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FLIGHT MEASUREMENTS OF THE FLYING QUALITIES OF AN F6F-3 AIRPLANE (BUAER NO. 04776)

II - LATERAL AND DIRECTIONAL STABILITY AND CONTROL

By Walter C. Williams and John P. Reeder

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NACA

WASHINGTON

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

MEMORANDUM REPORT

for the

Bureau of Aeronautics, Navy Department

FLIGHT MEASUREMENTS OF THE FLYING QUALITIES OF AN F6F-3 AIRPLANE (BUAER NO. 04776)

II - LATERAL AND DIRECTIONAL STABILITY AND CONTROL

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INTRODUCTION

At the request of the Bureau of Aeronautics, Navy Department, flight measurements were made of the flying qualities of an F6F-3 airplane. The results of measurements of the longitudinal stability and control are presented in reference 1. The present paper gives results of tests made to determine the lateral and directional stability and control of the subject airplane. The tests covering the stalling characteristics of the F6F-3 airplane will be described in a third report. This test program was conducted at the Langley Field laboratory of the National Advisory Committee for Aeronautics.

AIRPLANE

A three-view layout of the F6F-3 airplane is shown in figure 1. Pertinent details and dimensions of the F6F-3 airplane are given in reference 1. The relation between control-surface deflection and stick and rudder pedal position is shown in figure 2 for the rudder and aileron controls. Rudder angles are measured in degrees from the fin and aileron angles are referenced to neutral. Trim-tab angles are given in degrees from the control surface. Sections of the rudder are given in figure 3. Figure 4 gives aileron sections. Section letters on figures 3 and 4 correspond to the sections shown on figure 1. The products of the span and chord squared, on

which hinge-moment coefficients presented herein for the aileron and rudder are based, are as follows:

Aileron (each) 9.83 ft^3

Rudder 13.51 ft^3

Values of friction forces in the aileron and rudder control systems near neutral were found to be approximately ±2 pounds and ±15 pounds, respectively.

INSTRUMENTATION

Standard NACA photographically recording instruments were used to measure the various quantities necessary to determine the flying qualities of the subject airplane. A detailed description of the instrumentation used in the present tests is given in reference 1.

TESTS, RESULTS, AND DISCUSSION

The various flight conditions used in the present tests are defined below.

Condition	Flaps	Landing gear	Canopy	Cowl flaps	Oil and intercooler shutters	RPM	Manifold pressure (in.Hg)
Gliding	Up	Up	Closed	Closed	Closed	Engine idling	
Climbing	Up	Up	Closed	Closed	Closed	2550	43
Landing	Down	Down	Open	Closed	Closed	Engine idling	
Wave-off	Down	Down	Open	Open	Open	2550	43

The gross weight of the airplane for the present tests was approximately 11,200 pounds at take-off. The tests were conducted at altitudes ranging from 5000 to 10,000 feet.

As in reference 1, the results are presented and analyzed in the order given in reference 2 with mention made of the specific requirements of reference 3.

II. Requirements for Lateral Stability and Control

II-A. Characteristics of uncontrolled lateral and directional motion

The characteristics of the uncontrolled lateral and directional motion were determined in the speed range from 100 to 300 miles per hour for the gliding condition and climbing condition. In these tests the airplane was trimmed for laterally level flight and continuous records were taken while the pilot abruptly deflected the rudder, then released all controls. Typical time histories of this maneuver are shown in figures 5 and 6. The variation of the period of the lateral oscillation with service indicated airspeed is shown in figure 7. It can be seen, on figures 5 and 6, that the short-period lateral oscillations damped to half amplitude within two cycles, satisfying the requirements. Figure 6, however, shows that a lateral oscillation of small amplitude continued and was poorly damped. This oscillation was noticed by the pilots and was considered objectionable.

The pilot attempted to obtain short-period aileron oscillations by abruptly deflecting the ailerons, then releasing all controls, but there was no ensuing oscillation of the aileron system itself.

II-B. Aileron-control characteristics (rudder fixed)

The aileron-control characteristics were measured in abrupt aileron rolls made from laterally level flight with the rudder held fixed. Aileron rolls were made with the airplane in the clean condition with power for level flight at approximately 50 miles per hour, increments from 100 to 400 miles per hour, indicated airspeed.

Figures 8 and 9 give time histories of typical aileron rolls made from laterally level flight. It should be noted that where the use of full aileron deflection is indicated, as in figure 9, the aileron stick force shown is not a true measure of the force required to deflect the ailerons as the stick is against the stops. The data obtained from the aileron rolls were evaluated to determine the variation of aileron effectiveness $pb/2V$ and change in aileron stick force with change in total aileron angle. These data are presented on figure 10. From these data, it was possible to determine the helix angle, $pb/2V$, and

rolling velocity obtainable with any stick force through the speed range of the tests. Figure 11 gives the values of pb/2V obtainable with a 30-pound stick force as a function of speed. The Navy and NACA requirements of values of pb/2V of 0.08 and 0.07, respectively, up to 80 percent of the maximum level-flight indicated airspeed (reference 2 and 3) are also shown on this figure. Figure 12 shows the rolling velocity obtained at 10,000 feet altitude with a 30-pound stick force through the speed range. The Navy requirement of a rolling velocity of 30° per second at 400 miles per hour indicated airspeed is shown on this figure.

The data obtained reveal the following facts about the aileron control characteristics of the F6F-3 airplane:

1. At any given speed, the maximum rolling velocity obtained by abrupt use of ailerons varied smoothly with aileron deflection.

2. The variation of rolling acceleration with time was in the correct direction following an abrupt aileron deflection and no lag was evident in developing the rolling moment.

3. The aileron effectiveness (pb/2V per degree aileron deflection) at 100 miles per hour was approximately 80 percent of that obtained at 200 miles per hour, the decrease being caused by adverse aileron yaw.

4. Because of the low values of pb/2V obtained in the level-flight speed range, the aileron control of the F6F-3 fails to meet the Navy requirement (Requirement F-9, reference 2) that specifies a value of pb/2V of 0.08 at speeds between 140 percent of the stalling speed and 80 percent of the maximum level-flight speed. (See fig. 11.) Requirement F-9 of reference 1 also states that fighter-type airplane should have ailerons capable of developing a rolling velocity of 30° per second at 400 miles per hour with a stick force of 30 pounds. Inspection of figure 44 shows that the F6F-3 met this requirement when the average of left and right rolls is considered.

5. The F6F-3 ailerons met the NACA minimum requirement of a value of pb/2V of 0.07 up to

80 percent of the maximum level-flight speed except in rolls to the left below 130 miles per hour. (See fig. 11.)

6. The value of K, aileron effectiveness factor (reference 4), was calculated for the F6F-3 and was found to be 0.495 which is unusually high for this type aileron.

7. The average value of $dC_h/d\delta$ for the left and right ailerons was approximately -0.0028 per degree. In this instance, C_h represents the overall hinge-moment coefficient as affected by deflection and by the response of the airplane in a steady roll. This value of $dC_h/d\delta$ is comparable to the hinge-moment coefficients of other current fighter-type airplanes.

8. The stretch in the aileron-control system in flight was determined by measuring simultaneously the angles of the ailerons and the control stick. The reduction in total aileron angle, due to stretch, was approximately 0.7° per 10 pounds of stick force which meets the Navy requirement for control system rigidity.

II-C. Sideslip due to ailerons (rudder fixed)

The sideslip due to ailerons was measured in the abrupt aileron rolls from laterally level flight described above and in abrupt rolls out of turns with the rudder held fixed. The latter maneuver has been adopted as standard practice at Langley for measuring sideslip due to ailerons because it has been found difficult to obtain maximum sideslip angle in a roll from laterally level flight, since the airplane usually reaches an extreme angle of bank before maximum sideslip angle is reached. In the present instance, it was possible to reach maximum sideslip angle in right rolls from laterally level flight. Figures 8 and 9 illustrate rolls from laterally level flight. Rolls out of turns are shown in figures 13, 14, and 15. Figure 16 shows the change in maximum sideslip angle as a function of change in total aileron angle in abrupt rolls made from laterally level flight at 98 miles per hour. Inspection of these figures shows that the use of full aileron deflection at approximately 100 miles per hour will result in approximately 18.5° of sideslip

in left rolls and 23.5° in right rolls which exceeds the specified maximum of 20°. The sideslip in right rolls is larger because of the greater available change in total aileron angle to the right at low speeds. In figure 16, maximum sideslip in left rolls with partial aileron deflection was not reached and is probably higher than the curve shown because of the decrease in directional stability at small angles of left sideslip which is discussed in section II-F. This decrease in directional stability at small sideslip angles was objectionable to the pilots because of the relatively large sideslip caused by use of partial aileron deflections.

II-D. Limits of rolling moment due to sideslip (dihedral effect)

The rolling moment due to sideslip was measured in gradually increasing sideslips which were made by slowly deflecting the rudder using the ailerons and elevators to maintain straight flight. A measure of the dihedral effect was obtained from the variation of total aileron angle with sideslip angle. Sideslips were made at various speeds in the landing, wave-off, gliding, and climbing conditions. The data are presented in figures 17 to 30. In these figures rudder, elevator, and aileron forces and deflections and the angle of bank are plotted as functions of sideslip angle. Figures 17 and 18 pertain to the landing condition and data for the wave-off condition are presented in figures 19 and 20. Data for the gliding and climbing condition are shown in figures 21 through 25 and figures 26 through 30, respectively. Additional sideslips were made at a later date in the landing and wave-off condition with control-position recorders installed to measure the landing flap blow-up characteristics. The flaps of the F6F-3 are in four segments which are spring-loaded and blow up independently of each other under aerodynamic loads. A detailed description of this flap arrangement is given in reference 1. During the aforementioned tests the airplane was equipped with an experimental spring tab rudder. The data obtained are shown in figures 31 through 34 where the angle of the four segments of the flaps and the rudder position are plotted as functions of the sideslip angle. Figures 31 and 32 apply to the landing condition and figures 33 and 34 show data for the wave-off condition. Another measure of the dihedral effect was obtained from rudder kicks in which the pilot deflected and held the rudder at a given position, holding the ailerons fixed at trim. Typical time histories of this maneuver are shown

in figure 35. The data obtained were used to determine the variation of maximum yawing and rolling velocity and maximum change in sideslip angle with change in rudder angle. These results are shown in figure 36.

Using the preceding data, the following may be concluded concerning the dihedral effect of the F6F-3 airplane:

1. There was positive dihedral effect in all conditions tested as indicated by the variation of aileron deflection with sideslip. The dihedral effect was positive in the wave-off condition at low speeds and was unusually large in the other flight conditions. The effective dihedral was calculated in the wave-off condition at 84 miles per hour and in the climbing condition at 300 miles per hour. The values of effective dihedral were 1.7° and 5.1°, respectively. The pilots found the large rolling moment due to sideslip objectionable in high-speed flight because of the low directional stability at high speeds. This latter item is discussed under section II-F.

2. The aileron control forces in sideslips was sufficient to return the control to neutral only at the higher speeds tested. At the lower speeds, there was little or no variation of aileron force with sideslip angle, the forces being less than the friction forces.

3. The blow-up characteristics of the landing flaps are such as to cause greater dihedral effect in the wave-off condition than would be obtained if the flaps were held in a fixed full-down position. With flaps that are held rigidly in the down position, dihedral effect is greatly reduced in the wave-off condition because of the additional lift on the trailing wing as the slipstream moves out over the wing with increasing sideslip angle. In the present instance, however, the destabilizing effect is decreased because the flap deflection is reduced by the slipstream over the trailing wing, which decreases the lift on that wing and causes more positive dihedral effect. Unpublished wind-tunnel tests of an F6F-3 model showed that in the wave-off condition at a lift coefficient of 1.46, which corresponds to a speed of approximately 90 miles per hour, the effective

dihedral with the flaps held fixed was 2.6°, while with the flap deflection varying with sideslip angle in the same manner as in the flight tests, the effective dihedral was 3.5°.

4. The rolling moment due to sideslip was never so great that a reversal of rolling velocity occurred as a result of sideslip due to ailerons. There was, however, a reduction in aileron effectiveness at low speeds (section II-B) which could be attributed to the large positive dihedral effect.

5. The use of rudder alone will result in considerable rolling velocity because of the large positive dihedral effect. For example, 6° change in rudder angle at 99 miles per hour will result in approximately the same rolling velocity as 20° change in total aileron angle. (See figs. 8 and 36.) Pilots, however, do not like to obtain rolling motion by use of the rudder mainly because of the greater lag between movement of the control and the resultant rolling motion of the airplane when the rudder, rather than the ailerons, is used.

II-E. Rudder-control characteristics

1. The power of the rudder in overcoming adverse aileron yaw was determined in rolls out of turns. Rolls were made where the pilot used less rudder deflection than he thought necessary to overcome adverse yaw and where the pilot used more rudder than he thought necessary to overcome adverse yaw. These maneuvers were made in the clean condition with power for level flight. Typical maneuvers of this type are shown in figures 37 to 40. It can be seen from inspection of these figures that 15° of rudder deflection is sufficient to maintain zero sideslip while using full aileron deflection at approximately 105 miles per hour. The change in rudder force is considerable (154 pounds) but is within the specified limit of 180 pounds (references 2 and 3).

2. The rudder control was sufficiently powerful to maintain directional control during take-off and landing. Time histories of a landing and take-off are shown in reference 1.

3. No tests were made to determine the spin-recovery characteristics of the F6F-3 airplane.

4. As shown by figures 16 to 29 right-rudder force was required to hold right-rudder deflections and left-rudder force was required to hold left-rudder deflections.

5. The hinge-moment coefficients C_{h_δ} and C_{h_α} of the rudder were estimated from the sideslip data and the data from the rudder kicks. C_{h_δ} is estimated to be -0.0054. C_{h_α} varied from a small negative value at 100 miles per hour to about 0.0011 at 300 miles per hour. In determining this value the change of angle of attack of the tail was assumed to equal the change in sideslip angle.

II-F. Yawing moment due to sideslip (directional stability)

1. As it is stated in paragraph II-C, the yawing moments due to sideslip (rudder fixed) were insufficient to restrict the sideslip due to use of ailerons to less than the specified limit of 20° in rolls to the right at approximately 100 miles per hour. The sideslip due to use of ailerons in left rolls at approximately 100 miles per hour was 18.5°.

2. The yawing moment due to sideslip was always in the correct direction indicating positive directional stability (rudder fixed); that is, right-rudder deflection was required to hold left sideslip, and left-rudder deflection was required to hold right sideslip. The rudder deflection did not vary linearly with sideslip angle. In the wave-off condition there is a marked decrease in directional stability for approximately 5° each side of the sideslip required for laterally level flight. The directional stability in the climbing and gliding condition is also decreased in the same manner as shown by the curves of rudder position versus sideslip angle. This decrease in directional stability at small angles of sideslips at low speeds is also shown in figure 16 by the nonlinearity of the curve of maximum sideslip angle due to use of the ailerons in abrupt rolls from laterally level flight in the clean condition with

power for level flight at approximately 98 miles per hour; and as stated in section II-C, the sideslip to the left may be quite large for partial aileron deflections. The decrease in directional stability for small rudder deflections at high speed is also illustrated in figure 36 by the increase in slope with speed of the curves of sideslip angle versus rudder position obtained in abrupt rudder kicks. This decrease in directional stability at small angles of sideslip may be one reason for the poor damping of the small-amplitude lateral oscillations even though the large oscillations are well damped (see section II-A). This decrease in directional stability at small angles of sideslip, in conjunction with the large positive dihedral effect, also makes it difficult for the pilot to maintain steady flight at high speeds.

3. The yawing moment due to sideslip (rudder free) was found to be such that the airplane would always tend to return to zero sideslip, regardless of the angle of sideslip to which it was forced in all conditions of flight tested. In the wave-off condition, however, there was reversal in the slope of the rudder force curves as can be seen by inspection of figures 19 and 20.

4. The directional trim characteristics were determined by measuring the rudder forces and angles required to trim at various speeds. These data are presented in figure 41 as the variation of rudder force and angle with indicated airspeed for various flight conditions. Figure 41 also shows the variation of aileron angle and force, and sideslip angle with indicated airspeed. There is no requirement specified for the change in rudder trim force with speed, but the pilots felt that in the case of the F6F-3 these changes in force were excessive. The pilots also reported a rudder shake which was present throughout the speed range in all flight conditions, which may be caused by a turbulent flow behind the elevator cutout.

5. The rudder trim force changes caused by changes in flight configuration at speed of 104 miles per hour are presented in table I. For these tests, the pilot used a given trim-tab setting as the flight configuration was changed and measurements were made

of the control force required to trim. Inspection of this table shows that the permissible rudder pedal force of 180 pounds was not exceeded.

II-G. Cross-wind force characteristics

The variation of cross-wind force with sideslip angle was in the correct direction; that is, right bank accompanied right sideslip and left bank accompanied left sideslip as shown by figures 17 to 30.

II-H. Pitching moment due to sideslip

The pitching moment due to sideslip is such that at the lowest speeds tested in each condition, except climbing, less than 1° of elevator movement is required to maintain longitudinal trim when the rudder is moved 5° right or left from its position for straight flight.

II-I. Power of rudder and aileron trimming devices

The power of the rudder trim tabs was measured in a manner similar to that used to determine the power of the elevator tabs. Measurements were made in the gliding and climbing condition. Figure 41 shows the variation of rudder pedal force with speed for two trim-tab settings in the gliding and climbing condition. The data were used to determine the change in rudder pedal force per degree trim-tab deflection. This factor is plotted as a function of indicated airspeed in figure 42.

From the data shown on figures 41 and 43, the following may be concluded regarding the power of the rudder trim tab of the F6F-3 airplane:

1. The rudder pedal force could not be trimmed to zero below approximately 155 miles per hour in the climbing condition.

2. The rudder trim tab was adequate in the gliding condition from approximately 100 miles per hour to the highest speeds tested.

3. The rudder pedal force could not be trimmed to zero with full deflection of the trim tab in either the approach or wave-off condition in the speed range tested.

4. The trim tab was sufficiently powerful in the landing condition to trim the rudder pedal forces to zero at 100 miles per hour with approximately half tab deflection.

5. In the gliding and climbing condition, deflection of the rudder tab caused no change in pedal force below 100 miles per hour.

6. At 280 miles per hour, 1° deflection of the trim tab caused a change in rudder hinge-moment coefficient of 0.0019.

No quantitative measurements were made of the power of the aileron trim tab. The aileron trim forces were small as shown by figure 41. The aileron trim tab was reported by the pilot to be adequate for trimming the airplane within the conditions and speed range tested.

CONCLUSIONS

The results of measurements of the lateral and directional stability and control characteristics of the F6F-3 showed the following:

1. The control-free lateral oscillations damped to 1/2 amplitude within two cycles but at the higher speeds tested small continuous oscillations occurred.

2. The aileron control characteristics did not completely fulfill the Navy or NACA minimum requirements.

3. The maximum sideslip due to use of full aileron deflection (aileron yaw) was approximately 18.5° in rolls to the left and 23.5° in rolls to the right at approximately 100 miles per hour. With partial aileron deflection, however, the aileron yaw was accentuated because of the decreased directional stability at small sideslip angles.

4. The dihedral effect was positive in all conditions and unusually large in the gliding and climbing condition. The high dihedral effect in conjunction with the low directional stability was considered objectionable.

5. The blow-up characteristics of the landing flaps were such as to increase the dihedral effect in the wave-off condition.

6. The rudder provided sufficient directional control during landing and take-off. The rudder was also sufficiently powerful to overcome sideslip due to use of the ailerons. Changes in rudder trim forces with speed were heavy. There was an objectionable rudder shake which the pilots reported existed in all flight conditions throughout the speed range.

7. The directional stability, rudder fixed and free, was positive in all conditions and speeds tested. There was, however, a decrease in directional stability rudder fixed for small angles of sideslip at high speeds in the climbing and gliding condition, which, in conjunction with the large positive dihedral effect, made the airplane difficult to control in high speed flight.

8. The pitching moment due to sideslip was within the required limits except in the climbing condition.

9. The power of the rudder trim tab was adequate at low speeds in only the landing condition. The aileron trim tab was adequate throughout the speed range.

Langley Memorial Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va., February 13, 1945

REFERENCES

1. Williams, Walter C., and Reeder, John P.: Flight Measurements of the Flying Qualities of an F6F-3 Airplane (BuAer No. 04776). I - Longitudinal Stability and Control. NACA MR No. L5B13, 1945.

2. Gilruth, R. R.: Requirements for Satisfactory Flying Qualities of Airplanes. NACA Rep. No. 755, 1943.

3. Anon.: Specification for Stability and Control Characteristics of Airplanes. SR-119, Bur. Aero., Oct. 1, 1942.

4. Gilruth, R. R., and Turner, W. N.: Lateral Control Required for Satisfactory Flying Qualities Based on Flight Tests of Numerous Airplanes. NACA Rep. No. 715, 1941.

TABLE I

Flight condition	Rudder force Vi = 104 mph, trim tab 0°
Landing	9 right
Approach	38 right
Wave-off	69 right
Gliding	14 right
Climbing	83 right

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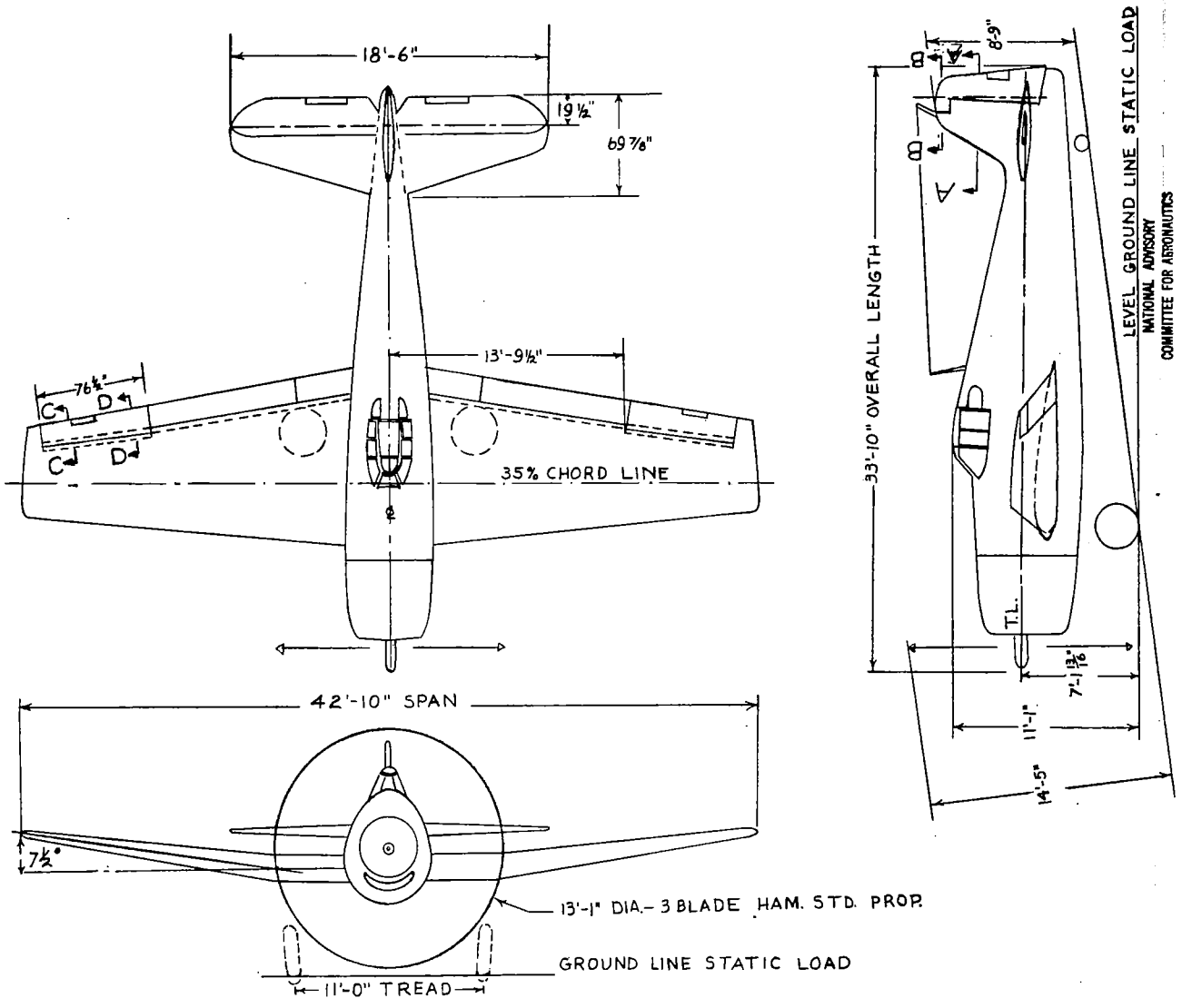

Figure 1. - Three-view layout of the F6F-3 airplane.

