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RESEARCH MEMORANDUM

TIME-HISTORY DATA OF MANEUVERS PERFORMED BY A MCDONNELL F2H-2 AIRPLANE DURING SQUADRON OPERATIONAL TRAINING

By Carl R. Huss, William H. Andrews, and Harold A. Hamer

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By MXA 12/10/57 See

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON
May 27, 1952

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RESEARCH MEMORANDUM

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SUMMARY

Preliminary results of one phase of a control-motion study program are presented in time-history form and are summarized as plots of load factors and angular accelerations against indicated airspeed. The results were obtained from 276 maneuvers performed by a McDonnell F2H-2 jet fighter airplane during normal squadron operational training. Most of the tactical maneuvers that the F2H-2 airplane is capable of performing are included in the data. The maneuvers were performed at pressure altitudes of 0 to 40,000 feet and at indicated airspeeds of 75 to 500 knots.

INTRODUCTION

The present methods of determining tail-surface design loads require, among other things, a knowledge of the control-surface motion. In the usual methods, control-surface motions or load-factor variations with time are specified so as to obtain maximum design loads; however, the actual control motions and load-factor variations obtained in regular operational flying may differ appreciably from the specified variations.

In order to obtain information on the actual control motions used in flight the National Advisory Committee for Aeronautics in cooperation with the Bureau of Aeronautics, Department of the Navy, and the U. S. Air Force is conducting a control-motion study program. This program is directed toward obtaining sample measurements on several fighter-type airplanes of rates, amounts, and combinations of control motions used by service pilots in carrying out regular operational training missions. From the results obtained from this program it may be possible to specify a more practical design criterion for tail-surface loads based on the actual critical control-surface motions. In addition, information may be obtained which could be useful in the design of airplane control boost systems. Reference 1 was the first report of data obtained from this program.

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This paper includes data in time-history form of maneuvers obtained by an F2H-2 airplane while performing regularly scheduled operational training missions. In order to make the data included in the time histories immediately available, only a minor analysis of the data is included in this paper.

TEST AIRPLANE

A standard United States Marine Corps McDonnell F2H-2 airplane, BuAer serial number 123256, was used for these tests. The F2H-2 airplane is a single-place, straight-wing, two-engine carrier- or land-based, jet-propelled fighter. It is powered by two Westinghouse J-34-WE-34 turbojet axial-flow engines mounted, one on either side of the fuselage, in the wing center section. It has speed brakes located in the upper and lower wing surfaces inboard of the aileron and just ahead of the partial-span flaps. These speed brakes consist of perforated rectangular plates which are extended vertically from the wing surfaces and are either in the "out" or "in" position. A hydraulic boost system was incorporated in the aileron control system.

The external appearance of the test airplane was unaltered by the NACA instrumentation except for the installation of a boom mounted in the nose of the airplane, used for measuring the sideslip angle, and a small electrical control-position transmitter mounted externally on the right-wing lower surface. A three-view drawing of the F2H-2 airplane is presented in figure 1 and its pertinent physical characteristics are given in table I.

INSTRUMENTS

Standard NACA photographically recording instruments were used to measure (1) the quantities defining the flight conditions; that is, airspeed, altitude, and speed-brake position, (2) the control-surface motions and (3) the response of the airplane in terms of angular velocities, load factors, and sideslip angle. The recorders were synchronized at 1-second intervals by means of a common timing circuit.

In order to relieve the pilot of any recording-instrument switching procedure and thus assist in obtaining normal operations, a pressure switch was used to automatically turn on the recording instruments at an indicated airspeed of approximately 80 knots. All recorders were mounted in the nose section with the exception of the angular-velocity recorders which were located in the aft radio compartment.

A standard two-cell pressure recorder connected to the airplane service system was used to measure the altitude and airspeed. The service system employs a total-pressure tube located on the leading edge of the vertical tail and flush static-pressure orifices on both sides of the fuselage below the windshield. (See fig. 1.)

A microswitch was used on the right speed brake to indicate the "in" or "out" position of this surface. The control-surface angles were measured by a control-position recorder having remote recording electrical transmitters installed at the control surface. The elevator and rudder transmitters were installed inside the tail fairing to take measurements in the vicinity of the inner hinge. Aileron deflections were obtained with a transmitter located externally at approximately the aileron midspan.

Angular velocities were recorded about three mutually perpendicular axes in which the X-axis is parallel to the fuselage reference line. (See fig. 1.) Load factors along these three axes were recorded by an air-damped three-component accelerometer located in the fuselage 76.5 inches forward, 14 inches to the right, and 10 inches above the average flight center-of-gravity location (26.5 percent of the wing mean aerodynamic chord).

The sideslip angle was measured by a flow directional recorder using a vane mounted on a boom 6 feet ahead of the fuselage nose. The boom was mounted in the left cannon port nearest the airplane center line. (See fig. 1.)

The estimated accuracies based on the instrument accuracy and a reading accuracy of 0.01 inch are as follows:

Indicated airspeed, V_i, knots	±5
Pressure altitude, H_p, ft	±50
Control position, deg	±0.5
Normal load factor	±0.05
Longitudinal and transverse load factor	±0.02
Rolling angular velocity, radians per second	±0.10
Pitching and yawing angular velocity, radians per second	±0.02
Sideslip angle, deg	±0.3

All the recording instruments were damped to about 0.65 of critical damping at sea level. The natural frequency of the elements in the three-component accelerometer was selected to give the best compromise value which would minimize the magnitudes of extraneous vibratory accelerations and still give correct response to the maneuver accelerations.

In order to expedite the presentation of time-history results all the instruments were adjusted to specified sensitivities and the film drums were selected so that they ran at the same constant speed. Thus in many

cases it was possible to trace the record lines directly on special grid paper with the exception of the airspeed and altitude which had to be plotted. Those records on which either the film speed had deviated from the selected standard or in which it was desired to change the sensitivity for better presentation of the data were processed on a newly developed enlarger. The enlarger effectively enabled the time scale or longitudinal dimension of the film and the scale or vertical dimension of the film to be either increased or decreased independently of each other so that the film record could be adjusted to fit accurately the scale of the grid paper. It is believed that this method has permitted a detailed, accurate, and rapid reproduction of the film records in time-history form.

TESTS

The tests consisted of 18 normal squadron operational training missions carried out during the months of February to April 1951. Included in these 18 flights were acrobatic, gunnery, bombing, and pilot familiarization missions. The maneuvers obtained from these missions were performed at altitudes from 0 to 40,000 feet and at airspeeds from 75 to 500 knots and included such maneuvers as turns, dives and pull-outs, pull-ups, slow rolls, barrel rolls, loops, Immelmans, lazy eights, Cuban eights, wing-overs, and stalls.

The test airplane normally is equipped with wing-tip tanks; however, all the maneuvers reported were performed with the wing-tip tanks empty.

Enough film was carried during each flight to allow 80 minutes of flight time to be recorded. This was usually sufficient time to record the complete flight. In this program 17.5 hours of flight time were recorded of which 2.5 hours are presented in this paper as maneuvers in time-history form.

Twelve pilots flew the test airplane during the course of this program. No pilot accounted for more than 10 percent of the total flight time. In an effort to obtain records which would contain representative samples of normal piloting technique in the performance of the maneuvers, the pilots were assured that the instrumentation would not restrict them as to type of maneuver, manner of control manipulation, or severity of maneuvering. It is also of interest to note that during these tests all of the pilots wore antigravity suits.

METHODS AND RESULTS

The results of this flight program are presented in figures 2 to 282. All the maneuvers performed during the 18 flights plus 3 landings are presented in figures 2 to 277 as time histories of the measured quantities. The three landings include a short portion of the landing approach prior to and including main-gear touch-down and were made by three different pilots. The time histories are arranged in this paper according to maneuver classification as given in table II. Included in the legends of these figures is the classification of the type of maneuver, estimated airplane weight, and estimated flight center-of-gravity location. The classification of the maneuvers was, of necessity, done in a general sense as it was sometimes difficult to determine from the flight records exactly the type of maneuver performed. However, it was comparatively simple to determine when the airplane was maneuvering, since in normal steady flight the record traces were fairly straight lines on or near the trim or zero position for the particular trace and during a maneuver the traces would, of course, vary from their trim or zero position. Some of the standard maneuvers are interpreted in references 2 and 3. The in-flight airplane weight and center-of-gravity location were estimated on the basis of the total amount of fuel used and the time of the flight including warm-up and taxying.

In these time histories the airspeed is indicated airspeed, defined as the reading of a differential-pressure airspeed indicator, calibrated in accordance with the accepted standard adiabatic formula to indicate true airspeed for standard sea-level conditions only (uncorrected for instrument and installation errors), and the altitude is the NACA standard pressure altitude. The control-position curves shown were measured with respect to their neutral position. Only the right aileron position was measured. It will be noted in figures 275 to 277 that the rudder trace has been dotted to avoid confusion with other traces. The position of the speed brakes is indicated on the time histories by the dash line and the words "brakes out."

In these figures load factors associated with forces acting up, forward, and to the left are positive. Nose up, nose right, and right wing down are positive for the pitching, yawing, and rolling angular velocities which are given in radians per second. No angular-velocity or angular-acceleration corrections to the recorded load factors, due to the displacement of the accelerometer from the center of gravity, have been made in these time histories.

The sideslip angle indicates the lateral angle between the airplane longitudinal axis and the relative wind.

A comparison between the maximum normal load factors obtained in these tests and the operational V-n diagram is presented in figure 278. The V-n envelopes shown in this figure as solid and dashed lines are the operational limitations for the test airplane at a gross weight of 16,400 pounds as specified by the Bureau of Aeronautics. The maximum normal load factors in figure 278 were taken directly from the time histories and are plotted without any angular-velocity or angular-acceleration corrections because such corrections were found to be small. Since the average flight weight of the airplane during this program was approximately 16,100 pounds, the values have been plotted without being corrected for weight. Only selected values of maximum normal load factor have been plotted to demonstrate to what extent the operational limit envelopes for altitude, airspeed, and normal load factor were obtained.

The maximum transverse load factors and corresponding indicated airspeeds are presented in figure 279. Because of the large number of transverse load factors available from the time histories, only the values above the arbitrary lower limit of 0.05 are shown. All the points given in this figure have been corrected for rolling and yawing angular velocity and angular acceleration.

The maximum pitching-, rolling-, and yawing-angular-acceleration variations with indicated airspeed are shown in figures 280, 281, and 282, respectively. The values of acceleration were obtained from the maximum slope of the appropriate angular-velocity curve in the time histories. As in the case of transverse load factor, only the values above some arbitrary limit are presented. These limits were 0.1 radian per second per second for pitch and yaw and 0.5 radian per second per second for roll.

DISCUSSION

The results of this investigation, as shown in figure 278, indicate that the present sampling of maneuvers includes, for the positive-load-factor region, the operational capabilities of the F2H-2 airplane. Although this investigation was limited to a few hours of actual flying time, the data obtained represent a cross section of the maneuvers performed during operational training and include most of the tactical maneuvers used by the test airplane.

Examination of the time histories indicates that usually the higher positive normal load factors were associated with pull-up or pitching types of maneuvers. In this program the highest positive value of normal load factor, 6.2, was obtained during an abrupt left turn. (See fig. 53.) The other high values between 5 and 5.5 occurred in

pull-outs and pull-ups during dives, loops, Immelmans, and Cuban eights. (See figs. 140, 151, 230, 245, 253, 258, and 272.) The largest negative normal load factors, -0.5, were associated with rolling maneuvers, usually a slow roll. (See figs. 151 and 166.)

It is evident from the maximum values of normal load factor obtained that the maximum operational value of normal load factor, 6.4, was not exceeded during these tests; furthermore, figure 278 indicates that at no time during these tests were the operational limits for combinations of load factor, airspeed, and altitude exceeded.

The maximum values of transverse load factor shown on the time histories are -0.26 (fig. 51) and -0.22 (fig. 53). However, when the angular-velocity and angular-acceleration corrections are added to these values, the maximum transverse load factors become -0.34 and -0.29. Both of these maximum values occurred during abrupt left turns. Examination of figure 279 indicates that the value of maximum transverse load factor was usually between ±0.1.

Longitudinal load factors were usually small. The largest deflection of the longitudinal-load-factor trace was a deceleration caused by the extension of the speed brakes. This speed-brake effect amounted to about -0.4 at 400 knots and 12,000 feet altitude. (See fig. 274.)

As would be expected, the largest rates and amounts of elevator movement occur during landings and maneuvers that necessitated pull-ups, such as Immelman, loop, entry into a stall, and recovery from dives. The largest positive elevator movement occurred in pull-ups, Immelmans, pull-outs, stall, loops, and landings. (See figs. 68, 93, 152, 245, 248, 251, 253, 273, and 277.) The greatest negative elevator movement occurred in push-overs, stalls, and landings. (See figs. 106, 273, and 277.) Greater negative rates of elevator movement were obtained than positive rates. (See figs. 106 and 273.)

The largest pitching accelerations obtained in these tests occurred at about 300 knots (fig. 280) and decreased above and below this airspeed. The greatest negative pitching acceleration, -1.4 radians per second per second, occurred during a recovery from a pull-up (fig. 83) and was about twice as large as the greatest positive pitching acceleration which occurred during an abrupt left turn. (See fig. 49.) This maximum value is about half of the value obtained for an airplane weight of 16,000 pounds from the envelope of maximum pitching accelerations given in reference 4.

The largest aileron displacement and rates of movement occurred during rolling maneuvers. An estimate of the magnitude of aileron rates and movements can be obtained from the time histories, such as figures 52, 152, 155, 197, 200, 228, 242, 254, and 256.

The maximum rolling accelerations obtained in these tests occurred at about 325 knots (fig. 281) and decreased above and below this airspeed. The maximum values occurred during an abrupt left turn (fig. 52) and amounted to 4.72 and -5.8 radians per second per second.

The maximum rolling velocity recorded in these tests occurred during slow rolls (figs. 155 and 157) and amounted to 1.7 radians per second at an altitude of about 10,000 feet and an indicated airspeed of about 300 knots. This value is less than the maximum obtainable rolling velocity of 2.5 radians per second at an altitude of 10,000 feet and an indicated airspeed of 310 knots as given in unpublished data for a McDonnell F2H-1 airplane.

In general, little rudder movement was used in any of the maneuvers. The greatest amount of rudder movement occurred in landings, stalls, rolls, split-S, and Immelman maneuvers. (See figs. 276, 251, 273, 154, 202, 203, 217, 226, 242, 253, 255, and 254.) The time histories show that these maximum rudder movements are usually associated with high yawing velocities, large sideslip angles, and large aileron movements. This result is to be expected since the rudder and aileron movements are usually coordinated.

The maximum yawing accelerations in these tests, as shown in figure 282, occurred at about 325 knots and decreased above and below this airspeed. These maximum values occurred during abrupt left turns (see figs. 51 and 53) and amounted to about -0.6 and 0.5 radian per second per second.

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2. National Advisory Committee for Aeronautics: Nomenclature for Aeronautics. NACA Rep. 474, 1933.

3. Cram, Jack R., and Brimm, Daniel J., Jr.: Part Three - Restricted Commercial Flight Course. Civil Pilot Training Manual, C. A. Bull. No. 23, CAA, U. S. Dept. Commerce, Sept. 1940.

4. Matheny, Cloyce E.: Maximum Pitching Angular Accelerations of Airplanes Measured in Flight. NACA TN 2103, 1950.

TABLE I

PHYSICAL CHARACTERISTICS OF TEST AIRPLANE

Wing:	
Total area (including flaps, ailerons, and 33.3 sq ft covered by fuselage), sq ft	294.1
Span (horizontal with tip tanks), in.	539.9
Span (horizontal without tip tanks), in.	500.8
Aspect ratio	5.89
Taper ratio (c_{tip}/c_{root})	0.52
Mean aerodynamic chord (at wing station 111.0 measured normal to airplane center line), in.	88.37
Sweepback (leading edge), deg	0
Sweepforward (0.25-chord line), deg	4.33
Root airfoil section	NACA 65_1-212
Tip airfoil section	NACA 63-209
Incidence of root section chord (measured from fuselage reference line), deg	-0.5
Incidence of tip section chord (measured from fuselage reference line), deg	-0.5
Dihedral (measured from wing reference plane), deg	3
Aileron area (one), sq ft	9.42
Aileron span, in.	88.4
Aileron root-mean-square chord, in.	15.42
Aileron static control limits, deg	±20
Dive brakes (total area including cut-outs), sq ft	11.6
Distance from nose to leading edge of mean aerodynamic chord, in.	.197
Horizontal tail:	
Total area (including 17.66 sq ft of elevator), sq ft	69.8
Span, in.	224.7
Aspect ratio	4.65
Taper ratio	0.603
Mean aerodynamic chord (horizontal-tail station 49.63 measured normal to airplane center line), in.	47.4
Airfoil section	NACA $65_{(10)}$-011
Incidence (measured from fuselage reference line), deg	0.42
Dihedral, deg	0
Tail length (leading edge of wing mean aerodynamic chord to 25 percent of mean aerodynamic chord of horizontal tail), in.	225.24
Elevator area (including 0.523 sq ft of horn area, 0.758 sq ft of trim-tab area, and 1.426 sq ft of spring-tab area) (one), sq ft	9.375

TABLE I

PHYSICAL CHARACTERISTICS OF TEST AIRPLANE - Continued

Elevator span (one), in.	94.1
Elevator root-mean-square chord, in.	13.65
Elevator static control limits, deg	±15
Vertical tail:	
Total area (including 1.63 sq ft of dorsal area) sq ft	40.5
Span, in.	86.0
Aspect ratio	1.34
Taper ratio	0.453
Mean aerodynamic chord (at water line 98.59 parallel to airplane reference line), in.	67.25
Airfoil section	NACA $65_{(10)}$-011
Tail length (leading edge of wing mean aerodynamic chord to 25 percent of mean aerodynamic chord of vertical tail), in.	227.46
Rudder area, sq ft	10.13
Rudder span, in.	86.0
Rudder root-mean-square chord, in.	17.2
Rudder static control limits, deg	±20
Fuselage:	
Total length (not including nose boom), in.	481.8
Maximum width, in.	46.9
Height (vertical tail above static ground line), in.	173.5
Frontal area (including 2.535 sq ft of canopy frontal area above fuselage), sq ft	18.185
Side area (including 7.43 sq ft of canopy side area above fuselage), sq ft	158.93
Plan area, sq ft	116.8
Tip tanks:	
Frontal area, sq ft	3.30
Fineness ratio	7.398
Capacity, gal	200
Power plant (two)	Westinghouse J-34-WE-34
Airplane weight (includes 2 cannons, no ammunition, instruments, 210 lb. pilot with parachute, fuel in all tanks except wing-tip tanks, and ballast), lb	17,944
Airplane center-of-gravity position corresponding to the airplane weight of 17,944 lb and with gear down, percent wing mean aerodynamic chord	26.59

TABLE I

PHYSICAL CHARACTERISTICS OF TEST AIRPLANE - Concluded

Airplane center-of-gravity position corresponding to the airplane weight of 17,944 lb and with gear up, percent wing mean aerodynamic chord	26.80
Airplane weight (average flight weight), lb	16,145
Airplane center-of-gravity location corresponding to average airplane flight weight (clean condition), percent wing mean aerodynamic chord	26.47
Estimated moments of inertia (wing-tip tanks on but empty), slug/ft^2:	
I_X	18,982
I_Y	26,288
I_Z	42,679

TABLE II

MANEUVER CLASSIFICATION AND ARRANGEMENT

	Figures
Maneuver classification:	
Right turns	2 to 18
Left turns	19 to 53
Series of turns	54 to 67
Pull-ups	68 to 103
Push-over	104 to 106
Pull-up push-over combination	107 to 108
Dives with various recoveries	109 to 153
Right slow rolls	154 to 167
Left slow rolls	168 to 201
Right barrel rolls	202 to 208
Left barrel rolls	209 to 223
Double rolls	224 to 237
Triple rolls	238 to 240
4-point rolls	241 to 244
Loop	245 to 251
Immelman	252 to 254
Split-S	255 to 256
Cuban eight	257 to 258
Lazy eight	259 to 260
Wing-over	261 to 263
Chandelle	264 to 268
Vertical reverse	269 to 271
Split-S into loop with slow rolls	272
Stall	273
Effect of speed brakes	274
Landing	275 to 277

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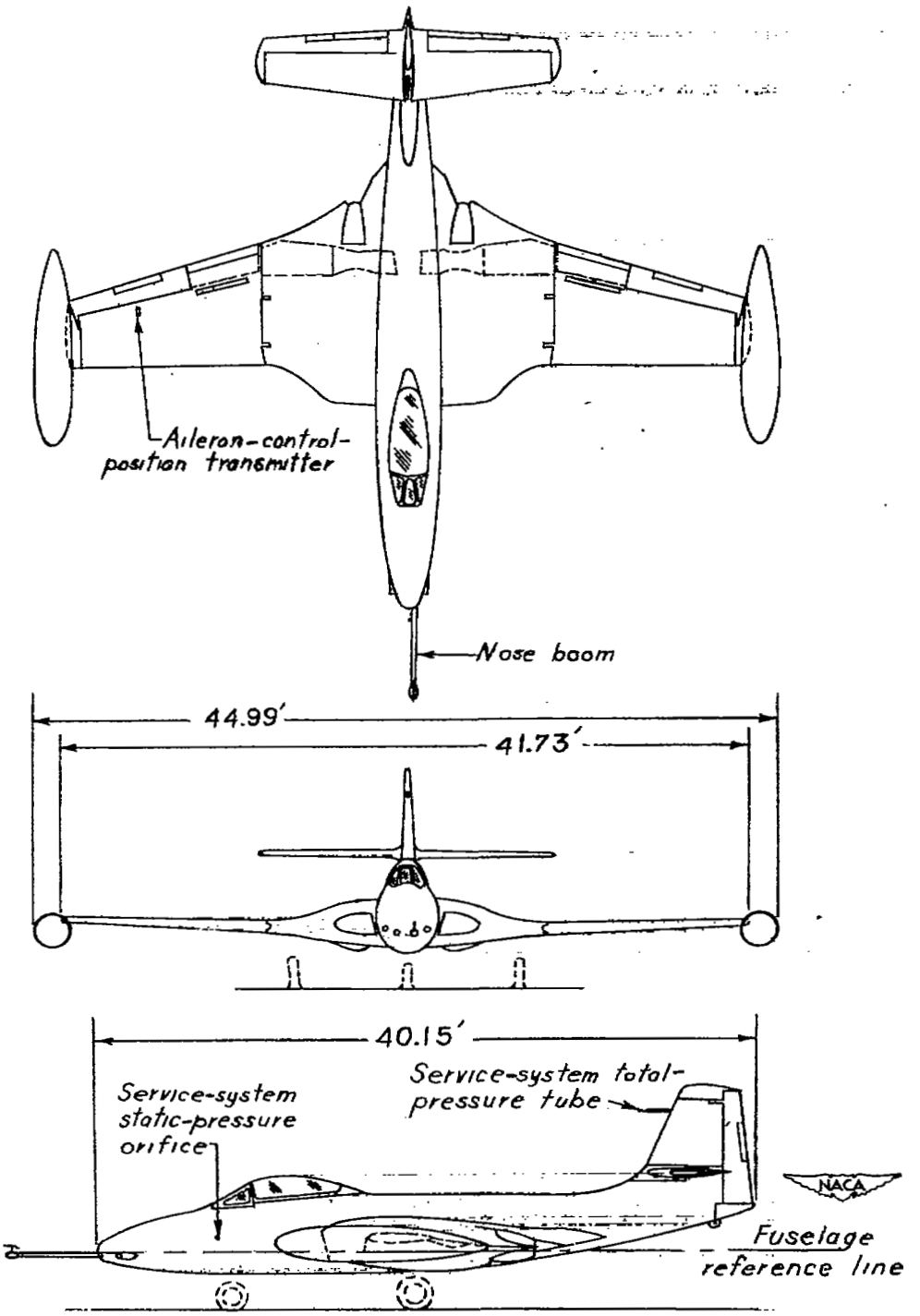

Figure 1.- Three-view drawing of F2H-2 test airplane.

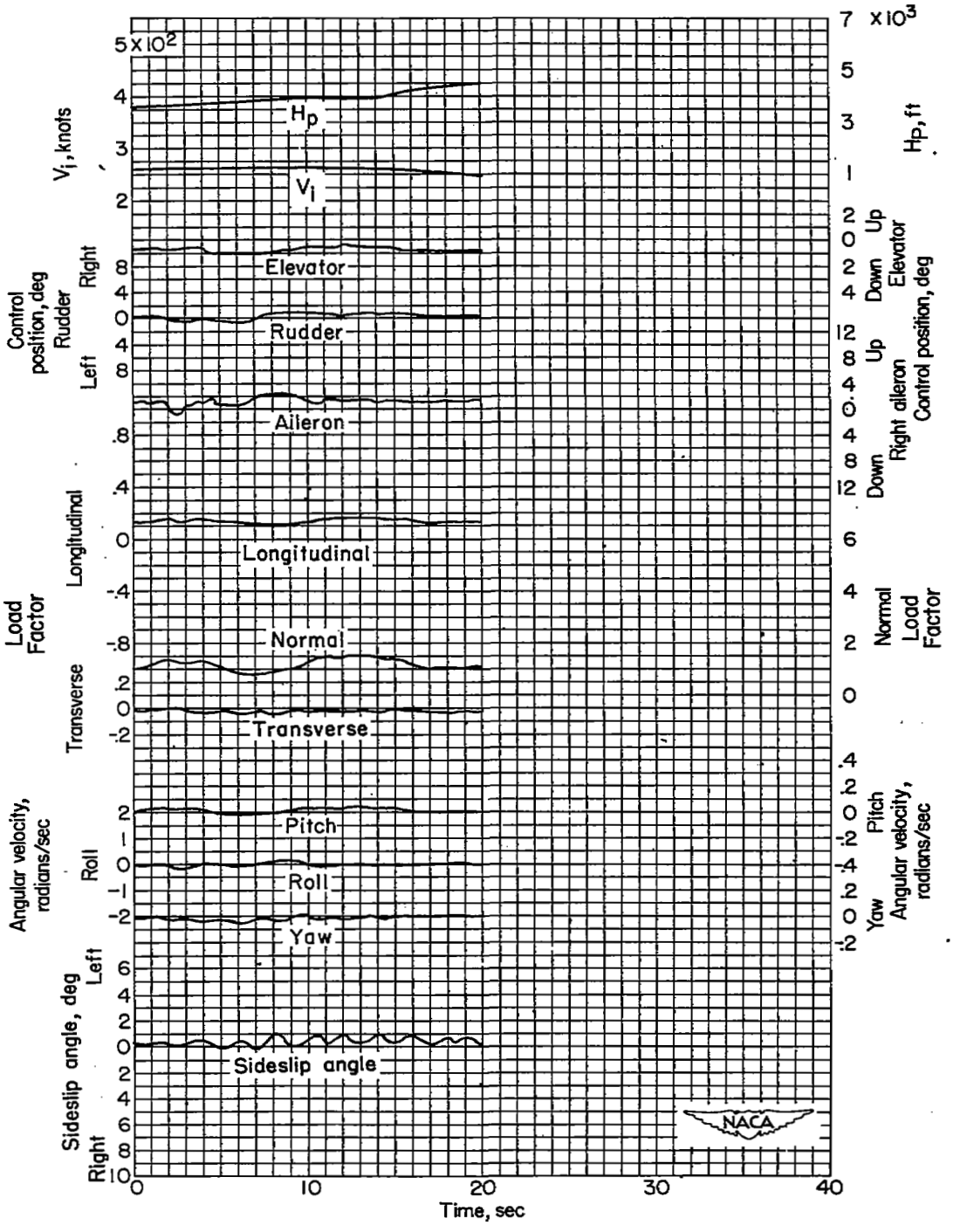

Figure 2.- Gentle right climbing turn; airplane weight, 14,900 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

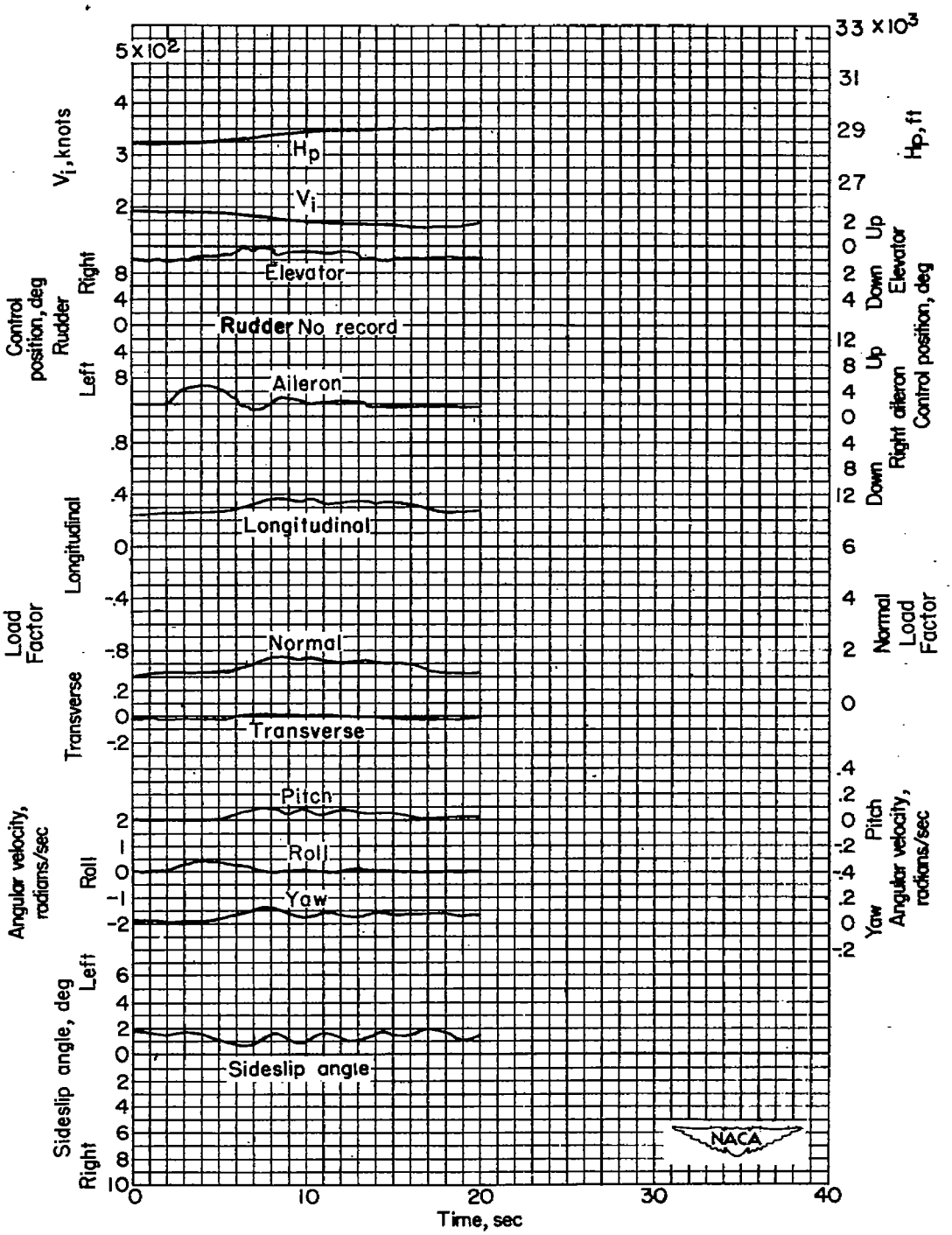

Figure 3.- Gentle right climbing turn; airplane weight, 16,470 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

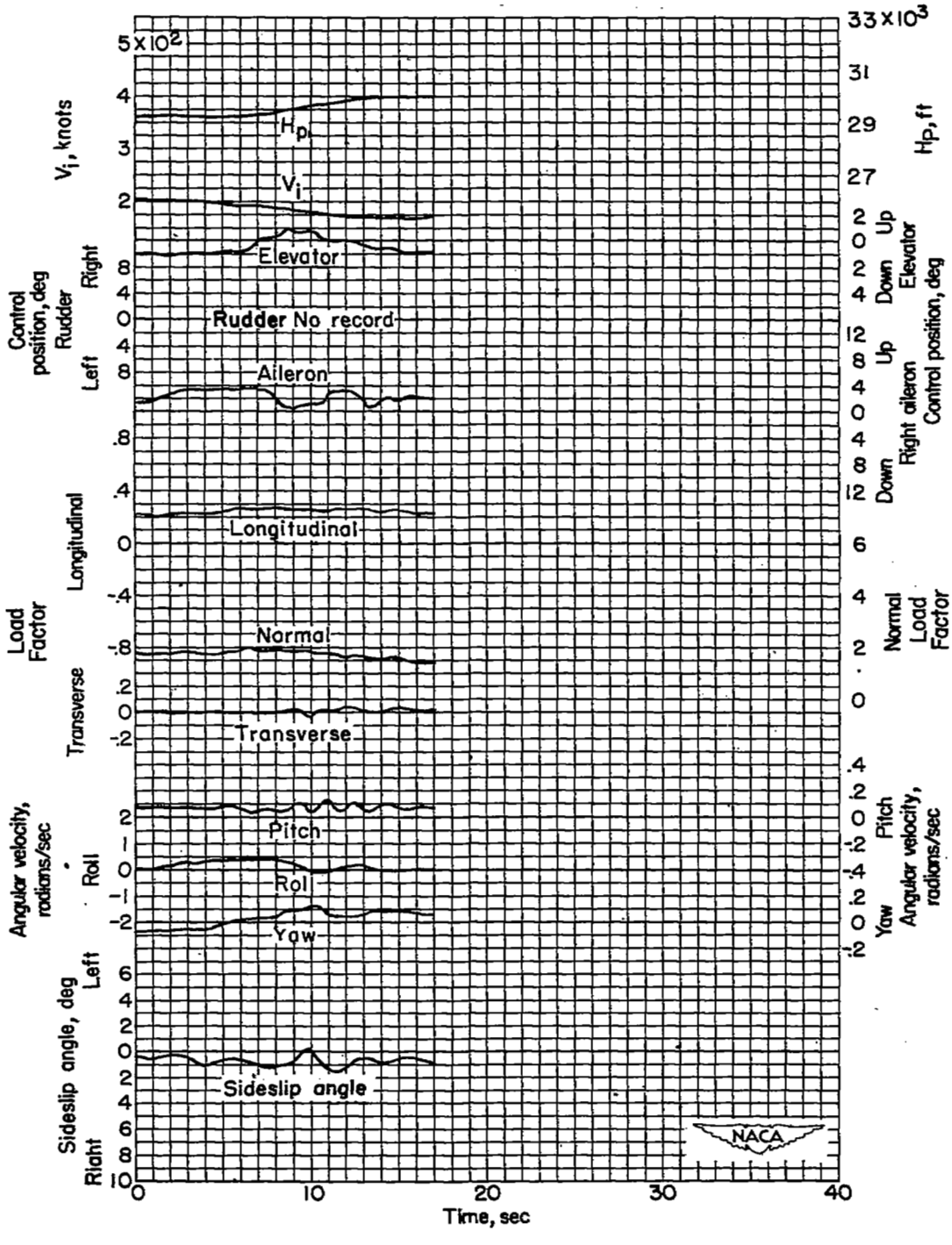

Figure 4.- Gentle right climbing turn; airplane weight, 16,060 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

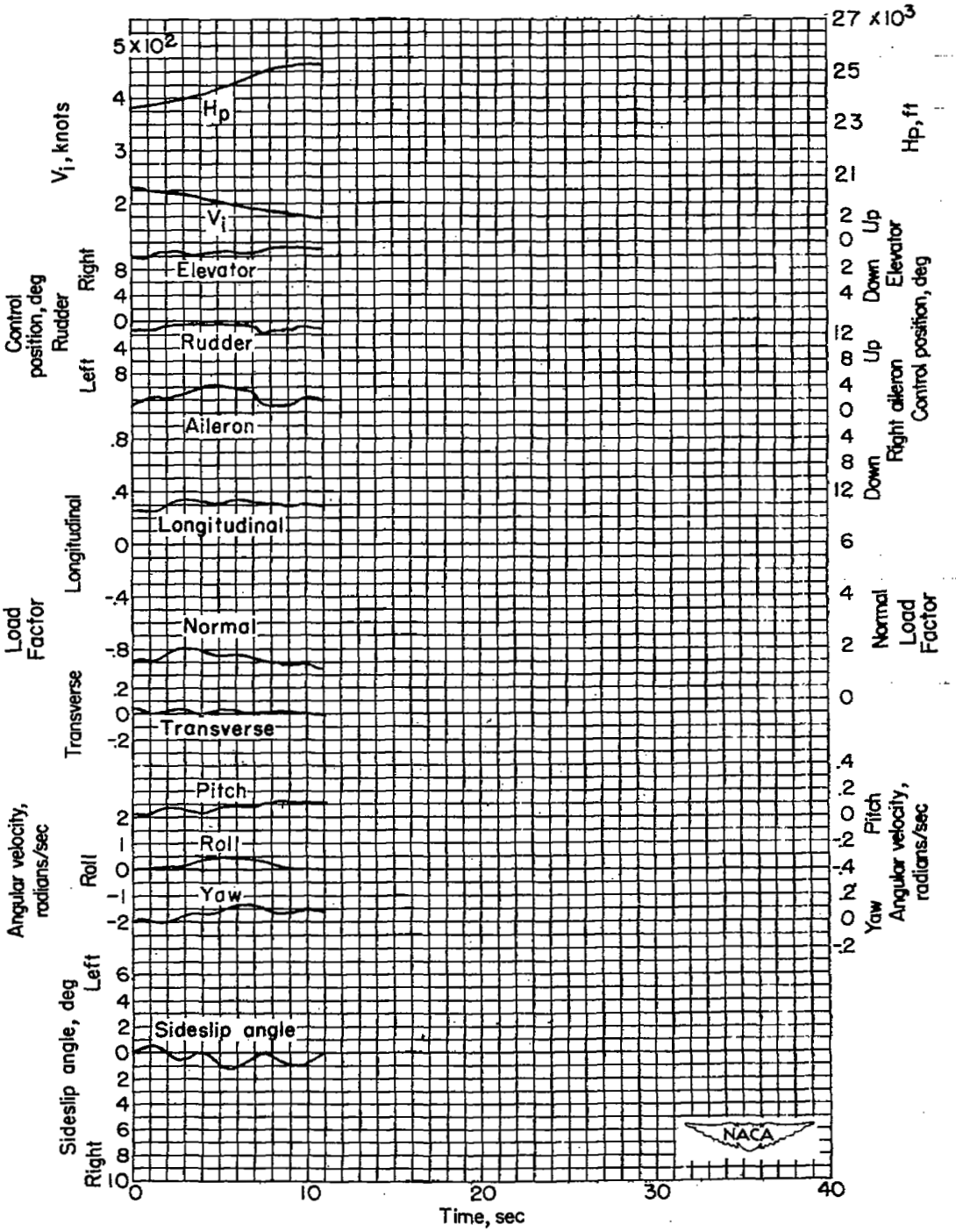

Figure 5.- Gentle right climbing turn; airplane weight, 17,680 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

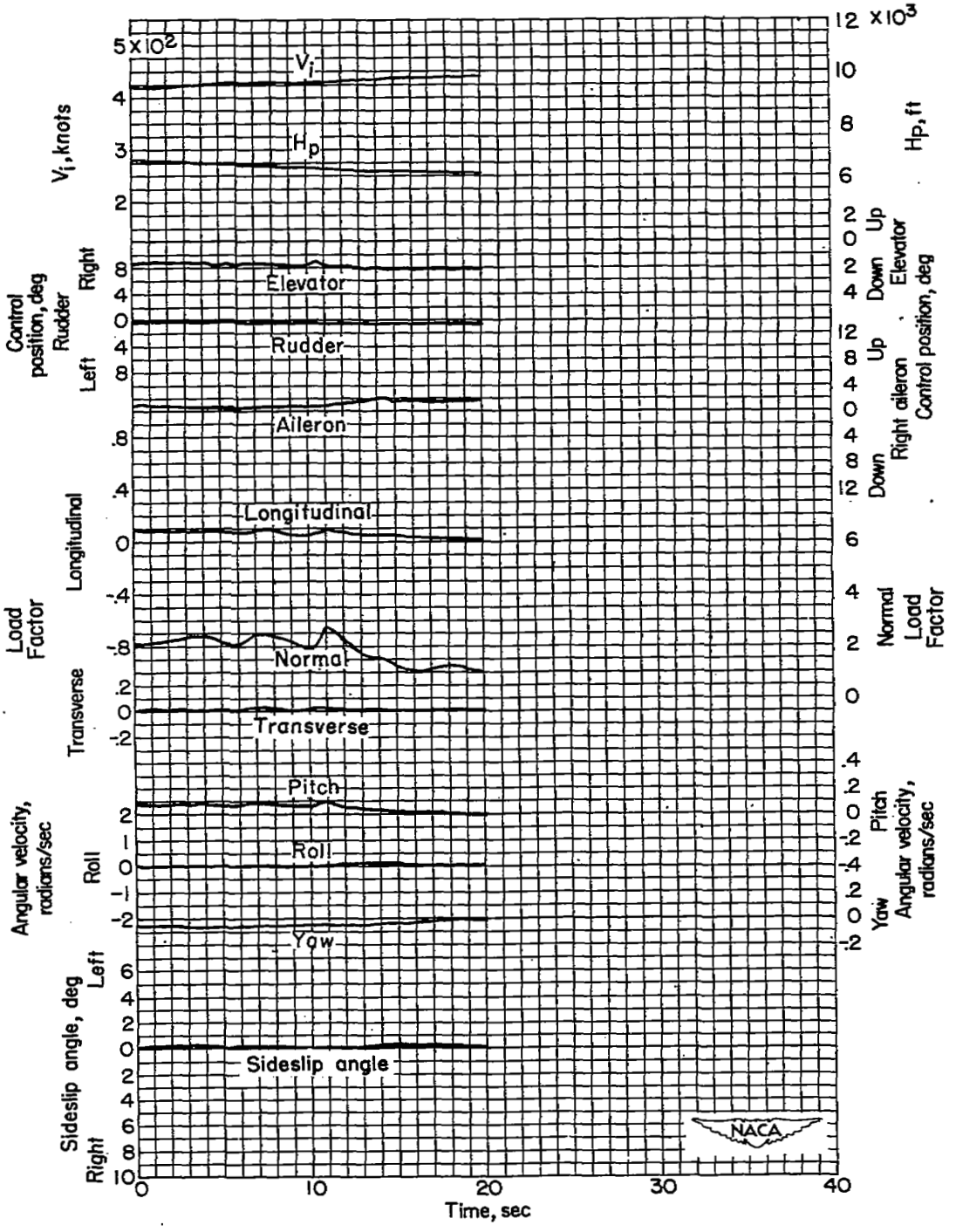

Figure 6.- Gentle right diving turn; airplane weight, 16,570 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

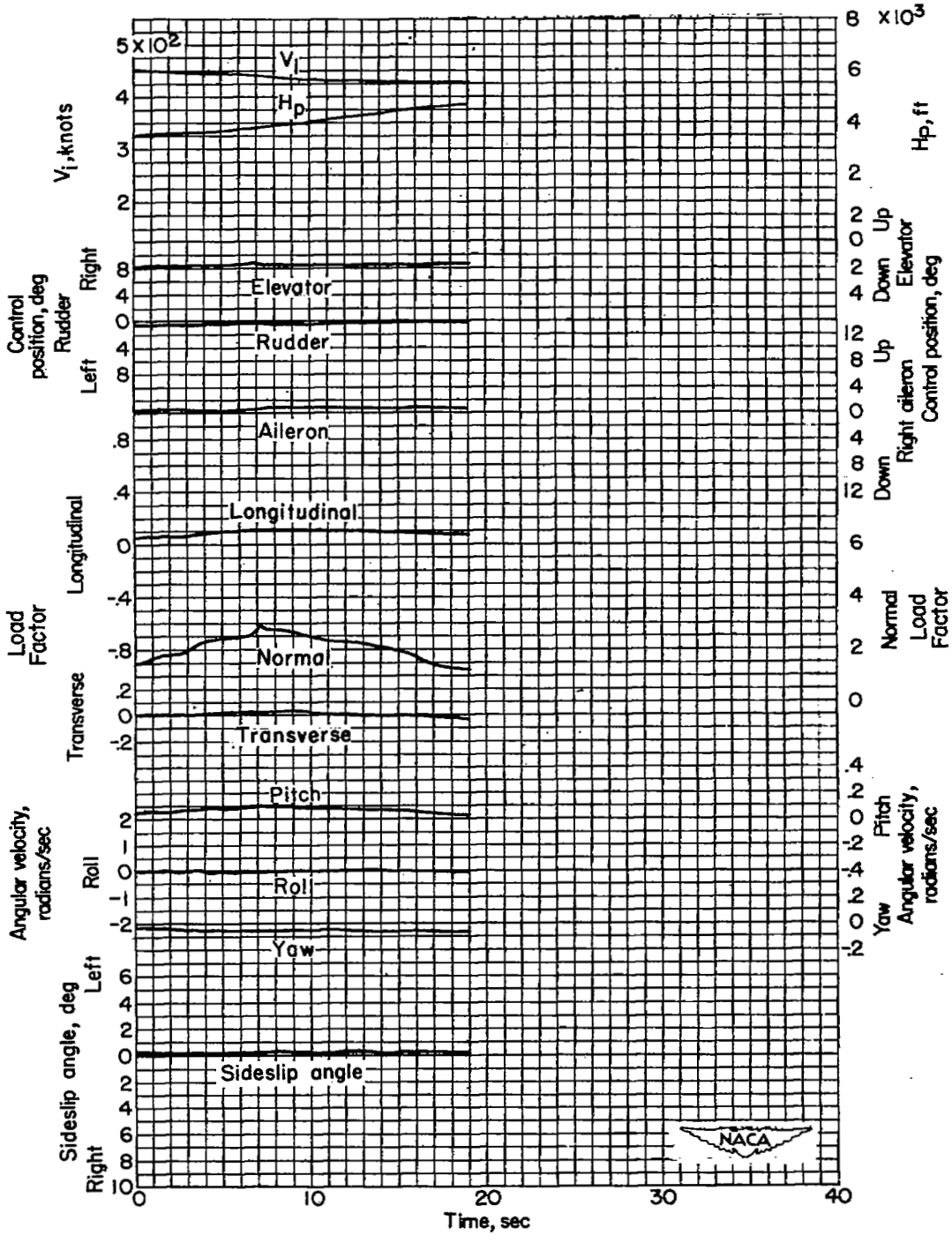

Figure 7.- Gentle right climbing turn; airplane weight, 16,500 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

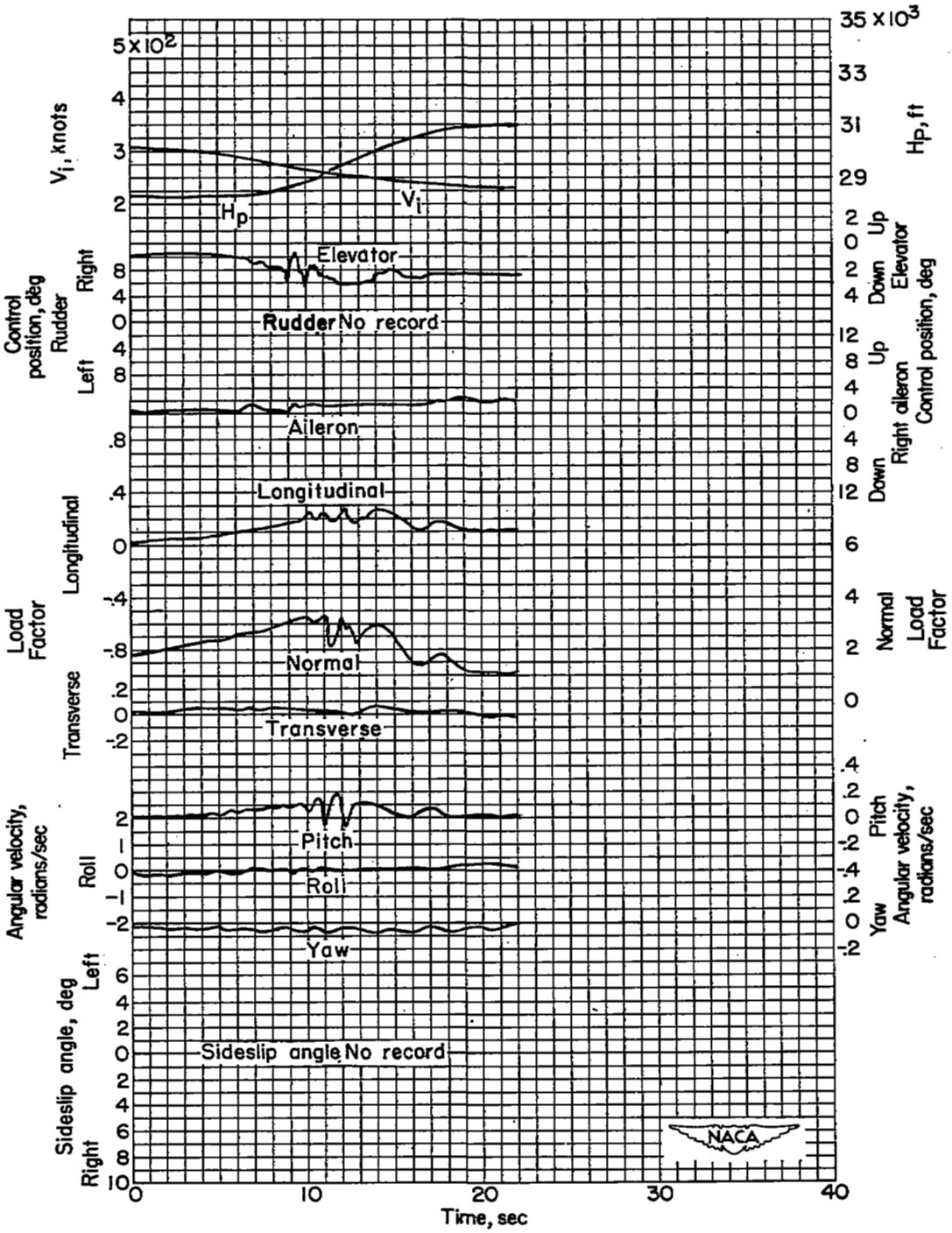

Figure 8.- Gentle right climbing turn; airplane weight, 14,870 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

[redacted]

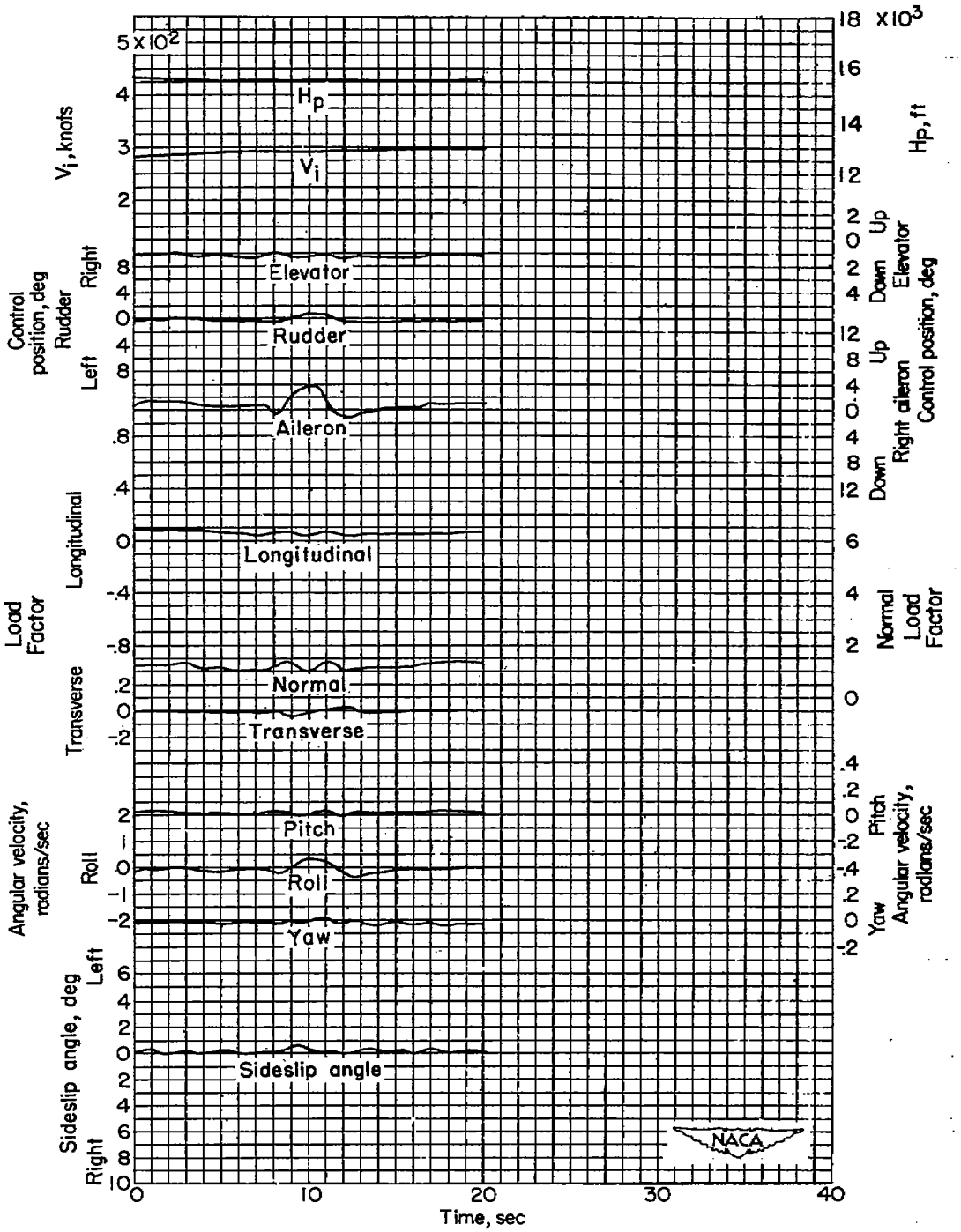

Figure 9.- Right turn; airplane weight, 16,480 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

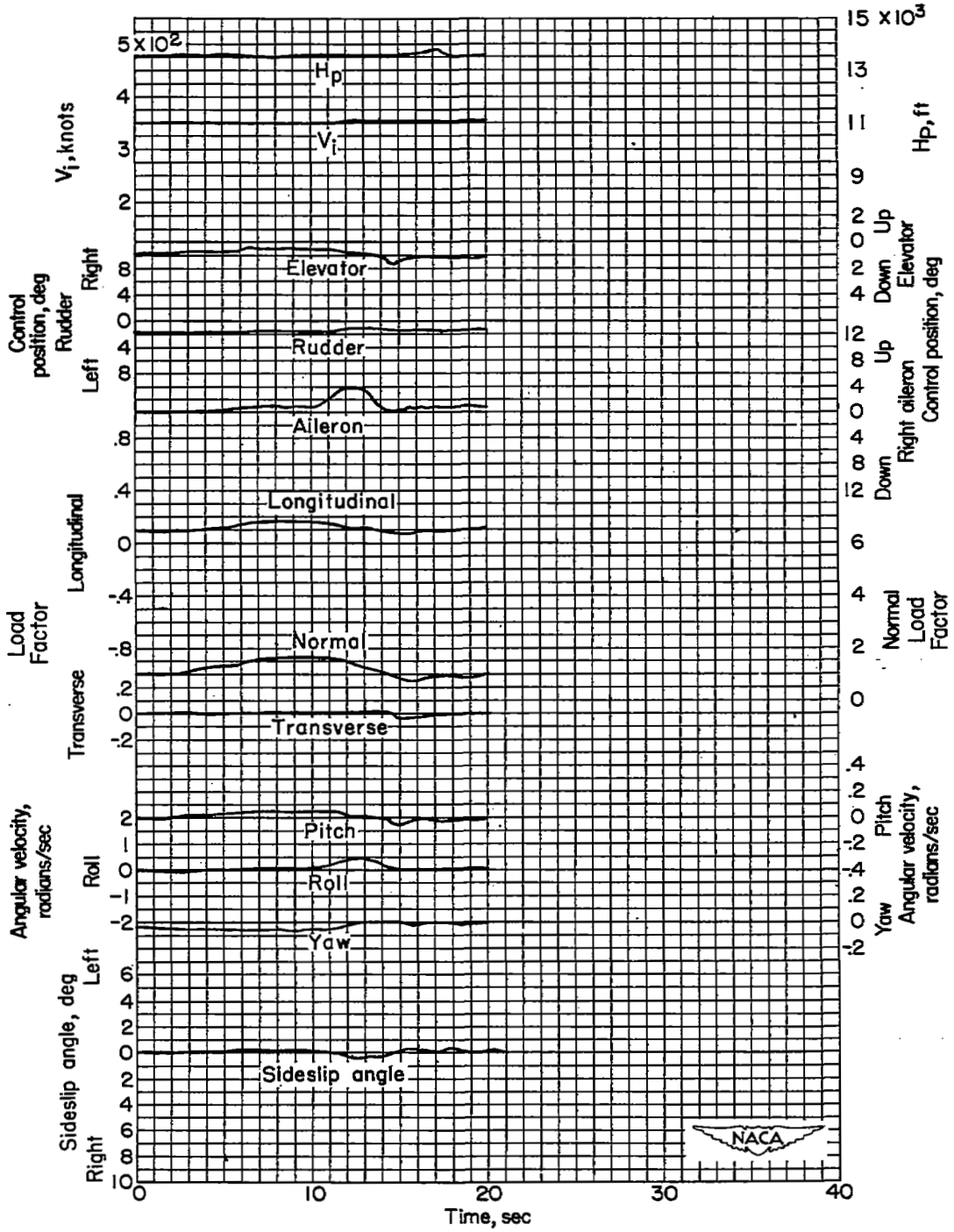

Figure 10.- Right turn; airplane weight, 15,900 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

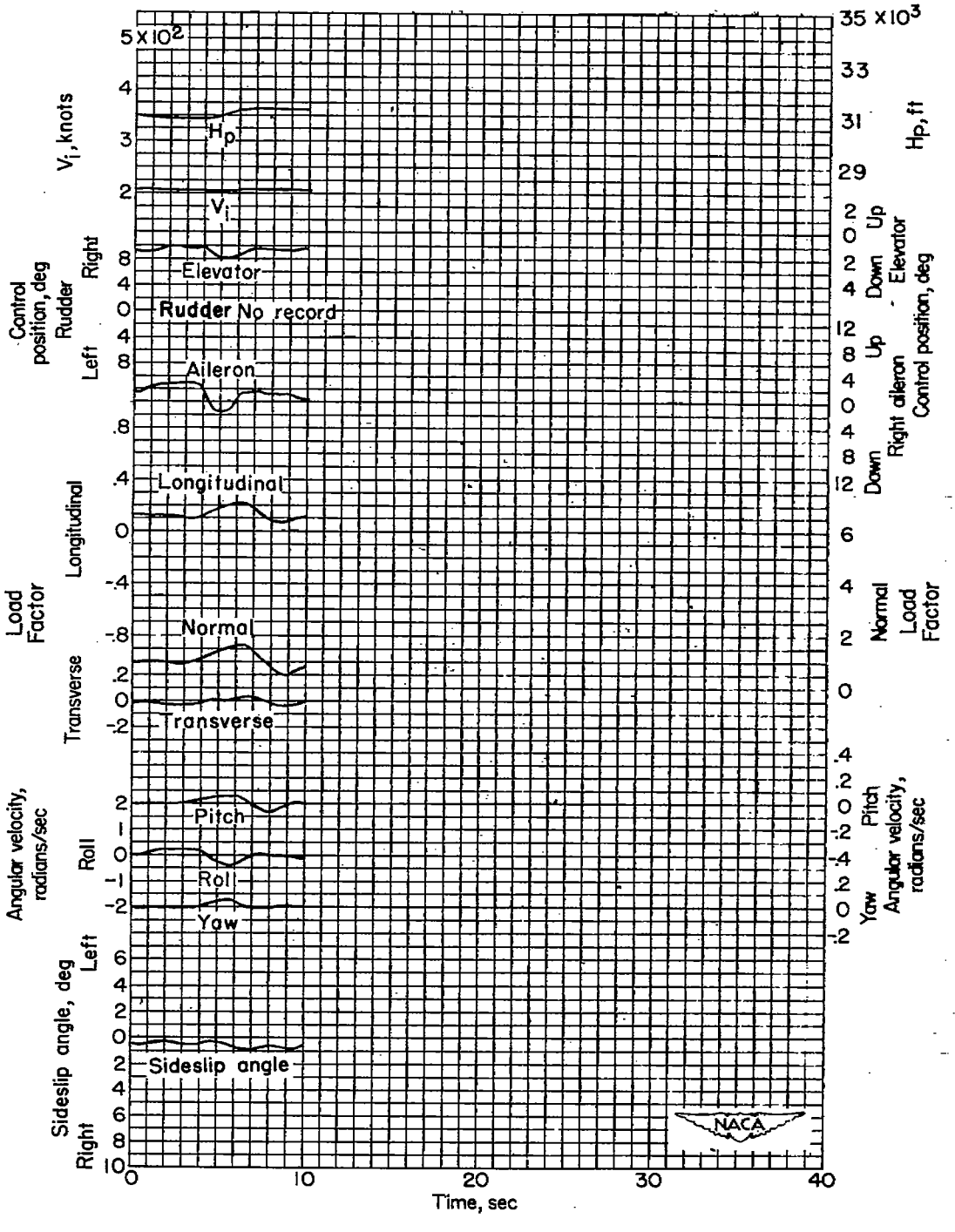

Figure 11.- Right turn; airplane weight, 16,240 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

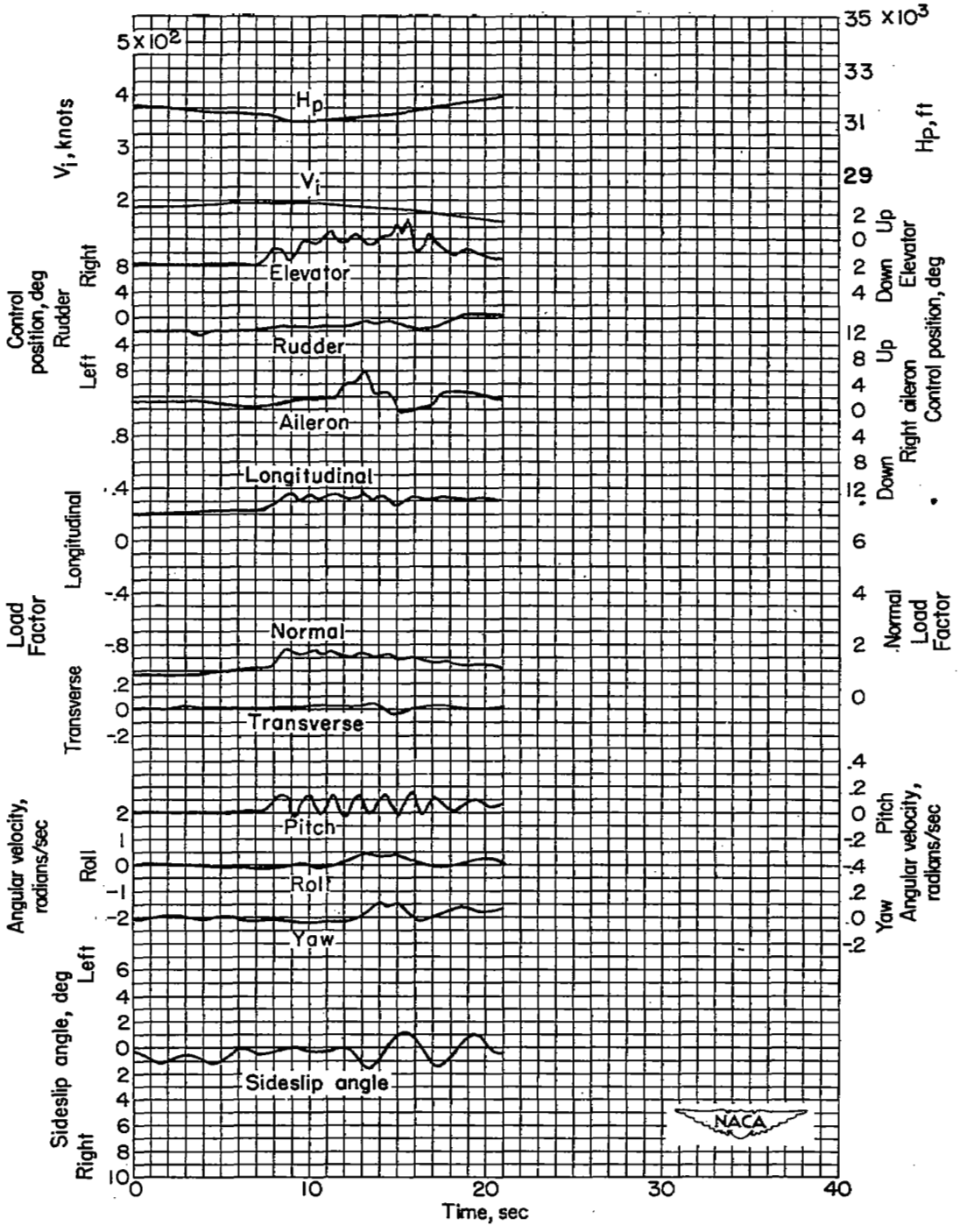

Figure 12.- Right climbing turn; airplane weight, 16,950 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

[redacted]

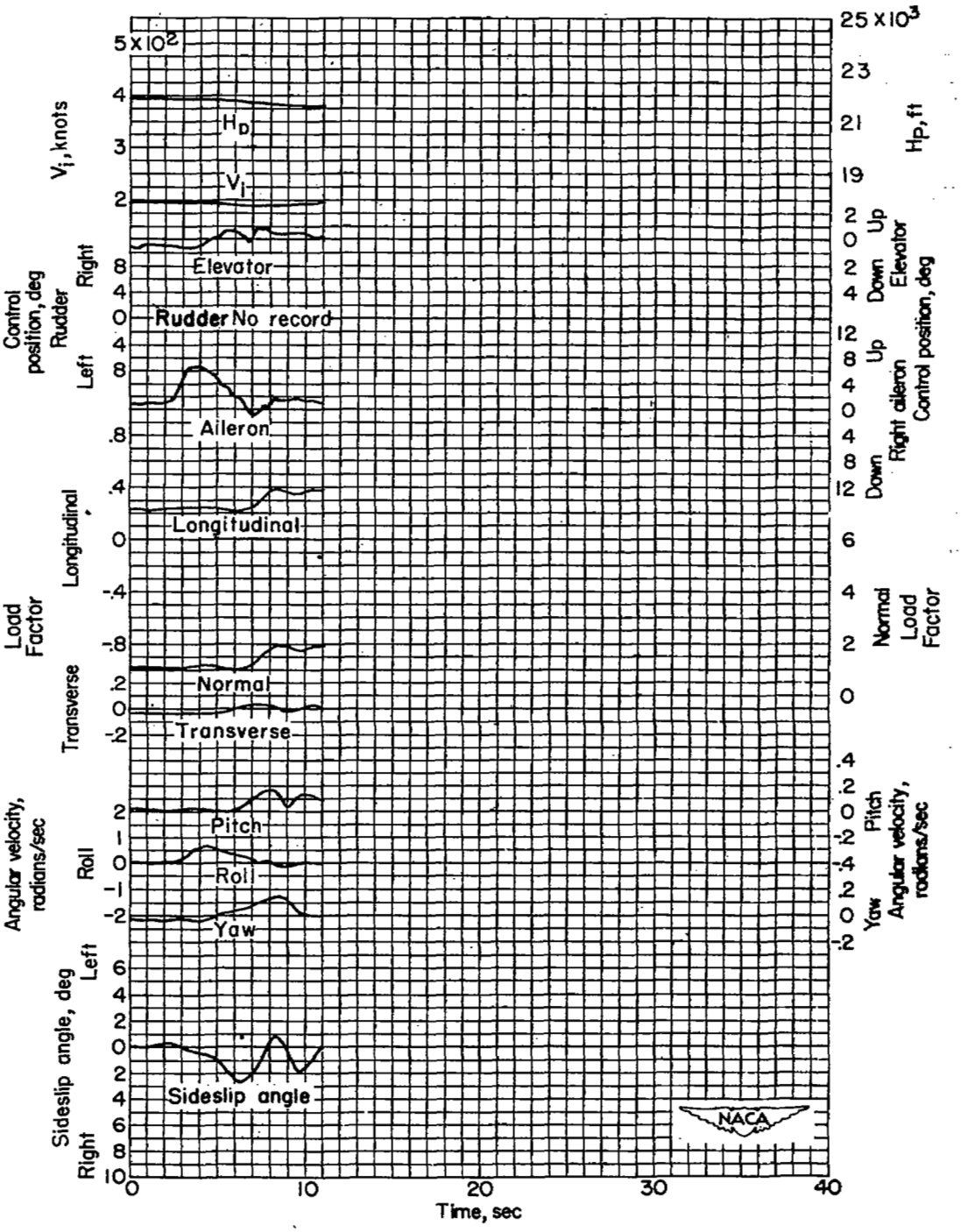

Figure 13.- Right turn; airplane weight, 16,820 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

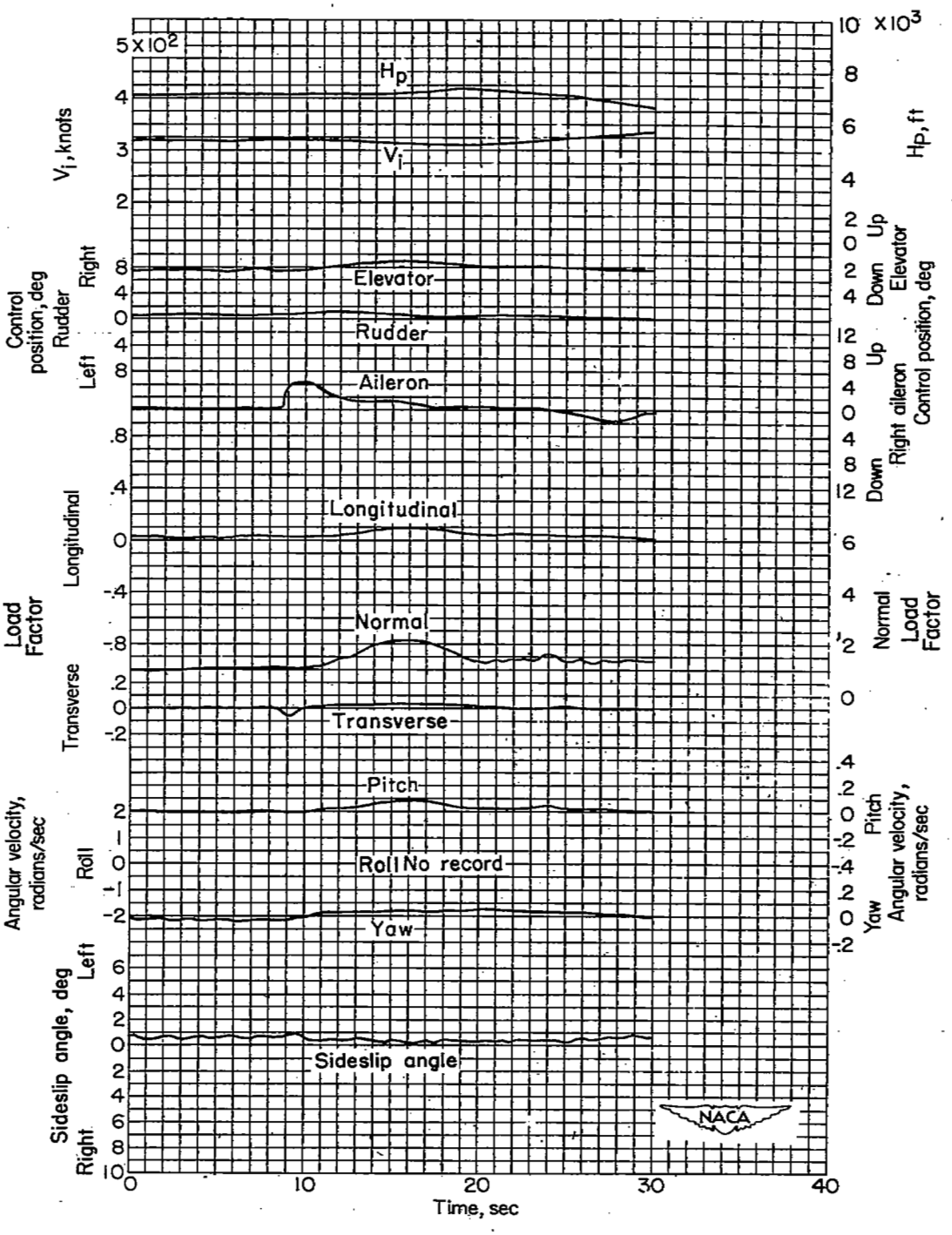

Figure 14.- Right turn; airplane weight, 15,650 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

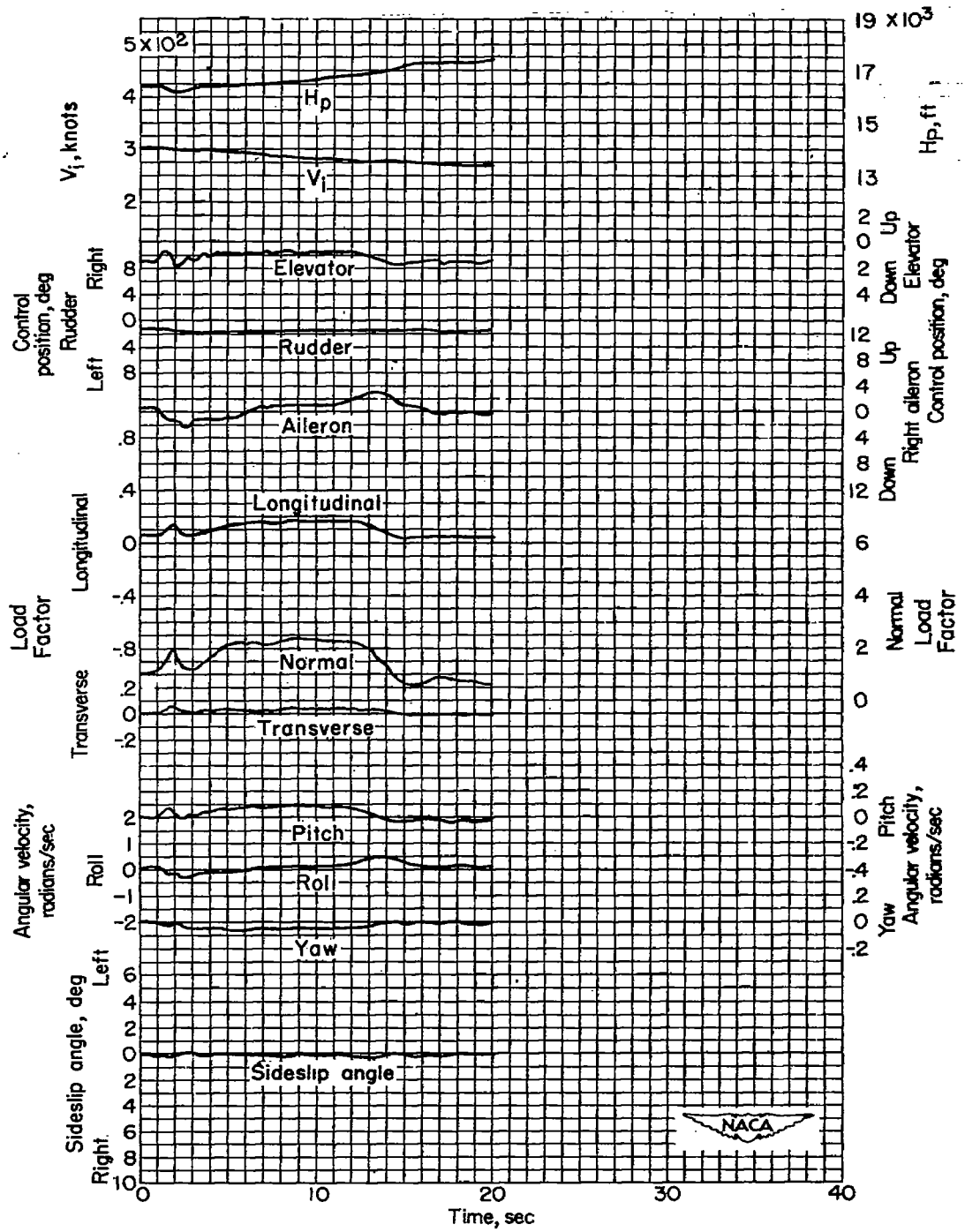

Figure 15.- Right climbing turn; airplane weight, 16,770 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

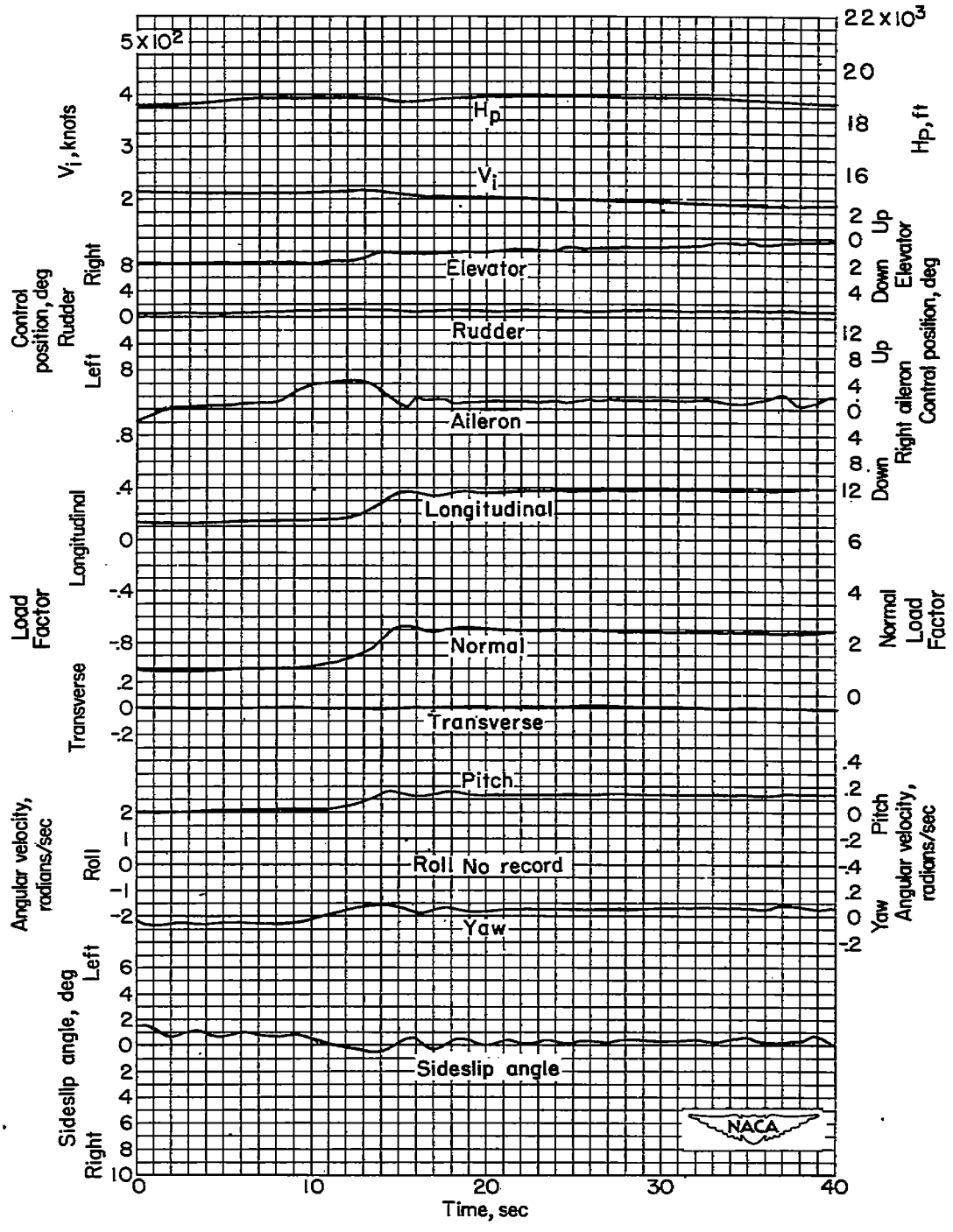

Figure 16.- Right turn; airplane weight, 15,210 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

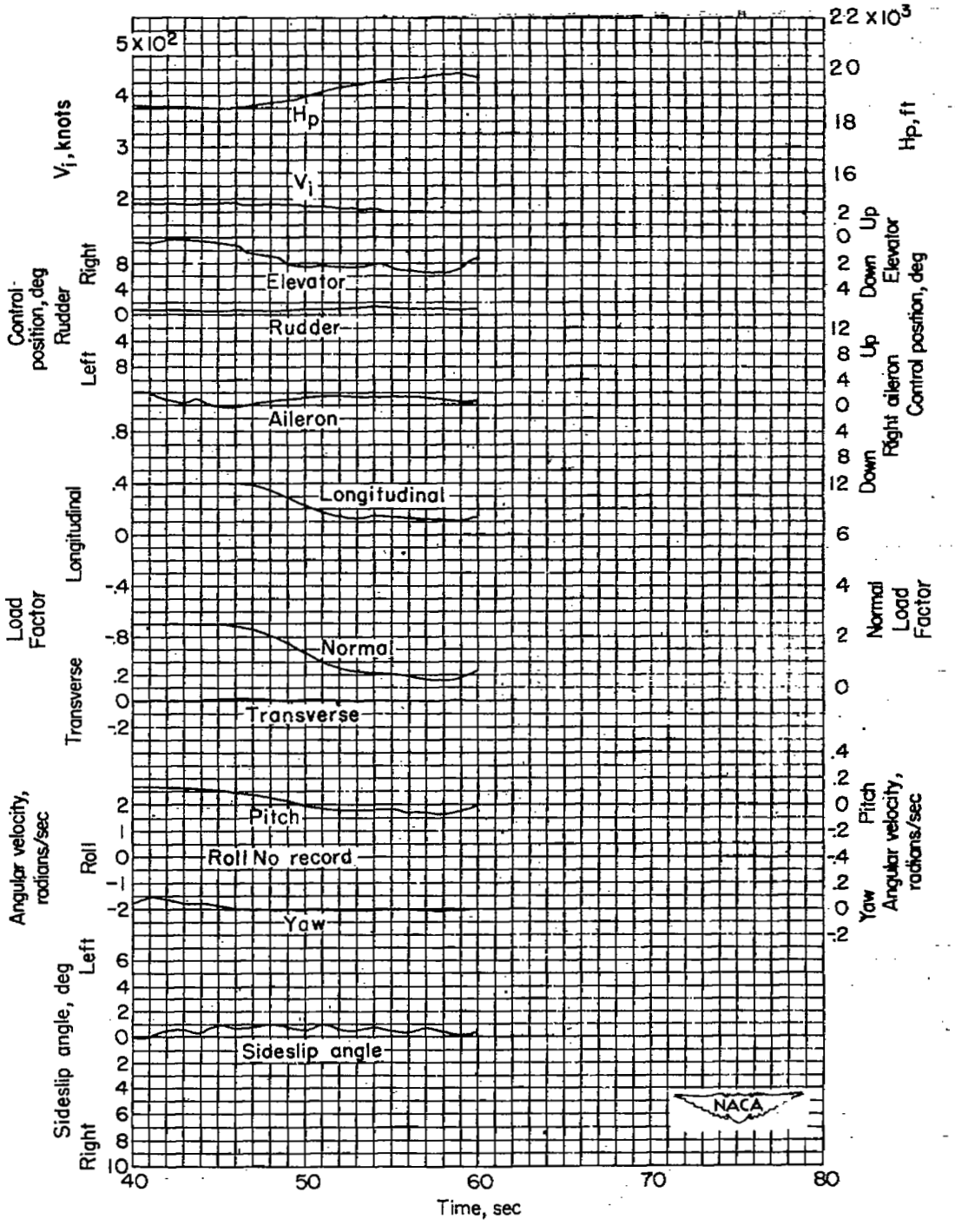

Figure 16.- Concluded.

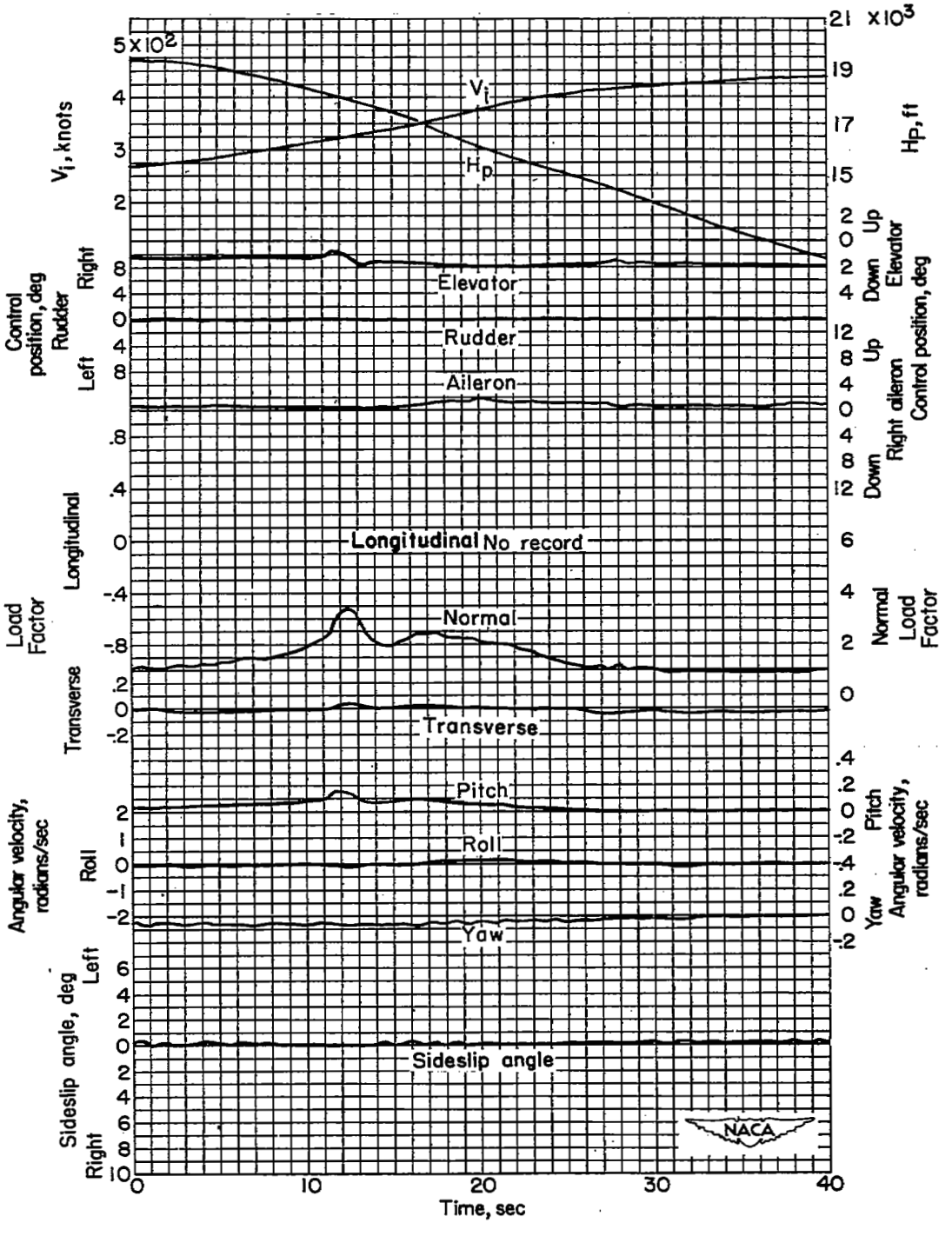

Figure 17.- Right diving turn; airplane weight, 14,660 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

[redacted]

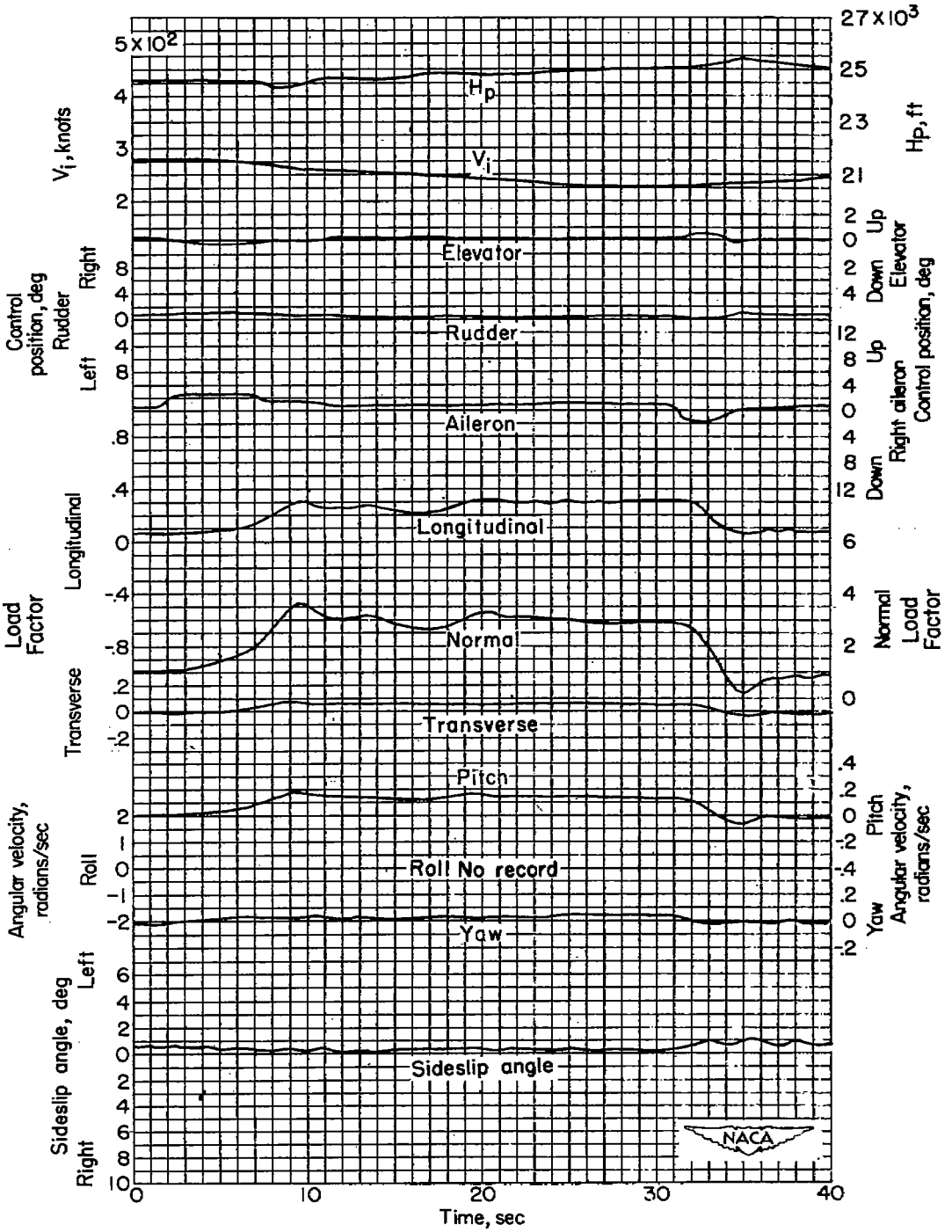

Figure 18.- Right turn; airplane weight, 14,820 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

5F

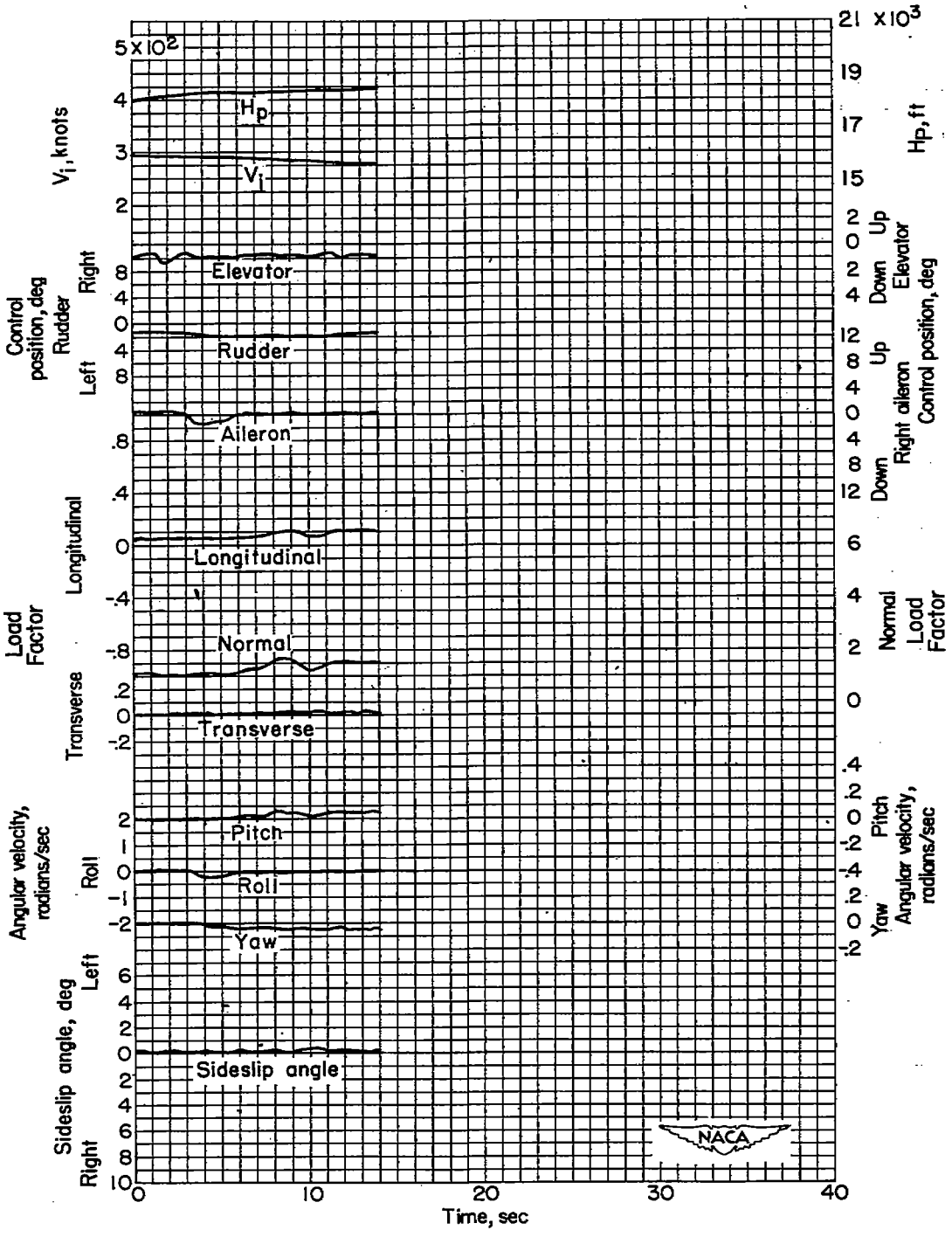

Figure 19.- Gentle left turn; airplane weight, 16,470 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

[redacted]

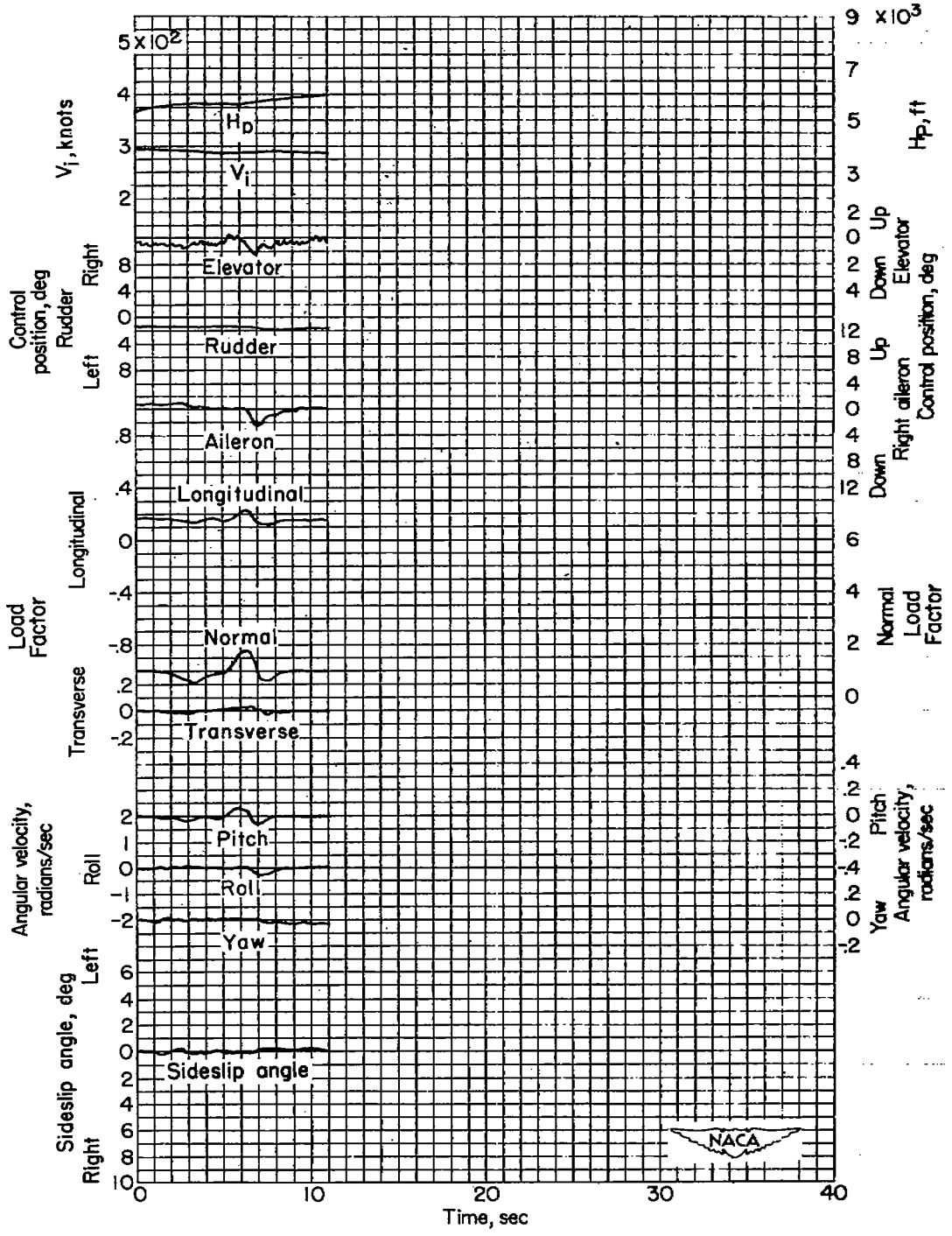

Figure 20.- Gentle left climbing turn; airplane weight, 17,200 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

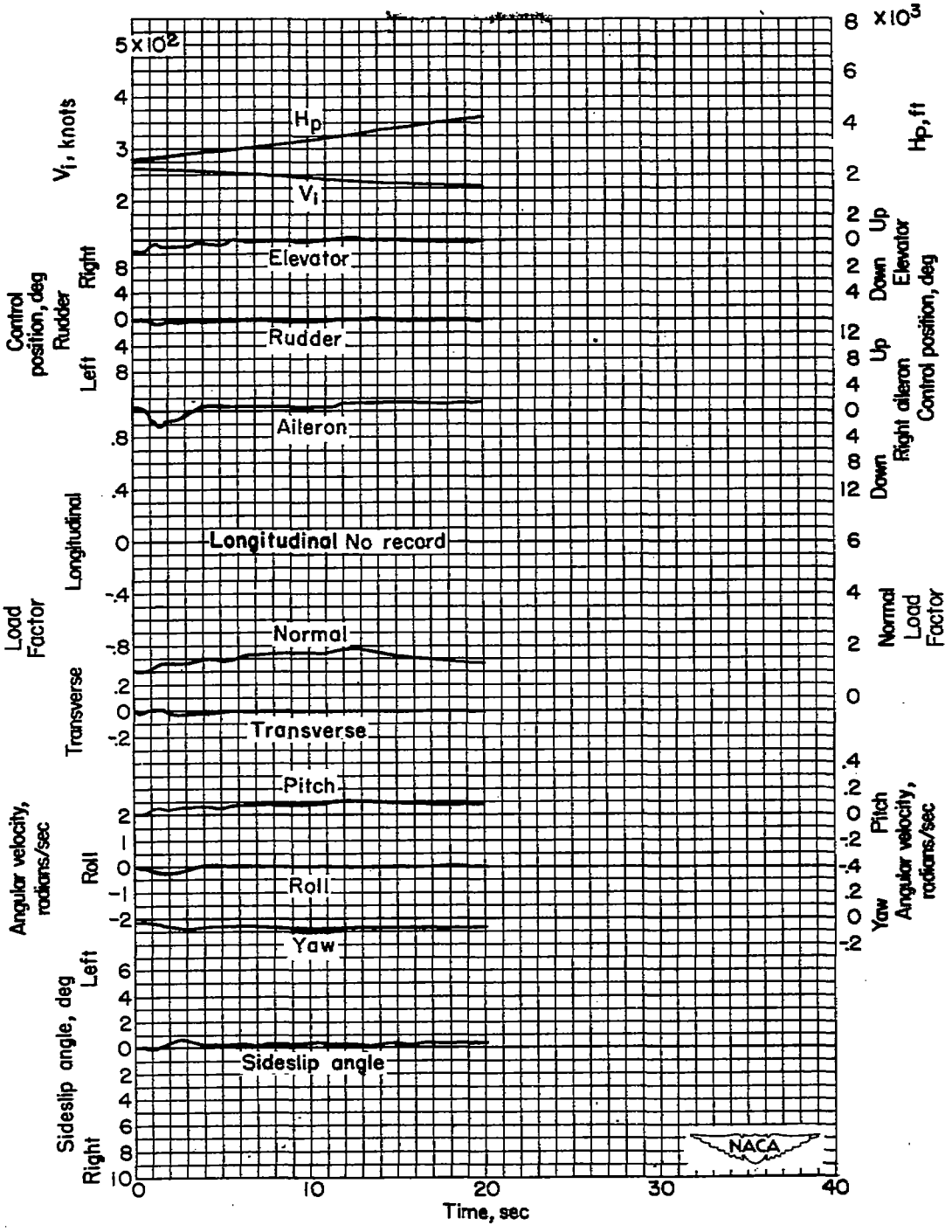

Figure 21.- Gentle left climbing turn; airplane weight, 16,060 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

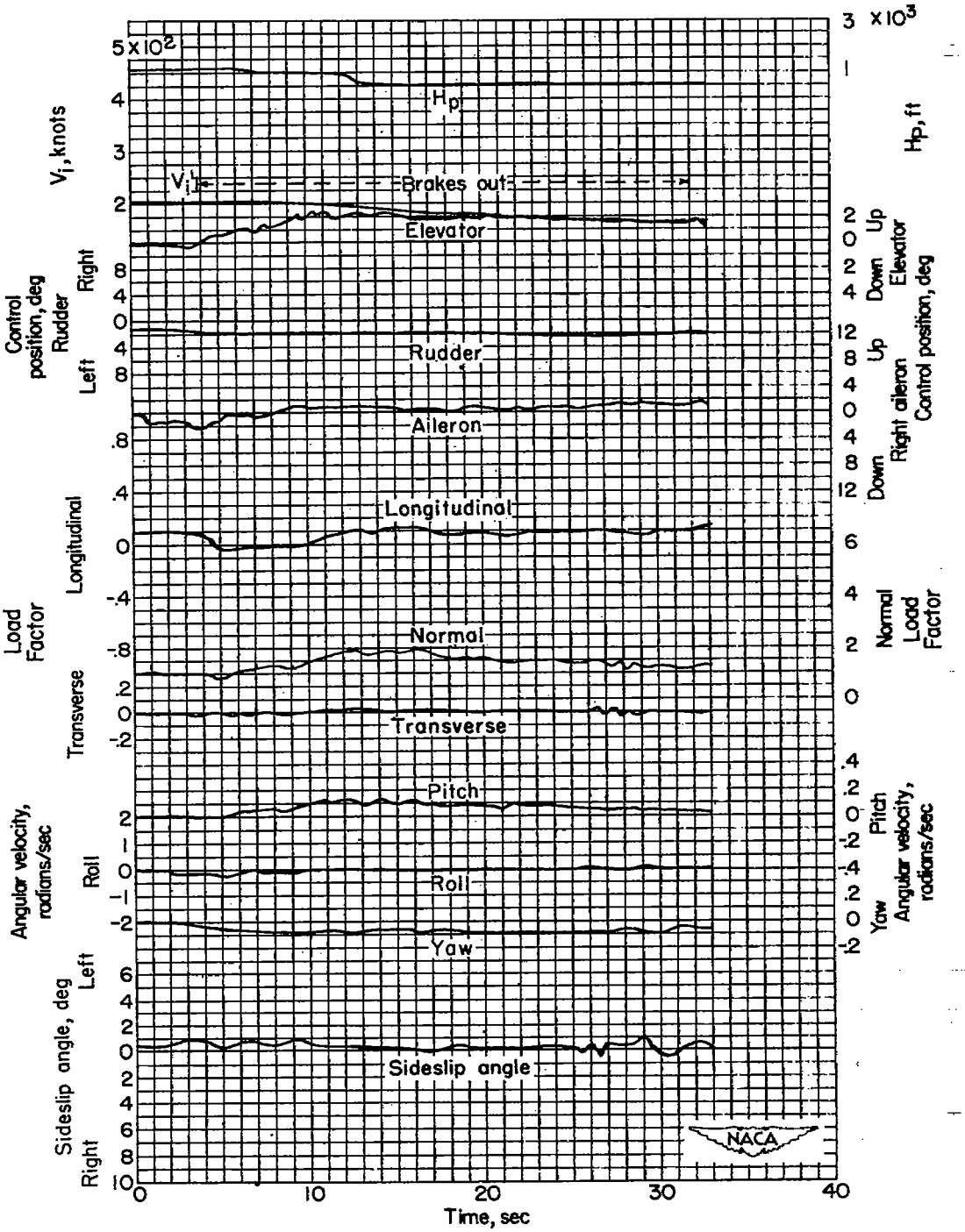

Figure 22.- Gentle left turn; airplane weight, 13,420 pounds; center-of-gravity location, 26.0 percent of the mean aerodynamic chord.

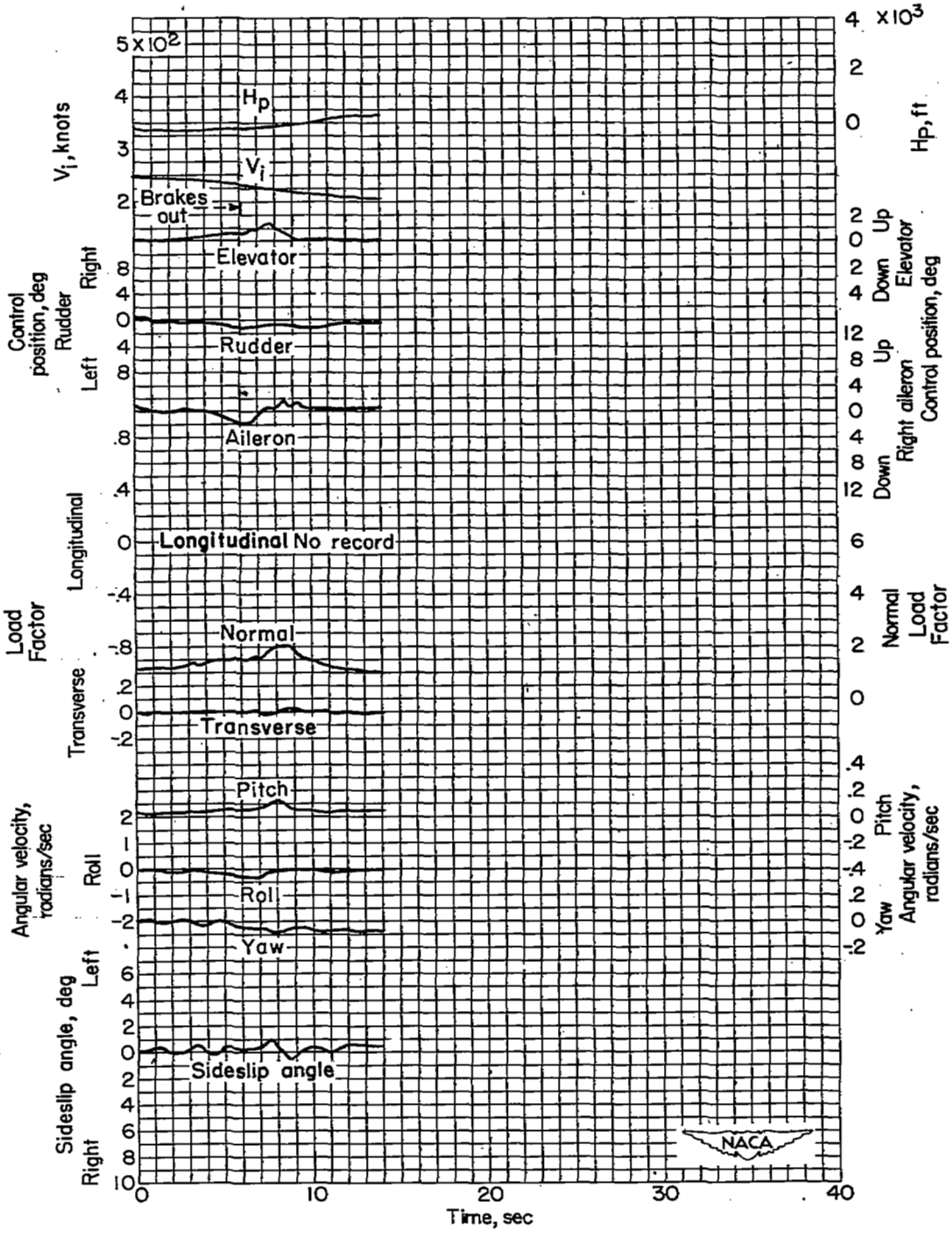

Figure 23.- Gentle left climbing turn; airplane weight, 15,620 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

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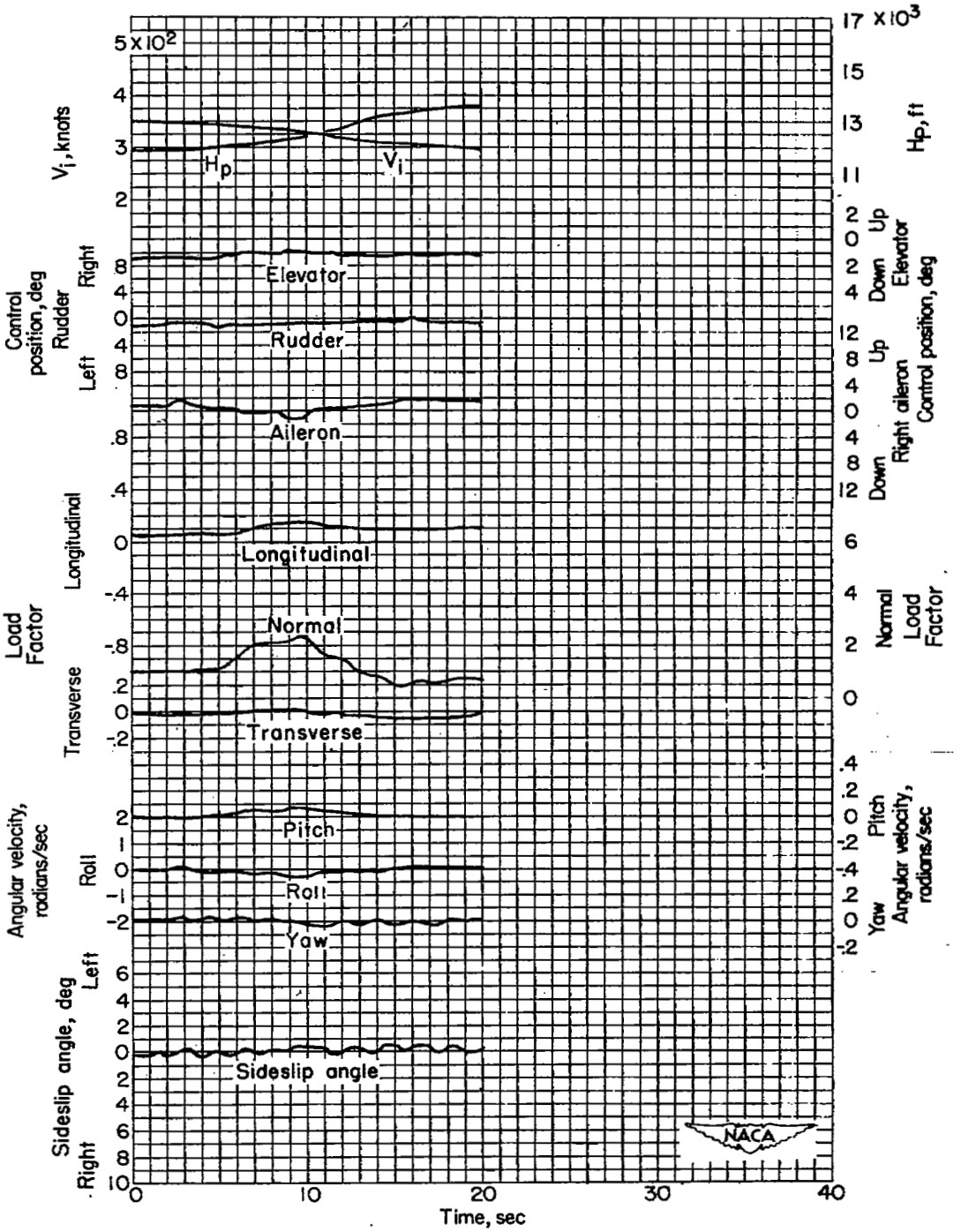

Figure 24.- Gentle left climbing turn; airplane weight, 16,170 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

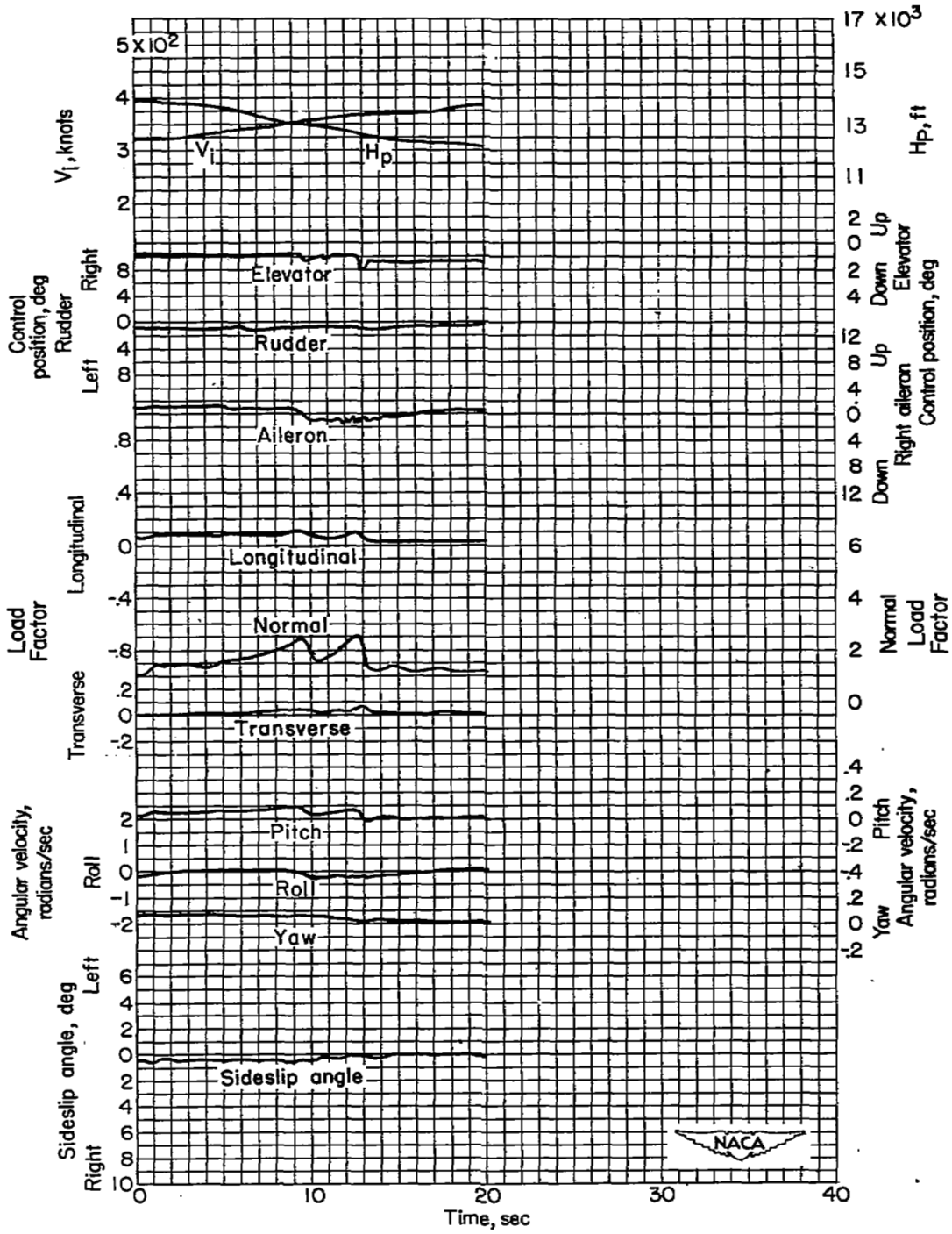

Figure 25.- Gentle left diving turn; airplane weight, 16,070 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

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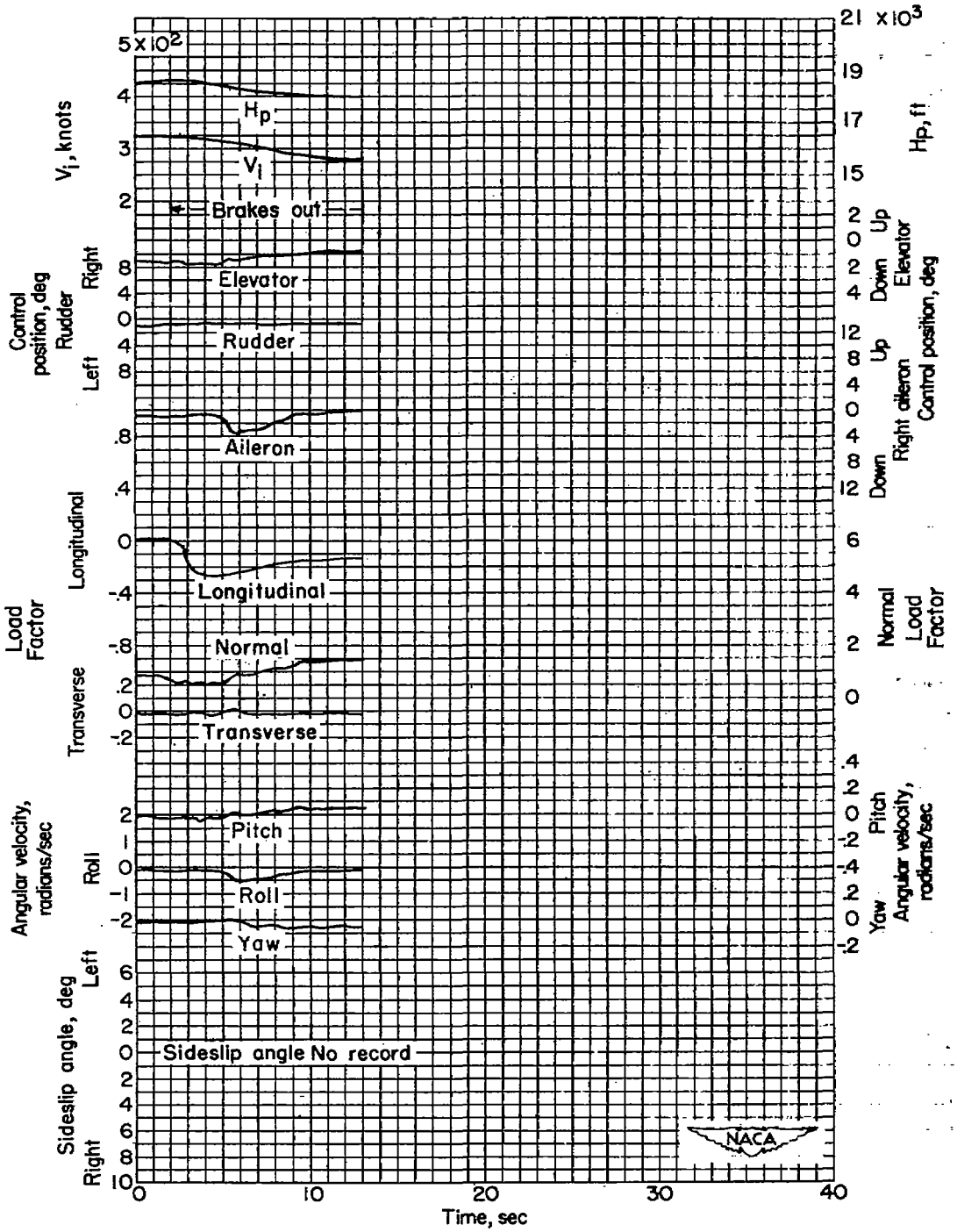

Figure 26.- Left diving turn; airplane weight, 16,830 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

3F

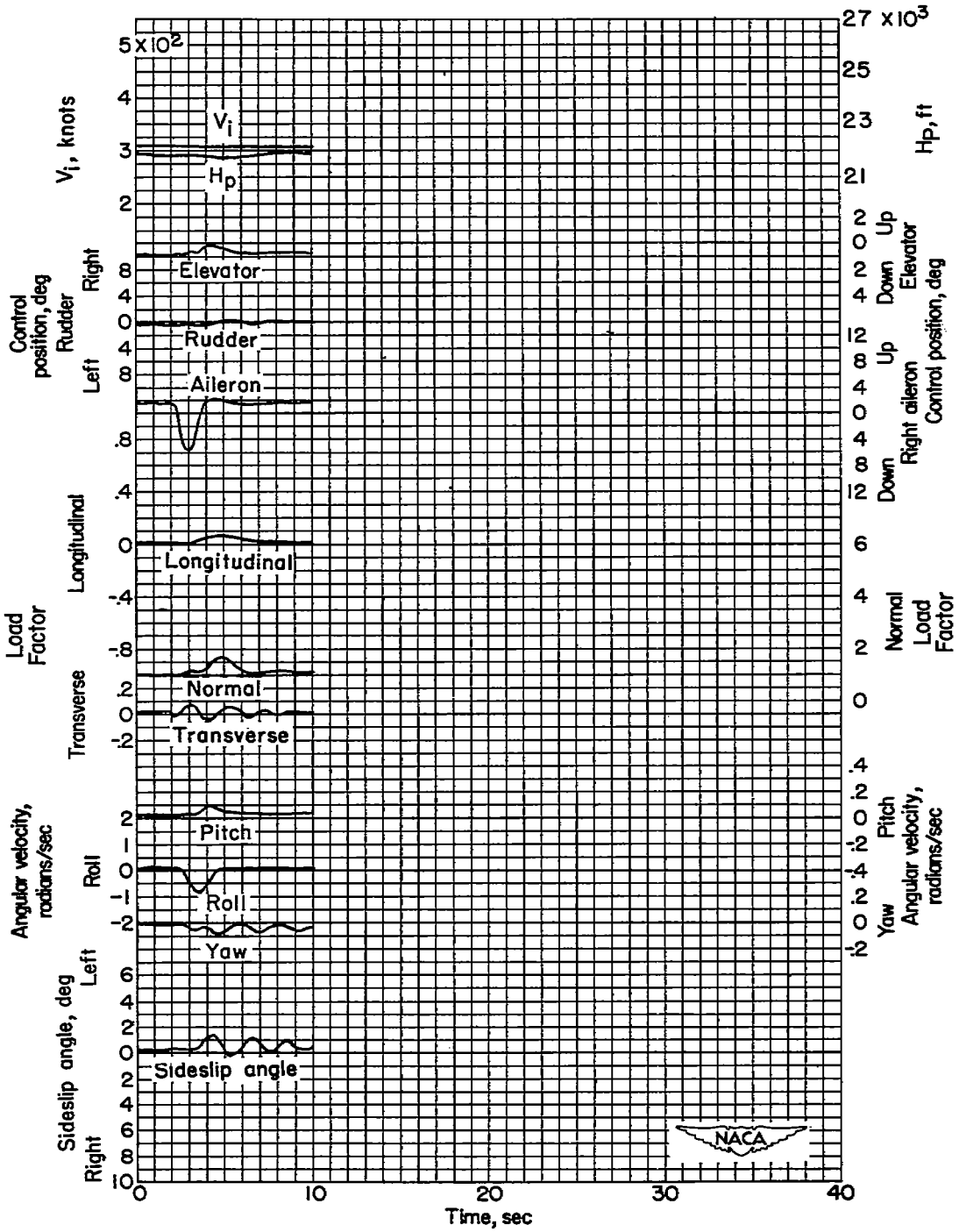

Figure 27.- Left turn; airplane weight, 18,720 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

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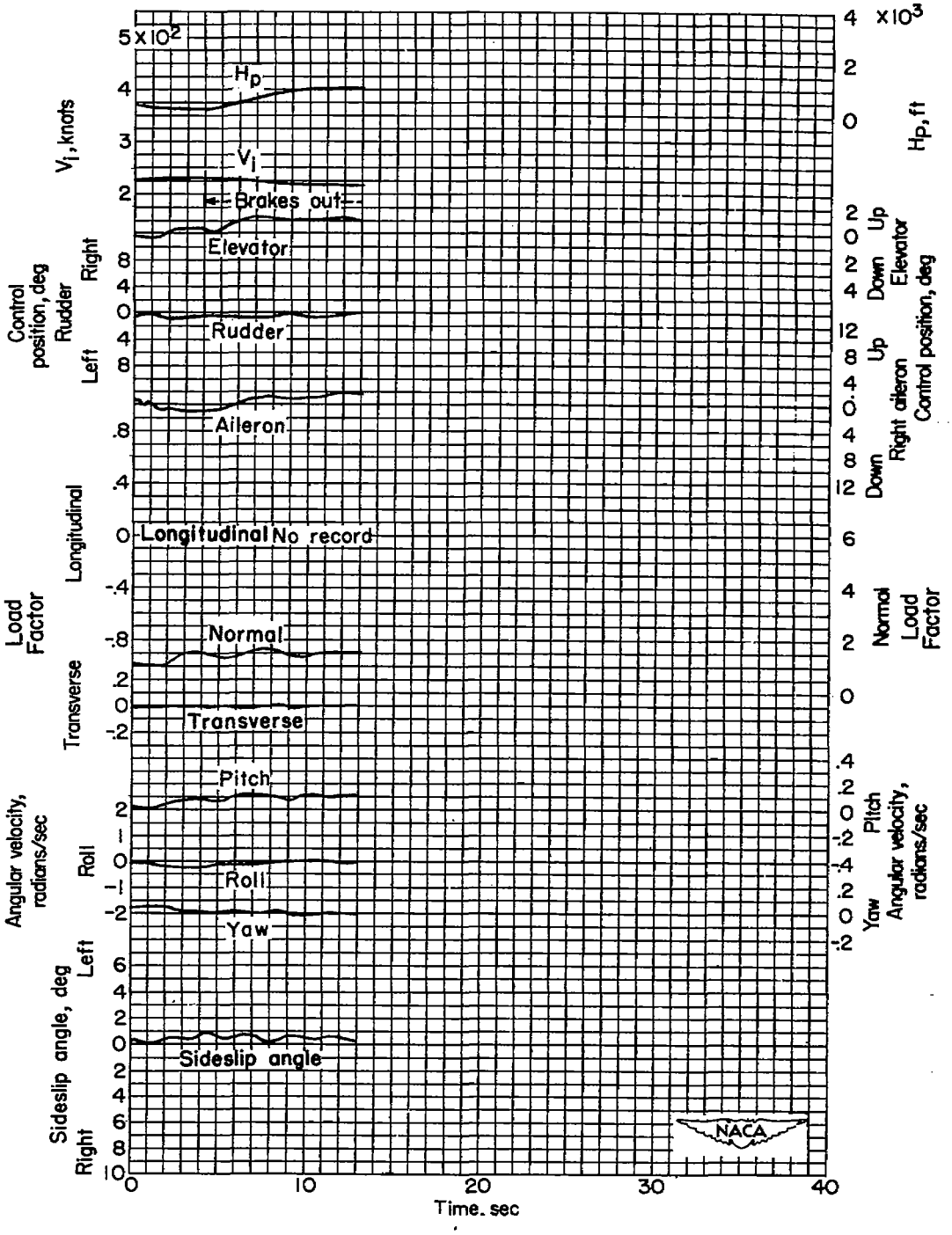

Figure 28.- Left climbing turn; airplane weight, 15,650 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

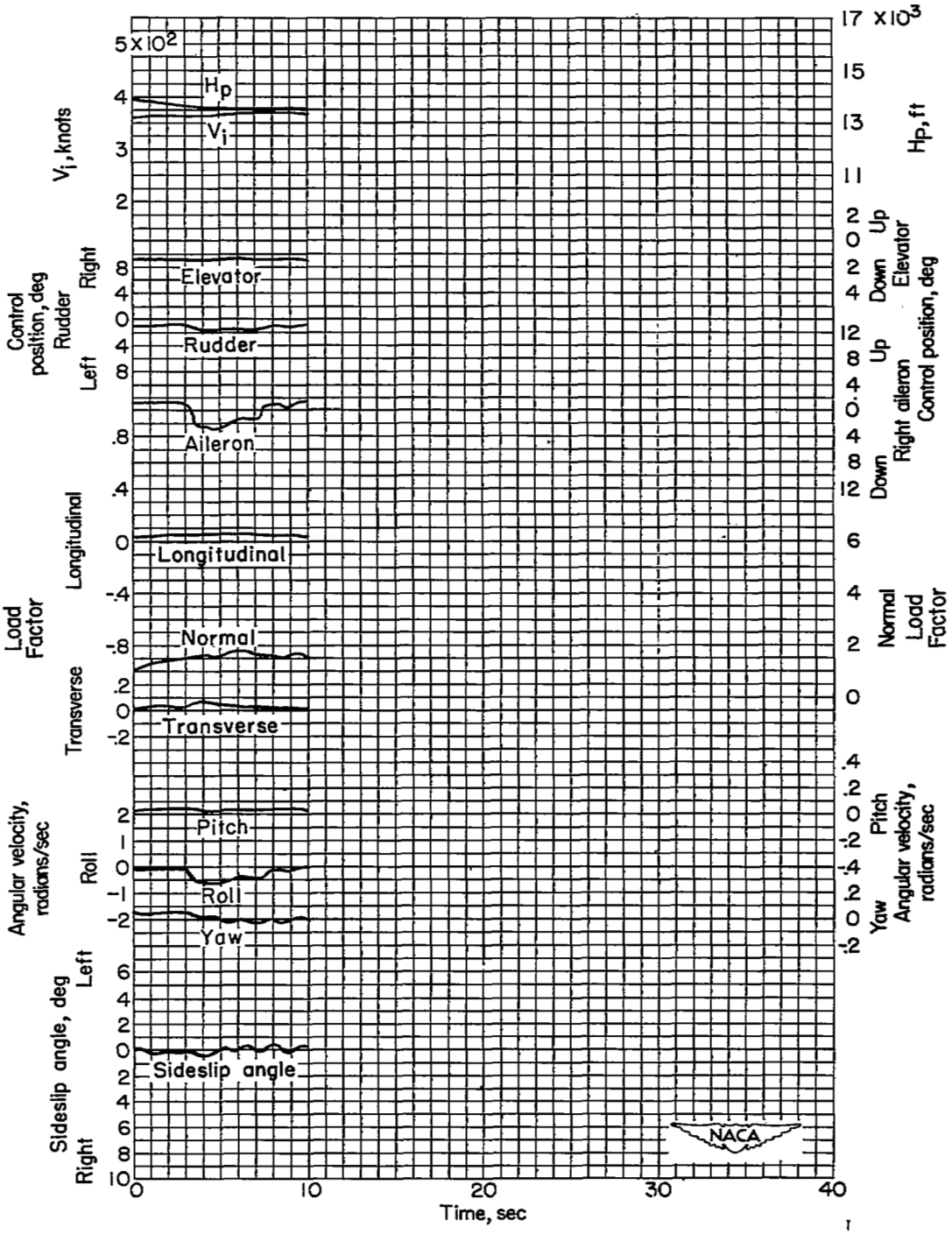

Figure 29.- Left diving turn; airplane weight, 16,700 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

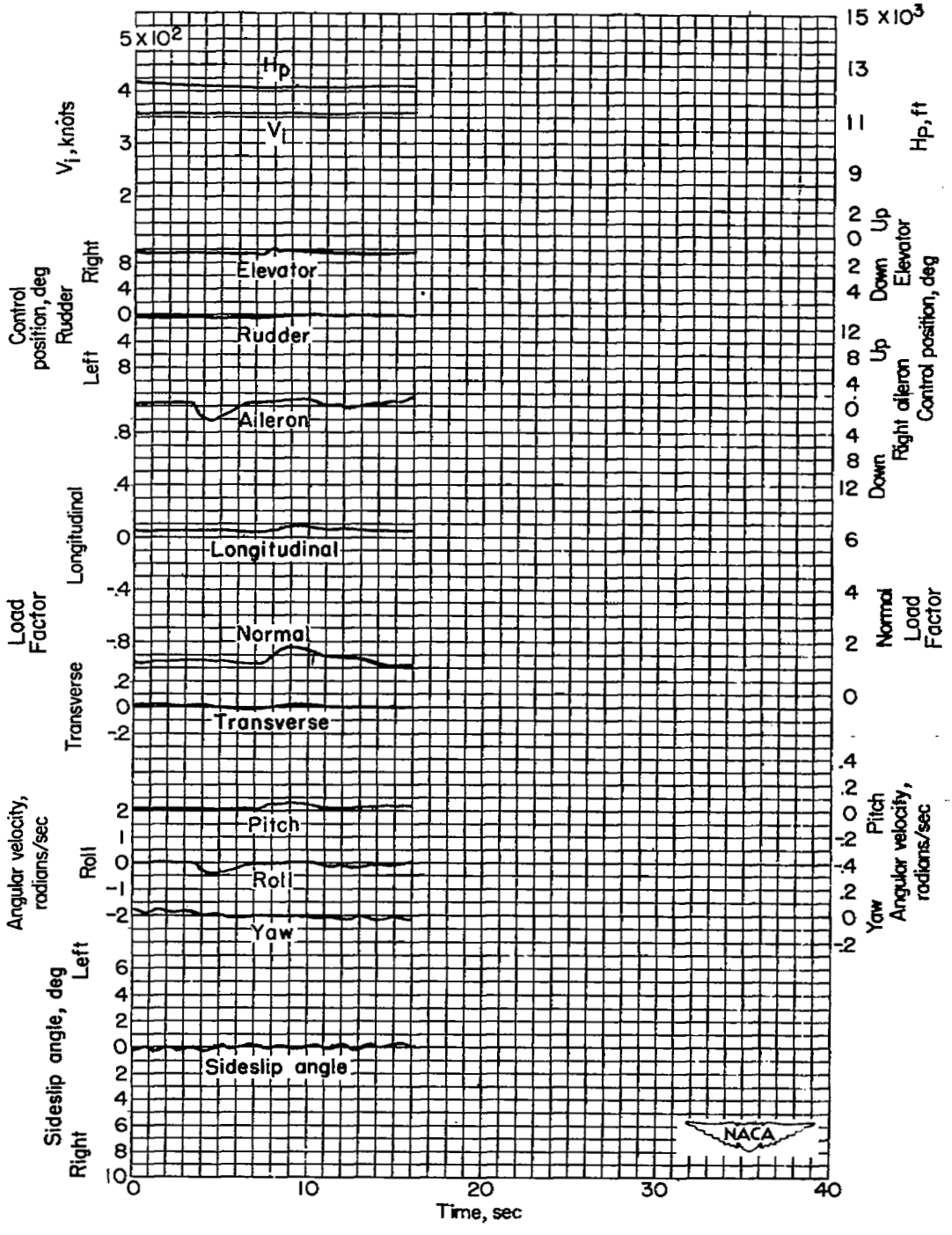

Figure 30.- Left turn; airplane weight, 16,460 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

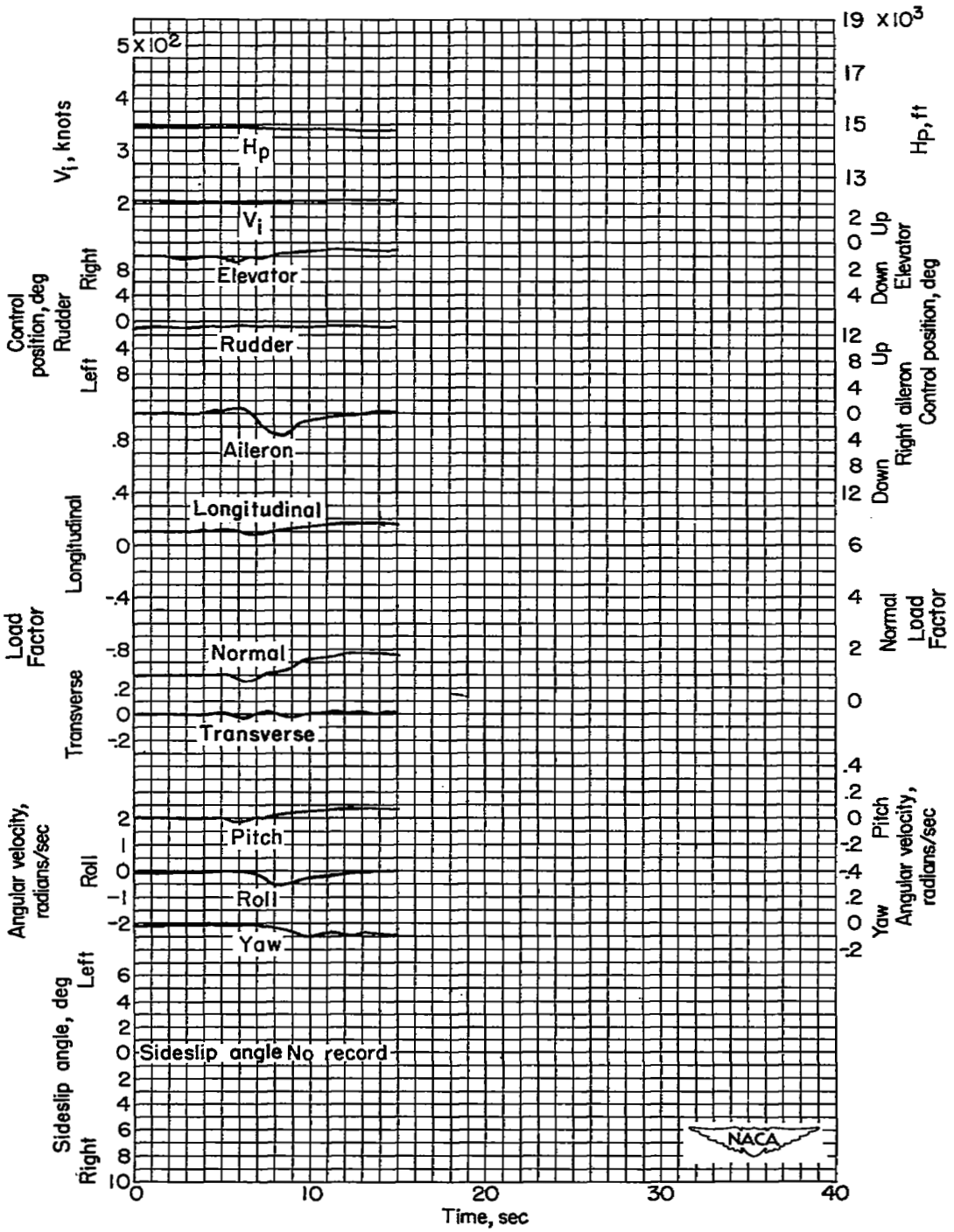

Figure 31.- Left turn; airplane weight, 16,930 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

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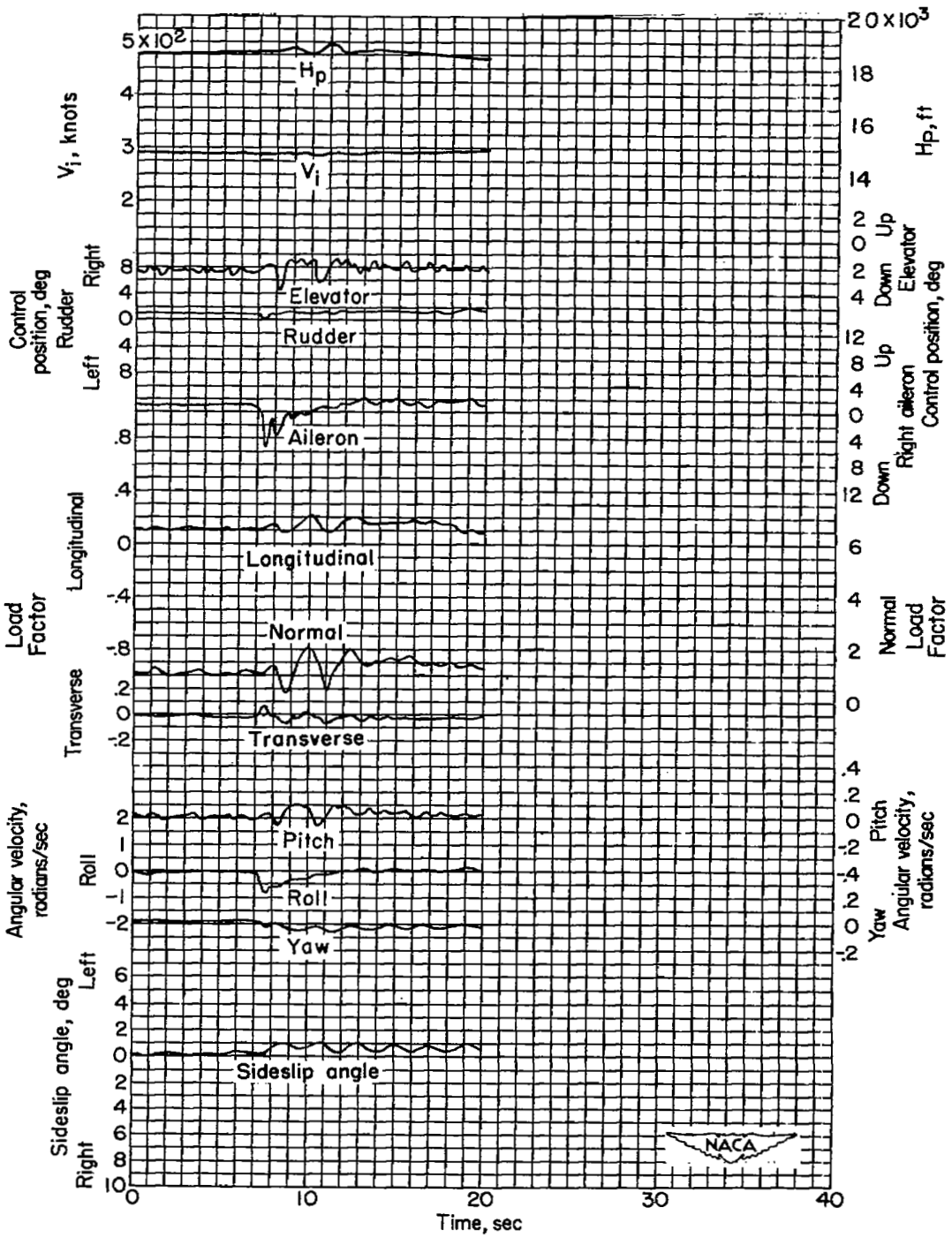

Figure 32.- Left turn; airplane weight, 16,660 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

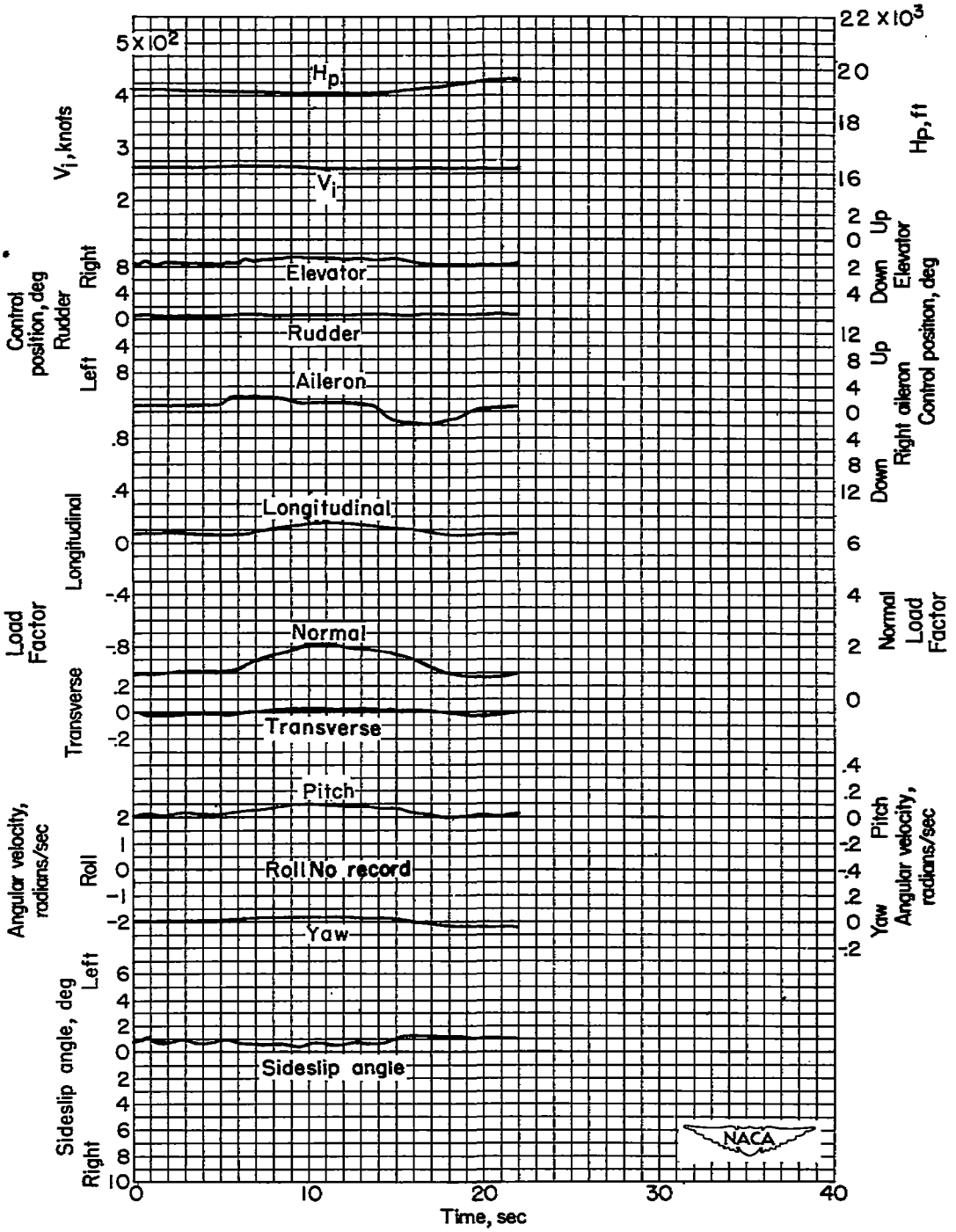

Figure 33.- Left climbing turn; airplane weight, 16,210 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

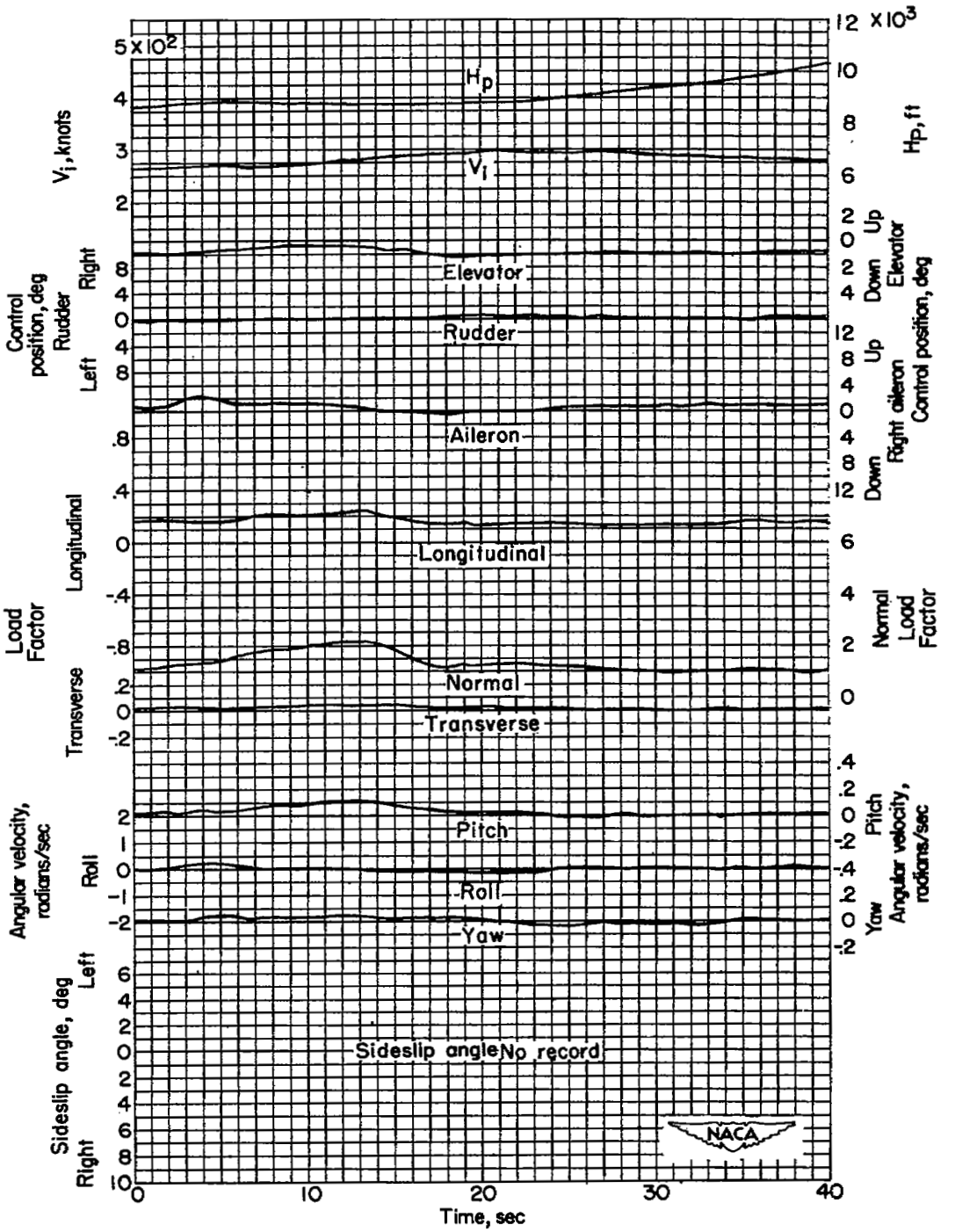

Figure 34.- Left climbing turn; airplane weight, 15,230 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

7F

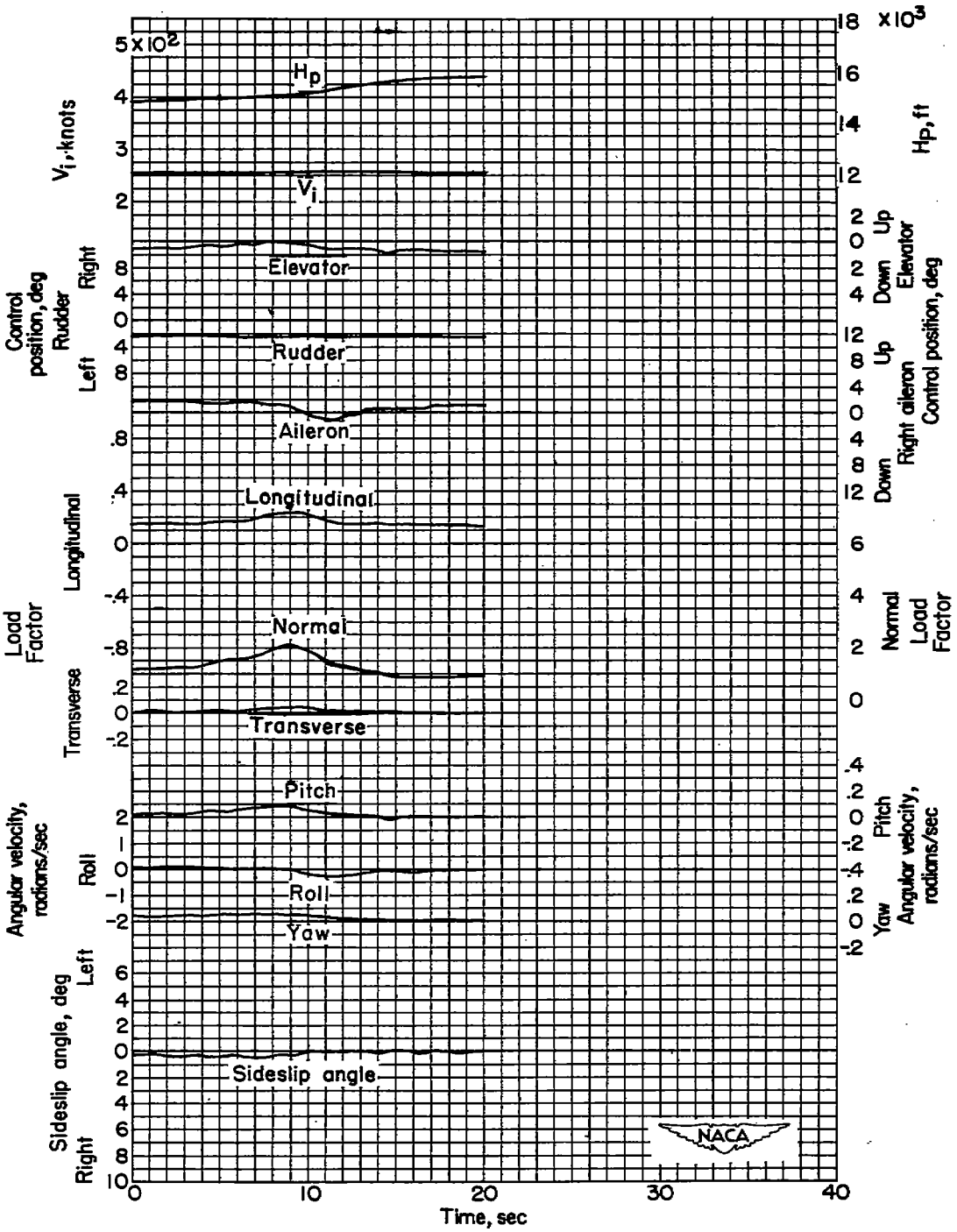

Figure 35.- Left climbing turn; airplane weight, 17,040 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

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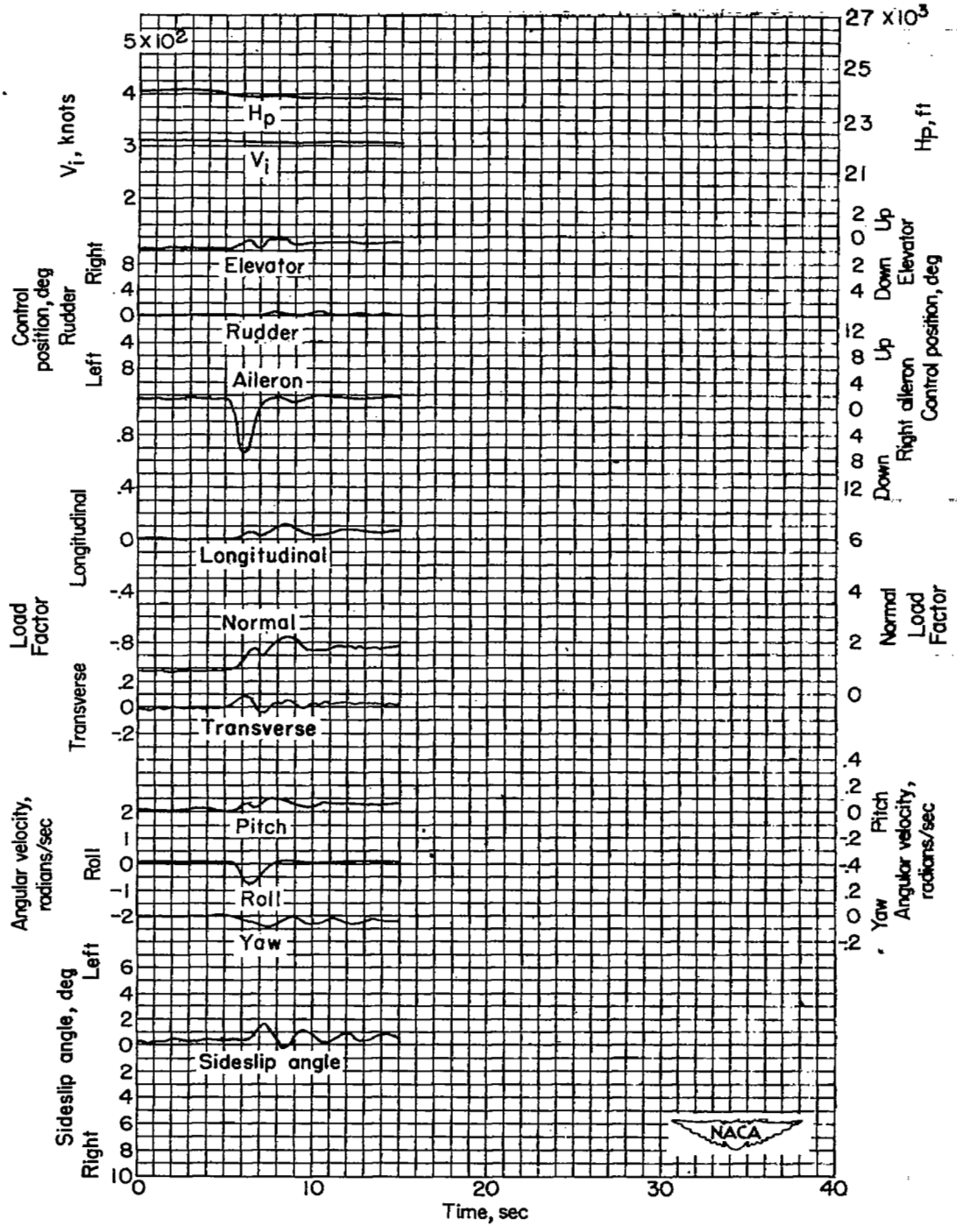

Figure 36.- Left turn; airplane weight, 18,980 pounds; center-of-gravity location, 26.0 percent of the mean aerodynamic chord.

