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FLIGHT TESTS OF THE LATERAL CONTROL CHARACTERISTICS OF AN F6F-3 AIRPLANE EQUIPPED WITH SPRING-TAB AILERONS

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ADVANCE RESTRICTED REPORT

FLIGHT TESTS OF THE LATERAL CONTROL CHARACTERISTICS OF AN F6F-3 AIRPLANE EQUIPPED WITH SPRING-TAB AILERONS

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SUMMARY

Flight tests were made to determine the lateral control characteristics of an F6F-3 airplane equipped with spring-tab ailerons, which were developed by the Grumman Aircraft Engineering Corp. and have been made a production installation on F6F airplanes.

The flight tests showed that the spring-tab ailerons had desirably light stick forces and no tendency to overbalance. Although the tabs were not mass-balanced, no flutter tendencies were indicated at speeds up to 400 miles per hour, and any oscillations following abrupt control deflections were heavily damped. The spring-tab ailerons gave 80 percent higher values of effectiveness with a 30-pound stick force at 400 miles per hour than the original ailerons on the F6F-3 airplane. At speeds lower than 275 miles per hour, the spring-tab ailerons were less effective than the original ailerons because of restricted aileron travel as a result of the use of large stick deflection to deflect the spring tab. Recommendations are made for modifications that would increase the aileron effectiveness at low speeds without affecting the lateral control at high speeds. The modifications consist of increasing the available aileron deflection and modifying the spring-tab arrangement. Such an arrangement might, however, be more susceptible to flutter than the production installation.

INTRODUCTION

Flight tests were made to determine the lateral control characteristics of an F6F-3 airplane equipped with spring-tab ailerons, which were developed by the Grumman Aircraft Engineering Corp. and have been made a production installation on F6F airplanes. Considerable interest has been shown in the use of spring tabs as a means of balancing control surfaces on high-speed airplanes, because spring tabs permit light control forces to be obtained at high speeds without making the balancing action critical to small changes in control-surface contour. These advantages are obtained because the balancing action provided by a spring tab is proportional to the applied control force, and very close aerodynamic balance of the control surface is not required.

AIRPLANE AND AILERONS

The F6F-3 airplane is a low-wing, single-place, single-engine, fighter-type monoplane. A three-view drawing of the airplane is shown as figure 1. The spring-tab ailerons have a Frise type nose balance and are identical to the original F6F-3 ailerons except that a spring tab has been installed on each aileron. These spring tabs are identical in size and location to the trim tab on the original F6F-3 ailerons; in the case of the spring-tab ailerons, however, the tab on the left aileron is a combination trim and spring tab. Details of the spring-tab aileron arrangement are shown in figures 2 and 3, which were furnished by the Grumman Aircraft Engineering Corp. Dimensions pertinent to the aileron characteristics are as follows:

Wing span, feet	42.83
Aileron span (each), feet	6.375
Distance from center line of airplane to inboard end of aileron, percent semispan	64
Aileron chord, percent wing chord	20
Aileron area behind hinge line (each), square feet	7.84
Spring-tab area (each), square foot	0.466
Spring-tab span (each), feet	1.375
Stick force required to deflect spring tab 1°, pounds	1.6

No preload was used in the spring of the arrangement tested and the tabs had no mass balance. The variation of stick position with right-aileron spring-tab angle with the aileron held neutral is shown in figure 4. The tab angles are measured in degrees from the aileron. The relation between stick position and right- and left-aileron angle, with no load on the control system, is shown in figure 5. The aileron angles are referenced to neutral.

INSTRUMENTATION

Standard NACA photographic recording instruments, synchronized by an electrical timer, were used to measure airspeed, rolling velocity, aileron stick force, and the position of the spring tab, aileron, and stick. Correct service indicated airspeed V_{i_s} used herein is defined as

$$V_{i_s} = Kf_o\sqrt{q_c}$$

where

$K = 45.08$

f_o compressibility correction at sea level

q_c impact pressure, measured difference between static and total-head pressures corrected for position error, inches of water

TEST RESULTS AND DISCUSSION

Tests were made to determine whether the spring-tab ailerons tended to oscillate or flutter in the speed range to 400 miles per hour. These tests consisted of maneuvers in which the pilot abruptly deflected and released the aileron control at various speeds. Typical time histories of the maneuvers are shown in figure 6, which indicates that any oscillation of the aileron or spring tab was heavily damped and disappeared completely within two cycles. The pilot reported no flutter in the speed range up to 400 miles per hour.

