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RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Navy Department

PARTIAL MEASUREMENTS IN FLIGHT OF THE FLYING QUALITIES OF A

GRUMMAN XF7F-1 AIRPLANE WITH A MODIFIED VERTICAL TAIL

By Howard L. Turner and George E. Cooper

FOR REFERENCE

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NACA RM No. A7D15

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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PARTIAL MEASUREMENTS IN FLIGHT OF THE FLYING QUALITIES OF A GRUMMAN XF7F-1 AIRPLANE WITH A MODIFIED VERTICAL TAIL

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SUMMARY

The results of limited flight tests to determine some of the handling qualities of a Grumman XF7F-1 airplane with a modified vertical tail are presented. These results are for low altitude and normal center-of-gravity conditions only.

A resumé of the characteristics investigated is given below:

1. The airplane was found to be satisfactory with respect to static longitudinal stability, longitudinal trim changes, static directional stability, dynamic lateral stability, and stick-free lateral stability for the conditions tested.

2. The airplane was considered by the pilots to have good stalling characteristics in the configurations and conditions tested.

3. The elevator control-force gradients were excessive at the center of gravity tested.

4. The maximum wing-tip helix angles developed by maximum aileron deflections did not satisfy current requirements.

INTRODUCTION

At the request of the Bureau of Aeronautics, Navy Department, handling qualities of the Grumman XF7F-1 airplane (Bureau No. 03550) were investigated at the Ames Aeronautical Laboratory. The airplane as tested had a modified vertical tail. The results of handling

[redacted]

qualities presented herein are of limited scope and include only the results obtained at low altitude and for the normal center-of-gravity position.

DESCRIPTION OF THE AIRPLANE

The Grumman XF7F-1 airplane is a twin-engine, single-seat, high-midwing monoplane fighter equipped with a fully retractable tricycle landing gear. A three-view drawing of the airplane with pertinent dimensions is presented in figure 1. General specifications of the Grumman XF7F-1 airplane are given in the appendix.

The vertical tail of the airplane tested was as modified by the Ames 40- by 80-foot wind tunnel (reference 1). A sketch of the modification as compared with the original tail is shown in figure 2.

INSTRUMENTATION

Standard NACA continuous-film-recording instruments were used to record airspeed, altitude, control positions and forces, angular velocities, angles of sideslip and bank, and normal acceleration.

All values of indicated airspeed given in this report are defined by the usual formula by which standard airspeed meters are calibrated and are corrected for position error.

TESTS, RESULTS, AND DISCUSSION

All tests in this report were made at low altitude (an average altitude of 10,000 ft) and for the normal center-of-gravity position (25.2 percent M.A.C.). Except where otherwise noted as pilot's opinion, the handling qualities were evaluated by comparison with the requirements of reference 2.

Longitudinal Stability and Control

Static longitudinal stability.- The static longitudinal-stability characteristics were measured in four test configurations. Short steady records were taken in steady straight flight, wings level, at various airspeeds. The variations of elevator angle and control forces with indicated airspeed are given in figure 3. The results of these tests indicate satisfactory static longitudinal stability for the test conditions investigated.

Elevator control power and forces in maneuvering flight.– The longitudinal control characteristics in maneuvering flight woro measured in steady turns at various normal acceleration factors and two airspeeds. The variations of elevator angle and control force with the normal acceleration factor for the two airspeeds are given in figure 4. The elevator control-force gradient of 13 pounds per g unit was excessive for the conditions tested.

Longitudinal trim changes.– The changes in elevator control force required to maintain steady straight flight following changes in flap, gear, and power settings are given in table I for various typical conditions. These results show that the changes were well below the specified maximum of 35 pounds.

Directional Stability and Control

Static directional stability.– The characteristics in steady sideslips were measured during short runs in steady straight flight at various angles of left and right sideslip within the maximum range permitted by structural limitations. In the power-on-clean condition, steady sideslips were made at various airspeeds. In the approach, landing, and wave-off configurations, however, sideslips were made at one airspeed. The variation with sideslip angle of elevator and rudder angles, elevator and aileron forces, and angle of bank are given in figures 5 to 8. The variations of rudder angle with sideslip angle show positive directional stability over the sideslip range for all test conditions. Rudder-force data were not available for these tests.

Rudder control power.– Abrupt, aileron-fixed, rudder kicks were performed in the power approach and in the power-on-clean conditions. While the airplane was trimmed in steady, straight, unbanked flight, the pilot abruptly deflected the rudder various amounts while attempting to hold the ailerons in the trimmed position. The variations with change in rudder angle of the maximum change in sideslip angle, rolling velocity and yawing velocity are shown in figure 9.

Lateral Stability and Control

Dynamic lateral stability.- Records were taken of the motions initiated by simultaneous deflection of the ailerons and rudder and abrupt release of all controls after a sizeable angle of sideslip had been reached. Records were also taken of similar maneuvers except that, after the desired sideslip angles had been reached, all controls were returned to neutral and held fixed. The airplane was trimmed in steady, straight, unbanked flight prior to each of these maneuvers, which were performed at several airspeeds in the power-on-clean condition.

Time histories of typical oscillations are given in figure 10. The damping characteristics, both controls fixed and controls free are shown in figure 11. The dynamic directional-stability characteristics appeared to be satisfactory, as the airplane oscillations damped to one-half amplitude in less than the specified maximum of two cycles.

Aileron control power and control forces in aileron rolls.- Abrupt rudder-fixed aileron rolls were performed at various airspeeds with the flap and gear both up and down. While the airplane was trimmed in steady, straight, unbanked flight, the ailerons were abruptly deflected and held until the maximum rolling velocity was attained. Power was varied to maintain level flight at each test speed.

The variation with change in aileron force of the maximum change in rolling velocity and maximum change in wing-tip helix angle $pb/2V$ is shown in figures 12 and 13. Since no aileron-deflection data are available, it was deduced from figures 12 and 13 that the variation of $pb/2V$ with aileron deflection would be smooth and nearly linear as required. It was also assumed that there was an increase in aileron force as the aileron deflections approached maximum. The maximum wing-tip helix angle developed with maximum available aileron deflection does not satisfy the requirements for the test conditions at any of the test speeds.

Stick-free lateral stability.- Positive stick-free lateral stability was indicated by the variation of aileron force with sideslip angles in steady sideslips. (See figs. 5 to 8.)

Stalling Characteristics

Stalls in straight flight.– Time histories of stalls entered slowly from straight flight in the glide and cruise conditions are presented in figure 14. Stalls were also made from straight flight in the landing and power-approach conditions, but as they do not differ appreciably from those made in turning flight (fig. 15) it was not felt necessary to include them here. The only difference noted was in the landing condition where the tendency to roll off at the stall was present only in turning flight.

The following discussion of the time histories includes remarks taken from the pilot's notes:

> Glide condition (fig. 14(a)).– "The stall was preceded by a very mild periodic buffeting and was characterized by a very mild pitching oscillation. The tendency to roll was relatively slight." This stall was similar to the power-approach stall from turning flight discussed later.
>
> Cruise condition (fig. 14(b)).– "The stall warning occurred as moderate buffeting which continued as further attempts were made to completely stall the aircraft. It was very difficult to distinguish between the warning and the stall." Examination of figure 14(b) shows a very mild pitching oscillation during the buffeting with roll-off to the right.

Stalls in turning flight.– Time histories of stalls entered slowly from turning flight in the landing and power-approach conditions are presented in figure 15. Stalls from turning flight were also made in the glide and cruising conditions, but as they did not differ appreciably from those made in straight flight (fig. 14) they are not included herein.

The following discussion of the time histories includes remarks taken from the pilot's notes:

> Landing condition (fig. 15(a)).– "The stall warning was good and consisted of a mild buffeting. The stall itself was characterized by a left roll and a pitch-down." Stalls were made both from turns to the left and right, but the roll-off was always to the left.
>
> Power-approach condition (fig. 15(b)).– "The stall warning was good and consisted of mild buffeting. The stall was

characterized by a pitching oscillation, but there was no tendency to roll." It was noted that the aircraft was still controllable during the warning period and that increased elevator deflection was required for the complete stall. During the one cycle of the pitching oscillation shown in figure 15(b), a slight amount of roll was recorded but no appreciable movement of the ailerons was required to control it.

In general, the stall warning which consisted primarily of buffeting and a mild pitching oscillation was considered satisfactory for all conditions investigated. Examination of the time histories and the pilot's opinions show that even when buffeting did not occur prior to the first stalling motion of the airplane (as in cruise condition, fig. 14(b)), the initial motions in the stall were so mild as to constitute a warning rather than a completely or dangerously stalled condition. The stalls were characterized by a mild pitch-up followed by a more definite pitch-down. The rolling tendency was small and inconsistent except in turning flight in the landing condition where the airplane had a definite left rolling tendency. Recovery could be effected easily in all conditions by normal use of the controls.

CONCLUSIONS

The following conclusions, based on the test results presented herein, pilot's opinion, and the requirements of reference 2, may be drawn with regard to the flying qualities of the modified Grumman XF7F-1 airplane tested:

1. The static longitudinal stability at the center-of-gravity position investigated (25.2 percent M.A.C.) was considered satisfactory.

2. In steady turns, the elevator control force varied smoothly with change in normal acceleration factor, but the elevator control-force gradient of 13 pounds per g unit was considered excessive.

3. For the conditions tested, the longitudinal-trim changes were small and satisfied the requirements.

4. Positive directional stability was obtained over the sideslip range and test conditions investigated.

5. The dynamic lateral stability was positive and the short-period oscillations of the airplane damped to one-half amplitude in less than the required two cycles.

6. Positive stick-free lateral stability was indicated for the conditions tested.

7. In abrupt rudder-fixed aileron rolls, the maximum wing-tip helix angle $pb/2V$ for full aileron deflection failed to meet requirements.

8. The stalling characteristics in straight and turning flight in all configurations tested were satisfactory. It was the pilot's opinion that stalling characteristics were good with all stalls being preceded by buffeting, and the tendency to roll off being negligible in all configurations except turning flight in the landing configuration.

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Moffett Field, Calif.

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George E. Cooper

George E. Cooper,
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Approved:

Harry J. Goott

Harry J. Goott,
Aeronautical Engineer.

APPENDIX

General Specifications of the Grumman XF7F-1 Airplane

Airplane – general

Span	51.5 ft
Over-all length	45.4 ft
Weight	
Empty	15,750 lb
Gross	21,450 lb

Wing

Airfoil section	
Root	NACA 23015
Tip	NACA 23012
Total area (including ailerons, flaps and 37.2 sq ft of fuselage)	455 sq ft
Root chord at center line of airplane	12.17 ft
Tip chord	5.83 ft
Mean aerodynamic chord	9.30 ft
Incidence (at root section to horizontal reference line)	3°
Dihedral (chordal plane)	6°
Sweepback	0°
Geometric aspect ratio	5.83

Ailerons (each)	Frise type
Area aft of hinge line	11.44 sq ft
Mean geometric chord aft of hinge line	1.286 ft
Average percent chord	16
Span	9.0 ft
Aileron tab	
Left	Combination spring-loaded and trim
Right	Spring-loaded
Span (each)	2.16 ft
Area (each)	0.86 ft
Flaps	Single-slotted
Total area	48.5 sq ft
Span (percent wing span, over-all)	61
Chord (aft of hinge, constant)	1.67 ft
Total chord	2.08 ft
Horizontal-tail surfaces	
Span	22 ft
Area (including elevators and fuselage)	108.8 sq ft
Incidence (with respect to fuselage reference line)	2°
Dihedral	0°
Leading-edge wing to elevator hinge line	26.17 ft

Elevator

Span	10.06 ft
Area (aft of hinge line, including tabs)	24.8 sq ft
Chord (aft of hinge line)	1.25 ft
Span of tab (each)	3.42 ft
Area of tabs (total)	2.28 sq ft

Vertical-tail surfaces . . . . . NACA modification

Span	12.3 ft
Area (including rudder)	58.4 sq ft
Offset from fuselage center line	0°

Rudder

Span	9.2 ft
Area (aft of hinge line, including tab)	20.1 sq ft
Leading-edge wing to rudder hinge line	28.33 ft

Tab

Type	Combination geared balance and trim
Span	3.26 ft
Area	2.7 sq ft

Power plant

Number of engines	Two
Type	Pratt & Whitney double-wasp "C"
Designation	Navy R-2800-22W
Superchargor	Two-speed-internal
Gear ratio	0.450:1
Propellers	
Type	Hamilton Standard, hydromatic
Blade design	6501-A-0
Number of blades	Three
Diameter	13.17 ft
Hub	Model 33E60
Pitch setting	
Low (fine)	26°
High (coarse)	93°
Ground clearance (normal condition)	$8\frac{1}{2}$ in.

