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USATECOM PROJECT NOS. 4-4-1532-03
4-5-1535-04
USAAVNTA PROJECT NOS. 63-81
65-1

ENGINEERING FLIGHT TEST OF UH-1B HELICOPTER EQUIPPED WITH XM-16 ARMAMENT SUBSYSTEM

AND

ENGINEERING FLIGHT TEST OF UH-1B HELICOPTER EQUIPPED WITH XM-21 ARMAMENT SUBSYSTEM

FINAL REPORT

BY

GEORGE M. YAMAKAWA
PROJECT ENGINEER

JOHN K. FOSTER
MAJOR, US ARMY, TC
PROJECT PILOT

JUNE 1966

U. S. ARMY AVIATION TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA

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ABSTRACT

Engineering flight tests of the UH-1B helicopter equipped with the XM-16 and XM-21 armament subsystems were conducted by the U. S. Army Aviation Test Activity (USAAVNTA). The overall objective was to determine the effect of the installation of the subsystems on the UH-1B. Specific objectives were to determine the existence of any safety-of-flight conditions by evaluation of quantitative stability and control and vibration data and to determine any performance losses.

The USAAVNTA was responsible for preparing test plan, executing test, and submitting final report. Tests were conducted at sites in Fort Irwin, Bakersfield, and Edwards Air Force Base, California. UH-1B/XM-16 tests were conducted from 19 July through 11 August 1965 and consisted of 39 flights totalling 35.8 productive flight hours, including 13 flights for 7.3 productive hours of weapon firing tests. UH-1B/XM-21 tests were conducted from 24 August through 2 September 1965 and consisted of 14 flights totalling 13.75 productive flight hours, including 3 flights for 2.5 productive hours of weapon firing tests.

Performance data showed that both armament subsystems caused an appreciable drag increase. The XM-16 caused a greater reduction in specific range than the XM-21. Compared with performance of clean UH-1B at 8000 pounds gross weight, 5000 feet altitude, and 324 rotor rpm, the installation of the XM-16 and XM-21 resulted in specific range reductions of 15 percent and 12 percent respectively.

Compared with clean UH-1B data (Report FTC-TDR-62-13), stability and control data showed no appreciable changes in flying characteristics of the UH-1B equipped with either armament subsystem.

Firing tests showed that both armament subsystem could be fired safely within the flight envelope established by the contractor.

Vibration characteristics were satisfactory under all conditions tested except for the lateral 4 cycles-per-revolution vibration with the XM-21 armament subsystem installed. The vibration level at all forward airspeeds slightly exceeded the 0.15-g limitation of MIL-H-8501A.

Hydraulic boost-off tests in hover, takeoff, climb, level flight, and landing were investigated. Qualitative pilot comments describing the helicopter's flying qualities with the boost off with either armament subsystem indicated that collective forces were high and could not be maintained for an extended period. The only practical method of landing was to execute a run-on landing. Attempting to transition to a hover resulted in over control and incipient loss of control due to high cyclic forces.

The performance data generated in this evaluation should be incorporated in the Operator's Manual.

FOREWORD

1. AUTHORITY

1.1 XM-16/UH-1B Helicopter Armament Subsystem

a. Letter, AMSTE-BG, Hq, U. S. Army Test and Evaluation Command (USATECOM), 17 October 1963, subject: "Directive for Engineering - Service Test of Combination 2.75" FFAR-M-6/UH-1B Helicopter Armament System, USATECOM Project-Task Number 4-4-1531-01, 02, 03."

b. Letter, AMSTE-BG, Hq, USATECOM, 31 March 1964, subject: "Flight Test of: a. Helicopter Armament System XM-16/UH-1B, USATECOM Project-Task Number 4-4-1532-03; b. Helicopter Armament System LAU3A/A and 32A/UH-1B, USATECOM Project-Task Number 4-4-1542-03."

1.2 XM-21/UH-1B Helicopter Armament Subsystem

Letter, AMSTE-BG, Hq, USATECOM, 5 January 1965, subject: "Test Directive, USATECOM Project Number 4-5-1535, Integrated Engineering/ Service Test of XM-21 Armament Subsystem for UH-1B Helicopter."

2. REFERENCES

A list of references is contained in Section 3, Appendix VI.

SECTION 1 - GENERAL

1.1 OBJECTIVES

1.1.1 UH-1B Helicopter Equipped with XM-16 Armament Subsystem

The overall test objective was to determine the effect of the XM-16 armament subsystem on the basic UH-1B helicopter. The specific objectives of the test were to:

a. Determine the existence of any safety-of-flight conditions by the measurement and subsequent analysis of quantitative stability and control and vibration data.

b. Determine the performance losses resulting from the installation of the XM-16 armament subsystem.

c. Verify the flight envelope proposed by the airframe contractor to be used during armament firings.

1.1.2 UH-1B Helicopter Equipped with XM-21 Armament Subsystem

The test objectives for the UH-1B helicopter equipped with the XM-21 armament subsystem were the same as those in Paragraph 1.1.1.

1.2 RESPONSIBILITIES

The U. S. Army Aviation Test Activity (USAAVNTA) was responsible for preparation of test plan, execution of test and submission of final report.

1.3 DESCRIPTION OF MATERIEL

1.3.1 XM-16 ARMAMENT SUBSYSTEM

The XM-16 armament subsystem is composed of a combination of the M-6 subsystem and the Aero 6D (LAU-32A/A), 7-round, 2.75-inch Folding-Fin Aerial Rocket (FFAR) rocket pod. the M-6 subsystem consists of four 7.62-millimeter (mm) M-60C machine guns, two machine-gun mount assemblies, and the necessary controls and hardware. A gun mount is attached to the rack assembly of the external stores support assembly on each side of the UH-1B helicopter, and the guns are aimed by means of a sighting station at the copilot's position. The four machine guns have a total weight of 796 pounds and a maximum capacity of 6600 rounds. Total lateral deflection is 12 degrees inboard to 70 degrees outboard and the vertical deflection is 9 degrees upward to 66 degrees downward. When either set of guns is traversed to its inboard limit stop, the guns cease firing.

The control panel consists of the OFF-SAFE-ARMED switch and the gun selector switch. Both switches are three-position toggle type and must be pulled upward to be operated. The guns fire only when the OFF-SAFE-ARMED switch is in the ARMED position. The gun selector switch enables the operator to select his fire power: with the switch in the LOWER position, only the lower guns operate; in the ALL position, both upper and lower guns operate; and in the UPPER position, only the upper guns operate.

The sighting station is located at the copilot's position and provides the means of remotely aiming the guns. When the "dead-man" switch is depressed, control of the guns is transferred from the cyclic control stick firing switches to the controller trigger. In this condition the guns cannot be fired from the cyclic control stick. The movement of the controller in elevation and deflection causes the guns to follow the controller. When the "dead-man" switch is released, the guns are returned to the "stow" position and can then be fired by depressing the fire button on the pilot's cyclic control stick.

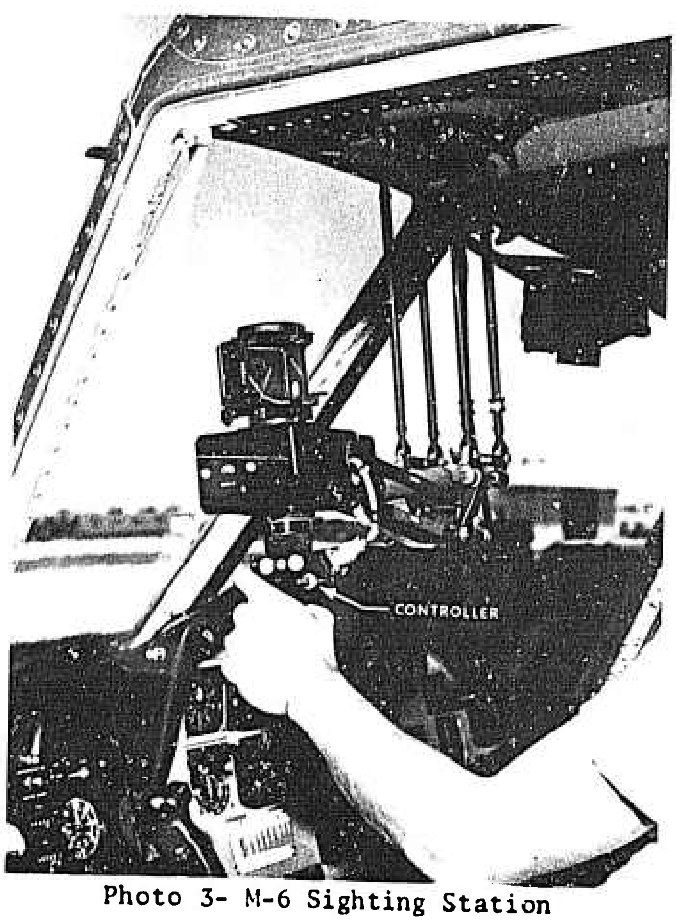


Photo 3- M-6 Sighting Station

Two LAU-32A/A, 7-round, 2.75-inch FFAR rocket pods, one for each side of the helicopter, are suspended from the MA-4A bomb racks and are expendable. The launcher attitude is of fixed variable design and can be changed in elevation only from the ground. The 2.75-inch FFAR's can be fired in ripples only and are ignited in pairs, one rocket simultaneously from each launcher. Up to 7 pairs of rockets may be selected. The number of pairs of rockets may be preset before firing and the subsystem is capable of firing 7 pairs of rockets forward from a fixed position of the launcher in 1.167 seconds. The rockets are fired from the same cyclic control stick firing switches that are used by the pilot or copilot to fire the M-6 machine guns. The trigger switches are located on each cyclic control stick. The rockets are aimed by pointing the aircraft and using either the M-6 machine guns as spotter rounds or the MK VIII sight mounted in the pilot's position. The two rocket pods can be jettisoned simultaneously by either electrical or mechanical means.

The machine guns and rockets cannot be fired simultaneously. When the ROCKET-GUN selector switch is placed in ROCKET, the copilot may use the controller on the sighting station to aim and fire the guns. The instant the pilot depresses the trigger on the cyclic control stick, the guns automatically stop firing and the rockets are ignited.

1.3.2 XM-21 ARMAMENT SUBSYSTEM

The XM-21 armament subsystem consists of a combination of 7.62-millimeter twin, high-rate-of-fire XM-20 machine guns and twin 2.75-inch rocket launchers (LAU-32A/A). The gun mount assemblies, which are installed one on each side of the helicopter, were originally designed to support two M-60C machine guns. Each mount of the test aircraft was modified to install a single, recoil mounted, automatic machine gun.

The XM-20 is an electrically driven, 6-barrel, Gatling-type, high-rate-of-fire machine gun. The two guns weigh 100 pounds. The weapon is capable of providing fire coverage up to 10 degrees in elevation, 90 degrees in depression, 12 degrees inboard, and 70 degrees outboard at rates of 2000 to 4000 rounds per minute. As with the M-6 subsystem the guns cease firing when either weapon traverses to its inboard limit. The slew rates are 40 degrees/second in elevation and depression and 75 degrees/second in deflection.

The sighting station, which is located at the copilot's position, is identical to the M-6 subsystem sighting station; and the operational functions are also the same. When the "dead-man" switch is depressed, the gun turrets follow the action of the controller on the sighting station and the guns can be fired only by the copilot. With the release of the "dead-man" switch, the guns return to the "stow" position, and both the pilot and copilot can fire the guns from the cyclic control sticks. The pilot is capable of firing the guns only in the "stow" position and directs the fire by aiming the helicopter.

Each of the XM-20 weapons is fed through a flexible ammunition chute supported at the forward side of the pylon. The rounds are fed from the right side, and the spent cases are ejected rearward and to the left. The links are ejected rearward and to the right by means of a rotary-type delinking feeder. The ammunition storage box configuration in the aircraft remains the same as that of the M-6 subsystem. Two forward rows of boxes supply the left-hand gun and two aft rows supply the right-hand gun. There is a total of 3000 rounds for each gun which are linked together to produce a single continuous belt through the cartridge drive crossover. The cartridge drive crossover enables each gun to be fed from the two rows of storage boxes at the dual rate of 2000 and 4000 rounds per minute. There is a burst limit time delay of approximately 3 seconds in the firing system.

The control panel is very similar to that of the M-6 subsystem except for the gun selector switch. The operator has the choice of firing either the left-hand gun only, right-hand gun only, or both guns.

The rocket launcher is the same LAU-32A/A, 7-round, 2.75-inch FFAR rocket pod as that of the XM-16 armament subsystem. The capabilities and firing sequences are also identical. Rocket firing is primary with the ROCKET-GUN switch in the ROCKET position. The number of rocket pairs to be fired per burst is selected on the ROCKET PAIR SELECTOR switch. Depressing a cyclic control stick trigger causes the preselected number of rocket pairs to fire. The circuitry is reset to the original condition whenever the trigger is released during a rocket burst so that the full selected number of rocket pairs will be fired at the next burst. Should the copilot be firing machine guns with the sighting station, depressing the pilot's cyclic control stick trigger stops the machine-gun fire and causes the rocket pairs to be fired. The pilot directs the rocket fire by maneuvering the aircraft and acquires the target through his reflex sight.

A detailed description of the UH-1B helicopter, S/N 60-3589, and an additional detailed description of the XM-16 and XM-21 armament subsystems are contained in Appendix IV.

1.4 BACKGROUND

1.4.1 QUALITATIVE MATERIEL REQUIREMENT

Combat Development Objectives Guide (CDOG) Paragraph 537a(2) states the following: "Armed Helicopter Weapons Systems. A series of armament systems capable of rapid mounting and demounting from Army observation and utility helicopters. The armament systems may consist of weapons and ammunition from current weapons systems of advanced design together with synchronized sighting, mounting, and firing devices providing for elevation, depression, and traverse where required. Specific armament systems required include light weapons, point target weapons, and area weapons. The systems will be employed in support of the full spectrum of ground combat operations from selected observation and utility helicopters in flight, at a hover, or on the ground. Weapons systems for observation helicopters and those utility helicopters used in the troop transport and utility role shall be light and simple to avoid degrading required helicopter agility. Selected utility helicopters will be armed for the primary mission as weapons helicopters and will mount a single-type weapon system. The systems will provide for full utilization of new weapons."

1.4.2 UH-1B HELICOPTER EQUIPPED WITH XM-16 ARMAMENT SUBSYSTEM

The effectiveness of the UH-1B helicopter equipped with either the M-3 (2.75-inch FFAR) or the M-6 (7.62-millimeter M-60C machine gun) armament subsystem has been demonstrated. In many tactical situations, however, the combined use of the machine guns and the rockets would have significantly increased the degree of mission success. The need to incorporate both weapons was recognized and as a result the combination of the two armament subsystems was fabricated in August 1963.

1.4.3 UH-1B HELICOPTER EQUIPPED WITH XM-21 ARMAMENT SUBSYSTEM

UH-1B helicopters are required to act as armed escort for troop landing operations or for screening operations. In addition, they make reconnaissance of enemy territory and should be capable of protecting themselves if fired upon. Current aircraft are equipped with the M-6 armament subsystem. This subsystem is not wholly satisfactory because accuracy in tracking and first-round hit requires improvements; reliability is low; and rate of fire is too low, in certain operations, to exploit fully the maneuverability of helicopters. An improved subsystem is required that will provide increased effectiveness in the destruction and neutralization of hostile elements. Employment of the subsystems should require a minimum restriction on the maneuverability of the aircraft. The heavy components of the subsystem (weapons and/or ammunition) must be designed for quick and easy removal from the aircraft.

1.4.4 GENERAL

The Weaponization Project Manager, Hq, U. S. Army Materiel Command (USAMC) assigned the engineering-service test of the UH-1B helicopter equipped with the XM-16 and XM-21 armament subsystems to Hq, U. S. Army Test and Evaluation Command (USATECOM). USATECOM, in test directive, 17 October 1963, as amended 31 March 1964, requested USAAVNTA to conduct an engineering flight test of the UH-1B helicopter equipped with the XM-16 armament subsystem. In Test Directive, 5 January 1965, USATECOM requested USAAVNTA to conduct an engineering flight test of the UH-1B equipped with the XM-21 armament subsystem.

The engineering flight tests were conducted at test sites in Fort Irwin, Bakersfield, and Edwards Air Force Base, California. The UH-1B/XM-16 tests were conducted during the period 19 July 1965 through 11 August 1965. Thirty-nine flights totalling 35.8 productive flight hours were required to accomplish this program.

The UH-1B/XM-21 tests were conducted during the period 24 August 1965 through 2 September 1965. Fourteen flights totalling 13.75 productive flight hours were required to accomplish this program.

A separate report of the UH-1B/XM-16 jettison tests outlined in Test Plan (Section 3, Appendix VI, Reference e) was submitted on 5 May 1965 (Reference n). An interim report on the UH-1B/XM-16 engineering flight test results was submitted on 13 September 1965 (Reference o).

USATECOM authorized USAAVNTA, on 21 August 1965, to incorporate the results of the engineering flight tests of the UH-1B equipped with the XM-16 and XM-21 armament subsystems in one final report.

1.5 FINDINGS

1.5.1 PERFORMANCE

1.5.1.1 Level Flight

The results of the level flight performance tests indicated that the UH-1B helicopter equipped with either the XM-16 or XM-21 armament subsystem required more power at the same airspeed than a clean helicopter (Reference s).

At 8000 pounds gross weight, 5000 feet altitude and 324 rotor rpm, the installation of the XM-16 armament subsystem resulted in a specific range reduction of 15 percent. The installation of the XM-21 armament subsystem at the same conditions resulted in a 12-percent reduction in specific range.

The minimum power required for level flight at a given coefficient of thrust (C_T) showed an average increase of approximately 7 percent for the UH-1B equipped with either armament subsystem.

1.5.1.2 Autorotation

The minimum rate of descent in autorotation of the UH-1B equipped with the XM-16 armament subsystem at gross weights between 6300 pounds and 7800 pounds was 1850 feet per minute (fpm) at 54 knots calibrated airspeed (KCAS). A minimum rate of descent of 1660 fpm was reported for the clean UH-1B at the same conditions (Reference s). The UH-1B equipped with the XM-16 and XM-21 exhibited the same characteristics in autorotation.

1.5.2 STABILITY AND CONTROL

1.5.2.1 Static Longitudinal Stability

The static longitudinal stability of the UH-1B helicopter with either weapon subsystem installed was satisfactory under all conditions tested. A comparison of stability with the weapon subsystems installed on the UH-1B showed that no appreciable difference existed under similar test conditions. As noted in earlier UH-1B evaluation (Reference r), instability occurred below 40 KCAS. This reversal was not objectionable. No appreciable difference was observed in the static longitudinal stability characteristics of the UH-1B with only one pod or with two pods, either full or empty.

1.5.2.2 Static Directional Stability

The static directional stability of the armed UH-1B in all configurations was satisfactory under all test conditions. Lateral control positions indicated less positive dihedral effect than in the clean UH-1B helicopter but this was not considered objectionable (Reference r). The variation in pedal position required for steady sideslips showed no significant change from test results of the previous evaluation (Reference r).

1.5.2.3 Sideward and Rearward Flight

Flying characteristics of the armed UH-1B in sideward and rearward flight were satisfactory and essentially unchanged from those of a clean UH-1B. Sufficient control was available to fly to the 30 knots true airspeed (KTAS) required by Paragraph 3.2.10 of MIL-H-8501A (Reference p) in both sideward and rearward flight.

1.5.2.4 Dynamic Stability

Comparison of the dynamic stability test results of the armed UH-1B and the clean UH-1B showed no difference in the dynamic stability characteristics of the two aircraft. The 1-inch control pulse disturbances were well damped about all three axes and were acceptable.

1.5.2.5 Controllability

The controllability of the armed UH-1B was satisfactory about all three axes. The maximum control sensitivity of the longitudinal, lateral and pedal responses were 10, 24 and 28 degrees/second^2/inch respectively at calibrated airspeeds of 48 through 95 knots in level flight. The longitudinal and lateral control responses at the identical conditions were 5 and 11 degrees/second/inch respectively. The directional control response was a maximum of 24 degrees/second/inch at 48 knots. A slight difference in controllability existed between the armed UH-1B and the clean UH-1B but this difference was not apparent to the pilot.

1.5.3 VIBRATION

1.5.3.1 Non-Firing

The vibration levels of the UH-1B equipped with the XM-16 armament subsystem were satisfactory. The vibration levels with the XM-21 armament subsystem installed, however, were magnified. At a frequency of 4/rev (21.6 cycles/second), the lateral acceleration exceeded 0.15g, the limit specified in Paragraph 3.7.1(b) of MIL-H-8501A (Reference p). This level was recorded from 43.5 KCAS to the airspeed limit (100 KCAS).

1.5.3.2 Firing

The vibration levels of the armed helicopter with the guns firing were within the limits of Paragraph 3.7.1(b) of MIL-H-8501A. The highest vibration level (0.15g) was recorded in the lateral plane of motion at a 4/rev (21.6 cycles/second) frequency.

1.5.4 FIRINGS

1.5.4.1 Machine-Gun Firings

The firing of the XM-16 (M-60C) and XM-21 (XM-20) machine guns had no significant effects on the handling qualities of the helicopter. The XM-20 machine guns created a reaction force opposite to the line of fire. When the controls were held fixed, the helicopter responded in the direction of the resulting moment but, as the guns ceased firing, returned to the initial trim position.

1.5.4.2 Rocket Firings

The firing of the 2.75-inch Folding-Fin Aerial Rockets (FFAR's) was satisfactory under all conditions tested. With the controls of the UH-1B held fixed, a nose-down attitude change of 4.5 degrees was experienced when a full complement of rockets (7 pairs) was fired. The pitching rate was approximately 4.8 degrees/second and was not considered hazardous. A pilot would normally unconsciously correct for this resultant pitch-down tendency.

1.5.5 BOOST-OFF

The results of these tests indicated that with the boost off it was possible to maintain level flight with either weapon subsystem installed on the UH-1B helicopter. The collective-pitch control had a tendency to creep down at a rate of .5 inches/second (1 second after the hydraulic boost was turned off). Collective forces measured were 76 pounds in sustained level flight with zero sideslip, and 90 pounds in a climb. Because of these forces extended flight with the boost off would be impossible. The only practical method of landing with boost off was to execute a run-on type of landing because of the high control forces and the incipient loss of control that resulted when attempting to transition to a hover.

1.6 Conclusions

The handling qualities of the UH-1B helicopter with either the XM-16 armament subsystem or XM-21 armament subsystem installed were essentially the same as those of a clean UH-1B.

A significant level flight performance penalty was experienced with either subsystem installed. The minimum rate of descent during autorotational descents with either subsystem installed was increased by approximately 200 fpm.

Results from the firing of both machine guns and rockets showed that there were no safety-of-flight limitations within the envelope specified by the airframe contractor.

1.7 Recommendations

The performance data generated during this evaluation should be incorporated in the Operator's Manual (Reference q).

SECTION 2 - DETAILS OF TESTS

2.0 INTRODUCTION

The engineering tests of the UH-1B equipped with the XM-16 armament subsystem were completed on 11 August 1965. The XM-21 armament subsystem was immediately installed and tested. The requirements of Paragraph 2.3.1 of the test plan (Reference g), Machine-Gun Firings of the UH-1B/XM-21, were executed as outlined. Portions of the other tests were omitted because of experience gained during the UH-1B/XM-16 tests. No problem areas were encountered during the XM-16 evaluation and because of the aerodynamic similarity of the XM-16 and the XM-21 only spot-checks of the various flight conditions were required for the XM-21 subsystem evaluation.

The performance portion of the test was limited to level-flight speed-power and autorotation tests. The most adverse flight conditions were concentrated on in the stability and control portion of the test. These limitations were imposed by the short calendar time allotted for this project.

Performance tests were conducted in a stabilized condition in non-turbulent air. All stability and control, boost-off, and weapons firing tests were conducted in non-turbulent atmospheric conditions so that test data would not be influenced by uncontrolled disturbances.

The test UH-1B helicopter, Serial Number 60-3589, crashed and burned on 2 September 1965.

Stability and control data was evaluated on the basis of requirements of Military Specification MIL-H-8501A (Reference p).

The results of the Jettison Tests of the UH-1B/XM-16 armament subsystem outlined in Test Plan (Reference e) were reported on 5 May 1965 in Reference n.

2.1 <u>PERFORMANCE</u>

2.1.1 LEVEL FLIGHT

2.1.1.1 <u>Objective</u>

Tests were conducted to determine airspeed, fuel flow, and power required relationships to define the level flight performance for any combination of gross weight, altitude and rotor rpm.

2.1.1.2 Method

Tests were conducted at various combinations of altitude, gross weight, and rotor speed in the armed (XM-16 or XM-21) configuration. Each speed power was flown at a constant value of gross weight divided by density (W/ρ). This involved increasing altitude on successive data points as fuel was consumed. Data was recorded in stabilized flight at various airspeeds throughout the allowable speed range at approximately 10-knot increments to define adequately the particular power required curve. In addition to basic power parameters, fuel-flow data was recorded.

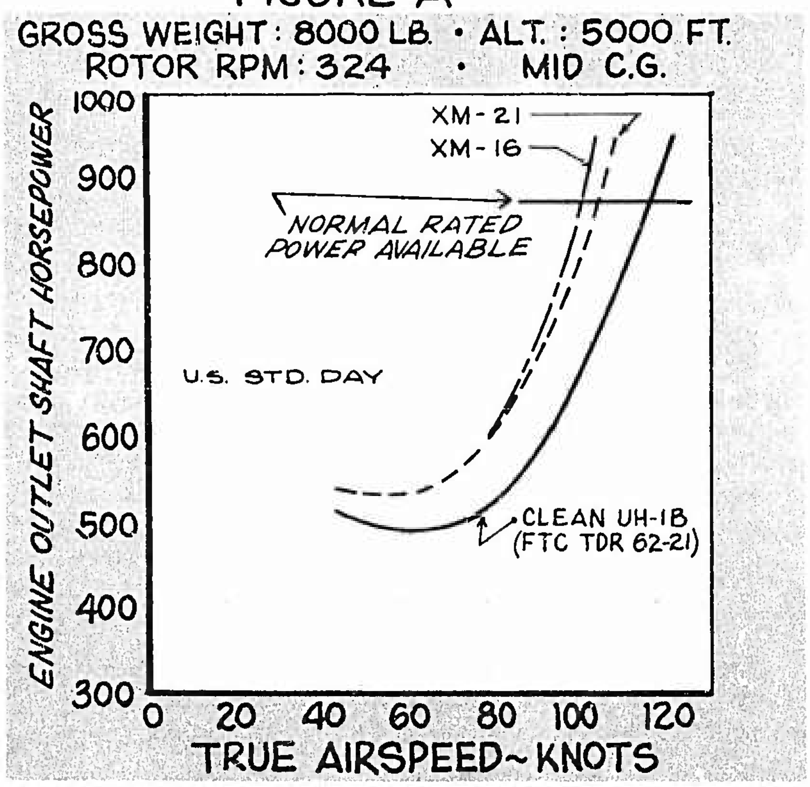
2.1.1.3 Results

Test results are presented graphically in Figures 4 through 15, Section 3, Appendix I. Non-dimensional summary plots are presented in Figures 1 through 3.

2.1.1.4 Analysis

The effect on power required due to the addition of the XM-16 or the XM-21 armament subsystem is illustrated in Figure A.

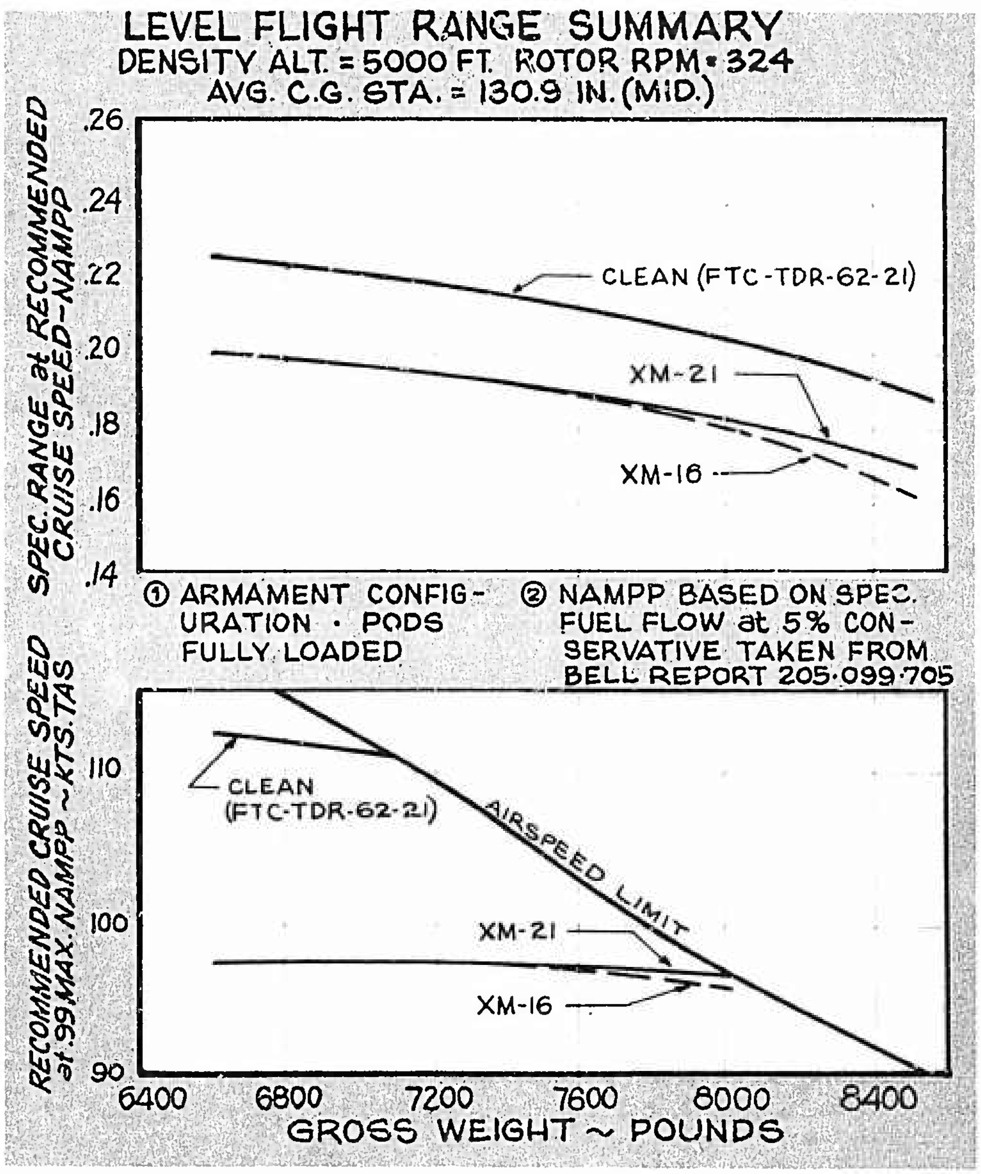
FIGURE A



Compared with the performance of a clean UH-1B at the conditions of Figure A, at the airspeed for normal rated power, the installation of the armament subsystems resulted in a 13-knot airspeed loss for the XM-21 and a 16.5-knot airspeed loss for the XM-16.

The performance penalty in terms of range performance is illustrated in Figure B.

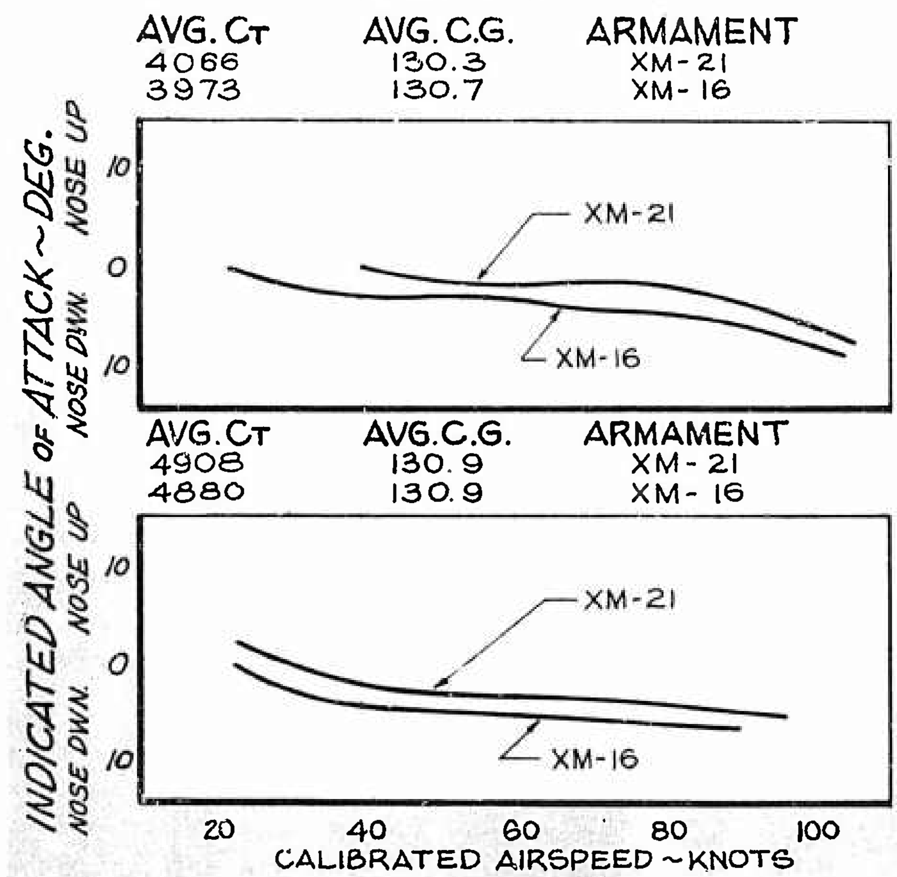
FIGURE B



Compared with the performance of a clean UH-1B at the conditions of Figure B, at 8500 pounds, the installation of the XM-16 resulted in a 15-percent decrease and the installation of the XM-21 resulted in a 12-percent decrease in specific range at optimum cruise airspeed. Compared with performance of a clean UH-1B, the optimum cruise airspeeds with the XM-16 or the XM-21 installed, varied from a decrease of 15 knots at light gross weights to zero knots at higher gross weights when optimum cruise was at the placard airspeed limit.

The UH-1B with the XM-16 installation showed a greater reduction in specific range than with the XM-21 installation. This difference can be explained by the greater drag surface of the XM-16. This greater drag surface resulted in an increased negative fuselage trim angle of attack for the XM-16 which in turn resulted in increased power required and, therefore, a greater reduction in specific range. The difference in trim angles of attack for the XM-16 and XM-21 is shown in Figure C.

FIGURE C



2.1.2 AIRSPEED CALIBRATION

2.1.2.1 Objective

The objective of these tests was to determine the airspeed position error for both the standard and test airspeed systems.

2.1.2.2 Method

The calibrated trailing bomb method was used to determine the airspeed calibration of the standard and test airspeed systems. The aircraft with the XM-16 installed was flown at various airspeeds in stabilized level flight at an average gross weight of 6980 pounds.

2.1.2.3 Results

Test results are presented graphically in Figures 19 and 20, Appendix I.

2.1.2.4 Analysis

The position error of the test airspeed system was nonlinear. This position error varied from +3.0 knots indicated airspeed (KIAS) to +4.5 KIAS. The position error of the standard airspeed system was identical to that of the airspeed system of a standard UH-1B (Reference q). This indicates that the installation of either the XM-16 or XM-21 had no effect on the ship airspeed system position error.

2.1.3 AUTOROTATIONAL DESCENTS

2.1.3.1 Objective

The objective of these tests was to determine the minimum rate of descent and the airspeed for minimum rate of descent during stabilized autorotations.

2.1.3.2 Method

Autorotational descents were conducted at various airspeeds throughout the allowable speed range. During the descents, time and altitude were recorded to determine the rate of descent. Stabilized descents at various airspeeds between 40 and 88 KCAS were flown to determine the airspeed for minimum rate of descent.

2.1.3.3 Results

Test results are presented graphically in Figure 21, Appendix I.

2.1.3.4 Analysis

The tests to determine the minimum rate of descent and the airspeed for minimum rate of descent were conducted with only the XM-16 installed on the UH-1B helicopter. Since other tests revealed the close similarity of the XM-16 and XM-21 armament subsystems in their effect on flight characteristics, autorotational descents with the XM-21 armament kit were not accomplished. The minimum rate of descent in autorotation of the armed UH-1B at average gross weights of 7000 pounds and average density altitudes of 7500 feet was 1850 feet per minute (fpm) compared with 1660 fpm for the unarmed UH-1B.

2.2 STABILITY AND CONTROL

2.2.1 STATIC LONGITUDINAL STABILITY

2.2.1.1 Objective

The objective of these tests was to determine the static longitudinal speed stability as the airspeed was varied from trim during level flight, autorotation, and partial power descents.

2.2.1.2 Method

Static longitudinal stability tests with either the XM-16 or XM-21 installed were conducted in two ways. The first method consisted of recording the control positions required for various stabilized airspeeds during level flight. These tests were conducted in conjunction with the level flight tests (Paragraph 2.1.1).

The second method of evaluating the static longitudinal stability consisted of fixing the collective stick at the various trim conditions specified in Paragraph 3.2.10 of MIL-H-8501A (Reference p). Once the helicopter was trimmed at a recommended airspeed, the collective stick was fixed, the airspeed was changed by the movement of the longitudinal cyclic stick and altitude was allow to vary.

2.2.1.3 Results

Test results are presented graphically in Figures 22 through 36, Appendix I.

2.2.1.4 Analysis

Static longitudinal stability was positive for all airspeeds above 40 knots at all conditions tested. No significant difference between the apparent degree of stability of the clean UH-1B (Reference r) and the armed UH-1B was indicated by comparison of the slope of the control position versus airspeed curves.

2.2.2 STATIC DIRECTIONAL STABILITY

2.2.2.1 Objective

The objective of these tests was to evaluate the lateral-directional flying qualities, effective dihedral, and directional stability for representative flight conditions.

2.2.2.2 Method

Static lateral-directional stability was investigated by obtaining the longitudinal, lateral and directional control positions necessary to maintain various steady sideslip angles at several different airspeeds and altitudes. The flight conditions tested were level flight, autorotation, and climb. The center-of-gravity (C.G.) locations were either forward or mid. Static directional stability was determined from the relationship between pedal position and angle of sideslip. Effective dihedral was determined from the relationship between lateral control and sideslip angle.

2.2.2.3 Results

Test results are presented graphically in Figures 37 through 46, Appendix I.

2.2.2.4 Analysis

The armed UH-1B helicopter exhibited strong positive static directional stability under all conditions tested. The dihedral effect was slightly weaker compared with the clean UH-1B evaluation (Reference r). Negative dihedral occurred at high-speed level flight and was more noticeable at a forward C.G. than at a mid C.G. Although not in accordance with MIL-H-8501A, (Reference p), this was not objectionable to the pilot. The angle of roll showed no change in attitude with increasing left sideslip; this was not a characteristic of a clean UH-1B. This condition was not objectionable to the pilot.

2.2.3 SIDEWARD AND REARWARD FLIGHT

2.2.3.1 Objective

The objective of these tests was to determine if sufficient control was available to hover in winds of up to 30 knots.

2.2.3.2 Method

The hovering characteristics of the armed UH-1B helicopter in crosswind and tailwind were simulated by recording control positions in sideward and rearward flight. The helicopter was stabilized at the various airspeeds by using a calibrated pacer ground vehicle.

2.2.3.3 Results

Test results are presented graphically in Figures 47 and 48, Appendix I.

2.2.3.4 Analysis

Sideward and rearward flights were satisfactory with the XM-16 installed. A slight difference, however, was noticed with the nonsymmetrical armament configuration. With one pod removed, the control positions shifted to counter the unbalanced weight loading but the flying qualities were still satisfactory. No problems were encountered in sideward flight through the speed range from zero to 33.5 knots true airspeed (KTAS) in both directions. During rearward flight at 23 KTAS, a longitudinal cyclic stick control margin of 0.9 inches of aft cyclic travel remained.

2.2.4 DYNAMIC STABILITY

2.2.4.1 Objective

The objective of these tests was to determine the capability of the armed UH-1B to return to trim following a disturbance.

2.2.4.2 Method

The armed UH-1B dynamic stability characteristics were determined from analysis of the time histories of the helicopter motions resulting from pulse-type control inputs. The longitudinal, lateral, and directional axes were subjected to 1-inch control inputs and the helicopter's responses were recorded. The tests were conducted in level flight at an average density altitude of 4990 feet, a mid C.G. (Station 130.9), a rotor rpm of 324, and an average gross weight of 6980 pounds. A control fixture was used to insure precise inputs.

2.2.4.3 Results

Time histories are presented in Figures 49 through 54, Appendix I.

2.2.4.4 Analysis

The UH-1B equipped with either the XM-16 or XM-21 showed no apparent difference in dynamic stability characteristics from those of a clean UH-1B. Following forward and aft longitudinal pulses, the aircraft was essentially deadbeat in pitch. A residual lateral-directional oscillation persisted after the initial disturbance damped out. Following directional or lateral pulse inputs the aircraft established a well damped "dutch roll" mode of motion which damped out in 4 to 5 cycles.

2.2.5 CONTROLLABILITY

2.2.5.1 Objective

The objective of these tests was to determine the changes in controllability of the UH-1B as a result of the installation of the armament subsystem.

2.2.5.2 Method

The controllability of the UH-1B with the XM-16 installed was determined by analyzing the helicopter's response to step-type control inputs about all three axes. A control fixture was used to insure constant inputs. The data was analyzed in terms of the maximum angular accelerations and rates and the time to reach the corresponding maximum values. The tests were conducted under the same flight conditions listed for the dynamic stability tests (Paragraph 2.2.4.2).

2.2.5.3 Results

Test results are presented graphically in Figures 55 through 63, Appendix I.

2.2.5.4 Analysis

The control sensitivity and response were determined through analysis of the angular accelerations and the angular rates respectively. Differences were found in comparison of the control sensitivity and response of the armed and unarmed UH-1B helicopters. The following table presents a comparison of the controllability of the armed and unarmed helicopters:

CONTROL SENSITIVITY

Configuration	Axis	Sensitivity deg/sec^2/in		Time to Peak sec
Clean	Pitch	Fwd 10.5	Aft 10.5	0.5
	Roll	Lt 23.8	Rt 30.0	0.4
	Yaw	Lt 24.0	Rt 29.9	0.5
Armed	Pitch	Fwd 8.4	Aft 10.0	0.5
	Roll	Lt 20.1	Rt 25.3	0.4
	Yaw	Lt 22.3	Rt 28.2	0.6

CONTROL RESPONSE

Configuration	Axis	Response deg/sec/in		Time to Peak sec
Clean	Pitch	Fwd 9.9	Aft 9.9	2.0
	Roll	Lt 10.2	Rt 15.0	1.2
	Yaw	Lt 9.9	Rt 13.2	0.9
Armed	Pitch	Fwd 6.5	Aft 4.9	1.5
	Roll	Lt 7.0	Rt 11.4	1.2
	Yaw	Lt 10.5	Rt 17.1	0.9

NOTE: Comparisons were made in level flight at 800 KCAS at a gross weight of 7000 pounds.

The controllability changes indicated were not significant enough to be perceptible to the pilot.

The installation of the XM-16 or XM-21 on the UH-1B caused a lower than normal vertical C.G. and increased the moment of inertia about all axes. Controllability increased at a lower C.G. and decreased with a larger moment of inertia. This would explain the differences between the controllability of the clean UH-1B and the armed UH-1B.

2.3 VIBRATION

2.3.1 OBJECTIVE

The objectives of these tests were to determine the vibrations induced by the installation of the armament subsystems and to determine the vibrations due to the firing of the guns.

2.3.2 METHOD

Vibration tests were recorded during the entire flying portion of the program. The helicopter was equipped with two velocity-type accelerometers at the passenger station to record lateral and vertical vibrations. At the initial phase of the flying program, the test UH-1B helicopter was flown in the clean configuration and its vibration characteristics were established. The vibration characteristics of subsequent flights in the armed configuration were compared with those of the clean helicopter.

2.3.3 RESULTS

Test results are presented graphically in Figures 64 through 66, Appendix I.

2.3.4 ANALYSIS

The armed (XM-16 or XM-21) UH-1B showed satisfactory vibration characteristics during the firing of both subsystems and during the non-firing of the XM-16 subsystem. During the non-firing of the XM-21, however, the lateral vibration acceleration exceeded the allowable level defined in Paragraph 3.7.1 of MIL-H-8501A (Reference p). The following table gives a comparison of the vibrations:

VIBRATION TEST CONDITIONS
UH-1B/XM-16

Vibration Frequency S.A.*	CAS kt	Lateral Acceleration g	Vertical Acceleration g	Frequency	C.G.	Flight Phase
1/rev	97.0	.0225	.0209	5.3	131.2	Non-Firing
	99.0	.02925	.0273	5.4	128.3	Firing
2/rev	97.0	.077	.072	10.6	131.2	Non-Firing
	99.0	.077	.072	10.8	128.3	Firing
4/rev	97.0	.000	.000	21.2	131.2	Non-Firing
	99.0	.000	.000	21.6	128.3	Firing

*S.A. = Single Amplitude

VIBRATION TEST CONDITIONS
UH-1B/XM-21

Vibration Frequency S.A.	CAS kt	Lateral Acceleration g	Vertical Acceleration g	Frequency	C.G.	Flight Phase
1/rev	101.	.0552	.039	5.4	130.7	Non-Firing
	100.	.0315	.03315	5.4	126.1	Firing
2/rev	101.	.133	.078	10.8	130.7	Non-Firing
	100.	.09	.072	10.8	126.1	Firing
4/rev	101.	.250	.170	21.6	130.7	Non-Firing
	100.	.145	.07	21.6	126.1	Firing

VIBRATION TEST CONDITIONS
CLEAN UH-1B

Vibration Frequency S.A.*	CAS kt	Lateral Acceleration g	Vertical Acceleration g	Frequency	C.G.	Flight Phase
1/rev	96.5	.0154	.0171	5.3	129.8	Non-Firing
2/rev	96.5	.063	.096	10.6	129.8	Non-Firing
4/rev	96.5	.000	.000	21.2	129.8	Non-Firing

2.4 FIRINGS

2.4.1 MACHINE-GUN FIRINGS

2.4.1.1 Objective

The objective of these tests was to evaluate the effects on stability and control of the UH-1B during the gun firings at various flight conditions and to insure that there was no compromise of safety of flight throughout the flight envelope.

2.4.1.2 Method

The firing of the machine guns of the XM-16 and XM-21 armament subsystems was conducted at zero KCAS, 48 KCAS, 67 KCAS, and 95 KCAS. Hover firings were conducted at approximately 50 feet above the ground, and level flight firings were conducted at 500 feet above the ground. Tests for both weapons were conducted in the machine-gun firing positions listed in the following table:

MACHINE-GUN FIRING POSITIONS
XM-16 & XM-21

Elevation	Depression	Traverse Rt	Traverse Lt
* Zero	Zero	Zero	Zero
Zero	Zero	Extreme	----
Zero	Zero	----	Extreme
Maximum	----	Zero	Zero
Maximum	----	Extreme	----
Maximum	----	----	Extreme
----	Maximum	Zero	Zero
----	Maximum	Extreme	----
----	Maximum	----	Extreme

NOTE: 1. * indicates "stow" position.

2. Maximum travel of guns.

	XM-16	XM-21
Upward:	9°	10°
Downward:	66°	90°
Inboard:	12°	12°
Outboard:	70°	70°

3. Guns will cease fire when their inboard limit is reached.

2.4.1.3 Results

Time histories of machine-gun firings are presented in Figures 67 through 72, Appendix I.

2.4.1.4 Analysis

Firing the M-60C machine guns of the XM-16 subsystem did not adversely affect the stability and control of the helicopter at any of the conditions tested. Firing the XM-20 machine guns of the XM-21 produced a reactionary force opposite to the direction of fire. The helicopter's reaction can be clearly seen in Figures 67 through 72, Appendix I. The helicopter returned to the original trim position after the guns ceased firing. This condition was not objectionable to the pilot.

2.4.2 ROCKET FIRINGS

2.4.2.1 Objective

The objective of these tests was to insure that there were no adverse flight characteristics introduced during the firing of the rockets.

2.4.2.2 Method

The firing of the 2.75-inch FFAR was conducted at 7300 pounds gross weight, 324 rotor rpm, and forward C.G. The rockets were fired at the conditions listed in the following table:

Flight Condition	Airspeed KCAS	Altitude Above Ground ft
Hover	0	IGE*
Hover (Left Pod Empty)	0	IGE
Level Flight	48,84,99	500
Level Flight (10° Rt Sideslip)	85	700
Level Flight (10° Lt Sideslip)	85	650
Level Flight (Lt Pod Empty)	85	600
Climb (400 fpm)	61	700
Descent (400 fpm)	57	1300
Autorotation	90	900
Maneuvering (Rt Pull-up)	95	700
Maneuvering (Lt Pull-up)	95	700

* IGE denotes in ground effect

For each of the conditions listed, except the one-pod-empty condition, 7 pairs of rockets were fired; for the one-pod-empty condition, 7 single rockets were fired.

2.4.2.3 Results

Time histories are presented in Figures 73 through 79, Appendix I.

2.4.2.4 Analysis

The rocket firing tests were characterized by a nose-down pitching motion of the helicopter under all conditions tested. The pitch angle change was approximately 4.5 degrees with a maximum angular rate of 4.8 degrees/second. The rate was so slight that the pilot would automatically correct the pitching motion without thinking about it. This pitching motion could be attributed to a moment about the pitch axis resulting from the rocket blast. The sudden loss of weight of the rockets would also add to this motion. The rocket pods were located at an aft C.G. (Station 136.0), and the firing of 14 rockets (252 pounds) in 1.167 seconds would move the C.G. forward.

2.5 BOOST-OFF FLIGHT

2.5.1 OBJECTIVE

The objective of these tests was to determine if flight was feasible with the weapon systems installed and the hydraulic control boost inoperative.

2.5.2 METHOD

Power-boosted or power-operated control failure was simulated by switching off the hydraulic boost system on the armed UH-1B helicopter. The forces necessary to maintain control of the helicopter were measured by strain gages for the longitudinal and lateral forces and a hand-held force indicator for the collective force. Tests were conducted in hover, climb, level flight and landing. Paragraph 3.5.8 of MIL-H-8501A (Reference p) was used as a basis for evaluating the results.

2.5.3 RESULTS

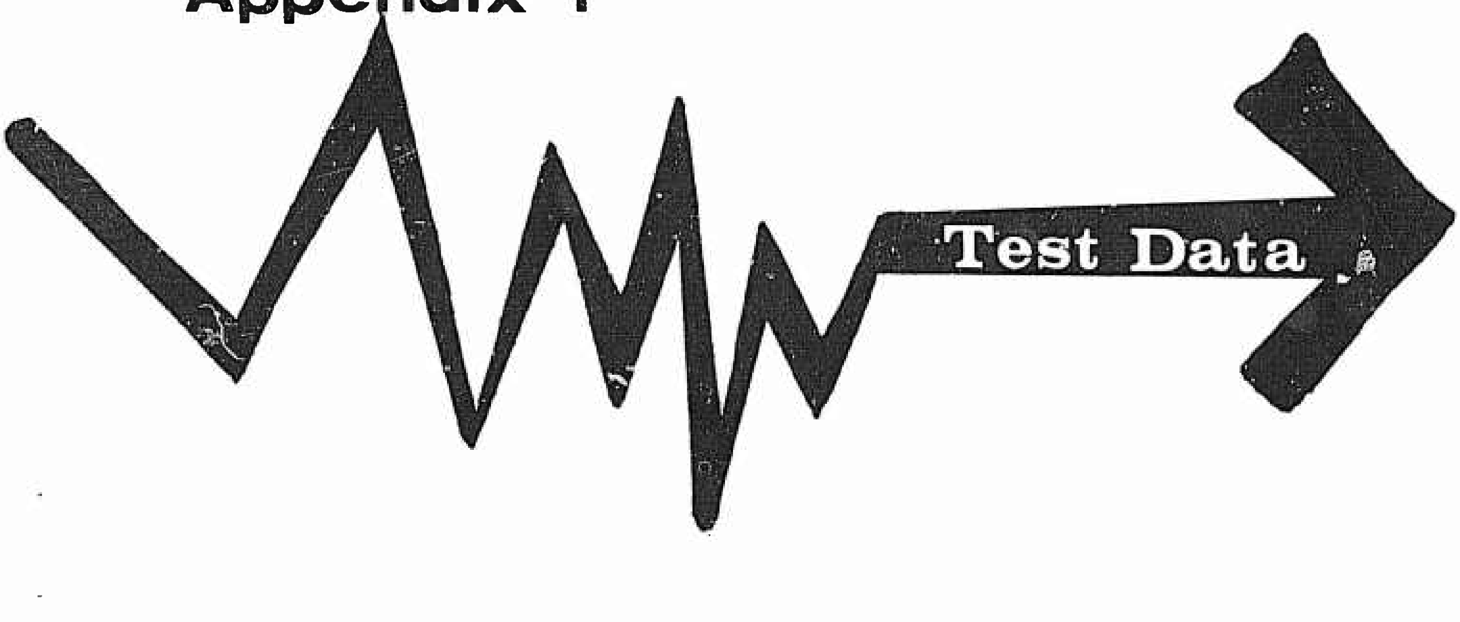
Time histories are presented in Figures 80 and 81, Appendix I.

2.5.4 ANALYSIS

The longitudinal, lateral, and pedal control forces were satisfactory under all conditions tested. The collective position force exceeded the maximum limit (25 pounds) stated in Paragraph 3.5.8, MIL-H-8501A (Reference p). The collective force measured 90 pounds in a climb and could not be maintained for an extended period. A run-on landing was the only practical method of landing. Incipient loss of control resulted from over-controlling when transitioning to a hover because of the high cyclic forces.