The lateral control characteristics were measured in abrupt aileron rolls with the rudder held fixed as described in reference 1. These rolls were made at increments of 50 miles per hour from approximately 100 to 400 miles per hour. The results are given as the variation of helix angle pb/2V and change in aileron stick force at various speeds with the change in total aileron angle in figure 7 and with stick position in figure 8. No force data are shown in these figures for most of the end points on the $\frac{pb}{2V}$-curves because the control stick was against the stops and the forces recorded were a measure of how hard the pilot was pushing against the stops rather than a measure of the force required to deflect the ailerons. Limited stick deflections were used at 350 and 400 miles per hour in order that the structural design loads of the system would not be exceeded. Figures 7 and 8 show that the aileron stick forces are quite light and there is no tendency toward overbalance. It should be noted however that, although the end test points in figure 7 indicate partial aileron deflection, figure 8 shows that substantially full stick travel was used to obtain these aileron deflections. This condition occurs because considerable stick travel is used to deflect the spring tab.

In all flights for which data are presented herein, the transmitter of an NACA electrical control-position recorder was mounted externally on the right aileron to measure the spring-tab angles. A flight made without the transmitter, however, showed that this protuberance caused no change in the aileron characteristics. The results of the measurements of spring-tab angles during the abrupt aileron rolls are shown in figure 9 as the variation of spring-tab angle on the right aileron with deflection of that aileron. The similarity of these curves to curves of hinge-moment coefficients for a Frise type aileron, such as is used on the F6F-3 airplane, indicate that the tab angle is proportional to the stick force required to deflect the aileron. That is, for the down-aileron deflections, the large tab angles indicate little aerodynamic balance; while for the up-aileron deflections the negative tab angles tend to oppose the aileron travel, which indicates aerodynamic overbalance, until separation occurs about the nose. Separation decreases the aerodynamic balance and causes the spring tab to deflect in a direction to aid in deflecting the ailerons.

The over-all efficiency of the spring-tab ailerons is compared with that of the original F6F-3 ailerons in figures 10 and 11. These figures present, respectively, the pb/2V and the rolling velocity at an altitude of 10,000 feet obtained throughout the speed range with full stick deflection or 30-pound stick force, whichever occurred first. The data for the original ailerons were obtained from a flight investigation (unpublished) of the handling qualities of the F6F-3 airplane. These data show that the spring-tab ailerons are less effective than the original ailerons at speeds lower than approximately 275 miles per hour. The loss in effectiveness of the spring-tab ailerons is caused by the limited aileron travel, which results from the use of large stick deflection to deflect the spring tab. At speeds greater than 275 miles per hour, the effect of the lighter stick forces of the spring-tab ailerons becomes predominant and, as a result, the aileron effectiveness obtained with a 30-pound stick force at 400 miles per hour is approximately 80 percent higher with the spring-tab ailerons than the aileron effectiveness obtained with the original ailerons.

The loss in effectiveness of the spring-tab ailerons can be decreased at low speeds without affecting the desirably light stick forces at high speeds if a stiffer spring is used and if, at the same time, the length of the tab actuating arm (fig. 2) is so increased that the ratio of stick force to tab deflection is kept the same as in the spring-tab aileron tested. In this suggested arrangement, the stick deflection required for full tab deflection would be decreased and this decrease would allow larger aileron deflection. Such an arrangement, however, might make the tab installation more susceptible to flutter (reference 2); that is, the tab would have a greater mechanical advantage over the control system than the spring-tab tested and, therefore, inertia effects of the tab would be more likely to cause flutter. Further increases in aileron effectiveness at the lower speeds could be accomplished by increasing the down-aileron deflection to the same value as the present up-aileron deflection. Increases in the up-aileron deflection are not recommended, however, since figure 9 indicates flow separation about the nose balance and any increase in up-aileron deflection might therefore result in aileron buffet at full deflection. Although the increase in down-aileron deflection might result in somewhat higher stick forces throughout the speed range, some reduction could be made in the spring stiffness to reduce the stick forces to the present values and, at the same time, retain increased aileron effectiveness at low speeds.

CONCLUSIONS

Flight tests to determine the lateral control characteristics of an F6F-3 airplane equipped with spring-tab ailerons indicated the following conclusions:

1. The spring-tab ailerons on the F6F-3 airplane showed no tendency to flutter in the speed range up to 430 miles per hour, and any oscillations following abrupt control deflection were heavily damped.

2. The spring-tab ailerons had desirably light stick forces without any tendency to overbalance.

3. The spring-tab ailerons gave 80 percent higher values of effectiveness with a 30-pound stick force at 400 miles per hour than the original F6F-3 ailerons. At speeds lower than 275 miles per hour, the spring-tab ailerons had less effectiveness than the original ailerons because of restricted aileron travel as a result of the use of large stick deflection to deflect the spring tab.

4. The available aileron effectiveness with the spring-tab ailerons at the lower speeds could be increased without affecting high-speed lateral control by an increase in the available aileron deflection and a modification of the spring-tab arrangement. Such an arrangement might, however, be more susceptible to flutter than the production installation.

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National Advisory Committee for Aeronautics
Langley Field, Va.