REFERENCES

1. Hunton, Lynn W.: An Investigation of the Low-Speed Directional- and Lateral-Control Characteristics of the Grumman XF7F-1 Airplane in the Ames 40- by 80-Foot Wind Tunnel (TED No. NACA 2346). NACA RMR No. A6B28, Mar. 1946.

2. Anon: Specification for Stability and Control Characteristics of Airplanes. Spec. No. SR-119A, Bur. Aero., Navy Dept., Apr. 7, 1945.

TABLE I.– LONGITUDINAL TRIM CHANGES OF A
MODIFIED GRUMMAN XF7F-1 AIRPLANE

Condition	Flap	Gear	Manifold pressure (in. Hg)	Engine speed setting (rpm)	Indicated airspeed (mph)	Elevator angle (deg)	Elevator control force (lb)
Glide	Up	Up	20.3	2300	128	1.6 up	0
– – –	– –	Down	20.3	2300	128	6.0 up	7 pull
– – –	Down	– –	20.3	2300	128	0.40 down	1.5 push
Approach	Down	Down	20.3	2300	112	3.0 up	0
Landing	Down	Down	Power off	2300	112	11.0 up	12.0 pull
Wave-off	Down	Down	41.5	2600	112	1.4 down	4.5 push
– – –	– –	Up	41.5	2600	112	5.8 down	10.5 push
– – –	Up	– –	41.5	2600	112	.80 down	6.0 push
Power-on-clean	Up	Up	41.5	2600	281	.30 down	0
– – –	Up	Up	Power off	2600	281	.40 up	2.5 pull

FIGURE LEGENDS

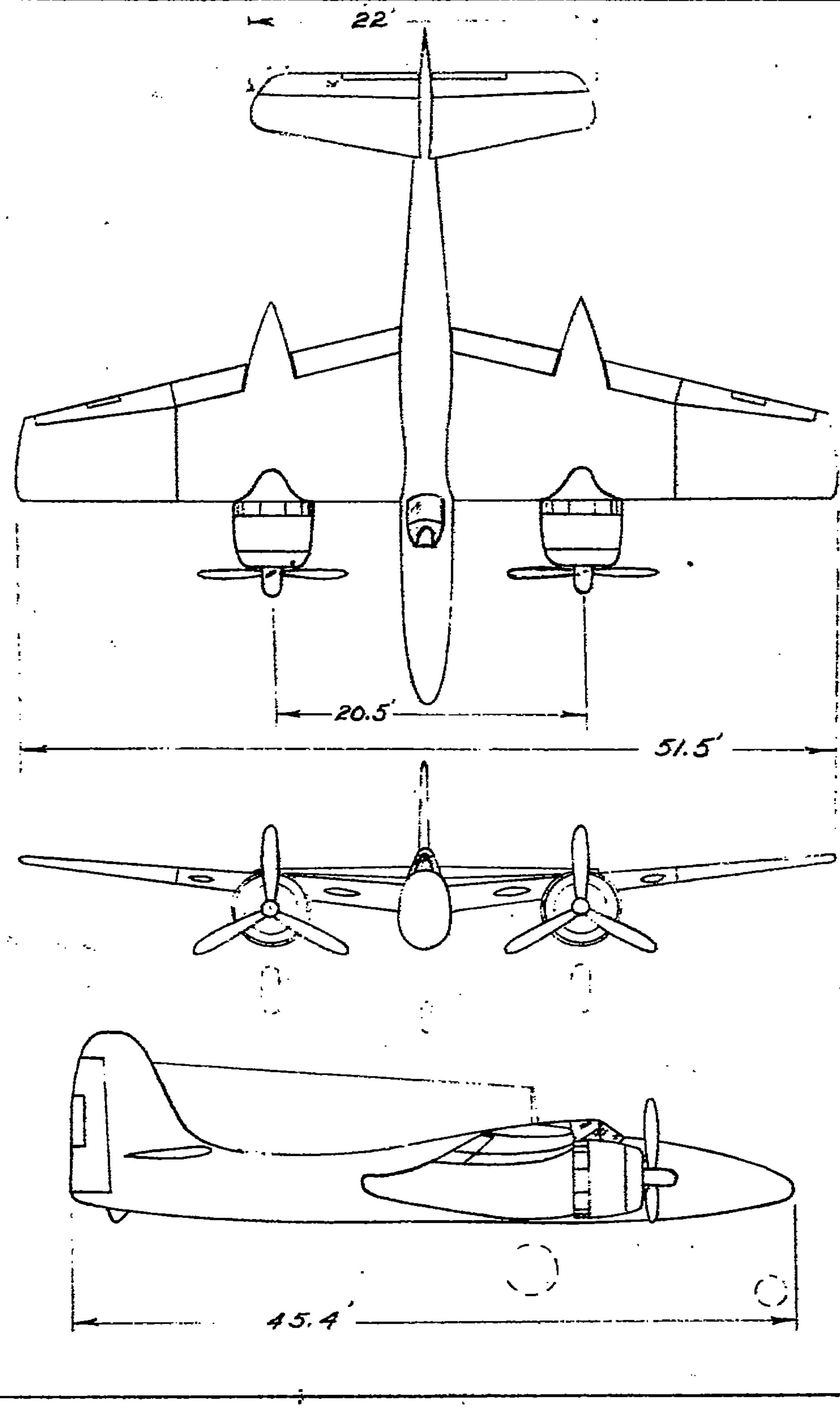

Figure 1.- Three-view drawing of Grumman XF7F-1 airplane with a modified vertical-tail.

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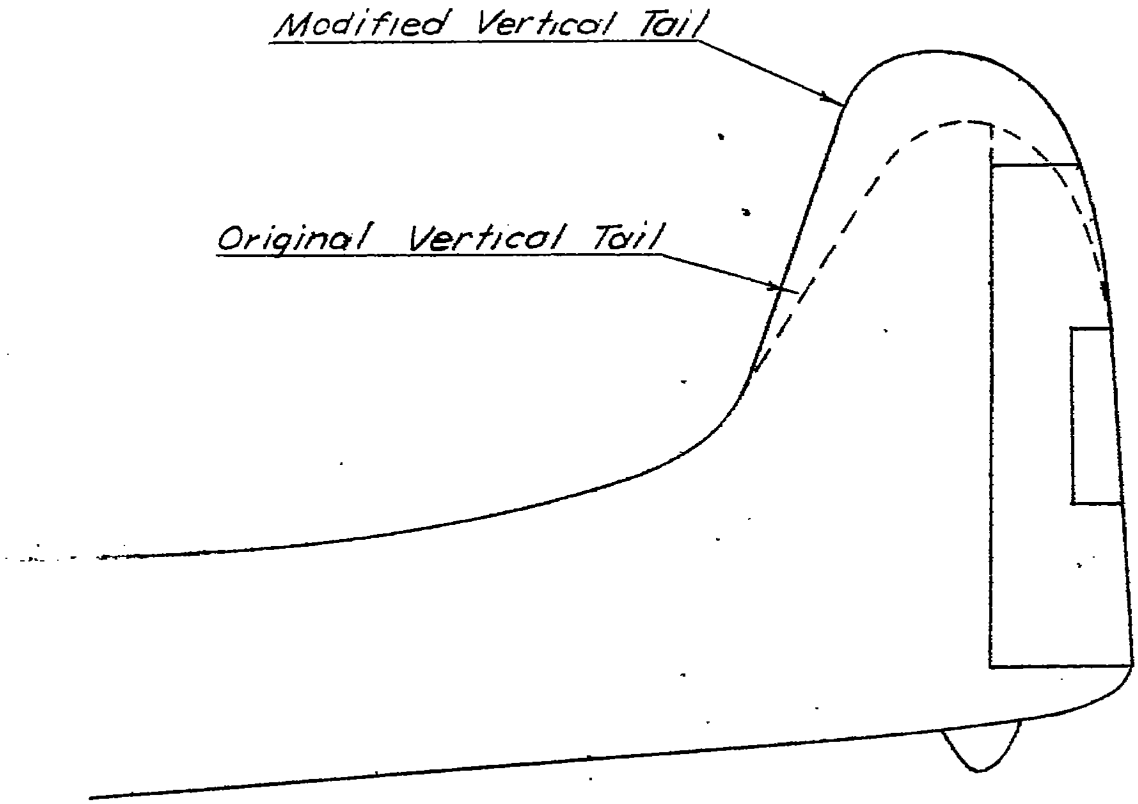
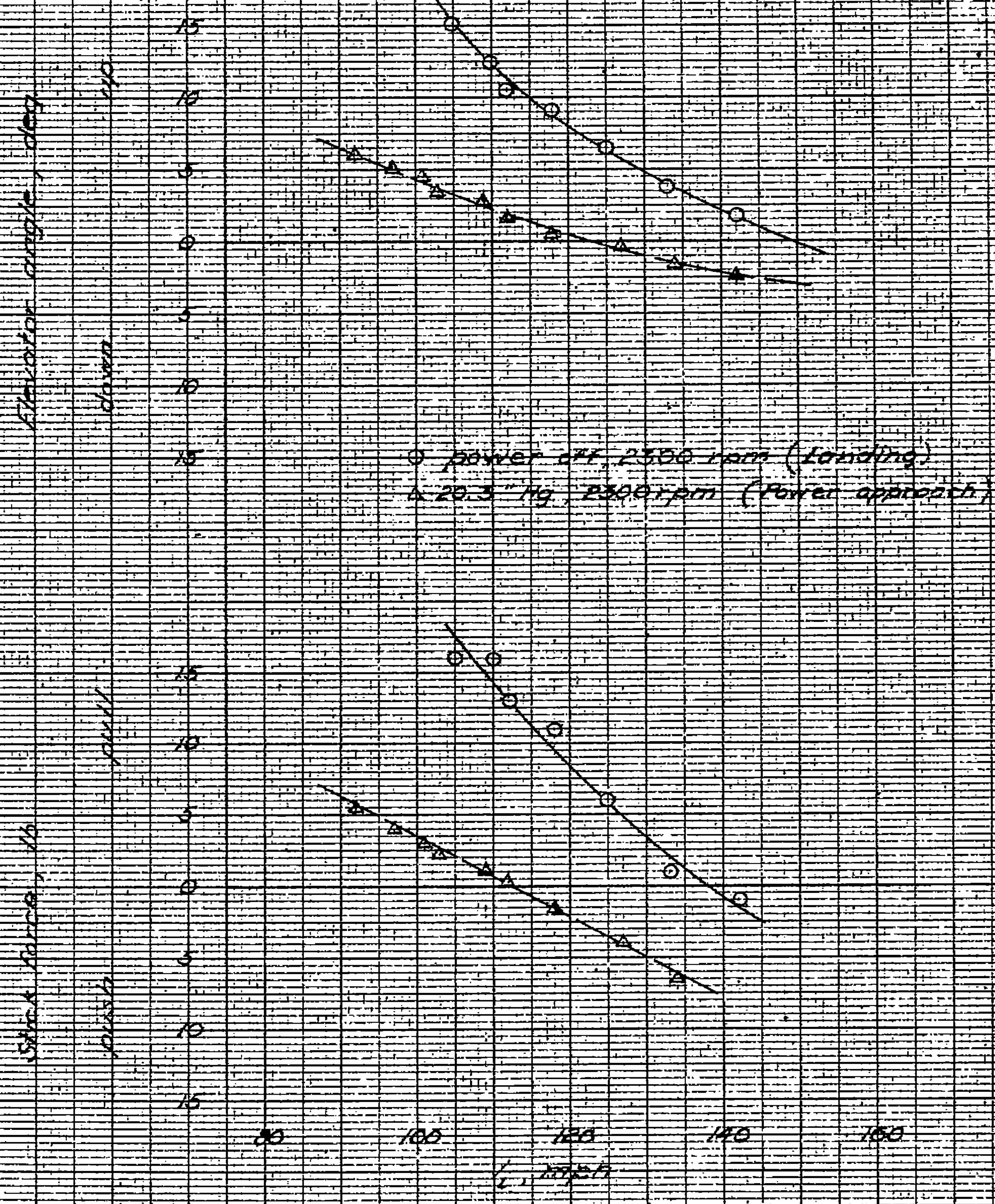


Original Tail		Modified Tail	
Rudder Area	19.9 sq. ft.	Rudder Area	20.1 sq ft
Rudder Chord	2.22 ft	Rudder Chord	2.23 ft
Fin Area	28.0 sq. ft	Fin Area	38.3 sq. ft

Figure 2.- Original and modified vertical-tails, Grumman XF7F-1 airplane.

