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LANDING CHARACTERISTICS OF A MODEL OF A FLYING BOAT WITH THE DEPTH OF STEP REDUCED TO ZERO BY MEANS OF A RETRACTABLE PLANING FLAP

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LANDING CHARACTERISTICS OF A MODEL OF A FLYING BOAT WITH THE DEPTH OF STEP REDUCED TO ZERO BY MEANS OF A RETRACTABLE PLANING FLAP

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SUMMARY

A model of a flying boat was tested in the NACA tank No. 1 to determine the landing characteristics when the depth of step was reduced to zero by means of a retractable planing flap on the forebody. The model exhibited exceptionally stable landing characteristics over a wide range of the location of the center of gravity and at trims from about 5.5° (afterbody horizontal) to 12° (full stall). A high-speed landing at a trim of 5° or less was stable if the model was decelerated rapidly. With less rapid decelerations the model would increase trim after landing at low trims and would take off again. Measurements of the water resistance indicated that the landing run required for the flying boat to decelerate from the landing speed to the hump speed would be decreased from 2100 feet to 1100 feet by fully retracting the step.

INTRODUCTION

It is generally known that a very shallow step on a flying-boat hull will cause violent instability because of the intermittent development of suction forces aft of the step. The present investigation was therefore undertaken in the NACA tank No. 1 to determine the landing stability characteristics when the depth of step was reduced to zero by employing a planing flap of the type investigated in reference 1. The tests of the model with zero depth of step were extended to include measurements of the resistance in order to calculate the deceleration during the landing run.

MODEL AND PROCEDURE

Views of the model, which is the same as that described in reference 1, are shown in figure 1. The dimensions are as follows:

	Assumed full-size	1/12-size model
Dimensions of hull		
Beam, maximum	14.24 ft	14.24 in.
Length of forebody	39.11 ft	39.11 in.
Length of afterbody	49.74 ft	49.74 in.
Length of tail extension	32.95 ft	32.95 in.
Length, over-all	121.80 ft	121.80 in.
Angle of forebody keel	1.3°	1.3°
Angle of afterbody keel	5.5°	5.5°
Angle of dead rise	20.0°	20.0°
Length of forebody of model with 5-percent-beam step	46.50 ft	46.50 in.
Moment of inertia	1.72×10^6 slug-ft^2	9.3 slug-ft^2
Gross load	160,000 lb	91.8 lb
Gross-load coefficient, C_{Δ_0}	0.87	0.87
Dimensions of wing		
Area	3680 sq ft	25.58 sq ft
Span	200 ft	200 in.
Root chord (NACA 23020)	28 ft	28.00 in.
Tip chord (NACA 23012)	9.33 ft	9.33 in.
Angle of wing setting with respect to base line	5.5°	5.5°
L.E. at root, aft of forward perpendicular	38.01 ft	38.01 in.
M.A.C.	20.12 ft	20.12 in.
Dimensions of horizontal tail surface		
Area	505 sq ft	3.51 sq ft
Span	41.38 ft	41.38 in.
Angle of tail setting with respect to base line	3°	3°
Dihedral	14°	14°
L.E. of wing root chord to L.E. of tail root chord	65.77 ft	65.77 in.
Root chord (NACA 0015)	14.83 ft	14.83 in.
Tip chord (NACA 0015)	9.63 ft	9.63 in.

The stability tests were made by accelerating the towing carriage until the model took off, adjusting the trim of the model while it was in the air, and then decelerating the carriage and observing the behavior of the model during the landing. The resistance tests were made by towing the model at constant speeds and measuring the total water and air resistance.

RESULTS AND DISCUSSION

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Stability tests.- Figure 2 shows the variation of trim with speed when the model was accelerated from rest to get-away speed at a constant rate of 1 foot per second per second. The trim of a similar model with a depth of step equal to 5 percent of the beam is included in figure 2(b) for comparison. A notable result obtained with zero depth of step is that the trim was not affected at any speed by more than approximately 2° when the center of gravity was shifted from 24 to 38 percent mean aerodynamic chord. Manipulating the elevators from full down to full up was also relatively ineffective in changing the trim. Even though the slipstream and the thrust were not reproduced on the model, it appears that the hydrodynamic moments would predominate throughout the landing run in controlling the trim of a flying boat with the step retracted and that the location of the center of gravity would have no great effect. The variation of trim with speed during accelerations to get-away speed was practically the same as that obtained during the decelerations after landing.