REFERENCES

1. Johnson, Harold I.: NACA Procedure for Flight Tests of Aileron Characteristics of Airplanes. NACA RB No. 3G24, 1943.

2. Collar, A. R.: The Prevention of Flutter of Spring Tabs. Rep. No. S.M.E. 3249, British R.A.E., May 1943.

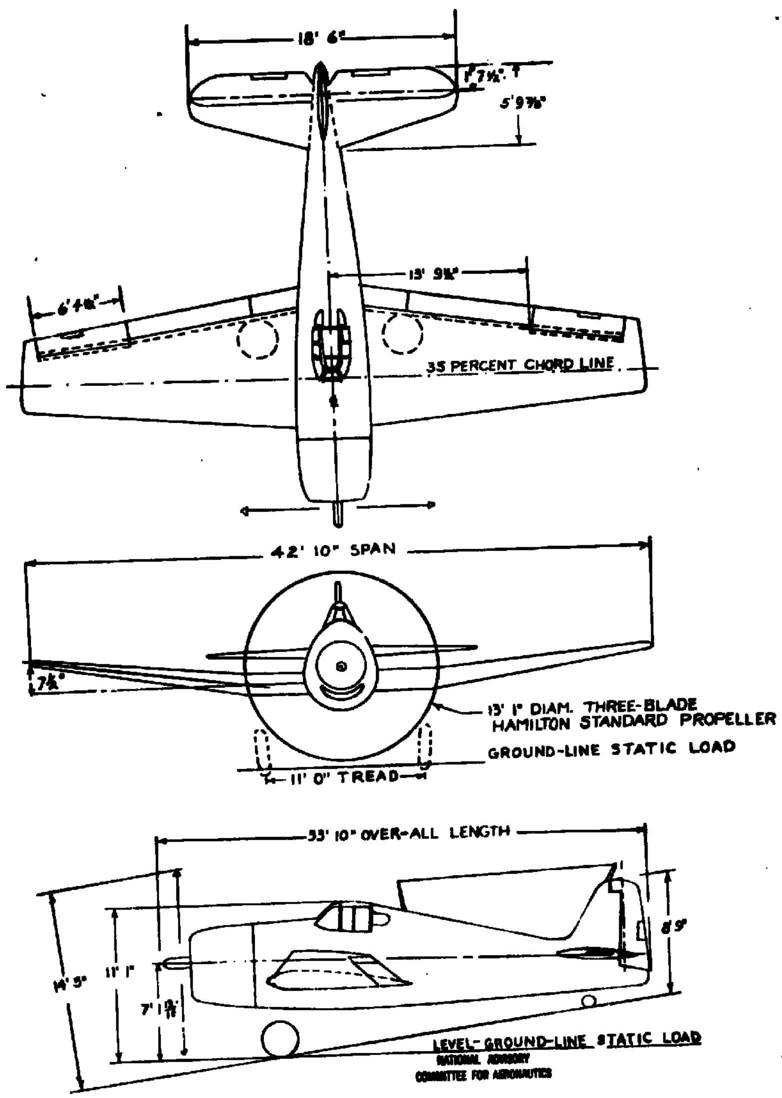

Figure 1.- Three-view drawing of F6F-3 airplane.