[redacted]



a) Flap and gear down

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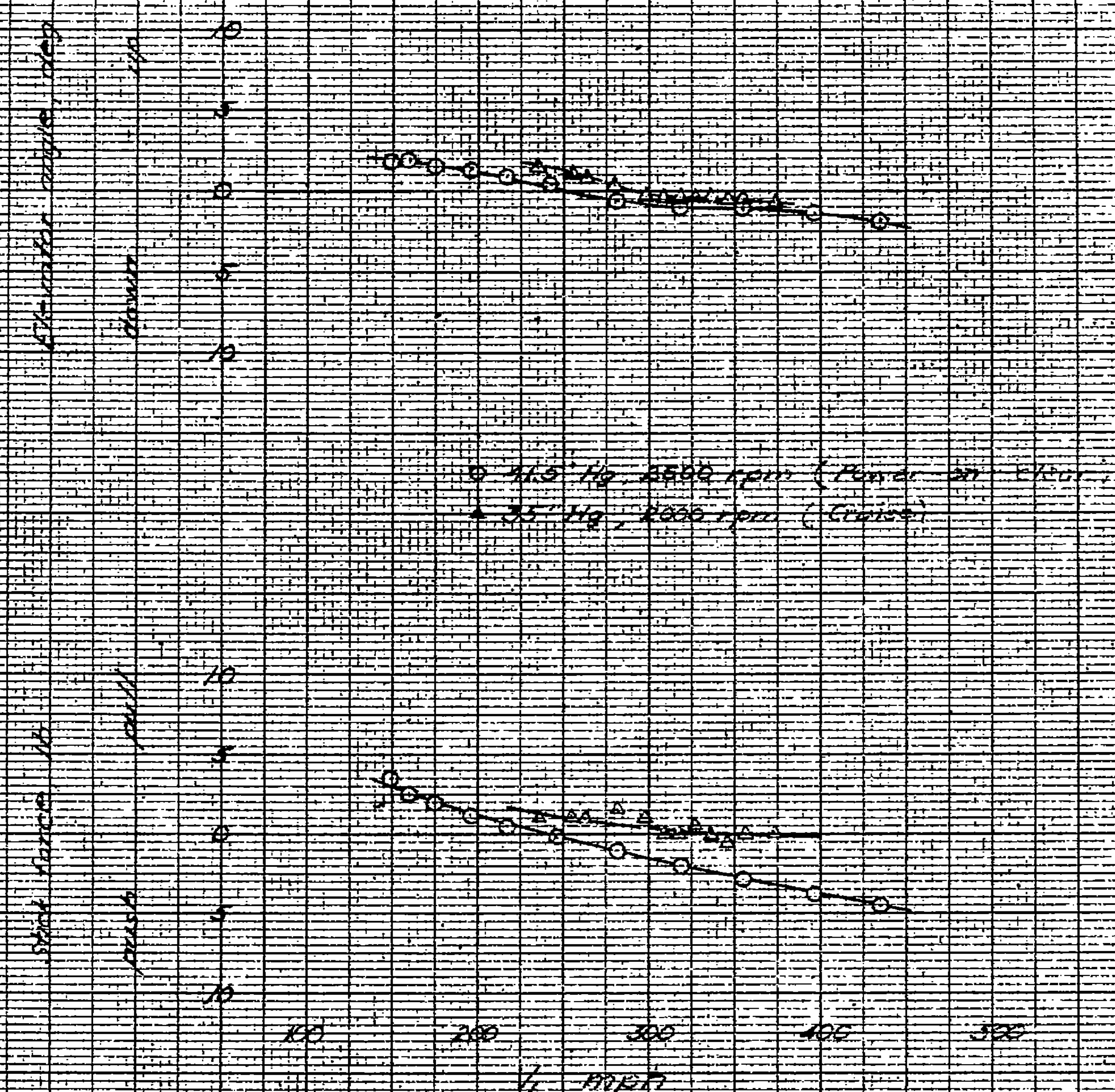
Figure 3.- Variation of elevator angle and elevator stick force with indicated airspeed, Grumman XF7F-1 airplane.



(b) Flap and gear up

Figure 3 - Concluded

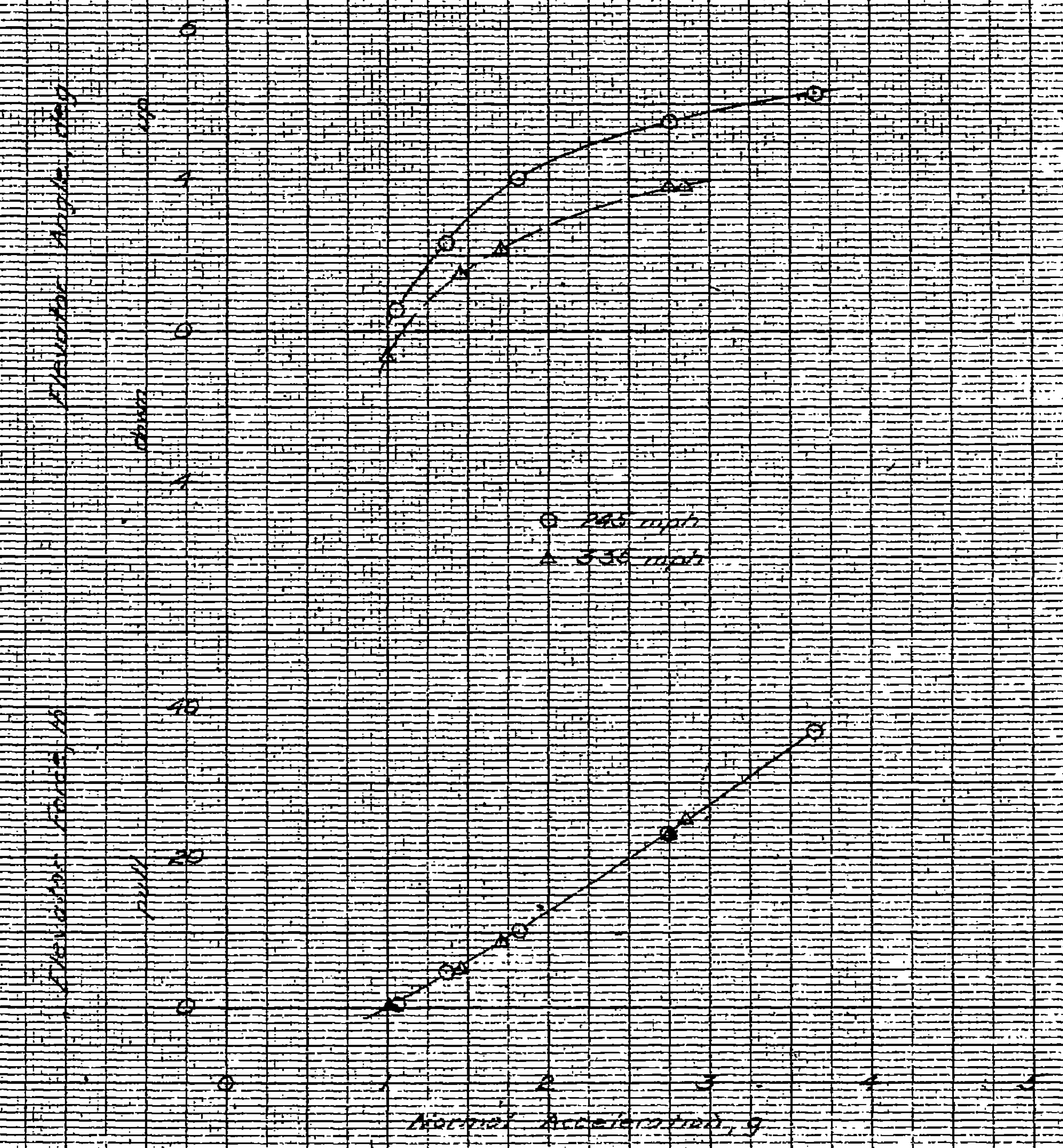


Figure 4.- Variation of elevator angle and elevator control force with normal acceleration in steady turns, Grumman XF8F-1 airplane.

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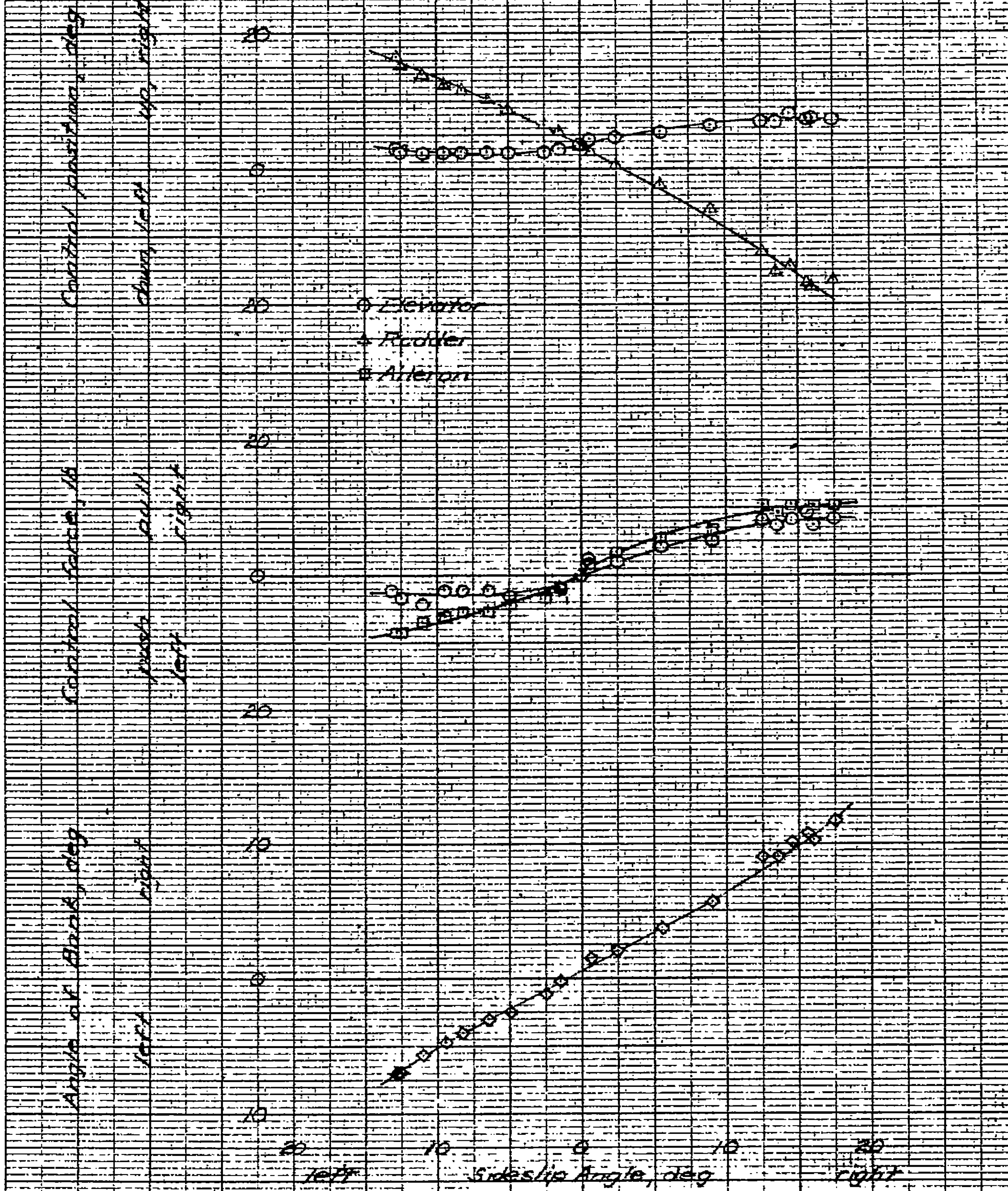

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Figure 5.- Characteristics in steady sideslips, approach condition, Vt = 115 mph, average altitude 10,000 ft, Grumman XF7F-1 airplane.

