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RESEARCH MEMORANDUM

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for the

Bureau of Aeronautics, Navy Department

By authority of H. L. Dryden Date 6-5-53
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TANK TESTS OF A 1/7-SIZE DYNAMIC MODEL OF THE GRUMMAN XJR2F-1 AMPHIBIAN TO DETERMINE THE EFFECT OF SLOTTED- AND SPLIT-TYPE FLAPS ON TAKE-OFF STABILITY - NACA MODEL 212

TED NO. NACA 2378

By

Norman S. Land and Howard Zeck

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

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TANK TESTS OF A 1/7-SIZE DYNAMIC MODEL OF THE GRUMMAN XJR2F-1 AMPHIBIAN TO DETERMINE THE EFFECT OF SLOTTED- AND SPLIT-TYPE FLAPS ON TAKE-OFF STABILITY - NACA MODEL 212

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SUMMARY

Additional tests of a 1/7-size model of the Grumman XJR2F-1 amphibian were made in Langley tank no. 1 to compare the behavior during take-off of the model equipped with split- and slotted-type flaps. The slotted flap had a large effect on locating the forward center-of-gravity limits for stable take-offs. Stable take-offs within the normal operating range of positions of the center of gravity could be made with the split flaps deflected 45° or with the slotted flaps deflected less than 20°. At flap deflections required for similar take-off stability, the use of split flaps resulted in lower take-off speeds than the use of slotted flaps. An increase in forward acceleration from 1.1 to 4.8 feet per second per second moved the center-of-gravity limit forward approximately 3-percent mean aerodynamic chord.

INTRODUCTION

The take-off and landing stability of a 1/7-size powered dynamic model of the Grumman XJR2F-1 amphibian with slotted flaps has been described in reference 1. These results indicated that the range of positions of the center of gravity for stable take-off was well aft of the desired operating range if flap deflections of 20° or more were used. In order to take off from rough water at as low a speed as possible, this airplane was supposed to have satisfactory take-off stability with flap deflections of 45°. With such large deflections of the slotted flaps, the bow-down aerodynamic pitching moments caused excessive lower-limit porpoising.

Additional tests of the model with the flap design changed from the original slotted flap to a split flap of the same plan form area was requested by the Bureau of Aeronautics in their letter of March 27, 1946, Aer-RD-62-FWSL. It was requested that the tests include the determination of the forward limits of the center of gravity for stable take-offs with the stabilizer incidence decreased and elevators at -30° in combination with the split flap and slotted flap. It was thought that the reduction in aerodynamic pitching moment with the split-type flap would be great enough to permit stable take-offs with full down flaps at forward positions of the center of gravity.

In accordance with the request of the Bureau of Aeronautics, Navy Department, the forward limits for stable positions of the center of gravity were determined with both types of flaps. These data were obtained at two rates of forward acceleration. Sufficient aerodynamic tests were made to determine the approximate lift and pitching-moment characteristics with the two types of flaps.

DESCRIPTION OF THE MODEL

The principal dimensions and general arrangement of the model are presented in reference 1. The stabilizer was set at -2.5° to the wing chord in accordance with changes that had been made in the design of the full size. The angle of incidence of the stabilizer is 2° less than that used during the tests described in reference 1.

The split flaps had the same plan form area as that of the slotted flaps. The tip sections of the slotted and split flaps are shown in figure 1.

APPARATUS AND PROCEDURE

The test procedure was similar to that used in reference 1.

Unless otherwise specified, the following conditions were maintained for all of the tests:

Stabilizer, 2.5° to base line

Leading-edge slats on wing

Position of center of gravity
Vertical position, 16.06 inches above keel at step
Horizontal position, 25-percent M.A.C.

Full power, 7100 rpm, 12° blade angle at 3/4 radius

Nose-wheel drains sealed

Step vented to interior of hull through main wheel well compartment

The trim was referred to the base line of model

Moments tending to raise the bow were considered positive

A gross load of 65.2 pounds corresponding to full-scale design gross load was used for all of the take-off stability tests. The forward limits for stable positions of the center of gravity during take-off were determined with full power and elevators deflected -30°. Records were taken of the time history of trim and speed during take-off. Where possible these records were supplemented by visual observations of maximum amplitude of porposing and trim. All center-of-gravity limits were determined for two rates of acceleration, 1.1 and 4.8 feet per second per second. At the higher rate of acceleration, it was sometimes difficult to determine whether or not the model was starting a cycle of porpoising. The motion was not considered porpoising unless a complete oscillation in trim occurred.

For the aerodynamic tests, which were made with full power, the aerodynamic lift and pitching moments were determined for a range of speeds from 22 to 35 feet per second.

RESULTS AND DISCUSSION

The variation of the trim with speed during take-off with the slotted flaps deflected 5°, 15°, 20°, and 45° is presented in figures 2 to 5, respectively. As the flap deflection was increased, the free-to-trim tracks were lowered and, with flaps deflected 45° and the center of gravity at 32-percent mean aerodynamic chord, lower limit porpoising occurred over most of the take-off run. Since the elevators were already full up, a recovery from this porpoising was not possible.

The variation of the trim with speed for split flaps deflected 45° is presented in figure 6. At positions of the center of gravity of 20 percent and 22 percent mean aerodynamic chord, lower limit porpoising occurred during most of the take-off. The trim tracks were similar to those with 45° slotted flaps and the center of gravity at 30 percent and 32 percent mean aerodynamic chord. Stable take-offs with split flaps (fig. 6) therefore were possible at more forward positions of the center of gravity than with slotted flaps at the same deflection (fig. 5).

The maximum amplitude of porpoising is plotted against position of the center of gravity in figures 7 and 8. Assuming an amplitude of 2° as the maximum permissible porpoising during take-off, these results may be summarized as a plot of flap deflection against forward limit for the center of gravity, figure 9. The large shift in the forward limit with change in flap deflection of the slotted flaps is clearly shown in this figure. A change in flap deflection from 5° to 45° shifted the forward limit aft 12-percent mean aerodynamic chord. Satisfactory take-off stability at positions of the center of gravity forward of 25 percent mean aerodynamic chord is possible only if the deflection of the slotted flaps is less than 20°. The forward limit, with the split flaps deflected 45°, is approximately the same as that obtained with the slotted flaps deflected $12\frac{1}{2}^\circ$.

The effect of acceleration on the trim tracks is shown in figures 2 to 6. In general, the trim tracks at rates of acceleration of 1.1 and 48 feet per second per second, respectively, are approximately the same except at speeds where porpoising occurred. The period of the oscillation in trim during porpoising was approximately the same at both rates of acceleration. The effect of acceleration on the forward limit for the center of gravity is shown in figure 9. An increase in acceleration of 3.7 feet per second per second shifted the forward limit forward approximately 3-percent mean aerodynamic chord.

The aerodynamic lift and pitching moment is plotted against speed in figures 10 to 13 for slotted flaps deflected 0°, 10°, and 45° and for split flaps deflected 45°. For similar take-off stability at forward positions of the center of gravity, it has been shown that a $12\frac{1}{2}^\circ$ deflection of the slotted flap is approximately equivalent to a 45° deflection of the split flaps. From a comparison of the lifts of the slotted and split flaps it will be noted that at deflections of the flaps for similar take-off stability, the use of split flaps would result in lower take-off speeds than the use of slotted flaps.

In order to enable comparisons to be made of the data in this report with that presented in reference 1, a few take-offs were made with the stabilizer setting of 4.5° to the hull base line and elevators deflected -30°. These results are presented in figure 14 and may be compared with data obtained at the new stabilizer setting of 2.5° to the hull base line presented in figure 7(c). The change in stabilizer had only a small effect on the maximum amplitudes of porpoising and consequently on the forward limit for the center of gravity.

CONCLUSIONS

Tests of a 1/7-size dynamic model of the Grumman XJR2F-1 amphibian showed that:

1. An increase in forward acceleration from 1.1 feet to 4.8 feet per second per second moved the forward limit of the center of gravity forward approximately 3 percent mean aerodynamic chord.