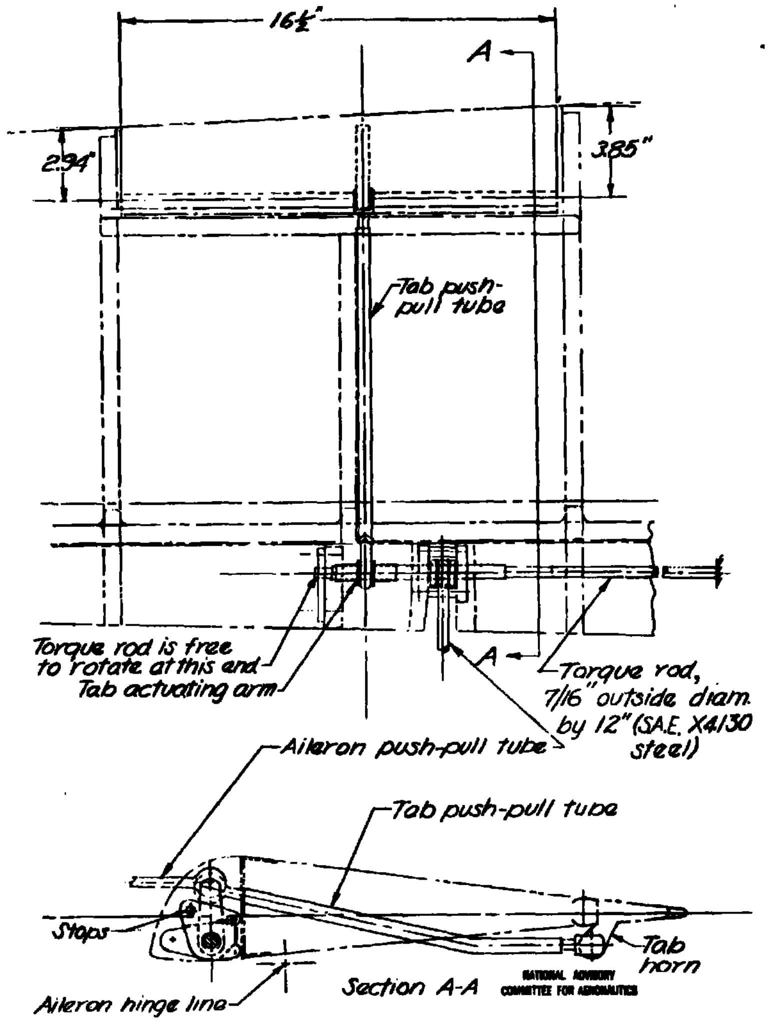

Figure 2.- Spring-tab-aileron arrangement of F6F-3 airplane. (Data furnished by Grumman Aircraft Engineering Corp.)

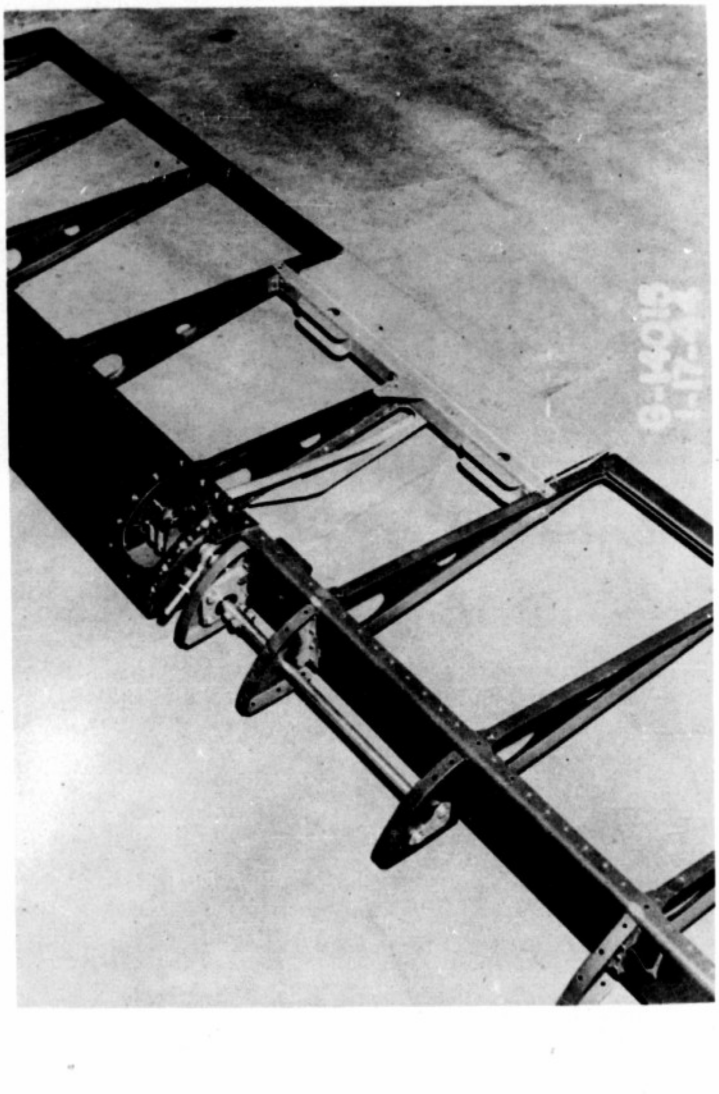

Figure 3.- Detail view of right spring-tab aileron. F6F-3 airplane.
(Photograph furnished by Grumman Aircraft Engineering Corp.)