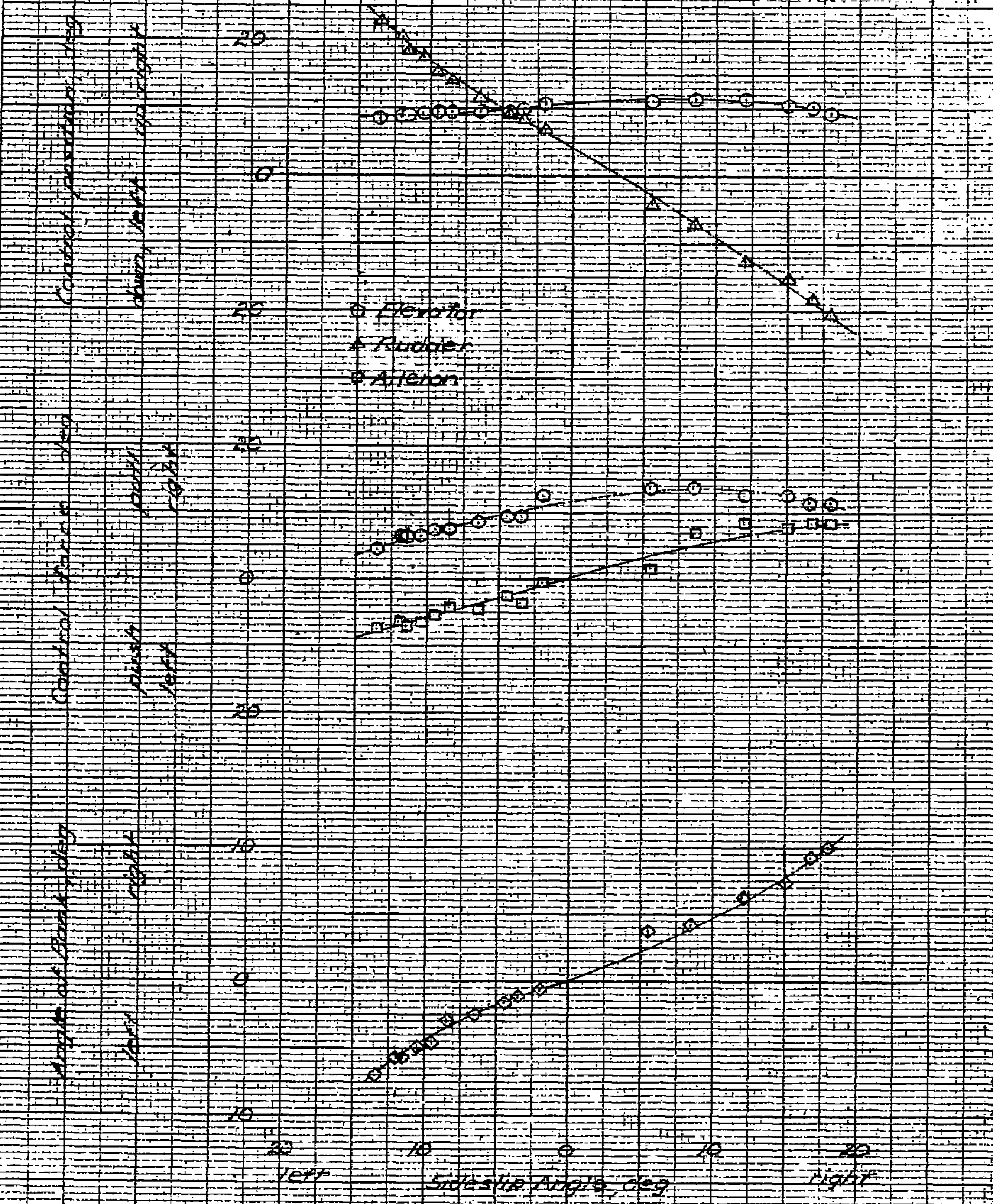

Figure 6.- Characteristics in steady sideslips, landing condition. V_i = 115 mph, average altitude 10,000 ft, Grumman XF7F-1 airplane

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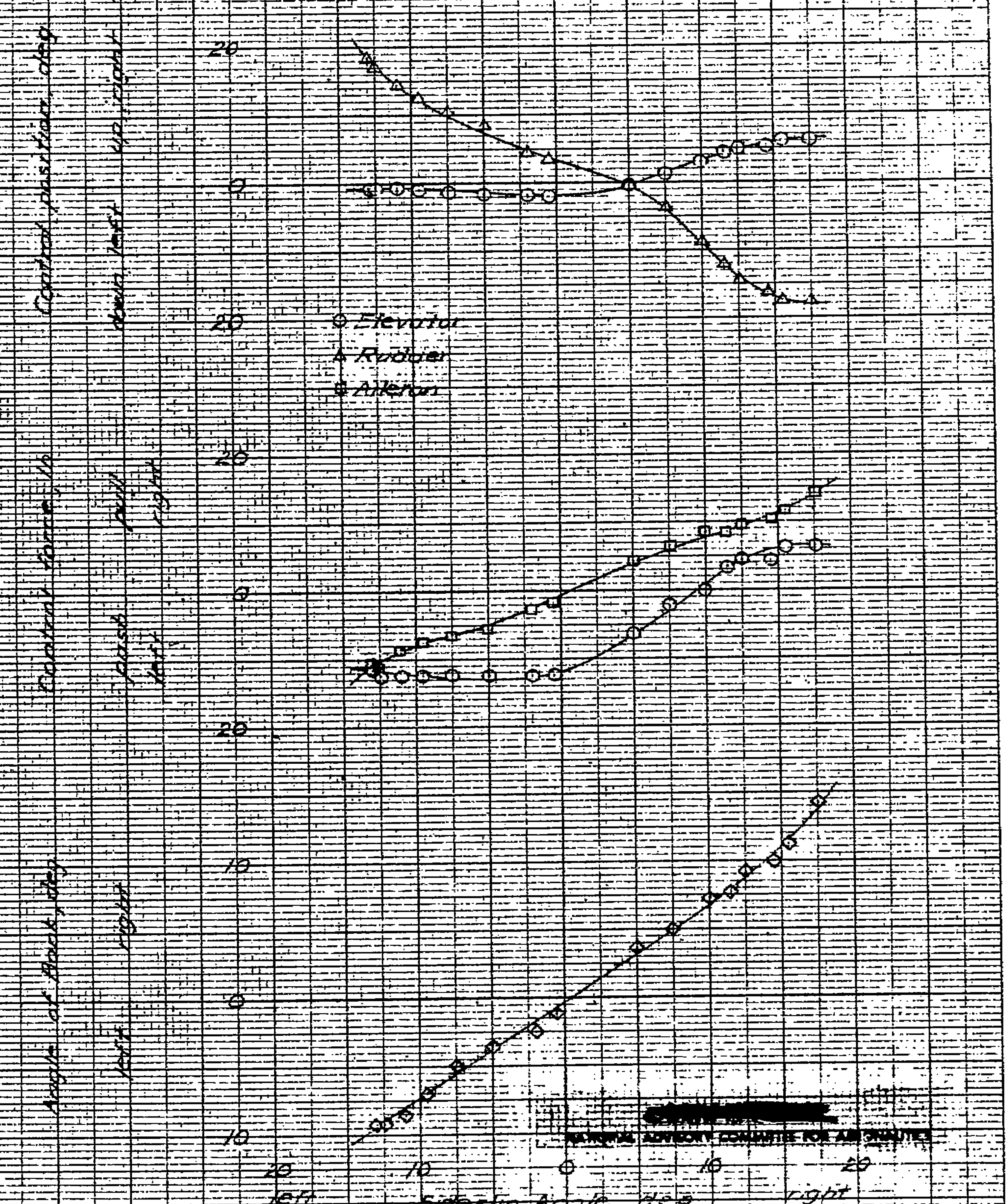

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Figure 7.- Characteristics in steady sideslips, wave-off condition, V_i = 125 mph, average altitude 10,000 ft. Grumman XF7F-1 airplane.

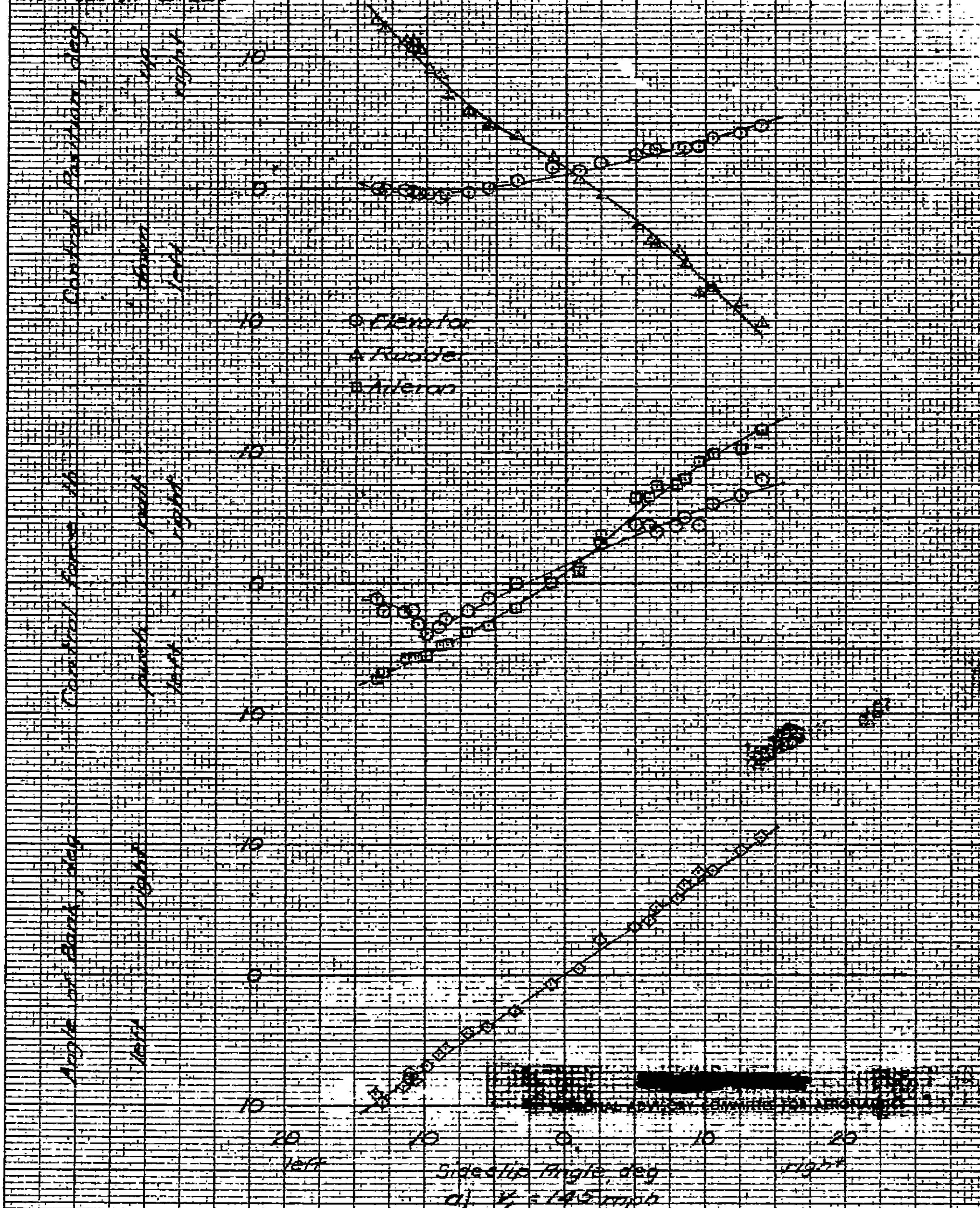
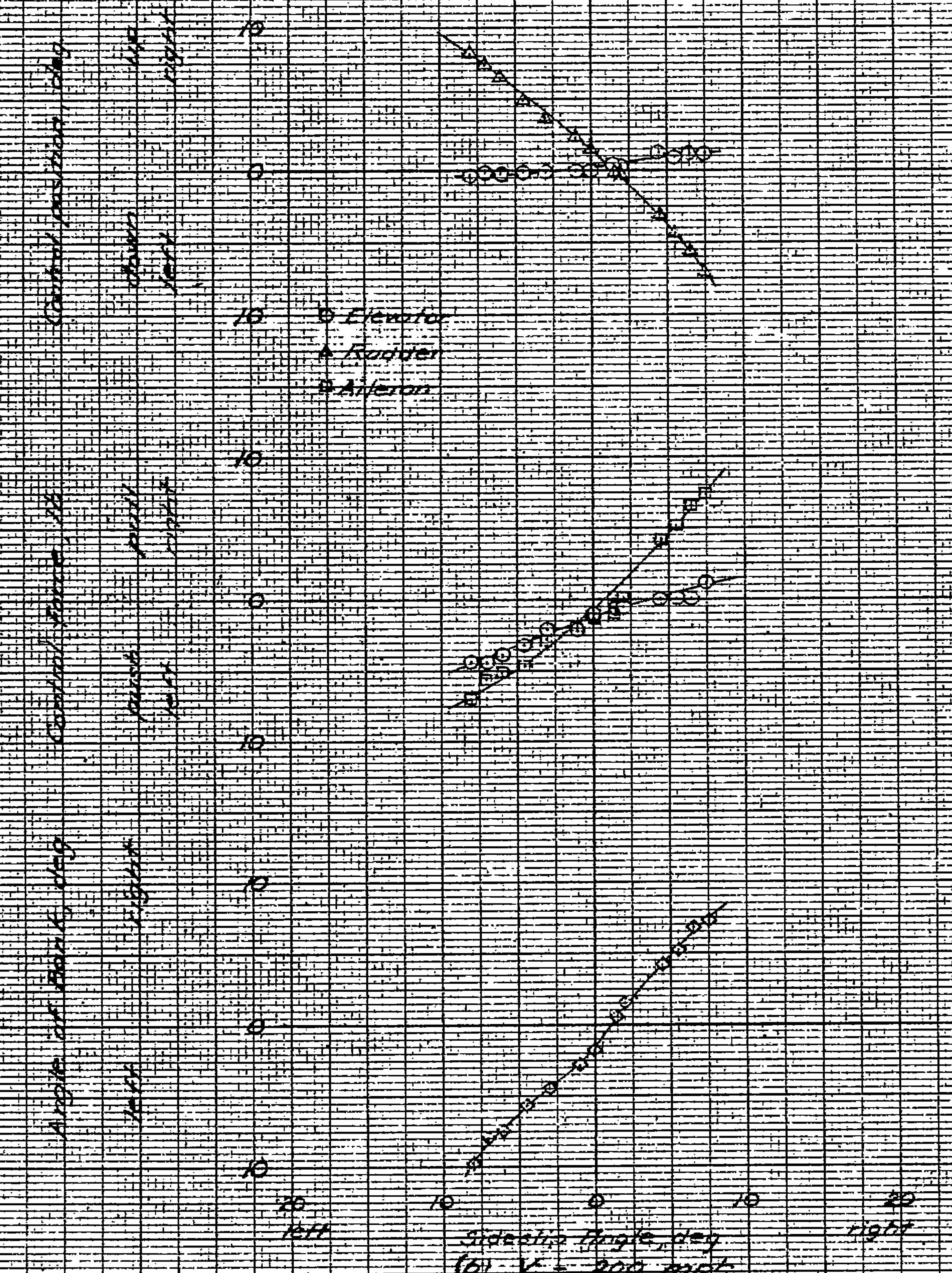