2. With a deflection of the slotted flaps of 45° take-off stability is satisfactory at positions of the center of gravity aft of 32 percent mean aerodynamic chord at the higher rate of forward acceleration.

3. With a deflection of the split flaps of 45° take-off stability is satisfactory at positions of the center of gravity aft of 22 percent mean aerodynamic chord at the higher rate of forward acceleration.

4. The forward center of gravity limit with split flaps deflected 45° is approximately the same as that with slotted flaps deflected $12\frac{1}{2}^{\circ}$.

For a similar range of stable positions of the center of gravity for take-off, the use of split flaps results in lower take-off speeds than the use of slotted flaps.

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

Norman S. Land
Aeronautical Engineer

Howard Zeck
Aeronautical Engineer

Approved:
John B. Parkinson
Chief of Hydrodynamics Research Division

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REFERENCE

1. Land, Norman S., and Zeck, Howard: Tank Tests of a 1/7-Size Powered Dynamic Model of the Grumman XJR2F-1 Amphibian. Spray Characteristics, Take-off and Landing Stability in Smooth Water - Langley Tank Model 212, TED No. NACA 2378. NACA RM No. L6J10, Bur. Aero., 1946.

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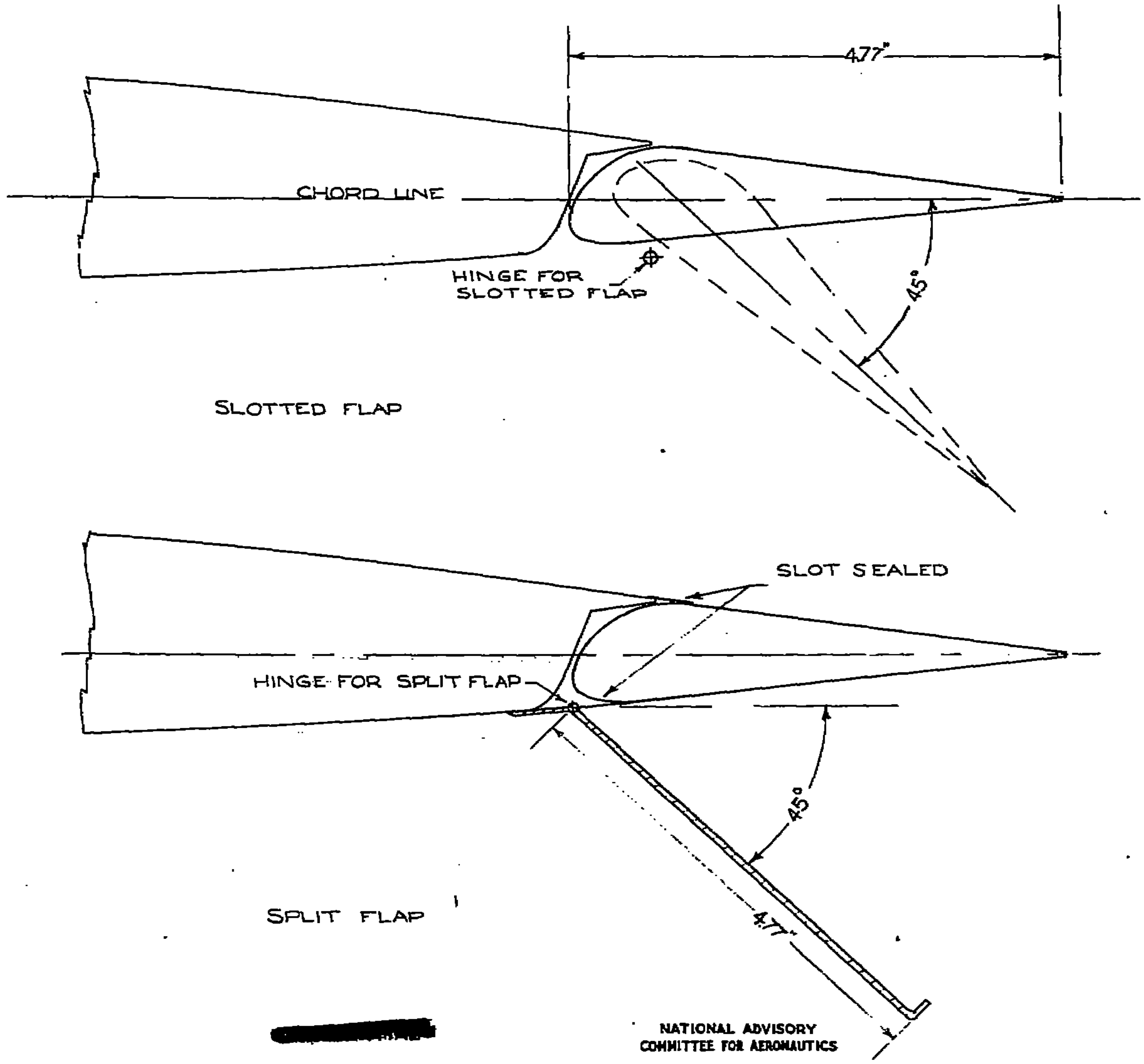

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FIGURE 1.- MODEL 212. COMPARISON OF TIPSECTION OF SLOTTED AND SPLIT TYPE FLAPS.