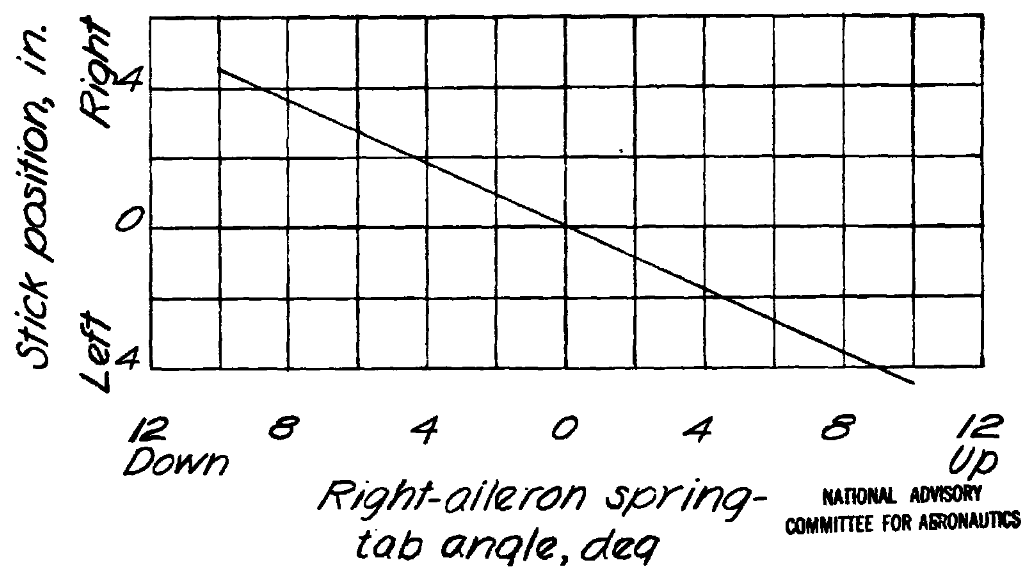

Figure 4.- Variation of stick position with right-aileron spring-tab angle. F6F-3 airplane; ailerons held neutral.

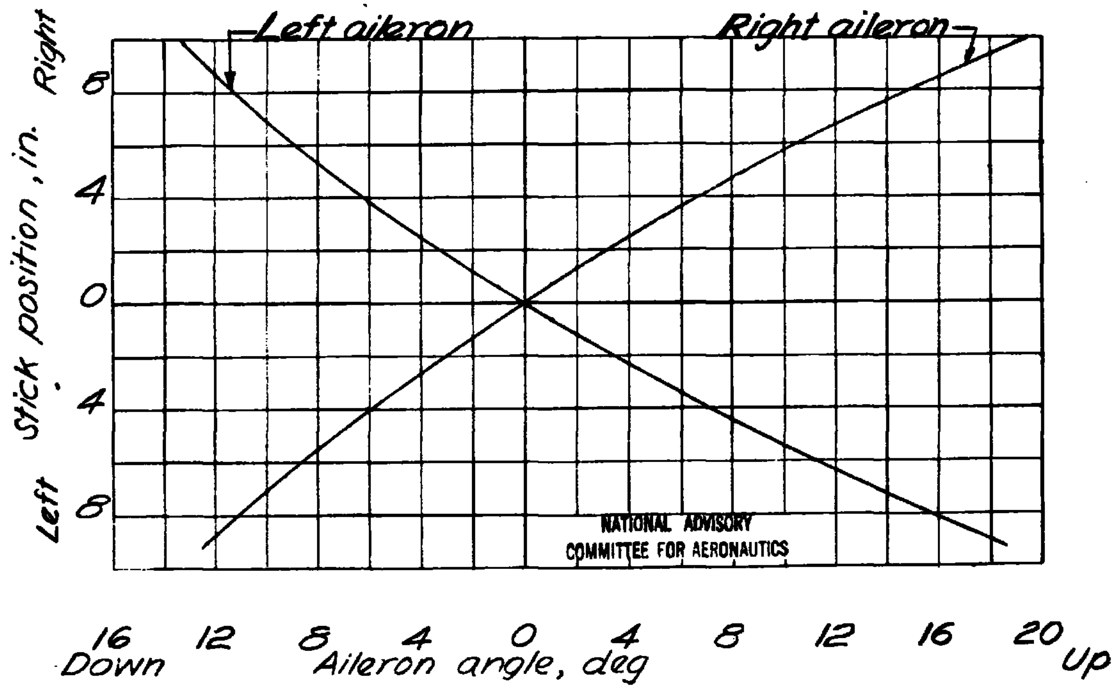

Figure 5.- Variation of stick position with left- and right-aileron angles. F6F-3 airplane with spring-tab ailerons; n^ load on control system.