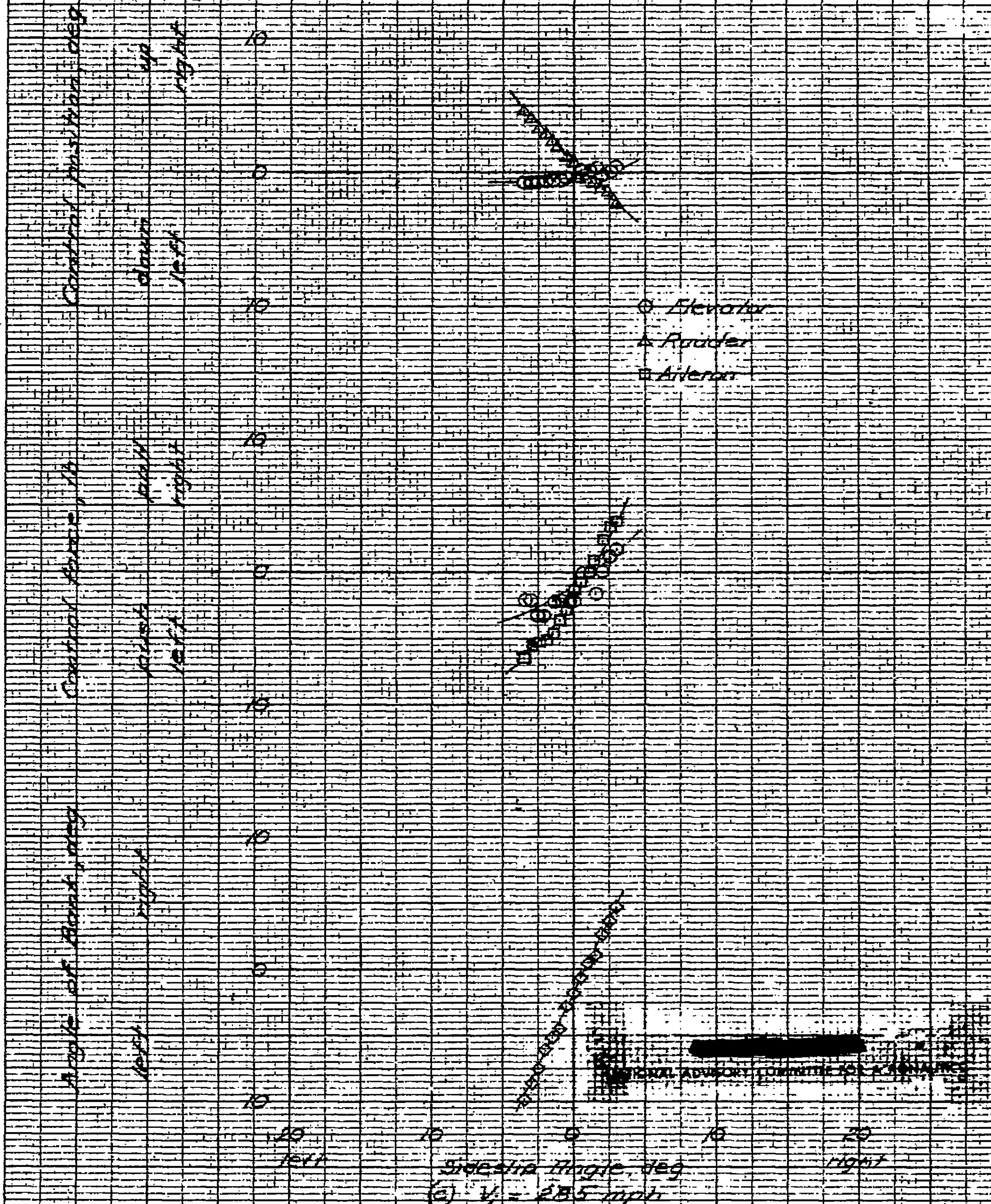
Figure 8.- Characteristics in steady sideslips, power-on clean condition, average altitude 10,000 ft, Grumman XF7F-1 airplane.



(b) V_i = 200 mph

Figure 8.- Continued.

[redacted]



(c) V_i = 285 mph

Figure 8.- Concluded.