SECTION 3 Appendices

Appendix I



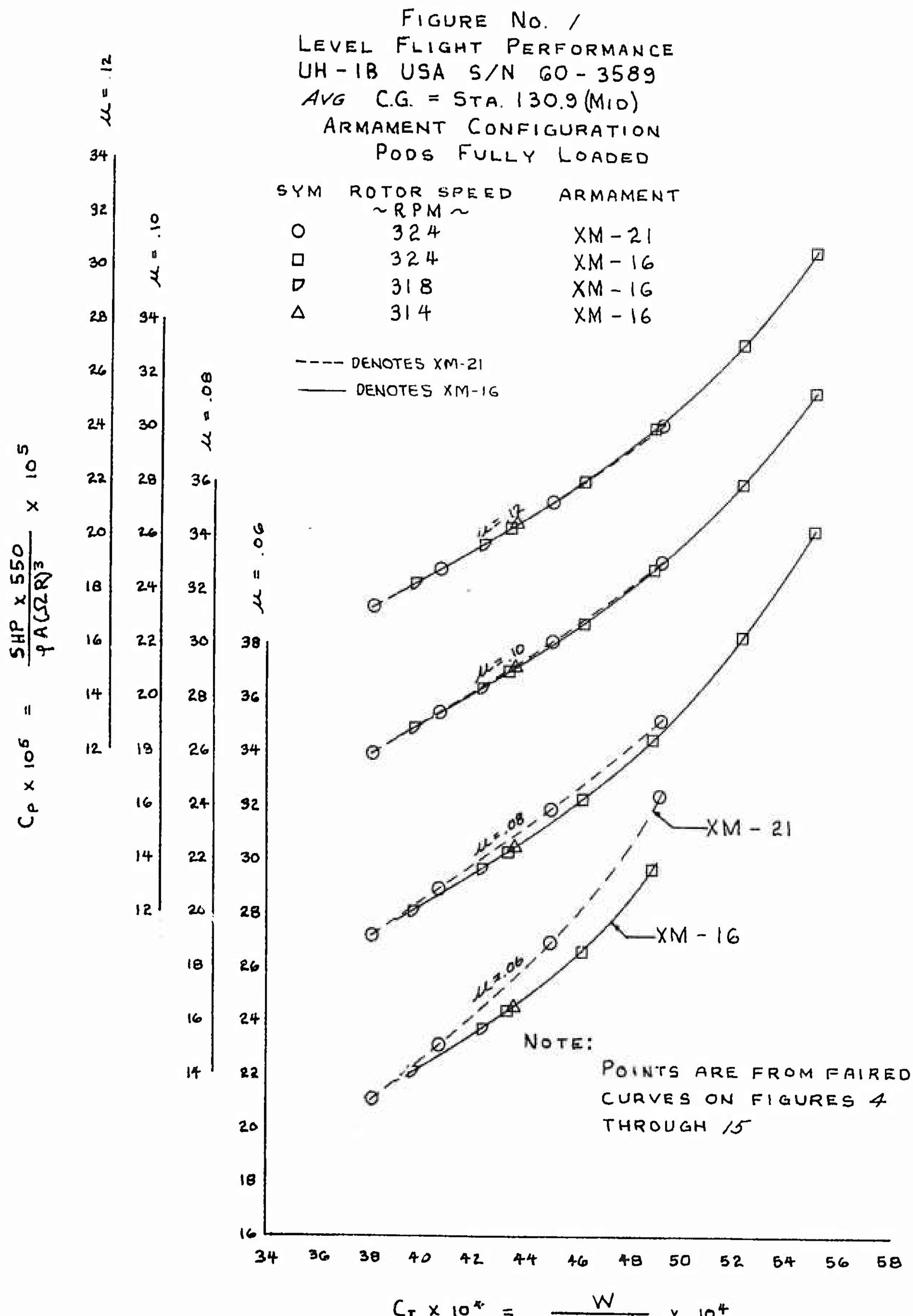


FIGURE NO. 1
LEVEL FLIGHT PERFORMANCE
UH-1B USA S/N 60-3589
AVG C.G. = STA. 130.9 (MID)
ARMAMENT CONFIGURATION
PODS FULLY LOADED
SYM
ROTOR SPEED ~RPM~
ARMAMENT
324
XM-21
324
XM-16
318
XM-16
314
XM-16
---- DENOTES XM-21
—— DENOTES XM-16
μ = .12
μ = .10
μ = .08
μ = .06
XM-21
XM-16
NOTE:
POINTS ARE FROM FAIRED CURVES ON FIGURES 4 THROUGH 15
$C_P \times 10^5 = \frac{SHP \times 550}{\rho A(\Omega R)^3} \times 10^5$
$C_T \times 10^4 = \frac{W}{\rho A(\Omega R)^2} \times 10^4$
34
36
38
40
42
44
46
48
50
52
54
56
58

FIGURE No. 2
LEVEL FLIGHT PERFORMANCE
UH-1B USA S/N 60-3589
AVG. C.G. = STA. 130.9 (MID)
ARMAMENT CONFIGURATION
PODS FULLY LOADED

SYM	ROTOR SPEED ~RPM~	ARMAMENT
○	324	XM-21
□	324	XM-16
◸	318	XM-16
△	314	XM-16

— — — DENOTES XM-21
——— DENOTES XM-16

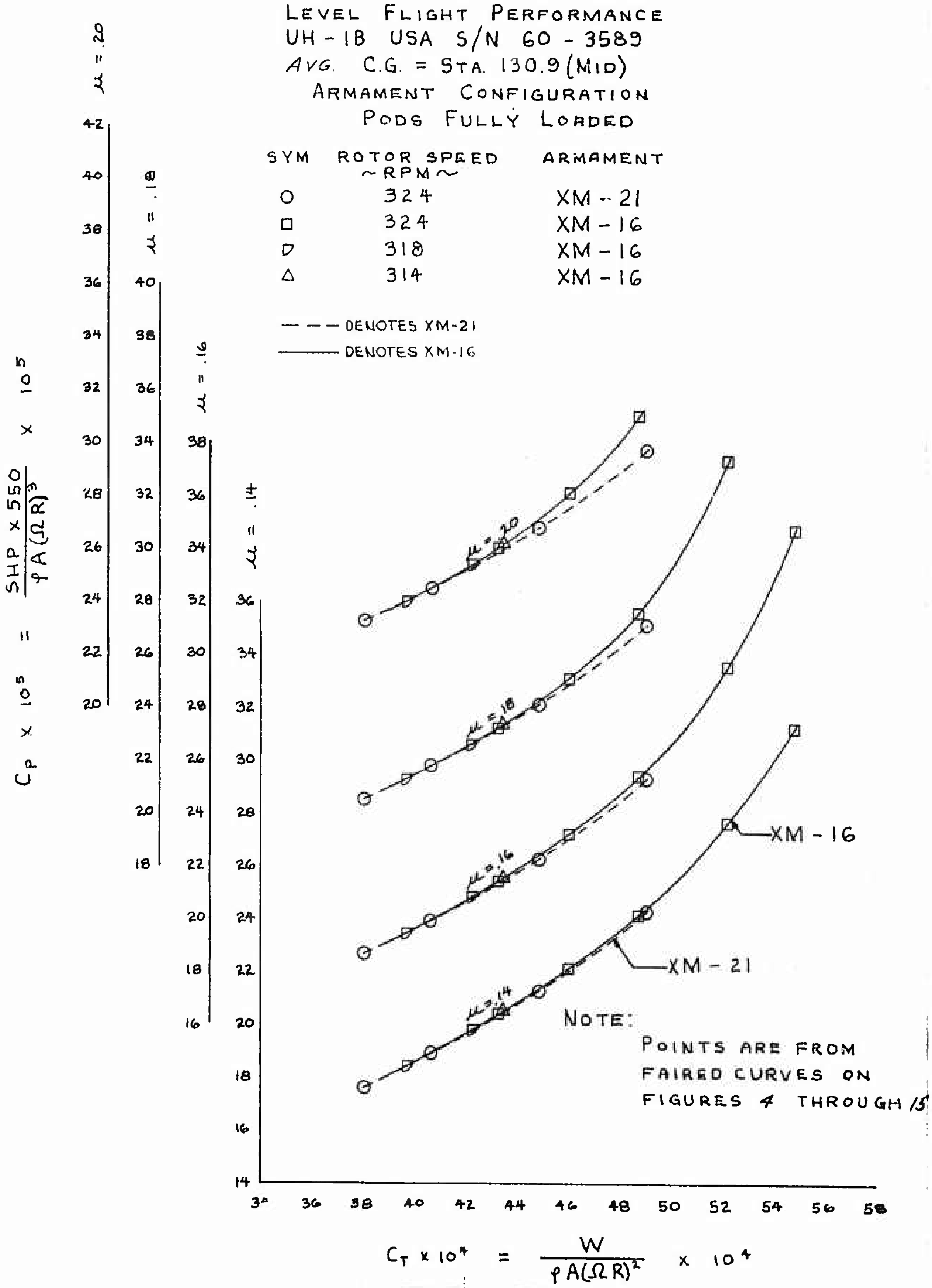
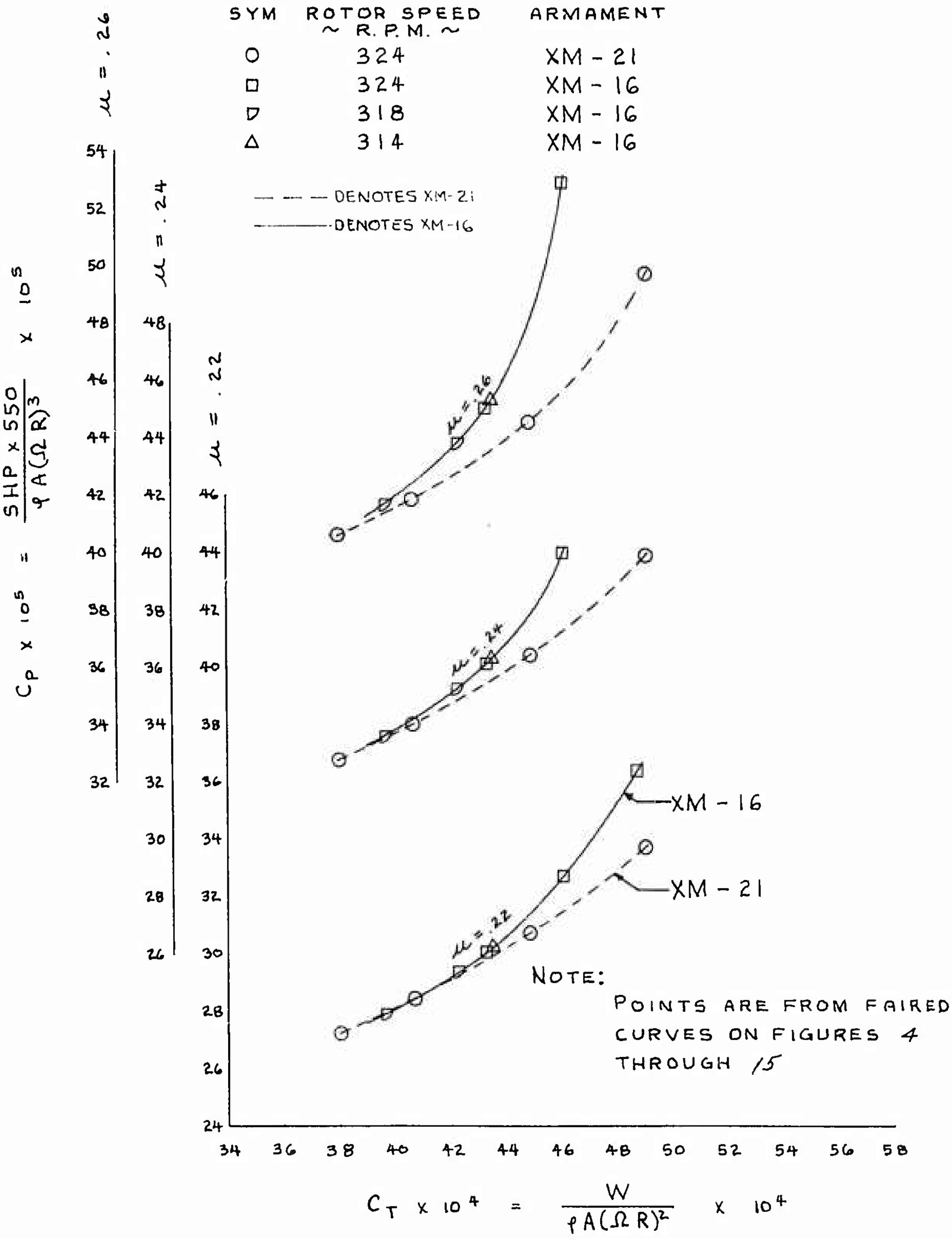


Figure No. 3
Level Flight Performance
UH-1B USA S/N 60-3589
Avg C.G. = Sta. 130.9 (Mid)
Armament Configuration
Pods Fully Loaded



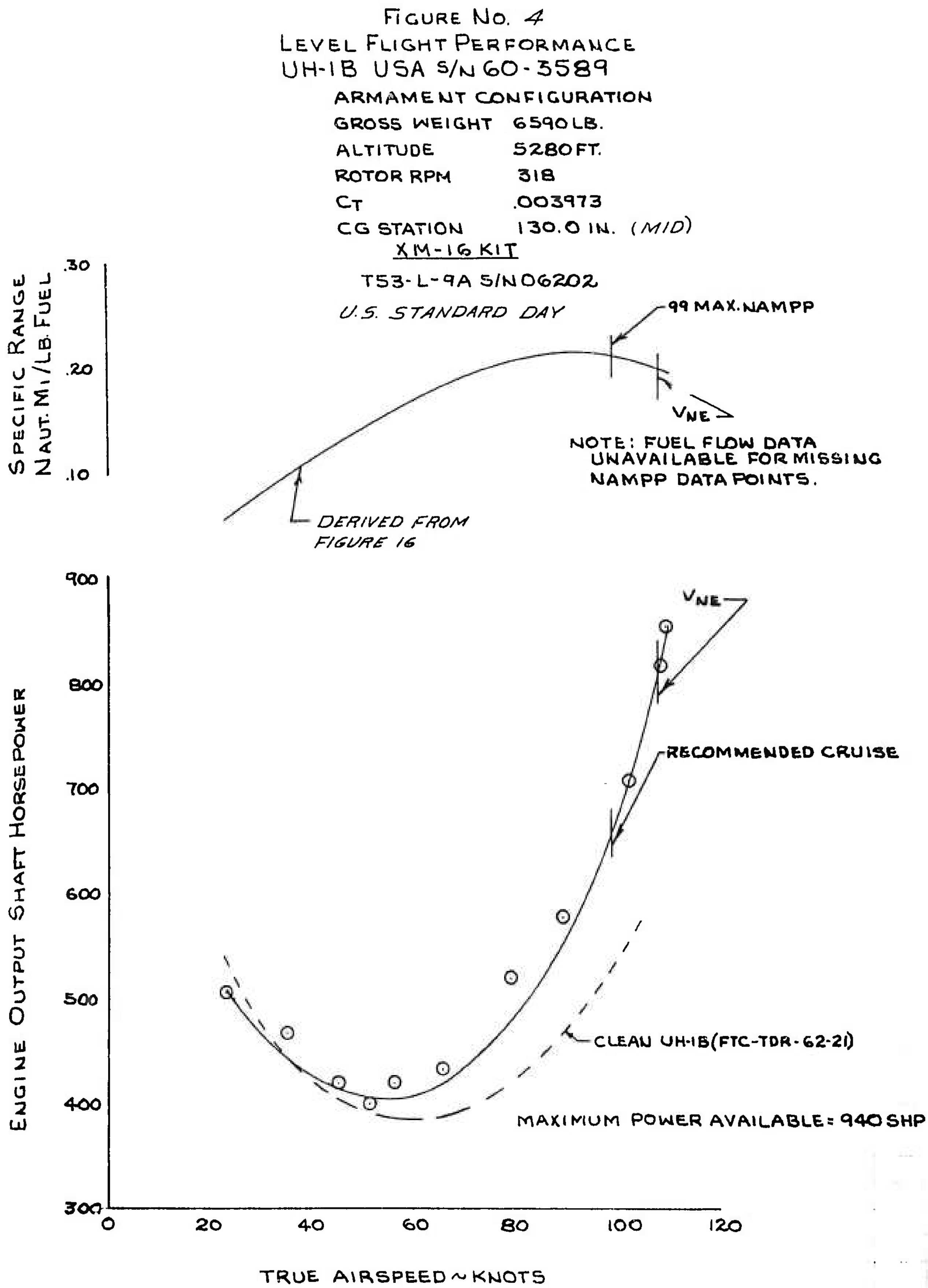


FIGURE NO. 4
LEVEL FLIGHT PERFORMANCE
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION
GROSS WEIGHT 6590 LB.
ALTITUDE 5280 FT.
ROTOR RPM 318
CT .003973
CG STATION 130.0 IN. (MID)
XM-16 KIT
T53-L-9A S/N 06202
U.S. STANDARD DAY
SPECIFIC RANGE NAUT. MI/LB. FUEL
.30
.20
.10
99 MAX. NAMPP
VNE
NOTE: FUEL FLOW DATA UNAVAILABLE FOR MISSING NAMPP DATA POINTS.
DERIVED FROM FIGURE 16
ENGINE OUTPUT SHAFT HORSEPOWER
900
800
700
600
500
400
300
VNE
RECOMMENDED CRUISE
CLEAN UH-1B (FTC-TDR-62-21)
MAXIMUM POWER AVAILABLE = 940 SHP
0
20
40
60
80
100
120
TRUE AIRSPEED ~ KNOTS

FIGURE No. 5
LEVEL FLIGHT PERFORMANCE
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION
GROSS WEIGHT 7010 LB.
ALTITUDE 5320 FT.
ROTOR RPM 318
C_T 004235
CG STATION 131.2 IN. (MID)
XM-16 KIT
T53-L-9A S/N 06202
US STANDARD DAY

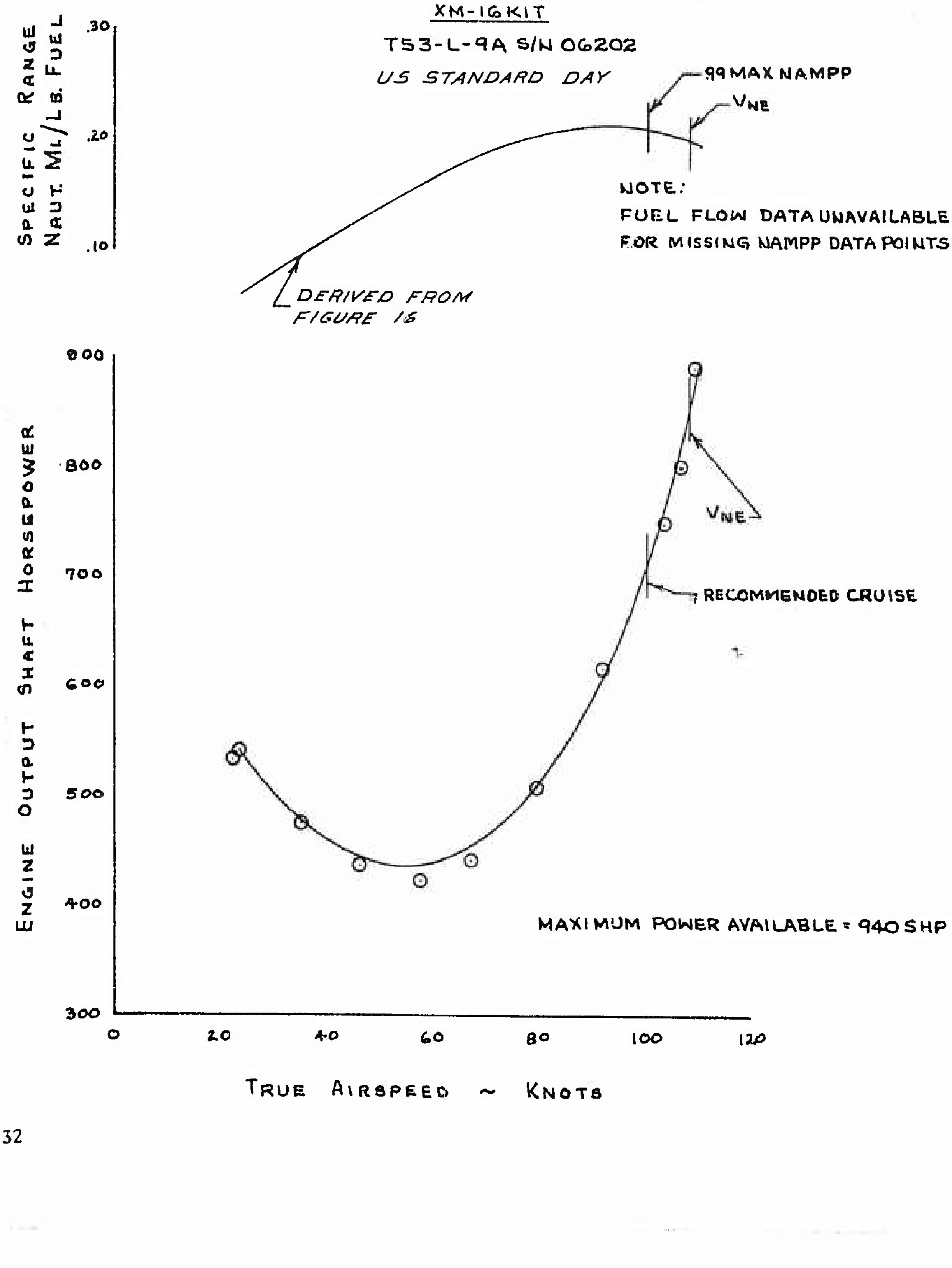


FIGURE NO. 6
LEVEL FLIGHT PERFORMANCE
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION

GROSS WEIGHT	7000 LB.
ALTITUDE	7300 FT.
ROTOR RPM	324
C_T	004330
CG STATION	131.2 IN. (MID)

XM-16 KIT
T53-L-9A S/N 06202
US STANDARD DAY

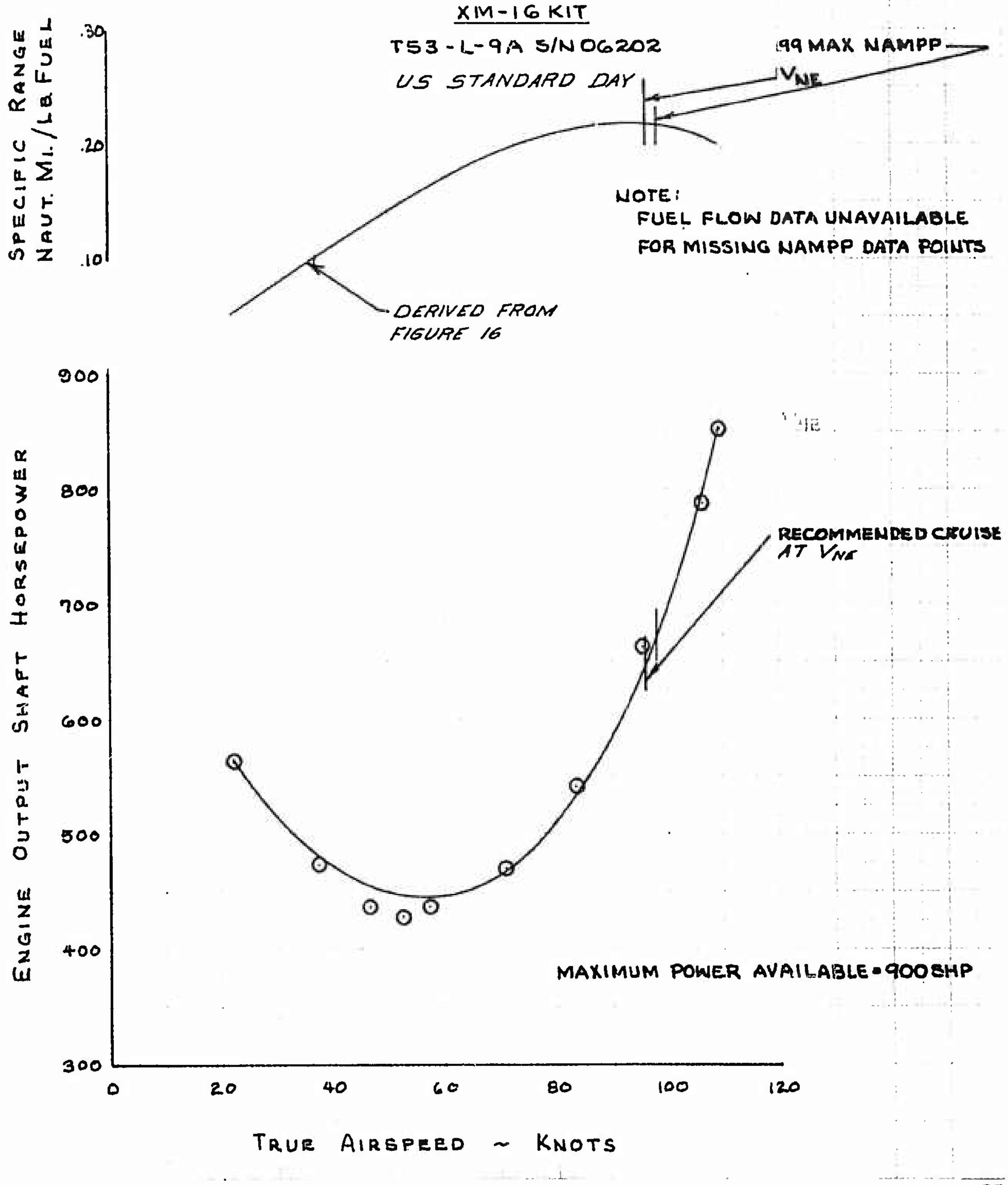


FIGURE No. 7
LEVEL FLIGHT PERFORMANCE
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION

GROSS WEIGHT	7160 LB.
ALTITUDE	4700 FT.
ROTOR RPM	314
C_T	004355
CG STATION	130.7 IN. (MID)

XM-16 KIT

T53-L-9A S/N 06202
US STANDARD DAY

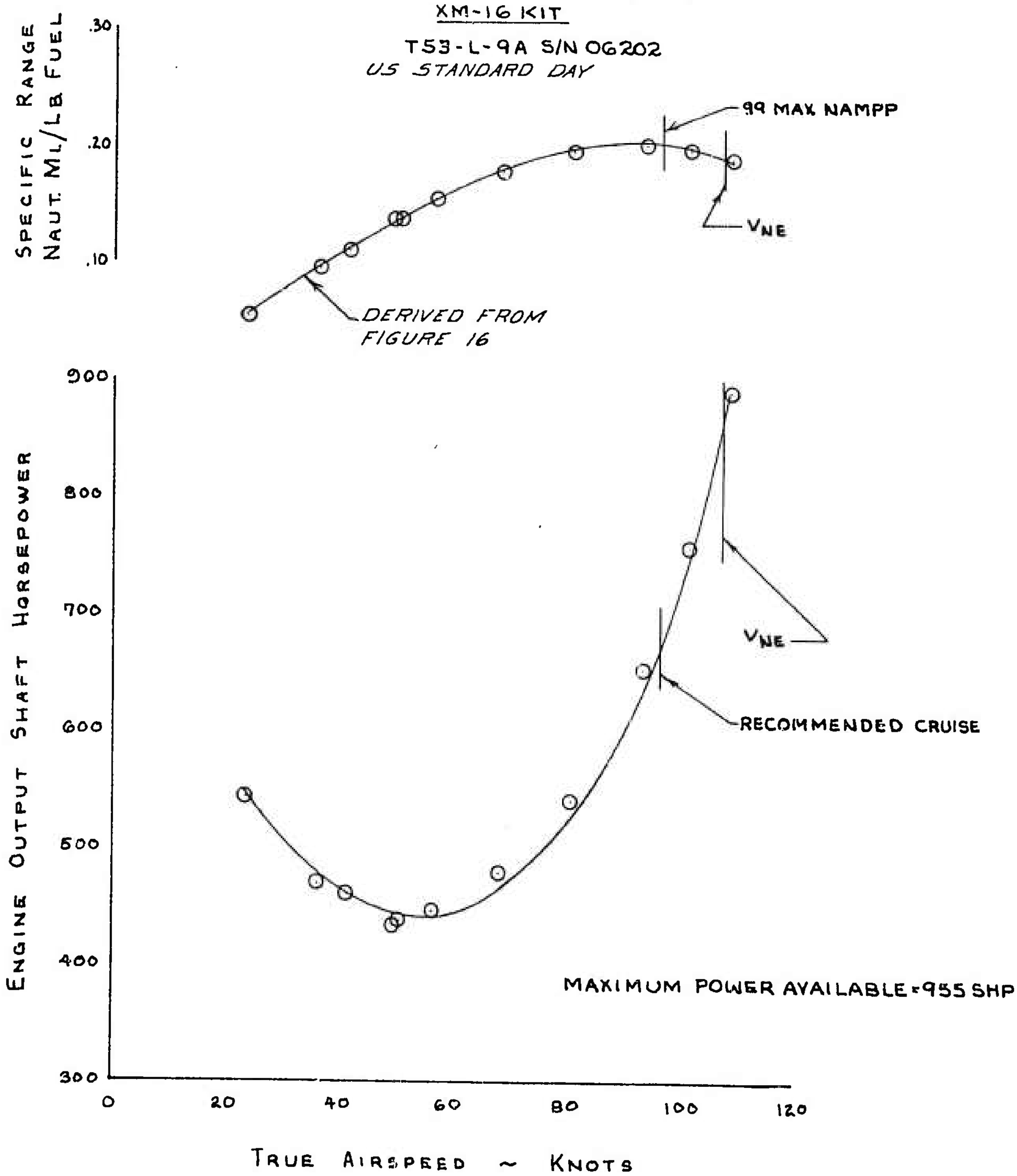


FIGURE NO. 8
LEVEL FLIGHT PERFORMANCE
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION
GROSS WEIGHT 6860 LB
ALTITUDE 9750 FT.
ROTOR RPM 323
C_T .004608
CG STATION 130.6 IN (MID)
XM-16 KIT
T53-L-9A S/N 06202
US STANDARD DAY

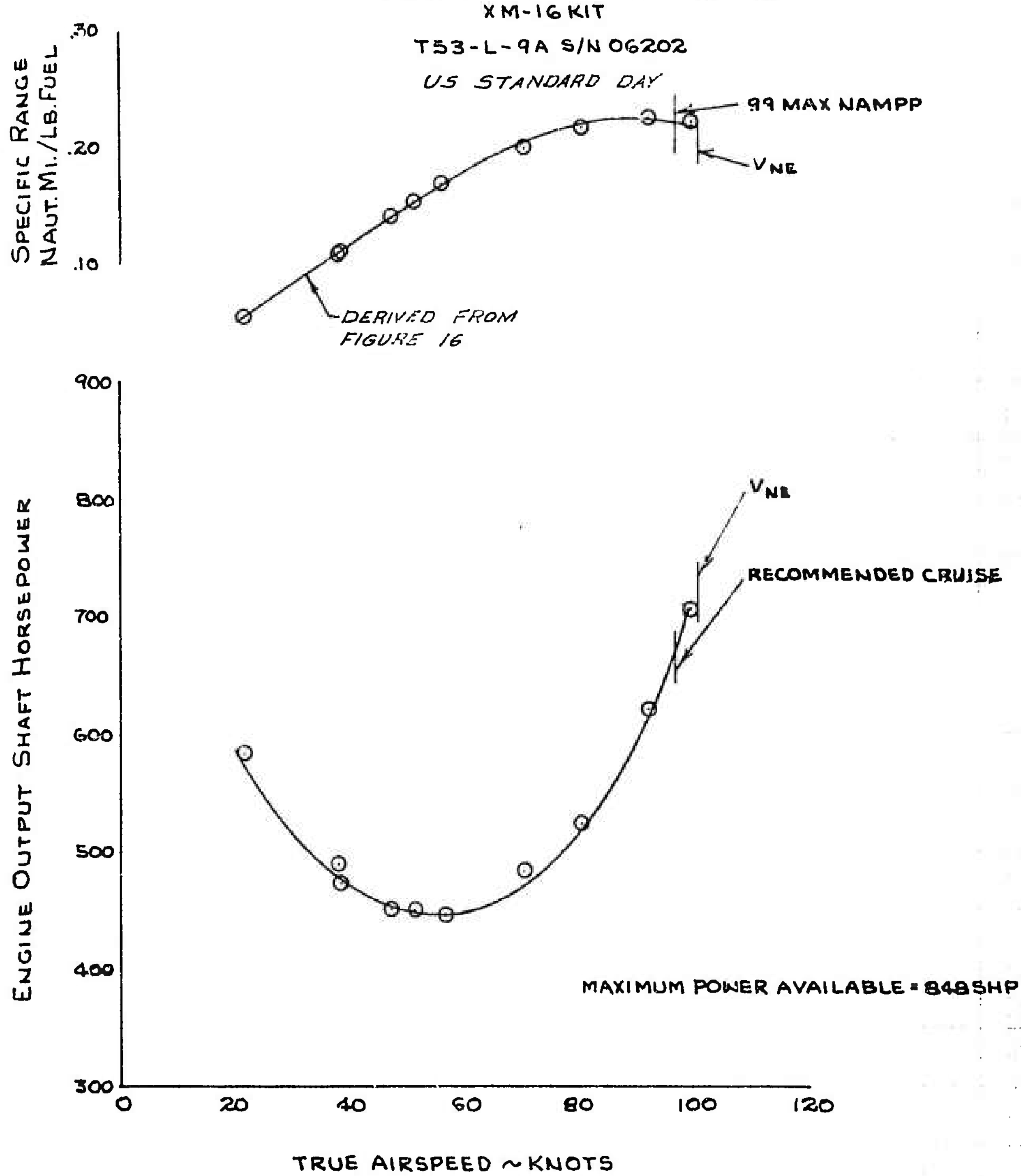


FIGURE NO. 9
LEVEL FLIGHT PERFORMANCE
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION

GROSS WEIGHT	7780 LB.
ALTITUDE	7750 FT
ROTOR RPM	324
C_T	.004880
CG STATION	130.7 IN. (MID)

XM-16 KIT

TS3-L-9A S/N 06202
US STANDARD DAY

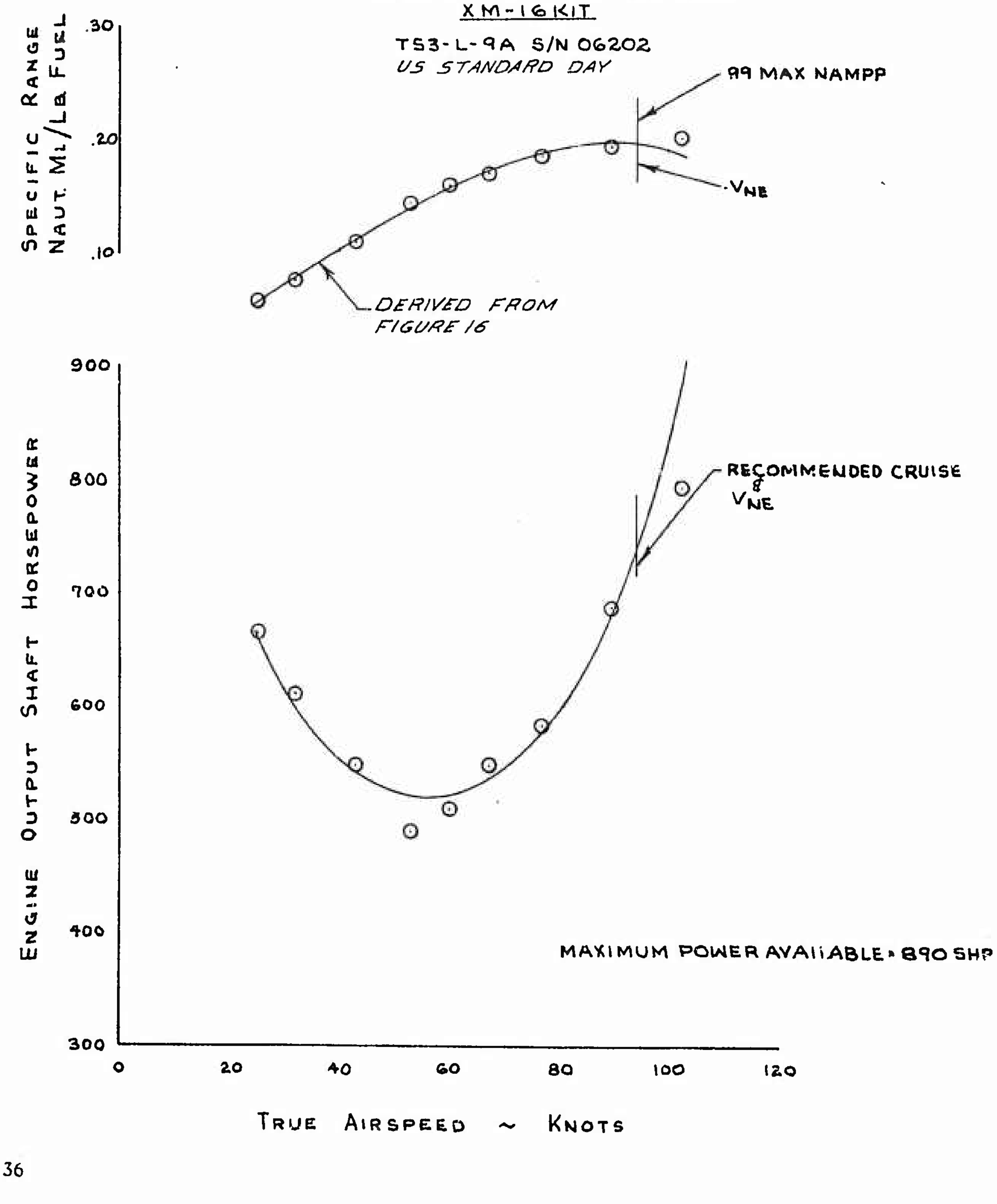


FIGURE No. 10
LEVEL FLIGHT PERFORMANCE
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION

GROSS WEIGHT	6720 LB
ALTITUDE	14530 FT.
ROTOR RPM	324
C_T	.005225
CG STATION	130.5 IN. (MID)

XM-16 KIT
T53-L-9A S/N 06202
US STANDARD DAY

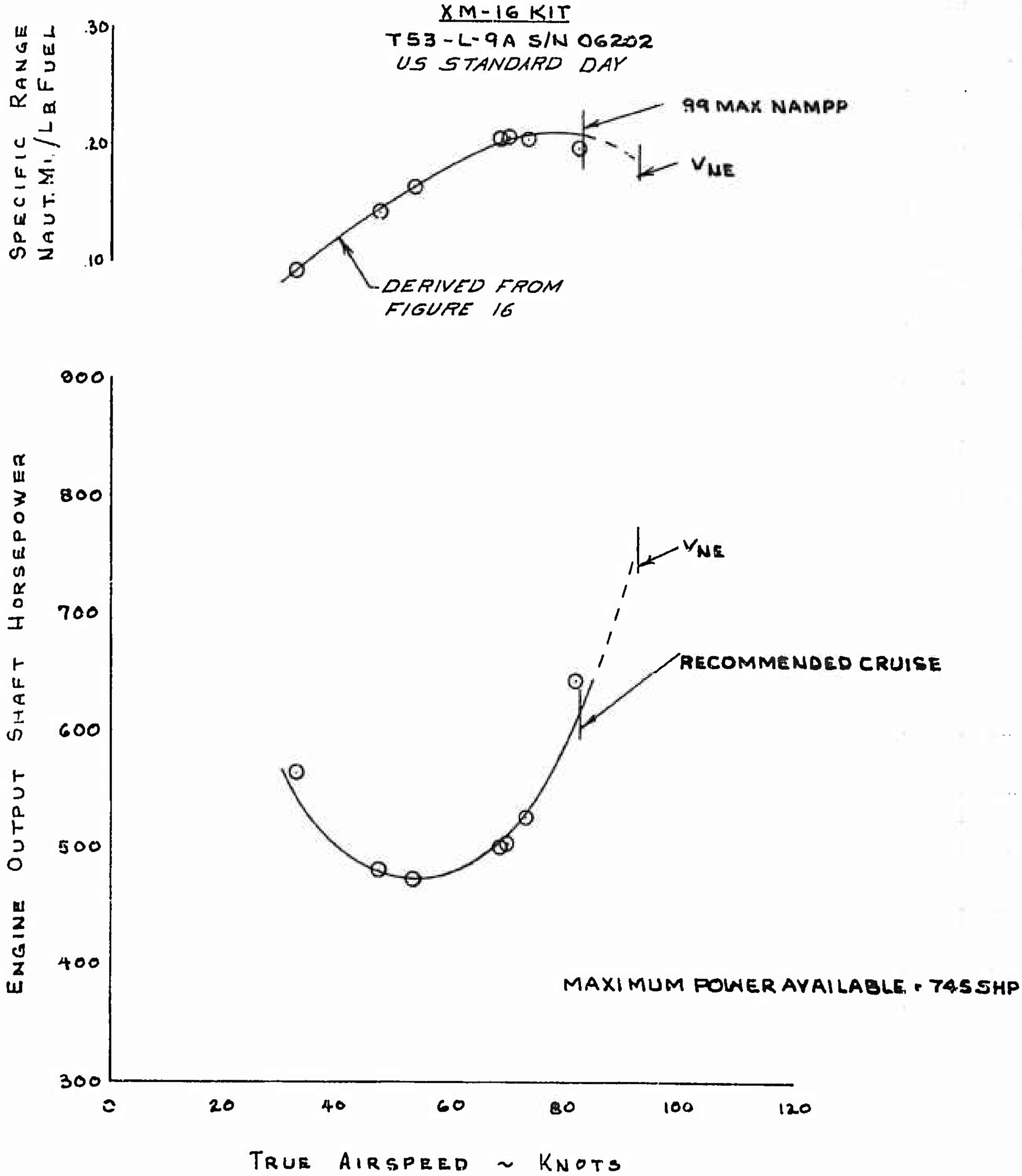


Figure No. 11
Level Flight Performance
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION

GROSS WEIGHT	6980 LBS
ALTITUDE	14900 FT
ROTOR RPM	324
C_T	.005495
CG STATION	130.6 IN. (MID)

XM-16 KIT
T53-L-9A S/N 06202
US STANDARD DAY

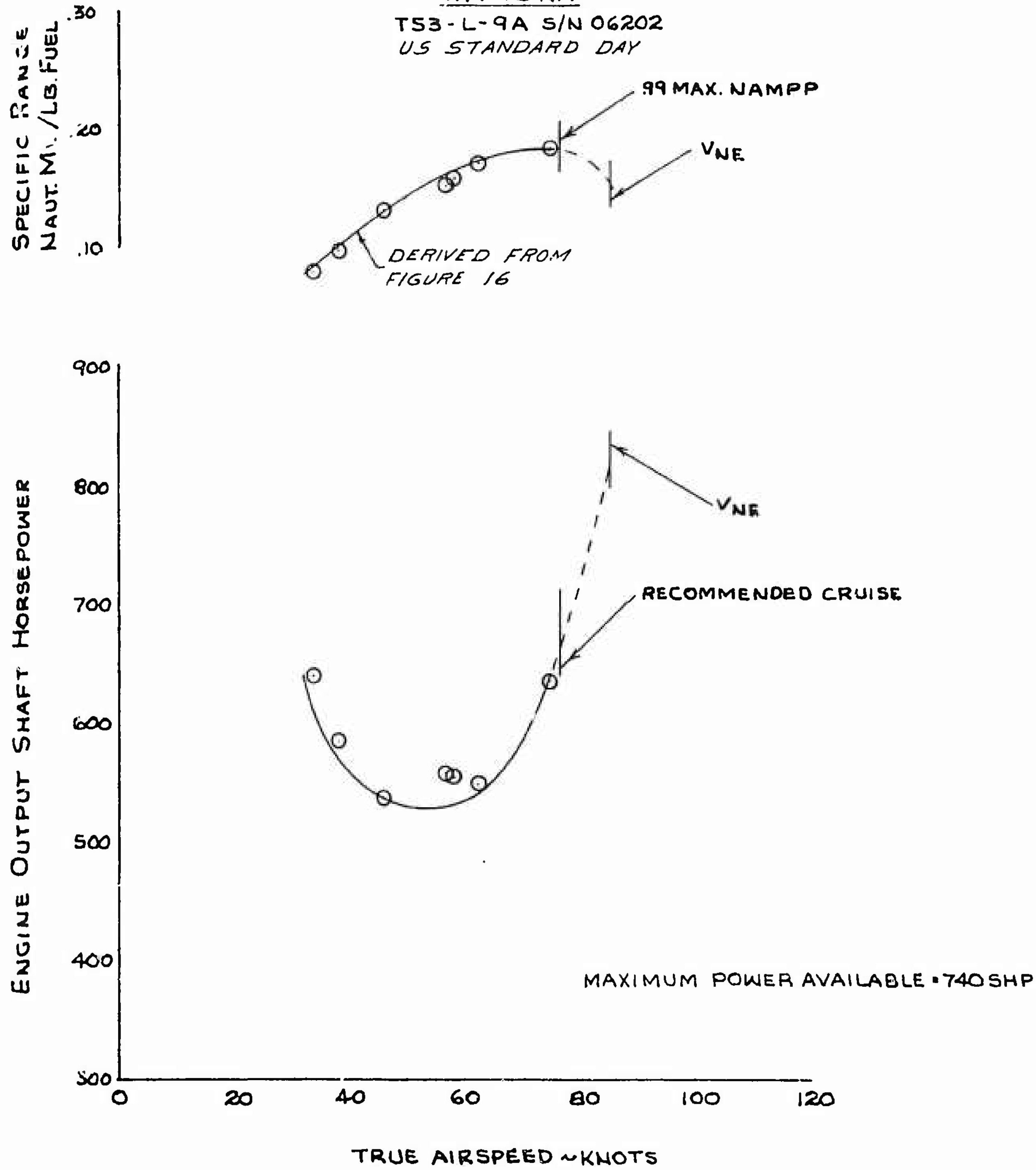
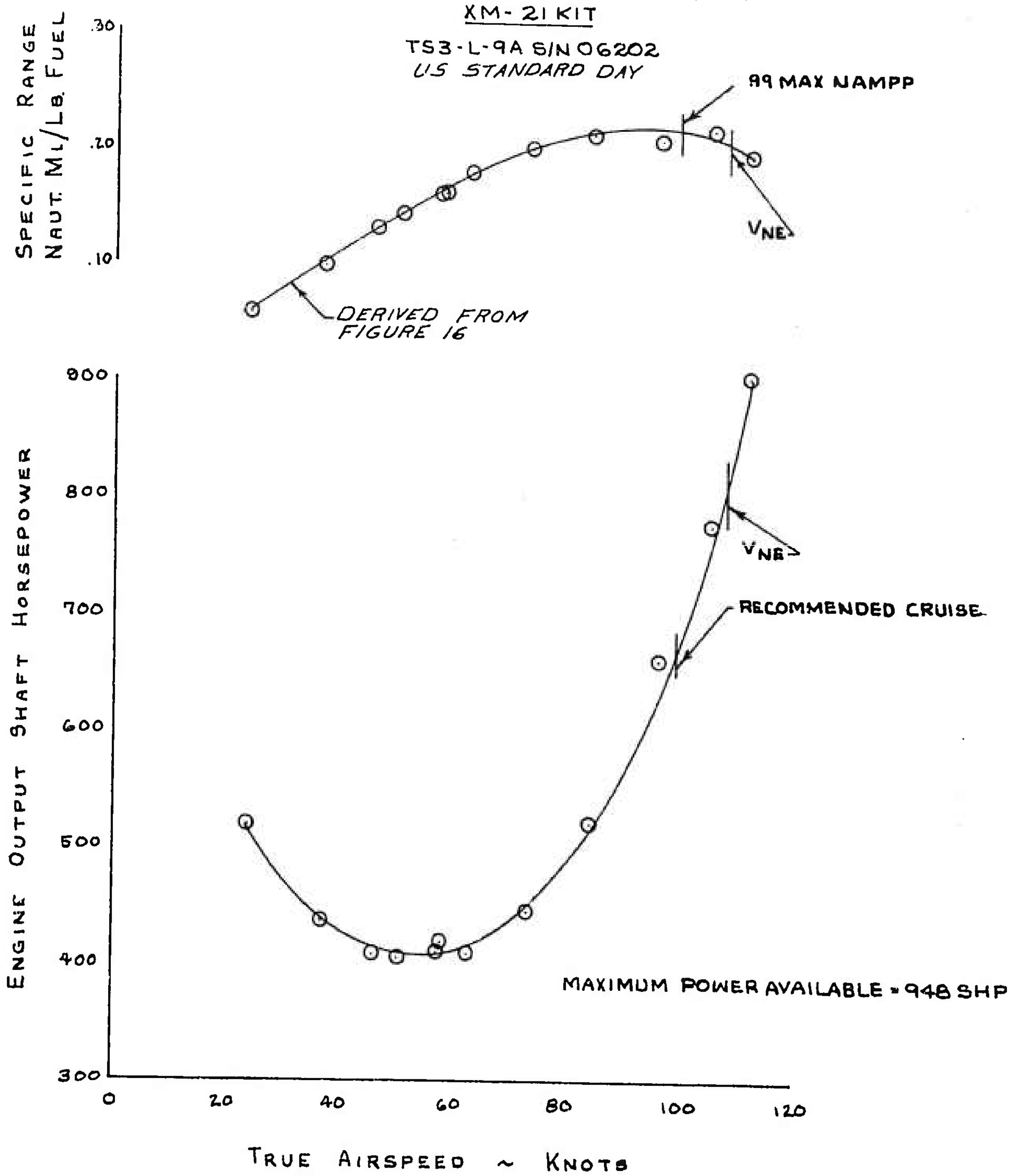


FIGURE NO. 12
LEVEL FLIGHT PERFORMANCE
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION

GROSS WEIGHT	6610 LB
ALTITUDE	4970 FT.
ROTOR RPM	324
C_T	003806
CG STATION	130.6 IN. (MID)

XM-21 KIT

TS3-L-9A S/N 06202
US STANDARD DAY



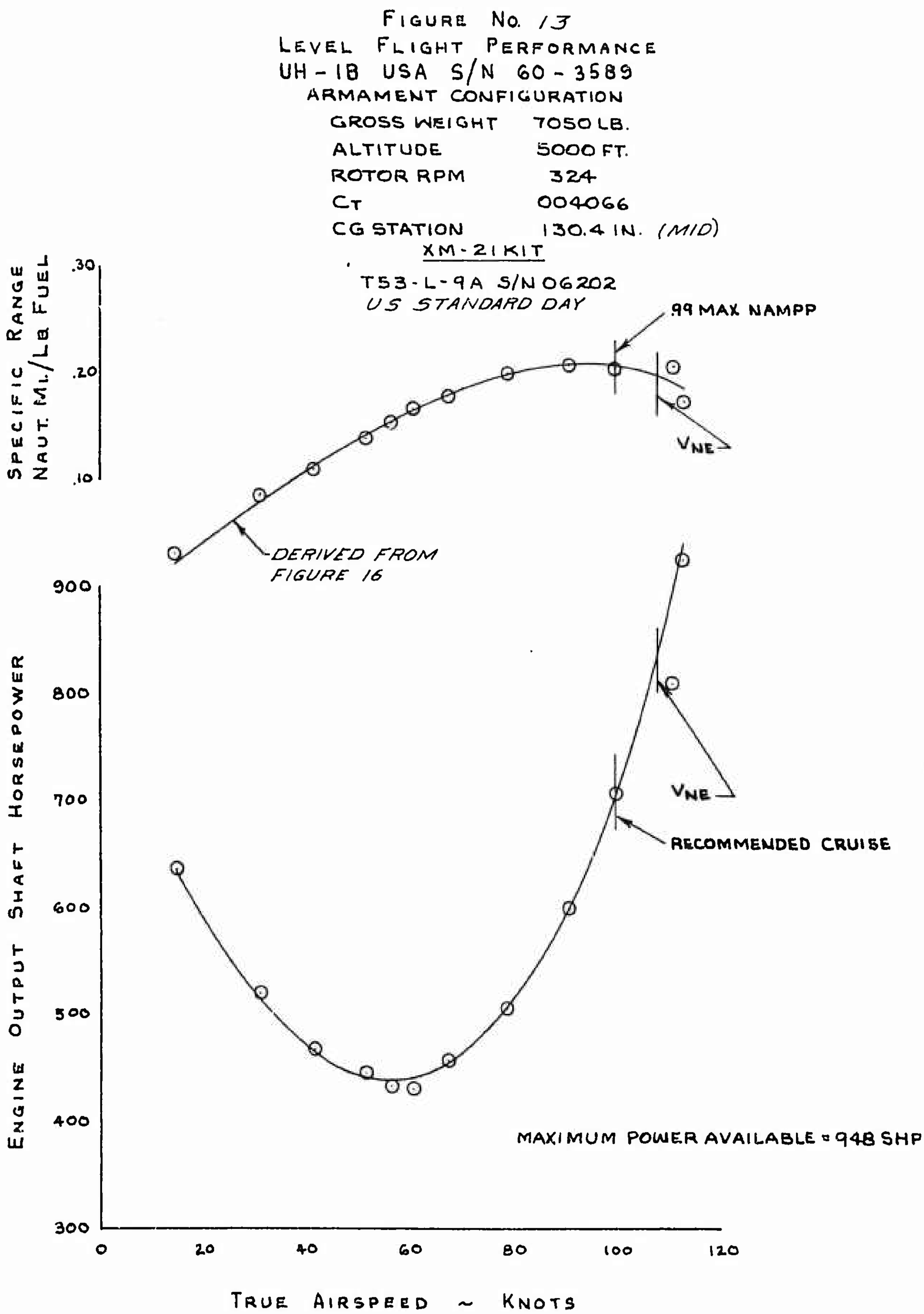


FIGURE NO. 13
LEVEL FLIGHT PERFORMANCE
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION
GROSS WEIGHT 7050 LB.
ALTITUDE 5000 FT.
ROTOR RPM 324
CT 004066
CG STATION 130.4 IN. (MID)
XM-21 KIT
T53-L-9A S/N 06202
US STANDARD DAY
.99 MAX NAMPP
VNE
DERIVED FROM FIGURE 16
RECOMMENDED CRUISE
MAXIMUM POWER AVAILABLE = 948 SHP
SPECIFIC RANGE NAUT. MI./LB FUEL
.30
.20
.10
ENGINE OUTPUT SHAFT HORSEPOWER
900
800
700
600
500
400
300
0
20
40
60
80
100
120
TRUE AIRSPEED ~ KNOTS

FIGURE No. 14
LEVEL FLIGHT PERFORMANCE
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION

GROSS WEIGHT	7340 LB.
ALTITUDE	6960 FT
ROTOR RPM	324
C_T	.004490
CG STATION	130.8 IN. (MID)

XM-21 KIT

T53-L-9A S/N 06202
US STANDARD DAY

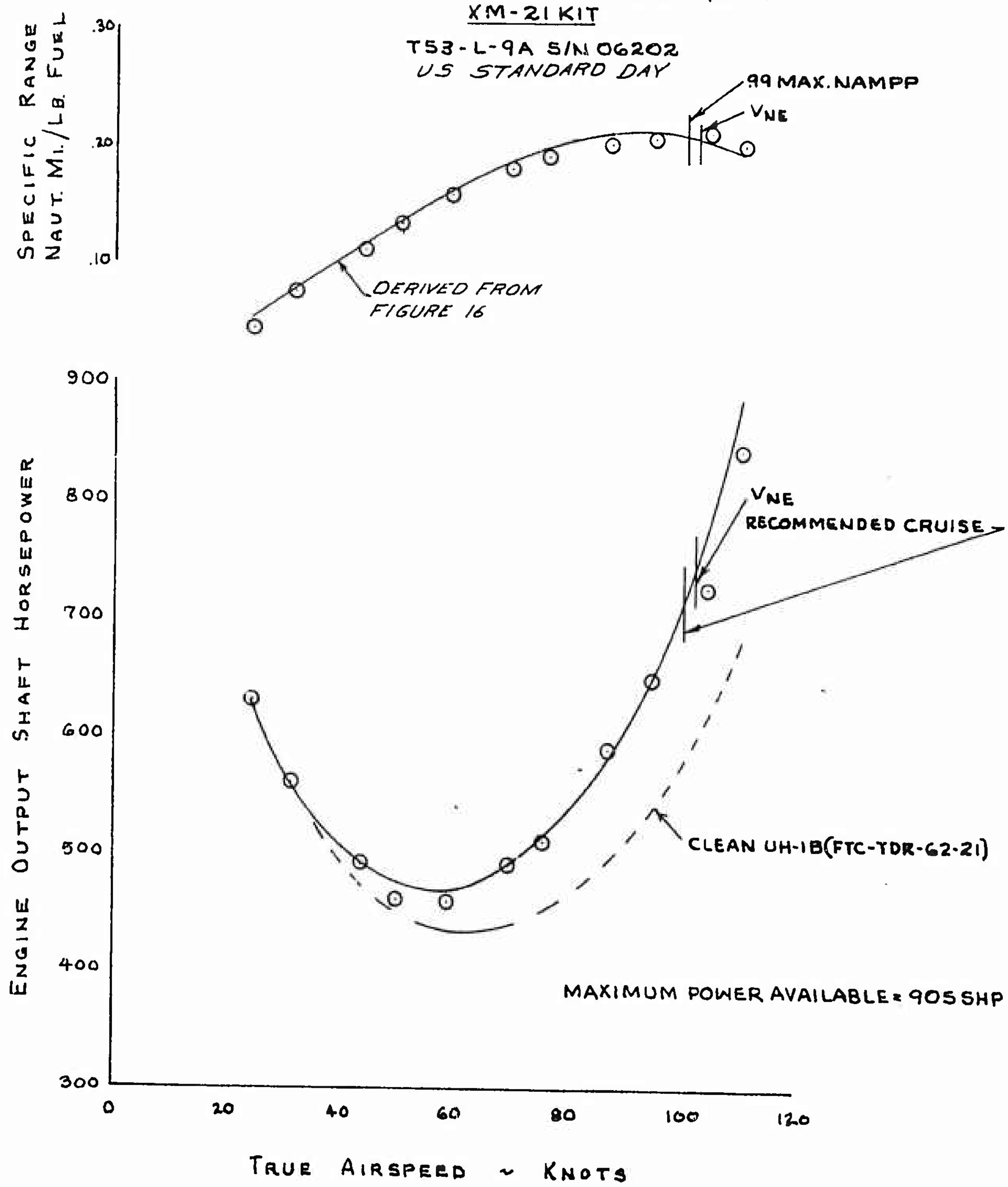


FIGURE No. 15
LEVEL FLIGHT PERFORMANCE
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION

GROSS WEI .HT 8380 LB.
ALTITUDE 5480 FT.
ROTOR RPM 324
C_T .004908
CG STATION 130.8 IN. (MID)

XM-21 KIT
T53-L-9A S/N 06202
U.S. STANDARD DAY

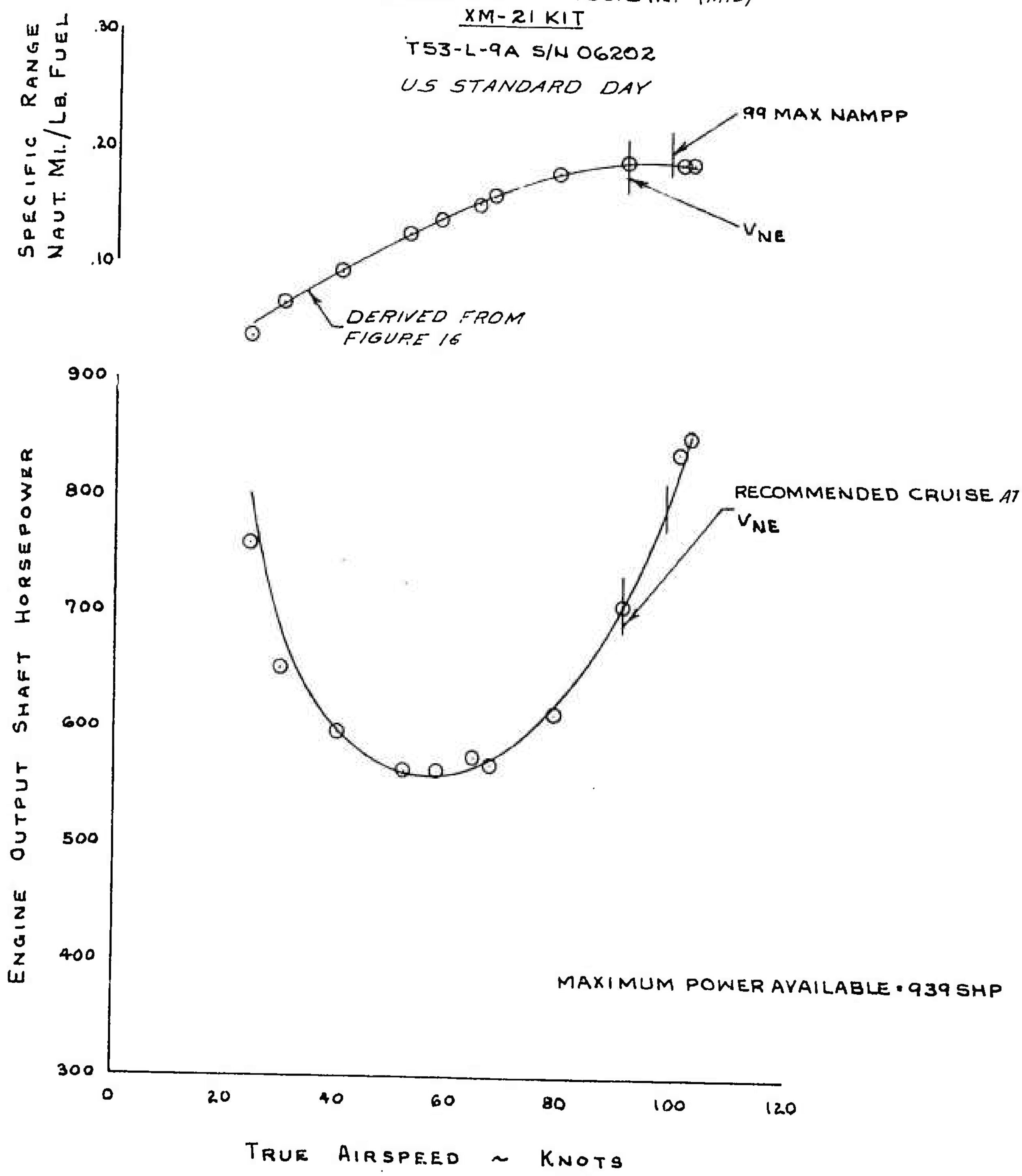


FIGURE NO. 16
ENGINE CHARACTERISTICS
UH-1B USA S/N 60-3589
T53-L-9A S/N 06202

1. θ BASED ON COMPRESSOR INLET AIR TEMPERATURE 2°C ABOVE AMBIENT (FTC-TDR-62-21).
2. δ BASED ON COMPRESSOR INLET AIR PRESSURE (FTC-TDR-62-21).
3. SHP OBTAINED FROM ENGINE DIFFERENTIAL TORQUE PRESSURE AND ENGINE CALIBRATION.

