

UNCLASSIFIED

AD NUMBER

AD869906

LIMITATION CHANGES

TO:

Approved for public release; distribution is unlimited.

FROM:

**Distribution: Further dissemination only as directed by Aeronautical Systems Division,
Attn: ASZTH, Wright-Patterson AFB, OH 45433,
MAY 1970, or higher DoD authority. This
document contains export-controlled technical
data.**

AUTHORITY

ASD, USAF ltr, 8 Feb 1974

THIS PAGE IS UNCLASSIFIED



**CATEGORY II PERFORMANCE
AND
FLYING QUALITIES TESTS
OF
THE HH-53C HELICOPTER**

WAYNE J. BARBINI
Project Engineer

PAUL J. BALFE
Major, USAF
Project Pilot

CLARK E. LOVRIEN Jr.
Major, USAF
Project Pilot

SUBSTANTIATING DOCUMENT NO. 70-9

MAY 1970

This document may be further distributed by any holder only
with the specific prior approval of ASD (ASZTH), Wright-
Patterson AFB, Ohio 45433.

**AIR FORCE FLIGHT TEST CENTER
EDWARDS AIR FORCE BASE, CALIFORNIA
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE**

AD 869906
**A
F
F
T
C**

PTC-SD-70-9

Qualified requesters may obtain copies of this report from the Defense Documentation Center, Cameron Station, Alexandria, Va. Department of Defense contractors must be established for DDC services, or have "need to know" certified by cognizant military agency at their project or contract.

DDC release to OTS is not authorized

When US Government drawings, specifications, or other data are used for any purpose other than a definitely related government procurement operation, the government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in anyway supplied the said drawings, specifications, or any other data is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

Do not return this copy, Retain or destroy

FTC-SD-70-8

**CATEGORY II
PERFORMANCE AND
FLYING QUALITIES TESTS
OF THE HH-53C HELICOPTER**

WAYNE J. BARBINI
Project Engineer

PAUL J. BALFE
Major, USAF
Project Pilot

CLARK E. LOVRIEN, Jr.
Major, USAF
Project Pilot

**This document may be further distributed by any holder only
with the specific prior approval of ASD (ASZTH) , Wright-
Patterson AFB, Ohio 45433.**

FOREWORD

The Category II Performance and Flying Qualities Tests of the HH-53C Helicopter USAF S/N 67-14993, were conducted at Sikorsky Aircraft Division of United Aircraft Corporation in Stratford, Connecticut, from 26 August 1969 to 27 February 1970. This substantiating document contains the quantitative data obtained during this evaluation along with the test techniques and the data analysis methods. The technical report, FTC-TR-70-8, (reference 1), was published in April 1970 and contained the results, conclusions, and recommendations. This test program was requested by the Aeronautical Systems Division and was conducted under the authority of AFFTC Project Directive 69-2 (Program Structure 482A).

Engineering assistance from Lieutenant Rodney L. Ritter is acknowledged.

Foreign announcement and dissemination by the Defense Documentation Center are not authorized because of technology restrictions of the U.S. Export Control Acts as implemented by AFR 400-10.

Prepared by:

WAYNE J. BARBINI
Project Engineer

Reviewed and
approved by:

7 May 1970

THOMAS J. CECIL
Colonel, USAF
Commander, 6512th Test Group

ALTON D. SLAY
Brigadier General, USAF
Commander

ABSTRACT

This substantiating document contains the test techniques, data analysis methods, and test data for the Category II Performance and Flying Qualities Tests of the HH-53C Helicopter. The results, conclusions, and recommendations were presented in FTC-TR-70-8, Category II Performance and Flying Qualities Tests of the HH-53C Helicopter, April 1970.

Table of Contents

LIST OF ILLUSTRATIONS	iv
LIST OF ABBREVIATION AND SYMBOLS	v
INTRODUCTION	1
TEST AND EVALUATION	2
General	2
Hovering Performance	2
Sawtooth Climbs	3
Level Flight Performance	4
Auterotational Characteristics	4
Airspeed Calibration	5
Power Determination and Engine Characteristics	5
Static Longitudinal Speed Stability	6
Static Directional Stability	7
Sideward and Rearward Flight	8
Dynamic Stability	9
Hover	9
Climb	9
Level Flight	10
Controllability	10
Hover	11
Climb and Auterotation	11
Level Flight	12
AFCS Hardovers	12
APPENDIX I	14
Data Plots	15
Flight Log	190
REFERENCES	193

List of Illustrations

1 CENTER OF GRAVITY EFFECTS ON LONGITUDINAL CONTROL POSITION 7

APPENDIX I

1-6	NONDIMENSIONAL HOVERING PERFORMANCE	15-20
7	SAWTOOTH CLIMB PERFORMANCE	21
8-24	LEVEL FLIGHT PERFORMANCE	22-38
25	LEVEL FLIGHT PERFORMANCE—LANDING GEAR EXTENDED	39
26	LEVEL FLIGHT PERFORMANCE—ENGINE AIR PARTICLE SEPARATORS INSTALLED	40
27	PERFORMANCE IN AUTOROTATION	41
28	AIRSPEED CALIBRATION	42
29-50	STATIC LONGITUDINAL SPEED STABILITY	43-64
51-65	STATIC DIRECTIONAL STABILITY	65-79
66	CONTROL POSITION IN SIDEWARD FLIGHT	80
67	CONTROL POSITION IN REARWARD FLIGHT	81
68-85	DYNAMIC STABILITY TIME HISTORIES	82-99
86-109	HOVER CONTROLLABILITY TIME HISTORIES	100-123
110-115	HOVER CONTROLLABILITY	124-129
116-121	CLIMB CONTROLLABILITY TIME HISTORIES	130-135
122-127	AUTOROTATION CONTROLLABILITY TIME HISTORIES	136-141
128-130	CLIMB AND AUTOROTATION CONTROLLABILITY	142-144
131-142	LEVEL FLIGHT CONTROLLABILITY TIME HISTORIES	145-156
143-145	LEVEL FLIGHT CONTROLLABILITY	157-159
146-167	AFCS HARDOVERS	160-181
168-175	ENGINE CHARACTERISTICS	182-189

List of Abbreviations and Symbols

<u>Item</u>	<u>Definition</u>	<u>Units</u>
A	rotor disc area	ft ²
ac	alternating current	- - -
C _P	power coefficient	dimensionless
C _T	thrust coefficient	dimensionless
EAPS	engine air particle separators	- - -
IGE	in ground effect	- - -
KCAS	knots calibrated airspeed	- - -
KTAS	knots true airspeed	- - -
M _{TIP}	advancing blade tip Mach number	dimensionless
N ₁	gas producer speed	pct
N _r	rotor speed	rpm
P _a	ambient pressure	in. Hg
P _{t₂}	compressor inlet total pressure	in. Hg
Q	torque	ft-lb
R	rotor radius	ft
SHP	shaft horsepower	550 <u>ft-lb</u> <u>sec</u>
T	temperature	deg K
V _t	true airspeed	kt
W _f	fuel flow	lb per hr
θ	temperature ratio (T_{t_2}/T_a)	dimensionless
μ	rotor advance ratio	dimensionless
ρ	air density	slugs per ft ³
Ω	rotor angular velocity	rad per sec
σ	rotor solidity ratio	dimensionless
δ	pressure ratio (P_{t_2}/P_a)	dimensionless
<u>Subscript</u>		
c	indicates parameter affected by compressibility	- - -



INTRODUCTION

The test helicopter was a production HH-53C which was instrumented by the contractor for performance and flying qualities. A test pitot-static head for measurement of airspeed and altitude was mounted on the refueling probe for the test program.

The objective of the Category II Performance and Flying Qualities Tests was to obtain data for inclusion in the Flight Manual (reference 2) and determine if selected requirements of MIL-H-8501A (reference 3) were met.

Tests not conducted during this test program which are normally completed during Category II were hover, takeoff, and height-velocity tests at a high altitude test site and level flight performance in extreme temperature conditions necessary to completely define the effects of compressibility.

A flight log of the tests flown during this program is presented in appendix I.

TEST AND EVALUATION

GENERAL

Dimensional analysis of the major items affecting helicopter performance yields several sets of dimensionless variables which may be used to present performance data in nondimensional form. The C_p , C_T , μ method is useful only when compressibility effects are not significant. These variables are defined as follows:

$$C_p = \frac{SHP \times 550}{\rho A(\Omega R)^3}$$

$$C_T = \frac{W}{\rho A(\Omega R)^2}$$

$$\mu = \frac{V_t}{\Omega R}$$

Since compressibility was a major item affecting the performance of the HH-53C, an additional dimensionless variable was required to make the C_p , C_T , μ method valid. The additional variable, the advancing blade tip Mach number was defined as:

$$M_{TIP} = \frac{V_t + \Omega R}{38.967\sqrt{T_a}}$$

HOVERING PERFORMANCE

In-ground-effect (IGE) and out-of-ground-effect (OGE) hovering performance data were obtained by tethered and free flight techniques to update the Flight Manual's estimated data. All hovering was done with the 450-gallon external fuel tanks installed and the landing gear down. Hovering performance data were obtained at wheel heights of 5, 10, 22, 47, 80 and 100 feet at a pressure altitude of sea level and referred rotor speed ($N_r/\sqrt{\theta}$) of 175 to 195 rpm. All hover tests were conducted in less than 3 knots of wind. During the tests a constant rotor tip Mach number was maintained by changing the rpm as ambient temperature changed to maintain a constant $N_r/\sqrt{\theta}$.

During the tethered hovering tests the helicopter was tethered to the ground by a cable and load cell. The load cell measured cable tension. Thrust produced by the helicopter was assumed equal to the gross weight of the helicopter, cable, load cell and cable tension. Power was determined by using the engine torquemeters and rotor speed.

Significant rotor blade compressibility was encountered during the hover tests as evidenced by an increase in power required at a constant thrust coefficient C_T as M_{TIP} was varied from minimum to the maximum obtainable. This effect became more evident as M_{TIP} and C_T were increased. Since tethered hovering was conducted at only one pressure altitude and a limited temperature range, this effect could not be completely determined for the entire range of operational conditions the HH-53C can encounter.

Figures 1 through 6, appendix I, show the power coefficient C_p plotted versus the thrust coefficients for each wheel height and at constant tip Mach numbers. These fairings were used to construct the nondimensional cross plots which define the power coefficient at a constant wheel height for various thrust coefficients and tip Mach numbers.

SAWTOOTH CLIMBS

Two-engine sawtooth climbs were flown during the test program to determine the climb performance and to make a comparison with the climb performance presented in the Flight Manual.

The tests were flown at military power when not limited by up collective at pressure altitudes of 4,500, 7,000, and 14,000 feet with the landing gear up and at a mid cg (340). Each climb was repeated on a reciprocal heading to average out the effects of wind. The observed rate of climb was corrected to test day tapeline rate of climb using the following equation:

$$R/C_t = \frac{dh}{dt} \times \frac{T_{at}}{T_{as}}$$

when R/C_t was the tapeline rate of climb in feet per minute, dh/dt being the slope of the pressure altitude versus time curve in feet per minute. T_{at}/T_{as} was the ratio of test day ambient temperature to the standard day temperature for the test altitude.

The results in table I indicate a considerable discrepancy between the Flight Manual and test results in both the test climb airspeed and the rate of climb. Test results are shown in figure 7, appendix I.

Table I

SAWTOOTH CLIMB PERFORMANCE					
Gross Weight (lb)	Altitude (ft)	Test Results		Flight Manual	
		Best Climb Speed (KCAS)	Rate of Climb (fpm)	Best Climb Speed (KCAS)	Rate of Climb (fpm)
35,000	4,500	88	2,700	75	2,250
35,000	7,000	79	2,300	73	1,950
35,000	14,000	61	1,960	66	950

LEVEL FLIGHT PERFORMANCE

The level flight tests were conducted to determine the power required as a function of airspeed, gross weight, and tip Mach number, and to define range and endurance characteristics. Data were not obtained with the personnel door or cargo ramp open, at forward or aft cg's, with the engine anti-ice on, or with only one engine operating.

The level flight performance tests were flown at a constant C_T/σ (σ being the rotor solidity ratio) and $N_r/\sqrt{\theta}$. This required varying rotor rpm to maintain $N_r/\sqrt{\theta}$ constant as ambient temperature changed. By using $N_r/\sqrt{\theta}$ the equation for computing C_T becomes a function of the gross weight to ambient pressure ratio (GW/δ). This technique required increasing pressure altitude as fuel was consumed to maintain a constant C_T . The test data were corrected for adiabatic temperature rise. Power required was determined from the installed engine torqueometers and rotor rpm. Plots of C_p versus μ are presented in figures 8 through 24, appendix I. The fairings were obtained from cross plots of C_p versus C_T at a constant μ .

An analysis of these level flight performance data was conducted to determine if there were any changes in power required when fuselage Reynolds number (R_e) was varied and all other independent variables were held constant. With the flight conditions and configurations flown during this program the R_e effects were not significant, reference figures 11 and 12, appendix I.

One speed-power was flown at a C_T/σ of 0.0785 to determine the drag penalty of extended landing gear. There was a 9.5-percent increase in power required at 144 KCAS, and this value gradually decreased until, at approximately 75 KCAS, there was no significant increase in power required. A comparison of the results is presented in figure 25, appendix I.

A level flight test to determine the effects on aircraft performance when both engines were equipped with engine air particle separators (EAPS) was conducted at a C_T/σ of 0.0595. At 155 KCAS there was a 5.5-percent increase in power required which decreased to less than 1 percent at 120 KCAS. The results of this test are presented in figure 26, appendix I.

AUTOROTATIONAL CHARACTERISTICS

Sawtooth autorotation descents were conducted in conjunction with the sawtooth climbs to determine the speed for minimum rate of descent and speed for maximum range in autorotation. The test conditions were the same as in the sawtooth climbs. The observed rate of descent was corrected to test day tapeline rate of descent by the following equation:

$$R/D_t = \frac{dh}{dt} \times \frac{T_{at}}{T_{as}}$$

where R/D_t was the tapeline rate of descent in feet per minute, dh/dt being the slope of the pressure altitude versus time curve in feet per minute. T_{at}/T_{as} was the ratio of test day ambient temperature to the standard day temperature for the test altitude. Figure 27, appendix I, shows R/D_t versus calibrated airspeed for the condition investigated.

The speed for minimum rate of descent was established as the minimum point on the curve. The tangent to this curve from the 0-0 point of the axis established the speed for maximum range in autorotation. Although the major portion of the autorotation testing was conducted at 185 rpm (100 percent) sufficient qualitative data were obtained at the lower rotor rpm of 176 (95 percent) to determine that the rate of descent was lowered by approximately 150 feet per minute. When operating at this lower rotor speed there was no noticeable difference in handling qualities of the helicopter.

AIRSPEED CALIBRATION

The standard airspeed system and the test airspeed system were calibrated throughout the airspeed range during level flight. A ground speed course was used and the test was conducted at 185 rotor rpm, 30,000-pound gross weight, mid cg, and a density altitude of sea level. The test was flown in nearly calm air (less than 3 knots).

The test system used a boom with a swivel pitot-static head. The standard airspeed system calibration was obtained for climb, level flights, and autorotation using the level flight ground speed course calibration for the test system. This assumed that the swivel pitot-static head used on the test system was unaffected by pitch and yaw angles of less than 20 degrees. The test and standard airspeed system calibration is presented in figure 28, appendix I.

POWER DETERMINATION AND ENGINE CHARACTERISTICS

The HH-53C employed an electronic torque monitoring system to measure the percent of torque being applied by each engine to the main transmission. A torque reading of 100 percent was equivalent to 3,200 shaft horsepower. The torque sensing system was located at the engine input section to the nose gearbox and was made up of the torque shaft, torque pickup, the phase detector, and the torque indicator. The torque sensor shaft consisted of an inner and outer shaft arranged so that the inner shaft was subjected to the power turbine load. The major diameter on each shaft was machined to contain 72 teeth. This portion of the shaft was the exciter. The torque pickup was a coil installed in the torque tube opposite the exciter.

The system measured torque by measuring the twist in the shaft connecting the engine to the load. To measure this twist a pickup was installed in the torque tube opposite a pair of gear teeth on the rotating shaft. As the shaft rotated, two ac signals were induced in the pickup coils. As the torque in the shaft increased, the two sets of teeth were displaced from each other as the shaft twisted and the phase angle difference between the two ac voltages changed. The output of the pickup coils was fed into a phase detector that electronically measured the phase angle change. This phase angle was then converted to an output voltage proportional to torque. Test shaft horsepower was determined from inflight torquemeter readings and rotor rpm using the following equation:

$$\frac{\text{SHP}}{\text{engine}} = \frac{(13,600) (\% \text{ rpm}) (\% Q) (1,235)}{5,250}$$

Shaft horsepower, fuel flow, gas producer speed, and turbine inlet temperature were corrected to standard atmospheric conditions. The engine characteristics were defined by the plots of the following parameters:

$$\frac{SHP}{\delta \sqrt{\theta}} \quad vs \quad \frac{N_1}{\sqrt{\theta}}$$

$$\frac{N_1}{\sqrt{\theta}} \quad vs \quad \frac{W_f}{\delta \sqrt{\theta}}$$

$$\frac{T_5}{\theta} \quad vs \quad \frac{N_1}{\sqrt{\theta}}$$

where

$$SHP = SHP_t \left(\frac{H_p}{CIP} \right) \sqrt{\frac{T_{aSL}}{T_{t2}}}$$

$$N_1 = N_{1t} \sqrt{\frac{T_{aSL}}{T_{t2}}}$$

$$T_5 = T_{5t} \left(\frac{T_{t2}}{T_{aSL}} \right)$$

and are presented in figures 168 through 175, appendix I.

STATIC LONGITUDINAL SPEED STABILITY

Static longitudinal speed stability tests were conducted at a fixed collective pitch setting. Specifically, longitudinal stick position versus airspeed and longitudinal stick movement required throughout the speed range were to be determined for most allowable cg locations. The test gross weights were varied from 31,000 to 41,000 pounds and pressure altitudes from 4,000 to 13,000 feet. Trim conditions were level flight at 35 KCAS, 0.6 V_{MAX}, 0.8 V_{MAX}, and V_{MAX}, climb at best climb airspeed, autorotation at the airspeed for minimum rate of descent, and partial power descent at 35 KCAS. Hover trim points were not obtained since the weather was not favorable at the time the speed stability testing was conducted.

The static longitudinal stability was generally positive for the conditions tested except for some neutral or slightly negative speed stability around the 35 KCAS trim point for level flight and partial power descent. The amount of negative stability encountered was not objectionable. Figure 1 shows control position as a function of airspeed for forward and aft center of gravity locations. As shown in figure 1, the slope of the curve was generally the same for both conditions and the cyclic control was displaced forward approximately 2 inches for the aft center of gravity loading, but did not change the stability characteristics of the helicopter. Tests were conducted per MIL-H-8501A.

NOTES:

LEVEL FLIGHT
AVG GROSS WEIGHT = 31,000 pounds
AVG PRESSURE ALTITUDE = 4,000 feet
ROTOR SPEED = 185 rpm

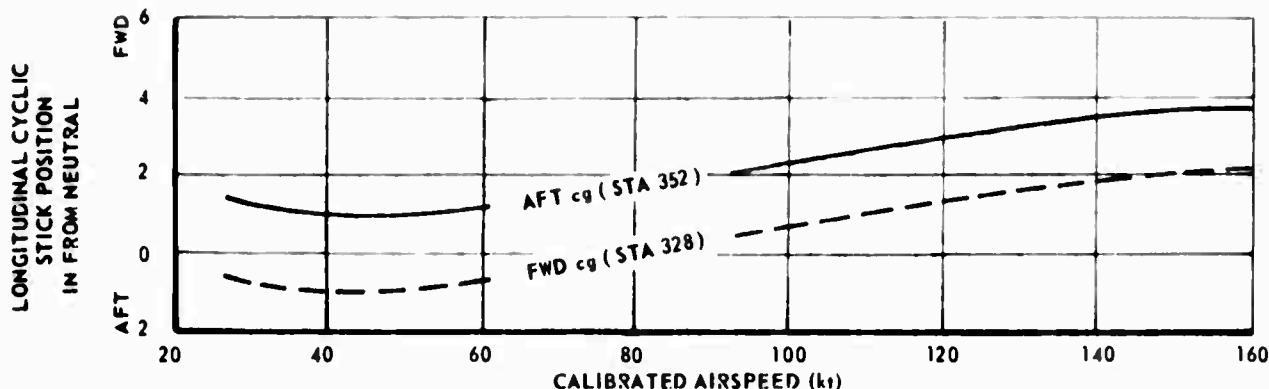


Figure 1 CENTER OF GRAVITY EFFECTS ON LONGITUDINAL CONTROL POSITION

The HH-53C did not meet the requirements of MIL-H-8501A in that the maximum airspeed trim points were usually limited by full up collective pitch. At the maximum airspeed trim point with an aft center of gravity, there was approximately 10-percent of the longitudinal cyclic control remaining. All the static longitudinal speed stability testing was conducted at 100-percent rotor speed (185 rpm) and therefore speed stability characteristics at a different rotor speed were not determined. Results of the static longitudinal speed stability tests are presented in figures 29 through 50, appendix I.

STATIC DIRECTIONAL STABILITY

Static directional stability of the HH-53C was investigated for similar flight conditions as the static longitudinal speed stability to determine compliance with MIL-H-8501A requirements. All static directional stability tests were conducted at the full aft cg location (352) with the AFCS operative and inoperative.

In conducting this test, the aircraft was trimmed in stabilized flight at a zero sideslip angle, and then the sideslip angle was introduced in both directions by opposite use of lateral stick and directional pedals while maintaining a constant airspeed.

In level flight the dihedral effects increased with increasing airspeed and altitude. Inoperative AFCS had no effect on the static directional stability characteristics of the aircraft. The data in figures 51 through 65, appendix I, show positive dihedral effect and static directional stability for the flight conditions and aircraft configurations investigated.

SIDEWARD AND AND REARWARD FLIGHT

Sideward and rearward flight tests were conducted on the HH-53C to determine the static stability characteristics of the helicopter in these flight regimes and determine compliance with MIL-H-8501A.

The HH-53C had acceptable sideward flight characteristics. Below translational lift (15 knots), smooth and steady flight was possible with a minimum of control inputs and no difficulty was encountered in holding the desired heading. During translational lift (15 to 25 knots) directional control was difficult and numerous control inputs were required to hold the desired heading. Above 25 knots, sideward flight was again smooth and steady. Examination of this data showed that there was adequate lateral cyclic control and directional control for sideward flight to the left and right up to 35 KTAS. The result of the sideward flight test is presented in figure 66, appendix I. At 35 KTAS to the right, there was less than 1 inch of pedal control remaining, which is less than 10 percent of the total control travel available. Adequate lateral control to hold attitude was available and from figure 66, appendix I, it can be observed that a linear gradient of lateral stick required versus airspeed existed from hover to 35 KTAS right. From translational lift sideward to the left, the lateral stick gradient was essentially flat and required approximately 1/2-inch left lateral stick out to 35 KTAS. This flat gradient presented no problems for sideward flight out to 35 KTAS.

Sideward flight tests with an asymmetric loading were not conducted during this test program. From the data obtained at the symmetrical loading condition investigated, it would seem likely that with an asymmetric loading (a full left external fuel tank and a jettisoned right external fuel tank) that the maximum airspeed obtainable in right sideward flight may be limited by directional pedal control. Therefore, with an asymmetric loading it would appear that the maximum crosswind component will be reduced when hovering over a spot, resulting in a degradation of the mission capability.

Rearward flight was tested from 0 to 32 KTAS. From a hover the helicopter accelerated easily into rearward flight. As translational lift was reached the HH-53C had a nose down tendency which required a 1-inch aft cyclic input to prevent nose down pitching. Above translational lift speed, the longitudinal cyclic stick gradient becomes nearly flat out to 32 KTAS when approximately 2 inches or 20 percent of aft longitudinal stick control remained. The graphic results of the rearward flight test are presented in figure 67, appendix I. To recover from rearward flight, the nose was lowered slightly to slow down, and at about 15 KTAS a turn to the right was started with the directional pedals. This resulted in a roll to the left. Full right cyclic control was just sufficient to stop this, but not enough to initiate a roll back to the right. An attempt to use the above maneuver to recover from rearward flight with an asymmetric loading, as described in sideward flight, would result in very marginal handling qualities and would be hazardous.

The sideward and rearward flight tests were conducted at 41,000 pounds gross weight with a cg location at the forward limit of 328 inches. The sideward and rearward flight operations were conducted in ground effect at a wheel height of approximately 20 feet at 185 rpm rotor speed.

DYNAMIC STABILITY

Dynamic stability characteristics were determined by analysis of the aircraft reaction to pulse type control inputs. The duration of the pulses were approximately 1 second with a magnitude of approximately 1 inch for longitudinal and lateral control and 2 inches for the directional control. A mechanical jig was used in making precise pulse inputs.

Hover

Dynamic stability in a hover (IGE) at sea level was investigated at forward and aft cg locations at 31,000 and 41,000 pounds gross weight with the AFCS both operative and inoperative. Aircraft reactions to all control inputs were comparable regardless of the gross weight or cg location.

The HH-53C was dynamically stable about all axes with the AFCS on and its rates were damped out within 2 seconds after the pulse inputs.

A pitch-roll-yaw coupling with the AFCS inoperative was slightly evident during longitudinal pulse disturbances. This coupling characteristic became more evident as gross weight was increased.

A pitch-roll-yaw coupling was produced during a lateral disturbance with the AFCS inoperative. Following the lateral pulse the helicopter's initial motion was in the proper direction, and approximately 1 second after pulse input the aircraft began to roll in the opposite direction at a slower rate accompanied by an oscillating pitch attitude and an increasing yaw rate in the direction of control input; this continued until recovery was made.

A directional pedal pulse produced a pitch-roll-yaw coupling of which the lateral-directional coupling was the most significant. Following a directional input the helicopter motion was an immediate yaw in the proper direction and this was accompanied by a roll oscillation in a direction opposite to the control input.

The results of the hover dynamic stability testing are presented in the form of time histories in figures 68 through 73, appendix I.

Climb

Dynamic stability characteristics during climb were investigated at a climb speed of 62 KCAS. Test conditions were 31,000 pounds gross weight, 15,000 feet density altitude, and an aft cg location with the AFCS on and off. A rotor speed of 185 rpm was used during the climb dynamic stability investigation.

The helicopter was stable about all axes following an artificial disturbance with the AFCS on. With the AFCS off, recovery was necessary in approximately 1-1/2 seconds following a longitudinal control pulse because of the high pitching attitudes.

The aircraft reaction to a lateral pulse with the AFCS off produced a pitch-roll-yaw coupling with the lateral-directional coupling predominating. The rolling motion was in the proper direction, followed by a divergent rolling motion in the opposite direction, requiring corrective action approximately 2-1/2 seconds after the pulse input.

Helicopter motion following a directional pedal pulse with the AFCS off produced an evident roll-yaw coupling. This significant yaw oscillation was accompanied by a roll in the direction of control pulse input, requiring a recovery maneuver approximately 3 seconds after control input. The results of the climb dynamic stability testing are presented in figures 74 through 79, appendix I.

Level Flight

Dynamic stability characteristics in level flight were determined at 31,000 and 41,000 pounds gross weight, 5,000 and 15,000 feet density altitude, and at the full forward and aft cg locations with the AFCS on and off. Airspeeds investigated were 50 KCAS, 0.6 V_{MAX}, and 0.8 V_{MAX}.

With the AFCS operative, the helicopter exhibited good dynamic stability about all axes after pulse inputs. Damping was high about the longitudinal and lateral axes and only slightly positive following a directional disturbance. With the AFCS inoperative, a longitudinal pulse input produced a divergent pitching moment in the proper direction requiring a recovery maneuver within 1 second at 0.8 V_{MAX}. This value increased to 2 seconds at 50 KCAS. In both cases, recovery was started after about 15 degrees of attitude change.

Following a lateral disturbance with the AFCS inoperative, an immediate pitch-roll-yaw coupling was present. Lateral-directional coupling was the most significant. A rolling motion was produced in the direction of control input followed by a divergent rolling oscillation in the other direction requiring a recovery maneuver. This divergence in roll was accompanied by a diverging pitch attitude. This coupling was more noticeable at the higher airspeeds.

Pitch-roll-yaw coupling was present for disturbances about the directional axis with the AFCS inoperative. Again the lateral-directional coupling was the most significant. Directional pulses resulted in attitude changes in the direction of input. The attitudes, rates, and accelerations generated required aircraft recovery when divergence in one or more axes became evident.

Representative time histories of the helicopter motion following pulse control displacement during level flight are presented in figures 80 through 85, appendix I.

CONTROLLABILITY

Time histories resulting from approximately 1 inch step control inputs were used in evaluating the controllability. Control power, control response, and control sensitivity were determined for various magnitudes of control displacement. As in dynamic stability, a jig was used to insure a constant control displacement. Flight conditions investigated were similar to those evaluated during the dynamic stability portion of the test program.

Hover

The controllability in hover IGE was determined by analysis of the time histories resulting from the step control displacement. The helicopter's control power, control response, and control sensitivity obtained from various magnitudes of control inputs are plotted in figures 110 through 115, appendix 1. Table II presents a general summary of these results obtained from a 1-inch control step input. As indicated by this table, the longitudinal and lateral requirements of MIL-H-8501A were met for both VFR and IFR flight with the AFCS both operative and inoperative, but these requirements were not met in the directional axis. Time histories resulting from 1-inch step inputs are presented in figures 86 through 109, appendix 1.

Climb and Autorotation

The climb and autorotational longitudinal and lateral controllability characteristics were similar. The directional angular acceleration and velocity were slightly greater during autorotation than climb. In any case there was always adequate control power to correct for gust disturbances and for maneuvering during climbs and autorotations. These

Table II

AIRCRAFT RESPONSE TO STEP INPUT IN HOVER

Gross Weight = 31,000 Pounds			Pressure Altitude = Sea Level			
Axis	Attitude Displacement (deg/in.)	Time Lapse (sec)*	Maximum Angular Velocity (deg/sec/in.)	Time Lapse (sec)**	Maximum Angular Acceleration (deg/sec ² /in.)	Time Lapse (sec)**
AFCS ON, AFT CG (352 INCHES)						
Pitch	2.6 UP /3.0 DOWN	1.0	4.0 UP /3.5 DOWN	0.87	9.0 UP /7.5 DOWN	0.33
Roll	2.0 LEFT/2.2 RIGHT	0.5	6.0 LEFT/6.0 RIGHT	0.56	10.7 LEFT/12.5 RIGHT	0.19
Yaw	2.7 LEFT/2.3 RIGHT	1.0	4.0 LEFT/3.7 RIGHT	0.89	6.0 LEFT/5.0 RIGHT	0.14
AFCS OFF, AFT CG (352 INCHES)						
Pitch	3.5 UP /3.7 DOWN	1.0	6.5 UP /8.3 DOWN	1.50	9.0 UP /7.5 DOWN	0.32
Roll	2.8 LEFT/3.5 RIGHT	0.5	10.5 LEFT/11.8 RIGHT	1.09	13.0 LEFT/11.2 RIGHT	0.19
Yaw	3.7 LEFT/3.5 RIGHT	1.0	5.3 LEFT/5.0 RIGHT	0.83	6.0 LEFT/5.0 RIGHT	0.21
AFCS ON, FWD CG (328 INCHES)						
Pitch	2.4 UP /2.2 DOWN	1.0	3.5 UP /4.0 DOWN	1.0	6.7 UP /6.8 DOWN	0.4
Roll	2.2 LEFT/2.0 RIGHT	0.5	7.0 LEFT/6.5 RIGHT	0.5	16.0 LEFT/19.0 RIGHT	0.19
Yaw	2.0 LEFT/1.6 RIGHT	1.0	10.0 LEFT/10.0 RIGHT		7.0 LEFT/6.5 RIGHT	0.15
AFCS OFF, FWD CG (328 INCHES)						
Pitch	3.1 UP /3.2 DOWN	1.0	7.5 UP /7.7 DOWN	1.5	6.7 UP /6.8 DOWN	0.4
Roll	4.4 LEFT/4.1 RIGHT	0.5	12.0 LEFT/14.0 RIGHT	1.2	16.0 LEFT/19.0 RIGHT	0.24
Yaw	2.5 LEFT/2.5 RIGHT	1.0	18.5 LEFT/16.0 RIGHT		8.5 LEFT/8.3 RIGHT	0.25

*MIL-H-8501A specified these time delays before measuring attitude change following a 1-inch control step input.

**Time required to reach maximum angular velocity or angular acceleration.

conditions and results of the 1-inch control step inputs are tabulated in table III. Time histories resulting from 1-inch step control inputs are presented in figures 116 through 127, appendix I. The aircraft's sensitivity and response for various control inputs are presented in figures 128 through 130, appendix I.

Level Flight

Time histories resulting from approximately 1-inch step inputs were obtained during level flight and are presented in figures 131 through 142, appendix I. AFCS had very little effect, under the conditions tested, on the longitudinal and lateral response and sensitivity to the above control inputs. These results are summarized in table IV, and were obtained from the various controllability plots presented in figures 143 through 145, appendix I. Overall, the control effectiveness was lower during level flight than while hovering or during climb and autorotation.

AFCS HARDOVERS

The AFCS incorporated in the HH-53C was composed of two systems which gave redundancy in pitch and roll but not in yaw. Hardover failures were electrically induced in one axis of one AFCS while the remaining axis of that AFCS and the remaining axes of the second AFCS were operating normally. The gross weight and cg location for these tests were 31,000 pounds and 328 inches.

Table III

AIRCRAFT RESPONSE TO STEP INPUT DURING CLIMB AND AUTOROTATION			
Gross Weight = 31,000 Pounds		Pressure Altitude = 15,000 Feet	
AFCS ON, MID CG (340 INCHES)			
Maximum Angular Velocity (deg/sec/in.)	Time Lapse (sec)*	Maximum Angular Acceleration (deg/sec ² /in.)	Time Lapse (sec)*
CLIMB AT 62 KCAS			
3.0 UP /3.7 DOWN	1.09	4.5 UP /4.7 DOWN	0.37
5.7 LEFT/6.0 RIGHT	0.56	9.0 LEFT/10.3 RIGHT	0.19
1.5 LEFT/1.8 RIGHT	1.45	2.5 LEFT/3.5 RIGHT	0.14
AUTOROTATION AT 72 KCAS			
3.0 UP /3.7 DOWN	0.92	4.5 UP /4.7 DOWN	0.32
5.7 LEFT/6.0 RIGHT	0.53	9.0 LEFT/10.3 RIGHT	0.26
2.5 LEFT/2.2 RIGHT	1.75	3.7 LEFT/3.5 RIGHT	0.13

*Time required to reach maximum angular velocity or angular acceleration.

Table IV

AIRCRAFT RESPONSE TO STEP INPUT DURING LEVEL FLIGHT			
Gross Weight = 41,000 Pounds Pressure Altitude = 7,000 Feet 113 KCAS			
Maximum Angular Velocity (deg/sec/in.)	Time Lapse (sec)*	Maximum Angular Acceleration (deg/sec ² /in.)	Time Lapse (sec)*
AFCS ON, FWD CG (328 INCHES)			
2.5 UP /2.0 DOWN	0.67	3.0 UP /3.5 DOWN	0.45
3.0 LEFT/3.5 RIGHT	0.54	5.5 LEFT/5.2 RIGHT	0.33
1.0 LEFT/1.0 RIGHT	0.63	1.3 LEFT/1.1 RIGHT	0.20
AFCS OFF, FWD CG (328 INCHES)			
2.8 UP /2.0 DOWN	0.75	4.5 UP /4.5 DOWN	0.58
5.5 LEFT/5.2 RIGHT	0.53	8.0 LEFT/8.0 RIGHT	0.48
1.0 LEFT/1.0 RIGHT	0.75	1.3 LEFT/1.1 RIGHT	0.20

*Time required to reach maximum angular velocity or angular acceleration.

While hovering, a hardover about the pitch axis resulted in a mild pitch up or pitch down in the appropriate direction. After the failure of the pitch channel, about 2 seconds were required before the redundant AFCS system damped this pitching moment and the aircraft then assumed a new pitch altitude up to 10 degrees different than before hardover. A hardover about the yaw axis resulted in a pure divergent yaw in the correct direction. After a hardover in yaw, corrective action was initiated after an attitude change of 15 degrees. This was reached 2 seconds after the hardover was induced. A 10 degree per second rate was the maximum encountered during a yaw hardover in either direction. In all cases investigated the aircraft had a mild reaction to all AFCS hardovers during hover.

AFCS hardovers were conducted for climb and autorotation at air-speeds for best rate of climb and minimum rate of descent. Maximum pitch rates of 5 degrees per second were encountered 1 second after the hardover was induced, and this same rate was obtained from a roll hardover in 1/2 second. Response to hardover inputs in yaw during climb and autorotation were divergent with rates of 6 degrees per second occurring 2 seconds after hardover.

During level flight, hardovers were induced in each axis at 50 and 130 KCAS. Maximum pitch and roll rates of 5 degrees per second were reached 1 second and 1/2 second, respectively, after the AFCS hardover was induced. AFCS yaw hardover at 50 KCAS resulted in divergent yawing with a maximum yaw rate of 6 degrees per second obtained in 1-1/2 seconds. The same results were obtained at 130 KCAS, and in addition the aircraft had a 5 degree per second roll rate in the direction of yaw.

Time histories of the hardovers conducted during this test program are presented in figures 146 through 167, appendix I.

APPENDIX I

data plots and flight log

5 - Foot Wheel Height
450 - gallon tiptanks installed
engines not equipped with EAPS

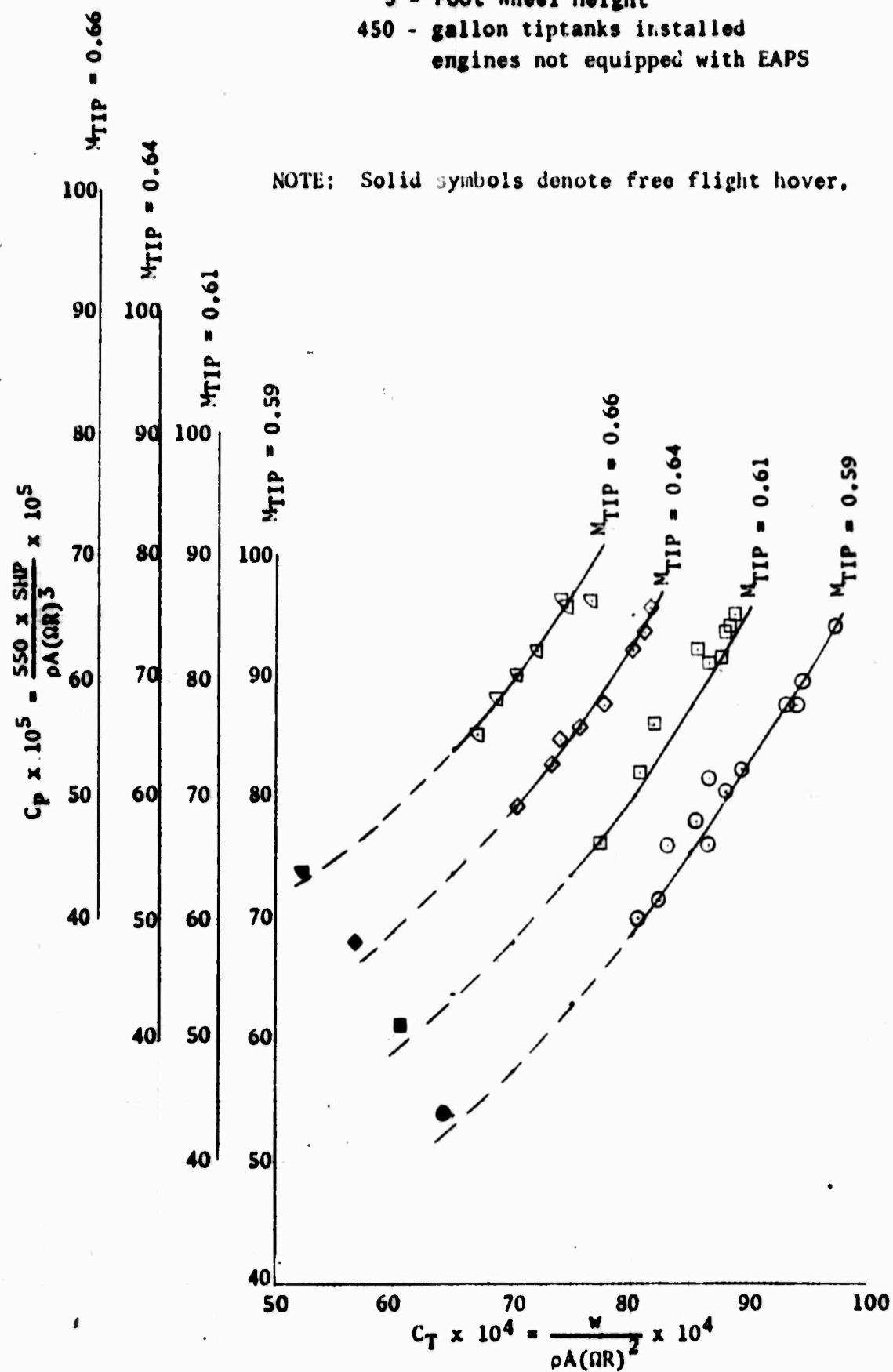


Figure 1. Nondimensional Hovering Performance

10 - Foot Wheel Height
 450 - gallon tiptanks installed
 engines not equipped with EAPS

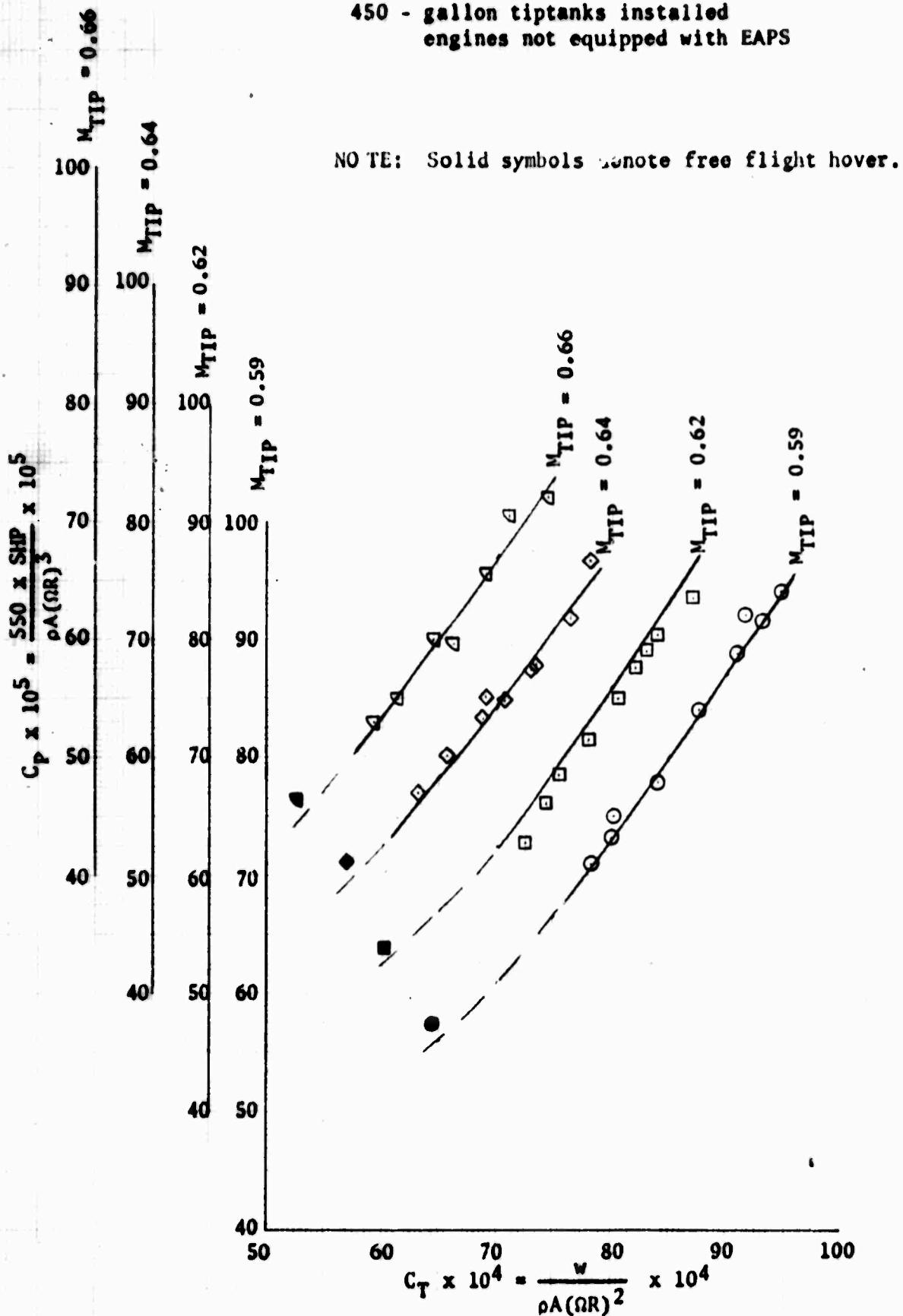


Figure 2. Nondimensional Hovering Performance

181-53C USAF S/N 62-12577
T64-GE-7 Engines

22 - Foot Wheel Height
450 - gallon tiptanks installed
engines not equipped with EAPS

NOTE: Solid symbols denote free flight hover.

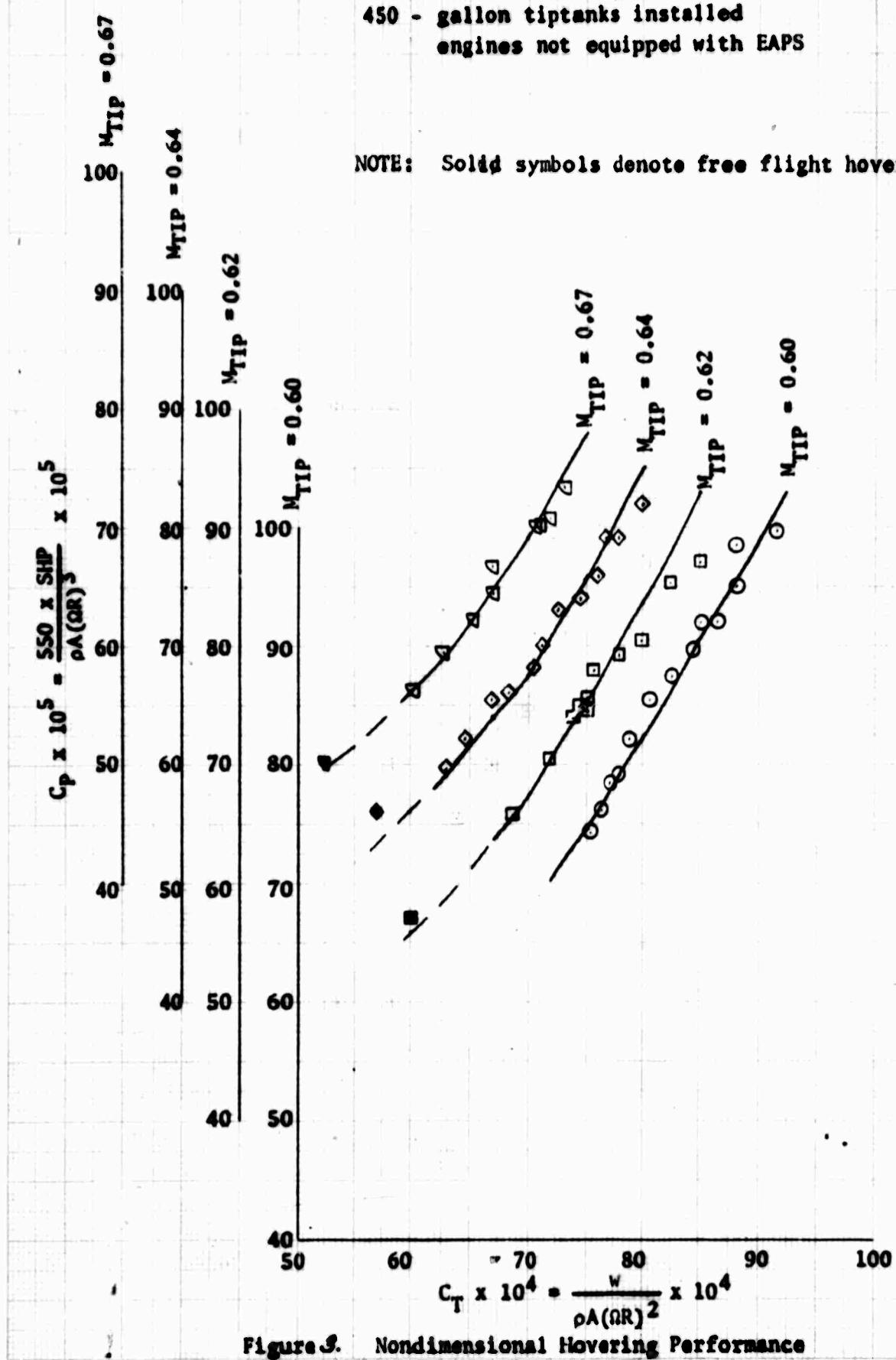


Figure 9. Nondimensional Hovering Performance

HH-53C USAF S/N 62-12577

T64-GE-7 Engines

47 - Foot Wheel Height

450 - gallon tiptanks installed
engines not equipped with EAPS

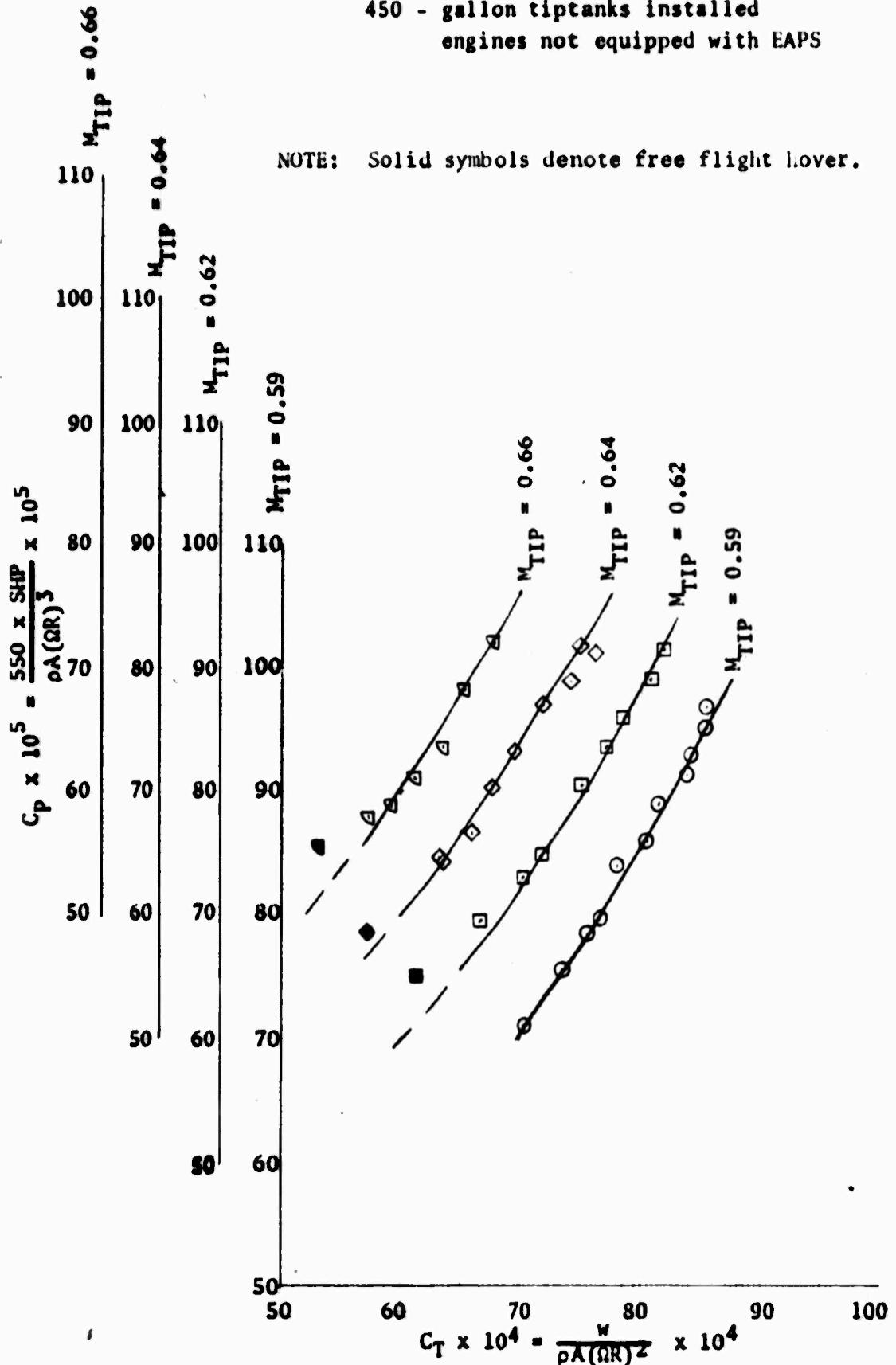


Figure 4. Nondimensional Hovering Performance

80 - Foot Wheel Height
450 - gallon tiptanks installed
engines not equipped with EAPS

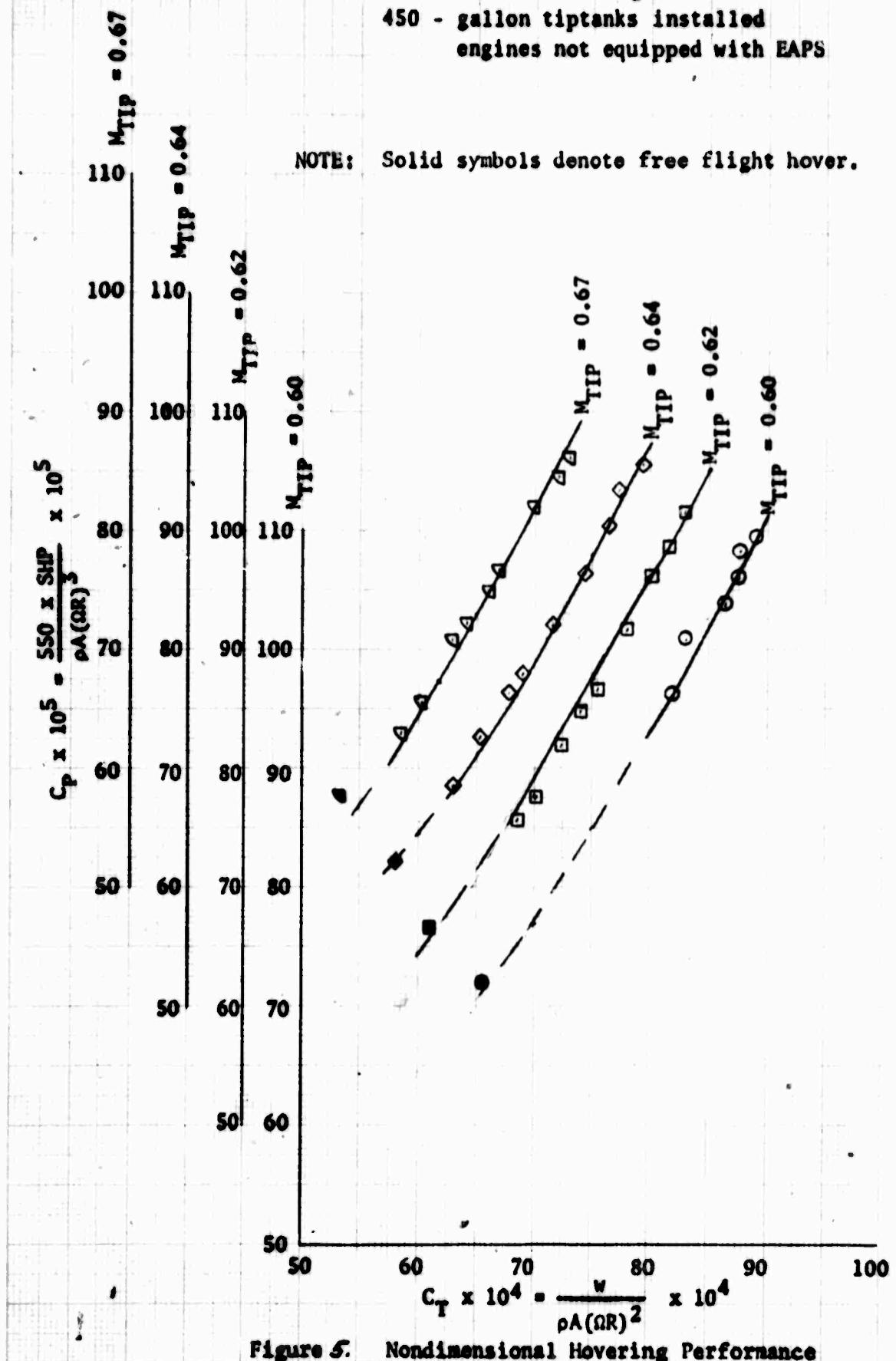


Figure 5. Nondimensional Hovering Performance

100 - Foot Wheel Height
450 - gallon tiptanks installed
engines not equipped with EAPS

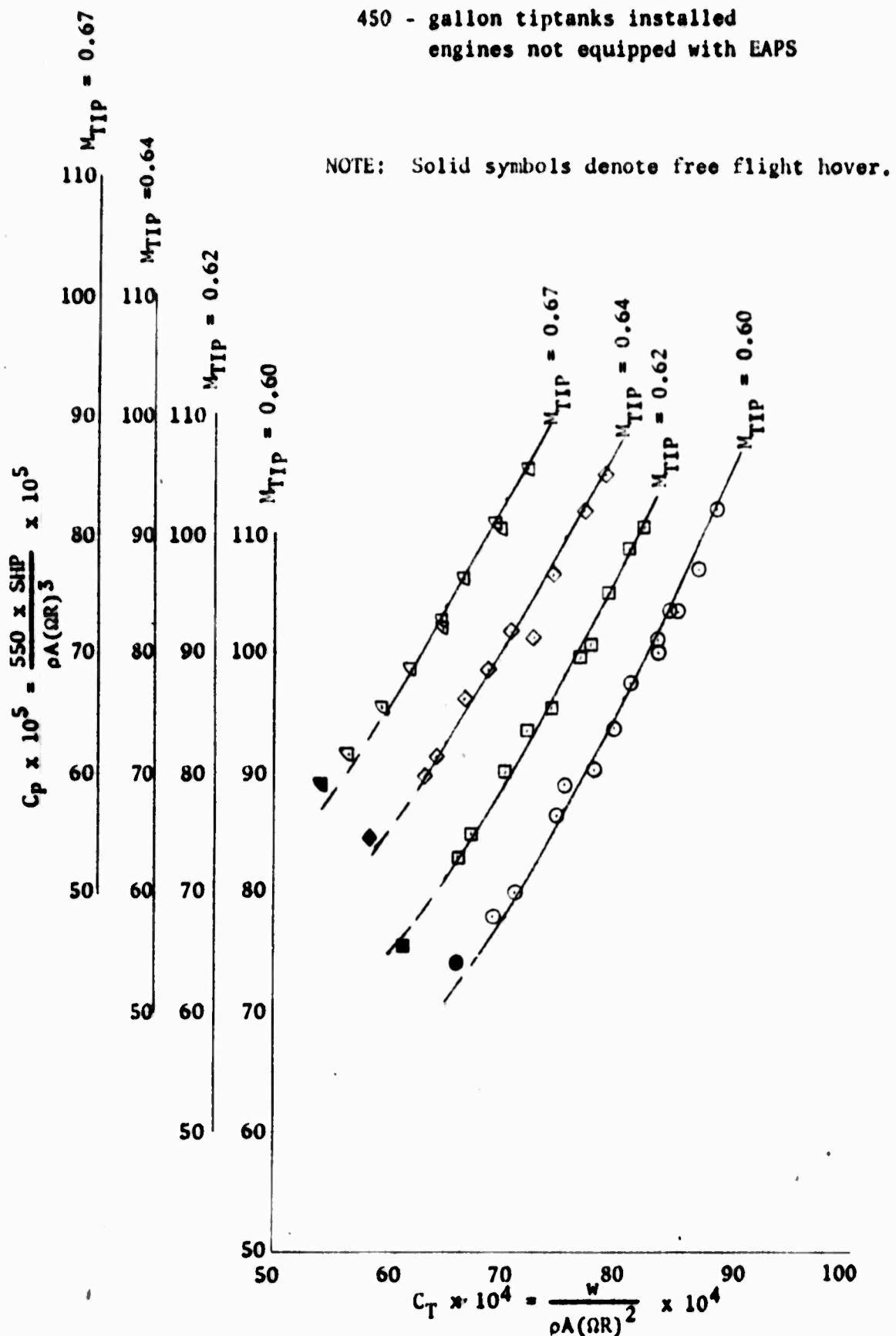


Figure 6. Nondimensional Hovering Performance

HH-53C USAF S/N 67-14993
T64-GE-7 Engines

Symbol	Avg GW (lb)	Avg Press Alt (ft)	Avg FAT (°C)	Avg cg (in)	Rotor Speed (rpm)
◊	35,000	4,500	6	340	185
□	35,000	7,000	17	340	185
○	35,000	14,000	2	340	185

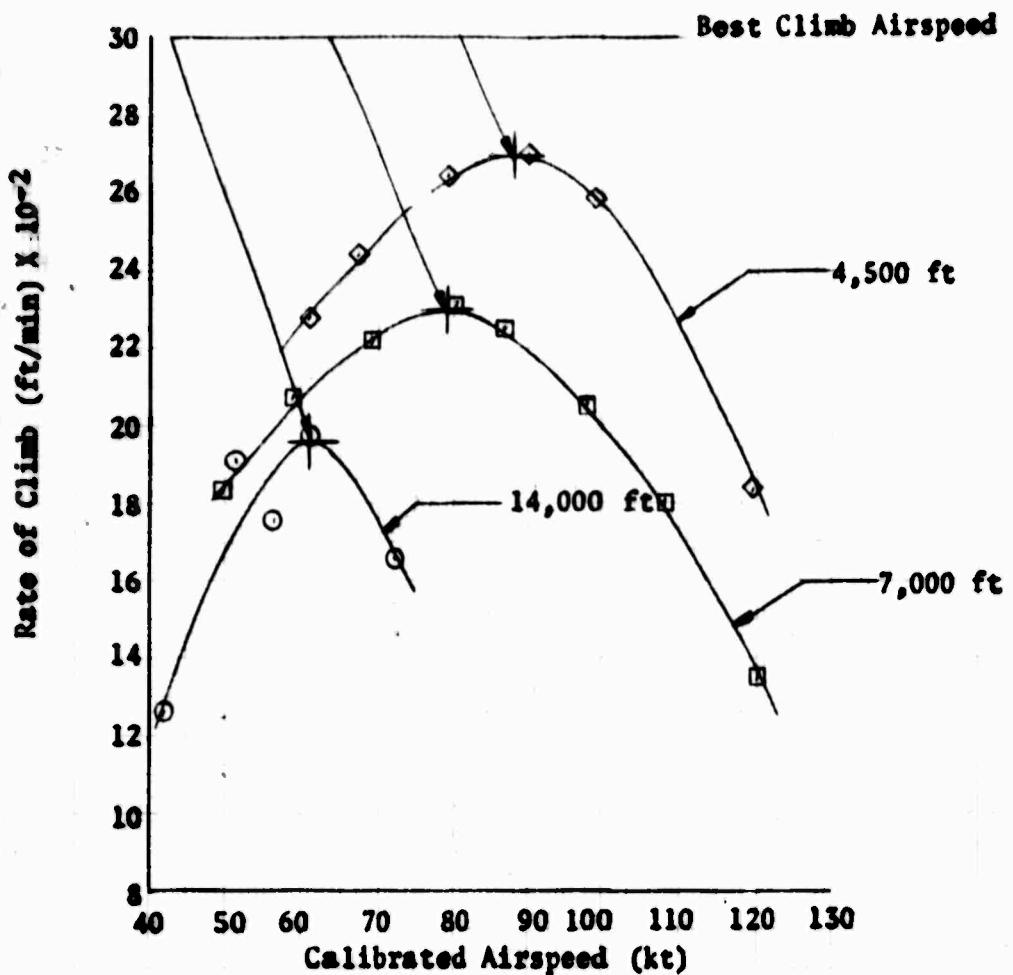
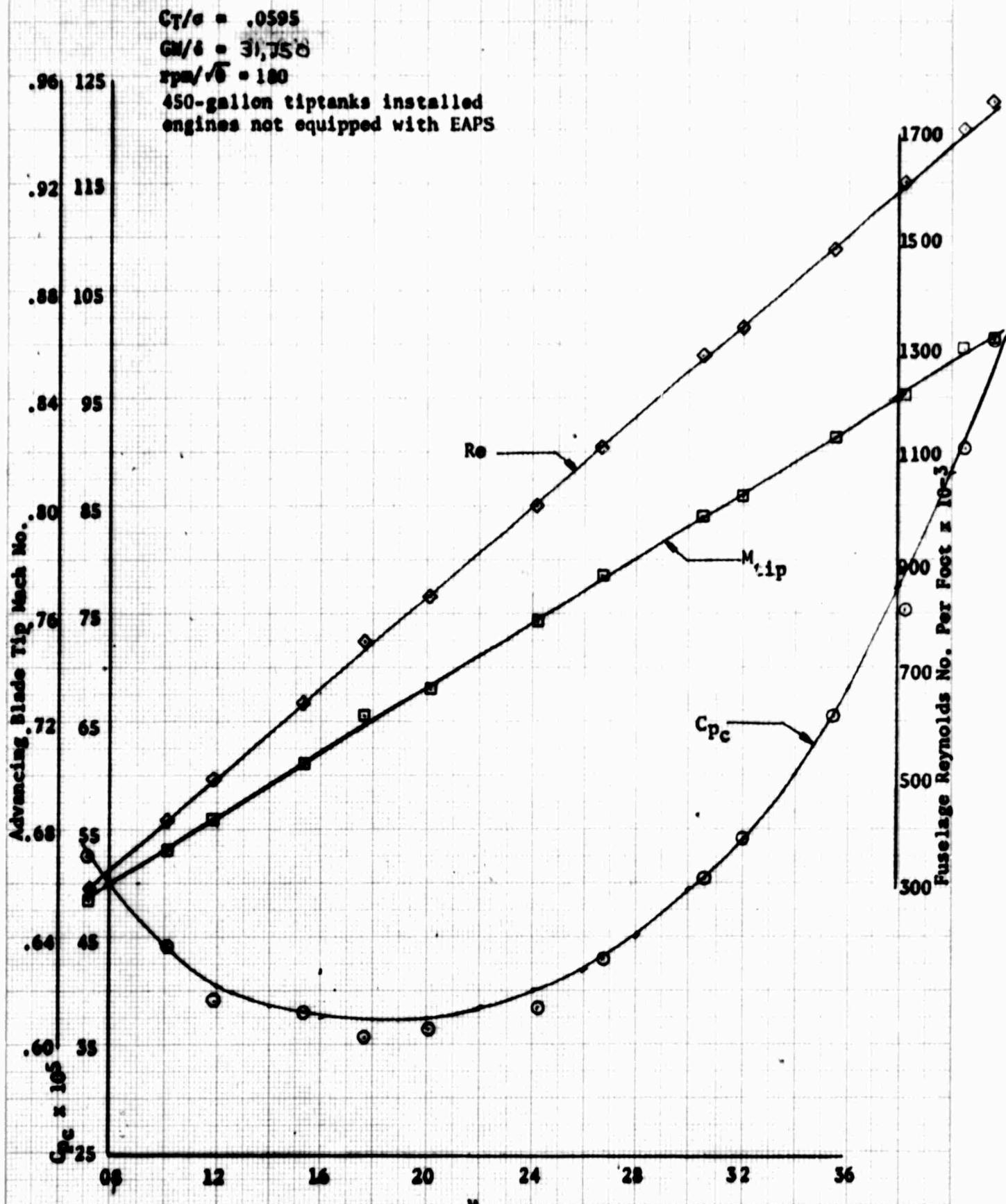


Figure 7. Sawtooth Climb Performance

MM-S3C USAF S/N 67-16993
T64-GE-7 Engines



HH-SSC USAF S/N 67-14993
T64-GE-7 Engines

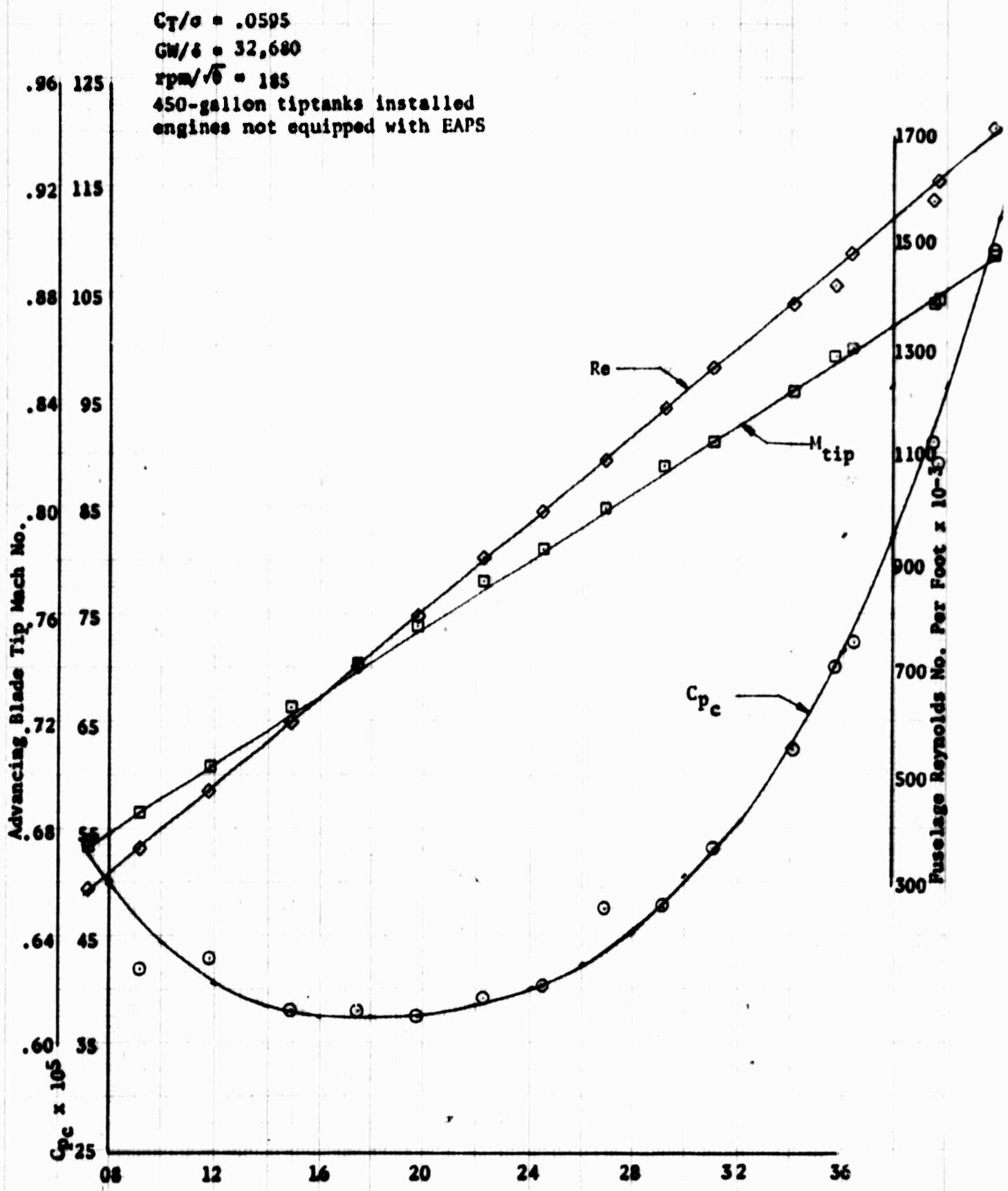


Figure 9. Level Flight Performance

HH-53C USAF S/N 67-14993
T64-GE-7 Engines

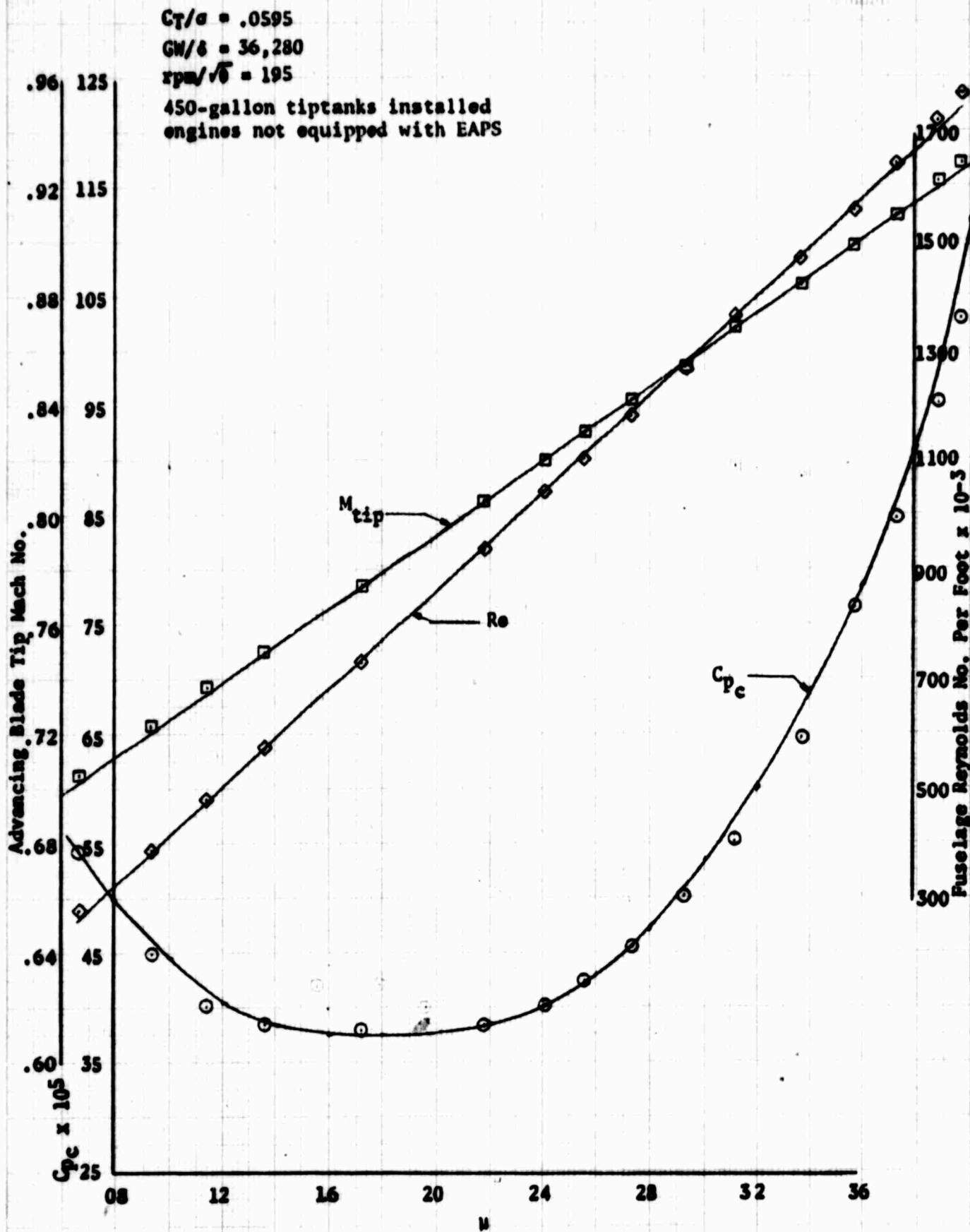


Figure 10. Level Flight Performance

HH-53C USAF S/N 67-14993
T64-GE-7 Engines

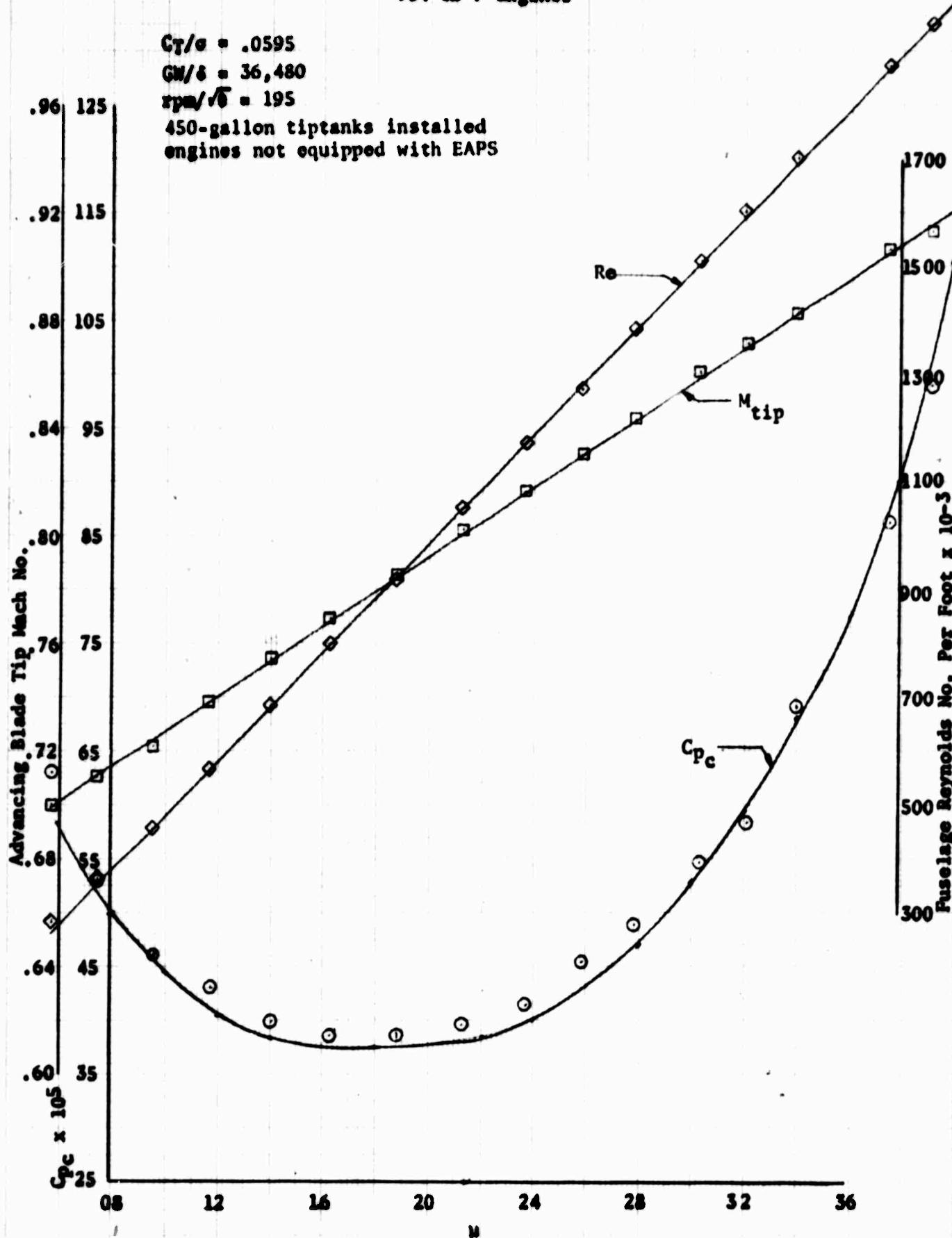


Figure 11. Level Flight Performance

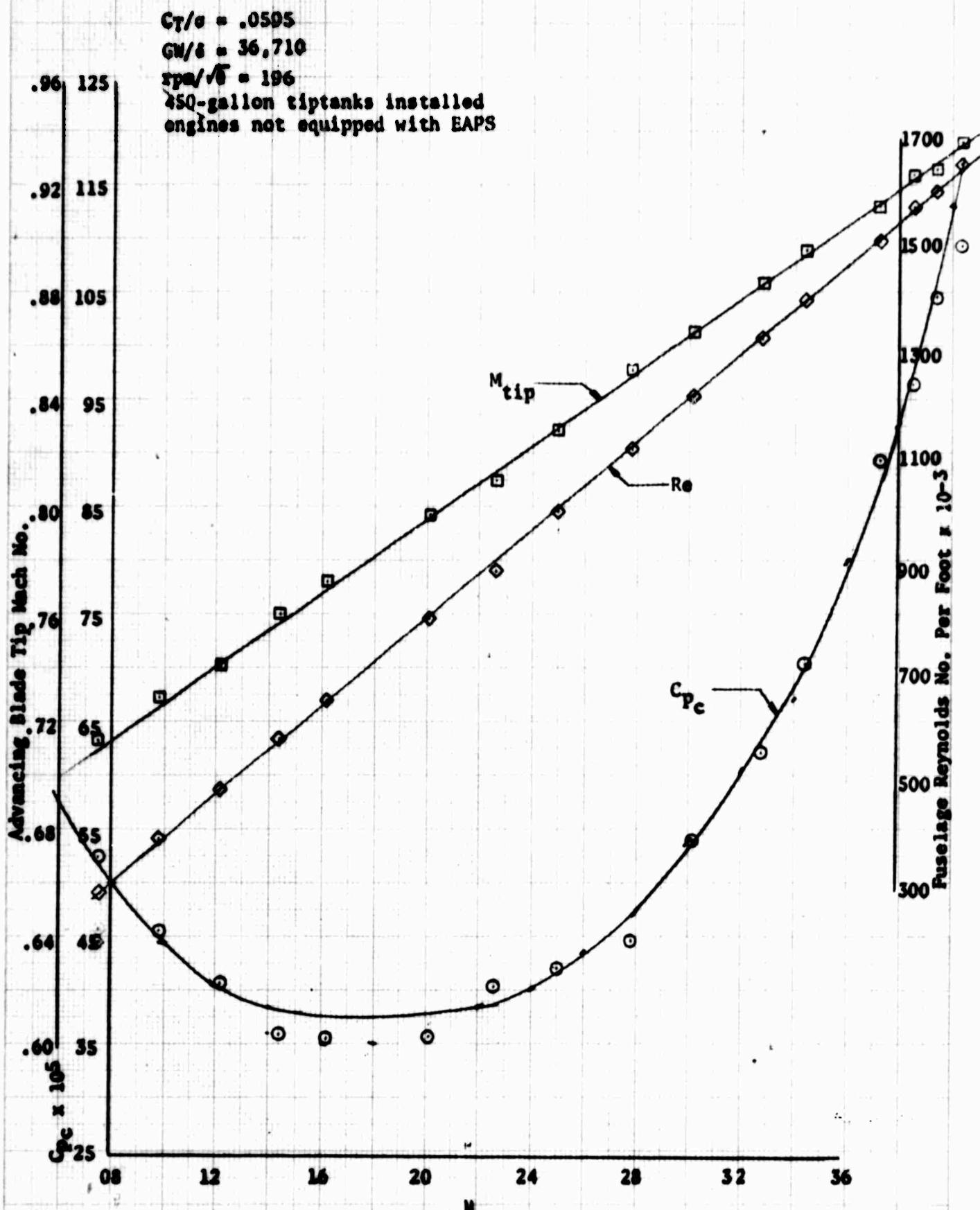


Figure 12. Level Flight Performance

HH-53C USAF S/N 67-14993

T64-GE-7 Engines

$$C_T/\sigma = .0595$$

$$GW/\delta = 40,070$$

$$rpm/\sqrt{\theta} = 206$$

450-gallon tip tanks installed
engines not equipped with EAPS

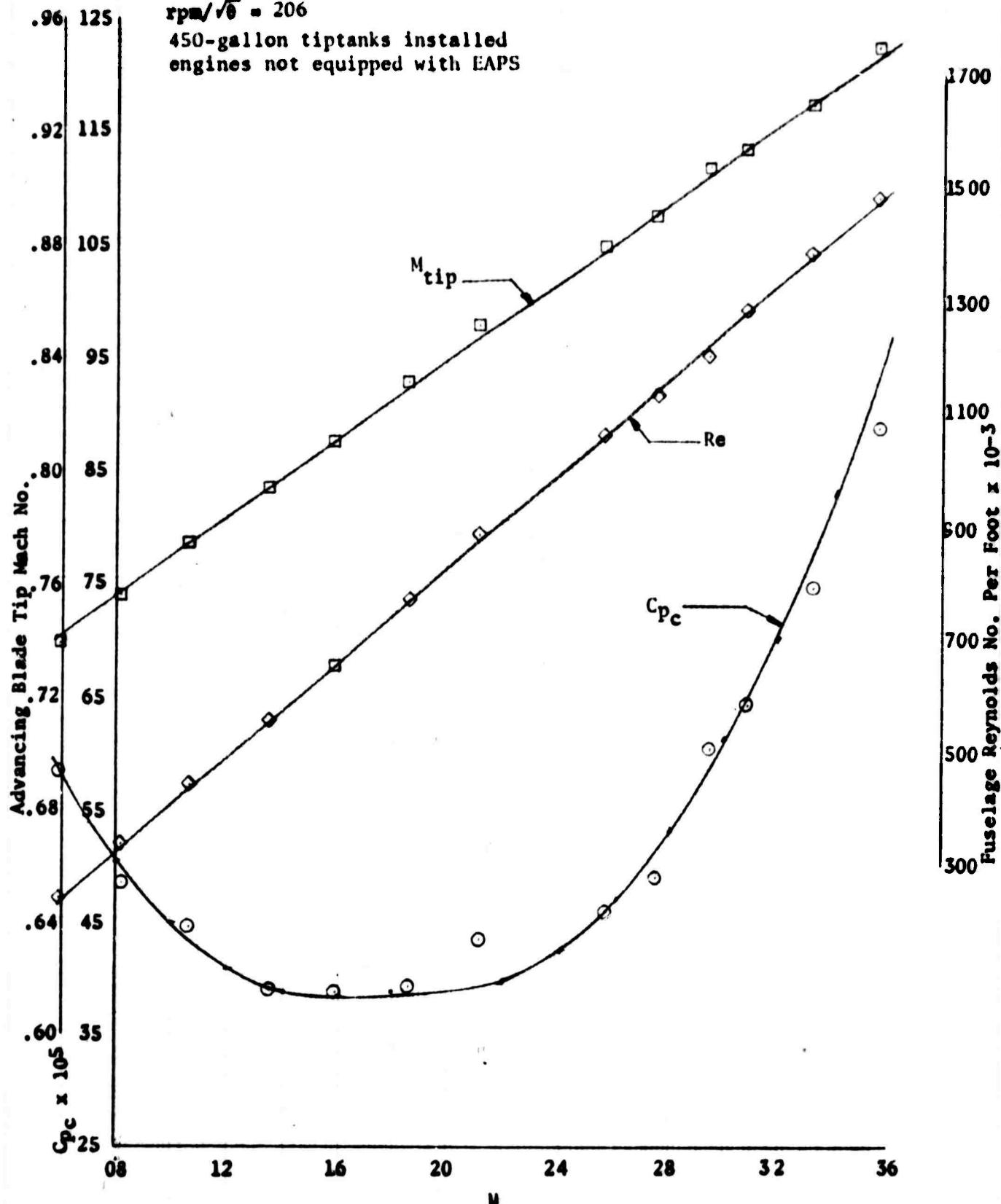


Figure 13. Level Flight Performance

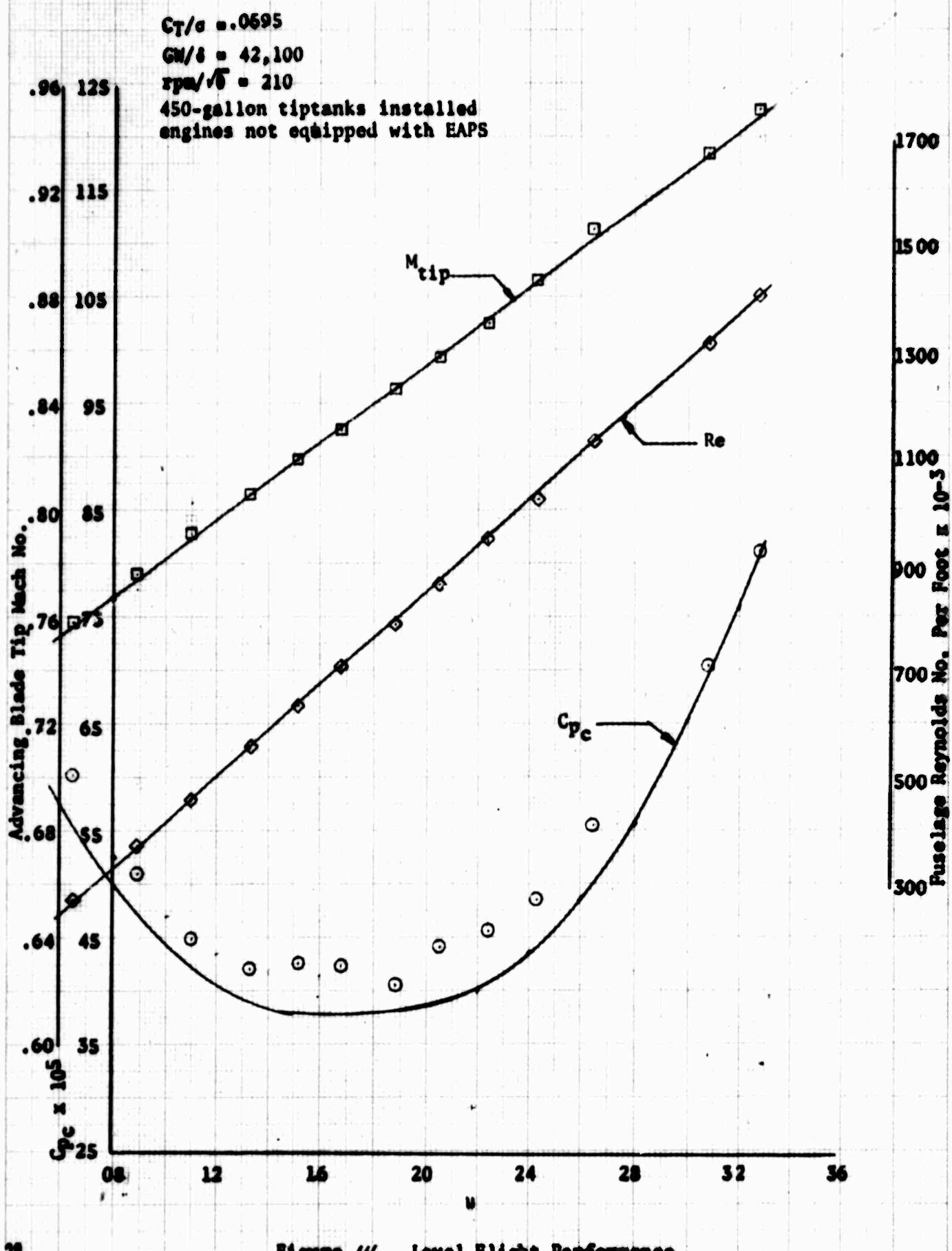


Figure 14. Level Flight Performance

HH-53C USAF S/N 67-14993
T64-GE-7 Engines

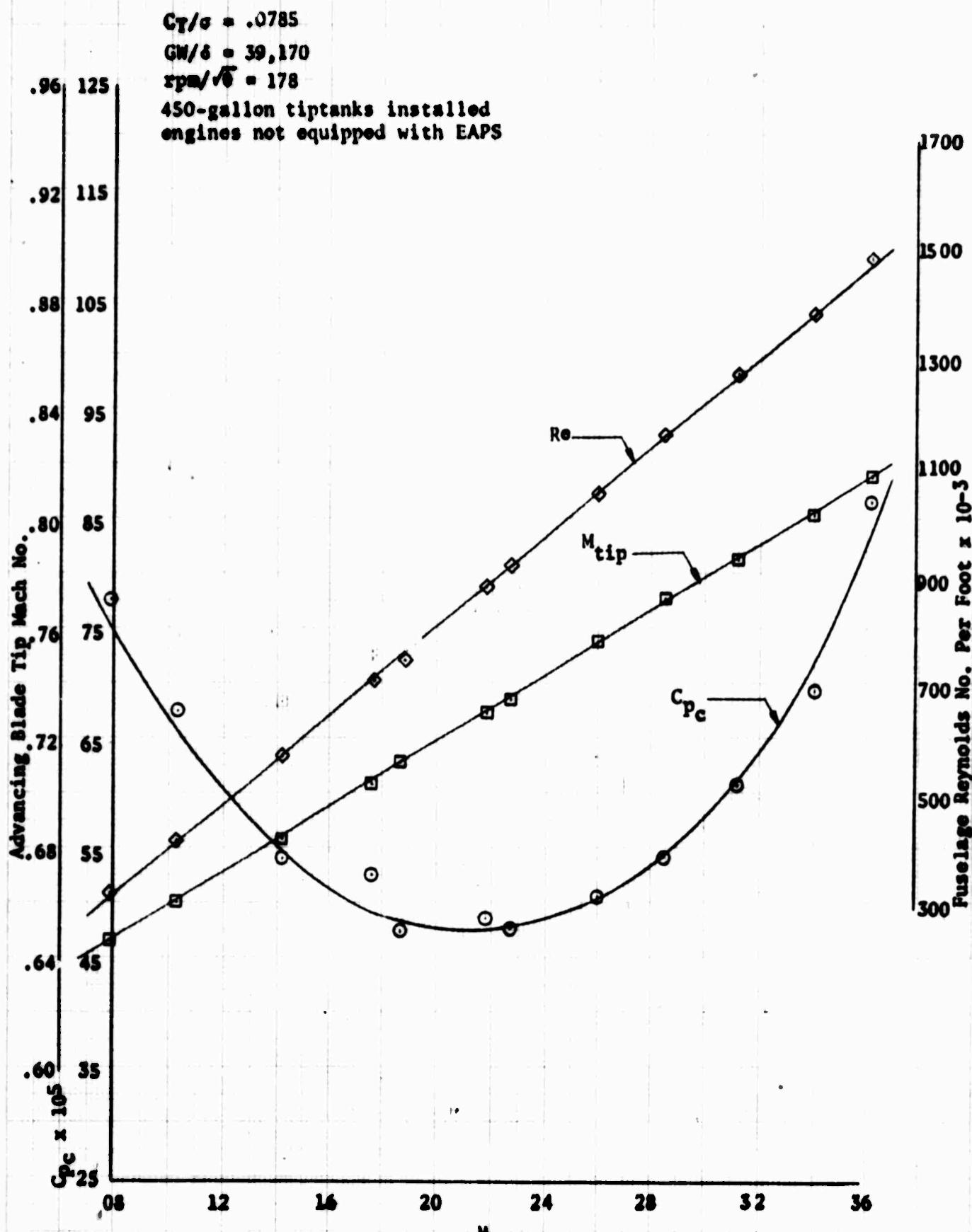


Figure 15. Level Flight Performance

HH-53C USAF S/N 67-14993

T64-GE-7 Engines

$$C_T/\sigma = .0785$$

$$GW/\delta = 43,680$$

$$\text{rpm}/\sqrt{\delta} = 184$$

450-gallon tiptanks installed
engines not equipped with EAPS

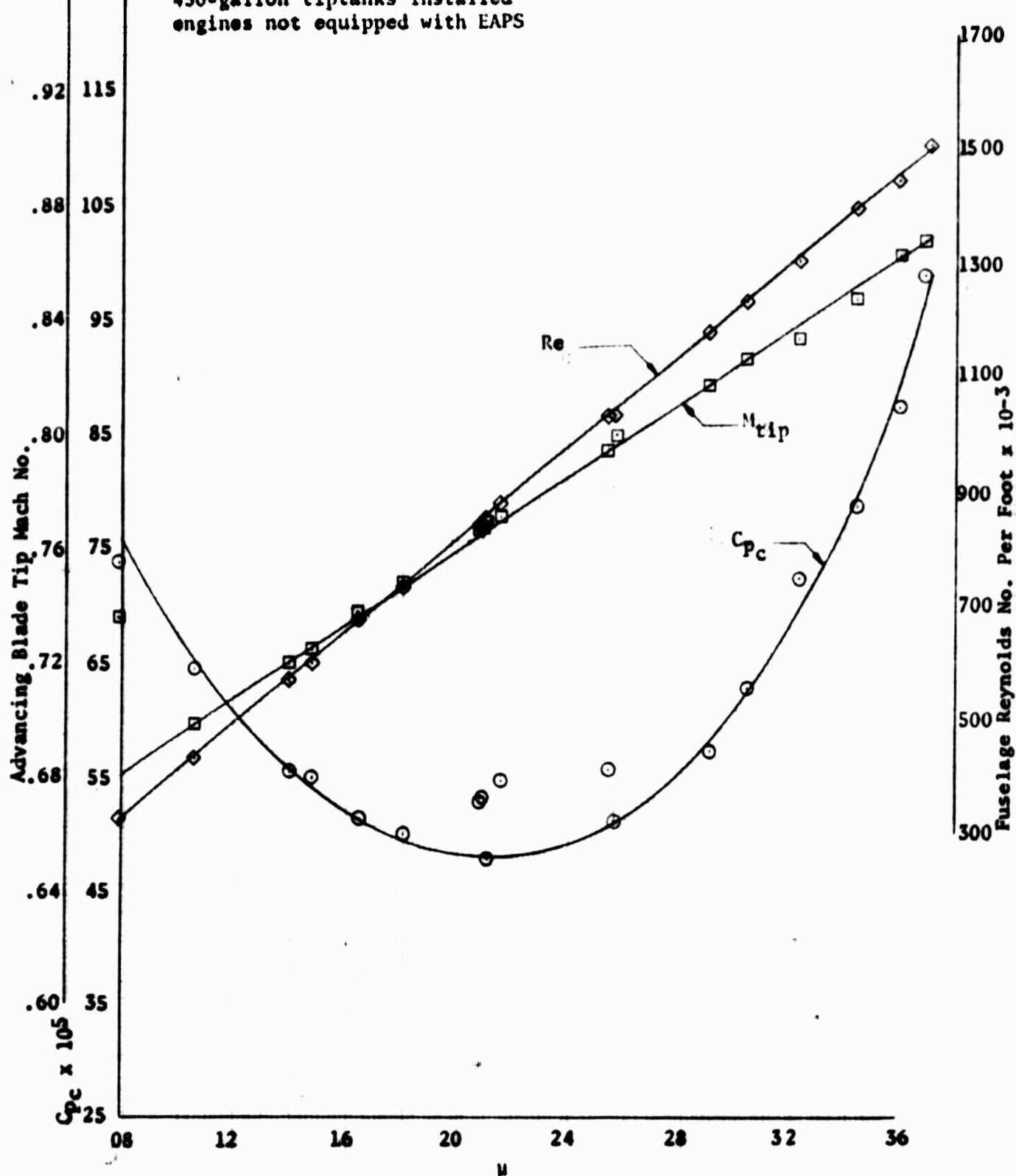


Figure 16. Level Flight Performance

HH-S3C USAF S/N 67-14993
T64-GE-7 Engines

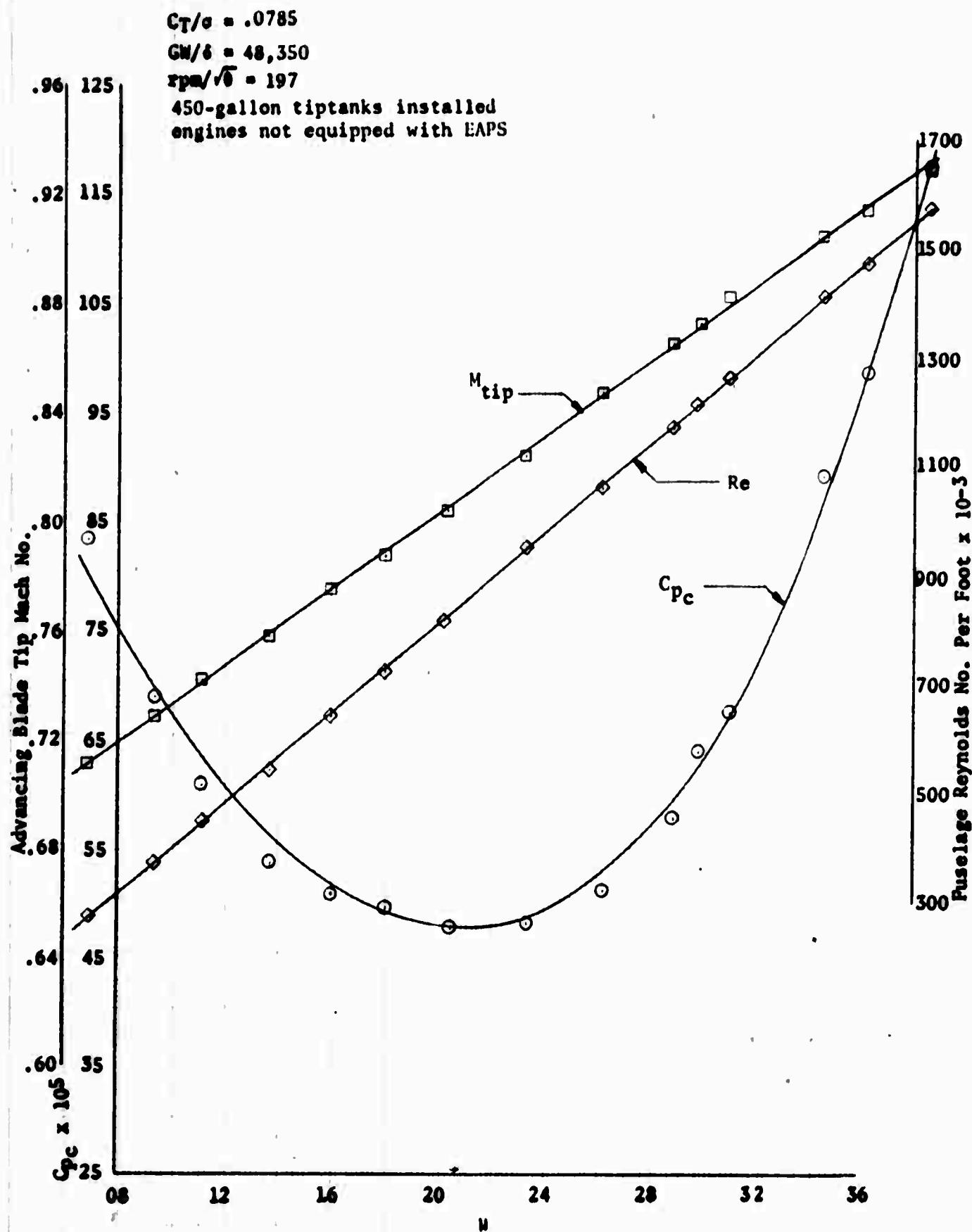


Figure 7. Level Flight Performance

HH-53C USAF S/N 67-14993
T64-GE-7 Engines

$C_T/c = .0785$
 $GW/g = 53,460$
 $rpm/\sqrt{g} = 205$
 450-gallon tiptanks installed
 engines not equipped with EAPS