Landing tests were made with the center of gravity at 24, 30, and 38 percent mean aerodynamic chord. The model exhibited almost no tendency to skip or to porpoise when landed at any trim from about 5.5° (afterbody horizontal) up to and including a full-stall landing at 12°. After landing, the trim would decrease quickly to about 5° and, as the speed decreased, the trim would vary approximately as shown in figure 2 for take-off. When landings were made at trims below 5°, the stability characteristics depended upon the rate at which the carriage was decelerated. With a rate of deceleration of 1 foot per second per second the model increased trim after contact and left the water. With very rapid decelerations, which were not measured but were believed to be about 12 feet per second per second, the model remained on the water after landing at trims less than 5°.

Resistance tests.- The resistance of the full-size flying boat represented by the model with zero depth of step is compared in figure 3 with the resistance of a similar model having a depth of step equal to 5 percent of the beam. The resistance with zero depth is excessive for a normal take-off. For a landing the high resistance may be of value in reducing the length of the landing run.

In figure 4 the variation of deceleration on the water is plotted as a function of time after landing. The comparison of the resistances for the two depths of step was extended by calculating the time and distance required to decelerate from a landing at 84 knots to a speed of 35 knots, which is near the hump speed. The results (figs. 5 and 6) show that fully retracting the step would reduce the time from 21 seconds to 12 seconds and the distance from 2100 feet to 1100 feet.

CONCLUSIONS

A model of a flying boat was tested to determine the landing characteristics when the depth of step was reduced to zero by means of a retractable planing flap on the forebody. No investigation was made of the effect that variations in angle of dead rise and in angle of afterbody keel might have upon the stability characteristics. Some doubt also exists as to the effect that inaccuracies in the alinement of a retracted step flap would introduce. Within these limitations the results indicated that:

1. A model of a flying boat with the depth of step reduced to zero by retracting a forebody flap had exceptionally stable characteristics for landing at trims from about 5.5° (afterbody horizontal) to 12° (full stall).

2. A high-speed landing at a trim of 5° or less was stable if the model decelerated rapidly; with less rapid decelerations the model would increase trim after landing at low trims and would take off again.

3. Reduction of the depth of step to zero by retracting a forebody flap reduced the planing run between landing and hump speed by about 50 percent.

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REFERENCE

1. Benson, James M., and Lina, Lindsay J.: The Use of a Retractable Planing Flap Instead of a Fixed Step on a Seaplane. NACA ARR No. 3E31, May 1943.