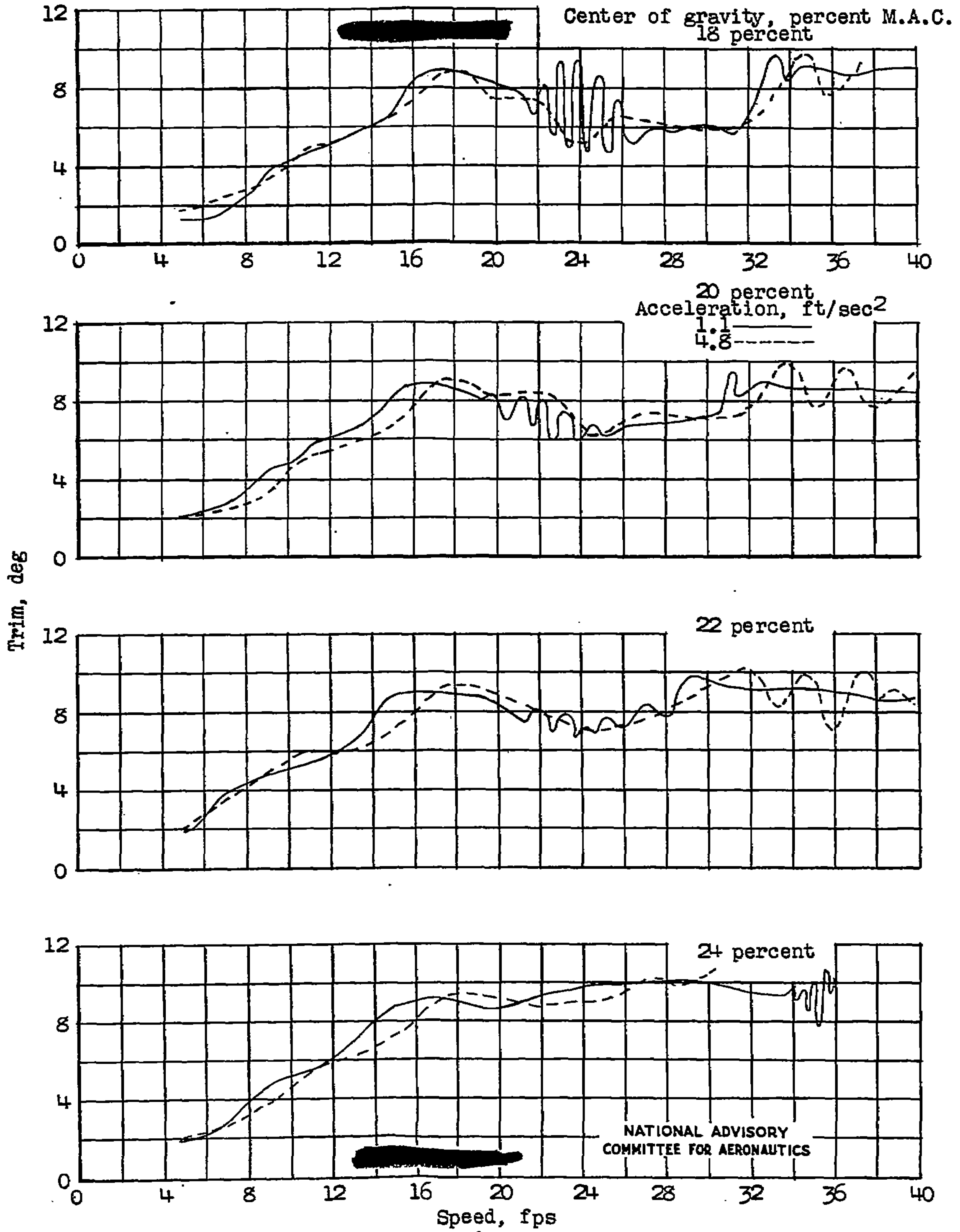

Figure 2.- Model 212. Variation of trim with speed for two accelerations. Gross load, 65.2 pounds; full power; slotted-type flaps, δ_f, 5°; elevator, δ_e, -30°; stabilizer, δ_s, 2.5°.

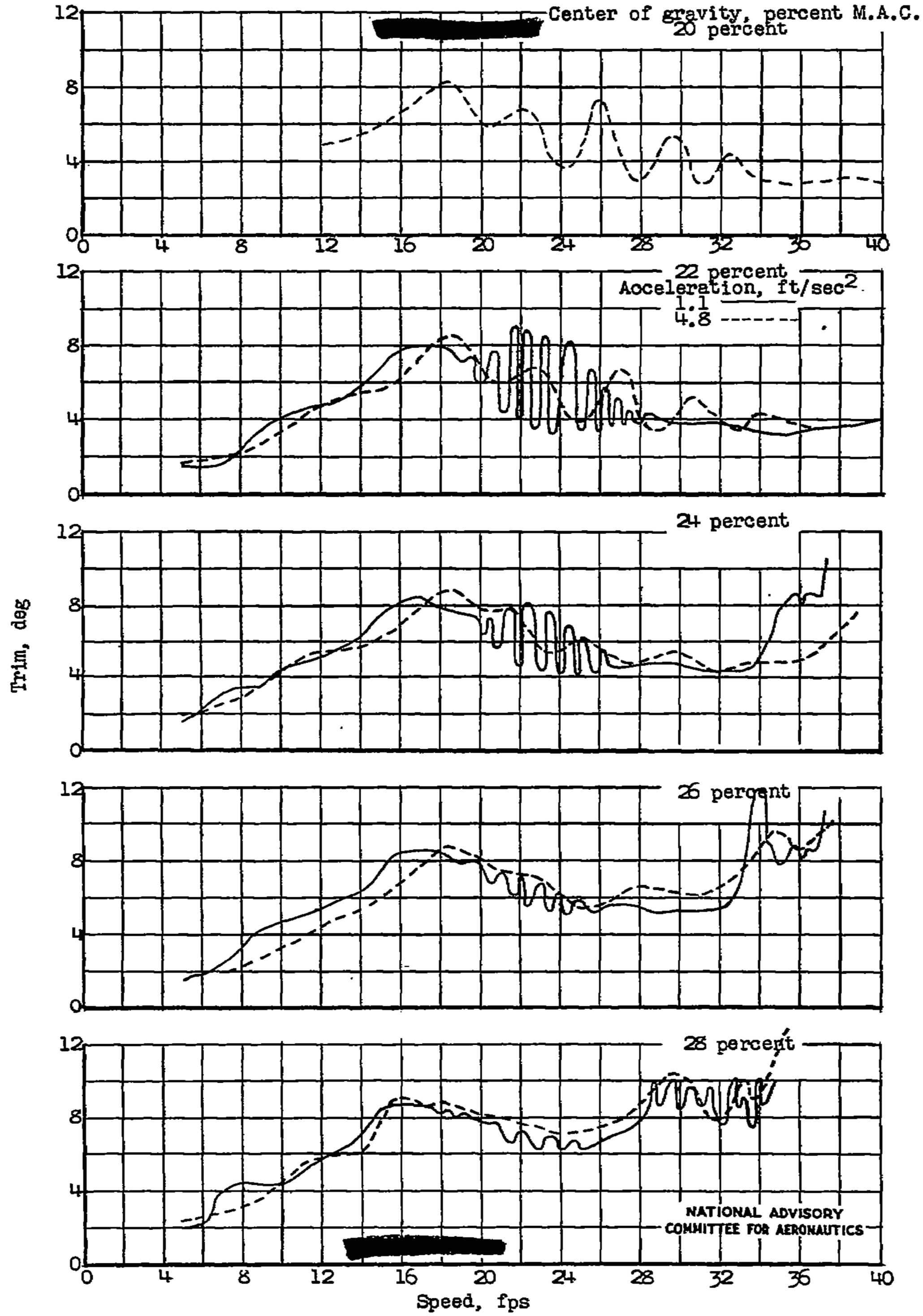

Figure 3.- Model 212. Variation of trim with speed for two accelerations. Gross load, 65.2 pounds; full power; slotted-type flaps, δ_f, 15°; elevator, δ_e, -30°; stabilizer, δ_s, 2.5°.