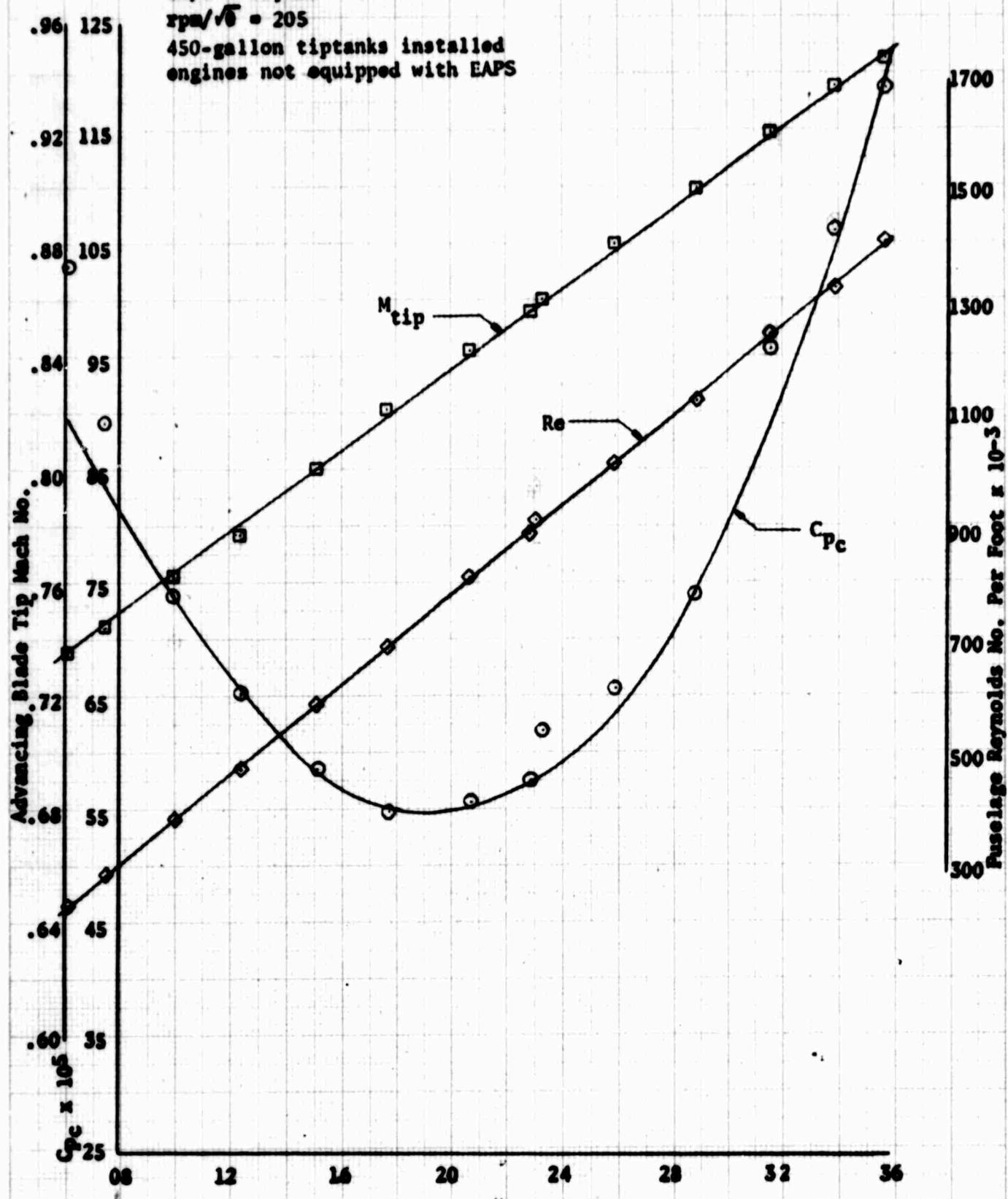


Figure 18. Level Flight Performance

HH-53C USAF S/N 67-14993
T64-GE-7 Engines

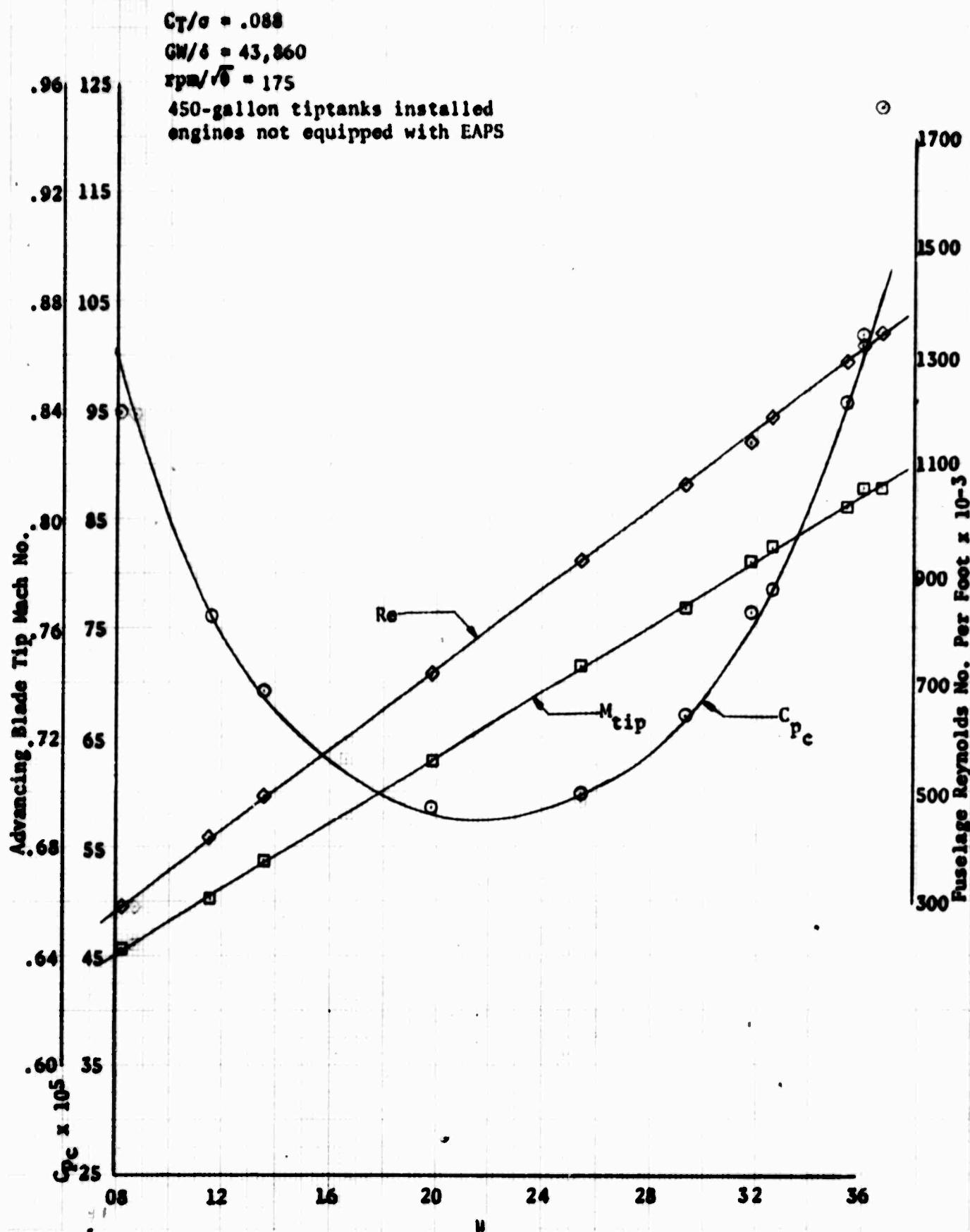
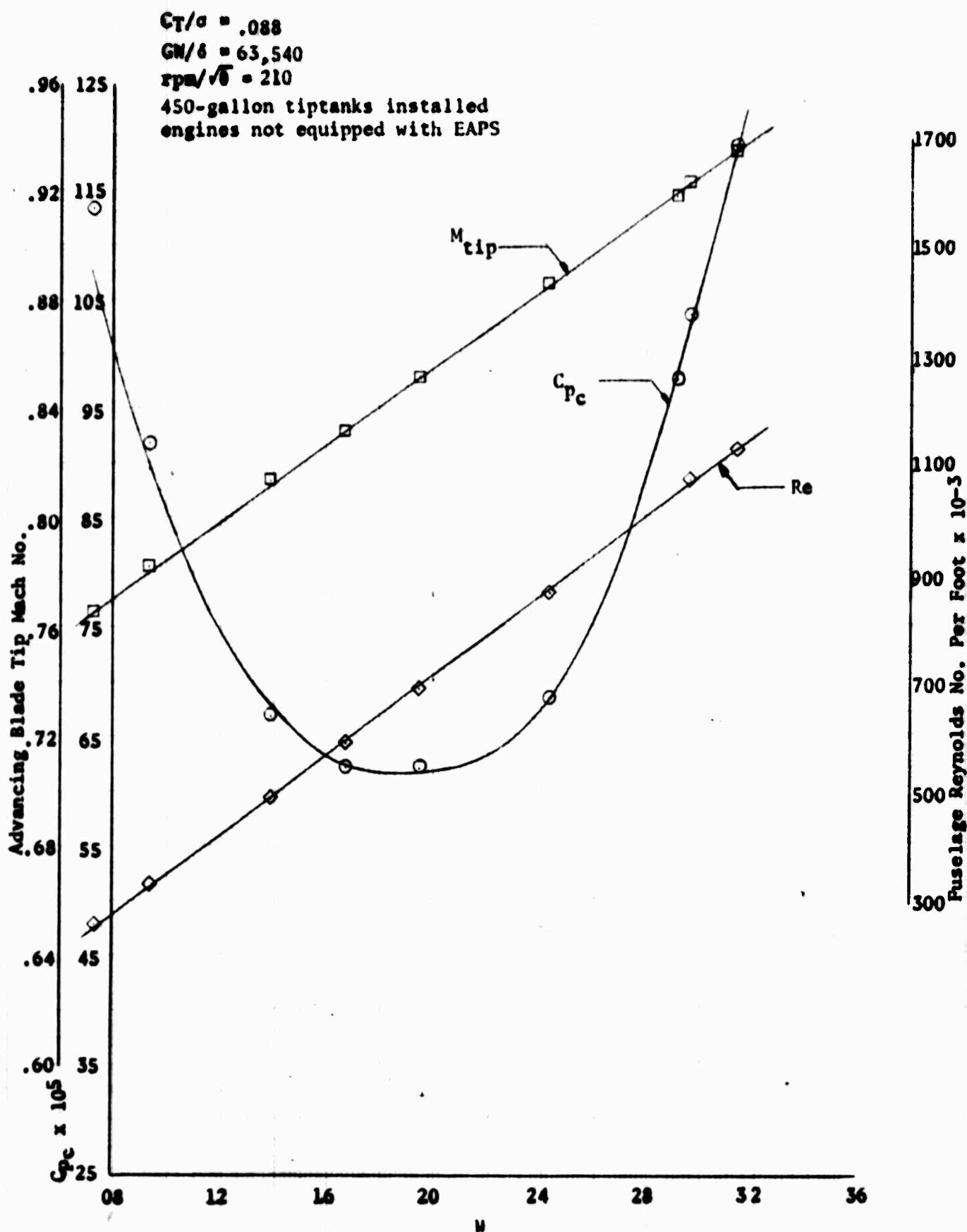


Figure 19. Level Flight Performance

MM-53C USAF S/N 67-14993

T64-GE-7 Engines



HH-53C USAF S/N 67-14993

T64-GE-7 Engines

$$C_T/\sigma = .099$$

$$GM/\delta = 54,610$$

$$\text{rpm}/\sqrt{\sigma} = 186$$

450-gallon tiptanks installed
engines not equipped with EAPS

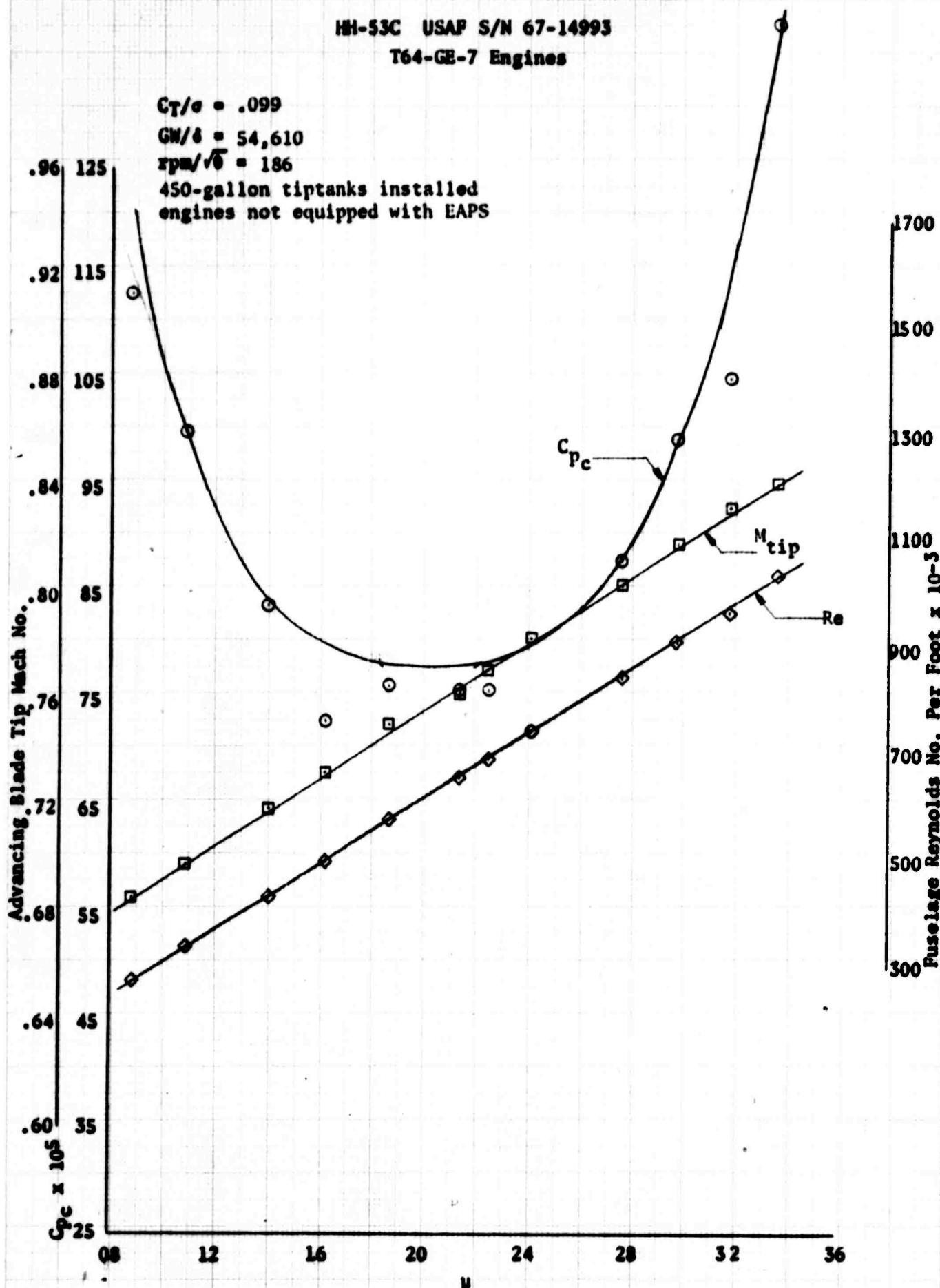


Figure 81. Level Flight Performance

HH-S3C USAF S/N 67-14993
T64-GE-7 Engines

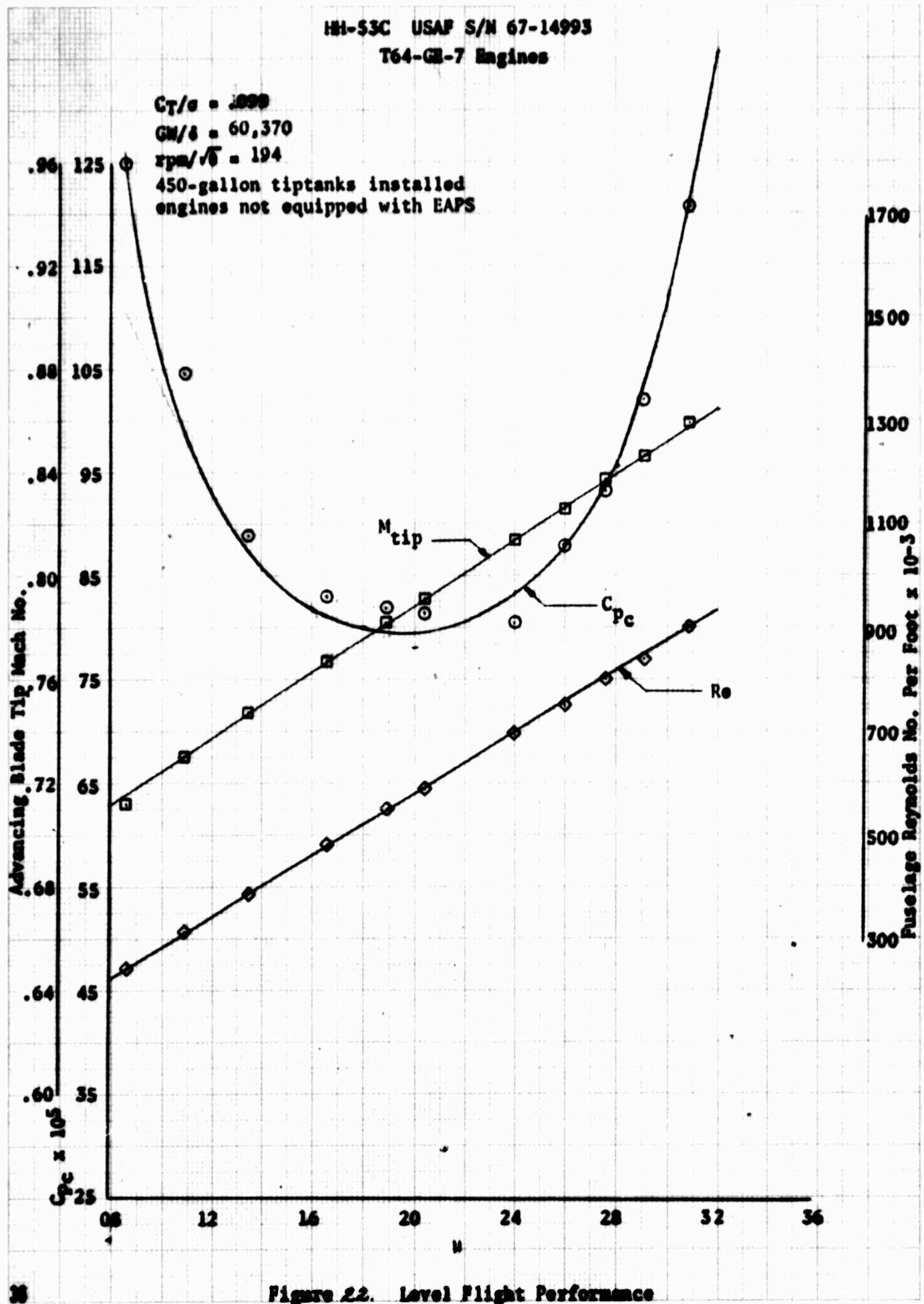


Figure 22. Level Flight Performance

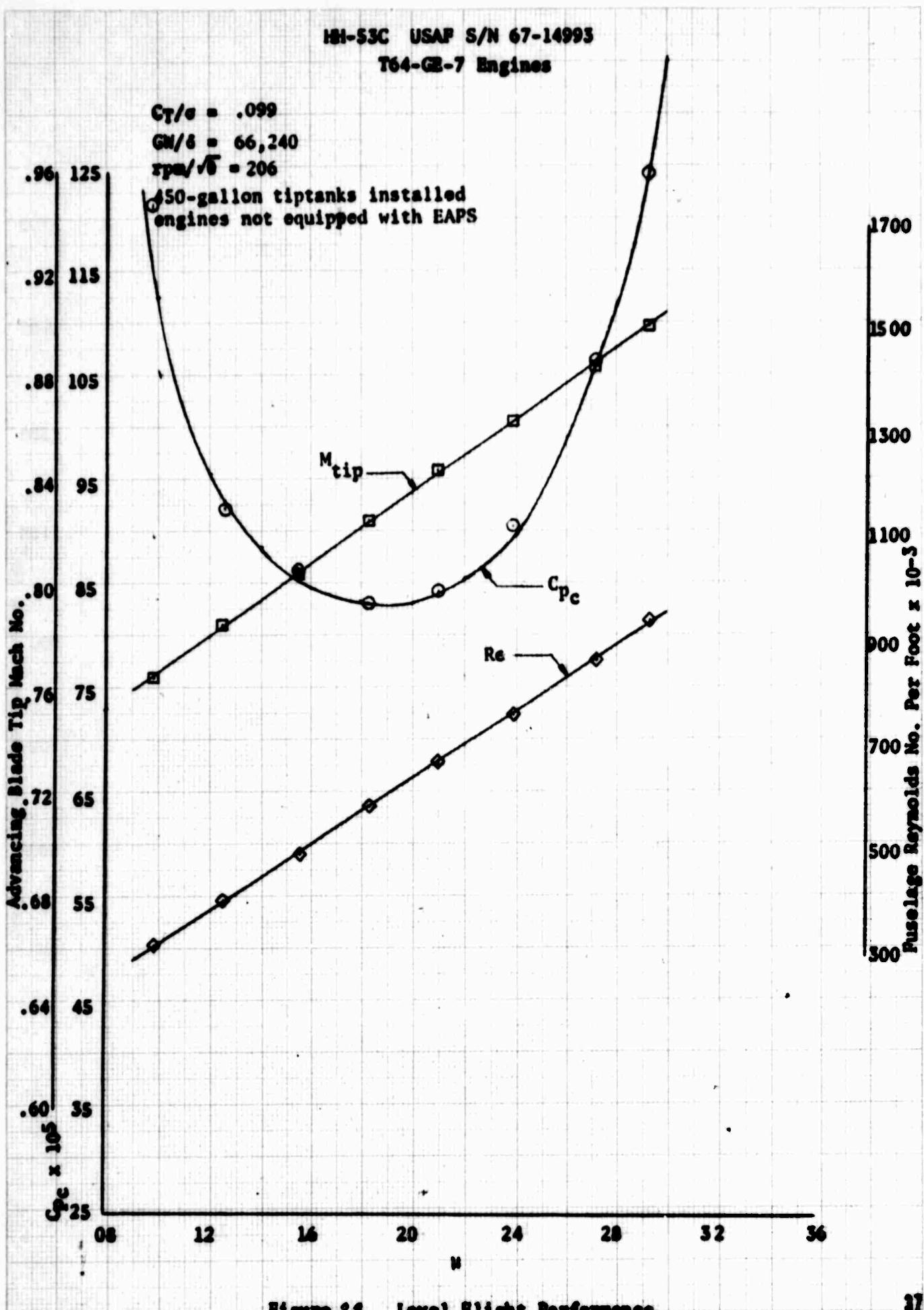
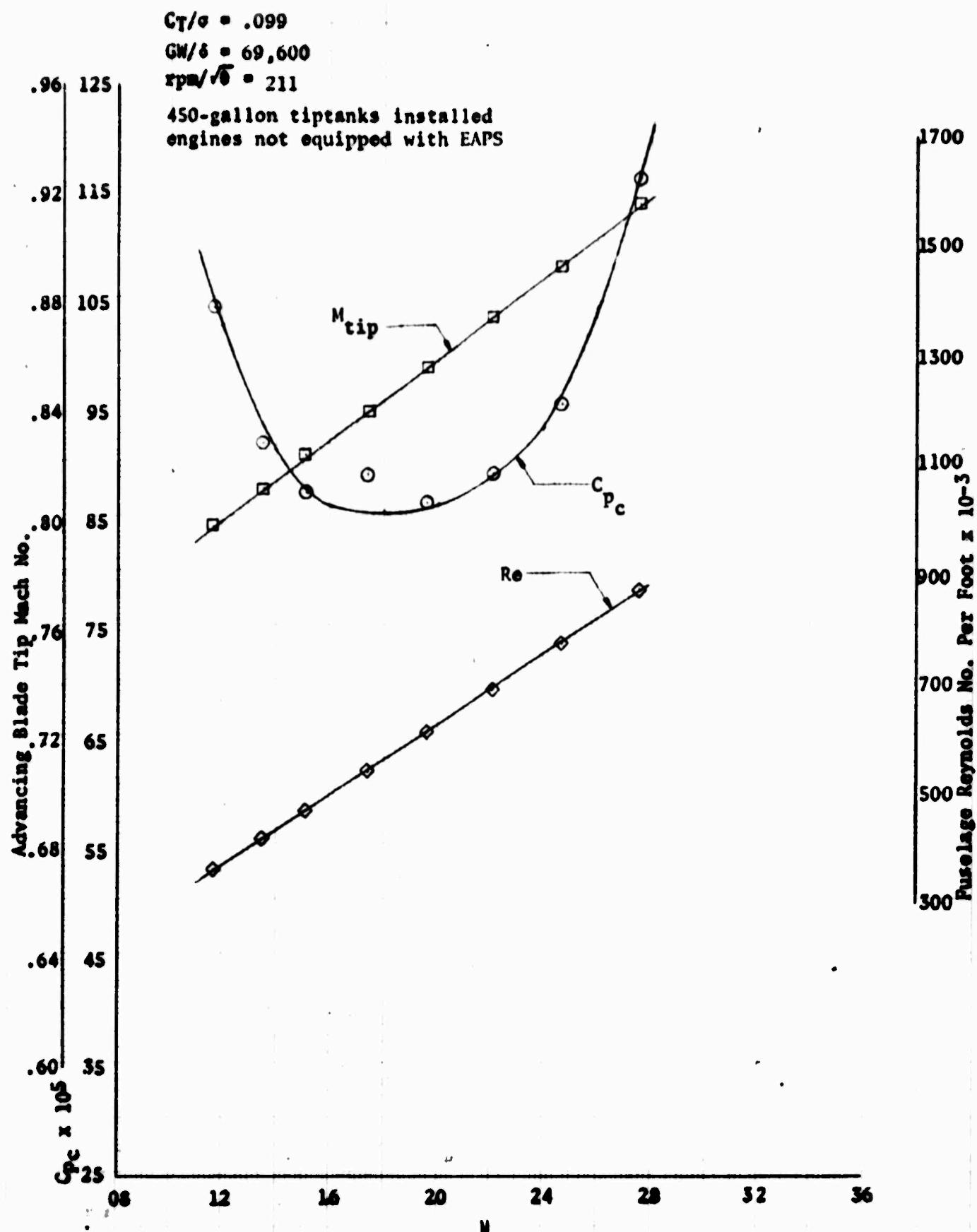


Figure 2.9. Level Flight Performance

HH-S3C USAF S/N 67-14993

T64-GE-7 Engines



$$C_T/\sigma = .0785$$

$$GW/\delta = 48,280$$

$$\text{rpm}/\sqrt{\sigma} = 197$$

——— Landing gear down
 - - - - - Landing gear up
 Dashed fairing obtained from
 Figure 17

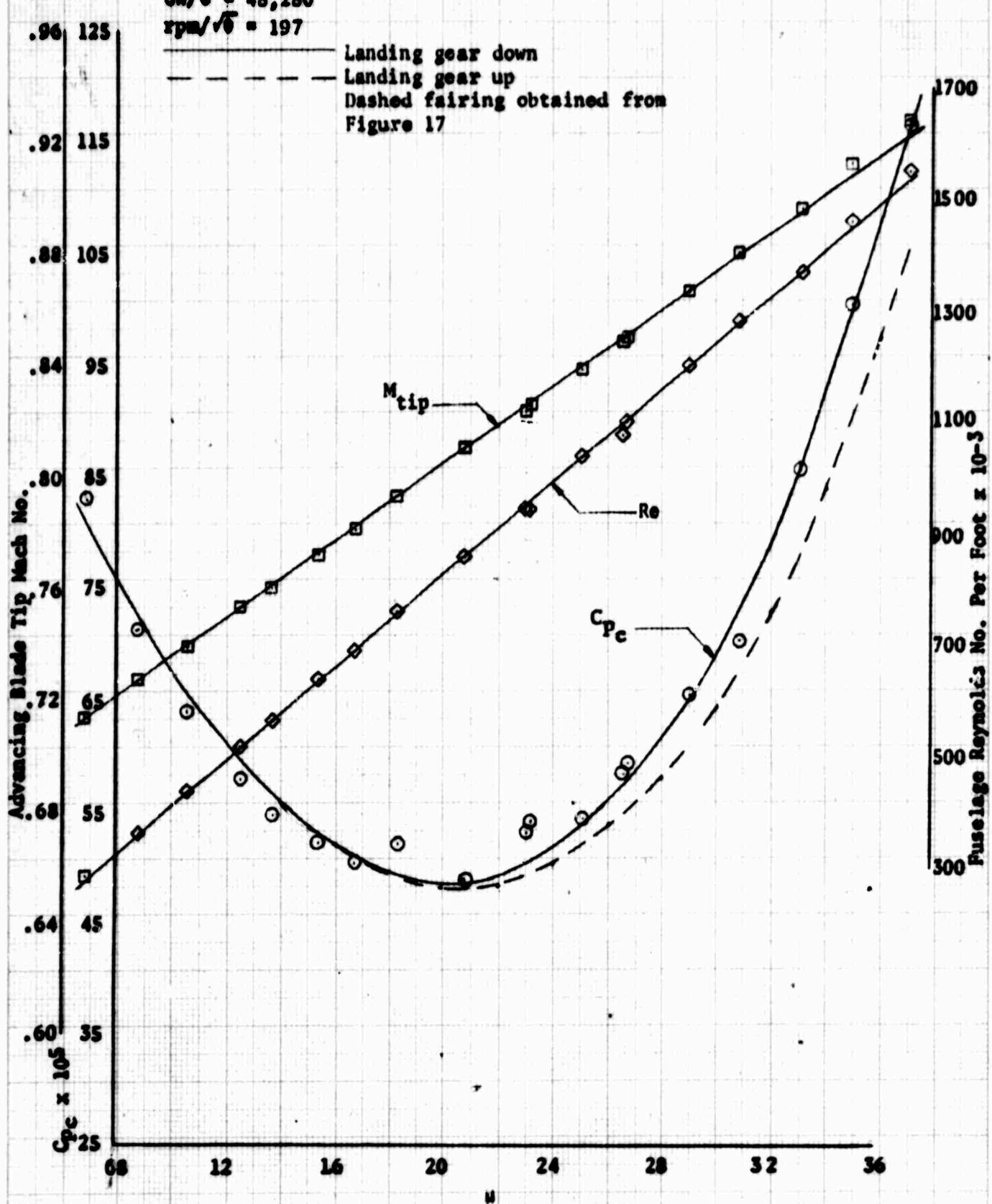


Figure 26. Level Flight Performance

HH-S3C USAF S/N 67-14993
T64-GE-7 Engines

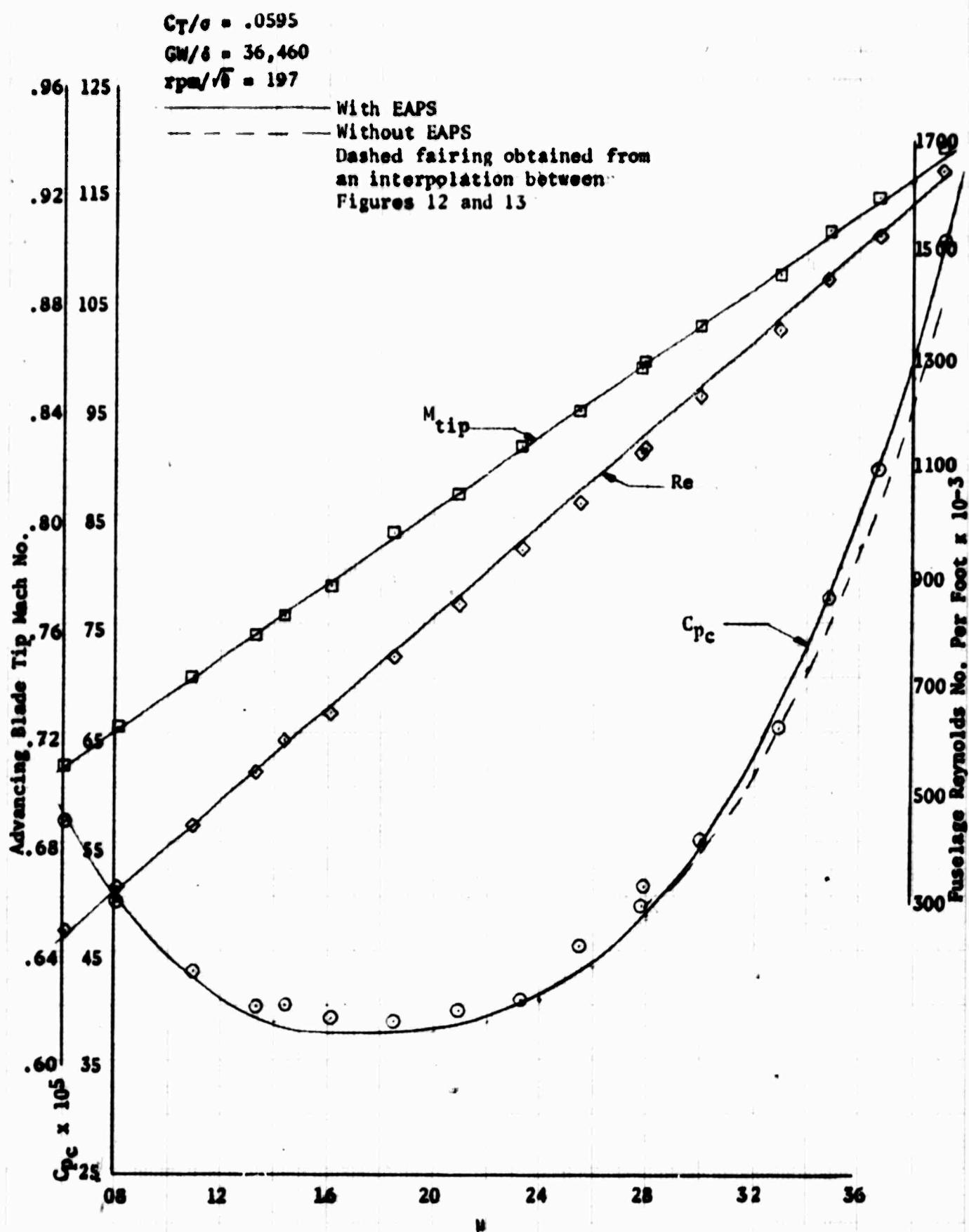


Figure 26. Level Flight Performance

HII-53C USAF S/N 67-14993

T64-GE-7 Engines

Symbol	Avg GW (lb)	Avg Press Alt (ft)	Avg FAT (°C)	Avg cg (in)	Rotor Speed (rpm)
○	35,000	4,500	6	340	185
□	35,000	7,000	17	340	185
◊	35,000	14,000	2	340	185

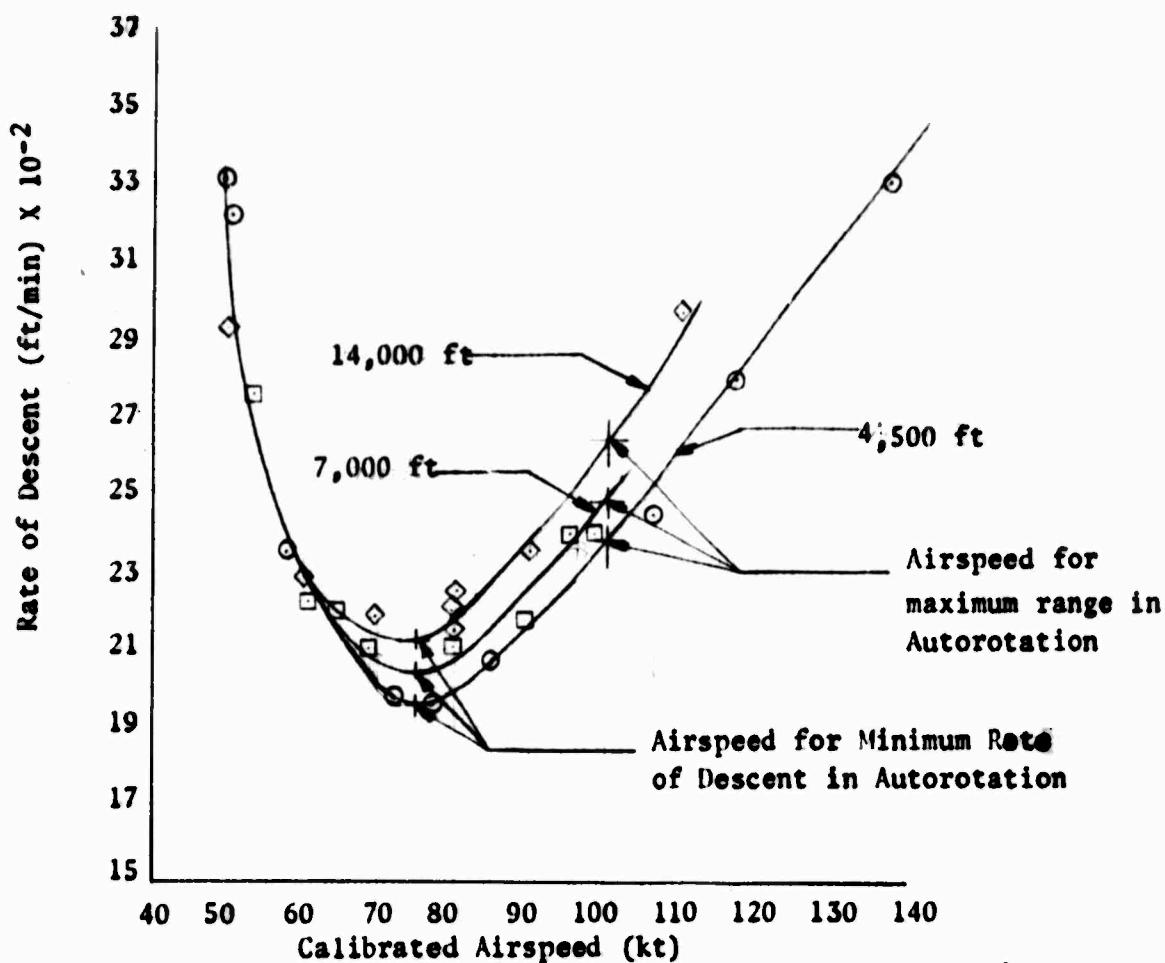


Figure 27. Performance in Autorotation

HII-53C USAF S/N 67-14993

T64-GE-7 Engines

NOTE : O Level Flight Ground Speed Course
□ Airspeed Calibration during climb
◊ Airspeed Calibration during autorotation

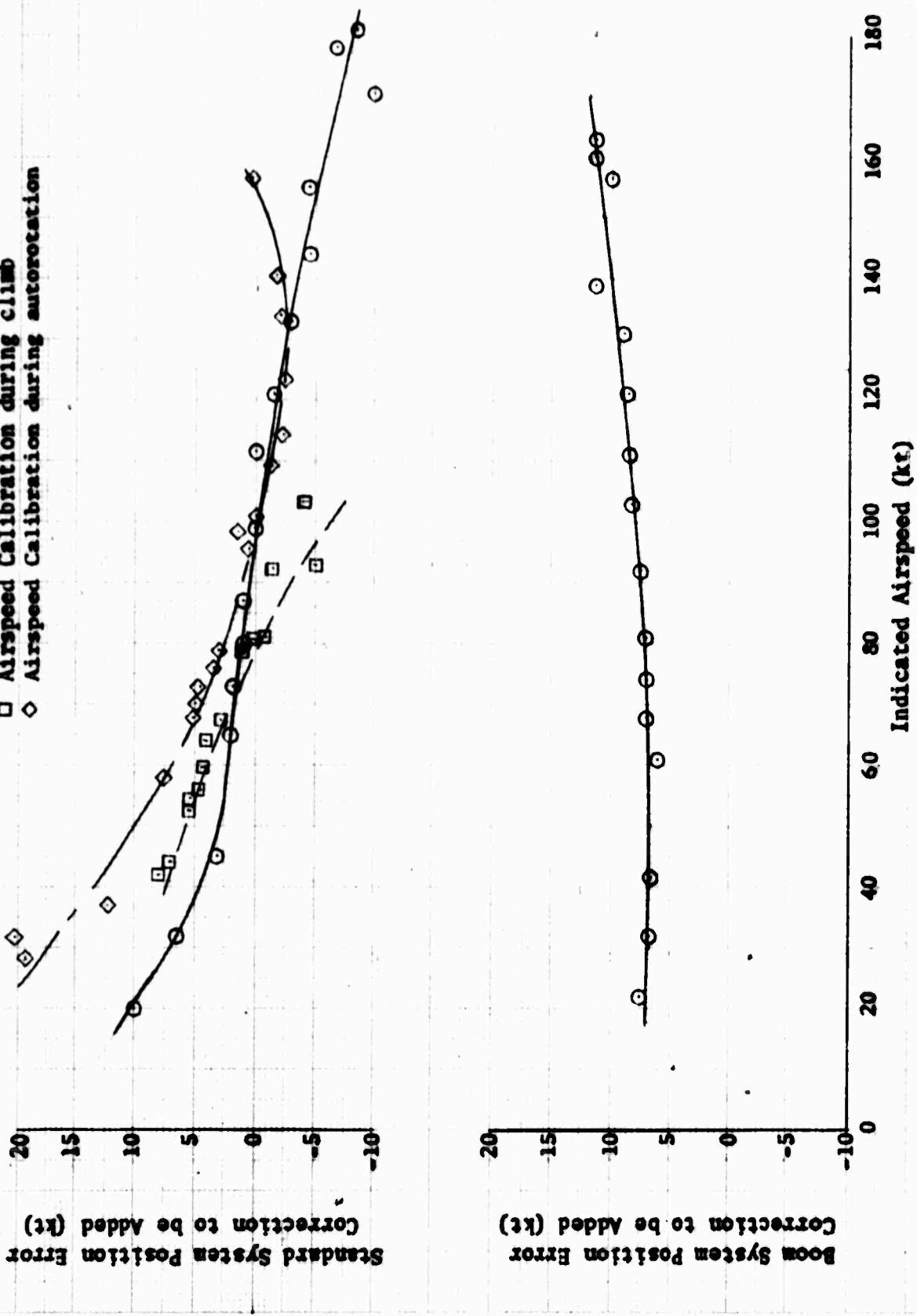


Figure 28. Airspeed Calibration

Flight Sym	Avg GM Condition	Avg cg (lb)	Avg Press. (in.)	Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	APCS
○	Level Flight	31,000	352	4,000	15	185	ON

NOTE: Solid Symbols Denote Trim Conditions

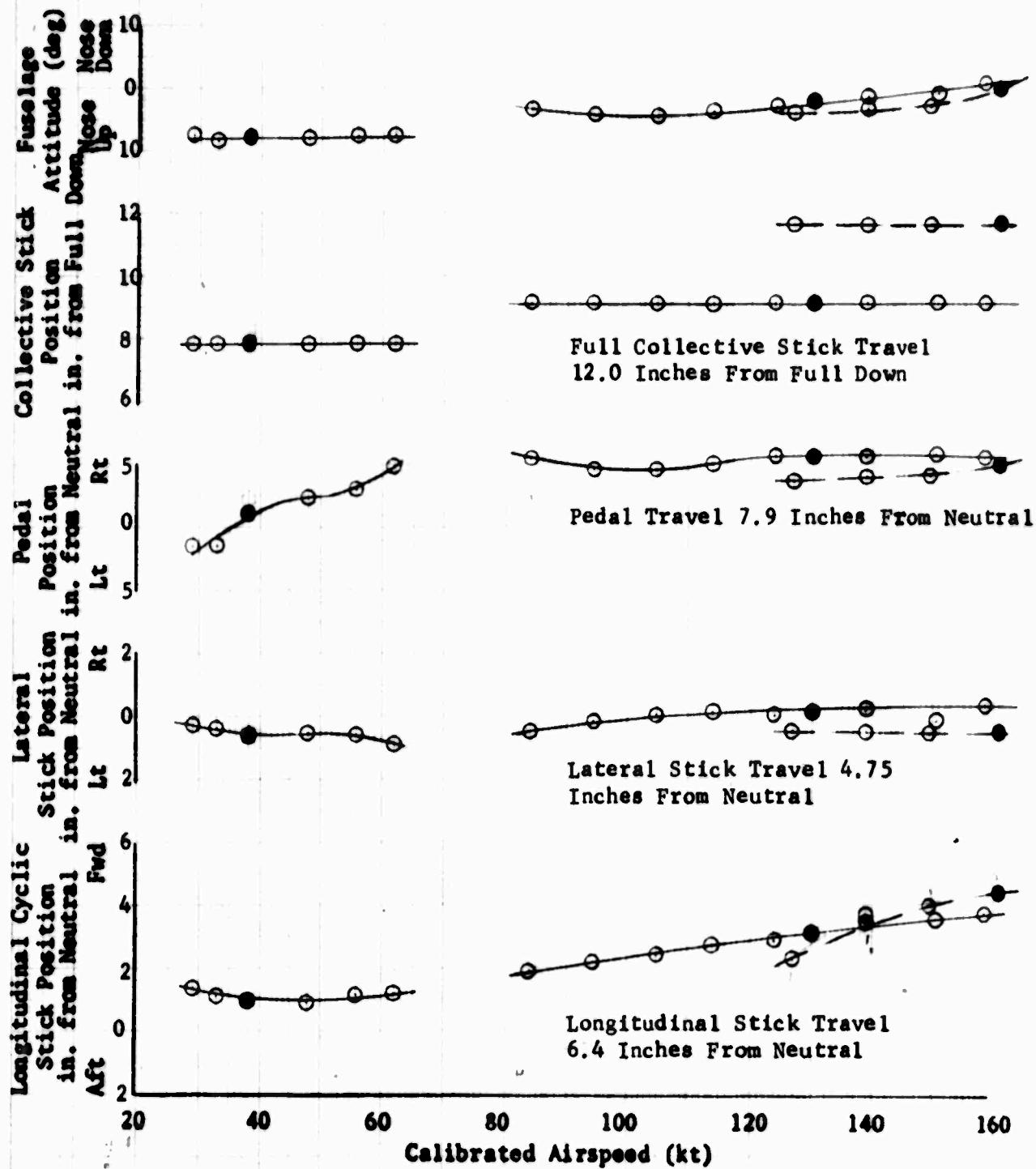
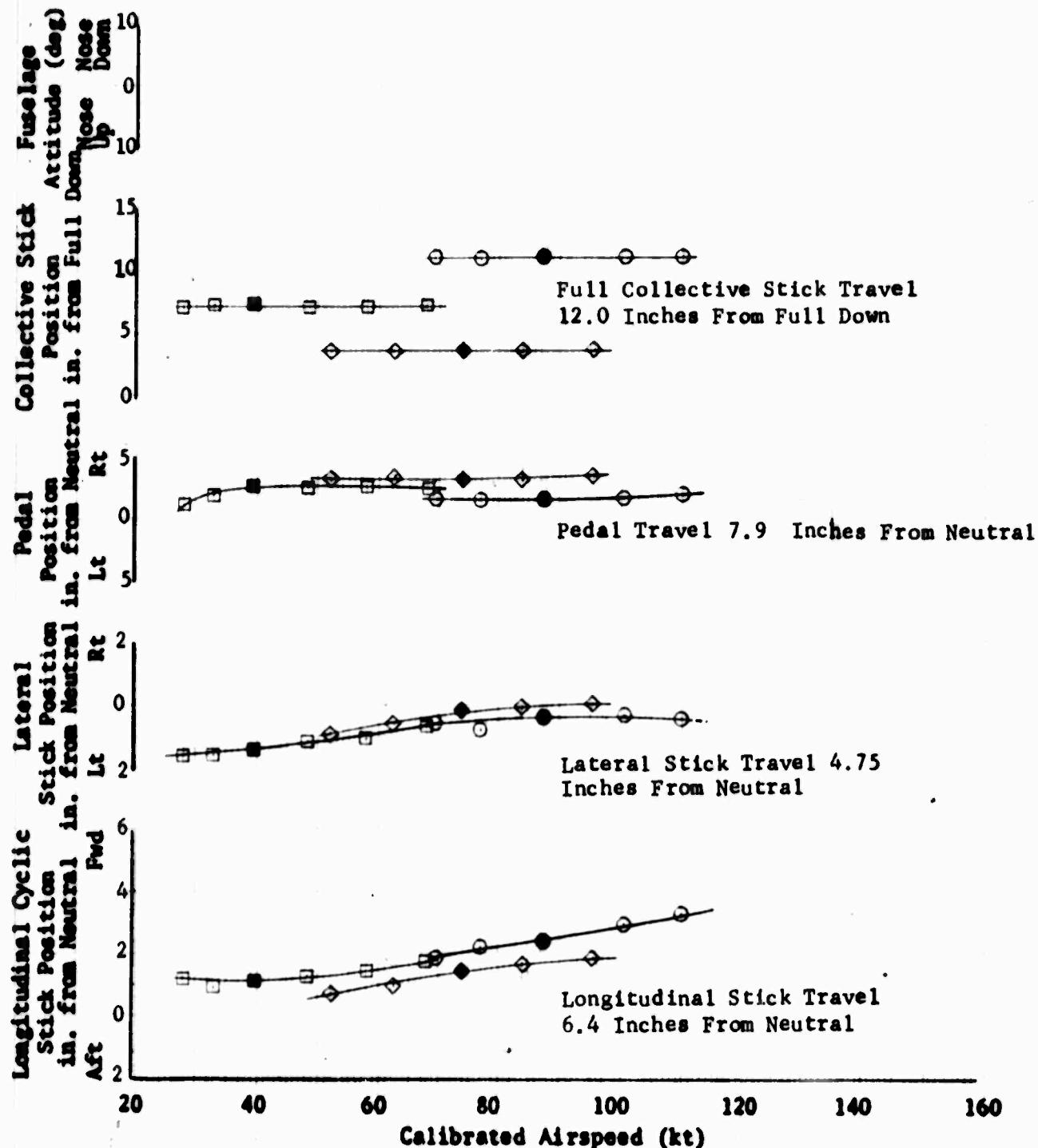


Figure 29. Static Longitudinal Speed Stability

	Flight Sym	Avg GW (lb)	Avg cg (in.)	Avg Press. (ft)	Alt (°C)	Avg FAT (rpm)	Rotor Speed APCS
○	Climb	31,000	352	4,000	15	185	ON
◇	Auto.	31,000	352	4,000	15	185	ON
□	Partial	31,000	352	4,000	15	185	ON
	Power Descent						

NOTE: Solid Symbols Denote Trim Conditions



Flight Sym	Avg GM Condition	Avg cg (lb)	Avg Press. (in.)	Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	APCS
○ Level Flight	31,000	328	4,000	16	185	ON	

NOTE: Solid Symbols Denote Trim Conditions

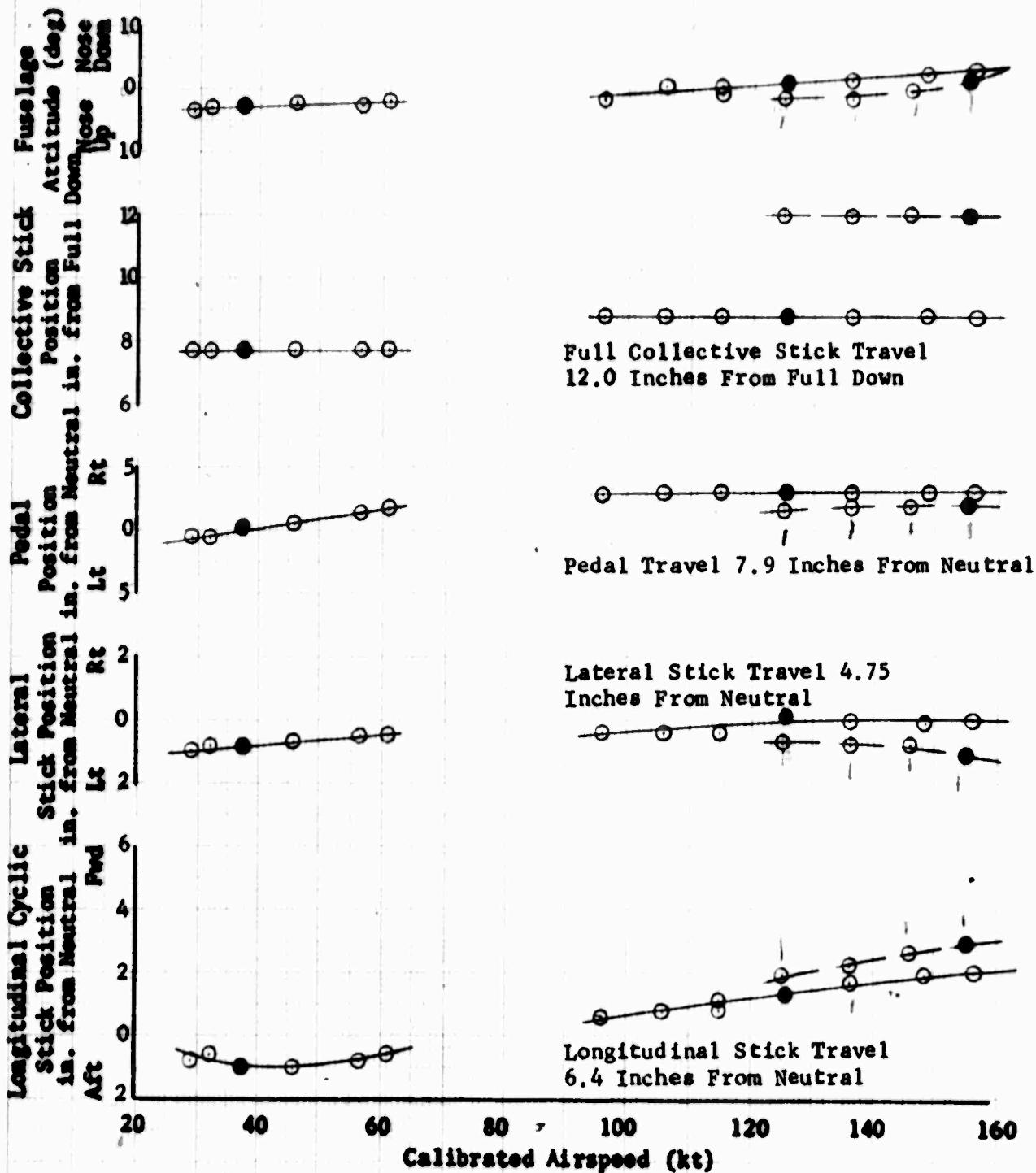
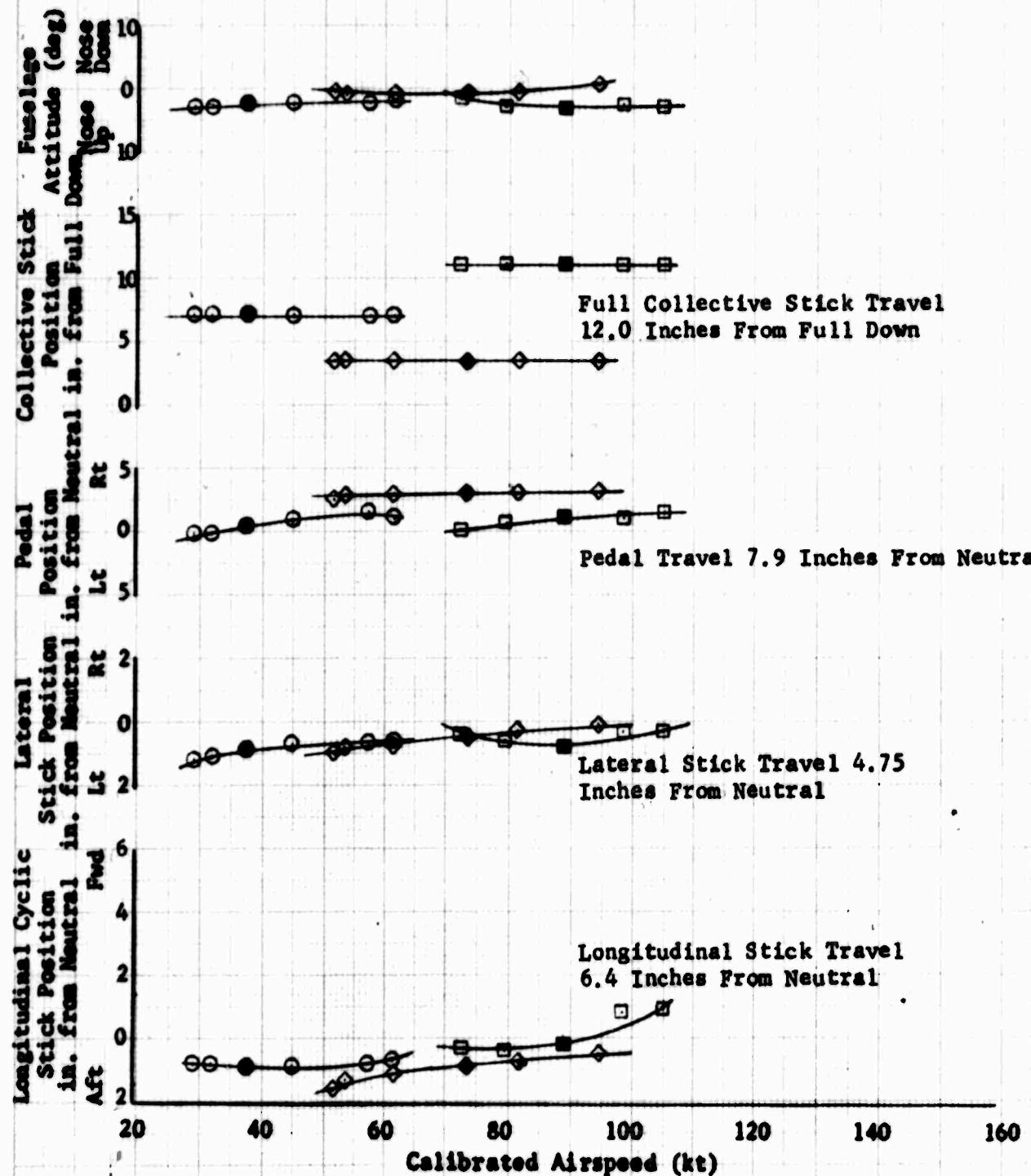


Figure 31. Static Longitudinal Speed Stability

Sym	Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS
□	Climb	31,000	328	4,000	16	185	ON
◊	Auto.	31,000	328	4,000	16	185	ON
○	Partial Power Descent	31,000	328	4,000	16	185	ON

NOTE: Solid Symbols Denote Trim Conditions



Sym	Flight Condition	Avg CW (lb)	Avg cg (in.)	Avg Press. (ft)	Alt (°C)	Avg FAT	Rotor Speed (rpm)	AFCS
○	Climb	31,000	352	9,500	5	185	185	ON
◇	Auto.	31,000	352	9,500	5	185	185	ON
□	Partial Power Descent	31,000	352	9,500	5	185	185	ON
<hr/>								

NOTE: Solid Symbols Denote Trim Conditions

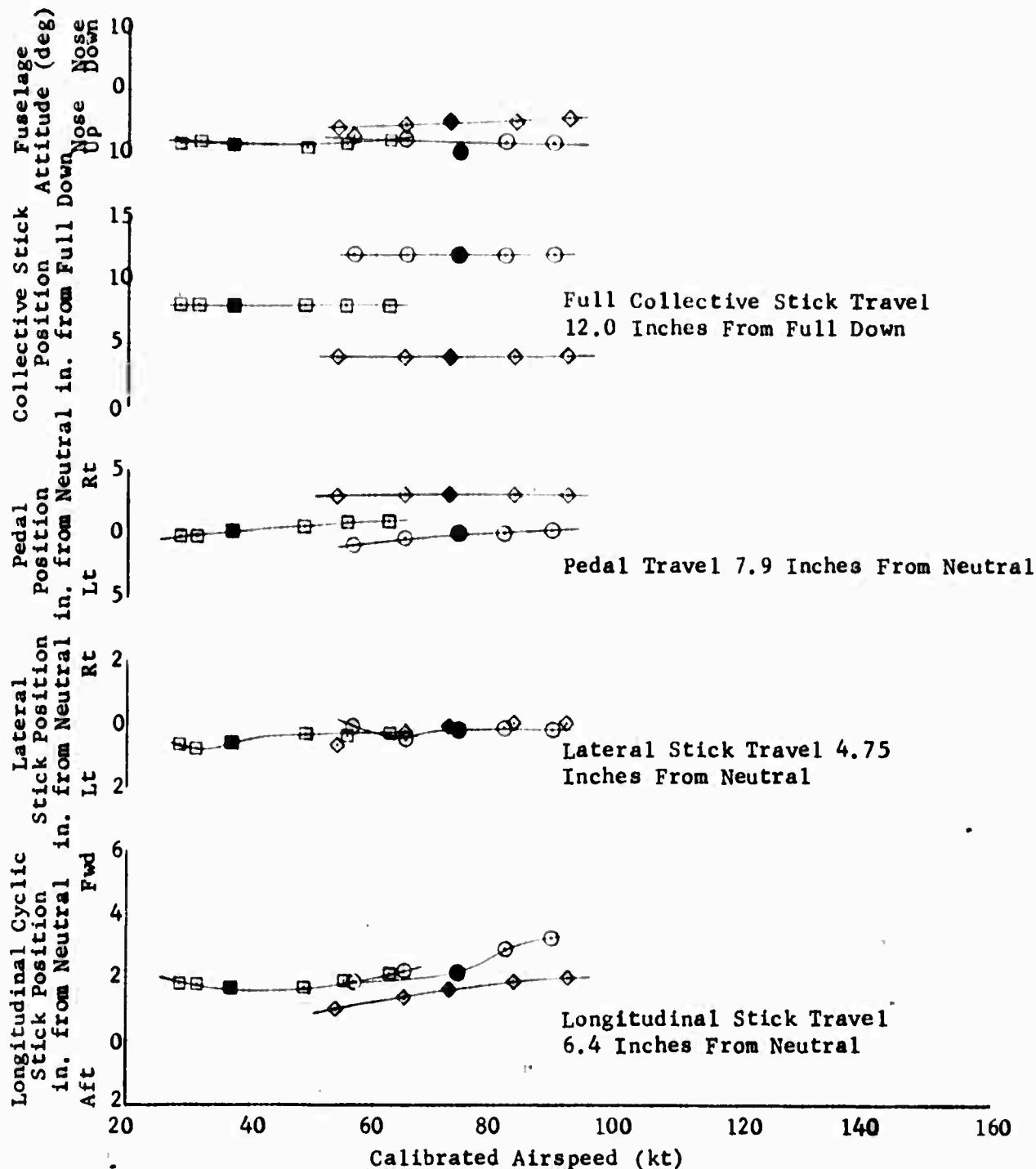


Figure 33. Static Longitudinal Speed Stability

Sym	Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	APCS
○	Level Flight	31,000	352	9,500	5	185	ON

NOTE: Solid Symbols Denote Trim Conditions

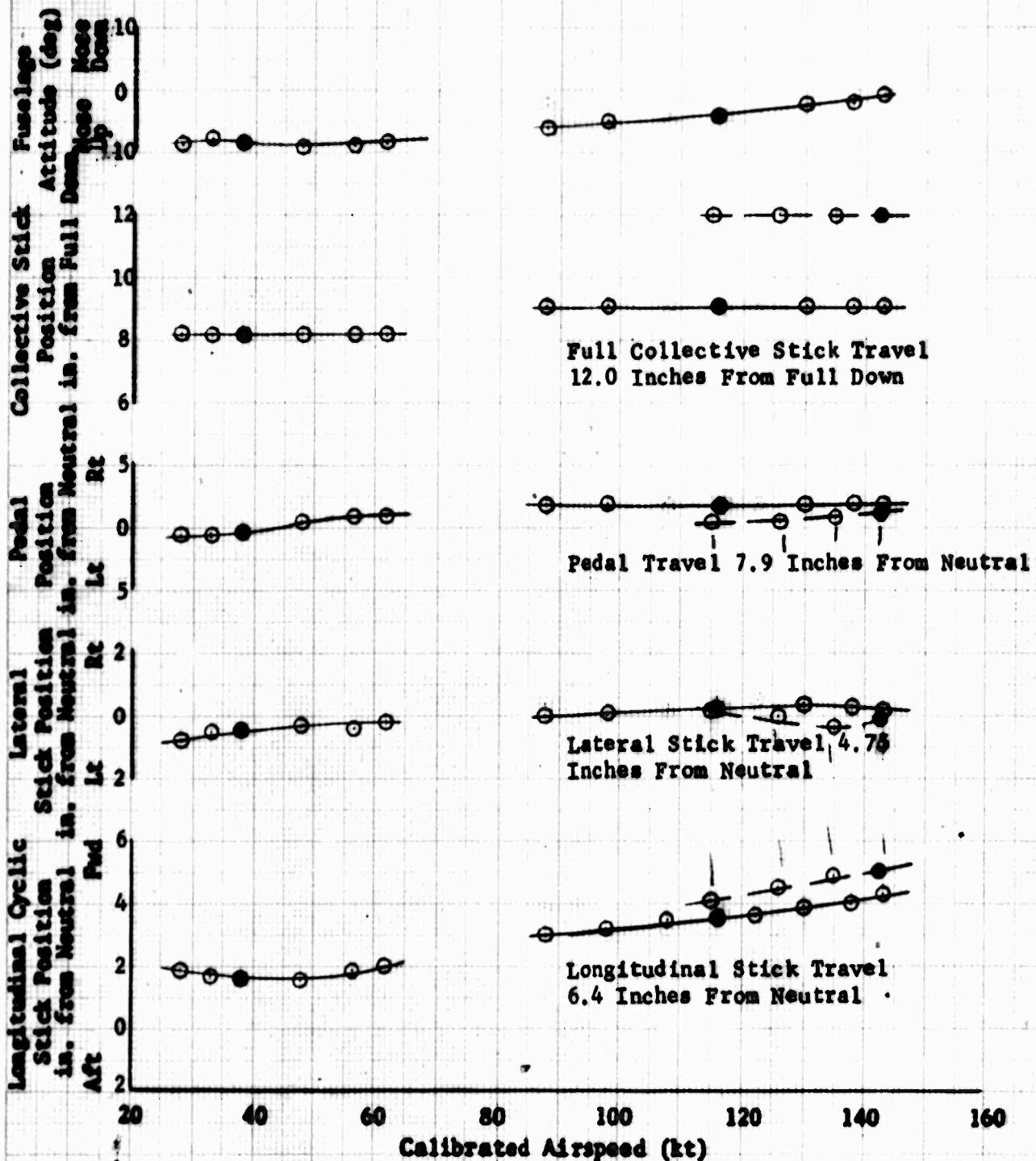


Figure 5% Static Longitudinal Speed Stability

HH-53C USAF S/N 67-14993

Sym Condition	Flight	Avg CW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS
○ Level Flight		31,000	352	13,000	-	185	ON

NOTE: Solid Symbols Denote Trim Conditions

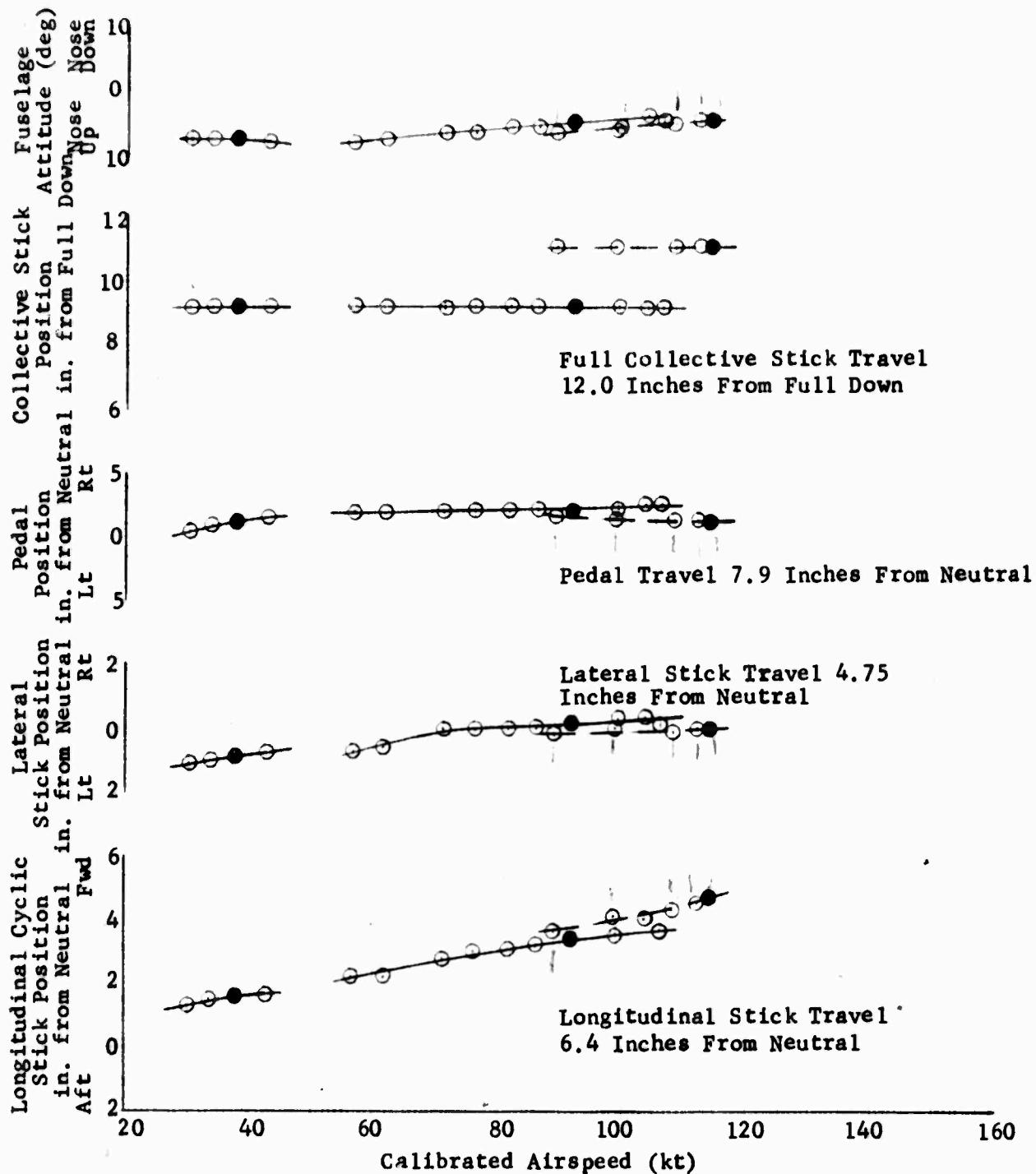


Figure 35. Static Longitudinal Speed Stability

HH-53C USAF S/N 67-14993

Flight Sym Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS
○ Climb	31,000	352	13,000	6	185	ON
◊ Auto.	31,000	352	13,000	6	185	ON
□ Partial Power Descent	31,000	352	13,000	6	185	ON

NOTE: Solid Symbols Denote Trim Conditions

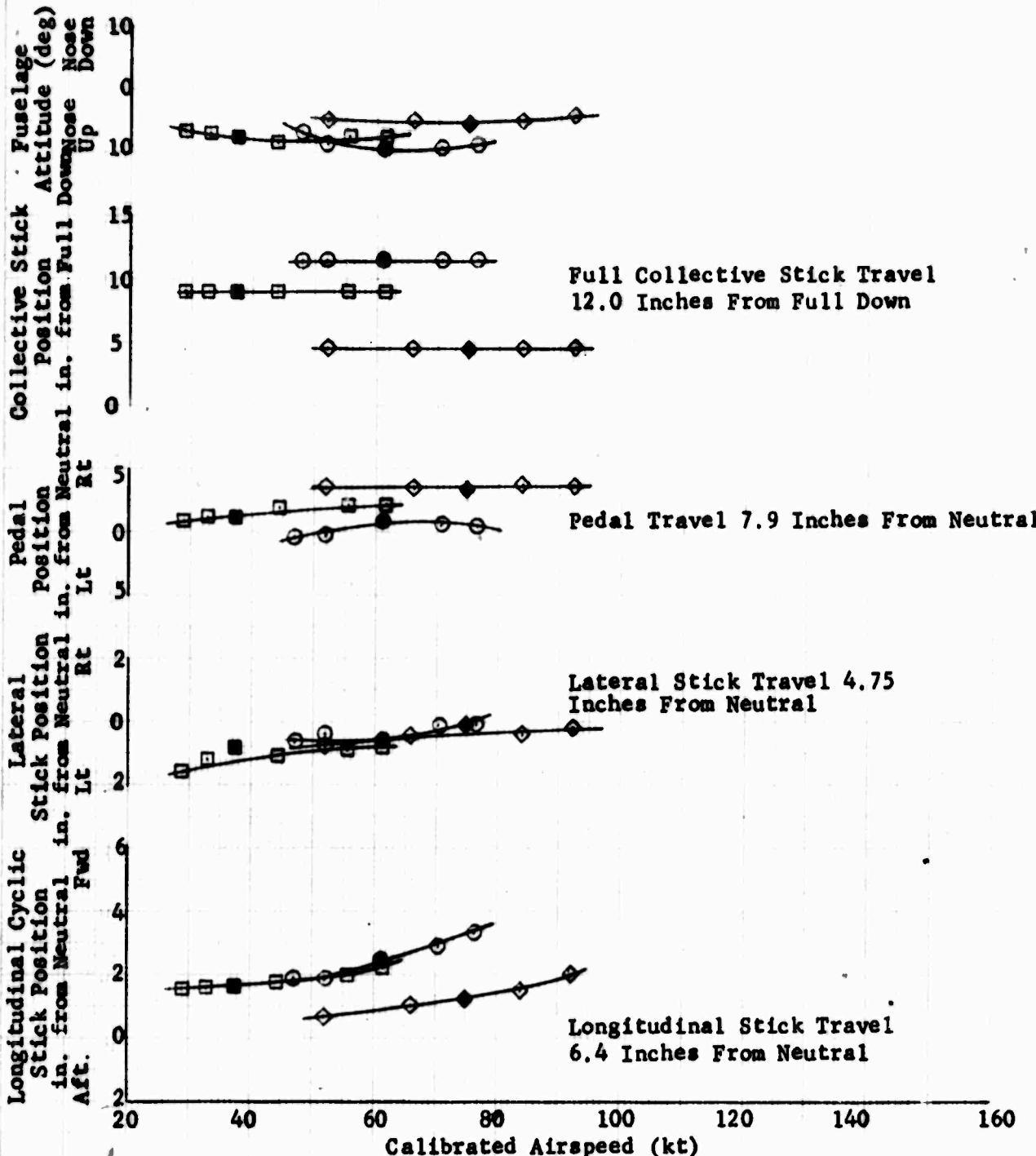


Figure 36. Static Longitudinal Speed Stability

HH-53C USAF S/N 67-14993

Sym	Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	APCS
○	Level Flight	37,000	352	4,500	10	185	ON

NOTE: Solid Symbols Denote Trim Conditions

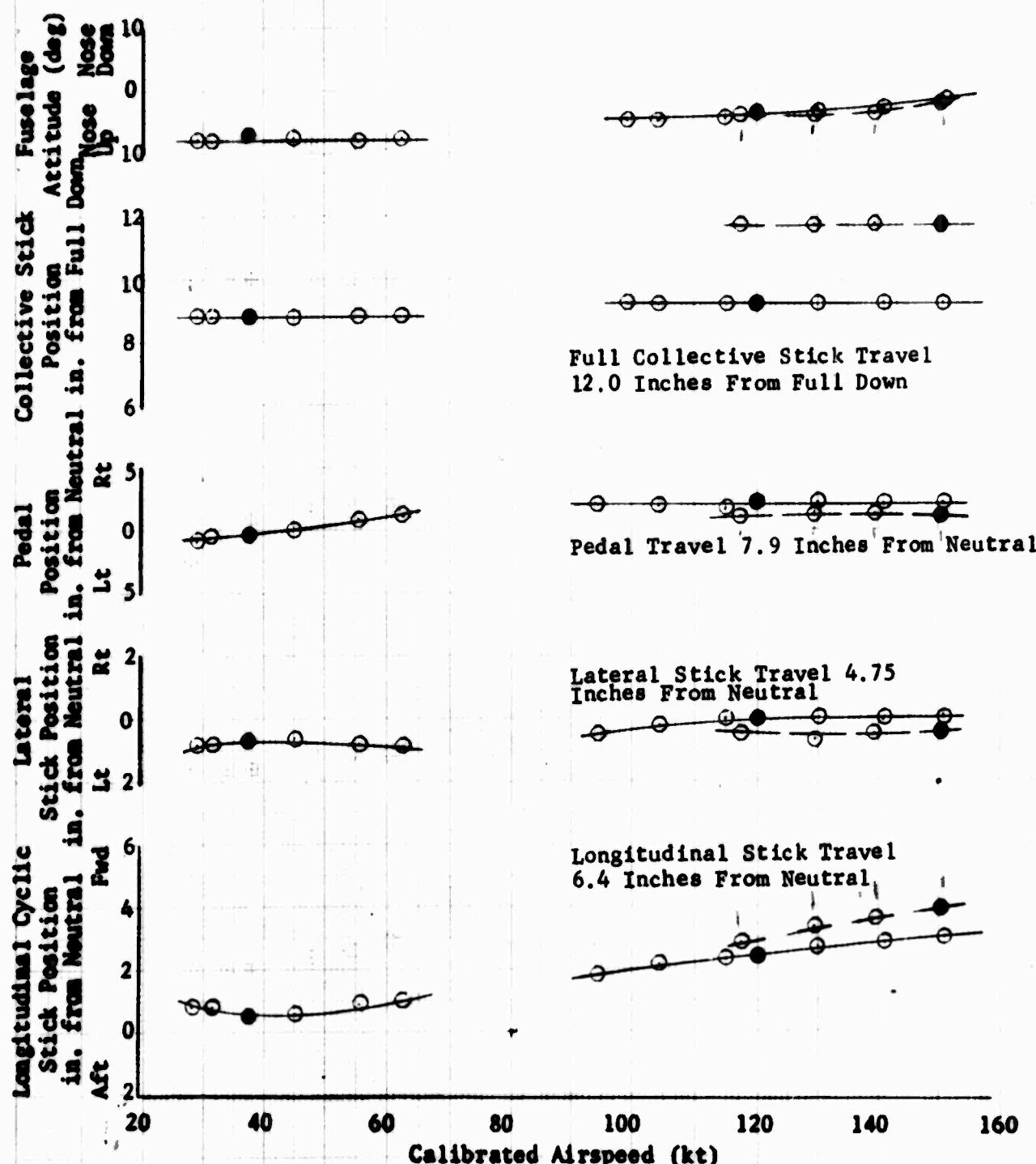
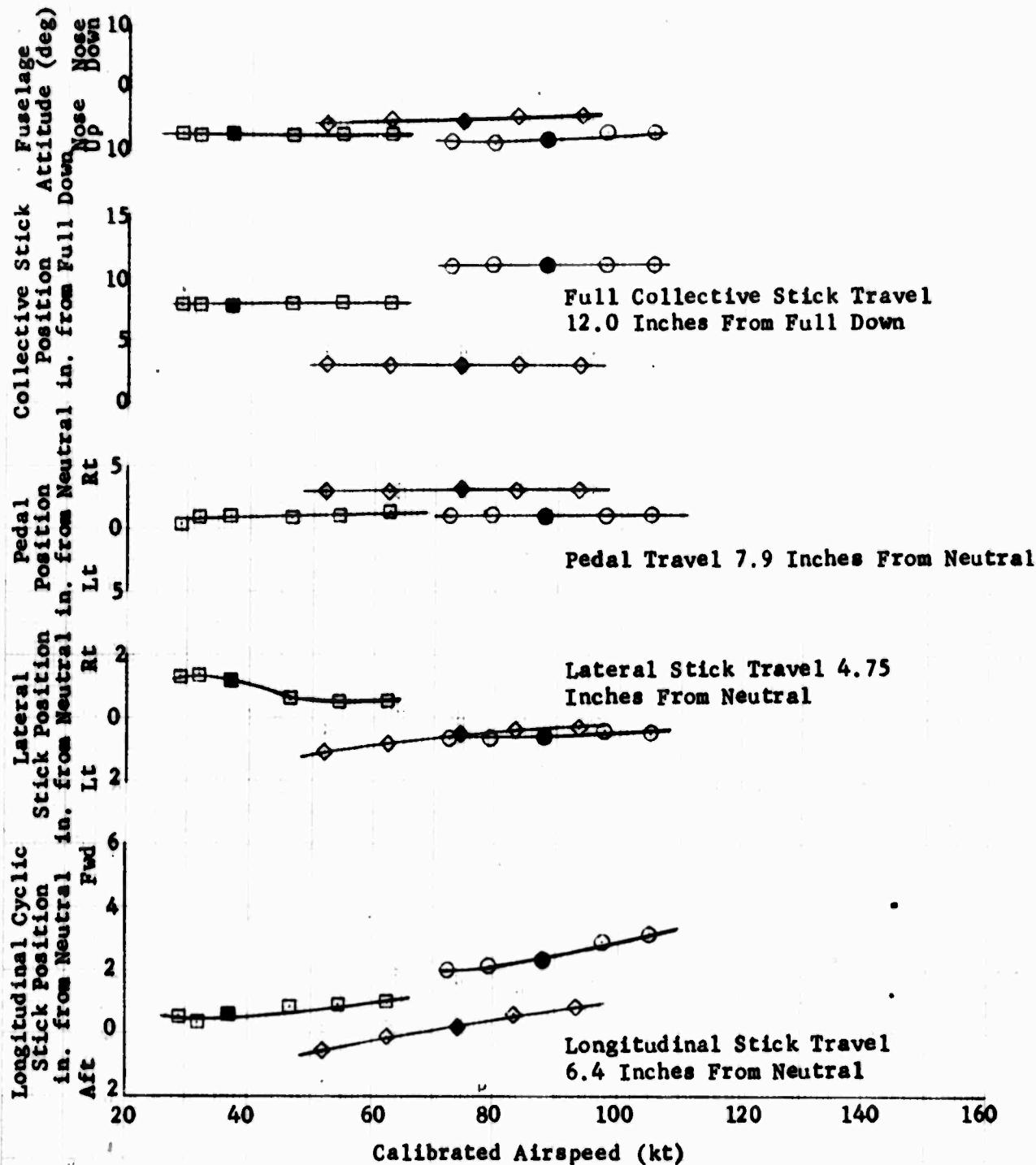


