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ENGINEERING FLIGHT TEST OF THE YCH-47C MEDIUM TRANSPORT HELICOPTER

ARMY PRELIMINARY EVALUATION II
FINAL REPORT

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US ARMY AVIATION SYSTEMS TEST ACTIVITY
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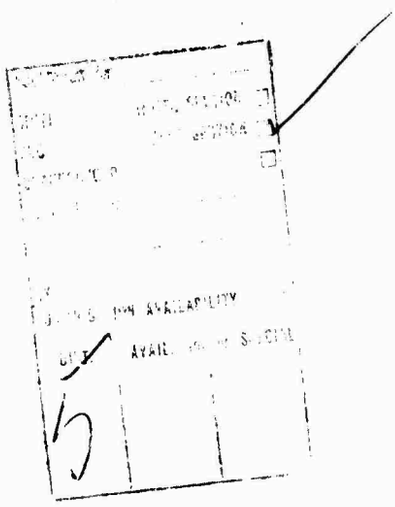

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US ARMY AVIATION SYSTEMS TEST ACTIVITY
Edwards Air Force Base, California 93523

Foreword

During the conduct of the CH-47C helicopter Army Preliminary Evaluation the test helicopter with installed special instrumentation was maintained by the Boeing Company, Vertol Division personnel. Data reduction support and office facilities were also provided by the Boeing Company, Vertol Division.

Abstract

The CH-47 helicopter Army Preliminary Evaluation II was conducted in the vicinity of Philadelphia, Pennsylvania and Millville, New Jersey. The evaluation consisted of limited level flight performance tests and stability and control tests. Within the scope of tests all but six stability and control requirements of the detail and military specifications were met. Correction of two deficiences is mandatory for acceptable mission capabilities. These deficiencies are the static and dynamic longitudinal stability characteristics. Correction of eight shortcomings is desirable for improved helicopter capabilities. Safety of flight was affected by aft rotor blade stall characteristics in maneuvering flight at bank angles above 30 degrees and requires a reduction in maximum bank angles permitted. High aft rotor flight control component stress levels associated with maneuvering flight and operation at limit airspeeds requires that a visual flight loads display be incorporated in the cockpit.

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INTRODUCTION

BACKGROUND

1. The hot-day high altitude performance degradation of the CH-47 helicopter in Vietnam has verified the importance of improving the helicopter's payload and speed capabilities. Based on the requirement for an increased payload capability for the CH-47A, a CH-47 Product Improvement Program evolved (ref 1, app I). The CH-47 Product Improvement Program outlines a two-step program to incorporate performance, stability and vibration level improvements in production CH-47 helicopters. The helicopter configured for step one modification has been designated the CH-47B. The second step in the CH-47 Product Improvement Program provides for the incorporation of higher power for a further increase in payload capability. The helicopter configured for step two modification has been designated the CH-47C.

2. Authority for the US Army Aviation Test Activity (USAAVNTA) participation in the CH-47 Product Improvement Program test was provided by the test directive issued by the US Army Test and Evaluation Command (USATECOM) on 17 June 1966 (ref 2, app I). The test plan (ref 3) for the Army Preliminary Evaluation (APE) was modified to have the APE conducted in three phases, APE I, (Performance Guarantee Compliance), APE II (Stability and Control and Limited Performance Tests) and APE III (Vibration and Noise Level Compliance). These modifications were approved by the CH-47 Project Manager and the US Army Aviation Materiel Command (USAAVCOM) in February 1968.

3. The APE I was completed 14 March 1968 and the final report was forwarded for distribution in June 1968 (ref 4, app I). All performance guarantees were met during APE I as specified in the detail specification (ref 5) for the model CH-47C helicopter.

TEST OBJECTIVES

4. The purpose of APE II was to furnish the CH-47 Project Manager and the procurring activity, USAAVCOM, with preliminary and timely results derived from US Army tests of the YCH-47C helicopter during the contractor's development program. Specific objectives were as follows:

a. To provide quantitative/qualitative engineering flight test data.

b. To serve as a basis for an estimate of the degree to which the aircraft is suitable for its intended mission.

c. To assist in determining the flight envelope to be used by Army pilots for future service and flight operations.

d. To detect and allow early correction of deficiencies as well as to provide a basis for evaluation of changes incorporated to correct deficiencies.

e. To provide preliminary aircraft performance data for operational use.

DESCRIPTION

5. The YCH-47C helicopter flown during APE II, serial number 66-19121 (production tab number B-379), was a prototype YCH-47C in the external configuration specified in the detail specification (ref 5, app I) less the cargo mirror. Nonstandard items mounted externally were slip ring assemblies on both rotor heads, Rosemont temperature probes on underside of the fuselage, and a pitot static boom on the nose. Significant changes from the CH-47B that were applicable to the test helicopter are noted in reference 4, appendix I, and in appendix IV. Additional changes incorporated after APE I and installed on the helicopter for APE II are shown in appendix V.

6. The test helicopter was powered by two prototype YT55-L-11 calibrated engines maximum power rated at 3750 shaft horsepower (shp) in lieu of production T55-L-11 engines which are to be incorporated on the production CH-47C helicopter at a later date. Design gross weight (G.W.) was 33,000 pounds and the alternate design G.W. was 46,000 pounds. The alternate design G.W. for APE I was 44,800 pounds and subsequently changed to 46,000 pounds for APE II by reference 6, appendix I. Increasing the alternate design G.W. resulted from APE I hover performance test results and uprated aft rotor flight control components per Engineering Change Proposal (ECP 585) installed prior to APE II. Physical characteristics of the CH-47C are presented in appendix VI. Cockpit instrumentation was nonstandard and helicopter loading was nonrepresentative due to ballast and instrumentation requirements. Photographs of the test helicopter are contained in appendix VII.

SCOPE OF TEST

7. The YCH-47C was evaluated with respect to its mission as a transport helicopter as defined in the detail specification. Twenty-two test flights were conducted for a total of 26.0

productive hours. Flying qualities were evaluated against the requirements of the military specification (ref 7, app I). Limited level flight performance testing was conducted as required by the flight envelope release (ref 8) to provide the contractor data for inclusion in the operator's manual (ref 9). The YCH-47C was tested under the conditions shown in table 1.

Table 1. Scope of Test.

Flight conditions	Hover, sideward, rearward, take-offs, landings, climbs, descents, autorotations, and maneuvering
Power	Dual and single engine.
Airspeed	0 - 158 KCAS forward flight 0 - 30 KTAS rearward flight 0 - 35 KTAS sideward flight
Takeoff gross weights	37,500 lb to 47,500 lb
Rotor speeds	232 rpm to 246 rpm
Density altitudes	Sea level (S.L.) to 13,500 ft
Takeoff center of gravity (cg location)	Longitudinal (location in inches from center line between rotors) 5.7 aft to 11.5 forward Lateral (location in inches from plane of symmetry of fuselage) 0 and 4.1 left
Stability augmentation system	On/off
Longitudinal cyclic speed trim modes	Automatic/manual
Differential collective pitch speed trim condition	Operating

8. The flight restrictions and operating limitations applicable to this evaluation are contained in appendix VIII and the flight

envelope release. The flight envelope release for APE II was significantly expanded in airspeed, altitude and G.W. as compared to the APE I release (ref 10, app I).

METHOD OF TESTS

9. Performance and stability and control tests were conducted in the vicinity of Philadelphia, Pennsylvania and Millville, New Jersey. Standard USAAVNTA test methods were used to acquire data for analysis and evaluation to determine military and detail specification compliance. A Pilot's Rating Scale was used to augment qualitative comments. This scale is presented in appendix X.

10. A detailed list of the test helicopter instrumentation is contained in appendix IX. Angular accelerations were obtained by differentiating rate signals. This was done by use of a differentiation circuit which received rate inputs from a rate signal generator. Photographs of the cockpit and cabin instrumentation installed on the test helicopter are presented in appendix VII.

11. Power and fuel flow data, as specified in the T55-L-11 Engine Model Sepcification (ref 11, app I), were used to derive performance conditions. Power required derived from rotor torque was compared with power derived from fuel flow to verify that engine degradation had not occurred.

CHRONOLOGY

12. The chronology of testing is as follows:

Test directive received	1 June 1966
Test aircraft received	17 June 1968
Test started	18 June 1968
Test completed	2 July 1968
APE II debriefing	29 July 1968
Draft report submitted	14 August 1968
Final report submitted	February 1969

RESULTS AND DISCUSSION

GENERAL

13. Performance tests were conducted to provide the contractor with preliminary flight test data for incorporation in the operator's manual. Reduction of data was based on engine characteristics contained in the engine model specification with amendment 1. A subsequent revision of the engine model specification requires a reevaluation of the performance guarantees determined during APE I.

14. The flying qualities of the helicopter were evaluated with respect to its mission as a day/night, VFR/IFR, medium cargo helicopter. The poor longitudinal static and dynamic stability characteristics made the IFR mission capability of the helicopter unacceptable. Other flying quality characteristics affecting mission capabilities were excessive longitudinal control free play, directional control unbalance, unstable or neutral longitudinal control position gradients, pitch to thrust coupling, high lateral control sensitivity, imprecise engine torque control and high thrust control rod sensitivity. Longitudinal and lateral control force gradient characteristics, lateral control sensitivity, and dynamic stability failed to meet the requirements of the military specification. Aft rotor blade stall encountered above 30-degree bank angles requires bank angle limitations less than those released for the evaluation. High stress levels in the aft rotor components associated with maneuvering flight and high airspeeds requires the incorporation in the cockpit of a reliable visual load display. Compliance with the detail and military specifications as pertains to dual engine failure and autorotation under critical loading and flight conditions has not been demonstrated by the contractor. Compliance should be accomplished at the earliest possible time.

PERFORMANCE

15. Level flight performance tests were conducted to provide data for the operator's manual. The test conditions are presented in figures 1 and 2, appendix II, for the indicated referred G.W.'s and rotor speeds. Determination of the generalized performance data and compressibility corrections to shp are as specified in reference 4, appendix I.

16. The engine model specification with amendment 1 (ref 11, app I) was used to determine range performance and power available

during APE I and II. Following APE II the engine model specification was revised by AVCO Lycoming (ref 12) and approved by USAAVSCOM. Changes from the old to the revised engine model specification will result in an increase of specific fuel consumption as reported in reference 4. Figure 3, appendix II, presents generalized shp with referred fuel flow for both engine model specifications and compares the change in specific fuel consumption for SL standard day. The increase in fuel specifics will degrade the performance capability of the CH-47C as reported in reference 4. It is recommended that USAAVSCOM reevaluate level flight performance guarantee compliance based on figure 3 and the test data presented in reference 4.

17. Figures 4 through 6, appendix II, present shp available with pressure altitude as a function of free air temperature for normal power (NP), military power (MP) and maximum power as obtained from the revised engine model specification. Power available is similar at S.L. standard day when comparing these figures with the test results of reference 4, appendix I, for 245 rpm. These figures are used for 230 to 245 rpm as power available is essentially constant with rpm changes. At 10,000 feet standard day, power available increased by 30 shp for NP, 90 shp for MP and 60 shp for maximum power as a result of the revised engine model specification. It is recommended that USAAVSCOM reevaluate climb performance guarantee compliance based on figures 4 through 6 and the test data presented in reference 4.

STABILITY AND CONTROL

Flight Control System

18. The flight control system of the CH-47C was the same as that incorporated on the CH-47B except for modification of the longitudinal cyclic speed trim (LCST) and differential collective pitch speed trim (DCPST) schedules.

19. Figure 7, appendix II, compares the differences in programming between the CH-47B and CH-47C LCST schedules. Programming was optimized for the CH-47C to reduce noise and vibration levels, stress levels on the rotor blade trailing edge and rotor shaft bending moments. Full extension was changed from 120 KCAS on the CH-47B to 160 KCAS for the CH-47C. Additionally, for airspeeds below 60 KCAS the swashplate tilt was changed from -1.5 degree forward on the CH-47B to +.5-degree aft tilt for the CH-47C. LCST schedules for the CH-47B and CH-47C programmed a total of 4.5 degree forward swashplate tilt extension on both rotors. The programming of LCST with airspeed results in unstable pitching moments when airspeed varies from a trimmed

flight condition. The unstable pitching moments were evident in the long term dynamic response characteristics following simulated gust upsets and contributed to the divergent dynamic response of the CH-47C (para 56). Figure 8 shows that for all flight conditions tested the LCST schedule was programming within the ±15 kt tolerance band established by the contractor.

20. Figure 9, appendix II, compares the CH-47B and CH-47C DCP schedules. The DCPST schedule was incorporated to provide positive longitudinal control position stability with airspeed. The programming of DCPST with airspeed results in stable pitching moments when airspeed deviates from a trim condition. The greater the incremental change in DCPST with airspeed the stronger the stable pitching moment following a long term dynamic response of the helicopter to a gust upset. Changing the DCPST schedule from the CH-47B to the CH-47C resulted in decreasing the stabilizing pitching moment and contributed to the divergent dynamic response of the helicopter (para 56). Figure 9 shows that for all flight conditions tested the DCPST schedule was programming within the contractor's tolerance band.

Control Force Characteristics

21. The irreversible hydraulic boosted flight control system of the CH-47C results in control forces which do not reflect aerodynamic feedback characteristics and permits force measurements on the ground with the rotors stationary. Control forces were measured with a handheld force gage with the auxiliary power unit (APU) engaged as specified in deviation 58 of the detail specification. Control force characteristics were evaluated against the requirements of the military specification and deviation 4 of the detail specification. Test results are summarized in tables 2 and 3.

Table 2. Limit Control Forces and Breakout Including Friction Forces.

Flight Control	Limit Control Force[1] lb	Test Results[2] lb	Breakout Including Friction[1]		Test Results lb	Maximum Friction Band lb
			Minimum lb	Maximum lb		
Longitudinal	8	6.6 Push 7.6 Pull	0.5	2.0	1.25 Push 1.10 Pull	1.5 Fwd 1.6 Aft
Lateral	7	5.6 Left 5.7 Right	0.5	2.0	1.6 Left 1.3 Right	1.5 Left 1.5 Right
Directional	34	36 Left 36 Right	3	20	15 Left 15 Right	3.0 Left 1.5 Right
Collective	10	13 Up 17 Down	1	10	4 Up 3 Down	N/A

(1) Forces specified in deviation 4 of the detail specification.

(2) Neutral trim position (mid travel) to control stops, except collective in which case neutral is 1.5 inches up from lower stop (3 degree detent).

Table 3. Control Force Gradients.

Flight Control	Force Gradient[1]		Test Results lb	Gradient[1] Versus Breakout Including Friction	Gradient for first inch travel from trim greater than remaining gradient
	Minimum lb	Maximum lb			
Longitudinal	0.5	2.0	0.8 Push 1.35 Pull	Less[2] Greater	Yes Yes
Lateral	0.5	2.0	0.9 Left 1.2 Right	Less[2] Less[2]	Yes Yes

(1) Requirements of paragraphs 3.2.4 and 3.3.11 of the military specification for first inch of travel from trim.

(2) Gradient for first inch of travel from trim less breakout including friction force. Fails to meet the requirements of paragraphs 3.2.4 amd 3.3.11 of the military specification.

22. The longitudinal control force characteristics are presented in figure 10, appendix II, and summarized in tables 2 and 3. The longitudinal control force characteristics forward from trim failed to meet the requirement of paragraph 3.2.4 of the military specification in that the breakout including friction exceeded the incremental force required for a one inch travel from trim by 0.45 pound (56 percent). The breakout including friction force for an aft displacement from trim was 1.10 pounds with a force gradient of 1.35 pounds for the first inch of travel which met the requirements of paragraph 3.2.4 of the military specification. Although the gradient for the first inch forward from trim did not meet the military specification requirements, the gradient was stable and did not degrade the longitudinal control feel. The longitudinal control force characteristics are satisfactory for Army use (PRS A3).

23. The longitudinal control exhibited a free play of $\pm$0.15 inch about trim and met the requirement of paragraph 3.5.10 of the military specification which permits a free play of $\pm$0.20 inch. However, the free play coupled with the weak static longitudinal stability of the helicopter (para 38), made it difficult for the pilot to precisely command pitch rates to control pitch attitude. Correction of this shortcoming is desirable for improved helicopter operation (PRS A4).

24. The lateral control force characteristics are presented in figure 11, appendix II, and summarized in tables 2 and 3. The lateral control force gradient left and right from trim failed to meet the requirements of paragraph 3.3.11 of the military specfication for the first inch of travel. The forces required for the first inch of travel was 0.9 of a pound left and 1.2 pounds right. Those values were 0.7 pound (44 percent) and 0.1 pound (8 percent) less than the breakout including friction forces respectively. Although the force gradients did not meet the requirements of the military specification the gradients were stable and provided the pilot with a satisfactory control feel. The lateral control gradient characteristics are satisfactory for Army use (PRS A3).

25. The directional control force characteristics are presented in figure 12, appendix II, and summarized in table 1. The limit control forces for left and right pedal displacements from the neutral position were 2 pounds (5.9 percent) greater than specified in deviation 4 of the detail specification. However, within the scope of the tests, pedal displacements required for normal operational requirements did not exceed one inch from an inflight trim position. The force required for a one inch displacement was 22 pounds left and 19 pounds right; well within the

limit force of 34 pounds specified in deviation 4 of the detail specification and met the requirements of paragraph 3.3.12 of the military specification. The directional control force characteristics provide the pilot with a satisfactory force feel when pedal displacements from trim are necessary during maneuvering with control centering ON. A ±0.15 inch free play about trim is shown on figure 12, appendix II. The free play was not apparent in flight and precise pedal inputs were easily made with control centering ON. The directional control force characteristics are satisfactory for Army use (PRS A2).

26. The collective control force characteristics are presented in figure 13, appendix II, and summarized in table 2. The limit control forces for up and down collective displacements from the neutral (3-degree detent) position were 13 pounds and 17 pounds respectively. These forces were 3 pounds (30 percent) and 7 pounds (70 percent) greater than the 10 pounds specified in deviation 4 of the detail specification. However, within the scope of the tests, collective displacements required for normal operational requirements did not require forces exceeding 10 pounds and met the requirements of paragraph 3.4.2 of the military specification. Overcoming limit control forces are within the capability of the average pilot and will allow for full control displacement should the need arise. The collective control force characteristics allowed the pilot to make positive control displacements and are satisfactory for Army use (PRS A2).

Trimmability

27. Within the scope of these tests, the longitudinal, lateral and directional control forces were easily trimmed to zero by use of the control centering switch. The flight controls exhibited positive self-centering characteristics, met the requirements of paragraphs 3.2.3 and 3.3.10 of the military specification and are satisfactory for Army use (PRS A3).

28. Directional control characteristics were objectionable when attempting to retrim in flight due to the left pedal creeping forward at 0.5 in/sec when the control centering switch on the cyclic control was depressed and resulted in an unbalanced pedal condition. When making pedal inputs, the pilot felt no force to the left and a force to the right which resulted in an initial pilot induced oscillation tendency until trim could be established. The effort required to attain directional trim with control centering released made it difficult for the pilot to maintain coordinated flight (PRS A5). Correction of the directional pedal unbalance with control centering released is desirable for improved helicopter operation.

29. Longitudinal and lateral trim changes with rate of climb and descent were satisfactory for all test conditions and met the requirements of paragraphs 3.2.10.2 and 3.3.17 of the military specification (PRS A3). The maximum longitudinal control trim change was 2.25 inches aft and occurred when transitioning from a maximum performance climb to an autorotation at 75 KCAS at 46,000 pounds aft cg. The lateral trim change for the same condition was less than 0.5 inch right.

Control Trim Positions

30. Control trim position characteristics were investigated by trimming the helicopter in steady heading level flight, and sideward and rearward flight. Airspeed was increased in approximately 10 kt increments by adjusting collective setting to maintain altitude and data were recorded for each stabilized condition. A calibrated pace vehicle was used to determine airspeed during the sideward, forward and rearward in ground effect (IGE) flight. Figures 14 thru 24, appendix II, present the control position trim curves obtained during the tests. The contribution of the DCPST to provide longitudinal control trim position is shown as the difference between DCPST "off" longitudinal stick position and DCPST "on" longitudinal stick position as shown on these figures.

31. Longitudinal control trim positions were evaluated in level flight from approximately 49 KCAS to maximum level flight airspeed (V_{max}) and are presented in figures 14 thru 18, appendix II. The data show that the longitudinal control trim position gradients were unstable to 75 KCAS and then became neutral to stable with increased airspeed to V_{max}. Pilot effort was higher than normal when making airspeed changes in the region of the unstable portion of the gradients because the pilot was required to hunt for a new trim-position. Correction of the unstable and neutral longitudinal trim position gradients is desirable for improved helicopter operation (PRS A4).

32. Collective inputs in level flight when changing airspeed resulted in a pitch to thrust coupling. Increasing collective (power) resulted in a nose down pitching moment and decreased collective resulting in a nose up pitching moment. Unless pilot corrective action was taken immediately the helicopter continued to pitch with a subsequent gain or loss of airspeed. The magnitude of the pitching rate increased with the magnitude of collective application. Considerable pilot effort was required to compensate for the pitch to thrust coupling (PRS A4). Correction of the pitch to thrust coupling when making power changes in level flight is desirable for improved helicopter operation.

33. The lateral and directional control trim position gradients obtained for the conditions tested in paragraph 28 show less than 0.5 inch variations as airspeed was increased from 40 KCAS to V_{max}. In figures 14 through 18, appendix II, the data show that right directional and lateral control trim changes were required as airspeed was increased. The small directional and lateral control trim changes required with increased airspeed minimizes pilot effort when trimming and is satisfactory for Army Use (PRS A2).

34. Longitudinal, directional and lateral control trim positions were evaluated in IGE flight from hover to 30 KTAS forward and rearward flight and are presented in figures 19 through 21, appendix II. The data show that very small changes in trim positions of the lateral and directional controls were required to transition between forward and rearward flight (PRS A2). Control motion characteristics of the longitudinal control were essentially linear and stable. Slight nonlinearities existed between hover and 25 KTAS forward flight but were not objectionable to the pilot (PRS A3). Normal flight operation in this speed band occurs when transitioning from a hover to forward flight in close ground proximity. Pitch attitude variation was from approximately 5 degrees nose up in 30 kt rearward flight to 5 degrees nose down in 30 kt forward flight and was not objectionable. Changes in control position trim characteristics due to rpm changes were insignificant (fig 18). Adequate longitudinal control margins existed for the conditions tested and met the requirements of paragraph 3.2.1 of the military specification. Pilot effort to transition to forward and rearward flight was low for all conditions tested and is satisfactory for Army use (PRS A2).

35. Longitudinal, directional and lateral control trim positions were evaluated in IGE flight from hover to 35 KTAS left and right and are presented in figures 22 thru 24, appendix II. These figures show that the lateral control gradients were positive from hover to approximately 20 KTAS left and right, then become essentially neutral at 35 KTAS. The directional control gradient remained essentially neutral with increasing lateral airspeed at approximately the Mission I G.W. (37,100 pounds) and required approximately 0.5 inch left displacement between 35 KTAS right and 35 KTAS left sideward flight at approximately the alternate design G.W. (46,000 lb)(PRS A2). Longitudinal control trim positions were within 0.8 inch of hover trim and did not exhibit any degrading nonlinearities. Collective control positions indicated decreasing power required with increasing lateral airspeed. There were no significant changes of control position with G.W. except for increased collective setting. Maximum obtainable lateral cg resulted in approximately a 0.7 inch change and control displacement for similar test conditions (figs 20 and 21). Roll attitudes attained during tests were acceptable. Pilot effort to transition to side-

ward flight was low. The sideward flight characteristics of the CH-47C met the requirements of para 3.3.2 of the military specification and are satisfactory for Army use (PRS A3)

36. Within the scope of the tests, the longitudinal, directional and lateral control trim position gradients were not significantly affected by rpm or cg for similar G.W.'s. Longitudinal and lateral control trim positions shifted with longitudinal and lateral cg's but did not affect the flying qualities of the helicopter.

Static Longitudinal Stability

37. Static longitudinal stability characteristics were investigated by trimming the helicopter in steady heading level flight, NP climb, partial power descent and autorotation. Airspeed was increased and decreased in approximately 5 kt increments about the trim airspeed with collective fixed and data were recorded for each stabilized condition tested. Figures 25 through 35, appendix II, present static longitudinal stability characteristics. The contribution of the DCPST to provide longitudinal control gradients is shown as the difference between the DCPST OFF longitudinal stick position and DCPST on longitudinal stick position as shown on these figures. The DCPST failed to program an adequate contribution of equivalent control travel to provide positive stable longitudinal characteristics for most test conditions.

38. Static longitudinal stability test conditions and longitudinal control position characteristics in level flight are summarized in table 4. Figure 25, appendix II, shows that the static longitudinal stability characteristics for the approximate Mission I G.W. varied from unstable at low-trim airspeeds to stable at high trim airspeeds. At 52 KCAS a high degree of instability existed as shown by the control position gradient. Control motion was approximately 0.6 inch per 10 kt incremental airspeed change in the unstable (negative) direction below trim airspeed and 0.3 inch per 10 kt incremental airspeed change in the unstable direction above trim airspeed. At 117 KCAS trim airspeed the gradient was positive and control motion was approximately 0.3 inch per 10 kt incremental change above and below the trim airspeed. AT 141 KCAS trim airspeed the gradient aft of trim was similar to that for 117 KCAS. However, forward of trim a less positive to neutral gradient was exhibited. Figures 25 through 27 show that the static longitudinal stability characteristics for the Mission I G.W. are essentially invarient with changes in altitude, rpm and cg for similar trim airspeeds. The directional and lateral control positions versus airspeed gradients about trim airspeed were essentially neutral and required minimum pilot effort to retrim when airspeed changed. Figures 28 through 31 show that the static

stability characteristics for G.W.'s up to approximately the alternate design G.W. are similar to those at the Mission I G.W. These characteristics are essentially invariant with changes in altitude, rpm and cg for similar trim airspeeds. Figures 25 through 31 show that for most conditions tested in level flight the static longitudinal stability characteristics of the CH-47 failed to meet the requirement of deviations 5 and 10 of the detail specification. The poor static longitudinal stability characteristics below 90 KCAS presented in figures 25 through 31 resulted in excessive pilot effort to maintain a trim air speed within ±10 kt in light turbulence. When coupled with the dynamic instability characteristics (para 56), pilot effort to control airspeeds for the IFR mission was unacceptably high for airspeeds below 90 KCAS (PRS U7) and marginally acceptable for the VFR mission (PRS A6). Correction of the static longitudinal instability characteristics in level flight is mandatory for the IFR mission for acceptable aircraft operation and desirable for the VFR mission.

Table 4. Static Longitudinal Stability in Level Flight.

Trim Airspeed KCAS	Average Gross Weight lb	Rotor Speed rpm	Average Density Altitude ft	Average in.	Stability Characteristics
52(.4V_{NE})(4)	36,680	232	5,170	6.6 aft	Negative above and below trim speed (fig 25)(1)
117(.8V_{NE})	35,720	233	5,641	7.1 aft	Positive above and below trim speed (fig 25)(2)
141(V_{NE})	36,987	234	5,640	6.6 aft	Positive above and positive to neutral below trim speed (fig 25)(2)
115(.7V_{NE})	38,207	235	550	18.0 fwd	Positive above and neutral below trim speed (fig 26)

Table 4. Continued.

Trim Airspeed KCAS	Average Gross Weight lb	Rotor Speed rpm	Average Density Altitude ft	Average cg in.	Stability Characteristics
97(V_{NE})	37,330	233	10,090	6.3 aft	Negative to positive below and neutral above trim speed (fig 27)(1)
62(.5V_{NE})	45,972	244	5,260	4.0 aft	Negative above and below trim speed (fig 28)(1)
93(.8V_{NE})	45,088	244	5,310	4.5 aft	Negative above and positive below trim speed (fig 28)(1)
116(.9V_{NE})	42,872	245	4,850	7.5 aft	Positive above and below trim speed (fig 28)(2)
54(.6V_{NE})	45,940	244	7,250	4.1 aft	Negative above and below trim speed (fig 29)(3)
69(.9V_{NE})	45,810	244	7,930	4.1 aft	Positive above and negative below trim speed (fig 29)(3)
50(.4V_{NE})	43,372	242	4,840	9.0 fwd	Negative above and below trim speed (fig 30)(1)
93(.8V_{NE})	45,062	243	4,647	10.5 fwd	Neutral above and Positive below trim speed (fig 30)(2)
54(.7V_{NE})	45,491	242	7,934	10.0 fwd	Negative above and below trim speed (fig 31)(3)
70(V_{NE})	46,265	242	7,958	10.5 fwd	Negative above and below trim speed (fig 31)(3)

Table 4. Continued.

(1) Failed to meet the requirements of deviation 5 and 10 of the detail specification.

(2) Met the requirements of deviation 5 (VFR flight) and 10 (IFR flight) of the detail specification.

(3) Met the requirements of deviation 5 of the detail specification. Failed to meet the requirements of deviation 10 of the detail specification.

(4) Never exceed airspeed (V_{NE}).

39. Static longitudinal stability test conditions and longitudinal control position characteristics in NP climbs are summarized in table 5. Figure 32, appendix II, shows that the static stability characteristics for the approximate alternate design G.W. differed from those in level flight. At 76 KCAS the negative gradient below trim speed was similar to that exhibited in level flight; however, above trim speed the gradient was positive (approximately 0.2 inches control motion per 10 kt incremental change in airspeed). Figures 32 and 33 show that the static stability characteristics for the alternate design G.W. were essentially invariant with altitude and cg at airspeed for maximum rate of climb (V_{max} R/C) (approximately 76 KCAS). Figure 33 shows that at 72 KCAS and the approximate Mission I G.W. the gradient aft of the trim airspeed became slightly positive to neutral. Pitch attitude increases with increasing airspeed and the directional and lateral control - airspeed gradients about trim airspeed were similar to those exhibited in level flight (para 39). Figures 32 and 33 show that in NP climbs the static longitudinal stability characteristics of the CH-47C failed to meet the requirements of deviation 5 and 10 of the detail specification for gradients below the trim airspeed. The weak static longitudinal stability characteristics for NP climbs were manifested in the excessive pilot effort required to maintain a trim airspeed within ±5 kt in light turbulence. Considerable pilot effort to achieve reasonable performance was required for the IFR (PRS A6) and VFR (PRS A5) missions. Correction of the static longitudinal stability characteristics in NP climbs is desirable for improved aircraft operation.

40. Static longitudinal stability test conditions and longitudinal control position characteristics in partial power descents at 500 fpm rate of descent (R/D) and autorotation are summarized in table 6. Figure 34, appendix II, shows that static stability characteristics for the approximate Mission I G.W. were similar to the NP climb (para 40) for the gradient below the trim airspeed. Above the trim

airspeed the gradient was negative and control motion was approximately 0.2 inch per 10 kt incremental change in the unstable direction from the trim airspeed. Stability characteristics in autorotation at the approximate Mission I and alternate design G.W.'s were similar. The gradients were essentially neutral about the trim airspeeds of 97 and 109 KCAS. Pitch attitude changes with airspeed and the directional and lateral control airspeed gradients about trim airspeed were similar to those exhibited in level flight (para 39). Figures 34 and 35, show that in partial power descent and autorotation the static longitudinal stability characteristics of the CH-47C failed to meet the requirements of deviation 5 and 10 of the detail specification. The weak static longitudinal stability characteristics for partial power descents and autorotation were manifested in excessive pilot effort required to maintain a trim airspeed within ±5 kt in light turbulence (PRS A5 for VFR mission and PRS A6 for IFR). Correction of the static longitudinal instability characteristics in partial power descent and autorotation is desirable for improved aircraft operation.

Static Lateral-Directional Stability

41. Static lateral-directional stability characteristics were investigated by trimming the helicopter in steady heading sideslips at a trim airspeed with collective fixed in level flight, climbs, partial power descent and autorotation. Sideslip angle was increased in approximately 5-degree increments and data were recorded for each stabilized condition. The stability augmentation system (SAS) provided stable pedal and lateral control position sideslip angle gradients for all flight conditions tested. Figures 36 through 46, appendix II, present static lateral-directional stability characteristics. The contribution of the directional SAS extensible link actuators to provide stable directional pedal gradients is determined as the difference between the SAS OFF directional pedal positions and SAS ON directional pedal positions shown on the figures 36 through 46.

42. Level flight lateral-directional stability characteristics are presented in figures 36 through 41, appendix II, and the test conditions are summarized in table 7. For the conditions listed in table 7 the maximum sideslip angles attained met the requirements of deviation 6 of the detail specification. Deviation 6 of the detail specification requires that between sideslip angles of ±15 degrees the curves of directional and lateral controls plotted against sideslip angles shall be linear. For all conditions tested the directional and lateral control-sideslip angle gradients were stable and linear for angles to at least ±15 degrees. The forward head droop stops were contacted at 136 KCAS (V_{max}) trim airspeed

and 234 in a 12-degree left sideslip and 12 degrees in a right sideslip. The droop-stop contact did not limit the operational capability of the helicopter (SAS ON) since the coordination turn feature normally kept sideslip angles within ±3 degrees. However, during SAS OFF flight (para 68), at all speeds, sideslip angles above ±10 degrees were reached and the possibility of droop-stop contact existed at 235 rpm. Increasing rpm to 245 alleviated droop-stop contact to sideslip angles greater than ±15 degrees. Droop-stop contact also occurred at 90 KCAS and 110 KCAS as shown on figures 36 and 37 in maneuvering flight under some conditions (para 61). It is recommended that the following caution be put in the operator's manual:

> "Increase rotor speed to 245 rpm when flying SAS OFF below 40,000 pounds gross weight to alleviate forward head droop stop contact."

It is further recommended that the contractor investigate means to eliminate droop-stop contact at low sideslip angles and high airspeeds. The static directional stability characteristics were similar for all level flight conditions listed in table 7. Directional control position-sideslip angle gradients were approximately 0.05 inch per 1 degree increase in sideslip angle. The lateral stability characteristics varied for different trim airspeeds. The lateral control position - sideslip angle gradients became more stable from a trim airspeed of 51 KCAS (0.025 inches per 1 degree increase in sideslip angle) to a trim airspeed of 136 KCAS (0.08 inch per 1 degree increase in sideslip angle) and roll attitude changes were in the right direction. This indicated increased positive dihedral with increased airspeed. For all level flight test conditions at least 10 percent margin of both lateral and longitudinal control travel remained. As sideslip angle was increased about a trim airspeed, increased aft longitudinal control was required. The degree of longitudinal control input for a given sideslip angle increased with airspeed. Pilot effort to maintain a trim airspeed became objectionable above sideslip angles of 15 degrees due to deterioration of airspeed control. Since normal operational use of the helicopter does not require a need for high sideslip angle capability, the aft longitudinal control required to maintain a trim airspeed does not significantly effect operational use of the helicopter. The static lateral-directional stability characteristics in level flight were essentially invarient with G.W., altitude, cg and rpm for similar calibrated trim airspeeds. The static lateral-directional stability characteristics of the CH-47C in level flight are satisfactory for Army use (PRS A3).

Table 5. Static Longitudinal Stability in NP Climbs.

Trim Airspeed KCAS	Average Gross Weight lb	Rotor Speed rpm	Average Density Altitude ft	Average cg in.	Stability Characteristics
76 (V_{max}R/C)	46,805	242	7,290	11.0 fwd	Positive above and negative below trim speed (fig 32)(1)
76 (V_{max}R/C)	46,915	244	5,350	3.5 aft	Positive above and negative below trim speed (fig 32)(1)
77 (V_{max}R/C)	47,000	244	3,170	11.2 fwd	Positive above and negative below trim speed (fig 33)(2)
72 (V_{max}R/C)	38,110	232	7,630	5.8 aft	Positive to neutral below trim speed (fig 33)(3)

(1) Met the requirements of deviation 5 (VFR flight) of the detail specification. Failed to meet the requirements of deviation 10 (IFR flight) of the detail specification.

(2) Failed to meet the requirements of deviation 5 and 10 of the detail specification.

(3) Met the requirements of deviation 5 and 10 of the detail specification.

Table 6. Static Longitudinal Stability in Partial Power Descent and Autorotation.

Trim Airspeed KCAS	Average Gross Weight lb	Rotor Speed rpm	Average Density Altitude ft	Average cg in.	Stability Characteristics
73(1)	36,225	232	5,780	7.0 aft	Negative above and below trim speed (fig 34)(2)
109(3)	35,900	232	6,810	6.7 aft	Neutral above and below trim speed (fig 34)(2)
97(3)	45,550	246	4,490	4.2 aft	Neutral above and below trim speed (fig 35)(2)

(1) Partial power descent at airspeed for minimum rate of descent (V_{min} R/D).

(2) Failed to meet the requirements of deviation 5(VFR flight) and 10(IFR flight) of the detail specification.

(3) Autorotation.

Table 7. Static Lateral Directional Stability in Level Flight.

Trim Speed KCAS	Average Gross Weight lb	Rotor Speed rpm	Average Density Altitude ft	Average cg in.	Sideslip Angles Attained(1) degrees
136(V_{max})	36,480	234	4,640	7.0 aft	12 left and 8 right. Droop stop contact 12 left and 12.5 right (fig 36)
90(.9V_{NE})	36,650	234	10,130	7.0 aft	22.5 left and 21 right. Droop stop contact at 32 left and 22 right (fig 36)

Table 7. Continued.

52(.3V_{NE})	36,230	232	4,740	7.2 aft	34 left and 28 right (fig 32)
110(.7V_{NE})	35,040	232	4,460	8.0 aft	26 left and 17 right. Droop stop contact at 20 right (fig 37)
69(V_{NE})	45,950	243	8,360	10.0 fwd	29 left and 25 right (fig 38)
55(.8V_{NE})	45,180	242	8,180	9.5 fwd	36 left and 26 right (fig 39)
51(.5V_{NE})	44,540	242	5,880	9.0 fwd	29 left and 31 right (fig 39)
62(.5V_{NE})	45,710	244	4,690	4.1 aft	13 Left and 27 right (fig 39)
94(.8V_{NE})	44,760	244	5,240	5.6 aft	25 left and 21 right (fig 40)
115(.9V_{NE})	42,560	246	4,490	6.2 aft	23 left and 23 right (fig 40)
55(.6V_{NE})	45,180	244	7,560	5.0 aft	26 left and 26 right (fig 41)
72(V_{NE})	45,430	244	8,240	4.8 aft	23 left and 24 right (fig 41)

(1) All droop stop contact occurred on forward rotor head.

43. Static lateral-directional stability characteristics in climbs are presented in figures 42 through 44, appendix II, and the test conditions are summarized in table 8. Characteristics in climbs were generally similar to those exhibited in level flight (para 43). The aft longitudinal control required with increased sideslip in level flight was experienced in climbs but not to the same extent. The lateral-directional stability characteristics in climbs met the requirements of deviation 6 of the detail specification and are satisfactory for Army use (PRS A2).

Table 8. Static Lateral-Directional Stability in Climb.

Trim Speed KCAS	Average Gross Weight lb	Rotor Speed rpm	Average Density Altitude ft	Average cg in.	Sideslip Angles Attained degrees
65($.5V_{NE}$)(1)	35,820	232	7,690	7.0 aft	14 left (fig 42)
87($.8V_{NE}$)(1)	37,930	235	4,080	5.9 aft	17 left and 19 right (fig 42)
76(V_{max}R/C)(1)	46,270	244	5,130	3.7 aft	24 left and right (fig 43)
76(V_{max}R/C)(2)	47,150	244	4,690	3.6 aft	19 left and 23 right (fig 43)
76(V_{max}R/C)(1)	47,240	243	3,550	11.2 fwd	19 left and 23 right (fig 44)
78(V_{max}R/C)(1)	46,700	244	6,430	10.5 fwd	25 left and 15 right (fig 44)

(1) Military Power (MP) climb. (2) NP climb.

44. Static lateral-directional stability characteristics in partial power descent are presented in figure 45, appendix II, and the test conditions are summarized in table 9. Characteristics in partial power descent were generally similar to those exhibited in level flight (para 43) met the requirements of deviation 6 of the detail specification and are satisfactory for Army use (PRS A2).

Table 9. Static Lateral-Directional Stability in Partial Power Descent.

Trim Speed KCAS	Average Gross Weight lb	Rotor Speed rpm	Average Density Altitude ft	Average cg in.	Sideslip Angles Attained degrees
79(V_{min}R/D)	36,246	232	3,780	7.5 aft	28 left and 32 right (fig 45)
76(V_{min}R/D)	46,356	244	4,080	3.8 aft	24 left and 29 right (fig 45)

45. Static lateral-directional stability characteristics in autorotation are presented in figure 46, appendix II, and the test conditions are summarized in table 10. Characteristics in autorotation were similar to those in level flight (para 43)except for the aft longitudinal control required with increased sideslip which was not as great as in level flight. Extrapolation of data on figure 46 indicates the lateral control position-sideslip variation will be linear to 30-degree sideslip angle. The static lateral-directional stability characteristics in autorotation appeared to meet the requirements of deviation 6 of the detail specification and are satisfactory for Army use (PRS A2).

Table 10. Static Lateral Directional Stability in Autorotation.

Trim Speed KCAS	Average Gross Weight lb	Rotor Speed rpm	Average Density Altitude ft	Average cg in.	Sideslip Angles Attained degrees
97(.7V_{NE})	44,036	245	3,380	5.5 aft	15 left and 15 right (fig 46)

Controllability

46. The controllability of the CH-47C was measured about the pitch, roll and yaw axes in hovering, sideward, rearward and forward flight as defined by the helicopter control sensitivity (angular acceleration), control effectiveness (angular rate), and control power (angular displacement in a specified time) following step inputs. Step inputs from 0.25 inch to 3.00 inches were made using a mechanical fixture or a SAS pulser box operating through the number one SAS pitch, roll and yaw axes. SAS inputs were 50 percent and 100 percent of the applicable extensible link authorities for each axis. The controllability for each flight condition was determined by making at least two step inputs of increasing displacement in each direction about each axis to establish the controllability trends. The controllability characteristics are presented in figures 47 through 65, appendix II. Summary plots of the data presented in figures 47 through 65 are presented in figures 66 through 68. Time histories of representative step inputs are presented in figures 69 through 76. The data show that the control power exhibited by the CH-47C was satisfactory about the three major axes for all flight conditions tested. The IGE

hovering control power was evaluated against the requirements of the military specification and the results are summarized in table 11. The IGE hovering control power about the three major axes met the requirements of paragraphs 3.2.1, 3.2.12, 3.2.13, 3.3.5, 3.3.6, 3.3.7, 3.3.18 and 3.6.1.1 of the military specification and is satisfactory for Army use (PRS A2).

Table 11. IGE Hovering Control Power.

Average Gross Weight (lb)	Center of Gravity (in.)	Longitudinal (Deg. in 1 Sec)				Lateral (Deg. in 1/2 Sec)				Directional (Deg. in 1 Sec)			
		(1) SPEC		TEST		(2) SPEC		TEST		(3) SPEC		TEST	
		VFR	IFR	AFT	FWD	VFR	IFR	L	R	VFR	IFR	L	R
37,000(4)	6.5 Aft	N/A	N/A	5.0	4.8	N/A	N/A	1.9	2.0	N/A	N/A	1.6	2.0
37,100	17 Fwd 4.1 Left	N/A	N/A	3.5	4.8	N/A	N/A	1.9	1.1	N/A	N/A	2.2	2.0
46,000	12 Fwd	1.25	2.04	4.7	6.7	0.75	1.12	2.0	2.2	3.05	3.05	3.3	3.3
46,000	4 Aft	1.25	2.04	4.7	5.0	0.75	1.12	2.0	2.2	3.05	3.05	N/A	N/A

(1) Paragraphs 3.2.13 and 3.6.1.1 of the military specification.

(2) Paragraphs 3.3.18 and 3.6.1.1 of the military specification.

(3) Paragraphs 3.3.5 and 3.6.1.1 of the military specification.

(4) OGE and IGE.

47. The normal acceleration and angular velocity response characteristics following longitudinal step inputs met the maneuver stability response requirements of paragraph 3.2.11.1 of the military specification. The normal acceleration and angular velocity responses became concave downward within 2.0 seconds following the start of a longitudinal step input. Time histories of typical responses to step inputs are presented in figures 69 throuh 76, appendix II. The angular acceleration response characteristics following longitudinal, lateral and directional control displacements met the requirements of paragraphs 3.2.9 and 3.3.16 of the military specification. Angular acceleration response developed in the proper direction within 0.2 seconds after control displacements. Time histories of typical responses are presented in figures 69 through 76. The maneuver stability and angular acceleration response characteristics of the CH-47C allowed the pilot to easily control the helicopter while maneuvering and are satisfactory for Army use (PRS A2).

48. Longitudinal controllability characteristics are presented in figures 47 through 50 and 59 through 62, appendix II. The longitudinal control sensitivity of the helicopter varied from 10 to 23 degrees/sec^2 per inch of control travel in hover, 30 KTAS forward and rearward flight, MP climbs, autorotation and level flight. The control effectiveness varied from 6 to 10 degrees/sec per inch of control travel. The control power was approximately 4.5 degrees per inch of control in one second. Control sensitivity increased from hover to 30 KTAS rearward flight where it was higher than for any other flight condition. In level flight the control sensitivity decreased with increasing G.W. and altitude but was similar for different airspeeds.

49. Lateral controllability characteristics are presented in figures 51 through 54 and 63 through 65, appendix II. Lateral control sensitivity varied from 14 to 24 degrees/sec^2 per inch of control travel in hover, sideward, and level flight. The control effectiveness was approximately 10 degrees/sec inch of control travel. In a hover there was a slightly greater sensitivity at an aft cg as compared to a forward cg. In level flight there was little effect on control sensitivity as a result of G.W. or altitude. Control effectiveness and control power was relatively independent of G.W., cg, altitude and airspeed. The lateral control was overly sensitive when small roll attitude changes were required to maintain steady heading level flight. Attempts to retrim longitudinally usually resulted in a requirement to retrim roll attitude. Slight inadvertent lateral inputs caused a one to two degree roll attitude change which was annoying to the pilot. Any lateral vibrations caused a noticeable tendency toward lateral pilot induced oscillations which made the retrimming task more

difficult with control centering released. The lateral control sensitivity failed to meet the requirements of paragraph 3.3.15 of the military specification and was too high for small lateral control inputs (PRS A4). Correction of the high lateral control sensitivity is desirable for improved helicopter operation.

50. Directional controllability characteristics are presented in figures 55 through 58 and 63 through 65, appendix II. Directional control sensitivity varied from 8 to 12 degrees/sec^2 per inch control travel in hover, 35 KTAS sideward, level flight and MP climbs. The control effectiveness was approximately 6 degrees/sec per inch of control displacement. The control power was approximately 2 to 3 degrees/inch of control travel. Directional sensitivity was relatively unaffected by G.W., altitude, or flight conditions. A slight reduction in sensitivity existed at a forward cg in hover as compared to an aft cg. Left sideward flight resulted in approximately a 1/3 reduction in sensitivity for right and left step inputs as compared to right sideward flight. Directional controllability of the helicopter was good and pilot effort to command precise heading changes in a hover was low (PRS A2).

Dynamic Stability

51. Dynamic stability characteristics were investigated in steady heading level flight, climb, partial power descent, autorotation, hover, sideward and rearward flight. Forward and aft pulses of approximately one inch and 1/2 second were made to simulate gust upsets by using a mechanical fixture or a SAS pulser box input operating through the number one SAS pitch, roll and yaw axes. SAS inputs were 100 percent of the applicable extensible link authorities for each axis. A calibrated pace vehicle was used to determine airspeed during the sideward and rearward flight. Representative time histories of pitch, roll and yaw dynamic stability characteristics for all conditions tested are presented in figures 77 through 110, appendix II. For most level flight conditions tested, the long term dynamic pitch response of the helicopter was divergent and noncompliance with the military specification was based on time to double amplitude for pitch attitude responses.

52. Dynamic stability test results in hover about the pitch, roll and yaw axes SAS ON and SAS OFF are summarized in table 12. Figures 77 through 82, appendix II, present typical SAS ON and SAS OFF helicopter responses about all axes. Lateral and directional responses were similar to those of the pitch responses following pulse inputs. The short period rate and attitude responses were essentially damped in 3/4 cycles as shown in figure 77. Normal acceleration remained essentially zero from pulse inputs until recovering from the resulting helicopter response. With SAS

Table 12. Dynamic Stability in Hover.

Average Gross Weight lb	Rotor Speed rpm	Average Density Altitude ft	Average cg in.	Type Pulse	Helicopter Response to Pulse Input	Recovery Time sec	Reason for Recovery	Suitability
46,300	245	160	10.7 Aft	Forward	Oscillatory convergent	N/A	N/A	Satisfactory (fig 77)
35,990	235	780	6.9 Aft	Aft	Oscillatory divergent	3.8	Attitude unsafe	Satisfactory (1) (fig 78)
46,180	245	160	10.6 Fwd	Left lateral	Oscillatory convergent	N/A	N/A	Satisfactory (fig 79)
34,940	235	600	7.0 Aft	Left lateral	Oscillatory divergent	1.3	Rate unsafe	Satisfactory (1) (fig 80)
36,120	235	630	6.8 Aft	Left directional	Oscillatory convergent	4.9	N/A	Satisfactory (1) (fig 81)
36,610	234	730	6.6 Aft	Left directional	Aperiodic convergent to 8 degrees left	3.8	N/A	Satisfactory (fig 82)

(1) SAS off. Flying qualities satisfactory for emergency operations. Met requirements of paragraph 3.5.9 of the military specification.

ON, the pitch, roll and directional responses were similar regardless of G.W., cg, and rpm. There were no apparent long term responses that were bothersome to the pilot (PRS A2). The dynamic stability characteristics in hover about the pitch, roll and yaw axes met the requirements of paragraphs 3.2.11, 3.2.11.2 and 3.6.1.2 of the detail specification and are satisfactory for Army use (PRS A3).

53. Figure 78, 80 and 81 show that with SAS OFF the helicopter pitch response was divergent about the pitch, roll and yaw axes and recovery was usually required within four seconds to avert unsafe attitudes developing. A sufficient degree of stability and control existed (SAS OFF) about all axes to permit a safe landing under VFR conditions. The dynamic response characteristics about all axes (SAS OFF) met the requirements of paragraph 3.5.9 of the military specification and are suitable for continued flight to effect a safe landing under emergency conditions.

54. Dynamic stability test results in rearward flight about the pitch axes SAS ON are summarized in table 13. Figures 83 and 84, appendix II, present typical helicopter responses following pulse inputs. The helicopter response characteristics about the pitch axes were similar to those exhibited in hover and are satisfactory for Army use (PRS A2).

55. Dynamic stability test results in sideward flight about the roll and yaw axes are summarized in table 14. Figures 85 and 86, appendix II, present typical helicopter responses about the roll and yaw axes in sideward flight. Figure 85 shows that the roll attitude was essentially aperiodic convergent to slightly greater than the trim roll attitude within 3 seconds after a lateral pulse input. A noticeable roll to sideslip coupling of approximately 5 degrees in yaw from the trim attitude as shown on figure 85 was apparent to the pilot but not objectionable. Although the pitch rates and angular accelerations show roll to pitch coupling it was not apparent to the pilot in pitch attitude change. All oscillatory responses were essentially damped to less than 1/2 amplitude in less than one cycle. Although small angular acceleration oscillations persisted about the pitch, roll and yaw axes there were no apparent attitude changes. Figure 86 shows that the yaw attitude was essentially aperiodic convergent to within 5 degrees of the trim attitude in 4 seconds after a directional pulse input. A noticeable sideslip to roll coupling of approximately 4 degrees in roll from the trim attitude as shown on figure 85 was apparent to the pilot but not objectionable. Although the pitch attitudes, rates, and angular acceleration show sideslip to pitch coupling the responses were not objectionable to the pilot. All oscillatory responses were essentially damped to

Table 13. Dynamic Stability in 30 KTAS Rearward Flight.

Average Gross Weight lb	Rotor Speed rpm	Average Density Altitude ft	Average cg in.	Type Pulse	Helicopter Response to Pulse Inputs	Suitability
45,300	242	600	10.0 Fwd	Aft	Oscillatory convergent	Satisfactory (fig 83)
45,500	242	2600	4.2 Aft	Forward	Oscillatory convergent	Satisfactory (fig 84)

Table 14. Dynamic Stability in 35 KTAS Sideward Flight.

Average Gross Weight lb	Rotor Speed rpm	Average Density Altitude ft	Average cg in	Type Pulse	Helicopter Response to Pulse Input	Recovery Time sec(3)	Suitability
35,400(1)	235	2,660	15.8 Aft	Left lateral	Oscillatory convergent	5.0	Satisfactory
45,900(2)	245	2,460	4.0 Aft	Left lateral	Oscillatory convergent	2.1	Satisfactory
34,390(1)	235	2,660	15.3 Aft	Right lateral	Oscillatory convergent	4.8	Satisfactory
36,780(2)	233	980	6.6 Aft	Right lateral	Oscillatory convergent	2.9	Satisfactory (fig 85)
36,700(2)	232	970	6.6 Aft	Left directional	Aperiodic convergent to 5 degrees left	3.1	Satisfactory (fig 86)

(1) Right sideward flight.
(2) Left sideward flight.
(3) Recovery initiated to terminate test.

less than 1/2 amplitude in less than one cycle. Although small angular accelerations persisted about the pitch, roll and yaw axes they were not apparent to the pilot in attitude changes. The lateral and directional dynamic stability response characteristics in sideward flight were easily controllable by the pilot and suitable for Army use (PRS A3).

56. Dynamic stability test results in level flight at the approximate Mission I and alternate G.W.'s are summarized in table 15 for helicopter responses to aft pulses about the pitch axis. Figures 87 through 100 present typical divergent pitch responses to aft pulses. The short term pitch rate response was essentially damped in 1/4 cycle and the pitch acceleration in 3/4 cycle. Small rate and acceleration oscillations were persistent but were not apparent in attitude responses. Normal acceleration increase during the short and long term pitch responses was less than 0.25 g and met the requirements of paragraph 3.2.11.2 of the military specification. For most conditions tested the long term pitch response was divergent nose up with time to double amplitude varying between 2.4 seconds to 4.6 seconds at the approximate Mission I G.W., and 1.3 seconds to 3.6 seconds at the approximate alternate G.W. Recovery from the nose up divergence was initiated from approximately 4 seconds to 10 seconds after pulse inputs to preclude encountering dangerous pitch attitude and rate buildup and to avoid excessive aft rotor flight control component stress. In general the aft cg, high altitude, low airspeed conditions exhibited the more rapid divergent characteristics. For most conditions tested the longitudinal dynamic response characteristics following a pulse input or gust upset in light to moderate turbulence failed to meet the dynamic stability response characteristics requirements of paragraphs 3.2.11 and 3.6.1.2 of the military specification for VFR and IFR flights respectively. Longitudinal dynamic responses following pulse inputs or gust upsets in light to moderate turbulence required considerable pilot effort to maintain acceptable pitch attitude control under VFR conditions (PRS A6). Pilot effort to control pitch attitude and rates under simulated IFR conditions was unacceptable for most conditions tested (PRS U7). Correction of dynamic stability characteristics is mandatory for the IFR Mission for acceptable operation and desirable for the VFR mission.

TABLE 15. NEXT THREE PAGES

Table 15. Longitudinal Dynamic Stability Test Conditions in Level Flight.

Trim Airspeed KCAS	Average Gross Weight lb	Rotor Speed rpm	Average Density Altitude ft	Average cg in.	Type Pulse	Helicopter Response to Pulse Input	Time to Double Amplitude sec	Reason for Recovery	Suitability
68(.8V_{NE})	35,020	246	13,600	7.5 Aft	Aft	Aperiodic divergent	3.1	Pitch rate	Unacceptable (fig 87)
75(.5V_{NE})	35,860	245	9,850	6.8 Aft	Aft	Aperiodic divergent	3.1	Pitch rate	Unacceptable (fig 90)
87(.8V_{NE})	36,300	235	9,860	6.5 Aft	Aft	Aperiodic divergent	2.7	Pitch rate	Unacceptable (fig 91)
127(.9V_{NE})	36,700	236	4,820	6.4 Aft	Aft	Aperiodic divergent	4.25	Attitude	Unacceptable (fig 93)
74(.5V_{NE})	37,100	235	4,610	6.2 Aft	Aft	Aperiodic divergent	3.1	Pitch rate	Unacceptable (fig 89)
70(.8V_{NE})	35,260	246	13,790	7.3 Aft	Aft	Aperiodic divergent	2.4	Pitch rate	Unacceptable (fig 88)
85(.8V_{NE})	36,400	235	9,950	6.5 Aft	Fwd	Aperiodic convergent to 8 degrees nose down	N/A	Airspeed	Satisfactory

Table 15. Continued.

Trim Airspeed KCAS	Average Gross Weight lb	Rotor Speed rpm	Average Density Altitude ft	Average cg in.	Type Pulse	Helicopter Response to Pulse Input	Time to Double Amplitude sec	Reason for Recovery	Suitability
122(.9V_{NE})	36,900	236	5,000	6.3 Aft	Fwd	Oscillatory neutral	N/A	N/A	Satisfactory (fig 102)
75(.5V_{NE})	37,350	236	4,850	6.0 Aft	Fwd	Aperiodic divergent	3.4	Attitude	Unacceptable
77(.7V_{NE})	35,750	235	10,000	7.0 Aft	Fwd	Aperiodic divergent	3.2	Attitude	Unacceptable (fig 101)
56(.8V_{NE})	46,200	245	8,150	1.8 Aft	Fwd	Aperiodic divergent	1.8	Pitch rate	Unacceptable (fig 103)
69(V_{NE})	46,730	245	7,960	1.6 Aft	Fwd	Aperiodic divergent	Less than 3 seconds	Pitch rate	Unacceptable
56(.8V_{NE})	46,040	245	8,170	10.6 Fwd	Fwd	Aperiodic divergent	Less than 4 seconds	Attitude	Unacceptable
75(.7V_{NE})	46,040	245	4,950	1.9 Aft	Fwd	Aperiodic divergent	Less than 3 seconds	Pitch rate	Unacceptable
66(.7V_{NE})	44,000	245	7,930	4.8 Aft	Fwd	Aperiodic divergent	Less than 4 seconds	Attitude	Unacceptable
70(.9V_{NE})	45,050	245	7,880	10.0 Fwd	Fwd	Oscillatory convergent	N/A	N/A	Satisfactory

Table 15. Continued.

Trim Airspeed KCAS	Average Gross Weight lb	Rotor Speed rpm	Average Density Altitude ft	Average cg in.	Type Pulse	Helicopter Response to Pulse Input	Time to Double Amplitude sec	Reason for Recovery	Suitability
105(.9V_{NE})	44,430	245	4,200	9.7 Fwd	Fwd	Oscillatory neutral	N/A	N/A	Satisfactory (fig 104)
75(.7V_{NE})	46,150	245	5,000	1.9 Aft	Aft	Aperiodic divergent	3.6	Attitude	Unacceptable (fig 96)
70(V_{NE})	46,850	245	8,140	1.5 Aft	Aft	Aperiodic divergent	1.3	Pitch rate	Unacceptable (fig 98)
68(.8V_{NE})	43,900	245	7,920	4.9 Aft	Aft	Aperiodic divergent	1.3	Pitch rate	Unacceptable (fig 97)
55(.8V_{NE})	46,500	244	8,110	1.7 Aft	Aft	Aperiodic divergent	2.6	Pitch rate	Unacceptable (fig 95)
104(.8V_{NE})	45,700	245	4,780	2.0 Aft	Aft	Aperiodic divergent	2.1	Pitch rate	Unacceptable (fig 99)
68(.6V_{NE})	44,450	242	5,410	9.7 Fwd	Fwd	Aperiodic divergent	2.2	Pitch rate	Unacceptable (fig 100)
55(.8V_{NE})	46,000	242	8,130	10.6 Fwd	Aft	Aperiodic divergent	2.9	Pitch rate	Unacceptable (fig 94)

57. Dynamic stability test results in level flight at the approximate Mission I and alternate design G.W.'s are summarized in table 15 for helicopter responses to forward pulses about the pitch axis. Figures 101 through 104, appendix II show typical longitudinal dynamic response characteristics to forward pulses. The response characteristics for airspeeds less than 105 KCAS were similar to those exhibited for aft pulses (para 57) except divergence was nose down and airspeed always increased. In one case normal acceleration decreased to 0.5 "g" during recovery (fig 103). The V_{NE}'s were easily exceeded following simulated nose down gust upsets and airspeed excursions to V_{NE} + 20 kt were not uncommon during tests. Careful and slow longitudinal manipulation was required during tests when recovering at high airspeeds to prevent encountering high stress levels on aft rotor flight control components. The dynamic responses following forward pulses at 105 KCAS and 122 KCAS were oscillatory and appeared to be divergent in both cases with 20 second attitude periods (figs 102 and 104).

58. Dynamic stability test results in level flight about the roll and yaw axes; about the pitch axis in climb and autorotation are summarized in table 16. Figures 101 through 110, appendix II, present typical SAS ON helicopter responses to pulses. The dynamic responses to lateral and directional pulses in level flight were similar to those exhibited in sideward flight (para 56), are satisfactory for Army use (PRS A3) and met the requirements of paragraph 3.6.1.2 of the military specification. Typical lateral and directional dynamic stability characteristics are presented in figures 105 and 106. The dynamic responses to longitudinal pulses in a climb at 71 KCAS were essentially neutral with small changes in pitch attitudes developing which were not apparent to the pilot (figs 107 and 109). The dynamic response to an aft pulse input at 105 KCAS in a MP climb was convergent to a nose up attitude of approximately 10 degrees (fig 108). The dynamic response to a forward pulse in autorotation at 81 KCAS resulted in pitch damping in 3/4 cycle with no apparent long term pitch attitude change from the trim condition (fig 110). The longitudinal dynamic response of the helicopter in climb and autorotation met the requirements of paragraphs 3.2.11 and 3.6.1.2 of the military specification and is satisfactory for Army use (PRS A3).

MANEUVERING FLIGHT

59. Maneuvering flight was evaluated by conducting banked turns to the maximum bank angles specified in the flight envelop release. Altitude and airspeed for constant altitude maneuvering were maintained in the turn by increasing torque. If altitude and airspeed could not be maintained with maximum allowable torque then airspeed was allowed to decrease to hold altitude.

Table 16. Longitudinal, Lateral and Directional Dynamic Stability Test Conditions in Level Flight, Climb and Autorotation.

Trim Airspeed KCAS	Average Gross Weight lb	Rotor Speed rpm	Average Density Altitude ft	Average cg in.	Type Pulse	Helicopter Response to Pulse Input	Suitability
66($.8V_{NE}$) (2)	44,000	245	7,960	4.8 Aft	Left lateral	Aperiodic convergent to 4 degrees nose lift	Satisfactory (fig 105)
71($.7V_{NE}$) (2)	37,620	235	9,990	6.1 Aft	Left directional	Aperiodic convergent to 13 degrees nose lift	Satisfactory (fig 106)
85($.9V_{NE}$) (2)	37,000	235	9,990	6.5 Aft	Left directional	Aperiodic convergent	Satisfactory
71($.7V_{NE}$) (2)	37,590	235	9,990	6.3 Aft	Left lateral	Aperiodic convergent	Satisfactory
87($.8V_{NE}$) (2)	36,780	235	10,000	6.4 Aft	Left lateral	Aperiodic convergent	Satisfactory
69($.8V_{NE}$) (2)	44,800	245	7,600	9.9 Fwd	Left lateral	Aperiodic convergent	Satisfactory
71(V_{max}R/C) (3)	45,300	245	4,100	2.1 Aft	Aft	Aperiodic convergent to 3 degrees nose down	Satisfactory (fig 107)
105($.8V_{NE}$) (3)	45,100	244	3,630	2.2 Aft	Aft	Aperiodic convergent to 15 degrees nose up	Satisfactory (fig 108)
74(V_{max}R/C) (4)	38,180	236	8,780	5.6 Aft	Aft	Oscillatory neutral	Satisfactory (fig 109)

Table 16. Continued.

Trim Airspeed KCAS	Average Gross Weight lb	Rotor Speed rpm	Average Density Altitude ft	Average cg in.	Type Pulse	Helicopter Response to Pulse Input	Suitability
81(.6V_{NE})(5)	36,780	236	5,500	6.4 Aft	Fwd	Damped	Satisfactory (fig 110)

(1) Dynamic response characteristics met requirements of paragraphs 3.2.11 and 3.6.1.2 of the military specification.

(2) Level flight

(3) MP climb

(4) NP climb

(5) Autorotation.

Bank angle limitations for the test (app VIII) were 35 degrees at V_{NE} and 45 degrees for V_{NE}-10 kt and below with a one degree increase in bank angle permitted for each one kt decrease in airspeed from V_{NE} to V_{NE}-10 kt.

60. Normal flight maneuvering characteristics at constant altitude, in climbs and descents up to 30 degree bank angles were good with control centering on. Table 17 summarizes maneuvering flight test conditions. Control force and controllability characteristics resulted in good control harmony and response when maneuvering with control centering on. Roll attitude control to maintain a desired bank angle was annoying due to the high roll sensitivity about a trim control position. The high roll sensitivity about a trim control position is discussed in paragraph 48. Since maneuvering flight is generally transient the roll sensitivity did not degrade the maneuvering capabilities of the helicopter. The trim coordination feature usually maintained sideslip angles within ±3 degrees during transient maneuvers up to 30-degree bank angles. Below airspeeds of .9V_{NE} for some flight conditions bank angles in excess of 40 degrees resulted in poor airspeed control and excessive sideslip angles developing when attempting to maintain constant altitude. At V_{NE} for bank angles above 30 degrees the same airspeed and sideslip angle control problems were exhibited. Forward head droop stop contact was encountered under some flight conditions. When airspeed and sideslip angle control problems developed, aft rotor blade stall was usually encountered. The stall was characterized by a nose pitch up which increased in a rate buildup when forward longitudinal control was applied to lower the nose. Airframe shudder occurred when deep in the stall indicating high stress loads on aft rotor flight control components. Recovery from the stall was initiated by reducing roll attitude and lowering collective to obtain a normal longitudinal control response to pilot inputs. Exceeding bank angles of 30 degrees at V_{NE} and 40 degrees at V_{NE}-10 kt and below may result in encountering aft rotor blade stall, high sideslip angles, poor airspeed control and consequently high altitude losses. Operation in close proximity to the ground could result in unsafe flight conditions. It is recommended that the APE II bank angle limitations be reduced to 30 degrees at V_{NE} and 40 degrees at V_{NE}-10 kt and below for an operational envelope. Within the scope of the tests the maneuvering flight characteristics met the requirements of paragraphs 3.3.9.1 and 3.3.9.2 of the military specification and are satisfactory for Army use (PRS A3).

61. The occurrence of high stress levels associated with maneuvering flight was unpredictable but when encountered was discernible by airframe shudder. The shudder also occurred in level flight following longitudinal control inputs when compensating

Table 17. Maneuvering Flight at Constant Altitude, in Climbs and Descent.

Trim Airspeed KCAS	Average Gross Weight lb	Rotor Speed rpm	Average Density Altitude ft	cg Location	Remarks
156 (V_{NE})	36,700	245	2,500	Aft	Left bank to 35 degrees. Aft rotor stall above 30 degrees with poor airspeed, pitch and altitude control.
146 (.9V_{NE})	36,700	245	2,500	Aft	Right bank to 45 degrees. No aft rotor stall.
151 (.9V_{NE})	38,000	235 245	1,000	Aft	Left and right banks to 45 degrees. No aft rotor stall.
69 (.7V_{NE})	38,000	235	10,000	Aft	Left and right banks to 45 degrees. No aft rotor stall.
88 (V_{NE})	38,000	235	10,000	Aft	Left and right banks to 35 degrees. Aft rotor stall above 30 degrees with poor airspeed, pitch and altitude control.
67 (.9V_{NE})	45,700	245	8,000	Fwd	Left and right banks to 35 degrees. Forward head droop stop contact, sideslip angle of 18 degrees and poor airspeed and altitude control above 30 degrees.
116 (.9V_{NE}) 122 (V_{max})	36,000	245	10,000	Fwd	Left and right banks to 45 degrees. Aft rotor stall above 40 degrees with poor airspeed, pitch and altitide control.
70 (V_{NE})	36,000	245	13,200	Aft	Left and right banks to 35 degrees. No aft rotor stall (1)
75 (V_{min}R/D) (2) (V_{max}R/C)	46,000	245	3,500	Aft	360 degree left and right 30 degree bank turns. No aft rotor stall.

(1) Test conducted with LCST fully extended in manual and with LCST in automatic.

(2) Autorotation and MP climb.

for gust upsets. A visual load display is required in the cockpit to warn the pilot when high stress loads are being encountered to reduce the probability of fatigue damage to dynamic components during maneuvering. A visual load display would also allow the pilot to use the full operational capability of the helicopter without exceeding design limits. A reliable visual load display should be developed and installed in the cockpit to indicate when high stress levels approaching endurance limits of dynamic components are encountered.

TAKEOFFS AND LANDINGS

62. Normal takeoffs and landings and running takeoffs and landings were qualitatively evaluated. Tests were conducted at 37,000 pounds and 46,000 pounds G.W.'s at forward and aft cg's and at density altitude from S.L. to 2,500 feet.

63. Vertical takeoffs and landings were smoothly accomplished with minimum pilot effort in winds up to 25 kt. No objectionable handling qualities were exhibited during these tests. All controls were conventional and characteristics were similar for all test conditions. Transition to forward flight from out of ground effect (OGE) or IGE hover was characterized by a nose pitch down as thrust was applied which was indicative of the pitch to thrust coupling discussed in paragraph 30. The pitch to thrust coupling when transitioning to forward flight was not objectionable to the pilot because of adequate visual cues when in close proximity to the ground (PRS A3). Approaches to landings were conventional until within close proximity to the ground and approaching a hover. When thrust was applied the pitch to thrust coupling occurred requiring as much as 3 inches aft longitudinal control to arrest. Pitch attitudes required to arrest the forward speed were as high as 10 degrees. The pitch to thrust coupling and high pitch attitude was not objectionable because of adequate visual cues when in close proximity to the ground. Within the scope of the tests, the vertical takeoff and landing characteristics were satisfactory for Army use and met the requirements of paragraph 3.5.4.1 of the military specification.

64. Running takeoffs were conducted from a hard surfaced runway by applying sufficient thrust to make the helicopter light on the wheels then applying forward longitudinal control for takeoff. Takeoffs were smoothly accomplished by normal use of controls and the helicopter exhibited good handling qualities during the ground roll and when translating into forward flight. Tests were conducted with the landing gear on the ground at estimated speeds up to 35 kt. Running landings were conducted on a hard surfaced runway by simulating single engine power available with both engines operating. Touchdowns were easily accomplished at estimated speeds of from zero to 40 kt by conventional use of flight controls and

braking action. Forward motion from touchdown to a stop varied from zero feet to an estimated 200 feet at 40 kt ground speed. The running takeoff and landing characteristics met the requirements of paragraphs 3.5.4.2 and 3.5.4.3 of the military specification and are satisfactory for Army use (PRS A2).

SIMULATED SINGLE ENGINE FAILURES

65. Simulated single engine failures were conducted by placing an engine condition lever from the flight to ground position with the flight controls fixed and observing the resulting helicopter response. Tests were conducted at the aft critical cg's.

66. Simulated single engine failure test conditions are summarized in table 18. The helicopter response was mild for all conditions tested. No roll or yaw attitude changes were apparent following an engine failure; however, a slow nose pitch up of less than 4 degrees usually occurred with controls fixed. Recovery from unusual attitudes was not required for any test condition. Following the simulated engine failure the "good" engine immediately assumed power required or maximum power available. Rotor speed loss was 15 rpm for all conditions tested and collective application was not required to preclude an unsafe rotor speed from developing. Within the scope of the tests the single engine characteristics were satisfactory for Army use (PRS A2) and met the requirements of paragraph 3.5.1 of the military specification. It is recommended the contractor demonstrate compliance with deviations 8 and 9 of the detail specification and paragraph 3.5.5.1 of the military specification for dual engine failures and autorotation under critical loading and flight conditions.

Table 18. Single Engine Failures.

Trim Airspeed KCAS	Average Gross Weight lb	Rotor Speed rpm	Average Density Altitude ft	cg Location	Remarks
104 (19 V_{max})	46,000	245	5,000	Aft	Rpm drop of 15, recovery not required.
66 (.3V_{NE})	36,000	245	2,000	Aft	Rpm drop of 15, recovery not required.
160 (V_{max})	36,000	235	1,500	Aft	Rpm drop of 15, recovery not required.
80 (MRP climb)	46,000	245	2,000	Aft	Rpm drop of 15, recovery not required.

SAS OFF FLIGHT

67. SAS OFF flight was qualitatively evaluated to determine any changes in flying qualities between the CH-47B and CH-47C which resulted from increased G.W. and rpm. Tests were conducted at 37,000 and 46,000 pounds G.W.'s, forward and aft critical cg's S.L. to 10,000 ft H_D and from hover to V_{max}. Complete SAS disengagement was accomplished by placing the emergency SAS release switch to the release position.

68. The SAS OFF flying qualities about all axes were similar to the CH-47B. A decrease in pilot effort was noticeable as rpm was increased from 235 to 245 and G.W. was increased from 37,000 pounds to 46,000 pounds. The cg location did not appear to have an effect on flying qualities. As with the CH-47B the SAS OFF airspeed and bank angle limitations remain a function of pilot proficiency. The SAS OFF flying qualities met the requirements of paragraph 3.5.9(d) of the military specification and are satisfactory for emergency operation.

MECHANICAL INSTABILITY

69. Mechanical instability characteristics were evaluated at 37,000 pounds and 46,000 pounds G.W.s, 235 rpm and 245 rpm, and forward and aft critical cg's. Flight controls were not specifically manipulated to induce instability, rather the tendency for instability was checked by normal flight control inputs from hover to landing. The helicopter displayed satisfactory landing characteristics and there were no tendencies towards sustained PIO or ground contact oscillations with control centering ON or OFF (PRS A3).

70. The contractor was conducting mechanical instability tests during APE II. A purpose of the tests was to qualify all CH-47 model helicopters for a standard tire pressure of 88 psi. During APE II, the tire pressure for the test helicopter varied from 77 psi to 99 psi. It is recommended that mechanical instability characteristics be checked during APE III using the tire pressure resulting from contractor tests for the CH-47 model helicopters.

MISCELLANEOUS

Vibration

71. A significant reduction in vibration levels was exhibited by the helicopter for airspeeds above V_{NE}-15 kt as compared to levels experienced during APE I (ref 4, app I). Following APE I the contractor conducted extensive tests to reduce vibration levels of

the CH-47C. As a result of the contractor tests the self tuning vibration absorbers (STVA) mounted in the nose (photo 10, app VII) and under the pilot's and copilot's seats were modified to improve the absorbers control system stability in high speed flight. A discussion of the STVA is contained in appendix V.

72. A qualitative evaluation of cockpit vibration levels was made during stability and control tests. The following definitions were used in assessing vibration levels as affecting the pilot's ability to conduct a mission:

Light (L):	PRS A2
Light to moderate (L-M):	PRS A3 to A4
Moderate (M):	PRS A5
Moderate to heavy (M-H):	PRS A6
Heavy (H):	PRS U7

73. Vibration levels were predominantly three vibrations per rotor revolution (3/rev) in a vertical plane and appeared to increase in intensity as a function of increased airspeed and rotor rpm. Table 19 summarizes vibration test conditions. Vibration levels were similar at the forward and aft cg's and consequently only test conditions for the aft cg are presented in table 19. Within the scope of tests the vibration levels were satisfactory for continuous operation at the best range airspeeds or V_{NE}, whichever was less (PRS A3). Cruise airspeed for 37,000 pounds at 235 rpm and 245 rpm was 138 KTAS and 131 KTAS respectively as determined during APE I (ref 4, app II). Operation above the best range airspeed would normally be conducted for short periods and the moderate vibration levels exhibited would not result in extended periods of exposure effecting pilot or passenger comfort.

74. As reported during APE I, the V_{NE} was easily exceeded at high altitudes and 235 rpm and a visual load display was recommended which would allow the pilot to readily remain within flight envelope airspeed limits. With the vibration absorber improvement discussed in paragraph 71, it was possible for V_{NE} to be exceeded when V_{NE} was less than 150 KTAS due to a lack of an increased vibration level warning to the pilot. The need for a visual load display is discussed in paragraph 61.

75. A slight increase in vibration level resulted when making rpm changes of greater than three rpm. Since the rpm is normally set by the pilot for a given G.W. condition the slight increased vibration is satisfactory and only transient in nature. Minor changes in rpm occurred during rpm droop or gust upsets but did not appear to result in vibration level increases.

Table 19. Vibration Test Conditions.