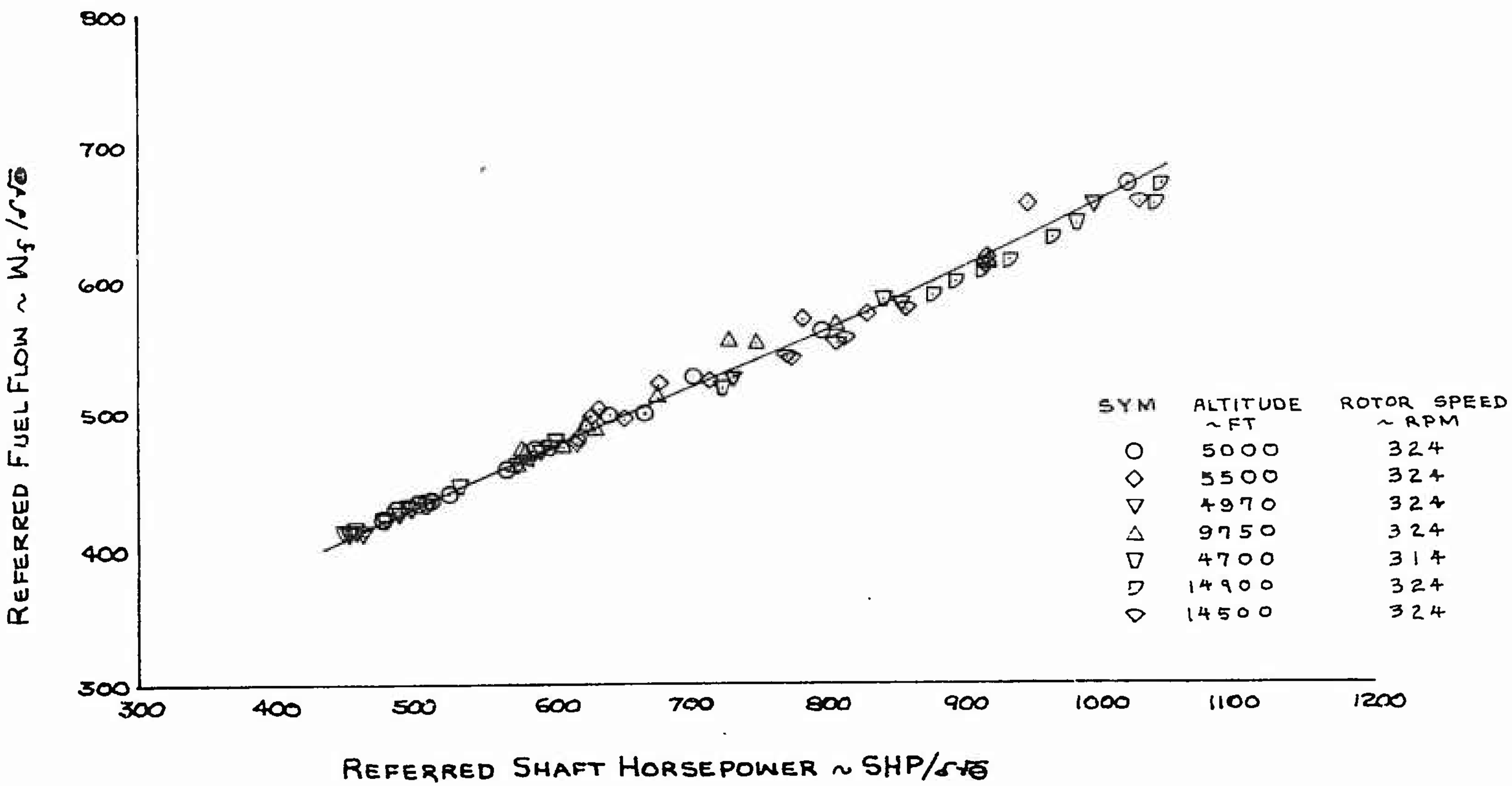


FIGURE No. 17
ENGINE CHARACTERISTICS
T53-L-9A S/N 06202
BASED ON ENGINE TEST STAND CALIBRATION

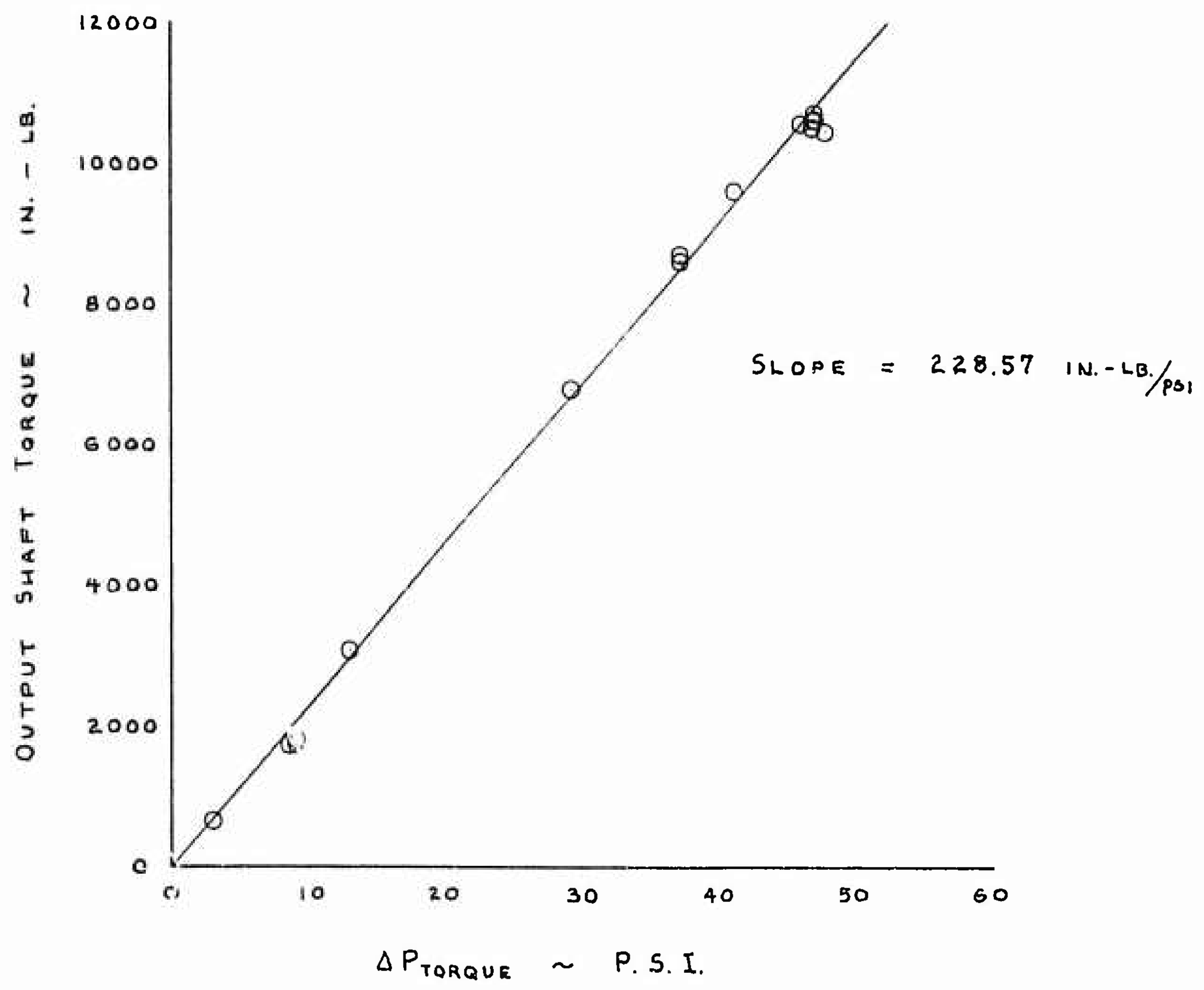
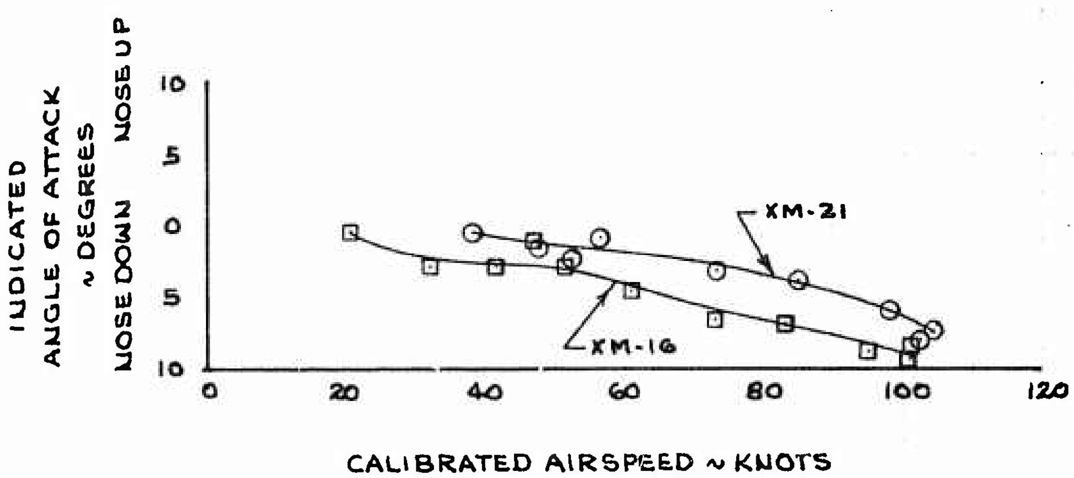


FIGURE NO. 18
ANGLE OF ATTACK WITH ARMAMENT INSTALLATION
UH-1B USA S/N 60-3589
LEVEL FLIGHT

SYM	AVG C_T	AVG C.G.	ARMAMENT	CONFIGURATION
O	.004066	130.3 IN (MID)	XM-21	BOTH PODS FULL
□	.003973	130.7 IN (MID)	XM-16	BOTH PODS FULL



SYM	AVG C_T	AVG C G	ARMAMENT	CONFIGURATION
O	.004908	130.9 IN (MID)	XM-21	BOTH PODS FULL
□	.004880	130.9 IN (MID)	XM-16	BOTH PODS FULL

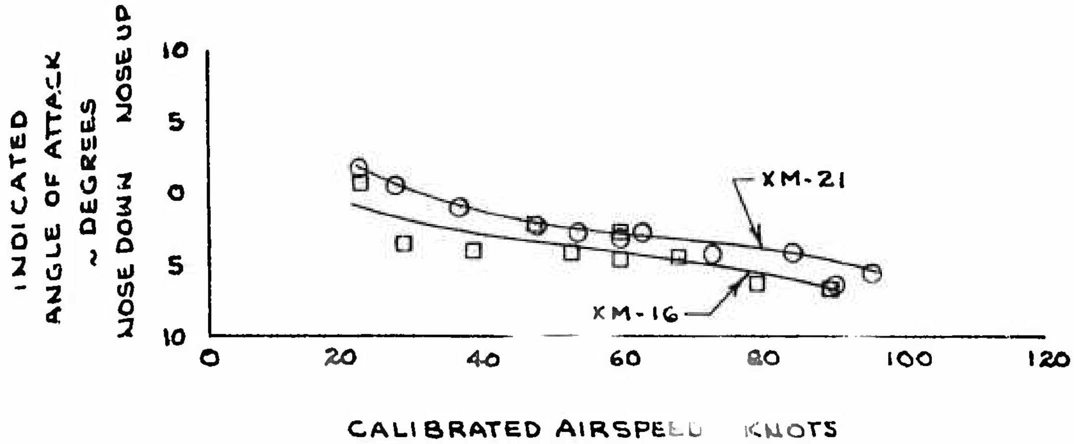


FIGURE No. 19

AIRSPEED CALIBRATION

UH-1B USA S/N 60-3589

TRAILING BOMB METHOD

SHIP SYSTEM

GROSS WEIGHT 6980 LB

CG STATION 131.2 IN.

ROTOR RPM 324

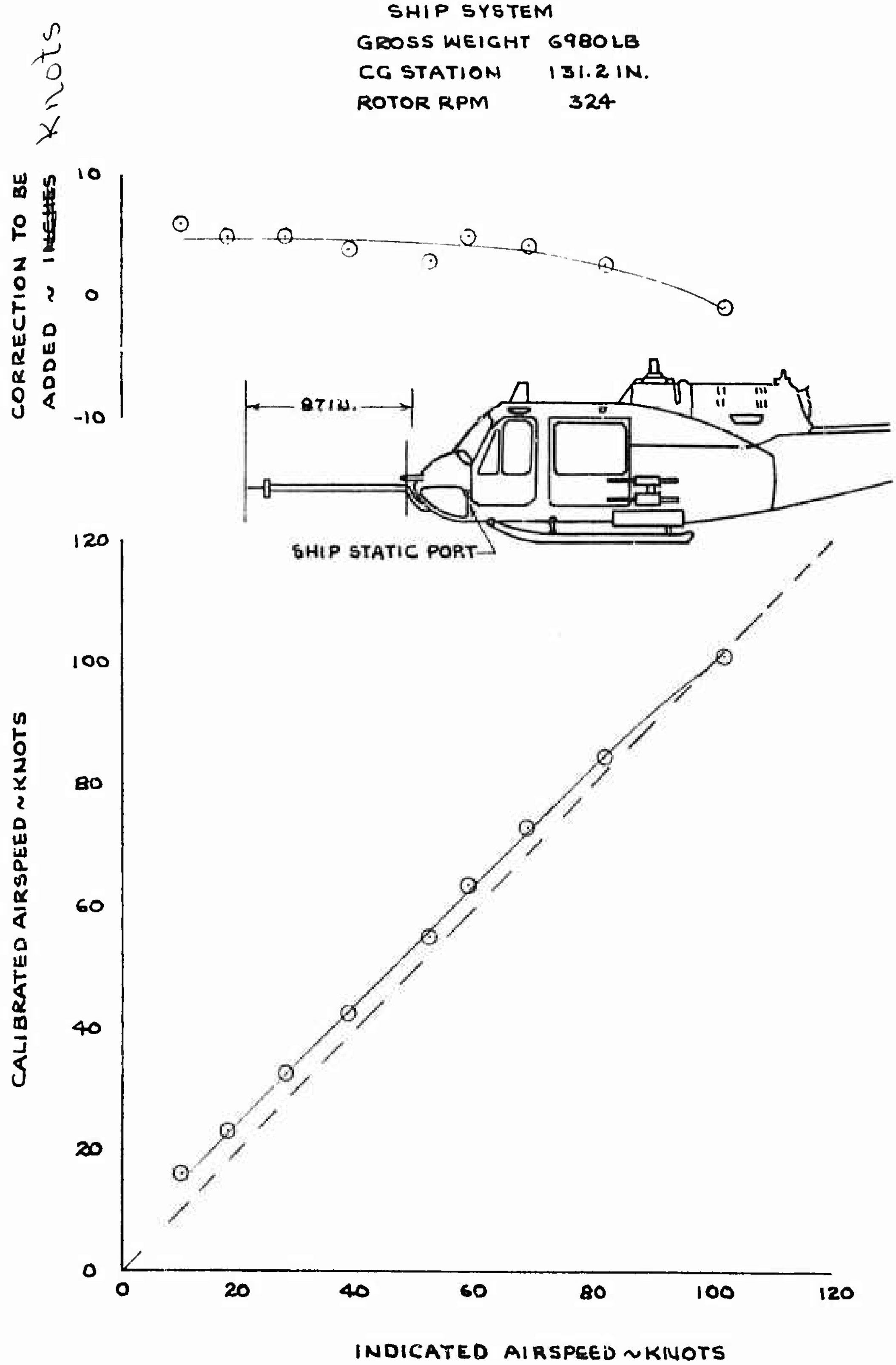


FIGURE NO. 20
AIRSPEED CALIBRATION
UH-1B USA S/N 60-3589
TRAILING BOMB METHOD
BOOM SYSTEM
GROSS WEIGHT 6980 LB.
CG STATION 131.2 IN.
ROTOR RPM 324

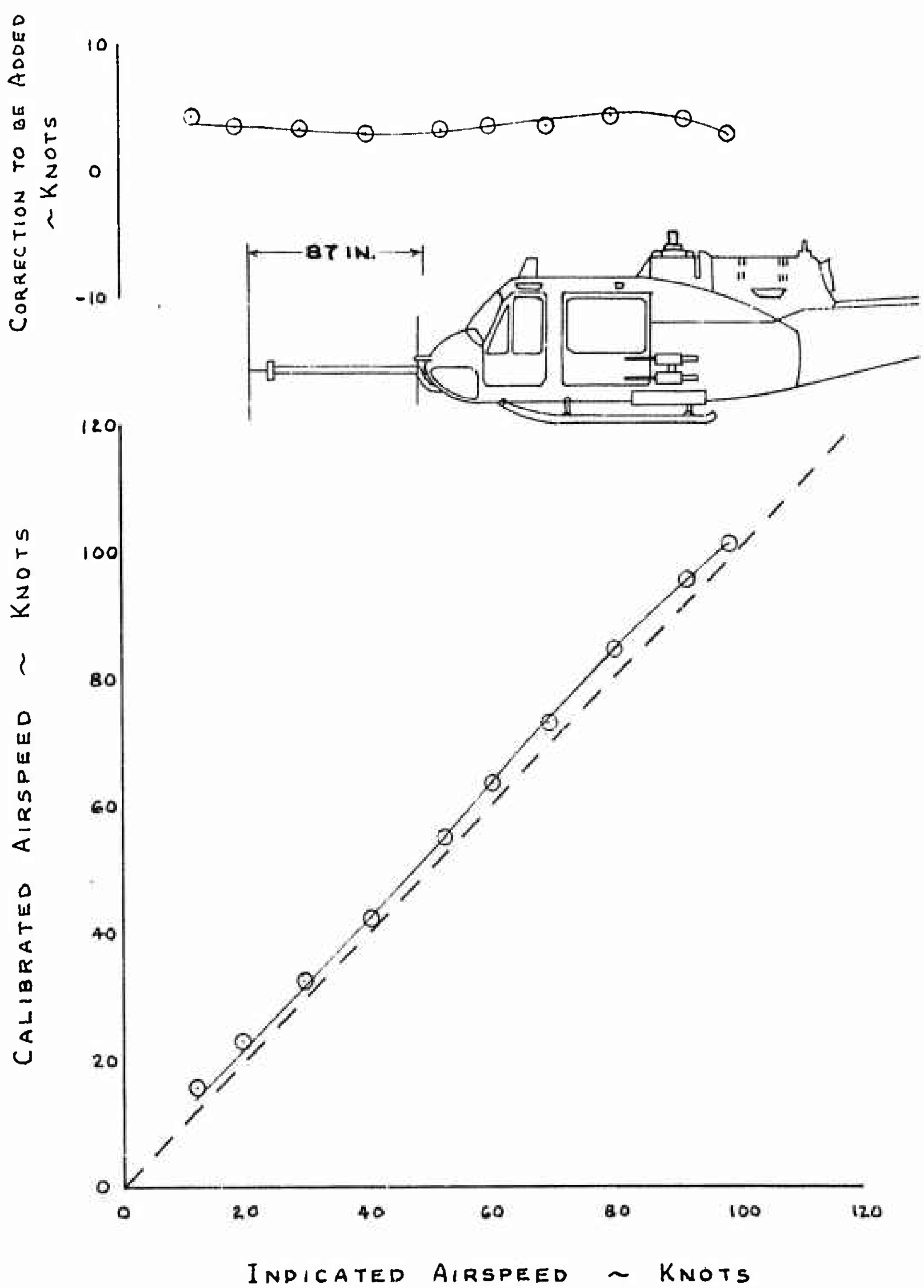


FIGURE NO. 21
AUTOROTATIONAL DESCENT
UH-1B USA S/N60-3589
ROTOR SPEED = 324
ARMED CONFIGURATION
XM-16

SYM	H_D	GW	CG
○	6600	7380	125.0
△	7500	6760	131.0
□	6380	7150	125.3
◇	7820	6720	130.5

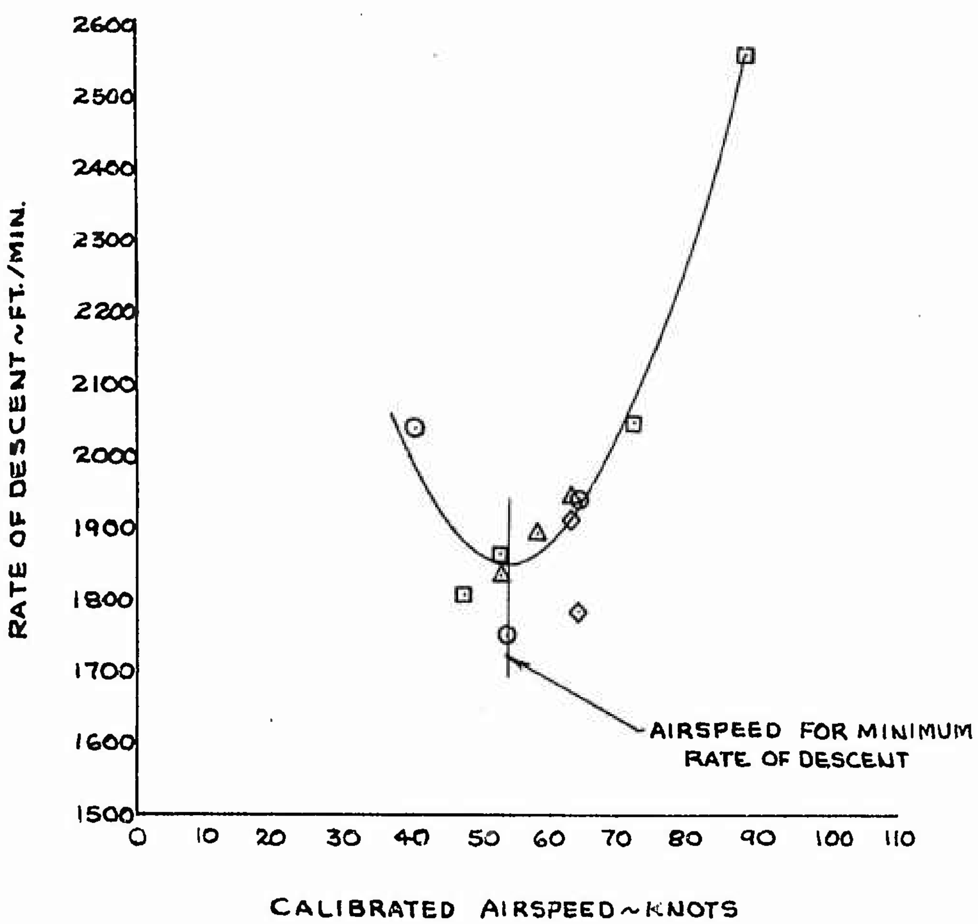


FIGURE No. 20

CONTROL POSITIONS IN LEVEL FLIGHT

UH-1B USA S/N 60-3539

ARMAMENT CONFIGURATION

H_D 5290 FT AVG G.W. 6590 LB

RPM 324 AVG CG 130.8 IN.

$C_{T_{AVG}}$ .003973 XM-16 KIT

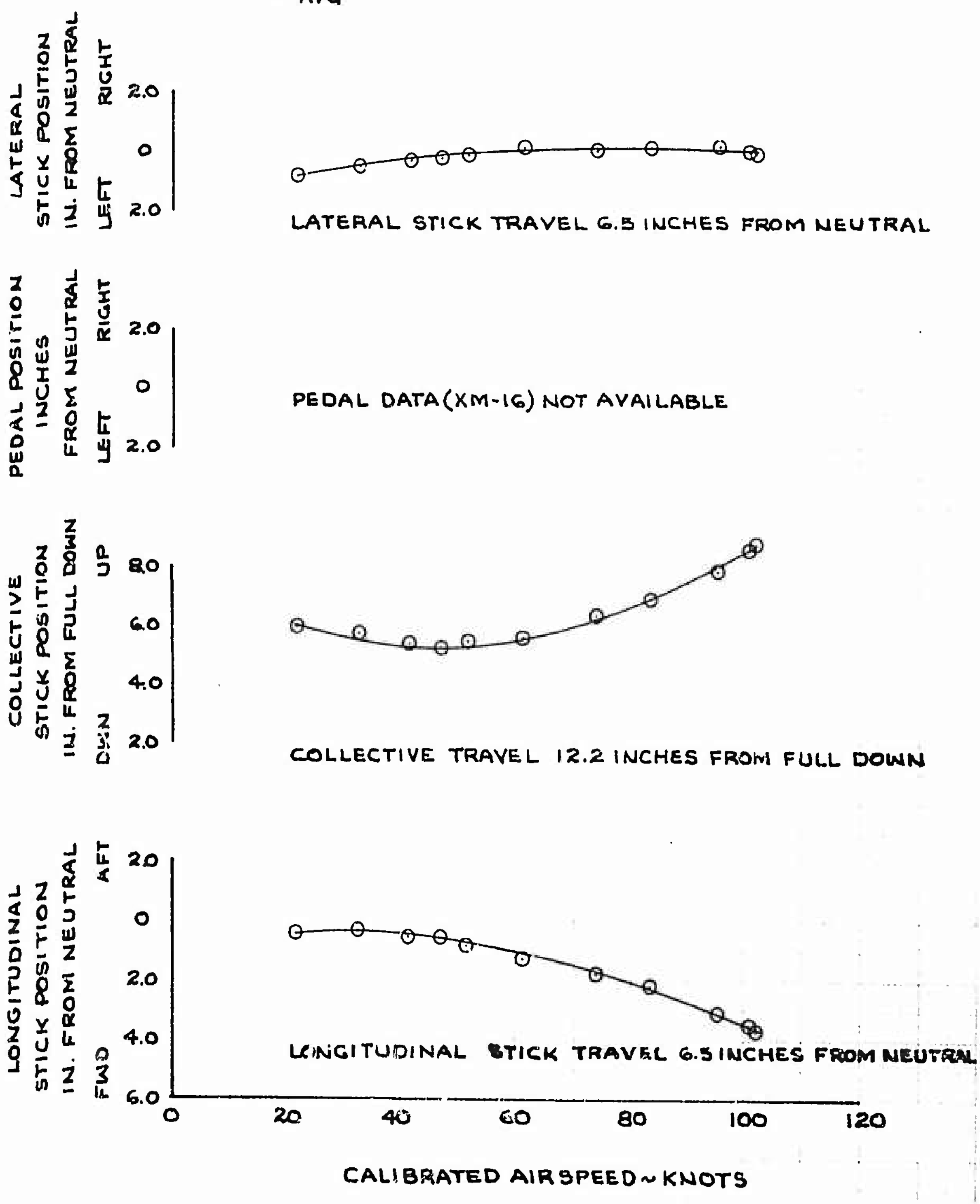


FIGURE NO. 23
CONTROL POSITIONS IN LEVEL FLIGHT
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION

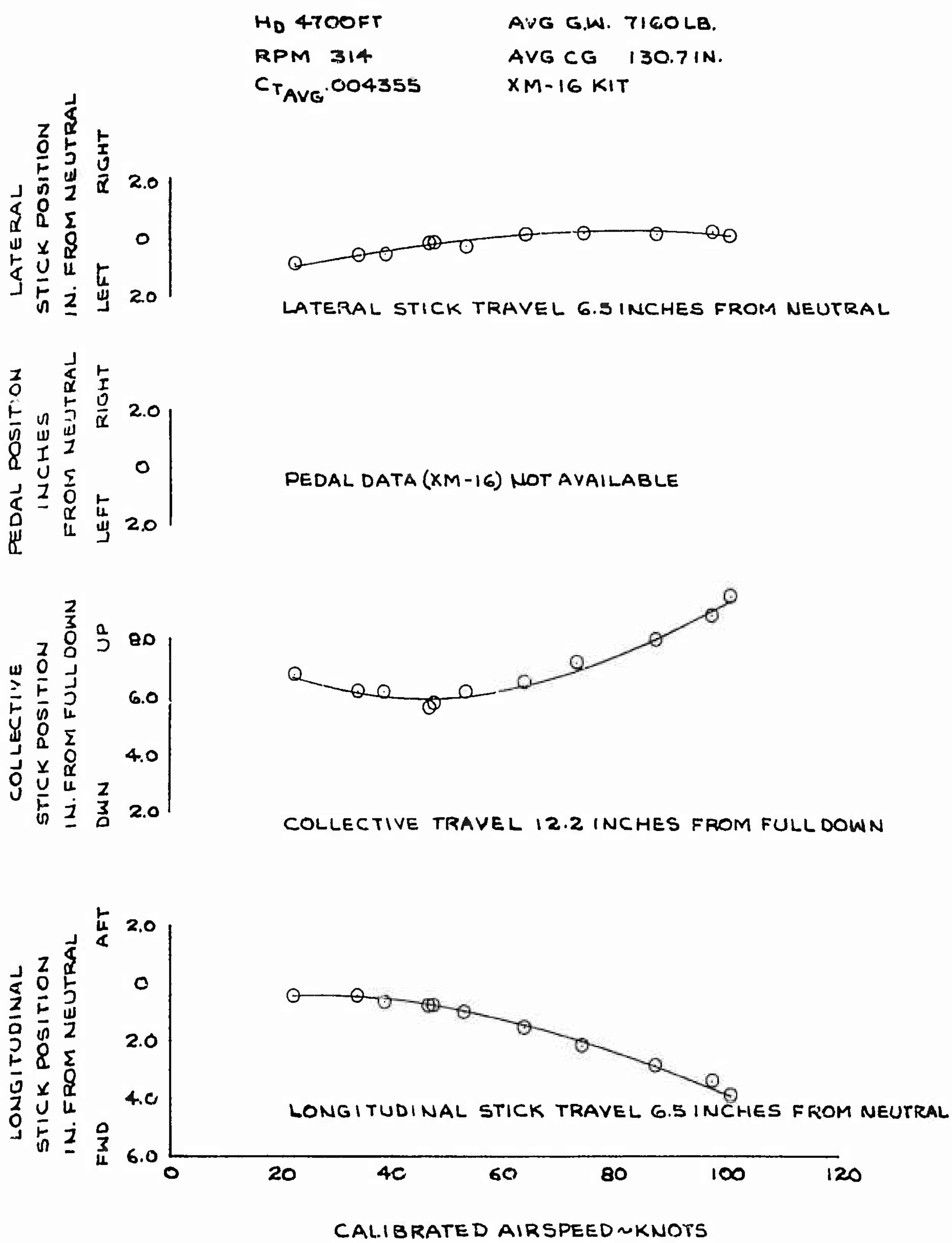


FIGURE NO. 24
CONTROL POSITIONS IN LEVEL FLIGHT
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION

H_D 9750 FT.
RPM 323
$C_{T_{AVG}}$ .004608

AVG G.W. 6870 LB
AVG CG 130.6 IN.
XM-16 KIT

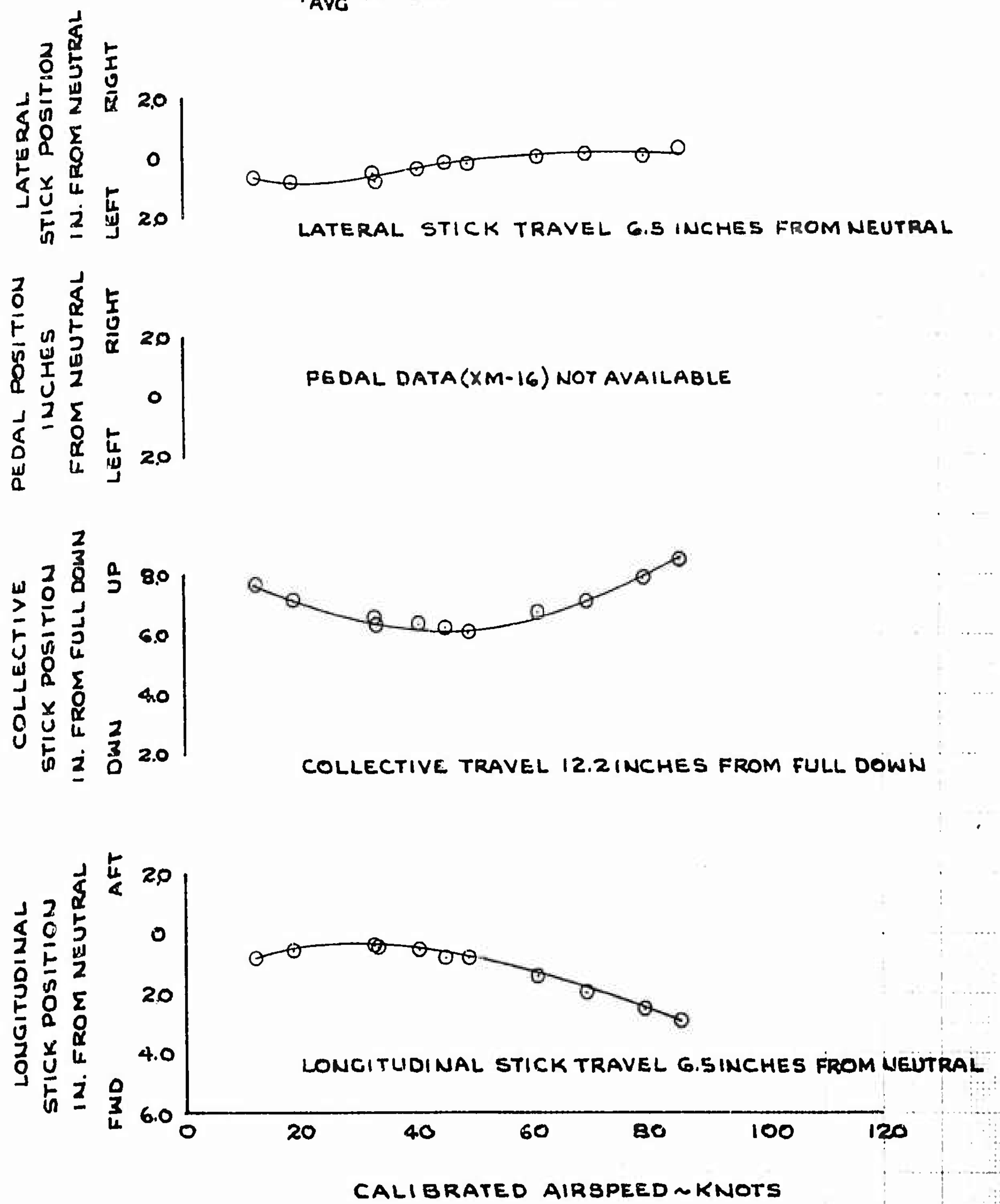


FIGURE NO. 25
CONTROL POSITIONS IN LEVEL FLIGHT
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION

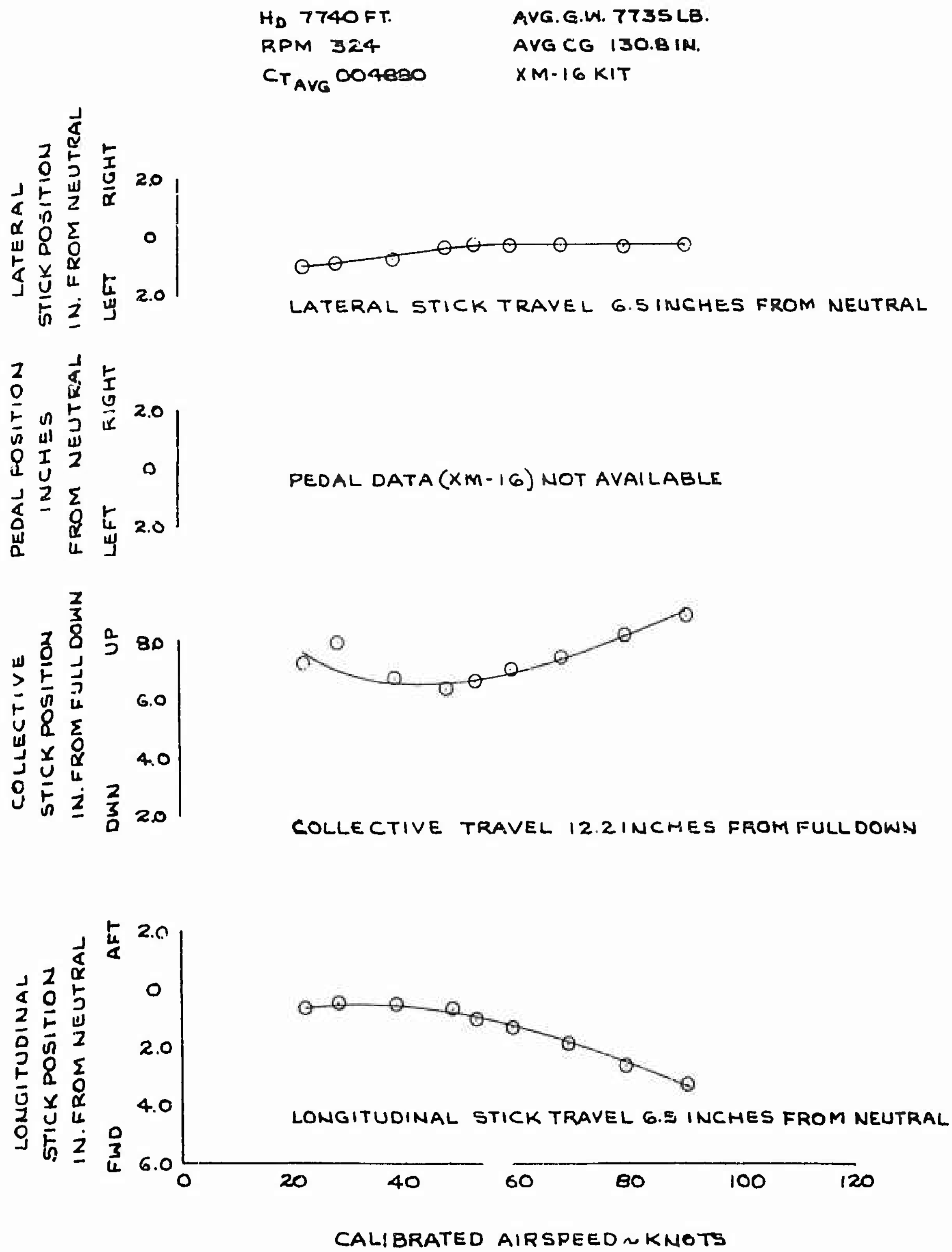


FIGURE NO. 26

CONTROL POSITIONS IN LEVEL FLIGHT

UH-1B USA S/N 60-3589

ARMAMENT CONFIGURATION

BOTH PODS FULLY LOADED

H_D 4970 FT. AVG. G.W. 6600 LB

RPM 324 AVG. C.G. 130.6 IN.

$C_{T AVG.}$ .003806 XM-21 KIT

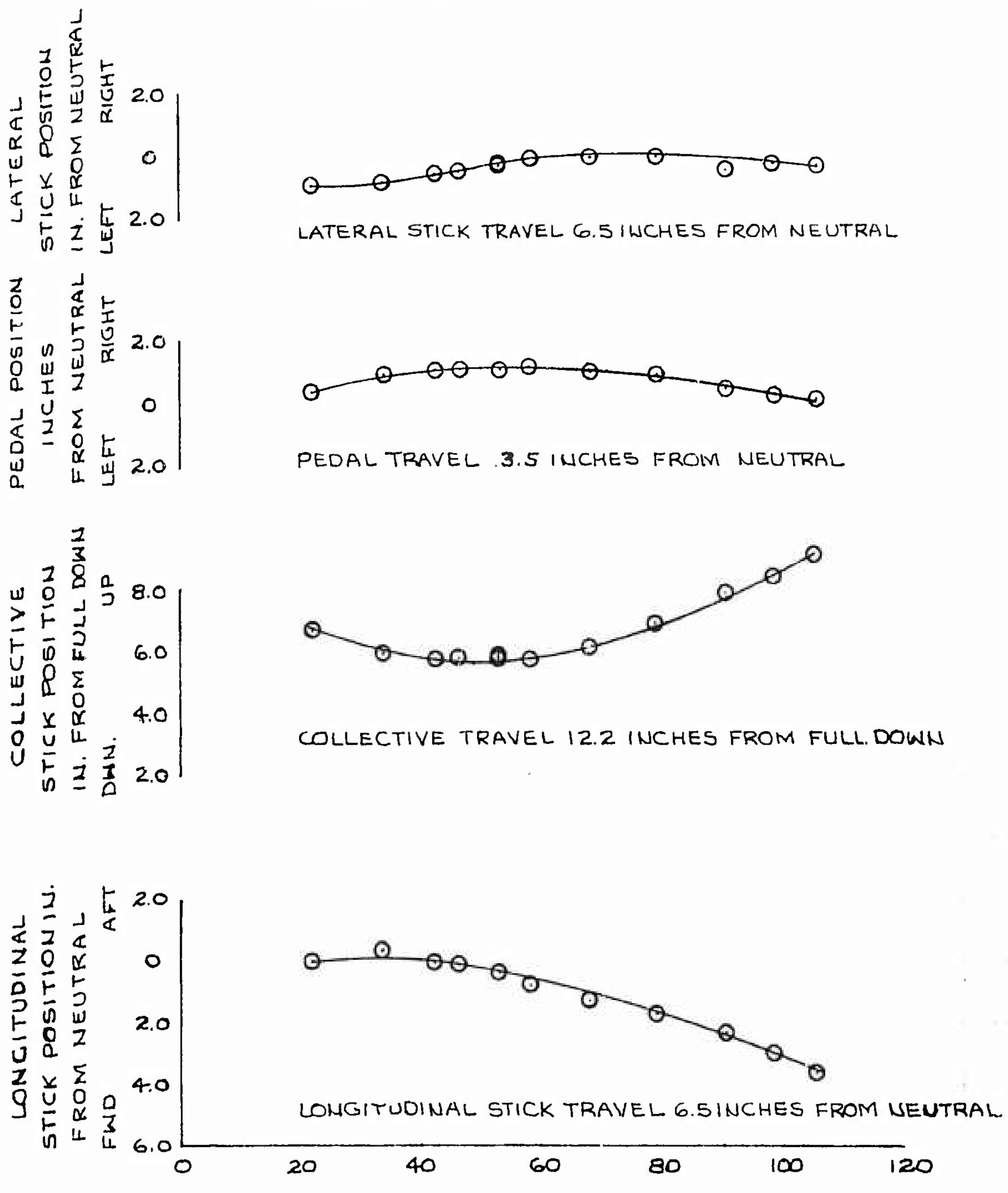


FIGURE NO. 27
CONTROL POSITIONS IN LEVEL FLIGHT
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION
BOTH PODS FULLY LOADED

H_D 5000 FT. AVG. G.W. 7040 LB
RPM 324 AVG. C.G. 130.5 IN.
$C_{T\,AVG.}$ .004066 XM-21 KIT

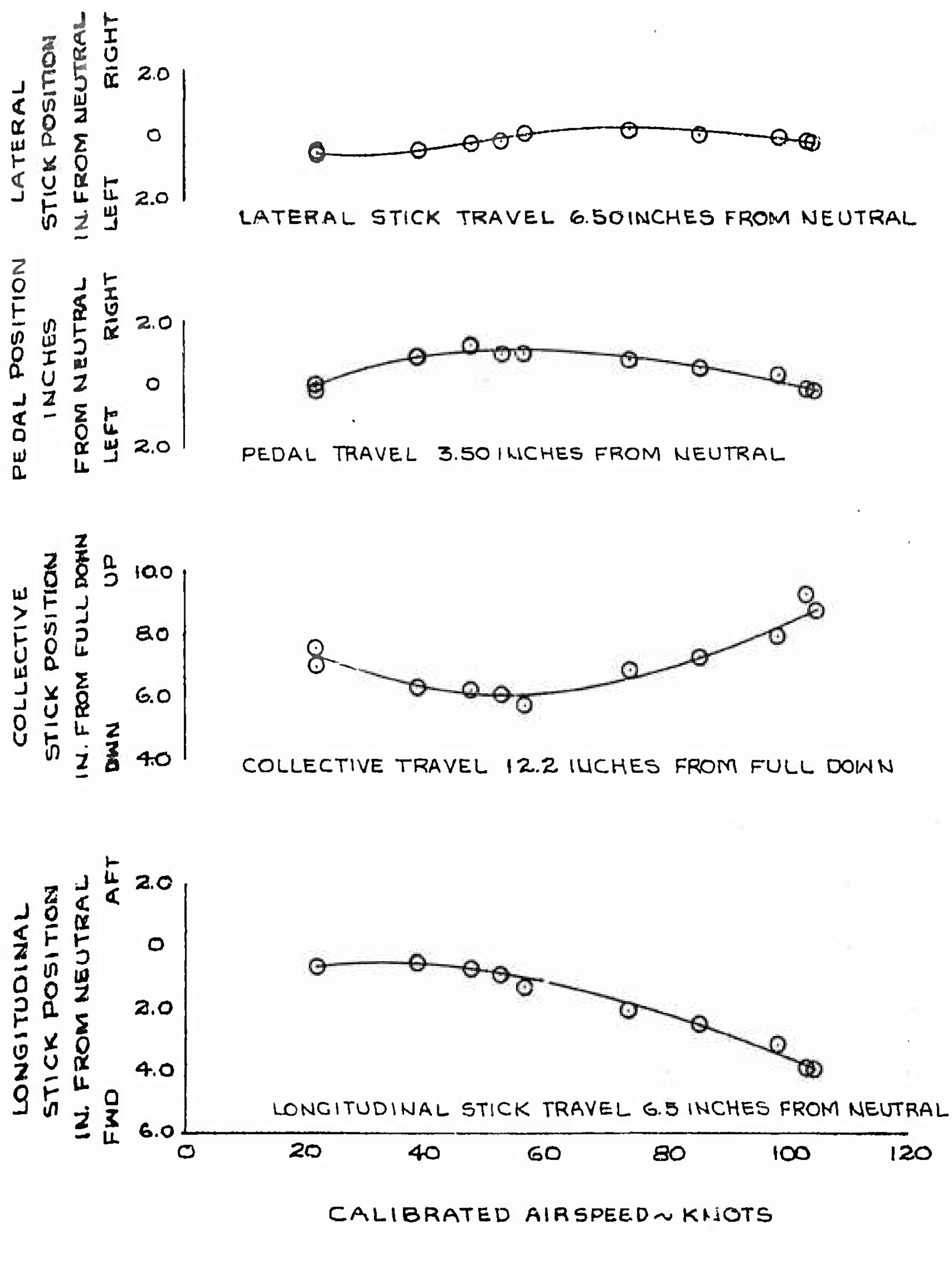


FIGURE NO. 28
CONTROL POSITIONS IN LEVEL FLIGHT
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION
BOTH PODS FULLY LOADED

H_D 6960 FT. AVG G.W. 7320 LB.
RPM 324 AVG. C.G. 130.7 IN.
C_T AVG. .004490 XM-21 KIT

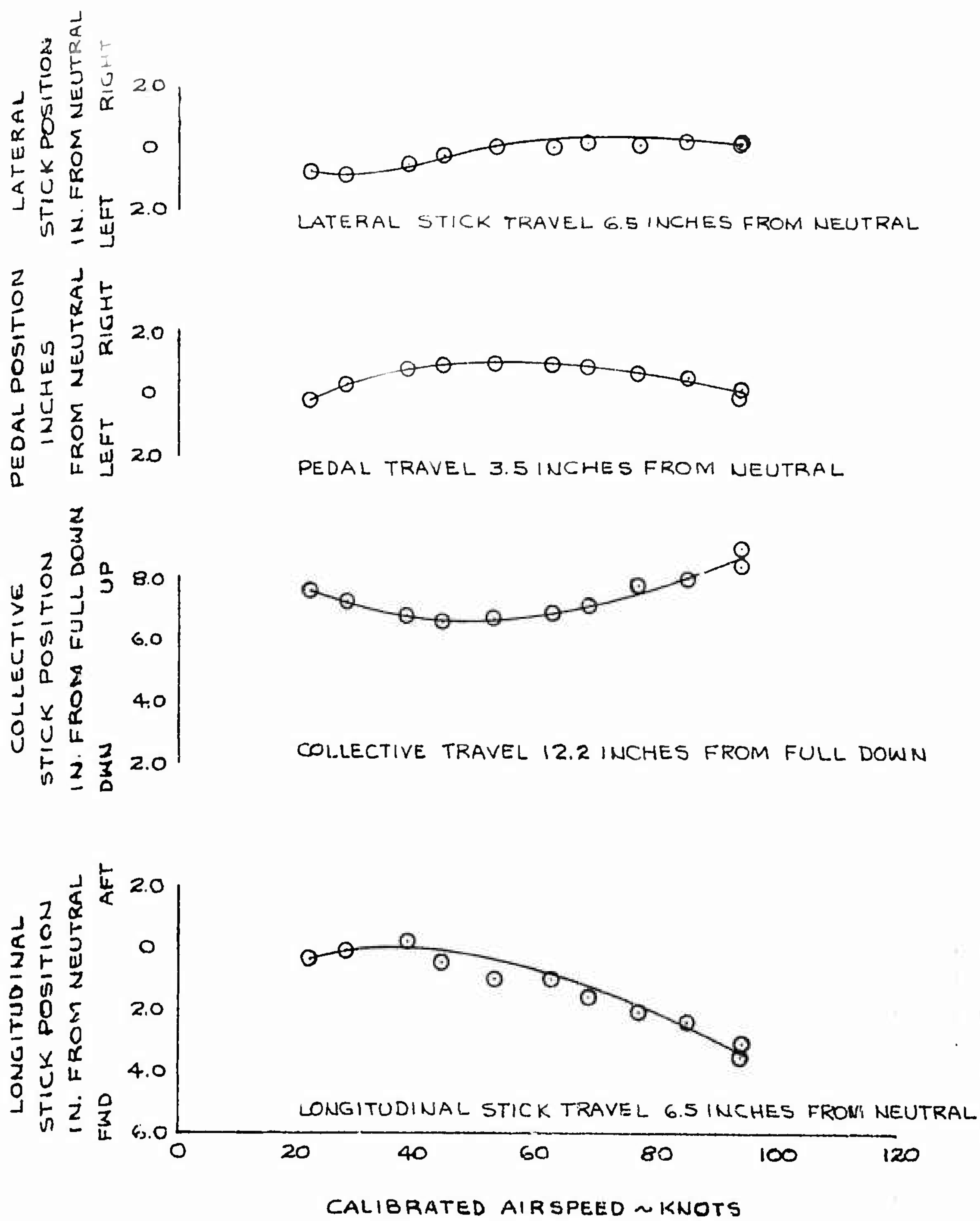


FIGURE NO. 29

CONTROL POSITIONS IN LEVEL FLIGHT

UH-1B USA S/N 60-3589

ARMAMENT CONFIGURATION

BOTH PODS FULLY LOADED

H_D 5480 FT.	AVG G.W. 8380 LB
RPM 324	AVG. C.G. 131.0 IN.
$C_{T\,AVG}$ .004908	XM-21 KIT

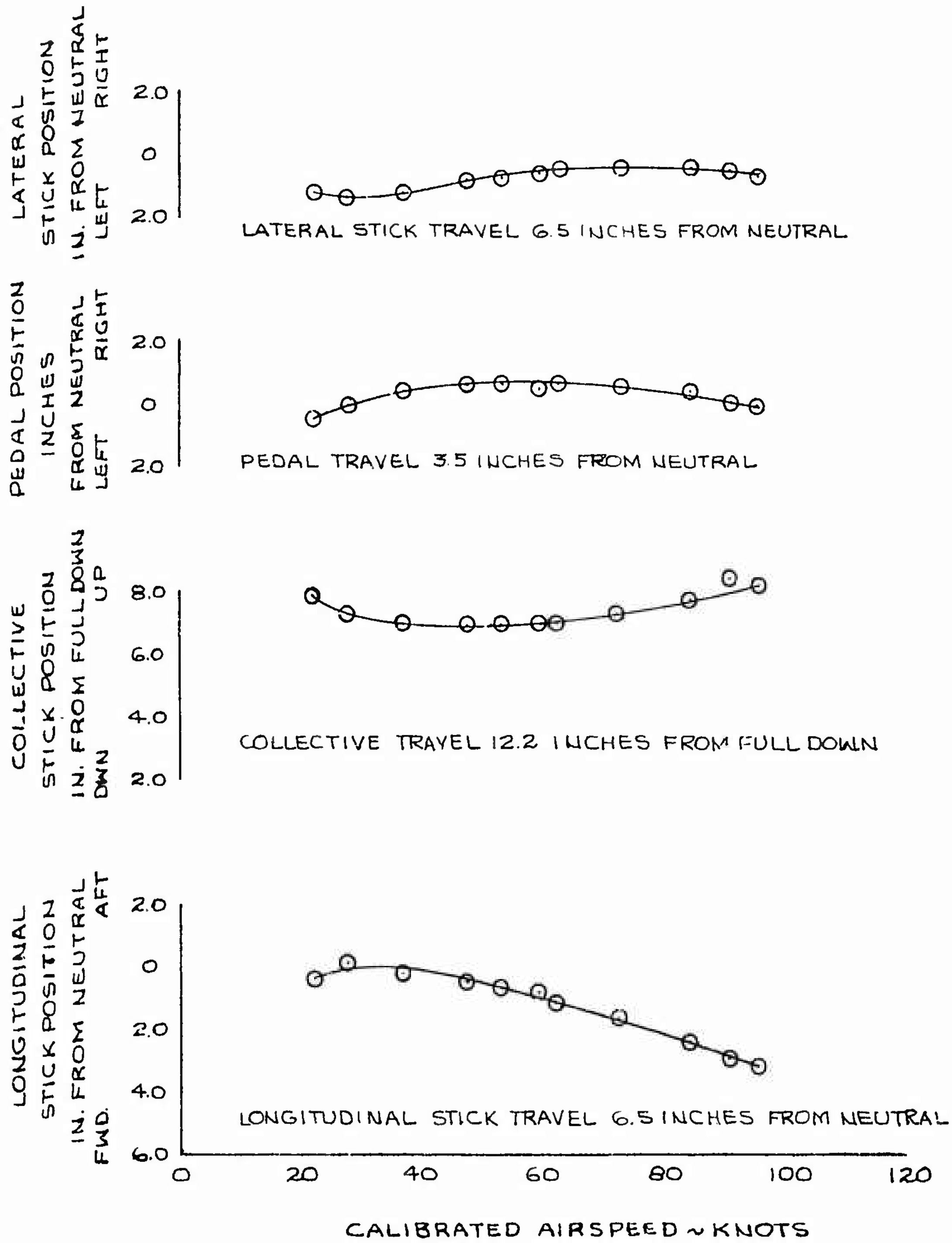


FIGURE NO. 30
STATIC LONGITUDINAL SPEED STABILITY
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION
LEVEL FLIGHT

SYM	TRIM CAS	AVG H_D	AVG G.W.	AVG. C.G	RPM	ARMAMENT	CONFIG.
○	38.0	4820	7230	127.2	324	XM-21	BOTH PODS FULL
□	52.0	4760	7635	125.7	323	XM-16	BOTH PODS FULL
◇	48.0	5160	7580	125.3	324	XM-16	BOTH PODS EMPTY

SHADED SYMBOLS DENOTE TRIM CONDITION

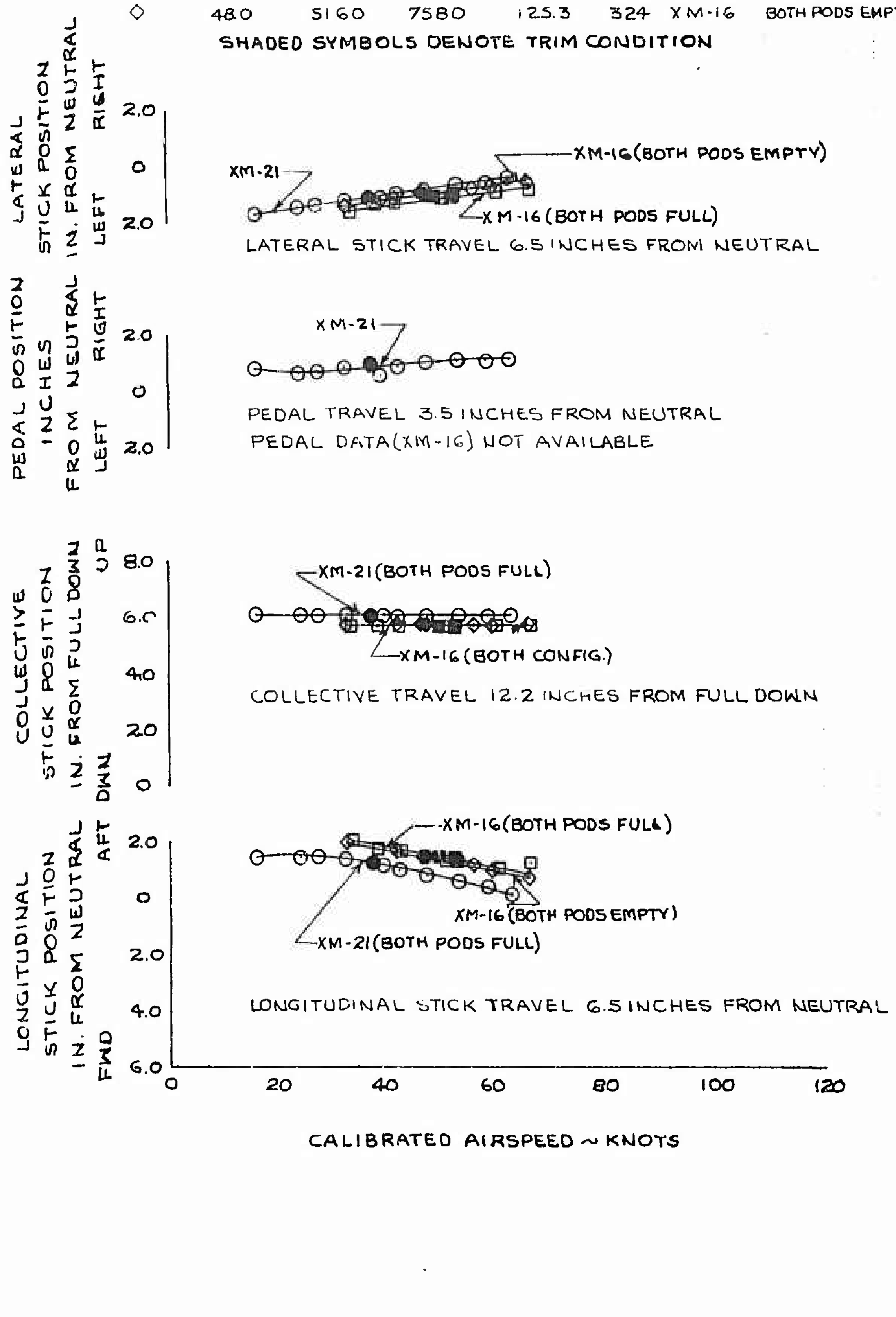


FIGURE NO. 31
STATIC LONGITUDINAL SPEED STABILITY
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION
LEVEL FLIGHT

SYM	TRIM CAS	AVG H_D	AVG G.W.	AVG CG	RPM	ARMAMENT	CONFIG
○	85.0	5150	7155	127.0	324	XM-21	BOTH PODS FULL
□	84.0	5250	7550	125.7	323	XM-16	BOTH PODS FULL
◇	86.0	5650	7525	125.2	324	XM-16	BOTH PODS EMPTY

SHADED SYMBOLS DENOTE TRIM CONDITION

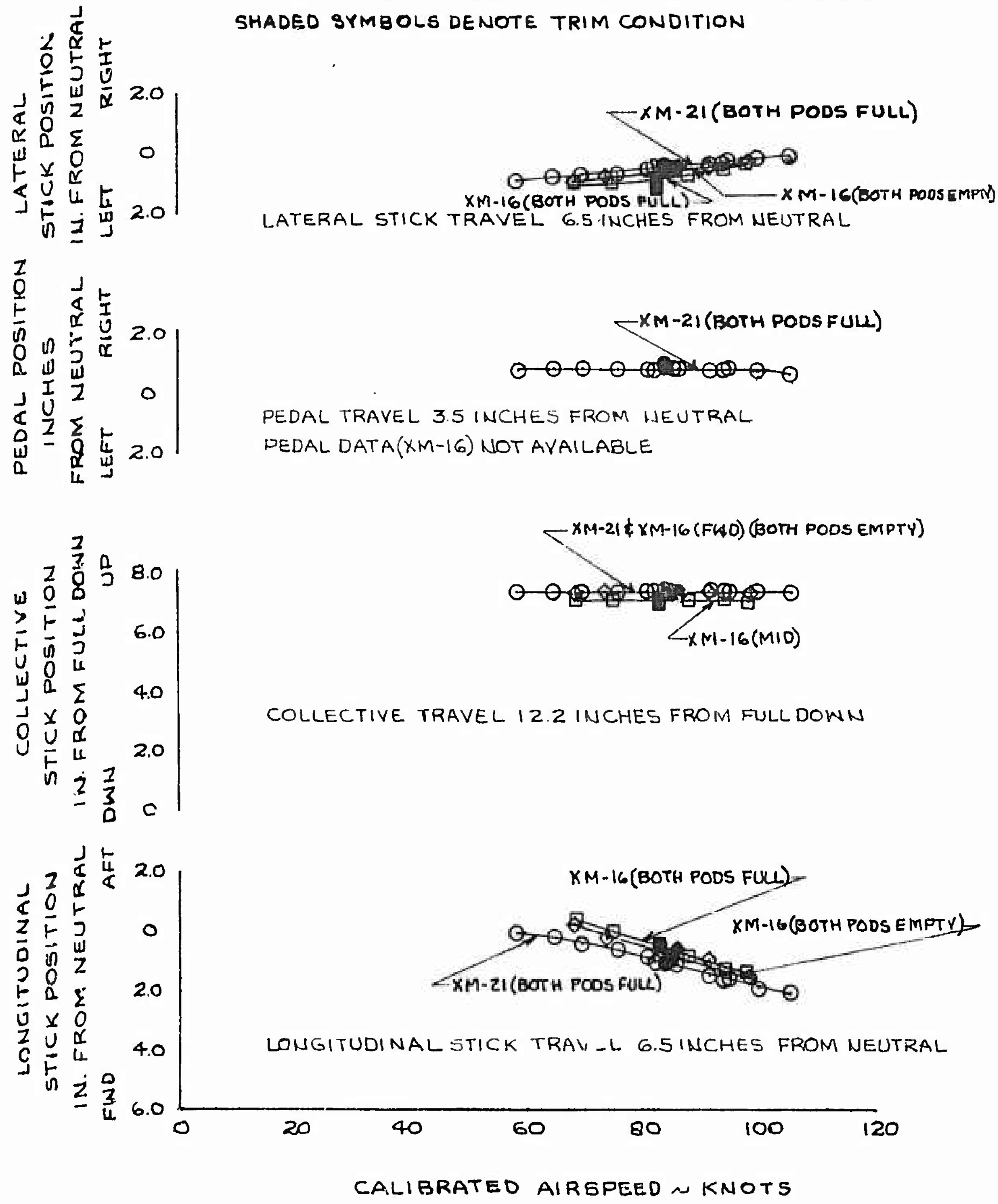


FIGURE NO. 32
STATIC LONGITUDINAL SPEED STABILITY
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION
LEVEL FLIGHT

SYM	TRIM CAS	AVG H_D	AVG G.W	AVG CG	RPM	ARMAMENT CONFIG
○	102.0	6230	7060	126.8	324	XM-21 BOTH PODS FULL
□	96.0	6480	7330	125.6	322	XM-16 BOTH PODS FULL
◇	96.0	6020	7465	125.2	324	XM-16 BOTH PODS EMPTY

