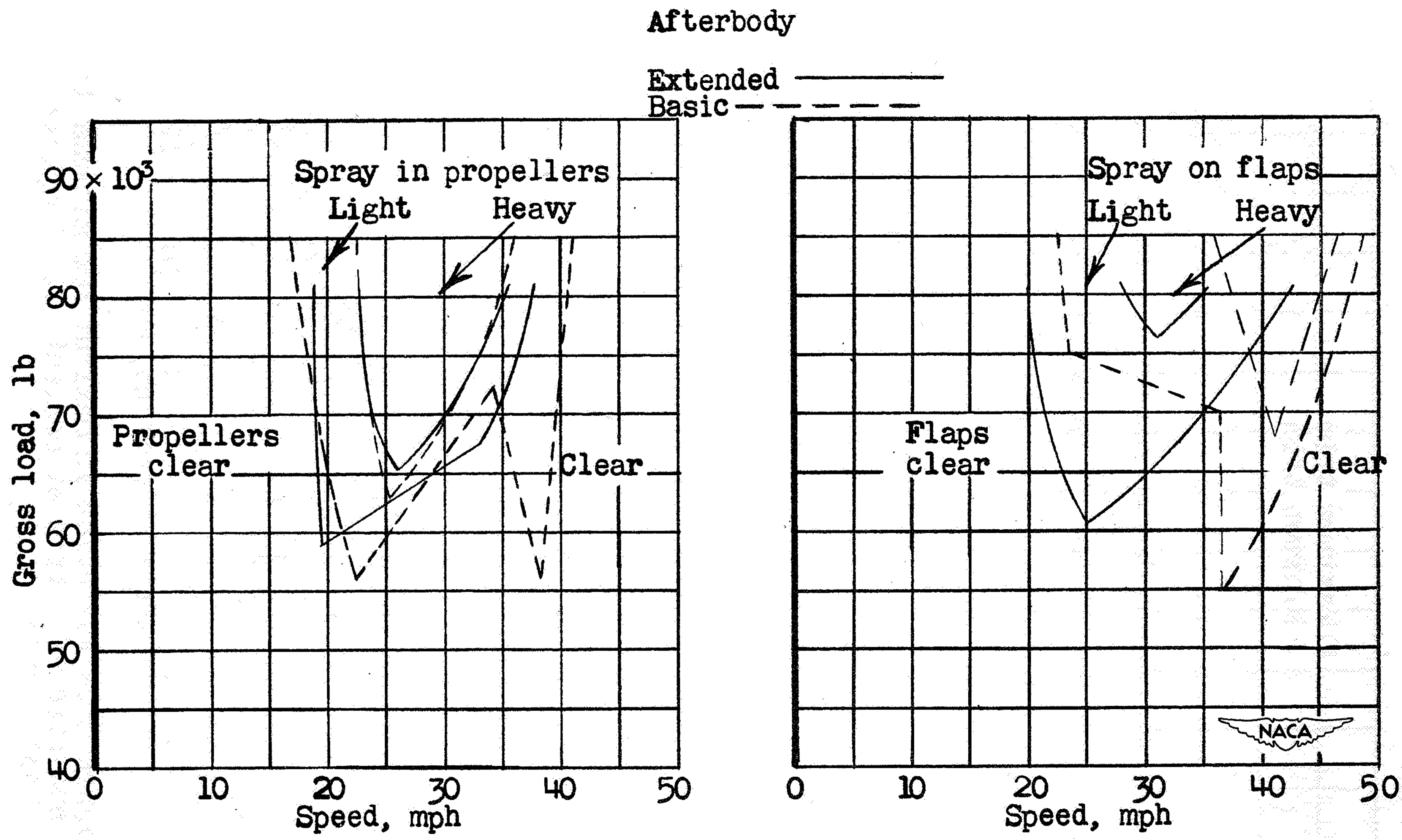