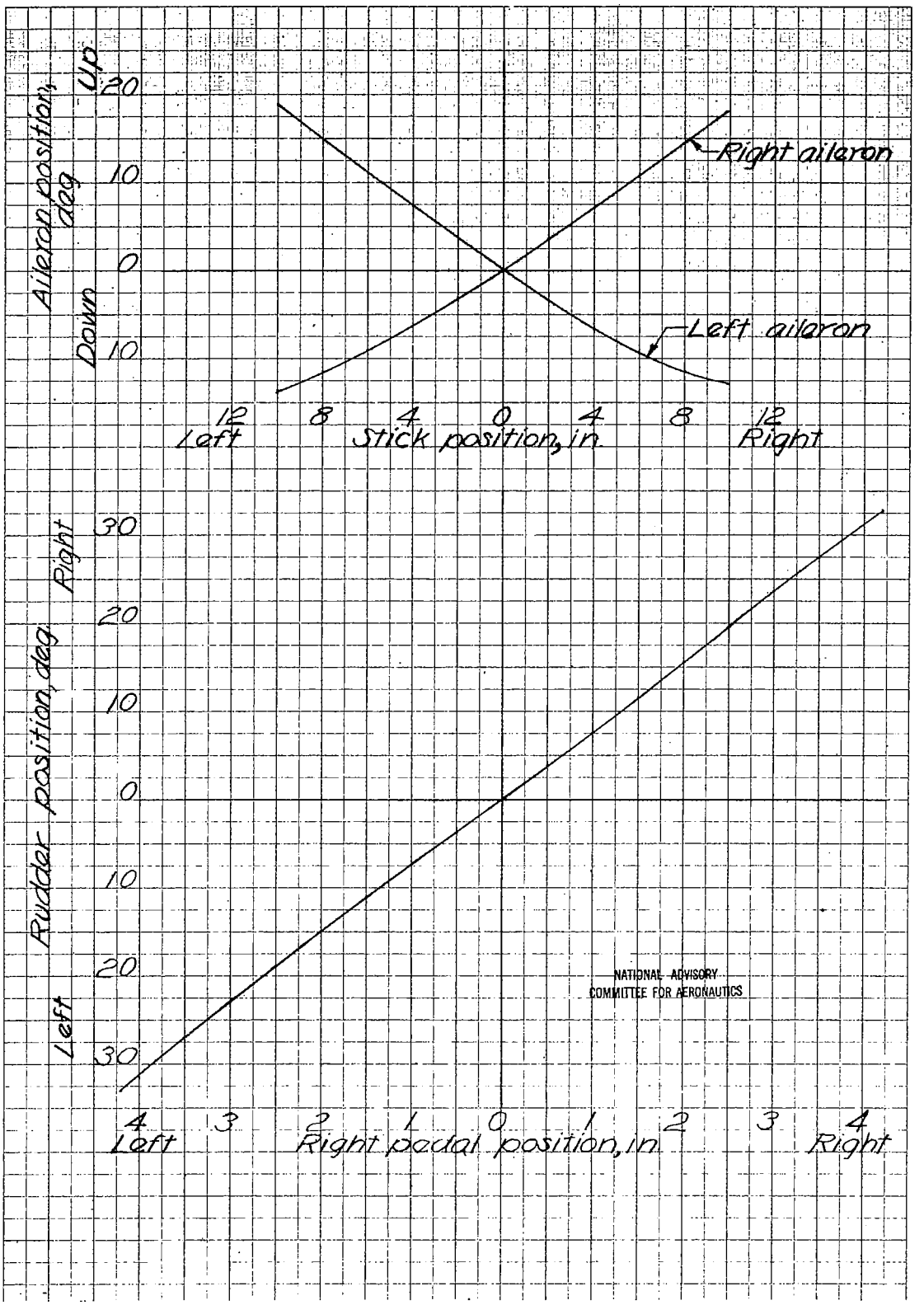

Figure 2. - Variation of control-surface deflection with stick and rudder pedal position. F6F-3 airplane.

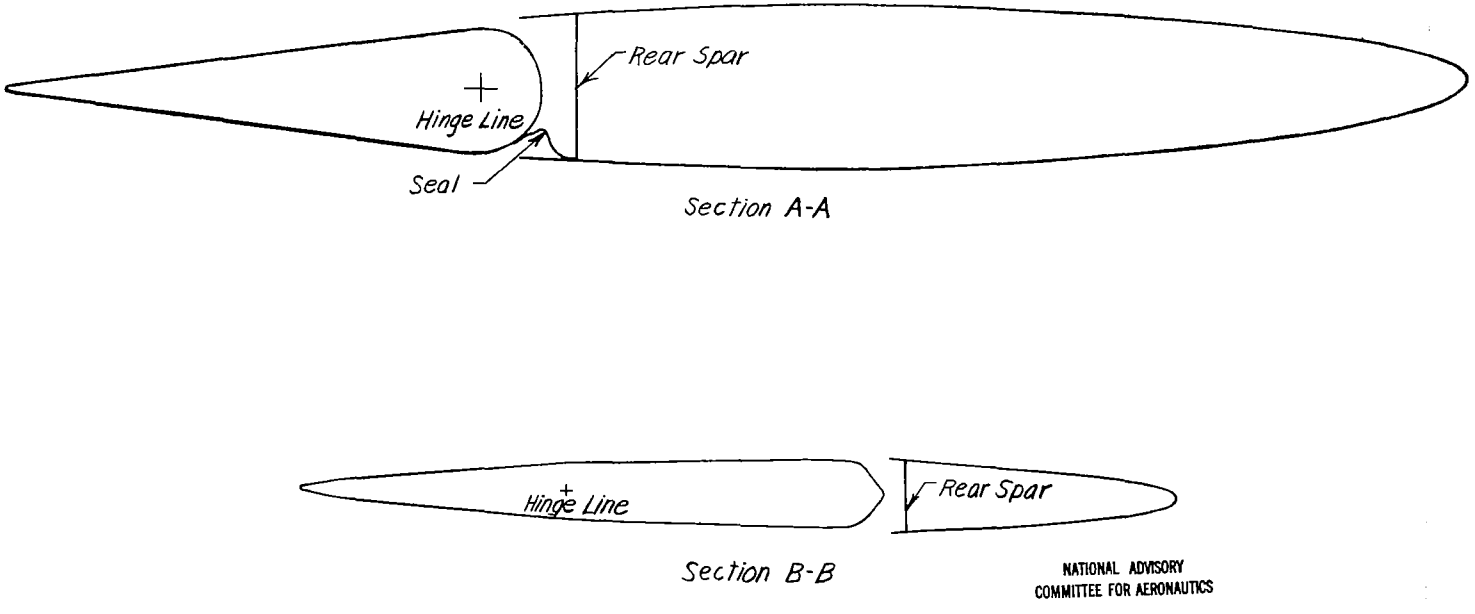

Figure 3. - Section of vertical tail, F6F-3 airplane.

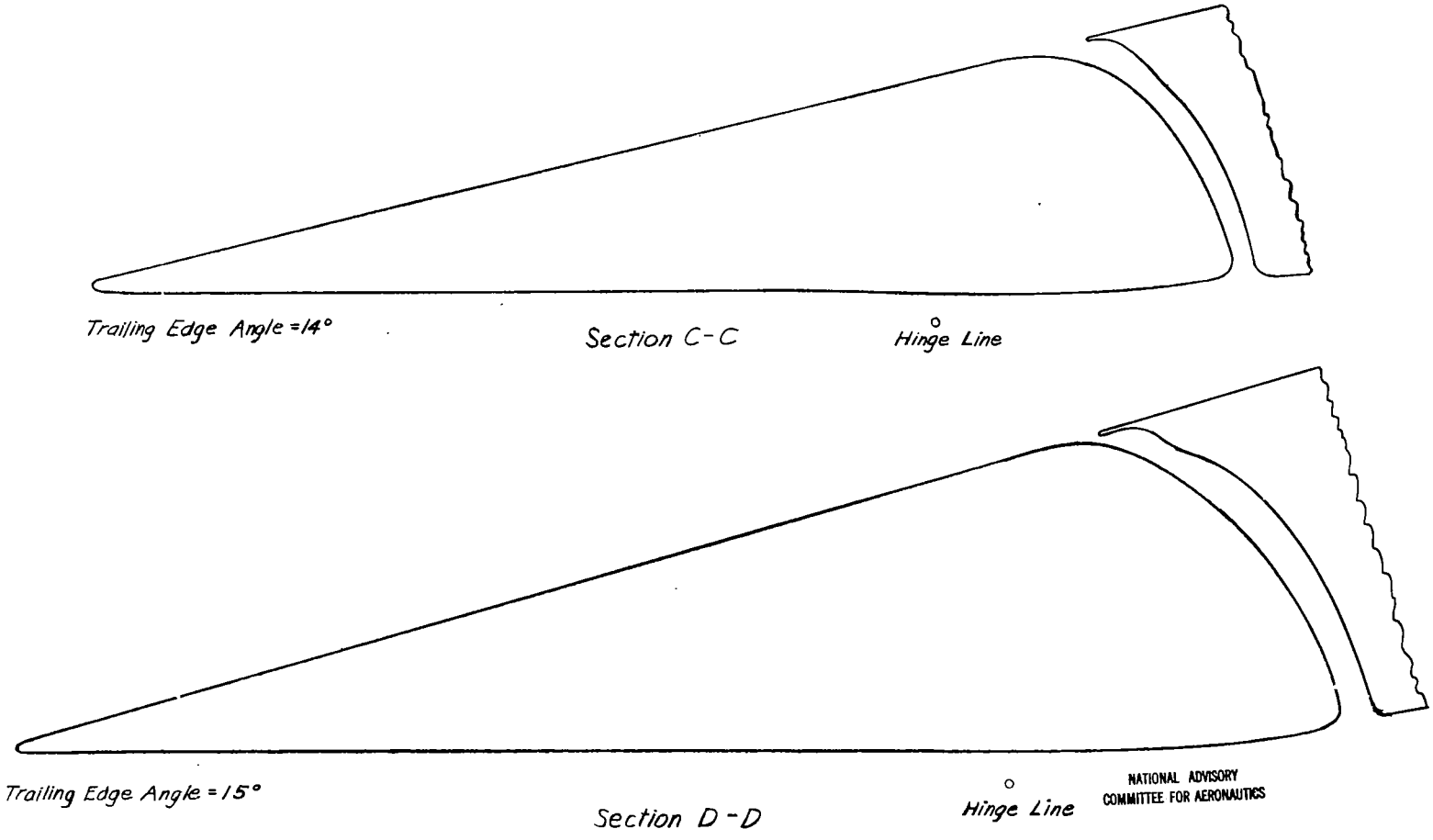

Figure 4. - Section of right aileron, F6F-3 airplane.

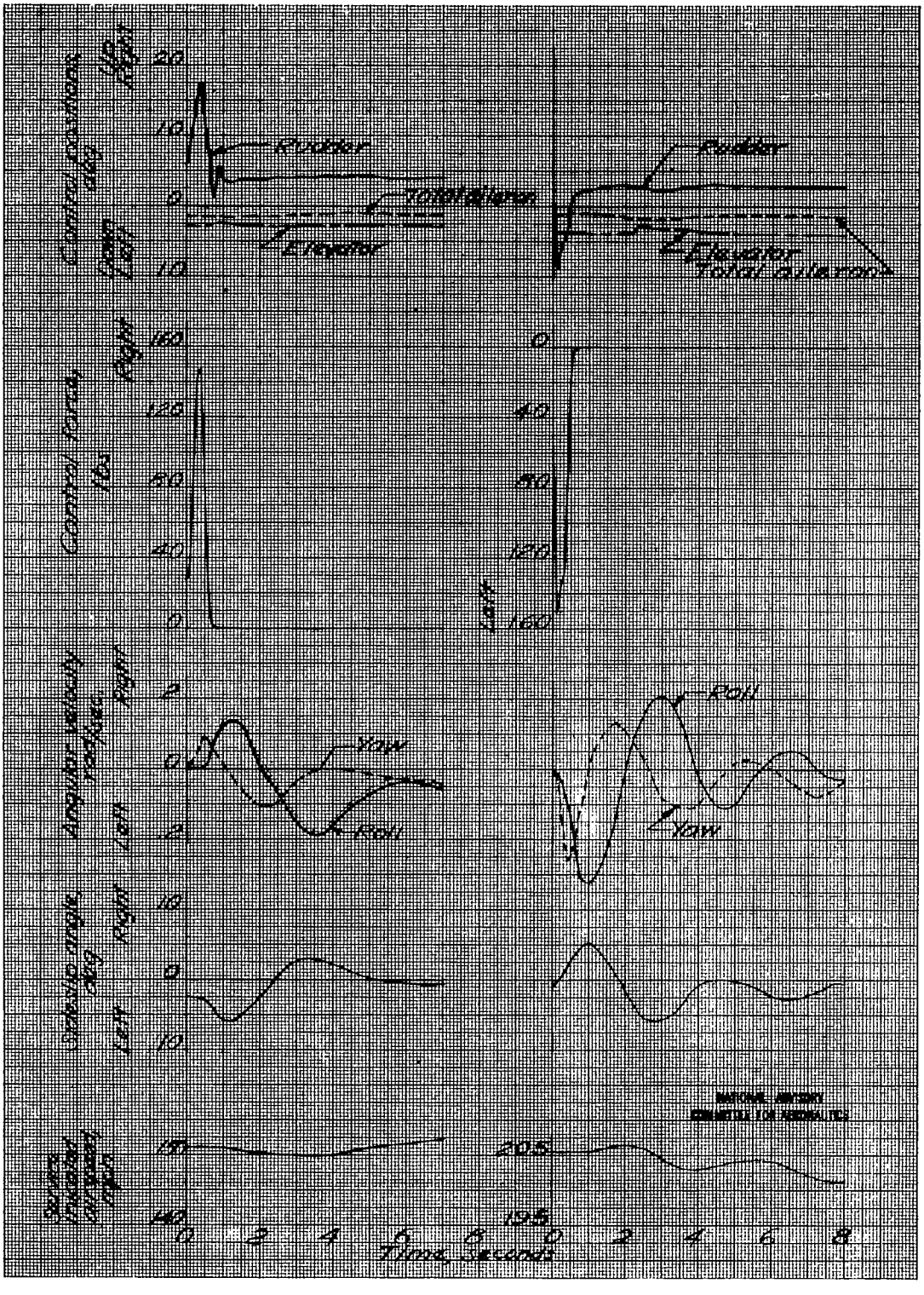

Figure 5. - Time histories of typical lateral oscillations following abrupt rudder deflection, climbing condition, F6F-3 airplane.

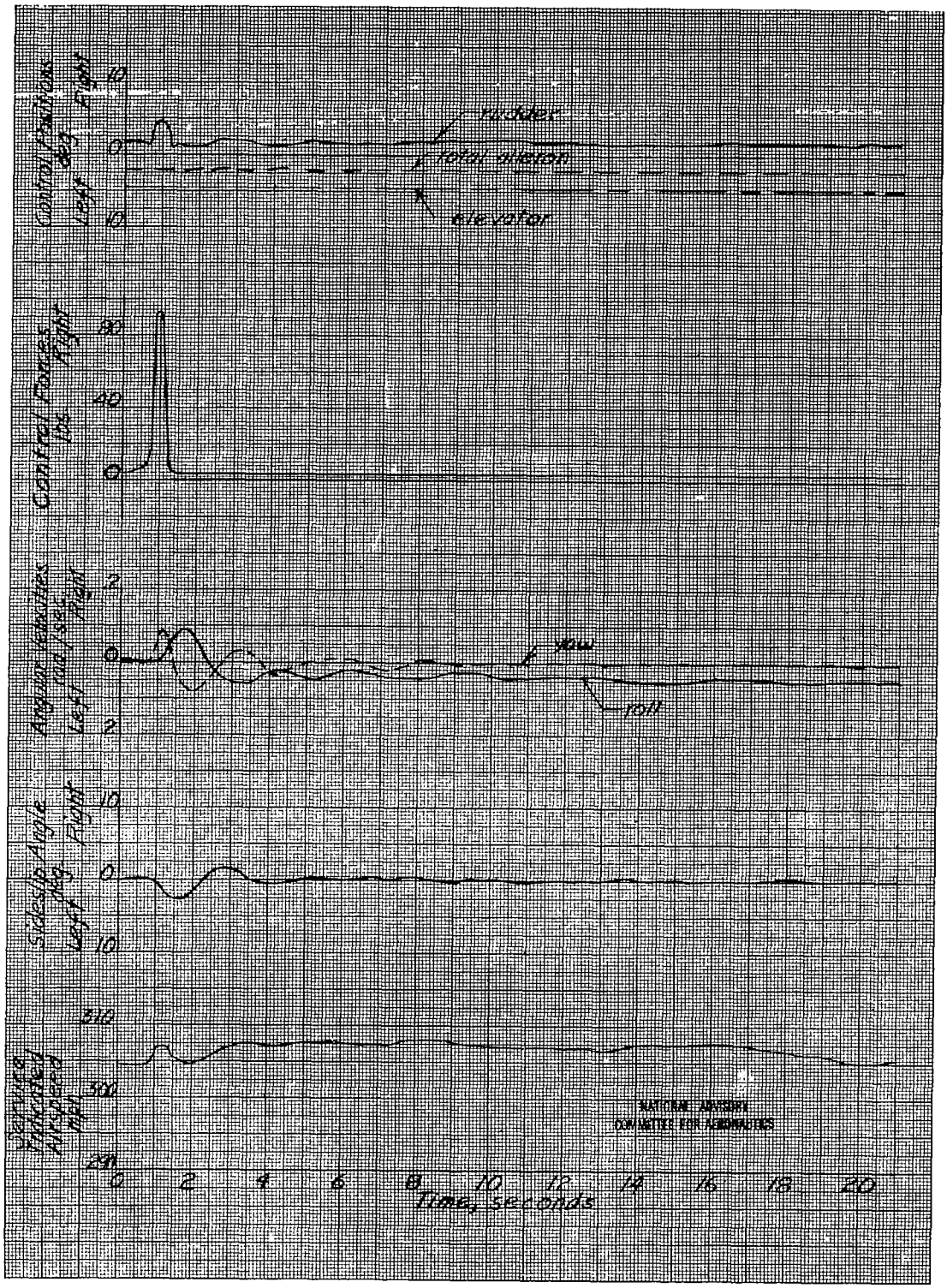

Figure 6. Time history of a typical lateral oscillation following an abrupt rudder deflection at approximately 305 miles per hour, climbing condition, F6F-3 airplane.

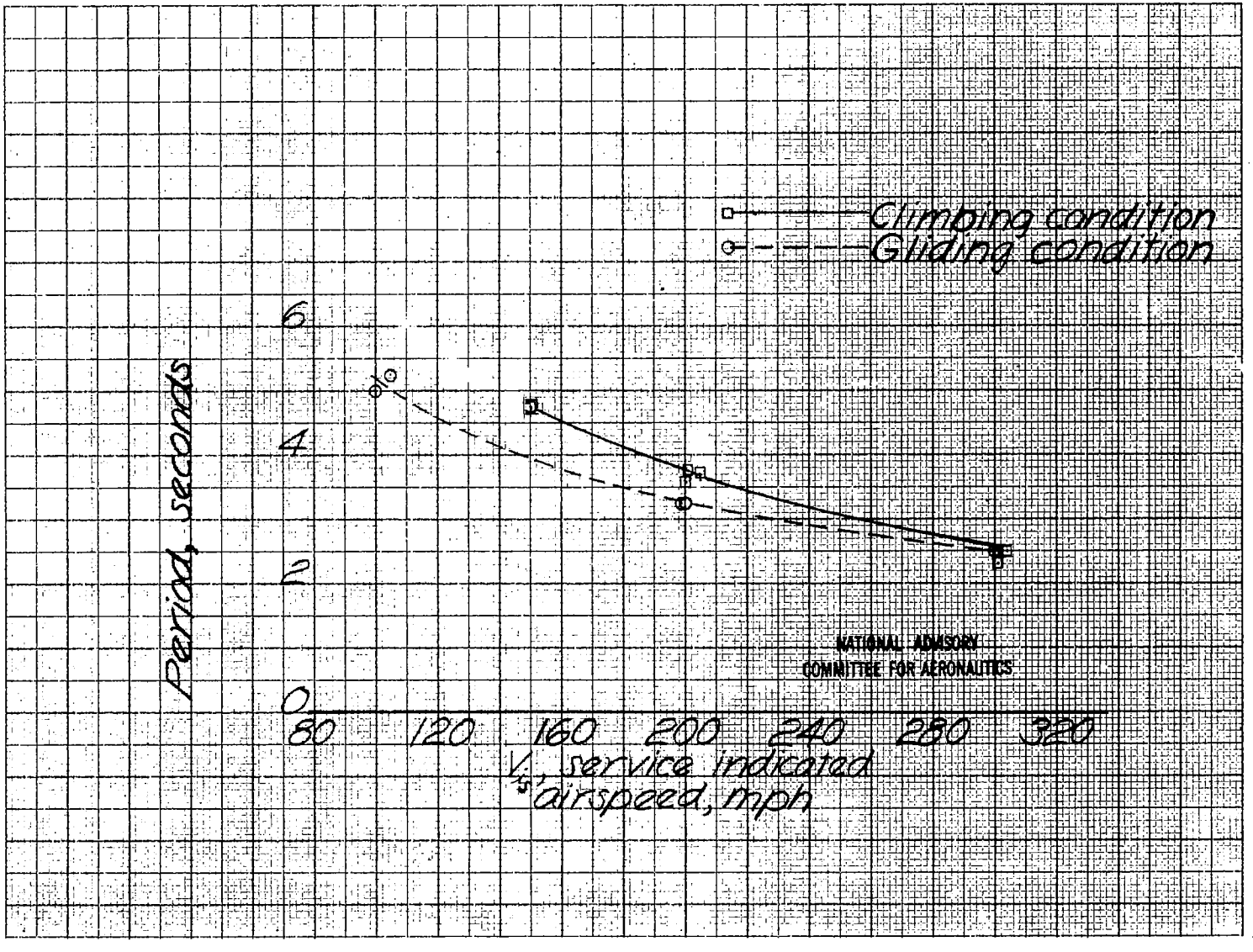

Figure 7. - Variation of the period of lateral oscillations with service indicated airspeed, F6F-3 airplane.