SHADED SYMBOLS DENOTE TRIM CONDITION

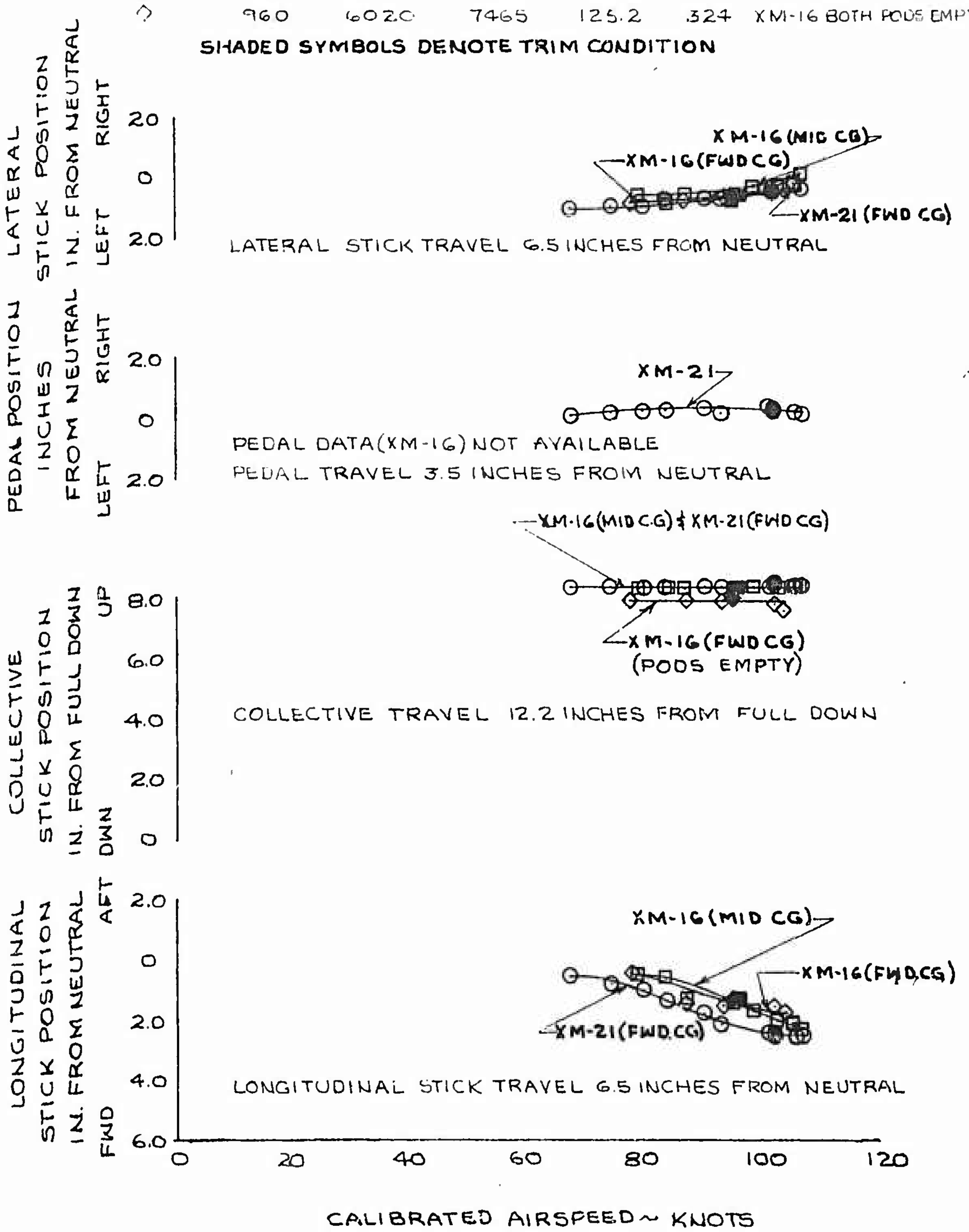


FIGURE NO. 23
STATIC LONGITUDINAL SPEED STABILITY
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION
AUTOROTATION

SYM	TRIM CAS	AVG H_D	AVG G.W	AVG C.G	RPM	ARMAMENT CONFIG
○	54.0	5500	8410	126.4	324	XM-21 BOTH PODS FULL
□	56.0	5950	7620	130.7	318	XM-16 BOTH PODS FULL

SHADED SYMBOLS DENOTE TRIM CONDITION

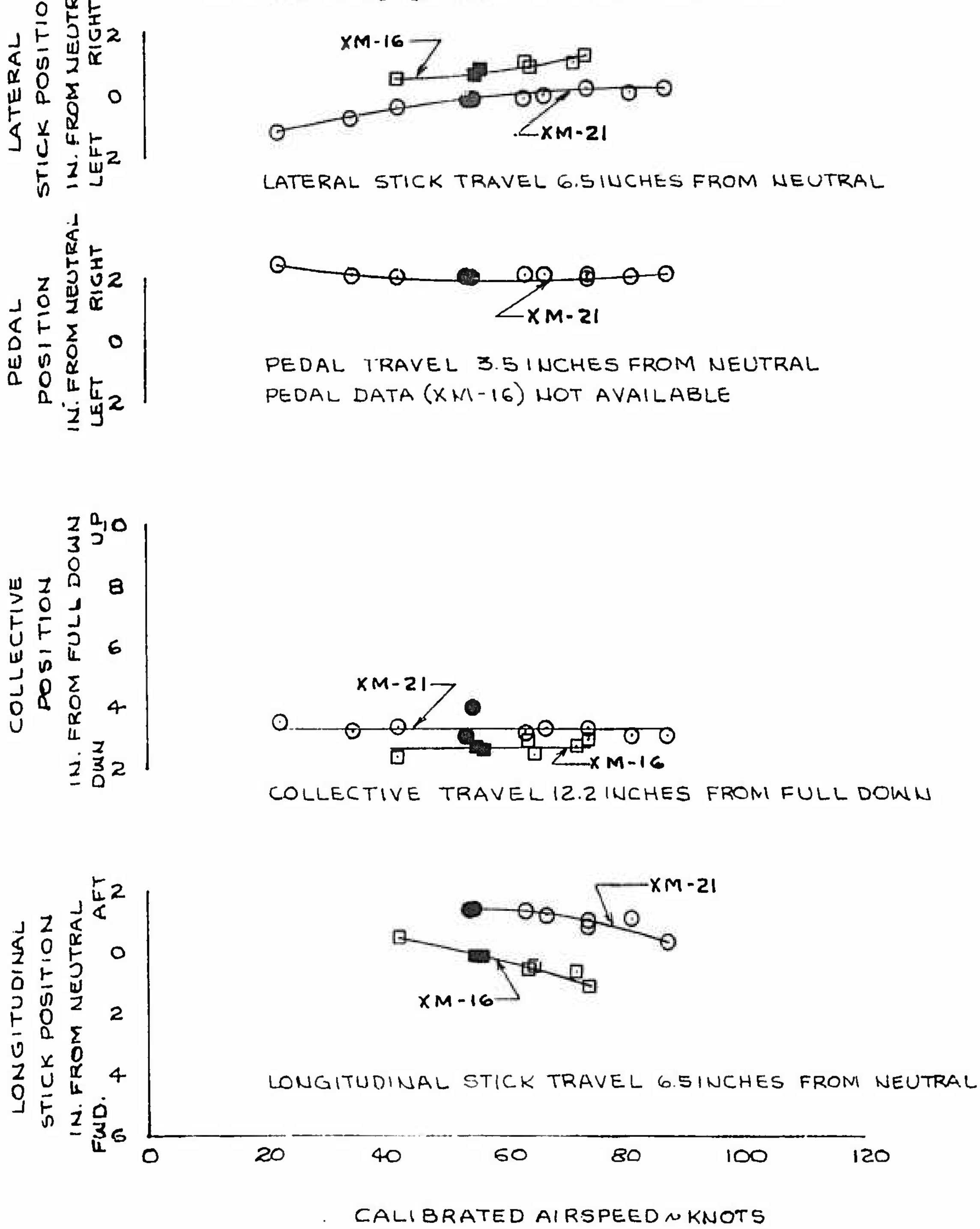


FIGURE NO. 34

STATIC LONGITUDINAL SPEED STABILITY

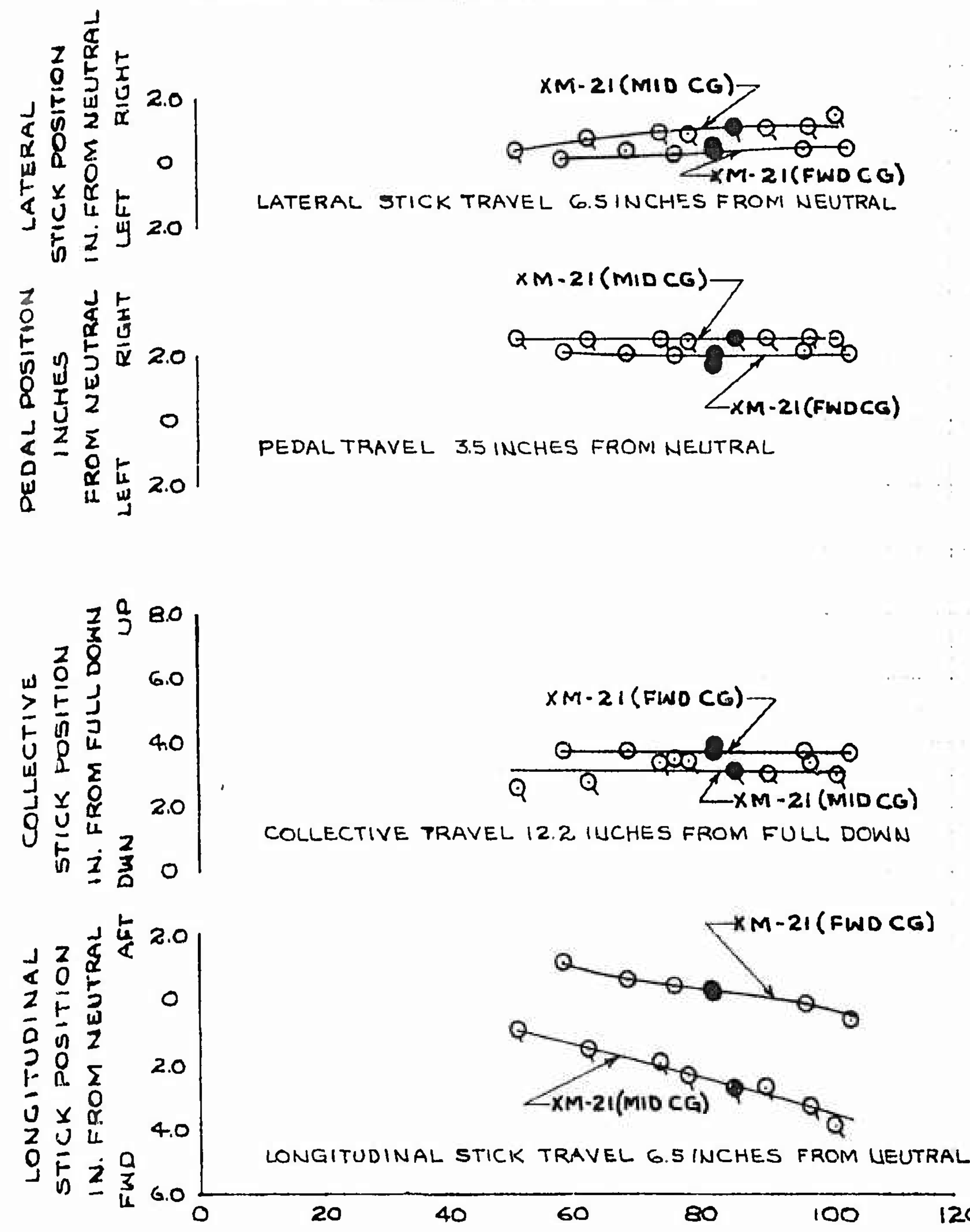
UH-1B USA S/N 60-3589

ARMAMENT CONFIGURATION

AUTOROTATION

SYM	TRIM CAS	AVG H_D	AVG GW.	AVG CG	RPM	ARMAMENT	CONFIG.
O	83.0	5070	8560	126.5	323	XM-21	BOTH PODS FULL
Q	86.0	5700	7630	131.2	322	XM-21	BOTH PODS FULL

SHADED SYMBOLS DENOTE TRIM CONDITION



Calibrated Airspeed

FIGURE NO. 35

STATIC LONGITUDINAL SPEED STABILITY

UH-1B USA S/N 60-3589

ARMAMENT CONFIGURATION

PARTIAL POWER DESCENT (400 FT/MIN)

SYM	TRIM CAS	AVG H_D	AVG G.W.	AVG. C.G.	RPM	ARMAMENT CONFIG
△	38.0	4960	7685	128.2	324	XM-16 RT. POD ONLY
◇	37.0	5500	7675	125.5	324	XM-16 BOTH PODS EMPTY

SHADED SYMBOLS DENOTE TRIM CONDITION

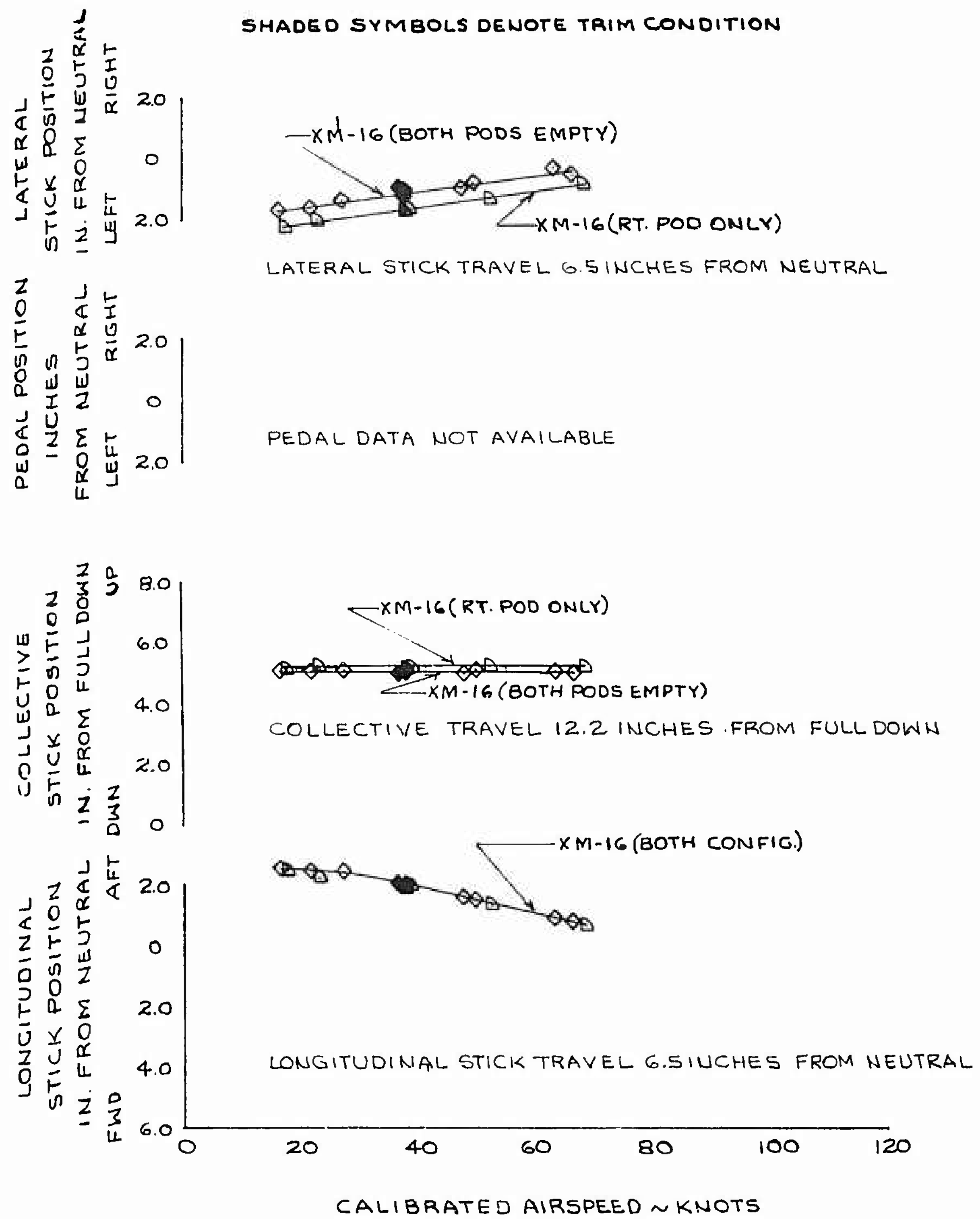


FIGURE NO. 36

STATIC LONGITUDINAL SPEED STABILITY

UH-1B USA S/N 60-3589

ARMAMENT CONFIGURATION

PARTIAL POWER DESCENT (400 FT./MIN.)

SYM	TRIM CAS	AVG H_D	AVG G.W.	AVG C.G	RPM	ARMAMENT	CONFIG
○	480	5540	7415	126.1	324	XM-21	BOTH PODS FULL
□	370	5850	7755	131.0	324	XM-16	BOTH PODS FULL

SHADED SYMBOLS DENOTE TRIM CONDITION

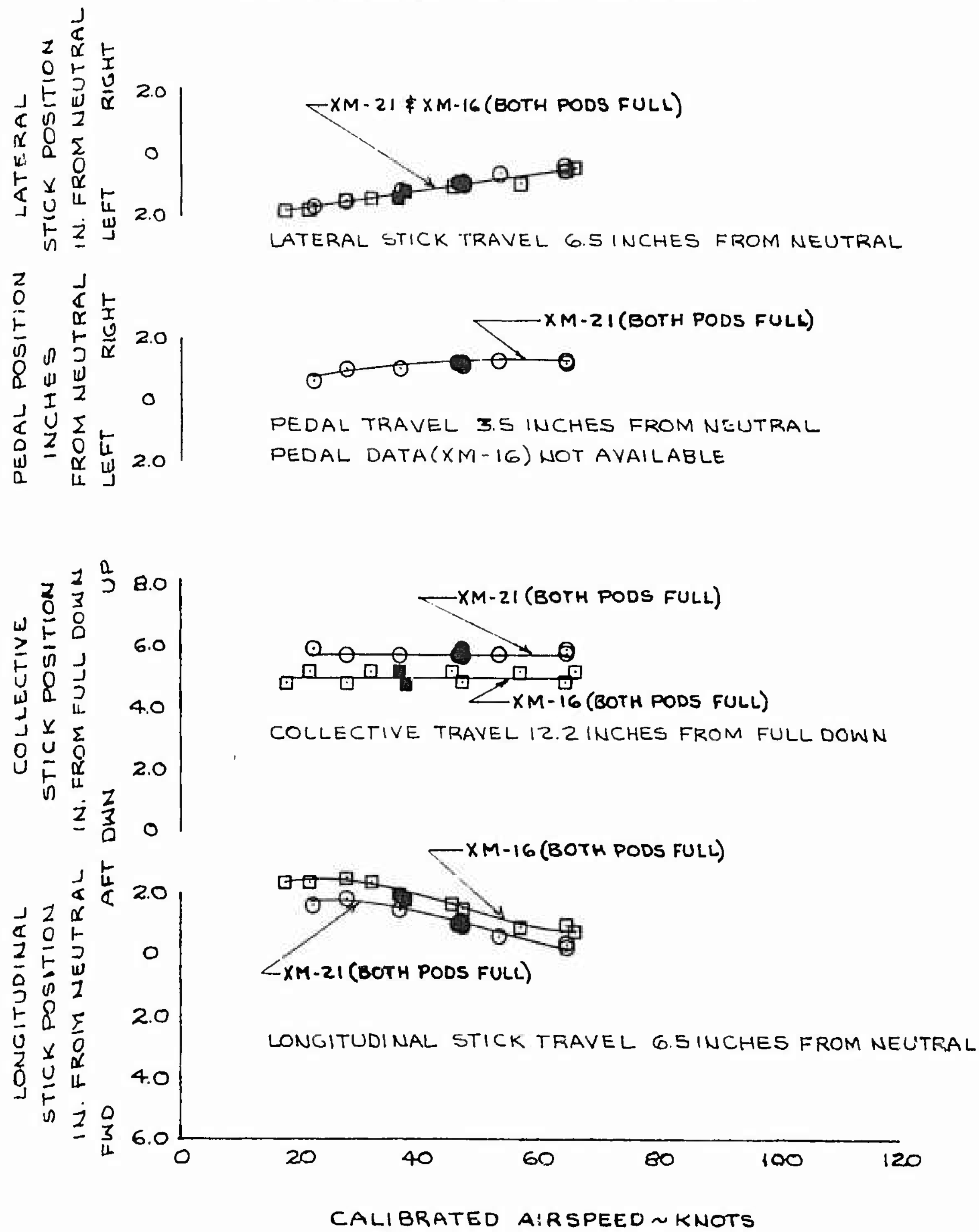


FIGURE No 37

STATIC DIRECTIONAL STABILITY

UH-1B USA S/N 60-3589

ARMAMENT CONFIGURATION

CLIMB

SYM	TRIM CAS	AVG. H_D	AVG. G.W	AVG CG	RPM	ARMAMENT CONFIG
○	61.0	7420	6995	126.8	322	XM-21 BOTH PODS FULL
□	61.0	6610	7315	125.6	322	XM-16 BOTH PODS FULL

SHADED SYMBOLS DENOTE TRIM CONDITION

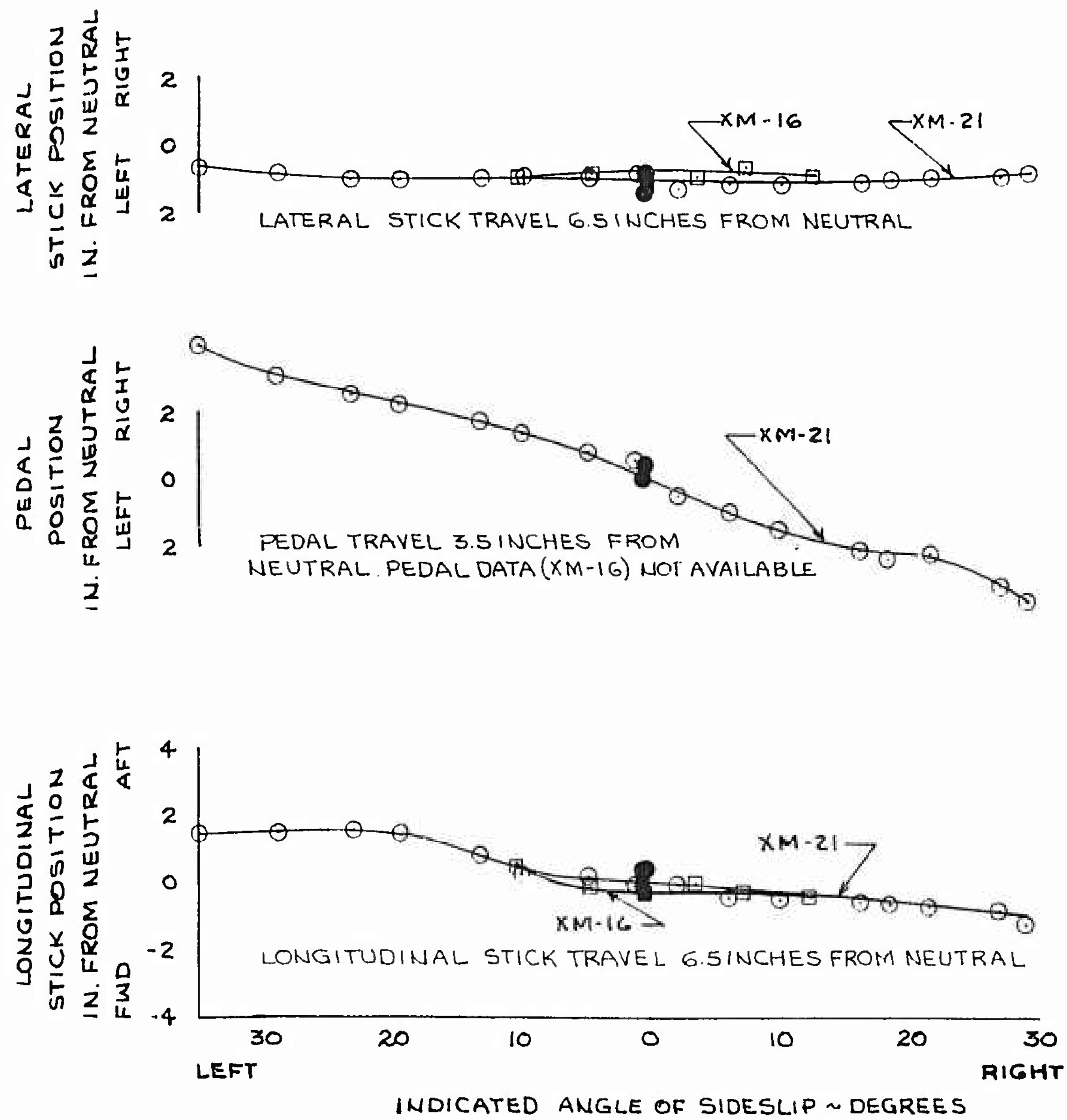


FIGURE NO. 38

STATIC DIRECTIONAL STABILITY

UH-1B USA S/N 60-3589

ARMAMENT CONFIGURATION

CLIMB

SYM	TRIM CAS	AVG H_D	AVG G.W.	AVG CG	RPM	ARMAMENT CONFIG
○	61.0	7420	6995	126.8	322	XM-21 BOTH PODS FULL
□	61.0	6610	7315	125.6	322	XM-16 BOTH PODS FULL

SHADED SYMBOLS DENOTE TRIM CONDITION

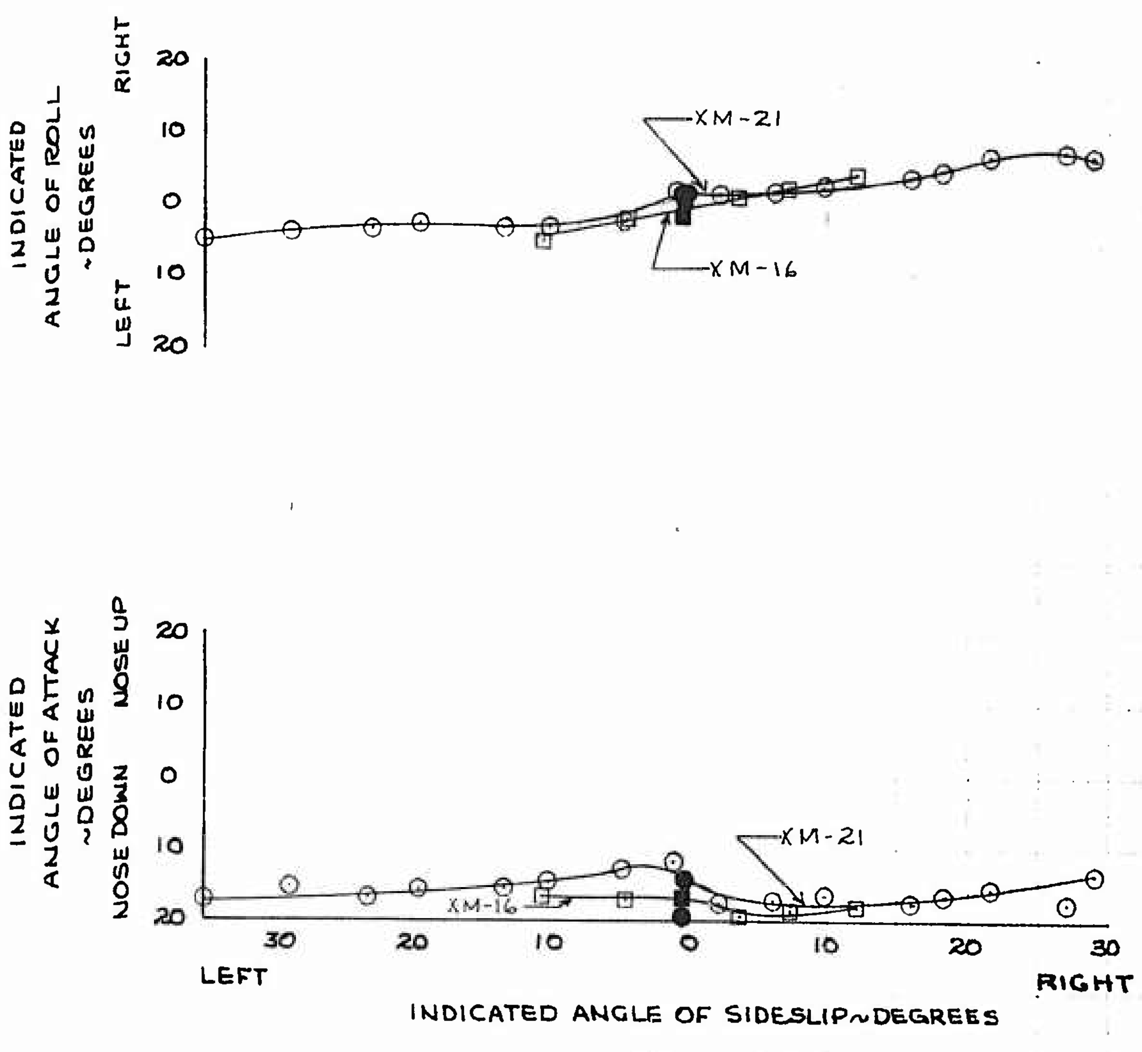


FIGURE No. 39

STATIC DIRECTIONAL STABILITY

UH-1B USA S/N 60-3589

ARMAMENT CONFIGURATION

LEVEL FLIGHT

SYM	TRIM CAS	AVG H_D	AVG G.W.	AVG CG	RPM	ARMAMENT CONFIG
○	87.0	4940	6820	125.5	323	XM-21 BOTH PODS FULL
□	86.0	5340	7230	125.4	323	XM-16 BOTH PODS FULL
◻̸	84.0	5270	7385	130.4	323	XM-16 BOTH PODS FULL

SHADED SYMBOLS DENOTE TRIM CONDITION

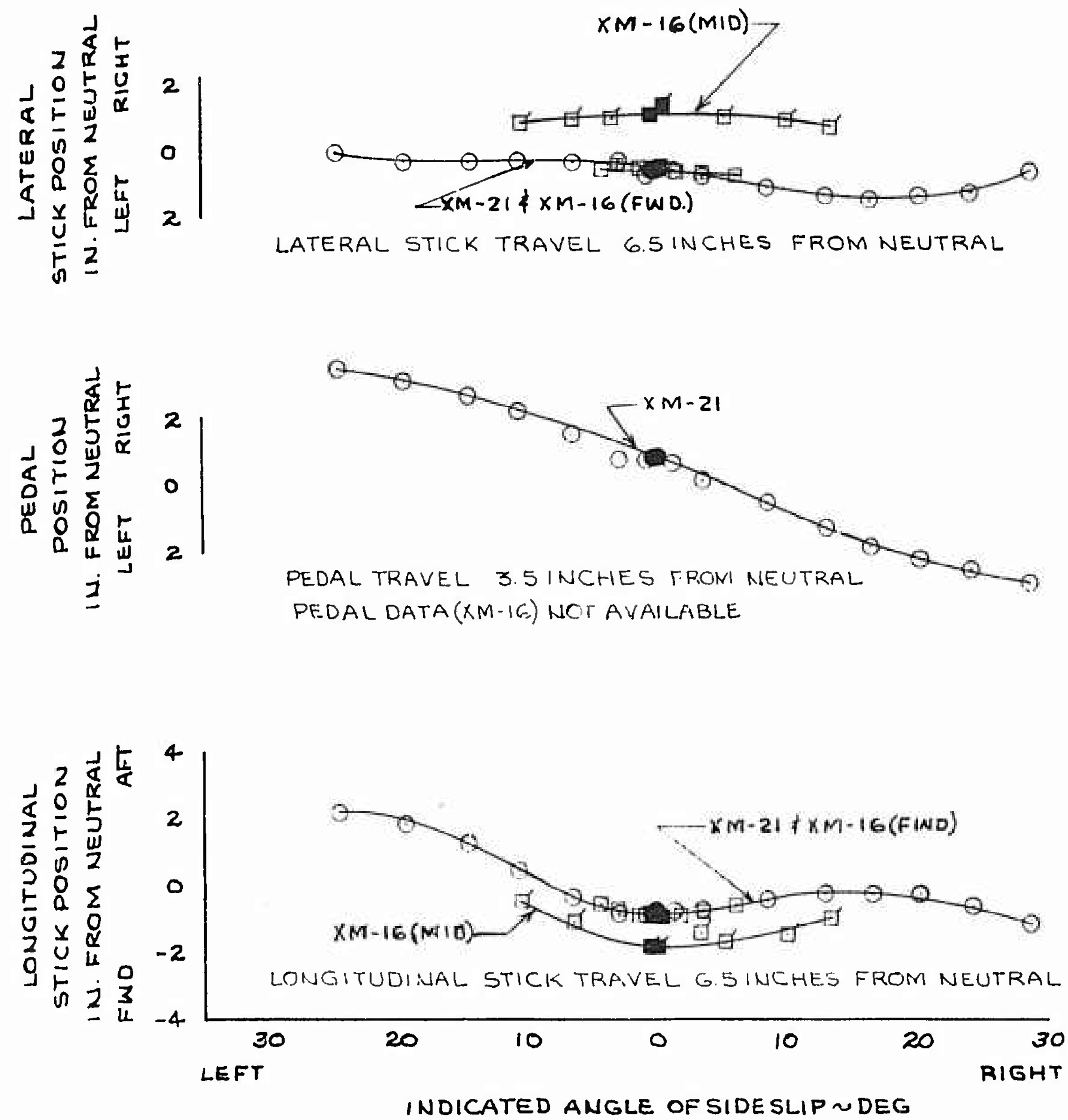


FIGURE No. 40
STATIC DIRECTIONAL STABILITY
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION
LEVEL FLIGHT

SYM	TRIM CAS	AVG. H_D	AVG G.W.	AVG. CG	RPM	ARMAMENT CONFIG.
○	87.0	4940	6820	125.5	323	XM-21 BOTH PODS FULL
□	86.0	5340	7230	125.4	323	XM-16 BOTH PODS FULL
◻̸	84.0	5370	7385	130.4	323	XM-16 BOTH PODS FULL

SHADED SYMBOLS DENOTE TRIM CONDITION

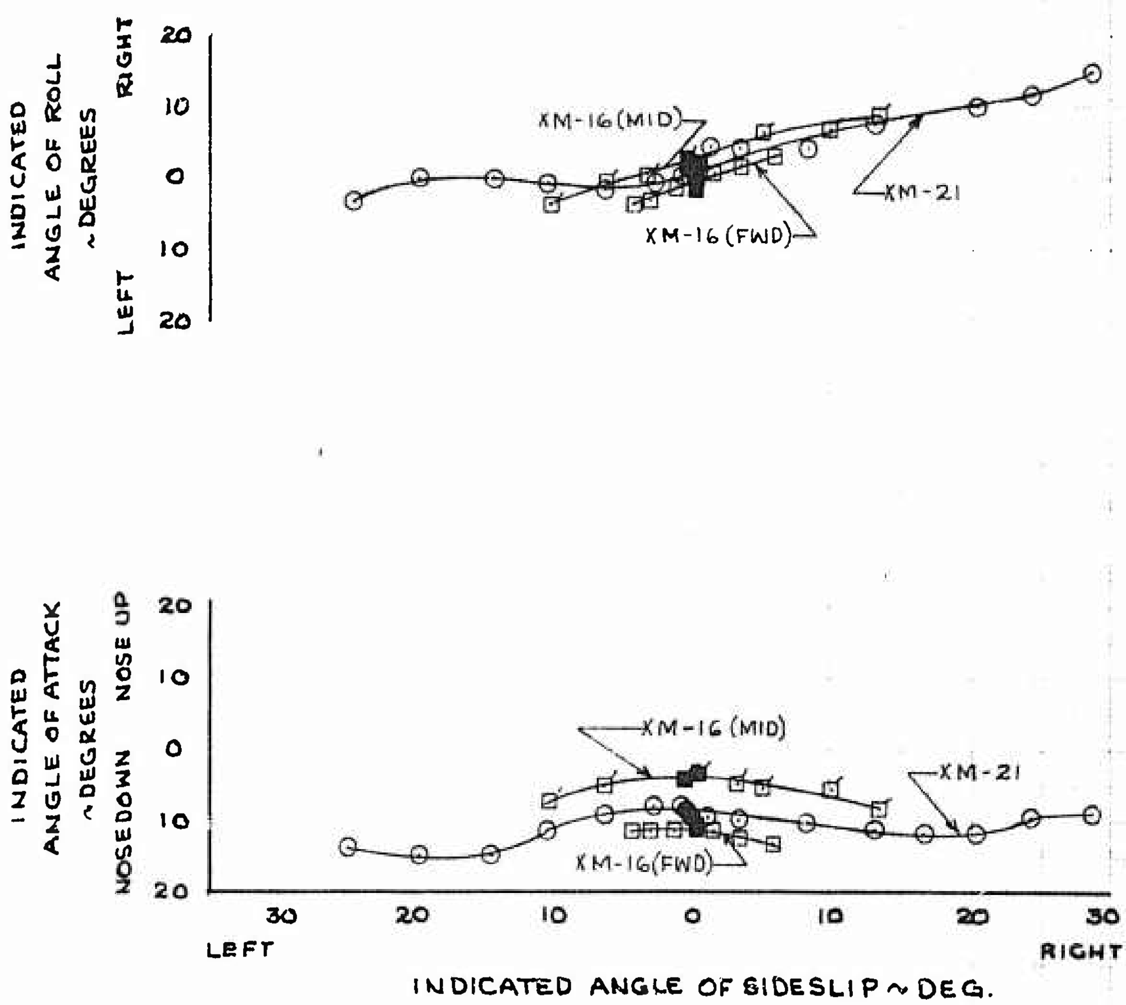


FIGURE NO. 41

STATIC DIRECTIONAL STABILITY

UH-1B USA S/N 60-3589

ARMAMENT CONFIGURATION

LEVEL FLIGHT

SYM	TRIM CAS	AVG H_D	AVG G.W.	AVG CG	RPM	ARMAMENT	CONFIG
○	103.0	5000	6920	126.5	322	XM-21	BOTH PODS FULL
□	96.0	5030	7160	125.2	323	XM-16	BOTH PODS FULL
◸	93.0	5660	7305	130.3	323	XM-16	BOTH PODS FULL

SHADED SYMBOLS DENOTE TRIM CONDITION

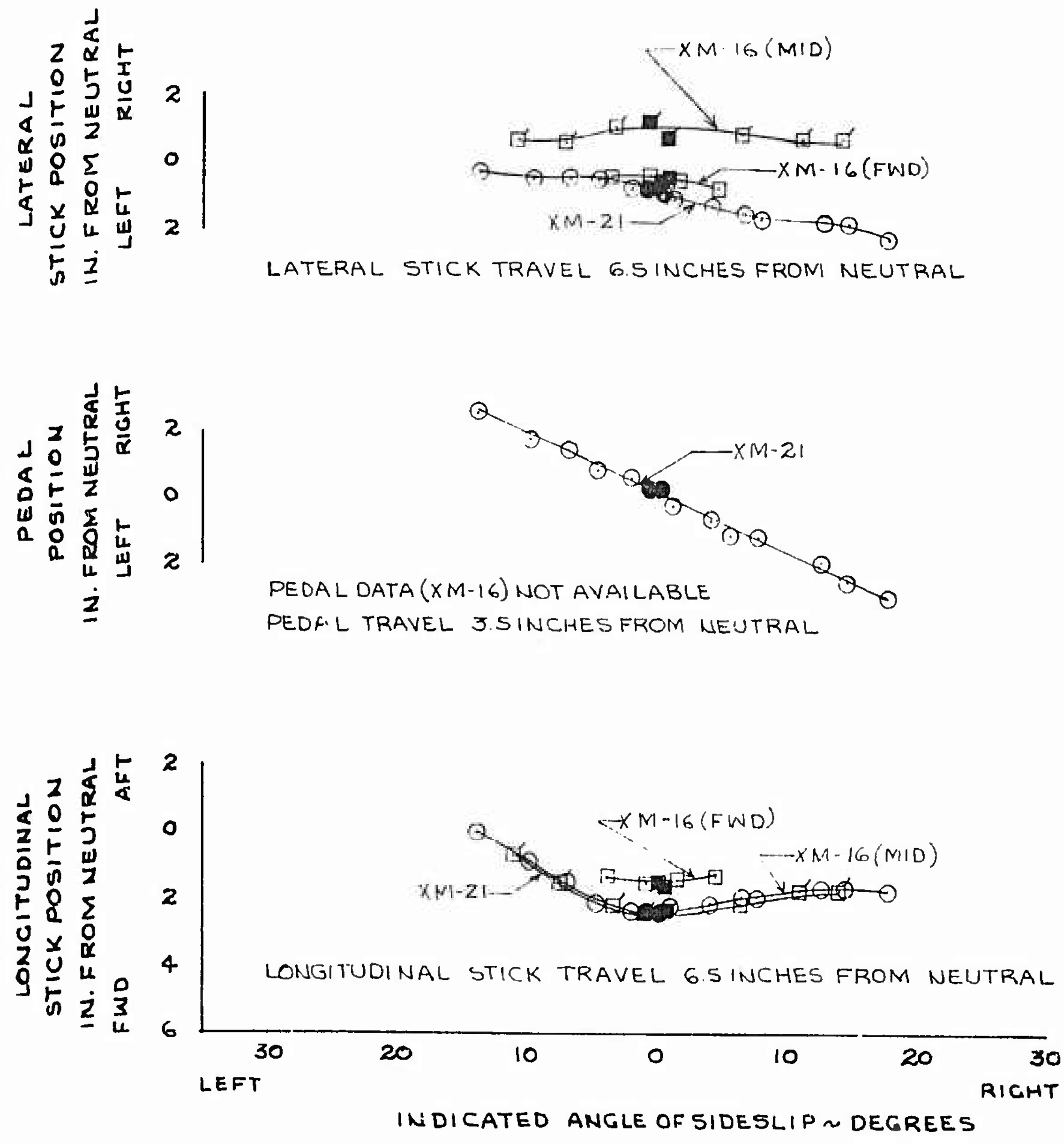


FIGURE NO. 42
STATIC DIRECTIONAL STABILITY
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION
LEVEL FLIGHT

SYM	TRIM CAS	AVG H_D	AVG G.W.	AVG.CG	RPM	ARMAMENT CONFIG.
○	103.0	5000	6920	126.5	322	XM-21 BOTH PODS FULL
□	96.0	5030	7160	125.2	323	XM-16 BOTH PODS FULL
□́	930	5660	7305	130.3	323	XM-16 BOTH PODS FULL

SHADED SYMBOLS DENOTE TRIM CONDITION

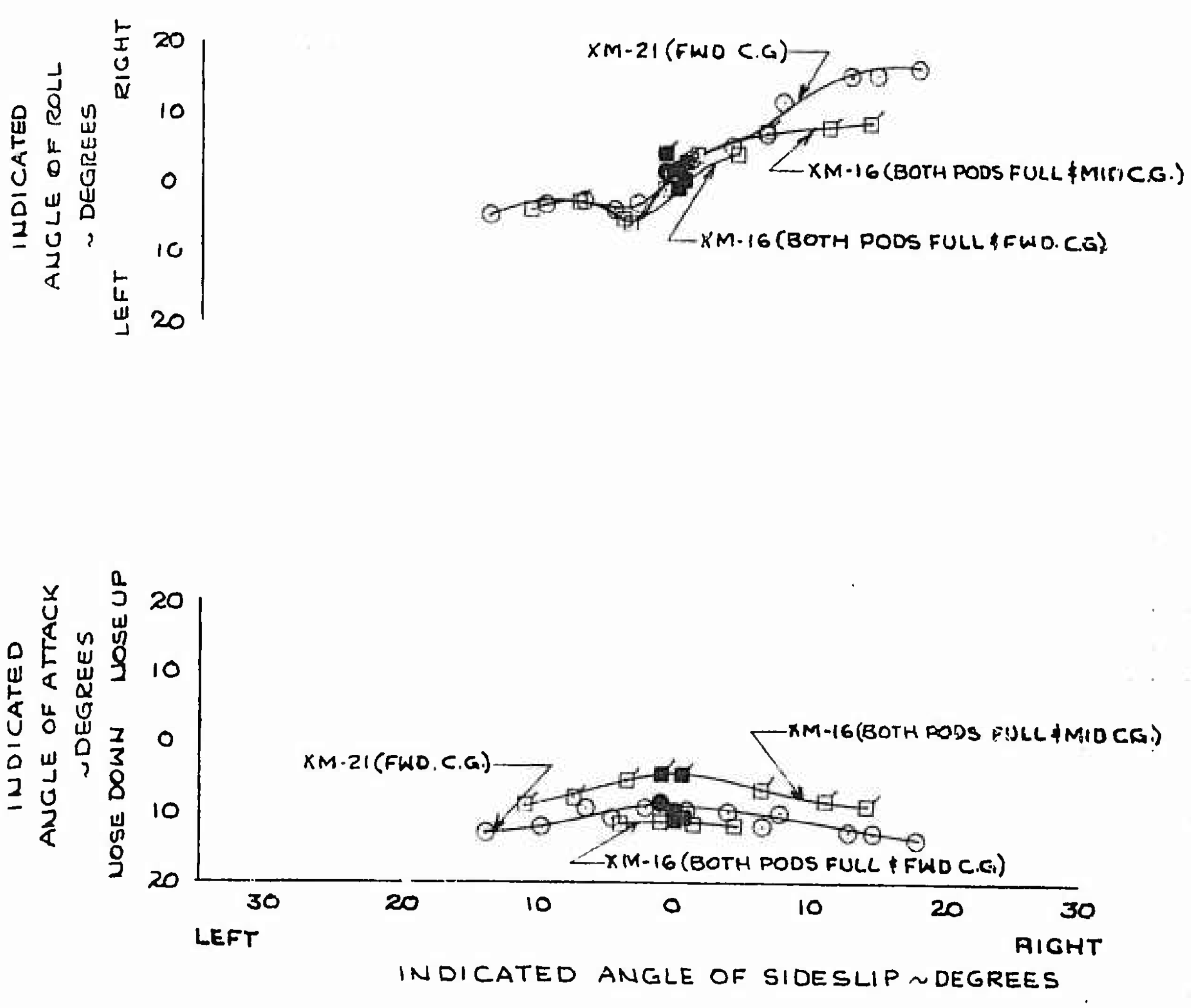


FIGURE NO. 4B

STATIC DIRECTIONAL STABILITY

UH-1B USA S/N 60-3589

ARMAMENT CONFIGURATION

LEVEL FLIGHT

SYM	TRIM CAS	AVG H_D	AVG. G.W.	AVG. CG	RPM	ARMAMENT CONFIG.
○	39.0	4890	7160	127.0	324	XM-21 BOTH PODS FULL
□	48.0	5050	7310	125.5	323	XM-16 BOTH PODS FULL
⊏̸	47.0	5320	7480	130.5	323	XM-16 BOTH PODS FULL

SHADED SYMBOLS DENOTE TRIM CONDITION

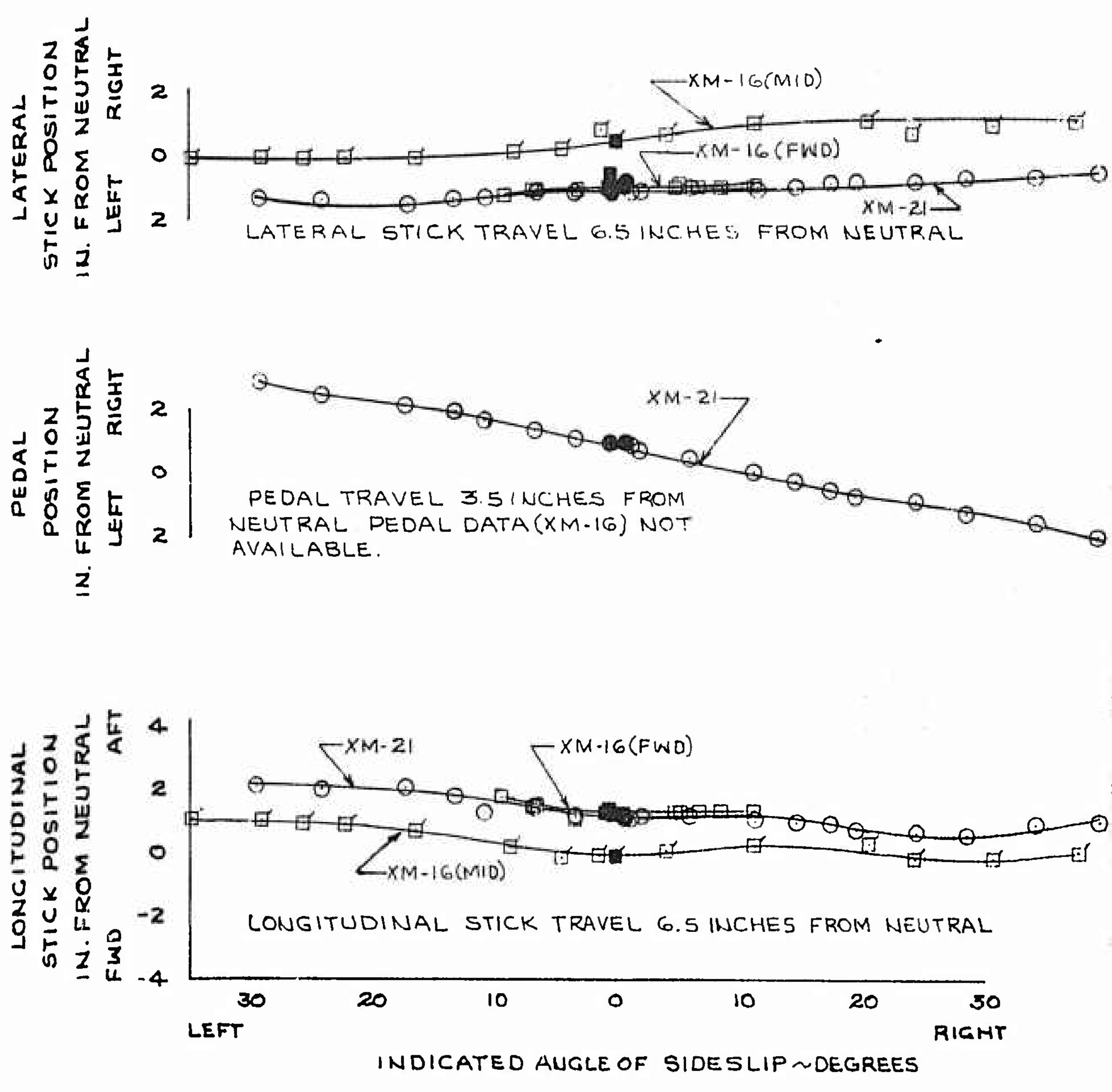


FIGURE NO. 44
STATIC DIRECTIONAL STABILITY
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION
LEVEL FLIGHT

SYM	TRIM CAS	AVG. H_D	AVG. G.W.	AVG. CG	RPM	ARMAMENT	CONFIG.
○	39.0	4890	7160	127.0	324	XM-21	BOTH PODS FULL
□	48.0	5050	7310	125.5	323	XM-16	BOTH PODS FULL
⌑	47.0	5320	7480	130.5	323	XM-16	BOTH PODS FULL

SHADED SYMBOLS DENOTE TRIM CONDITION

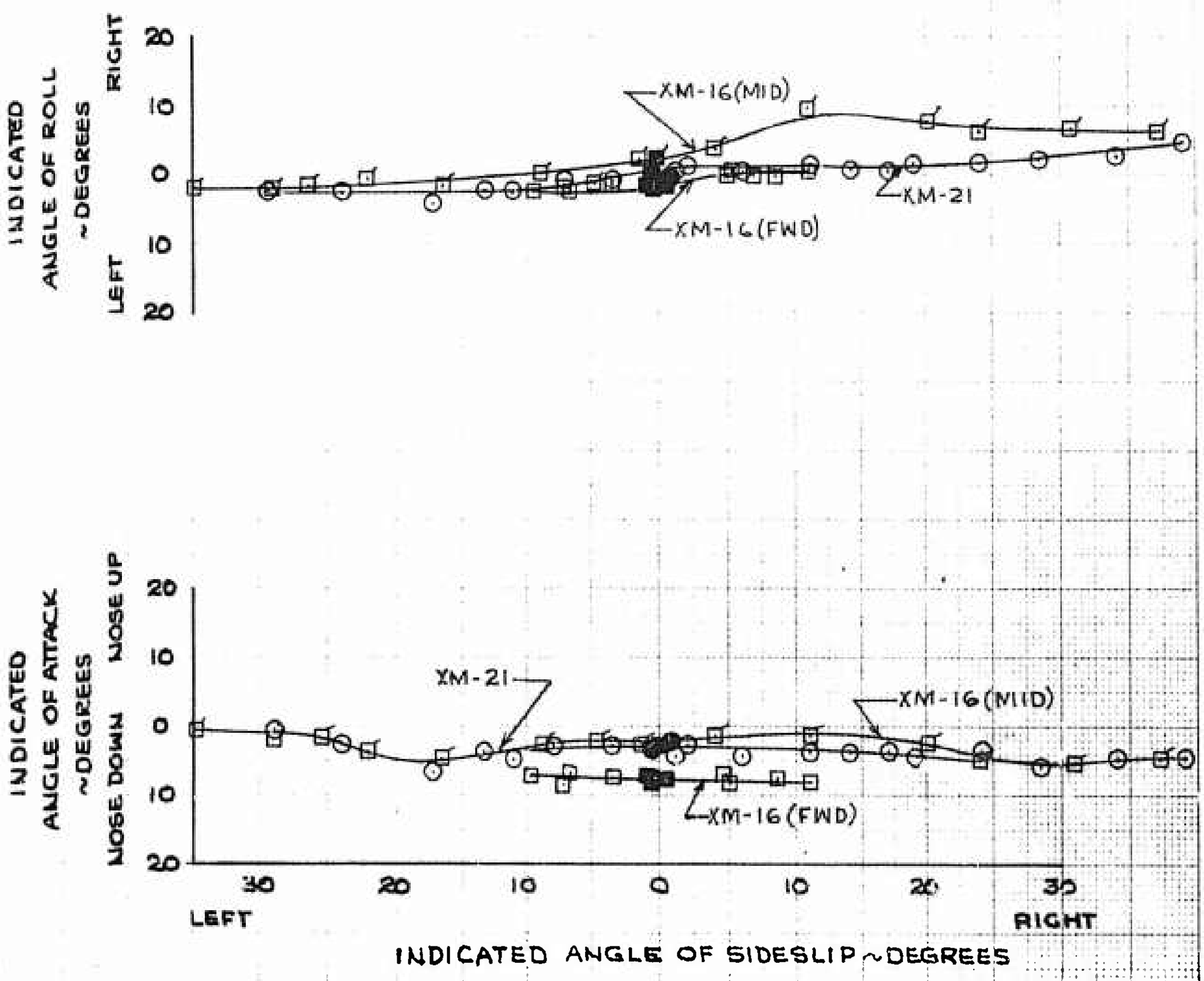


FIGURE NO. 45
STATIC DIRECTIONAL STABILITY
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION
AUTO ROTATION

SYM	TRIM CAS	AVG H_D	AVG G.W.	AVG CG	RPM	ARMAMENT CONFIG
○	55.0	6100	6945	126.7	306	XM-21 BOTH PODS FULL
□	55.0	6190	7265	125.5	324	XM-16 BOTH PODS FULL