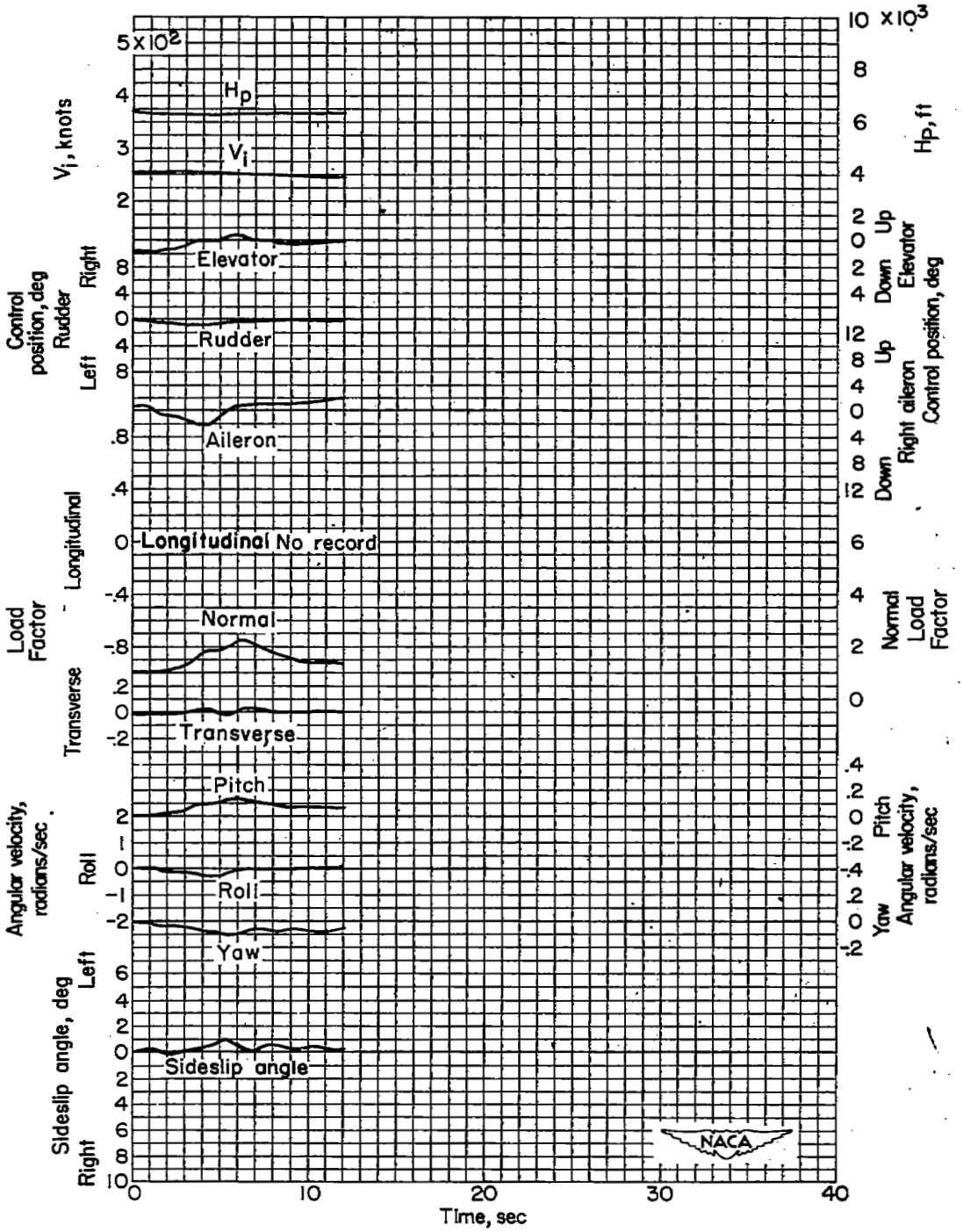

Figure 37.- Left turn; airplane weight, 15,950 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

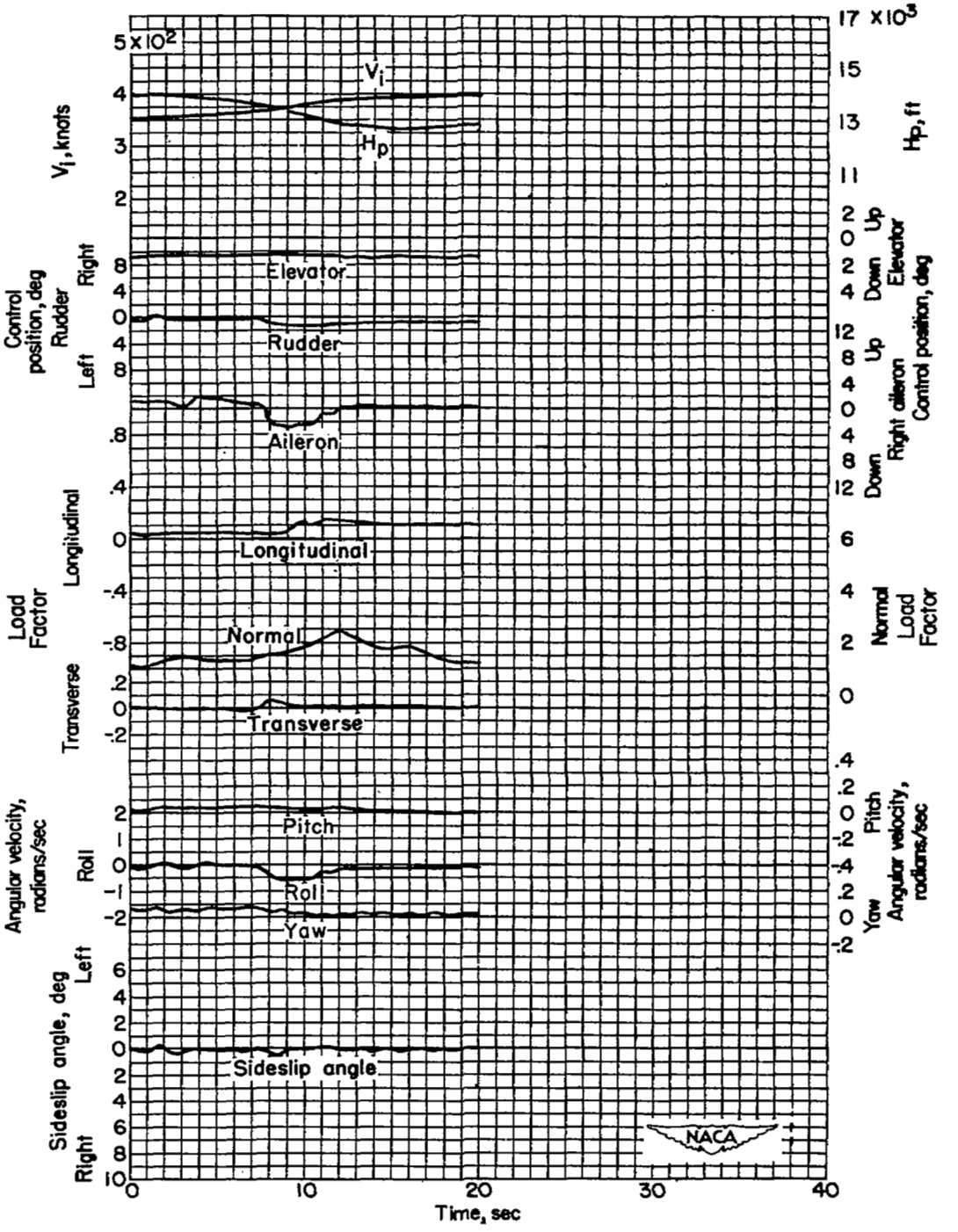

Figure 38.- Left diving turn; airplane weight, 16,670 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

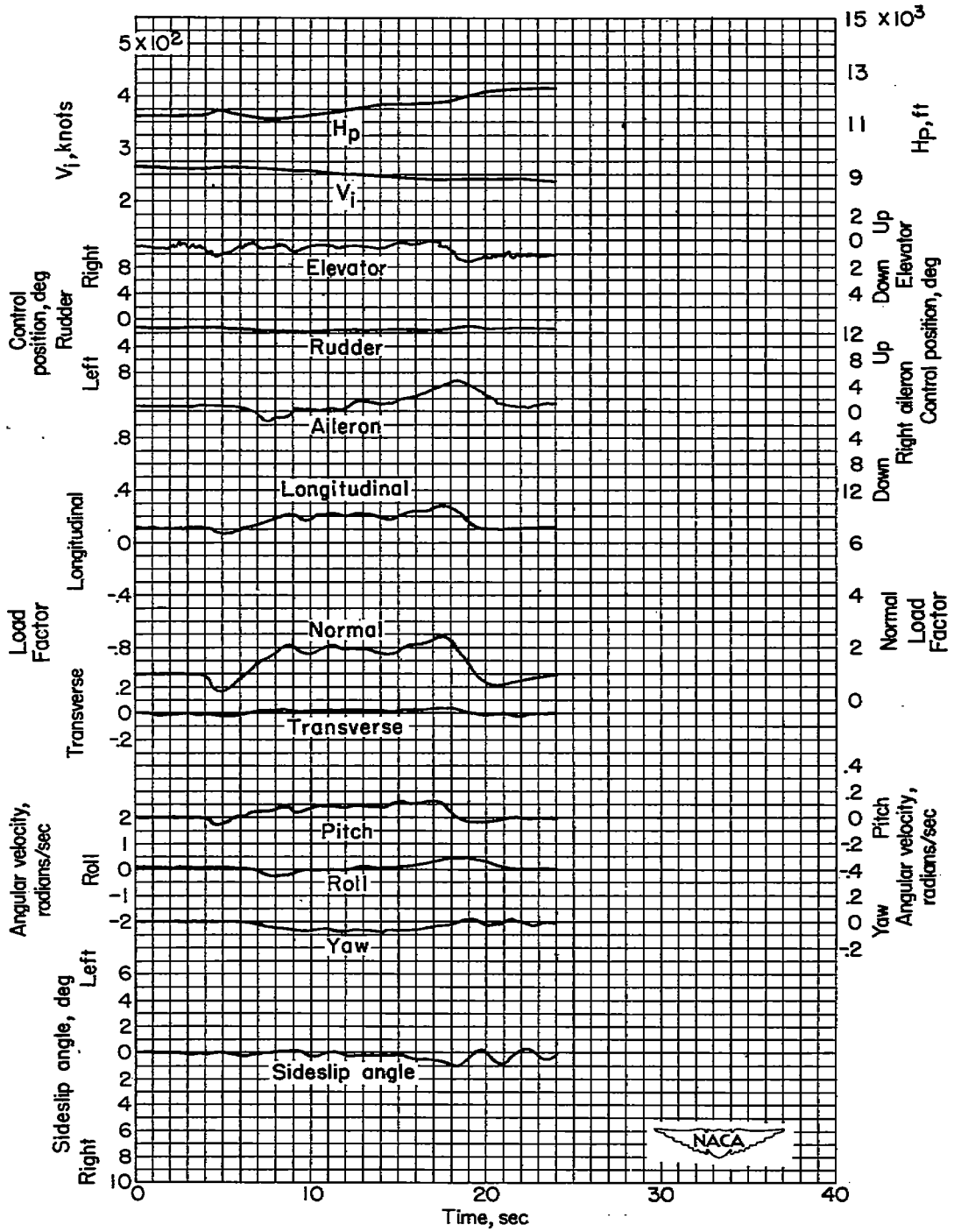

Figure 39.- Left climbing turn; airplane weight, 17,070 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

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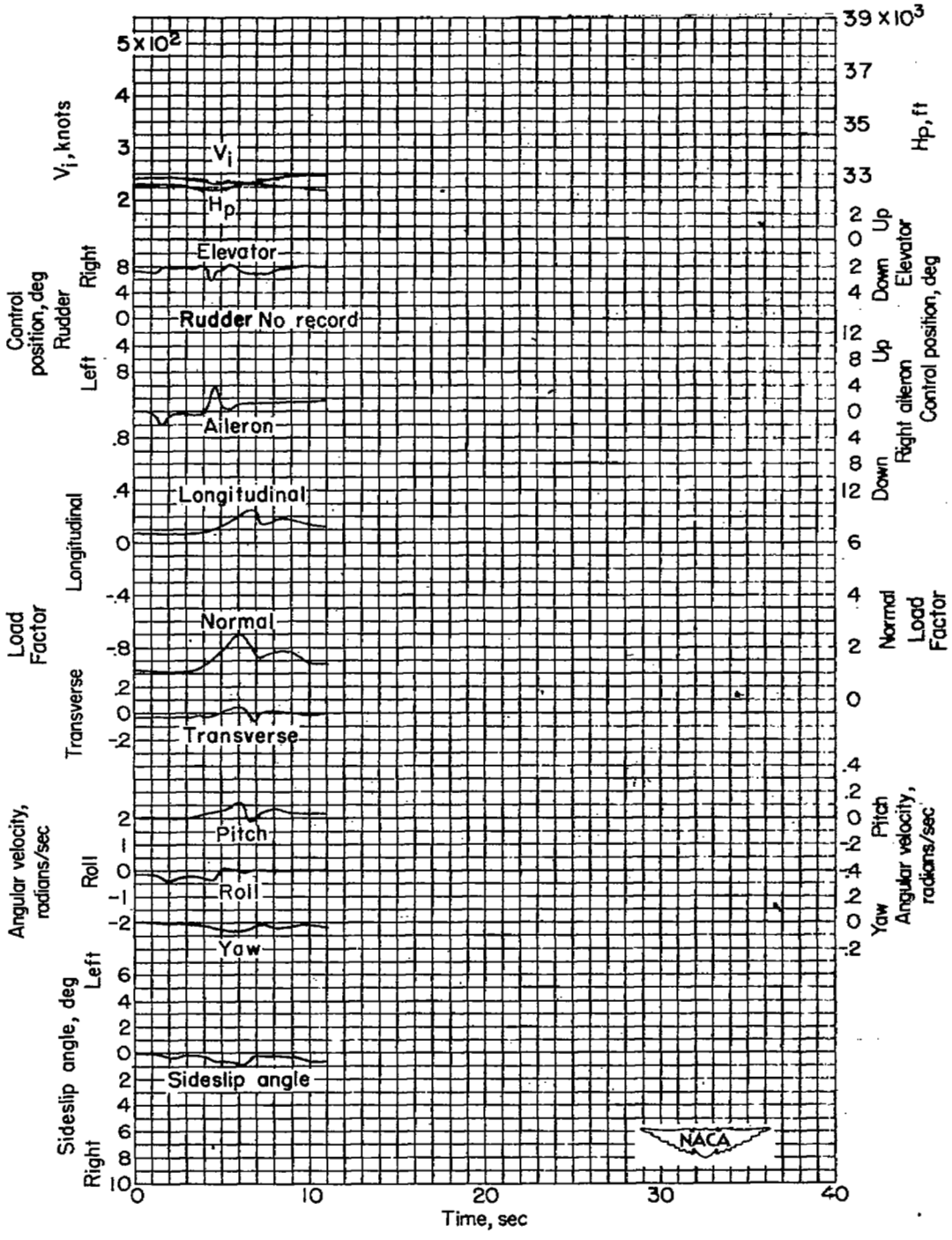

Figure 40.- Left climbing turn; airplane weight, 14,980 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

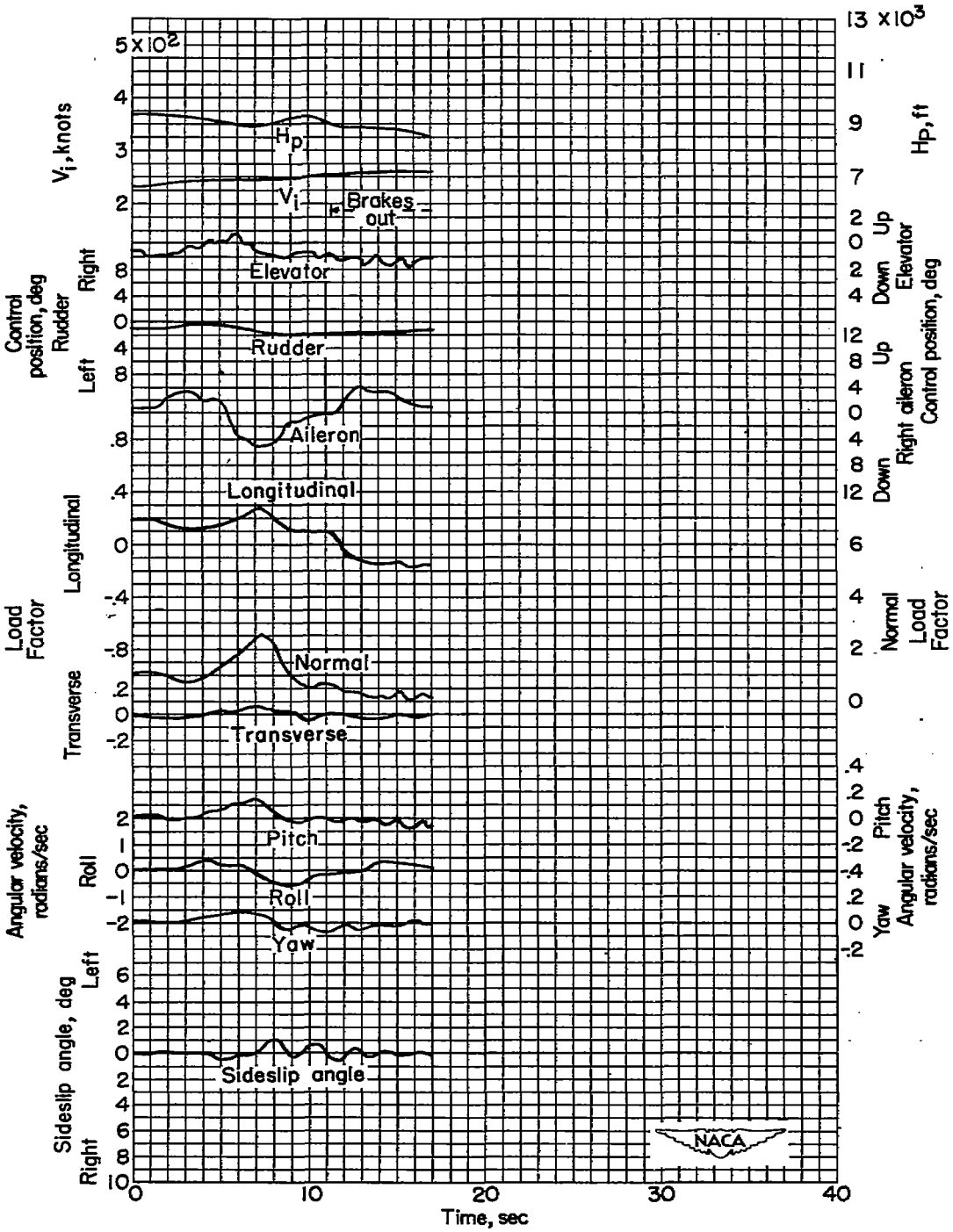

Figure 41.- Left turn; airplane weight, 13,690 pounds; center-of-gravity location, 26.0 percent of the mean aerodynamic chord.

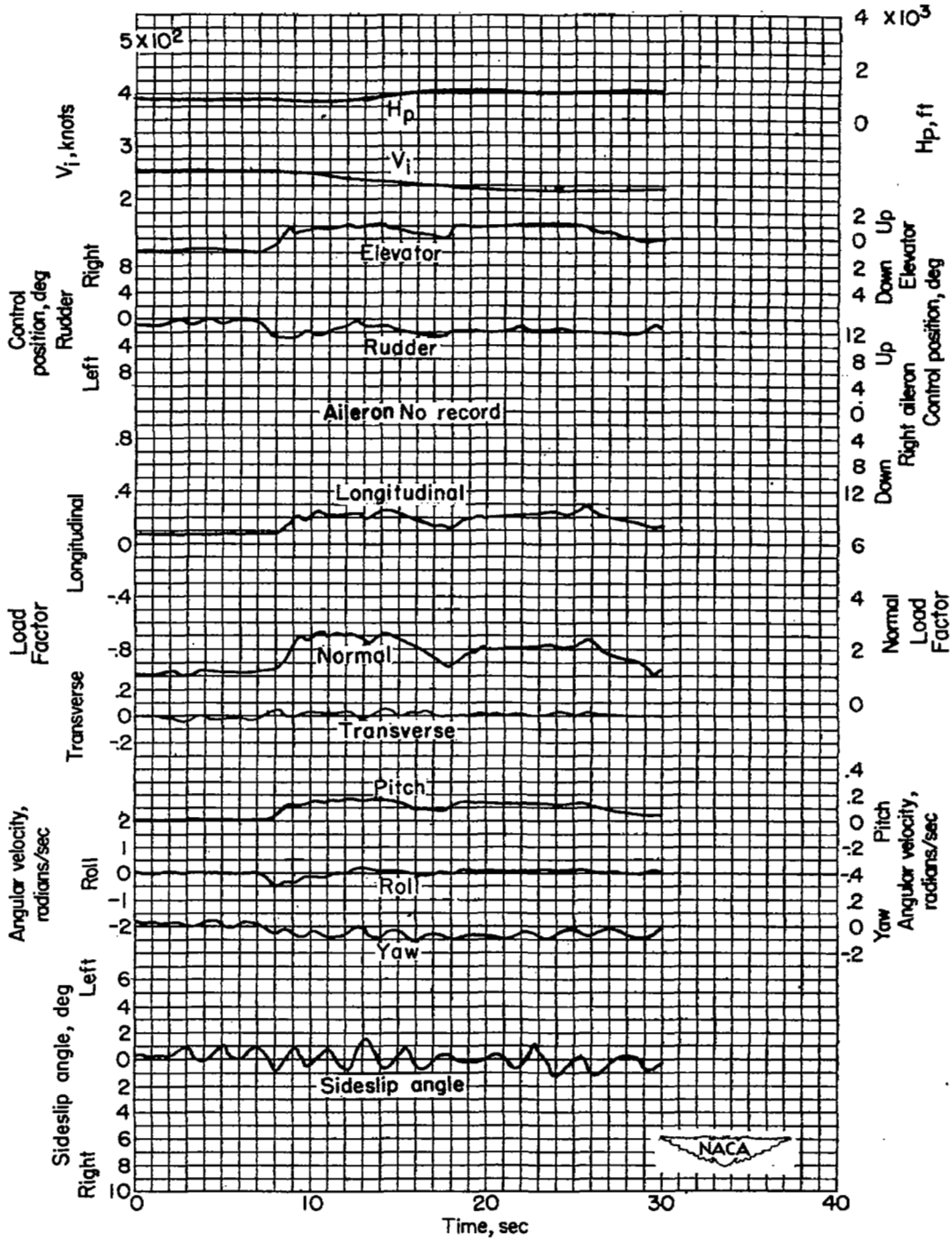

Figure 42.- Left turn; airplane weight, 15,240 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

8F

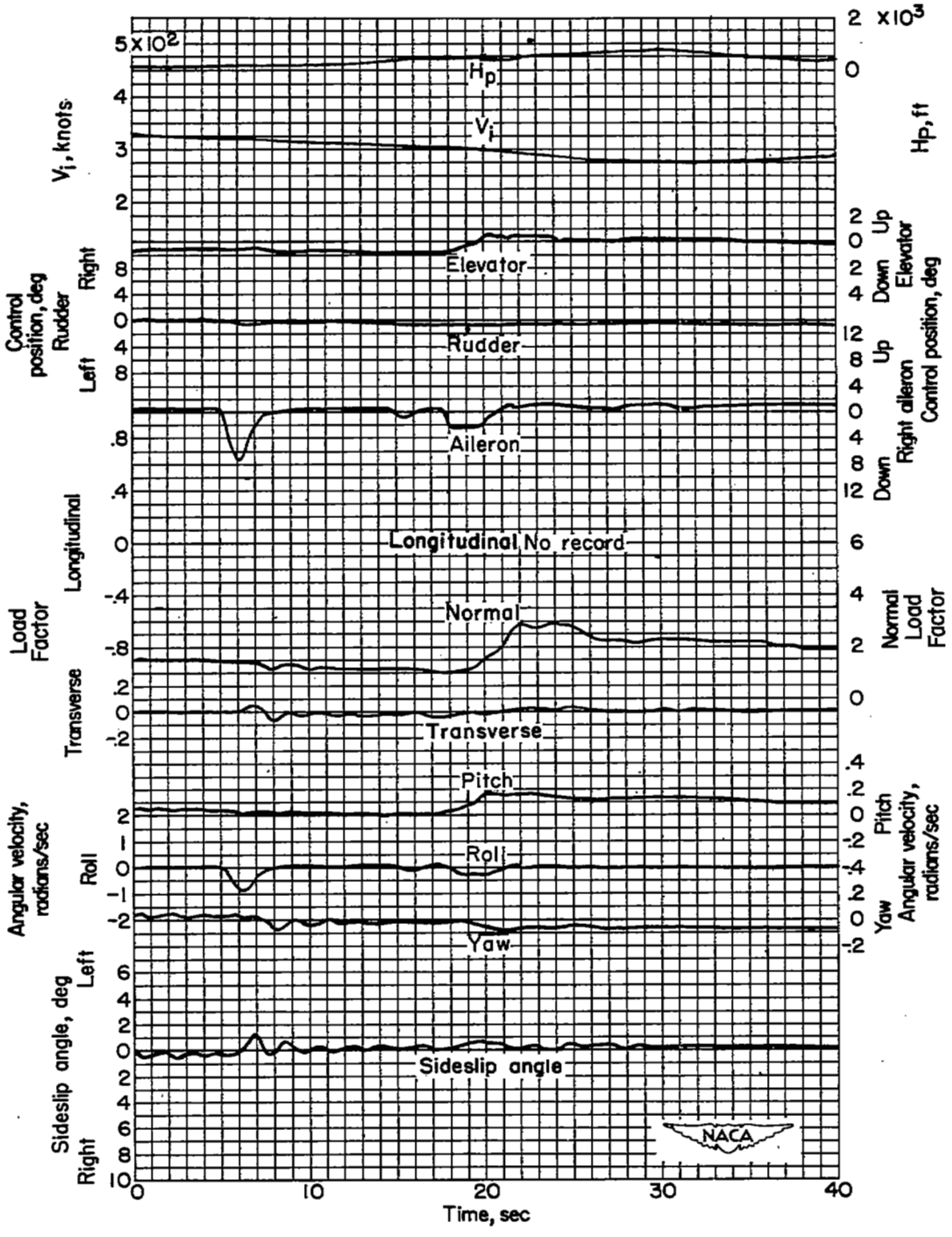

Figure 43.- Left turn; airplane weight, 16,170 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

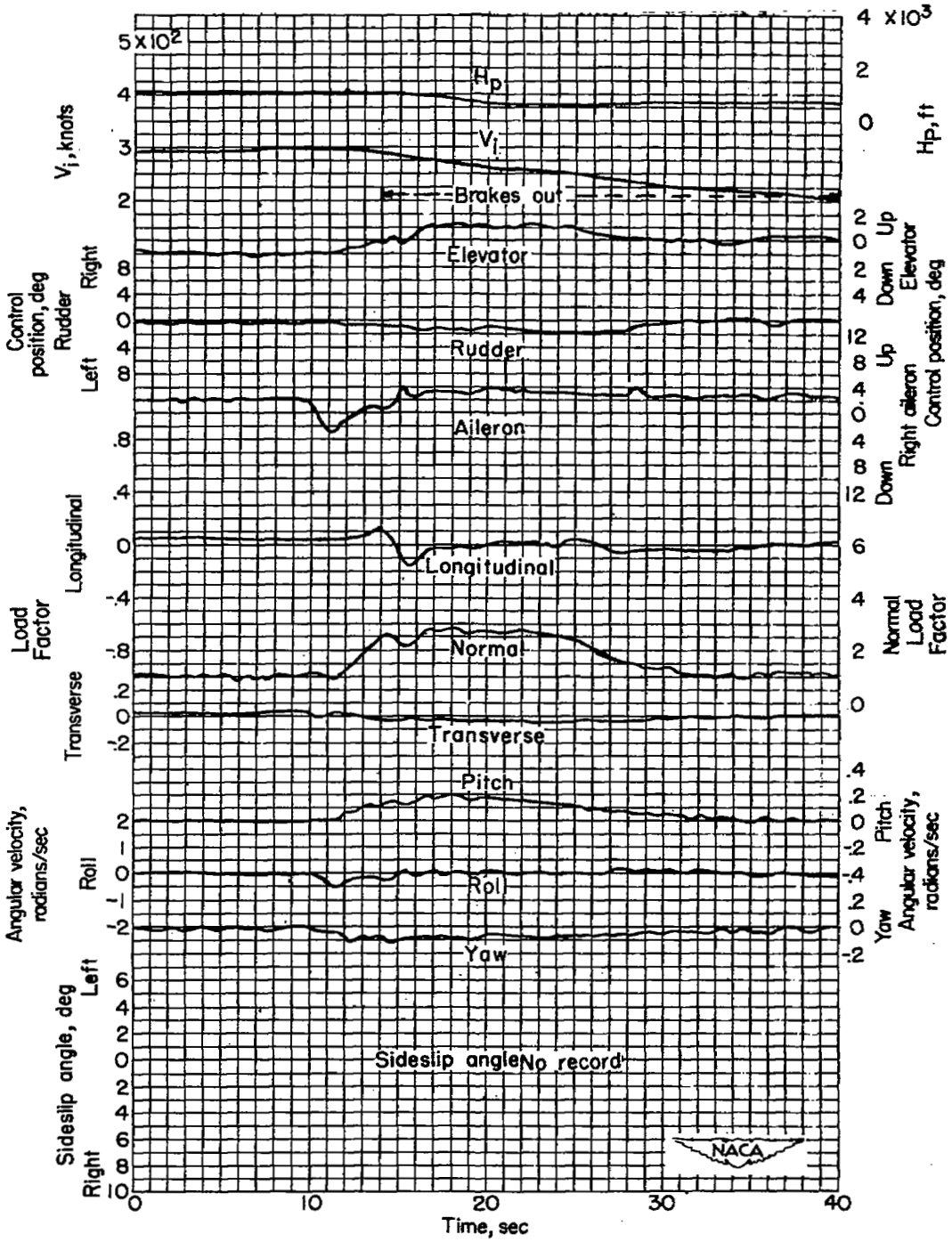

Figure 44.- Left turn; airplane weight, 14,080 pounds; center-of-gravity location, 26.1 percent of the mean aerodynamic chord.

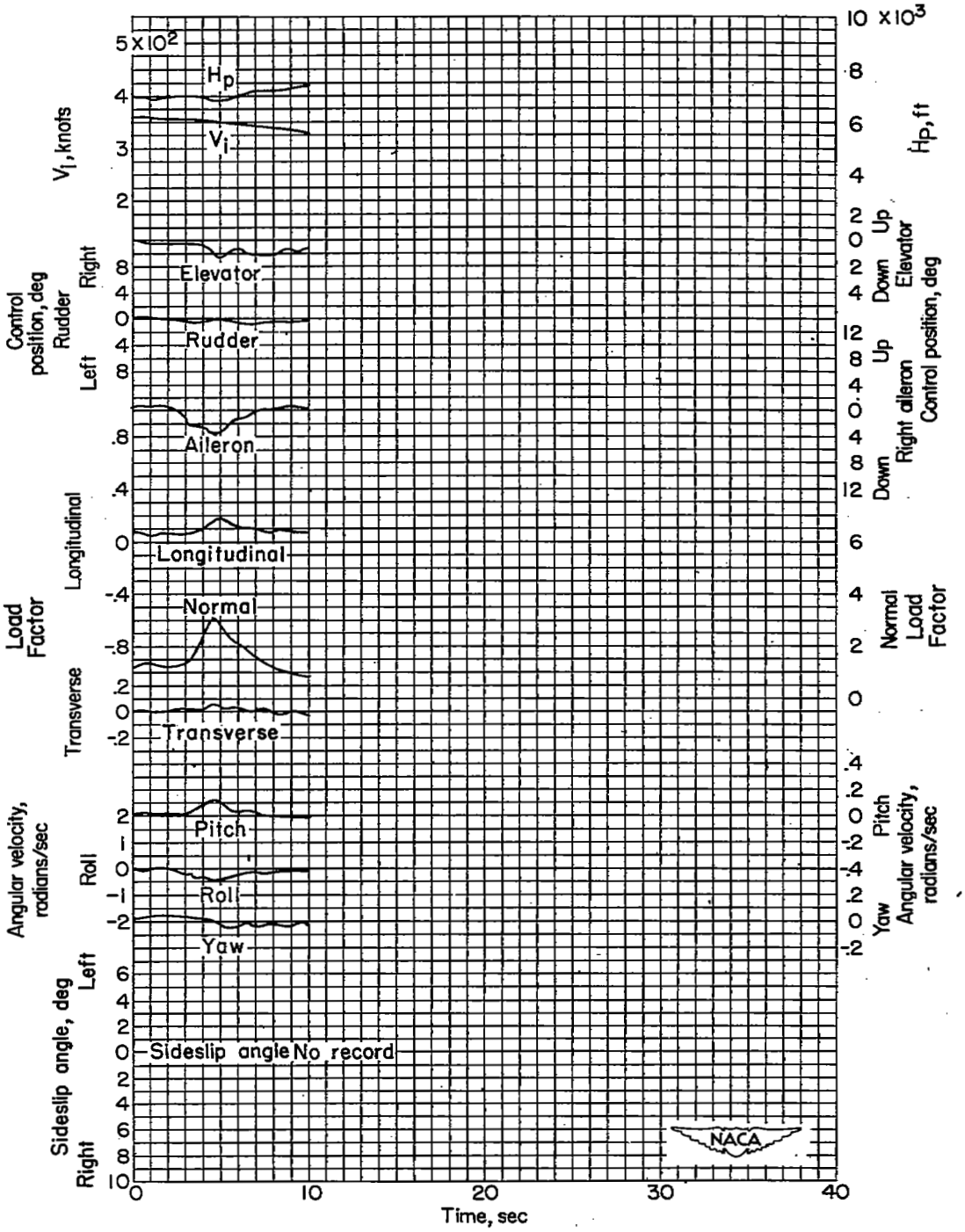

Figure 45.- Left climbing turn; airplane weight, 16,570 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

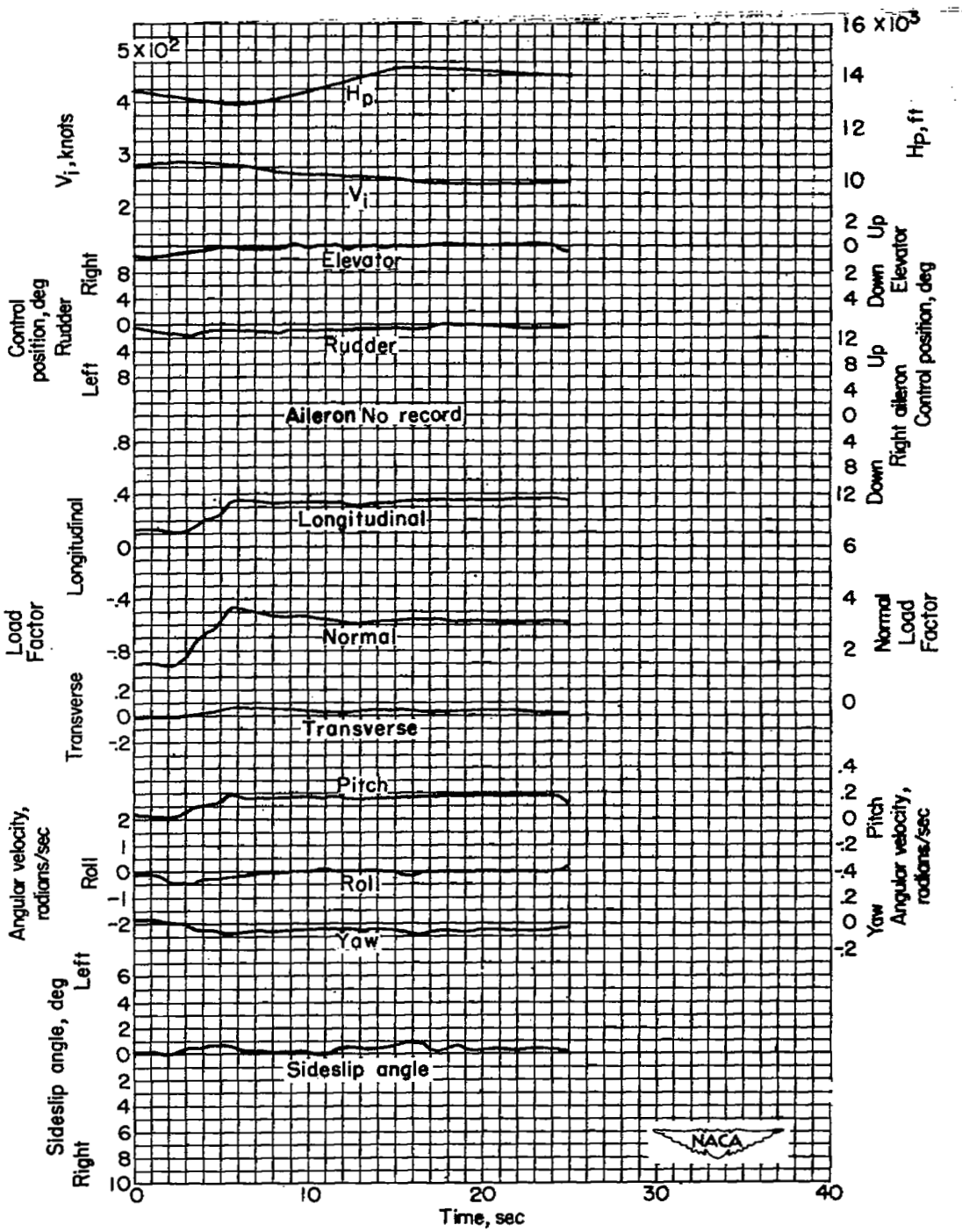

Figure 46.- Left climbing turn; airplane weight, 16,720 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

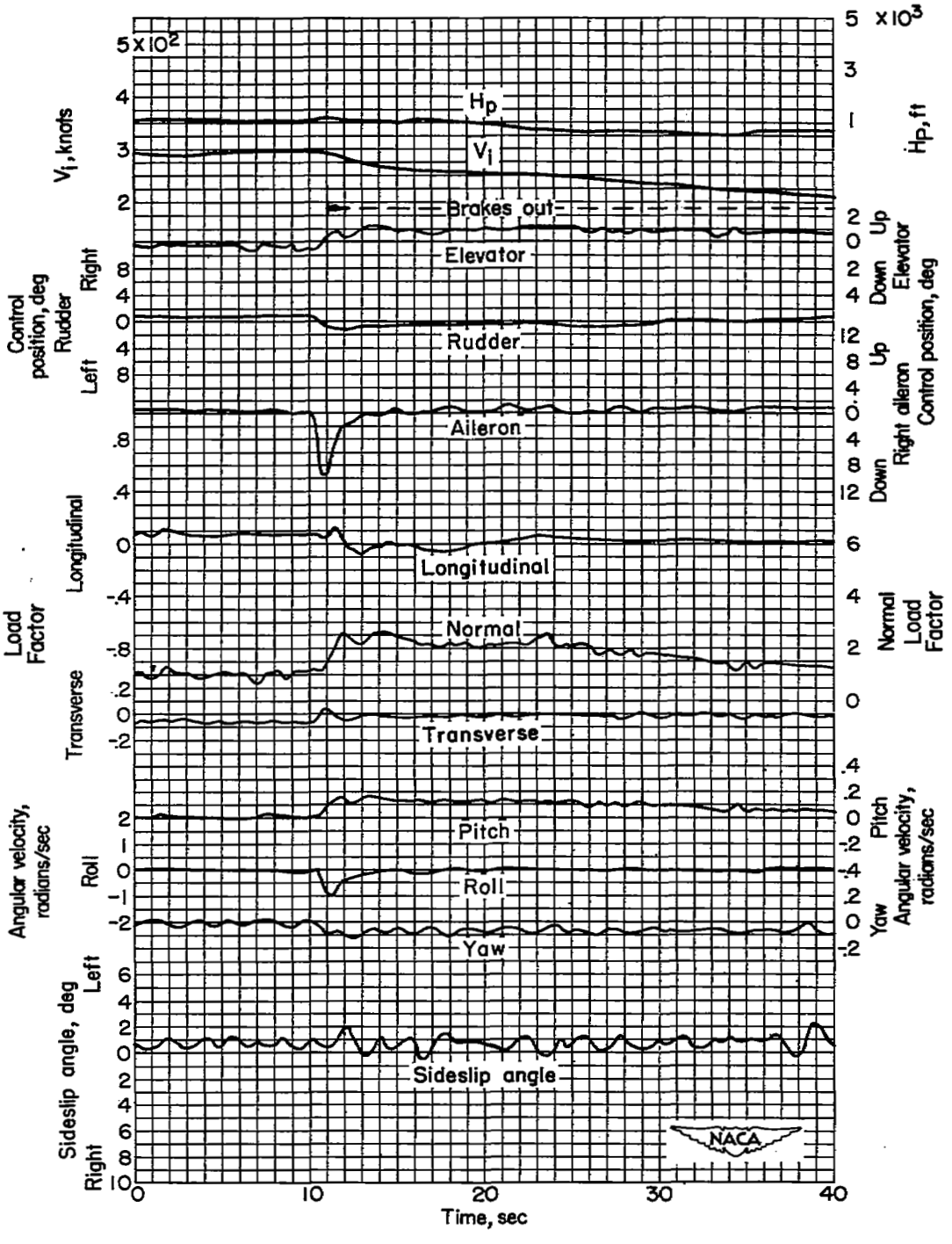

Figure 47.- Abrupt left turn; airplane weight, 14,430 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

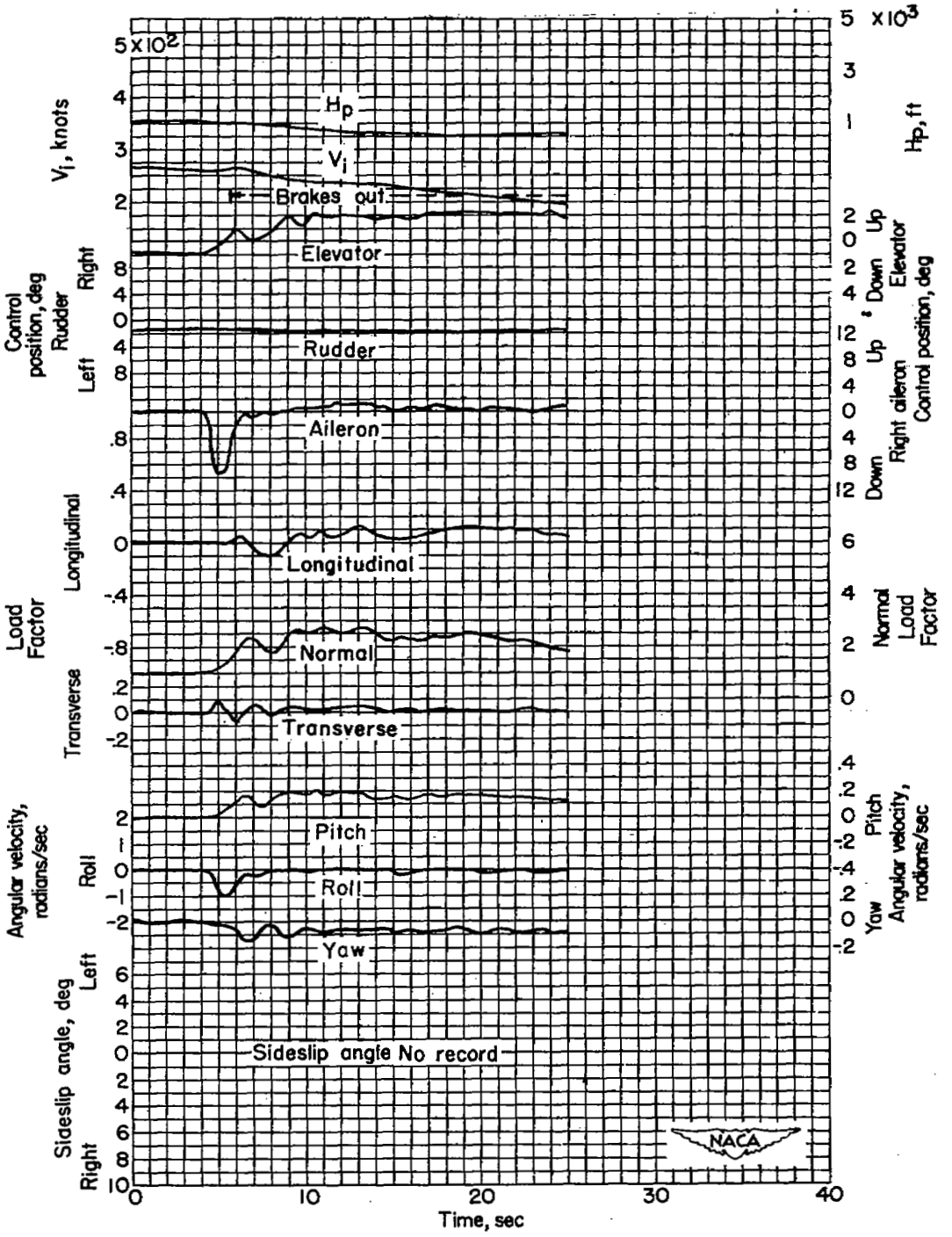

Figure 48.- Abrupt left diving turn; airplane weight, 14,600 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

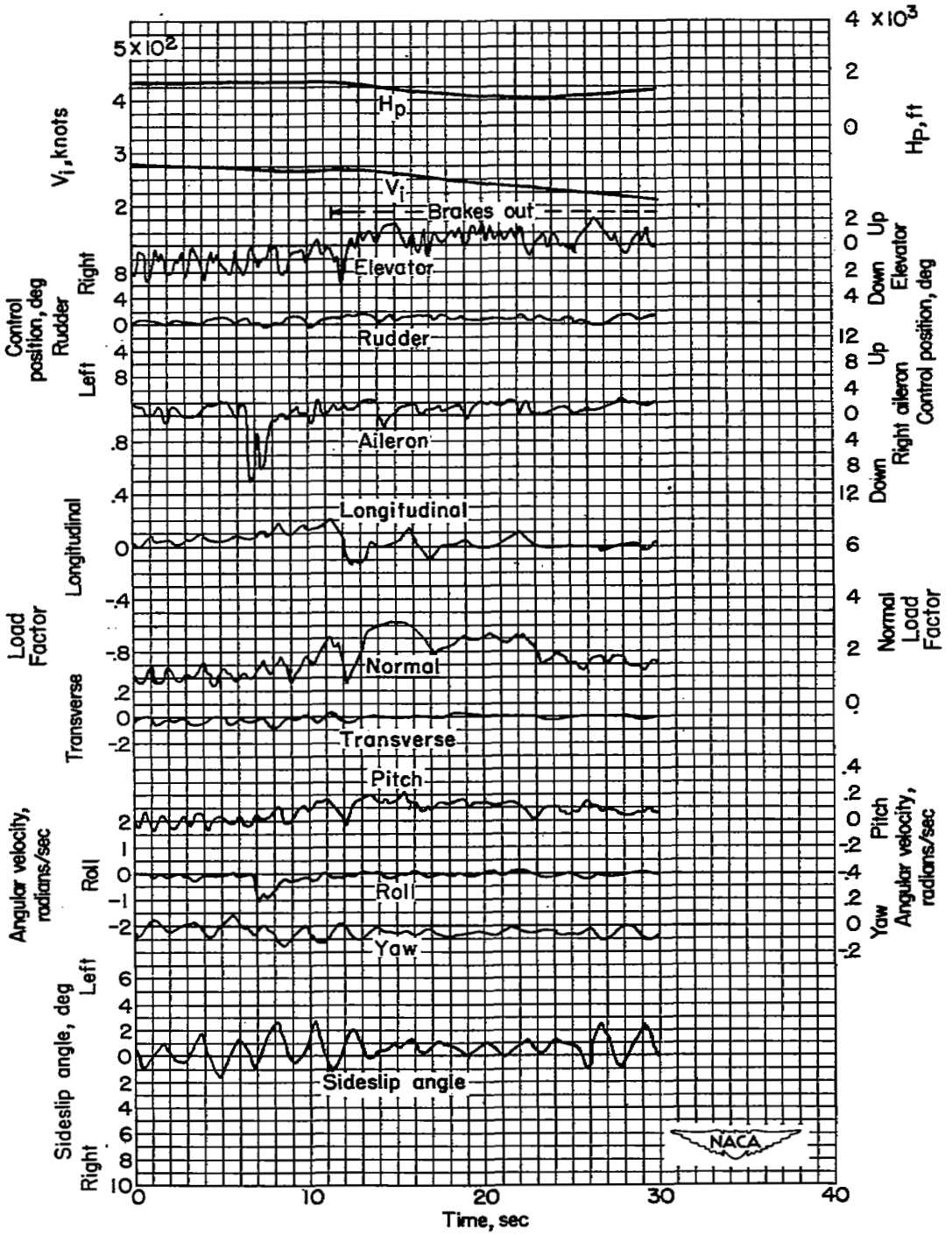

Figure 49.- Abrupt left turn; airplane weight, 15,140 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

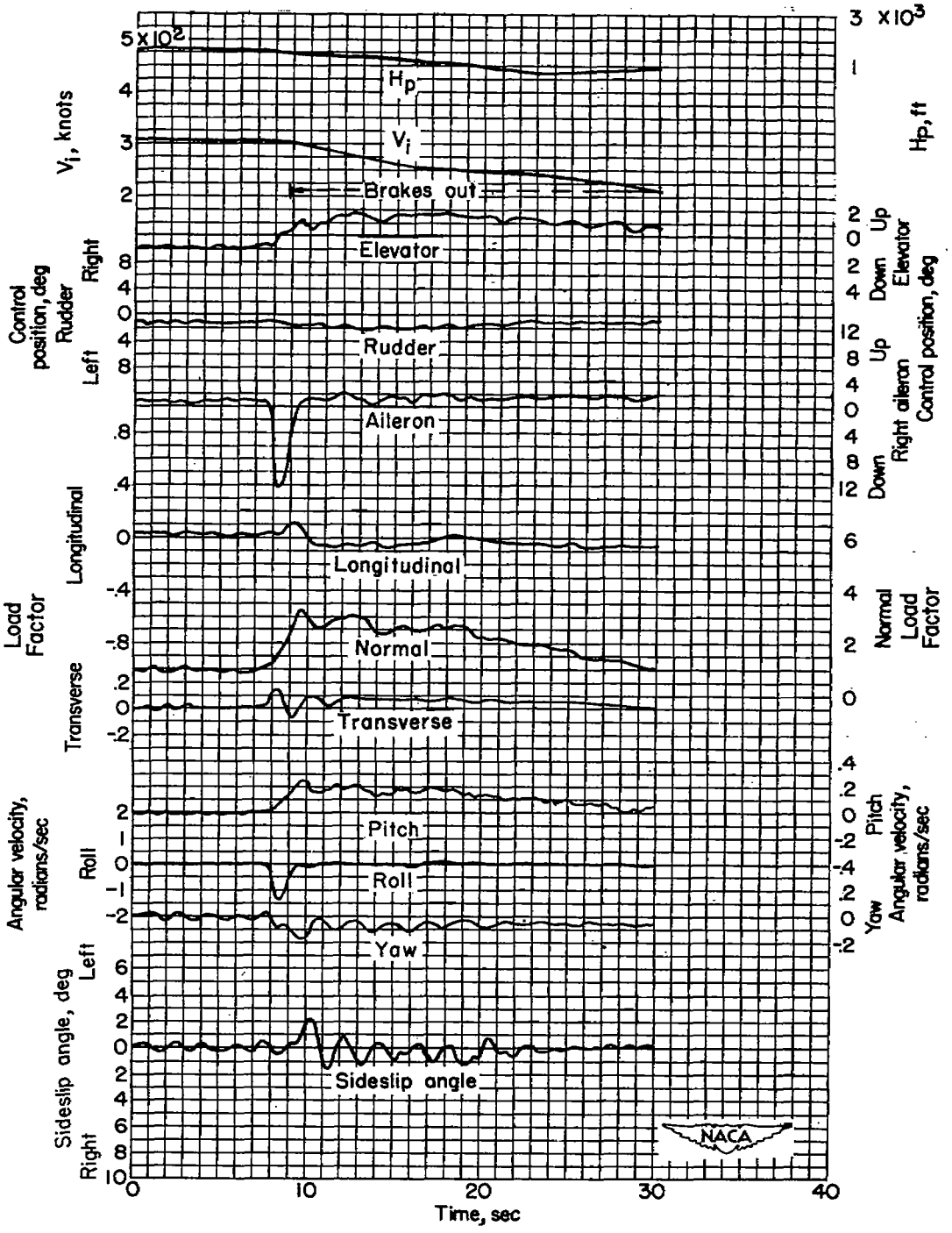

Figure 50.- Abrupt left diving turn; airplane weight, 15,650 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

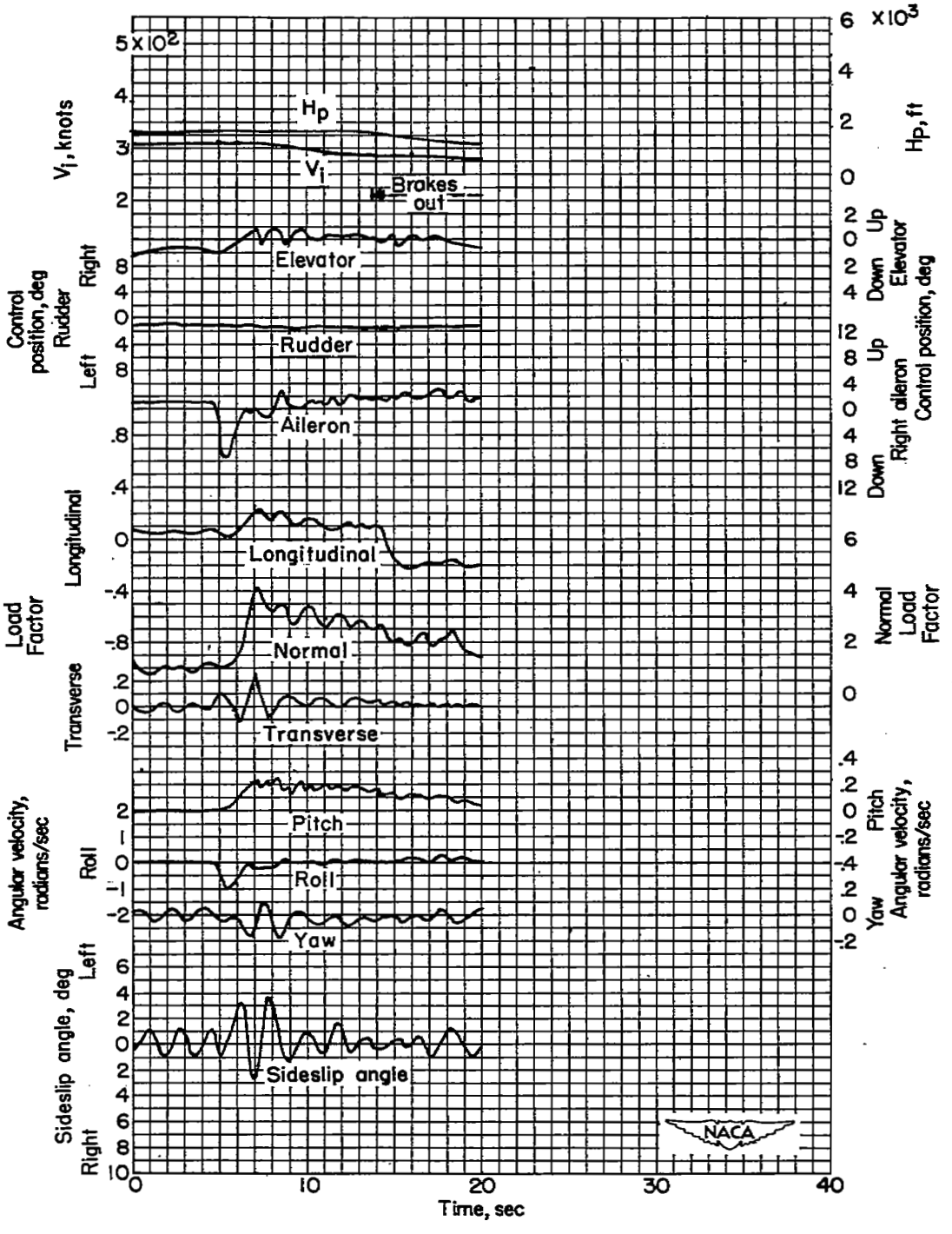

Figure 51.- Abrupt left turn; airplane weight, 14,225 pounds; center-of-gravity location, 26.1 percent of the mean aerodynamic chord.

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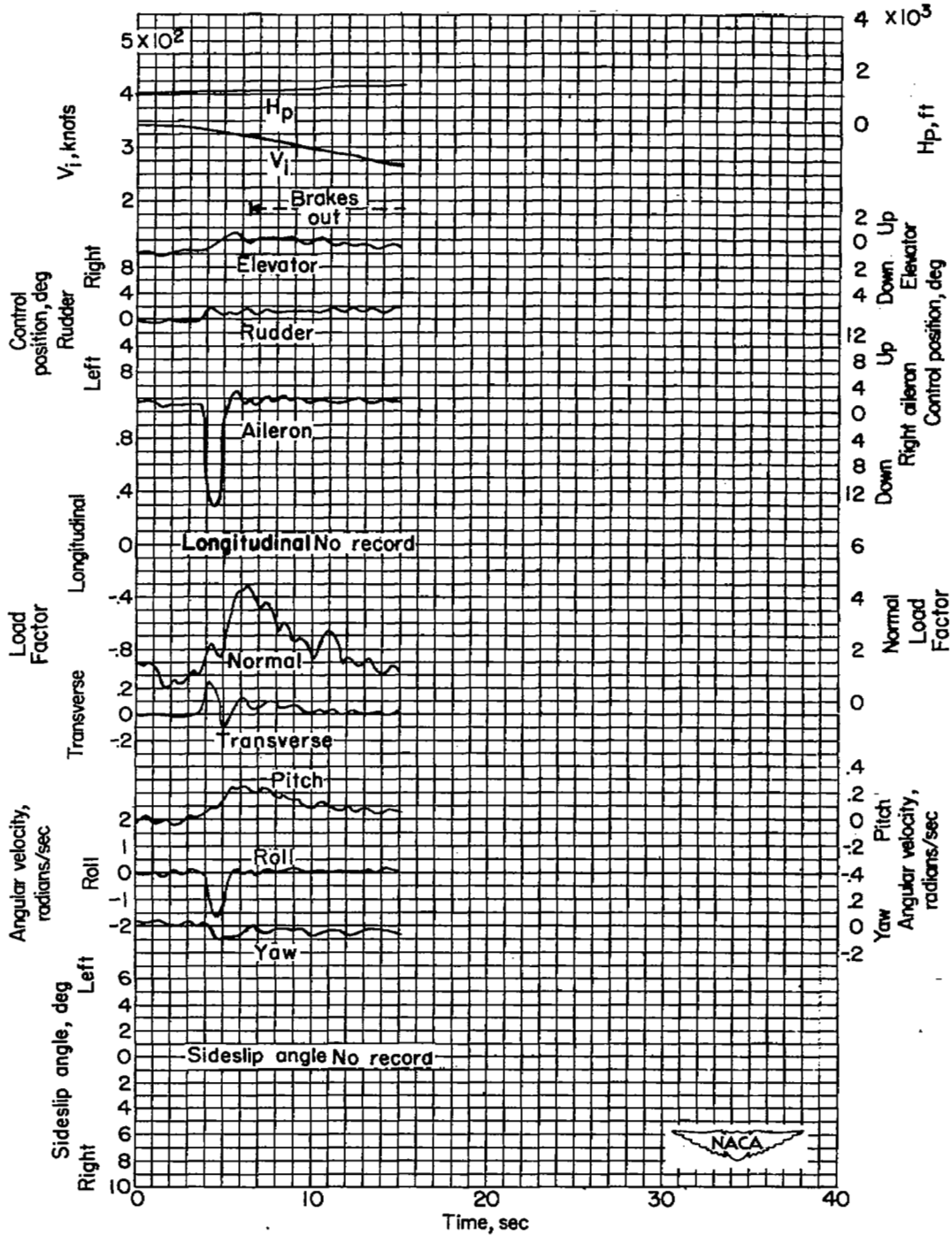

Figure 52.- Abrupt left turn; airplane weight, 13,320 pounds; center-of-gravity location, 26.0 percent of the mean aerodynamic chord.

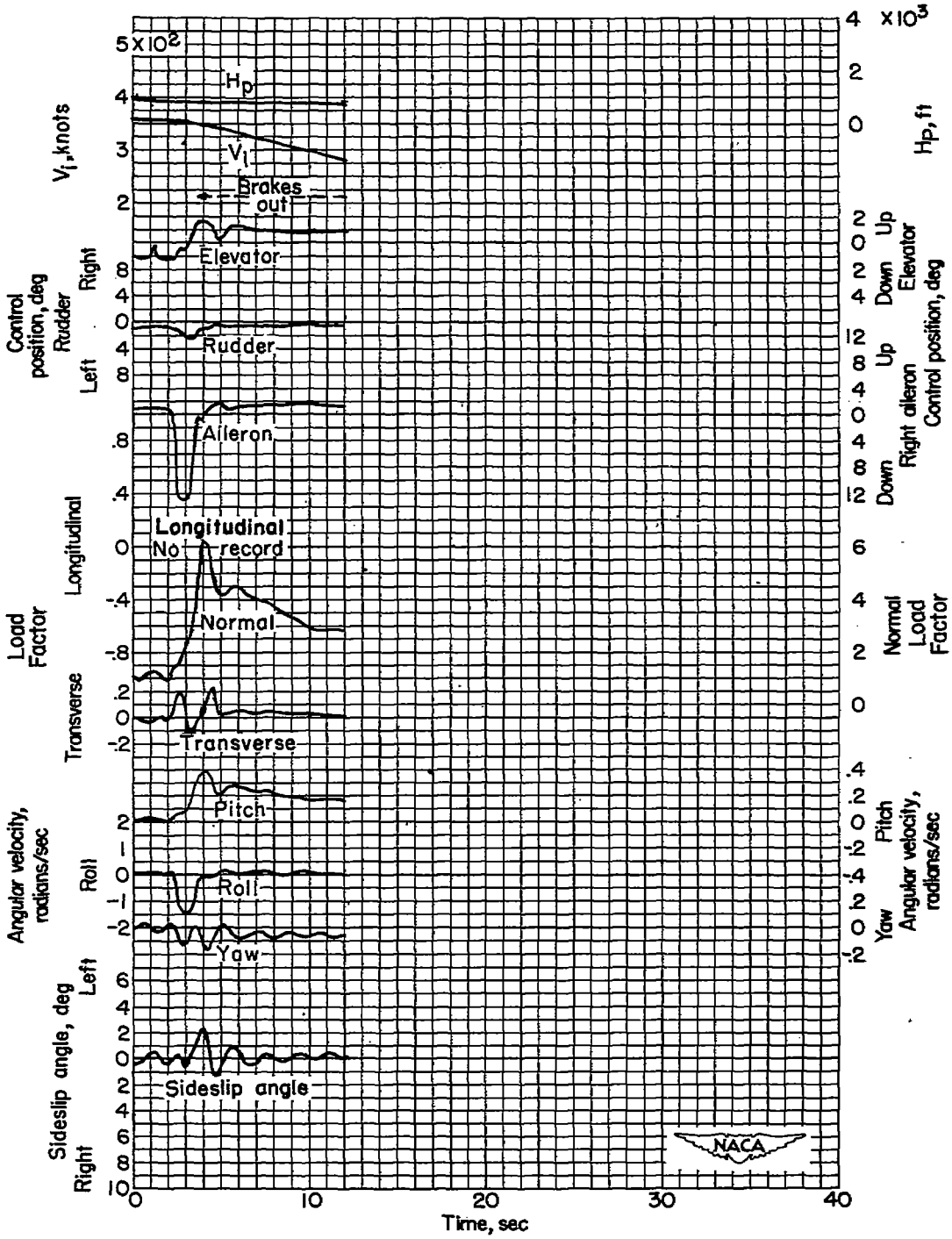

Figure 53.- Abrupt left turn; airplane weight, 13,750 pounds; center-of-gravity location, 26.1 percent of the mean aerodynamic chord.

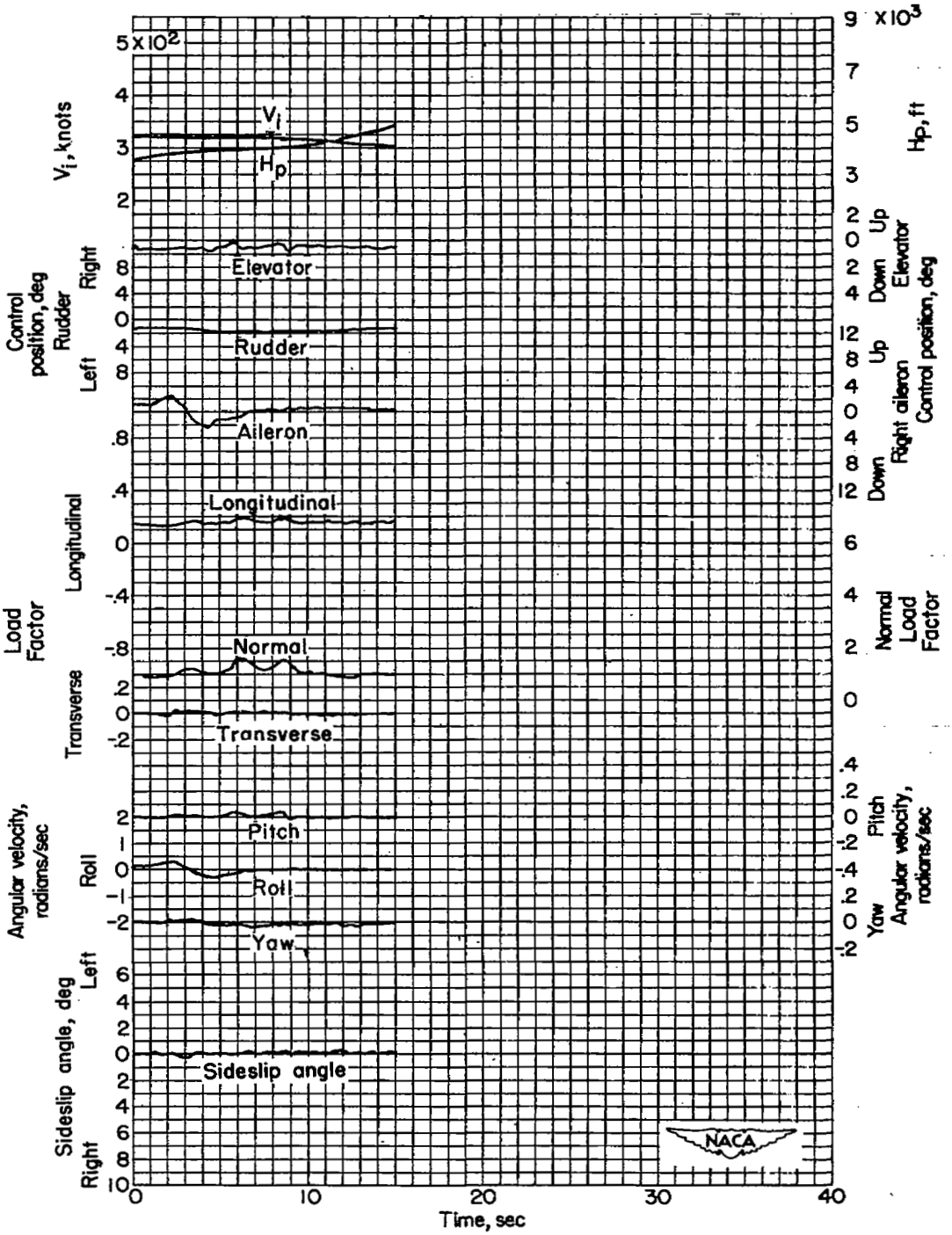

Figure 54.- Series of climbing turns; airplane weight, 17,220 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

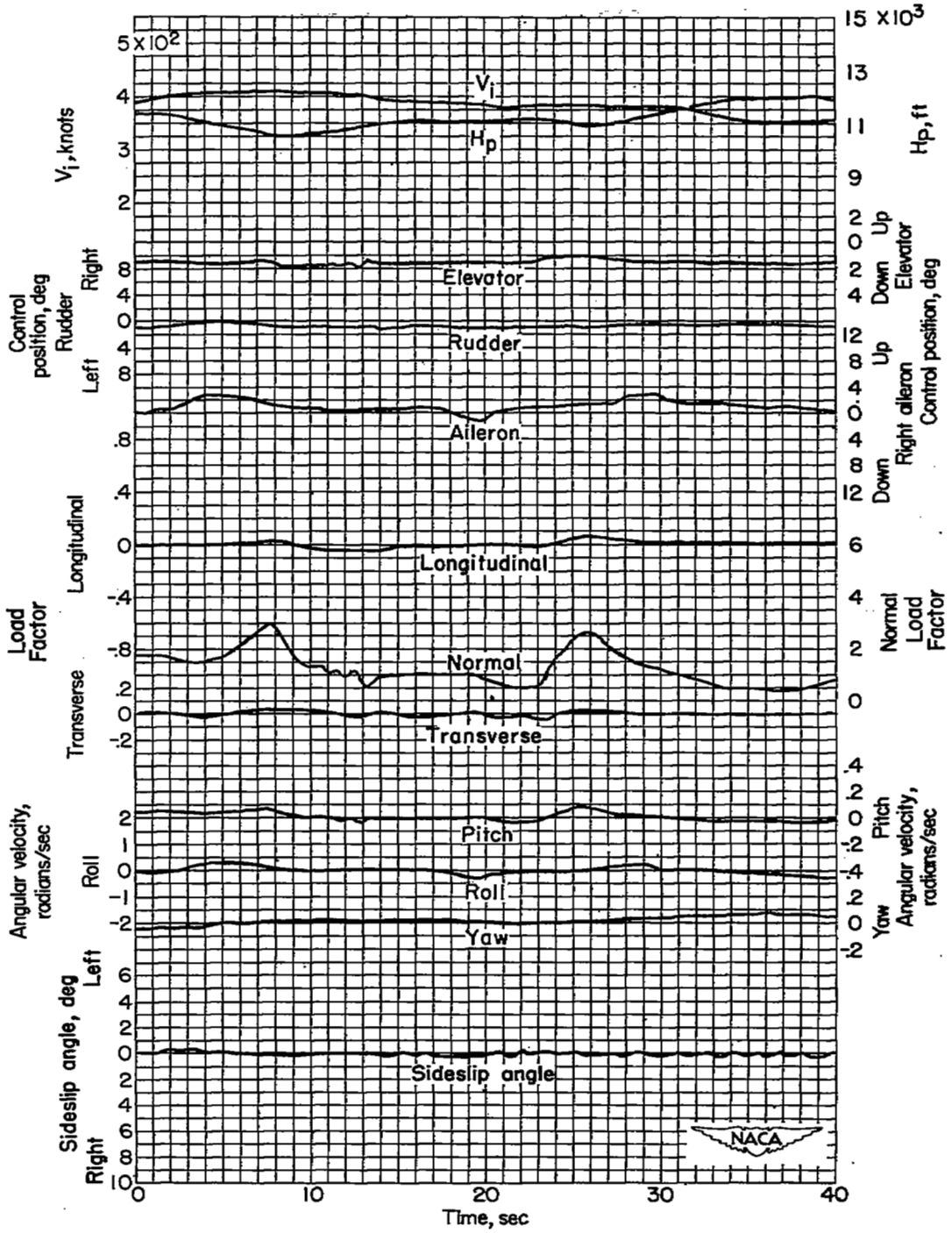

Figure 55.- Series of climbing turns; airplane weight, 15,920 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

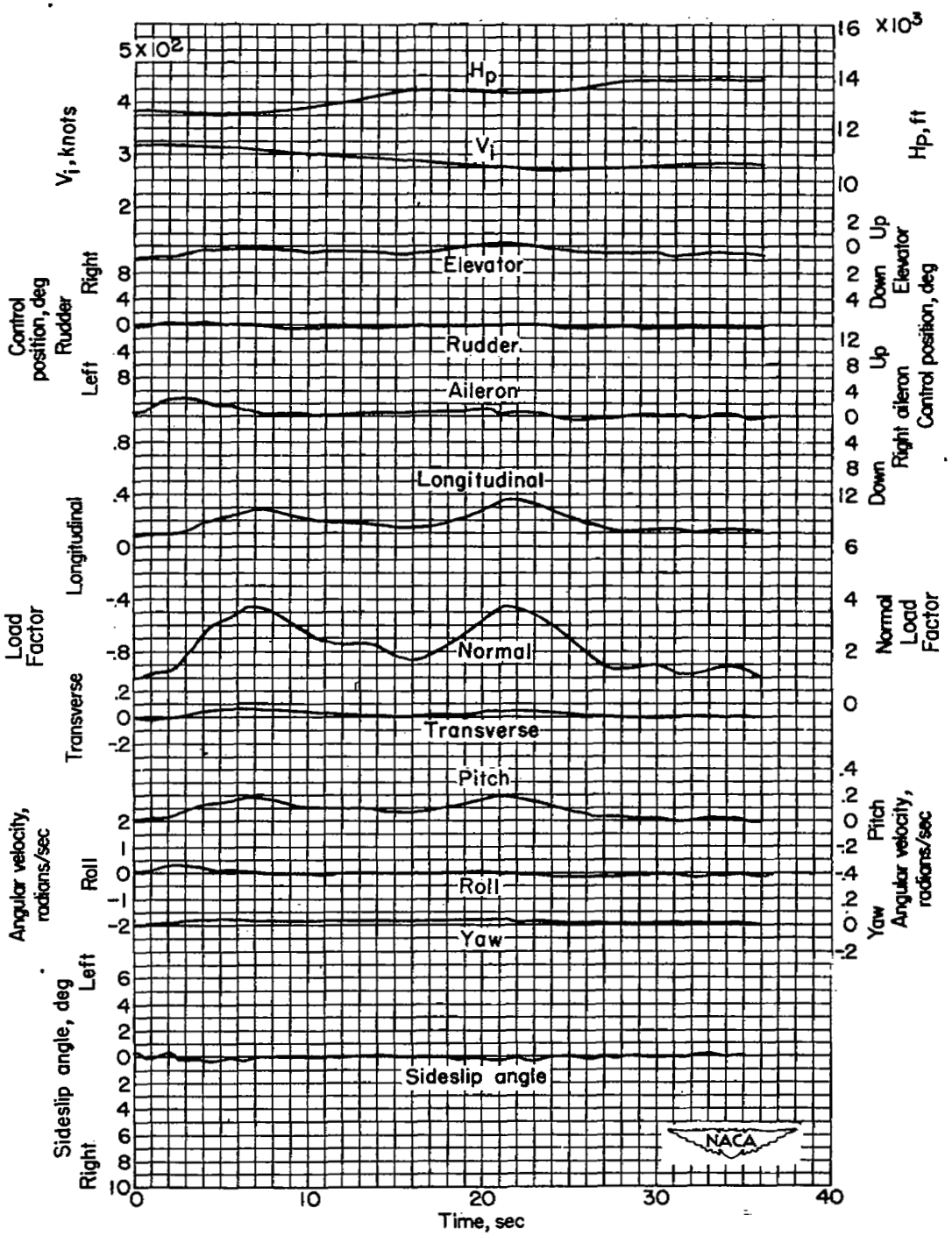

Figure 56.- Series of climbing turns; airplane weight, 15,000 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

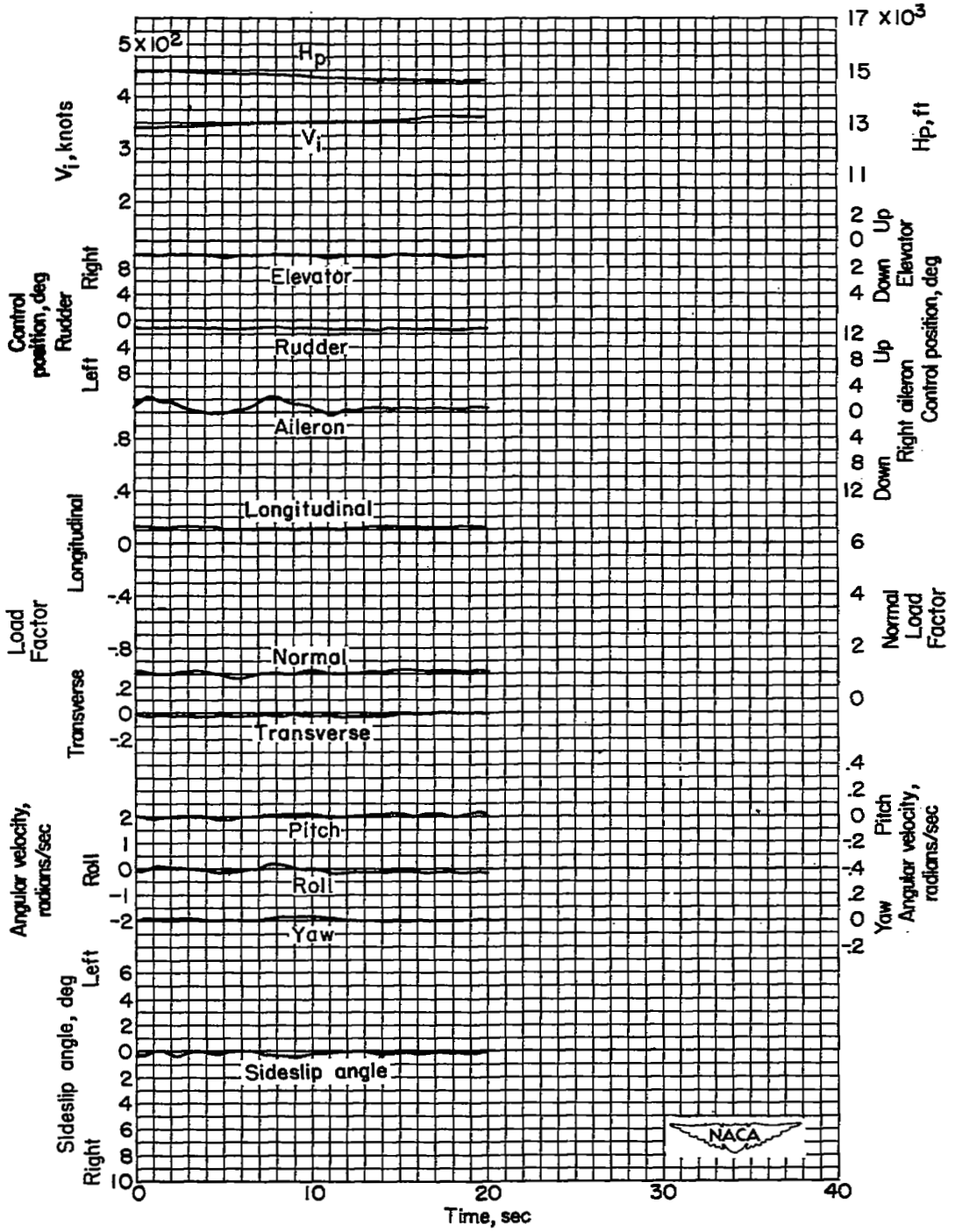

Figure 57.- Series of turns; airplane weight, 15,830 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

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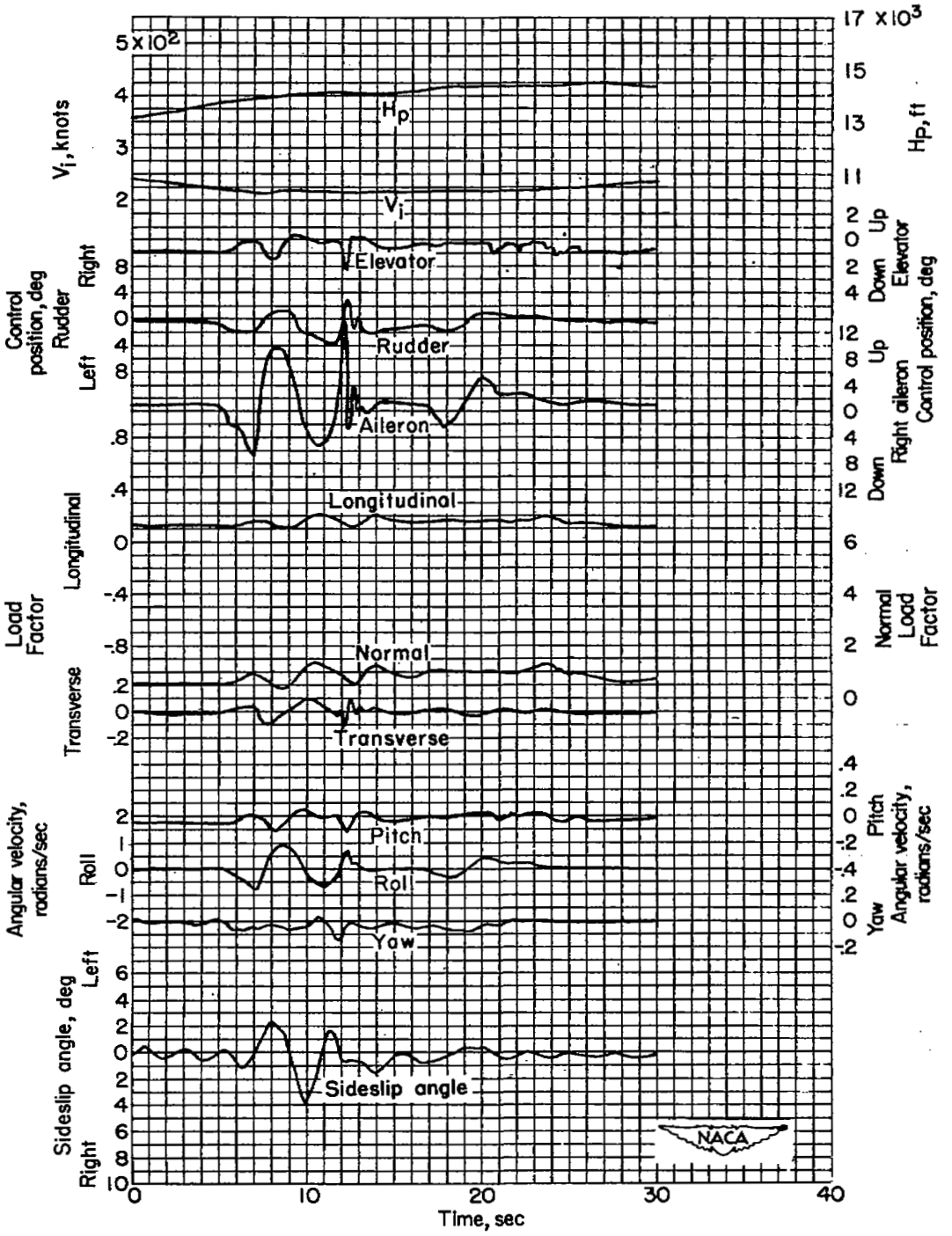

Figure 58.- Series of turns; airplane weight, 17,080 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

10F

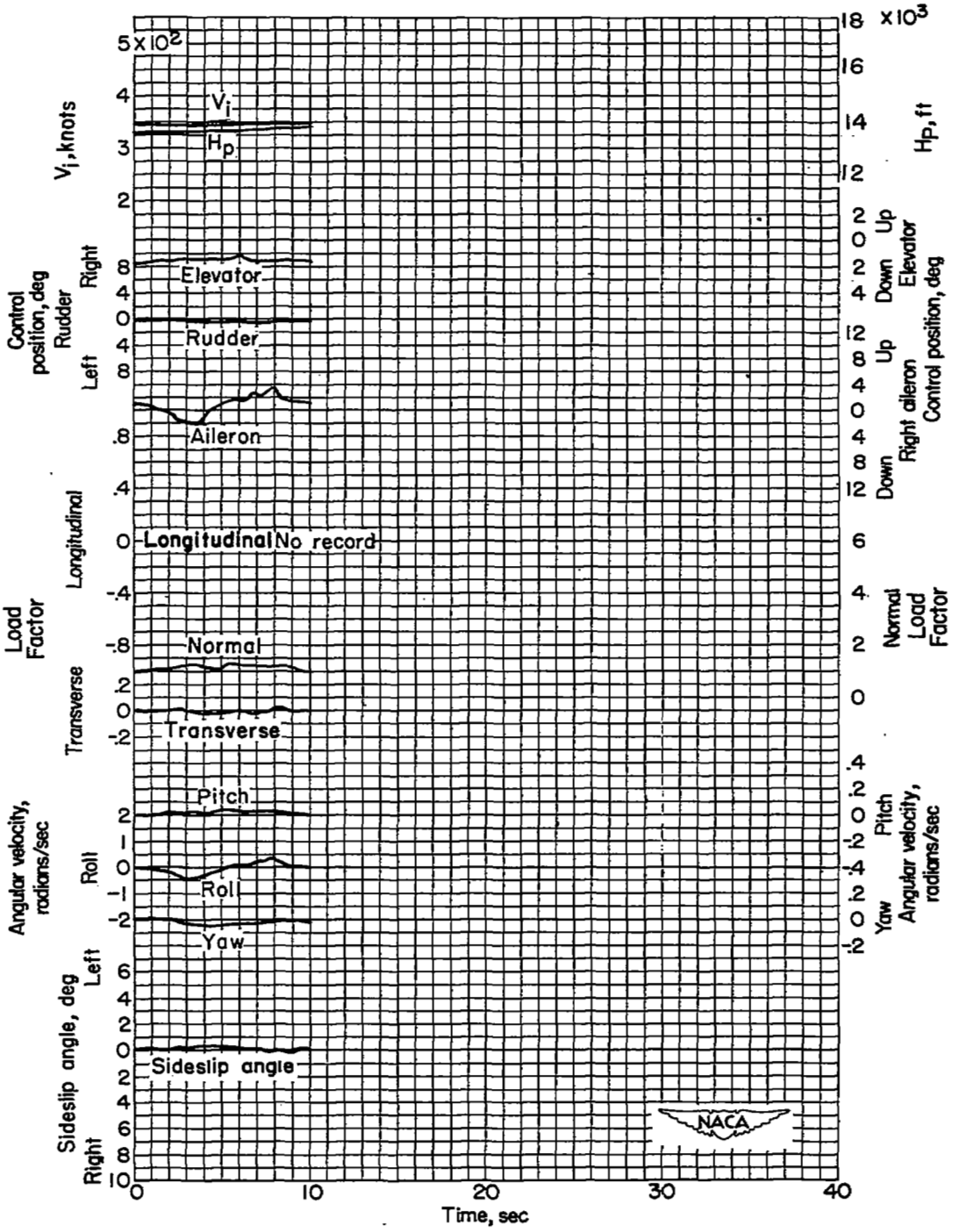

Figure 59.- Series of turns; airplane weight, 14,350 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

[redacted]

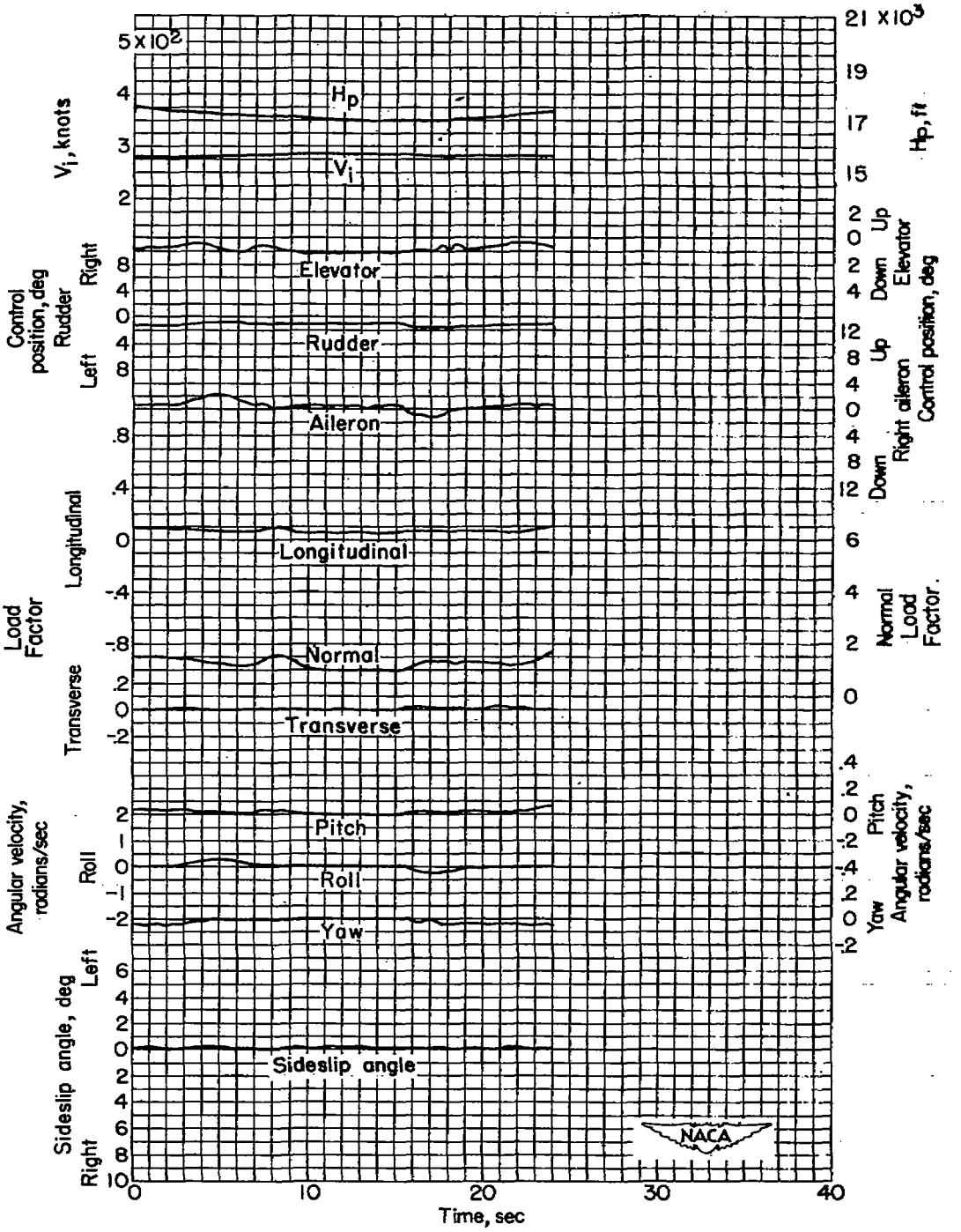

Figure 60.- Series of turns; airplane weight, 16,440 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

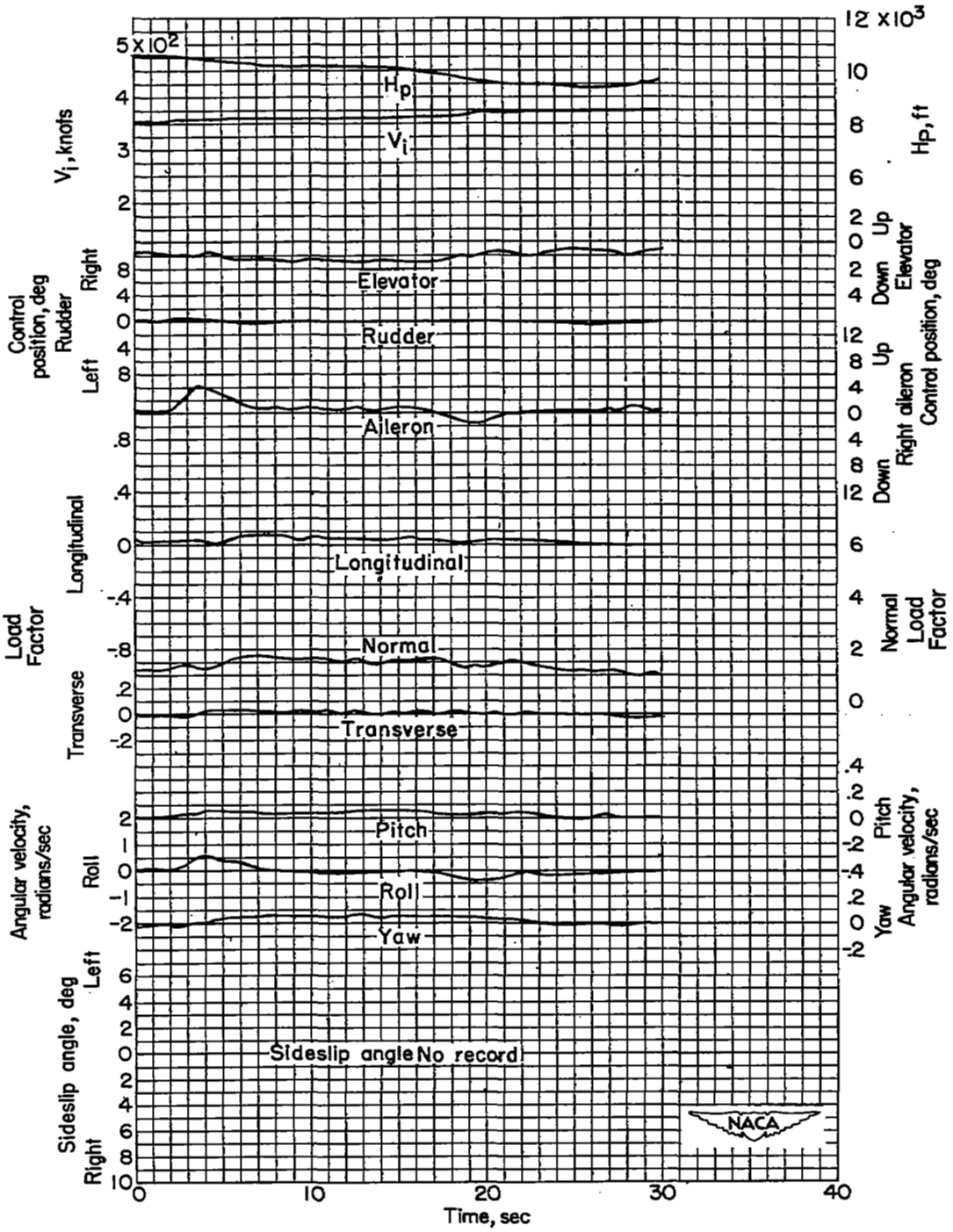

Figure 61.- Series of turns; airplane weight, 16,100 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

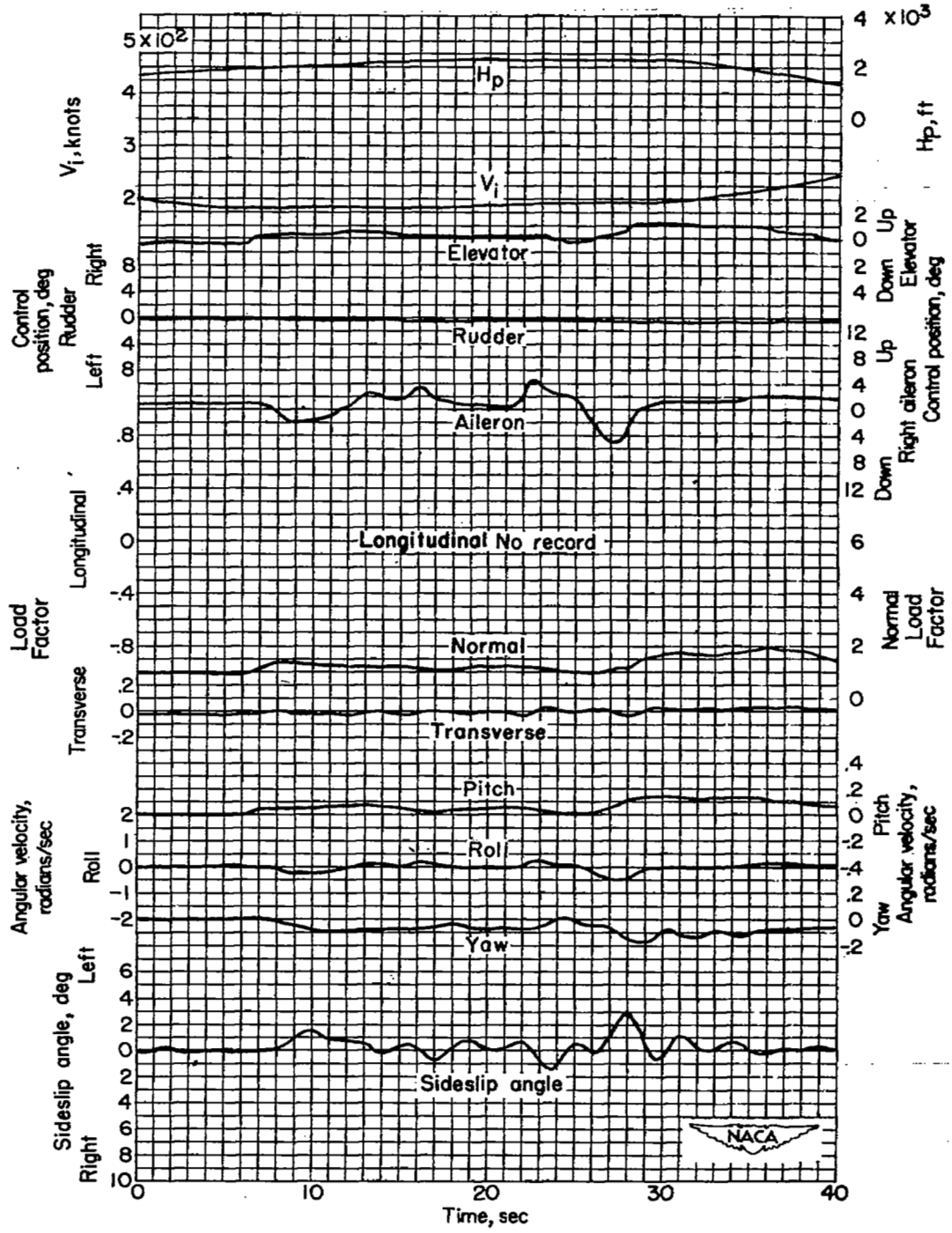

Figure 62.- Series of turns; airplane weight, 15,500 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

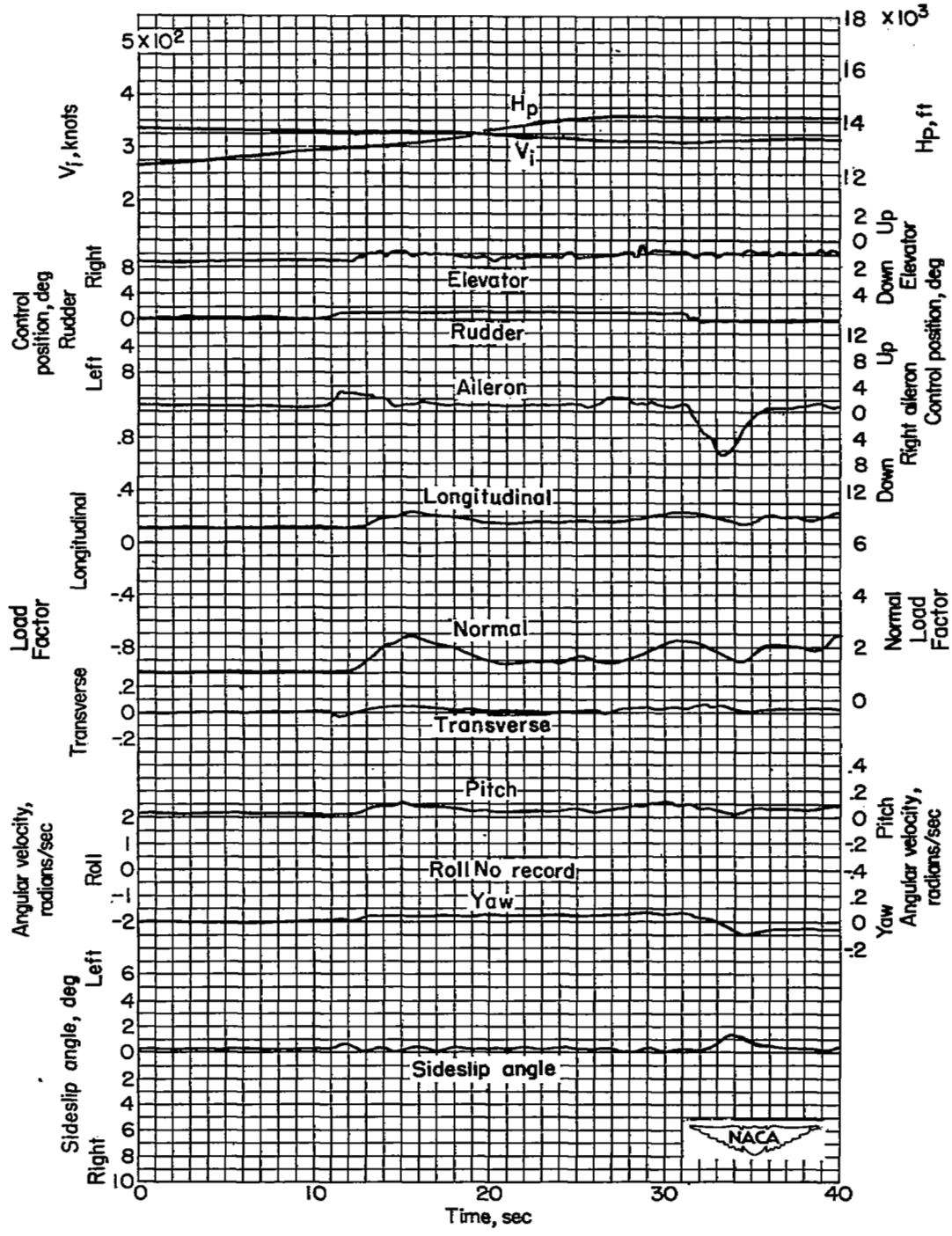

Figure 63.- Series of turns; airplane weight, 17,280 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

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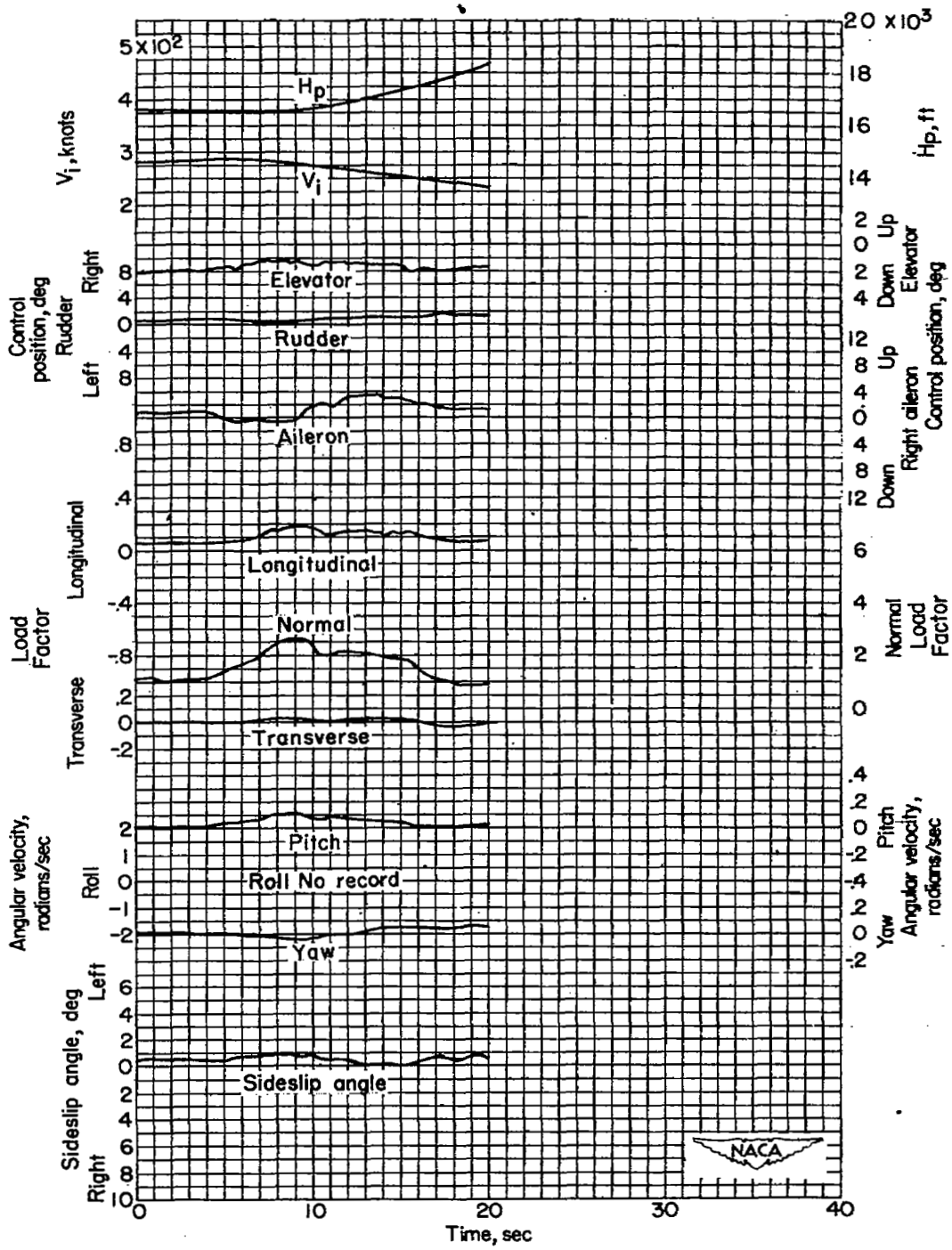

Figure 64.- Series of turns; airplane weight, 16,420 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

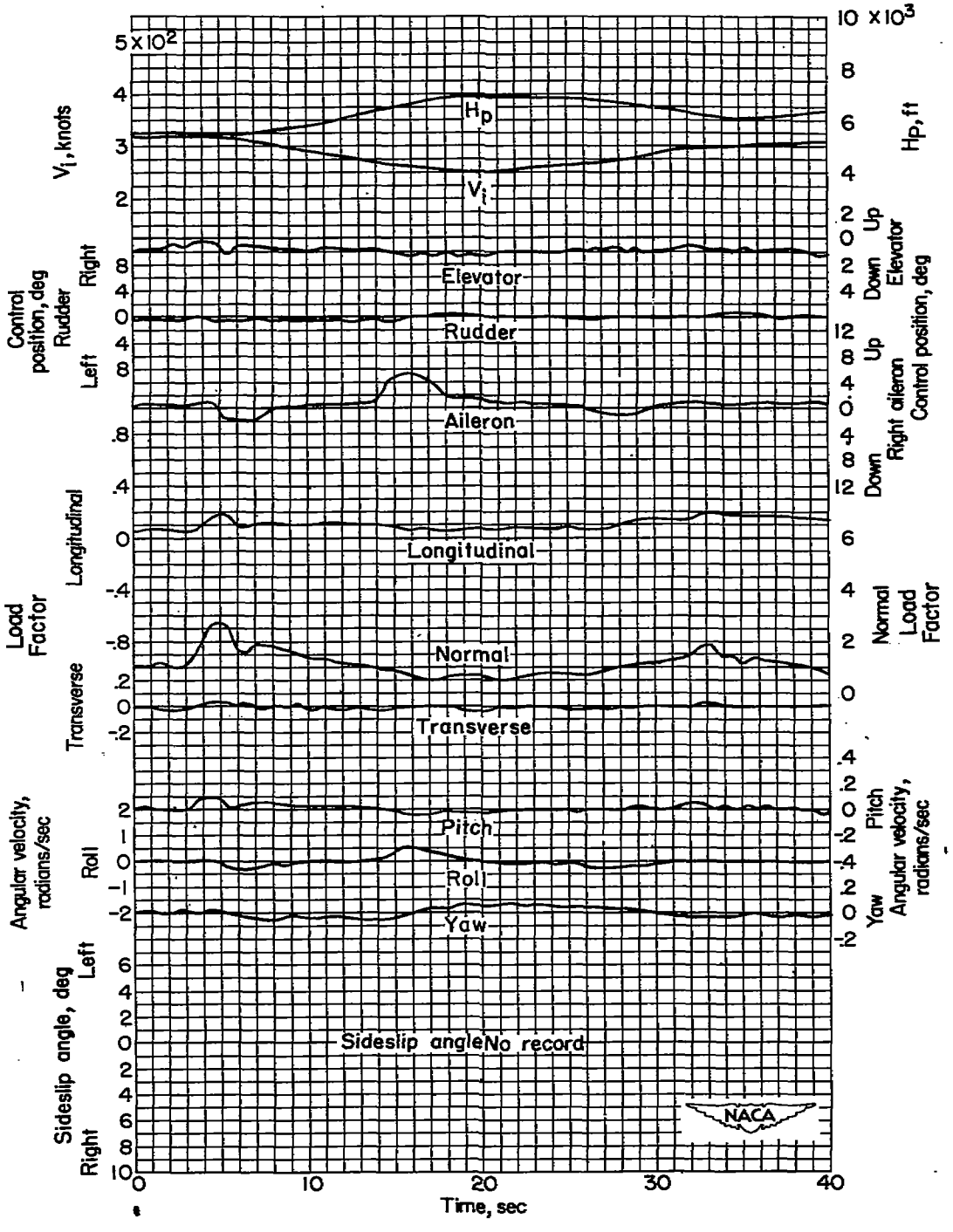

Figure 65.- Series of gentle turns; airplane weight, 16,690 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

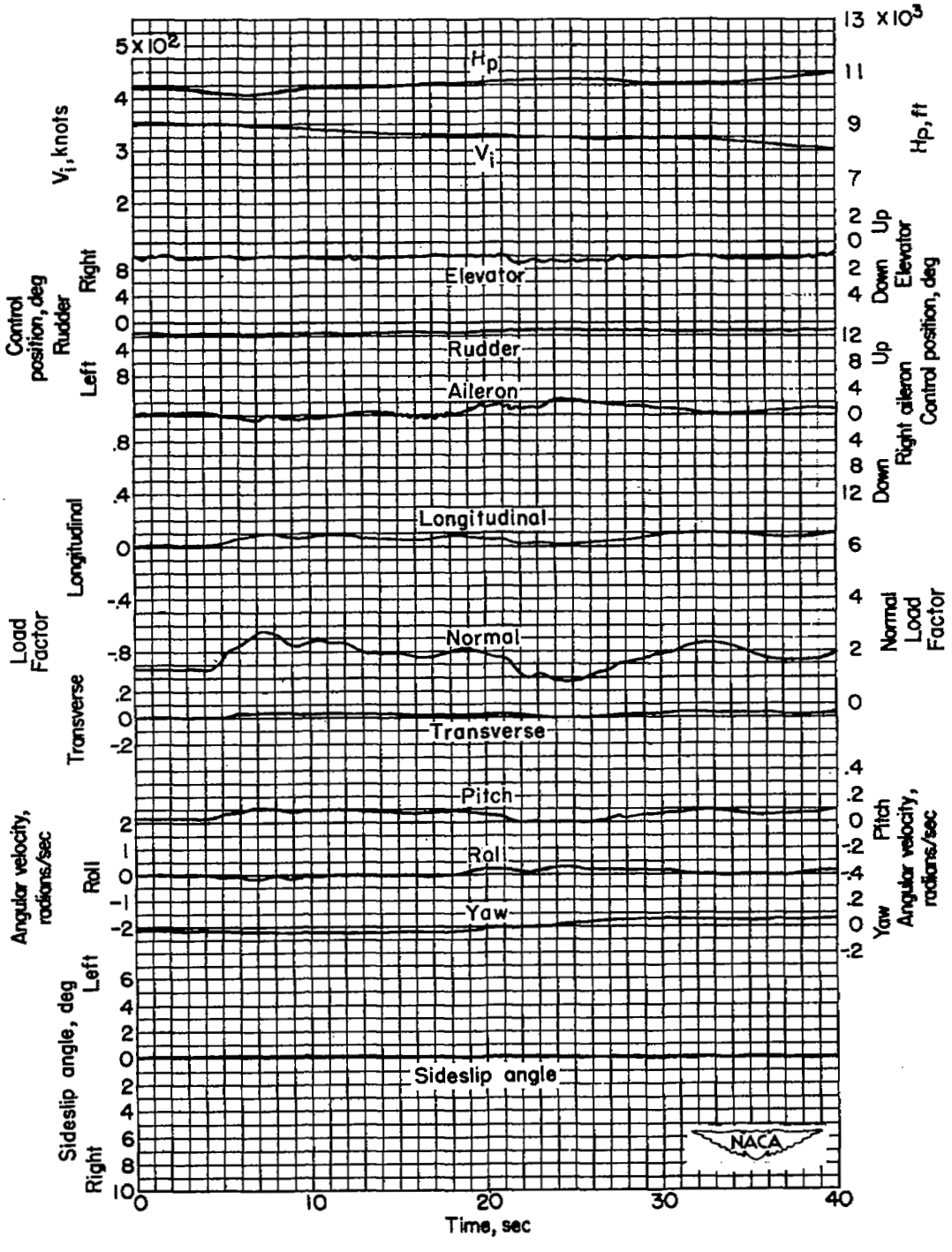

Figure 66.- Series of turns; airplane weight, 15,570 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

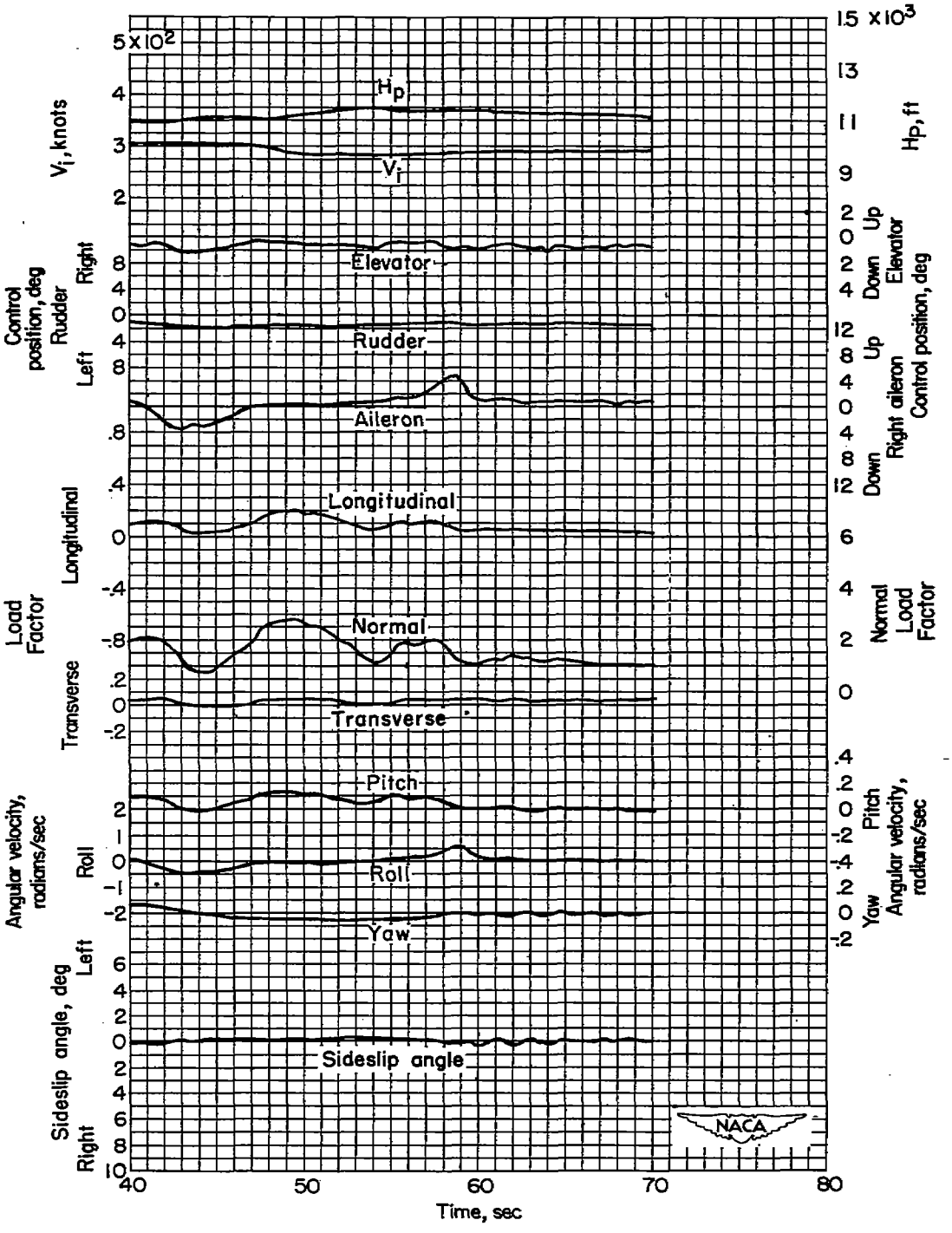

Figure 66.- Concluded.

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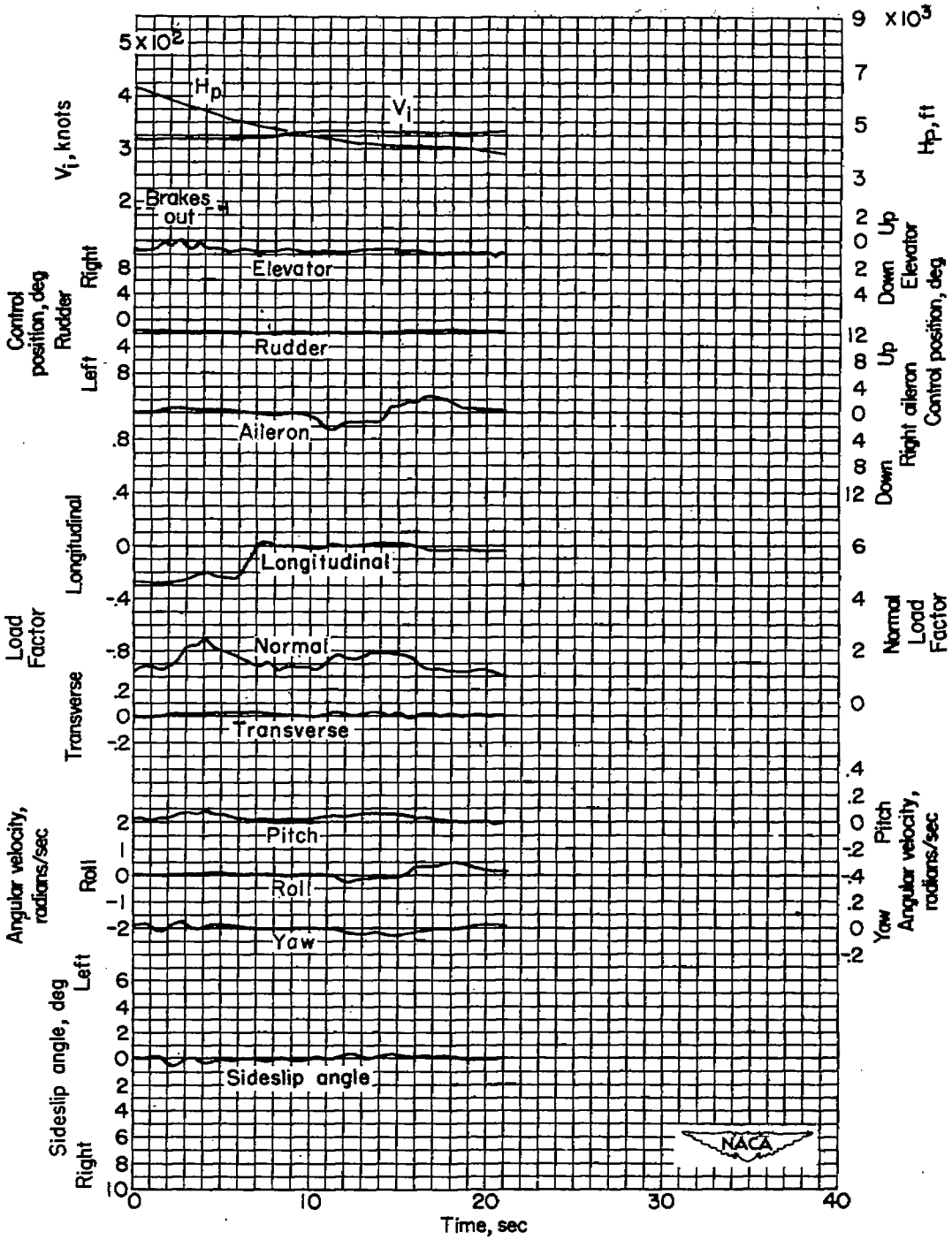

Figure 67.- Series of diving turns; airplane weight, 13,660 pounds; center-of-gravity location, 26.0 percent of the mean aerodynamic chord.

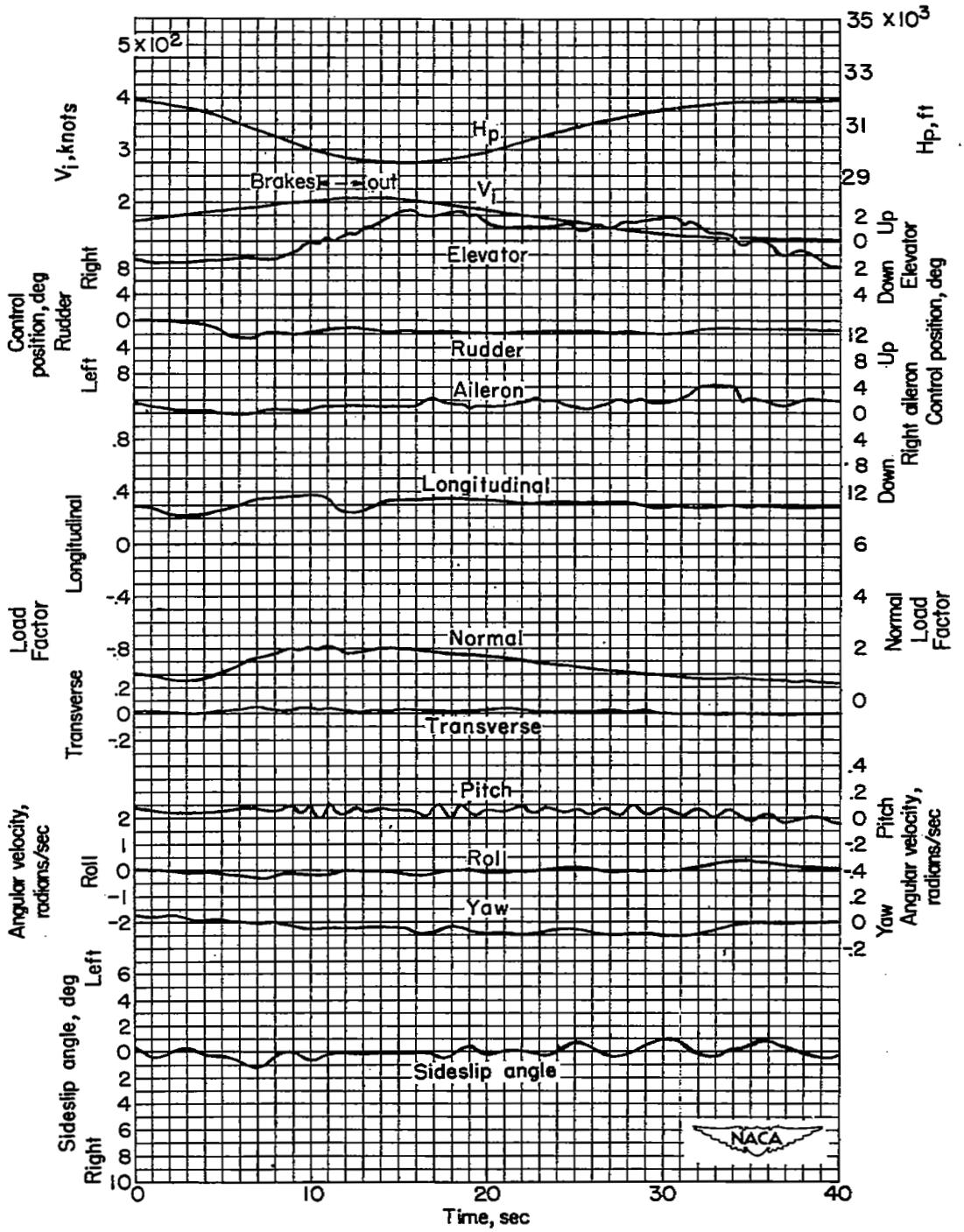

Figure 68.- Gentle pull-up; airplane weight, 16,900 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

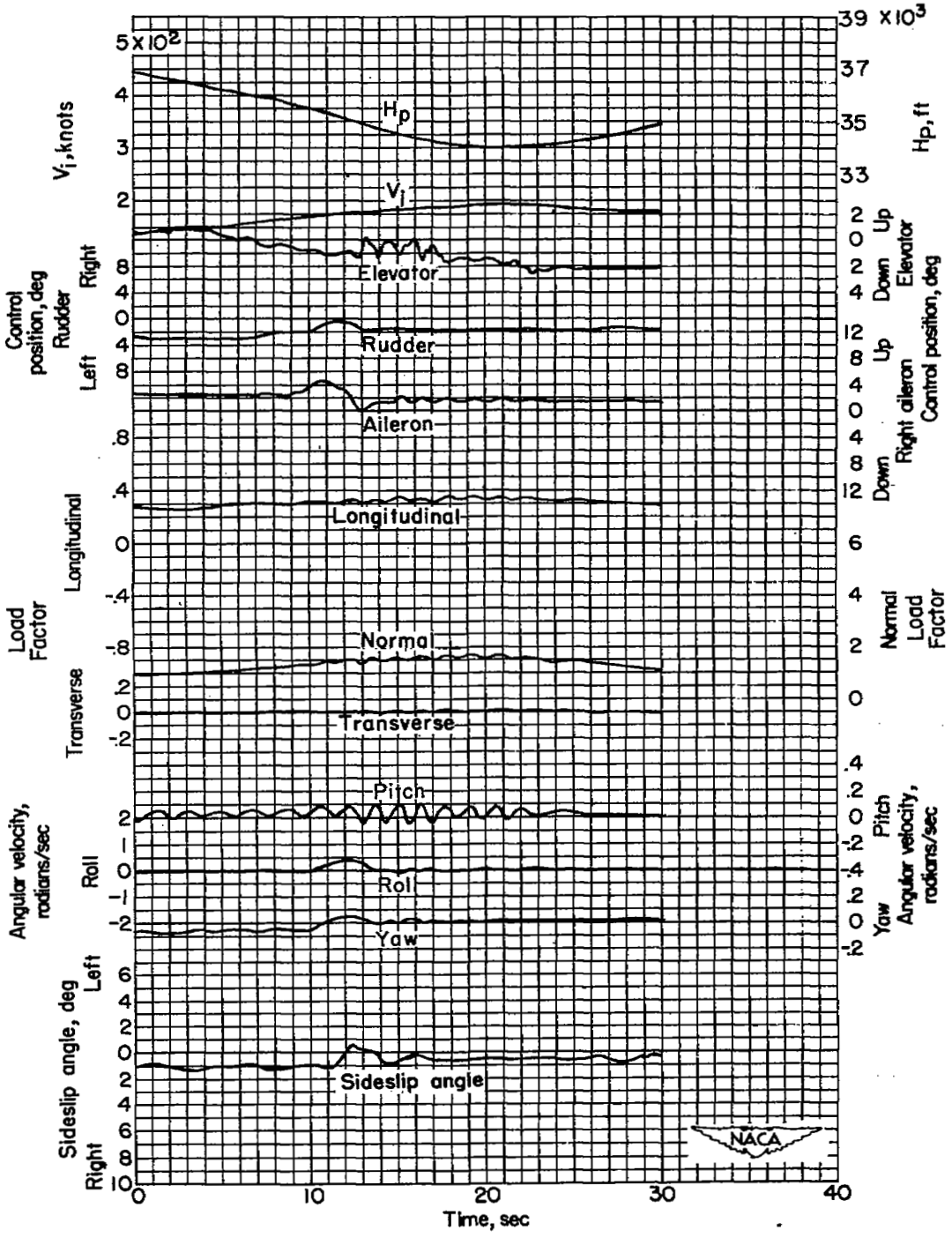

Figure 69.- Gentle pull-up; airplane weight, 15,920 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

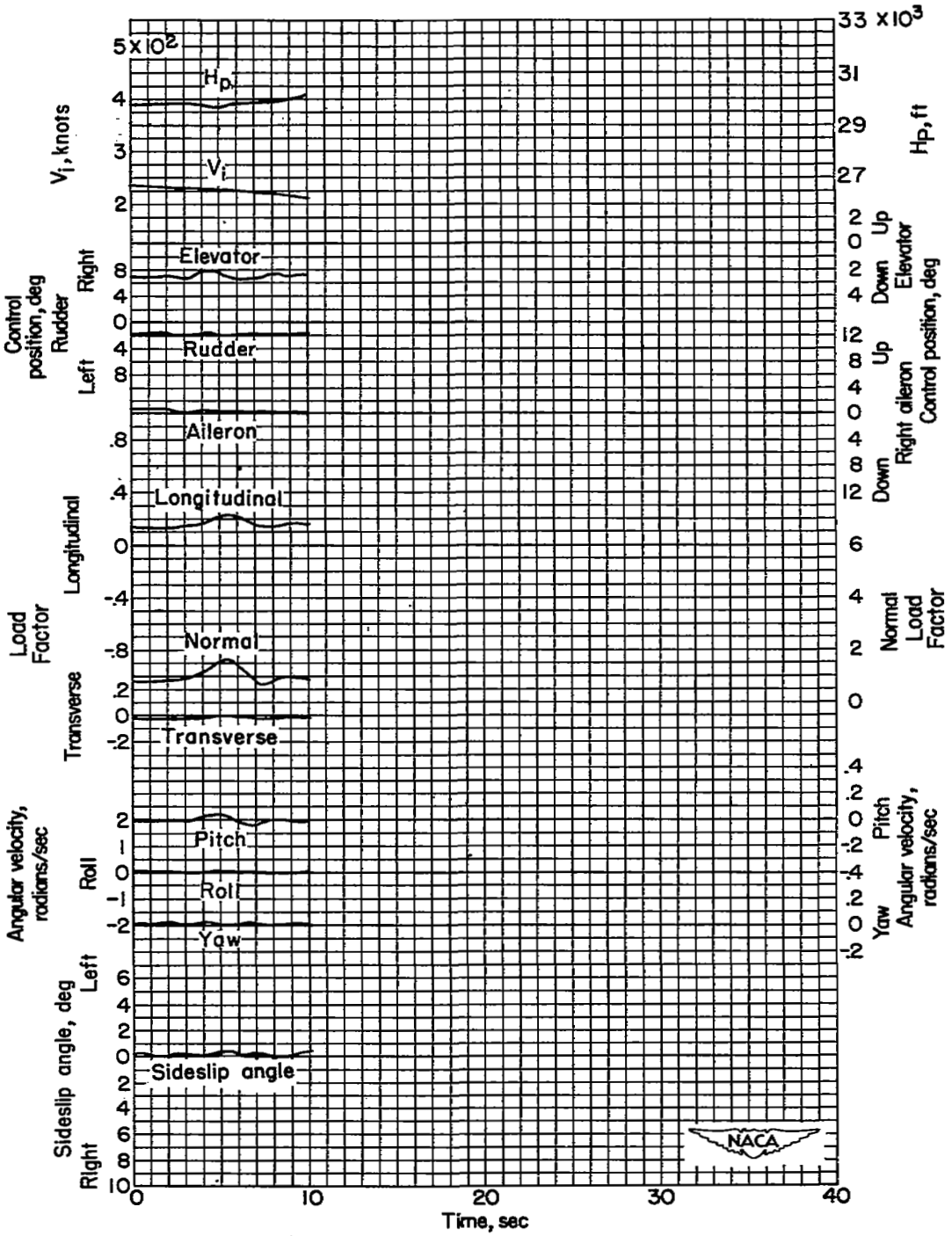

Figure 70.- Gentle pull-up; airplane weight, 15,740 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

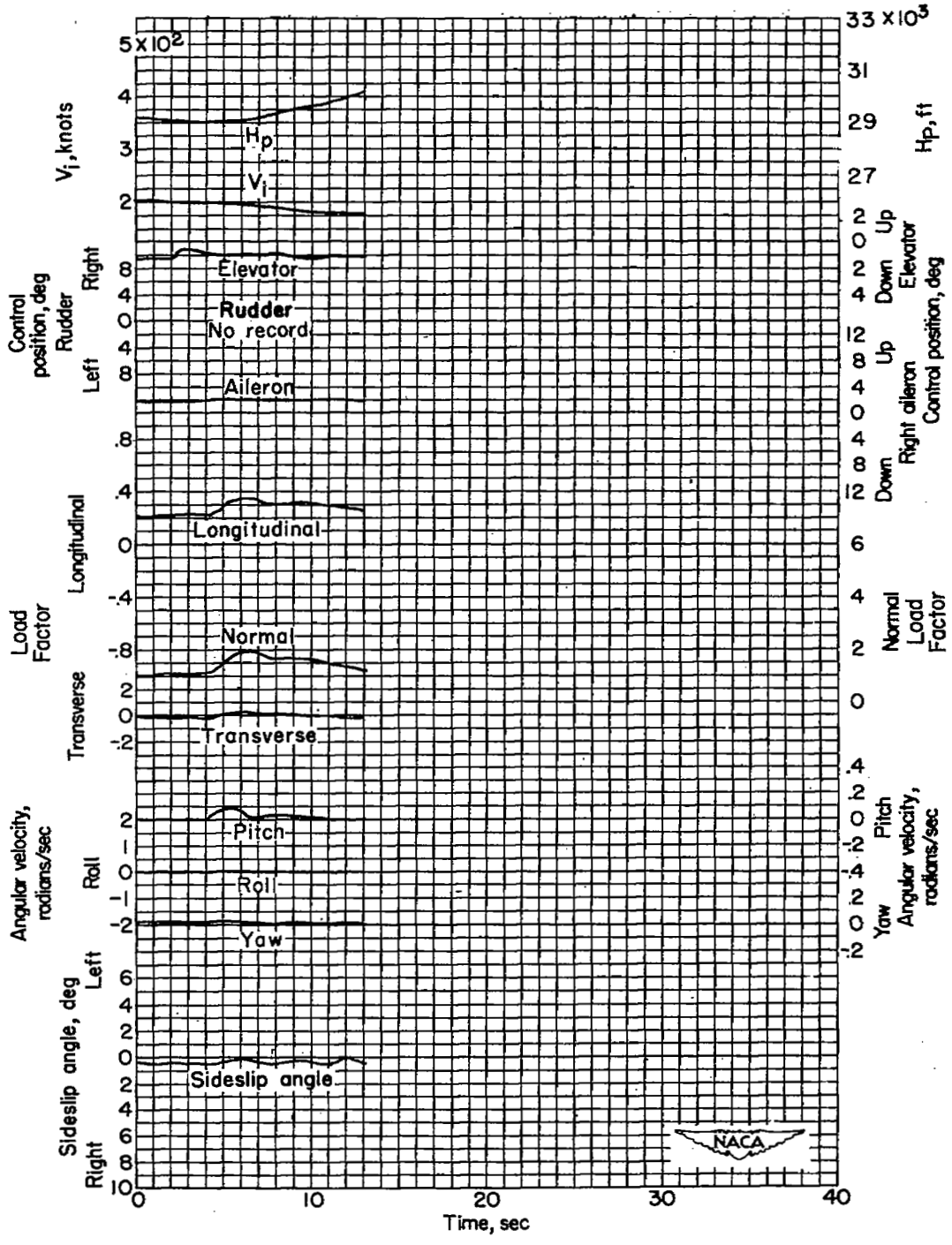

Figure 71.- Gentle pull-up; airplane weight, 16,410 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

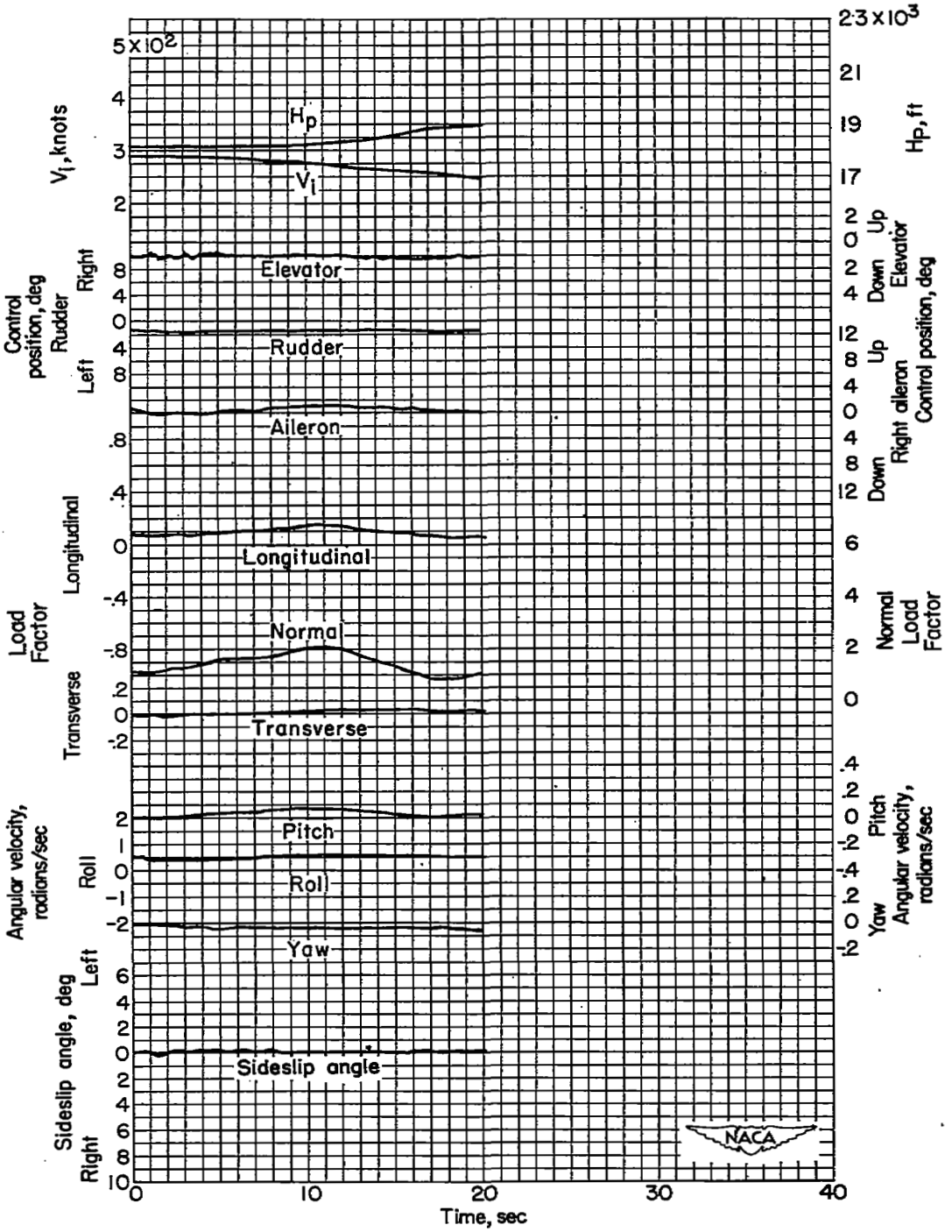

Figure 72.- Gentle pull-up; airplane weight, 16,620 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

[redacted]

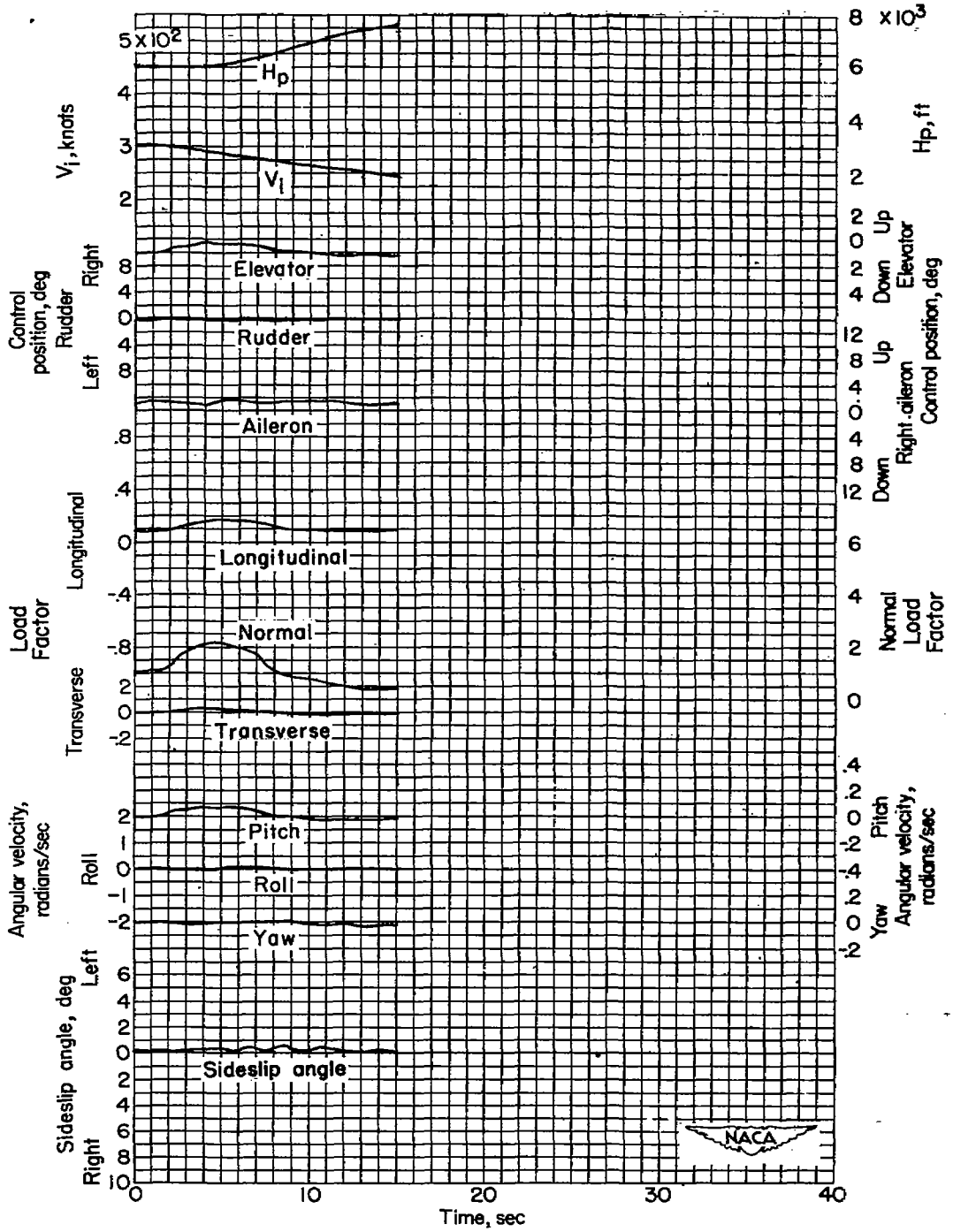

Figure 73.- Gentle pull-up; airplane weight, 17,090 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

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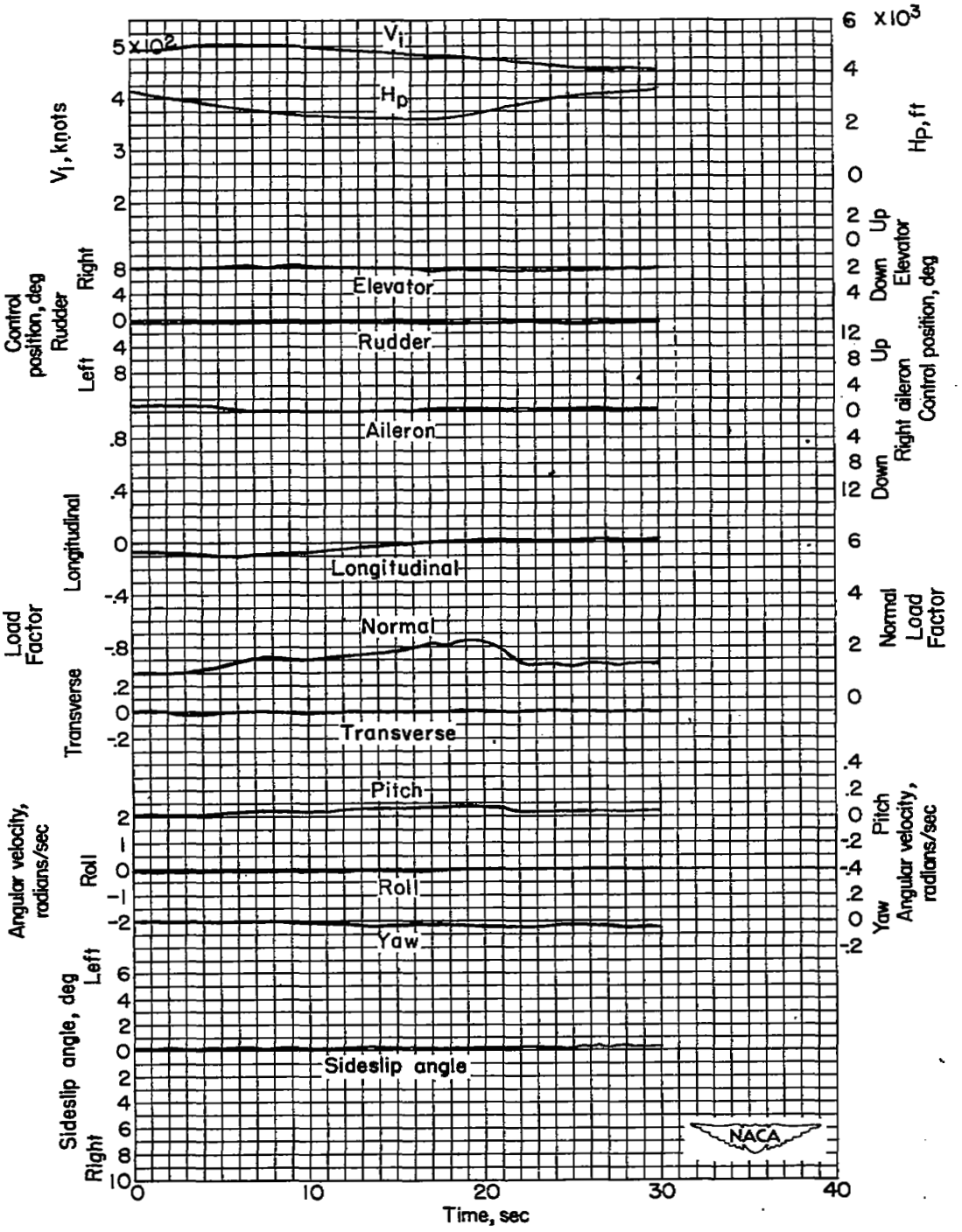


Figure 74.- Gentle pull-up; airplane weight, 16,520 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

[redacted]

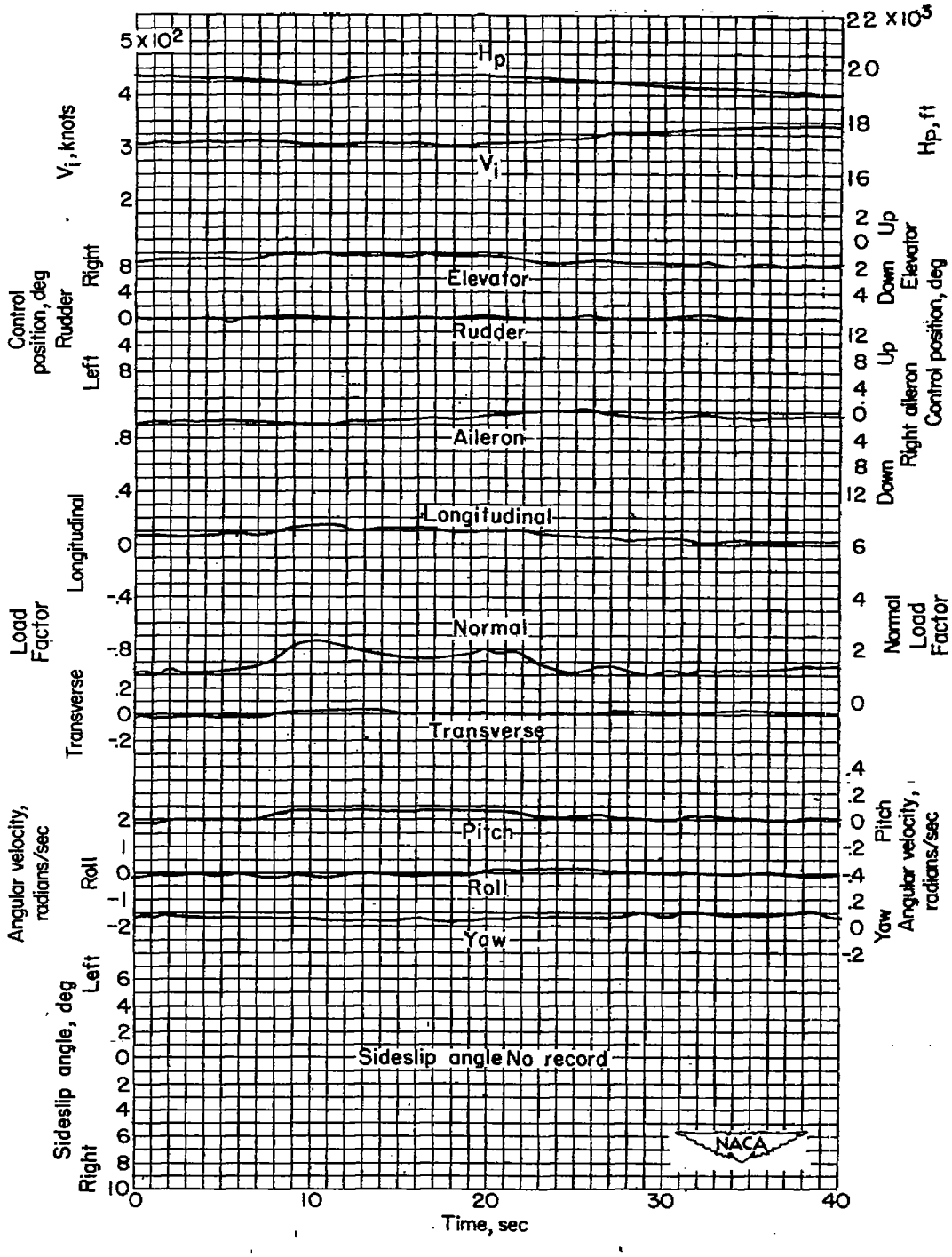


Figure 75.- Gentle pull-up; airplane weight, 14,770 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

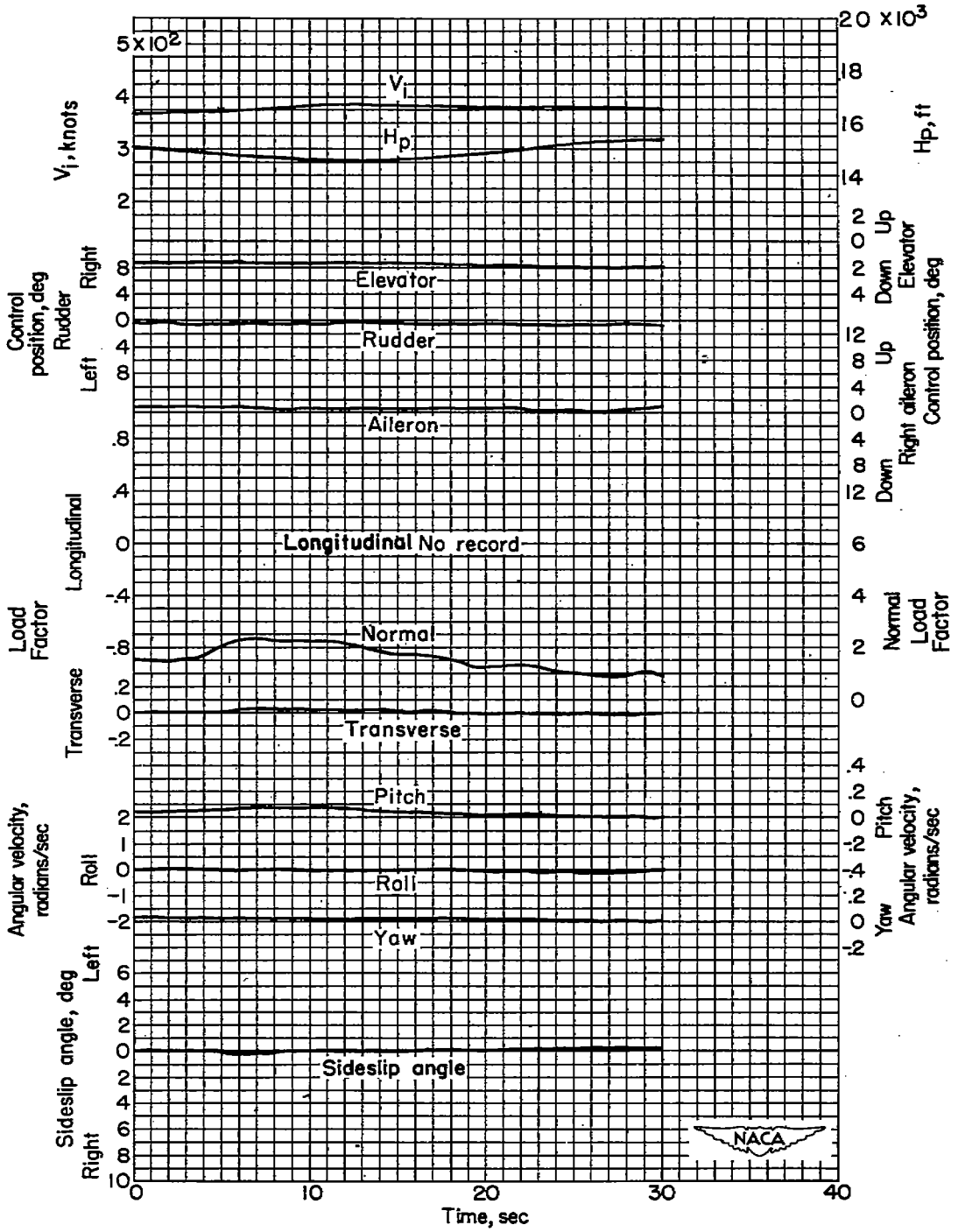


Figure 76.- Gentle pull-up; airplane weight, 14,240 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

[redacted]

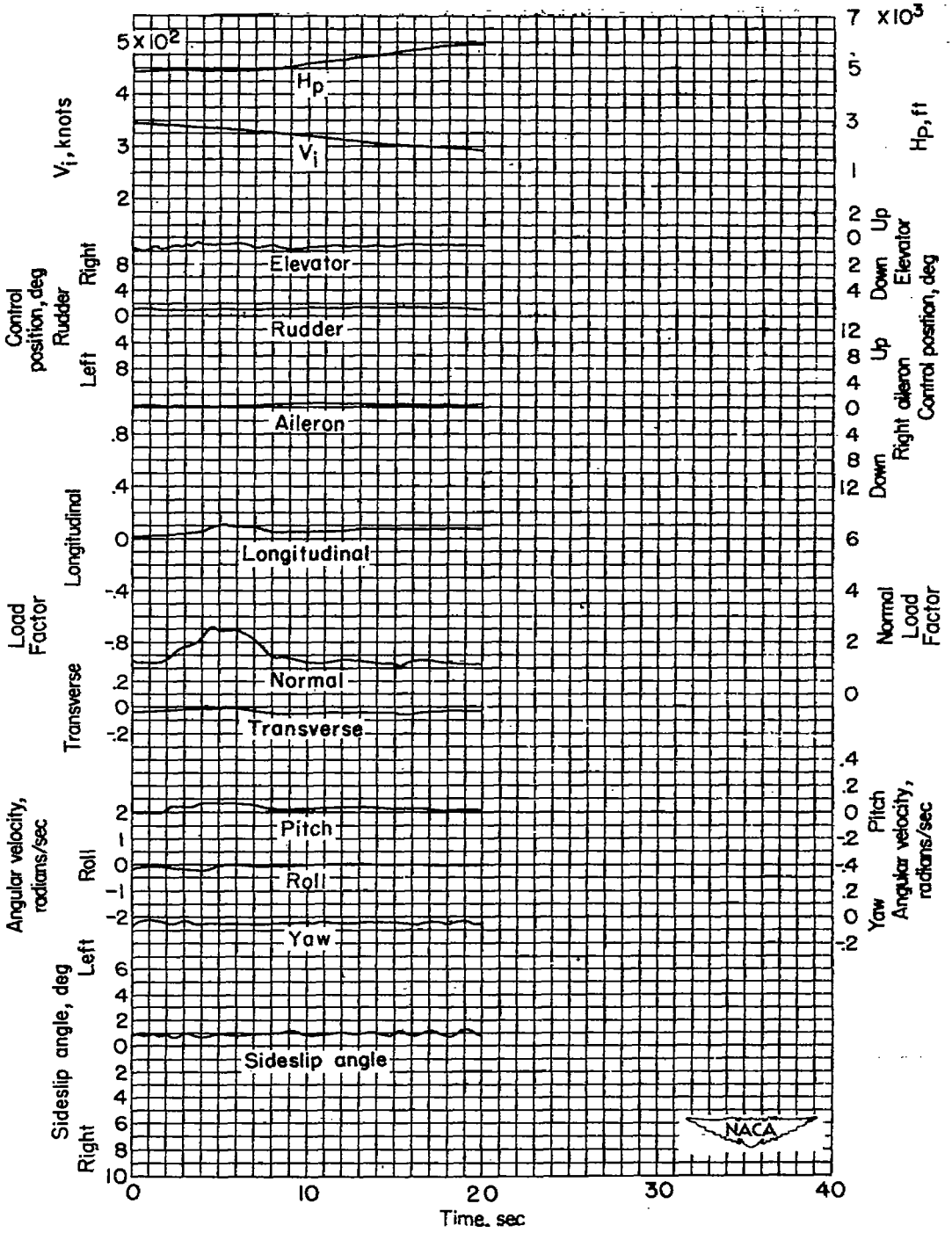


Figure 77.- Gentle pull-up; airplane weight, 15,030 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

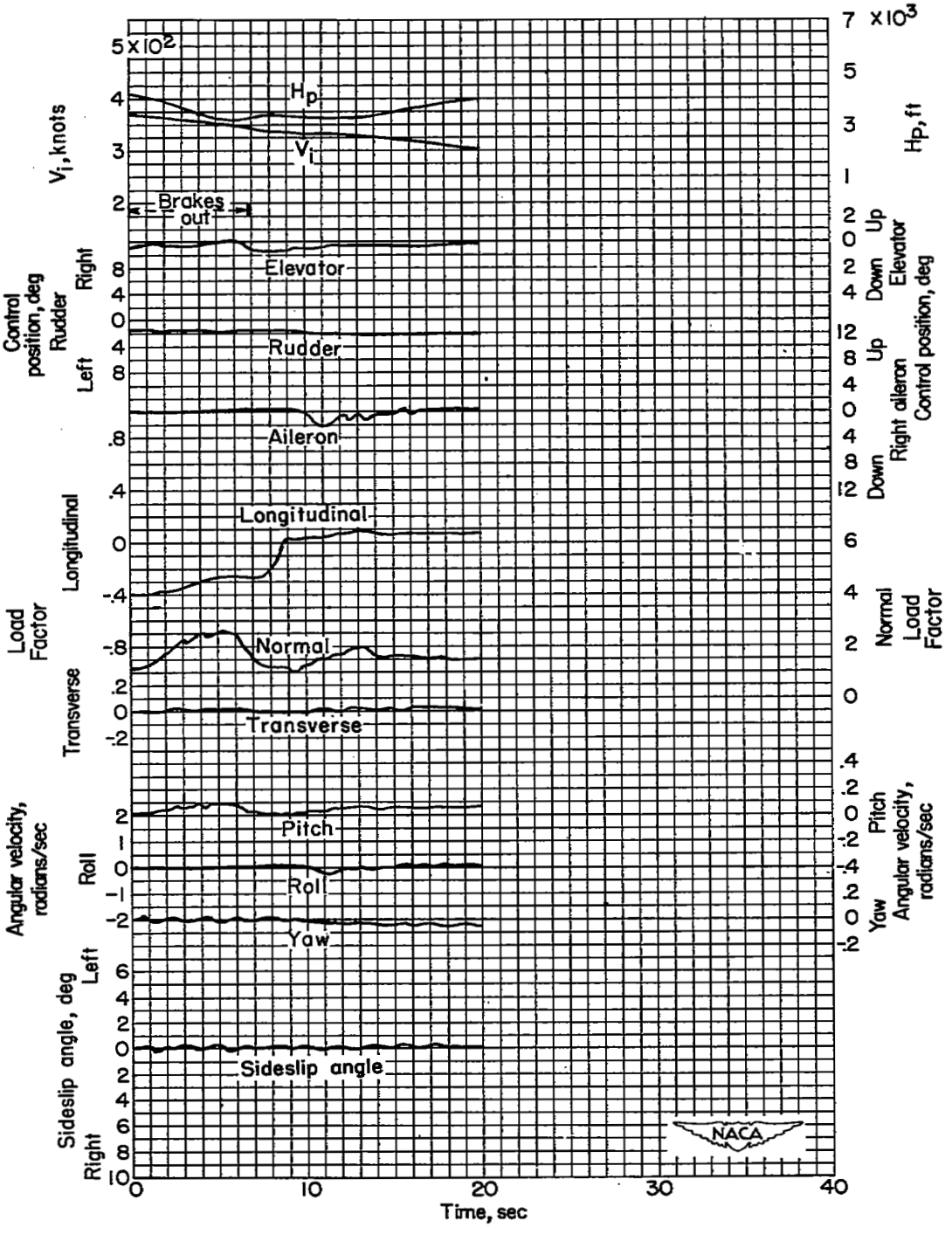


Figure 78.- Gentle pull-up; airplane weight, 15,170 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

[redacted]

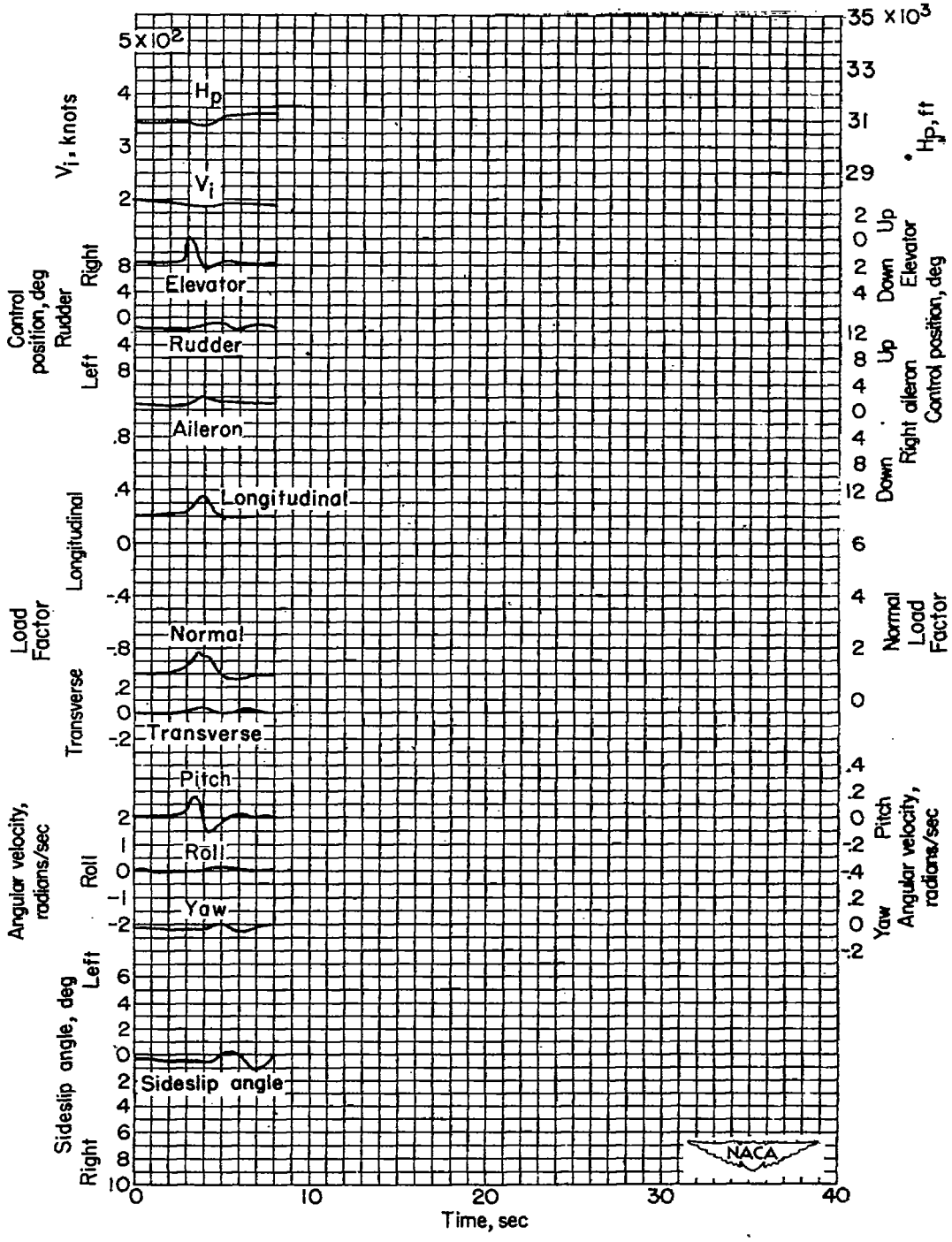


Figure 79.- Pull-up; airplane weight, 16,960 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

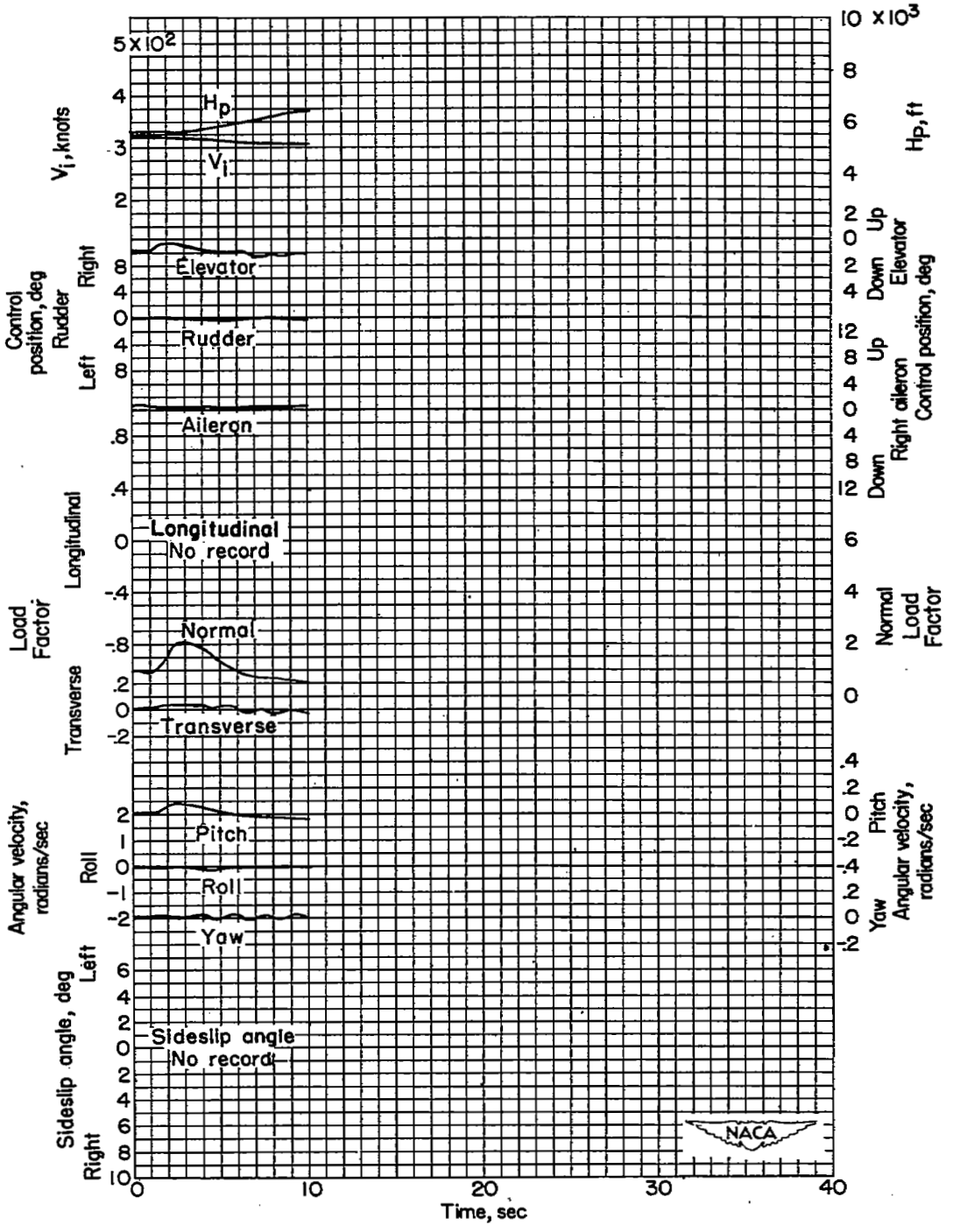


Figure 80.- Pull-up; airplane weight, 14,990 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

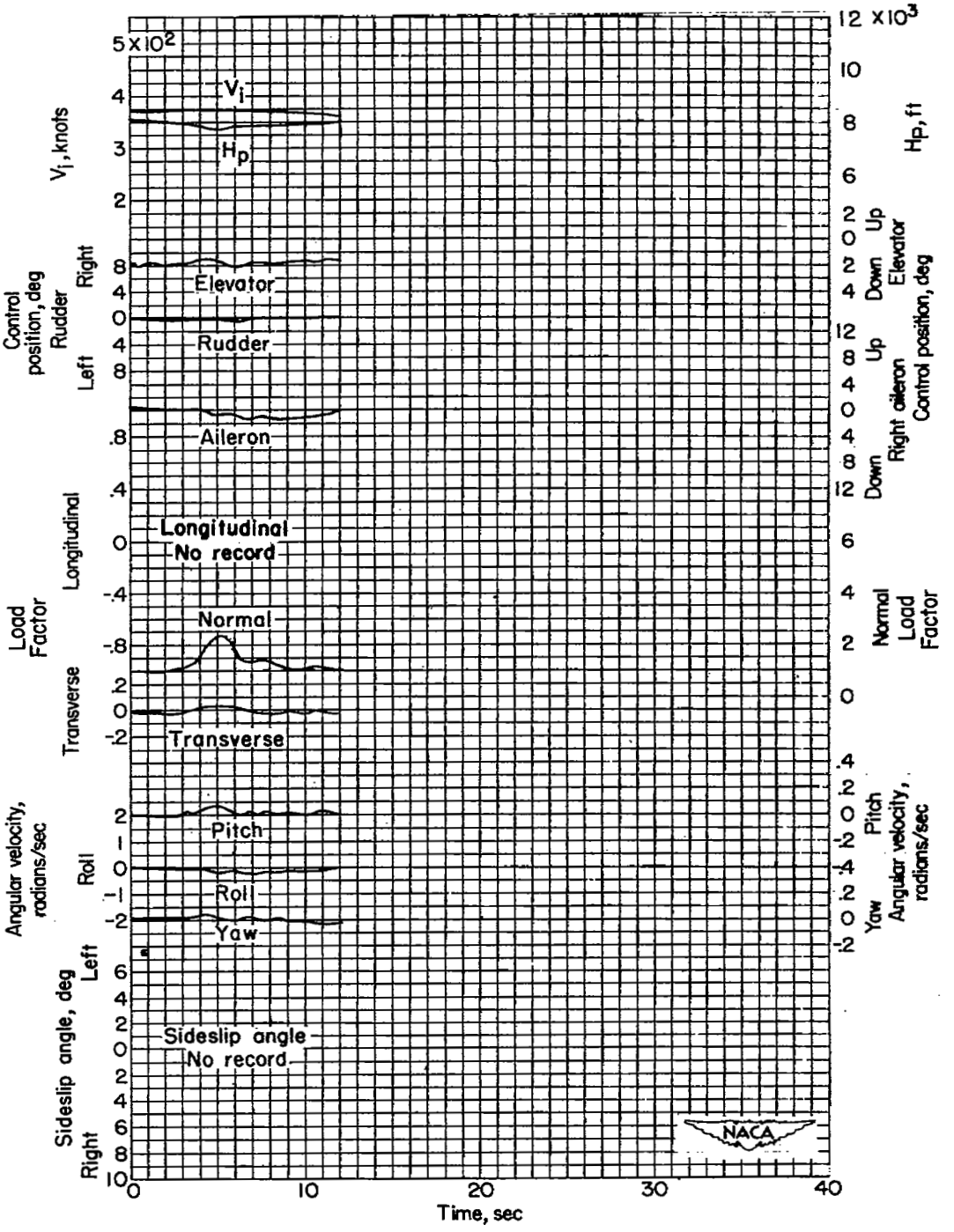


Figure 81.- Pull-up; airplane weight, 15,980 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

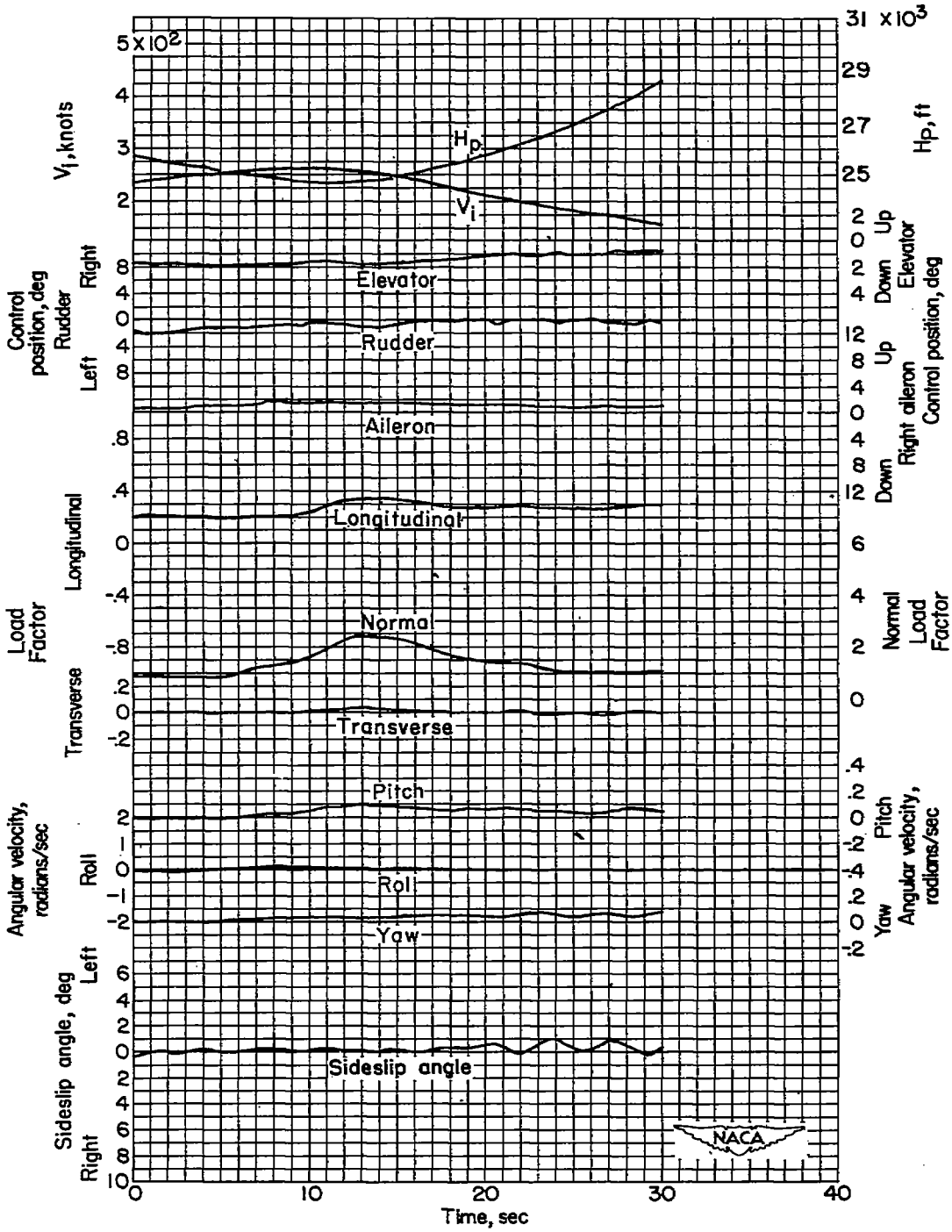


Figure 82.- Pull-up; airplane weight, 17,740 pounds; center-of-gravity location, 26.8 percent of the mean aerodynamic chord.