Figure 97. Static Longitudinal Speed Stability

Sym	Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS
○	Climb	37,000	352	4,500	10	185	ON
◇	Auto.	37,000	352	4,500	10	185	ON
□	Partial Power Descent	37,000	352	4,500	10	185	ON

NOTE: Solid Symbols Denote Trim Conditions



Flight Sym	Condition	Avg GM (lb)	Avg cg (in.)	Avg Press. (ft)	Alt (°C)	Avg FAT (rpm)	Rotor Speed
○	Level Flight	37,000	328	4,000	16	185	APCS ON

NOTE: Solid Symbols Denote Trim Conditions

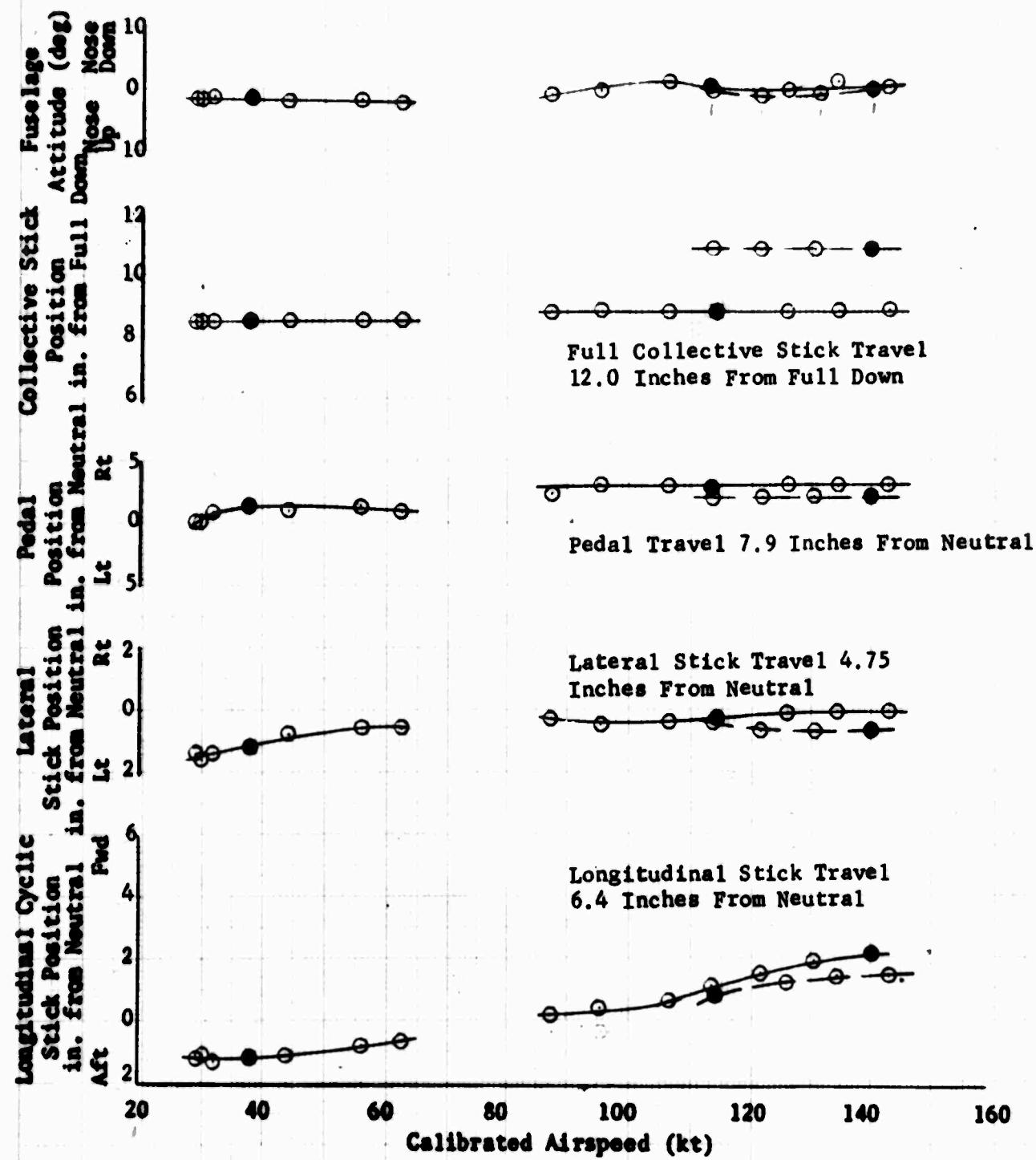
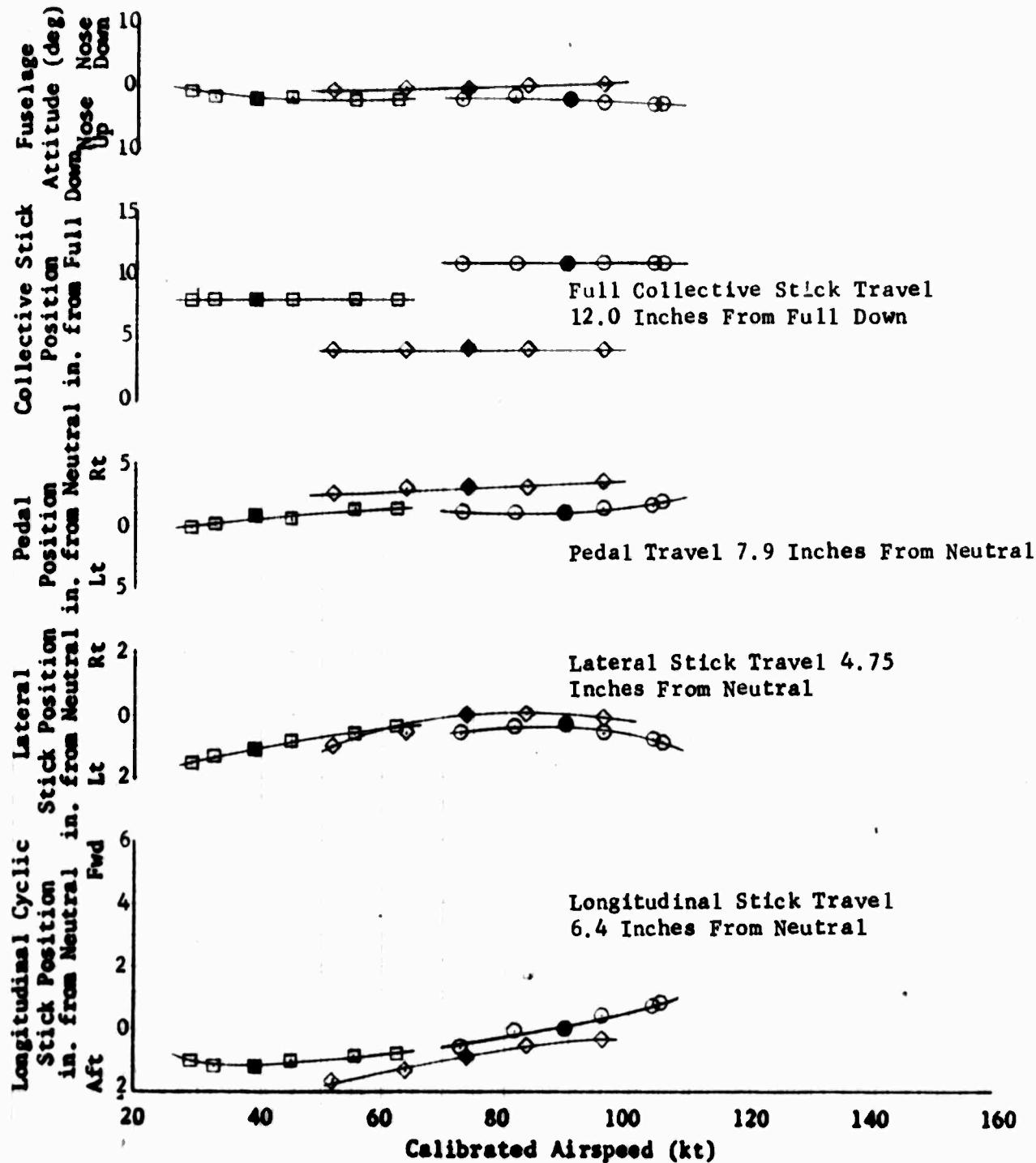


Figure 57. Static Longitudinal Speed Stability

Sym	Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	APCS
○	Climb	37,000	328	4,000	16	185	ON
◊	Auto.	37,000	328	4,000	16	185	ON
□	Partial Power Descent	37,000	328	4,000	16	185	ON

NOTE: Solid Symbols Denote Trim Conditions



HH-53C USAF S/N 67-14993

Flight Sym Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS
○ Level Flight	37,000	352	13,300	2	185	ON

NOTE: Solid Symbols Denote Trim Conditions

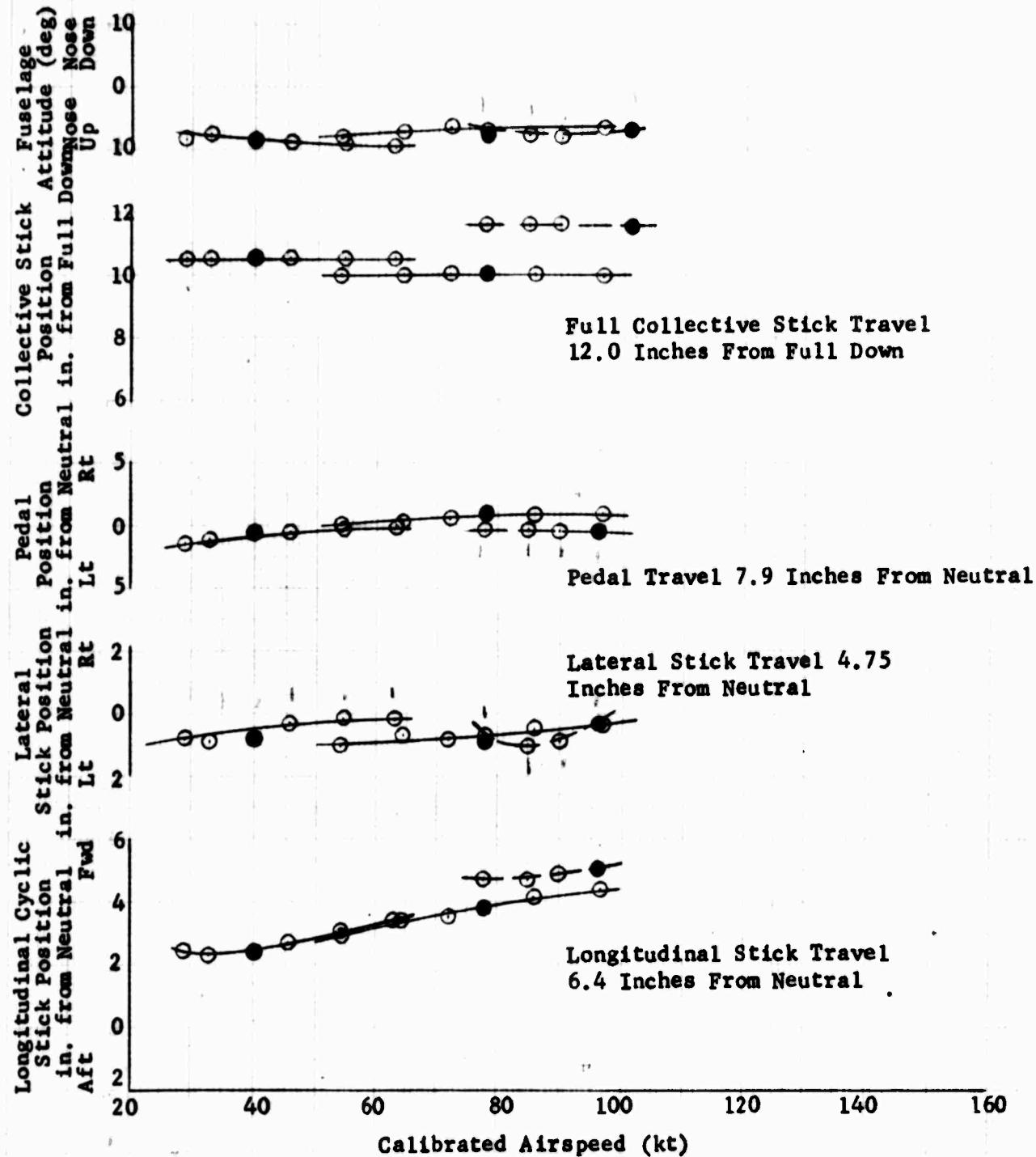


Figure 41. Static Longitudinal Speed Stability

HH-53C USAF S/N 67-14993

Flight Sym	Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. (ft)	Alt (°C)	Avg FAT (rpm)	Rotor Speed	AFCS
○	Climb	37,000	352	13,300	2	185	185	ON
○	Auto.	37,000	352	13,300	2	185	185	ON
□	Partial Power Descent	37,000	352	13,300	2	185	185	ON

NOTE: Solid Symbols Denote Trim Conditions

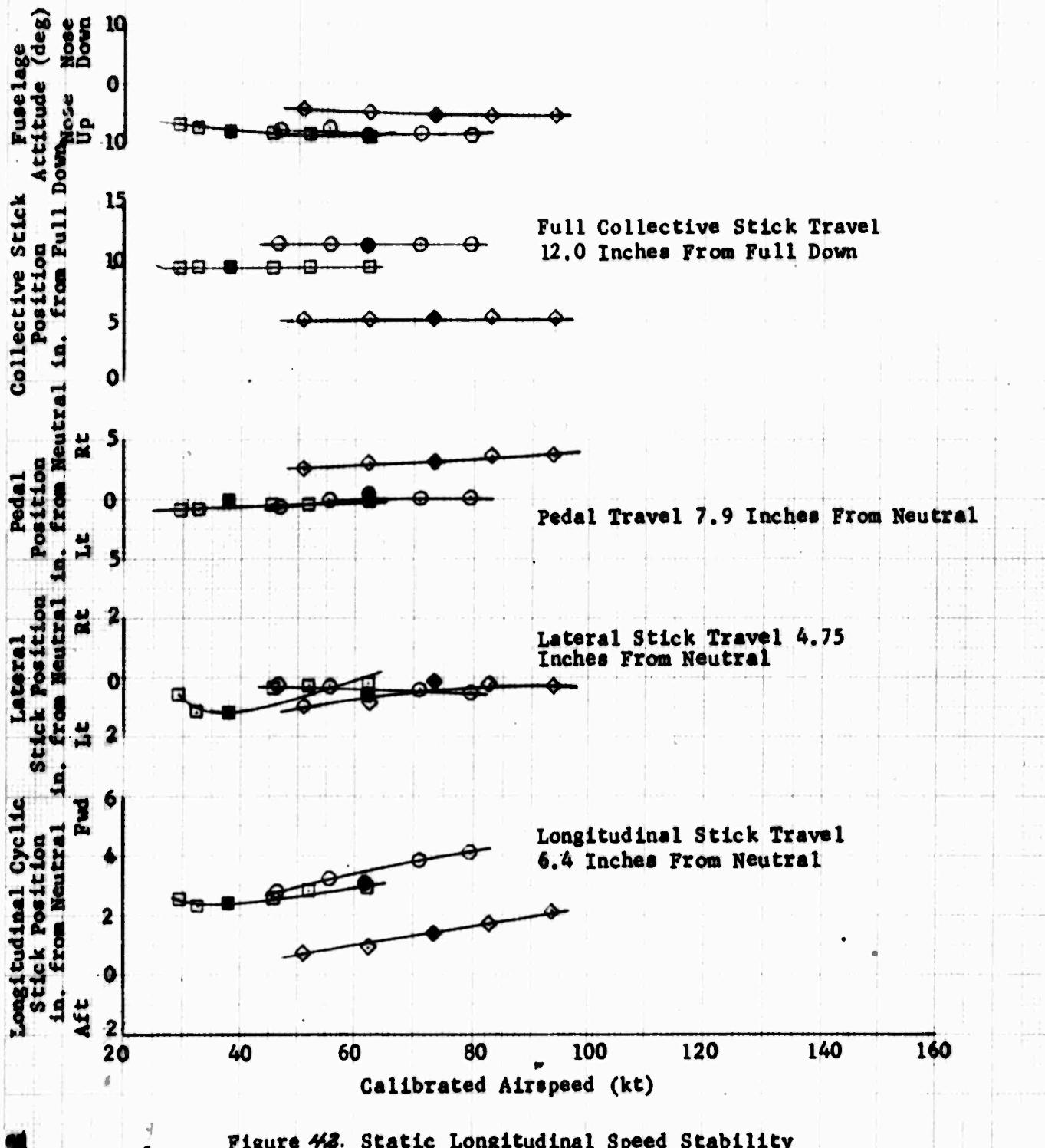


Figure 48. Static Longitudinal Speed Stability

HH-53C USAF S/N 67-14993

Sym	Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS ON
○	Level Flight	41,000	352	4,000	16	185	

NOTE: Solid Symbols Denote Trim Conditions

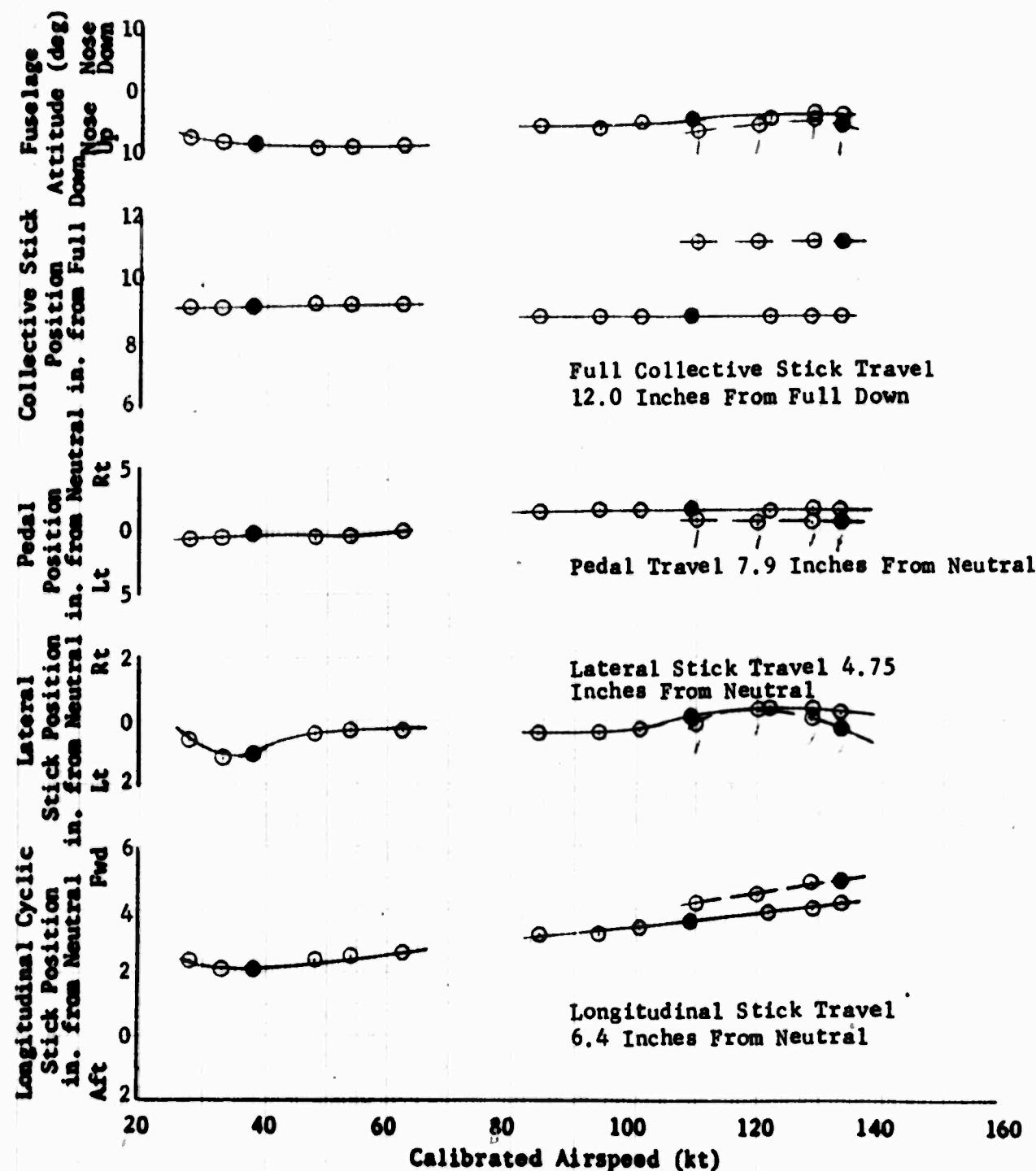
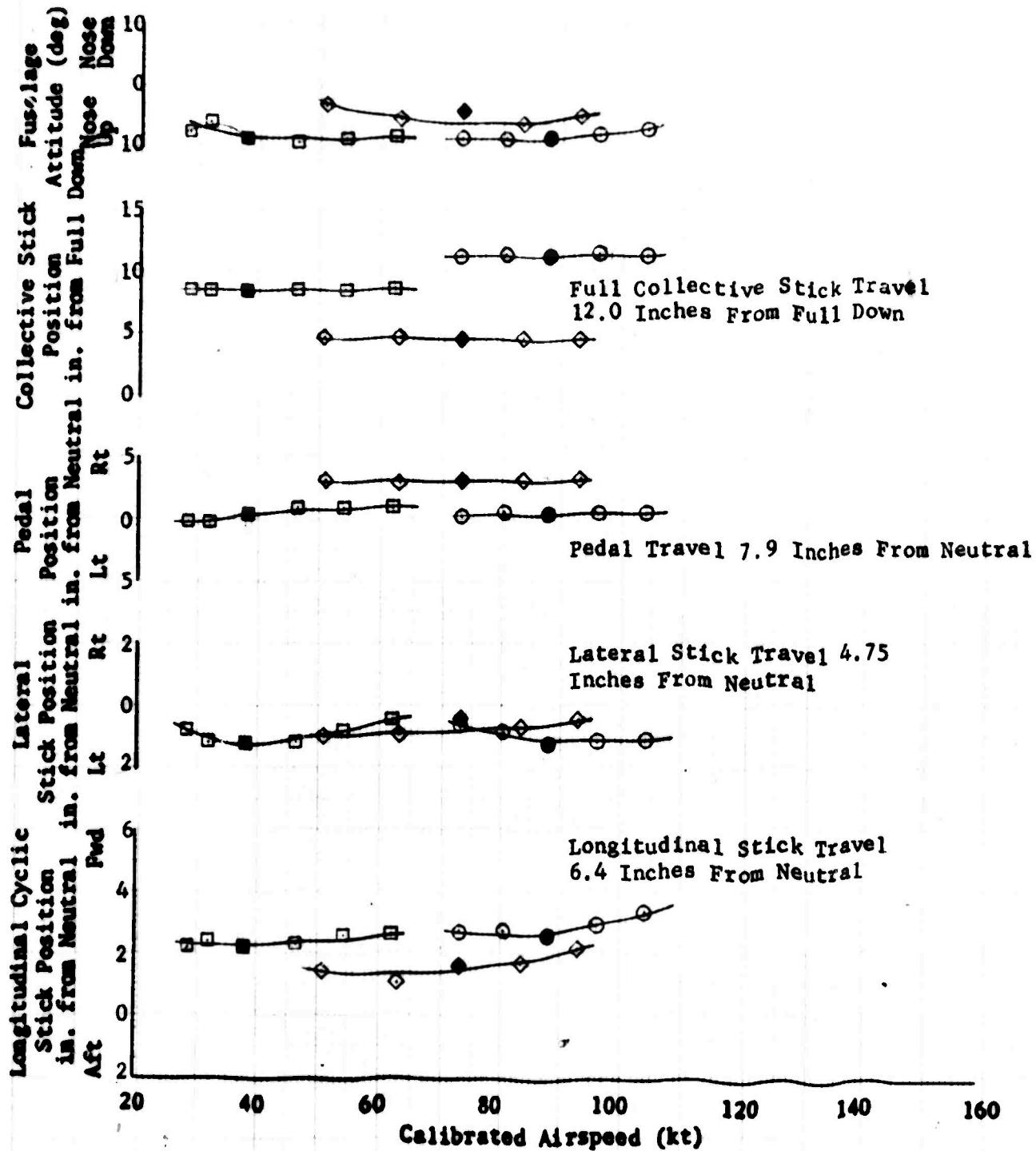


Figure 43. Static Longitudinal Speed Stability

Sym	Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS
○	Climb	41,000	352	4,000	16	185	ON
◇	Auto.	41,000	352	4,000	16	185	ON
□	Partial Power Descent	41,000	352	4,000	16	185	ON

NOTE: Solid Symbols Denote Trim Conditions



HH-53C USAF S/N 67-14993

Sym	Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. (ft)	Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS
O	Level Flight	41,000	328		4,700	10	185	ON

NOTE: Solid Symbols Denote Trim Conditions

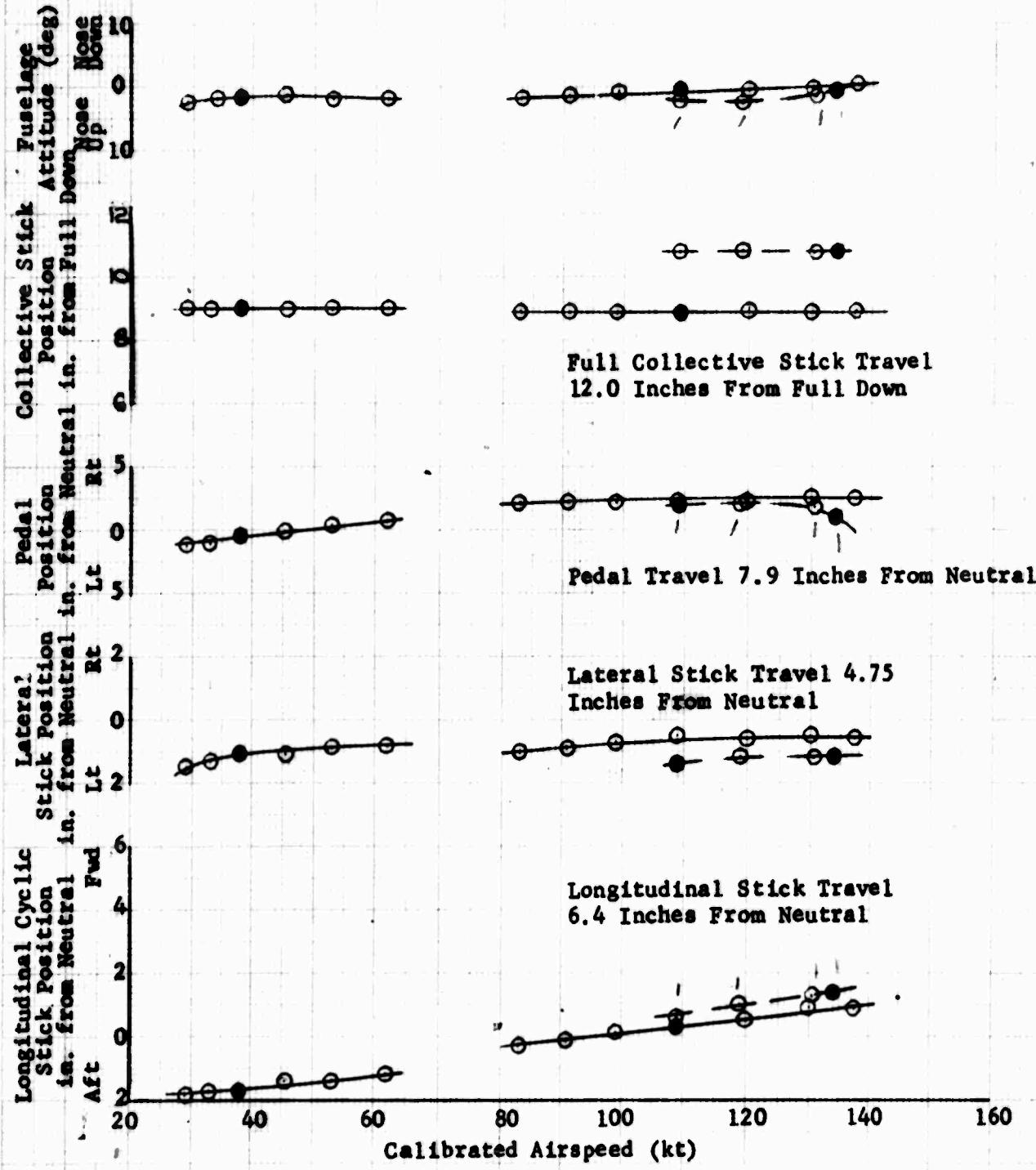
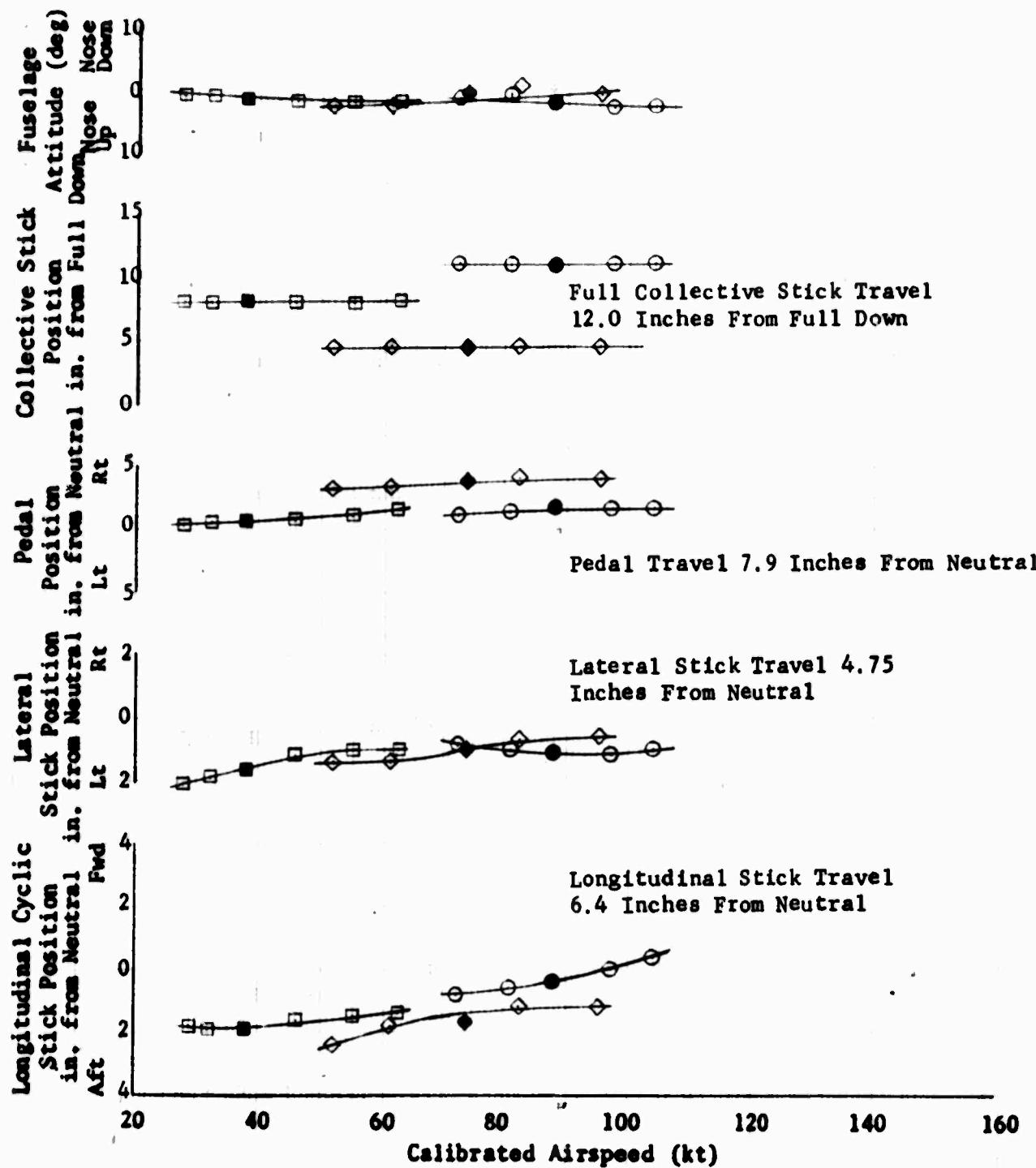


Figure 46. Static Longitudinal Speed Stability

Flight Sym	Condition	Avg GM (lb)	Avg cg (in.)	Avg Press. (ft)	Alt (°C)	Avg FAT (rpm)	Rotor Speed	APCS
○	Climb	41,000	328	4,700	10	185	185	ON
◇	Auto.	41,000	328	4,700	10	185	185	ON
□	Partial Power Descent	41,000	328	4,700	10	185	185	ON

NOTE: Solid Symbols Denote Trim Conditions



Sym	Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS
○	Level Flight	41,000	352	8,000	16	185	ON

NOTE: Solid Symbols Denote Trim Conditions

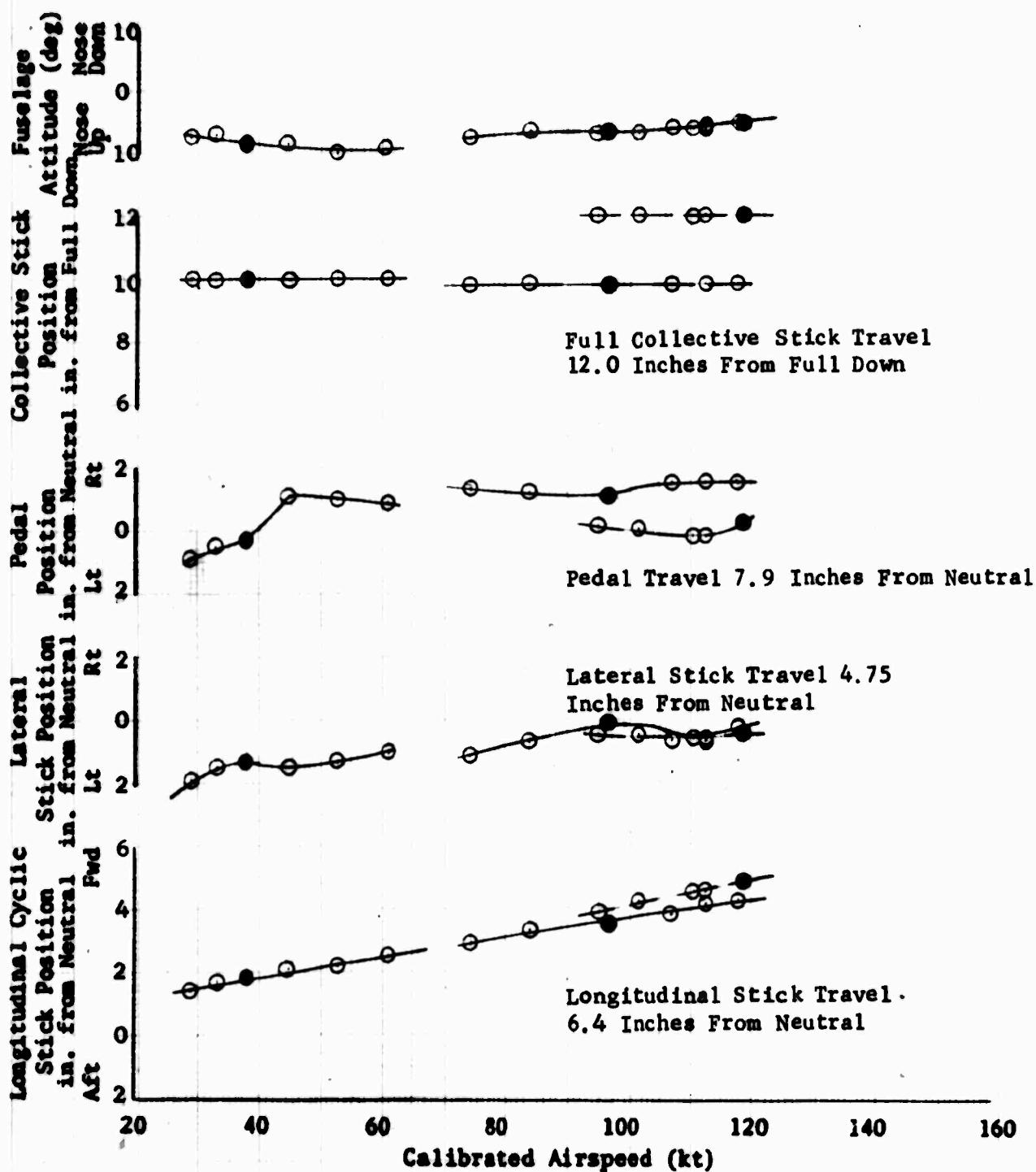


Figure 47. Static Longitudinal Speed Stability

Flight Sym Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS
○ Climb	41,000	352	8,000	16	185	ON
◊ Auto.	41,000	352	8,000	16	185	ON
□ Partial Power Descent	41,000	352	8,000	16	185	ON

NOTE: Solid Symbols Denote Trim Conditions

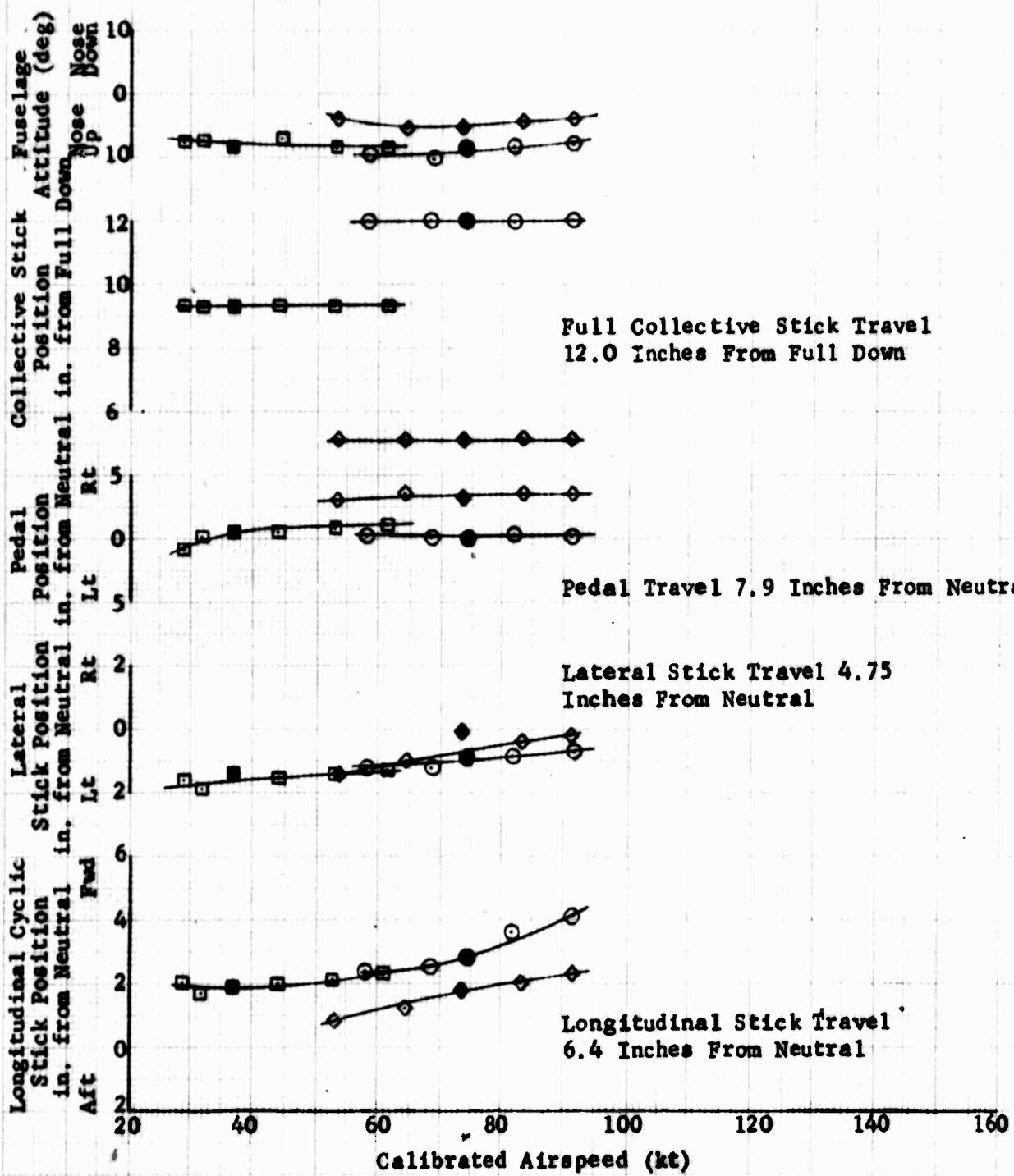


Figure 48. Static Longitudinal Speed Stability

Sym	Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. (ft)	Alt (°C)	Avg FAT (rpm)	Rotor Speed	AFCS
○	Level Flight	41,000	352	9,000	7	185		ON

NOTE: Solid Symbols Denote Trim Conditions

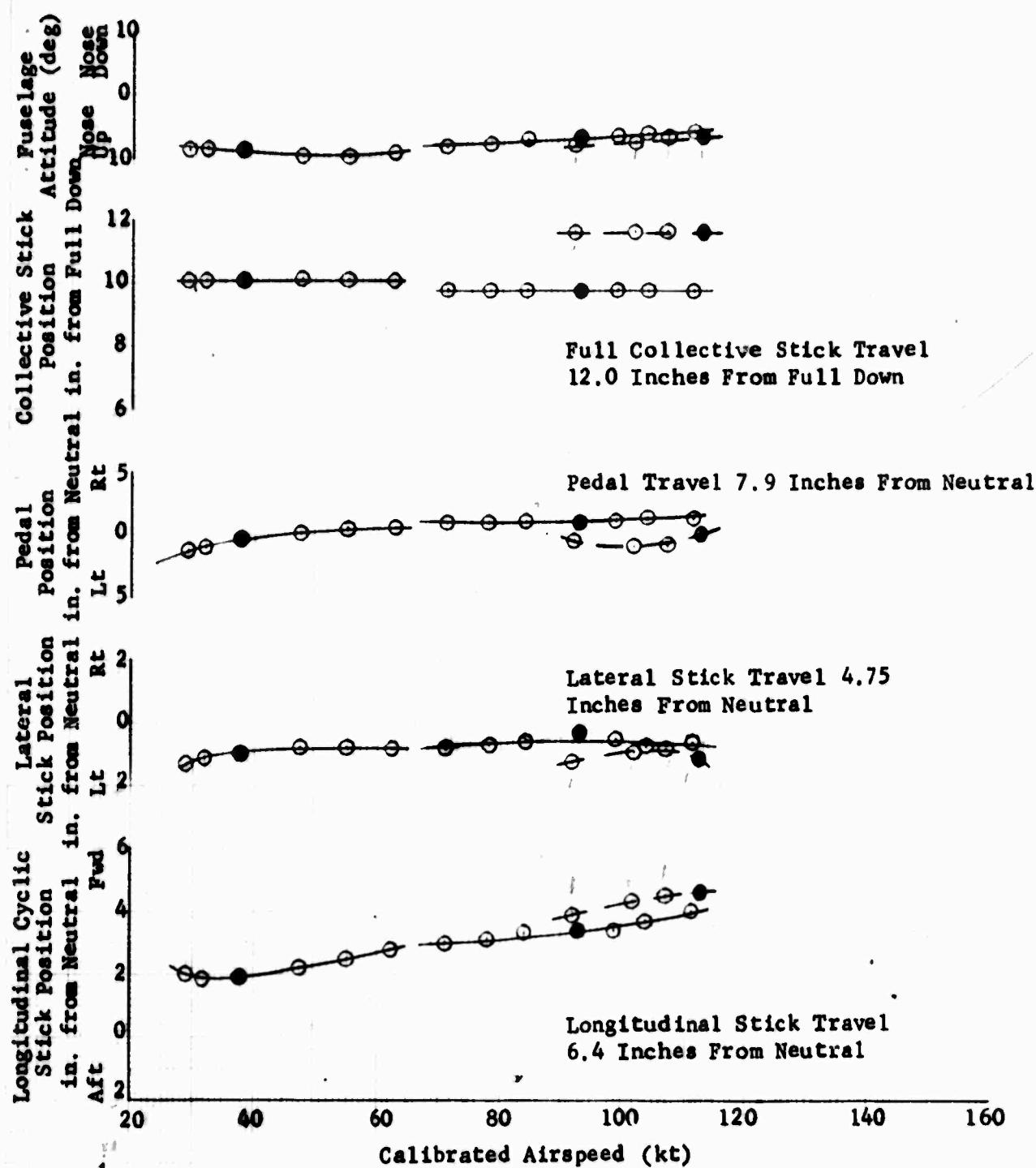
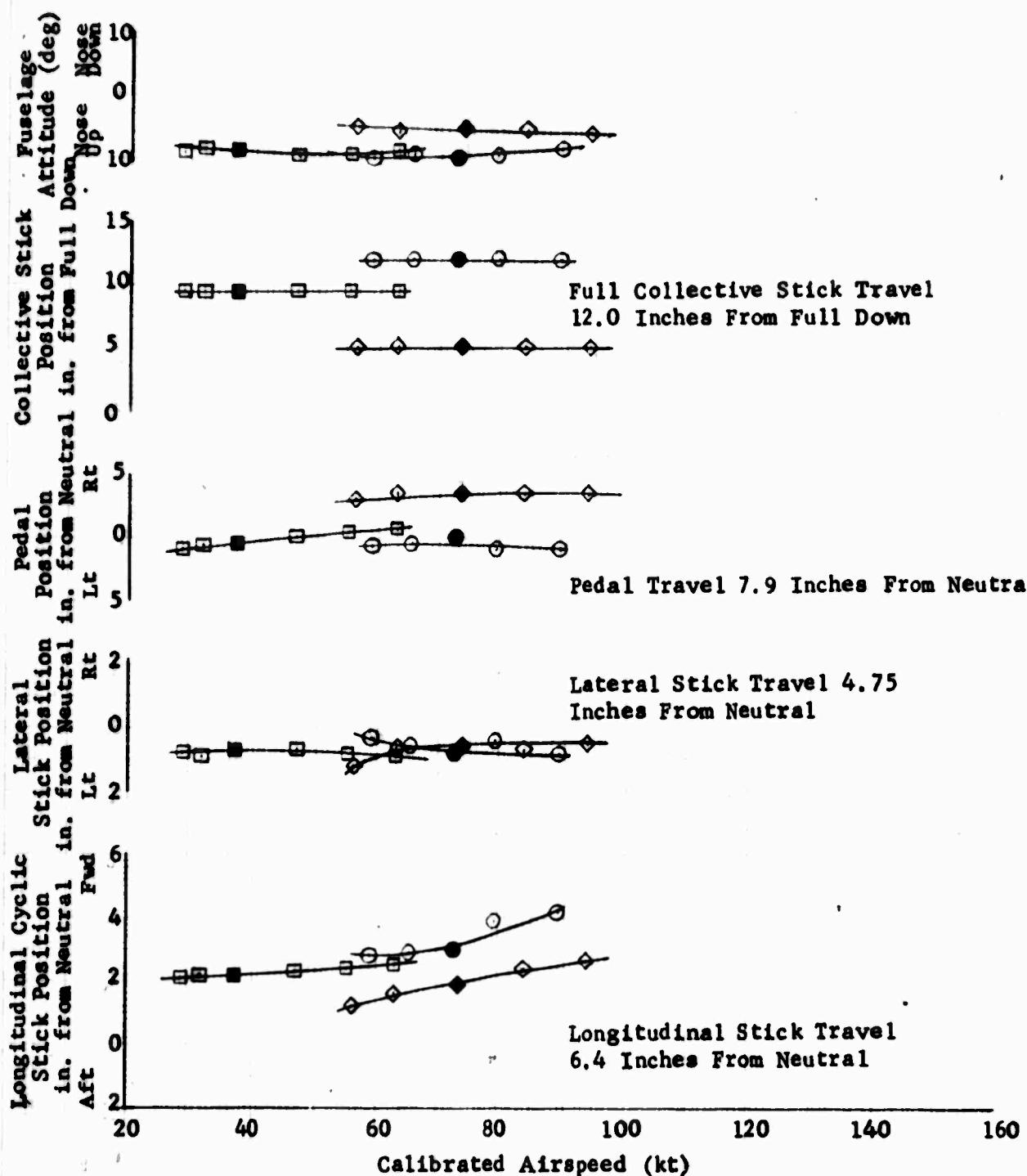


Figure 49. Static Longitudinal Speed Stability

Sym	Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg PAT ($^{\circ}$ C)	Rotor Speed (rpm)	AFCS
○	Climb	41,000	352	9,000	7	185	ON
◊	Auto.	41,000	352	9,000	7	185	ON
□	Partial Power Descent	41,000	352	9,000	7	185	ON

NOTE: Solid Symbols Denote Trim Conditions



Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Avg Rotor Speed (rpm)	AFCS	KCAS
Level Flight	31,000	352	5,100	5	185	ON	160

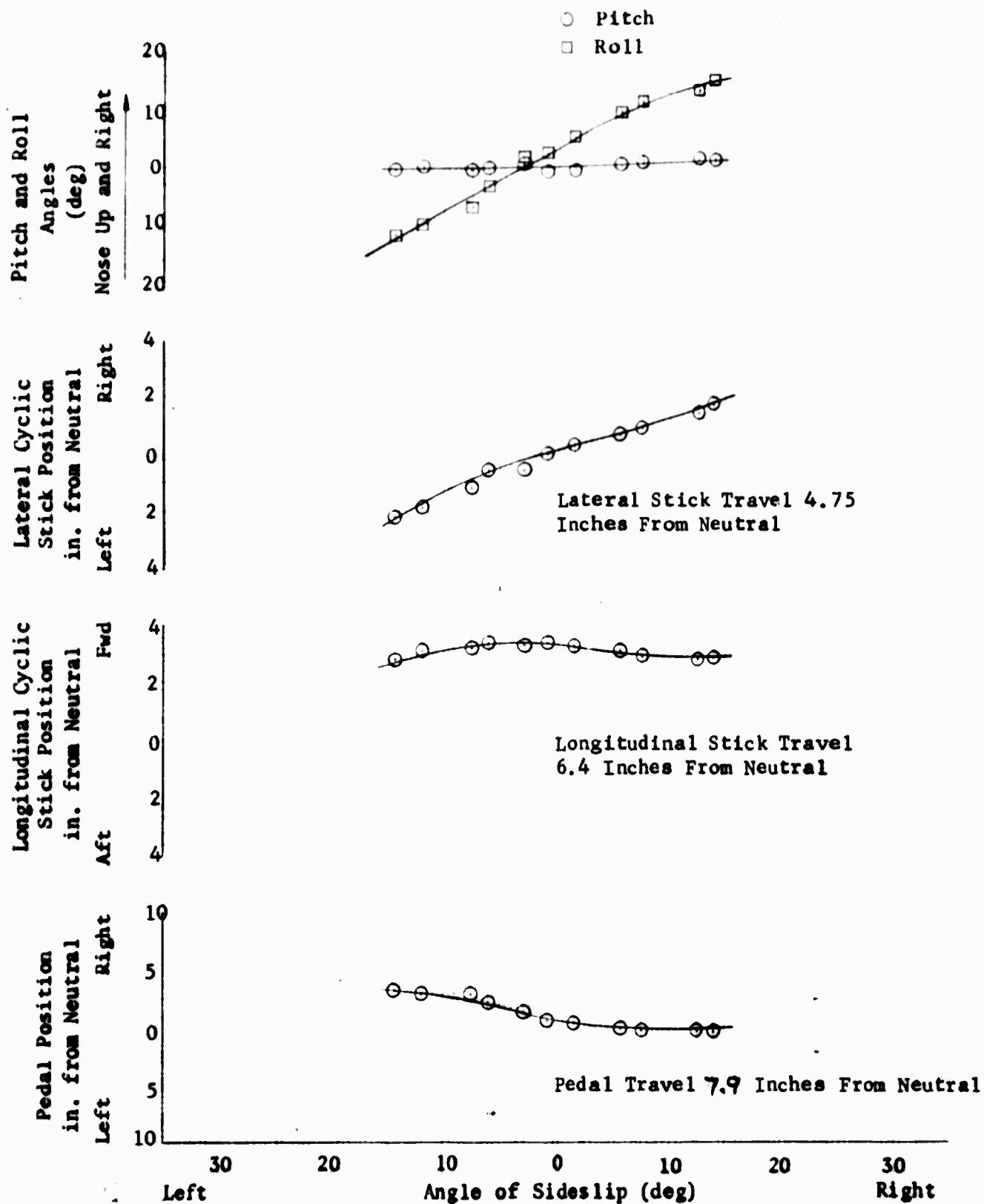
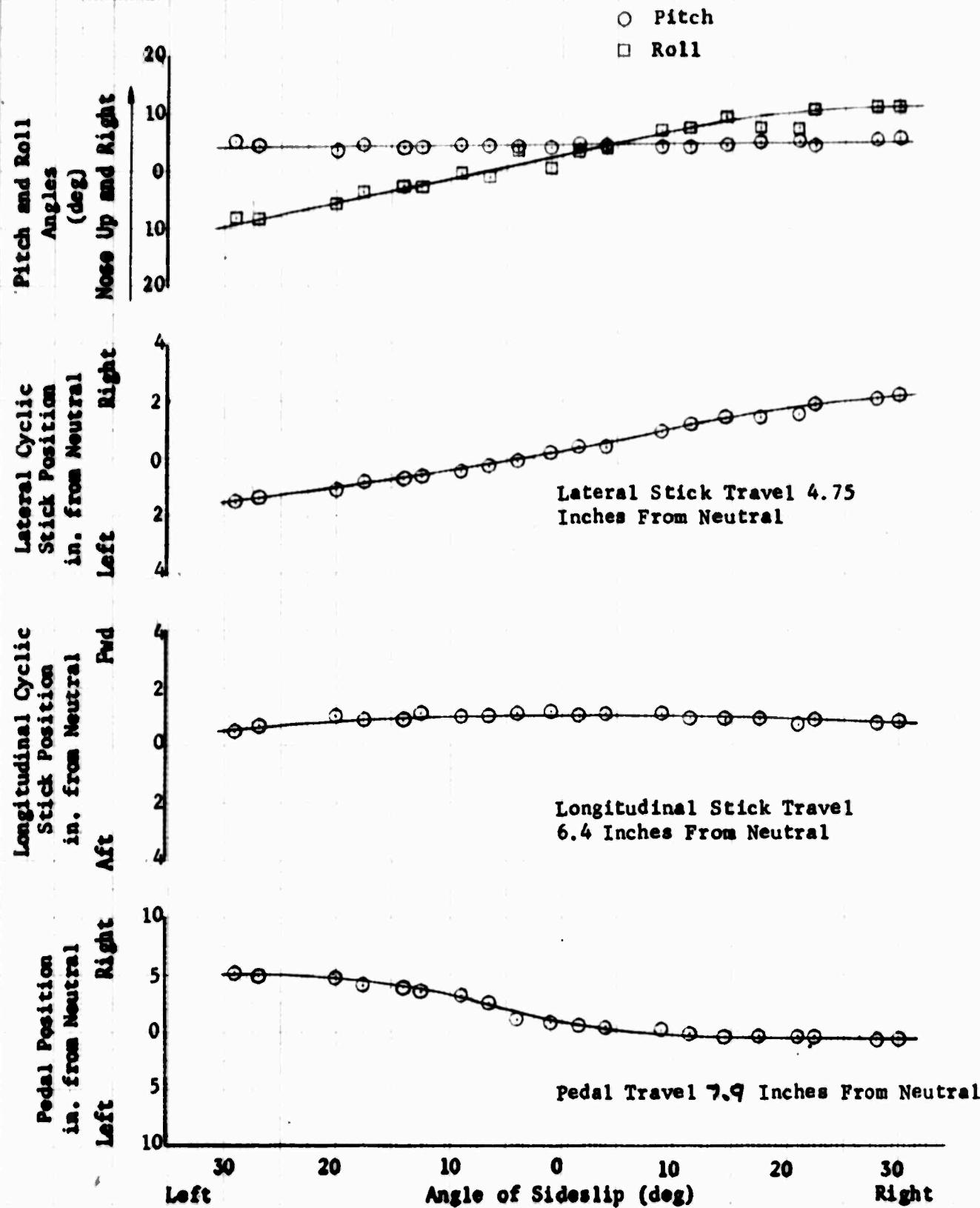


Figure 5% Static Directional Stability

Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS	KCAS
Level Flight	31,000	352	5,100	5	185	ON	100



Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS	KCAS
Level Flight	31,000	352	5,100	5	185	ON	60

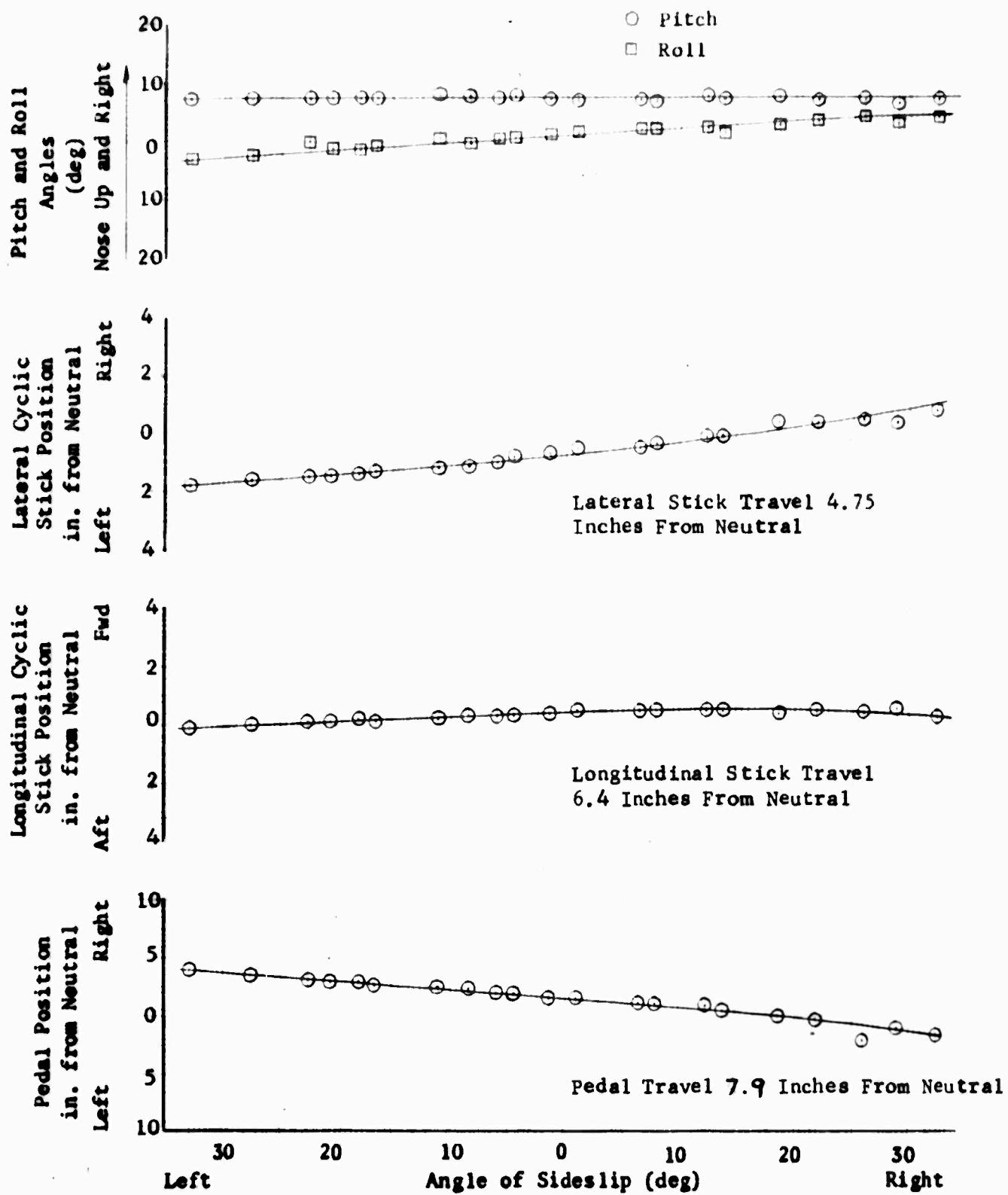
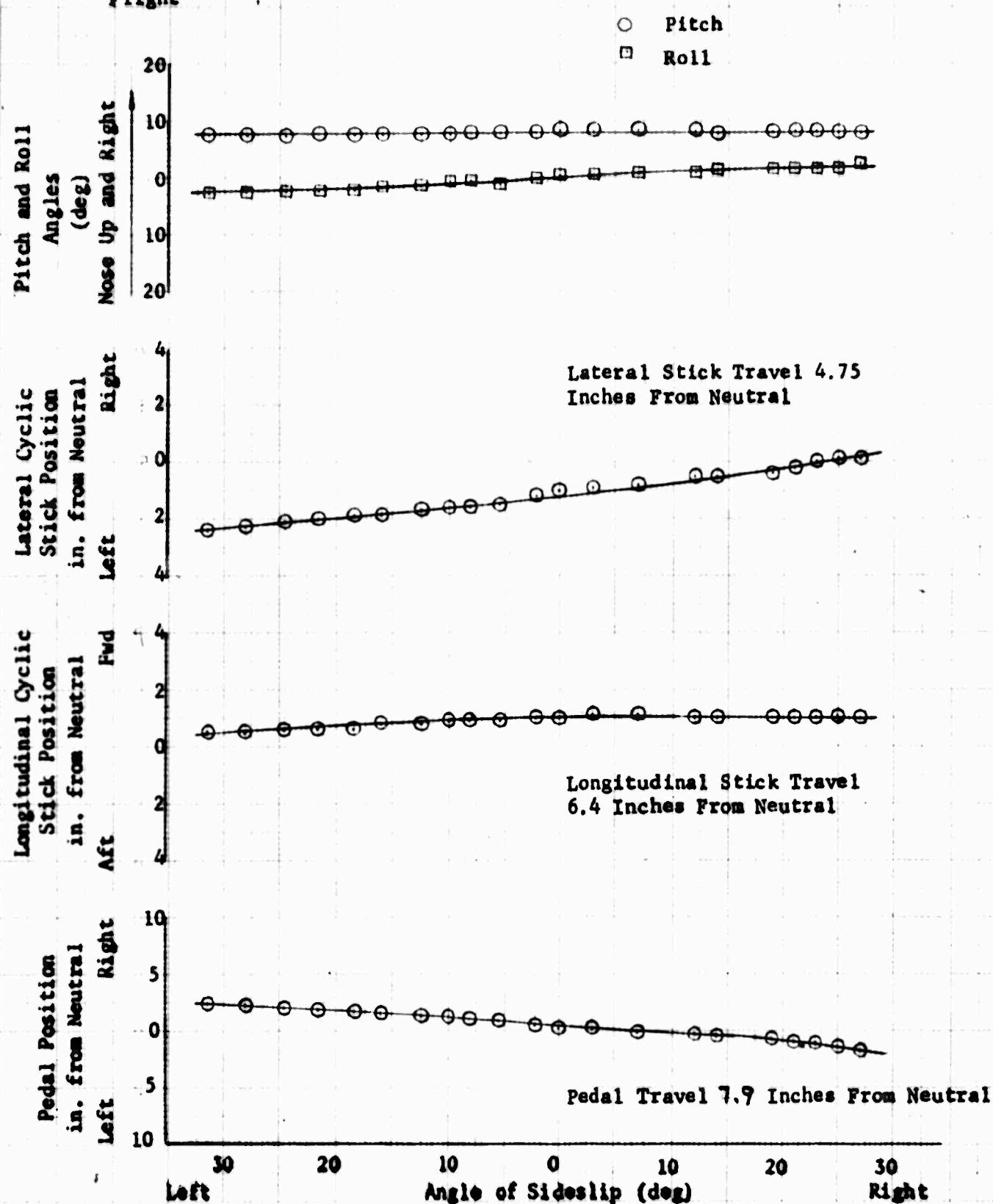


Figure 53. Static Directional Stability

HH-53C USAF S/N 67-14993

Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS	KCAS
Level Flight	31,000	352	14,800	-10	185	ON	53



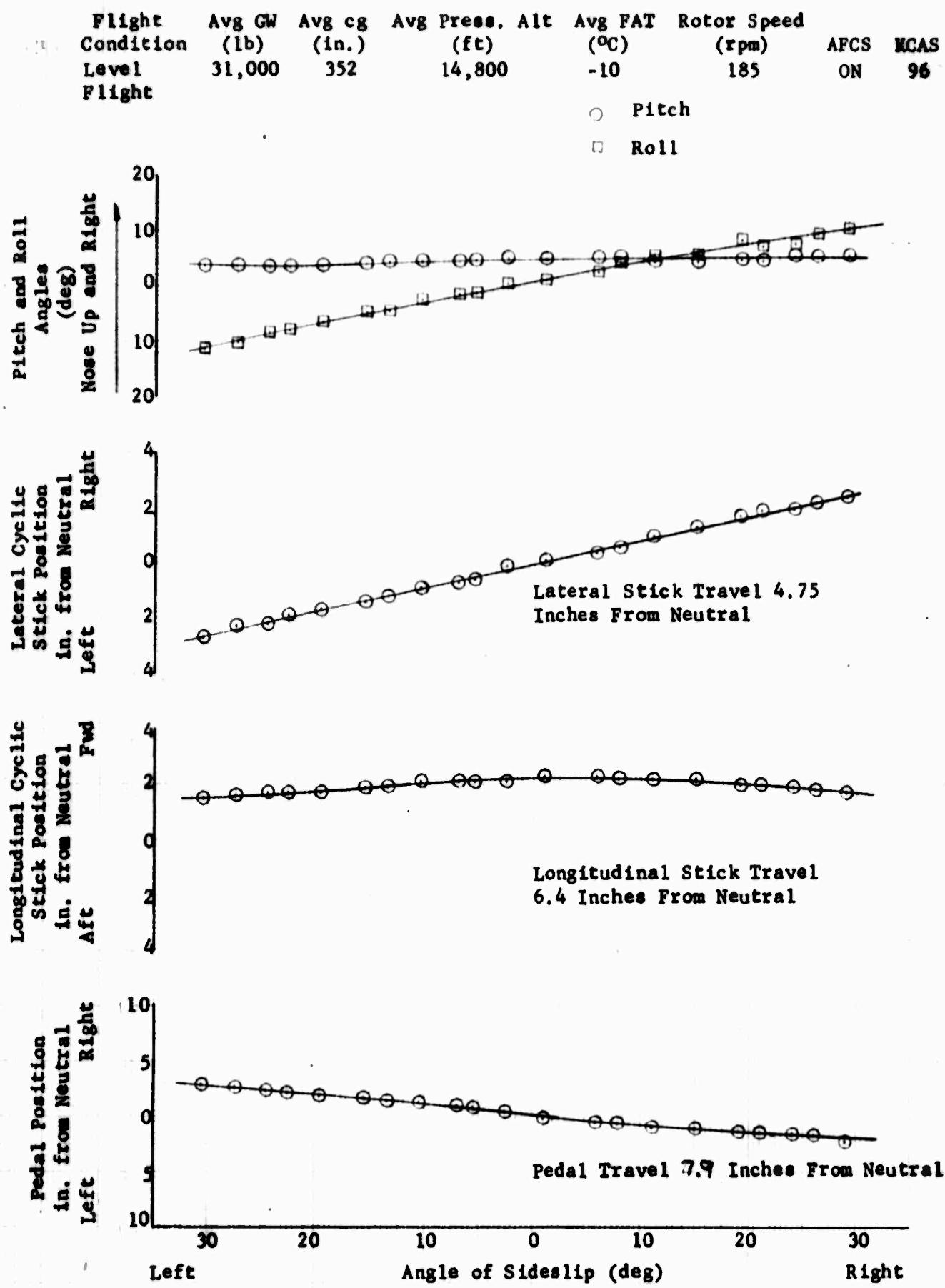


Figure 66. Static Directional Stability

Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS	KCAS
Climb	31,000	352	14,500	-11	185	ON	63

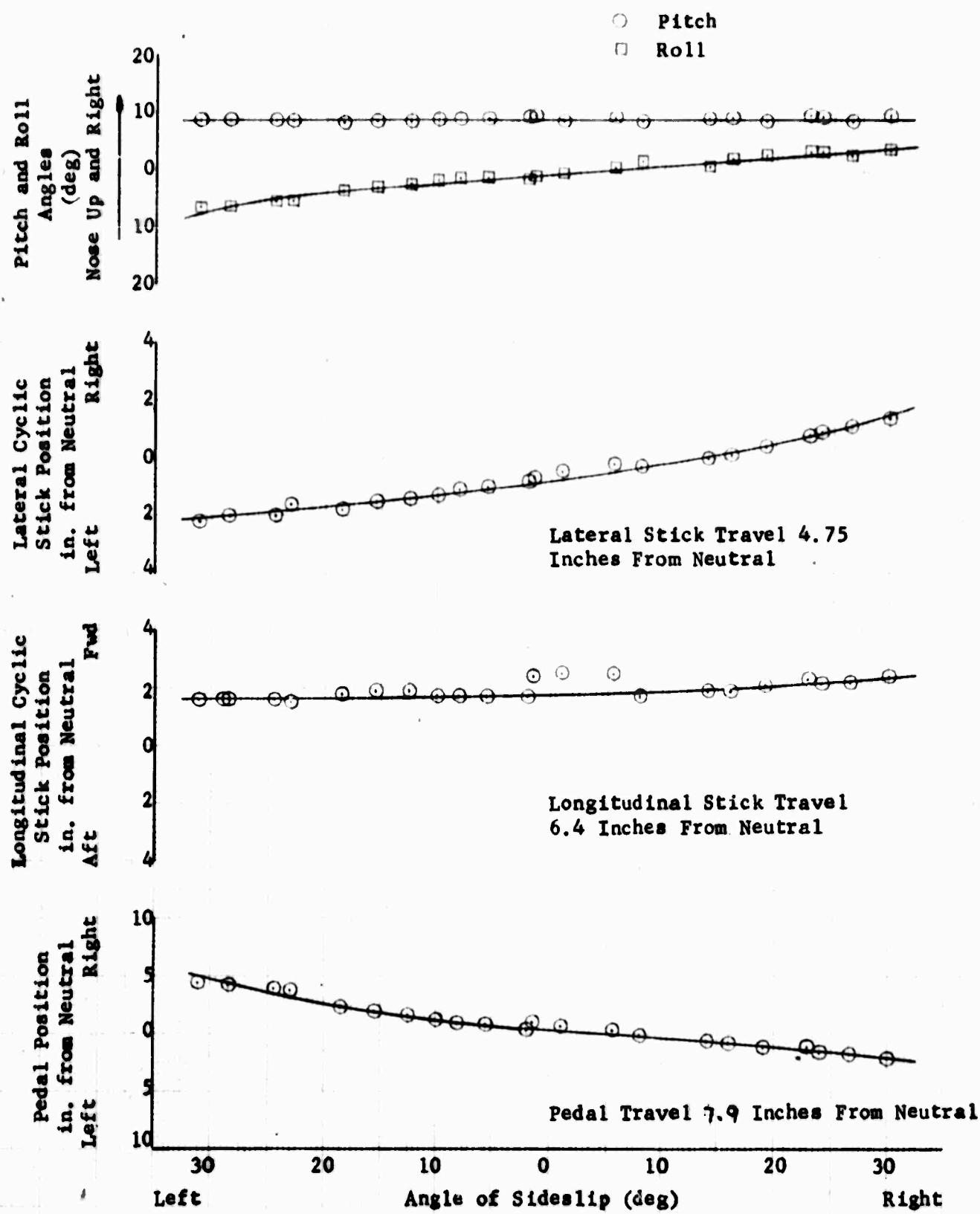


Figure 56. Static Directional Stability

Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. (ft)	Alt (°C)	Avg FAT (rpm)	Rotor Speed (rpm)	AFCS	KCAS
Partial Power Descent	31,000	352	14,800	-10	185	185	ON	53

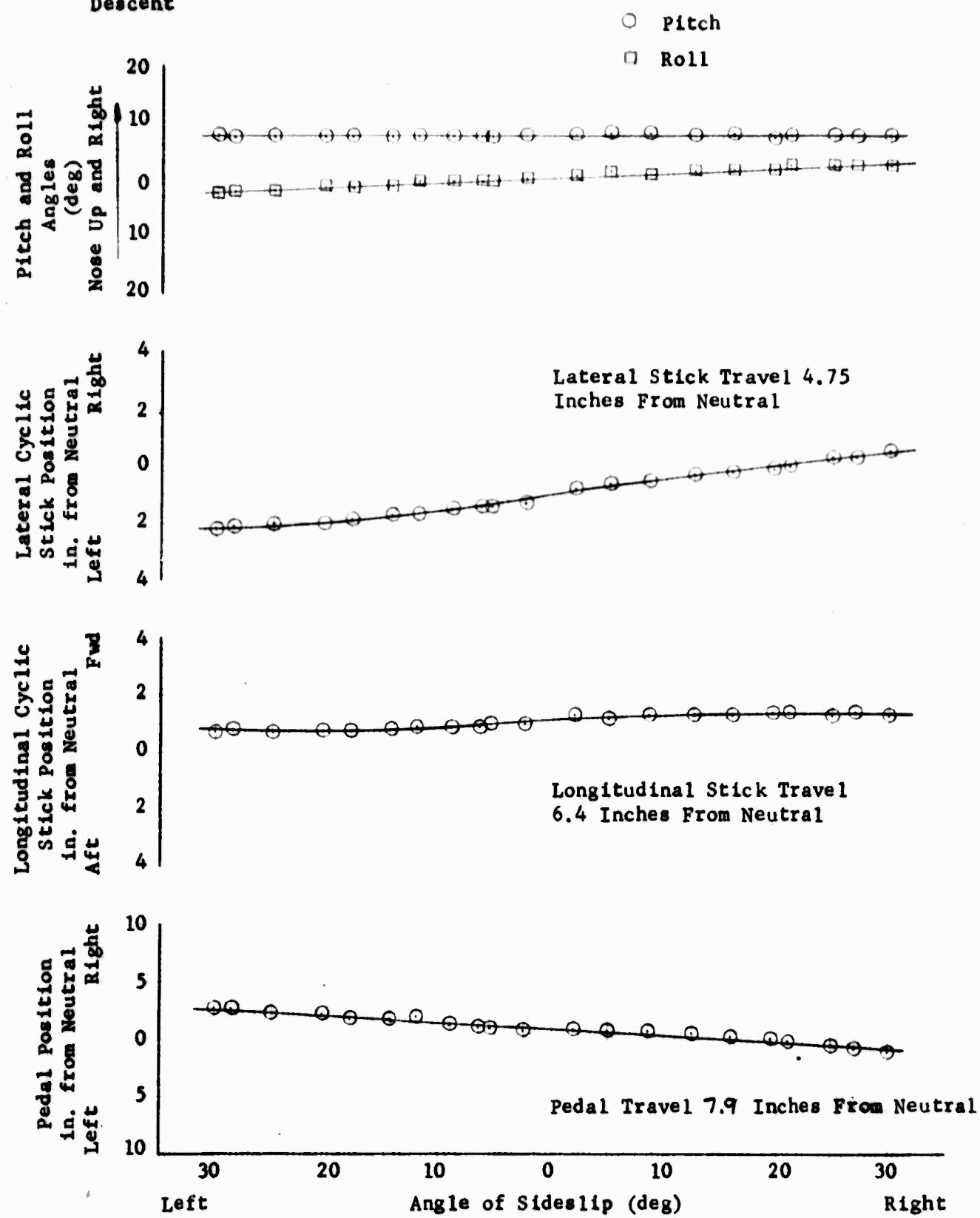
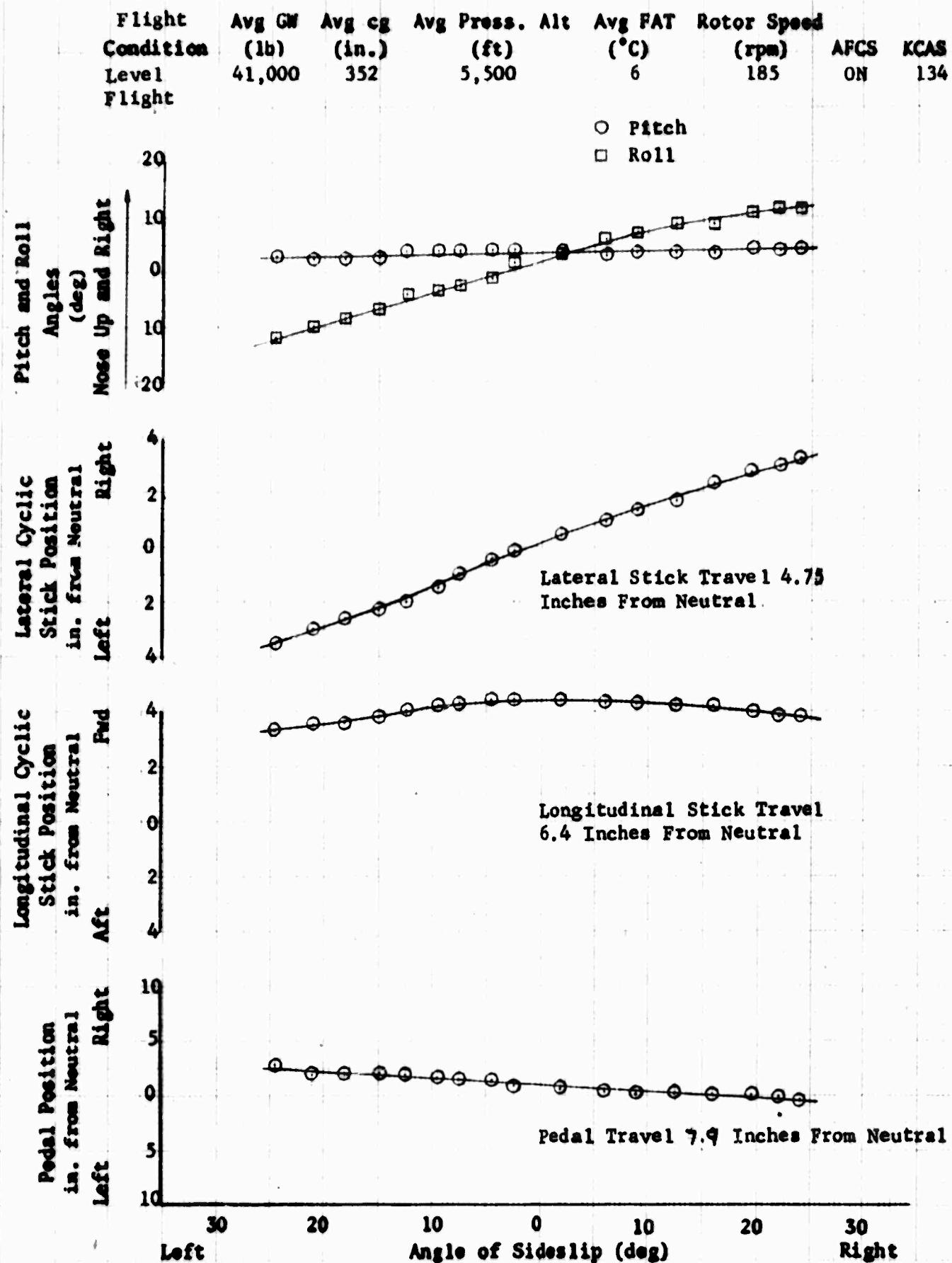


Figure 57. Static Directional Stability



HH-53C USAF S/N 67-14993

Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS	KCAS
Level Flight	41,000	352	5,500	6	185	ON	87

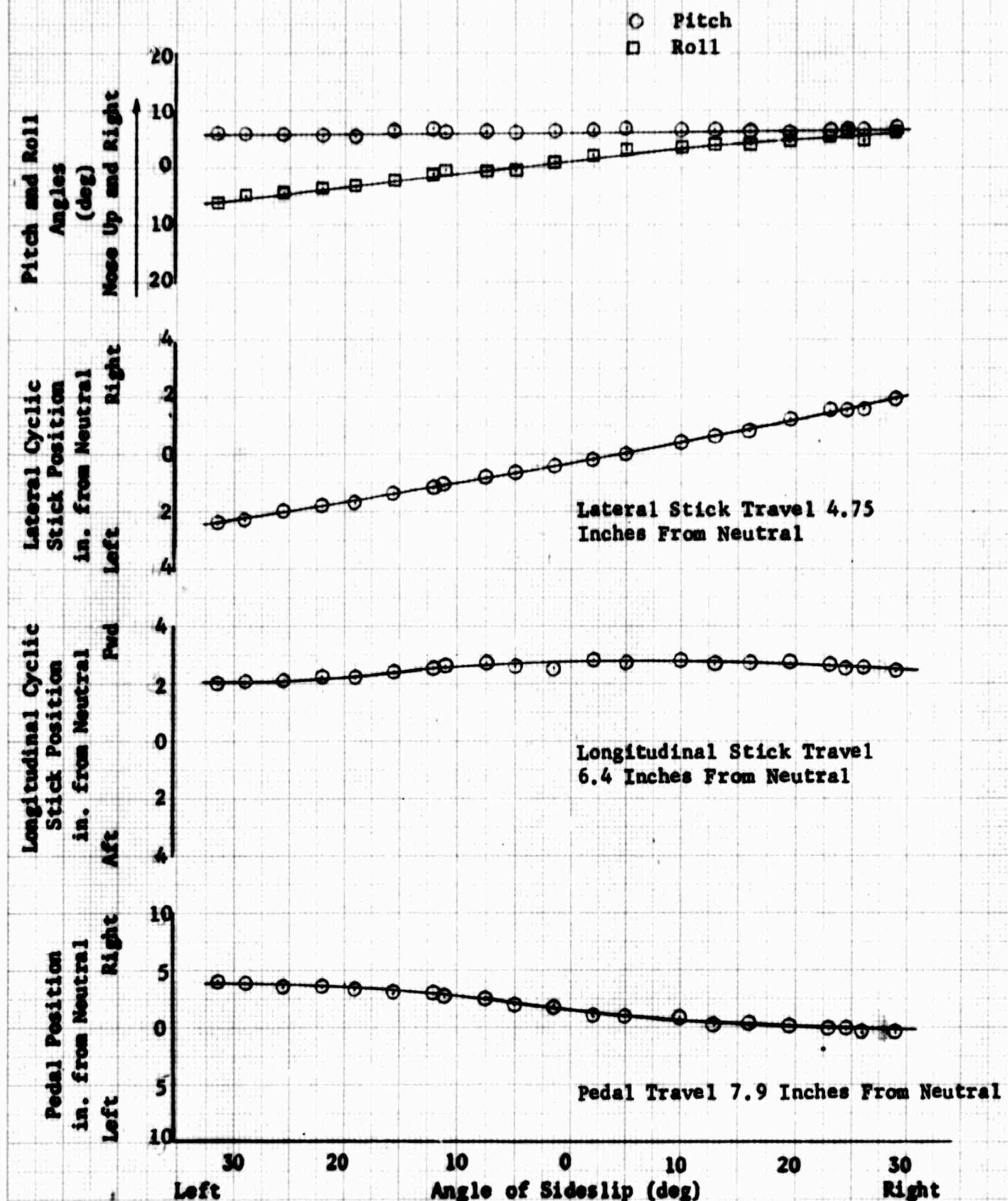


Figure 57. Static Directional Stability

HH-53C USAF S/N 67-14993

Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. (ft)	Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS	KCAS
Level Flight	41,000	352		5,500	6	185	ON	52

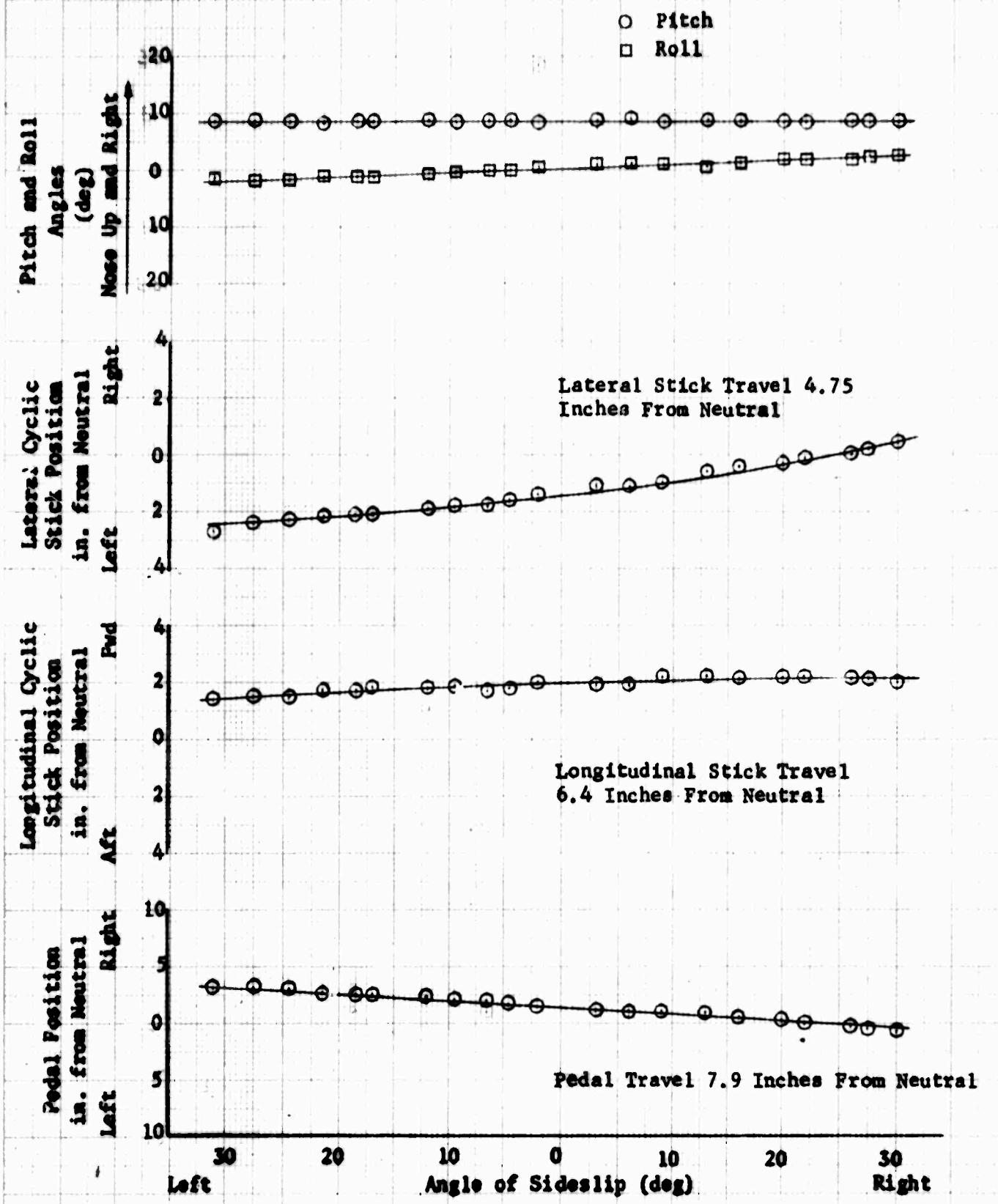


Figure 60. Static Directional Stability

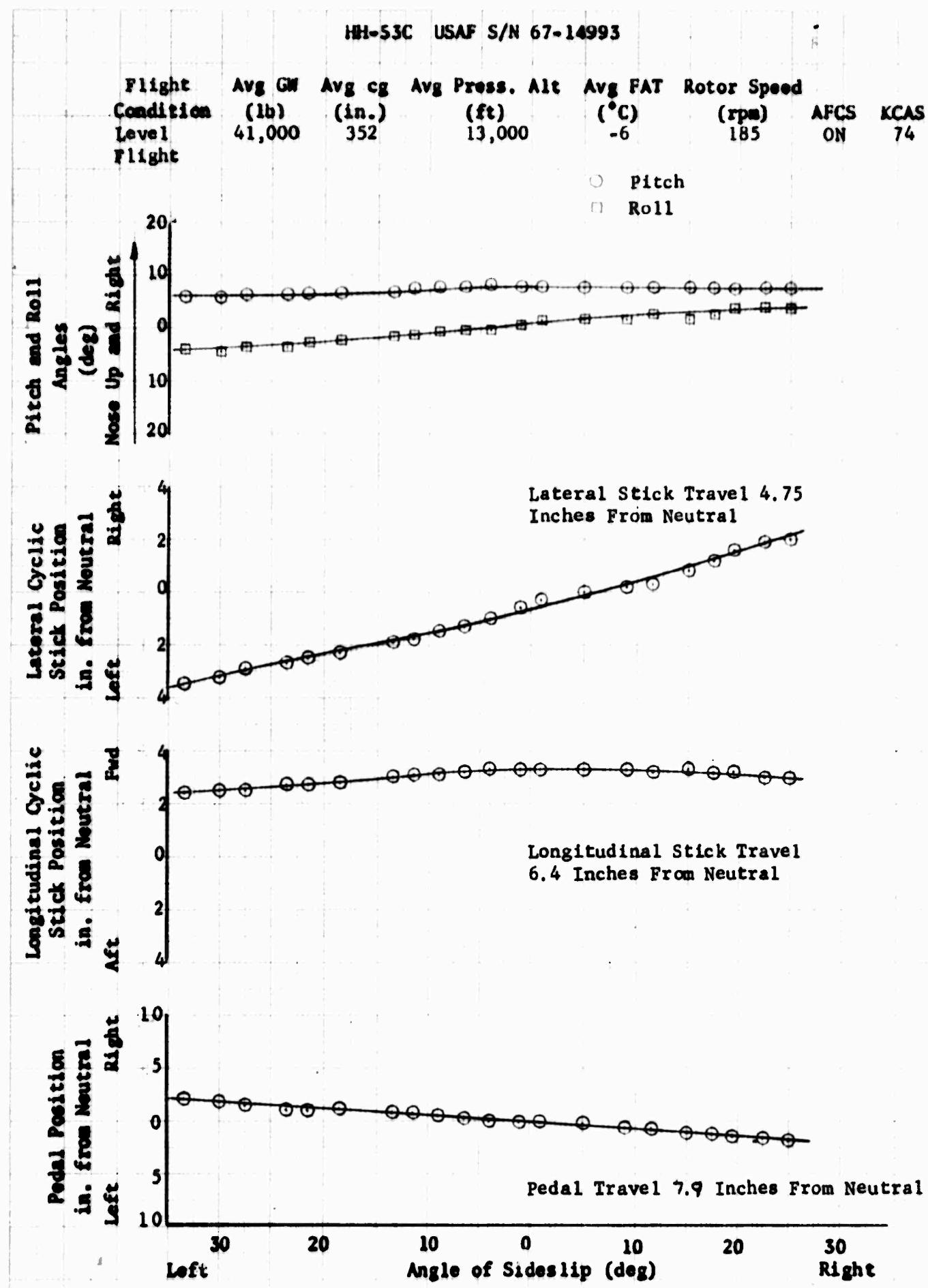


Figure 61. Static Directional Stability

HH-53C USAF S/N 67-14993

Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS	KCAS
Level Flight	41,000	352	13,000	-6	185	ON	53