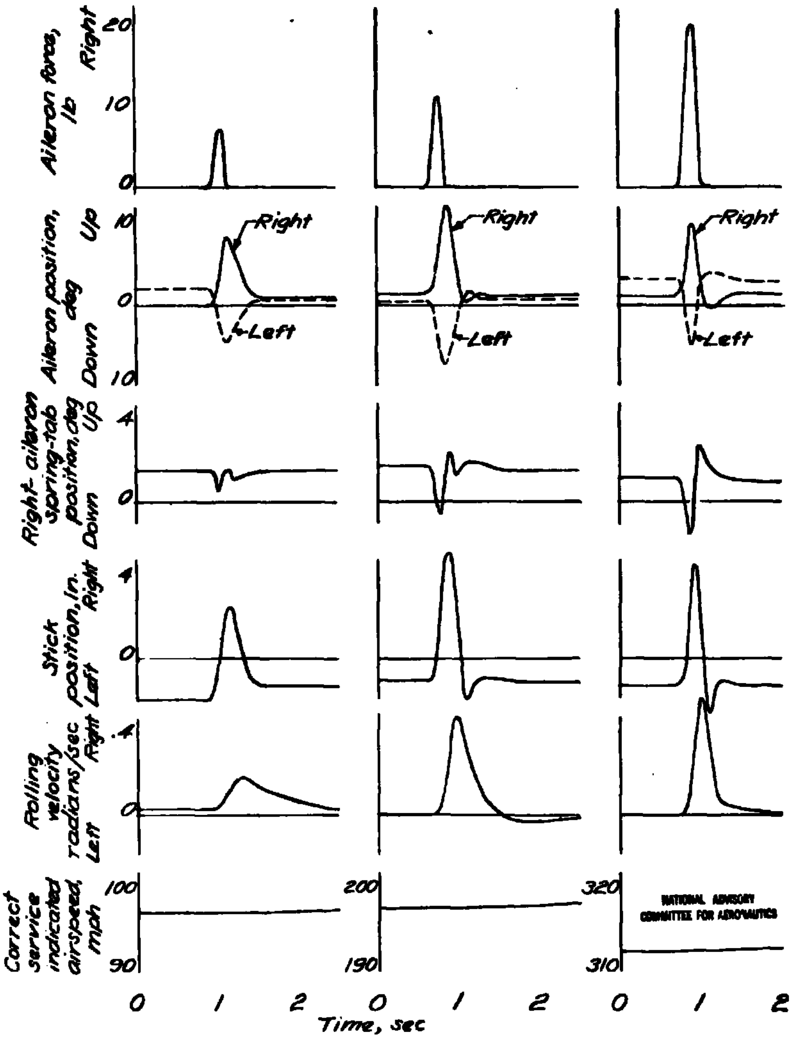

Figure 6.- Time histories of typical attempted aileron oscillations following abrupt deflection of control. F6F-3 airplane with spring-tab ailerons.

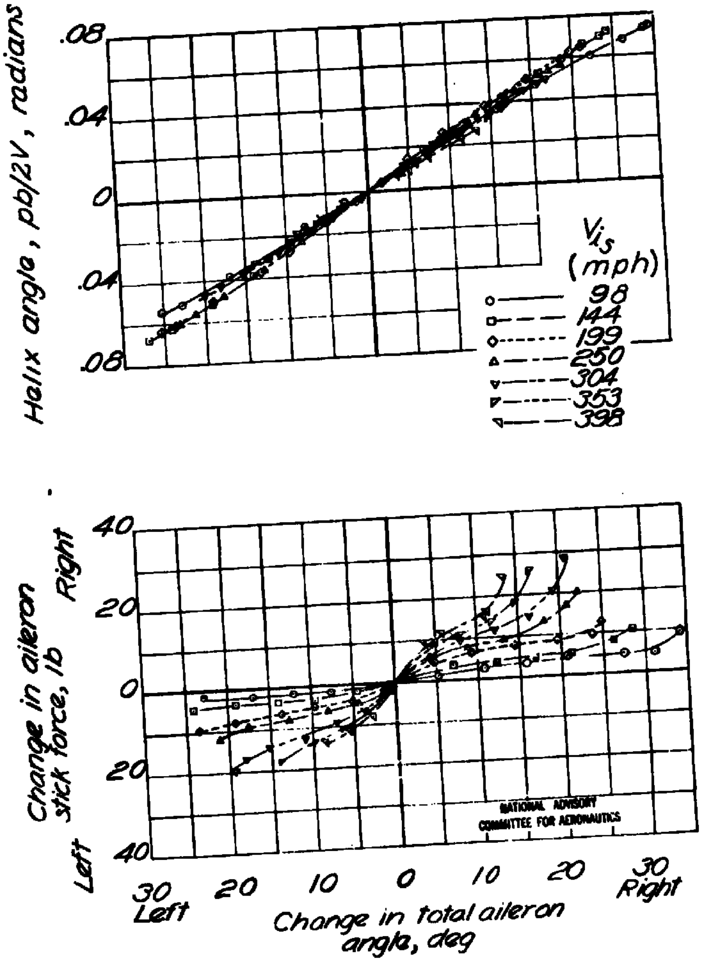

Figure 7.- Variation of pb/2V and change in aileron stick force with change in total aileron angle. F6F-3 airplane with spring-tab ailerons.