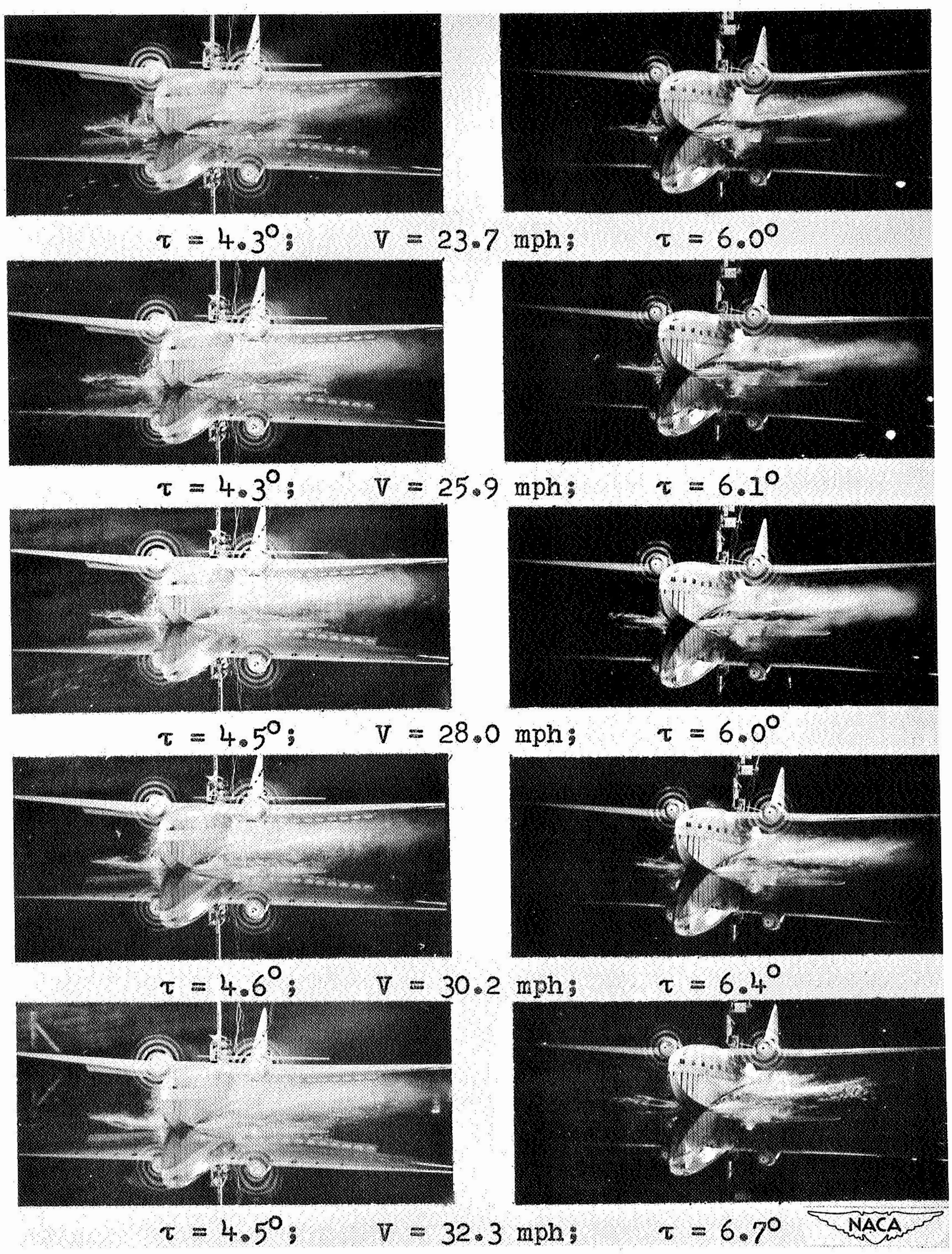