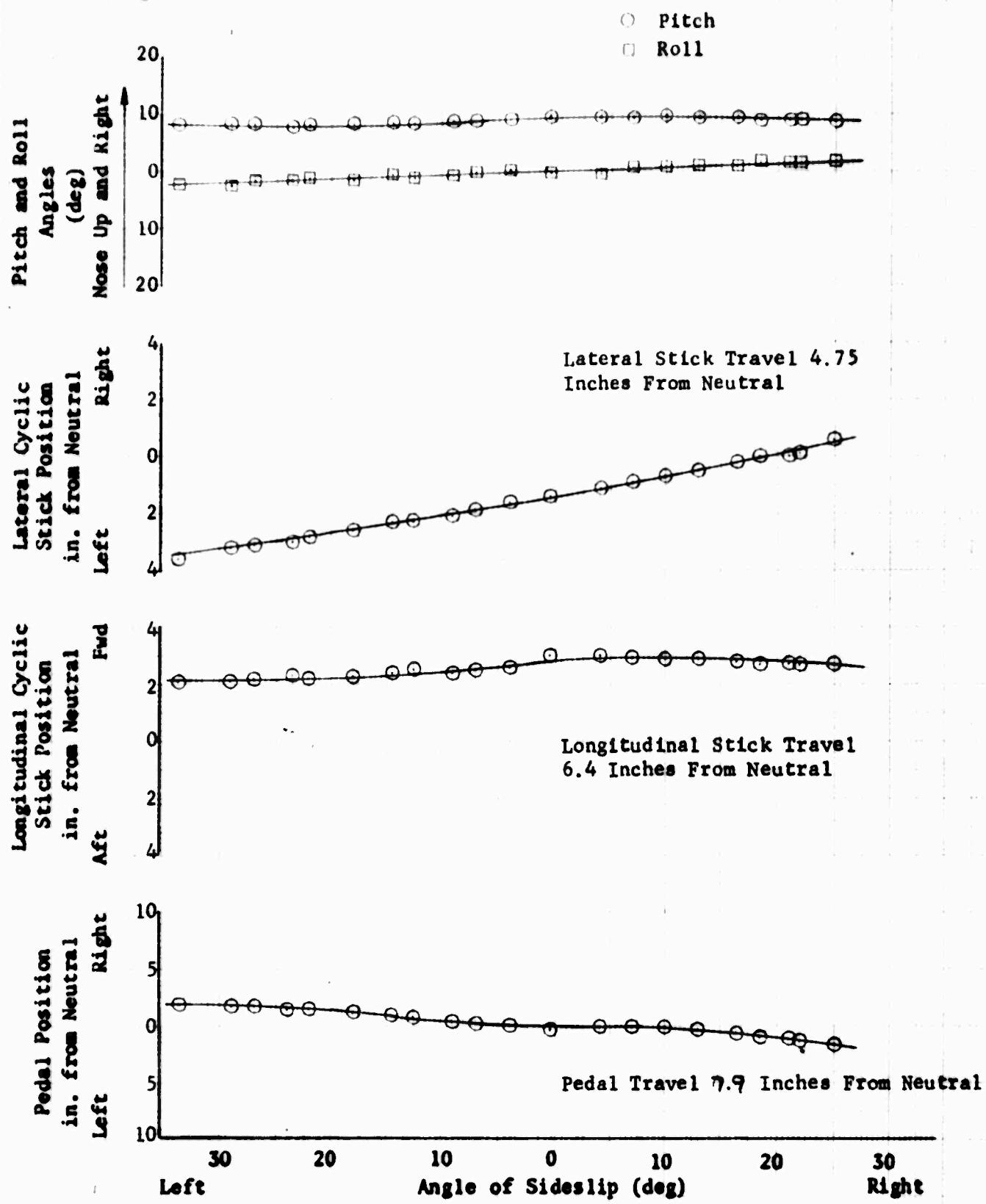


Figure 62. Static Directional Stability

HH-53C USAF S/N 67-14993

Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS	KCAS
Climb	41,000	352	6,000	-5	185	ON	87

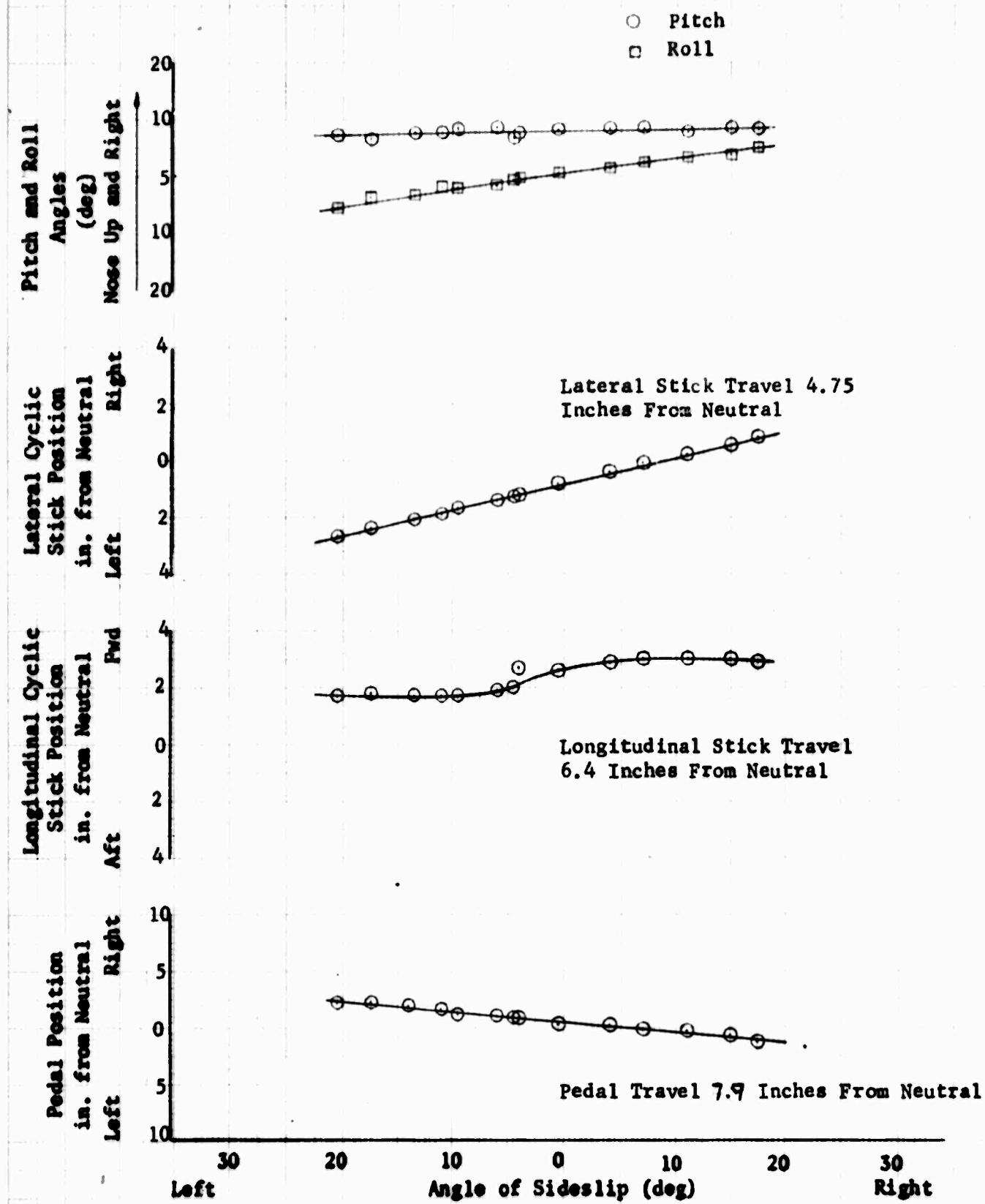
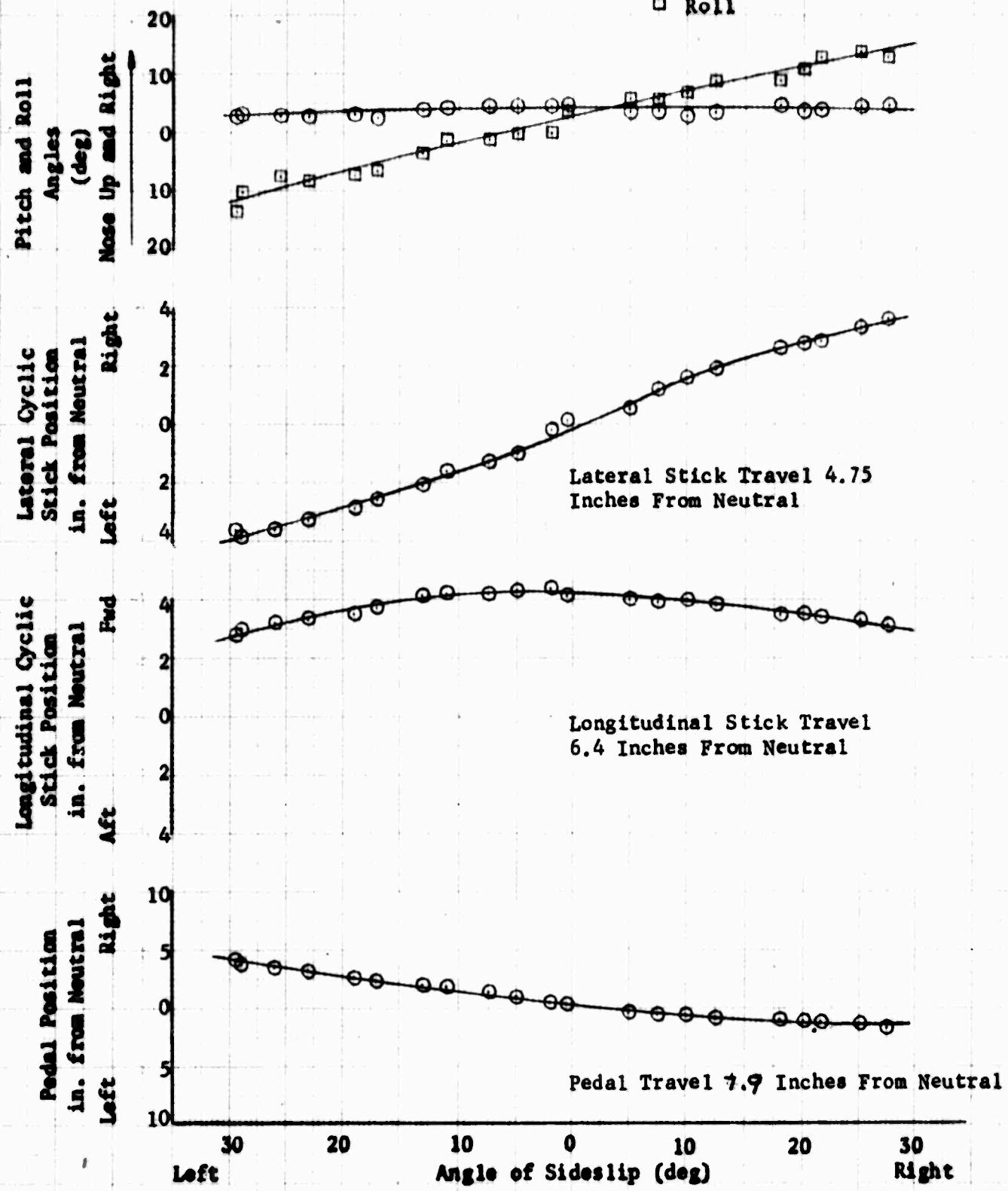


Figure 63. Static Directional Stability

HH-53C USAF S/N 67-14993

Flight Condition	Avg GW (lb)	Avg cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS	KCAS
Partial Power Descent	41,000	352	5,000	5	185	ON	130

○ Pitch
□ Roll



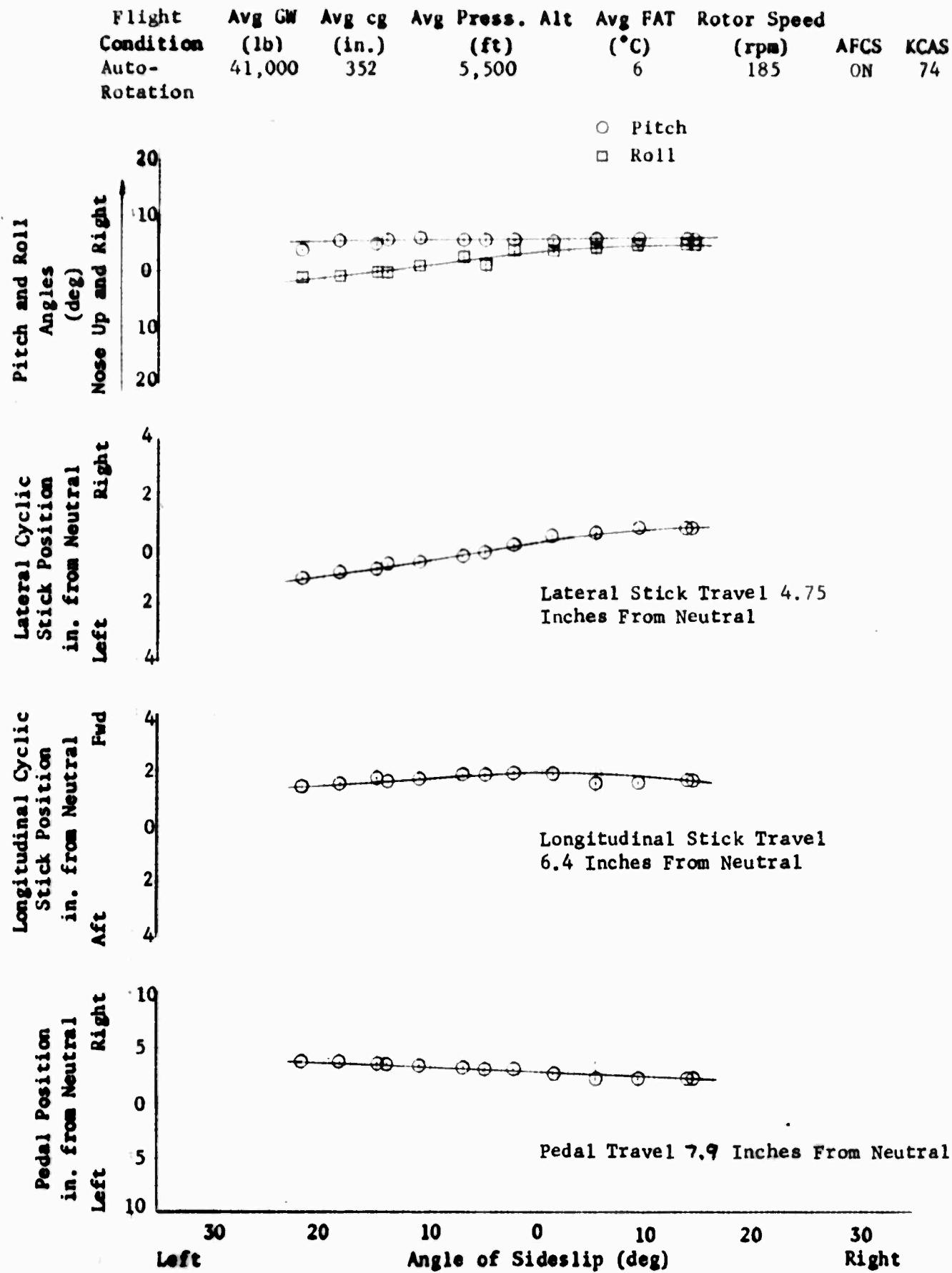


Figure 65. Static Directional Stability

HH-53C USAF S/N 67-14993
 Gross Weight = 41,000 lbs.
 Pressure Altitude = -120 Pt.
 Free Air Temperature = 0°C
 cg Location = 328

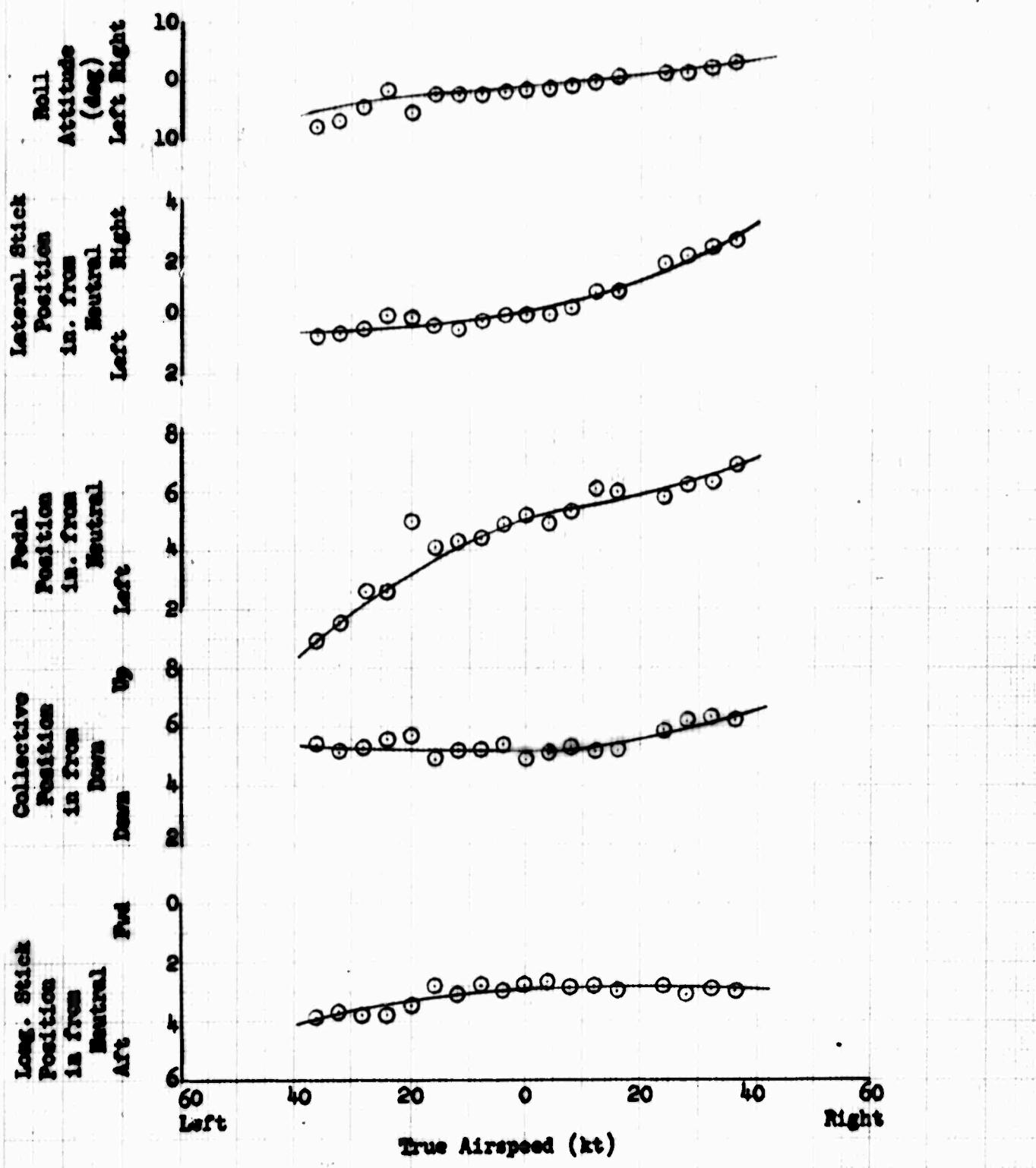


Figure 66. Control Position in Sideward Flight

MM-53C USAF S/N 67-14993
 Gross Weight = 41,000 lbs.
 Pressure Altitude = 120 Ft.
 Free Air Temperature = 0°C
 cg Location = 328

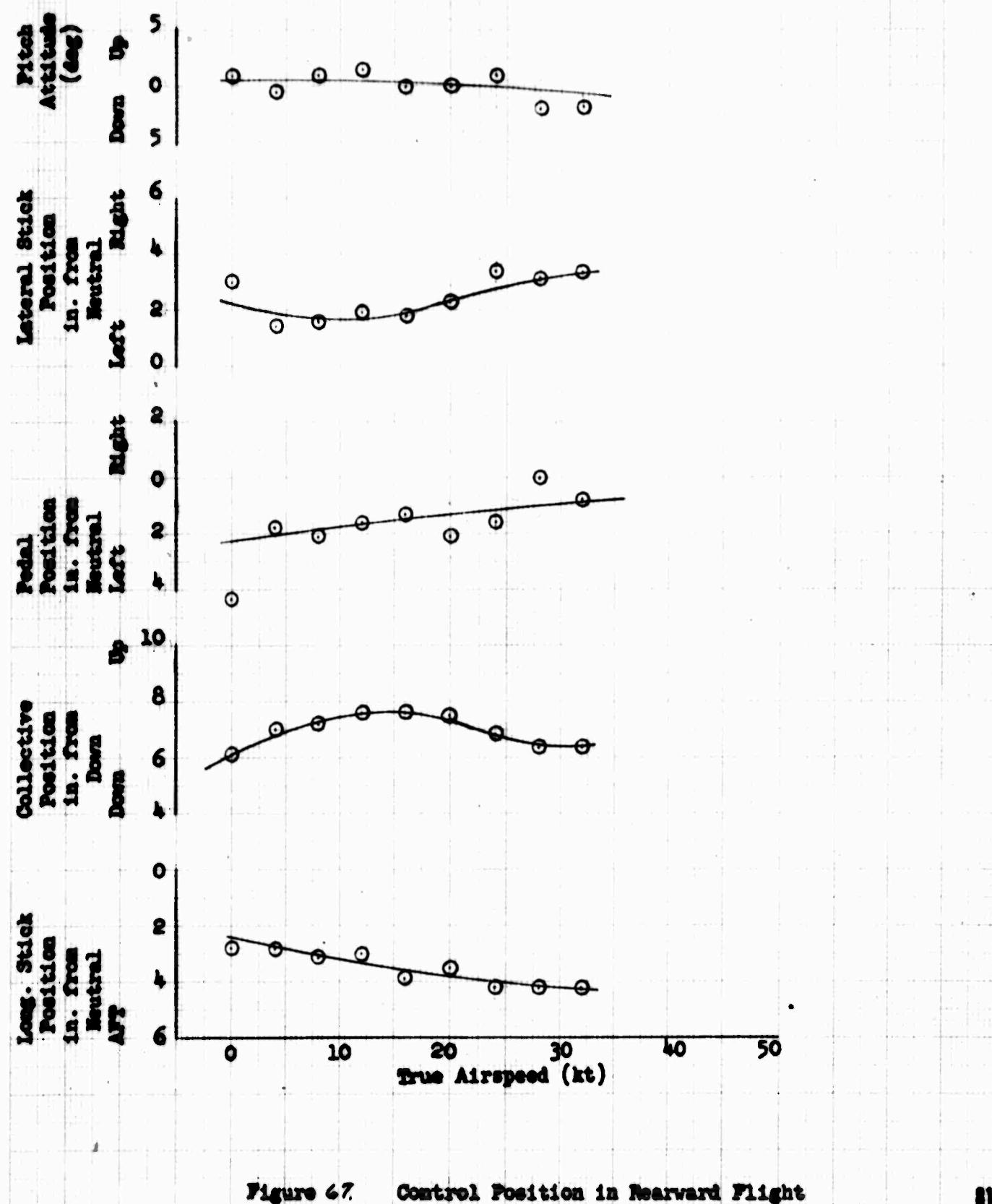


Figure 67. Control Position in Rearward Flight

FLIGHT MM-53C USAF 67-14993
 COND (LBS) AVG GN (IN) AVG CG (FT) AVG ALT (DEG C) ROTOR SPEED (RPM)
 HOY IGE 31000 328 300 10 185

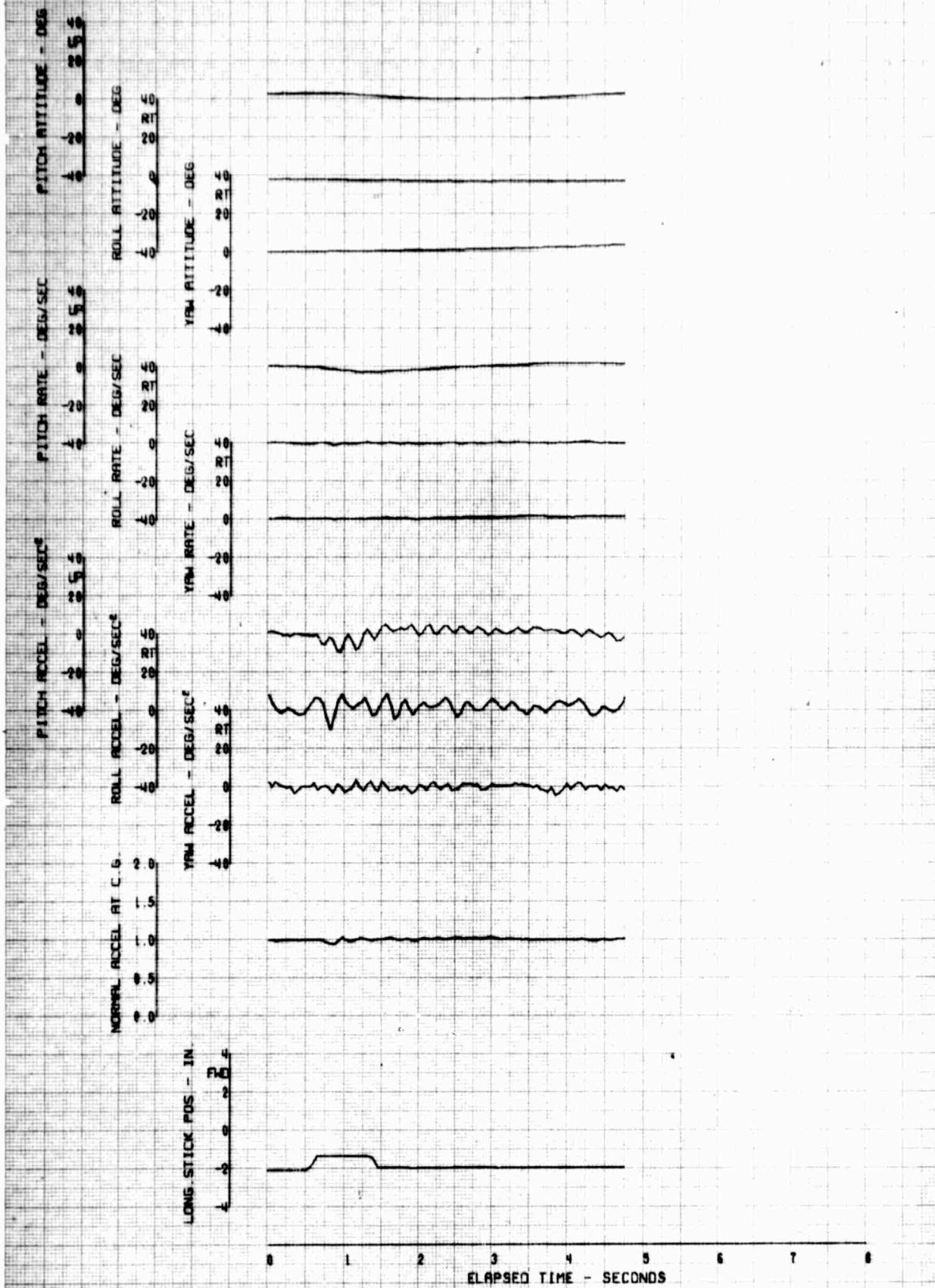


FIGURE 60. REACTION TO A FORWARD LONGITUDINAL PULSE

FLIGHT HH-53C USAF 67-14993
 COND COND
 HOV LGE 31000 AVG GW 326 AVG CG 300 AVG ALT 10 AVG FRT (DEG C) ROTOR SPEEDO (RPM)
 RFCS COND OFF

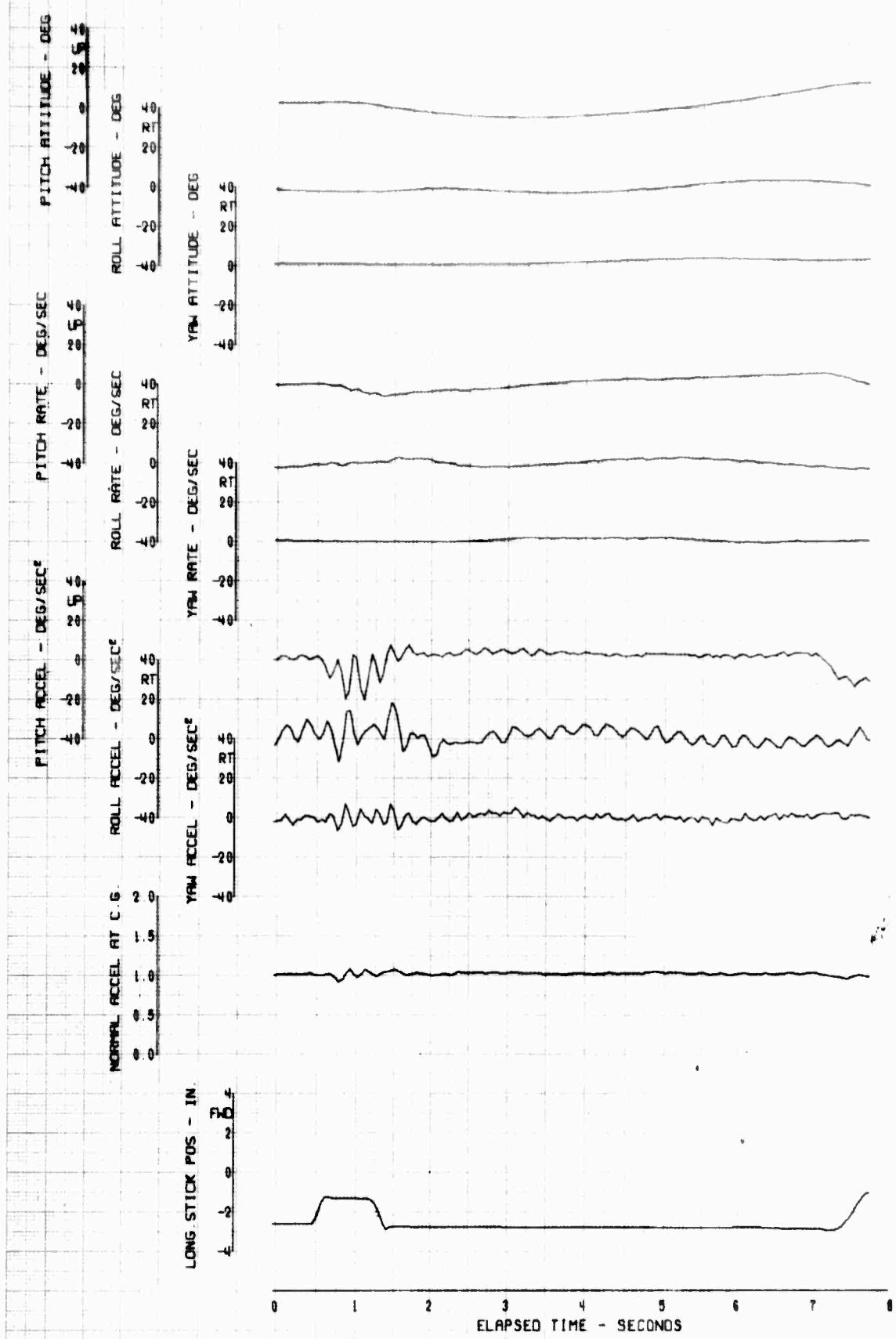


FIGURE 69. REACTION TO A FORWARD LONGITUDINAL PULSE

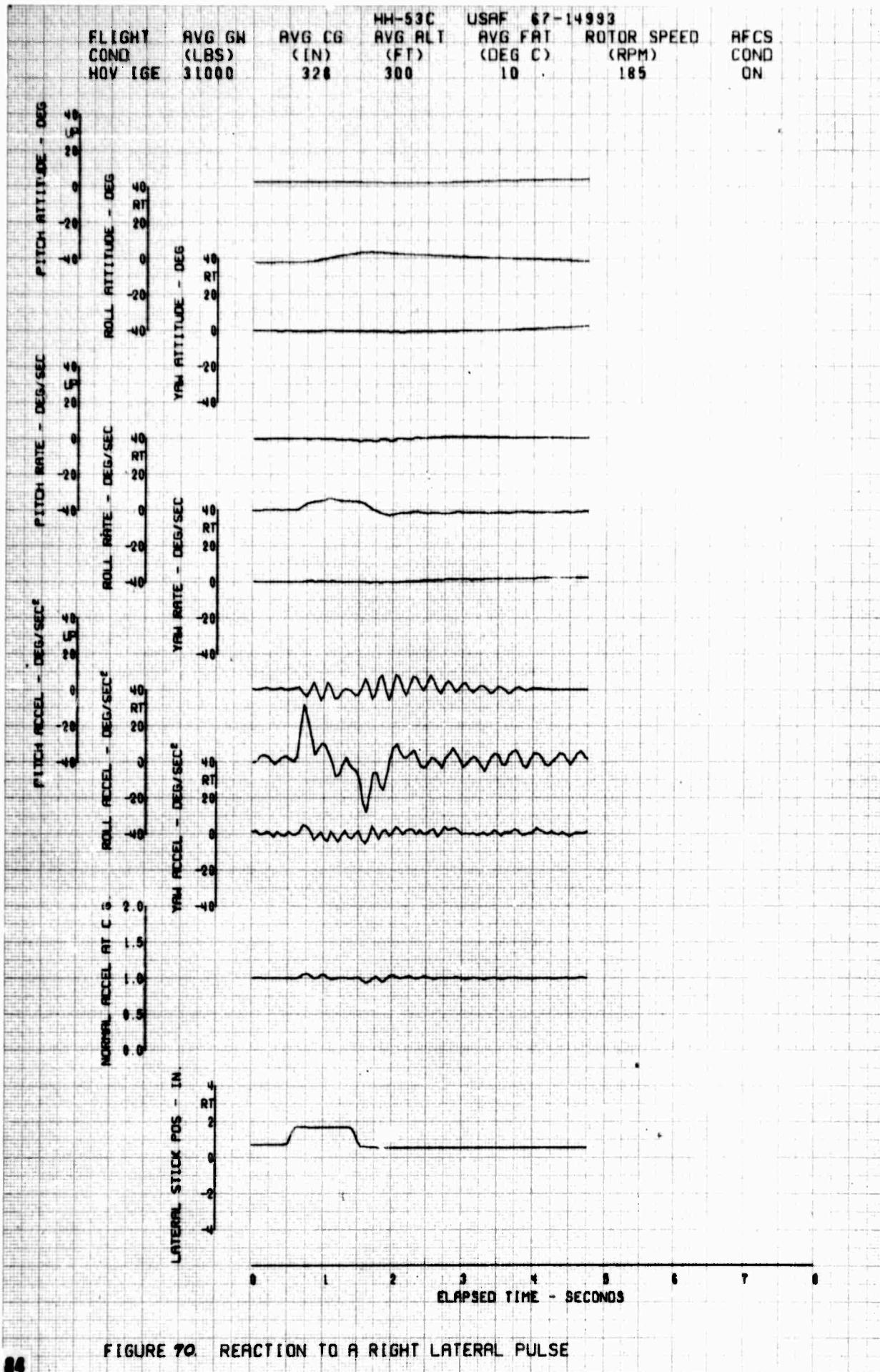


FIGURE 70. REACTION TO A RIGHT LATERAL PULSE

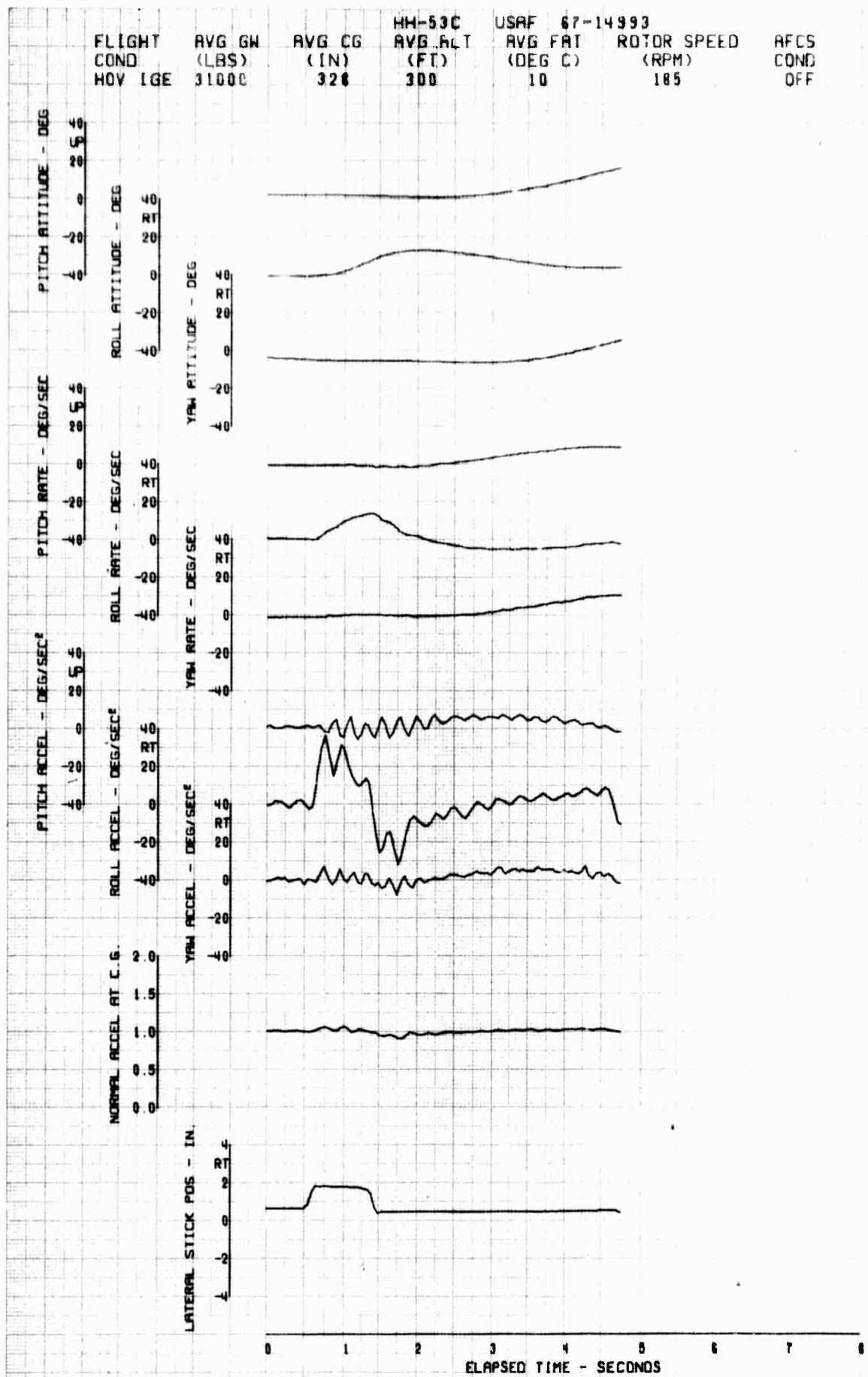


FIGURE 7. REACTION TO A RIGHT LATERAL PULSE

FLIGHT COND	Avg GW (LBS)	Avg CG (IN)	MM-53C Avg Alt (FT)	USAF Avg Fat (Deg C)	67-14993 Rotor Speed (RPM)	RFCs Cond Off
HOV LGE	31000	326	300	10	185	

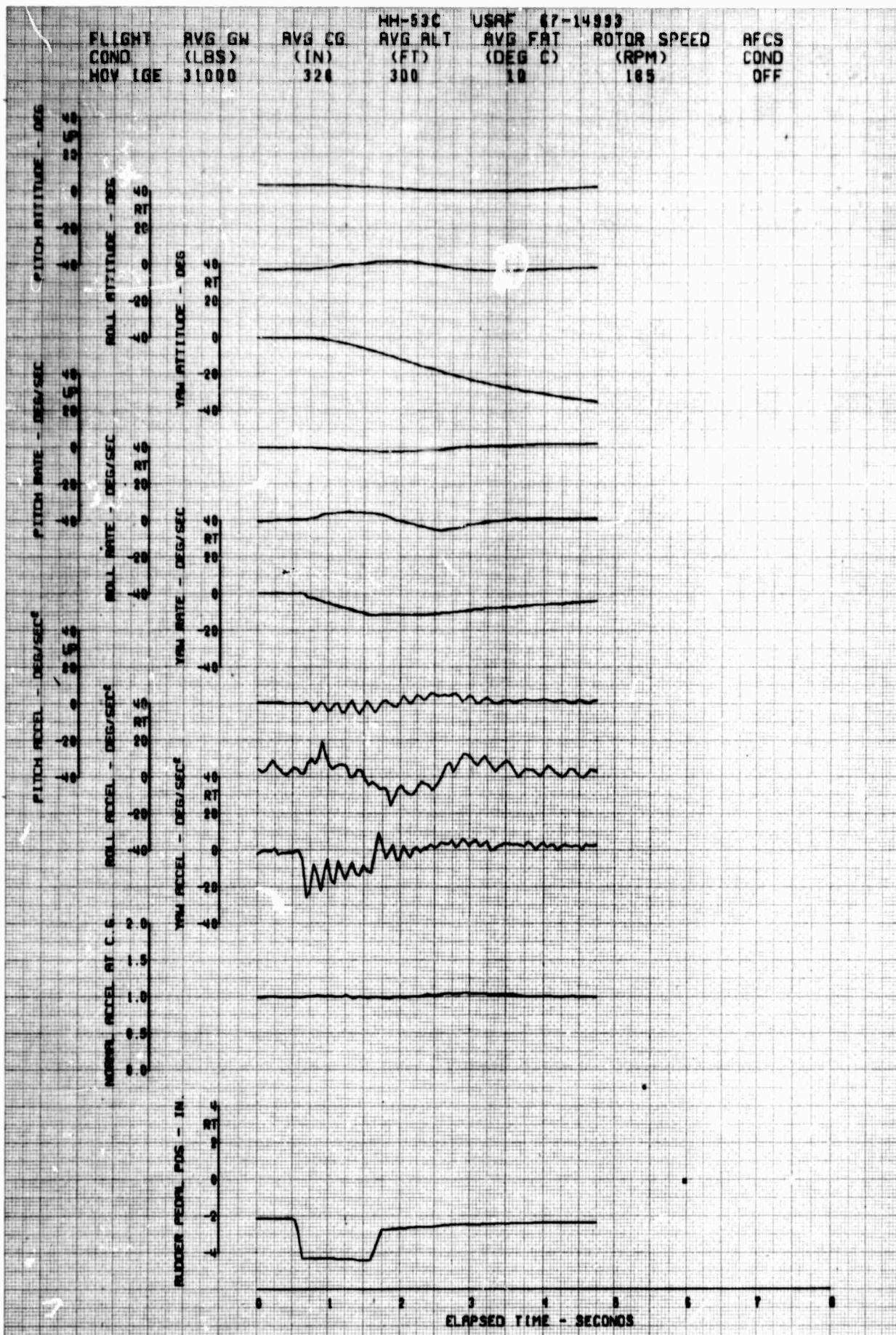


FIGURE 7C. REACTION TO A LEFT DIRECTIONAL PULSE

FLIGHT HH-53C USAF 67-14993
 COND (LBS) AVG GW (IN) AVG CG (FT) AVG RLT (DEG C) ROTOR SPEED (RPM)
 HOV IGE 31000 328 300 10 185
 AFCS COND ON

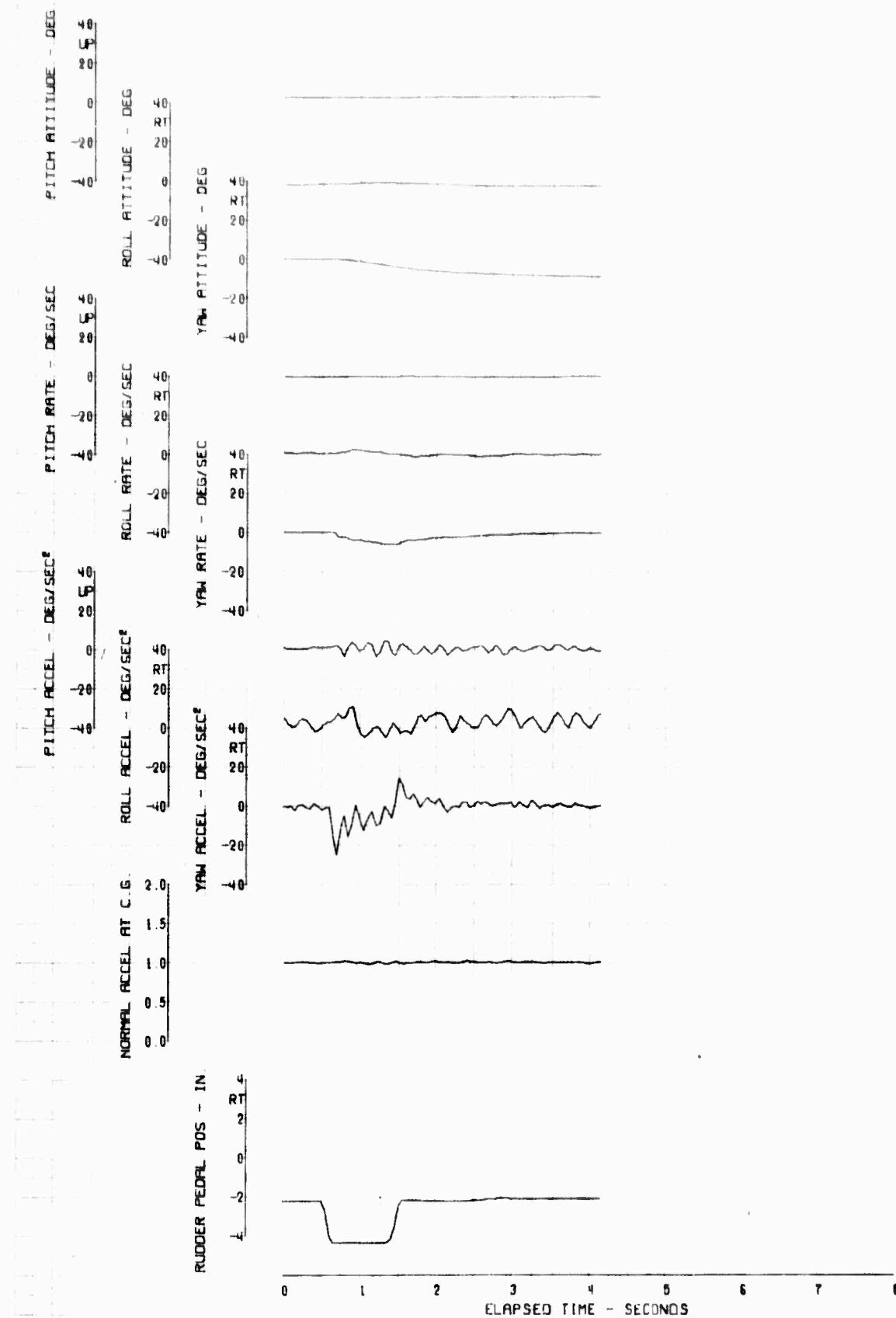


FIGURE 73. REACTION TO A LEFT DIRECTIONAL PULSE

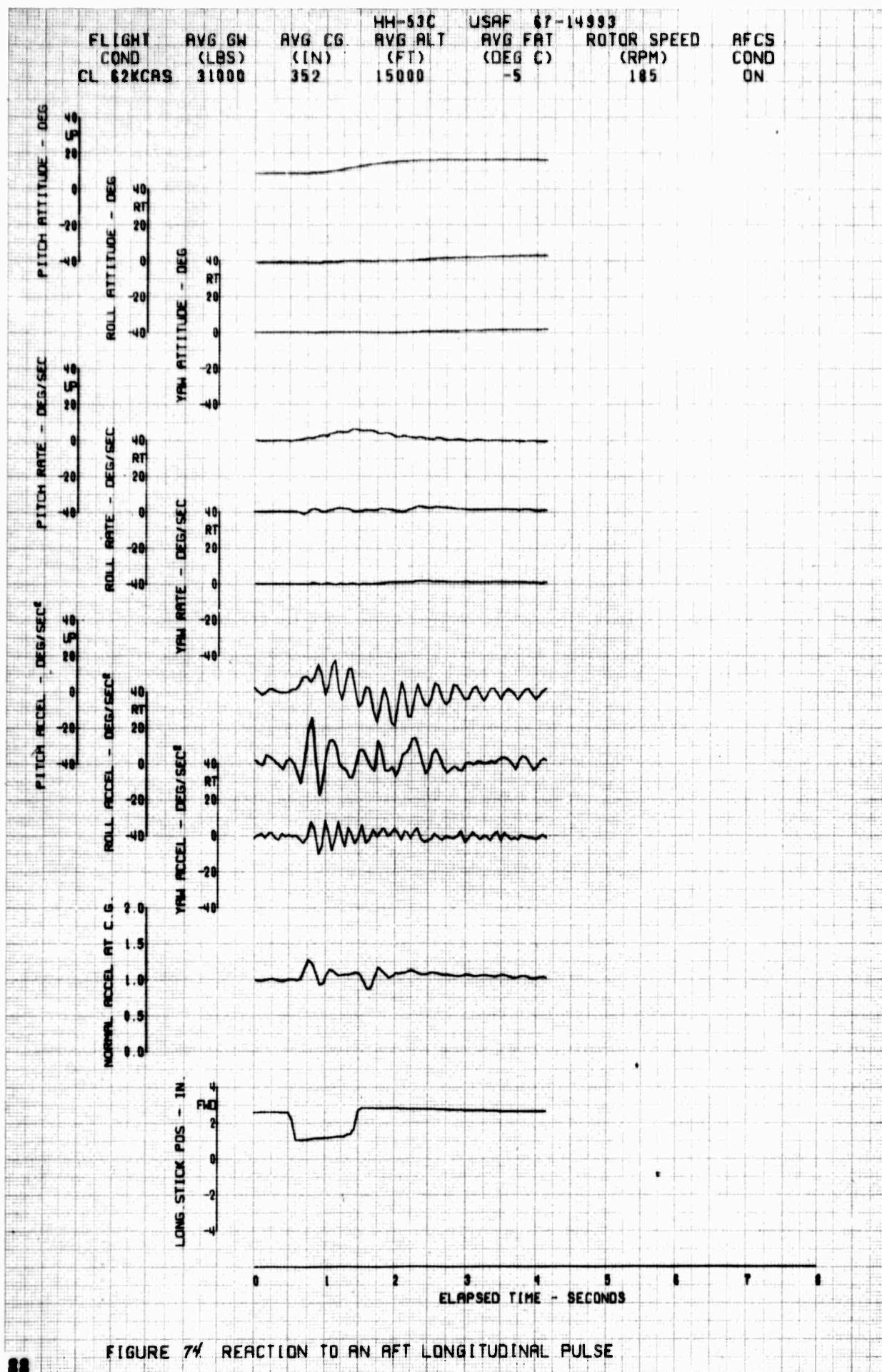


FIGURE 74 REACTION TO AN AFT LONGITUDINAL PULSE

FLIGHT HH-53C USAF 67-14993
 COND CL 62KCRS AVG GW 31000 AVG CG 352 AVG ALT 15000 AVG FRT -5 ROTOR SPEED 185
 RFCS COND OFF

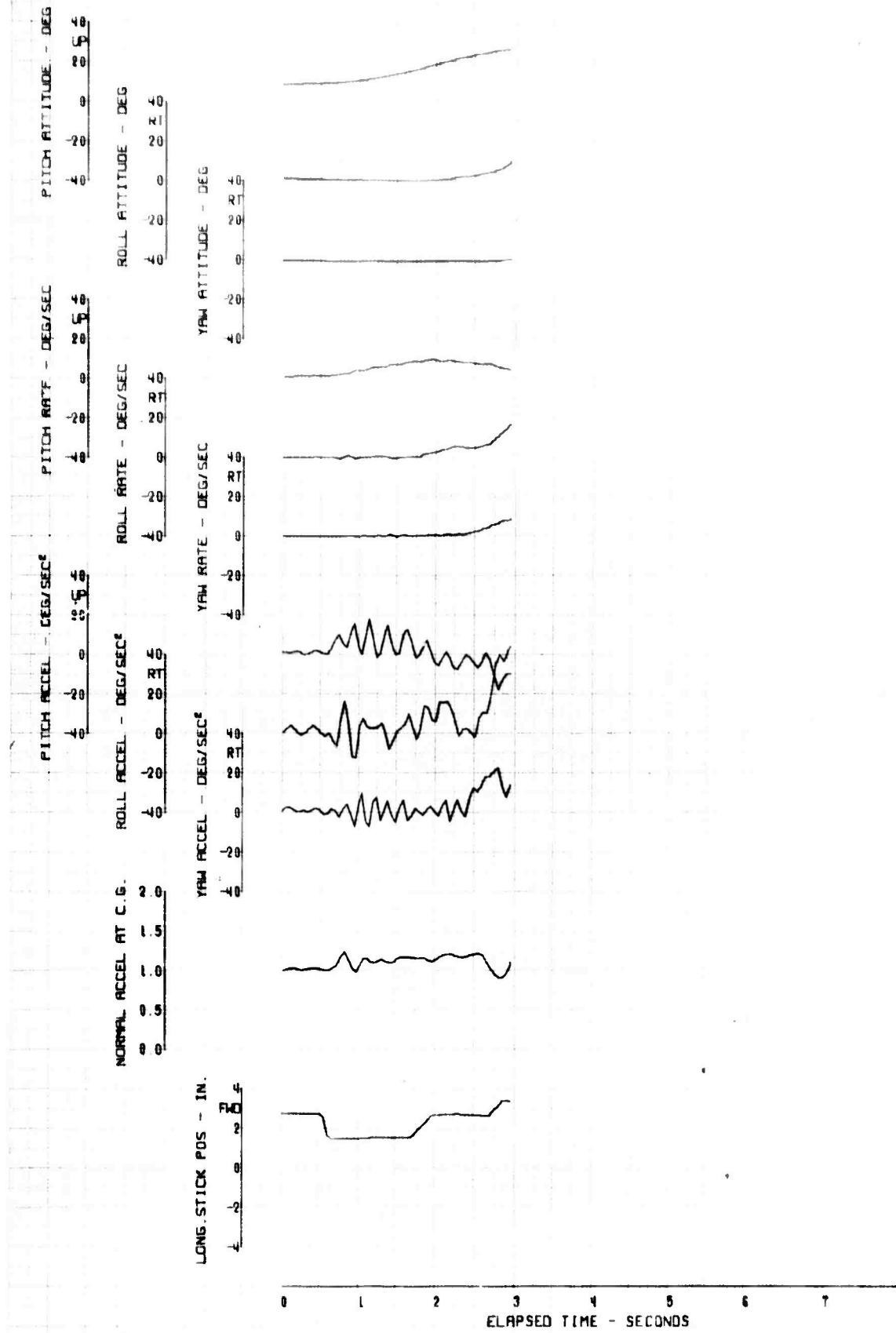


FIGURE 75. REACTION TO AN AFT LONGITUDINAL PULSE

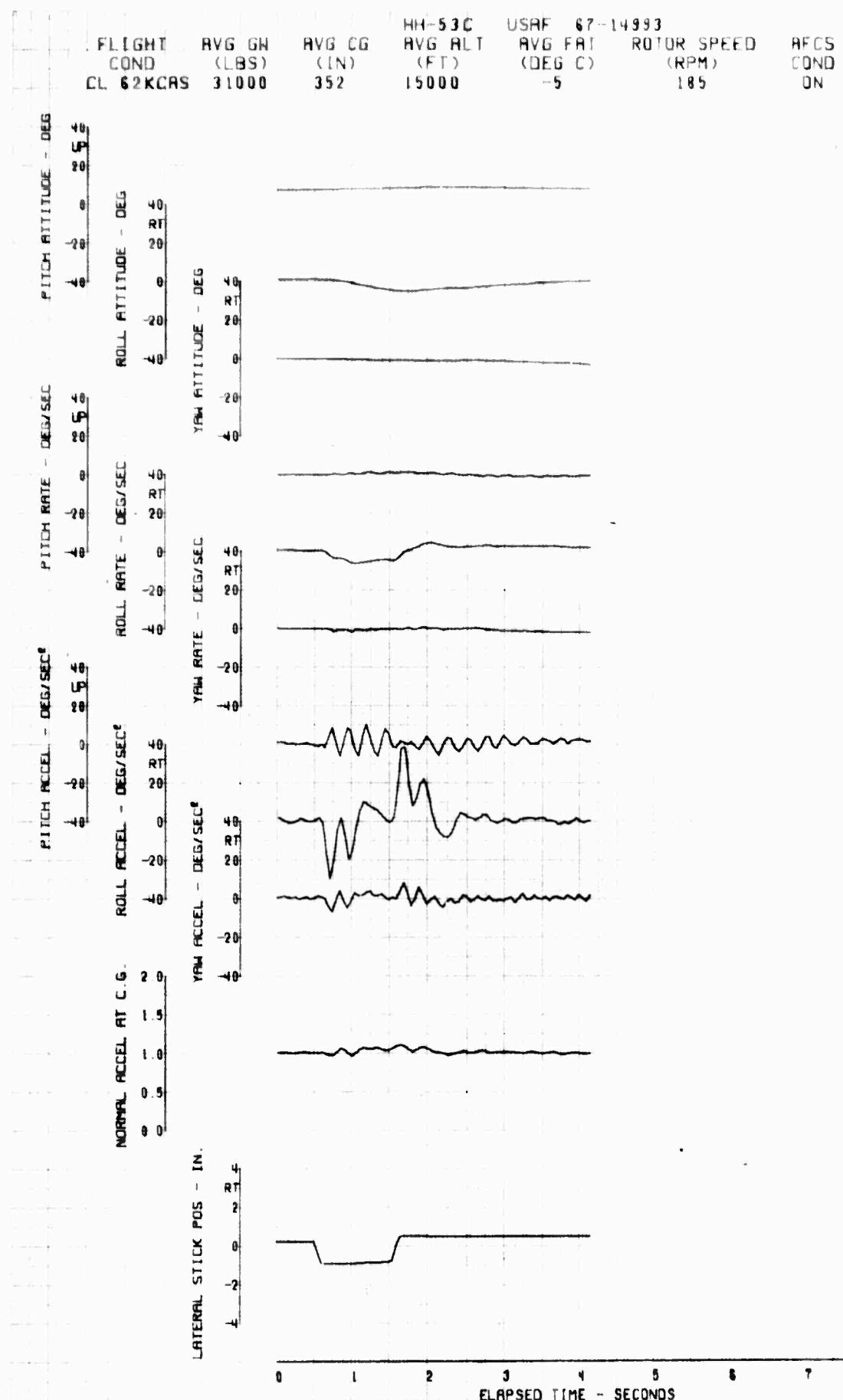


FIGURE 76. REACTION TO A LEFT LATERAL PULSE

FLIGHT COND CL 62KCRS
 AVG GW (LBS) 31000
 AVG CG (IN) 352
 HH-53C USAF 67-14993
 AVG ALT (FT) 15000
 AVG FRT (DEG C) -5
 ROTOR SPEED (RPM) 185
 AFCS COND OFF

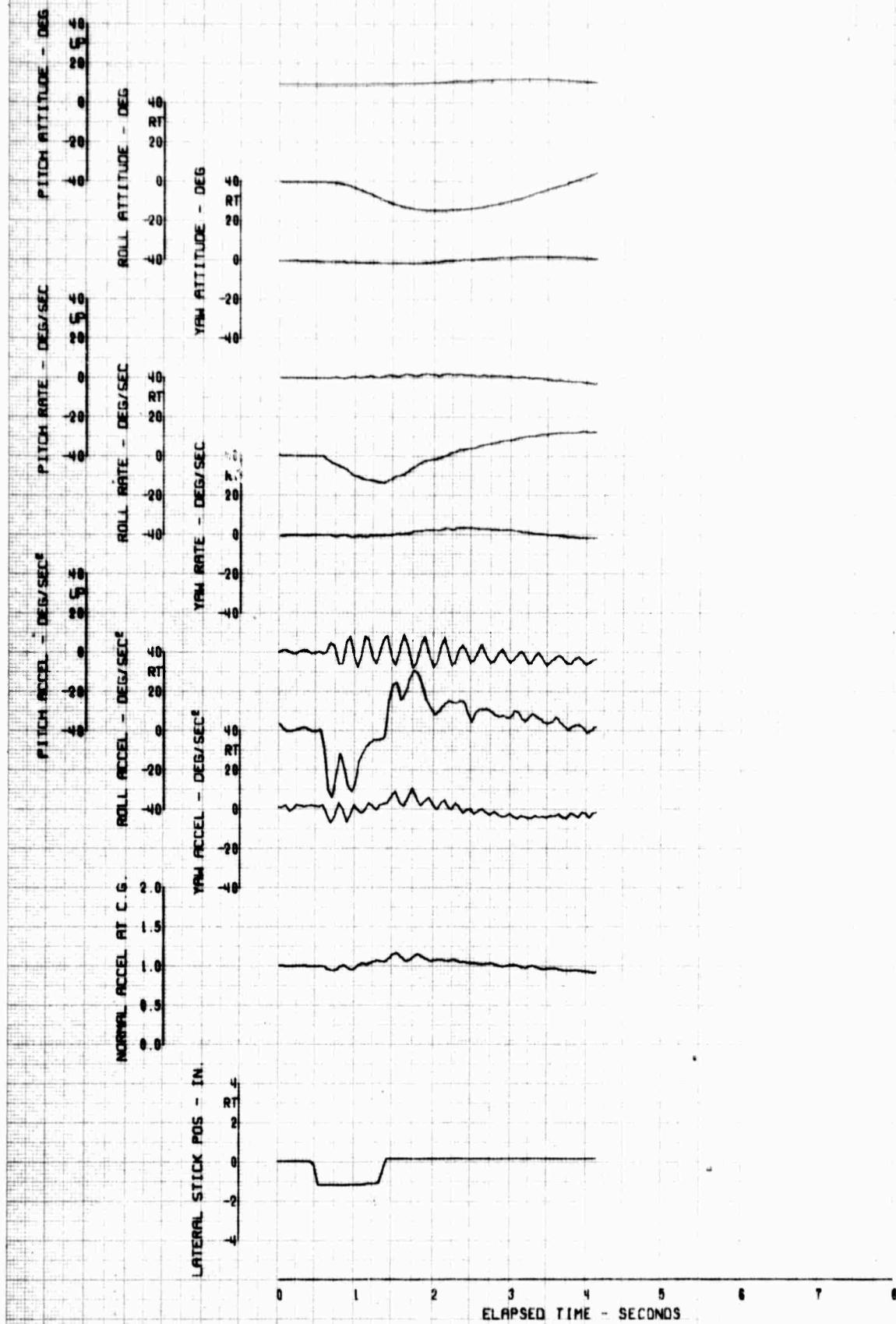


FIGURE 77 REACTION TO A LEFT LATERAL PULSE

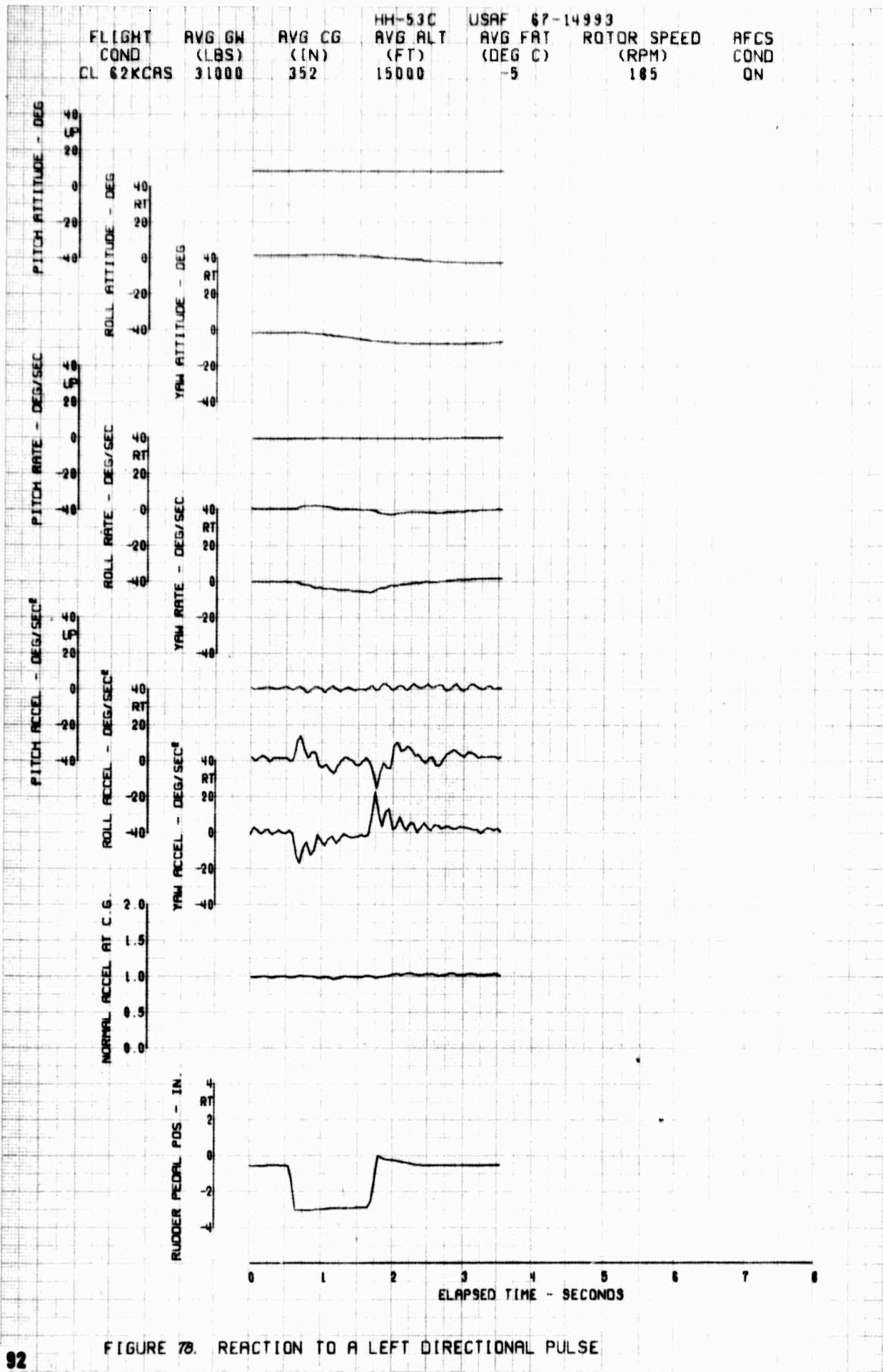


FIGURE 7B. REACTION TO A LEFT DIRECTIONAL PULSE

FLIGHT 4H-53C USAF 67-14993
 COND. AVG GW AVG CG AVG ALT AVG FWT ROTOR SPEED RFCS
 CL 62KCRS (LBS) (IN) (FT) (DEG C) (RPM) COND
 31000 352 15000 -5 185 OFF

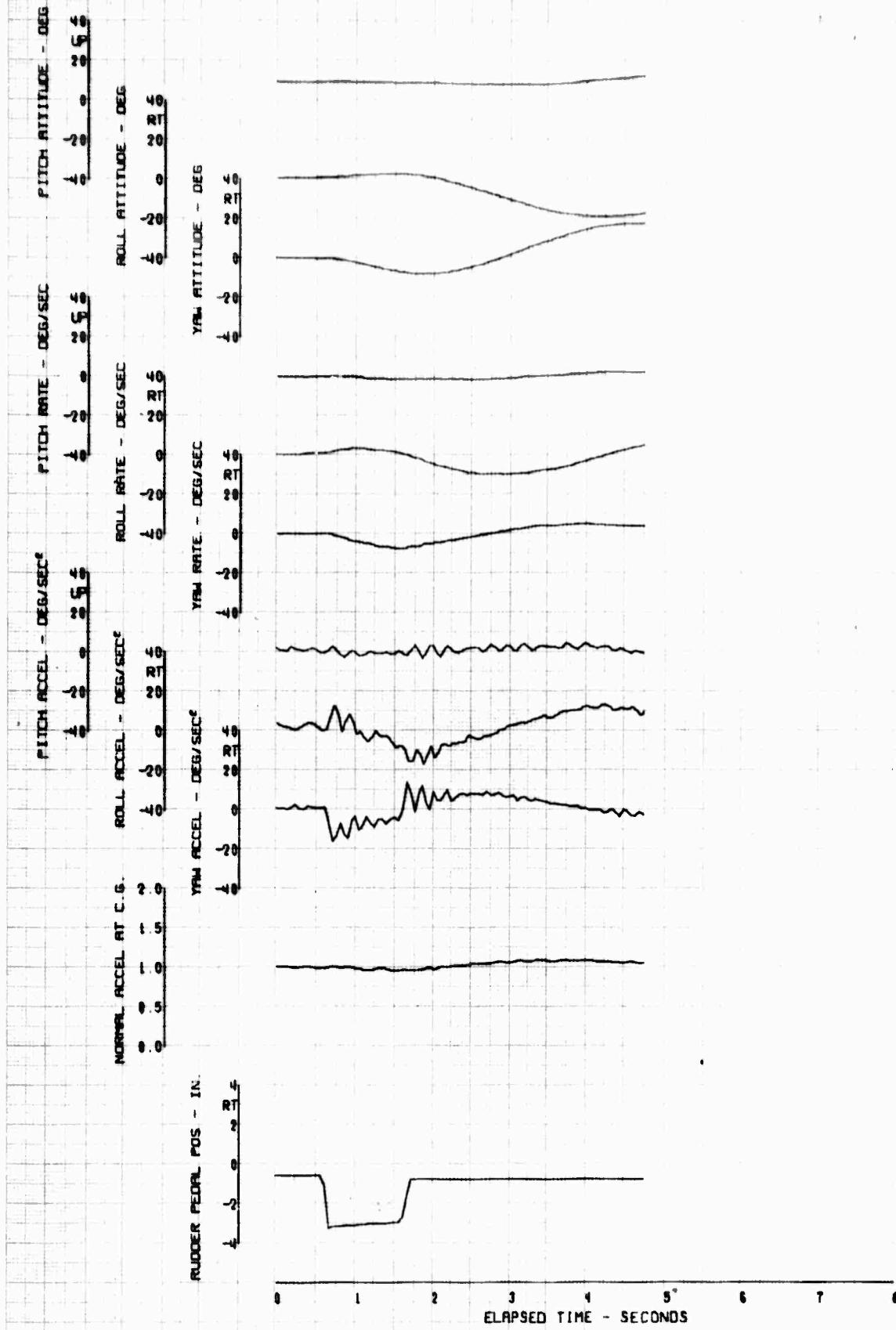


FIGURE 79. REACTION TO A LEFT DIRECTIONAL PULSE

FLIGHT AVG GW AVG CG AVG ALT ROTO SPEED
 COND (LBS) (IN) (FT) (DEG C) (RPM)
 LF 113KCRS 41000 328 7000 -18 0 185
 USAF 67-14993
 RFCS COND
 ON

EXTERNAL TANKS FULL

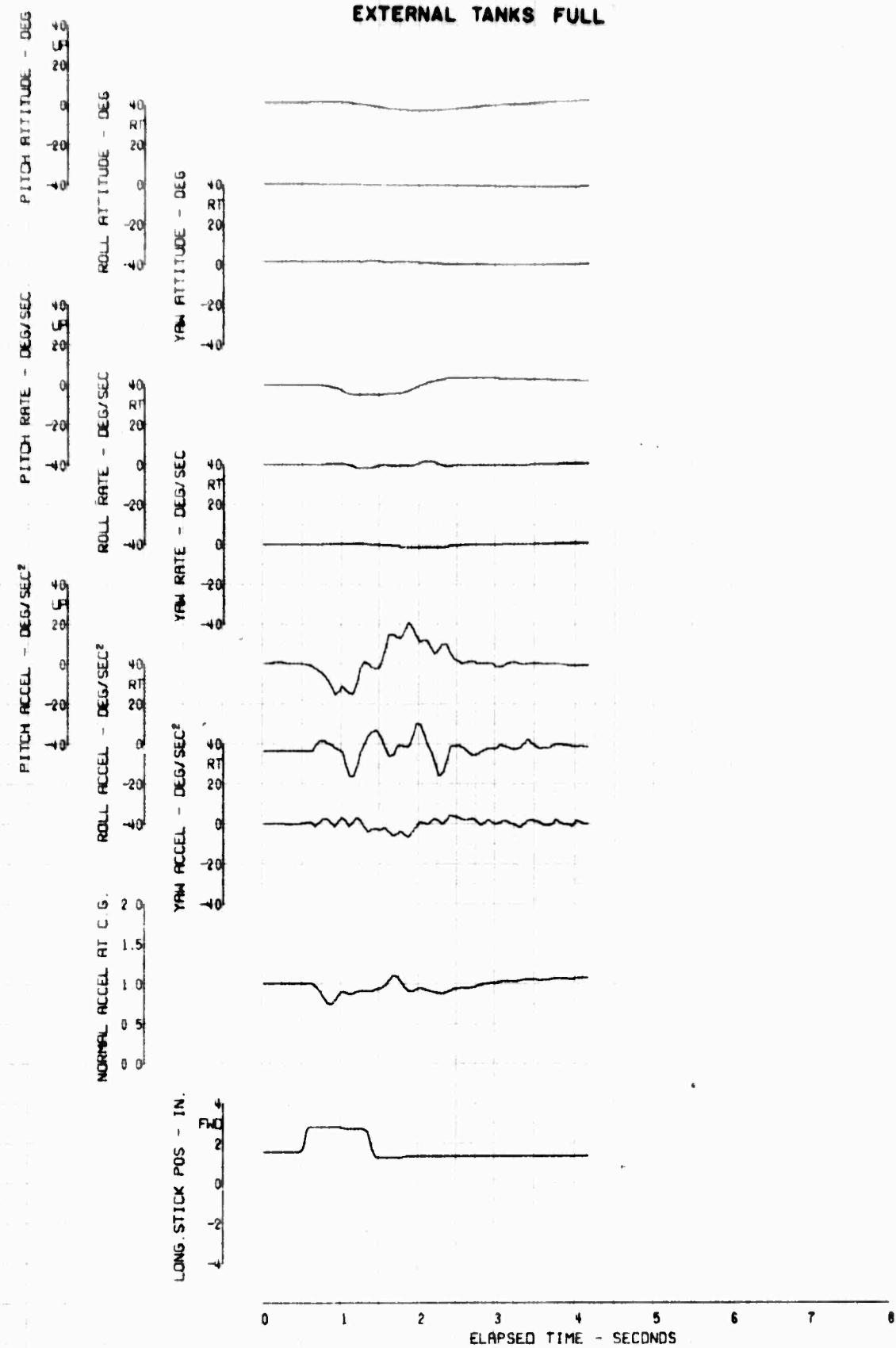


FIGURE 80. REACTION TO A FORWARD LONGITUDINAL PULSE

FLIGHT HH-53C USAF 67-14993
 COND. AVG GW AVG CG AVG ALT AVG FAT ROTOR SPEED AFCS
 LF 113KCRS 41000 (LBS) (IN) (FT) (DEG C) (RPM) COND
 328 7000 -18.0 185 OFF

EXTERNAL TANKS FULL

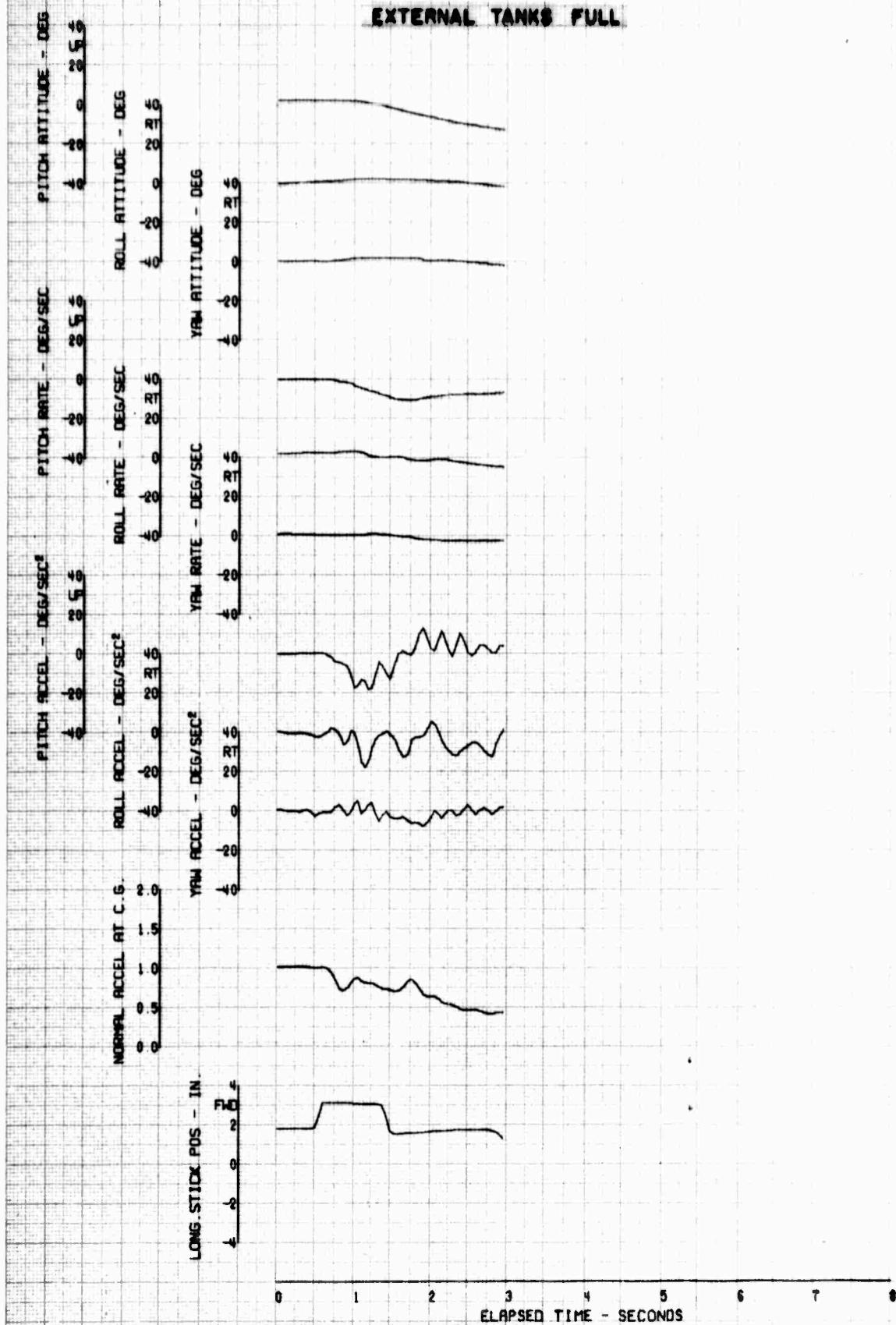


FIGURE 61. REACTION TO A FORWARD LONGITUDINAL PULSE

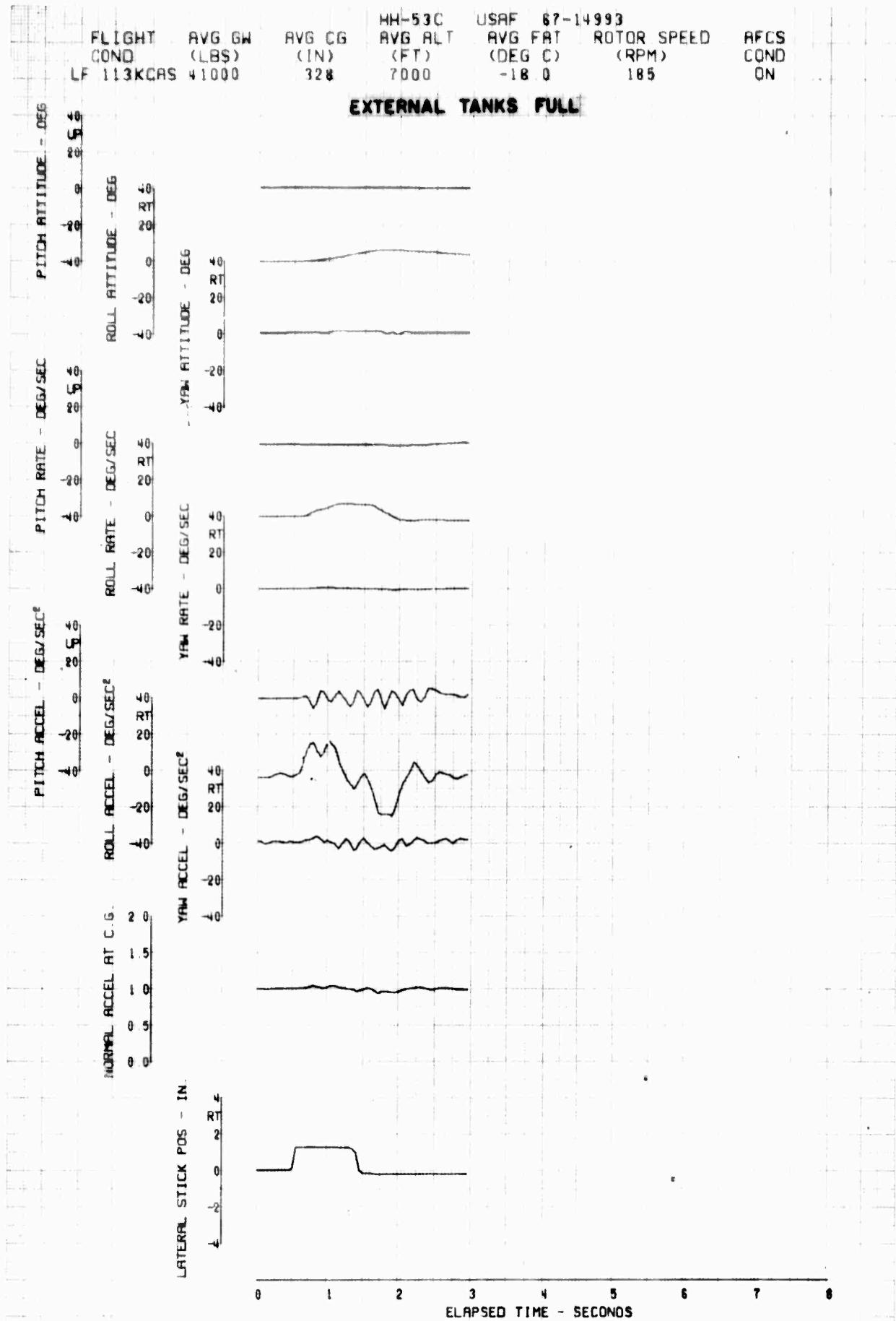


FIGURE 82. REACTION TO A RIGHT LATERAL PULSE

FLIGHT HH-53C USAF 67-14993
 COND COND
 LF 113KCAS AVG GW AVG CG AVG ALT AVG FWT ROTOR SPEED AFCS
 (LBS) (IN) (FT) (DEG C) (RPM) COND
 41000 328 7000 -18.0 185 OFF

EXTERNAL TANKS FULL

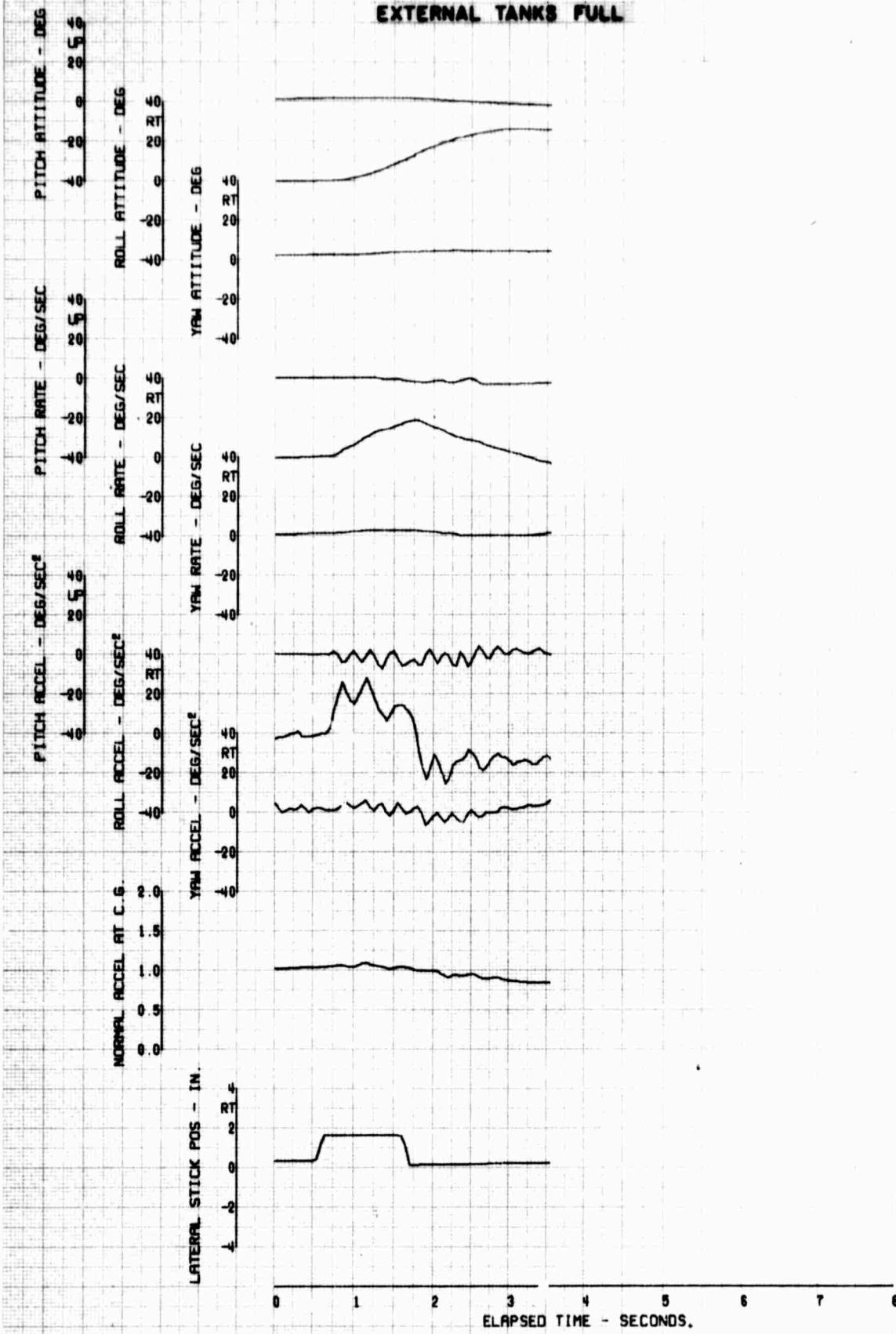


FIGURE 89. REACTION TO A RIGHT LATERAL PULSE

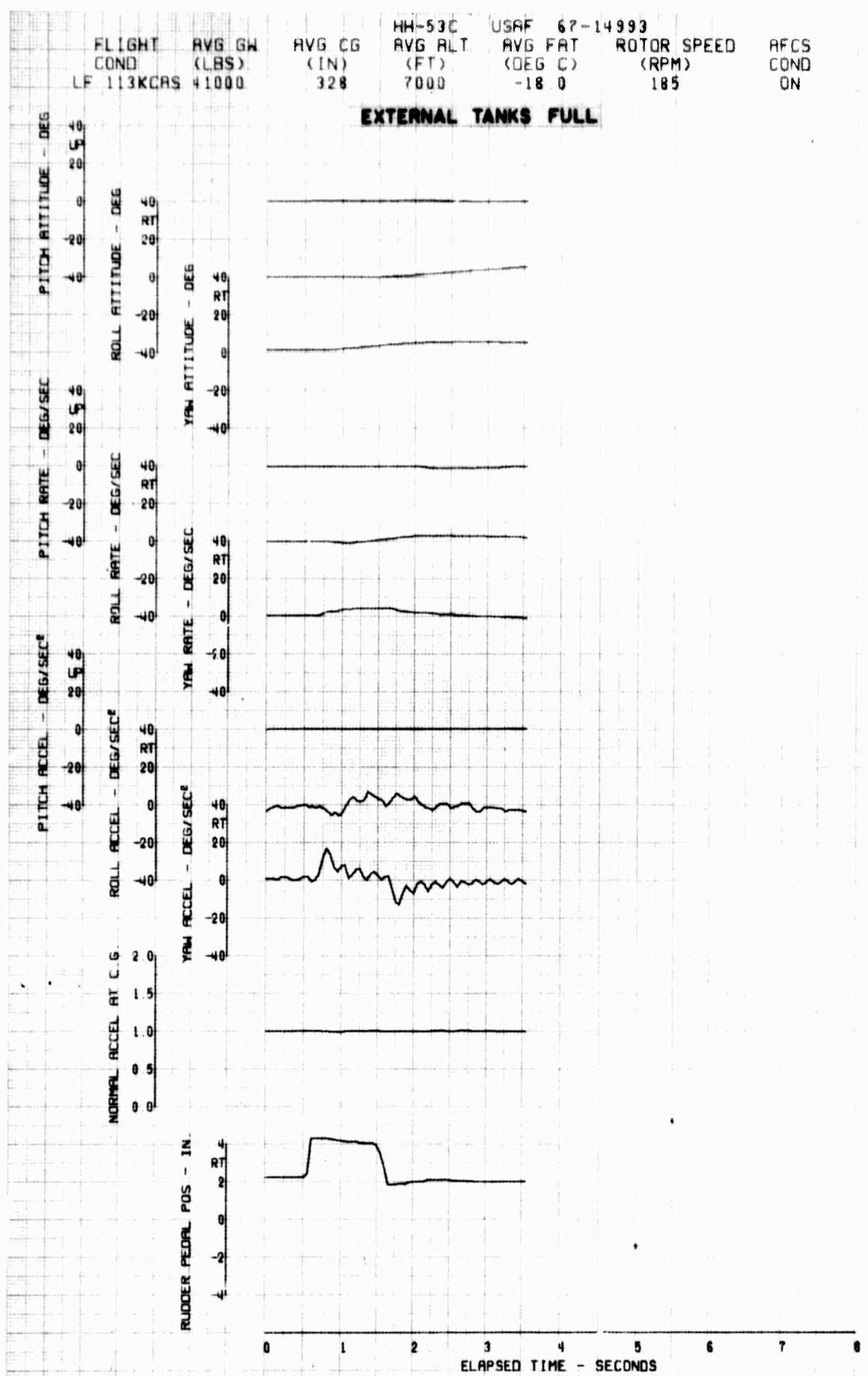


FIGURE 84 REACTION TO A RIGHT DIRECTIONAL PULSE

FLIGHT AVG GW AVG CG HH-53C USAF 67-14993
 COND (LBS) (IN) AVG ALT AVG FAT ROTOR SPEED RFCS
 LF 113KCRS 41000 328 7000 -18 0 185 COND
 OFF