SHADED SYMBOLS DENOTE TRIM CONDITION

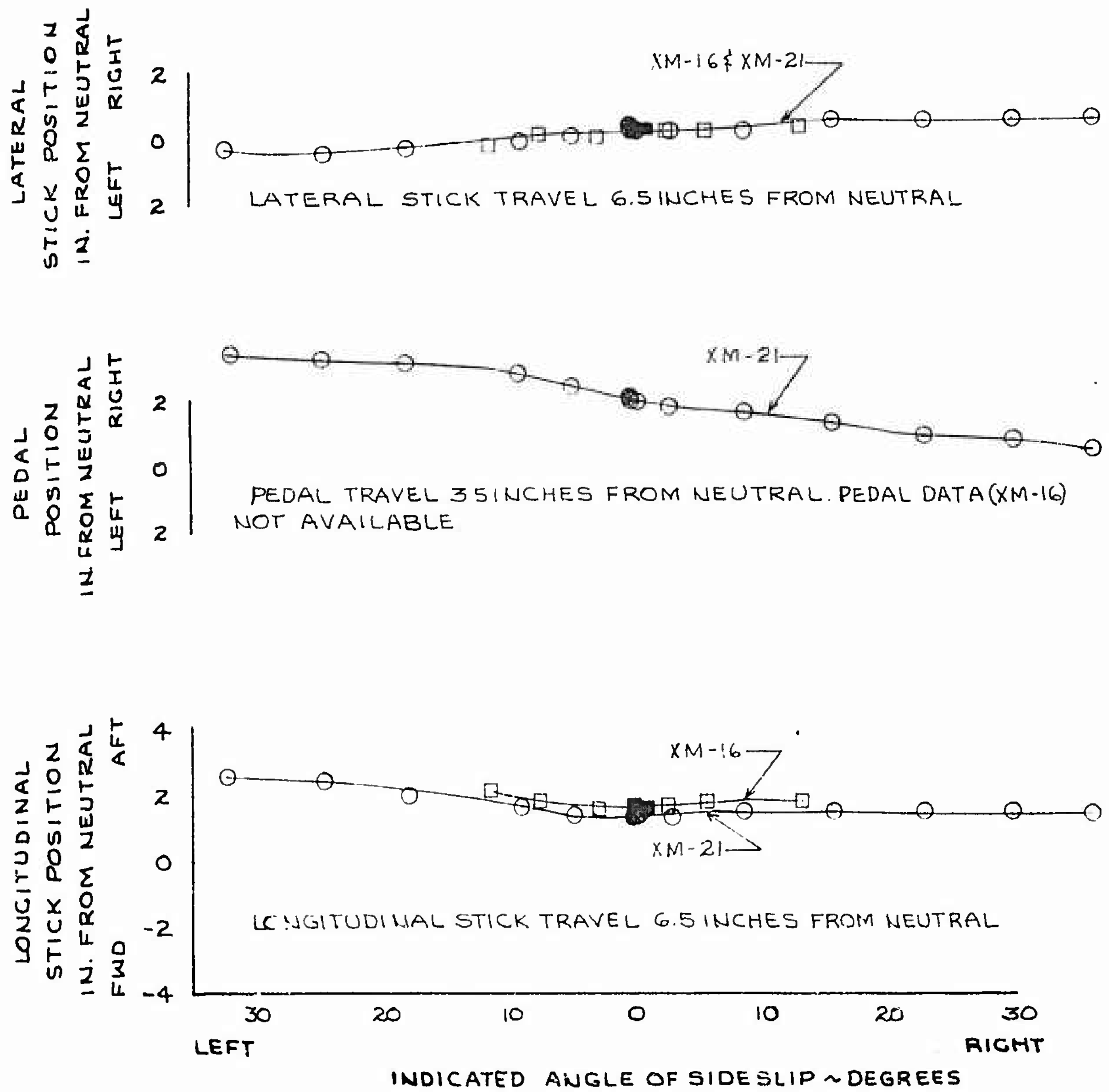


FIGURE NO. 46

STATIC DIRECTIONAL STABILITY

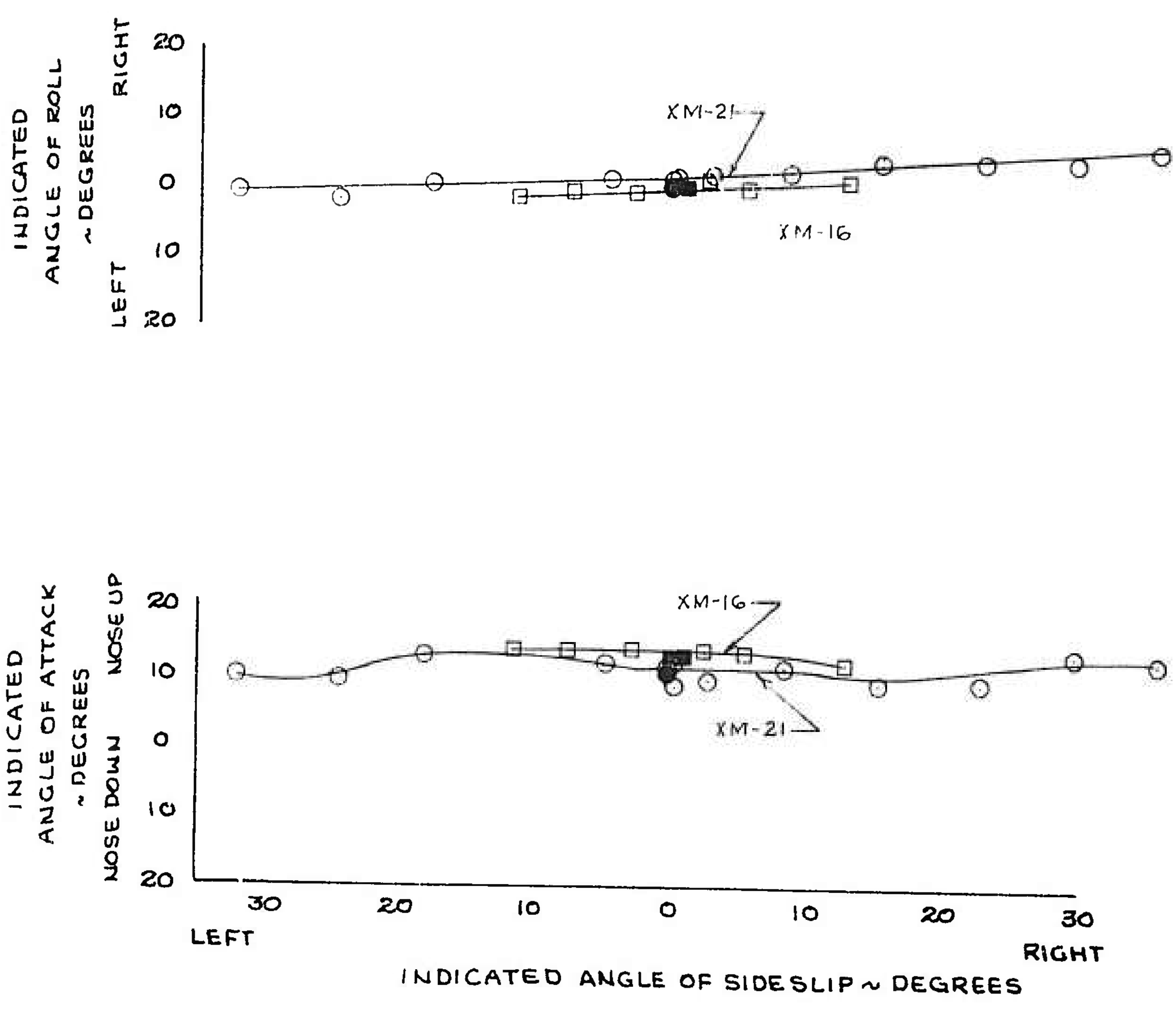
UH-1B USA S/N 60-3589

ARMAMENT CONFIGURATION

AUTOROTATION

SYM	TRIM CAS	AVG. H_D	AVG G.W.	AVG. CG	RPM	ARMAMENT CONFIG
○	55.0	6100	6945	126.7	306	XM-21 BOTH PODS FULL
□	55.0	6190	7265	125.5	324	XM-16 BOTH PODS FULL

SHADED SYMBOLS DENOTE TRIM CONDITION



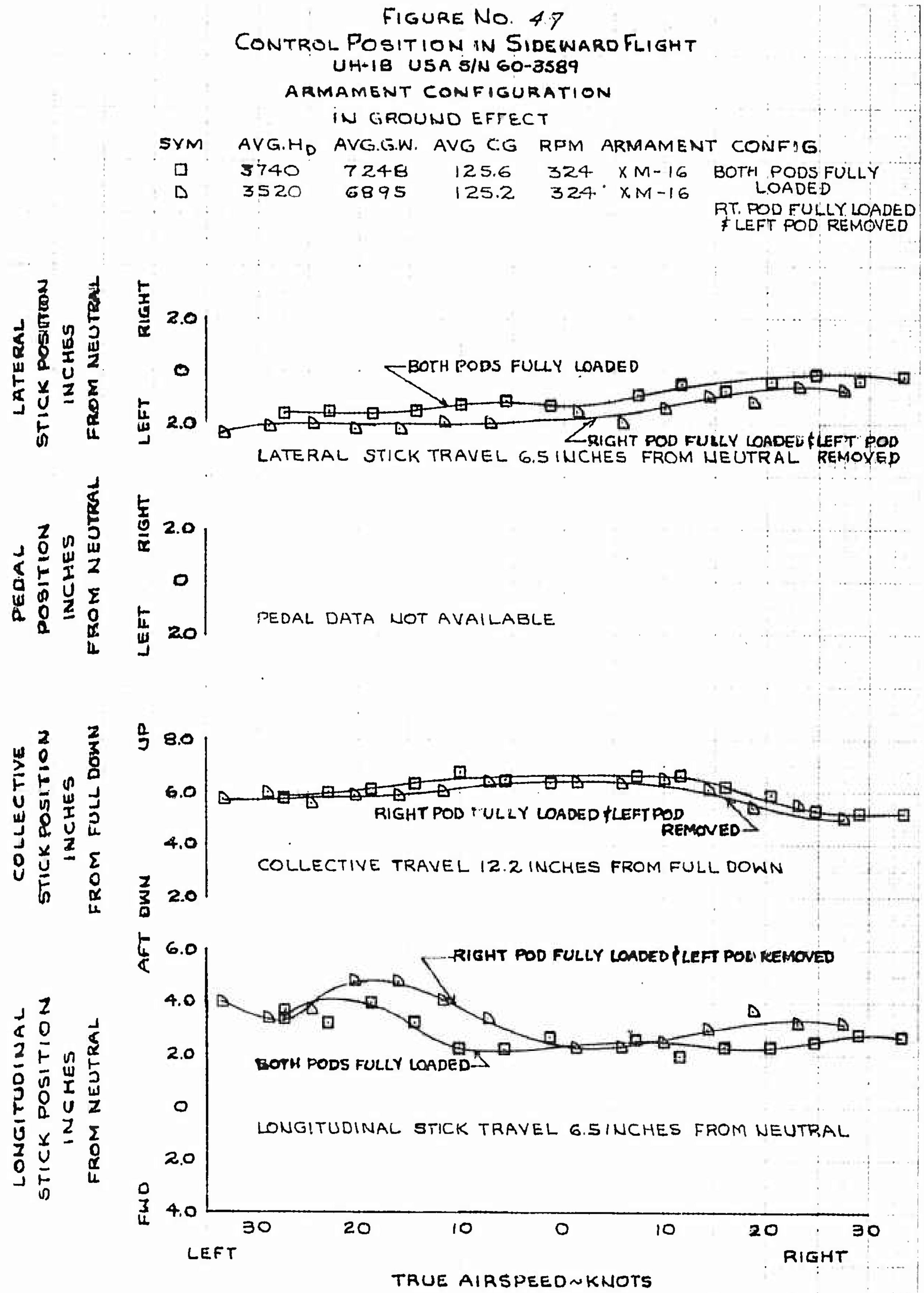


FIGURE NO. 47
CONTROL POSITION IN SIDEWARD FLIGHT
UH-1B USA S/N 60-3589
ARMAMENT CONFIGURATION
IN GROUND EFFECT
SYM AVG.HD AVG.G.W. AVG CG RPM ARMAMENT CONFIG.
□ 3740 7248 125.6 324 XM-16 BOTH PODS FULLY LOADED
△ 3520 6895 125.2 324 XM-16 RT. POD FULLY LOADED & LEFT POD REMOVED
LATERAL STICK POSITION INCHES FROM NEUTRAL
LEFT RIGHT
BOTH PODS FULLY LOADED
RIGHT POD FULLY LOADED & LEFT POD REMOVED
LATERAL STICK TRAVEL 6.5 INCHES FROM NEUTRAL
PEDAL POSITION INCHES FROM NEUTRAL
PEDAL DATA NOT AVAILABLE
COLLECTIVE STICK POSITION INCHES FROM FULL DOWN
UP DWN
RIGHT POD FULLY LOADED & LEFT POD REMOVED
COLLECTIVE TRAVEL 12.2 INCHES FROM FULL DOWN
LONGITUDINAL STICK POSITION INCHES FROM NEUTRAL
AFT FWD
RIGHT POD FULLY LOADED & LEFT POD REMOVED
BOTH PODS FULLY LOADED
LONGITUDINAL STICK TRAVEL 6.5 INCHES FROM NEUTRAL
LEFT RIGHT
TRUE AIRSPEED~KNOTS

FIGURE NO 48

CONTROL POSITION IN REARWARD FLIGHT

UH-1B USA S/N 60-3589

ARMAMENT CONFIGURATION

IN GROUND EFFECT

SYM	AVG. H_D	AVG G.W	AVG CG	RPM	ARMAMENT	CONFIG.
□	3740	7248	125.6	324	XM-16	BOTH PODS FULLY LOADED
◺	3520	6895	125.2	324	XM-16	RT. POD FULLY LOADED & LEFT POD REMOVED

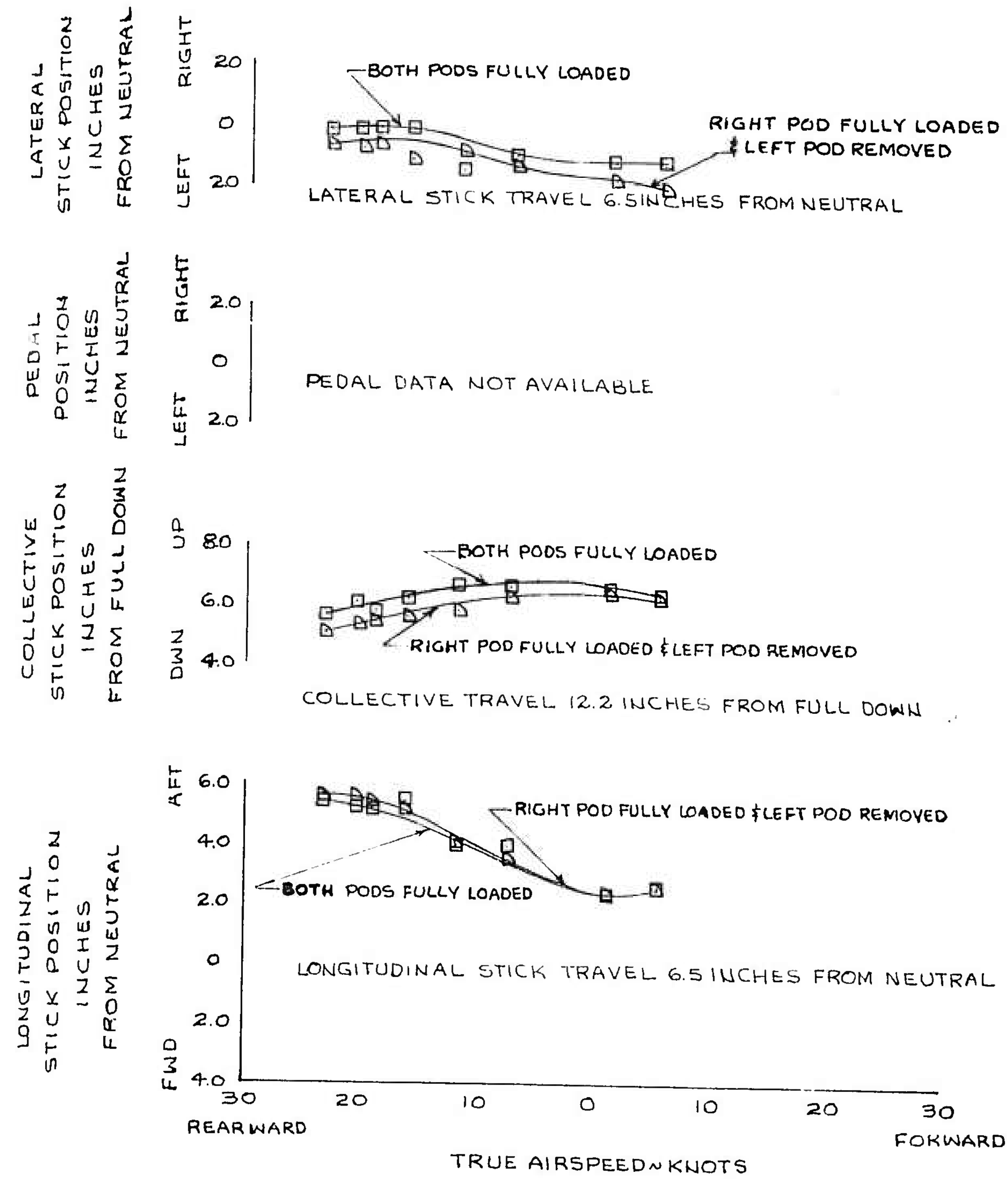


FIGURE NO. 49

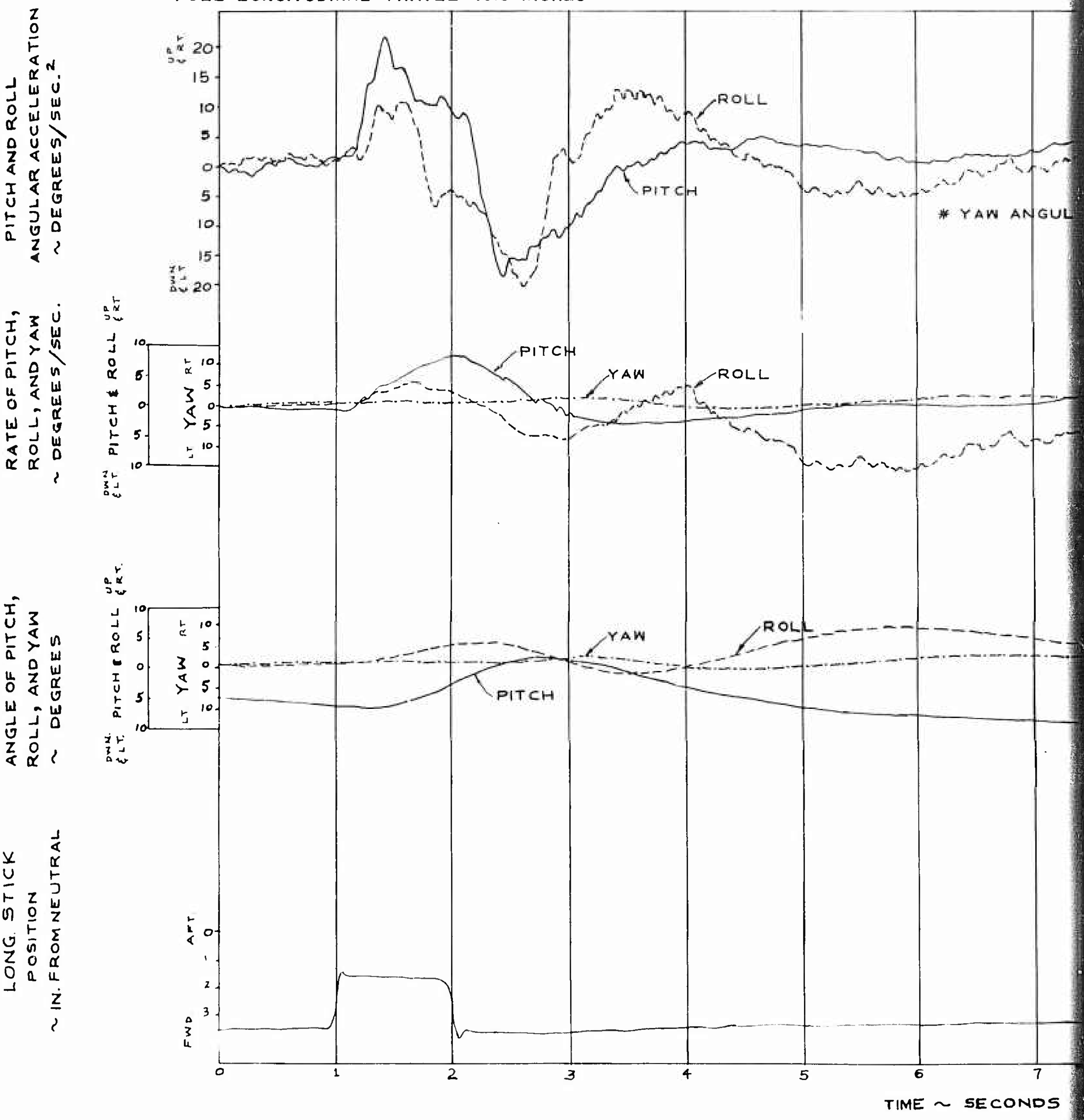
AFT LONGITUDINAL PULSE

UH-1B, U.S.A., S/N 60-3589

ARMAMENT: XM-16 PODS FULLY LOADED

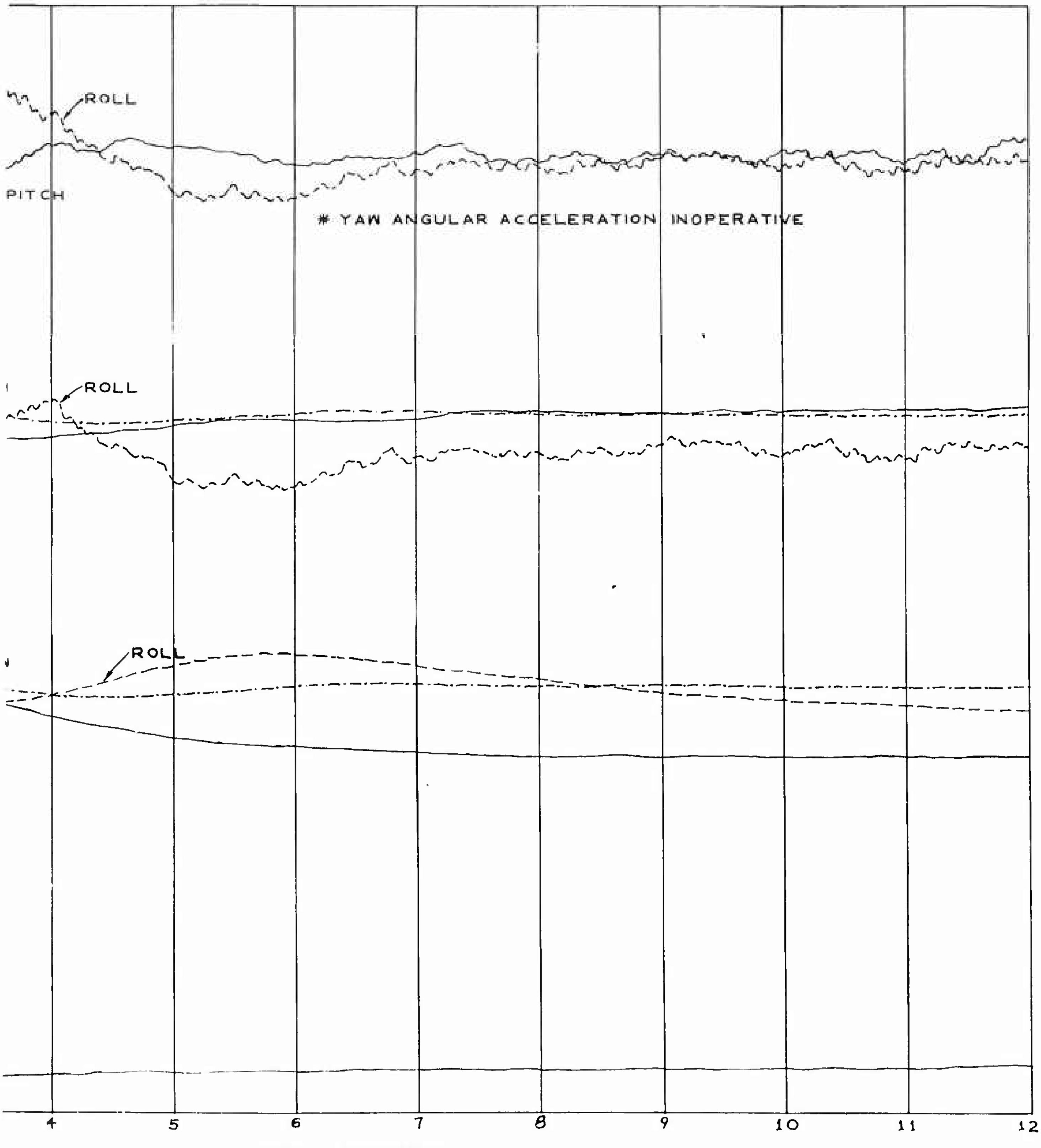
FULL LONGITUDINAL TRAVEL: 13.0 INCHES

AVERAGE GROSS WE
LONGITUDINAL C.G. L
FLIGHT CONDITIOINS:
TRIM C.A.S.: 95.5 KTS.
DENSITY ALTITUDE: 5
ROTOR SPEED: 324 R



A

AVERAGE GROSS WEIGHT: 7180 LBS.
LONGITUDINAL C.G. LOCATION: 131.2 IN.
FLIGHT CONDITIOINS: LEVEL FLIGHT
TRIM C.A.S.: 95.5 KTS.
DENSITY ALTITUDE: 5120 FEET
ROTOR SPEED: 324 RPM



B

FIGURE NO. 50

AFT LONGITUDINAL PULSE

UH-1B, U.S.A., S/N60-3589

ARMAMENT: XM-21 PODS FULLY LOADED

FULL LONGITUDINAL TRAVEL: 13.0 INCHES

AVERAGE GROSS

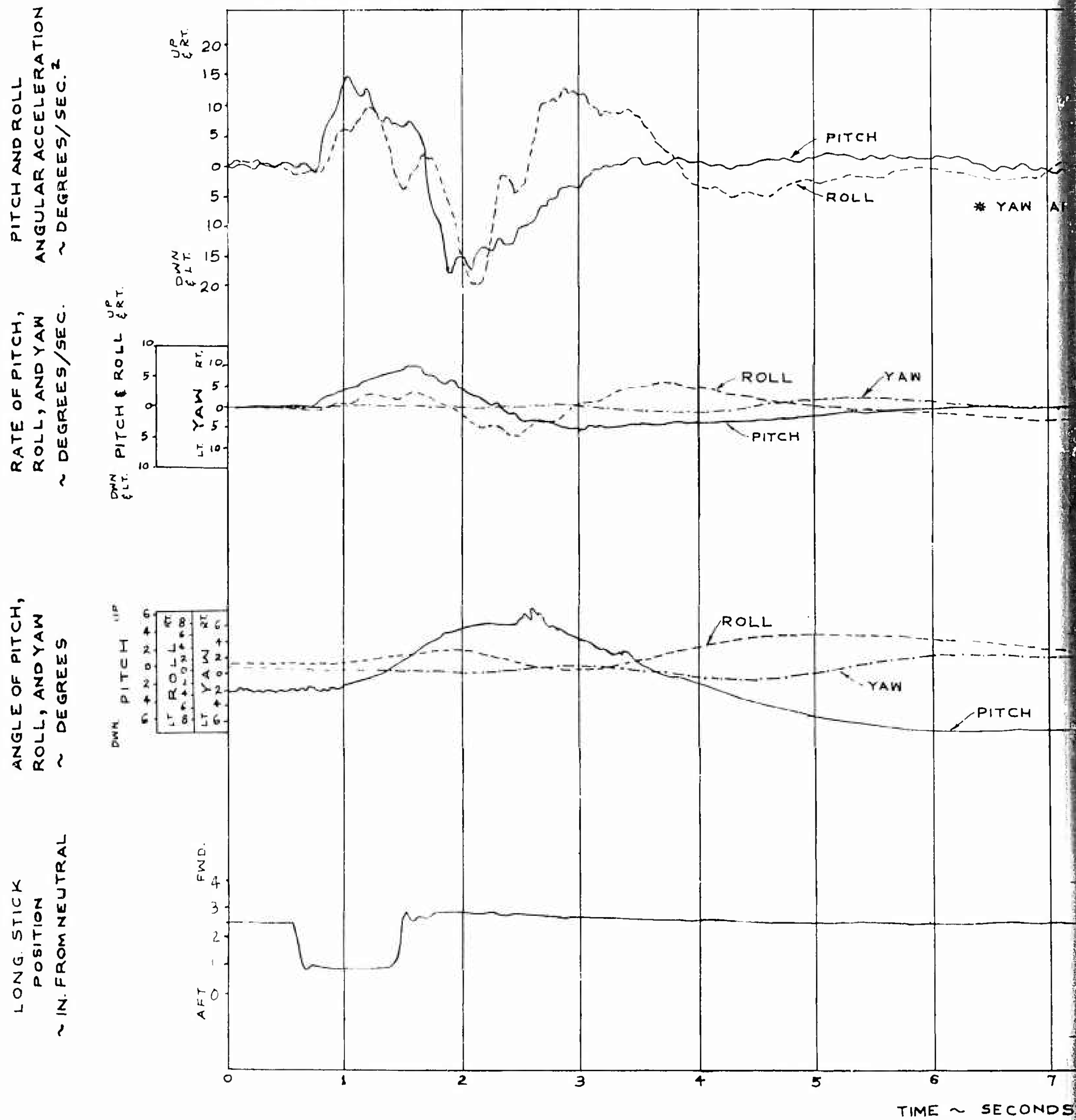
LONGITUDINAL C.G

FLIGHT CONDITION

TRIM C.A.S.: 84.3 K

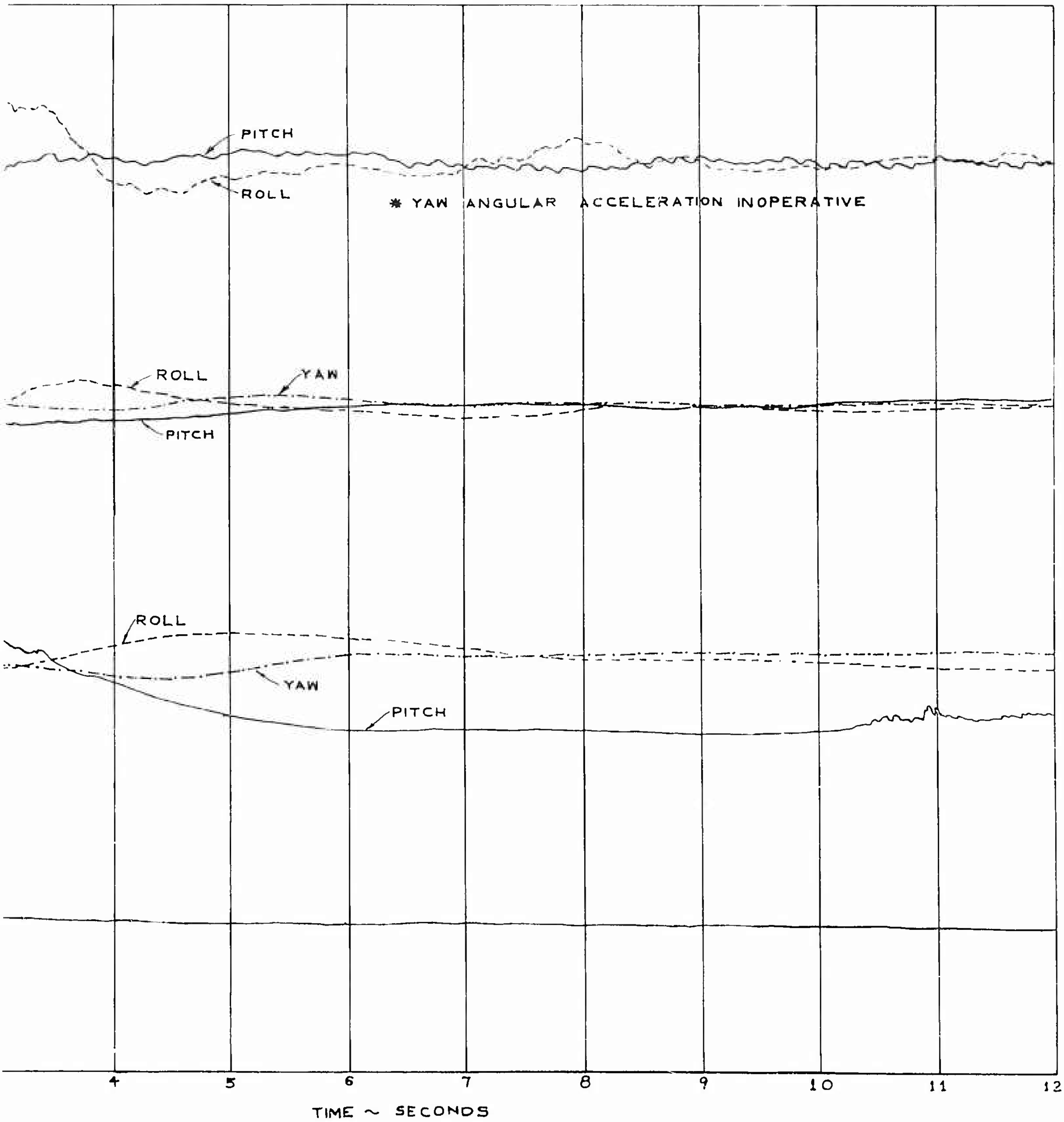
DENSITY ALTITUD

ROTOR SPEED: 32



4

AVERAGE GROSS WEIGHT: 6680 LBS
LONGITUDINAL C.G. LOCATION: 130.6 IN.
FLIGHT CONDITIONS: LEVEL FLIGHT
TRIM C.A.S.: 84.3 KTS.
DENSITY ALTITUDE: 4850 FEET
ROTOR SPEED: 324 RPM



B

FIGURE NO. 51

LEFT LATERAL PULSE

UH-1B, U.S.A., S/N 60-3589

ARMAMENT: XM-16 PODS FULLY LOADED

FULL LATERAL TRAVEL: 13.0 INCHES

AVERAGE GROSS

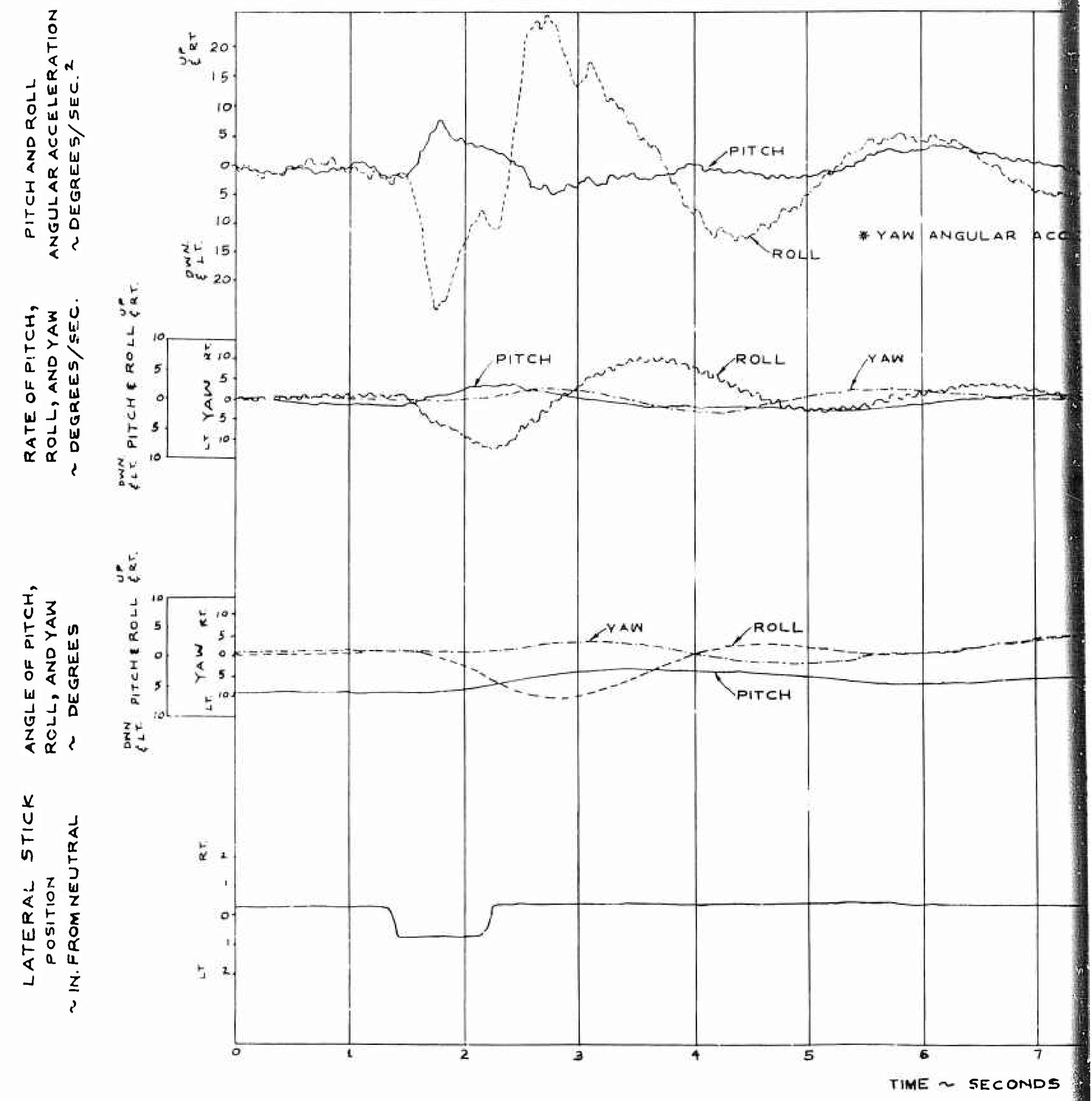
LONGITUDINAL C.G

FLIGHT CONDITION

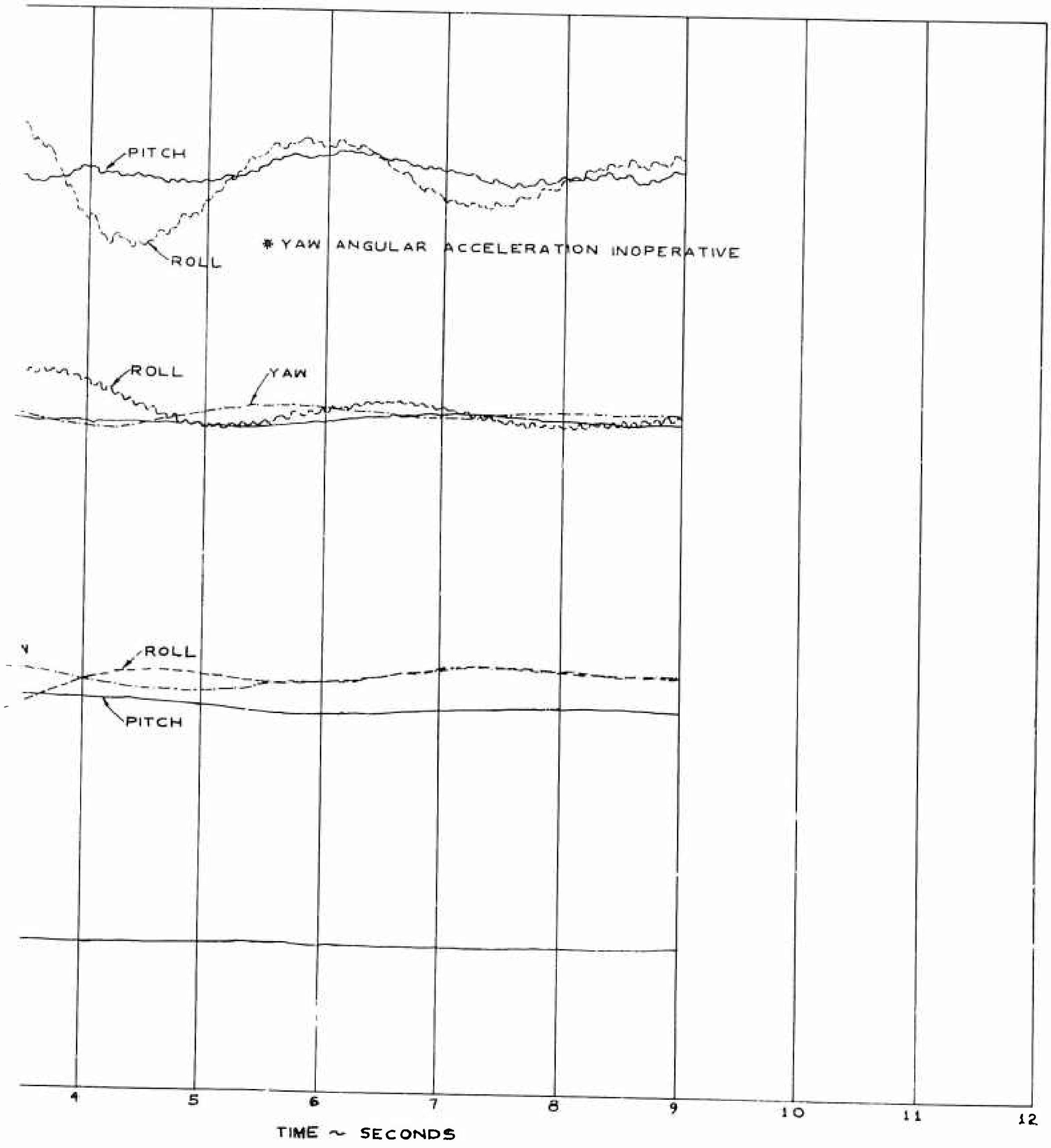
TRIM C.A.S.: 95.5 K

DENSITY ALTITUDE

ROTOR SPEED: 32



AVERAGE GROSS WEIGHT: 7180 LBS.
LONGITUDINAL C.G. LOCATION: 131.2 IN.
FLIGHT CONDITIONS: LEVEL FLIGHT
TRIM C.A.S.: 95.5 KTS.
DENSITY ALTITUDE: 5120 FEET
ROTOR SPEED: 324 RPM



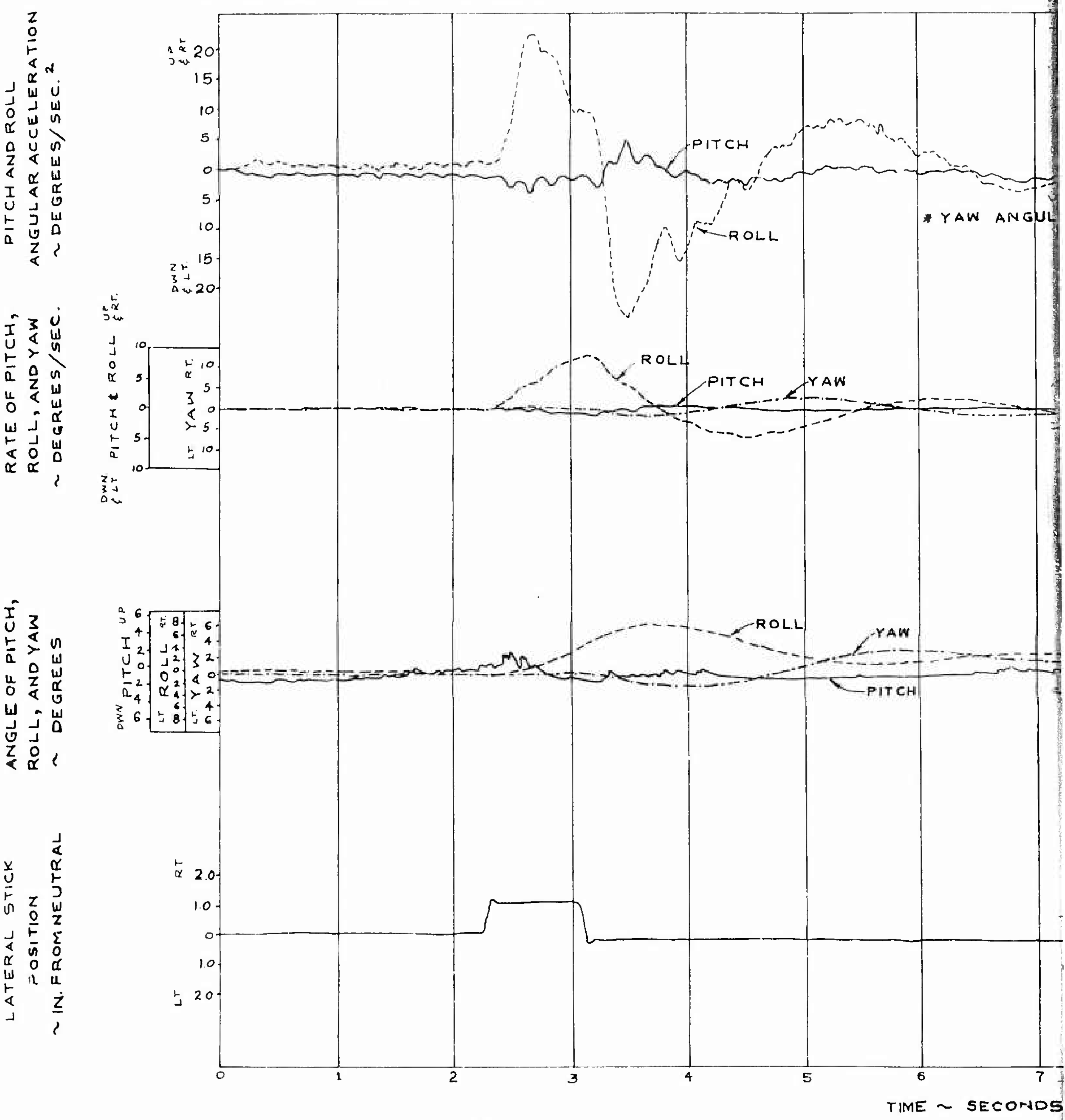
13

FIGURE NO. 52

RIGHT LATERAL PULSE

UH-1B, U.S.A., S/N 60-3589
ARMAMENT: XM-21 PODS FULLY LOADED
FULL LATERAL TRAVEL: 13.0 INCHES

AVERAGE GROSS
LONGITUDINAL C.G.
FLIGHT CONDITION
TRIM C.A.S.: 85.4 K
DENSITY ALTITUDE
ROTOR SPEED: 324



AVERAGE GROSS WEIGHT: 6680 LBS.
LONGITUDINAL C.G. LOCATION: 130.6 IN.
FLIGHT CONDITIONS: LEVEL FLIGHT
TRIM C.A.S.: 85.4 KTS.
DENSITY ALTITUDE: 4920 FEET
ROTOR SPEED: 324 RPM

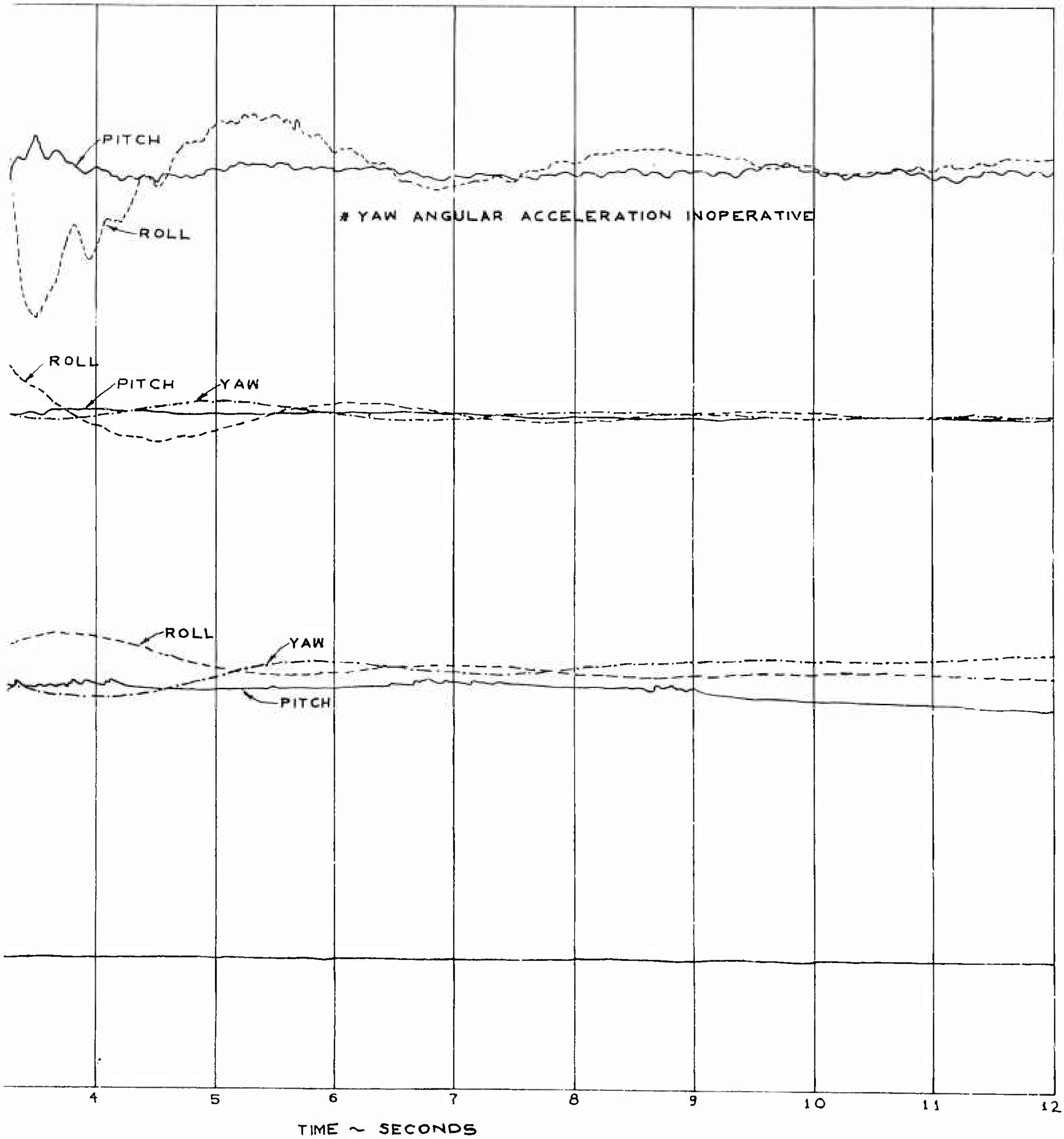


FIGURE NO.53

RIGHT PEDAL PULSE

UH-IB, U.S.A., S/N 60-3589

ARMAMENT: XM-16 PODS FULLY LOADED

FULL PEDAL TRAVEL: 70 INCHES

AVERAGE GROSS

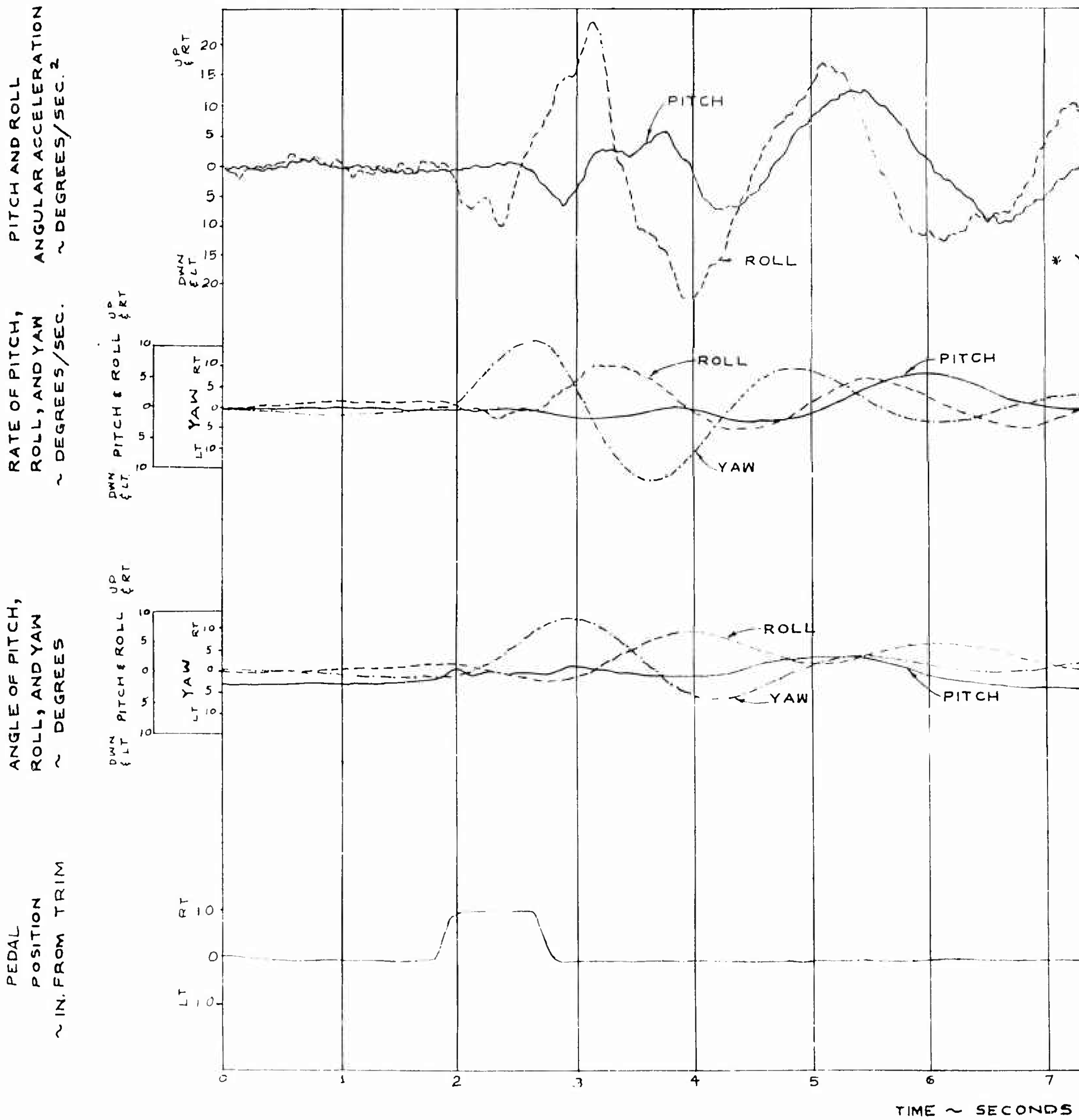
LONGITUDINAL

FLIGHT CONDIT

TRIM CAS 9

DENSITY ALTIT

ROTOR SPEED



AVERAGE GROSS WEIGHT: 7180 LBS
LONGITUDINAL C.G. LOCATION: 131.2 IN.
FLIGHT CONDITIONS: LEVEL FLIGHT
TRIM CAS 95.5 KTS
DENSITY ALTITUDE 5120 FEET
ROTOR SPEED 324 RPM

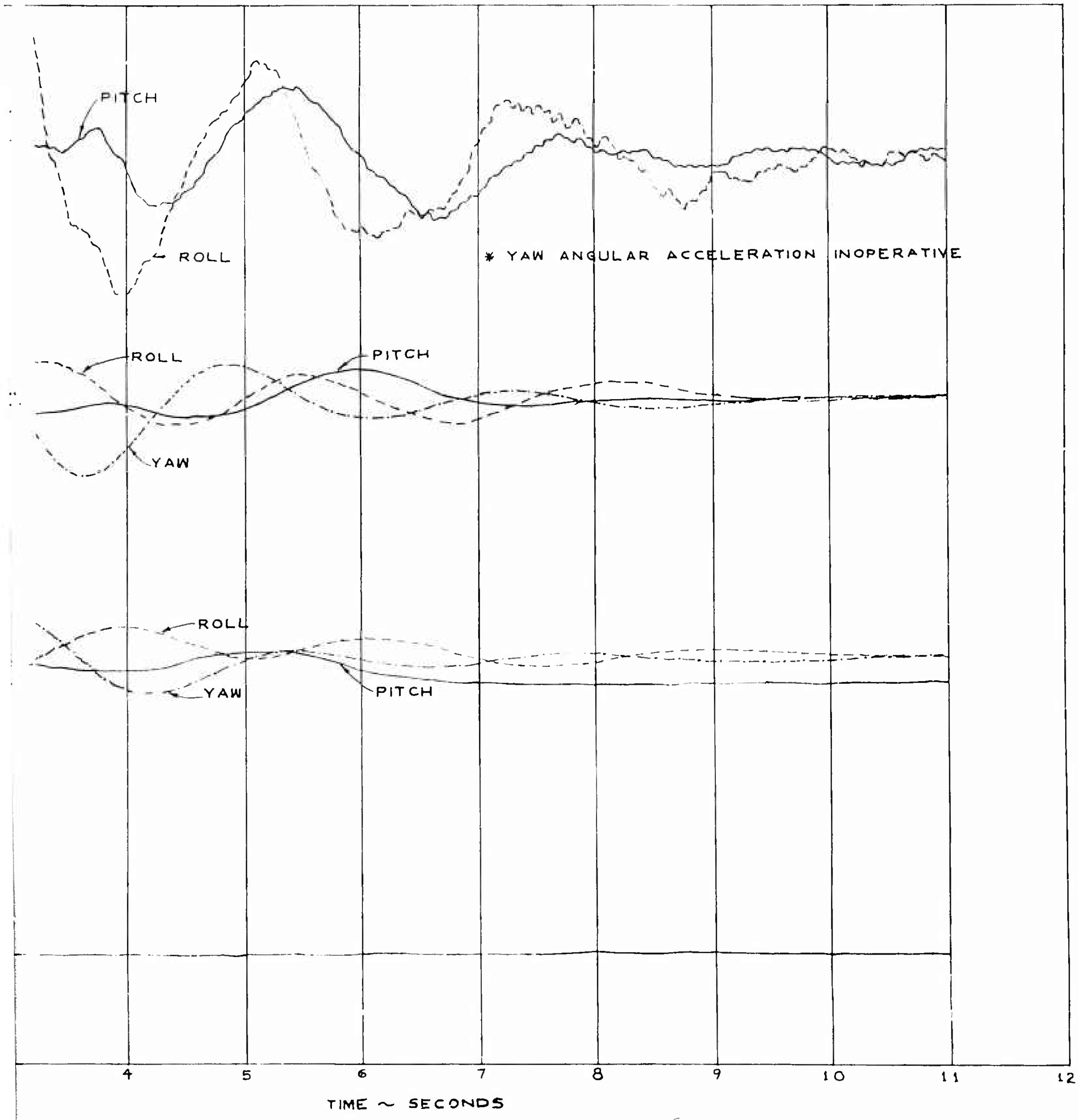


FIGURE NO. 54

RIGHT PEDAL PULSE

UH-1B, U.S.A., S/N 60-3589

ARMAMENT: XM-21 PODS FULLY LOADED

FULL PEDAL TRAVEL: 7.0 INCHES

ROTOR SPEED: 32

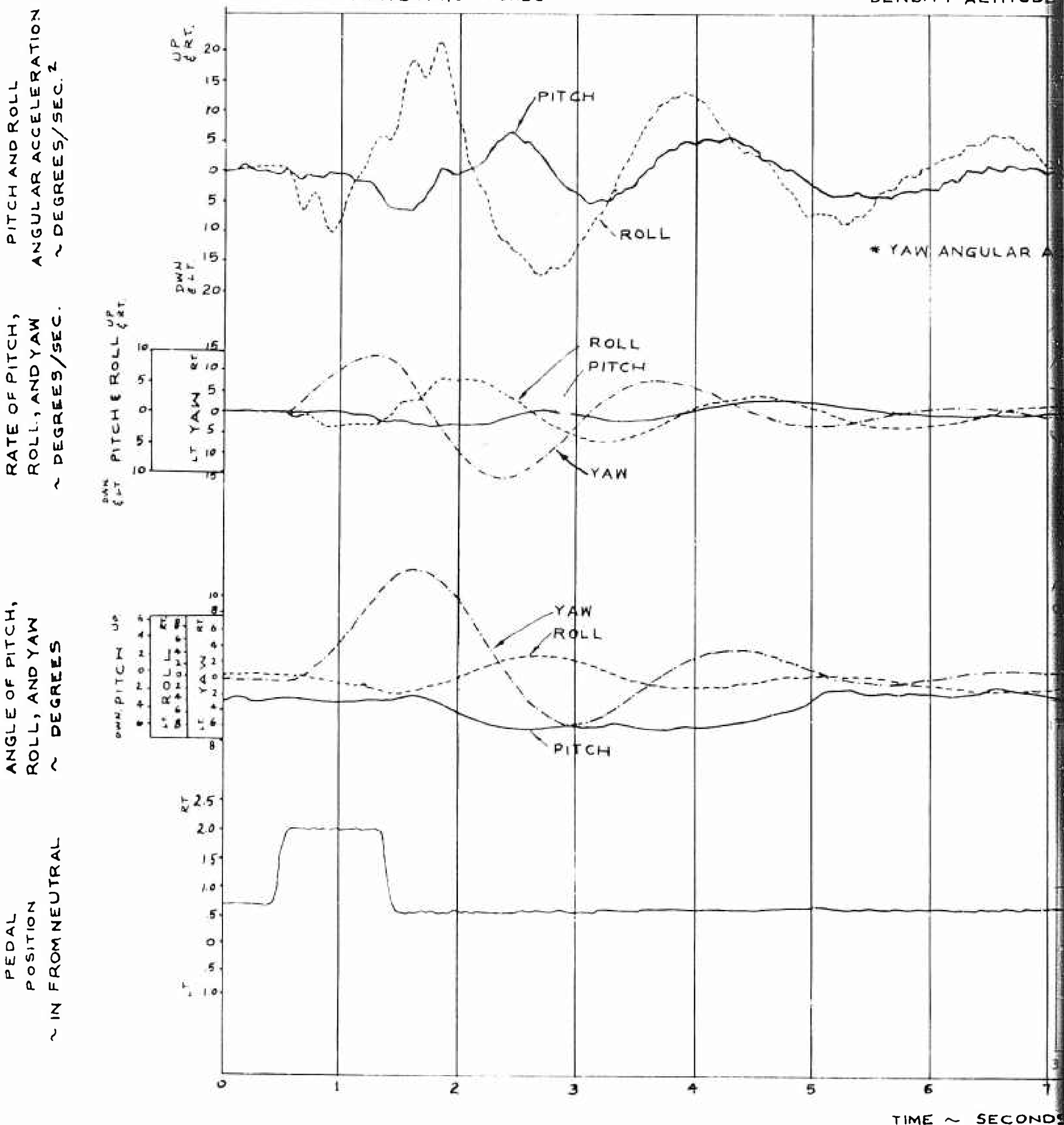
AVERAGE GROSS

LONGITUDINAL C.G.