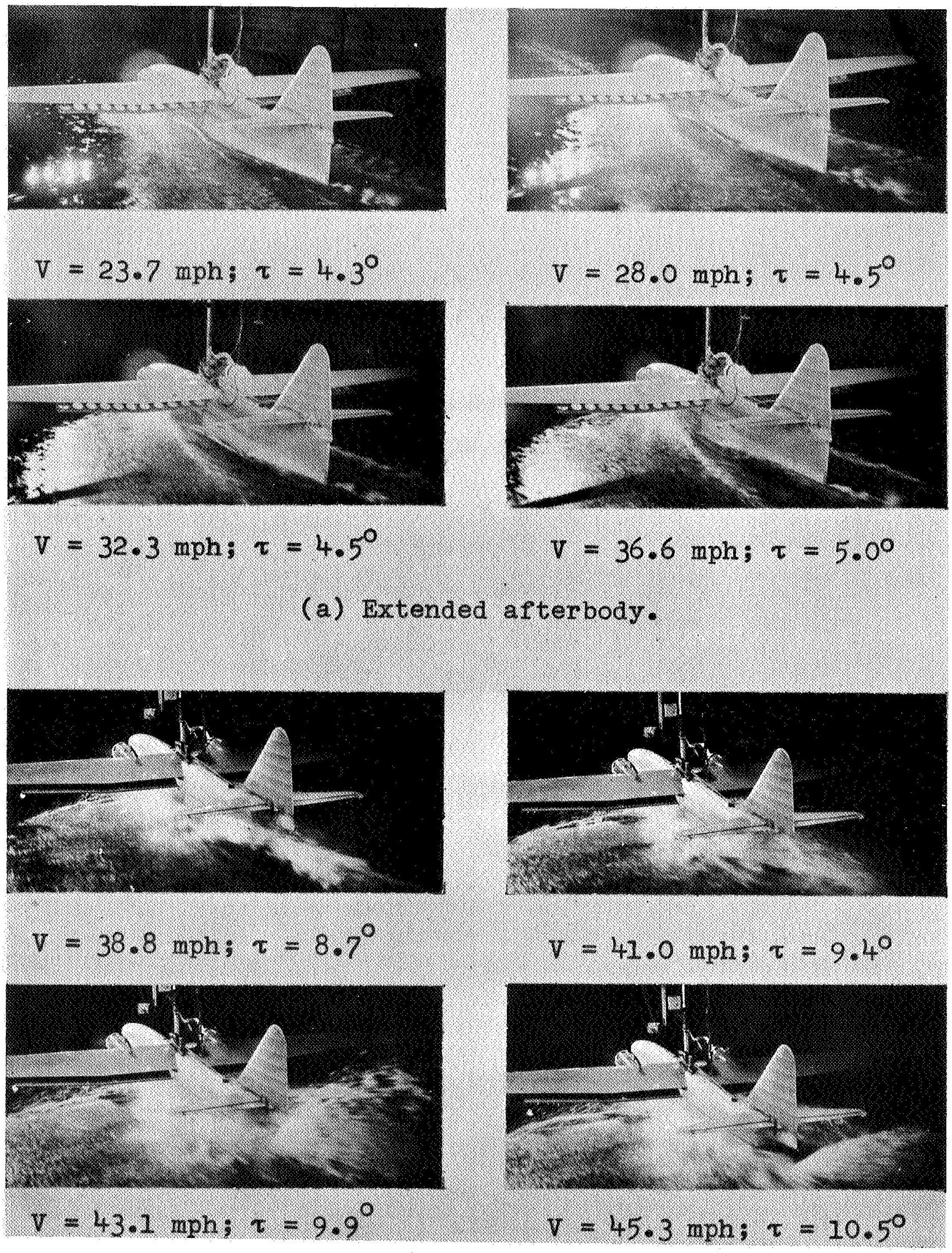