Condition	Airspeed (KTAS)												
	40	50	60	70	80	90	100	110	120	130	140	150	160
37,000 lb. aft cg., 235 rpm 5,000 ft H_D(1)	---	L-M	L	L	L	L	L	L	L-M	L-M	M	M	M-H
37,000 lb, aft cg., 245 rpm 1,8000 ft H_D(2)	L-M	L-M	L-M	L	L	L	L	L-M	L-M	M	M	M-H	M-H
37,000 lb, aft cg., 235 rpm 10,000 ft H_D(3)	---	L-M	L-M	L-M	L	L	L	L-M	L-M	---	---	---	---
46,000 lb, aft cg., 245 rpm 5,000 ft H_D(4)	---	---	---	L-M	L	L	L	L-M	L-M	---	---	---	---

(1) V_{NE} = 154 KTAS (3) V_{NE} = 123 KTAS

(2) V_{NE} = 170 KTAS (4) V_{NE} = 123 KTAS

Torque Control and Thrust Control Rod Sensitivity

76. When engine torque was set with collective at a desired value and the thrust rod brake switch released, torque would decrease, but collective position remained constant. This resulted in a requirement for the pilot to set torque higher than actually desired. This imprecise torque control was exhibited in APE I and reported in reference 4, appendix I. It appeared that the impreciseness of torque control was greater in APE II. Figure 111, appendix II, shows that an initial 3-percent higher torque was required to stabilize at 38 percent engine torque and 6 percent at 78 percent engine torque (transmission limits). At power settings above 70 percent torque and, particularly, when operating in a hover at maximum G.W. and at the transmission limit, pilot effort to obtain a desired torque was excessive. This effort resulted from a pilot requirement to estimate large torque over-settings to compensate for the imprecise torque control. The pilot effort was further increased by the nonuniform torque distribution exhibited in APE I and reported in reference 4. The imprecise torque control resulted in a requirement to make excessive collective inputs while hovering and detracts from the mission capabilitites such as sling load operations (PRS A6). Correction of the imprecise torque control is desirable for improved helicopter operation.

77. Thrust control-rod sensitivity characteristics are presented in figure 111, appendix II. This figure shows that for engine torque value less than 70 percent, a collective imput of approximately 5 percent control travel (0.4 inch) resulted in a 10-percent increase in engine torque. For engine torque values above 70 percent, the thrust control-rod sensitivity increased approximately 3-percent control travel (0.24 inch) for a 10-percent increase in engine torque. When coupled with the imprecise torque control (para 76) the high, thrust control-rod sensitivity above 70-percent engine torque resulted in small collective inputs which produced large power changes and, consequently, excessive pilot effort to precisely control torque (PRS A6). Correction of the high, thrust control-rod sensitivity is desirable for improved helicopter operation.

CONCLUSIONS

GENERAL

78. The following conclusions were reached upon completion of the APE II tests:

a. Sufficient level flight performance testing was conducted to provide the contractor with preliminary data for the operator's manual (para 15).

b. The revised engine model specification requires that a reevaluation be made of performance guarantee compliance test results obtained during APE I (para 16 and 17).

c. Modification of the longitudinal cyclic speed trim and differential collective pitch speed trim schedules from the CH-47B schedules contributed to the unacceptable static and dynamic longitudianl stability characteristics (para 20 and 21).

d. Maneuvering flight involving bank angles greater than 30 degrees resulted in aft rotor blade stall (para 61).

e. Lack of a visual load display subjects the aft rotor flight control components to damage during maneuvering and restricts the full operational capability of the helicopter (para 61).

f. Vibration levels were significantly reduced from levels exhibited during APE I (para 71, 72 and 73).

DEFICIENCIES AND SHORTCOMINGS AFFECTING MISSION ACCOMPLISHMENT

79. Correction of the following deficiencies is mandatory for acceptance of the helicopter.

a. Unacceptable static longitudinal stability characteristics below 90 KCAS in level flight for IFR operations (para 38).

b. Unacceptable dynamic longitudinal stability characteristics for IFR operations (para 56).

80. Correction of the following shortcomings is desirable for improved operation and mission capabilities.

a. Longitudinal cyclic control free play (para 23).

b. Directional pedal control unbalance with control centering released (para 28).

c. Unstable or neutral longitudinal control trim position gradients (para 31).

d. Pitch to thrust coupling resulting from power changes (para 32).

e. Static longitudinal collective fixed stability below 90 KCAS for VFR operations (para 38, 39 and 40).

f. High lateral control sensitivity (para 44).

g. Dynamic longitudinal stability characteristics for VFR operations (para 56).

h. Imprecise torque control and high thrust control rod sensitivity at high power settings (para 75 and 76).

SPECIFICATION CONFORMANCE

81. Within the scope of these tests the stability and control characteristics of the CH-47C met the requirements of the military specification except those listed below:

a. Paragraph 3.2.4, in that breakout including friction exceeded the incremental force required for a one inch travel from trim by 0.45 pounds (56 percent)(para 22).

b. Paragraph 3.3.11, in that the force required for the first inch of travel was 0.9 pounds left and 1.2 pounds right and were 0.7 pound (44 percent) and 0.1 pound (8 percent) less than the break-out including friction forces respectively (para 24).

c. Paragraph 3.2.11 and 3.6.1.2 in that pitch response to gust inputs was divergent (para 56).

82. Within the scope of these tests the stability and control characteristics of the CH-47C met the requirements of the detail specification except those listed below:

a. Deviations 5 and 10 in that control position gradients were unstable for airspeeds less than 90 KCAS in level flight (para 38).

b. Deviations 5 and 10 in that control position gradients were unstable for climbs, partial power descents and autorotations (para 39 and 40).

RECOMMENDATIONS

83. Correction of deficiencies, for which correction is mandatory, be accomplished prior to service tests and delivery of the CH-47C with T55-L-11 engines (para 79).

84. Correction of shortcomings, for which correction is desirable, be accomplished at the earliest possible time (para 80).

85. The USAAVCOM reevaluate level flight and climb performance guarantee compliance determined during APE I (para 16 and 17).

86. The following caution be put in the operator's manual:

> "Increase rotor speed to 245 rpm when flying SAS off below 40,000 lb gross weight to alleviate forward head droop stop contact" (para 42).

87. The contractor investigate means to eliminate droop stop contact at low sideslip angles and high airspeeds (para 42).

88. Bank angle limitations be reduced to 30 degrees at V_{NE} and 40 degrees at V_{NE}-10 kt and below for an operation envelope (para 60).

89. A reliable visual load display be developed and installed in the helicopter to indicate to the pilot when high stress levels approaching endurance limits of dynamic components are encountered (para 61).

90. Mechanical instability characteristics be checked during APE III (para 70).

91. The contractor demonstrate compliance with deviation 8 and 9 of the detail specification and paragraph 3.5.5.1 of the military specification for dual engine failures and autorotations under critical loading and flight conditions (para 60).

APPENDIX I. REFERENCES

1. Report, Vertol Division of the Boeing Company, D8-0315, "CH-47C Product Improvement Program, CH-47B and CH-47C Helicopter," 13 February 1967, revised.

2. Letter, USATECOM, AMSTE-BG, subject: "Test Directive, Product Improvement Test, CH-47C Helicopter," 17 June 1966.

3. Test Plan, USAAVNTA,"Engineering Flight Test of the CH-47C Helicopter, Army Preliminary Evaluation," March 1968.

4. Final Report, USAAVNTA Project No. 66-28, "Engineering Flight Test of the YCH-47C, Medium Transport Helicopter, Army Preliminary Evaluation I," June 1968.

5. Specification, Vertol Division of the Boeing Company, 114-PJ-803, "Detail Specification for the Model CH-47C Helicopter," 7 December 1967.

6. Message, USAAVCOM, AMSAV-EF 6-1308, subject: "CH-47C Max Alternate Gross Weight, APE II," 4 June 1968.

7. Military Specification, MIL-H-8501A, "General Requirements for Helicopter Flying and Ground Handling Qualities, " 7 September 1961, with Amendment 1, 3 April 1962.

8. Letter, USAAVCOM, AMSAV-EF, subject: "Preliminary Flight Envelope, CH-47C," 14 June 1968.

9. Technical Manual, TM 1520-227-10, "Operator's Manual, Army Model CH-47B and CH-47C Helicopters," February 1968.

10. Letter, USAAVCOM, AMSAV-EF, subject: "Preliminary Flight Envelope, CH-47C," 16 February 1968, with Revision 1, 21 February 1968.

11. Specification, Lycoming Div of AVCO Corp, "Shaft Turbine Engine (Lycoming LTC4B-11B) Specification Number 124.27," 15 February 1965 with Amendment 1, 31 March 1966.

12. Specification, Lycoming Div of AVCO Corp, "Model Specification, Engine, Aircraft, Turboshaft, T55-L-11, (Lycoming LTC4B-11B) Specification Number 124.27A," Revision 24, May 1968.

APPENDIX I

TEST DATA

FIGURE NO. 1
LEVEL FLIGHT PERFORMANCE
YCH-47C USA S/N 66-19121
MID C.G.
$N/\sqrt{\theta}$ = 245 RPM

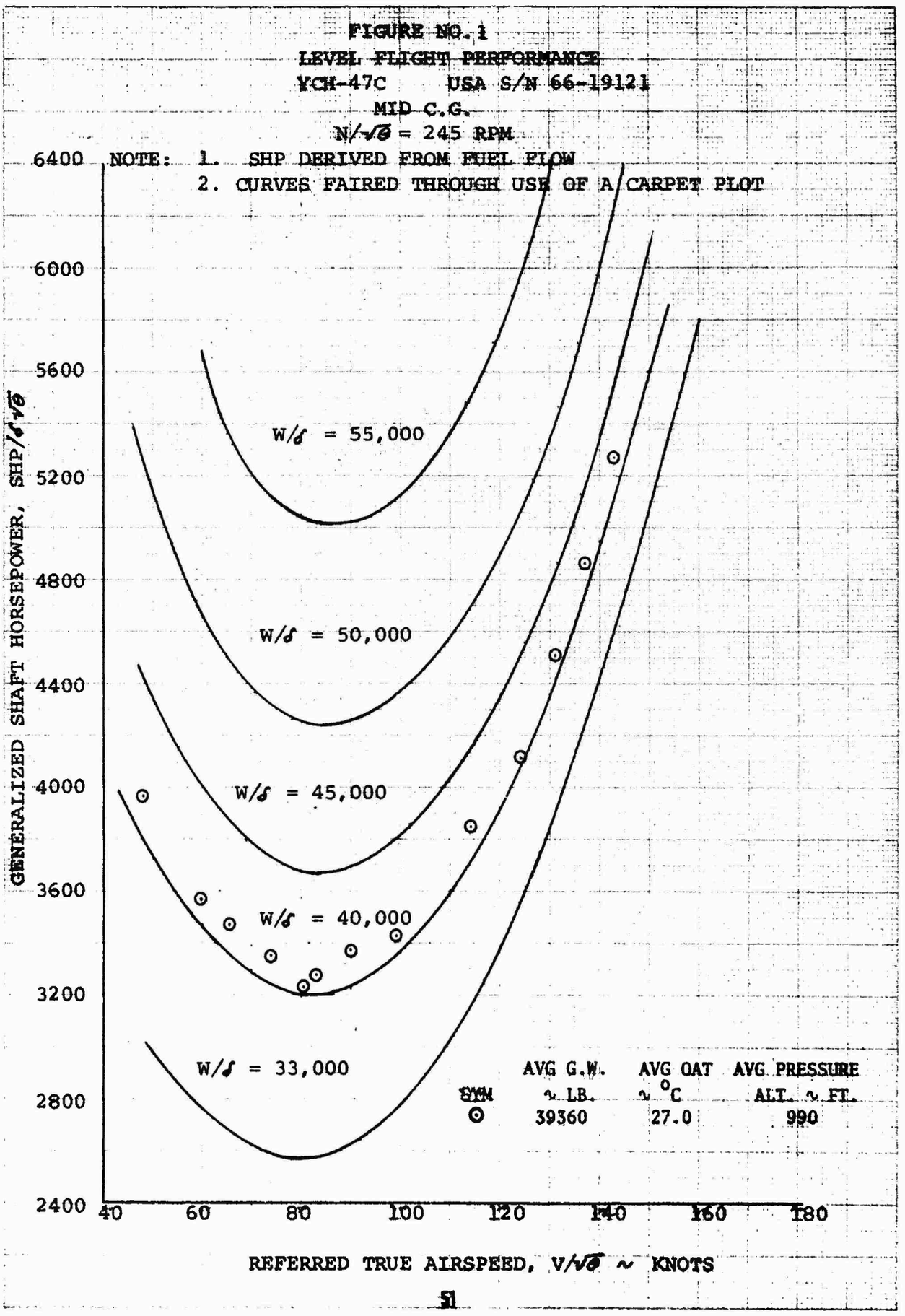


FIGURE NO. 2

LEVEL FLIGHT PERFORMANCE

YCH-47C USA S/N 66-19121

MID C.G.

$N/\sqrt{\theta}$ =225

NOTE: 1. W/δ = 45,000 LB

2. SHP DERIVED FROM FUEL FLOW

AVG G.W. ~ LB.	AVG OAT ~ °C	AVG PRESSURE ALT, ~ FT.
42260	24.8	1930

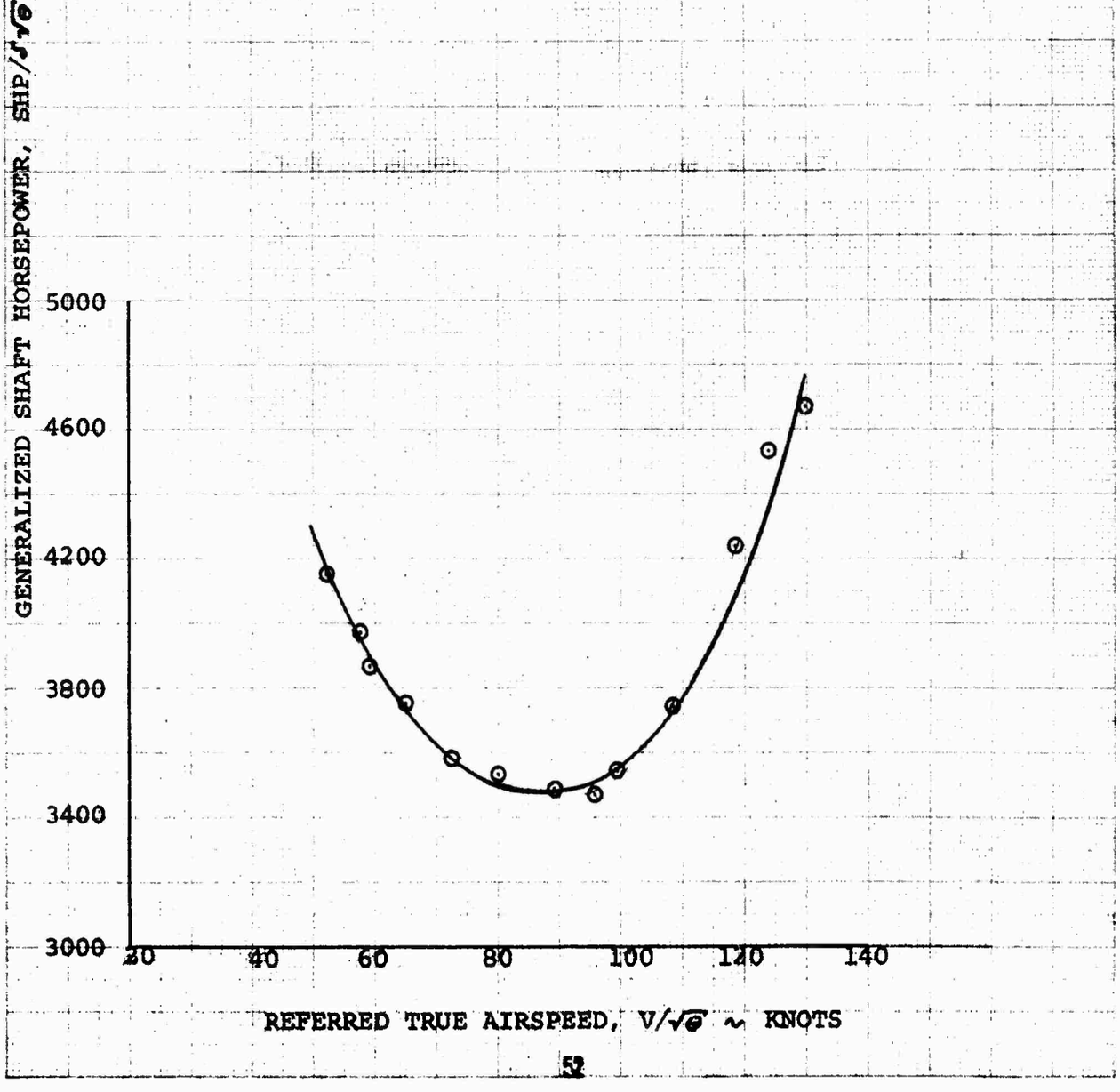


FIGURE NO. 3
GENERALIZED SHAFT HORSEPOWER
vs. REFERRED FUEL FLOW
CH-47C
T55-L-11 245 ROTOR RPM

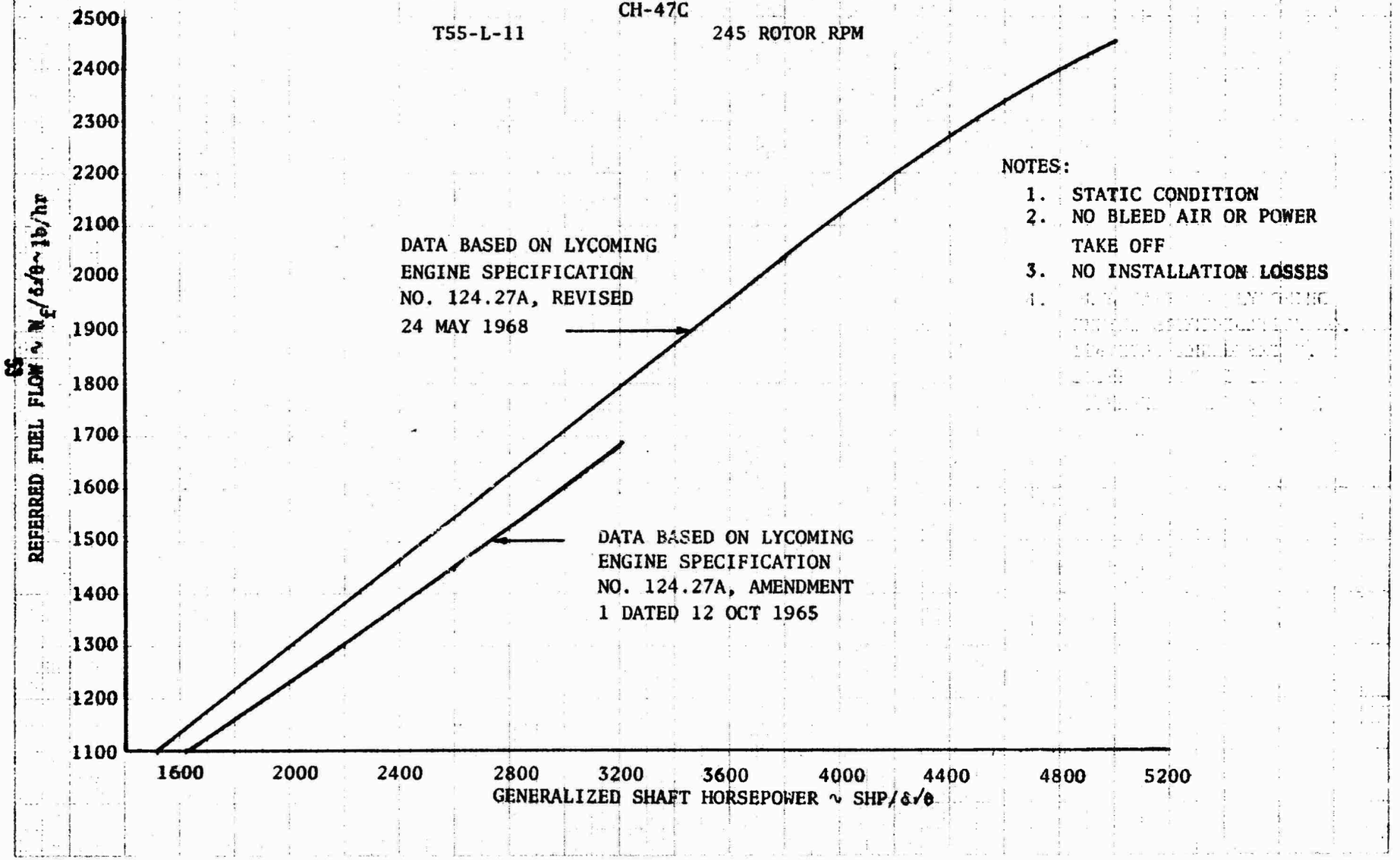
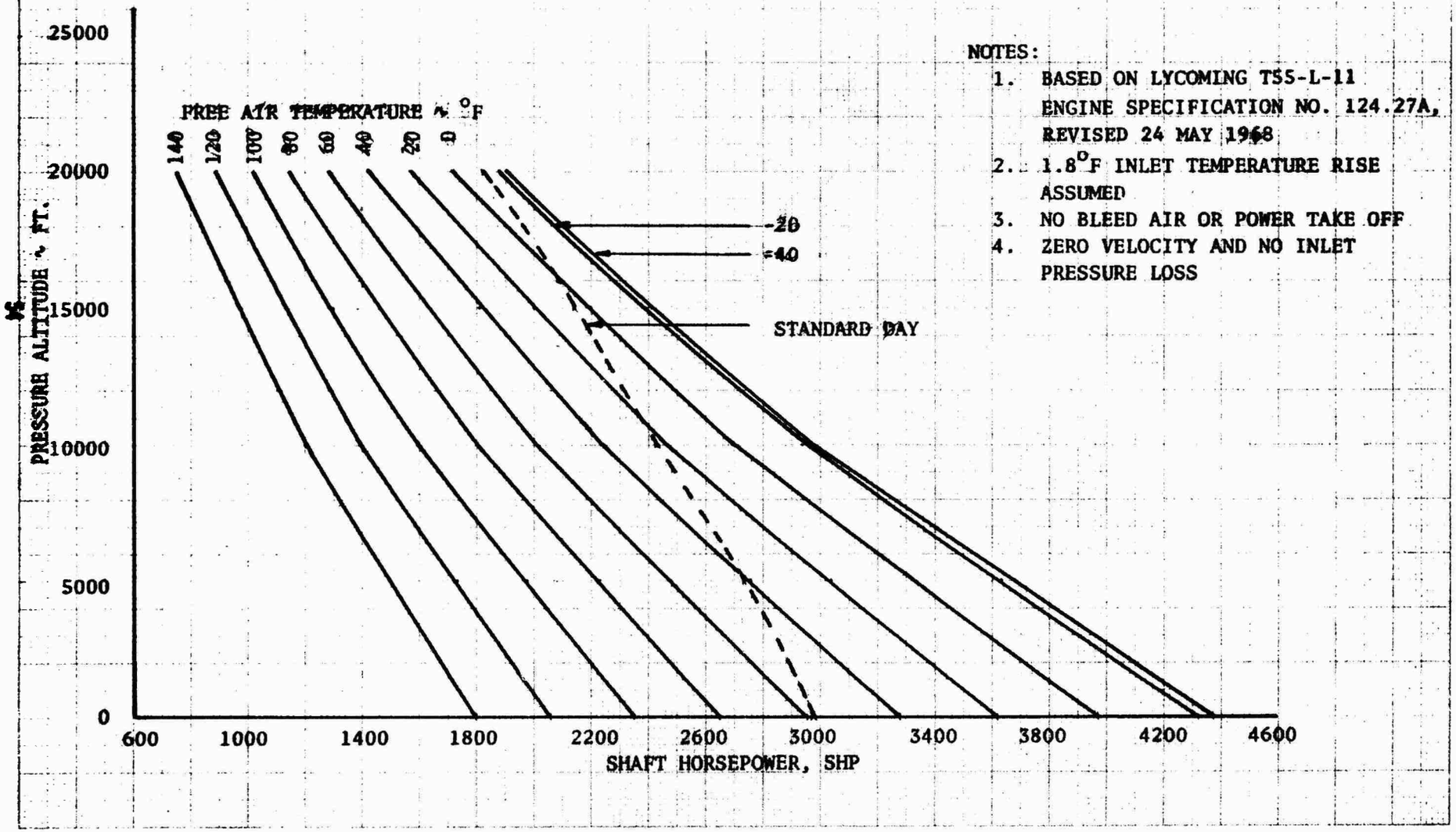


FIGURE NO. 4
SHAFT HORSEPOWER AVAILABLE
CH-47C

T55-L-11
NORMAL POWER

245 ROTOR RPM
ONE ENGINE

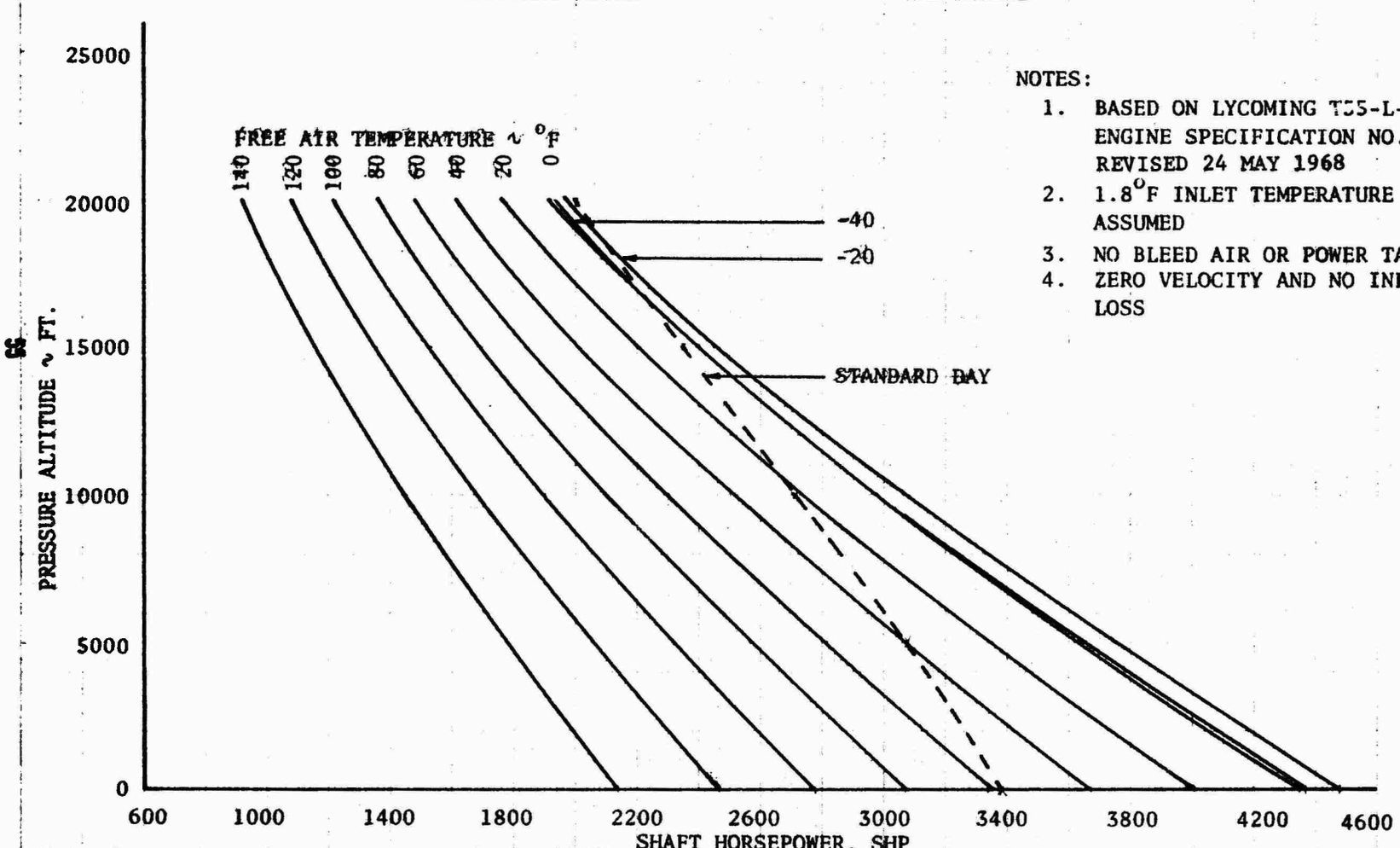


NOTES:

1. BASED ON LYCOMING T55-L-11 ENGINE SPECIFICATION NO. 124.27A, REVISED 24 MAY 1968
2. 1.8°F INLET TEMPERATURE RISE ASSUMED
3. NO BLEED AIR OR POWER TAKE OFF
4. ZERO VELOCITY AND NO INLET PRESSURE LOSS

FIGURE NO. 5
SHAFT HORSEPOWER AVAILABLE
CH-47C

T55-L-11 — 245 ROTOR RPM
MILITARY POWER — ONE ENGINE

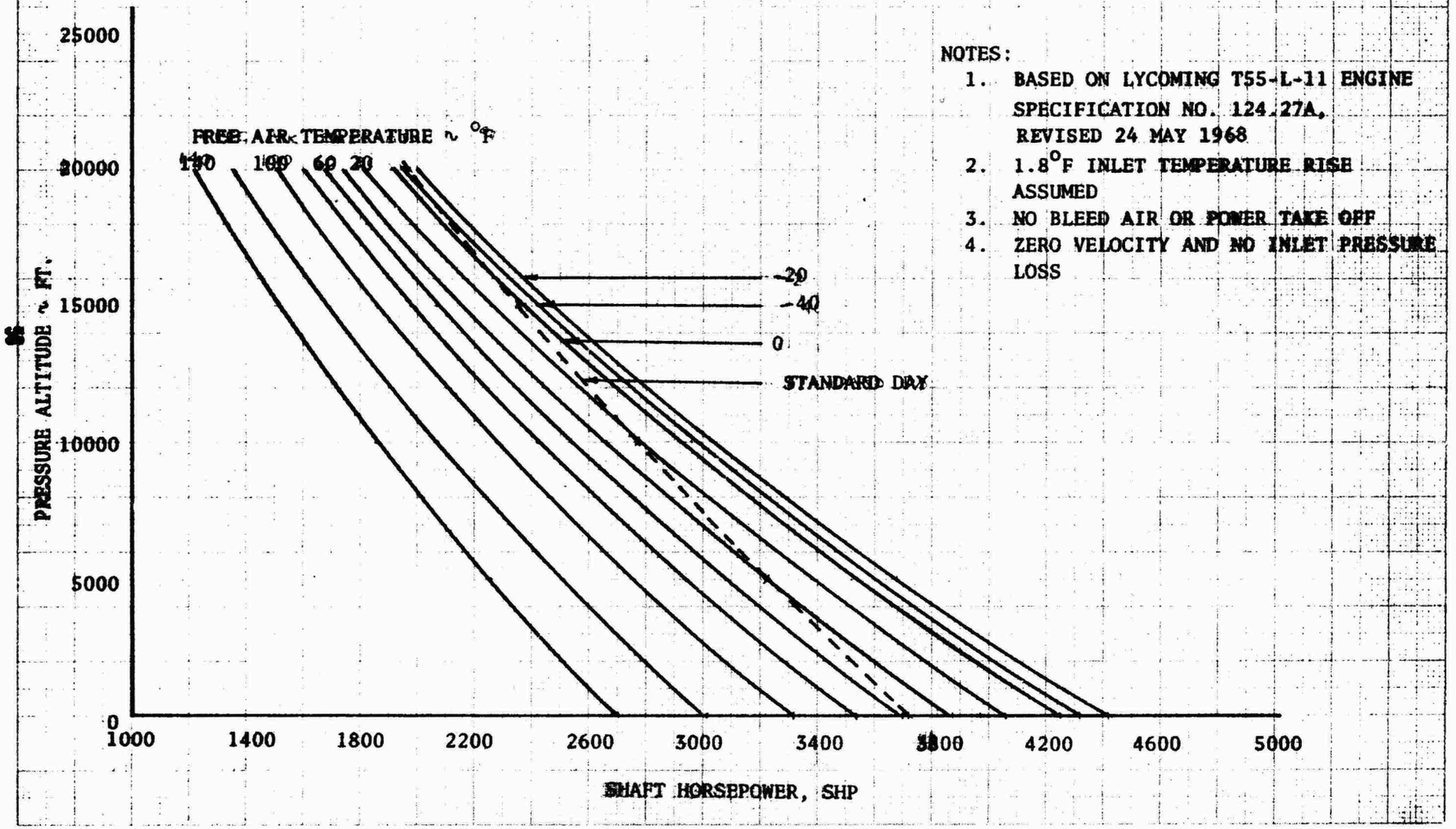


NOTES:
1. BASED ON LYCOMING T55-L-11 ENGINE SPECIFICATION NO. 124.27A REVISED 24 MAY 1968
2. 1.8°F INLET TEMPERATURE RISE ASSUMED
3. NO BLEED AIR OR POWER TAKE OFF
4. ZERO VELOCITY AND NO INLET PRESSURE LOSS

FIGURE NO. 6
SHAFT HORSEPOWER AVAILABLE
CH-47C

T55-L-11
MAXIMUM POWER

245 ROTOR RPM
ONE ENGINE



NOTES:

1. BASED ON LYCOMING T55-L-11 ENGINE SPECIFICATION NO. 124.27A, REVISED 24 MAY 1968
2. 1.8°F INLET TEMPERATURE RISE ASSUMED
3. NO BLEED AIR OR POWER TAKE OFF
4. ZERO VELOCITY AND NO INLET PRESSURE LOSS

FIGURE NO. 7

LONGITUDINAL CYCLIC SPEED TRIM SCHEDULE

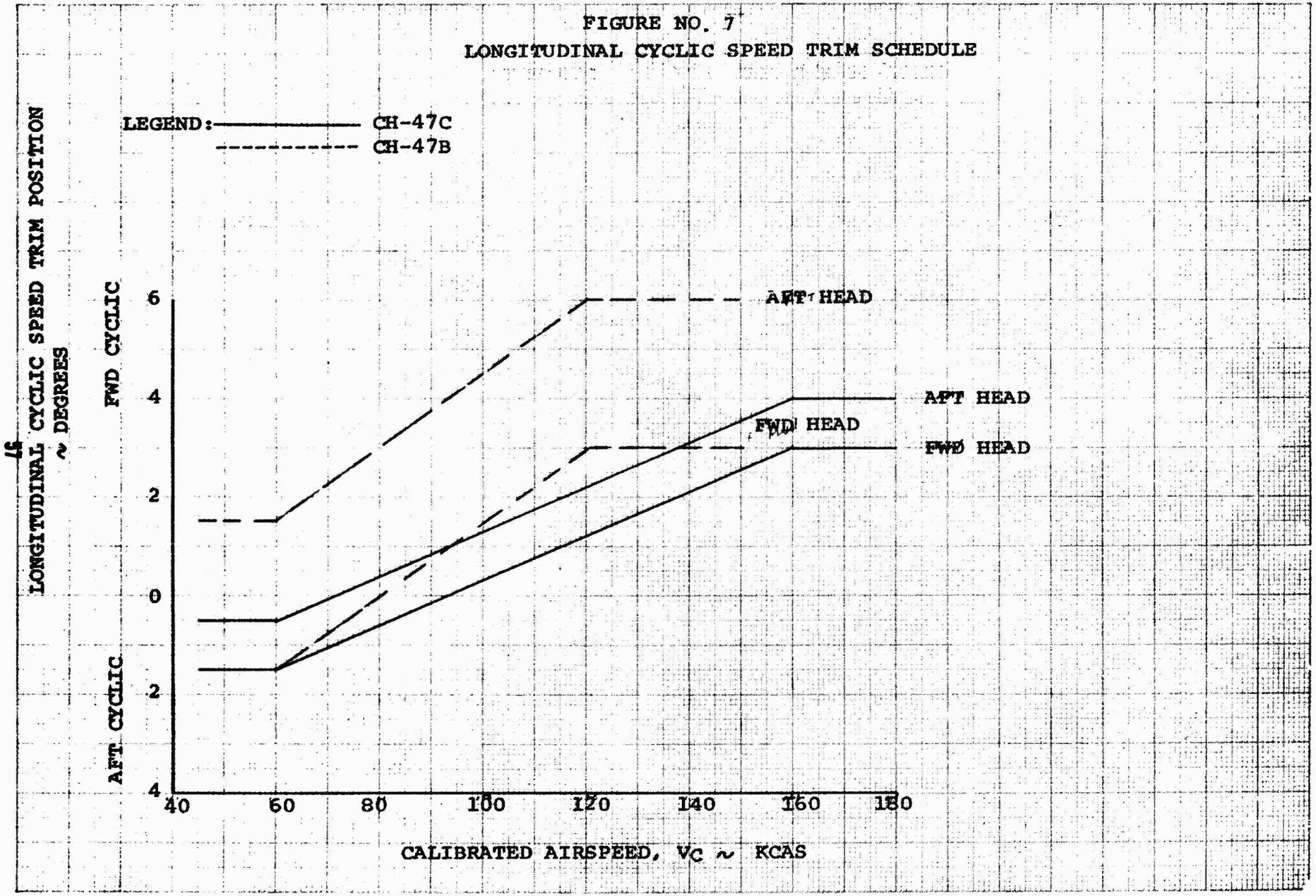


FIGURE NO. 8

LONGITUDINAL CYCLIC SPEED TRIM SCHEDULE

YCH-47C USA S/N 66-19121

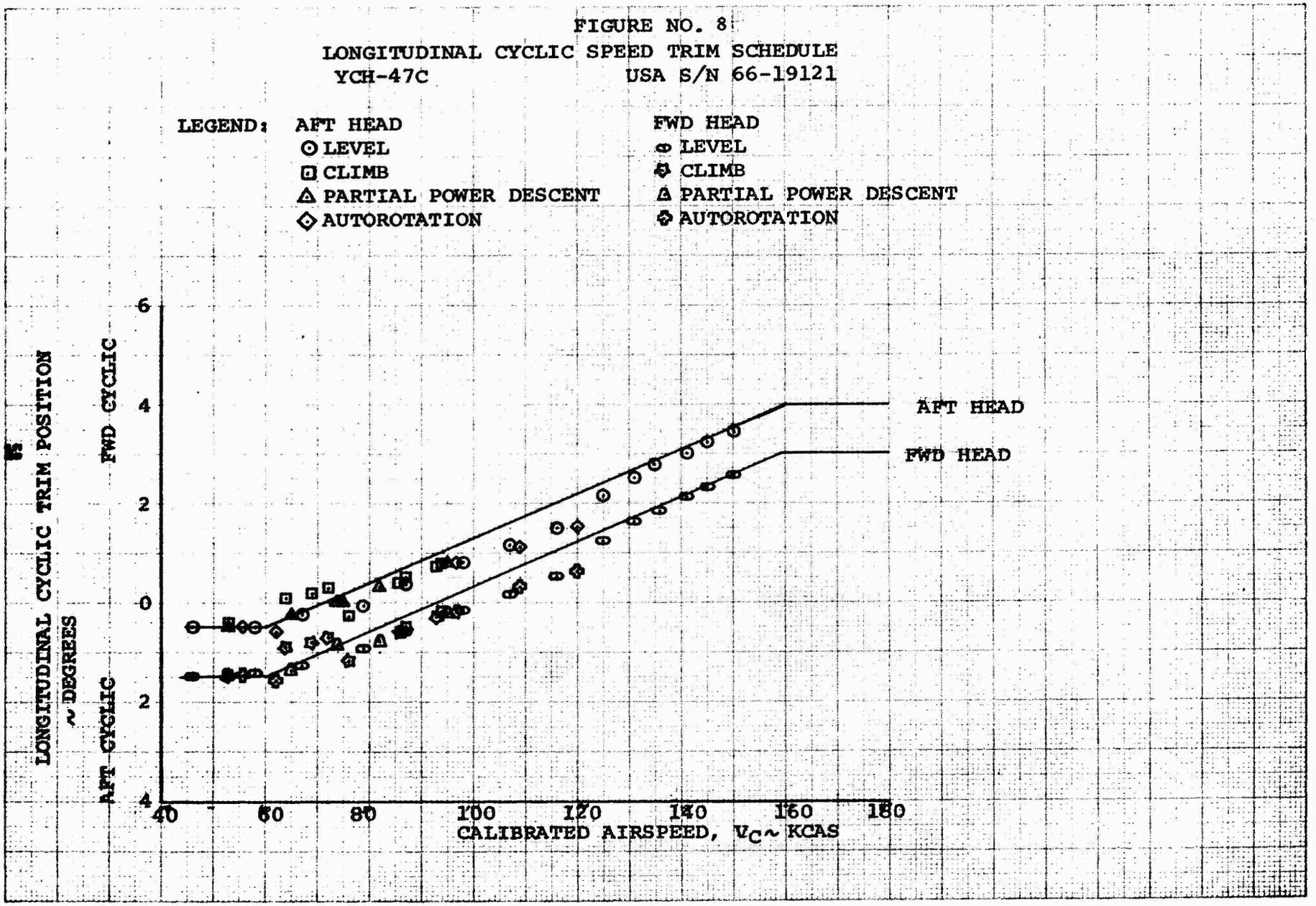


FIGURE NO. 9

DIFFERENTIAL COLLECTIVE PITCH SCHEDULE

YCH-47C USA S/N 66-19121

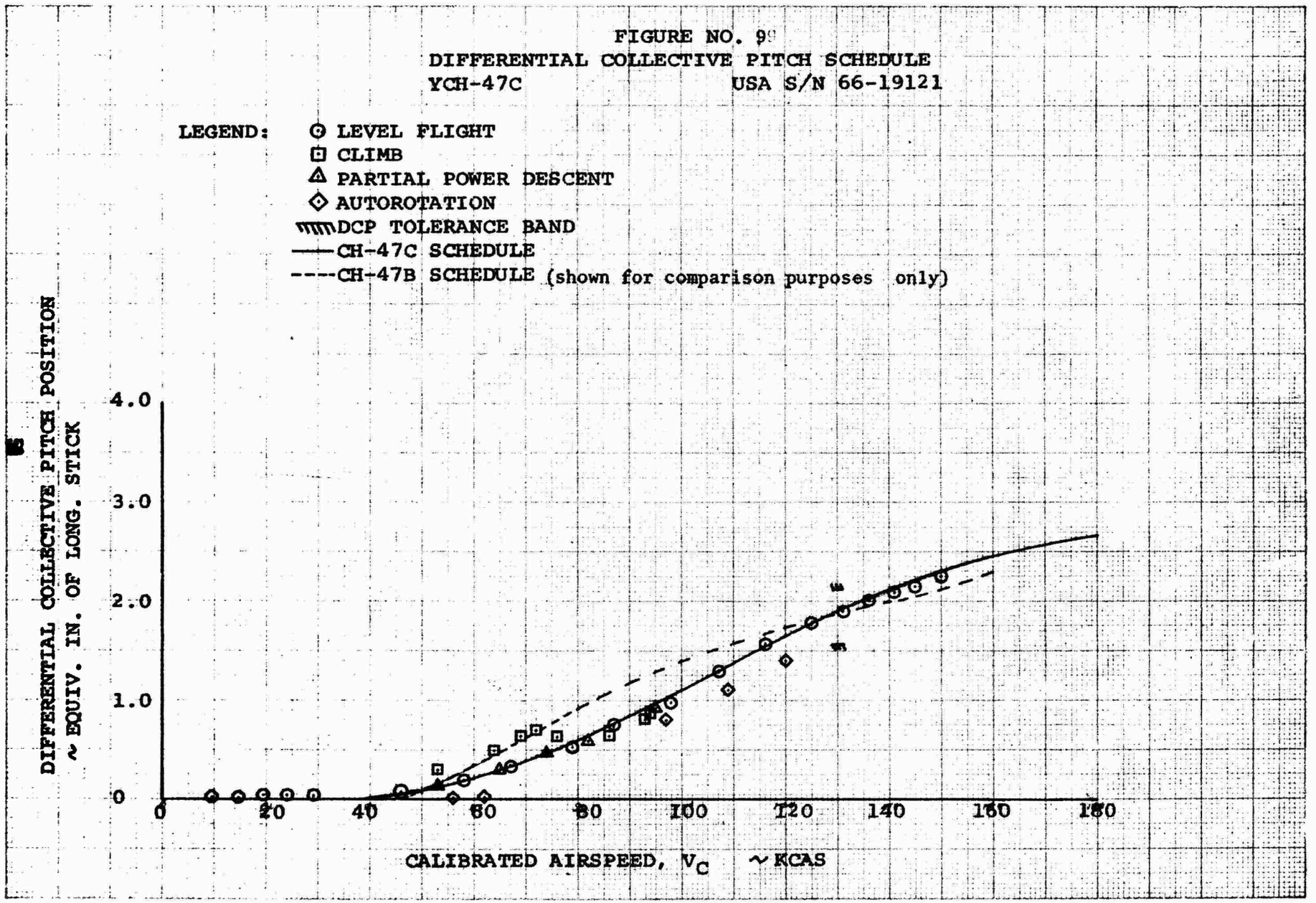


FIGURE NO. 10
LONGITUDINAL STICK FORCE VS. POSITION
YCH-47C USA S/N 66-19121

NOTE:

1. TEST CONDUCTED ON GROUND WITH APU SUPPLYING PRESSURE.
2. TOTAL LONGITUDINAL CONTROL TRAVEL = 13.95 IN.
3. CONTROL CENTERING ON.

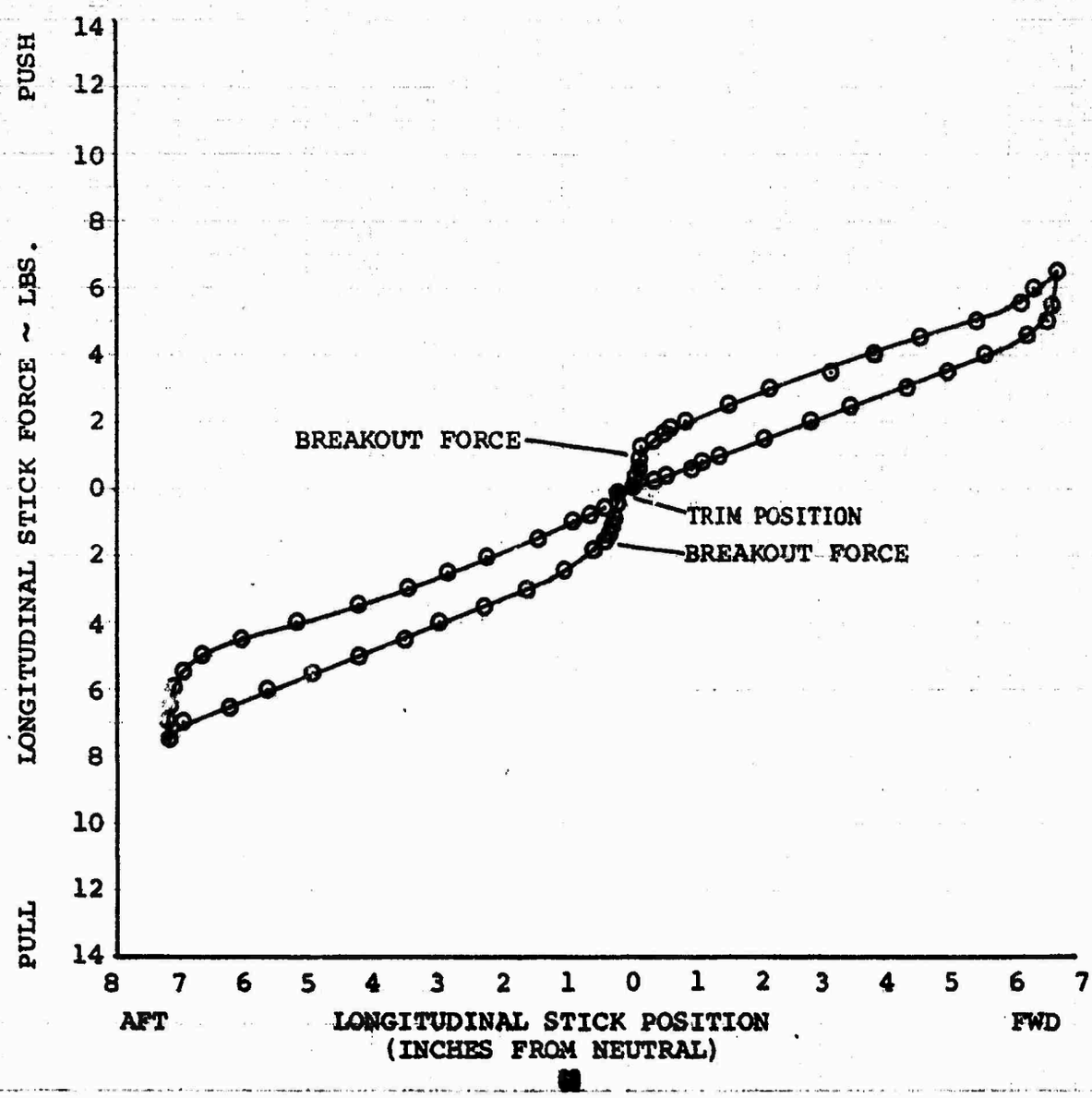


FIGURE NO. 11
LATERAL STICK POSITION VS. FORCE
YCH-47C USA S/N 66-19121

NOTE:

1. TEST CONDUCTED ON GROUND WITH APU SUPPLYING PRESSURE.
2. TOTAL LATERAL CONTROL TRAVEL = 8.88 IN.
3. CONTROL CENTERING ON.

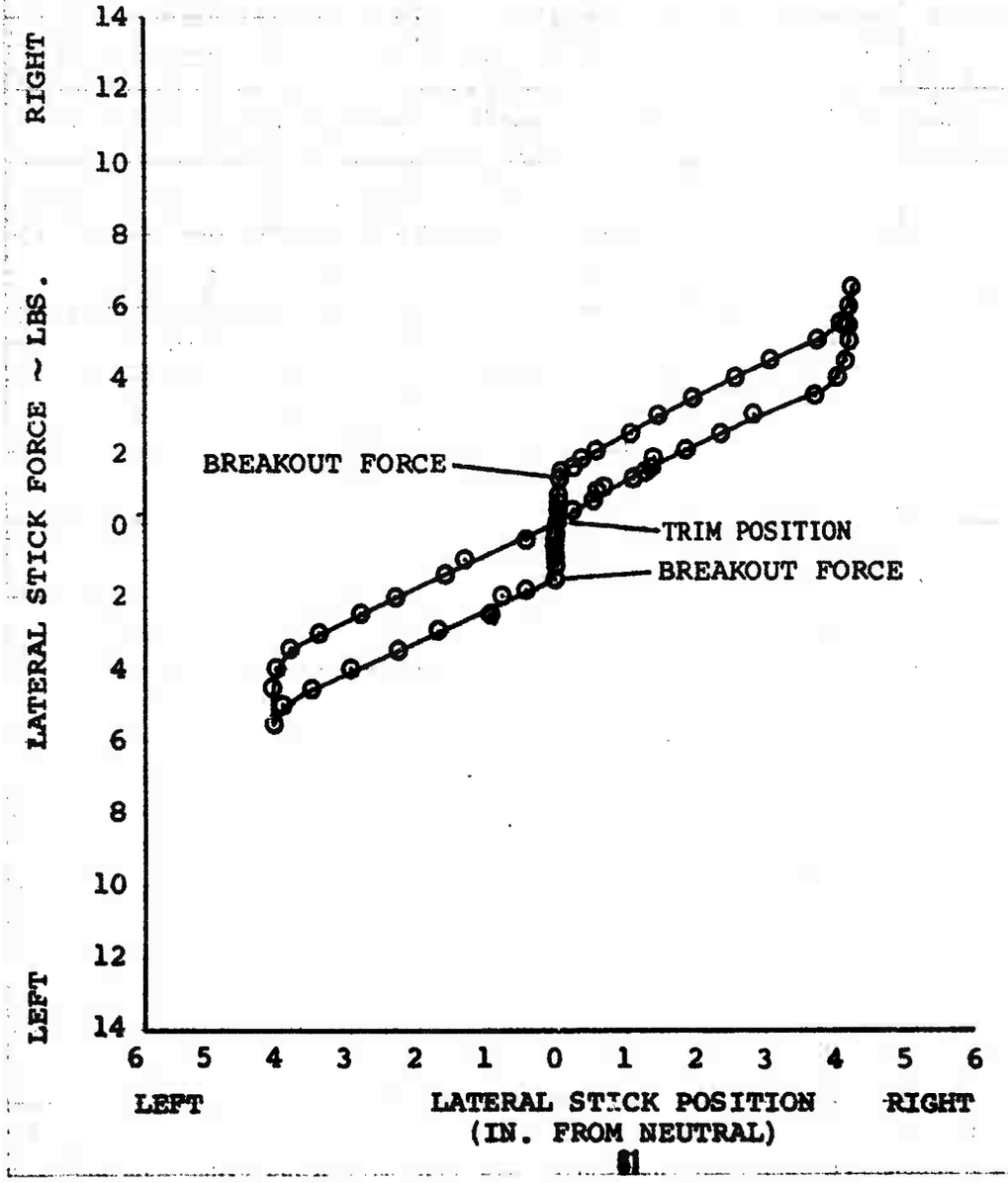


FIGURE NO. 12
DIRECTIONAL PEDAL FORCE VS. POSITION
YCH-47C USA S/N 66-19121

NOTE:

1. TEST CONDUCTED ON GROUND WITH APU SUPPLYING PRESSURE
2. TOTAL DIRECTIONAL CONTROL TRAVEL = 8.02 IN.
3. CONTROL CENTERING ON.

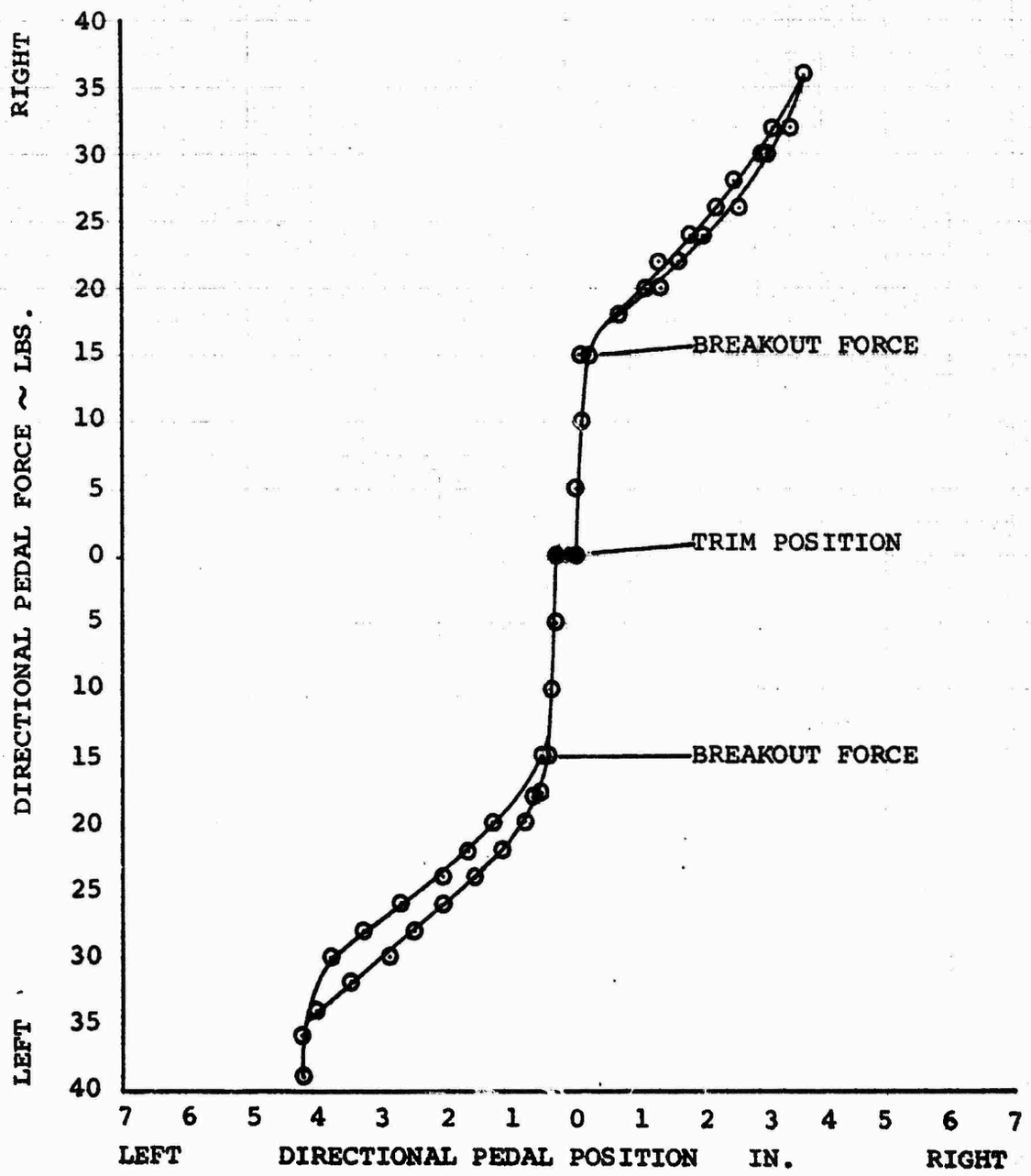


FIGURE NO. 13
COLLECTIVE STICK FORCE VS. POSITION
YCH-47C USA S/N 66-19121

NOTE:

1. TEST CONDUCTED ON GROUND WITH APU SUPPLYING PRESSURE.
2. TOTAL COLLECTIVE CONTROL TRAVEL = 9.0 IN.
3. THRUST CONTROL ROD MAGNETIC BRAKE SWITCH DEPRESSED

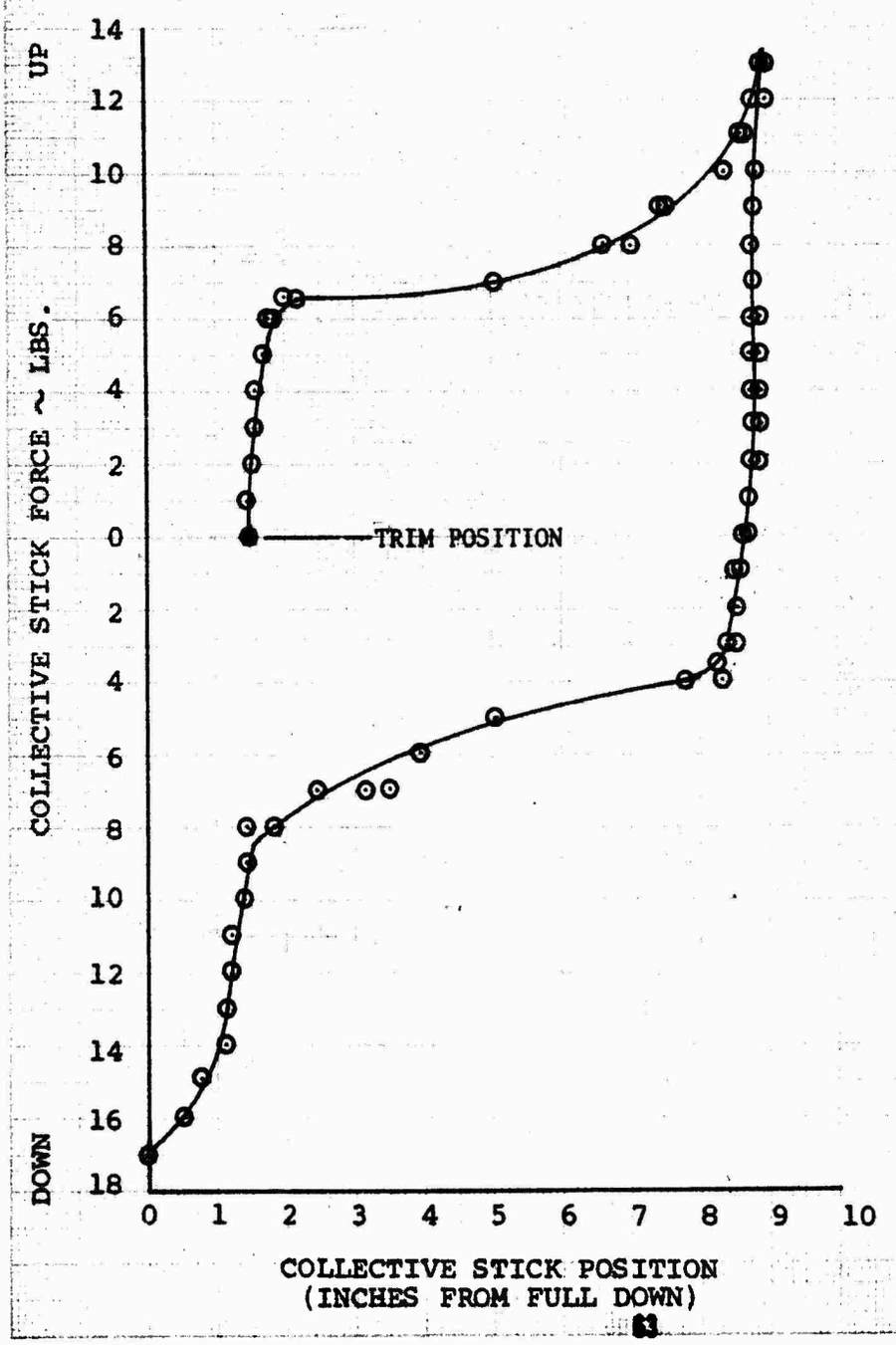


FIGURE NO. 14

CONTROL POSITION TRIM CURVES

YCH-47C USA S/N 66-19121

LEVEL FLIGHT

AVG. GROSS WEIGHT = 31,070 LBS. AVG. C.G. LOCATION = 0.0 IN
AVG. ROTOR SPEED = 235 RPM SAS CONFIGURATION = ON
AVG. DENSITY ALT. = 600 FT. SPEED TRIM (DCP & LONG CYC) = AUTO.

NOTE: APE I DATA

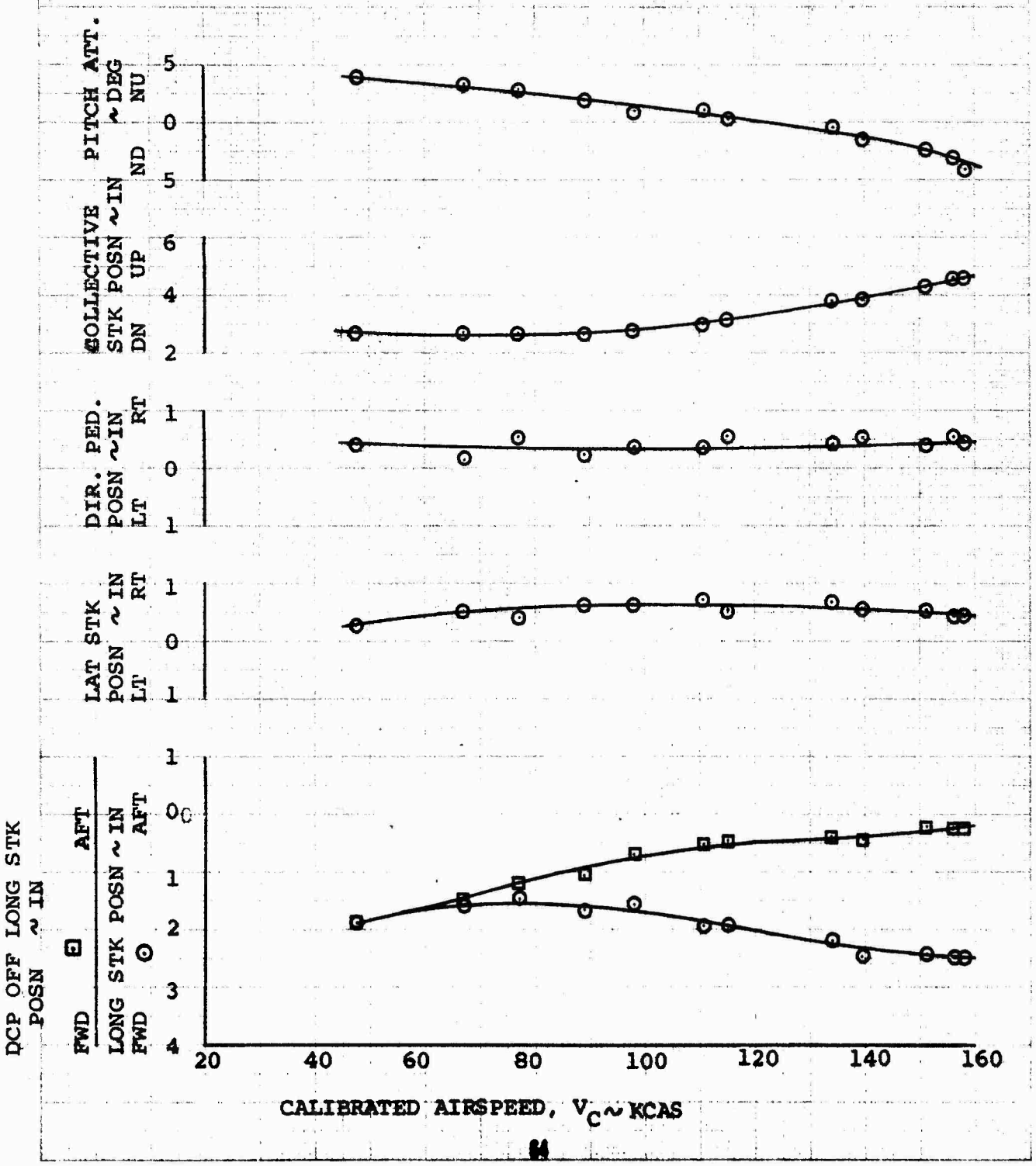


FIGURE NO. 15

CONTROL POSITION TRIM CURVES

YCH-47C USA S/N 66-19121

LEVEL FLIGHT

AVG. GROSS WEIGHT = 37550 LB
AVG. ROTOR SPEED = 234 RPM
AVG. DENSITY ALT. = 4900 FT

AVG. C.G. LOCATION = 6.2" AFT
SAS CONFIGURATION = ON
SPEED TRIM (DCP & LONG CYC) = AUTO

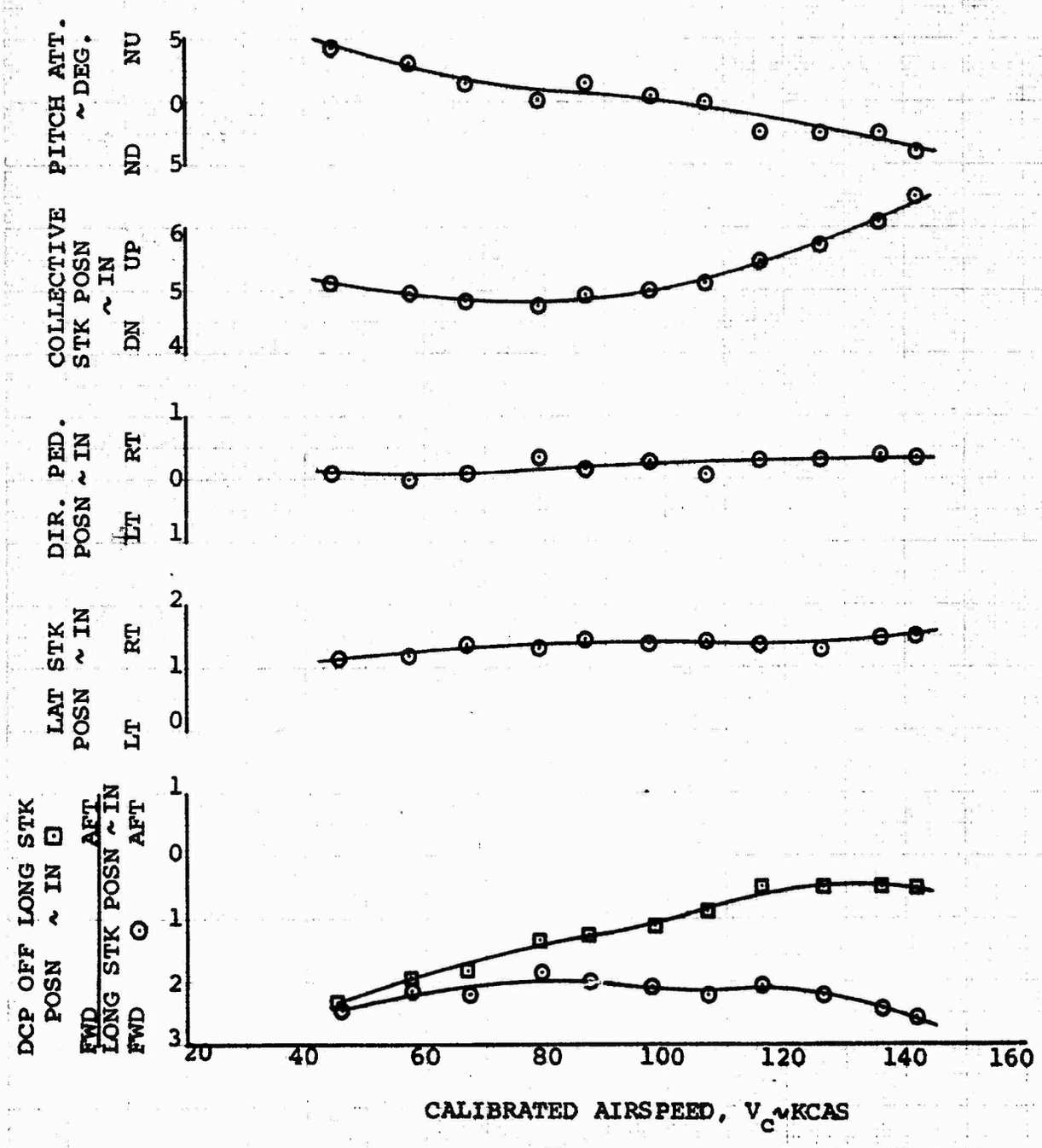


FIGURE NO. 16

CONTROL POSITION TRIM CURVES

YCH-47C USA S/N 66-19121

LEVEL FLIGHT

AVG. GROSS WEIGHT = 37,540 LB
AVG. ROTOR SPEED = 242 RPM
AVG. DENSITY ALT. = 1570 FT

AVG. C.G. LOCATION = 6.2" AFT
SAS CONFIGURATION = ON
SPEED TRIM (DCP & LONG CYC)=AUTO

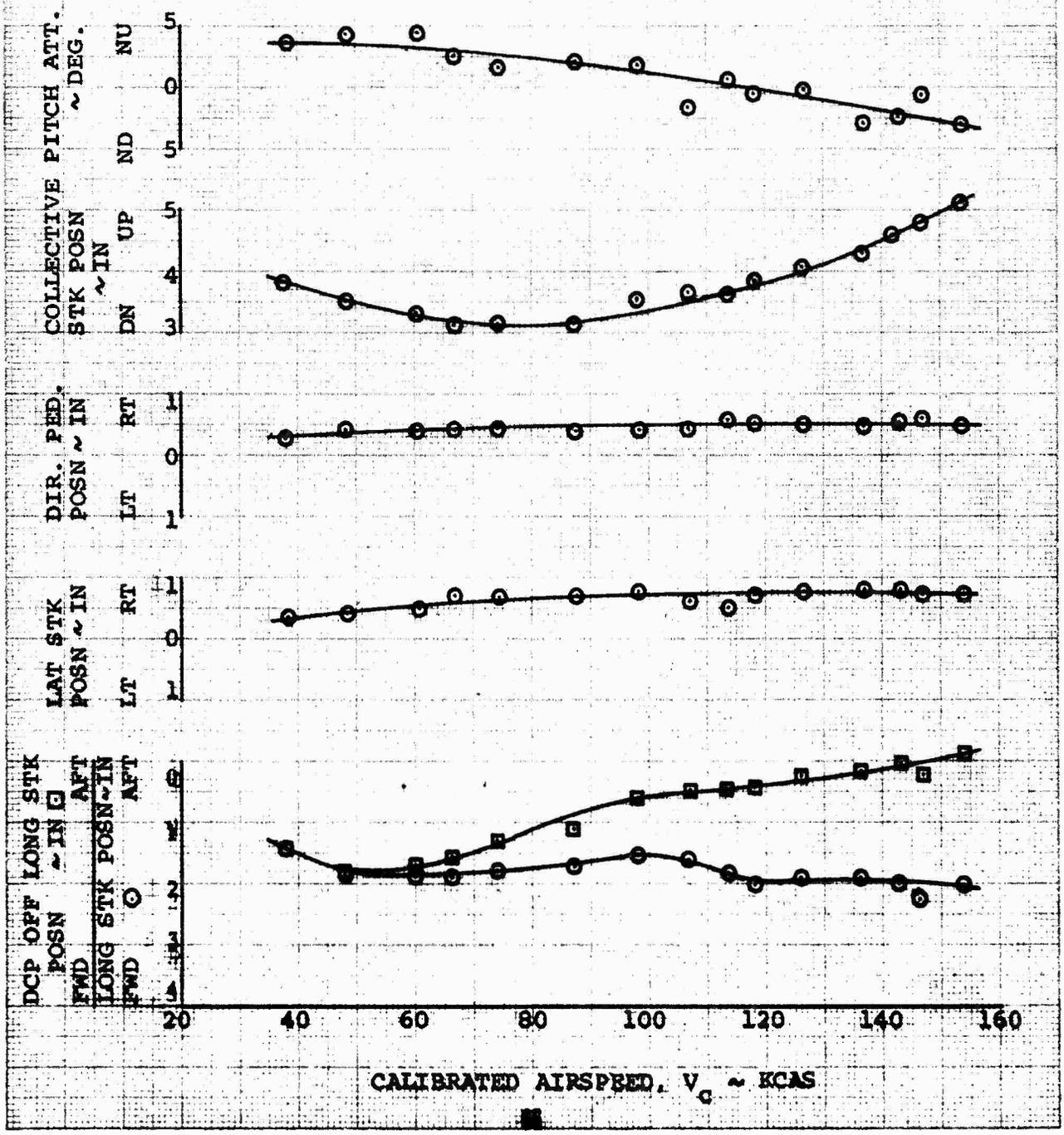


FIGURE NO. 17

CONTROL POSITION TRIM CURVES

YCH-47C USA S/N 66-19121

LEVEL FLIGHT

AVG. GROSS WEIGHT = 37,620 LB
AVG. ROTOR SPEED = 258
AVG. DENSITY ALT. = 9700 FT

AVG. C.G. LOCATION = 6.2" AFT
SAS CONFIGURATION = ON
SPEED TRIM (DCP & LONG CYC)=AUTO

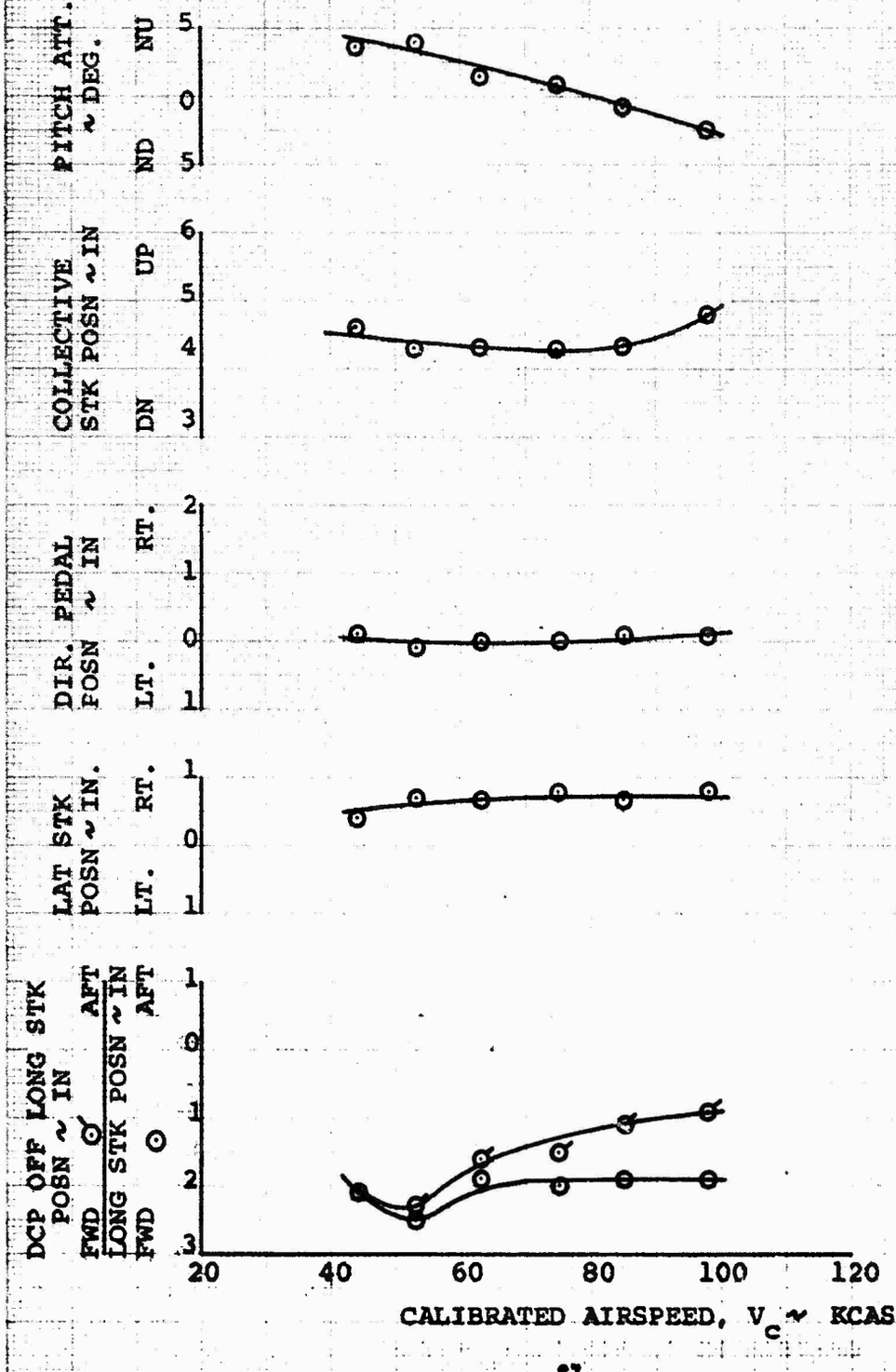


FIGURE NO. 16

CONTROL POSITION TRIM CURVES

YCH-47C USA S/N 66-19121

LEVEL FLIGHT

AVG. GROSS WEIGHT = 40,420 LBS AVG. C.G. LOCATION = 0.0 IN.
AVG. ROTOR SPEED = 236 RPM SAS CONFIGURATION = ON
AVG. DENSITY ALT. = 4,650 FT. SPEED TRIM (DCP & LONG CYC)=AUTO

NOTE: APE I data

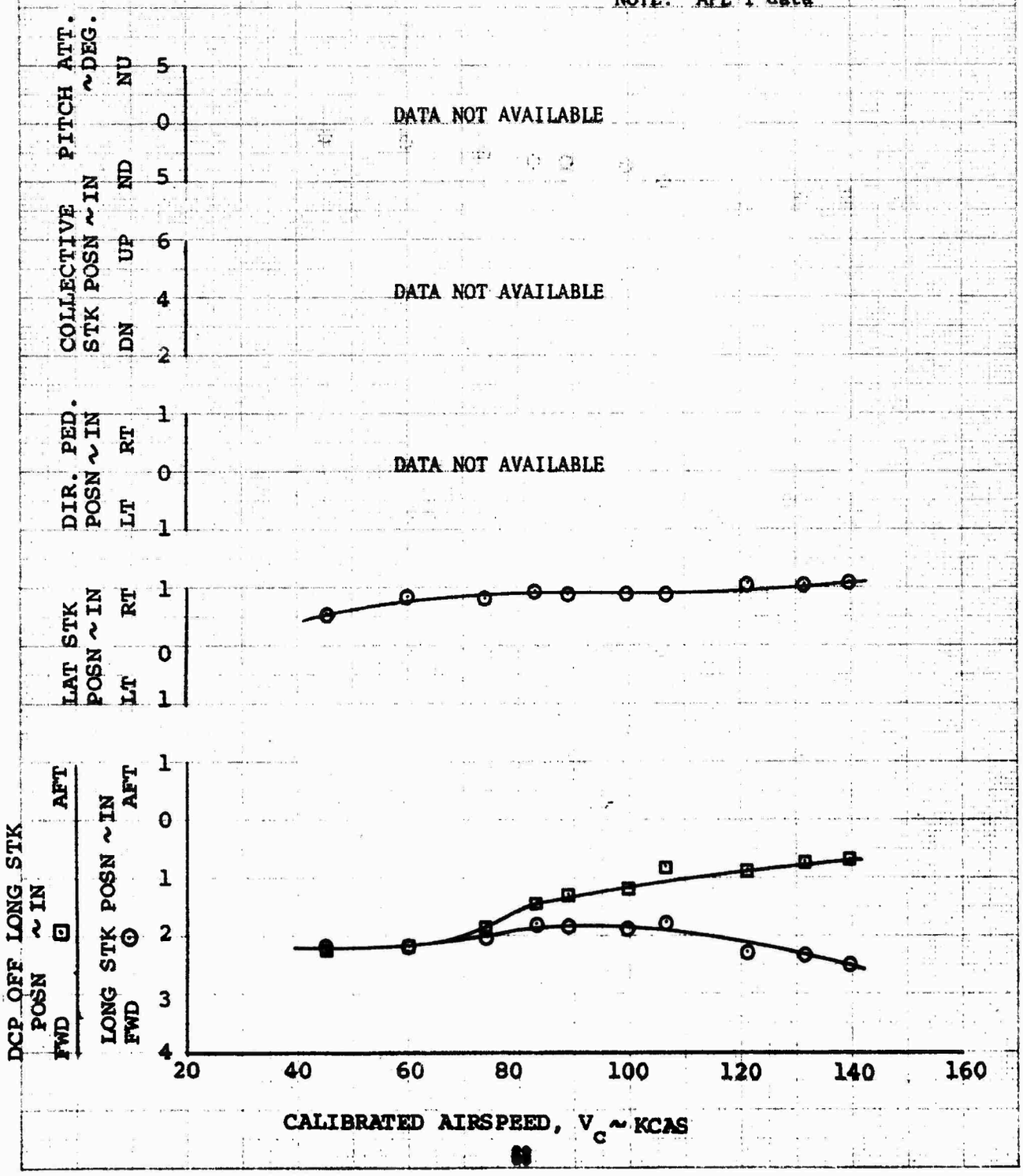


FIGURE NO. 19

CONTROL POSITION TRIM CURVES

YCH-47C USA S/N 66-19121

IGE LEVEL FLIGHT

FORWARD & REARWARD FLT.