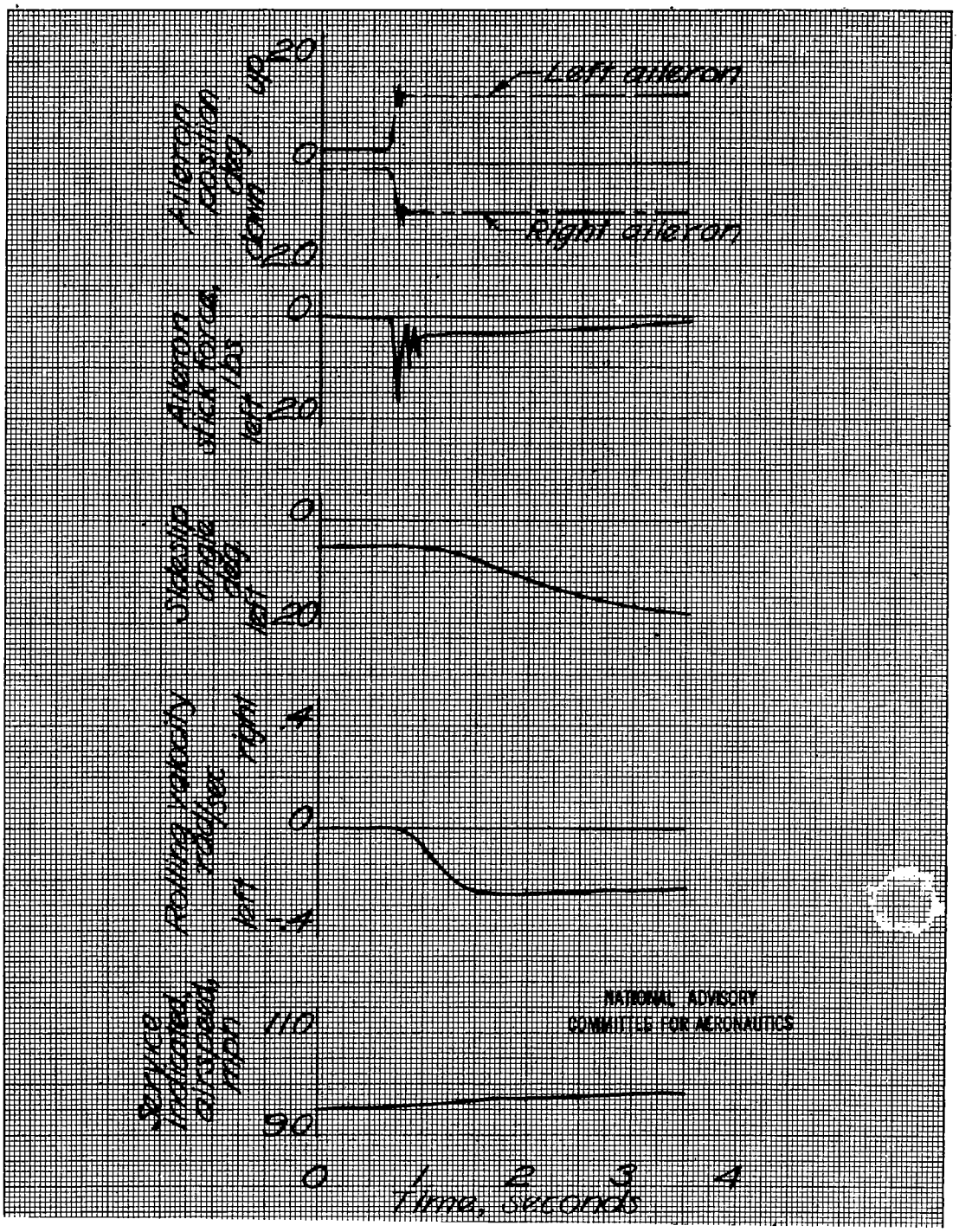

Figure 8. - Typical time history of an abrupt aileron roll made at approximately 95 miles per hour using partial aileron deflection, rudder fixed, clean condition, power for level flight, F6F-3 airplane.

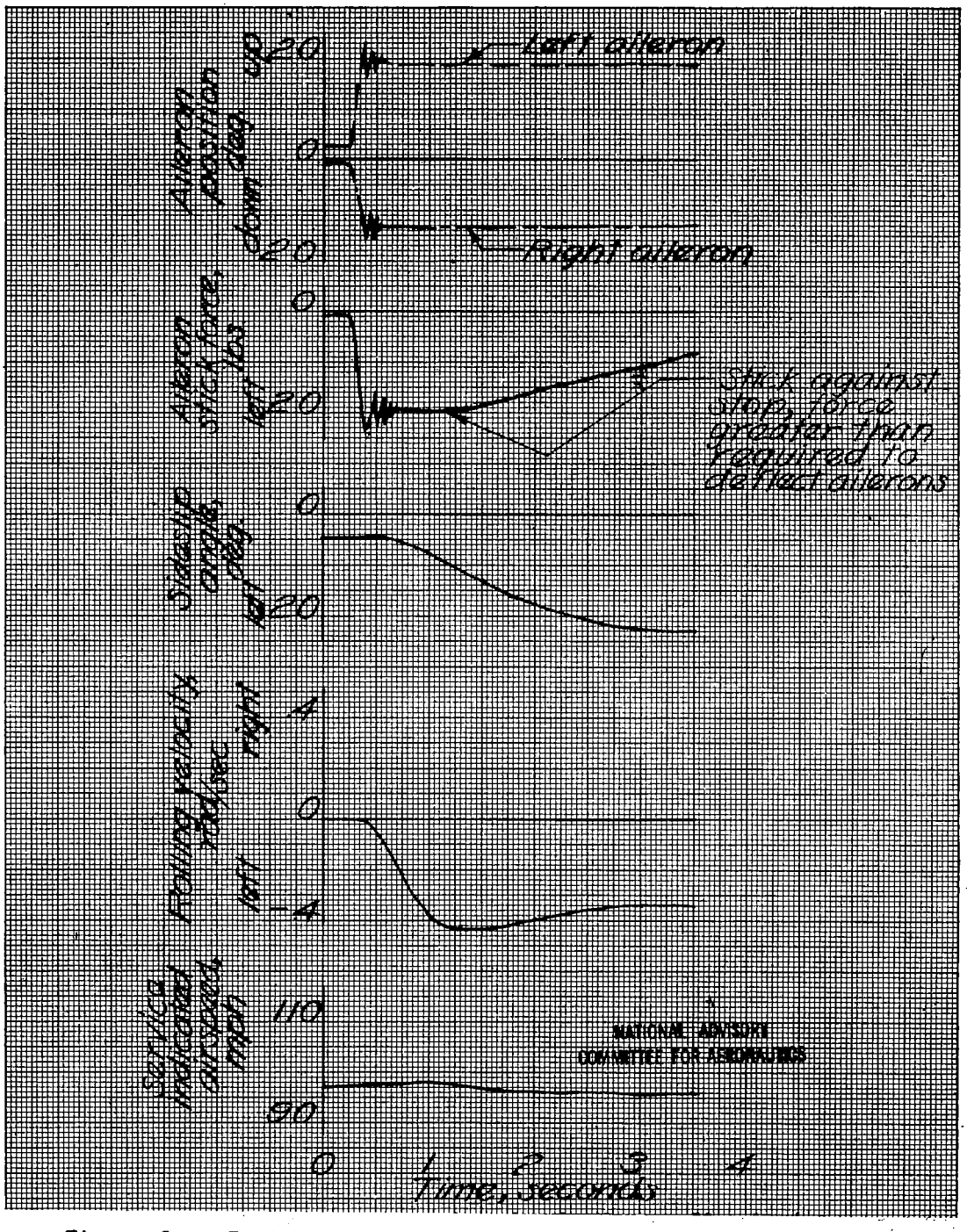

Figure 9. - Typical time history of an abrupt aileron roll made at approximately 97 miles per hour, using full aileron deflection. Clean condition, power for level flight, F6F-3 airplane.

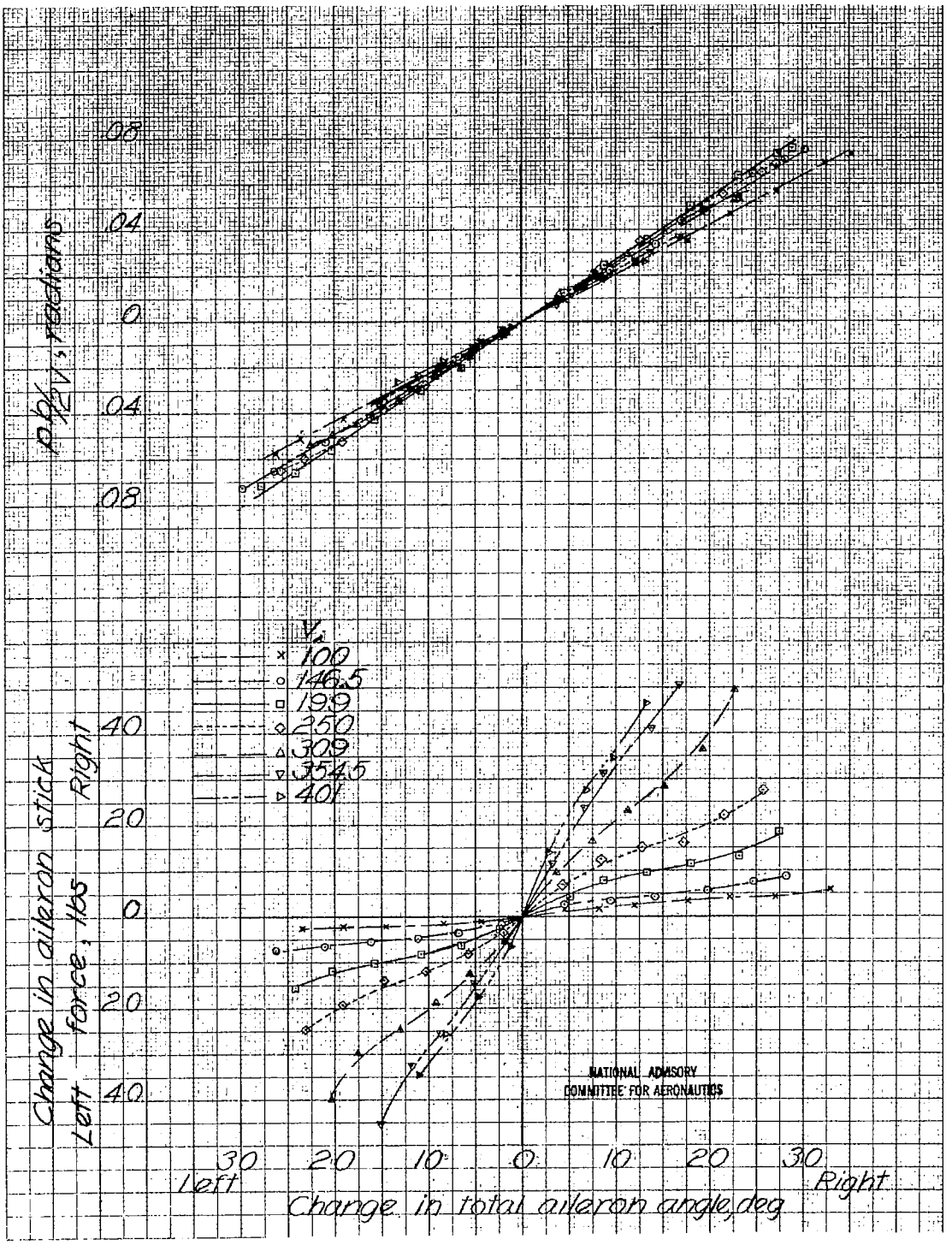

Figure 10. - Variation of the helix angle pb/2V and change in aileron stick force with change in total aileron angle at various speeds, F6F-3 airplane.

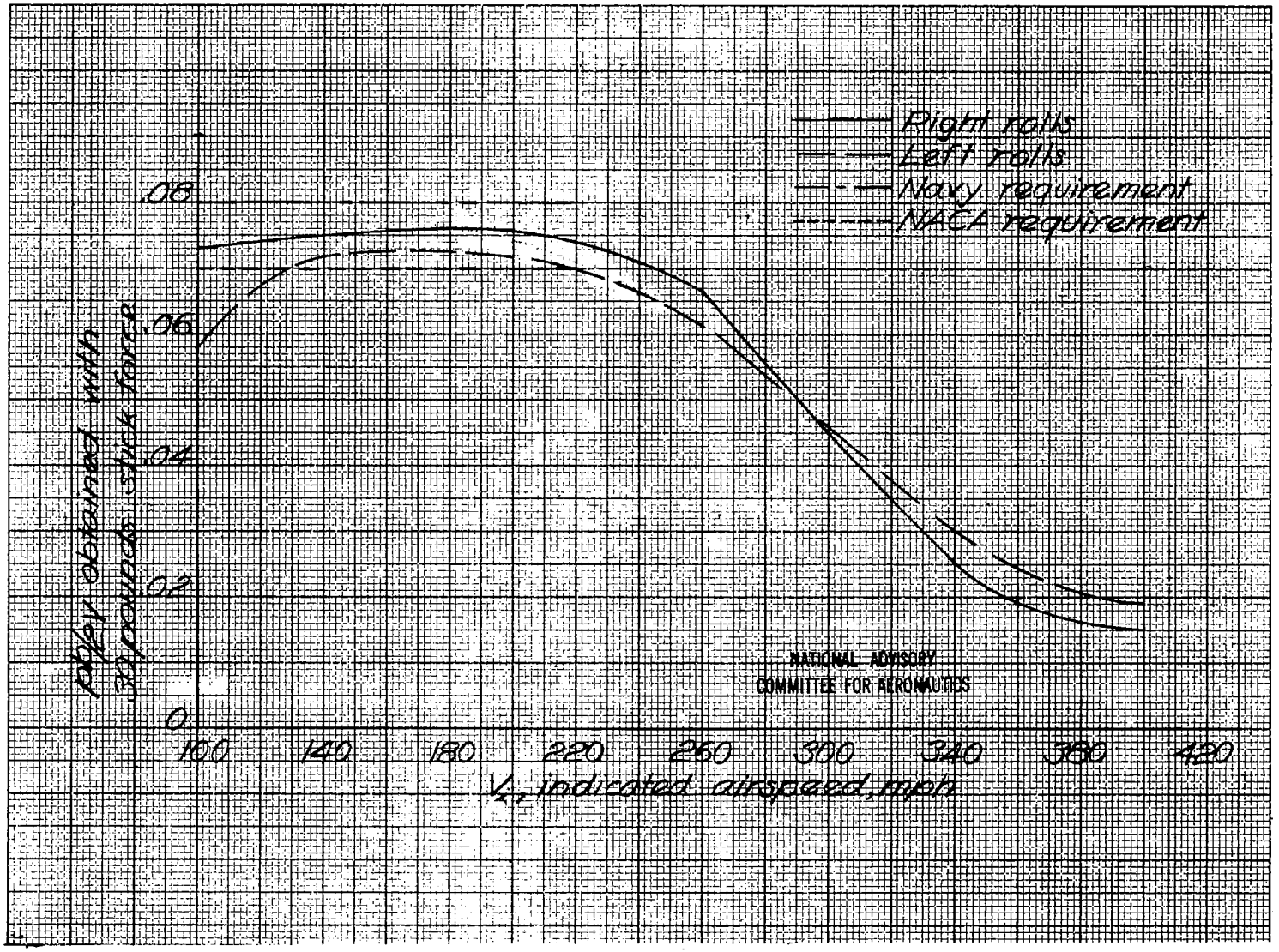

Figure 11. - Variation with indicated airspeed of the pb/2V obtained with a 30-pound stick-force limit F6F-3 airplane.

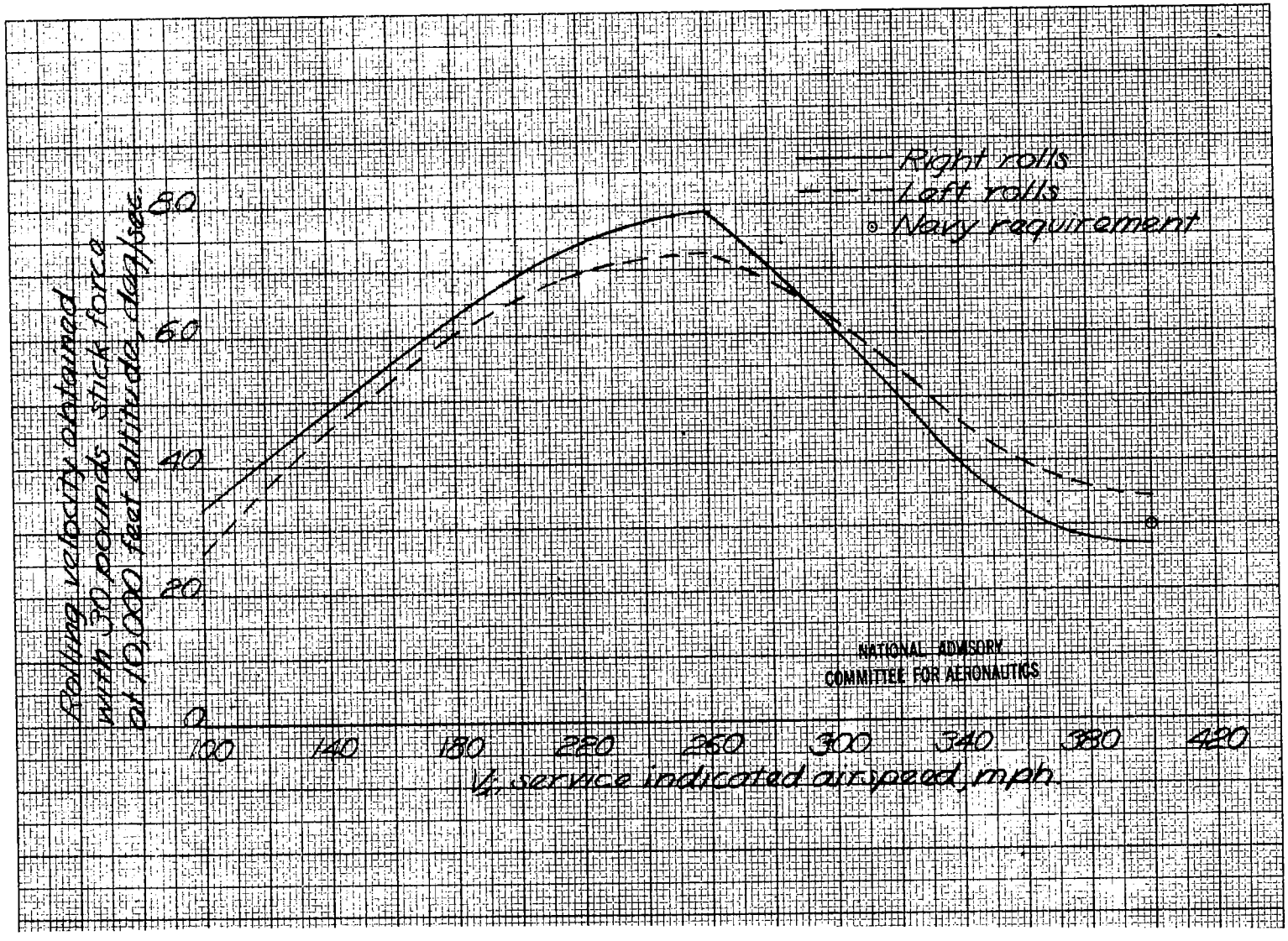

Figure 12. - Variation with indicated airspeed of the rolling velocity obtained at 10,000 feet altitude with a 30-pound stick-force limit, F6F-3 airplane.

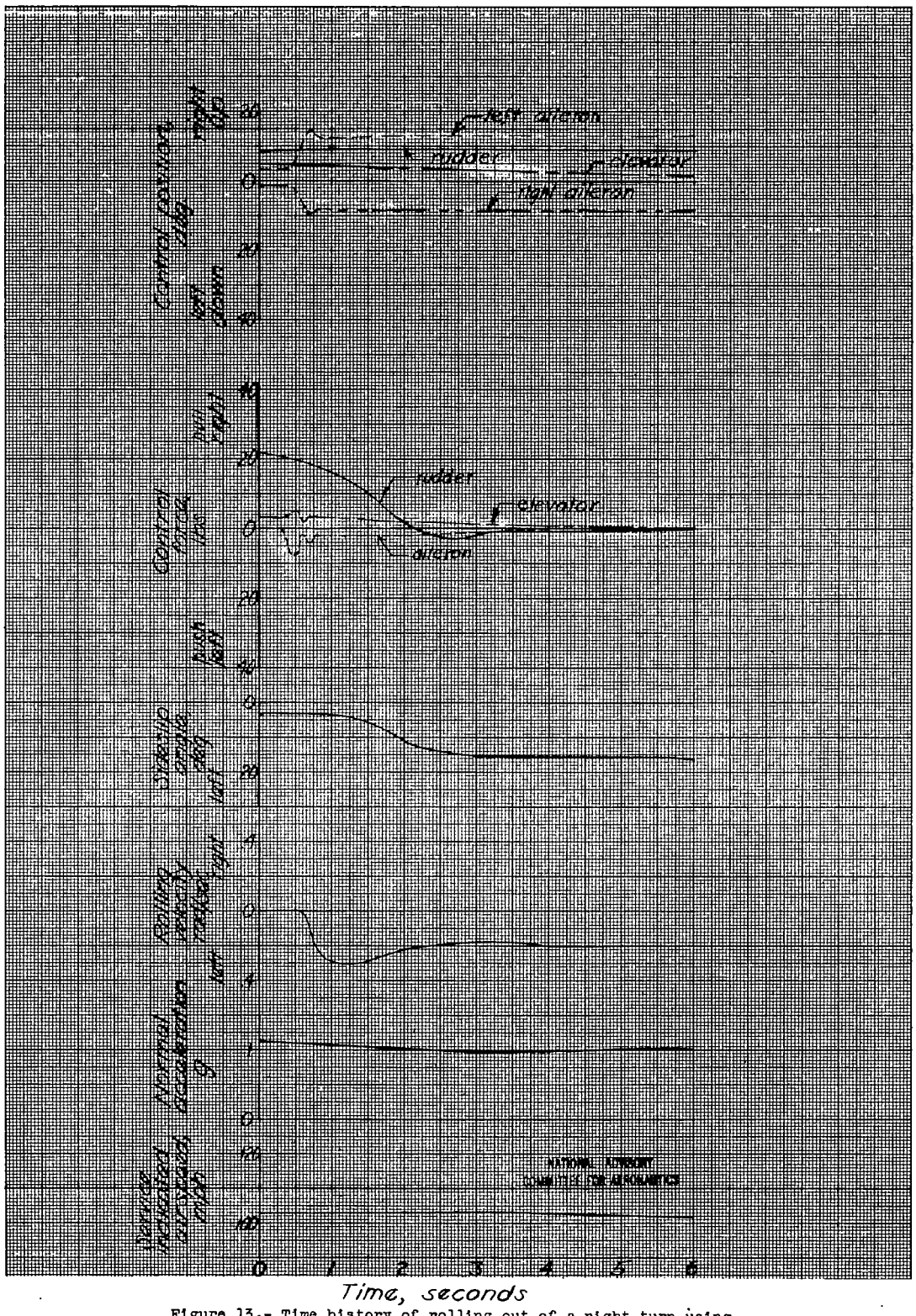

Figure 13.- Time history of rolling out of a right turn using partial aileron deflection with rudder held fixed. Clean condition, power for level flight, F6F-3 airplane.