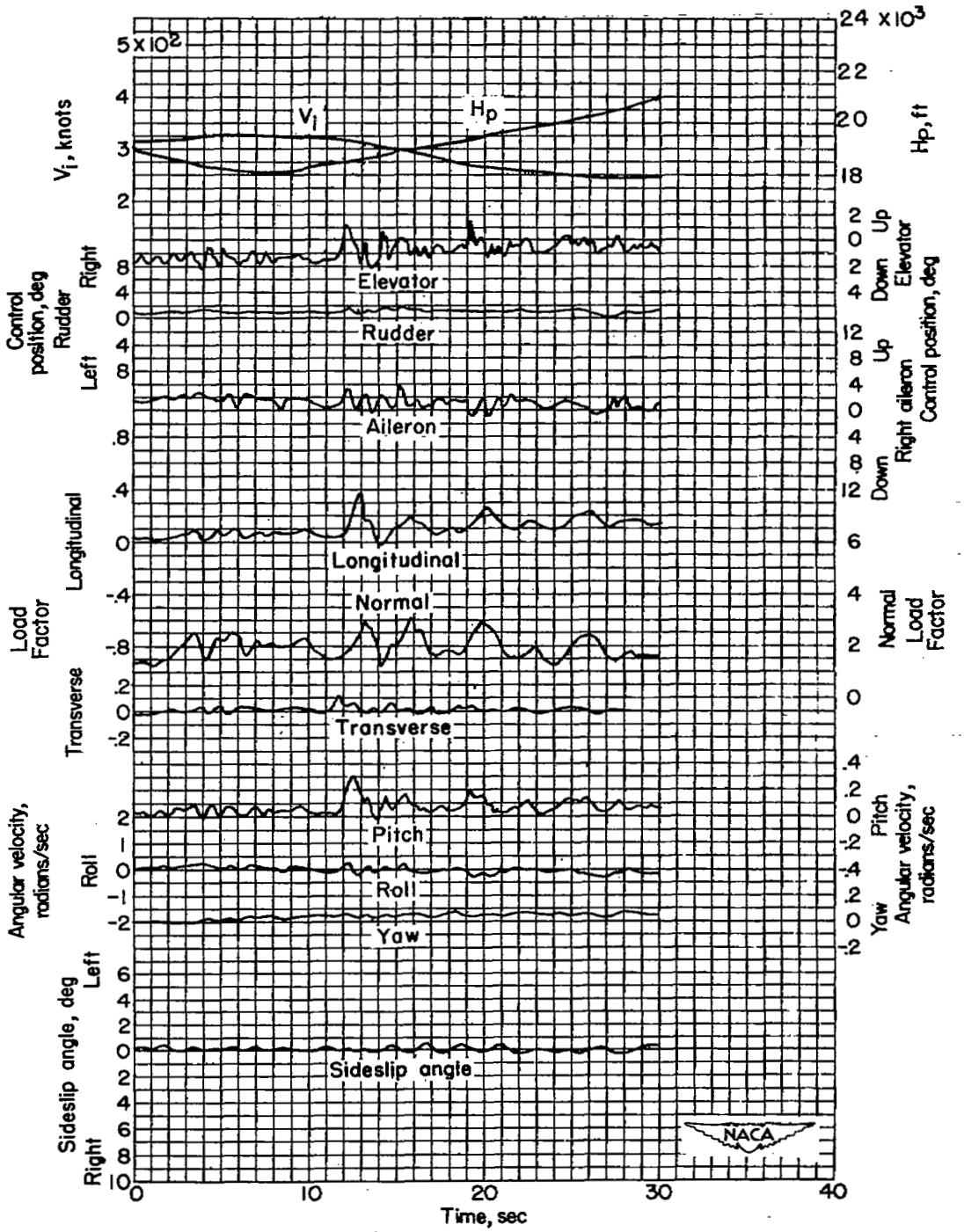


Figure 83.- Pull-up; airplane weight, 17,920 pounds; center-of-gravity location, 26.8 percent of the mean aerodynamic chord.

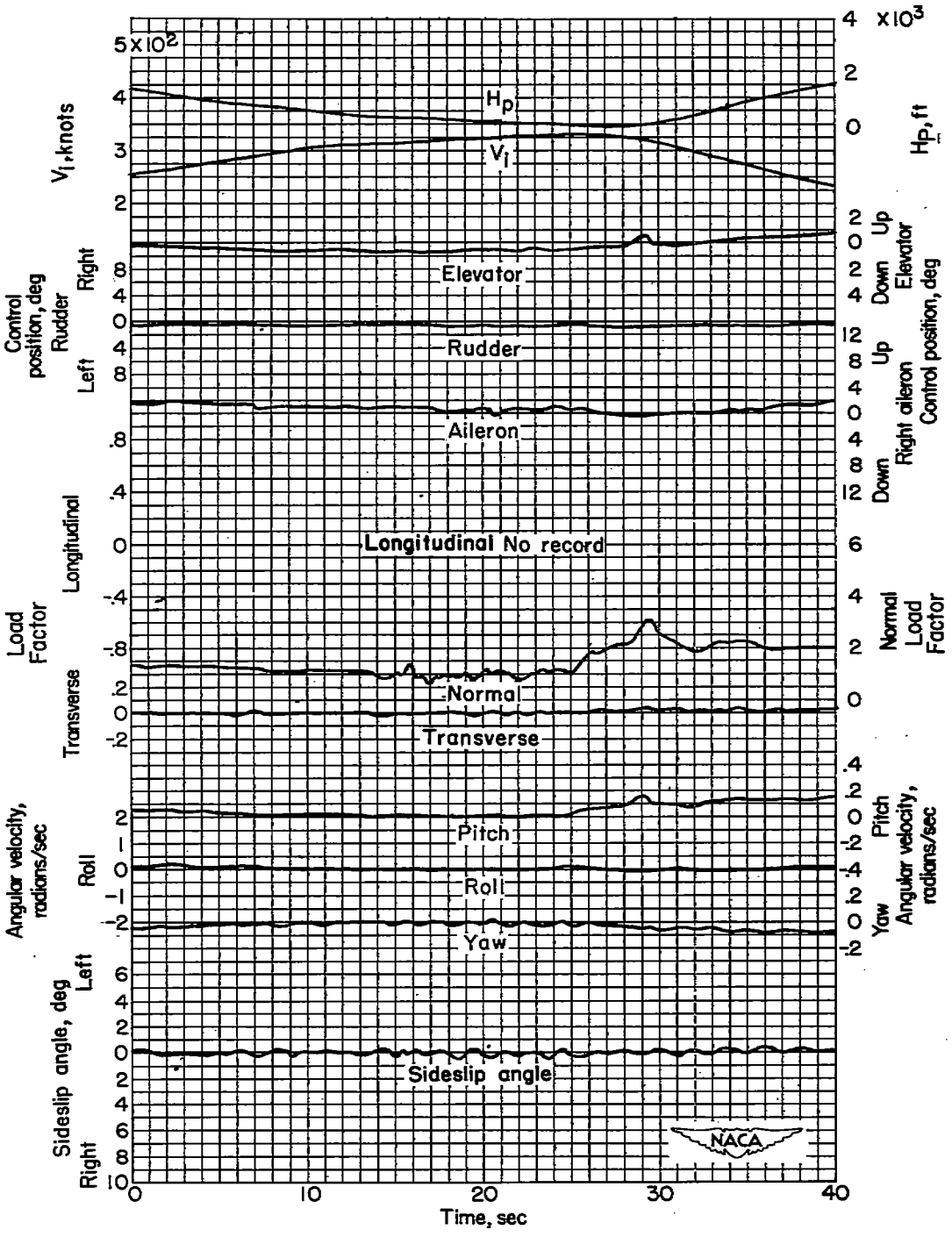


Figure 84.- Pull-up; airplane weight, 15,440 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

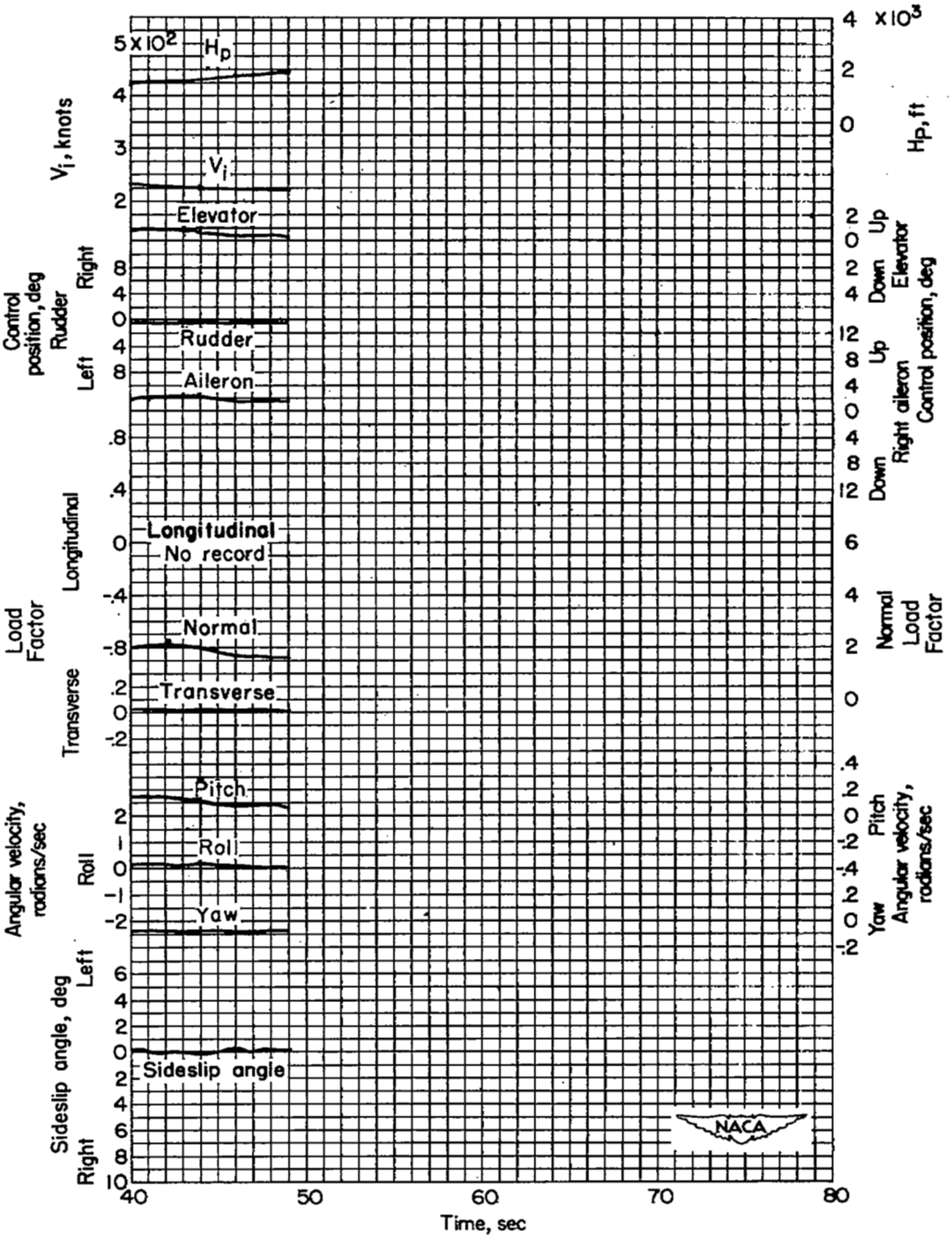


Figure 84.- Concluded.

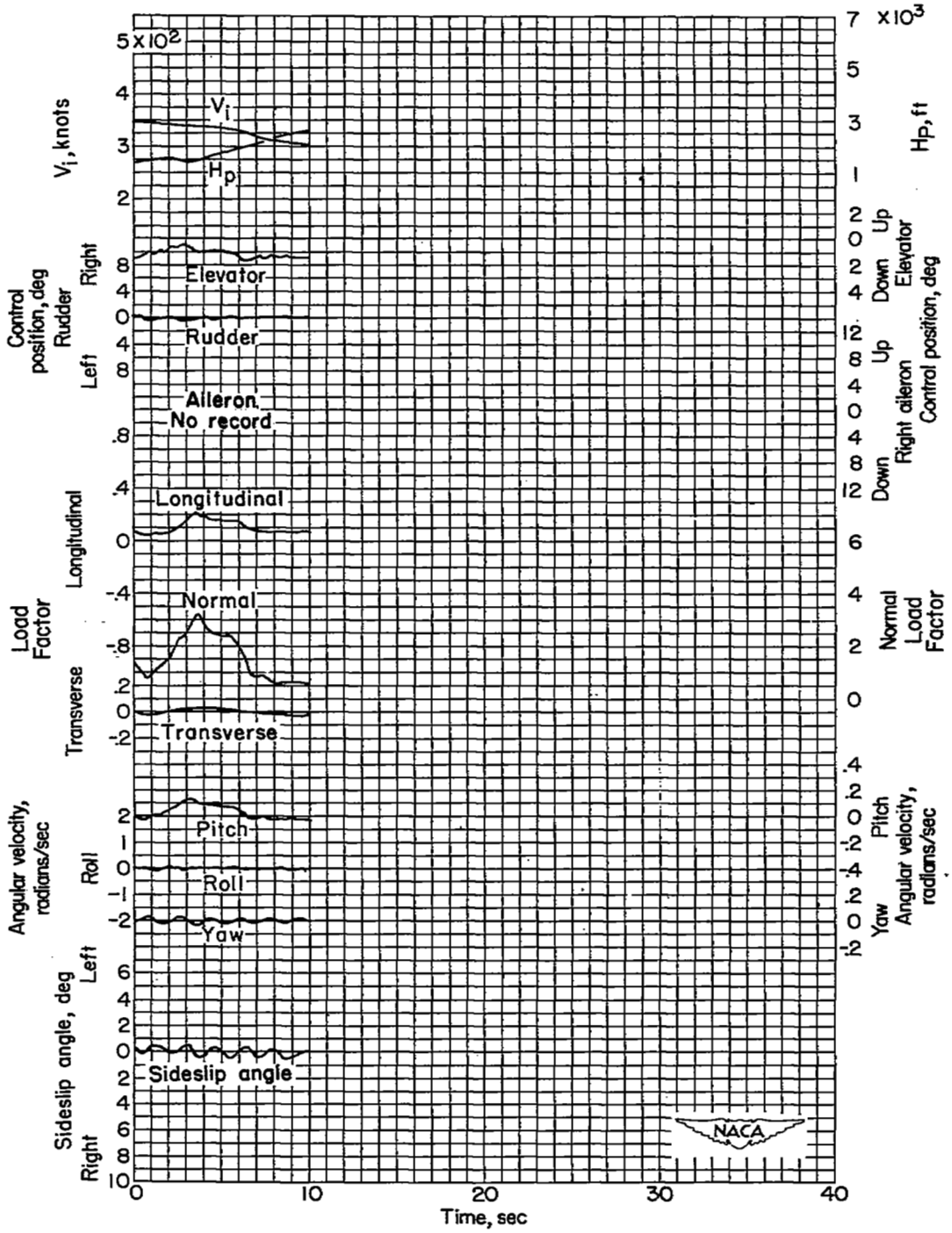


Figure 85.- Pull-up; airplane weight, 17,250 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

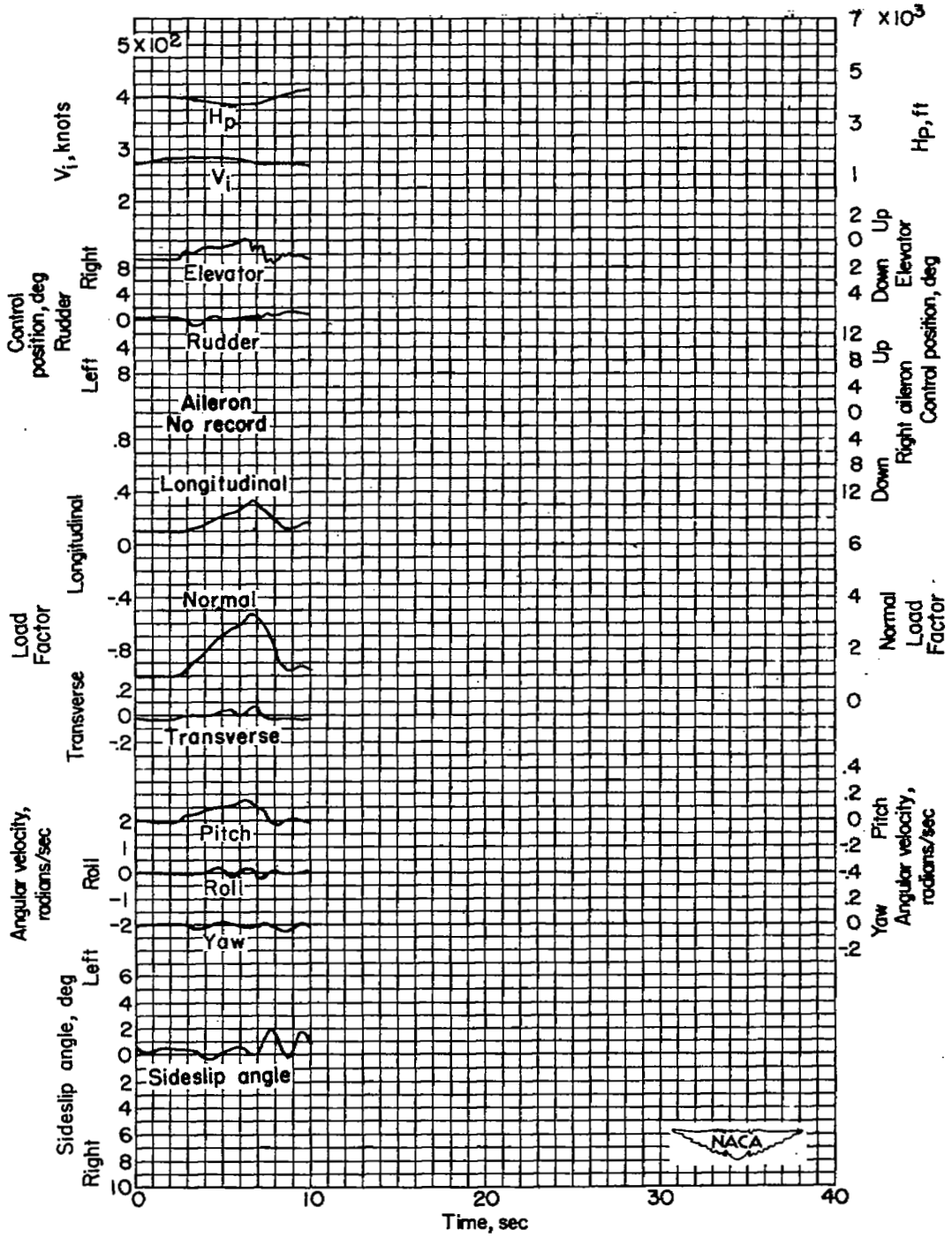


Figure 86.- Pull-up; airplane weight, 17,200 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

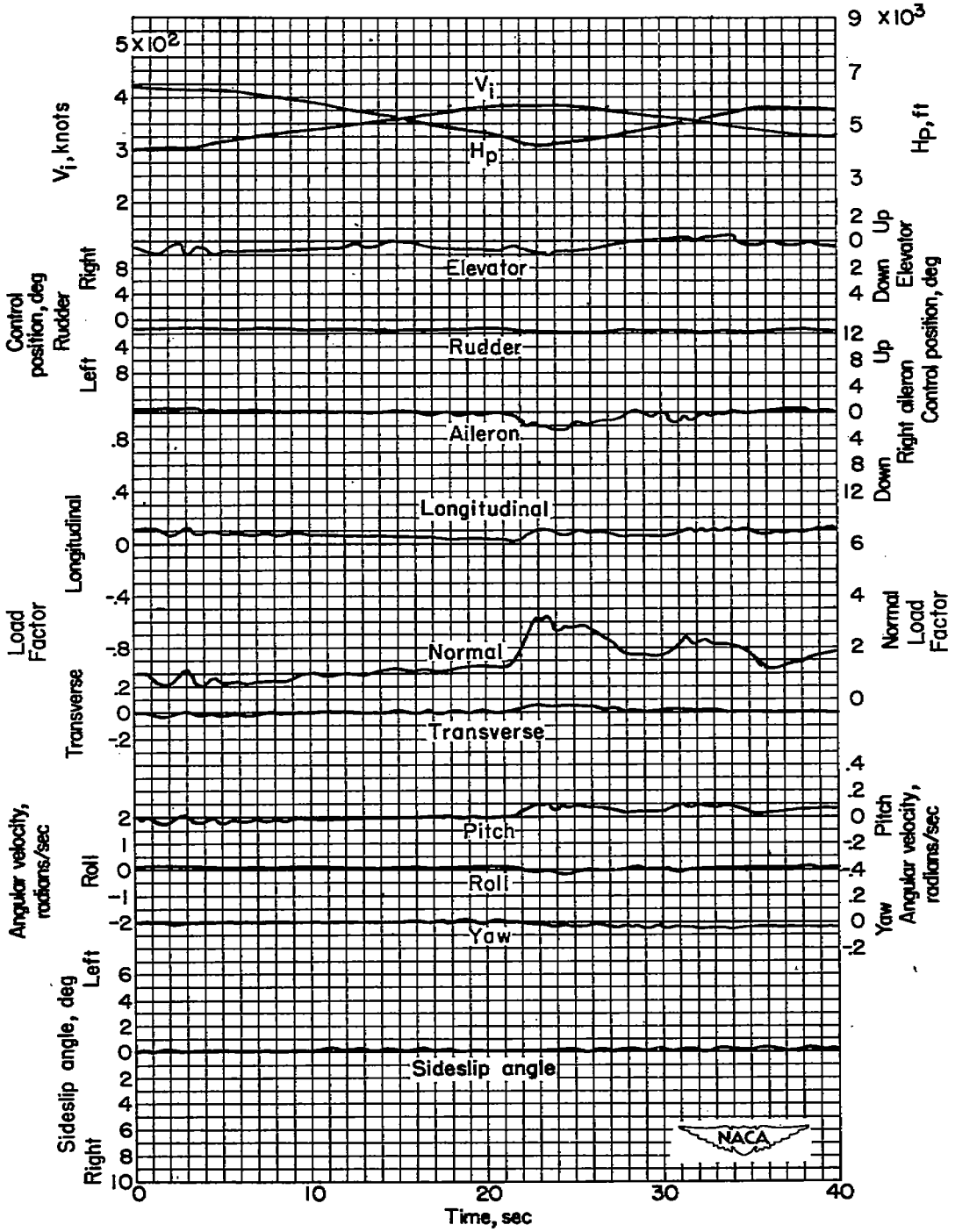
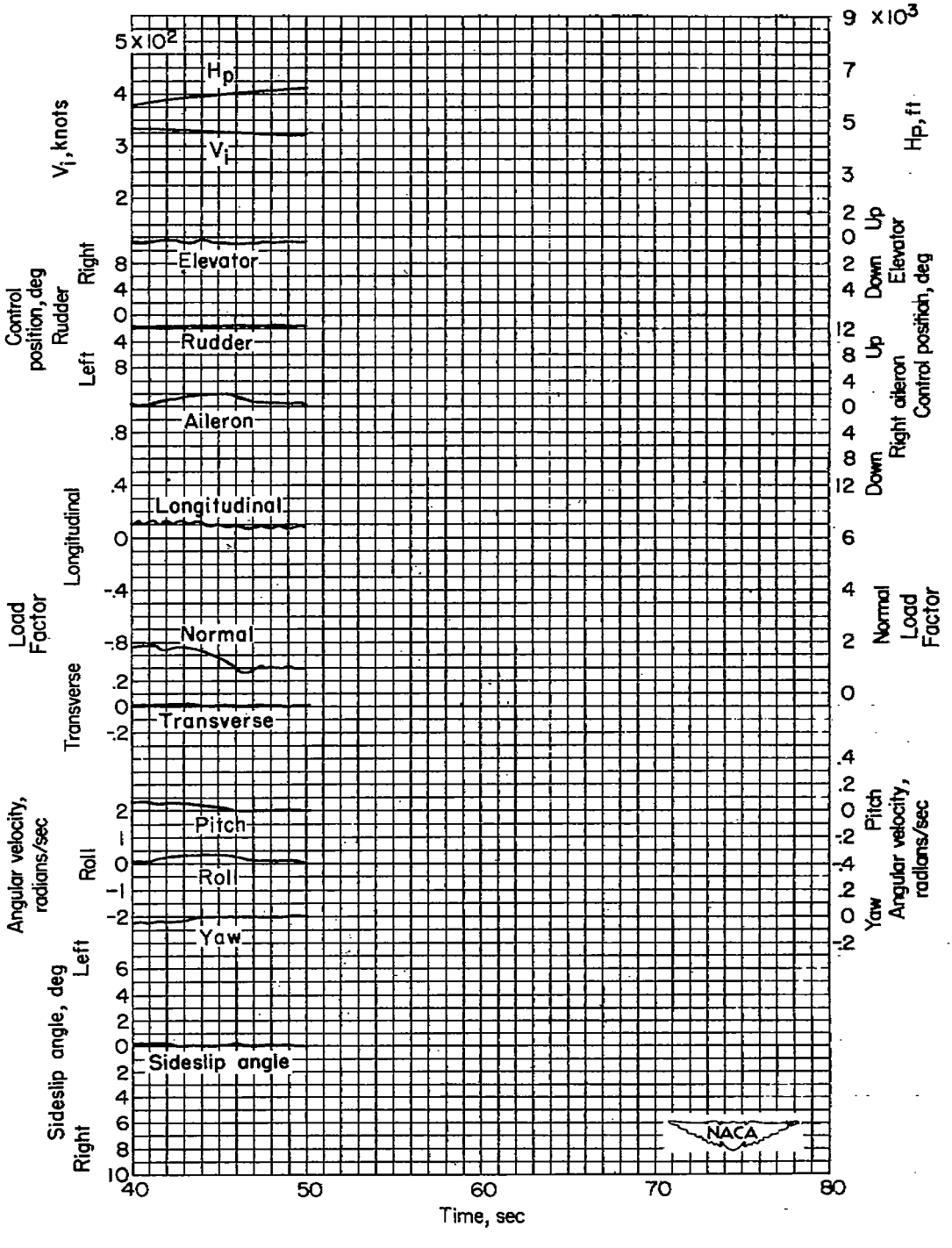


Figure 87.- Pull-up; airplane weight, 15,050 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.



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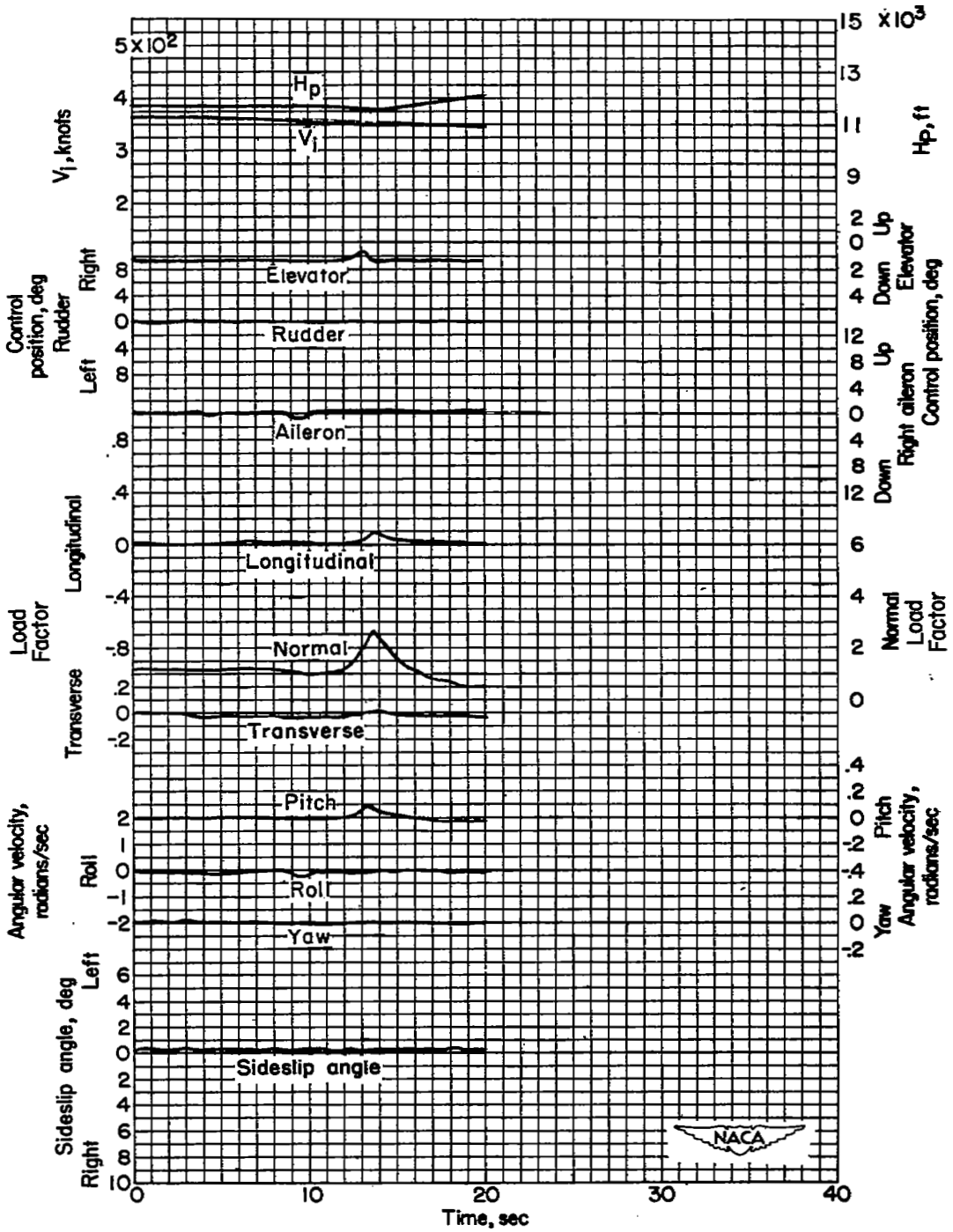

Figure 88.- Abrupt pull-up; airplane weight, 14,150 pounds; center-of-gravity location, 26.1 percent of the mean aerodynamic chord.

[redacted]

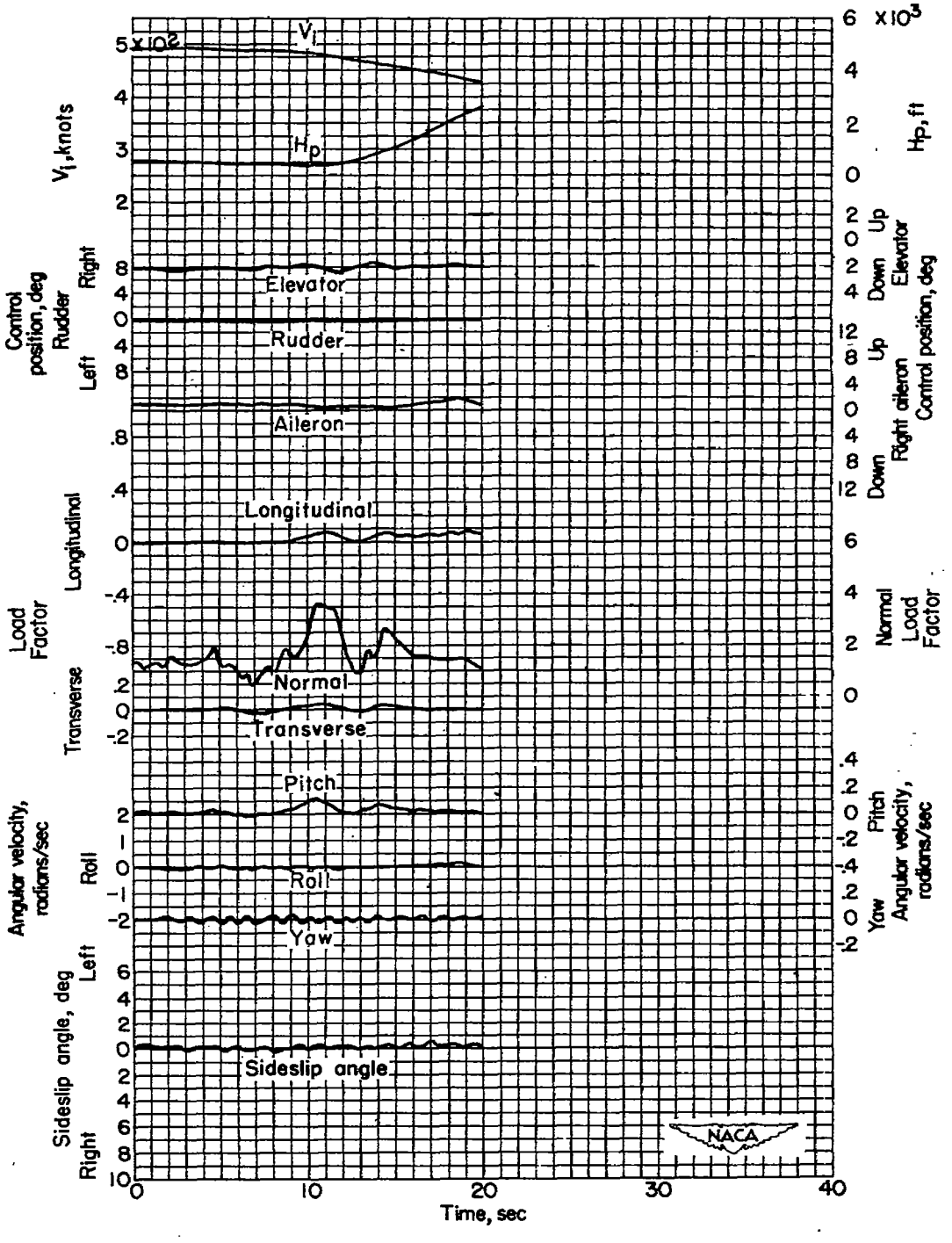

Figure 89.- Abrupt pull-up; airplane weight, 16,430 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

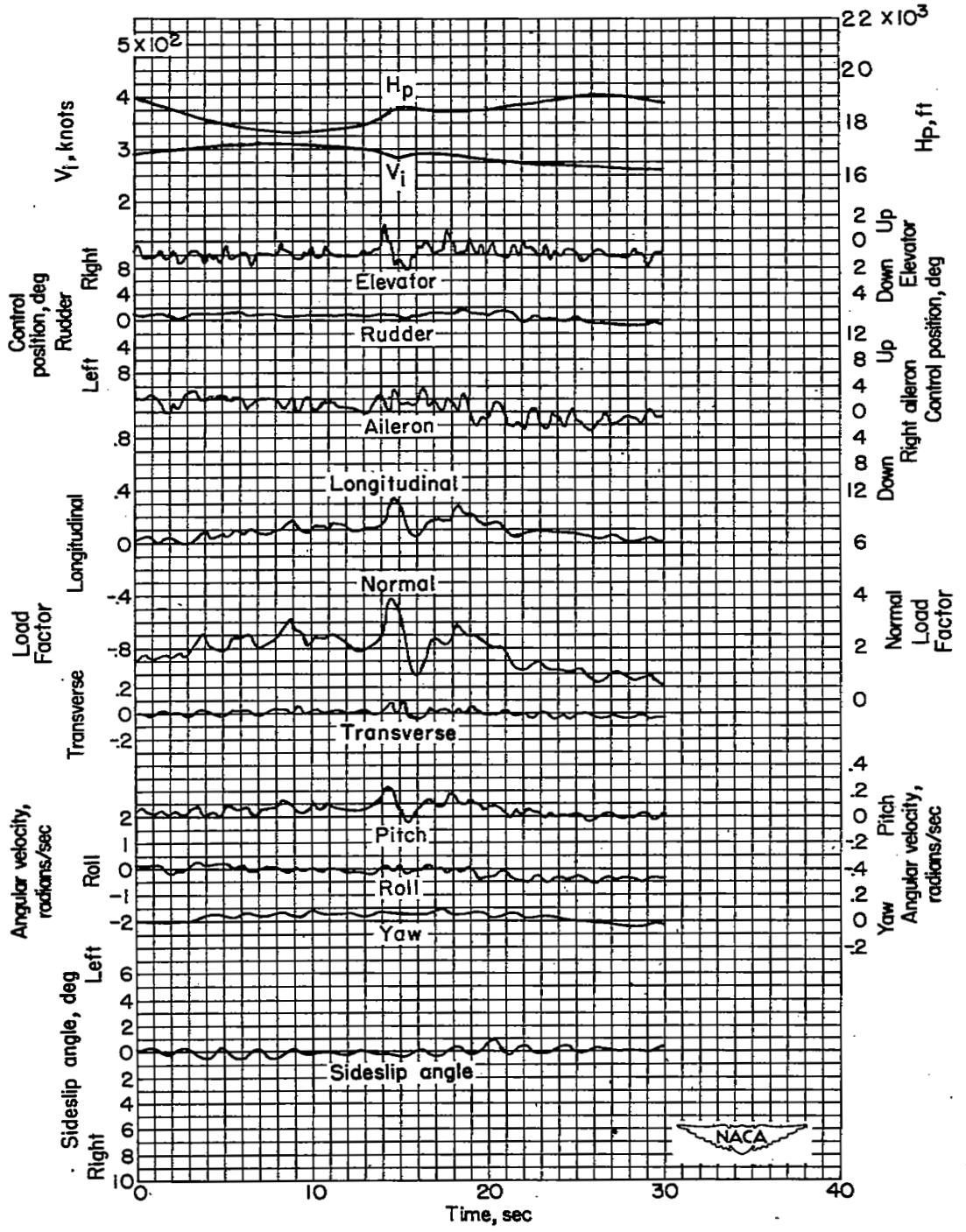

Figure 90.- Abrupt pull-up; airplane weight, 17,850 pounds; center-of-gravity location, 26.8 percent of the mean aerodynamic chord.

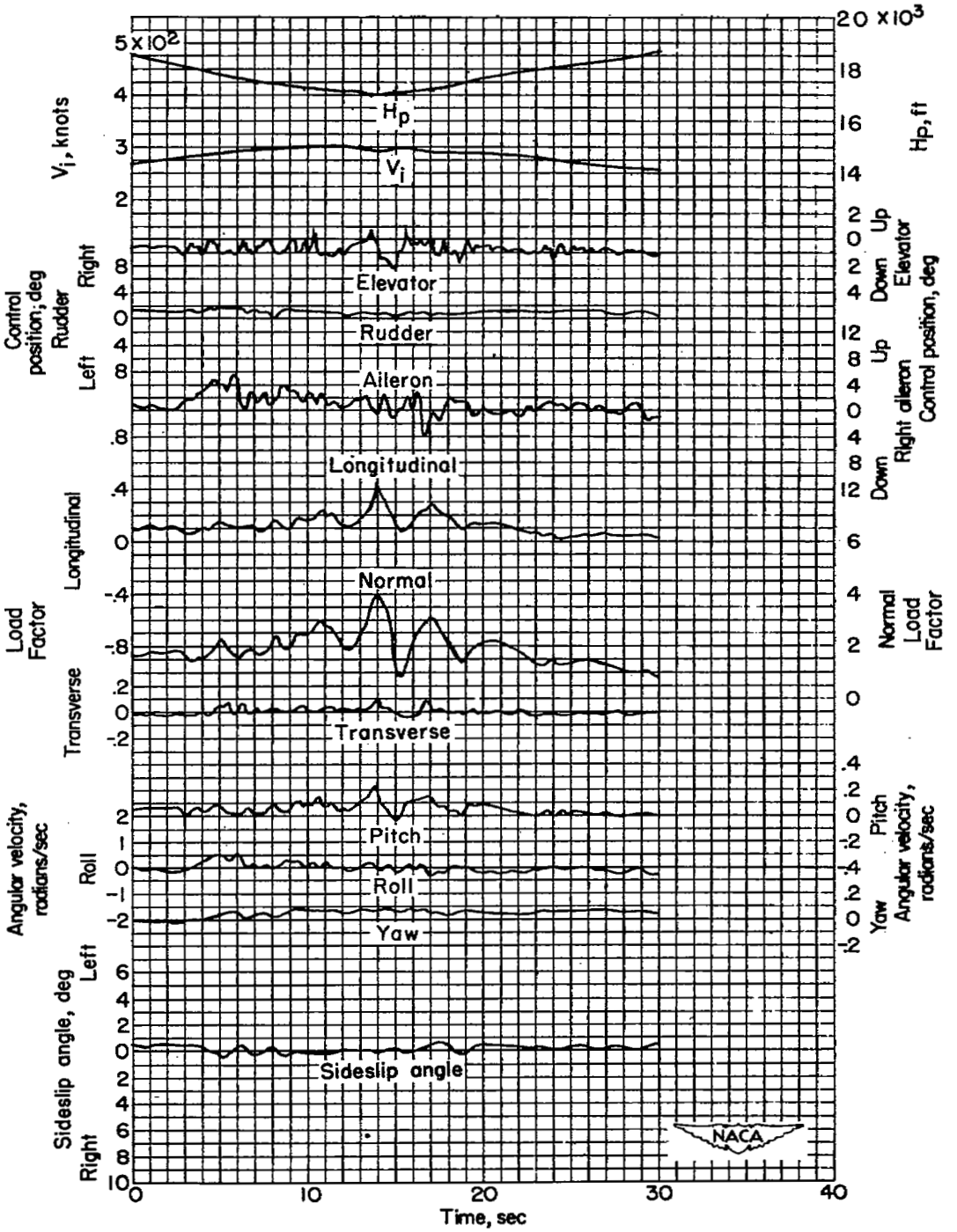

Figure 91.- Abrupt pull-up; airplane weight, 17,800 pounds; center-of-gravity location, 26.8 percent of the mean aerodynamic chord.

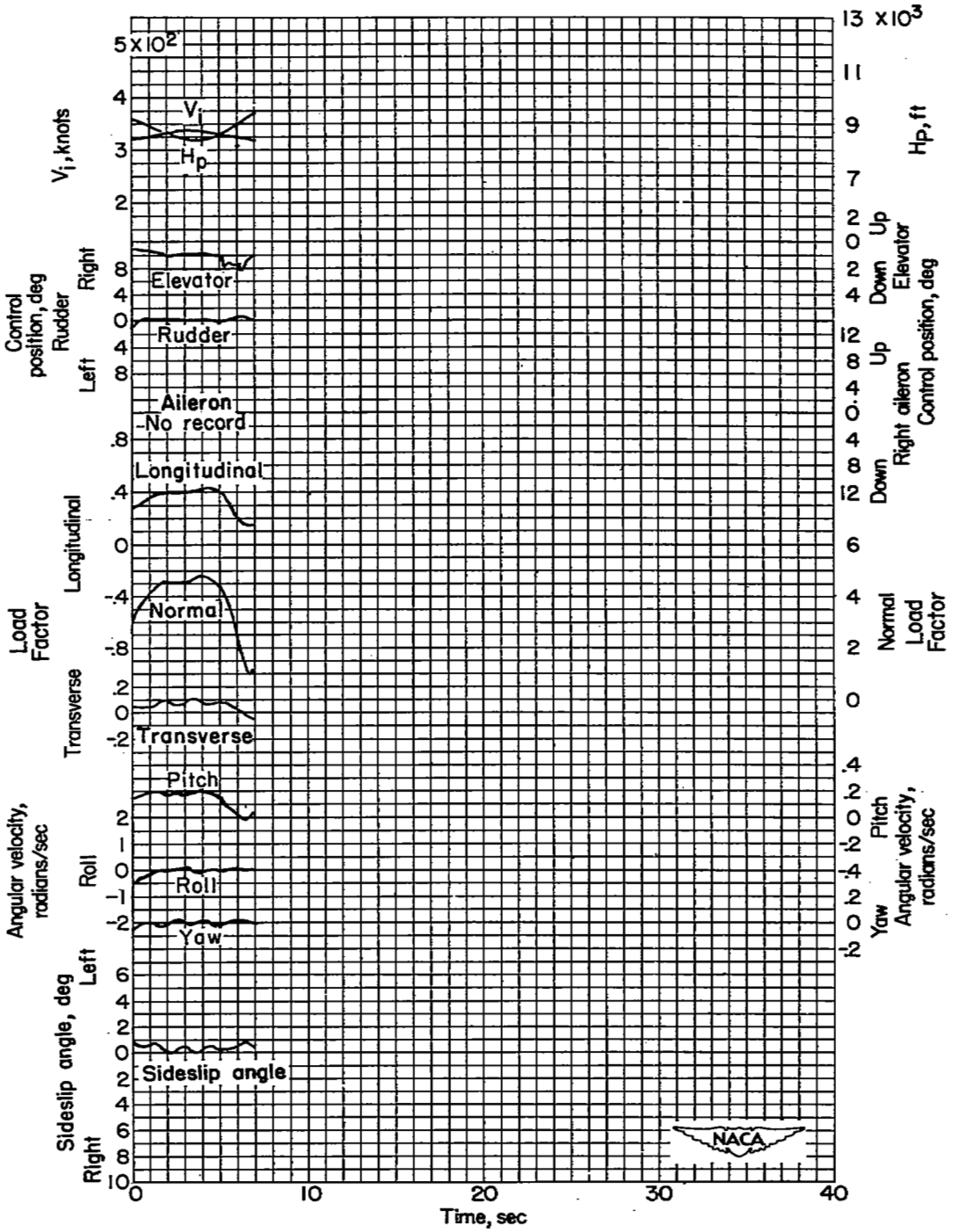

Figure 92.- Abrupt pull-up; airplane weight, 17,090 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

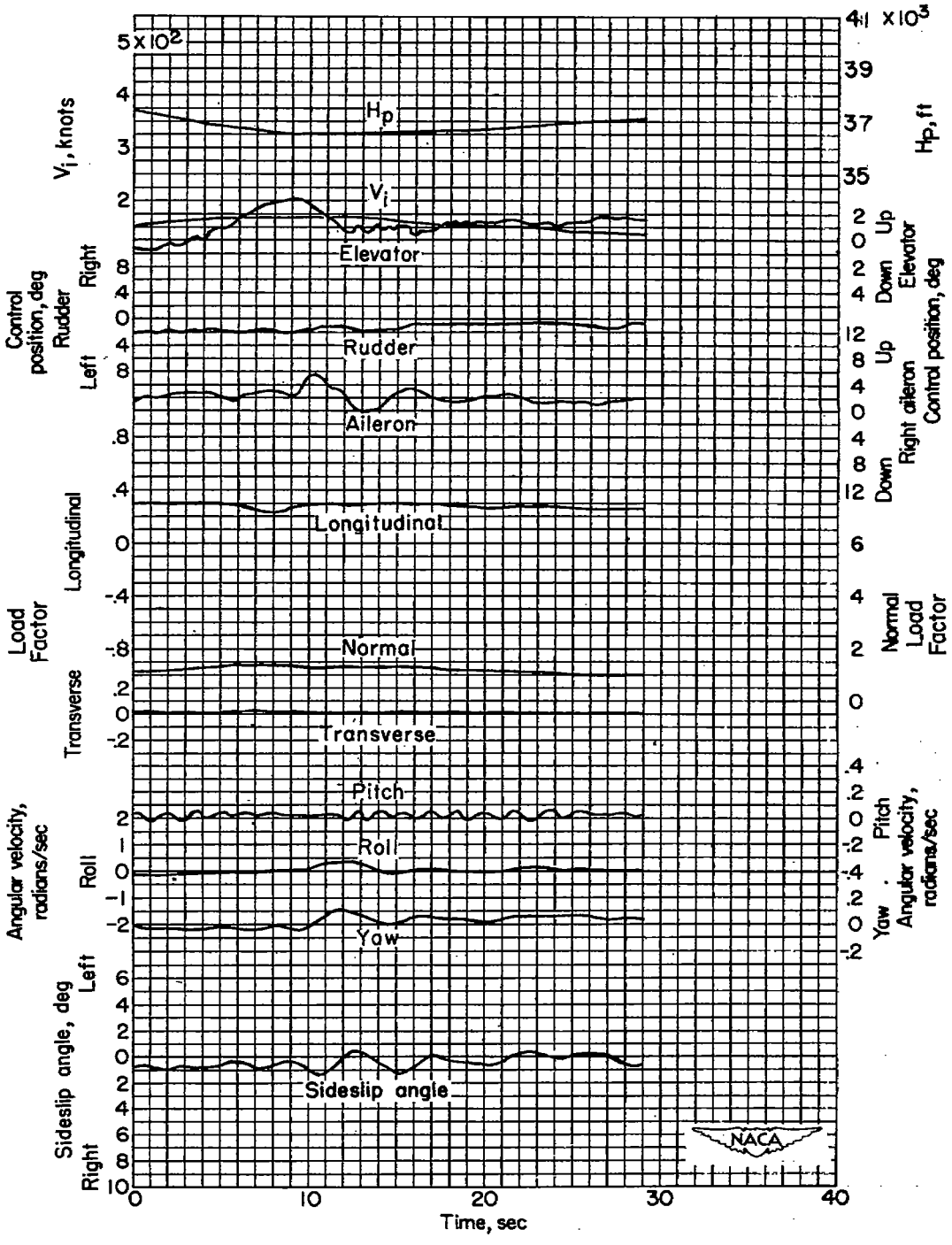

Figure 93.- Rolling pull-out; airplane weight, 15,940 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

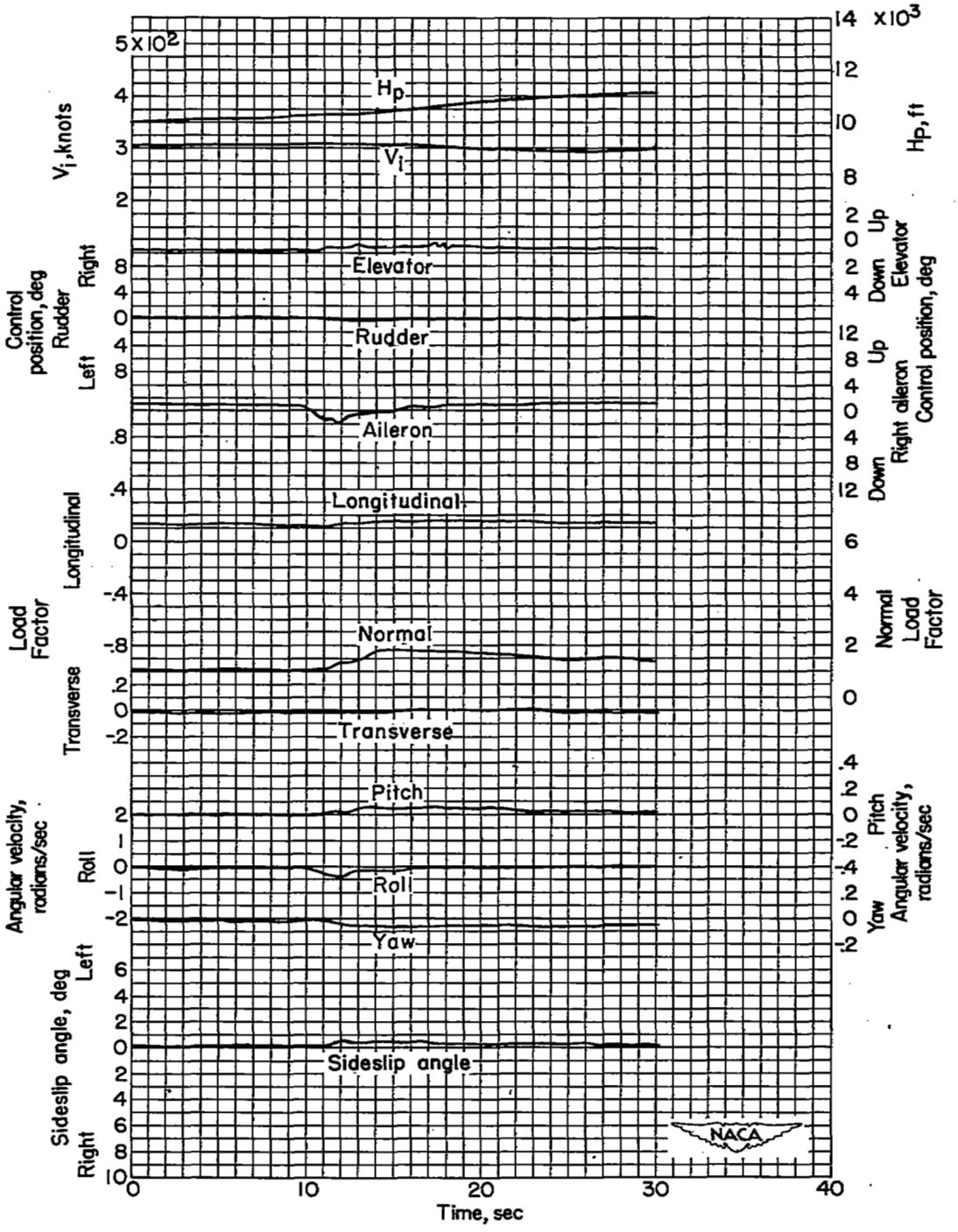

Figure 94.- Rolling pull-up; airplane weight, 14,500 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

[redacted]

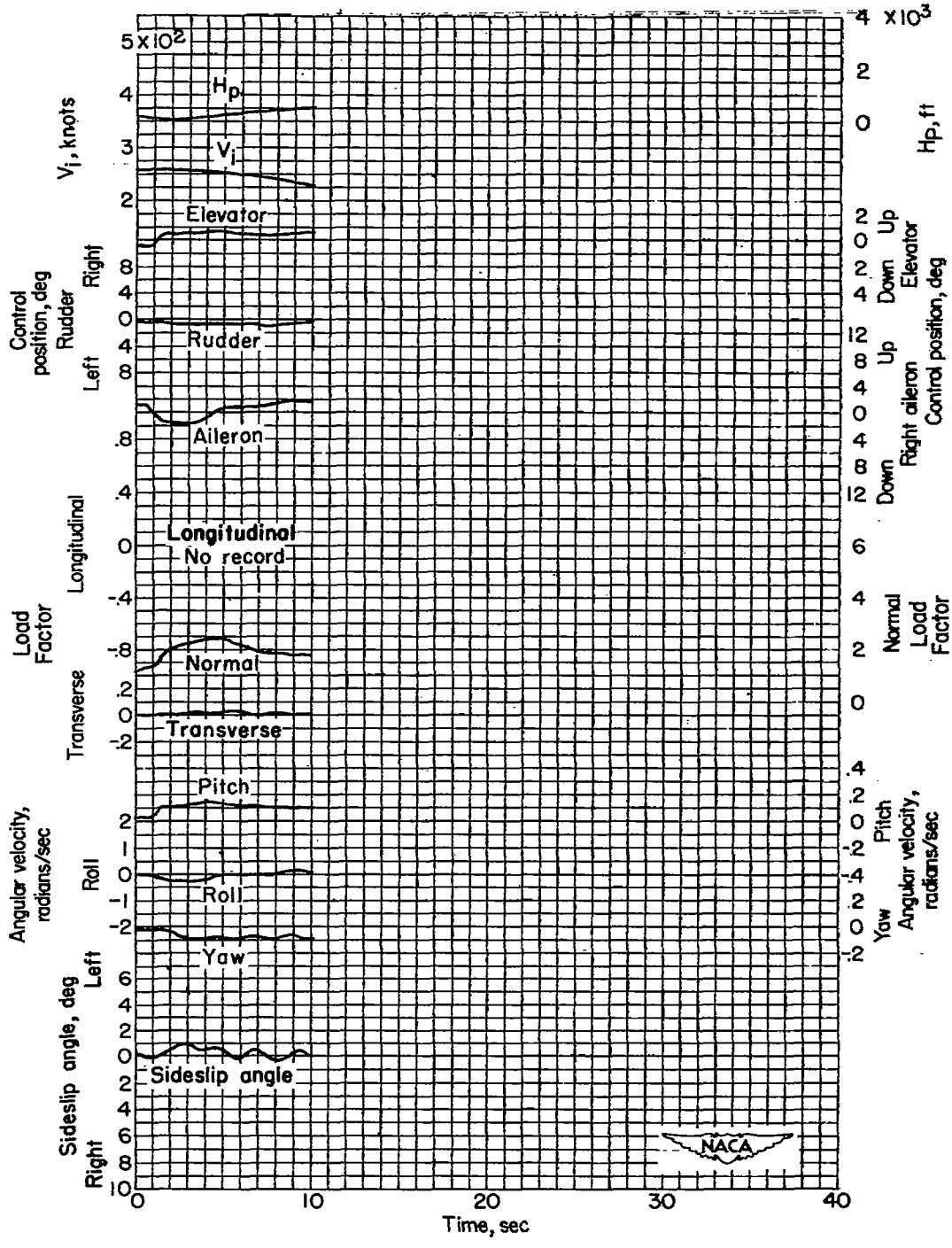

Figure 95.- Rolling pull-up; airplane weight, 15,560 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

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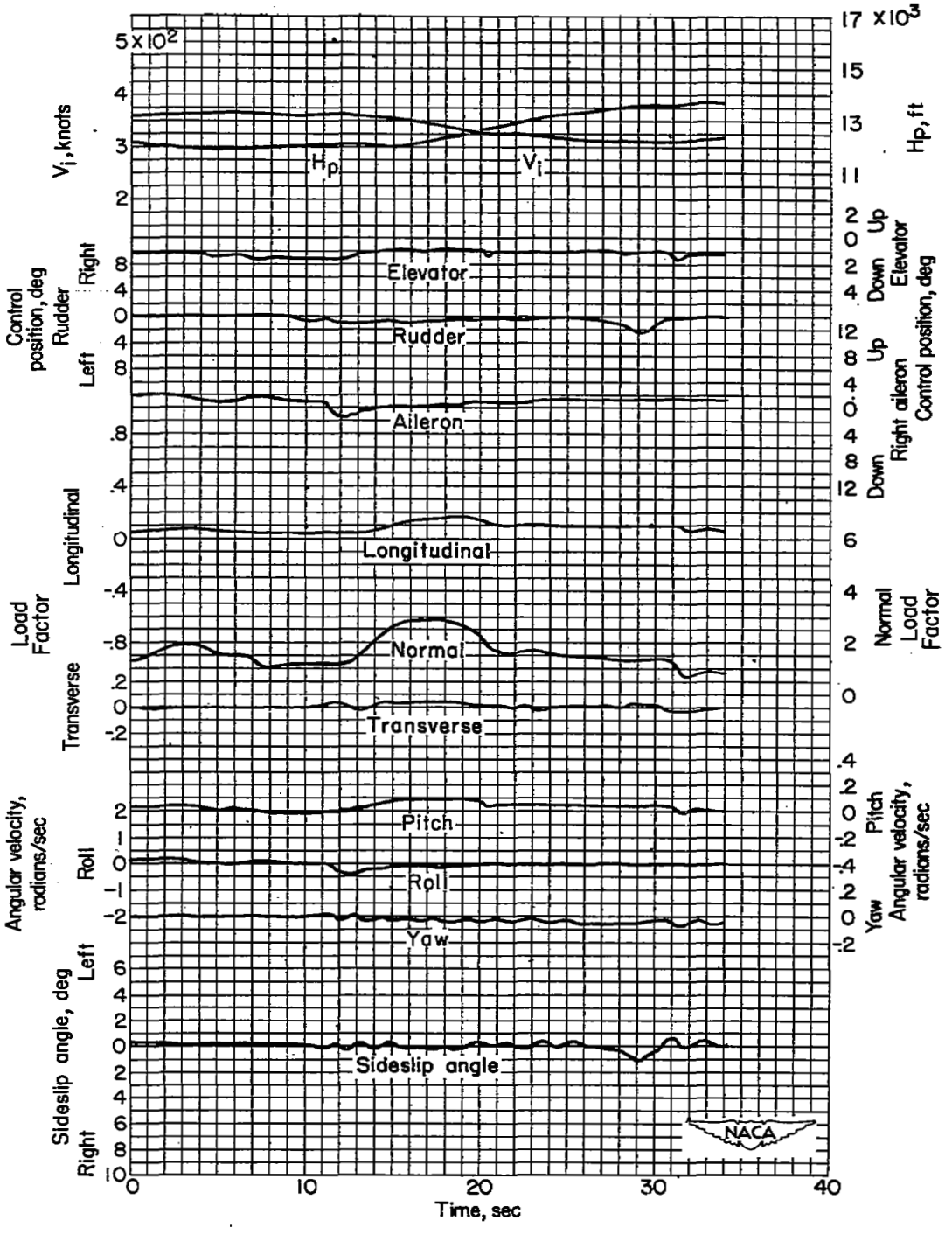


Figure 96.- Gentle rolling pull-up; airplane weight, 16,440 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

[redacted]

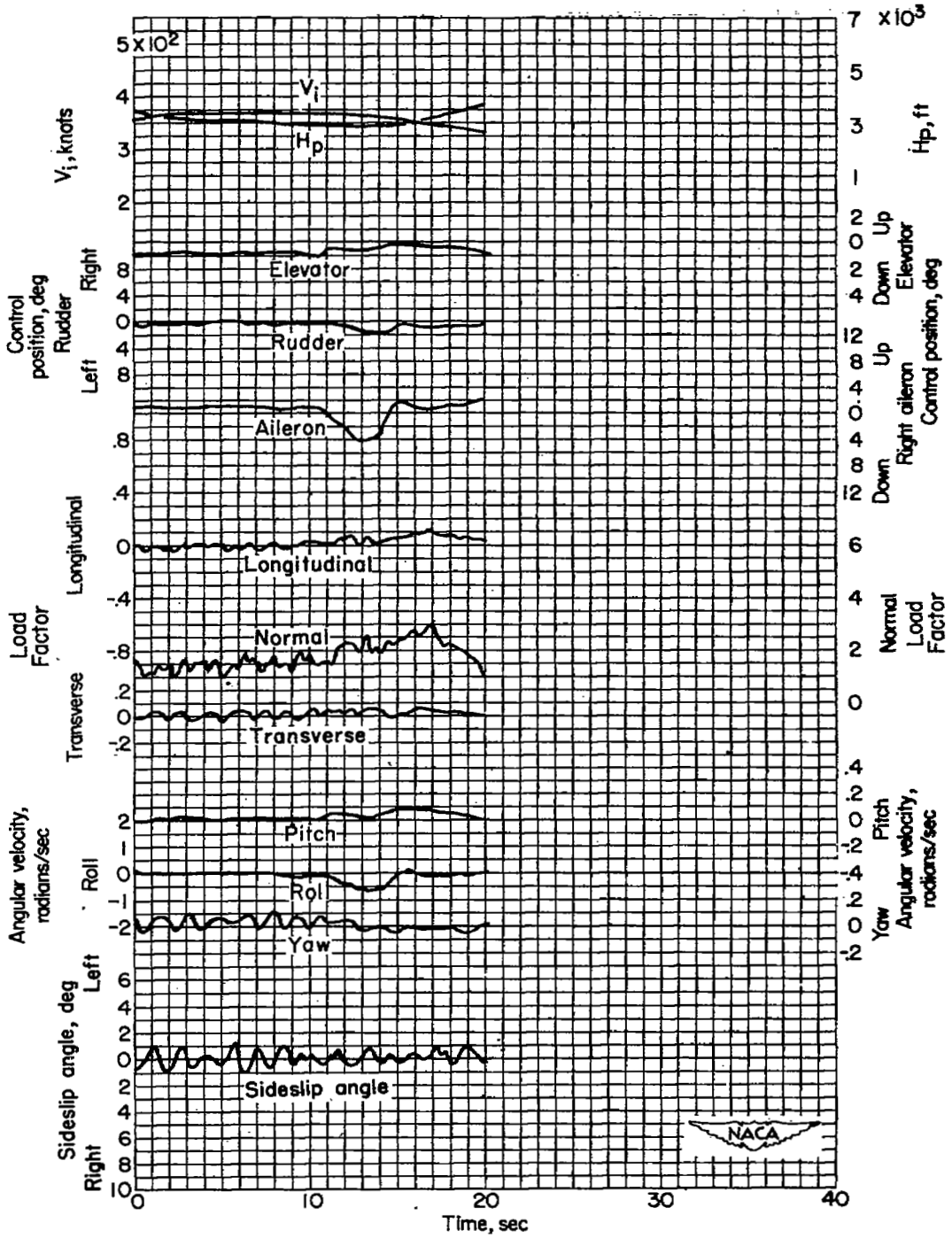


Figure 97.- Gentle rolling pull-up; airplane weight, 15,470 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

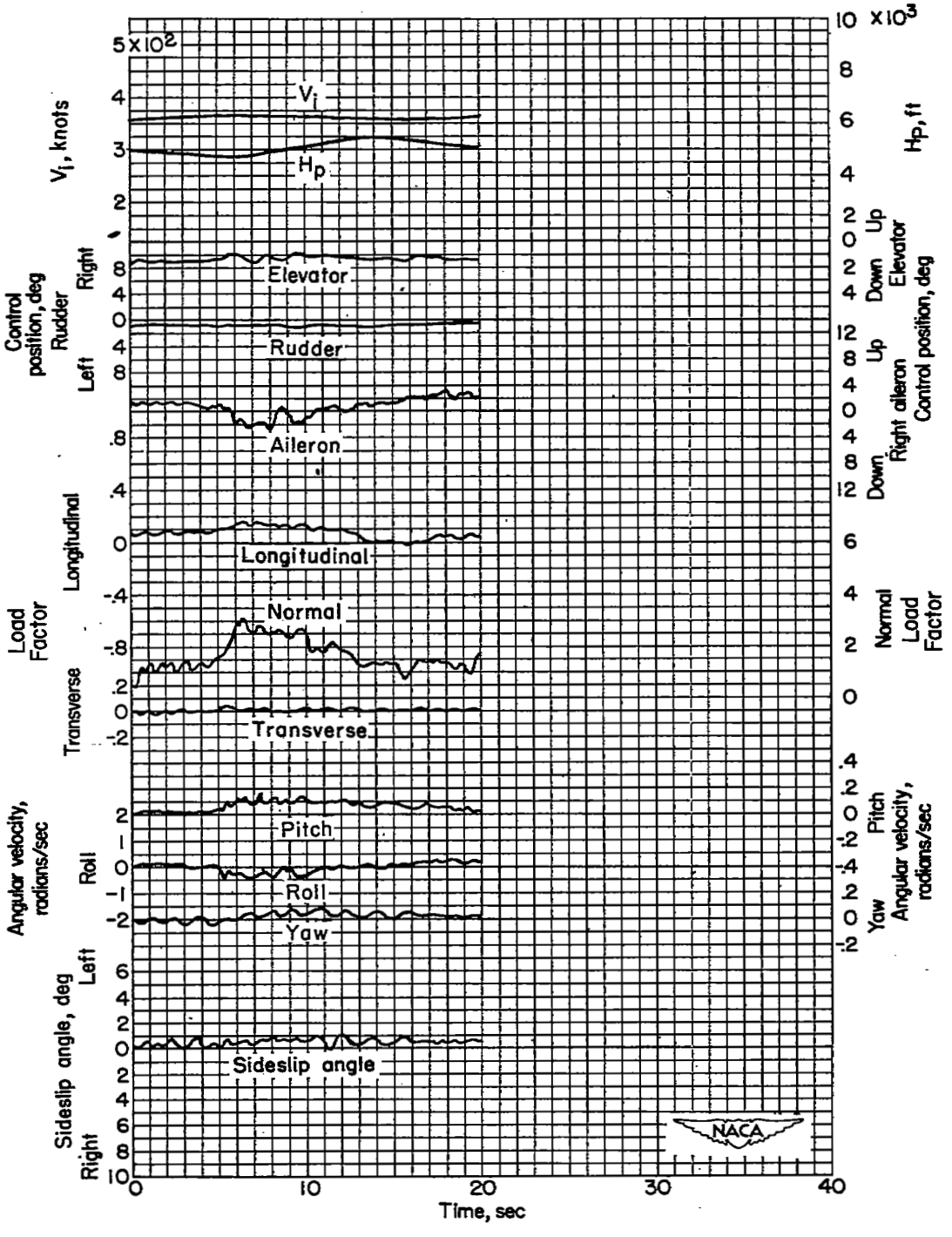


Figure 98.- Gentle rolling pull-up; airplane weight, 14,840 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

[redacted]

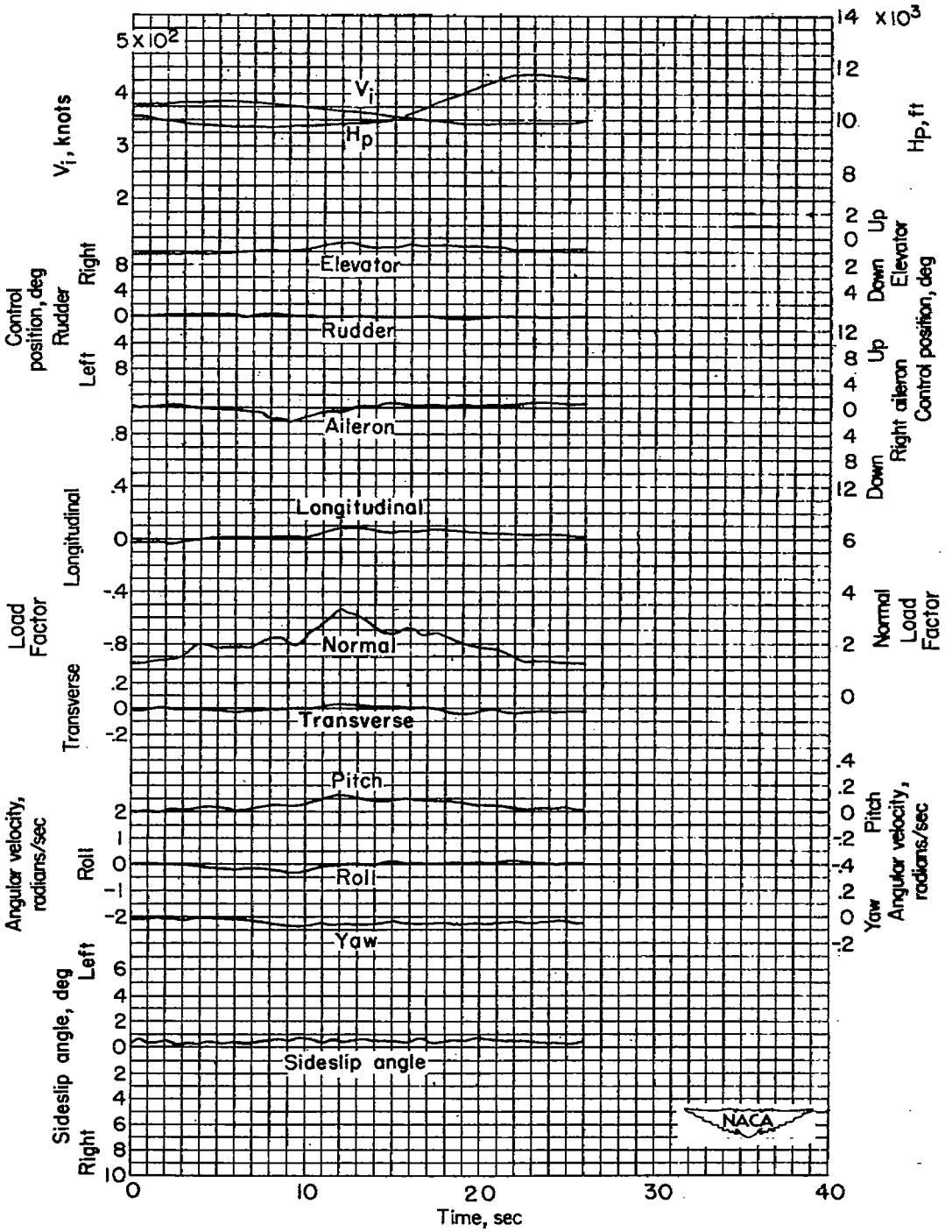


Figure 99.- Rolling pull-up; airplane weight, 14,030 pounds; center-of-gravity location, 26.1 percent of the mean aerodynamic chord.

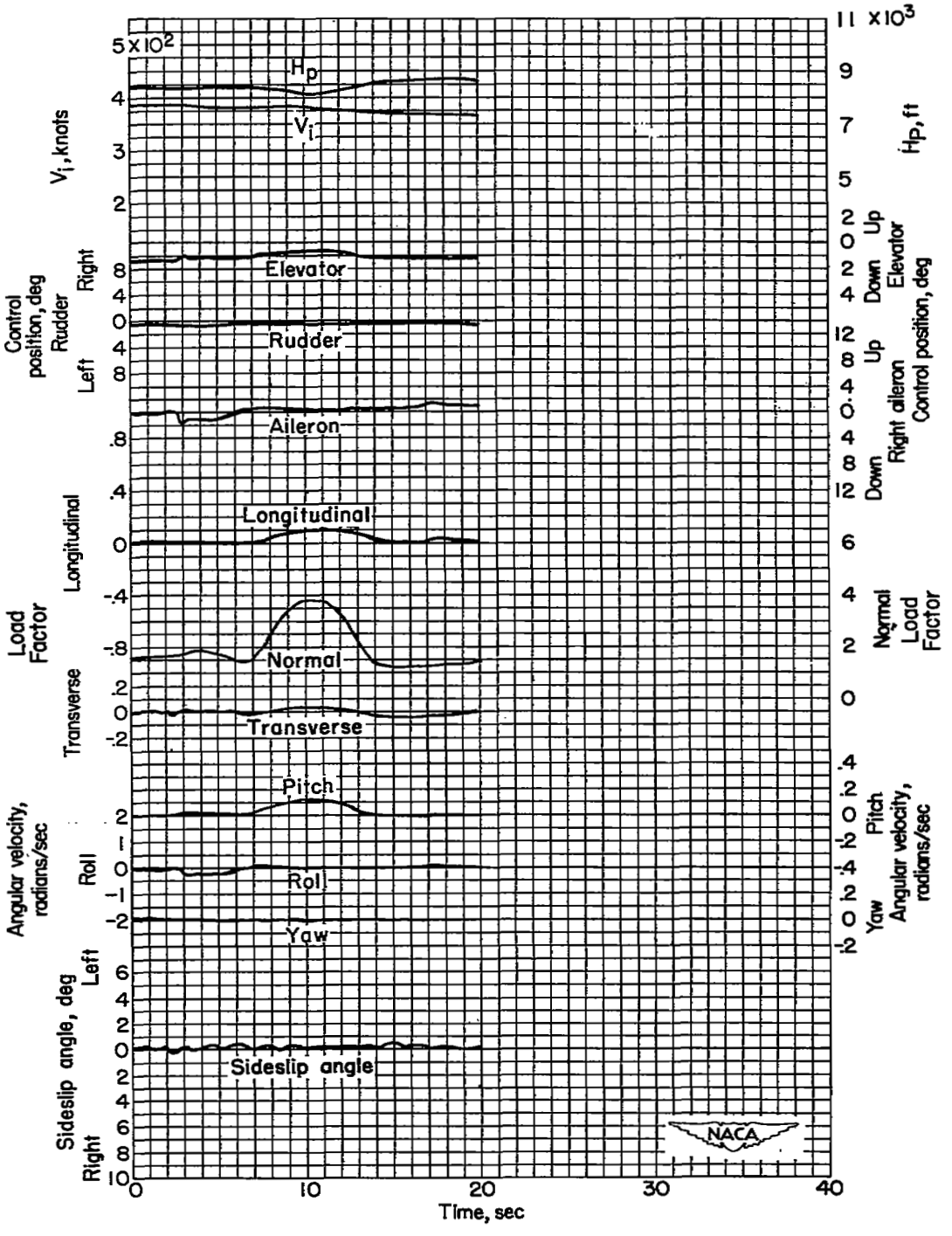


Figure 100.- Rolling pull-up; airplane weight, 15,770 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

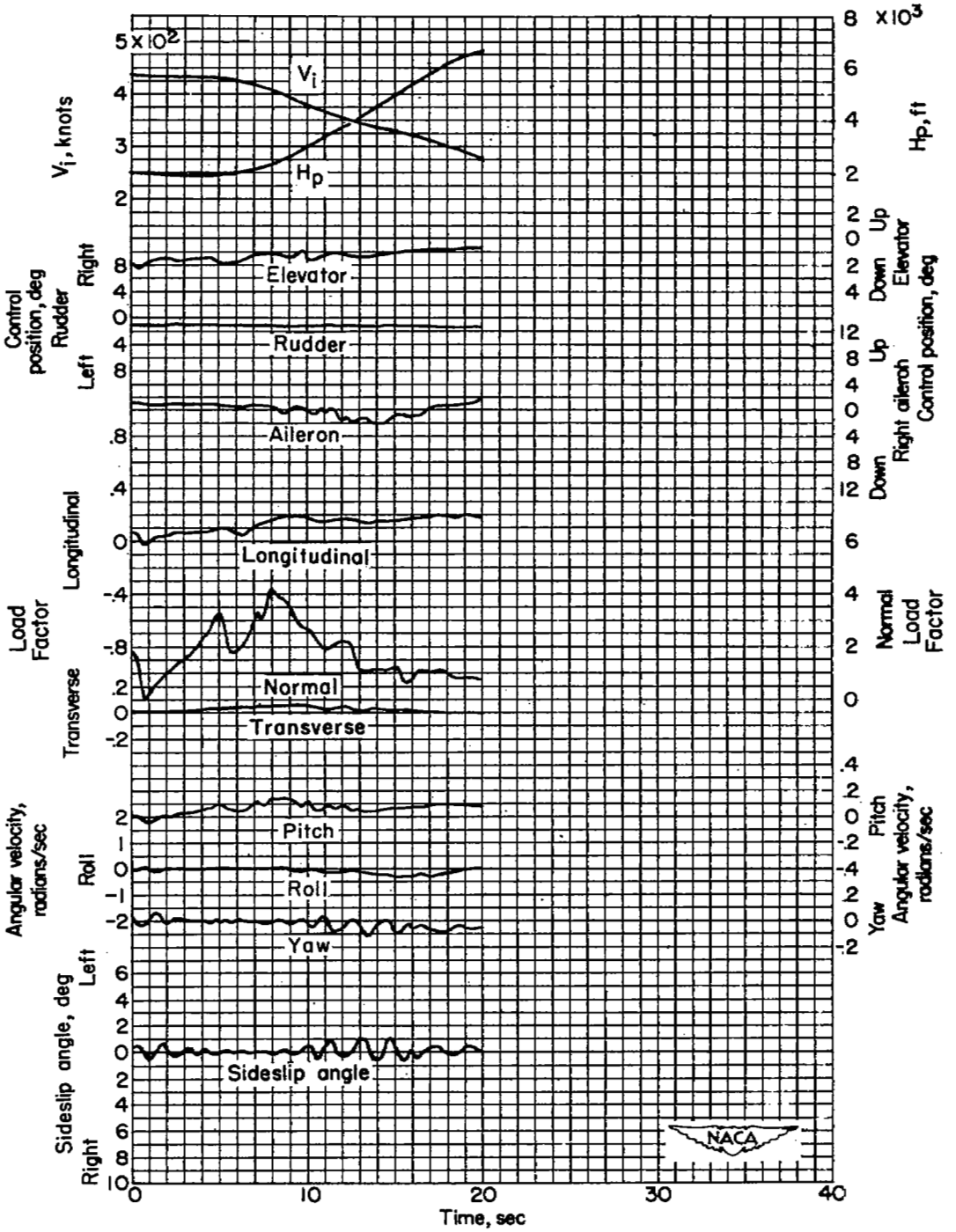


Figure 101.- Abrupt rolling pull-up; airplane weight, 14,505 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

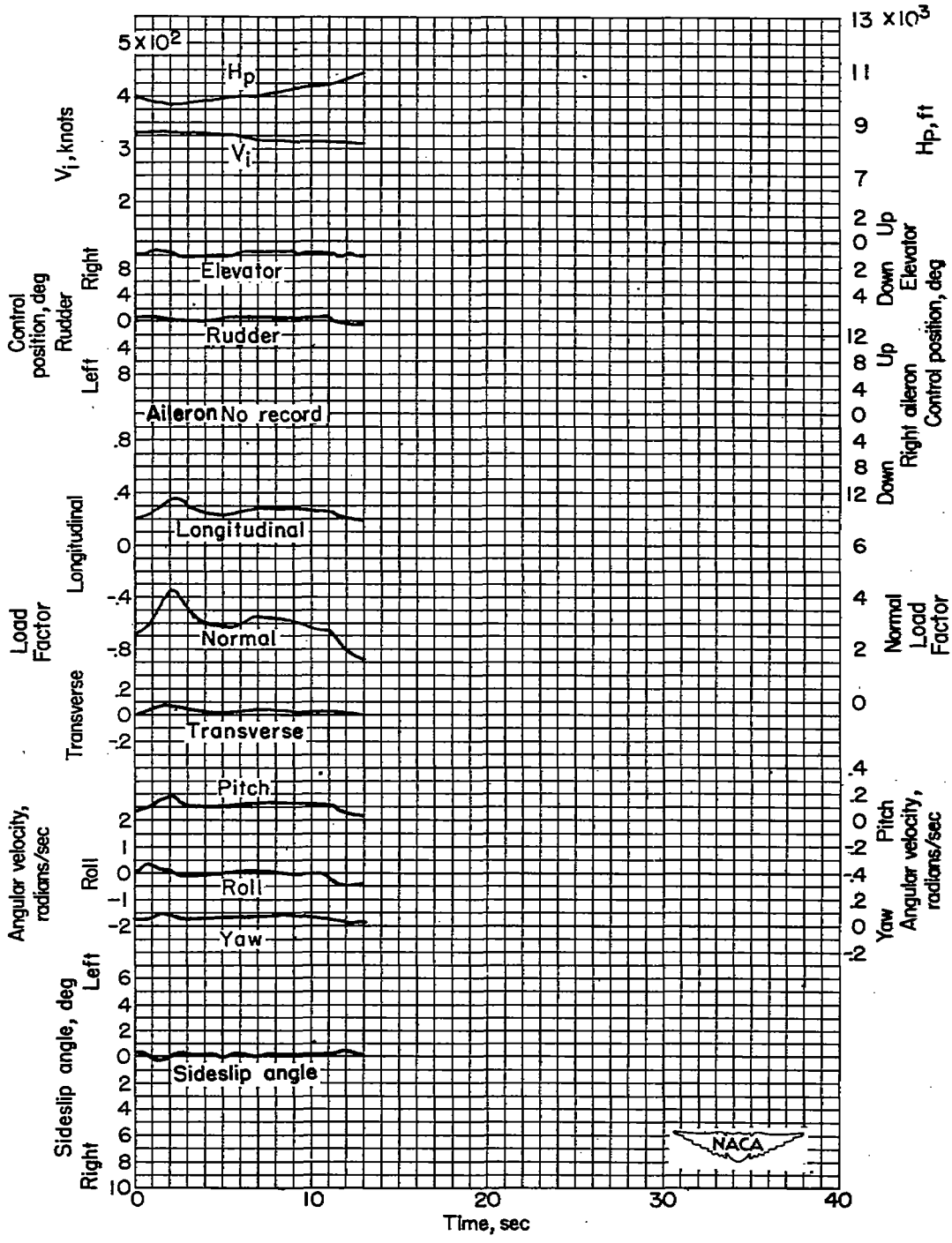


Figure 102.- Rolling pull-out; airplane weight, 17,000 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

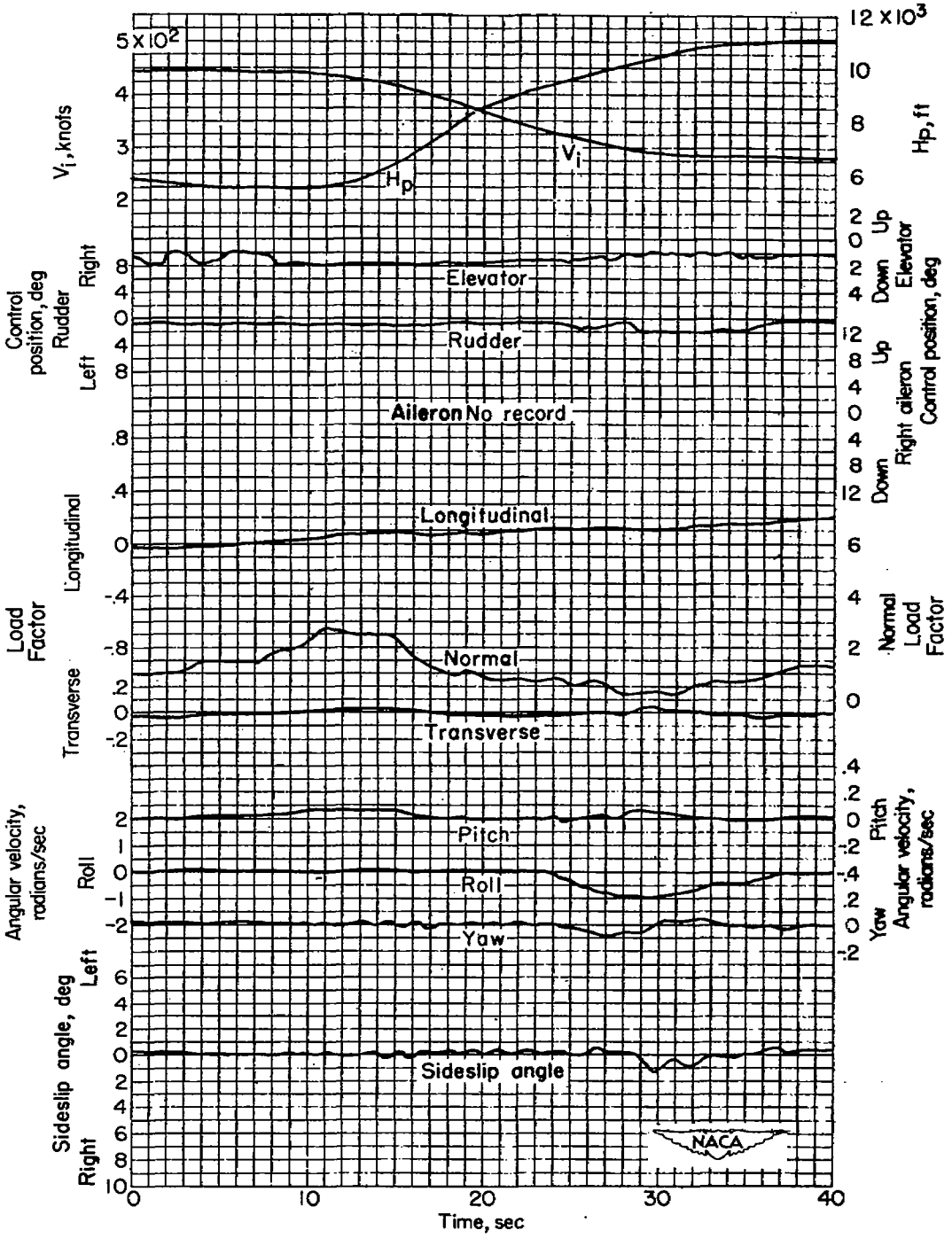


Figure 103.- Pull-up with left slow roll recovery; airplane weight, 16,460 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

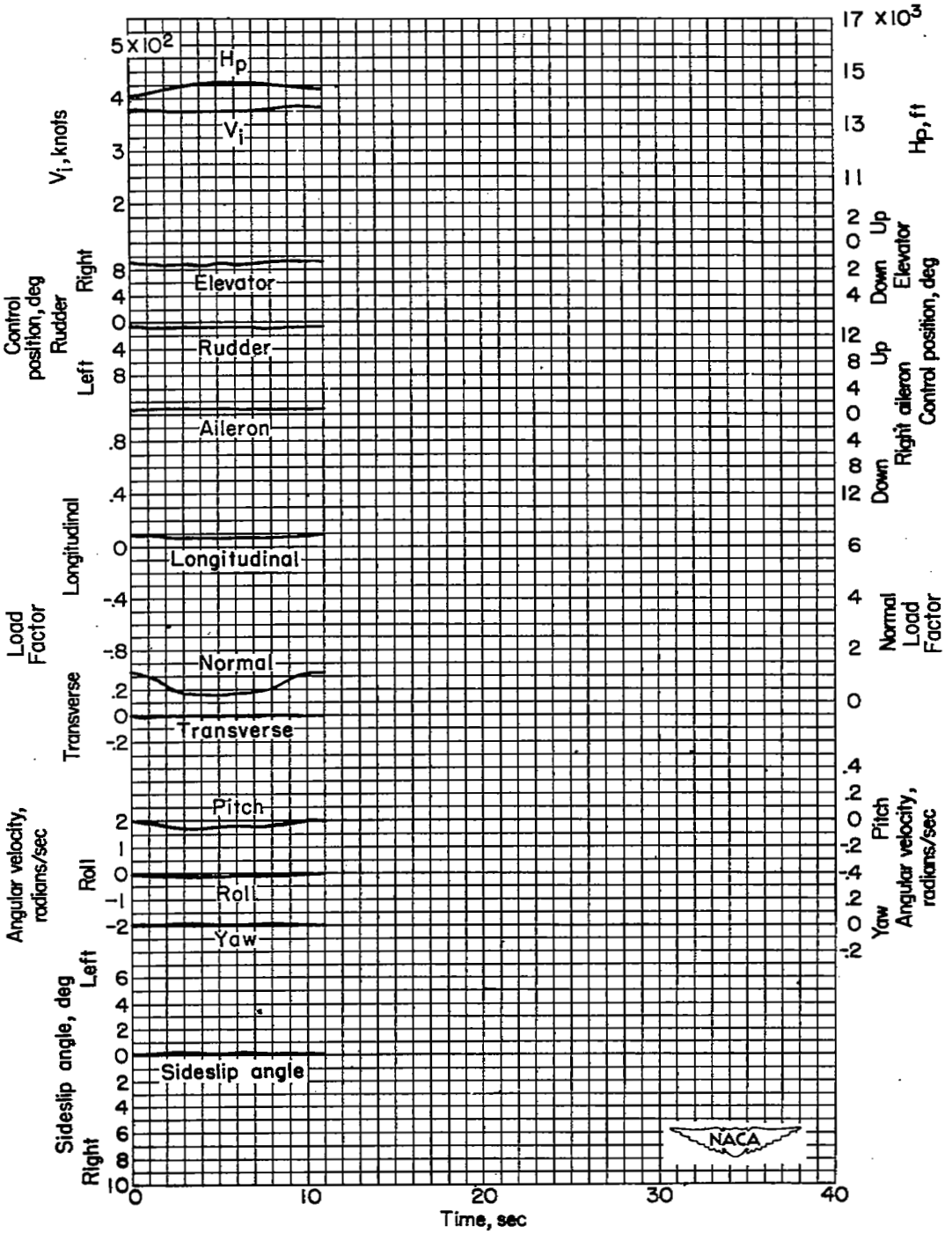


Figure 104.- Push-over; airplane weight, 16,640 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

[redacted]

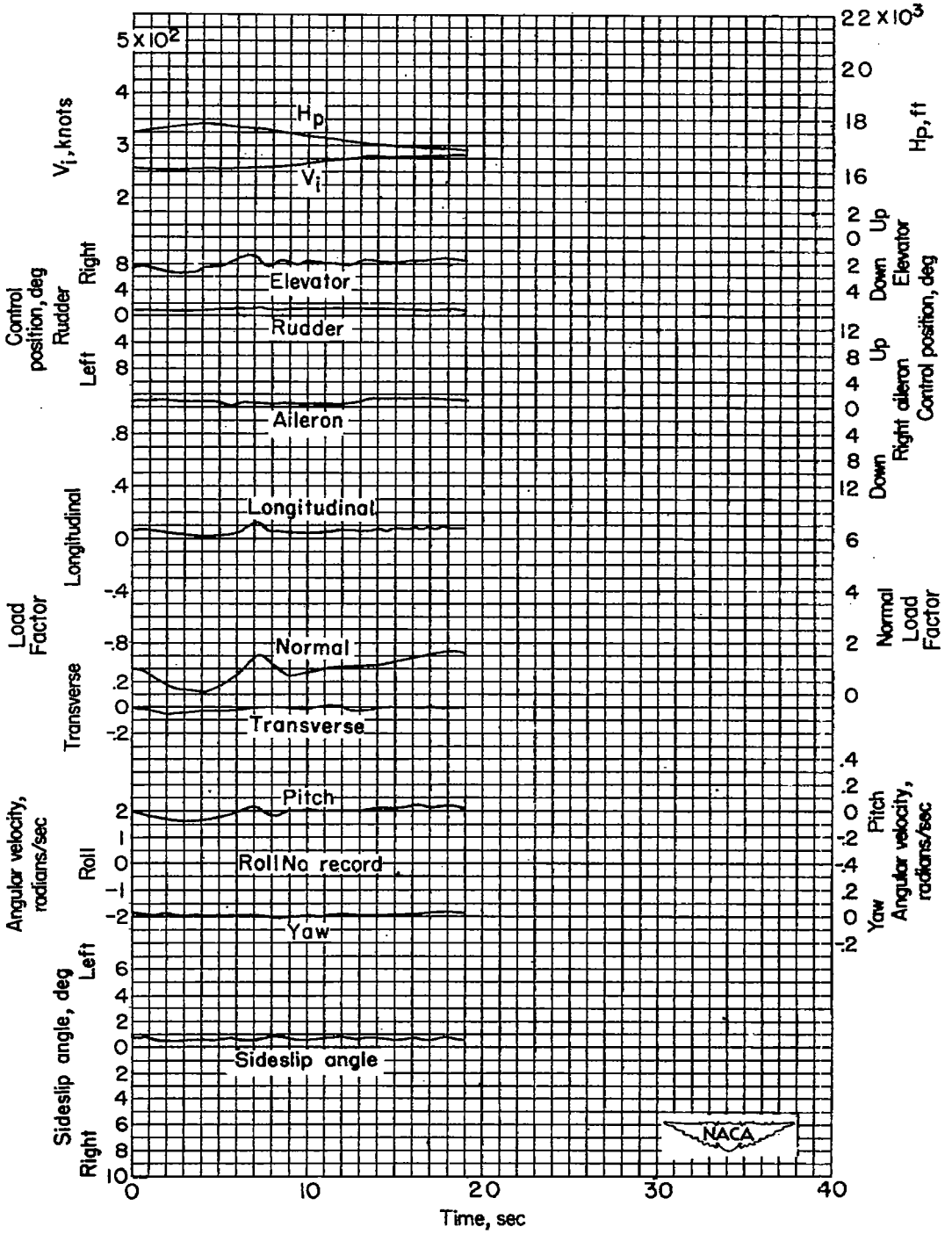


Figure 105.- Push-over; airplane weight, 16,400 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

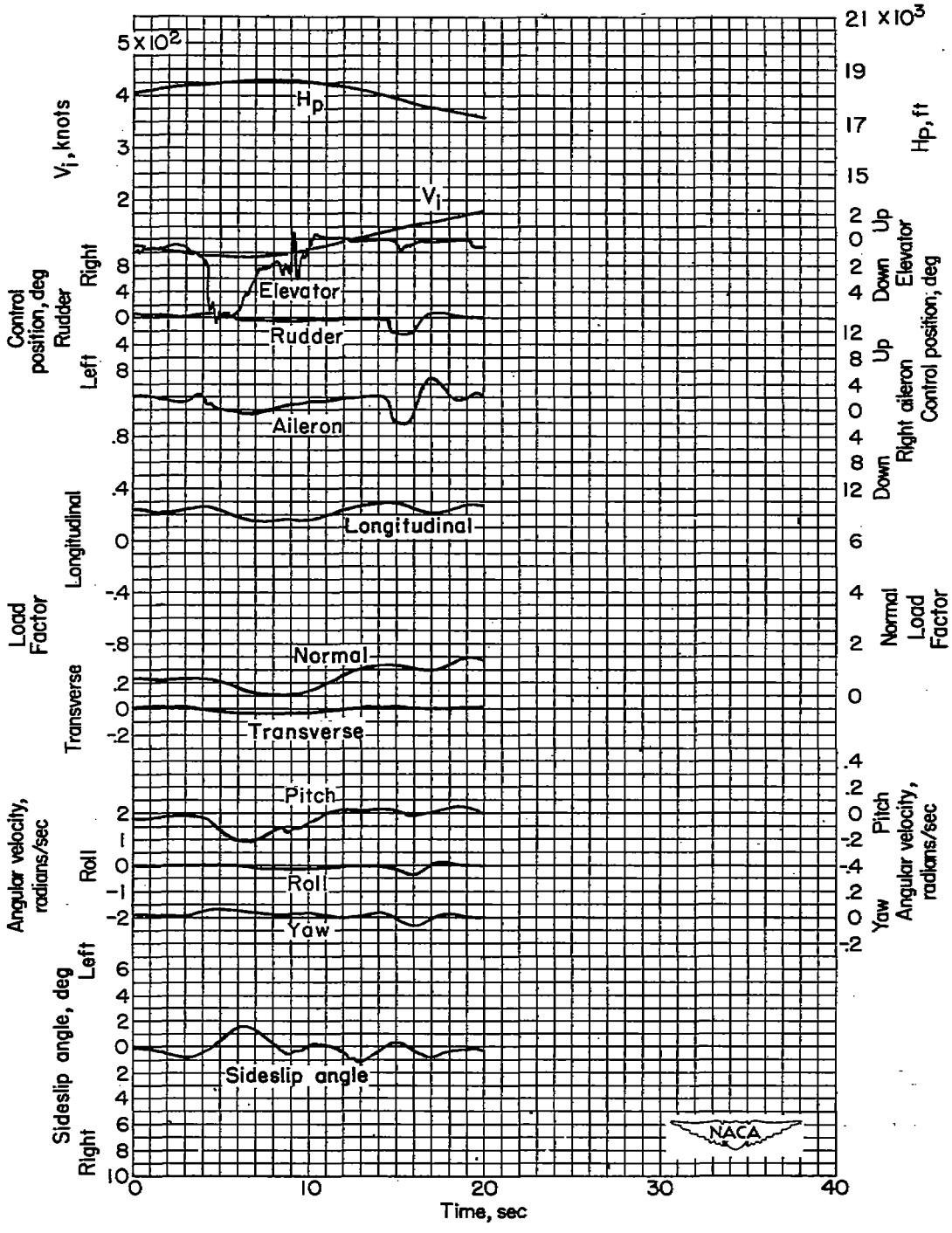


Figure 106.- Push-over; airplane weight, 16,950 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

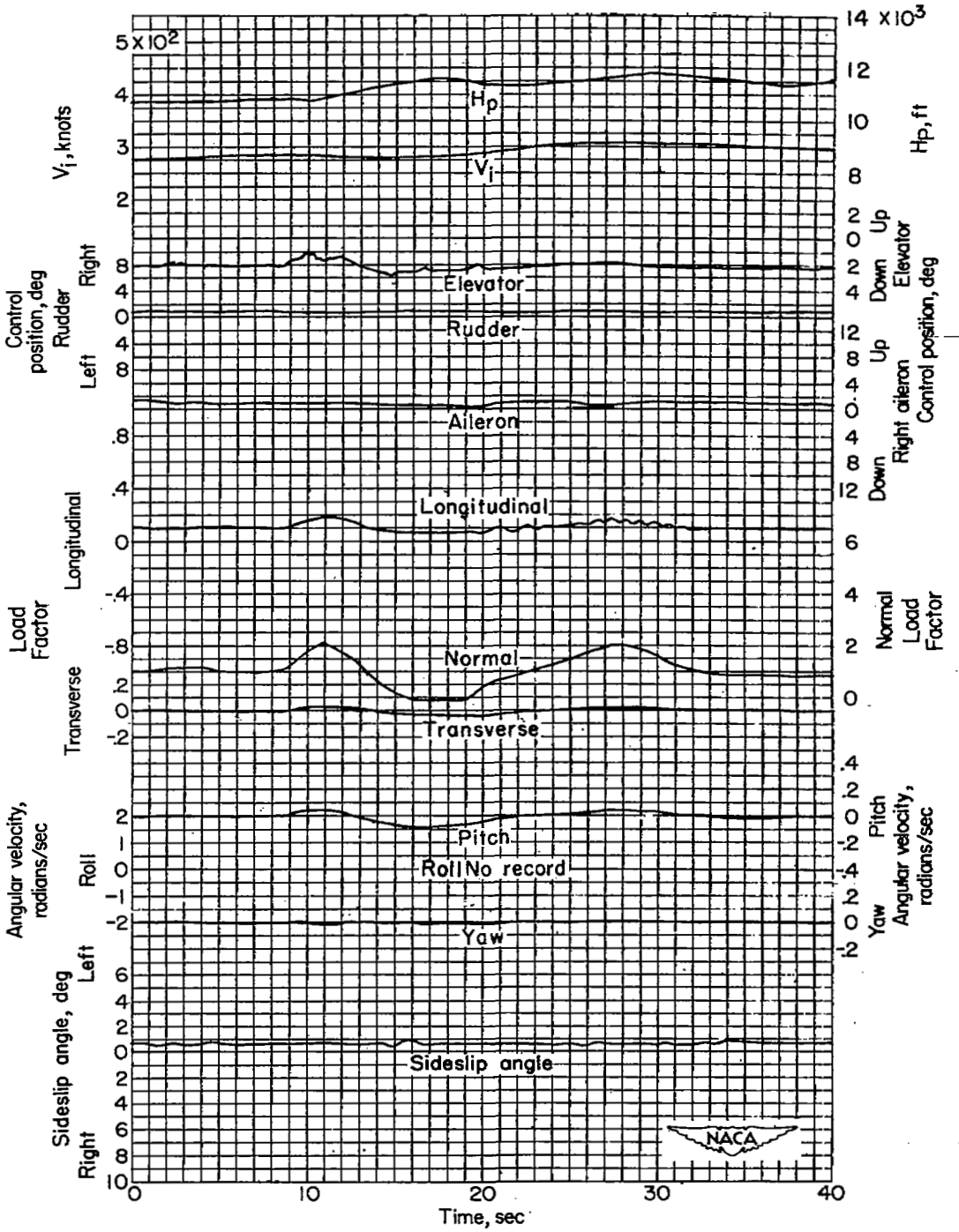


Figure 107.- Pull-up, push-over, and pull-out; airplane weight, 15,380 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

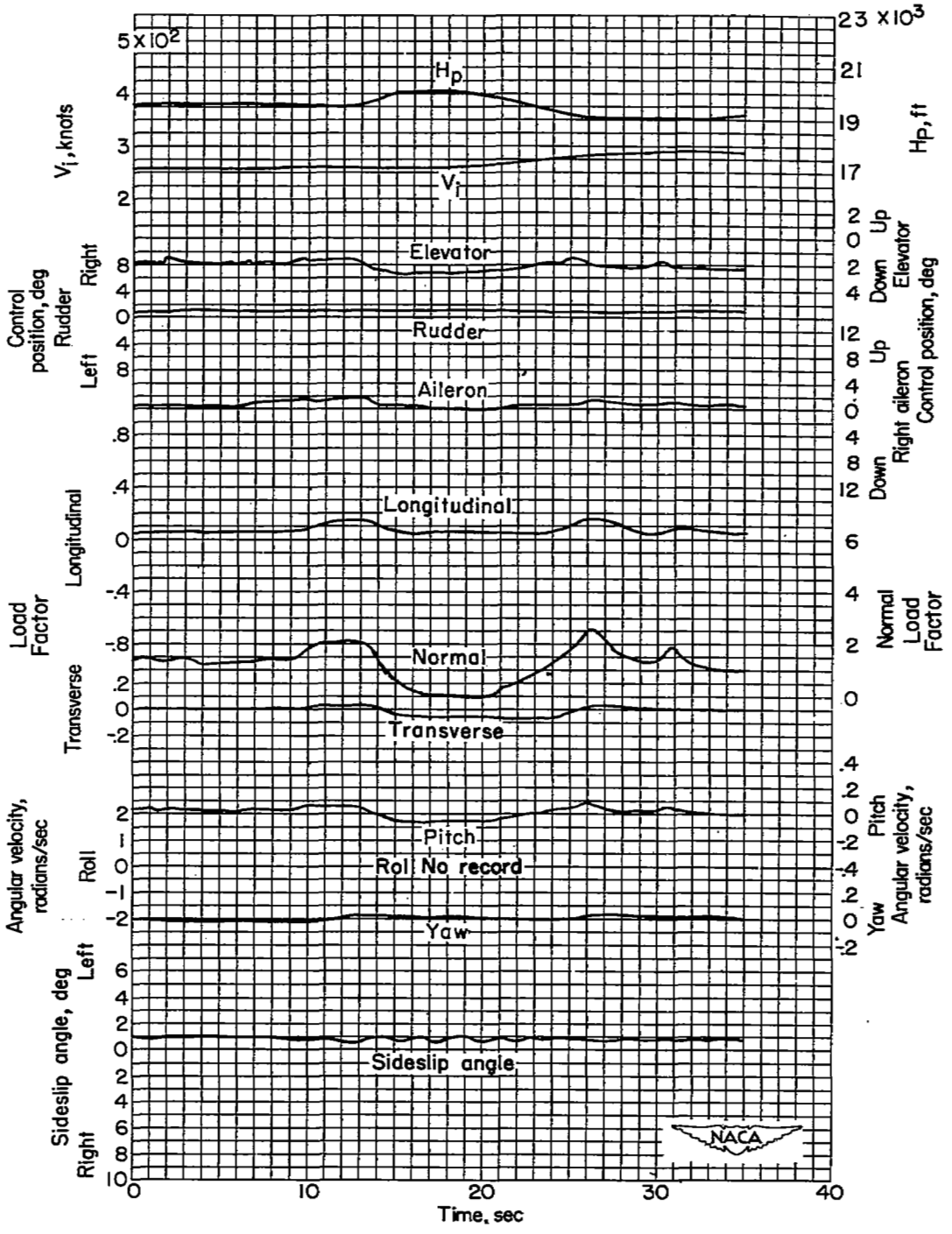


Figure 108.- Pull-up, push-over, and pull-out; airplane weight, 16,180 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

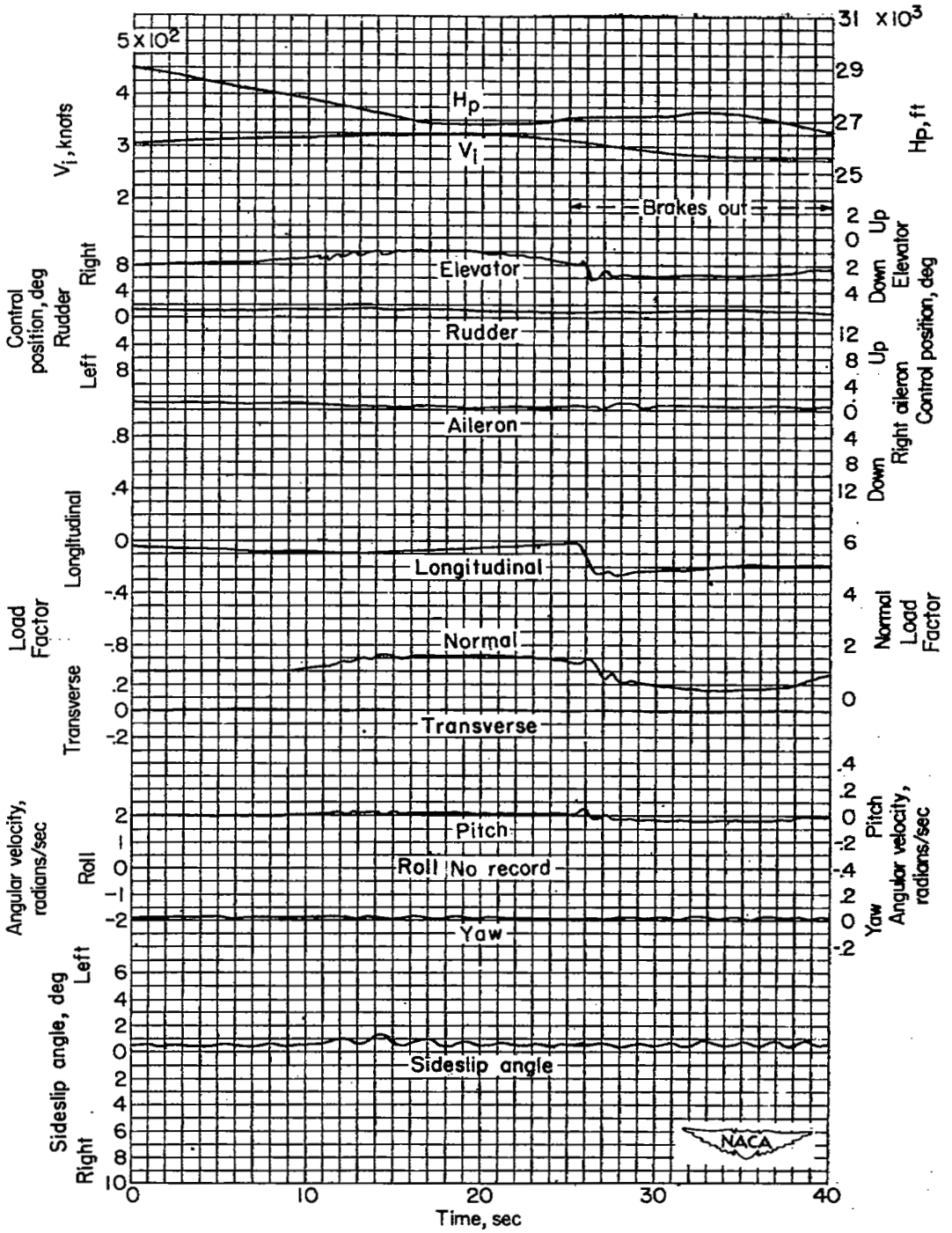


Figure 109.- Dive with normal pull-out; airplane weight, 16,620 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

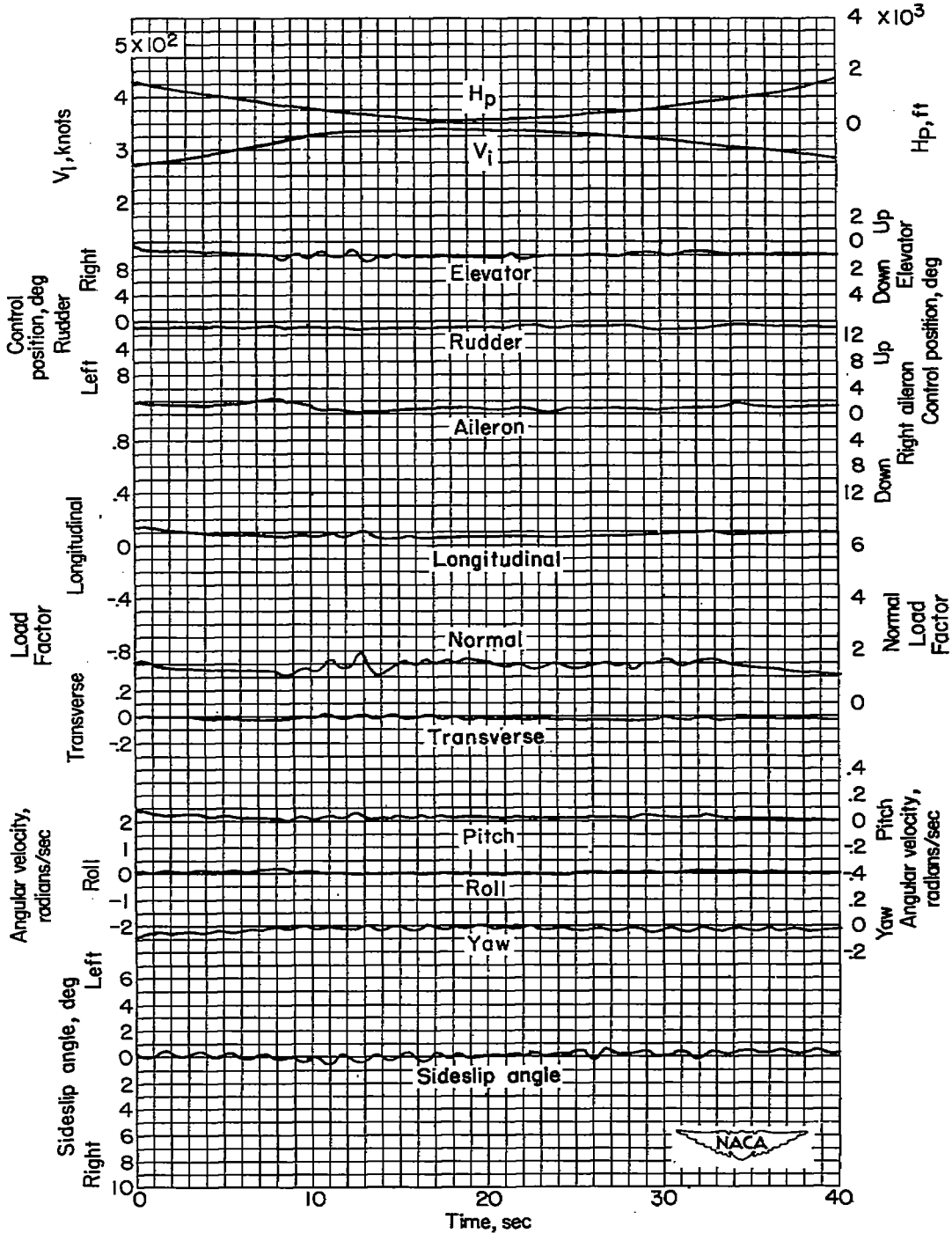


Figure 110.- Dive with normal pull-out; airplane weight, 15,020 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

[redacted]

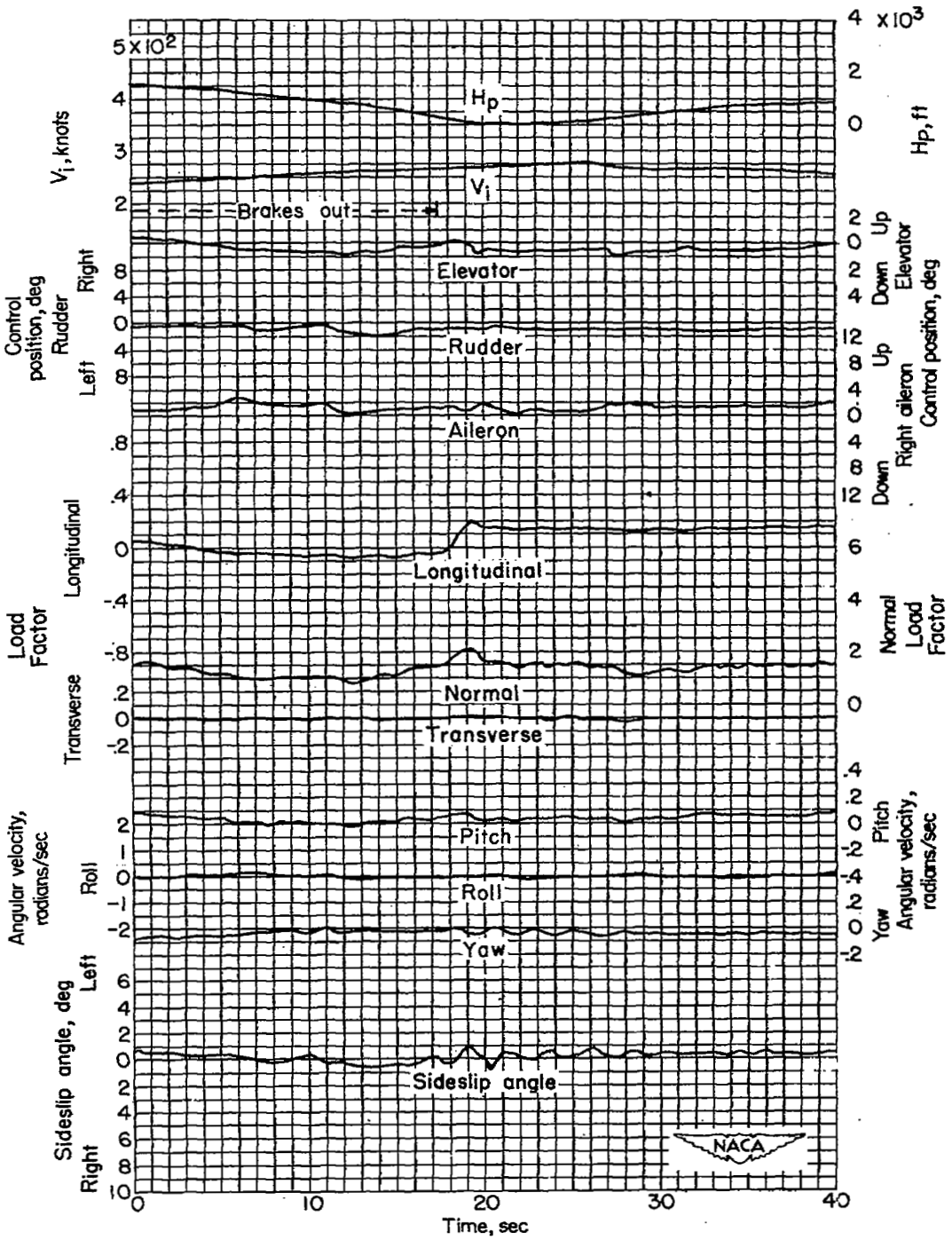


Figure 111.- Dive with normal pull-out; airplane weight, 15,170 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

17F

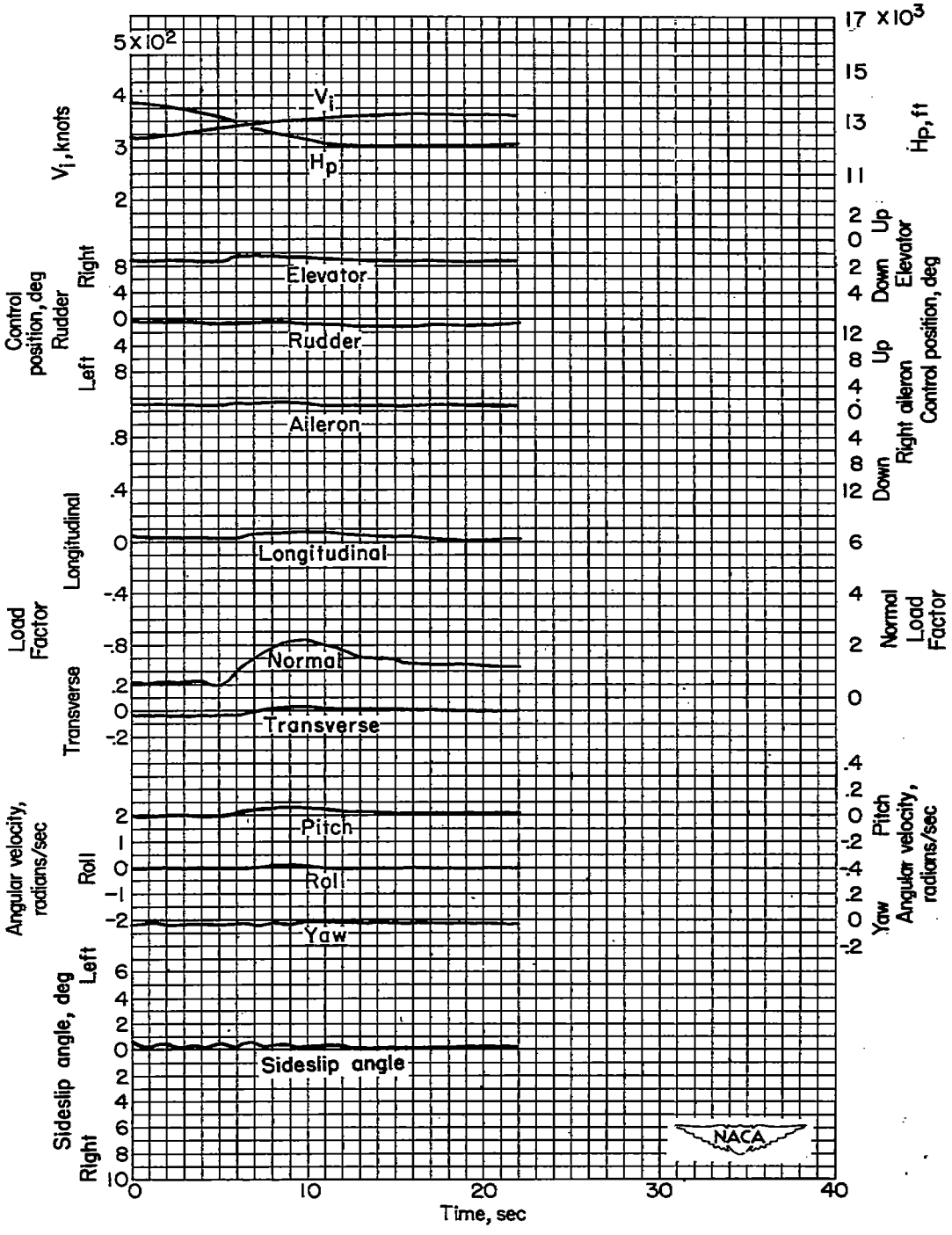


Figure 112.- Dive with normal pull-out; airplane weight, 16,420 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

[redacted]

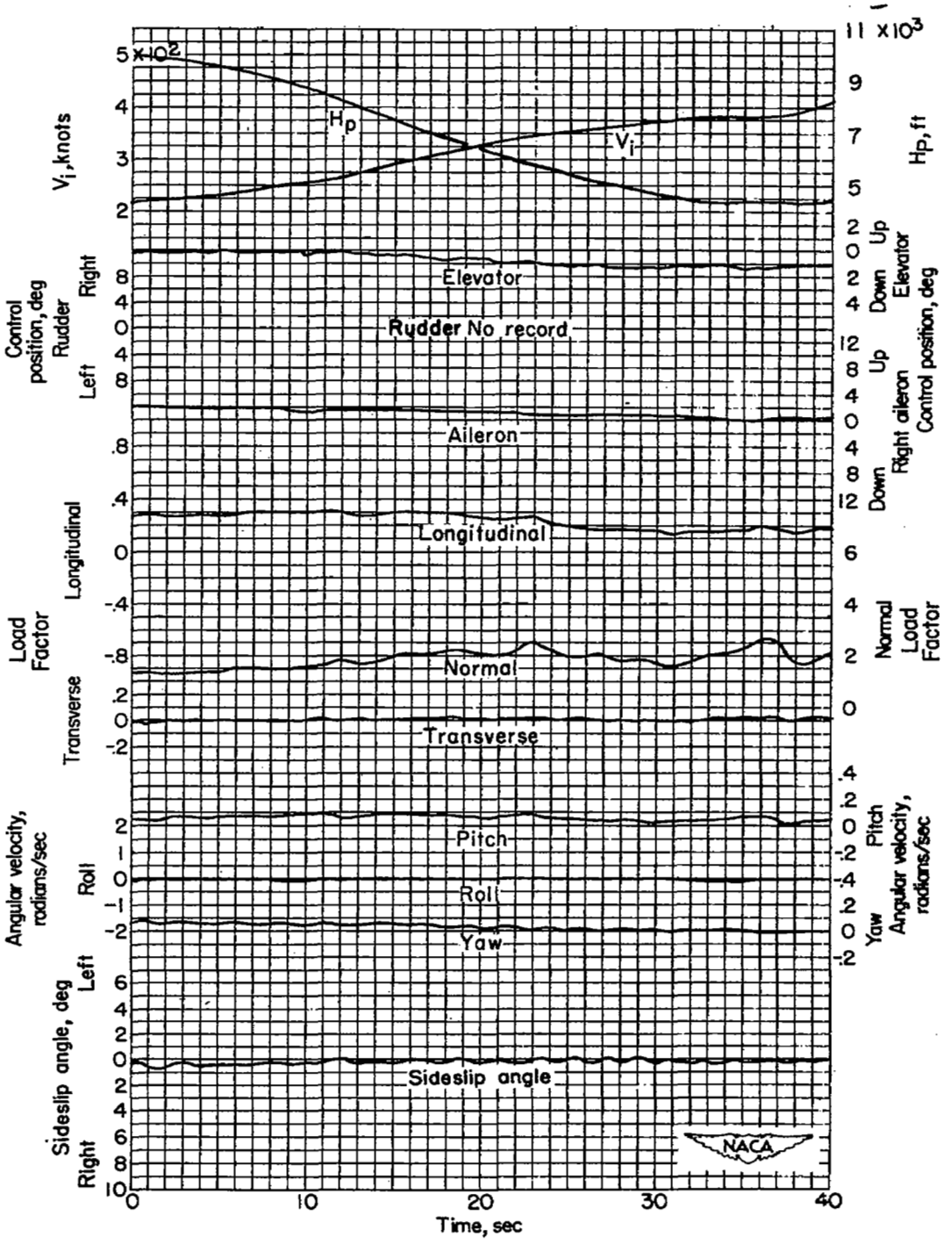


Figure 113.- Dive with normal pull-out; airplane weight, 17,780 pounds; center-of-gravity location, 26.8 percent of the mean aerodynamic chord.