EXTERNAL TANKS FULL

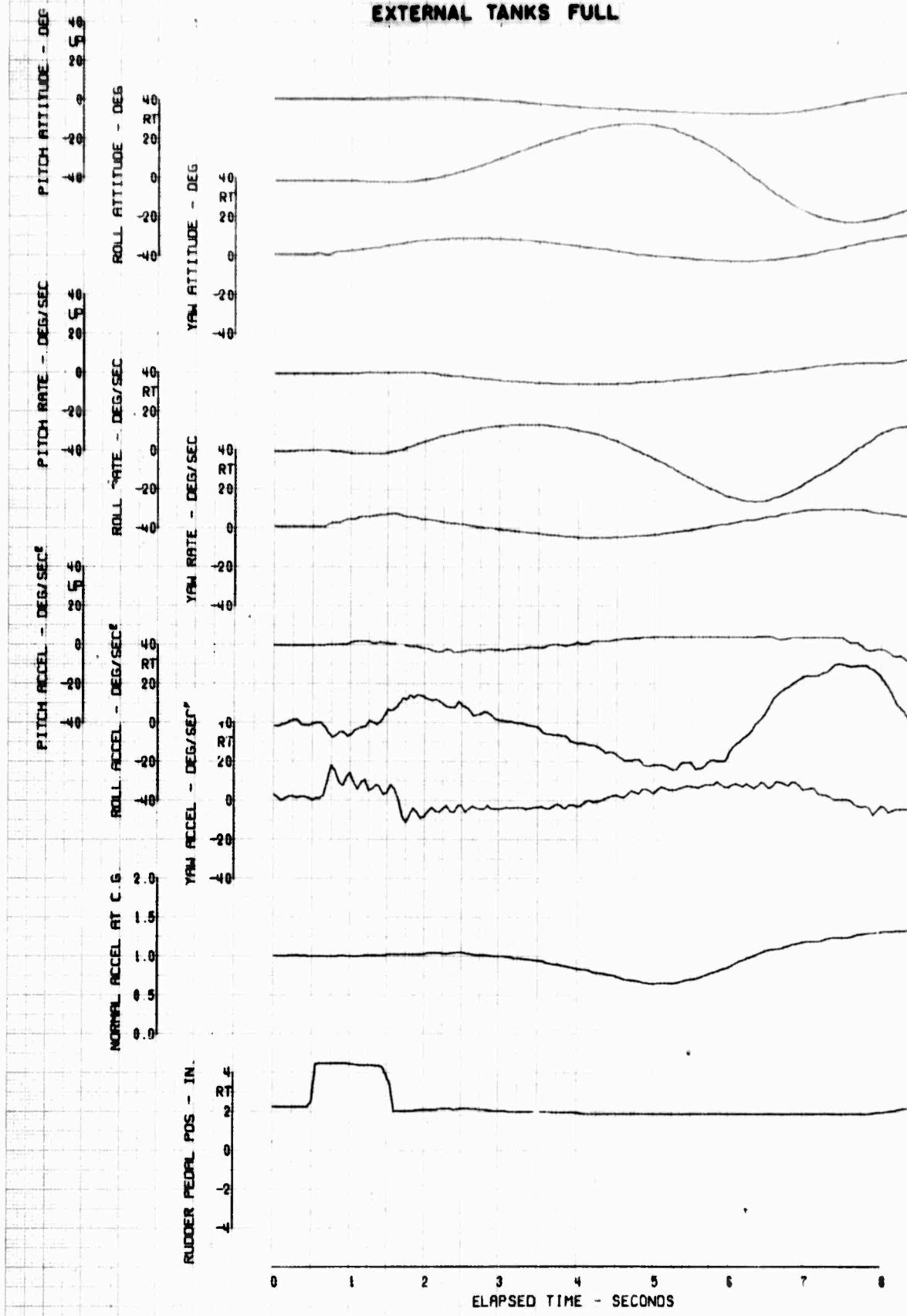


FIGURE 85. REACTION TO A RIGHT DIRECTIONAL PULSE

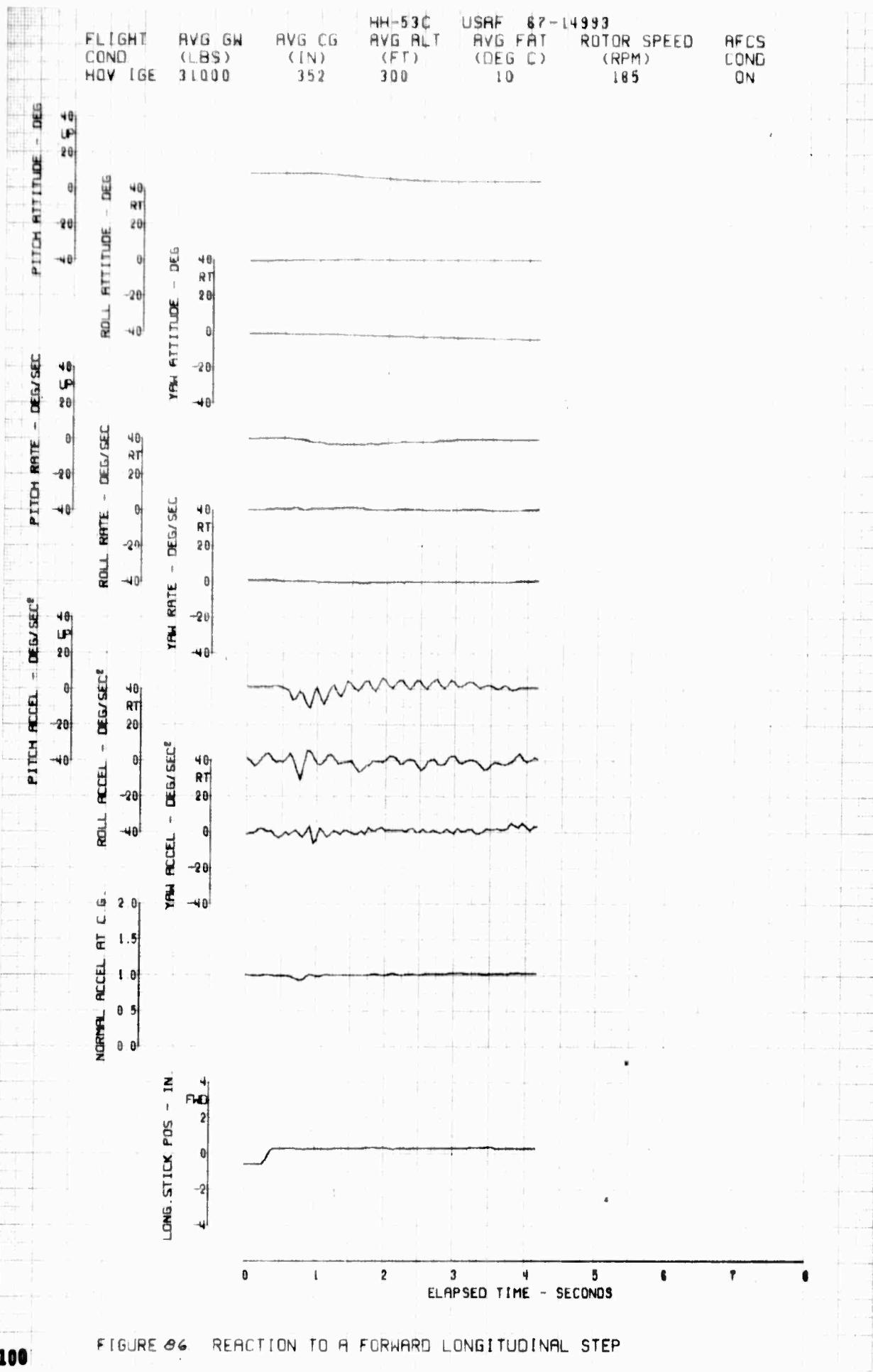


FIGURE 86 REACTION TO A FORWARD LONGITUDINAL STEP

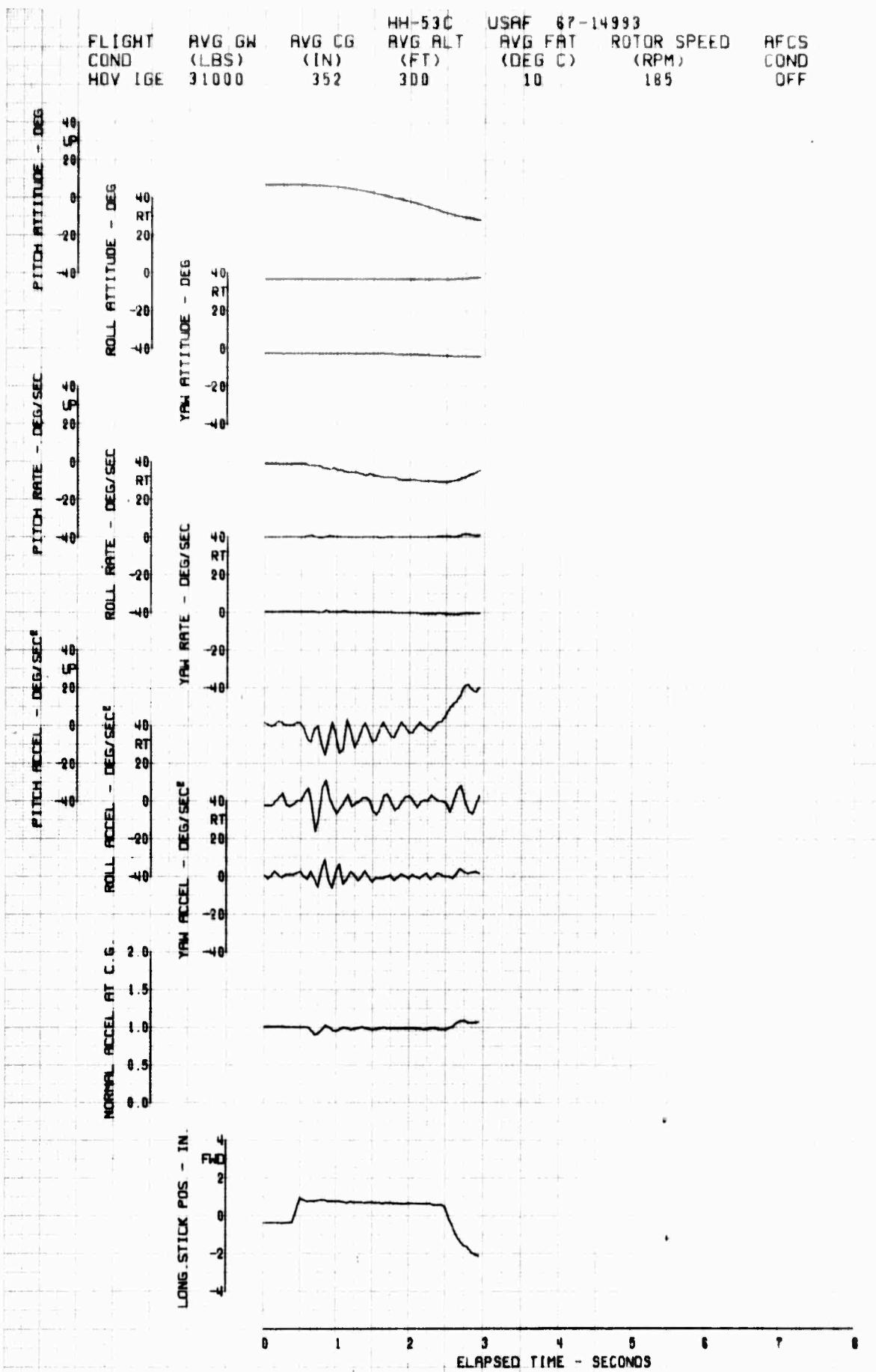
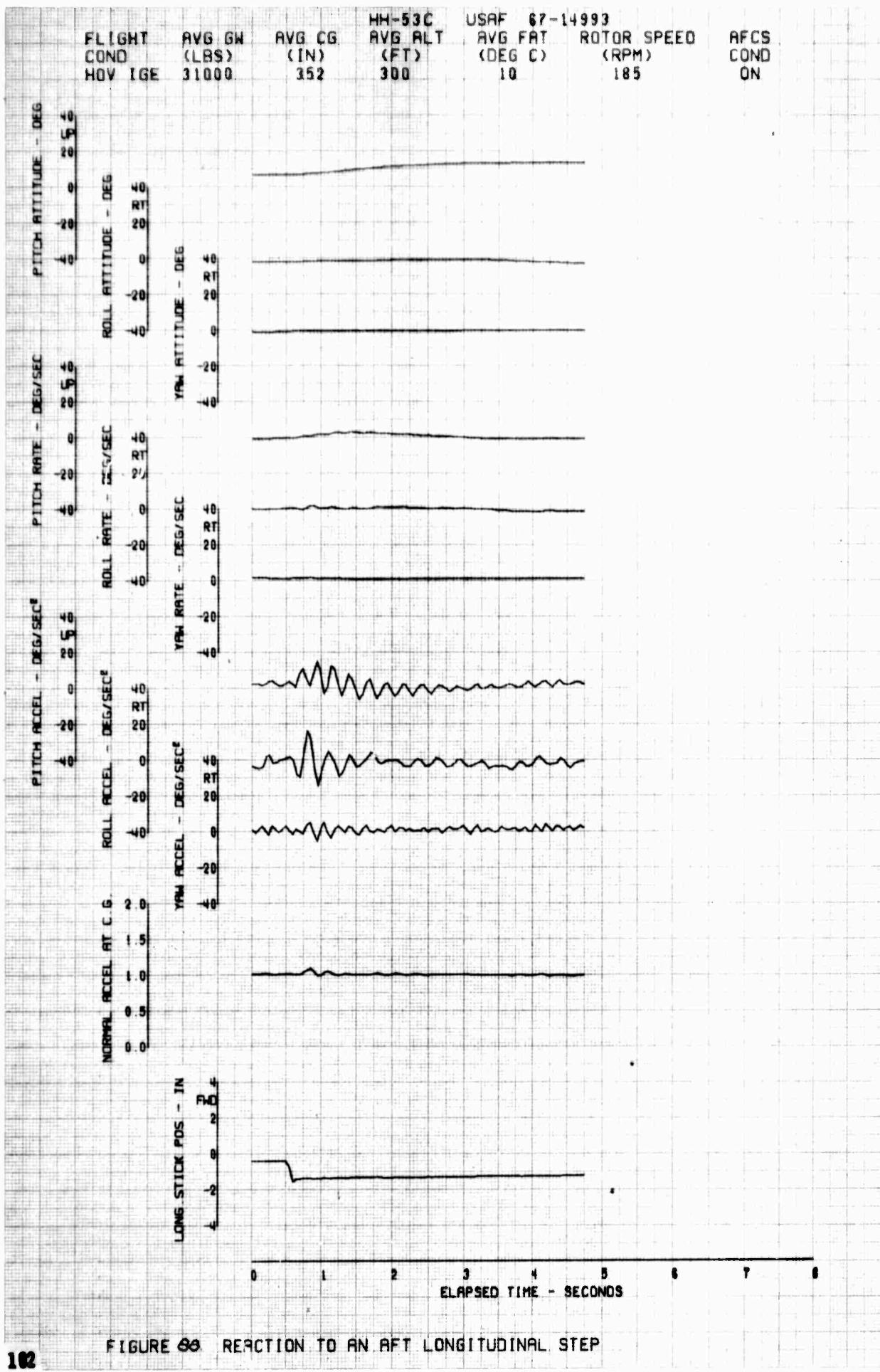


FIGURE 67. REACTION TO A FORWARD LONGITUDINAL STEP



102

FIGURE 98 REACTION TO AN AFT LONGITUDINAL STEP

FLIGHT HH-53C USAF 67-14993
 COND (LBS) AVG CG AVG ALT AVG FWT ROTOR SPEED RFCS
 HOV LGE 31000 352 300 10 (RPM) COND
 OFF

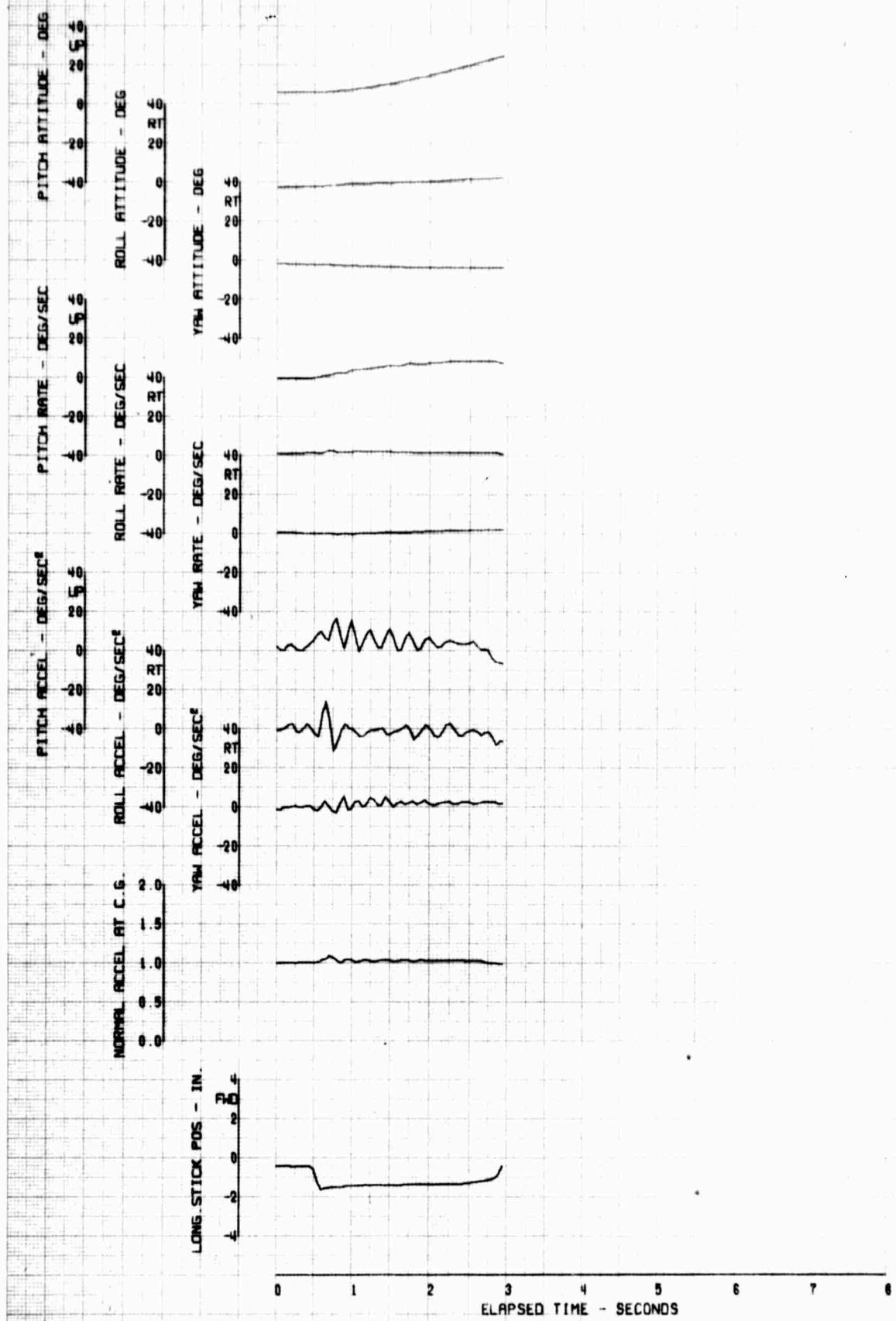


FIGURE 89. REACTION TO AN AFT LONGITUDINAL STEP

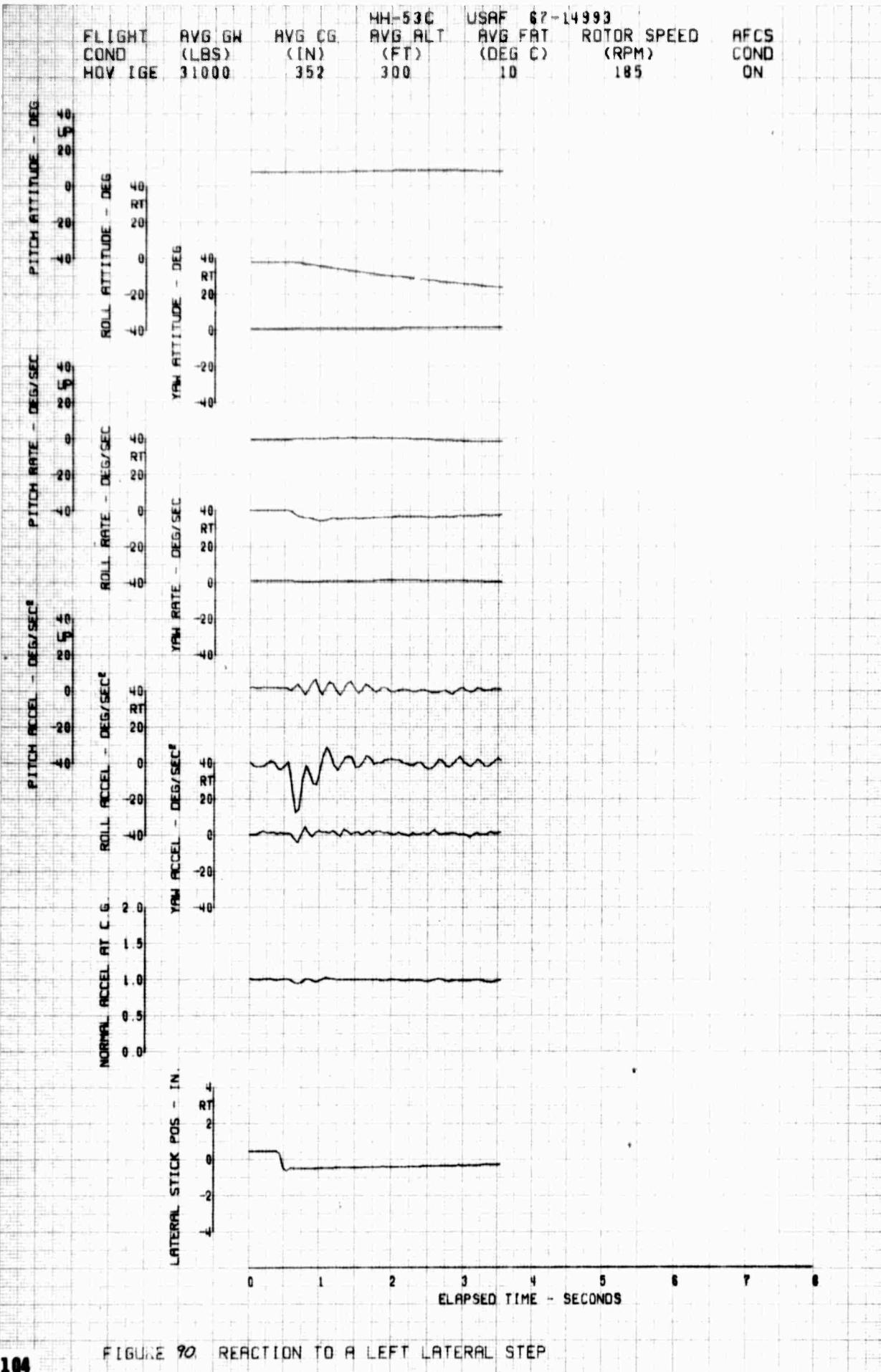


FIGURE 90 REACTION TO A LEFT LATERAL STEP

FLIGHT HH-53C USAF 67-14993
 COND COND
 HOV LGE 31000 AVG GW 352 AVG CG 300 AVG ALT 10 AVG FAT 185 ROTOR SPEED RPM
 AFCS COND OFF

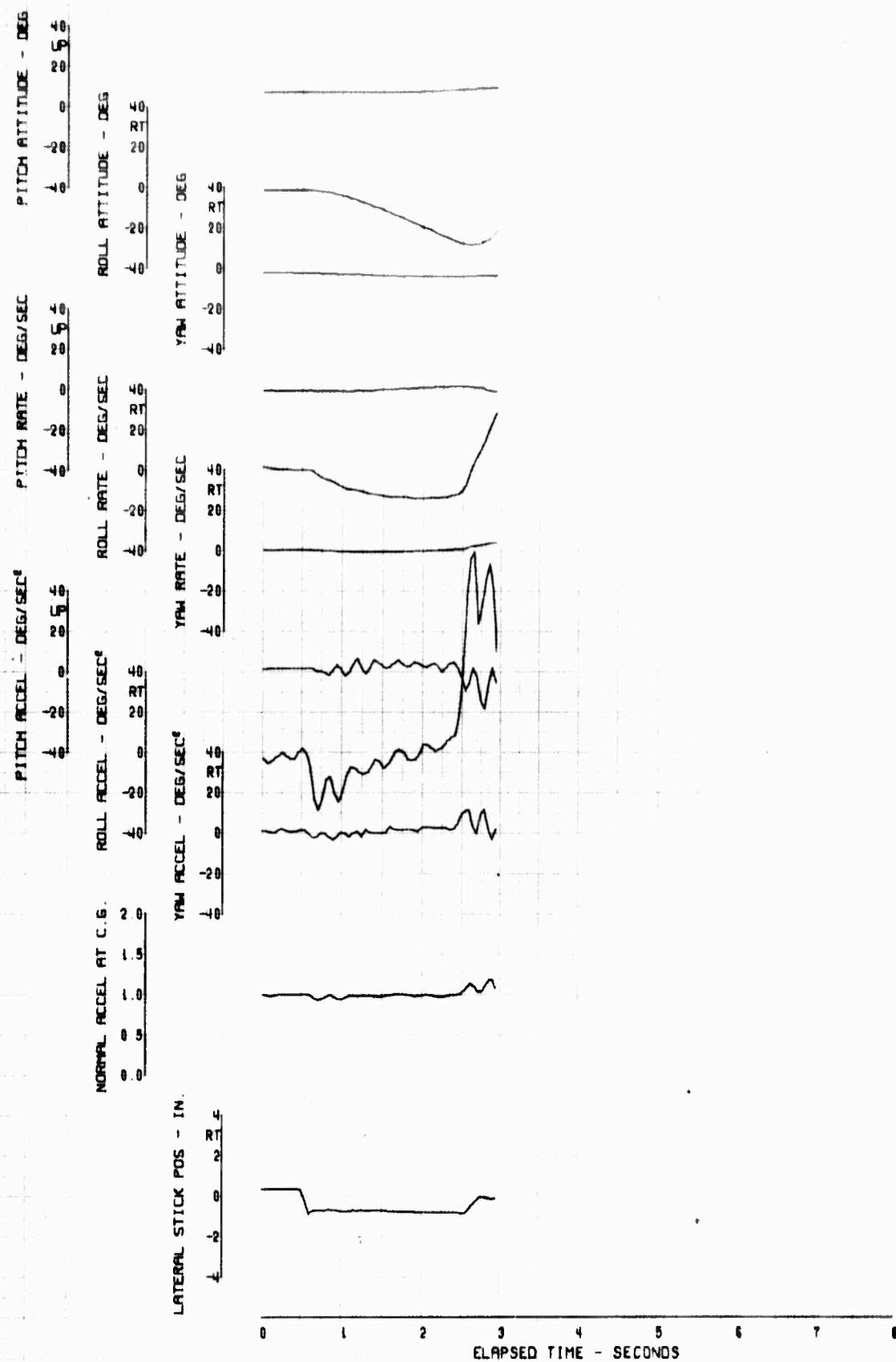
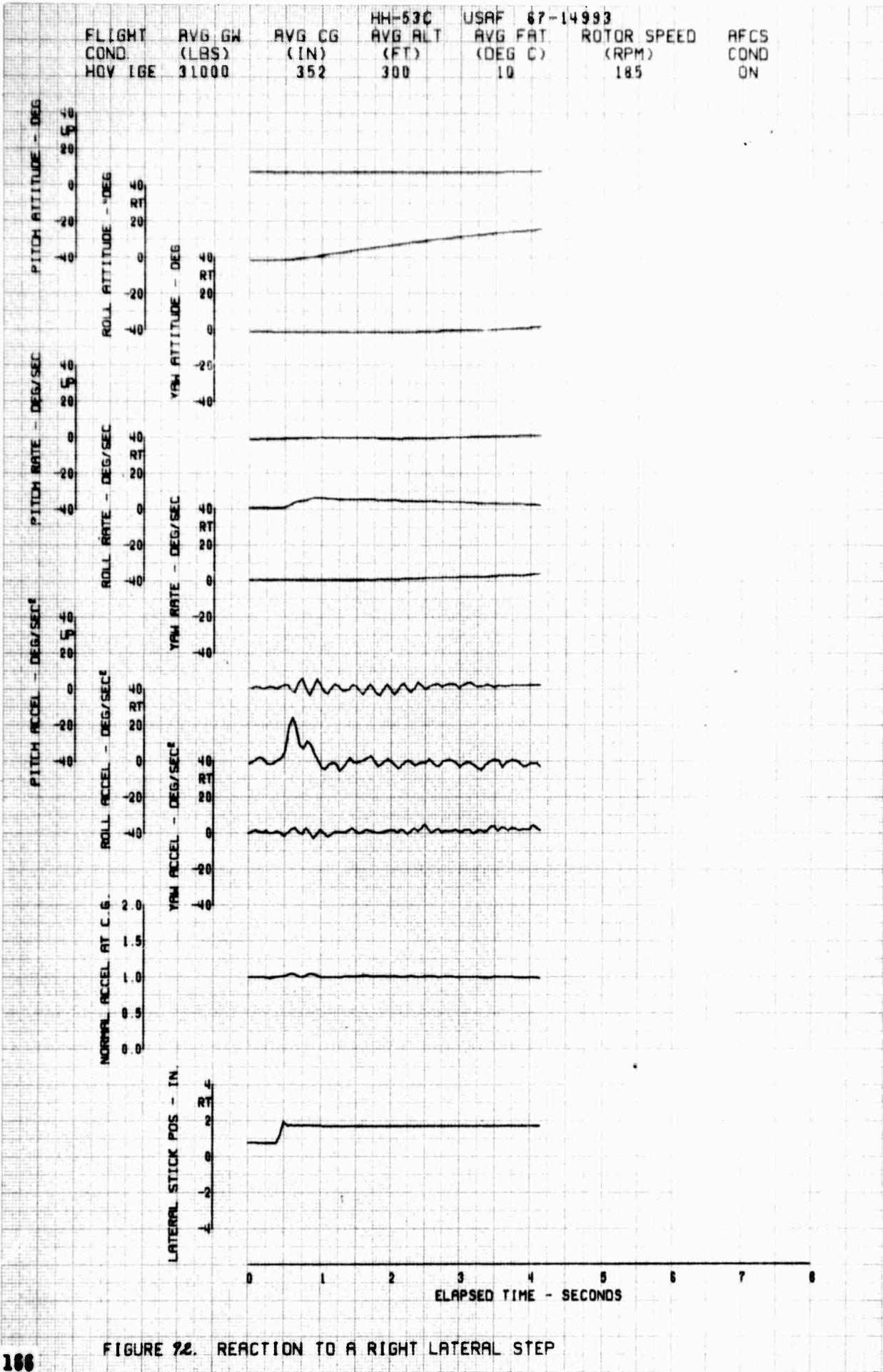


FIGURE 9/ REACTION TO A LEFT LATERAL STEP



100 FIGURE 92. REACTION TO A RIGHT LATERAL STEP

FLIGHT HH-53C USAF 67-14993
 COND (LBS) AVG CG AVG ALT AVG FAT ROTOR SPEED RFCS
 HOV IGE 31000 (IN) (FT) (DEG C) (RPM) COND
 352 300 10 185 OFF

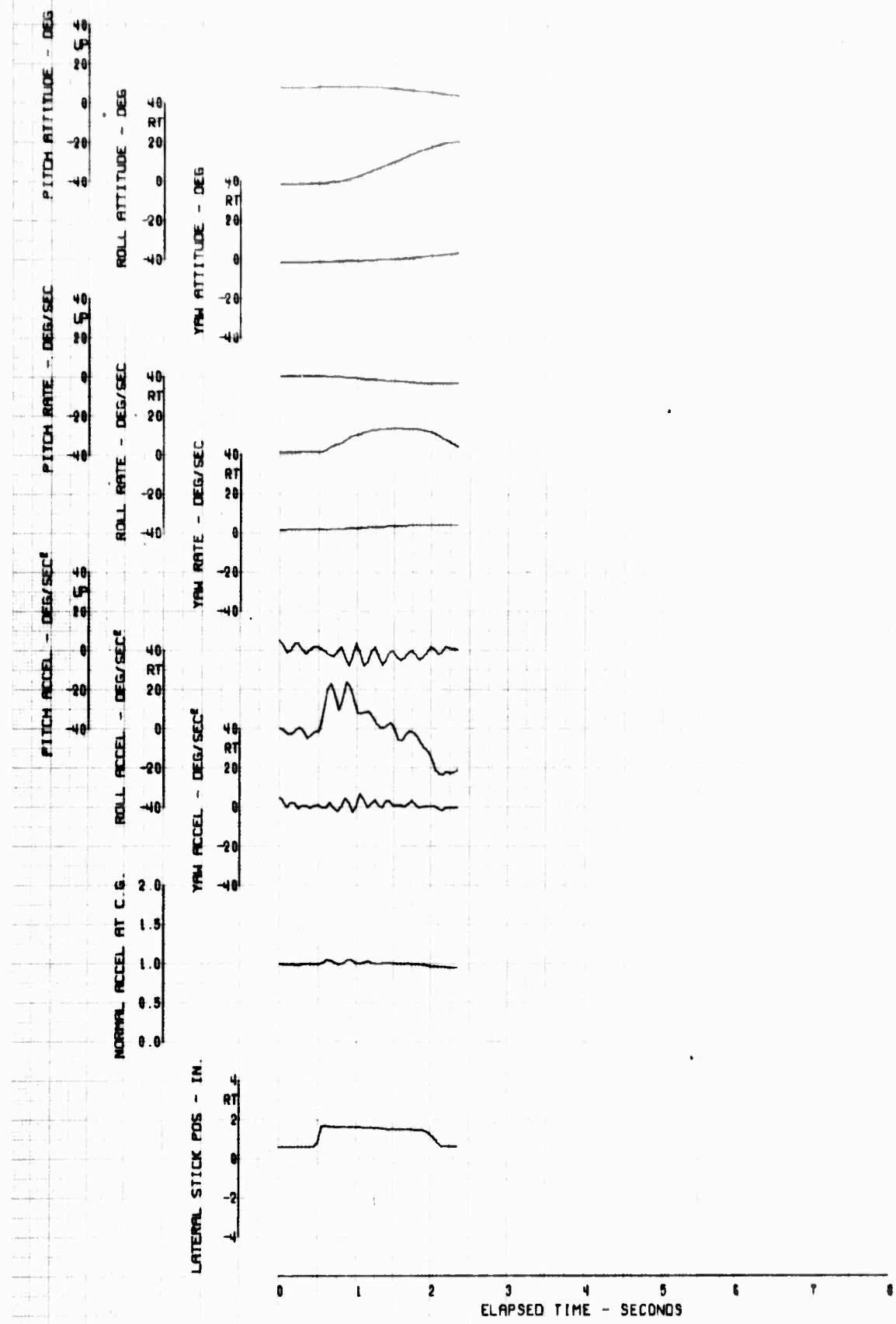


FIGURE 93. REACTION TO A RIGHT LATERAL STEP

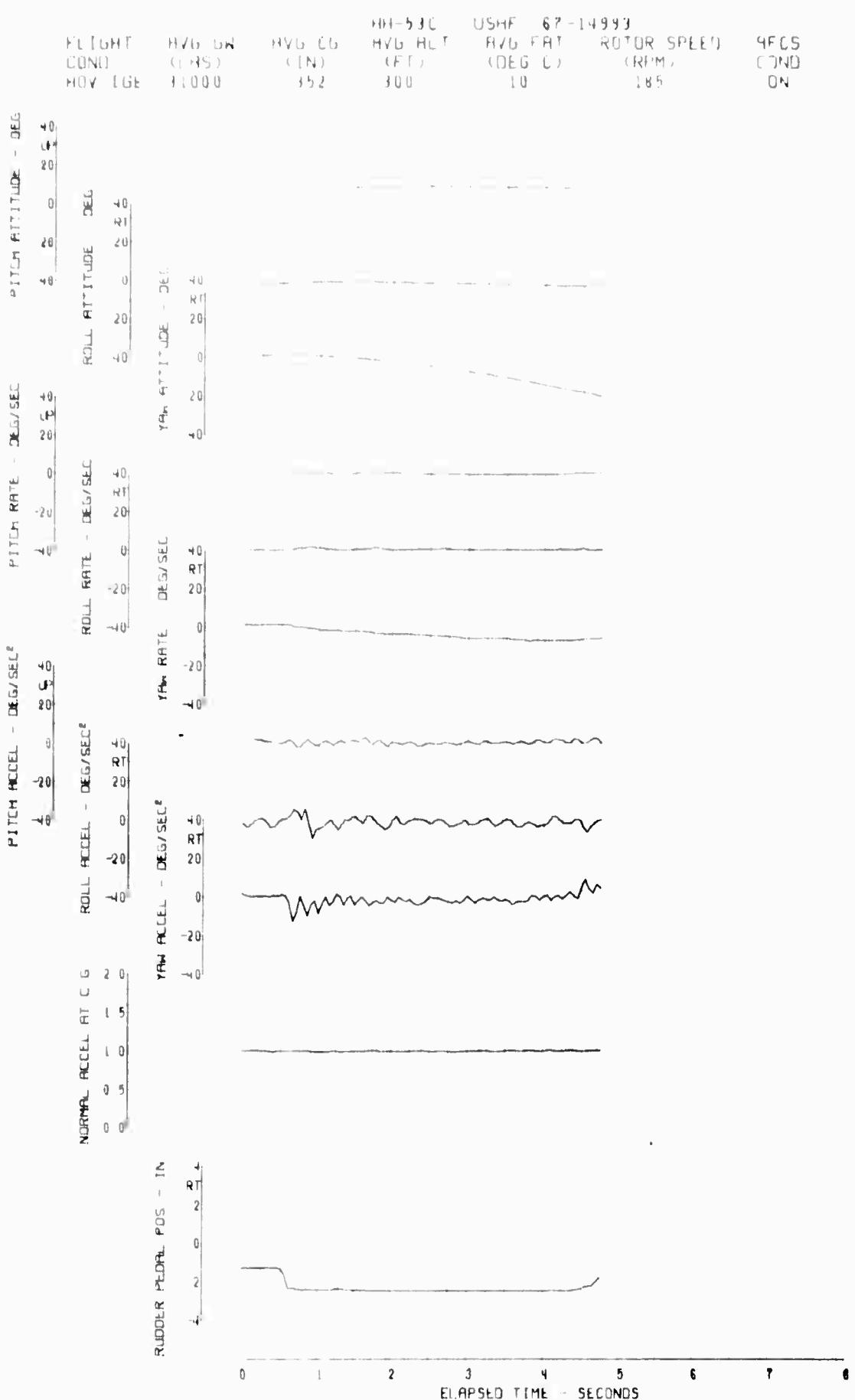


FIGURE 94 REACTION TO A LEFT DIRECTIONAL STEP

FLIGHT HH-53C USAF 67-14993
 COND. OF TESTS
 HOV IGE
 AVG GW (LBS) 31000
 AVG CG (IN) 352
 AVG ALT (FT) 300
 AVG FAT (DEG C) 10
 ROTOR SPEED (RPM) 185
 RFCS COND.
 OFF

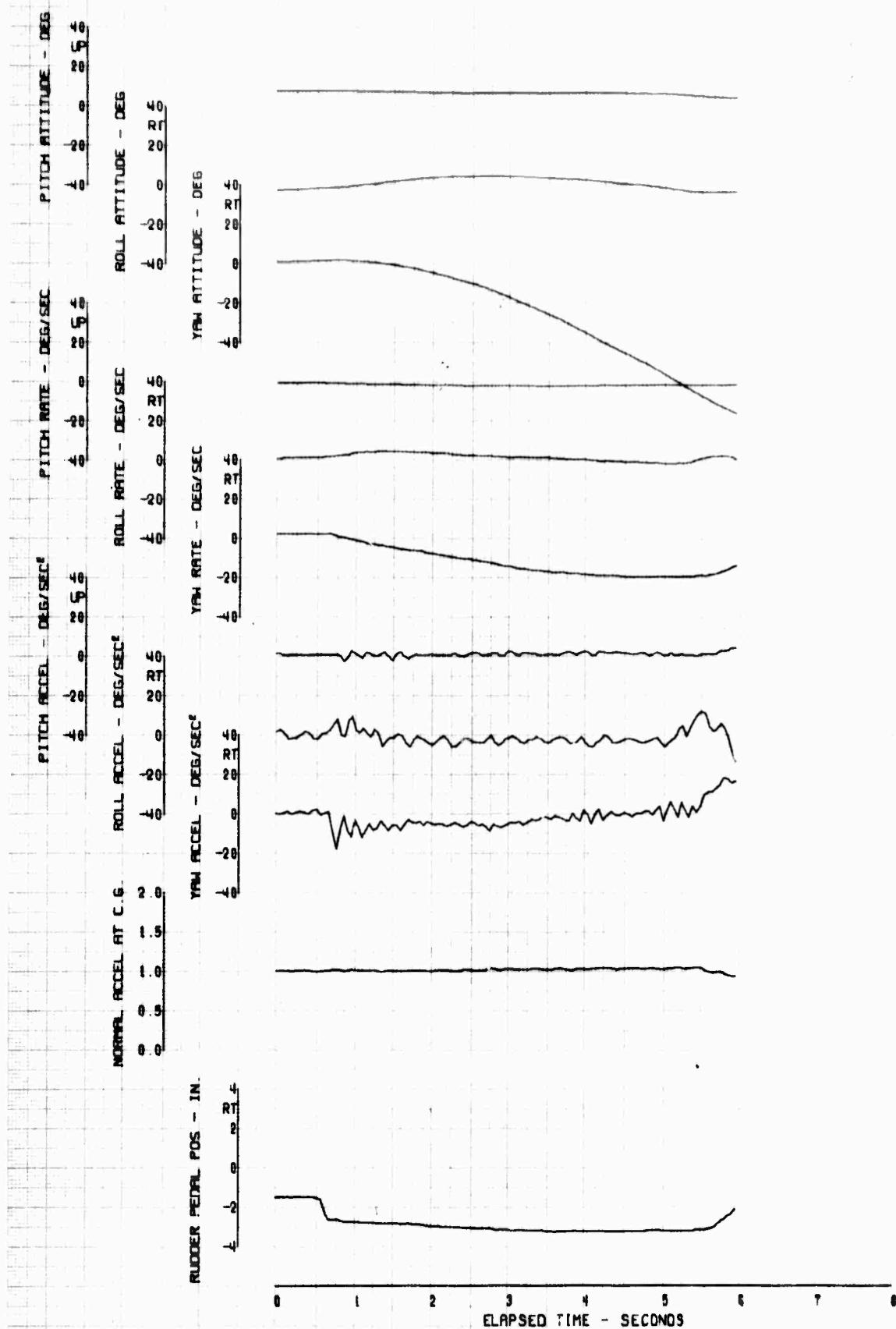


FIGURE 95. REACTION TO A LEFT DIRECTIONAL STEP

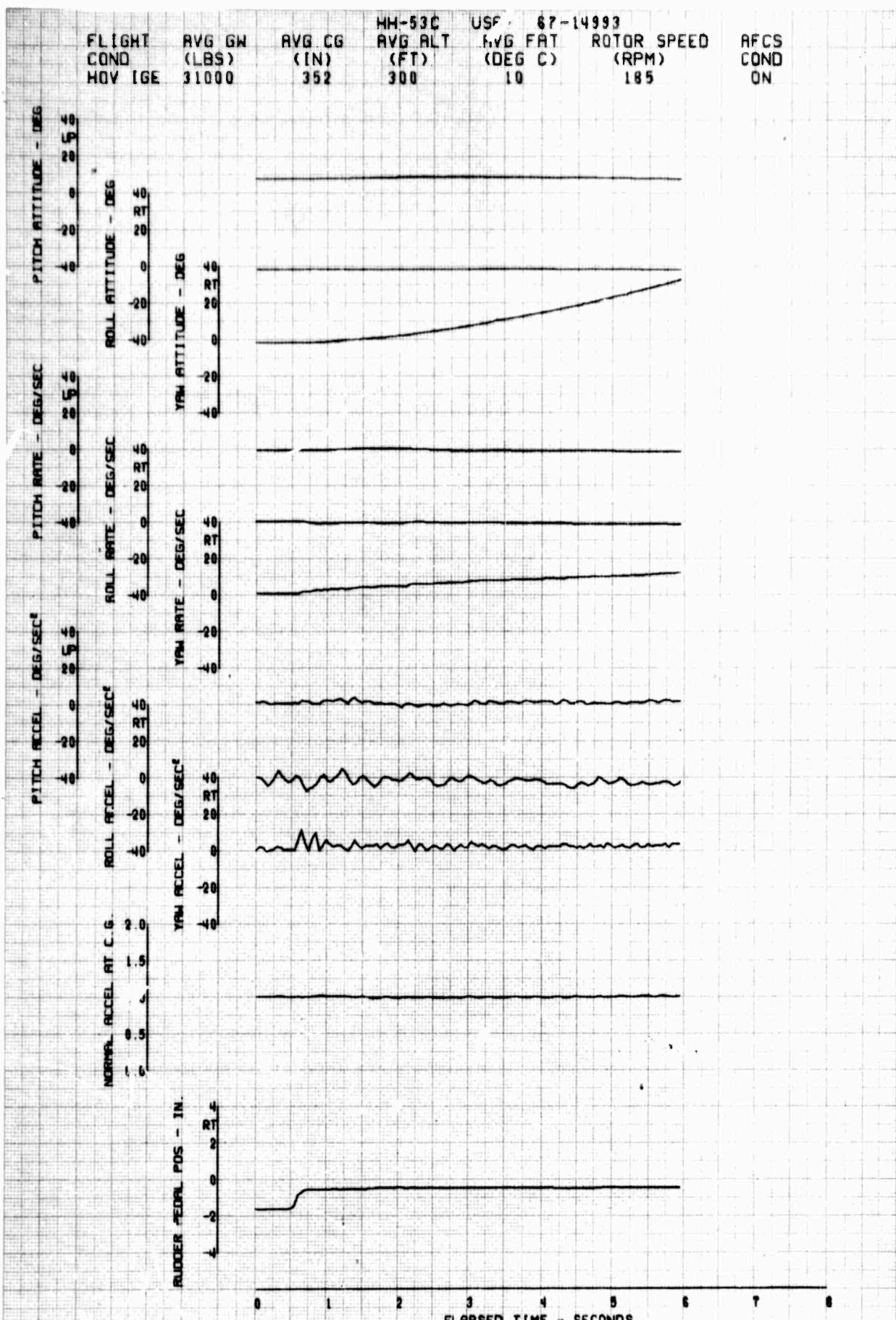


FIGURE 96. REACTION TO A RIGHT DIRECTIONAL STEP

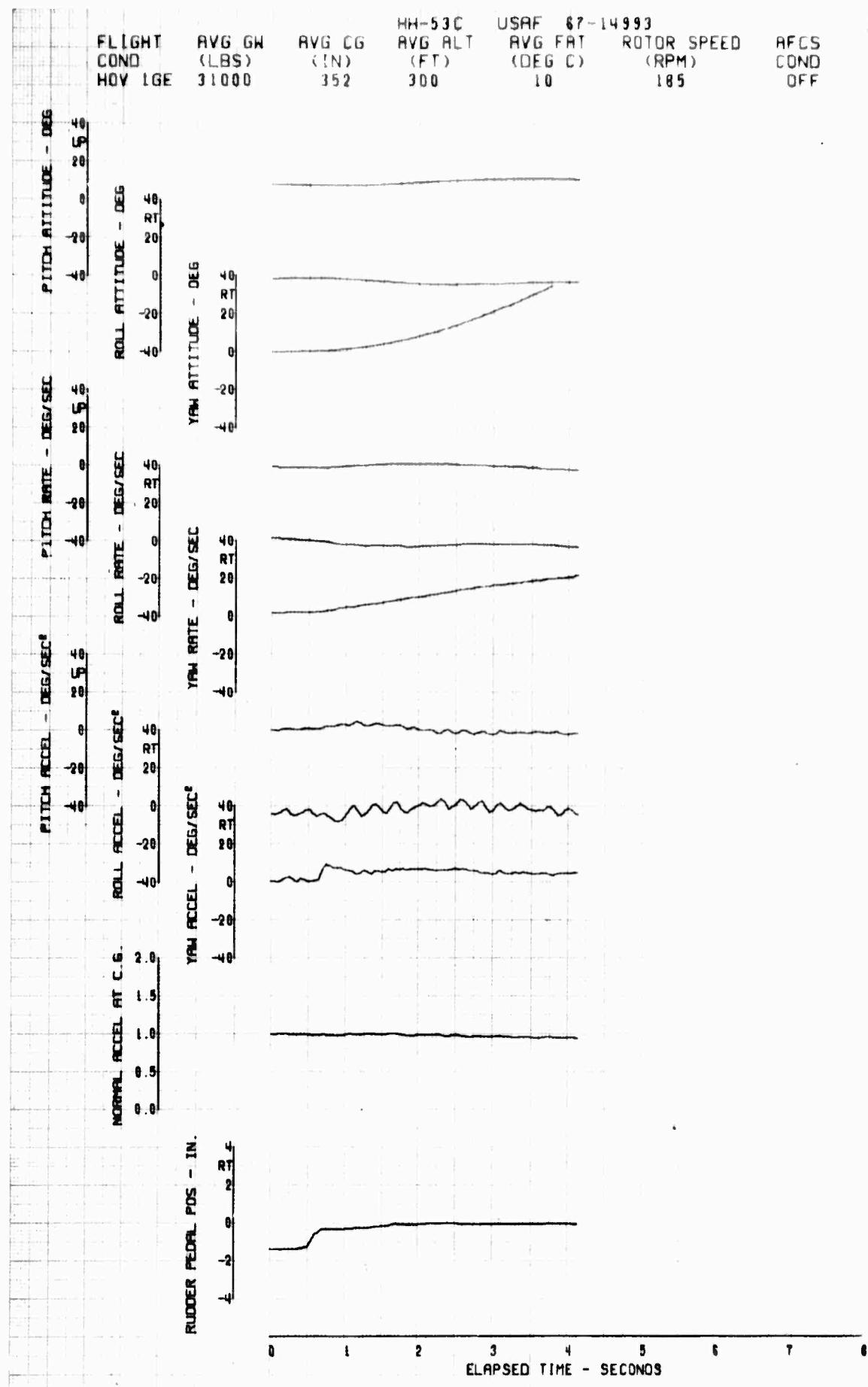
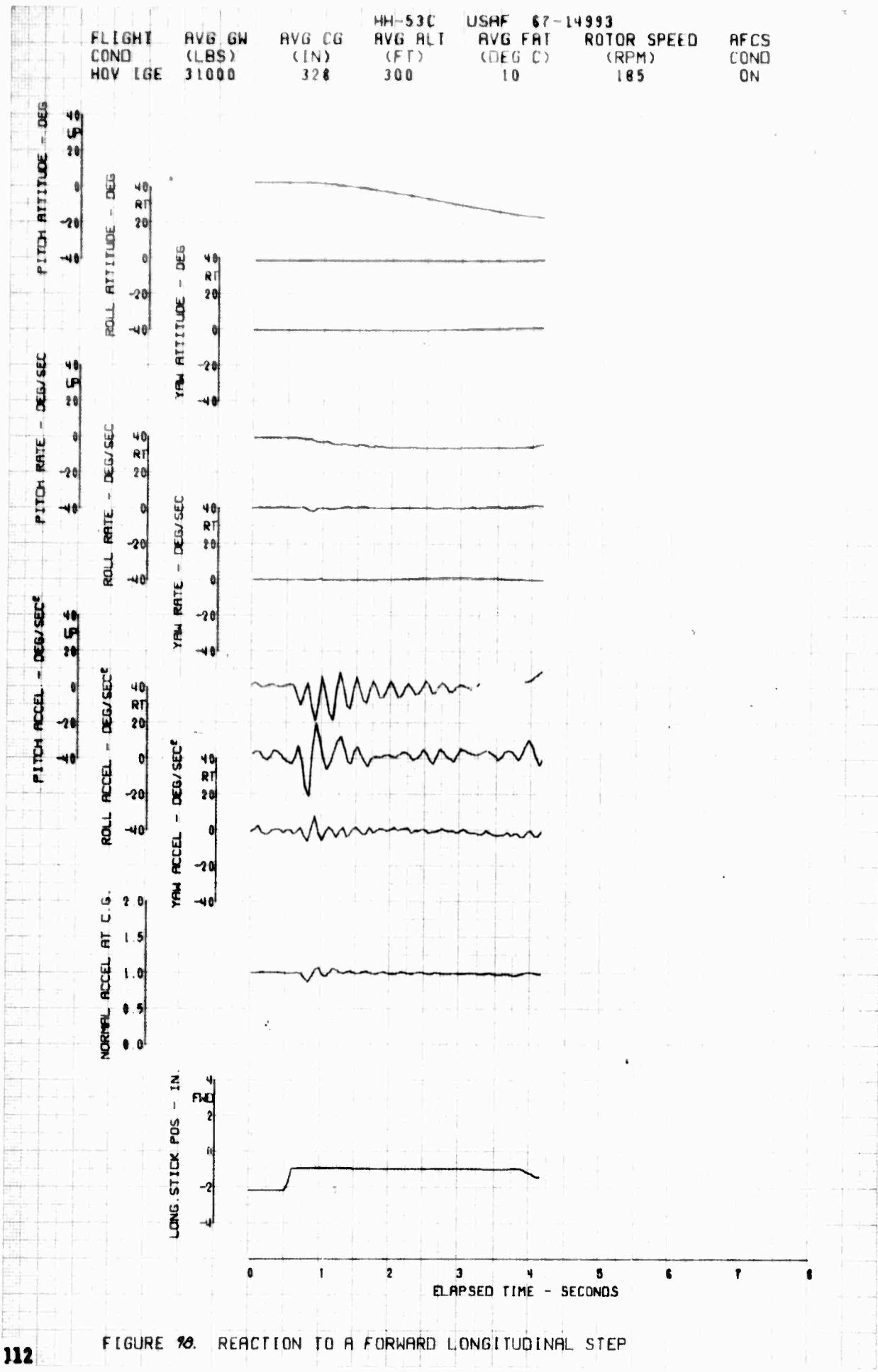


FIGURE 97 REACTION TO A RIGHT DIRECTIONAL STEP



112

FIGURE 10. REACTION TO A FORWARD LONGITUDINAL STEP

FLIGHT HH-53C USAF 67-14993
 COND COND
 HOV IGE 31000 328 300 10 185
 (LBS) (IN) (FT) (DEG C) (RPM)
 RFCS COND
 OFF

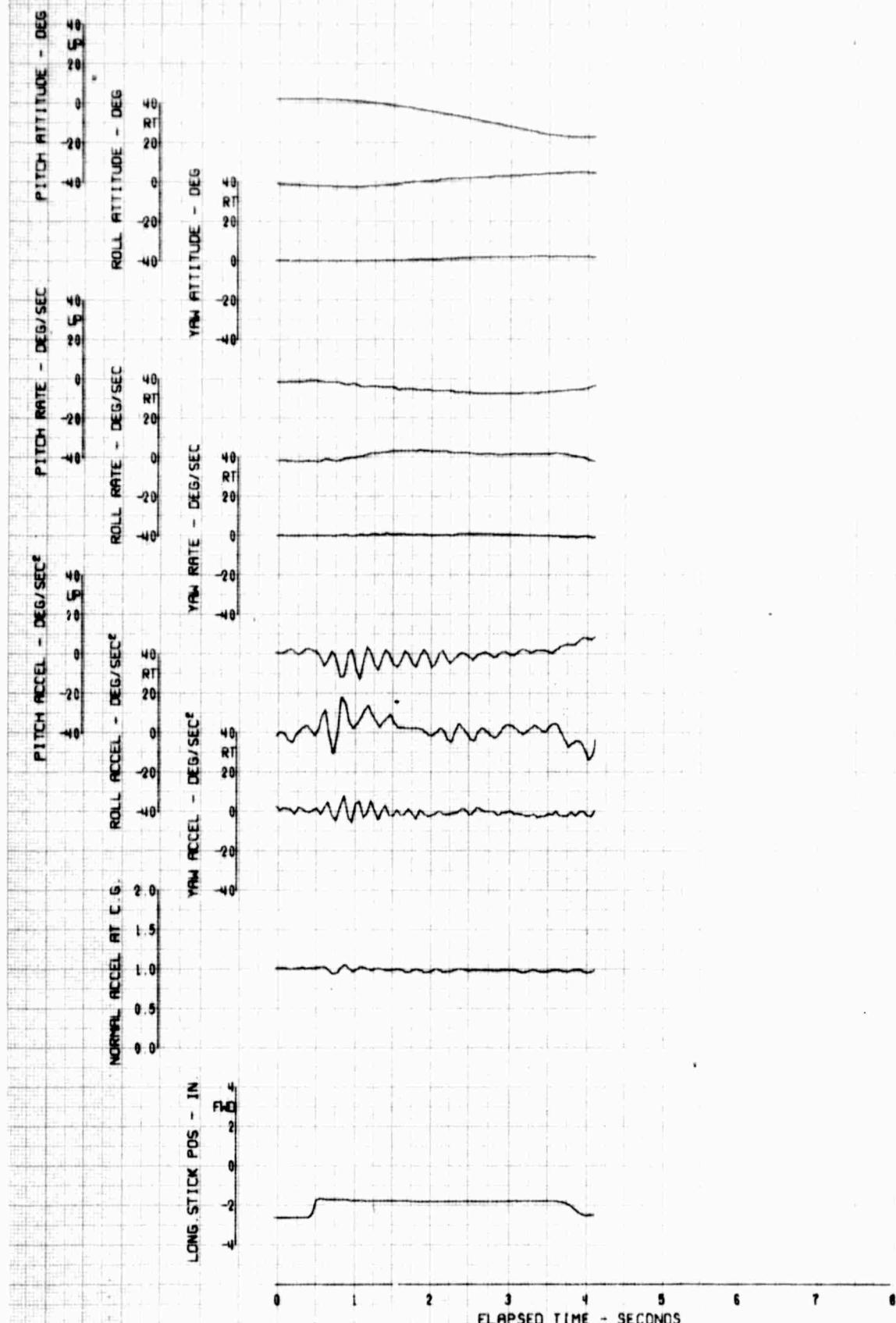


FIGURE 99 REACTION TO A FORWARD LONGITUDINAL STEP

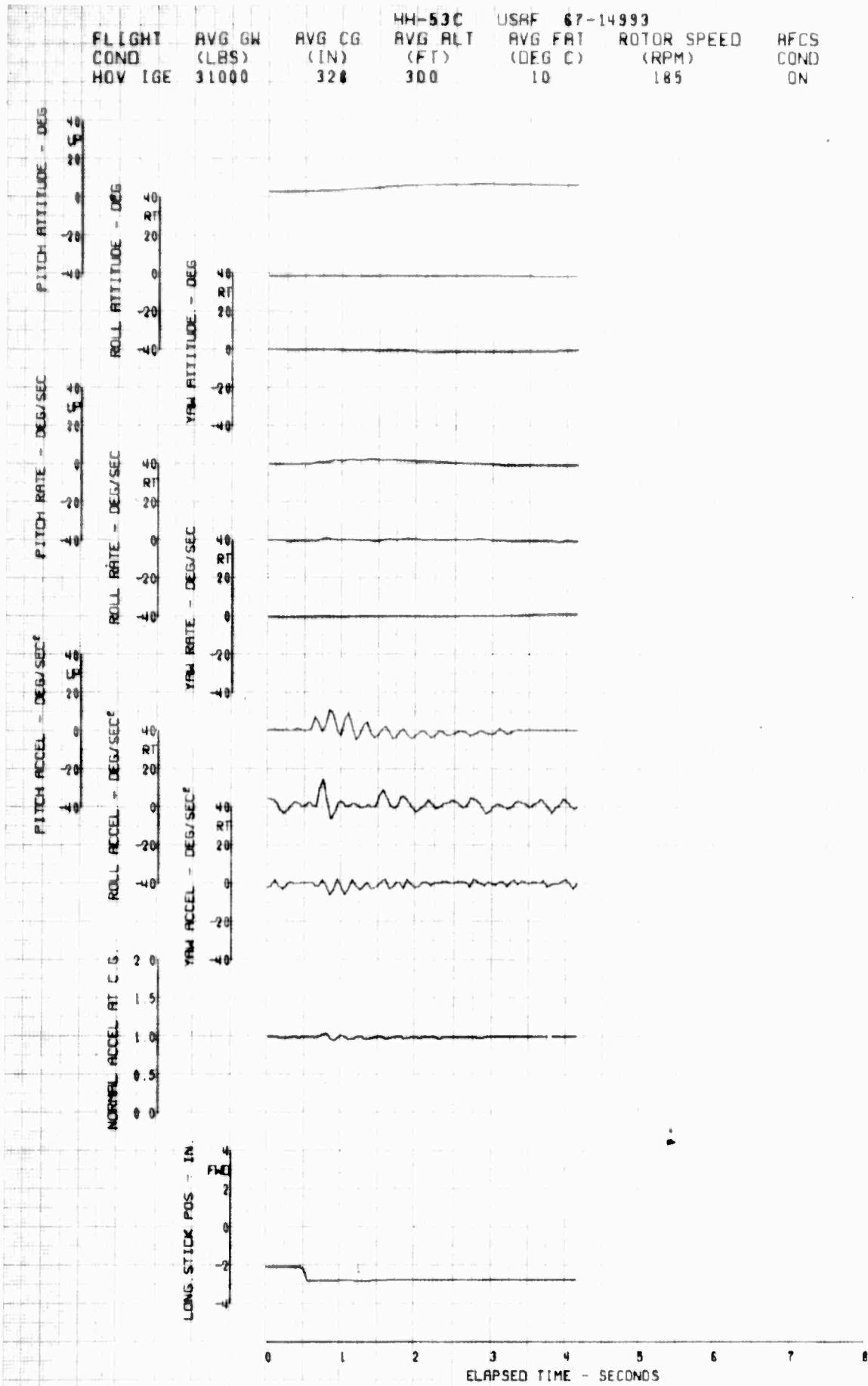


FIGURE 100 REACTION TO AN AFT LONGITUDINAL STEP

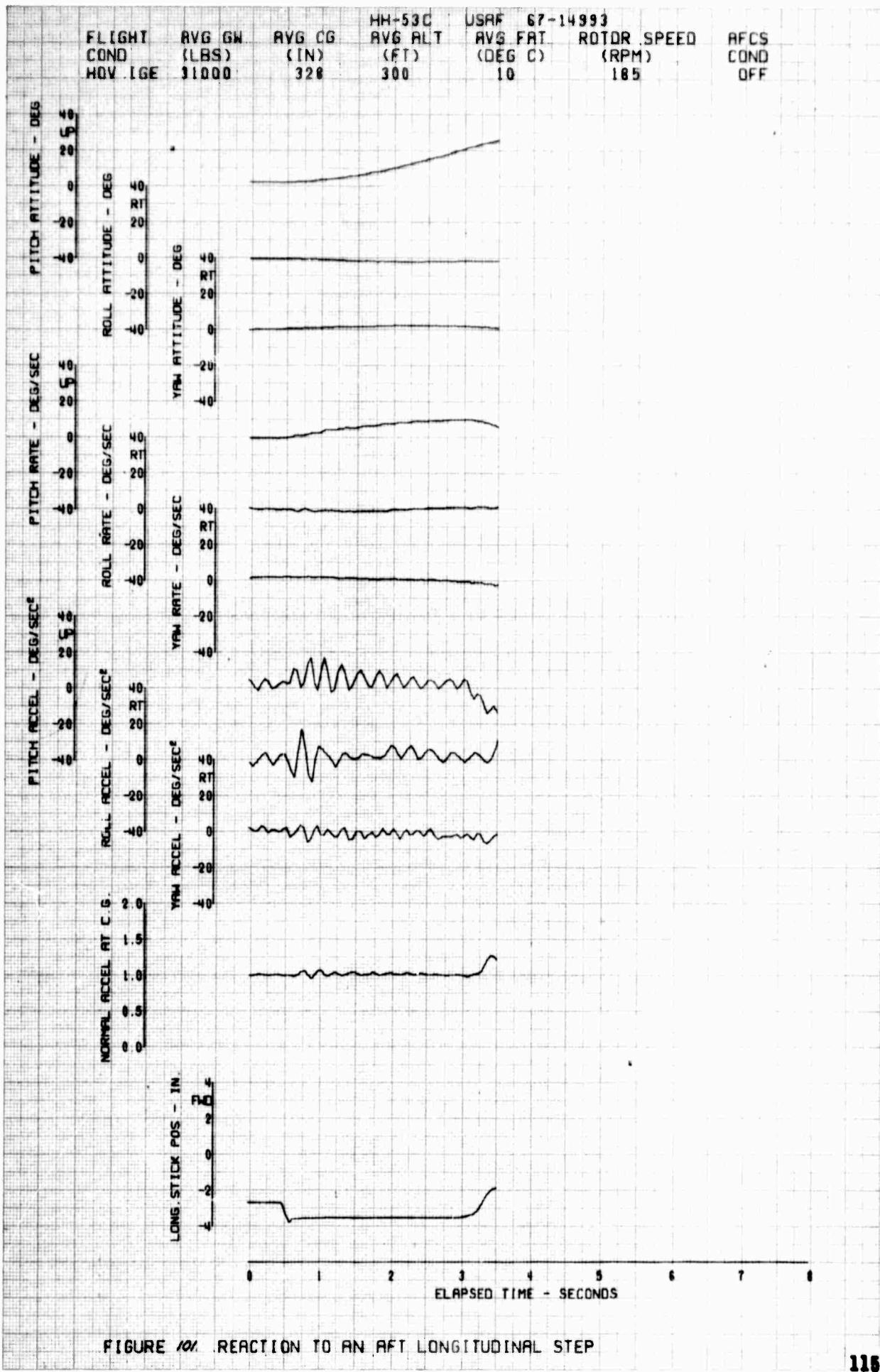


FIGURE 101. REACTION TO AN AFT LONGITUDINAL STEP

FLIGHT COND: HOV IGE AVG GW (LBS): 31000 AVG CG (IN): 328 HH-53C USAF 67-14993
 AVG ALT (FT): 300 AVG FRT (DEG C): 10 ROTOR SPEED (RPM): 185 RFCS COND: ON

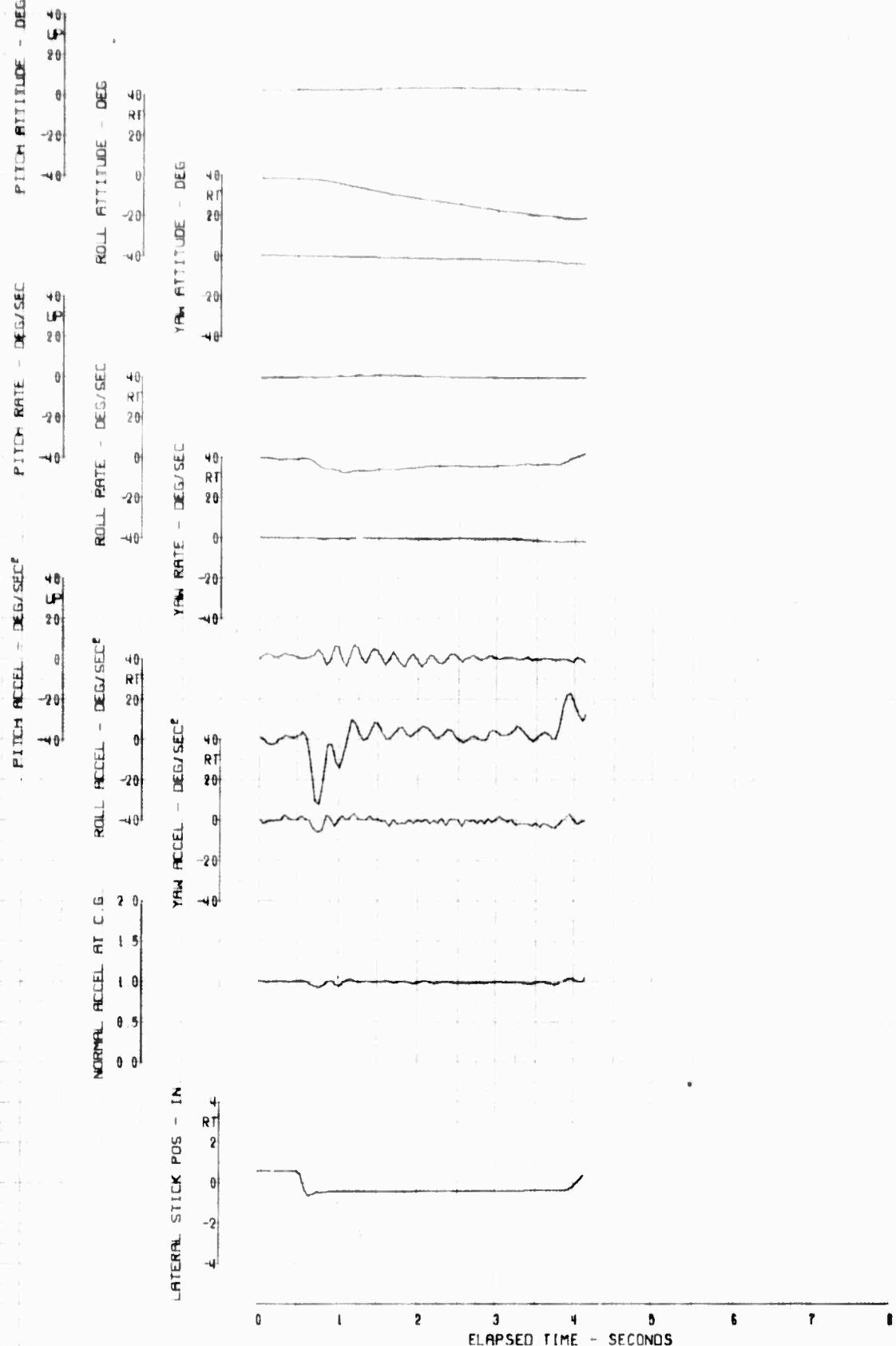


FIGURE 102 REACTION TO A LEFT LATERAL STEP

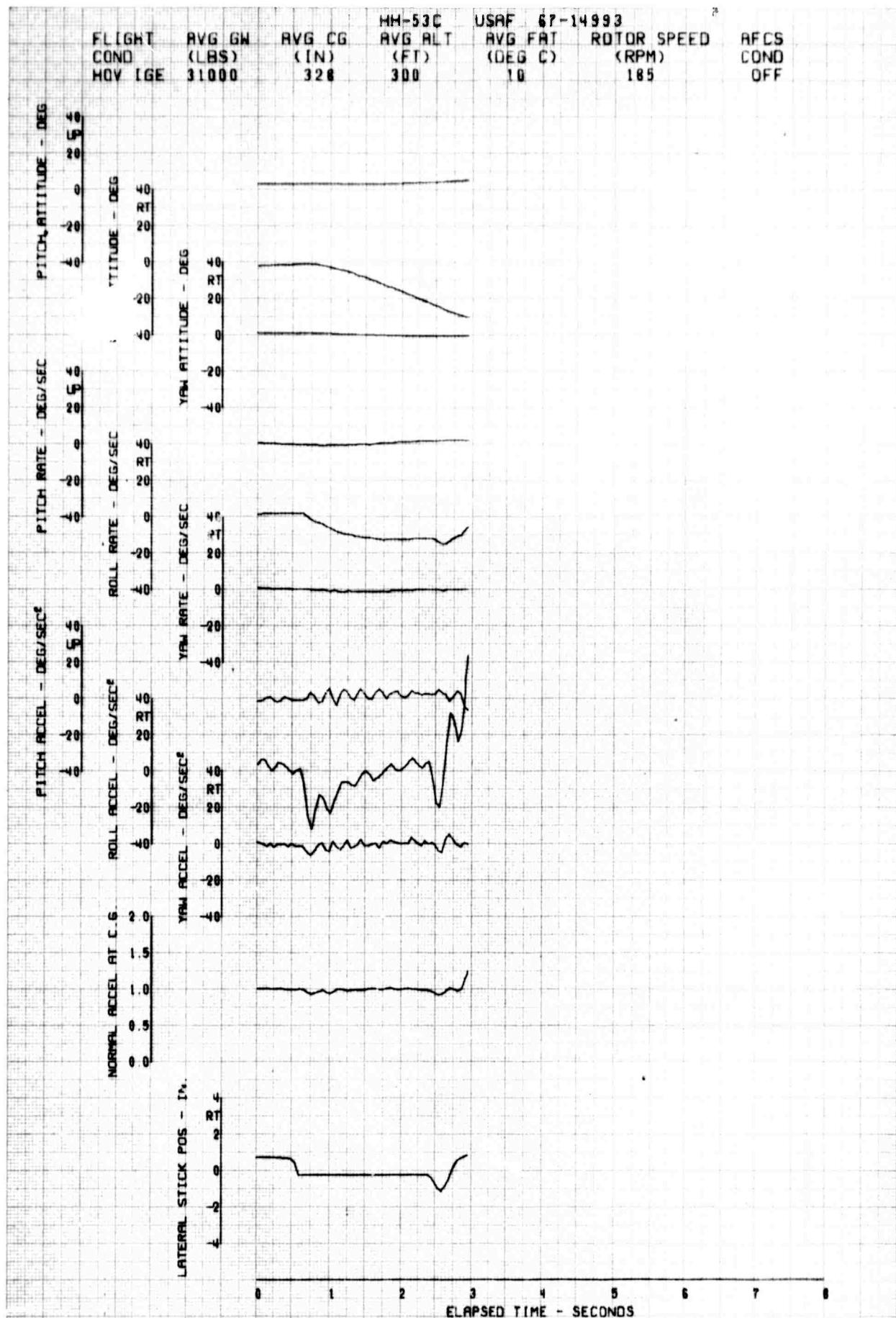


FIGURE 103. REACTION TO A LEFT LATERAL STEP.

FLIGHT HH-53C USAF 67-14993
 COND. 1
 HOV IGE AVG GW 31000 AVG CG 328 AVG ALT 300 AVG FWT 10 ROTOR SPEED 185
 RFCS COND ON

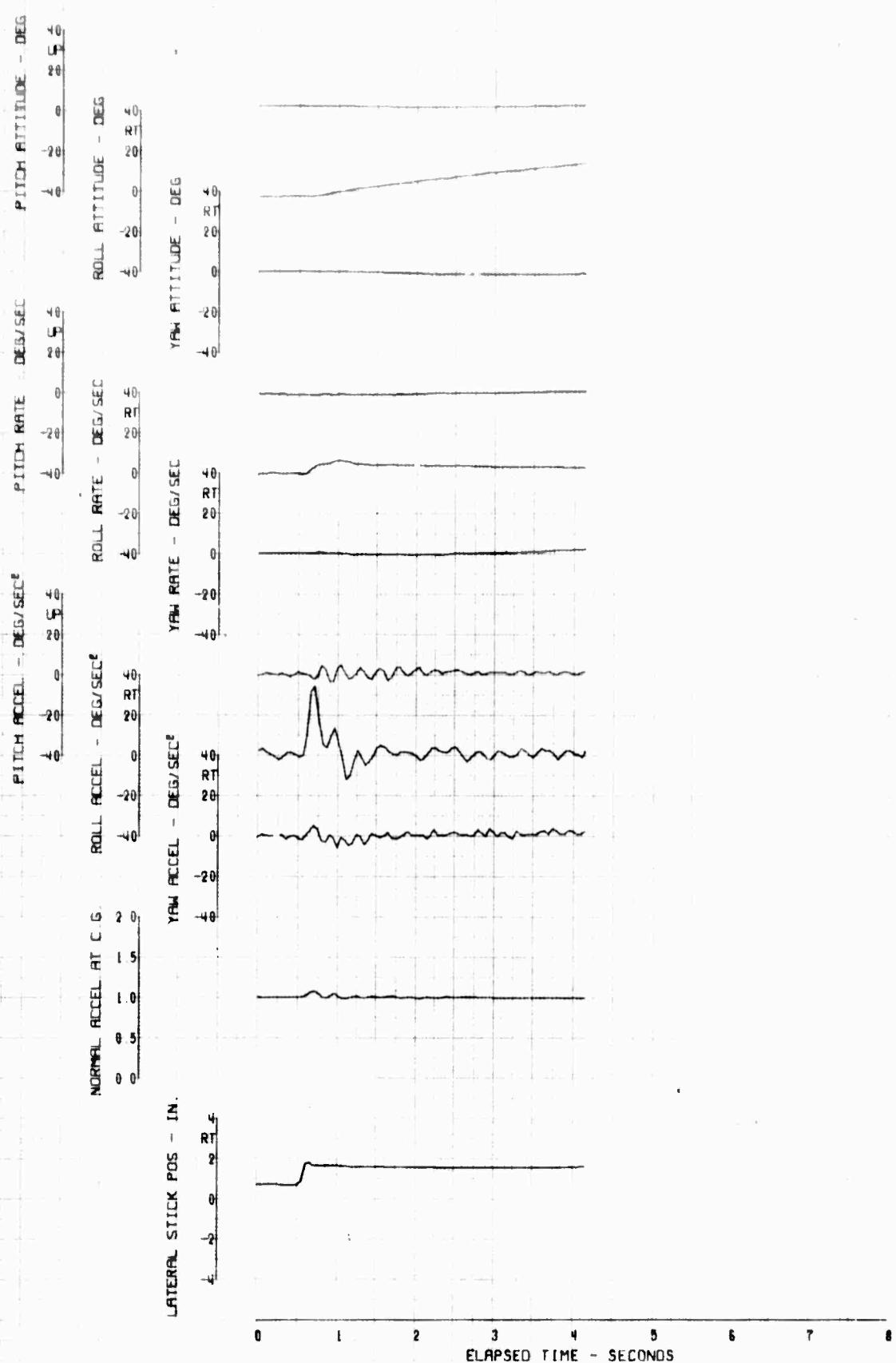


FIGURE 104 REACTION TO A RIGHT LATERAL STEP
118

FLIGHT HH-53C USAF 67-14993
 COND. RFCS COND.
 HOV LGE 31000 328 300 10 185 OFF

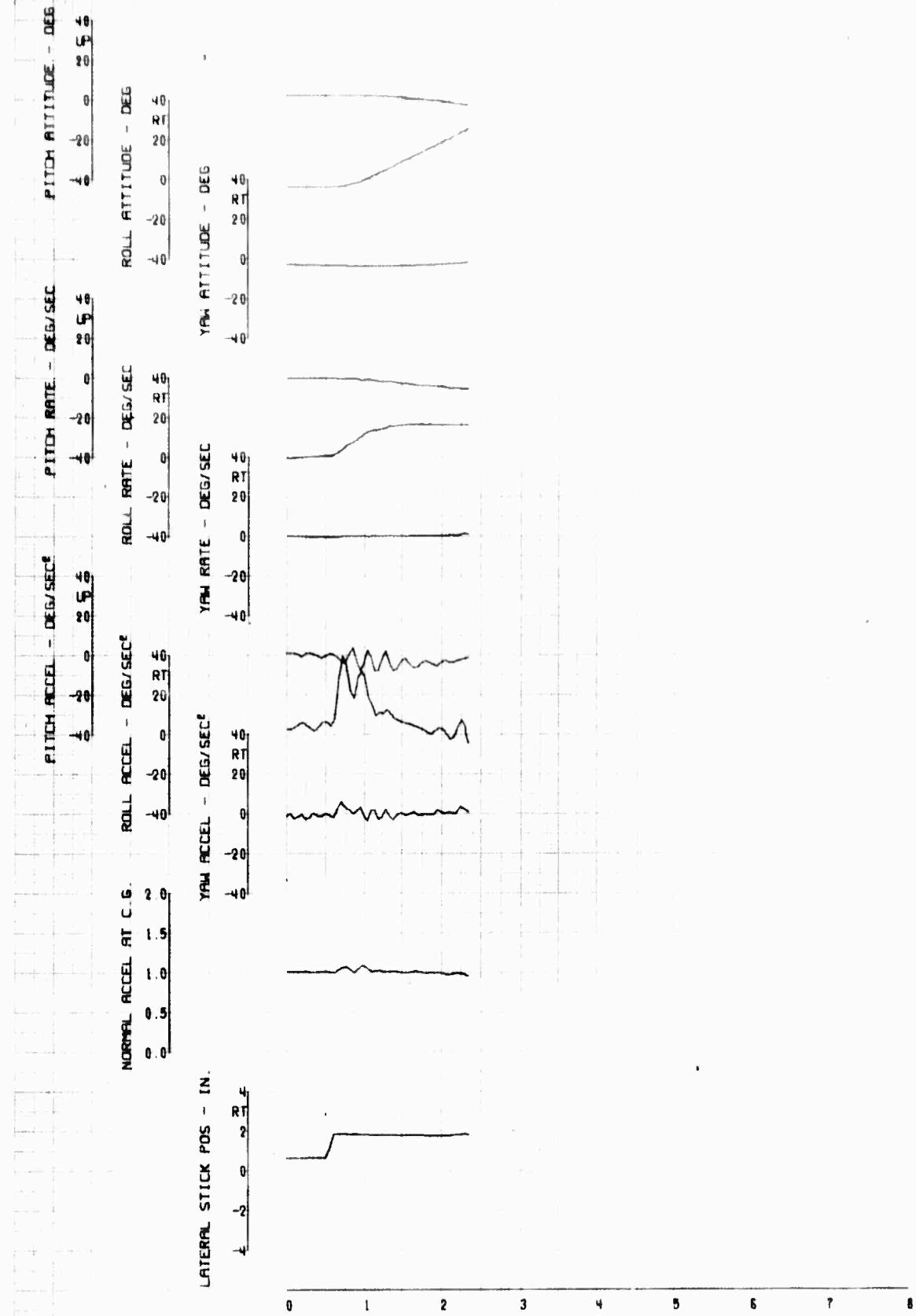


FIGURE 105. REACTION TO A RIGHT LATERAL STEP

FLIGHT HH-53C USAF 67-14993
 COND COND
 HOV IGE RVG GW (LBS) AVG CG (IN) AVG ALT (FT) AVG FRT (DEG C) ROTOR SPEED (RPM)
 31000 328 300 10 185

AFCs
COND
ON

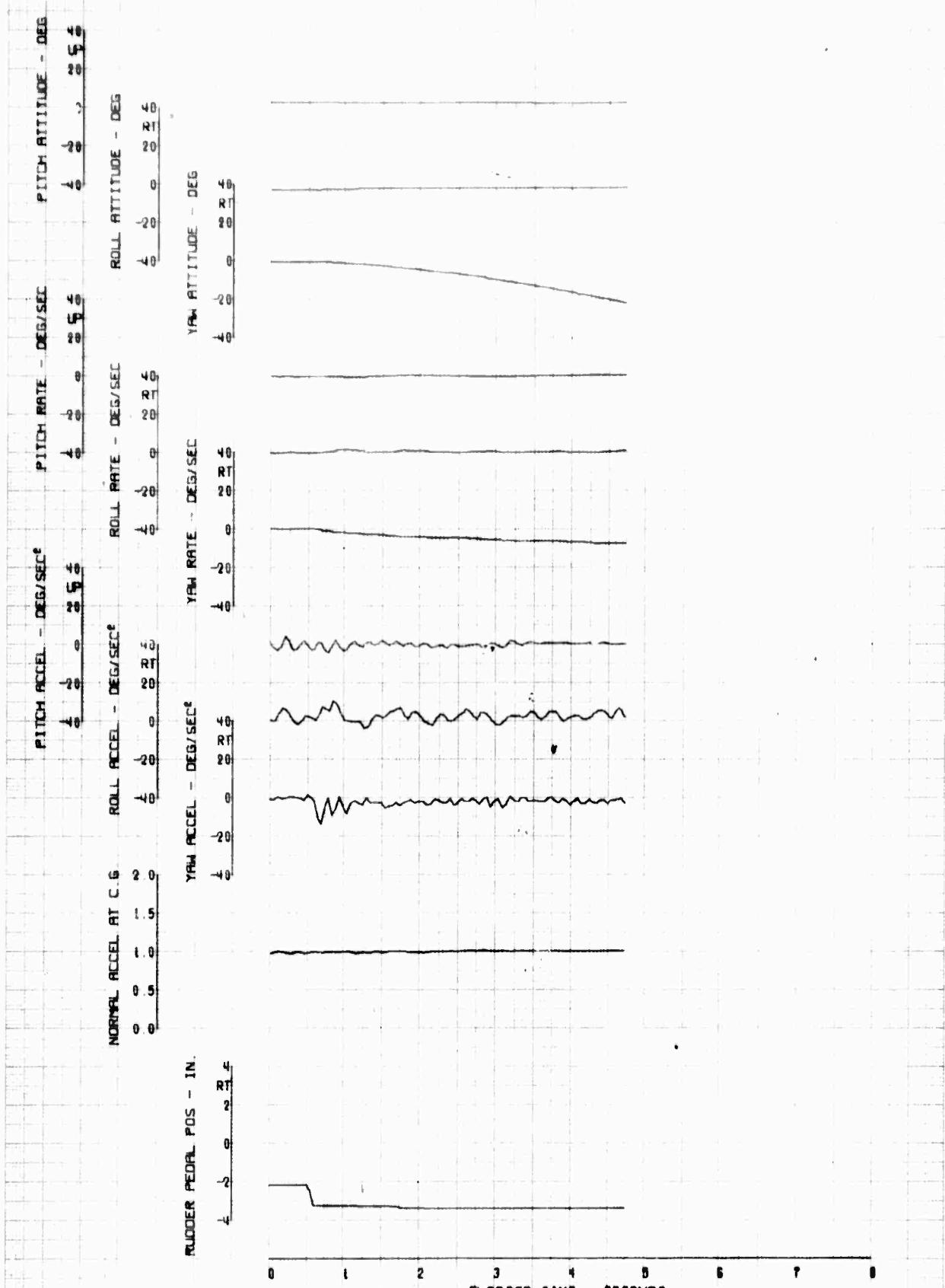


FIGURE 106. REACTION TO A LEFT DIRECTIONAL STEP

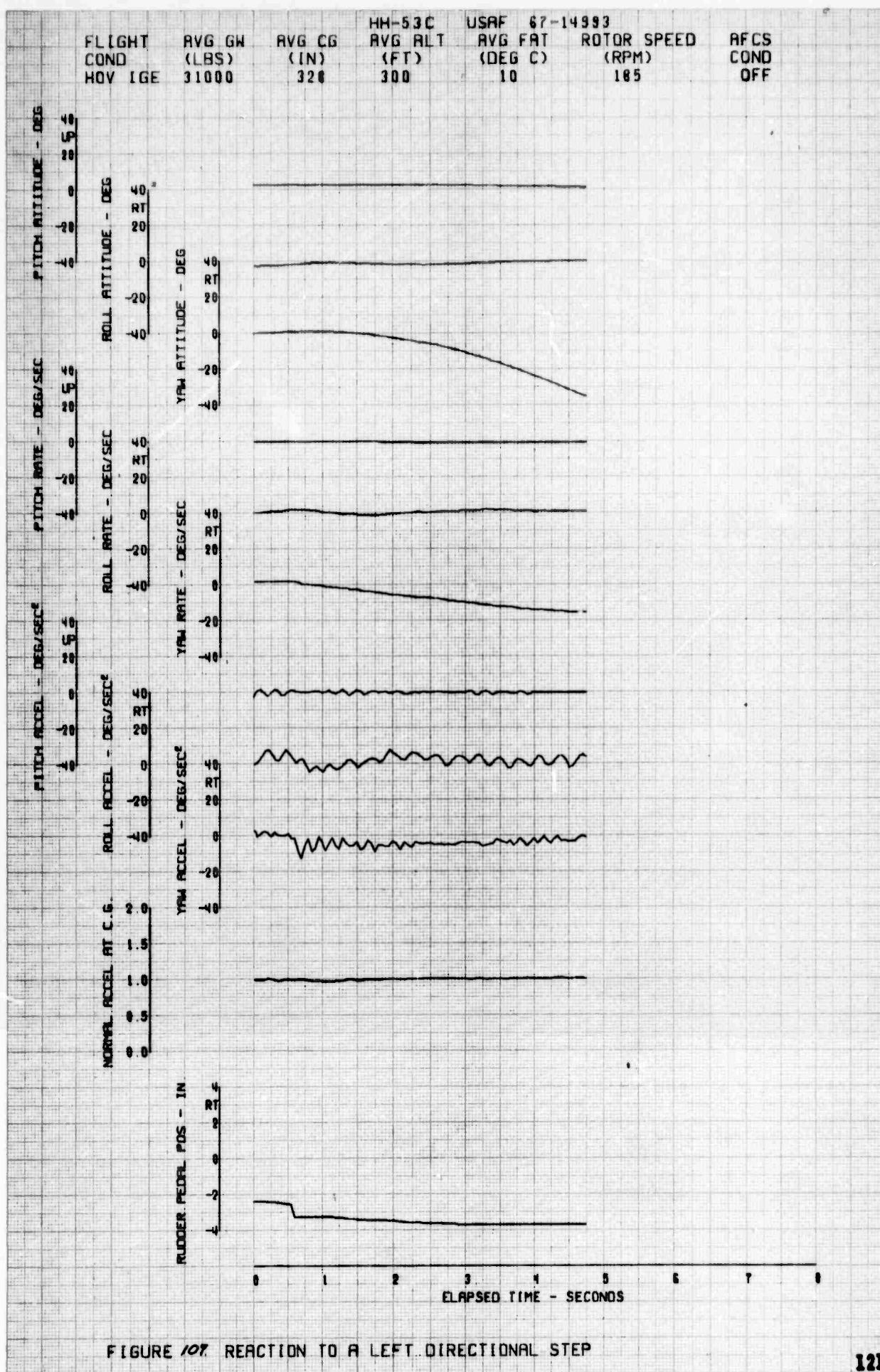


FIGURE 107 REACTION TO A LEFT DIRECTIONAL STEP

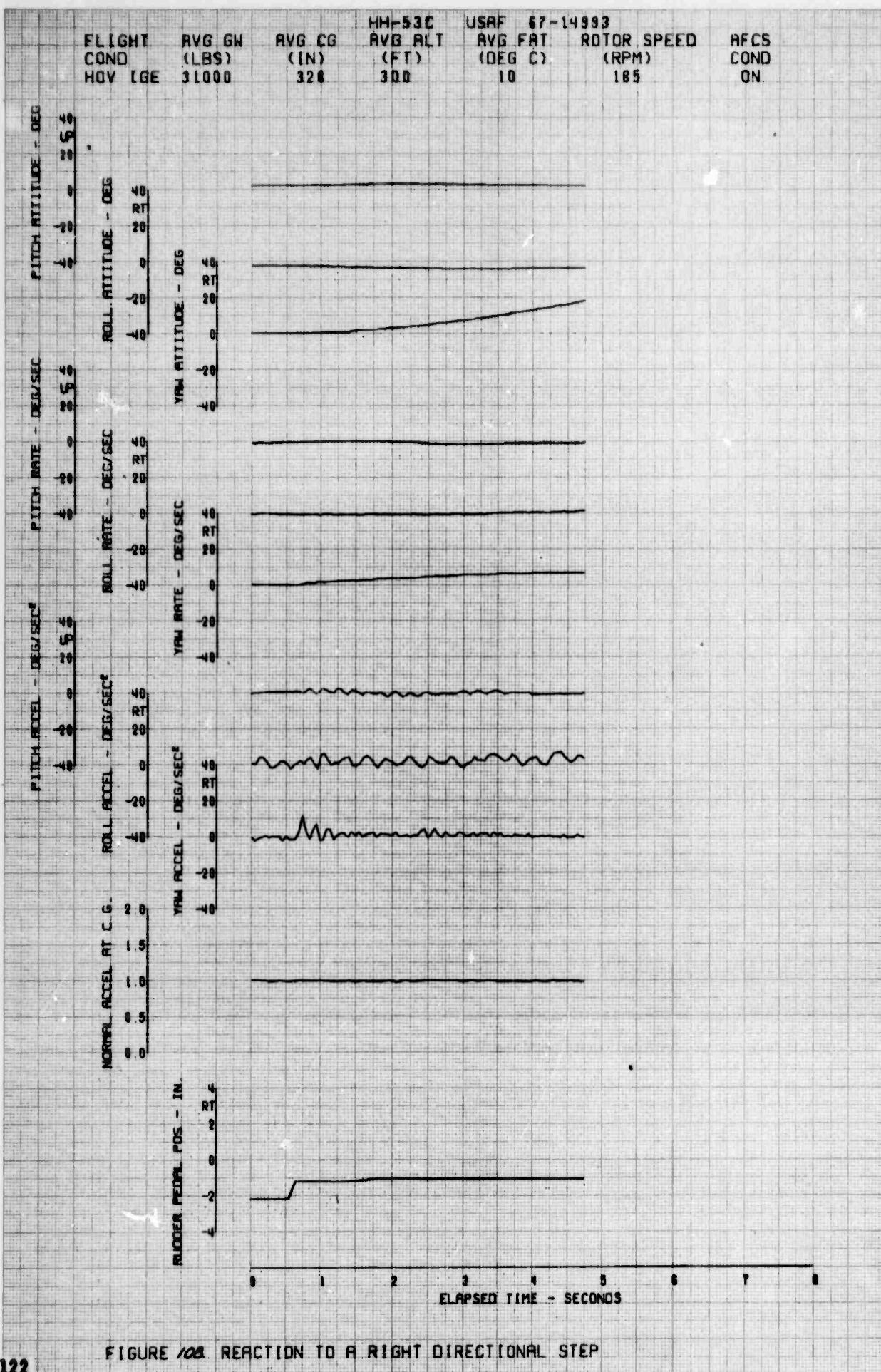


FIGURE 108. REACTION TO A RIGHT DIRECTIONAL STEP

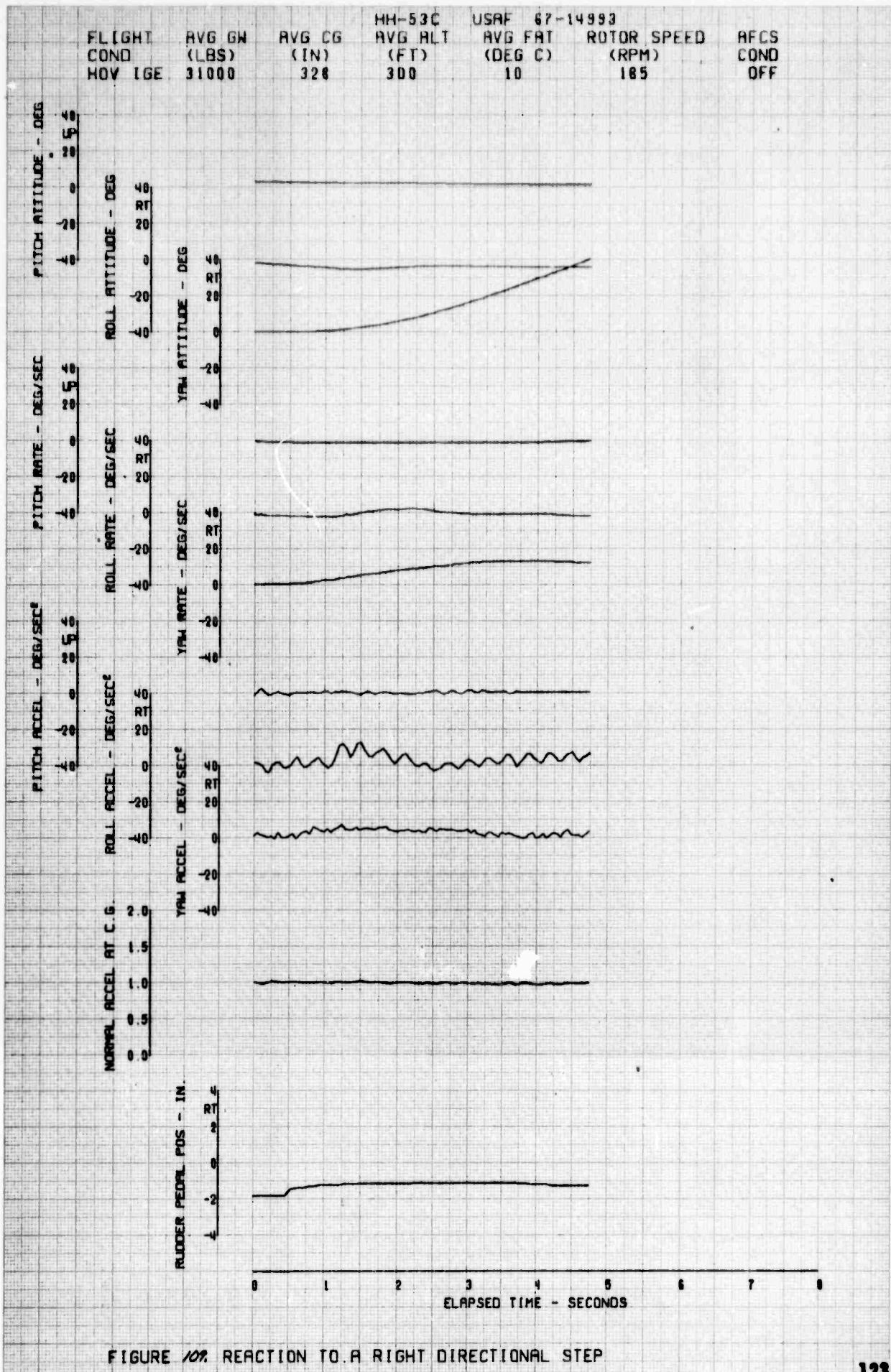


FIGURE 109. REACTION TO A RIGHT DIRECTIONAL STEP.