Figure 10.- Variation of range of speed for spray in propellers and on flaps with gross load.



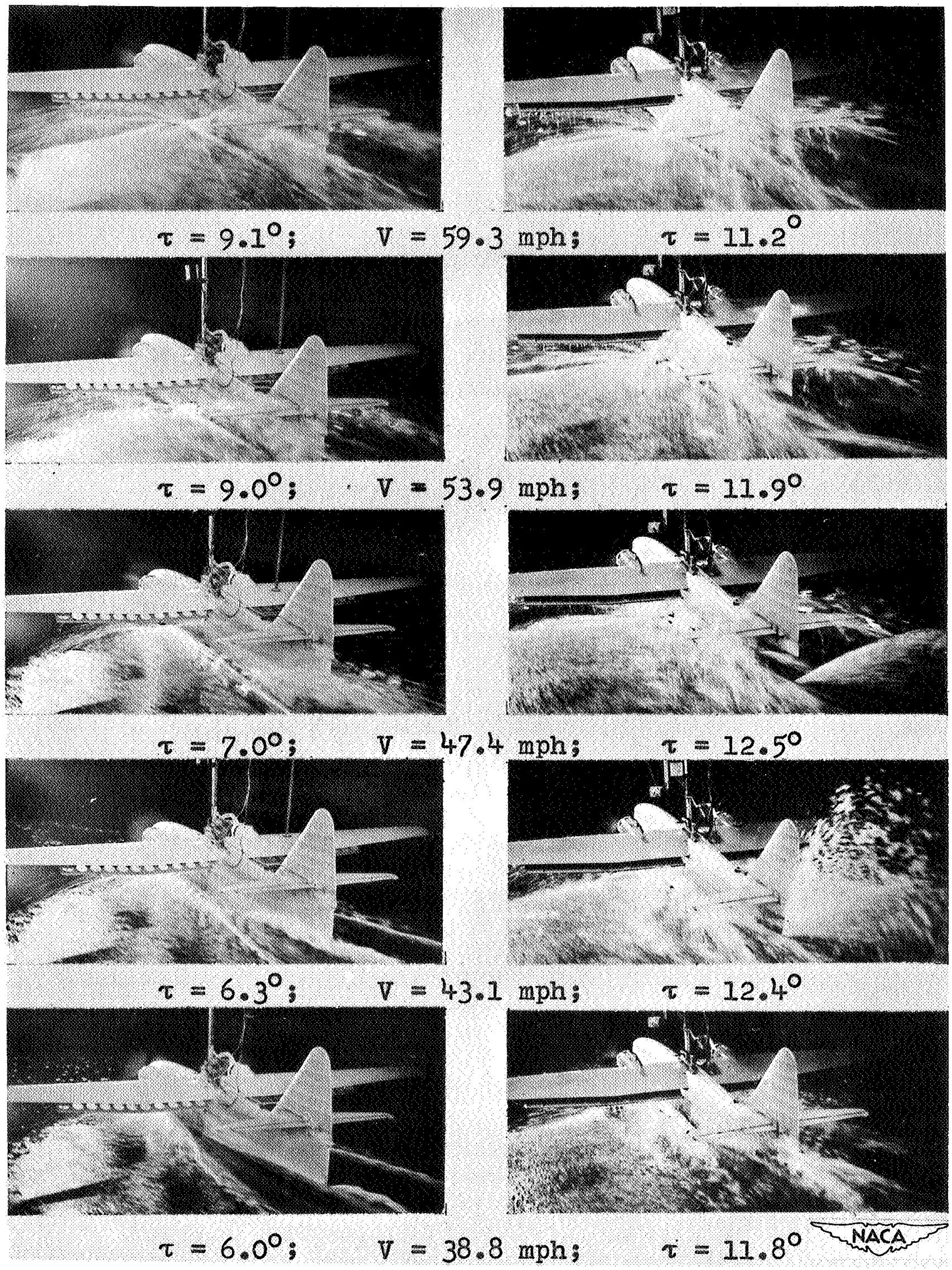
(a) Extended afterbody. (b) Basic afterbody.