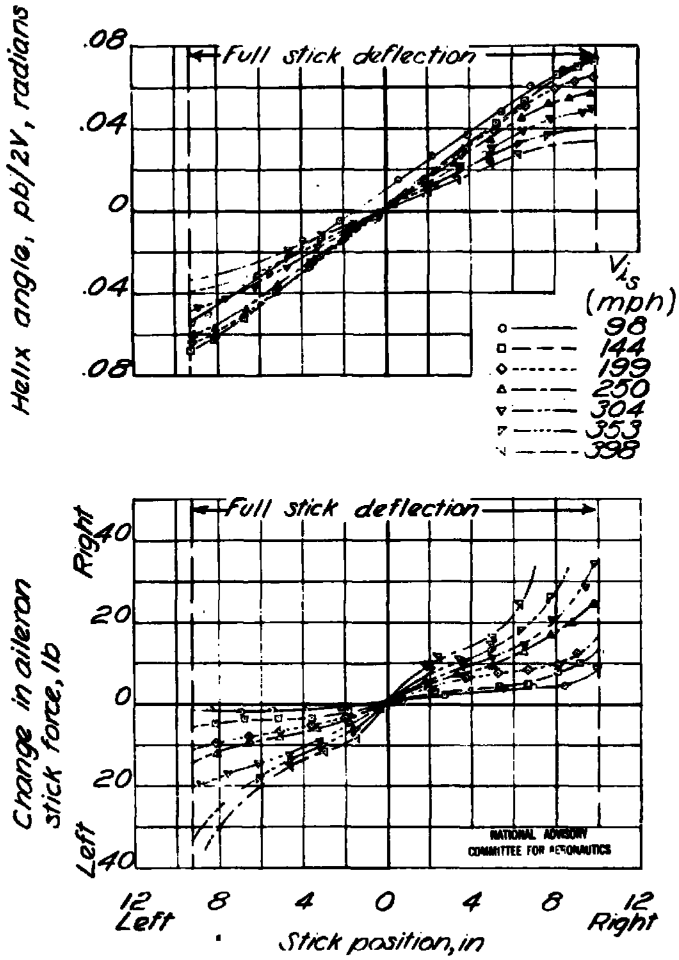

Figure 8.- Variation of pb/2V and change in aileron stick force with stick position. F6F-3 airplane with spring-tab ailerons.

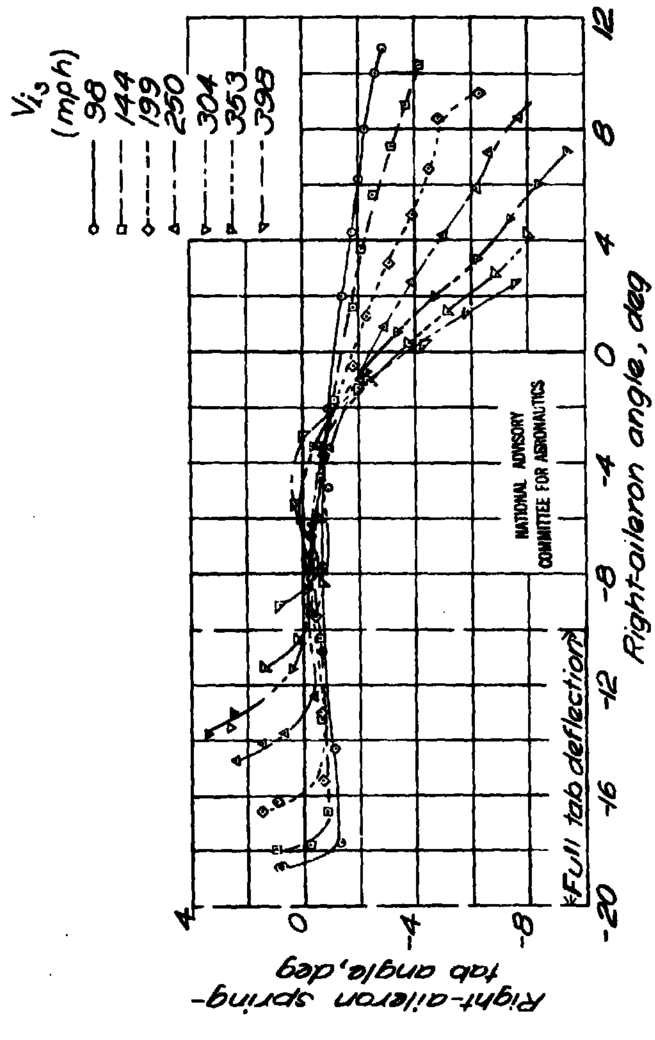

Figure 9.- Variation of right-aileron spring-tab angle with right-aileron angle in abrupt aileron rolls. F6F-3 airplane.