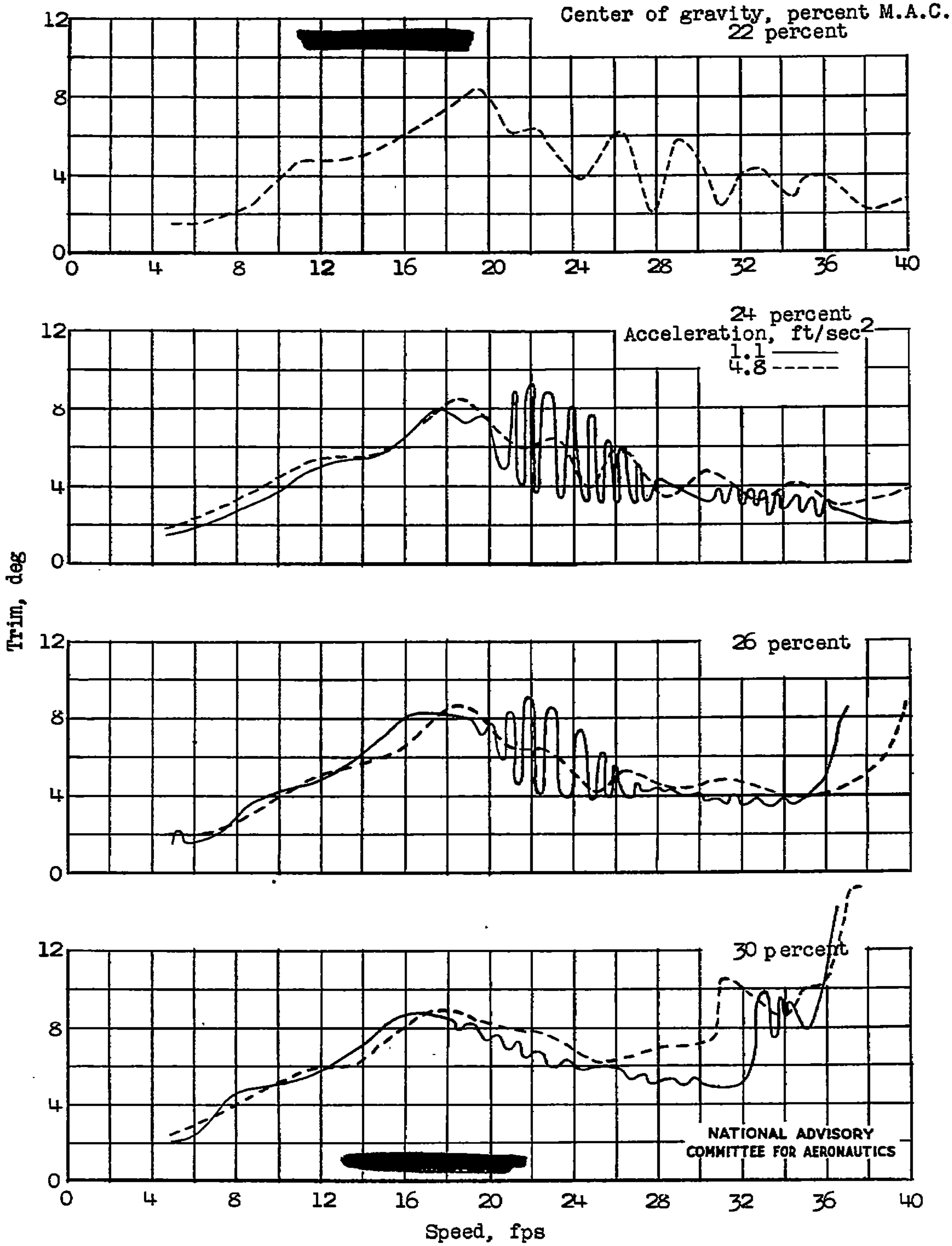

Figure 4 .- Model 212. Variation of trim with speed for two accelerations. Gross load, 65.2 pounds; full power; slotted-type flaps, δ_f, 20°; elevator, δ_e, -30°; stabilizer, δ_s, 2.5°.

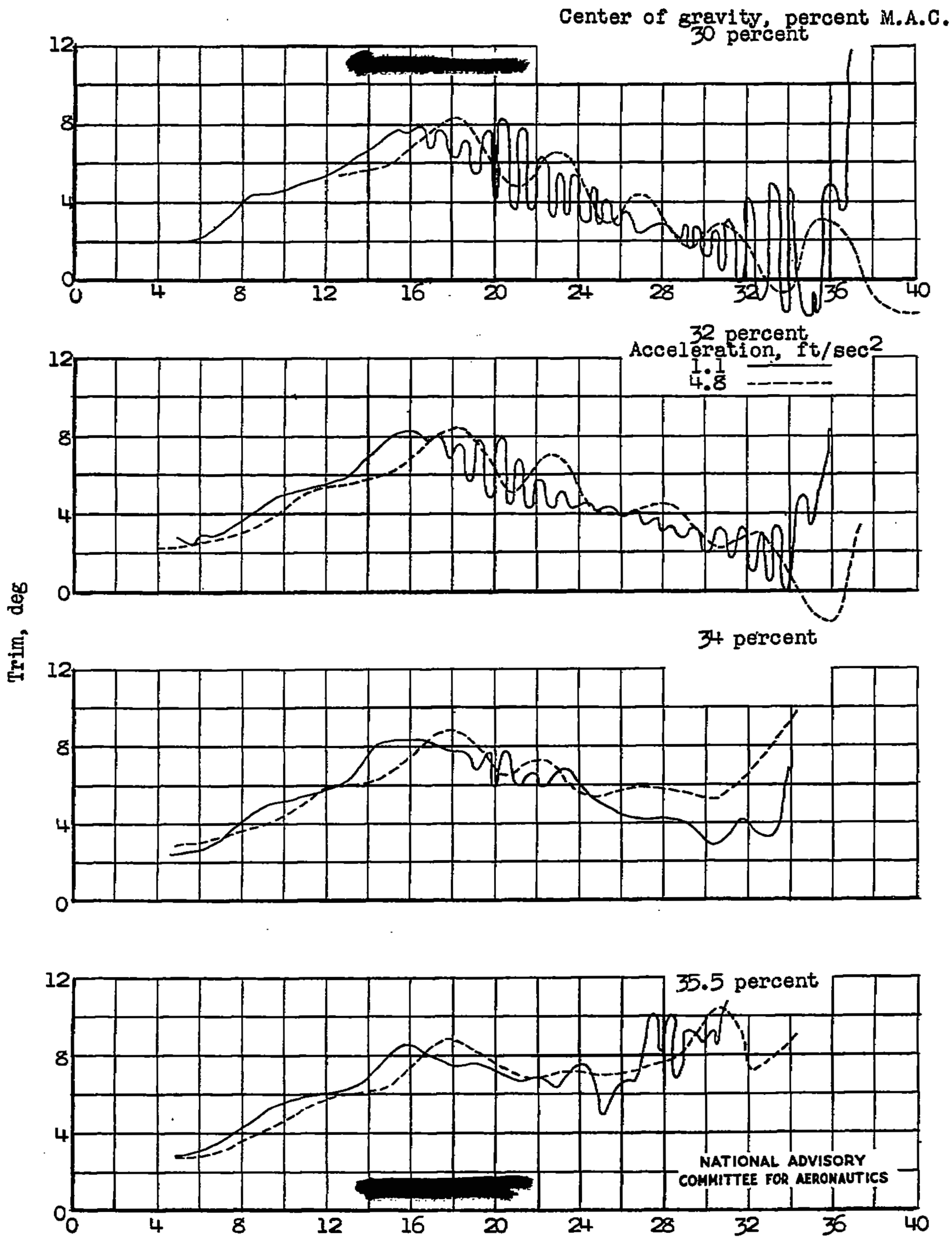

Figure 5.- Model 212. Variation of trim with speed for two accelerations. Gross load, 65.2 pounds; full power; slotted-type flaps, δ_f, 45°; elevator, δ_e, -30°; stabilizer, δ_s, 2.5°.