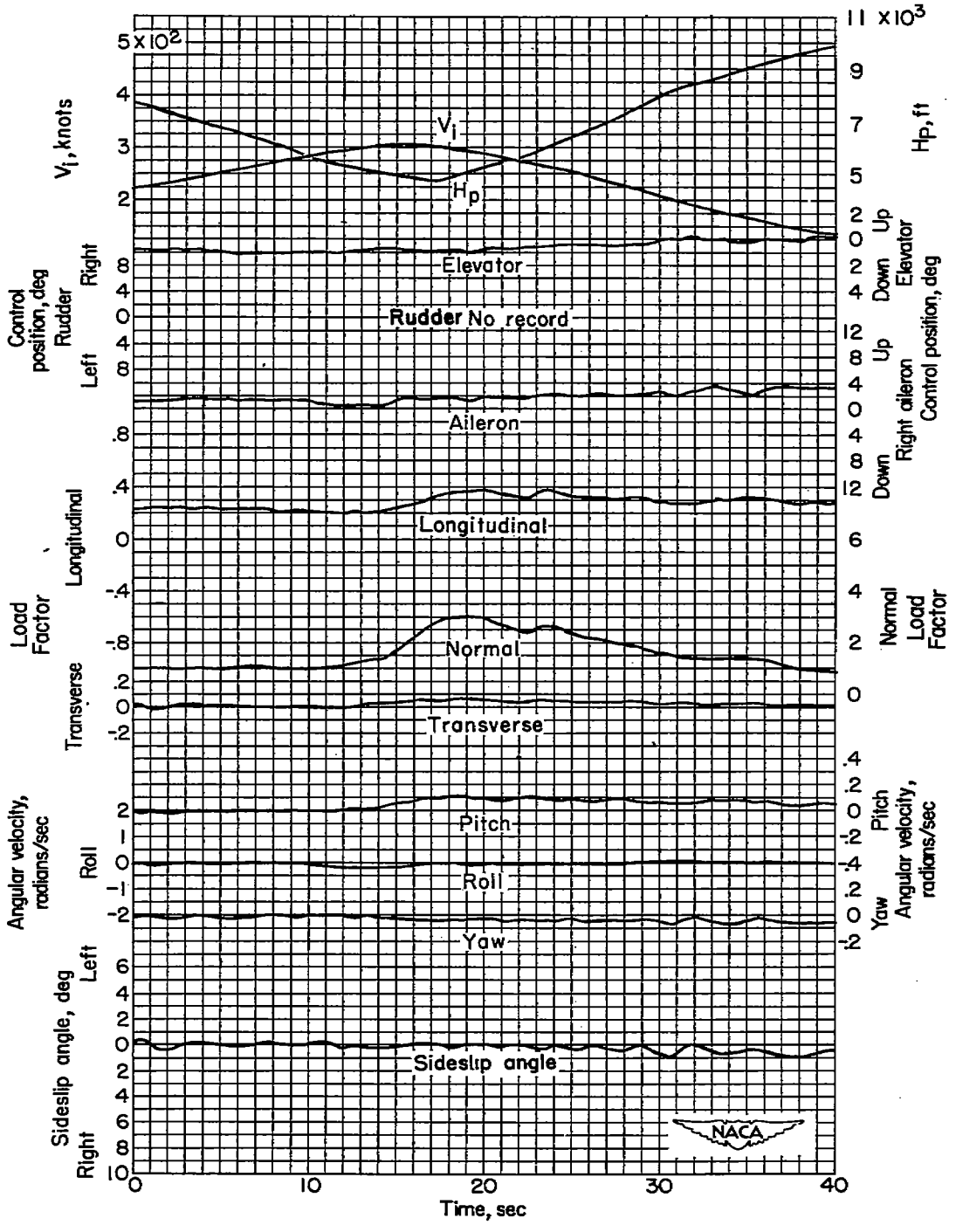


Figure 114.- Dive with normal pull-out; airplane weight, 17,600 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

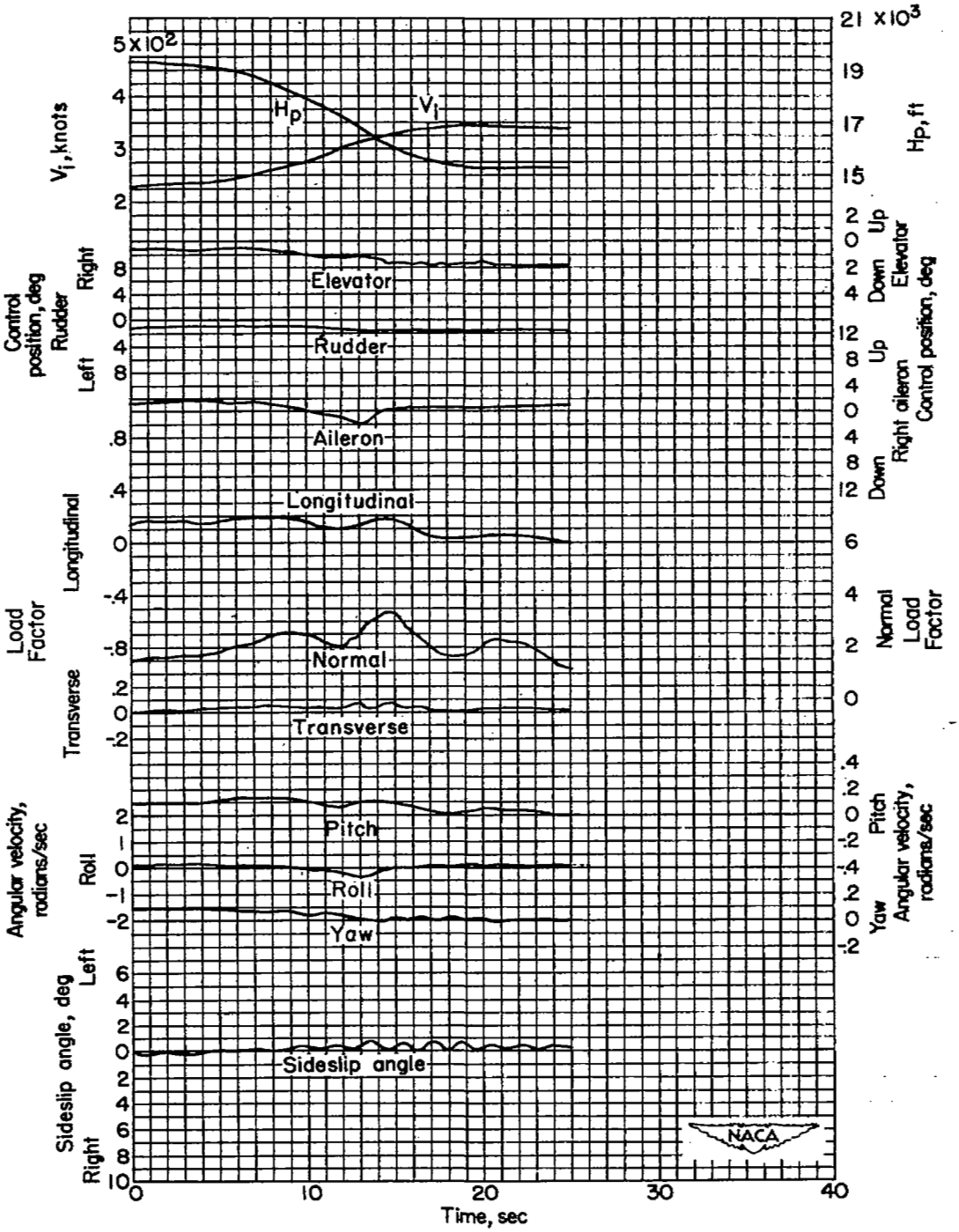


Figure 115.- Dive with normal pull-out; airplane weight, 16,280 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

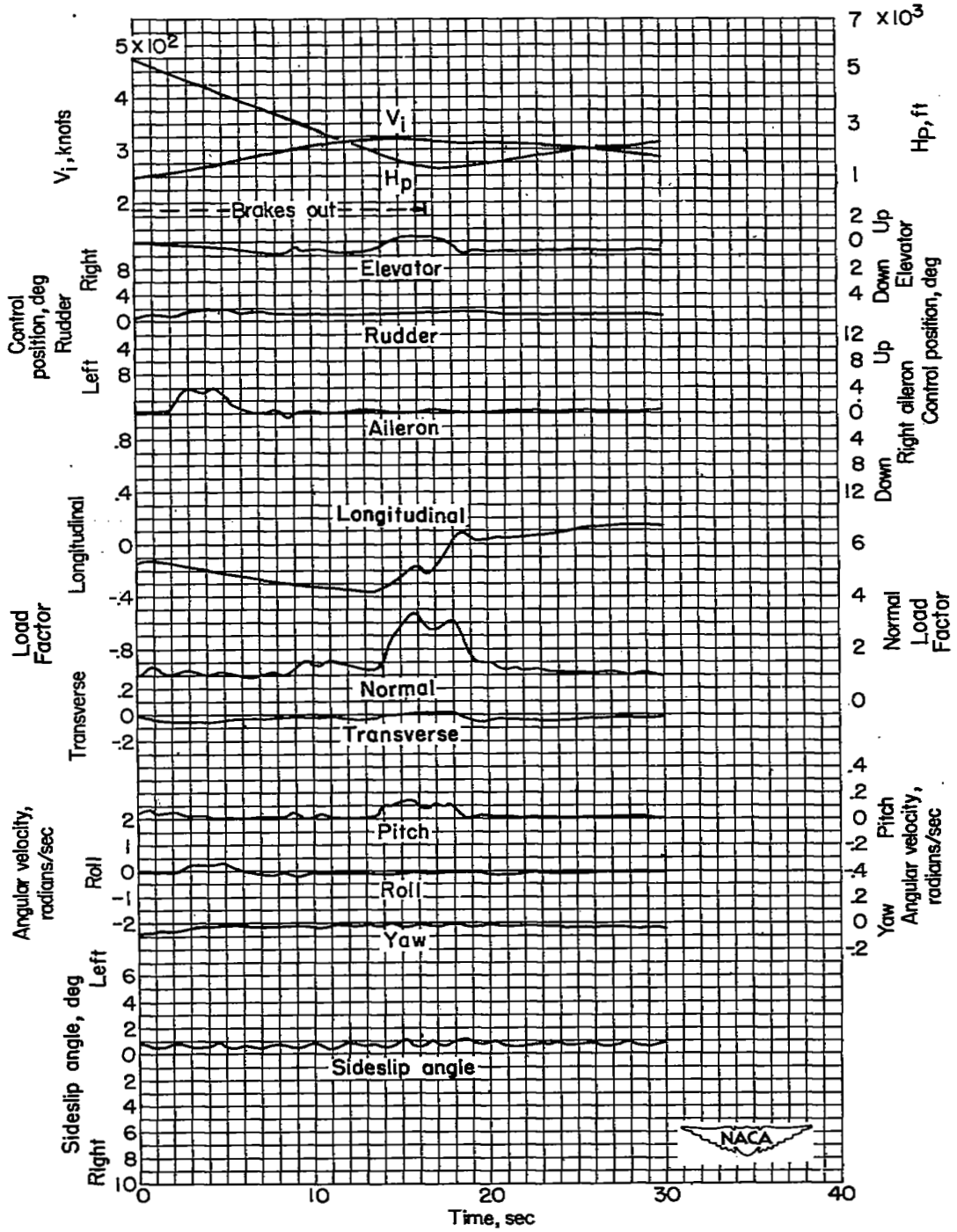


Figure 116.- Dive with normal pull-out; airplane weight, 14,920 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

[redacted]

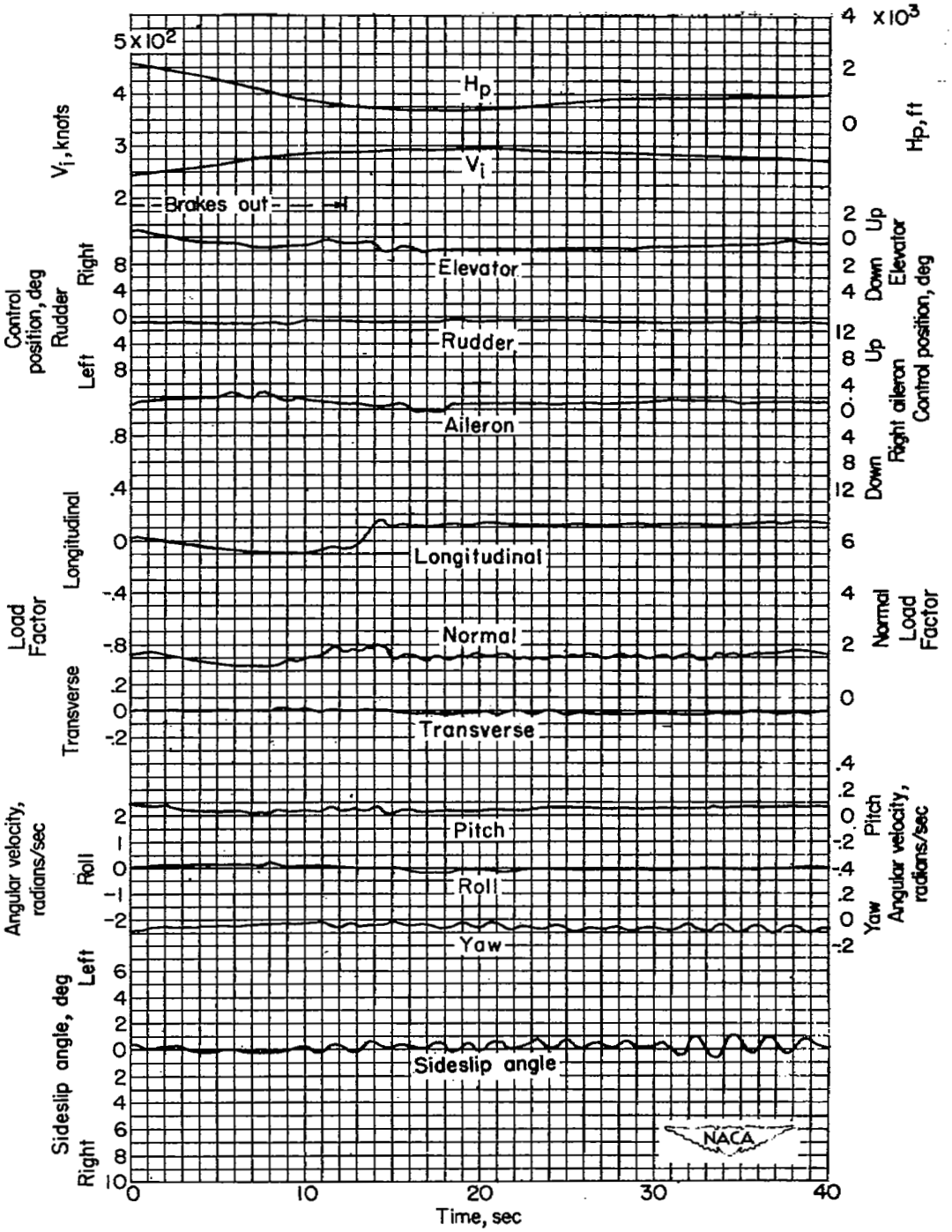


Figure 117.- Dive with rolling entry and gentle rolling pull-out; airplane weight, 15,250 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

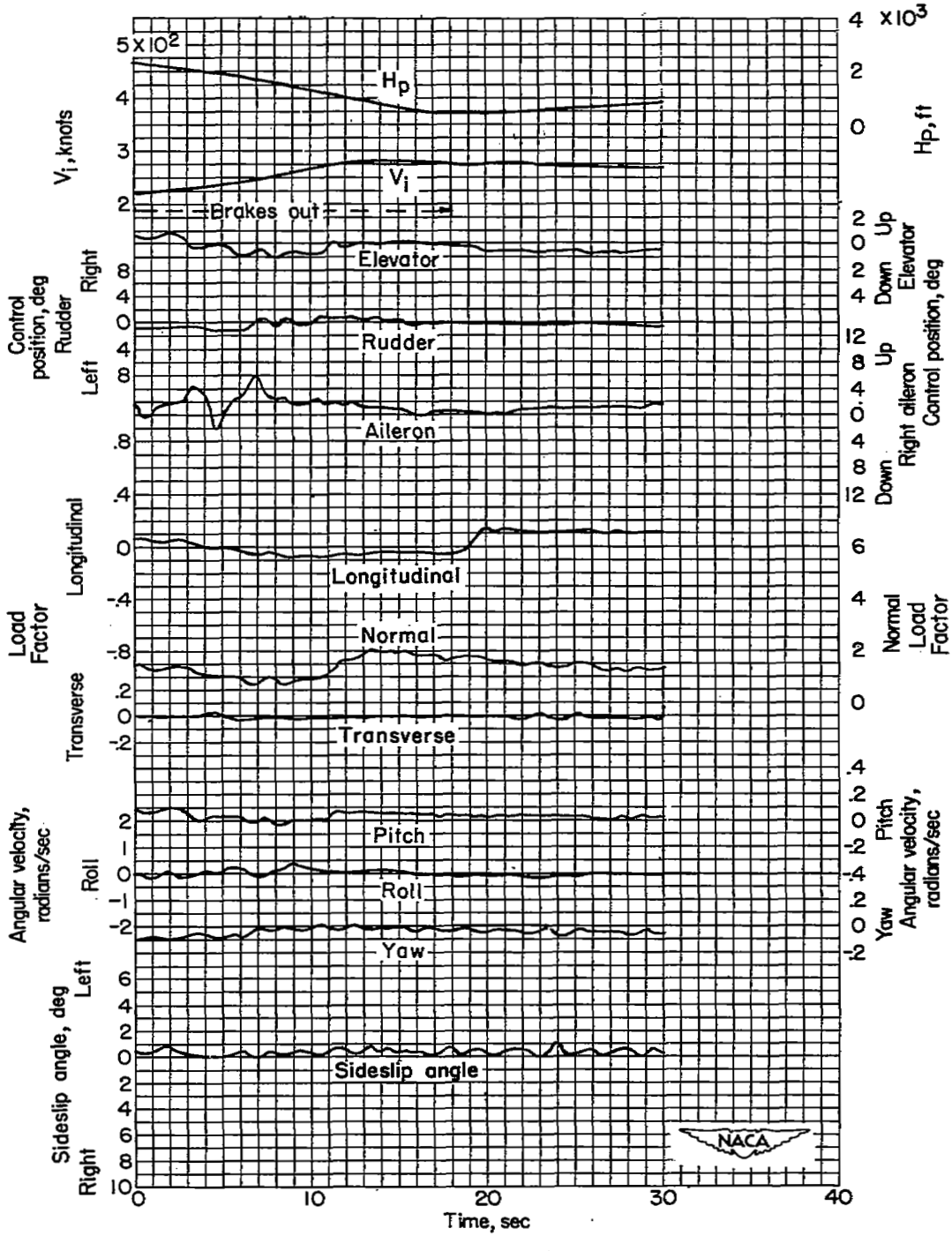


Figure 118.- Dive with rolling entry and normal pull-out; airplane weight, 15,500 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

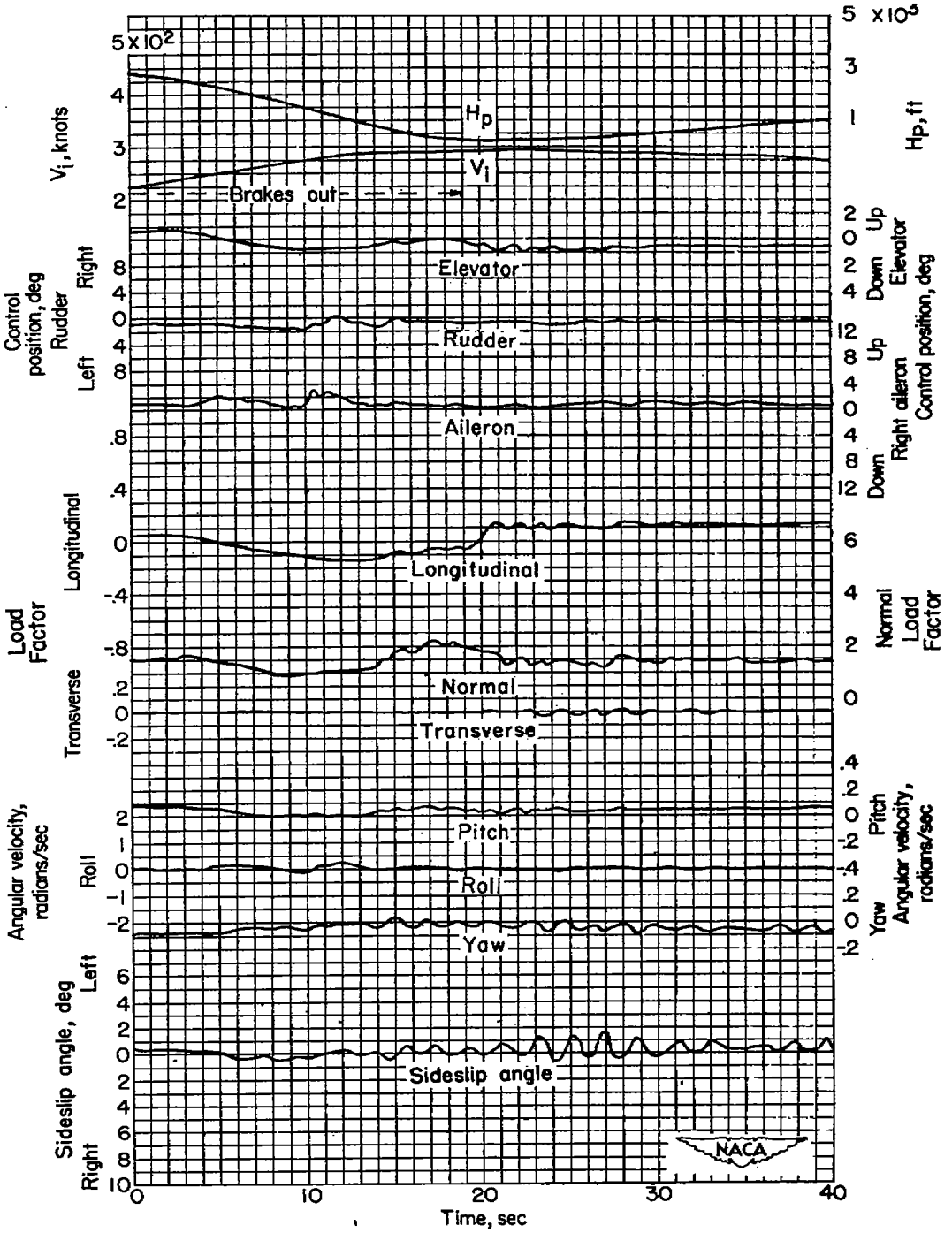


Figure 119.- Dive with rolling entry and normal pull-out; airplane weight, 15,370 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

18F

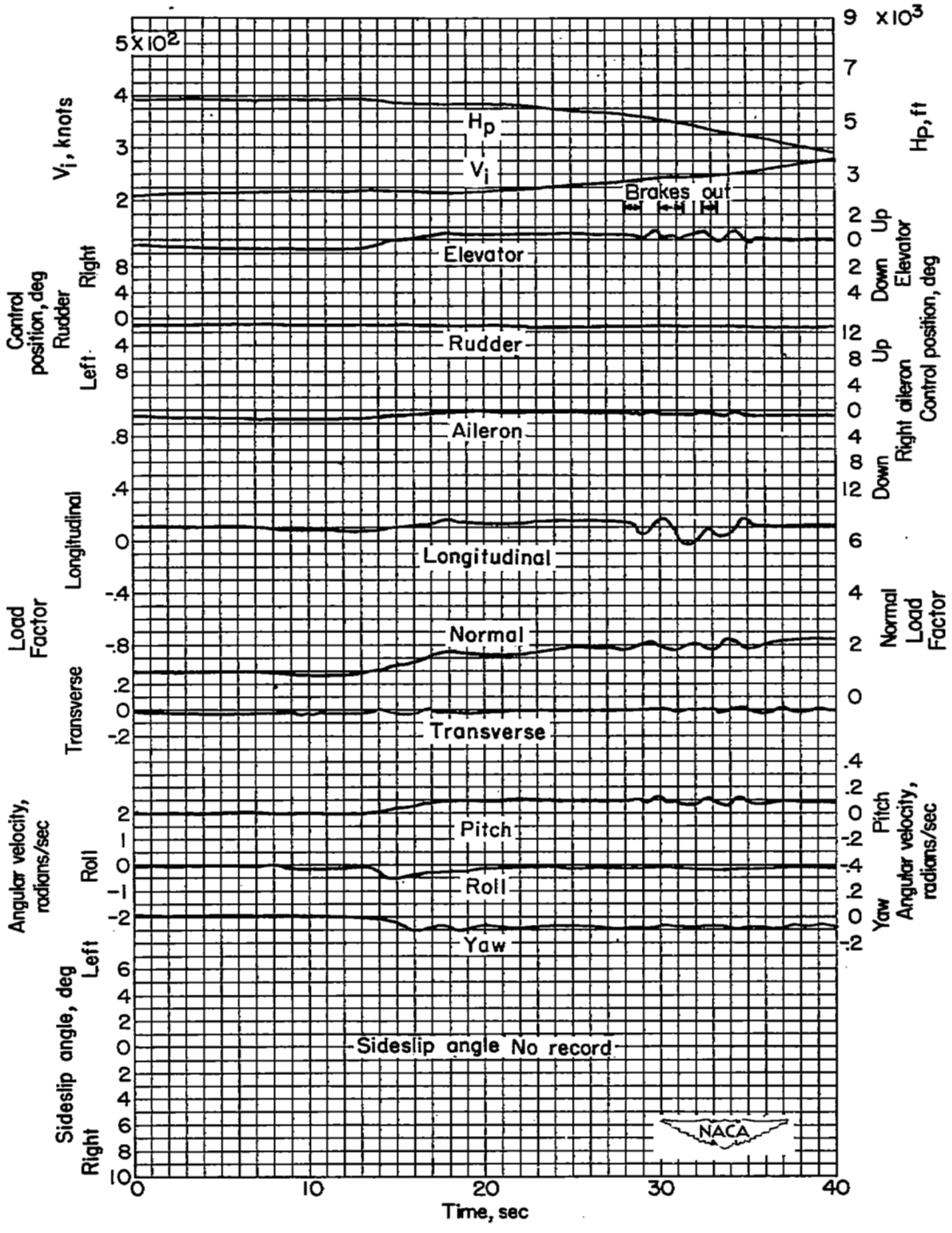


Figure 120.- Gentle dive with rolling entry; airplane weight, 14,750 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

[redacted]

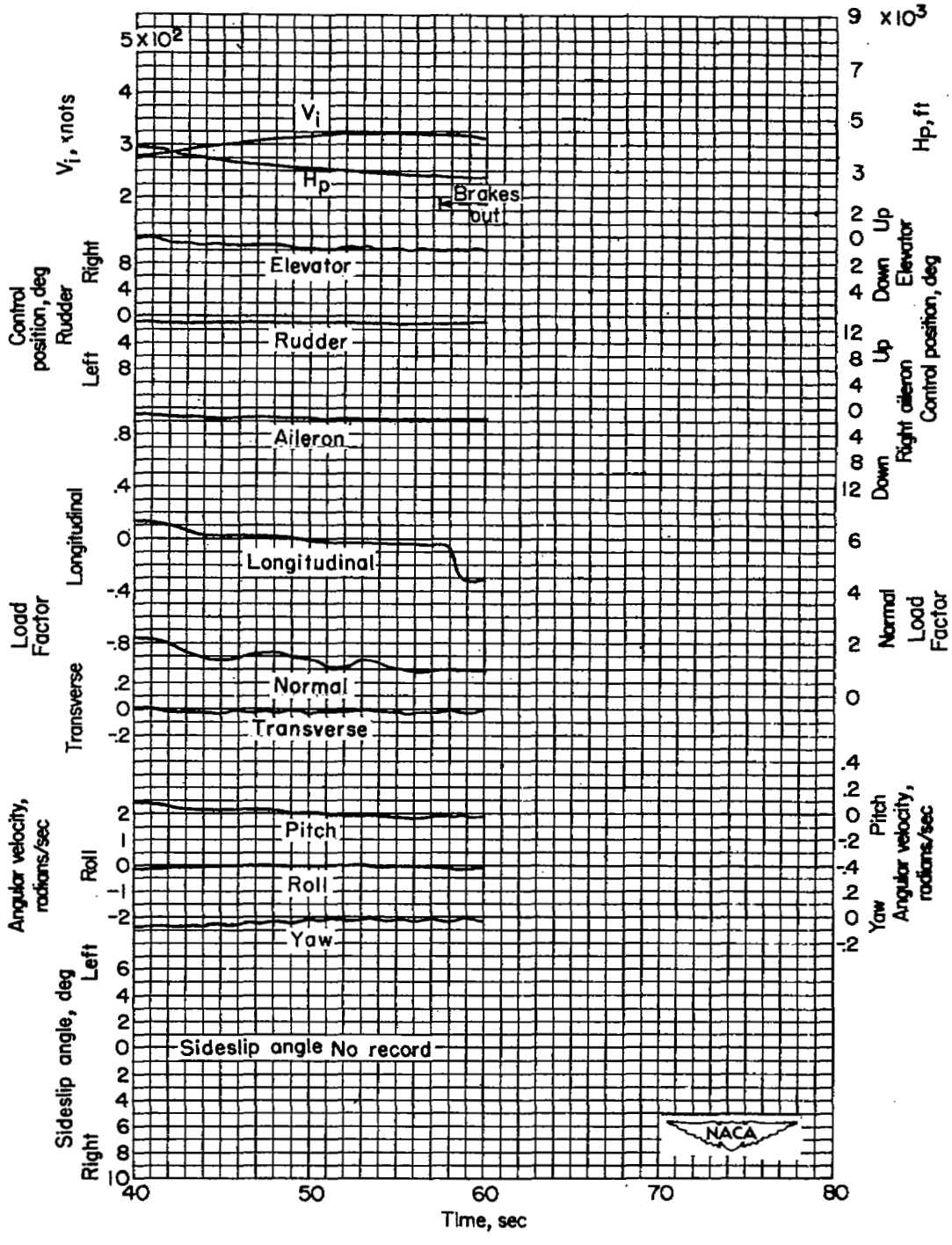


Figure 120.- Concluded.

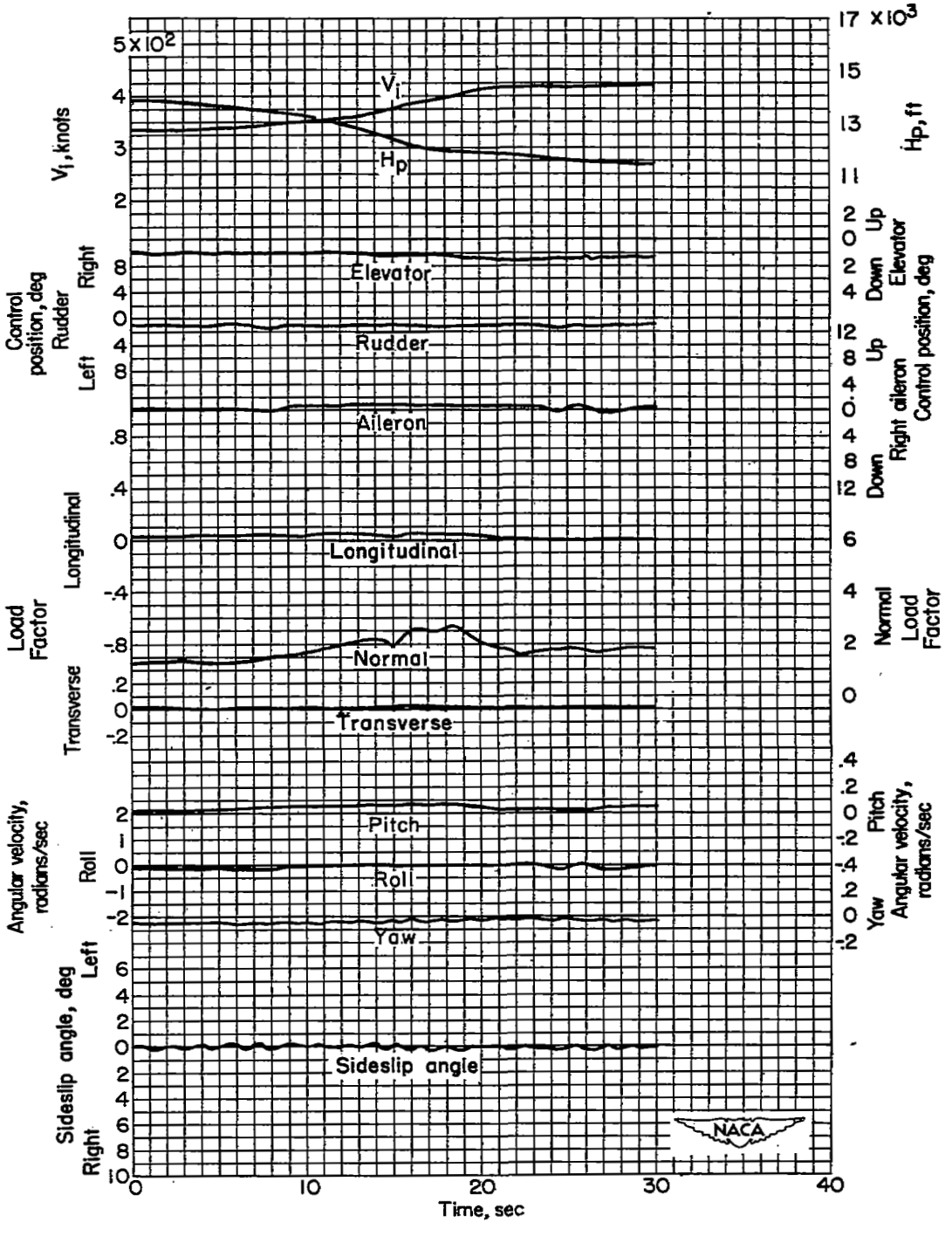


Figure 121.- Dive with rolling entry and pull-out; airplane weight, 15,960 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

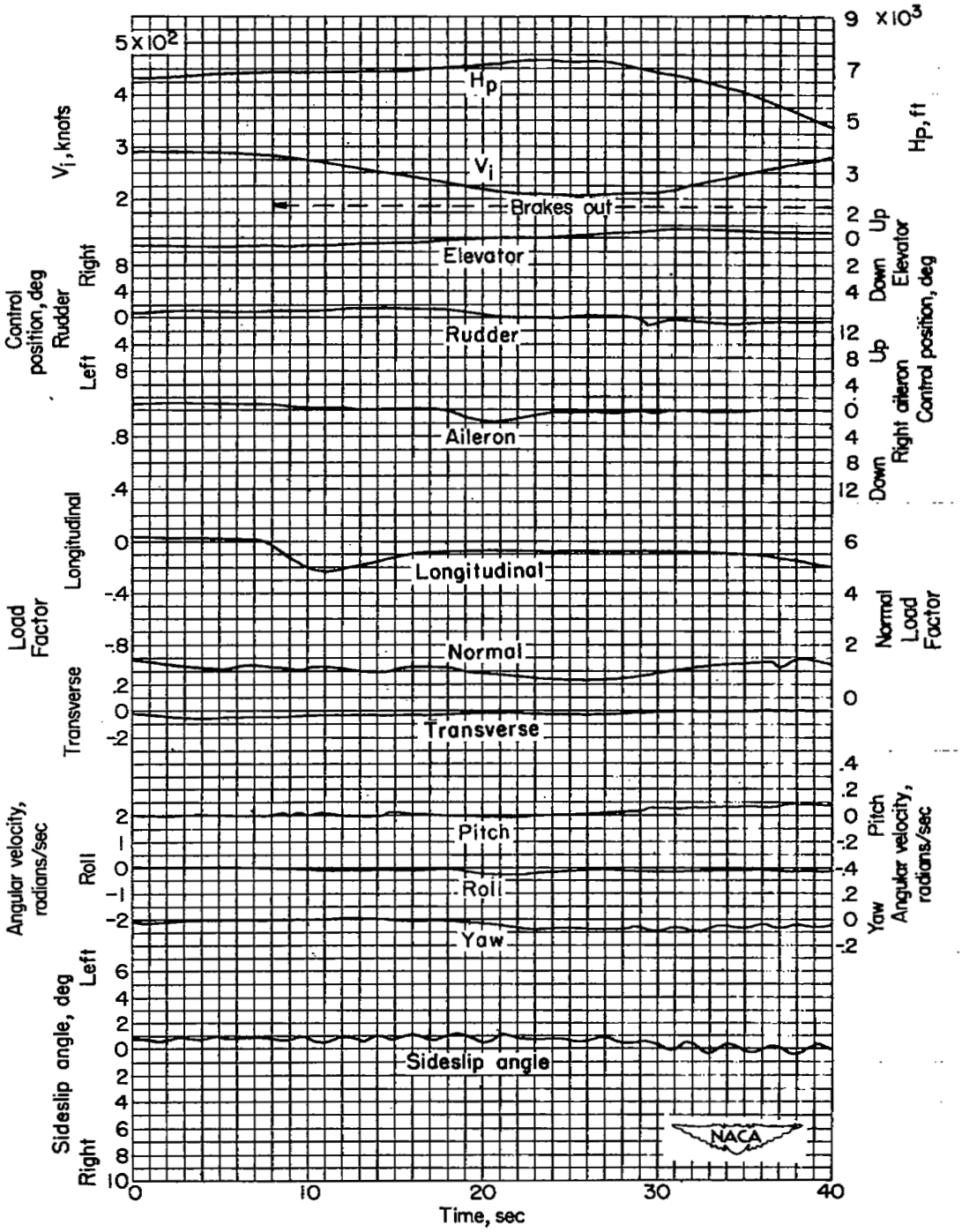
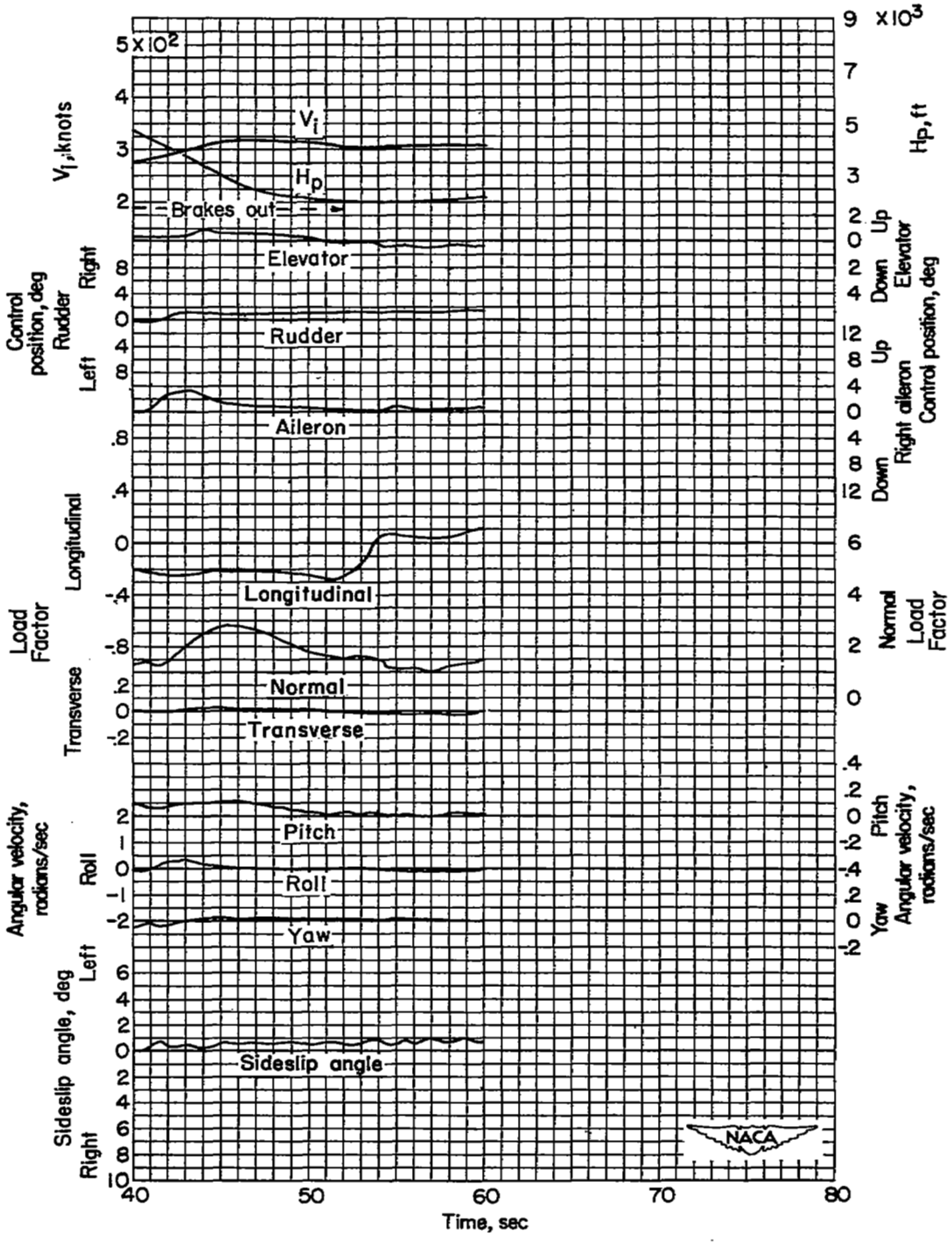


Figure 122.- Dive with rolling entry and normal pull-out; airplane weight, 14,800 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.



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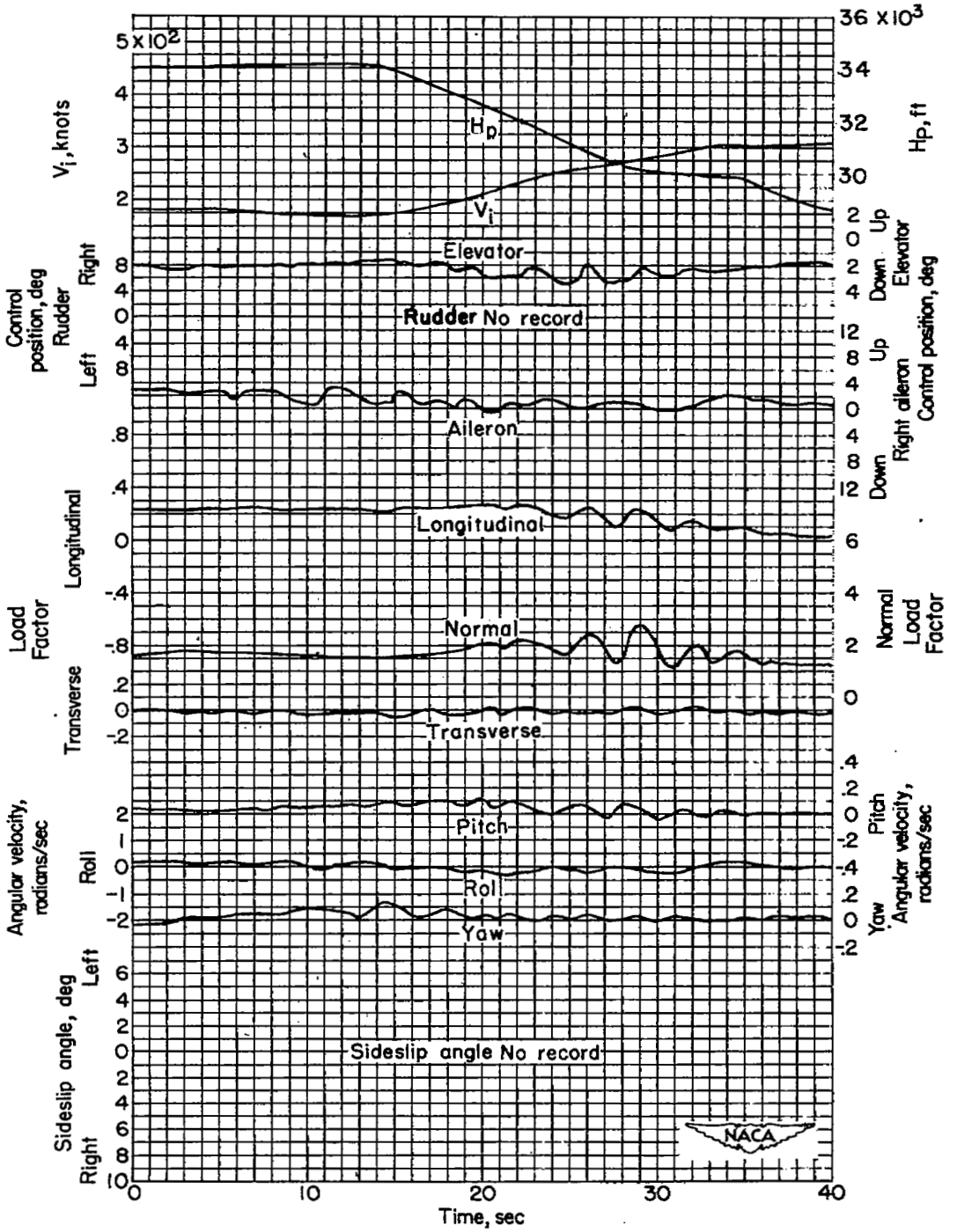


Figure 123.- Dive with rolling entry and partial pull-out recovery; airplane weight, 14,910 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

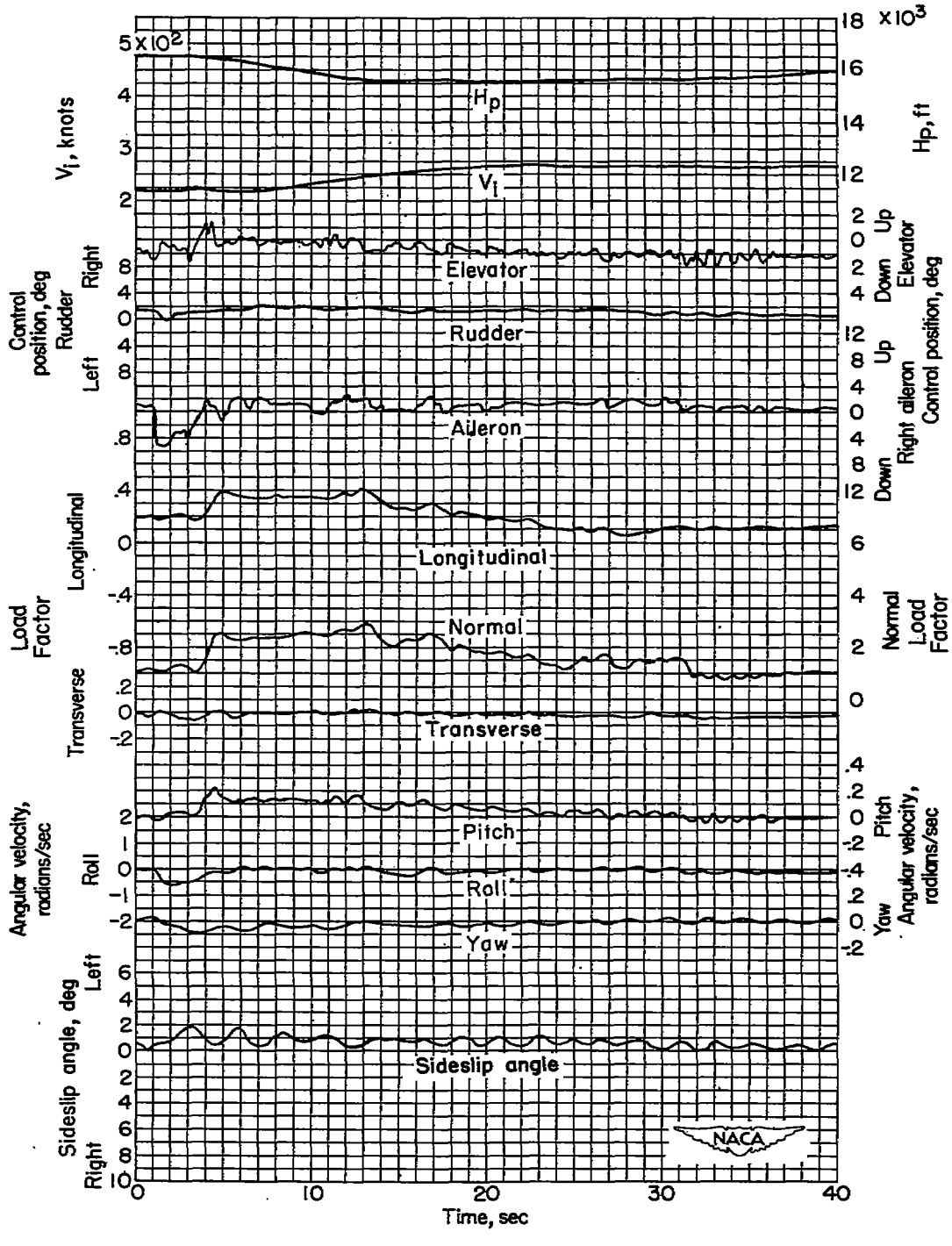


Figure 124.- Dive with rolling entry and gentle pull-out recovery; airplane weight, 16,750 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

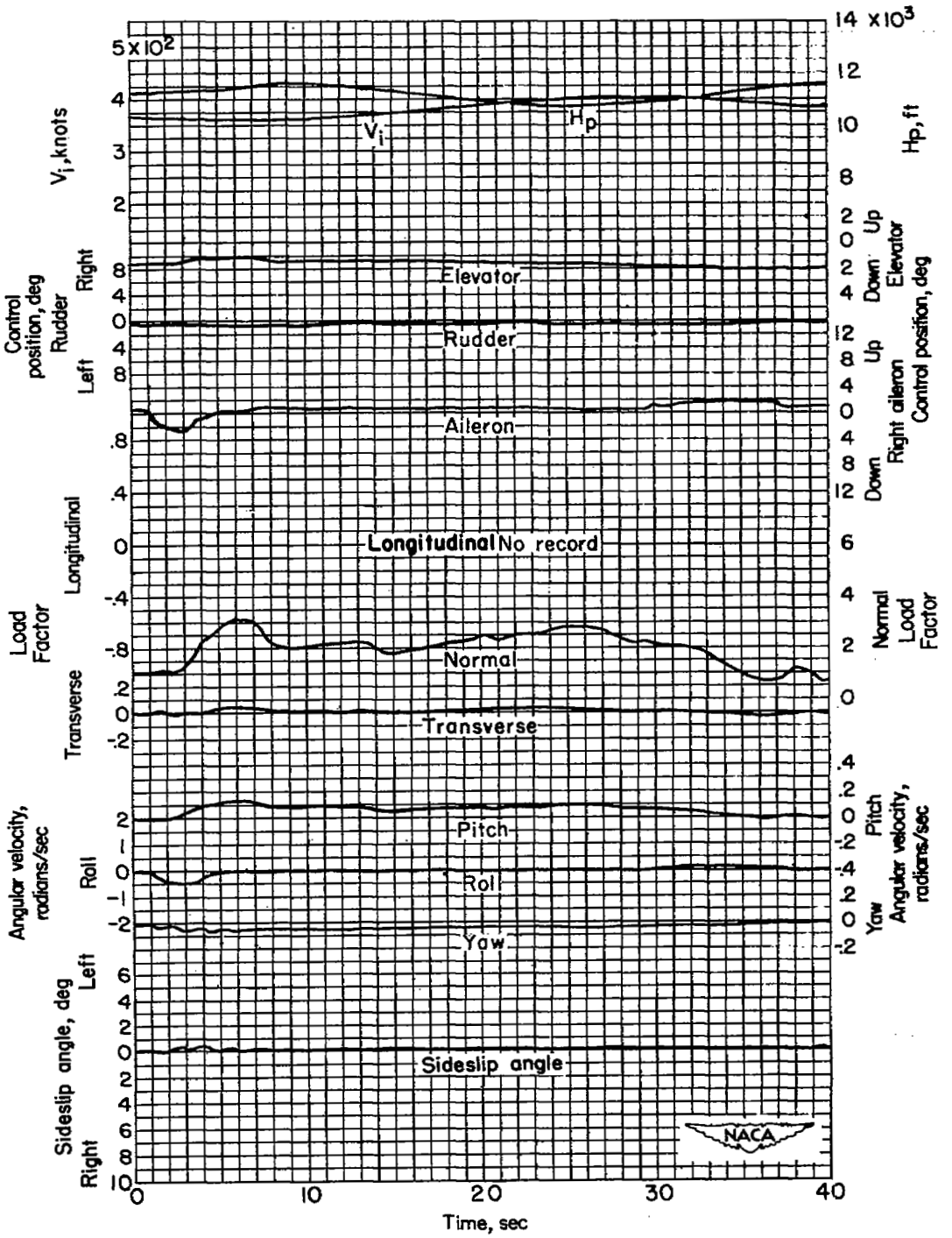


Figure 125.- Dive with rolling entry and normal pull-out; airplane weight, 14,430 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

19F

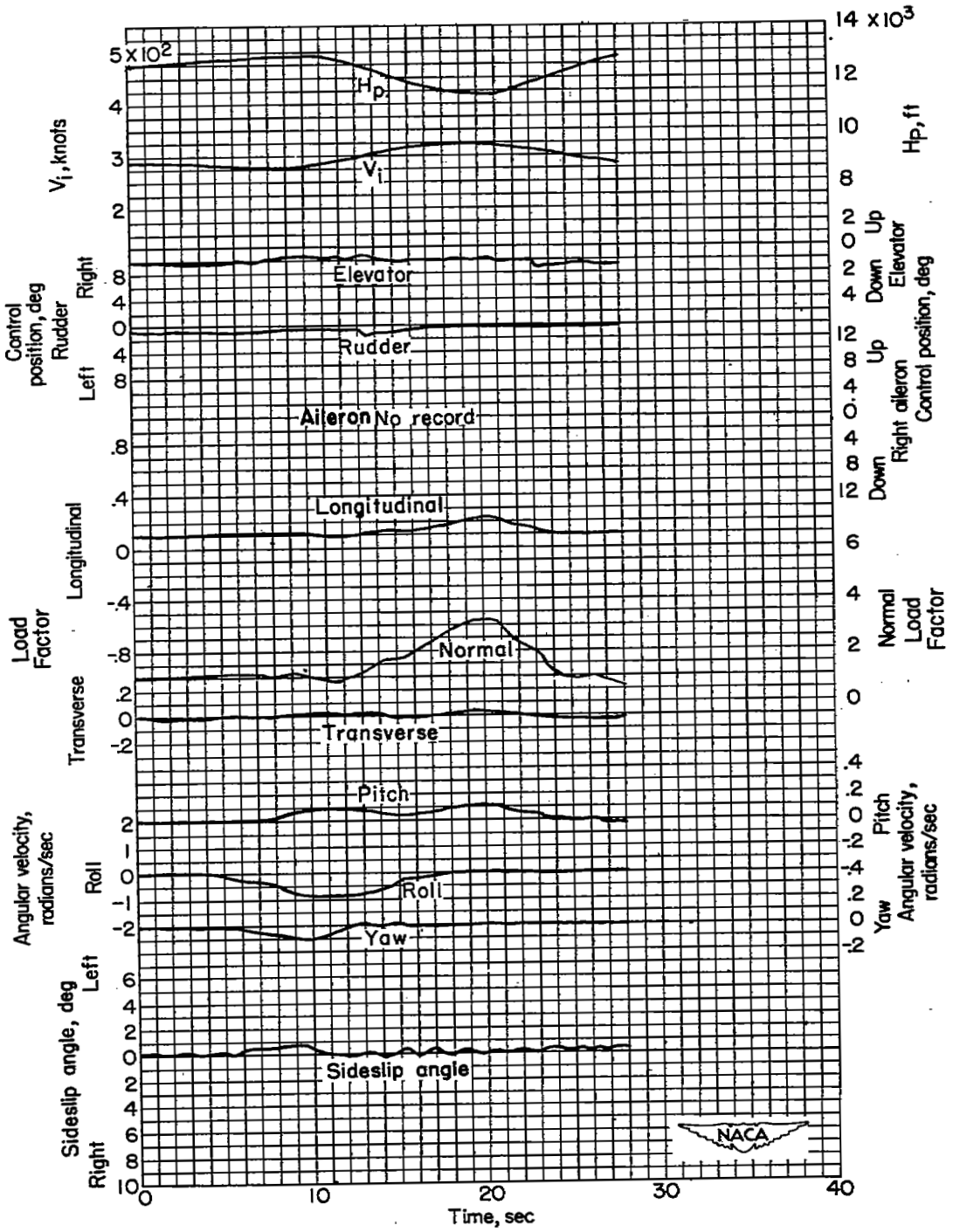


Figure 126.- Dive with rolling entry and normal pull-out; airplane weight, 16,890 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

[redacted]

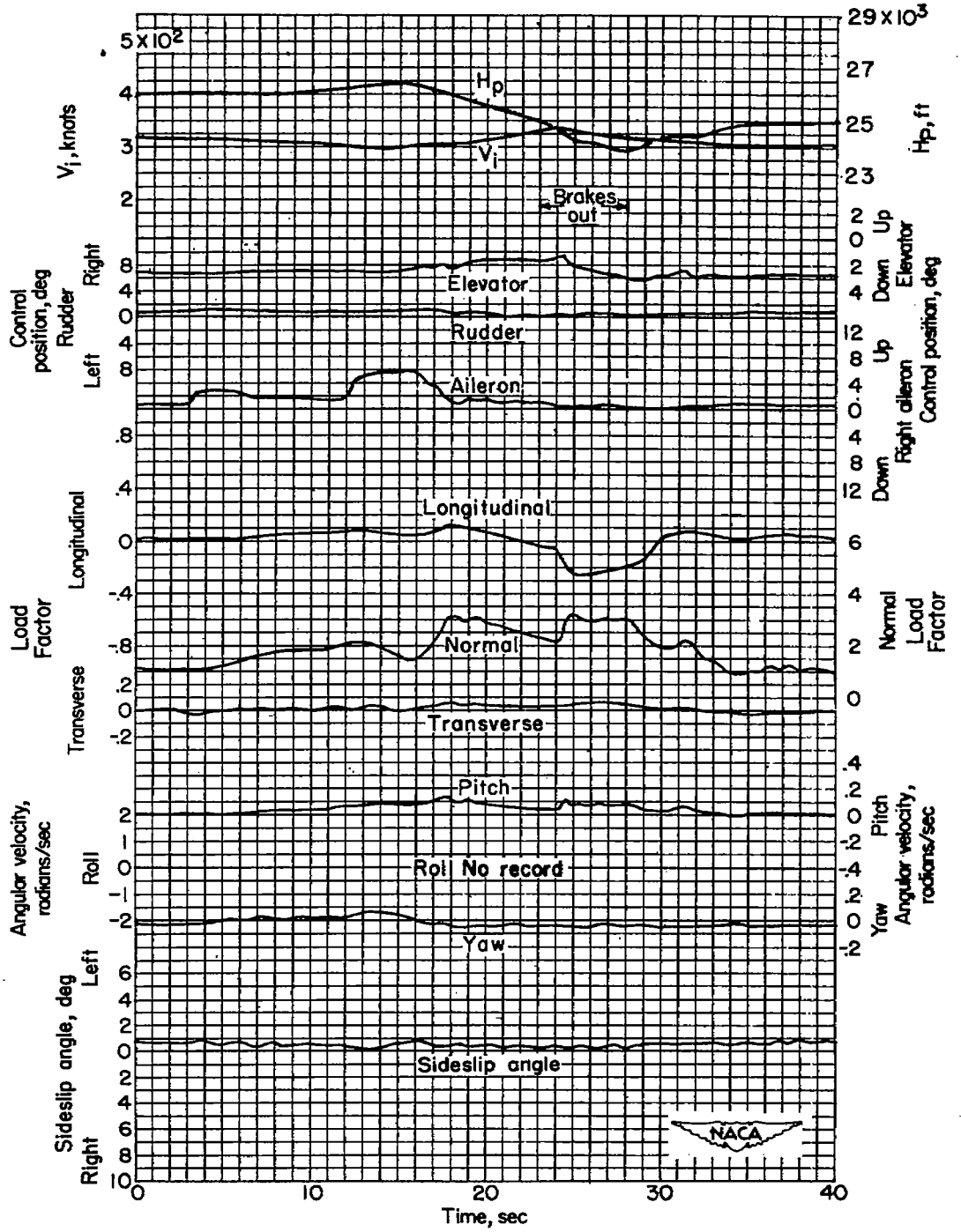


Figure 127.- Dive with rolling entry and normal pull-out; airplane weight, 14,530 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

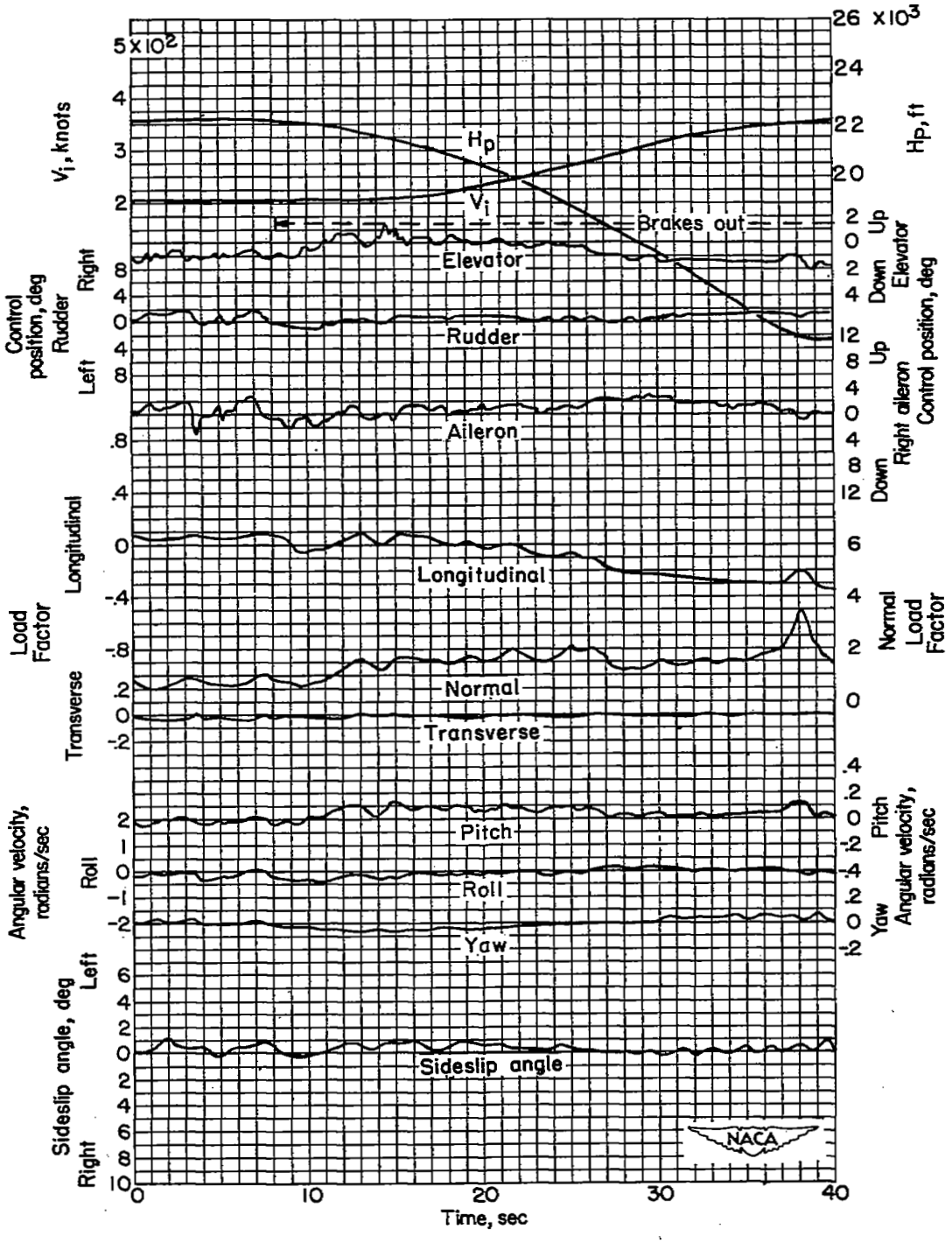
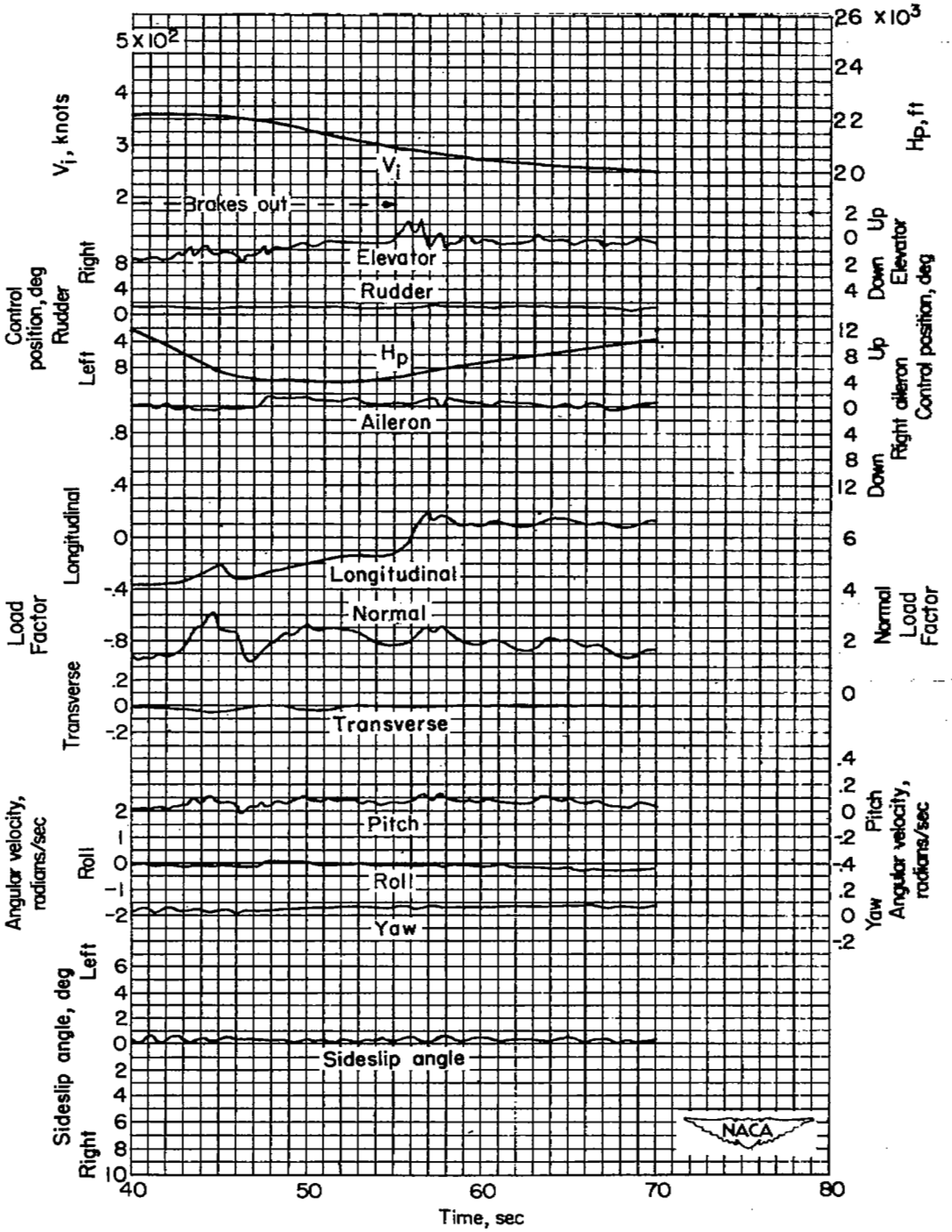


Figure 128.- Dive with rolling entry and normal pull-out; airplane weight, 17,470 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.



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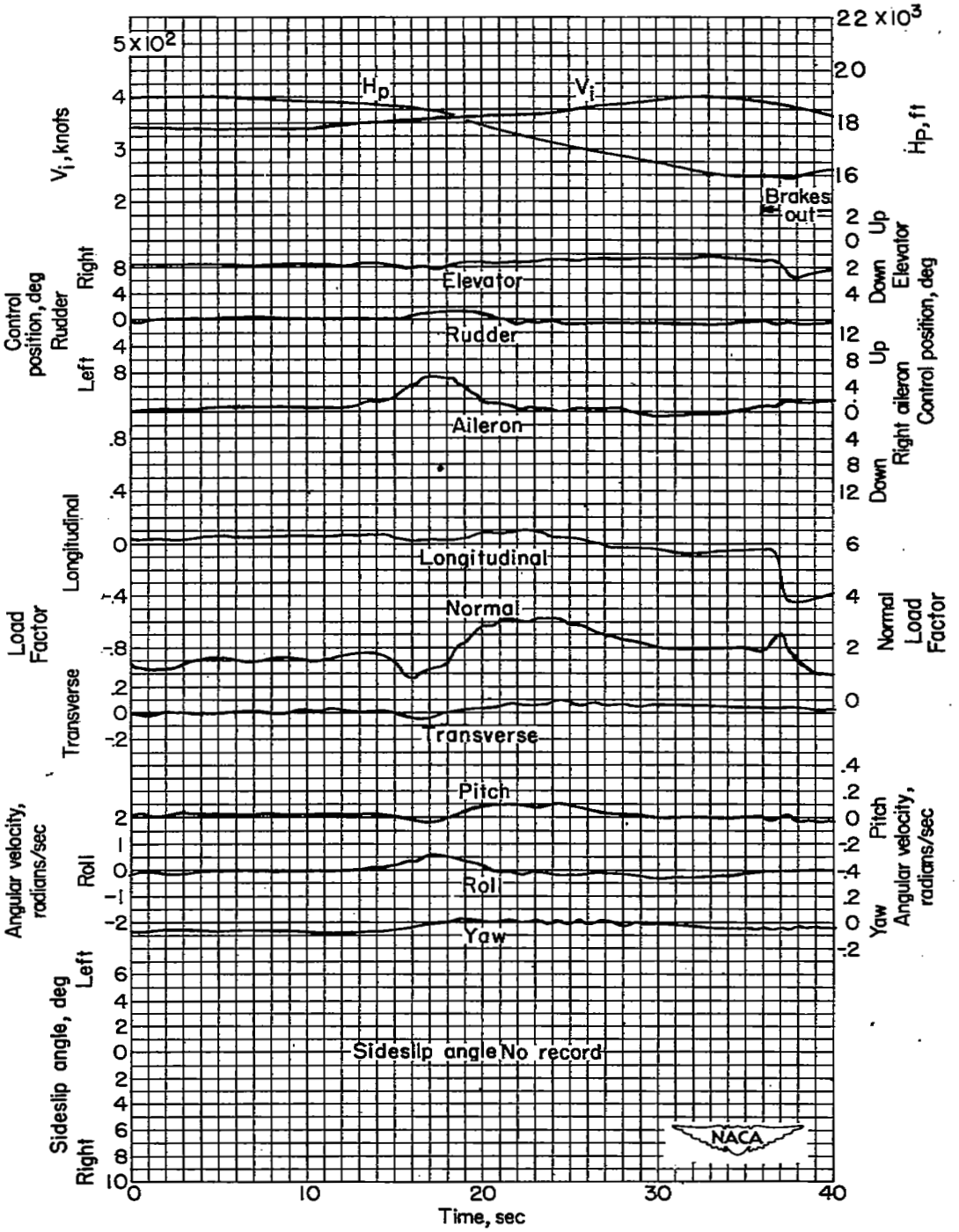


Figure 129.- Dive with rolling entry and normal pull-out; airplane weight, 14,675 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

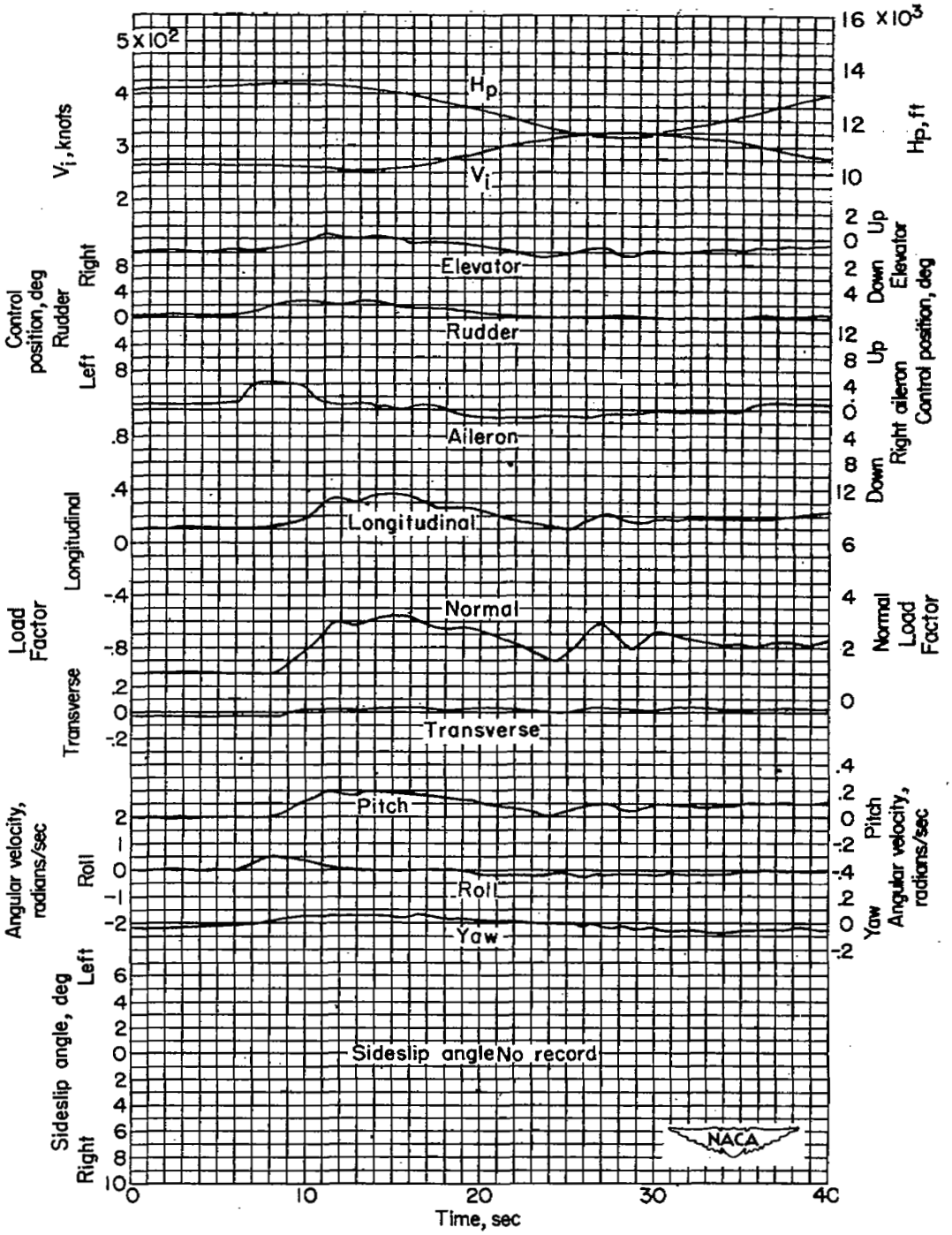
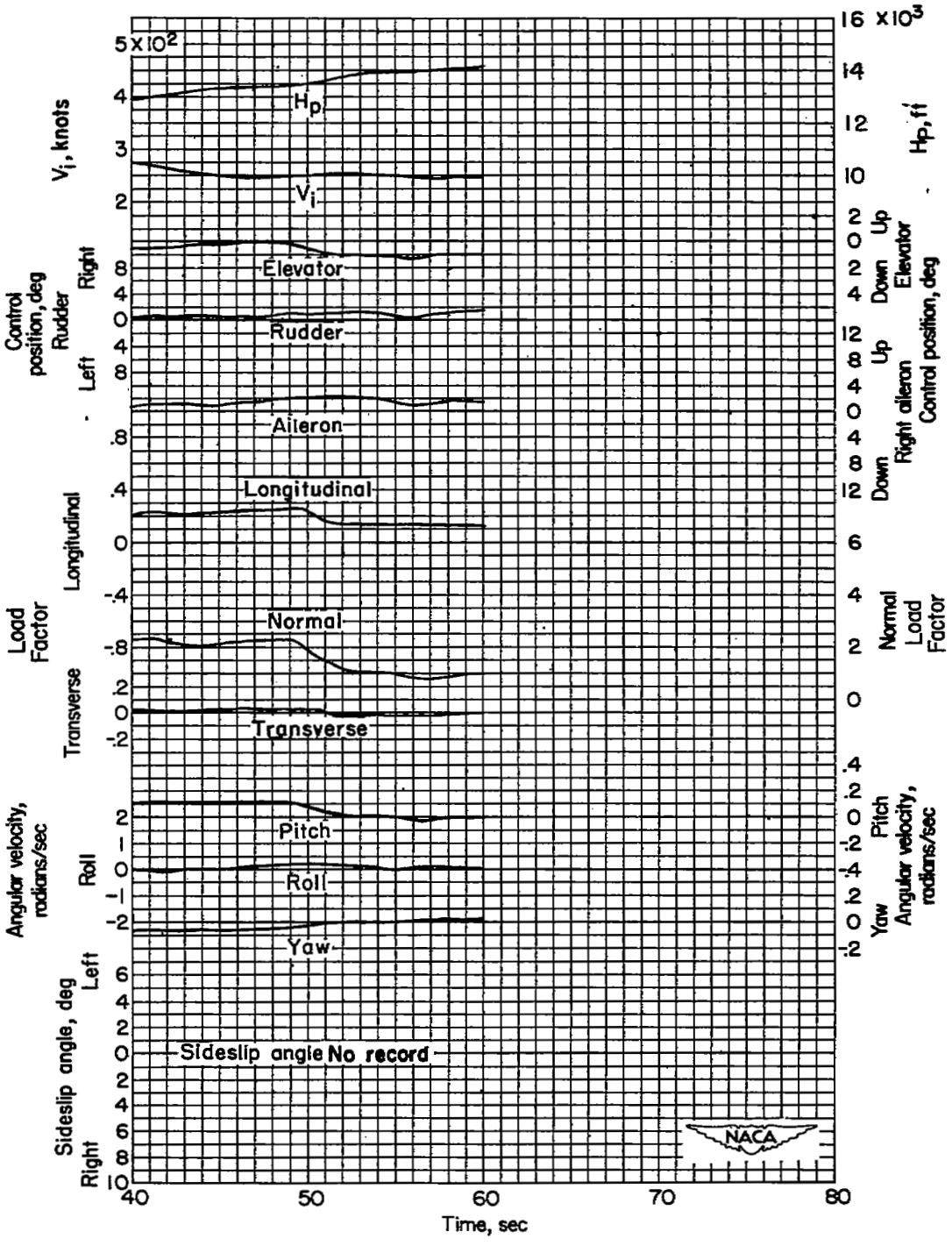


Figure 130.- Dive with rolling entry and pull-out; airplane weight, 17,000 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.



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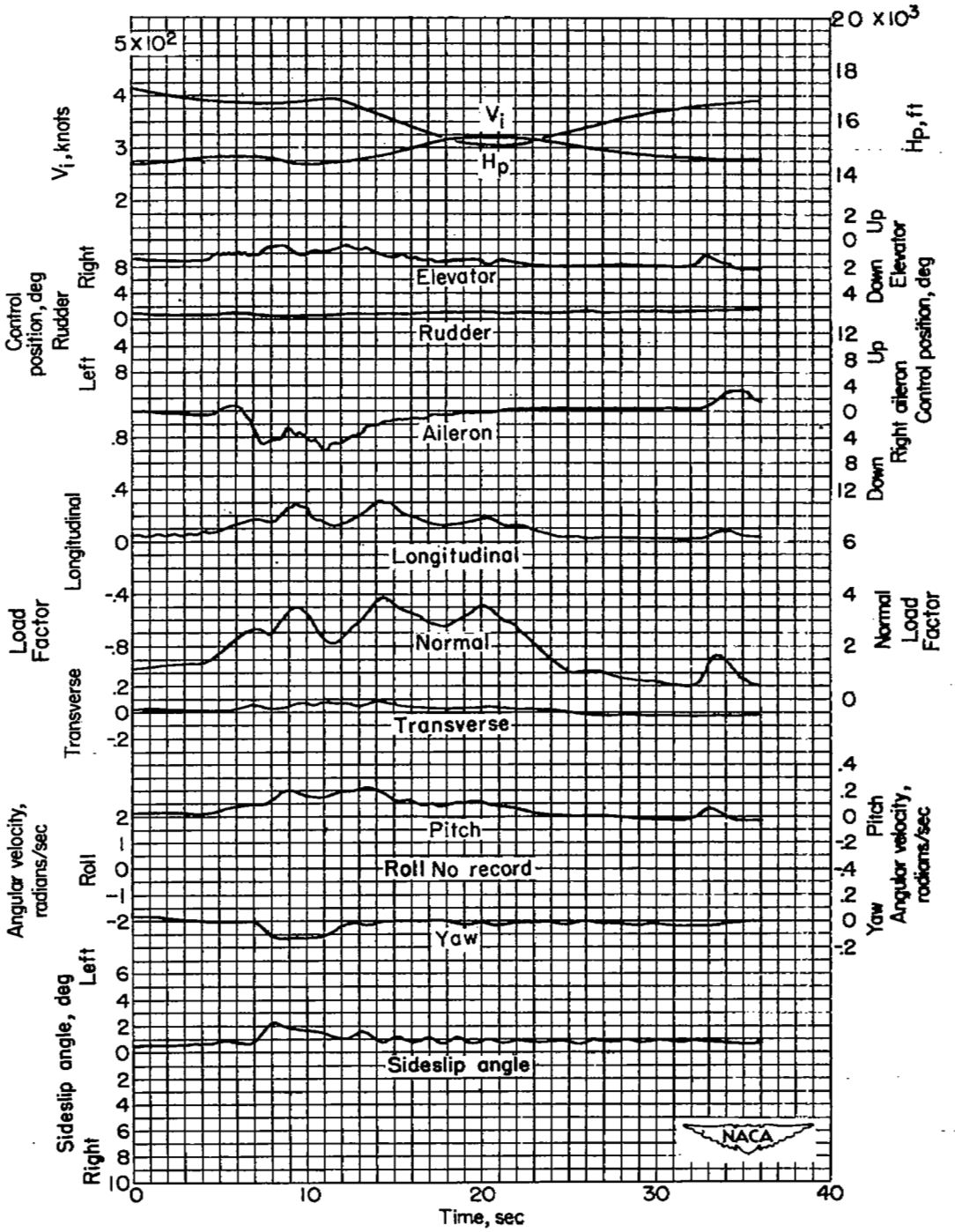


Figure 131.- Dive with rolling entry and normal pull-out; airplane weight, 16,480 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

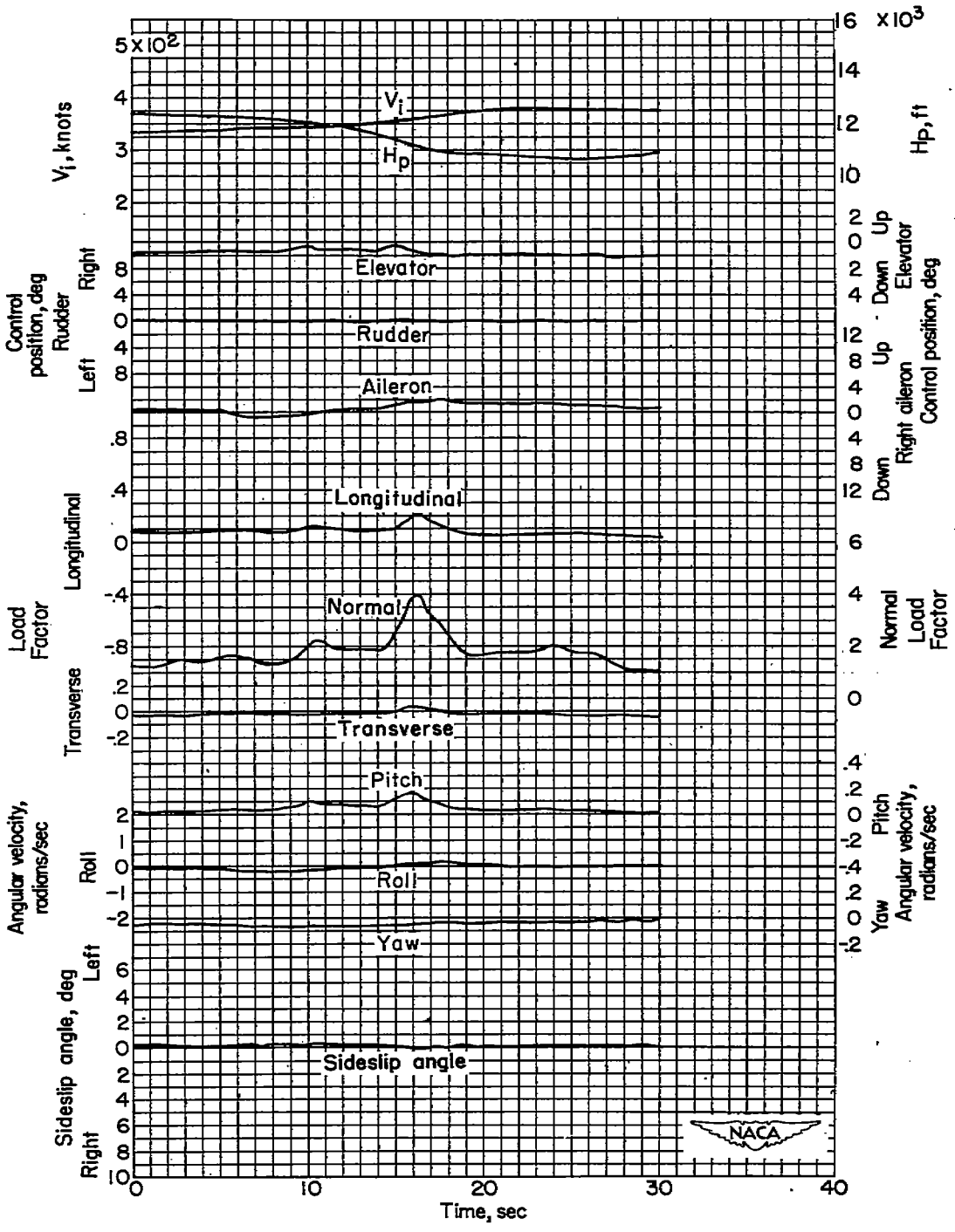


Figure 132.- Dive with rolling entry and pull-out; airplane weight, 14,770 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

[redacted]

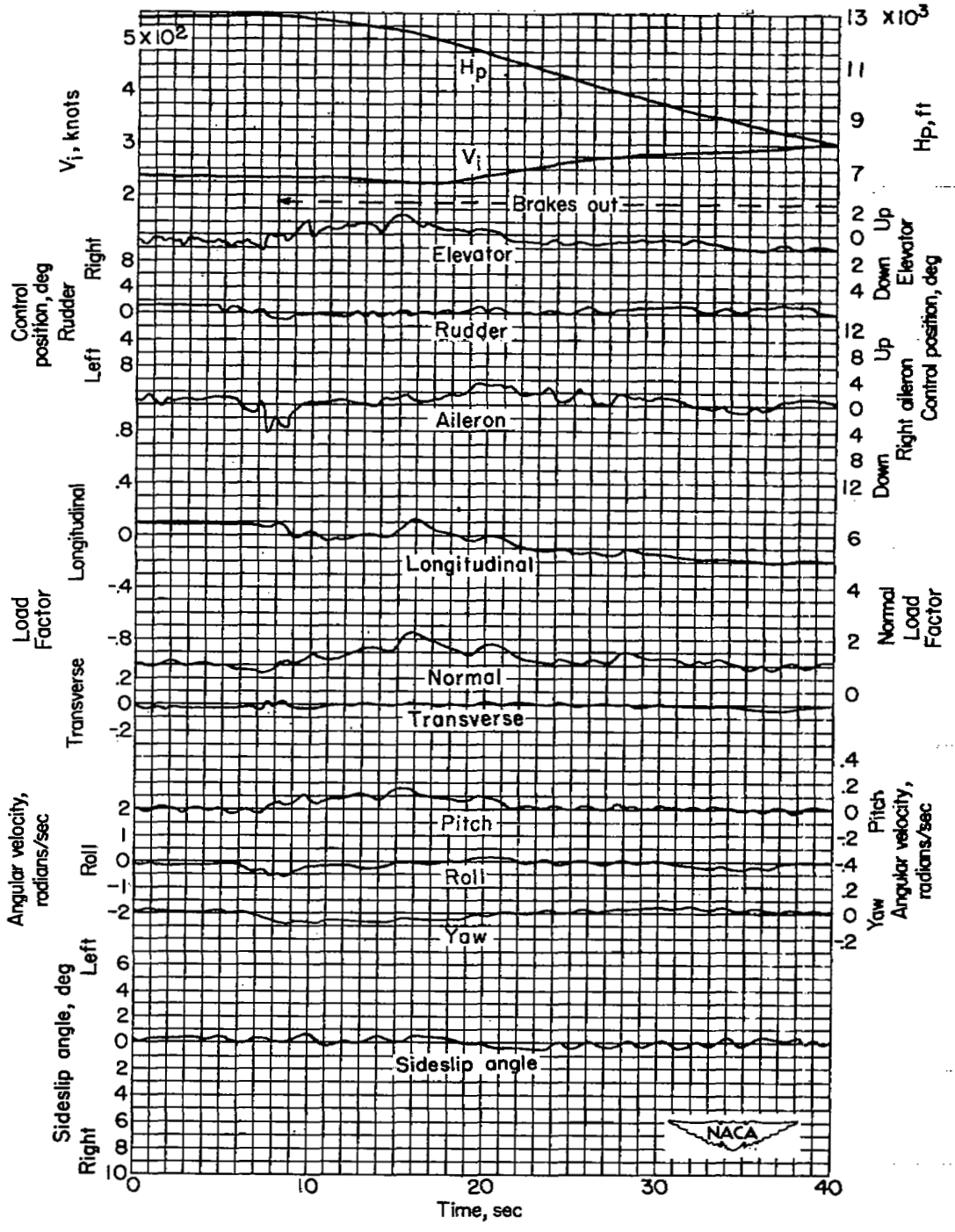
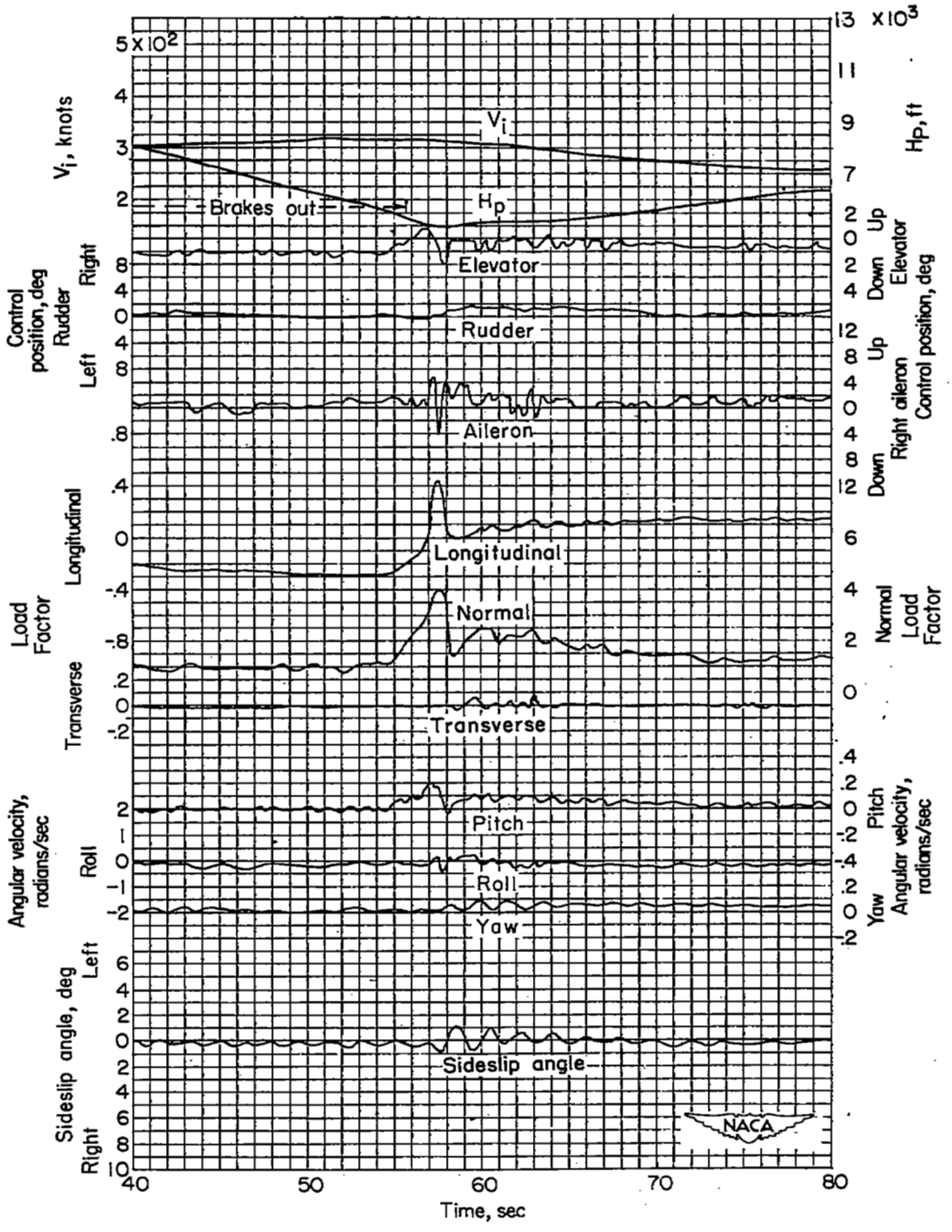


Figure 133.- Dive with rolling entry and abrupt pull-up recovery; airplane weight, 17,070 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.



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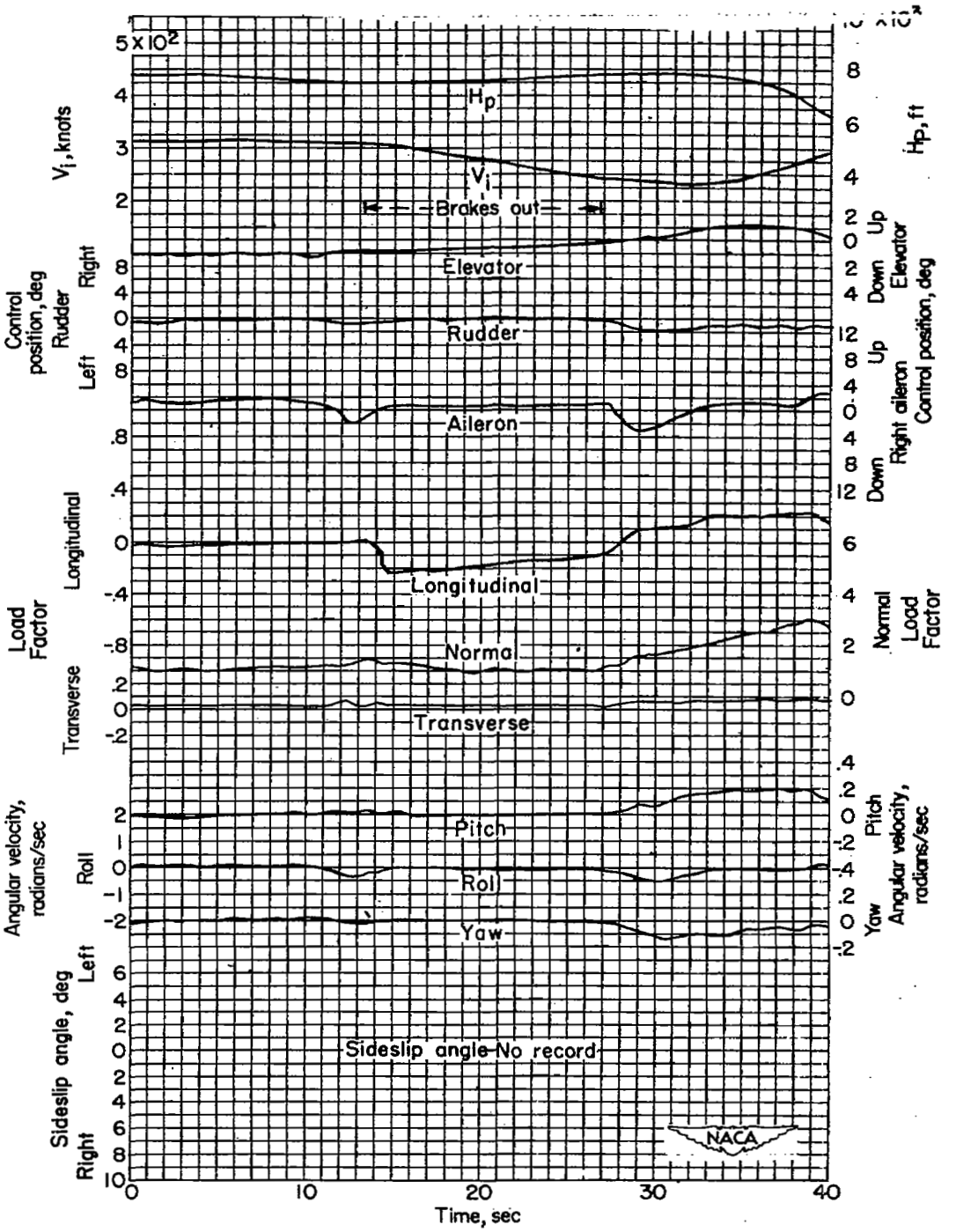
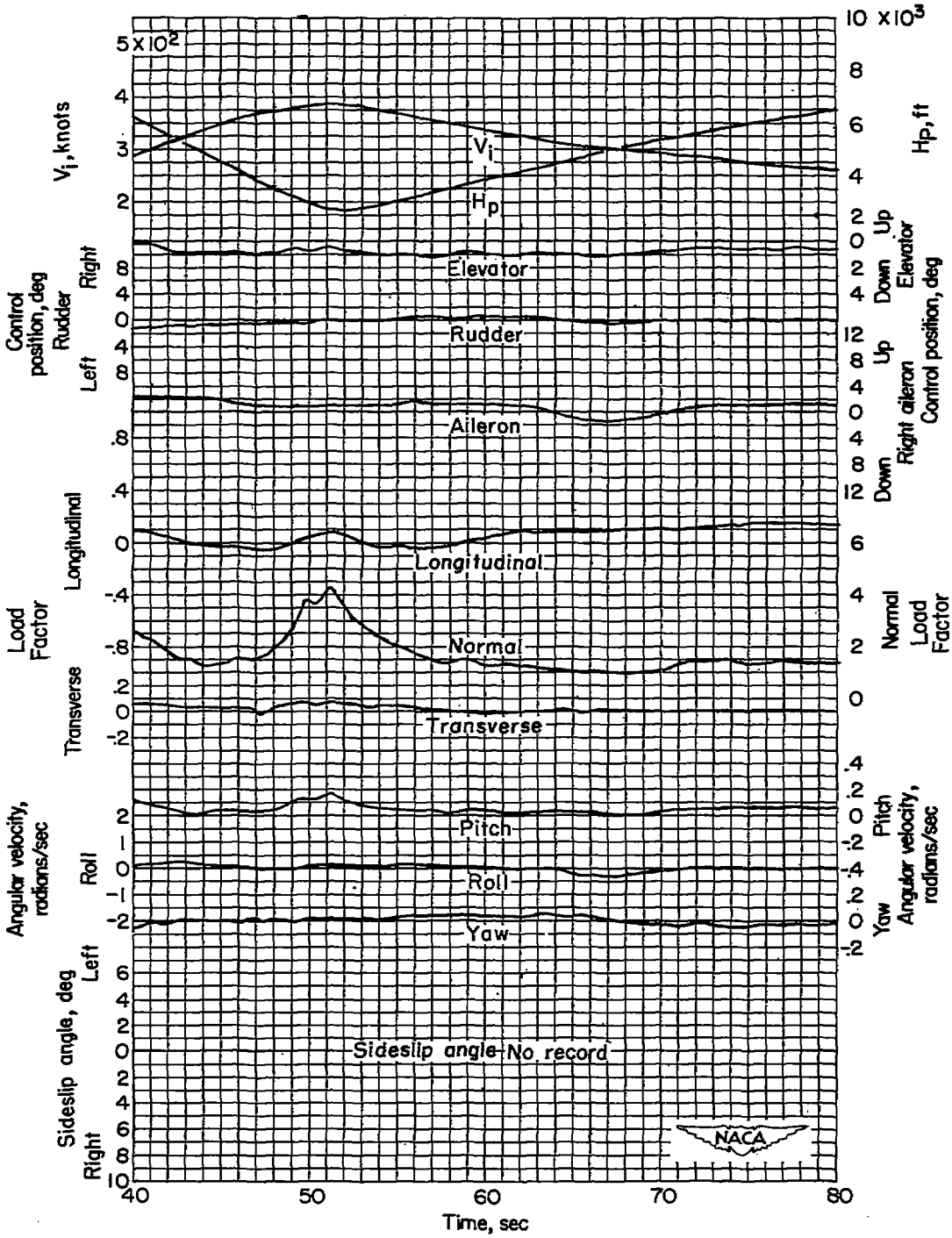


Figure 134.- Dive with rolling entry and normal pull-out; airplane weight, 15,600 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.



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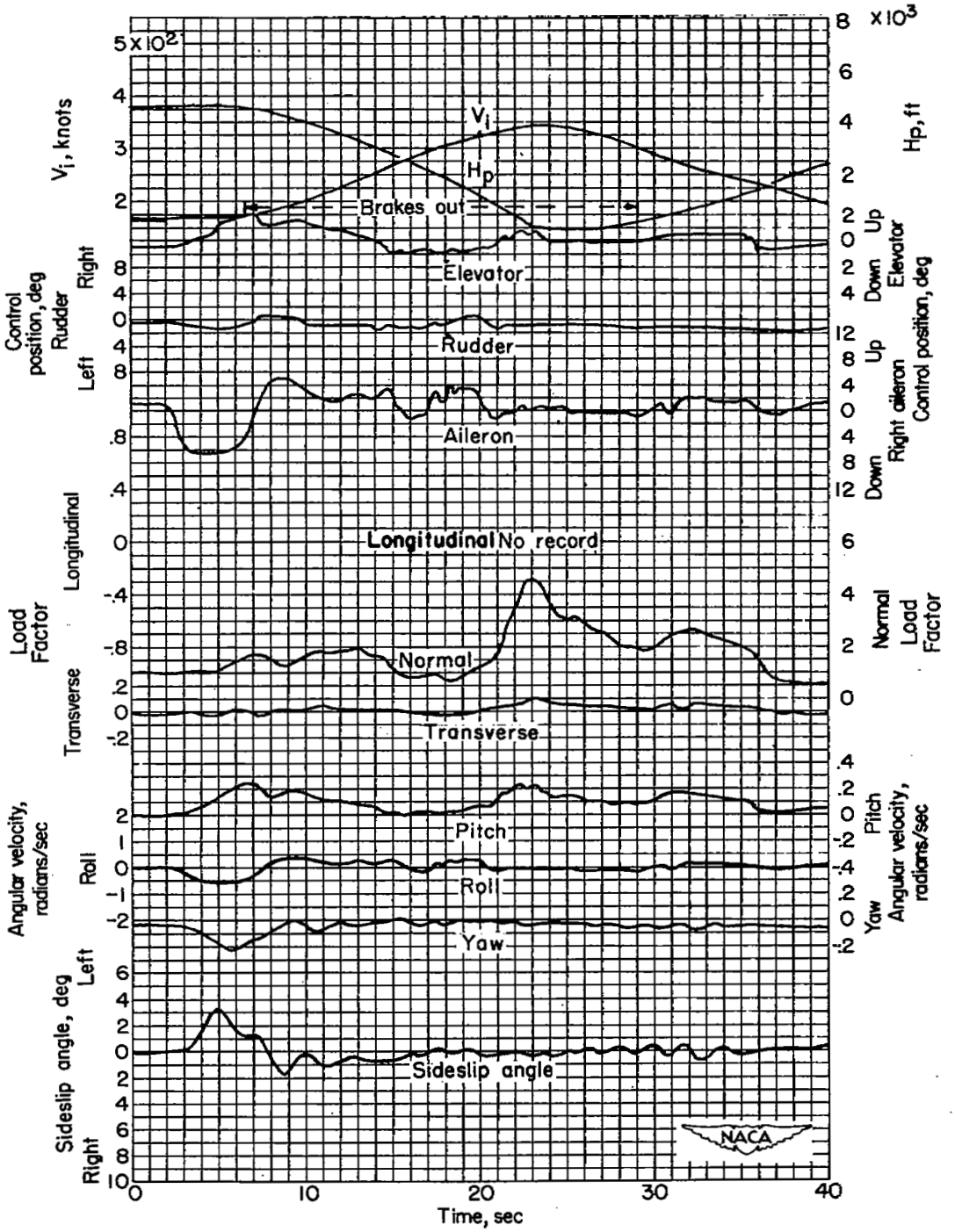


Figure 135.- Dive with rolling entry and normal pull-out; airplane weight, 15,800 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

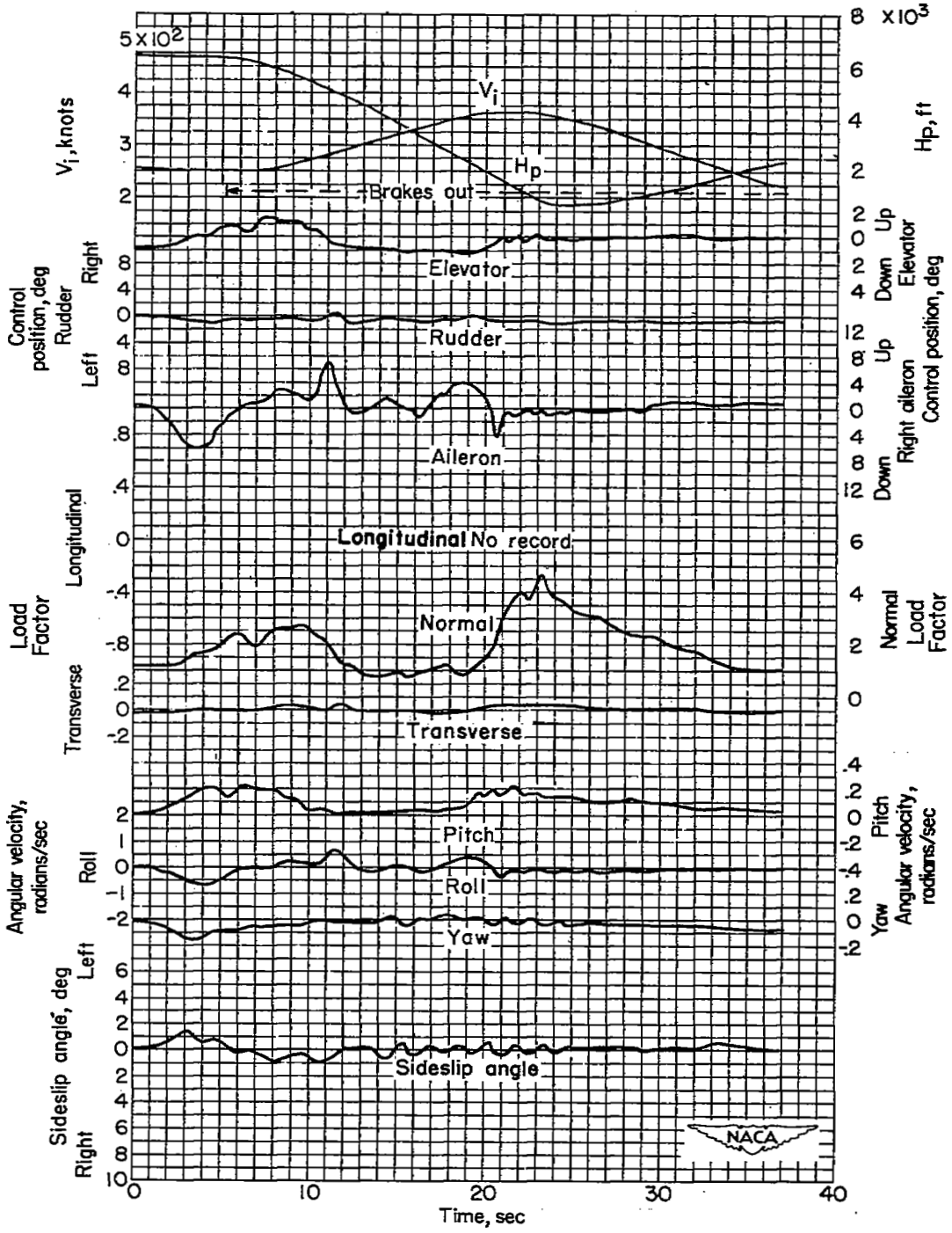


Figure 136.- Dive with rolling entry and normal pull-out; airplane weight, 15,920 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

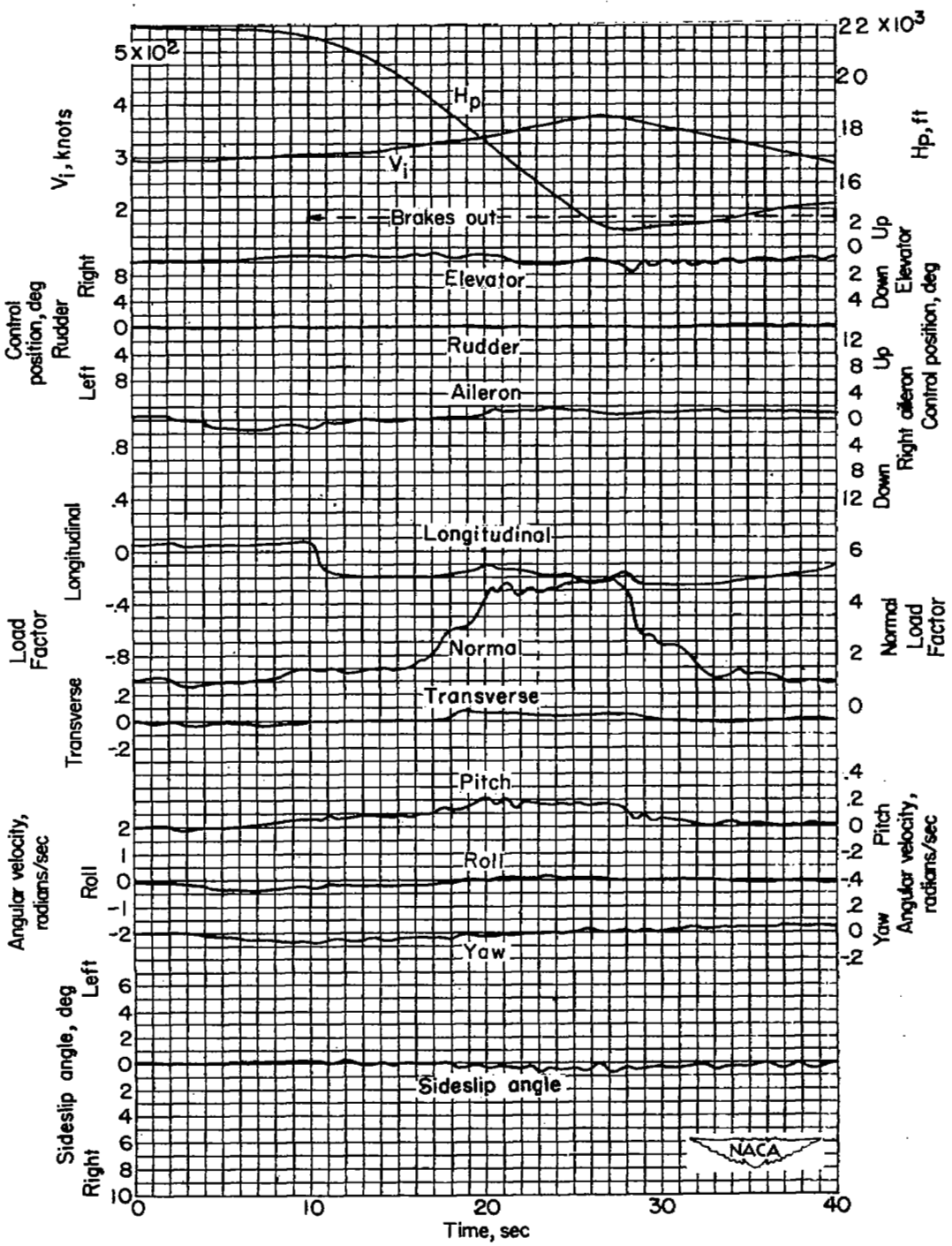


Figure 137.- Dive with rolling entry and normal pull-out; airplane weight, 15,350 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

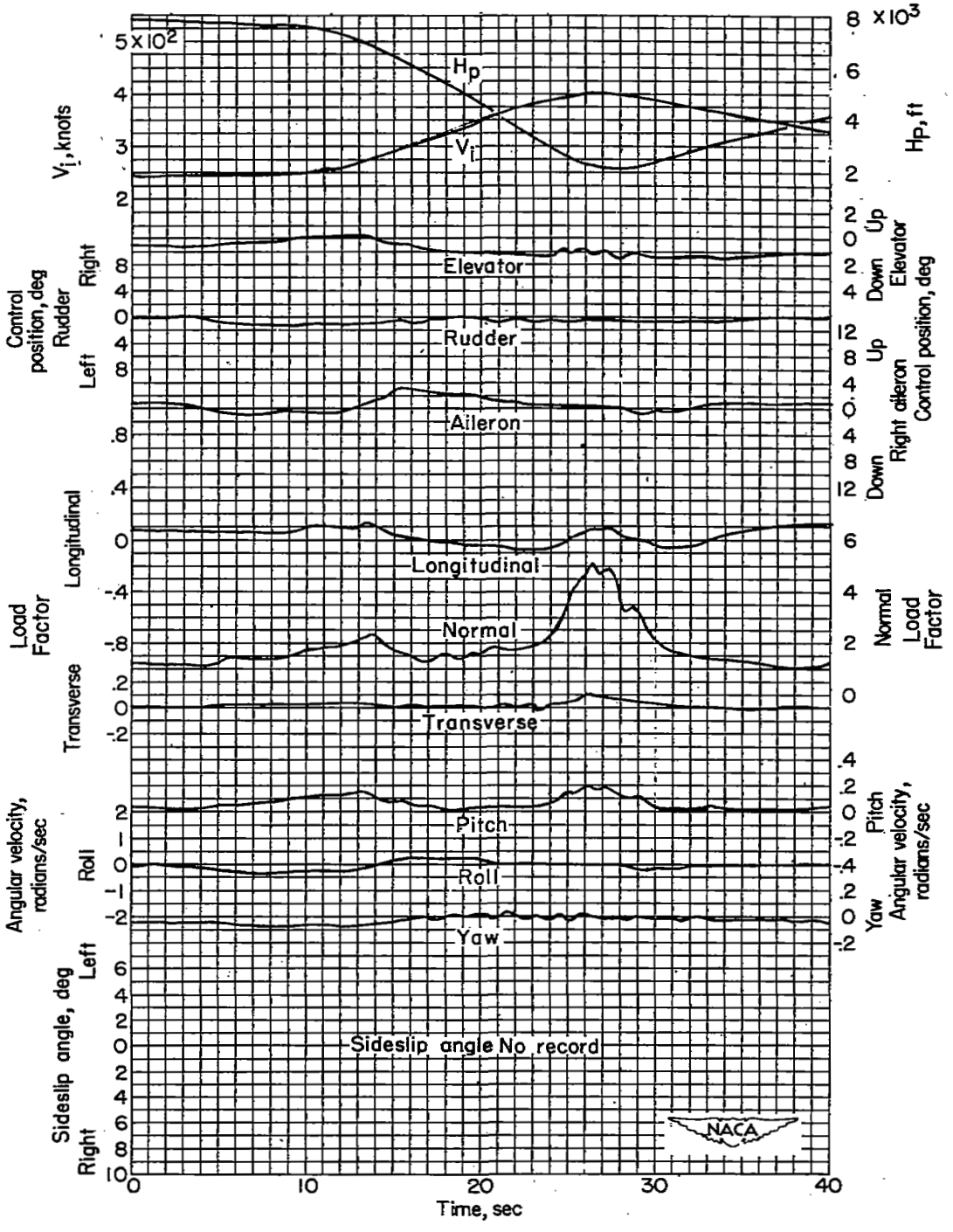


Figure 138.- Dive with rolling entry and normal pull-out; airplane weight, 15,425 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

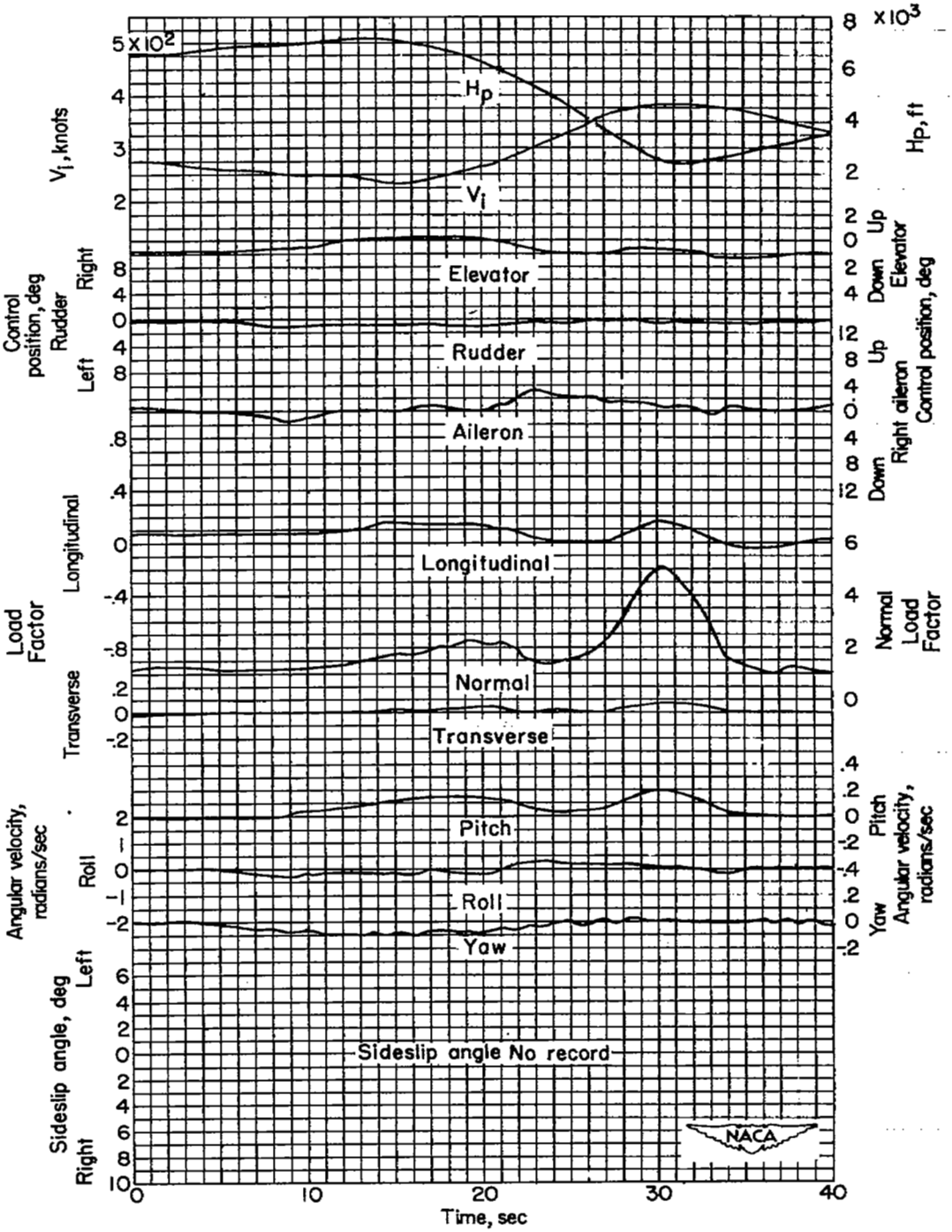


Figure 139.- Dive with rolling entry and normal pull-out; airplane weight, 15,320 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

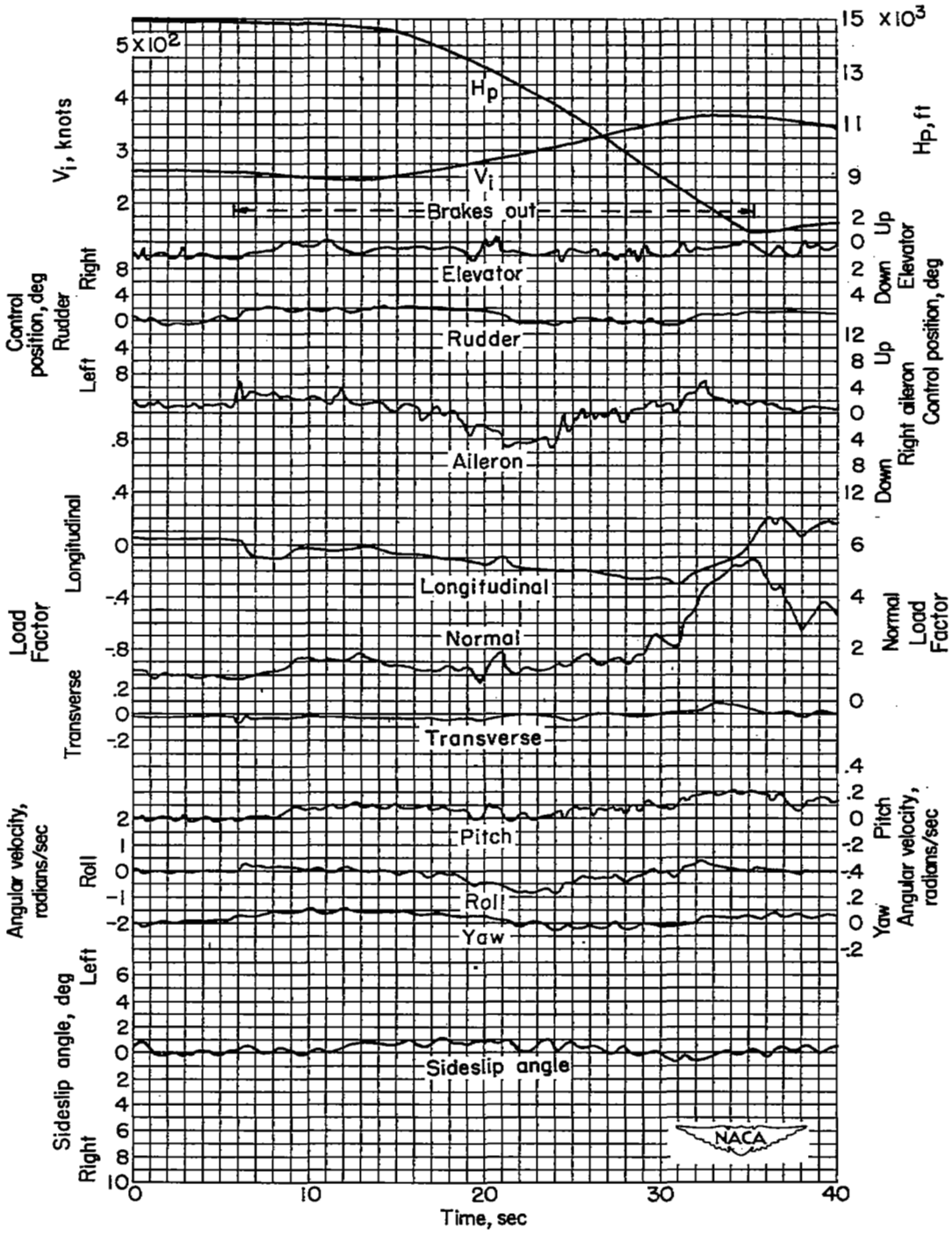
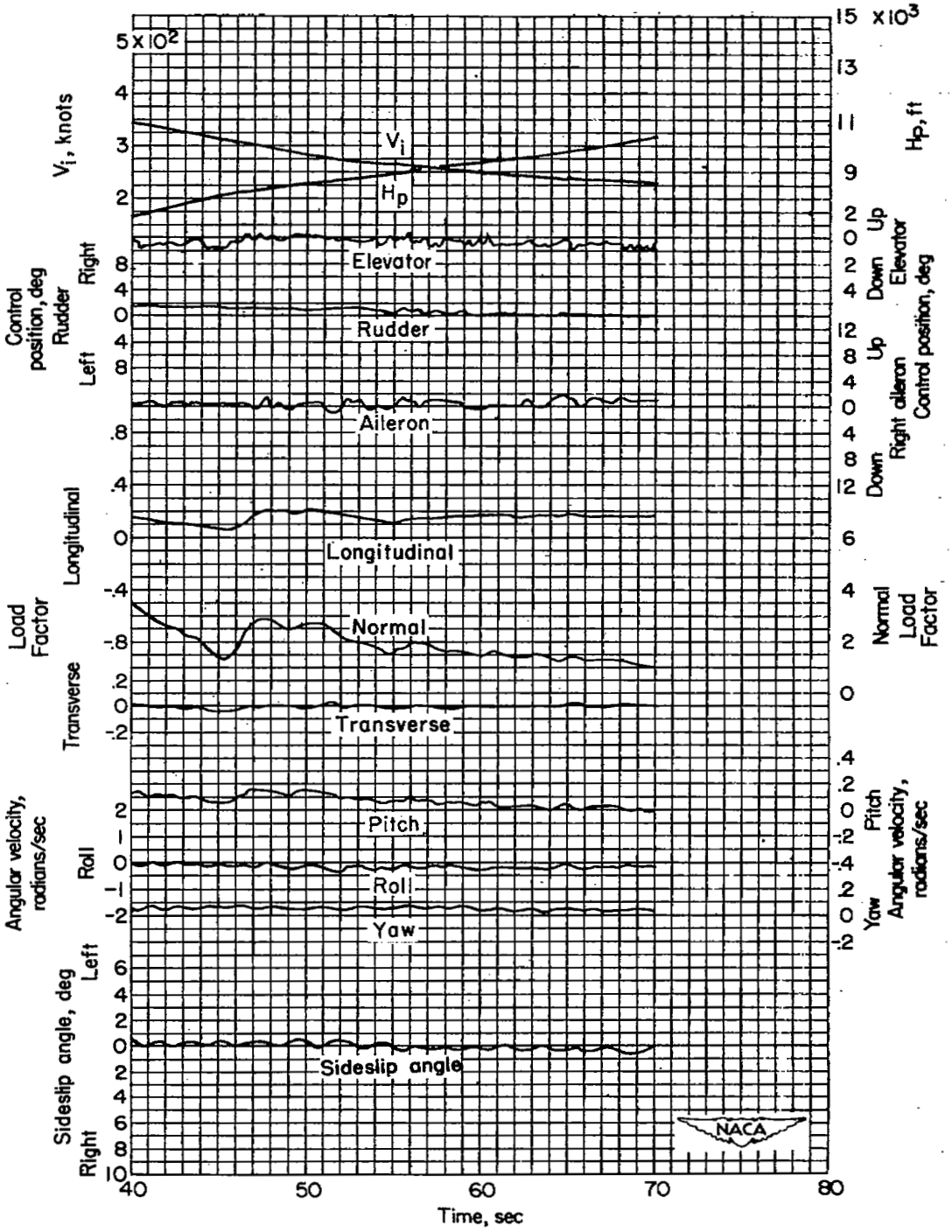


Figure 140.- Dive with rolling entry and normal pull-out; airplane weight, 17,270 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

[redacted]



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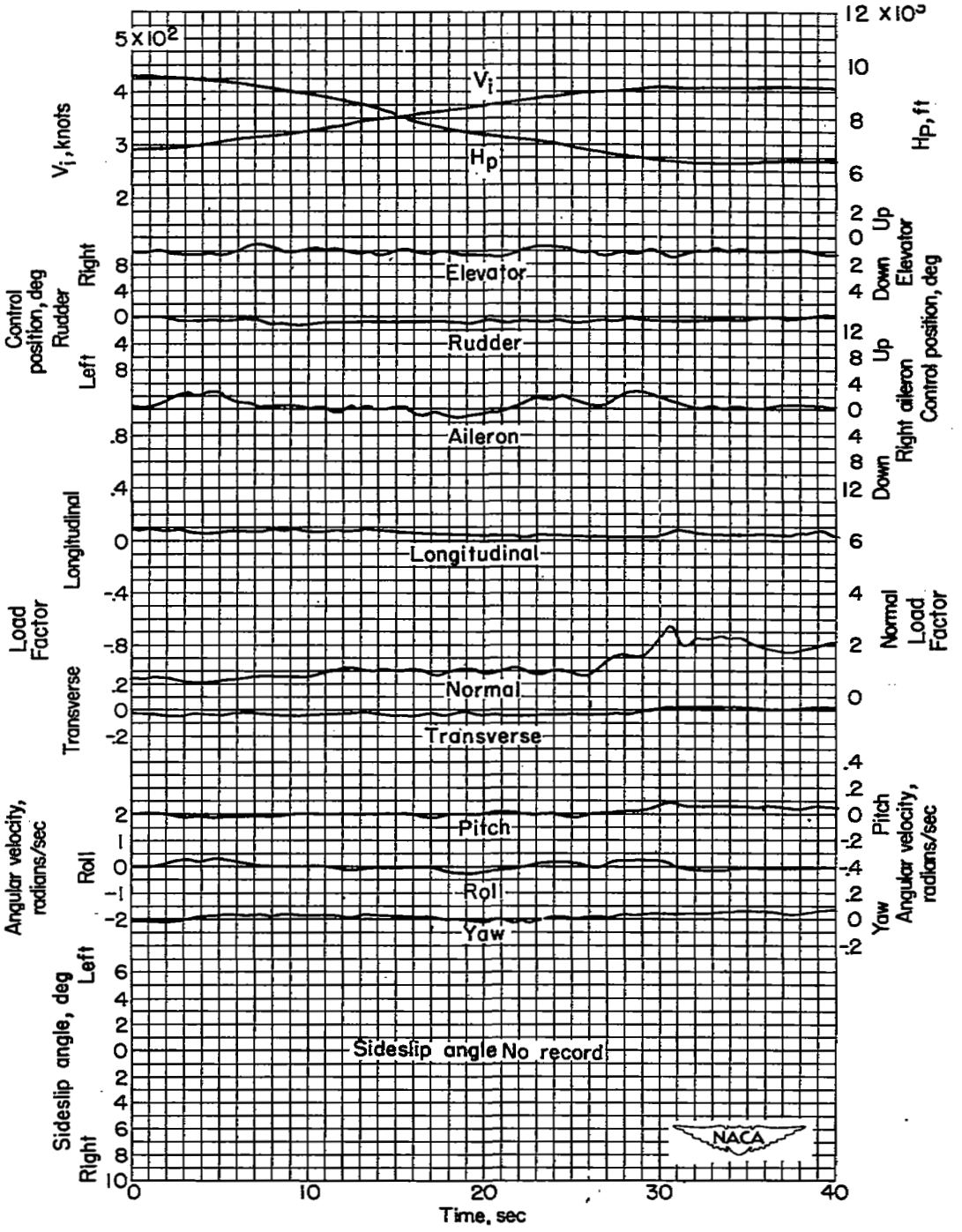
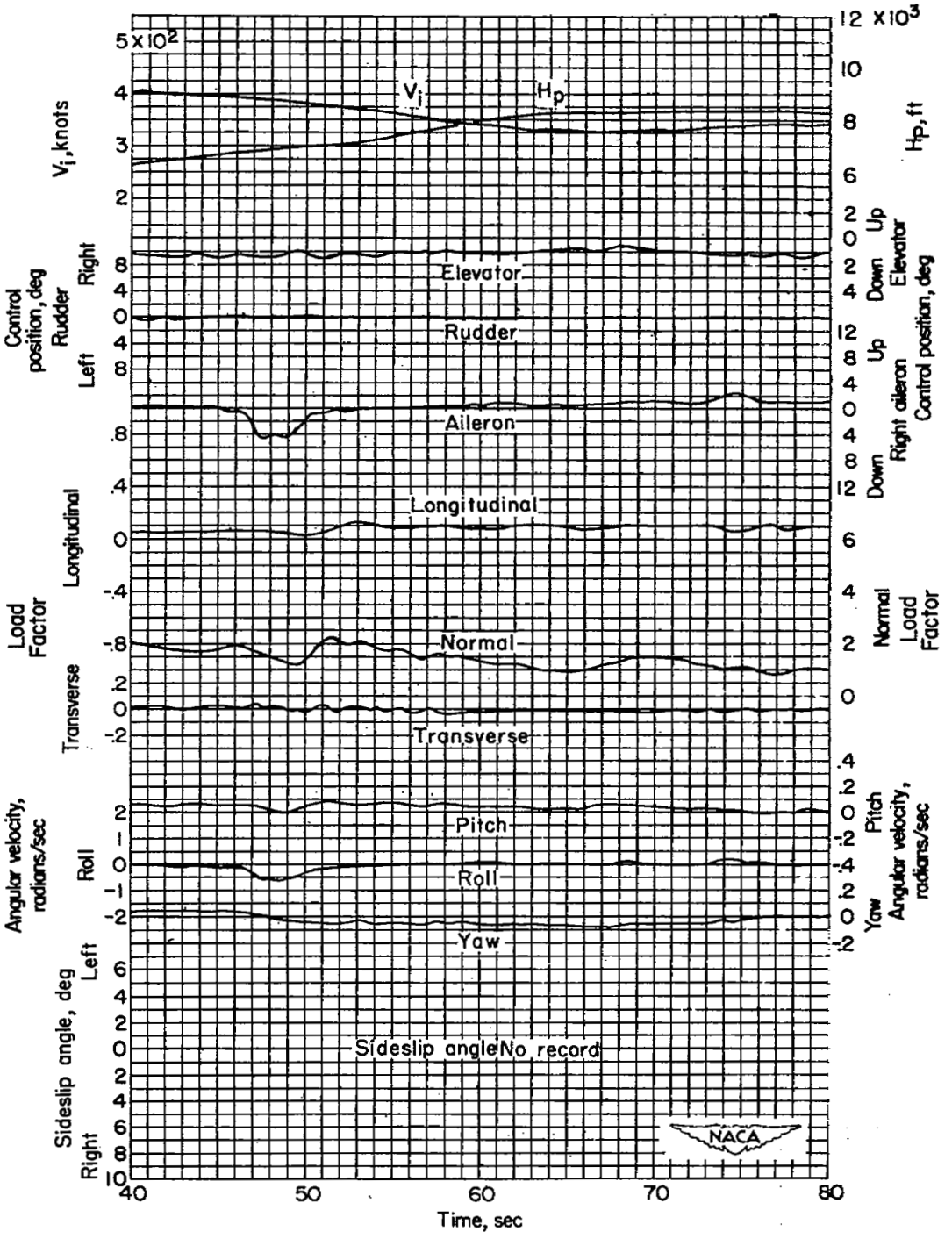


Figure 141.- Dive with rolling recovery and normal pull-out; airplane weight, 16,500 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.



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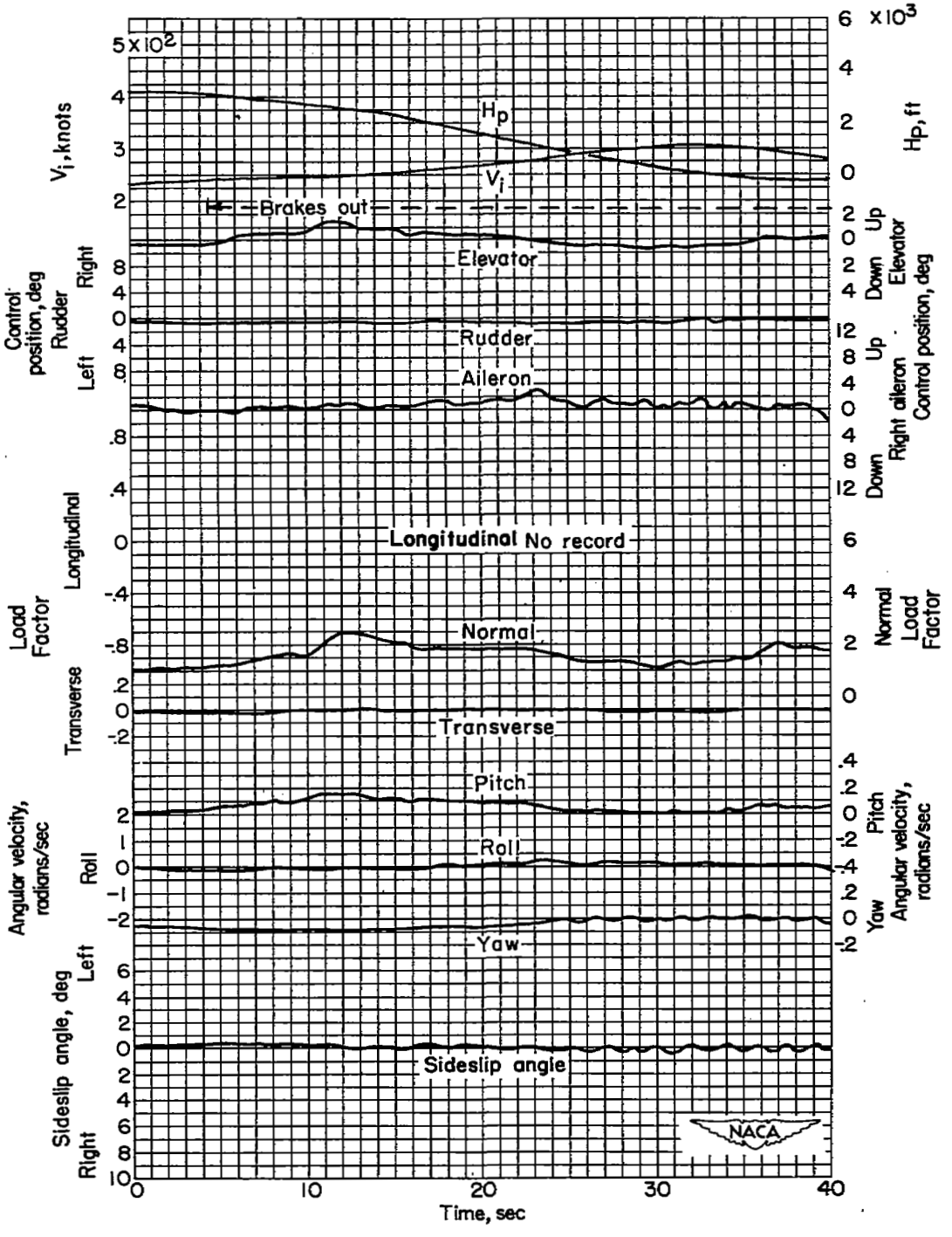

Figure 142.- Dive with rolling pull-out; airplane weight, 15,730 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

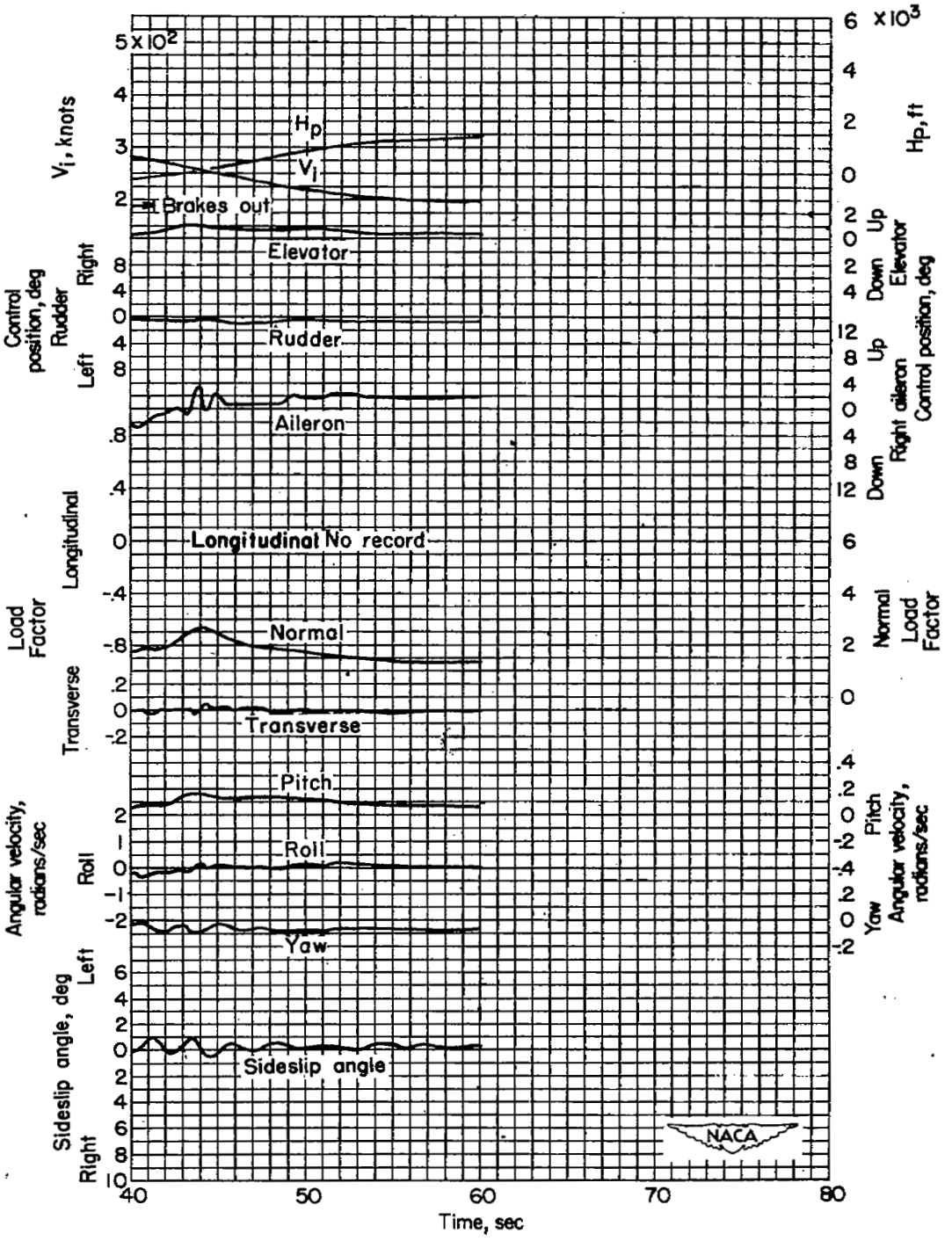

Figure 142.- Concluded.

22F

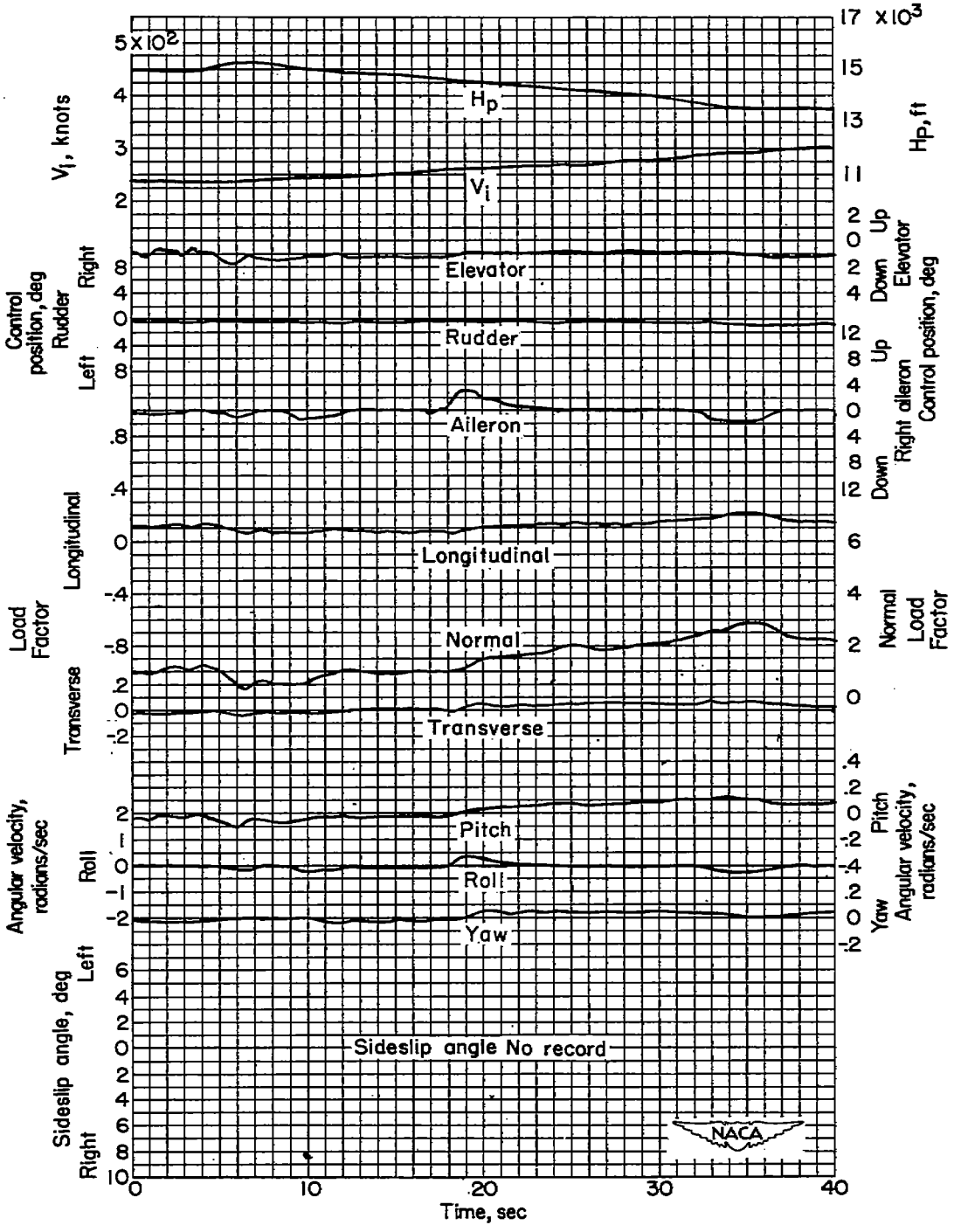

Figure 143.- Dive with gentle rolling recovery; airplane weight, 16,500 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

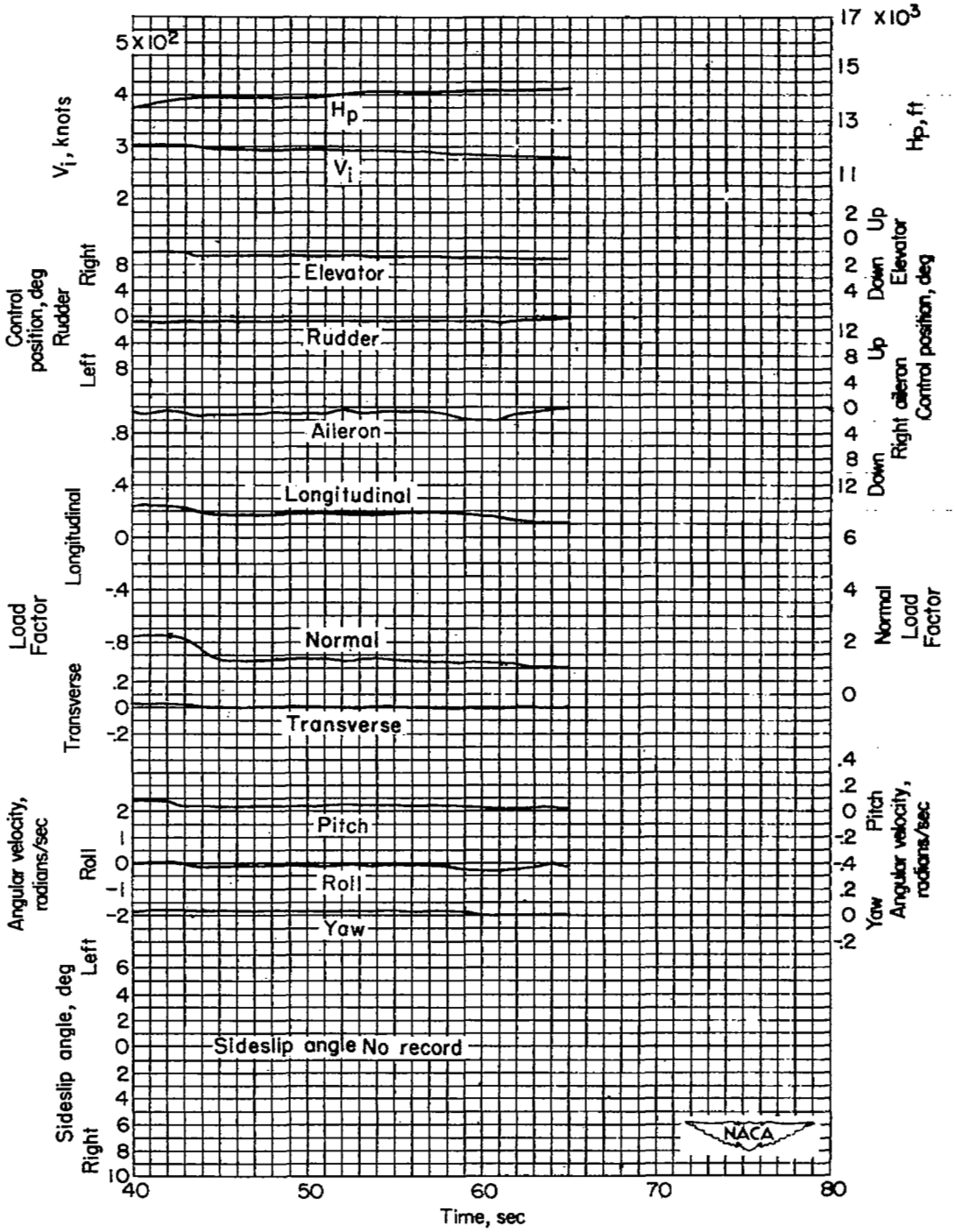

Figure 143.- Concluded.

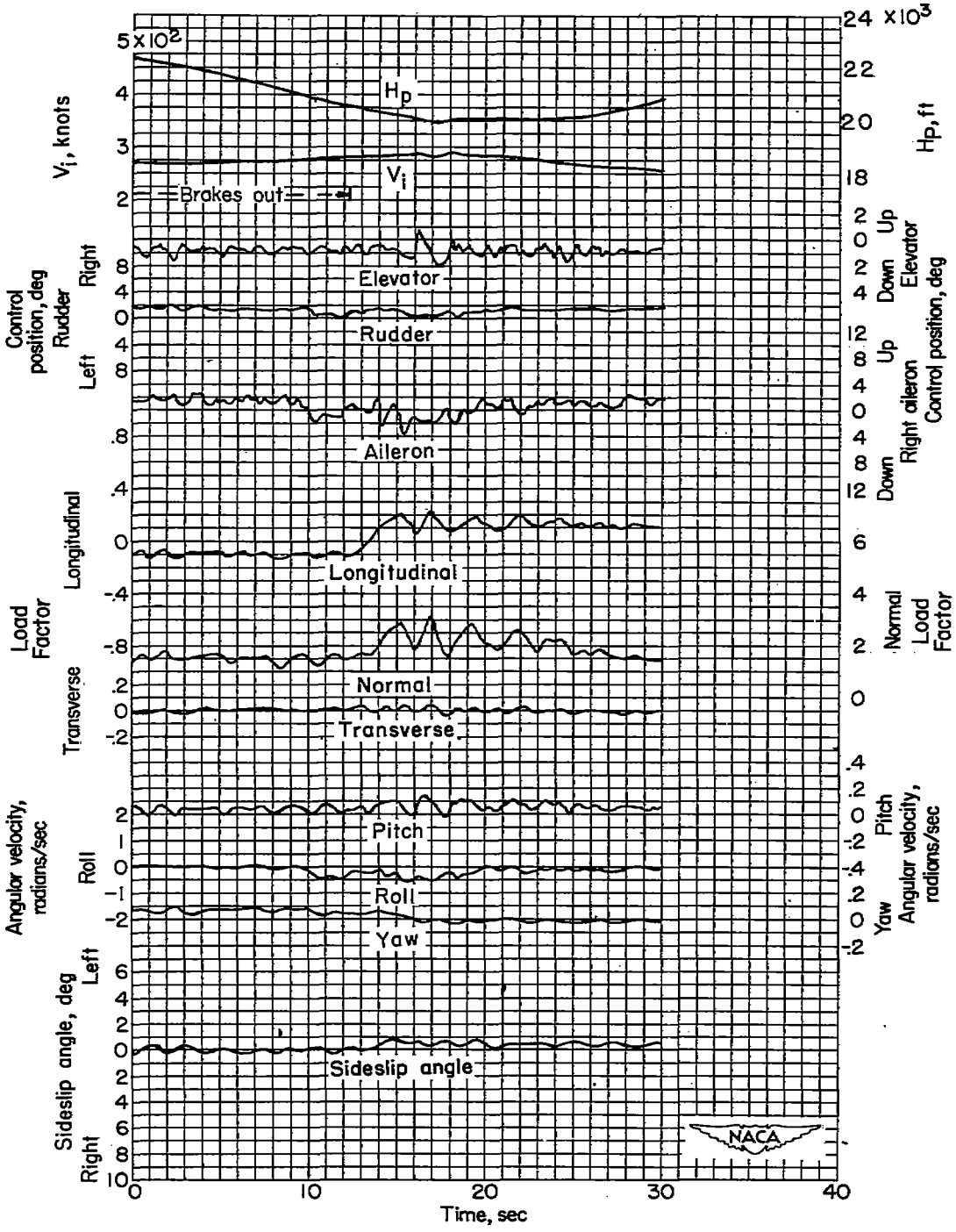

Figure 144.- Dive with rolling pull-out; airplane weight, 17,980 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

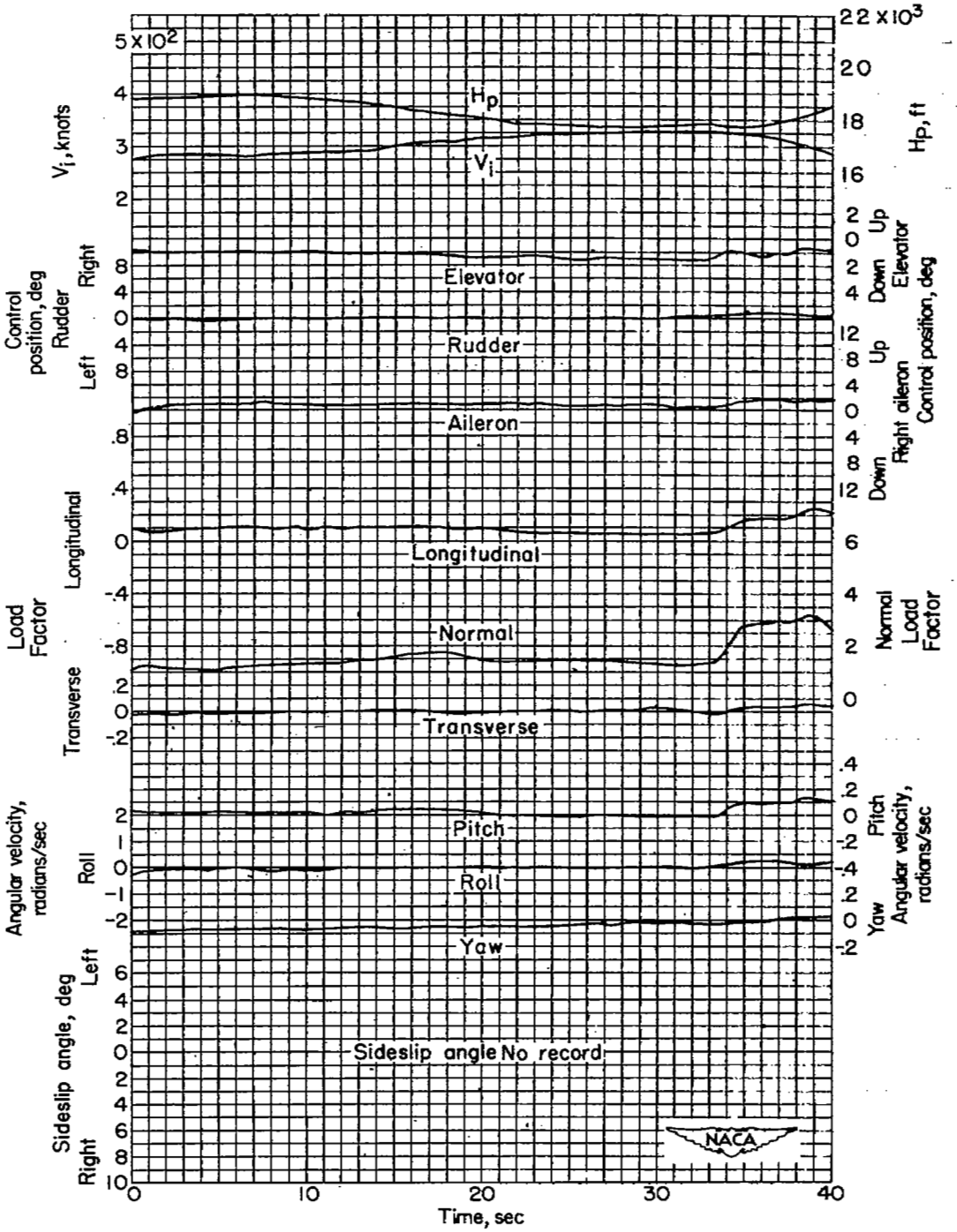

Figure 145.- Gentle dive with rolling pull-out followed by rolling entry into a dive; airplane weight, 16,640 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

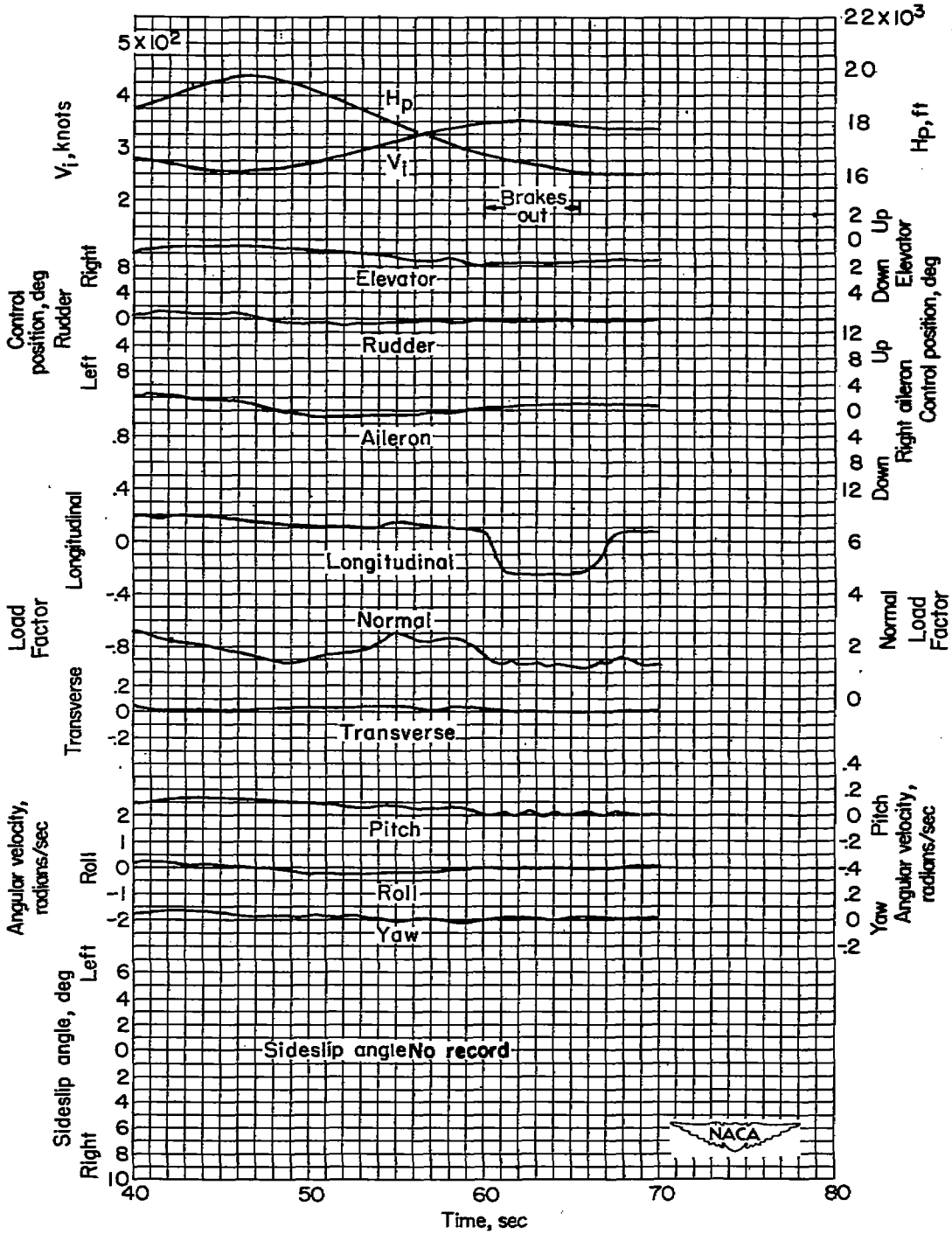

Figure 145.- Concluded.

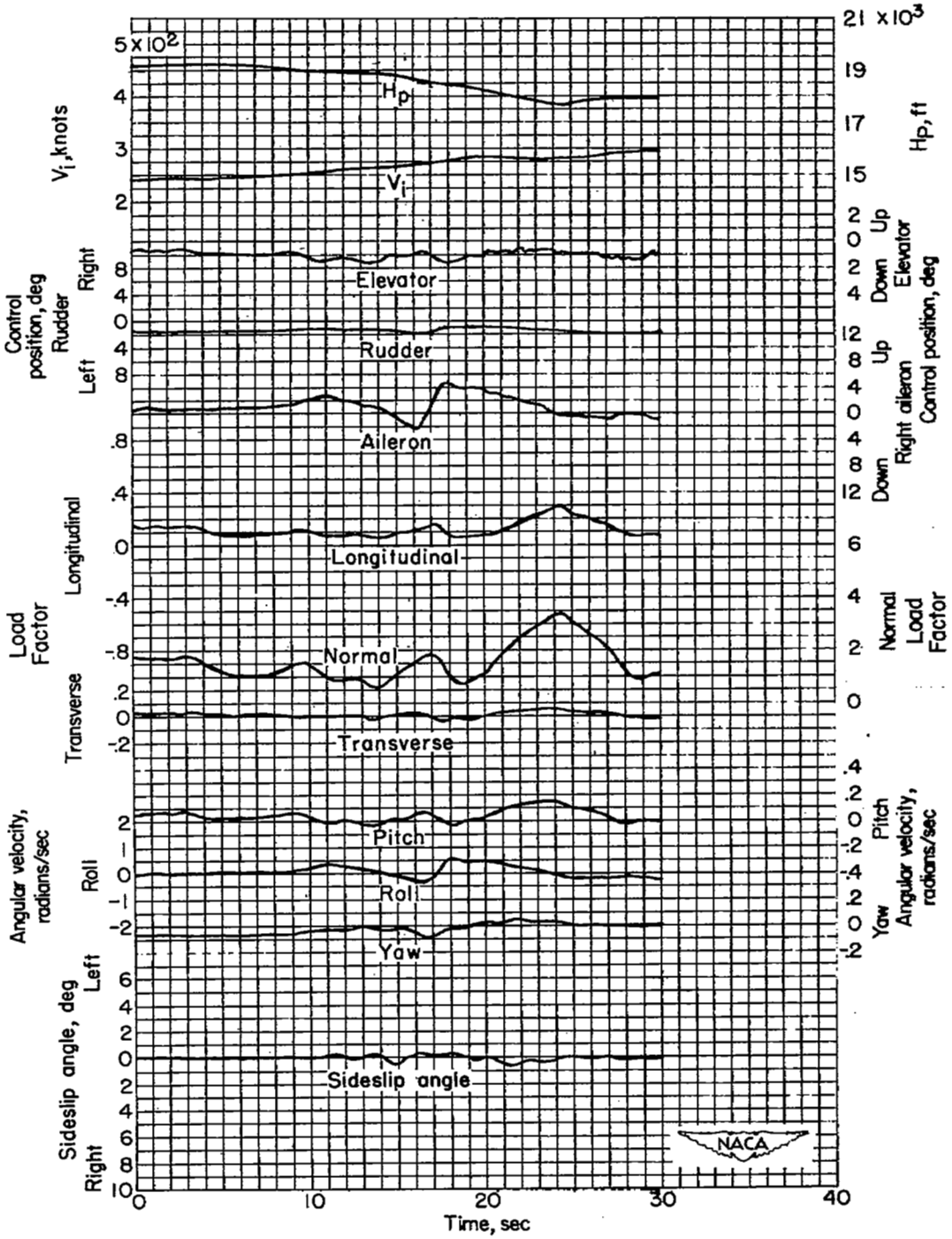

Figure 146.- Dive with turns and rolling pull-out; airplane weight, 16,570 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

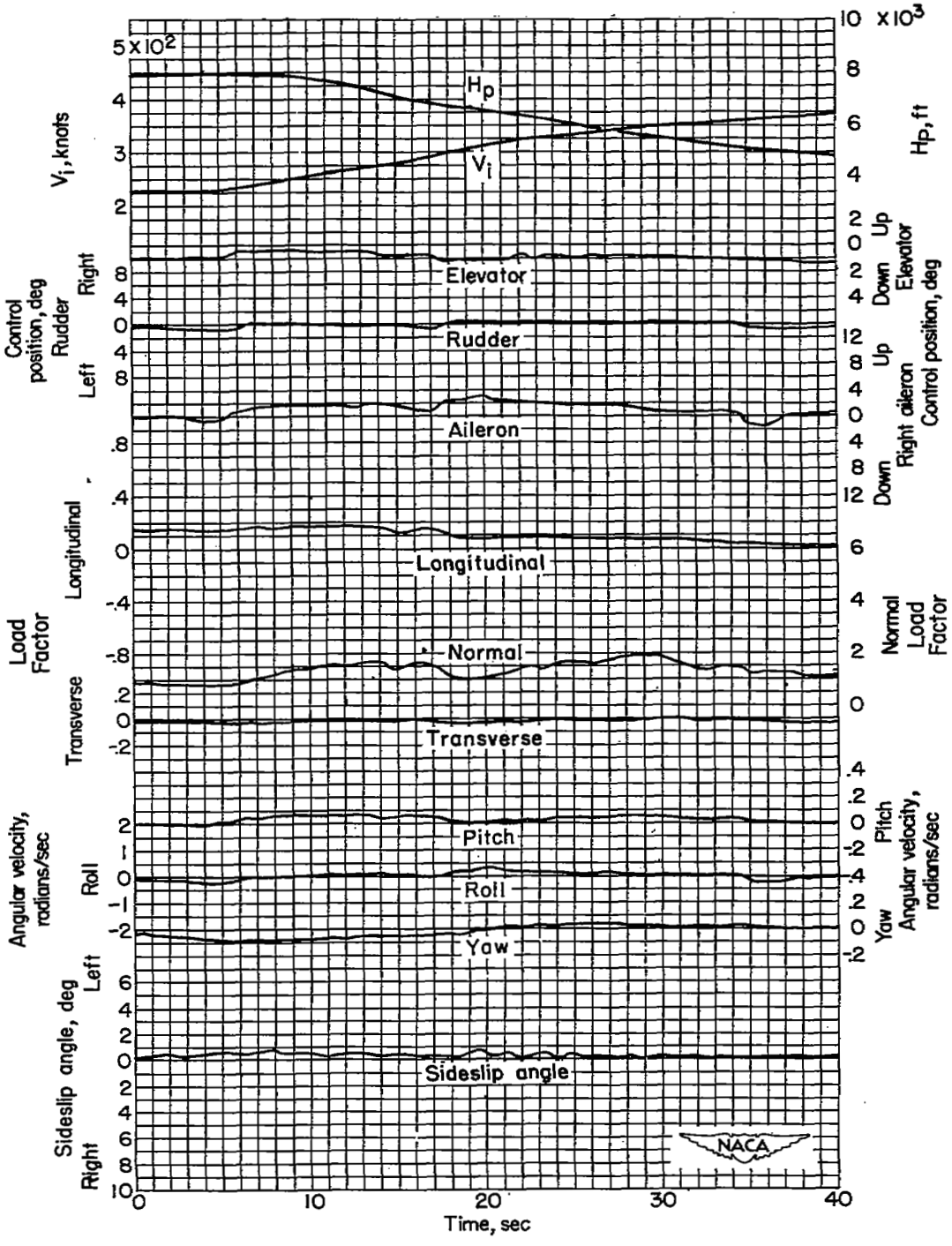

Figure 147.- Dive with rolling entry and gentle rolling recovery; airplane weight, 14,000 pounds; center-of-gravity location, 26.1 percent of the mean aerodynamic chord.