FLIGHT CONDITION

TRIM C.A.S.: 85.3 K

DENSITY ALTITUDE



ROTOR SPEED: 323.7 R.P.M.
AVERAGE GROSS WEIGHT: 7080 LBS.
LONGITUDINAL C.G. LOCATION: 130.9 IN.
FLIGHT CONDITIONS: LEVEL FLIGHT
TRIM C.A.S.: 85.3 KTS.
DENSITY ALTITUDE: 4930 FEET

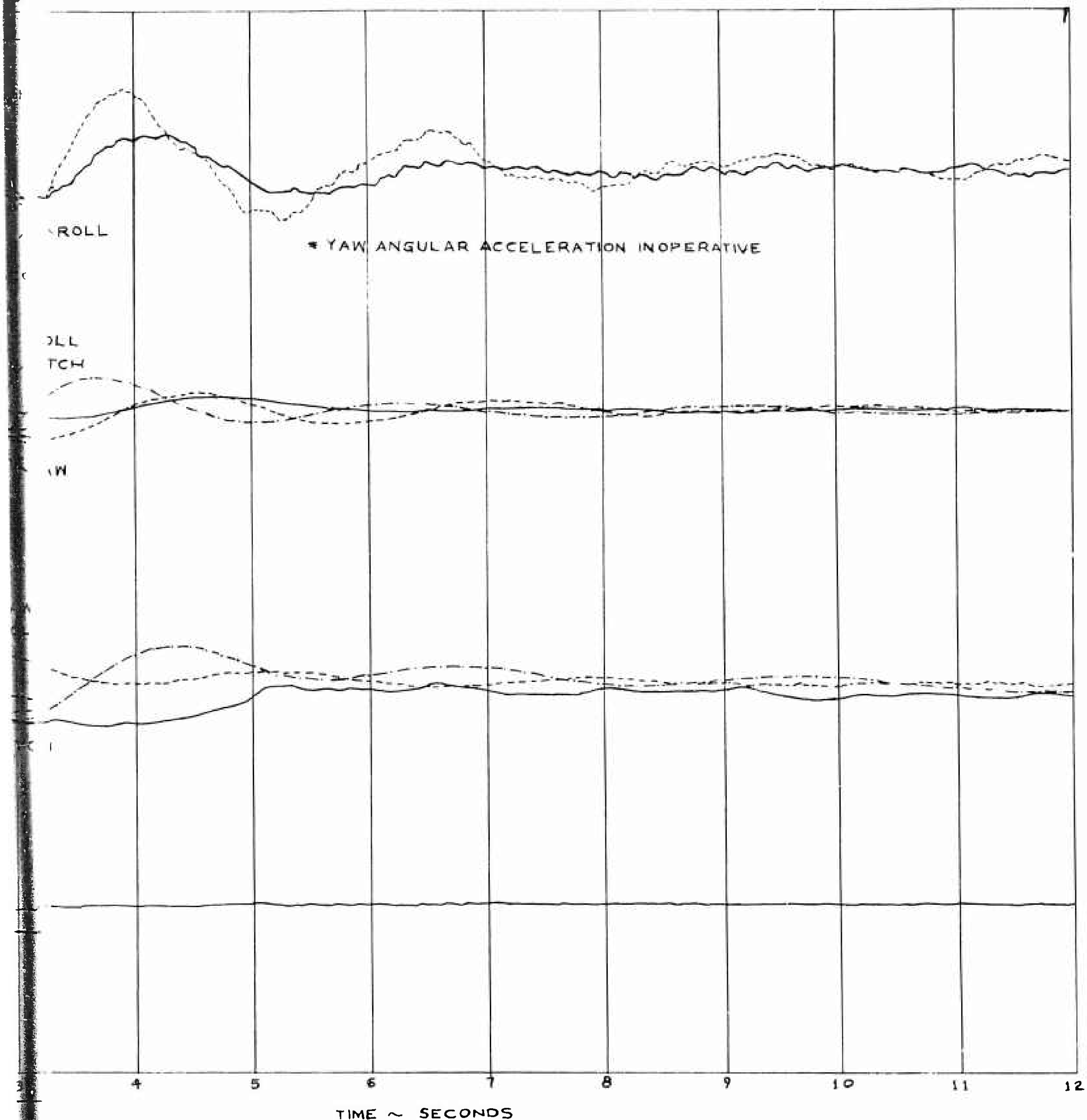


FIGURE NO. 55

SUMMARY OF CONTROL SENSITIVITY

UH-1B USA S/N 60-3589

ARMAMENT CONFIGURATION

SYM	CAS	AVG.G.W.	AVG.CG	AVG H_D	RPM	ARMAMENT CONFIGURATION	
○	48	7080	131.2	5140	325	XM-16	BOTH PODS FULL
□	68	6915	130.9	5490	325	XM-16	BOTH PODS FULL
△	95	6745	130.5	5590	325	XM-16	BOTH PODS FULL

LEVEL FLIGHT

NOTE: PLAIN SYMBOLS DENOTE RIGHT OR AFT
SHADED SYMBOLS DENOTE LEFT OR FORWARD

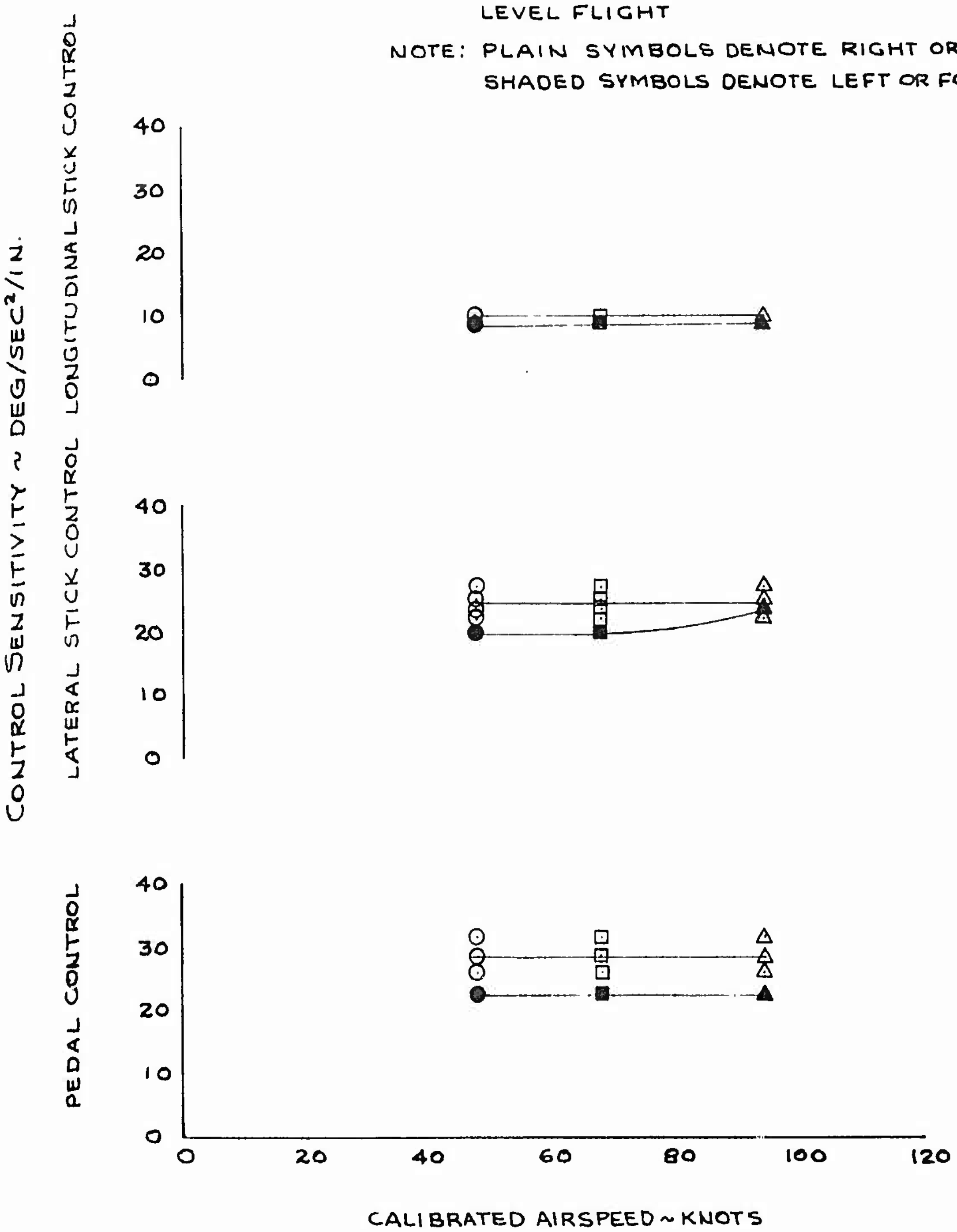


FIGURE NO. 56

SUMMARY OF CONTROL RESPONSE

UH1B USA S/N 60-3589

ARMAMENT CONFIGURATION

SYM	CAS	AVG. G.W.	AVG CG	AVG H_D	RPM	ARMAMENT	CONFIGURATION
○	48	7080	131.2	5140	325	XM-16	BOTH PODS FULL
□	68	6915	130.9	5490	325	XM-16	BOTH PODS FULL
△	95	6745	130.5	5590	325	XM-16	BOTH PODS FULL

LEVEL FLIGHT

NOTE: PLAIN SYMBOLS DENOTE RIGHT OR AFT
SHADED SYMBOLS DENOTE LEFT OR FORWARD

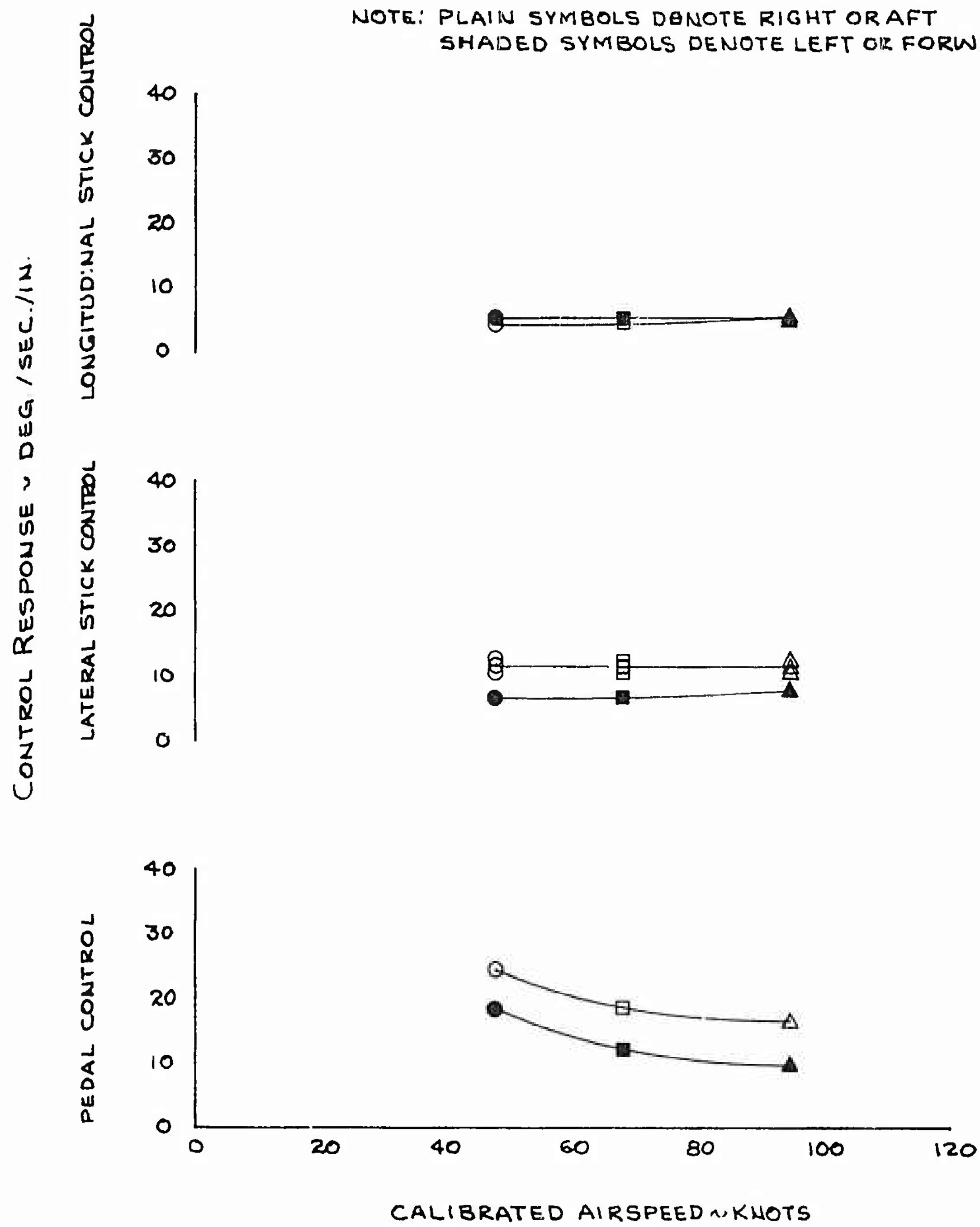


FIGURE No 57

LONGITUDINAL CONTROLLABILITY

UH-1B USA S/N 60-3589

ARMAMENT CONFIGURATION

SYM	CAS	AVG G.W.	AVG.CG	AVG. H_D	RPM	ARMAMENT	CONFIGURATION
○	48	7080	131.2	5140	325	XM-16	BOTH PODS FULL
□	68	6915	130.9	5490	325	XM-16	BOTH PODS FULL
△	95	6745	130.5	5590	325	XM-16	BOTH PODS FULL

NOTE:

MAXIMUM ANGULAR ACCELERATION REACHED IN 0.5 SECONDS

MAXIMUM ANGULAR VELOCITY REACHED IN 1.5 SECONDS

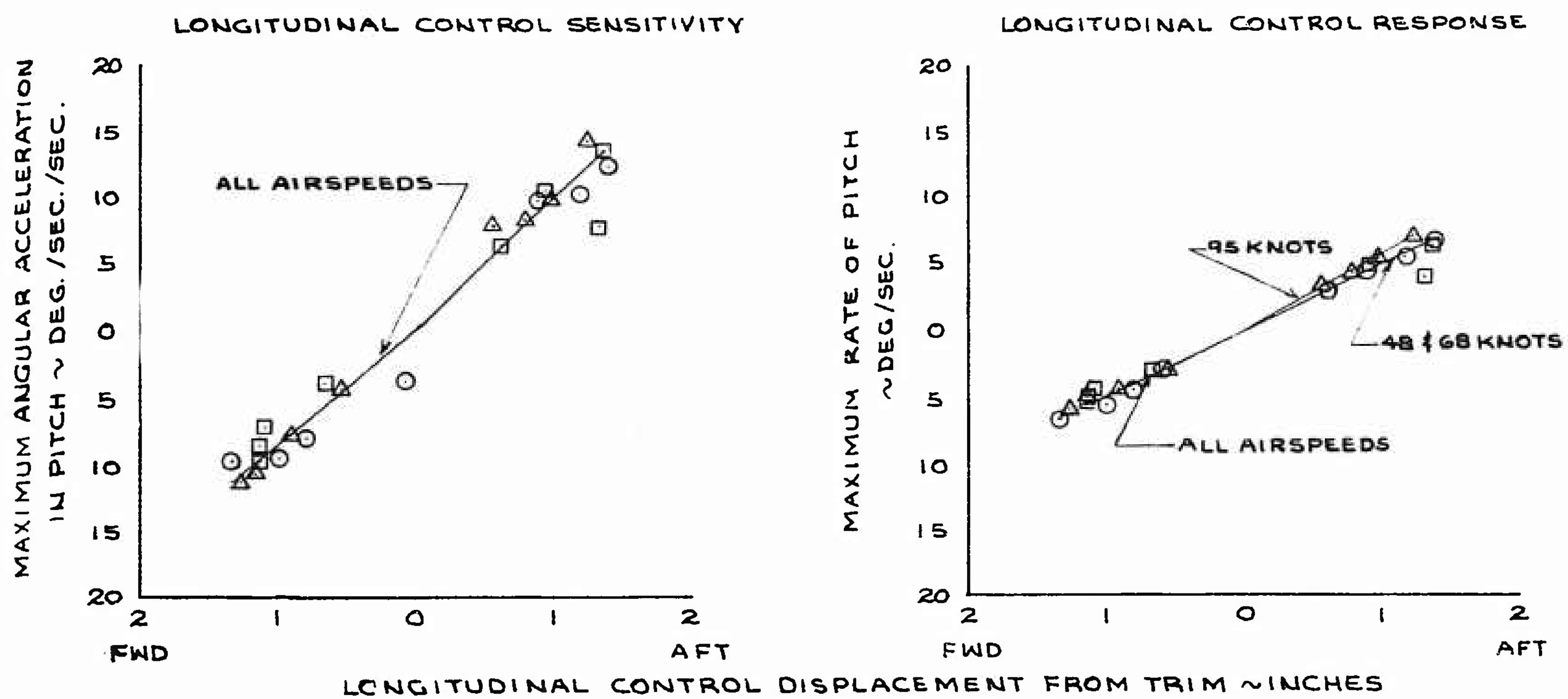


Figure No. 58

Lateral Controllability

UH-1B USA S/N 60-3589

Armament Configuration

SYM	CAS	AVG G.W.	AVG CG	AVG H_D	RPM	ARMAMENT	CONFIGURATION
○	48	7080	131.2	5140	325	XM-16	BOTH PODS FULL
□	68	6915	130.9	5490	325	XM-16	BOTH PODS FULL
△	95	6745	130.5	5590	325	XM-16	BOTH PODS FULL

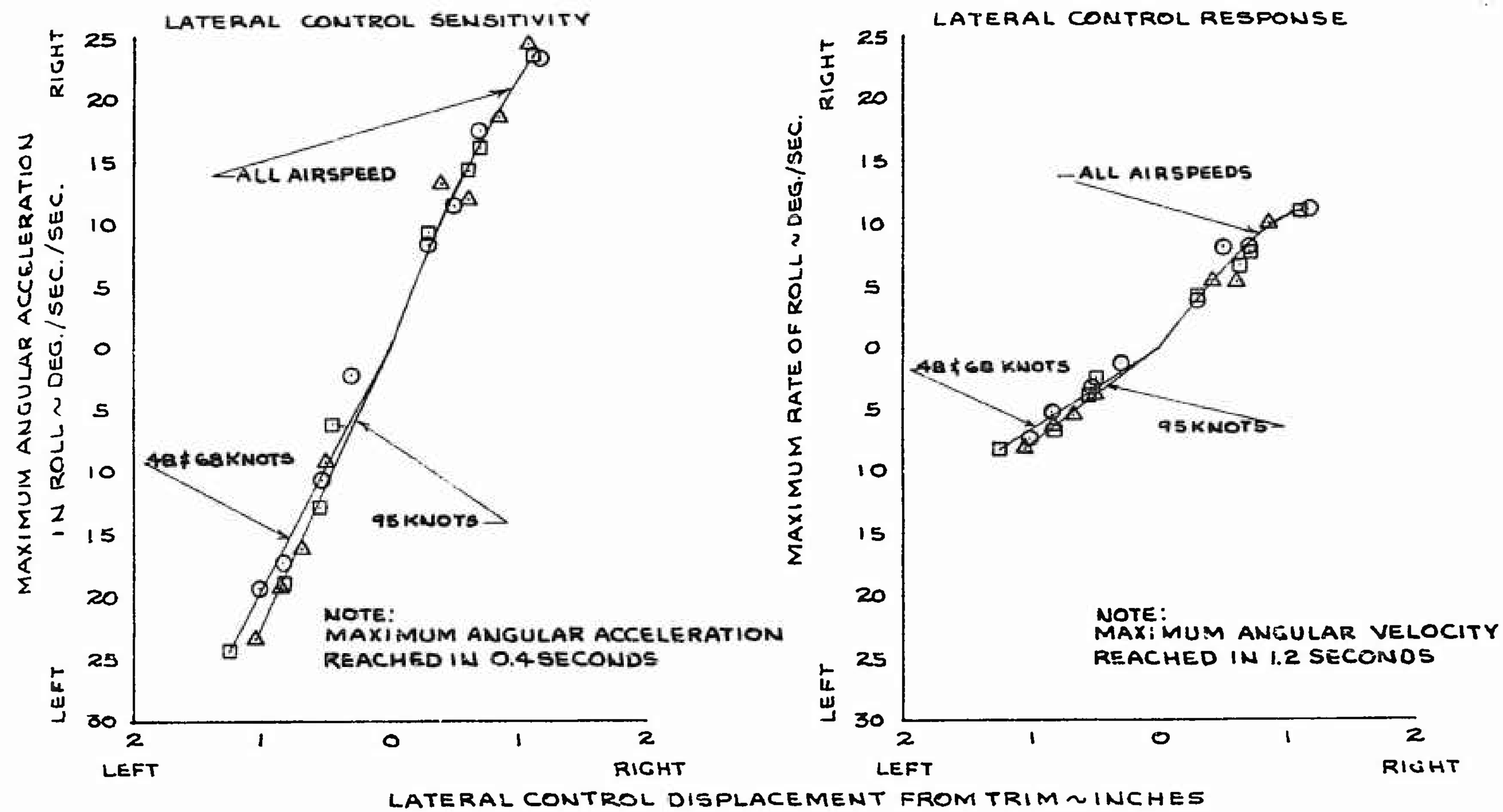


FIGURE No. 59

DIRECTIONAL CONTROLLABILITY

UH-1B USA S/N 60-3589

ARMAMENT CONFIGURATION

SYM	CAS	AVG. G.W.	AVG. CG	AVG. H_D	RPM	ARMAMENT	CONFIGURATION
○	48	7080	131.2	5140	325	XM-16	BOTH PODS FULL
□	68	6915	130.9	5490	325	XM-16	BOTH PODS FULL
△	95	6745	130.5	5590	325	XM-16	BOTH PODS FULL

NOTE:
MAXIMUM ANGULAR VELOCITY REACHED IN 0.9 SECONDS

DIRECTIONAL CONTROL RESPONSE

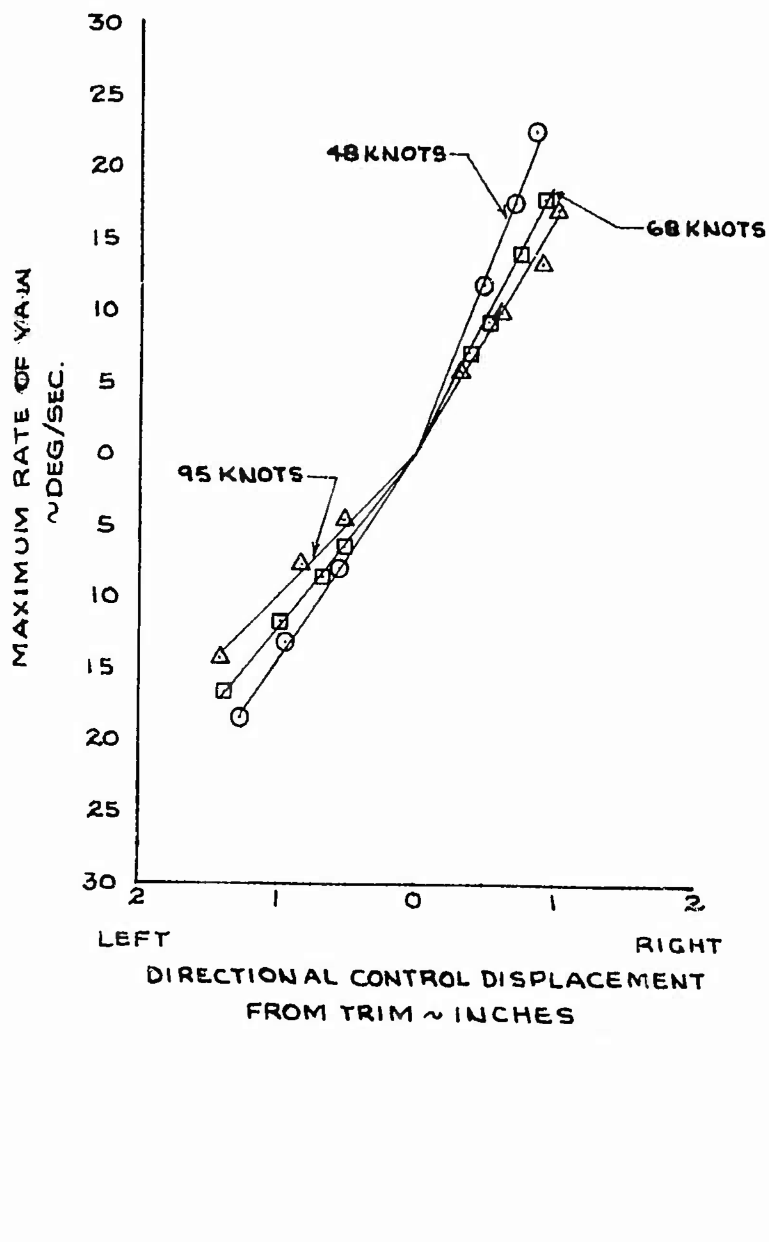


FIGURE No. 60

DIRECTIONAL CONTROLLABILITY

UH-1B USA S/N 60-3589

ARMAMENT CONFIGURATION

SYM	CAS	AVG G.W.	AVG.CG	AVG H_D	RPM	ARMAMENT	CONFIGURATION
○	48	7080	131.2	5140	325	XM-16	BOTH PODS FULL
□	68	6915	130.9	5490	325	XM-16	BOTH PODS FULL
△	95	6745	130.5	5590	325	XM-16	BOTH PODS FULL

DIRECTIONAL CONTROL SENSITIVITY

NOTE:

MAXIMUM ANGULAR ACCELERATION REACHED IN 0.6 SEC.

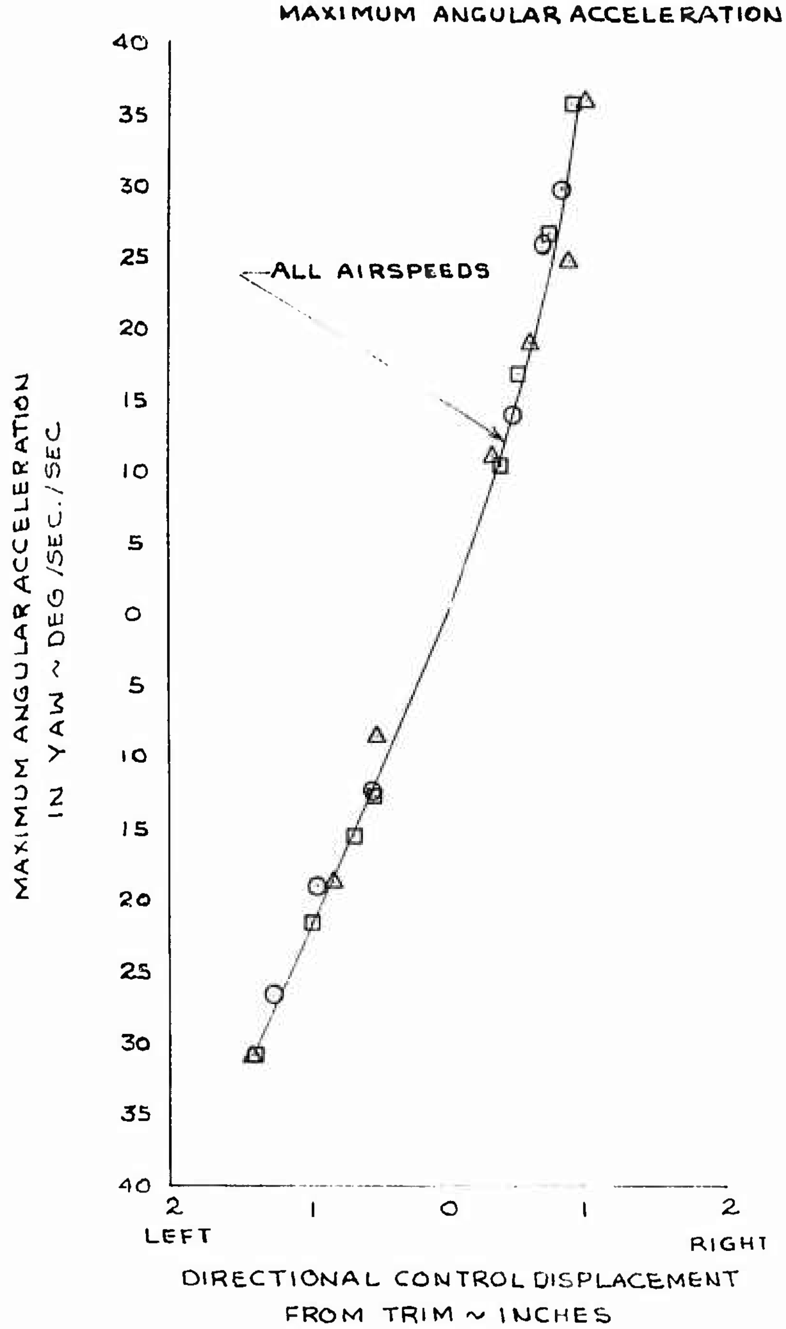


FIGURE NO. 61

FWD. LONGITUDINAL STEP

UH-1B, U S A , S/N 60-3589

ARMAMENT: XM-16

AVG. G.W.	LONG. C.G	COND.	TRIM C.A.S.	Hp	R.P.M.
7125 LBS.	131.1 IN.	LEVEL FLT.	47.5 KTS.	5170 FT.	324

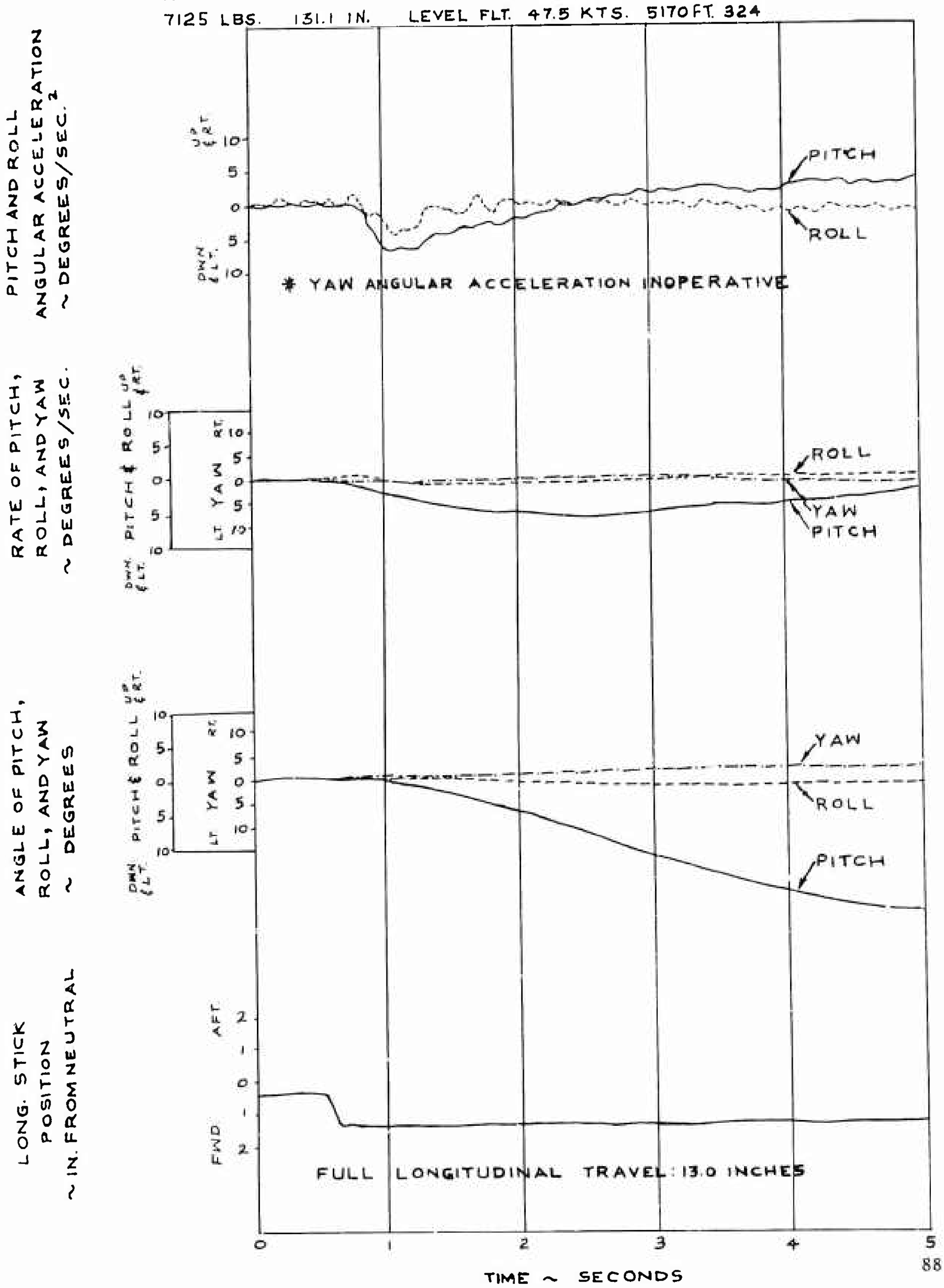


FIGURE NO 62

LEFT LATERAL STEP

UH-1B, U.S.A., S/N 60-3589

ARMAMENT: XM-16

AVG. G.W.	LONG C.G.	COND.	TRIM C.A.S.	Hd	R.P.M.
7125 LBS.	131.1 IN.	LEVEL FLT.	47.5 KTS	5170FT.	324

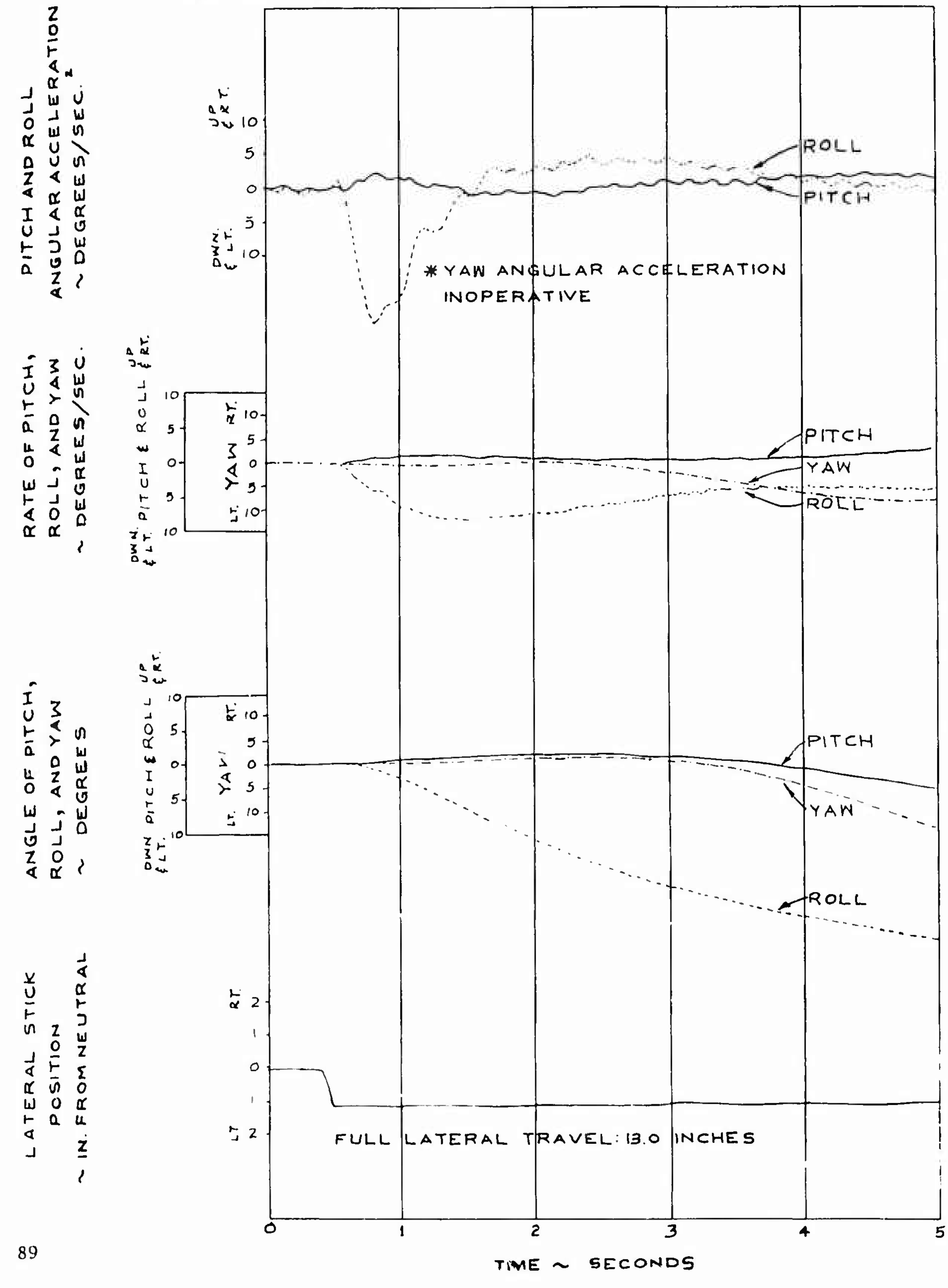


FIGURE NO. 63

LEFT PEDAL STEP

UH-1B, U.S.A., S/N 60-3589

ARMAMENT: XM-16

AVG. G.W.	LONG. C.G.	COND.	TRIM C.A.S.	Hd	R.P.M.
7125 LBS.	131.1 IN.	LEVEL FLT.	47.5 KTS.	5170 FT.	324

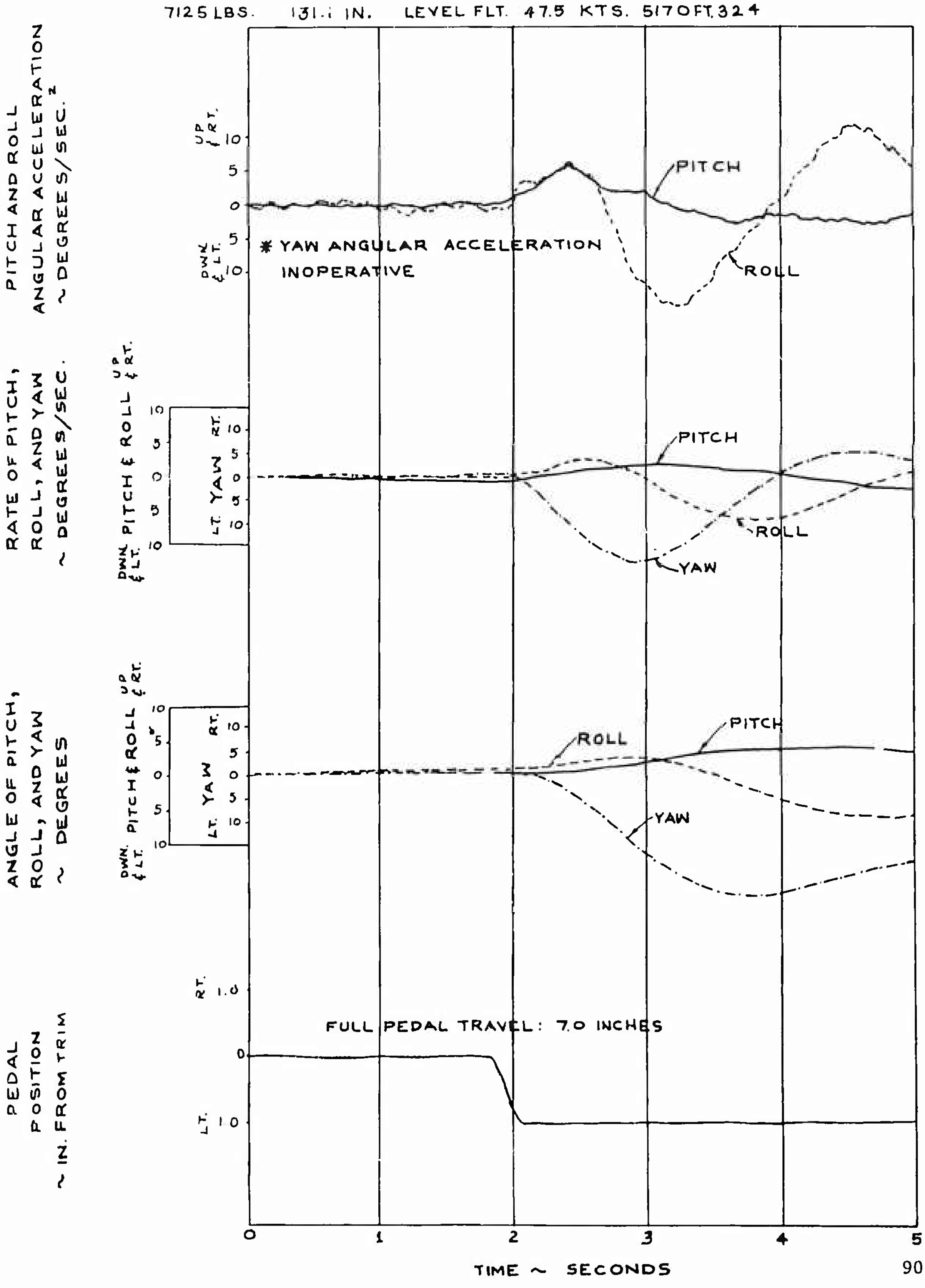
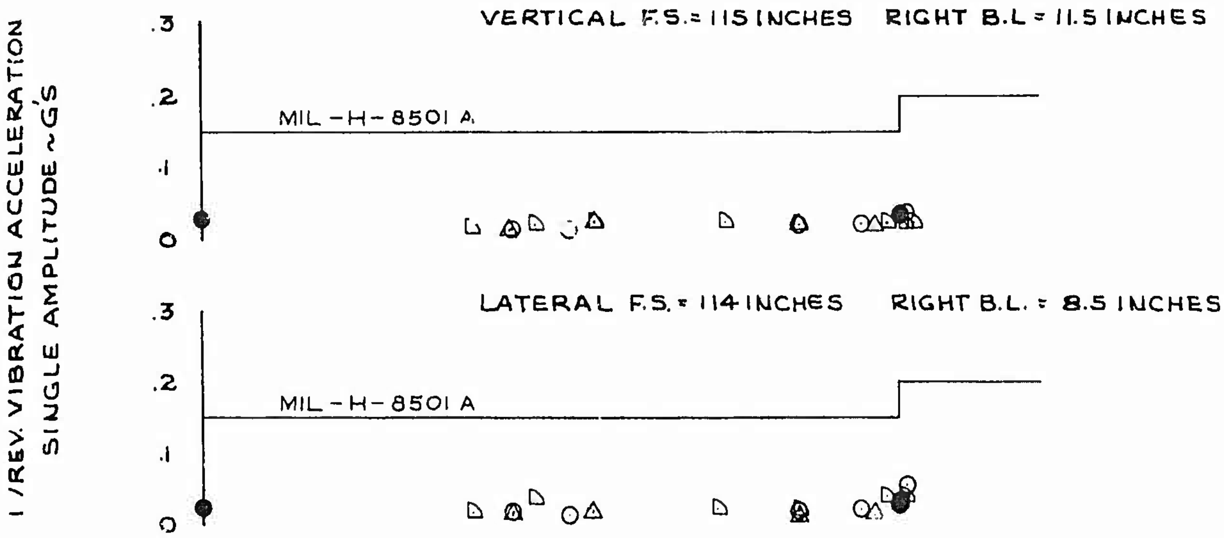


FIGURE No. 64
VIBRATION CHARACTERISTICS
UH-1B USA S/N 60-3589

SYM	G.W.~LB	H_D~FT	RPM	FREQUENCY	C.G.	ARMAMENT
○	7320	6600	324	5.4	130.7	XM-21 (NON-FIRING)
●	7210	5740	324	5.4	126.1	XM-21 (FIRING)
□	7245	5240	318	5.3	131.2	XM-16 (NON-FIRING)
■	7050	6100	324	5.4	128.3	XM-16 (FIRING)
△	7290	4930	318	5.3	129.8	CLEAN
◺	7040	5000	324	5.4	130.5	XM-21 (NON-FIRING)

XM-21 ARMAMENT



XM-16 ARMAMENT

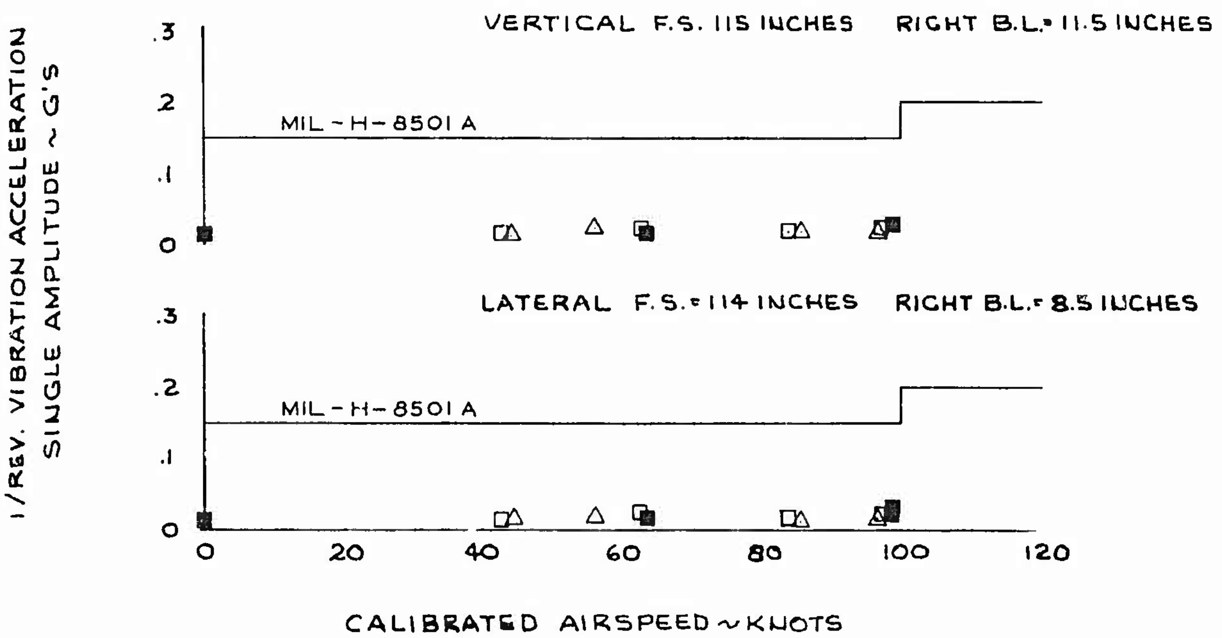


FIGURE No. 65

VIBRATION CHARACTERISTICS

UH-1B USA S/N 60-3589

SYM	G.W.~LB.	H_D~FT.	RPM	FREQUENCY	C.G.	ARMAMENT
○	7320	6600	324	10.8	130.7	XM-21 (NON-FIRING)
●	7210	5740	324	10.8	126.1	X-21 (FIRING)
□	7245	5240	318	10.6	131.2	XM-16 (NON-FIRING)
■	7050	6100	324	10.8	128.3	XM-16 (FIRING)
△	7290	4930	318	10.6	129.8	(CLEAN)
◺	7040	5000	324	10.8	130.5	XM-21 (NON-FIRING)

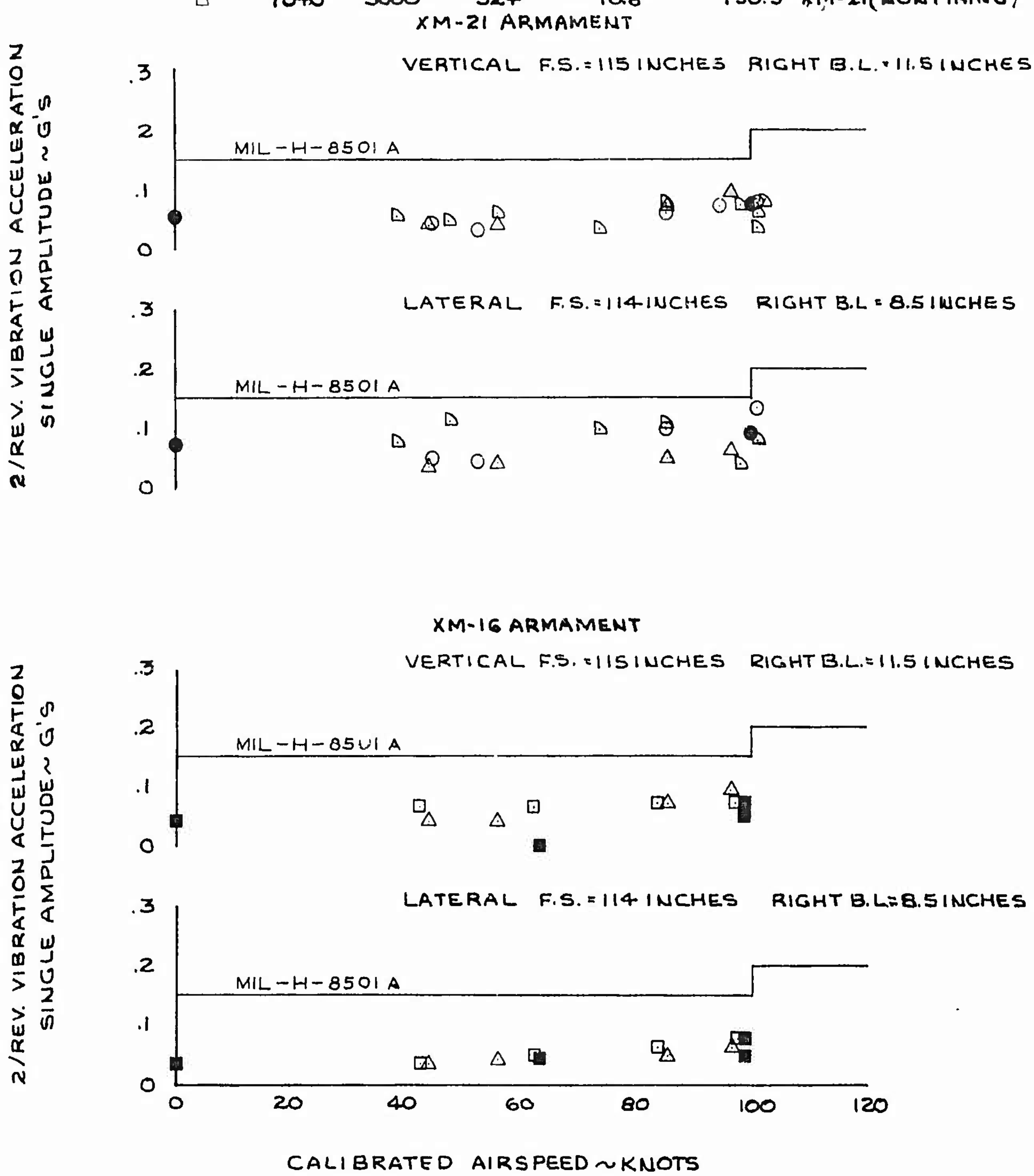


FIGURE NO. 66

VIBRATION CHARACTERISTICS

UH-1B USA S/N 60-3589

SYM.	G.W~LB.	H_D~FT.	RPM	FREQUENCY	C.G.	ARMAMENT
○	7320	6600	324	21.6	130.7	XM-21 (NON FIRING)
●	7210	5740	324	21.6	126.1	XM-21 (FIRING)
□	7245	5240	318	21.2	131.2	XM-16 (NON-FIRING)
■	7050	6100	324	21.6	128.3	XM-16 (FIRING)
△	7290	4930	318	21.2	129.8	(CLEAN)
◺	7040	5000	324	21.6	130.5	XM-21 (NON-FIRING)

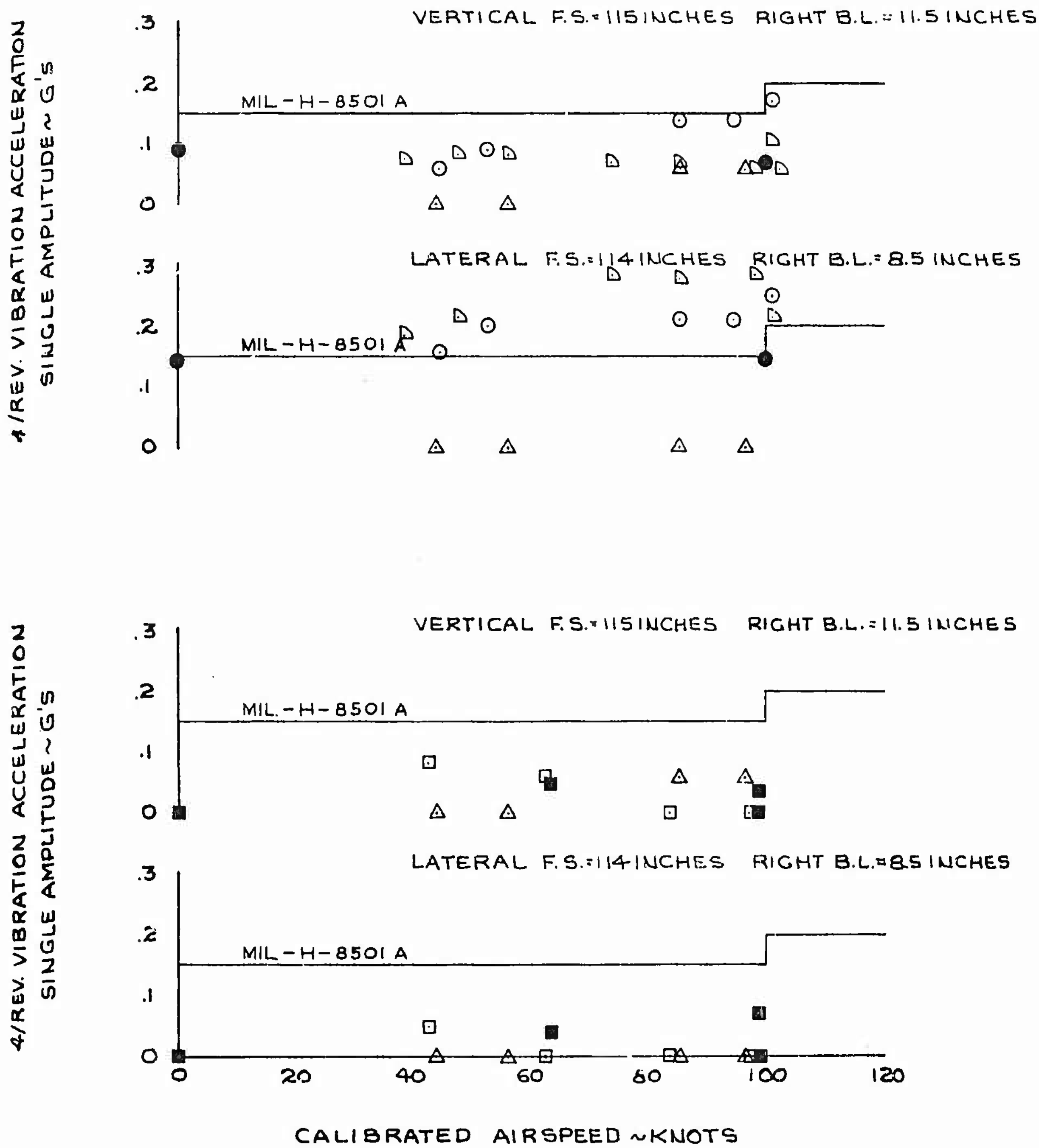


FIGURE NO. 67

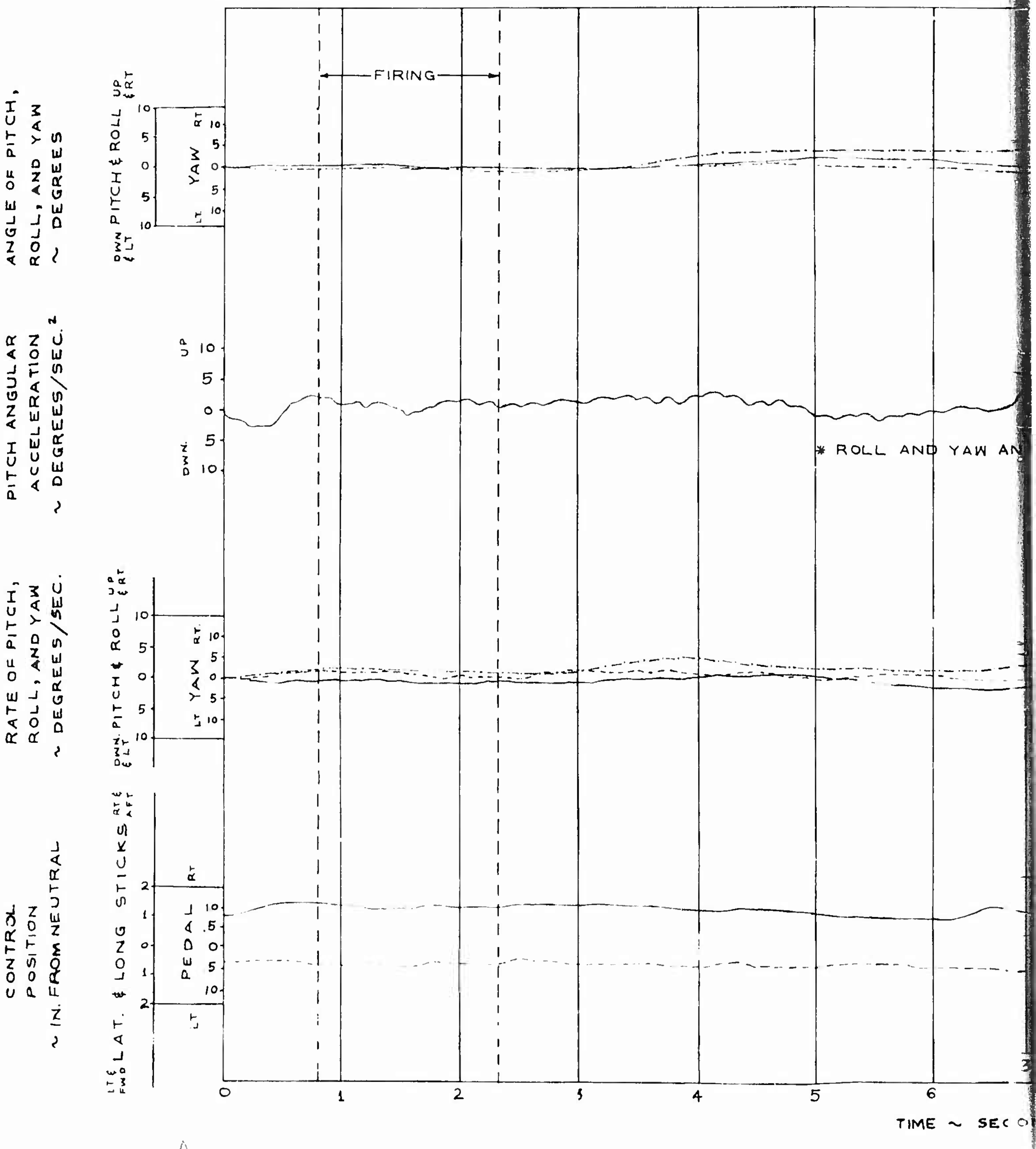
TIME HISTORY OF WEAPONS FIRING

UH-1B, U.S.A., S/N 60-3589

ARMAMENT: XM-16 GUNS

CONFIGURATION: BOTH GUNS, ELEV. DOWN, TRAVERSE: ZERO

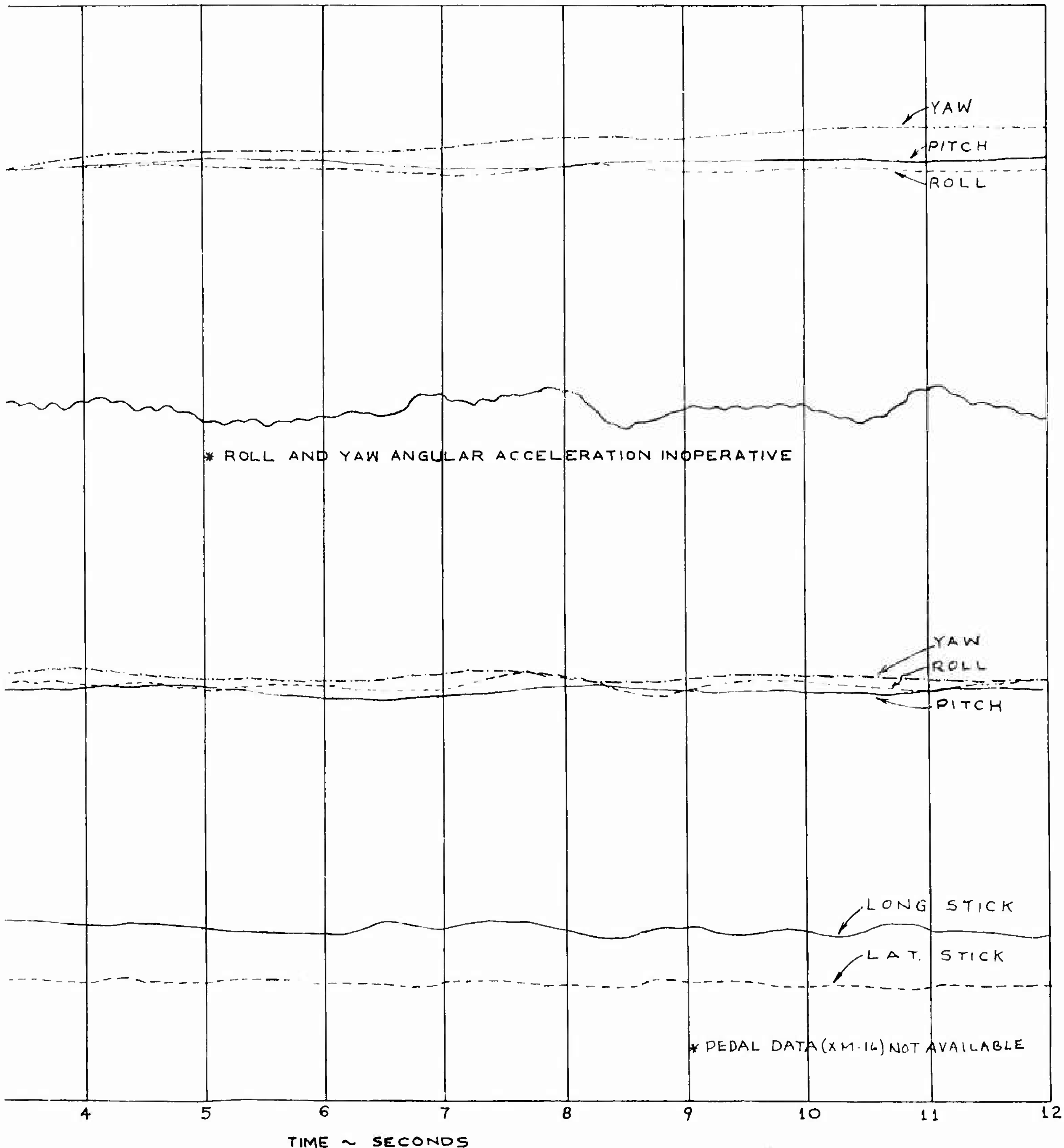
AVERAGE GR
LONGITUDINAL
FLIGHT COND
DENSITY ALTI
ROTOR SPEED



...NG

AVERAGE GROSS WEIGHT: 7120 LBS.
LONGITUDINAL C.G. LOCATION: 128.2 IN.
FLIGHT CONDITIONS: HOVER (I.G.E.)
DENSITY ALTITUDE: 5990 FEET
ROTOR SPEED: 324 RPM

...AVERSE: ZERO



B

FIGURE NO. 68

TIME HISTORY OF WEAPONS FIRING

UH-1B, U.S.A., S/N 60-3589

ARMAMENT: XM-16 GUNS

CONFIGURATION: BOTH GUNS, ELEV.: UP, TRAVERSE: ZERO

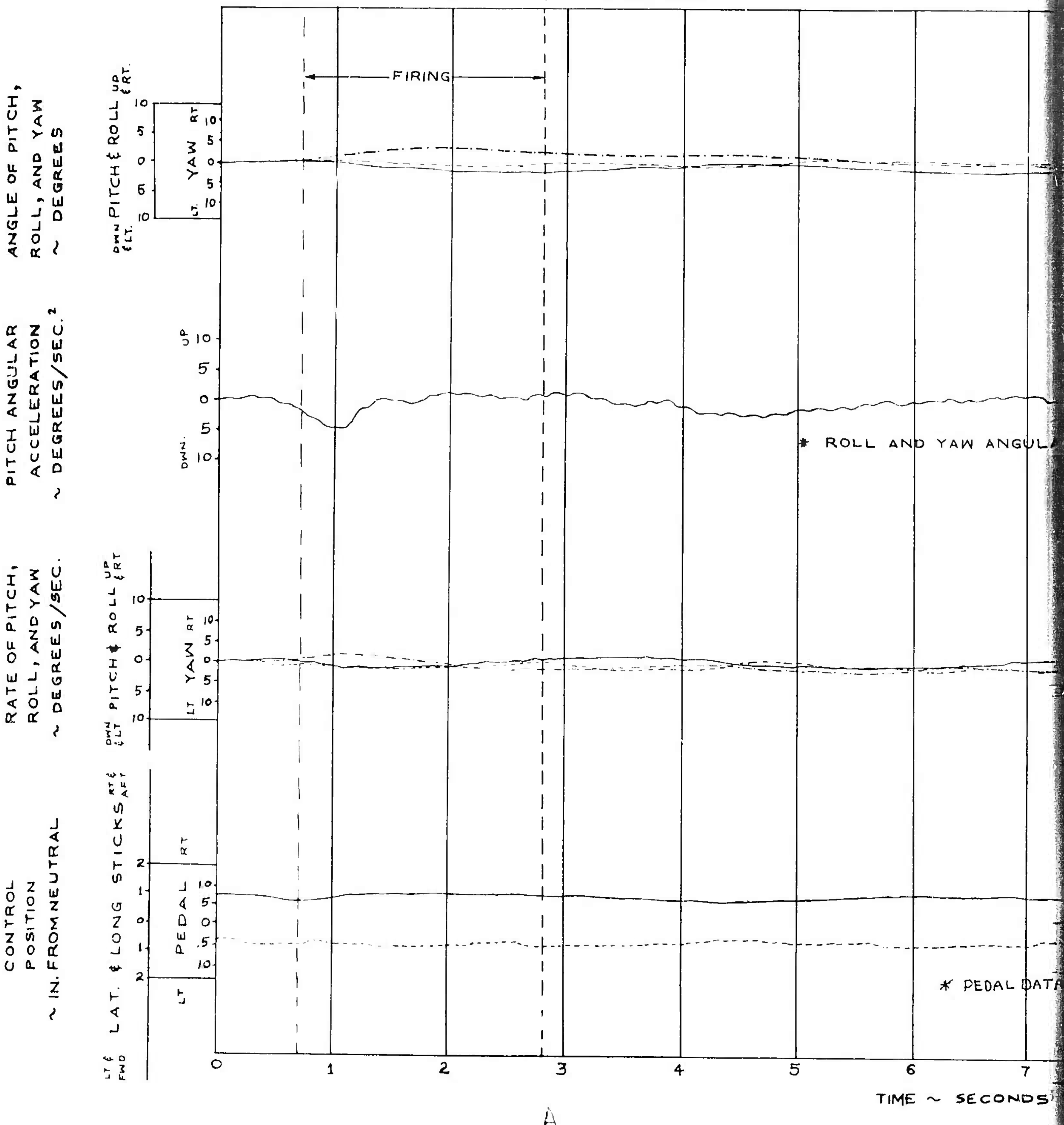
AVERAGE GROSS

LONGITUDINAL C.G.