AVG. GROSS WEIGHT = 37330 LB
AVG. ROTOR SPEED = 230.5
AVG. DENSITY ALT. = 2710 FT

AVG. C.G. LOCATION = 4.1" L.LAT 16.0" FWD
SAS CONFIGURATION = ON
SPEED TRIM (DCP & LONG CYC)=AUTO

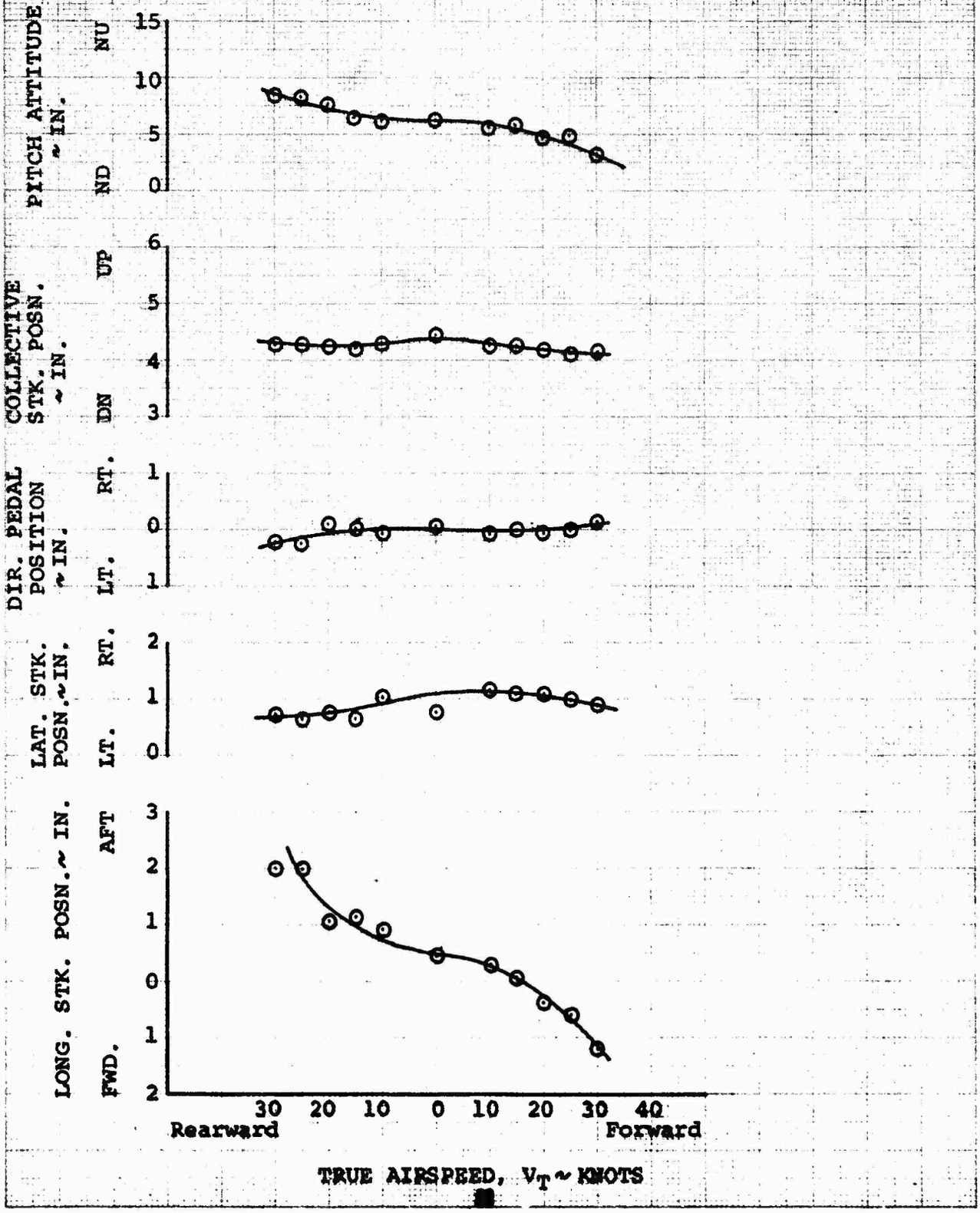


FIGURE NO. 20

CONTROL POSITION TRIM CURVES

YCH-47C USA S/N 66-19121

FORWARD & REARWARD FLT.

IGE LEVEL FLIGHT.

AVG. GROSS WEIGHT = 38175 LB
AVG. ROTOR SPEED = ⊙233 ⊡ 243
AVG. DENSITY ALT. = 1610 FT

AVG. C.G. LOCATION = 2.3" AFT
SAS CONFIGURATION = ON
SPEED TRIM (DCP & LONG CYC.)=AUTO

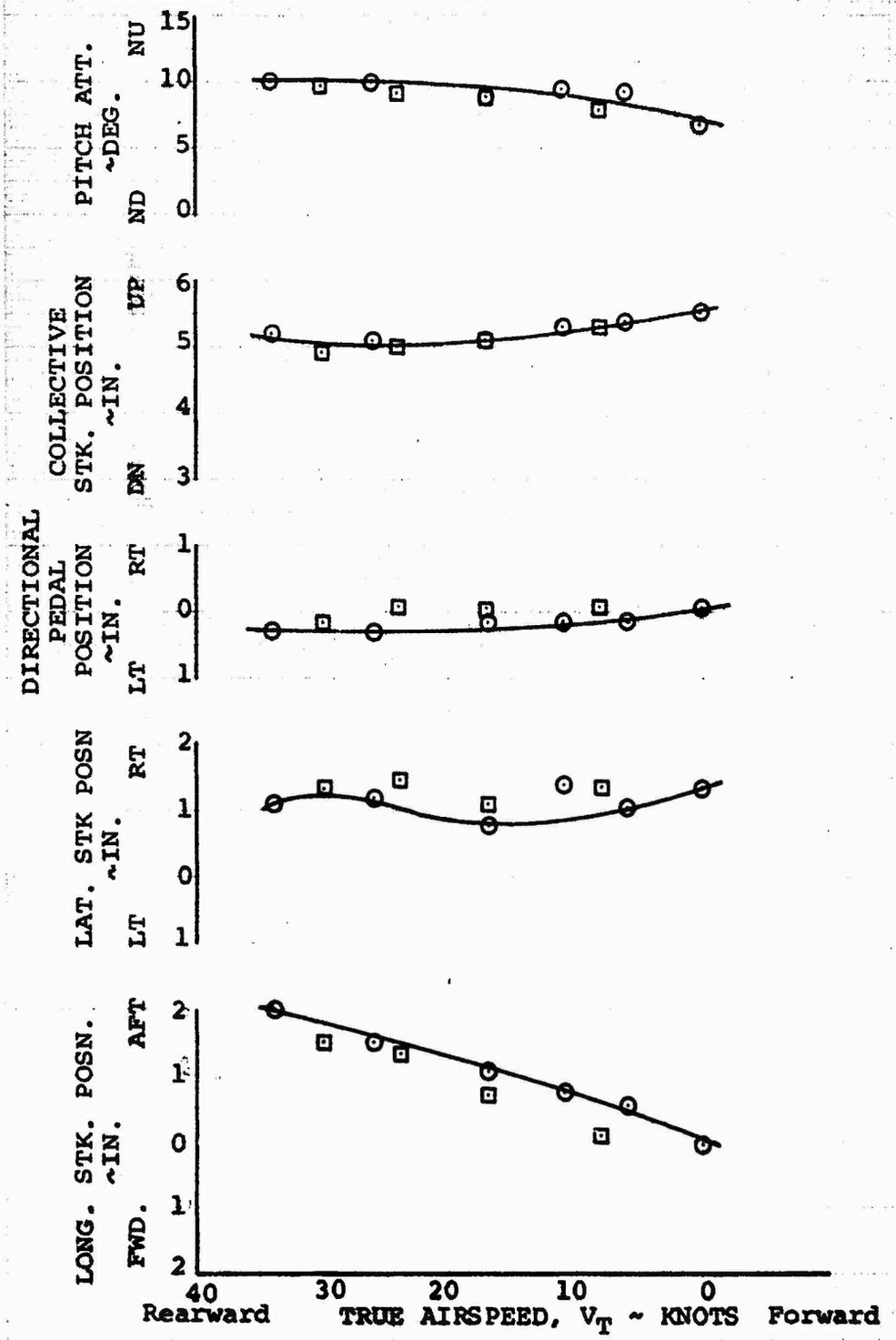


FIGURE NO. 21

CONTROL POSITION TRIM CURVES

YCH-47C USA S/N 66-19121

IGE LEVEL FLIGHT

REARWARD FLIGHT

AVG. GROSS WEIGHT = 43600 LB
AVG. ROTOR SPEED = 242
AVG. DENSITY ALT. = 400 FT

AVG. C.G. LOCATION = 9.0" AFT
SAS CONFIGURATION = ON
SPEED TRIM (DCP & LONG CYC)=AUTO

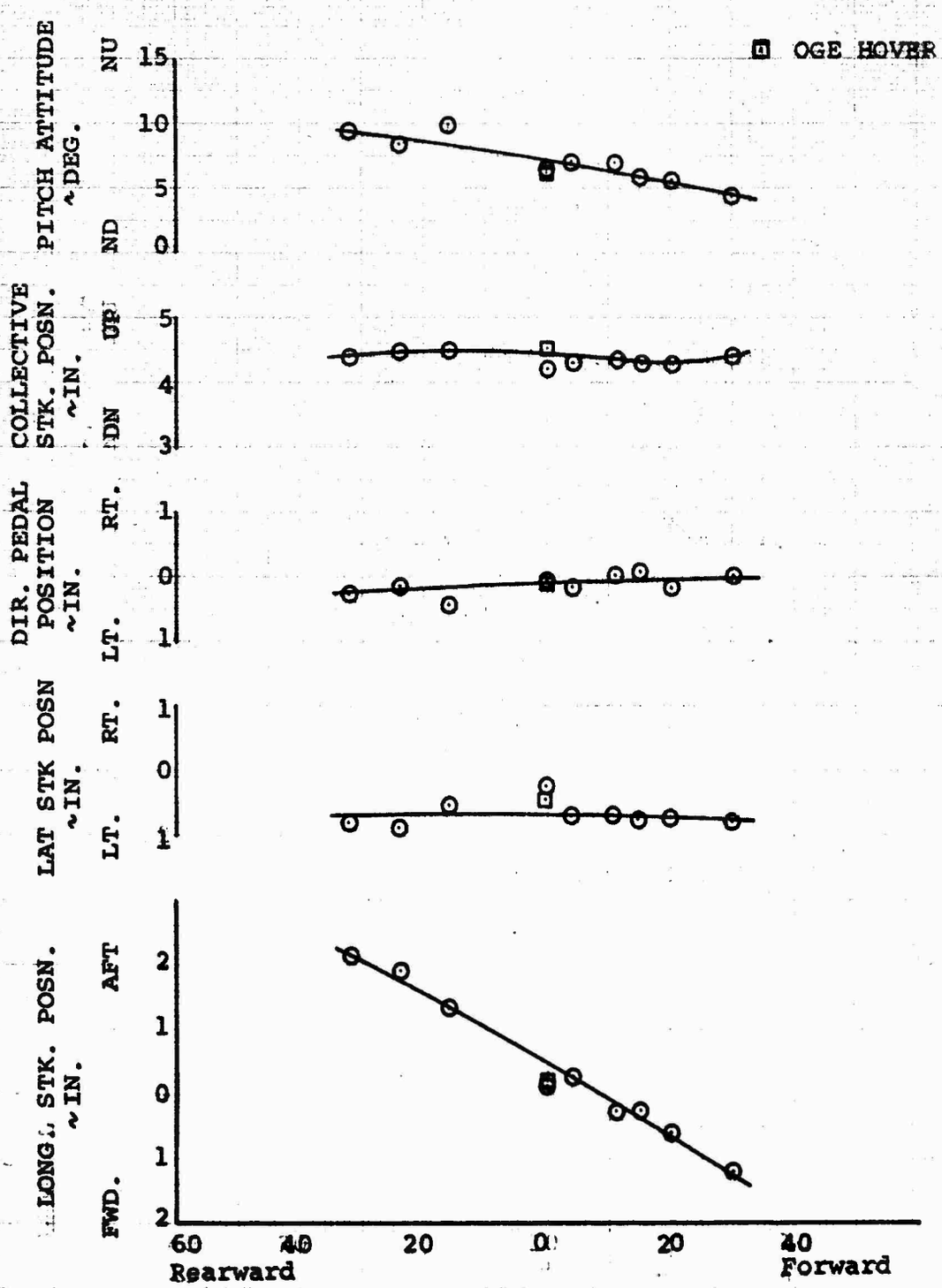


FIGURE NO. 22

CONTROL POSITION TRIM CURVES
YCH-47C USA S/N 66-19121
SIDEWARD FLIGHT
CONTROL MOTION

AVG. GROSS WEIGHT	=	35,770 LB	AVG. C.G. LOCATION	=	4.1" L.LAT. 16.0" FWD
AVG. ROTOR SPEED	=	235	SAS CONFIGURATION	=	ON
AVG. DENSITY ALT.	=	2540 FT	SPEED TRIM (DCP & LONG CYC)	=	AUTO

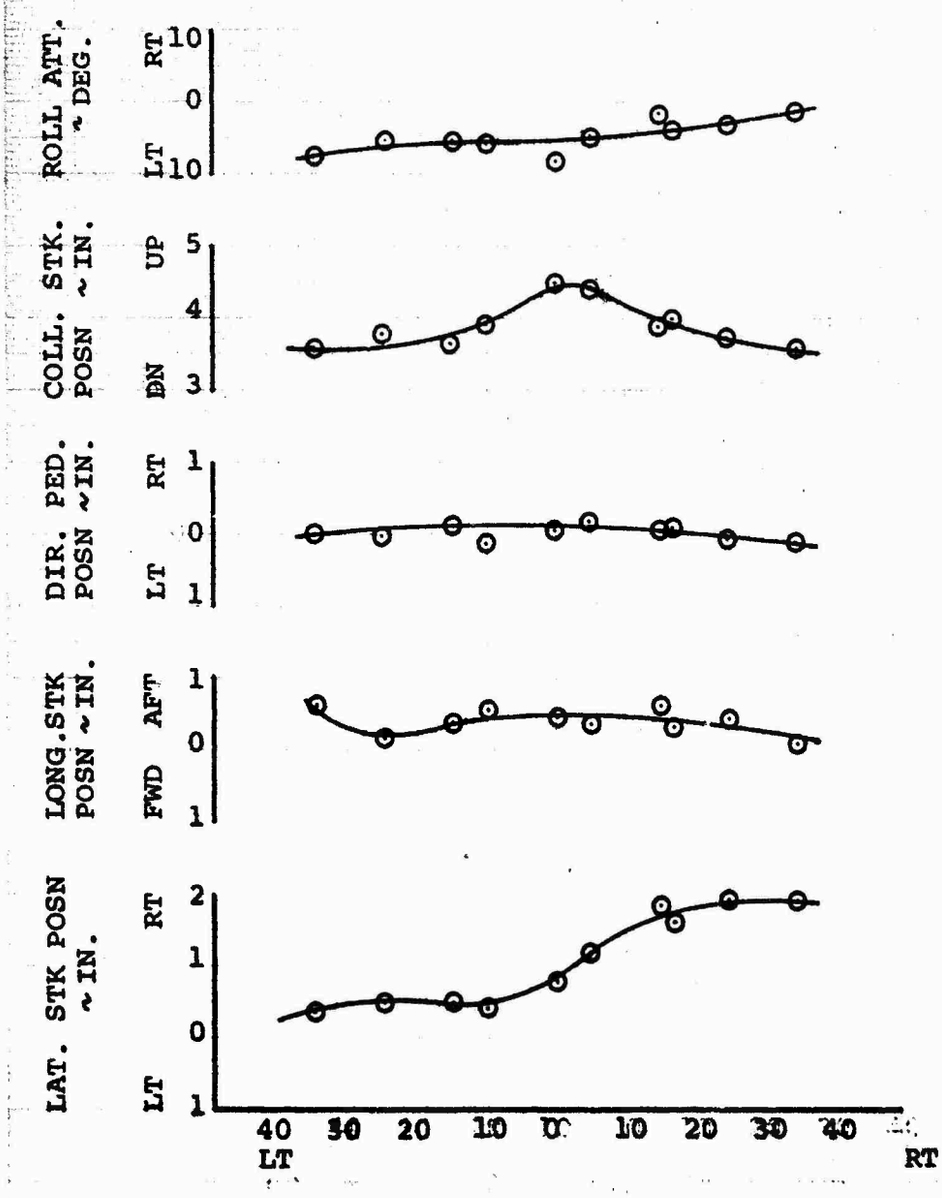


FIGURE NO. 23

CONTROL POSITION TRIM CURVES
YCH-47C USA S/N 66-19121
SIDEWARD FLIGHT
CONTROL MOTION

AVG. GROSS WEIGHT = 36,880 LB
AVG. ROTOR SPEED = ⊙234.5 ⊡240.
AVG. DENSITY ALT. = 930 FT
AVG. C.G. LOCATION = 6.5" AFT
SAS CONFIGURATION = ON
SPEED TRIM (DCP & LONG CYC)=AUTO

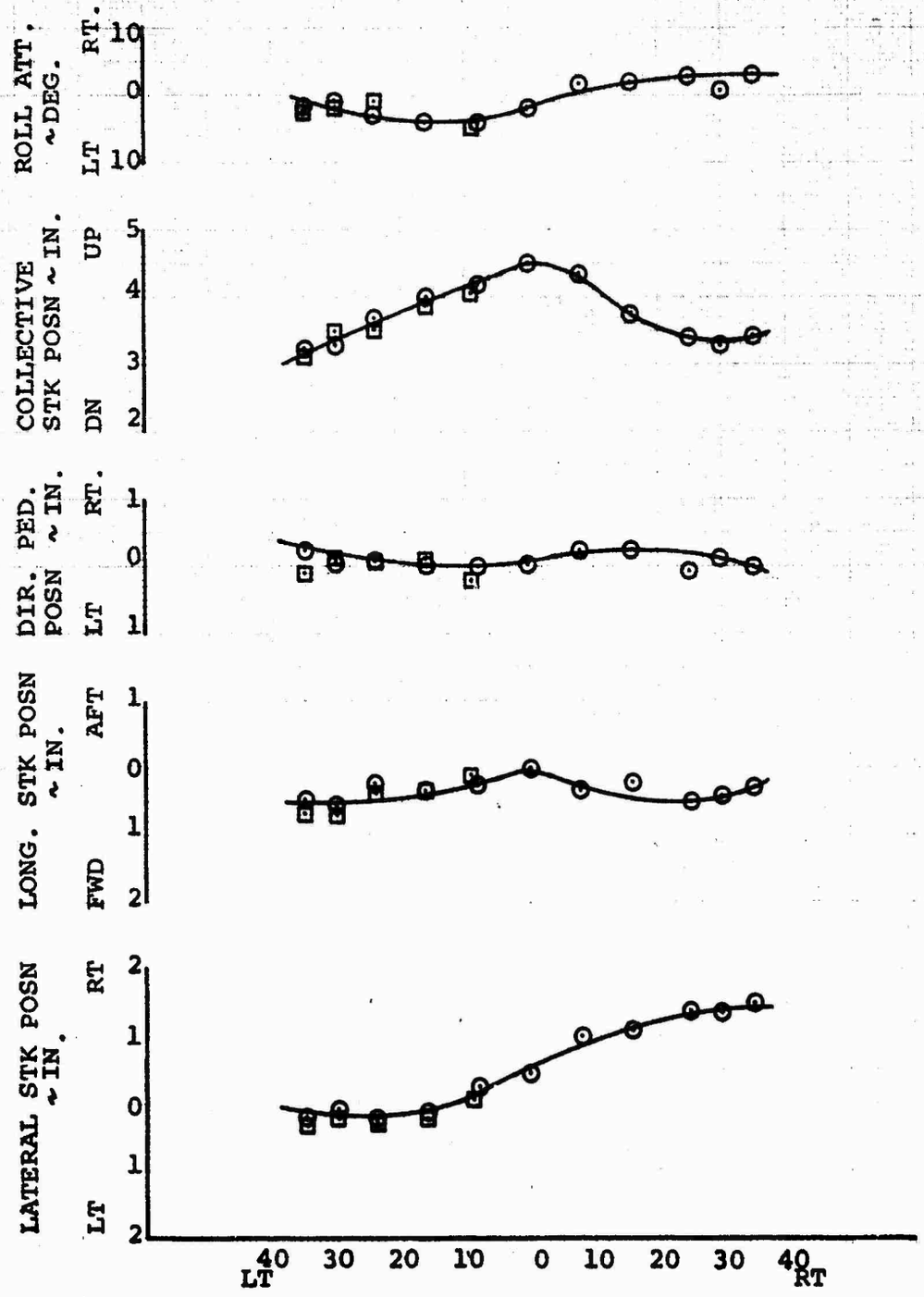


FIGURE NO. 24

CONTROL POSITION TRIM CURVES
YCH-47C USA S/N 66-19121
SIDEWARD FLIGHT
CONTROL MOTION

AVG. GROSS WEIGHT	= 44,580 LB	AVG. C.G. LOCATION	= 10.0" FWD
AVG. ROTOR SPEED	= 243	SAS CONFIGURATION	= ON
AVG. DENSITY ALT.	= 260 FT	SPEED TRIM (DCP & LONG CYC)	=AUTO

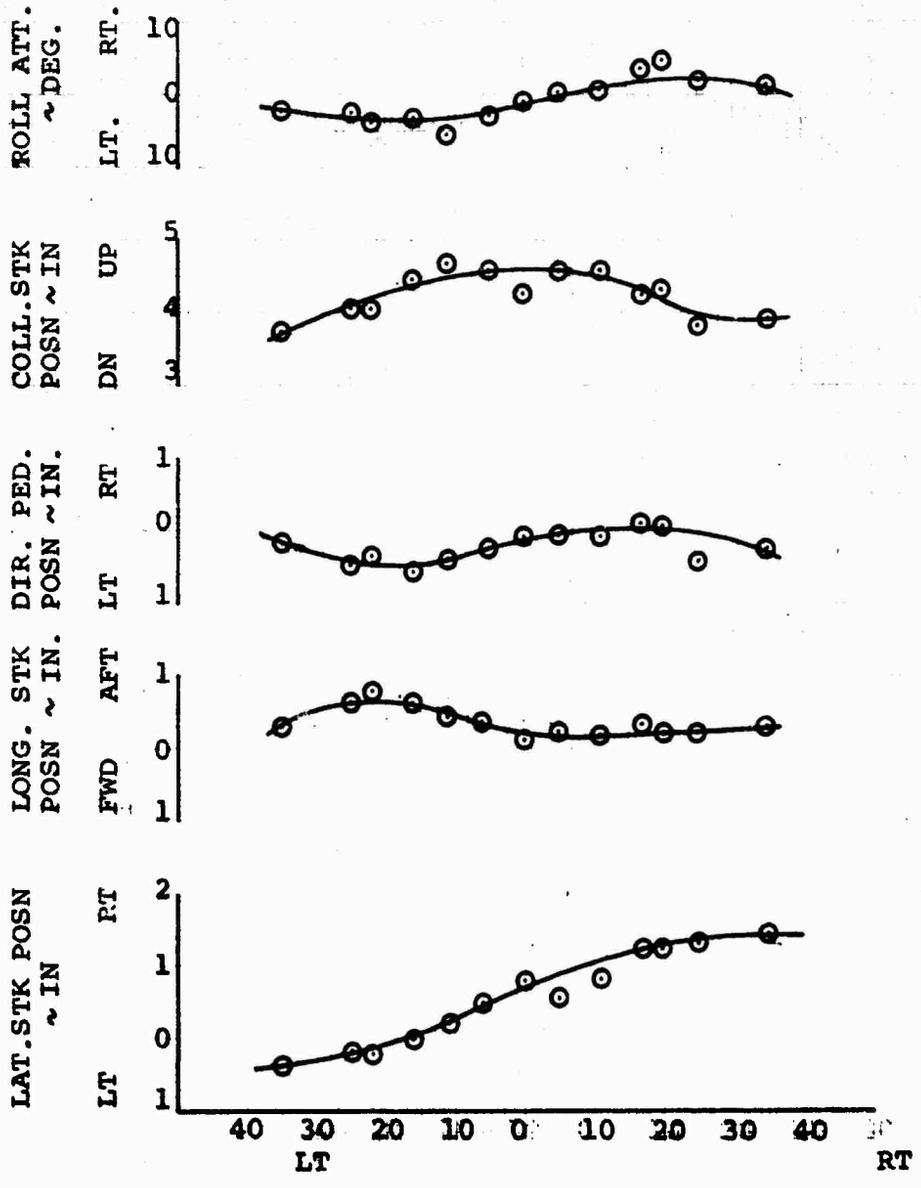


FIGURE NO. 25

STATIC LONGITUDINAL COLLECTIVE-FIXED STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG. G.W. ~LB.	ROTOR SPEED ~RPM	AVERAGE DENSITY ALT ~ FT.	AVERAGE C.G. LOC~IN.	C/P POSN ~IN
△	52	Level	36,680	232	5170	6.6 AFT	3.91
⊙	141	Level	36,987	234	5508	6.6 AFT	5.56
⊡	113	Level	35,720	233	5648	7.1 AFT	4.42

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.

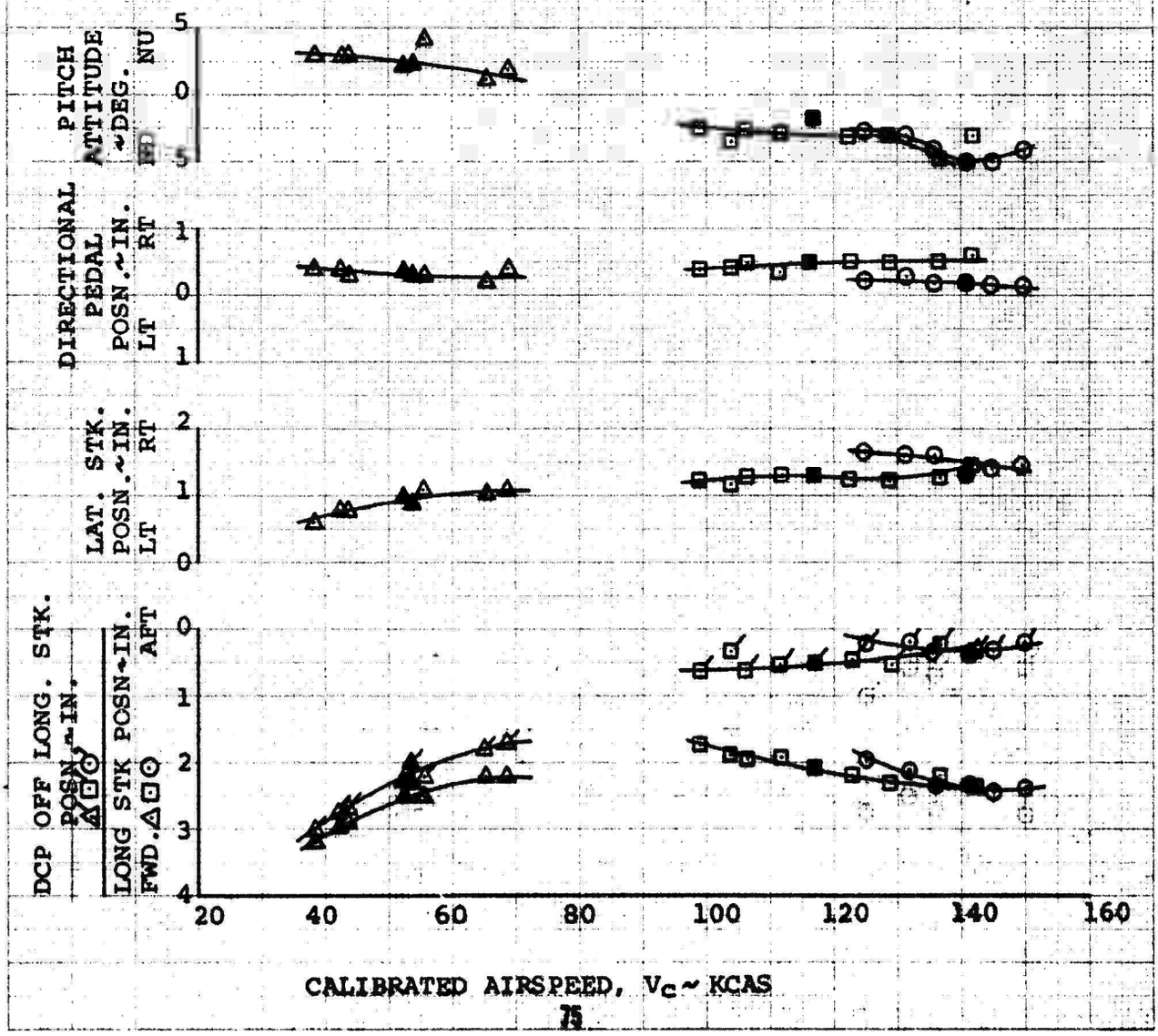


FIGURE NO. 26

STATIC LONGITUDINAL COLLECTIVE-FIXED STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG. G.W. ~ LB	ROTOR SPEED ~RPM	AVERAGE DENSITY ALT ~ FT	AVERAGE C.G. LOC ~ IN	C/P POSN ~ IN
⊙	115	LEVEL	37,280	244	10,450	18.0 FWD	4.60

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.

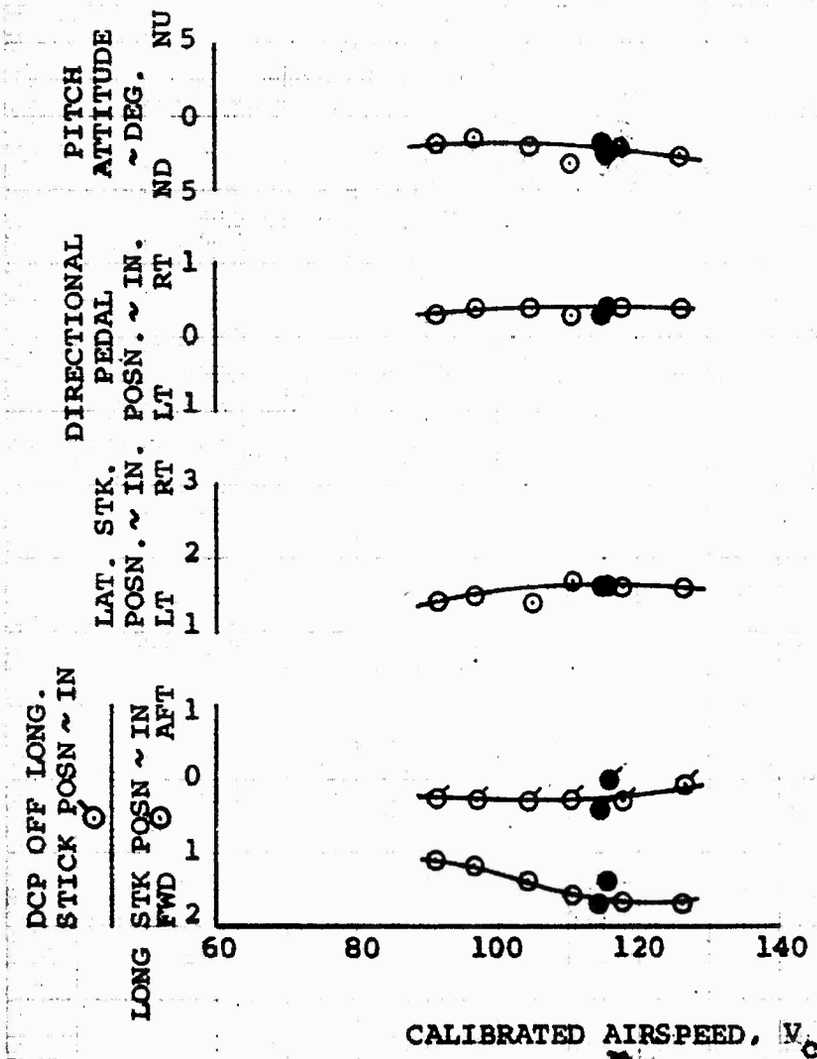


FIGURE NO. 27

STATIC LONGITUDINAL COLLECTIVE-FIXED STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG. G.W. ~LB	ROTOR SPEED ~RPM	AVERAGE DENSITY ALT~FT	AVERAGE C.G. LOC ~ IN	C/P POSN ~ IN
⊙	51	LEVEL	36,485	233	10270	6.6 AFT	4.2
⊡	97	LEVEL	37,330	233	10090	6.3 AFT	4.6

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.

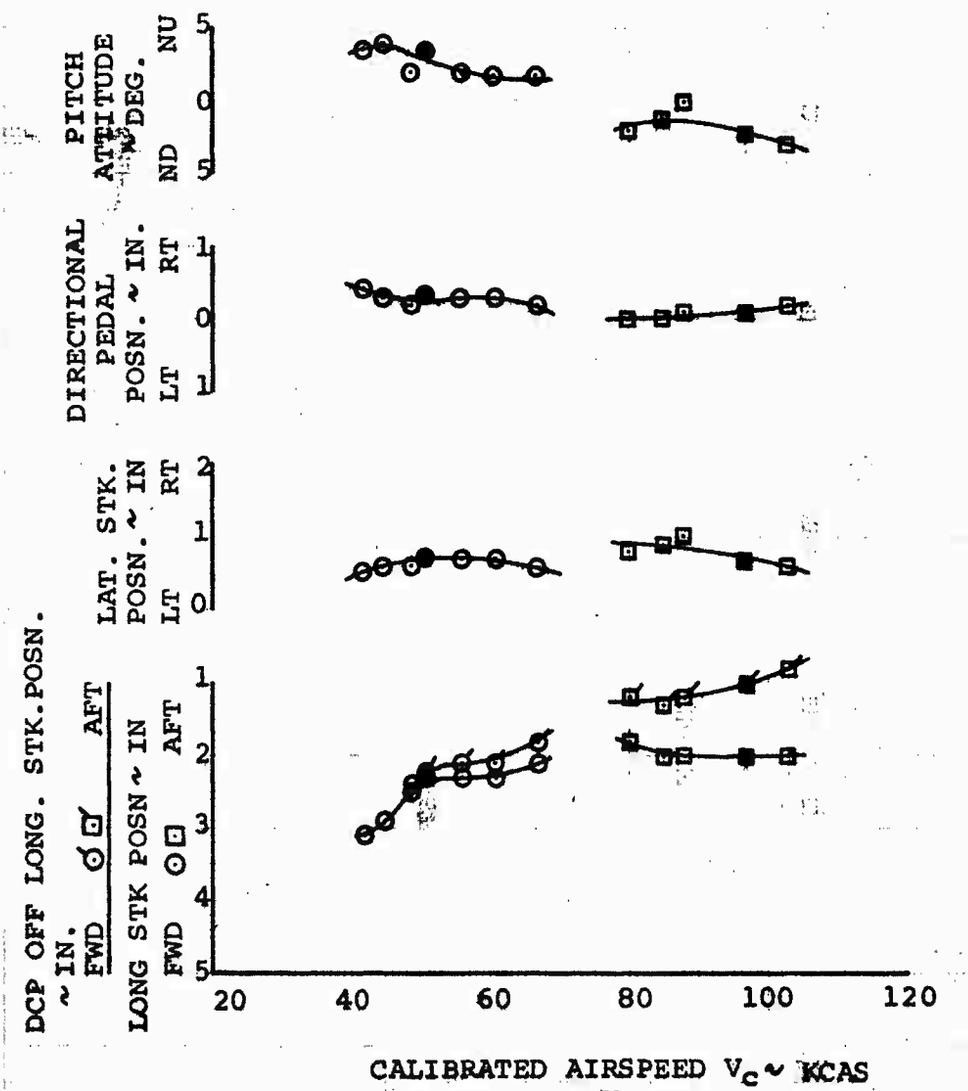


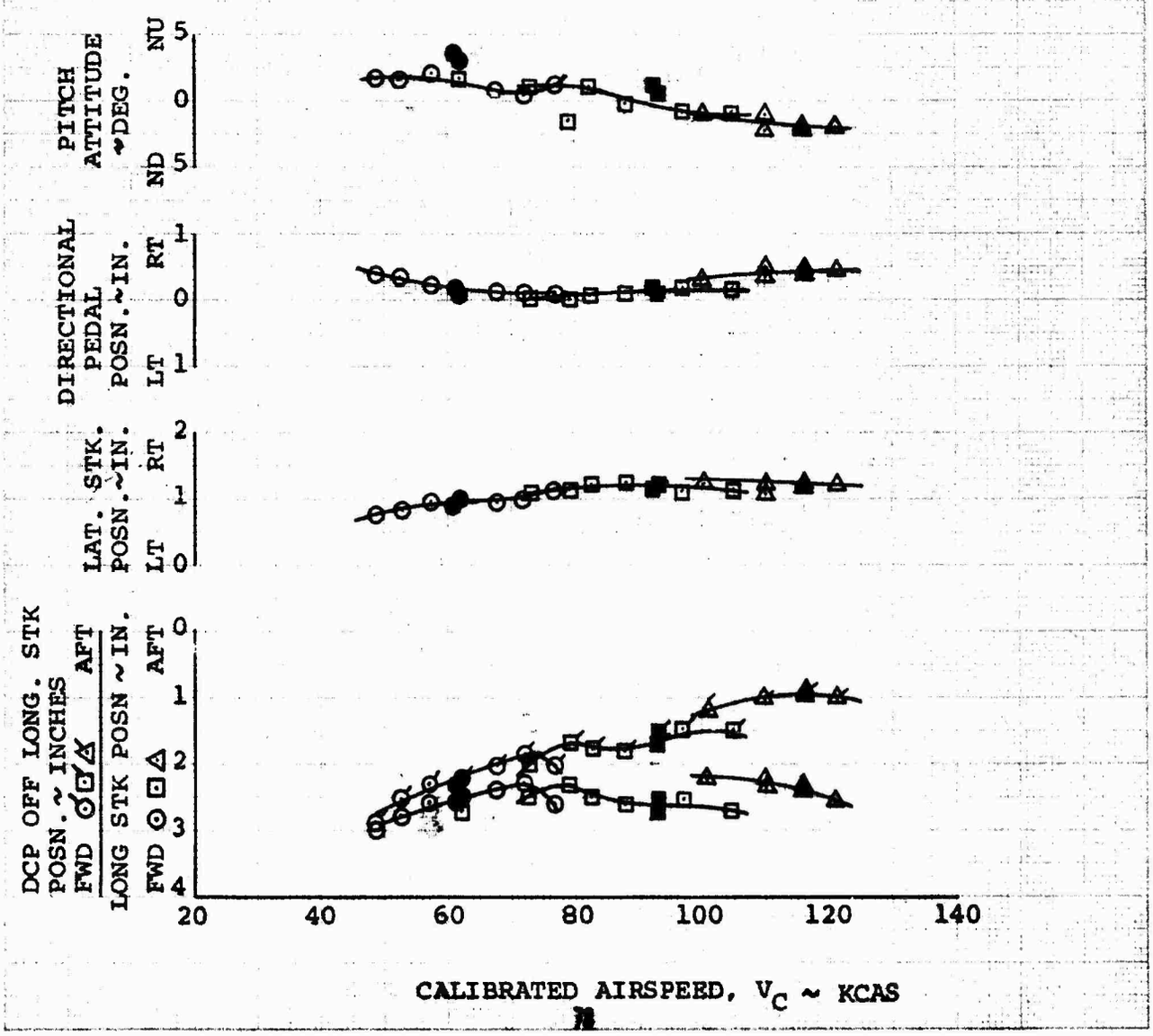
FIGURE NO. 28

STATIC LONGITUDINAL COLLECTIVE-FIXED STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM AIR-SPEED	FLIGHT CONDITION	AVG G.W. ~ LB	ROTOR SPEED ~ RPM	AVERAGE DENSITY ALT ~ FT	AVERAGE C.G. LOC ~ IN	C/P POSN ~ IN
⊙	62	Level	45,972	244	5260	4.0 AFT	4.44
⊡	93	Level	45,088	244	5310	4.5 AFT	4.35
△	116	Level	42,872	245	4850	7.5 AFT	4.53

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.



[redacted] NO. 329

STATIC LONGITUDINAL COLLECTIVE-FIXED STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG. G.W. ~LB.	ROTOR SPEED ~RPM	AVERAGE DENSITY ALT~FT.	AVERAGE C.G. LOC ~IN	C/P POSN ~IN
⊡	69	LEVEL	45,810	244	7930	4.1 AFT	4.75
⊙	54	LEVEL	45,940	244	7250	4.1 AFT	4.6

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.

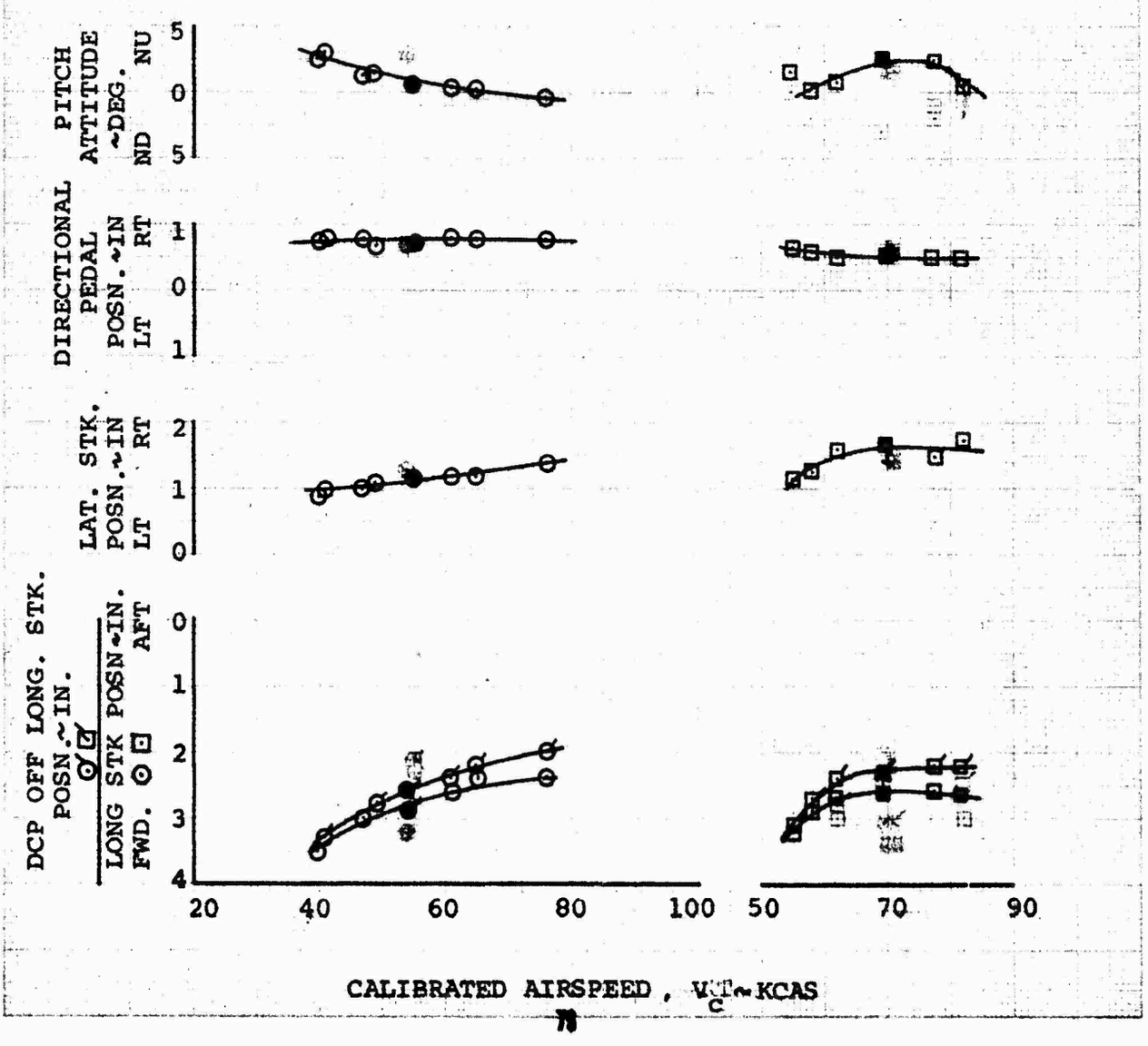


FIGURE NO. 39

STATIC LONGITUDINAL COLLECTIVE-FIXED STABILITY
YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG. G.W. ~LB.	ROTOR SPEED ~RPM	AVERAGE DENSITY ALT~ FT.	AVERAGE C.G. LOC~ IN	C/P POSN~ IN
⊡	93	Level	45,062	243	4650	10.5 FWD	4.25
⊙	50	Level	43,372	242	4840	9.0 FWD	4.26

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.

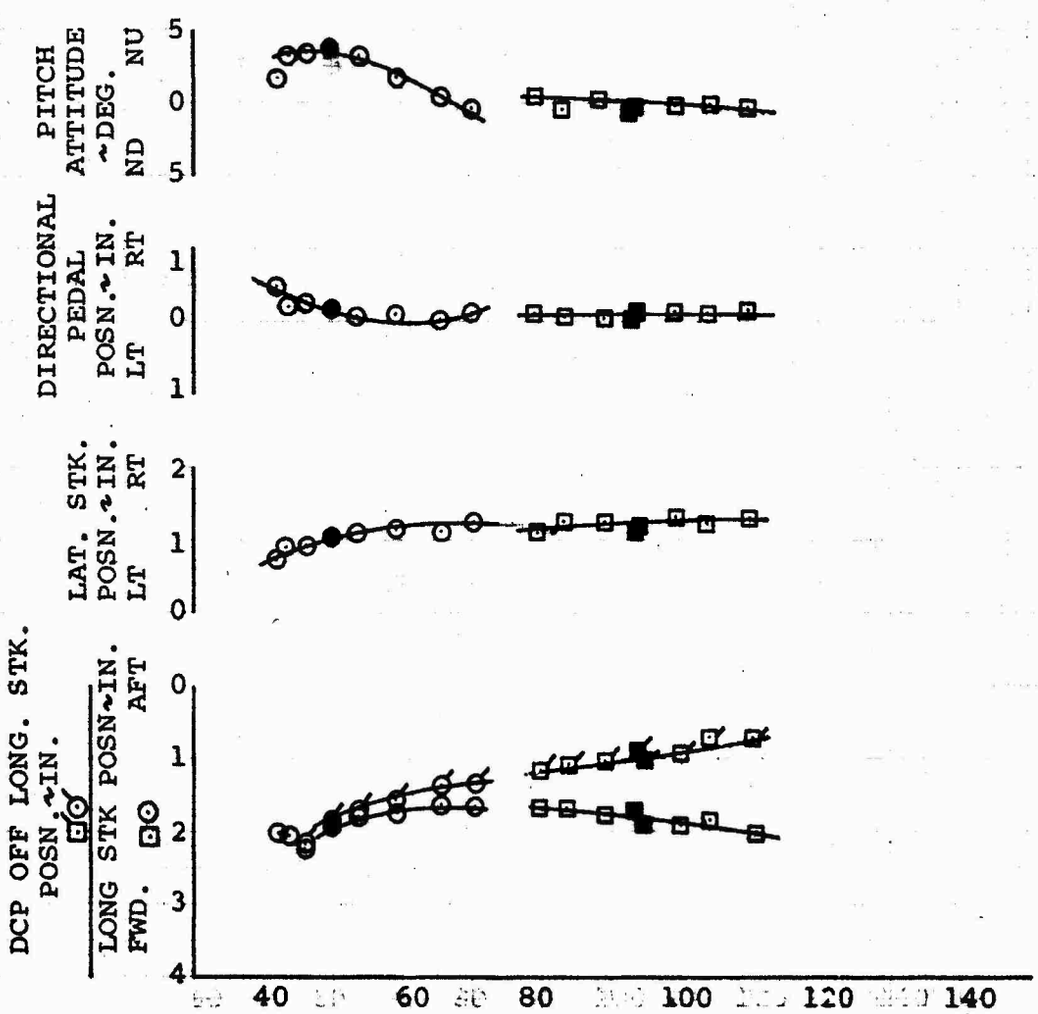


FIGURE NO. 31

STATIC LONGITUDINAL COLLECTIVE-FIXED STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM AIR-SPEED	FLIGHT CONDITION	AVG G.W. ~ LB.	ROTOR SPEED ~ RPM	AVERAGE DENSITY ALT ~ FT	AVERAGE C.G. LOC ~ IN	C/P POSN ~ IN
⊡	70	LEVEL	46,265	242	7960	10.5 FWD	4.65
⊙	54	LEVEL	45,491	242	7930	10.0 FWD	4.61

NOTE:
1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO.
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.

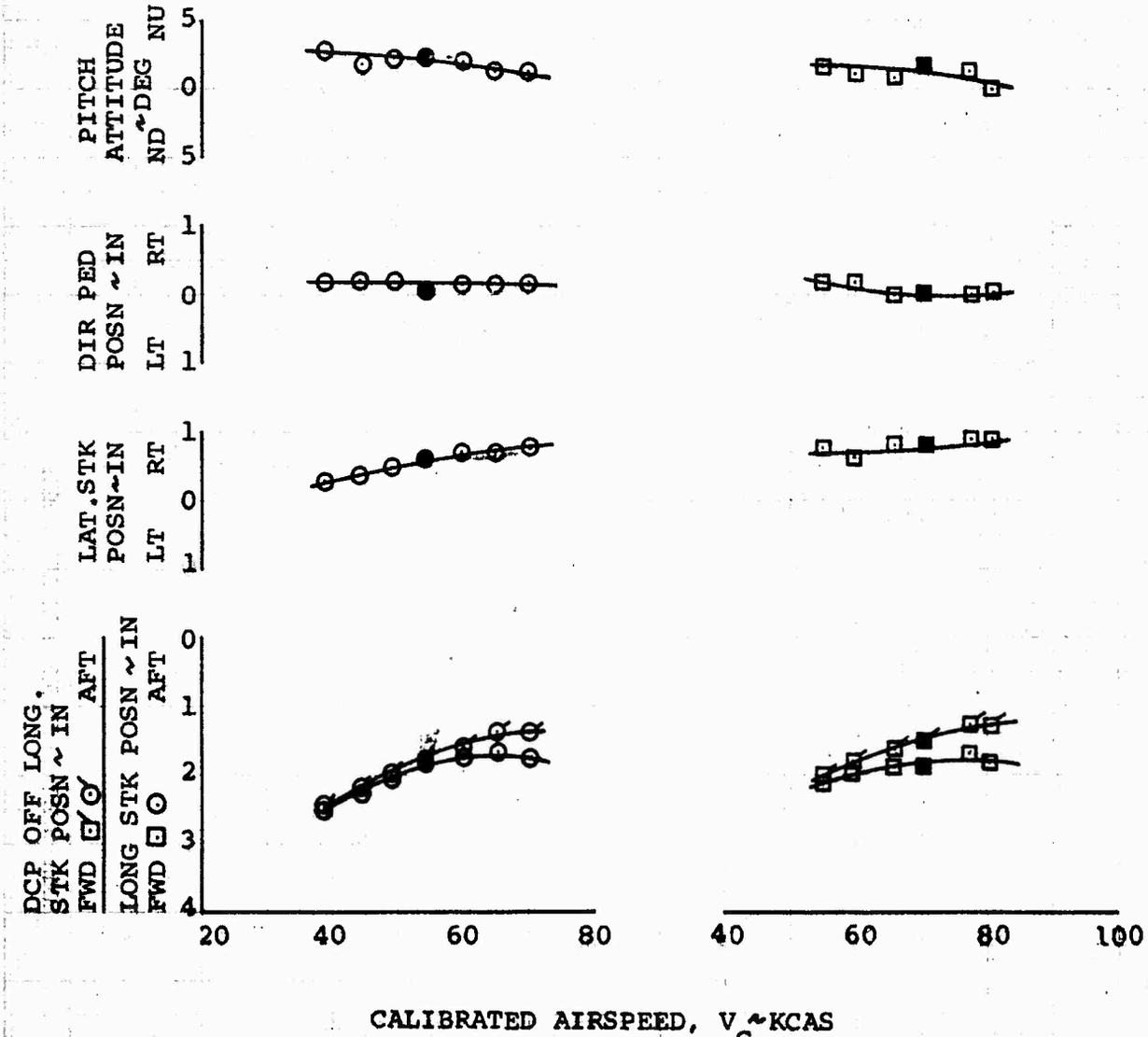


FIGURE NO. 32

STATIC LONGITUDINAL COLLECTIVE-FIXED STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG. G.W. ~LB.	ROTOR SPEED ~RPM	AVERAGE DENSITY ALT~FT.	AVERAGE C.G. LOC ~ IN	C/P POSN ~ IN
⊙	76	NRP CLIMB	46,805	242	7290	11.0 FWD	4.85
⊡	76	NRP CLIMB	46,915	244	5350	3.5 AFT	4.95

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.

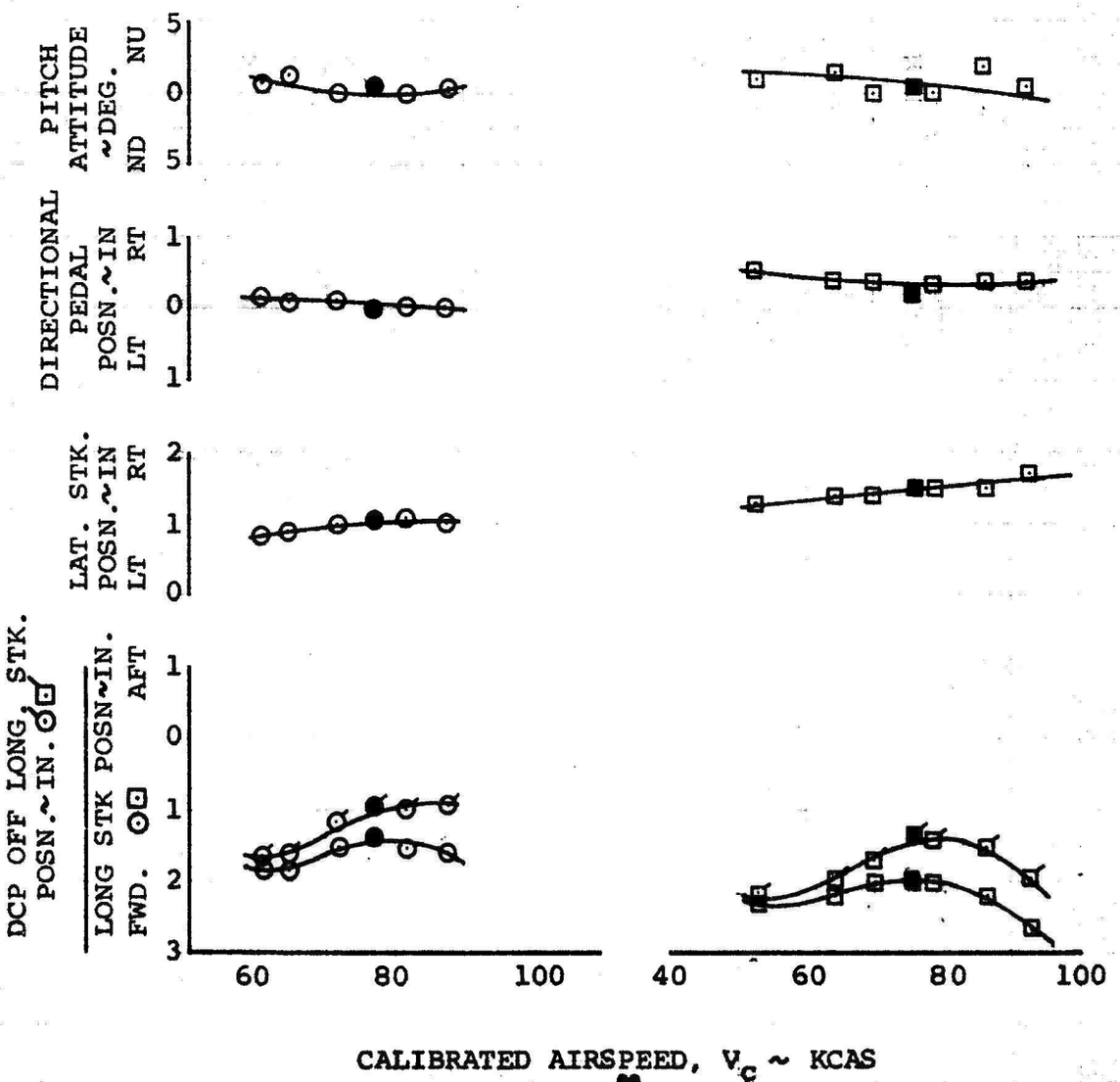


FIGURE NO. 23

STATIC LONGITUDINAL COLLECTIVE-FIXED STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG. G.W. ~ LB.	ROTOR SPEED ~ RPM	AVERAGE DENSITY ALT ~ FT	AVERAGE C.G. LOC ~ IN	C/P POSN ~ IN
⊙	77	NRP CLIMB	47,000	244	3170	11.2 FWD	4.60
⊡	72	NRP CLIMB	38,110	232	7630	5.8 AFT	5.37

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.

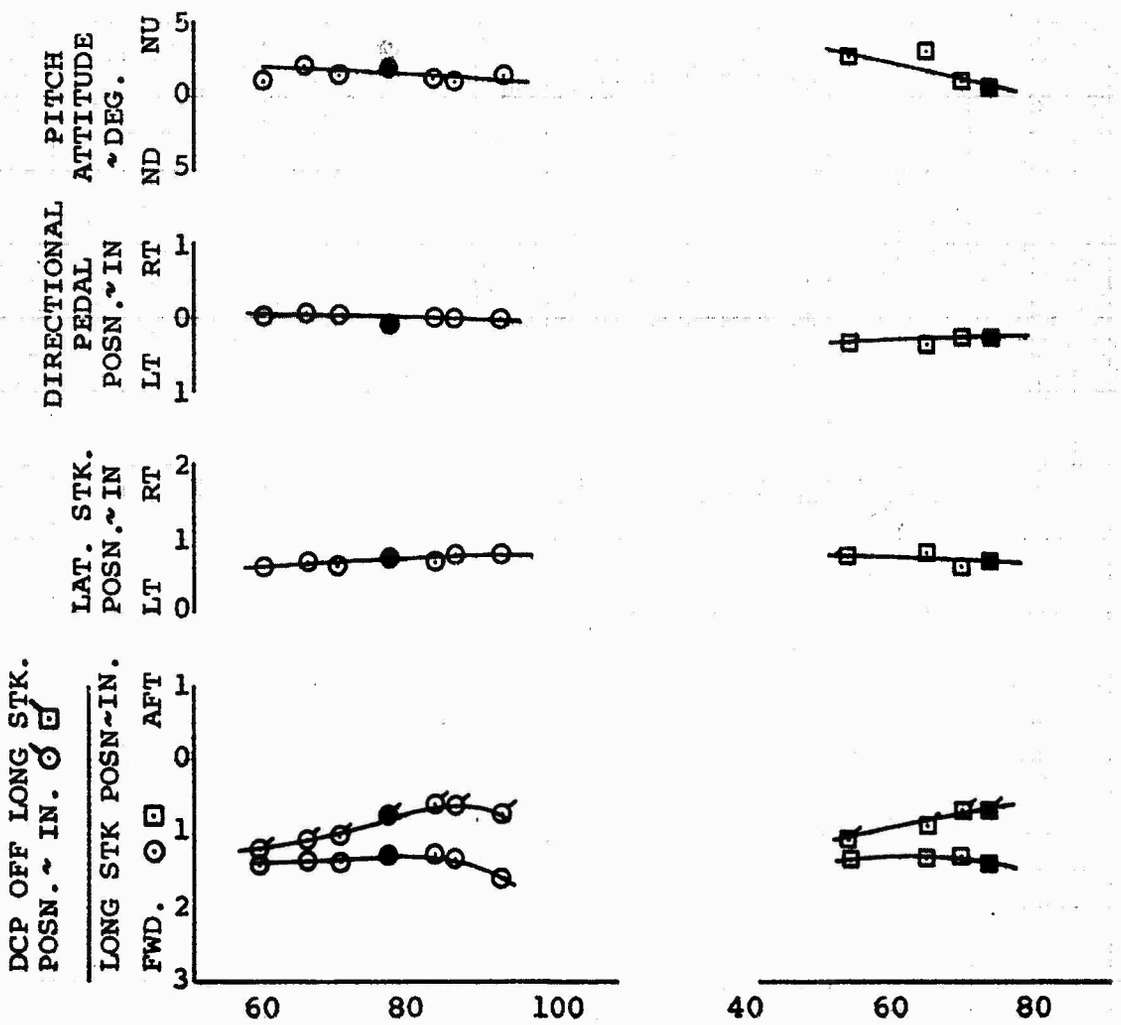


FIGURE NO. 34

STATIC LONGITUDINAL COLLECTIVE-FIXED STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG G.W. ~LB	ROTOR SPEED ~RPM	AVERAGE DENSITY ALT~FT.	AVERAGE C.G. LOC ~ IN	C/P POSN ~ IN
⊙	73	PARTIAL POW. DESC.	36,225	232	5780	7.0 AFT	3.4
⊡	109	AUTO-ROTATION	35,900	232	6810	6.7 AFT	1.3

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.

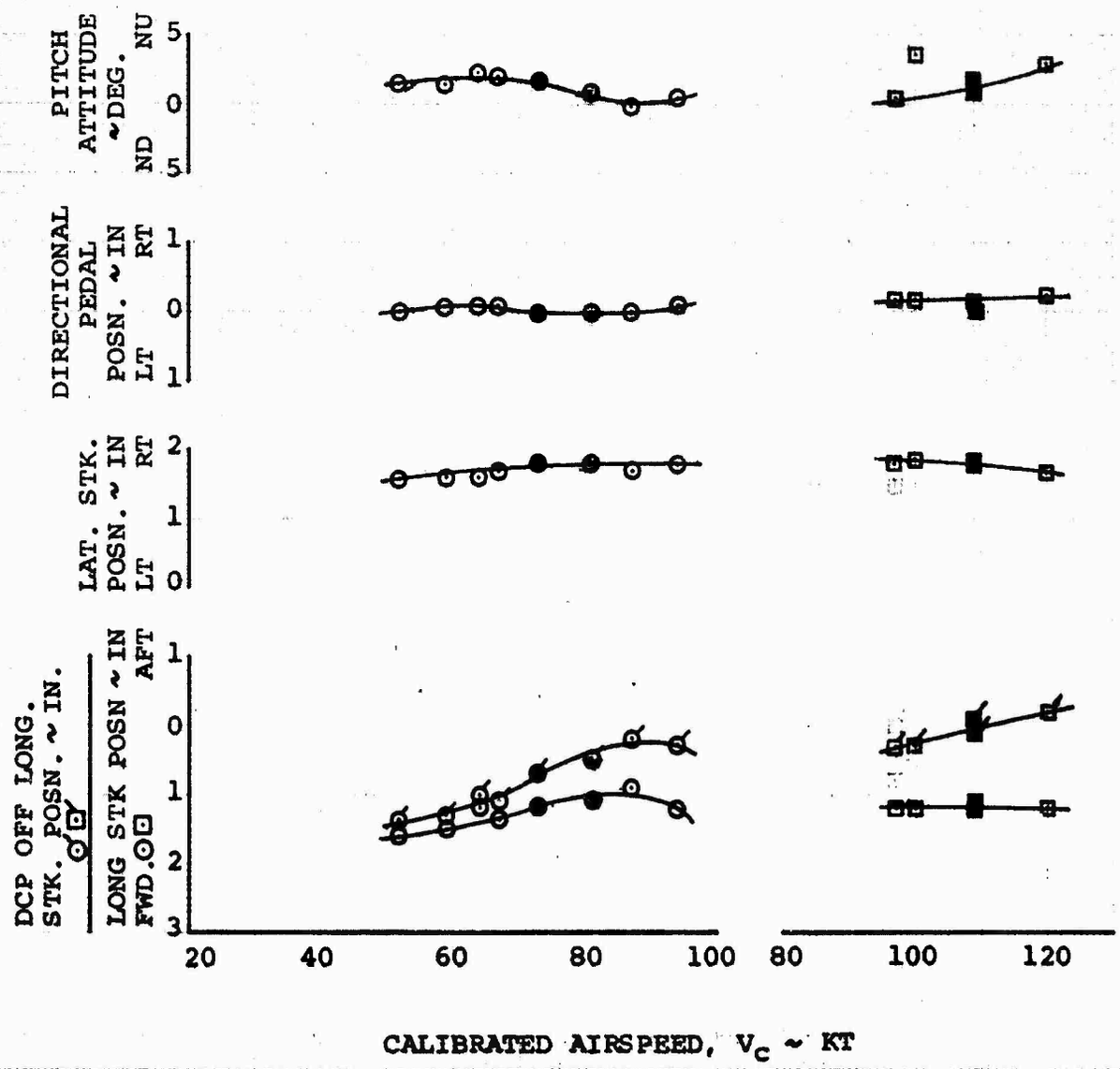


FIGURE NO. 35

STATIC LONGITUDINAL COLLECTIVE-FIXED STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG. G.W. ~LB	ROTOR SPEED ~RPM	AVERAGE DENSITY ALT ~ FT	AVERAGE C.G. LOC ~ IN	C/P POSN ~ IN
⊙	97	AUTO-ROTATION	45,550	246	4490	4.2 AFT	1.9

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.

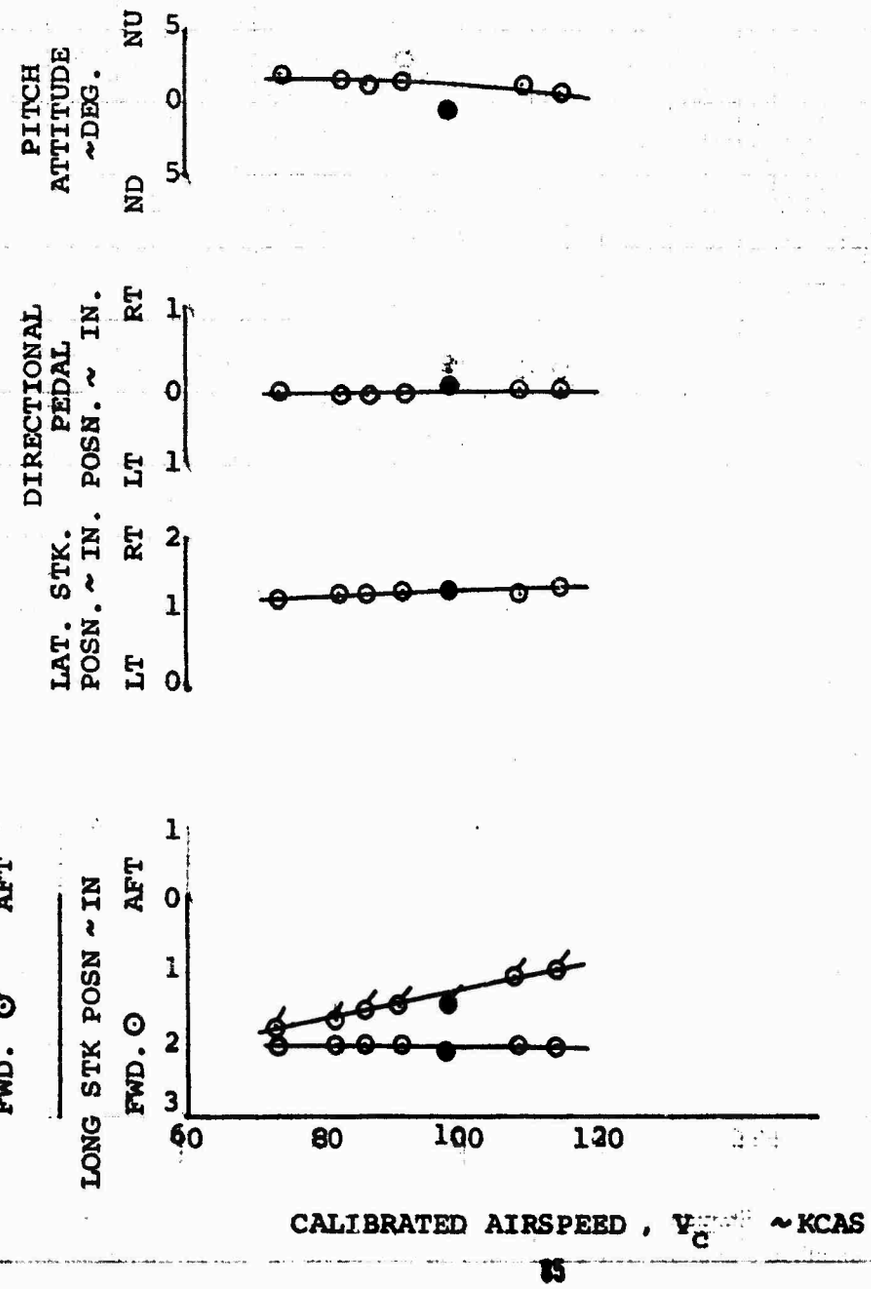


FIGURE NO. 36

STATIC LATERAL-DIRECTIONAL STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG G.W. ~LB.	ROTOR SPEED ~RPM	AVERAGE DENSITY ALT ~FT	AVERAGE C.G. LOC ~ IN	C/P POSN.~IN.
⊡	136	LEVEL	36,480	234	4640	7.0 AFT	5.48
⊙	90	LEVEL	36,650	234	10130	7.0 AFT	4.60

NOTE:
1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.
4. DSC = FORWARD HEAD DROOP STOP CONTACT

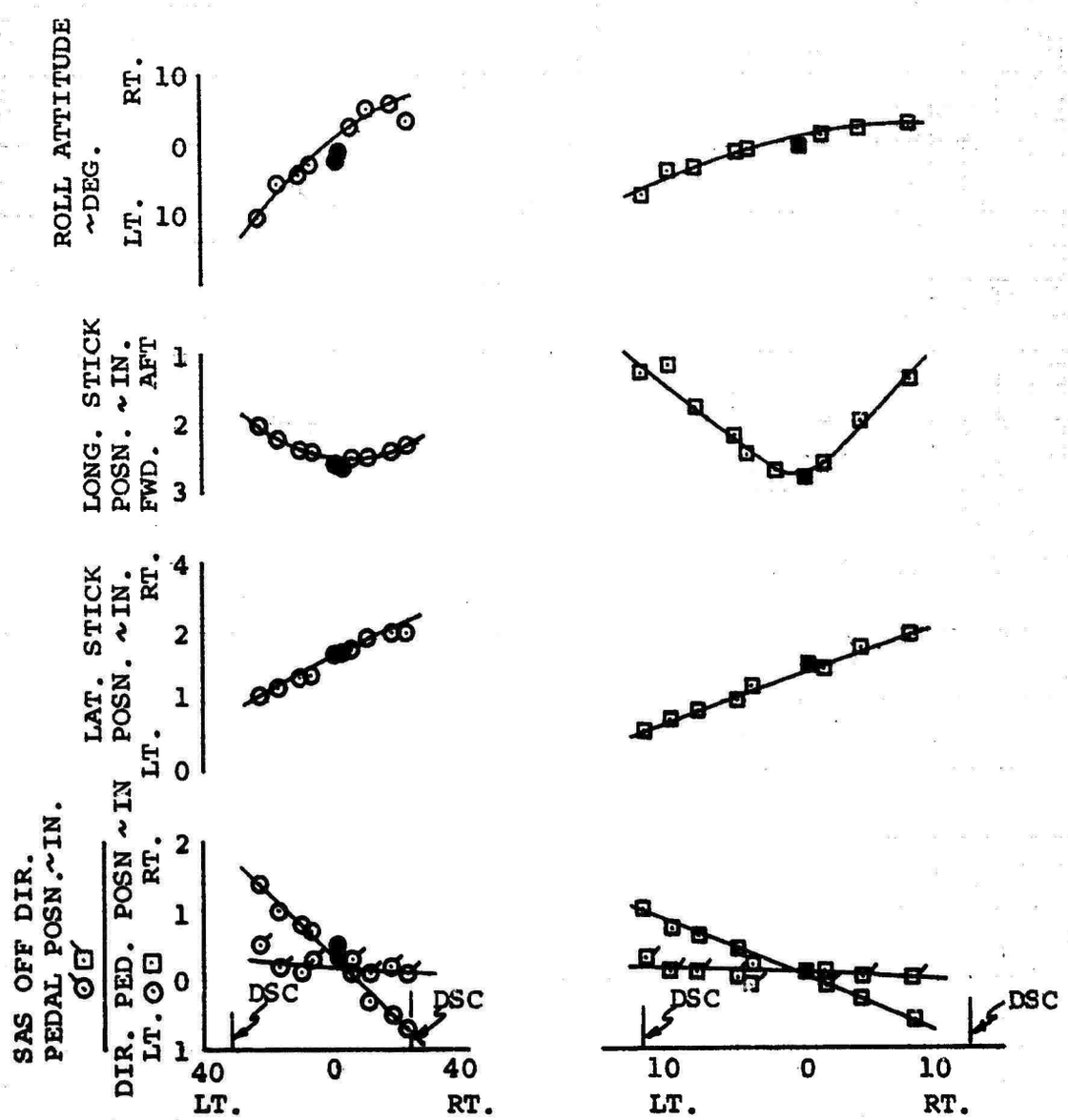


FIGURE NO. 37

STATIC LATERAL-DIRECTIONAL STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG G.W. ~LB.	ROTOR SPEED ~RPM	AVERAGE DENSITY ALT ~FT	AVERAGE C.G. LOC ~IN.	C/P POSN. ~IN
◭	52	LEVEL	36,230	232	4740	7.2 AFT	3.74
◨	110	LEVEL	35,040	232	4460	8.0 AFT	4.18

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.
4. DSC=FORWARD HEAD DROOP STOP CONTACT

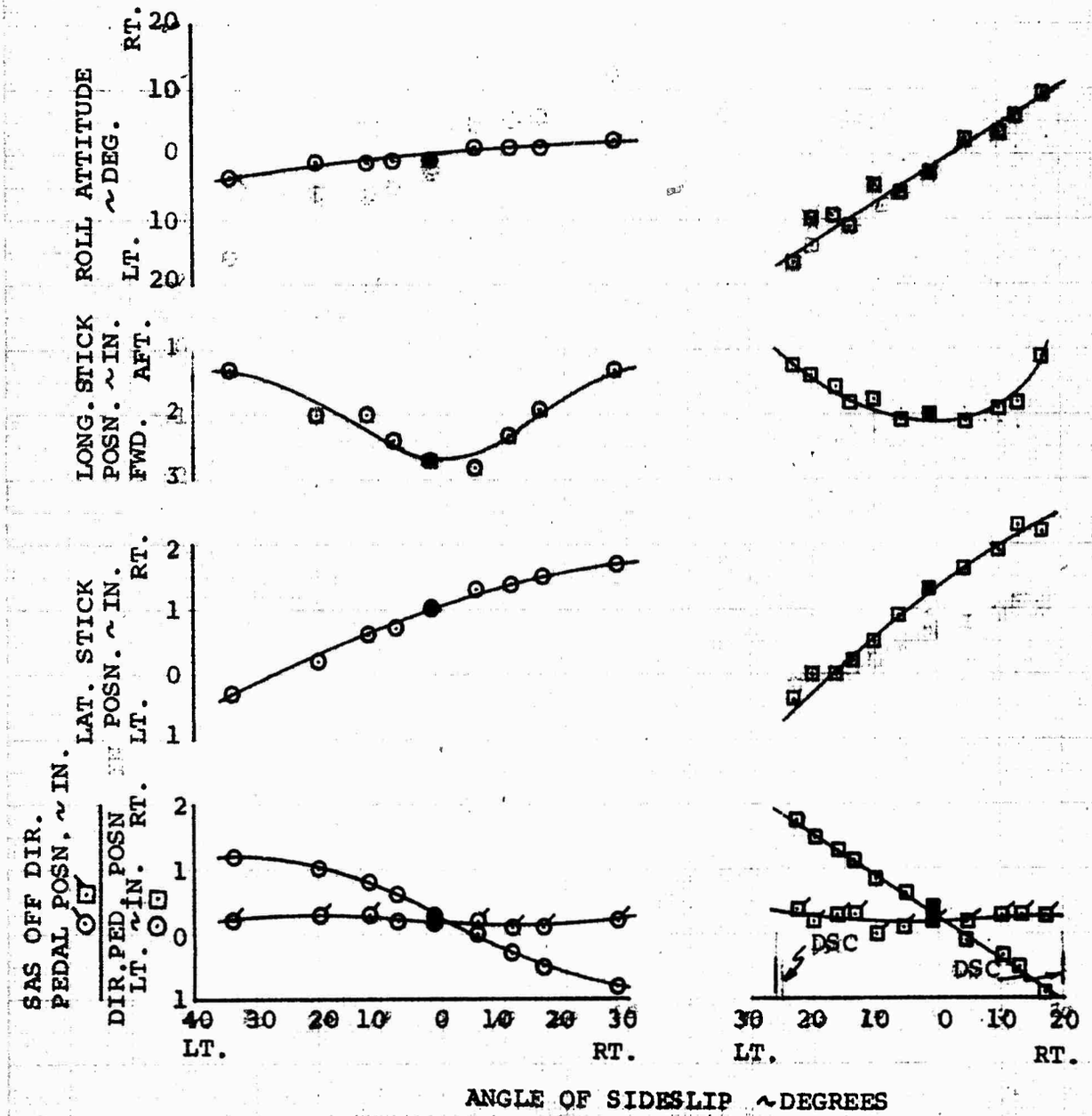


FIGURE NO. 36

STATIC LATERAL-DIRECTIONAL STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG. G.W. ~LB	ROTOR SPEED ~RPM	AVERAGE DENSITY ALT ~FT	AVERAGE C.G. LOC ~ IN	C/P POSN ~IN
⊙	69	LEVEL	45,850	242	8360	10.0 FWD	4.60
⊡	55	LEVEL	45,180	242	8180	9.5 FWD	4.60

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.