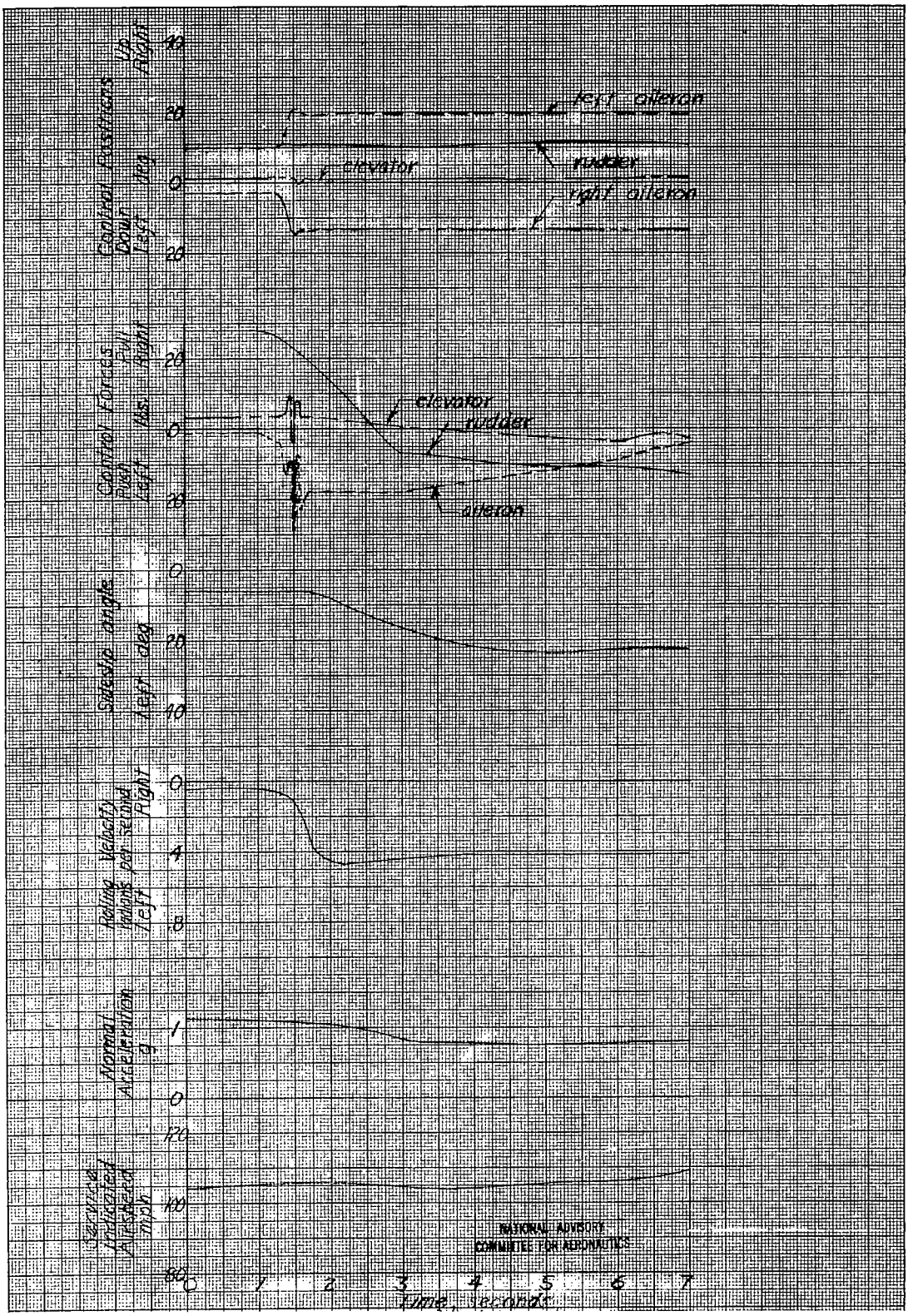

Figure 14. - Time history of rolling out of a right turn using full aileron deflection with rudder held fixed. Clean condition, power for level flight, F6F-3 airplane.

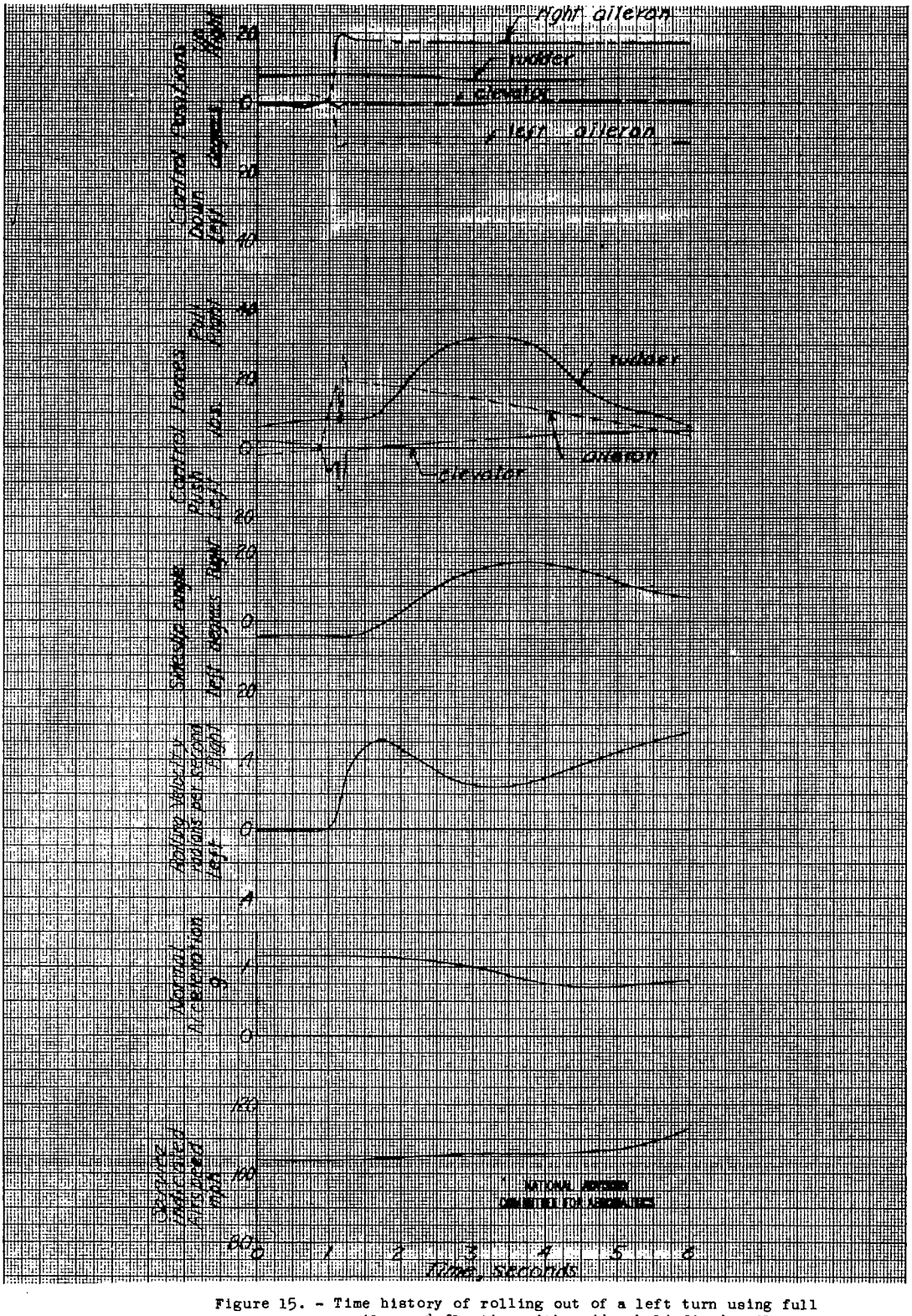

Figure 15. - Time history of rolling out of a left turn using full aileron deflection with rudder held fixed. Clean condition, power for level flight, F6F-3 airplane.

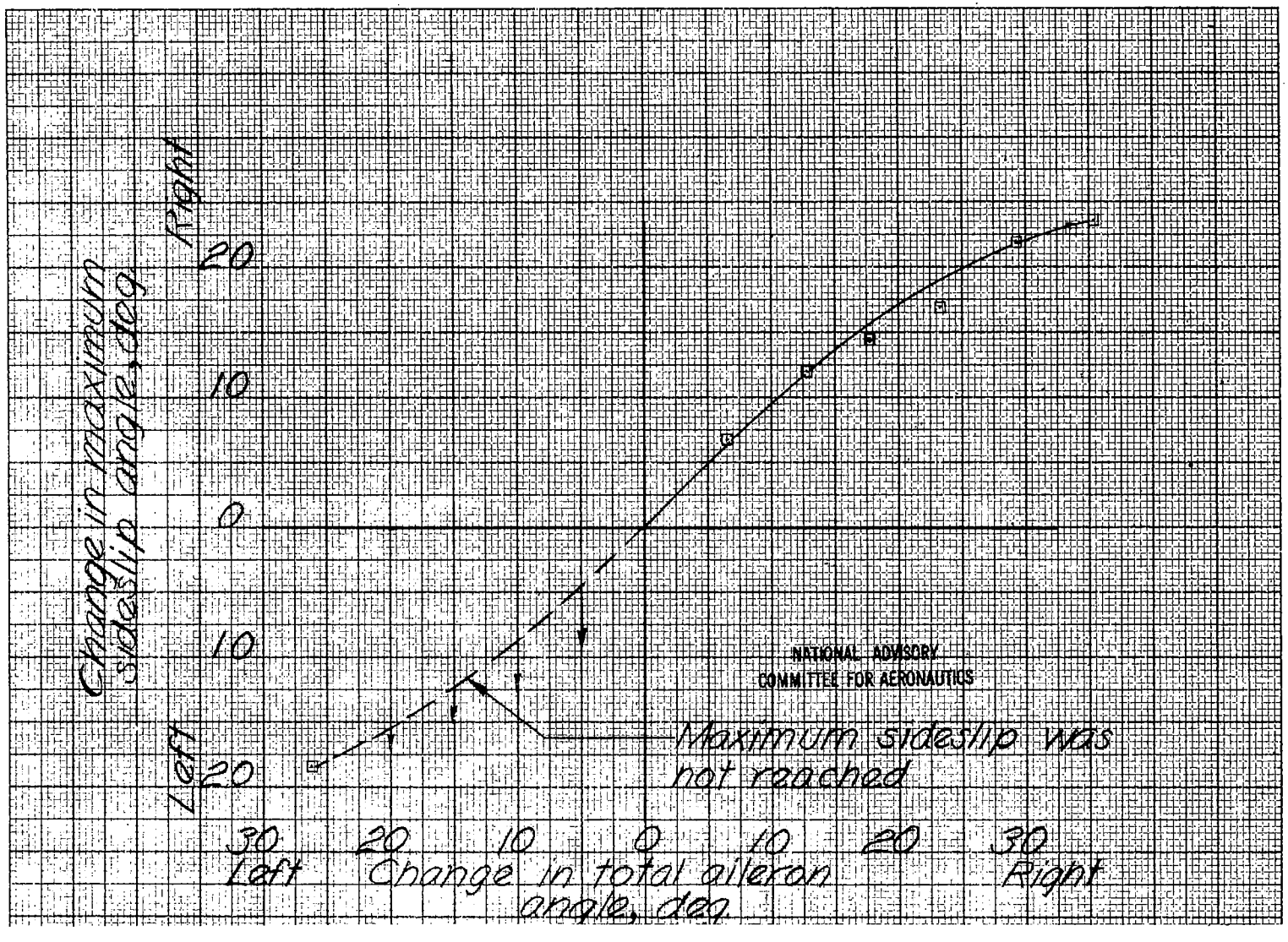

Figure 16. - Change in maximum sideslip angle with change in total aileron angle in abrupt aileron rolls made from laterally level flight at 98 miles per hour. Clean condition, power for level flight, F6F-3 airplane.

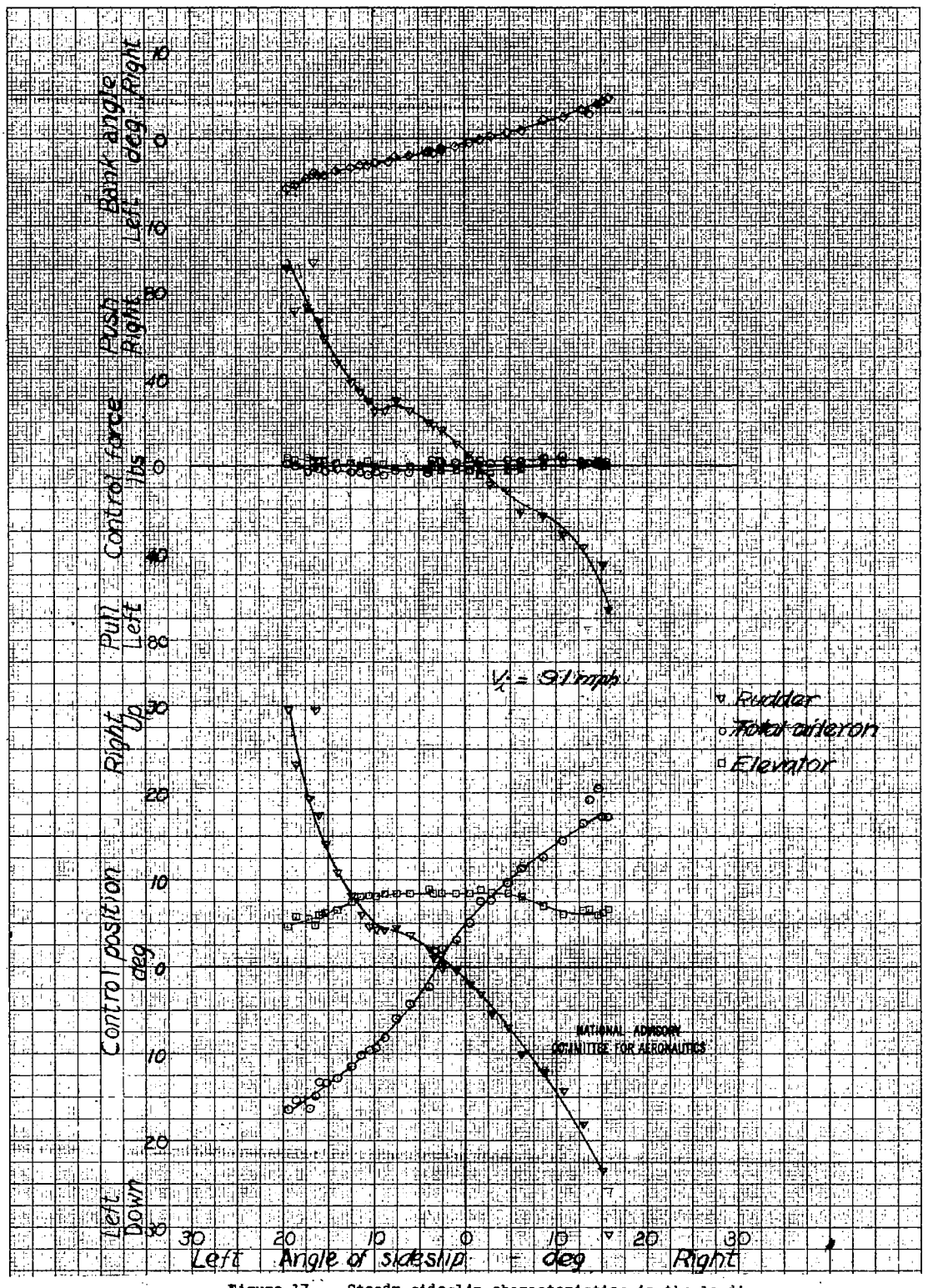

Figure 17. - Steady sideslip characteristics in the landing condition at 91 miles per hour, F6F-3 airplane.

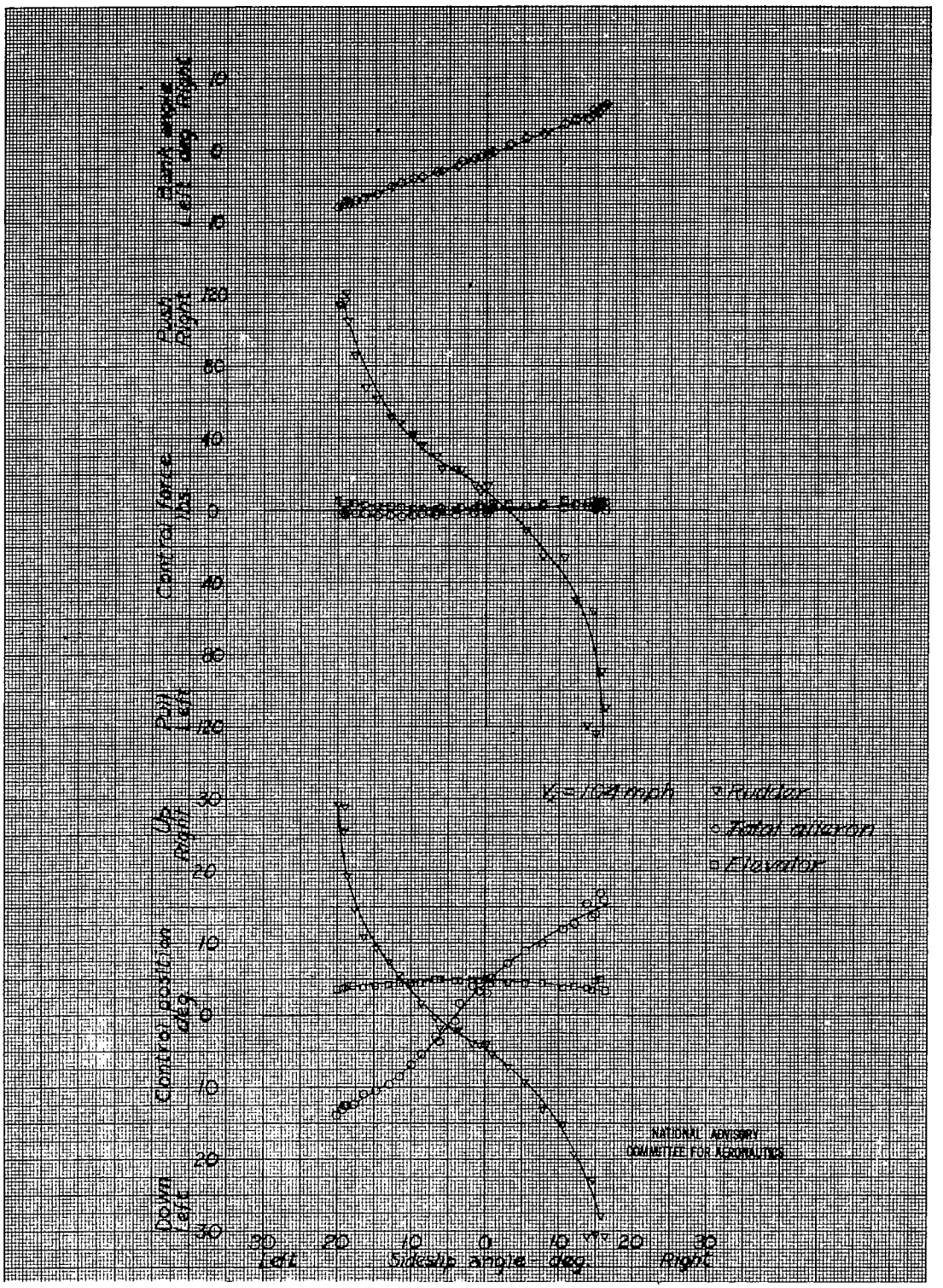

Figure 18. - Steady sideslip characteristics in the landing condition at 104 miles per hour, F6F-3 airplane.