Figure 11.- Spray in propellers during take-off.



(b) Basic afterbody.

Figure 12.- Spray on flaps during take-off.



(a) Extended afterbody. (b) Basic afterbody.

Figure 13.- Spray on tail surfaces during a typical landing; contact trim, approximately 9°.

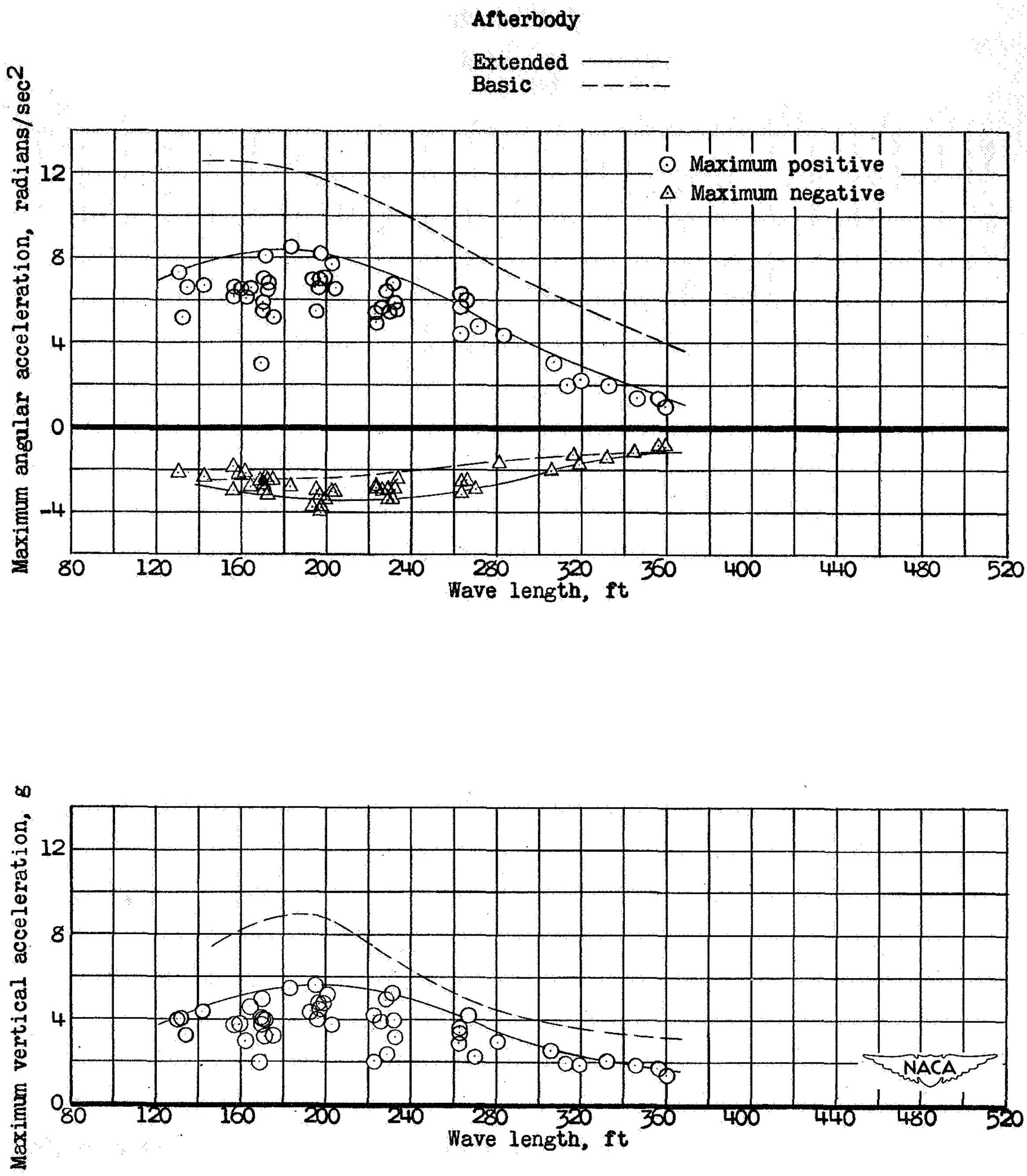


Figure 14.- Variation of maximum positive and negative angular and maximum vertical accelerations with wave length, for landings in waves 4 feet high.