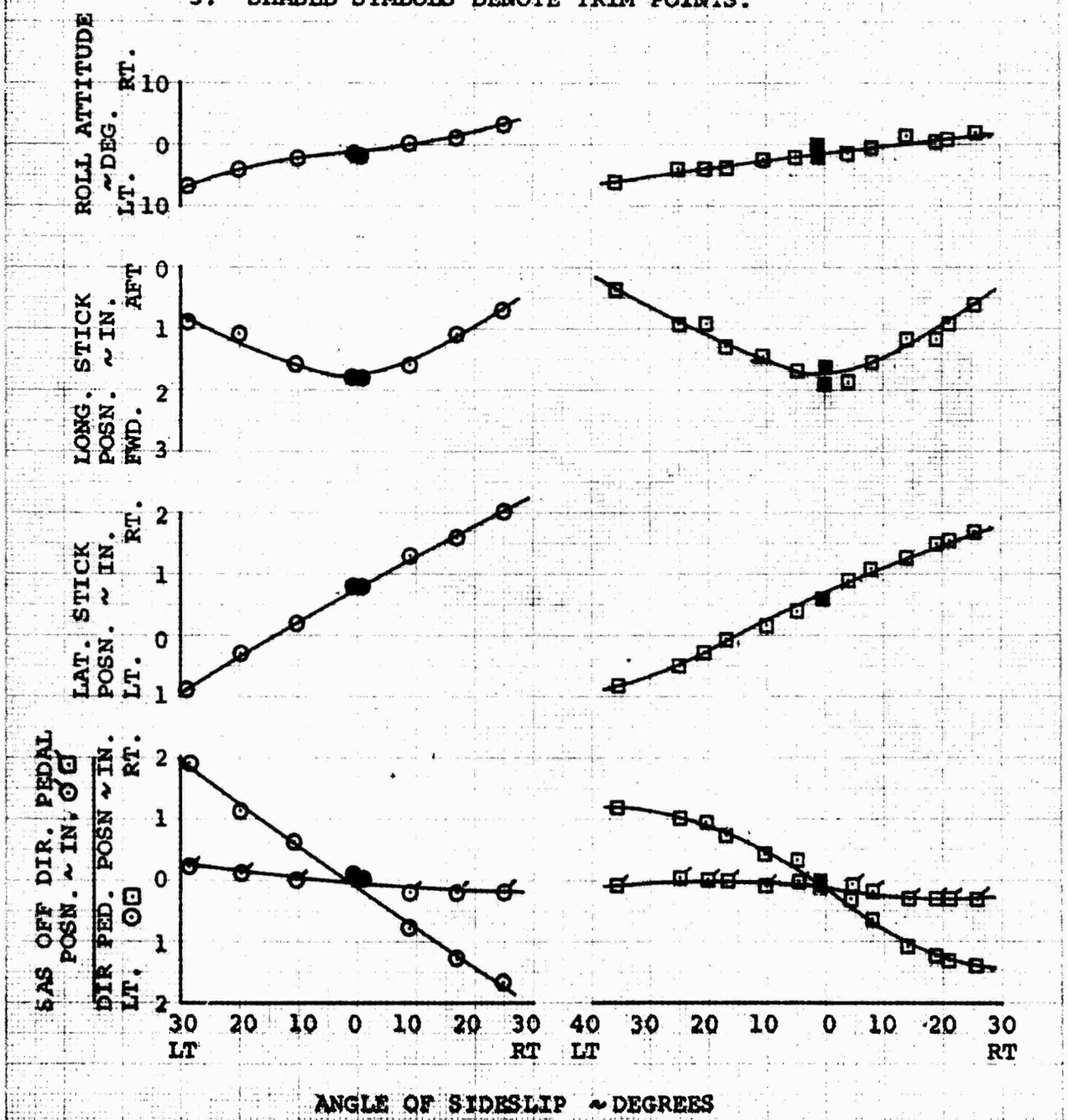


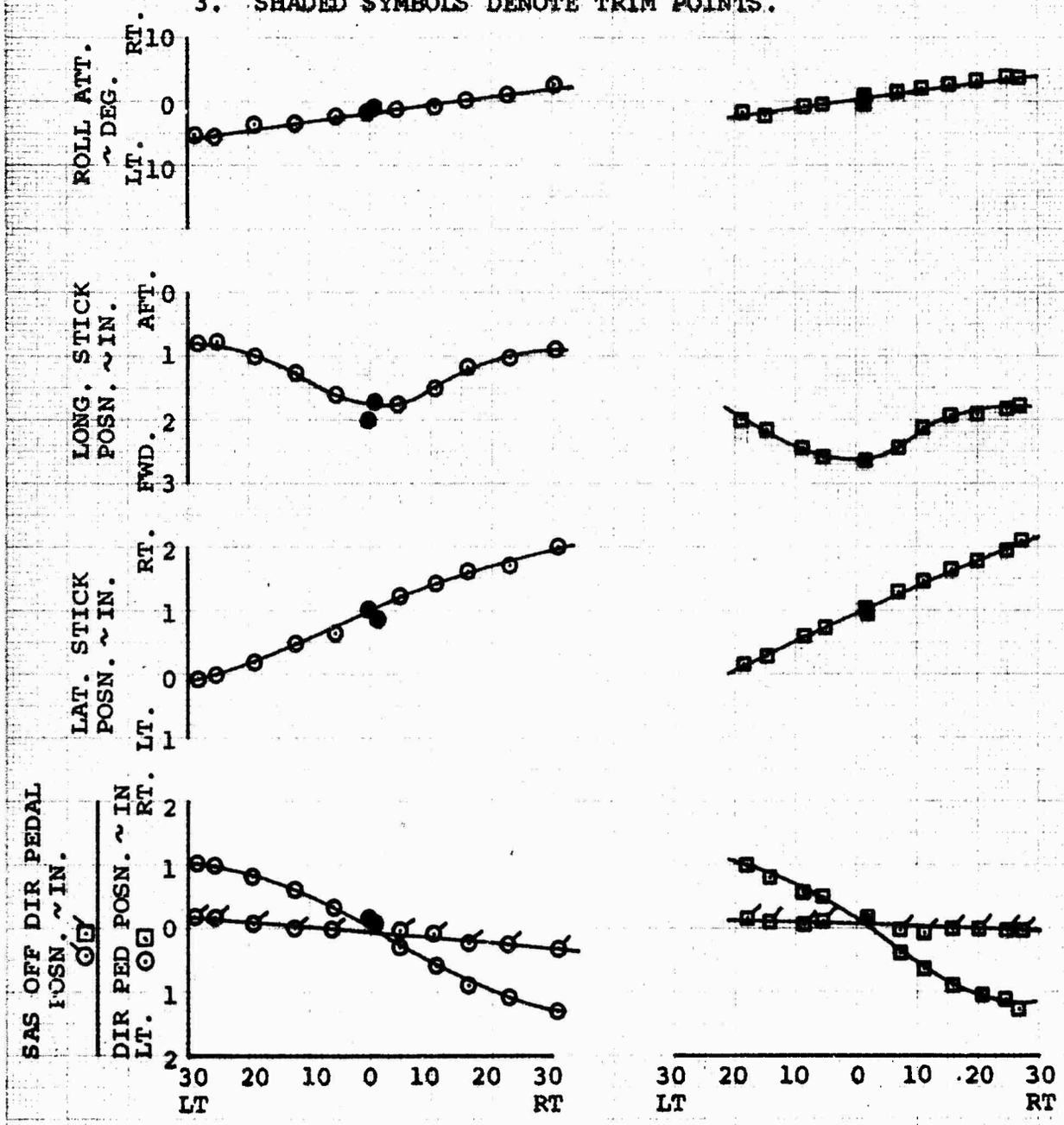
FIGURE NO. 39

STATIC LATERAL-DIRECTIONAL STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG G.W. ~LB.	ROTOR SPEED ~RPM	AVERAGE DENSITY ALT~FT	AVERAGE C.G. LOC~IN	C/P POSN~IN
●	51	LEVEL	44,5[illegible]	242	5880	9.0 FWD	4.49
⊡	62	LEVEL	45,7[illegible]	244	5690	4.1 AFT	4.47

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.



ANGLE OF SIDESLIP ~ DEGREES

FIGURE NO. 40

STATIC LATERAL-DIRECTIONAL STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG G.W. ~LB.	ROTOR SPEED ~RPM	AVERAGE DENSITY ALT ~FT	AVERAGE C.G. LOC ~IN.	C/P POSN. ~IN.
⊙	94	LEVEL	44,760	244	5240	5.6 AFT	4.32
⊡	115	LEVEL	42,560	246	4490	6.2 AFT	4.5

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.

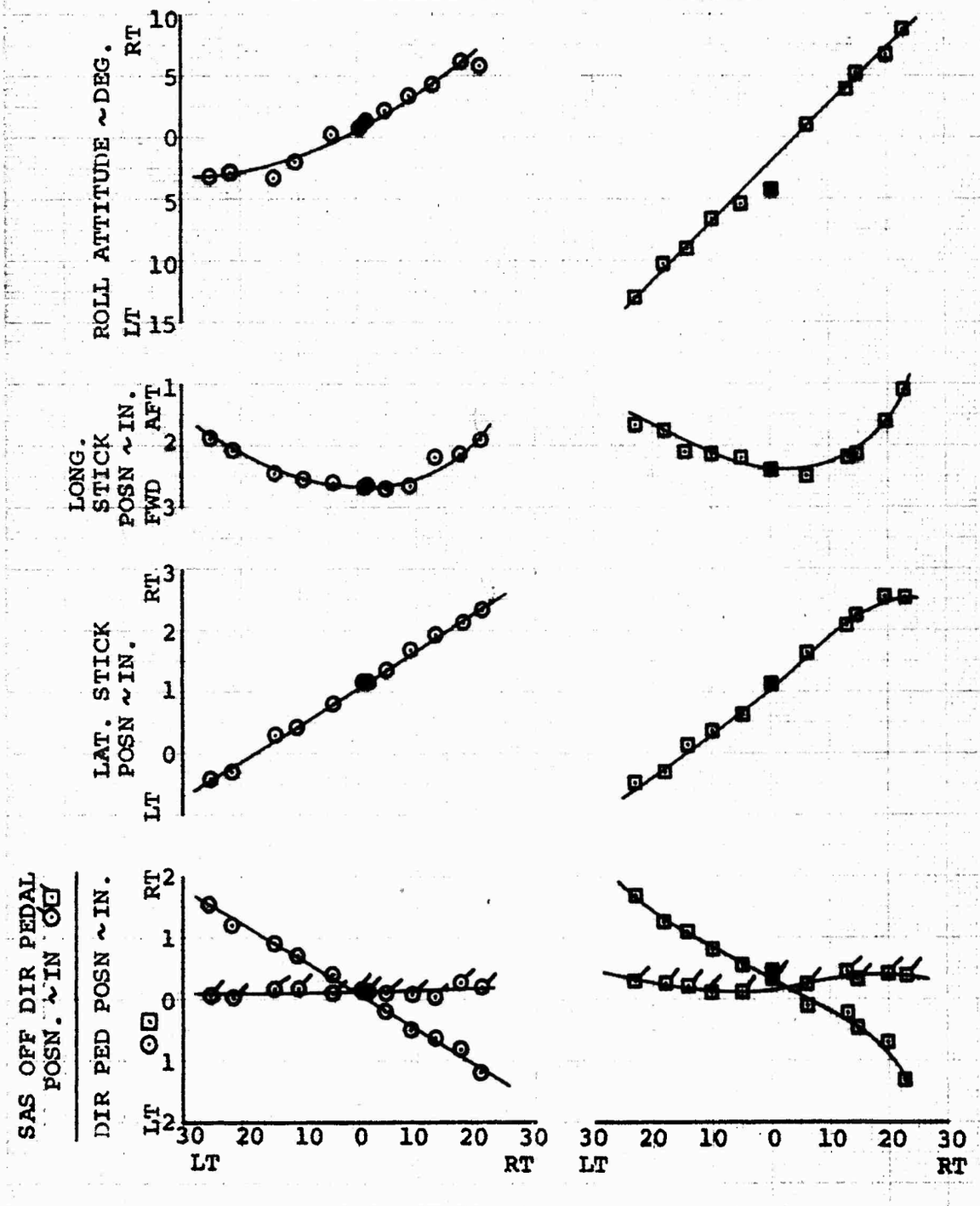


FIGURE NO. 41

STATIC LATERAL-DIRECTIONAL STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG G.W. ~LB.	ROTOR SPEED ~RPM	AVERAGE DENSITY ALT ~ FT	AVERAGE C.G. LOC ~IN	C/P POSN. ~IN.
⊙	55	LEVEL	45,180	244	7560	5.0 AFT	4.6
⊡	72	LEVEL	45,430	244	8240	4.8 AFT	4.73

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.

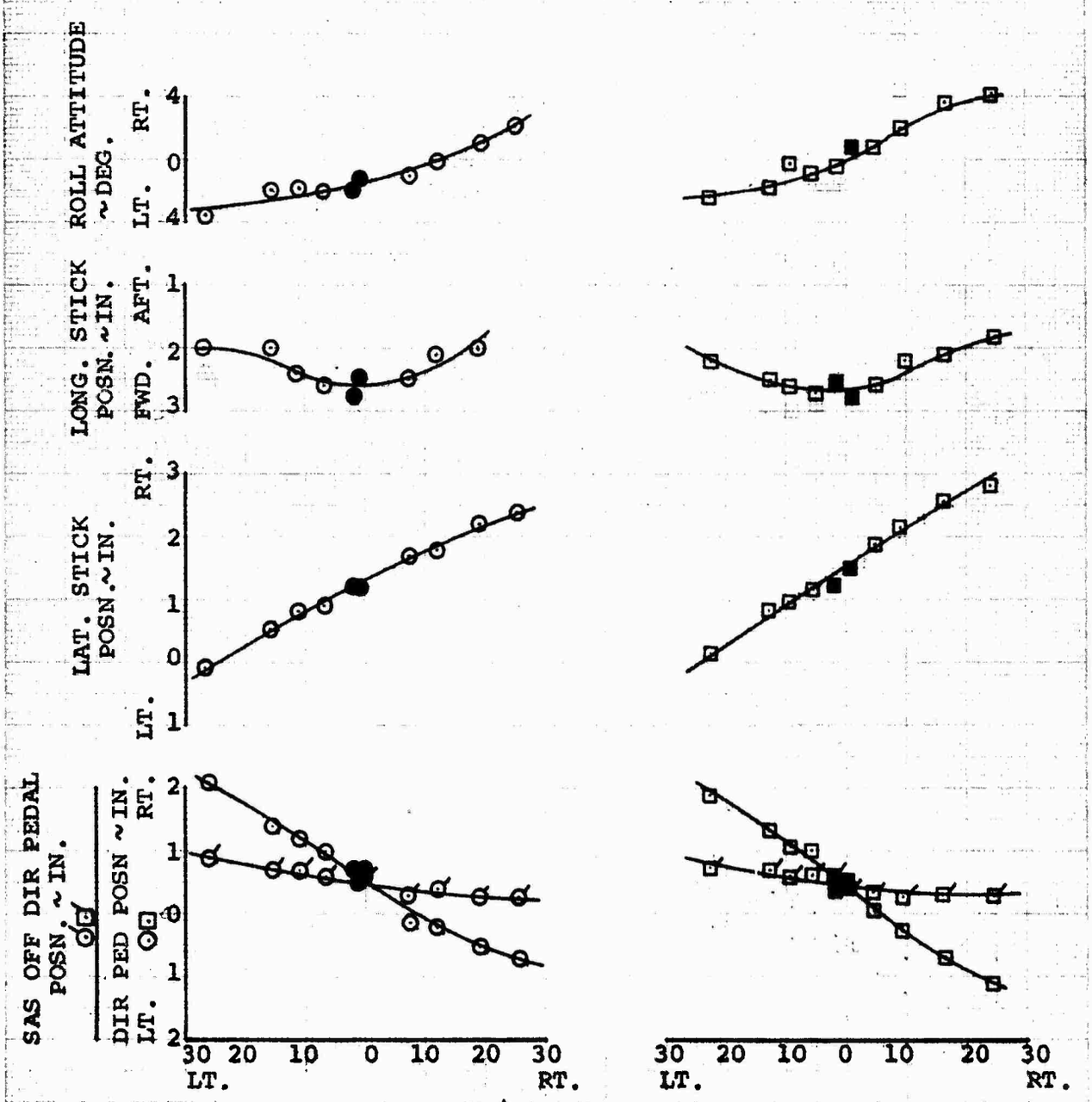


FIGURE NO. 42.

STATIC LATERAL-DIRECTIONAL STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG. G.W. ~ LB.	ROTOR SPEED ~ RPM	AVERAGE DENSITY ALT ~ FT	AVERAGE C.G. LOC ~ IN	C/P POSN ~ IN
⊙	65	NRP CLIMB	35,820	232	7690	7.0 AFT	5.10
⊡	87	NRP CLIMB	37,930	235	4080	5.9 AFT	5.10

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.

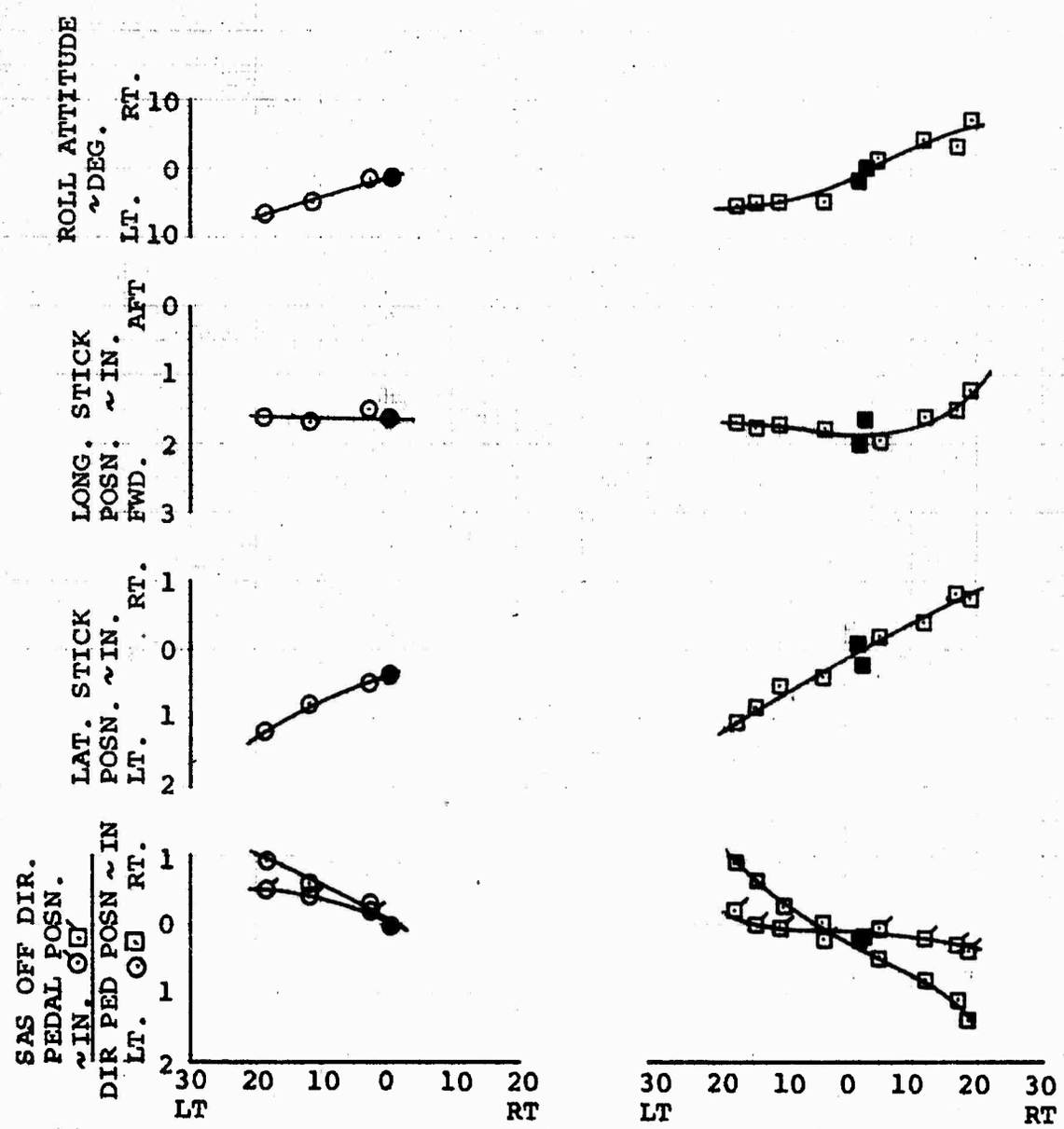


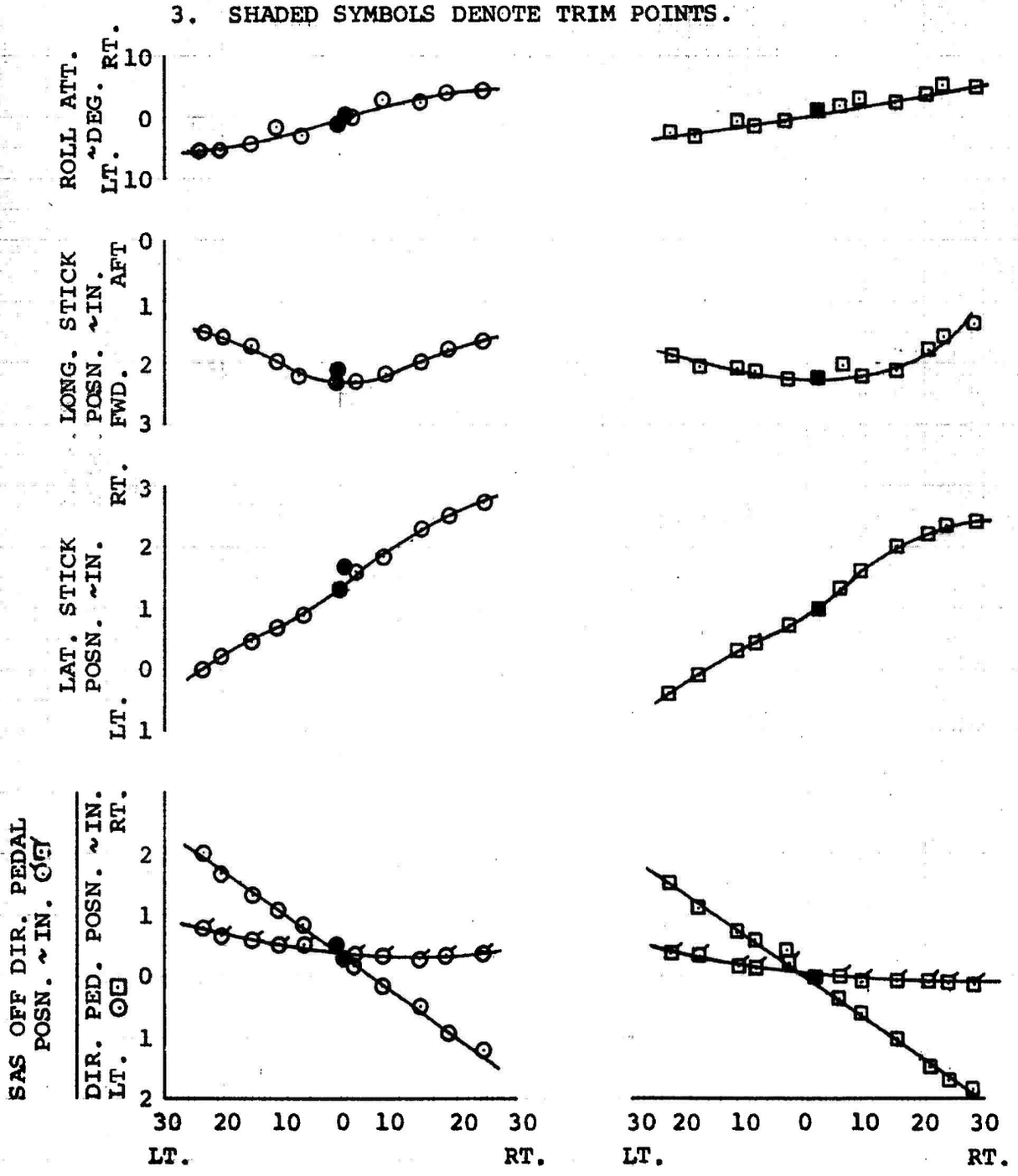
FIGURE NO. 43

STATIC LATERAL-DIRECTIONAL STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG. G.W. ~LB.	ROTOR SPEED ~RPM	AVERAGE DENSITY ALT ~ FT	AVERAGE C.G. LOC ~IN.	C/P POSN ~ IN
⊙	76	NRP CLIMB	46,270	244	5130	3.7 AFT	4.65
⊡	76	MRP CLIMB	47,150	244	4690	3.6 AFT	4.62

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.



ANGLE OF SIDESLIP ~DEGREES

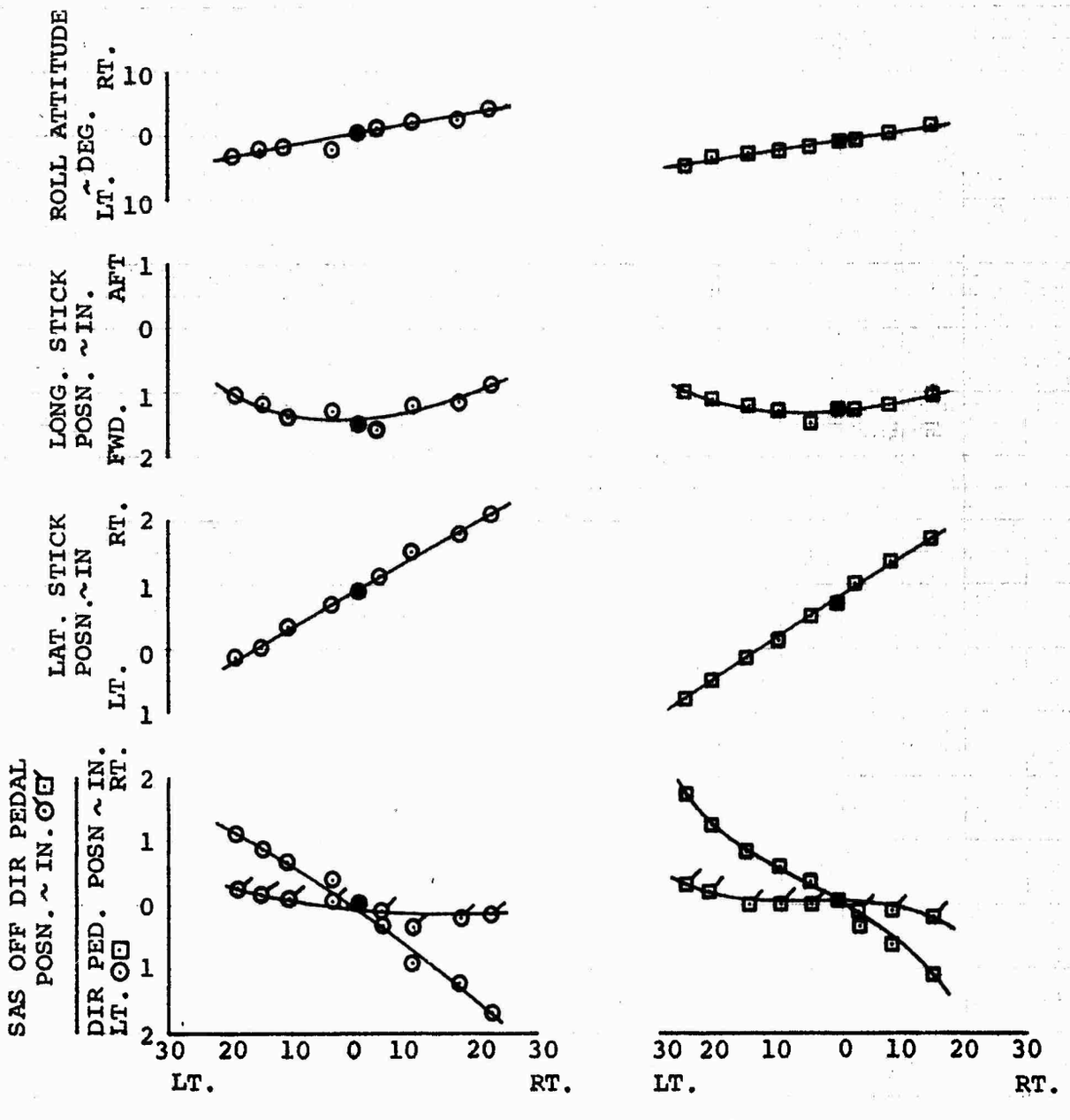
FIGURE NO. 44

STATIC LATERAL-DIRECTIONAL STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG. G.W. ~ LB.	ROTOR SPEED ~ RPM	AVERAGE DENSITY ALT ~ FT.	AVERAGE C.G. LOC ~ IN.	C/P POSN ~ IN
⊙	76	NRP CLIMB	47,240	243	3550	11.2 FWD	4.43
⊡	78	NRP CLIMB	46,700	244	6430	10.5 FWD	4.73

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.



ANGLE OF SIDESLIP ~DEGREES

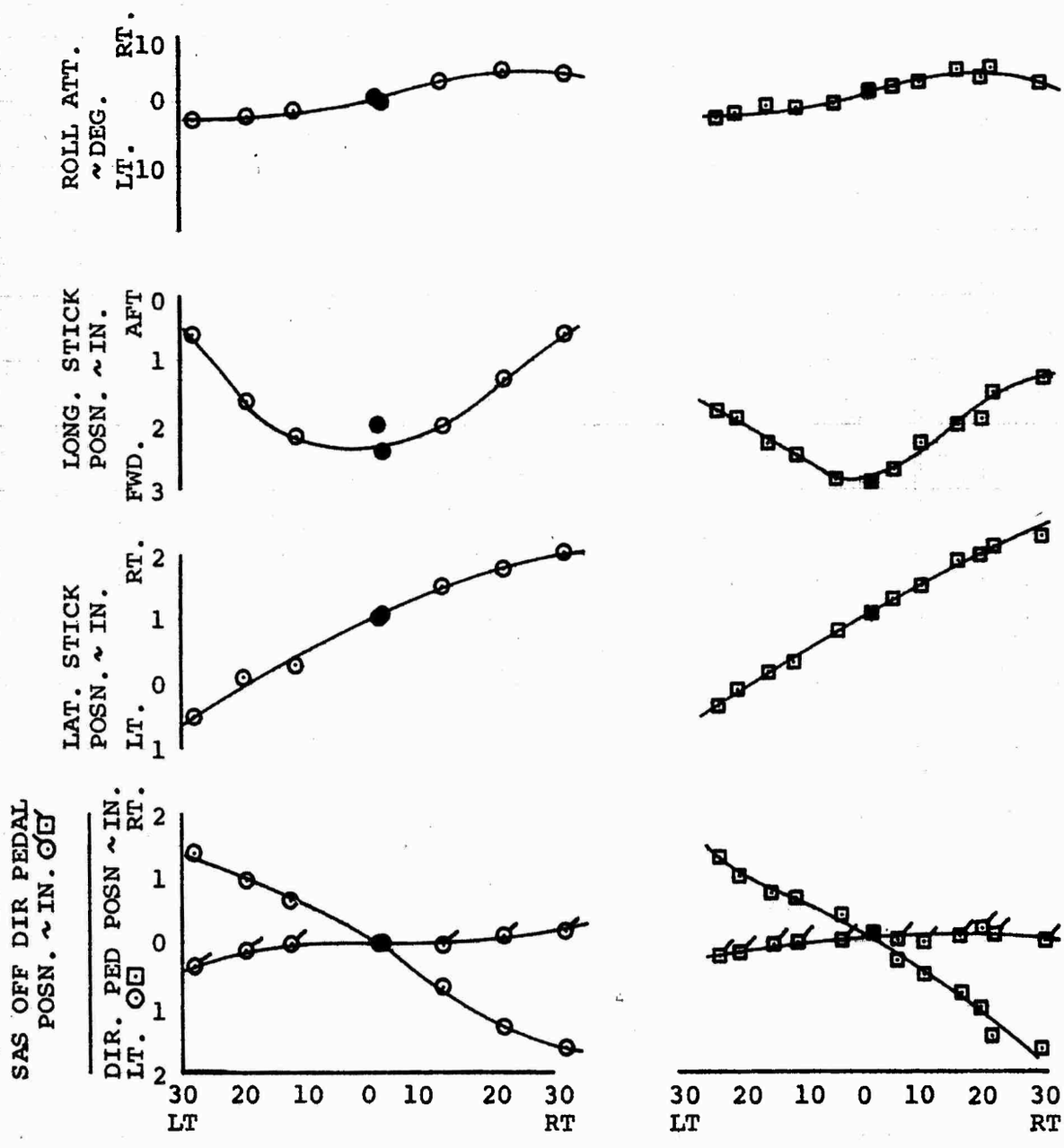
FIGURE NO. 45

STATIC LATERAL-DIRECTIONAL STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG G.W. ~LB.	ROTOR SPEED ~RPM	AVERAGE DENSITY ALT ~ FT	AVERAGE C.G. LOC ~ IN	C/P POSN ~ IN
⊙	79.	PARTIAL POW. DESCENT	36,260	232	3780	7.5 AFT	3.05
⊡	76.	PARTIAL POW. DESCENT	46,360	244	4080	3.8 AFT	3.72

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.



ANGLE OF SIDESLIP ~DEGREES

FIGURE NO. 46

STATIC LATERAL-DIRECTIONAL STABILITY

YCH-47C USA S/N 66-19121

SYM	TRIM SPEED	FLIGHT CONDITION	AVG. G.W. ~LB.	ROTOR SPEED ~RPM	AVERAGE DENSITY ALT.~FT	AVERAGE C.G. LOC.~IN.	C/P POSN.~IN.
⊙	97	AUTO-ROTATION	44,000	245	3380	5.5 AFT	1.9

NOTE: 1. SPEED TRIM (DCP AND LONG. CYCLIC) = AUTO
2. SAS CONFIGURATION = ON
3. SHADED SYMBOLS DENOTE TRIM POINTS.

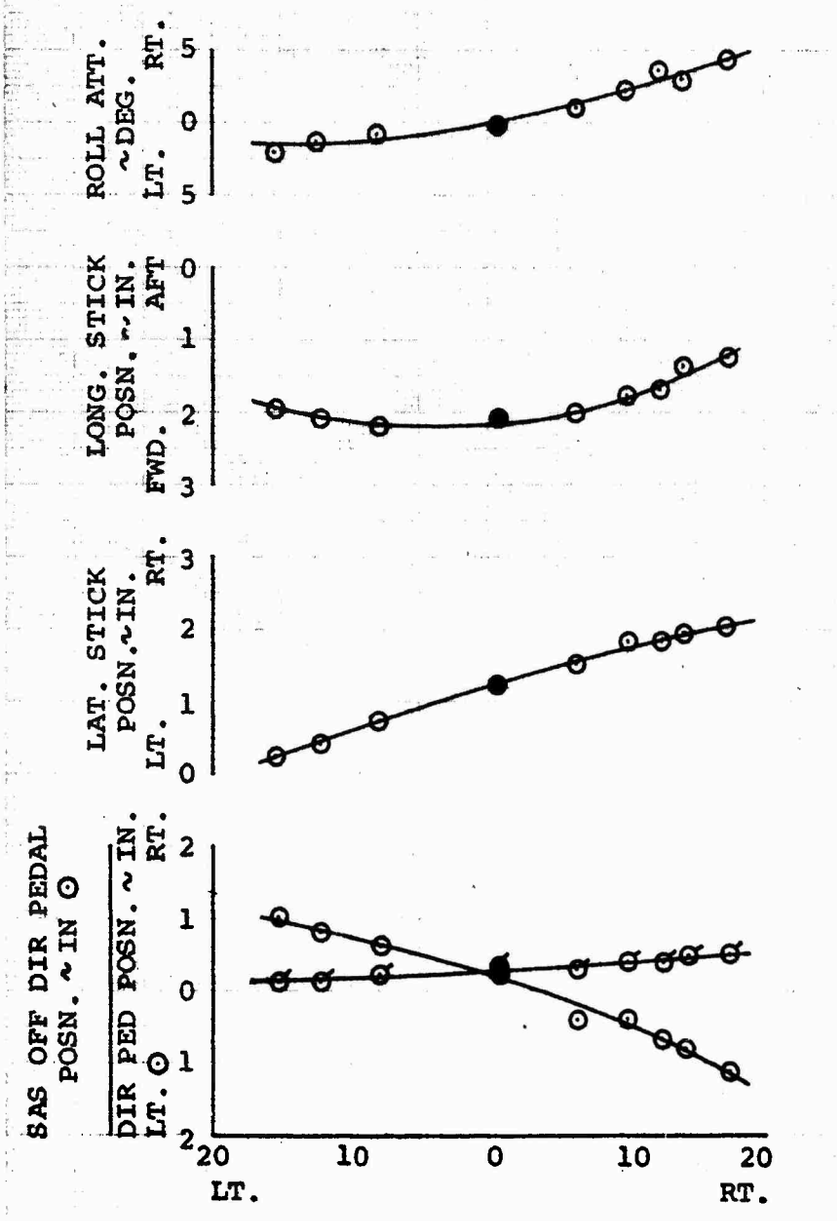
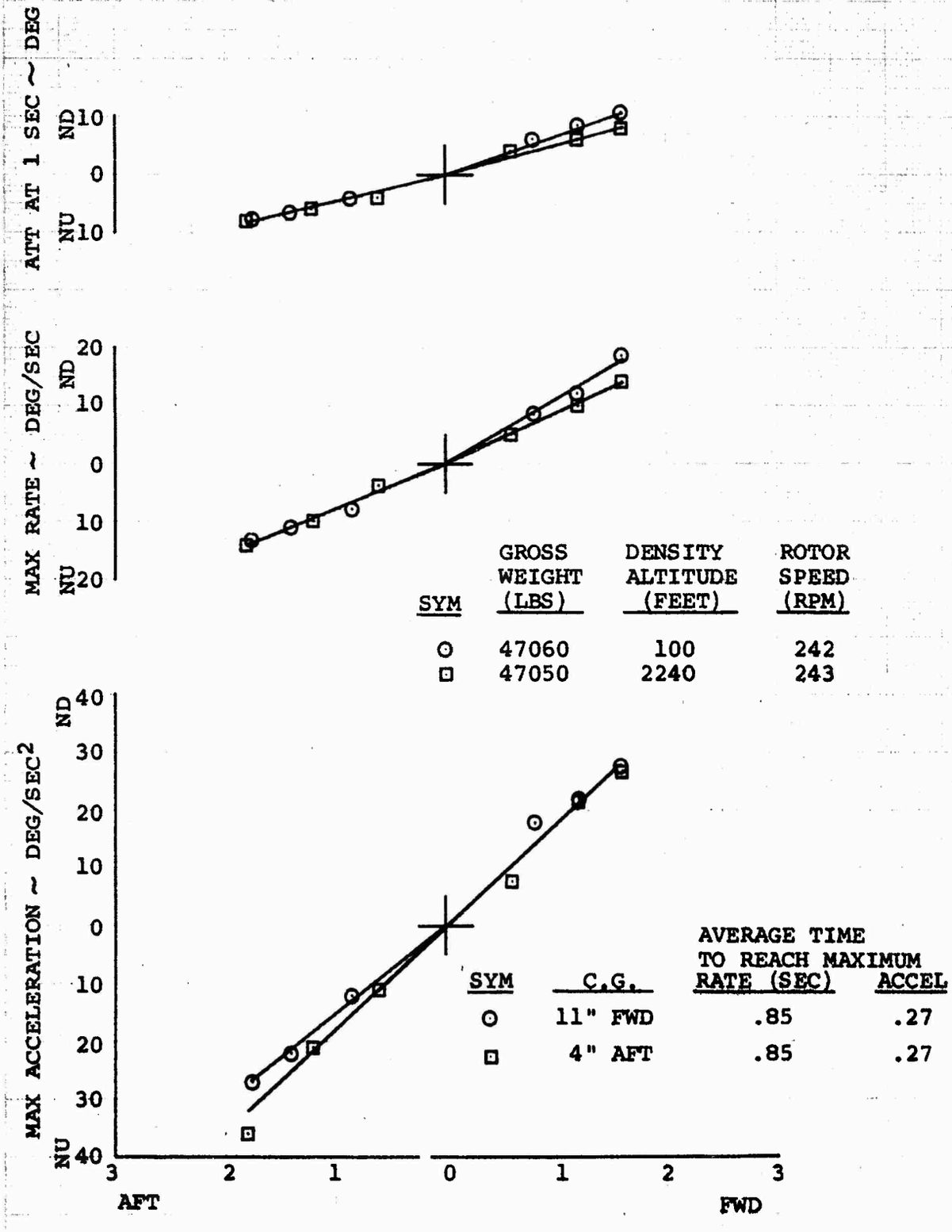


FIGURE NO. 47

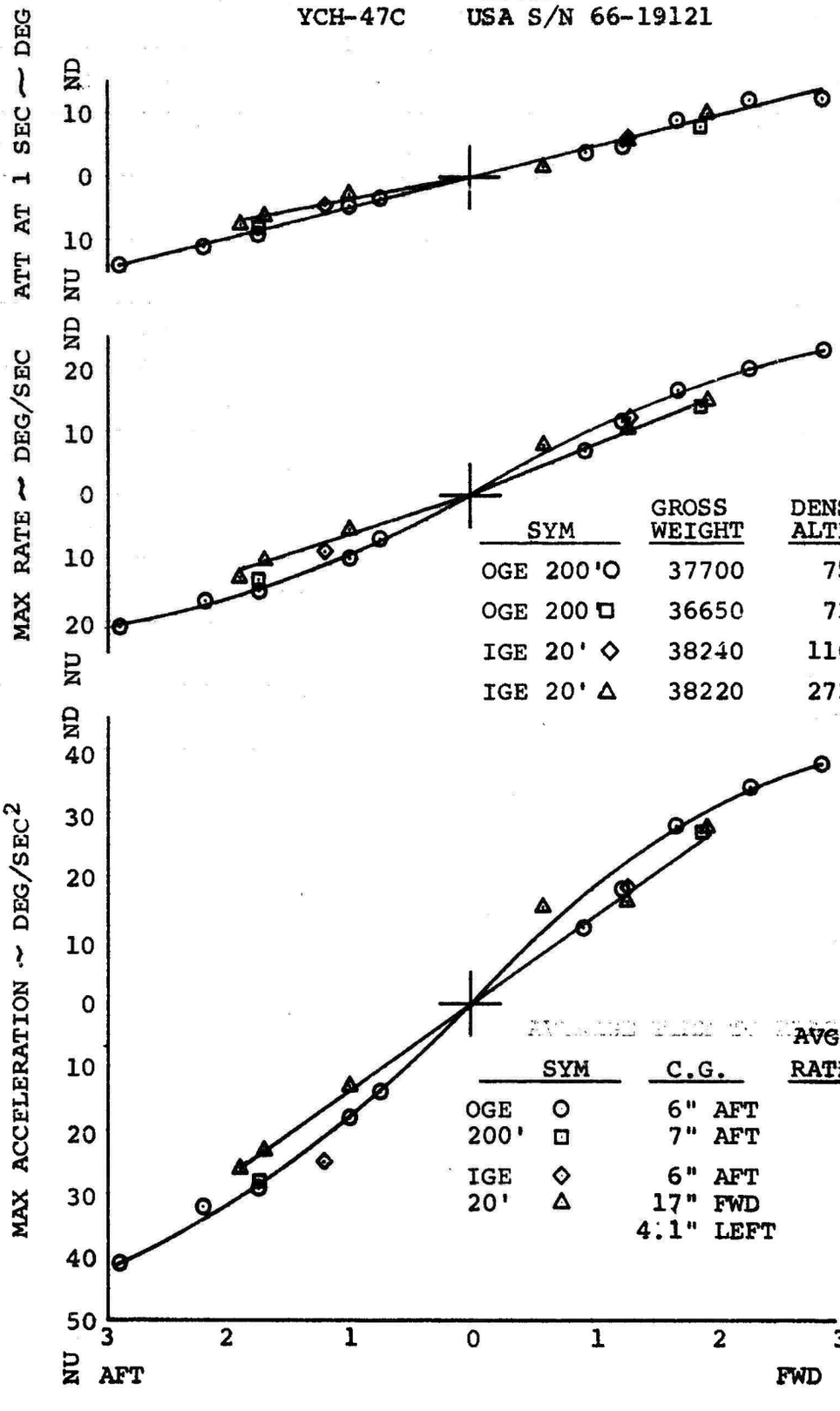
LONGITUDINAL CONTROLLABILITY
(IGE) HOVER
YCH-47C USA S/N 66-19121



SYM	GROSS WEIGHT (LBS)	DENSITY ALTITUDE (FEET)	ROTOR SPEED (RPM)
⊙	47060	100	242
⊡	47050	2240	243

SYM	C.G.	AVERAGE TIME TO REACH MAXIMUM RATE (SEC)	ACCEL
⊙	11" FWD	.85	.27
⊡	4" AFT	.85	.27

FIGURE NO. 48
LONGITUDINAL CONTROLLABILITY
HOVER
YCH-47C USA S/N 66-19121

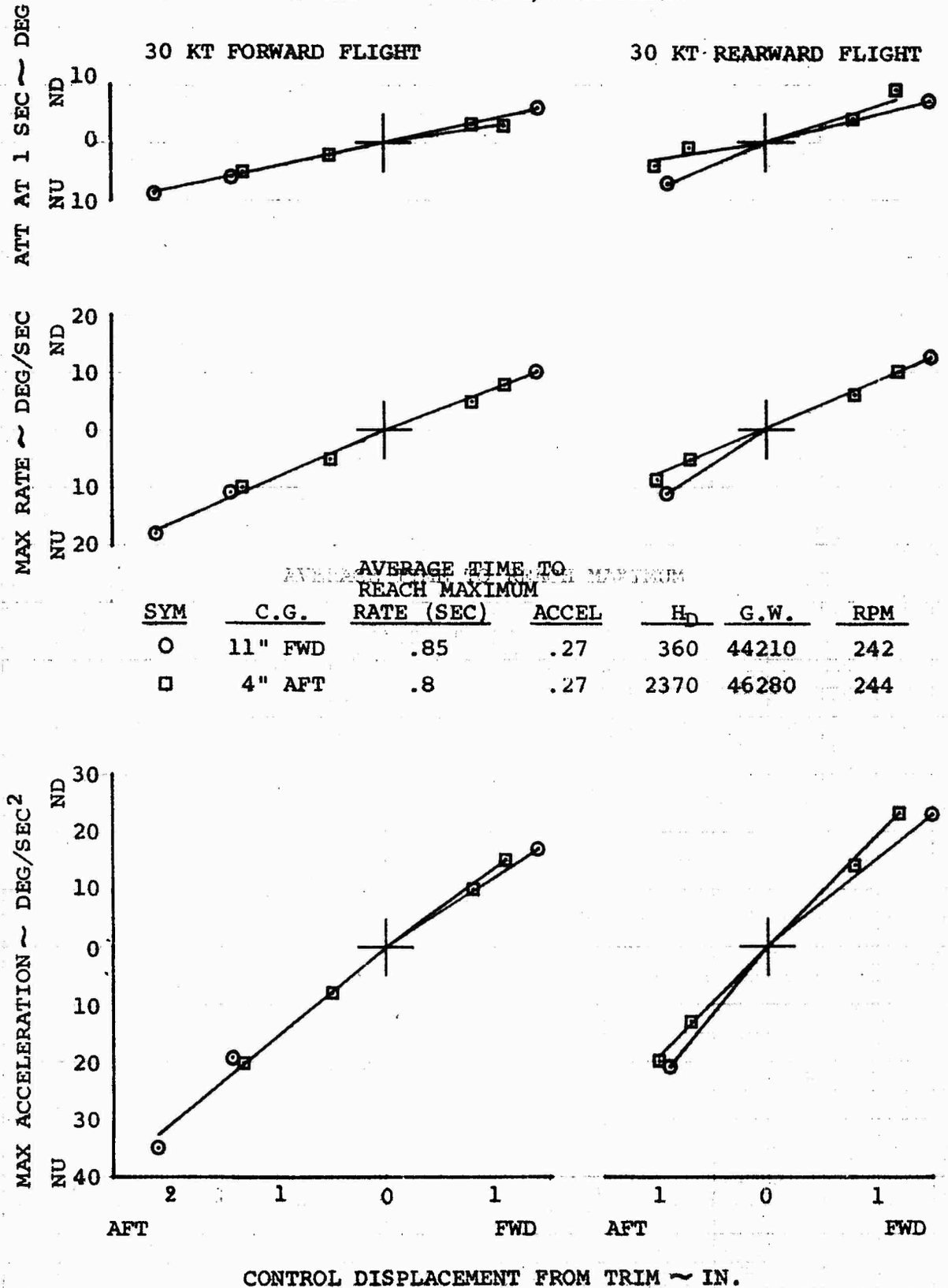


SYM	GROSS WEIGHT	DENSITY ALTITUDE	ROTOR SPEED
OGE 200' ○	37700	750	232
OGE 200' □	36650	730	241
IGE 20' ◇	38240	1160	235
IGE 20' △	38220	2730	235

SYM	C.G.	AVG TIME TO REACH MAX. RATE (SEC)	ACCEL
OGE ○	6" AFT	.9	.25
200' □	7" AFT	.8	.25
IGE ◇	6" AFT	.9	.3
20' △	17" FWD 4.1" LEFT	.85	.27

FIGURE NO. 49

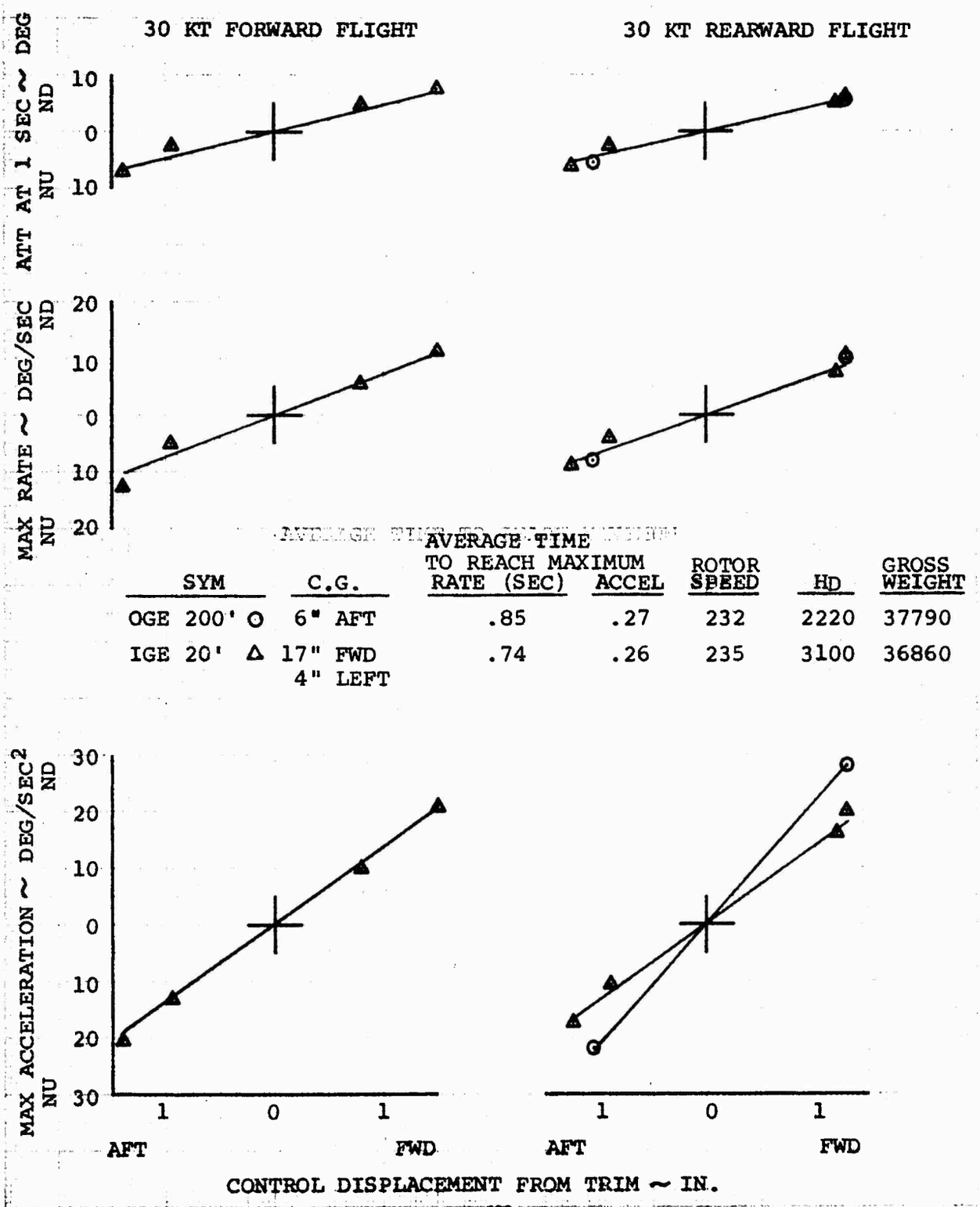
LONGITUDINAL CONTROLLABILITY
FORWARD & REARWARD FLIGHT (IGE)
YCH-47C USA S/N 66-19121



AVERAGE TIME TO REACH MAXIMUM

SYM	C.G.	RATE (SEC)	ACCEL	H_D	G.W.	RPM
O	11" FWD	.85	.27	360	44210	242
□	4" AFT	.8	.27	2370	46280	244

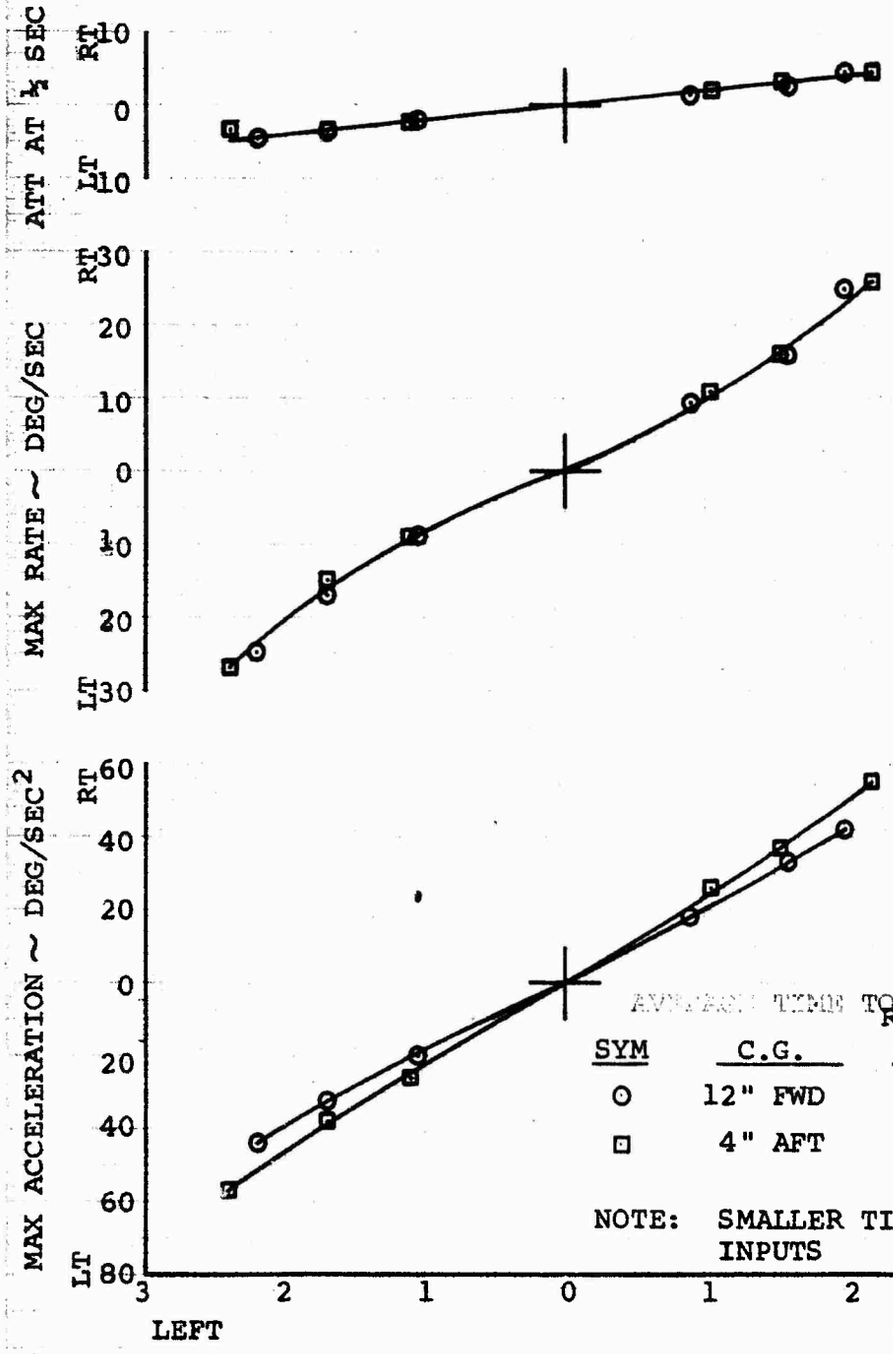
FIGURE NO. 50
LONGITUDINAL CONTROLLABILITY
FORWARD & REARWARD FLIGHT
YCH-47C USA S/N 66-19121



SYM	C.G.	AVERAGE TIME TO REACH MAXIMUM RATE (SEC)	ACCEL	ROTOR SPEED	HD	GROSS WEIGHT
OGE 200' ○	6" AFT	.85	.27	232	2220	37790
IGE 20' △	17" FWD 4" LEFT	.74	.26	235	3100	36860

FIGURE NO. 51
LATERAL CONTROLLABILITY
(IGE) HOVER
YCH-47C USA S/N 66-19121

SYM	C.G.	DENSITY ALTITUDE	GROSS WEIGHT	ROTOR SPEED
⊙	11" FWD	130	46760	242
⊡	4" AFT	2190	46800	243



AVERAGE TIME TO REACH MAXIMUM

SYM	C.G.	RATE (SEC)	ACCEL
⊙	12" FWD	.90	.30
⊡	4" AFT	.2 - 1.0	.2 - .3

NOTE: SMALLER TIMES ARE FOR SMALLER INPUTS

FIGURE NO. 52
LATERAL CONTROLLABILITY
HOVER
YCH-47C USA S/N 66-19121

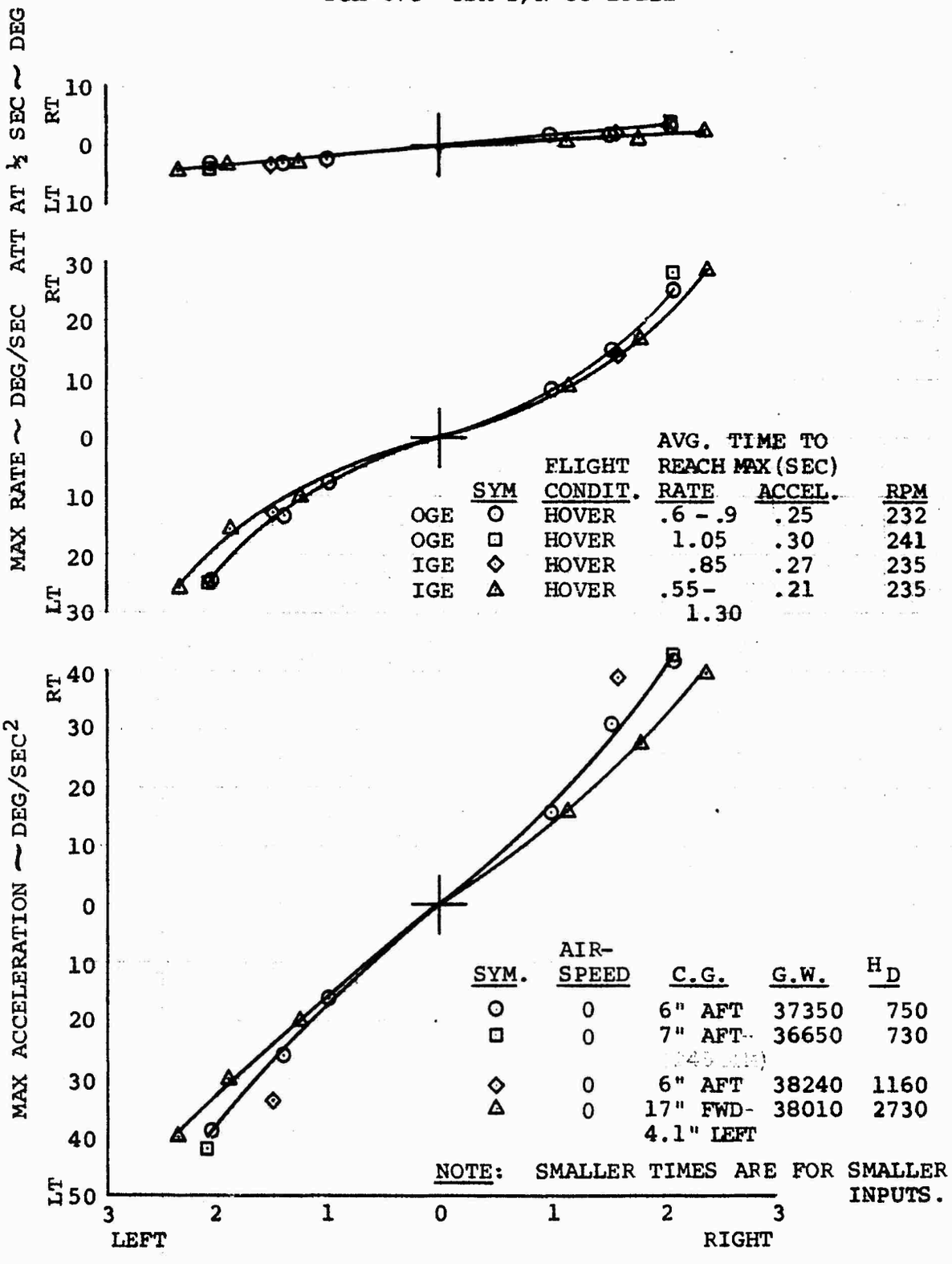
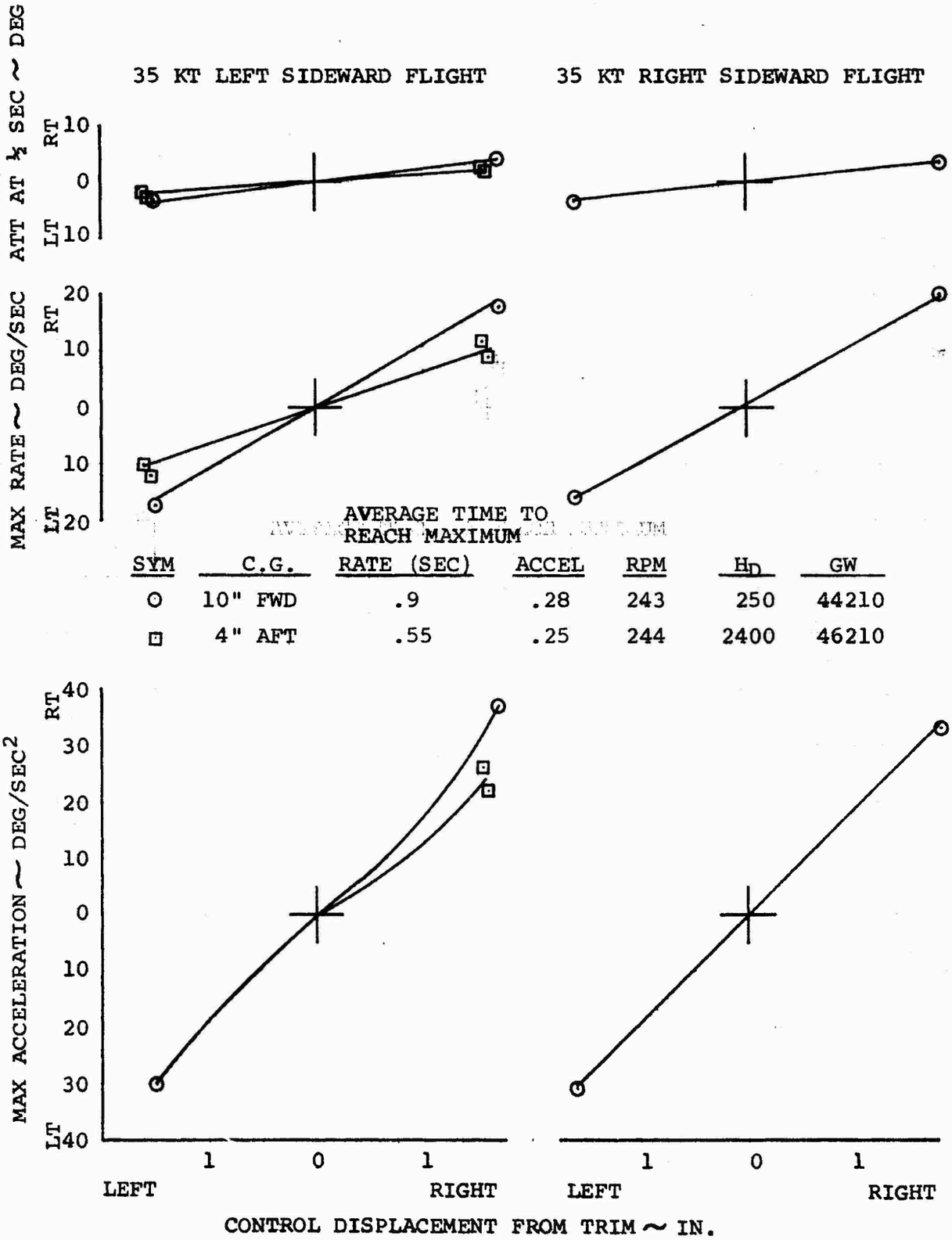


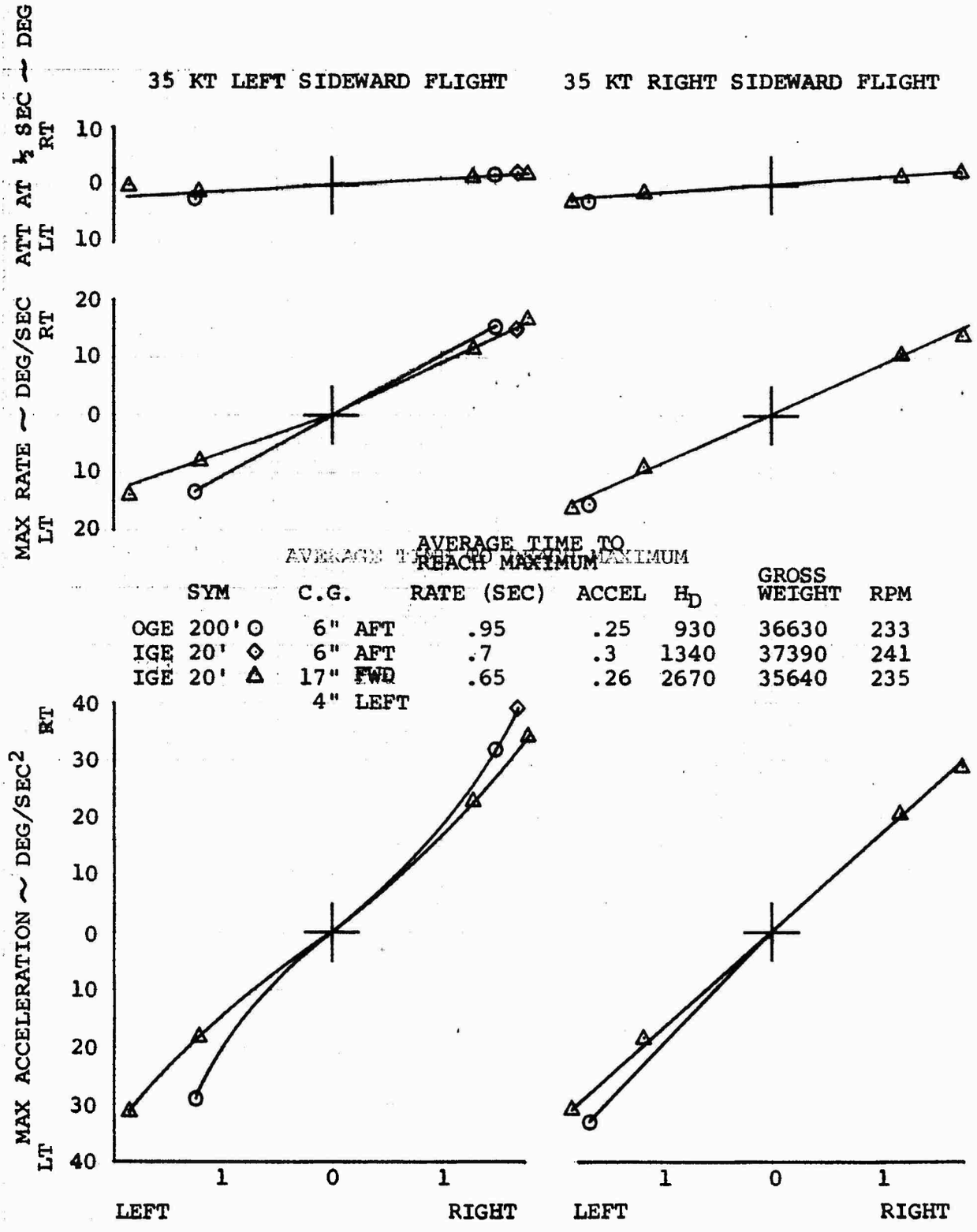
FIGURE NO. 53
LATERAL CONTROLLABILITY
SIDEWARD FLIGHT (IGE)
YCH-47C USA S/N 66-19121



AVERAGE TIME TO REACH MAXIMUM

SYM	C.G.	RATE (SEC)	ACCEL	RPM	H_D	GW
○	10" FWD	.9	.28	243	250	44210
□	4" AFT	.55	.25	244	2400	46210

FIGURE NO. 54
LATERAL CONTROLLABILITY
SIDEWARD FLIGHT
YCH-47C USA S/N 66-19121

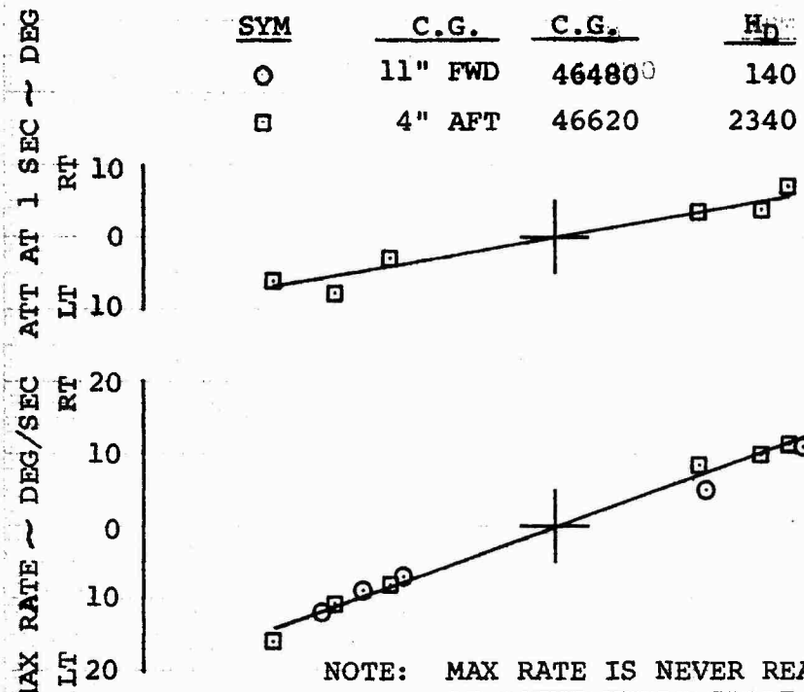


AVERAGE TIME TO REACH MAXIMUM

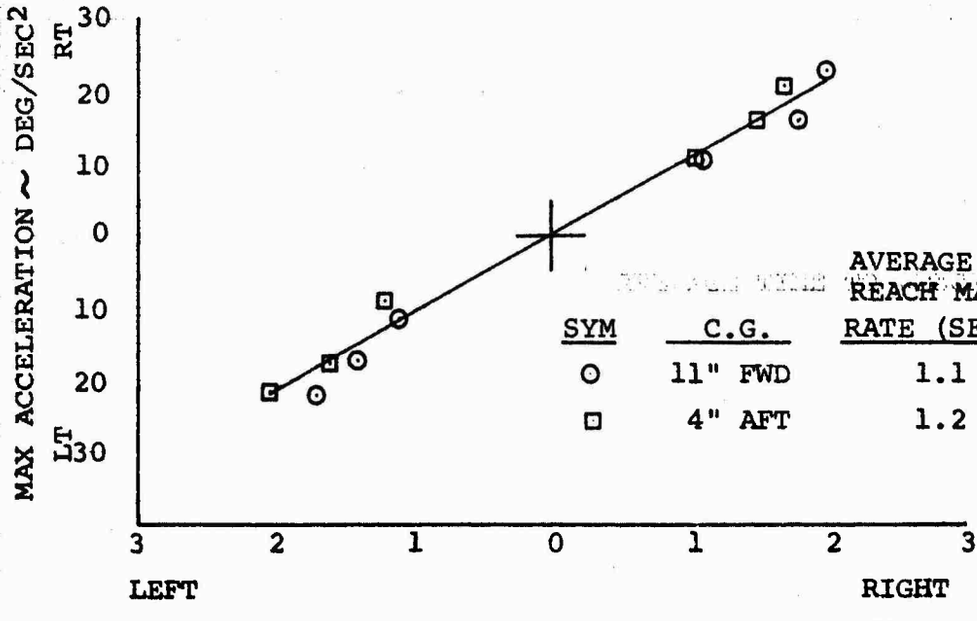
	SYM	C.G.	RATE (SEC)	ACCEL	H_D	GROSS WEIGHT	RPM
OGE 200'	○	6" AFT	.95	.25	930	36630	233
IGE 20'	◇	6" AFT	.7	.3	1340	37390	241
IGE 20'	△	17" FWD 4" LEFT	.65	.26	2670	35640	235

FIGURE NO. 55
DIRECTIONAL CONTROLLABILITY
(IGE) HOVER
YCH-47C USA S/N 66-19121

SYM	C.G.	C.G.	H_D	RPM
○	11" FWD	46480	140	242
□	4" AFT	46620	2340	241

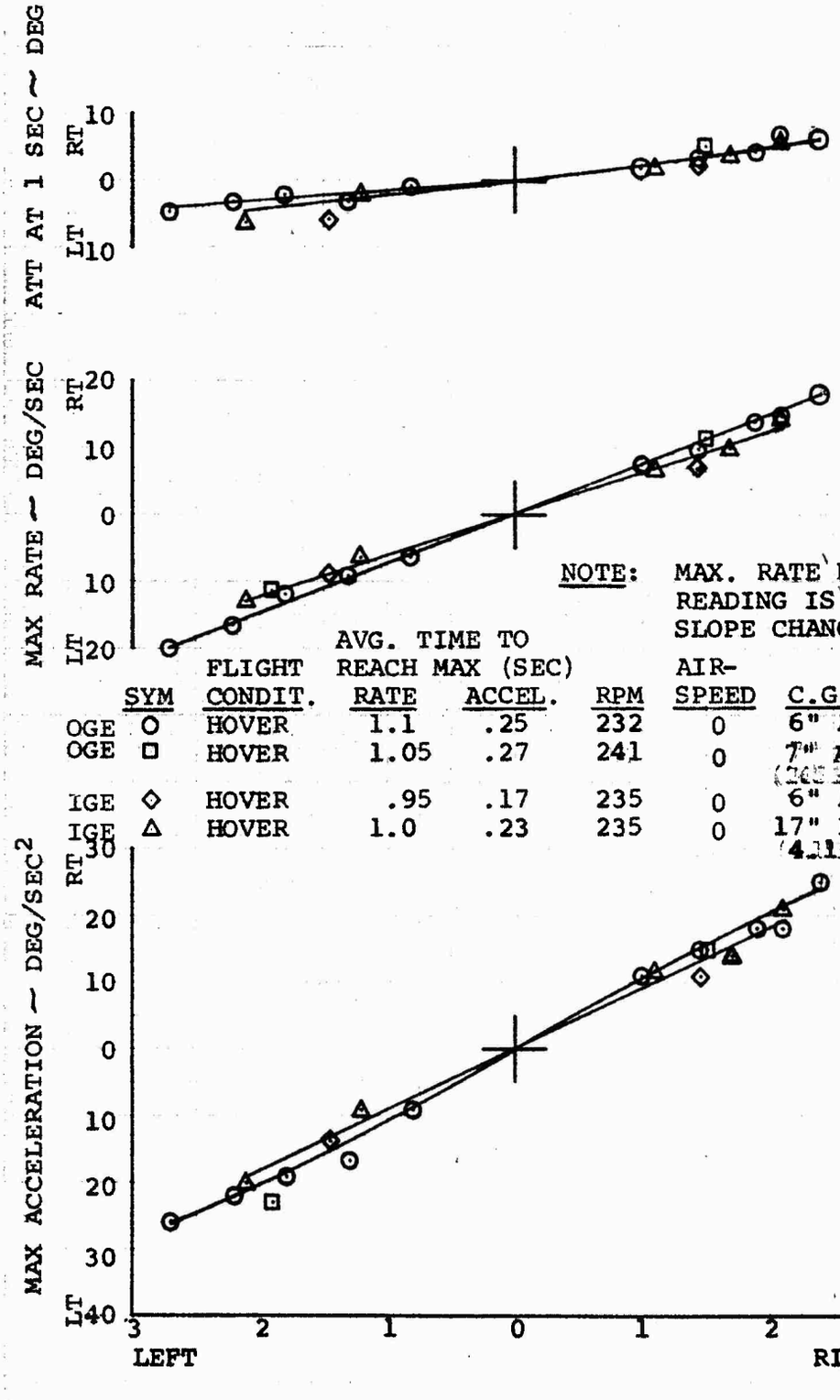


NOTE: MAX RATE IS NEVER REACHED. READING IS AT POINT WHERE SLOPE CHANGES.