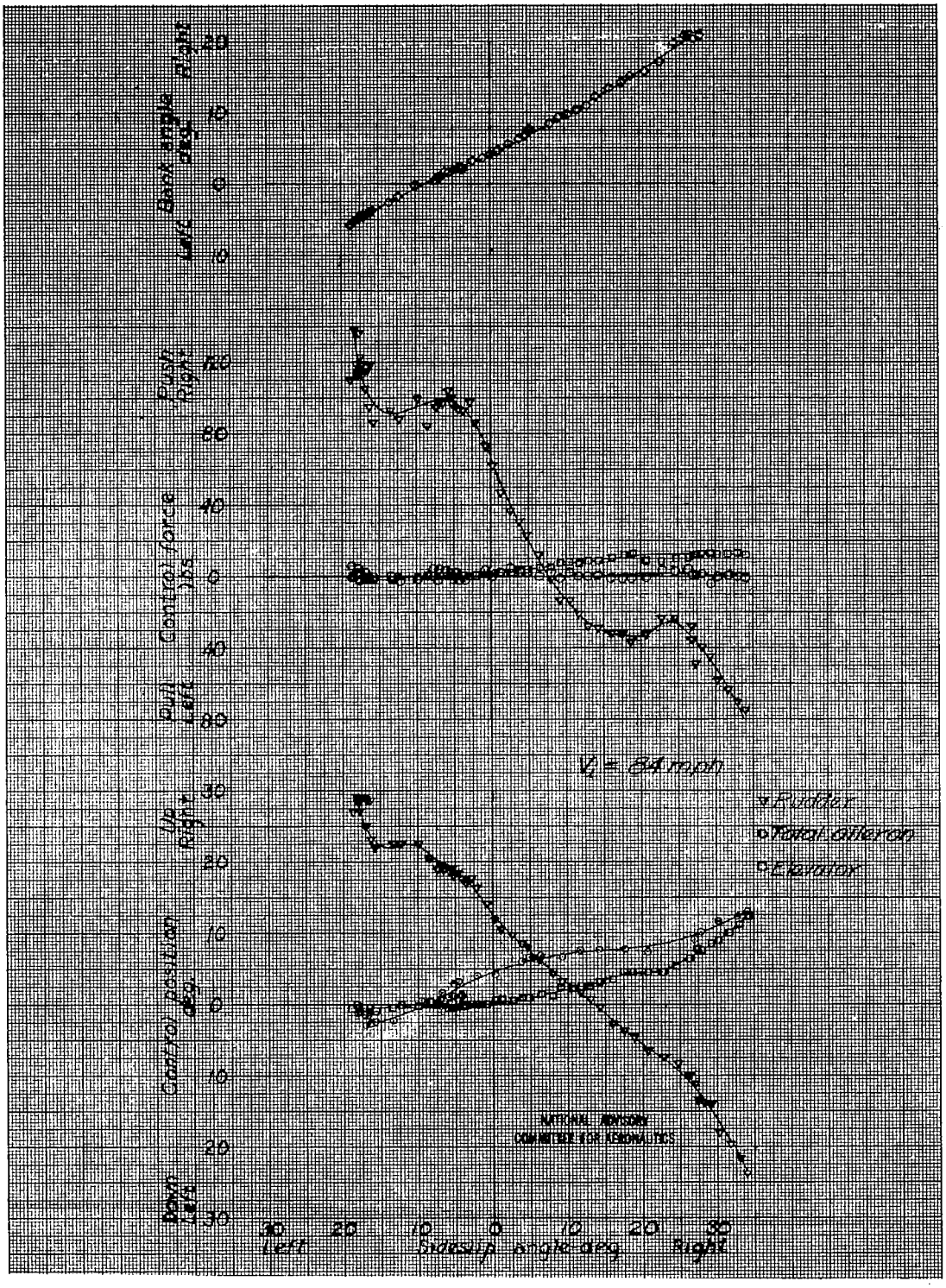

Figure 19. - Steady sideslip characteristics in the wave-off condition at 84 miles per hour, F6F-3 airplane.

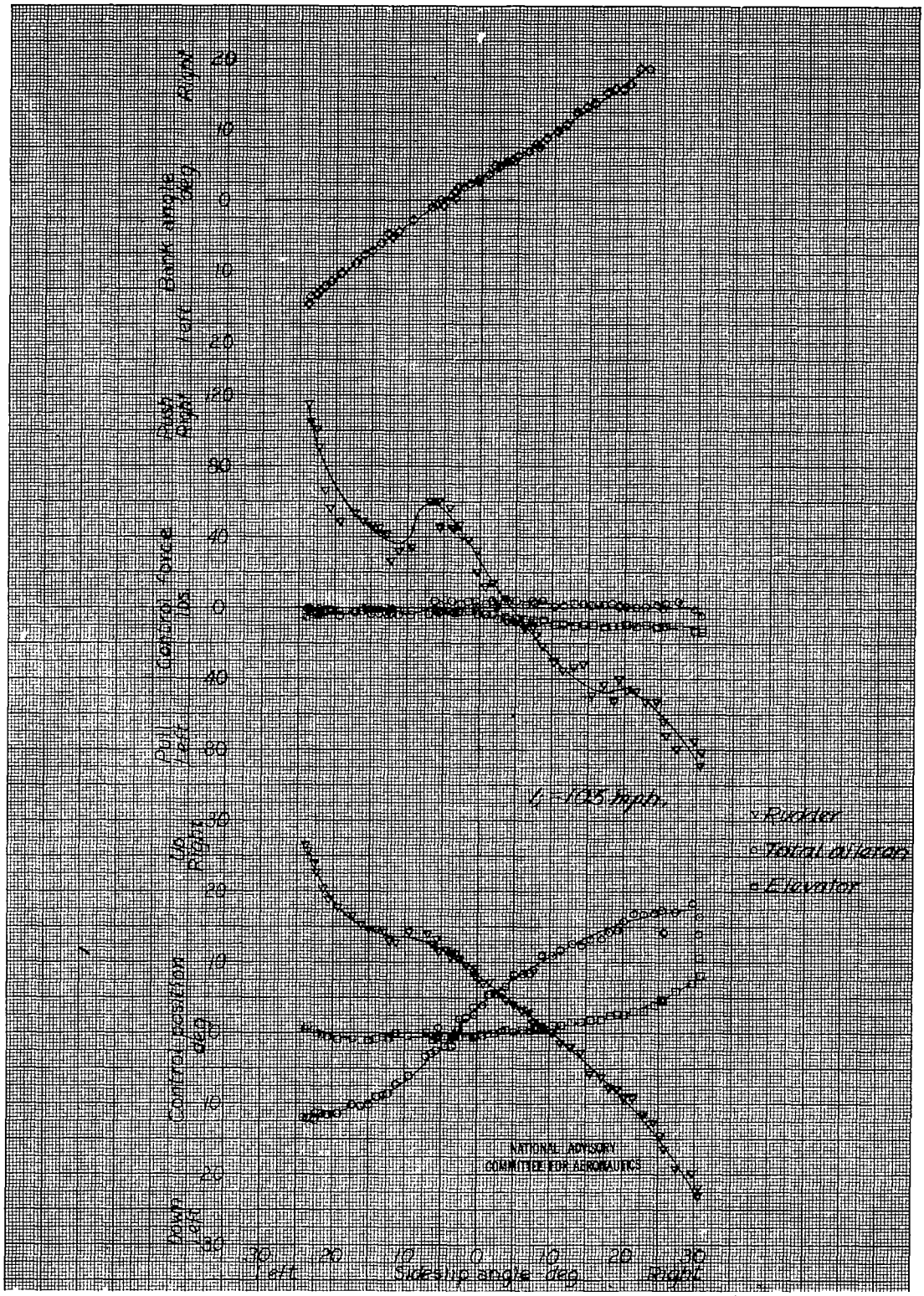

Figure 20. - Steady sideslip characteristics in the wave-off condition at 105 miles per hour, F6F-3 airplane.

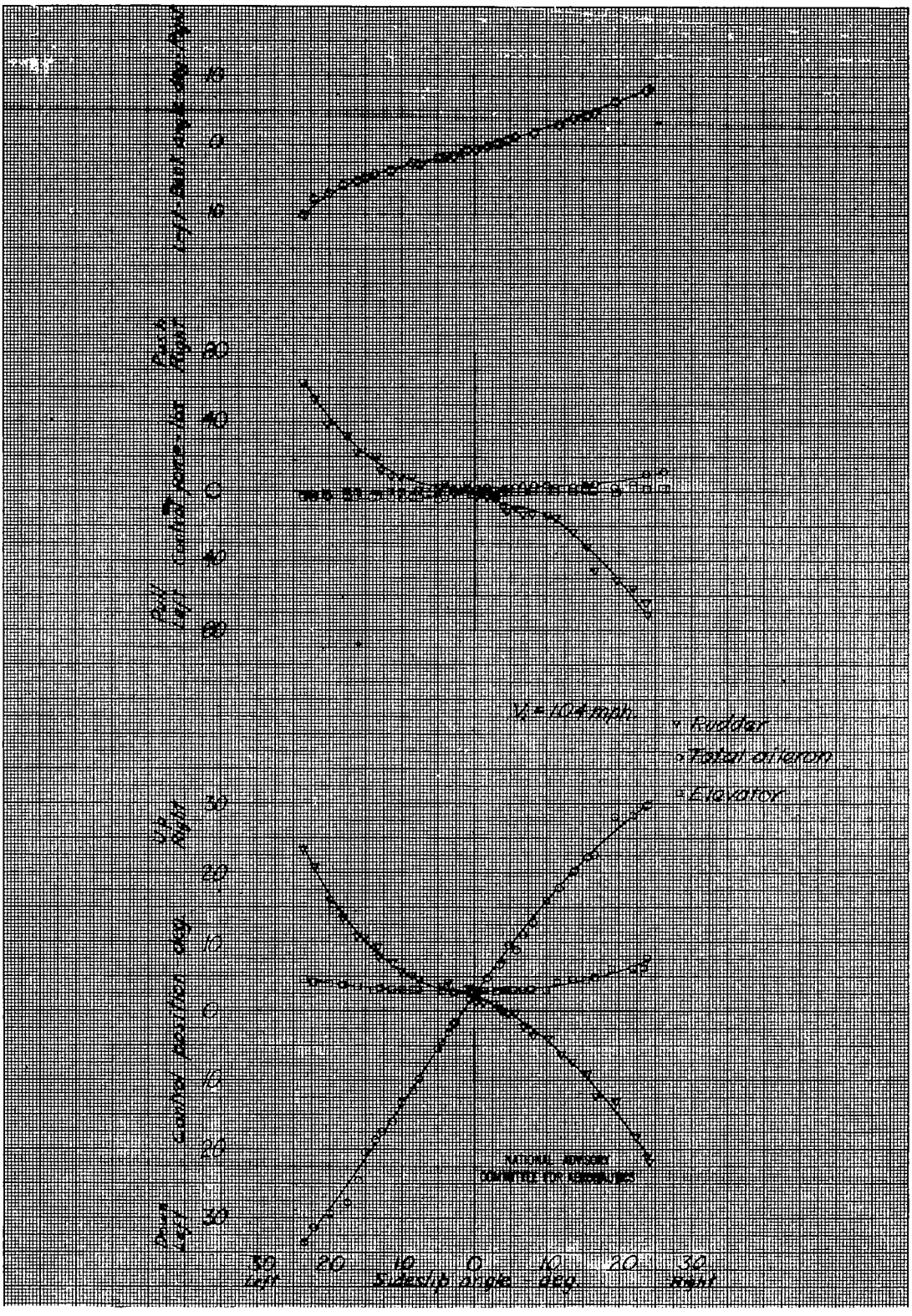

Figure 21. - Steady sideslip characteristics in the gliding condition at 104 miles per hour, F6F-3 airplane.

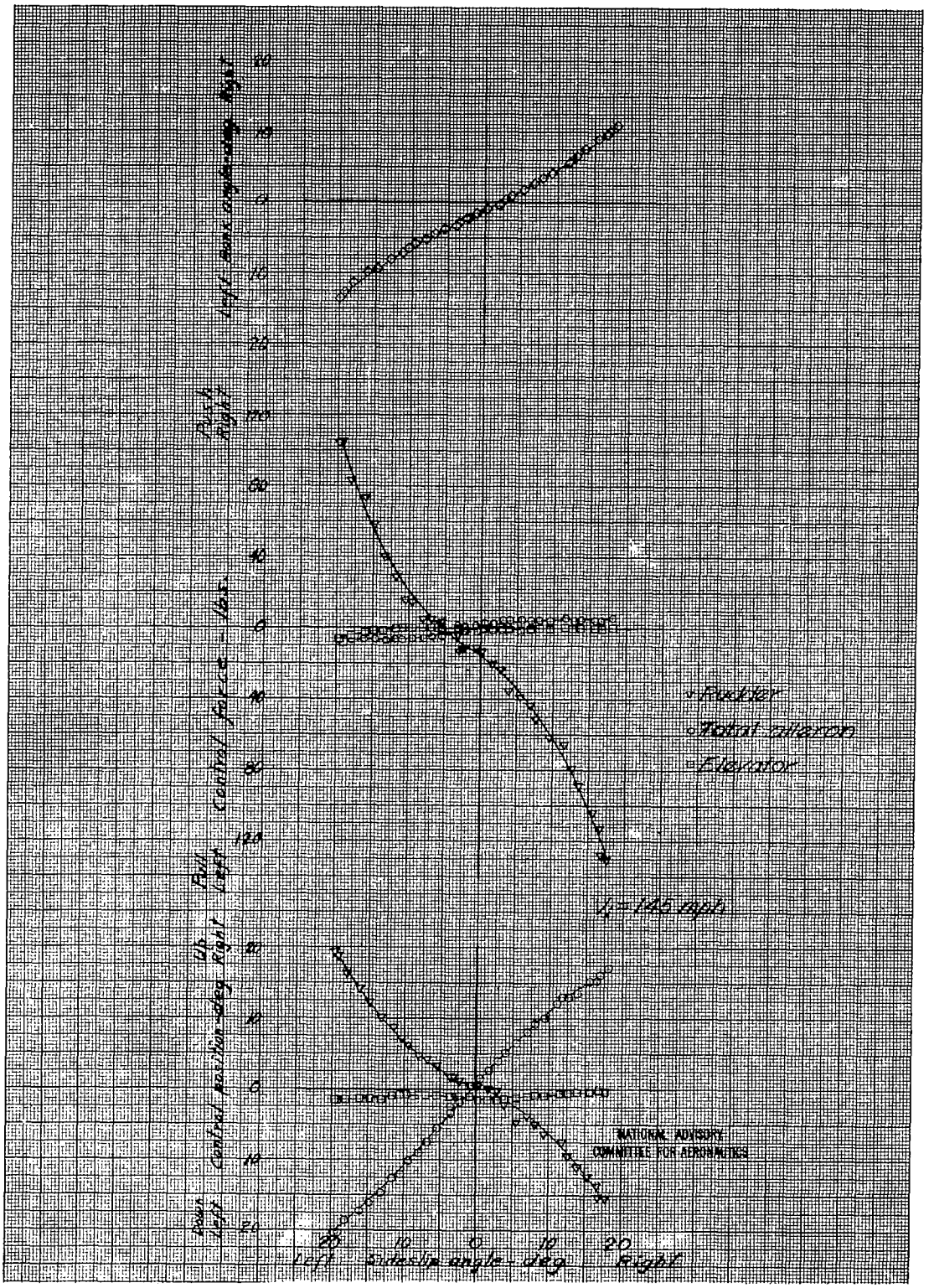

Figure 22. - Steady sideslip characteristics in the gliding condition at 145 miles per hour, F6F-3 airplane.

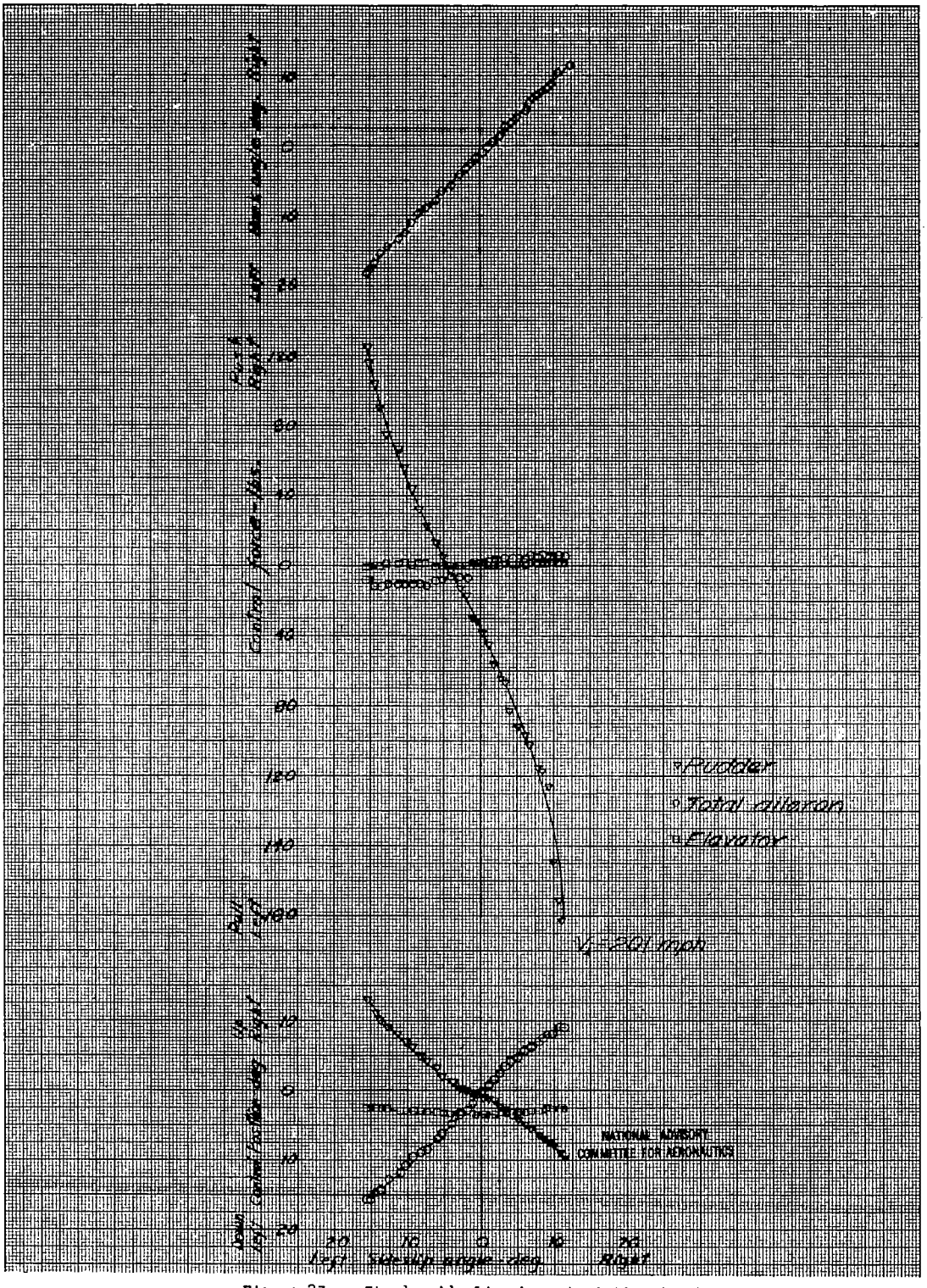

Figure 23. - Steady sideslip characteristics in the gliding condition at 201 miles per hour, F6F-3 airplane.

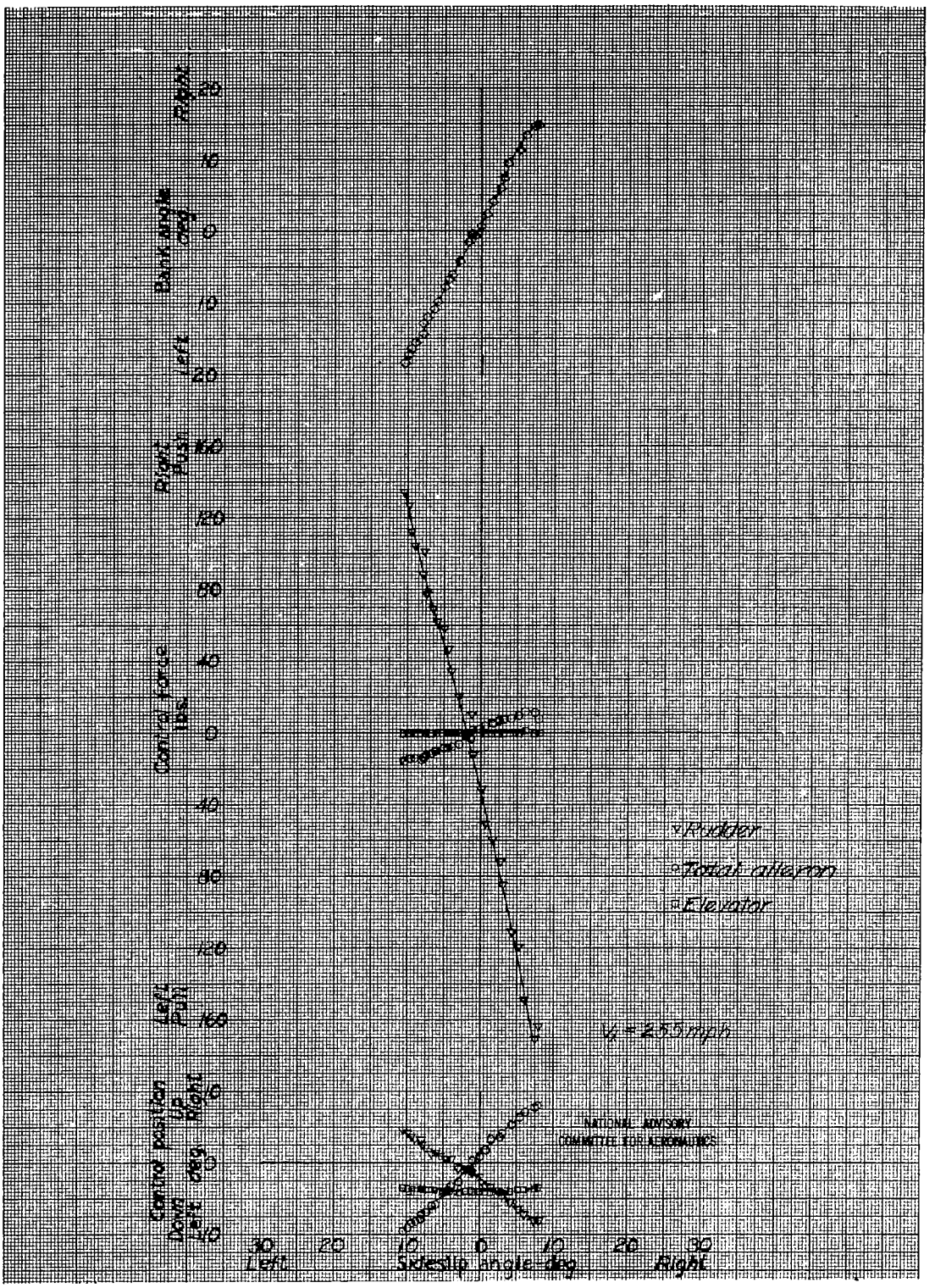

Figure 24. - Steady sideslip characteristics in the gliding condition at 255 miles per hour, F6F-3 airplane.