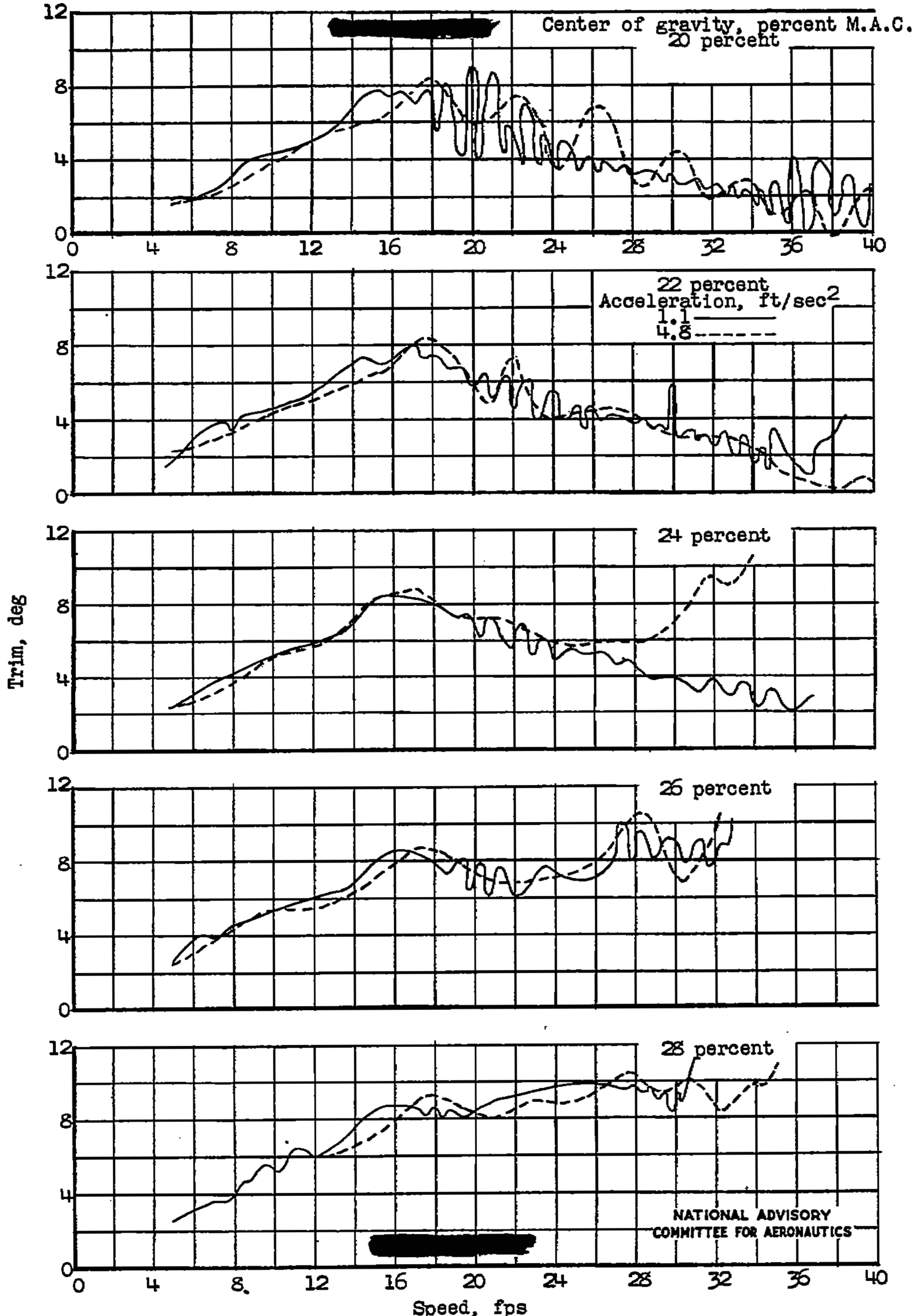

Figure 6.- Model 212. Variation of trim with speed for two accelerations. Gross load, 65.2 pounds; full power; split-type flaps, δ_f, 45°; elevator, δ_e, -30°; stabilizer, δ_s, 2.5°.

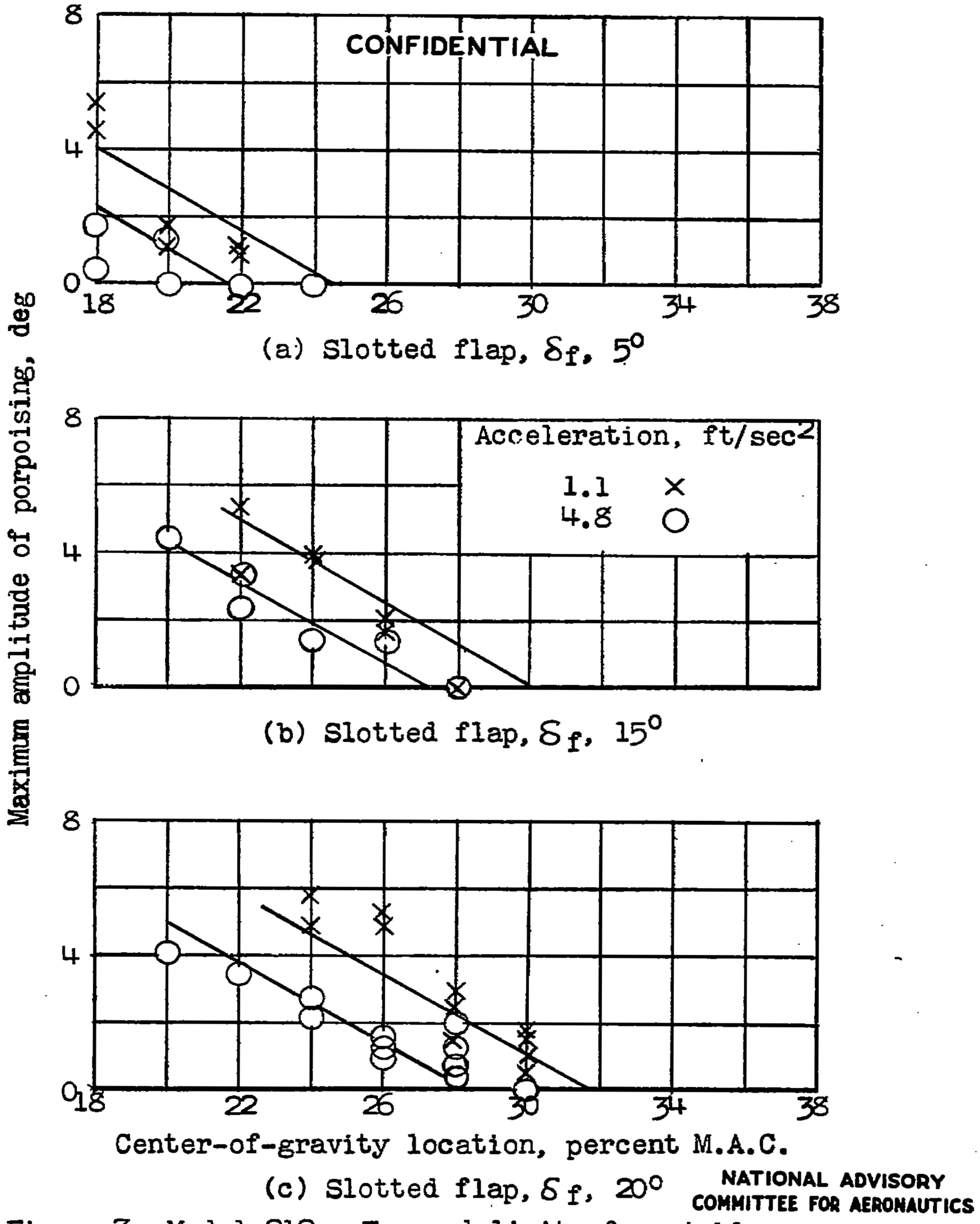

Figure 7.- Model 212. Forward limits for stable positions of center of gravity for two accelerations. Gross load, 65.2 pounds; full power; elevators, δ_e, -30°; stabilizer, δ_s, 2.5°.