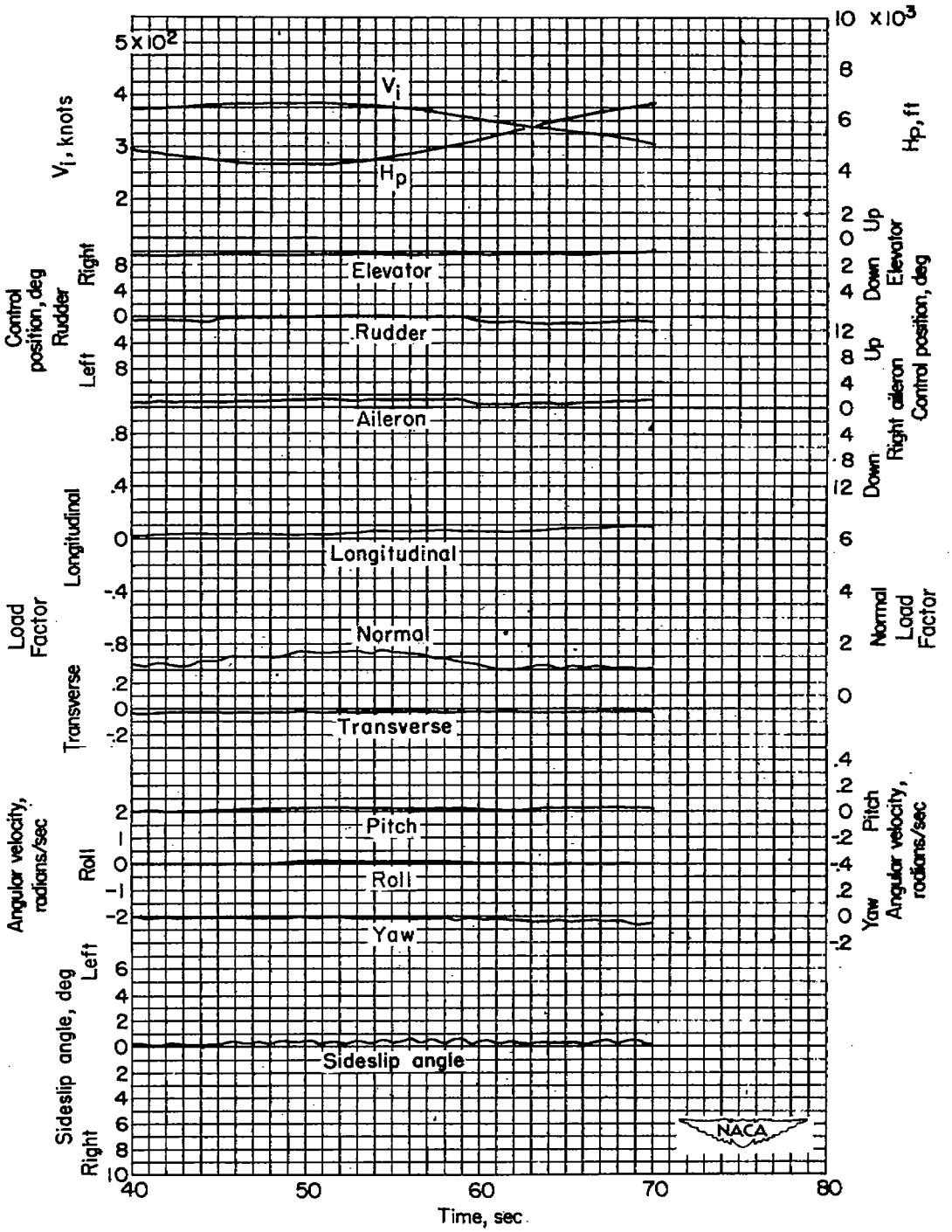

Figure 147.- Concluded.

23F

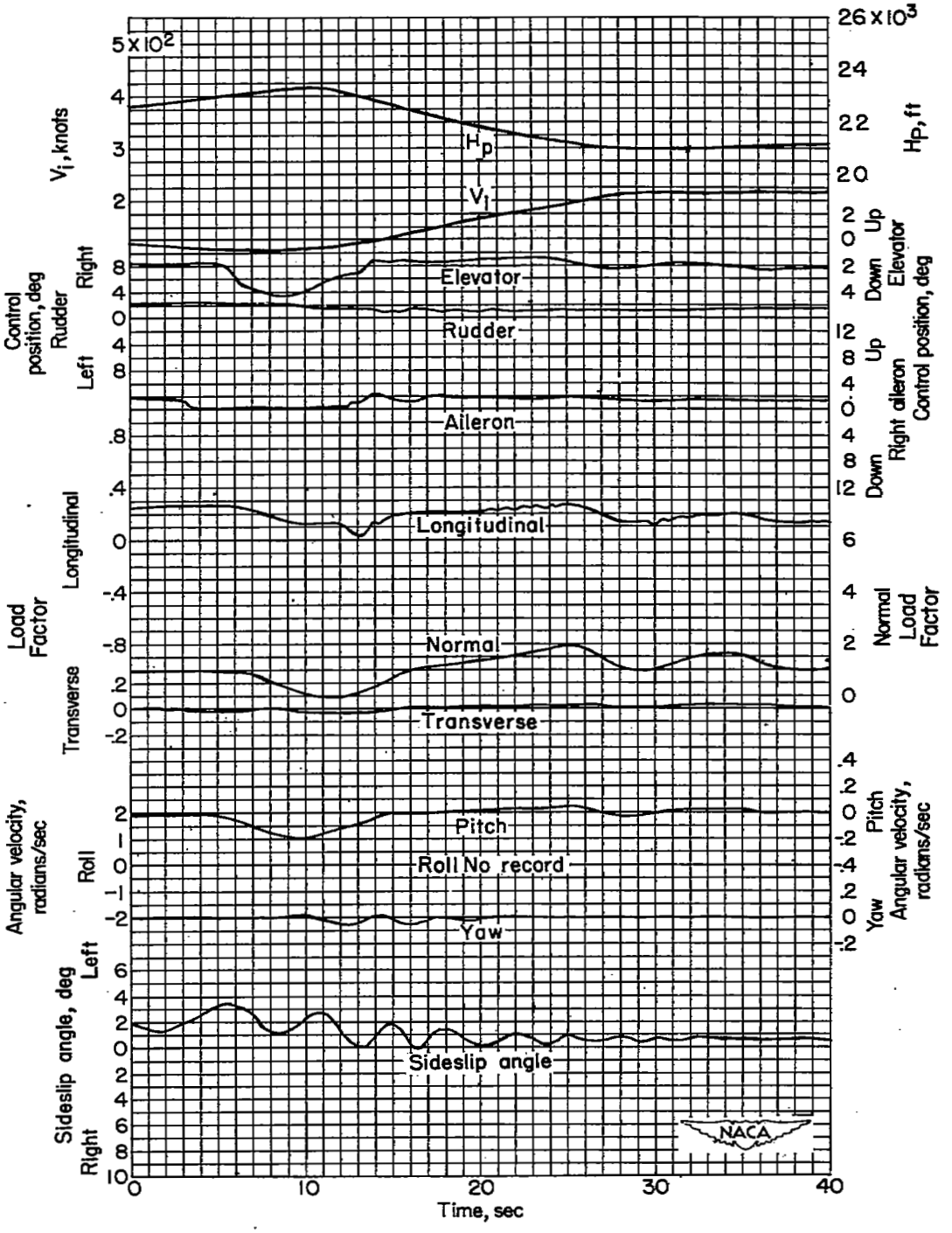

Figure 148.- Dive with push-over entry and normal pull-out; airplane weight, 15,120 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

[redacted]

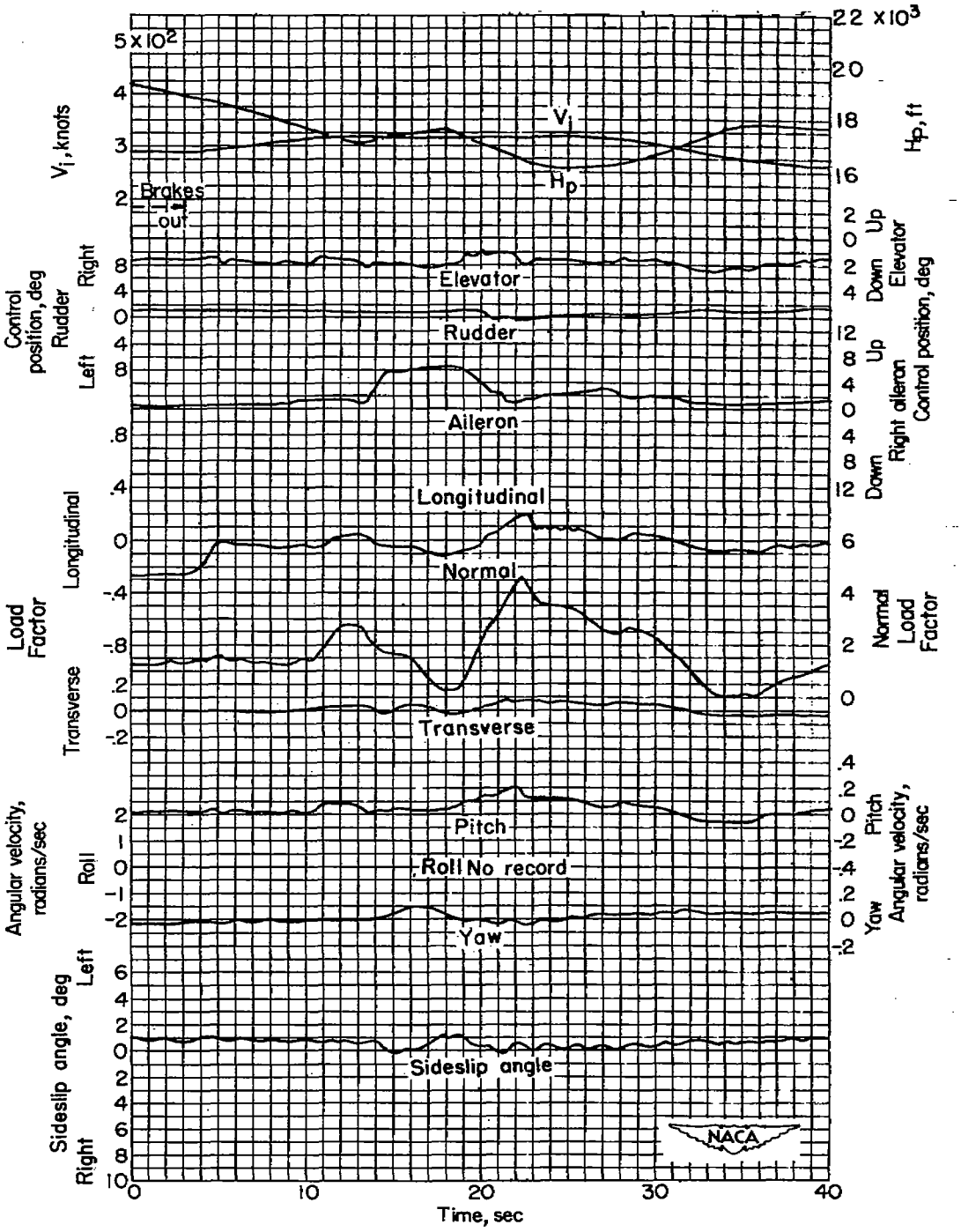

Figure 149.- Dive with right slow roll and gentle rolling pull-out; airplane weight, 16,510 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

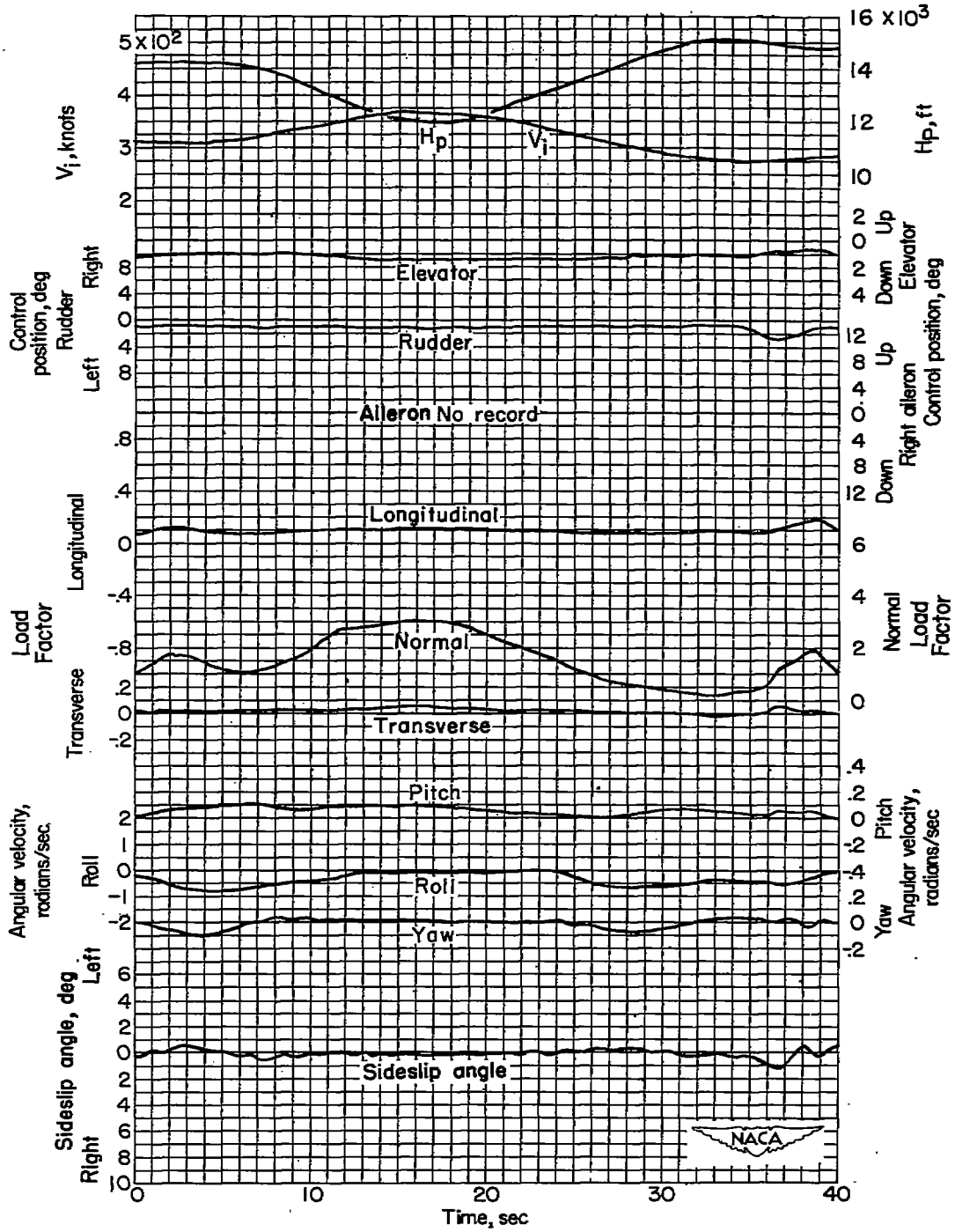

Figure 150.- Dive with rolling entry followed by a left slow roll; airplane weight, 15,960 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

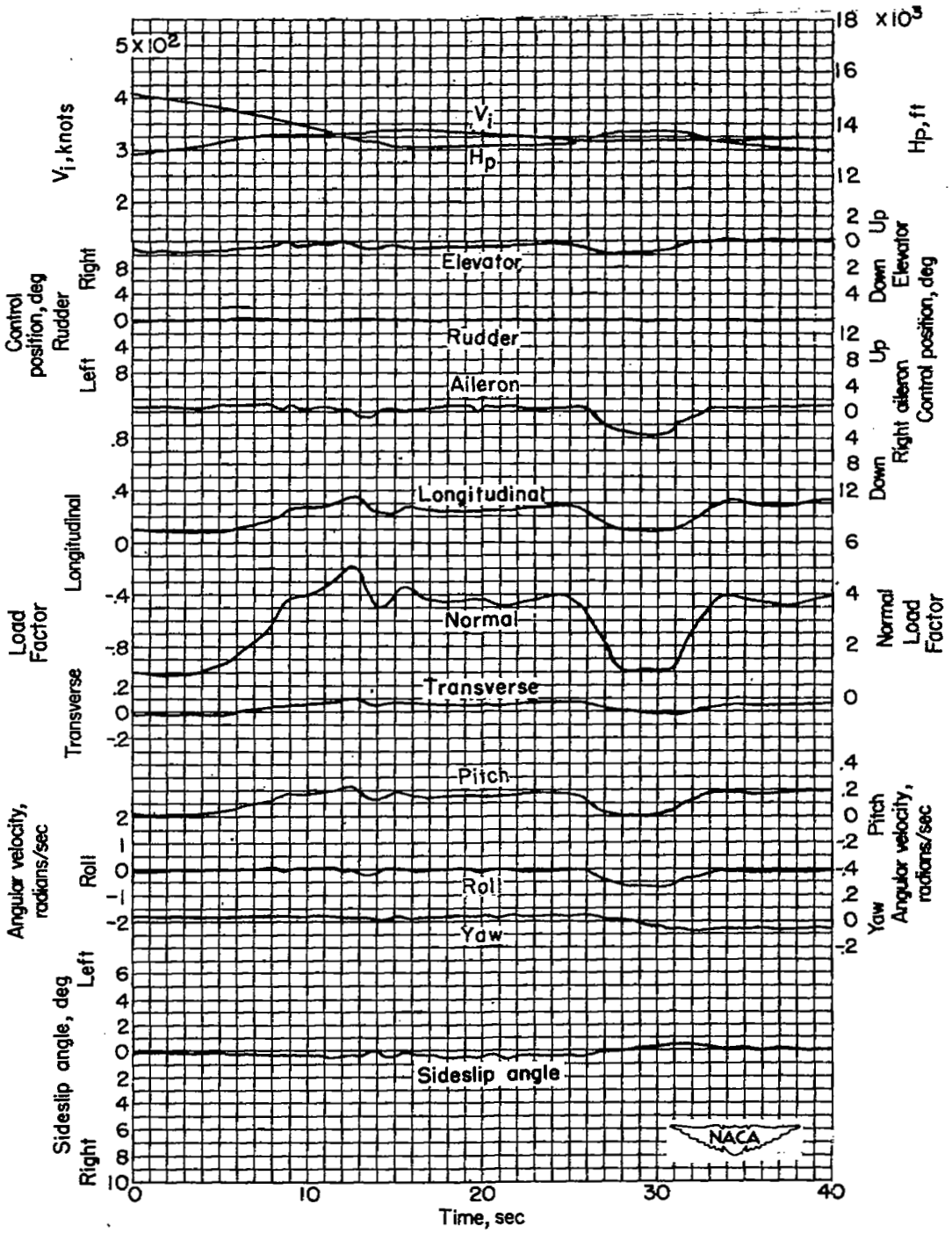

Figure 151.- Dive with rolling pull-out followed by dive with left slow roll; airplane weight, 15,290 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

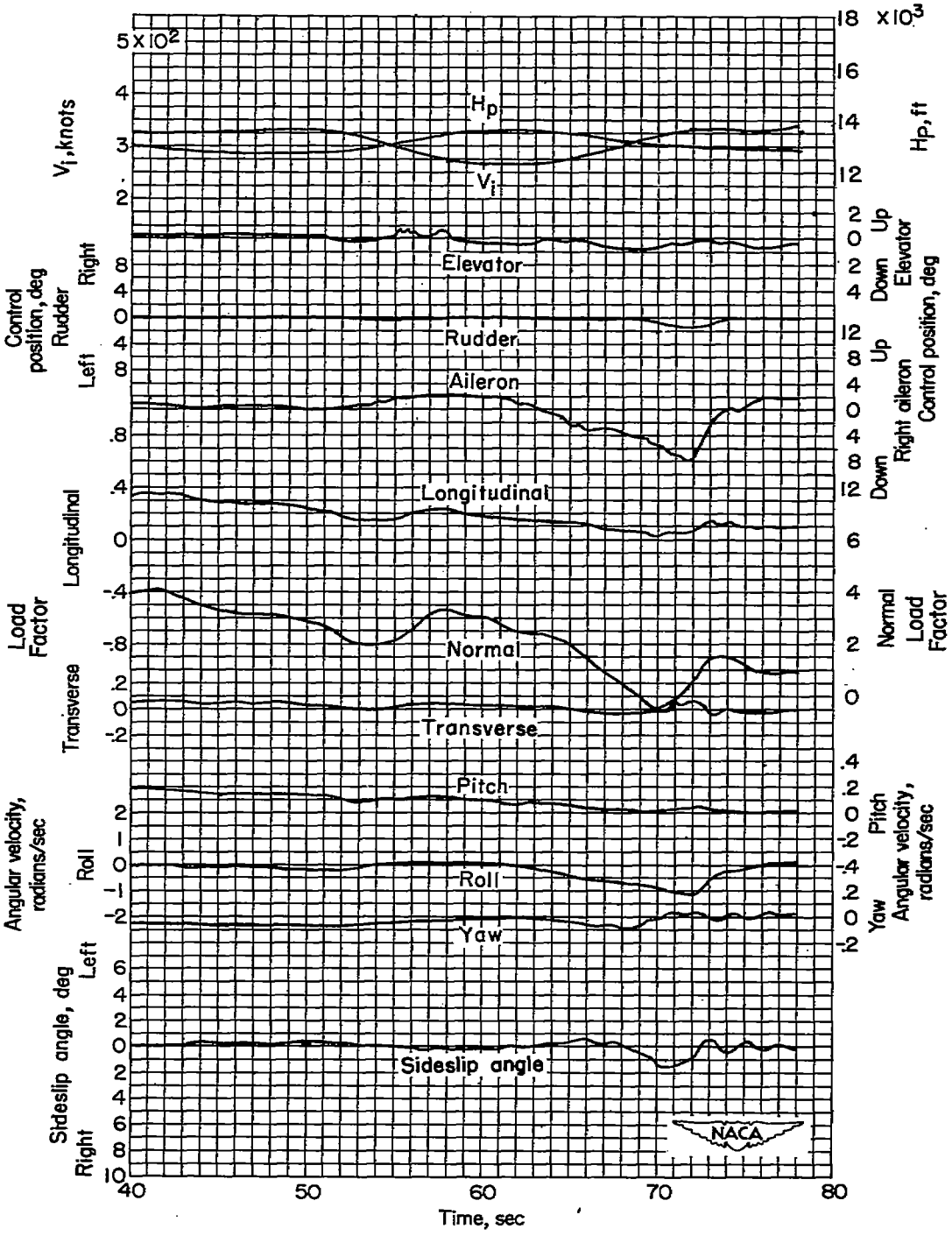

Figure 151.- Concluded.

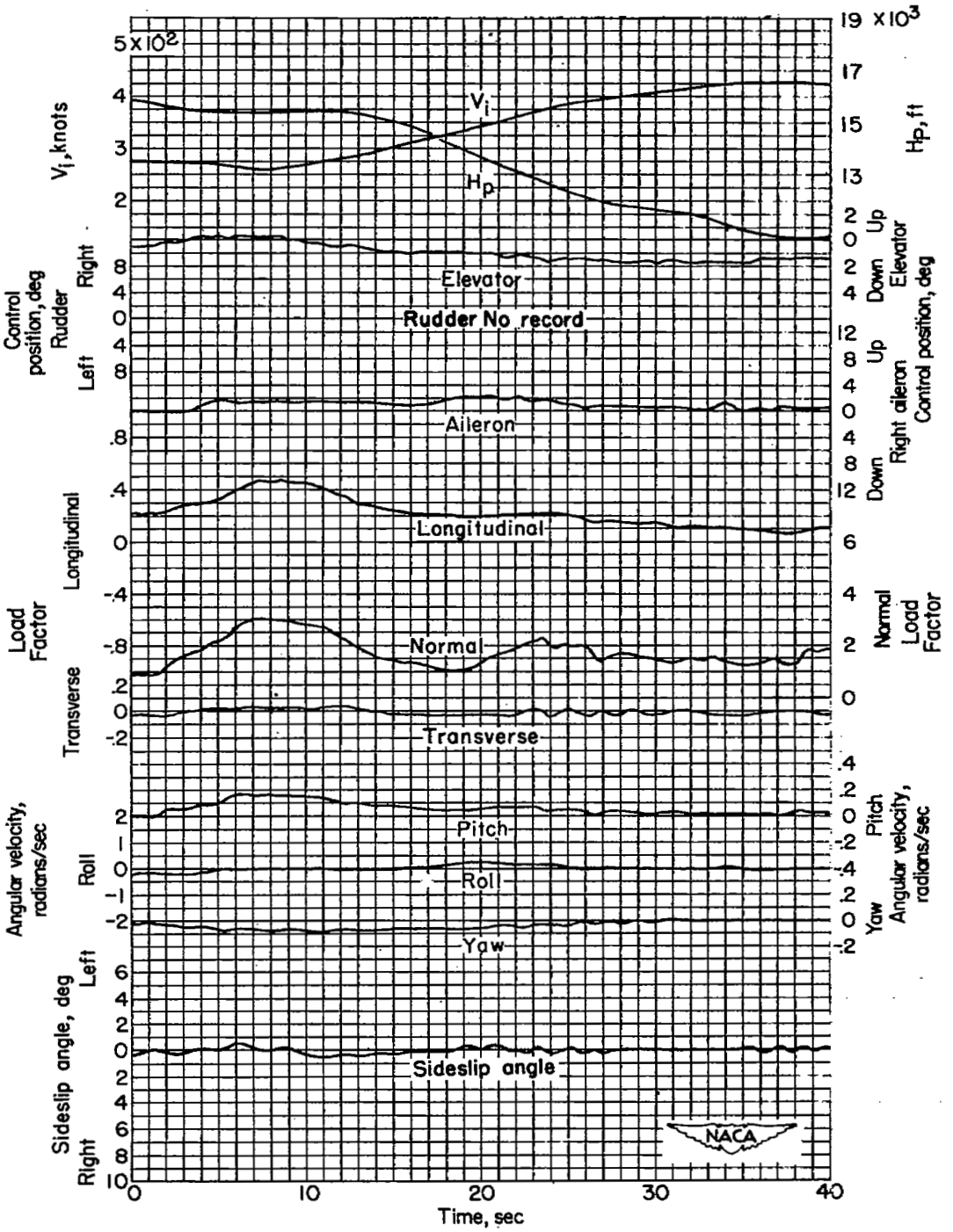

Figure 152.- Dive with Immelman recovery; airplane weight, 17,180 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

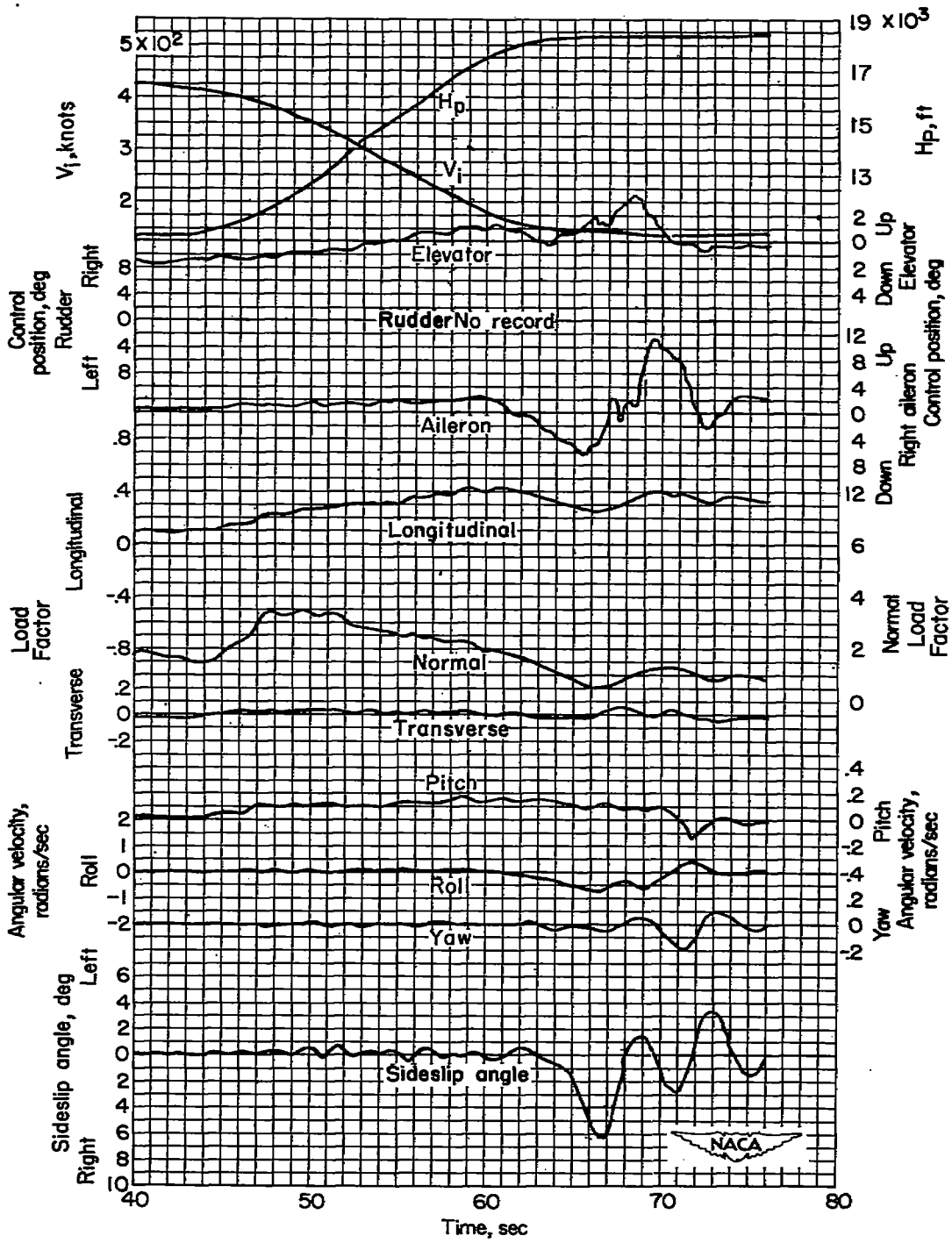

Figure 152.- Concluded.

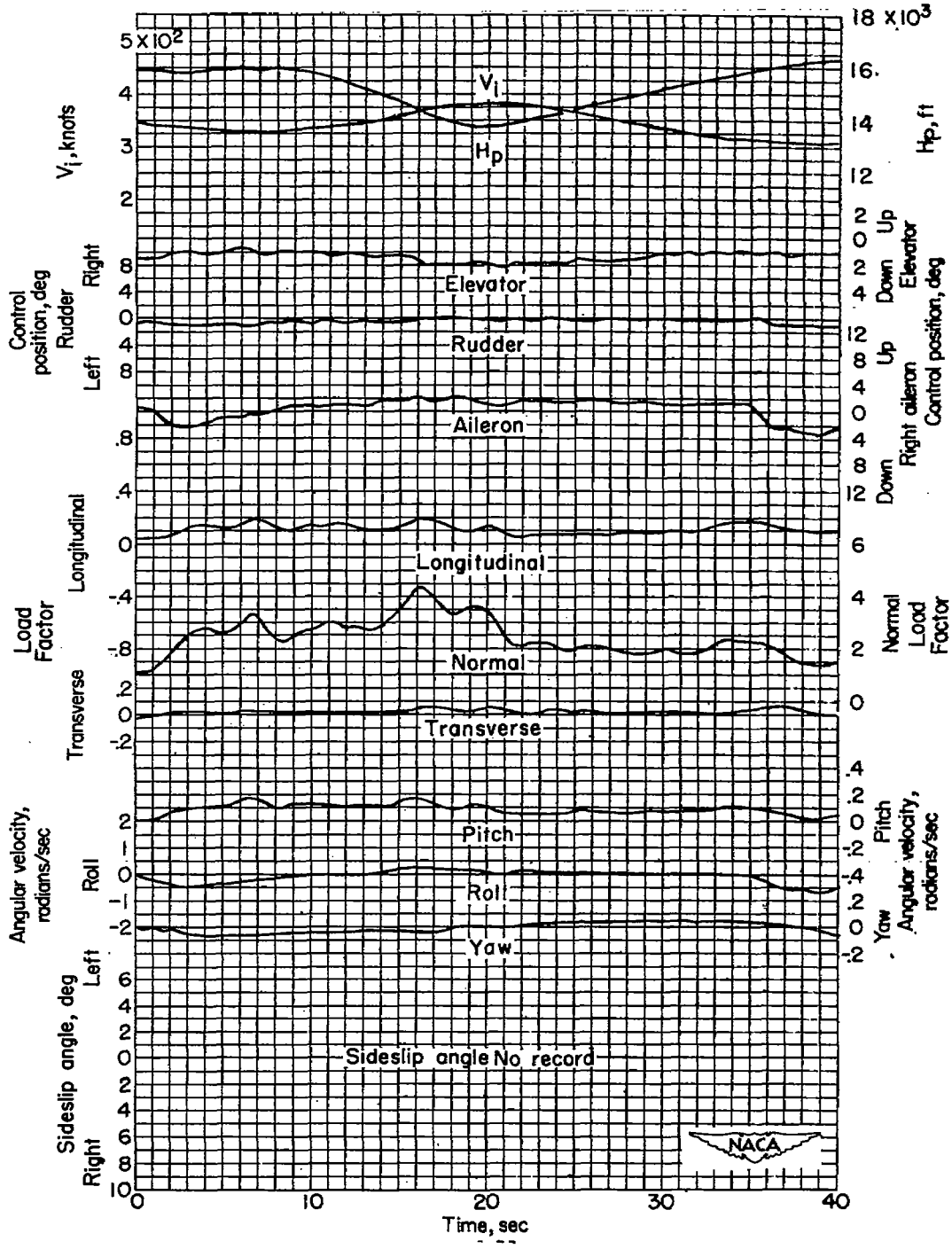

Figure 153.- Dive with rolling recovery followed by split-S into a dive; airplane weight, 16,550 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

24F

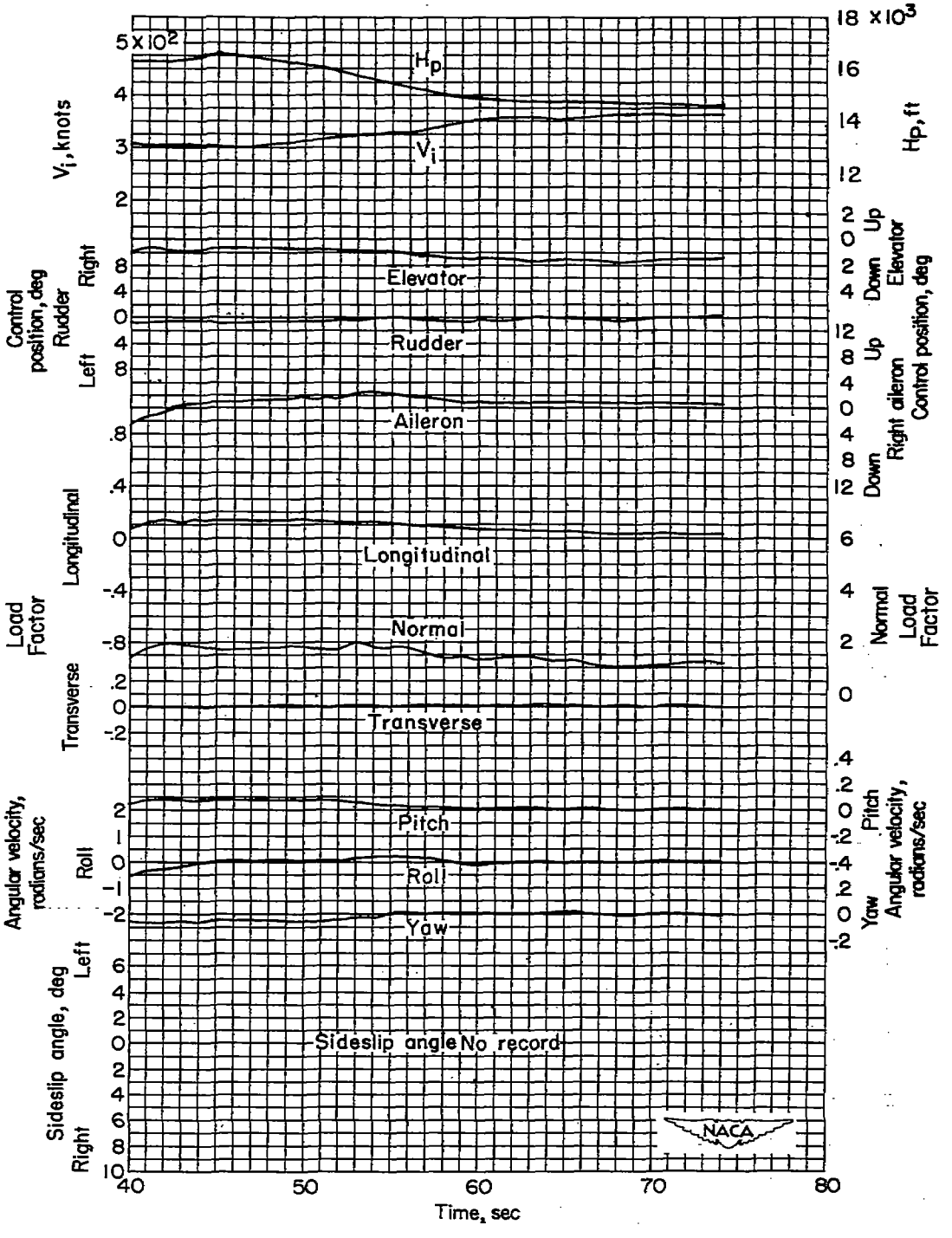

Figure 153.- Concluded.

[redacted]

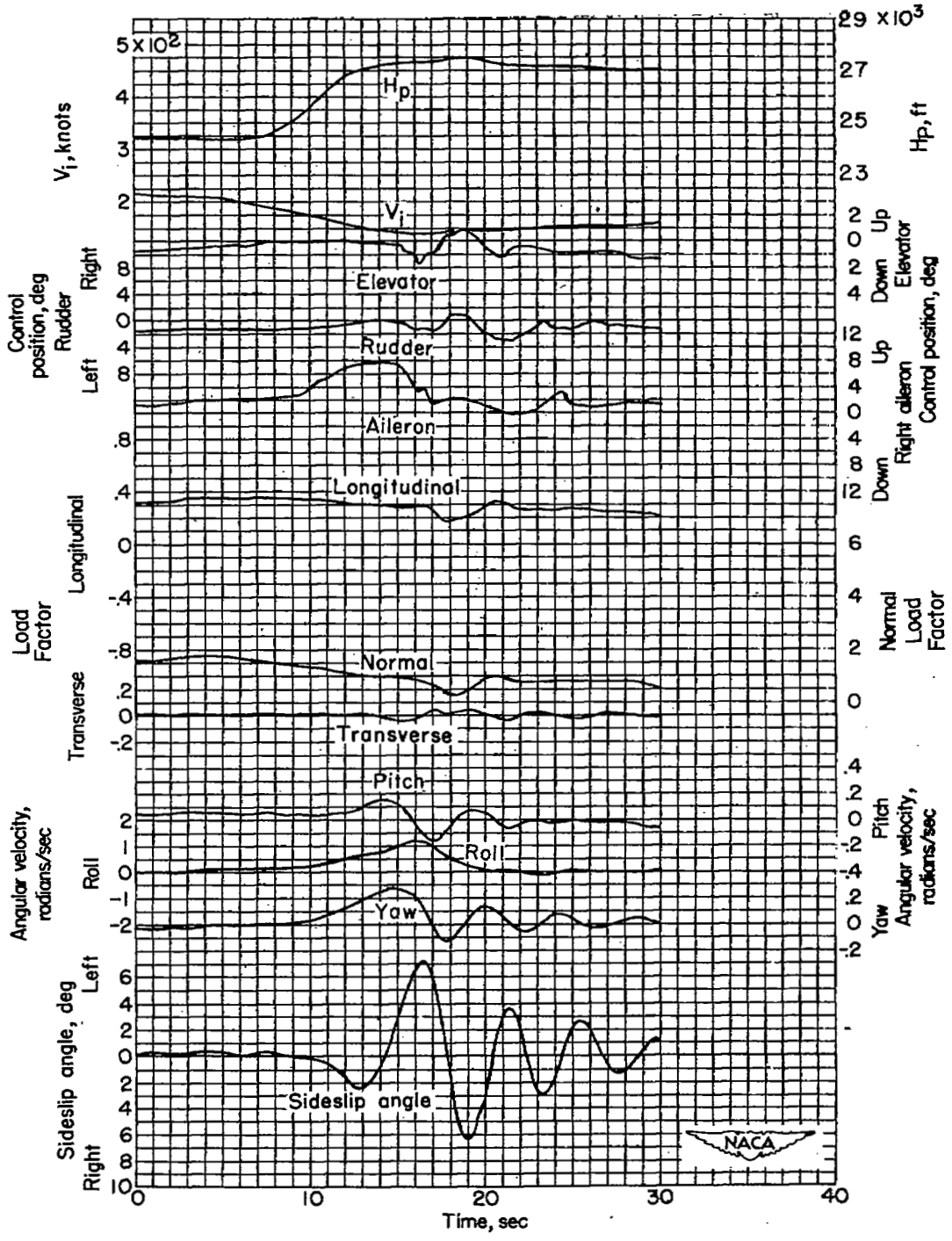

Figure 154.- Right slow roll; airplane weight, 17,860 pounds; center-of-gravity location, 26.8 percent of the mean aerodynamic chord.

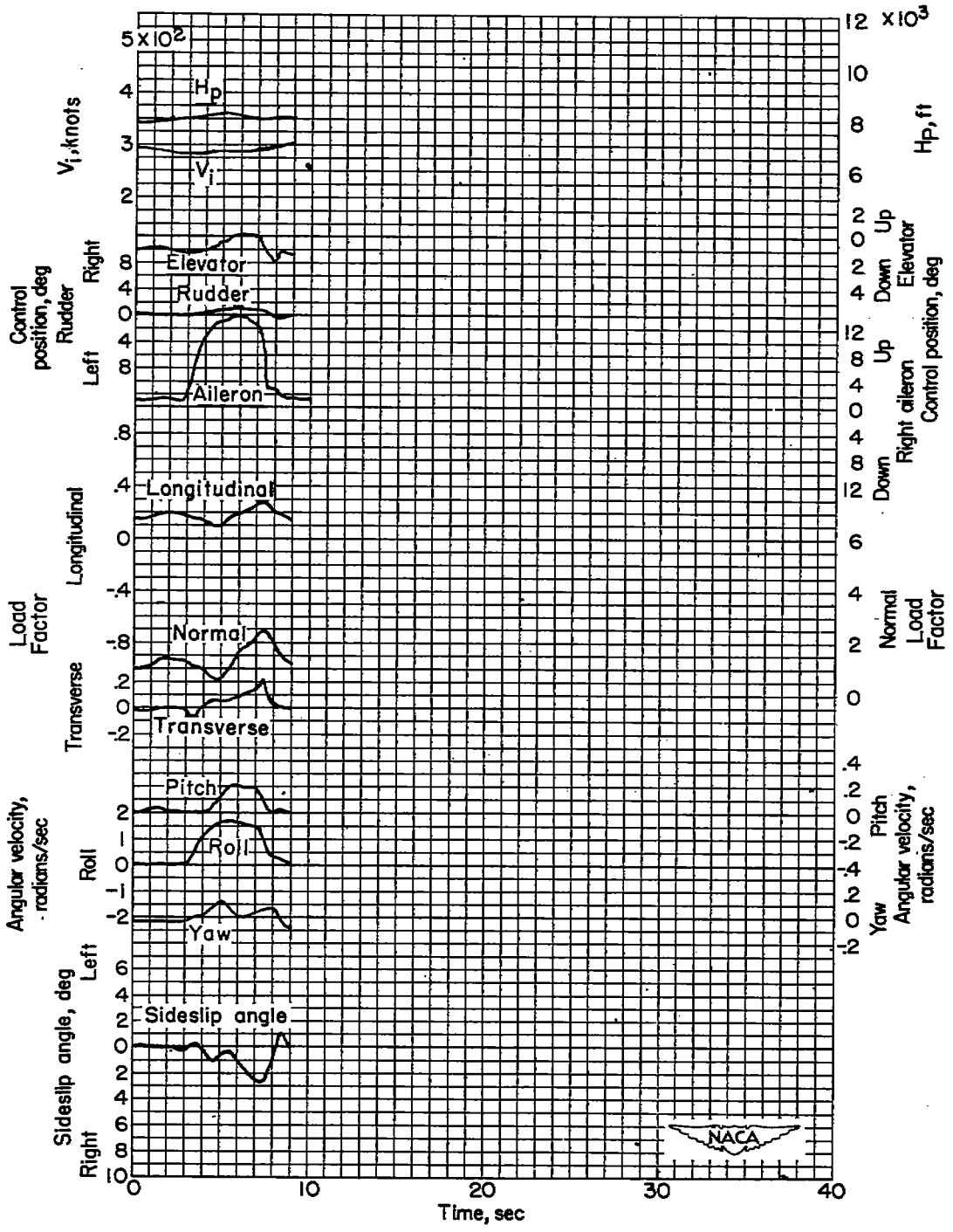

Figure 155.- Right slow roll; airplane weight, 16,720 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

[redacted]

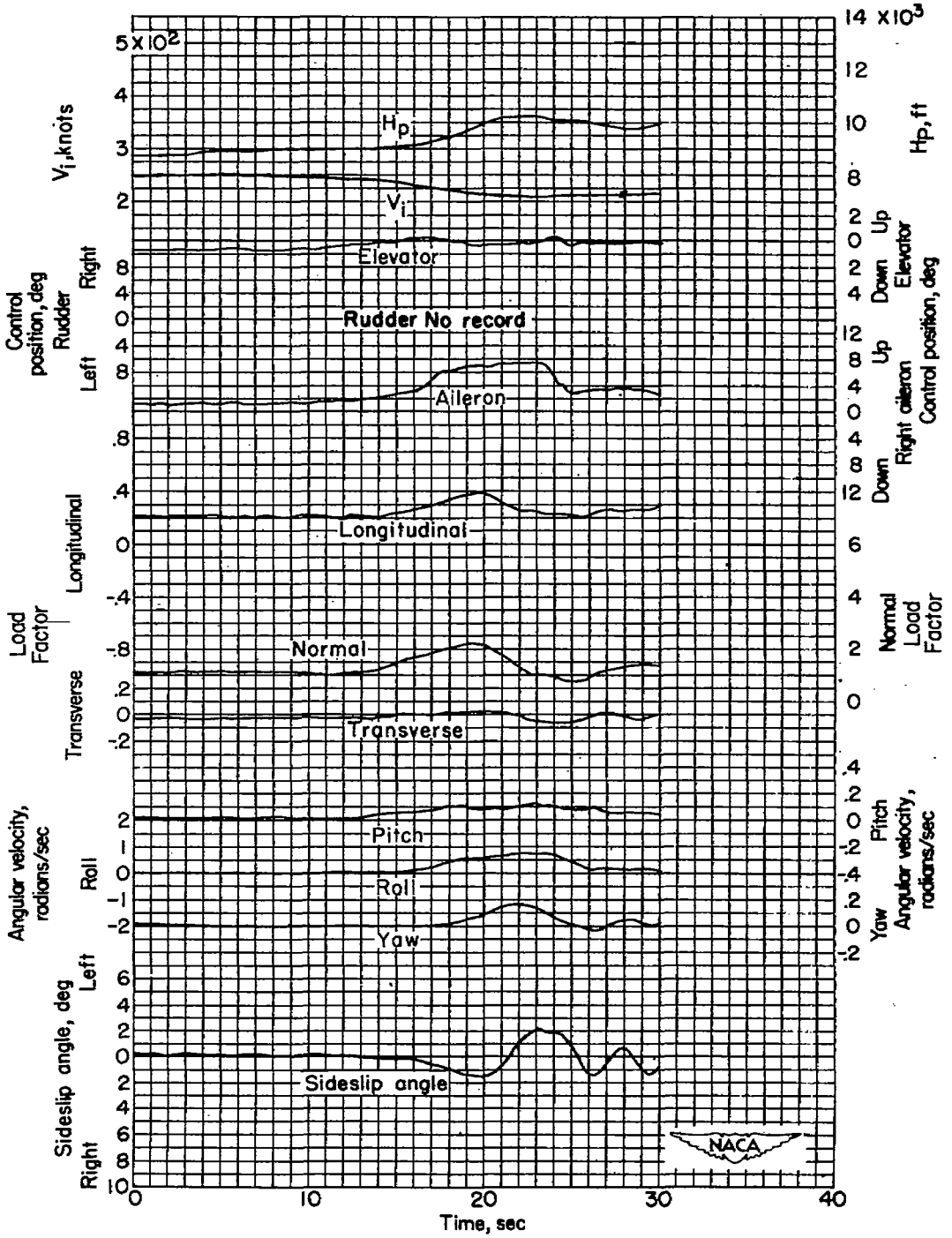

Figure 156.- Right slow roll; airplane weight, 17,830 pounds; center-of-gravity location, 26.8 percent of the mean aerodynamic chord.

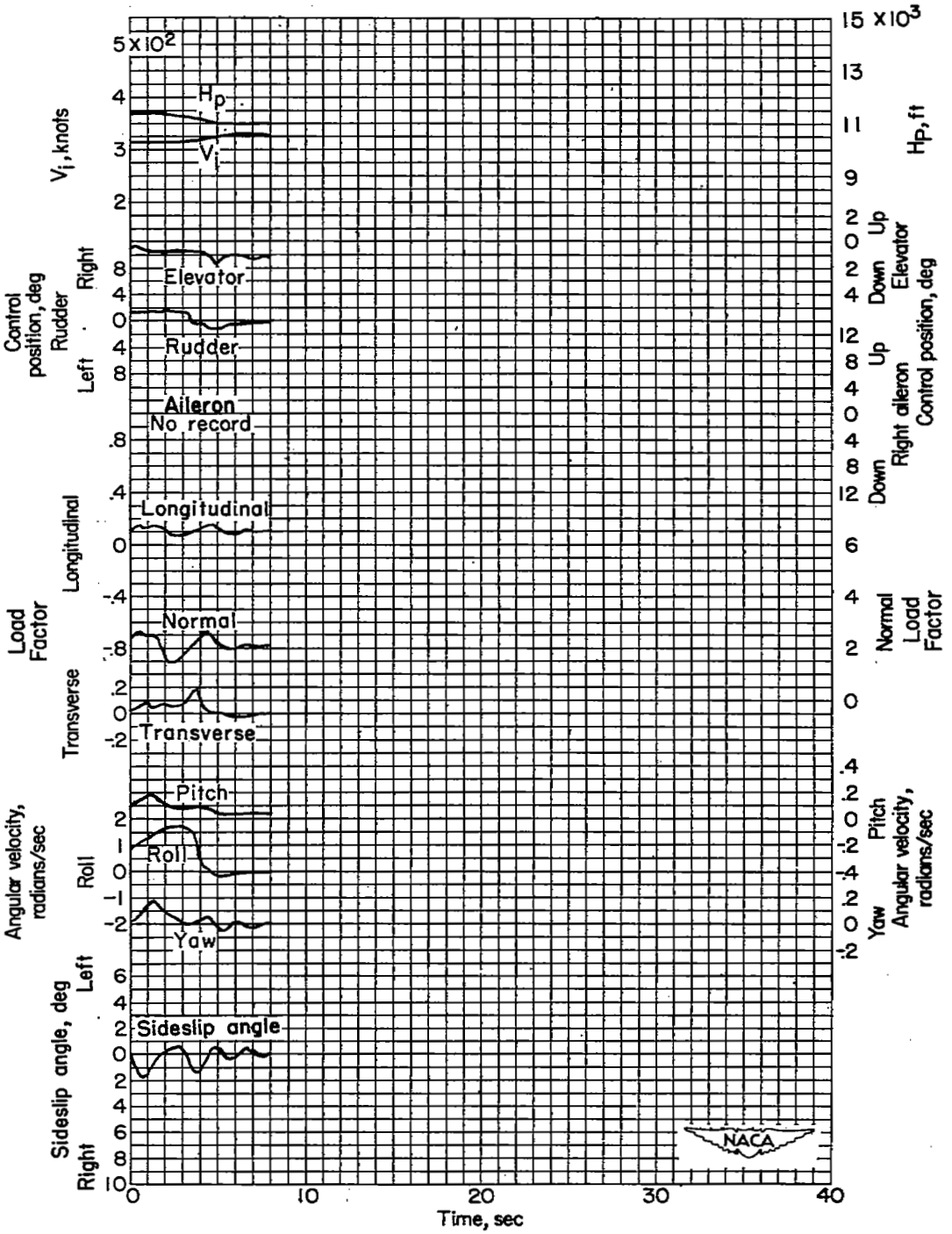

Figure 157.- Right slow roll; airplane weight, 16,950 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

[redacted]

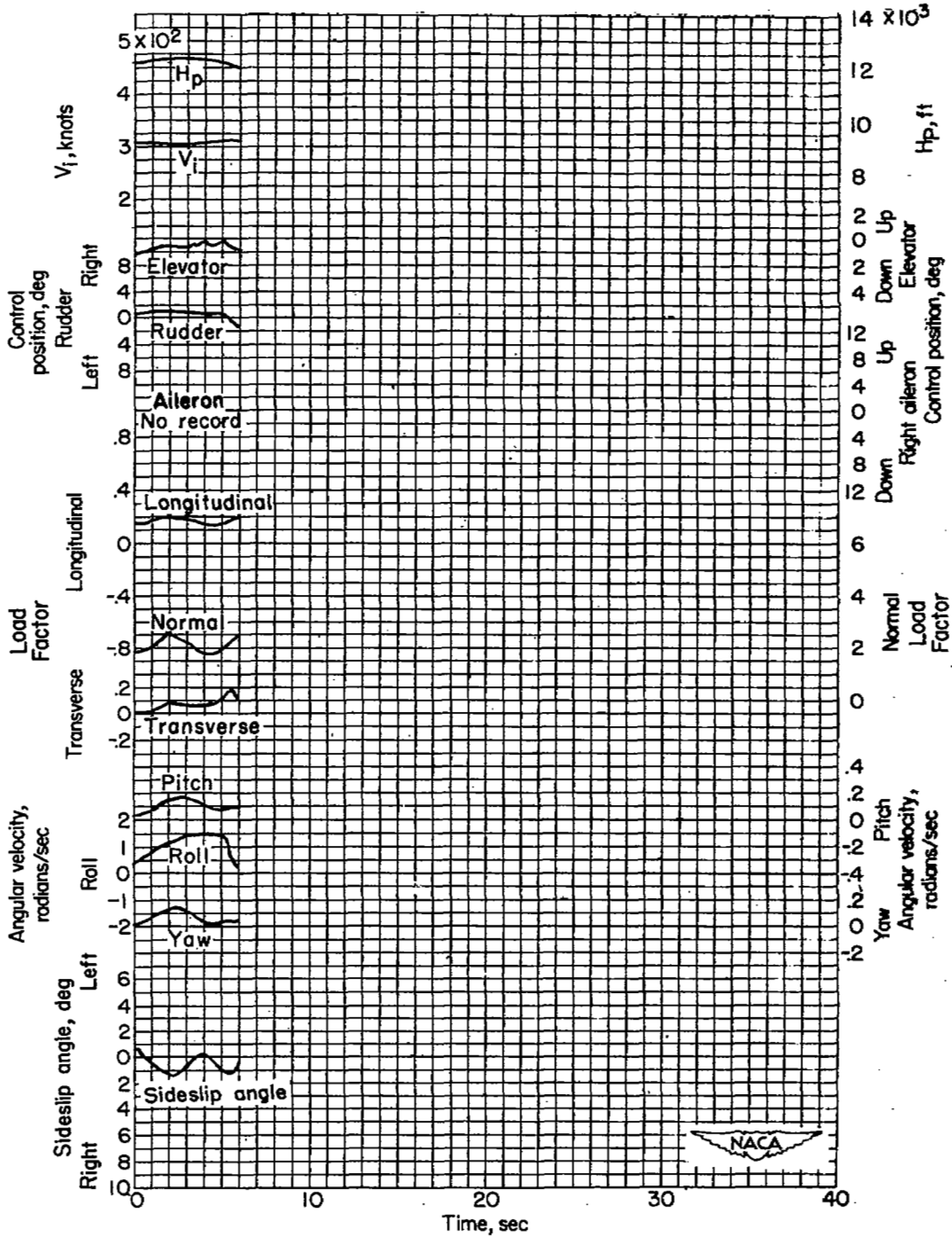

Figure 158.- Right slow roll; airplane weight, 16,790 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

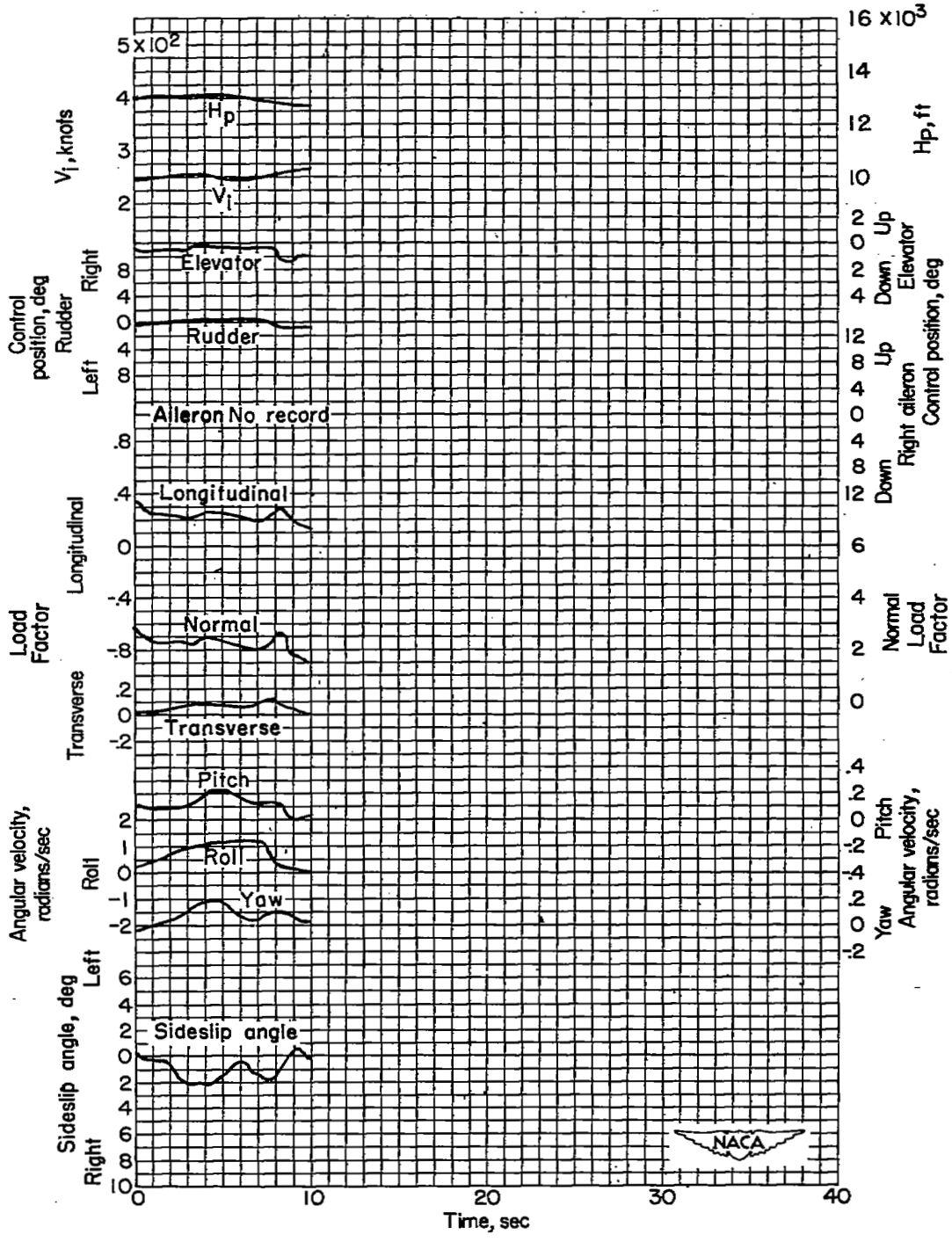

Figure 159.- Right slow roll; airplane weight, 16,700 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

[redacted]

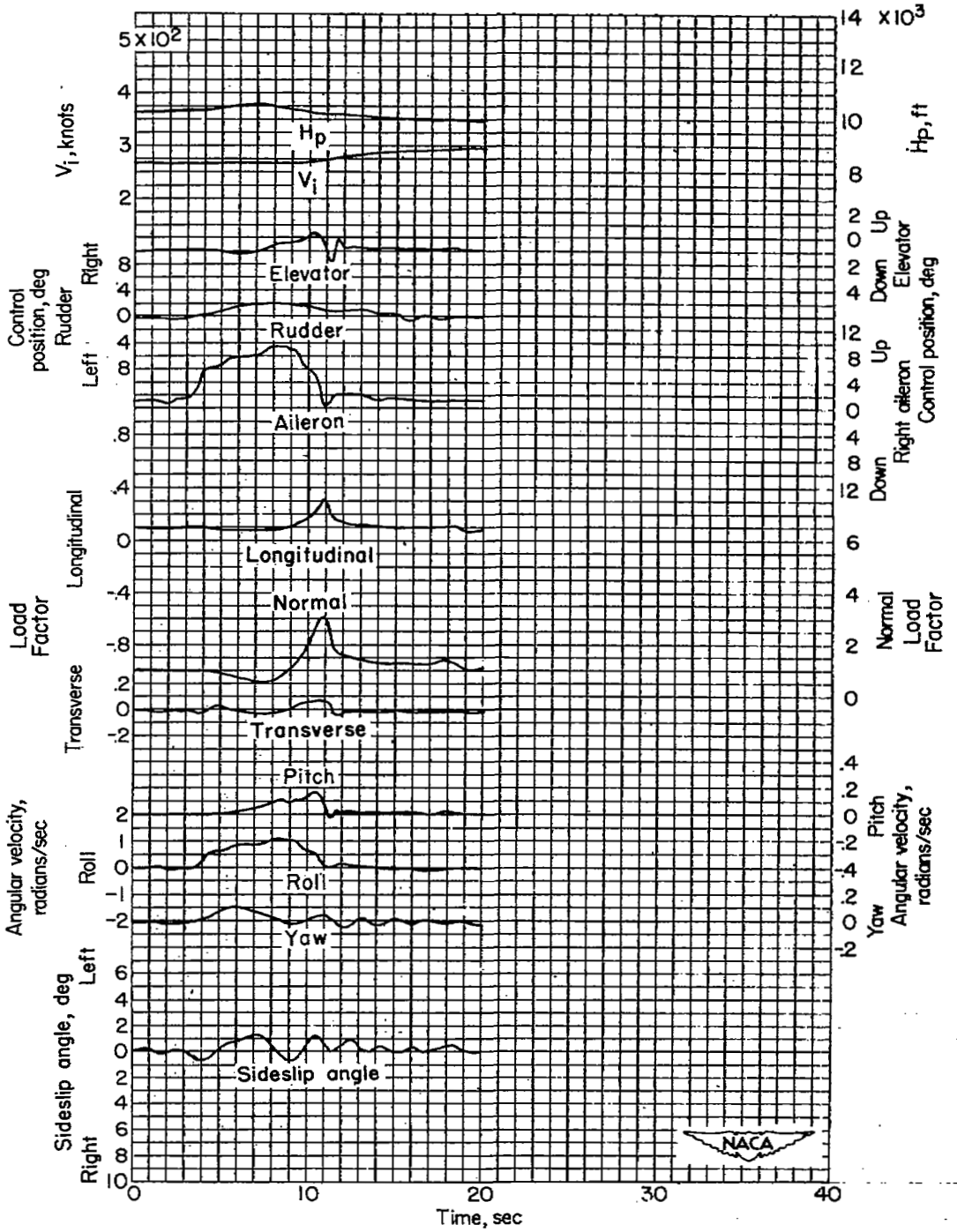

Figure 160.- Right slow roll; airplane weight, 16,950 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

25F

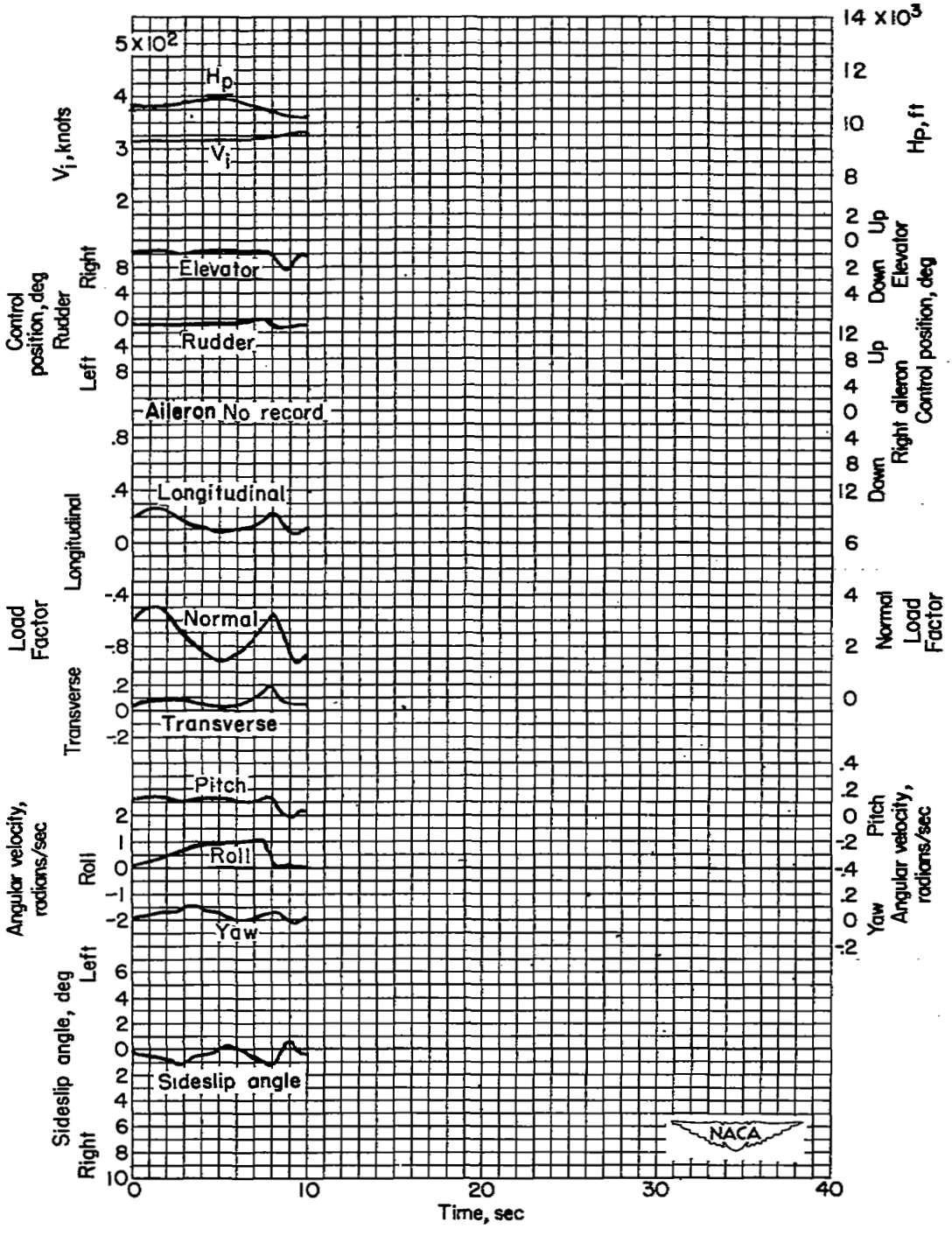

Figure 161.- Right slow roll; airplane weight, 16,260 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

[redacted]

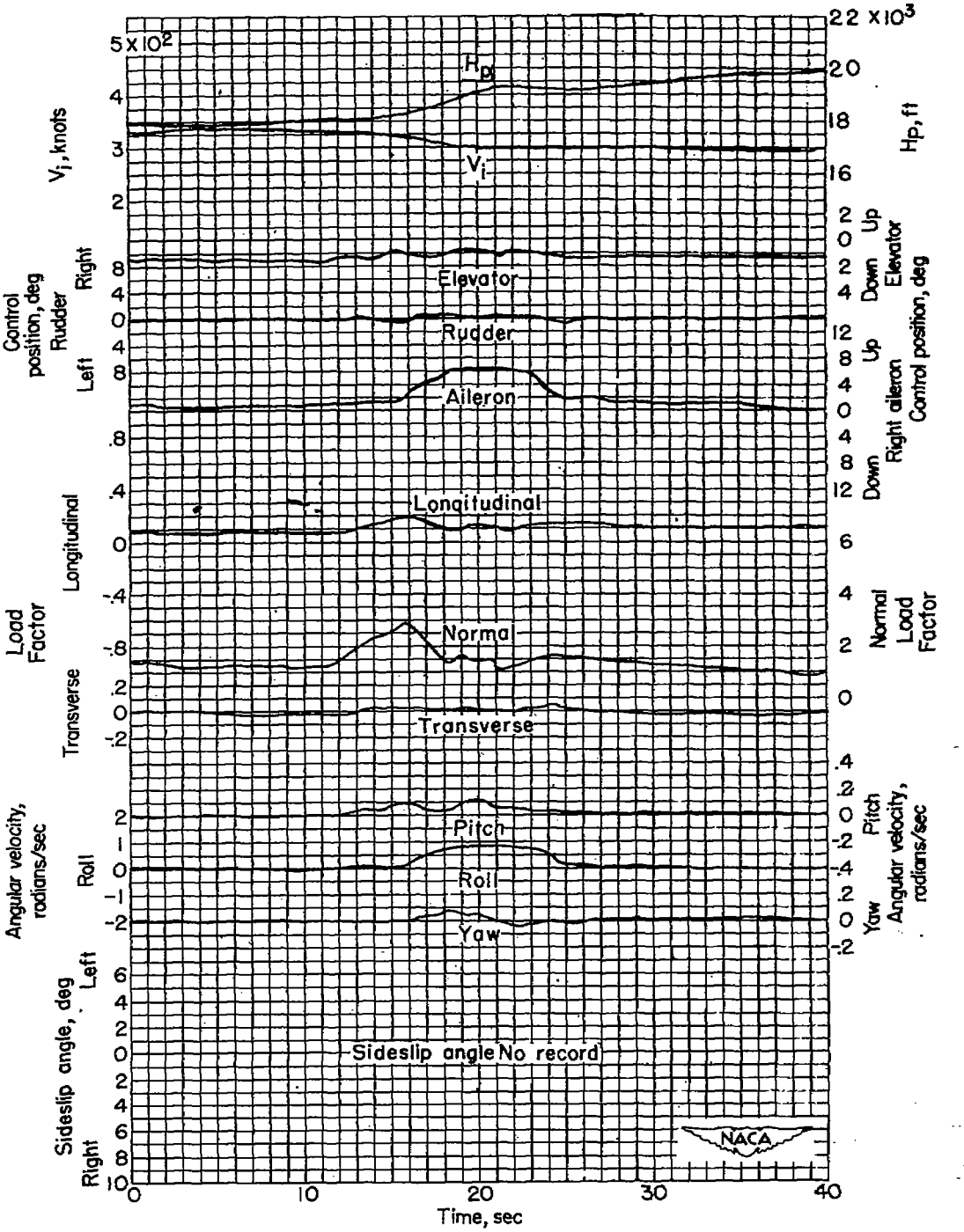

Figure 162.- Right slow roll; airplane weight, 14,810 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

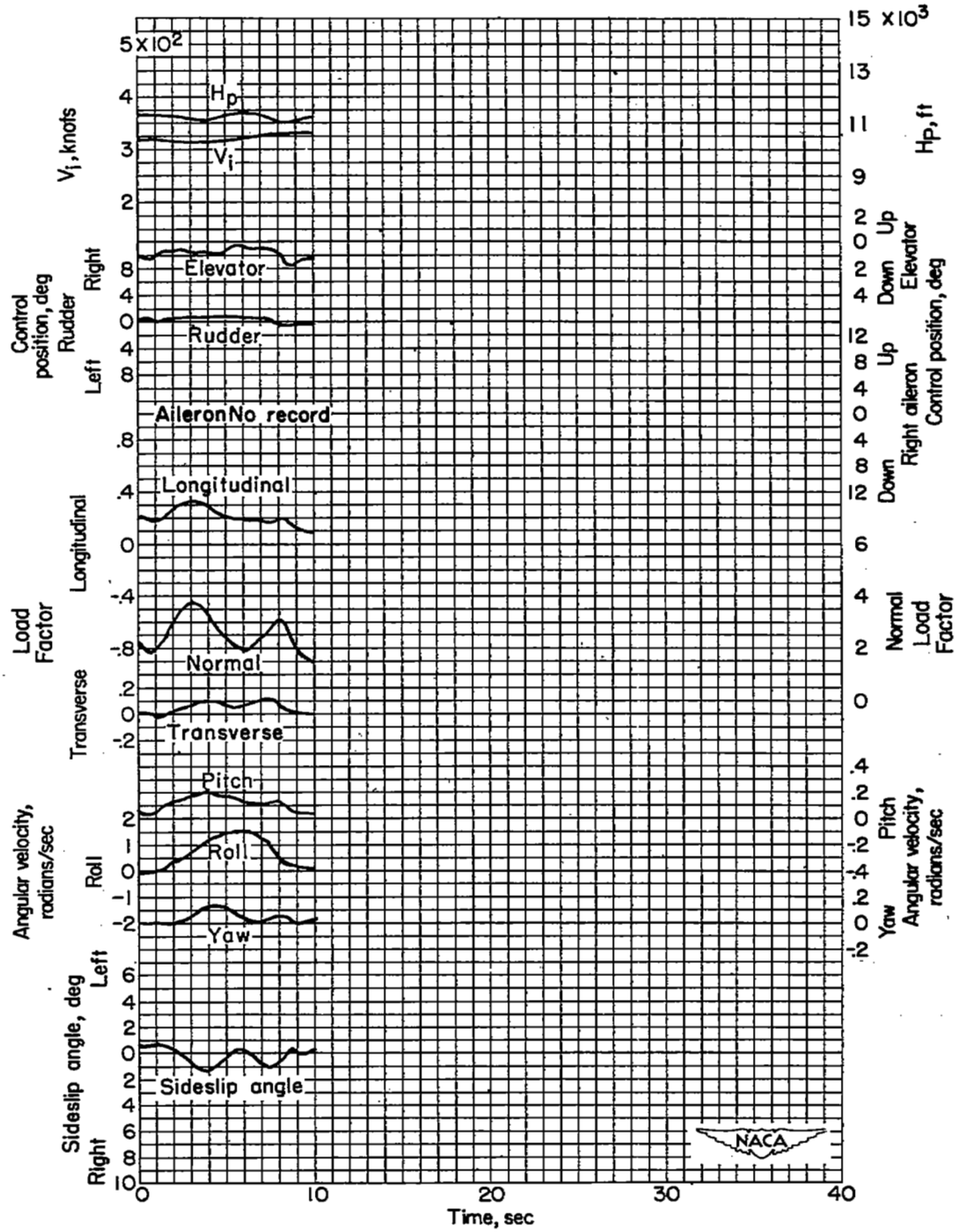

Figure 163.- Right slow roll; airplane weight, 16,970 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

[redacted]

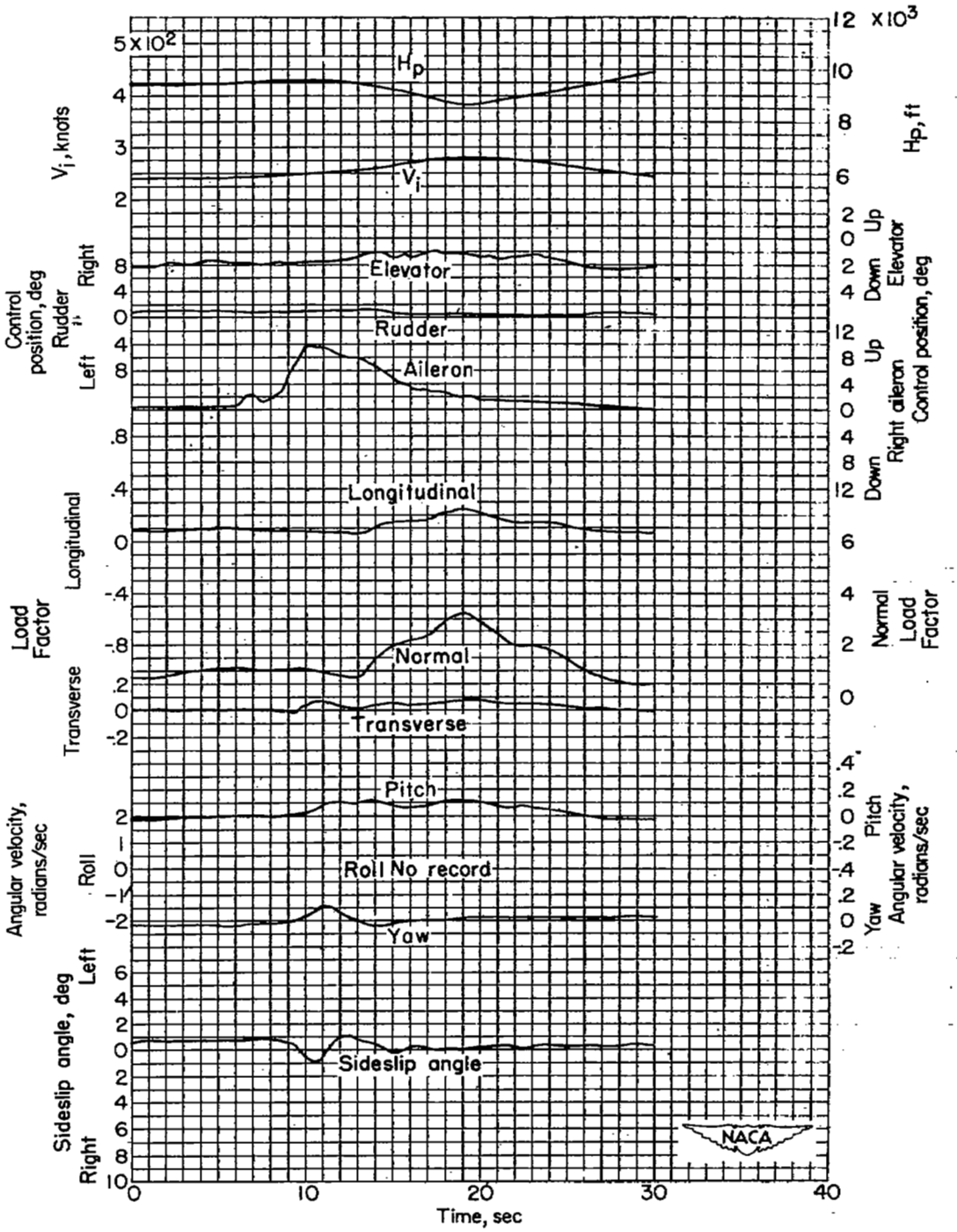

Figure 164.- Right slow roll; airplane weight, 16,955 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

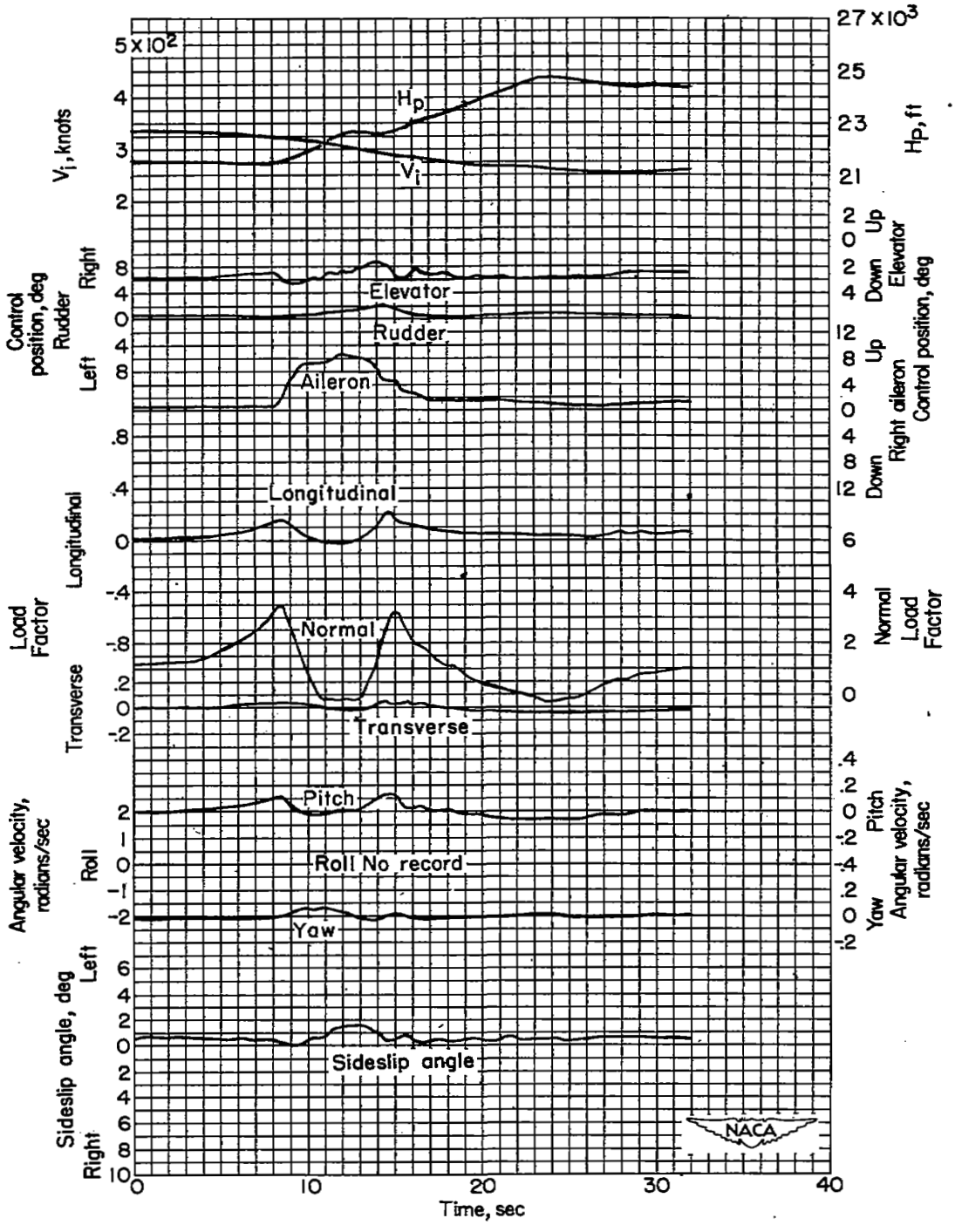

Figure 165.- Right slow roll; airplane weight, 14,870 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

[redacted]

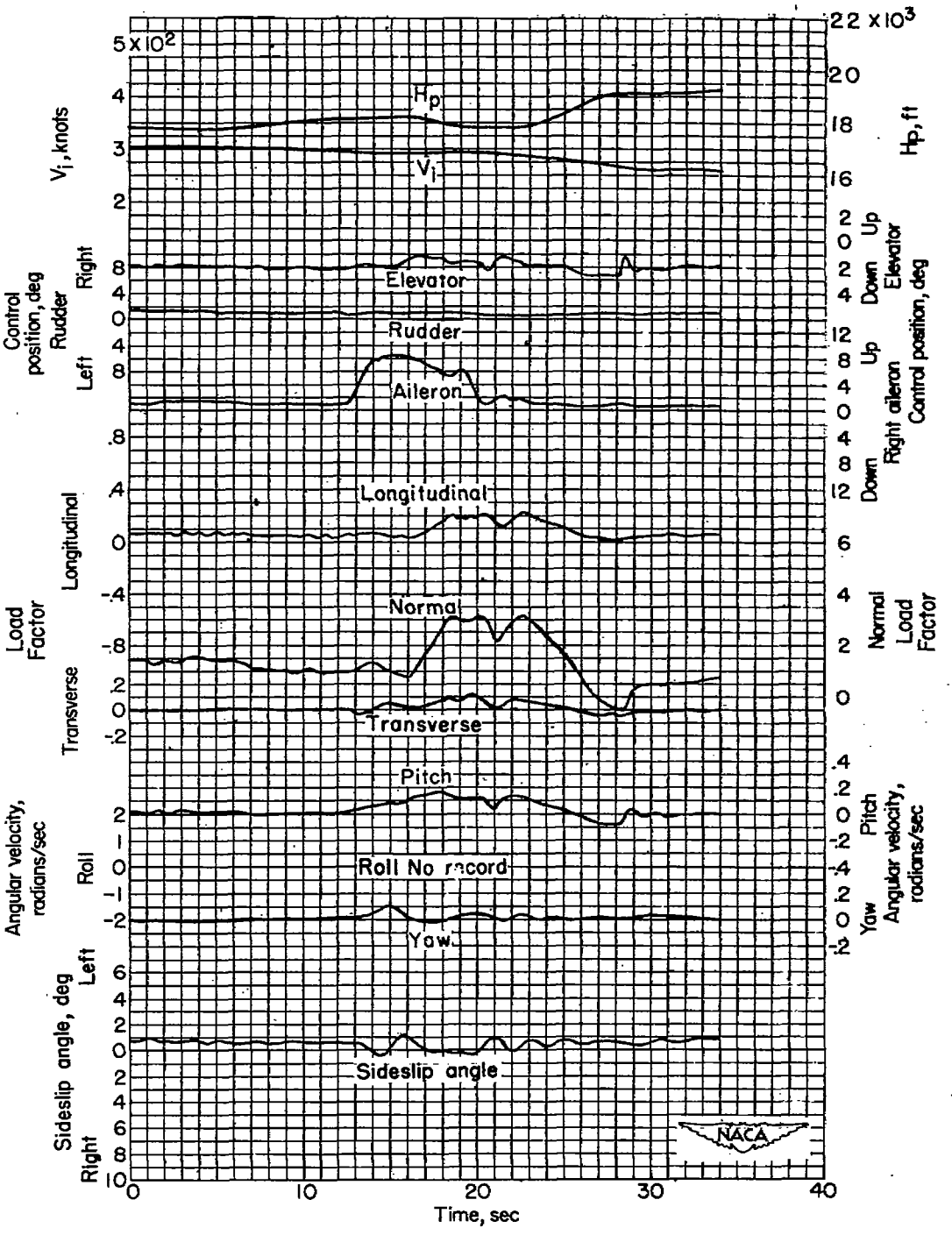

Figure 166.- Right slow roll followed by pull-up; airplane weight, 16,240 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

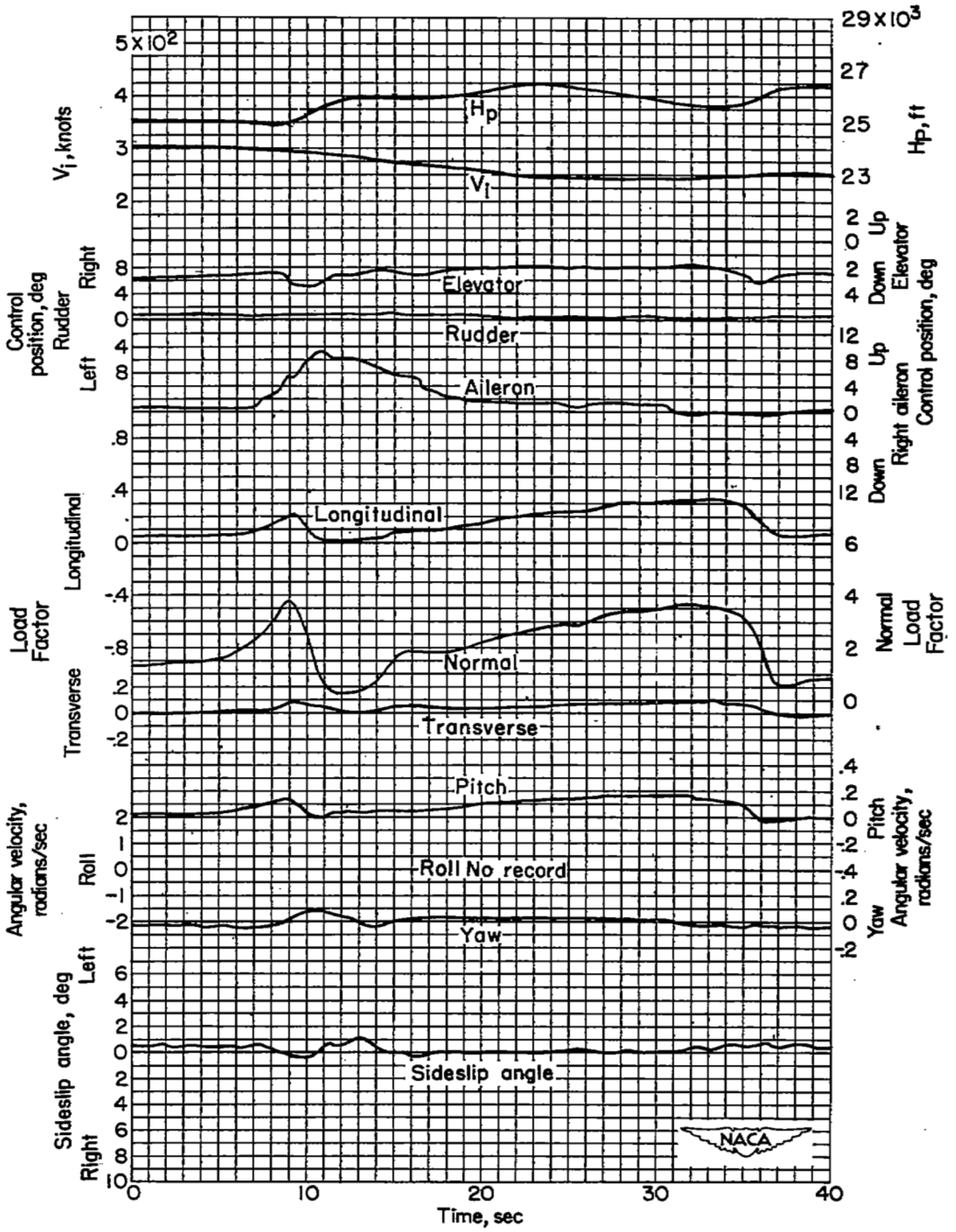

Figure 167.- Right slow roll; airplane weight, 14,500 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

[redacted]

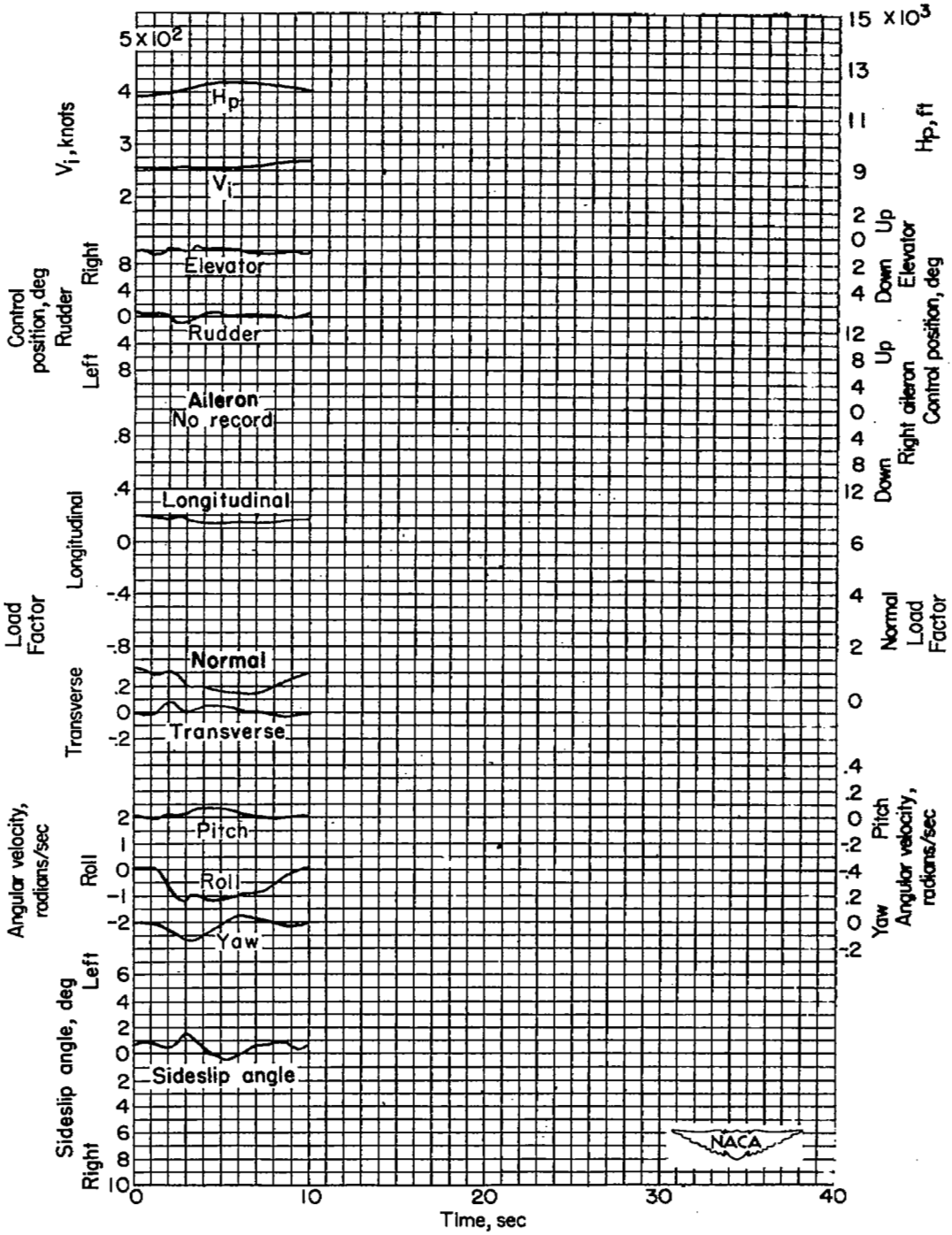

Figure 168.- Left slow roll; airplane weight, 17,060 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

26F

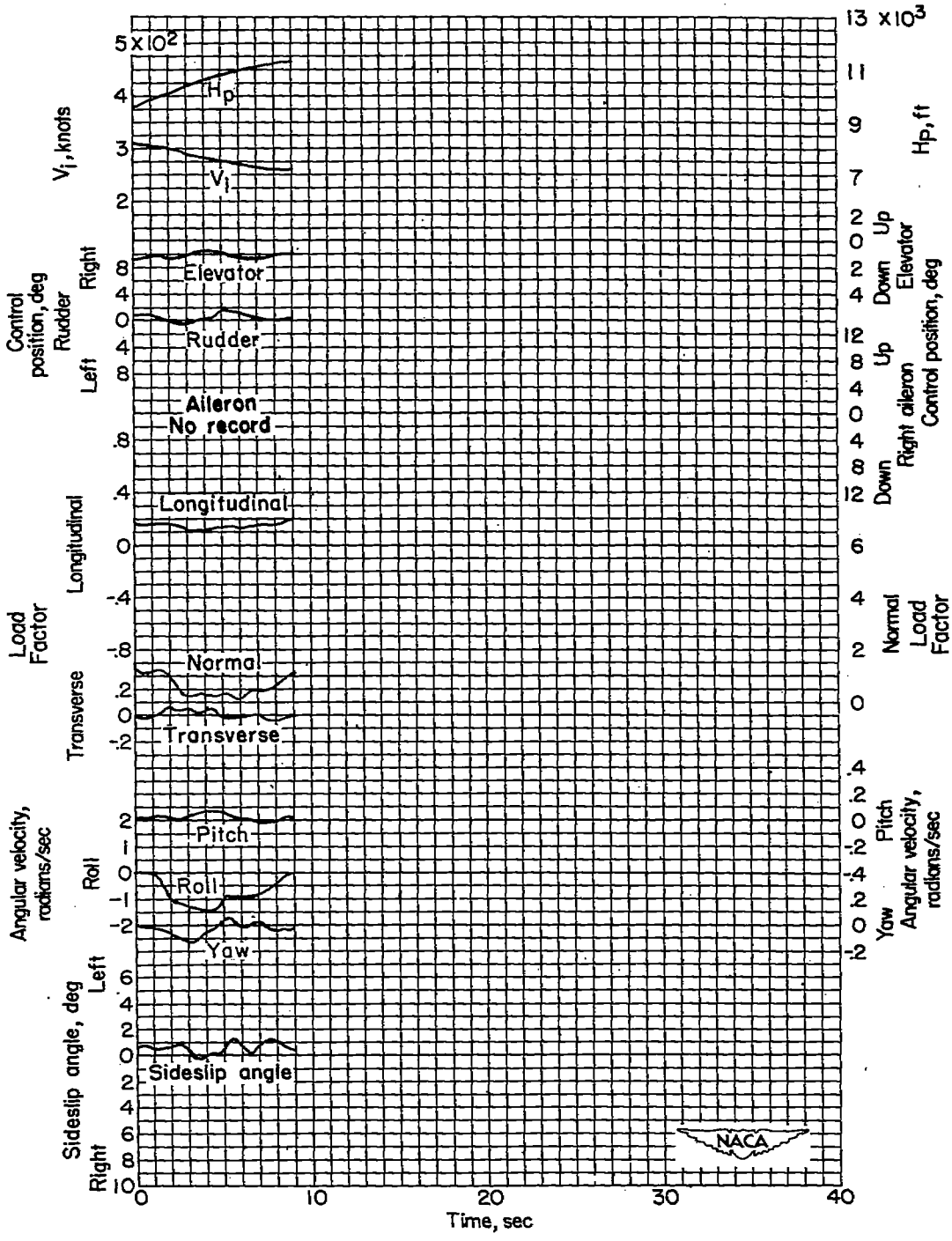

Figure 169.- Left slow roll; airplane weight, 17,080 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

[redacted]

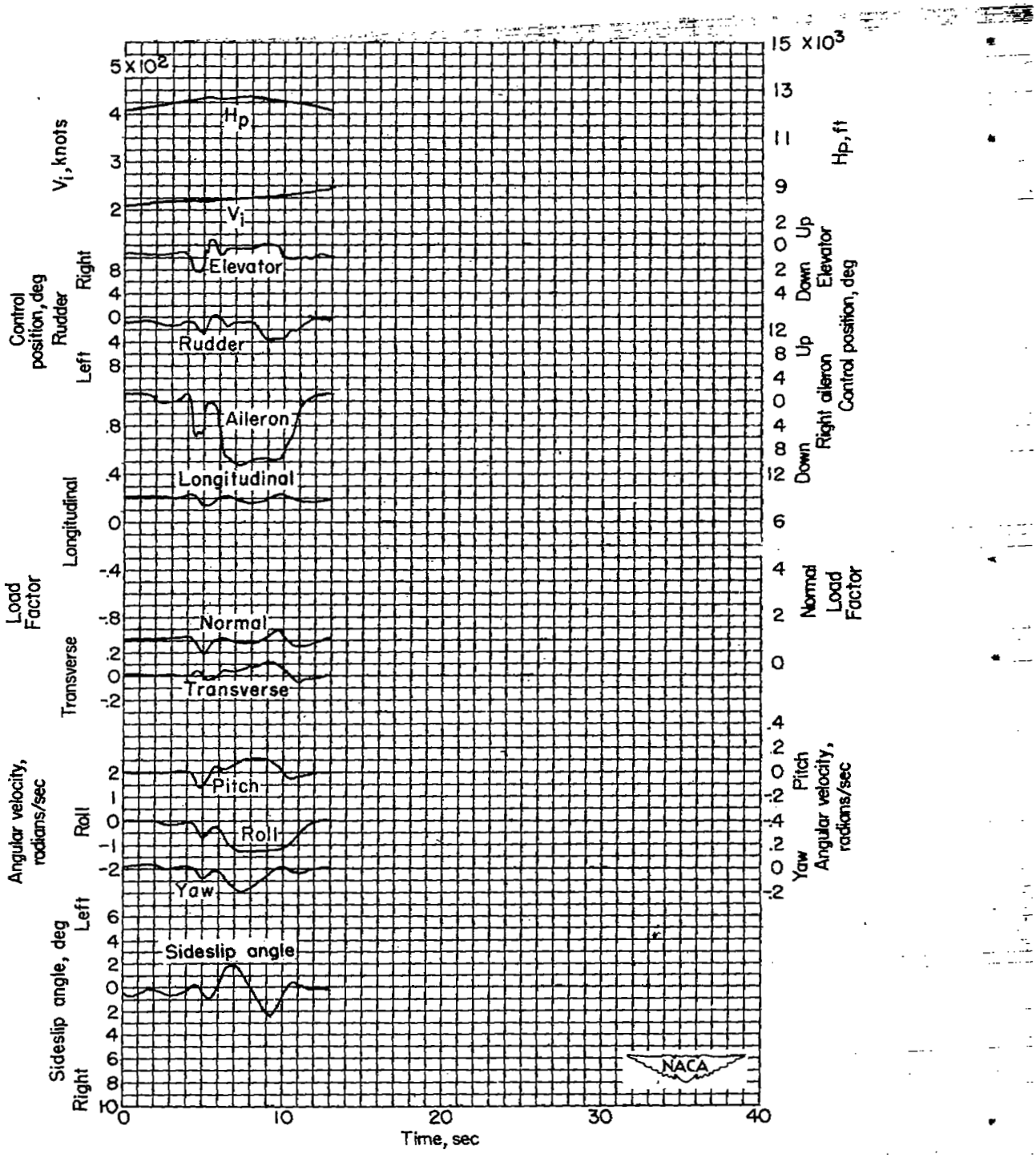

Figure 170.- Left slow roll; airplane weight, 17,200 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

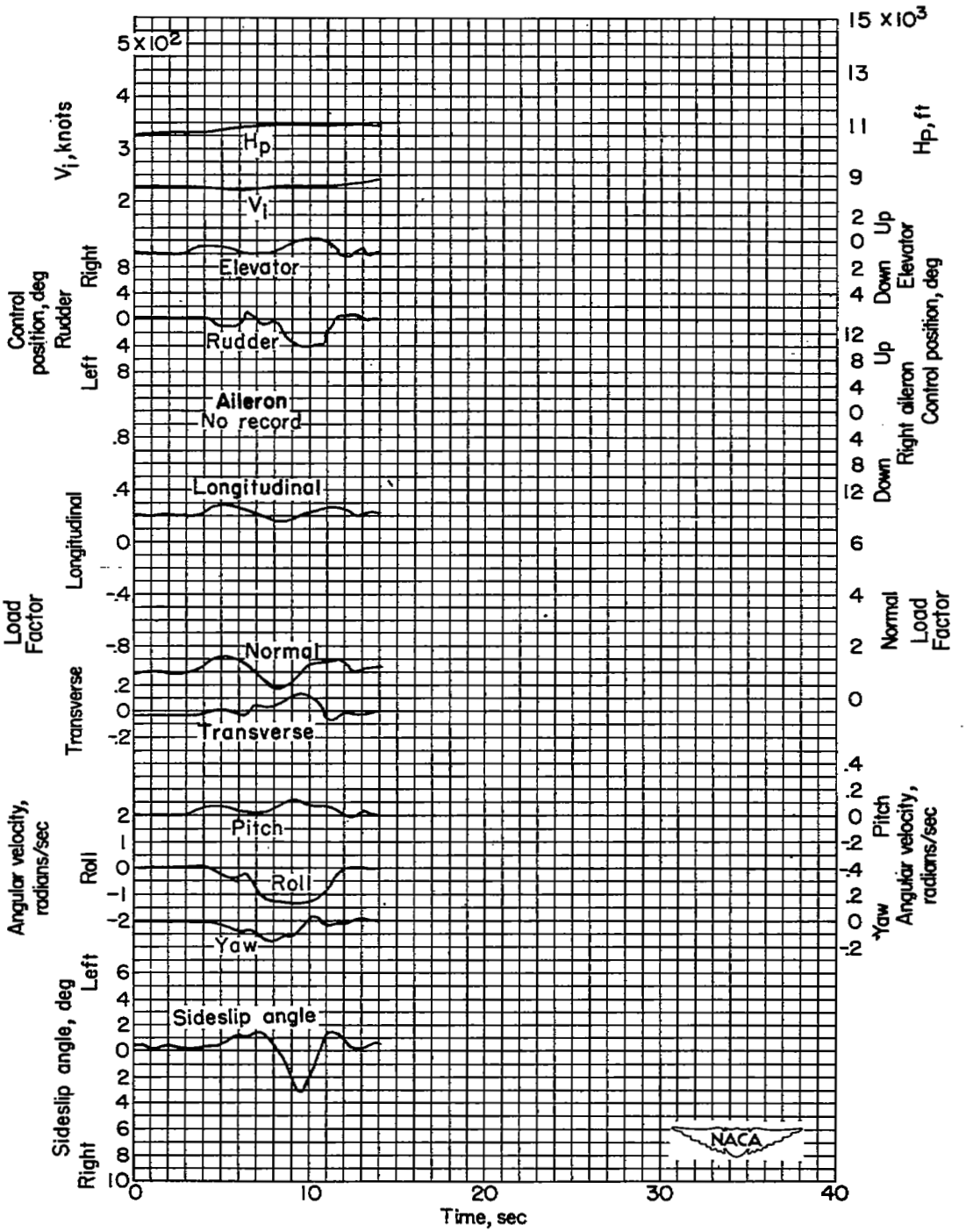

Figure 171.- Left slow roll; airplane weight, 17,100 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

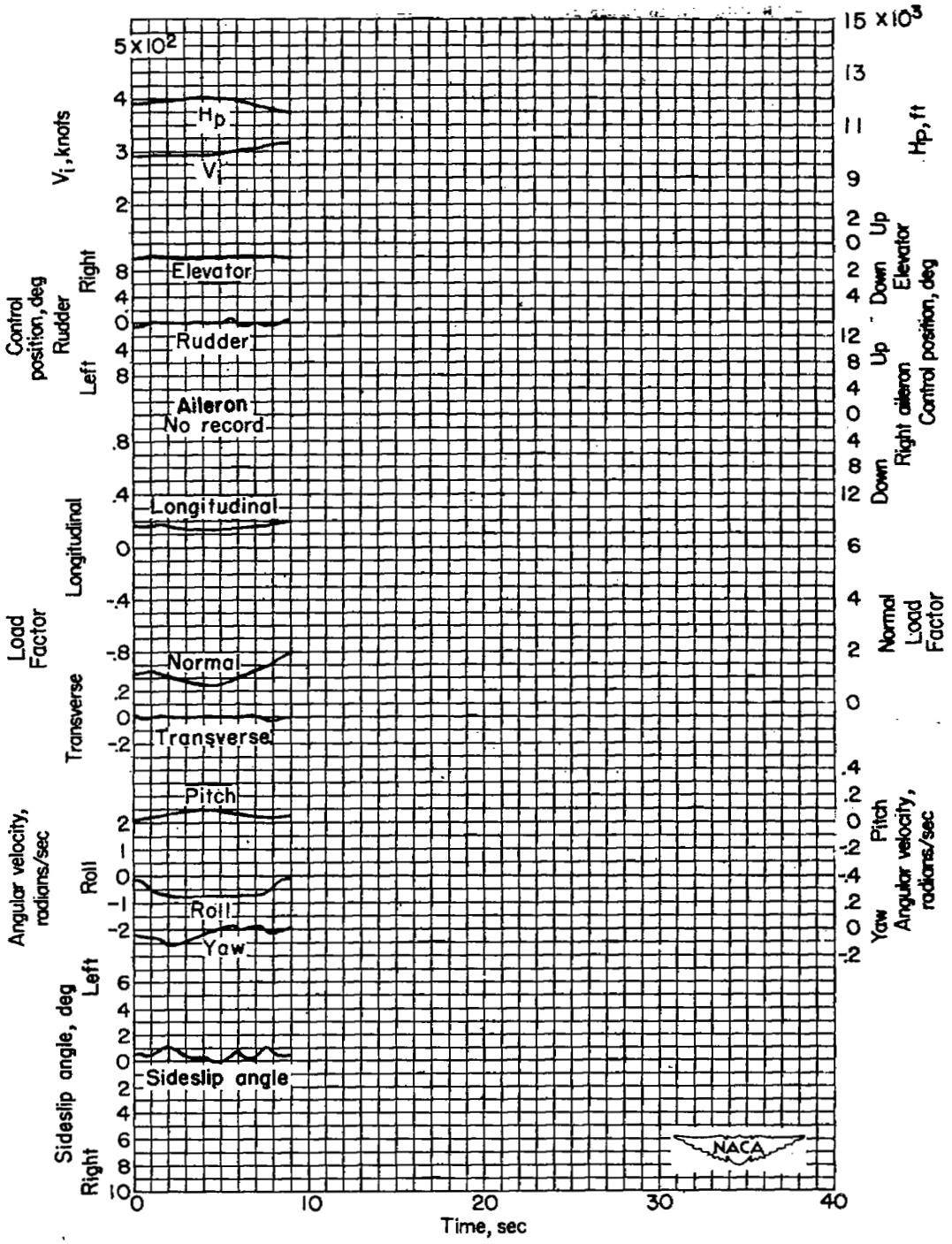

Figure 172.- Left slow roll; airplane weight, 16,980 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

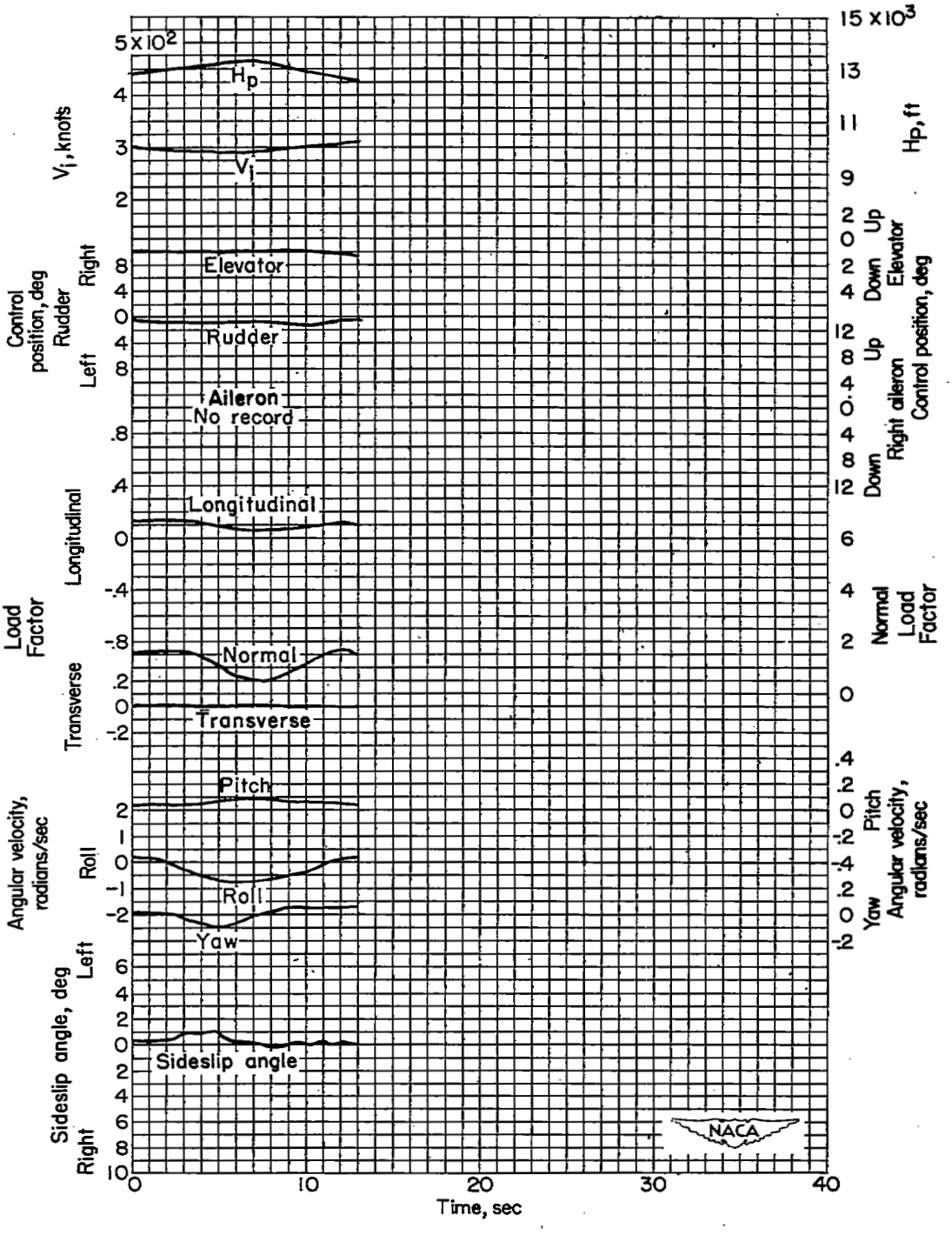

Figure 173.- Left slow roll; airplane weight, 16,560 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

[redacted]

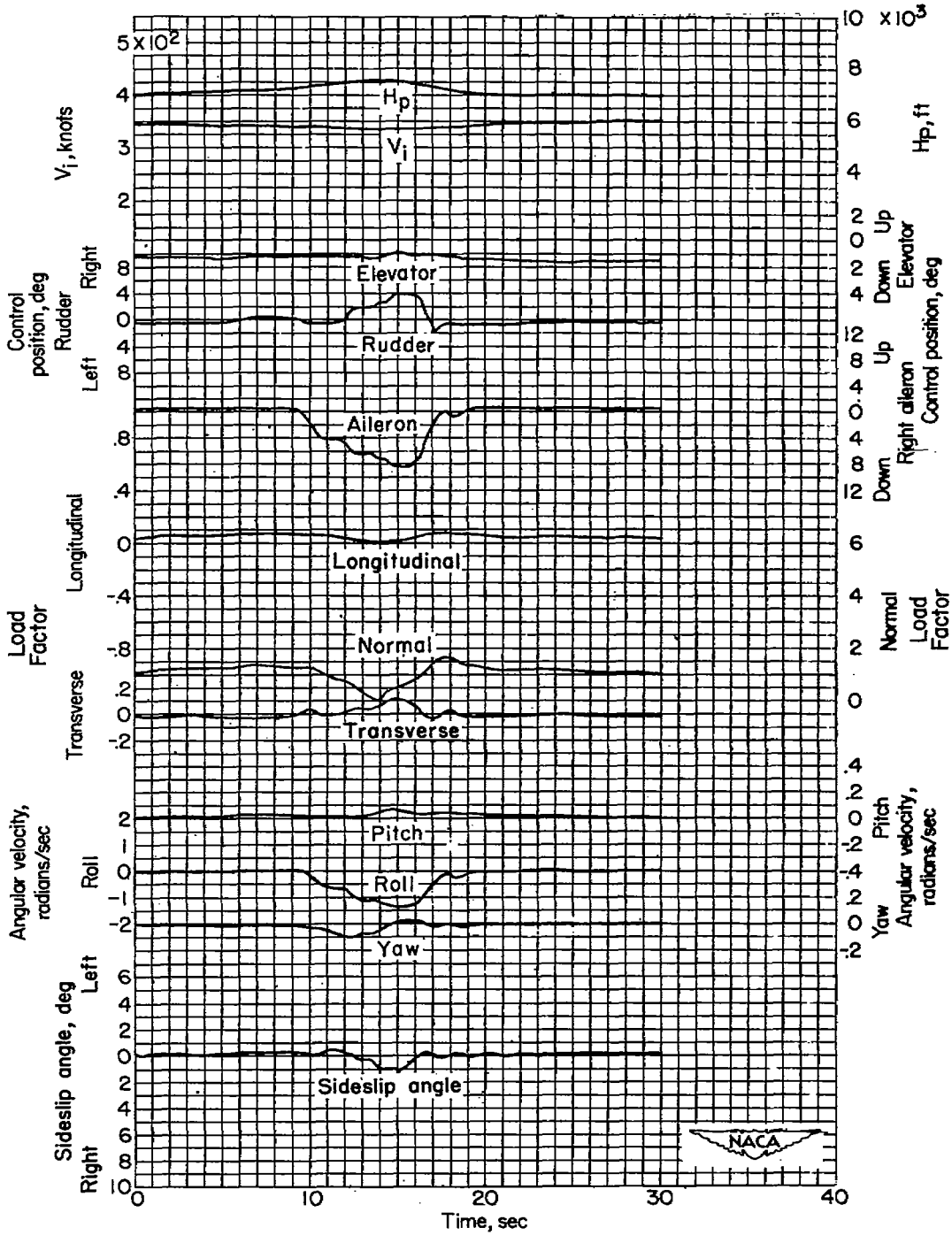

Figure 174.- Left slow roll; airplane weight, 13,820 pounds; center-of-gravity location; 26.1 percent of the mean aerodynamic chord.

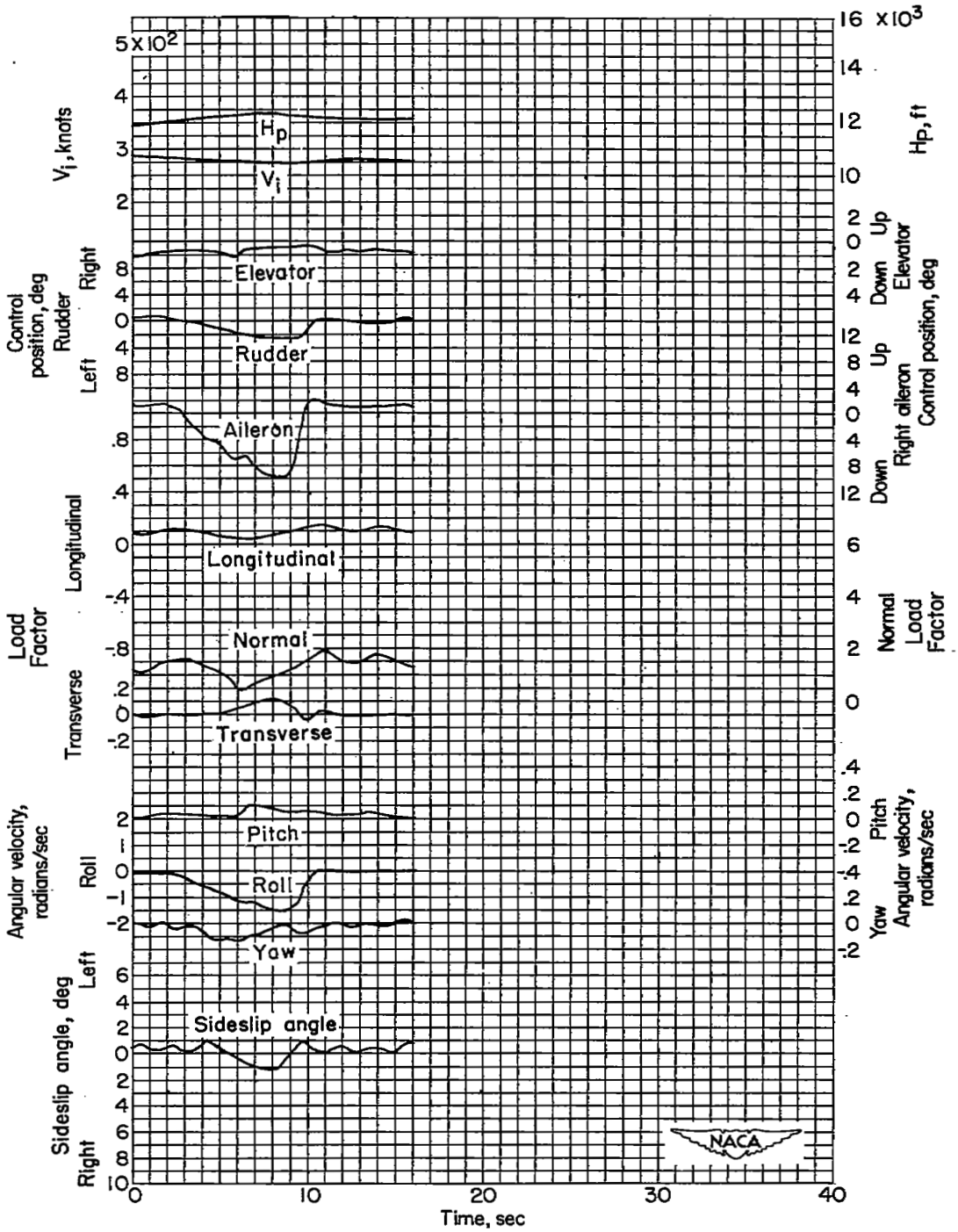

Figure 175.- Left slow roll; airplane weight, 16,825 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

[redacted]

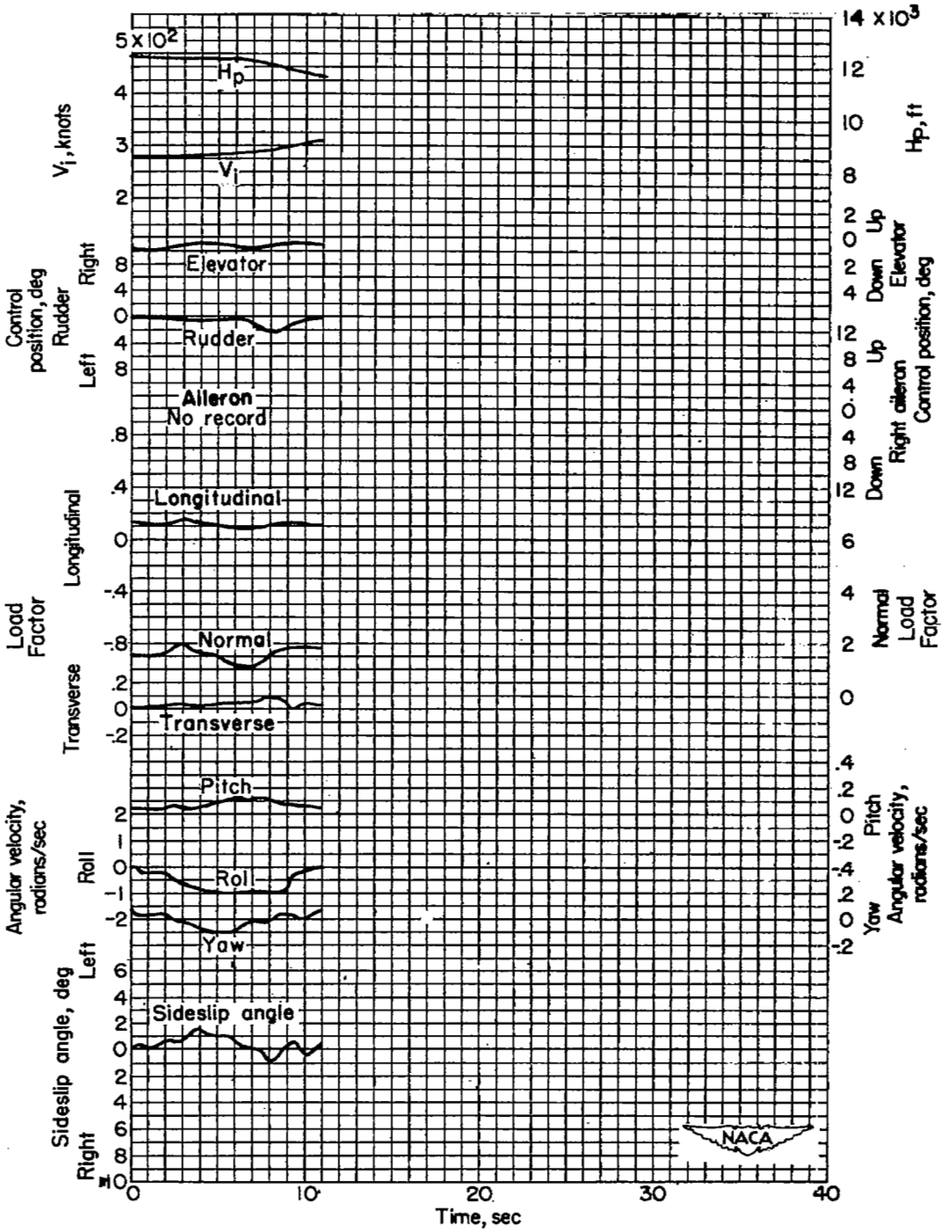

Figure 176.- Left slow roll; airplane weight, 16,670 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

27F

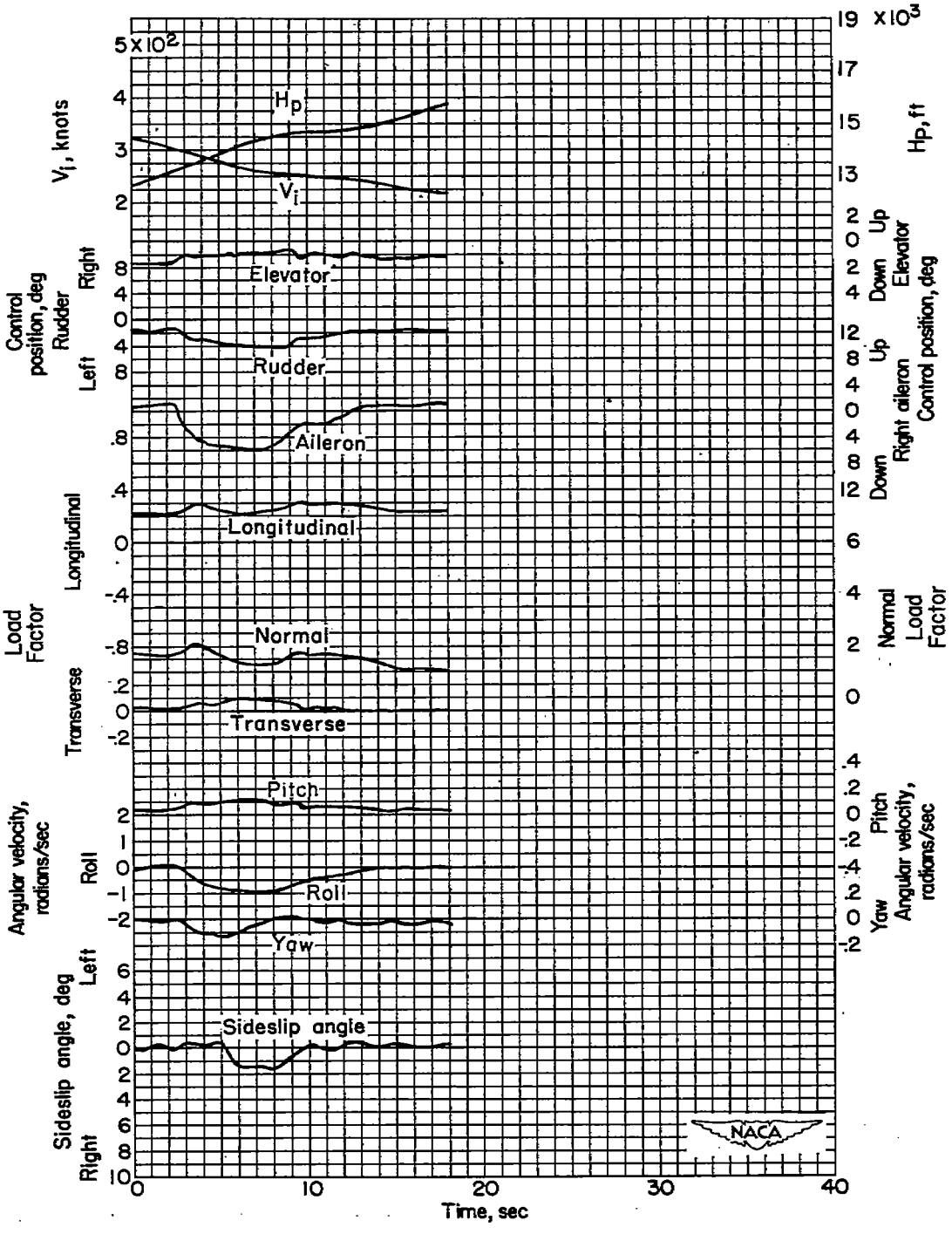

Figure 177.- Left slow roll; airplane weight, 17,550 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

[redacted]

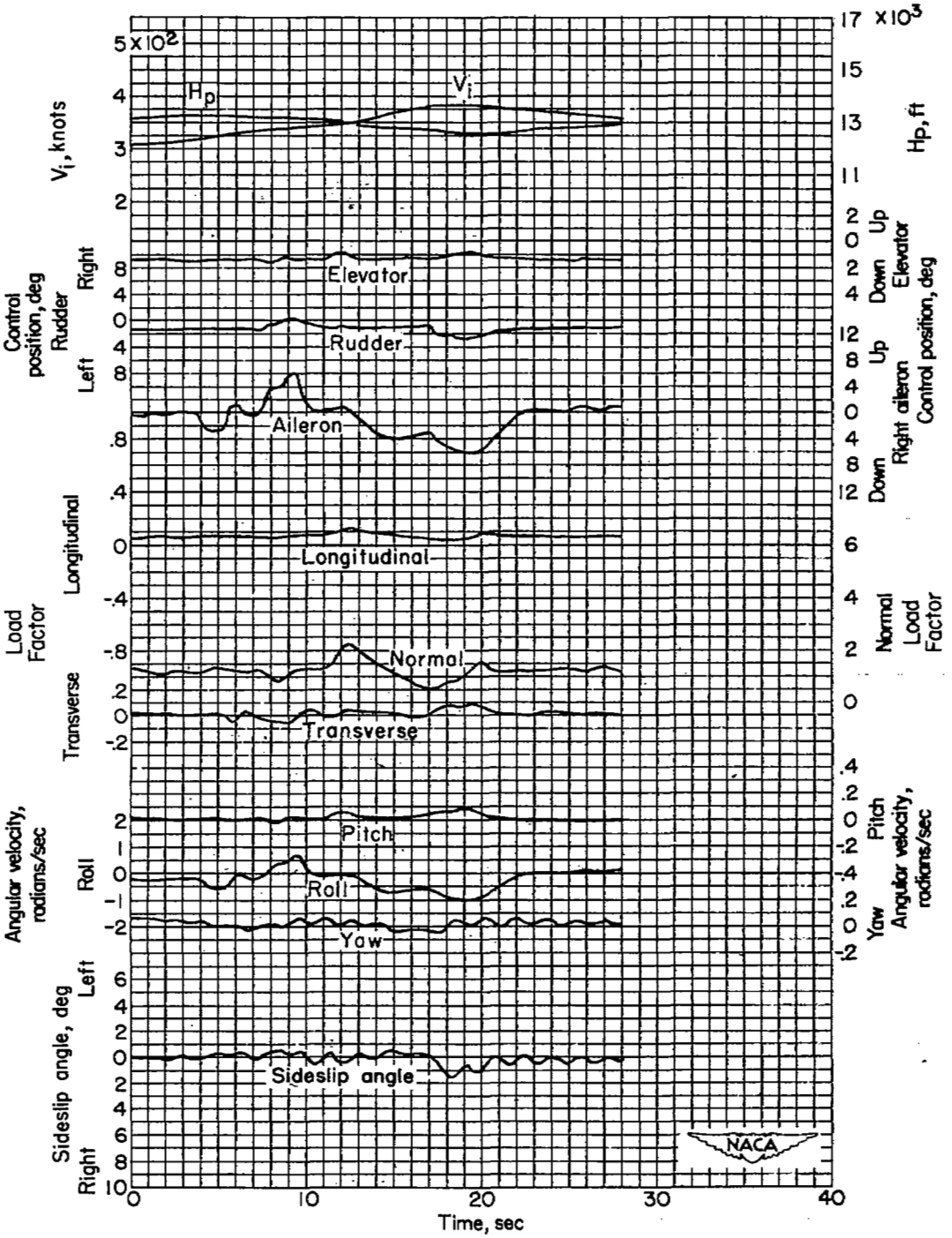

Figure 178.- Left slow roll; airplane weight, 16,820 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

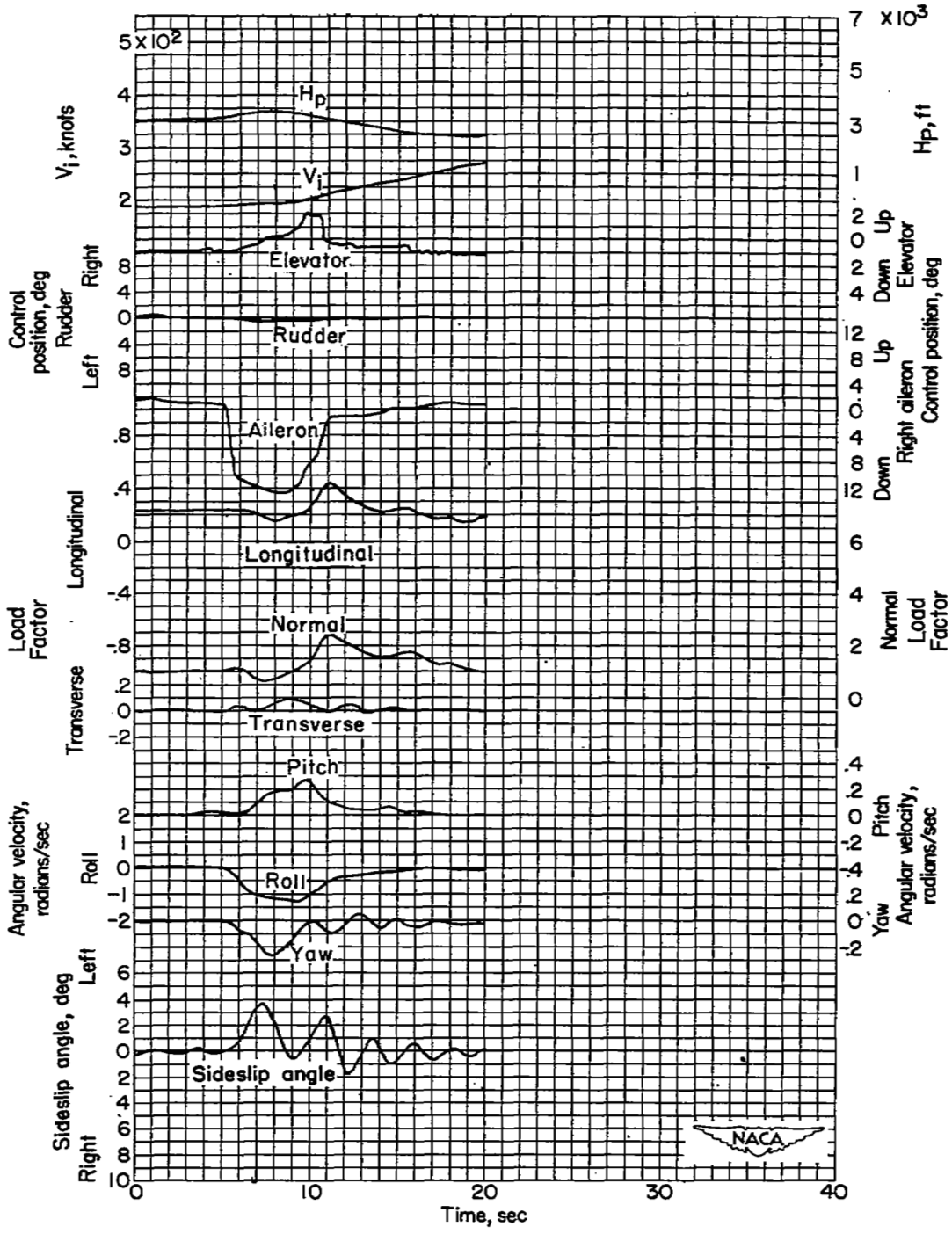

Figure 179.- Left slow roll; airplane weight, 16,820 pounds; center-of-gravity location; 26.7 percent of the mean aerodynamic chord.

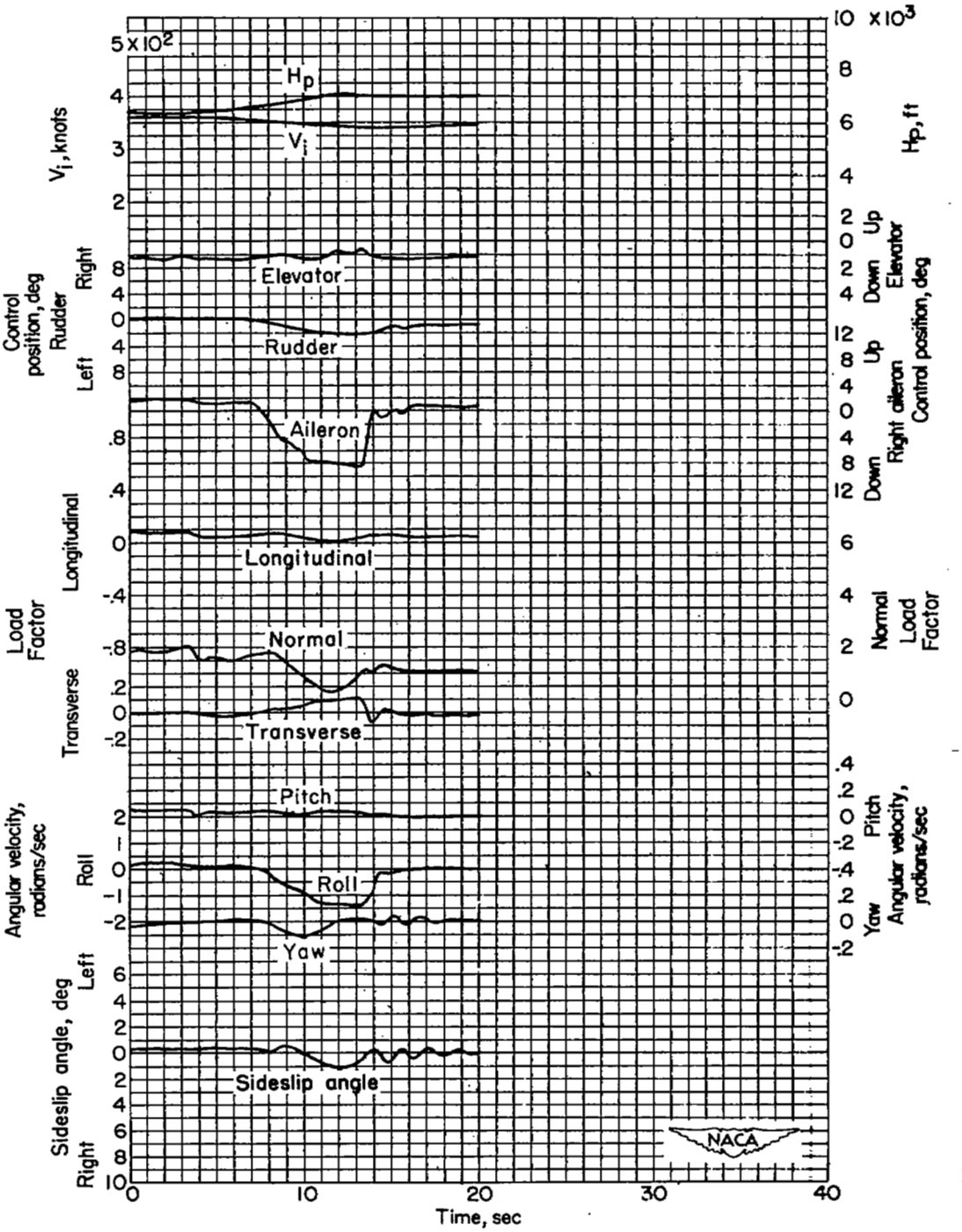

Figure 180.- Left slow roll; airplane weight, 13,880 pounds; center-of-gravity location, 26.1 percent of the mean aerodynamic chord.