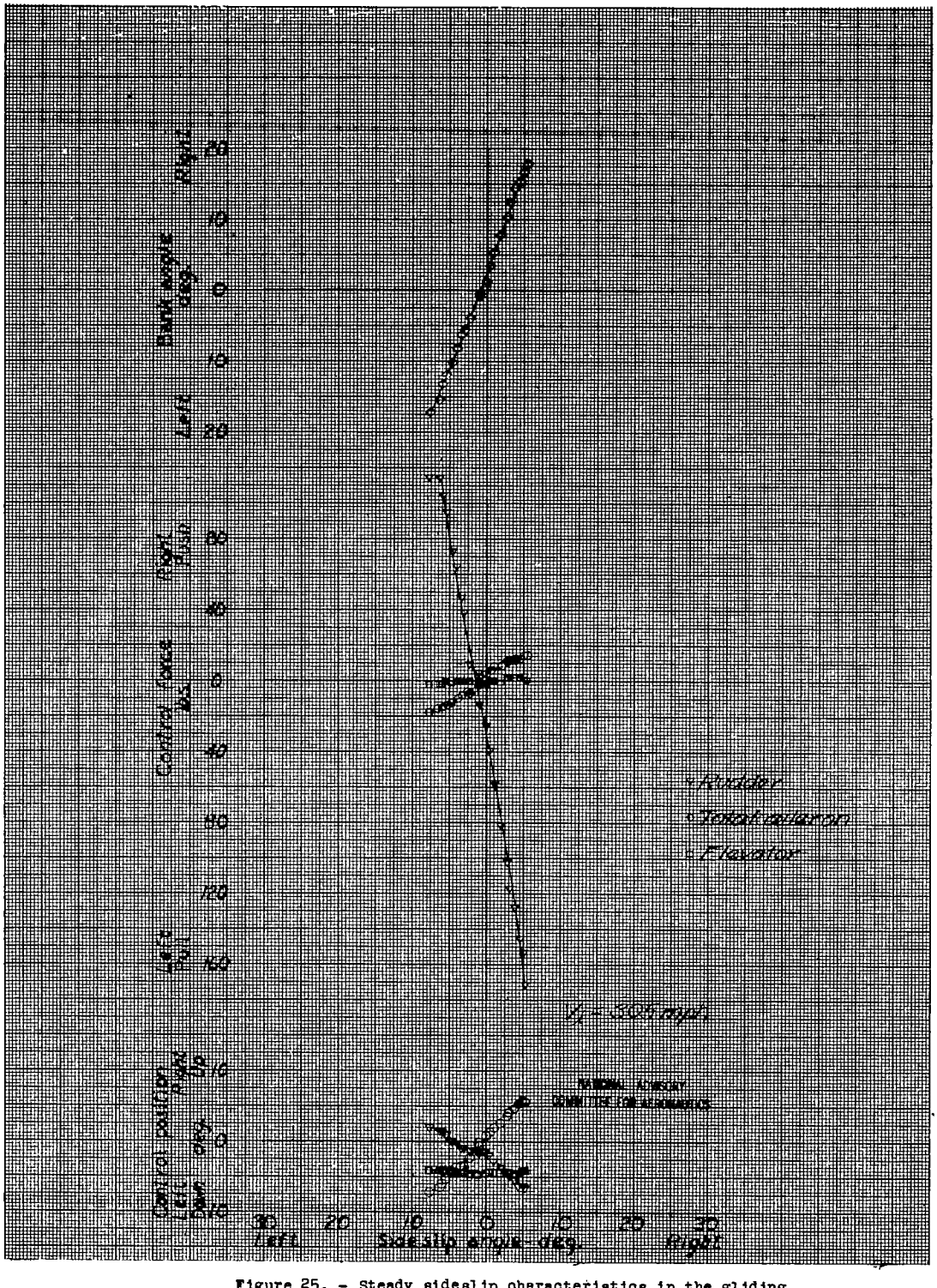

Figure 25. - Steady sideslip characteristics in the gliding condition at 305 miles per hour, F6F-3 airplane.

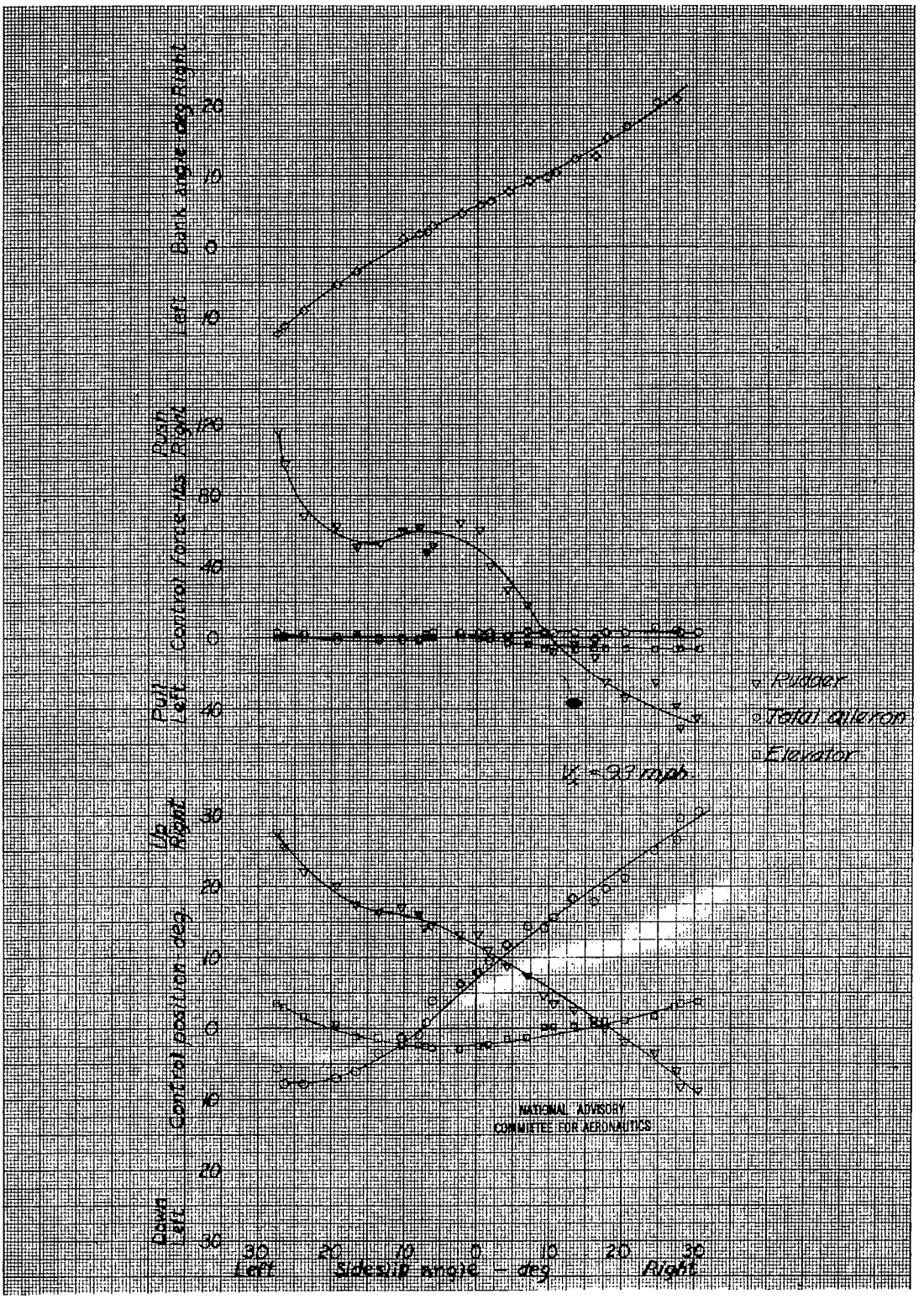

Figure 26. - Steady sideslip characteristics in the climbing condition at 93 miles per hour, F6F-3 airplane.

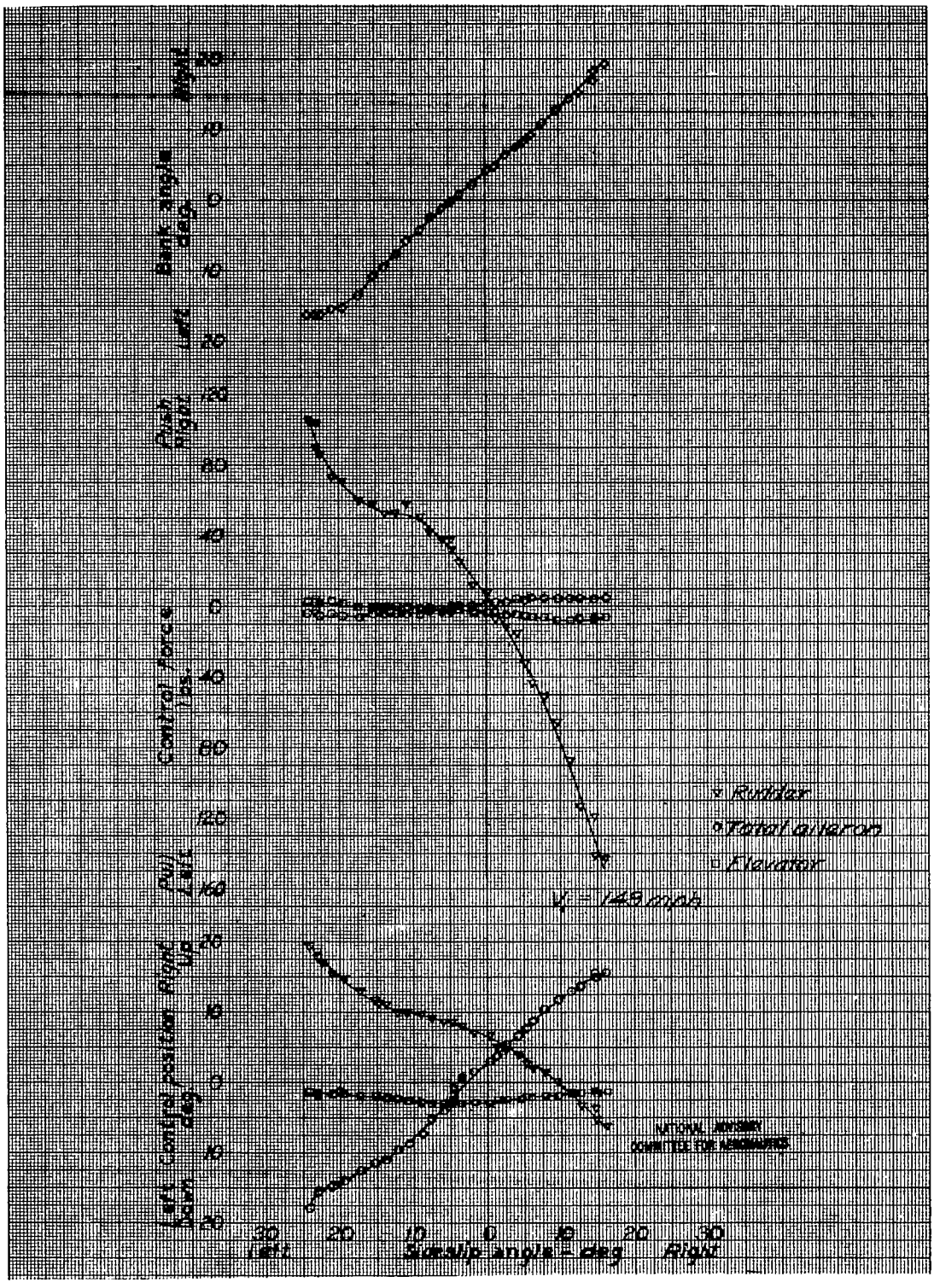

Figure 27. - Steady sideslip characteristics in the climbing condition at 149 miles per hour, F6F-3 airplane.

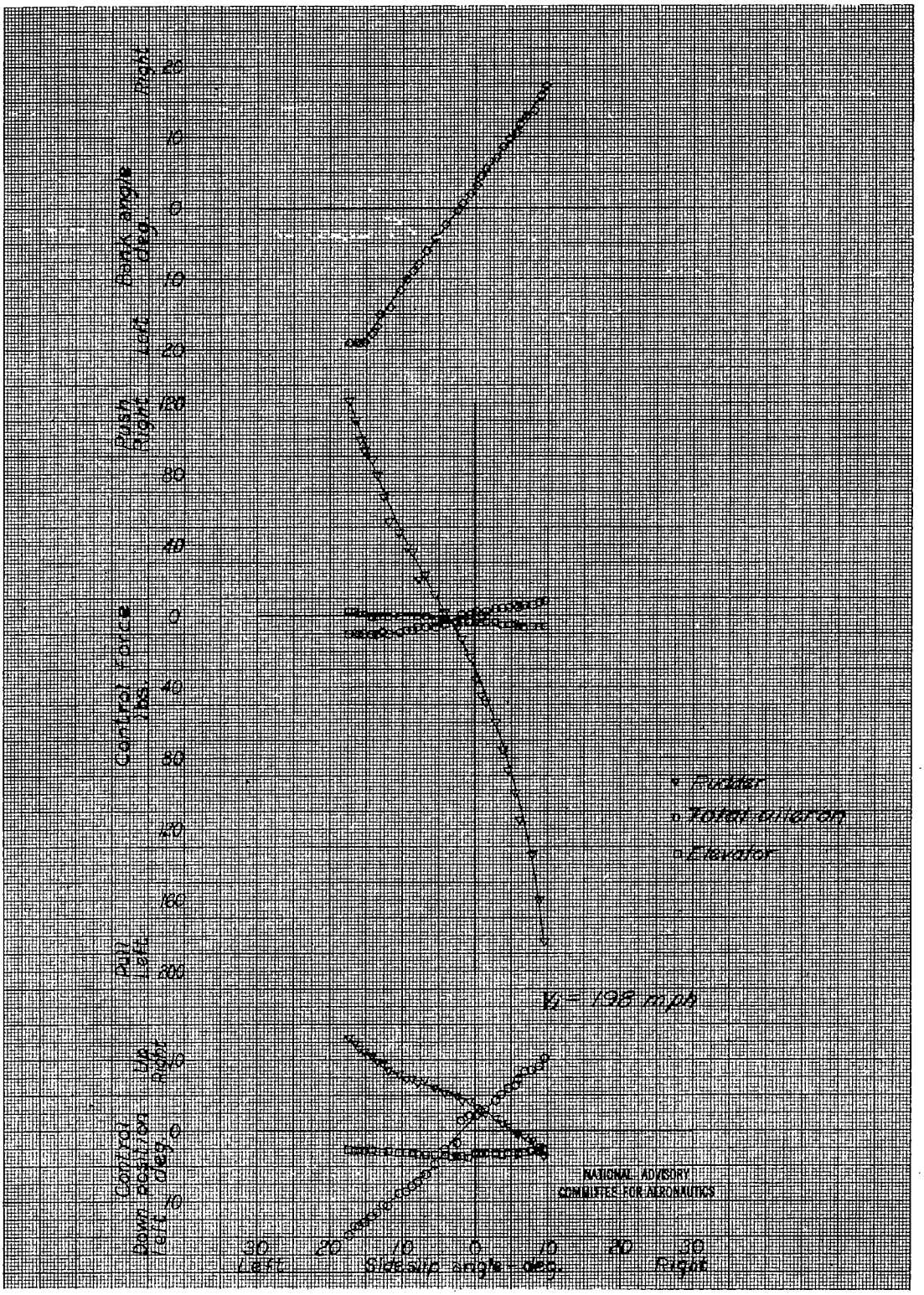

Figure 28. - Steady sideslip characteristics in the climbing condition at 198 miles per hour, F6F-3 airplane.

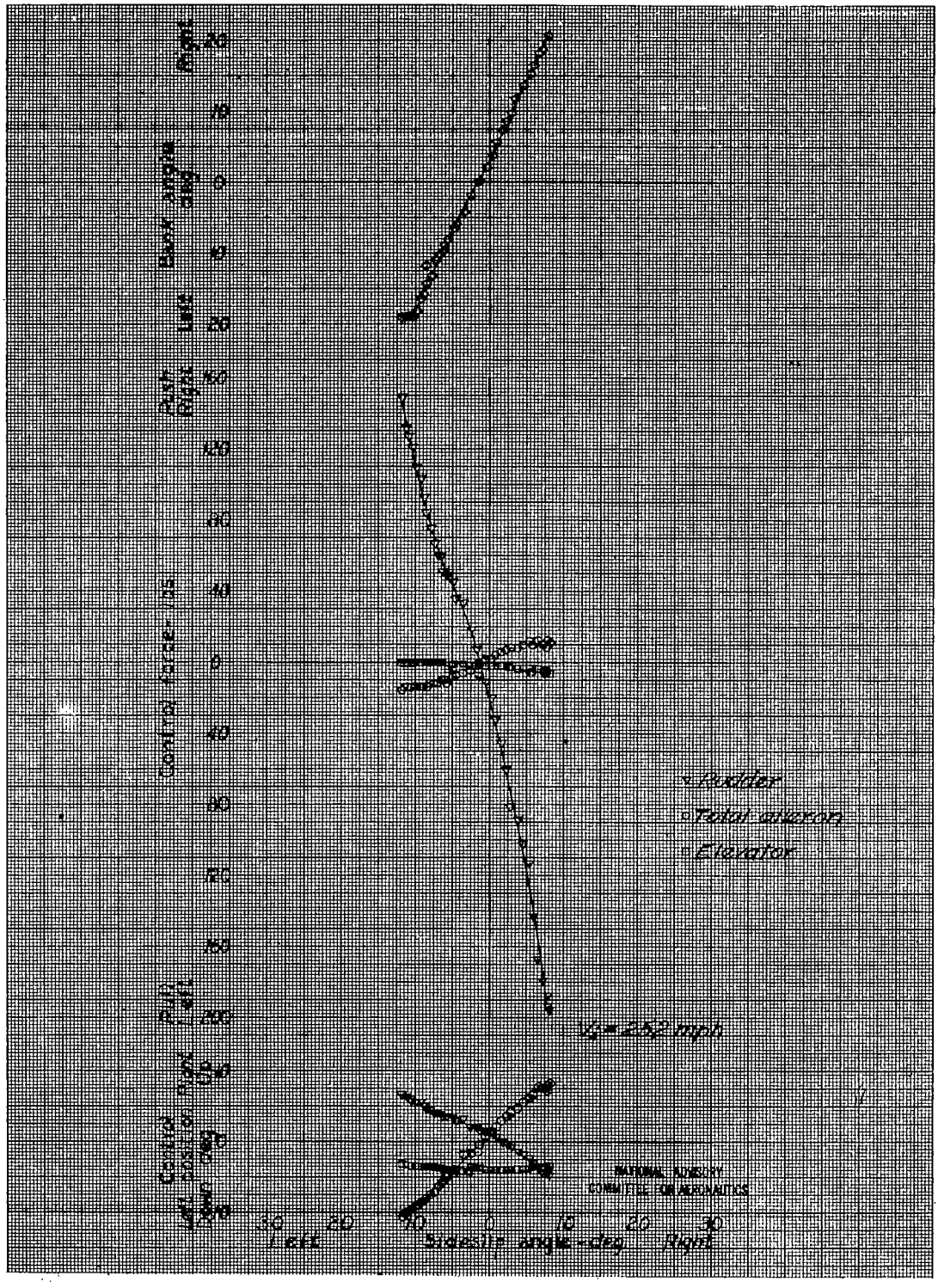

Figure 29. - Steady sideslip characteristics in the climbing condition at 252 miles per hour, F6F-3 airplane.

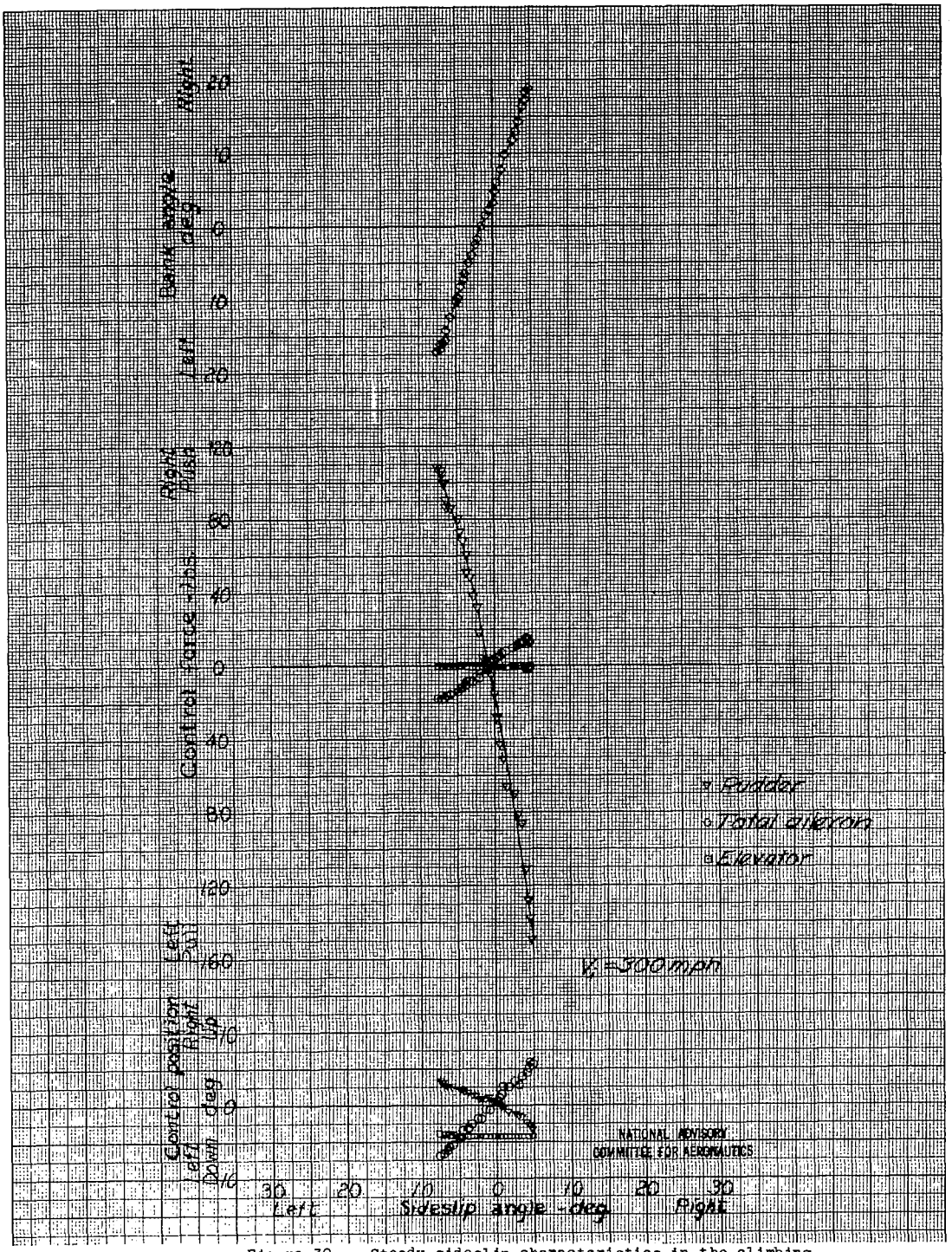

Figure 30. - Steady sideslip characteristics in the climbing condition at 300 miles per hour, F6F-3 airplane.

Figure 31. - Flap blow-up characteristics in steady sideslips, V_i = 88 miles per hour, landing condition, F6F-3 airplane.