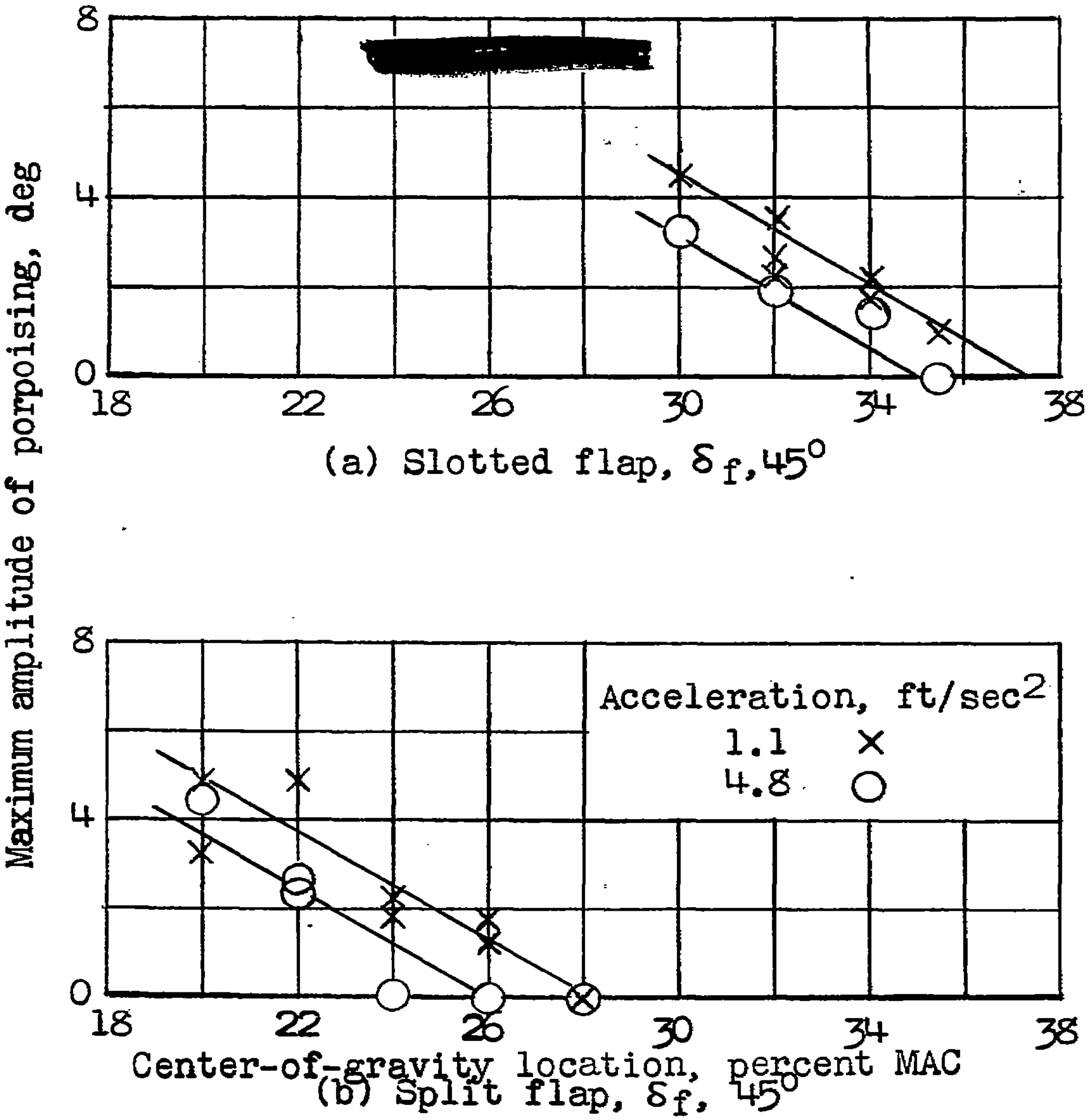

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Figure 8.- Model 212. Forward limits for stable positions of center of gravity for two accelerations. Gross load, 65.2 pounds; full power; elevators, δ_e, -30°; stabilizer, δ_s, 2.5°.

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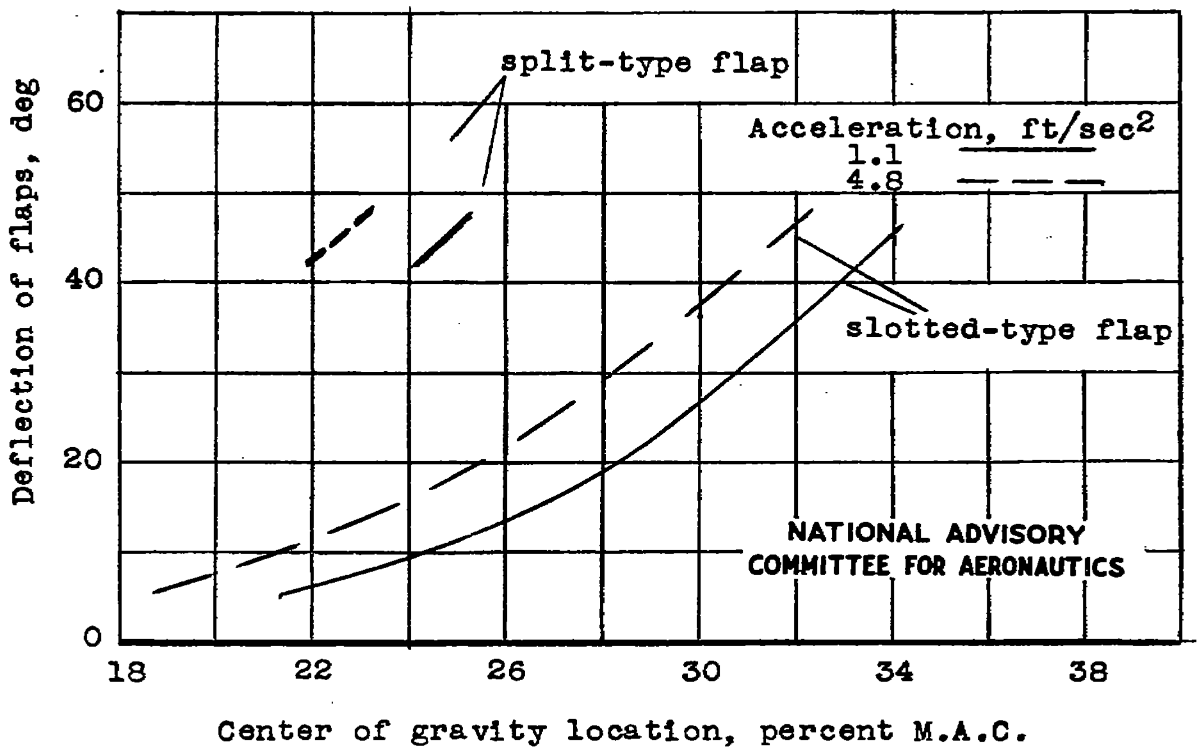

Figure 9.- Model 212. Effect of flap deflection and type of flaps on forward limit for stable positions of the center of gravity for two accelerations. Gross load, 65.2 pounds; full power; elevators, δ_e, -30°; stabilizer, δ_s, 2.5°.

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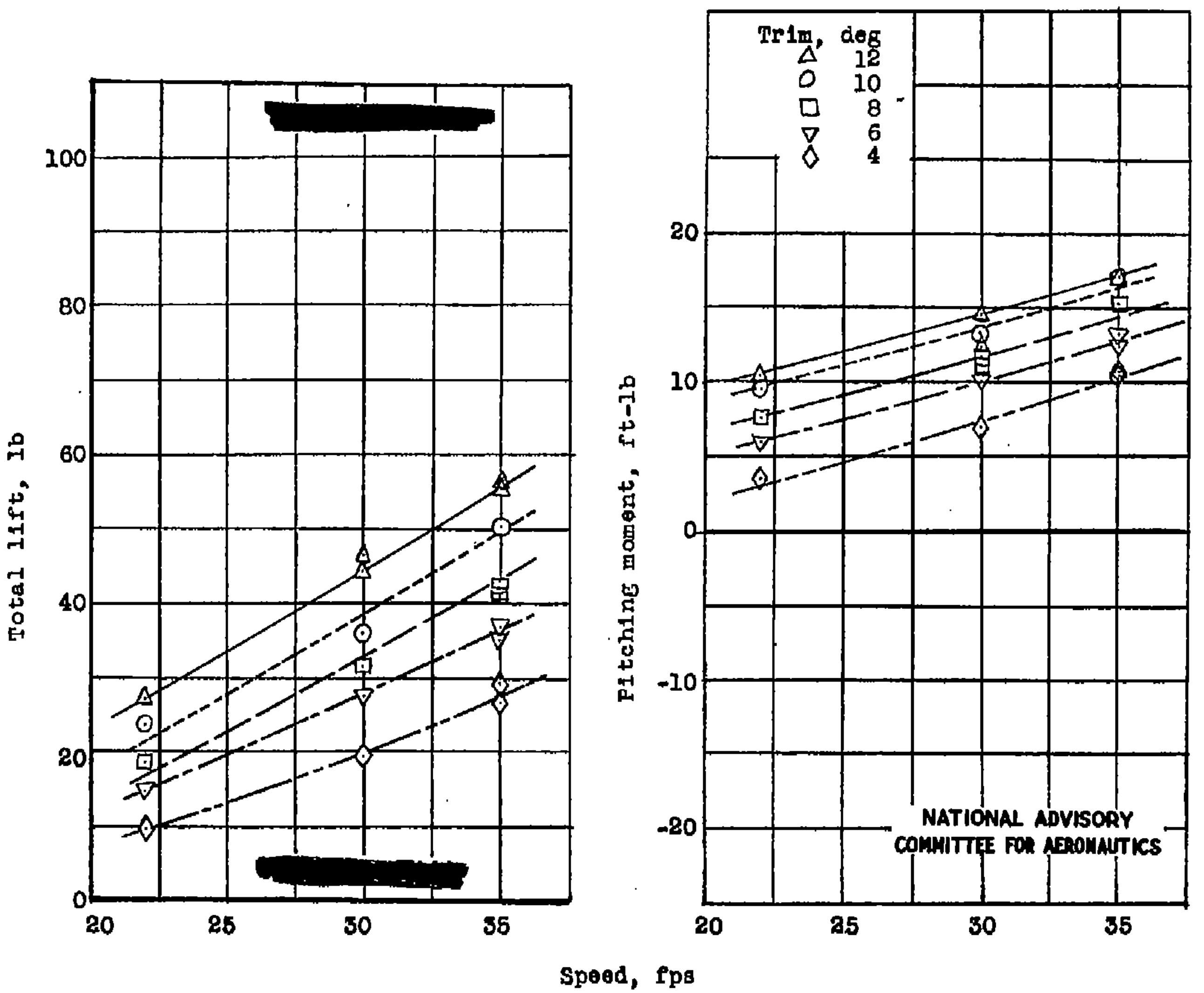