FLIGHT CONDITION

DENSITY ALTITUDE

ROTOR SPEED: 3



A

AVERAGE GROSS WEIGHT : 7120 LBS.
LONGITUDINAL C.G. LOCATION : 128.2 IN.
FLIGHT CONDITIONS : HOVER (I.G.E.)
DENSITY ALTITUDE : 5990 FEET
ROTOR SPEED : 324 RPM

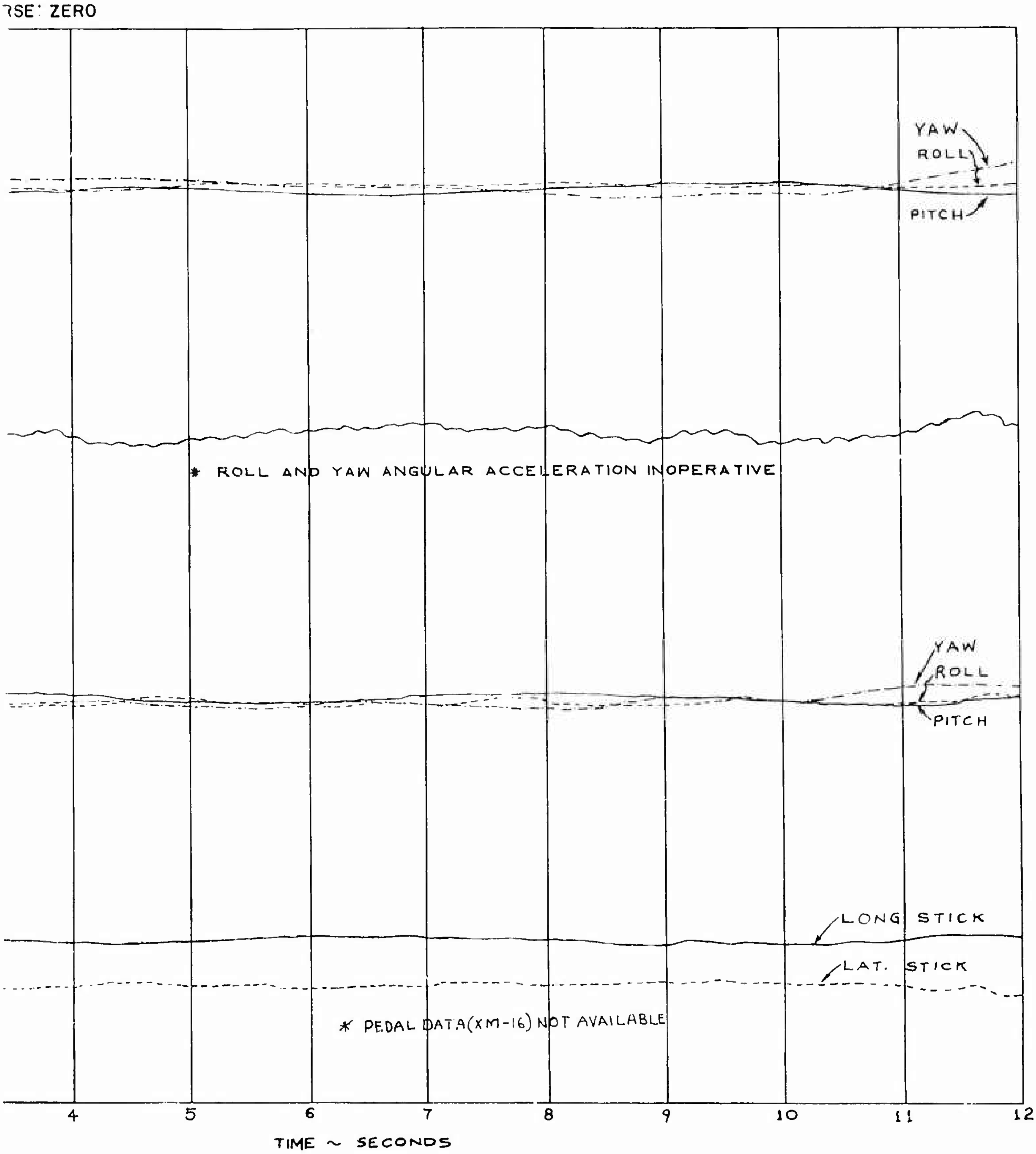


FIGURE NO.69

TIME HISTORY OF WEAPONS FIRING

UH-IB, U.S.A., S/N 60-3589

ARMAMENT: XM-21 GUNS

CONFIGURATION: BOTH GUNS, ELEV.: DOWN, TRAVERSE: ZERO

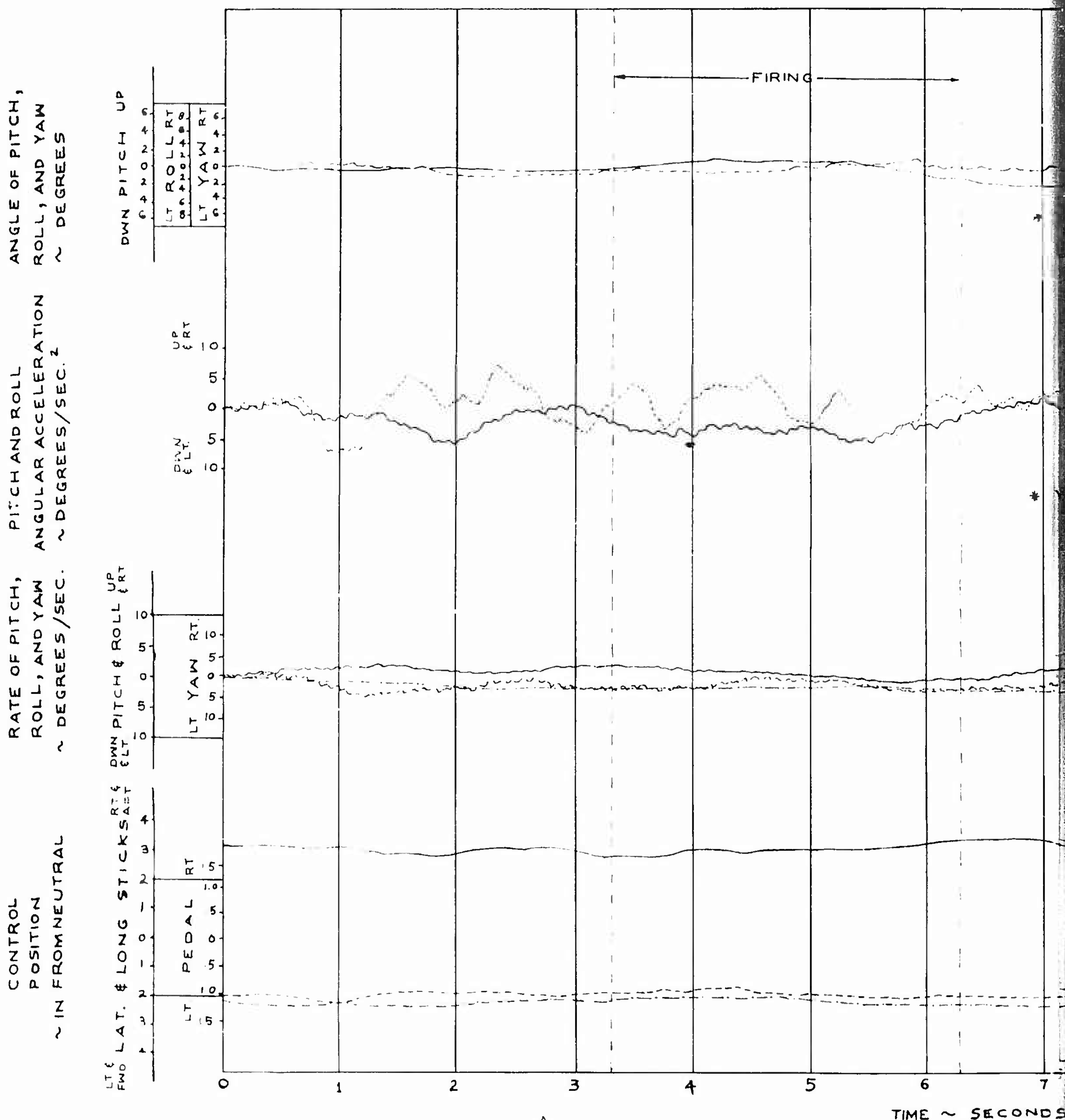
AVERAGE GROSS

LONGITUDINAL C.G.

FLIGHT CONDITION

DENSITY ALTITUDE

ROTOR SPEED 32



A

FIRING

TRAVERSE: ZERO

AVERAGE GROSS WEIGHT: 7280 LBS.
LONGITUDINAL C.G. LOCATION: 126.0 IN.
FLIGHT CONDITIONS: HOVER
DENSITY ALTITUDE: 5740 FEET
ROTOR SPEED: 324 RPM

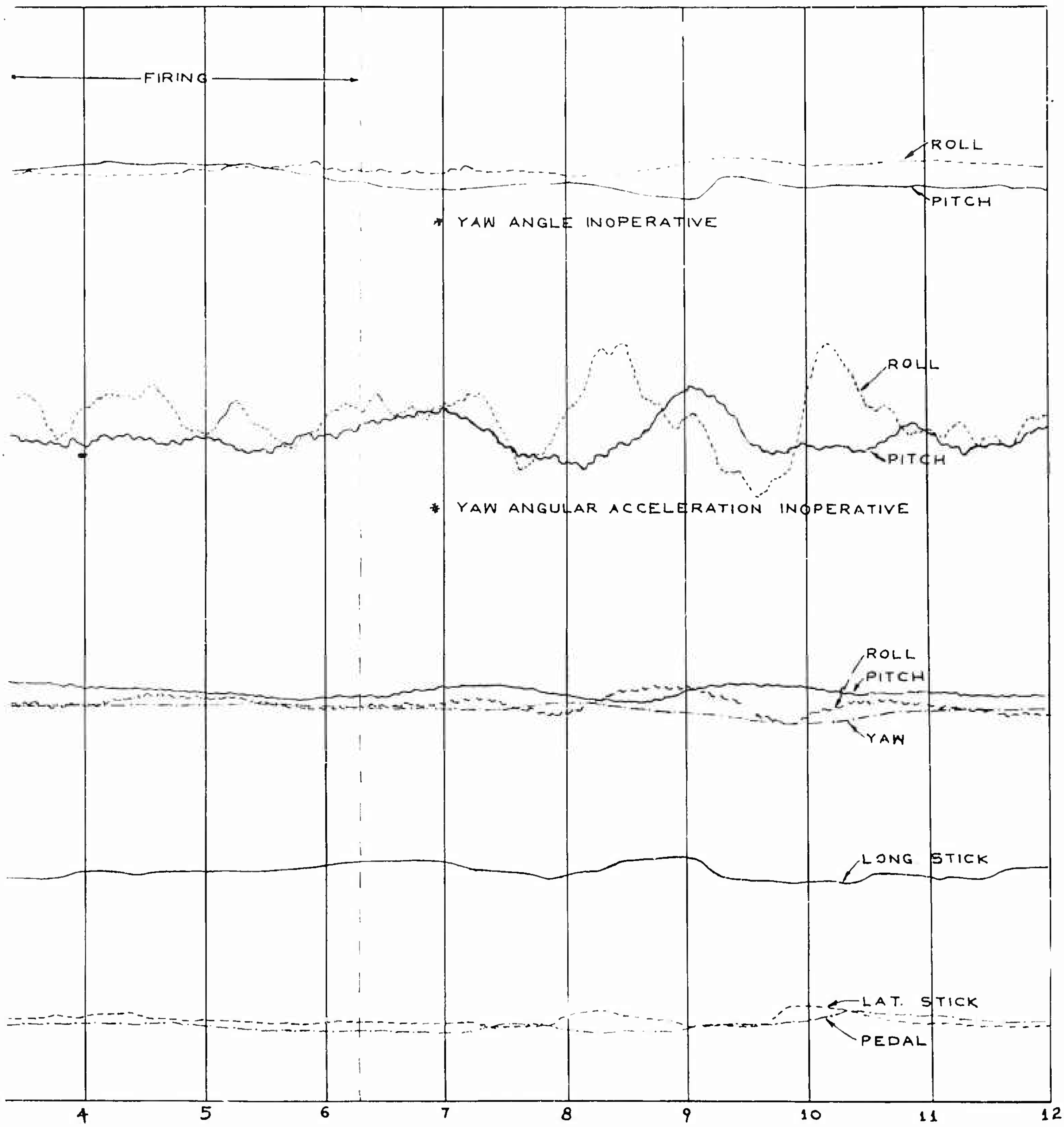


FIGURE NO. 70

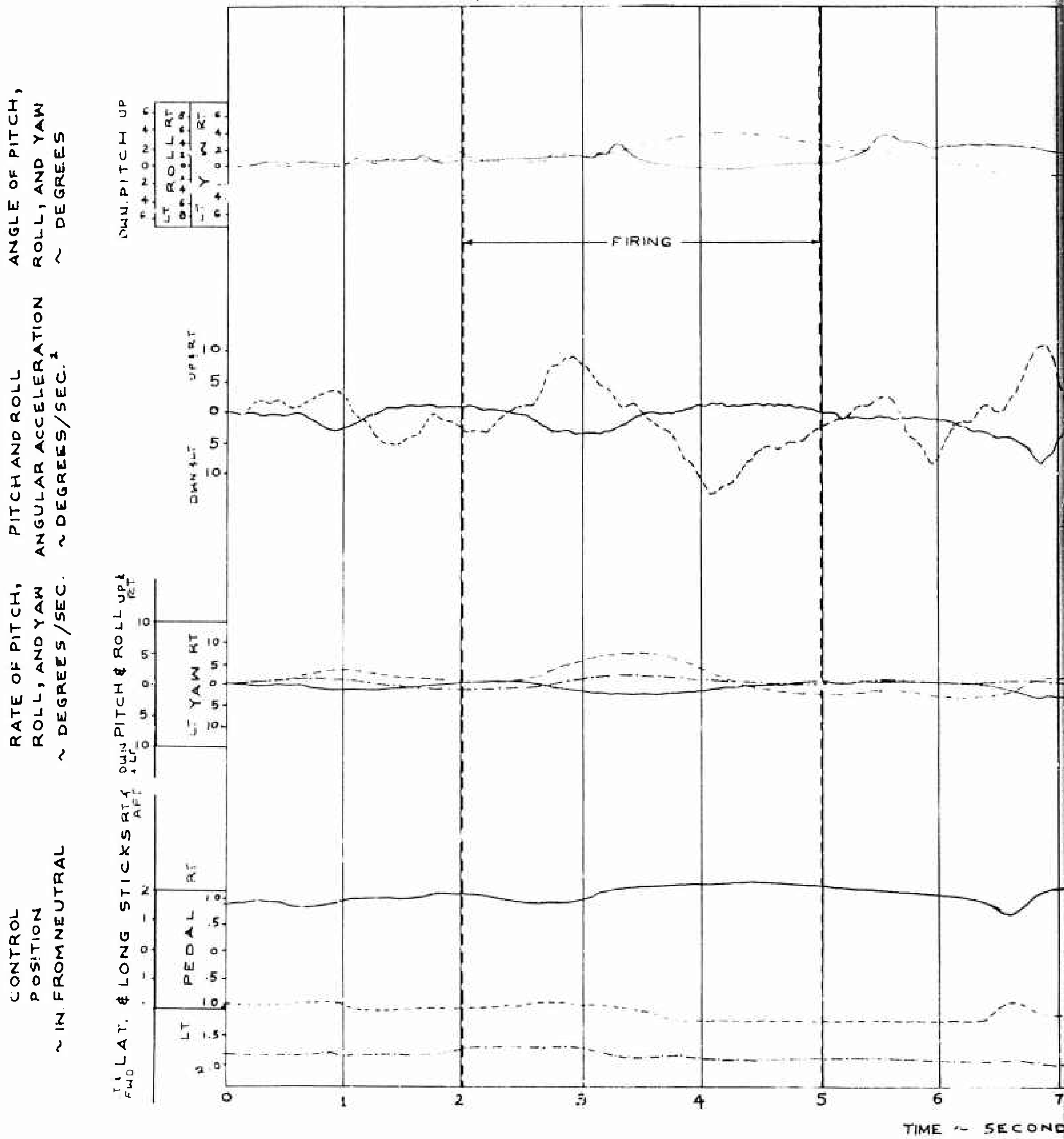
TIME HISTORY OF WEAPONS FIRING

UH-1B, U.S.A., S/N 60-3589

ARMAMENT: XM-21 GUNS

CONFIGURATION: BOTH GUNS, ELEV.: ZERO, TRAVERSE: RIGHT

AVERAGE GROSS
LONGITUDINAL C.
FLIGHT CONDITIO
DENSITY ALTITUD
ROTOR SPEED: 3



AVERAGE GROSS WEIGHT: 7280 LBS.
LONGITUDINAL C.G LOCATION: 126.0 IN
FLIGHT CONDITIONS: HOVER
DEN.SITY ALTITUDE: 5740 FEET
ROTOR SPEED: 324 RPM

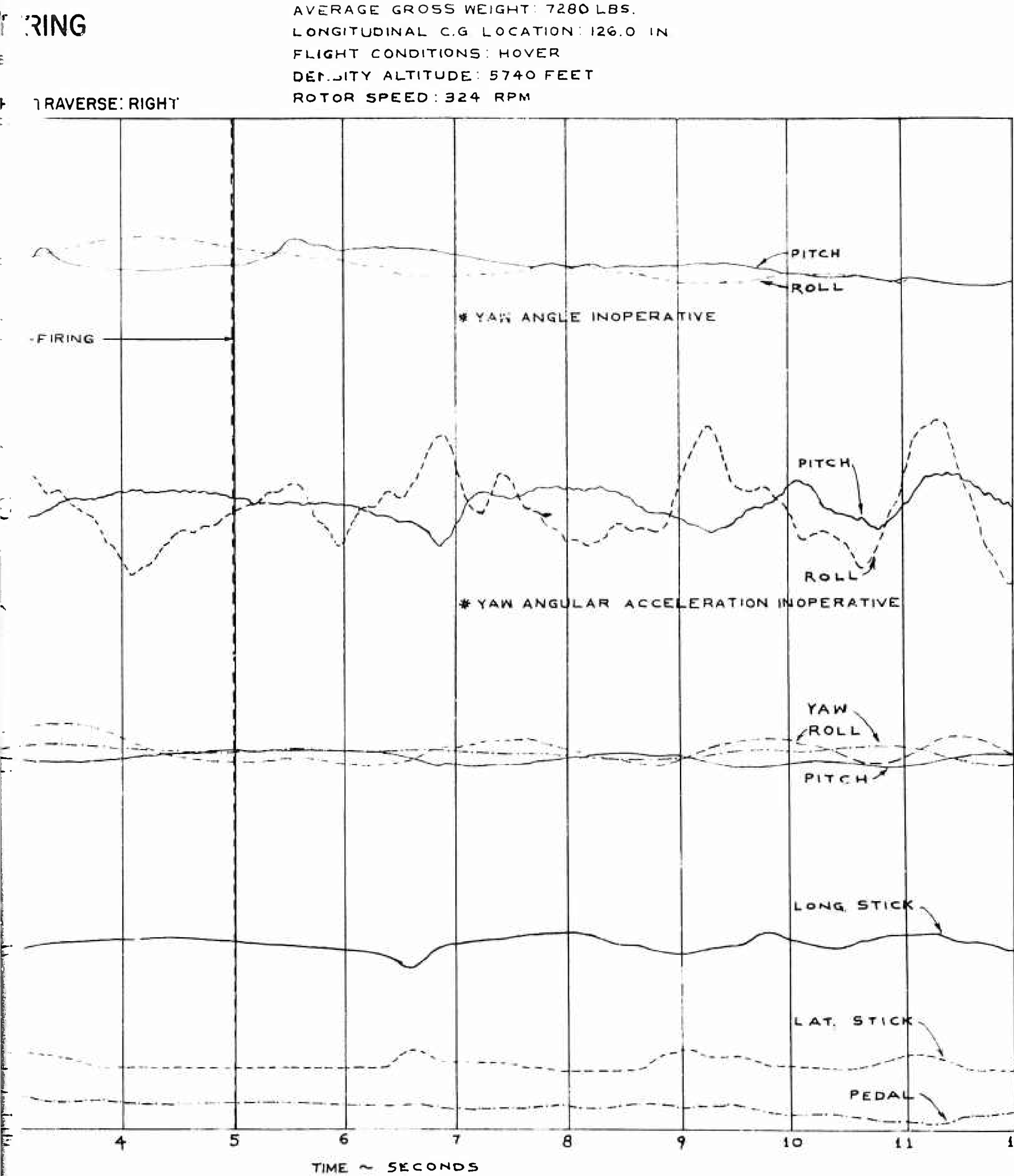


FIGURE NO. 71

TIME HISTORY OF WEAPONS FIRING

UH-1B, U.S.A., S/N 60-3589

ARMAMENT: XM-21 GUNS

CONFIGURATION: BOTH GUNS, ELEV. DWN., TRAVERSE ZERO

AVERAGE GROSS WE

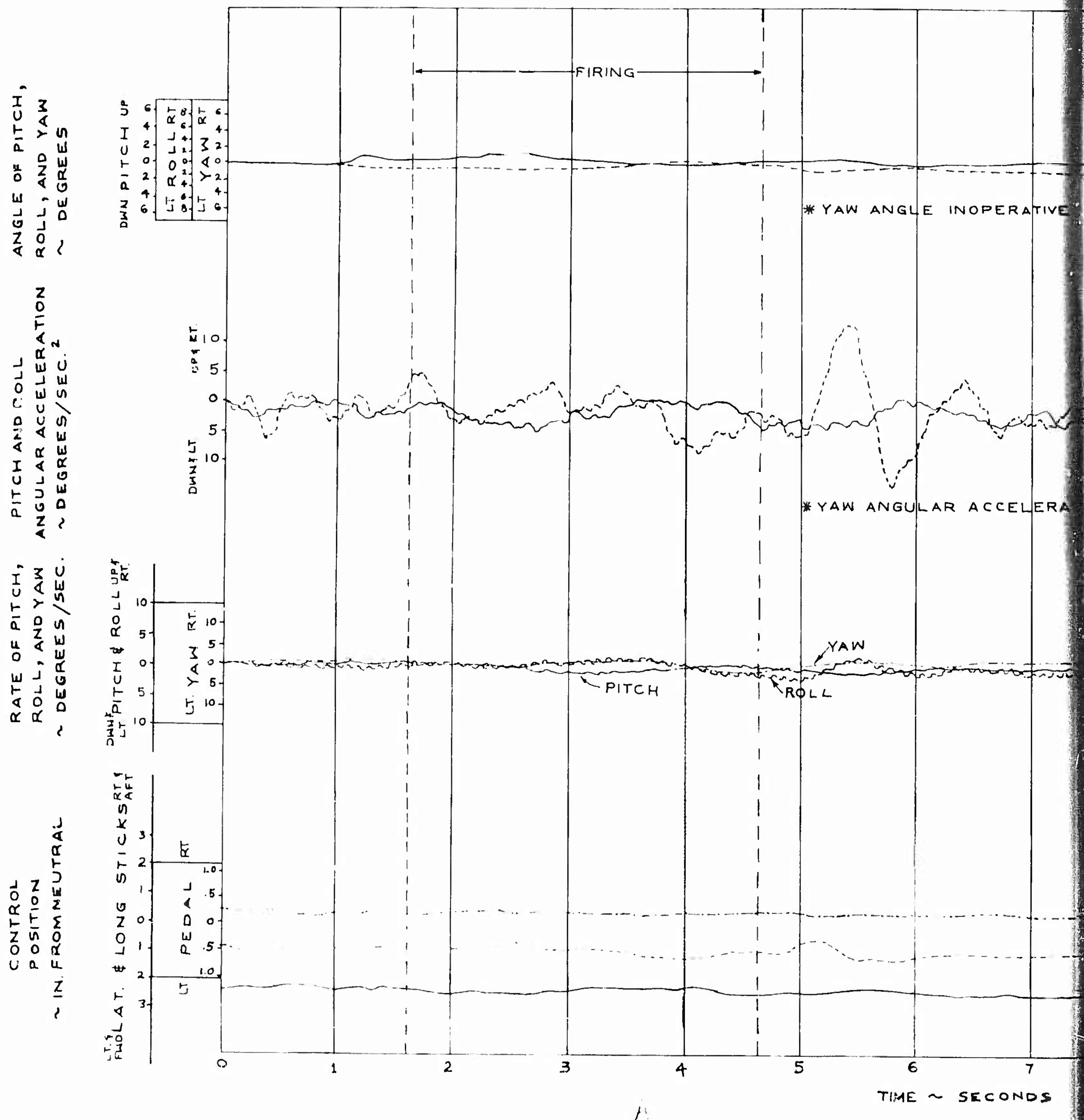
LONGITUDINAL C.G. L

FLIGHT CONDITIONS:

TRIM C.A.S. : 94.5 KT

DENSITY ALTITUDE:

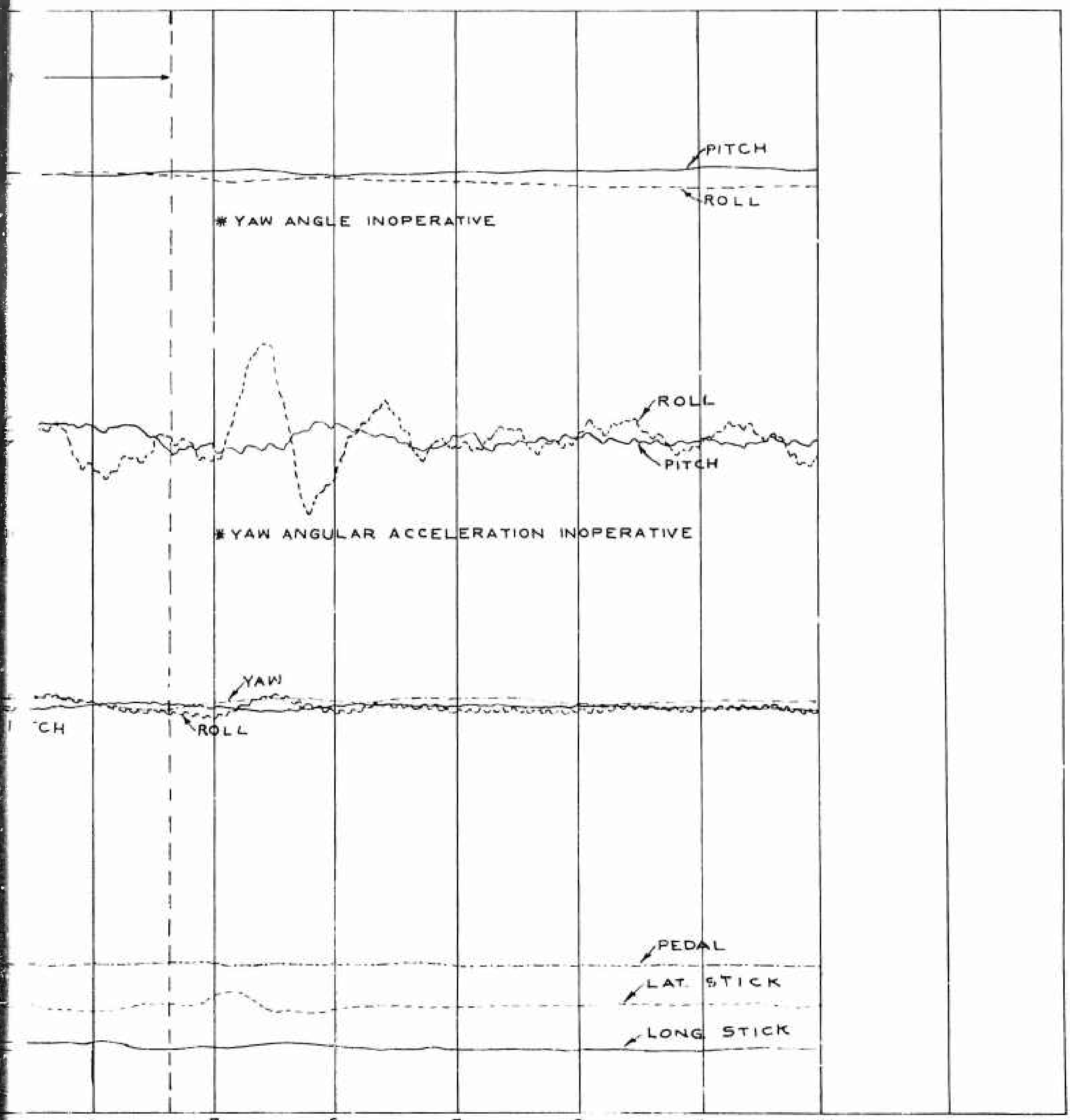
ROTOR SPEED: 324



...IG

AVERAGE GROSS WEIGHT: 7210 LBS.
LONGITUDINAL C.G. LOCATION: 125.8 IN.
FLIGHT CONDITIONS: LEVEL FLIGHT
TRIM C.A.S.: 94.5 KTS.
DENSITY ALTITUDE: 5740 FEET
ROTOR SPEED: 324 RPM

...VERSE ZERO



TIME ~ SECONDS

B

FIGURE NO.72

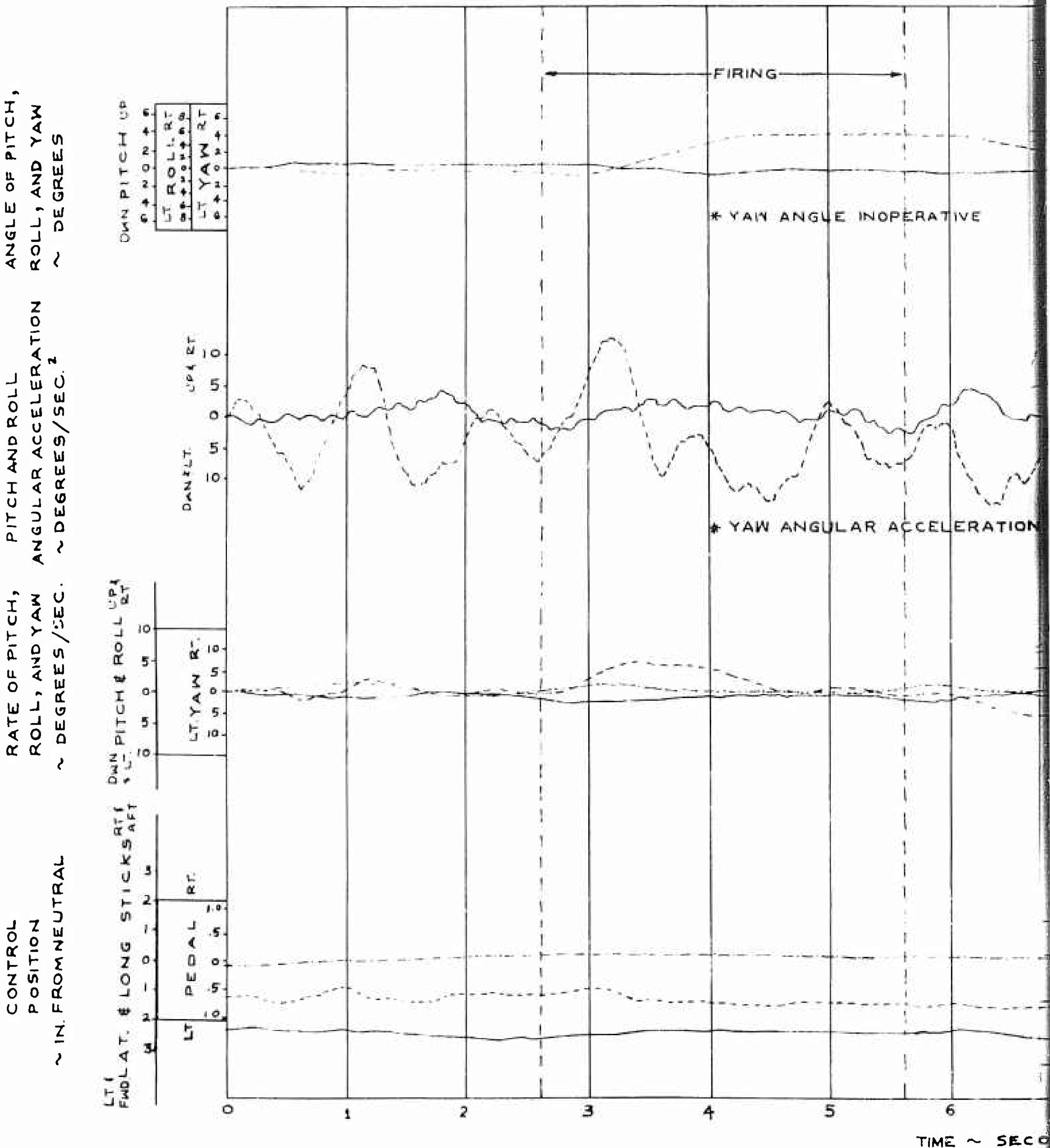
TIME HISTORY OF WEAPONS FIRING

UH-1B, U.S.A., S/N 60-3589

ARMAMENT: XM-21 GUNS

CONFIGURATION: BOTH GUNS, ELEV.: ZERO, TRAVERSE: RIGHT

AVERAGE GR
LONGITUDINAL
FLIGHT COND
TRIM CAS 9
DENSITY ALTI
ROTOR SPEED



ING

RAVERSE: RIGHT

AVERAGE GROSS WEIGHT: 7210 LBS.
LONGITUDINAL C.G. LOCATION: 125.8 IN.
FLIGHT CONDITIONS: LEVEL FLIGHT
TRIM C.A.S.: 94.5 KTS.
DENSITY ALTITUDE: 5740 FEET
ROTOR SPEED: 324 RPM

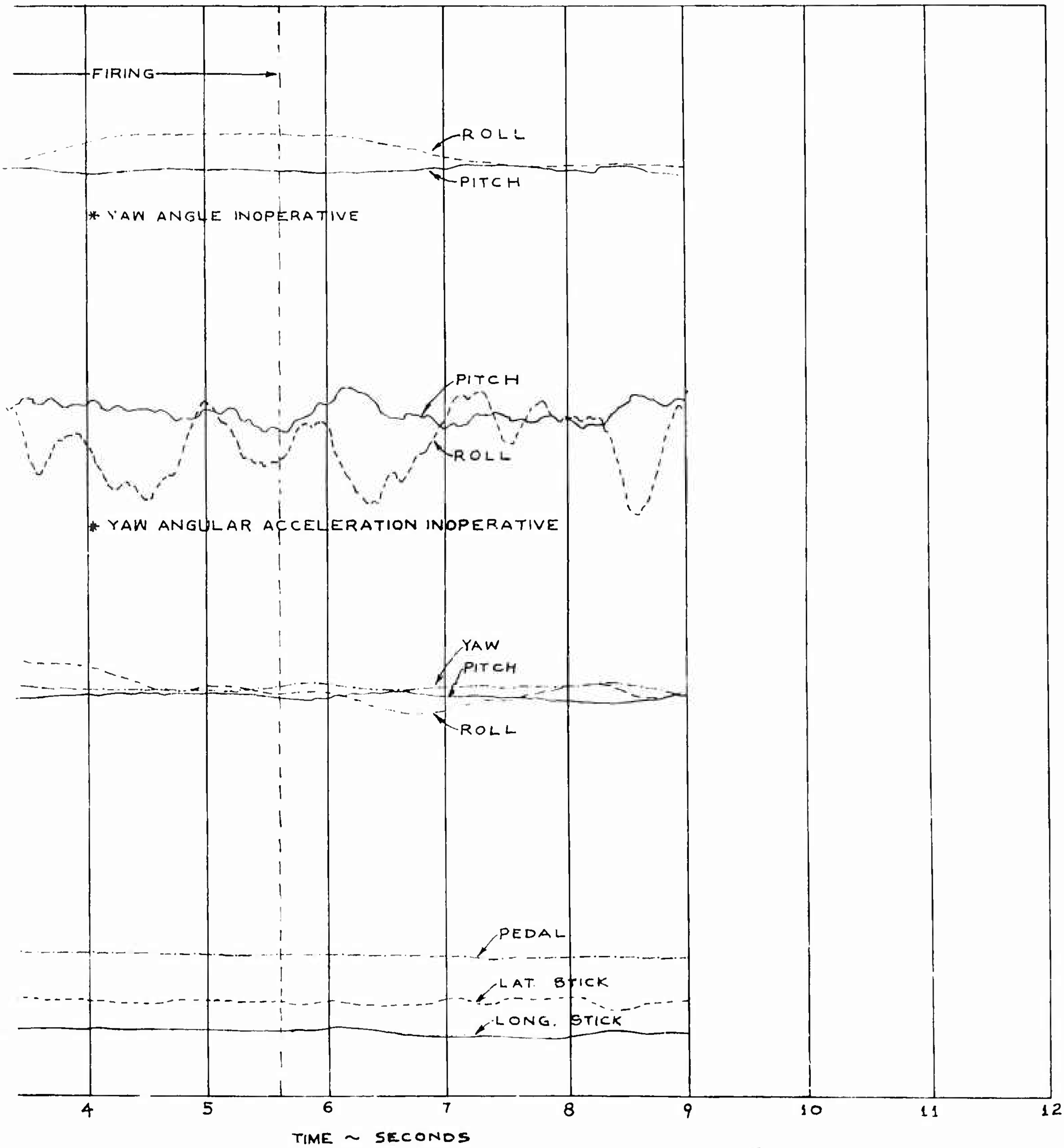


FIGURE NO. 73

TIME HISTORY OF WEAPONS FIRING

UH-1B, U.S.A., S/N 60-3589

ARMAMENT: XM-16 ROCKETS

CONFIGURATION: BOTH PODS, 14 ROCKETS

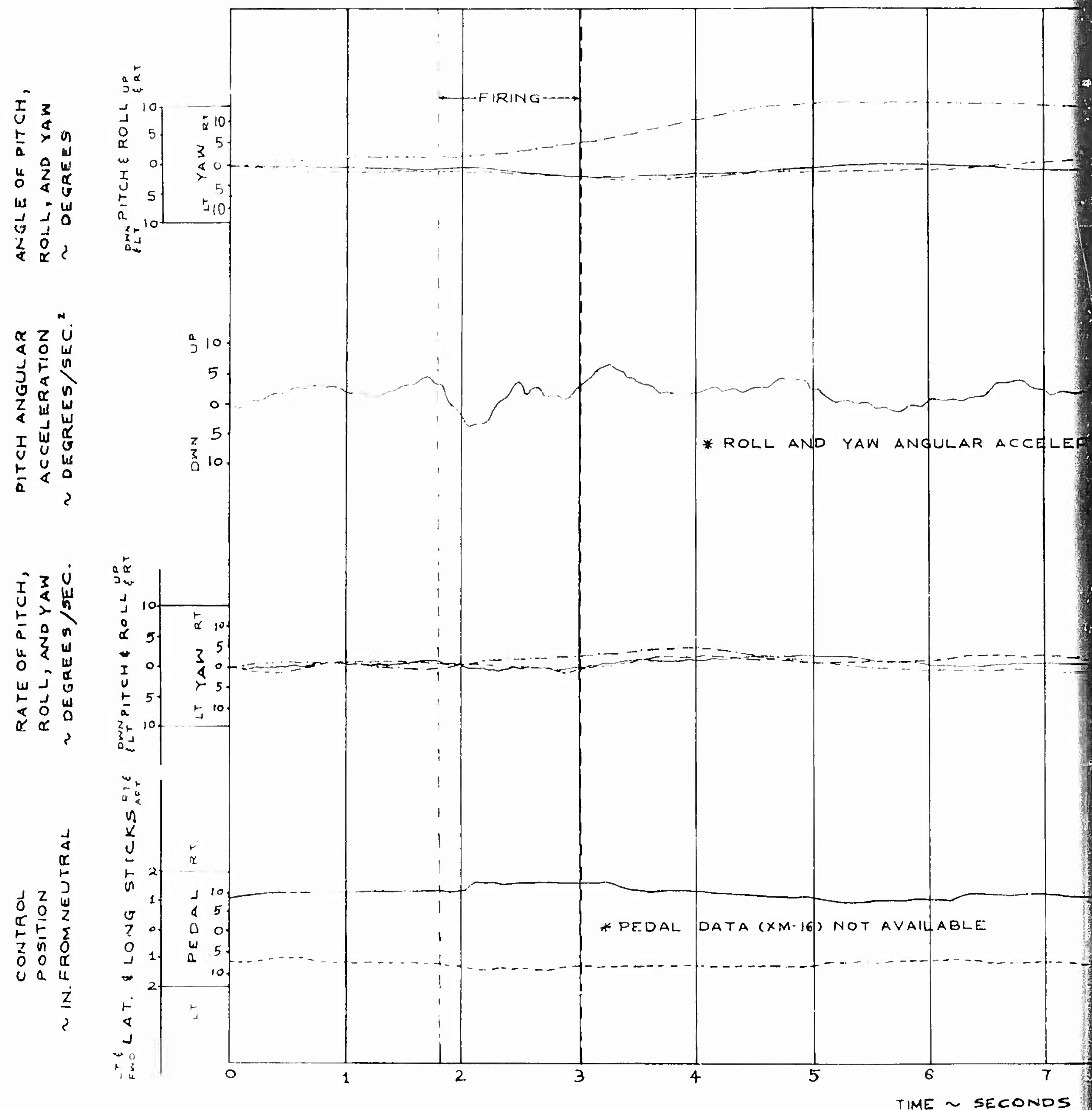
AVERAGE GROSS WE

LONGITUDINAL C.G.

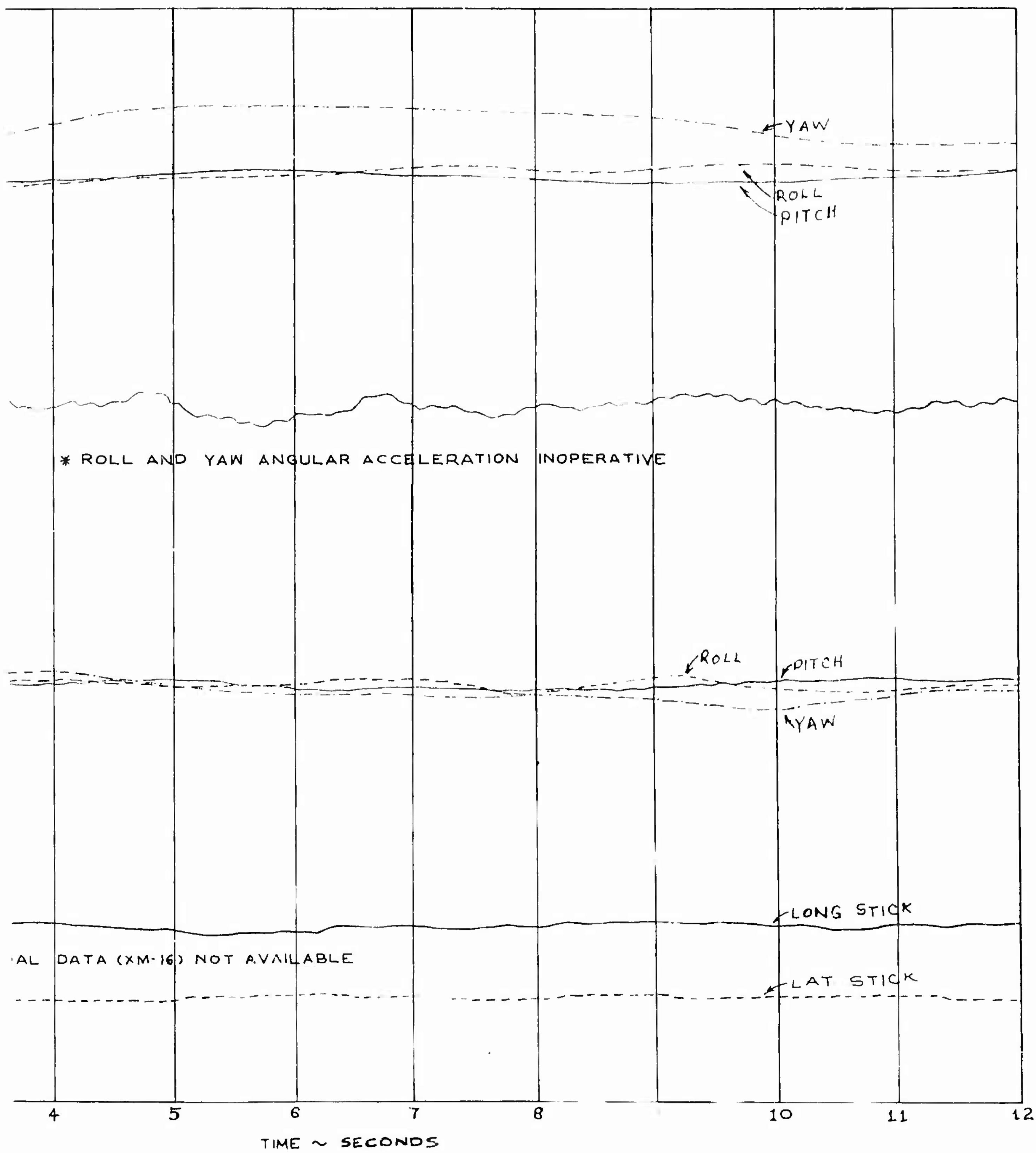
FLIGHT CONDITIONS

DENSITY ALTITUDE:

ROTOR SPEED: 324



AVERAGE GROSS WEIGHT: 7380 LBS.
LONGITUDINAL C.G. LOCATION 129.9 IN
FLIGHT CONDITIONS: HOVER (I.G.E.)
DENSITY ALTITUDE: 5990 FEET
ROTOR SPEED: 324 RPM



B

FIGURE NO. 74

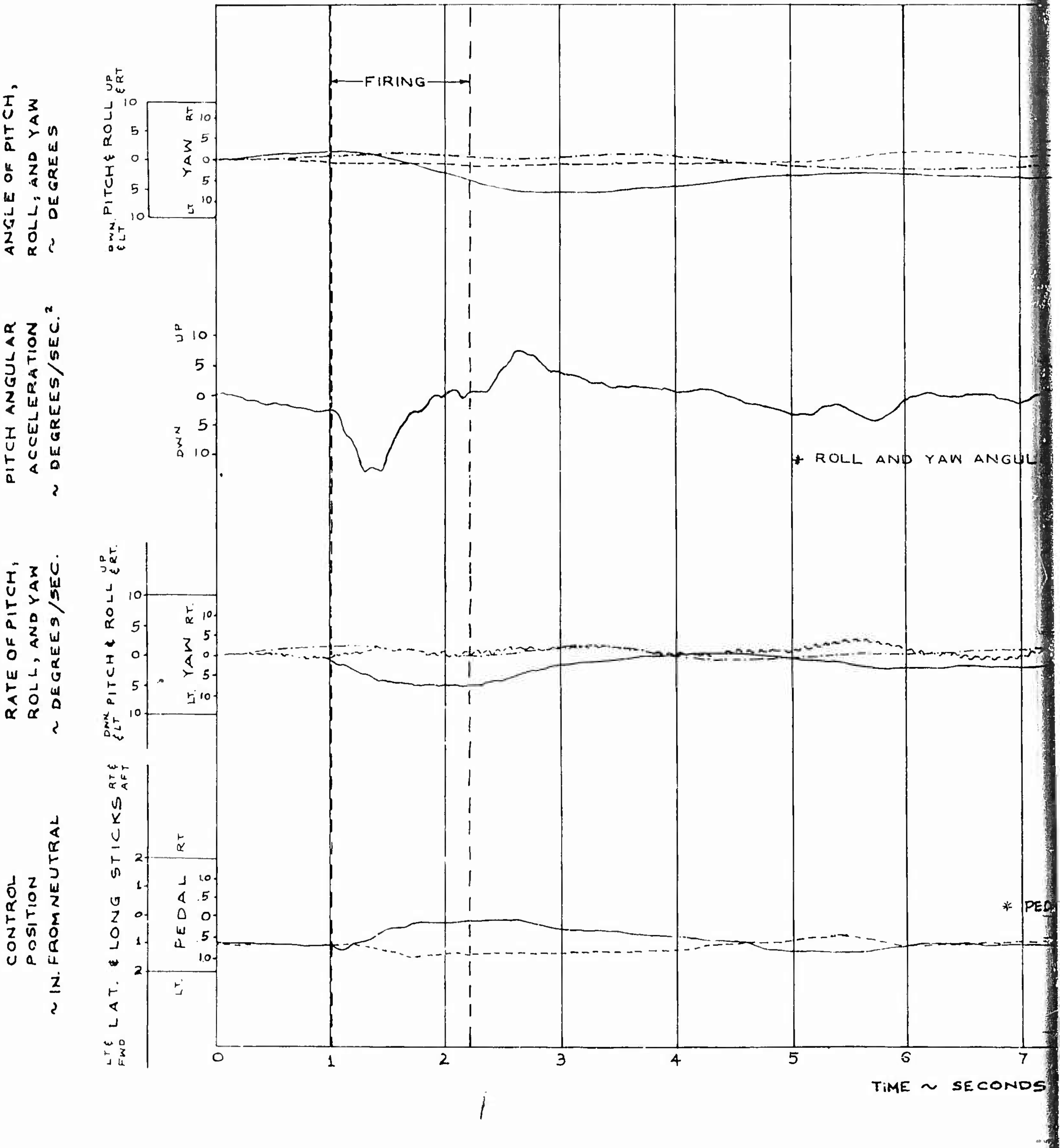
TIME HISTORY OF WEAPONS FIRING

UH-1B, U.S.A., S/N 60-3589

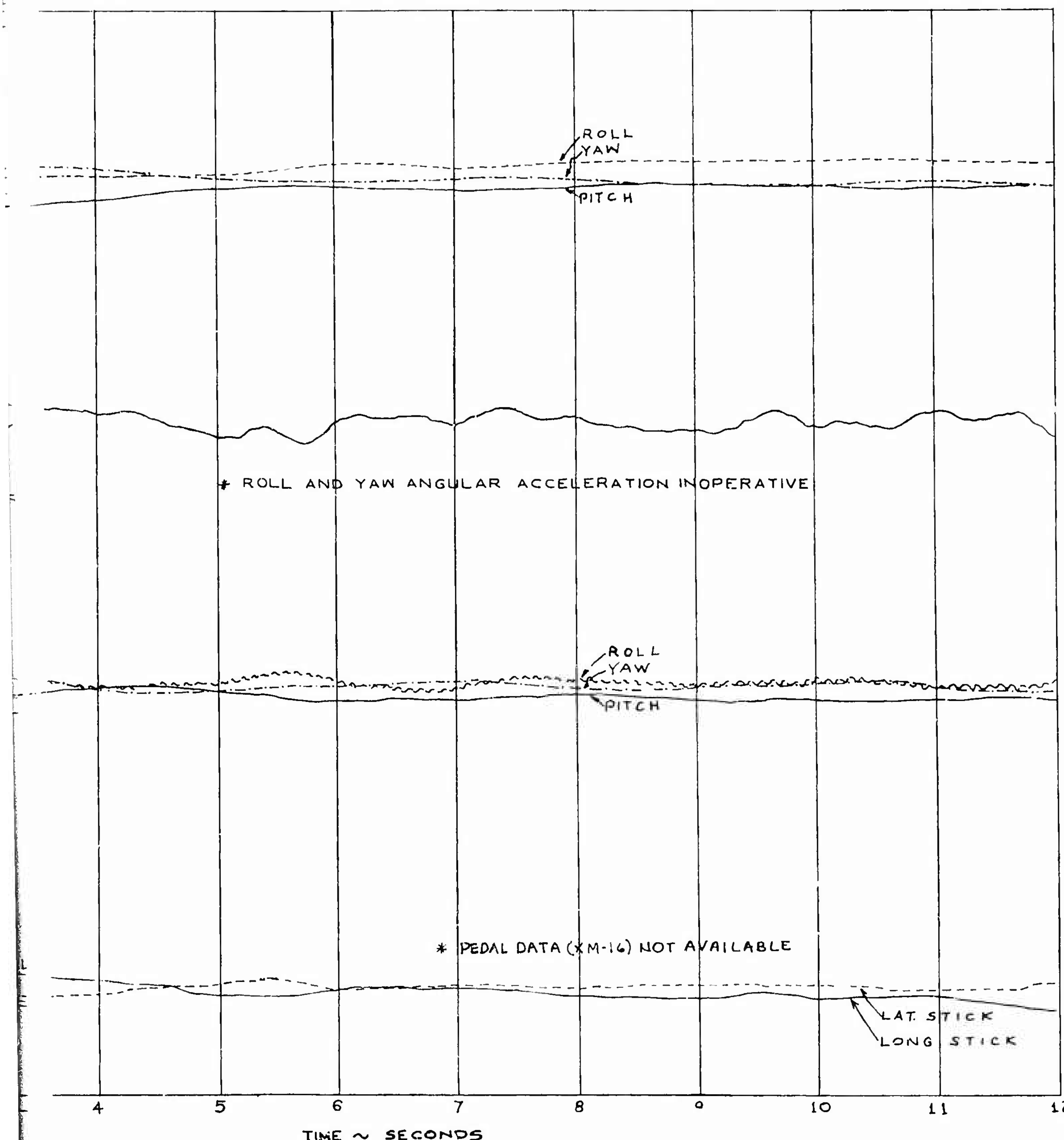
ARMAMENT: XM-16 ROCKETS

CONFIGURATION: BOTH PODS, 14 ROCKETS

AVERAGE GROSS
LONGITUDINAL C.G
FLIGHT CONDITION
TRIM C.A.S.: 61 0
DENSITY ALTITUDE
ROTOR SPEED: 32



AVERAGE GROSS WEIGHT: 7150 LBS.
LONGITUDINAL C.G. LOCATION: 128.3 IN.
FLIGHT CONDITIONS: CLIMB
TRIM C.A.S.: 61.0 KTS.
DENSITY ALTITUDE: 6290 FEET
ROTOR SPEED: 324 RPM