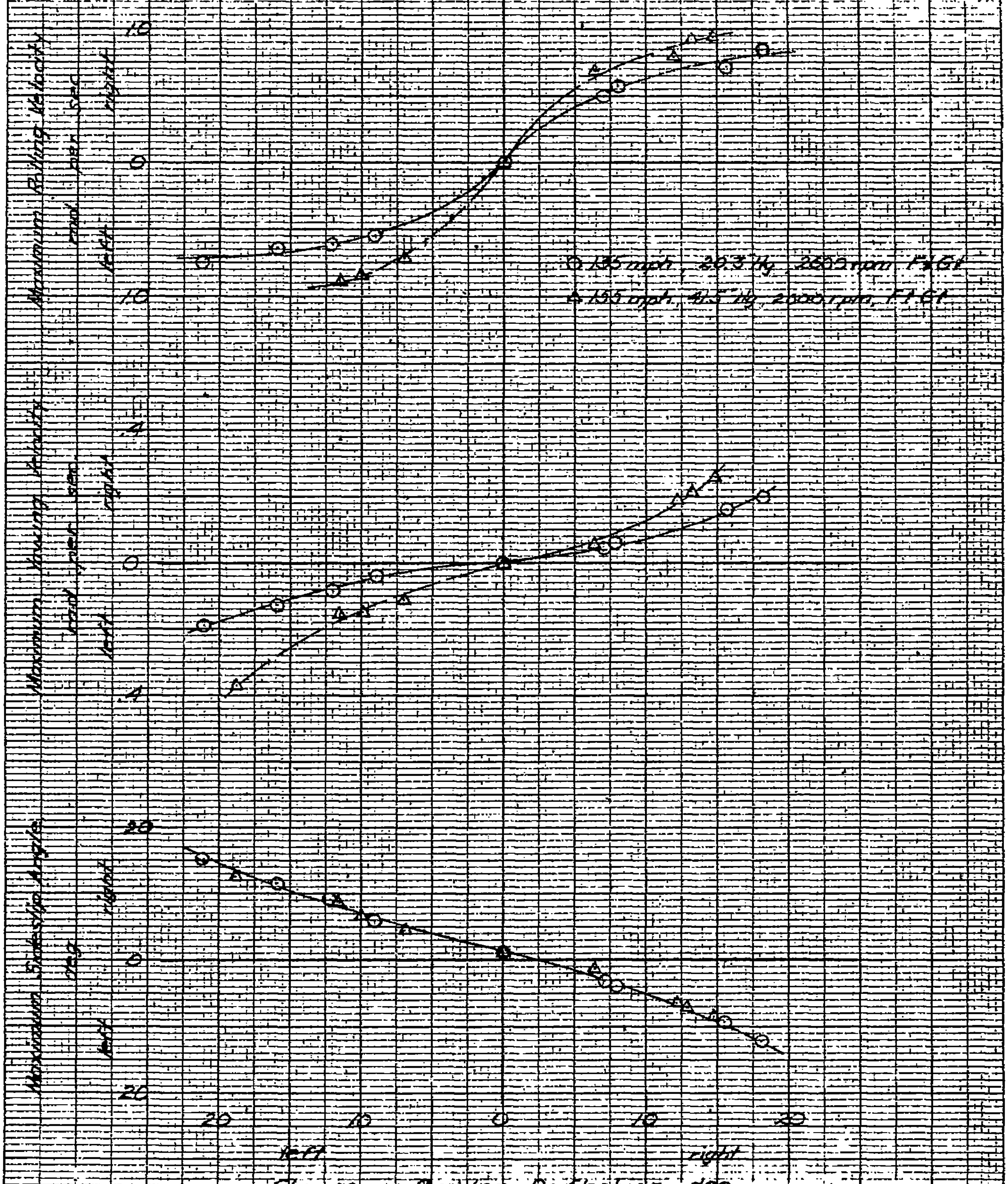


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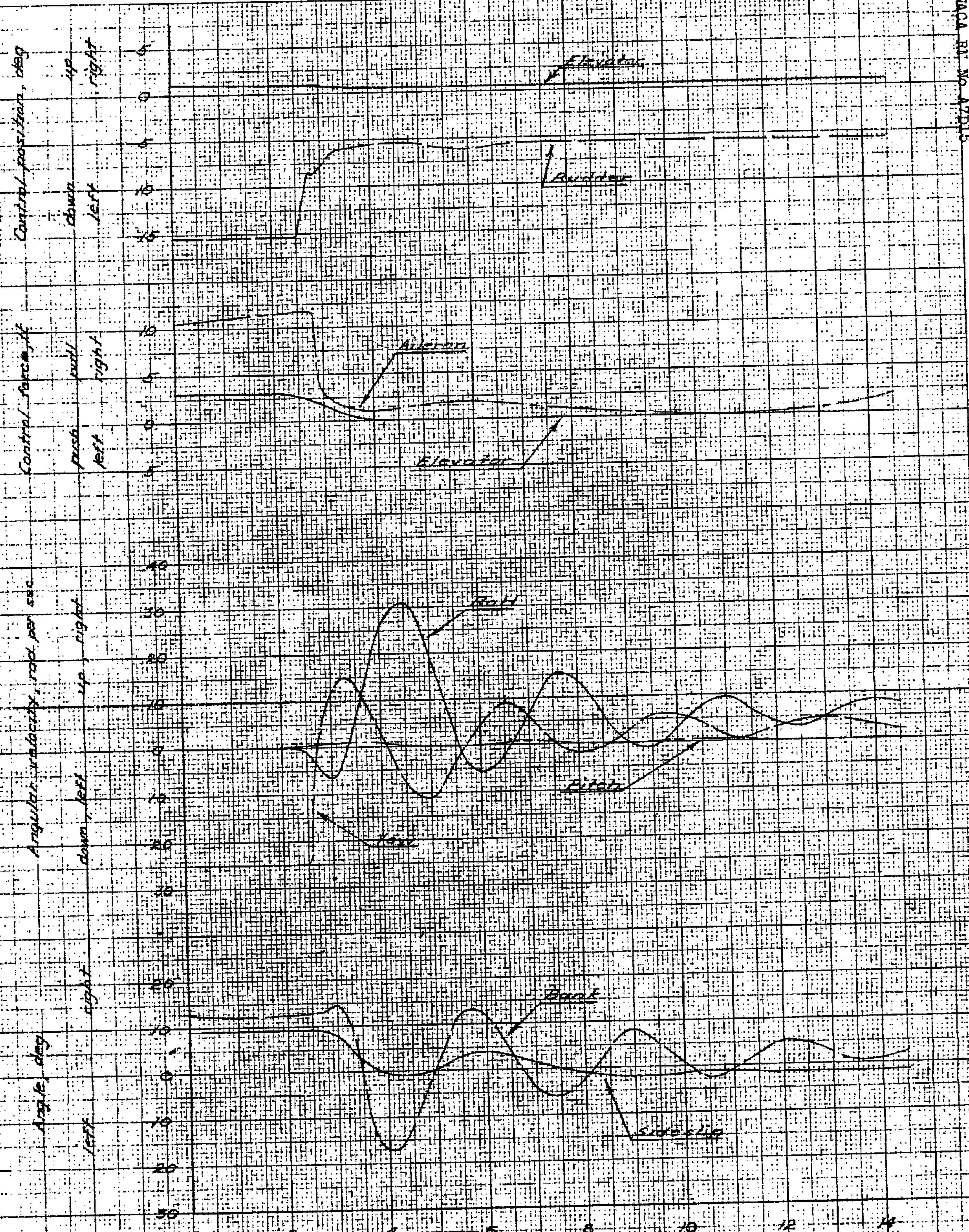
Figure 9.- Characteristics in aileron-fixed rudder kicks Grumman XF7F-1 airplane.



(a) Controls free

Figure 10.- Time history of lateral oscillations, power-on clean condition. V_i = 235 mph, average altitude 10,000 ft. Grumman XF7F-1 airplane.

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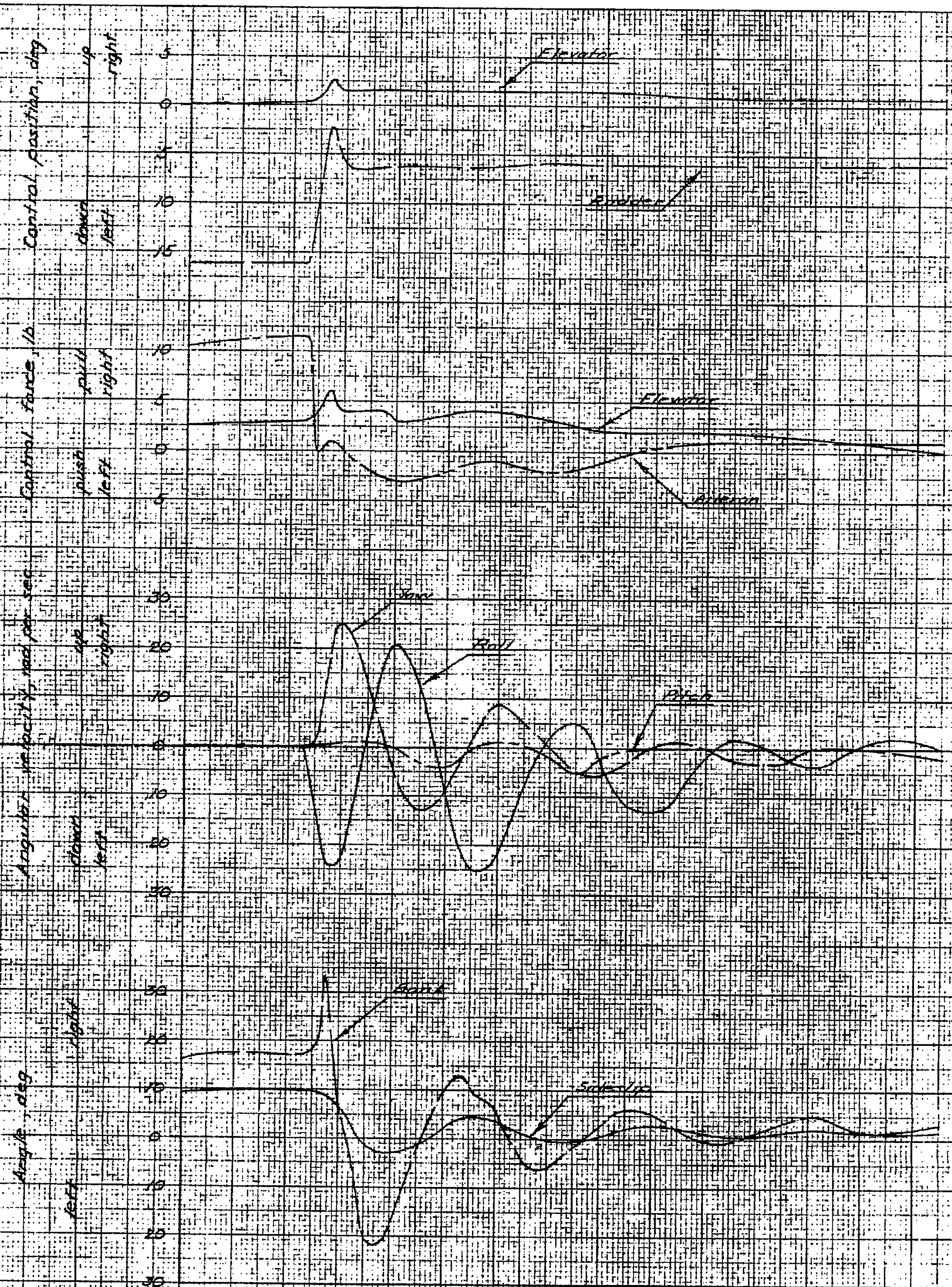

(b) Controls fixed

Figure 10.- Concluded.

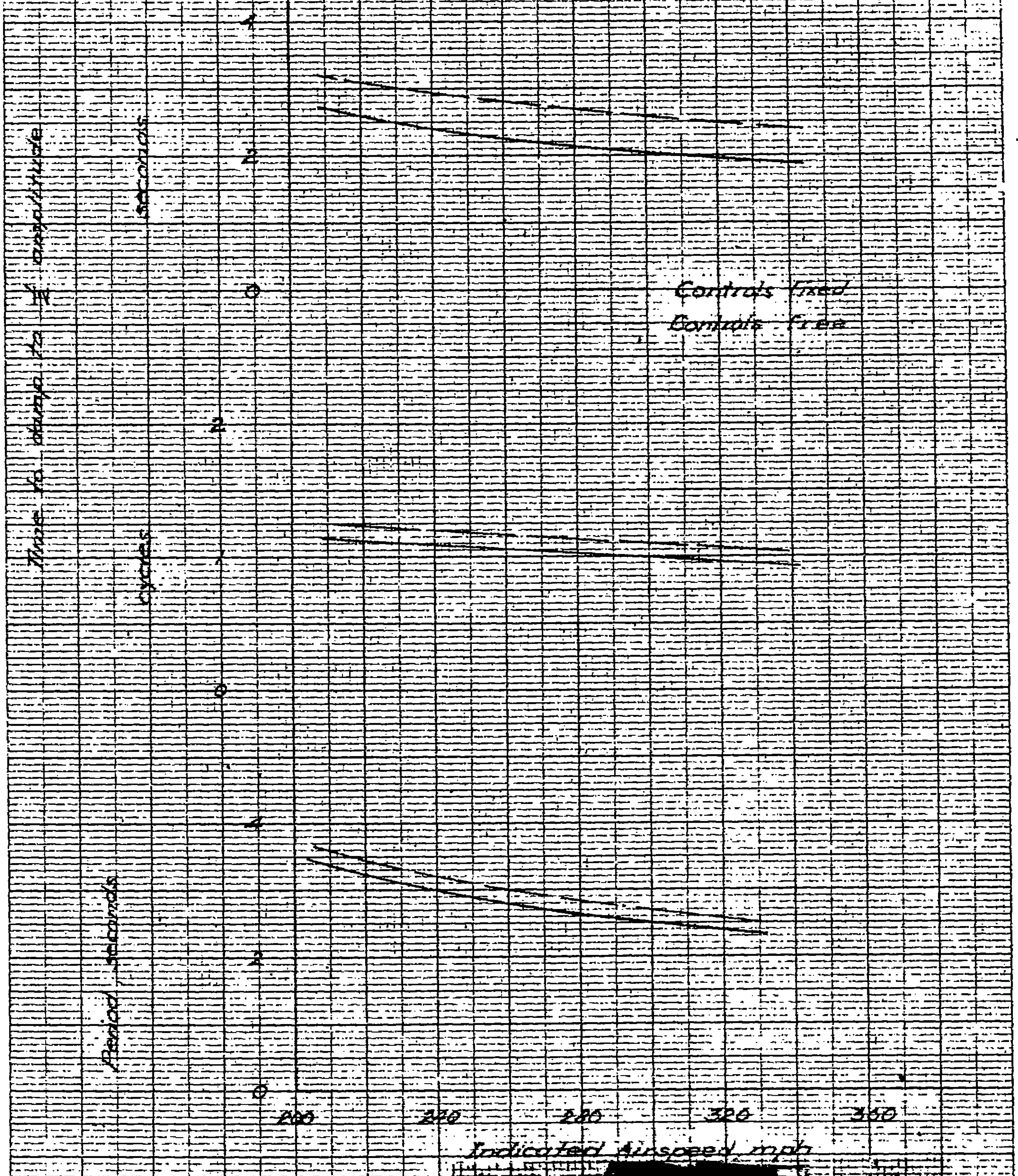

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Figure 11.- Damping characteristics in lateral oscillations. Power-on-clean condition, average altitude 10000 ft. Grumman XF7F-1 airplane.

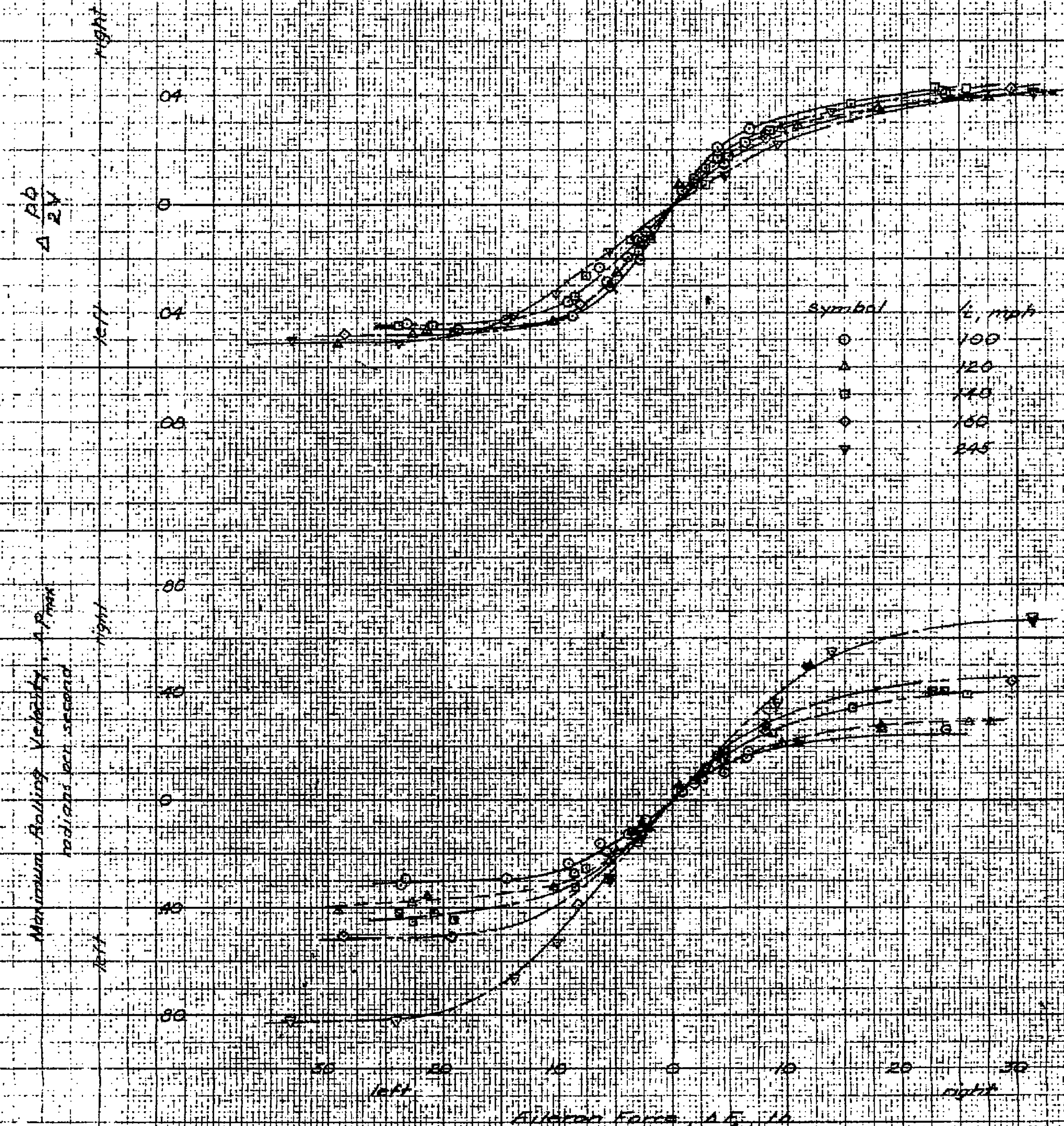


Figure 12.- Characteristics in rudder-fixed aileron rolls at various airspeeds. Power-approach condition, average altitude 10,000 ft. Grumman XF7F-1 airplane.