HH-53C USAF S/N 67-14993

Sym	Flight Condition	Avg GM (lb)	cg (in.)	Avg Press. Alt (ft)	Avg PAT ($^{\circ}$ C)	Rotor Speed (rpm)	Trim A/S
○	Hover R	31,000	328	300	10	185	AFCS ON 0
□	Hover	31,000	328	300	10	185	QRF 0

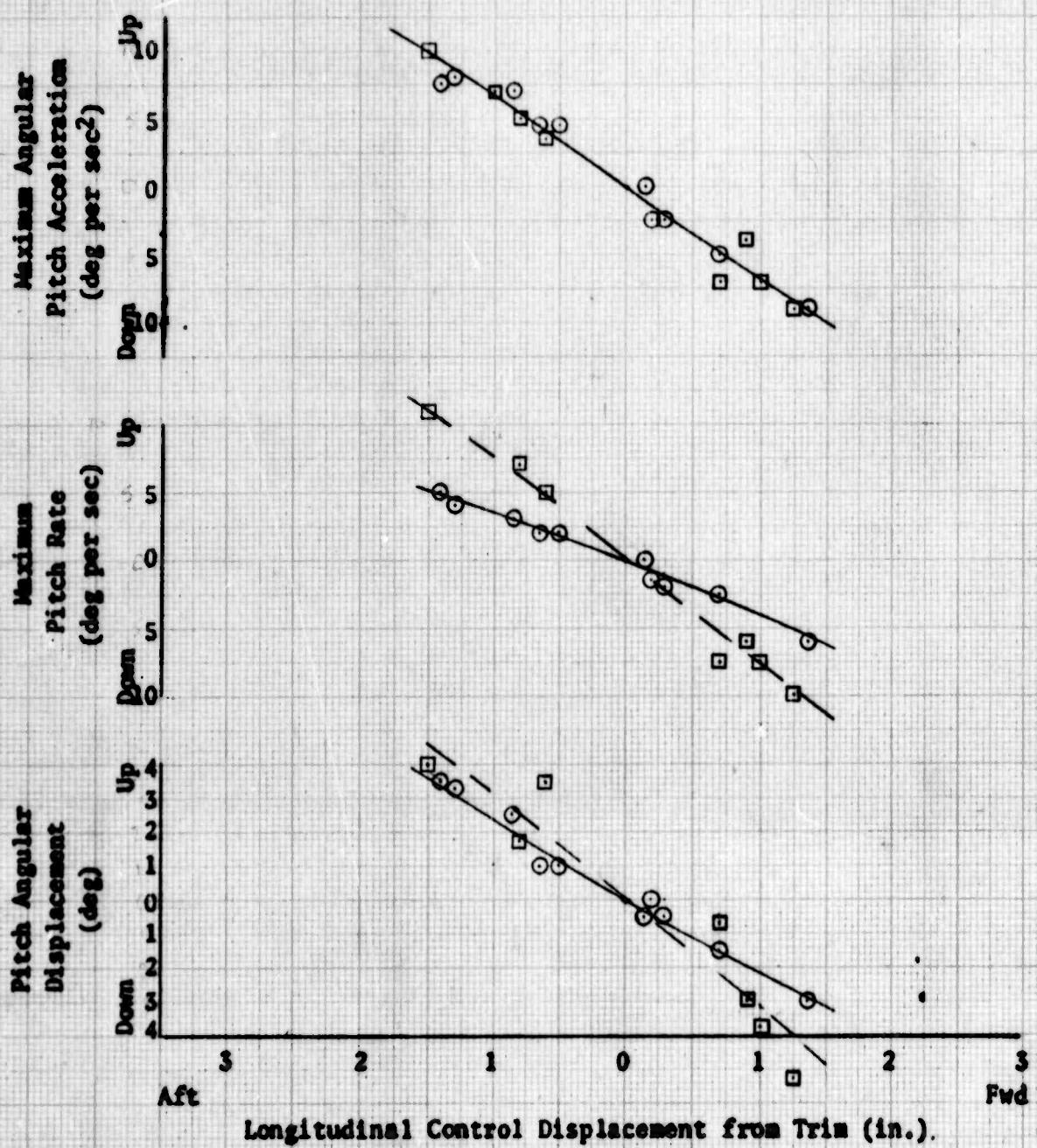


Figure 110. Longitudinal Controllability

Sym	Flight Condition	Avg GW (lb)	cg (in.)	Avg Press. (ft)	Alt (°C)	Avg FAT (rpm)	Rotor Speed (rpm)	Trim A/S AFCS	(kt)
○	Hover	31,000	328	300	10	183	183	ON	0
□	Hover	31,000	328	300	10	183	183	OFF	0

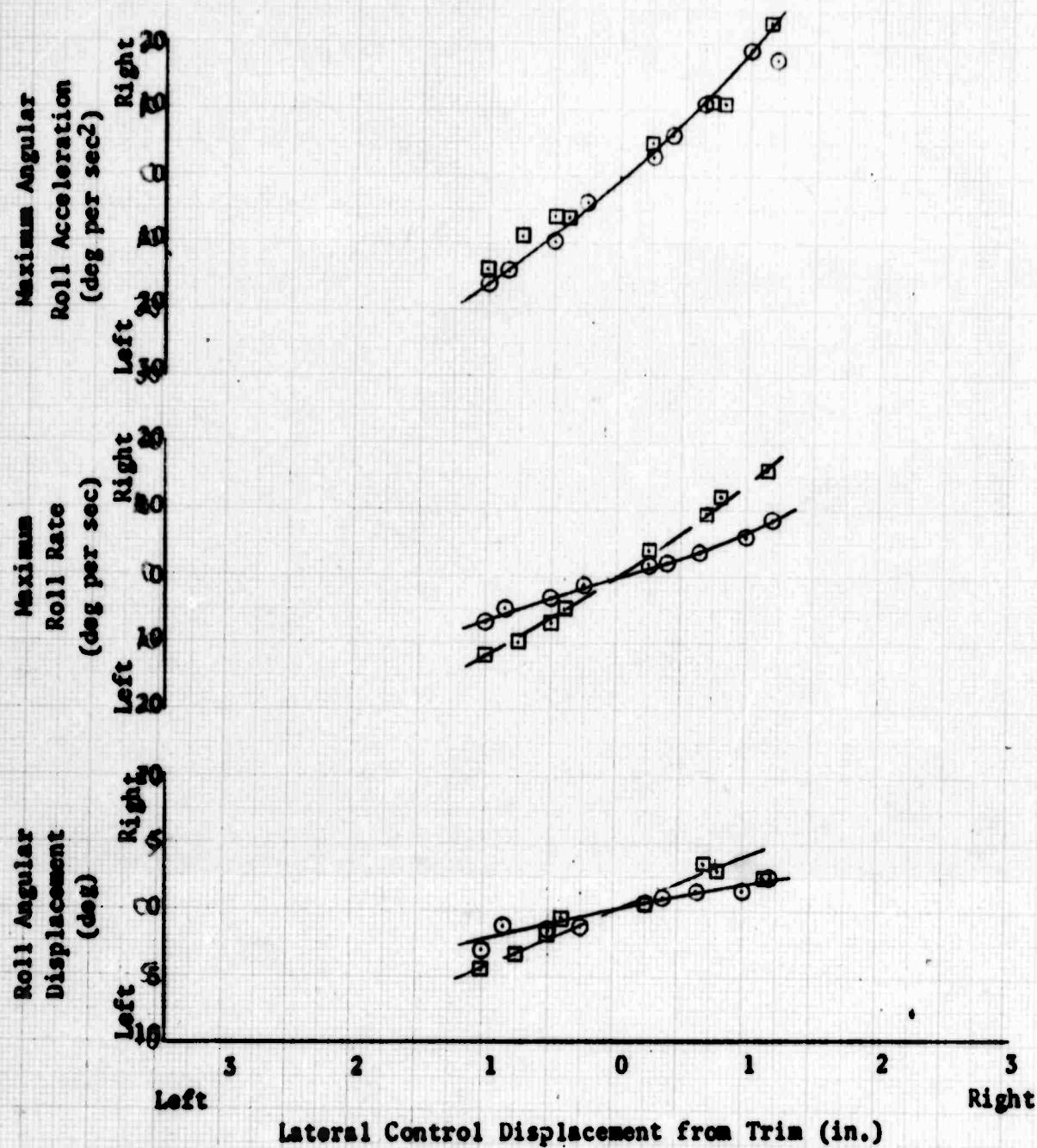
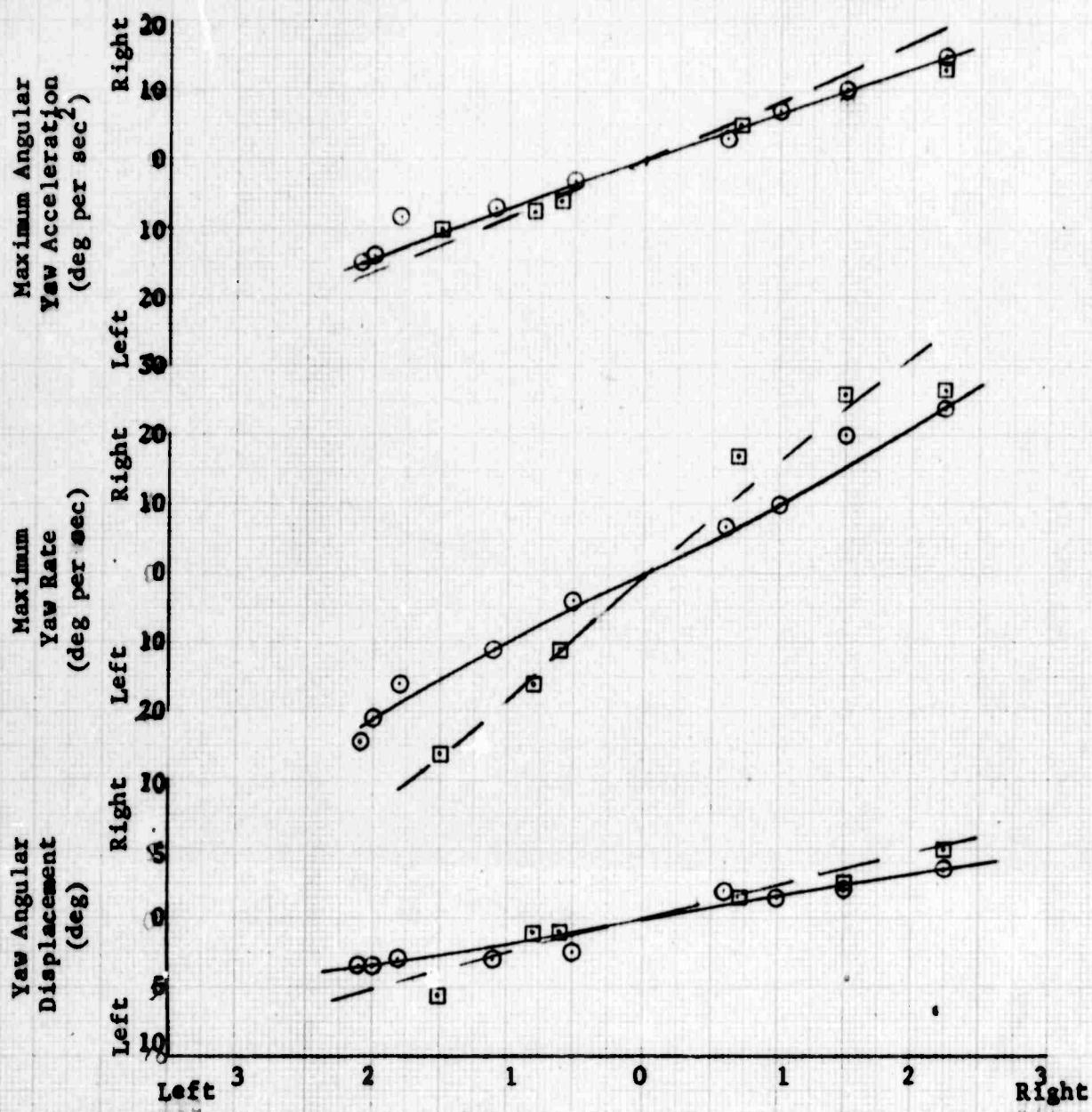


Figure III. Lateral Controllability

HH-53C USAF S/N 67-14993

Sym	Flight Condition	Avg GW (lb)	cg (in.)	Avg Press. Alt (ft)	Avg FAT ($^{\circ}$ C)	Rotor Speed (rpm)	AFCS	Trim A/S (kt)
○	Hover	31,000	328	300	10	185	ON	0
□	Hover	31,000	328	300	10	185	OFF	0



Directional Control Displacement from Trim (in.).

Sym	Flight Condition	Avg GM (lb)	cg (in.)	Avg Press. Alt (ft)	Avg PAT (°C)	Rotor Speed (rpm)	Trim A/S
○	Hover	31,000	352	300	10	185	AFCS ON
□	Hover	31,000	352	300	10	185	OFF

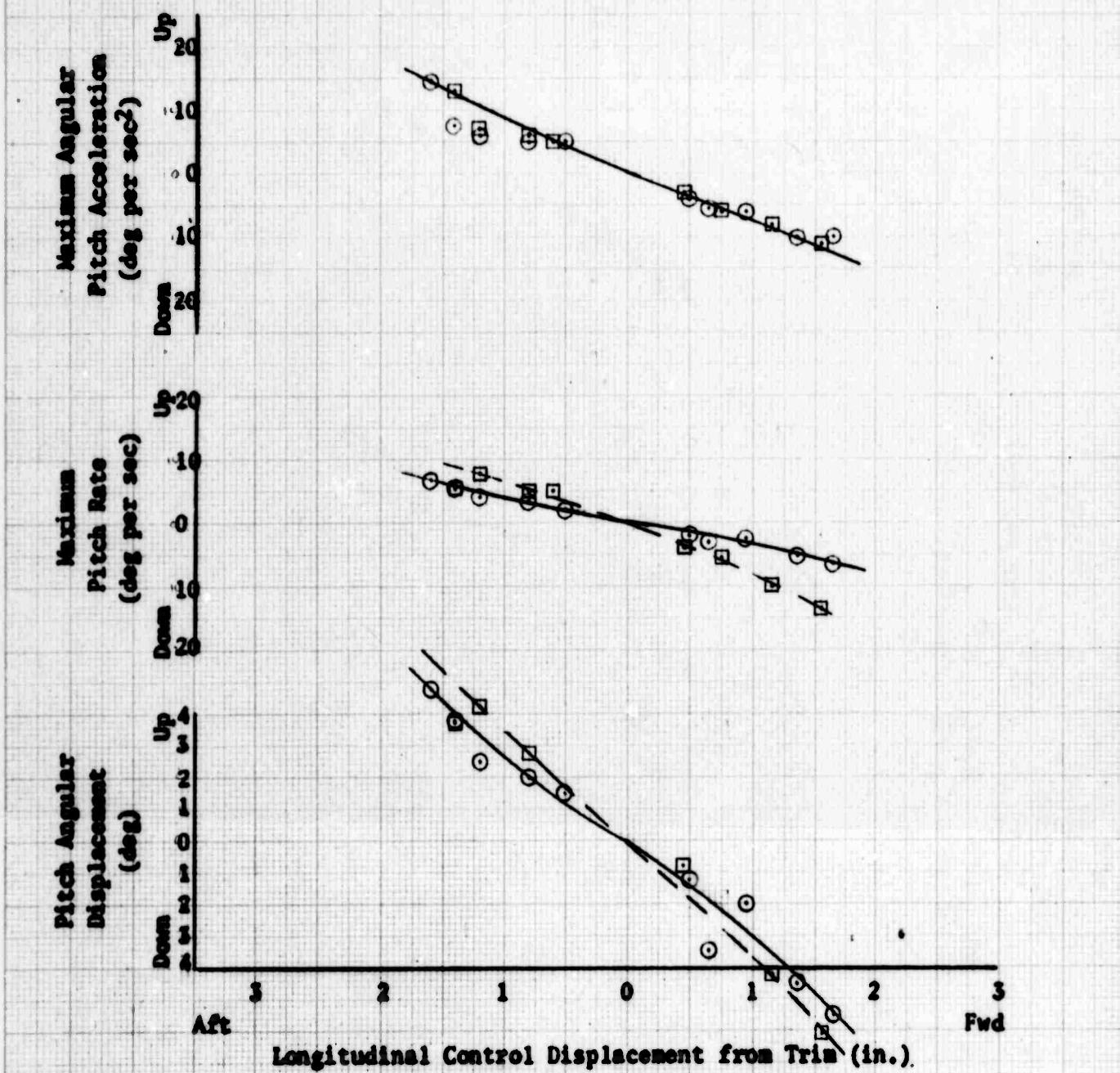
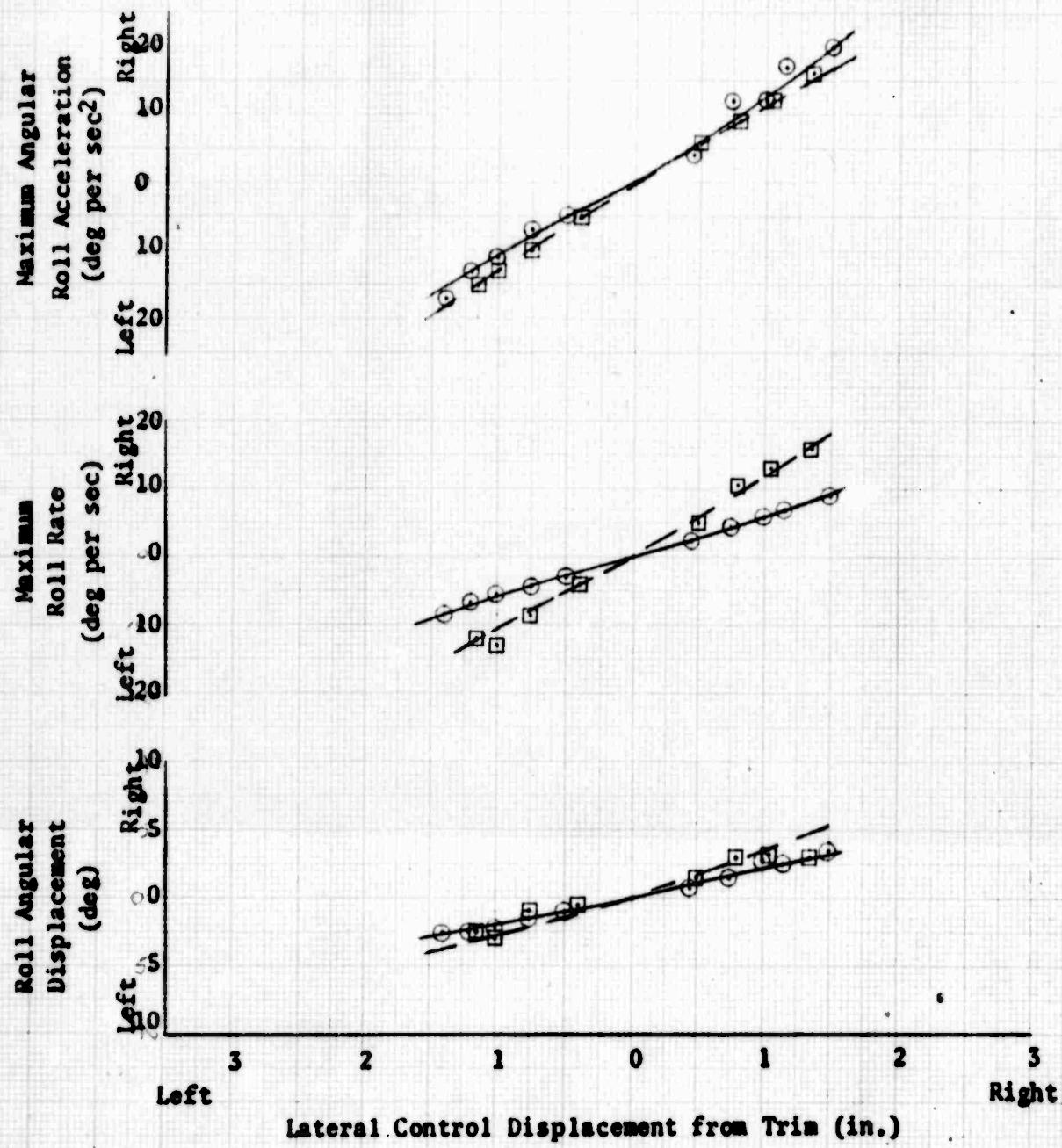


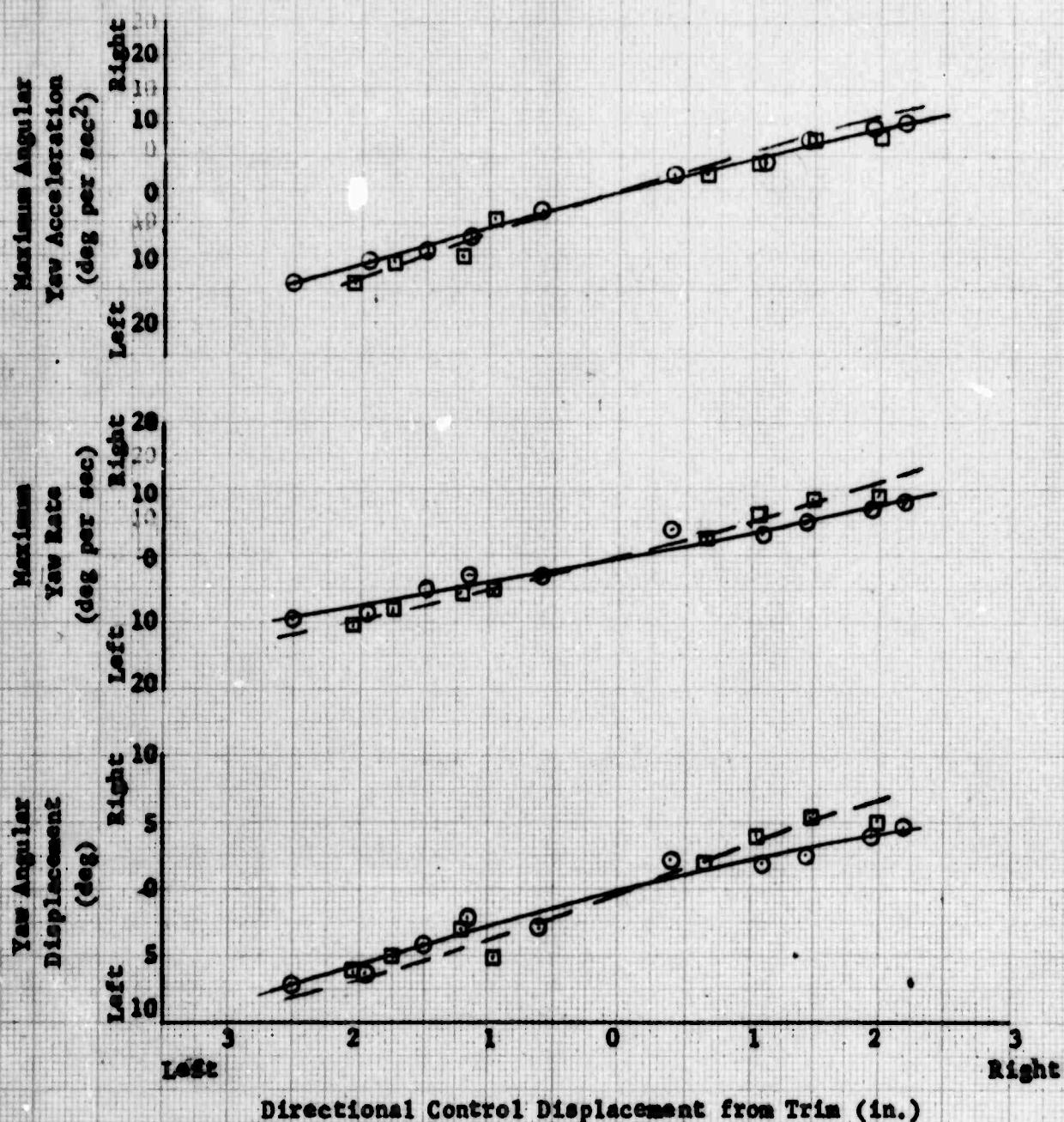
Figure 112. Longitudinal Controllability

HH-53C USAF S/N 67-14993

Sym	Flight Condition	Avg GW (lb)	cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	Trim A/S
O	Hover	31,000	352	300	10	185	AFCS ON 0
D	Hover	31,000	352	300	10	185	OFF 0



Sym	Flight Condition	Avg GW (lb)	cg (in.)	Avg Press. (ft)	Alt (°C)	Avg FAT	Rotor Speed (rpm)	AFCS	Trim A/S (kt)
○	Hover	31,000	352	500		10	185	ON	0
□	Hover	31,000	352	300		10	185	OFF	0



Directional Control Displacement from Trim (in.)

Figure NCP Directional Controllability

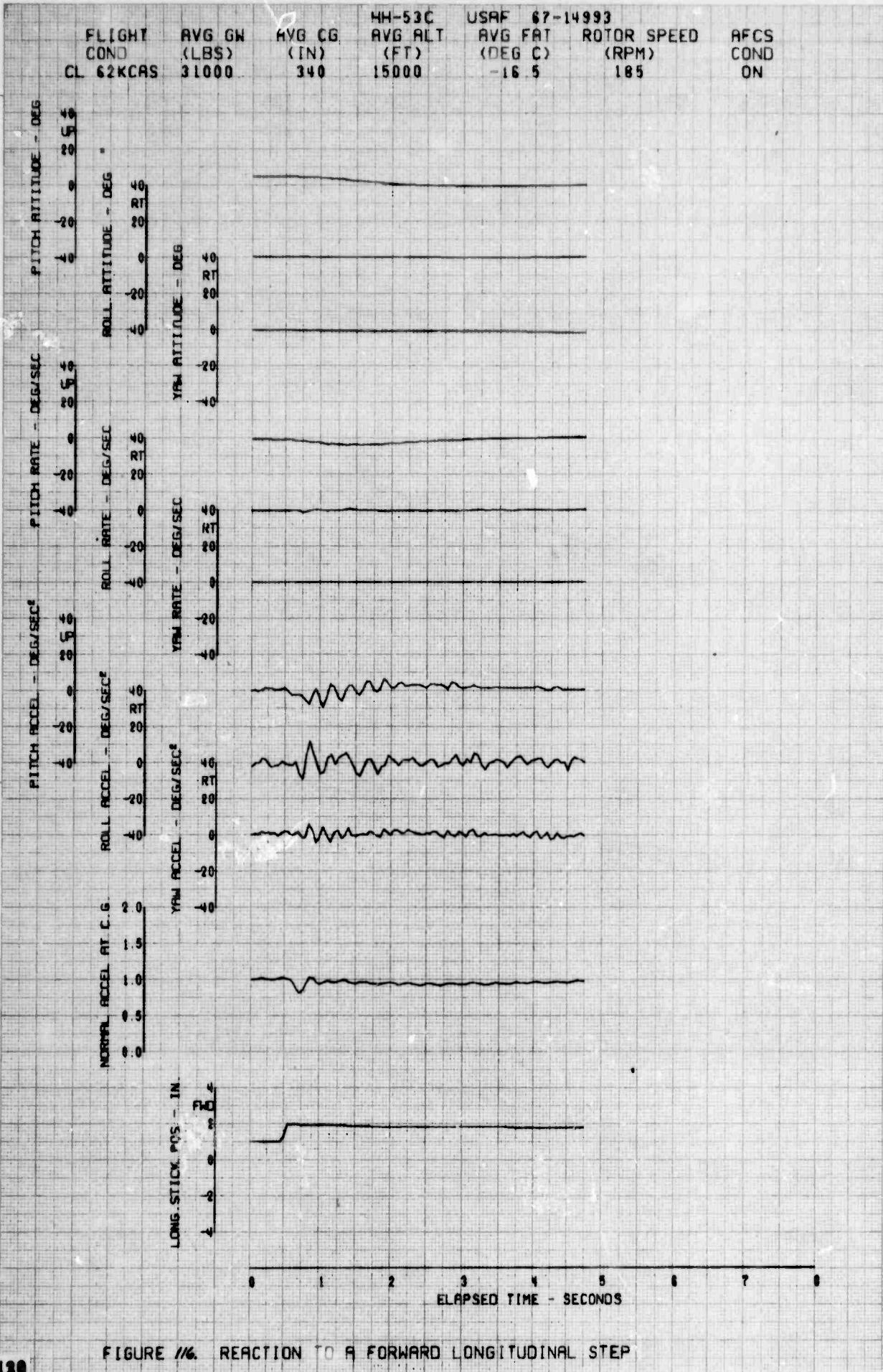


FIGURE 116. REACTION TO A FORWARD LONGITUDINAL STEP

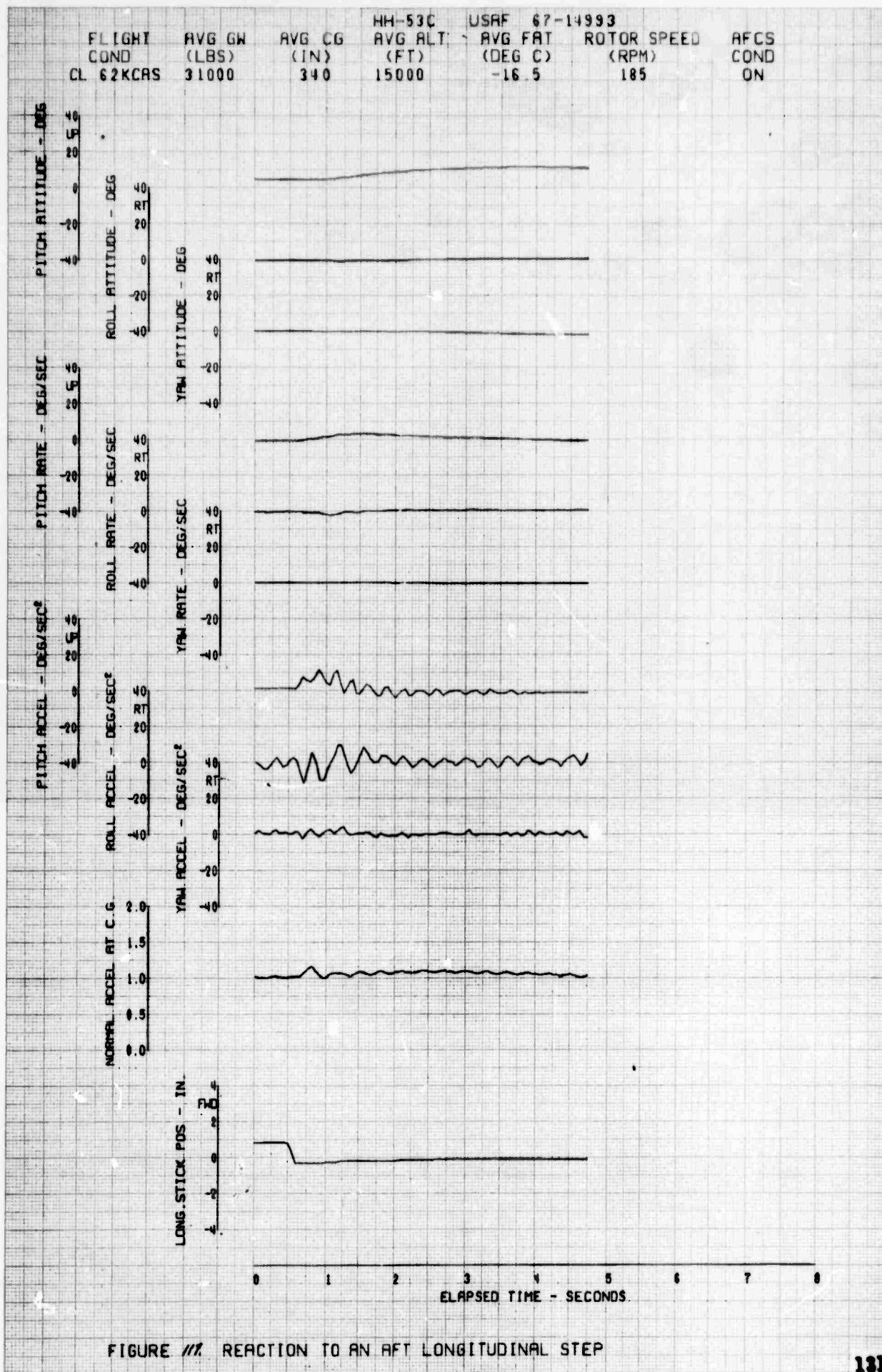


FIGURE 117 REACTION TO AN AFT LONGITUDINAL STEP

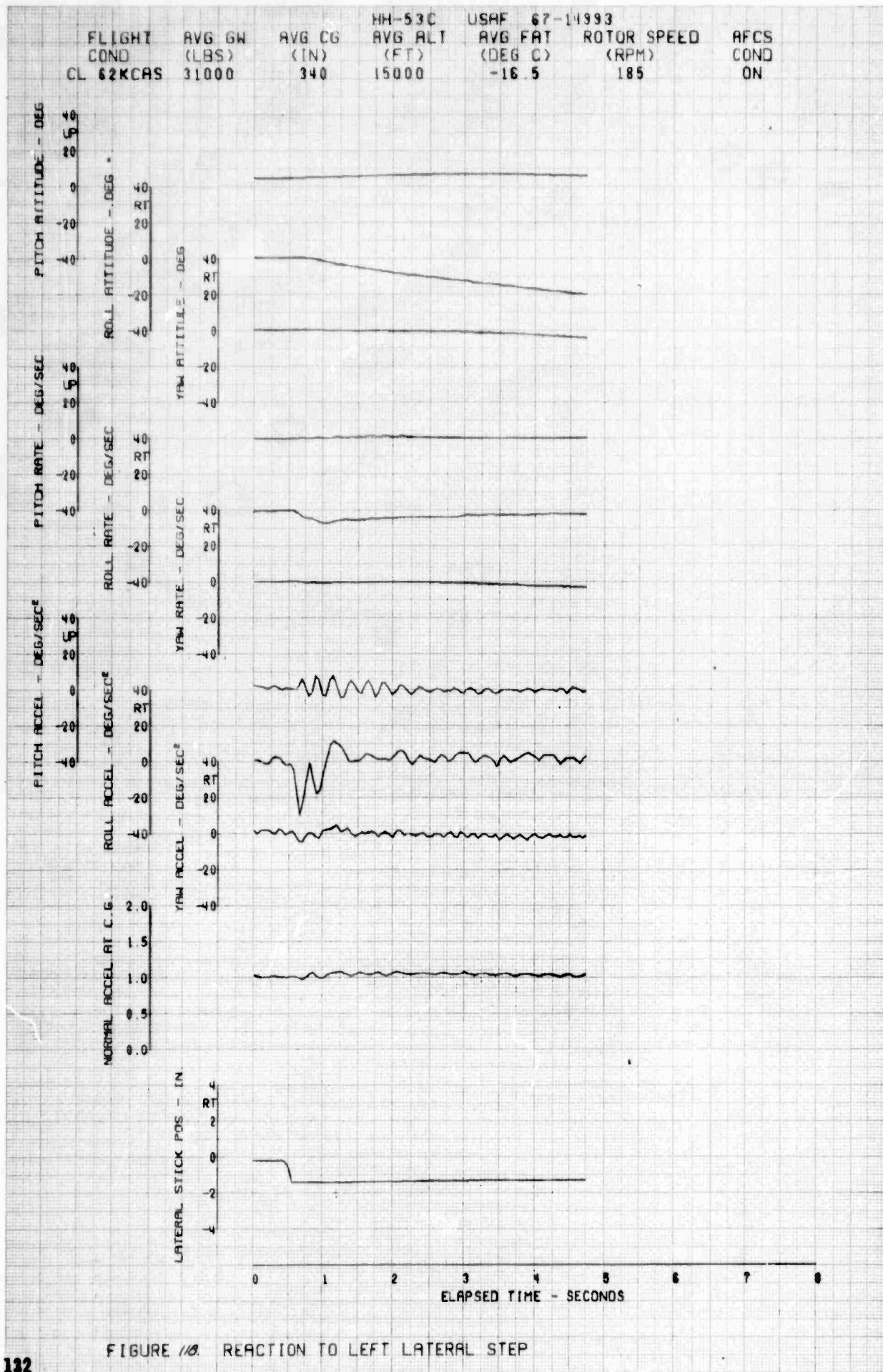


FIGURE 118. REACTION TO LEFT LATERAL STEP

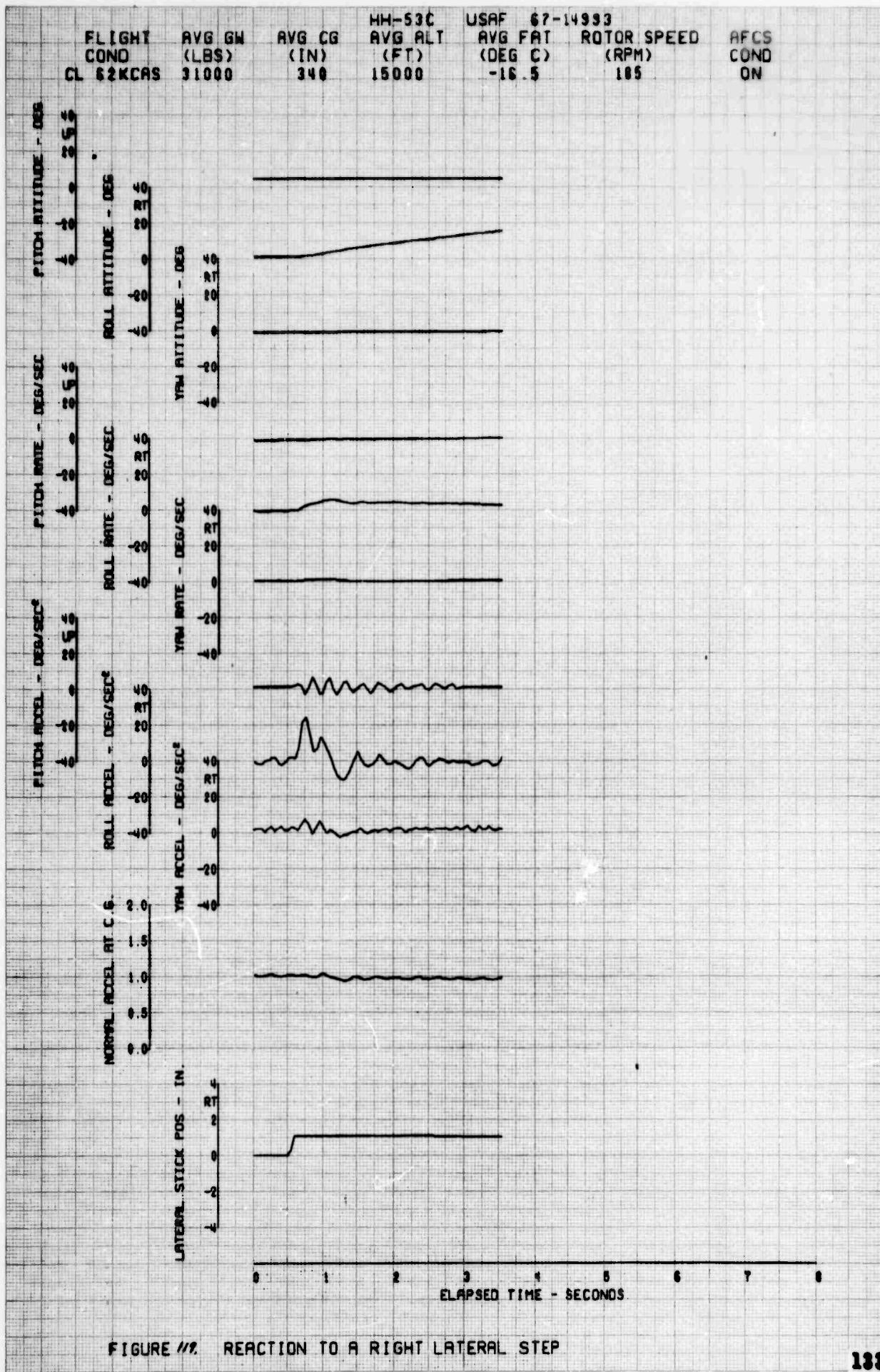


FIGURE 112. REACTION TO A RIGHT LATERAL STEP

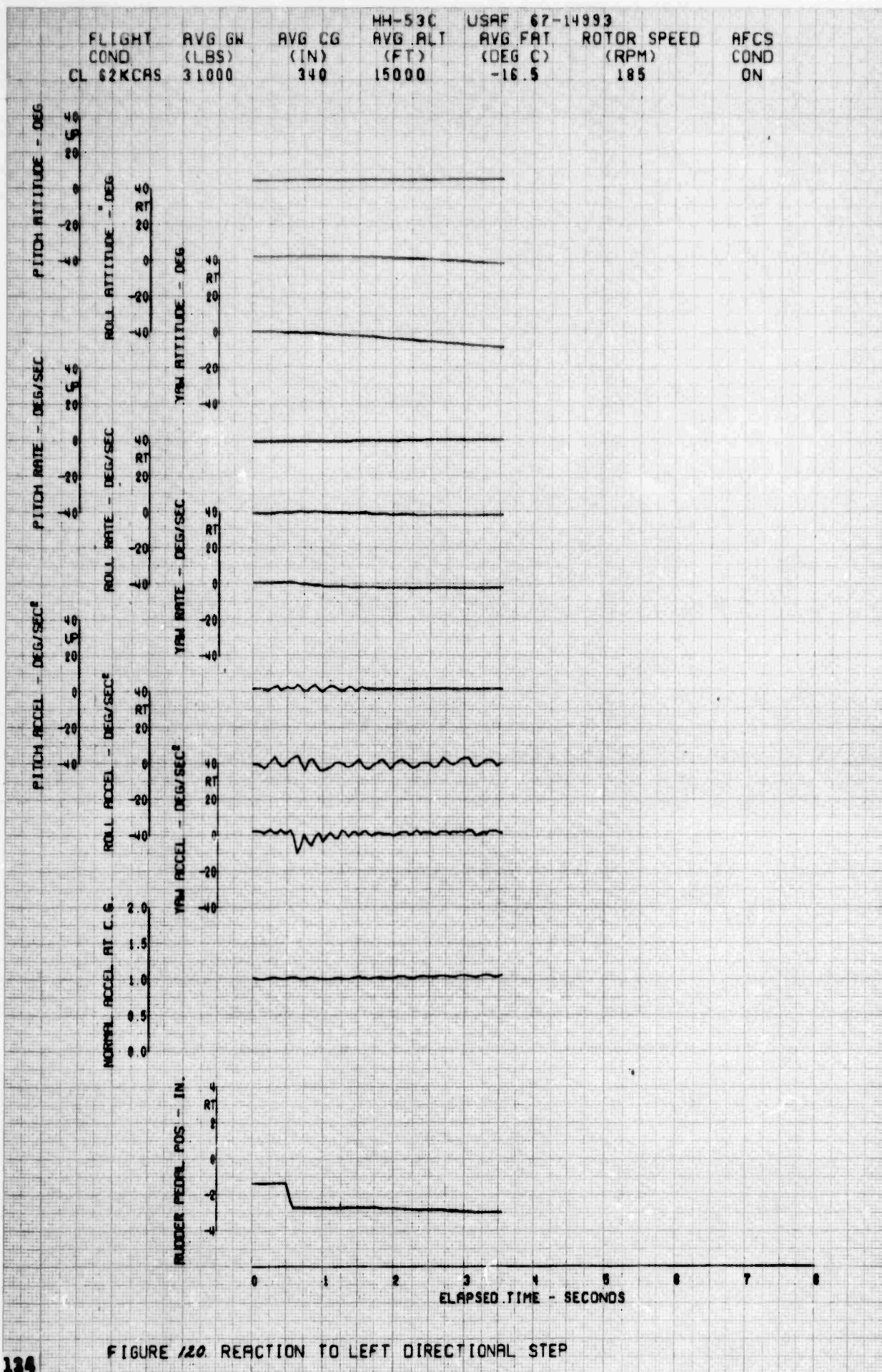


FIGURE 120. REACTION TO LEFT DIRECTIONAL STEP

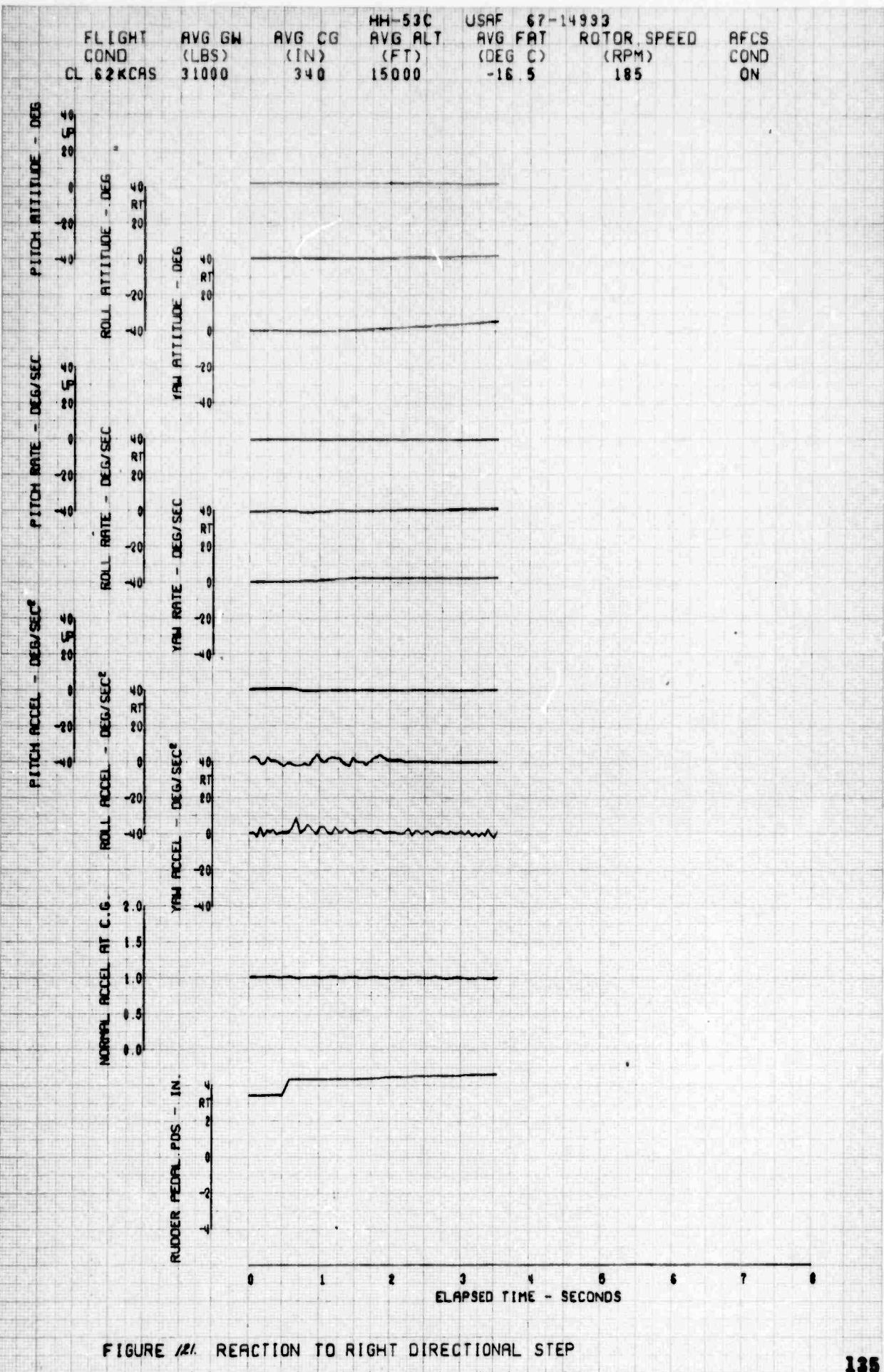


FIGURE 121. REACTION TO RIGHT DIRECTIONAL STEP

FLIGHT COND	Avg GW (LBS)	Avg CG (IN)	HH-53C	USAF 67-14993	ROTOR SPEED (RPM)	AFCS COND
AUTO 72KCAS	31000	340	15000	-16.5	185	ON

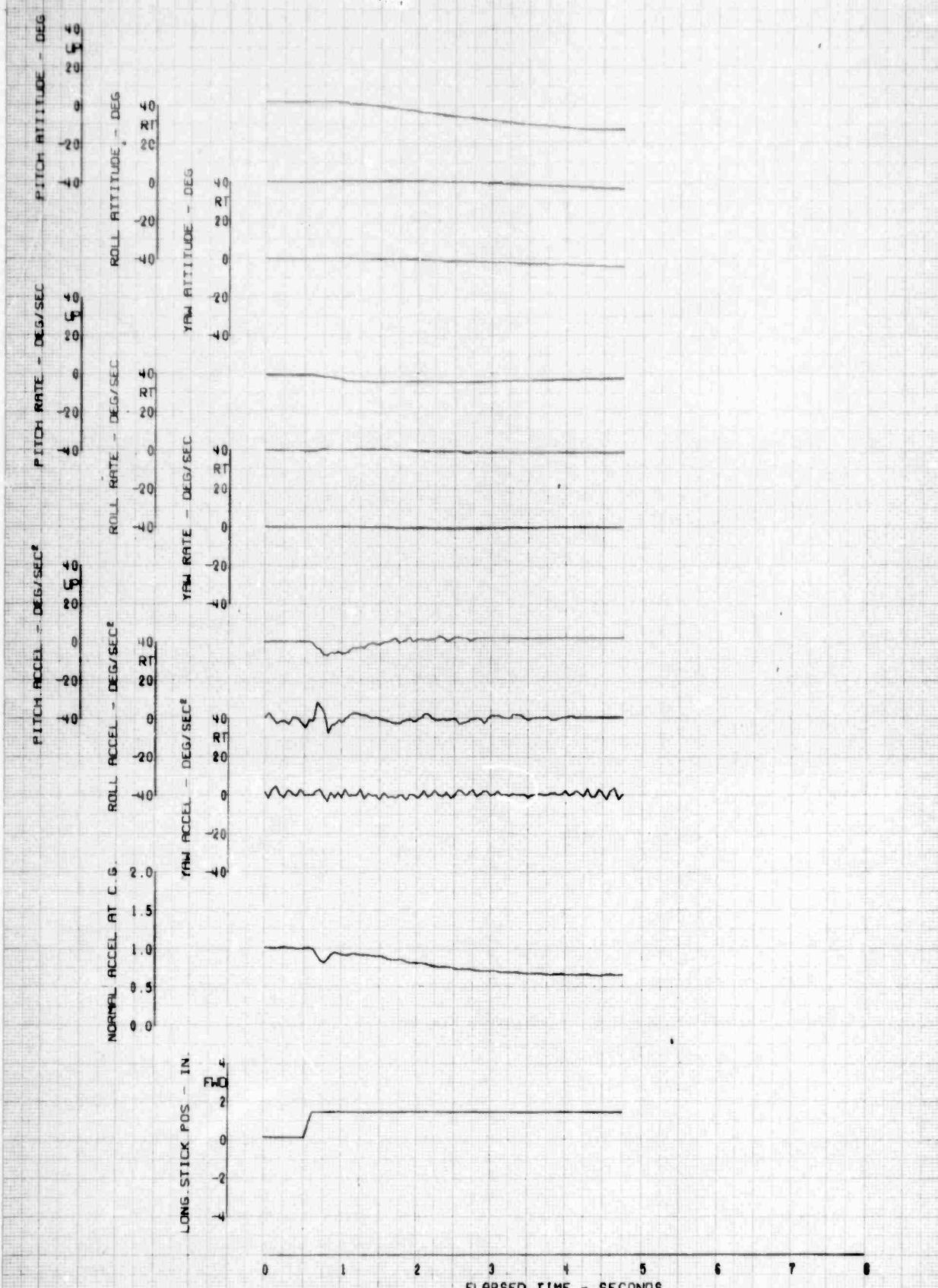


FIGURE 122. REACTION TO A FORWARD LONGITUDINAL STEP

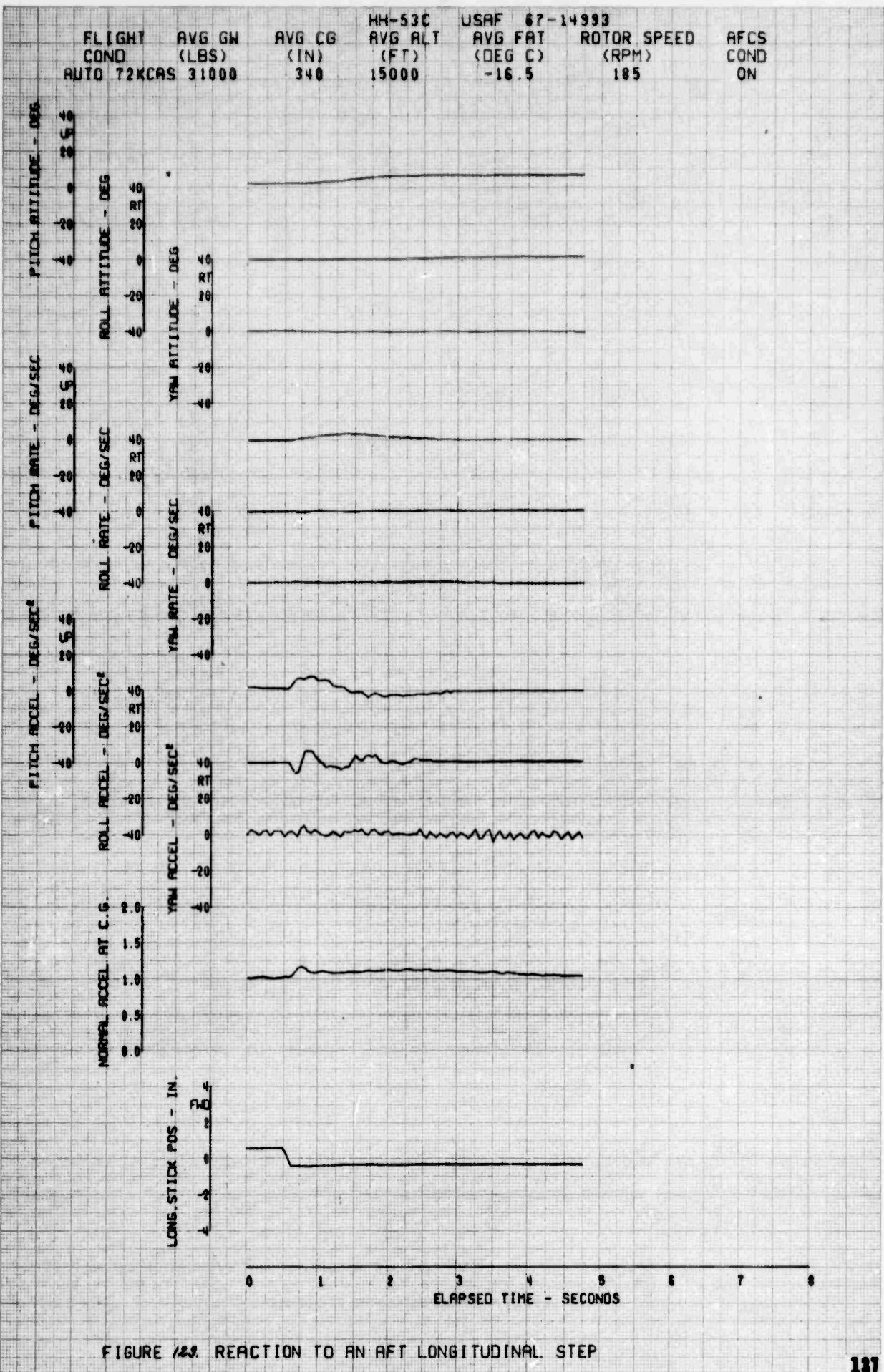


FIGURE 189. REACTION TO AN AFT LONGITUDINAL STEP

FLIGHT AVG GW AVG LG MM-53C USAF 67-14993
 COND : (LBS) (IN) ALT (FT) FAT (DEG C) ROTOR SPEED RPM AFCS
 AUTO 72KCRS 31000 340 15000 -16.5 185 COND ON

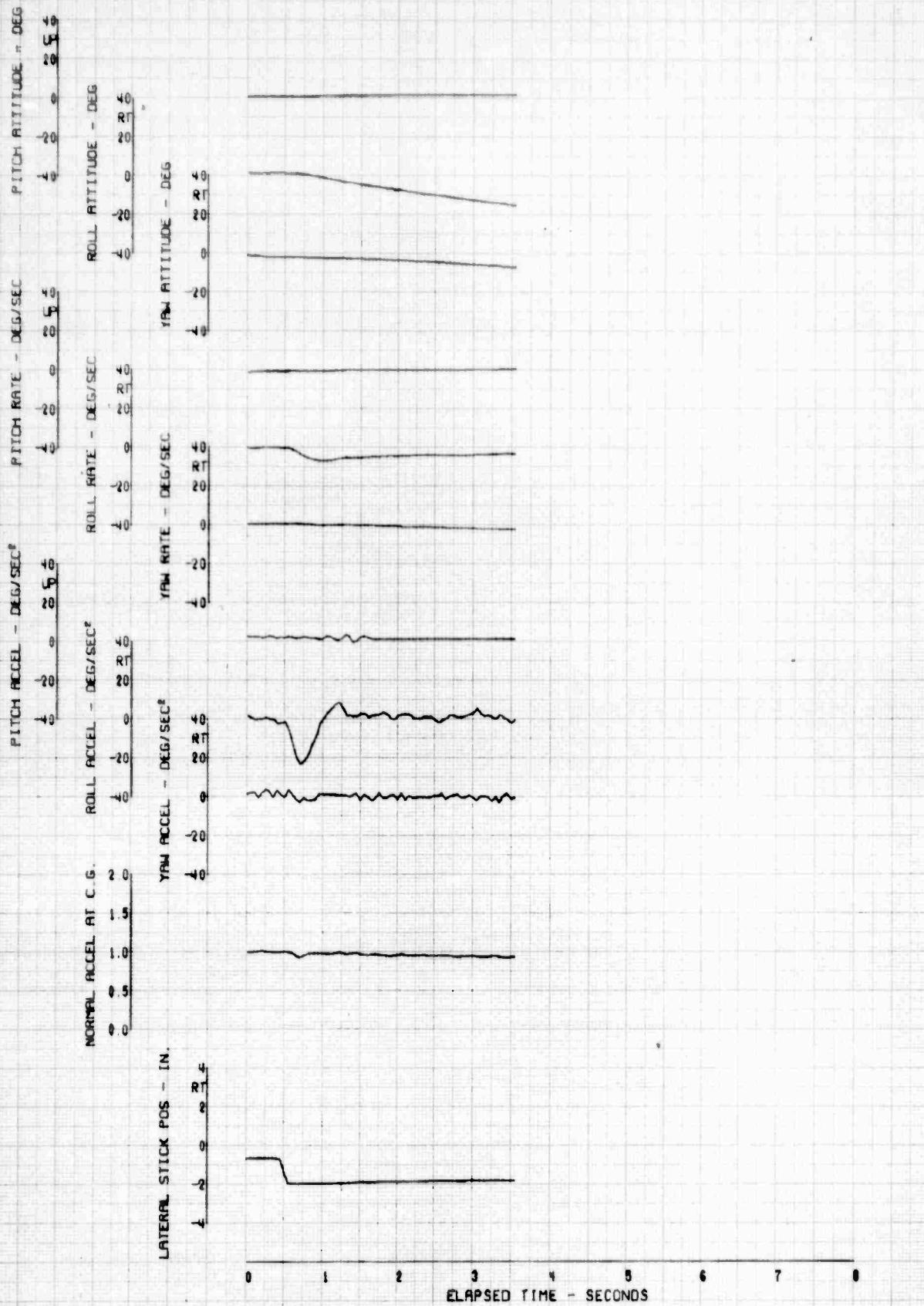


FIGURE 129 REACTION TO LEFT LATERAL STEP

FLIGHT AVG GW AVG CG HH-53C USAF 67-14993
 COND (LBS) (IN) ALT (FT) FAT (DEG C) ROTOR SPEED RPM AFCS
 AUTO 72 KCAS 31000 340 15000 -16.5 185 COND ON

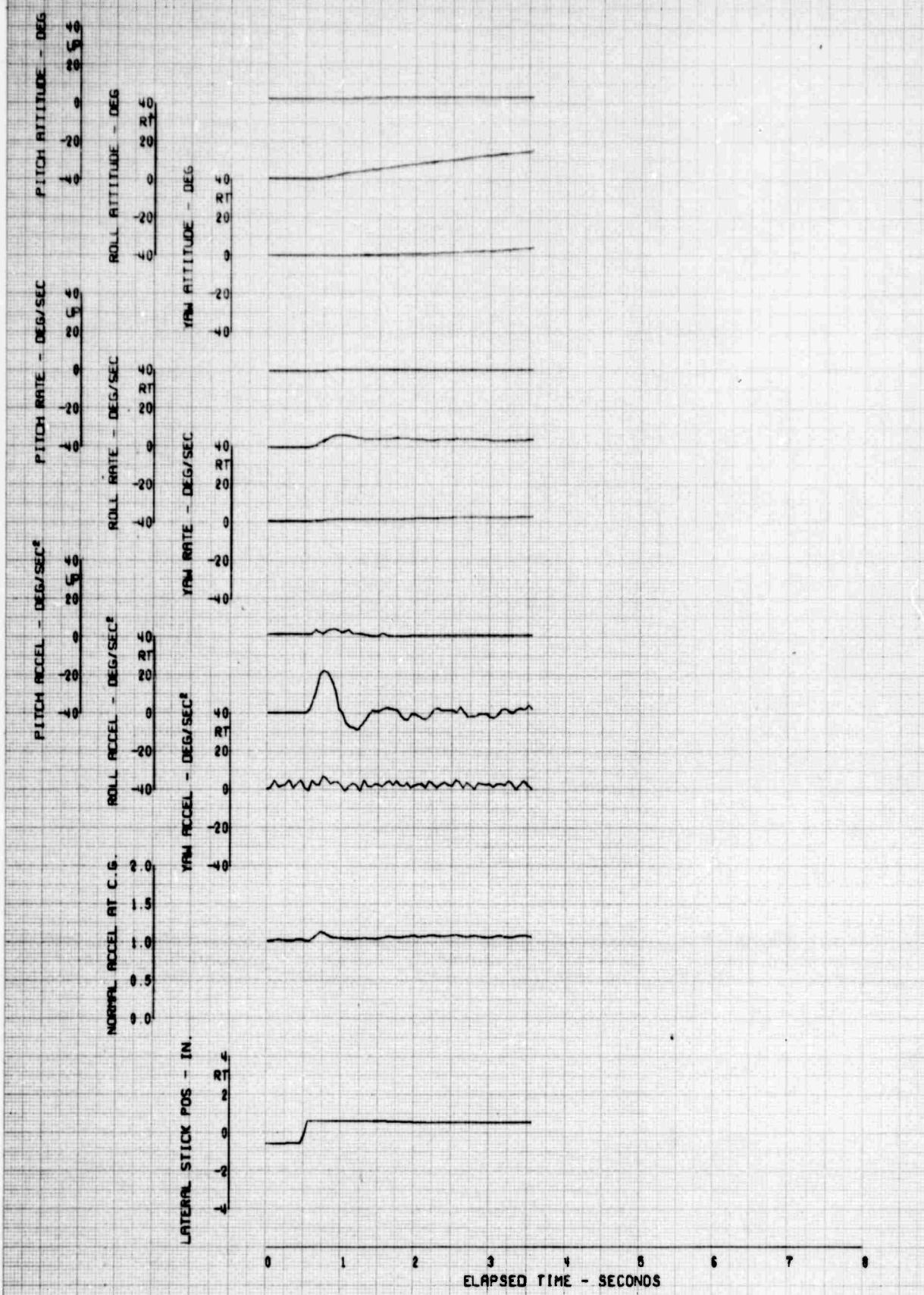


FIGURE 185. REACTION TO A RIGHT LATERAL STEP

FLIGHT COND. AUTO 72KCAS
 AVG. GW (LBS) 31000
 AVG. CG (IN) 340
 HH-53C USAF 67-14993
 AVG. ALT. (FT) 15000
 AVG. FRT (DEG C) -16.5
 ROTOR SPEED (RPM) 185
 AFCS COND. ON

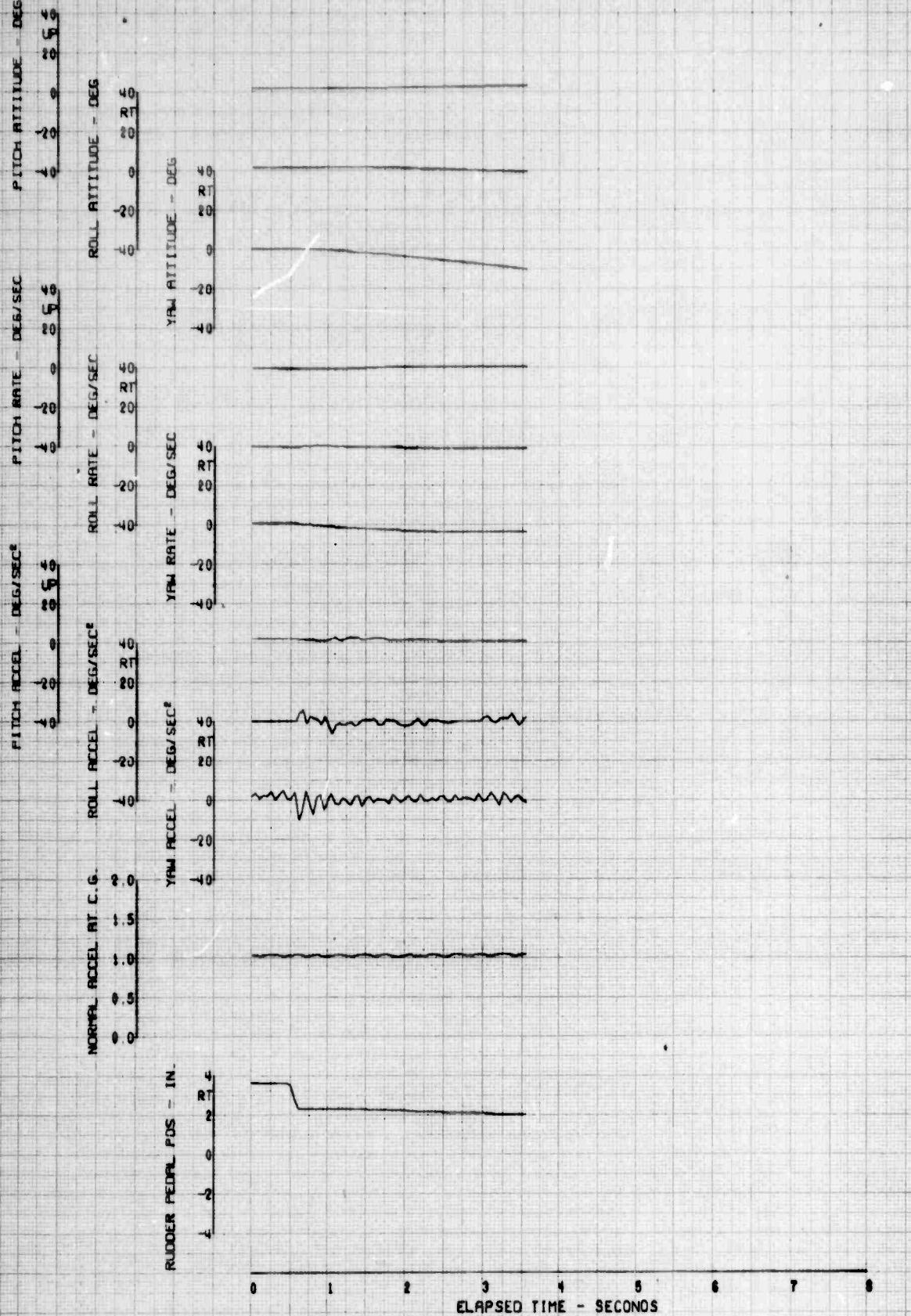


FIGURE 126. REACTION TO LEFT DIRECTIONAL STEP

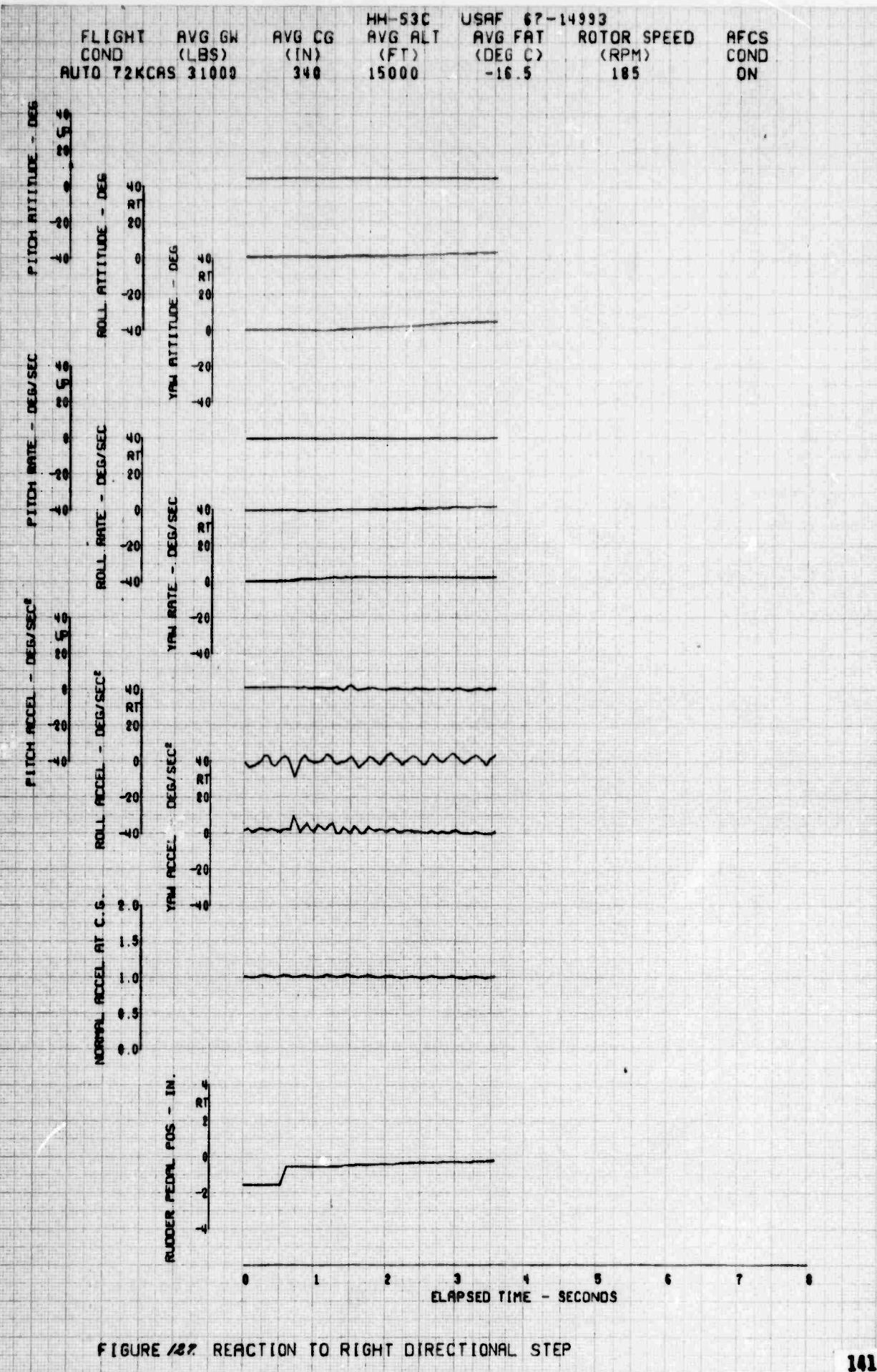
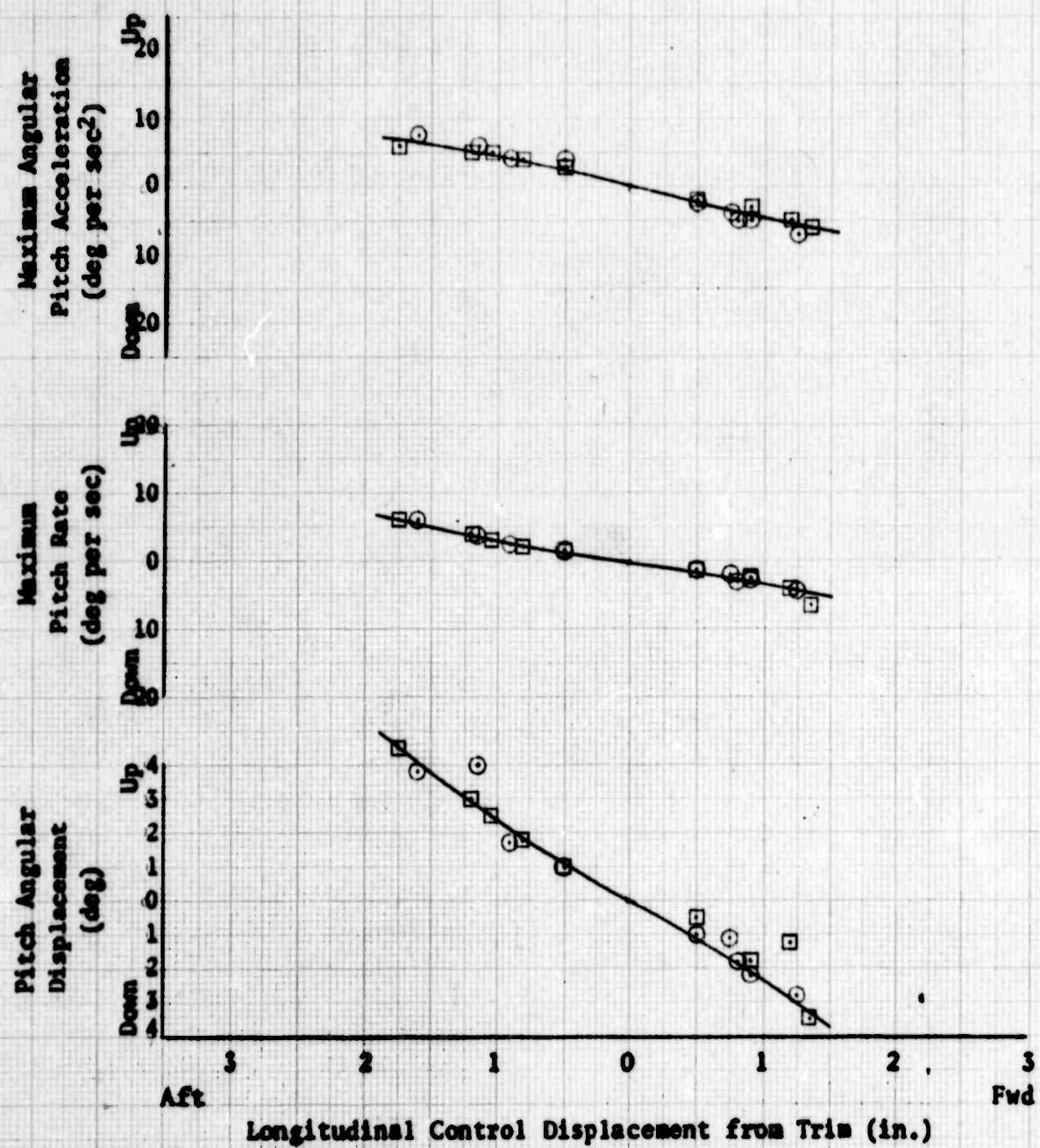


FIGURE 187. REACTION TO RIGHT DIRECTIONAL STEP

Sym	Flight Condition	Avg GM (lb)	cg (in.)	Avg Press. Alt (ft)	Avg FAD ($^{\circ}$ C)	Rotor Speed (rpm)	Trim A/S
	Climb	31,000	340	15,000	-16.5	185	AFCS ON (kt)
	Auto	31,000	340	15,000	-16.5	185	ON 72

Rotation



HH-53C USAF S/N 67-14993

Sym	Flight Condition	Avg GW (lb)	cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS	Trim A/S (kt)
○	Climb	31,000	340	15,000	-16.5	185	ON	62
□	Auto	31,000	340	15,000	-16.5	185	ON	72

Rotation

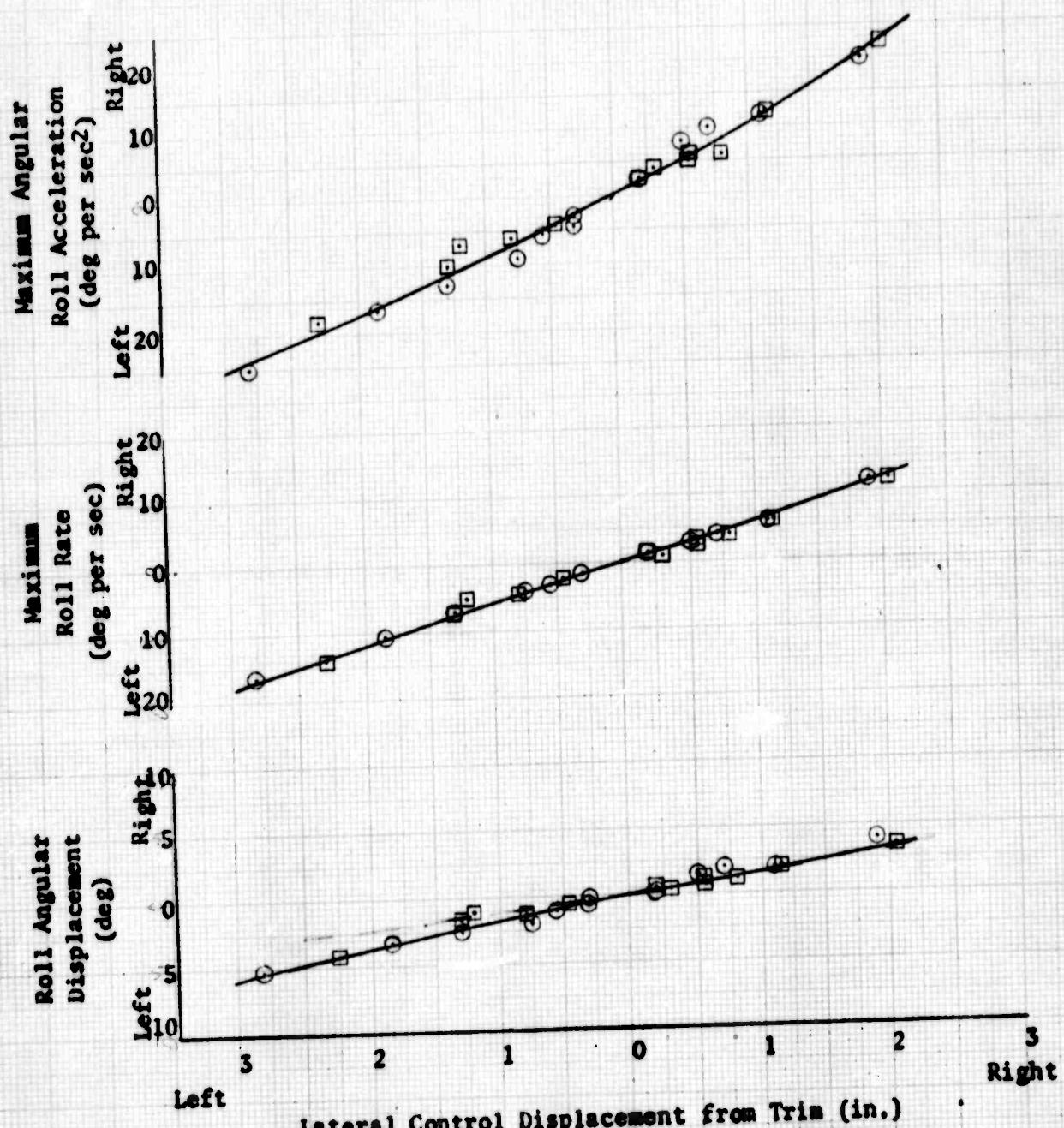


Figure 129. Lateral Controllability

HH-53C USAF S/N 67-14993

Sym	Flight Condition	Avg GW (lb)	cg (in.)	Avg Press. (ft)	Alt (ft)	Avg FAF (°C)	Rotor Speed (rpm)	AFCs	Trim A/S (kt)
O	Climb	31,000	340	15,000		-16.5	185	ON	62
□	Auto Rotation	31,000	340	15,000		-16.5	185	ON	72

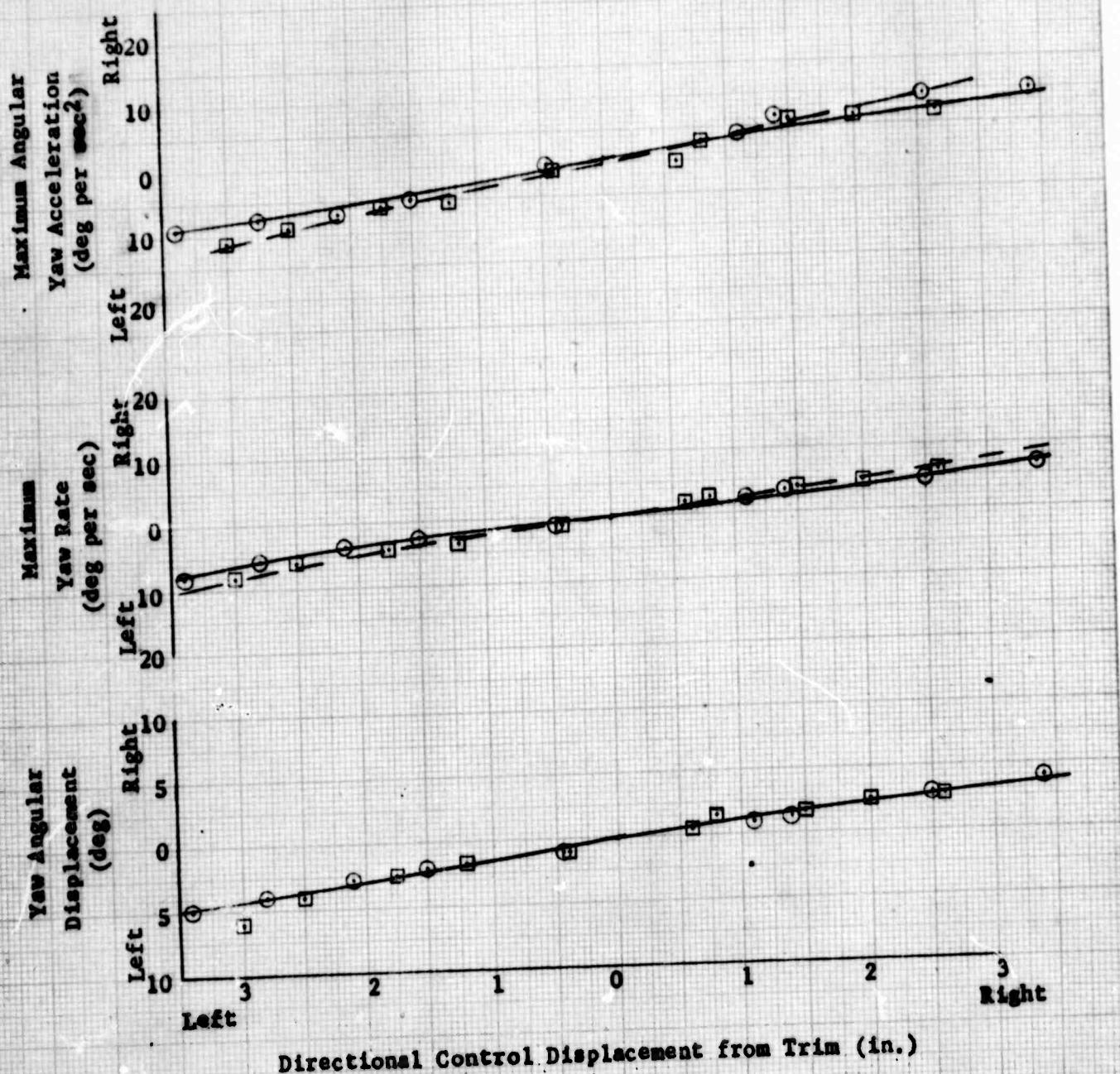


Figure 190. Directional Controllability

FLIGHT . AVG GW . AVG CG . AVG ALT . AVG FAT . ROTOR SPEED . AFCS
 COND (LBS) . (IN) . (FT) . (DEG C) . (RPM) . COND
 LF 113KGAS 41000 . 328 . 7000 . -18.0 . 185 . ON

EXTERNAL TANKS FULL

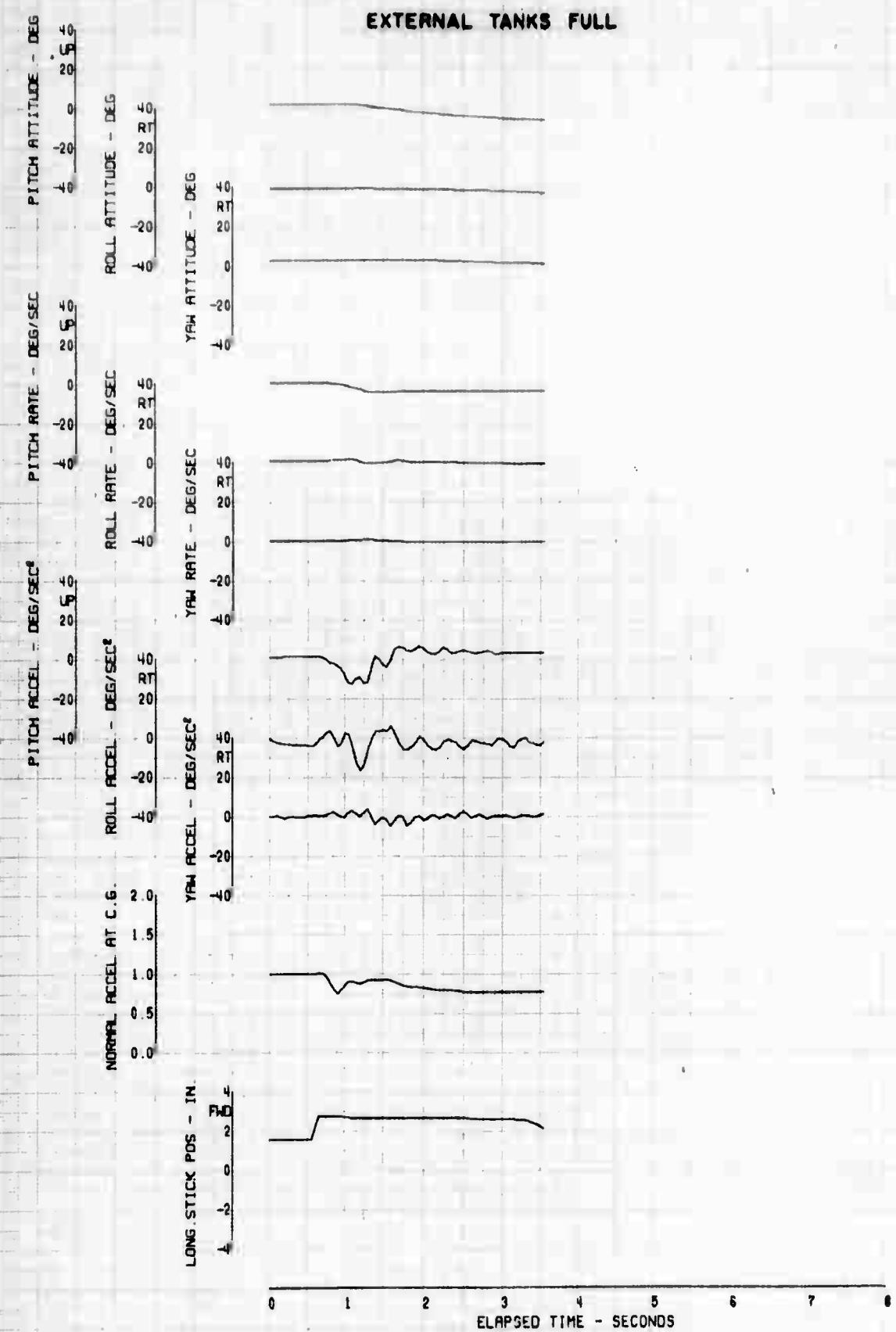


FIGURE 13% REACTION TO A FORWARD LONGITUDINAL STEP

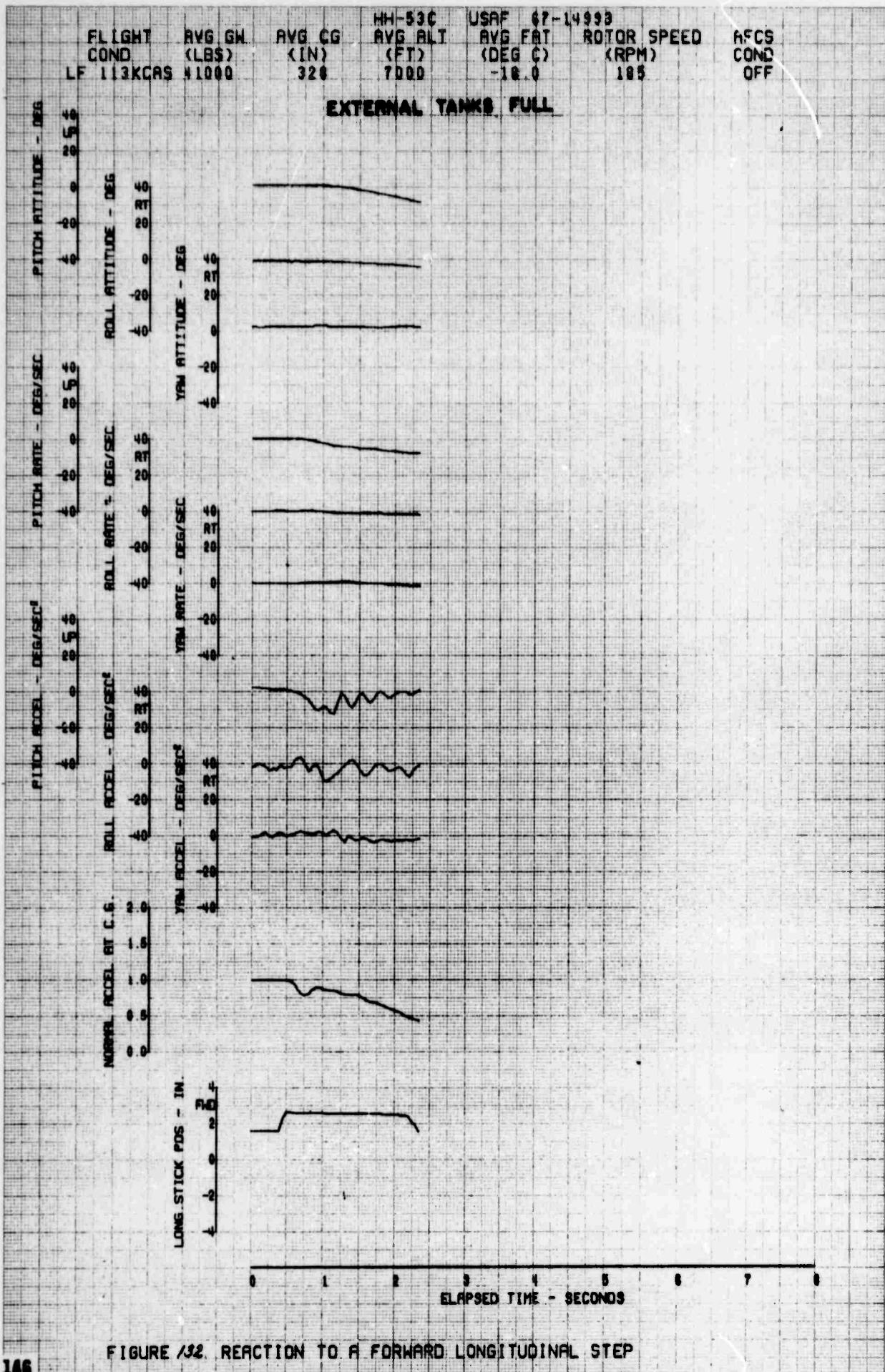


FIGURE 132. REACTION TO A FORWARD LONGITUDINAL STEP

FLIGHT COND LF 113KCAS
 AVG GW (LBS) 41000
 AVG CG (IN) 328
 AVG ALT (FT) 7000
 AVG FAT (DEG C) -18.0
 ROTOR SPEED (RPM) 185
 USAF 67-14993
 RFCS COND ON

EXTERNAL TANKS FULL

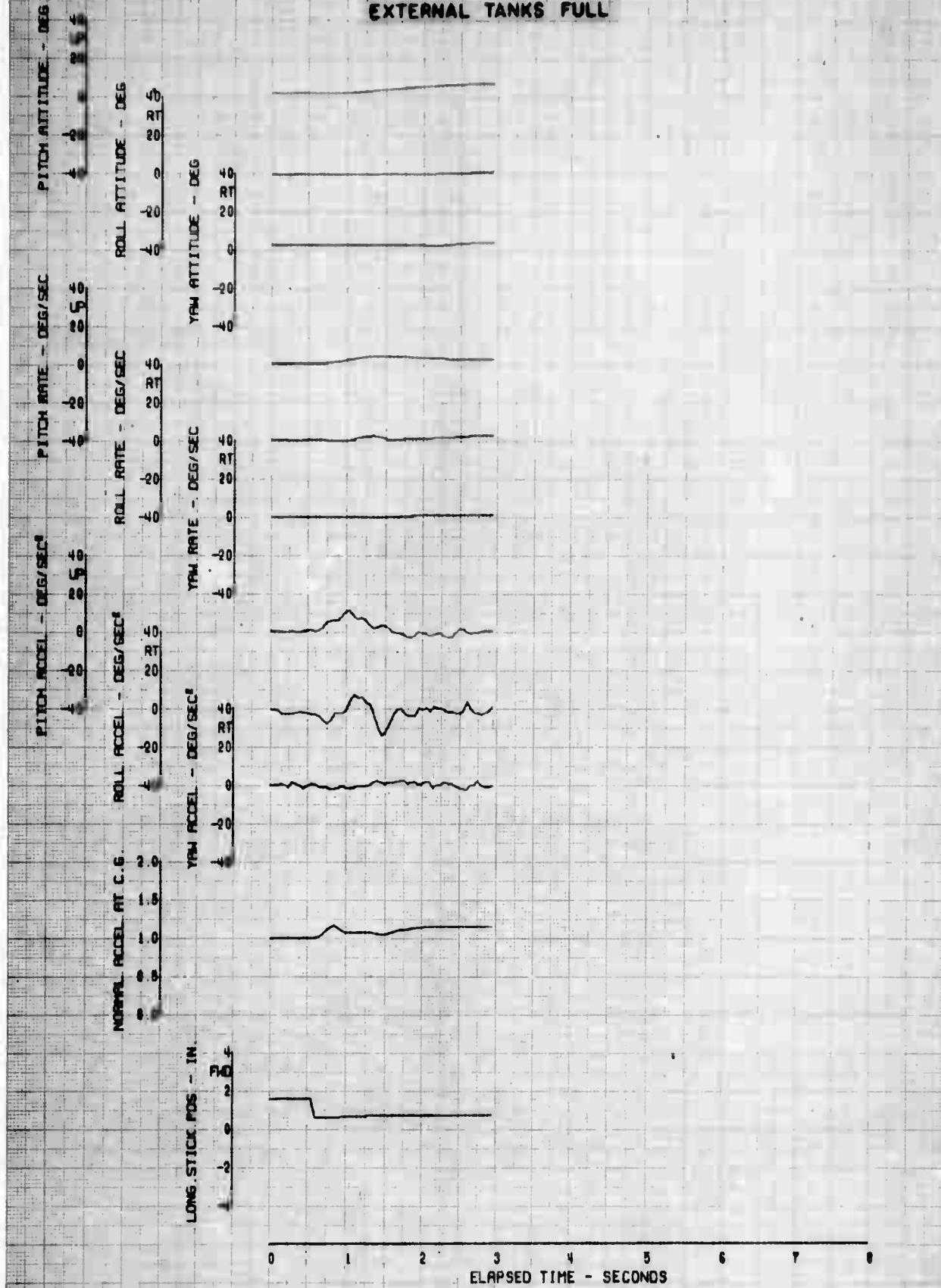


FIGURE 133. REACTION TO AN AFT LONGITUDINAL STEP.