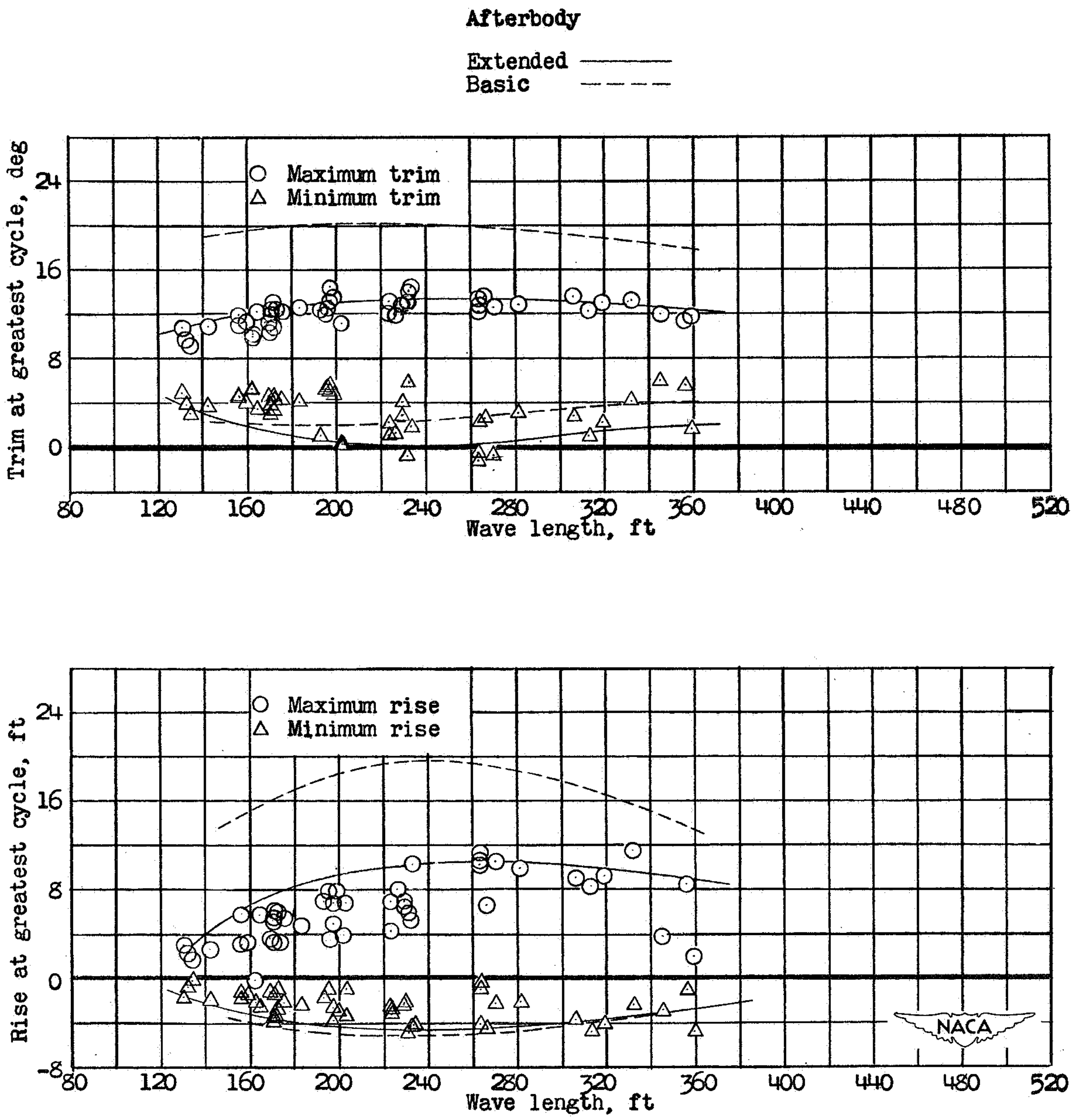


Figure 15.- Variation of maximum and minimum trim and rise with wave length, for landings in waves 4 feet high.