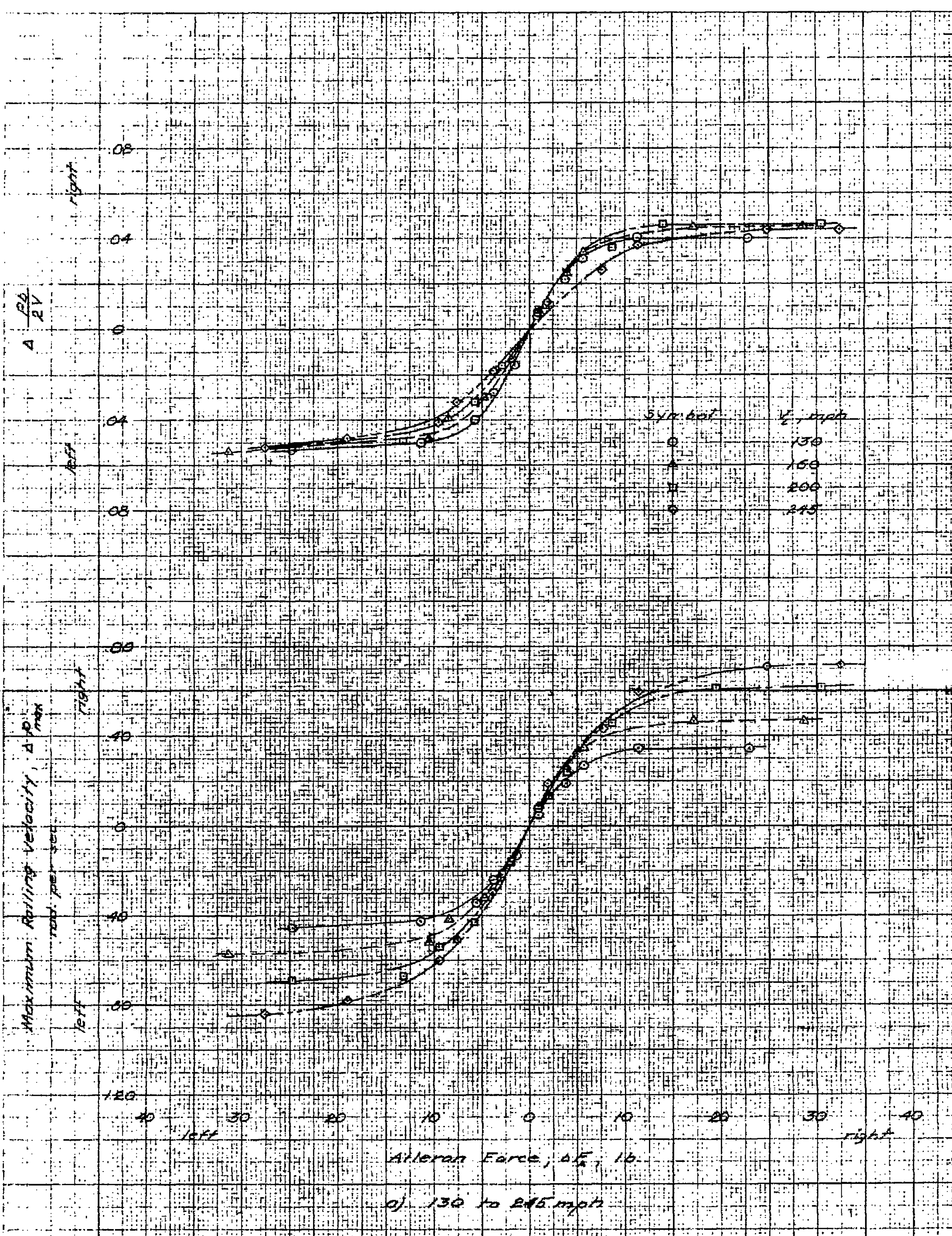
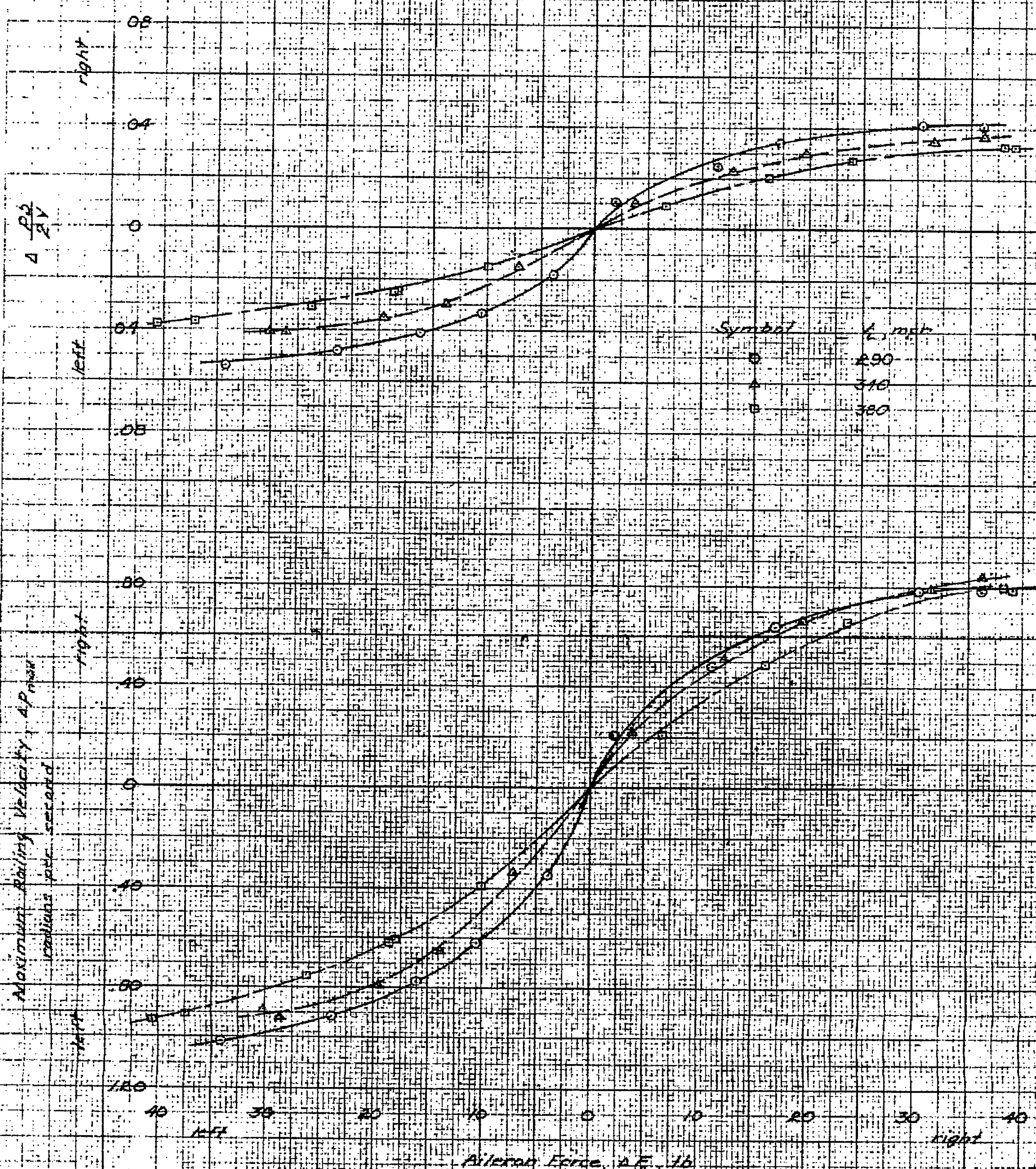
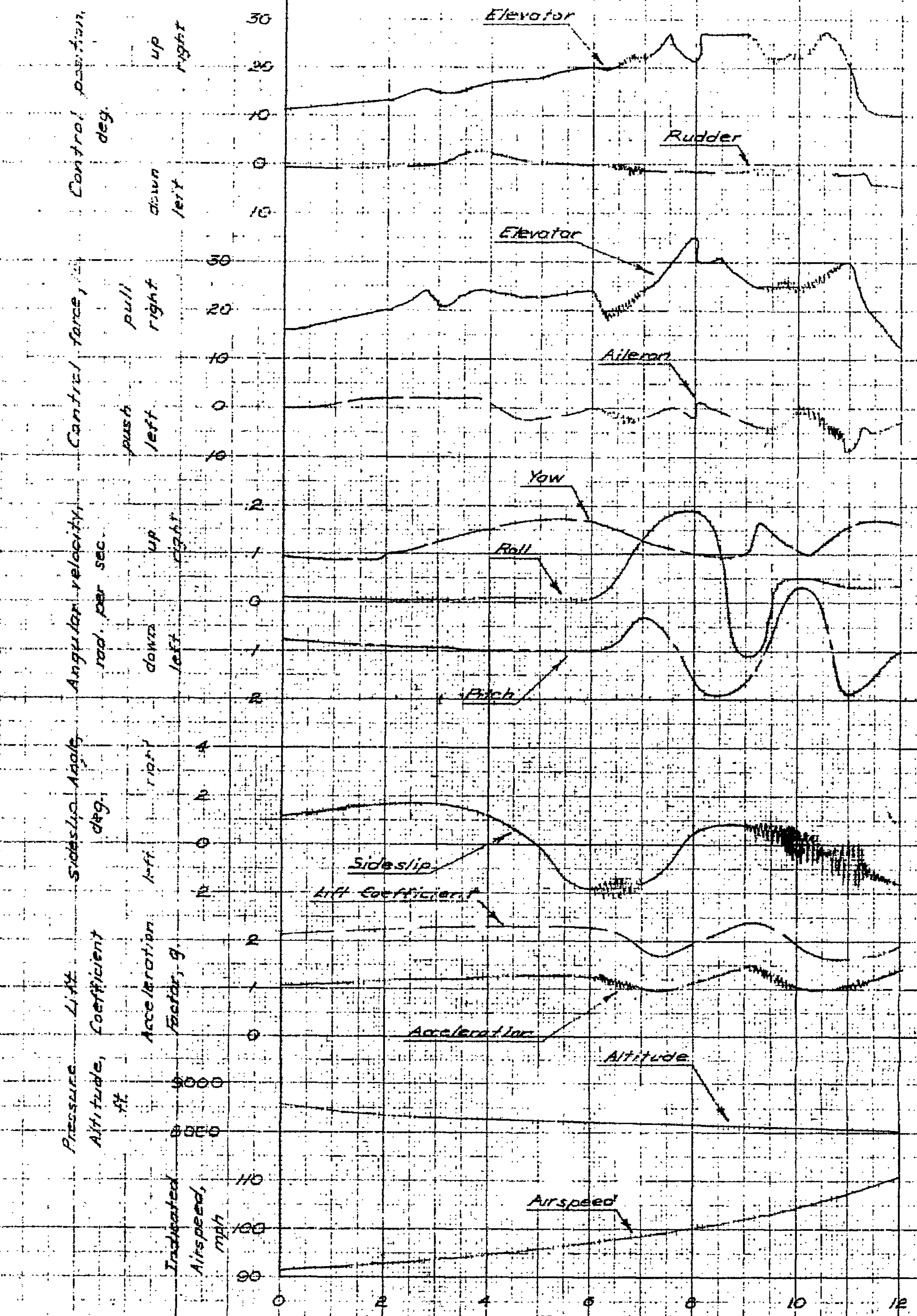


Figure 13.- Characteristics in rudder-fixed aileron rolls at various speeds. Cruise condition, average altitude 10,000 ft. Grumman XF7F-1 airplane.