SYM	C.G.	AVERAGE TIME TO REACH MAXIMUM RATE (SEC)	ACCEL
○	11" FWD	1.1	.2
□	4" AFT	1.2	.3

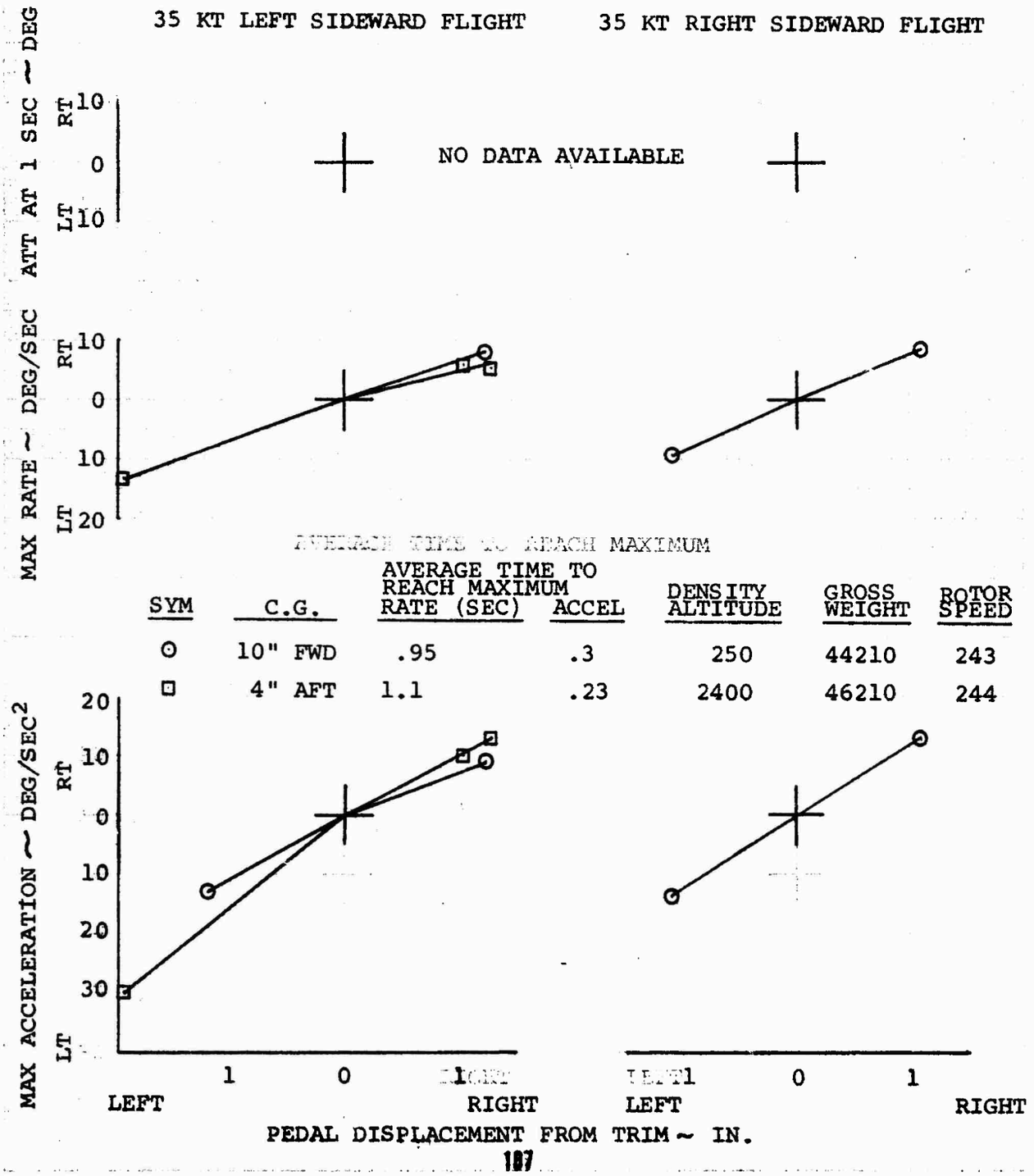
FIGURE NO. 56
DIRECTIONAL CONTROLLABILITY
HOVER
YCH-47C USA S/N 66-19121



NOTE: MAX. RATE NEVER REACHED. READING IS AT POINT WHERE SLOPE CHANGES.

SYM	FLIGHT CONDIT.	AVG. TIME TO REACH MAX (SEC) RATE	ACCEL.	RPM	AIR-SPEED	C.G.	G.W.	H_D
OGE ○	HOVER	1.1	.25	232	0	6" A	37050	740
OGE □	HOVER	1.05	.27	241	0	7" A (20[illegible] DH)	36650	730
IGE ◇	HOVER	.95	.17	235	0	6" A	38240	1160
IGE △	HOVER	1.0	.23	235	0	17" F 4.1" LEFT	37800	2730

FIGURE NO. 57
DIRECTIONAL CONTROLLABILITY
SIDEWARD FLIGHT (IGE)
YCH-47C USA S/N 66-19121

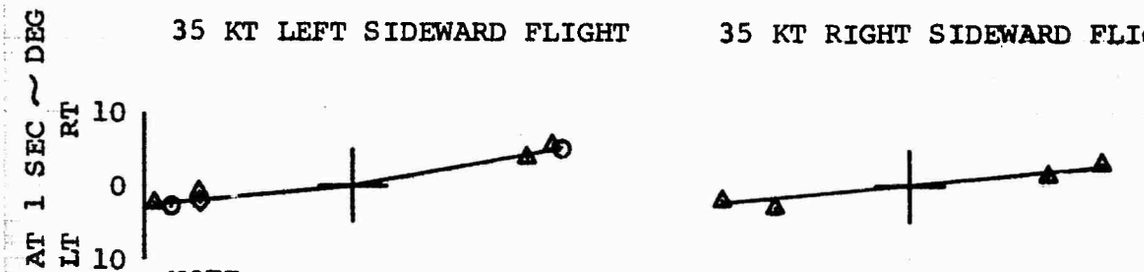


SYM	C.G.	AVERAGE TIME TO REACH MAXIMUM RATE (SEC)	ACCEL	DENSITY ALTITUDE	GROSS WEIGHT	ROTOR SPEED
⊙	10" FWD	.95	.3	250	44210	243
□	4" AFT	1.1	.23	2400	46210	244

FIGURE NO. 58
DIRECTIONAL CONTROLLABILITY
SIDEWARD FLIGHT
YCH-47C USA S/N 66-19121

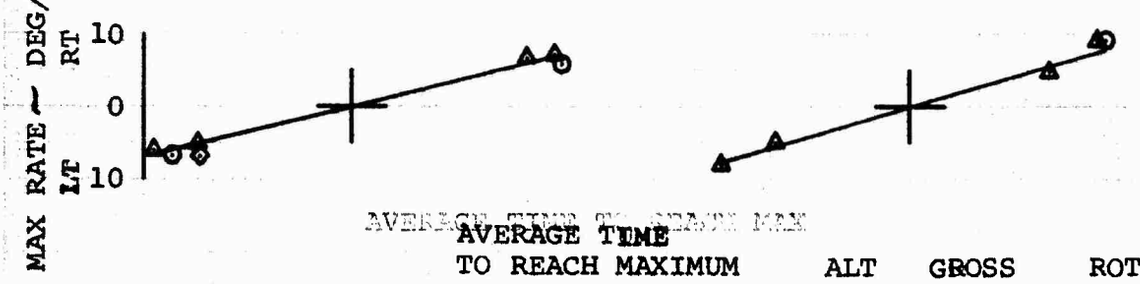
35 KT LEFT SIDEWARD FLIGHT

35 KT RIGHT SIDEWARD FLIGHT



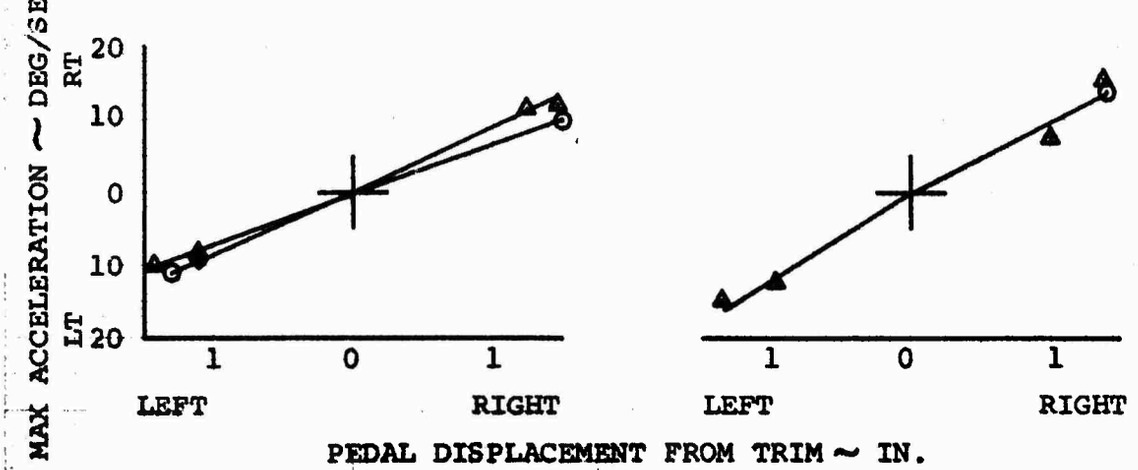
NOTE:

1. MAX RATE NEVER REACHED. READING IS AT POINT WHERE SLOPE CHANGES.
2. SMALLER TIMES TO REACH MAX ARE FOR CONTROL INPUTS OPPOSITE TO THE DIRECTION OF MOTION. FOR THESE TYPE INPUTS THE YAW ACCELERATION DIES OFF MORE QUICKLY.



AVERAGE TIME TO REACH MAX

SYM	C.G.	AVERAGE TIME TO REACH MAXIMUM RATE (SEC)	ACCEL	ALT H_D	GROSS WEIGHT	ROTOR SPEED
O OGE	6.4" AFT	.9-1.2	.15-.40	930	36630	233
◇ IGE	6.4" AFT	1.0	.40	1340	37390	241
△ IGE	17" FWD 4.1" LEFT	1.0	.17-.47	2670	35640	235

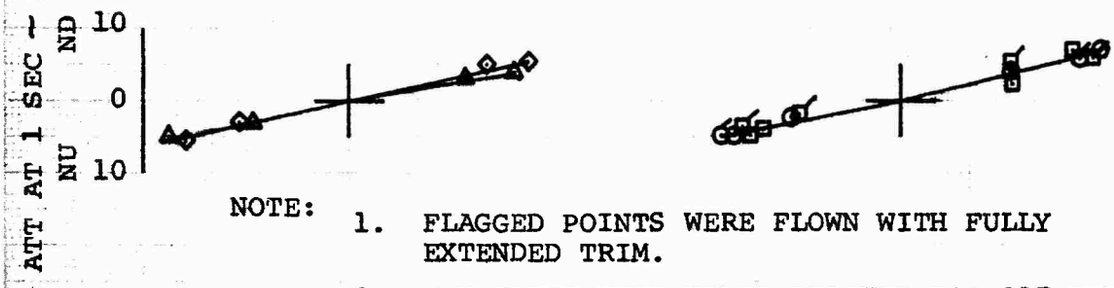


PEDAL DISPLACEMENT FROM TRIM ~ IN.

FIGURE NO. 59
LONGITUDINAL CONTROLLABILITY
LEVEL FLIGHT
YCH-47C USA S/N 66-19121

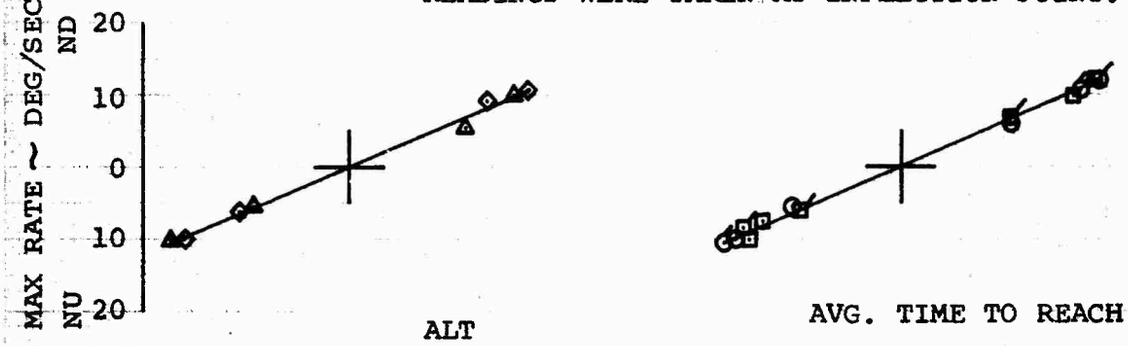
ROTOR SPEED
235 RPM

ROTOR SPEED
245 RPM



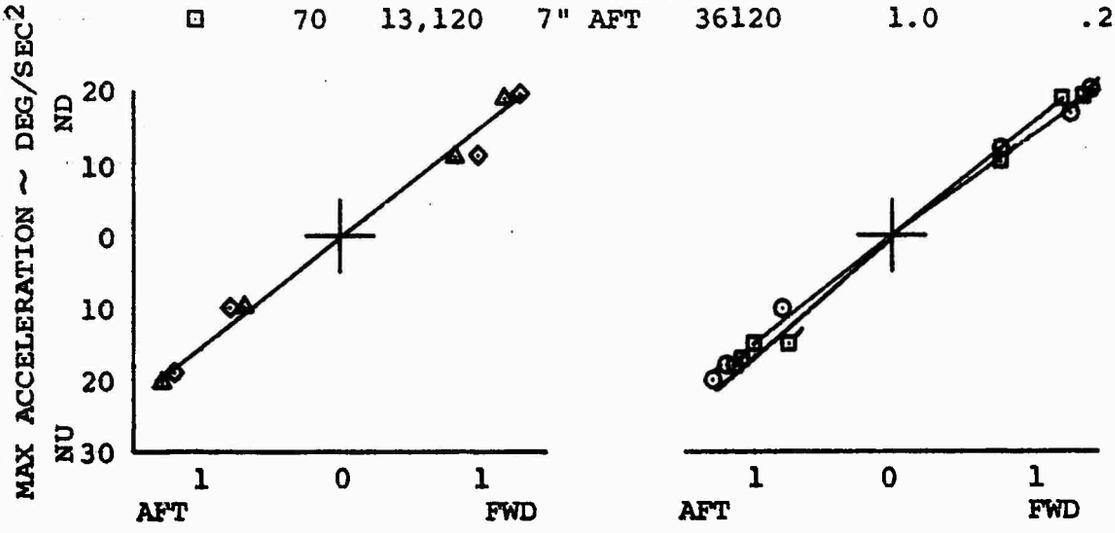
NOTE:

1. FLAGGED POINTS WERE FLOWN WITH FULLY EXTENDED TRIM.
2. MAX RATES WERE NEVER REACHED FOR 235 RPM POINTS AND 13,200' POINTS AT NORMAL TRIM. READINGS WERE TAKEN AT INFLECTION POINT.



AVG. TIME TO REACH MAX

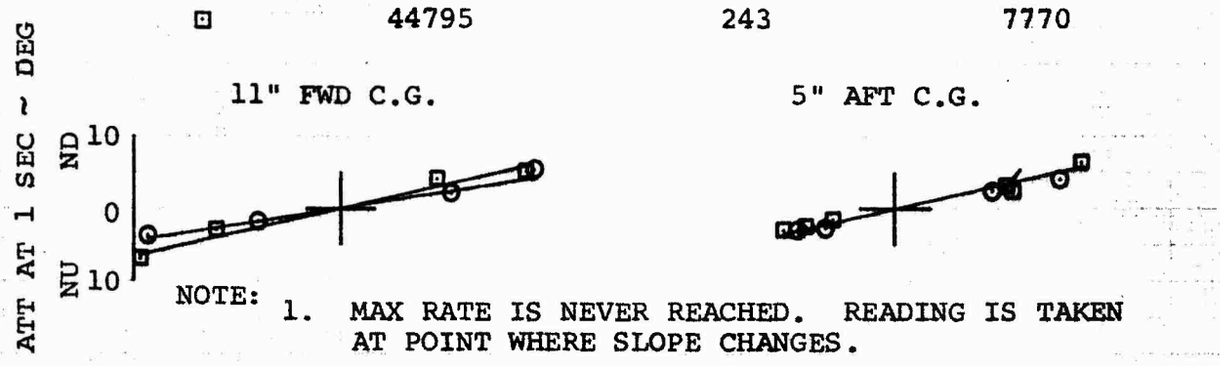
SYM	C.A.S.	ALT H_D	C.G.	G.W.	RATE (SEC)	ACCEL
△	72	10,070	6" AFT	37830	1.1	.26
◇	86	10,070	6" AFT	37130	1.15	.28
○	113	9,650	17" FWD 4.1" LEFT	36740	.90	.28
⊡	70	13,120	7" AFT	36120	1.0	.25



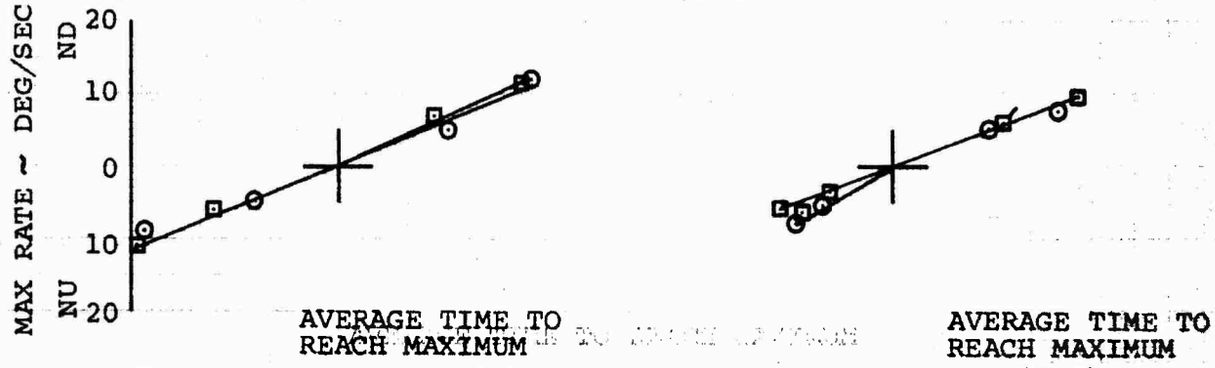
CONTROL DISPLACEMENT FROM TRIM ~ IN.

FIGURE NO. 60
LONGITUDINAL CONTROLLABILITY
LEVEL FLIGHT
YCH-47C USA S/N 66-19121

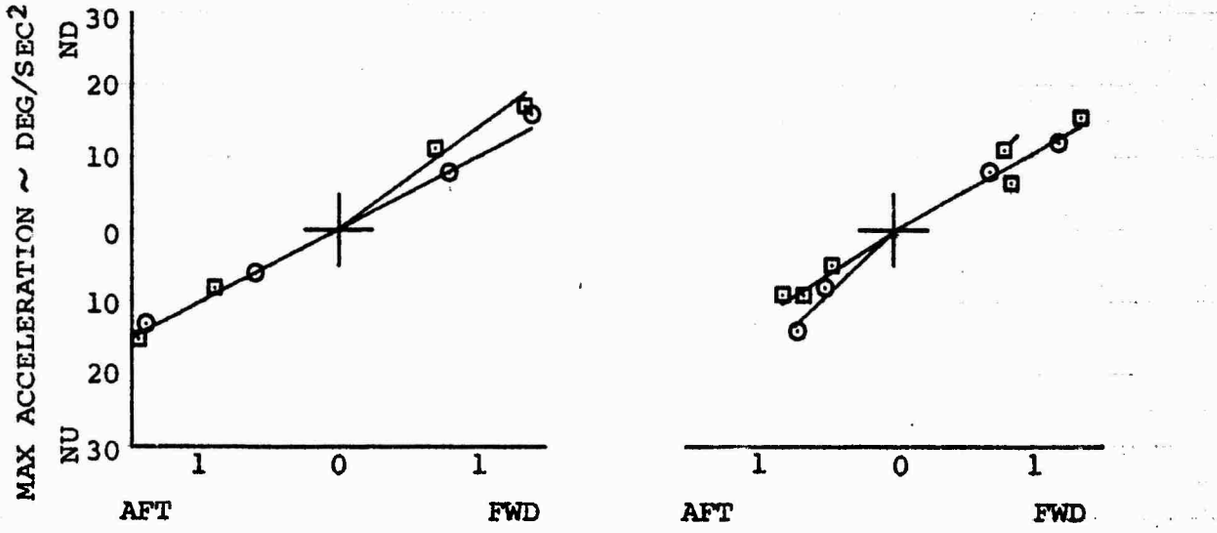
SYM	GROSS WEIGHT	ROTOR SPEED	DENSITY ALT
⊙	45460	243	8230
⊡	44795	243	7770



NOTE:
1. MAX RATE IS NEVER REACHED. READING IS TAKEN AT POINT WHERE SLOPE CHANGES.
2. FLAGGED POINT IS 100% INPUT WITH SAS PULSER BOX.



SYM	AVERAGE TIME TO REACH MAXIMUM RATE (SEC)	ACCEL	CALIB. AIRSPEED	AVERAGE TIME TO REACH MAXIMUM RATE (SEC)	ACCEL
⊙	1.0	.28	55	.9	.25
⊡	.9	.28	71	.9	.3

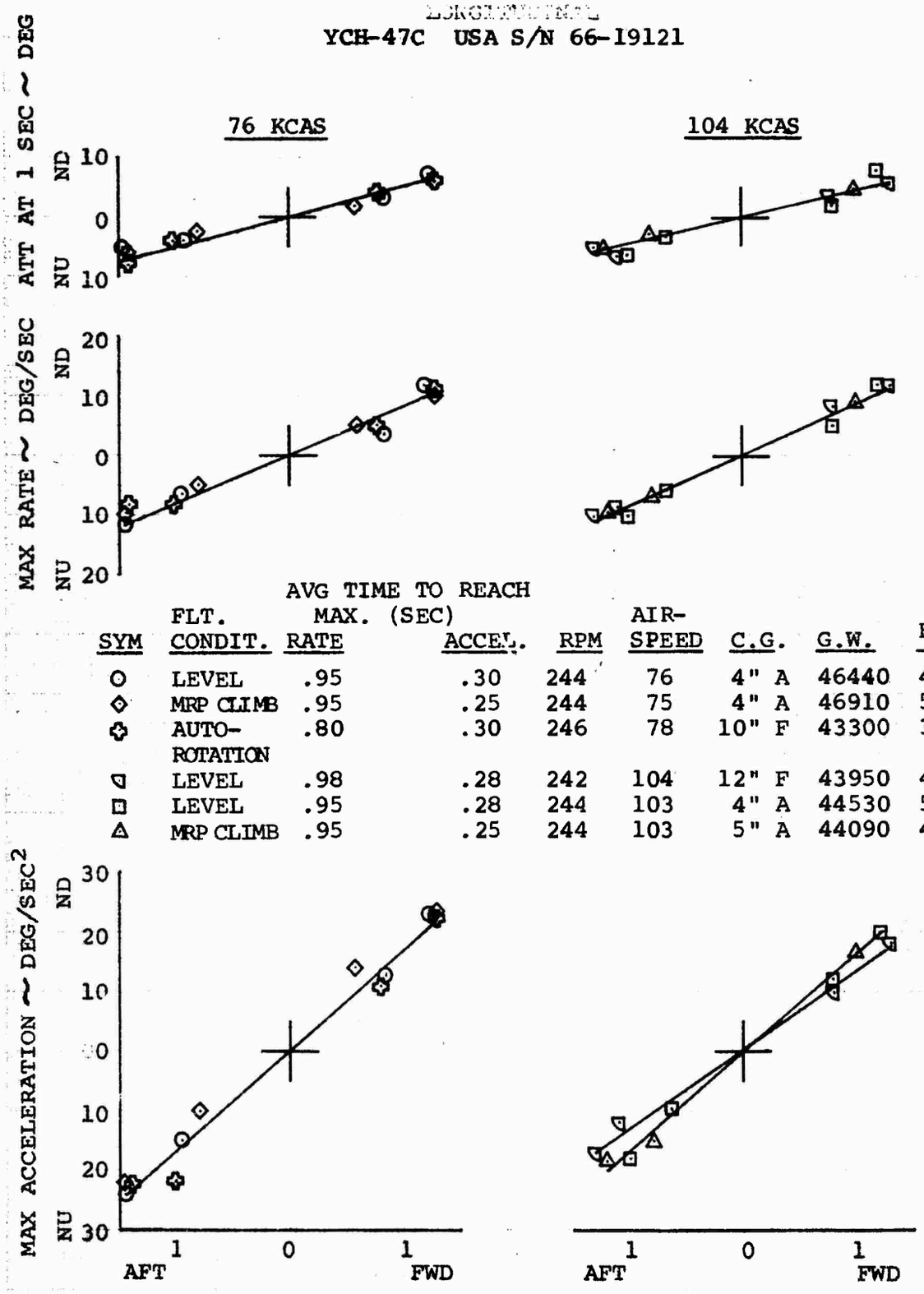


CONTROL DISPLACEMENT FROM TRIM ~ IN.

FIGURE NO. 61

LONGITUDINAL CONTROLLABILITY,
LEVEL FLIGHT, CLIMBS, AND AUTOROTATIONS

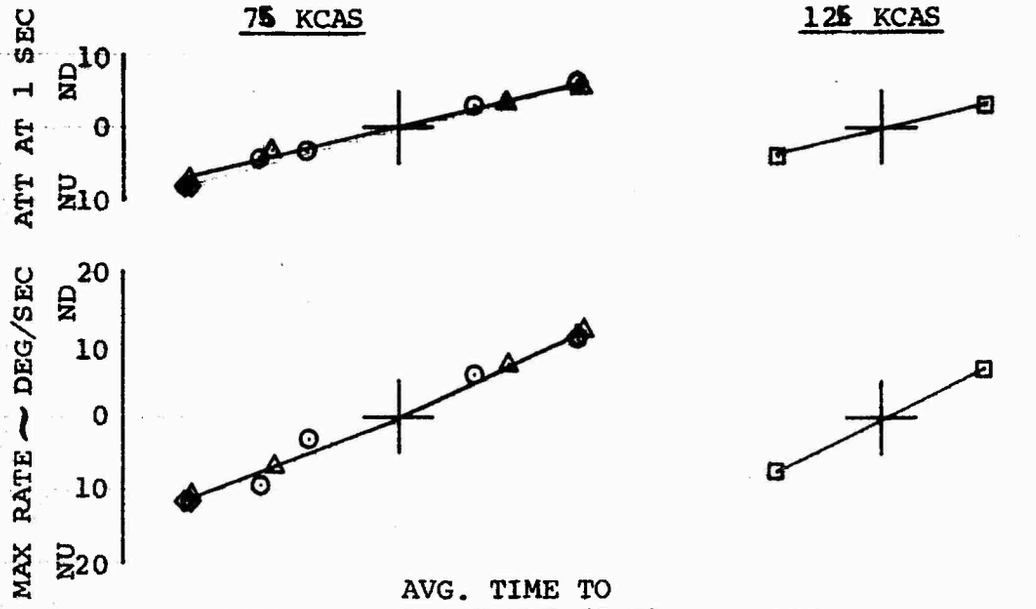
YCH-47C USA S/N 66-19121



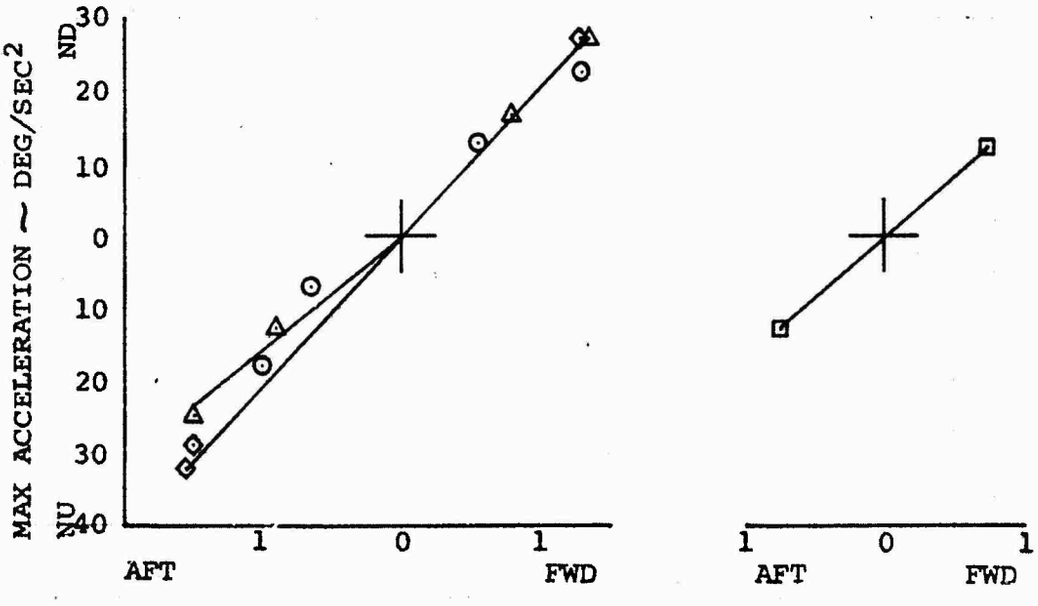
SYM	FLT. CONDIT.	AVG TIME TO REACH MAX. (SEC) RATE	ACCEL.	RPM	AIR-SPEED	C.G.	G.W.	H_D
○	LEVEL	.95	.30	244	76	4" A	46440	4770
◇	MRP CLIMB	.95	.25	244	75	4" A	46910	5290
✿	AUTO-ROTATION	.80	.30	246	78	10" F	43300	3450
◁	LEVEL	.98	.28	242	104	12" F	43950	4920
□	LEVEL	.95	.28	244	103	4" A	44530	5380
△	MRP CLIMB	.95	.25	244	103	5" A	44090	4210

FIGURE NO. 62

LONGITUDINAL CONTROLLABILITY
LEVEL FLIGHT, NRP CLIMB, AND AUTOROTATION
YCH-47C USA S/N 66-19121



SYM	FLT. CONDIT.	AVG. TIME TO REACH MAX (SEC) RATE	ACCEL.	RPM	AIR-SPEED	C.G.	G.W.	H_D
○	LEVEL	.90	.27	235	74	6" A	37390	4660
△	NRP CLIMB	.90	.28	236	74	6" A	38300	3900
◇	AUTO-ROTATION	.85	.25	232	76	7" A	35510	2770
□	LEVEL	.90	.30	234	125	6" A	36880	5100



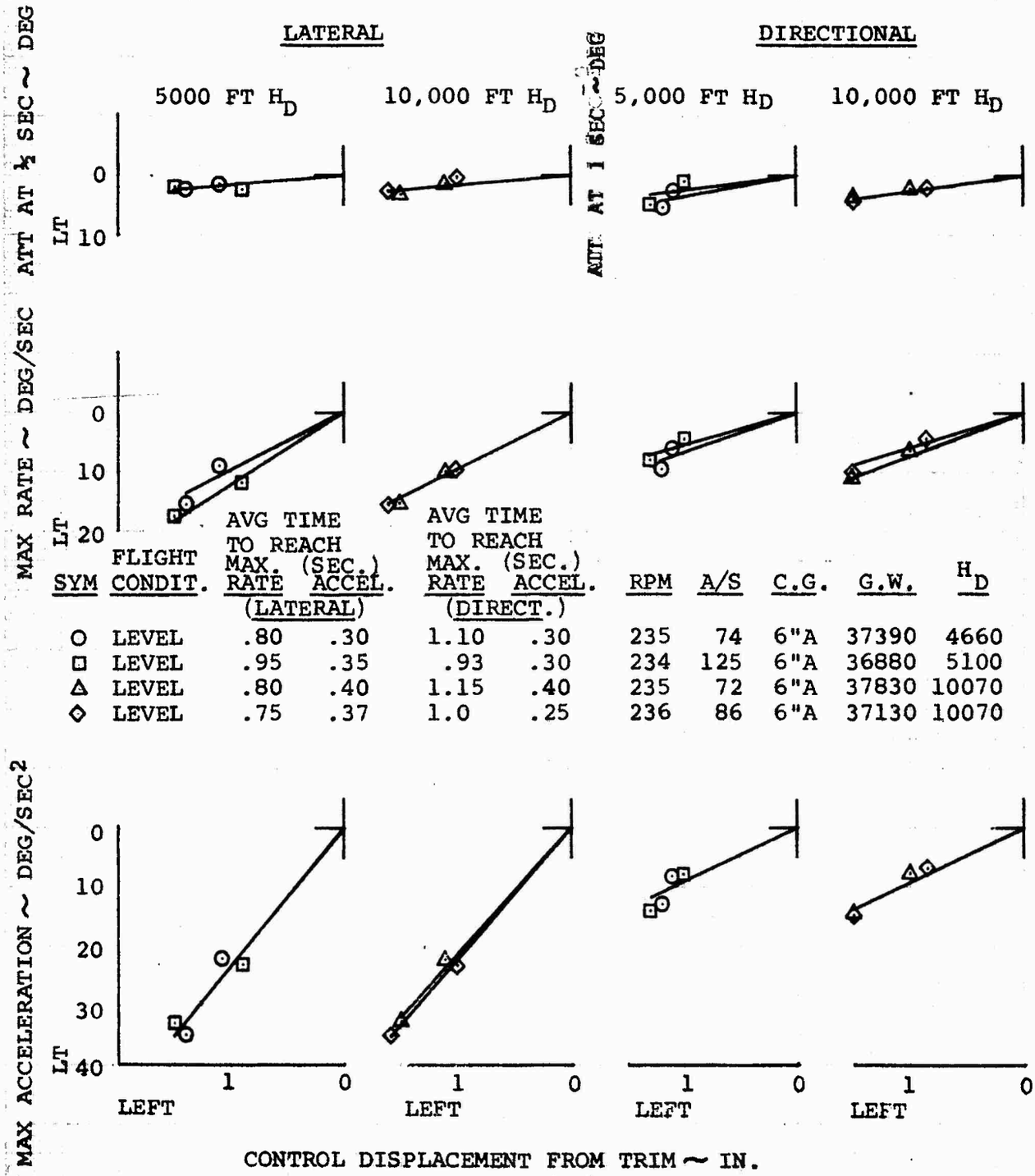
CONTROL DISPLACEMENT FROM TRIM ~ IN.

FIGURE NO. 63

LATERAL AND DIRECTIONAL CONTROLLABILITY

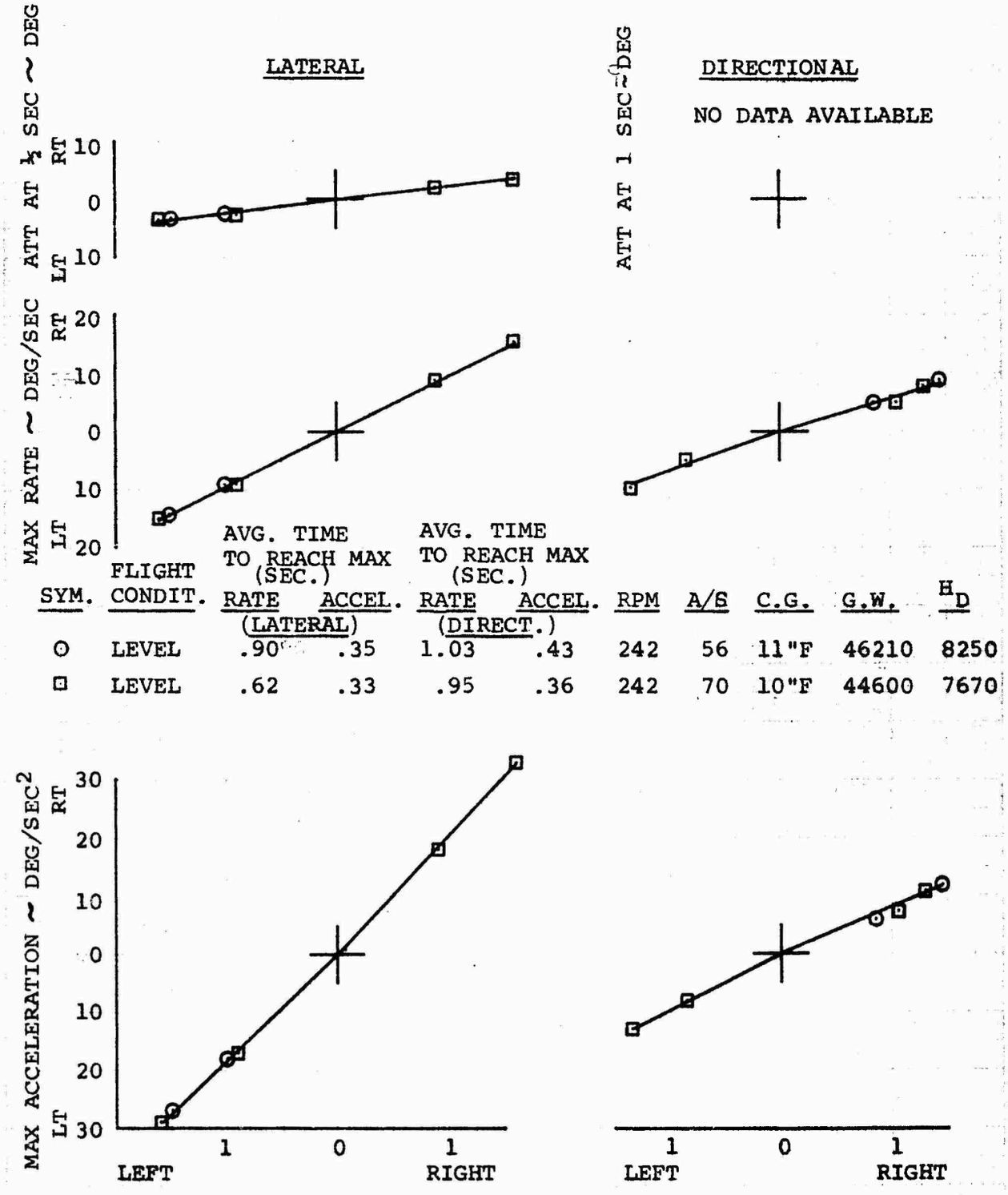
LEVEL FLIGHT

YCH-47C USA S/N 66-19121



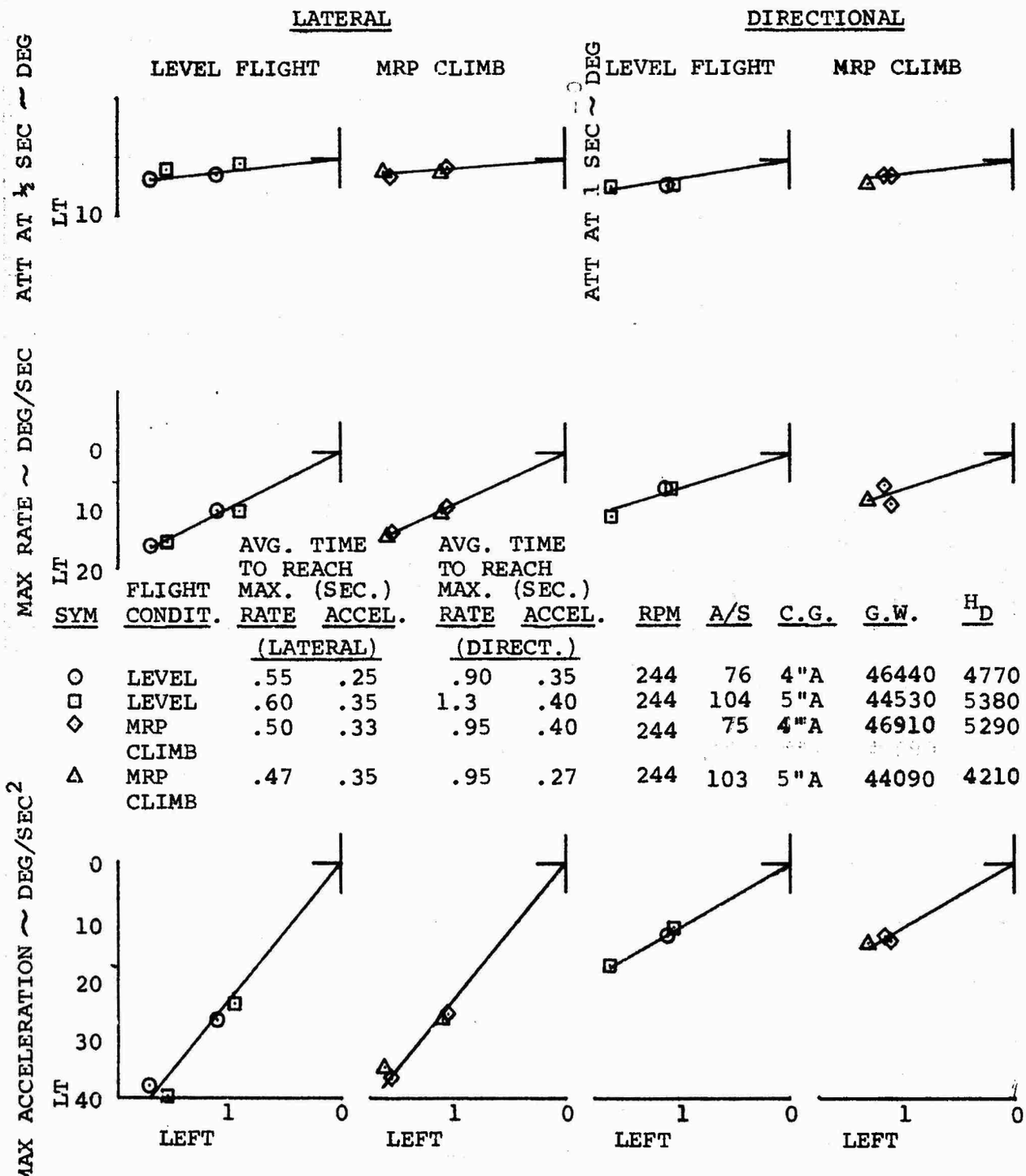
SYM	FLIGHT CONDIT.	AVG TIME TO REACH MAX. (SEC.) RATE (LATERAL)	ACCEL.	AVG TIME TO REACH MAX. (SEC.) RATE (DIRECT.)	ACCEL.	RPM	A/S	C.G.	G.W.	H_D
○	LEVEL	.80	.30	1.10	.30	235	74	6"A	37390	4660
□	LEVEL	.95	.35	.93	.30	234	125	6"A	36880	5100
△	LEVEL	.80	.40	1.15	.40	235	72	6"A	37830	10070
◇	LEVEL	.75	.37	1.0	.25	236	86	6"A	37130	10070

FIGURE NO. 64
LATERAL AND DIRECTIONAL CONTROLLABILITY
LEVEL FLIGHT
YCH-47C USA S/N 66-19121



SYM.	FLIGHT CONDIT.	AVG. TIME TO REACH MAX (SEC.) RATE (LATERAL)	ACCEL.	AVG. TIME TO REACH MAX (SEC.) RATE (DIRECT.)	ACCEL.	RPM	A/S	C.G.	G.W.	H_D
○	LEVEL	.90	.35	1.03	.43	242	56	11"F	46210	8250
□	LEVEL	.62	.33	.95	.36	242	70	10"F	44600	7670

FLIGHT NO. 65
LATERAL AND DIRECTIONAL CONTROLLABILITY
LEVEL FLIGHT & MRP CLIMB
YCH-47C USA S/N 66-19121



SYM	FLIGHT CONDIT.	AVG. TIME TO REACH MAX. (SEC.) RATE (LATERAL)	ACCEL.	AVG. TIME TO REACH MAX. (SEC.) RATE (DIRECT.)	ACCEL.	RPM	A/S	C.G.	G.W.	H_D
○	LEVEL	.55	.25	.90	.35	244	76	4"A	46440	4770
□	LEVEL	.60	.35	1.3	.40	244	104	5"A	44530	5380
◇	MRP CLIMB	.50	.33	.95	.40	244	75	4"A	46910	5290
△	MRP CLIMB	.47	.35	.95	.27	244	103	5"A	44090	4210

FIGURE NO. 66

SUMMARY OF LONGITUDINAL CONTROLLABILITY

YCH-47C USA S/N 66-19121

SYM	GROSS WEIGHT (LBS)	DENSITY ALTITUDE (FT)	CENTER OF GRAVITY (INCHES)	ROTOR SPEED (RPM)
⊙	37400	1210	6 Aft	234
◔	37540	2920	17 Fwd 4 Left	235
⊡	46660	2300	4 Aft	244
◪	45640	230	11 Fwd	242
▽	37130	4880	6 Aft	234
○	45480	5080	4 Aft	244
◔	43950	4920	12 Fwd	242
△	37480	10070	6 Aft	235
◇	44850	8040	5 Aft	243
◈	45400	7960	11 Fwd	243
✿	36120	13120	7 Aft	245
✿	36740	9650	17 Fwd 4 Left	245

Note: (1) Shaded symbols denote different values for forward and aft steps. Forward steps have the upper half of the symbol shaded and aft steps have the lower half shaded.
(2) Controllability in autorotations and climbs was similiar to level flight. (Ref. Figure)

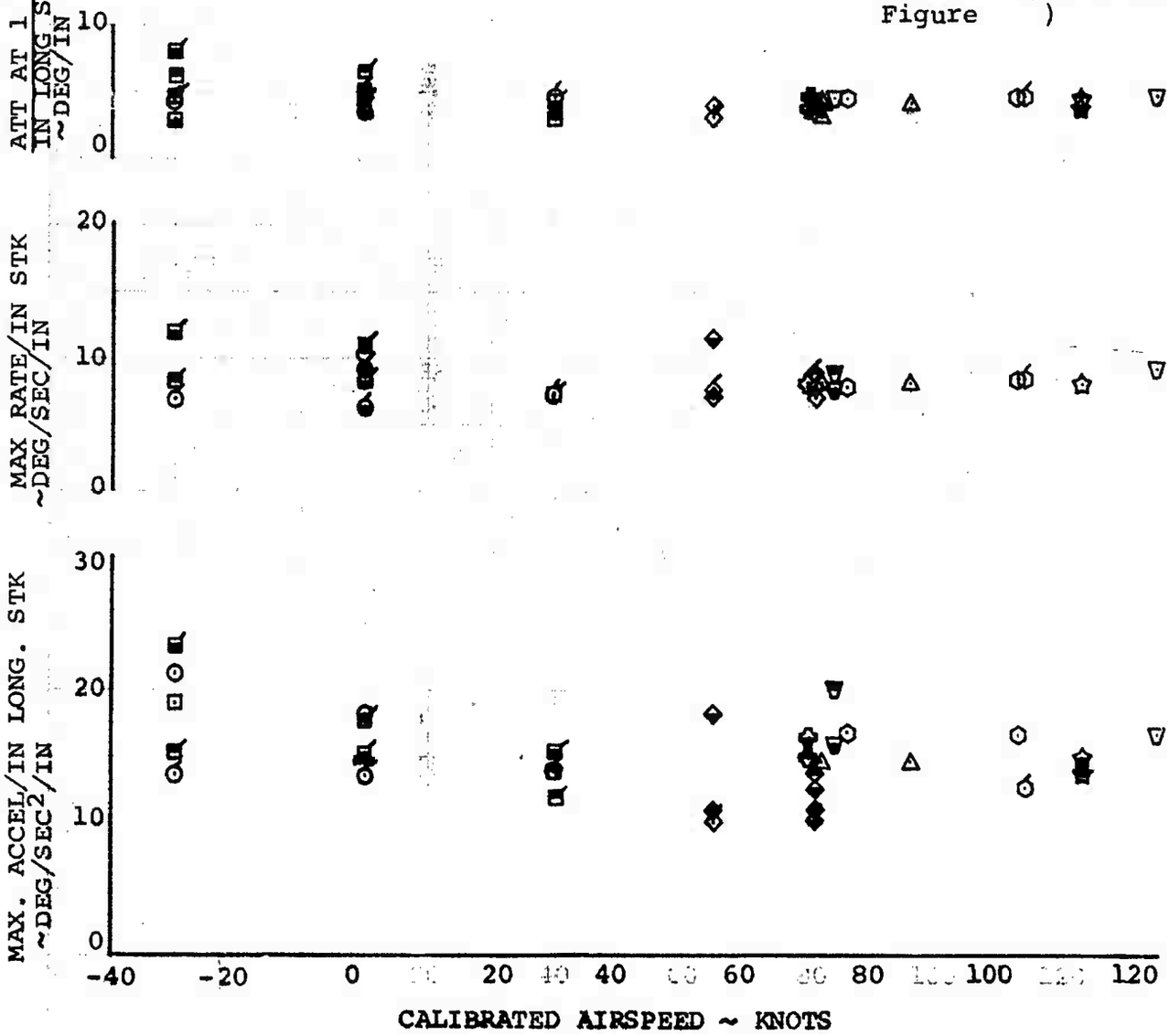


FIGURE NO. 67

SUMMARY OF LATERAL CONTROLLABILITY

YCH-47C USA S/N 66-19121

SYM	GROSS WEIGHT (LBS)	DENSITY ALTITUDE (FT)	CENTER OF GRAVITY (IN)	ROTOR SPEED (RPM)
○	37410	880	6 Aft	236
◐	38010	2730	17 Fwd 4 Left	235
□	46800	2190	4 Aft	243
◧	46760	130	11 Fwd	242
▽	37140	4880	6 Aft	235
⊙	45490	5080	5 Aft	244
△	37480	10070	6 Aft	236
◆	45400	7960	11 Fwd	242

Note: Shaded symbols denote different values for left and right steps. Right steps have the upper half of the symbol shaded and left steps have the lower half shaded.

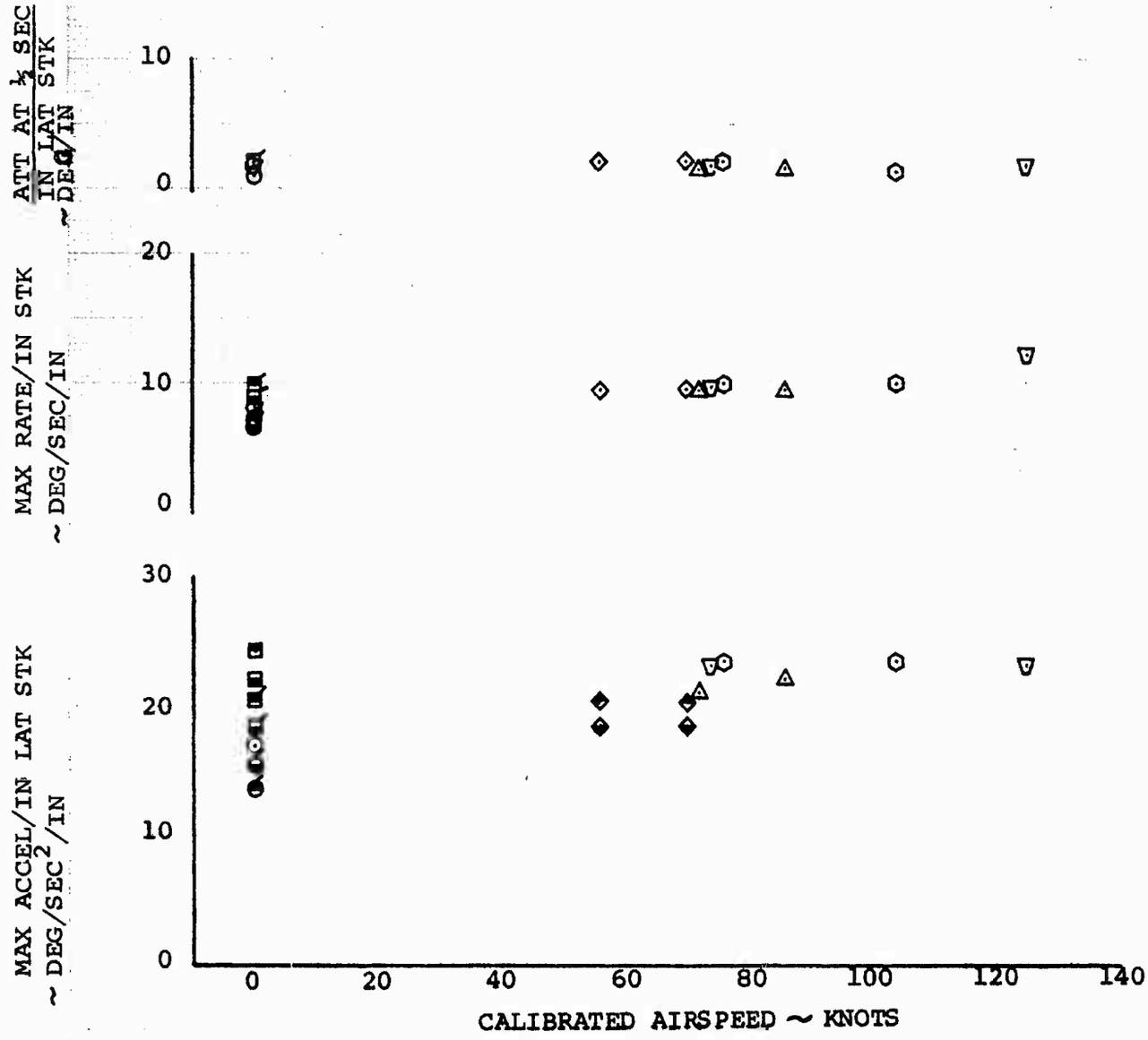


FIGURE NO. 68

SUMMARY OF DIRECTIONAL CONTROLLABILITY

YCH-47C USA S/N 66-19121

SYM	GROSS WEIGHT (LBS)	DENSITY ALTITUDE (FT)	CENTER OF GRAVITY (IN)	ROTOR SPEED (RPM)
⊙	37650	880	6 Aft	236
♂	37800	2730	17 Fwd 4 Left	235
◻	46620	2340	4 Aft	241
◻	46480	140	11 Fwd	242
▽	37140	4880	6 Aft	235
○	45490	5080	5 Aft	244
△	37480	10070	6 Aft	236
◇	45400	7960	11 Fwd	242

Note: Shaded symbols denote different values for left and right steps. Right steps have the upper half of the symbol shaded and left steps have the lower half shaded.

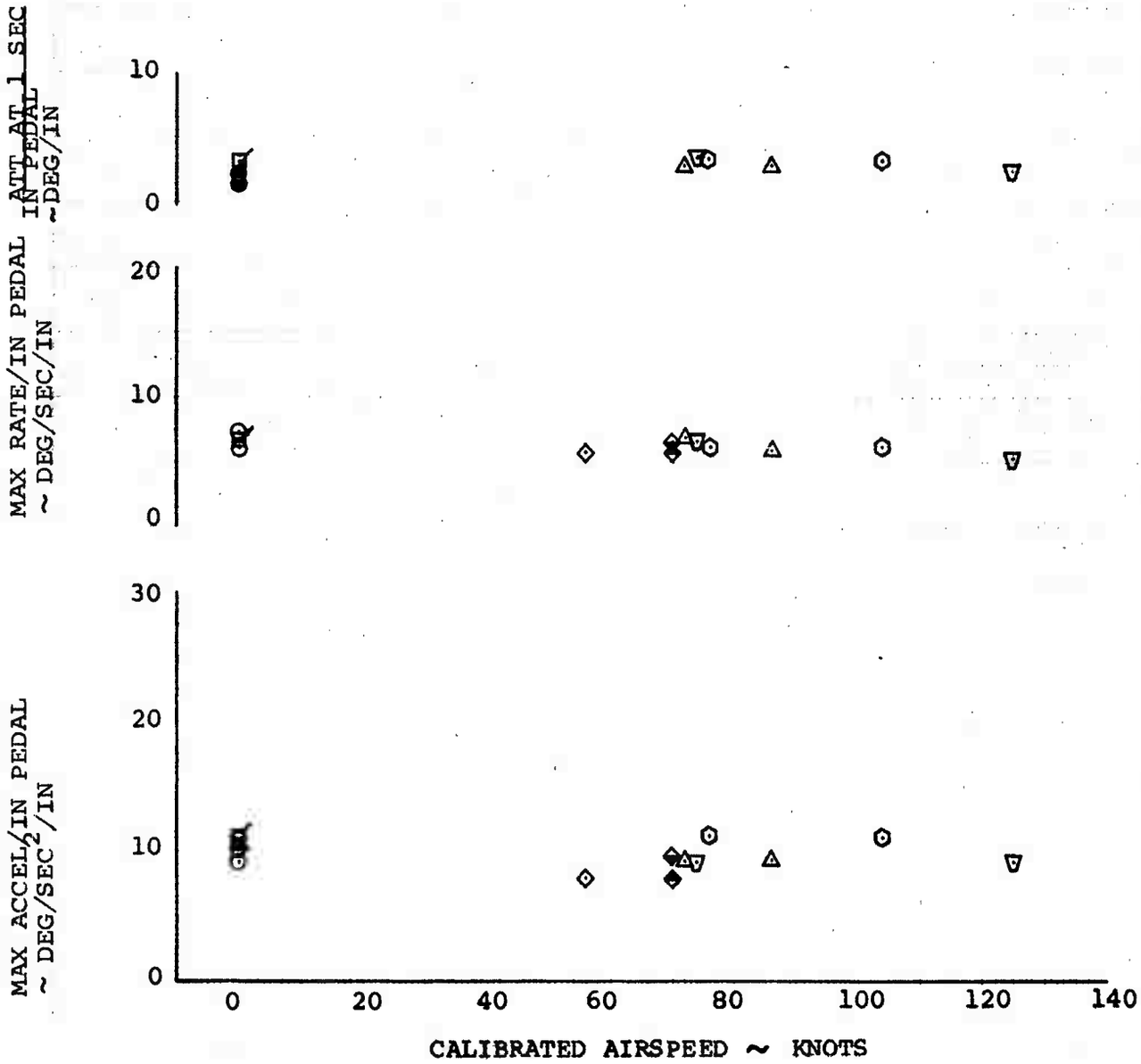


FIGURE NO. 69

AFT LONGITUDINAL STEP

YCH-47C USA S/N 66-19121

LEGEND
PITCH - - - - -
ROLL ———
YAW —·—·—

LEVEL FLIGHT
TRIM AIRSPEED = 77 KTS
AVG. DENSITY ALTITUDE = 4530 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 37440 LB
AVG. ROTOR SPEED = 234 RPM
C.G. LOCATION = 5.9 " AFT
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

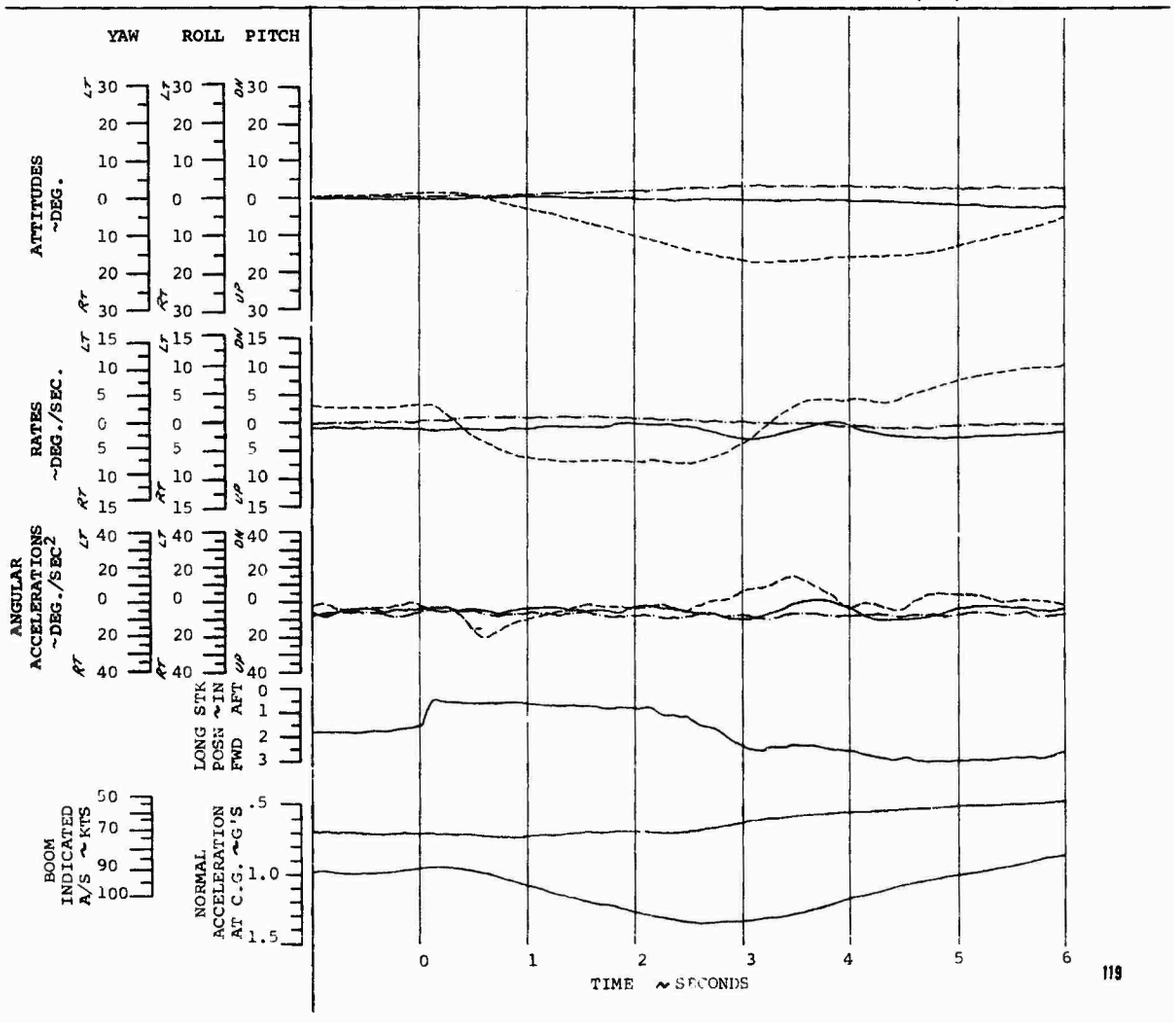


FIGURE NO. 70
AFT LONGITUDINAL STEP
YCH-47C USA S/N 66-19121

LEGEND
PITCH — — — —
ROLL ————————
YAW —·—·—·—

LEVEL FLIGHT
TRIM AIRSPEED = 76 KTS
AVG. DENSITY ALTITUDE = 4800 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 45300 LB
AVG. ROTOR SPEED = 244 RPM
C.G. LOCATION = 4.4 INCH AFT
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

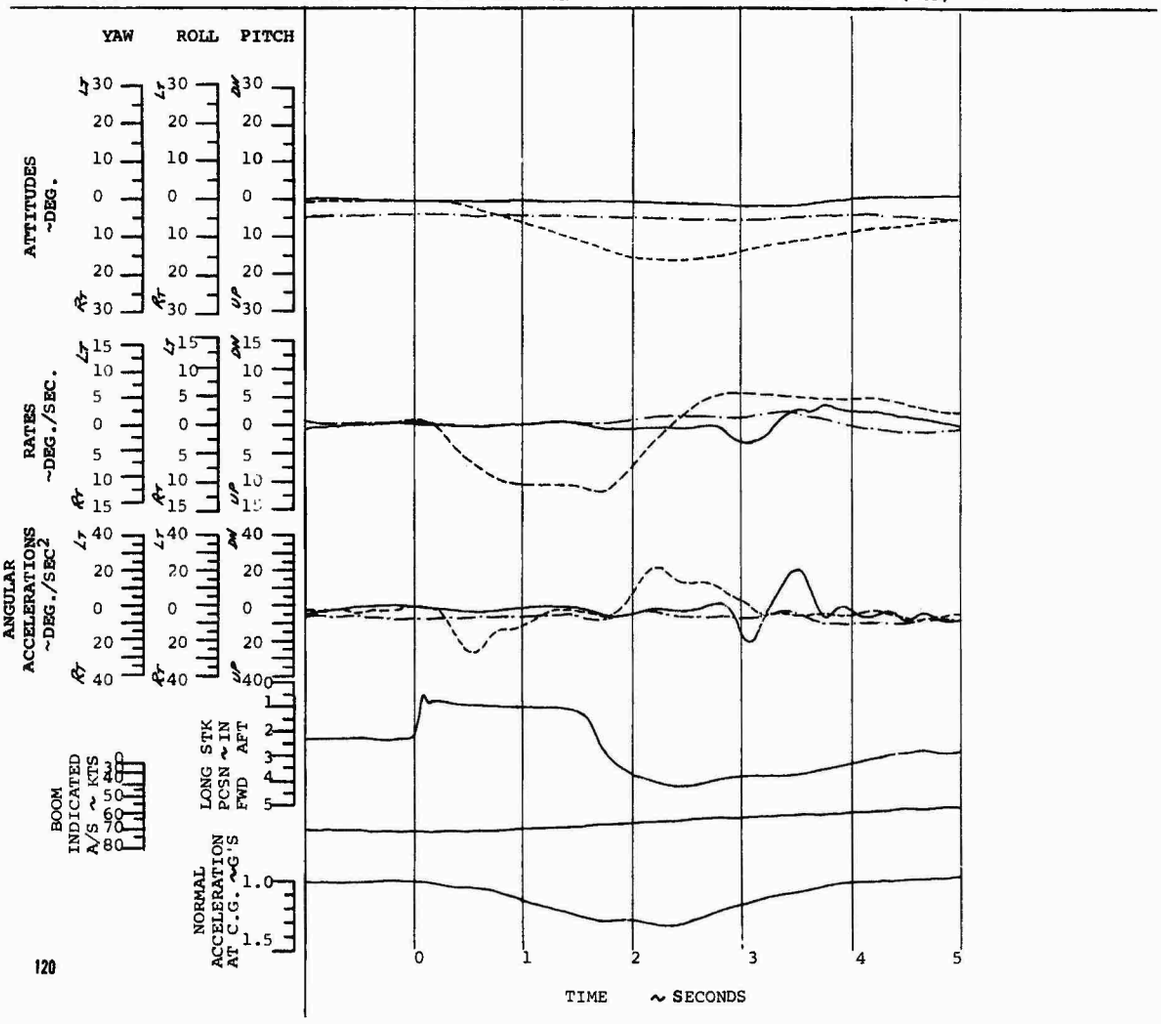


FIGURE NO. 71
AFT LONGITUDINAL STEP
YCH-47C USA S/N 66-19121

LEGEND
PITCH – – – – –
ROLL ————
YAW —·—·—

LEVEL FLIGHT
TRIM AIRSPEED = 102 KTS
AVG. DENSITY ALTITUDE = 5250 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 44,000 LB
AVG. ROTOR SPEED = 242 RPM
C.G. LOCATION = 9.5" FWD
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

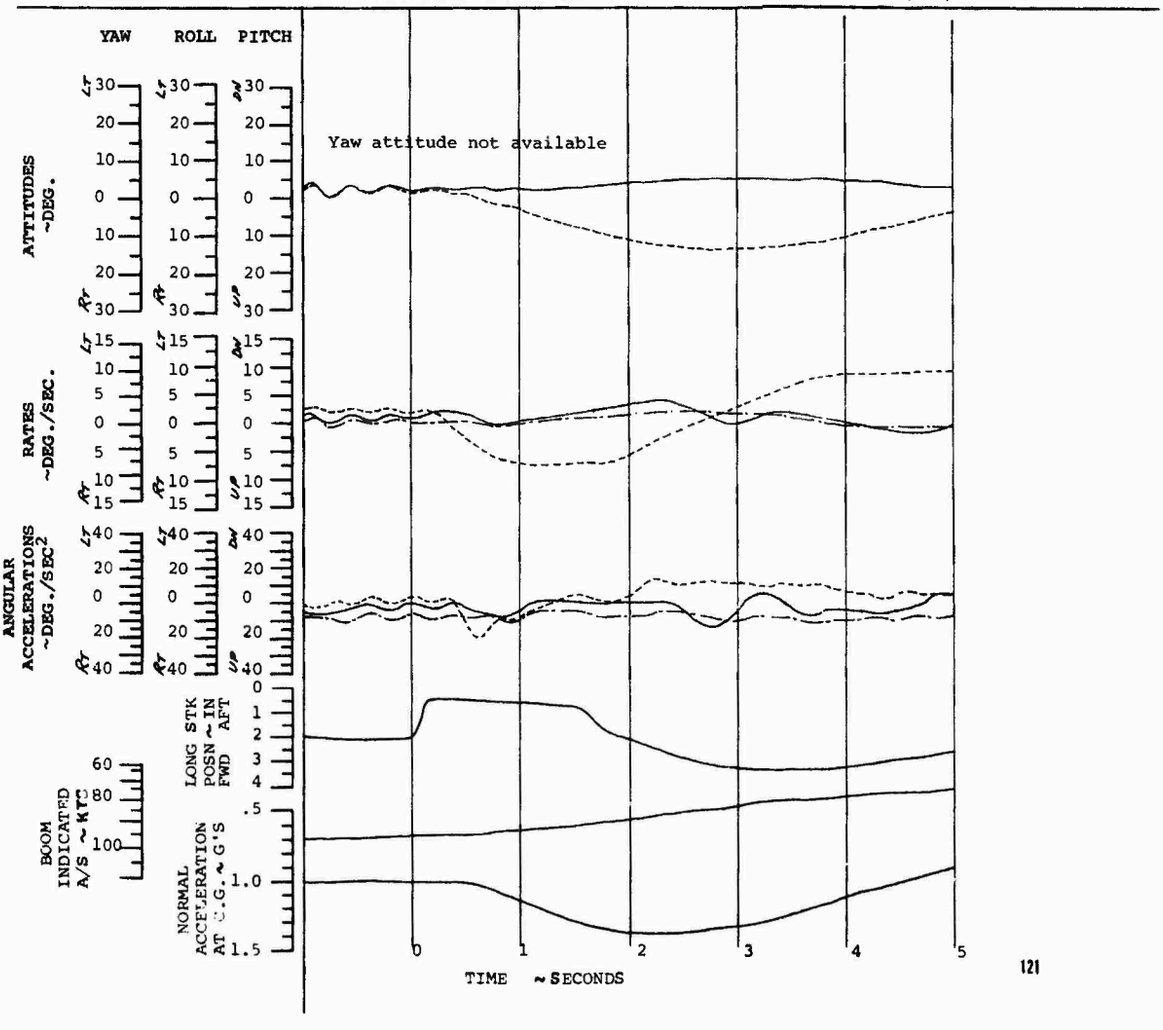


FIGURE NO. 72

AFT LONGITUDINAL STEP

YCH-47C USA S/N 66-19121

LEGEND
PITCH – – – – –
ROLL ————
YAW —·—·—

LEVEL FLIGHT
TRIM AIRSPEED = 70 KTS
AVG. DENSITY ALTITUDE = 13170 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 36090 LB
AVG. ROTOR SPEED = 245 RPM
C.G. LOCATION = 6.8" AFT
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