Figure 10.- Model 212. Variation of aerodynamic lift and pitching moment with speed. Full power; center of gravity, 25 percent M.A.C.; slotted-type flaps, δ_f, 0°; elevators, δ_e, -30°; stabilizer, δ_s, 2.5°.

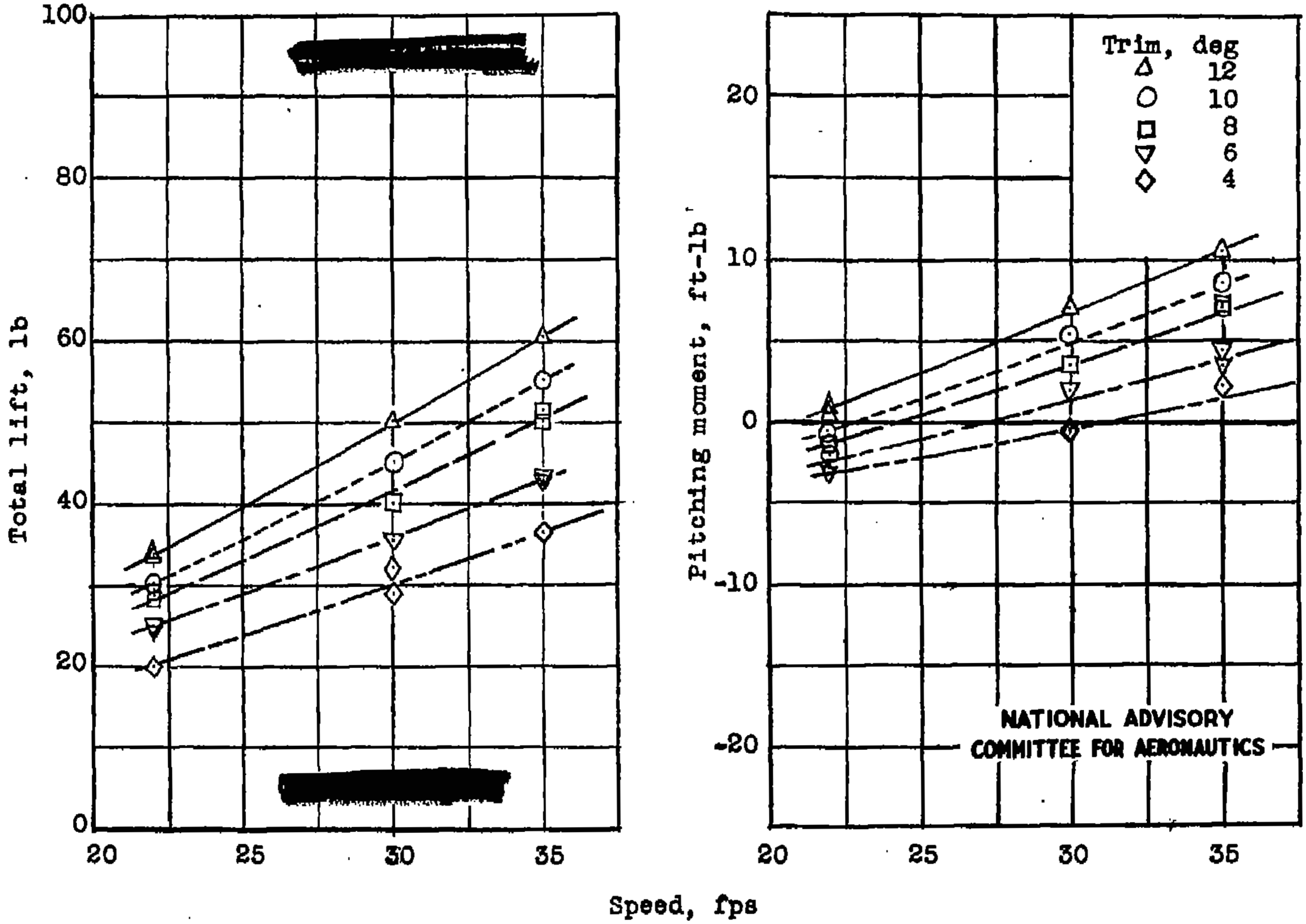

Figure 11.- Model 212. Variation of aerodynamic lift and pitching moment with speed. Full power; center of gravity, 25 percent M.A.C.; slotted-type flaps, δ_f, 10°; elevators, δ_e, -30°; stabilizer, δ_s, 2.5°.

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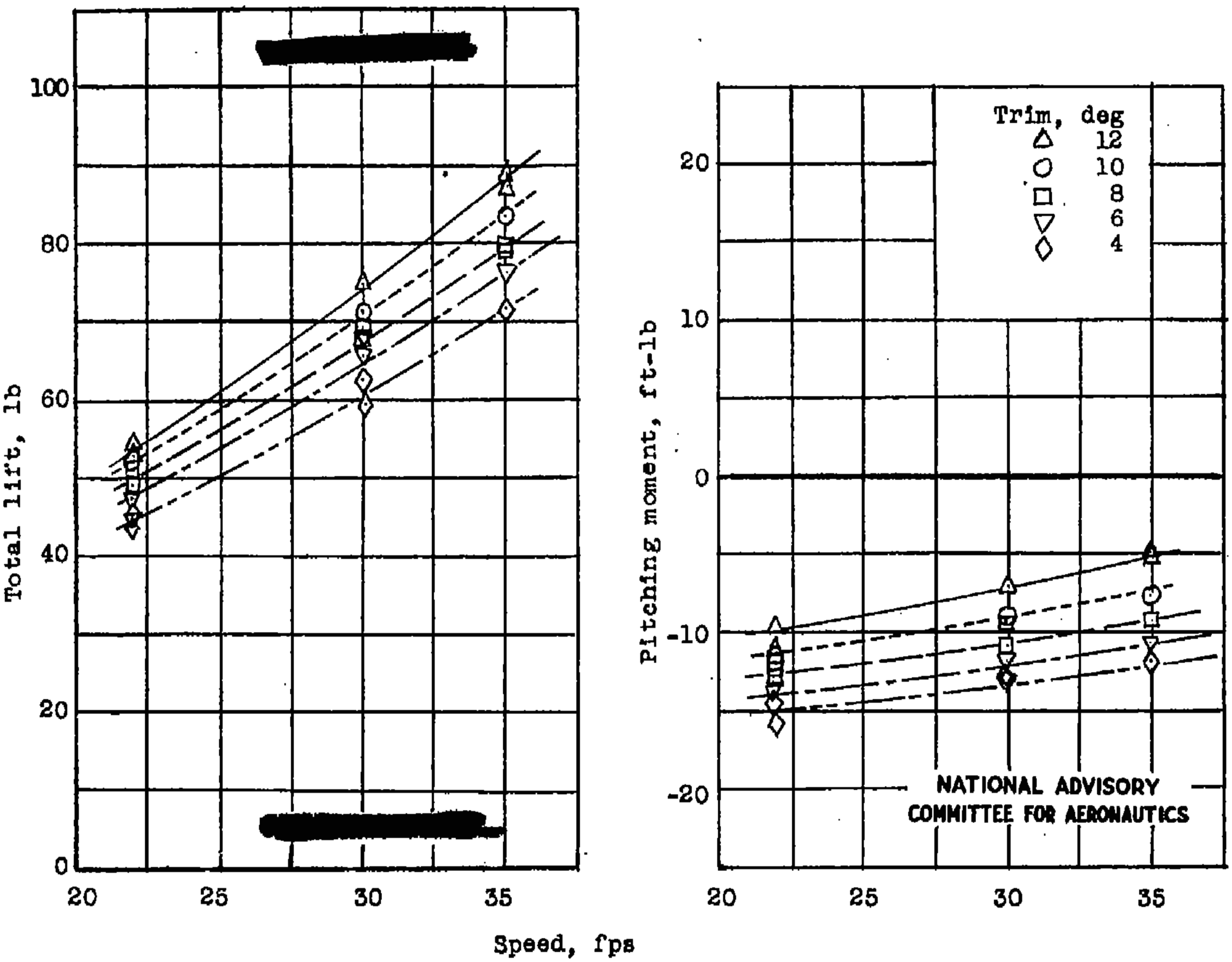