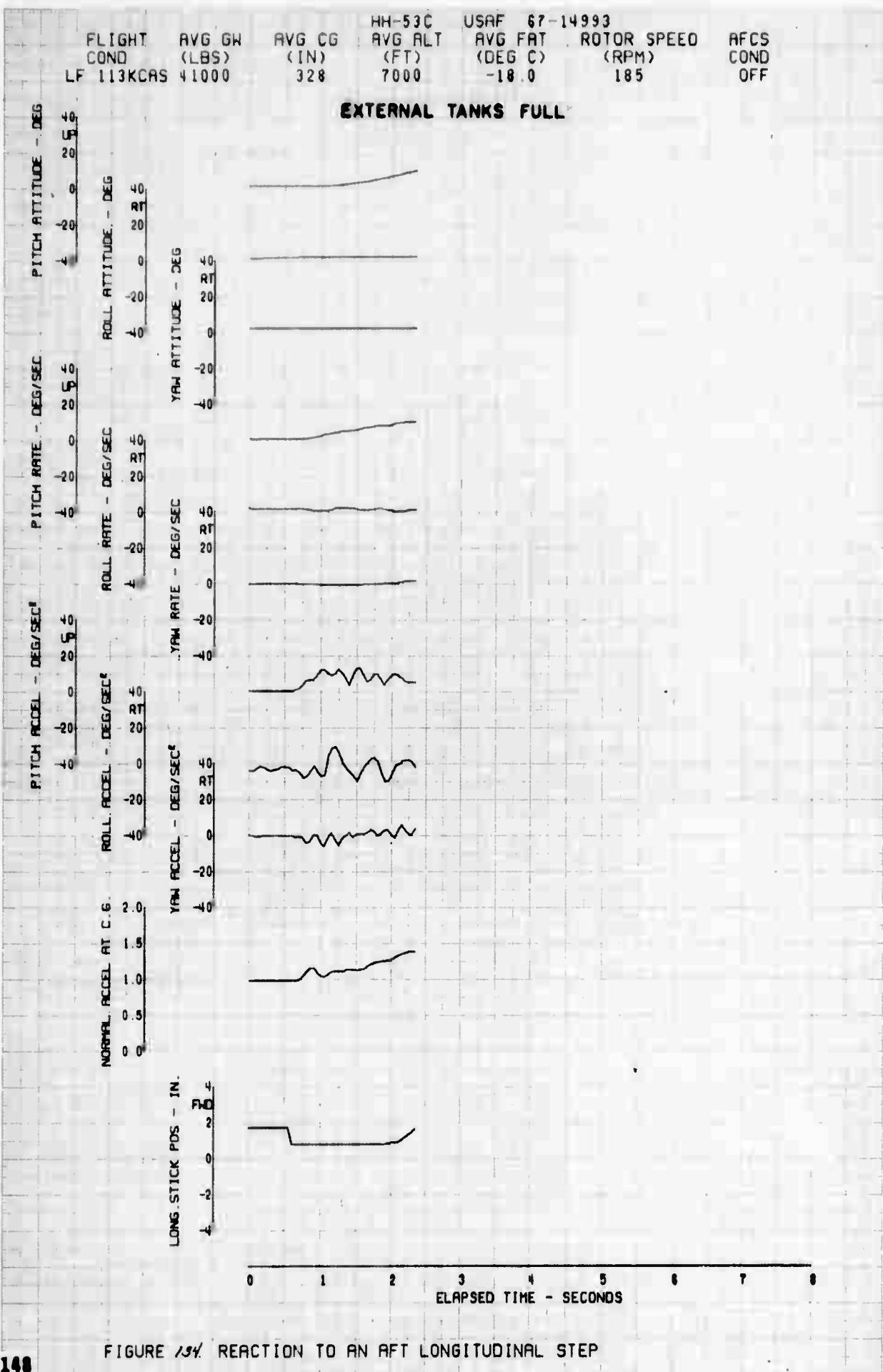


FIGURE 154 REACTION TO AN AFT LONGITUDINAL STEP

FLIGHT COND LF 113KCAS 41000 AVG GW (LBS) 328 AVG CG (IN) 328 HH-53C USAF 67-14993
 AVG ALT (FT) 7000 AVG FAT (DEG C) -18.0 ROTOR SPEED (RPM) 185
 RFCS COND ON

EXTERNAL TANKS FULL

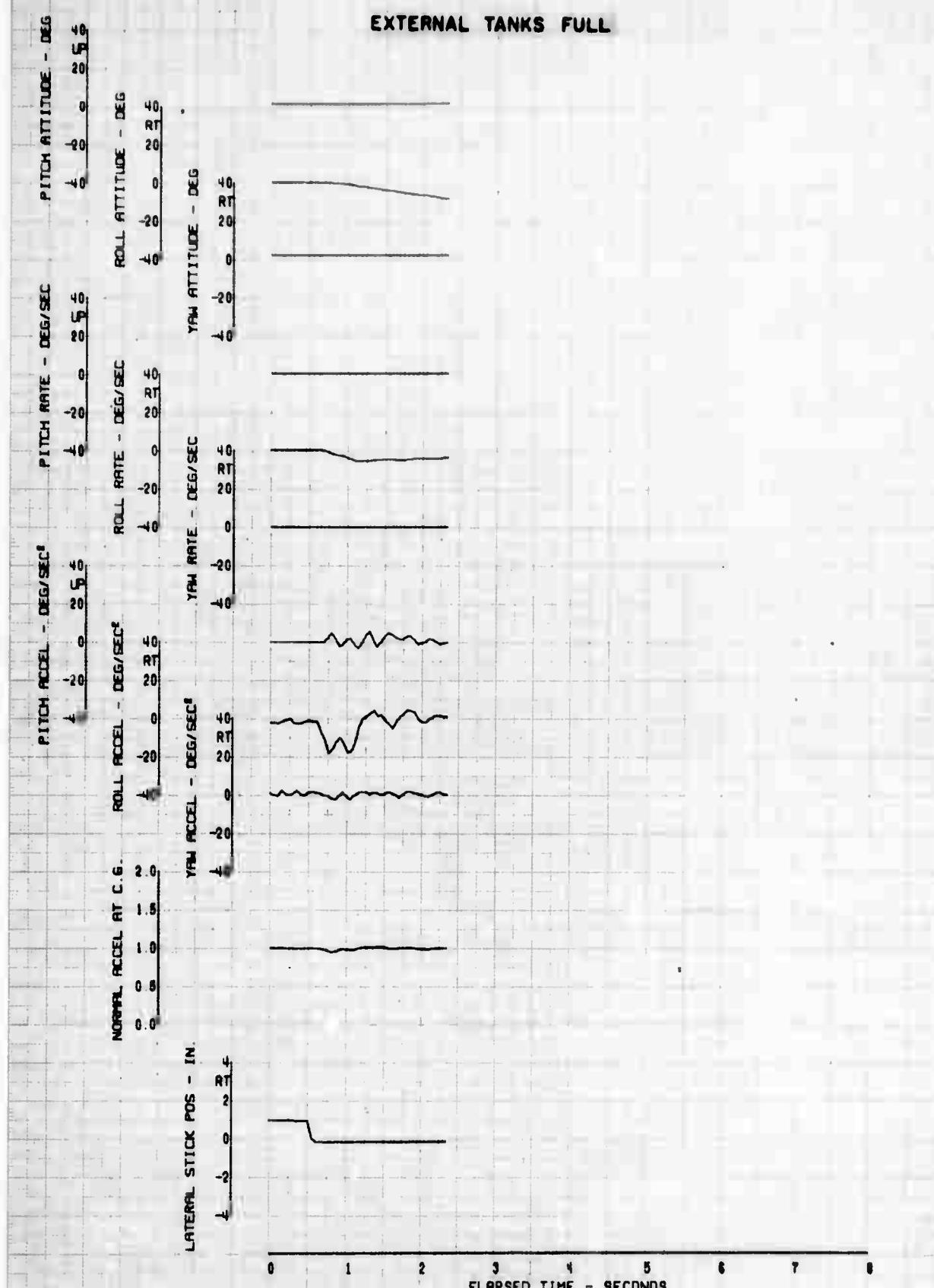


FIGURE 105' REACTION TO A LEFT LATERAL STEP

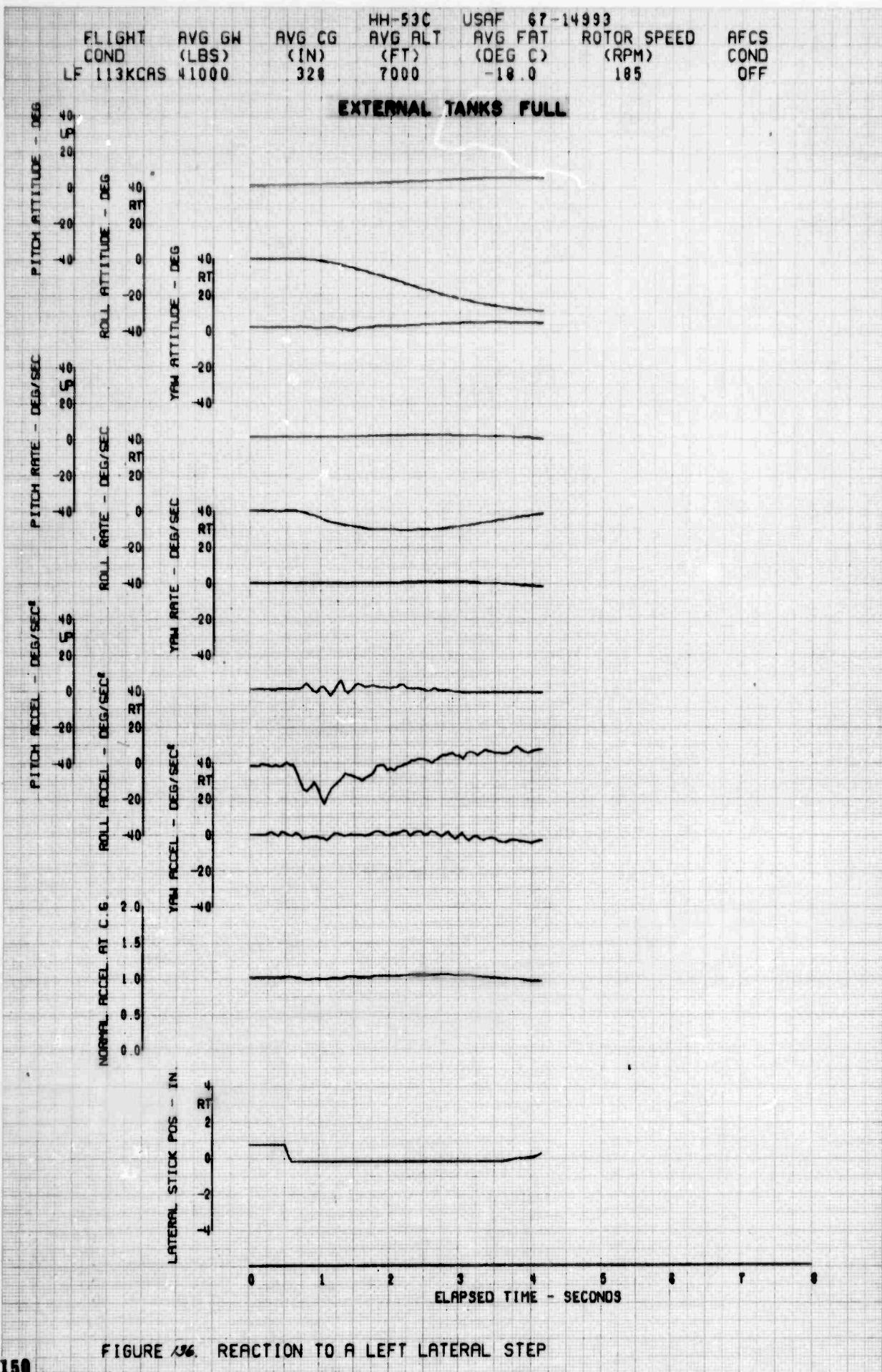


FIGURE 156. REACTION TO A LEFT LATERAL STEP

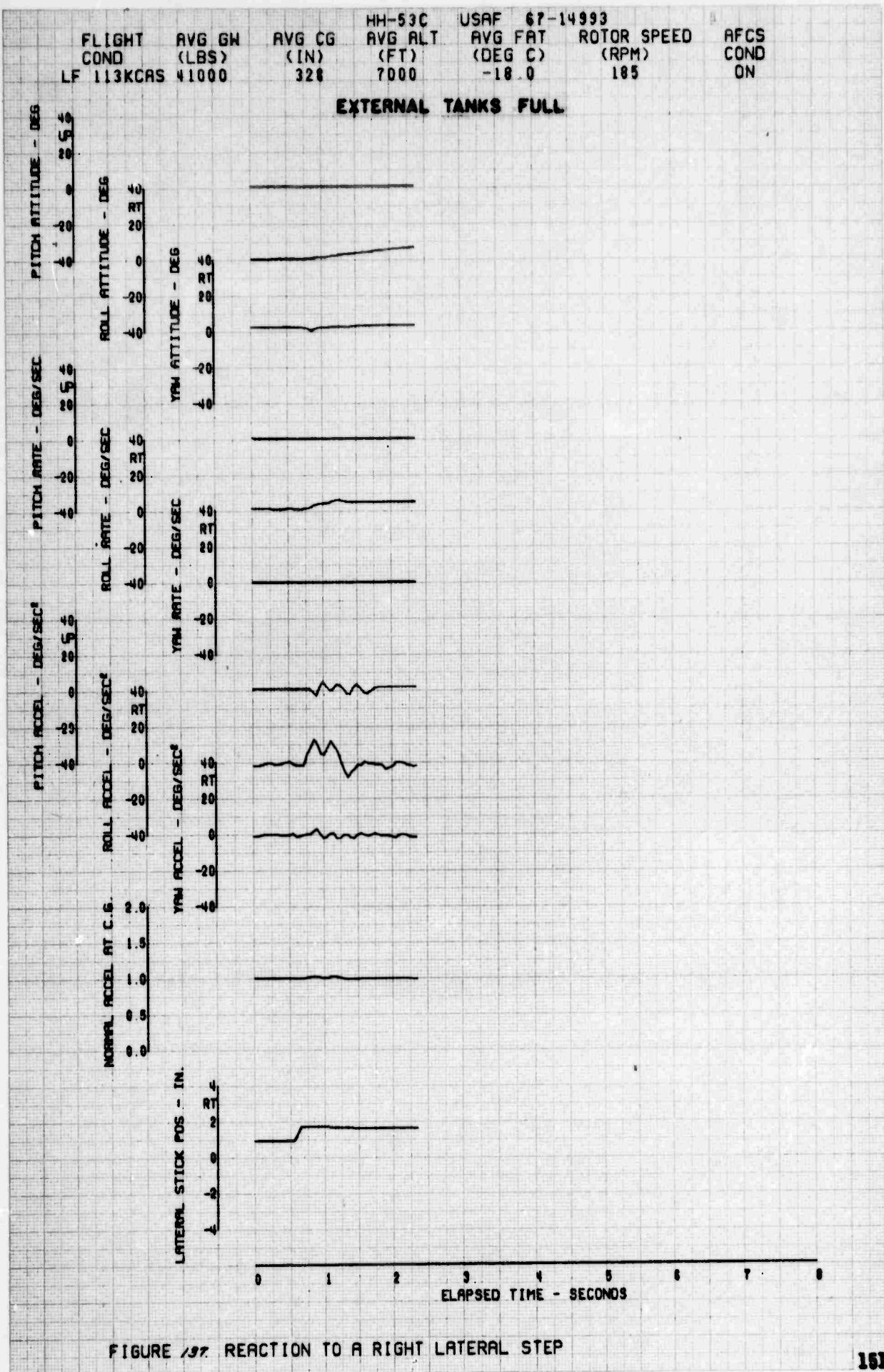


FIGURE 197. REACTION TO A RIGHT LATERAL STEP

FLIGHT COND. LF 113KCRS
 AVG GW (LBS) 41000
 AVG CG (IN) 328
 AVG ALT (FT) 7000
 AVG FAT (DEG C) -18.0
 ROTOR SPEED (RPM) 185
 AFCS COND OFF

EXTERNAL TANKS FULL

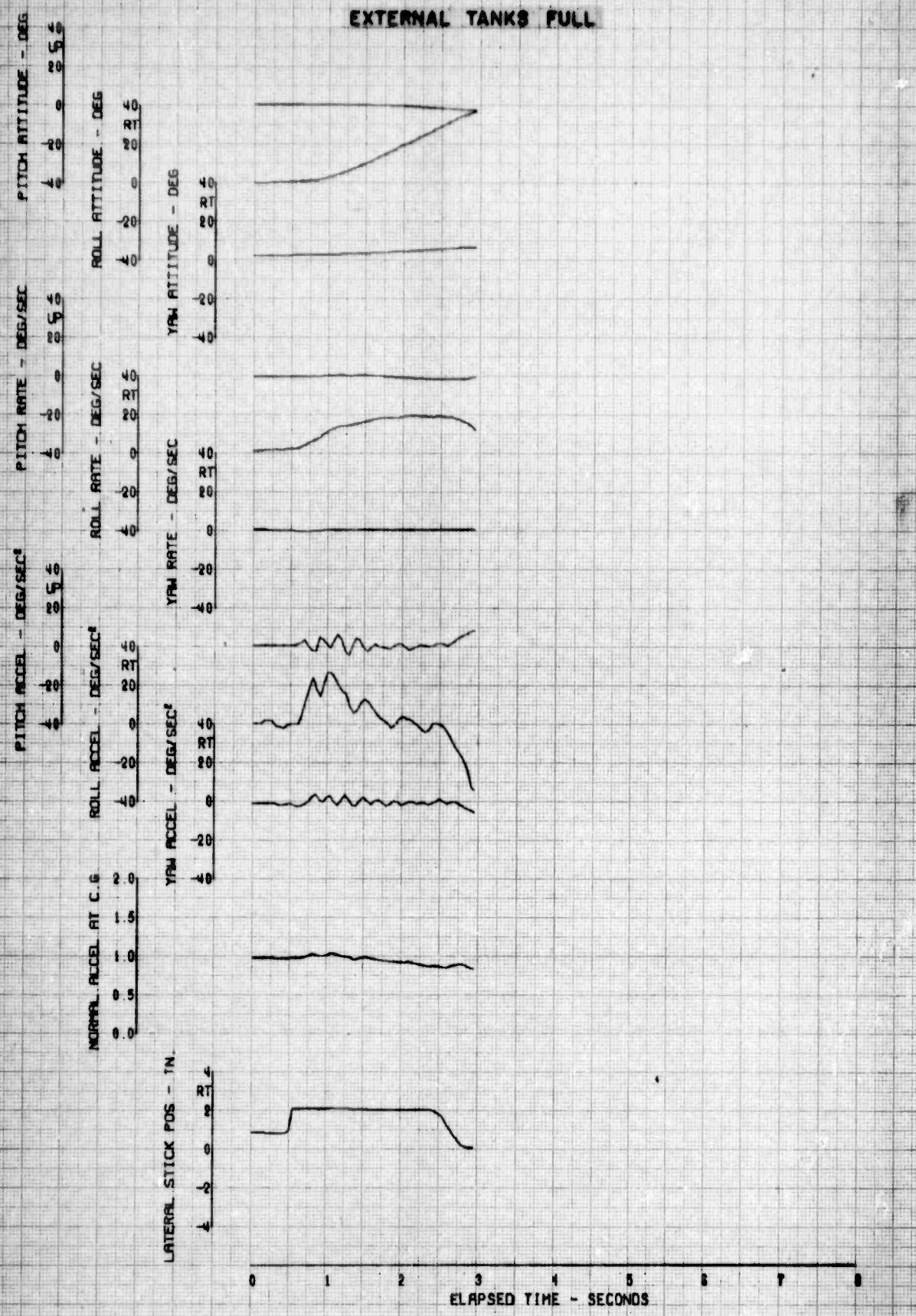
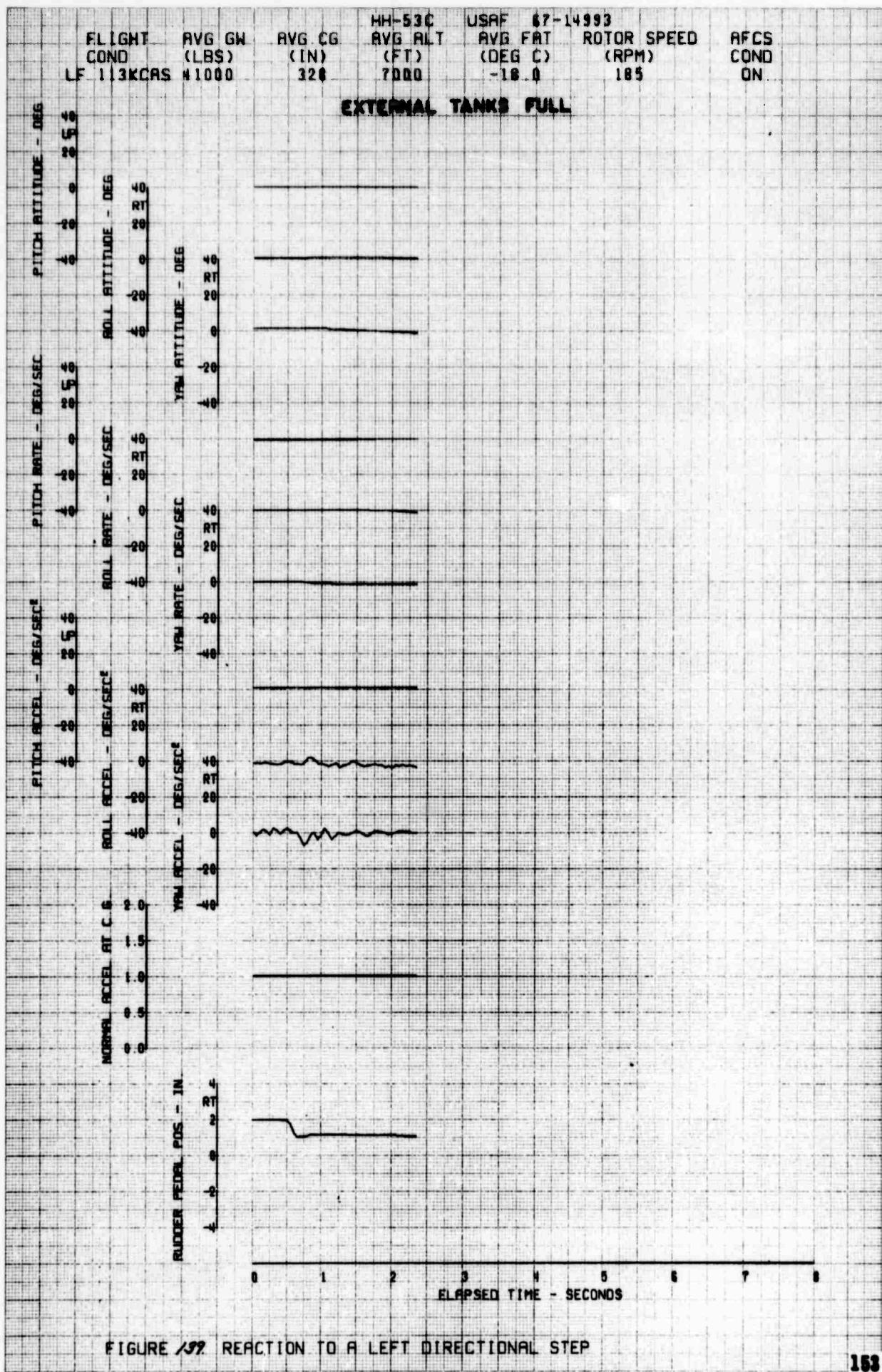


FIGURE 190 REACTION TO A RIGHT LATERAL STEP



FLIGHT HH-53C USAF 67-14993
 COND COND
 LF 113KCAS 41000 AVG GW AVG CG AVG ALT AVG FWT ROTOR SPEED
 (LBS) (IN) (FT) (DEG C) (RPM)
 328 7000 -18.0 185
 RFCS COND
 ON

EXTERNAL TANKS FULL

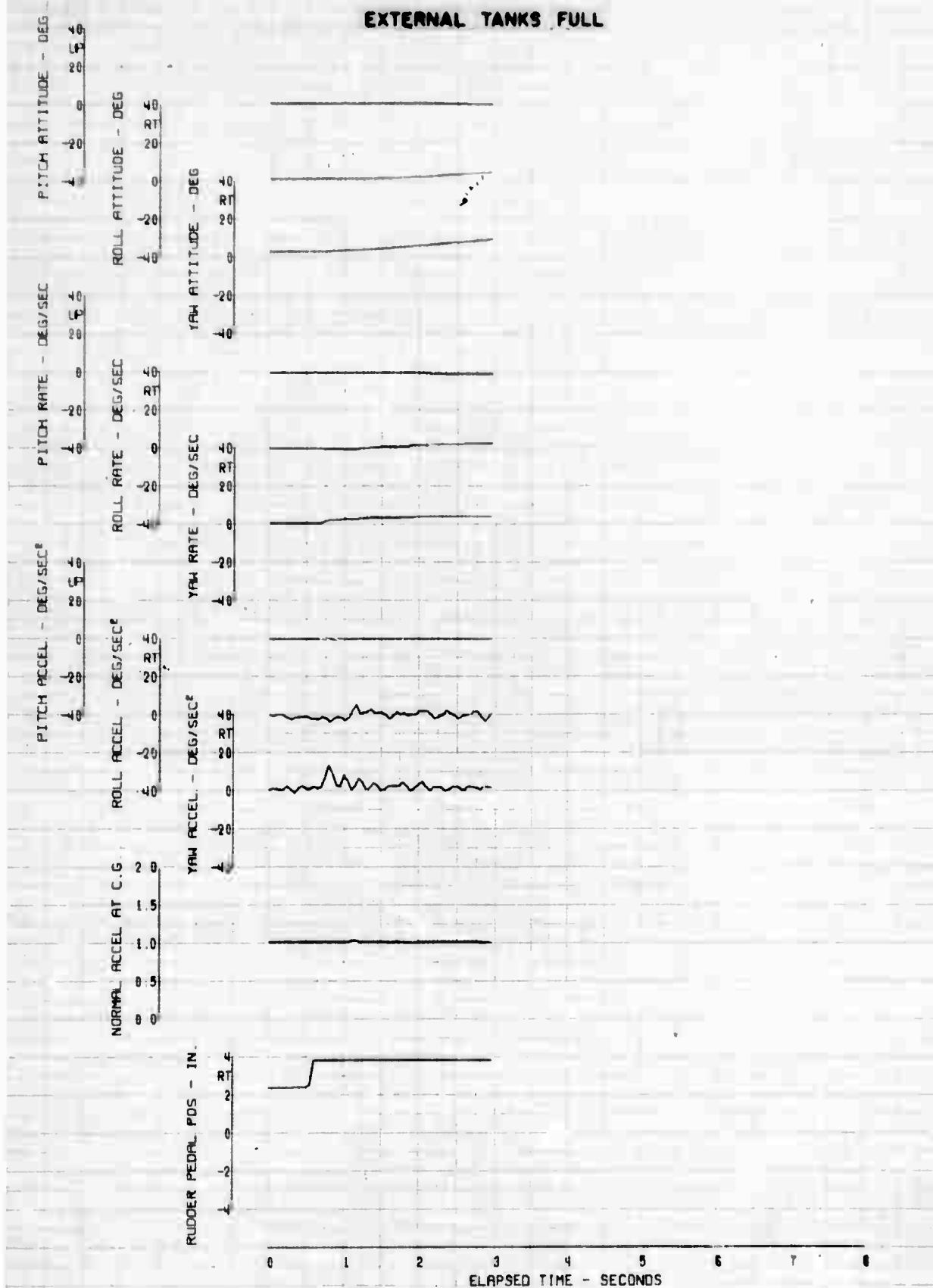


FIGURE 140. REACTION TO A RIGHT DIRECTIONAL STEP

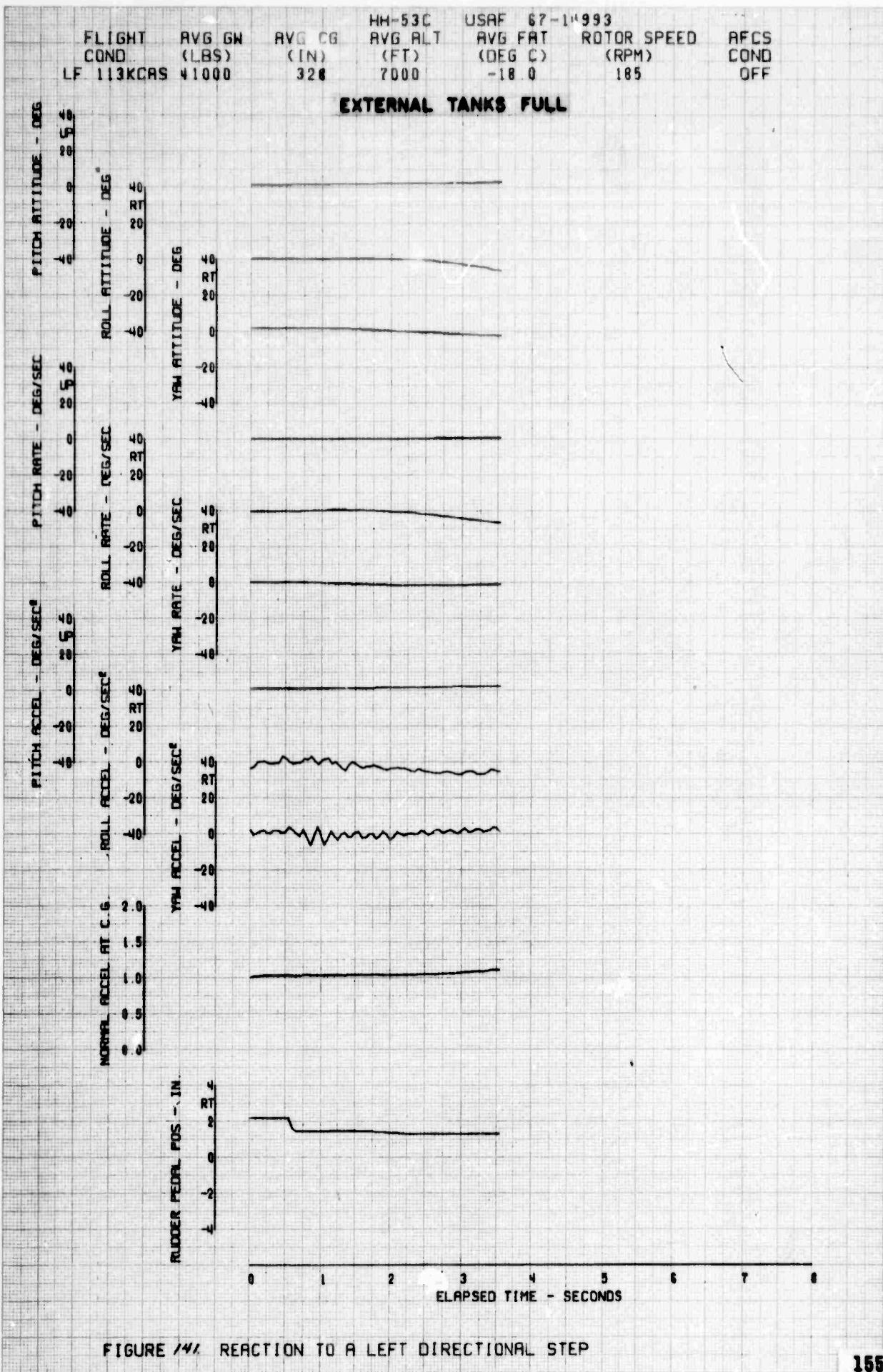


FIGURE 141 REACTION TO A LEFT DIRECTIONAL STEP

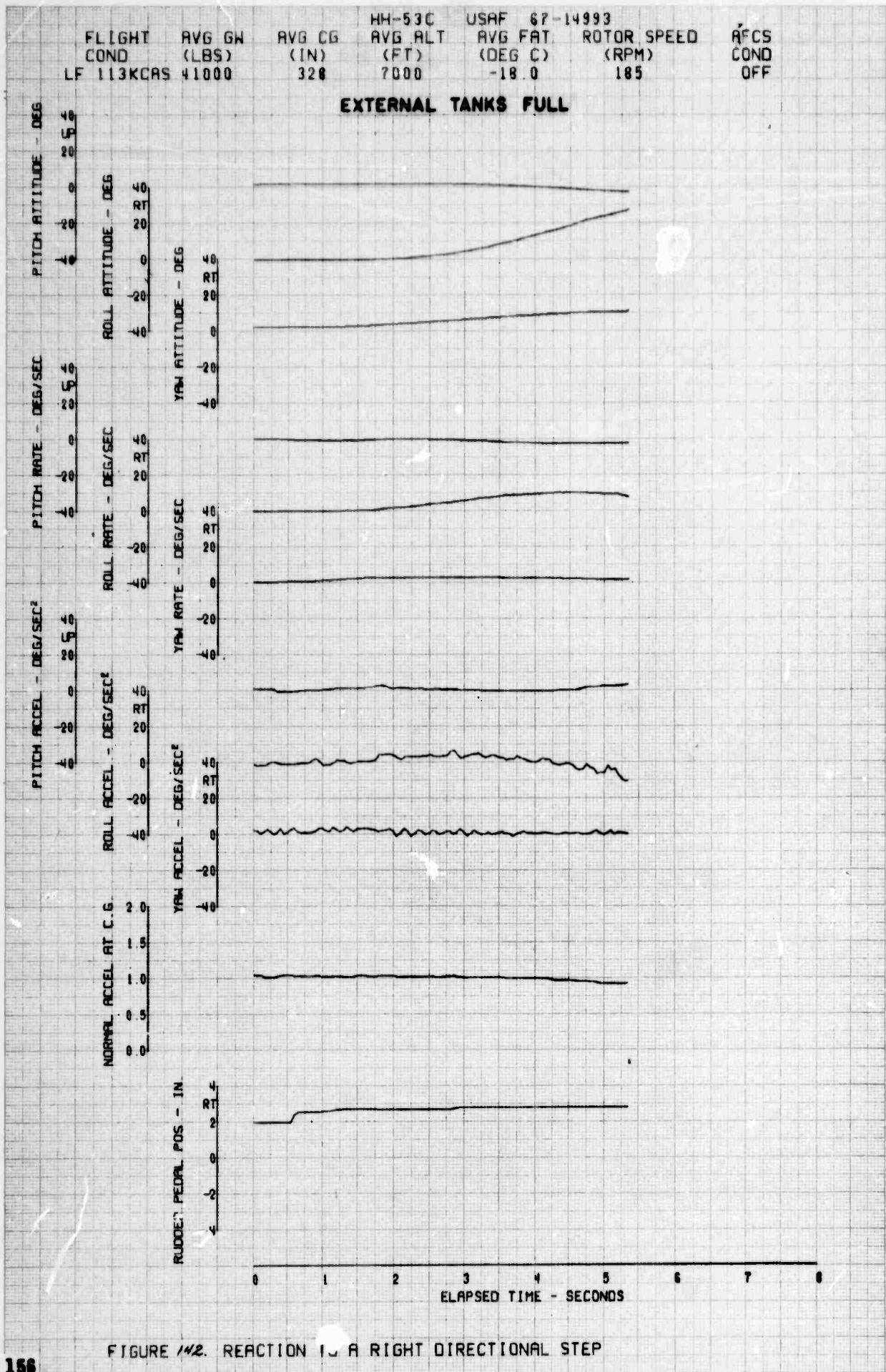


FIGURE 142. REACTION TO A RIGHT DIRECTIONAL STEP

Sym	Flight Condition	Avg GM (lb)	cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS ON	Trim A/S (kt)
○	Level Flight	41,000	328	7,000	-18	185	ON	113
□	Level Flight	41,000	328	7,000	-18	185	OFF	113

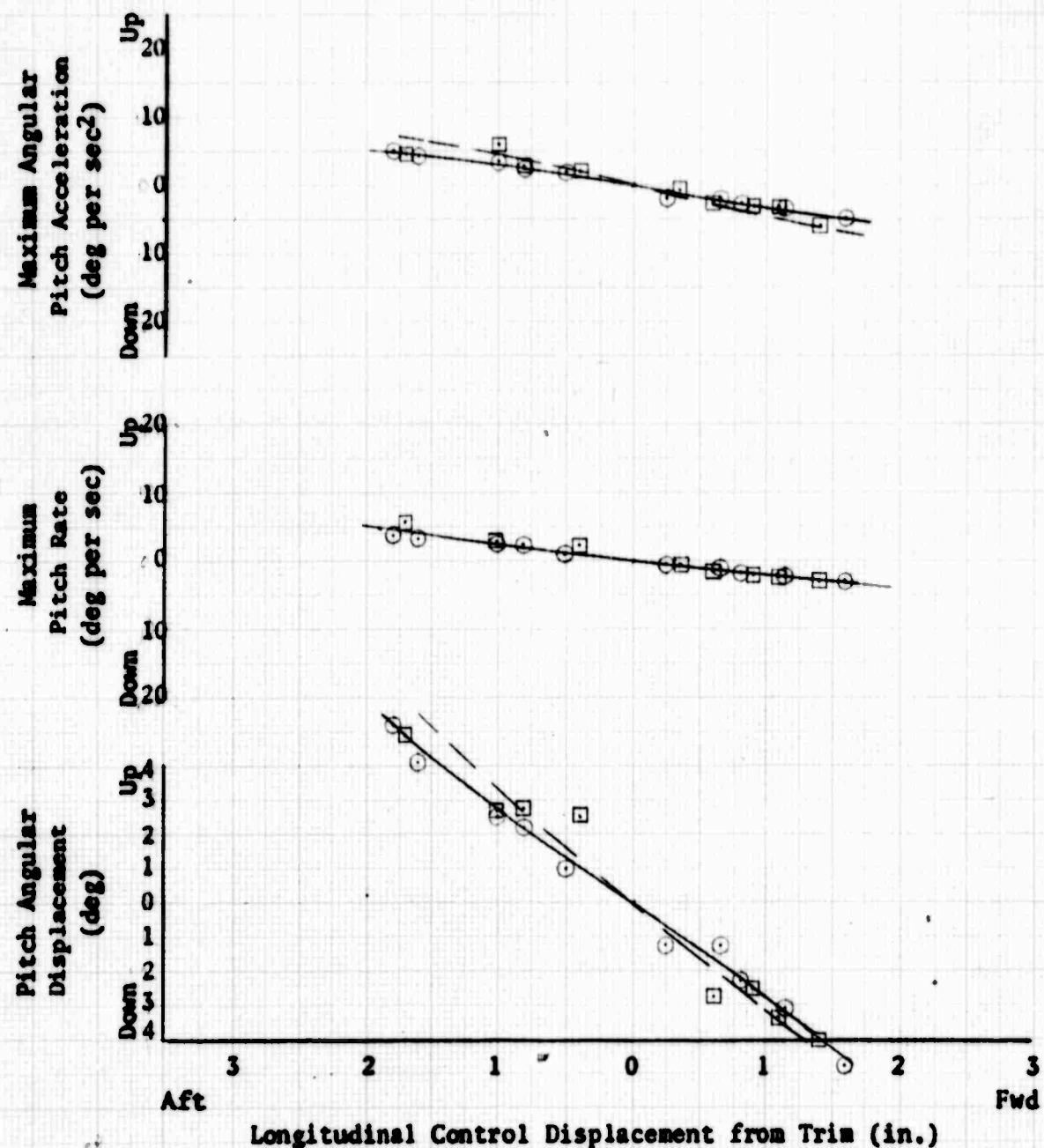
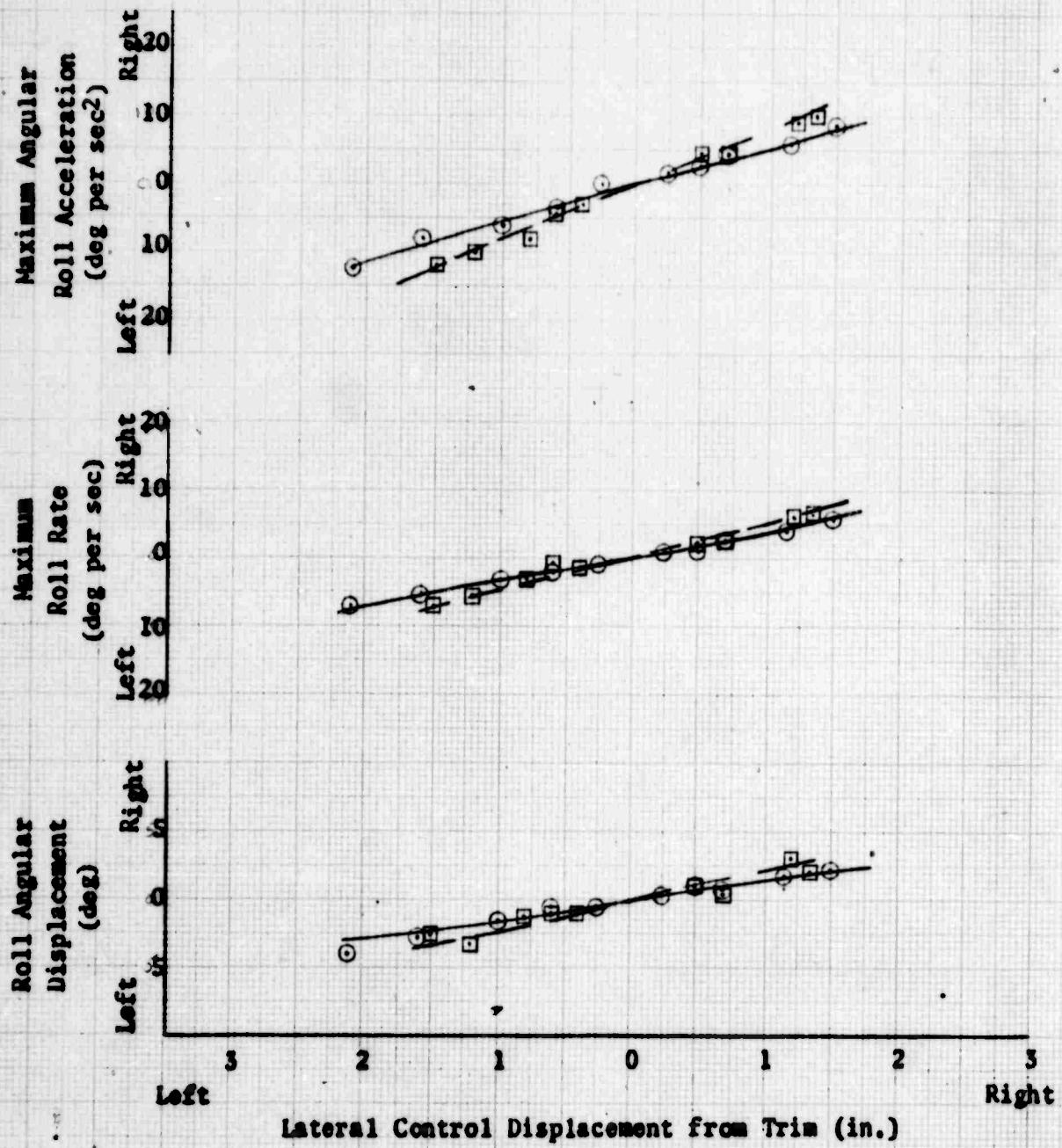


Figure 143. Longitudinal Controllability

Sym	Flight Condition	Avg GW (lb)	cg (in.)	Avg Press. Alt (ft)	Avg FAT ($^{\circ}$ C)	Rotor Speed (rpm)	AFCS	Trim A/S (kt)
○	Level Flight	41,000	328	7,000	-18	185	ON	113
□	Level Flight	41,000	328	7,000	-18	185	OFF	113



Sym Condition	Avg GW (lb)	cg (in.)	Avg Press. Alt (ft)	Avg FAT (°C)	Rotor Speed (rpm)	AFCS	Trim A/S (kt)
○ Level Flight	41,000	328	7,000	-18	185	ON	113
□ Level Flight	41,000	328	7,000	-18	185	OFF	113

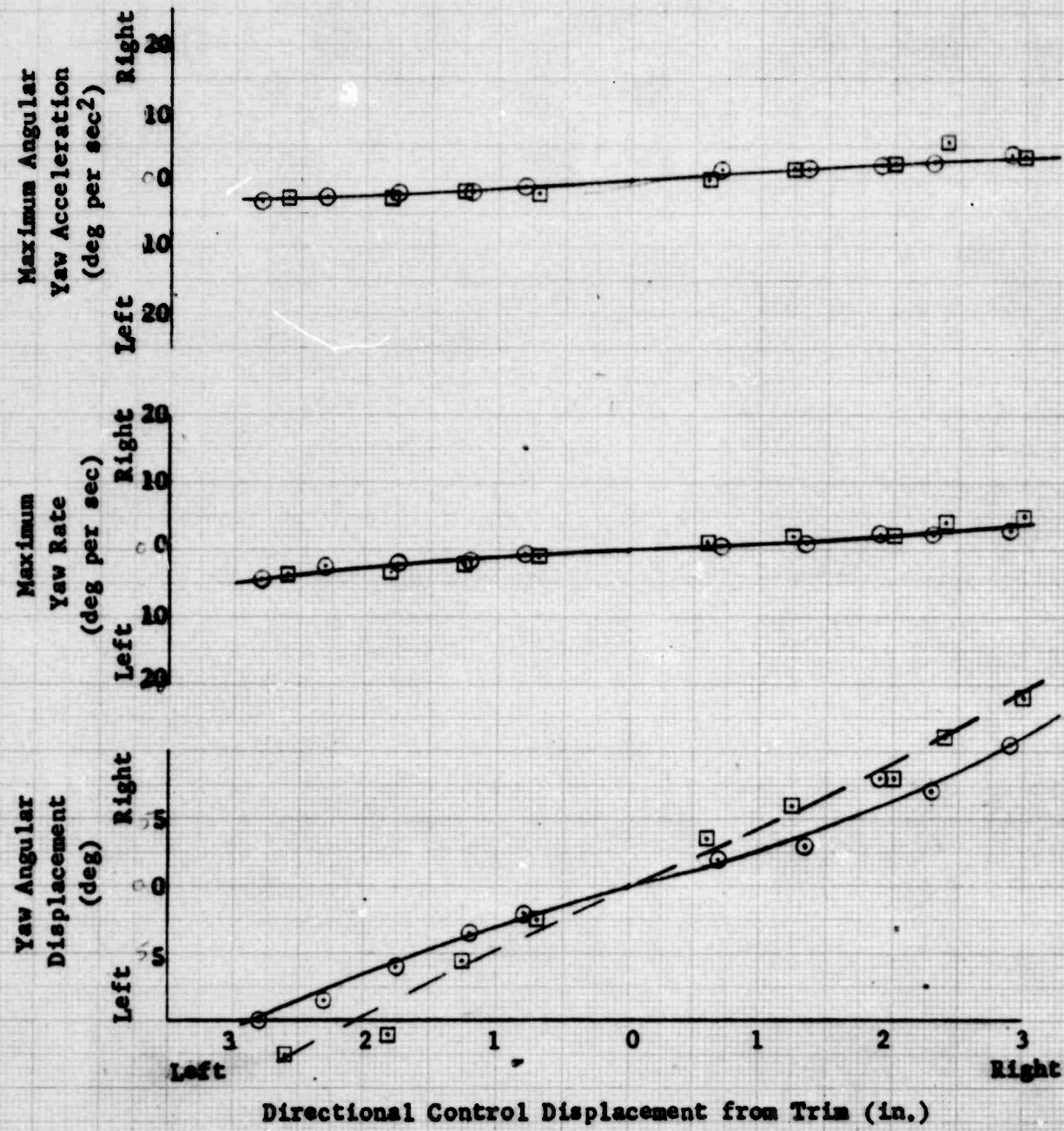


Figure 146. Directional Controllability

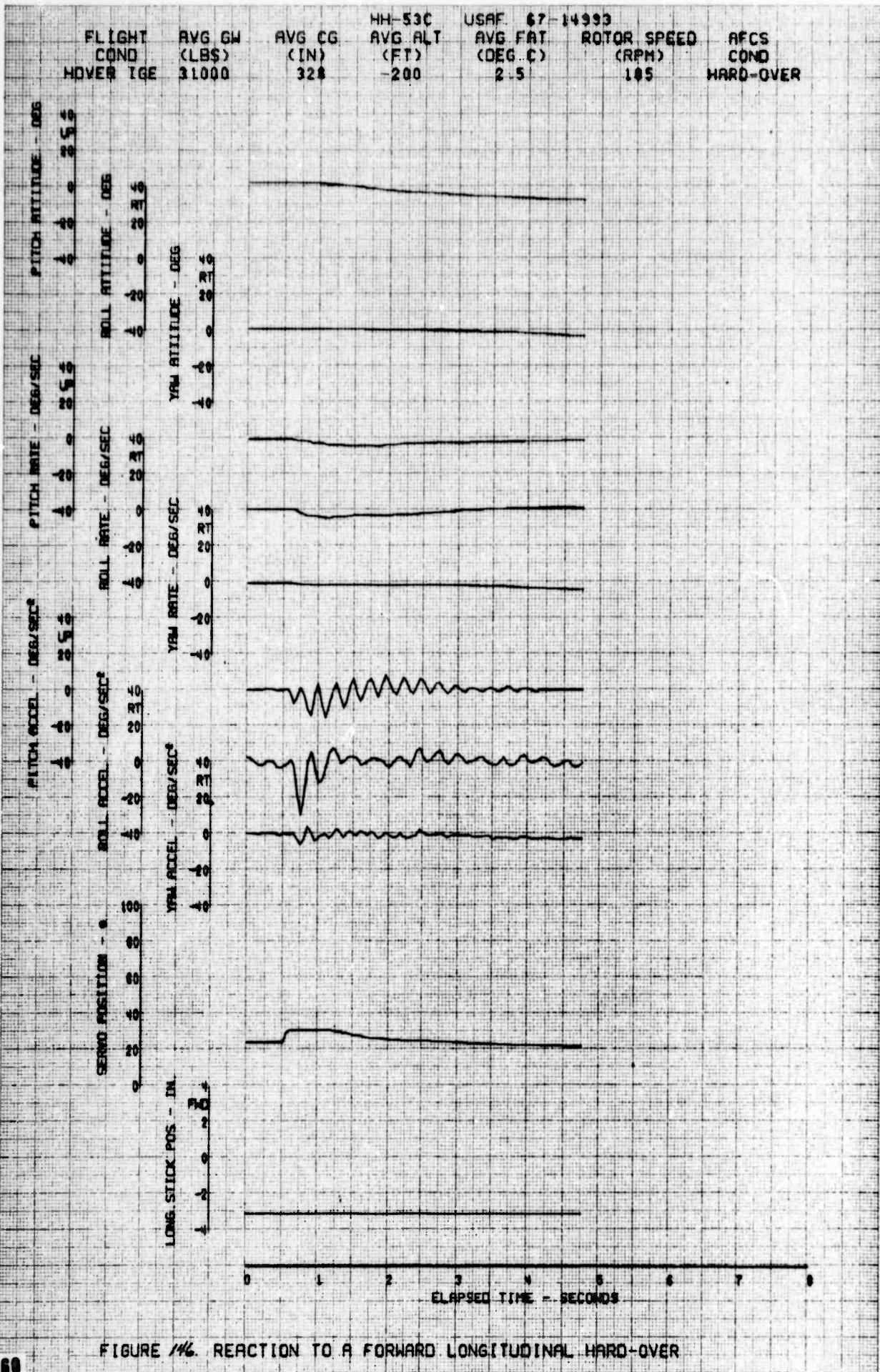


FIGURE 146. REACTION TO A FORWARD LONGITUDINAL HARD-OVER

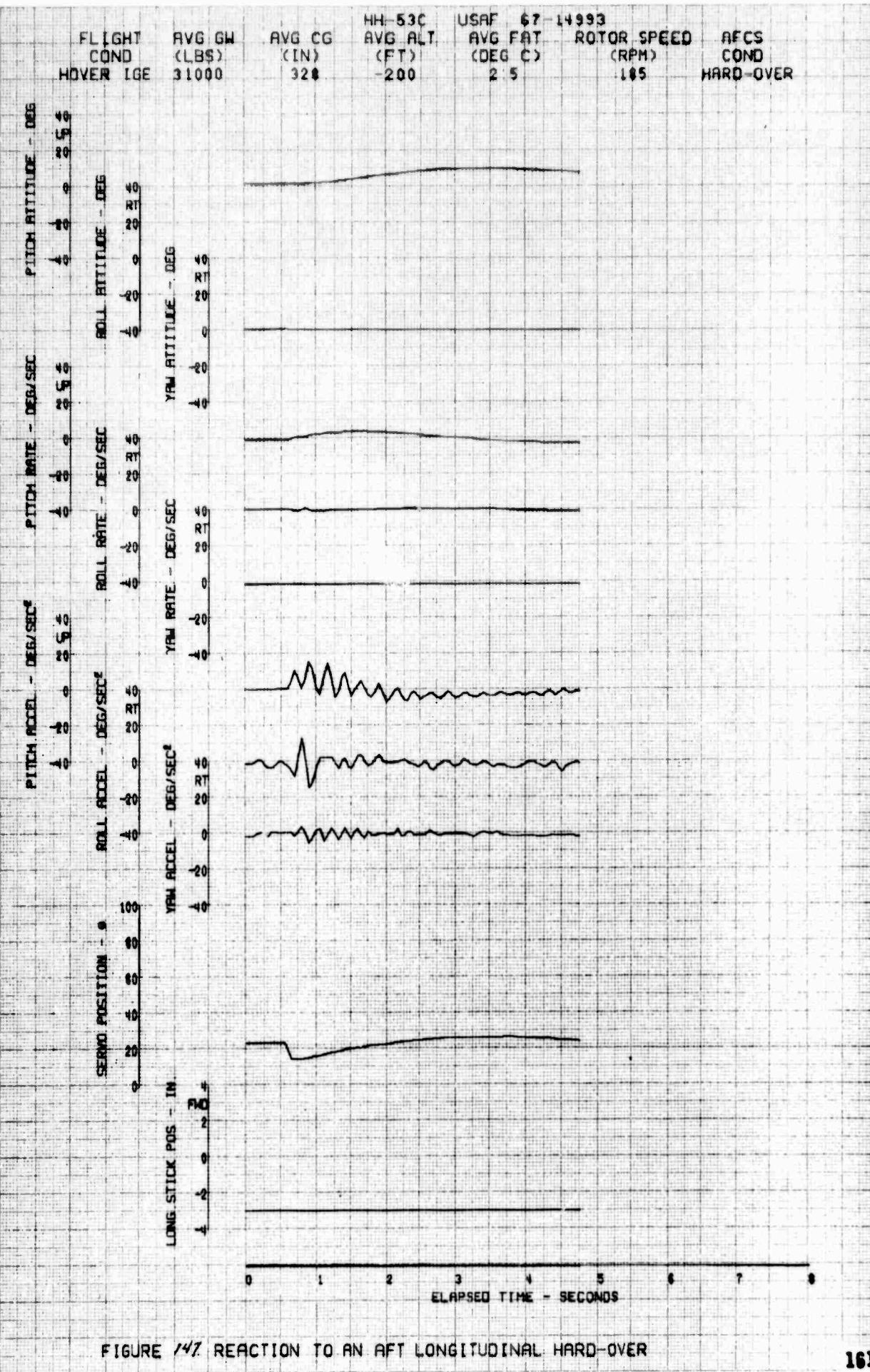


FIGURE 147. REACTION TO AN AFT LONGITUDINAL HARD-OVER

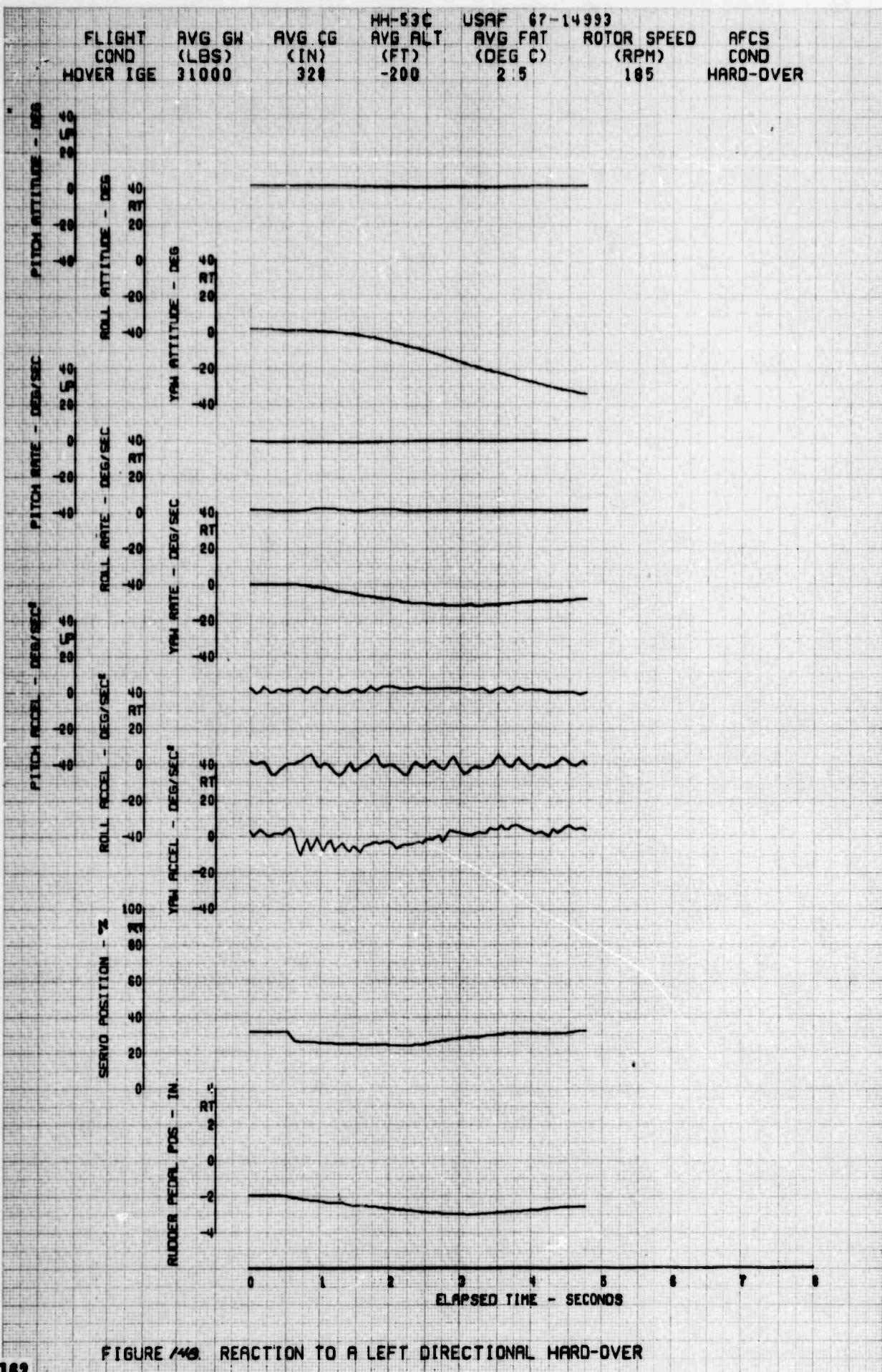


FIGURE 140. REACTION TO A LEFT DIRECTIONAL HARD-OVER

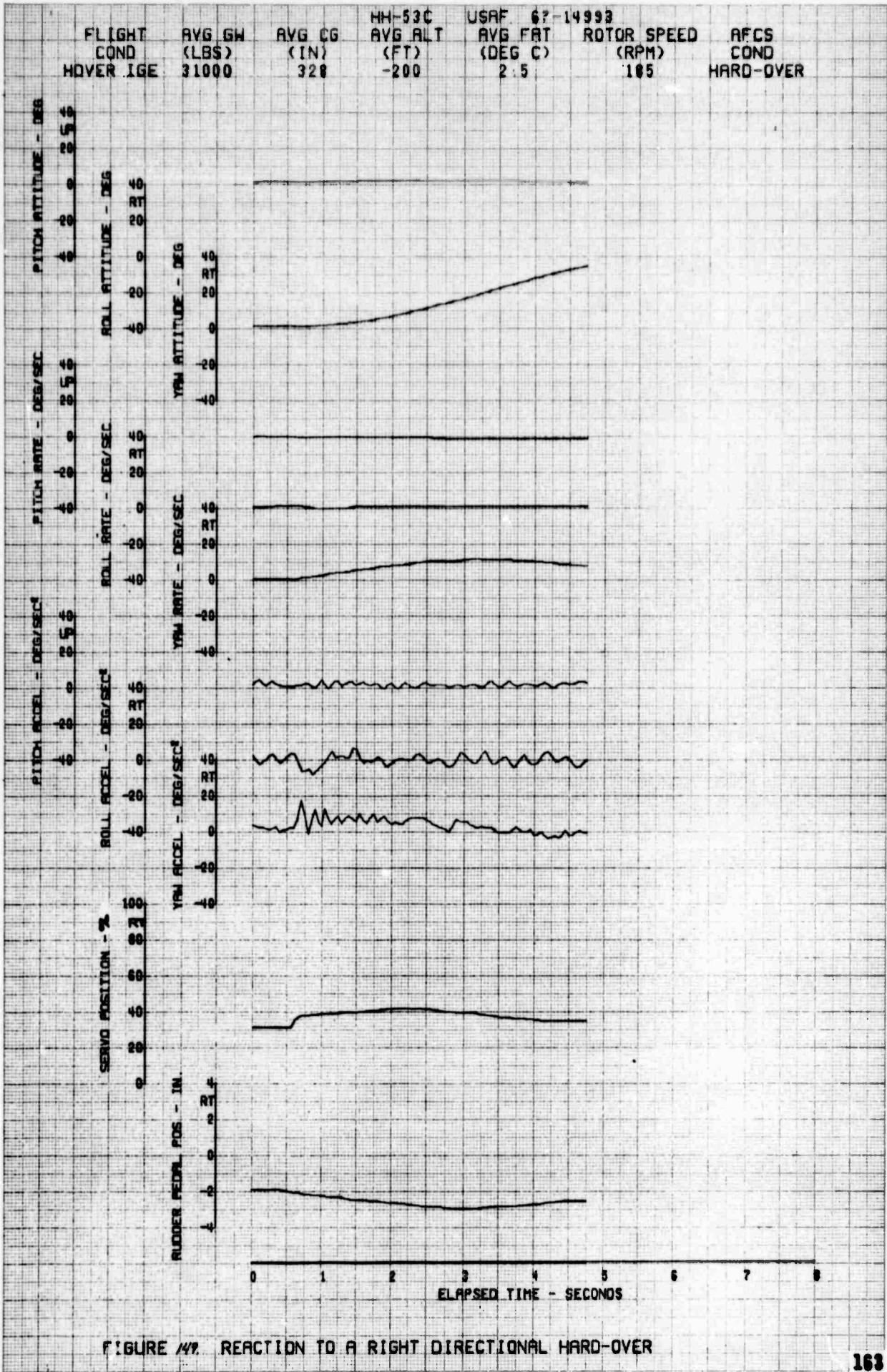


FIGURE 149. REACTION TO A RIGHT DIRECTIONAL HARD-OVER

FLIGHT AVG BN AVG CG AVG ALT AVG FST MOTOR SPEED APCS
 COND (LBS) (IN) (FT) (DEG C) (RPM) COND
 CL 17 KCAS 31000 328 5500 -0.5 185 HARD-OVER

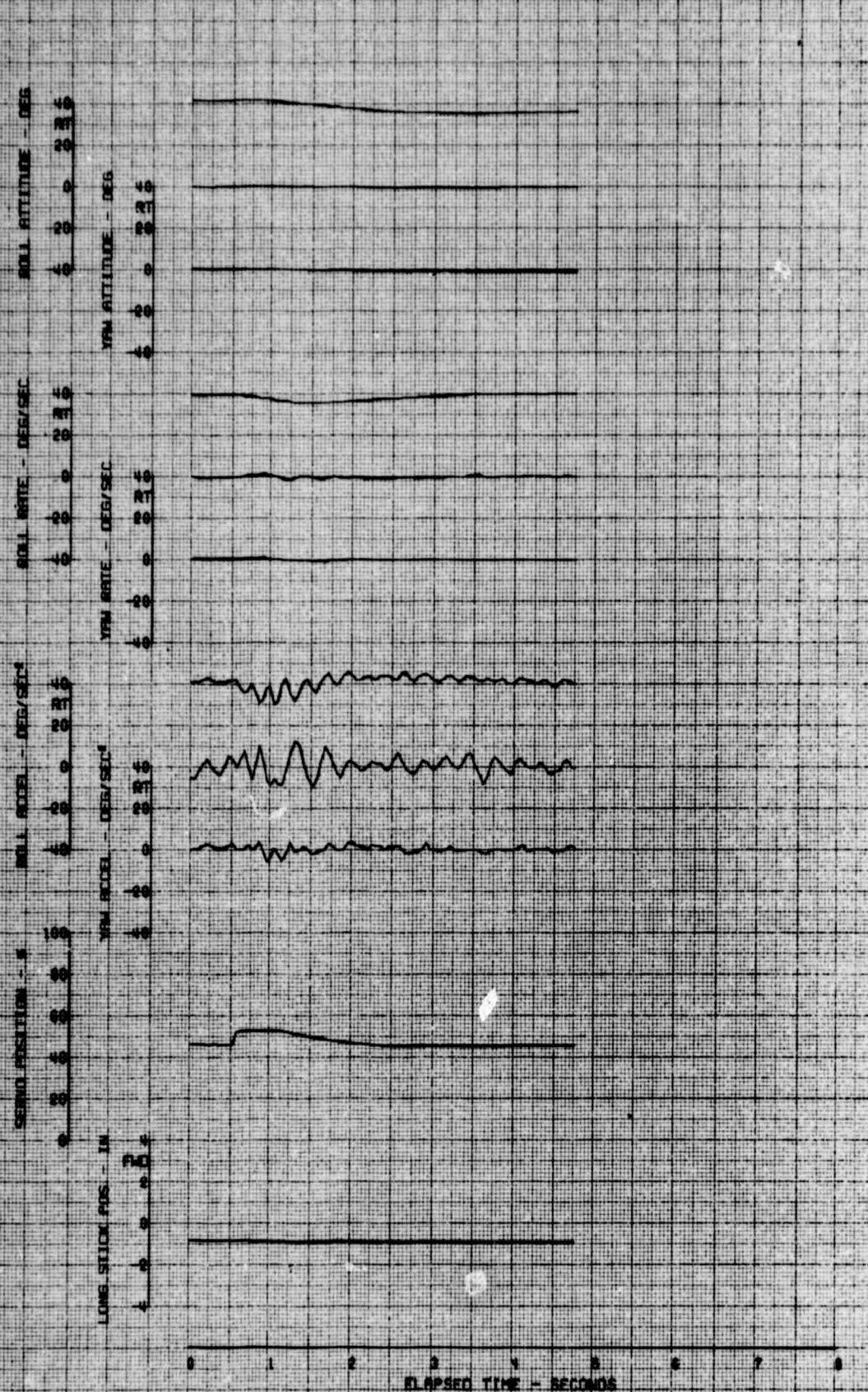


FIGURE A-2. REACTION TO A FORWARD LONGITUDINAL HARD-OVER

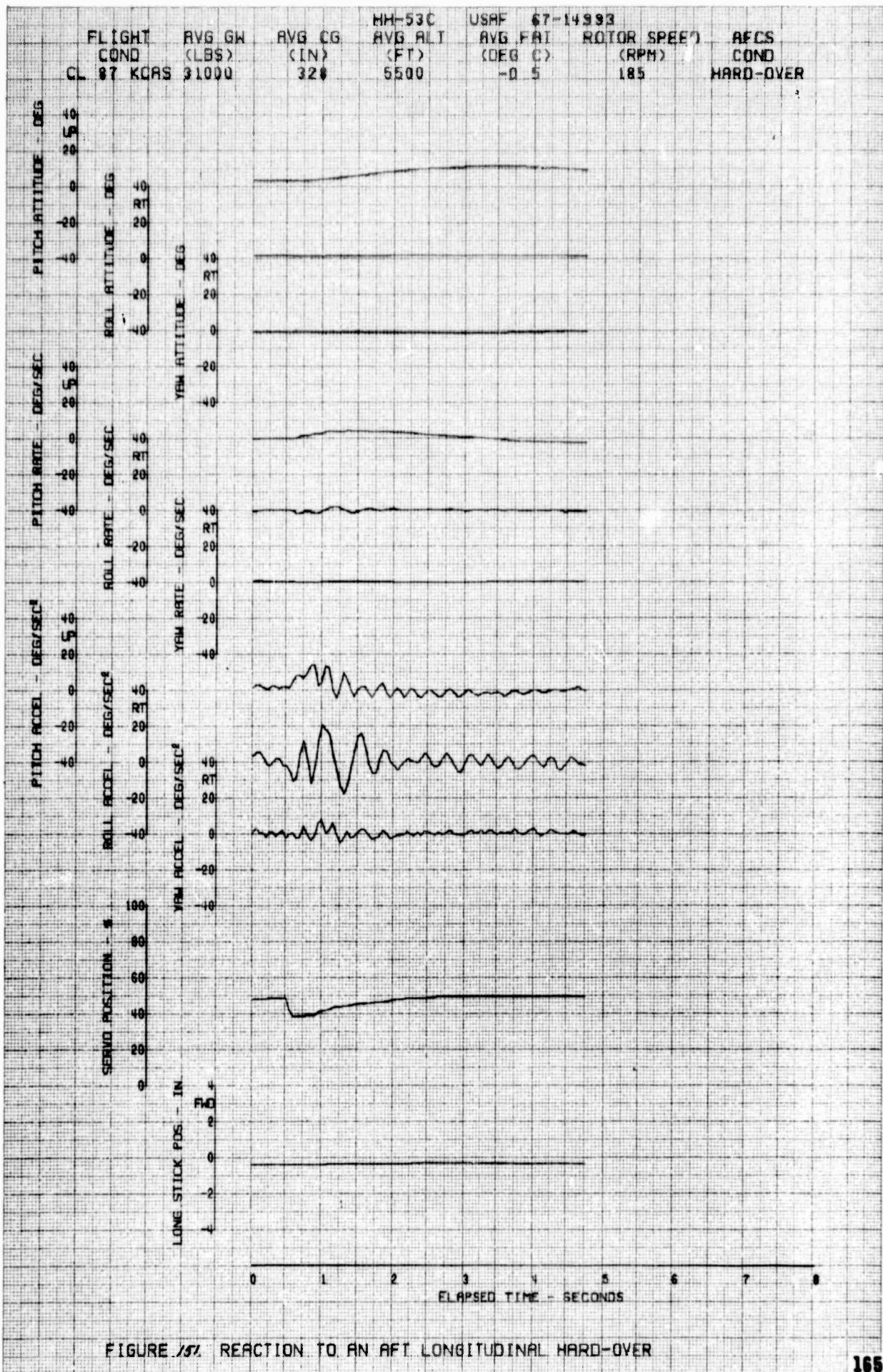


FIGURE 157 REACTION TO AN AFT LONGITUDINAL HARD-OVER

FLIGHT AVG GW AVG CG MM-53C USAF 67-14333
 COND: (LBS) (IN) (F.T.) (FT) ROTOR SPEED AFCS
 CL 37 KCHS 31000 328 5500 0.5 185 COND
 HARD-OVER

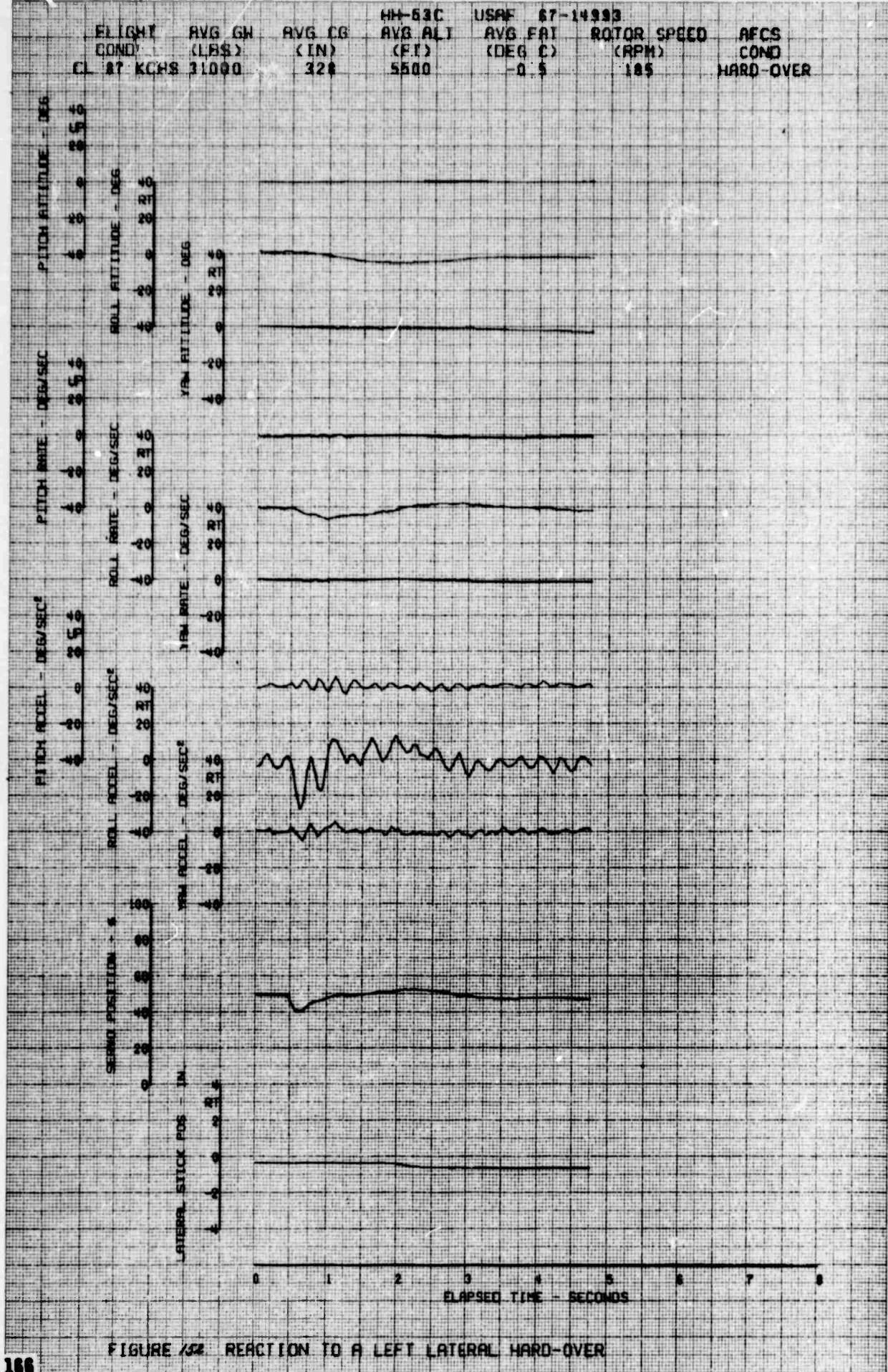


FIGURE 152 REACTION TO A LEFT LATERAL HARD-OVER

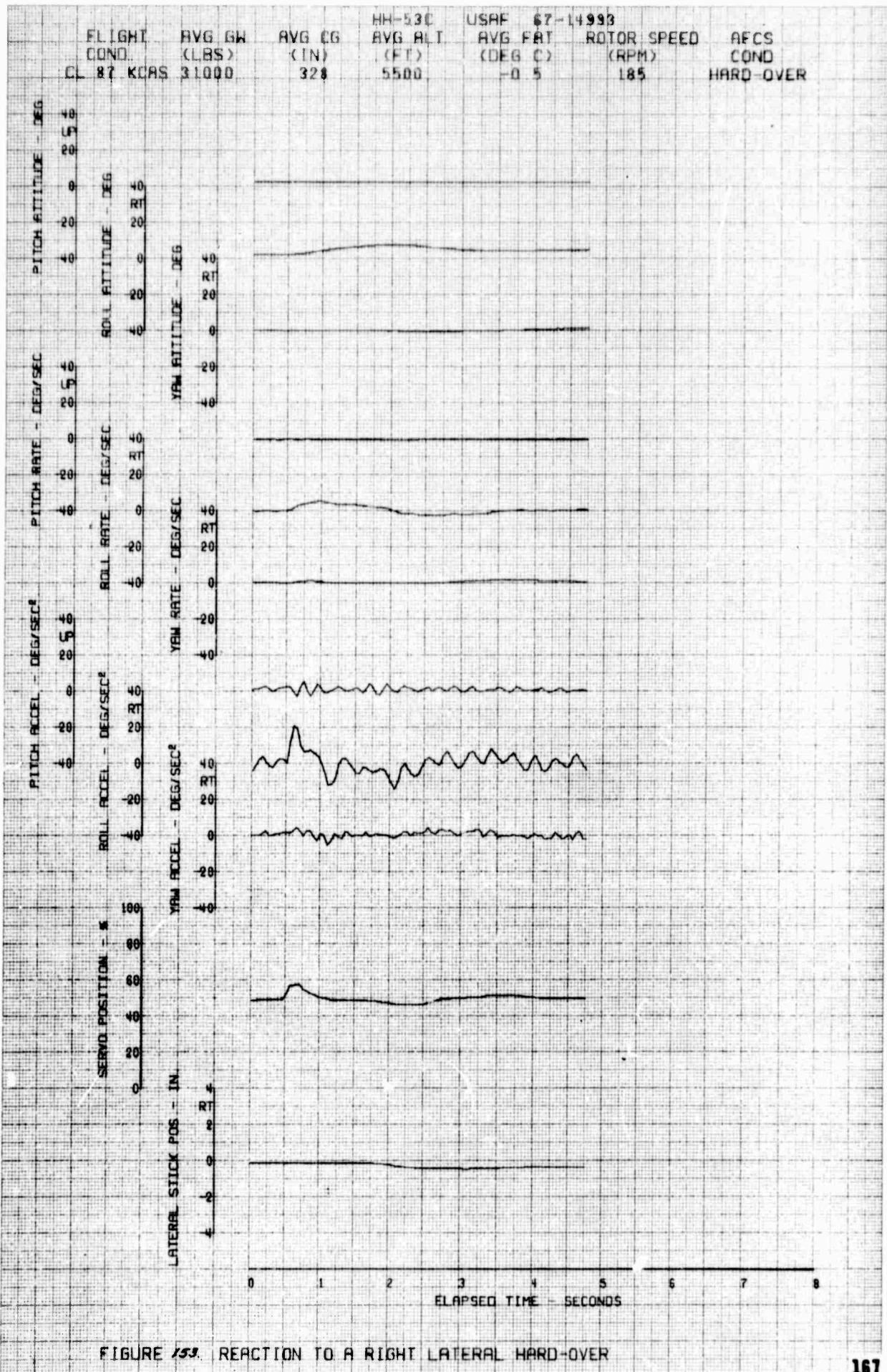


FIGURE 153. REACTION TO A RIGHT LATERAL HARD-OVER

FLIGHT HH-53C USAF 67-14993
 COND AVG GW AVG CG ROTOR SPEED AFCS
 CL 87 KCRS 31000 (LBS) (IN) (FT) (DEG C) (RPM) COND
 328 5500 -0.5 185 HARD-OVER

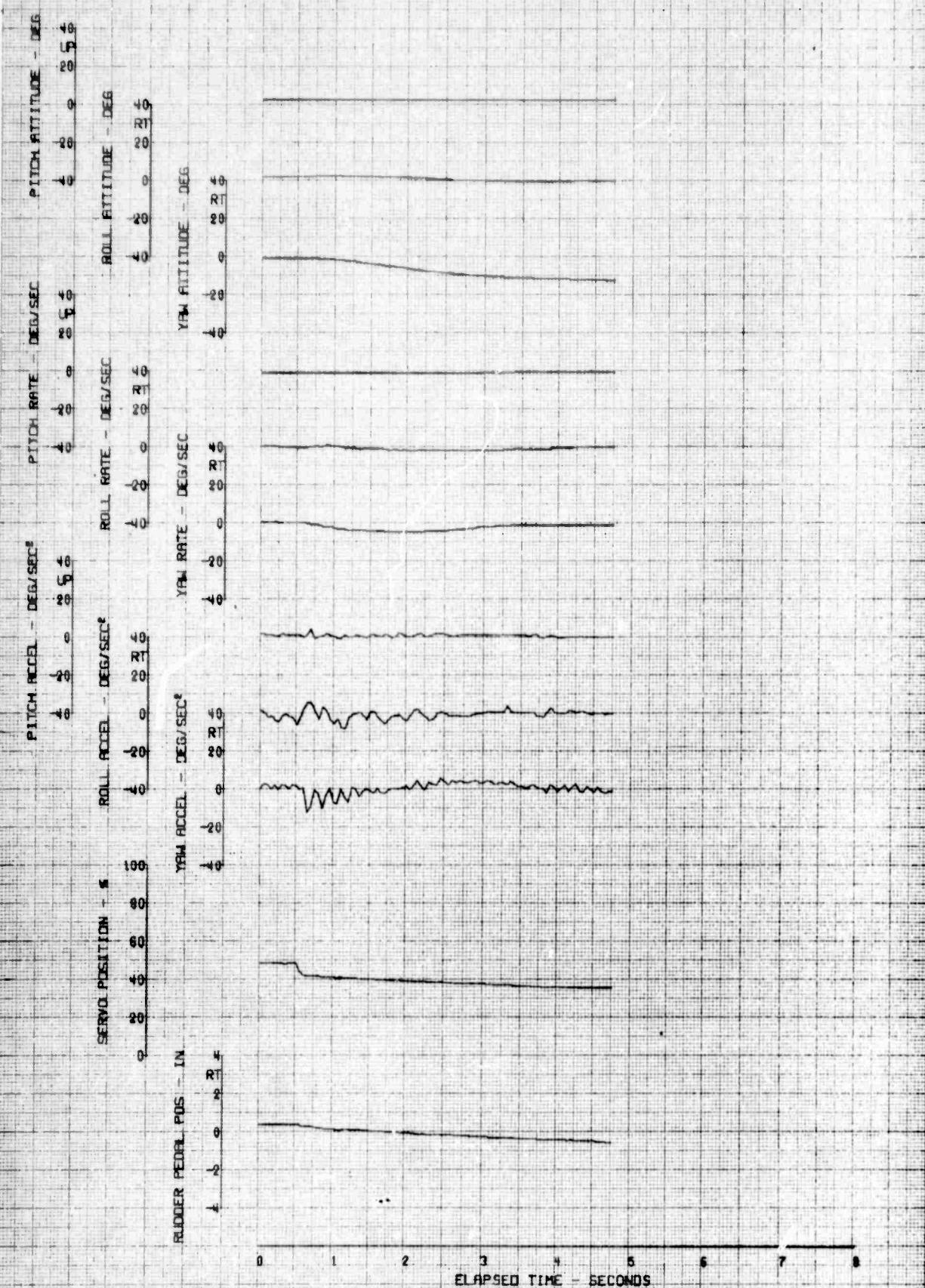


FIGURE 154 REACTION TO A LEFT DIRECTIONAL HARD-OVER

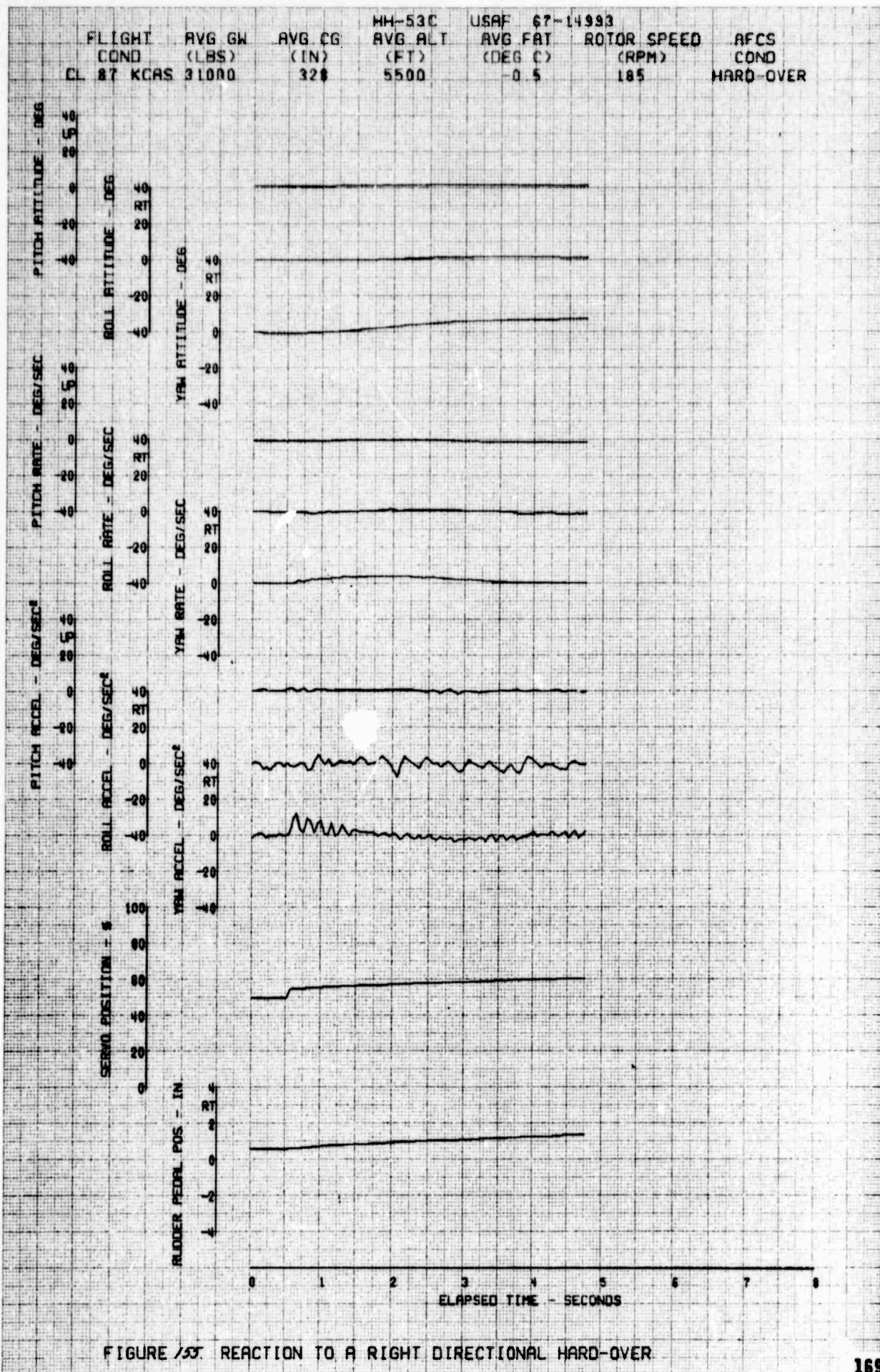


FIGURE 155. REACTION TO A RIGHT DIRECTIONAL HARD-OVER

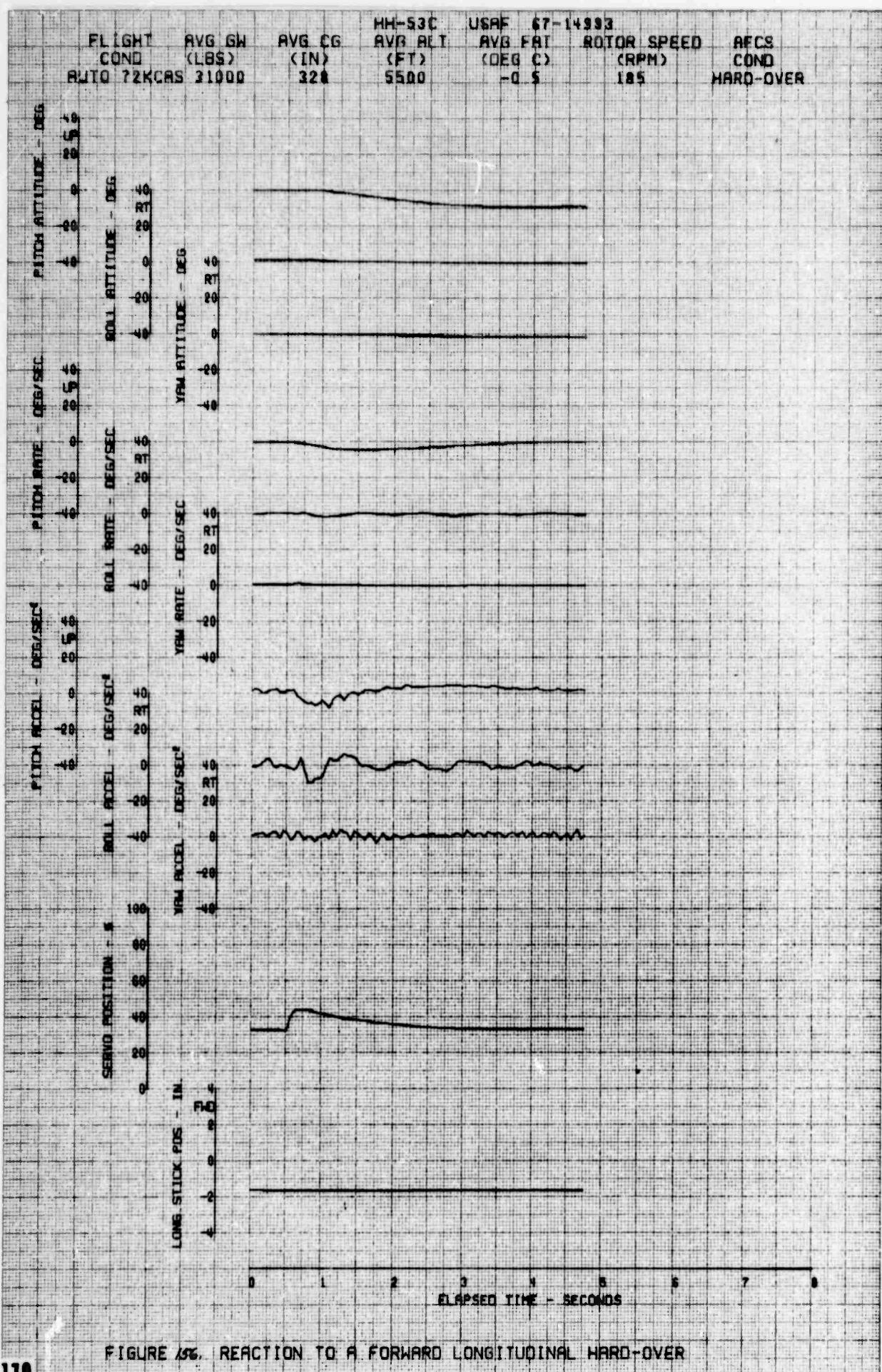


FIGURE 196. REACTION TO A FORWARD LONGITUDINAL HARD-OVER

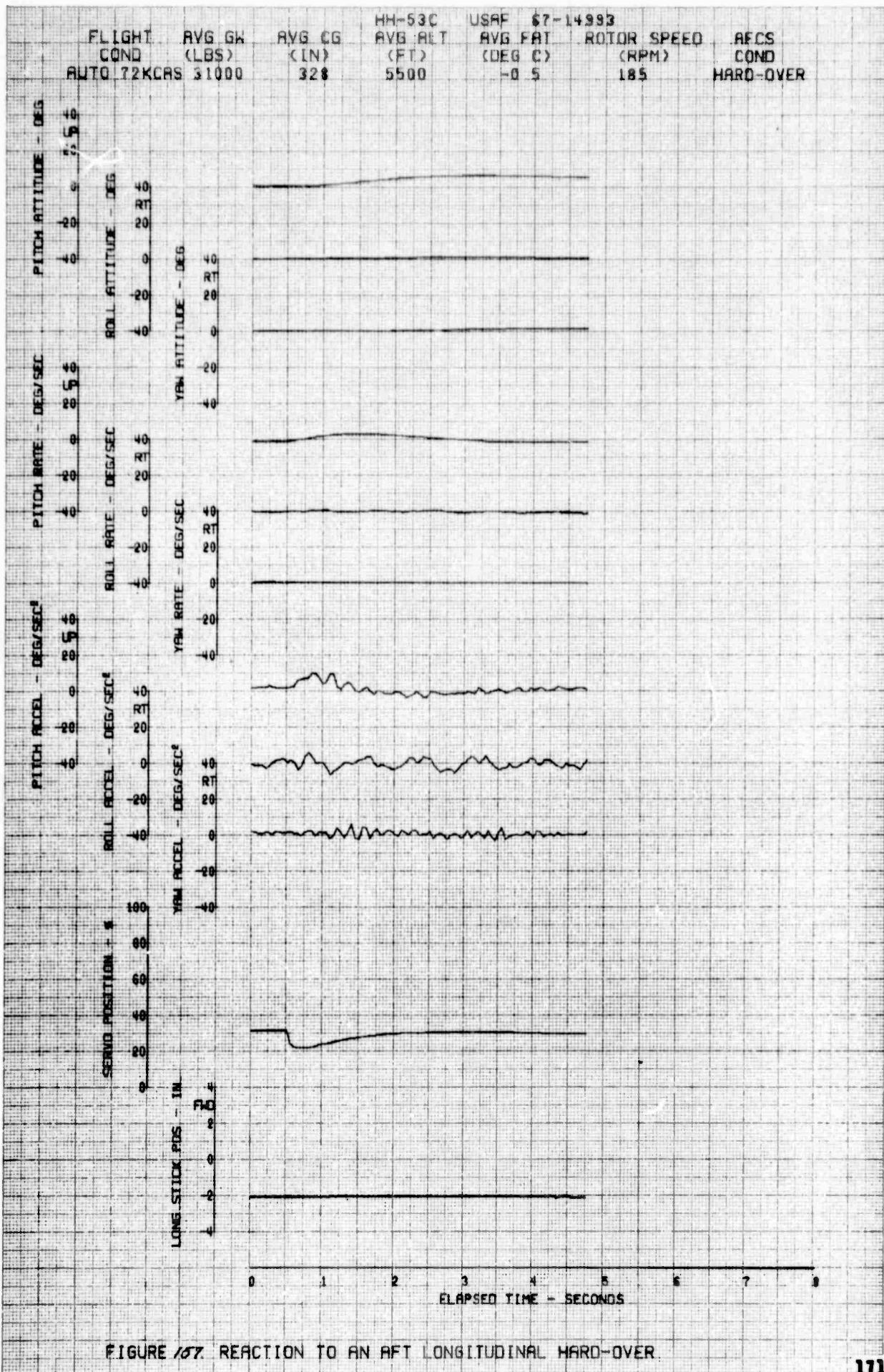


FIGURE 107. REACTION TO AN AFT LONGITUDINAL HARD-OVER.