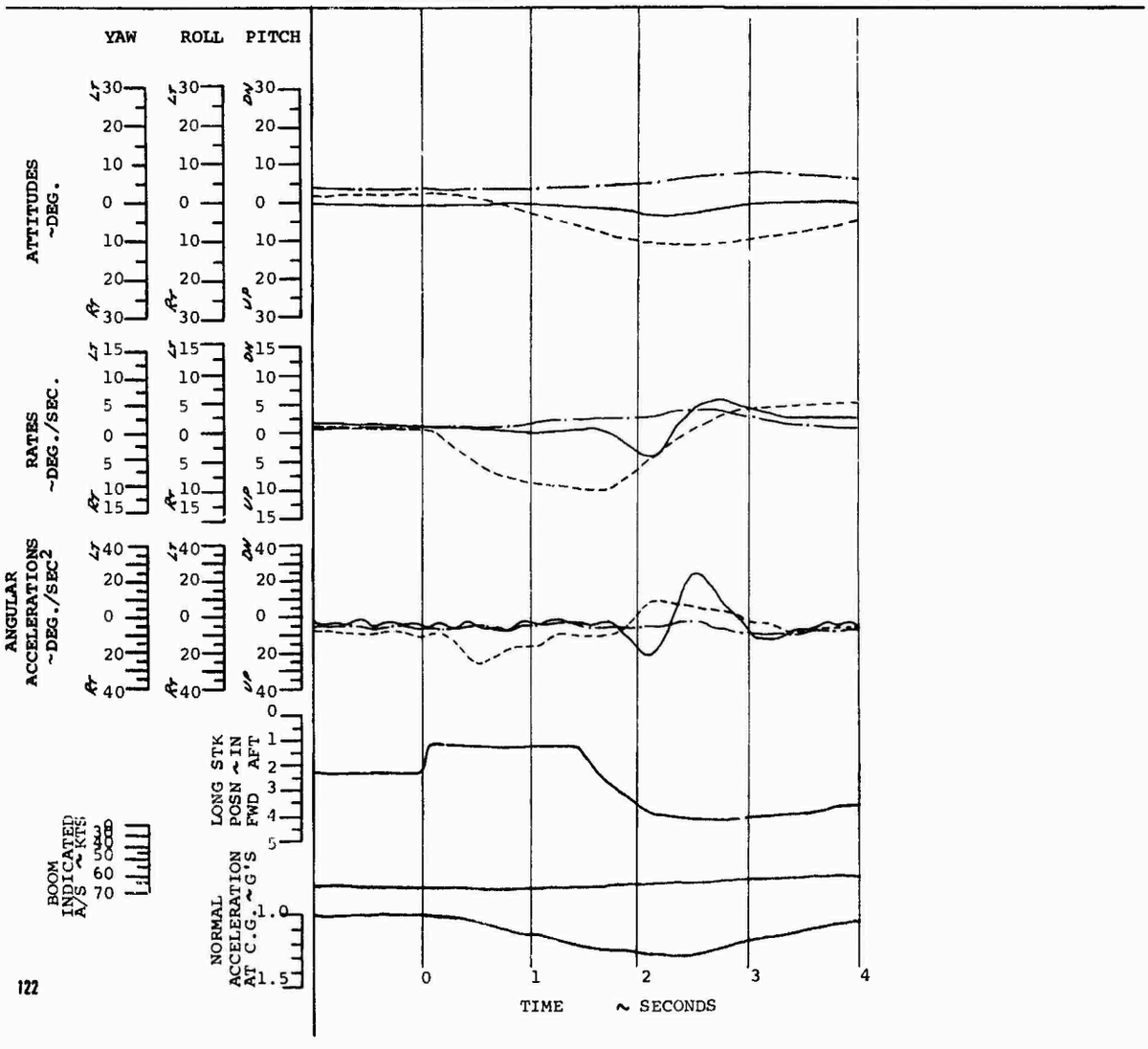


FIGURE NO. 73
AFT LONGITUDINAL STEP
YCH-47C USA S/N 66-19121

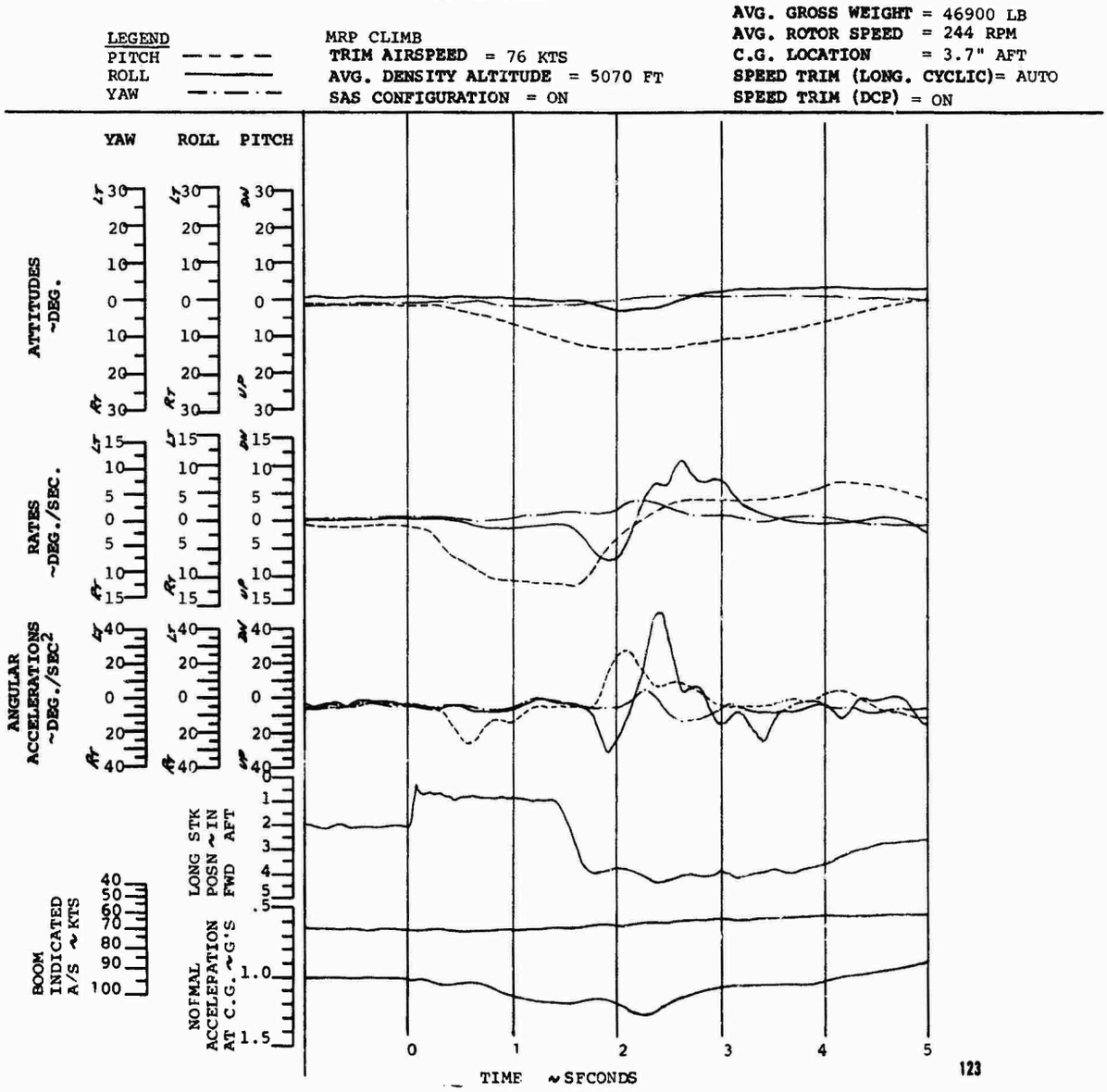


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FIGURE NO. 74
AFT LONGITUDINAL STEP
YCH-47C USA S/N 66-19121

LEGEND
PITCH - - - - -
ROLL ———
YAW —·—·—

IGE HOVER
TRIM AIRSPEED = 0 KTS
AVG. DENSITY ALTITUDE = 130 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT =47070 LB
AVG. ROTOR SPEED = 242 RPM
C.G. LOCATION = 11.0" FWD
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

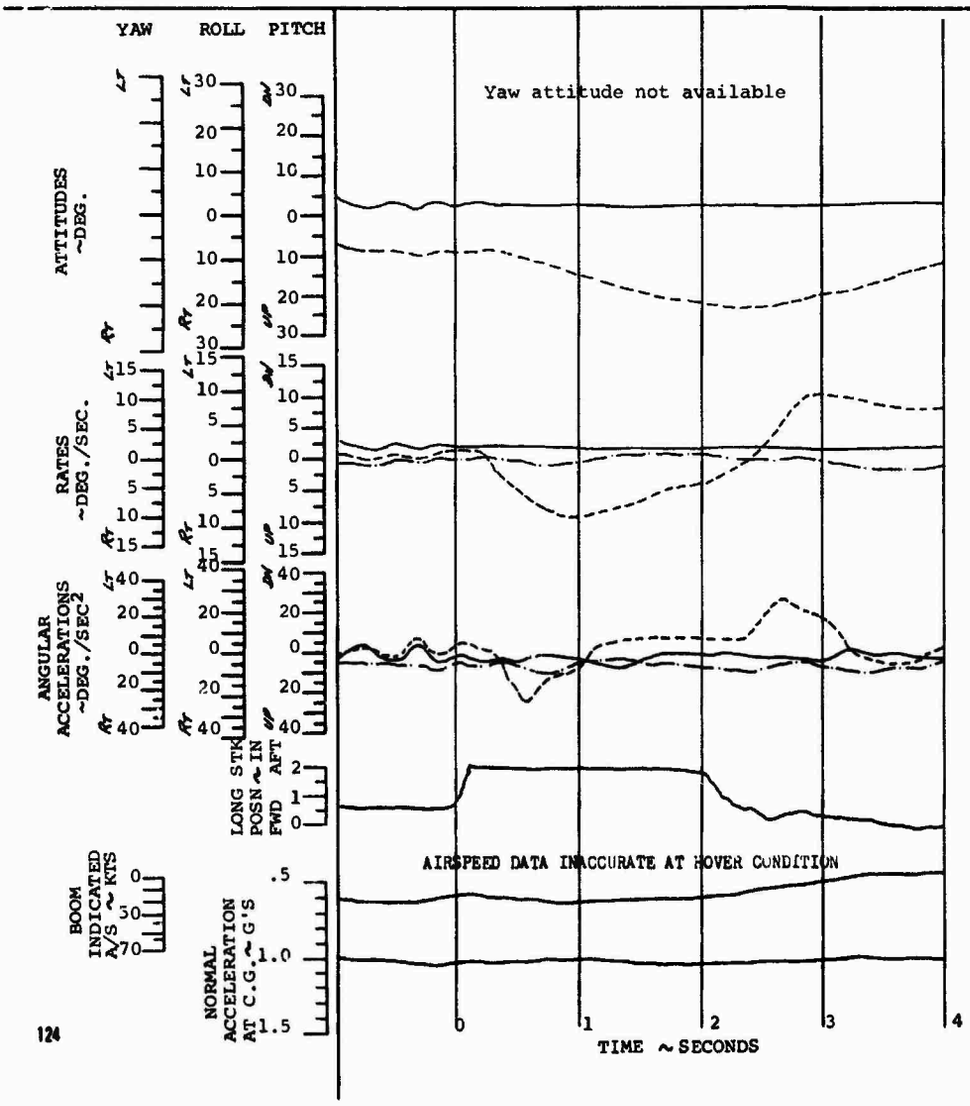

FIGURE NO. 75

LEFT DIRECTIONAL STEP

YCH-47C USA S/N 66-19121

LEGEND
PITCH
ROLL
YAW

IGE HOVER
TRIM AIRSPEED = 0 KTS
AVG. DENSITY ALTITUDE = 130 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 46450 LB
AVG. ROTOR SPEED = 242 RPM
C.G. LOCATION = 10.7" FWD
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

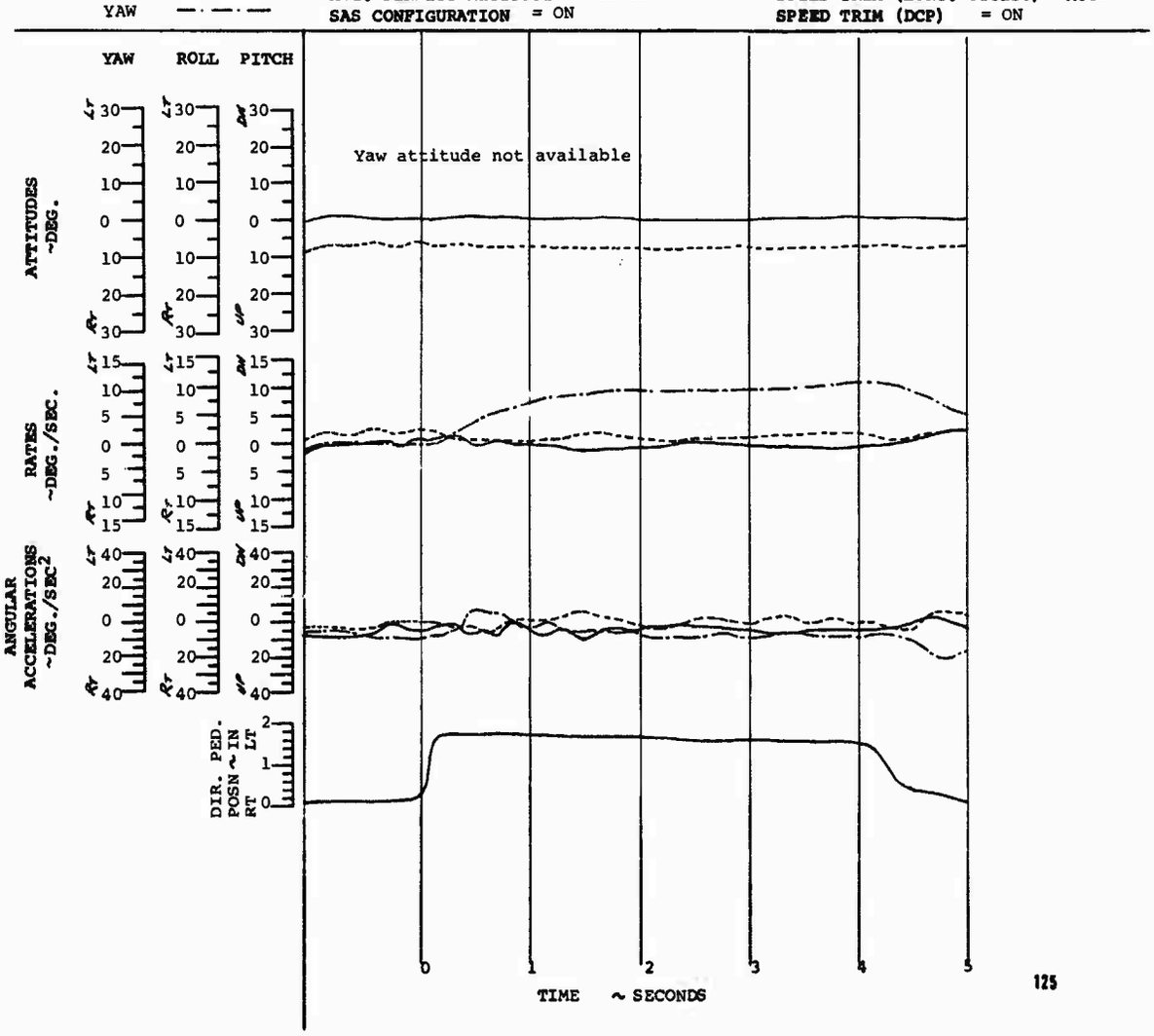

FIGURE NO. 76
RIGHT LATERAL STEP

YCH-47C USA S/N 66-19121

LEGEND
PITCH - - - - - -
ROLL ————————
YAW —·—·—·—

IGE HOVER
TRIM AIRSPEED = 0 KTS
AVG. DENSITY ALTITUDE = 230 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 46,800 LB
AVG. ROTOR SPEED = 242 RPM
C.G. LOCATION = 10.8"
SPEED TRIM (LONG. CYCLIC)= AUTO
SPEED TRIM (DCP) = ON

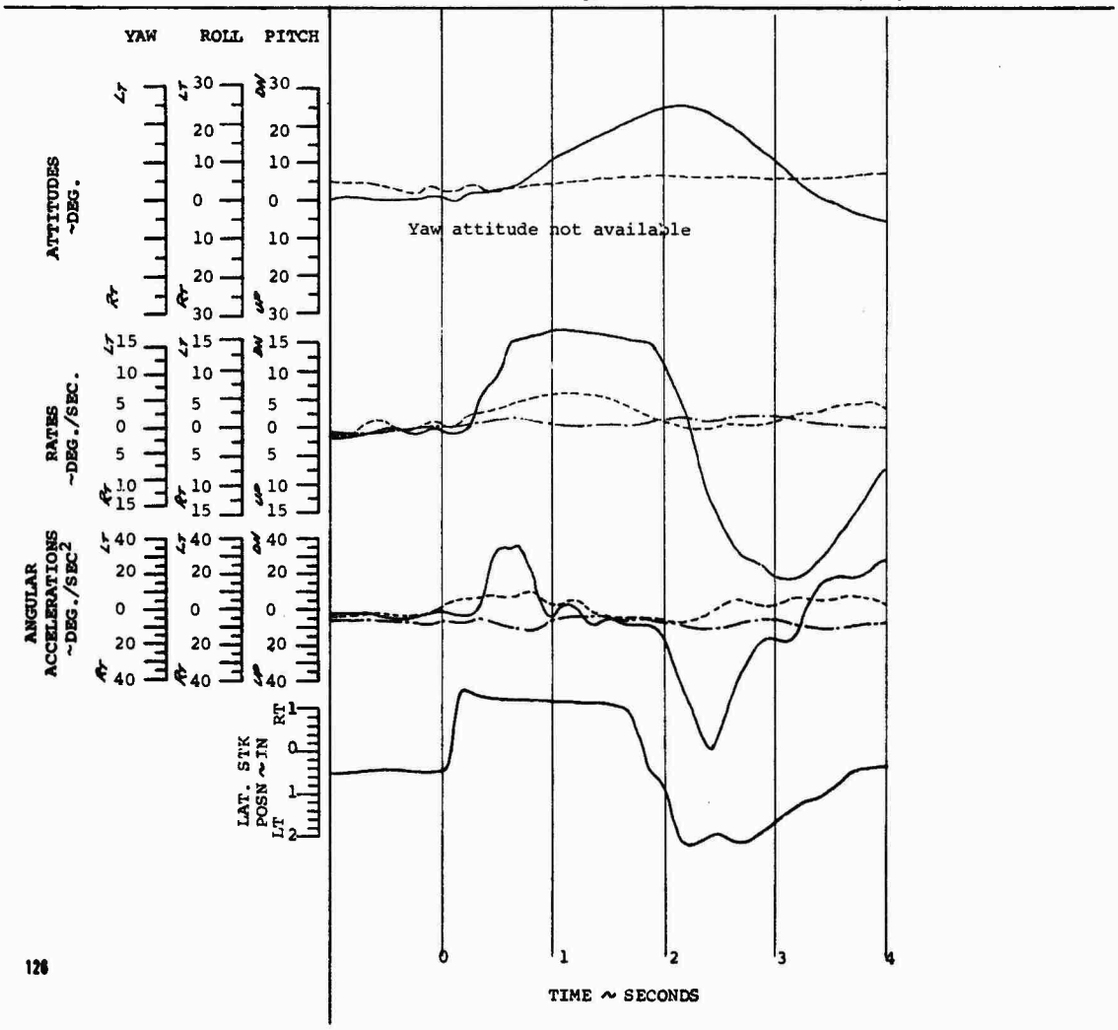

FIGURE NO. 77

LONGITUDINAL FORWARD PULSE

YCH-47C USA S/N 66-19121

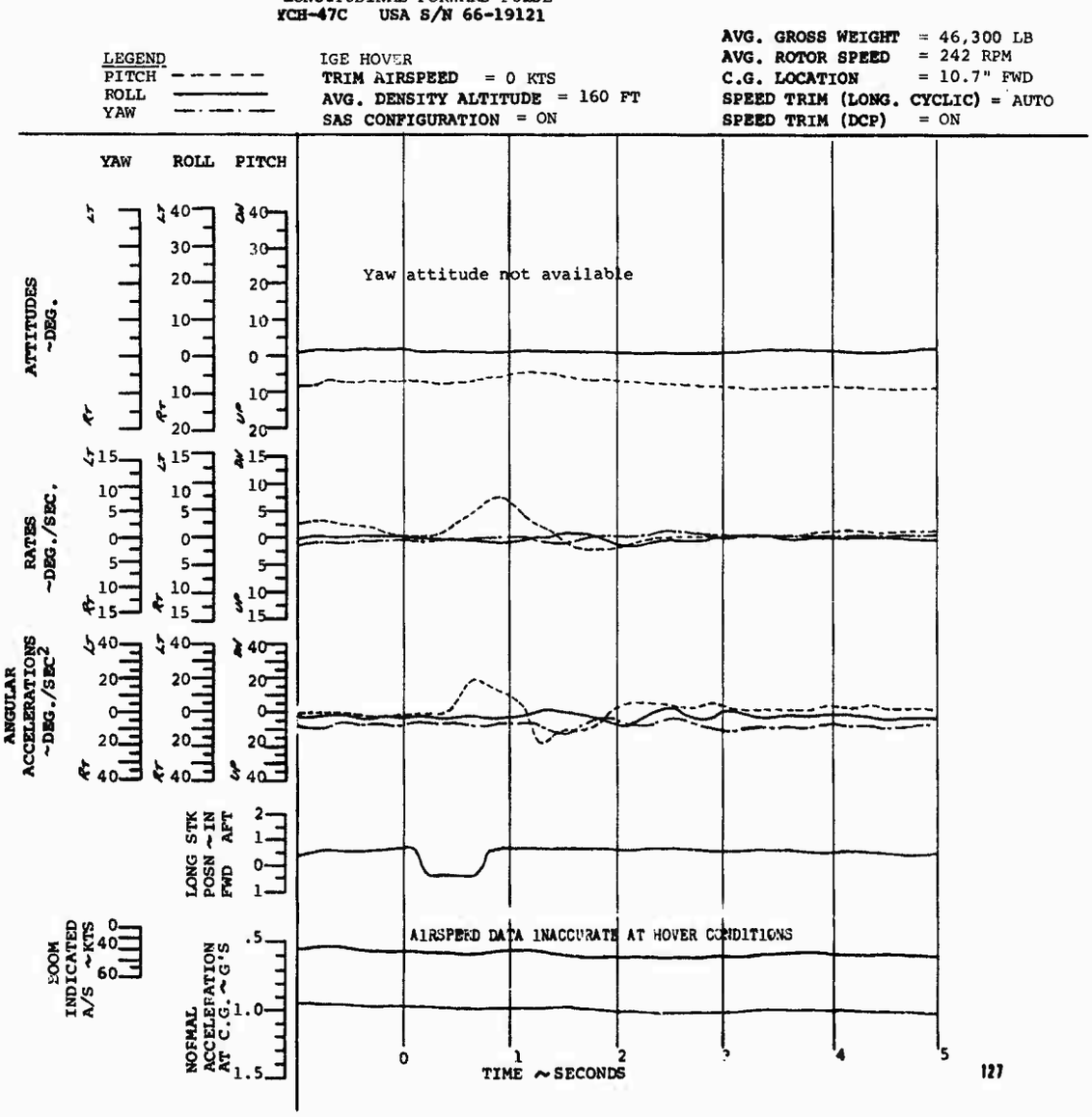

FIGURE NO. 78
AFT LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH
ROLL
YAW

OGE HOVER
TRIM AIRSPEED = 0 KTS
AVG. DENSITY ALTITUDE = 780 FT
SAS CONFIGURATION = OFF

AVG. GROSS WEIGHT = 35990 LB
AVG. ROTOR SPEED = 242 RPM
C.G. LOCATION = 6.9" AFT
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

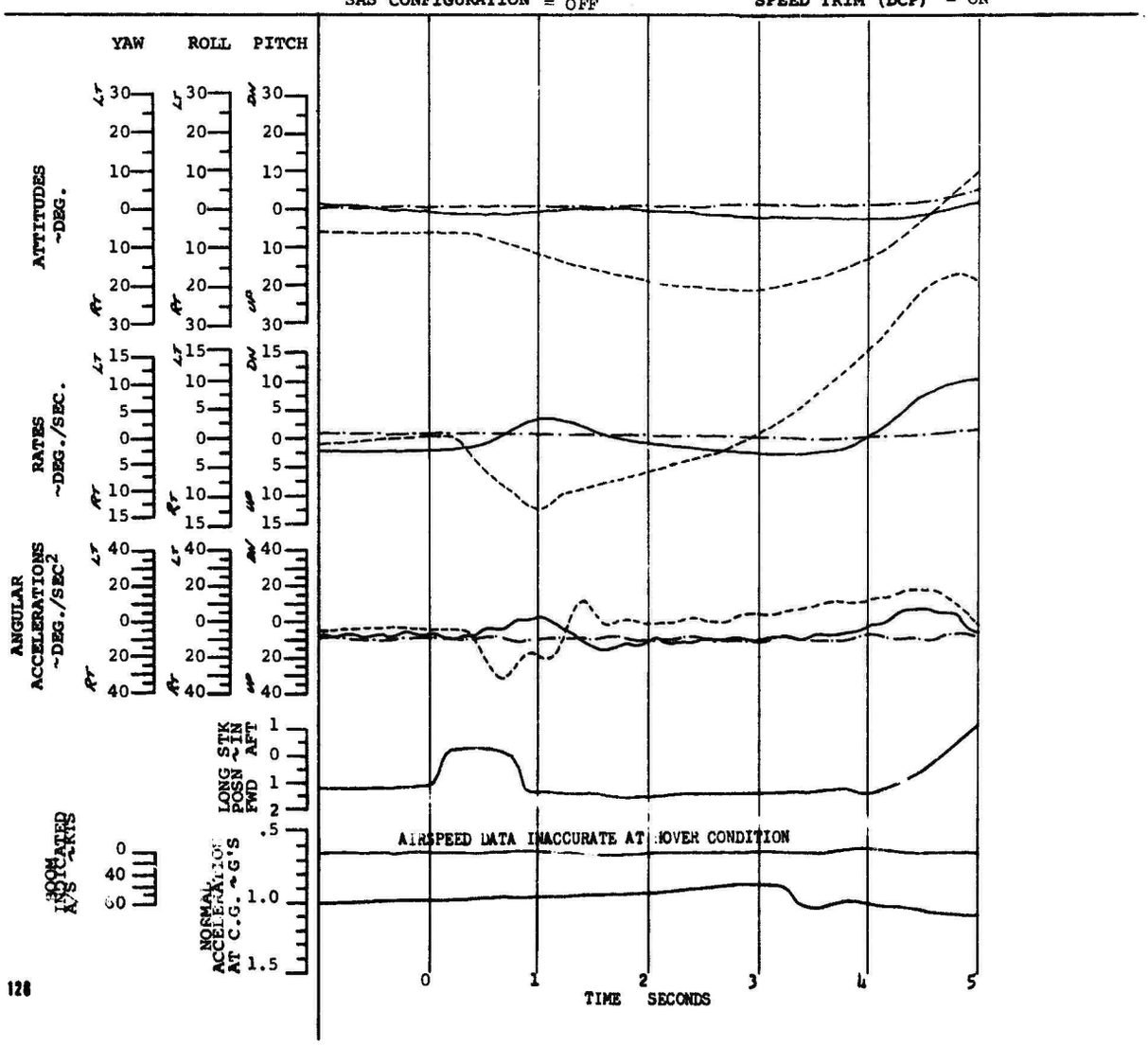

FIGURE NO. 79

LEFT LATERAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH ------
ROLL ————
YAW —·—·—

IGE HOVER
TRIM AIRSPEED = 0 KTS
AVG. DENSITY ALTITUDE = 160 FT
SAS CONFIGURATION : ON

AVG. GROSS WEIGHT = 46,180 LB
AVG. ROTOR SPEED = 242 RPM
C.G. LOCATION = 10.6" FWD
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

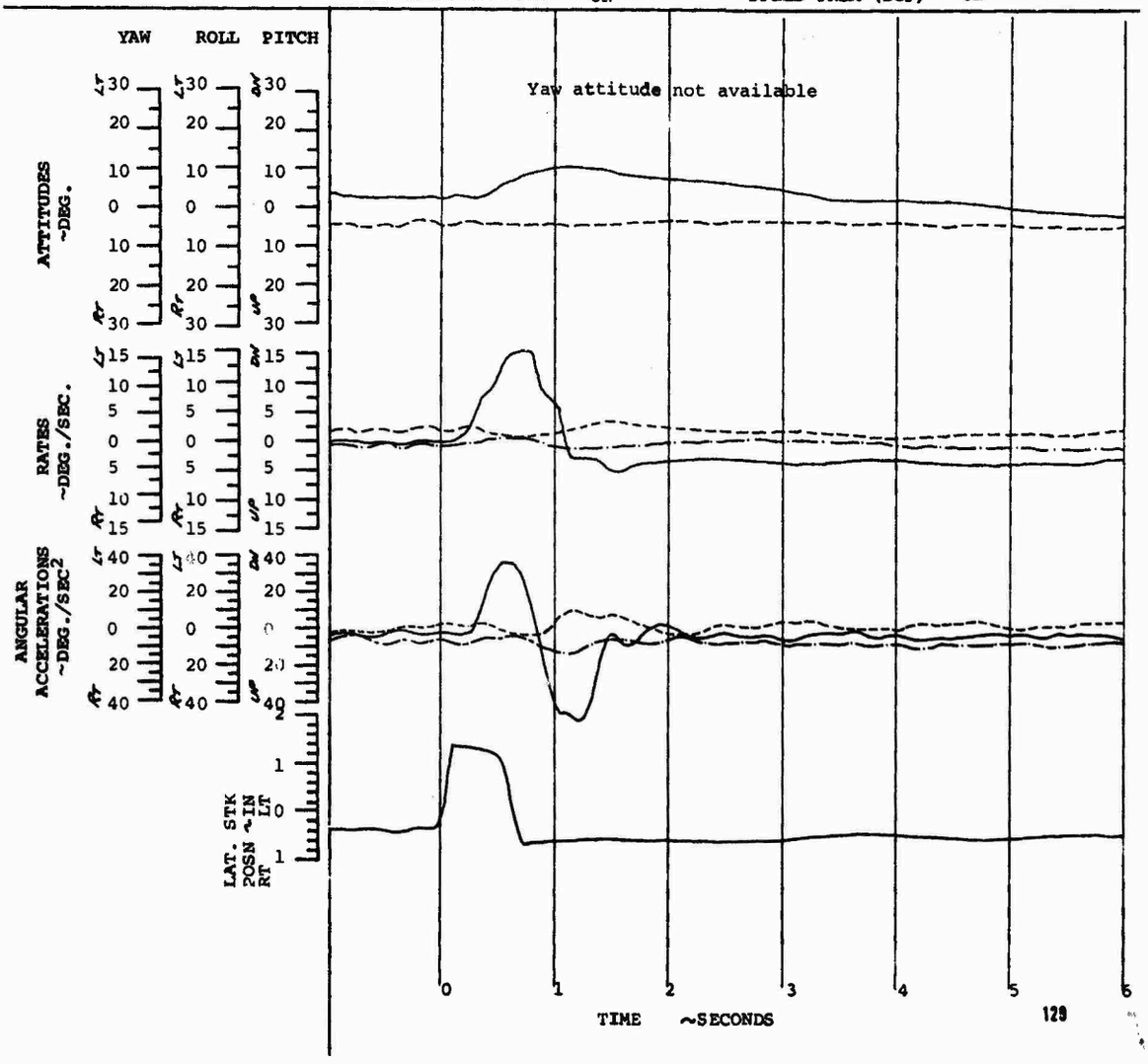

FIGURE NO. 80

LEFT LATERAL PULSE

YCH-47C USA S/N 66-19121

LEGEND
PITCH - - - - - -
ROLL ———
YAW —·—·—

OGE HOVER
TRIM AIRSPEED = 0 KTS
AVG. DENSITY ALTITUDE = 600 FT
SAS CONFIGURATION = OFF

AVG. GROSS WEIGHT = 34940 LB
AVG. ROTOR SPEED = 241 RPM
C.G. LOCATION = 7.0" AFT
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

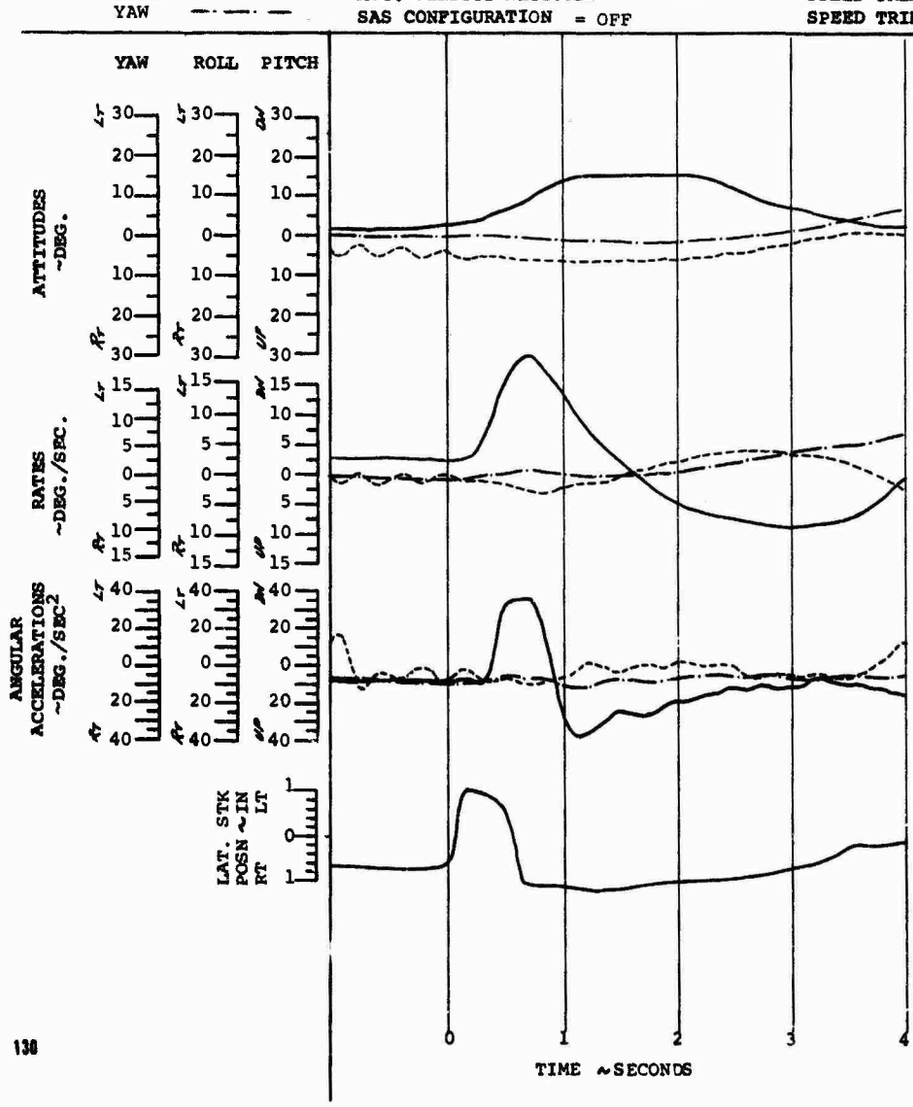

FIGURE NO. 81

LEFT DIRECTIONAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
ROLL - - - - -
PITCH ———
YAW —·—·—

OGE HOVER
TRIM AIRSPEED = 0 KTS
AVG. DENSITY ALTITUDE = 630 FT
SAS CONFIGURATION = OFF

AVG. GROSS WEIGHT = 36,120 LB
AVG. ROTOR SPEED = 234 RPM
C.G. LOCATION = 6.8" Aft
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

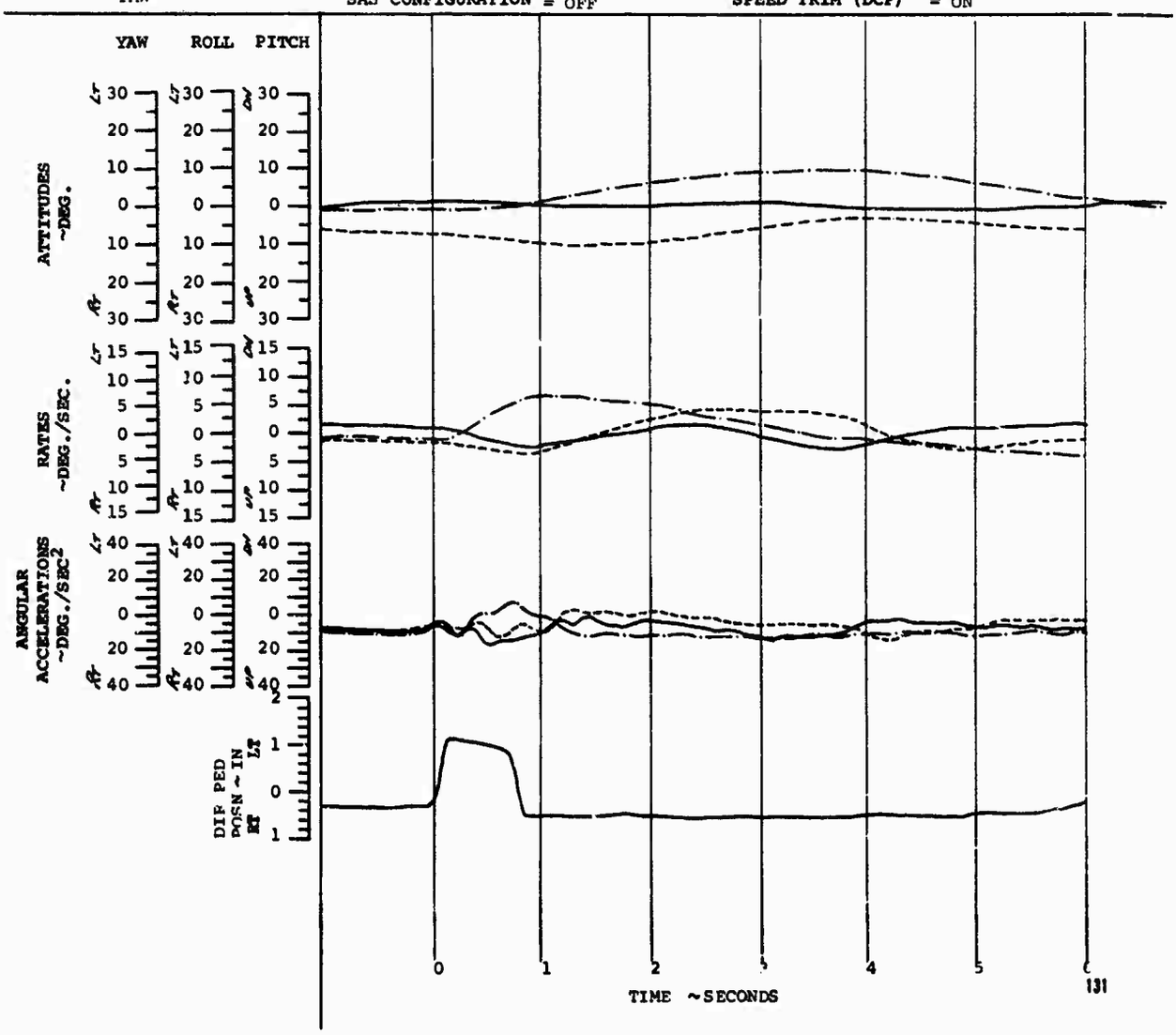

FIGURE NO. 82

LEFT DIRECTIONAL PULSE

YCH-47C USA S/N 66-19121

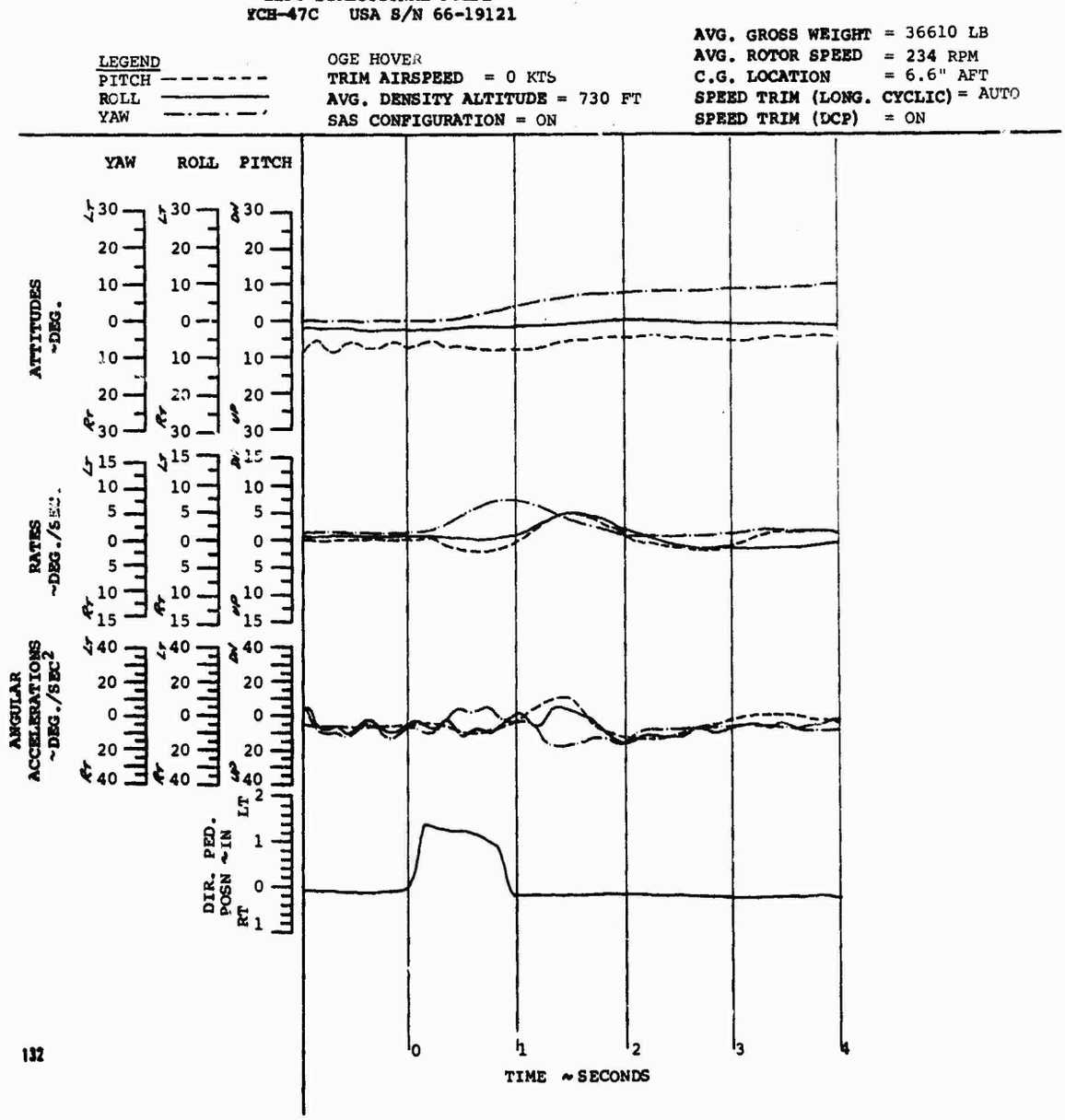

FIGURE NO. 83

FORWARD LONGITUDINAL PULSE

YCH-47C USA S/N 66-19121

LEGEND
PITCH - - - - - -
ROLL ———
YAW —·—·—·—

REARWARD FLIGHT
TRIM AIRSPEED = 30 KTS
AVG. DENSITY ALTITUDE = 2600 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 45500 LB
AVG. ROTOR SPEED = 242 RPM
C.G. LOCATION = 4.2" AFT
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

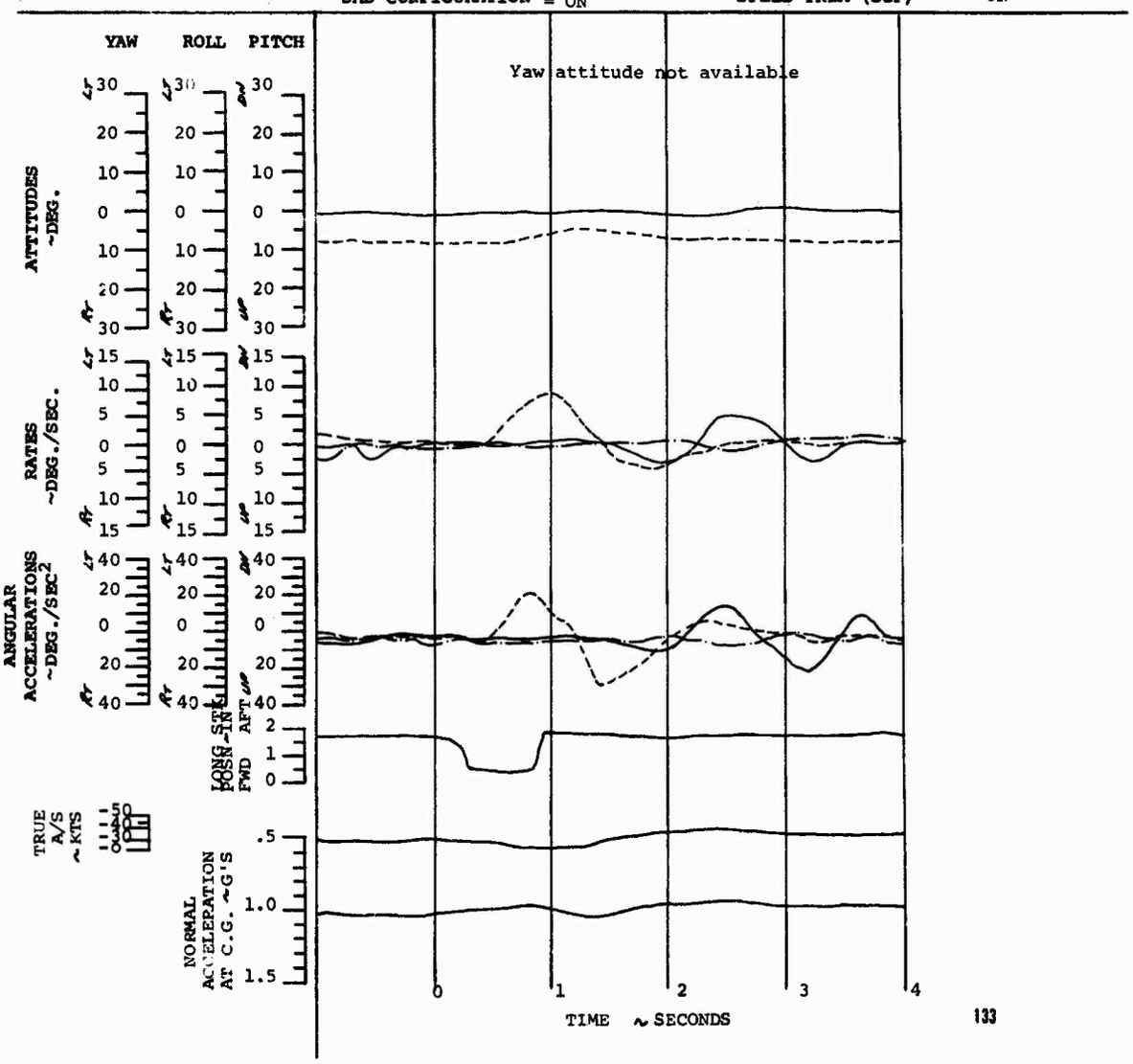

FIGURE NO. 84

AFT LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH - - - - -
ROLL ———
YAW —·—·—

REARWARD FLIGHT
TRIM AIRSPEED = 30 KTS
AVG. DENSITY ALTITUDE = 600 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 45300 LB
AVG. ROTOR SPEED = 242 RPM
C.G. LOCATION = 10.0" FWD
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

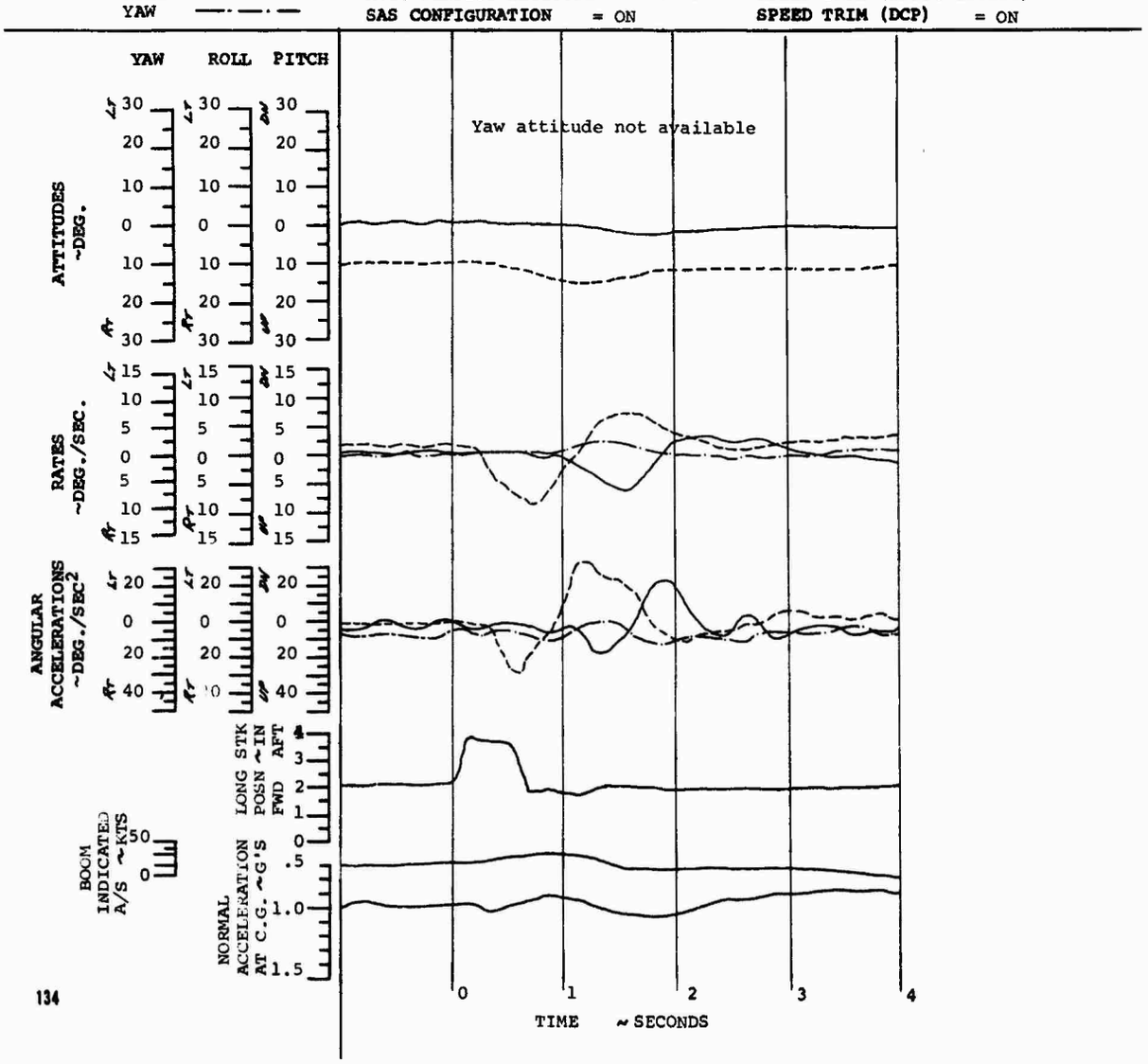

FIGURE NO. 85

RIGHT LATERAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH - - - - -
ROLL ———
YAW —·—·—

LEFT SIDEWARD FLIGHT
TRIM AIRSPEED = 35 KTS
AVG. DENSITY ALTITUDE = 980 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 36780 LB
AVG. ROTOR SPEED = 233 RPM
C.G. LOCATION = 6.6" AFT
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

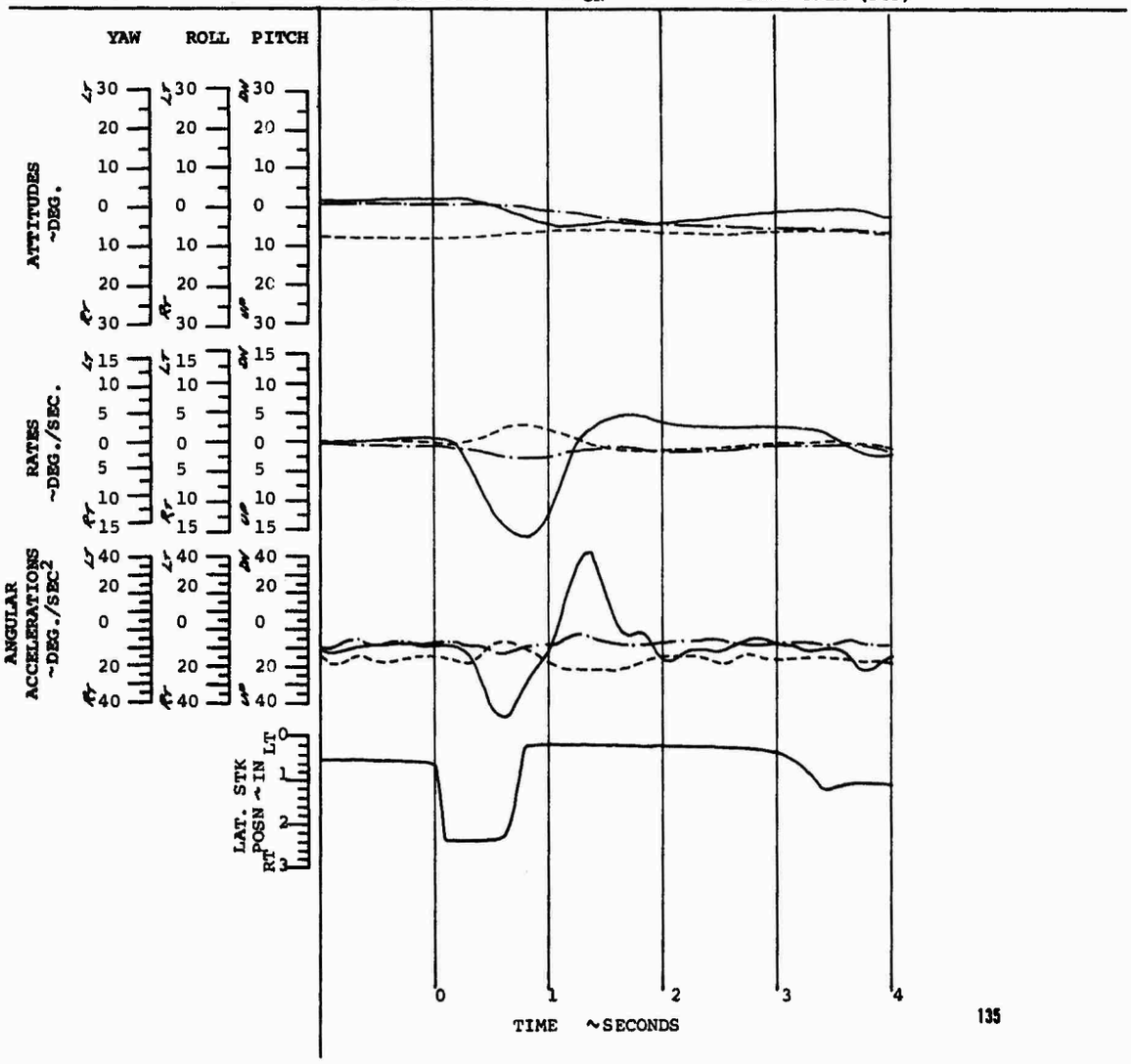

FIGURE NO. 86
LEFT DIRECTIONAL PULSE

YCH-47C USA S/N 66-19121

LEGEND
PITCH ------
ROLL ———
YAW _·_·_·

LEFT SIDEWARD FLIGHT
TRIM AIRSPEED = 35 KTS
AVG. DENSITY ALTITUDE = 970 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 36,700 LB
AVG. ROTOR SPEED = 232 RPM
C.G. LOCATION = 6.6" AFT
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

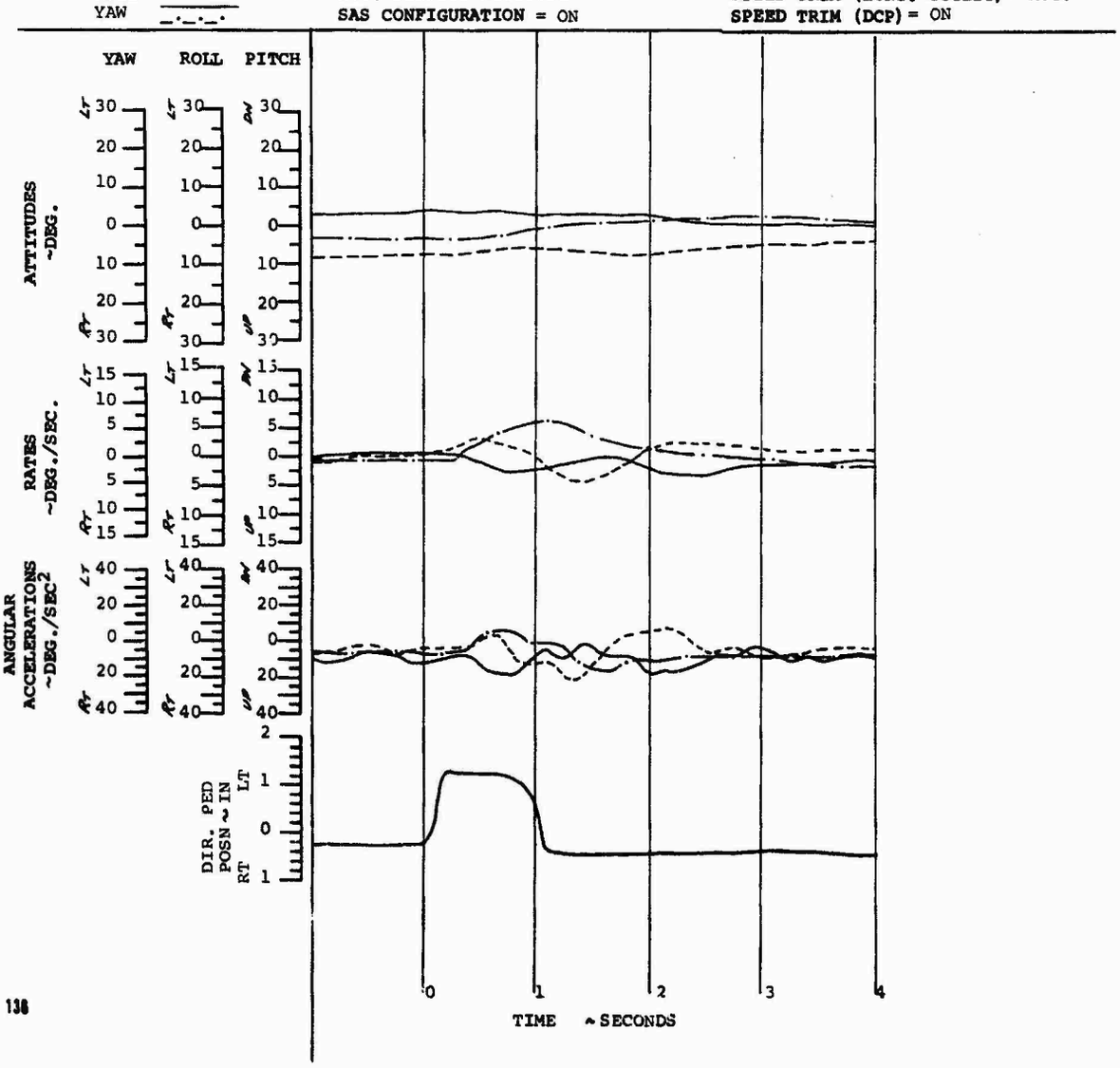

FIGURE NO. 87

AFT LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH ---------
ROLL ———————
YAW —·—·—·——

LEVEL FLIGHT
TRIM AIRSPEED = 68 KTS
AVG. DENSITY ALTITUDE = 13600 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 35,020 LB
AVG. ROTOR SPEED = 246 RPM
C.G. LOCATION = 7.5 IN AFT
SPEED TRIM (LONG. CYCLIC)=MAN.EXT.
SPEED TRIM (DCP) = ON

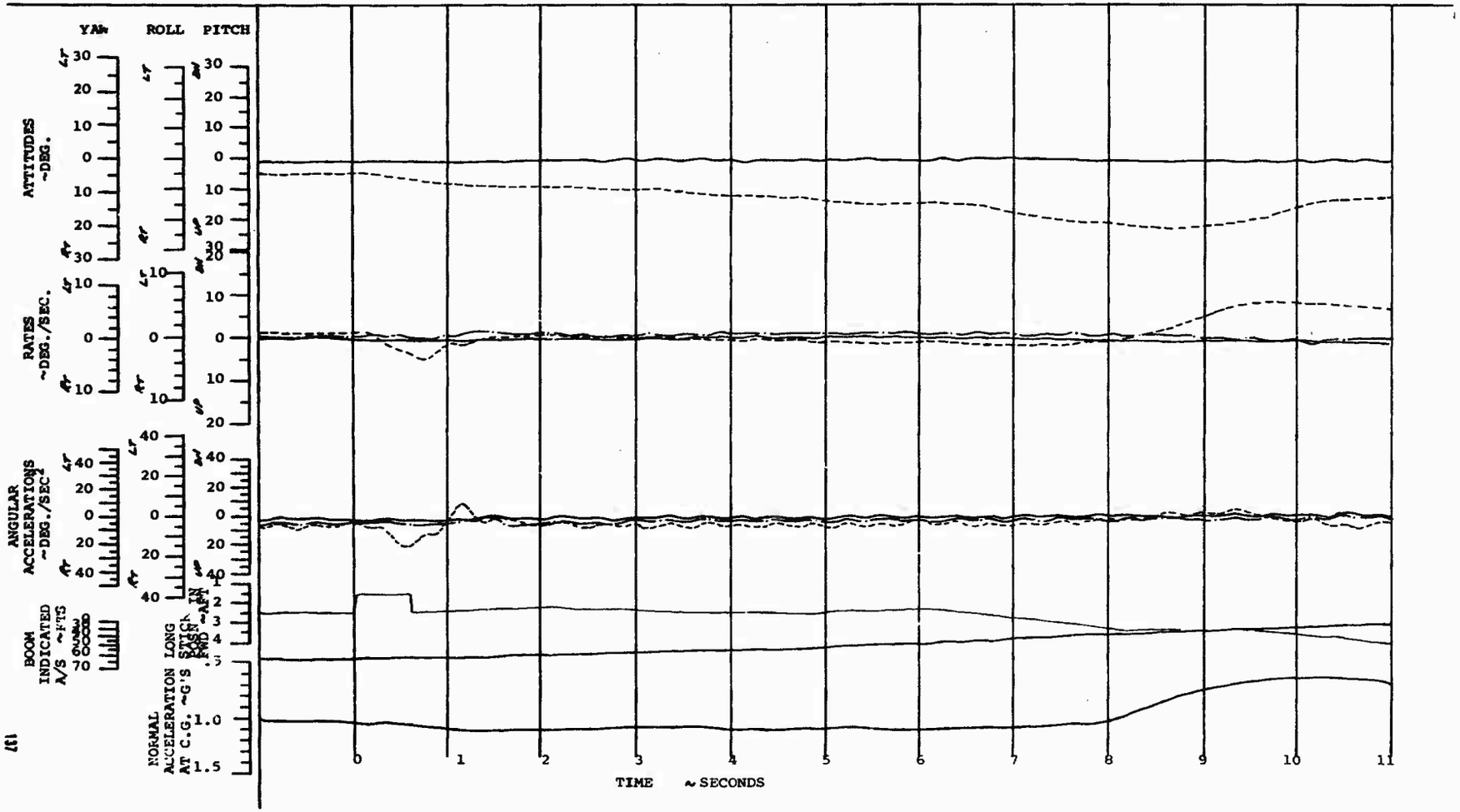

FIGURE NO. 88
AFT LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH ------
ROLL ————
YAW —·—·—

LEVEL FLIGHT
TRIM AIRSPEED = 70 KTS
AVG. DENSITY ALTITUDE = 13790 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 35260 LB
AVG. ROTOR SPEED = 246 RPM
C.G. LOCATION = 7.3 IN AFT
SPEED TRIM (LONG. CYCLIC)= AUTO
SPEED TRIM (DCP) = ON

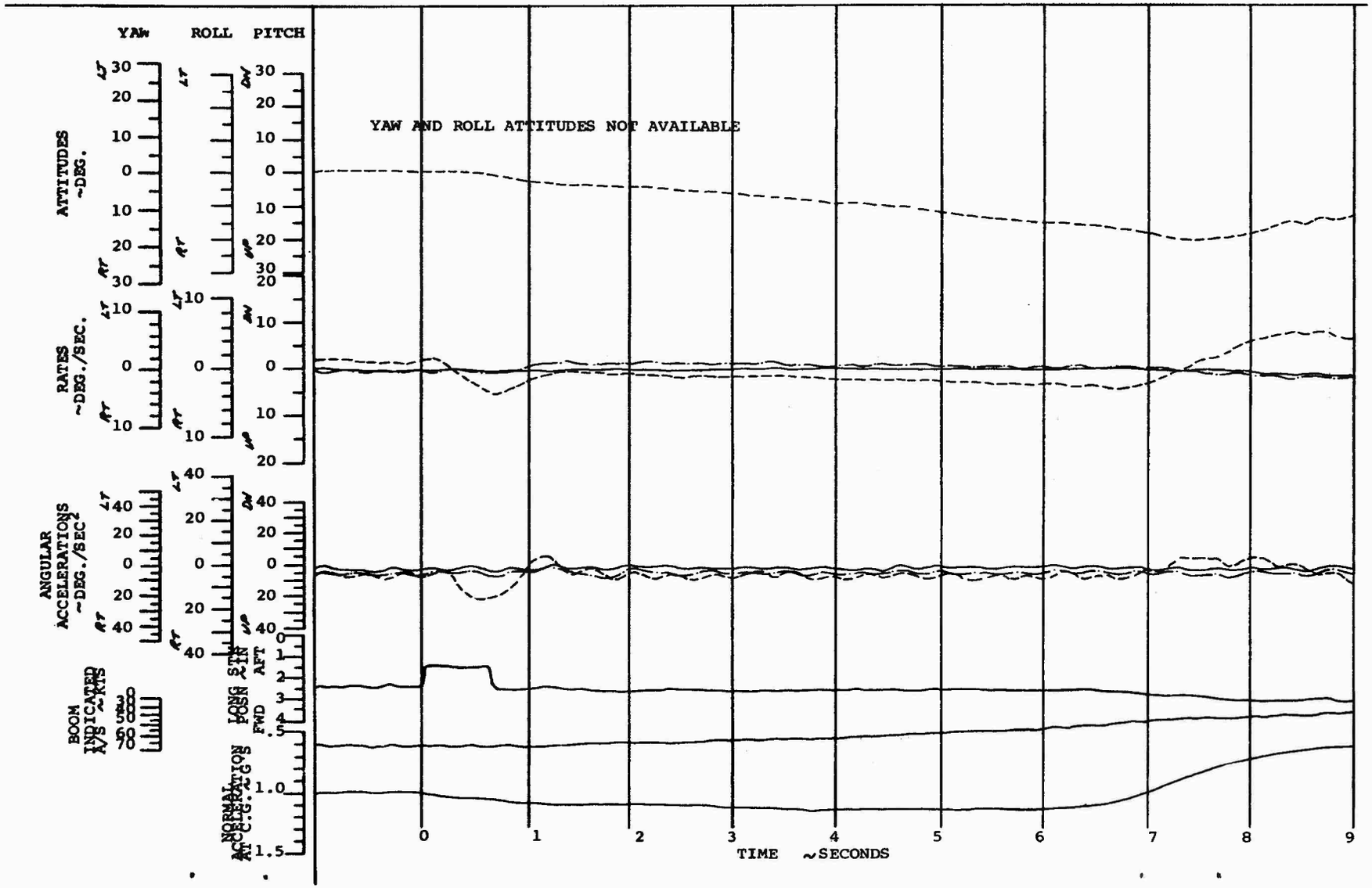

FIGURE NO. 89
AFT LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH ------
ROLL ———
YAW —·—·—

LEVEL FLIGHT
TRIM AIRSPEED = 74 KTS
AVG. DENSITY ALTITUDE = 4610 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT= 37100 LB
AVG. ROTOR SPEED = 235 RPM
C.G. LOCATION = 6.2" AFT
SPEED TRIM (LONG. CYCLIC)= AUTO
SPEED TRIM (DCP) = ON

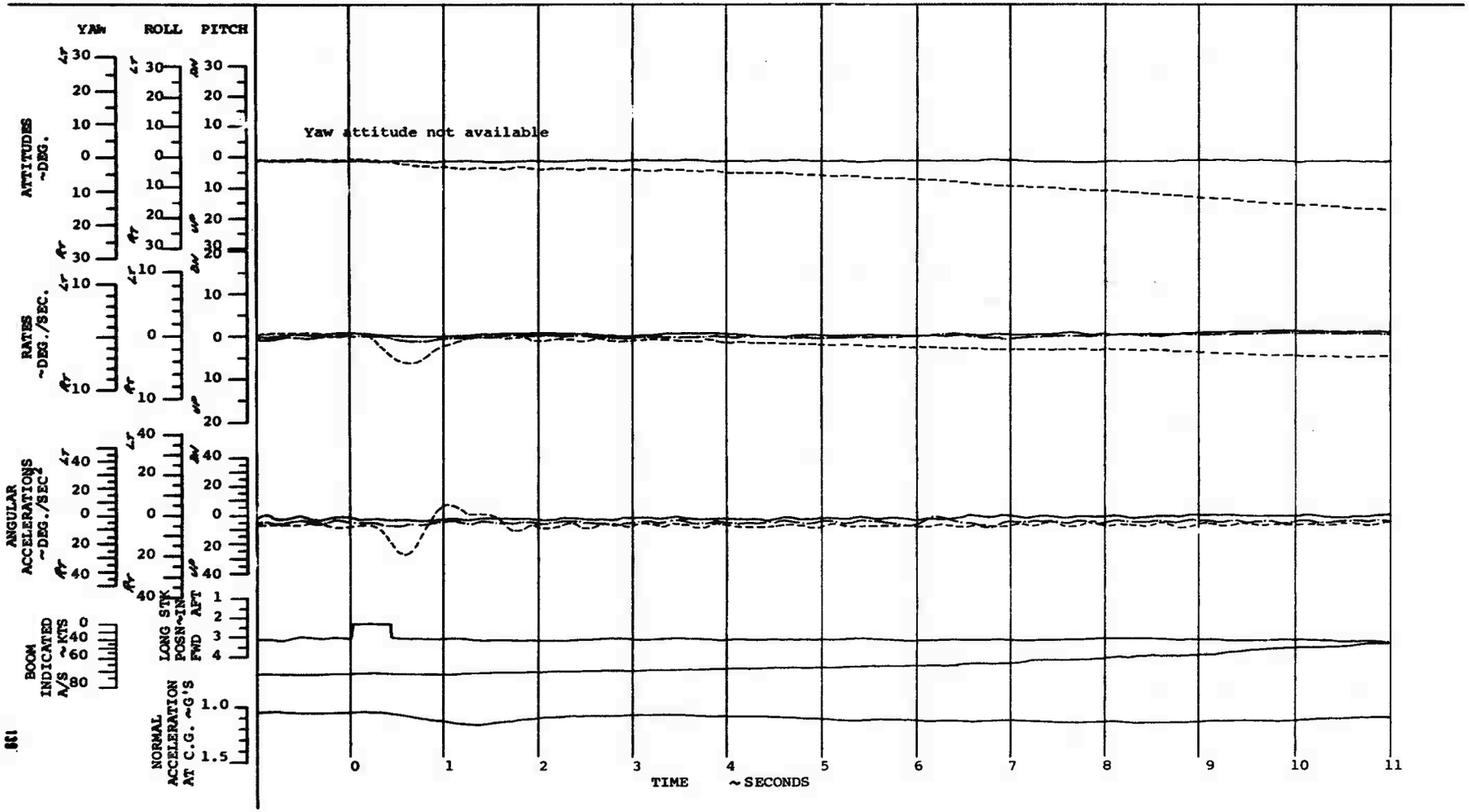

FIGURE NO. 90
AFT LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH
ROLL
YAW

LEVEL FLIGHT
TRIM AIRSPEED = 75 KTS
AVG. DENSITY ALTITUDE = 9850 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 35860 LB
AVG. ROTOR SPEED = 245 RPM
C.G. LOCATION = 6.8" AFT
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

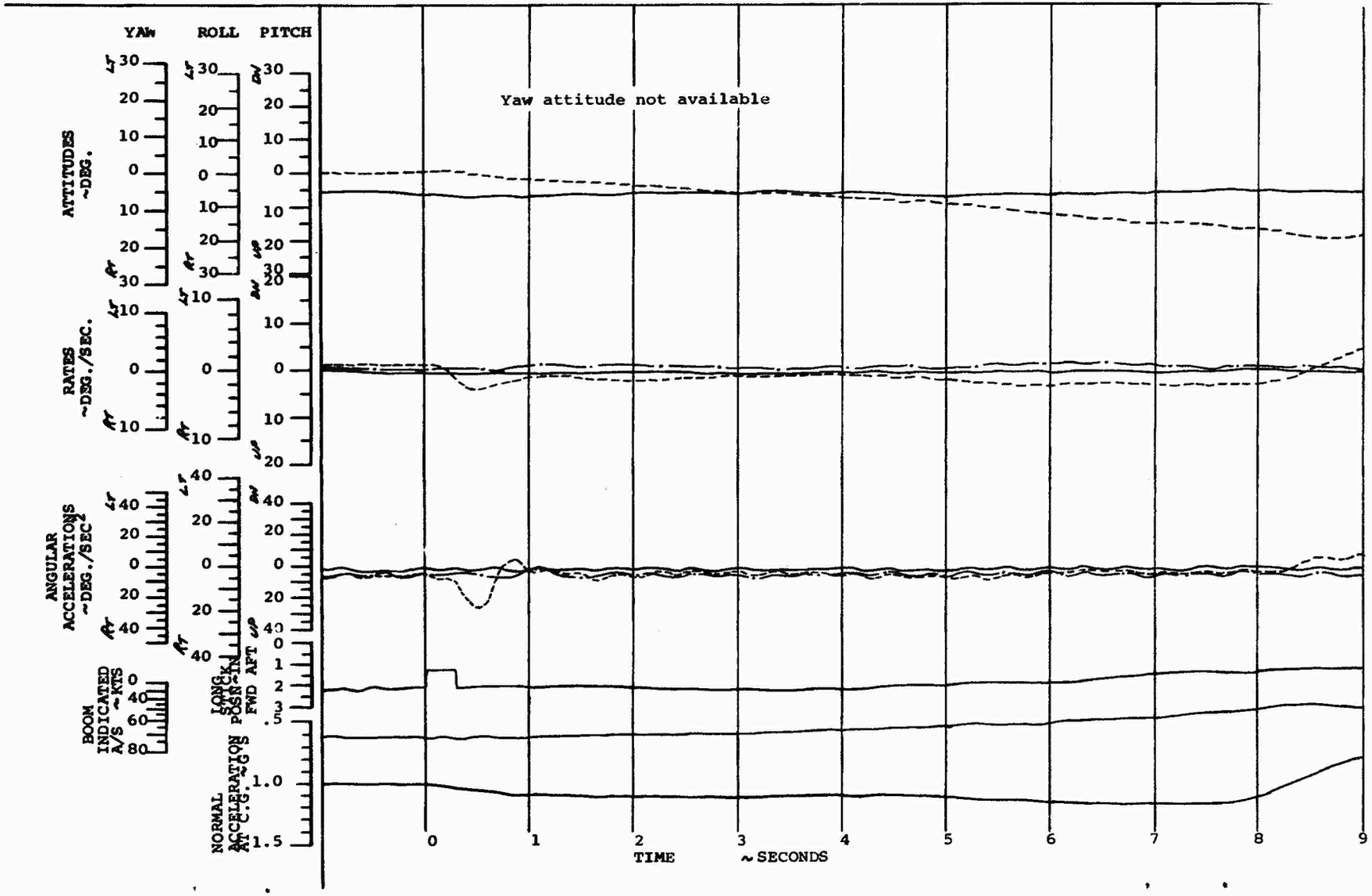

FIGURE NO. 91
AFT LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH - - - - - -
ROLL ———
YAW —·—·—·

LEVEL FLIGHT
TRIM AIRSPEED = 87 KTS
AVG. DENSITY ALTITUDE = 9860 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 36300 LB
AVG. ROTOR SPEED = 235 RPM
C.G. LOCATION = 6.5" AFT
SPEED TRIM (LONG. CYCLIC)= AUTO
SPEED TRIM (DCP) = ON