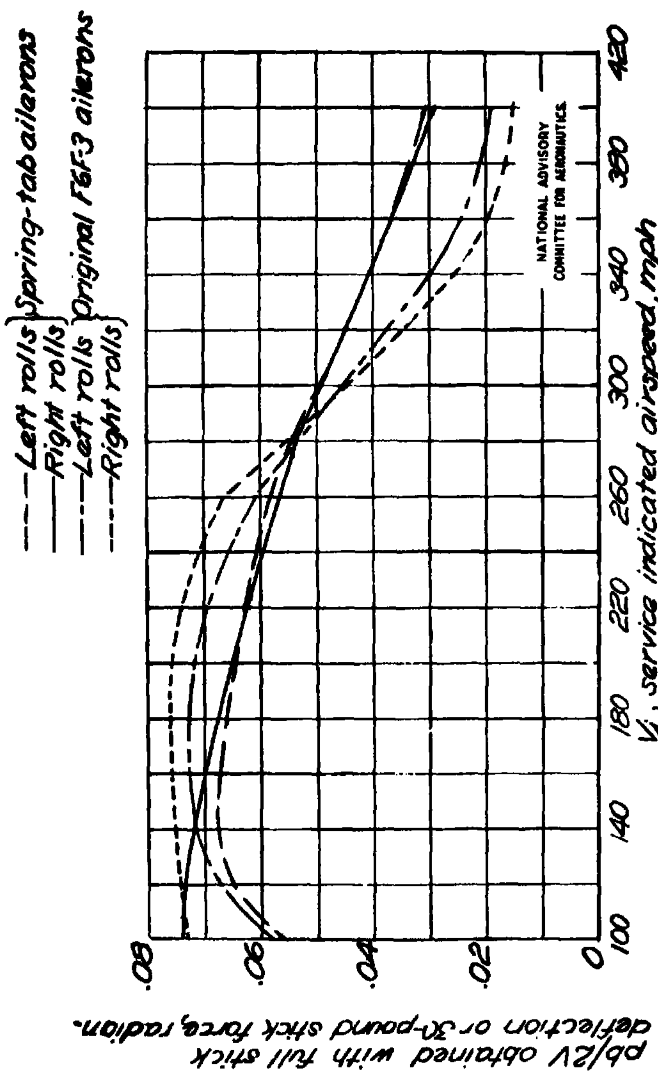

Figure 10.- Variation with correct service indicated airspeed of pb/2V obtained with full stick deflection or 30-pound stick force, whichever occurs first. F6F-3 airplane with spring-tab ailerons and with original F6F-3 ailerons.

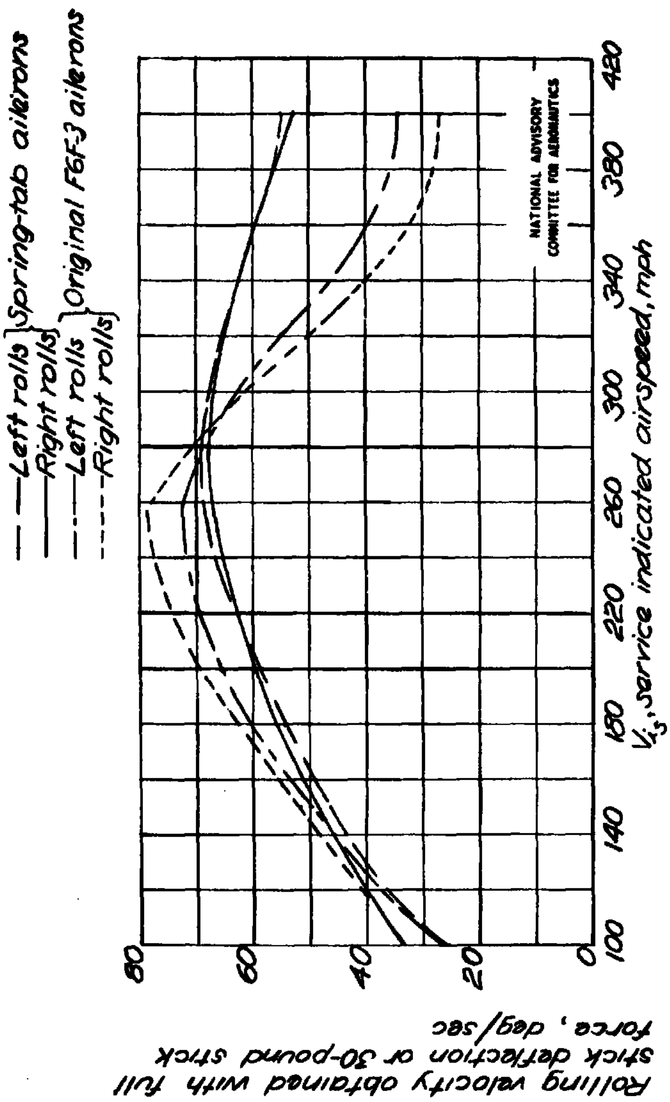

Figure 11.- Variation with correct service indicated airspeed of rolling velocity obtained at an altitude of 10,000 feet with full stick deflection or 30-pound stick force, whichever occurs first. F6F-3 airplane with spring-tab ailerons and with original F6F-3 ailerons.

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151

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