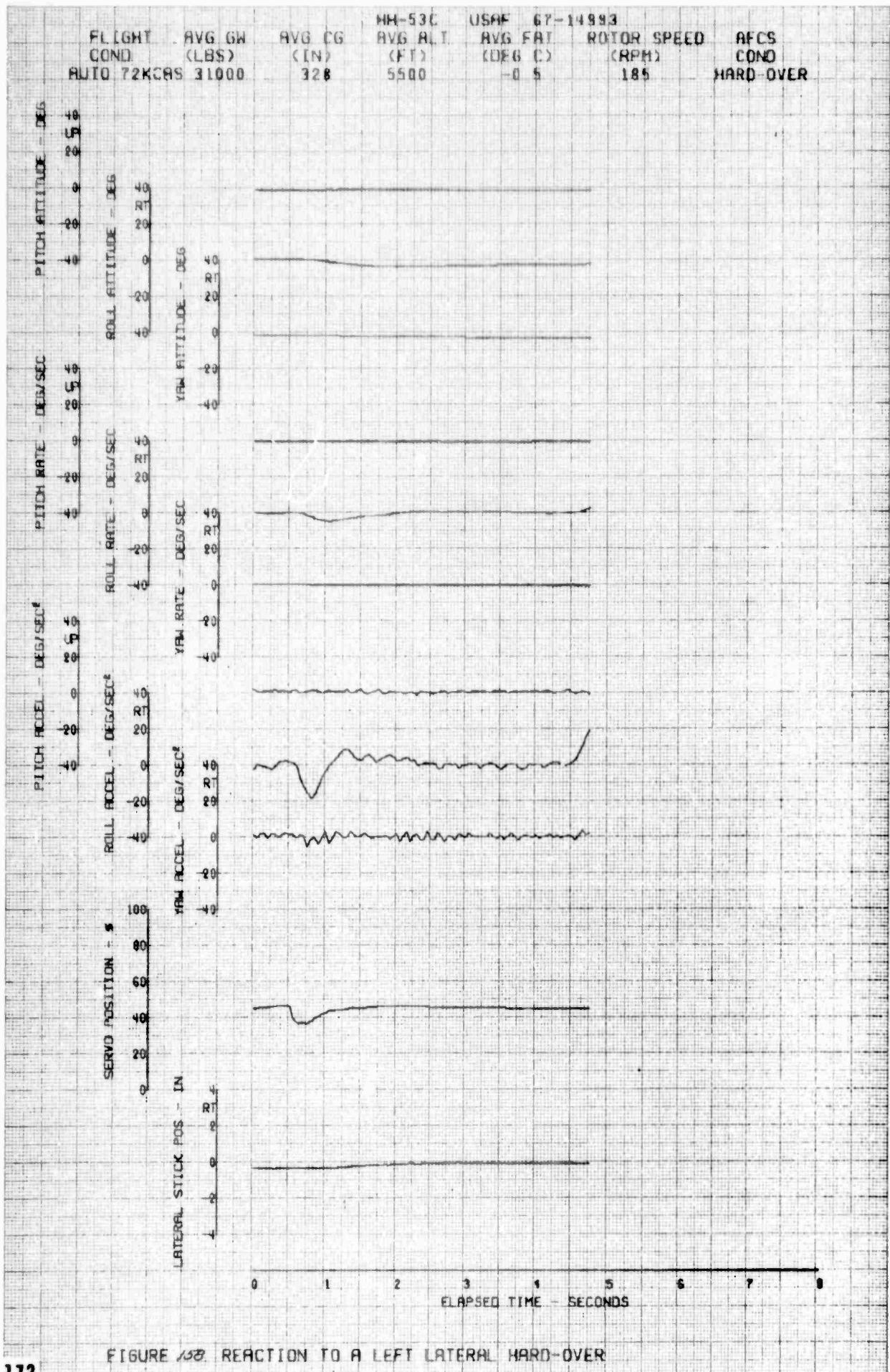


FIGURE 108. REACTION TO A LEFT LATERAL HARD-OVER

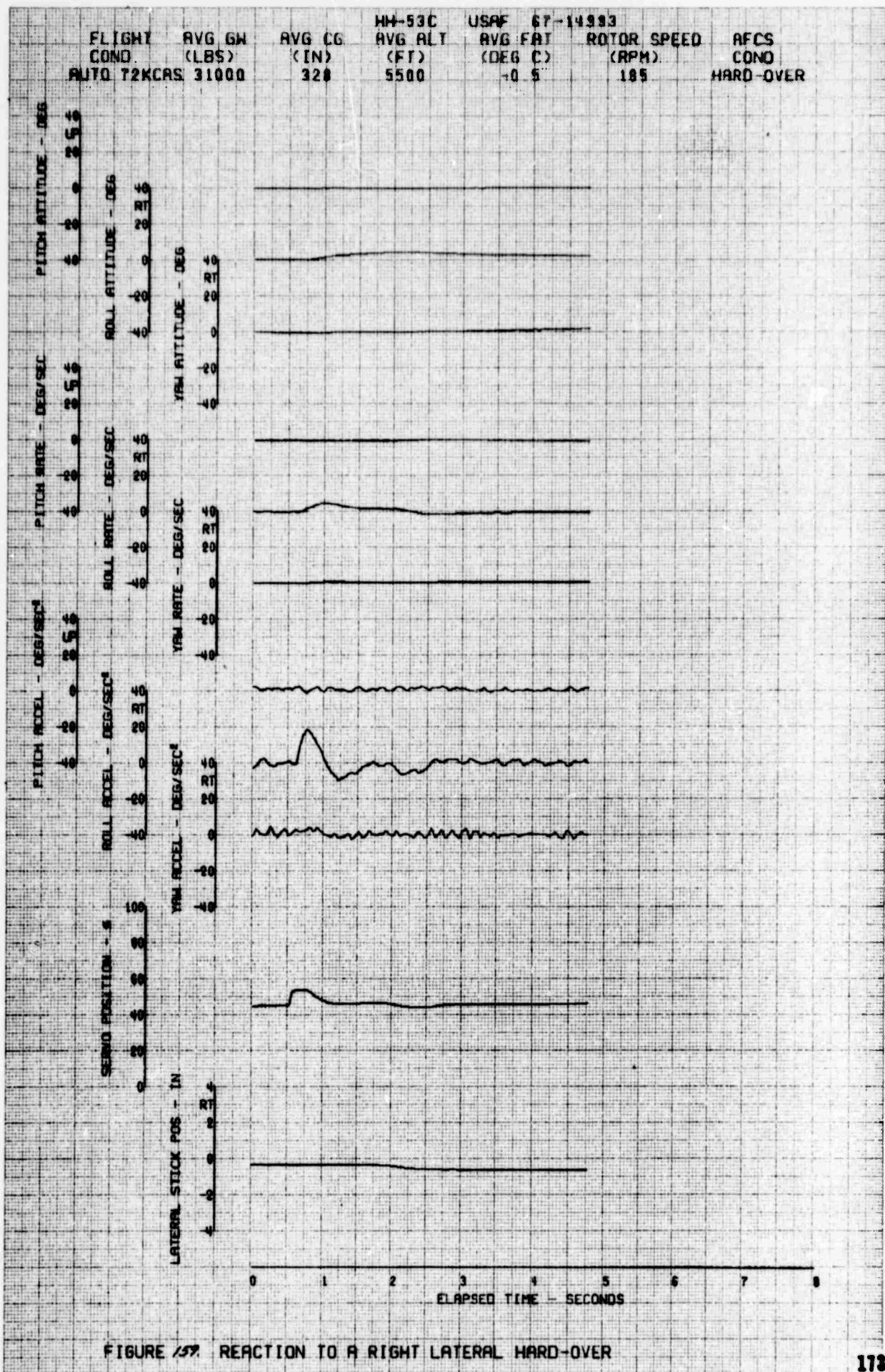


FIGURE 157. REACTION TO A RIGHT LATERAL HARD-OVER

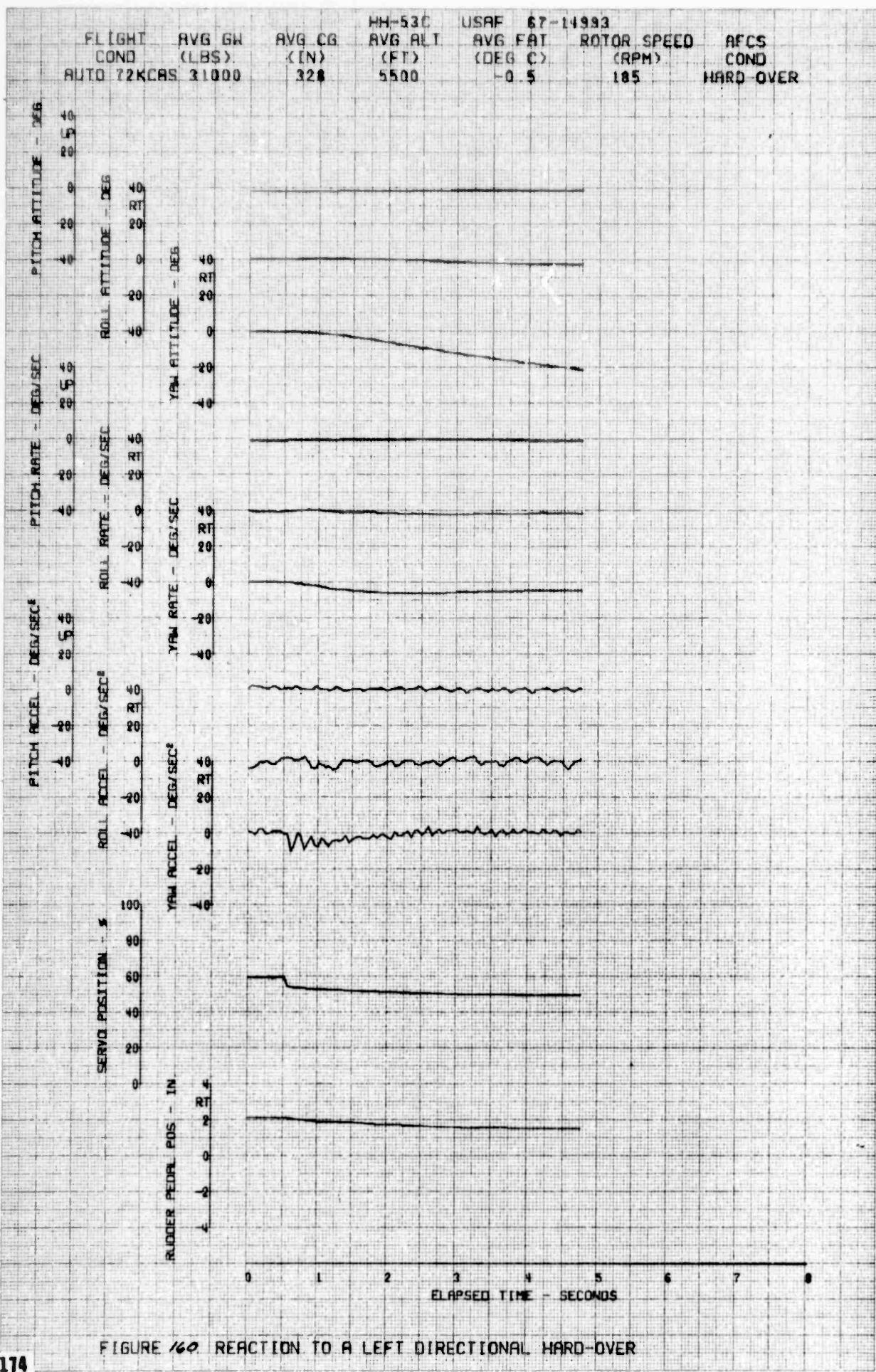


FIGURE 160. REACTION TO A LEFT DIRECTIONAL HARD-OVER

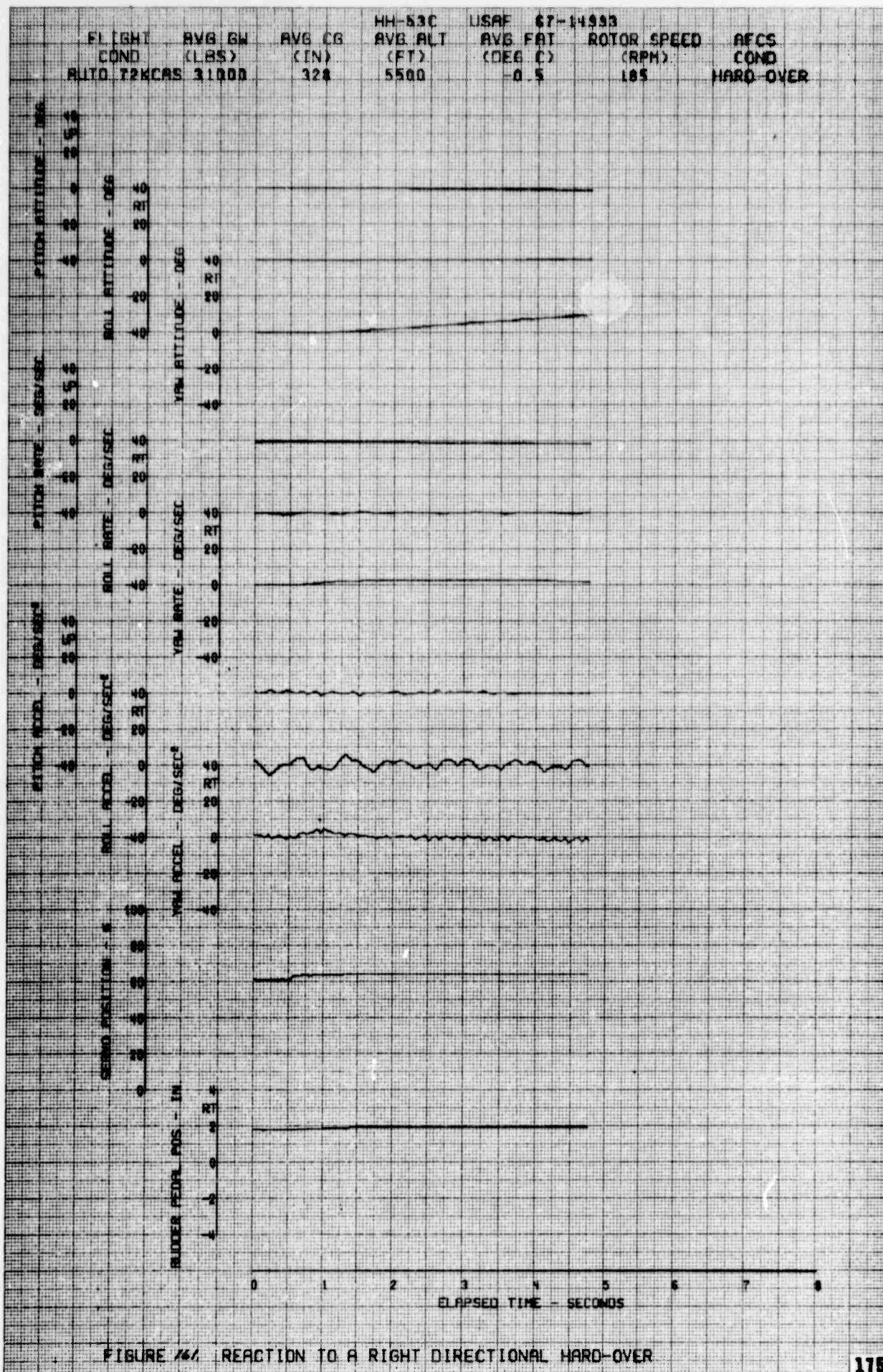


FIGURE 161. REACTION TO A RIGHT DIRECTIONAL HARD-OVER

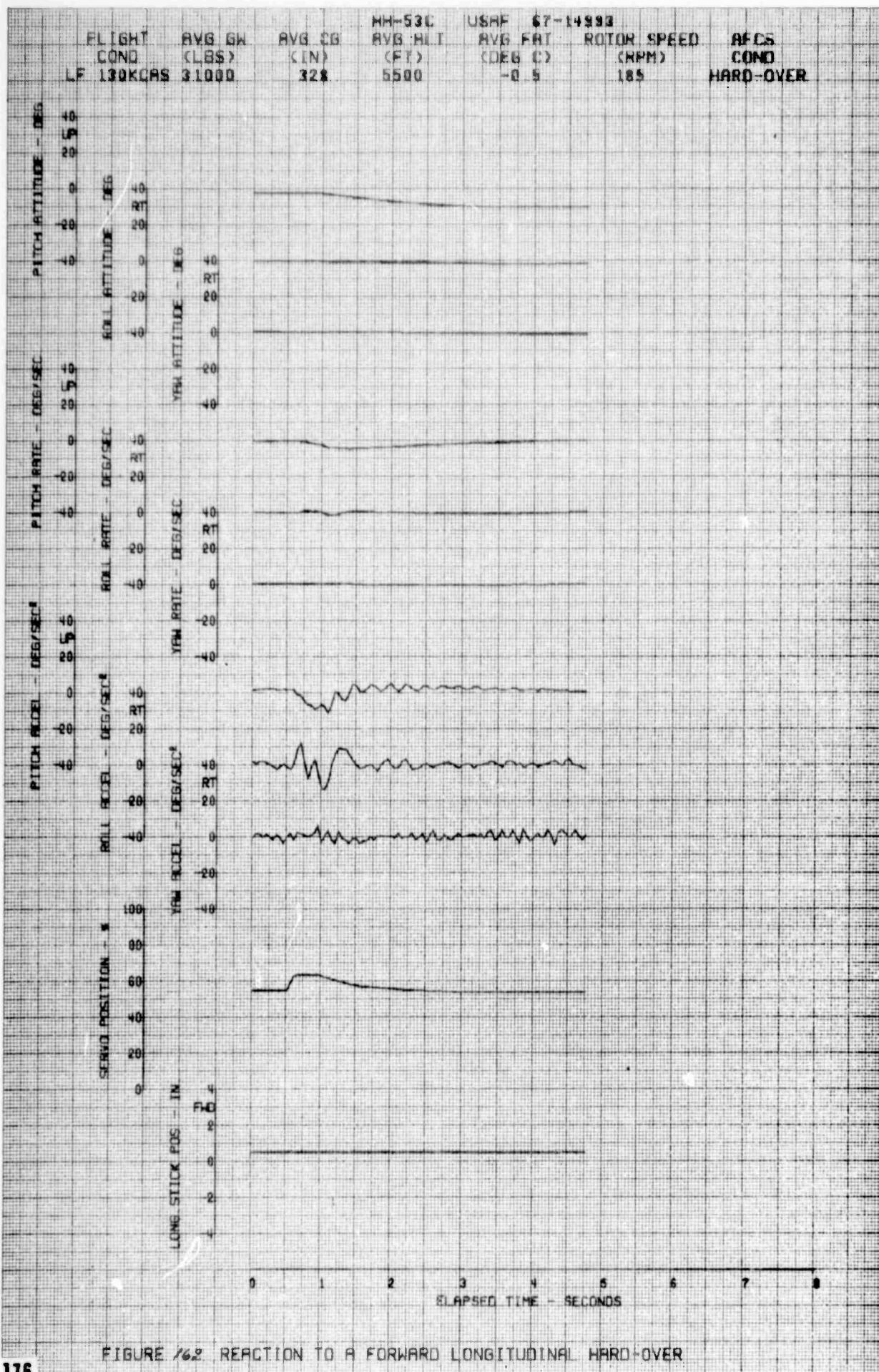


FIGURE 162 REACTION TO A FORWARD LONGITUDINAL HARD-OVER

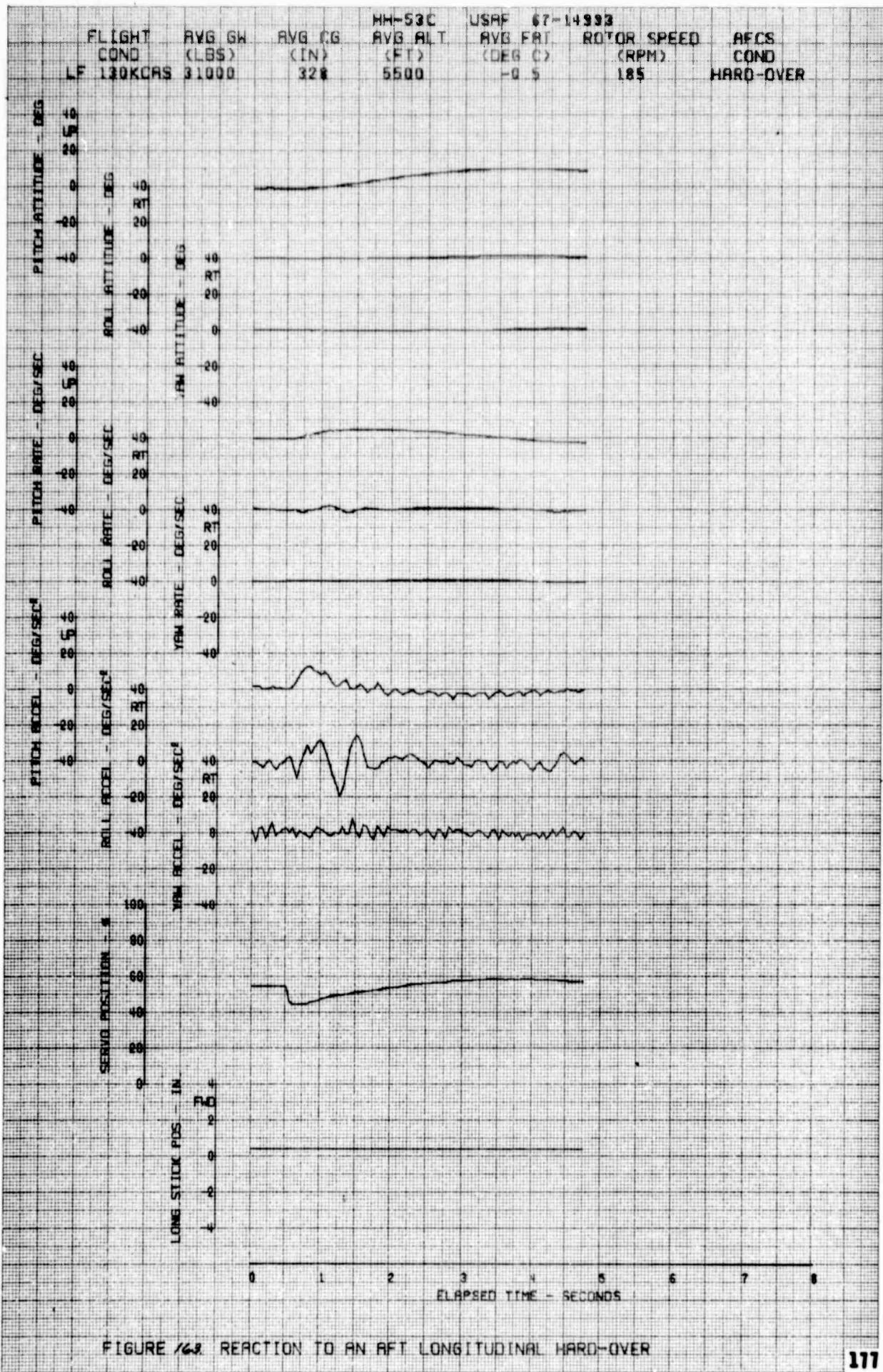


FIGURE 168. REACTION TO AN AFT LONGITUDINAL HARD-OVER

FLIGHT HH-53C USAF 67-14993
 COND AFCS
 LF 130KCAS 21000. AVG. GW (LBS) 328 AVG. CG (IN) 328 AVG. ALT (FT) 5500 AVG. FRI (DEG C) -0.5 ROTOR SPEED (RPM) 185 AFCS COND HARD-OVER

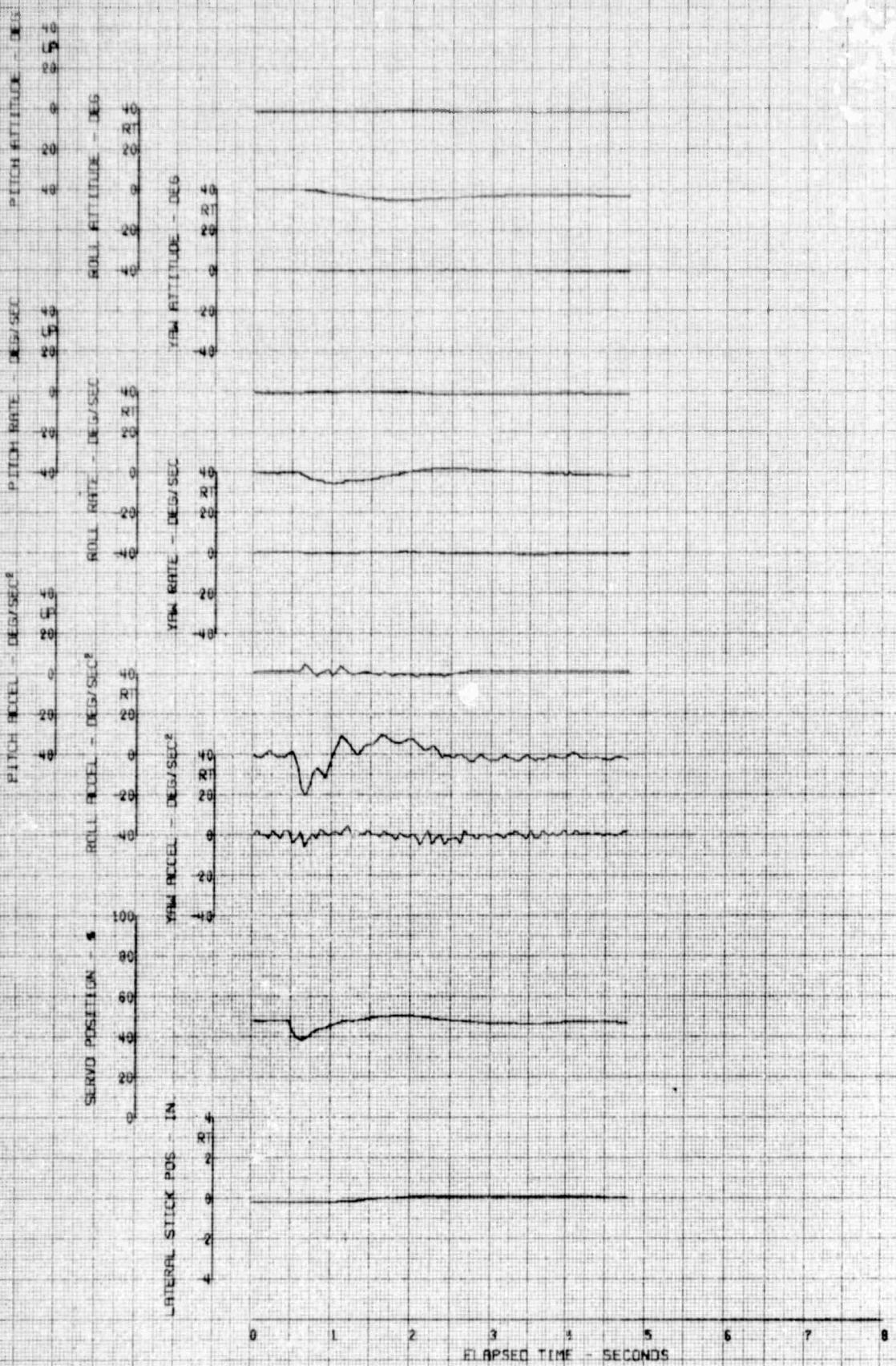


FIGURE 164. REACTION TO A LEFT LATERAL HARD-OVER.

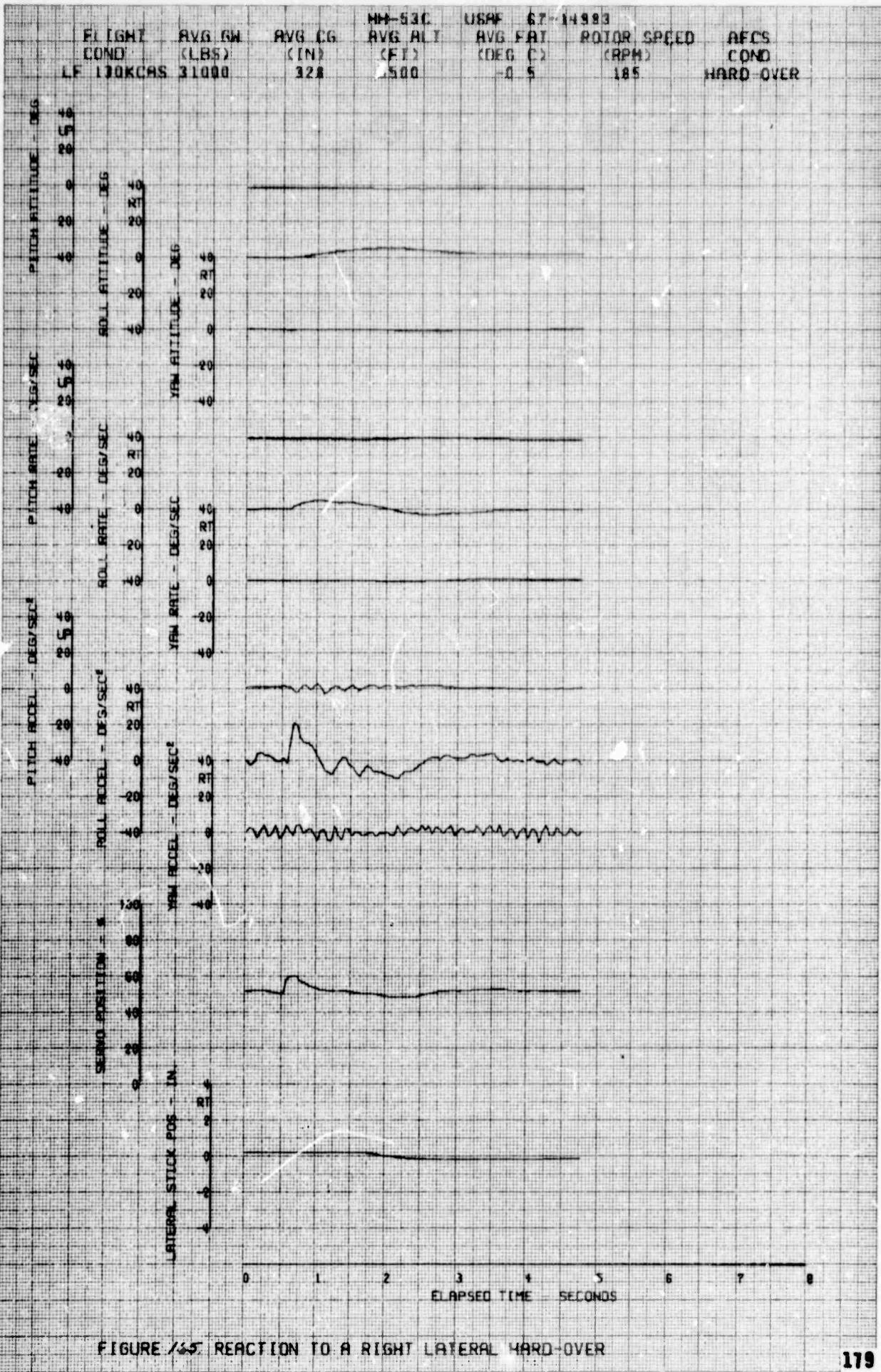


FIGURE 165. REACTION TO A RIGHT LATERAL HARD-OVER

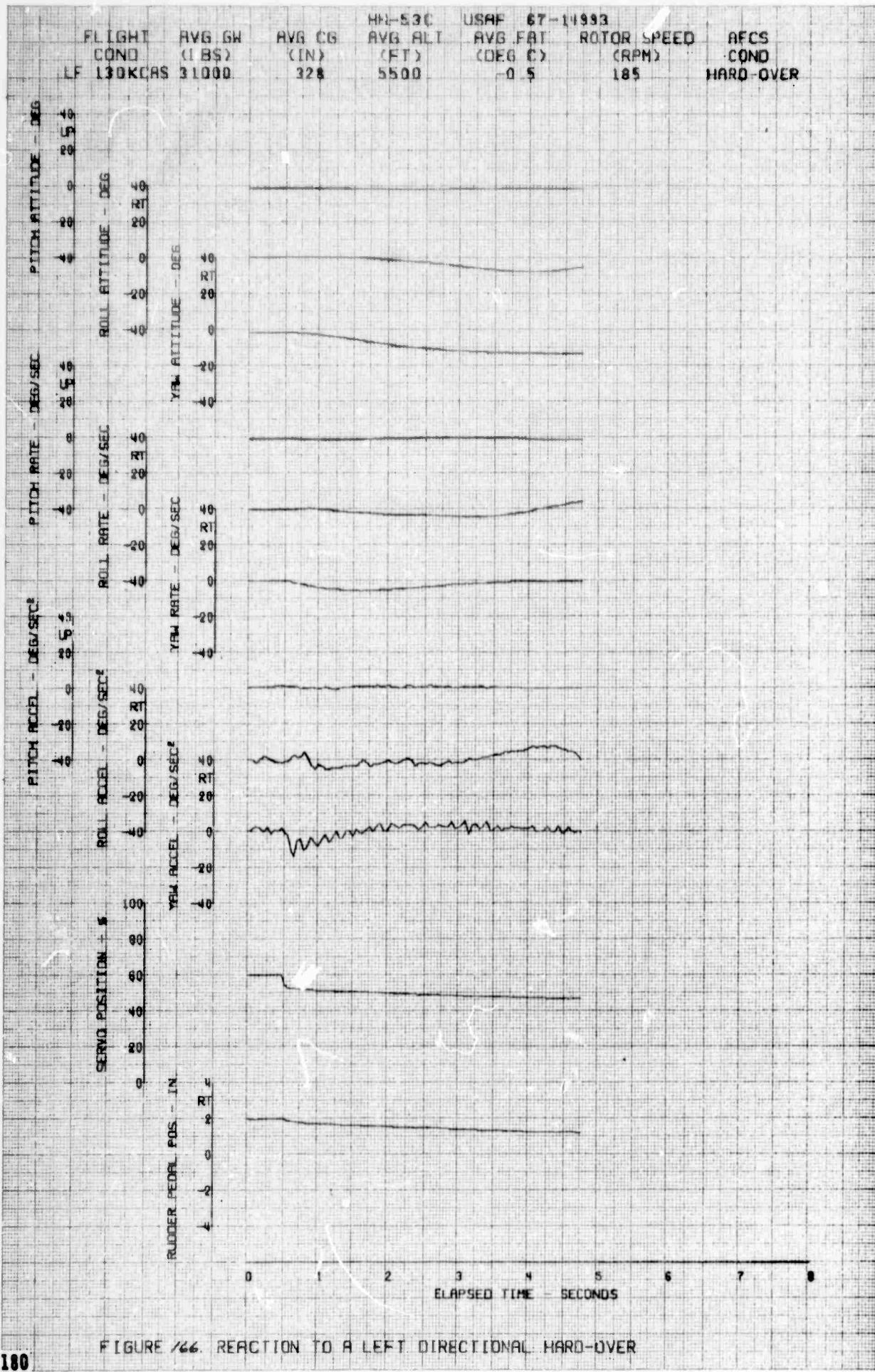


FIGURE 166. REACTION TO A LEFT DIRECTIONAL HARD-OVER

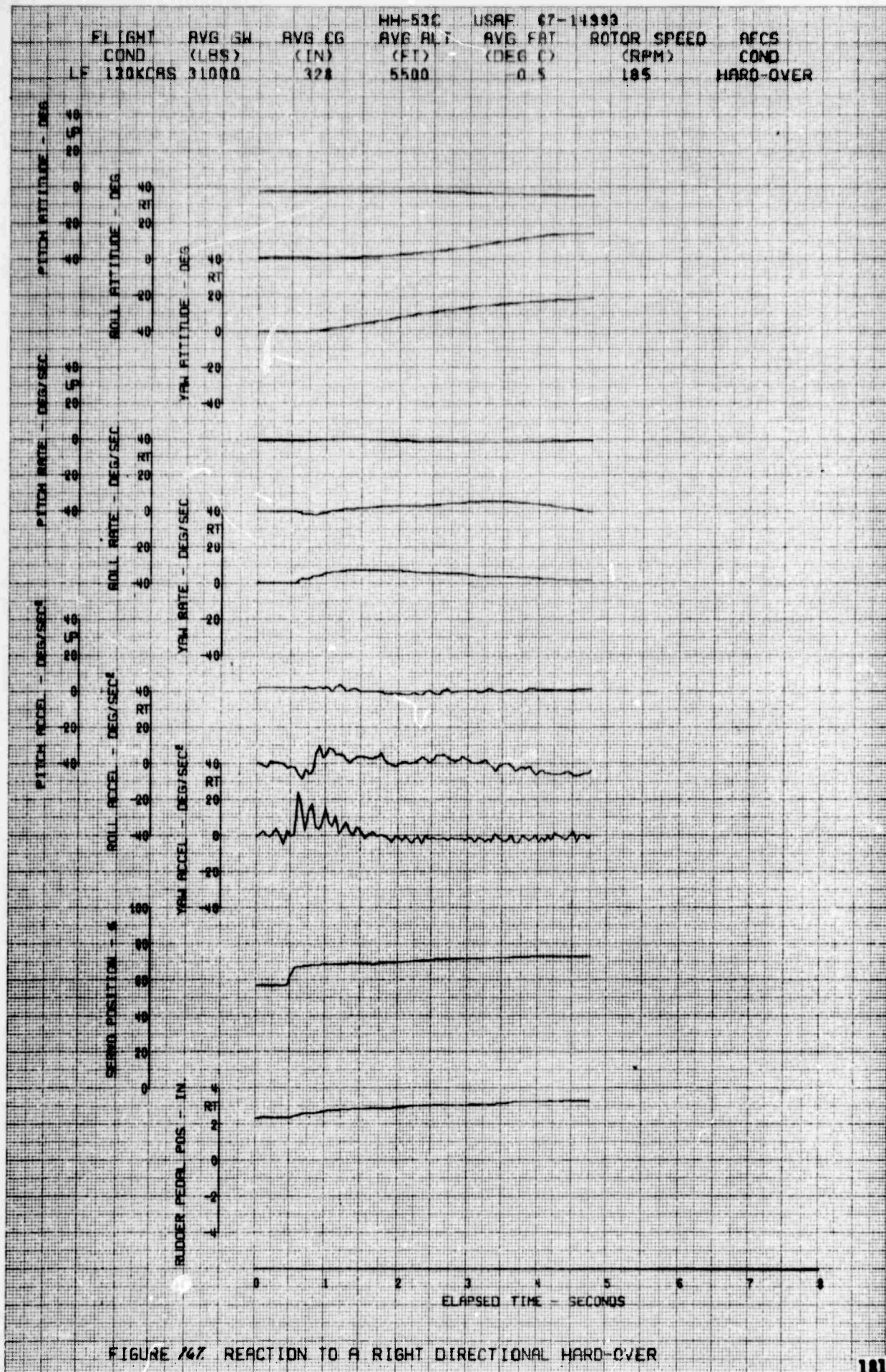
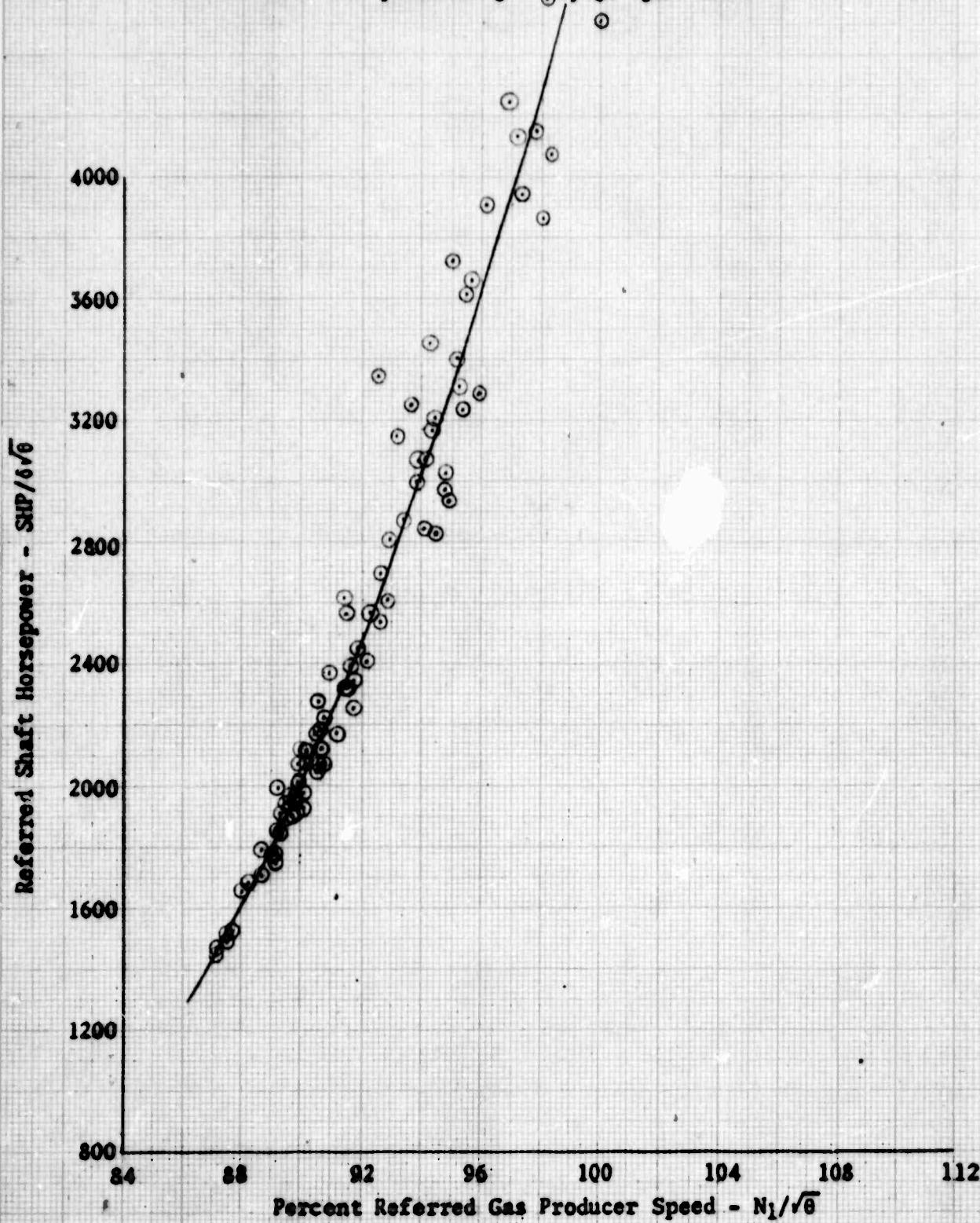


FIGURE 167. REACTION TO A RIGHT DIRECTIONAL HARD-OVER

HH-53C USAF S/N 67-14993
T64-GE-7 Engines
Right Engine S/N 661006

- Notes: 1. θ based on ambient temperature.
2. δ based on ambient pressure.
3. 100 percent $N_1 = 38,230$ rpm



HH-S3C USAF S/N 67-14993

T64-GE-7 Engines

Right Engine S/N 261006

- Note: 1. 0 based on ambient temperature.
2. 6 based on ambient pressure.
3. 100 percent $N_1 = 18,230$ rpm

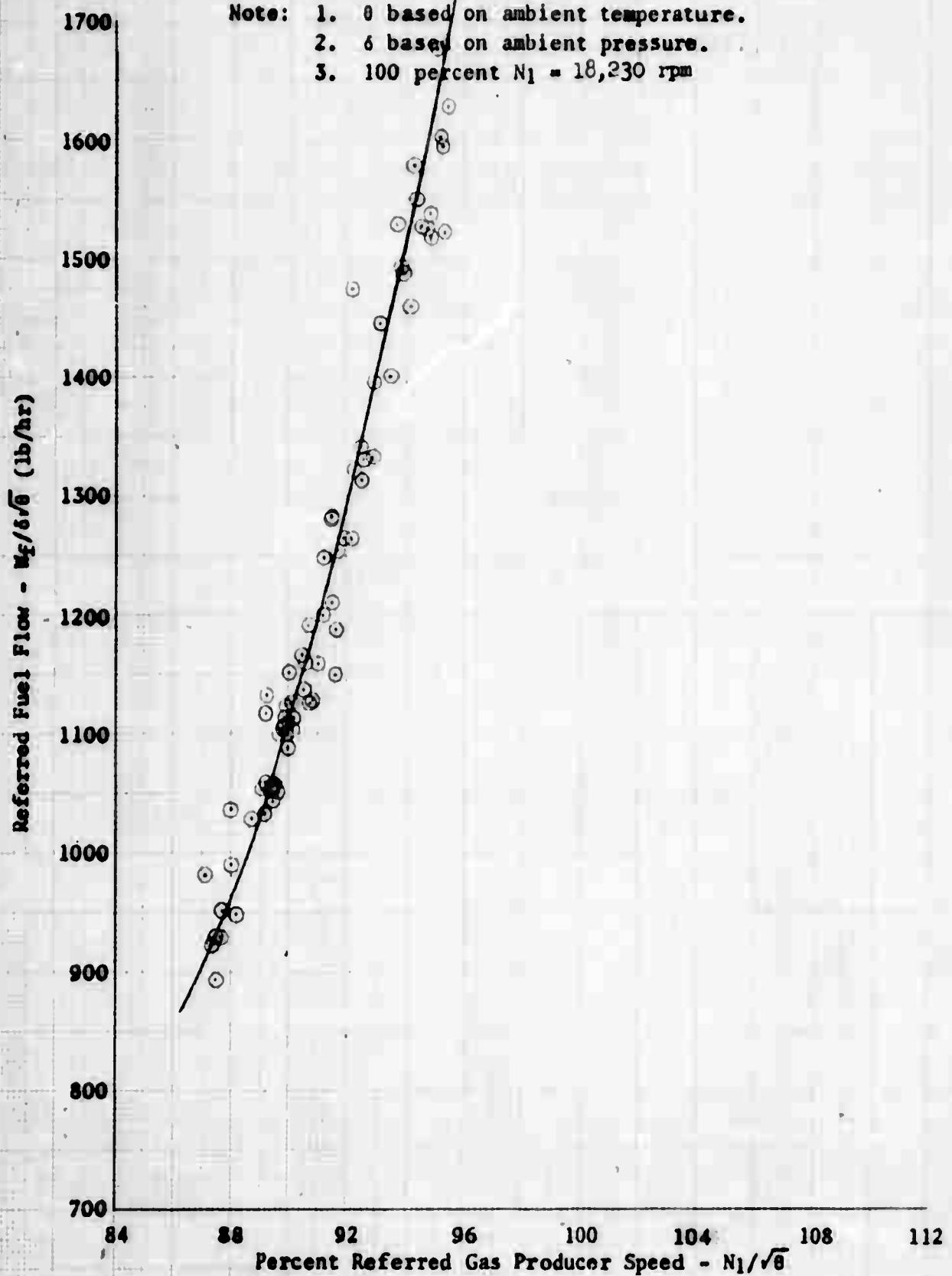
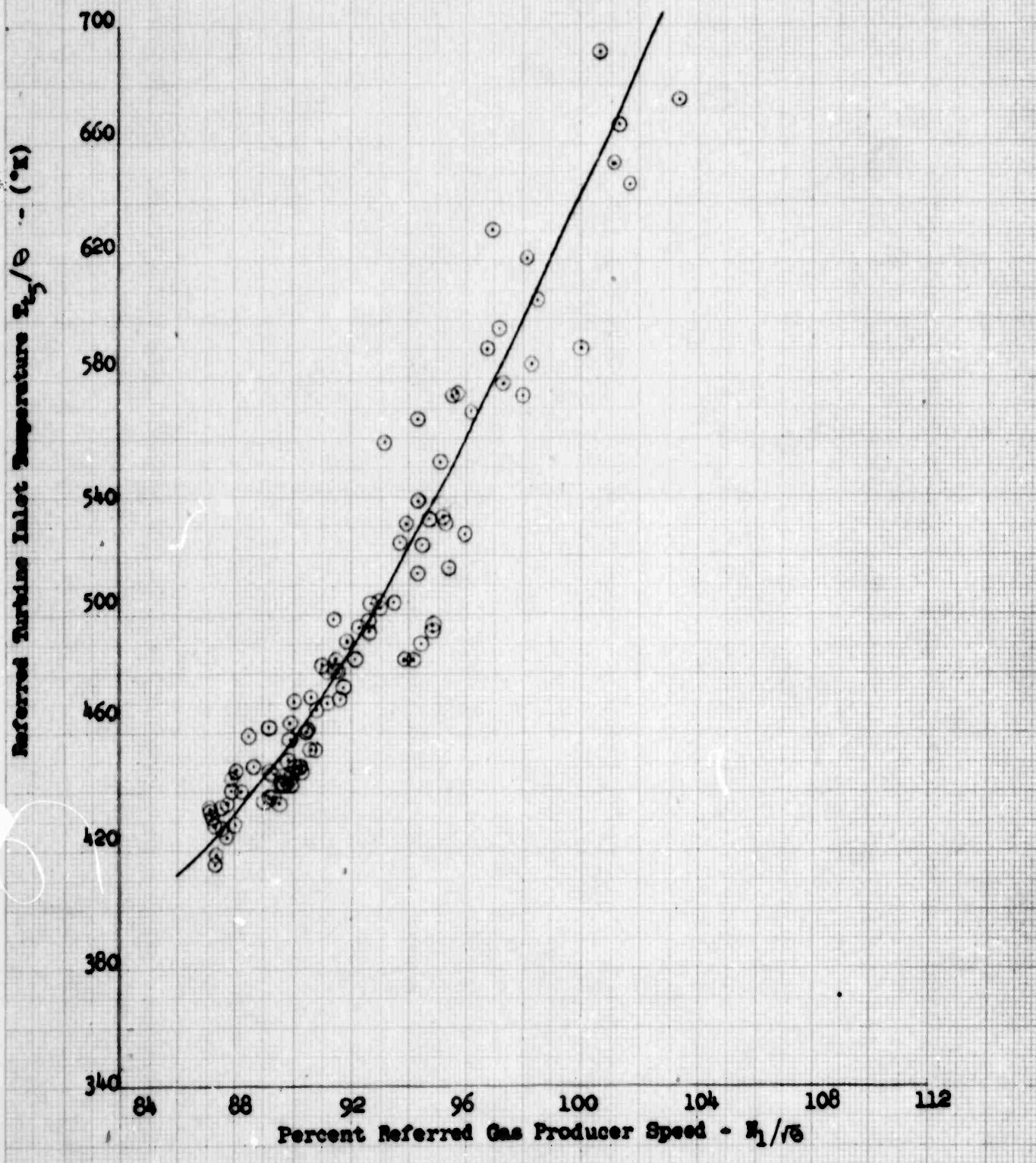


Figure 169. Engine Characteristics

MM-53C USAF S/N 67-14993

T64-GE-7 Engines
Right Engine S/N 261006

Notes: 1. based on ambient temperature
2. 100 percent N_1 - 18,230 rpm



HH-53C USAF S/N 67-14993

T64-GE-7 Engines

Right Engine S/N 261006

- Without EAPS
- With EAPS

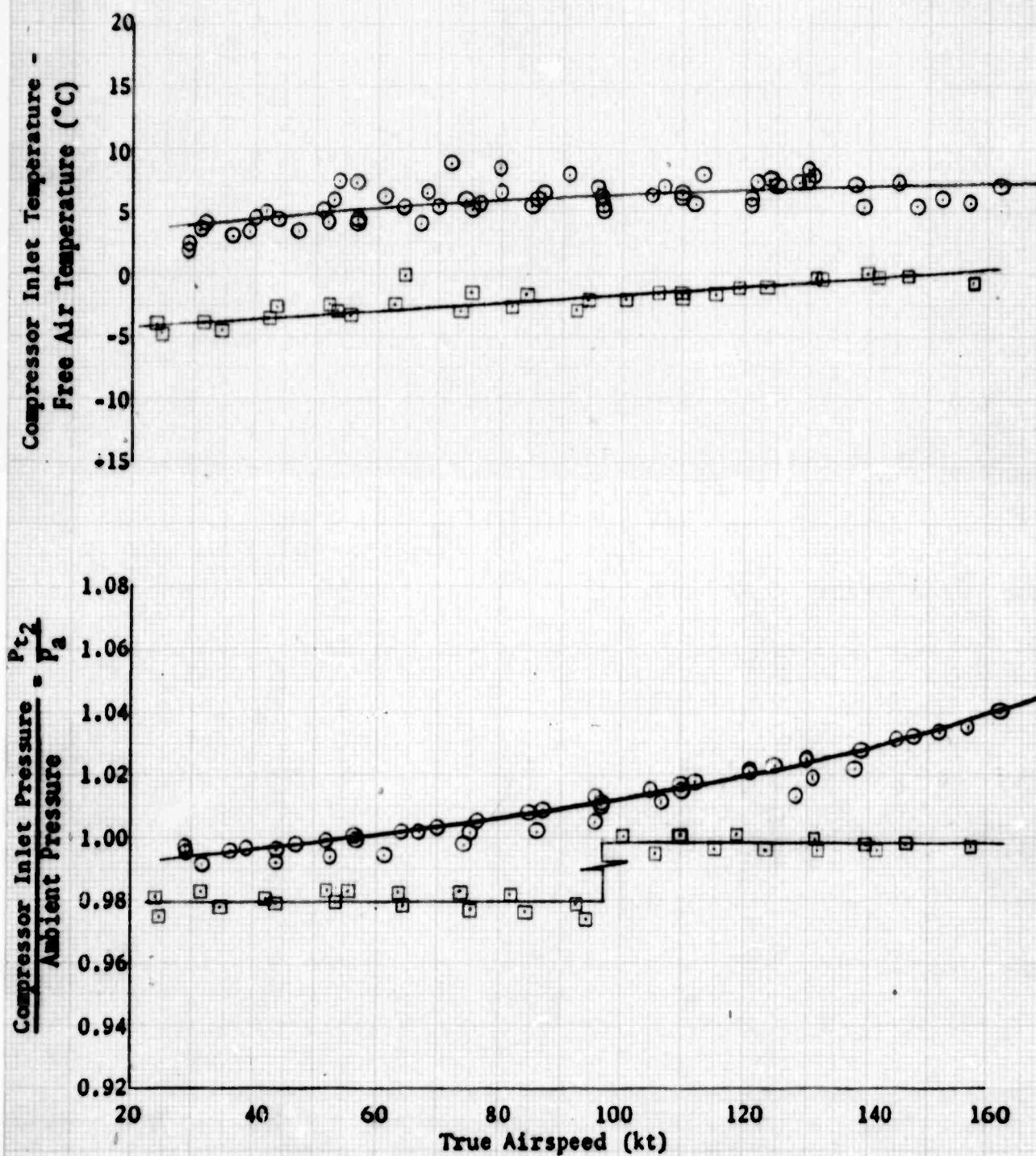


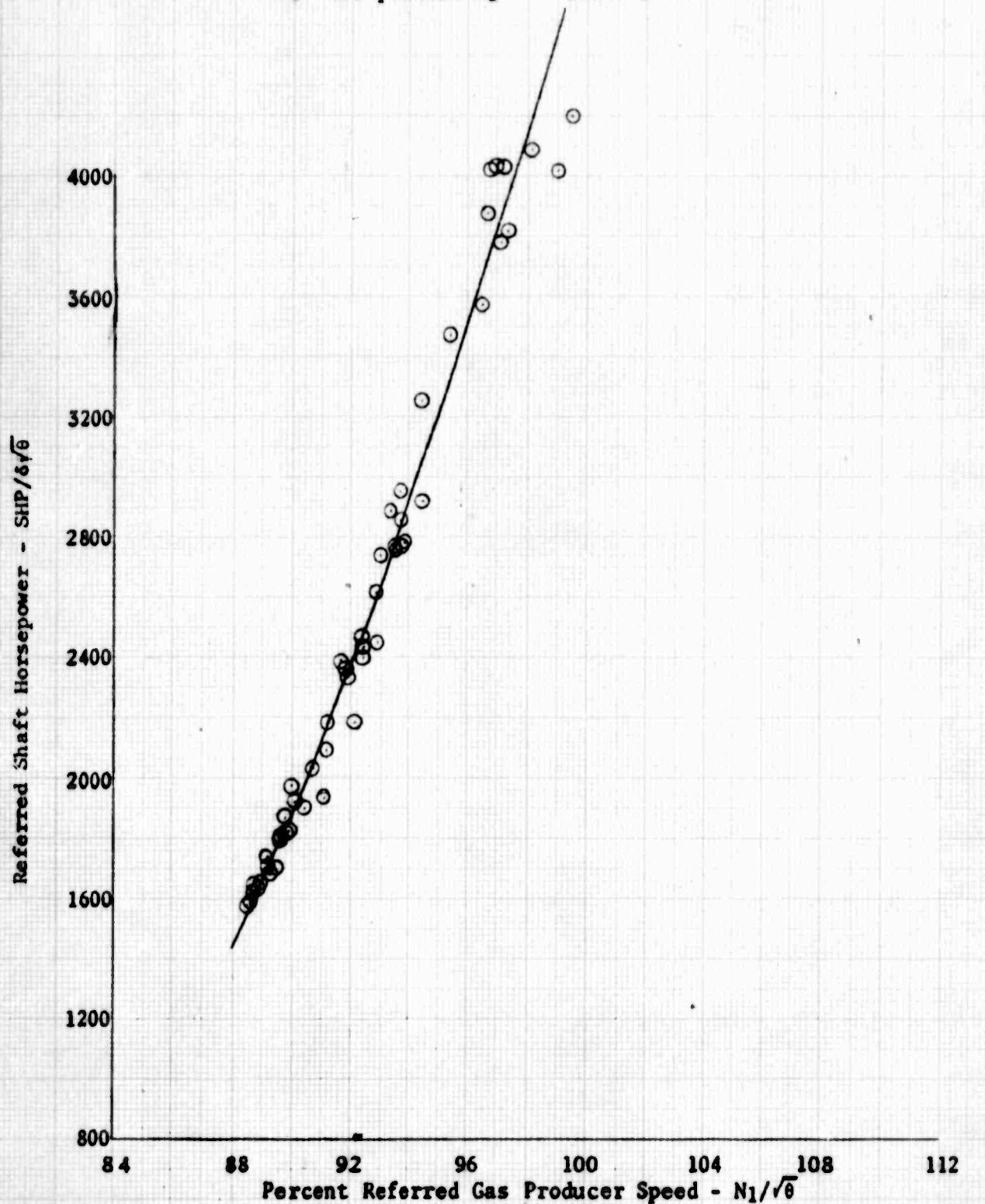
Figure 171. Engine Characteristics

HH-S3C USAF S/N 67-14993

T64-GE-7 Engines

Left Engine S/N 261005

- Notes:
1. θ based on ambient temperature.
 2. θ based on ambient pressure . ○ ○ ○
 3. 100 percent $N_1 = 18,230 \text{ rpm}$



HH-53C USAF S/N 67-14993

T64-GE-7 Engines
Left Engine S/N 261005

- Notes: 1. θ based on ambient temperature.
2. δ based on ambient pressure.
3. 100 percent $N_1 = 18,230$ rpm

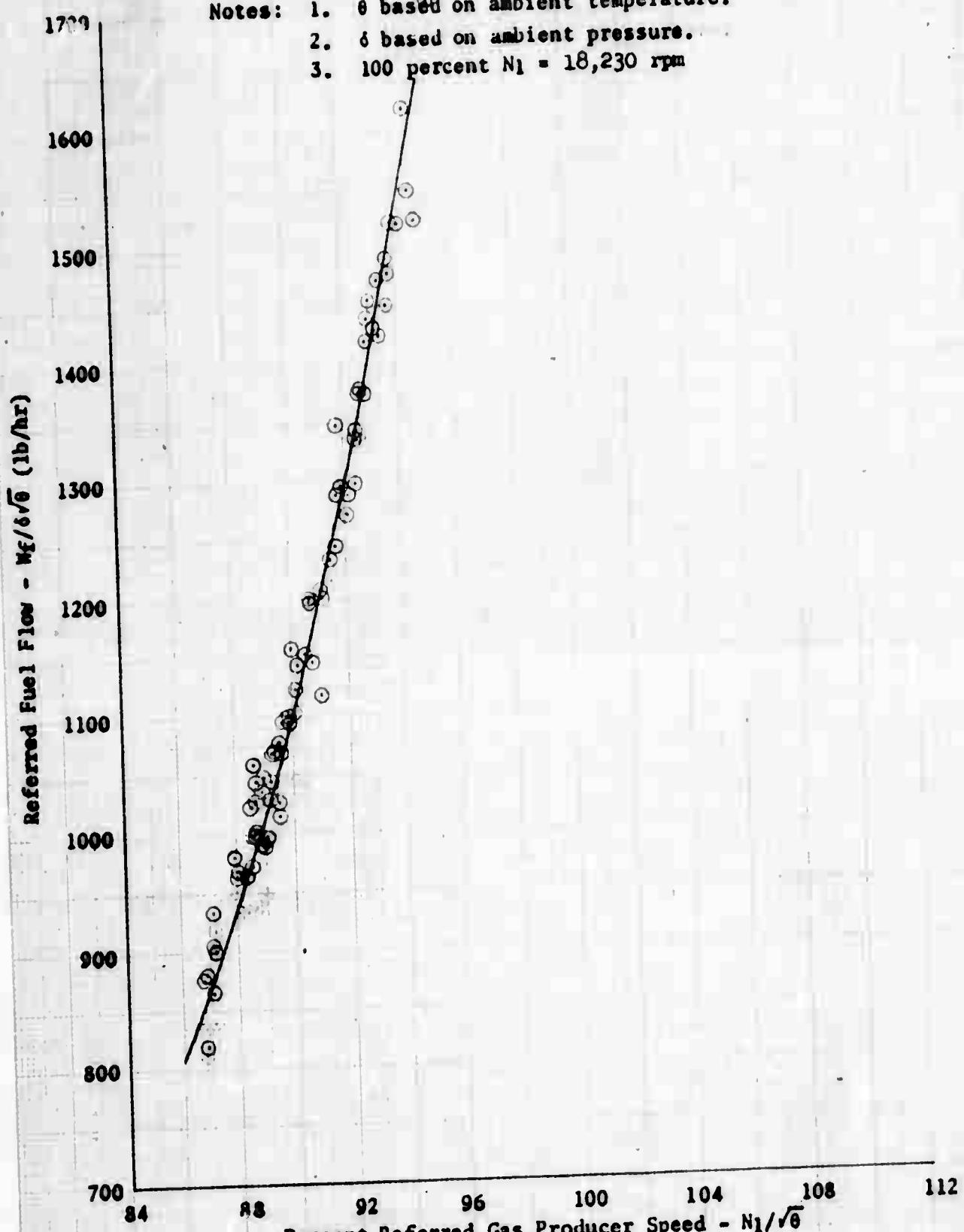
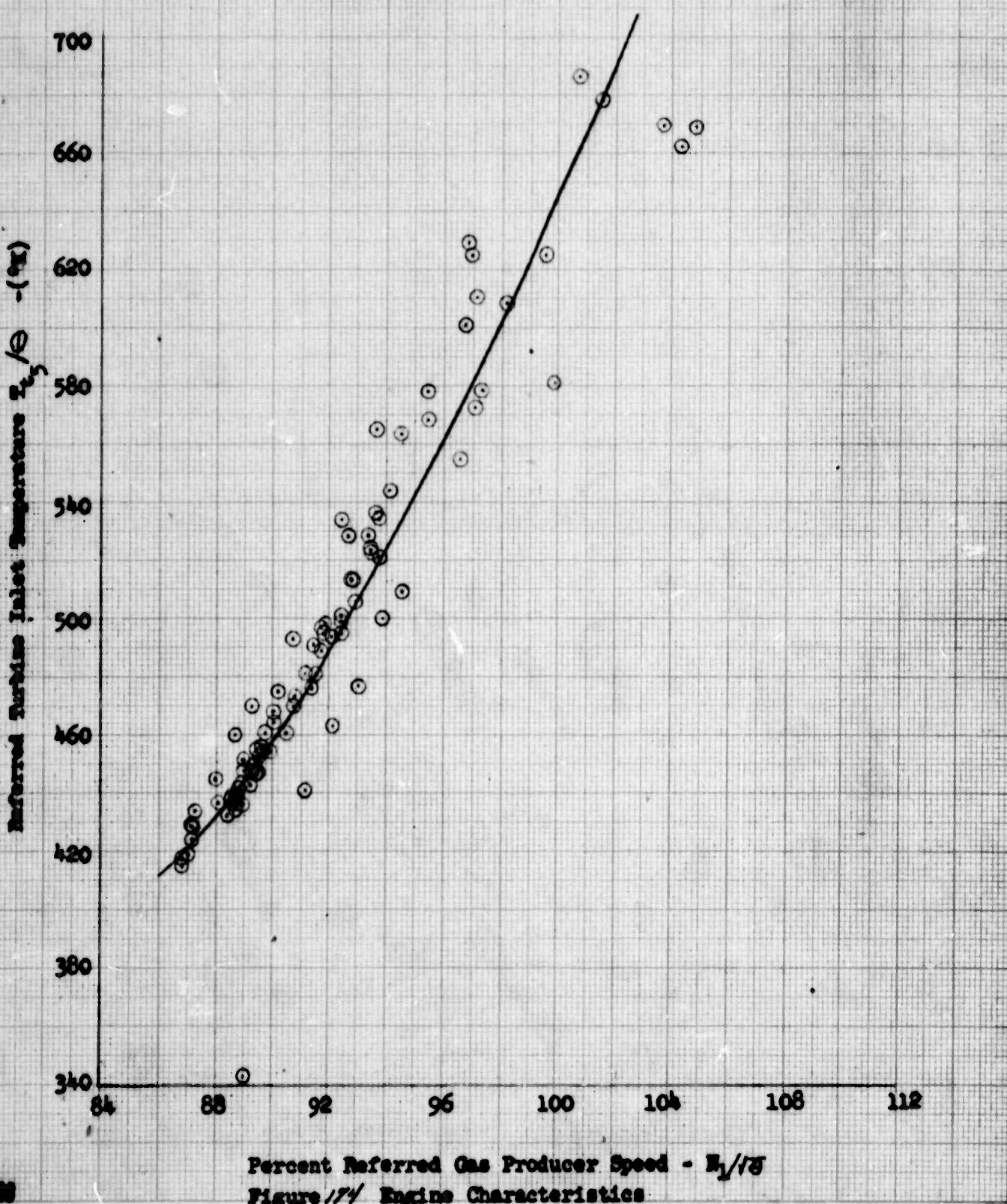


Figure 12. Engine Characteristics

HH-53C USAF S/N 67-14993
T64-GE-7 Engines
Left Engine S/N 261005

Notes: 1. \ominus based on ambient temperature
2. 100 percent $N_1 = 18,230$ rpm



HH-53C USAF S/N 67-14993
T64-GE-7 Engines
Left Engine S/N 261005

○ Without EAPS
□ With EAPS

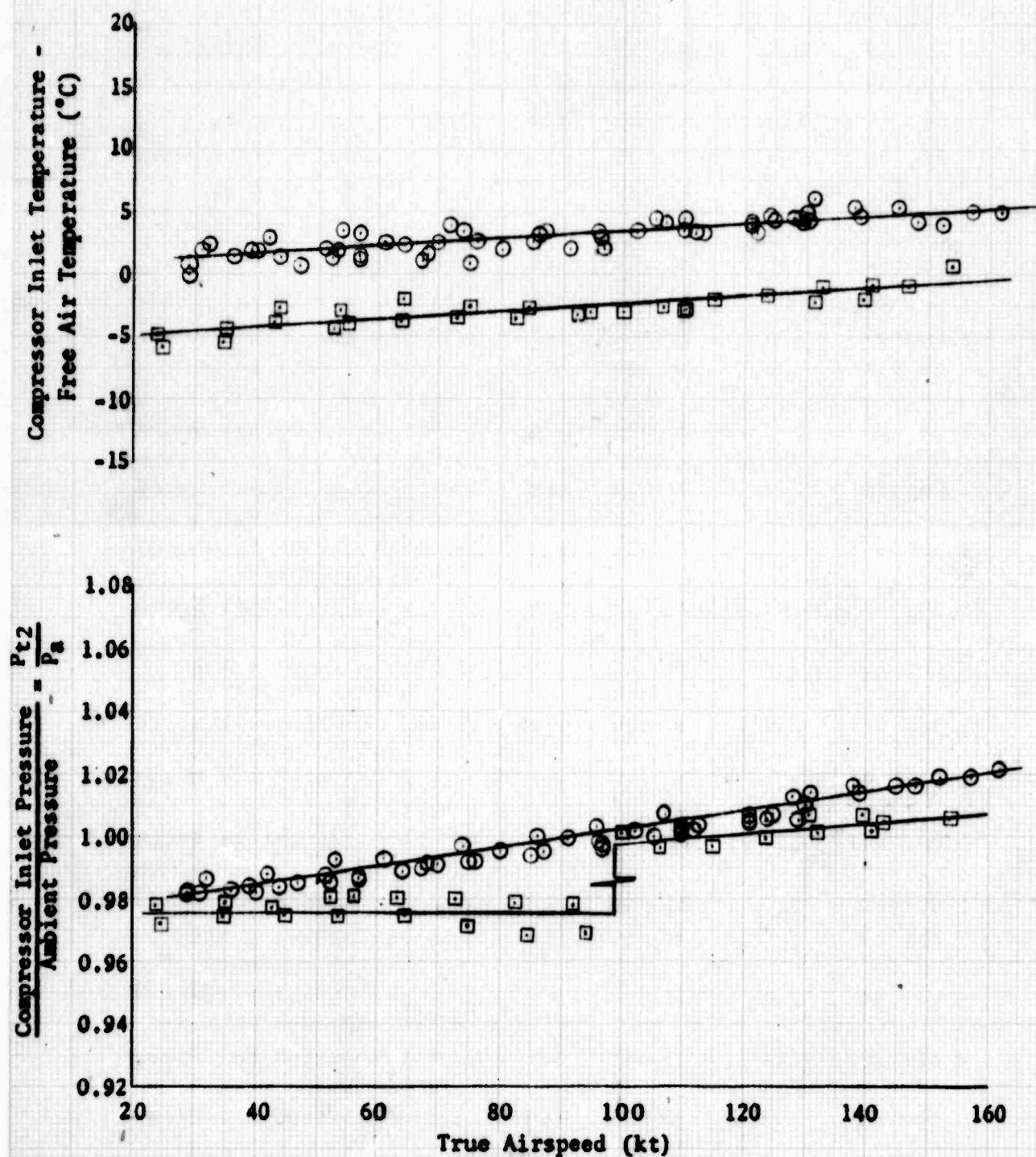


Figure 185. Engine Characteristics

FLIGHT LOG

<u>Flight No.</u>	<u>Date</u>	<u>Flight Time</u>	<u>ESGW</u>	<u>Cg</u>	<u>Test</u>
1	26 Aug 69	1.3	38,322	Mid	Level Flight Performance
2	27 Aug 69	1.3	38,422	Mid	Level Flight Performance
3	28 Aug 69	1.0	29,948	Mid	Level Flight Performance
4	29 Aug 69	1.0	38,522	Mid	Level Flight Performance
5	10 Sep 69	1.2	30,718	Mid	Level Flight Performance
6	10 Sep 69	1.5	30,664	Mid	Level Flight Performance
7	11 Sep 69	1.9	30,739	Mid	Airspeed Calibration
8	11 Sep 69	1.2	30,589	Mid	Level Flight Performance
9	11 Sep 69	1.0	35,364	Mid	Level Flight Performance
10	12 Sep 69	0.8	30,618	Mid	Level Flight Performance
11	12 Sep 69	1.0	36,008	Mid	Level Flight Performance
12	16 Sep 69	0.3	30,618	Mid	Tethered Hovering
13	19 Sep 69	1.3	33,168	Mid	Level Flight Performance
14	20 Sep 69	2.1	36,400	Mid	Sawtooth Climbs & Auto-rotational Descents
15	22 Sep 69	0.7	32,038	Aft	Static Longitudinal Speed Stability
16	23 Sep 69	1.2	32,038	Aft	Static Longitudinal Speed Stability
17	23 Sep 69	1.3	32,038	Aft	Sawtooth Climbs & Autorotational Descents
18	23 Sep 69	1.3	32,128	Aft	Static Longitudinal Speed Stability
19	24 Sep 69	2.0	36,400	Mid	Sawtooth Climbs & Auto-rotational Descents
20	30 Sep 69	1.1	38,158	Aft	Static Longitudinal Speed Stability
21	30 Sep 69	0.8	38,158	Aft	Static Longitudinal Speed Stability
22	30 Sep 69	0.7	38,158	Aft	Static Longitudinal Speed Stability
23	1 Oct 69	0.2	30,732	Mid	Tethered Hovering
24	1 Oct 69	1.8	36,400	Mid	Sawtooth Climbs & Auto-rotational Descents
25	4 Oct 69	1.5	36,000	Mid	Sawtooth Climbs & Auto-rotational Descents
26	4 Oct 69	0.9	42,000	Aft	Static Longitudinal Speed Stability
27	6 Oct 69	1.4	32,000	Fwd	Static Longitudinal Speed Stability

<u>Flight No.</u>	<u>Date</u>	<u>Flight Time</u>	<u>ESGW</u>	<u>Cg</u>	<u>Test</u>
28	7 Oct 69	0.2	30,730	Mid	Tethered Hovering
29	9 Oct 69	1.0	30,730	Mid	Tethered Hovering
30	10 Oct 69	1.1	38,000	Fwd	Static Longitudinal Speed Stability
31	13 Oct 69	0.7	42,000	Aft	Static Longitudinal Speed Stability
32	15 Oct 69	1.5	32,000	Aft	Static Longitudinal Speed Stability
33	15 Oct 69	1.2	38,000	Aft	Static Longitudinal Speed Stability
34	15 Oct 69	0.8	42,000	Aft	Static Longitudinal Speed Stability
35	16 Oct 69	1.1	42,000	Fwd	Static Longitudinal Speed Stability
36	16 Oct 69	0.8	42,000	Fwd	Static Longitudinal Speed Stability
37	18 Oct 69	1.0	42,000	Aft	Static Longitudinal Speed Stability
38	20 Oct 69	1.0	32,323	Mid	Tethered Hovering
39	20 Oct 69	1.2	42,000	Aft	Static Longitudinal Speed Stability
40	21 Oct 69	0.9	32,000	Aft	Static Directional Stability
41	23 Oct 69	0.7	31,000	Aft	Static Directional Stability
42	24 Oct 69	0.3	30,187	Mid	Tethered Hovering
43	25 Oct 69	1.3	42,000	Aft	Static Directional Stability
44	28 Oct 69	1.3	42,000	Aft	Static Directional Stability
45	29 Oct 69	1.0	42,000	Aft	Static Directional Stability
46	29 Oct 69	0.9	42,000	Aft	Static Directional Stability
47	30 Oct 69	1.0	38,000	Aft	Static Directional Stability
48	30 Oct 69	1.2	32,000	Aft	Static Directional Stability
49	31 Oct 69	1.3	32,000	Aft	Static Directional Stability
50	12 Nov 69	1.2	32,000	Aft	Dynamic Stability and Controllability
51	12 Nov 69	1.2	32,000	Fwd	Dynamic Stability and Controllability, Hover
52	13 Nov 69	1.3	32,000	Aft	Dynamic Stability and Controllability
53	13 Nov 69	1.3	32,000	Aft	Dynamic Stability and Controllability
54	17 Nov 69	1.2	32,000	Aft	Dynamic Stability and Controllability
55	17 Nov 69	1.3	32,000	Aft	Dynamic Stability and Controllability

<u>Flight No.</u>	<u>Date</u>	<u>Flight Time</u>	<u>ESGW</u>	<u>cq</u>	<u>Test</u>
56	17 Nov 69	0.7	32,000	Aft	Dynamic Stability and Controllability, Climb
57	20 Nov 69	1.2	32,000	Mid	Dynamic Stability and Controllability, Climb
58	20 Nov 69	0.9	32,000	Fwd	Hardovers, AFCS
59	21 Nov 69	0.6	32,000	Fwd	Hardovers, AFCS, Hover
60	22 Nov 69	0.3	30,569	Mid	Tethered Hover
61	24 Nov 69	1.1	30,569	Mid	Tethered Hover and Free Hover
62	2 Dec 69	1.3	42,000	Aft	Dynamic Stability and Controllability, Tanks Full
63	4 Dec 69	1.3	42,000	Aft	Dynamic Stability and Controllability, Tanks Full
64	9 Dec 69	1.1	42,000	Aft	Dynamic Stability and Controllability, Tanks Full
65	10 Dec 69	0.4	42,000	Aft	Dynamic Stability and Controllability, Hover, Tanks Full
66	12 Dec 69	0.8	42,000	Aft	Dynamic Stability and Controllability, Hover, Tanks Full
67	12 Dec 69	1.1	42,000	Fwd	Dynamic Stability and Controllability, Hover, Tanks Full
68	16 Dec 69	1.2	42,000	Fwd	Dynamic Stability and Controllability, Tanks Full
69	16 Dec 69	1.2	42,000	Fwd	Dynamic Stability and Controllability, Tanks Full
70	18 Dec 69	1.3	42,000	Fwd	Dynamic Stability and Controllability, Tanks Full
71	18 Dec 69	0.9	42,000	Aft	Dynamic Stability and Controllability, Tanks Full, Climb
72	6 Jan 70	0.9	36,500	Mid	Level Flight Performance
73	6 Jan 70	1.0	36,500	Mid	Level Flight Performance, Gear Down
74	13 Jan 70	1.2	39,500	Mid	Level Flight Performance
75	15 Jan 70	1.1	38,200	Mid	Level Flight Performance
76	20 Jan 70	0.9	42,000	Fwd	Sideward and Rearward
77	20 Jan 70	0.9	42,000	Aft	Dynamic Stability and Controllability, Hover
78	23 Jan 70	0.9	30,925	Mid	Level Flight Performance
79	27 Jan 70	1.3	36,000	Mid	Level Flight Performance
80	6 Feb 70	0.5	42,000	Aft	Dynamic Stability and Controllability

<u>Flight No.</u>	<u>Date</u>	<u>Flight Time</u>	<u>ESGW</u>	<u>Cg</u>	<u>Test</u>
81	9 Feb 70	0.7	42,000	Fwd	Sideward (Repeat Flight 76)
82	12 Feb 70	1.1	37,700	Mid	Level Flight Performance
83	12 Feb 70	1.5	30,100	Mid	Level Flight Performance, OGE Hover
84	16 Feb 70	1.0	36,000	Mid	Level Flight Performance
85	16 Feb 70	1.0	36,000	Mid	Level Flight Performance
86	17 Feb 70	1.2	30,200	Mid	Level Flight Performance, EAPS Installed
87	18 Feb 70	0.7	30,200	Mid	Level Flight Performance, EAPS Installed
88	27 Feb 70	0.5	30,500	Mid	Hover Performance, OGE

Fwd cg = 328 in.

Mid cg = 340 in.

Aft cg = 352 in.

REFERENCES

1. Barbini, Wayne J., Balfe, Paul G., Major USAF, Lovrien, Clark E. Jr., Major USAF, FTC-TR-70-8, Category II Performance and Flying Qualities Tests of the HH-53C Helicopter, Air Force Flight Test Center, April 1970.
2. T.O. 1H-53(H) B-1, Flight Manual USAF Series HH-53B, HH-53C Helicopter, 19 August 1968, changed 29 October 1968.
3. Military Specification, Helicopter Flying and Ground Handling Qualities; General Requirements for, MIL-H-8501A, 3 April 1962.

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

(Security classification or title, body of abstract and indexing annotation must be entered when the overall report is classified)	
1. ORIGINATING ACTIVITY (Corporate author) Air Force Flight Test Center Edwards AFB, California	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP N/A
3. REPORT TITLE Category II Performance and Flying Qualities Tests of the HH-53C Helicopter	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final	
5. AUTHOR(S) (First name, middle initial, last name) Wayne J. Barbini Paul J. Balfé, Major, USAF Clark E. Lovrien, Jr., Major, USAF	
6. REPORT DATE May 1970	7a. TOTAL NO. OF PAGES 193
8. CONTRACT OR GRANT NO	9a. ORIGINATOR'S REPORT NUMBER(S) FTC-SD-70-8
b. PROJECT NO Project Directive 69-2 c. Program Structure 482A d.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) N/A
10. DISTRIBUTION STATEMENT This document may be further distributed by any holder <u>only</u> with the specific prior approval of ASD (ASZTH), Wright-Patterson AFB, Ohio 45433.	
11. SUPPLEMENTARY NOTES None	12. SPONSORING MILITARY ACTIVITY 6512th Test Group Edwards AFB, California
13. ABSTRACT This substantiating document contains the test techniques, data analysis methods, and test data for the Category II Performance and Flying Qualities Tests of the HH-53C Helicopter. The results, conclusions, and recommendations were presented in FTC-TR-70-8, <u>Category II Performance and Flying Qualities Tests of the HH-53C</u> <u>Helicopter, April 1970.</u>	

DD FORM 1 NOV 65 1473

UNCLASSIFIED
Security Classification

UNCLASSIFIED
Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
HH-53C helicopter performance and flying qualities tests						

UNCLASSIFIED
Security Classification