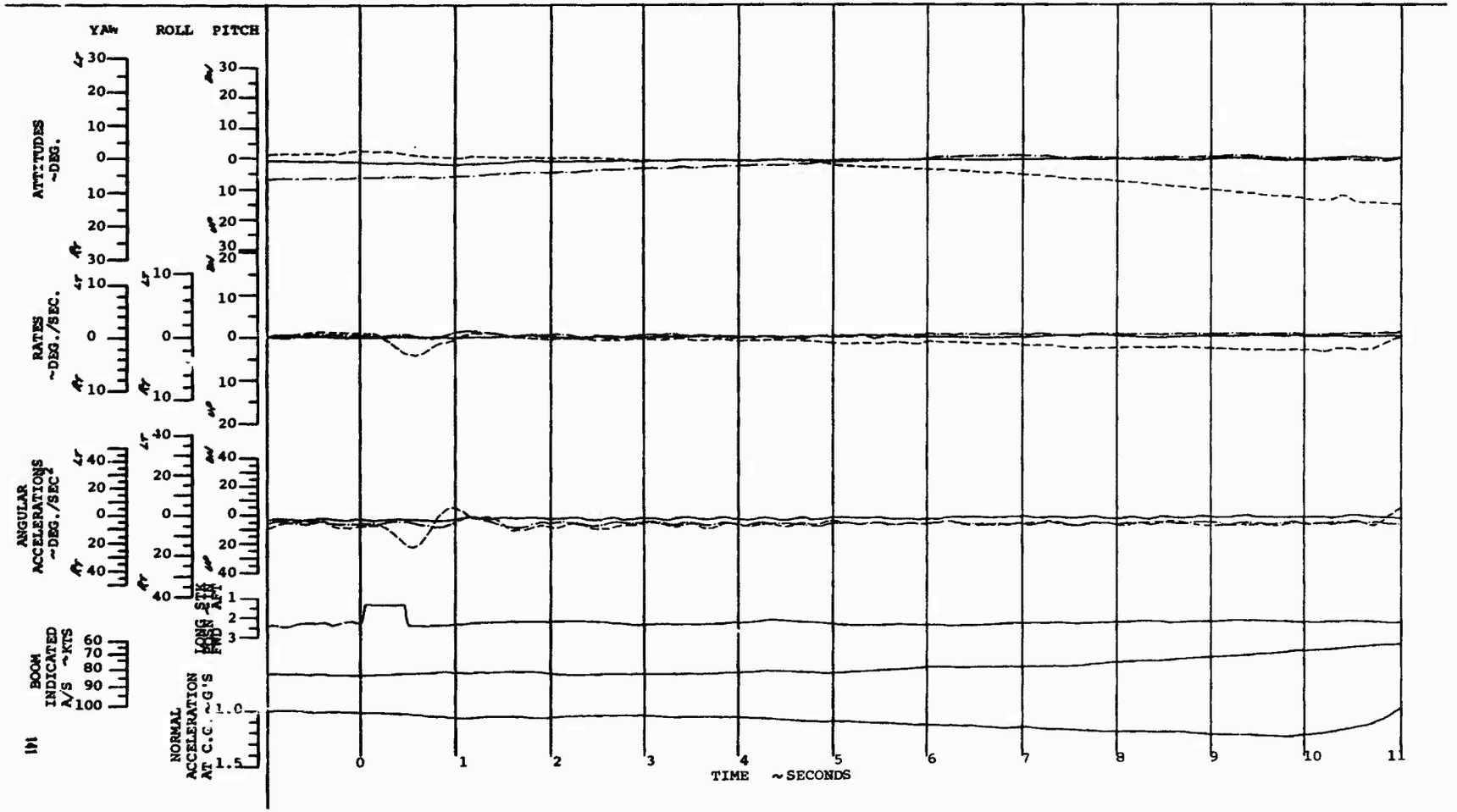

FIGURE NO. 92
AFT LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH
ROLL
YAW

LEVEL FLIGHT
TRIM AIRSPEED = 87 KTS
AVG. DENSITY ALTITUDE = 9730 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 35960 LB
AVG. ROTOR SPEED = 245 RPM
C.G. LOCATION = 6.7" AFT
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

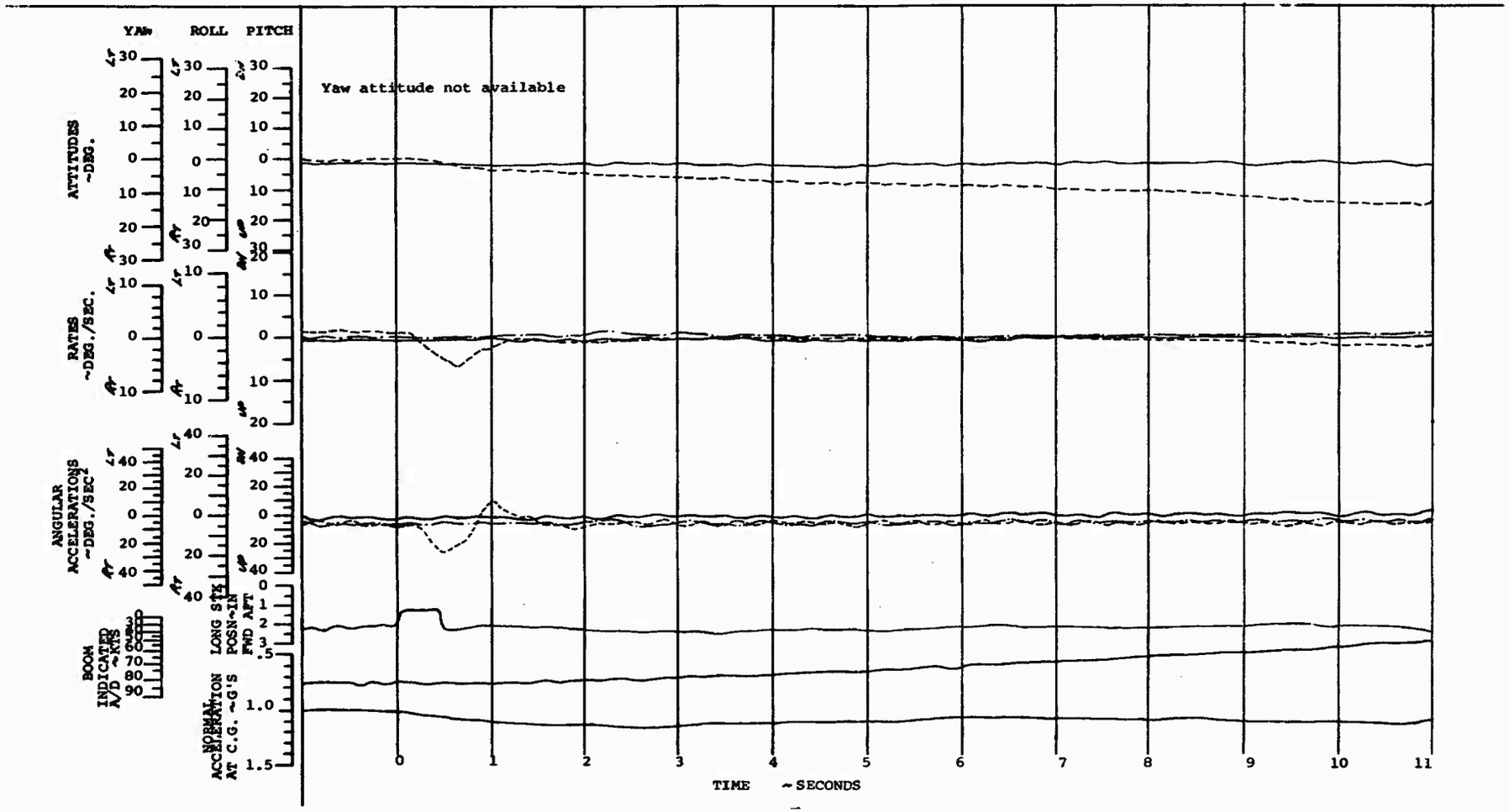

FIGURE NO. 93
AFT LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH - - - - - -
ROLL ———
YAW —·—·—·—

LEVEL FLIGHT
TRIM AIRSPEED = 127 KTS
AVG. DENSITY ALTITUDE = 4820 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 36,700 LB
AVG. ROTOR SPEED = 236 RPM
C.G. LOCATION = 6.4" AFT
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

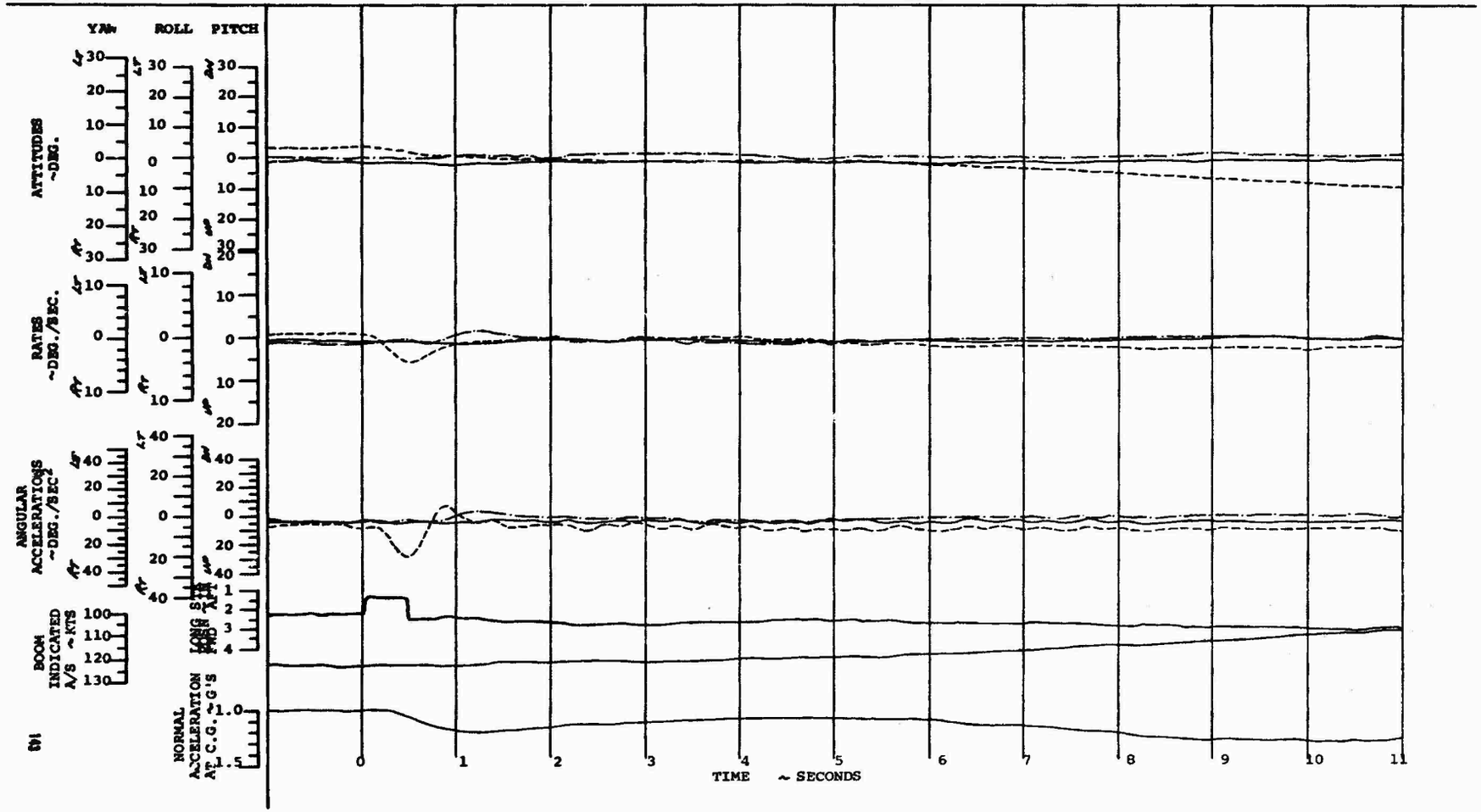

FIGURE NO. 94
AFT LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH
ROLL
YAW

LEVEL FLIGHT
TRIM AIRSPEED = 55 KTS
AVG. DENSITY ALTITUDE = 8130 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 46000 LB
AVG. ROTOR SPEED = 242 RPM
C.G. LOCATION = 10.6" FWD
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

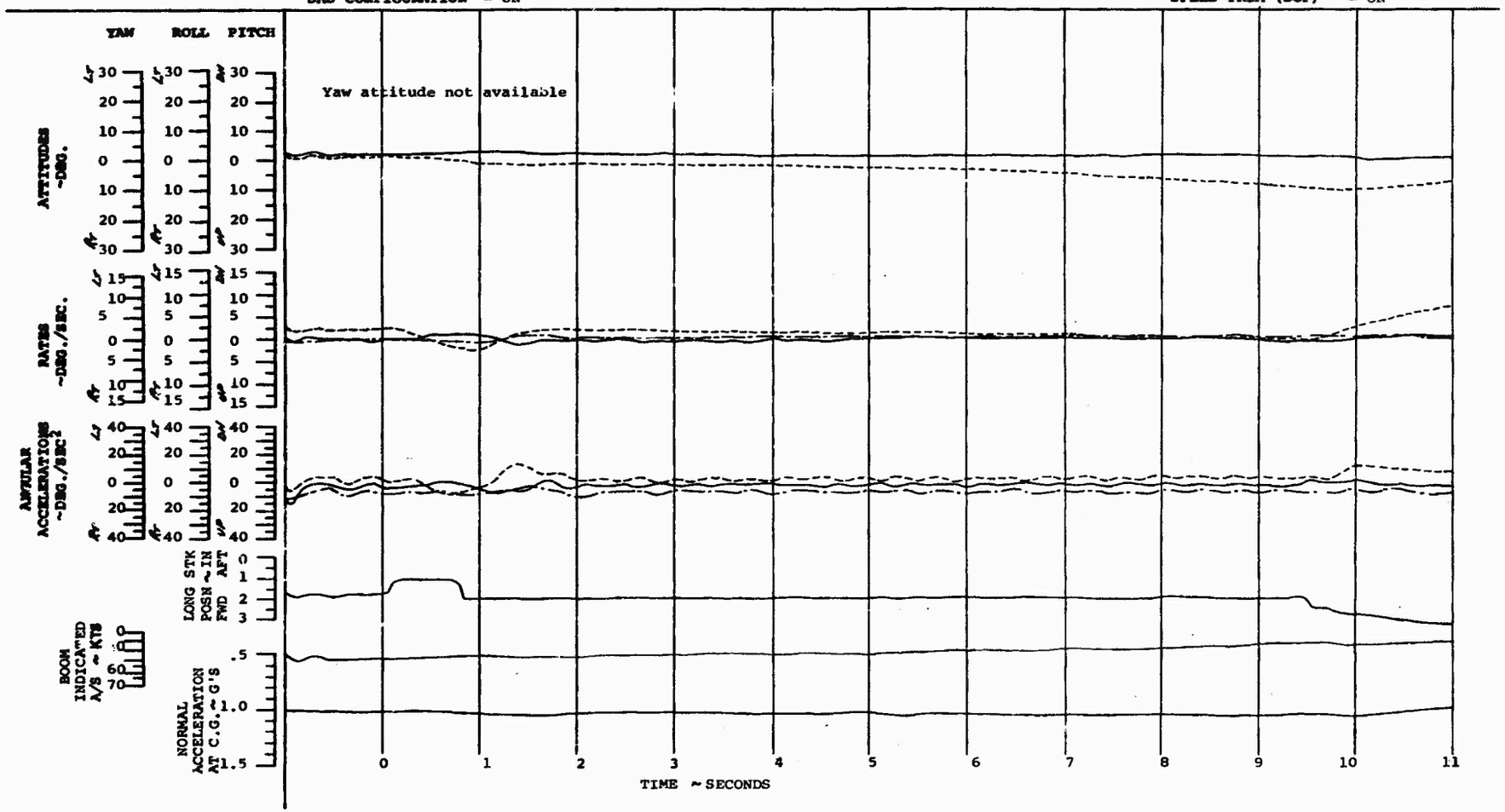

FIGURE NO. 95
AFT LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH - - - - - -
ROLL ———
YAW —·—·—

LEVEL FLIGHT
TRIM AIRSPEED = 55 KTS
AVG. DENSITY ALTITUDE = 8110 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 46500 LB
AVG. ROTOR SPEED = 244 RPM
C.G. LOCATION = 1.7" AFT
SPEED TRIM (LONG. CYCLIC)= AUTO
SPEED TRIM (DCP) = ON

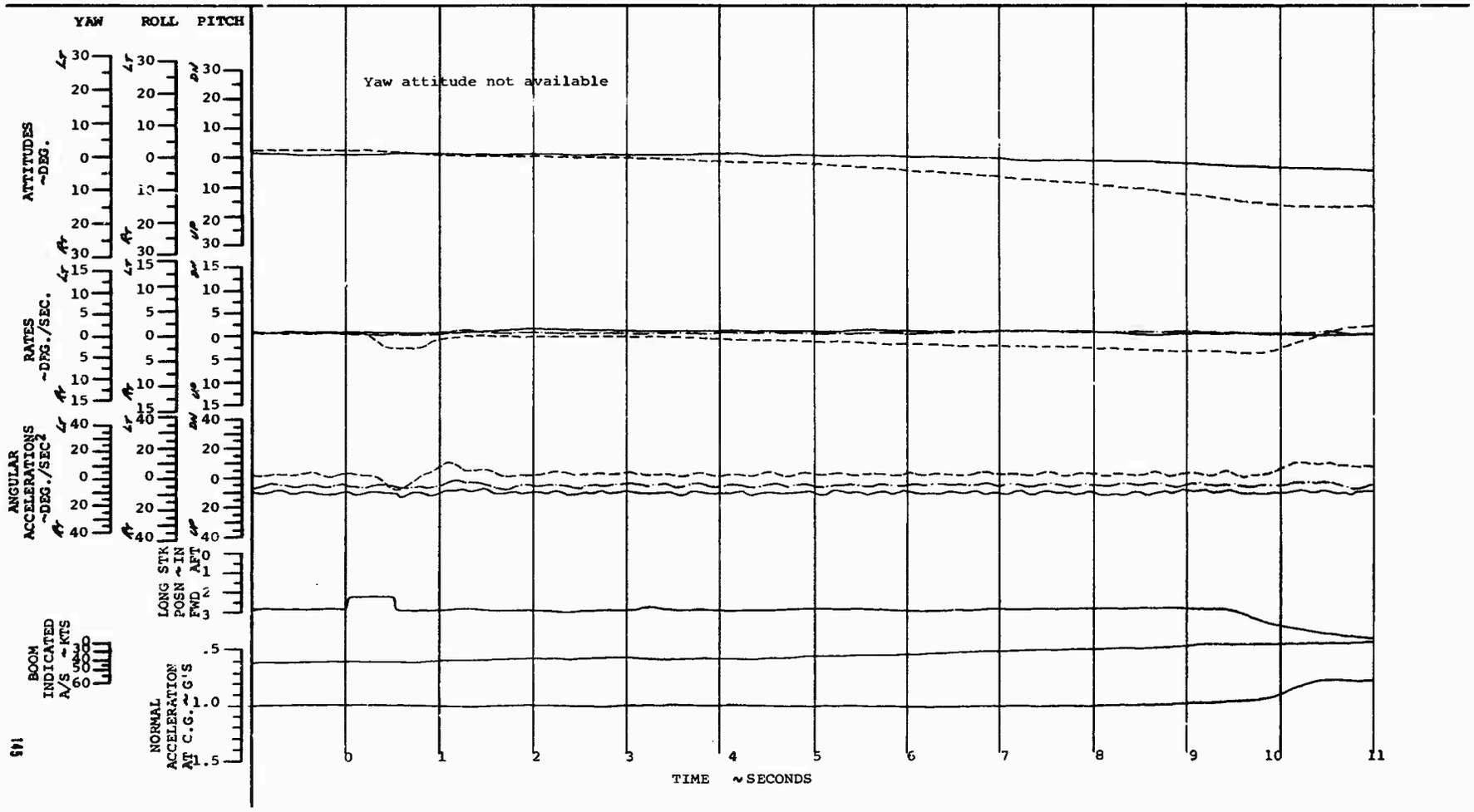

FIGURE NO. 96

AFT LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH
ROLL
YAW

LEVEL FLIGHT
TRIM AIRSPEED = 75 KTS
AVG. DENSITY ALTITUDE = 5000 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 46150 LB
AVG. ROTOR SPEED = 245 RPM
C.G. LOCATION = 1.9" AFT
SPEED TRIM (LONG. CYCLIC)= AUTO
SPEED TRIM (DCP) = ON

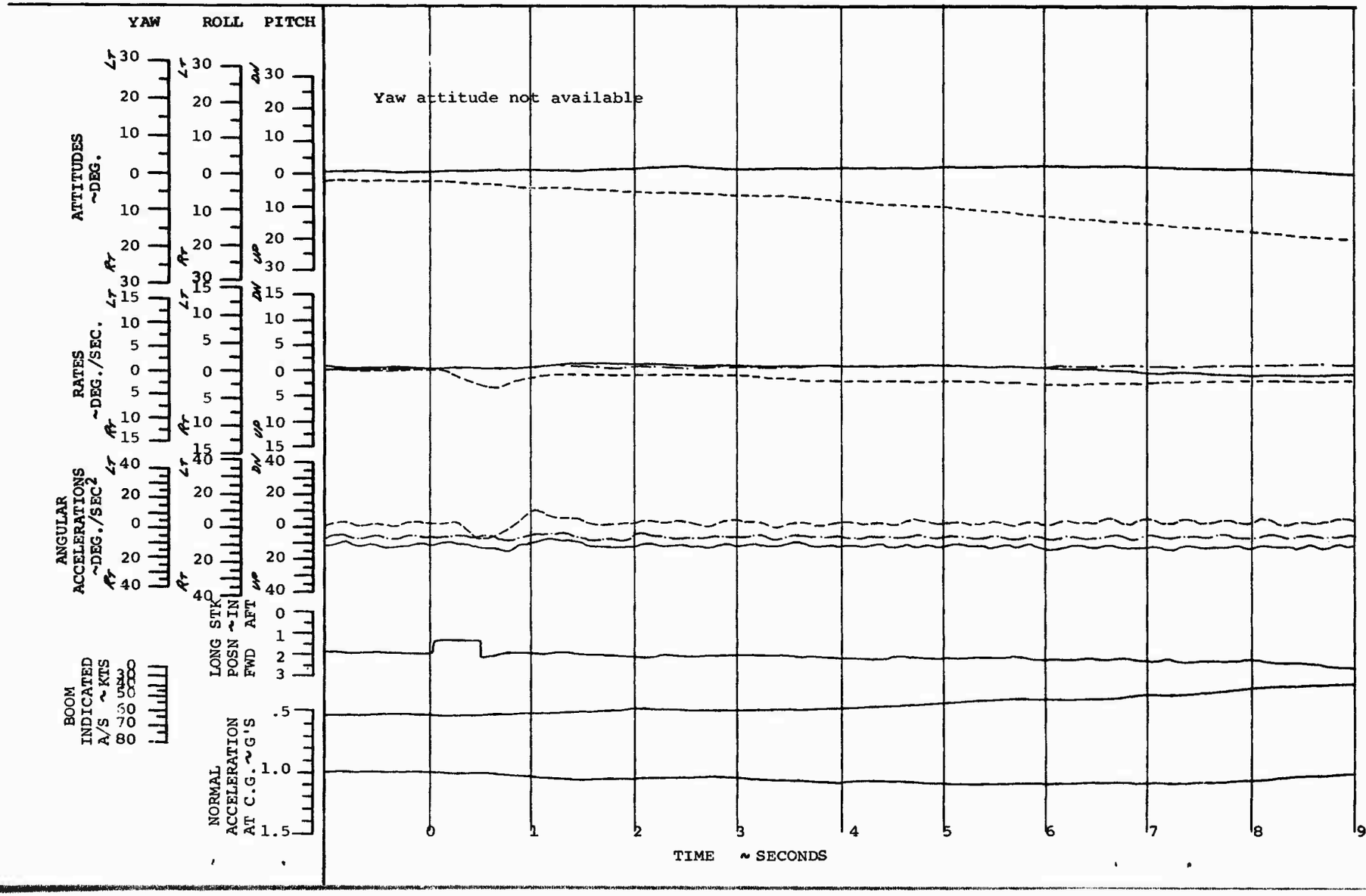

FIGURE NO. 97

AFT LONGITUDINAL PULSE

YCH-47C USA S/N 66-19121

LEGEND
PITCH - - - - - - -
ROLL ————————
YAW —·—·—·—

LEVEL FLIGHT
TRIM AIRSPEED = 68 KTS
AVG. DENSITY ALTITUDE = 7920 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 43900 LB
AVG. ROTOR SPEED = 245 RPM
C.G. LOCATION = 4.9" AFT
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

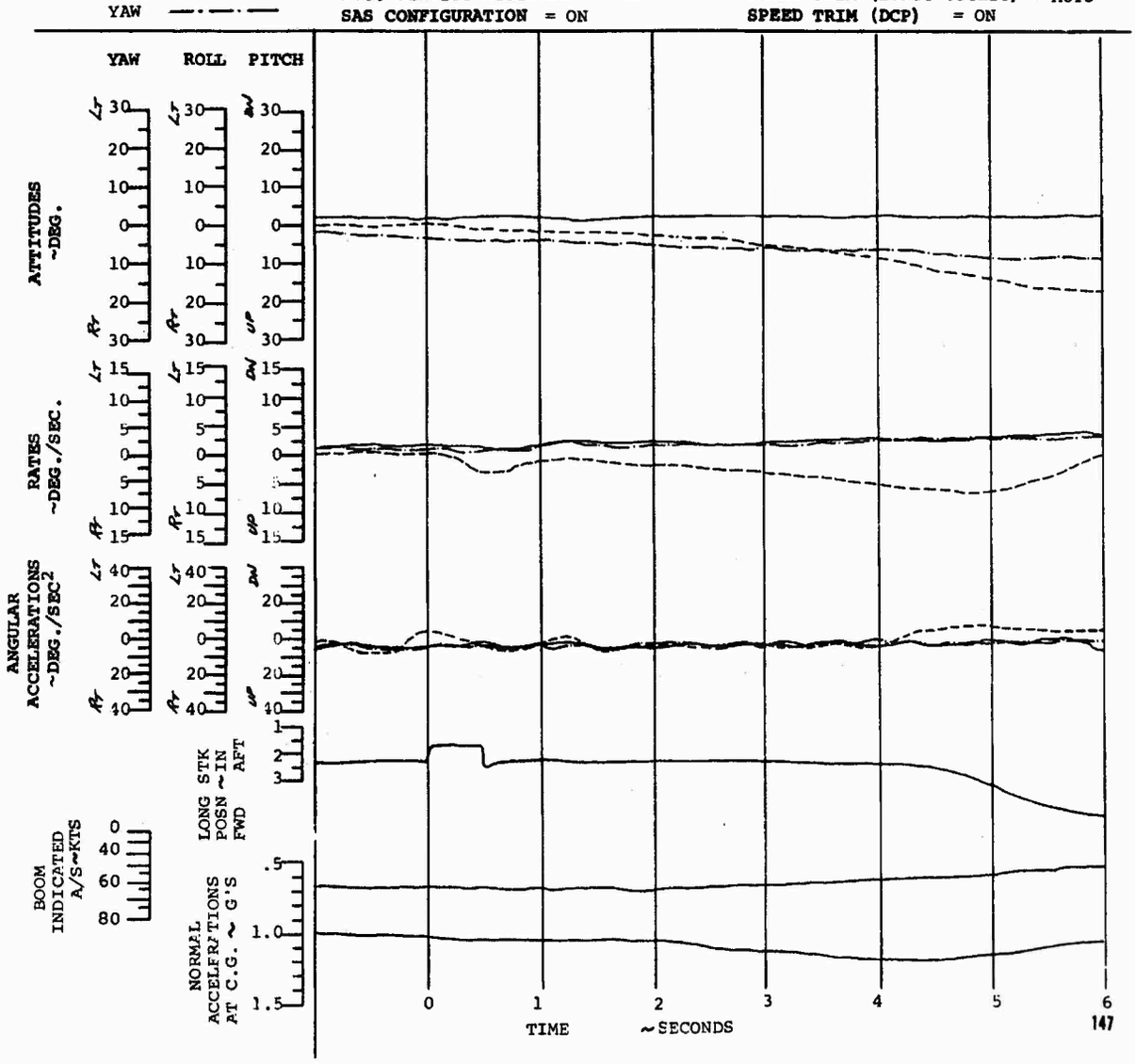

FIGURE NO. 98
AFT LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH ---
ROLL ———
YAW —·—·—

LEVEL FLIGHT
TRIM AIRSPEED = 70 KTS
AVG. DENSITY ALTITUDE = 8140 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 46850 LB
AVG. ROTOR SPEED = 245 RPM
C.G. LOCATION = 1.5" AFT
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

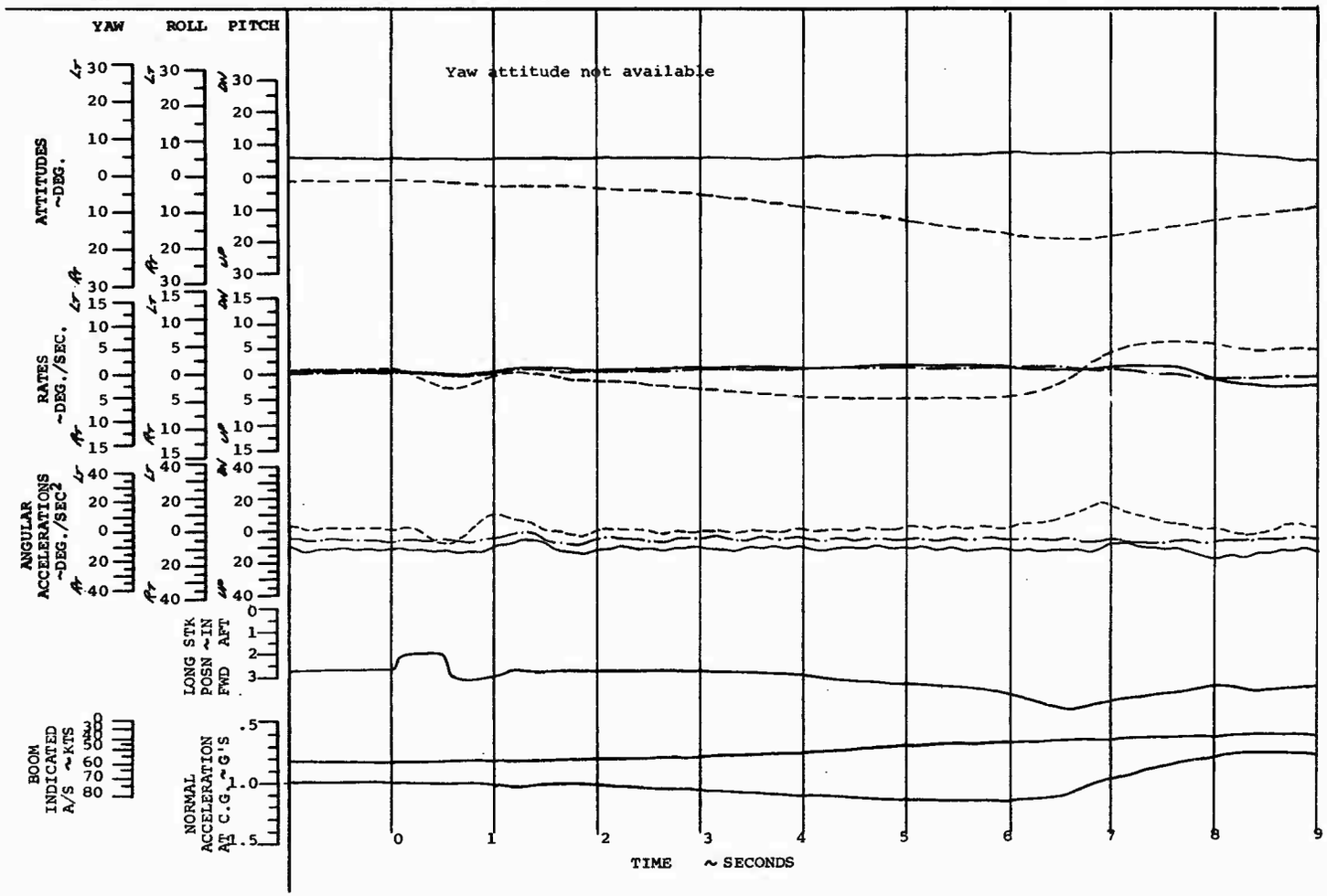

FIGURE NO. 99

AFT LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
ROLL ————————
PITCH – – – – – – –
YAW —·—·—·—

LEVEL FLIGHT
TRIM AIRSPEED = 104 KTS
AVG. DENSITY ALTITUDE = 4780 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 45700 LB
AVG. ROTOR SPEED = 245 RPM
C.G. LOCATION = 2.0" AFT
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

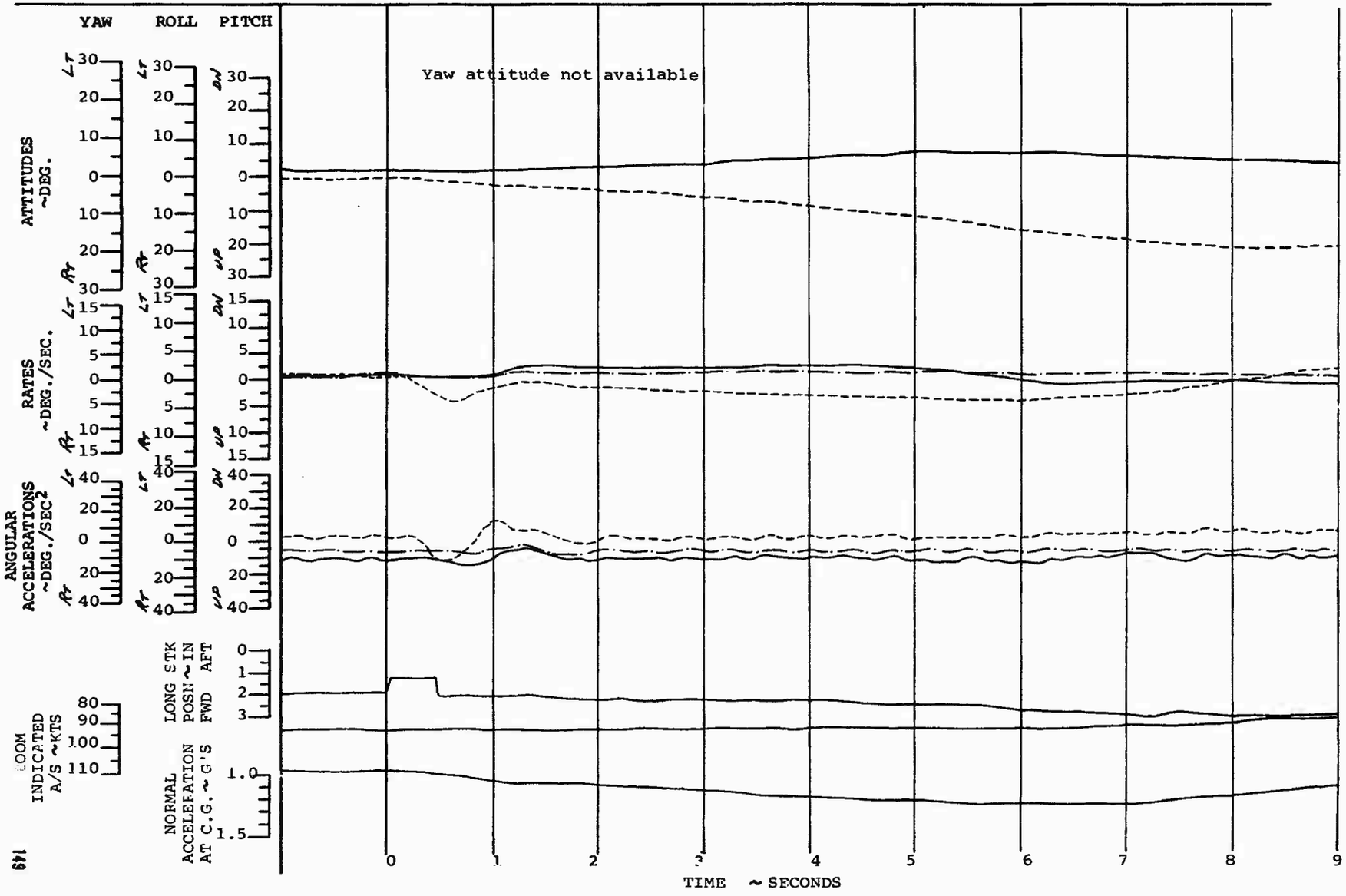

FIGURE NO. 100

AFT LONGITUDINAL PULSE

YCH-47C USA S/N 66-19121

LEGEND
PITCH – – – – – –
ROLL ————————
YAW —·—·—·—

LEVEL FLIGHT
TRIM AIRSPEED = 68 KTS
AVG. DENSITY ALTITUDE = 5410 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 44450 LB
AVG. ROTOR SPEED = 242 RPM
C.G. LOCATION = 9.7" FWD
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

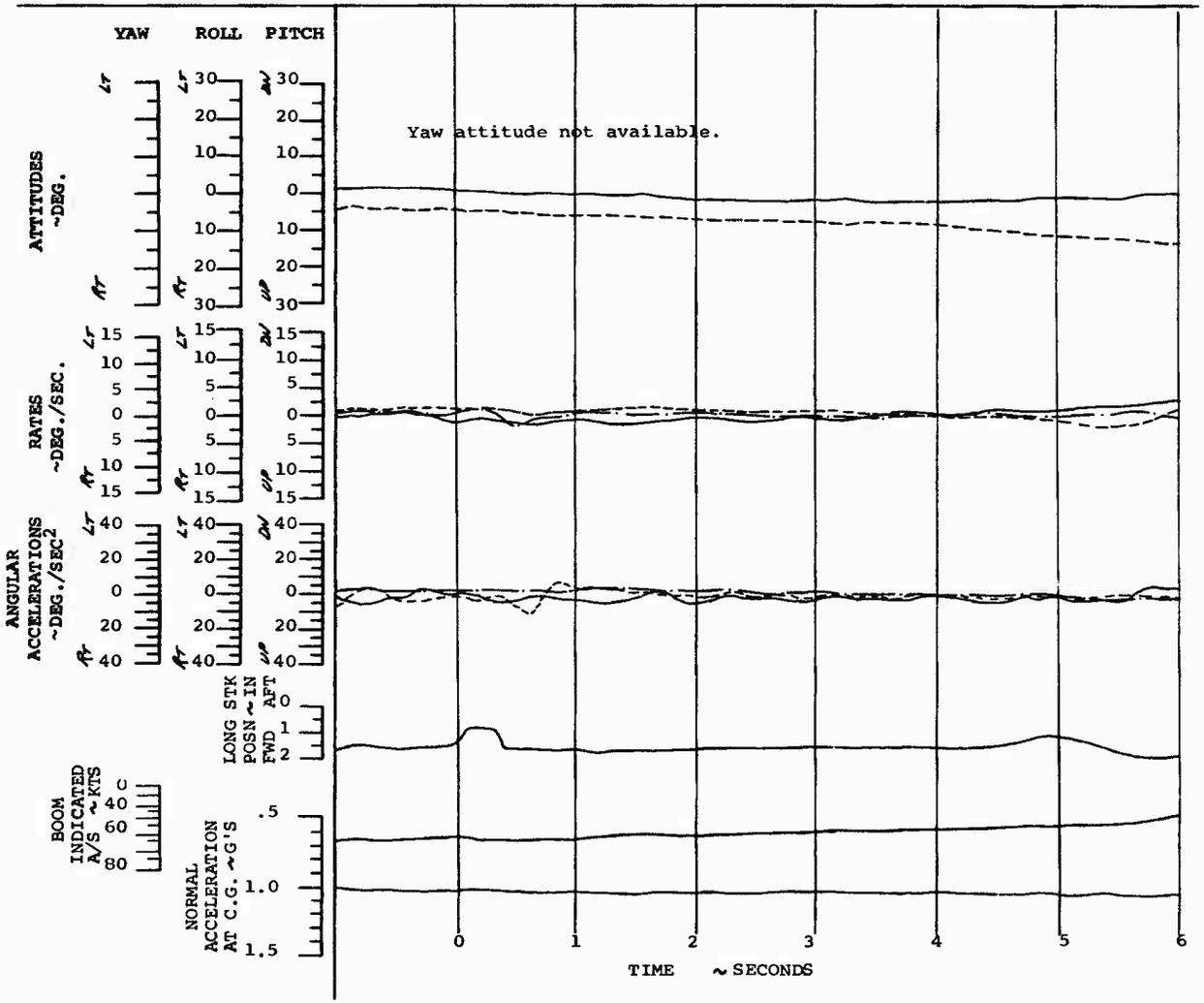

FIGURE NO. 101

FORWARD LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH – – – – –
ROLL ————
YAW —·—·—·—

LEVEL FLIGHT
TRIM AIRSPEED = 77 KTS
AVG. DENSITY ALTITUDE = 10,050 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 35750 LB
AVG. ROTOR SPEED = 236 RPM
C.G. LOCATION = 7.0" AFT
SPEED TRIM (LONG. CYCLIC)= AUTO
SPEED TRIM (DCP) = ON

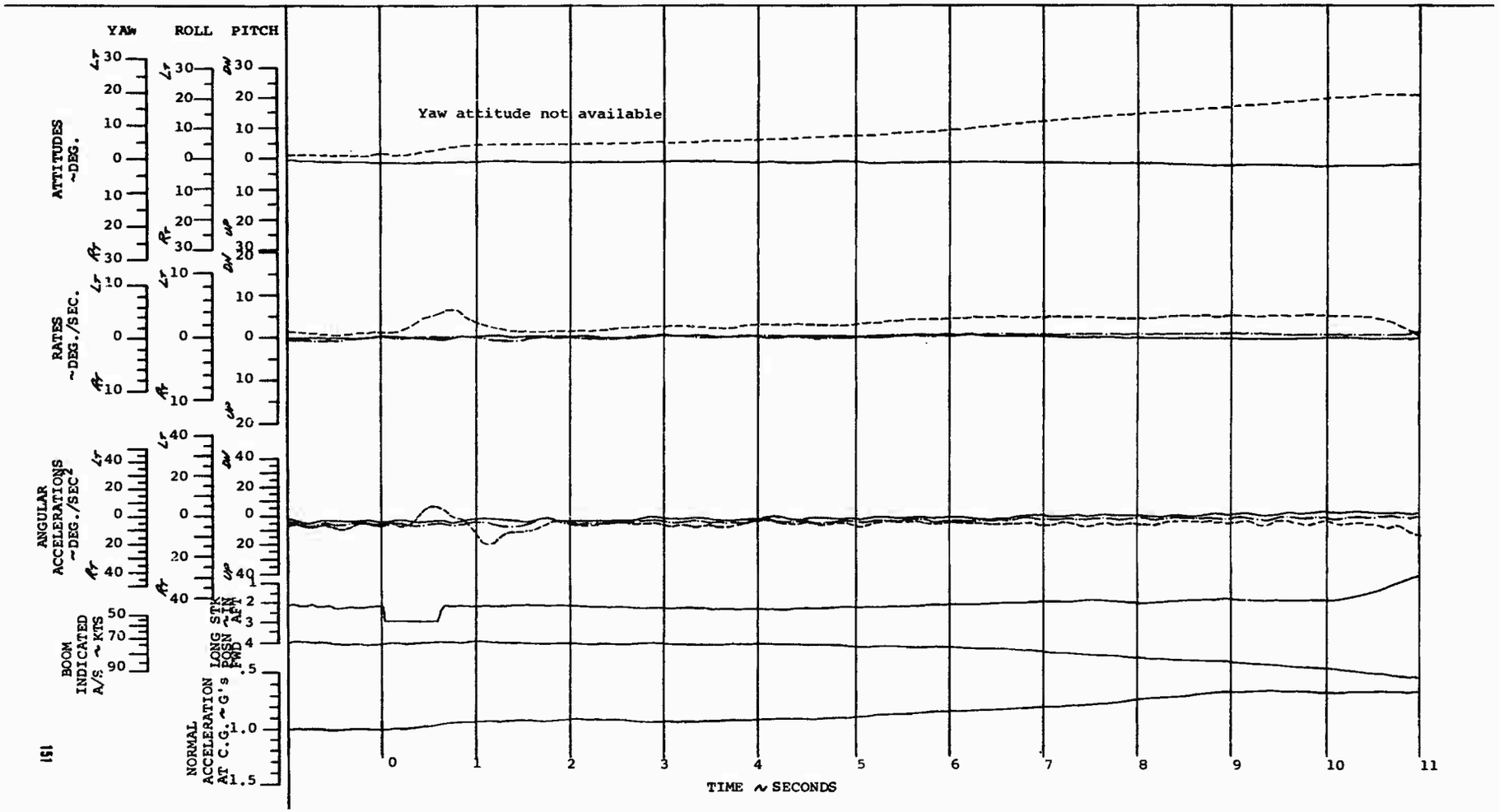

FIGURE NO. 102
FORWARD LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH
ROLL
YAW

LEVEL FLIGHT
TRIM AIRSPEED = 129 KTS
AVG. DENSITY ALTITUDE = 5000 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 36900 LB
AVG. ROTOR SPEED = 236 RPM
C.G. LOCATION = 6.3" AFT
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

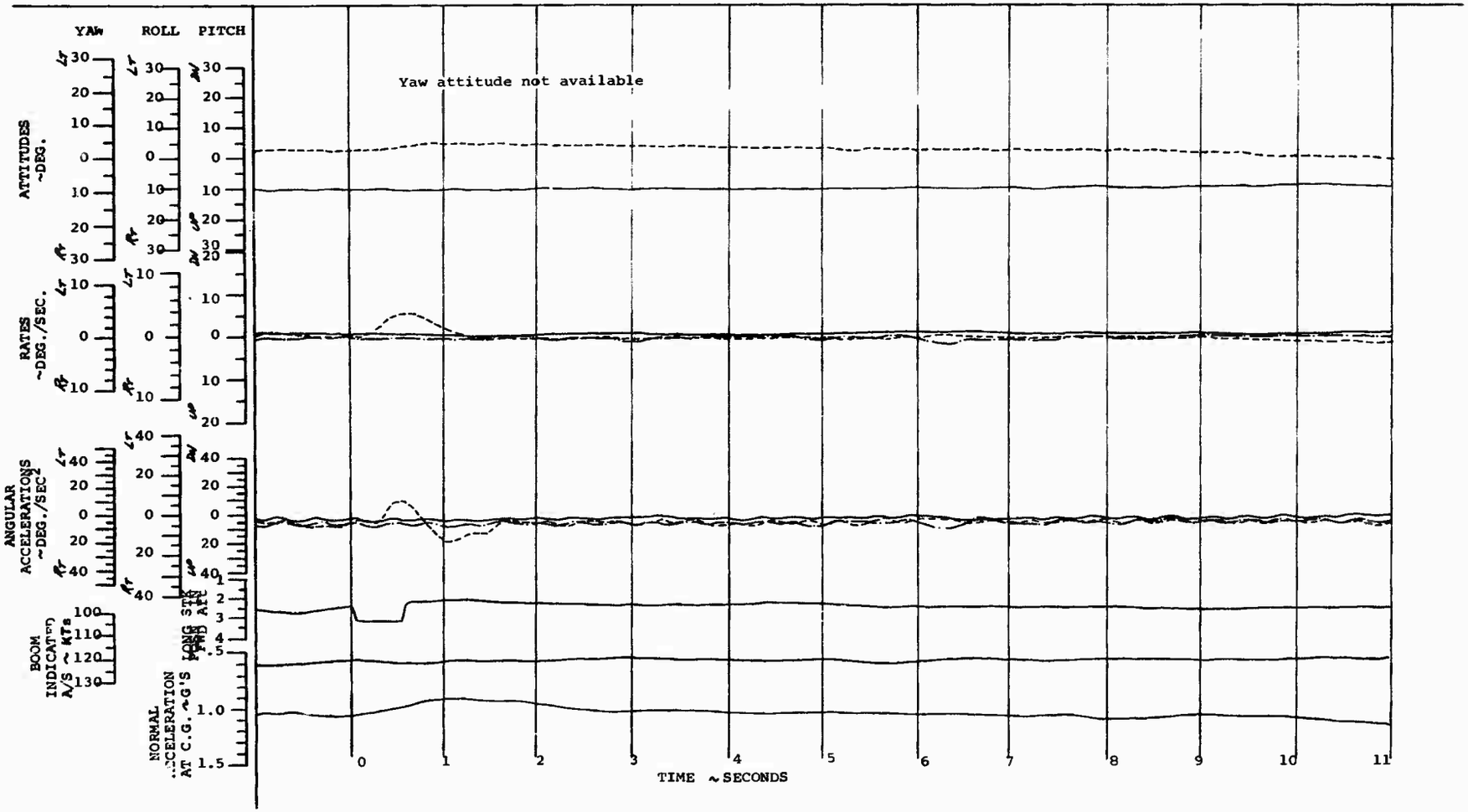

FIGURE NO. 103
FORWARD LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH ------
ROLL ——————
YAW —·—·—

LEVEL FLIGHT
TRIM AIRSPEED = 56 KTS
AVG. DENSITY ALTITUDE = 8150 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 46200 LB
AVG. ROTOR SPEED = 245 RPM
C.G. LOCATION = 1.8" AFT
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

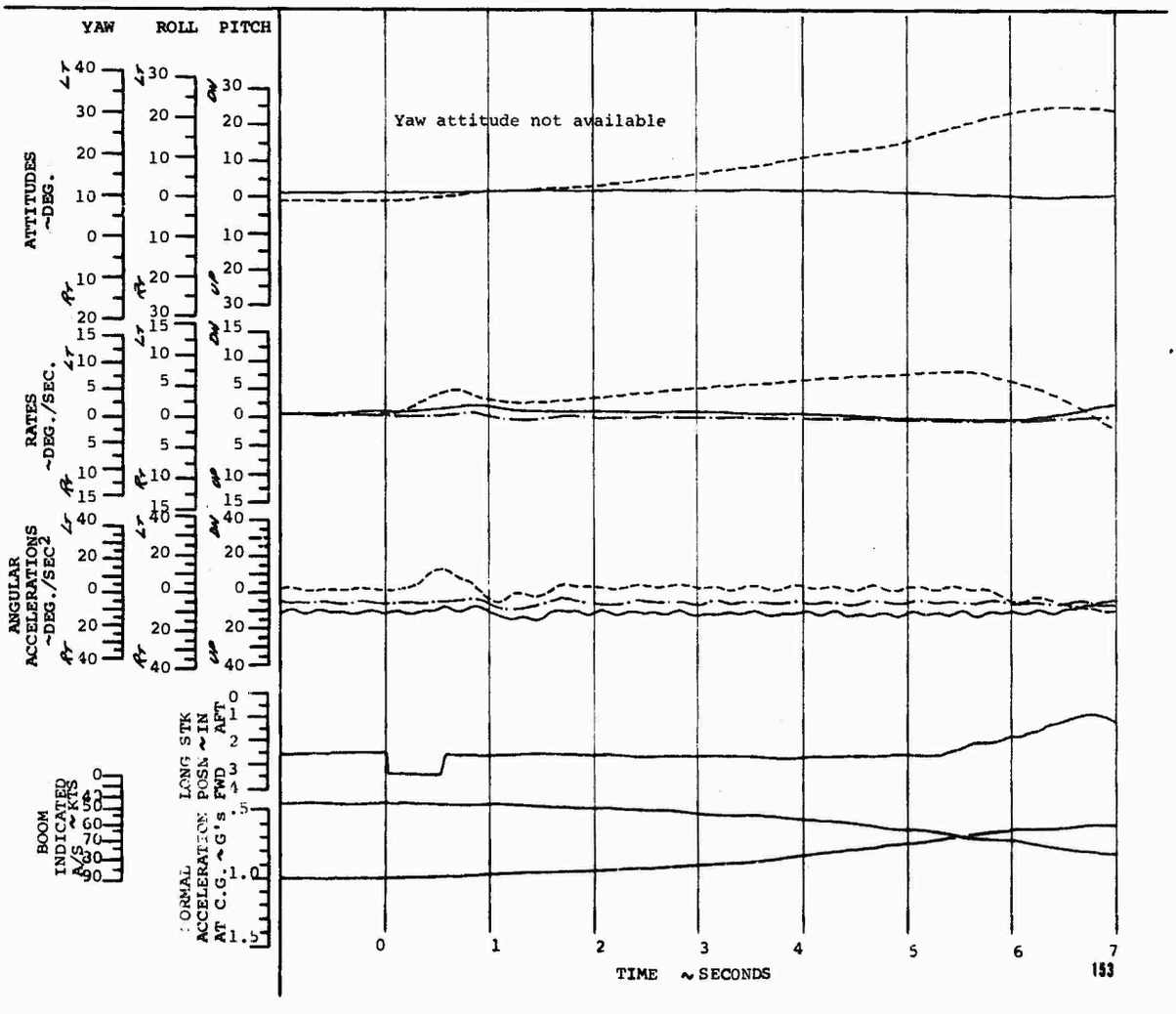

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FIGURE NO. 104
FORWARD LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH - - - - - - -
ROLL ————————
YAW —·—·—·—·—

LEVEL FLIGHT
TRIM AIRSPEED = 105 KTS
AVG. DENSITY ALTITUDE = 4200 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 44430 LB
AVG. ROTOR SPEED = 242 RPM
C.G. LOCATION = 9.7" FWD
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

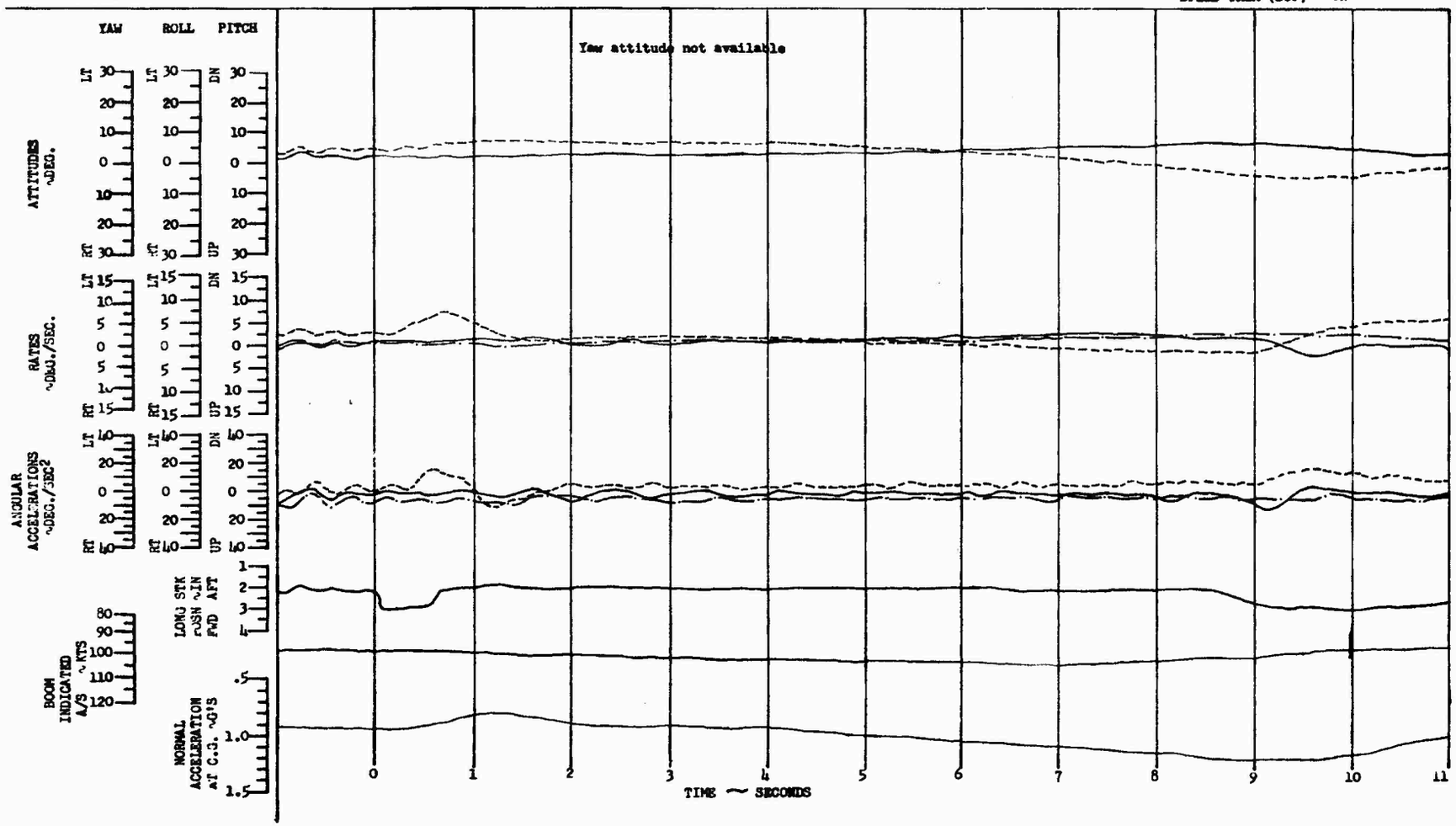

FIGURE NO. 105

LEFT LATERAL PULSE

YCH-47C USA S/N 66-19121

LEGEND
PITCH - - - - - - -
ROLL ———————
YAW —·—·—·—·—

LEVEL FLIGHT
TRIM AIRSPEED = 66 KTS
AVG. DENSITY ALTITUDE = 7960 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 44,000 LB
AVG. ROTOR SPEED = 245 RPM
C.G. LOCATION = 4.8" AFT
SPEED TRIM (LONG. CYCLIC) = AUTO
SPEED TRIM (DCP) = ON

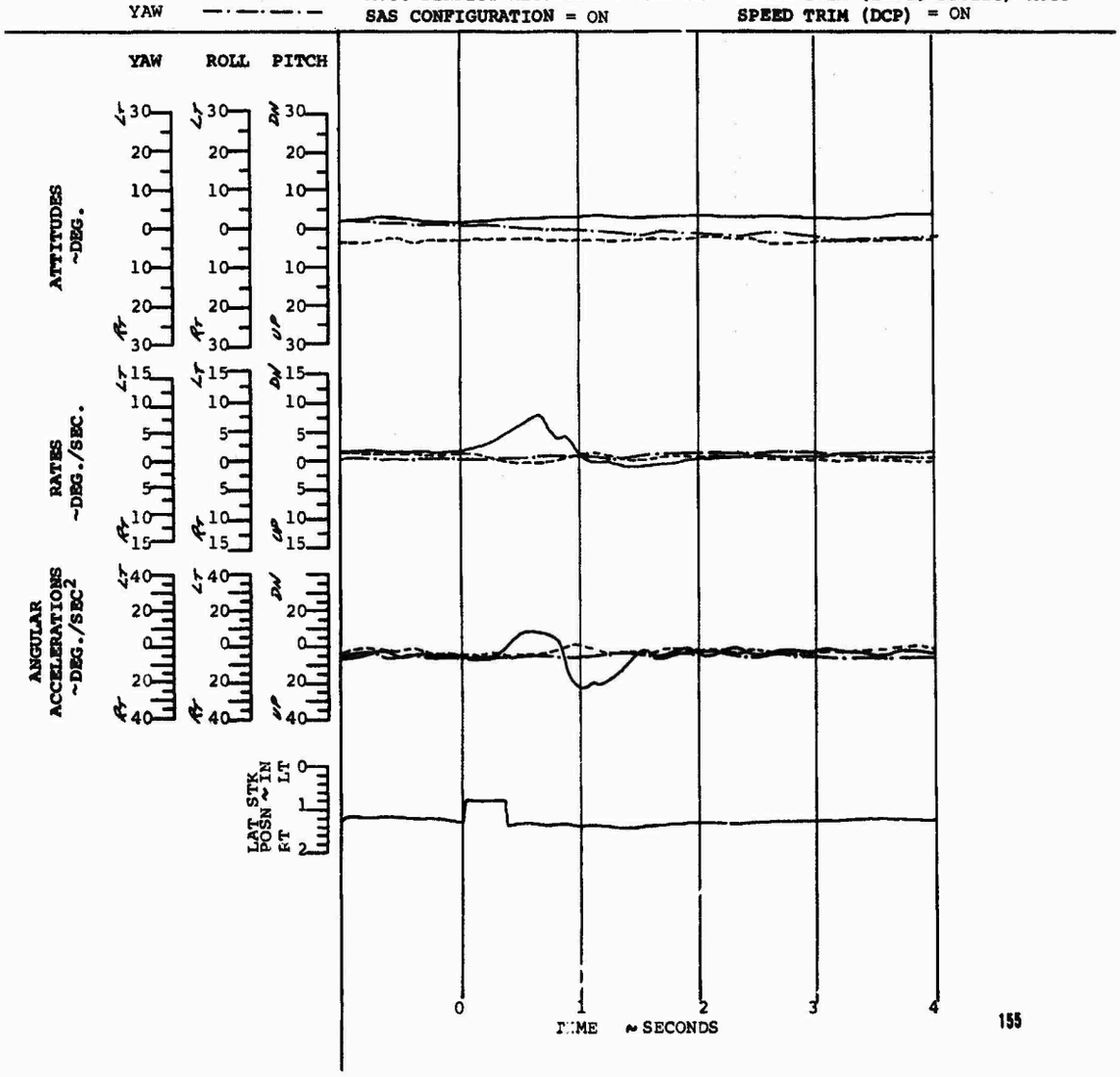

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FIGURE NO. 106
LEFT DIRECTIONAL PULSE
YCH-47C USA S/N 66-11921

LEGEND
PITCH - - - - -
ROLL ———
YAW —·—·—·—

LEVEL FLIGHT
TRIM AIRSPEED = 71 KTS
AVG. DENSITY ALTITUDE = 9990 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT =37620 LB
AVG. ROTOR SPEED = 234 RPM
C.G. LOCATION = 6.1" AFT
SPEED TRIM (LONG. CYCLIC)= AUTO
SPEED TRIM (DCP) = ON

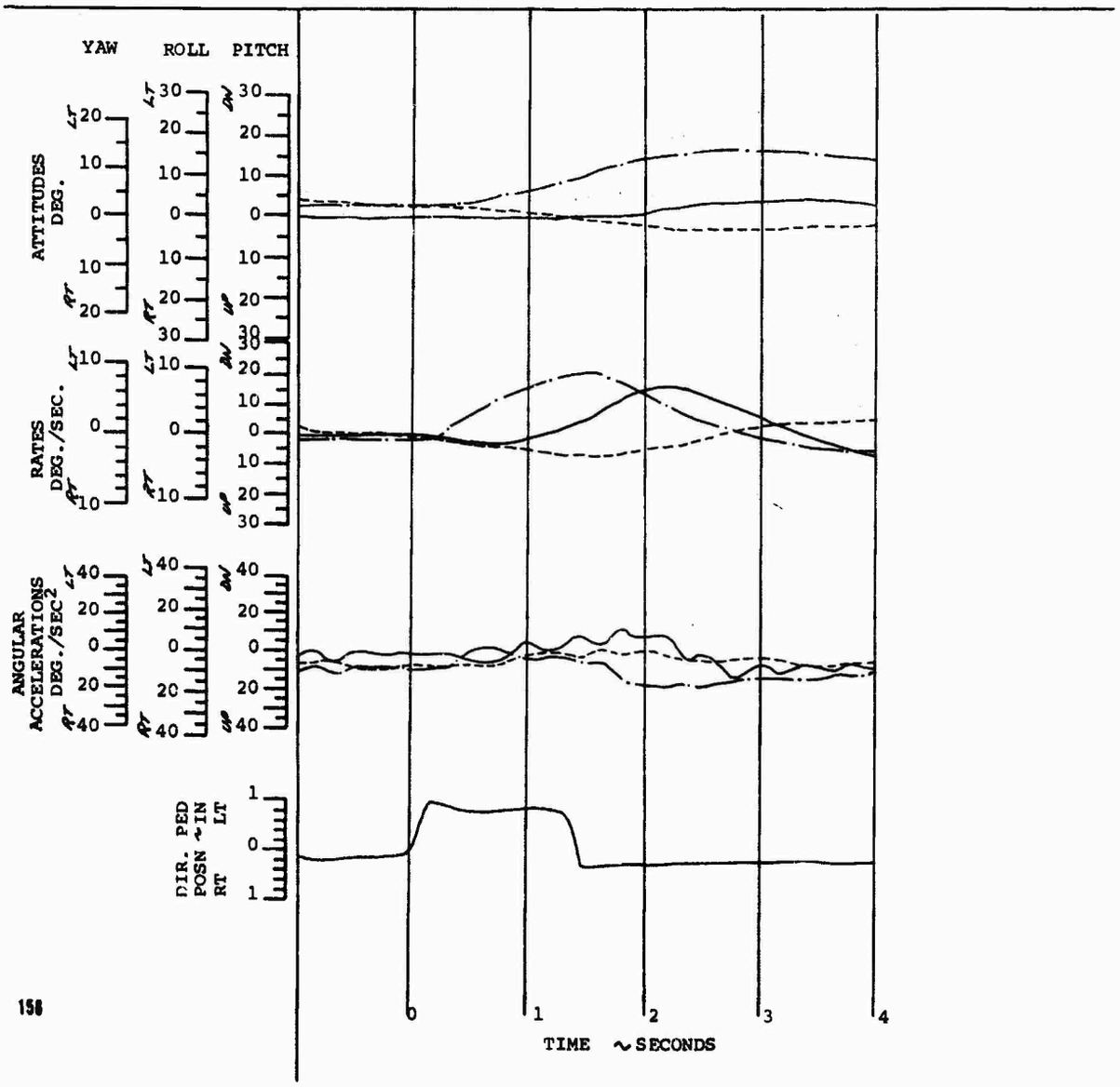


FIGURE NO. 107
AFT LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

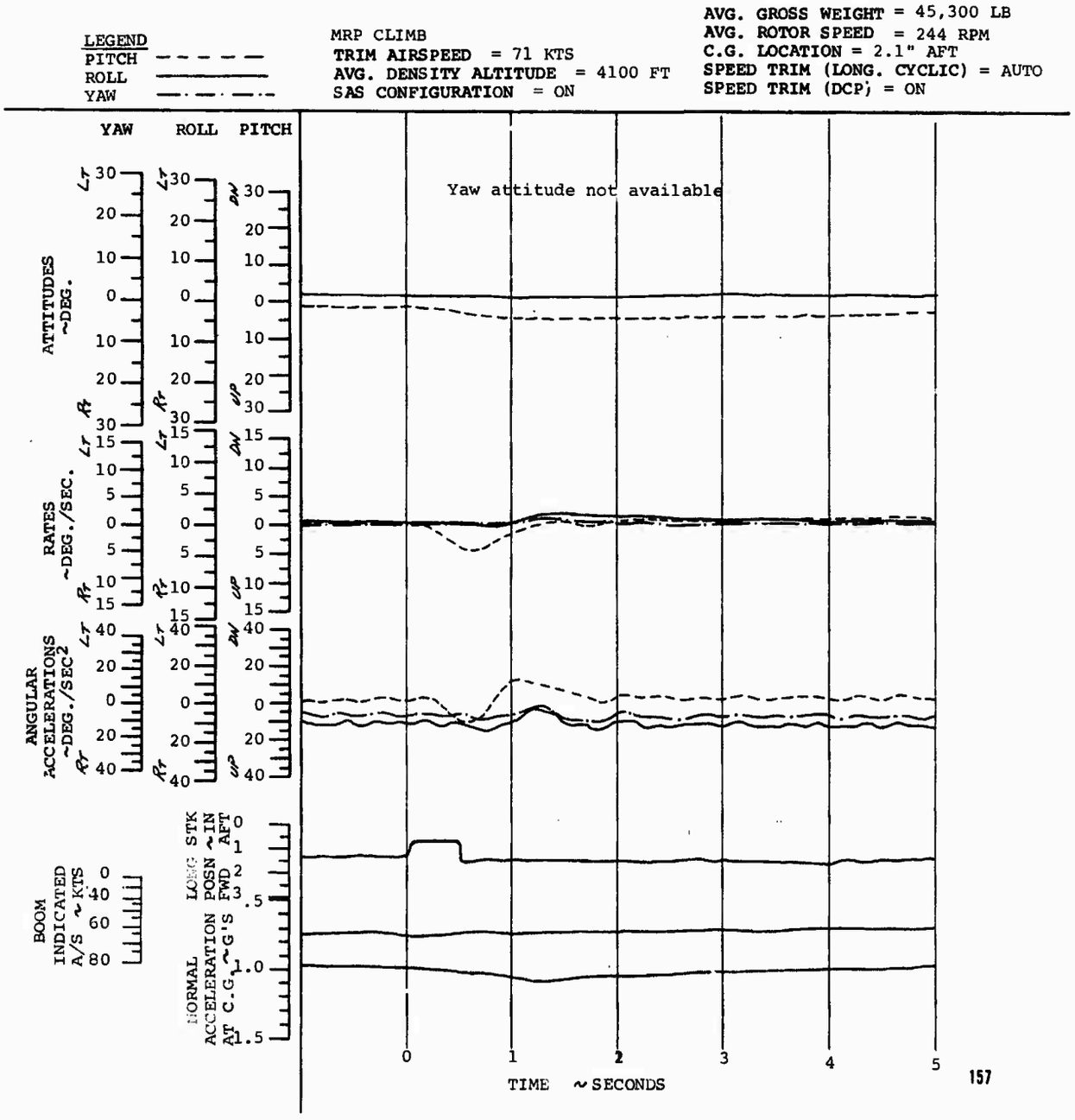


FIGURE NO. 108

AFT LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

LEGEND
PITCH
ROLL
YAW

MRP CLIMB
TRIM AIRSPEED = 105 KTS
AVG. DENSITY ALTITUDE = 3630 FT
SAS CONFIGURATION = ON

AVG. GROSS WEIGHT = 45,100 LB
AVG. ROTOR SPEED = 244 RPM
C.G. LOCATION = 2.2" AFT
SPEED TRIM (LONG. CYCLIC)= AUTO
SPEED TRIM (DCP) = ON

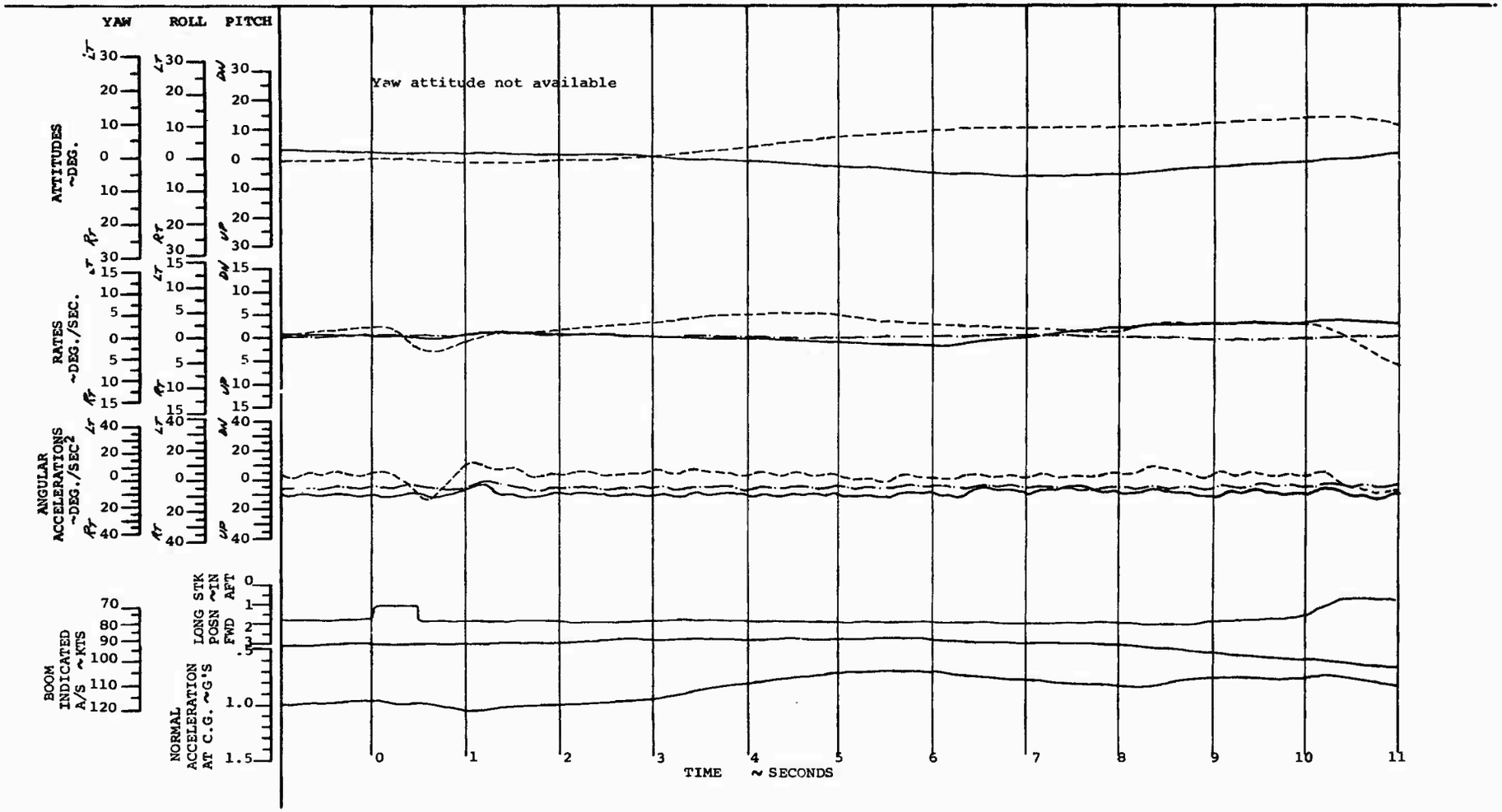


FIGURE NO. 109
AFT LONGITUDINAL PULSE
YCH-47C USA S/N 66-19121

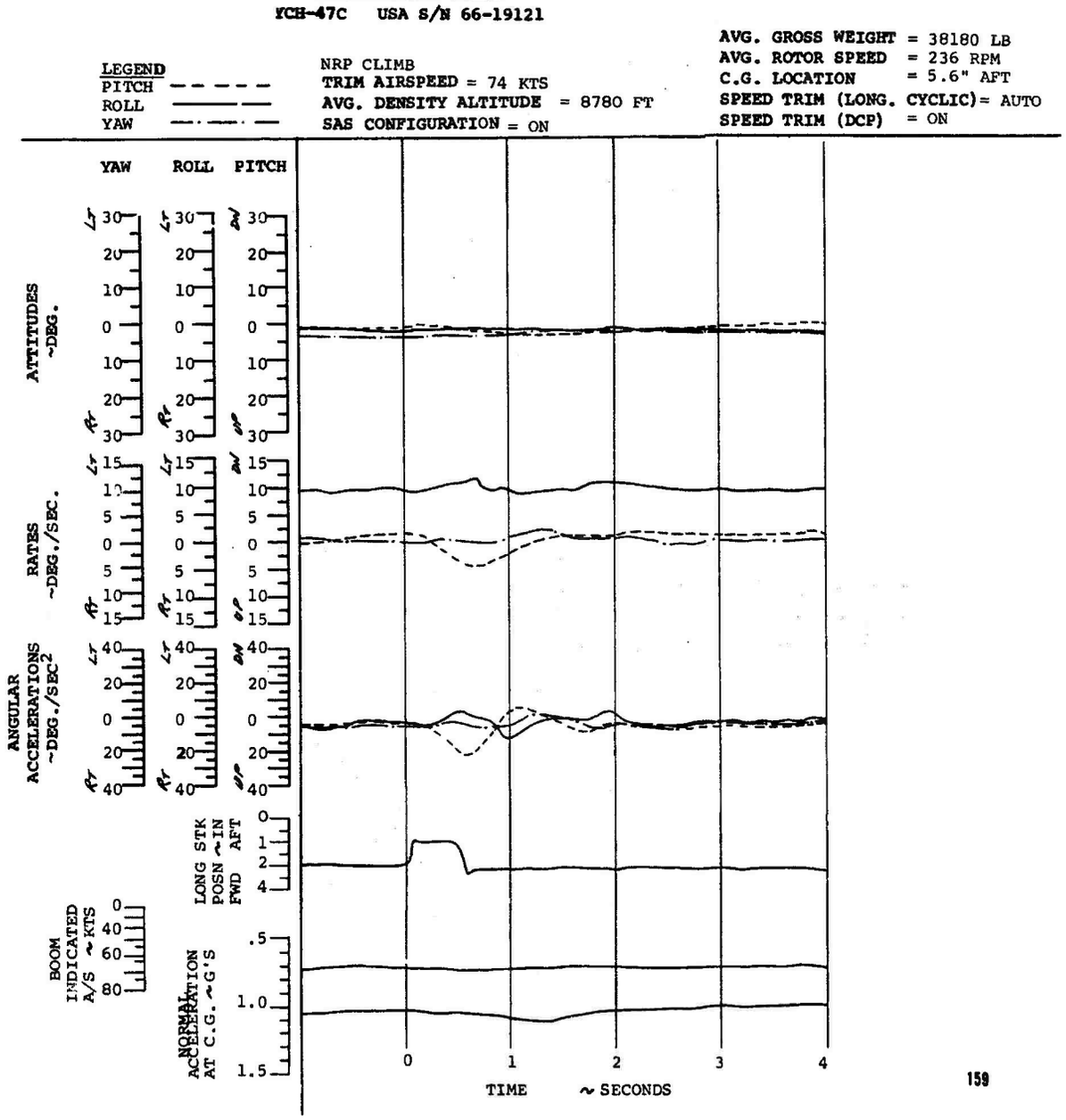


FIGURE NO. 110

FORWARD LONGITUDINAL PULSE

YCH-47C USA S/N 66-19121

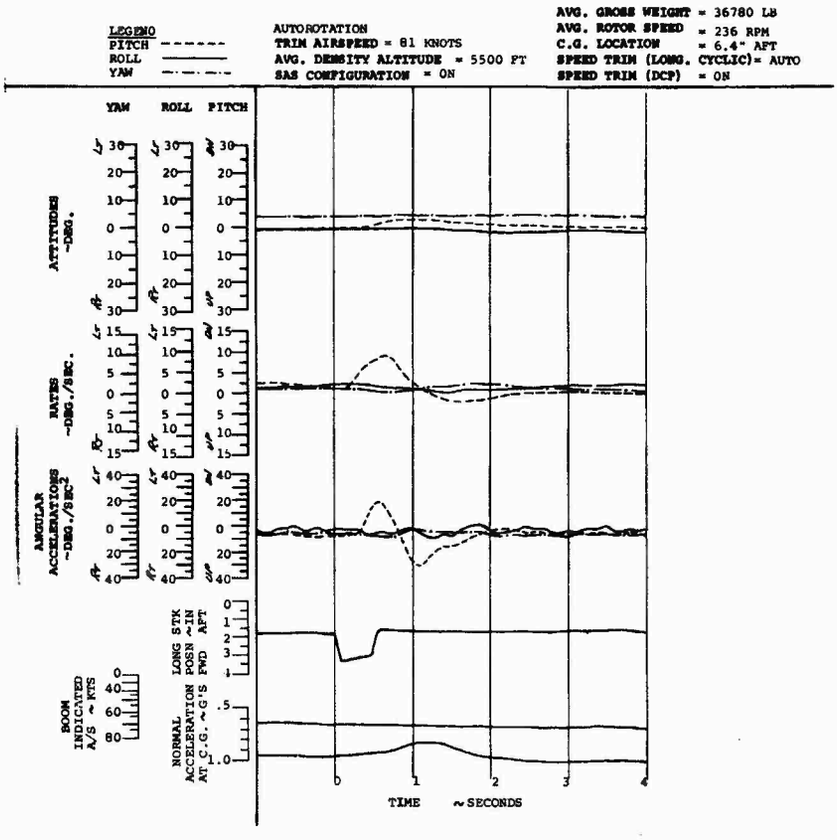
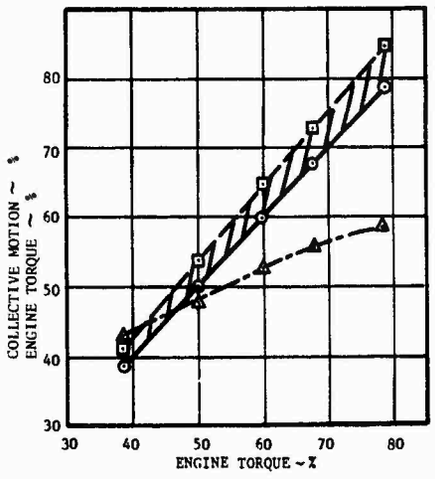


FIGURE NO. 111 THRUST ROD/TORQUE CONTROL CHARACTERISTICS

Desired Value of Engine Torque

Torque Value at which Magnetic Brake Trigger was Released

Collective Motion



APPENDIX III. GLOSSARY OF TERMS

SYMBOL	DEFINITION	UNIT
BL	Butt line	
g	Normal acceleration	g_o or G Gravitational constant
LH	Left hand	
N	Rotor speed	Revolutions per minute
$N/\sqrt{\theta}$	Referred rotor speed	
θ	Ratio of ambient temperature to standard temperature at sea level	
δ	Ratio of ambient pressure to standard pressure at sea level	
RH	Right Hand	
$SHP/\delta\sqrt{\theta}$	Generalized shaft horsepower	
V	Airspeed	
$V/\sqrt{\theta}$	Referred Airspeed	
W	Weight	
W_f	Fuel Flow	
$W_f/\delta\sqrt{\theta}$	Referred fuel flow	
WL	Water line	

APPENDIX IV. SIGNIFICANT DESIGN CHANGES from the CH-47B to the CH-47C

GENERAL

1. Significant design changes from the CH-47B to the CH-47C are noted in figure A. All changes were incorporated on the test helicopter except for the production fuel system and T55-L-11 engines (app V).