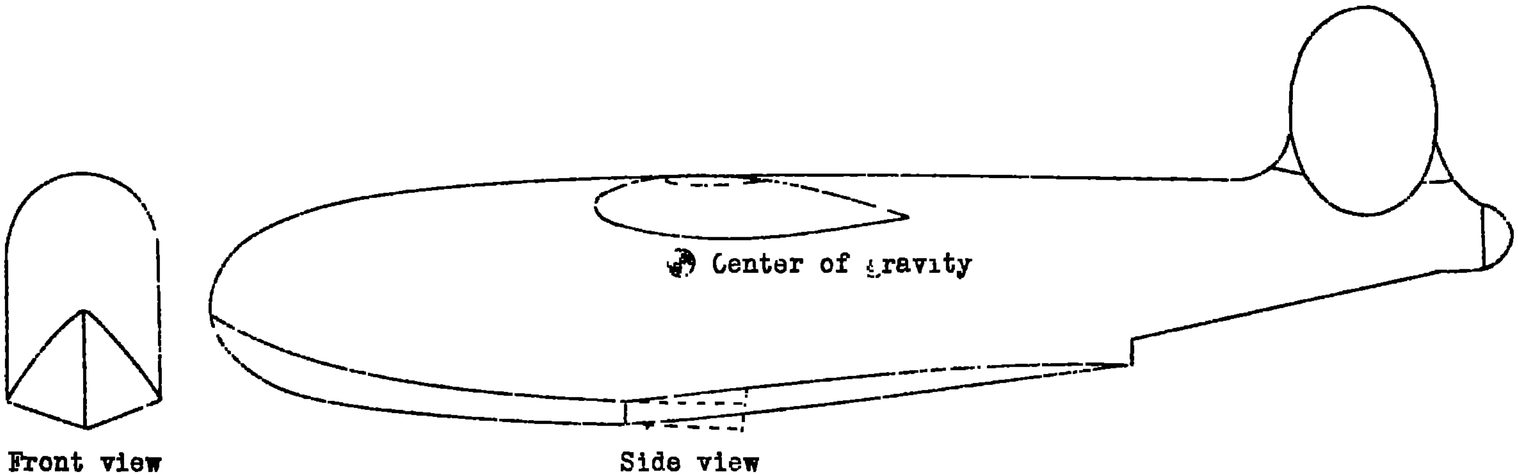
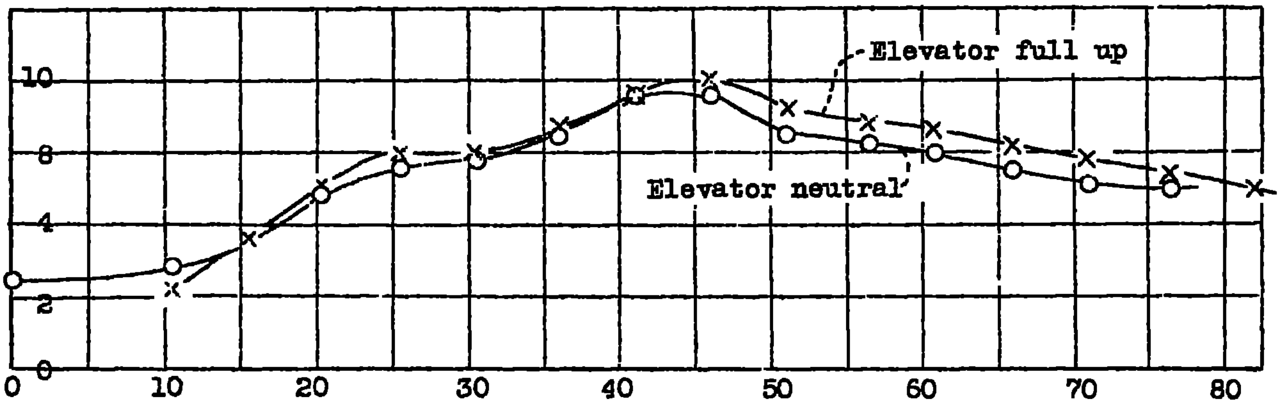
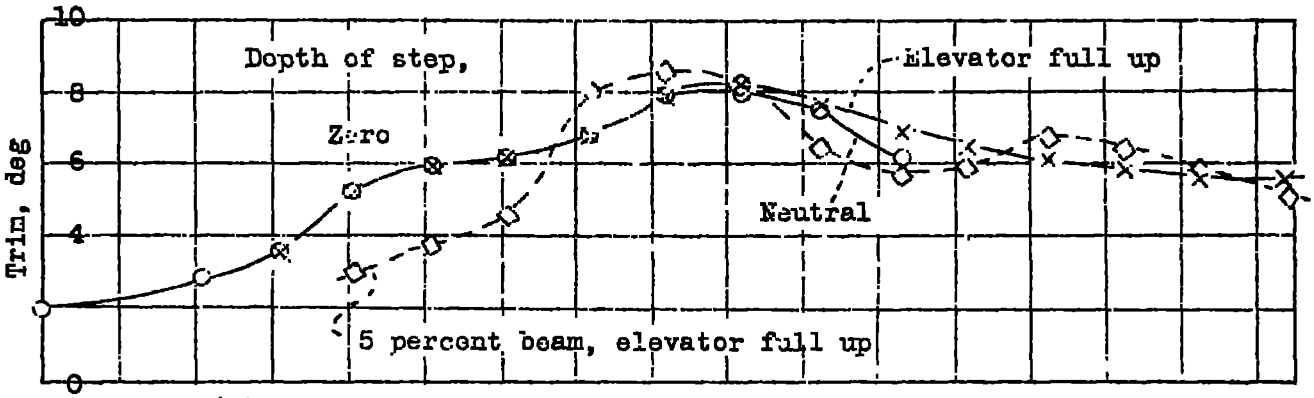


Figure 1.- Model of flying boat. Dashed lines indicate position of planing flap for normal take-off.