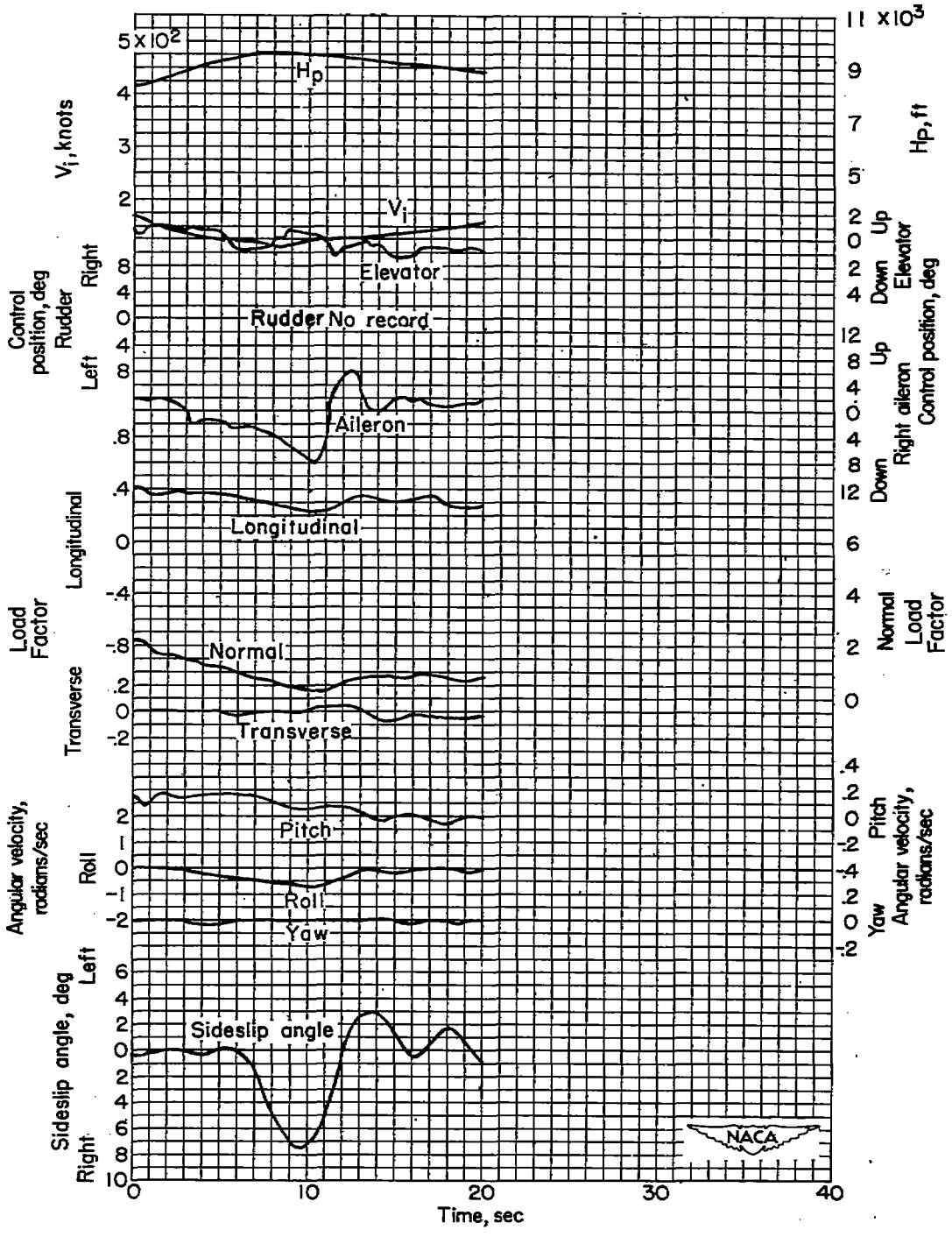

Figure 181.- Left slow roll; airplane weight, 17,670 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

[redacted]

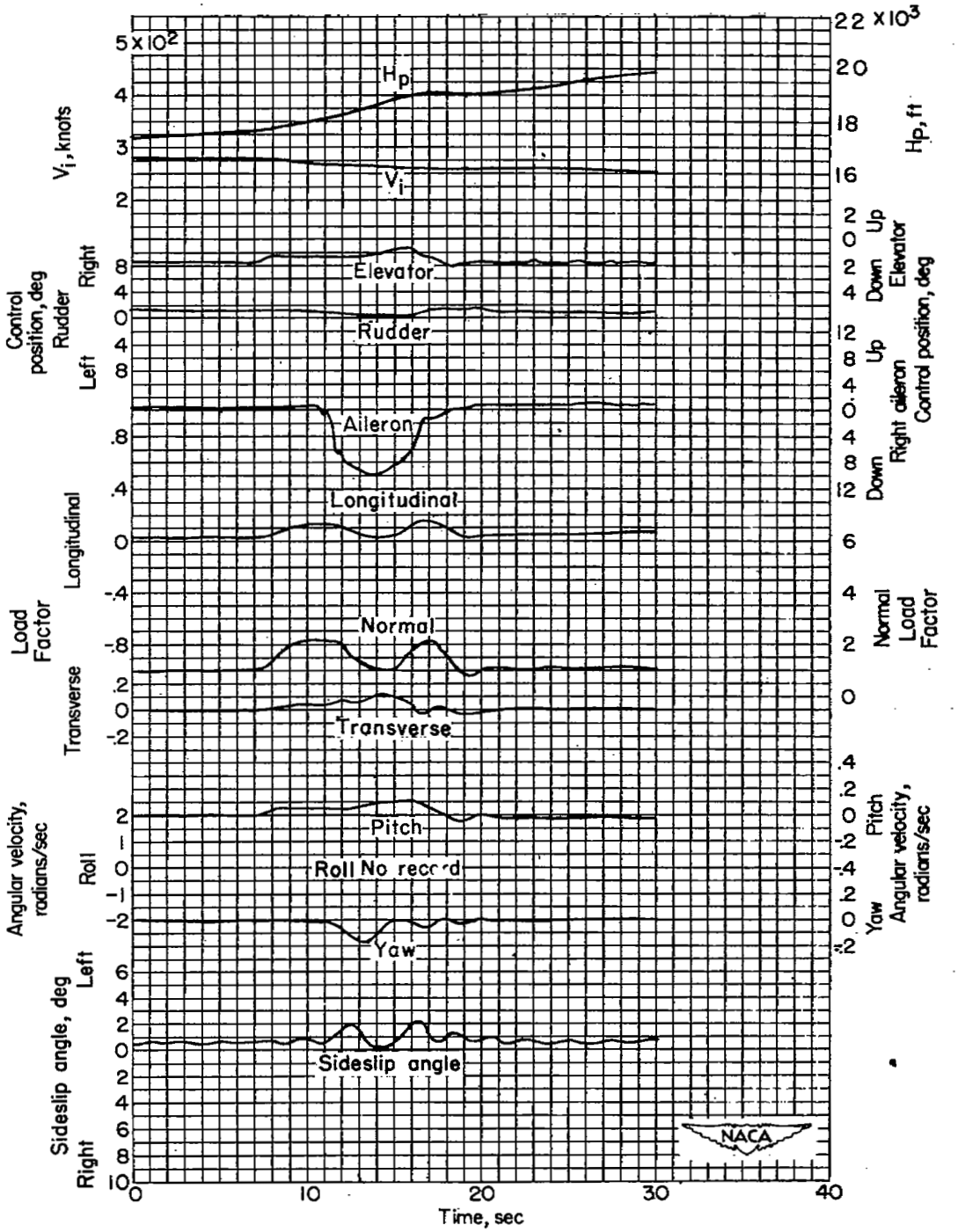

Figure 182.- Left slow roll; airplane weight, 16,330 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

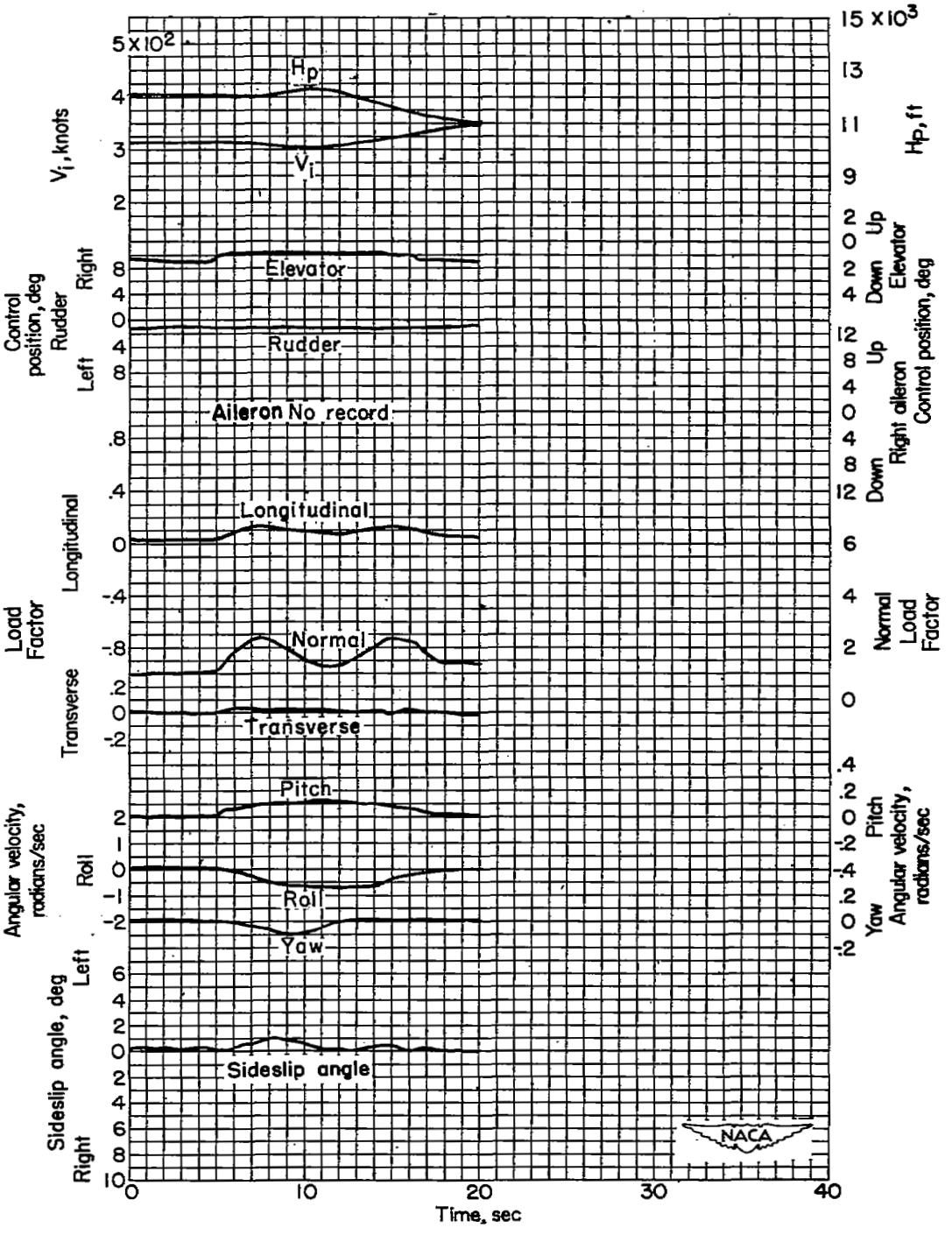

Figure 183.- Left slow roll; airplane weight, 16,340 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

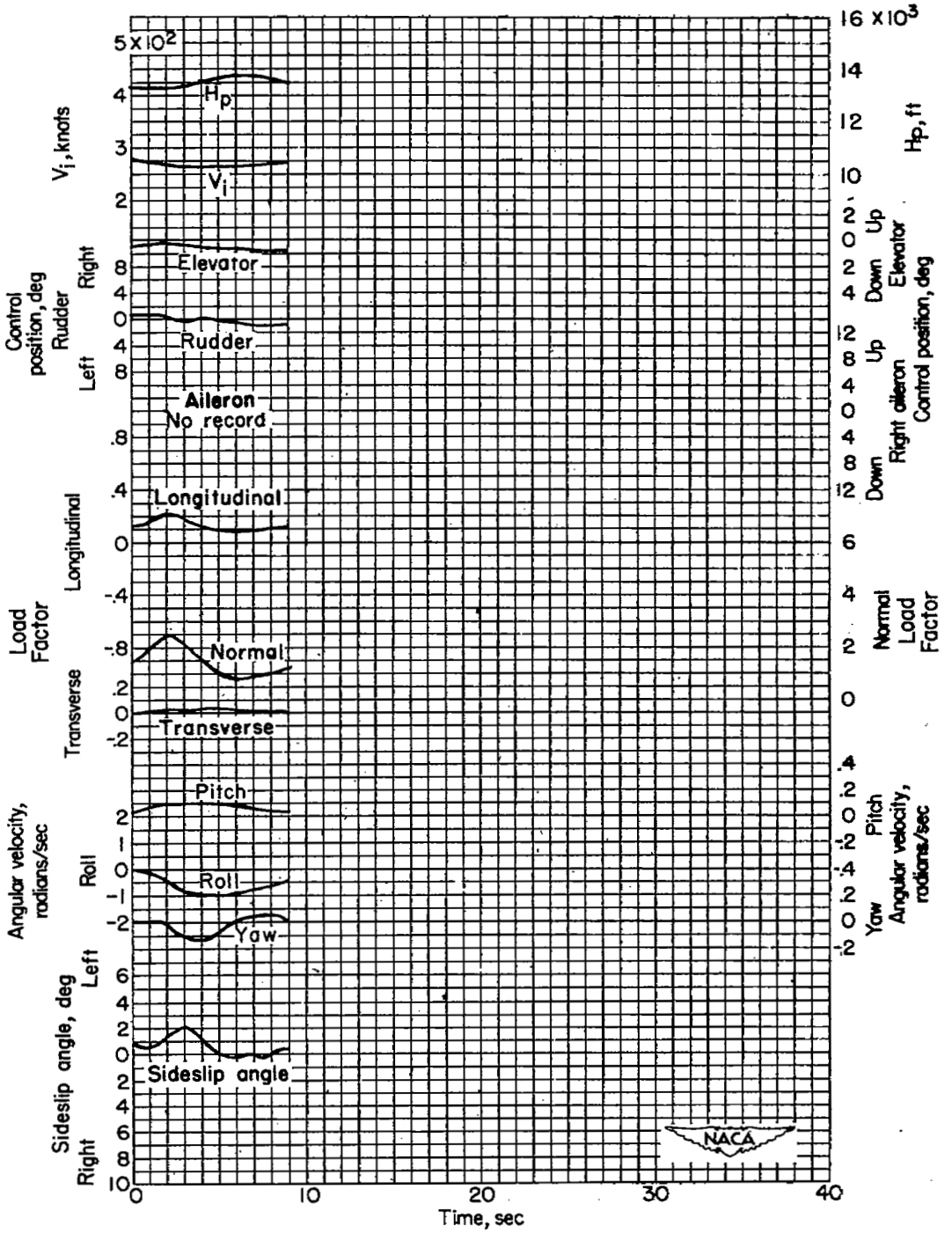

Figure 184.- Left slow roll; airplane weight, 16,730 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

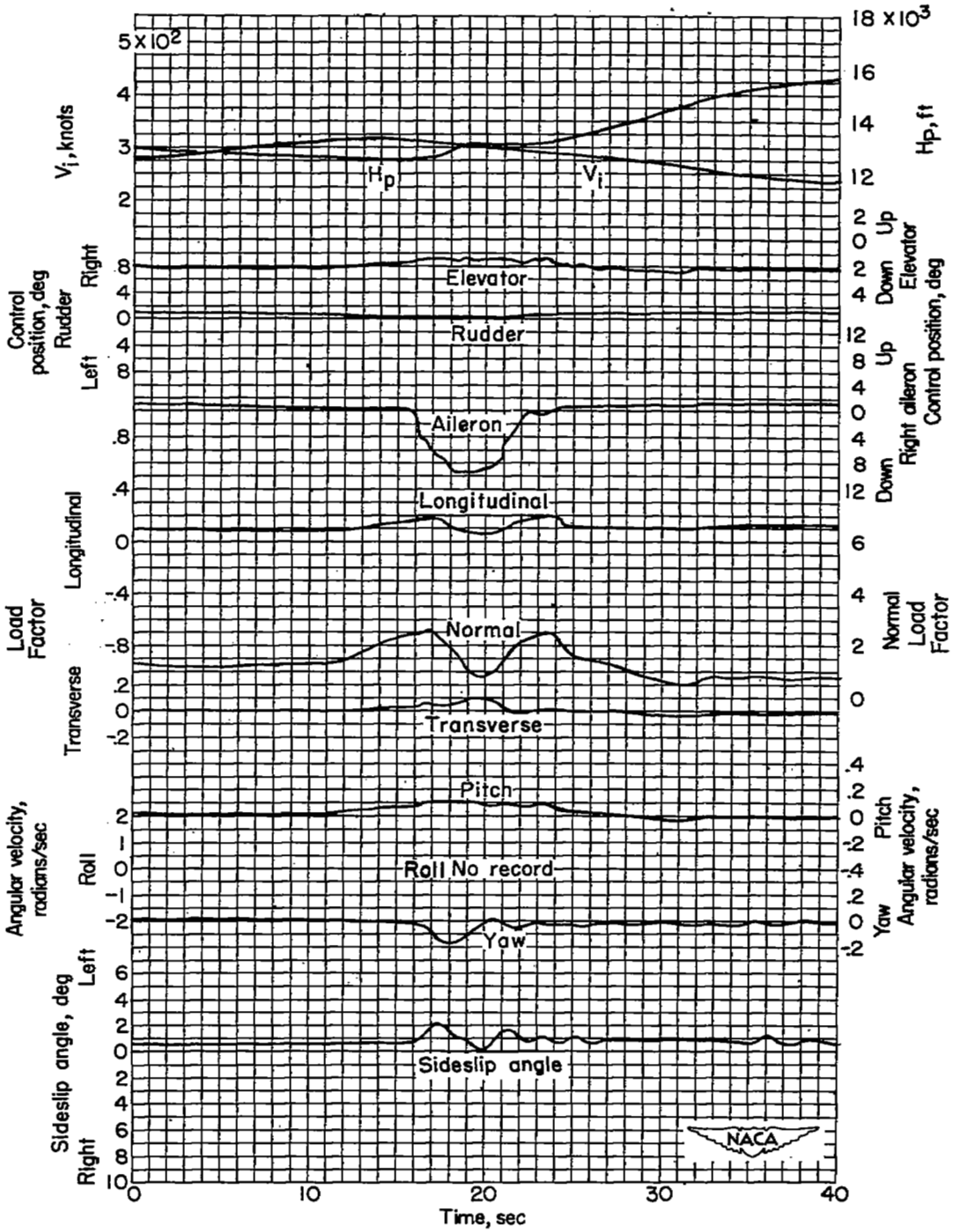

Figure 185.- Left slow roll; airplane weight, 15,320 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

[redacted]

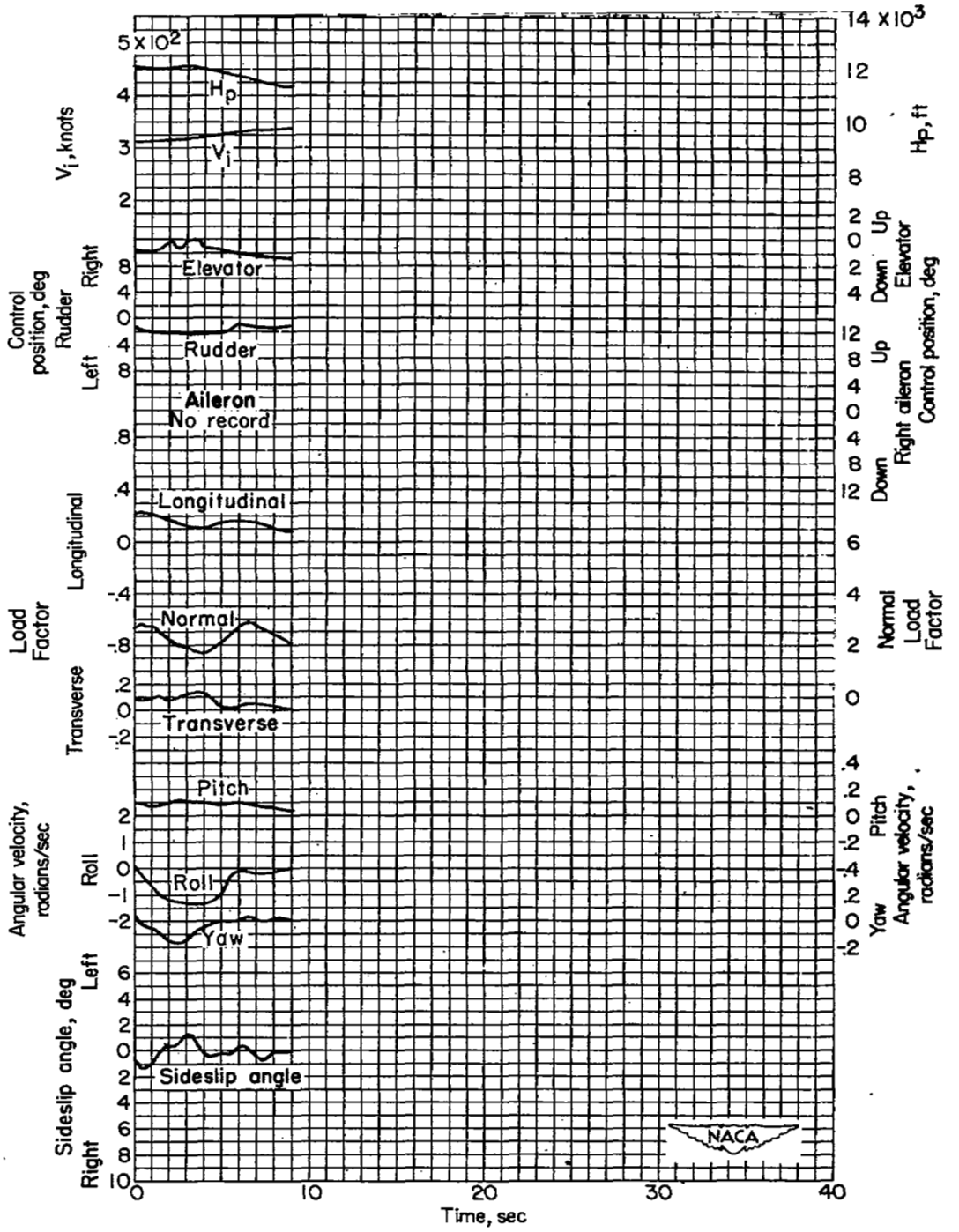

Figure 186.- Left slow roll; airplane weight, 16,780 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

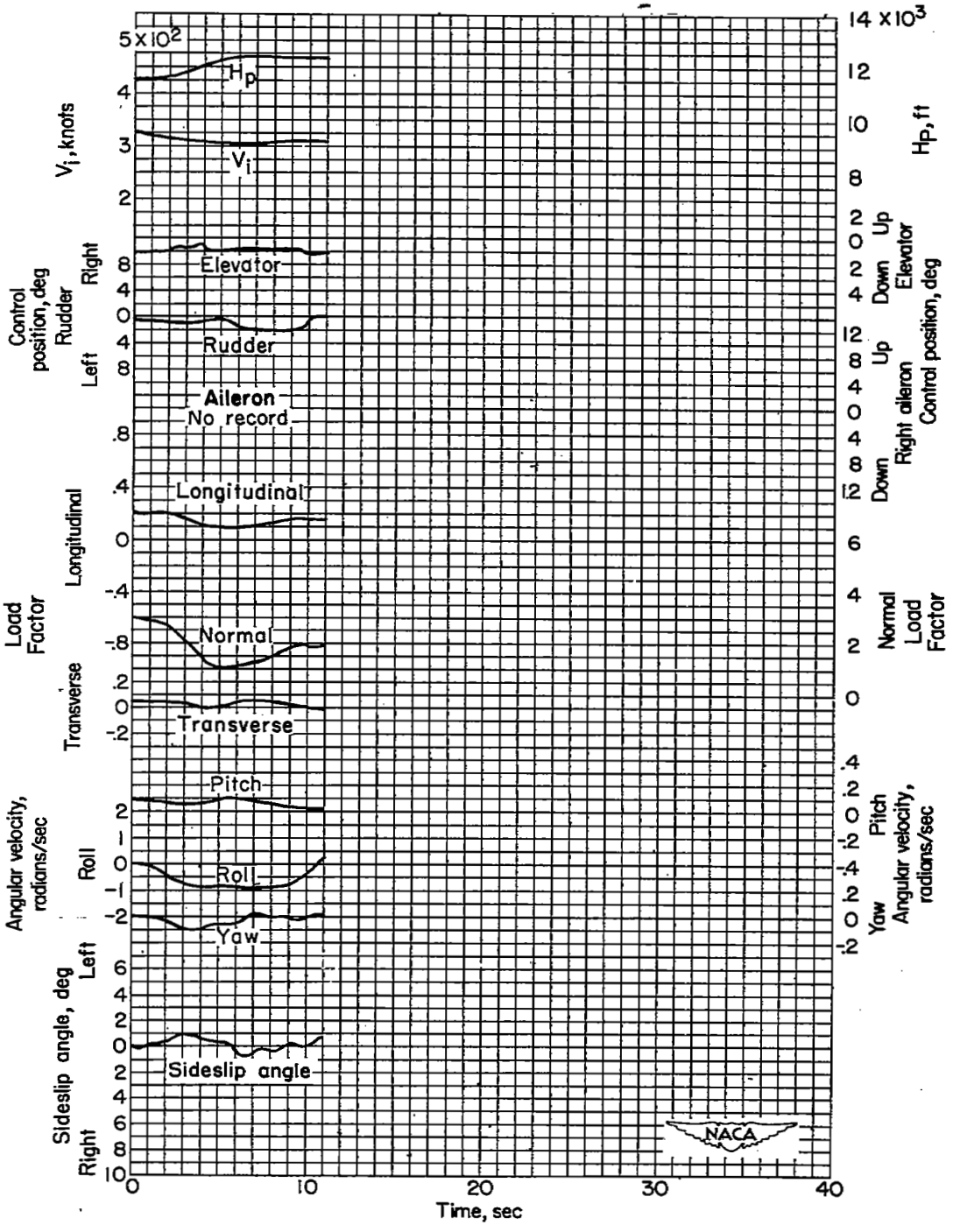

Figure 187.- Left slow roll; airplane weight, 16,800 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

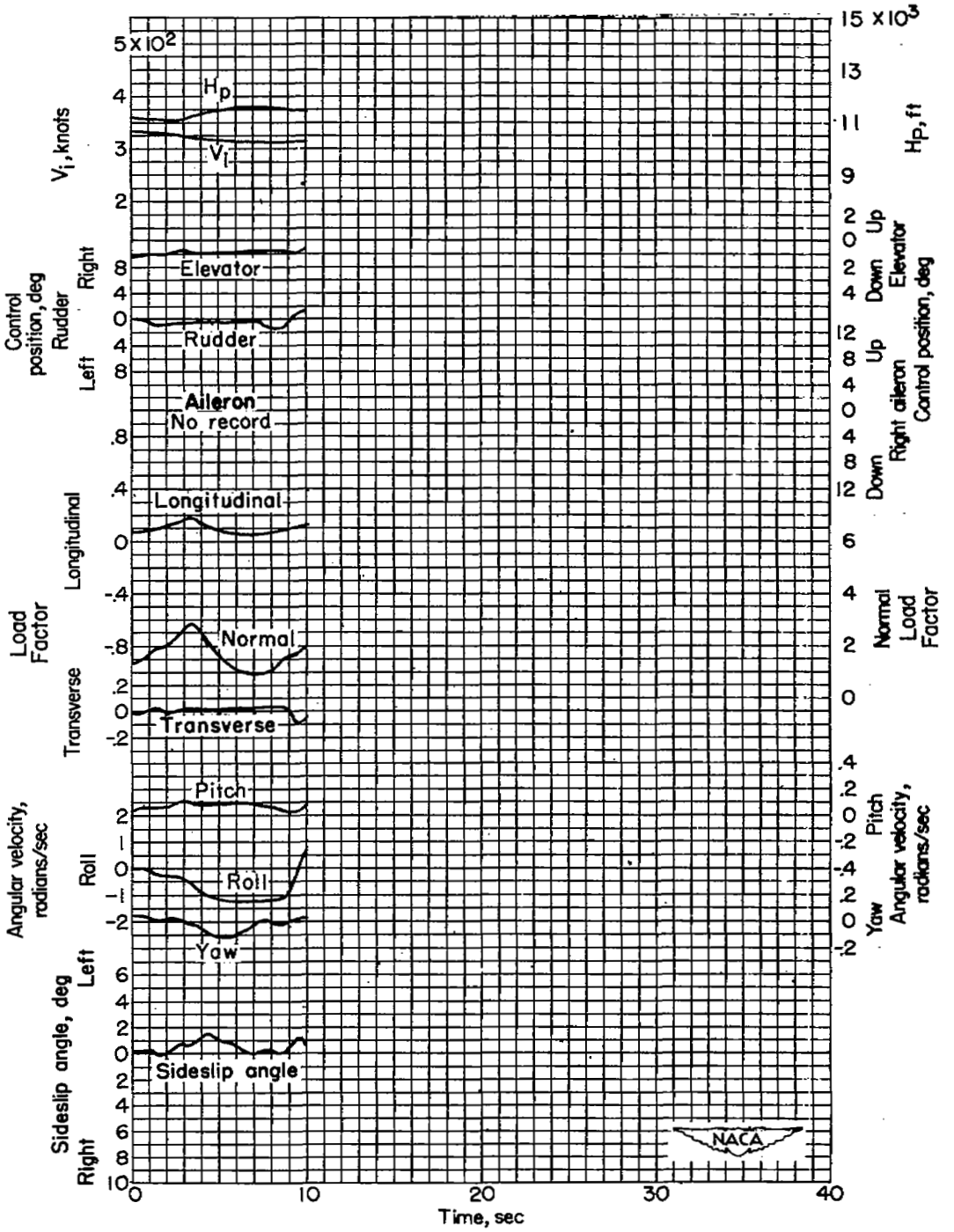

Figure 188.- Left slow roll; airplane weight, 16,955 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

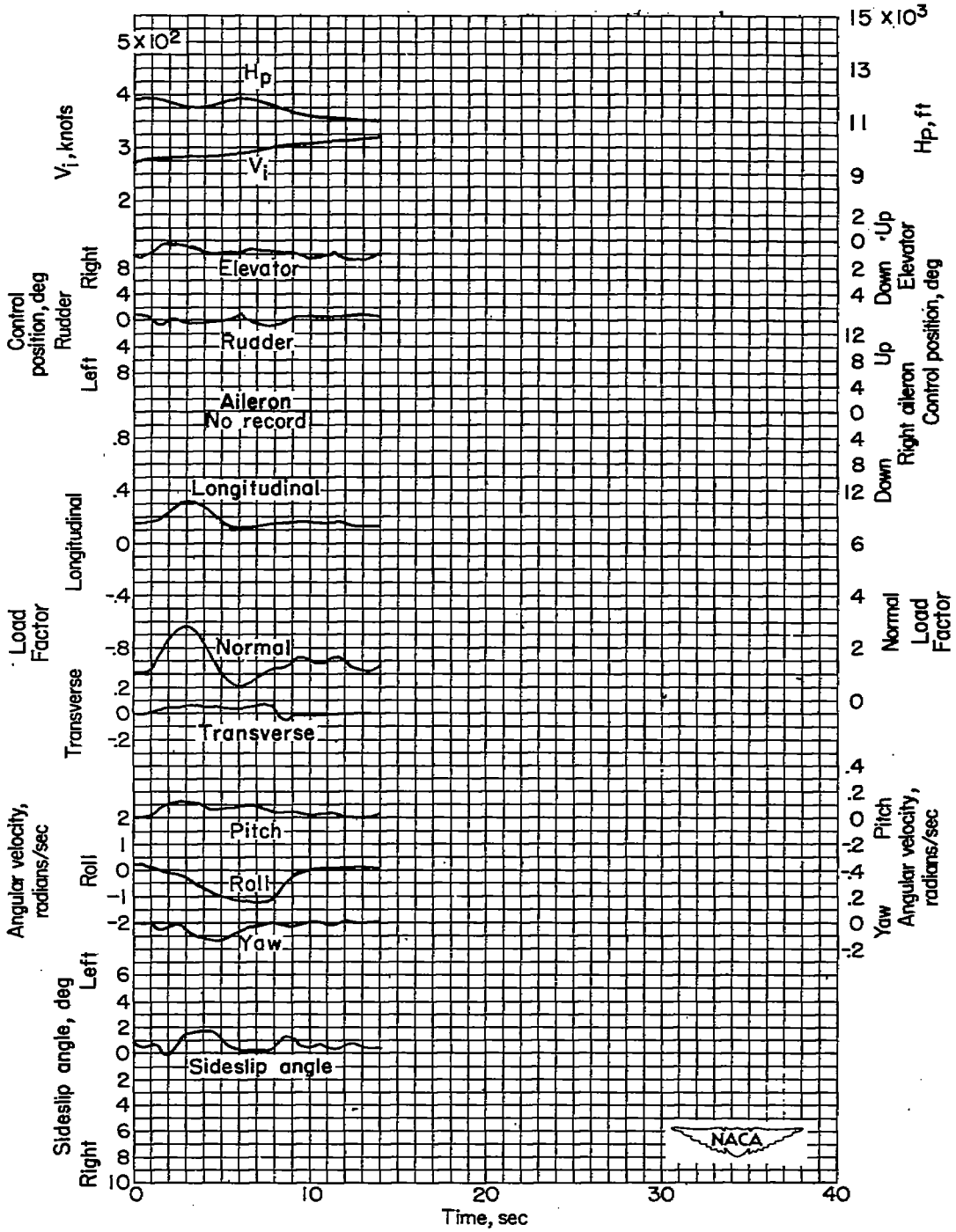

Figure 189.- Left slow roll; airplane weight, 17,050 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

[redacted]

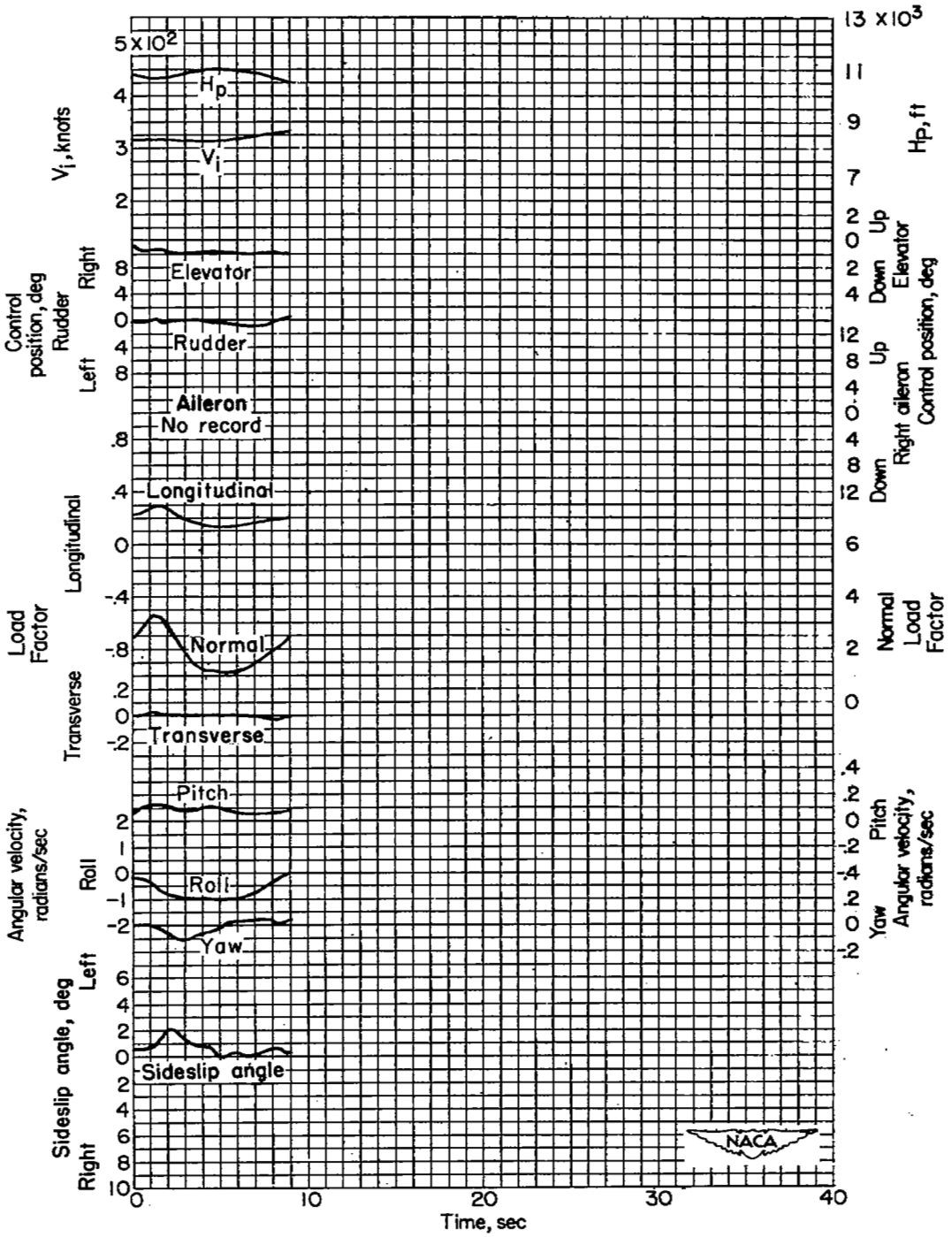

Figure 190.- Left slow roll; airplane weight, 17,020 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

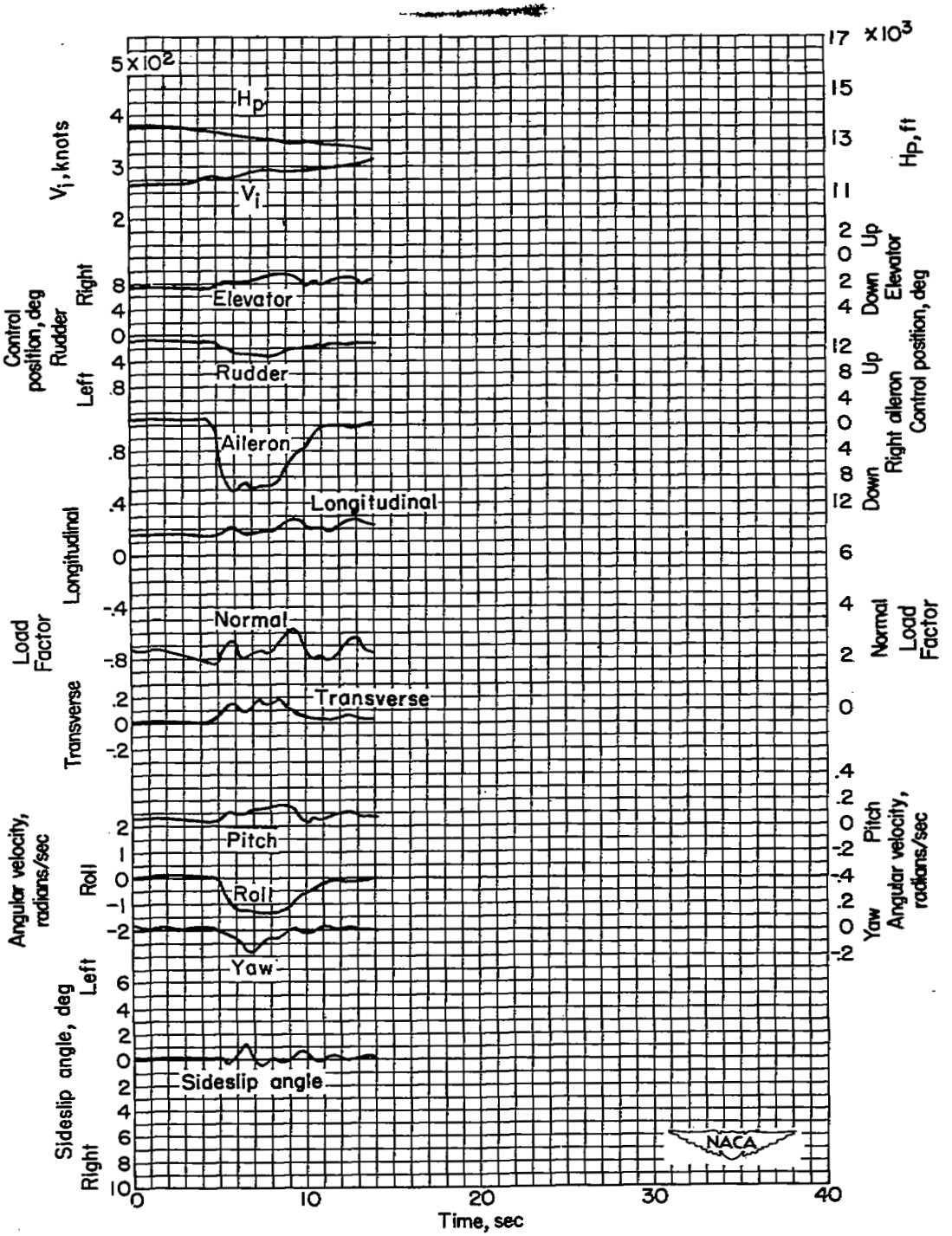

Figure 191.- Left slow roll; airplane weight, 17,580 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

[redacted]

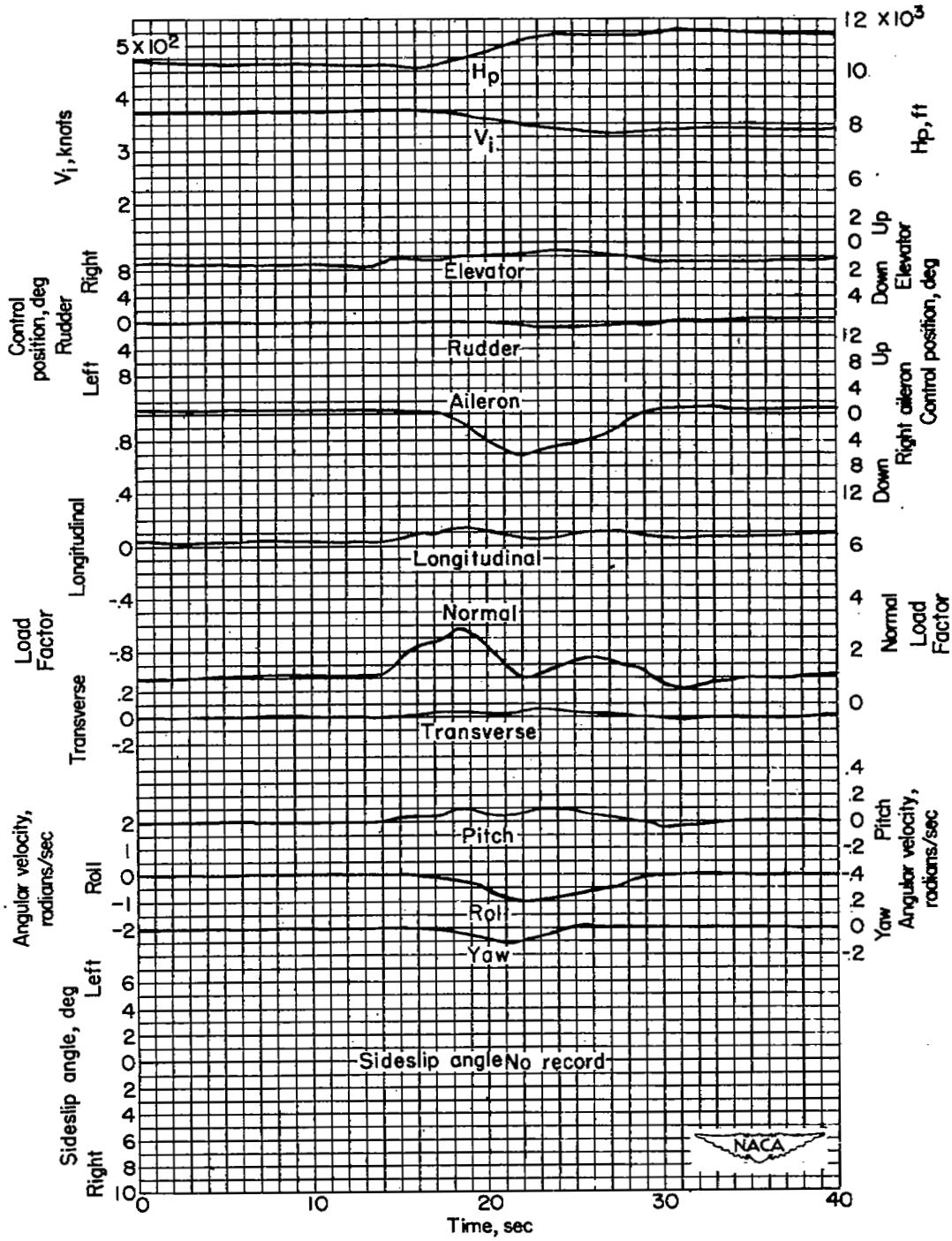

Figure 192.- Left slow roll; airplane weight, 15,930 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

29F

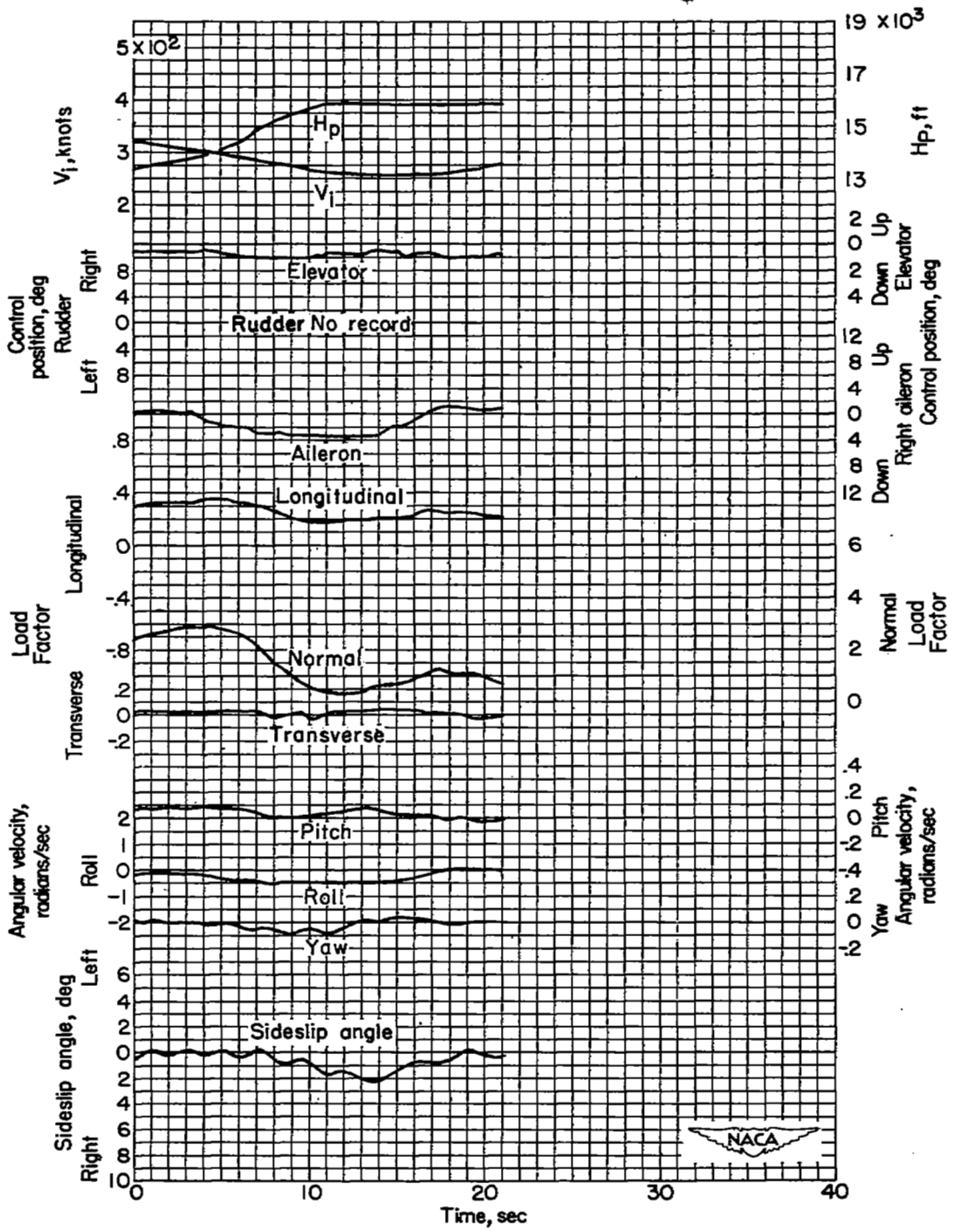

Figure 193.- Left slow roll; airplane weight, 17,230 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

[redacted]

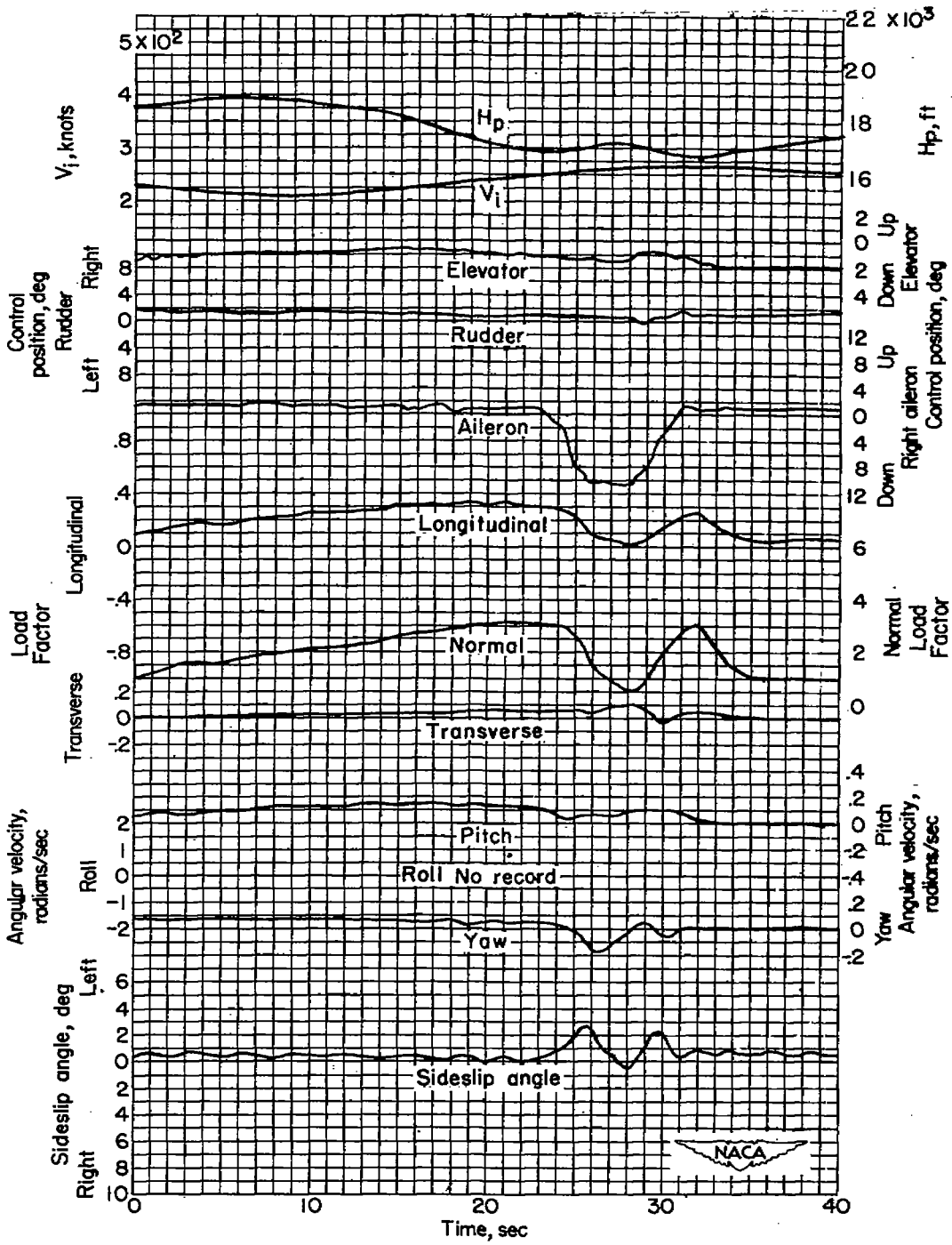

Figure 194.- Left slow roll; airplane weight, 16,400 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

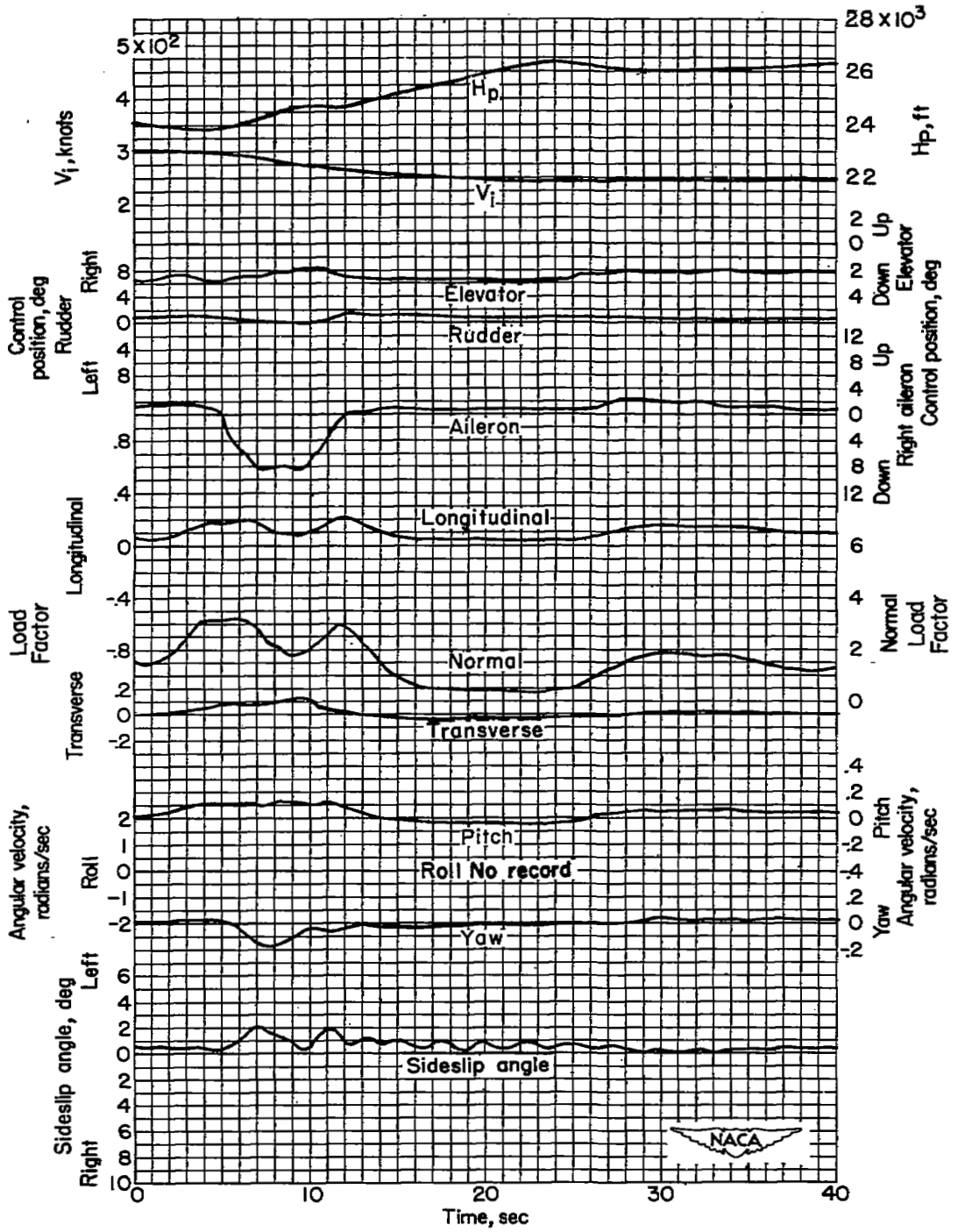

Figure 195.- Left slow roll; airplane weight, 14,740 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

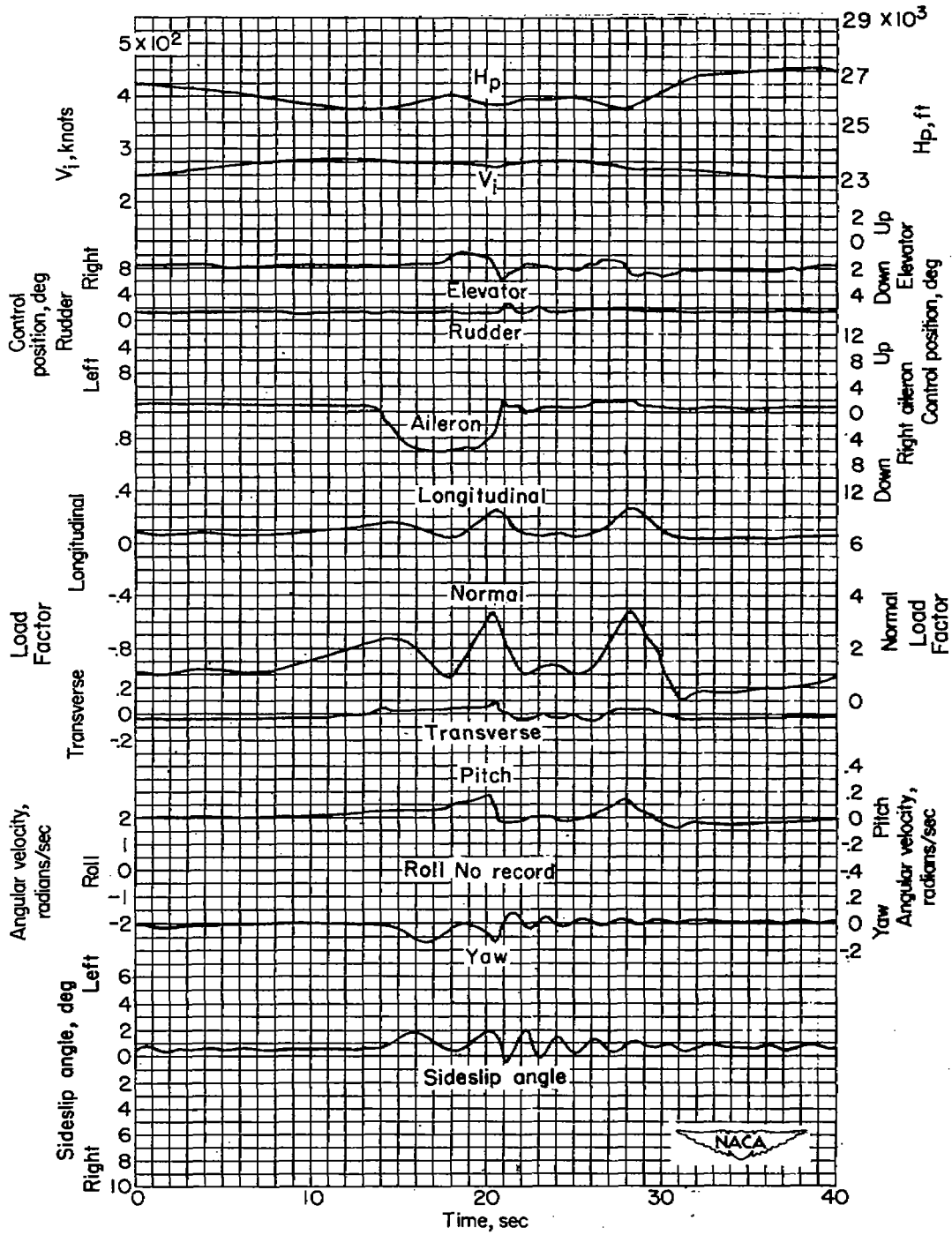

Figure 196.- Left slow roll; airplane weight, 16,880 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

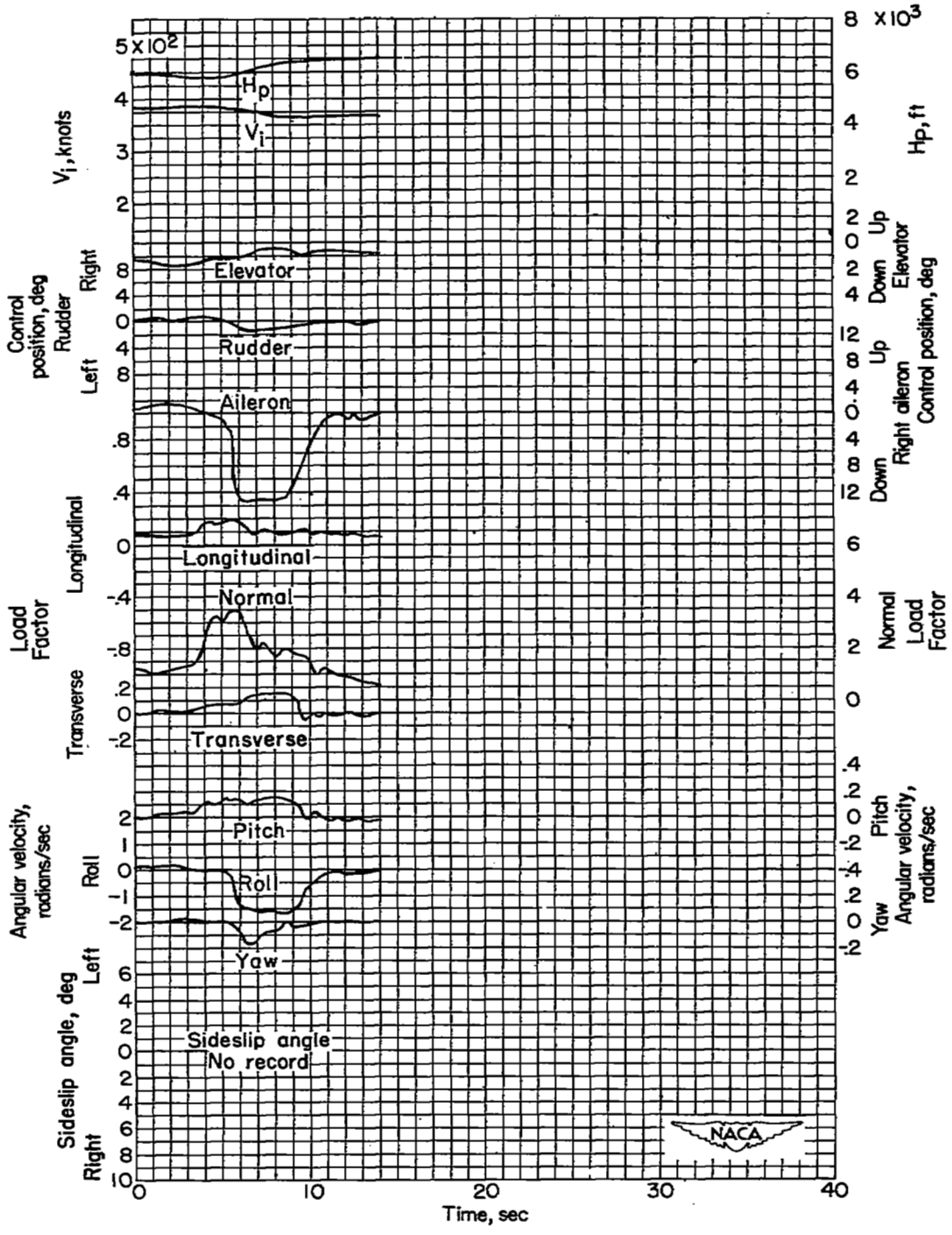

Figure 197.- Left slow roll; airplane weight, 16,630 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

[redacted]

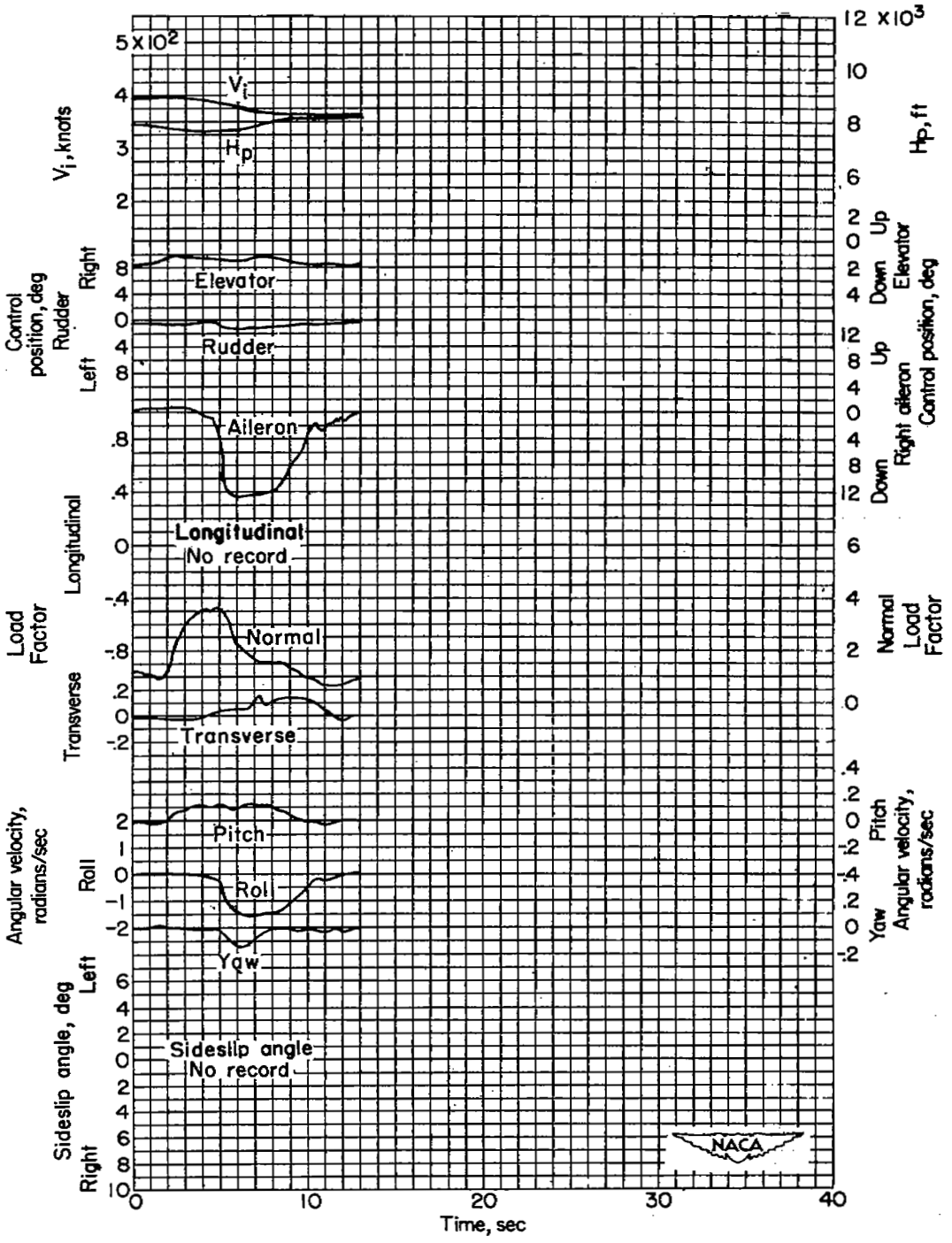

Figure 198.- Left slow roll; airplane weight, 16,020 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

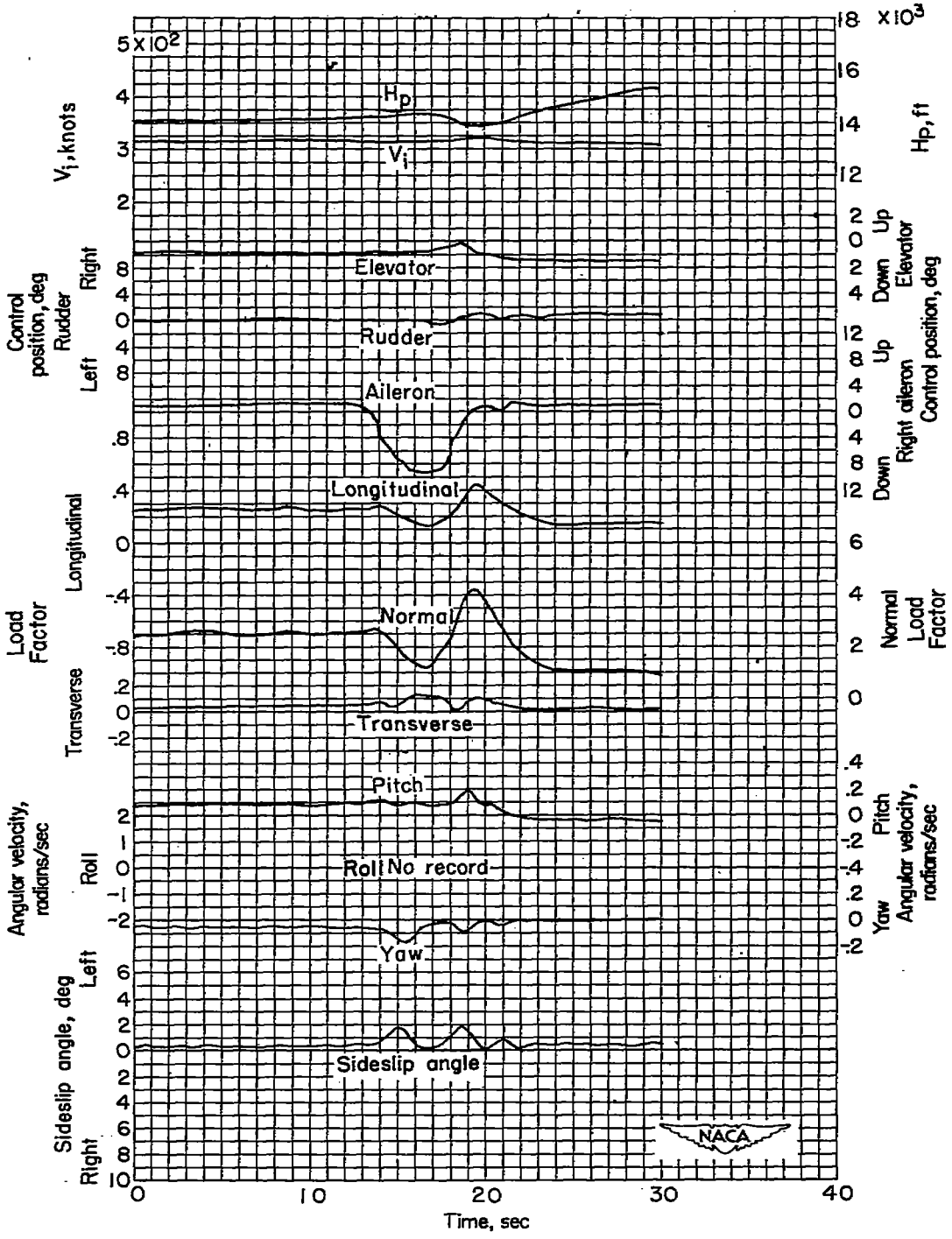

Figure 199.- Left slow roll; airplane weight, 17,280 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

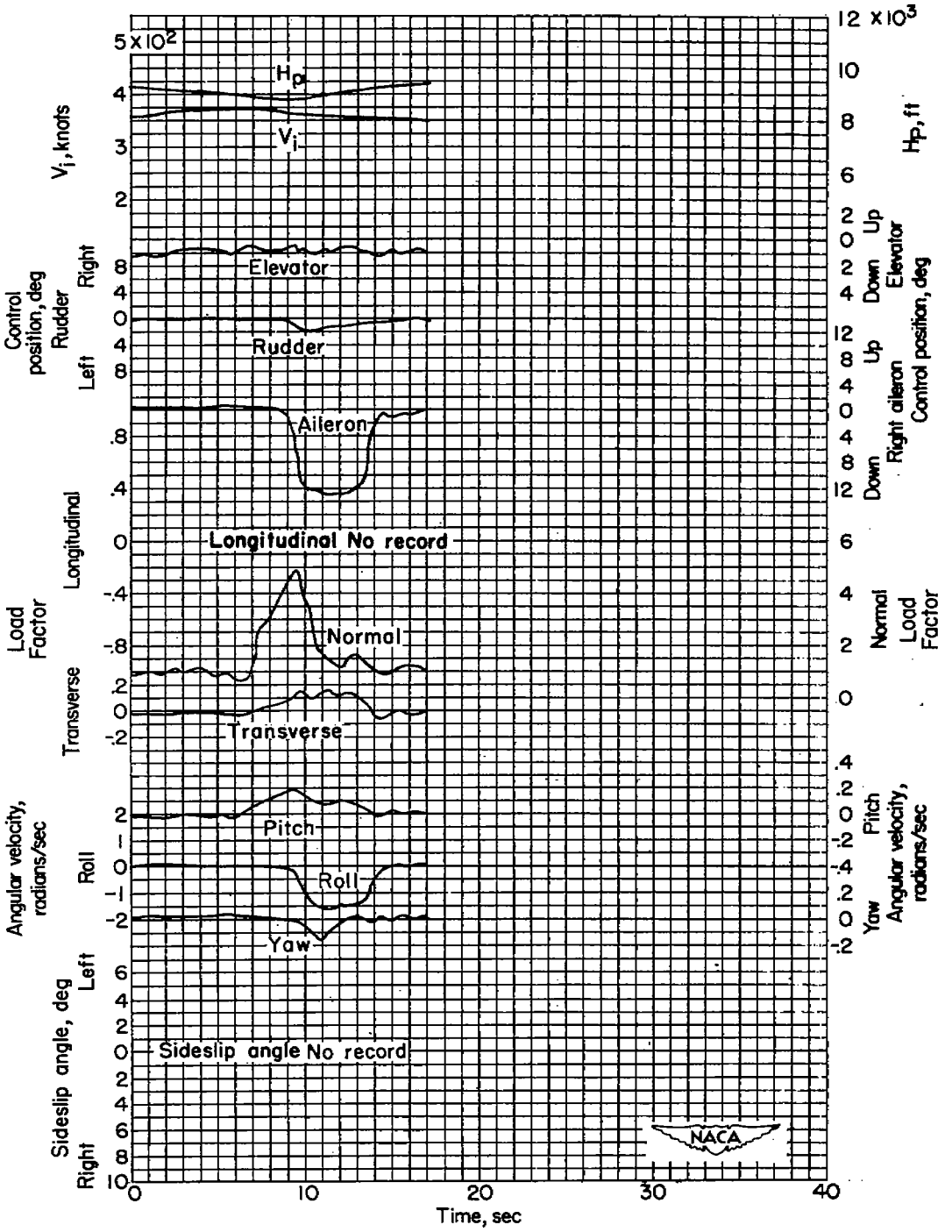

Figure 200.- Left slow roll; airplane weight, 14,750 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

30F

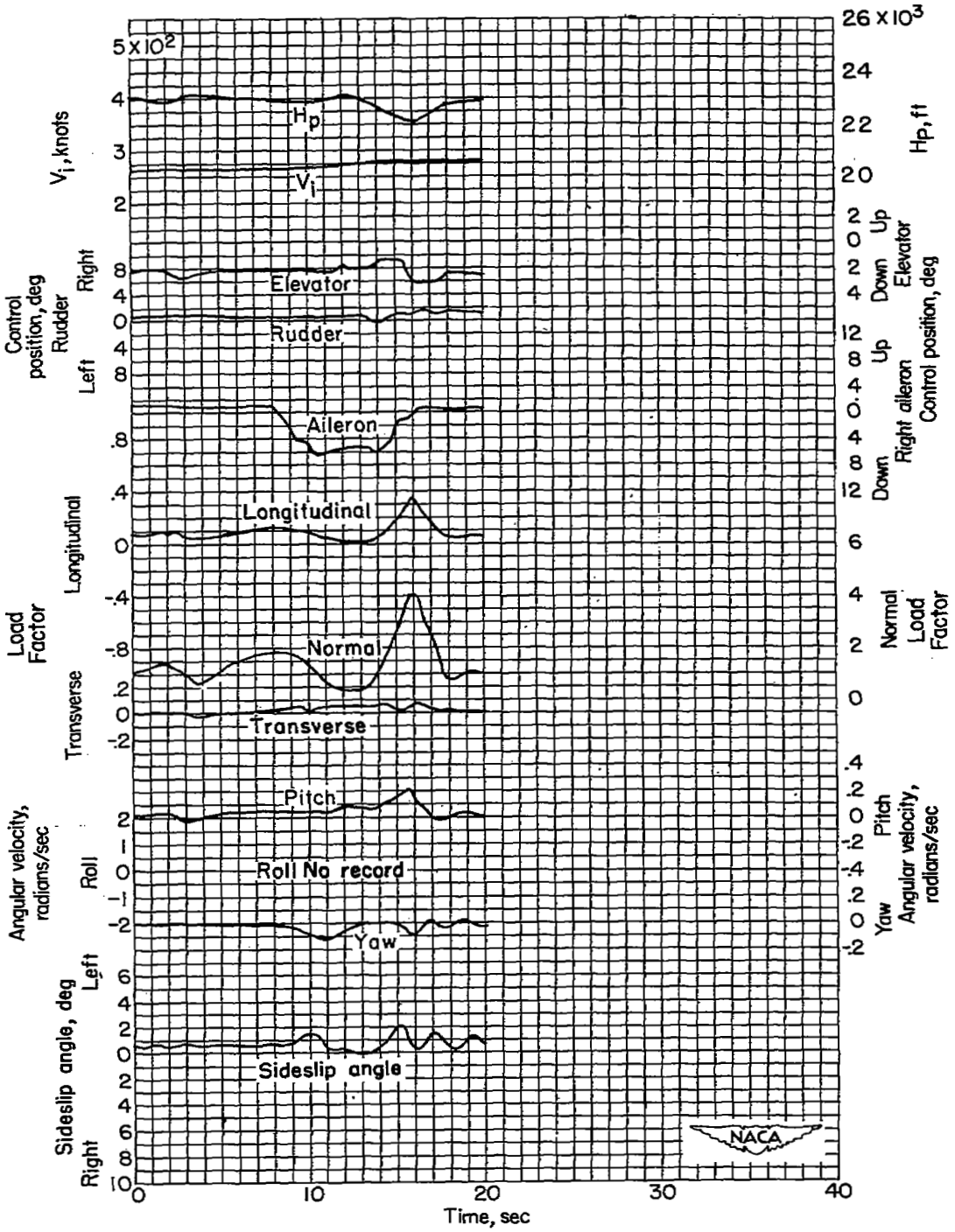

Figure 201.- Left slow roll; airplane weight, 14,990 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

[redacted]

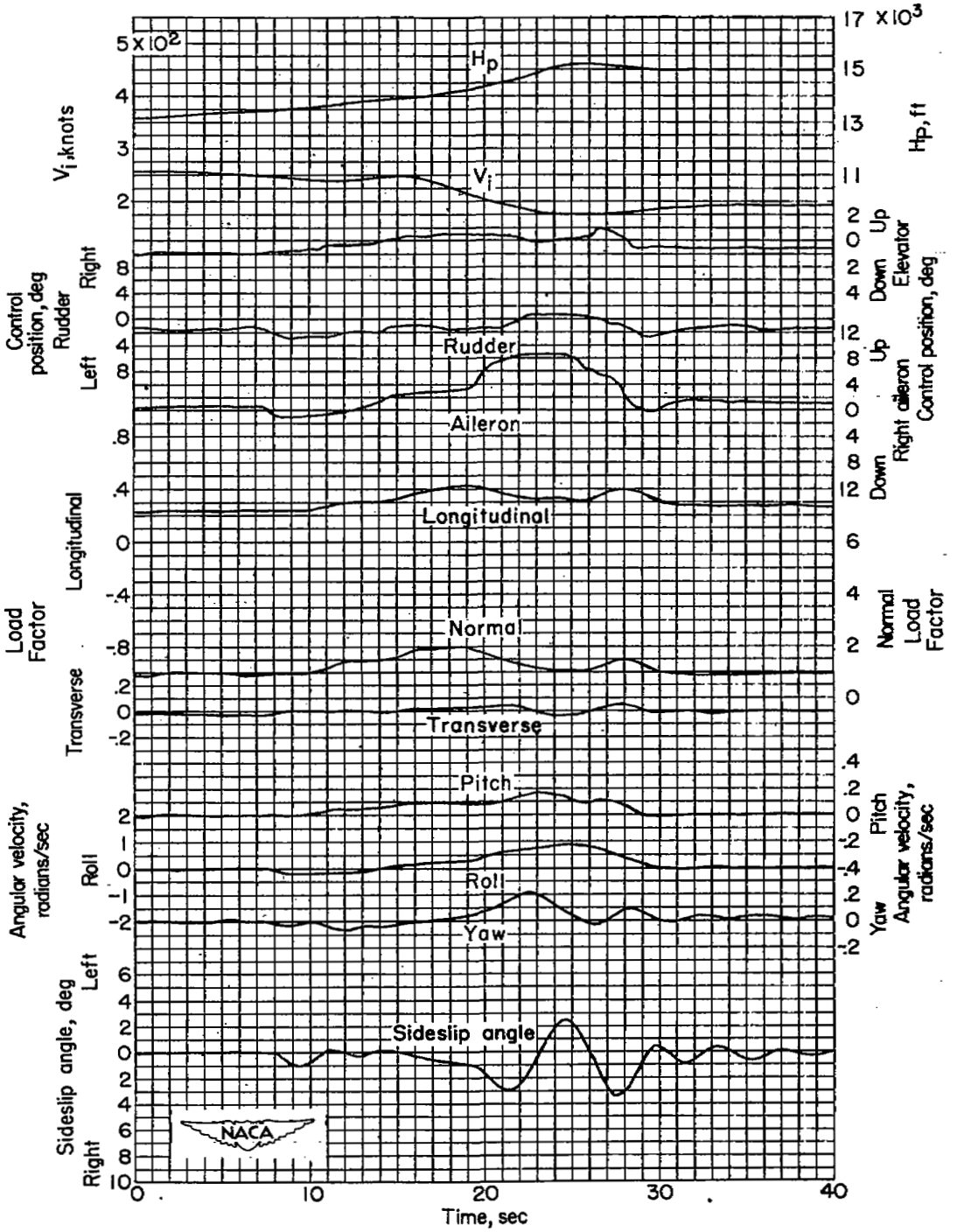

Figure 202.- Right barrel roll; airplane weight, 18,370 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

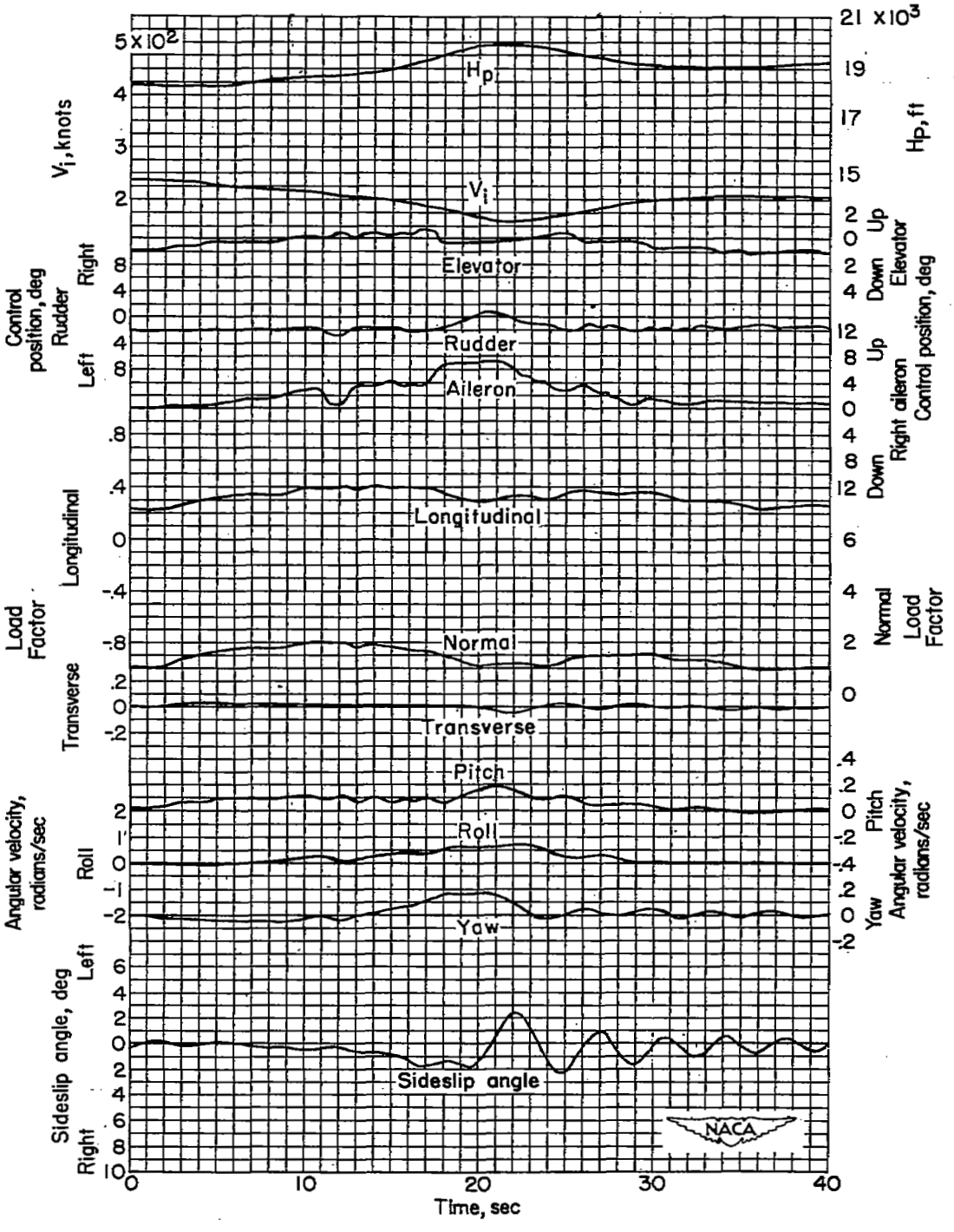

Figure 203.- Right barrel roll; airplane weight, 18,200 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

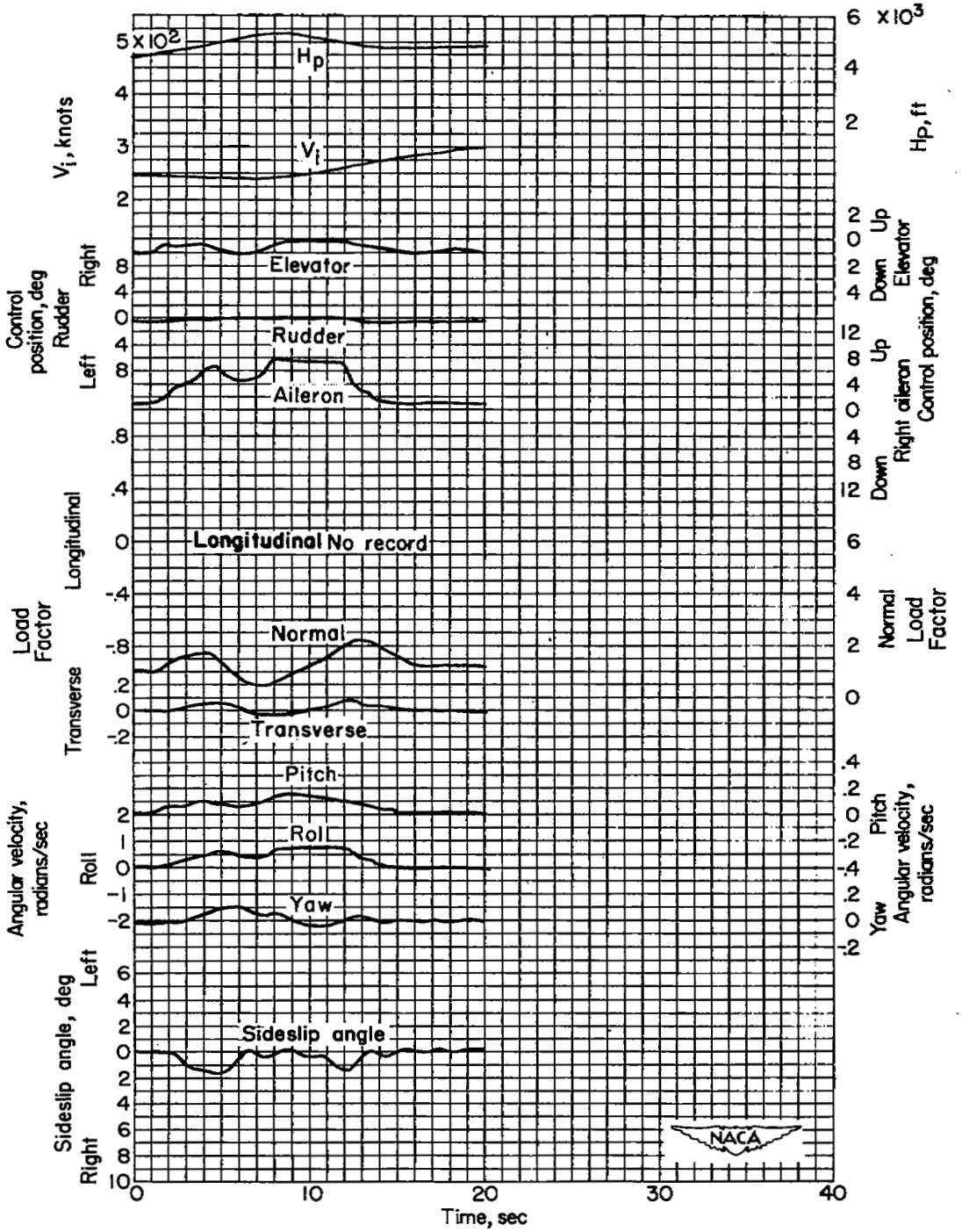

Figure 204.- Right barrel roll; airplane weight, 15,360 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

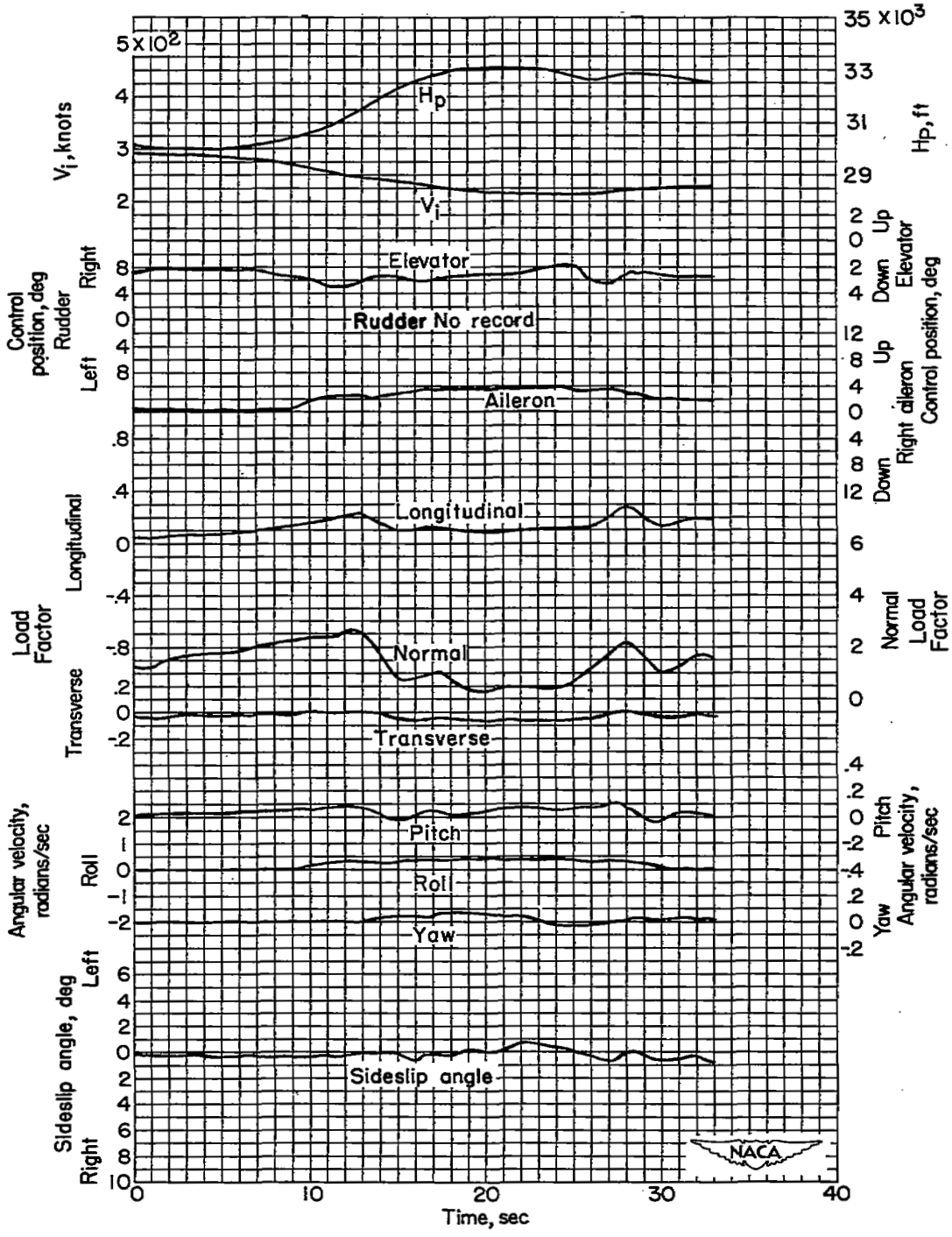

Figure 205.- Right barrel roll; airplane weight, 15,520 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

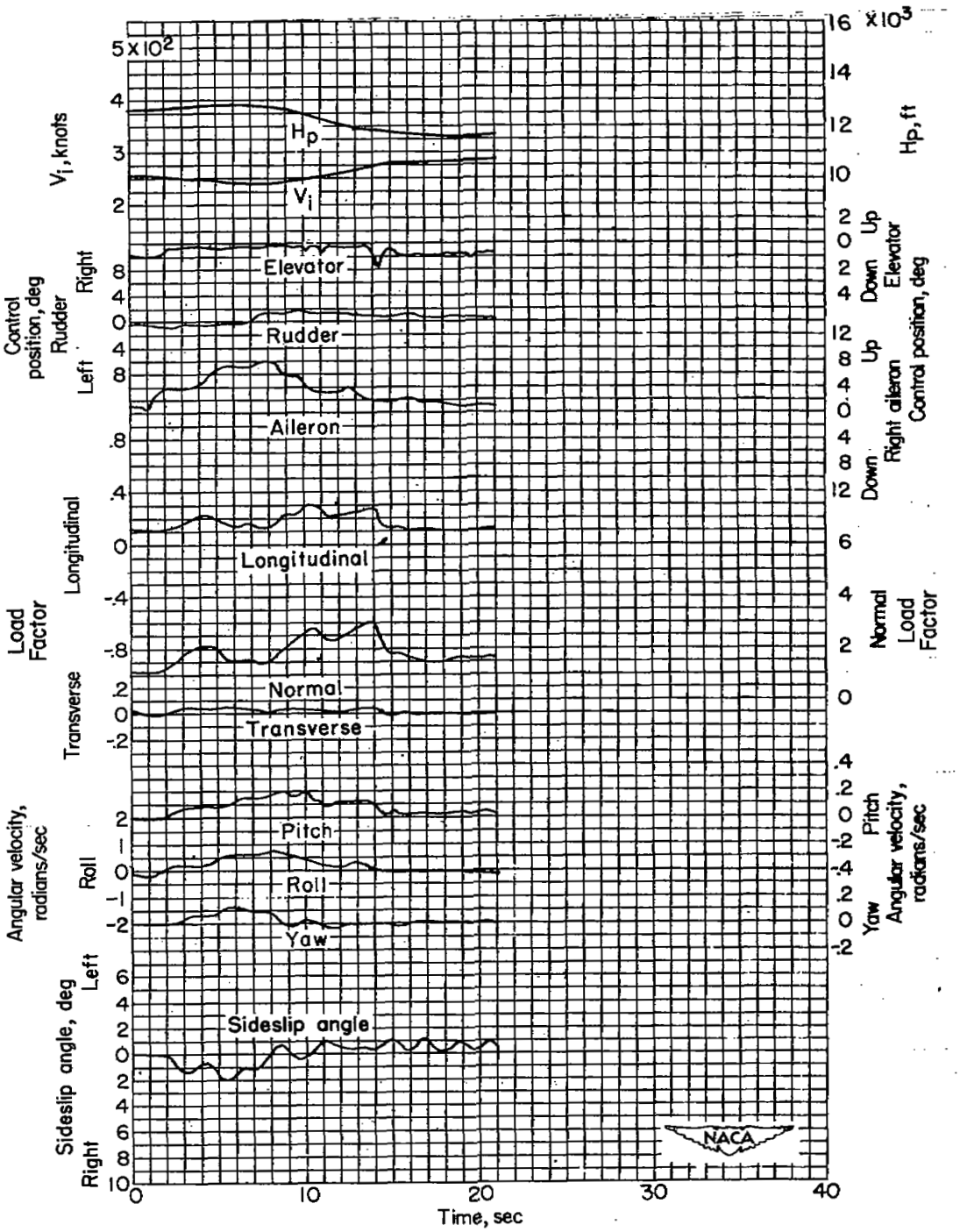

Figure 206.- Right barrel roll; airplane weight, 16,840 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

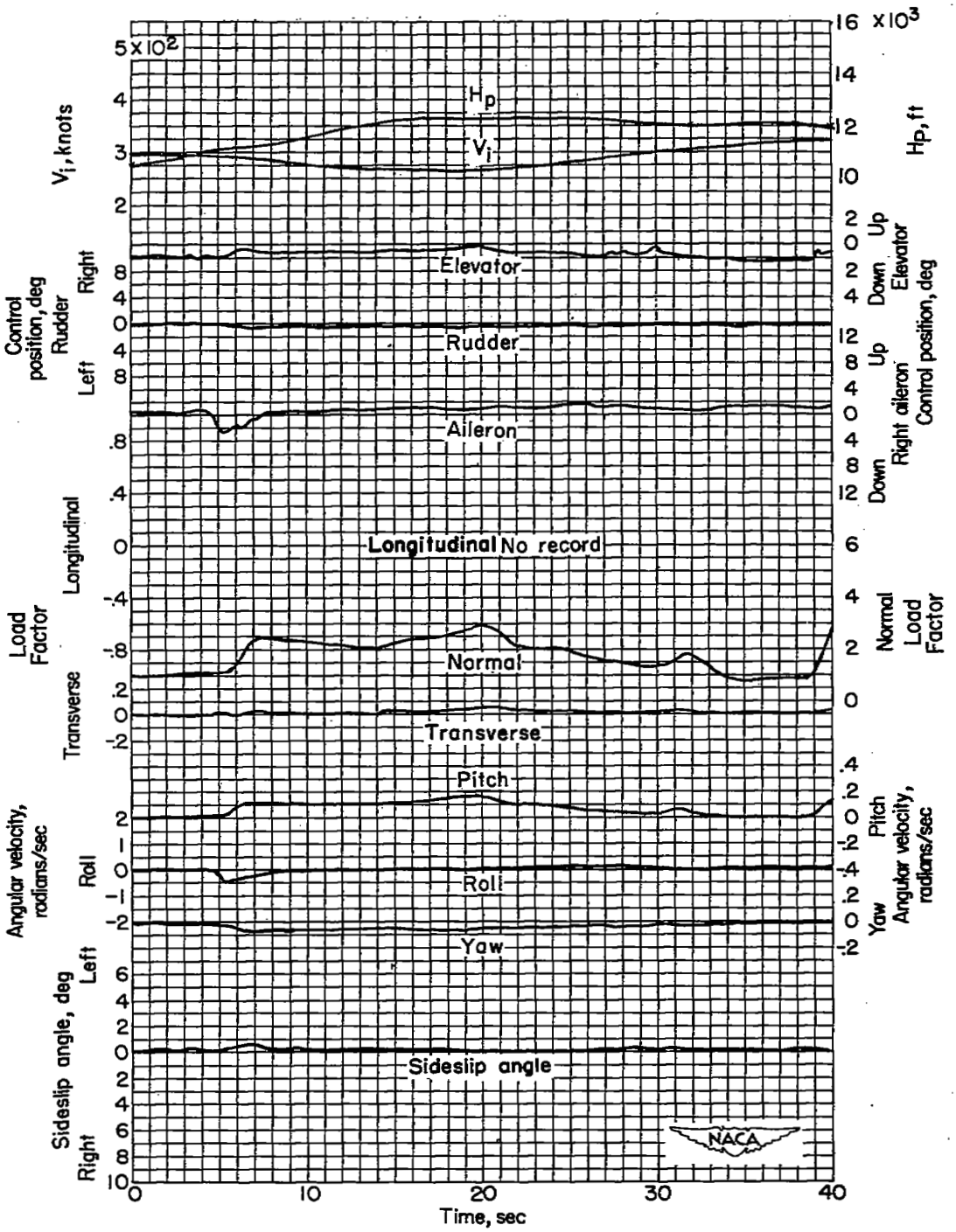

Figure 207.- Right barrel roll; airplane weight, 15,240 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

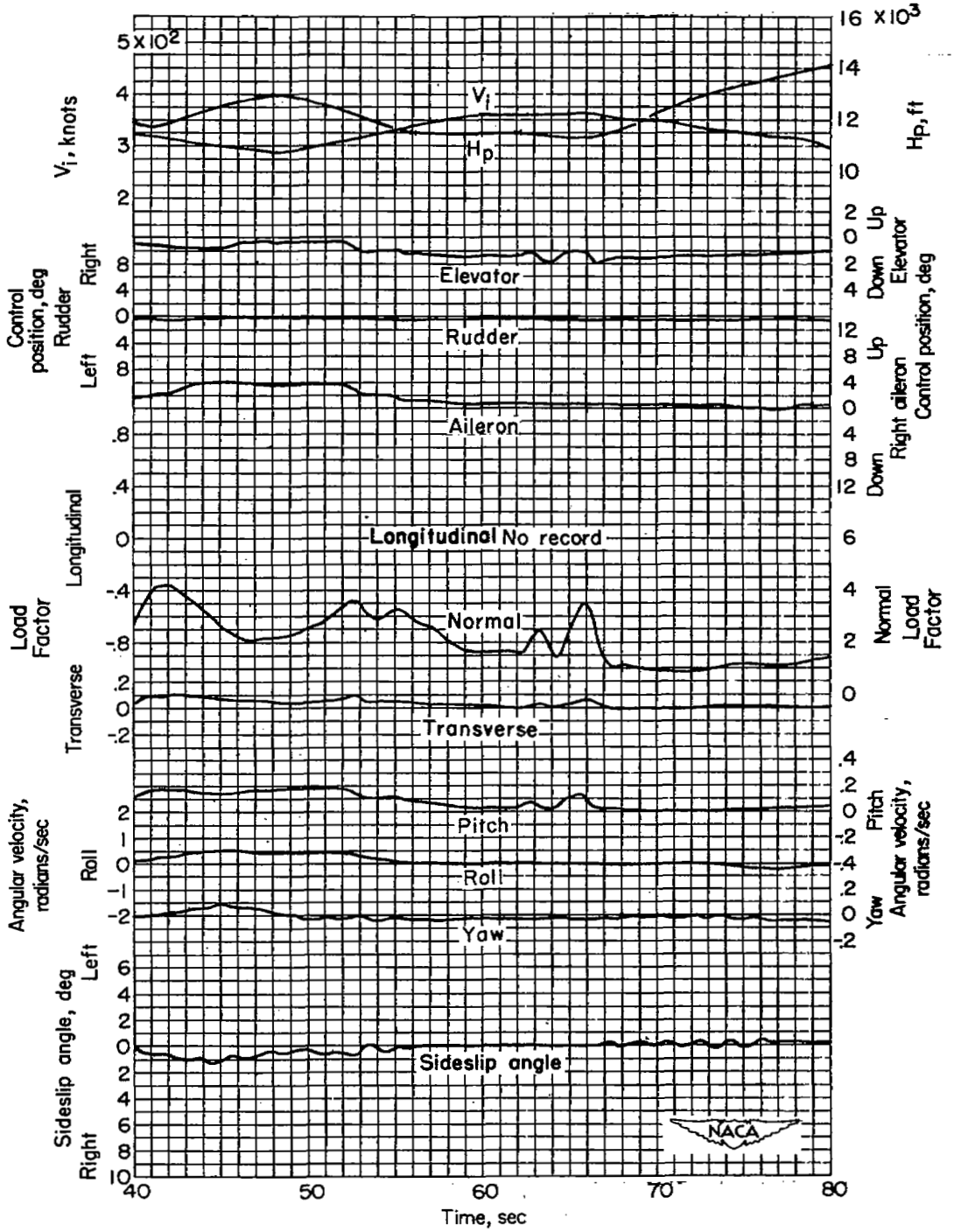

Figure 207.- Concluded.

1F

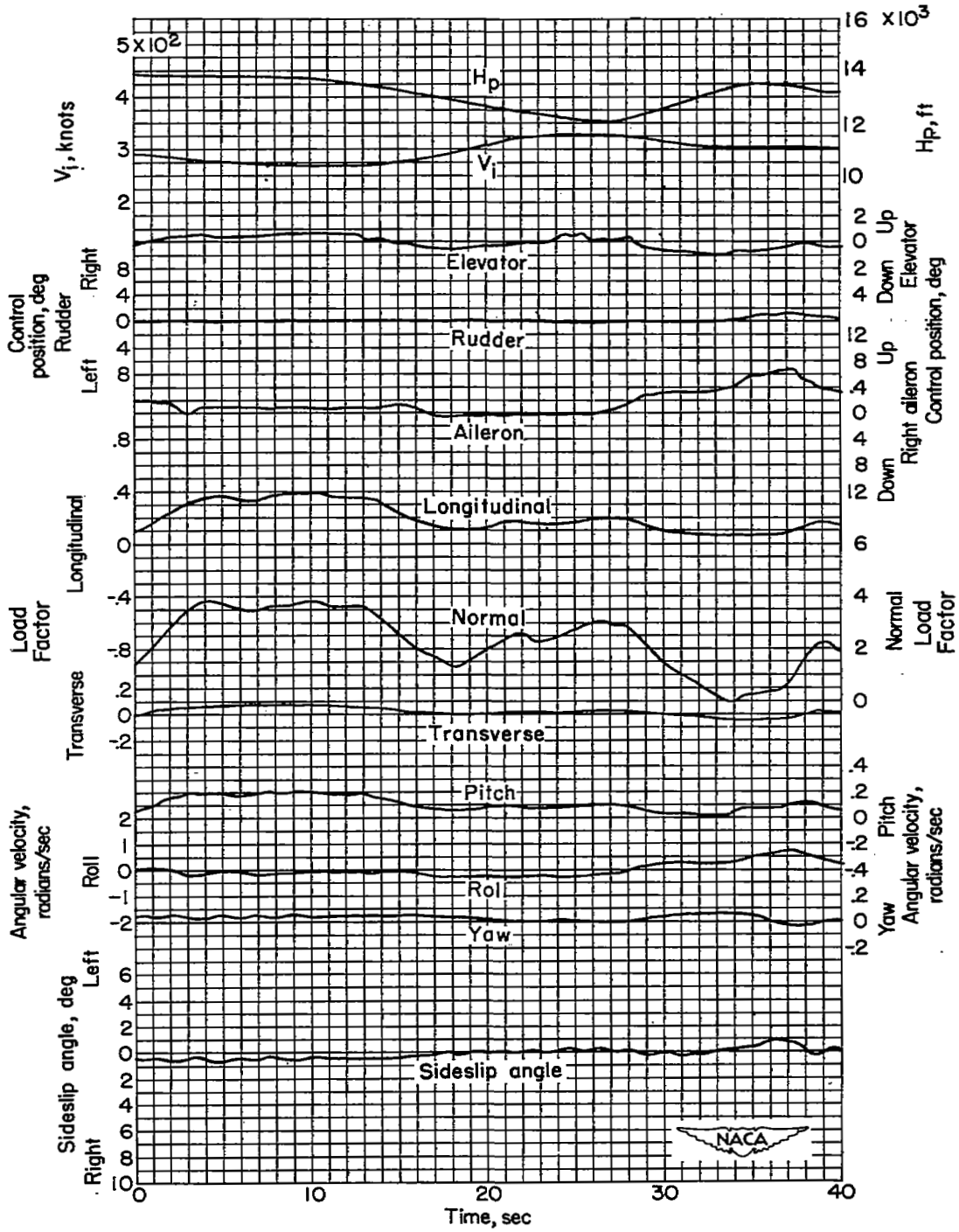

Figure 208.- Right barrel roll followed by dive with rolling pull-out; airplane weight, 15,210 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

[redacted]

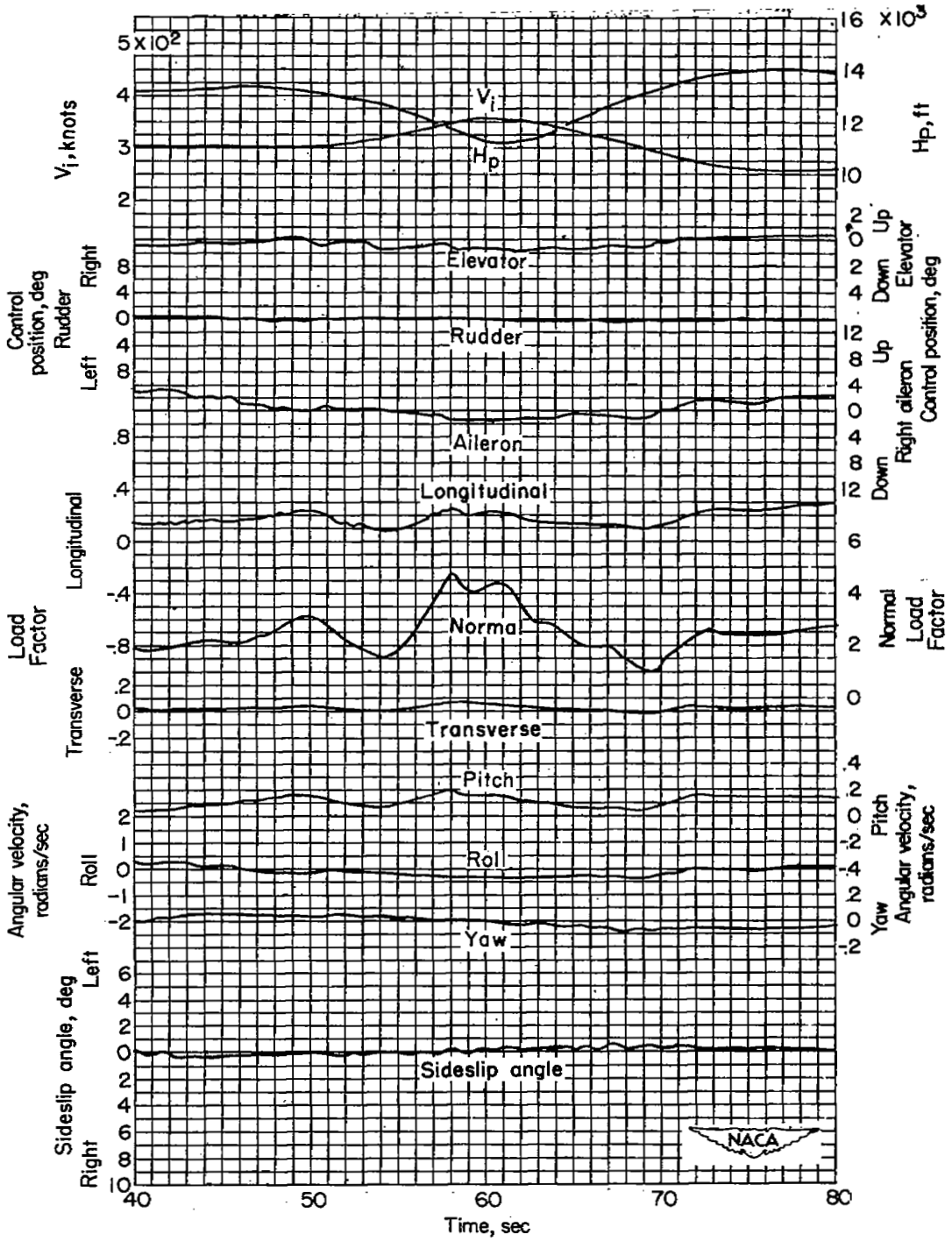

Figure 208.- Concluded.

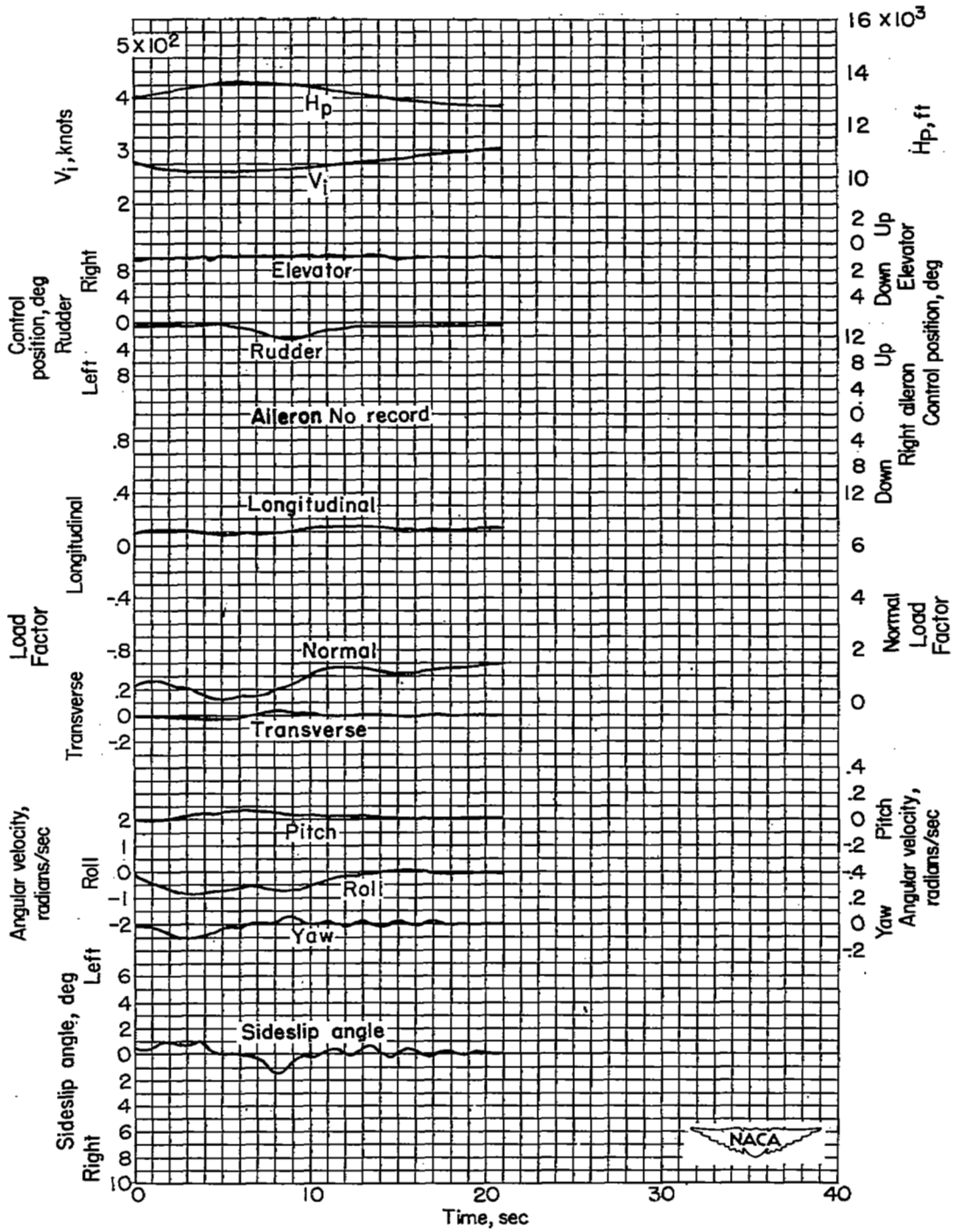

Figure 209.- Left barrel roll; airplane weight, 16,870 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

[redacted]

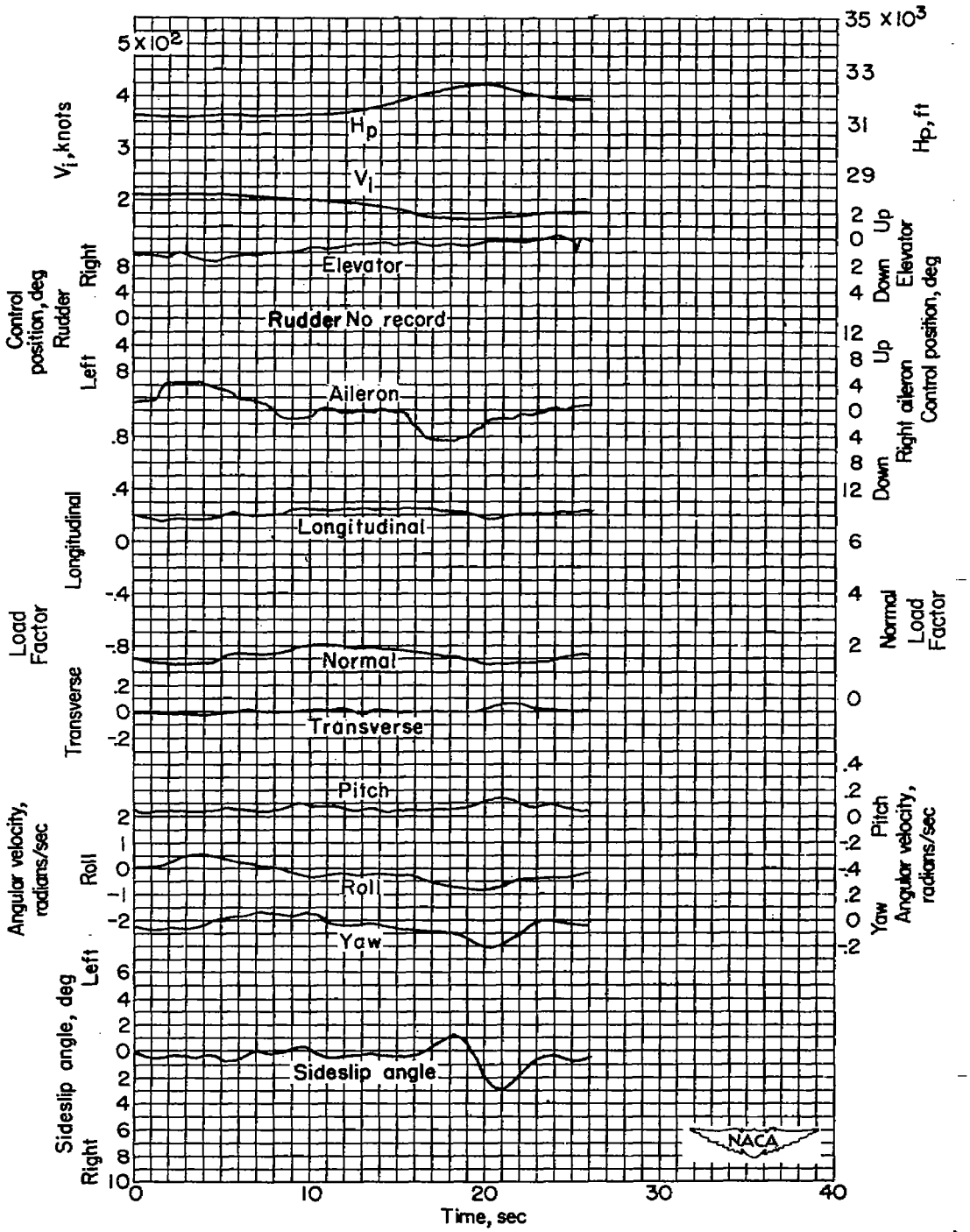

Figure 210.- Left barrel roll; airplane weight, 16,170 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

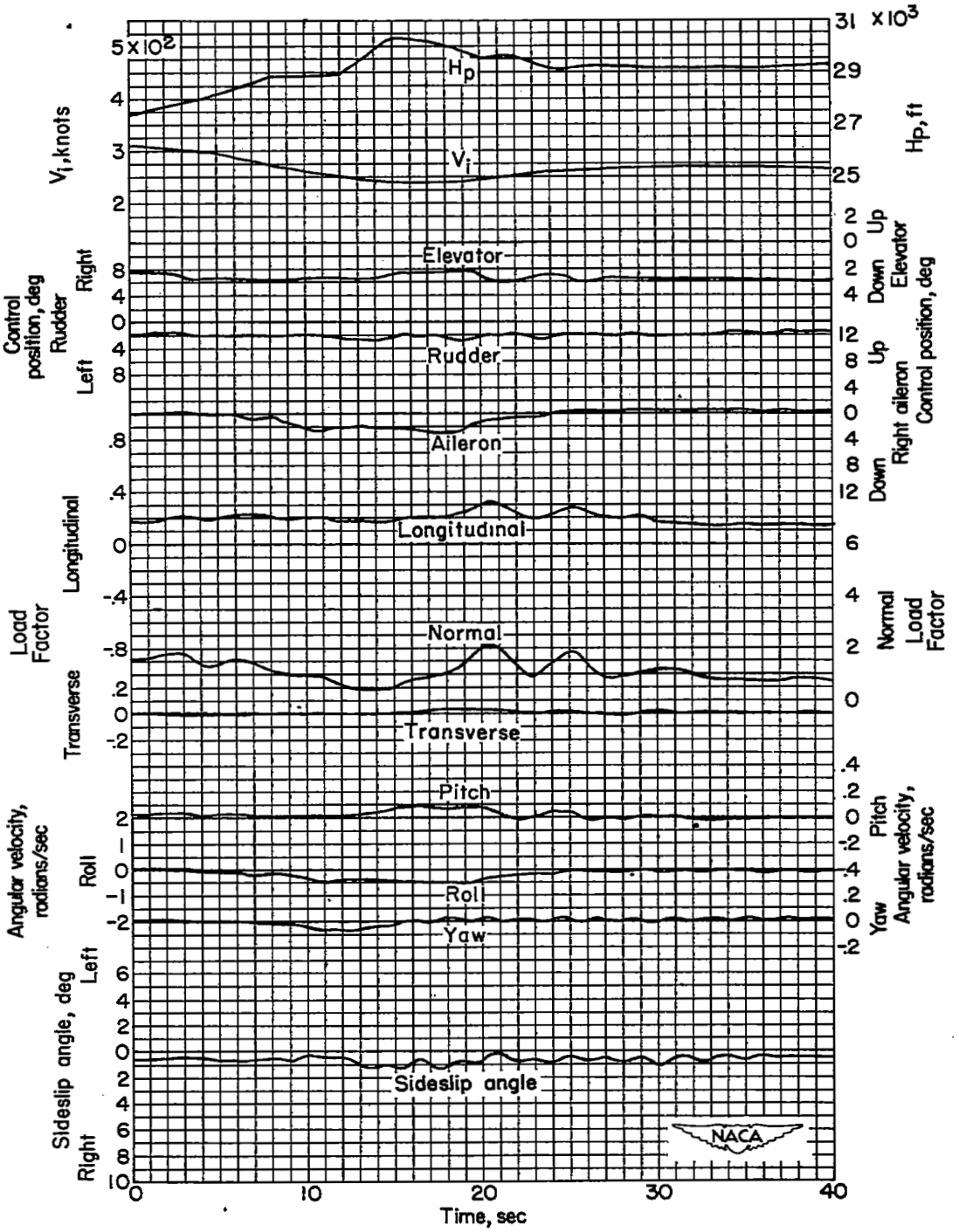

Figure 211.- Left barrel roll; airplane weight, 15,770 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

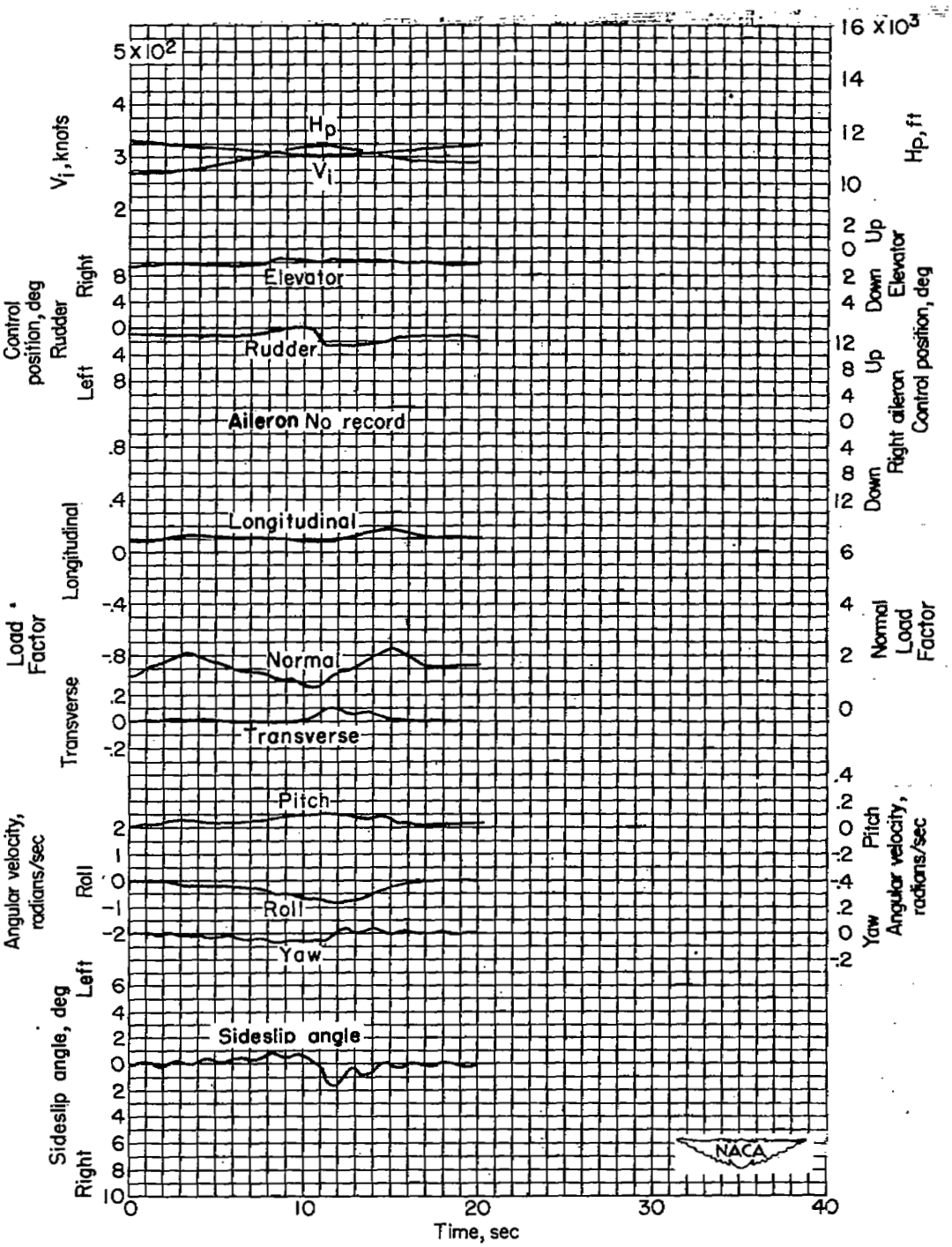

Figure 212.- Left barrel roll; airplane weight, 16,240 pounds; center-of gravity location, 26.5 percent of the mean aerodynamic chord.

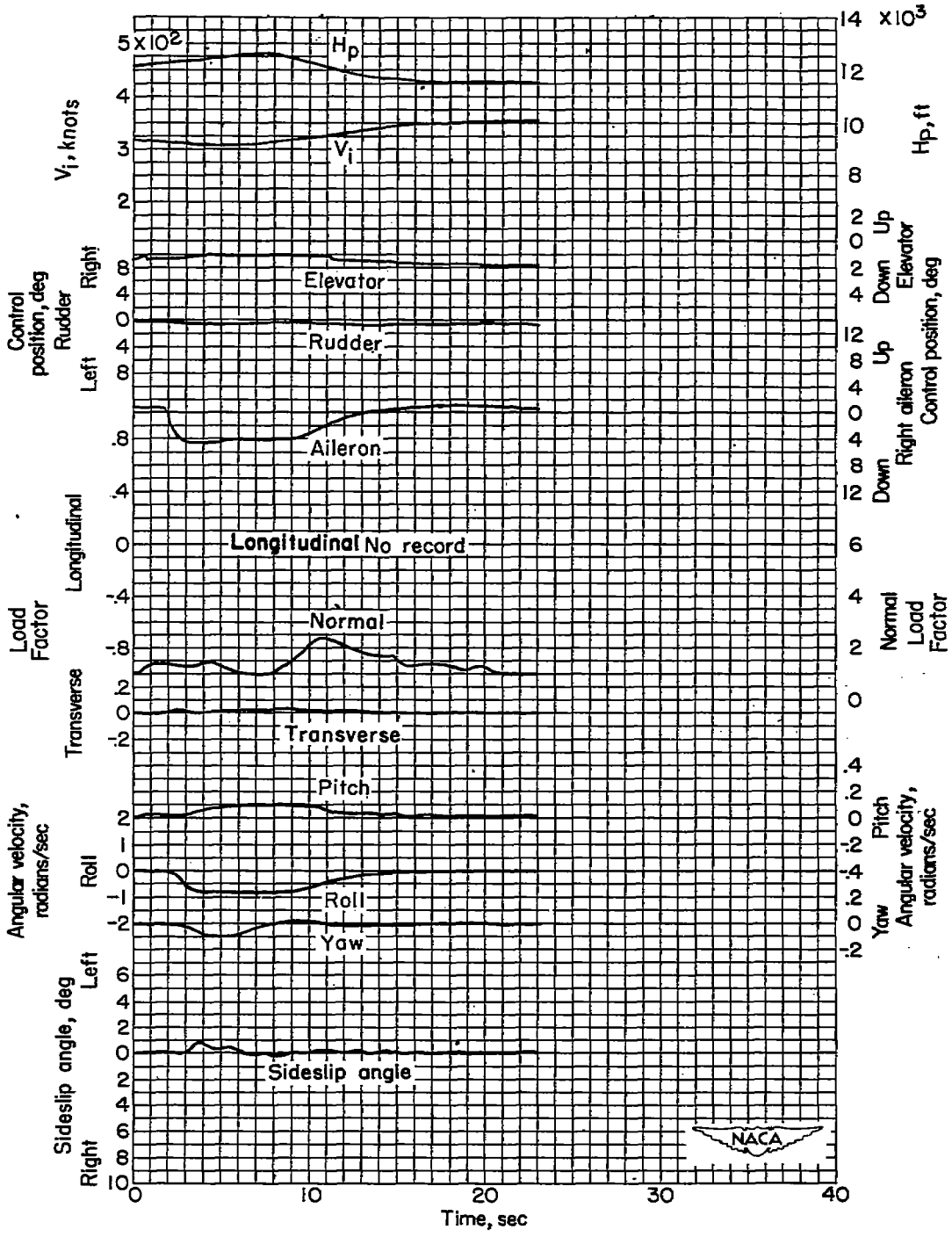

Figure 213.- Left barrel roll; airplane weight, 14,900 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

[redacted]

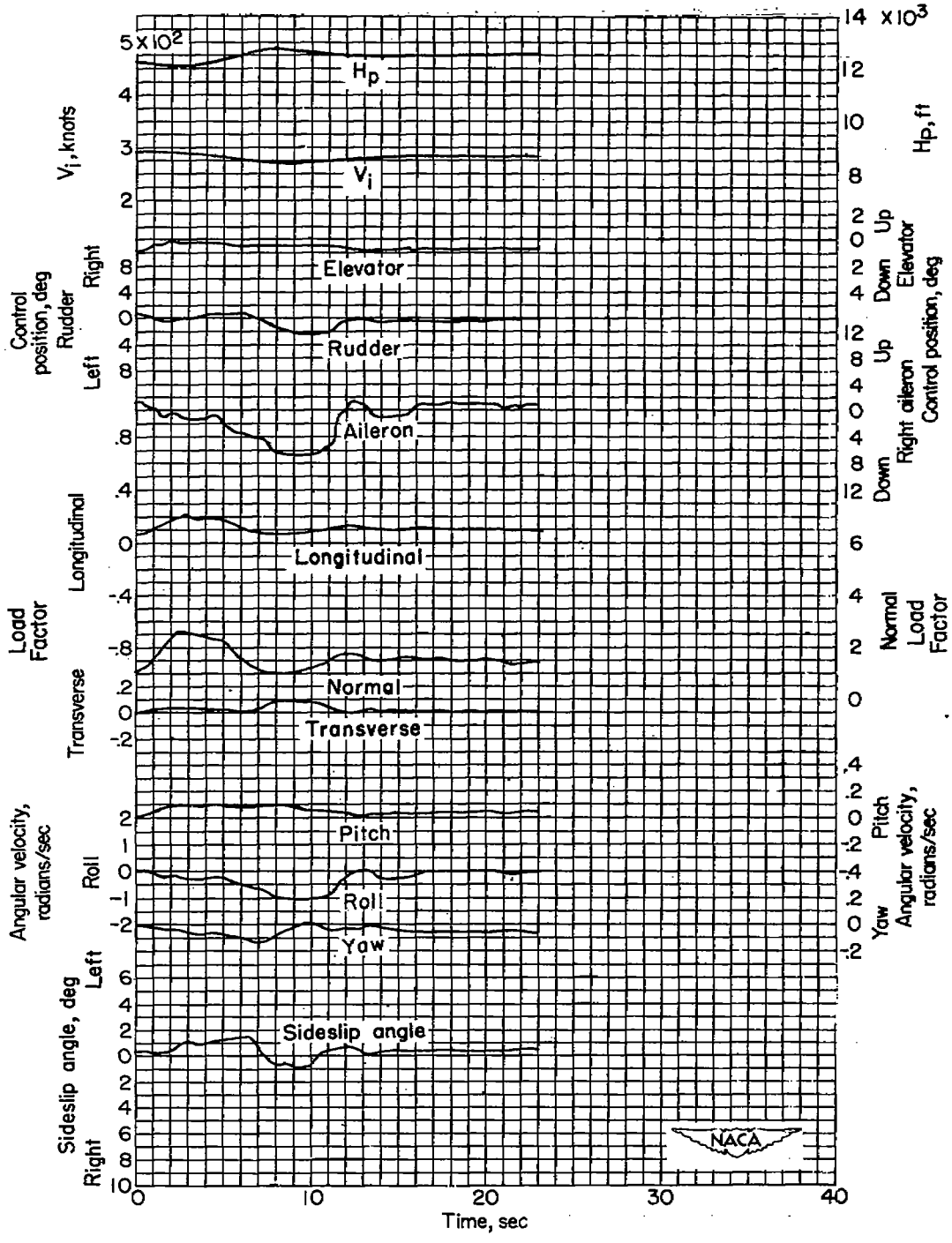

Figure 214.- Left barrel roll; airplane weight, 16,780 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

2F

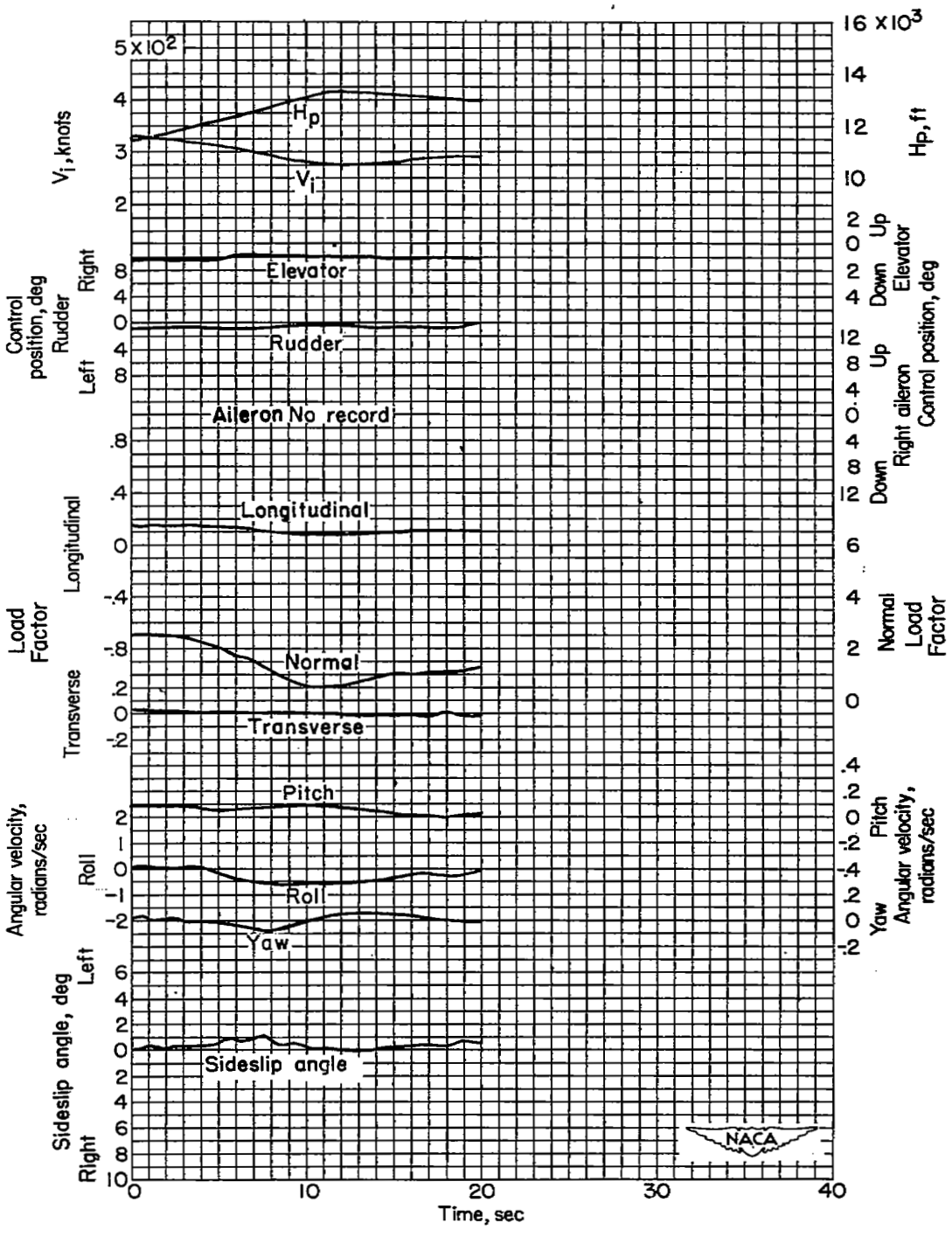

Figure 215.- Left barrel roll; airplane weight, 16,590 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

[redacted]

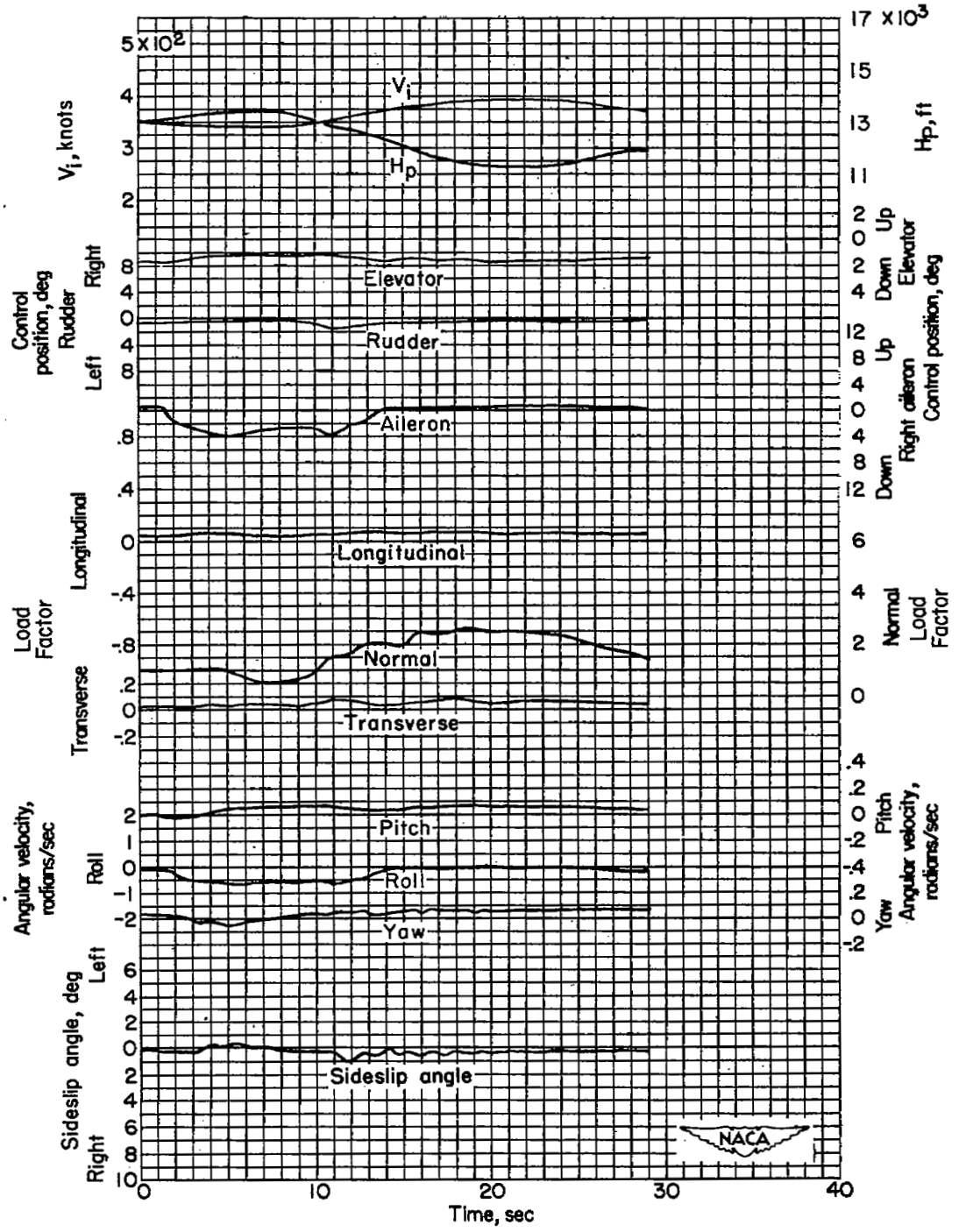

Figure 216.- Left barrel roll; airplane weight, 16,840 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

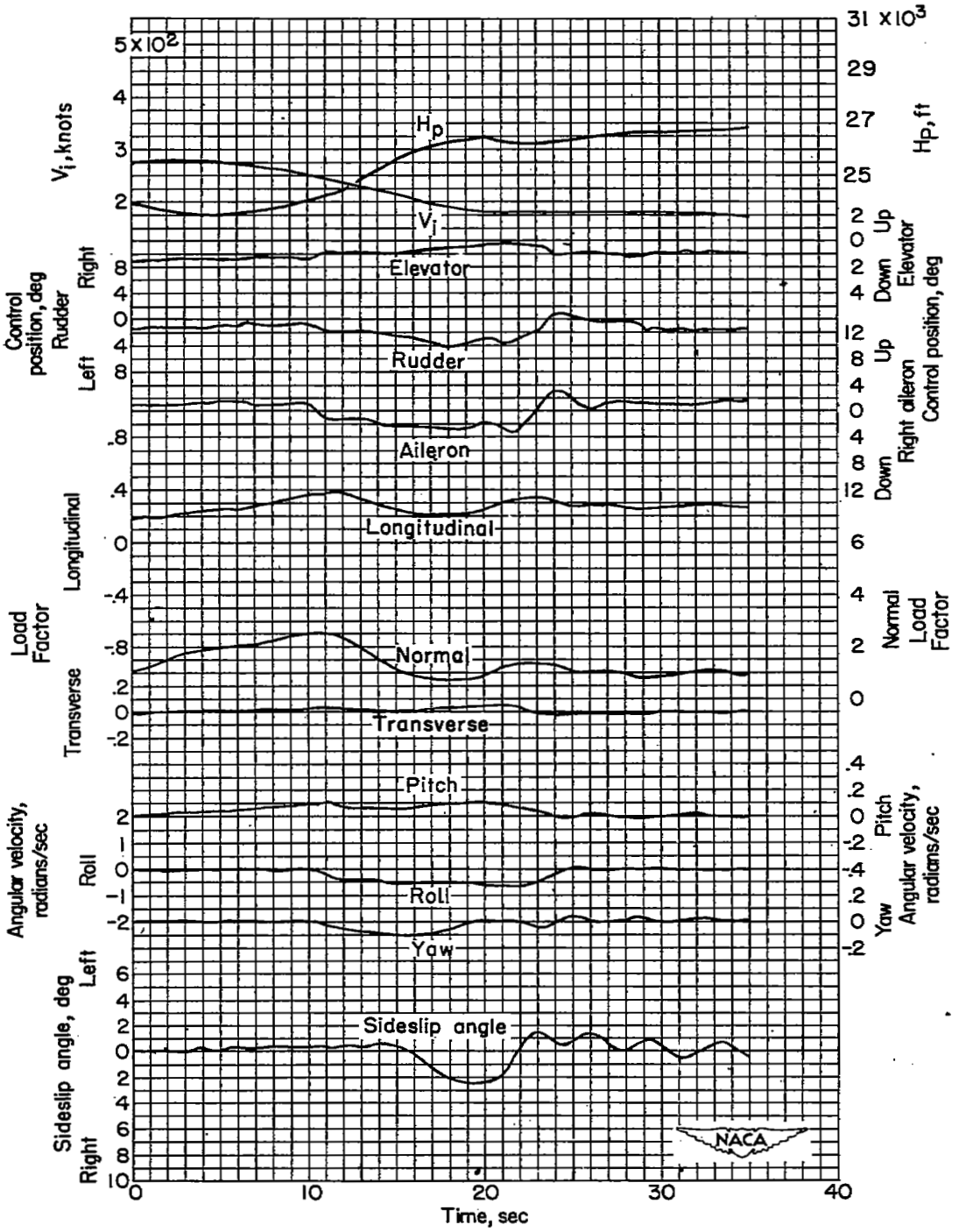

Figure 217.- Left barrel roll; airplane weight, 17,810 pounds; center-of-gravity location, 26.8 percent of the mean aerodynamic chord.

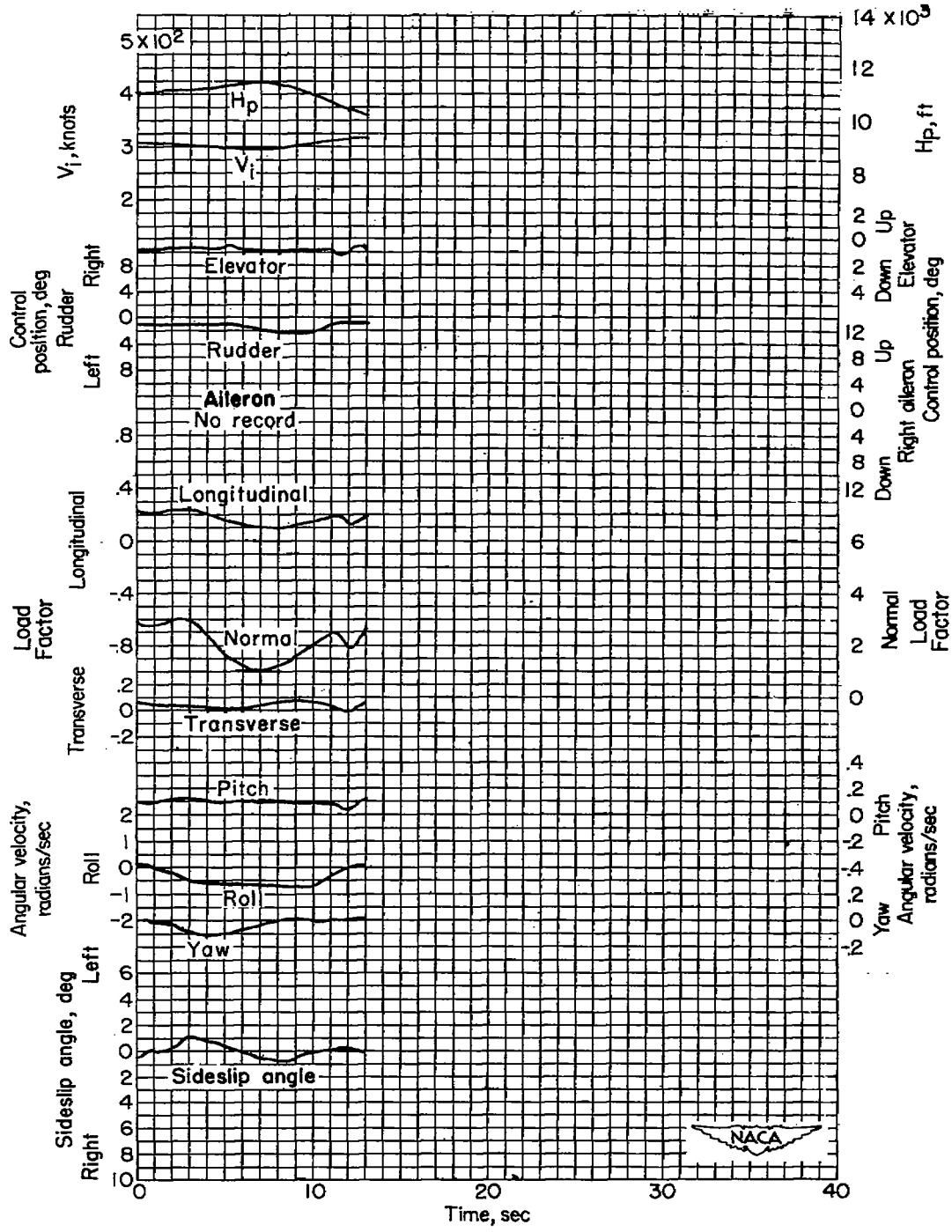

Figure 218.- Left barrel roll; airplane weight, 16,280 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

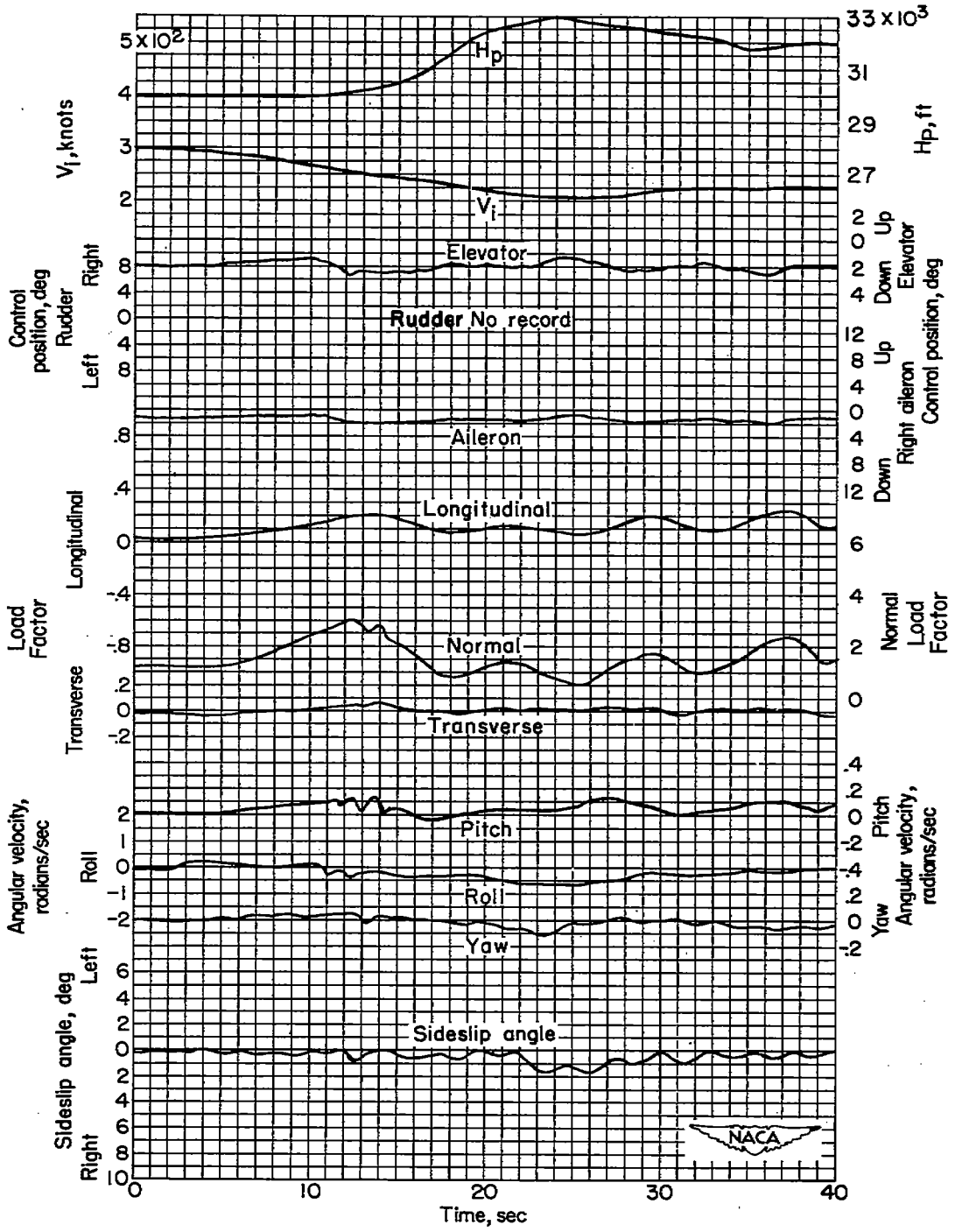

Figure 219.- Left barrel roll; airplane weight, 15,410 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

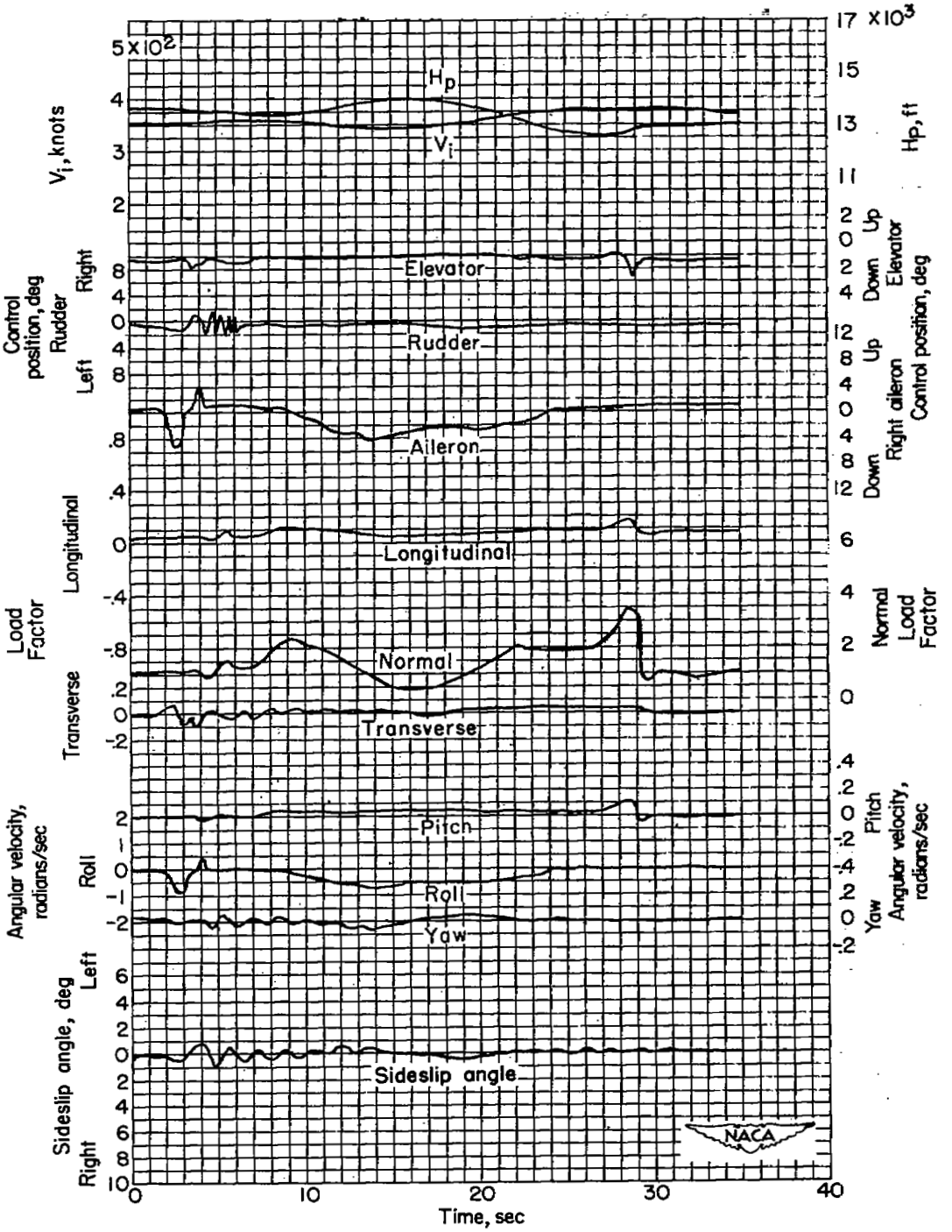

Figure 220.- Left barrel roll; airplane weight, 16,770 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

[redacted]

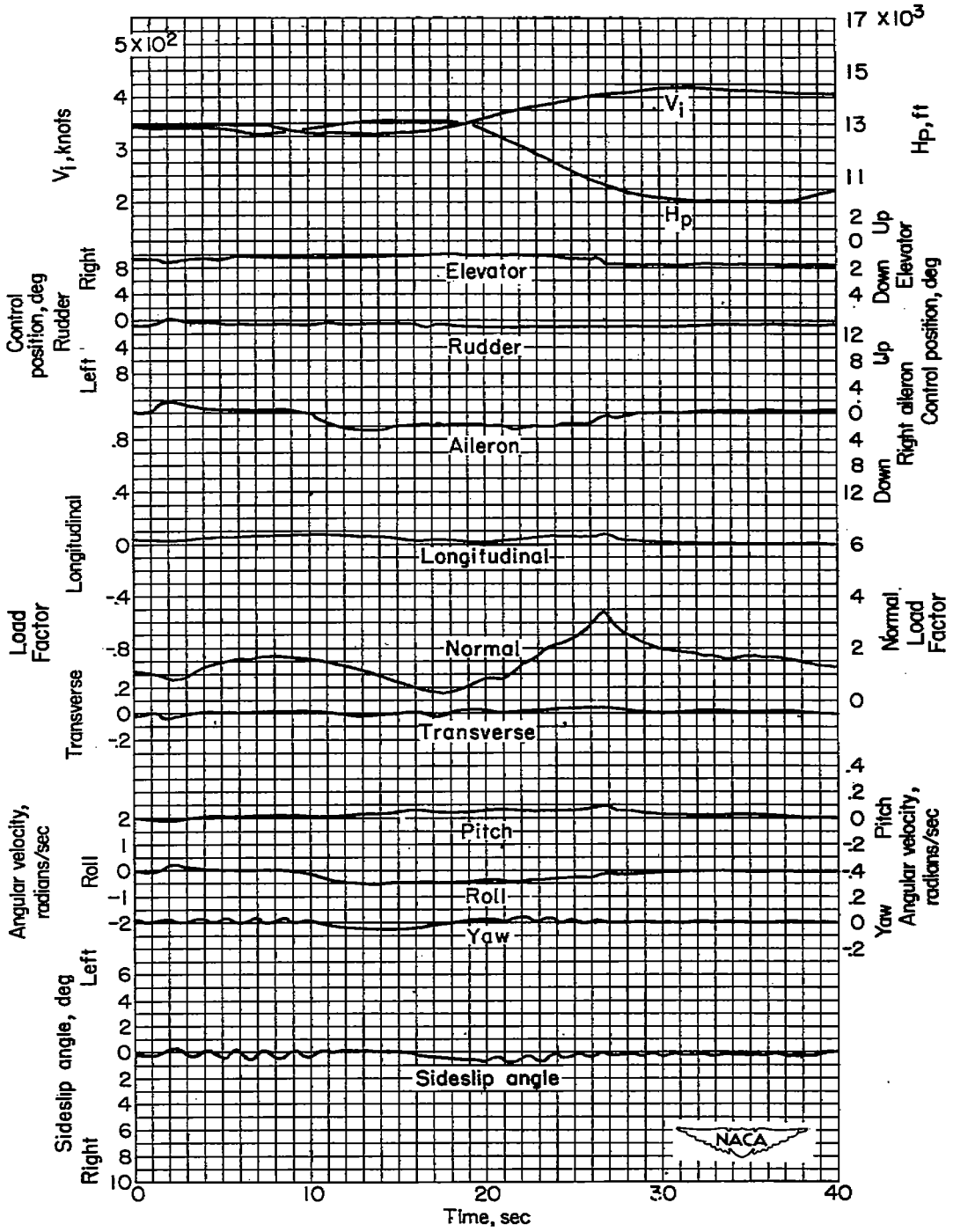

Figure 221.- Left barrel roll into a dive with normal recovery; airplane weight, 16,220 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

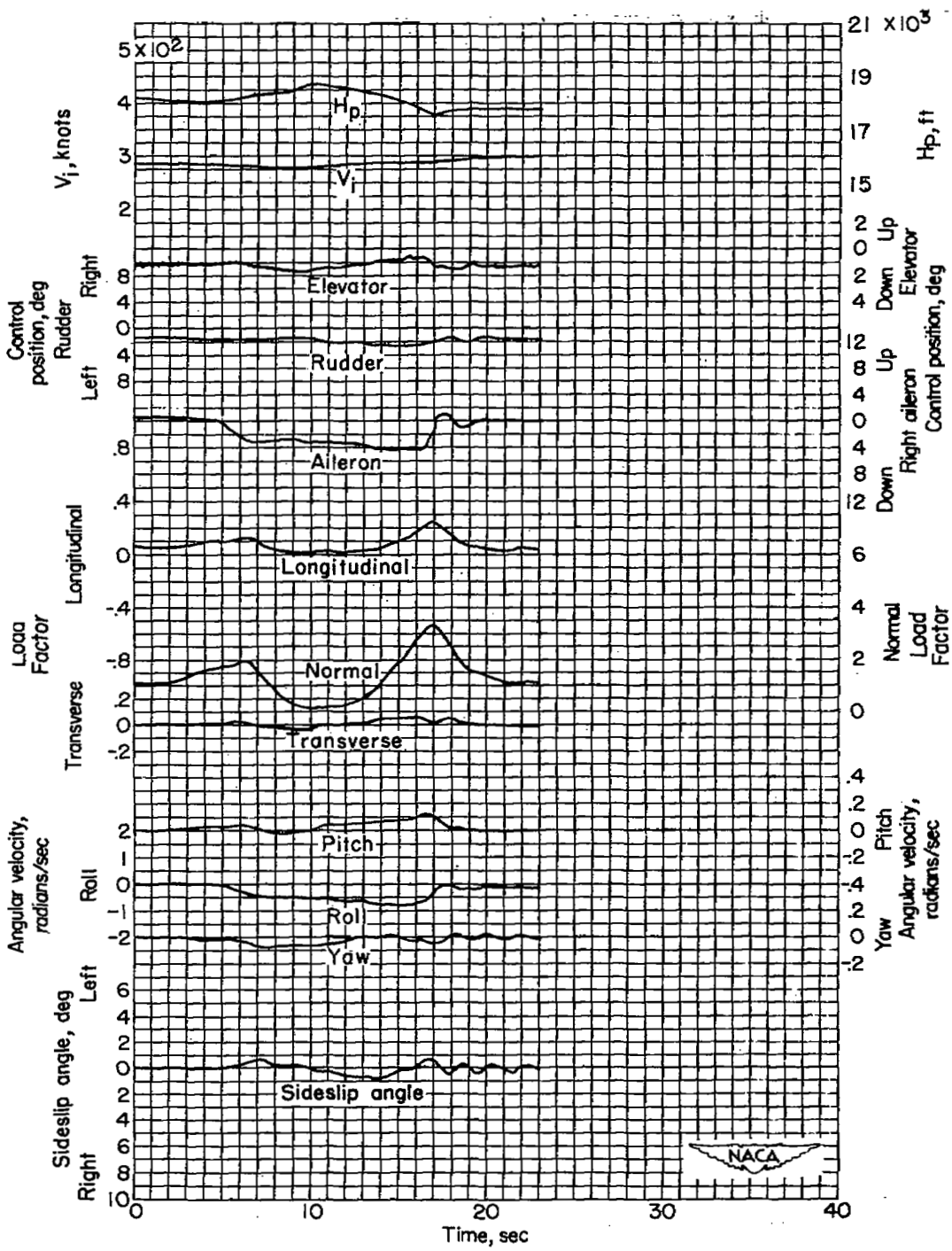

Figure 222.- Left barrel roll; airplane weight, 16,360 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

3F

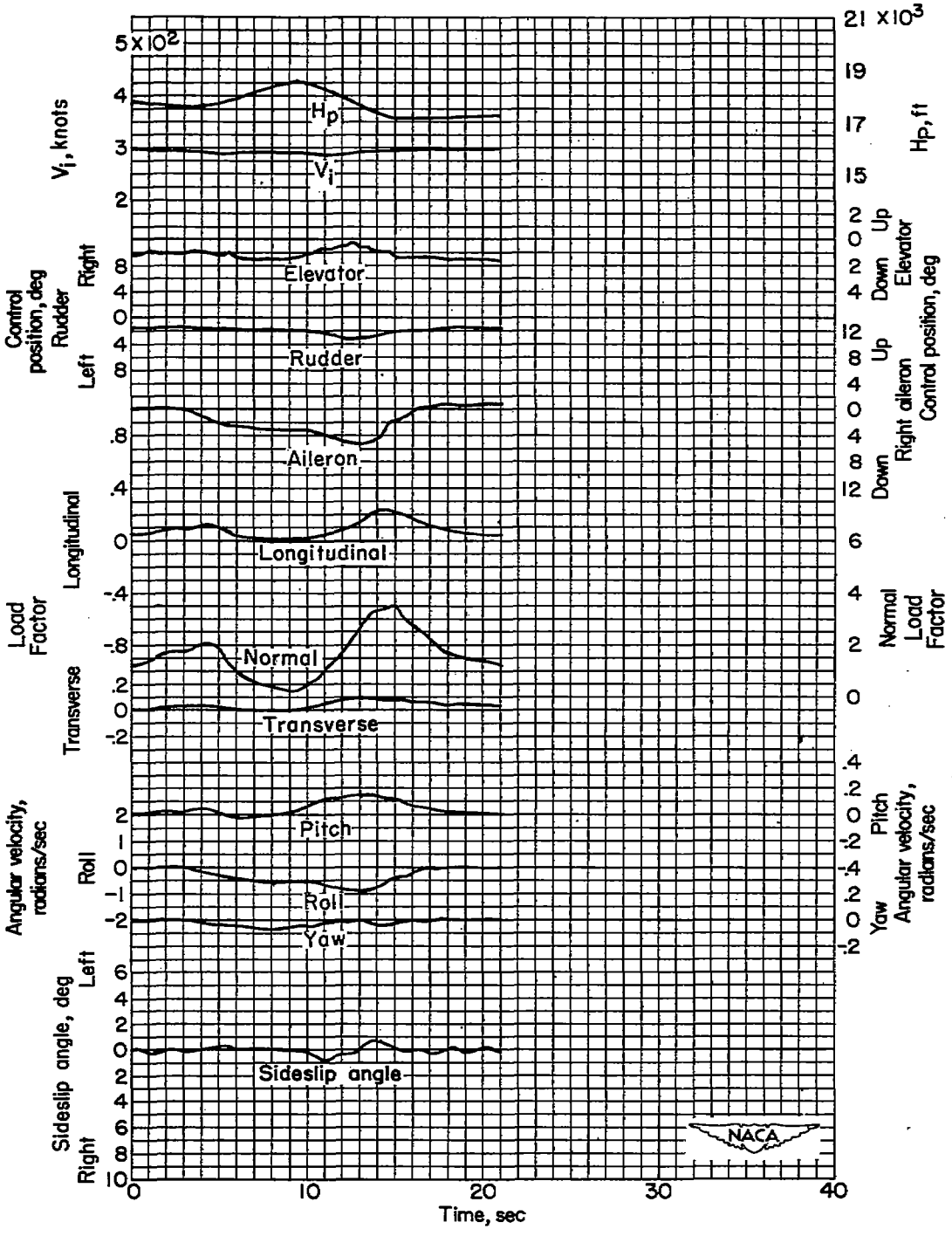

Figure 223.- Left barrel roll; airplane weight, 16,330 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

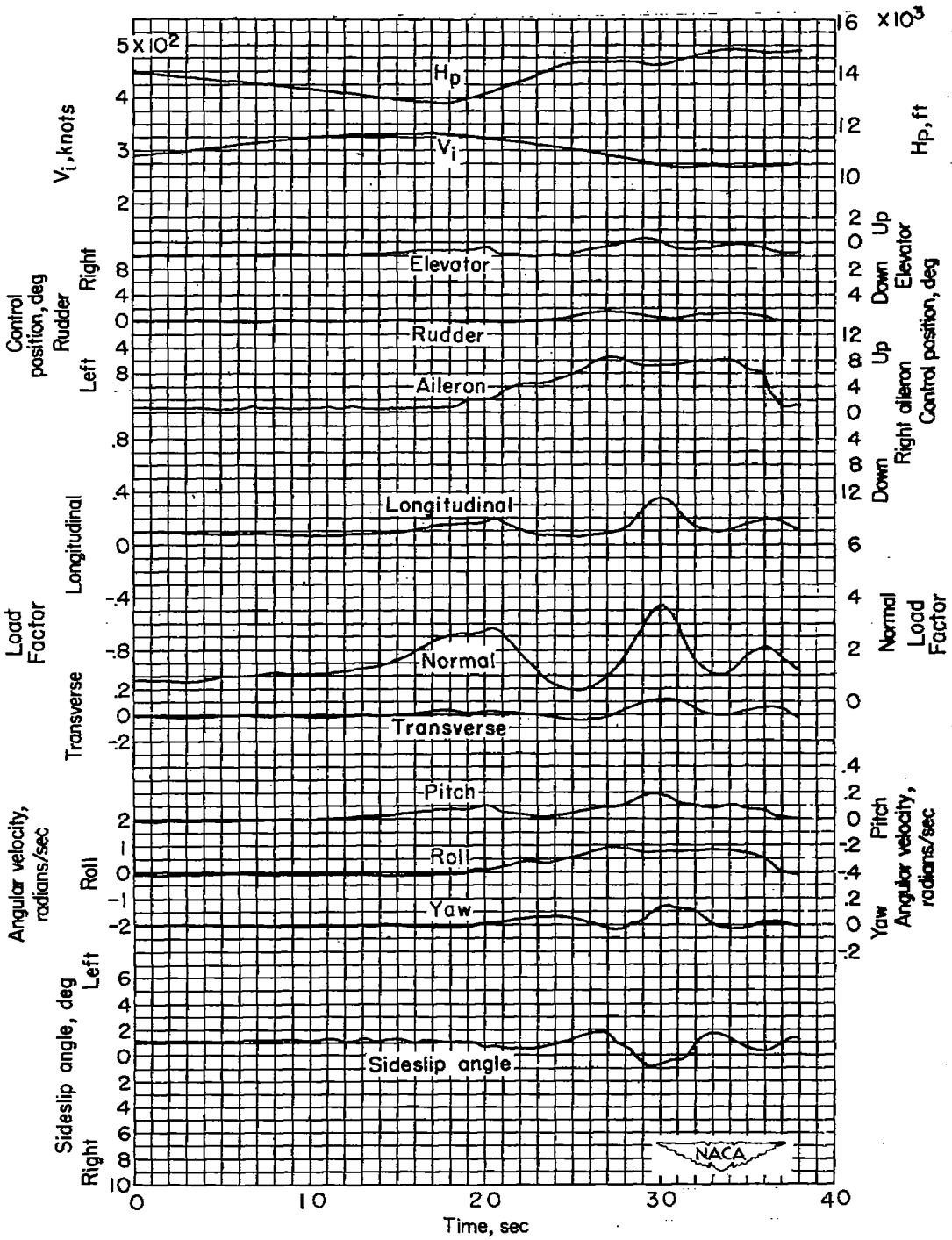

Figure 224.- Double right slow roll; airplane weight, 14,950 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

[redacted]

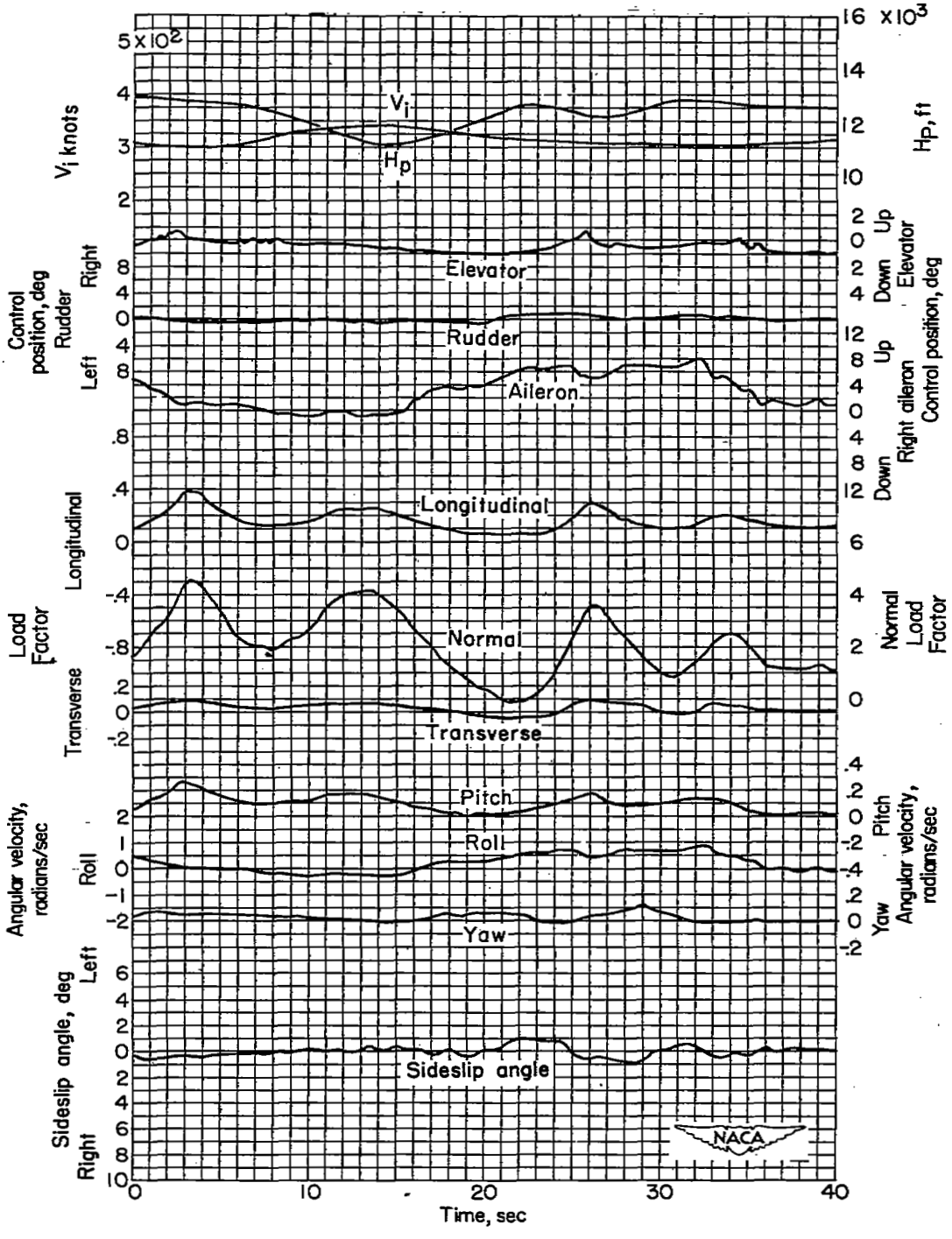

Figure 225.- Double right slow roll; airplane weight, 15,100 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

[redacted]

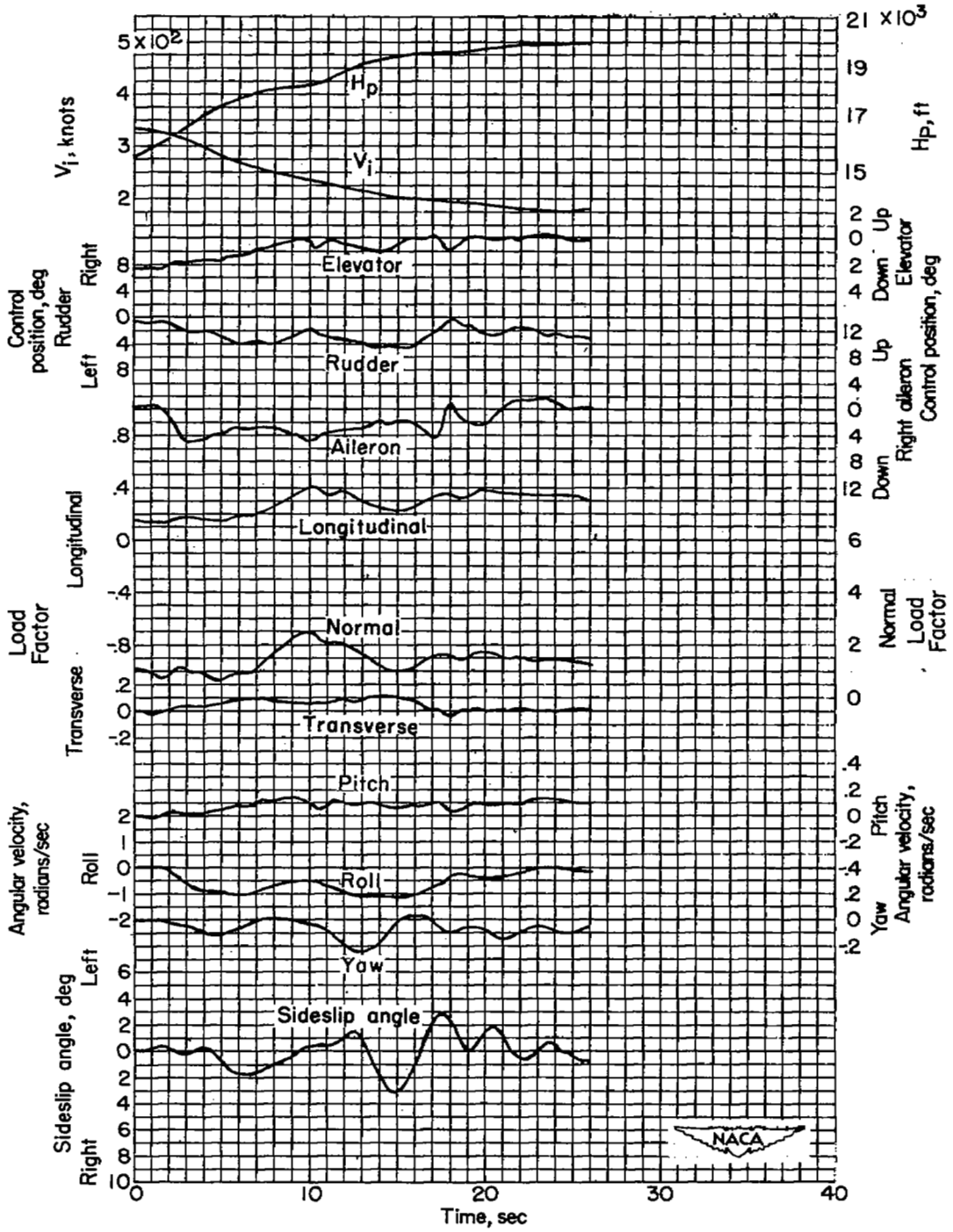

Figure 226.- Double left slow roll; airplane weight, 17,610 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

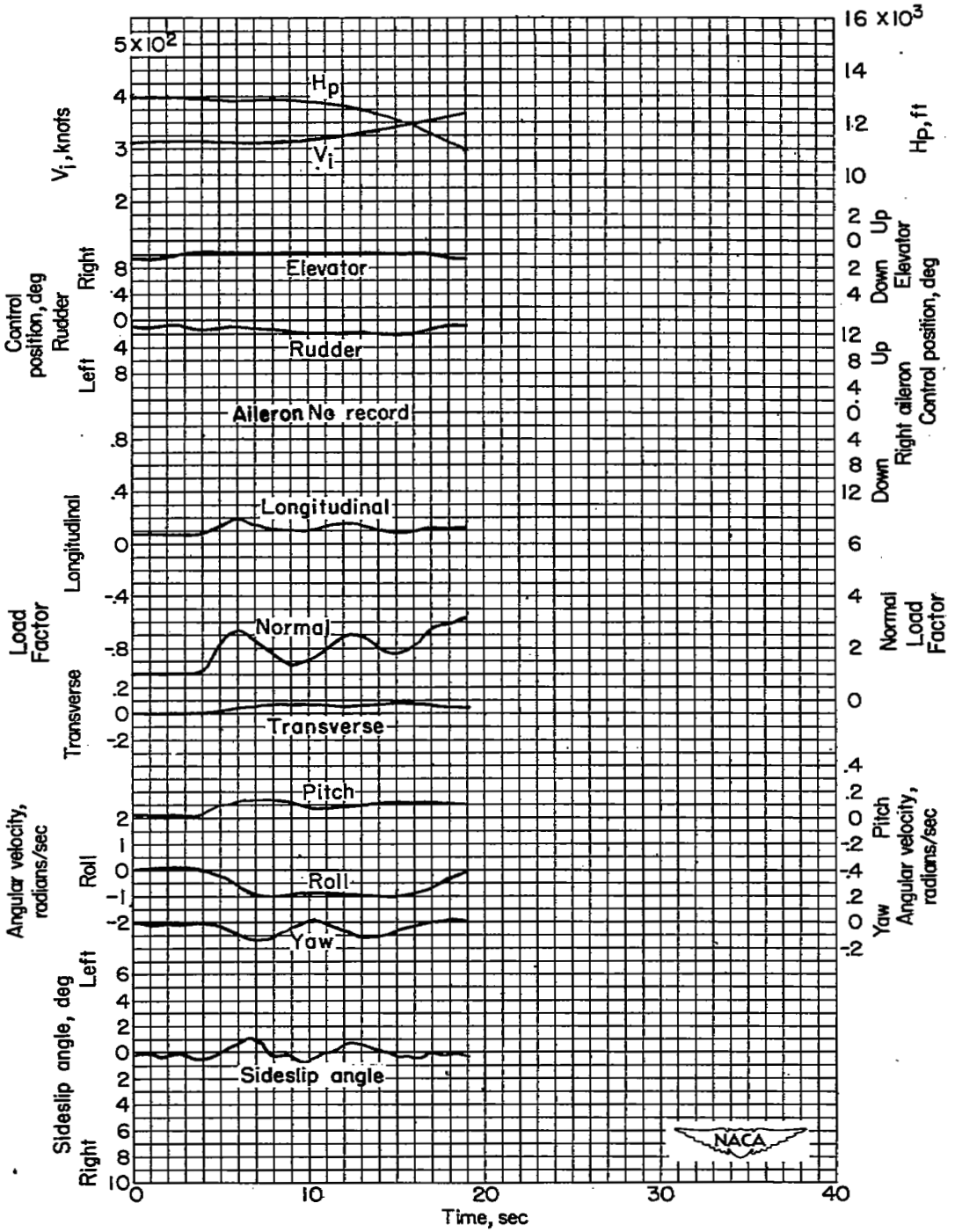

Figure 227.- Double left slow roll; airplane weight, 16,150 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

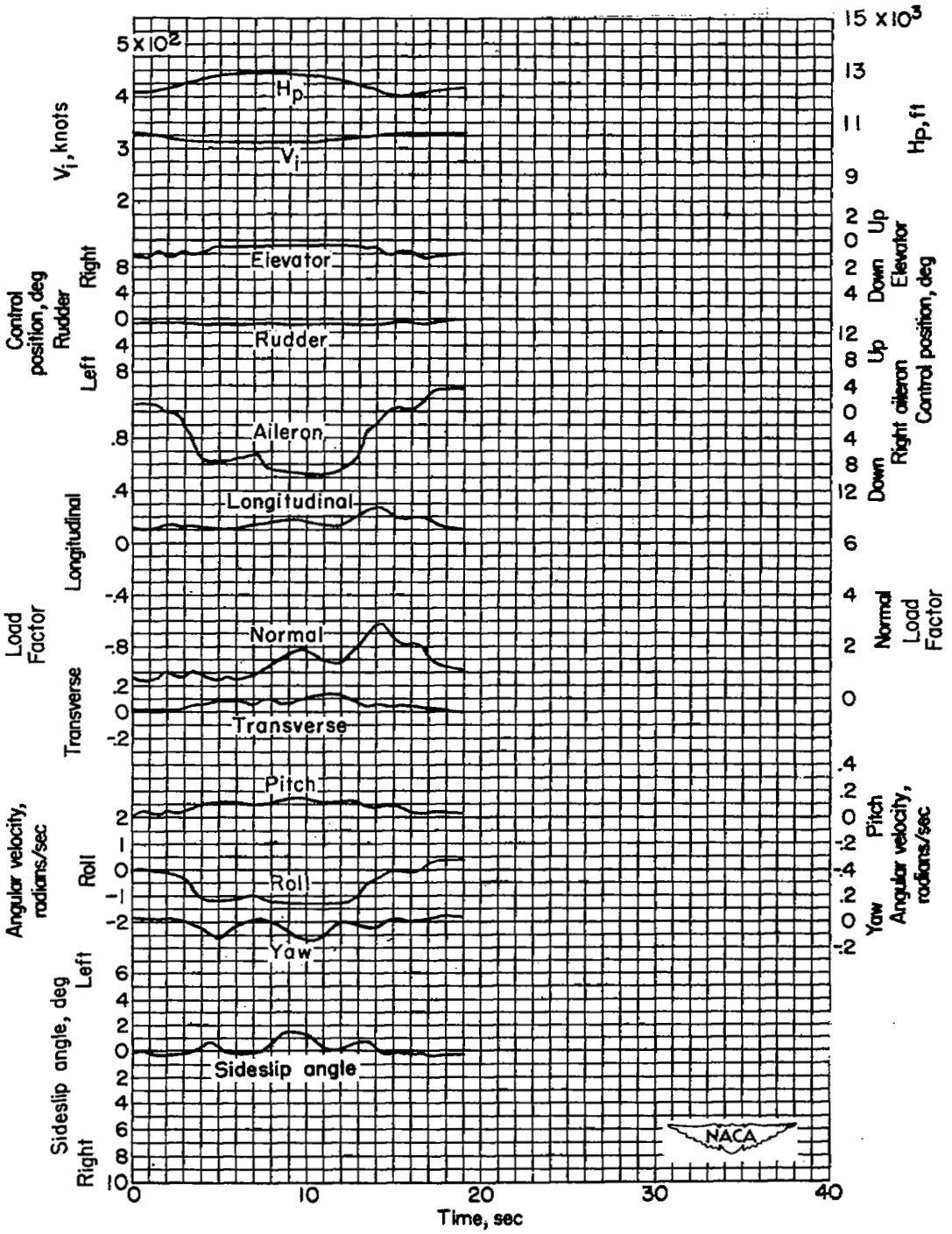

Figure 228.- Double left slow roll; airplane weight, 17,020 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

[redacted]

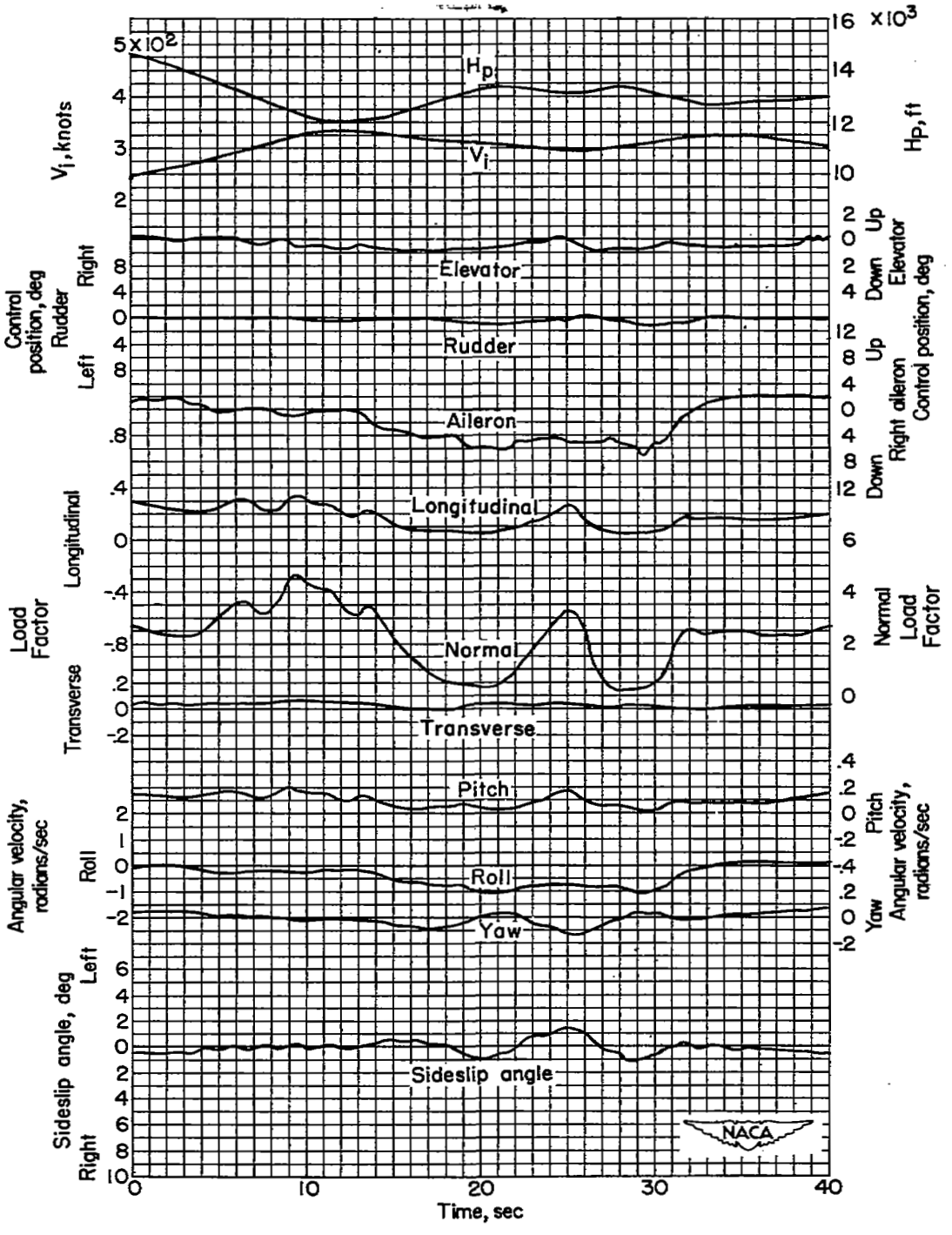

Figure 229.- Double left slow roll; airplane weight, 15,130 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

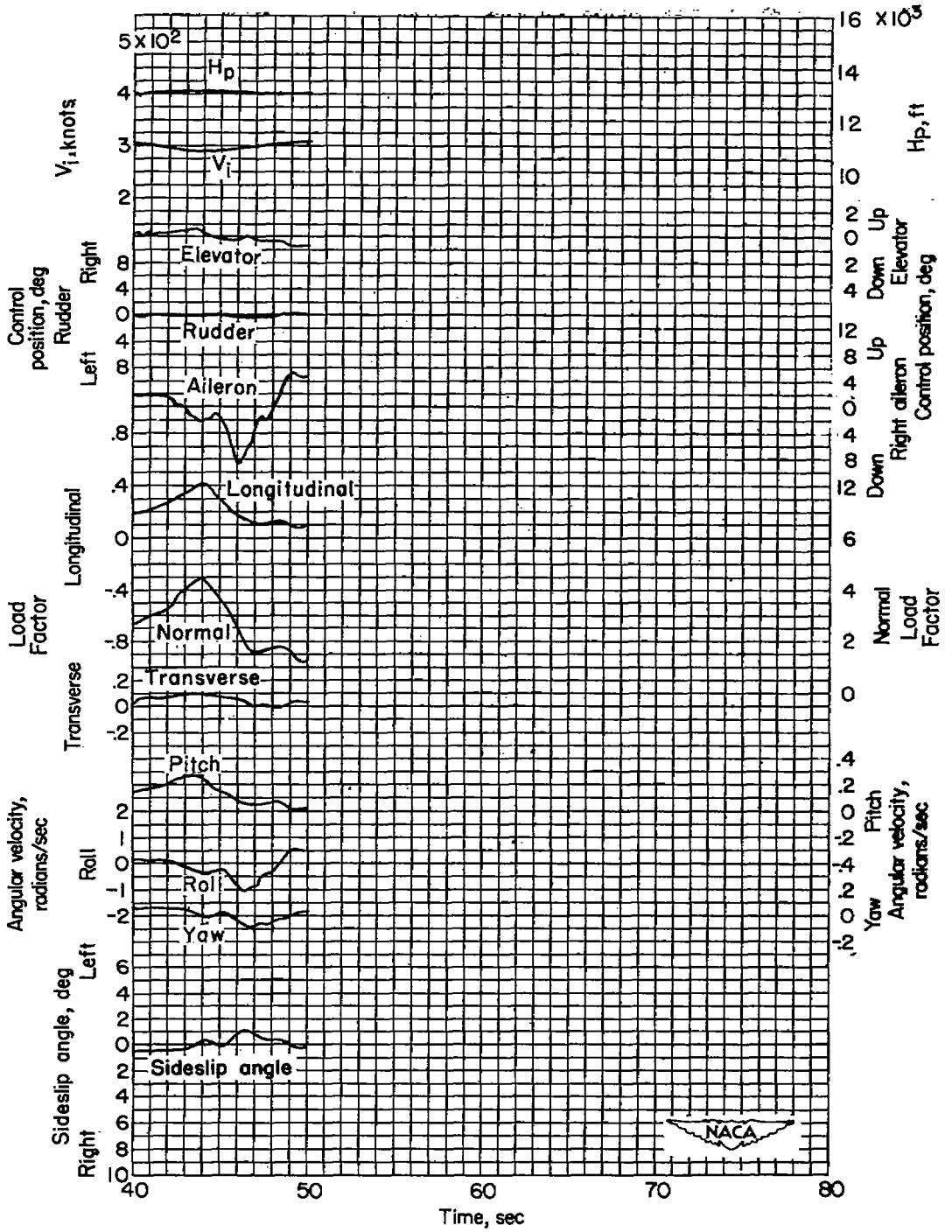

Figure 229.- Concluded.