(b) 290 to 380 mph

Figure 13.- Concluded



(d) Glide Condition

Figure 14.- Time history of a stall from straight flight, Grumman XF7F-1 airplane

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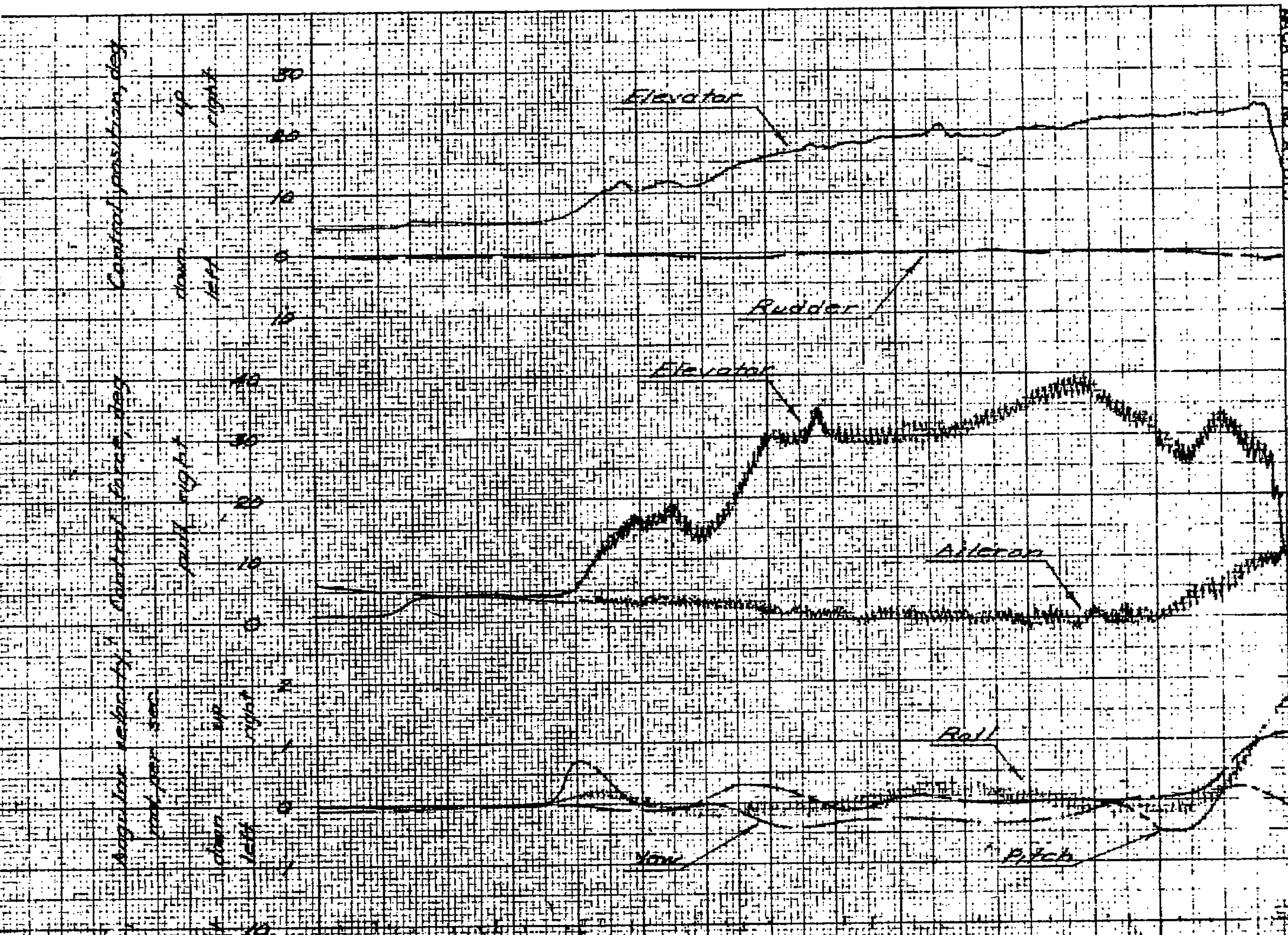
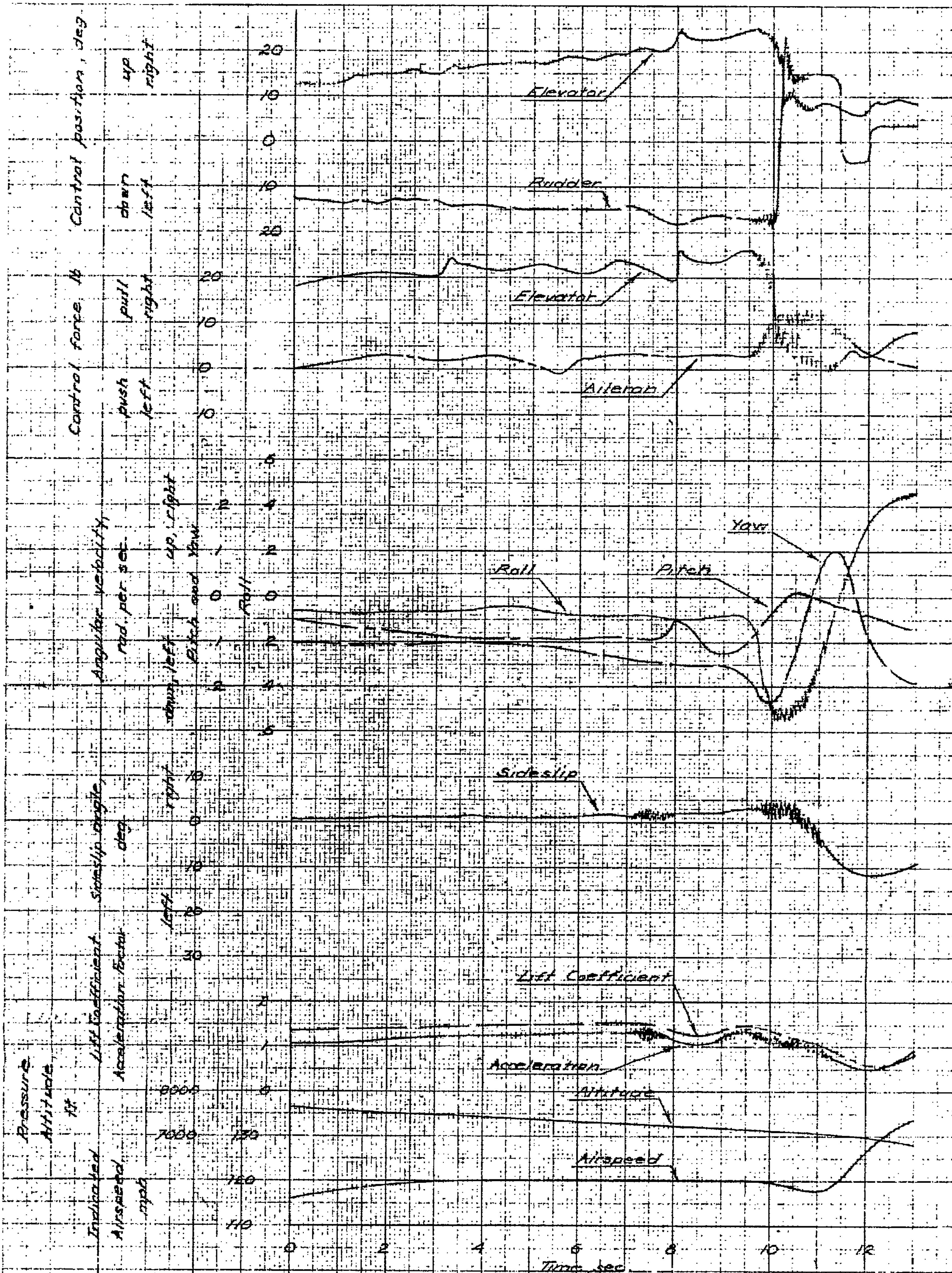


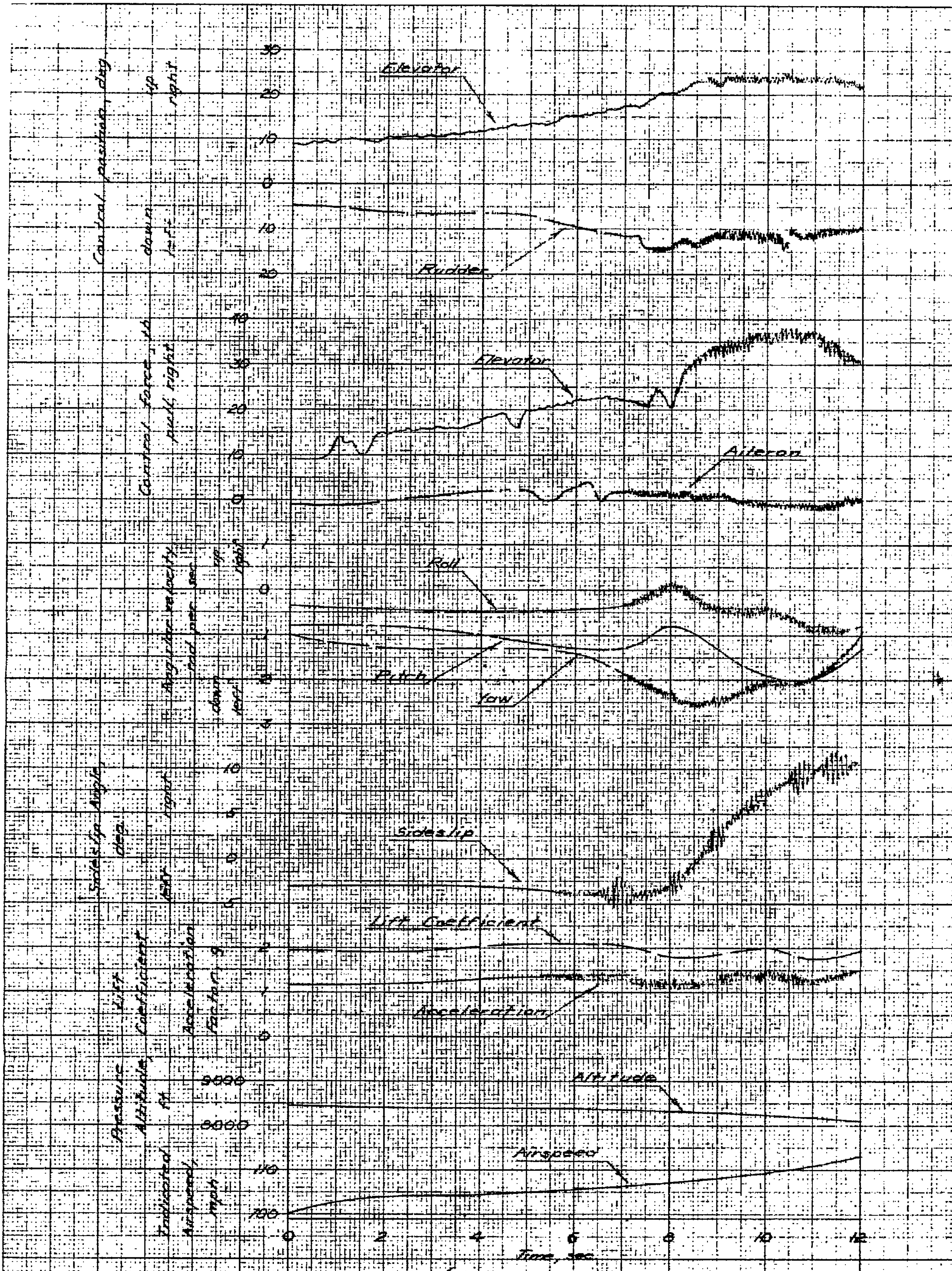
(b) Cruise condition.

Figure 14.- Concluded.



(d) Landing Condition

Figure 15.- Time history of a stall from turning flight Grumman XF7F-1 airplane.



(b) Power-approach condition.

Figure 15.- Concluded.

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