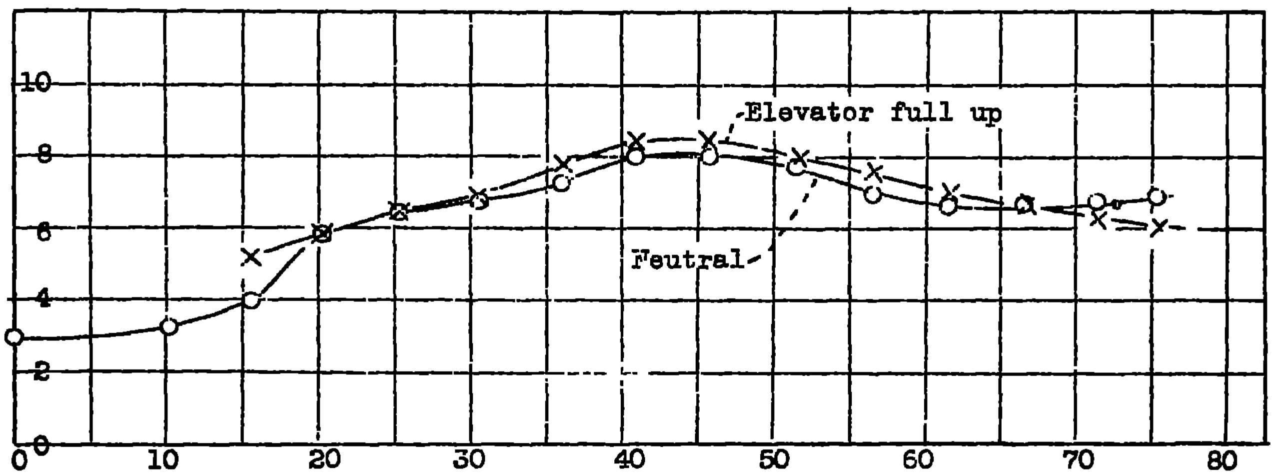


Zero depth of step

(a) Center of gravity, 24 percent M. A. C.



(b) Center of gravity, 30 percent M. A. C.



Zero depth of step

(c) Center of gravity, 38 percent M. A. C.

Figure 2.- Variation of trim with speed. Full-size; gross weight, 160,000 pounds; $C_{\Delta_0} = 0.87$.