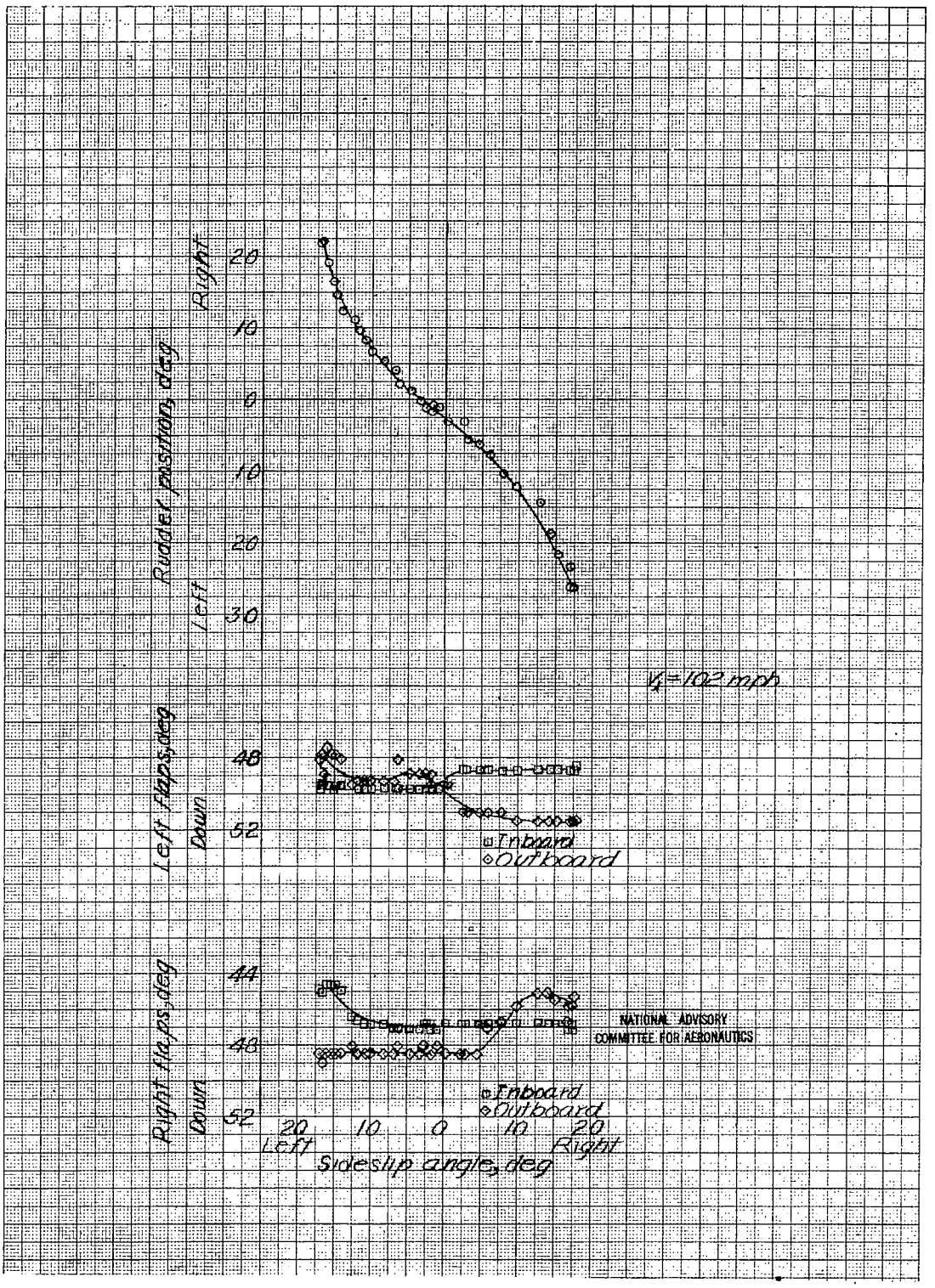

Figure 32. - Flap blow-up characteristics in steady sideslips V_i = 102 miles per hour, landing condition F6F-3 airplane.

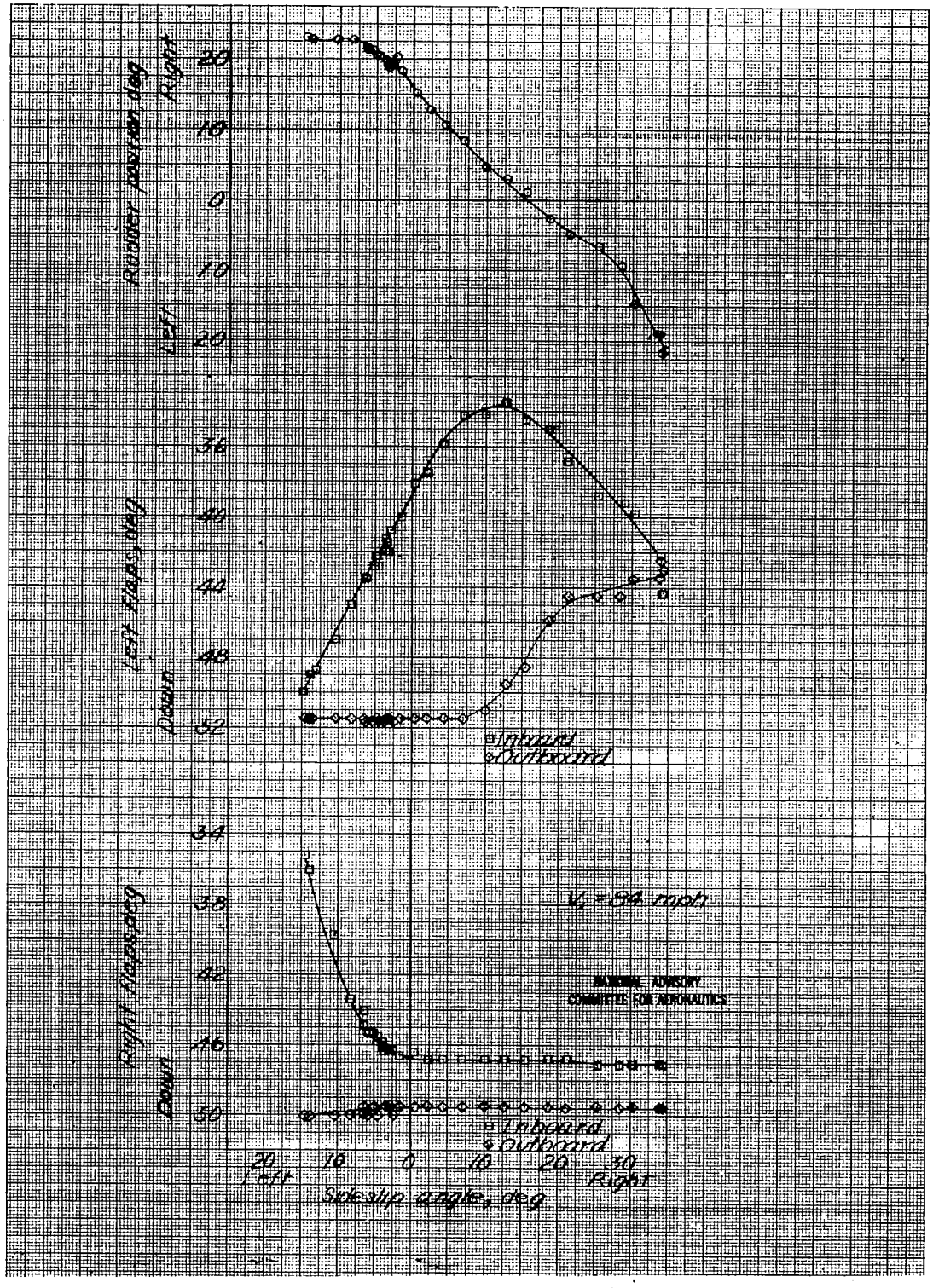

Figure 33. - Flap blow-up characteristics in steady sideslips V_i = 84 miles per hour, wave-off condition, F6F-3 airplane.

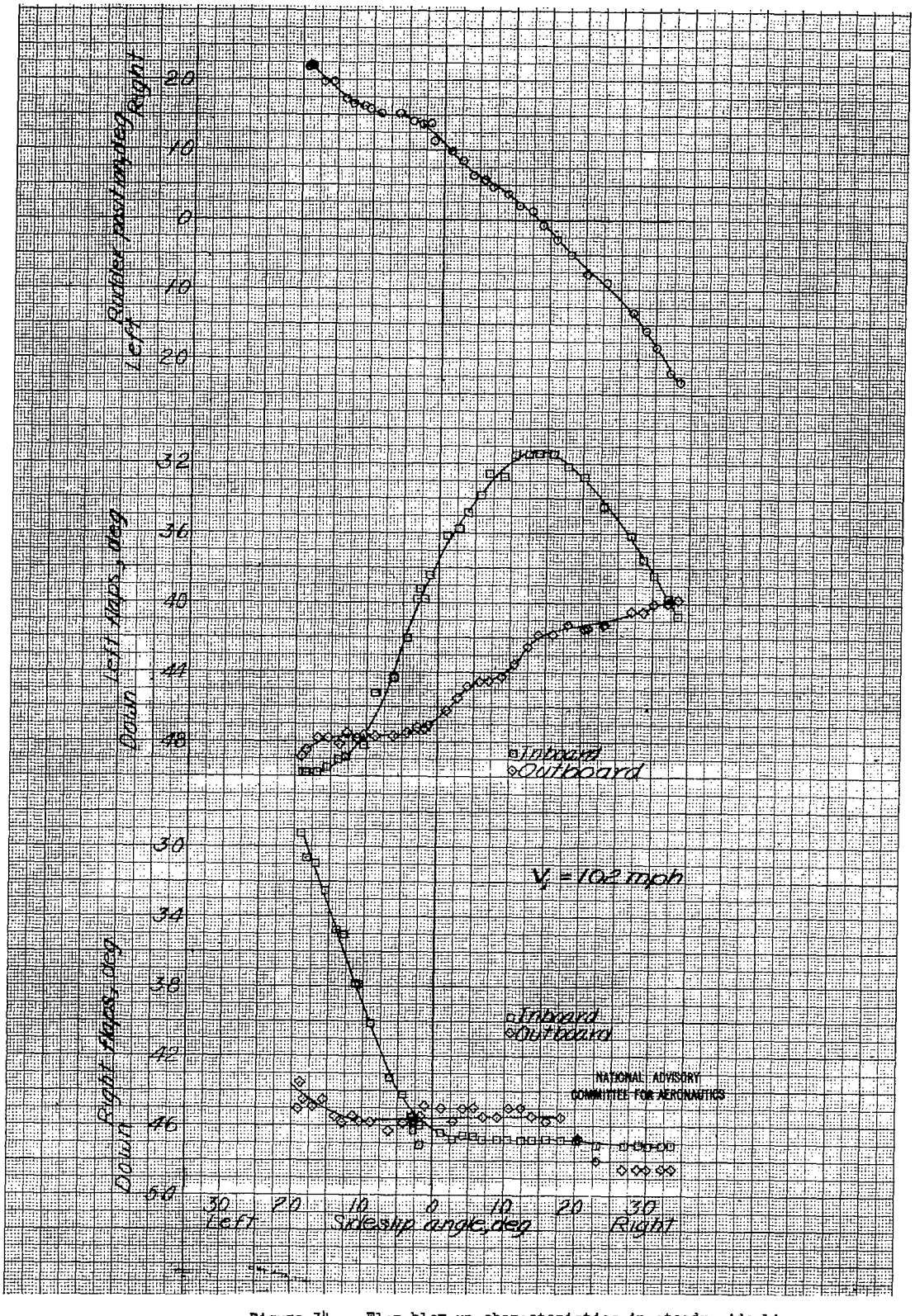

Figure 34. - Flap blow-up characteristics in steady sideslips V_i = 102 miles per hour, F6F-3 airplane.

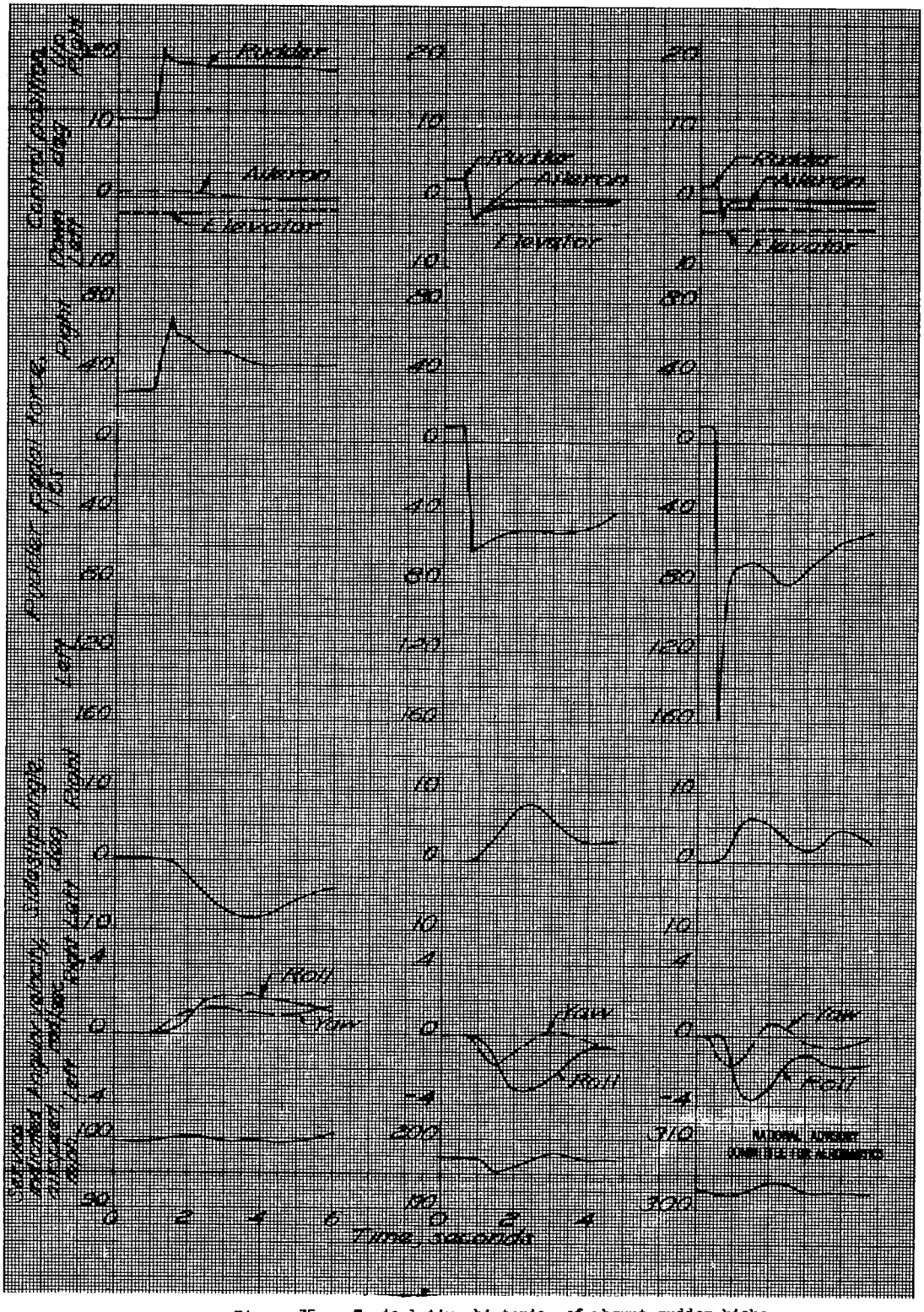

Figure 35. - Typical time histories of abrupt rudder kicks, clean condition, power for level flight, F6F-3 airplane.

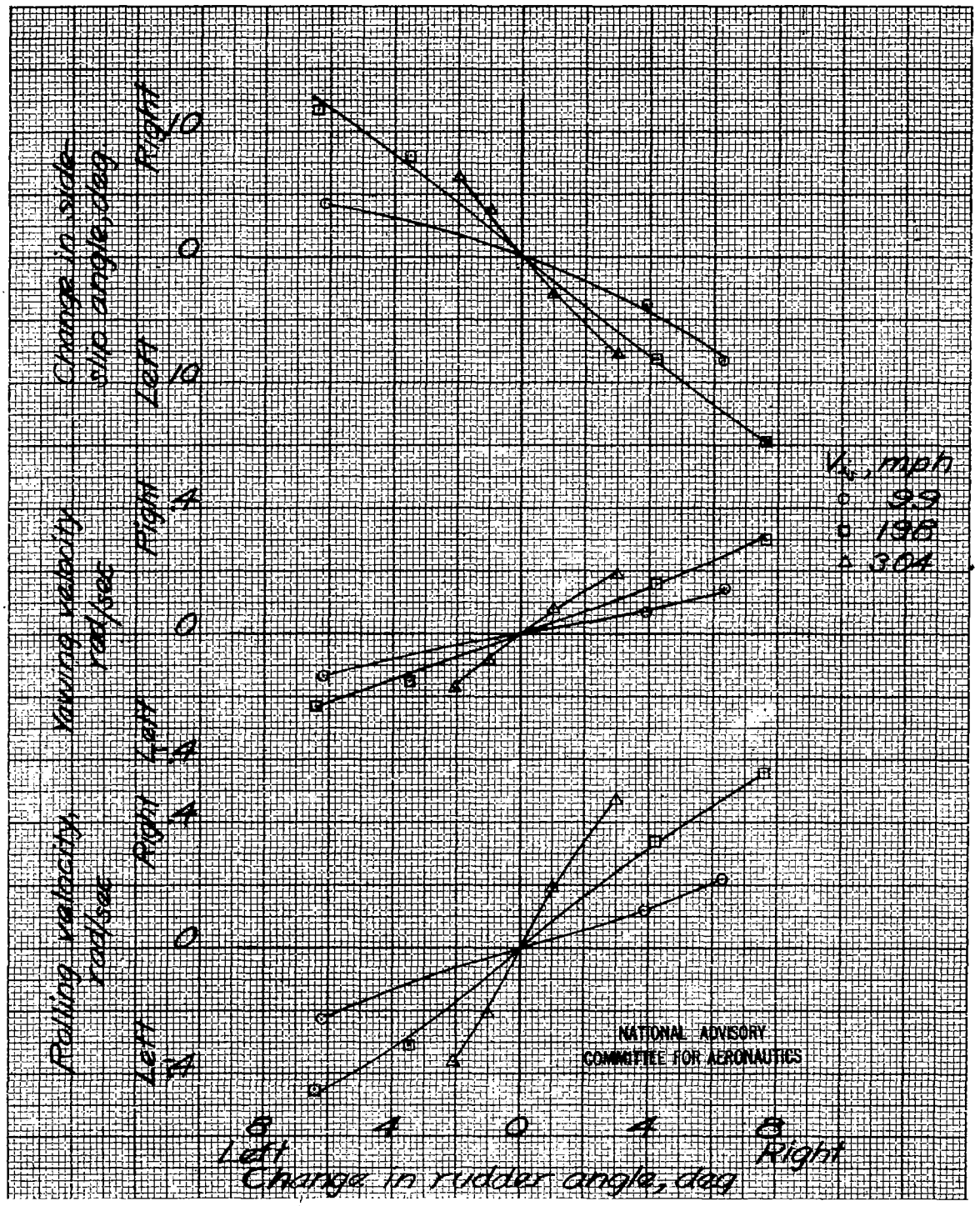

Figure 36. - Variation of maximum sideslip angle, yawing velocity, and rolling velocity with change in rudder angle in abrupt rudder kicks, F6F-3 airplane.

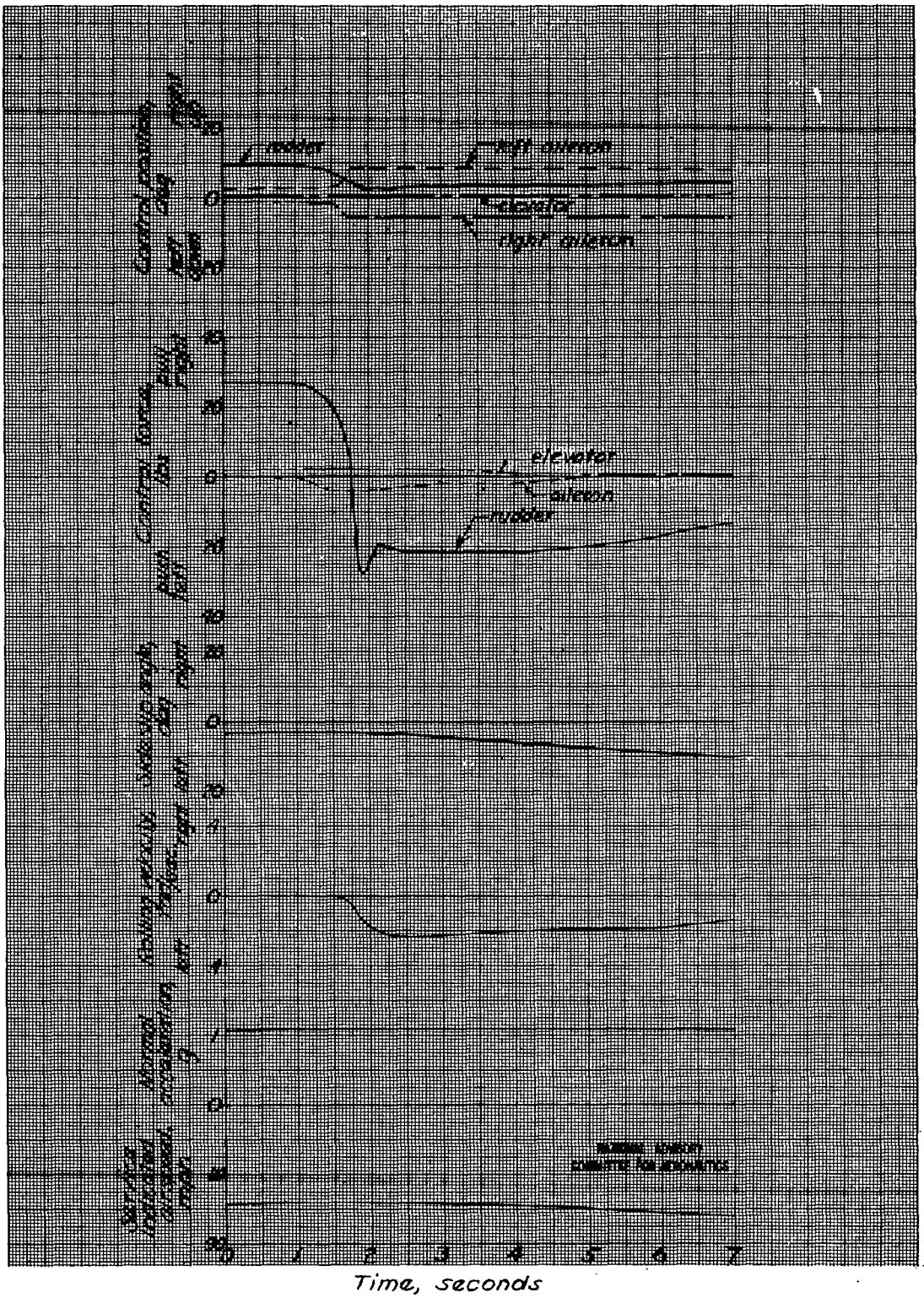

Figure 37.- Time history of rolling out of a right turn using partial aileron control and less rudder than necessary to overcome adverse aileron yaw. Clean condition, power for level flight, F6F-3 airplane.