4F

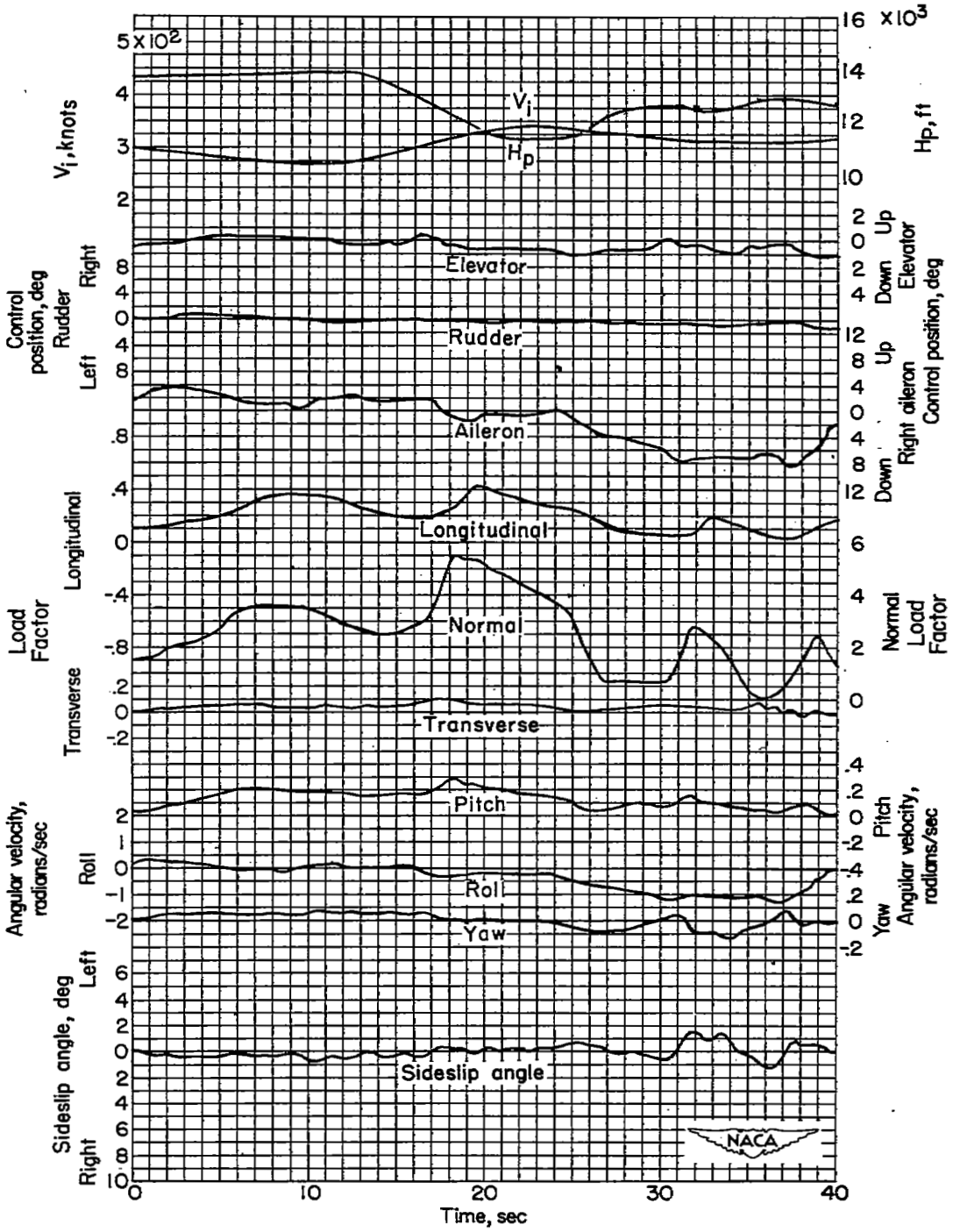

Figure 230.- Double left slow roll; airplane weight, 15,050 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

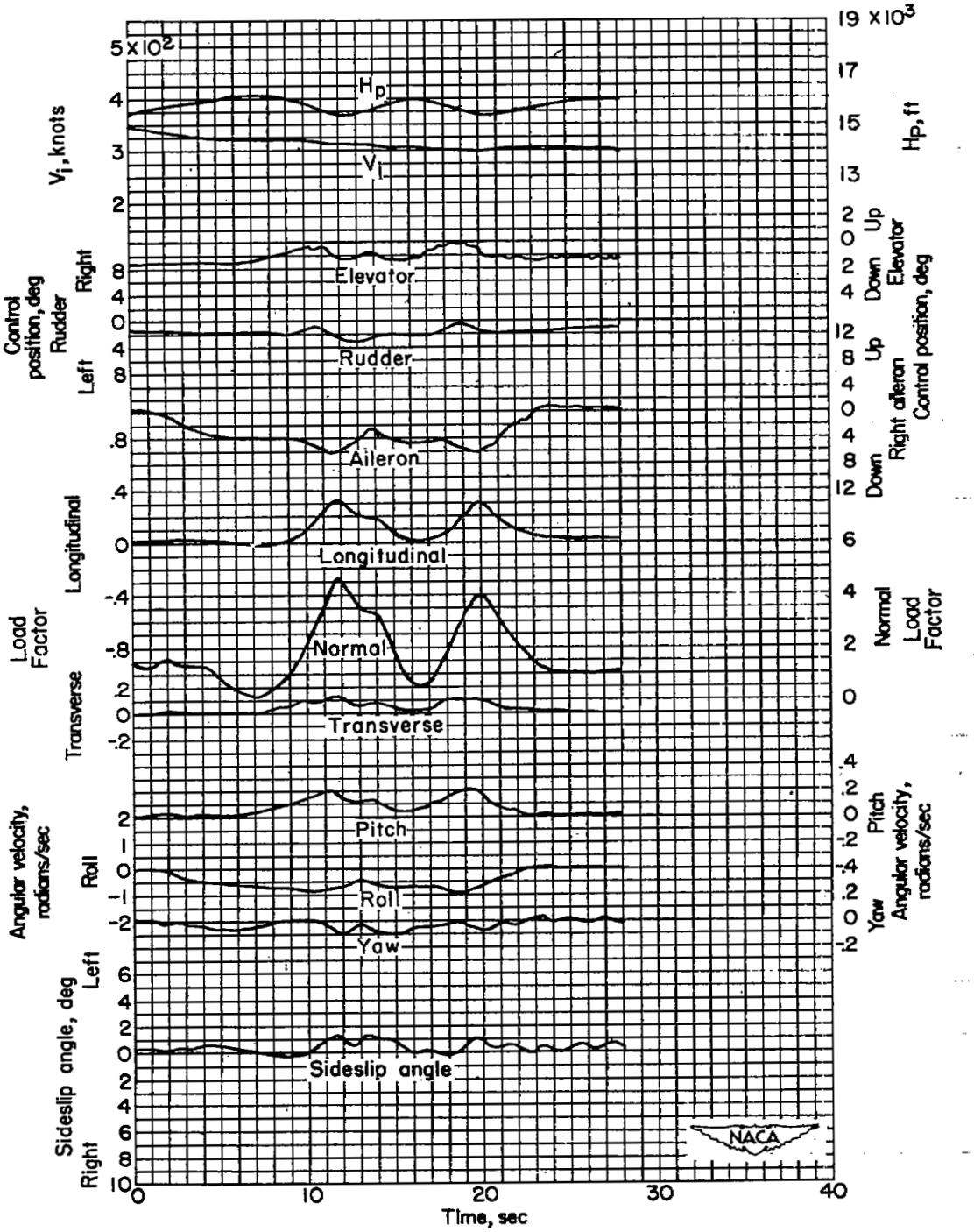

Figure 231.- Double left barrel roll; airplane weight, 16,230 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

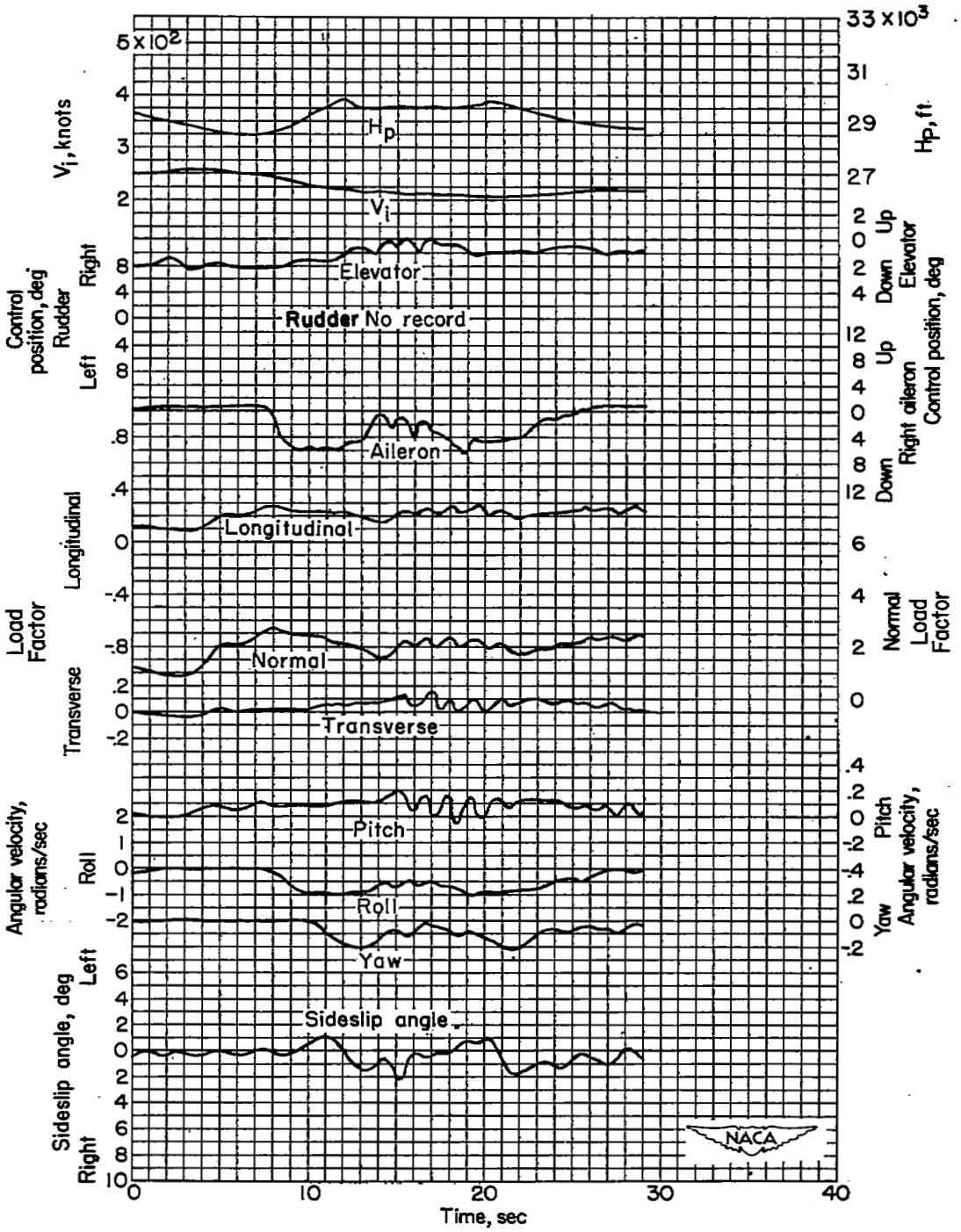

Figure 232.- Two left slow rolls; airplane weight, 16,100 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

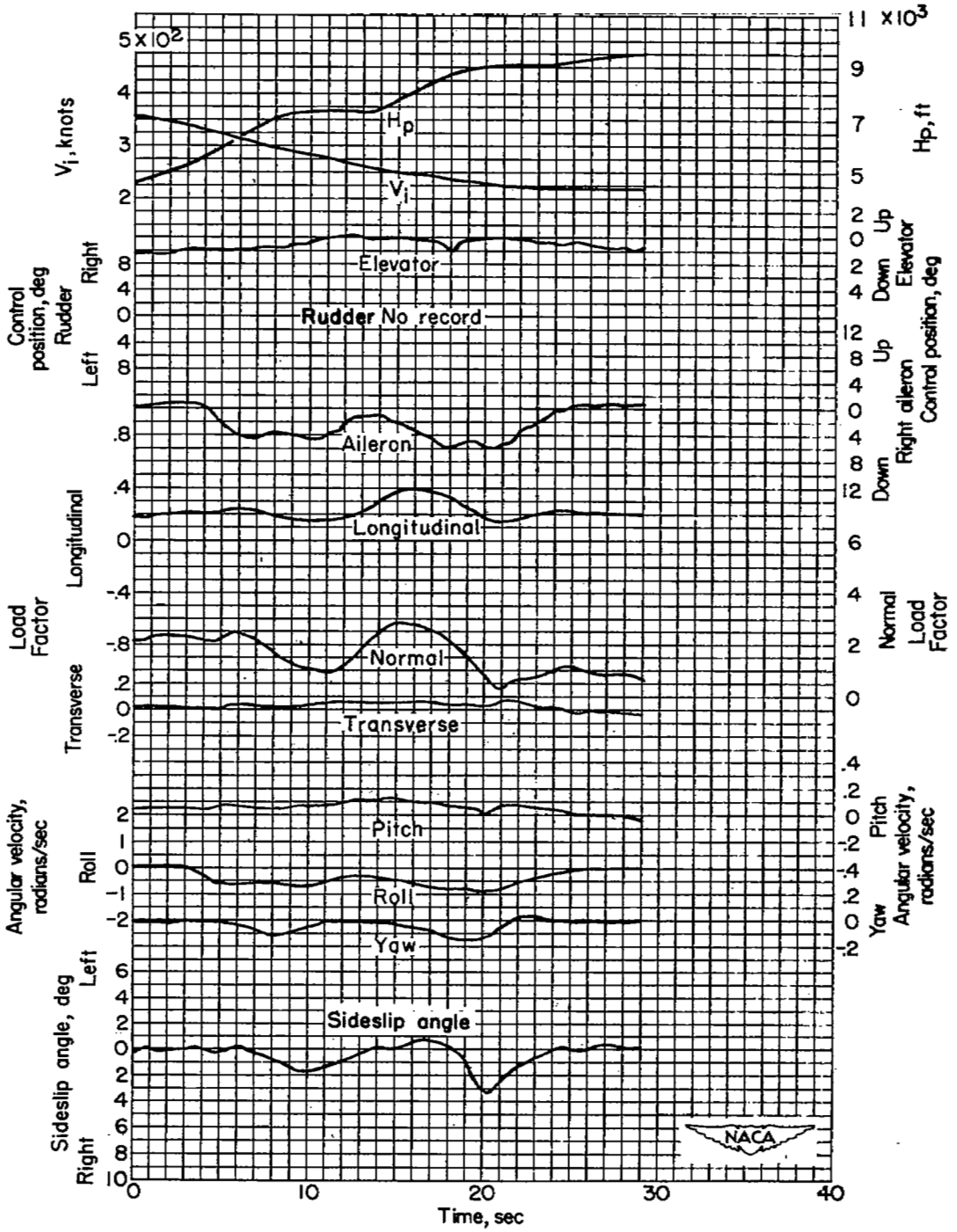

Figure 233.- Two left slow rolls; airplane weight, 17,760 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

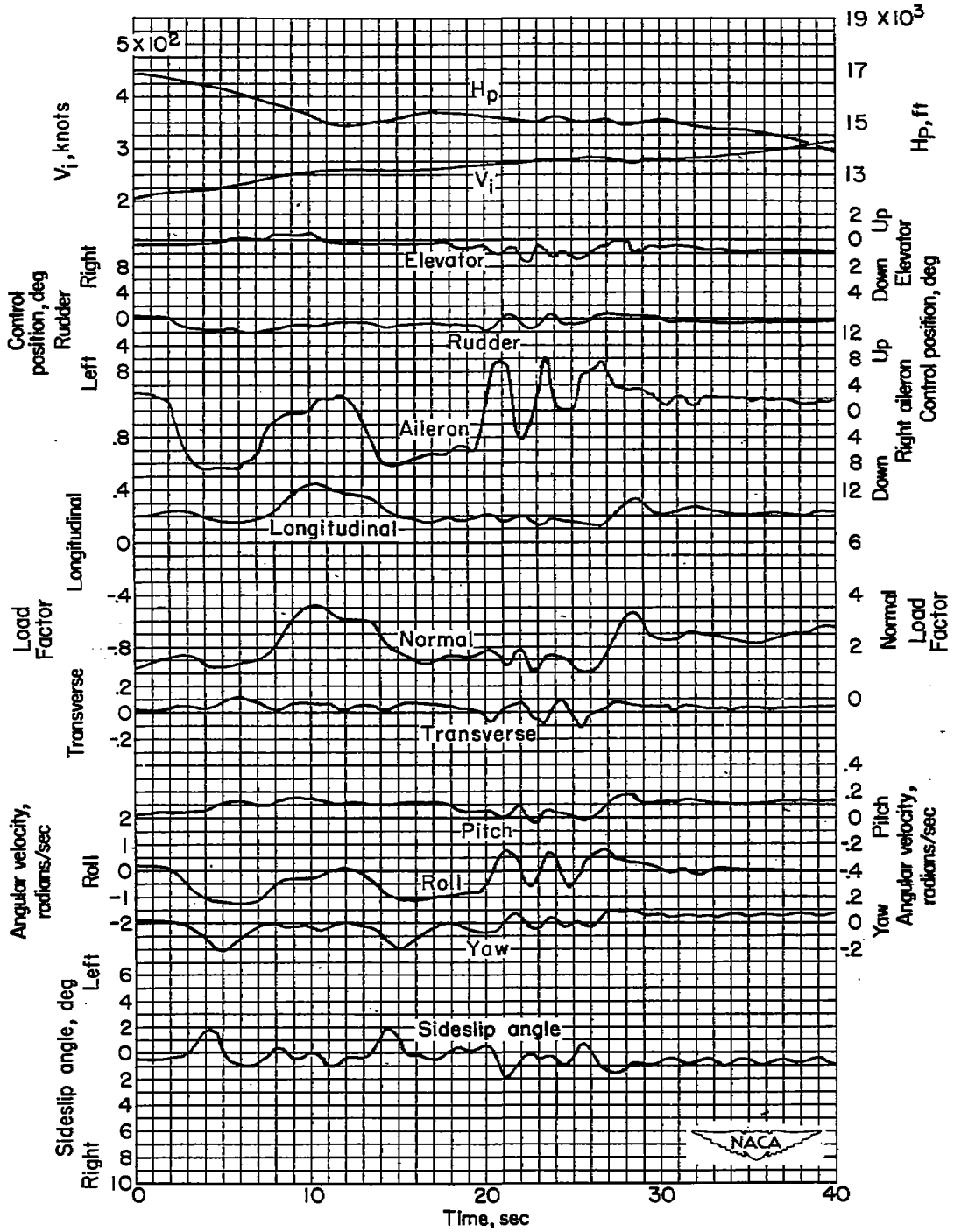

Figure 234.- Two left slow rolls followed by dive with gentle rolling pull-out; airplane weight, 16,900 feet; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

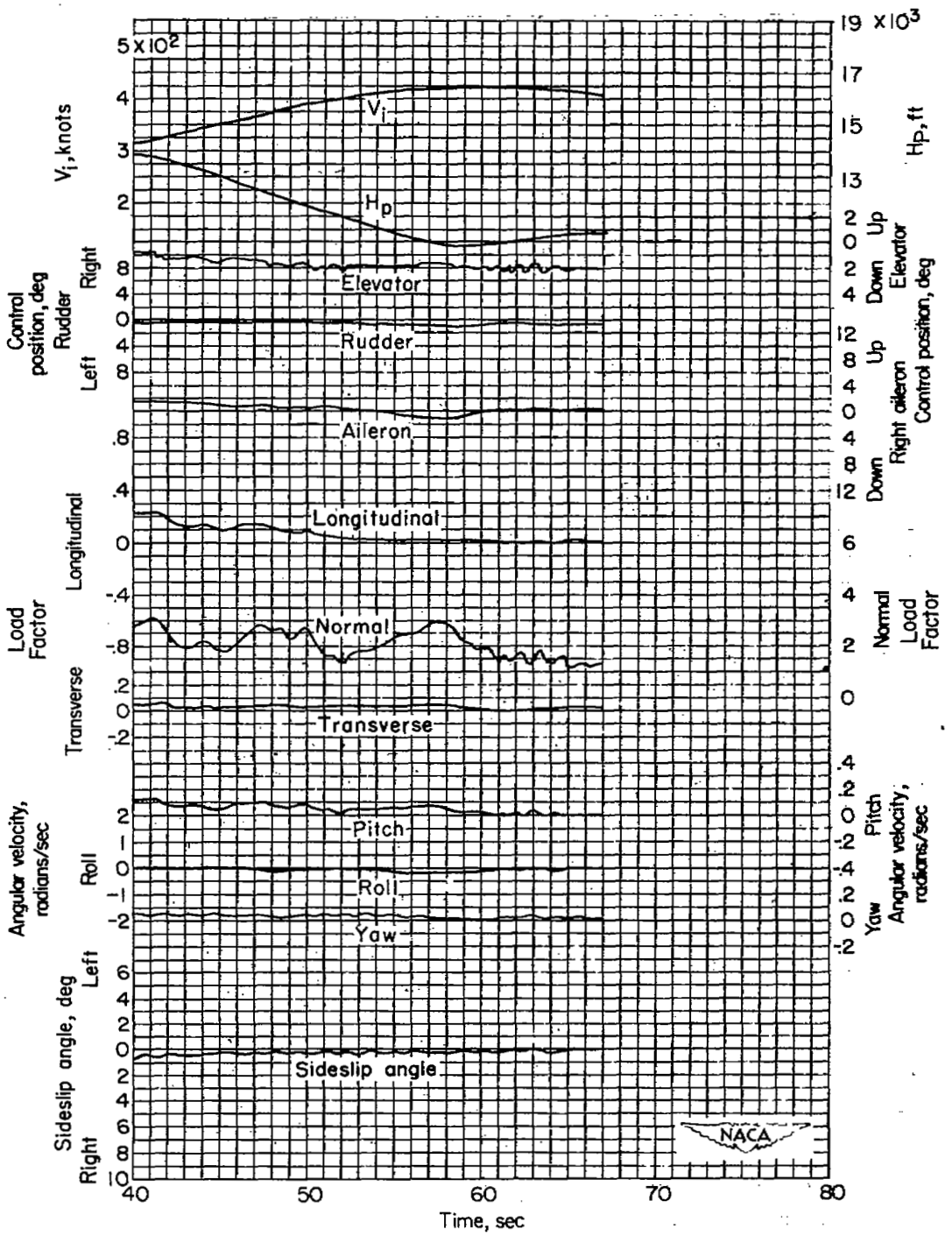

Figure 234.- Concluded.

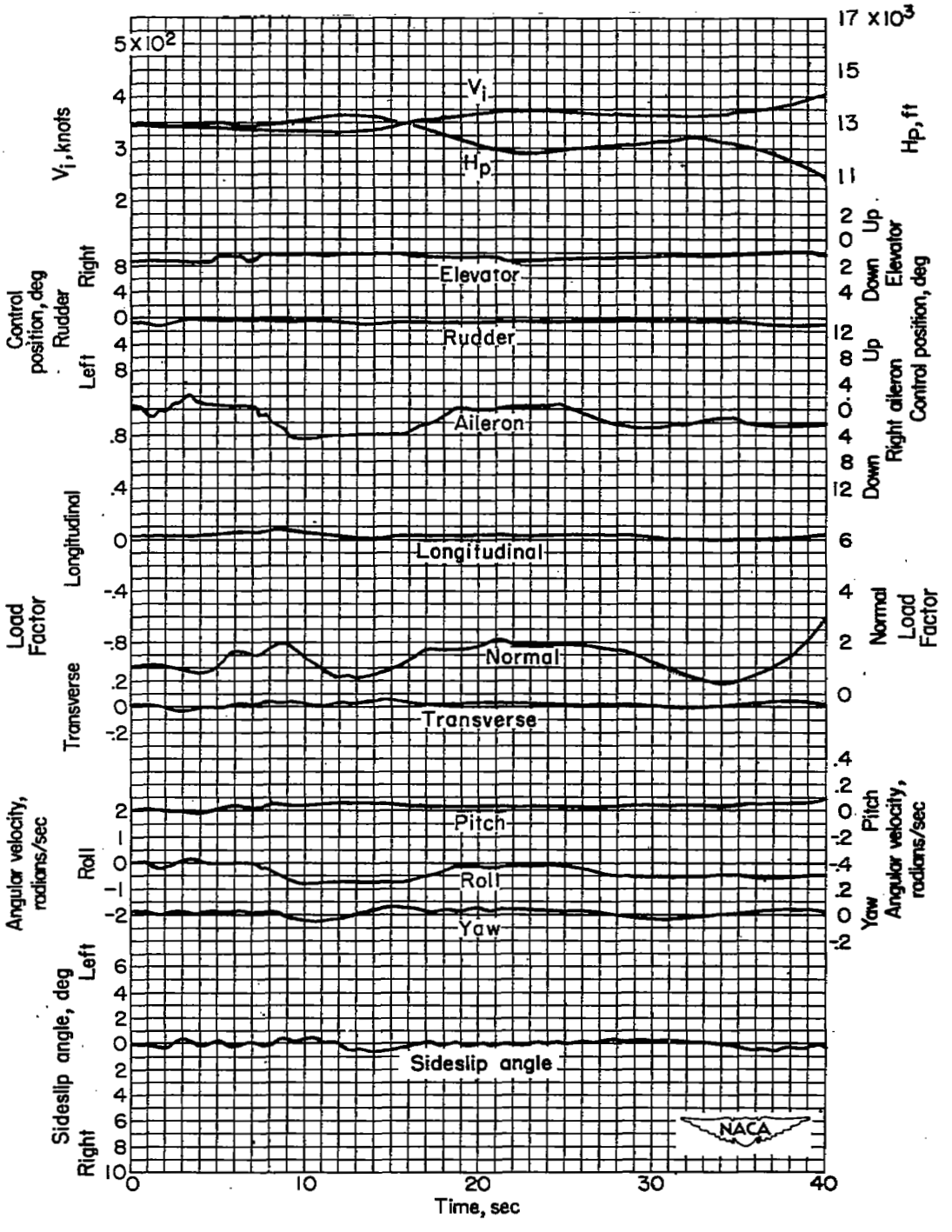

Figure 235.- Two left slow rolls followed by dive and normal pull-out; airplane weight, 16,330 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

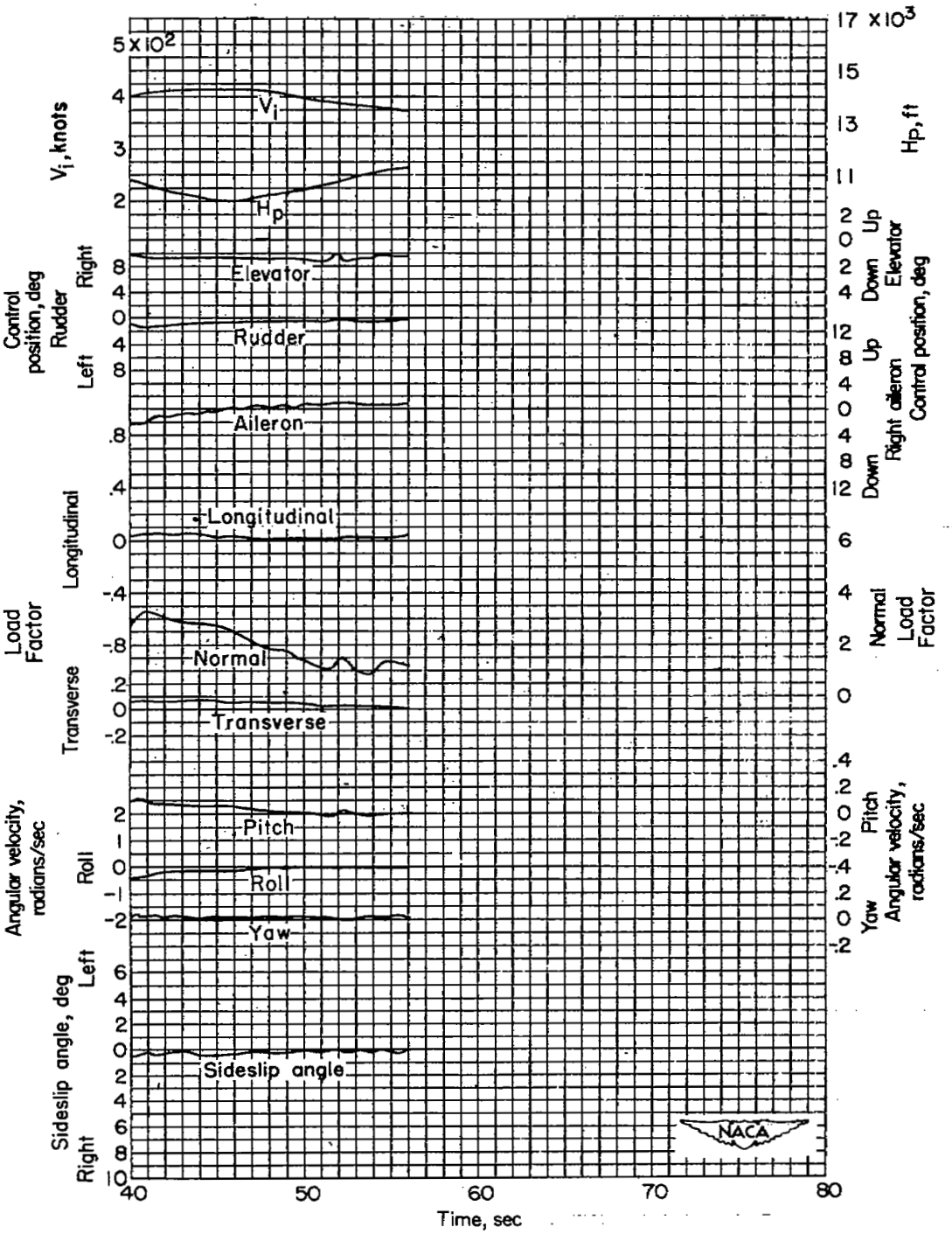

Figure 235.- Concluded.

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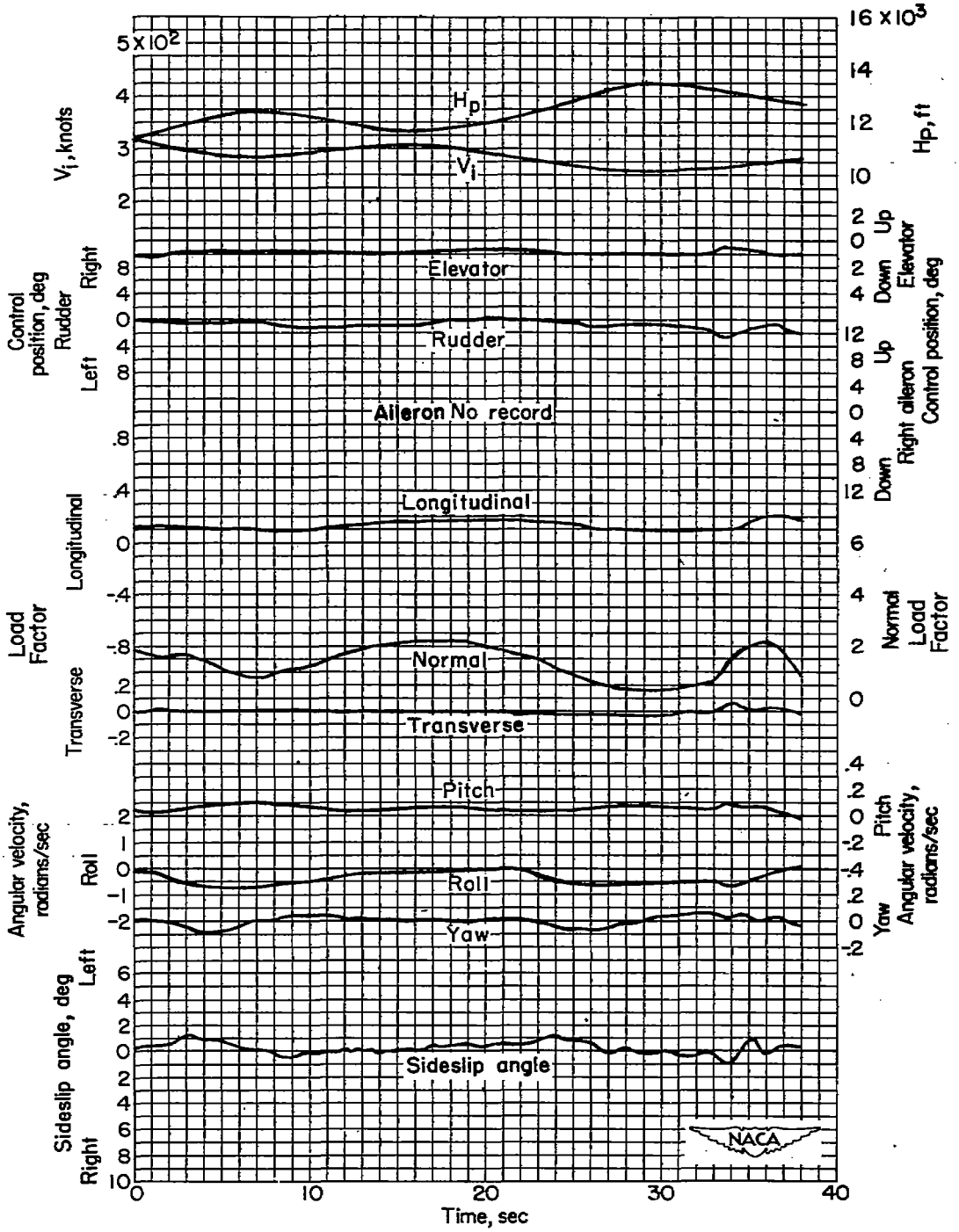

Figure 236.- Two left barrel rolls; airplane weight, 16,630 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

[redacted]

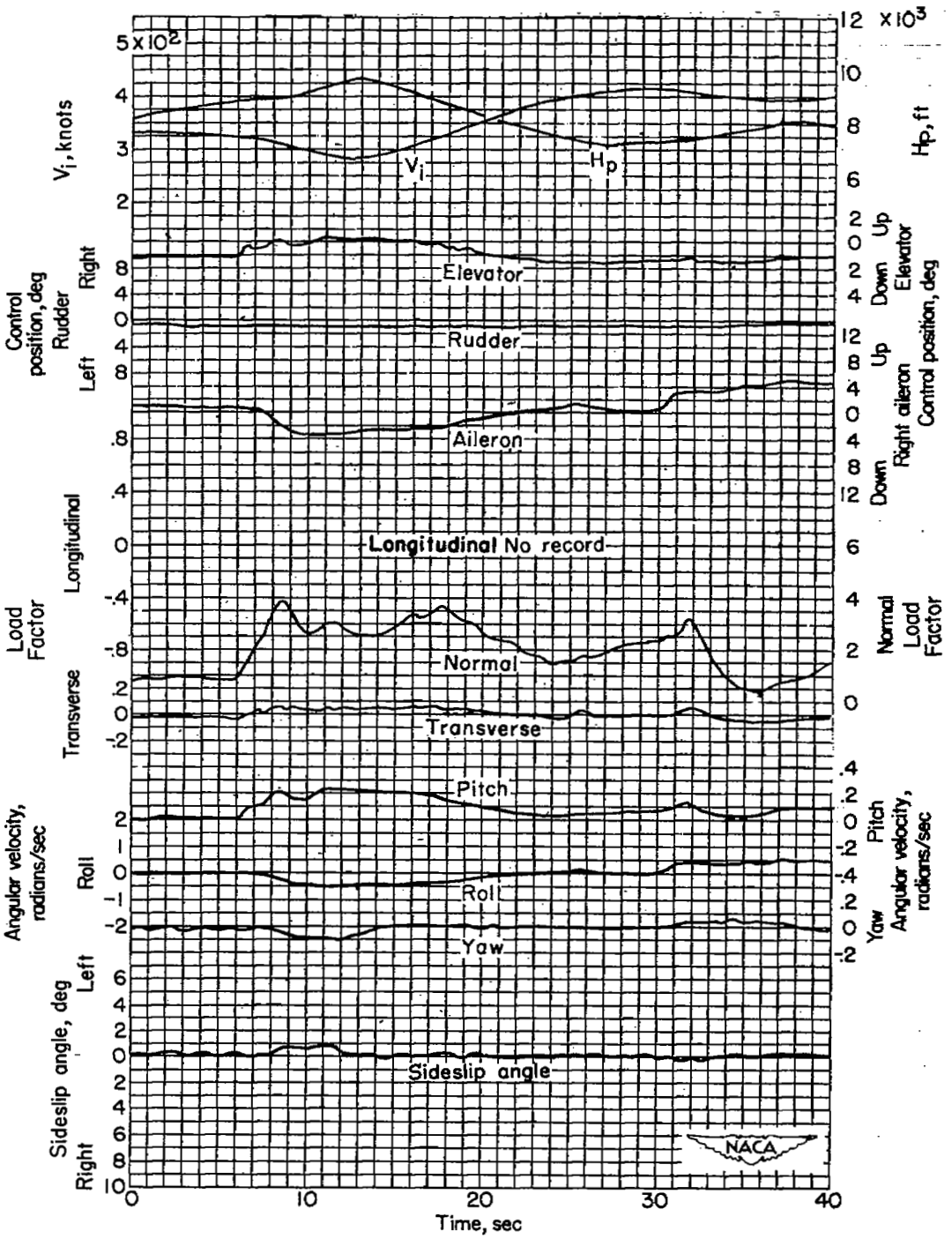

Figure 237.- Left barrel roll followed by right barrel roll; airplane weight, 14,530 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

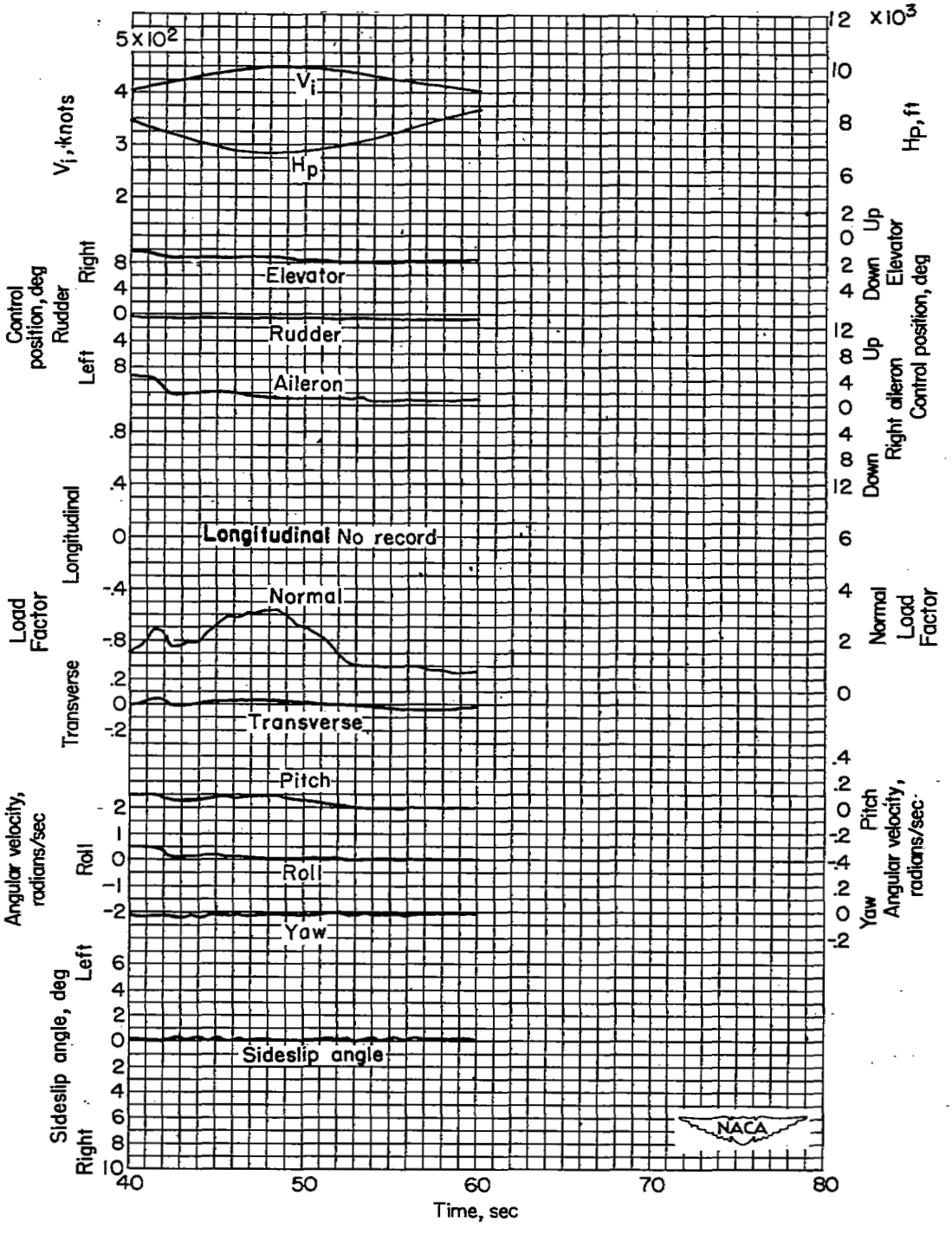

Figure 237.- Concluded.

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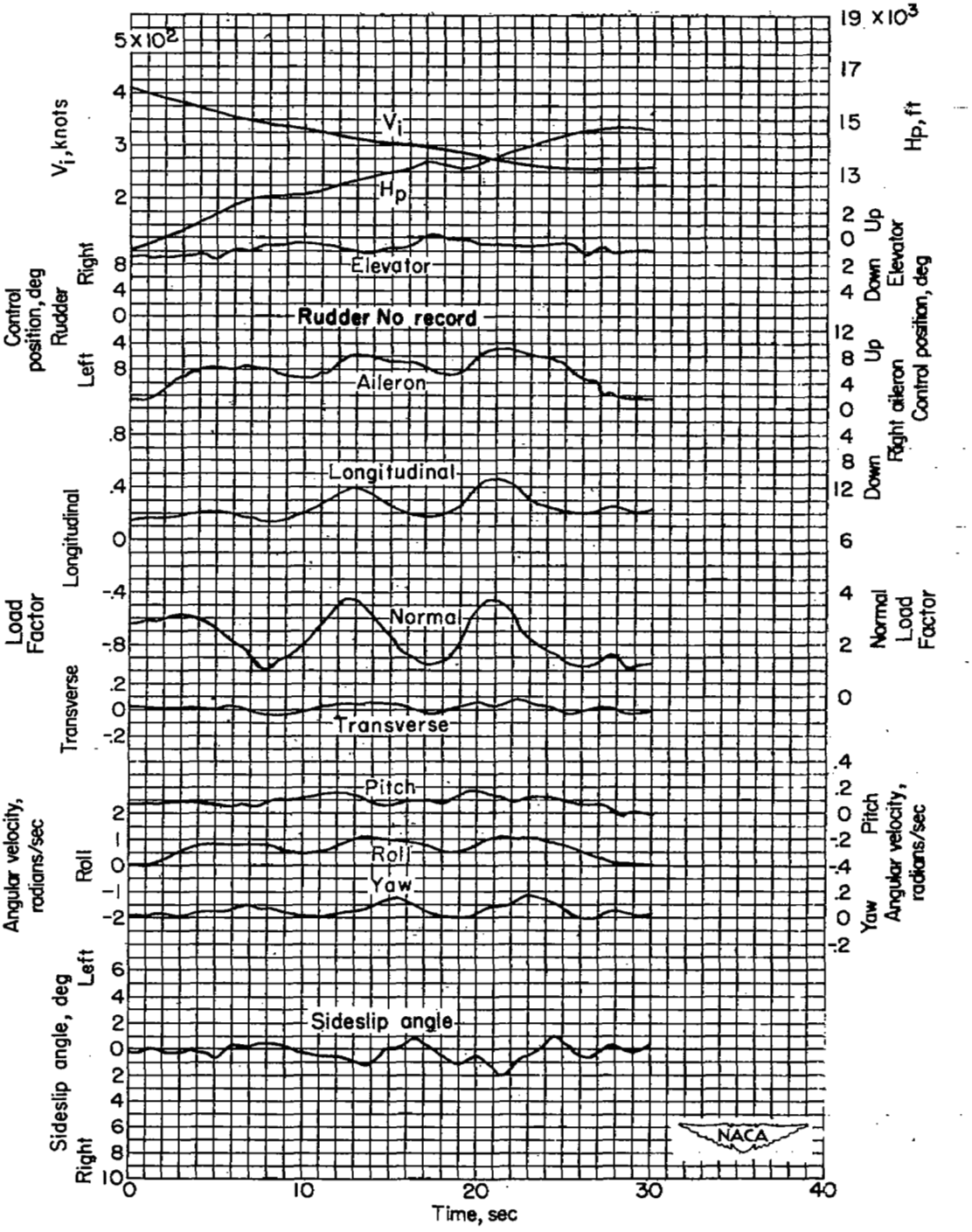


Figure 238.- Triple right slow roll; airplane weight, 17,120 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

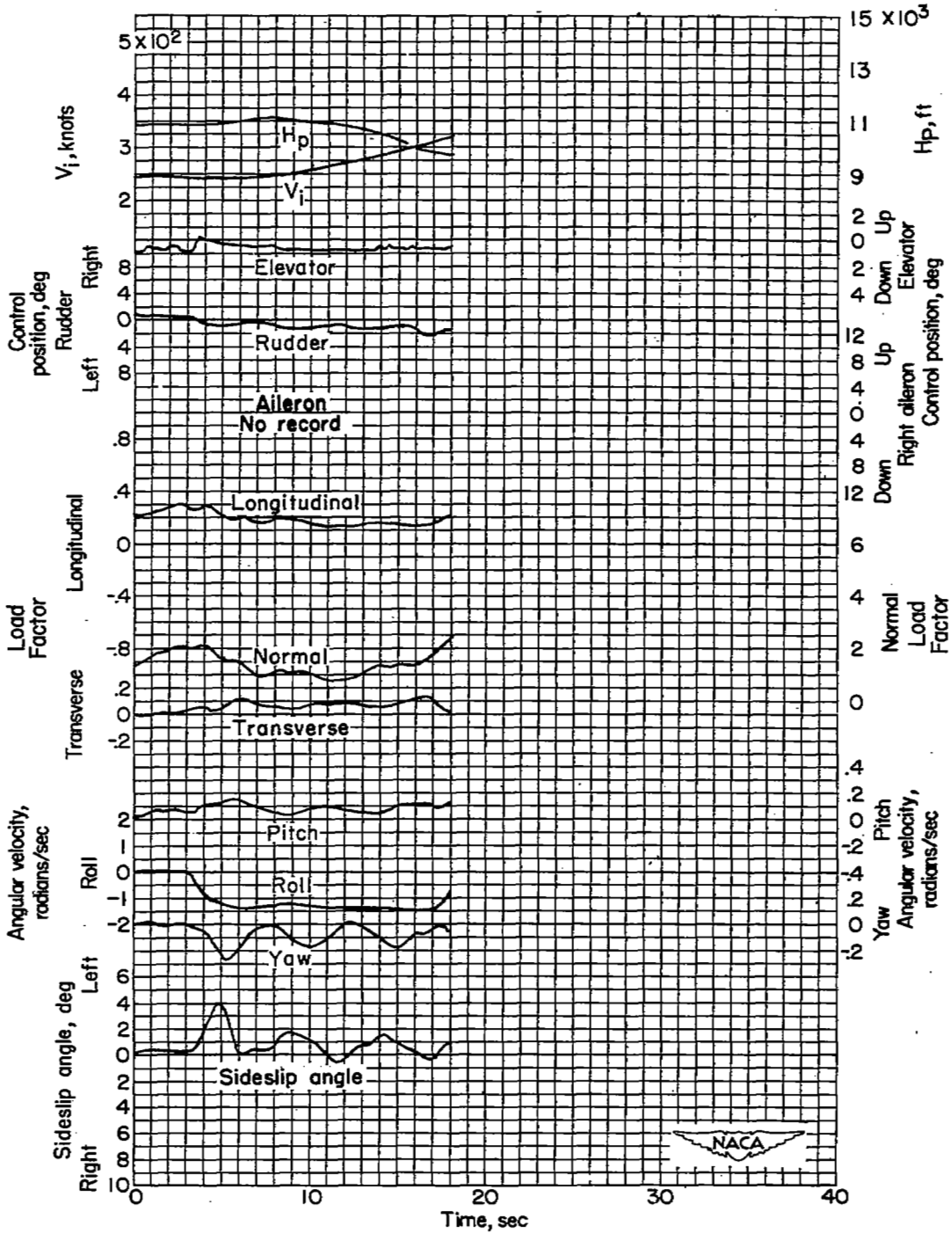


Figure 239.- Triple left slow roll; airplane weight, 17,095 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

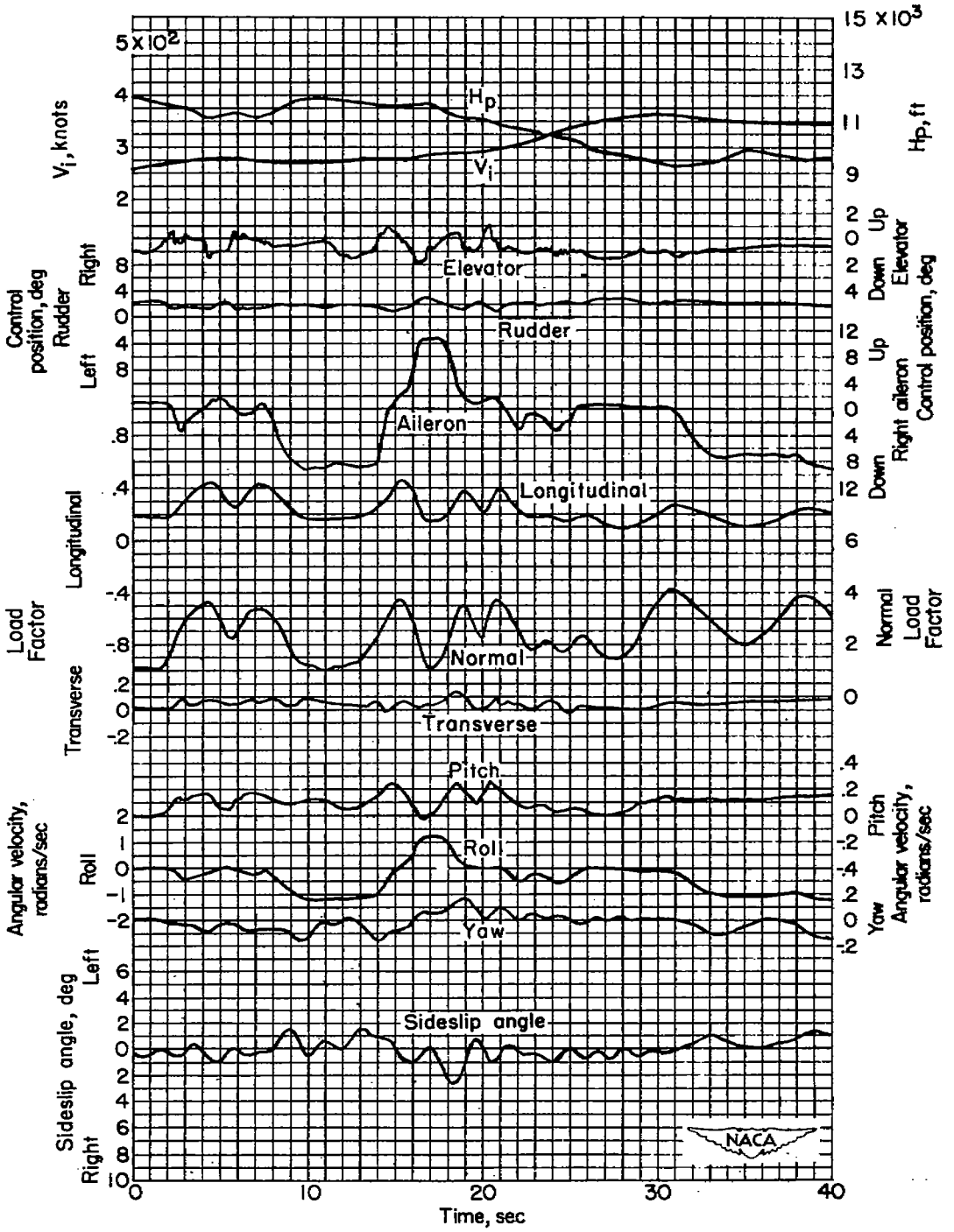


Figure 240.- Left slow roll followed by triple left slow roll; airplane weight, 17,150 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

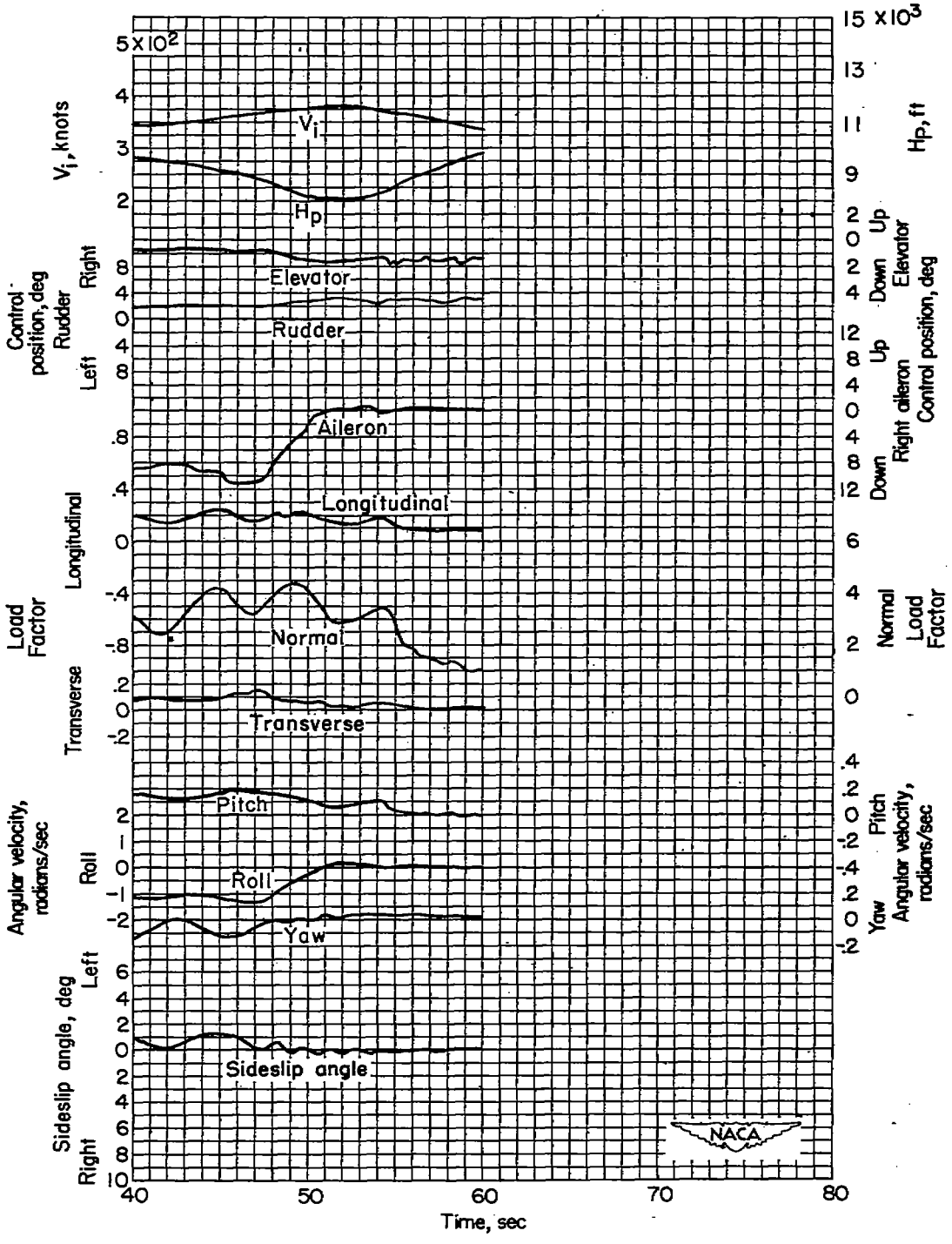


Figure 240.- Concluded.

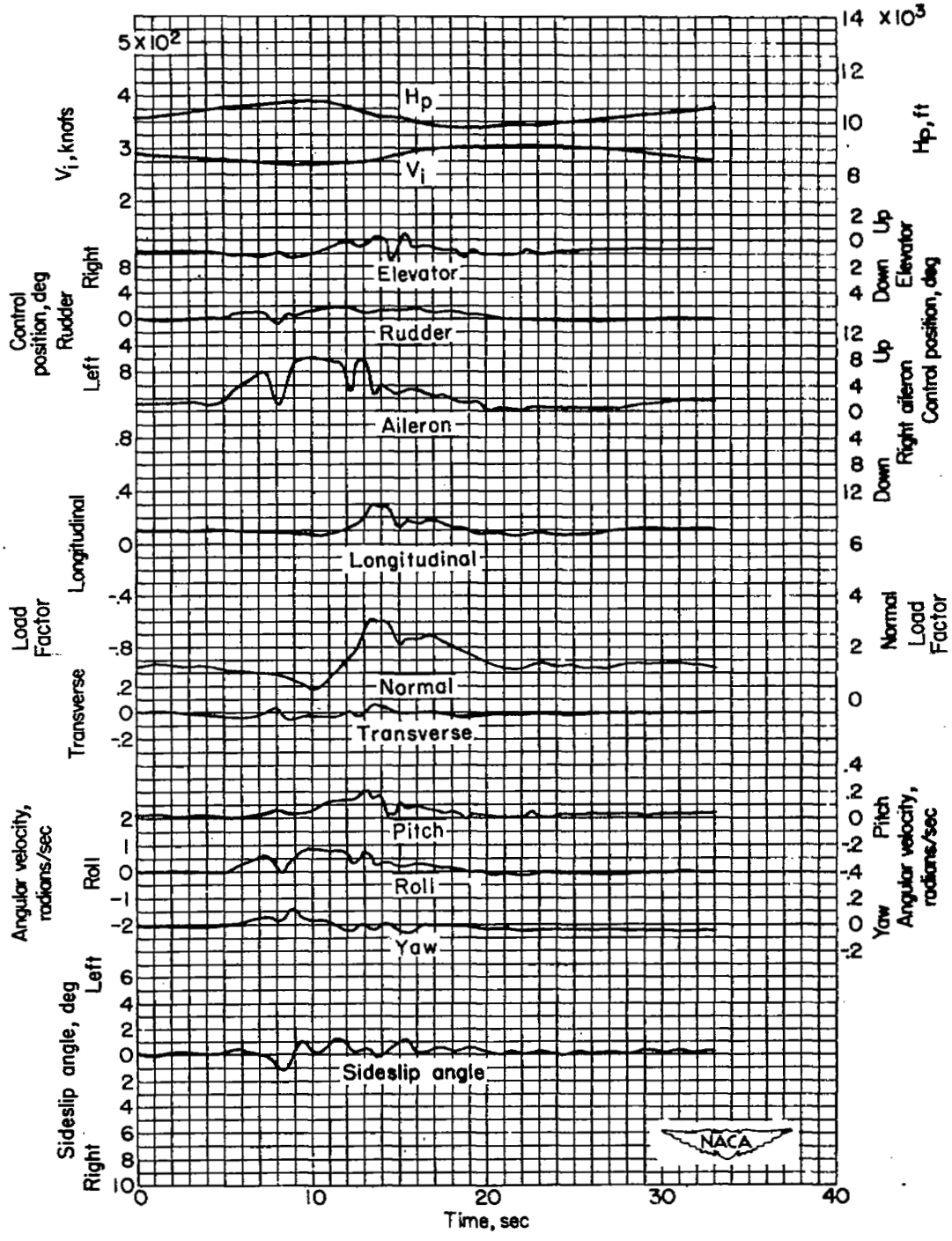


Figure 241.- Right four-point roll; airplane weight, 16,930 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

6F

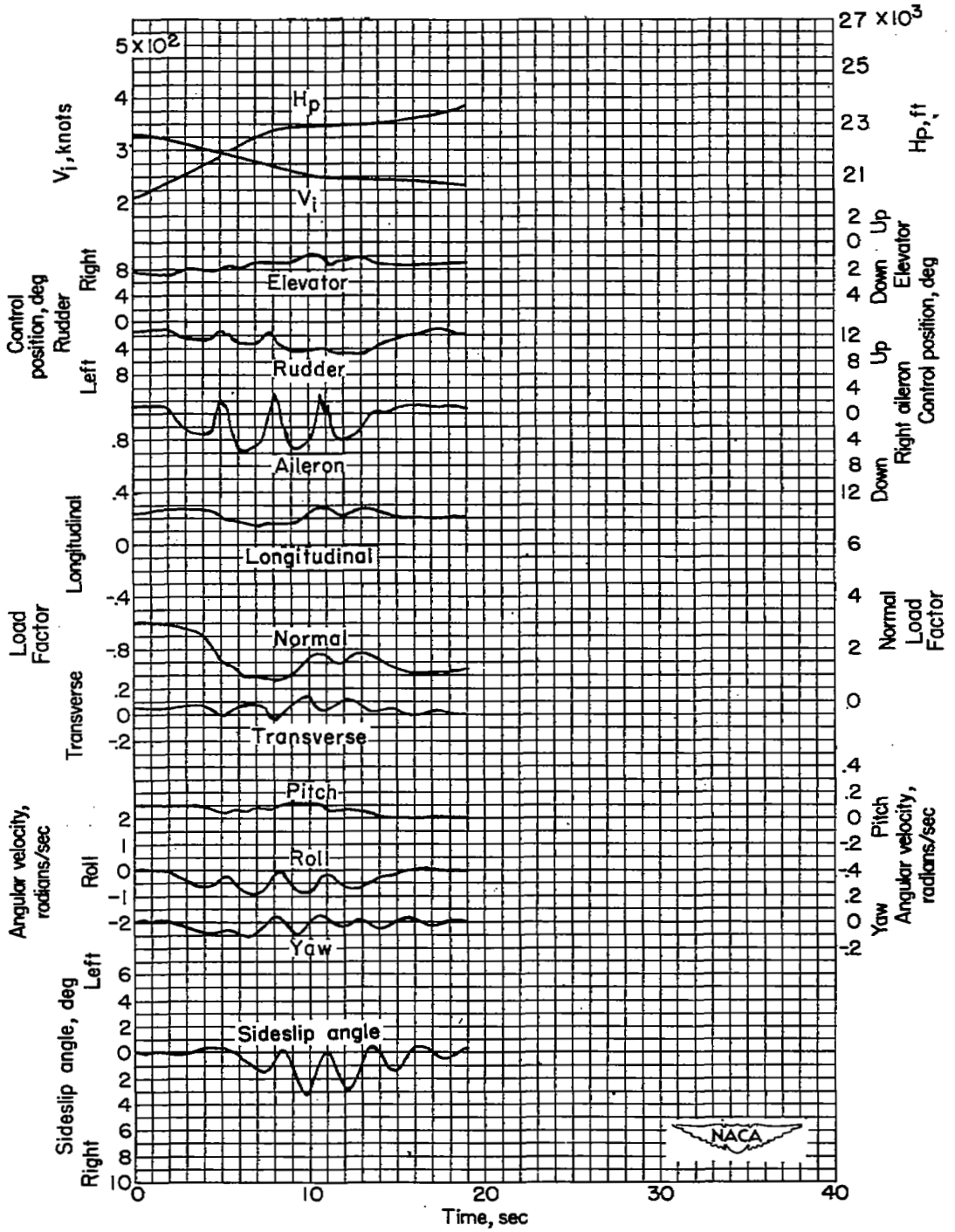


Figure 242.- Left four-point roll; airplane weight, 17,690 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

[redacted]

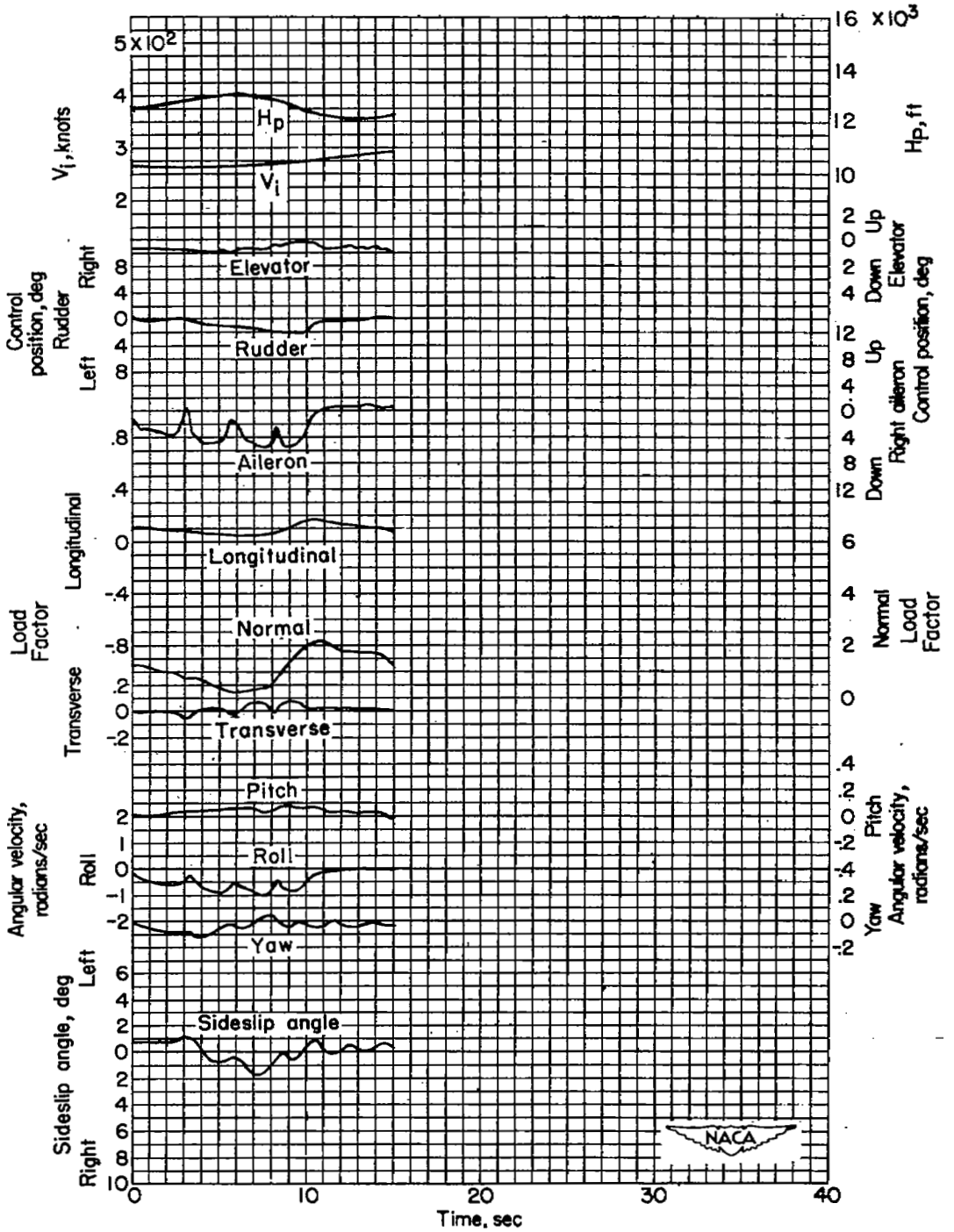


Figure 243.- Left four-point roll; airplane weight, 16,820 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

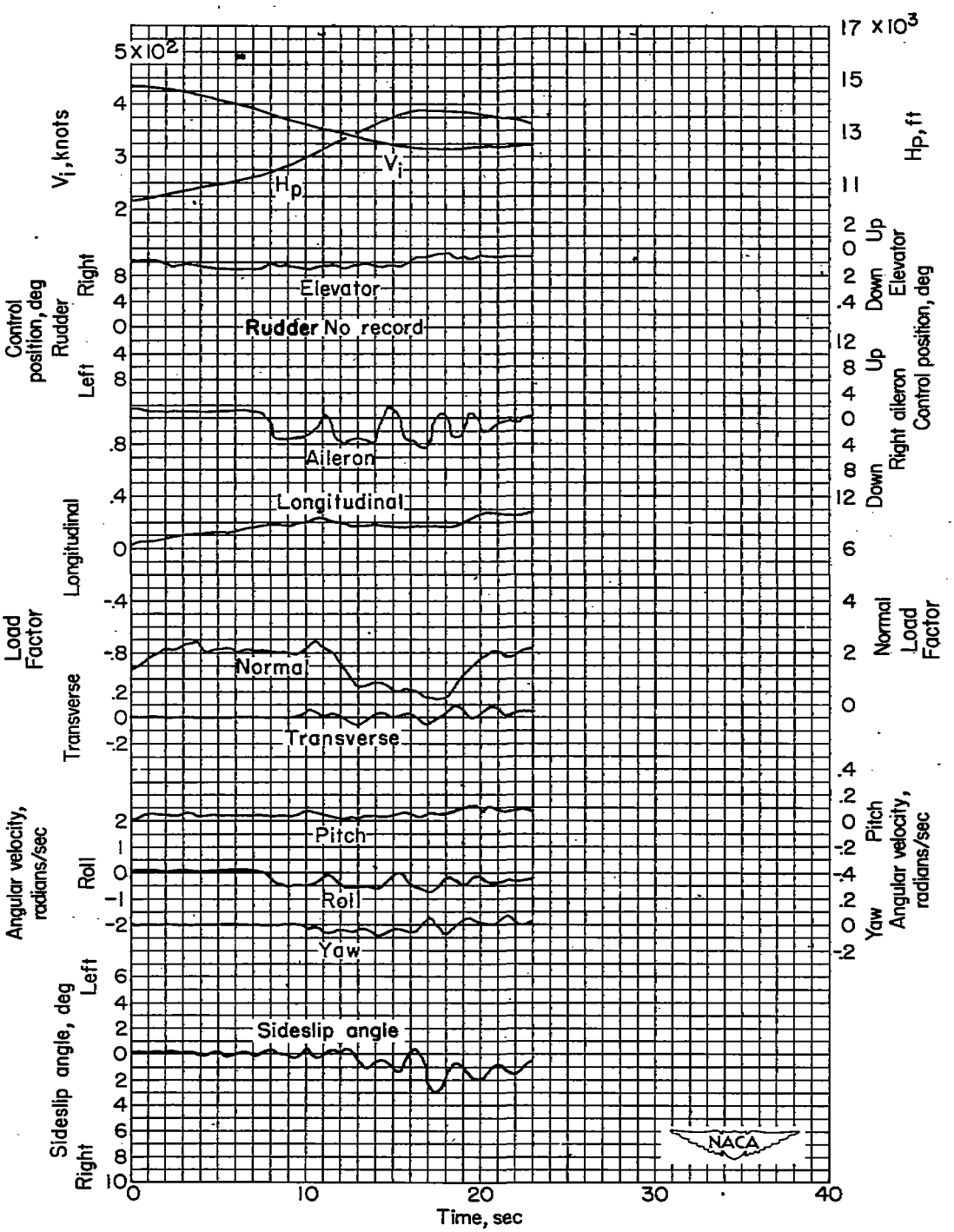


Figure 244.- Left four-point roll; airplane weight, 17,270 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

[redacted]

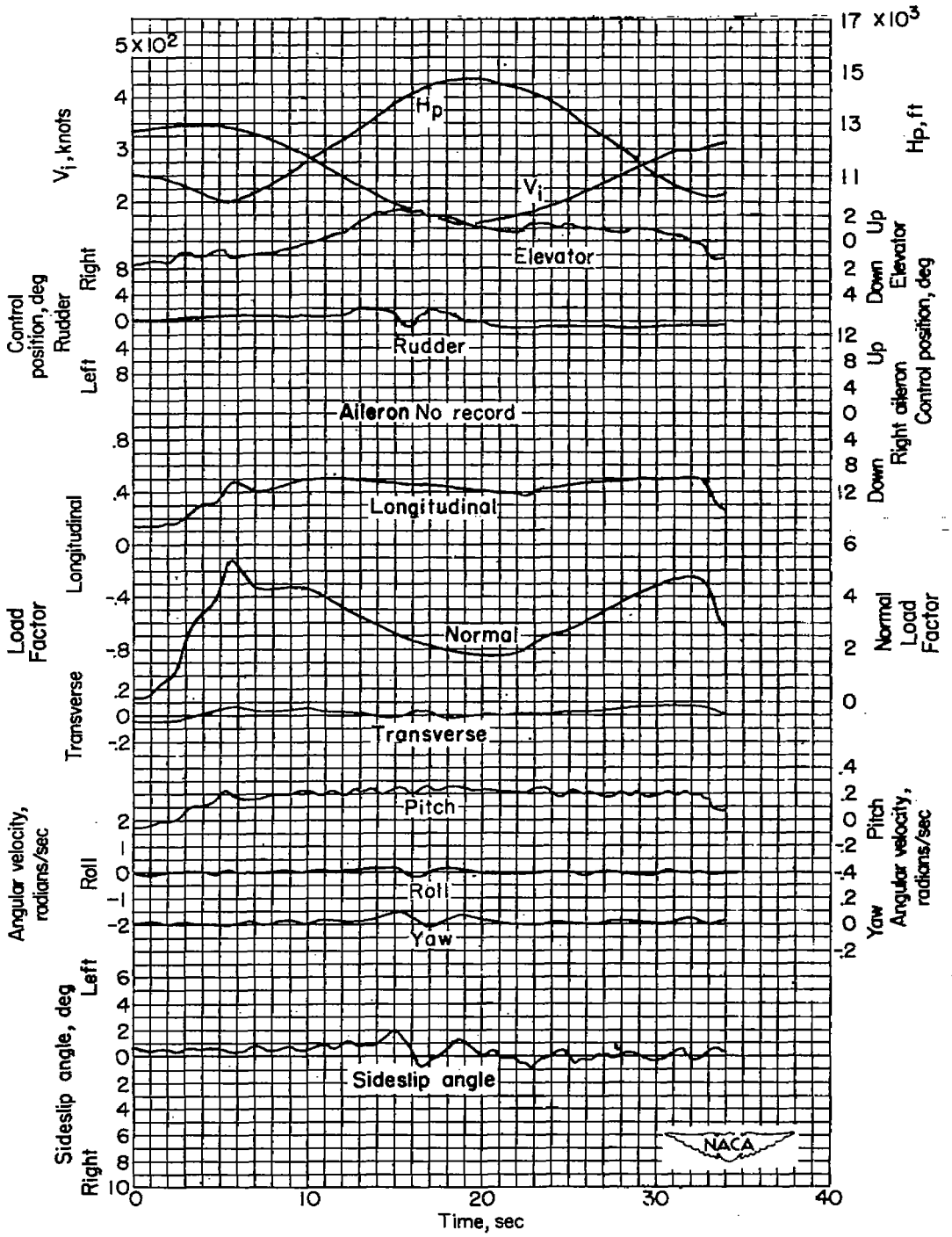


Figure 245.- Loop; airplane weight, 17,030 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

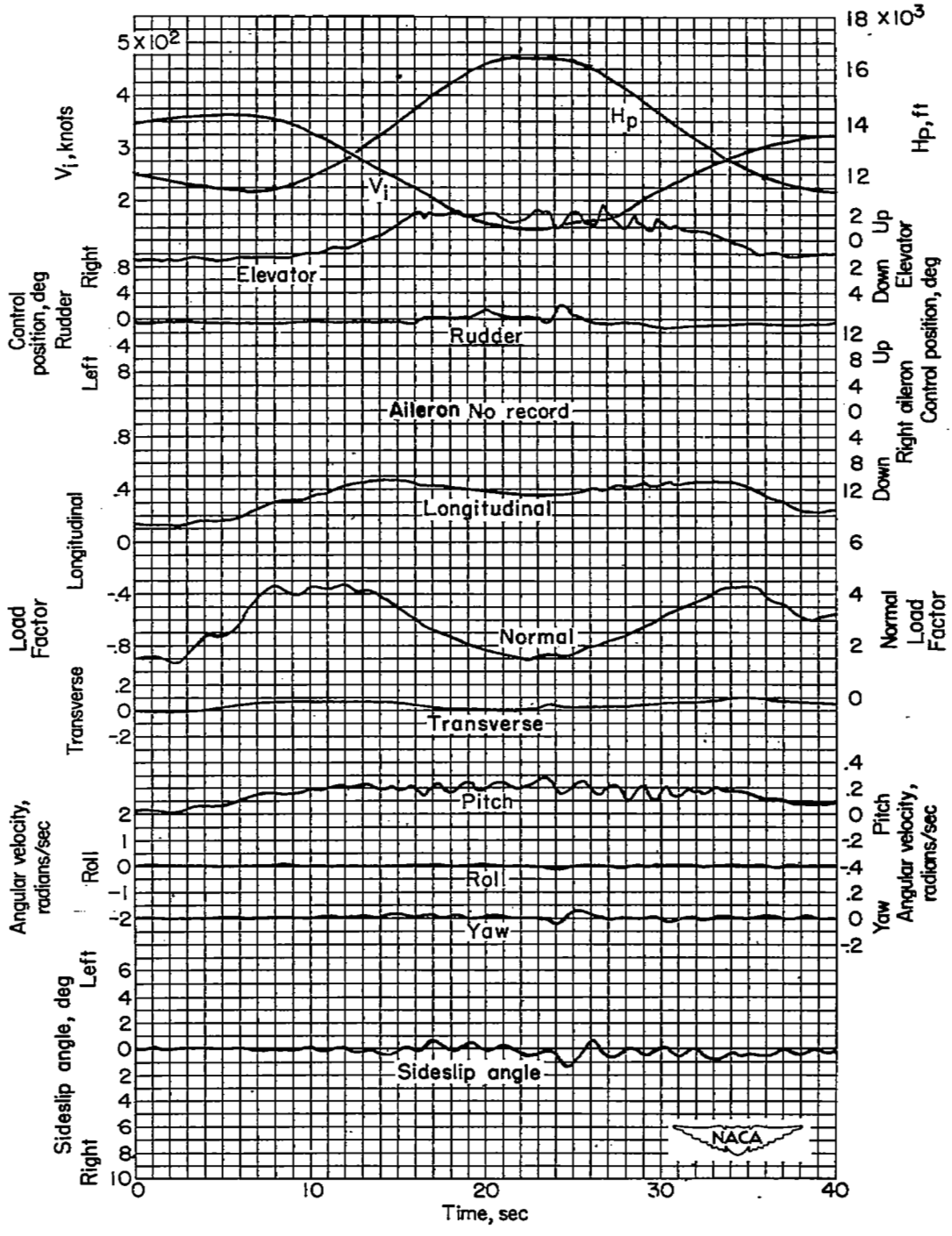


Figure 246.- Loop; airplane weight, 16,820 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

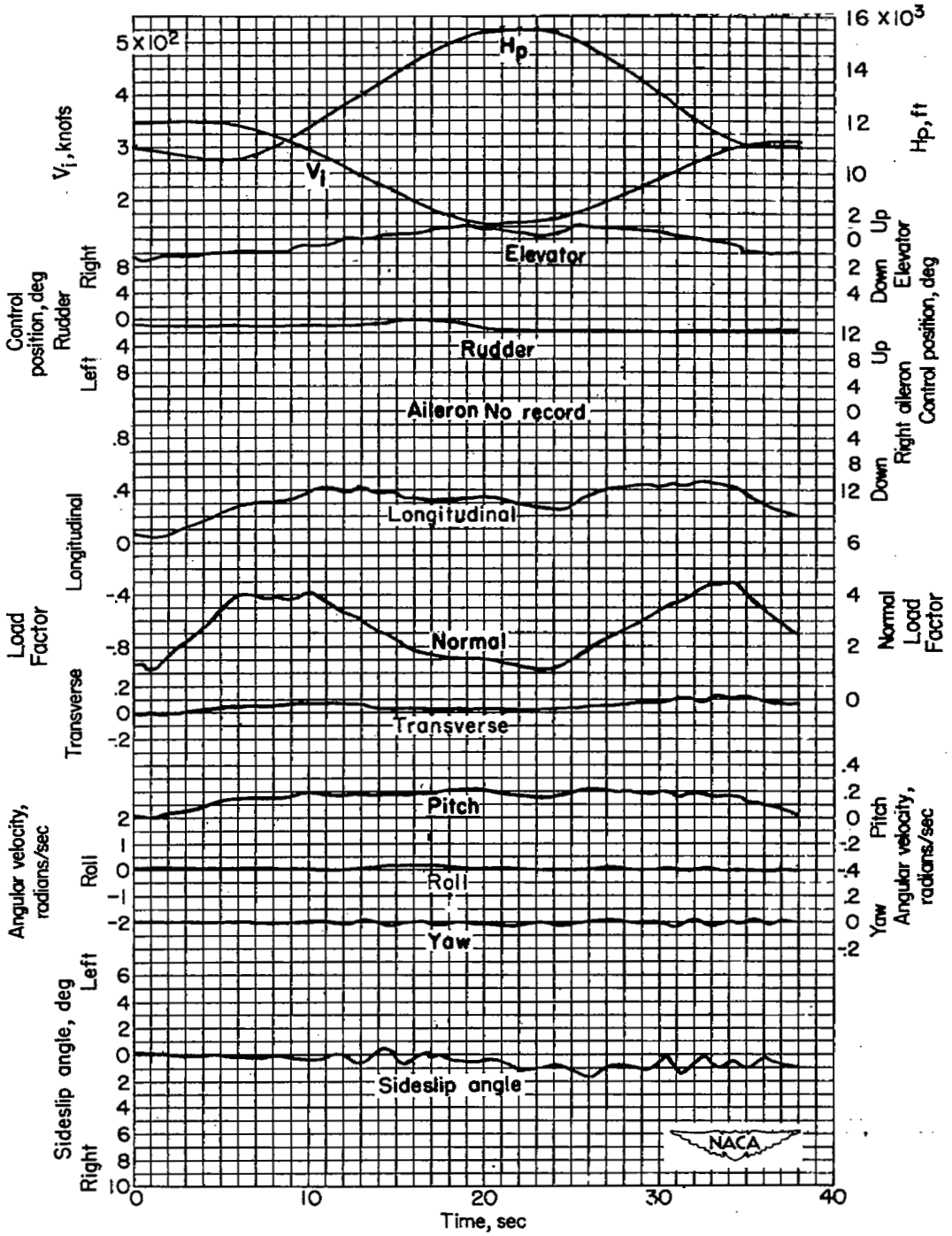


Figure 247.- Loop; airplane weight, 16,300 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

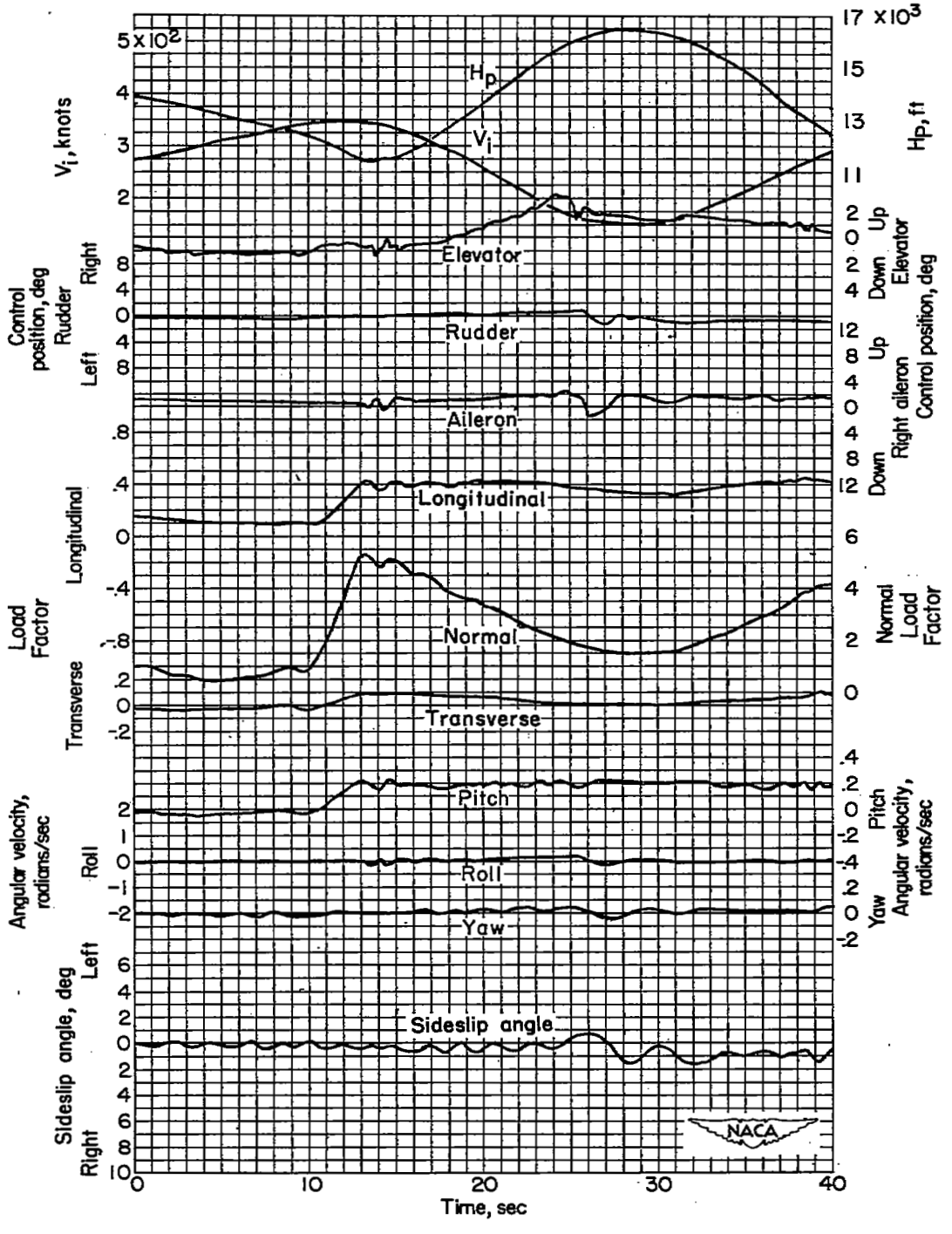


Figure 248.- Loop; airplane weight, 17,060 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

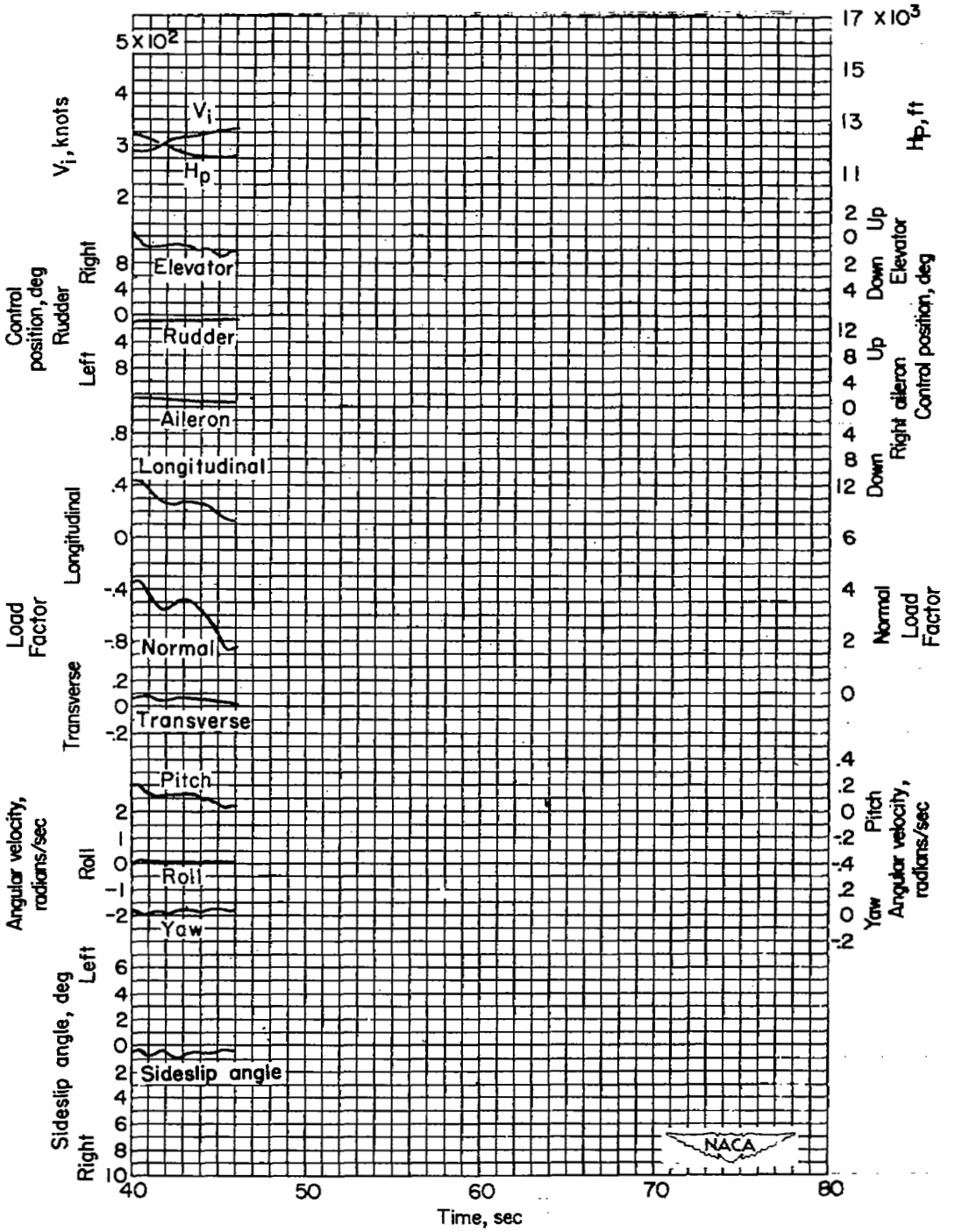


Figure 248.- Concluded.

[redacted]

7F

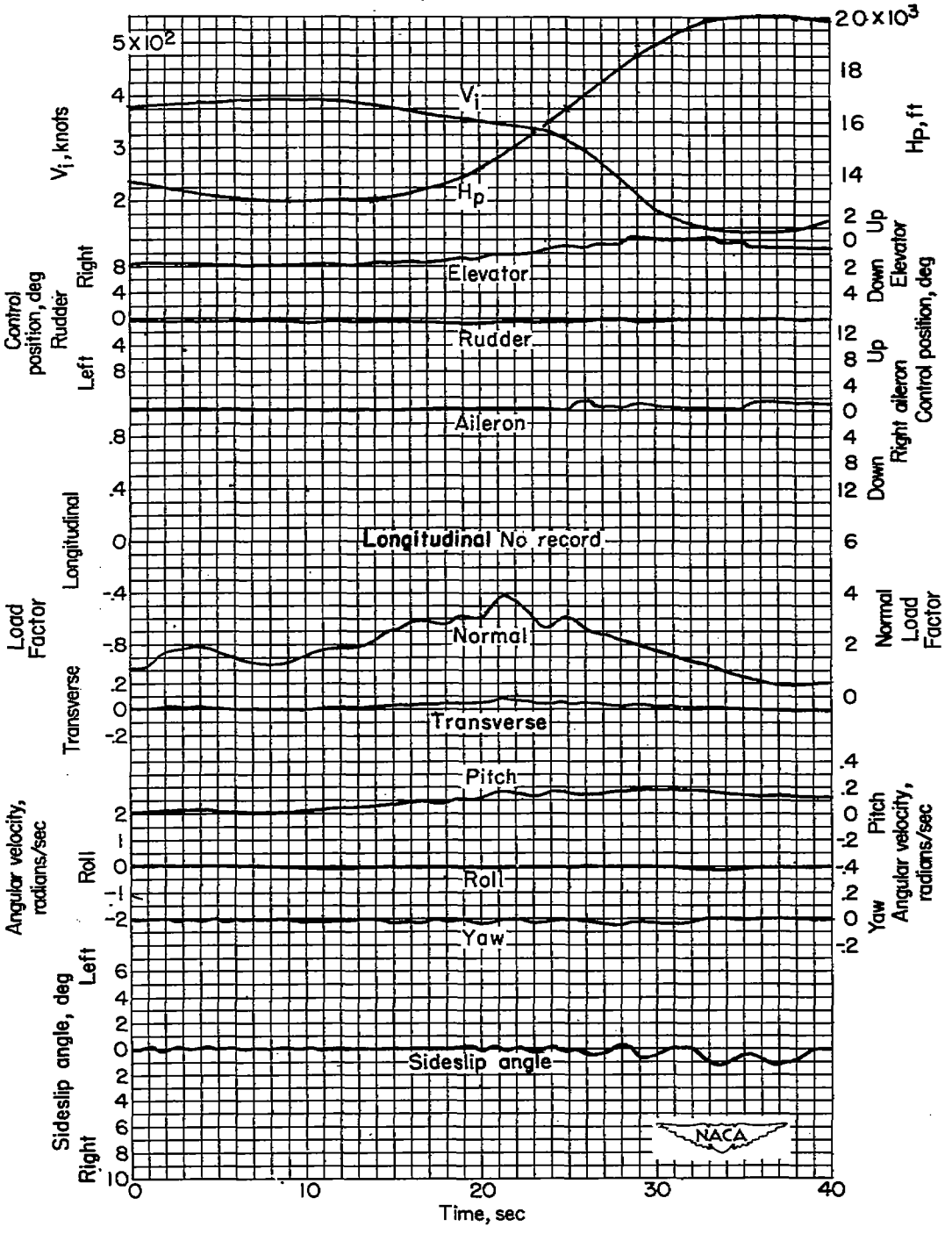
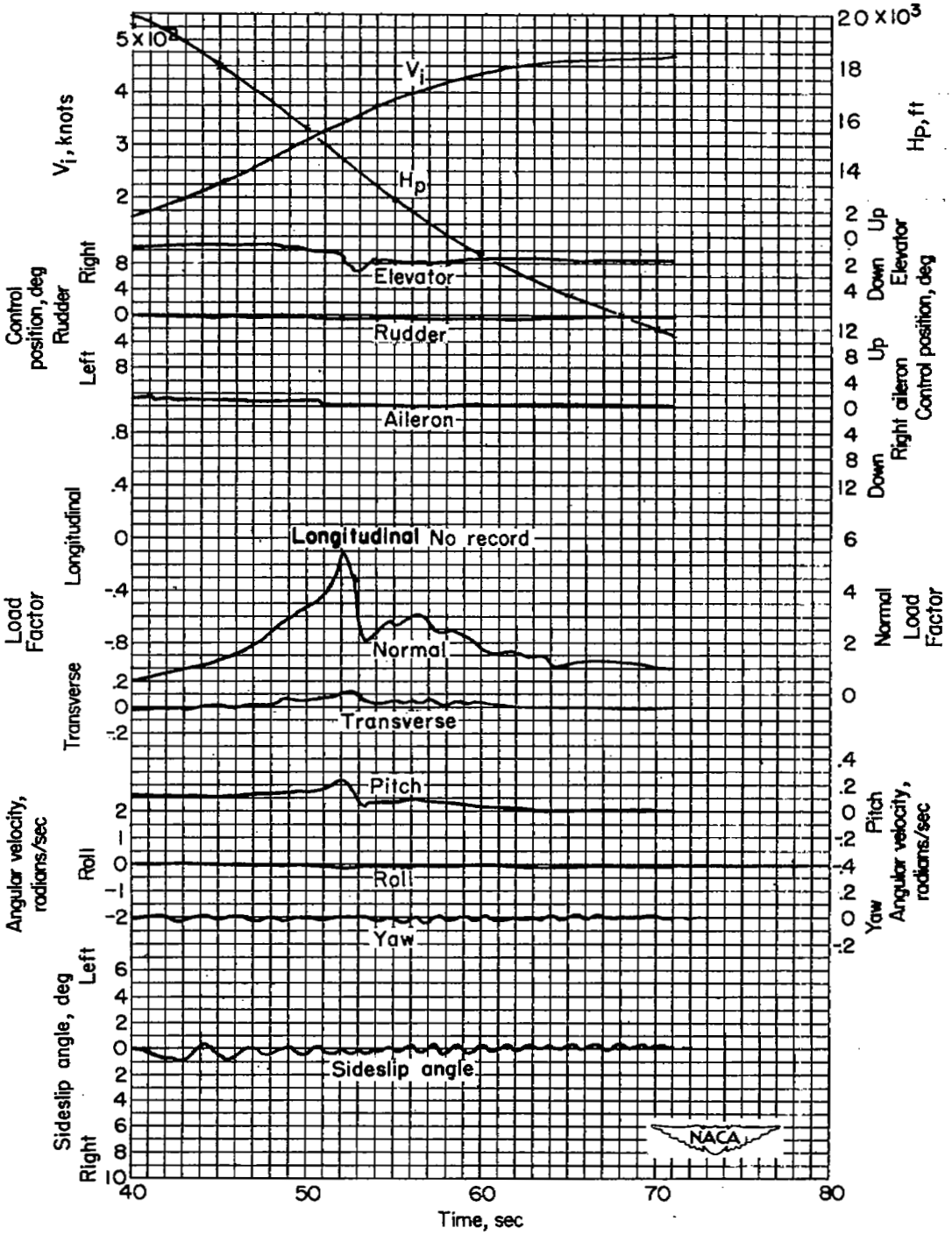


Figure 249.- Loop; airplane weight, 15,090 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

[redacted]



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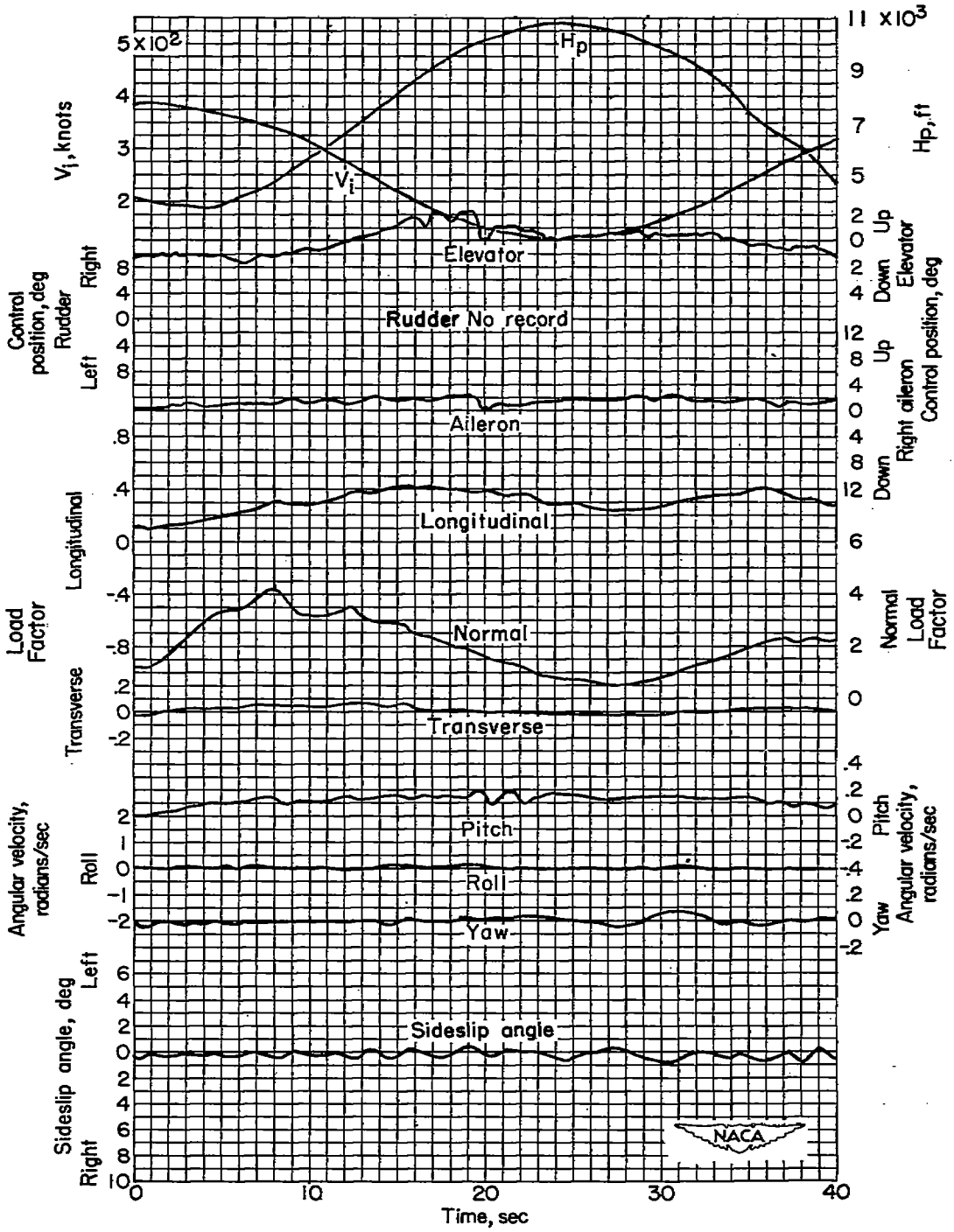

Figure 250.- Loop; airplane weight, 17,680 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

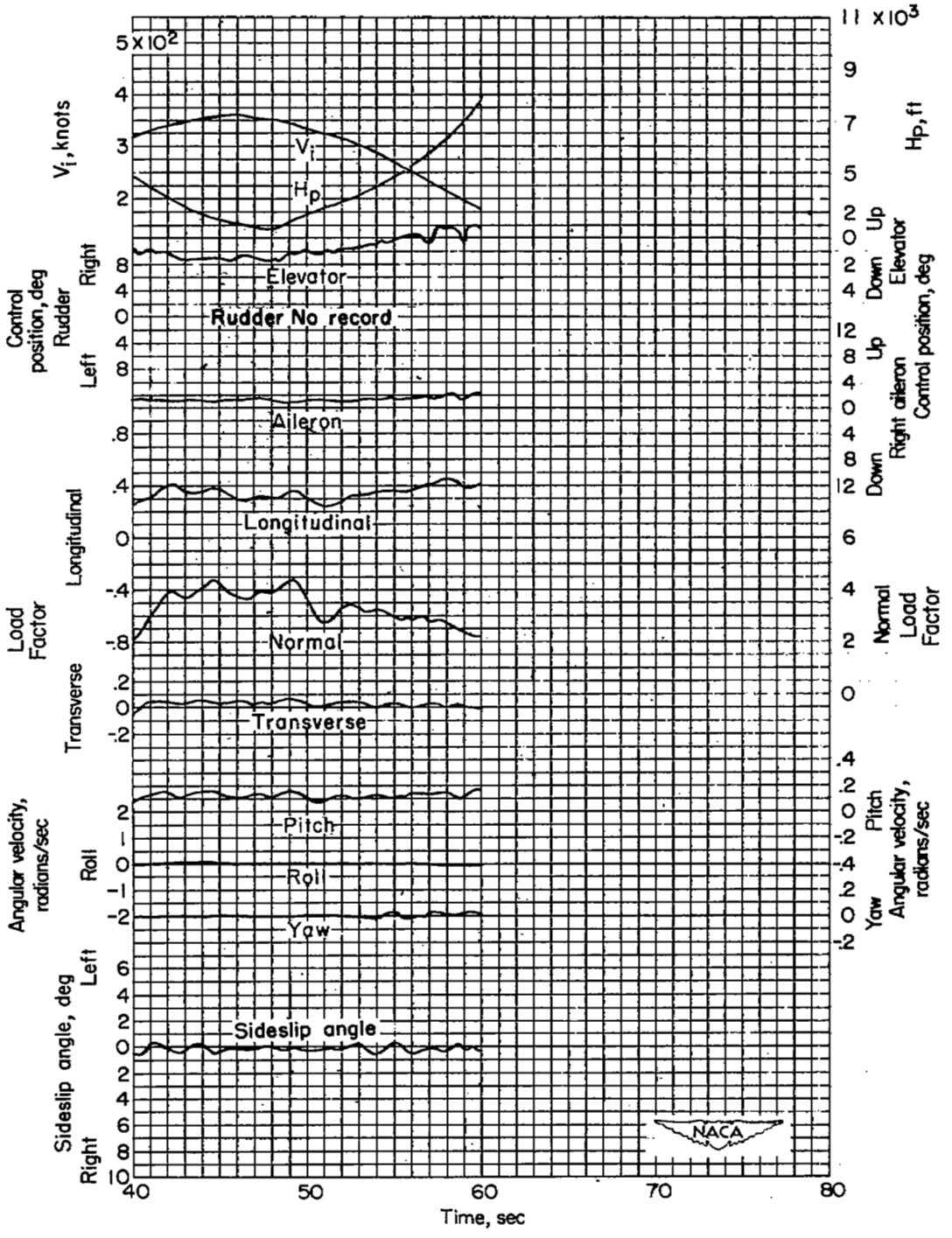

Figure 250.- Concluded.

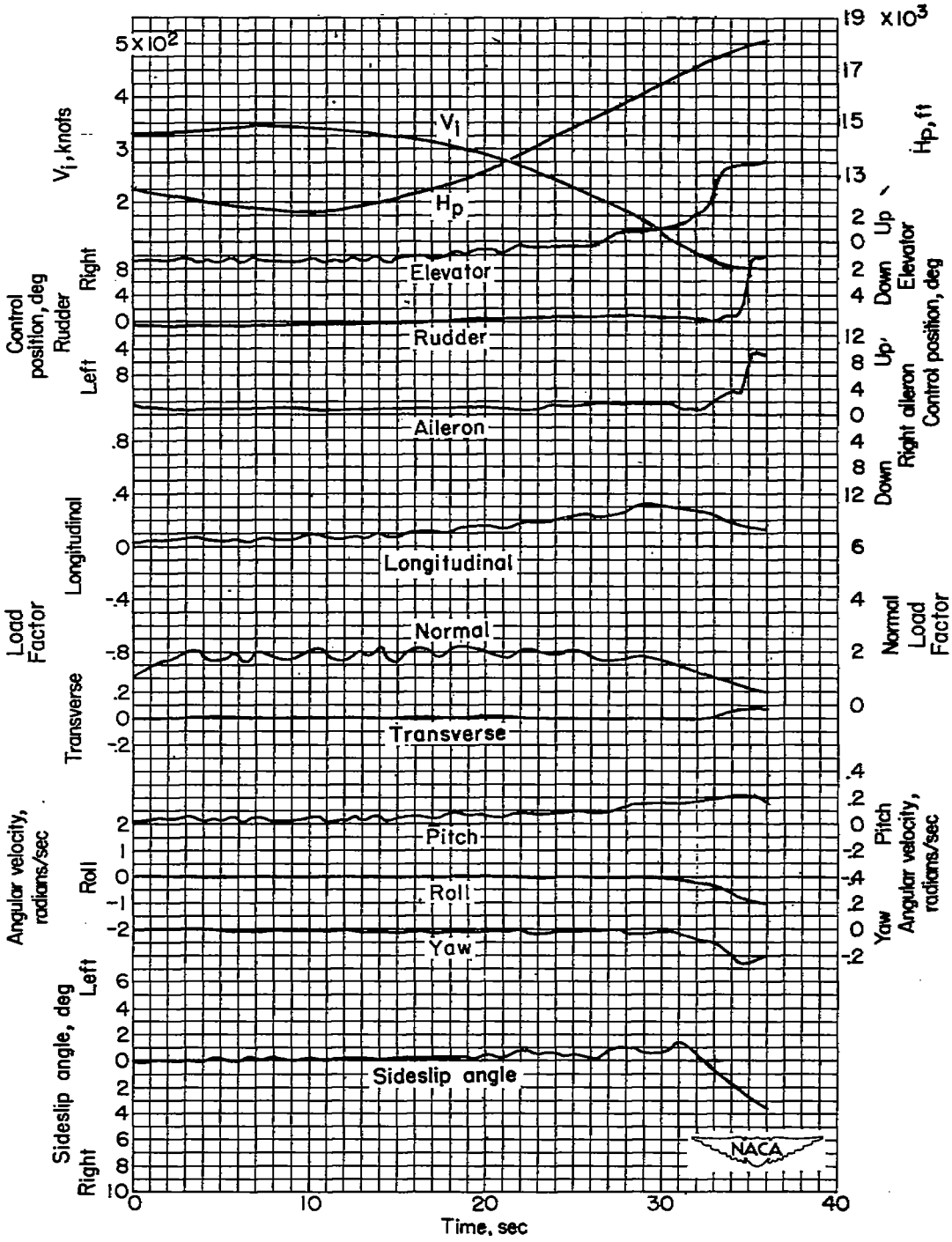

Figure 251.- Loop with stall at top; airplane weight, 16,670 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

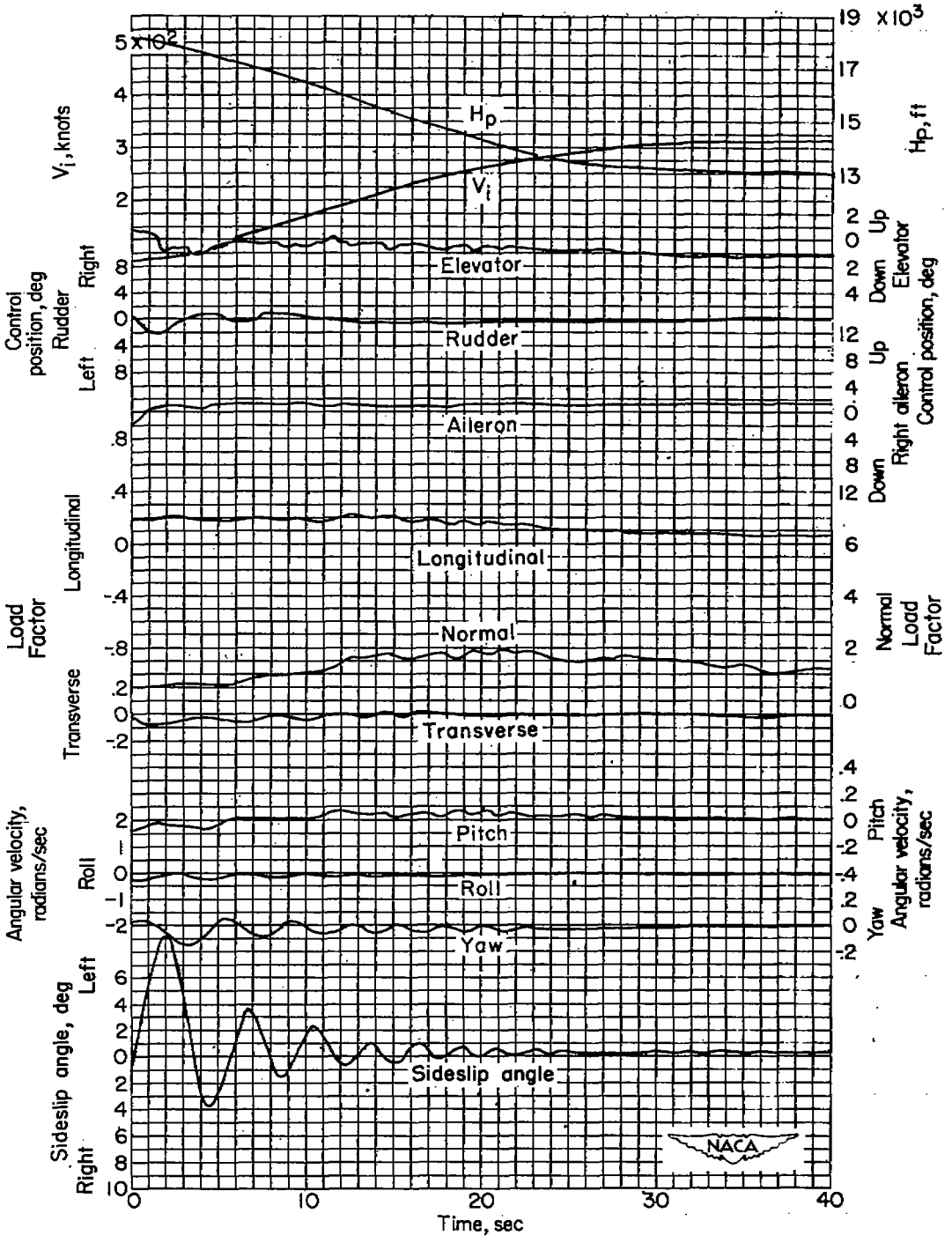

Figure 251.- Concluded.

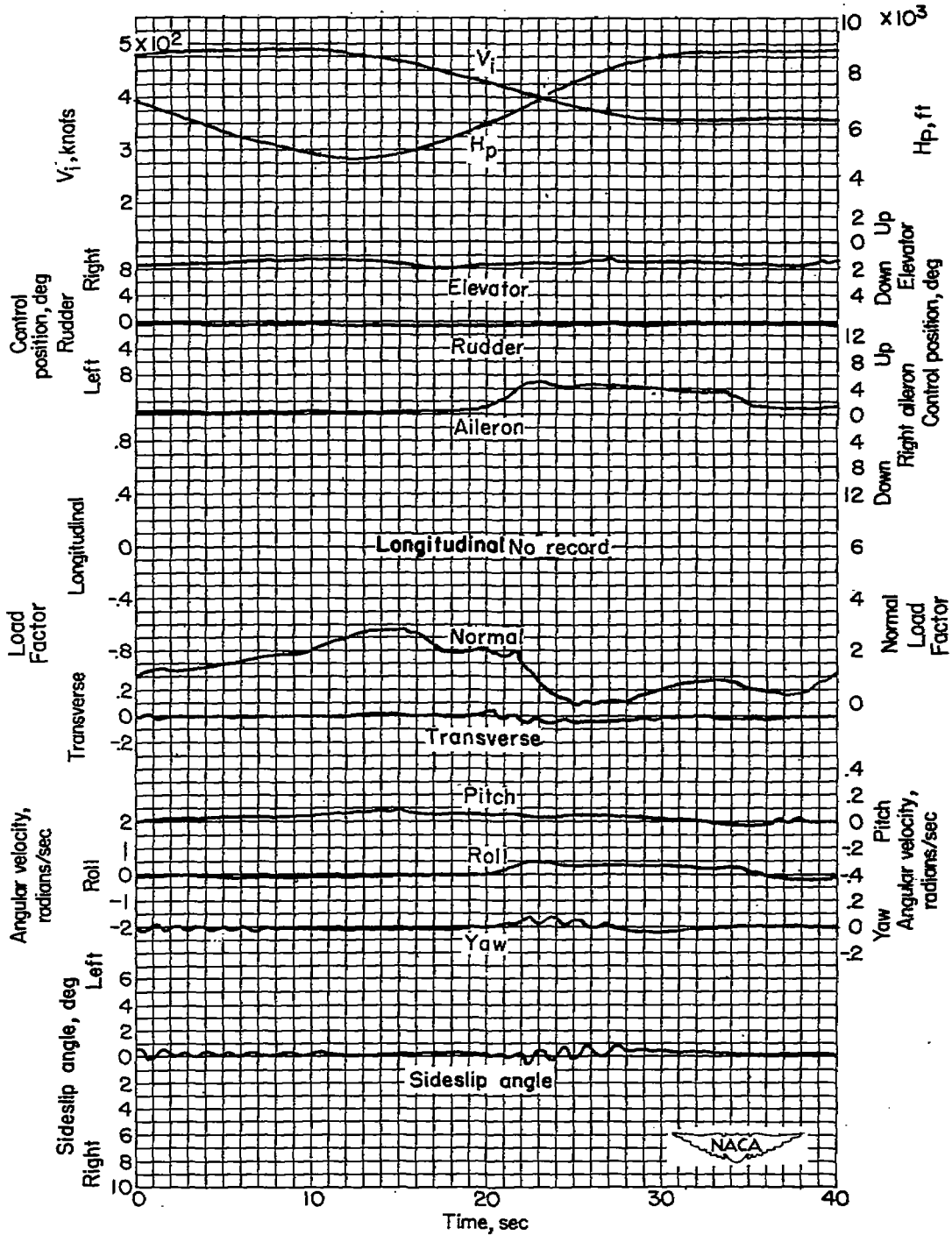

Figure 252.- Immelman; airplane weight, 15,030 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

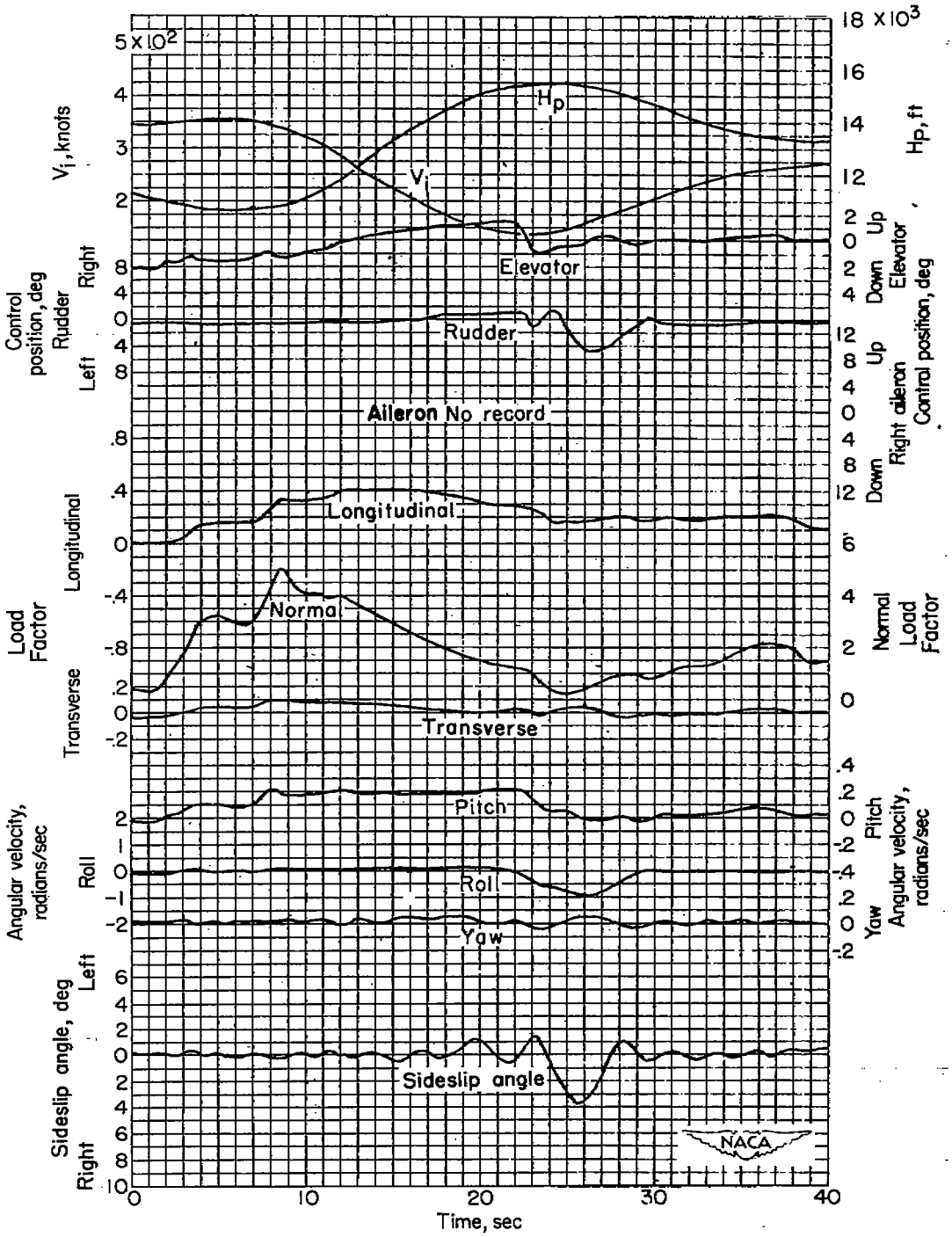

Figure 253.- Immelman; airplane weight, 16,750 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

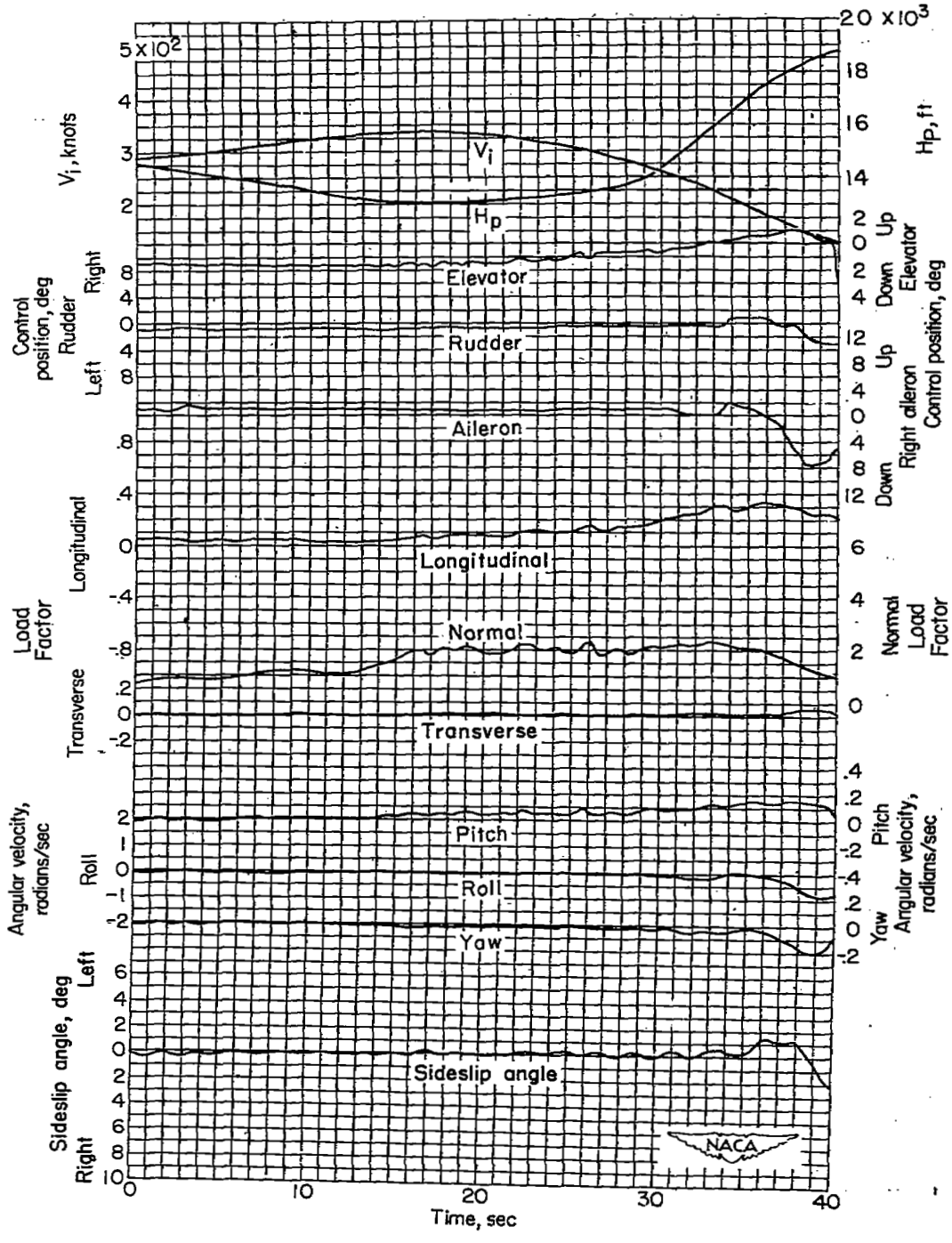

Figure 254.- Immelman; airplane weight, 16,540 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

[redacted]

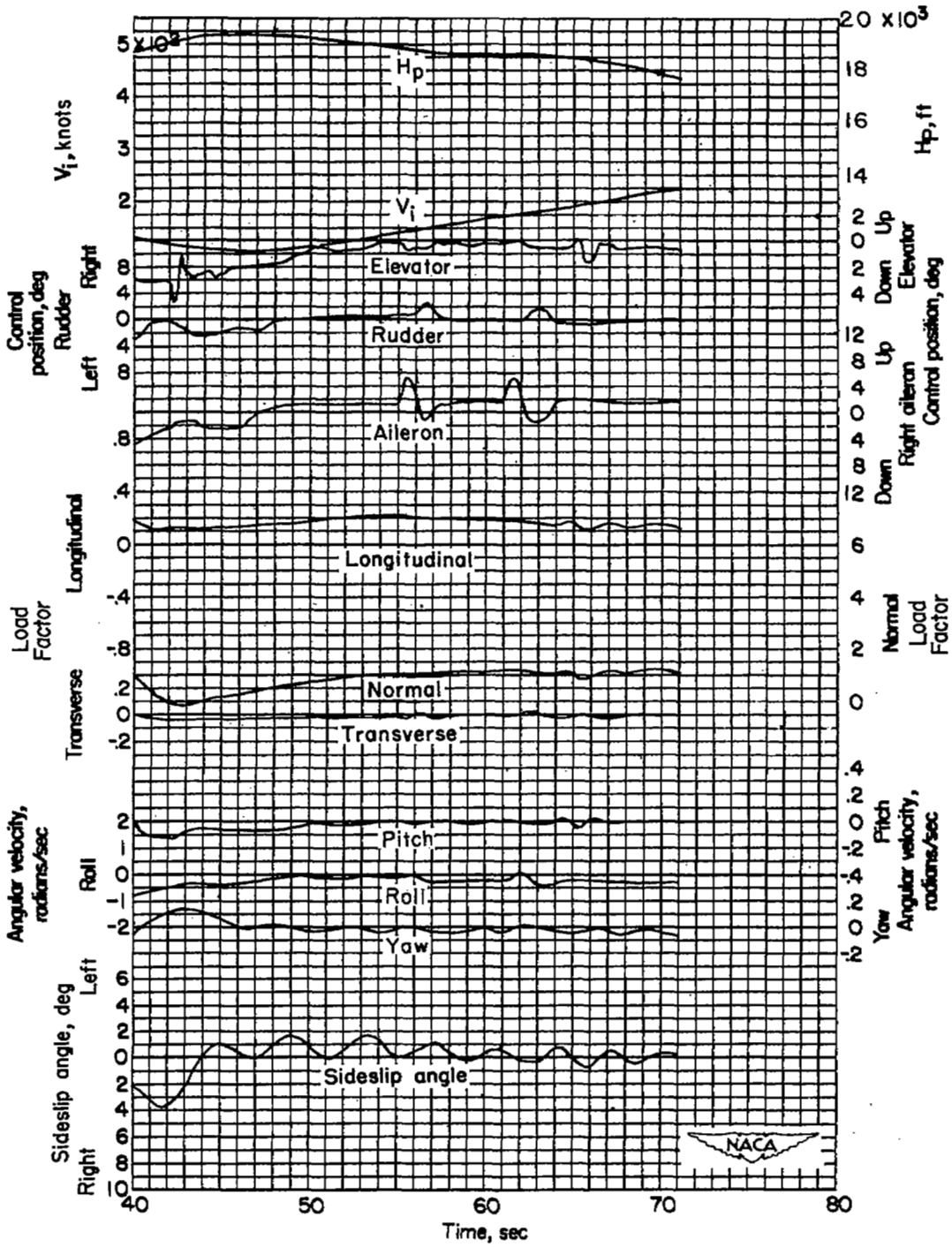

Figure 254.- Concluded.

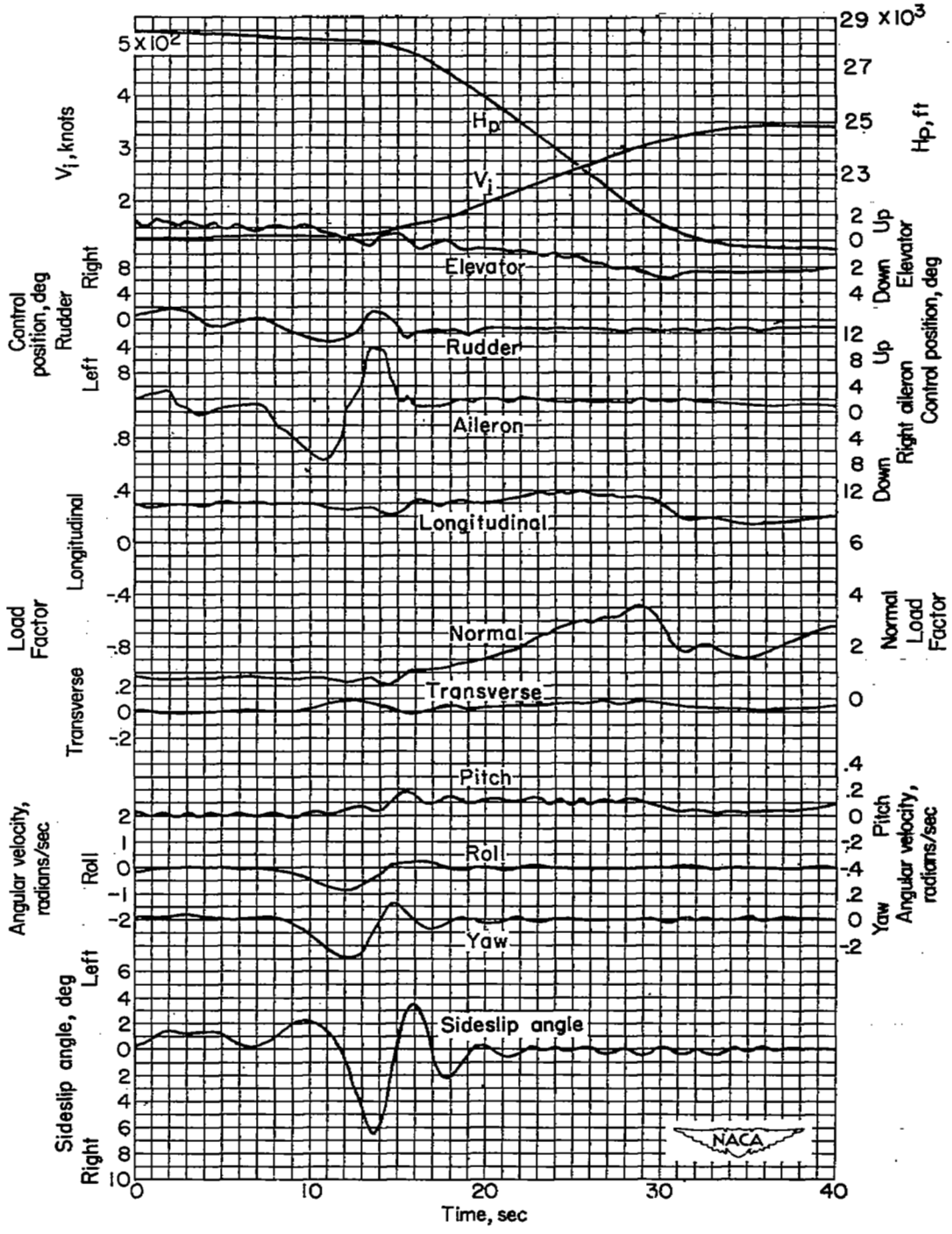

Figure 255.- Split-S; airplane weight, 17,720 pounds; center-of-gravity location, 26.7 percent of the mean aerodynamic chord.