Figure 12.- Model 212. Variation of aerodynamic lift and pitching moment with speed. Full power; center of gravity, 25 percent M.A.C.; slotted-type flaps, δ_f, 45°; elevators, δ_e, -30°; stabilizer, δ_s, 2.5°.

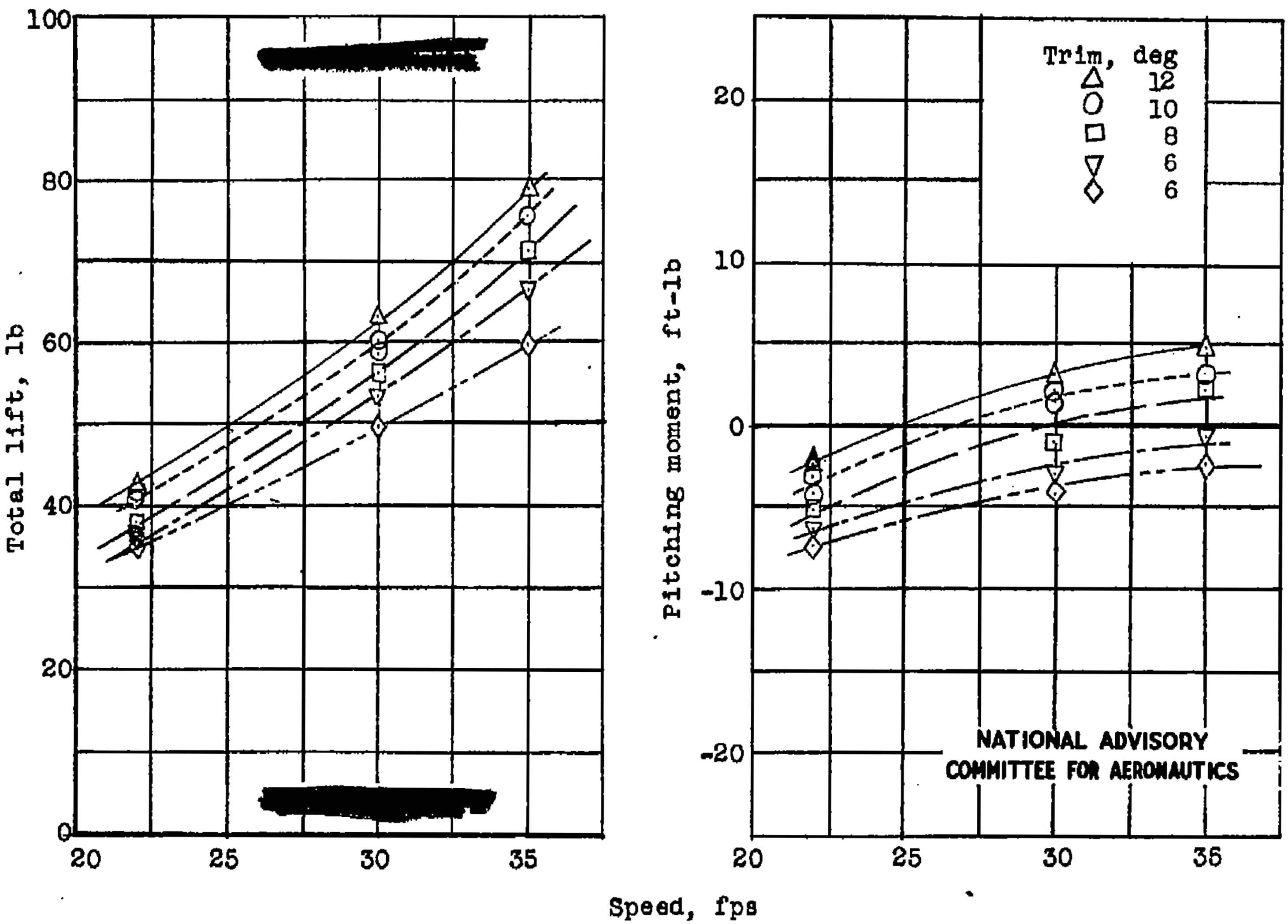
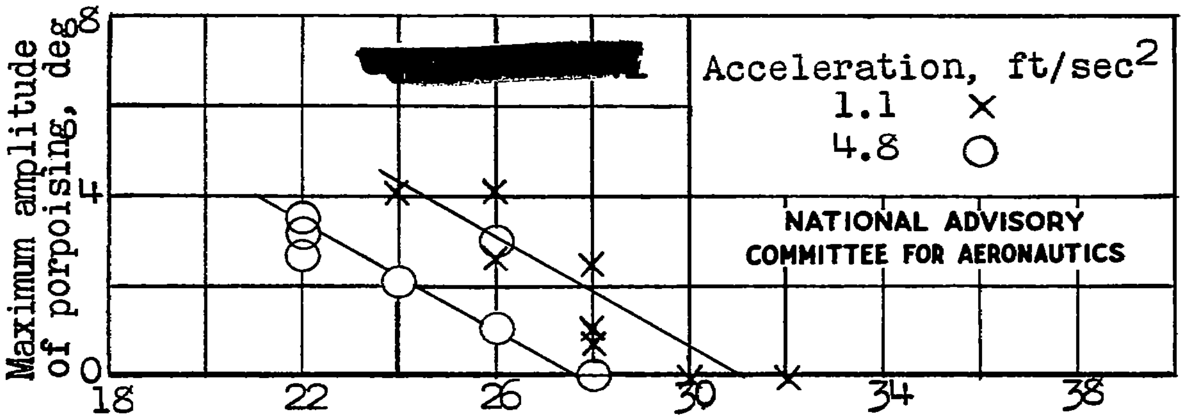


Figure 13.- Model 212. Variation of aerodynamic lift and pitching moment with speed. Full power; center of gravity, 25 percent M.A.C.; split-type flaps, δ_f, 45°; elevators, δ_e, -30°; stabilizer, δ_s, 2.5°.



Center-of-gravity location, percent M.A.C.

Slotted flap, δ_f, 20°; stabilizer, δ_s, 4.5°

Figure 14.- Model 212. Forward limits for stable positions of center of gravity for two accelerations. Gross load, 65.2 pounds; full power; elevators, δ_e, -30°. [redacted]