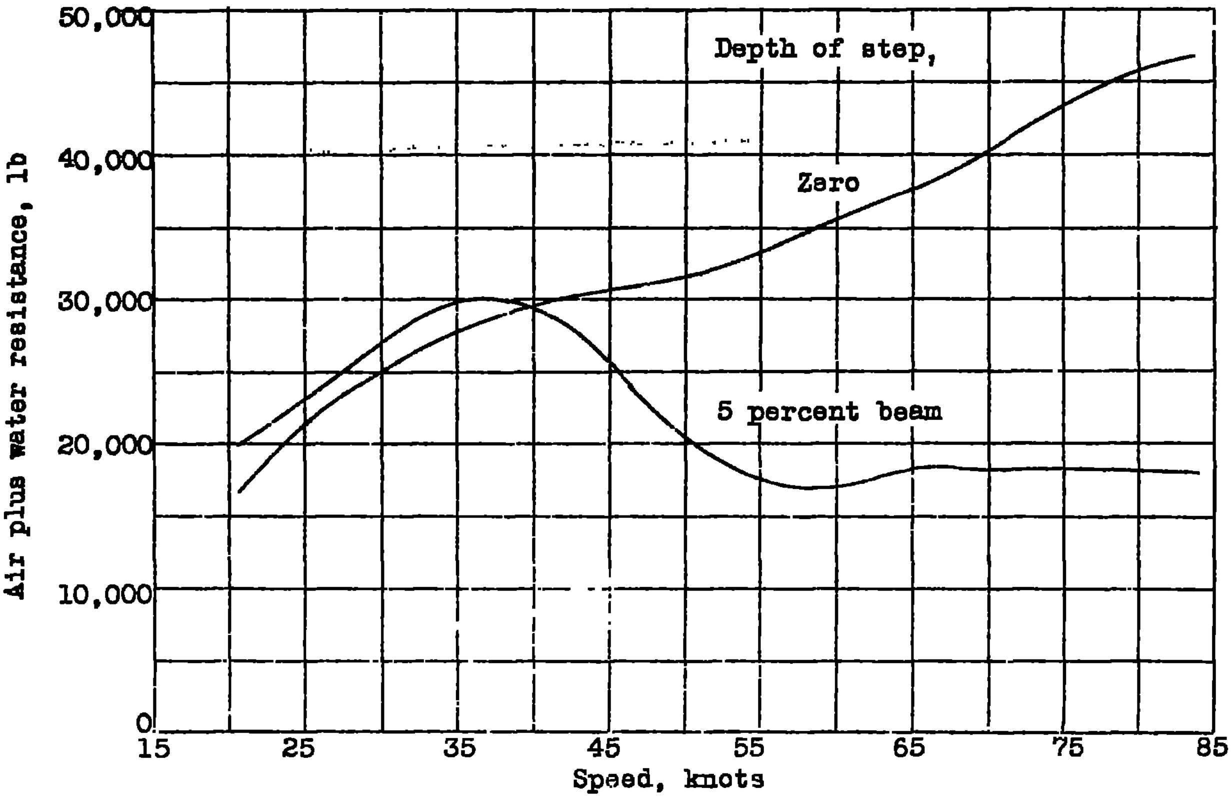


Figure 3.- Variation of total resistance with speed.

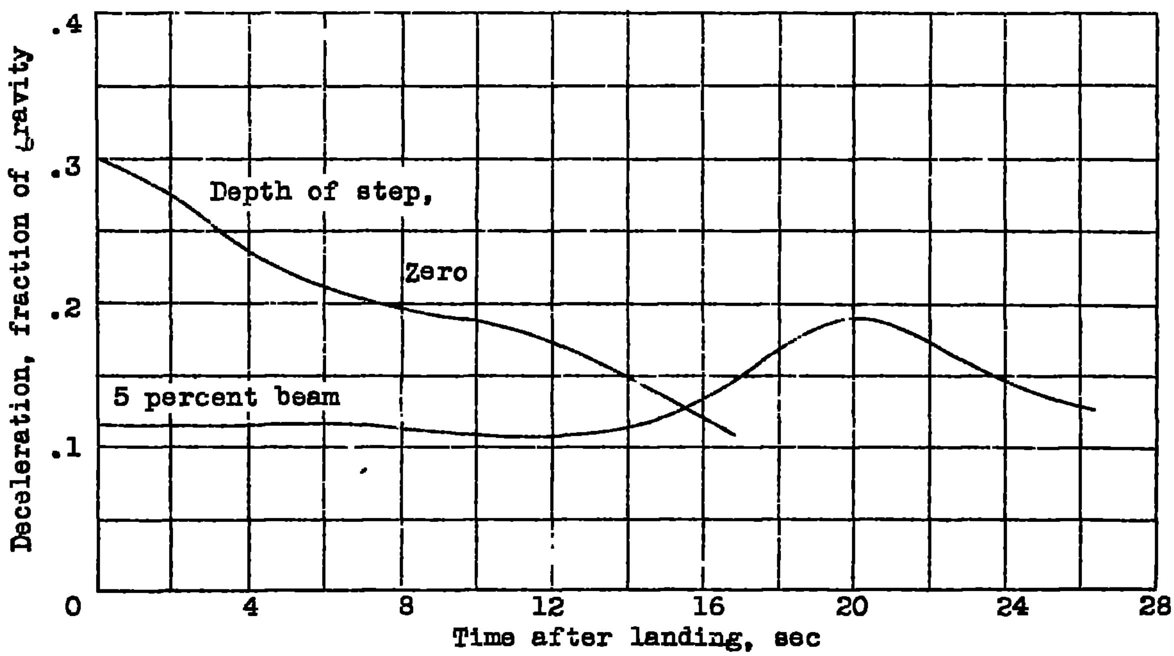


Figure 4.- Variation of deceleration with time.