ENGINES

2. The T55-L-11 engine incorporates state-of-the-art improvements into the basic T55-L-7C engine. The performance ratings at sea level standard conditions are shown below (based on engine model specification number 124.27A revised 24 May 1968):

Ratings	Shp	Output Shaft Speed rpm	Rated Gas Producer TIT degrees F
Maximum	3750	16,000	1875
Military	3400	16,000	1805
Normal	3000	15,400	1725

3. The principle elements which provide the T55-L-11 engine (fig B) with substantial performance improvements over the T55-L-7C engine are:

a. Modification to transonic compressor stages with increase flow passage areas to provide high mass flow.

b. The addition of a second compressor drive turbine stage to provide for the design pressure ratio increase from 6.5 to 8.5.

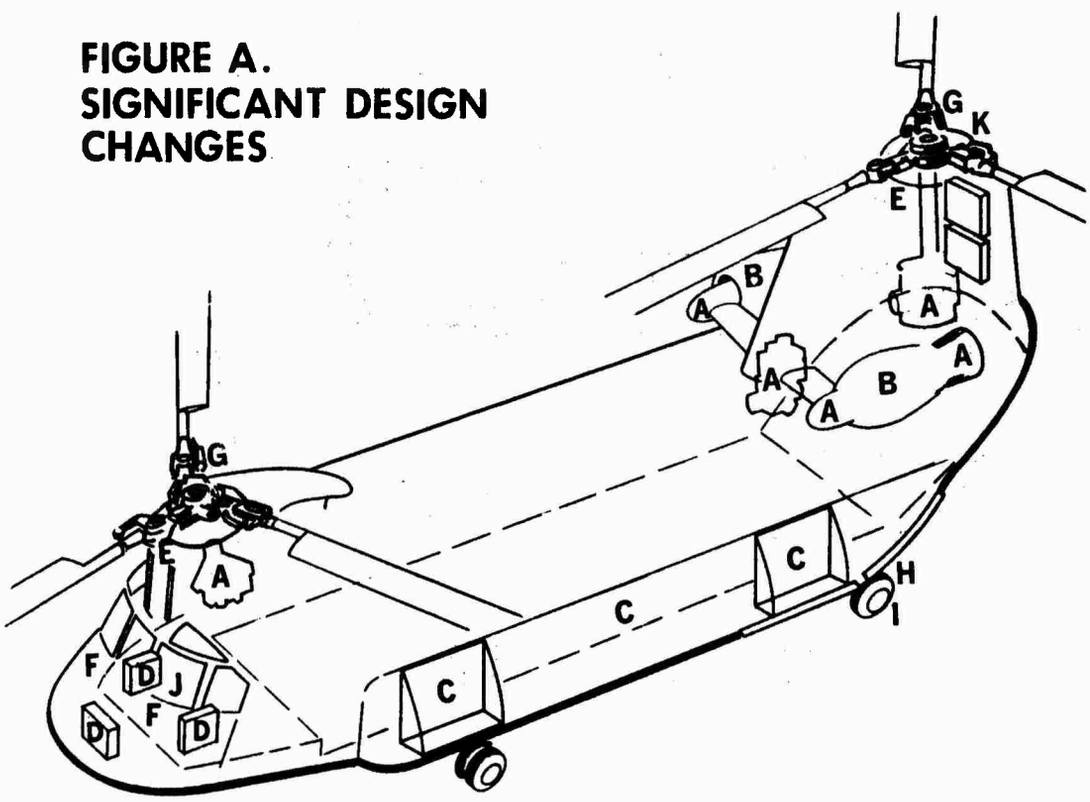
c. Incorporation of air cooled first stage turbine blade to permit higher turbine inlet temperatures. (T55-L-11 engine maximum TIT is 1930 degrees F compared with 1855 degrees F for T55-L-7C engine).

d. Incorporation of variable inlet guide vanes for improved transient characteristics.

e. A new electronic torquemeter system is added providing torque indication with 95 percent accuracy.

f. Fuel control system (Model JFC 31-14) incorporates a third cam change, horizontal trigger line, and inlet guide vane control.

FIGURE A.
SIGNIFICANT DESIGN CHANGES



A. TRANSMISSIONS
B. T55-L-7C ENGINES
C. FUEL SYSTEM
D. SELF-TUNING ABSORBERS
E. SPEED TRIM
F. TORQUEMETERS
G. LAG DAMPERS
H. TIRES
I. BRAKE SYSTEM
J. SAS OFF LIGHTS
K. UPRATED AFT ROTOR COMPONENTS

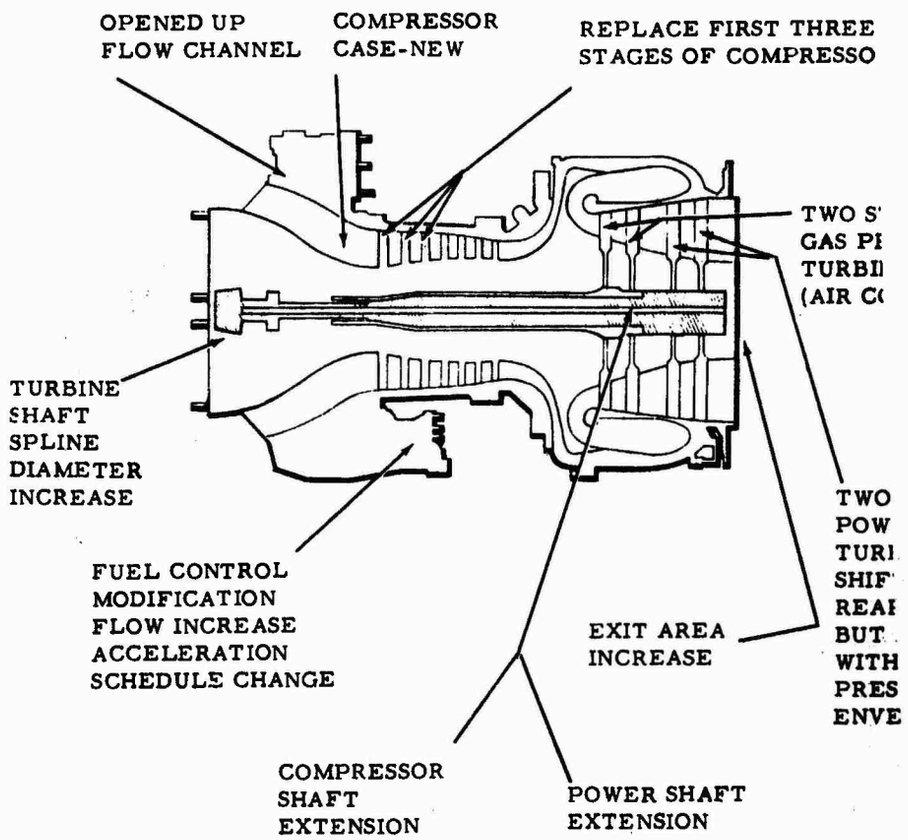


FIGURE B. T55-L-7C To T55-L-11 Engine Modifications

4. The YT55-L-11 engines installed for the APE were essentially similar to the T55-L-11 engine. The performance rating at sea level standard conditions are shown below (based on engine model specification number 124.30 dated 31 May 1966):

Ratings	Shp	Output Shaft Speed rpm	Rated Gas Producer TIT degrees F
Maximum	3750	16,000	1955
Military	3400	16,000	1865
Normal	3000	15,950	1760

5. Principle differences between the T55-L-11 and YT55-L-11 engines are:

a. The T55-L-11 engine was optimized by modification of the first three compressor stages and a decrease in the gas-producer-turbine channel height. The modification optimizes the engine for the Army hot-day mission.

b. The external change in the T55-L-11 engine was the deletion of the oil scavenging tray at the bottom of the accessory gear box. The T55-L-11 engine reverts to the earlier T55-11-7C engine oil-scavenging tube.

TRANSMISSIONS

6. The engine transmissions of the CH-47B were uprated for the CH-47C to accept the increased power output of the T55-L-11 engine. The gear ratio was changed to provide 250 rpm rotor speed at 16,000 rpm engine speed. Gear and pinion face-widths were increased and a clutch with a 57-percent increase in capacity was installed to accommodate the higher torque being transmitted. The finish on the spiral bevel-gear teeth was improved. New bearings for increased face-width gears were installed. The internal spline of the output-shaft pitch diameter was increased. Elliptical outer races for input pinion roller bearings of the new quill shaft were installed. Figure C summarizes major design changes to the engine transmissions.

7. The combining transmission of the CH-47B was uprated for the CH-47C. The transmission was uprated to accept 3750 shp at 14,000 engine rpm for single engine operation. The gear and pinion face-widths and input pinion spline pitch diameter were increased. The surface finish of the spiral bevel-gears was improved. The shaft adapter transmitting the higher torque leads aft of the collector gear was strengthened and shot peened. The output shaft ball bear-

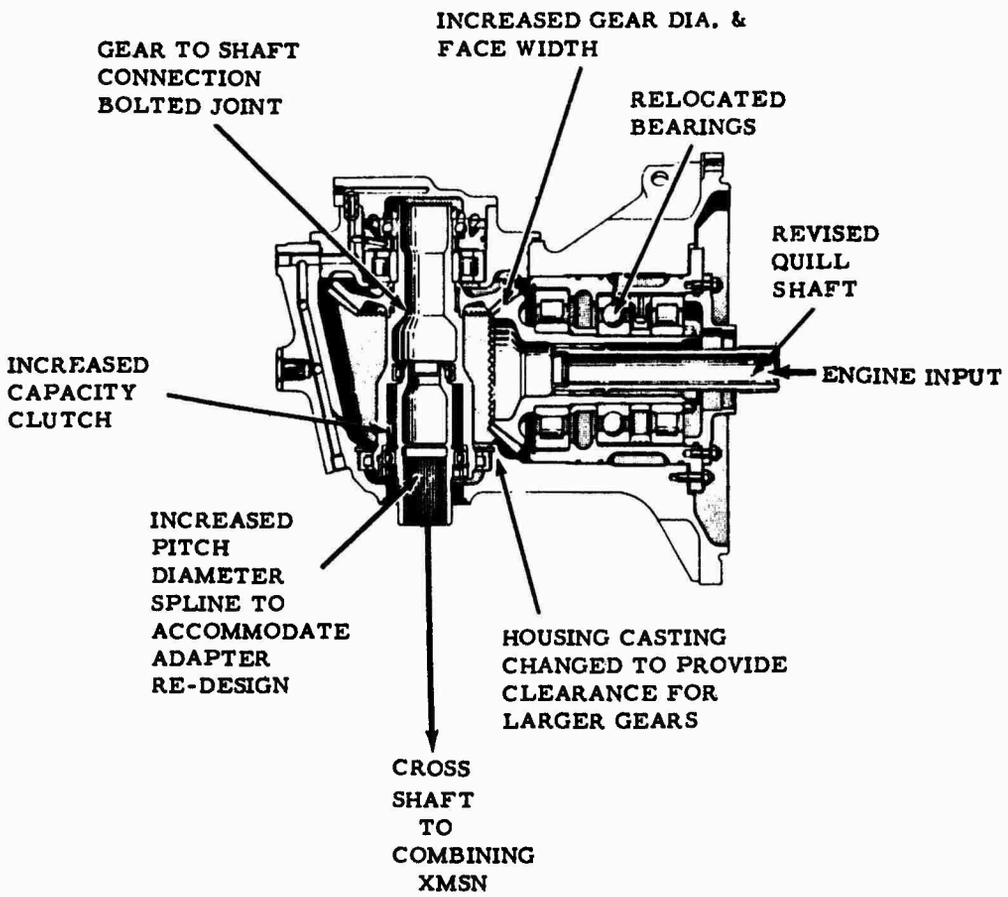


FIGURE C. CH-47C Engine Transmission Changes

ing was increased in size. The adjacent roller bearing material was changed from 52100 steel to 17250 vacuum melt steel. The input pinion roller bearing was redesigned. Figure D summarizes major design changes to the combining transmission.

8. The forward transmission of the CH-47B was uprated for the CH-47C to accept the increased power output of the T55-L-11 engines. The first stage sun gear and roller bearing, second stage planet rollers, first stage planetary inner race; and rollers and upper and lower material were changed from 52100 steel to M50 vacuum melt steel. The teeth of the first and second stage sun gears, planet gears and spiral bevel ring gears were shot peened. The rotor shaft thickness was increased and critical areas were shot peened. The first and second stage sun and planet gears were honed to improve the load carrying ability of the gear tooth surfaces. The surface of the spiral bevel gear and pinion teeth was improved. The forward rotor shaft wall has been increased in thickness to provide for the increased flight envelope. Figure E summarizes major design changes to the forward transmission.

9. The aft transmission of the CH-47B was uprated for the CH-47C to accept the increased power output of the T55-L-11 engines. Accessory gearbox gear ratio was decreased and a redesigned input spur gear incorporated. The first stage planetary inner race and rollers, first stage sun gear and roller bearings, and the second stage planet roller bearing material was changed from 51200 steel to M50 vacuum melt steel. The secondary sun gears, planet gears, and spiral ring gear were shot peened. The surface finish of the spiral bevel gear and pinion teeth were improved. The first and second stage sun and planet gear teeth were shot peened and honed. Figure F summarizes major design changes to the aft transmission.

10. Improvement of the engine drive shafts, aft, and combining transmission forward adapters were required to accept the increased power output of the T55-L-11 engines. The engine drive shaft adapters have increased pitch diameters to mate with the spline changes in the engine and combining transmission. The engine drive shaft wall thickness was increased and the shaft was shortened to compensate for the higher torque loads and increased routing distance of the combining transmission input pinion gear. Figure G summarizes major design changes to the drive shafting.

FUEL SYSTEM

11. The fuel injection system was changed from the CH-47B to the CH-47C. Major changes included the incorporation of four auxiliary fuel cells, necessary hardware to accomodate the expanded fuel system and the redesigned fuel control panel,

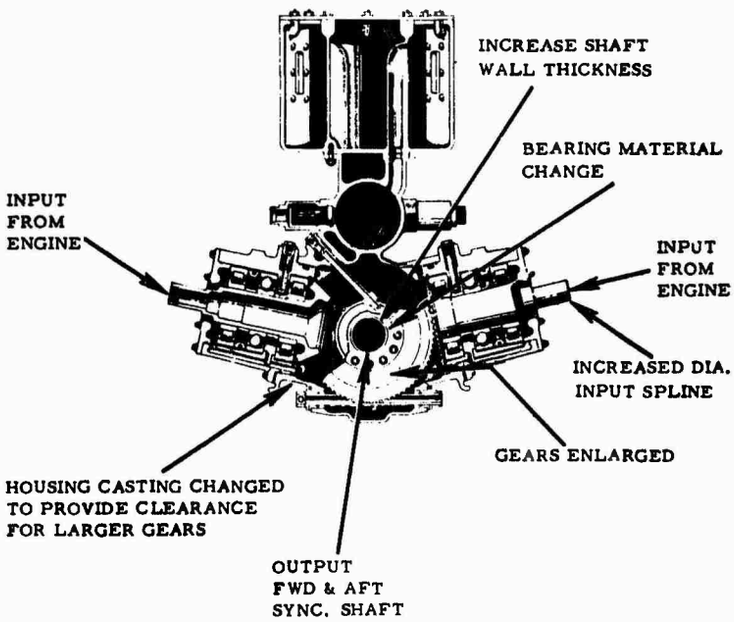


FIGURE D. CH-47B To CH-47C Combining Transmission Changes.

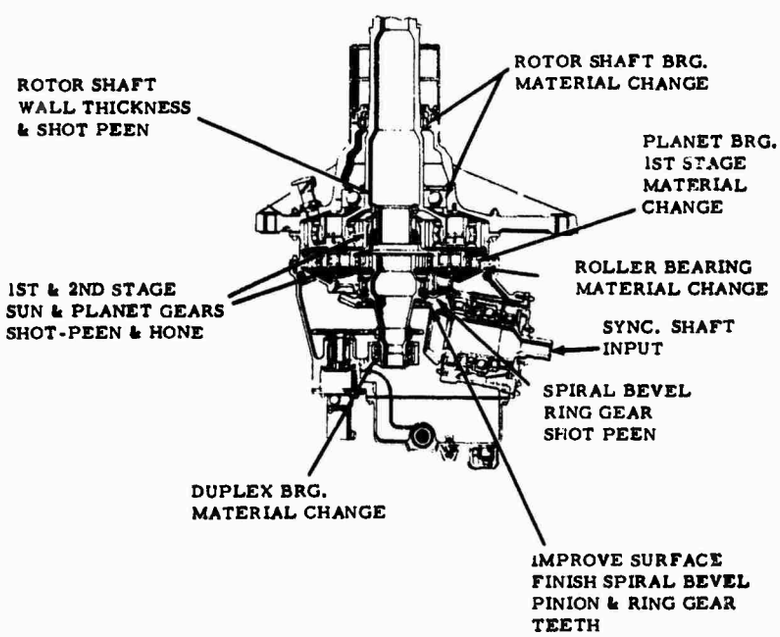


FIGURE E. CH-47A To CH-47B and C Forward Transmission Changes.

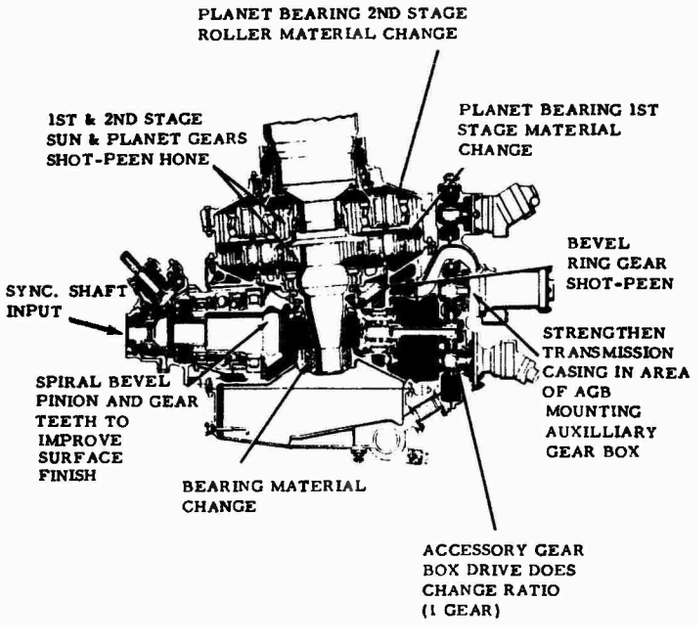


FIGURE F. CH-47A To CH-47B and C Aft Transmission Changes.

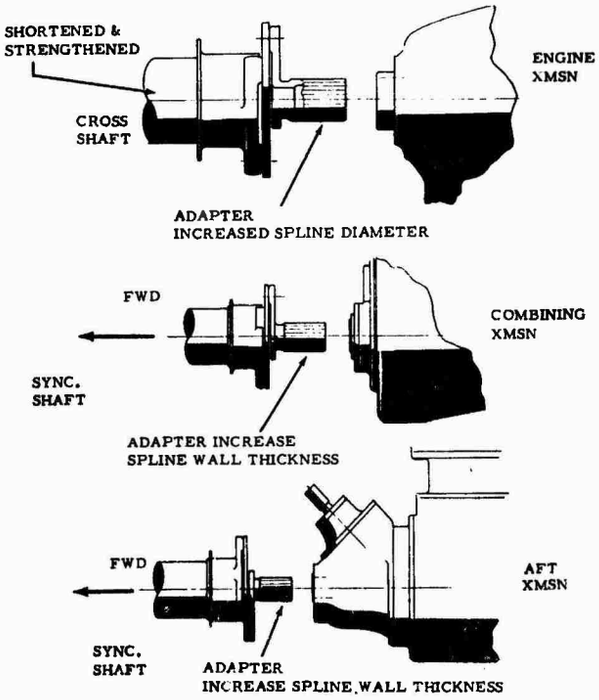


FIGURE G. CH-47B To CH-47C Drive Shafts and Adapters Changes.

fuel quantity indicator and fuel quantity selector switch (ECP 553R). The CH-47C production fuel supply system (fig H) furnishes fuel to the two T55-L-11 engines, the heater and the auxiliary power unit. The system consists of a fuel control panel and two separate fuel systems connected by a cross-feed line. Provisions are available within the cargo compartment for connecting external ferry fuel tanks to the two fuel systems. Each fuel system consists of three fuel tanks contained in a pod on each side of the fuselage. Each auxiliary fuel tank contains a fuel booster pump, a booster pump check valve, and a fuel measuring probe, a thermistor which senses fuel level, and a bypass check valve. During normal operation, with all booster pumps operating, fuel from all three tanks will supply fuel to the engine. The fuel from the auxiliary will be consumed at a faster rate than the fuel in the main tank because of the flow characteristics of the booster pump check valves. When the fuel is consumed from either of the auxiliary tanks, the check valve will close to prevent air from being pumped into the fuel system. However, the closing of the check valve does not deenergize that fuel booster pump. Should a fuel booster pump fail in an auxiliary tank, the fuel in that tank would not be useable. Should both the fuel booster pumps fail in the main tank, fuel would be drawn from the main tank only through the bypass check valve by the engine driven pump as long as the helicopter is operated below 6000 feet pressure altitude. A detailed discussion of the production CH-47C fuel system is contained in reference 9, appendix I.

12. The fuel system incorporated on the test helicopter during APE I and APE II was nonstandard and had an increased fuel capacity (6 fuel cells) with full fuel isolation per ECP 450 and ECP 553. Fuel is pumped to the engine from the main tank. Fuel is transferred from the auxiliary fuel tanks to the main tanks thereby maintaining fuel in the main tanks until the auxiliary tanks are empty.

SELF TUNING VIBRATION ABSORBERS (STVA)

13. The CH-47C incorporates self tuning vibration absorbers installed in the forward end of the helicopter. These absorbers replace the fixed tuned absorbers installed in the CH-47B. Additionally, both helicopters have two fixed tuned absorbers in the aft pylon. These fixed tuned absorbers are tuned to 240 rpm for the CH-47C.

14. A simplified schematic of the STVA system is presented in figure I. The frequency of the effective mass is varied mechanically changing the mass of the absorbers which operate through a two inch stroke. An absorber accelerometer signal is sensed by the accelerometer which is fed through a discrimination circuit to provide a phase shifted signal to mechanically

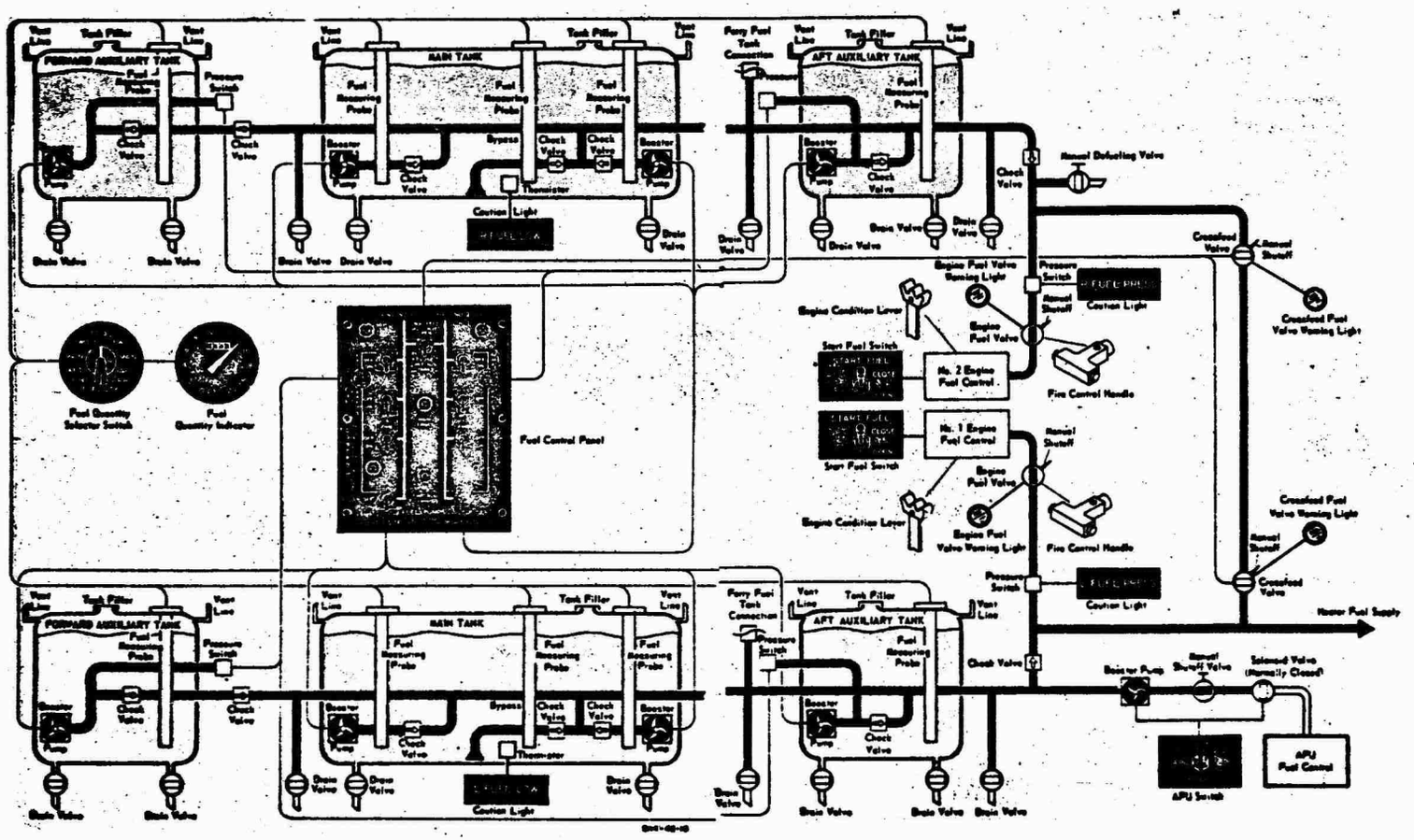


FIGURE H. ECP 553R FUEL SYSTEM SCHEMATIC.

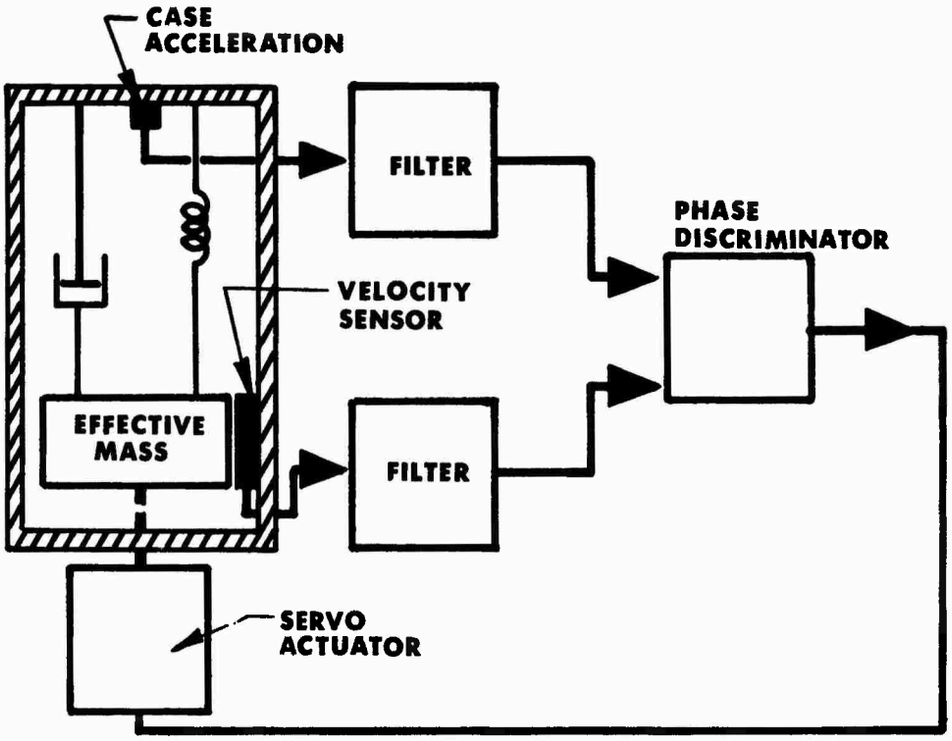


FIGURE I. Self Tuning Absorber System Schematic

change the absorbers effective mass through the servo actuator. This phase shift is required since the absorber displacement lags the fuselage displacement by a variable amount; depending on the natural frequency of the absorber which is varied by the servo control. A mass velocity sensor is provided to demodulate the acceleromater signal. This signal goes to the power amplifier and runs a trim mass motor. The motor velocity operates an actuator rate transducer which feeds back a signal to control the servo actuator rate. The system tunes to null at a controlled velocity based on the input acceleration and mass velocity signals. Filter circuits are incorporated in the system to reduce noise. The original control system installed on the helicopter during APE I was an integral feedback type based on a phase error. In that system, the actuator always required a discrete time to return the effective mass and corrections to rpm changes or airframe upsets were too slow and resulted in noncompensation for vibration levels at high airspeeds. Vibration levels were mainly reduced by incorporating proportional plus integral feedback signals to control the servo actuator rate. When the absorber is off tune, the proportional feedback causes the actuator to initially move more rapidly towards tune and the integral takes over significantly reducing the time to retune.

SPEED TRIM

15. The longitudinal cyclic speed trim schedule was changed from the CH-47B to the CH-47C to reduce noise and vibration levels, stress levels on the rotor blade trailing edge, and rotor shaft bending movements. Changing the trim schedule resulted in a change in the differential collective pitch trim schedule. A discussion of the trim schedules is presented in the Results and Discussion section of this report. Figure J. shows the effects of retracting and extending longitudinal cyclic speed trim and the change in indicator presentations from the CH-47B to the CH-47C.

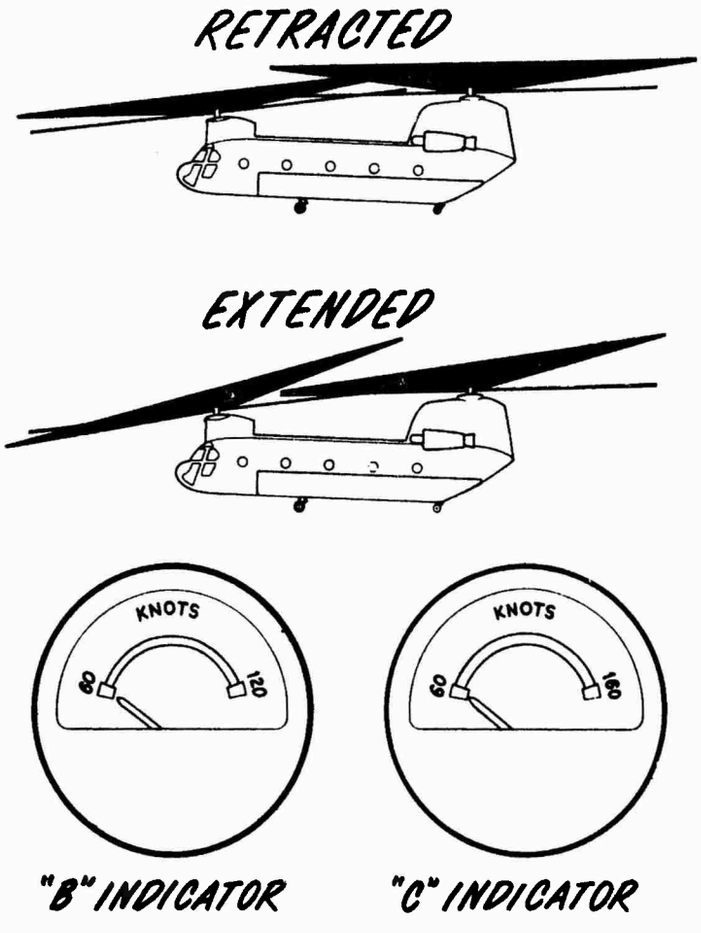


FIGURE J. Longitudinal Cyclic Speed Trim Indicator

TORQUEMETERS

16. The CH-47B engine torquemeter system operates through an internal sleeve arrangement on the output power shaft of the engine which produces a mechanical signal representing the amount of torque being developed. The signal is transmitted to an electromagnetic transmitting unit which translates the mechanical signal into an electrical selsyn signal which is transmitted to the dual torquemeter. The accuracy of the system was guaranteed to be ±4 percent. The torquemeter on the CH-47C is an electrical system which makes use of the magnetic striation effect which is the change of the magnetic reluctance of the metal as a function of stress imposed. The engine shaft develops tension and compression stress which essentially varies the reluctance of the shaft as a function of torque. A unique transformer called the head assembly is oriented around the shaft and has a primary and two secondary windings. The primary winding generates a constant magnetic flux and is oriented such that the shaft acts as the core of the transformer. One secondary winding is oriented in the tension direction of the shaft and the other in the compression direction. The current induced into the two secondary windings varies with the tension and compression stress caused by the torque applied to the shaft. As the shaft torque increases, so do the stresses and the differences in the currents induced in the secondary windings. The output of the secondary windings provides an electrical signal for the operation of the torquemeter. The system accuracy is guaranteed to be ±2 percent. The system accuracy at 73 percent engine torque was -1.5 percent as determined during APE I (ref 4, app I). A dial presentation of the electrical torquemeter system is shown in photo 3, appendix VII. Torque output is measured in percent on the CH-47C as compared to ft/lb on the CH-47B.

LAG DAMPERS

17. The CH-47B lag damper provides a 1750 pound preload at 0.26 in/sec and a damping slope of approximately 100 lb/in/sec and a ± 10 percent tolerance on the output load. The CH-47C lag damper provides a 3000 pound preload and a damping slope of approximately 30 lb/in/sec and a 7.5 percent load tolerance. A stronger housing and piston was incorporated to increase endurance limits. Larger rod end and lag end bearings were incorporated to increase wear life. One main control valve was incorporated to reduce the effects of tolerances and damper output. The reservoir air volume was increased to reduce pressure buildup due to oil temperature expansion.

TIRES

18. The tires on the CH-47B are 8-ply. The tires on the CH-47C are 10-ply to accomodate increased gross weights.

BRAKE SYSTEM

19. The brake system on the CH-47B incorporates single disk brakes on the forward and aft landing gear. Braking action with the directional pedals is applied only to the forward brakes. The aft brakes are only actuated when the parking brake knob is pulled out. The brake system on the CH-47C is equipped with self-adjusting disc type brakes on the forward and aft landing gear. Braking can be accomplished on the forward and aft wheels simultaneously or only on the forward wheels depending on the position of the swivel lock switch. The braking action incorporated into the aft gear is used to decelerate the helicopter for slope operations and to provide spot landings following a vertical descent.

SAS OFF LIGHTS

20. The SAS OFF caution lights on the CH-47B illuminate simultaneously and only when the SAS is locked out using the emergency SAS release switch. The SAS OFF caution lights on the CH-47C illuminate when the SAS is locked out and also illuminate individually when the respective flight control hydraulic system fails or when the SAS selector switch is used to select an individual SAS.

UPRATED AFT ROTOR COMPONENTS

21. The aft rotor components were uprated from the CH-47B to the CH-47C to accept the higher stress levels before endurance limits are reached. Figure K depicts components affected and estimated increases of new endurance limits. Uprating was required to maintain the CH-47C, APE II flight envelope for gross weights up to 46,000 pounds (alternate design G.W.).

AFT VERTICAL SHAFT

22. The aft vertical shaft was redesigned from the CH-47B to the CH-47C to accept increased power of the T55-L-11 engine. The upper section of the shaft has a thicker wall and is shortened. The middle section of the shaft has been shot peened.

FIGURE K PRESENTED ON PAGE 176

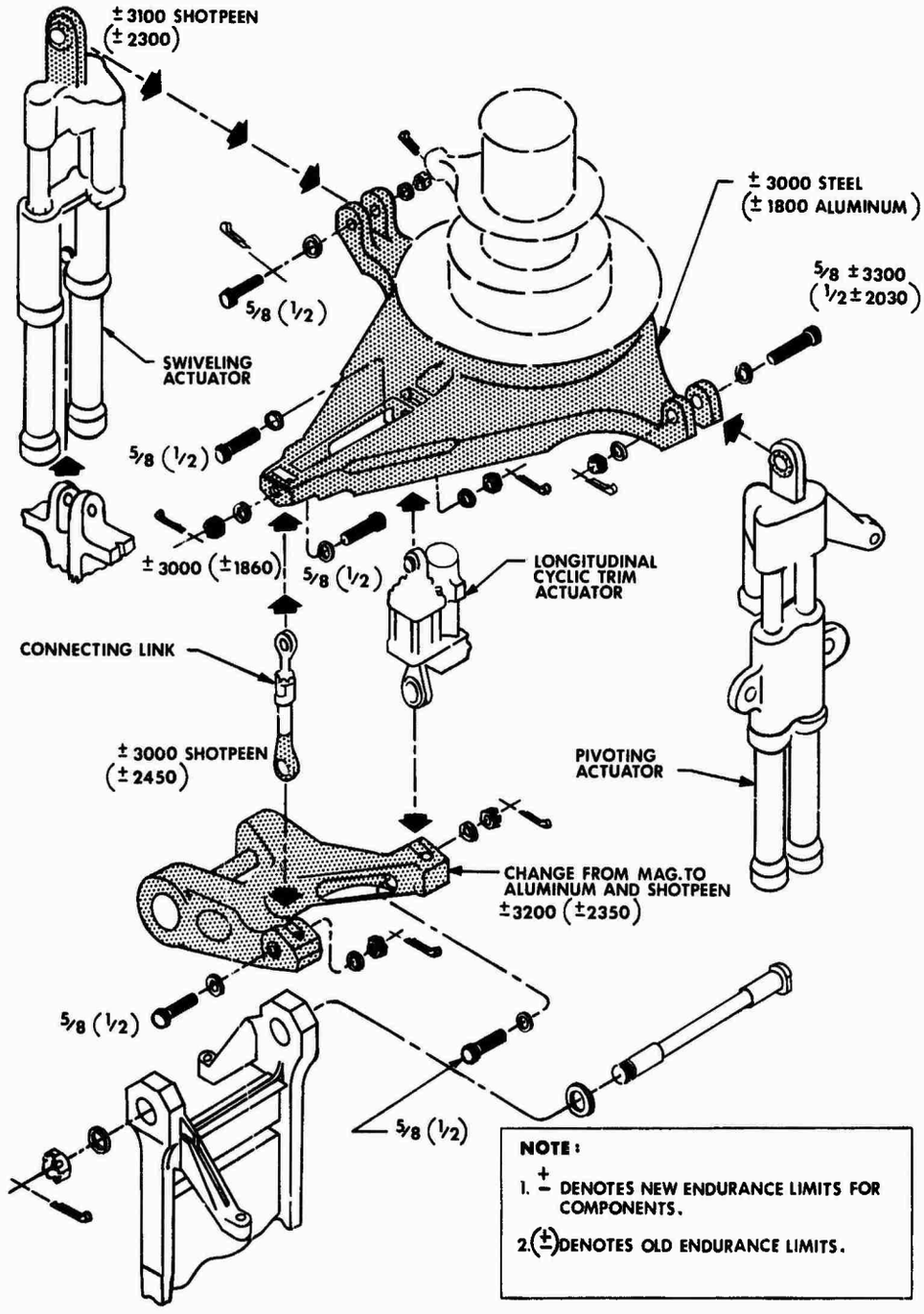


FIGURE K. ECP 585 - Uprated Aft Rotor Flight Control Components.

APPENDIX V. DESCRIPTION OF TEST HELICOPTER

1. The test helicopter was basically configured as a production CH-47C as stated in the detail specification except for the non-standard items installed as described in reference 4, appendix I. Items added to the test helicopter after APE I and prior to APE II are internally mounted water ballast tanks. They are as follows:

a. 1074 lb capacity installed from stations 195 to 225, BL 35 R H, mounted on isolated flooring.

b. 1072 lb capacity installed from stations 357 to 387, BL 35 R/H, mounted on isolated flooring.

c. 1070 lb capacity installed from stations 357 to 387, BL 35 L/H, mounted on isolated flooring.

d. 1055 lb capacity installed from stations 388 to 418, BL 35 R/H, mounted on isolated flooring.

e. 1034 lb capacity installed from stations 388 to 418, BL 35 L/H, mounted on isolated flooring.

f. 1066 lb capacity installed from stations 419 to 449, BL 35 R/H, mounted on isolated flooring.

g. 1055 lb capacity installed from stations 419 to 449, BL 35 L/H, mounted on isolated flooring.

h. 1065 lb capacity installed from stations 453 to 483, BL 35 R/H, mounted on isolated flooring.

i. 1057 lb capacity installed from stations 453 to 483, BL 35 L/H, mounted on isolated flooring.

2. The following installed development ECP's were incorporated on the test helicopter after APE I and prior to APE II:

ECP	Title	Effectivity
585	Revise aft upper control	

(1) Test helicopter had shotpeened 1/2" diameter cyclic trim actuator attachment upper and lower bolts rather than 5/8" diameter.

(2) Absorber tachometer generator was not qualified.

(3) Absorbers retuned from 243 rpm to 240 rpm.

3. The following development ECP was installed on the test helicopter during APE II.

ECP	Title	Effectivity
45R1	Installation of SAS failure light	B-464 (S/N 67-18494)

APPENDIX VI. PHYSICAL CHARACTERISTICS of the CH-47C

A. Areas:	
1. Rotor blade area (6 at 63.1 square ft).	9 square ft
2. Projected disc area.	5,000 square ft
3. Swept disc area (2 rotors at 2,827 square ft used in performance calculations).	5,655 square ft
B. Dimensions and General Data:	
1. Rotor spacing (distance between center line of rotors).	39 ft, 2 in.
2. Height (over rotor blades at rest).	18 ft, 7.1 in.
3. Sail area (cross section area of aircraft at butt line zero).	487 square ft
4. Sail area centroid.	Station 367.5, water line 28.6
5. Rotor blade clearance:	
a. Ground to tip, forward rotor static.	7 ft, 6.7 in.
b. Ground to tip rotors turning.	11 ft, 0.9 in.
c. Leading edge of aft pylon to forward rotor blade tip, rotor blade static.	16,7 in.
d. Leading edge of aft pylon to forward rotor blade tip, rotor turning.	40 in.
e. Elevation of aft rotor over forward rotor, at hub.	4 in.

6. Rotor data.

a. Rotor rpm (normal and military power).	225-250
b. Rotor rpm (maximum, autorotation).	261
c. Power loading at alternate design G.W. (46,000/5920).	7.76
d. Tip speed, normal at 245 rpm.	768 fps
e. Blade droop stop angle:	
(1) Aft	3.25 in.
(2) Forward	4.75 in.
f. Blade coning, stop angle.	30 degrees
g. Blade twist, centerline of rotor to tip.	9 degrees, 14 seconds
h. Rotor diameter.	60.0 ft
i. Number of blades, each rotor.	3
j. Projected disc loading (based on 39,000 lb).	6.90 lb/ft^2
k. Airfoil section designation and thickness.	Modified AMES droop snoot - t/c = .10
l. Aerodynamic chord, root and tip.	25.25 in.
m. Width, rotor blades turning.	60.0 ft
n. Length:	
(1) Maximum, rotor blades turning.	99.0 ft
(2) Maximum, rotor blades folded.	51.0 ft

APPENDIX VII. PHOTOGRAPHS

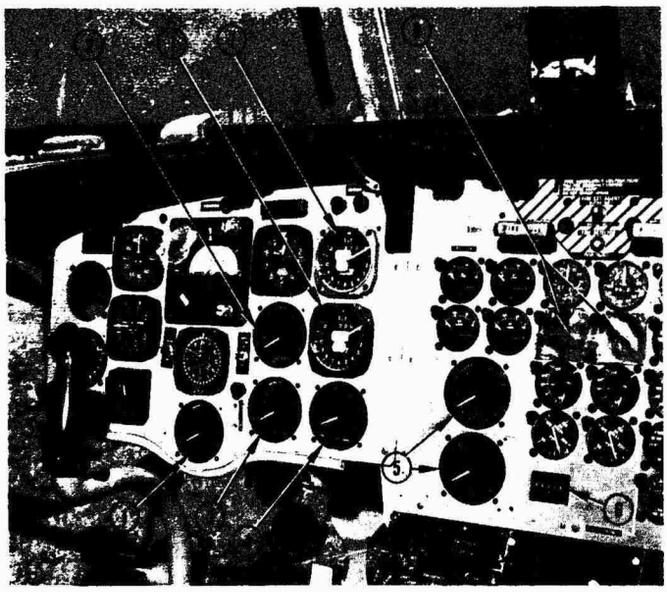


PHOTO 1 - Copilot's Central Instrumentation Panel, Indicators and Gages; (1) Longitudinal Control Position, (2) Collective Control Position, (3) Directional Control Position, (4) Lateral Control Position, (5) Nonstandard Longitudinal Cyclic Speed Trim, (6) Record Counter, (7) Nonstandard Turbine Inlet Temp, (8) Ship;s System Exhaust Gages Removed.

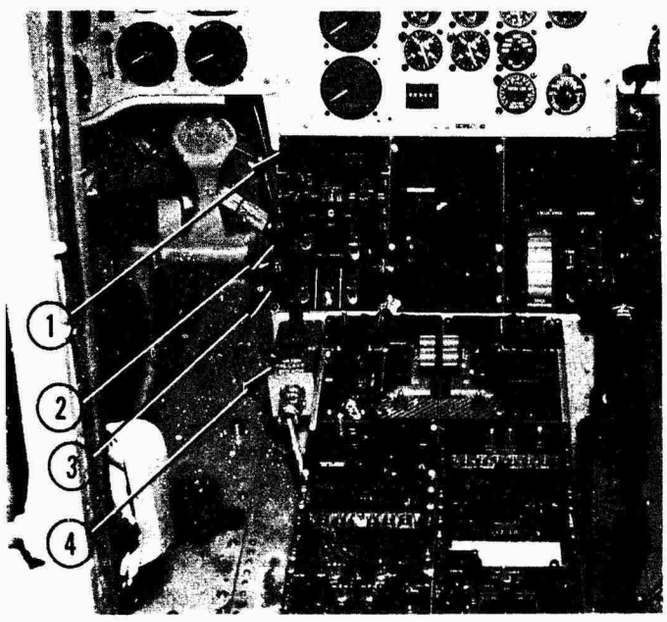


PHOTO 2 - Center Console: (1) Telemetry Track Selector, (2) Photopanel Control, (3) Tape Recorder Control Panel, (4) Water Ballast Jettison Control Box.

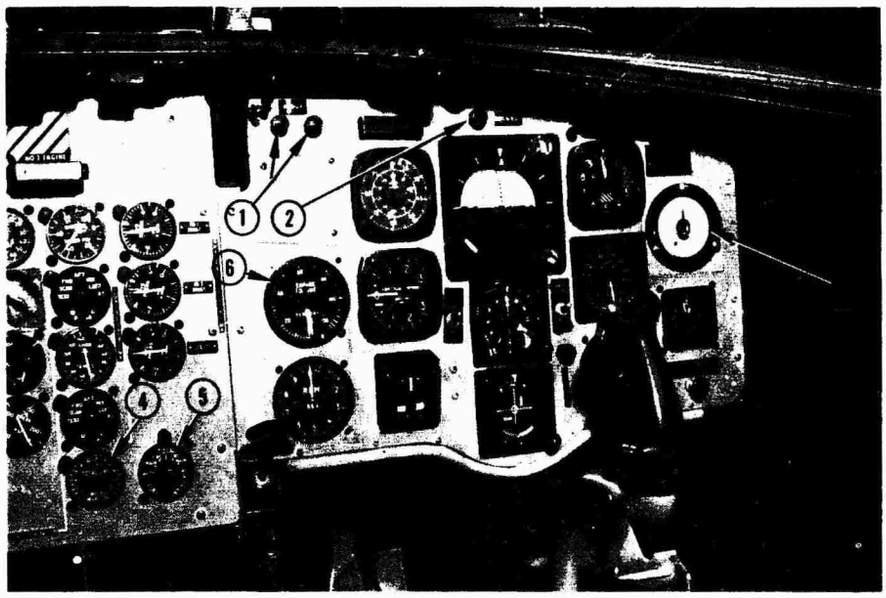


PHOTO 3 - Pilot's Instrument Panel: (1) Droop Stop Contact Lights, (2) Instrumentation Record Light, (3) Sideslip Angle Indicator.

PHOTO 4 - Pitot Static Boom Mounting On Nose Of Helicopter.

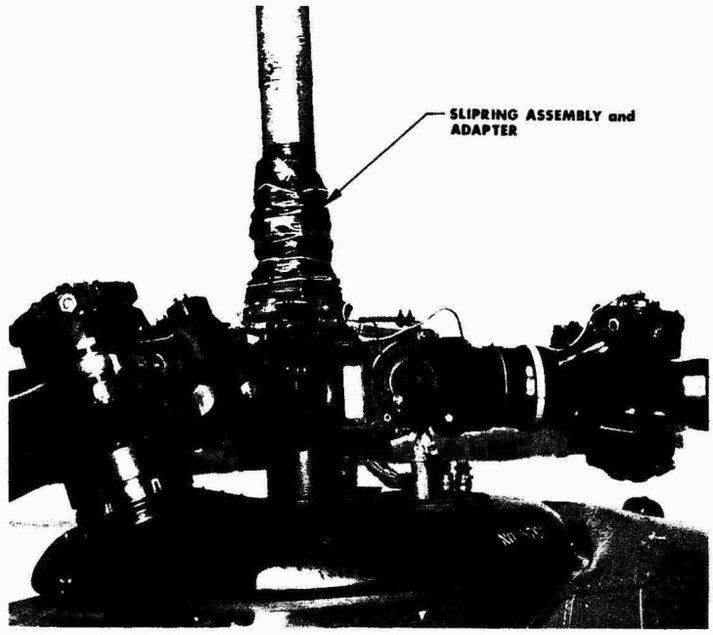


PHOTO 5 - Slip-ring Assembly and Adapter Mounted on Aft Rotor Head.
(Same Installation for Forward Head)

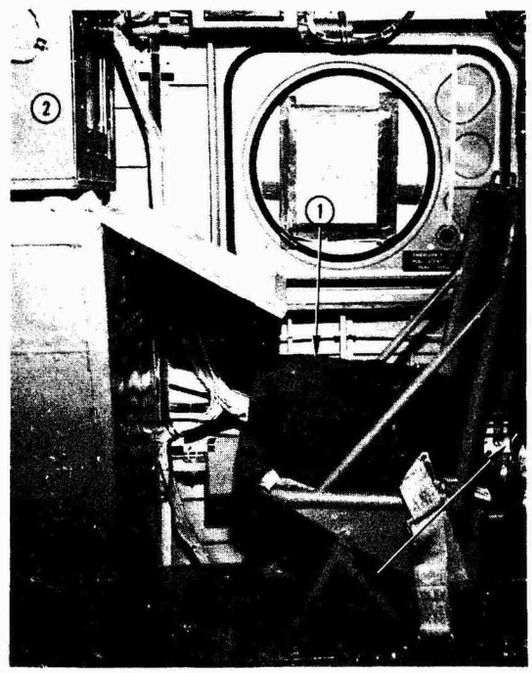


PHOTO 6 - Flight Engineer's Station at Forward Left Side of Cabin.
(1) Engineer's Seat, (2) Photo Panel, (3) Stowed In-flight Tape Recorder.

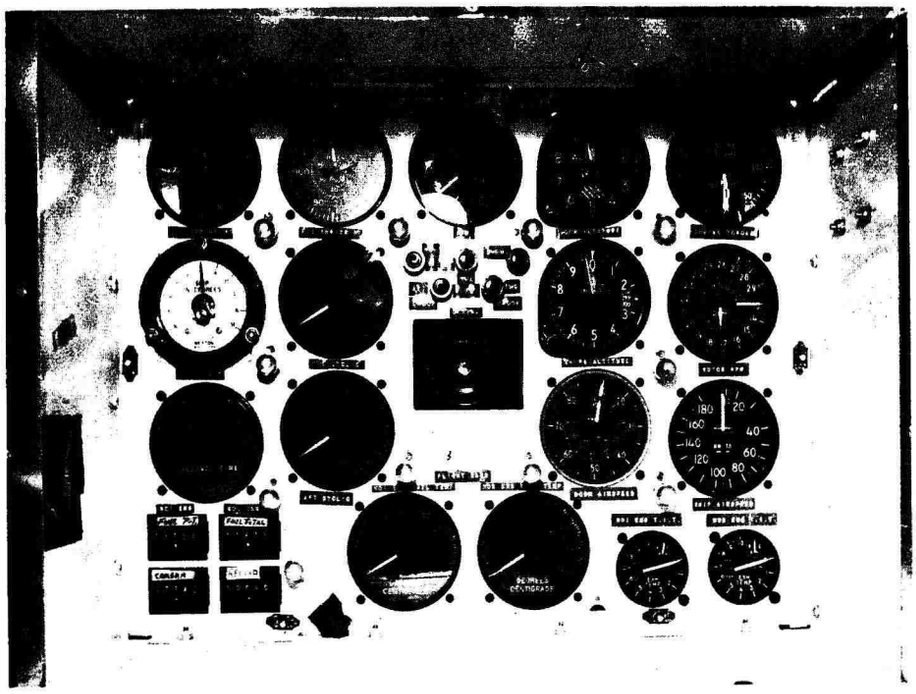


PHOTO 7 - Photo Panel Presentation.

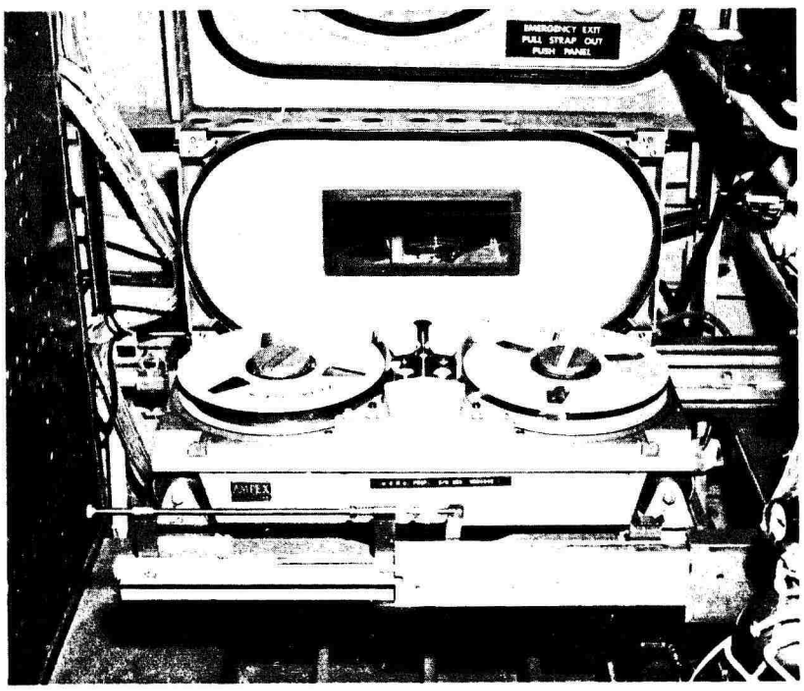


PHOTO 8 - Ampex In-flight Tape Recorder in Unstowed Position

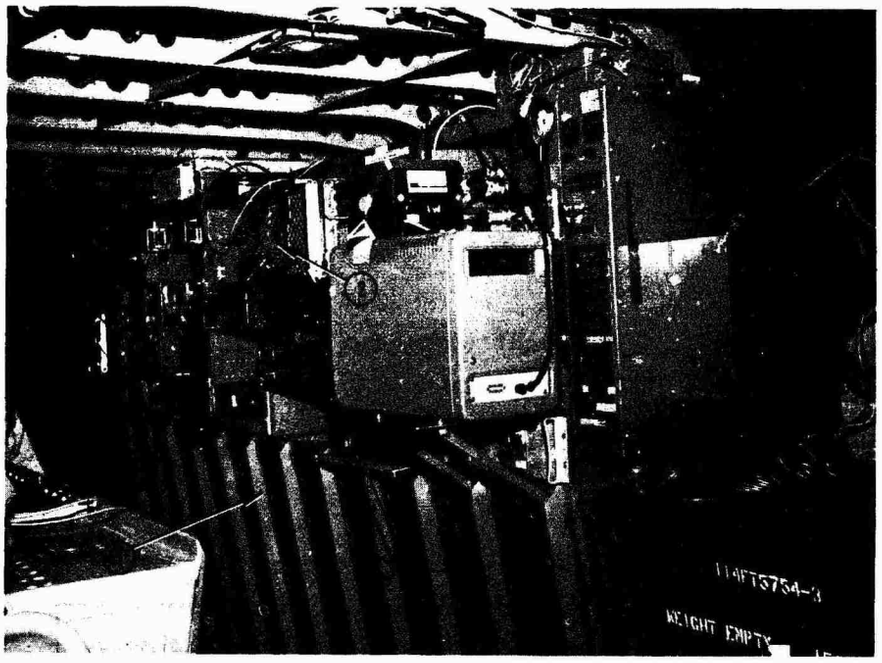


PHOTO 9 - (1) Water Ballast Tank Installed On Left Side Of Cabin (Installation Similiar For Right Side), (2) Instrumentation Racks And Calibration Equipment Mounted On Water Ballast Tanks.

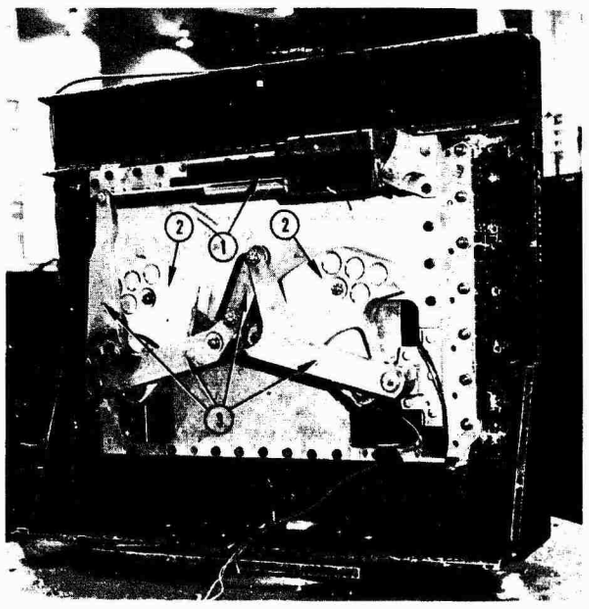


PHOTO 10 - Typical Self-tuning Vibration Absorber Removed From Helicopter And Mounted On Shaker Table: (1) Servo Actuator, (2) Tuning Masses, (3) Tuning Mass Levers.

APPENDIX VIII. CH-47C FLIGHT ENVELOPE for APE II

1. Operating Weights:

Maximum takeoff weight (for test purposes only)	47,500 lb
Maximum landing weight (for test purposes only)	47,500 lb

2. Gross Weight - Longitudinal C.G. Envelope:

Gross Weight (lb)	C.G. Range (in.)
20,000-28,500	30.0 fwd-18.0 aft
33,000	21.3 fwd- 7.0 aft
44,800	12.0 fwd- 5.0 aft
46,000	11.0 fwd- 4.0 aft

3. Load Factor - Gross Weight Envelope:

Gross Weight (lb)	Load Factor (N_z)
20,000-35,000	2.0
35,000-46,000	2.0-1.5

4. Airspeed - Altitude - Gross Weight:

Envelope - 235-244 rpm rotor speed	Figure A.

5. Airspeed - Altitude - Gross Weight:

Envelope - 245-247 rpm rotor speed	Figure B.

6. Airspeed - Sideslip Envelope:

Airspeed (KTAS)	Sideslip Angle (degrees)
0-36	90
37	47
170	15

FIGURE A
AIRSPEED-ALTITUDE-GROSS WEIGHT
ENVELOPE
235-244 RPM ROTOR SPEED

Note: With ECP 585 Controls
and ECP 540/592 Blades

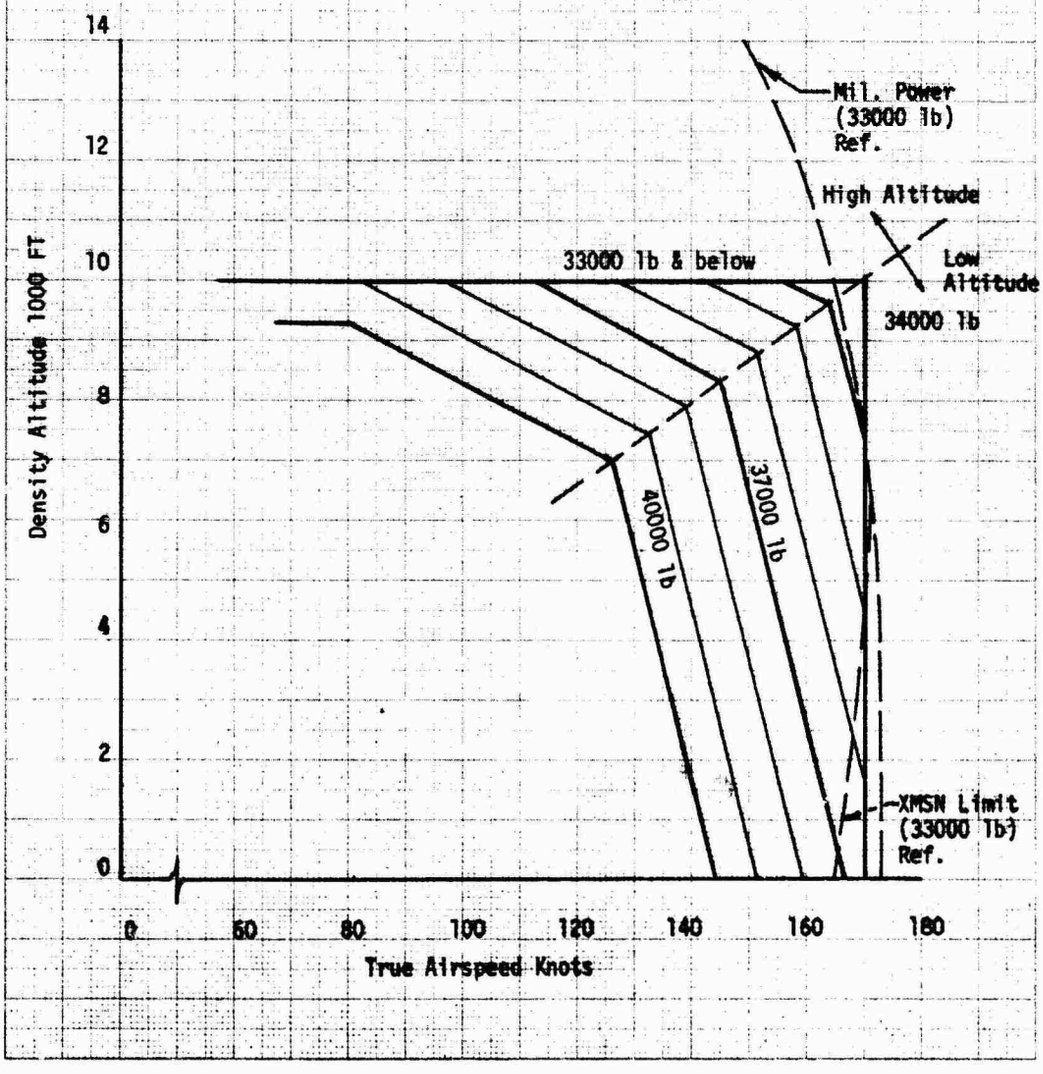
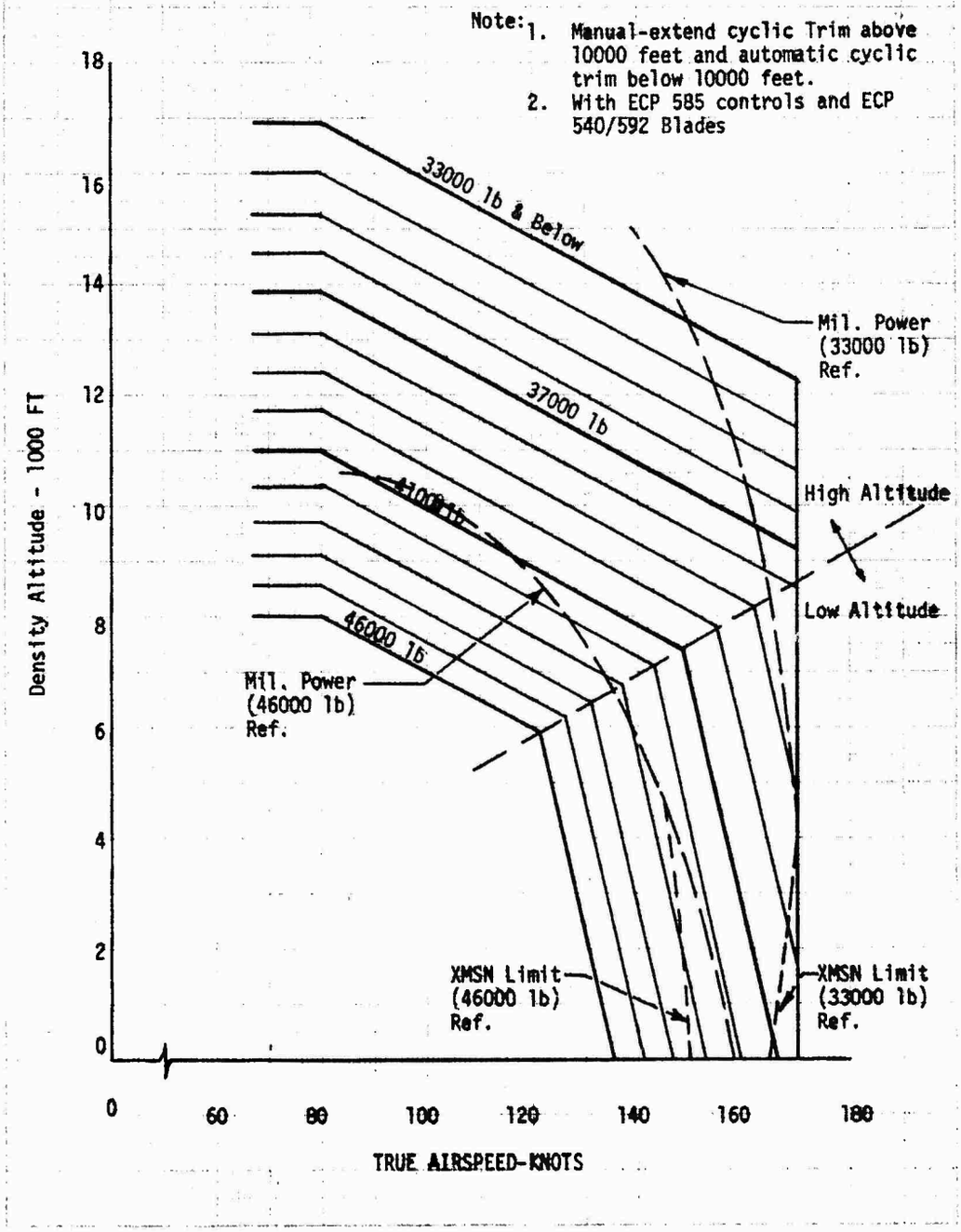


FIGURE B
AIRSPEED-ALTITUDE-GROSS WEIGHT
ENVELOPE
245-247 RPM ROTOR SPEED



7. Airspeed - Bank Angle Envelope:

Gross Weight (lb)	Airspeed (kt)	Bank Angle (degrees)
46,000 and below	V_{NE}	35
	V_{NE}-10 and below	45

8. Rotor Speed Limitations:

Power-on (hover)	223 to 250 rpm
Power-on (except hover)	223 to 242 rpm
Power-off	223 to 261 rpm

9. Engine Operating Limitations:

YT55-L-11 Ratings	shp	Output Shaft Speed rpm	Measured Gas Temperature T.I.T. °C
Maximum (10 min)	3750	16,000	896
Military (30 min)	3400	16,000	849
Normal	3000	15,950	804

N_1 per Engine Run Sheets.

Measured gas temperatures during starting and acceleration is 940°C and 910°C respectively.

Maximum torque is 1300 ft-lb

Engine Oil Data:

	Pressure psi	Temperature of
NRP	70 +20	190
GI	20 (minimum)	190

Note: Transmission ratio = output shaft speed/rotor Speed - 16,000/250 = 64:1

APPENDIX IX. TEST INSTRUMENTATION

Item	Photopanel	Cockpit	Magnetic Tape
Airspeed-boom	s	s	s
Airspeed-ship's	c	c	s
Altitude-boom	c	c	s
Altitude-ship's	c	c	s
OAT	s	c	s
TIME	s	s/s	s
Angle of sideslip	s	s	s
Rotor rpm	c	s	s
1/REV magnetic pickup			s
#1 Eng fuel flow rate			s
#2 Eng fuel flow rate			s
#1 Eng fuel temp	s		s
#2 Eng fuel temp	s		s
#1 Eng fuel counter	s		s
#2 Eng fuel counter	s		s
#1 Eng N_1	c	c	s
#2 Eng N_1	c	c	s
#1 Eng T.I.T.	s	s	
#2 Eng T.I.T.	s	s	
#1 Eng ENG. torque	c	c	
#2 Eng ENG. torque	c	c	
Fwd rotor torque			s
Fwd rotor torque			s
Fwd rotor torque			s
Aft rotor torque			s
Aft rotor torque			s
Aft rotor torque			s
Fwd cyclic trim pos.	s	s	s
Aft cyclic trim pos.	s	s	s
Record counter	c	c	
Fuel quantity indicator		s/s	
MA-1 compass		s/s	
Sideslip indicator		s/s	
Long. stick position		s	s
Lateral stick position		s	s
Dir. pedal position		s	s

Item	Photopanel	Cockpit	Magnetic Tape
Collective stick position		s	s
Altitude indicator		s/s	
Pitch attitude			s
Roll attitude			s
Yaw attitude			s
Vertical speed indicator	c	s/s	
Aft rotor upper control system stress parameters			
Pitch link			s
Pivoting actuator (axial)			s
Swiveling actuator (axial)			s
Fixed link			s
Lower drive arm			s

Additional instrumentation used
  Hand held:
    20 lb force gage - c
    40 lb force gage - c
    10 second chronometer

Legend:
  c - Production unit, calibrated.
  s - Sensitive unit, calibrated.
  s/s - Production unit, not calibrated.

APPENDIX X.
PILOT'S RATING SCALE

CONTROLLABLE CAPABLE OF BEING CONTROLLED OR MANAGED IN CONTEXT OF MISSION. WITH AVAILABLE PILOT ATTENTION	ACCEPTABLE MAY HAVE DEFICIENCIES WHICH WARRANT IMPROVEMENT, BUT ADEQUATE FOR MISSION. PILOT COMPENSATION, IF REQUIRED TO ACHIEVE ACCEPTABLE PERFORMANCE, IS FEASIBLE.	SATISFACTORY MEETS ALL REQUIREMENTS AND EXPECTATIONS. GOOD ENOUGH WITHOUT IMPROVEMENT CLEARLY ADEQUATE FOR MISSION.	EXCELLENT, HIGHLY DESIRABLE	A1
			GOOD, PLEASANT, WELL BEHAVED	A2
			FAIR. SOME MILDLY UNPLEASANT CHARACTERISTICS. GOOD ENOUGH FOR MISSION WITHOUT IMPROVEMENT.	A3
		UNSATISFACTORY RELUCTANTLY ACCEPTABLE. DEFICIENCIES WHICH WARRANT IMPROVEMENT. PERFORMANCE ADEQUATE FOR MISSION WITH FEASIBLE PILOT COMPENSATION.	SOME MINOR BUT ANNOYING DEFICIENCIES. IMPROVEMENT IS REQUESTED. EFFECT ON PERFORMANCE IS EASILY COMPENSATED FOR BY PILOT.	A4
			MODERATELY OBJECTIONABLE DEFICIENCIES. IMPROVEMENT IS NEEDED. REASONABLE PERFORMANCE REQUIRES CONSIDERABLE PILOT COMPENSATION.	A5
			VERY OBJECTIONABLE DEFICIENCIES. MAJOR IMPROVEMENTS ARE NEEDED. REQUIRES BEST AVAILABLE PILOT COMPENSATION TO ACHIEVE ACCEPTABLE PERFORMANCE.	A6
	UNACCEPTABLE DEFICIENCIES WHICH REQUIRE MANDATORY IMPROVEMENT. INADEQUATE PERFORMANCE FOR MISSION EVEN WITH MAXIMUM FEASIBLE PILOT COMPENSATION.		MAJOR DEFICIENCIES WHICH REQUIRE MANDATORY IMPROVEMENT FOR ACCEPTANCE. CONTROLLABLE. PERFORMANCE INADEQUATE FOR MISSION, OR PILOT COMPENSATION REQUIRED FOR MINIMUM ACCEPTABLE PERFORMANCE IN MISSION IS TOO HIGH.	U7
			CONTROLLABLE WITH DIFFICULTY. REQUIRES SUBSTANTIAL PILOT SKILL AND ATTENTION TO RETAIN CONTROL AND CONTINUE MISSION.	U8
			MARGINALLY CONTROLLABLE IN MISSION. REQUIRES MAXIMUM AVAILABLE PILOT SKILL AND ATTENTION TO RETAIN CONTROL.	U9
UNCONTROLLABLE CONTROL WILL BE LOST DURING SOME PORTION OF MISSION.			UNCONTROLLABLE IN MISSION.	10

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13. ABSTRACT

The CH-47 helicopter Army Preliminary Evaluation II was conducted in the vidinity of Philadelphia, Pennsylvania and Millville, New Jersey. The evaluation consisted of limited level flight performance tests and stability and control tests. Within the scope of tests all but six stability and control requirements of the detail and military specifications were met. Correction of two deficiencies is mandatory for acceptable mission capabilities. These deficiencies are the static and dynamic longitudinal stability improved helicopter capabilities. Safety of flight was affected by aft rotor blade stall characteristics in maneuvering flight at bank angles above 30 degrees and requires a reduction in maximum bank angles permitted. High aft rotor flight control component stress levels associated with maneuvering flight and operation at limit airspeeds requires that a visual flight loads display be incorporated in the cockpit.

DD FORM 1 NOV 68 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

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14 KEY WORDS	LINK A		LINK B		LINK C	
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CH-47 helicopter						
Army Preliminary Evaluation II						
Limited level flight performance tests						
Stability and control tests						
All but six requirements met						
Two deficiencies						
Static and dynamic longitudinal stability						
Eight shortcomings						