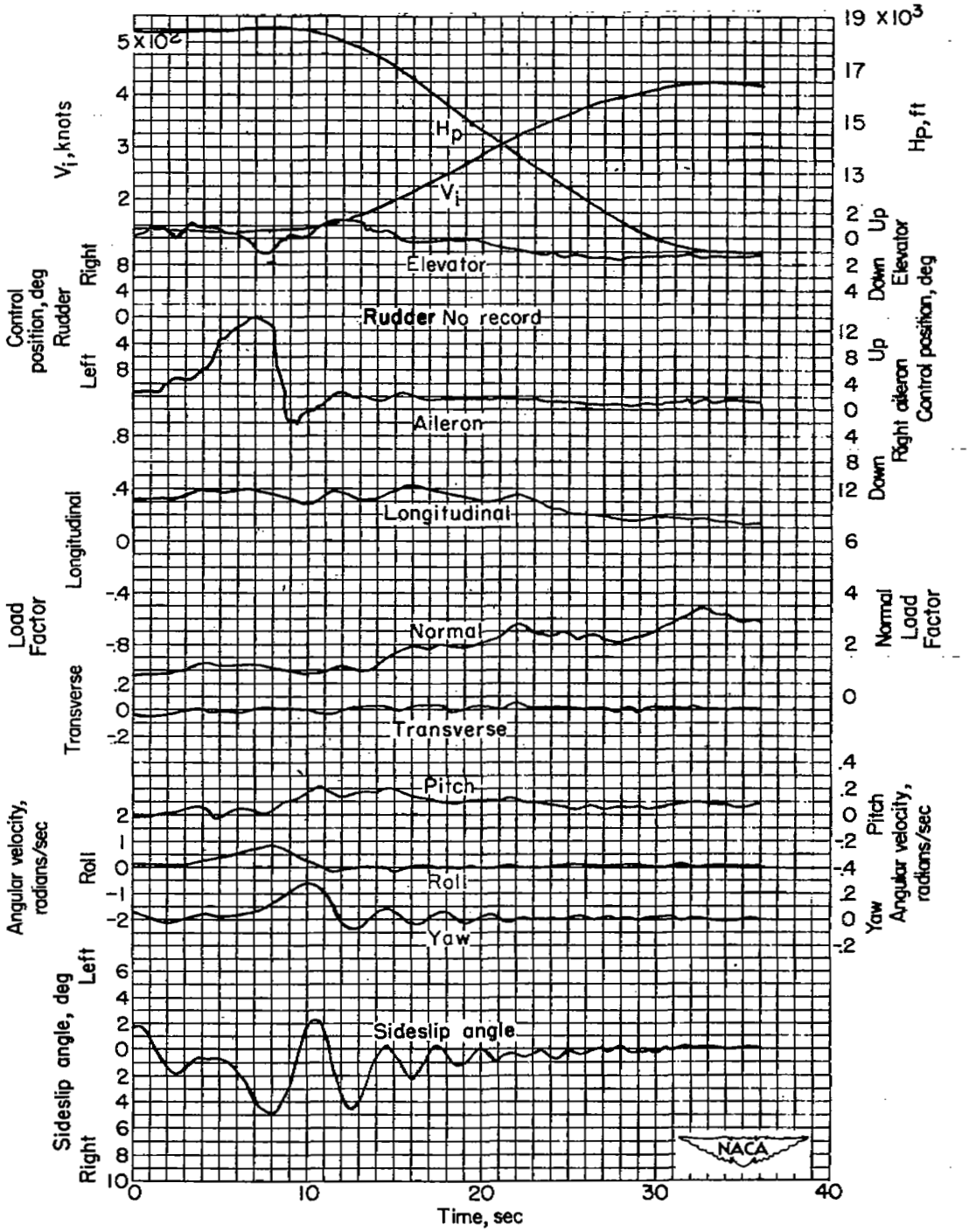

Figure 256.- Split-S; airplane weight, 17,150 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

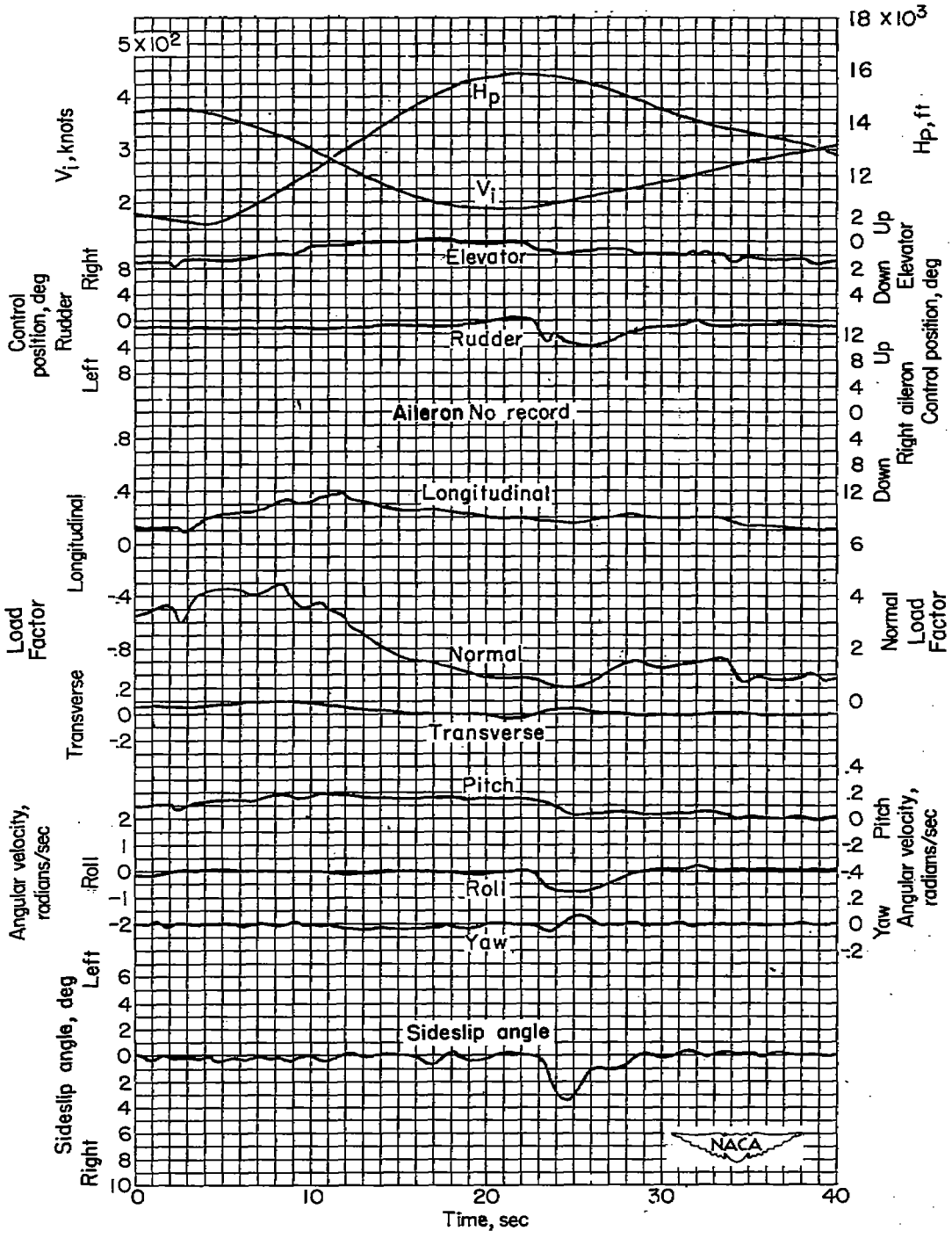

Figure 257.- Cuban eight; airplane weight, 16,090 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

[redacted]

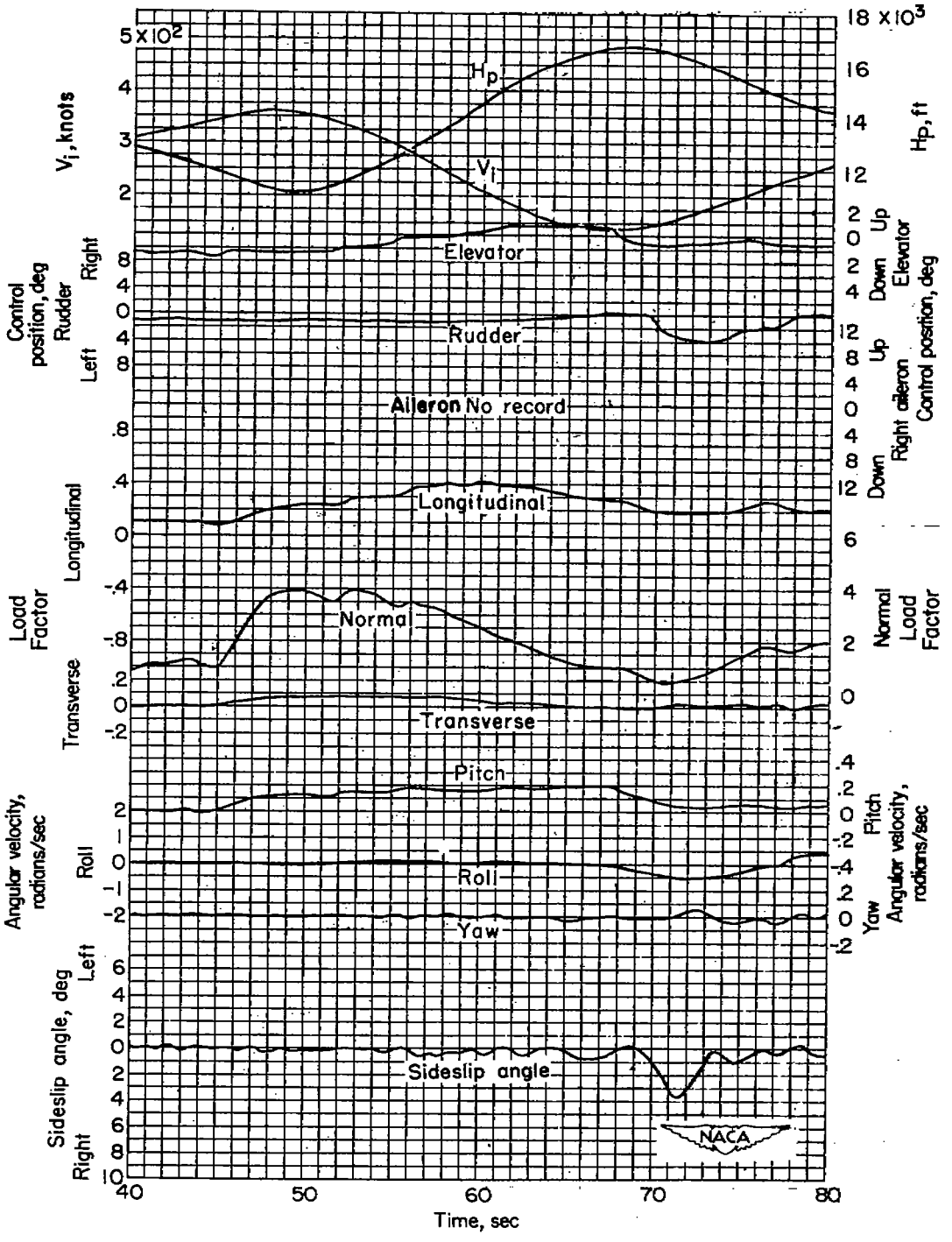

Figure 257.- Continued.

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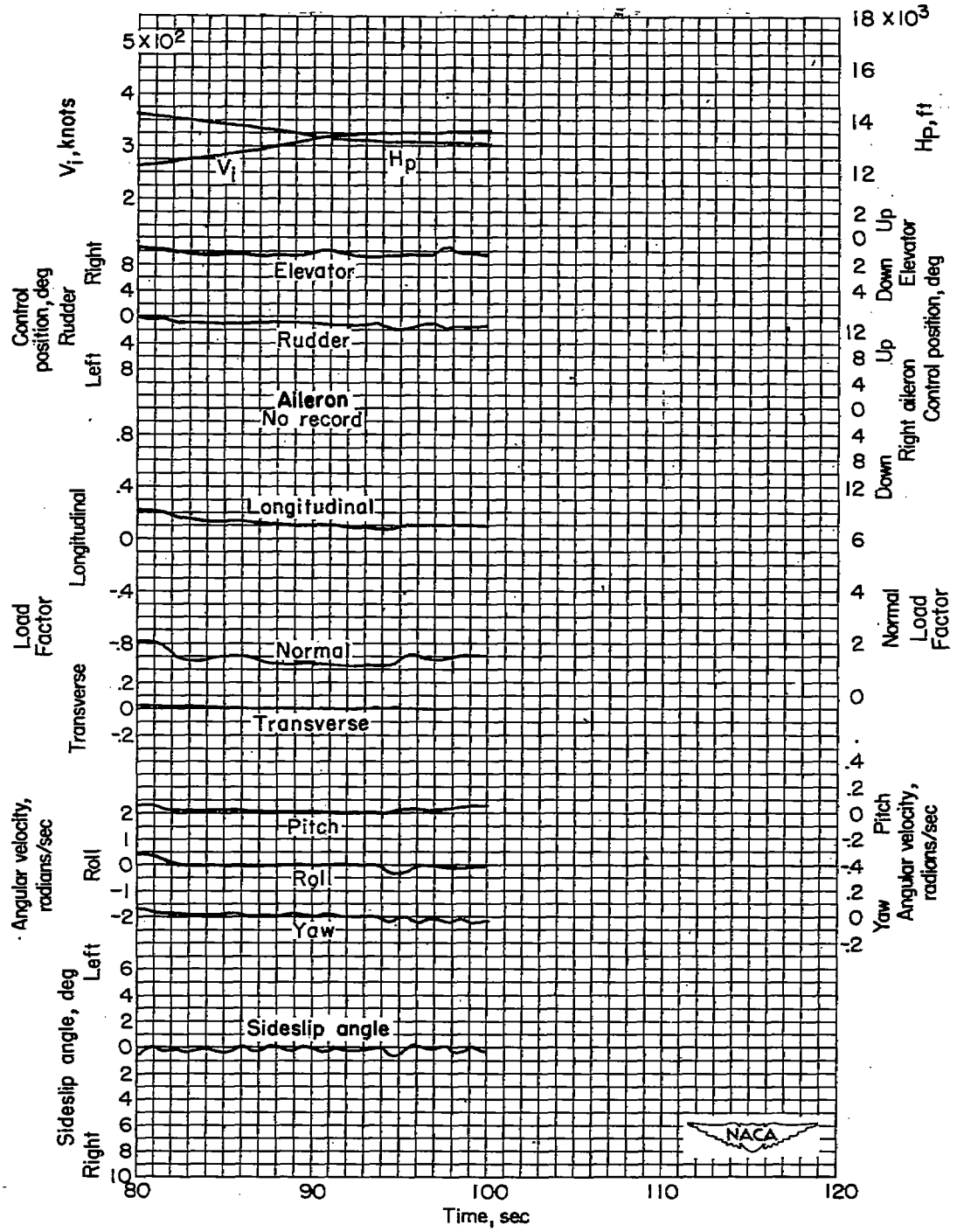

Figure 257.- Concluded.

[redacted]

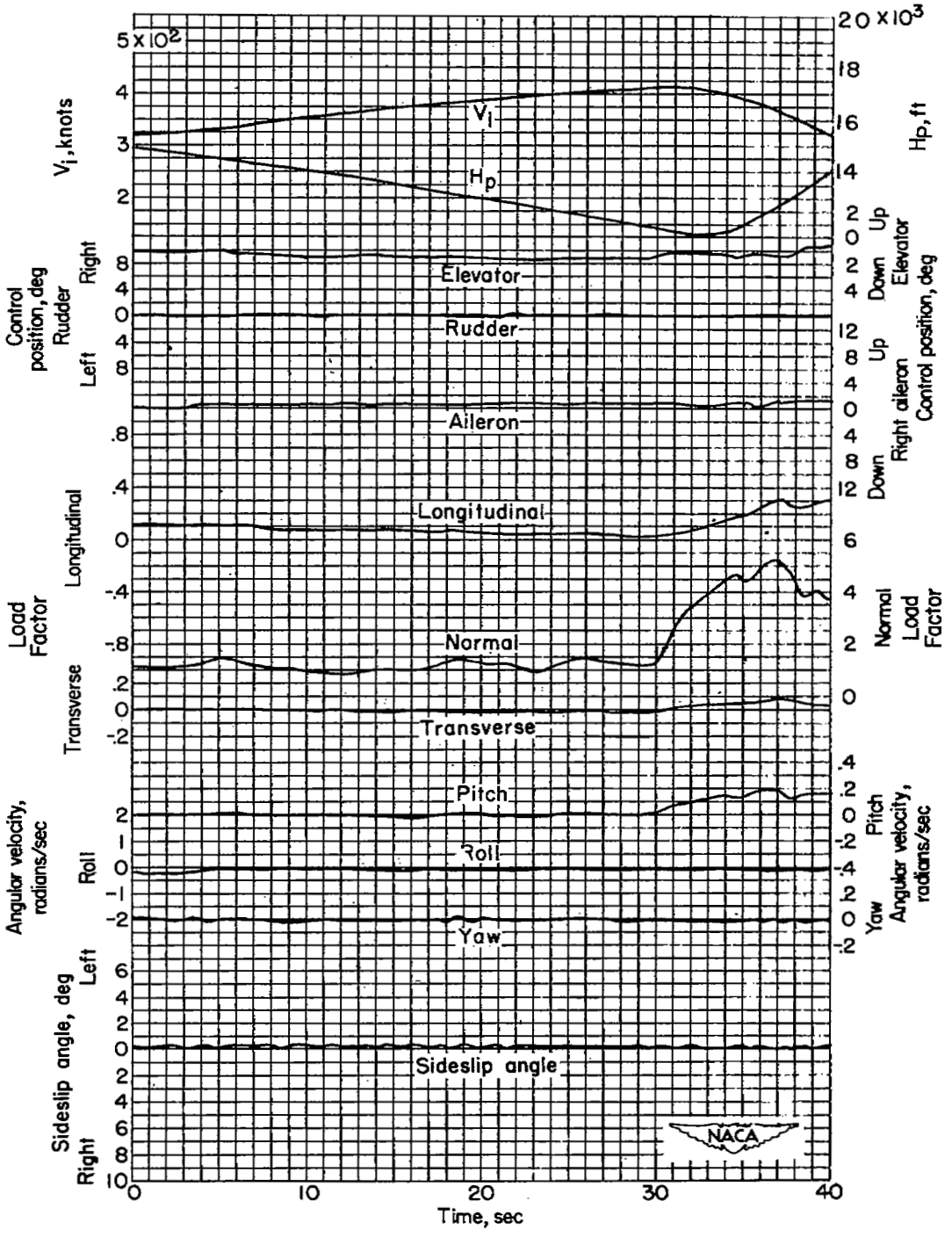

Figure 258.- Cuban eight; airplane weight, 14,270 pounds; center-of-gravity location, 26.1 percent of the mean aerodynamic chord.

9F

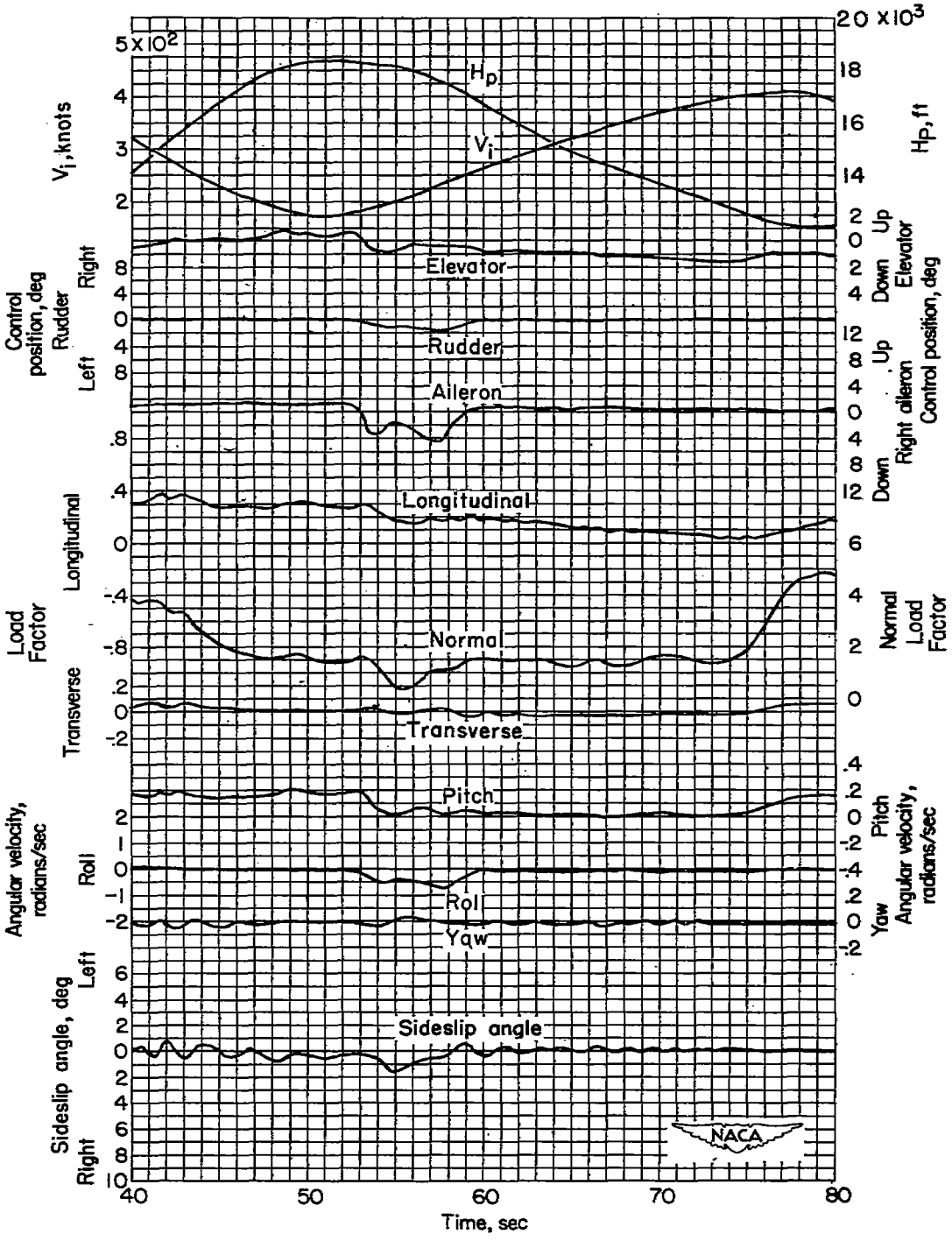

Figure 258.- Continued.

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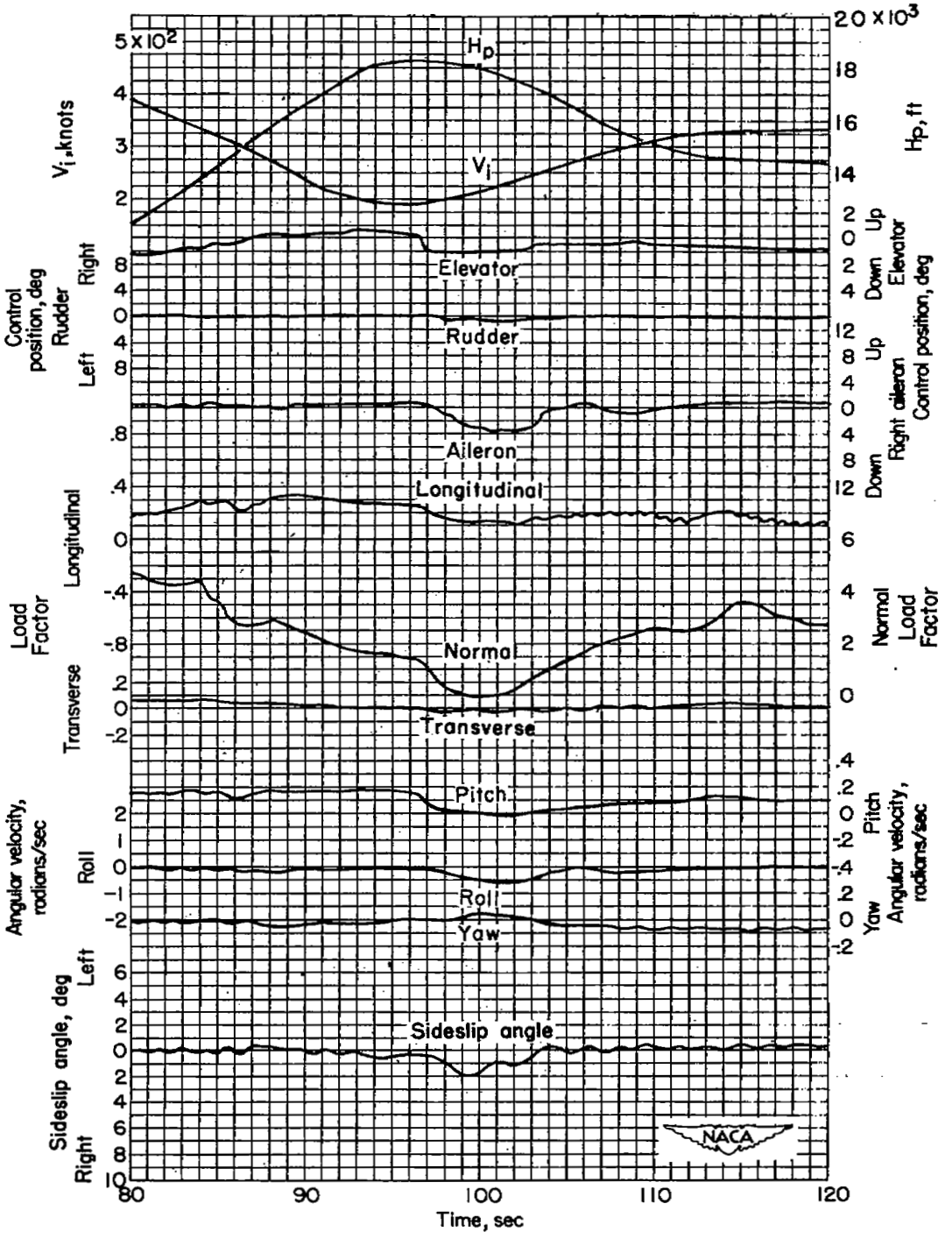


Figure 258.- Concluded.

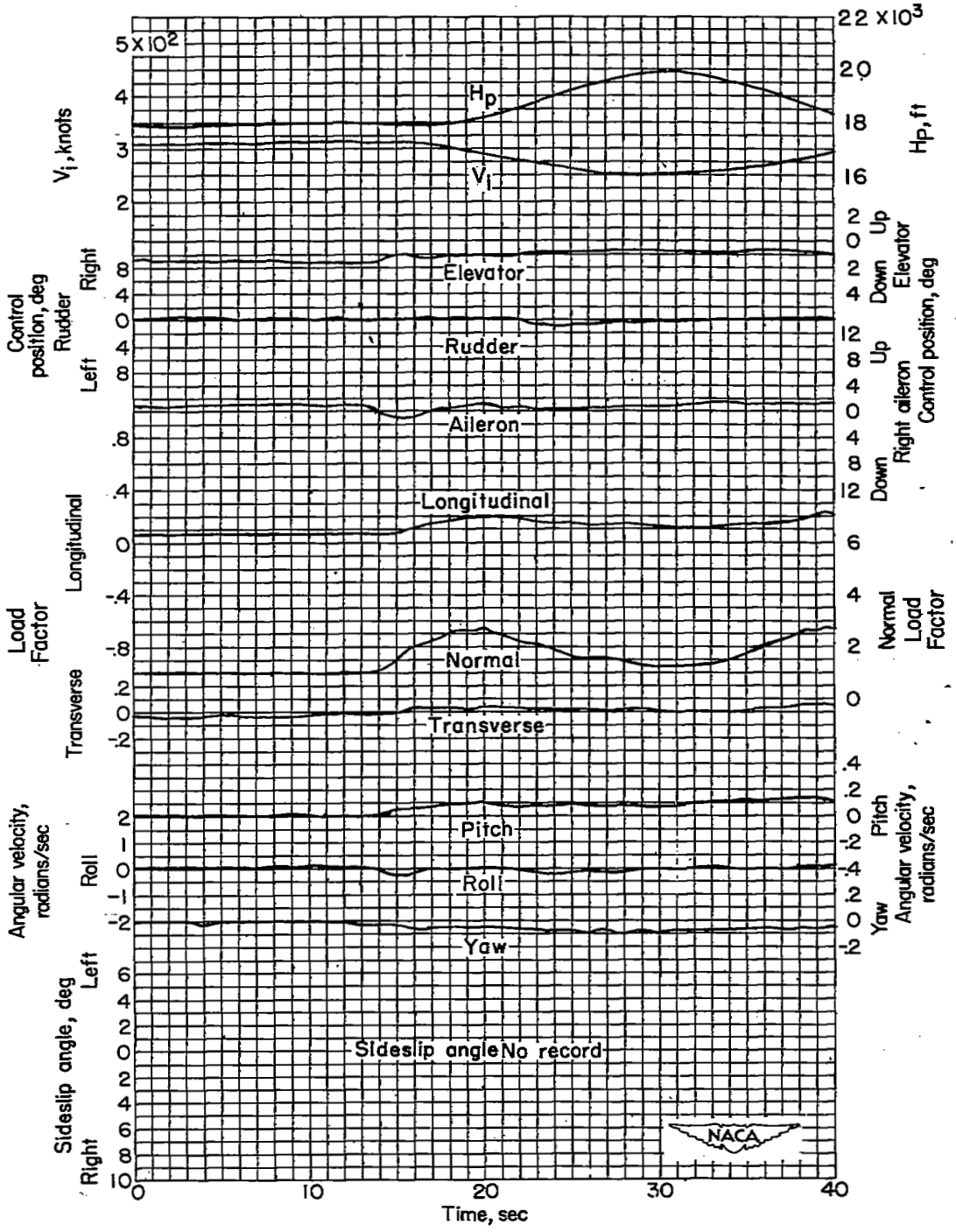


Figure 259.- Lazy eight followed by a left barrel roll; airplane weight, 16,750 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

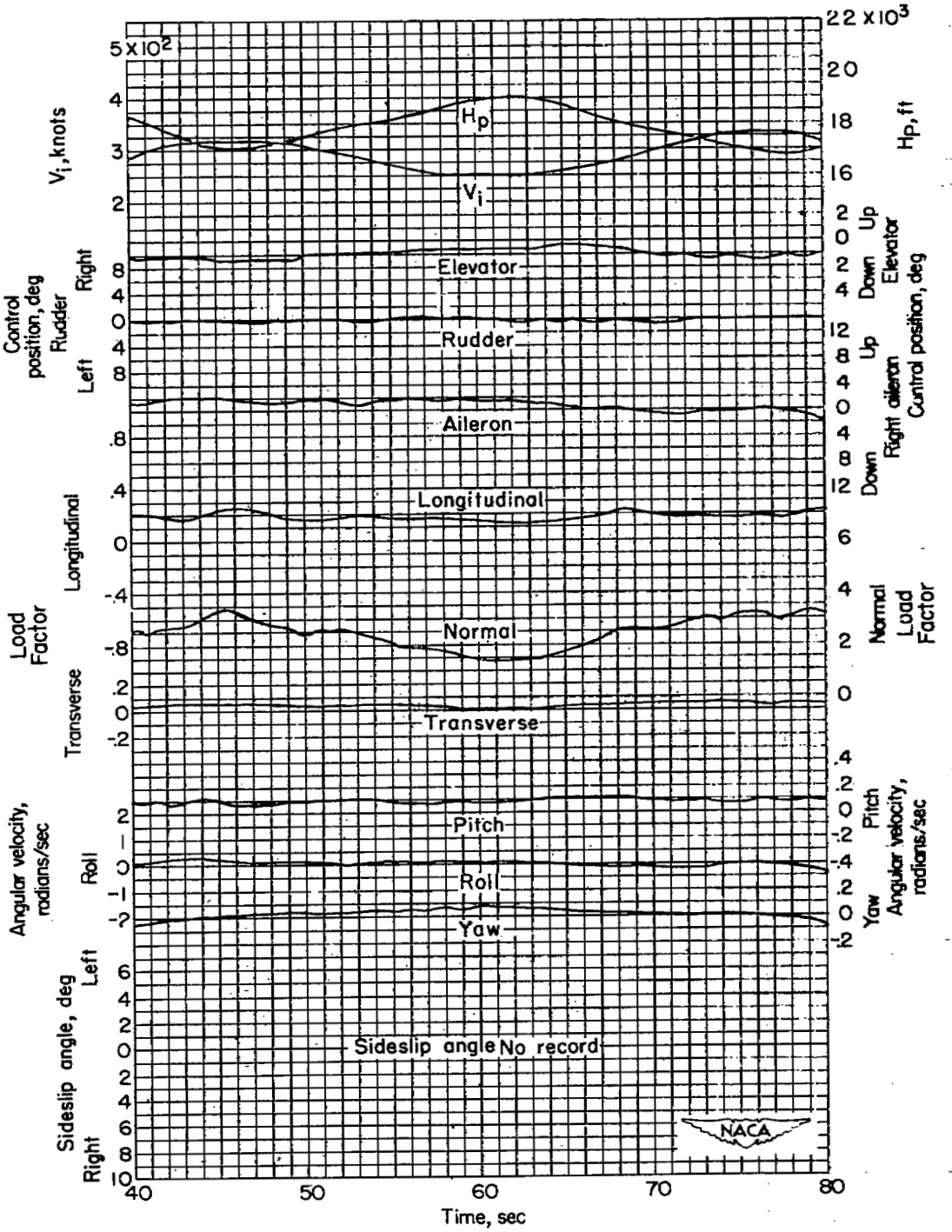
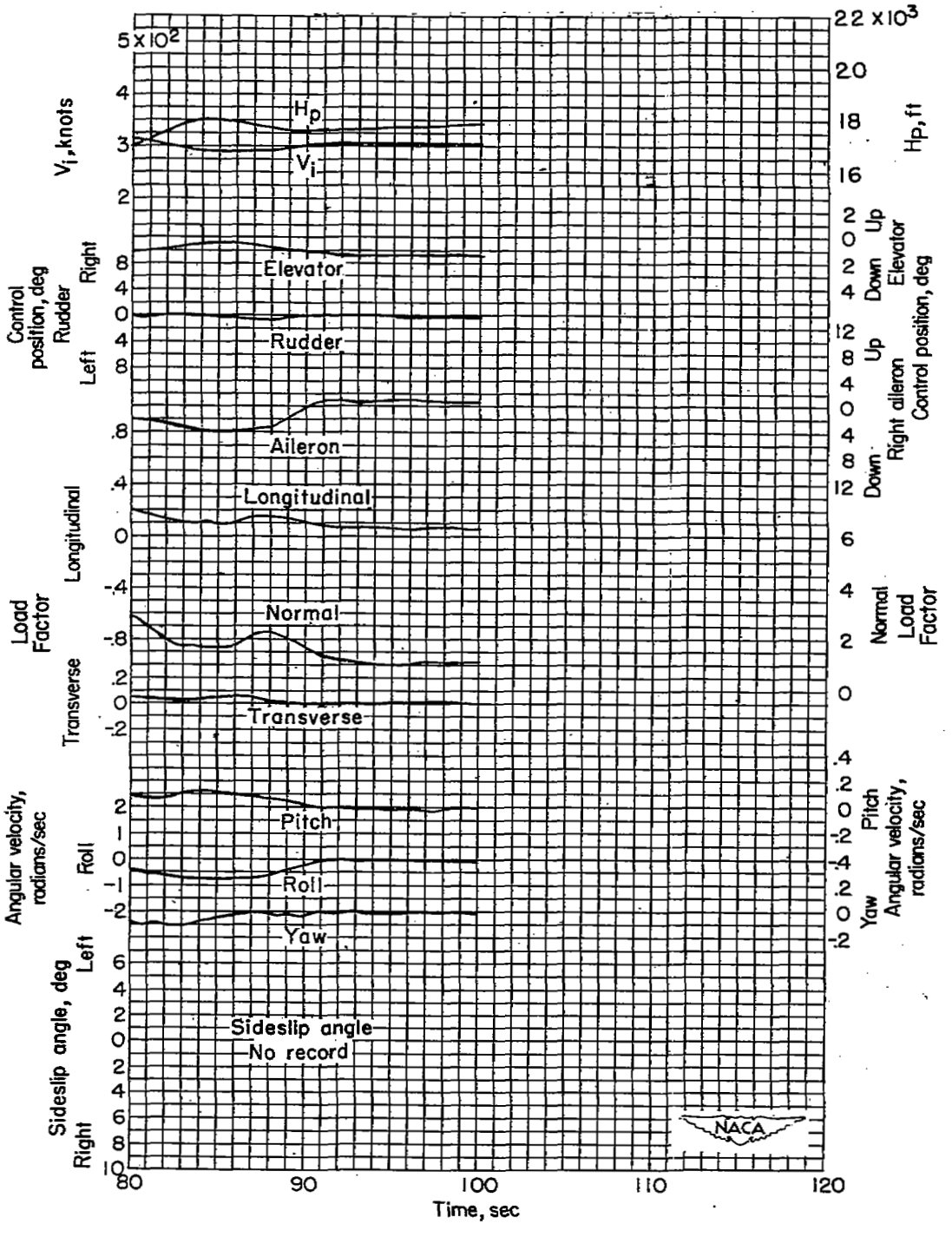


Figure 259.- Continued.



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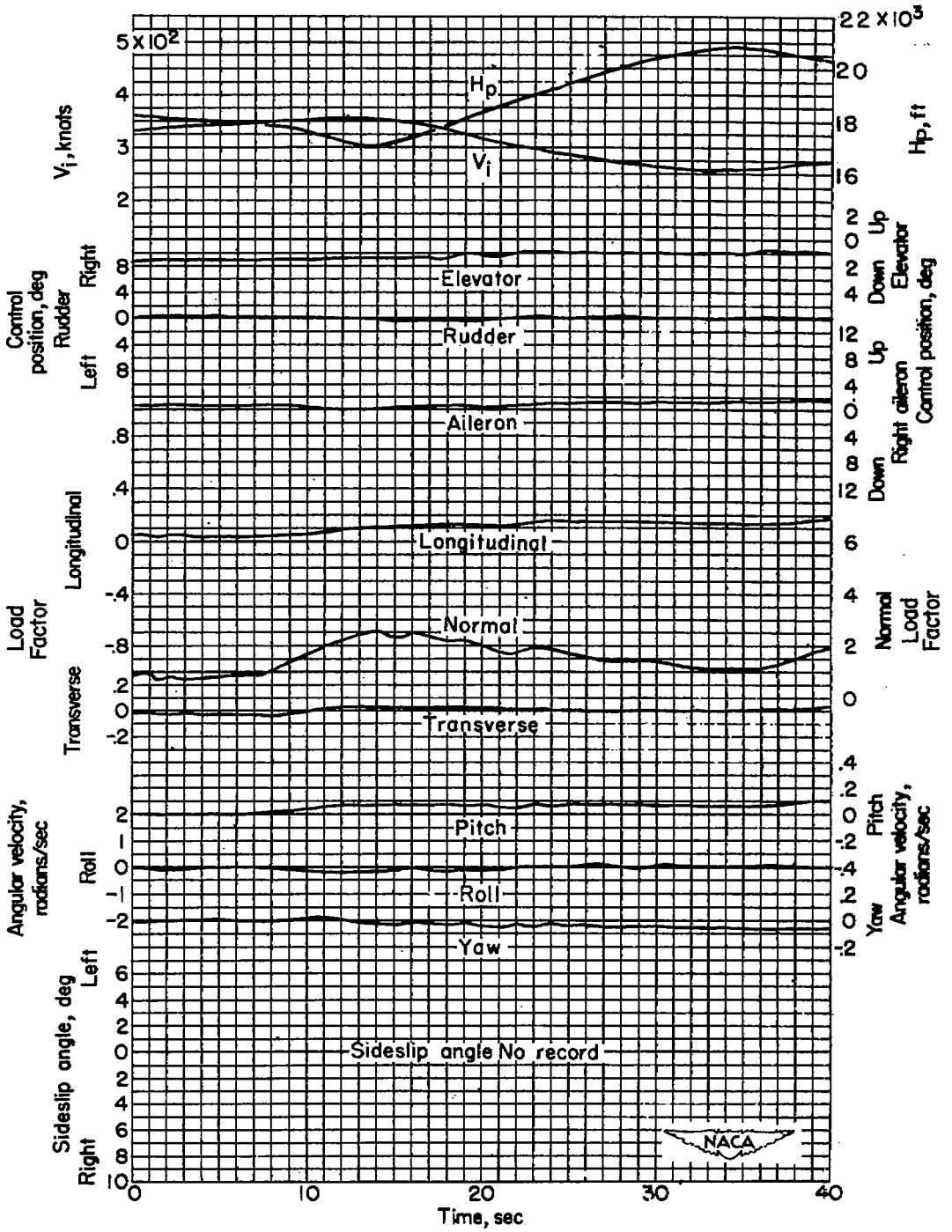

Figure 260.- Lazy eight followed by a left barrel roll; airplane weight, 14,900 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

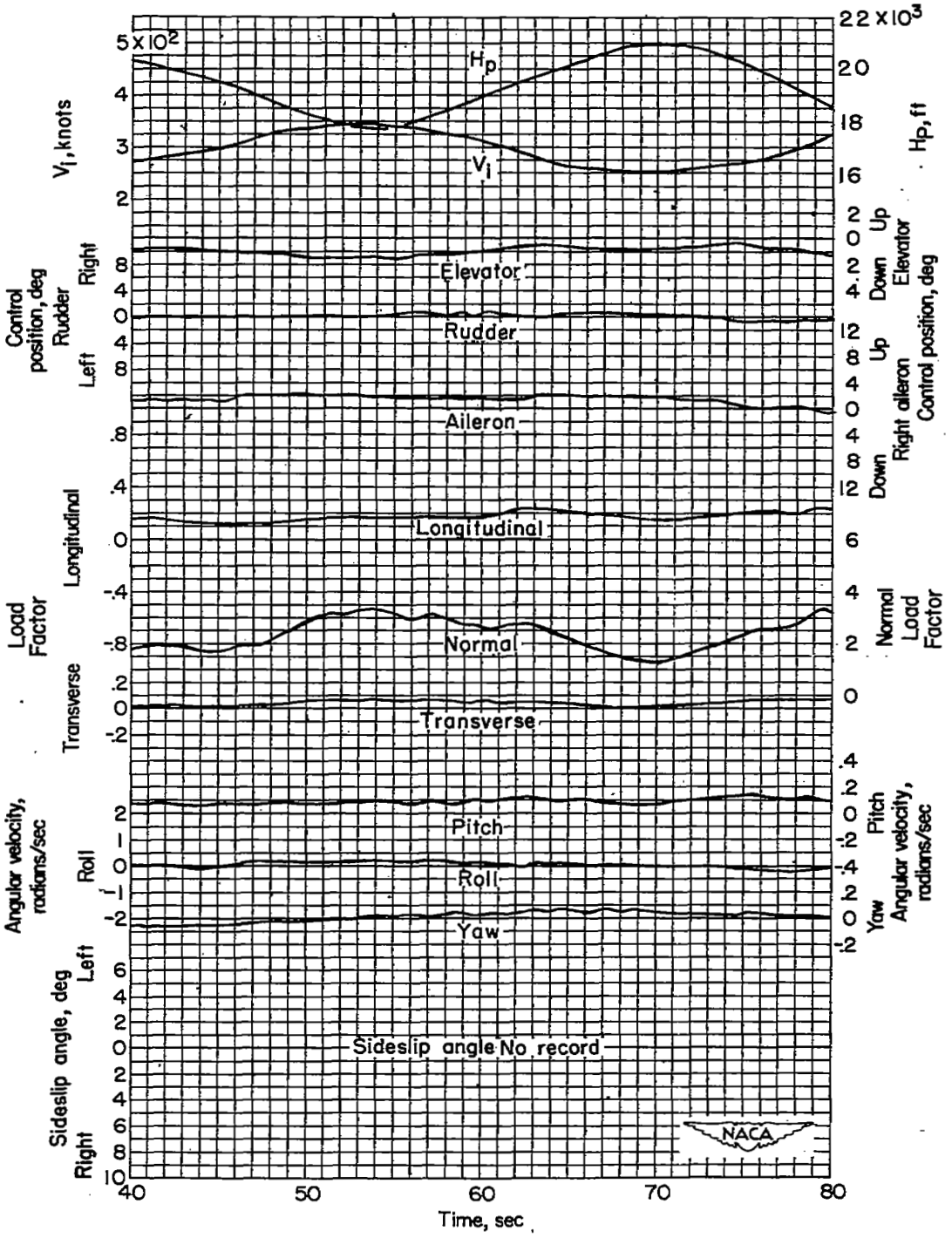

Figure 260.- Continued.

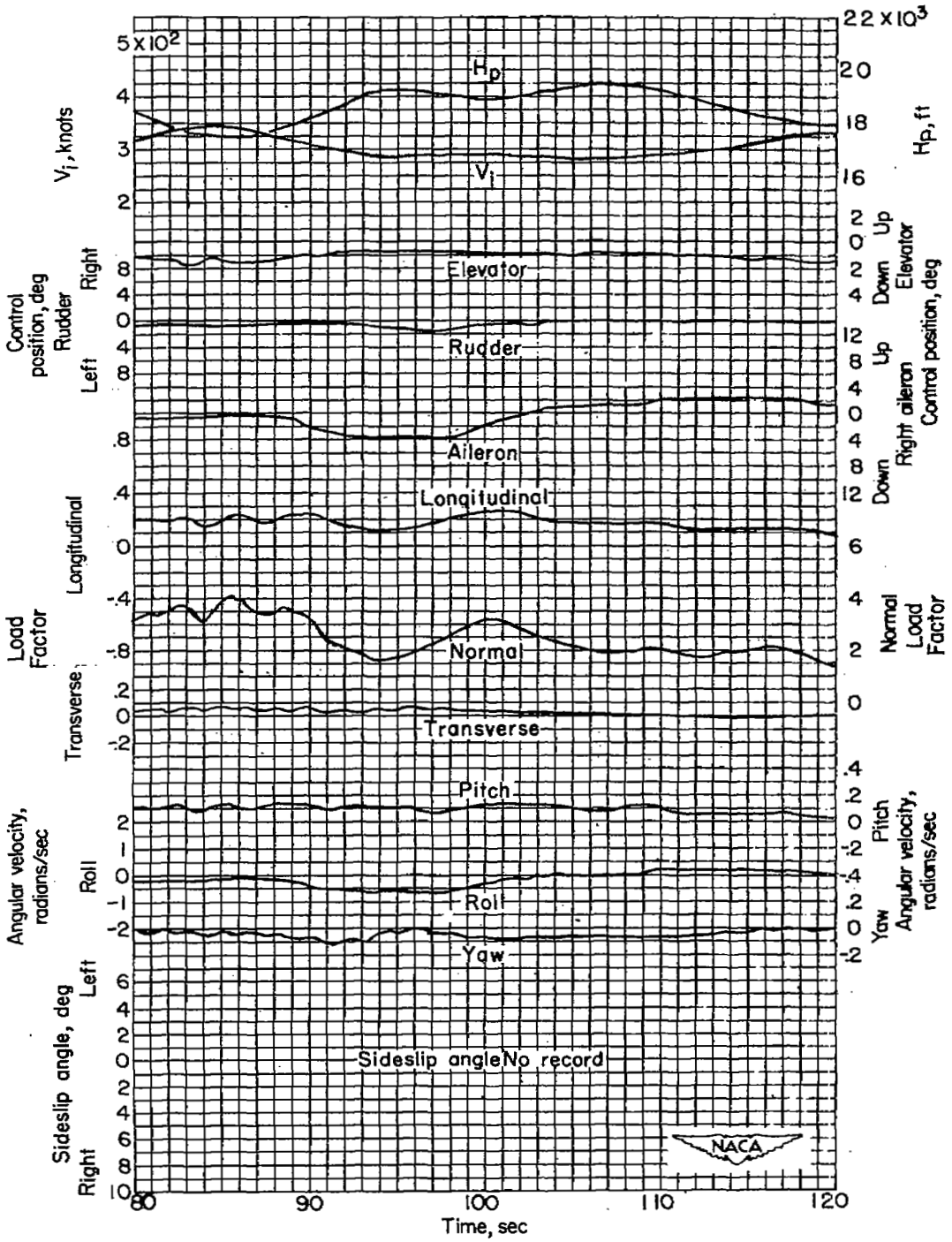

Figure 260.- Concluded.

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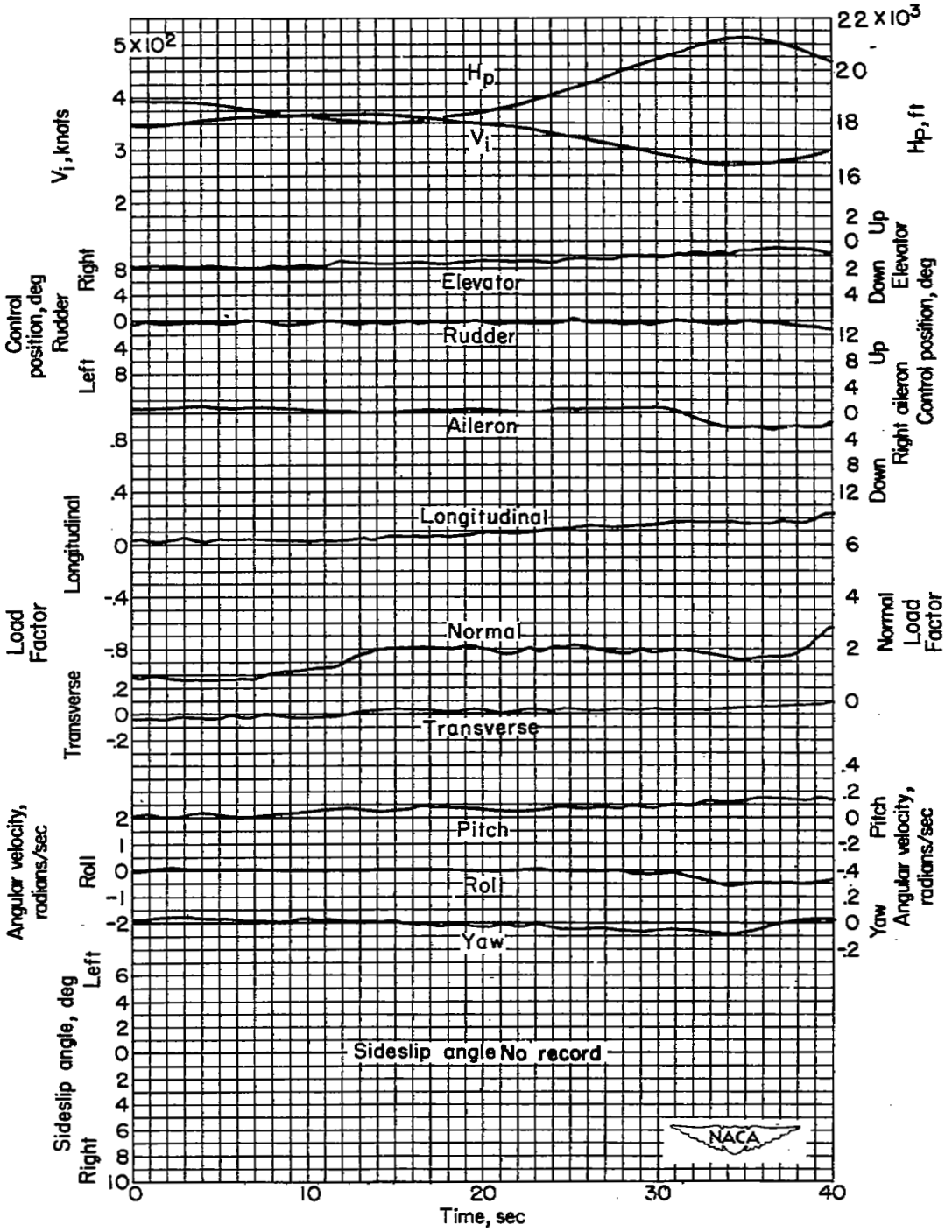
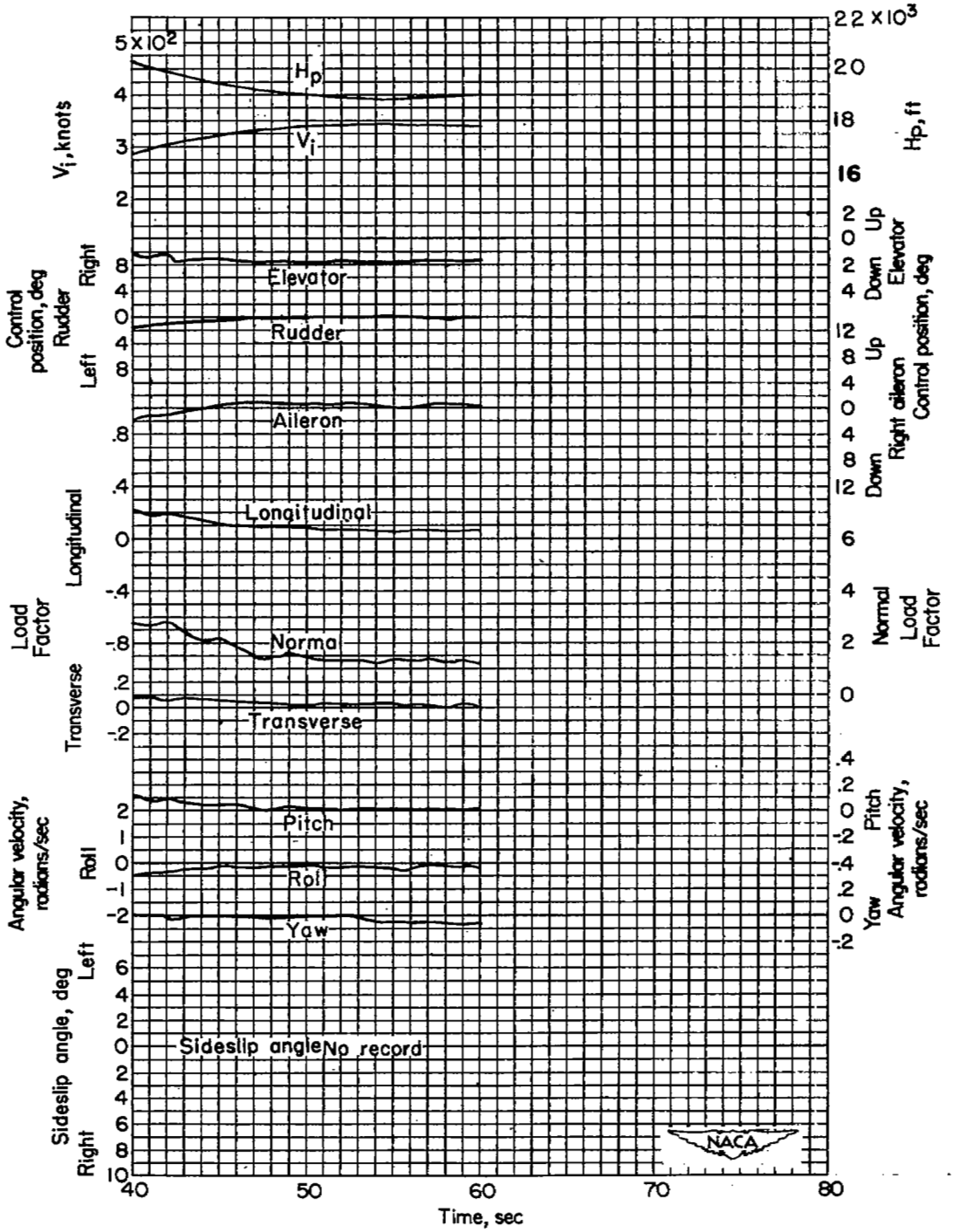


Figure 261.- Wing-over; airplane weight, 14,730 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

[redacted]



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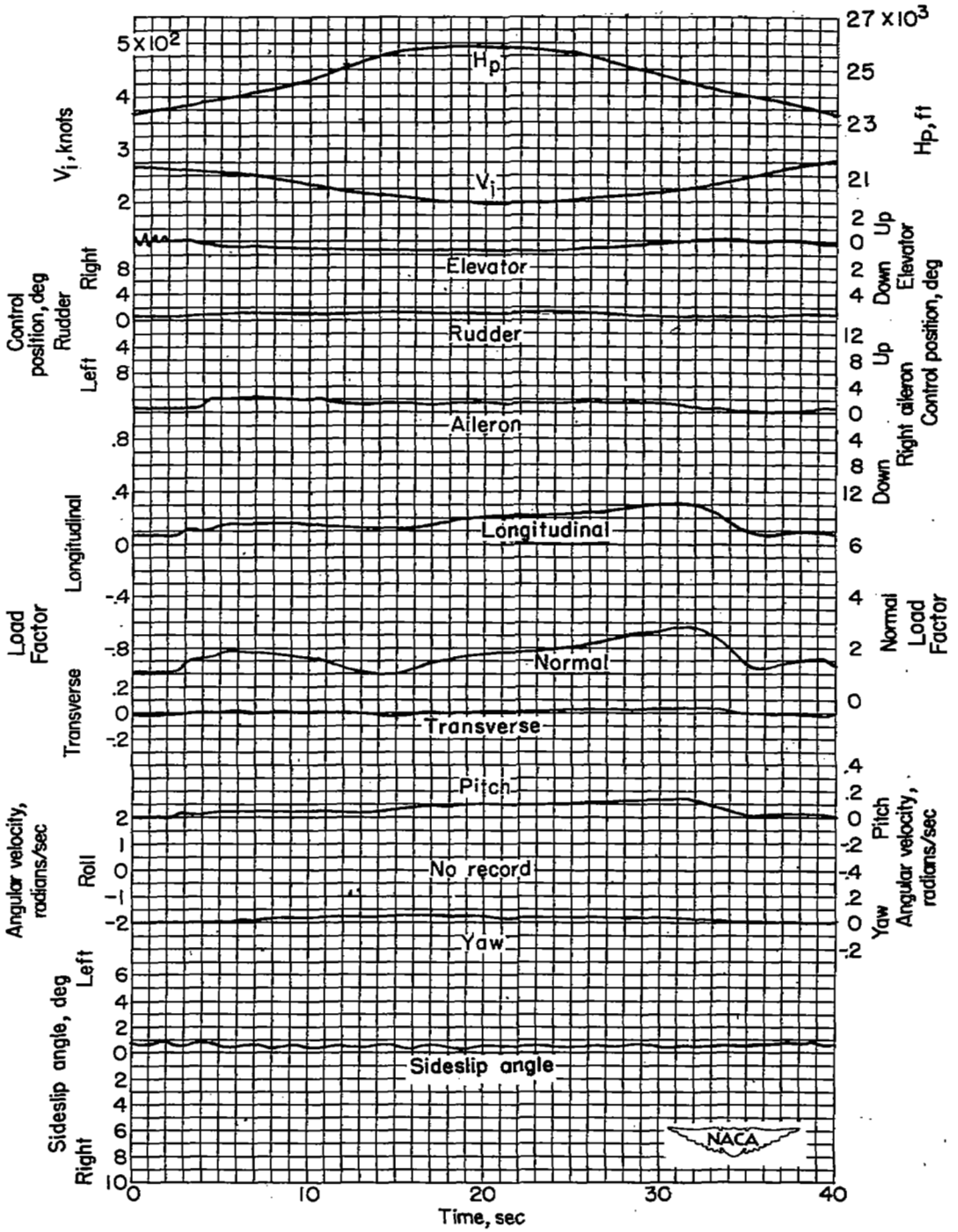

Figure 262.- Wing-over; airplane weight, 14,420 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

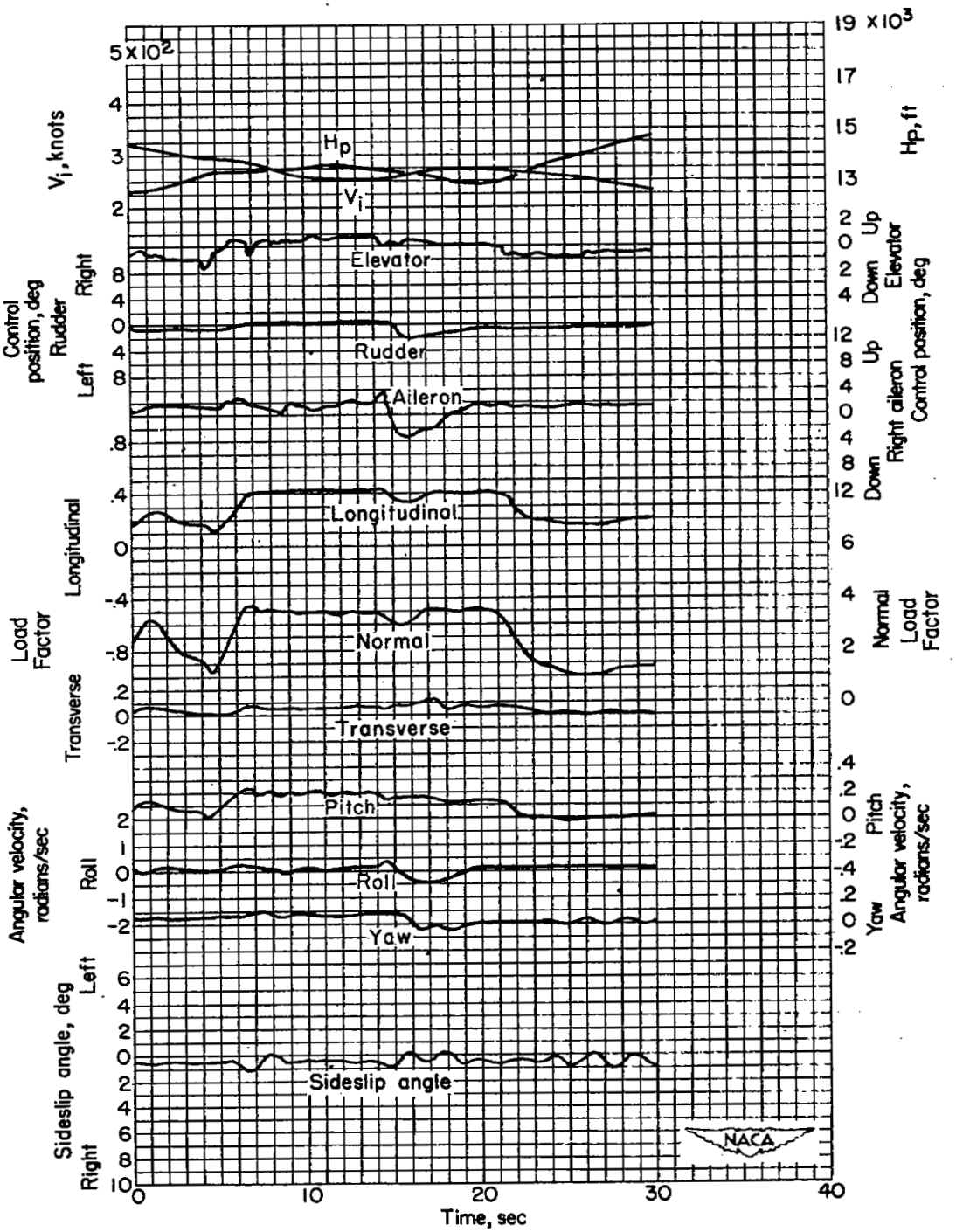

Figure 263.- Gentle wing-over preceding climb; airplane weight, 17,000 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

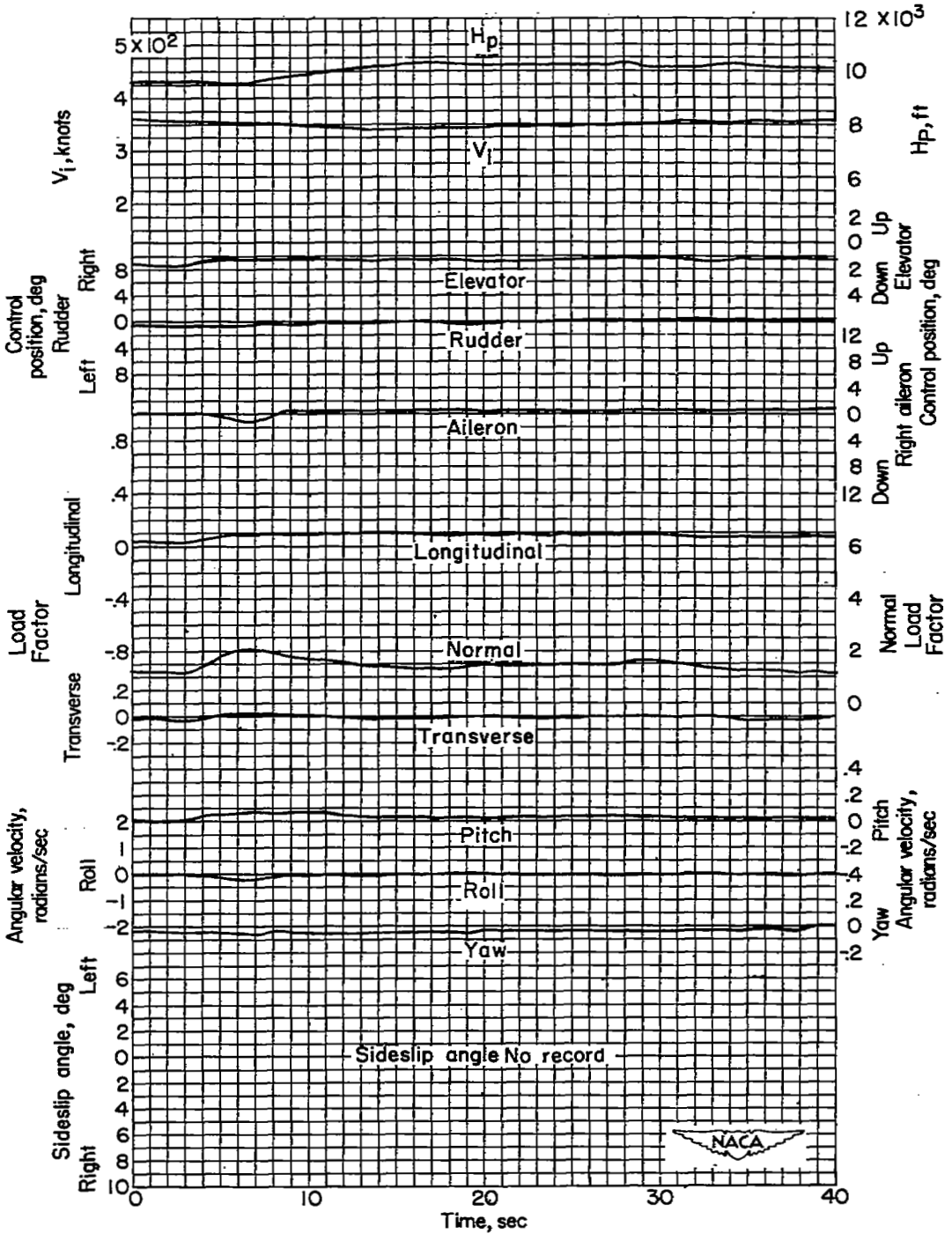

Figure 264.- Chandelle; airplane weight, 16,050 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

[redacted]

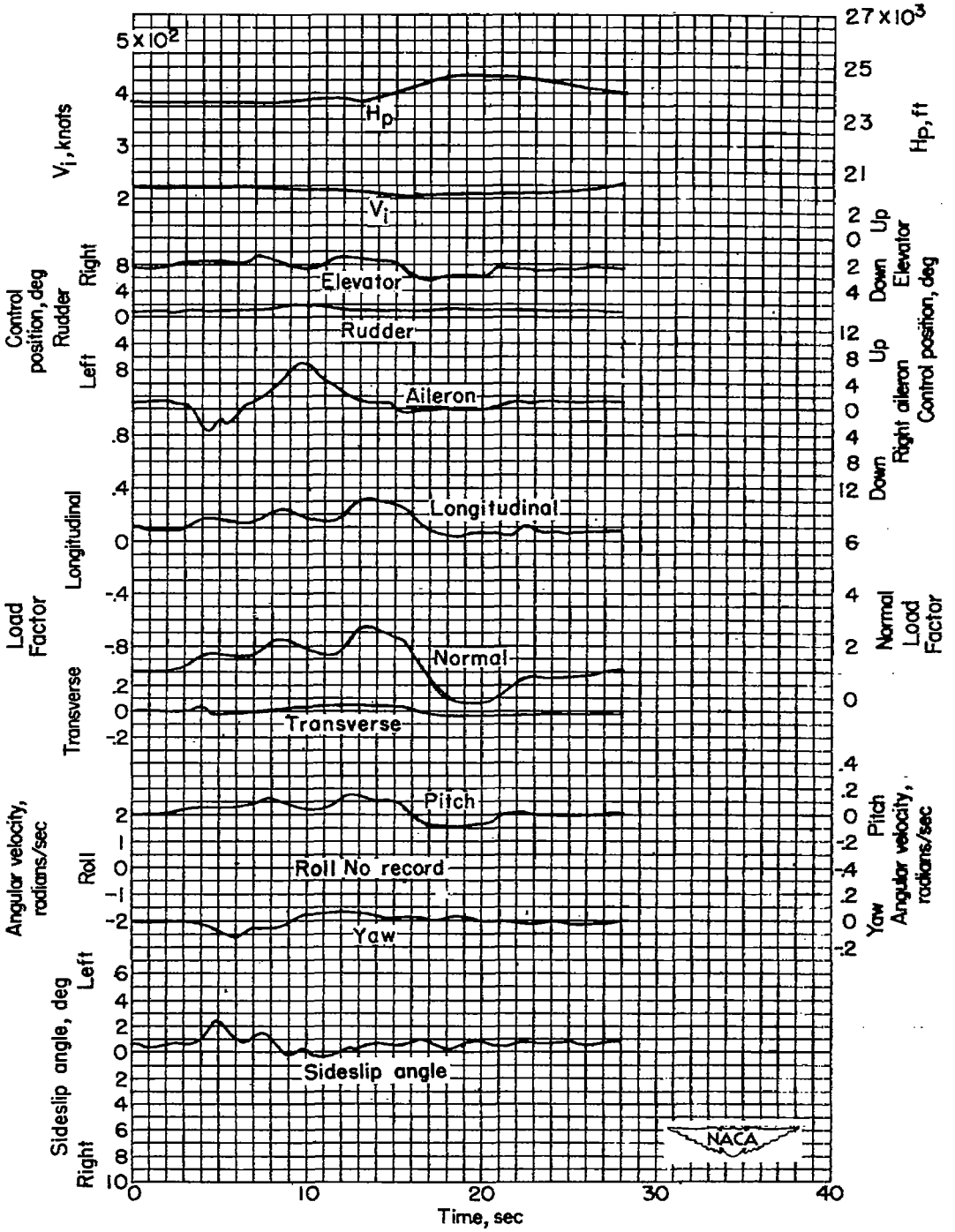

Figure 265.- Chandelle; airplane weight, 15,010 pounds; center-of-gravity location, 26.3 percent of the mean aerodynamic chord.

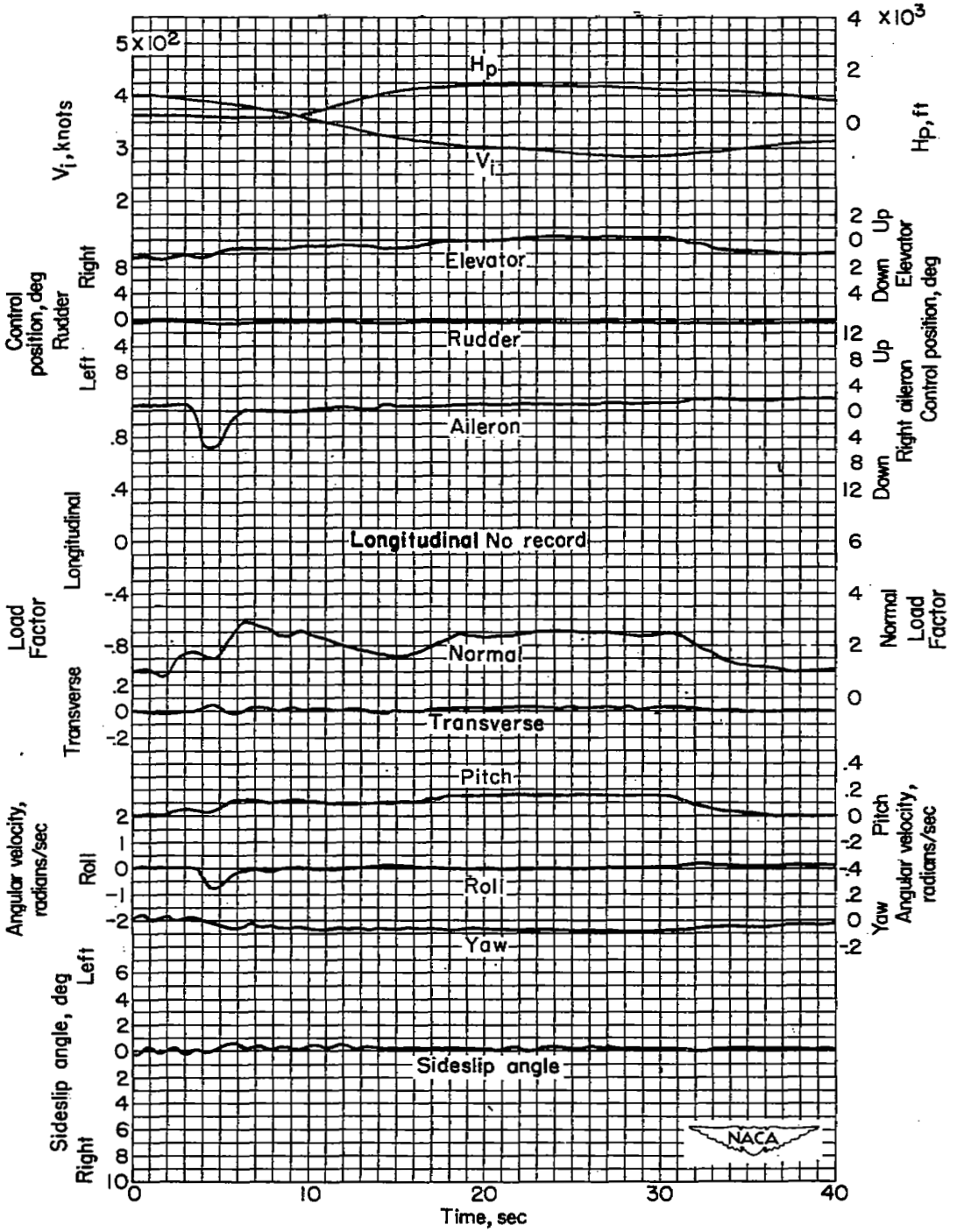

Figure 266.- Chandelle; airplane weight, 16,240 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

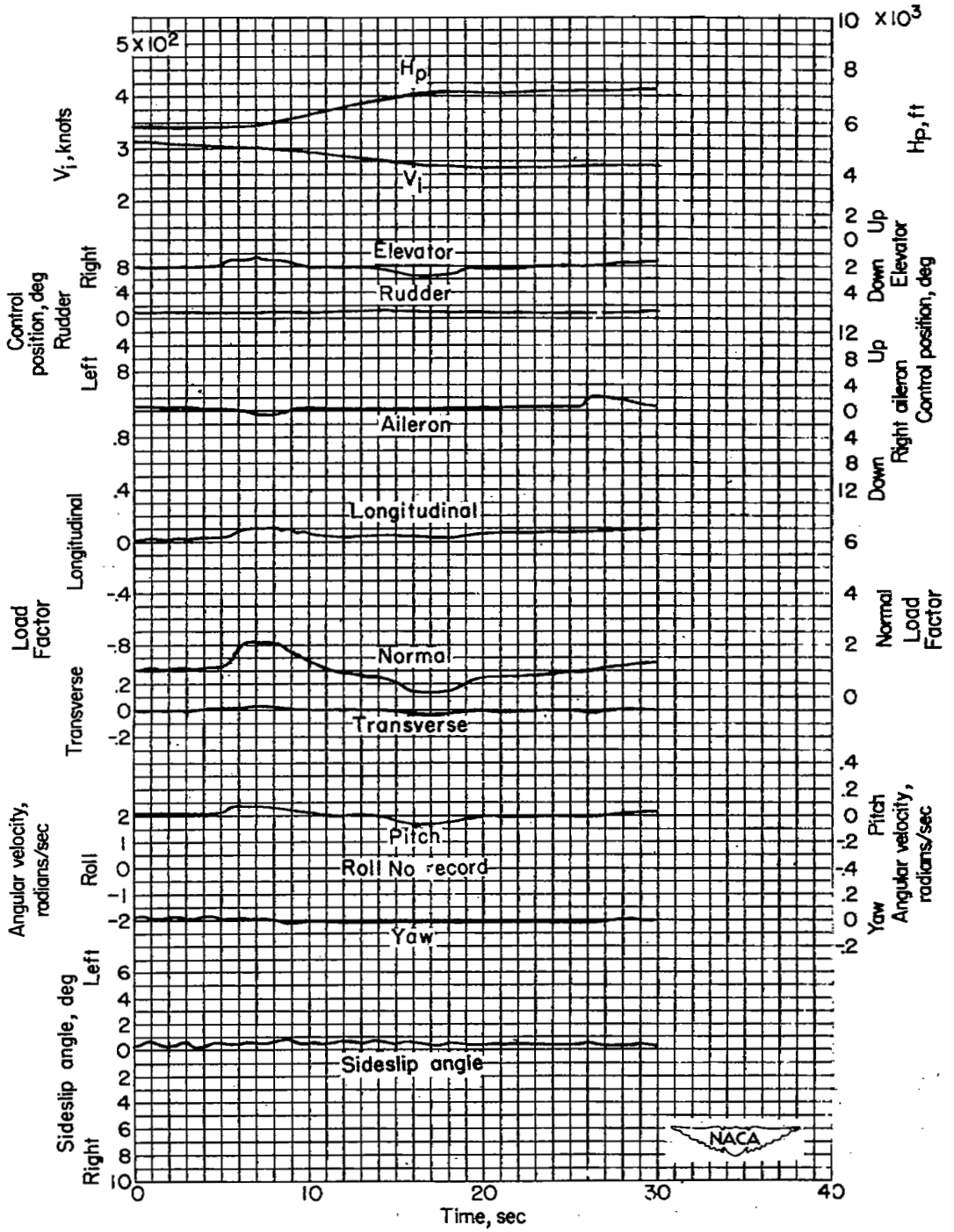

Figure 267.- Chandelle; airplane weight, 15,530 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

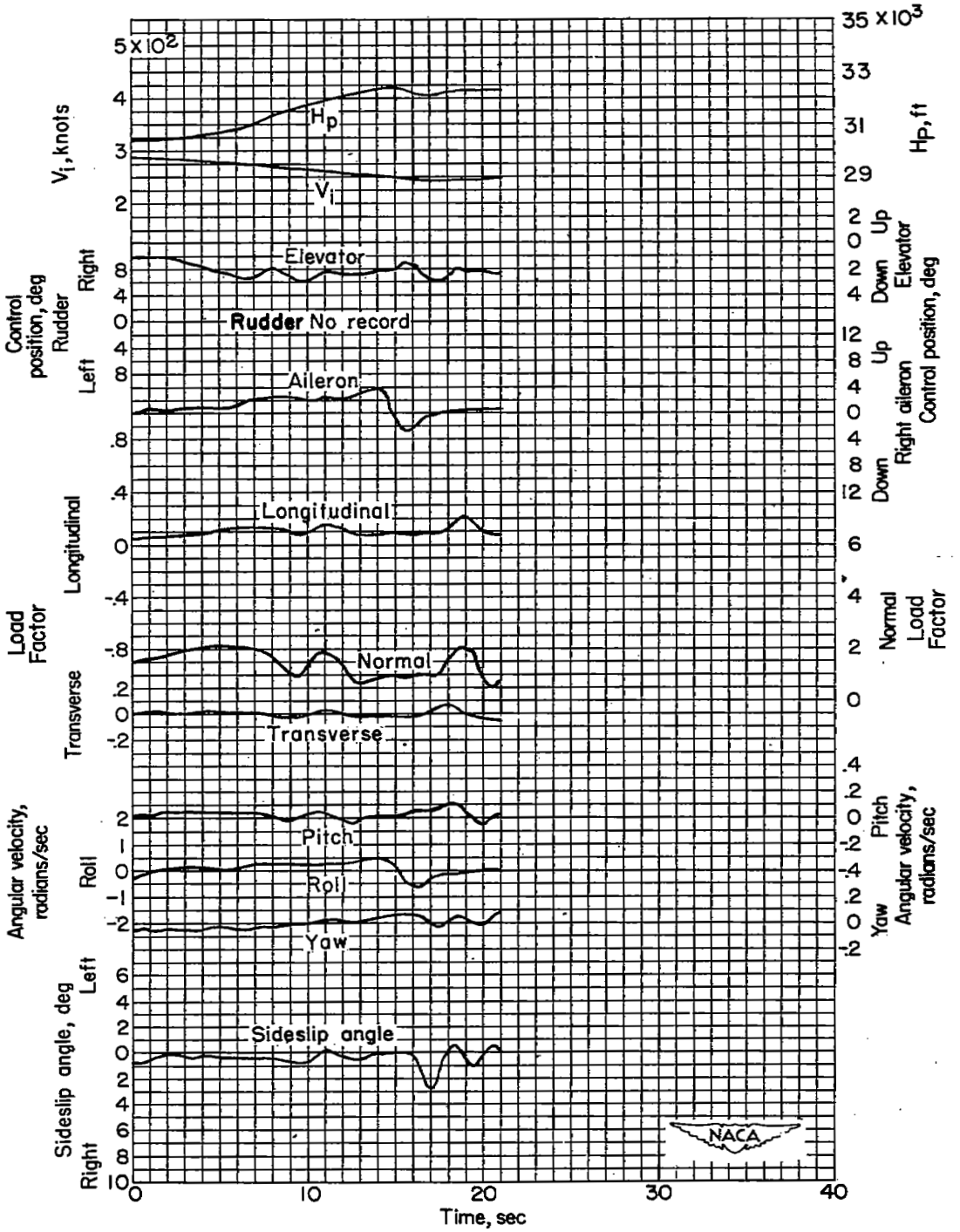

Figure 268.- Chandelle; airplane weight, 15,560 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

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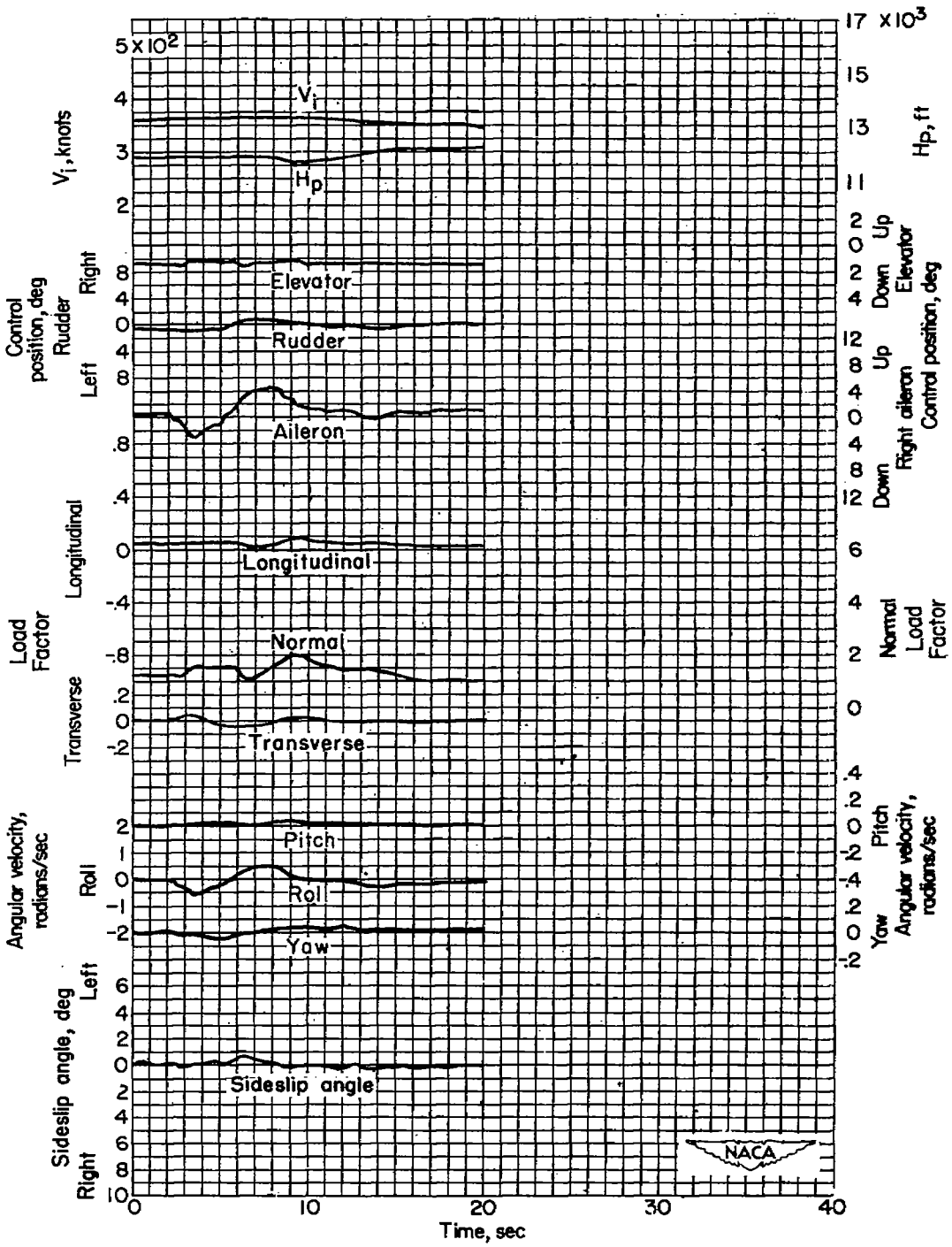

Figure 269.- Vertical reverse; airplane weight, 16,560 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

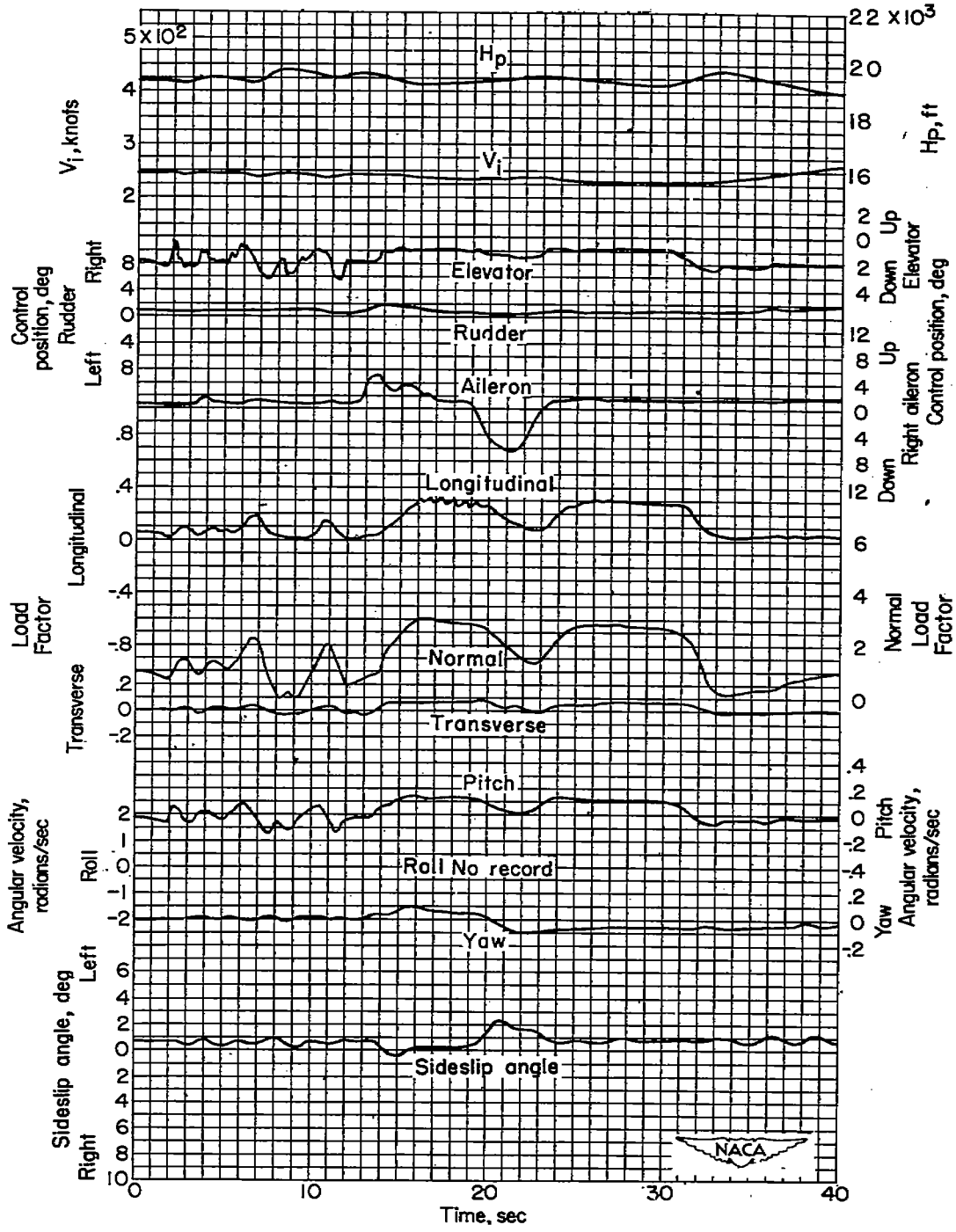

Figure 270.- Vertical reverse; airplane weight, 16,280 pounds; center-of-gravity location, 26.5 percent of the mean aerodynamic chord.

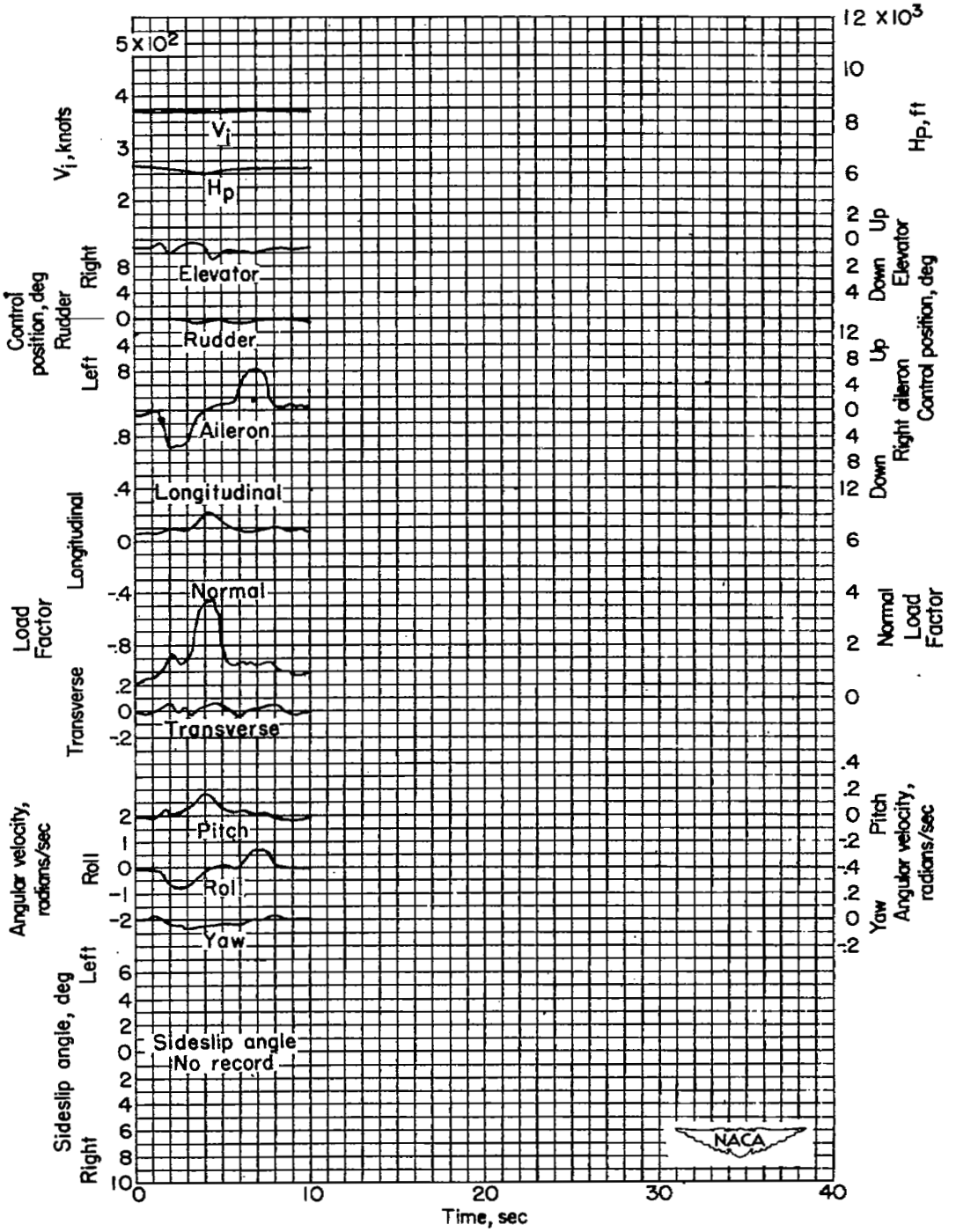

Figure 271.- Vertical reverse; airplane weight, 16,620 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

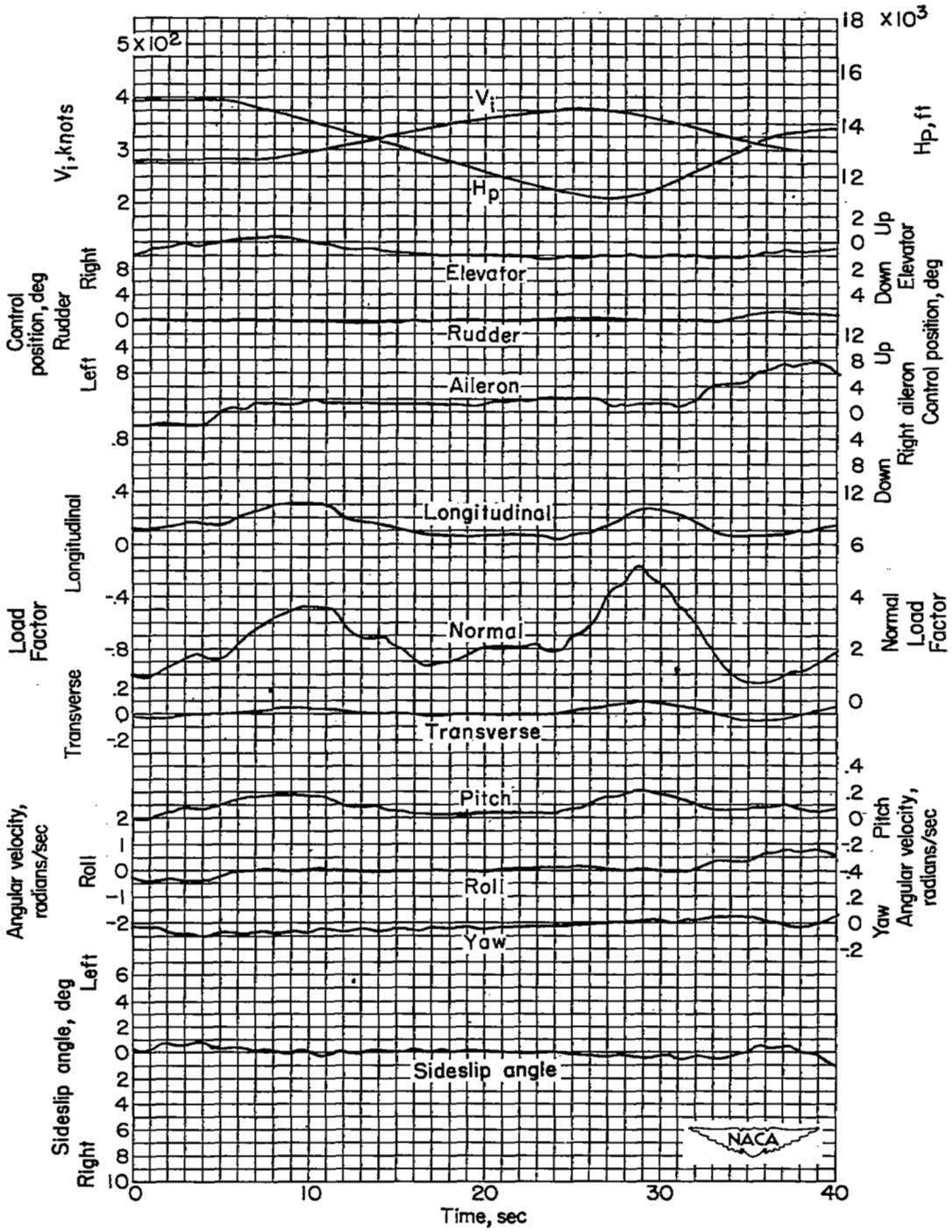

Figure 272.- Split-S into a loop with a vertical right slow roll, followed by a left slow roll; airplane weight, 14,880 pounds; center-of-gravity location, 26.2 percent of the mean aerodynamic chord.

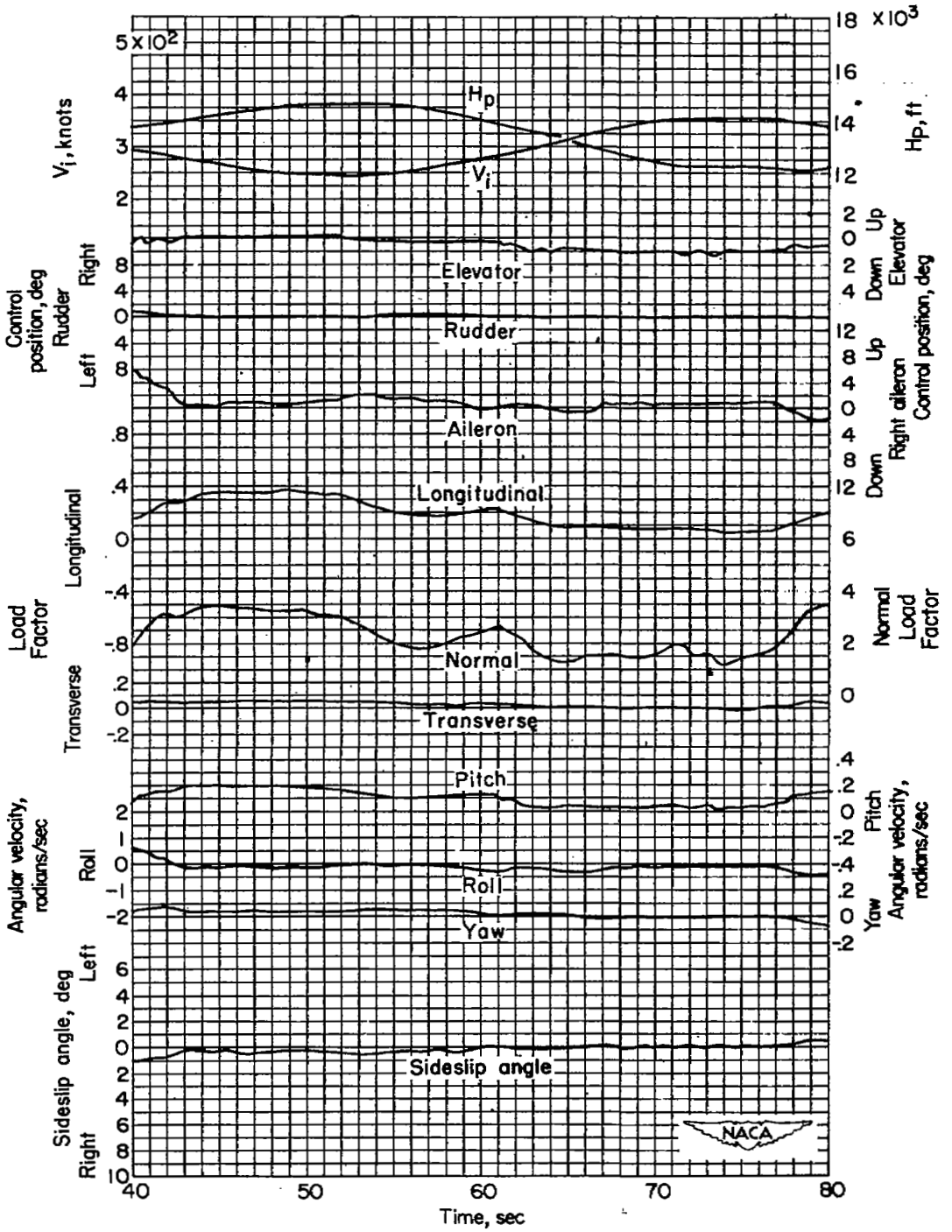

Figure 272.- Continued.

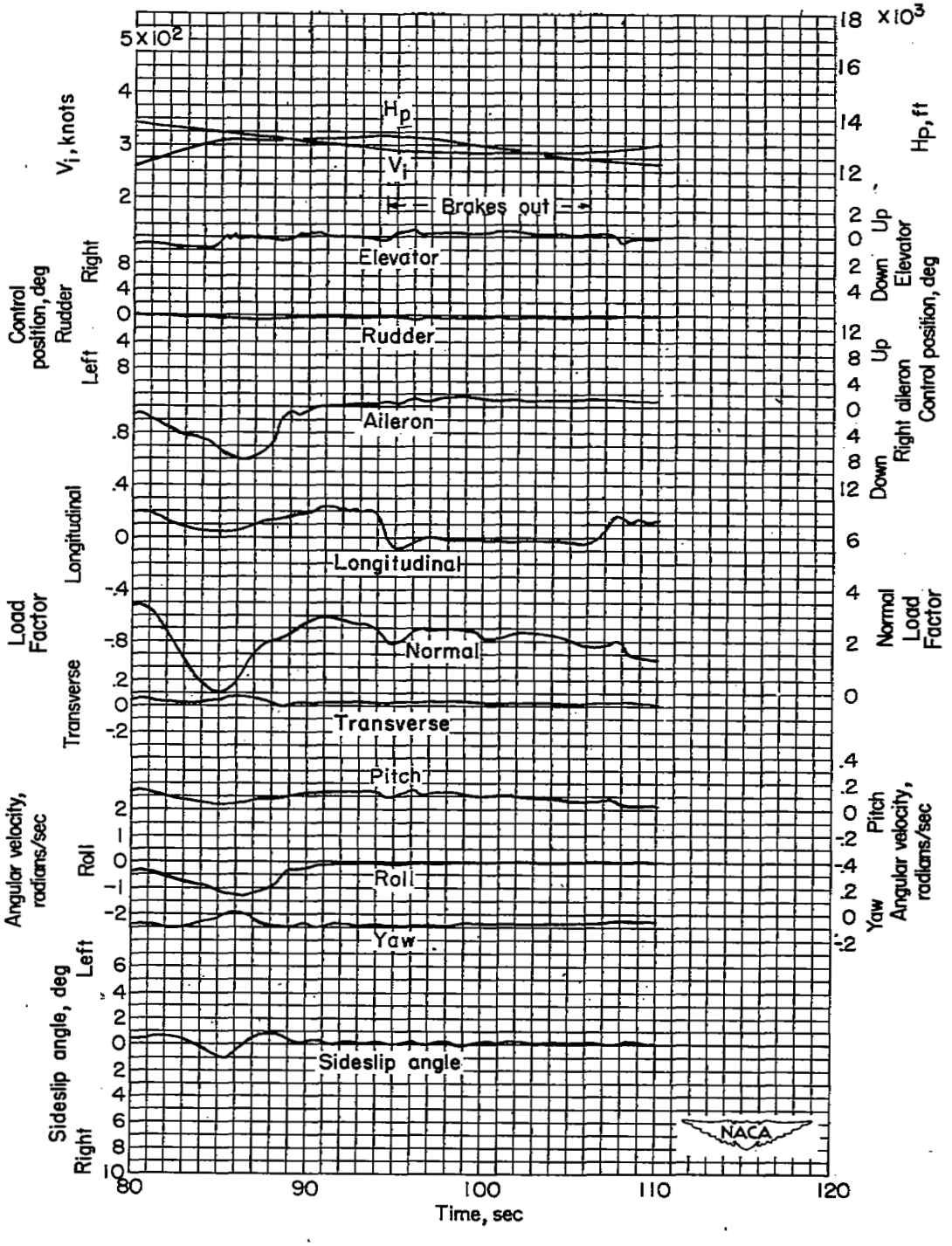

Figure 272.- Concluded.

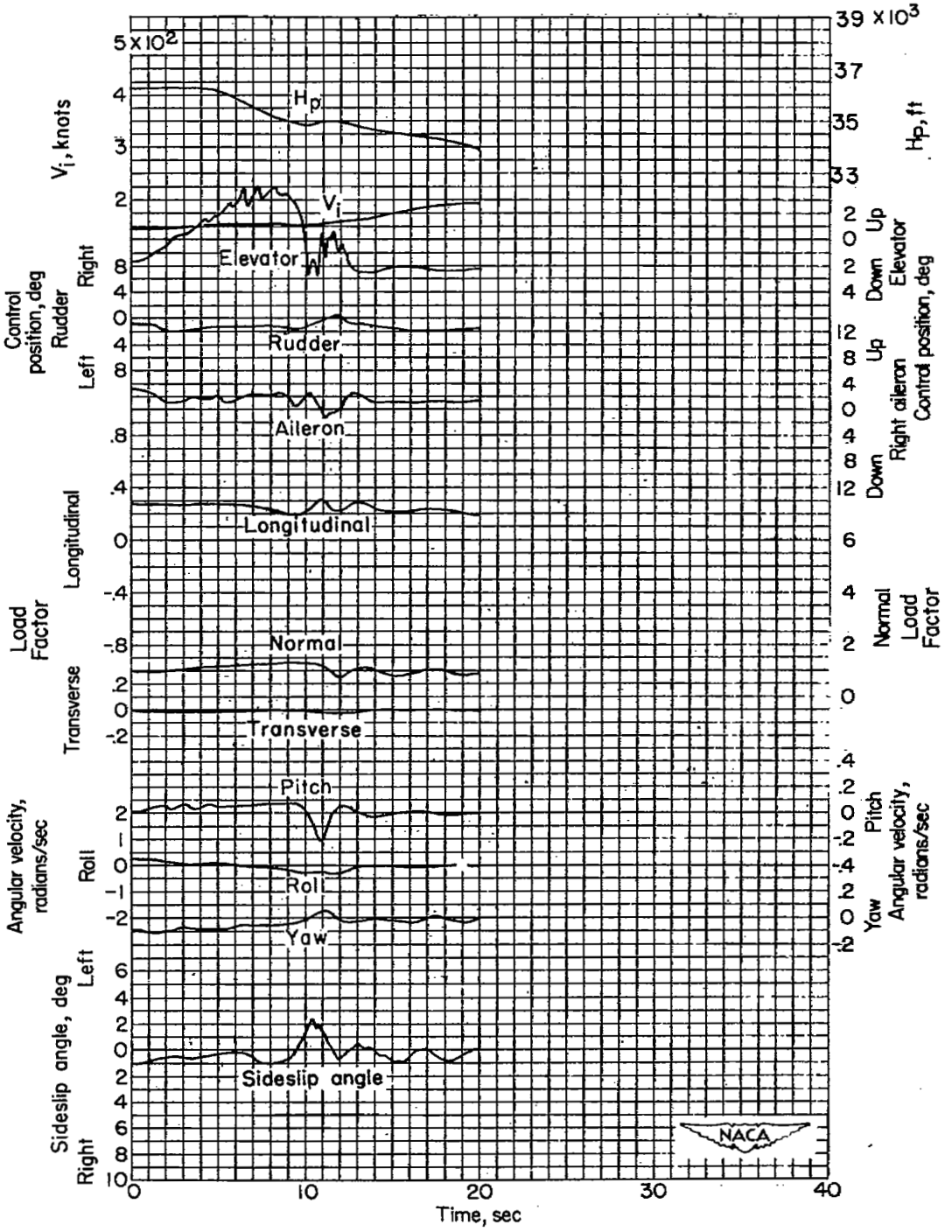

Figure 273.- Stall; airplane weight, 15,850 pounds; center-of-gravity location, 26.4 percent of the mean aerodynamic chord.

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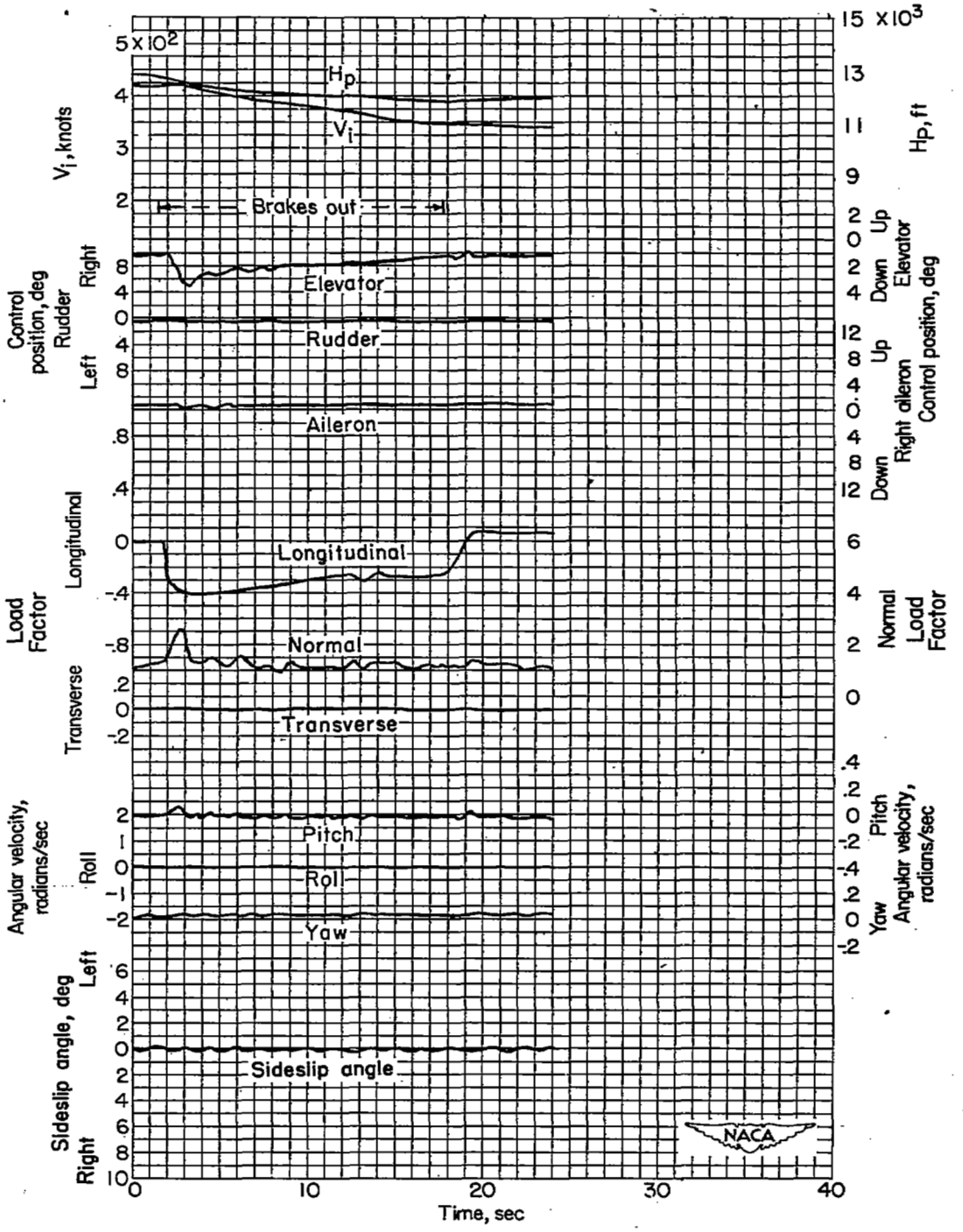

Figure 274.- Effect of speed brakes; airplane weight, 16,600 pounds; center-of-gravity location, 26.6 percent of the mean aerodynamic chord.

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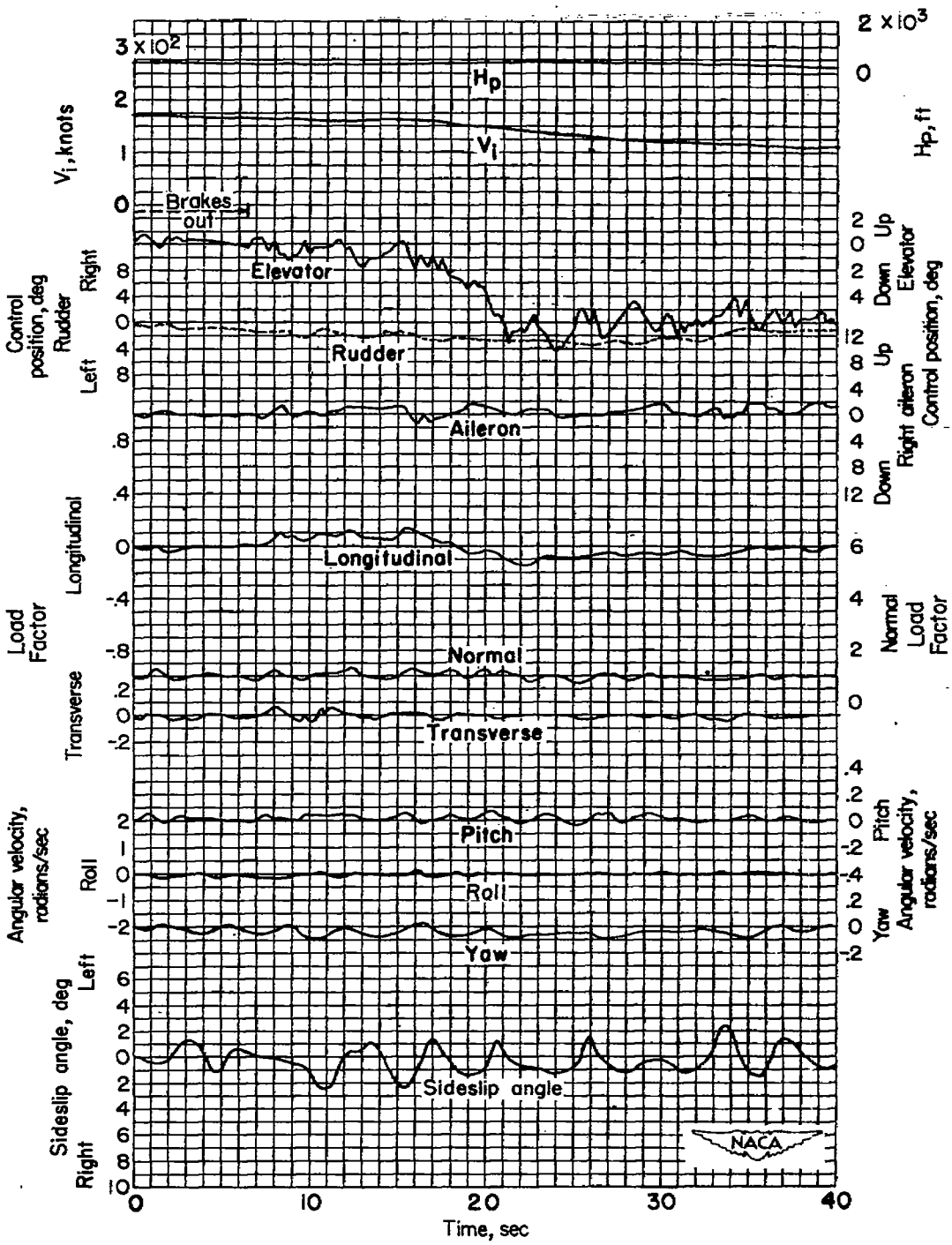

Figure 275.- Landing; airplane weight, 13,200 pounds; center-of-gravity location, 25.8 percent of the mean aerodynamic chord.

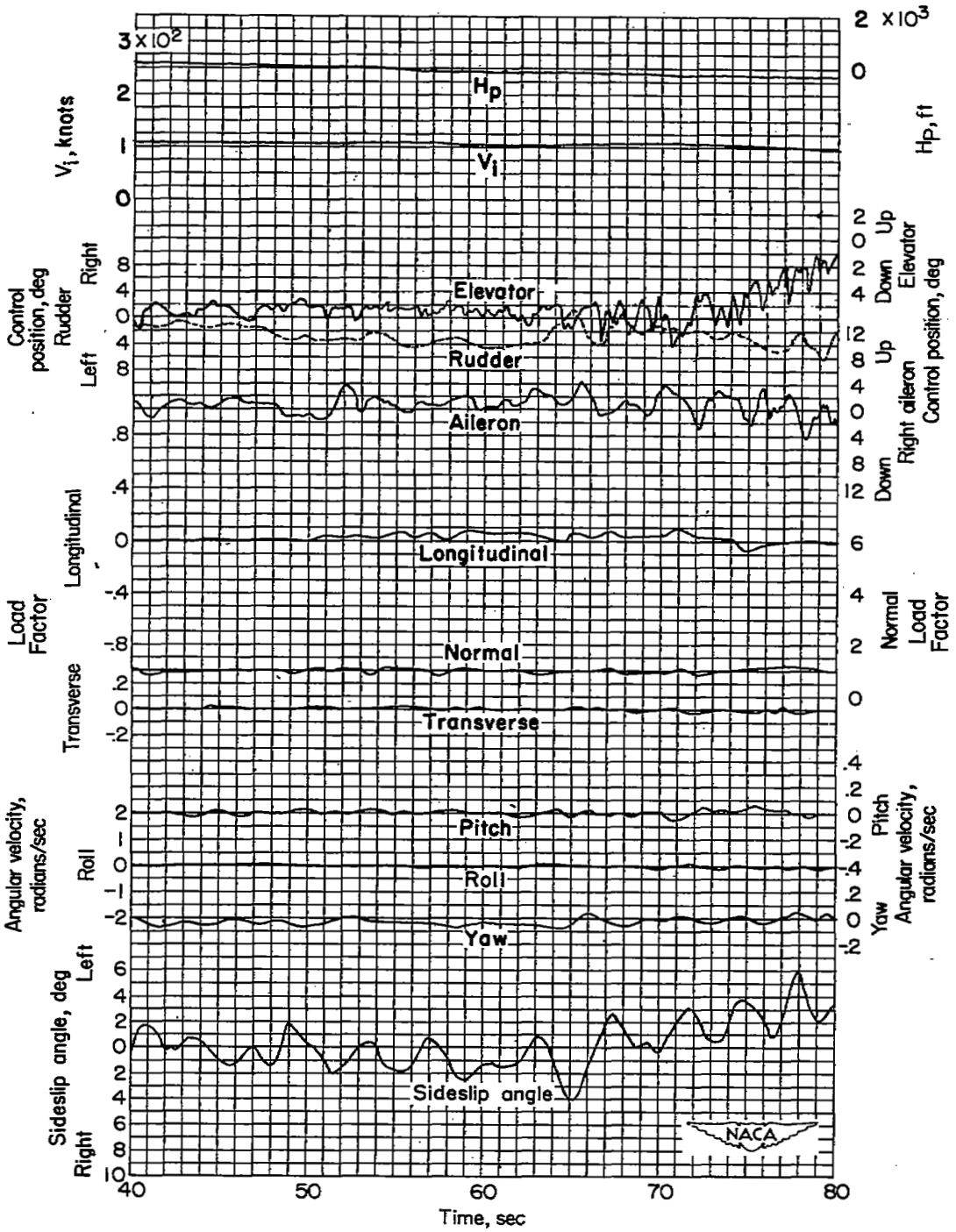

Figure 275.- Concluded.

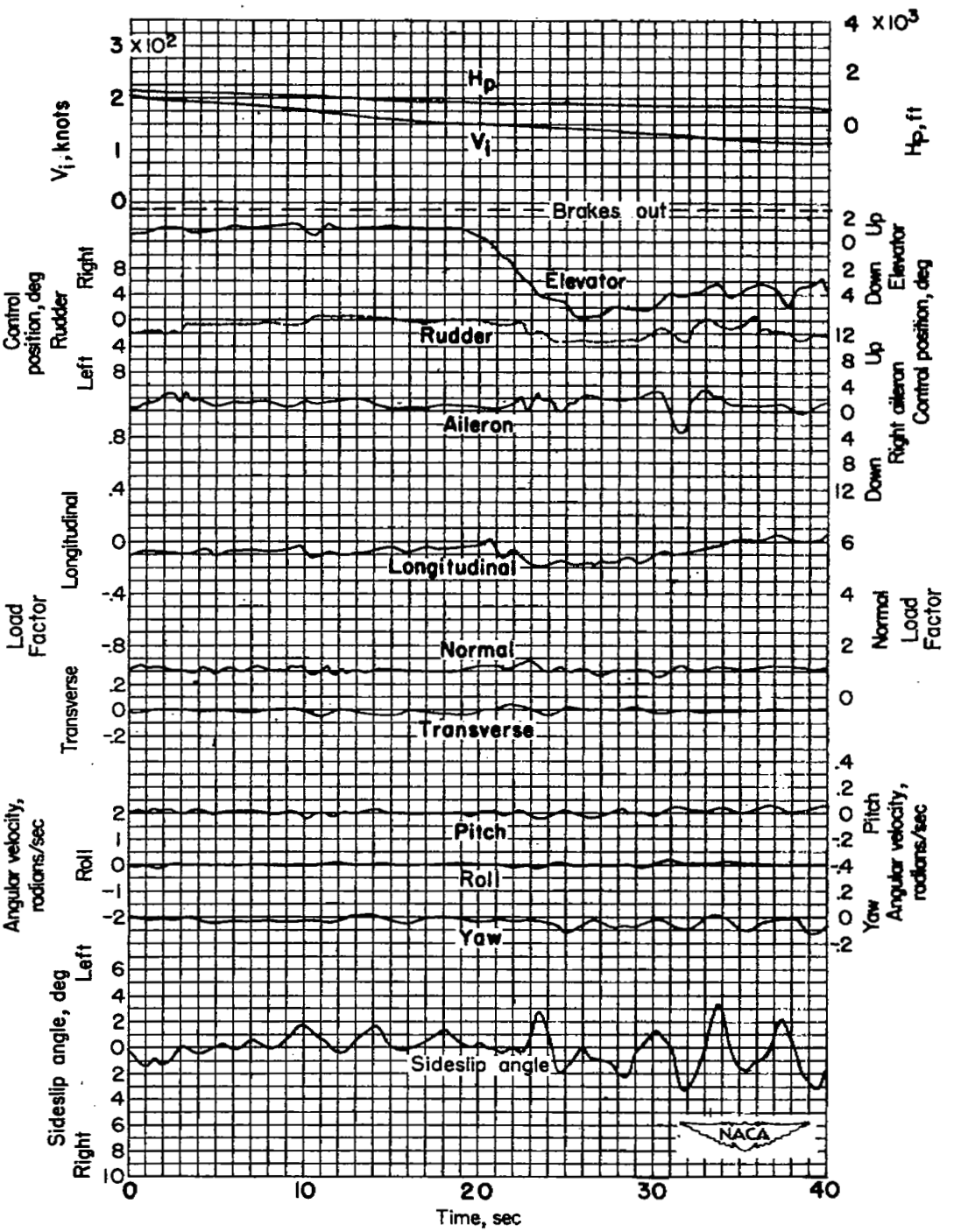

Figure 276.- Landing; airplane weight, 14,200 pounds; center-of-gravity location, 25.9 percent of the mean aerodynamic chord.

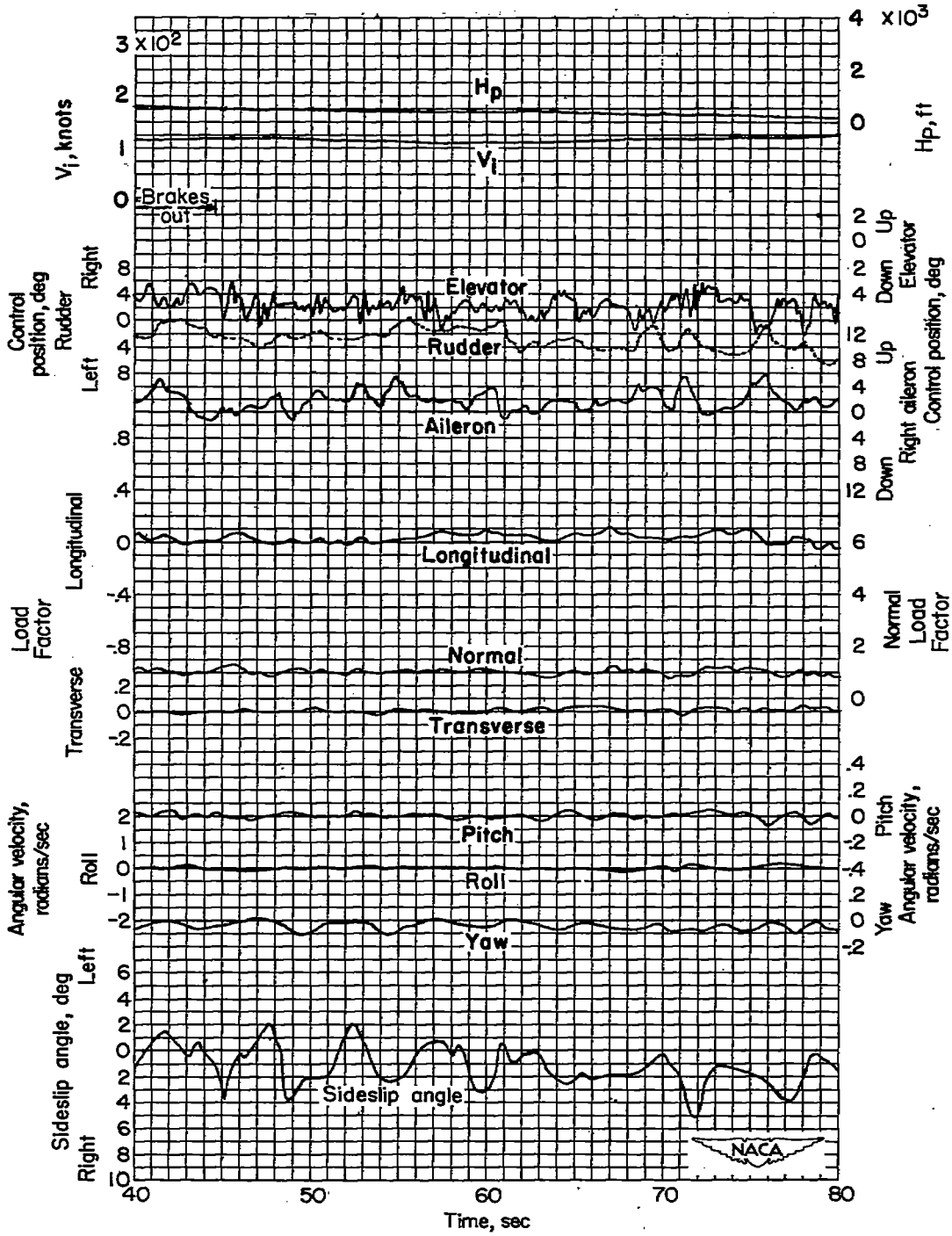

Figure 276.- Continued.

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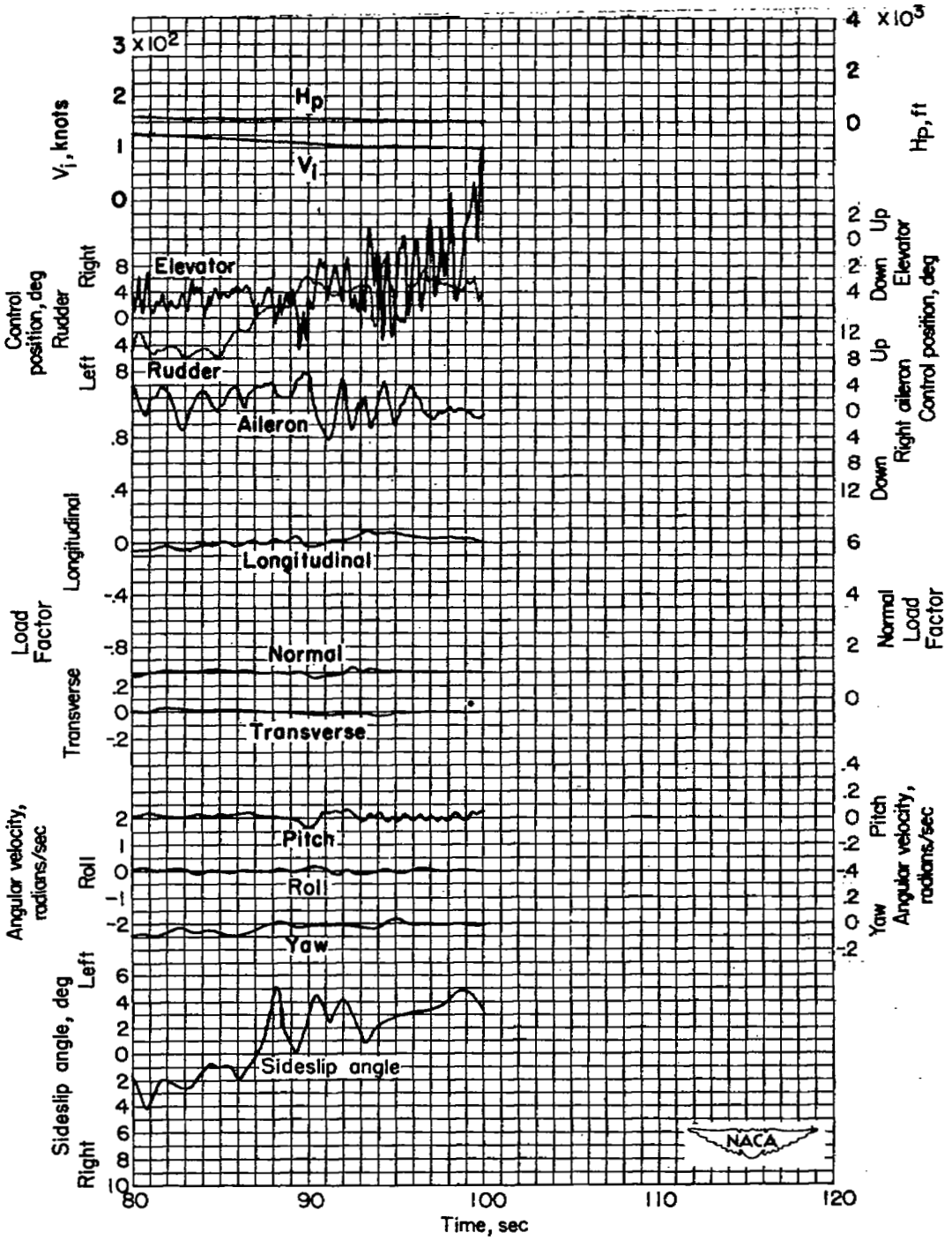

Figure 276.- Concluded.

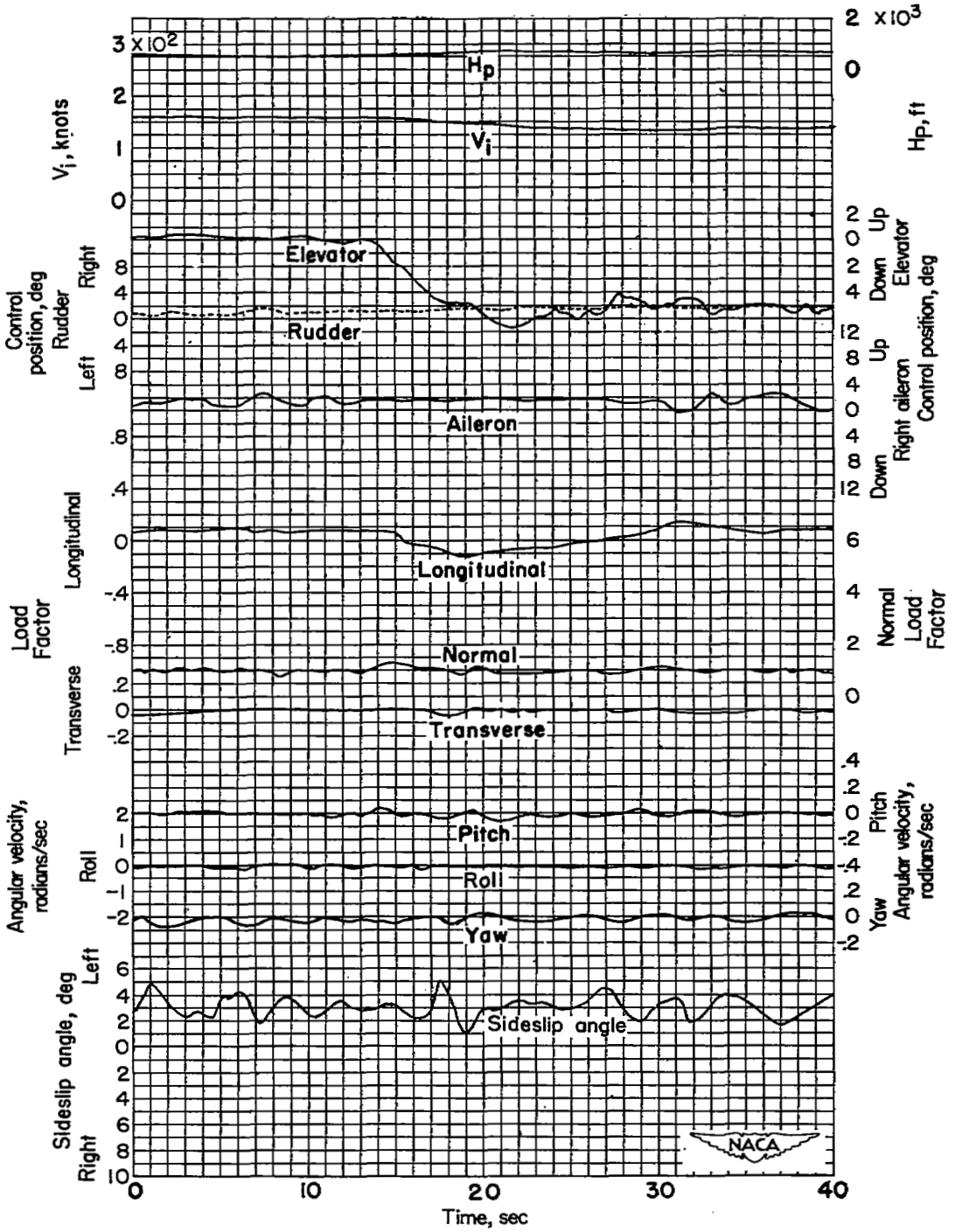

Figure 277.- Landing; airplane weight, 13,200 pounds; center-of-gravity location, 25.8 percent of the mean aerodynamic chord.

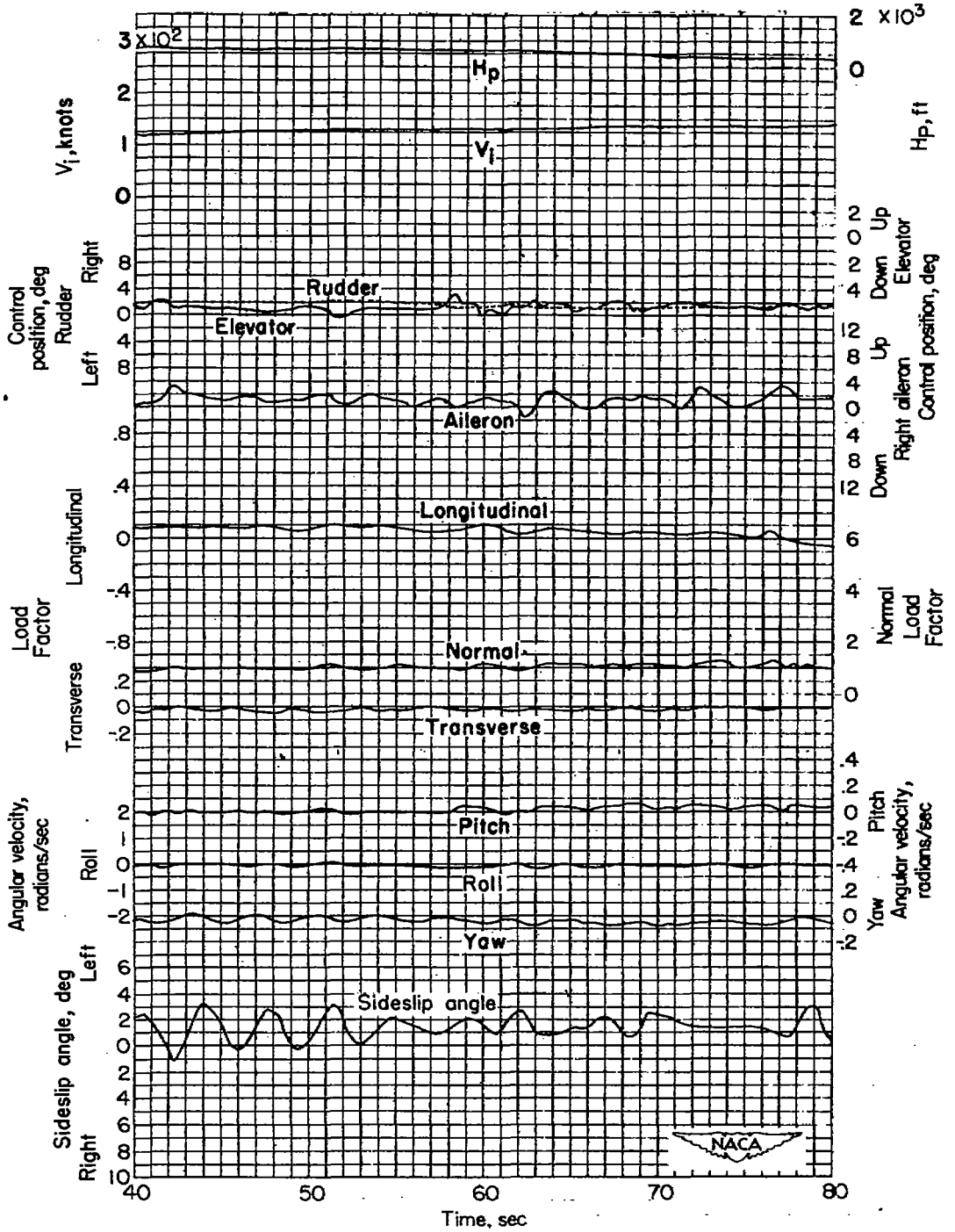

Figure 277.- Continued.

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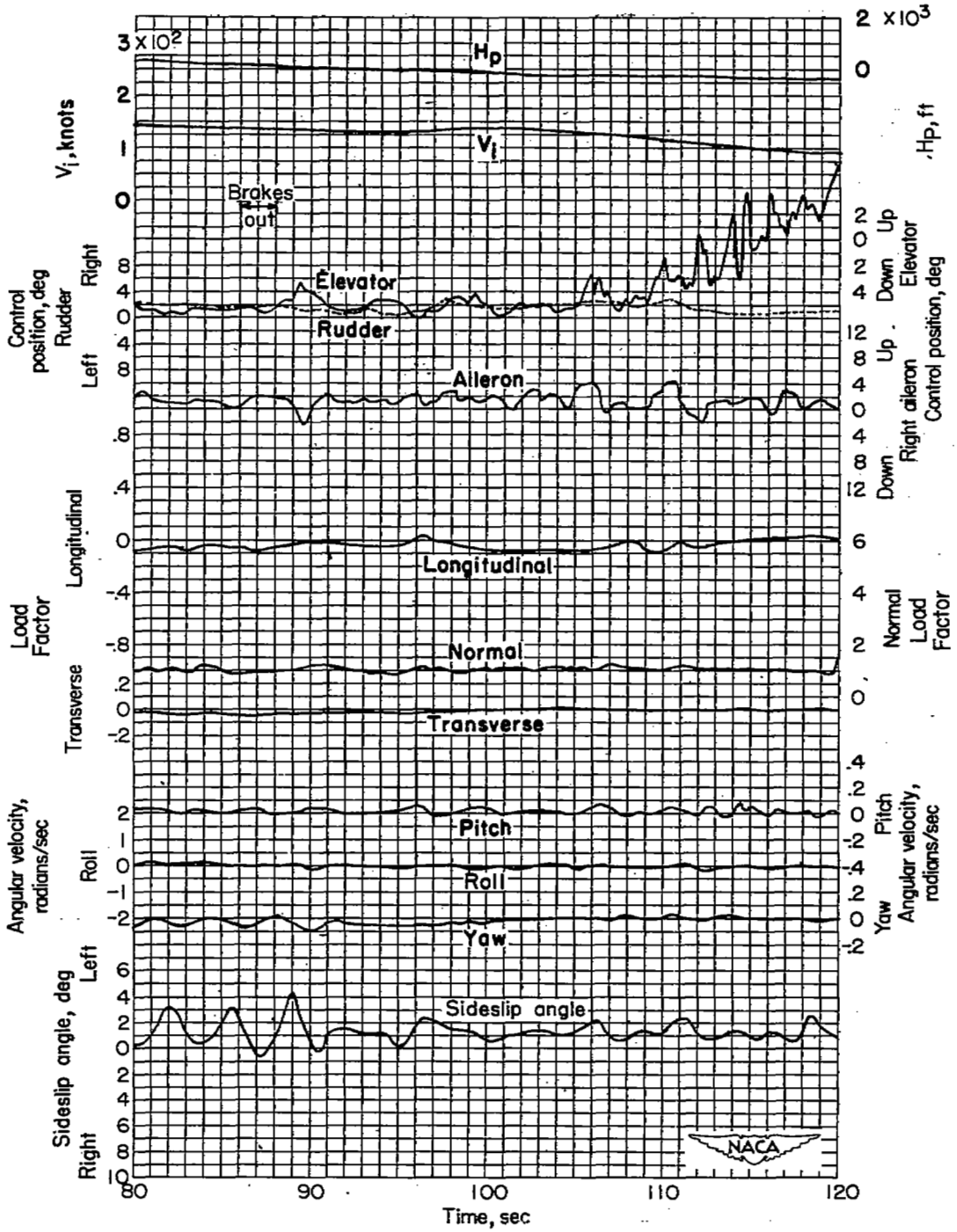

Figure 277.- Concluded.

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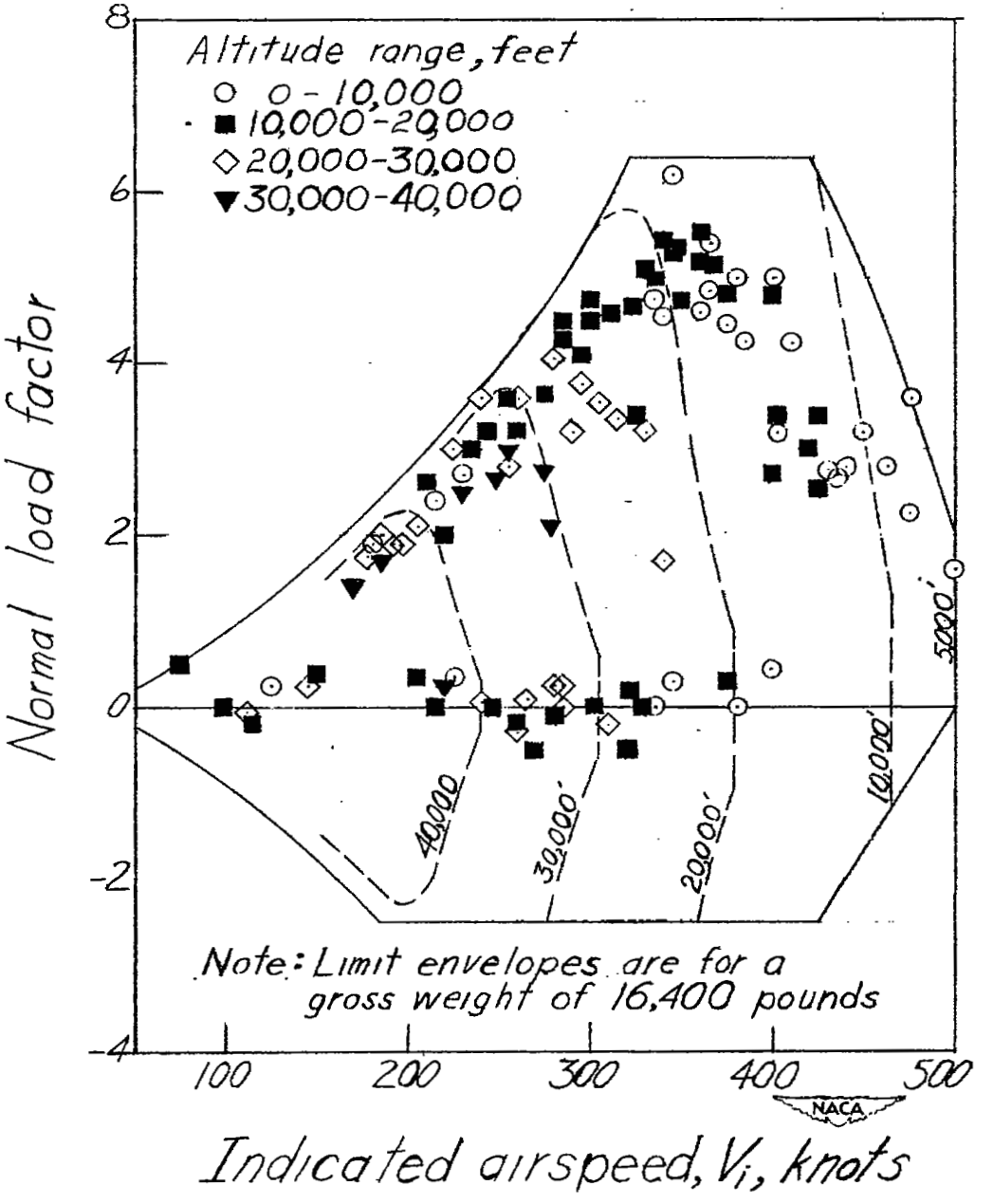

Figure 278.- Comparison of maximum measured normal load factors with the operational V-n diagram.

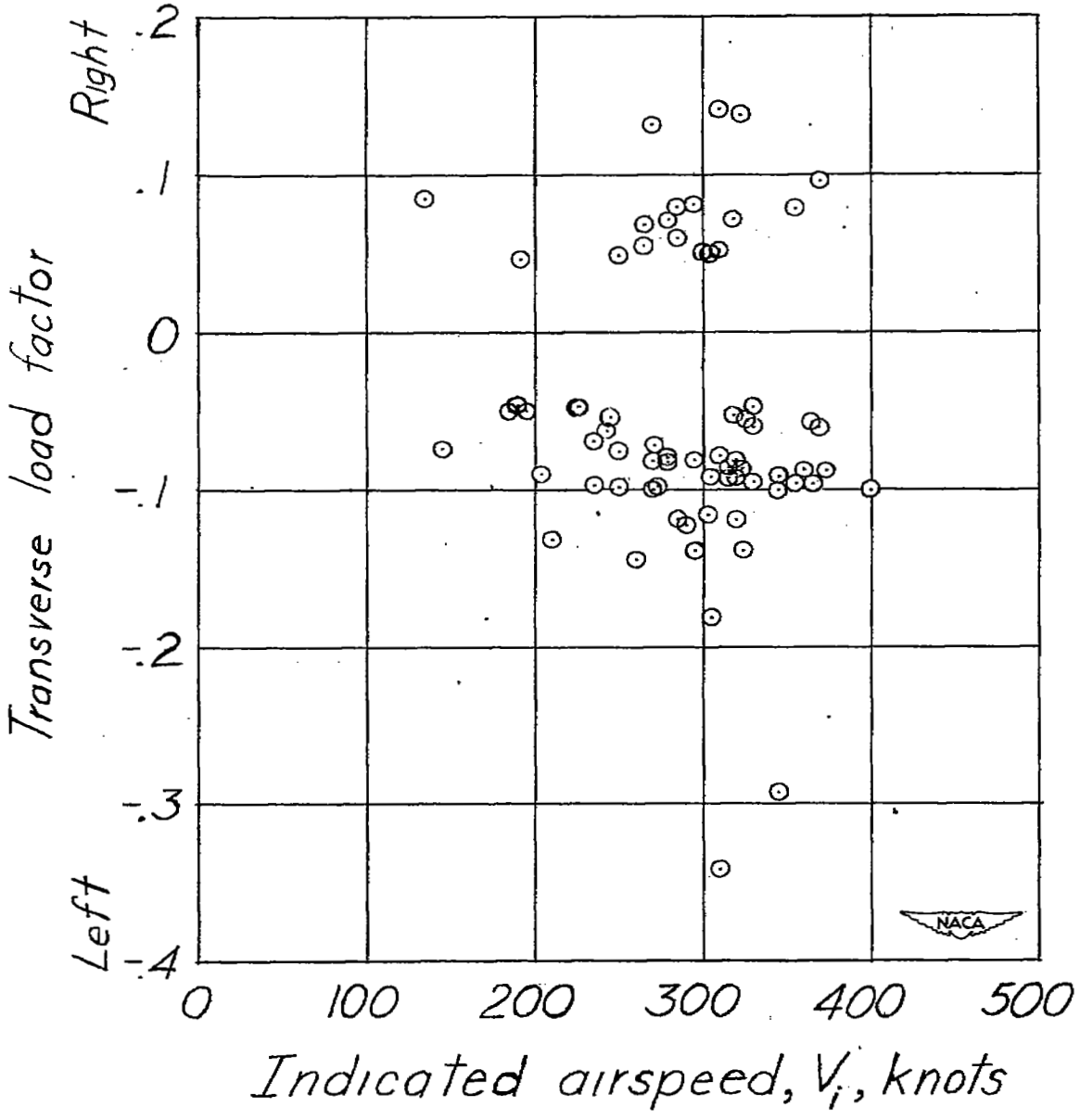

Figure 279.- Variation of maximum transverse load factor with indicated airspeed.

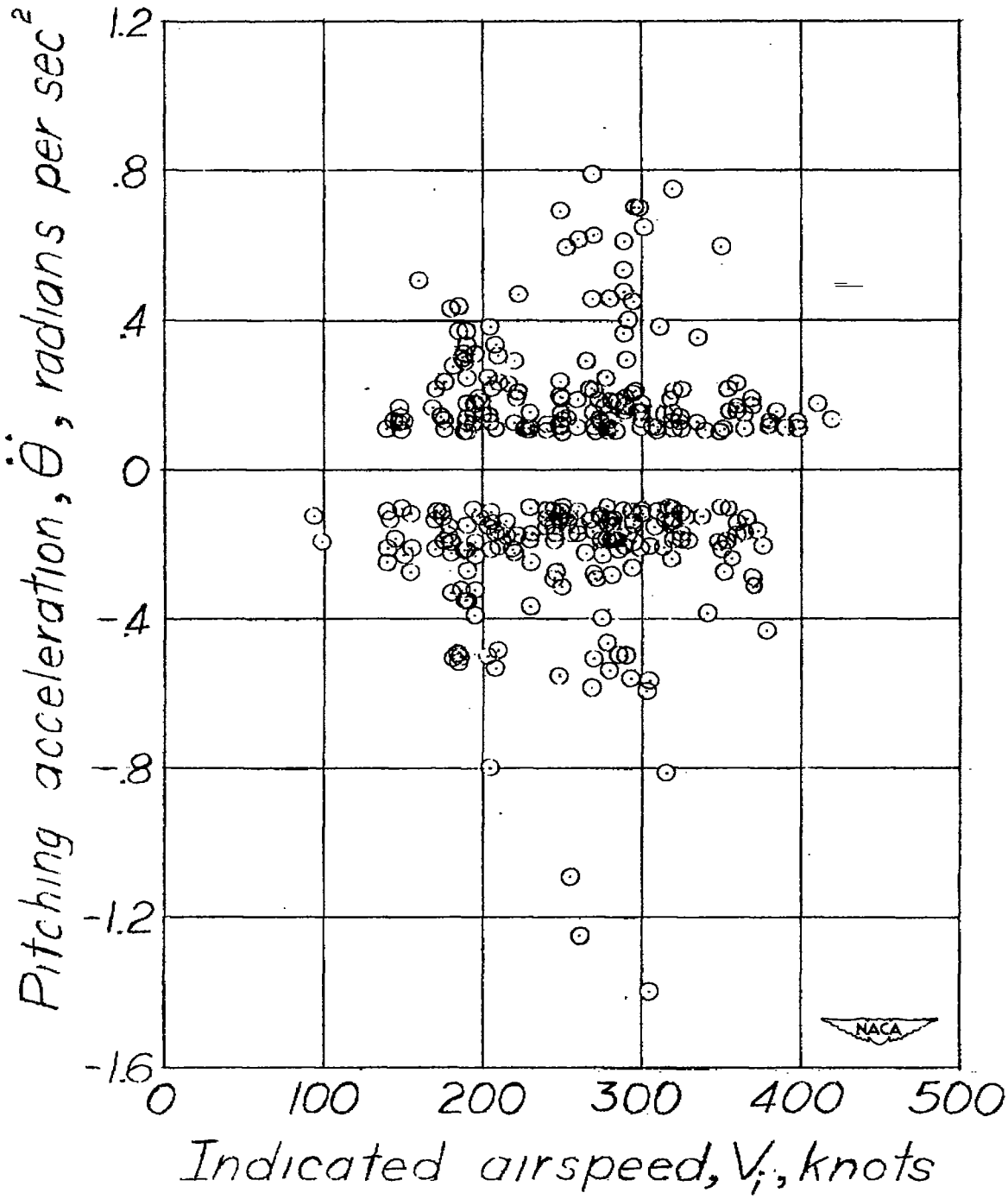

Figure 280.- Variation of maximum pitching acceleration with indicated airspeed.

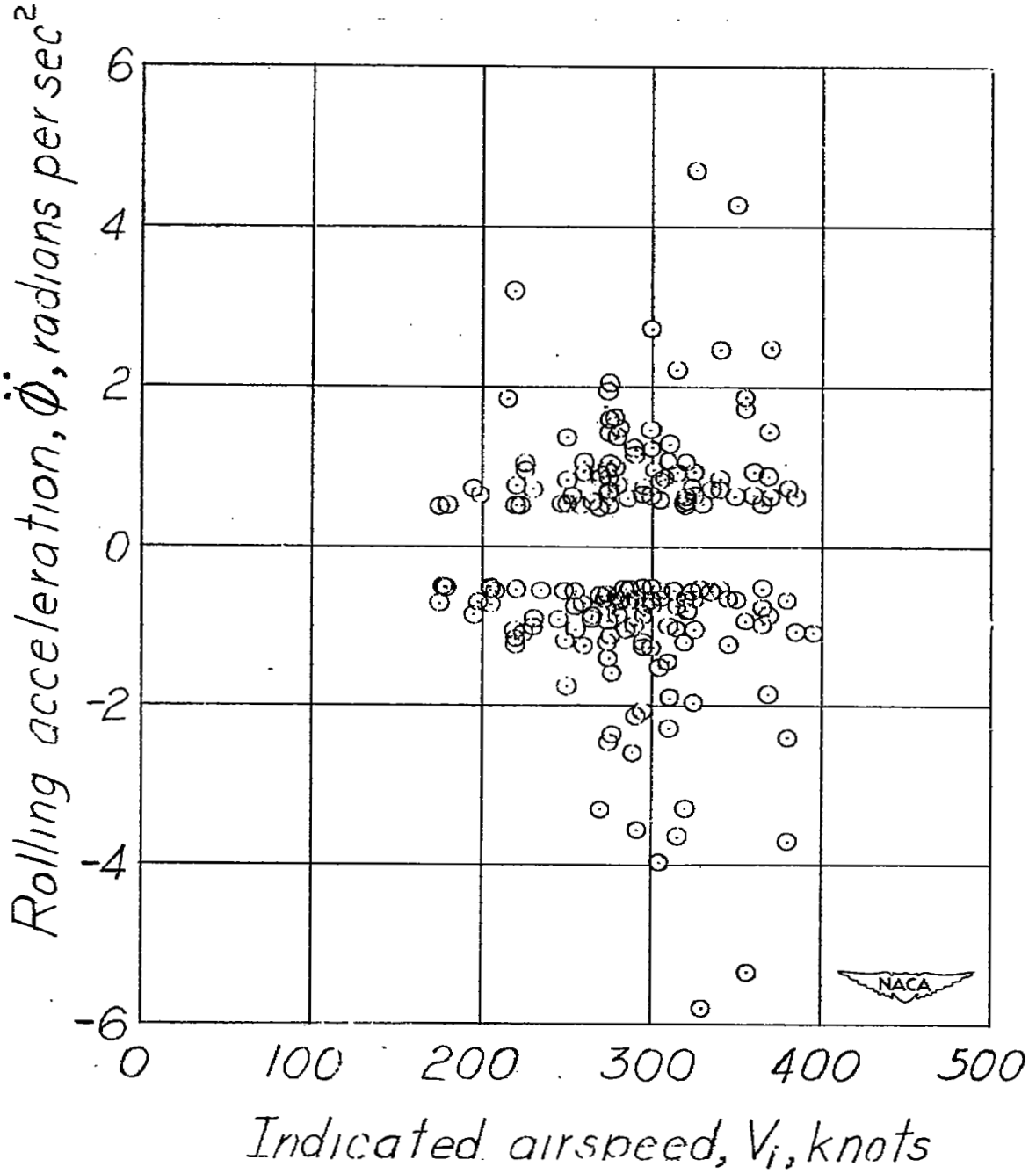

Figure 281.- Variation of maximum rolling acceleration with indicated airspeed.

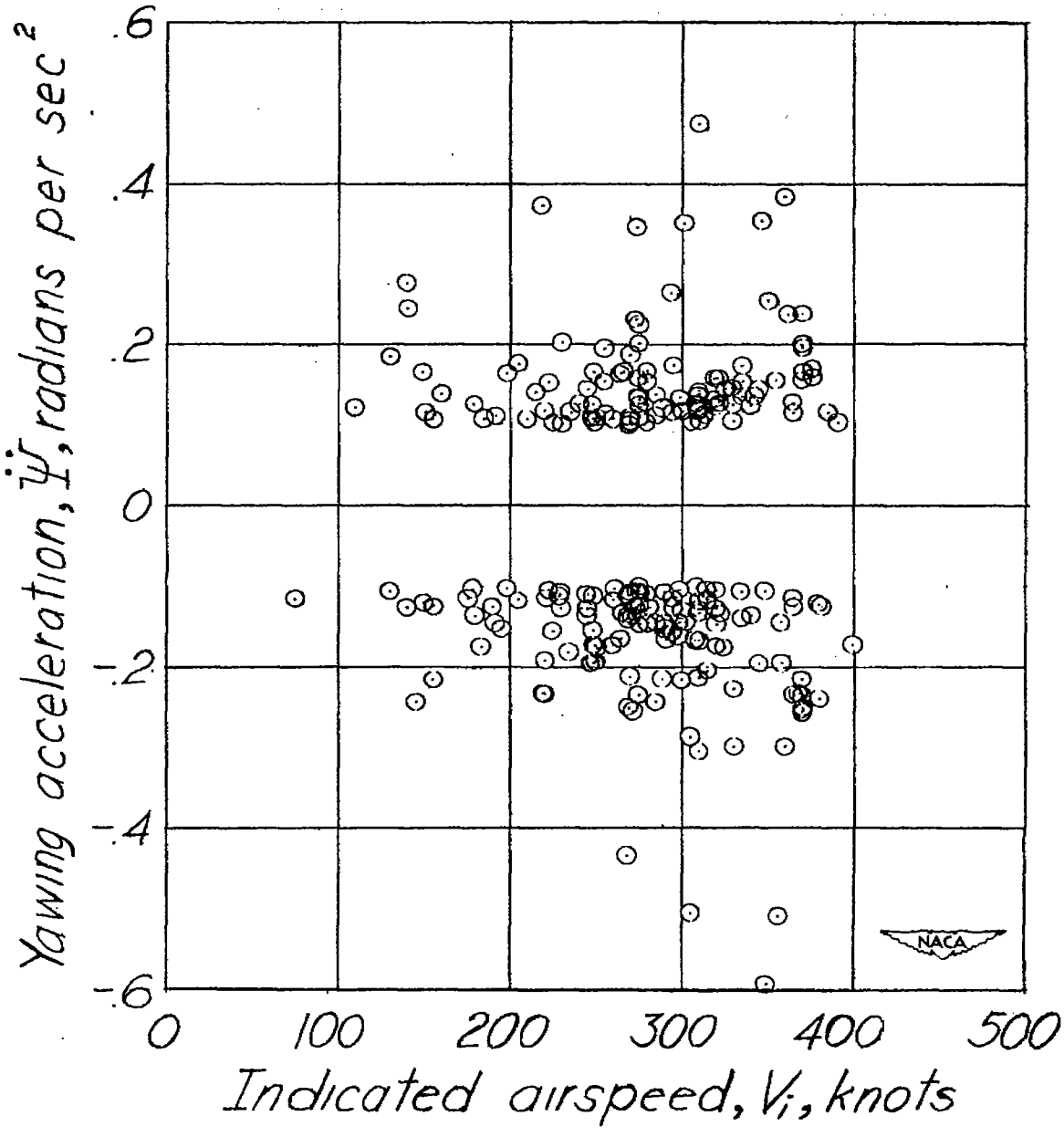

Figure 282.- Variation of maximum yawing acceleration with indicated airspeed.

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