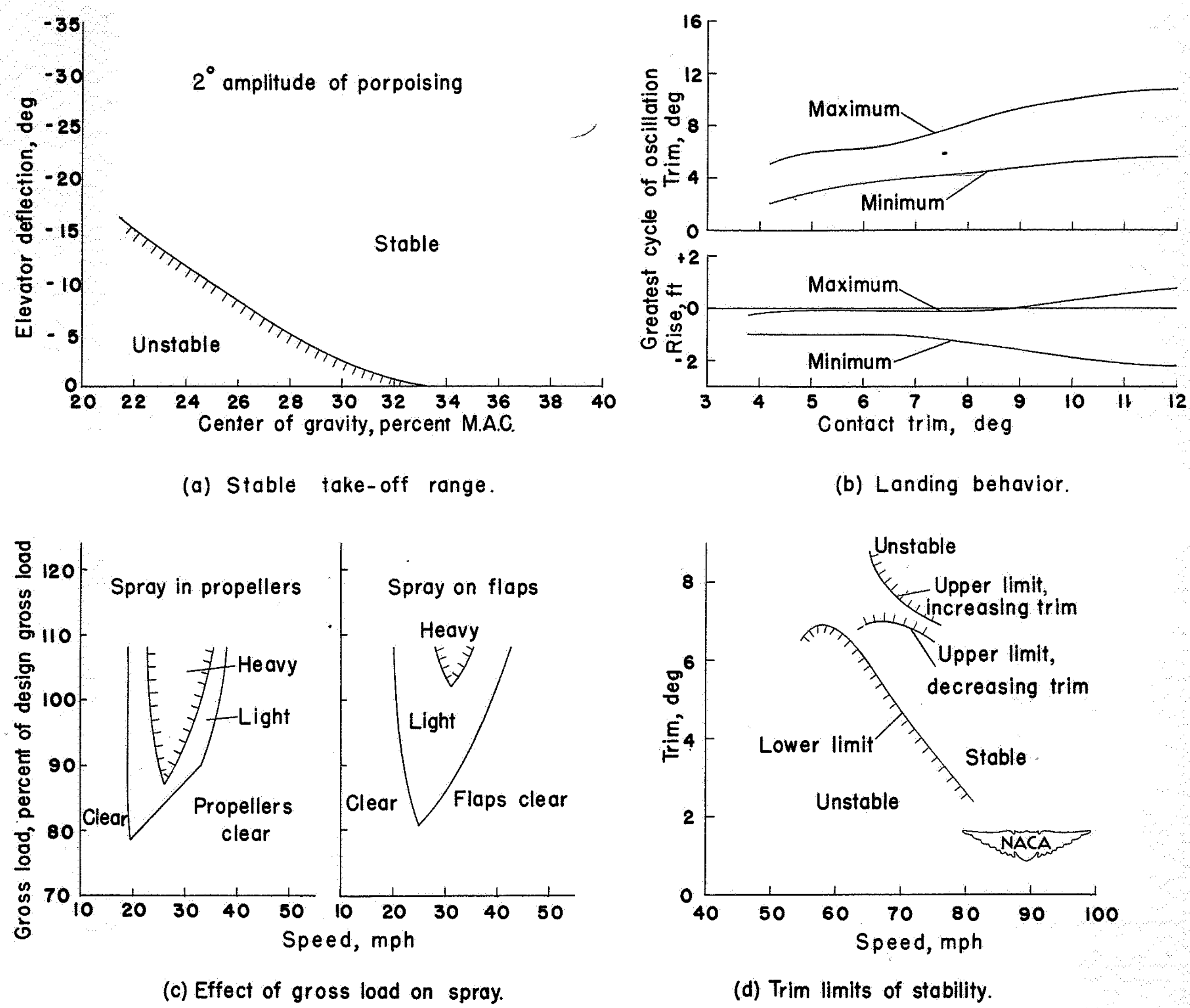


Figure 16. - Summary chart of principal hydrodynamic qualities of a flying boat having a hull of high length-beam ratio and an extended afterbody. Gross load, 75,000 pounds; power loading, 11.5 pounds per brake horsepower; wing loading, 41.1 pounds per square foot; flap deflection, 20°.