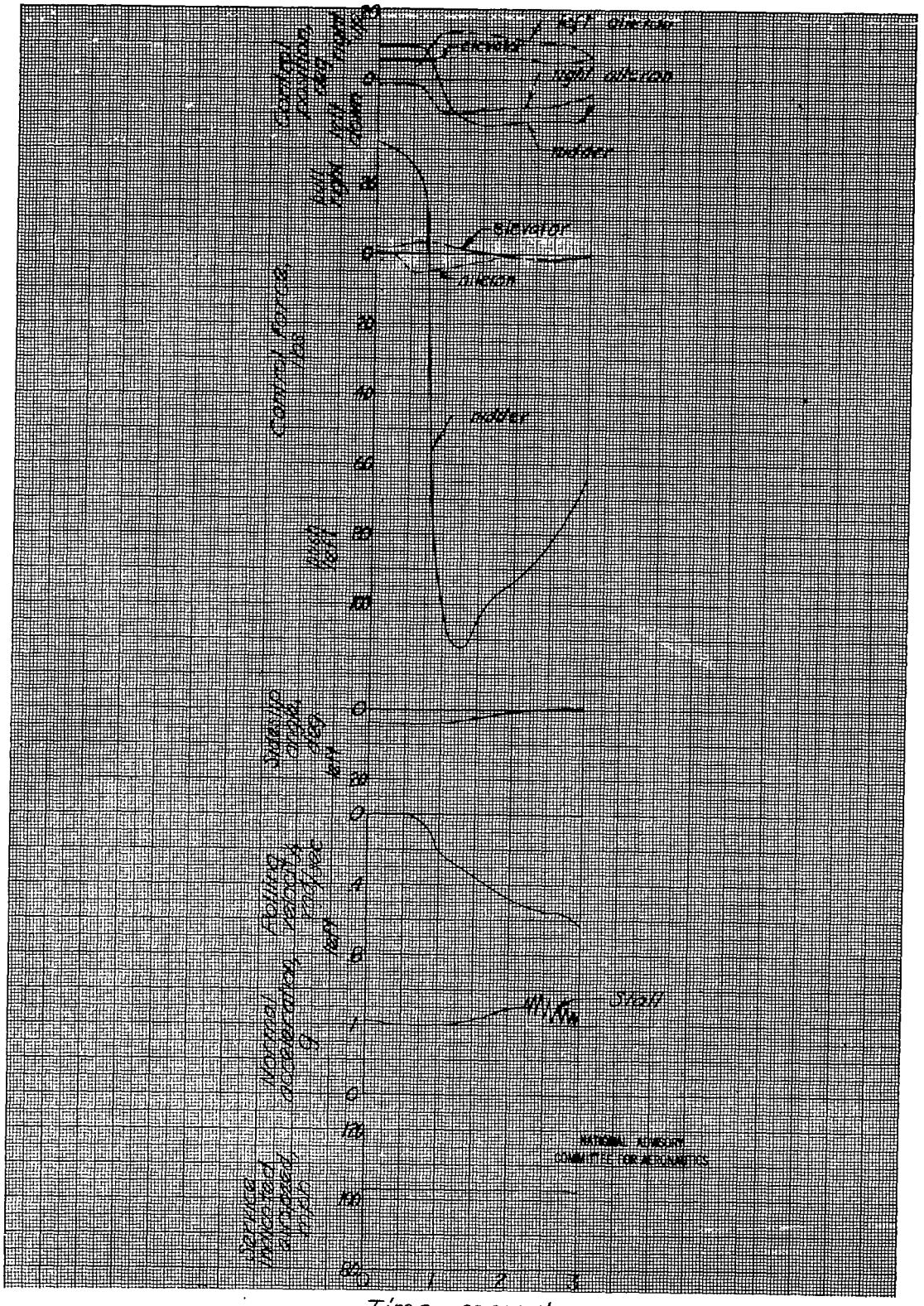

Figure 38.- Time history of rolling out of a right turn using partial aileron control and more rudder than necessary to overcome adverse aileron yaw. Clean condition, power for level flight, F6F-3 airplane.

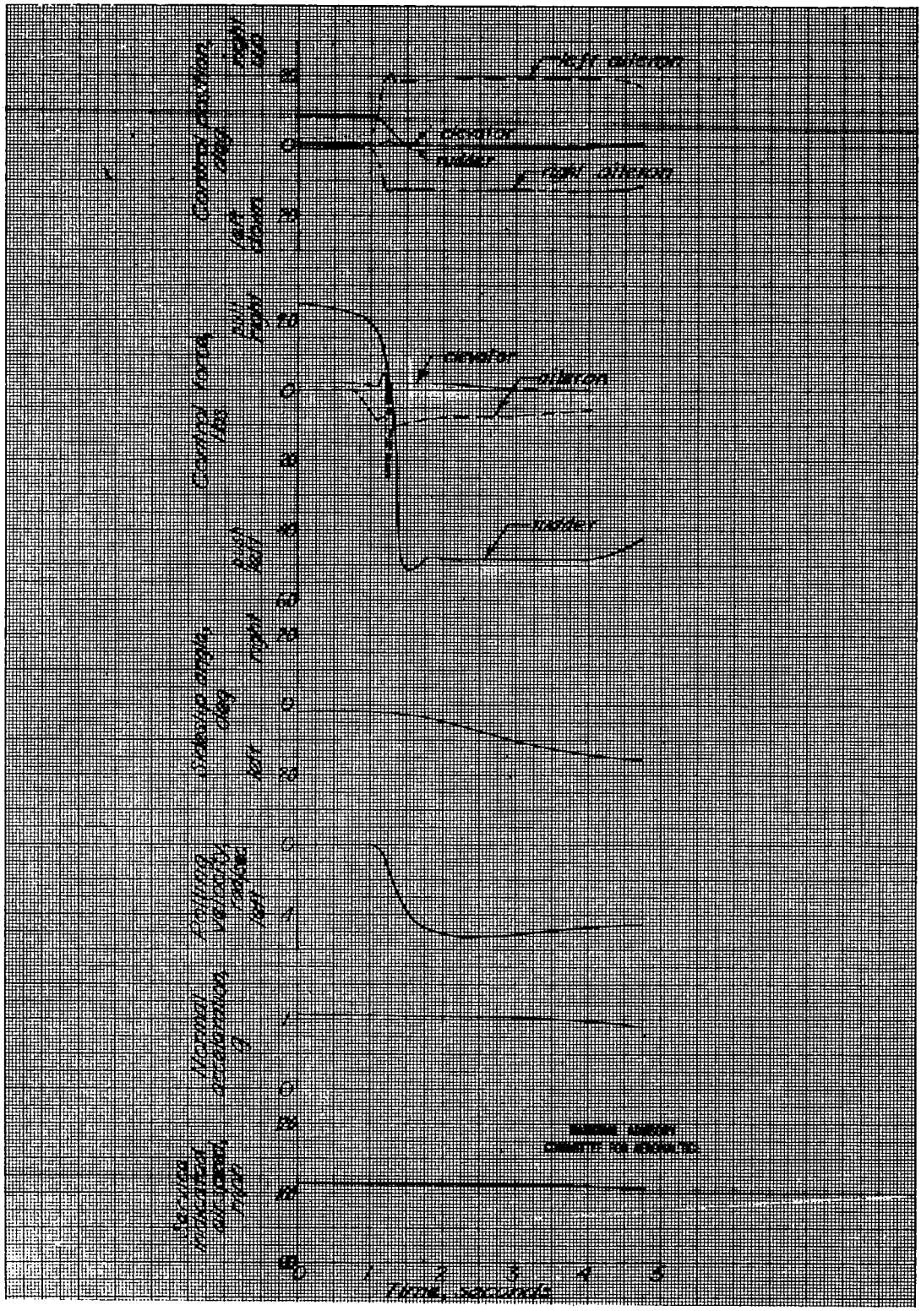

Figure 39. - Time history of rolling out of a right turn using full aileron deflection and less rudder than necessary to overcome adverse aileron yaw. Clean condition, power for level flight, F6F-3 airplane.

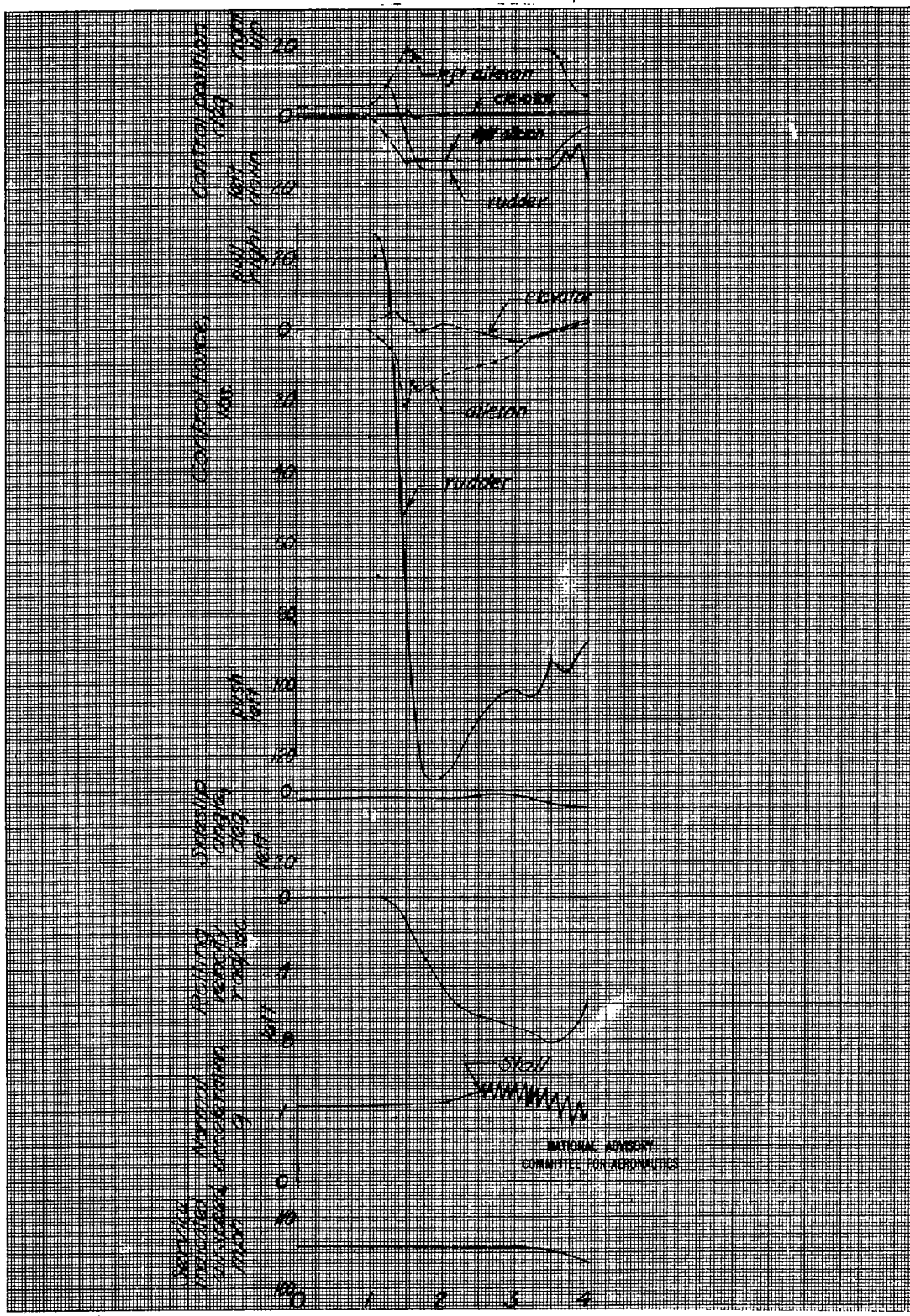

Figure 40.- Time history of rolling out of a right turn using full aileron and slightly more rudder deflection than necessary to overcome adverse aileron yaw. Clean condition, power for level flight, P6Y-3 airplane.

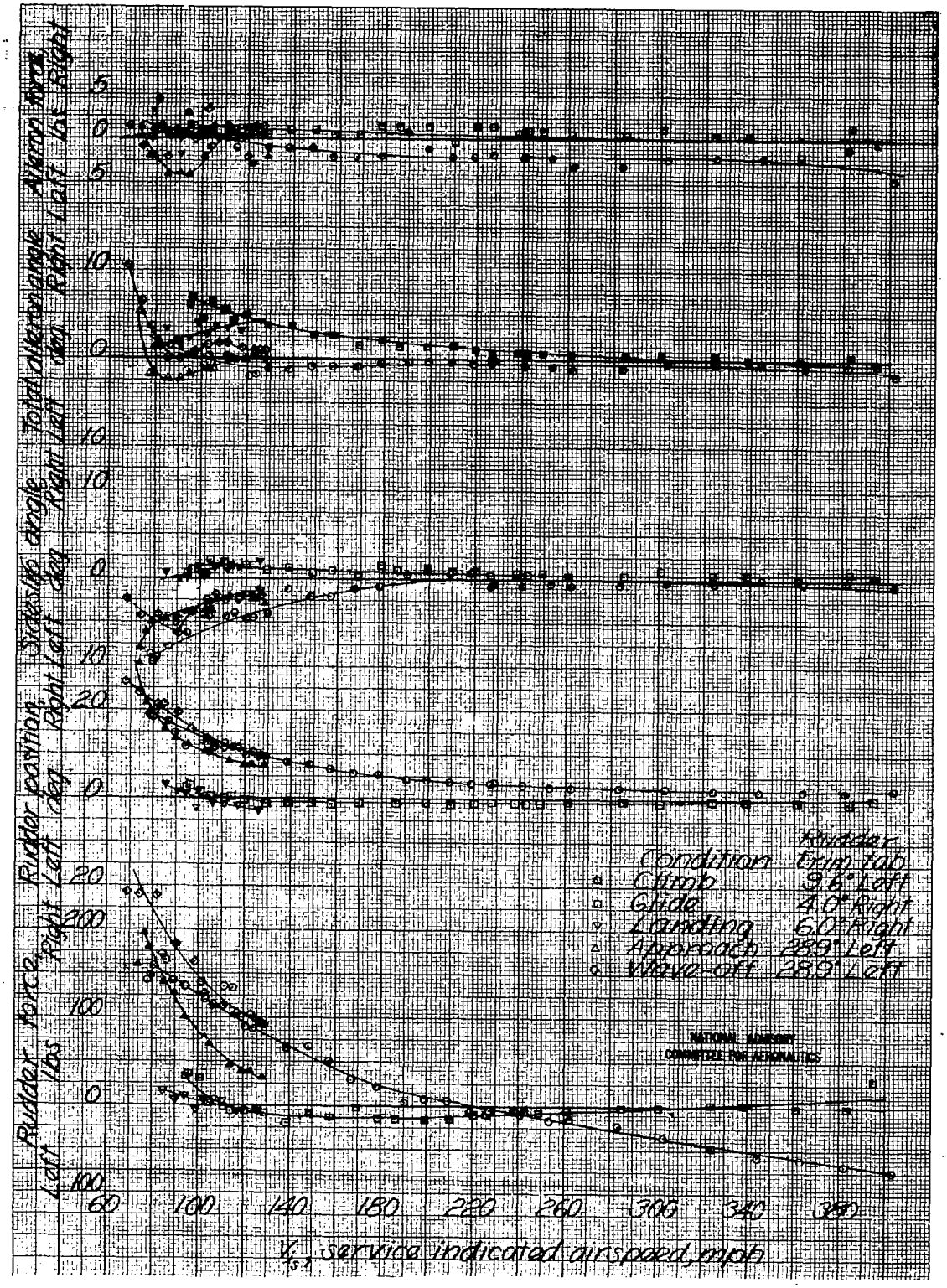

Figure 41. - Directional and lateral trim characteristics, F6F-3 airplane.

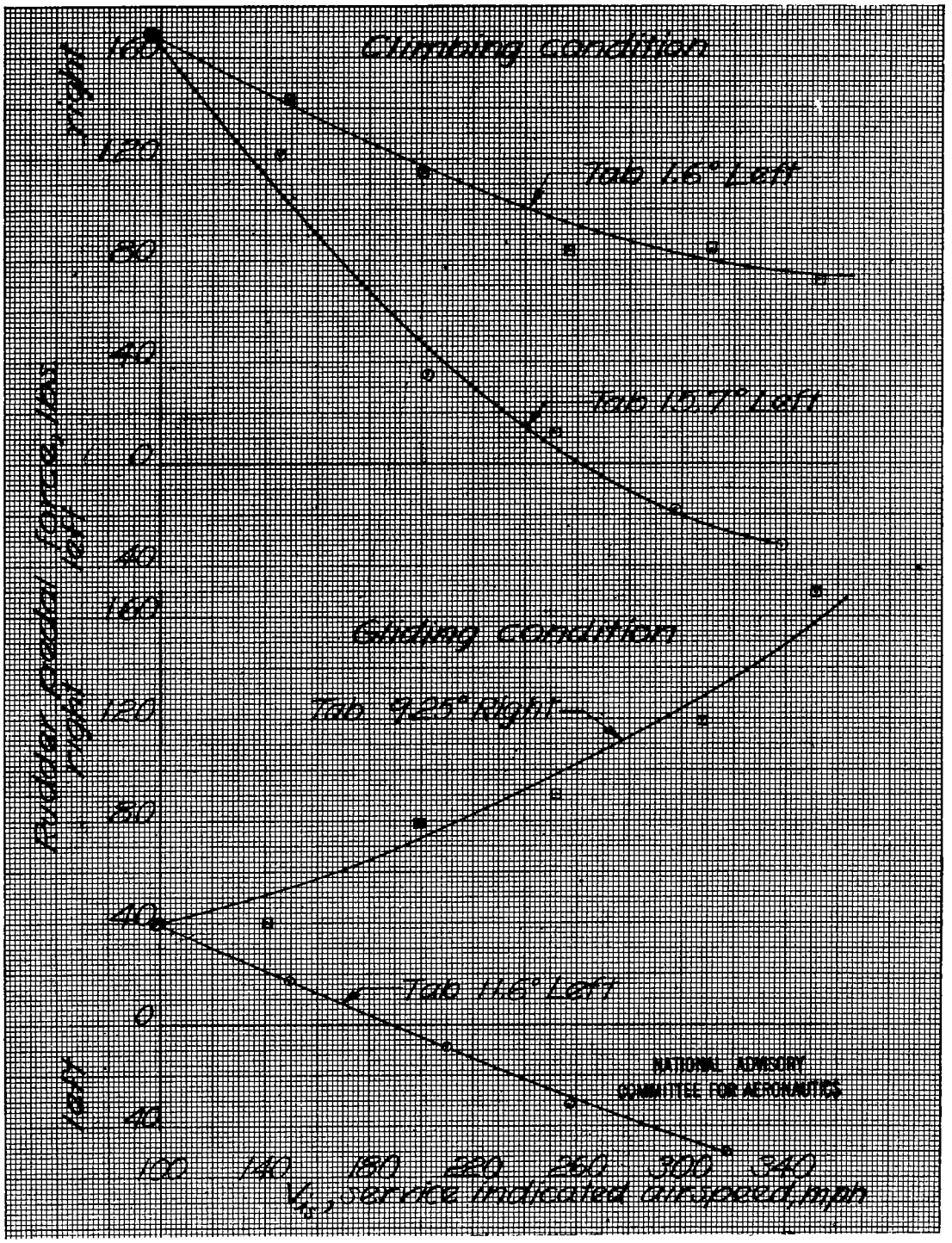

Figure 42. - Variation of rudder pedal force with indicated airspeed for two trim tab settings, gliding and climbing condition, F6F-3 airplane.

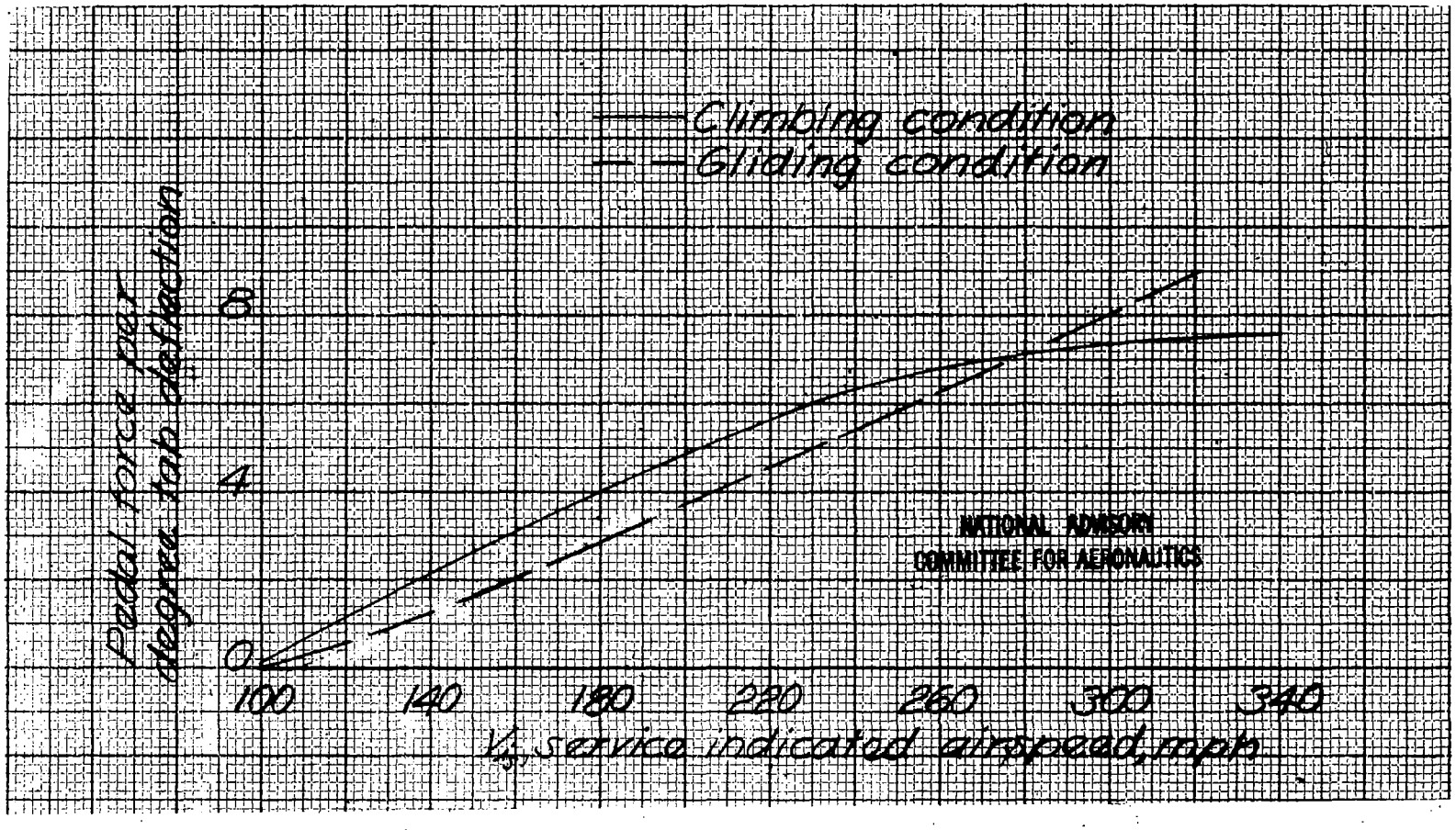

Figure 43. - Variation of rudder pedal force per degree trim tab deflection with indicated airspeed, gliding and climbing condition, F6F-3 airplane.

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