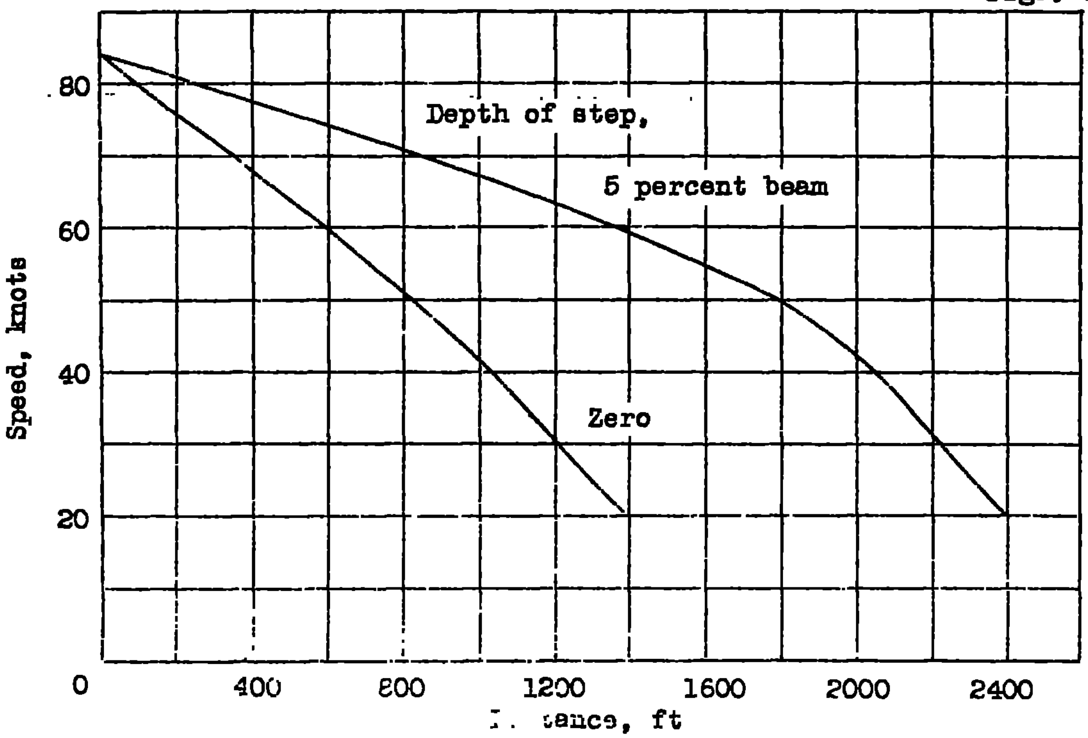


Figure 5.- Variation of speed with distance after landing.

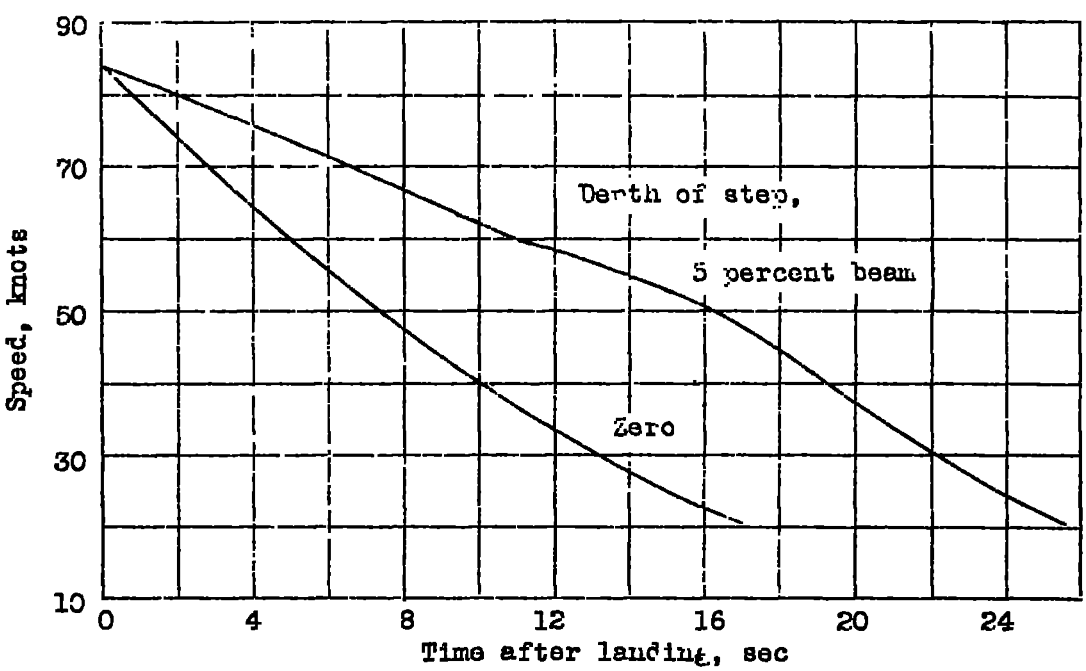


Figure 6.- Variation of speed with time after landing. Center of gravity, 30 percent M.A.C.; $C_{\Delta_0} = 0.87$.