AVERAGE GROSS
LONGITUDINAL C.
FLIGHT CONDITIO
TRIM C.A.S.: 99.
DENSITY ALTITUD
ROTOR SPEED:

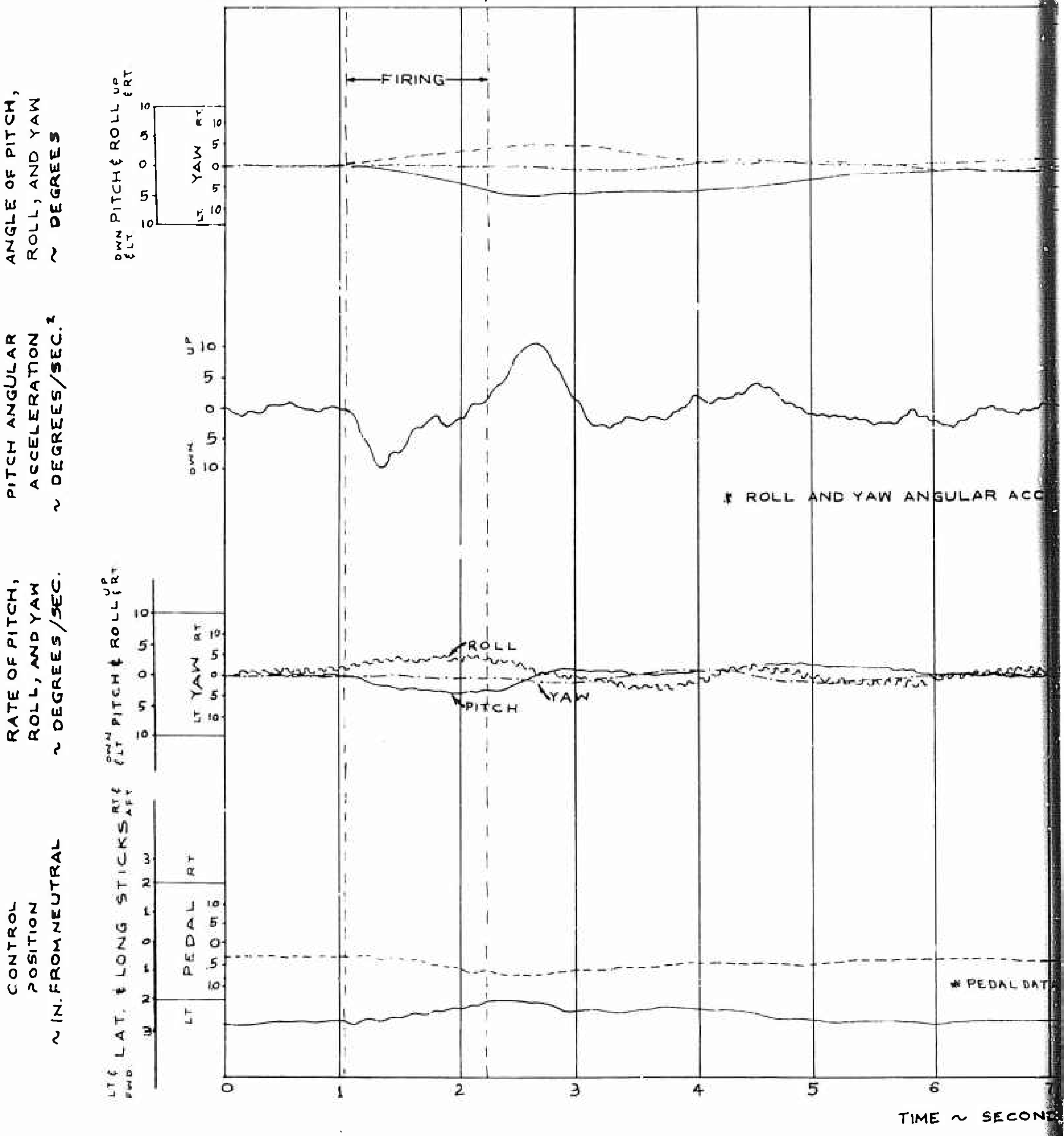
FIGURE NO. 75

TIME HISTORY OF WEAPONS FIRING

UH-1B, U.S.A., S/N 60-3589

ARMAMENT: XM-16 ROCKETS

CONFIGURATION: BOTH PODS, 14 ROCKETS



AVERAGE GROSS WEIGHT: 7025 LBS.
LONGITUDINAL C.G. LOCATION: 128.1 IN.
FLIGHT CONDITIONS: LEVEL FLIGHT
TRIM C.A.S.: 99.0 KTS.
DENSITY ALTITUDE: 6100 FEET
ROTOR SPEED: 324 RPM

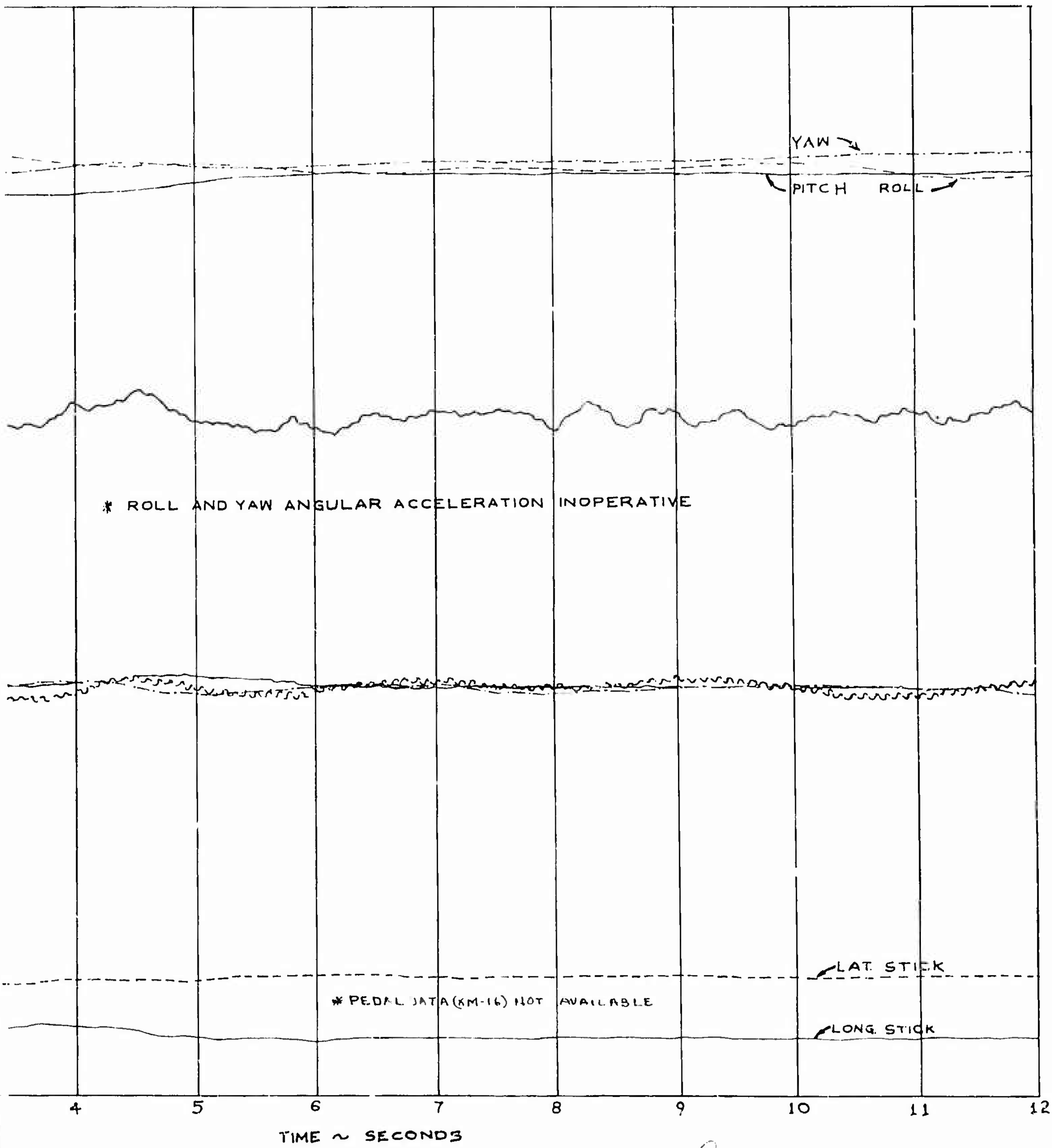


FIGURE NO.76

TIME HISTORY OF WEAPONS FIRING

UH-1B, U.S.A., S/N 60-3589

ARMAMENT: XM-16 ROCKETS

CONFIGURATION: BOTH PODS, 14 ROCKETS

AVERAGE GROSS W

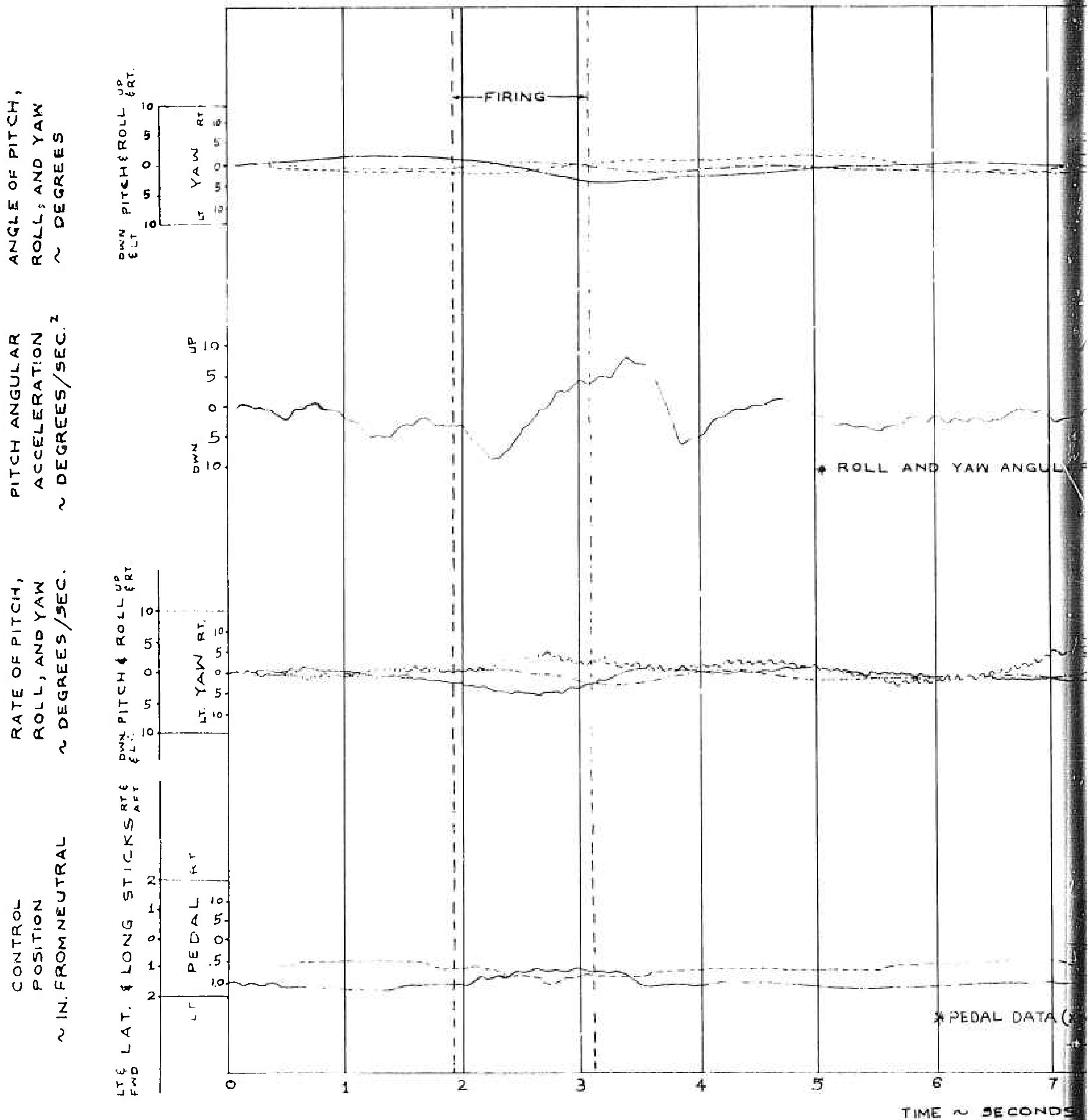
LONGITUDINAL C.G.

FLIGHT CONDITION

TRIM C.A.S.: 84.5

DENSITY ALTITUDE

ROTOR SPEED: 32



A

AVERAGE GROSS WEIGHT: 7350 LBS

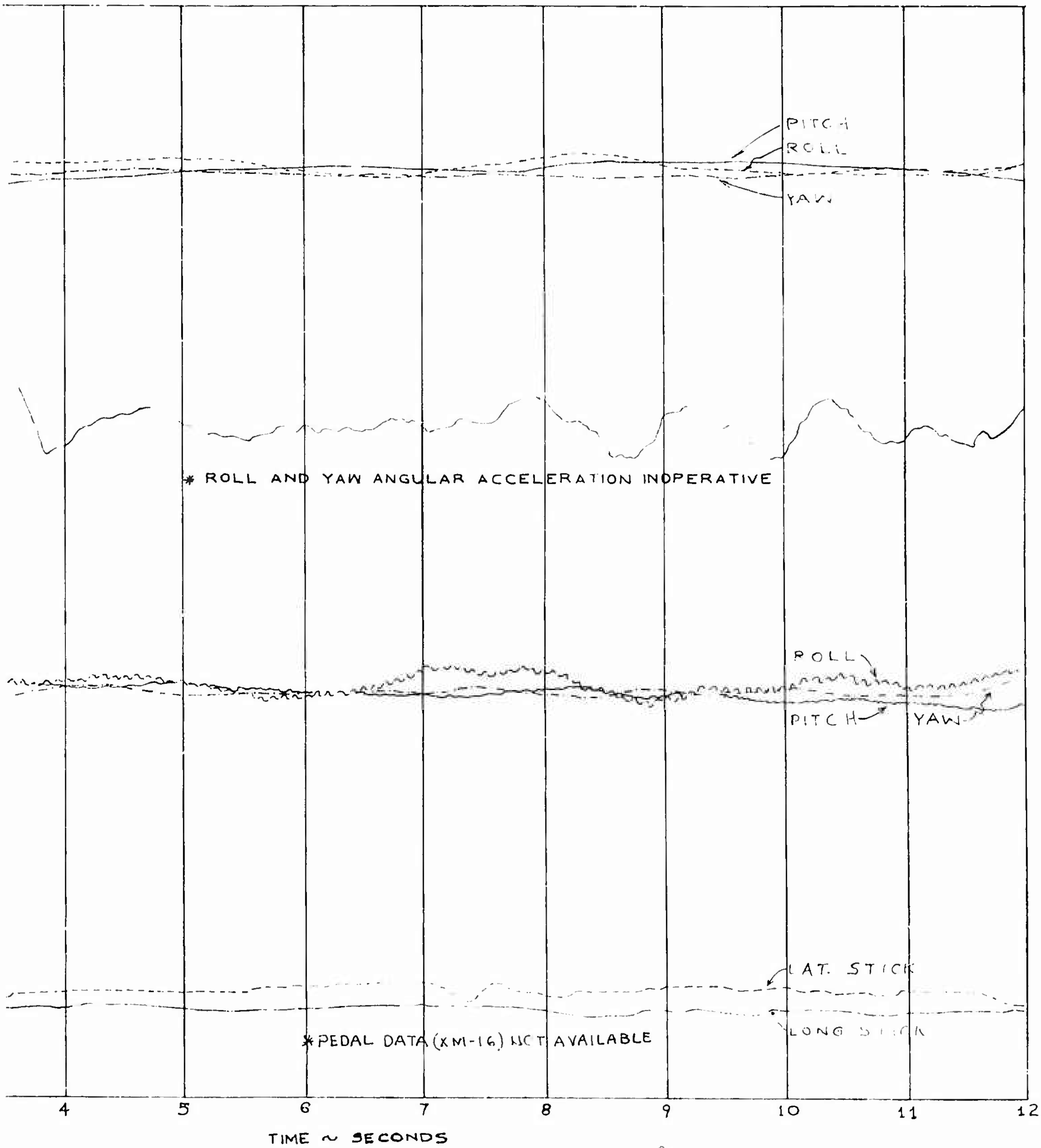
LONGITUDINAL C.G. LOCATION: 128.5 IN

FLIGHT CONDITIONS: 10° RIGHT SIDESLIP

TRIM C.A.S.: 84.5 KTS.

DENSITY ALTITUDE: 5840 FEET

ROTOR SPEED: 324 RPM



103

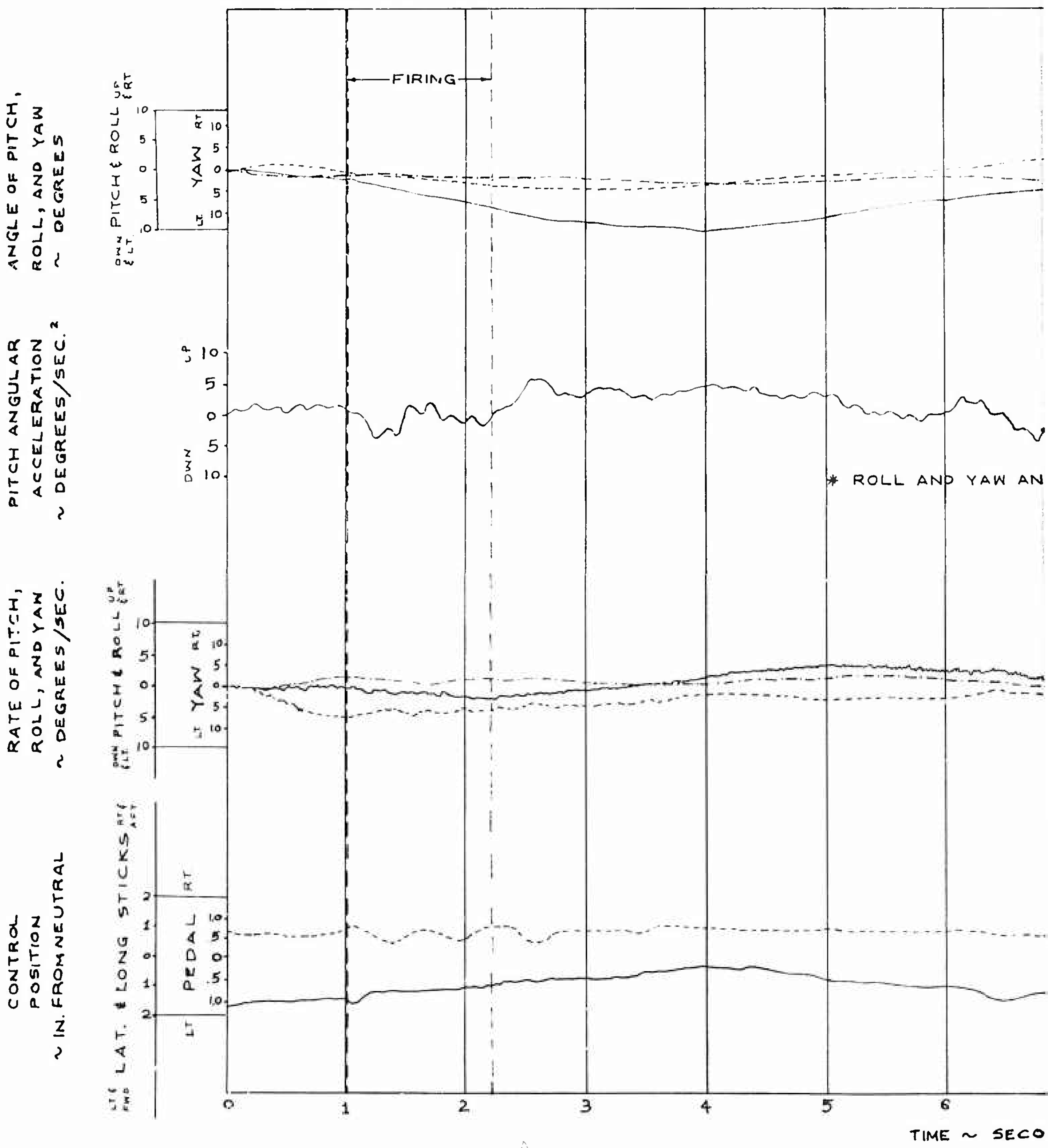
B

FIGURE NO. 77

TIME HISTORY OF WEAPONS FIRING

UH-1B, U.S.A., S/N 60-3589
ARMAMENT: XM-16 ROCKETS
CONFIGURATION: BOTH PODS, 14 ROCKETS

AVERAGE GROS
LONGITUDINAL
FLIGHT CONDIT
TRIM C.A.S.: 8
DENSITY ALTIT
ROTOR SPEED



A

AVERAGE GROSS WEIGHT: 7385 LBS.
LONGITUDINAL C.G. LOCATION: 128.5 IN.
FLIGHT CONDITIONS: AUTOROTATION @ MAX. R/D
TRIM C.A.S.: 89.5 KTS.
DENSITY ALTITUDE: 6000 FEET
ROTOR SPEED: 324 RPM

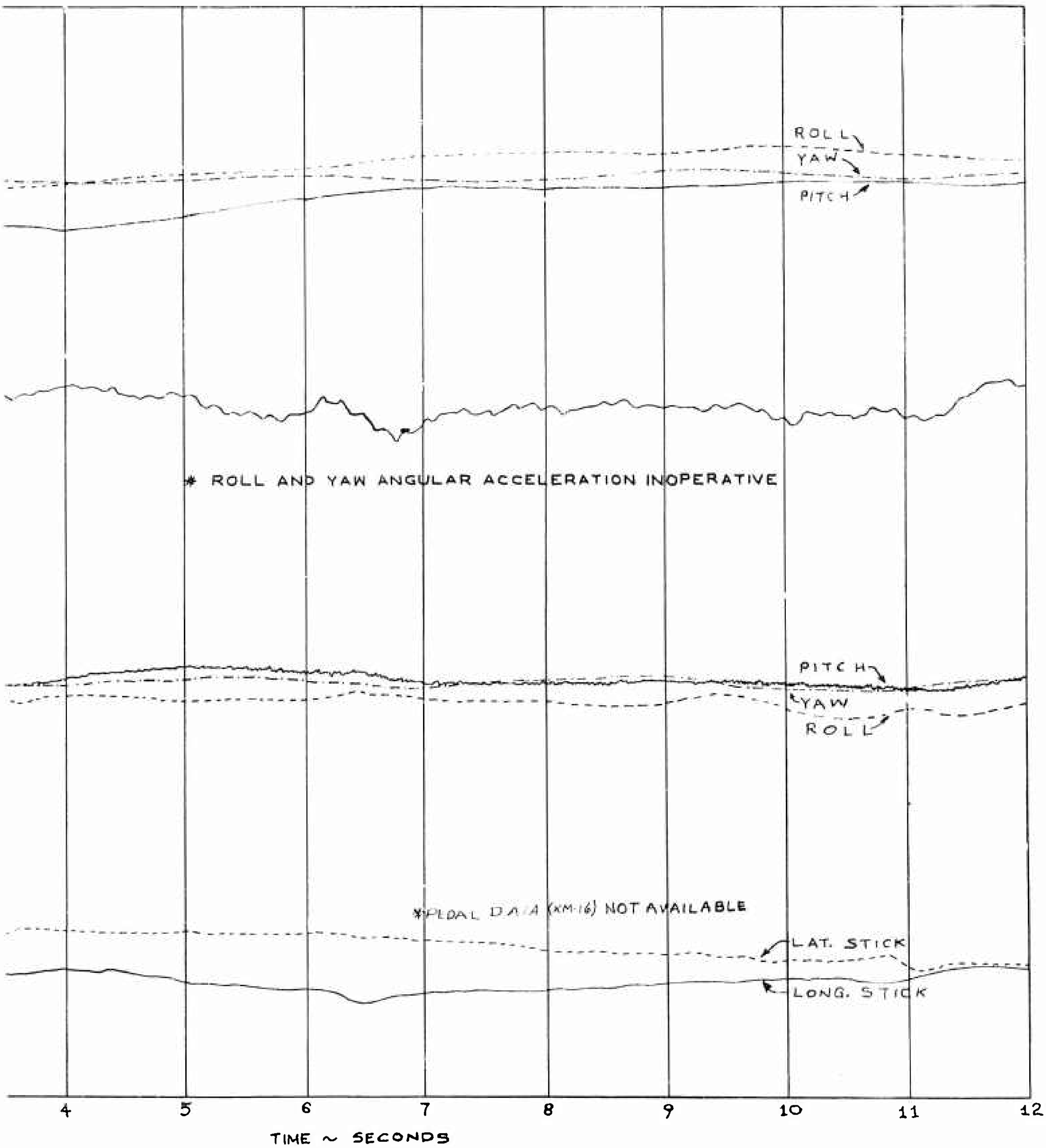
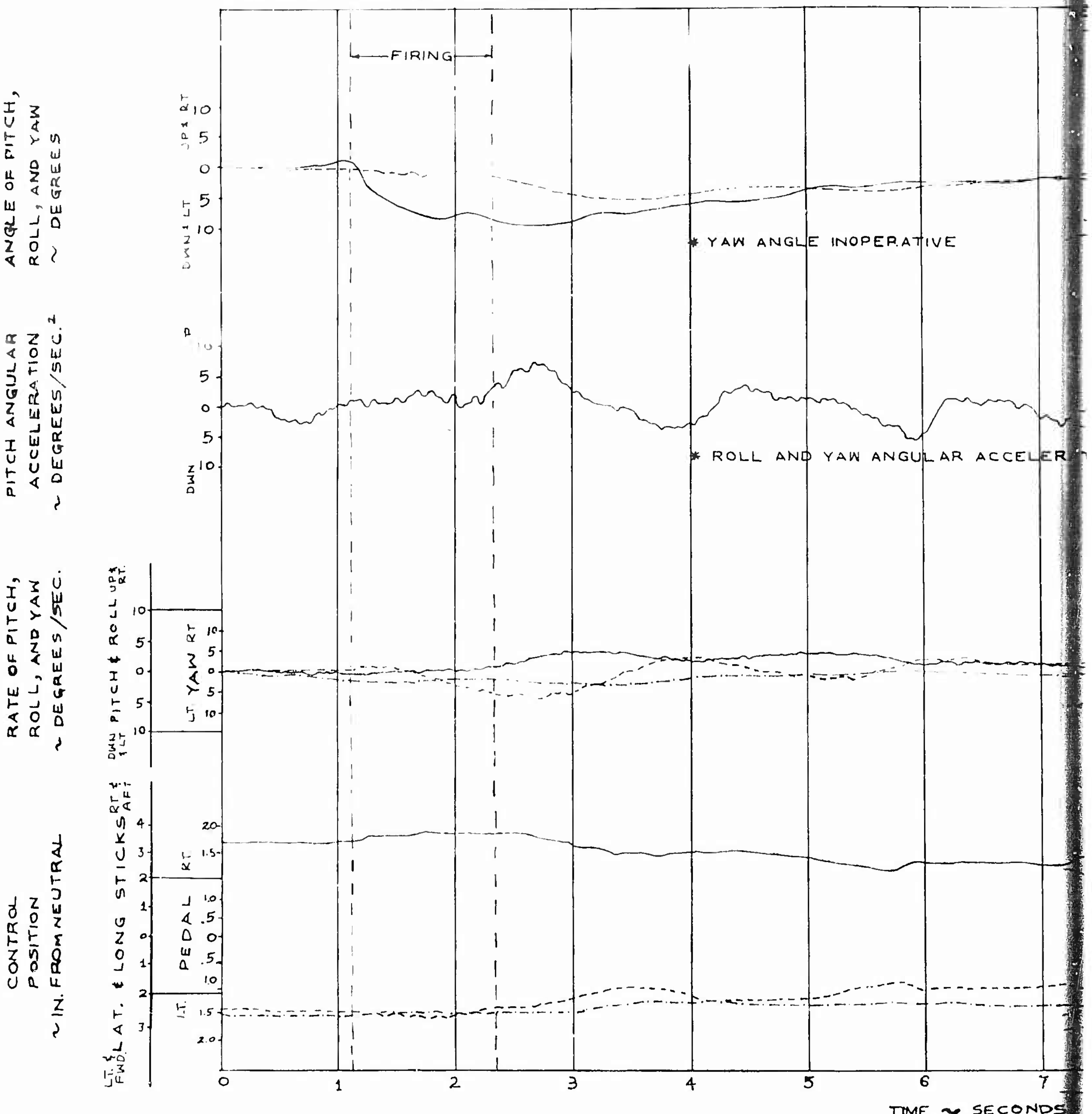


FIGURE NO. 78

TIME HISTORY OF WEAPONS FIRING

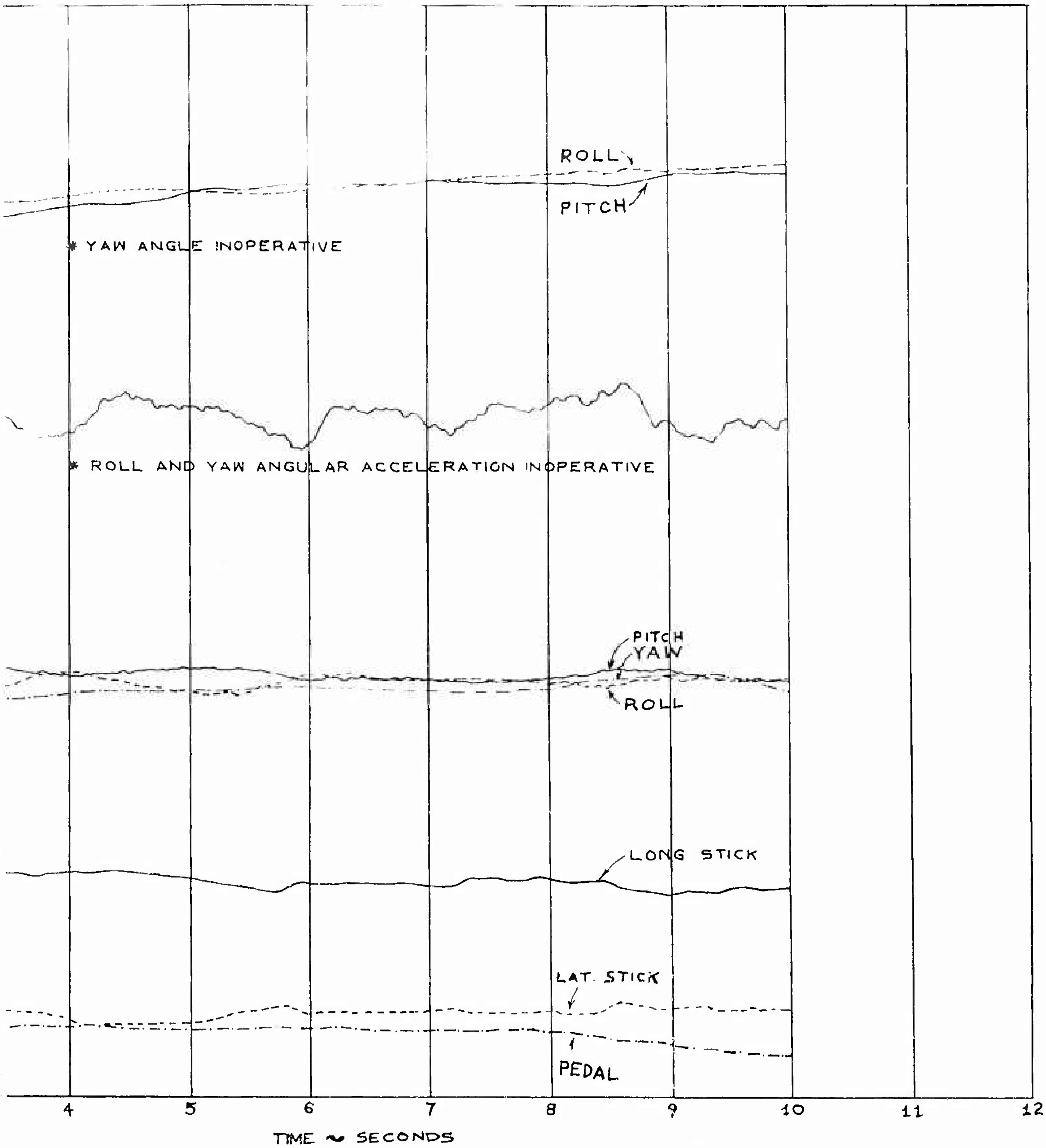
UH-1B, U.S.A., S/N 60-3589
ARMAMENT: XM-21 ROCKETS
CONFIGURATION RIGHT POD ONLY, 7 ROCKETS

AVERAGE GROSS WE
LONGITUDINAL C.G.
FLIGHT CONDITIONS
DENSITY ALTITUDE:
ROTOR SPEED 324



A

AVERAGE GROSS WEIGHT 7570 LBS.
LONGITUDINAL C.G. LOCATION 126.3 IN.
FLIGHT CONDITIONS: HOVER
DENSITY ALTITUDE: 5740 FEET
ROTOR SPEED: 324 RPM



B

FIGURE NO. 79

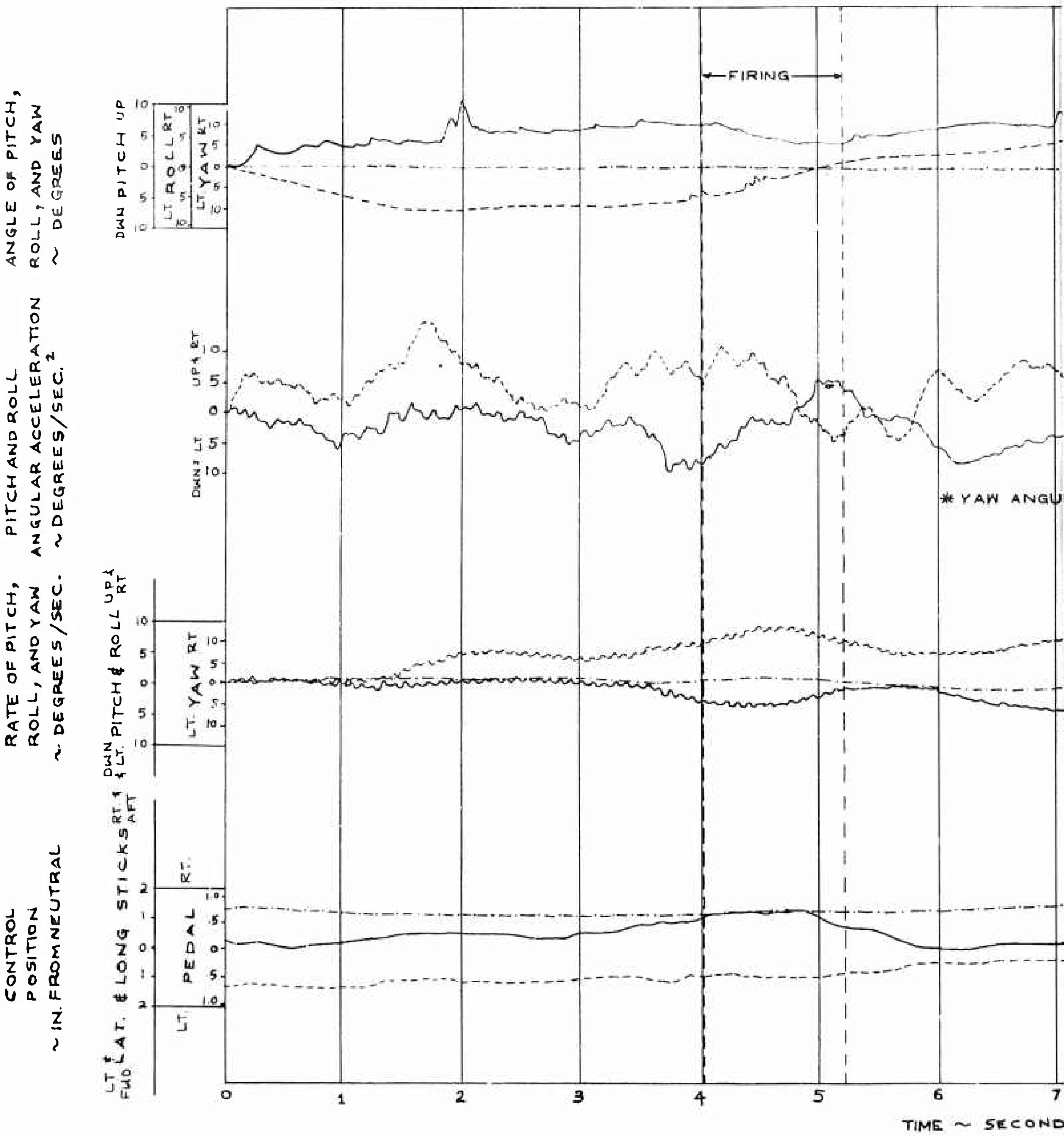
TIME HISTORY OF WEAPONS FIRING

UH-IB, U.S.A., S/N 60-3589

ARMAMENT XM-21 ROCKETS

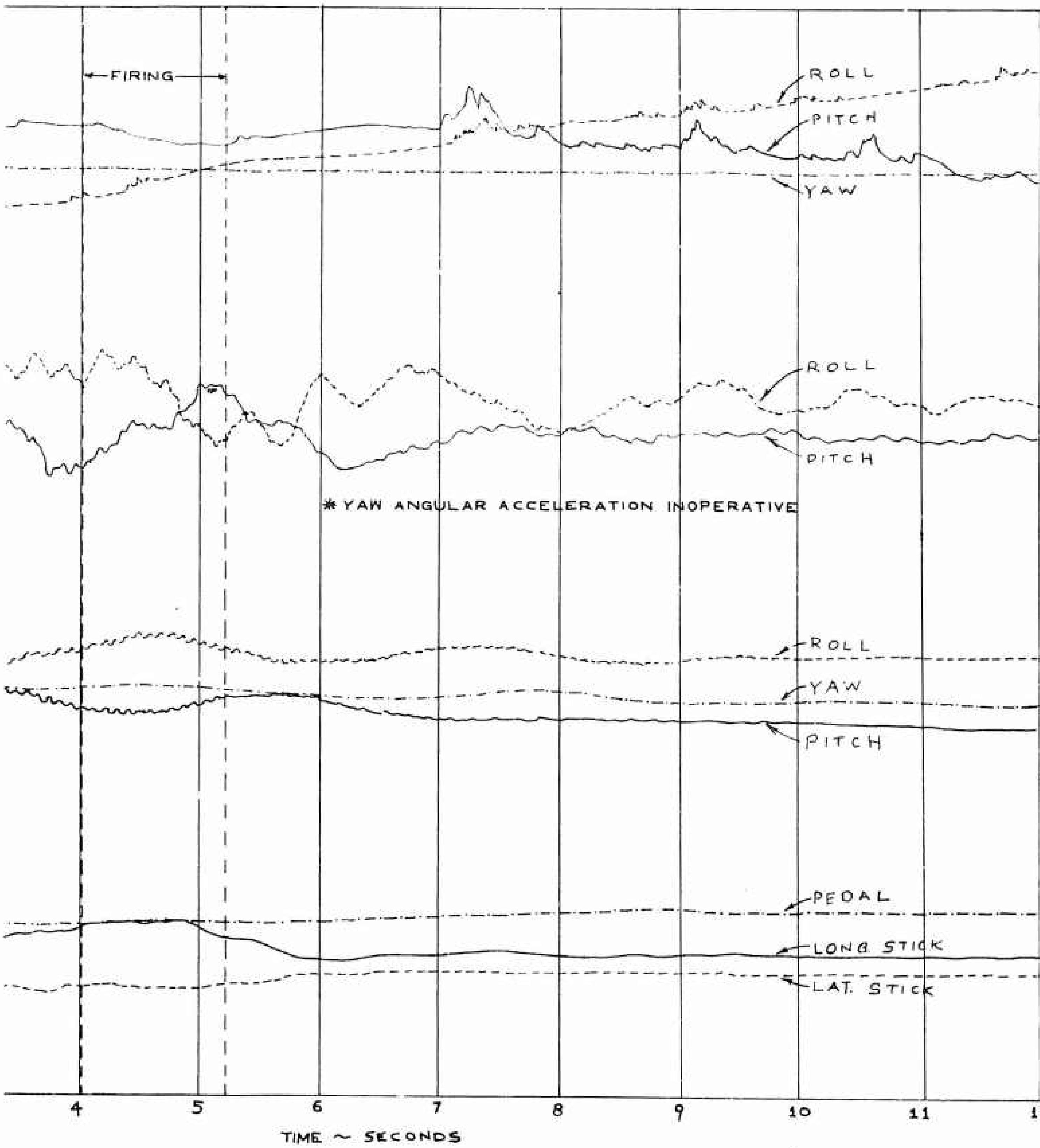
CONFIGURATION: BOTH PODS, 14 ROCKETS

AVERAGE GROSS
LONGITUDINAL C.G
FLIGHT CONDITION
TRIM C.A.S. 94.5 K
DENSITY ALTITUDE
ROTOR SPEED: 32



''NG

AVERAGE GROSS WEIGHT: 7290 LBS.
LONGITUDINAL C.G. LOCATION: 125.9 IN
FLIGHT CONDITIONS: MANEUVERING
TRIM C.A.S : 94.5 KTS.
DENSITY ALTITUDE: 6240 FEET
ROTOR SPEED: 324 RPM



B

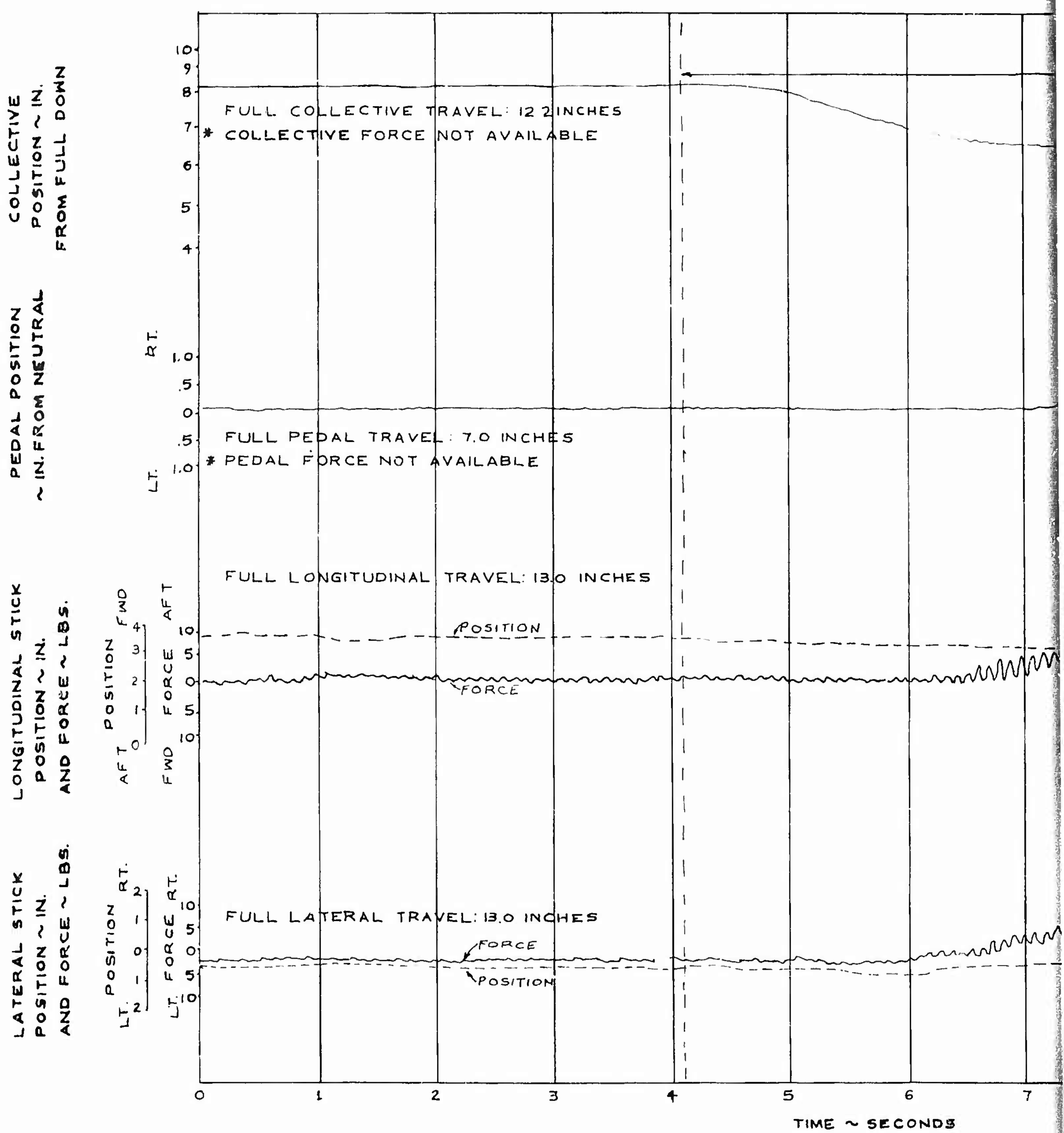
FIGURE NO. 80

TIME HISTORY OF BOOST-OFF FLIGHT

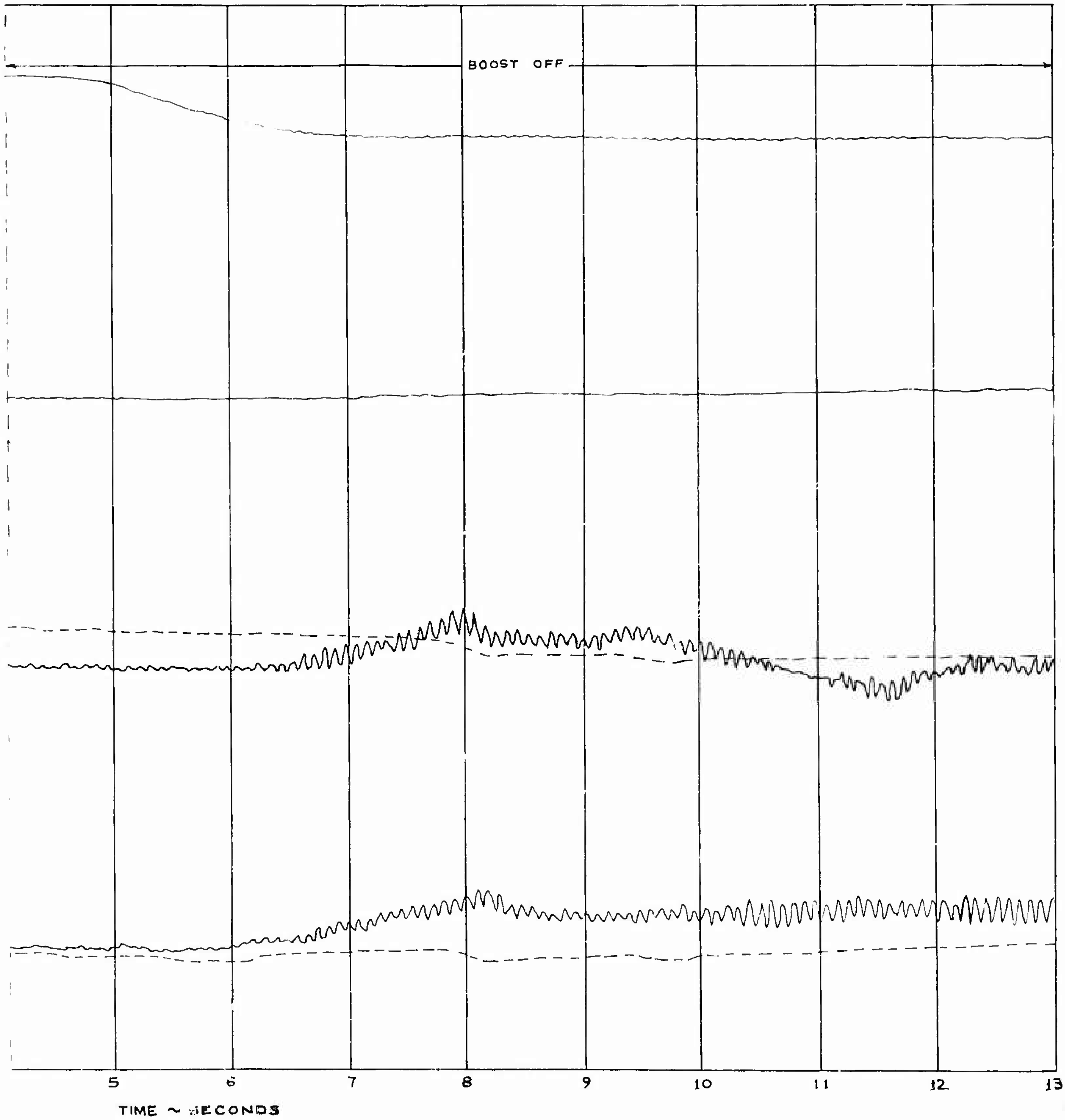
UH-1B, U.S.A., S/N 60-3589

ARMAMENT: XM-21 PODS FULLY LOADED

AVERAGE GROSS W
LONGITUDINAL C.G.
FLIGHT CONDITIONS
TRIM C.A.S. 94.5 KTS
DENSITY ALTITUDE
ROTOR SPEED: 324



AVERAGE GROSS WEIGHT: 7080 LBS.
LONGITUDINAL C.G. LOCATION: 130.9 IN.
FLIGHT CONDITIONS: LEVEL FLIGHT
TRIM C.A.S.: 94.5 KTS.
DENSITY ALTITUDE: 4340 FEET
ROTOR SPEED: 324 RPM



B

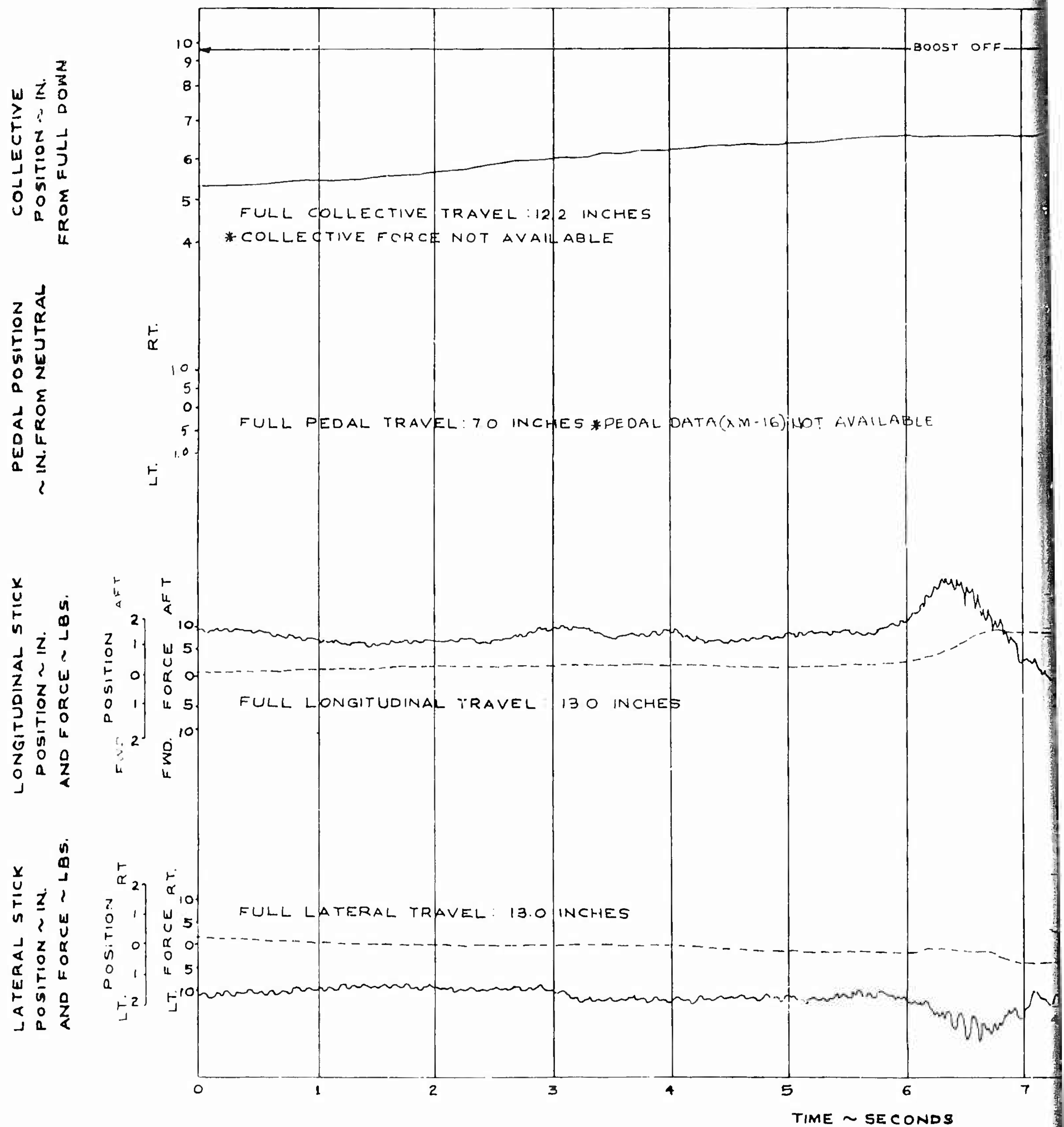
FIGURE NO. 81

TIME HISTORY OF BOOST-OFF FLIGHT

UH-1B, U S A, S/N 60-3589

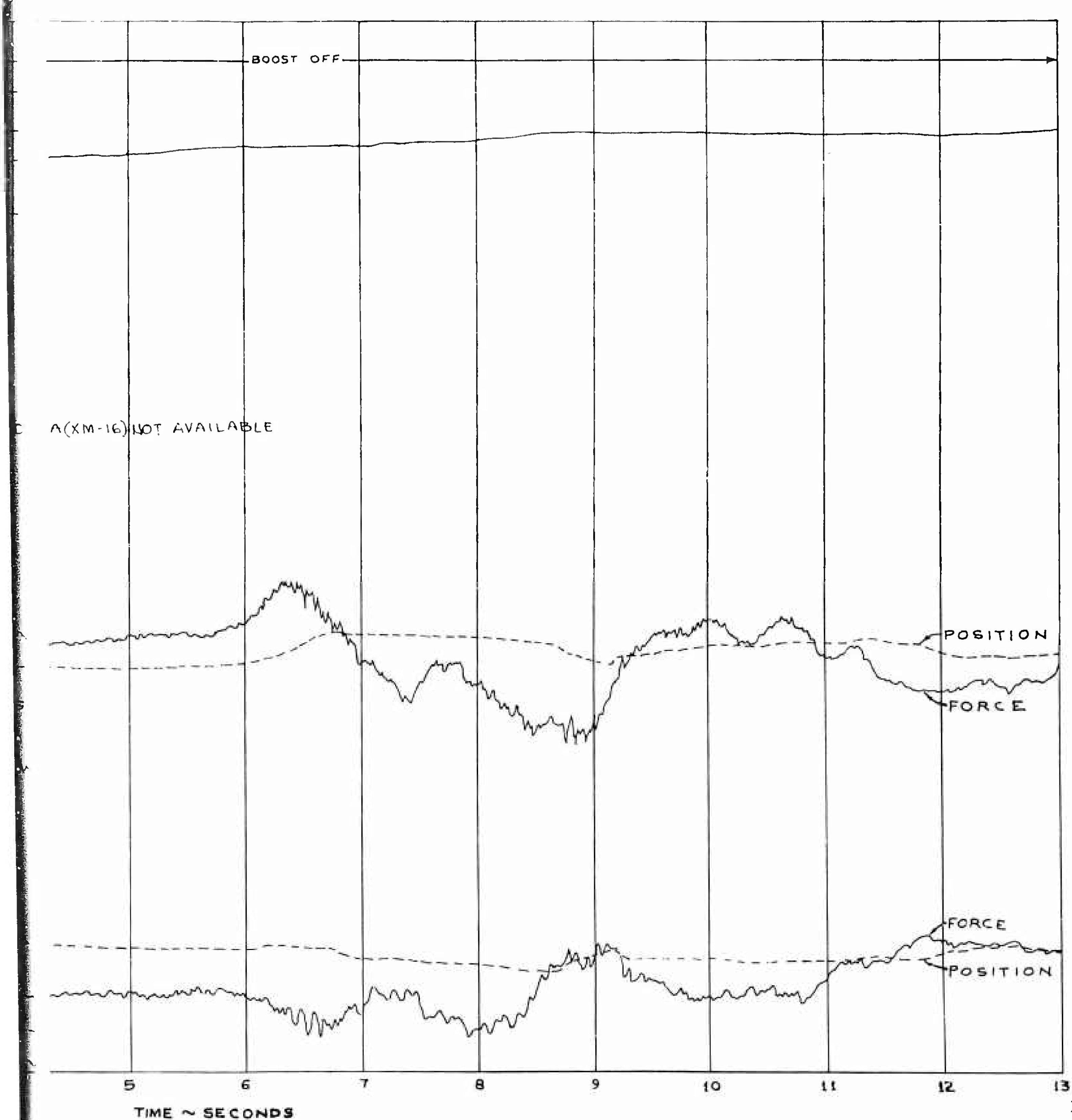
ARMAMENT: XM-16 PODS FULLY LOADED

AVERAGE GROSS
LONGITUDINAL C.G.
FLIGHT CONDITION
DENSITY ALTITUDE
ROTOR SPEED 32



A

AVERAGE GROSS WEIGHT 7015 LBS
LONGITUDINAL C.G. LOCATION 131.1 IN.
FLIGHT CONDITIONS TAKEOFF
DENSITY ALTITUDE 2520 FEET
ROTOR SPEED 324 RPM



APPENDIX II

DATA ANALYSIS METHOD

1.0 GENERAL

The equations and analysis method used to correct the performance of the helicopter to standard-day conditions are briefly described in this appendix.

The non-dimensional parameters used for data analysis are defined as follows:

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

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

$$\mu = \frac{1.689 \; V_t}{\Omega R}$$

where:

SHP = engine output shaft horsepower

ρ = air density, slugs/ft^3

A = total swept rotor disc area, ft^2

Ω = rotor angular velocity, radians/sec

R = rotor radius, ft

W = gross weight, lb

V_t = true velocity, kt

This non-dimensional method is useful only where compressibility effects are not significant. No significant compressibility effects were encountered during the test.

1.1 POWER DETERMINATION

The T53 gas turbine engine incorporates a hydro-mechanical torquemeter as an integral part of the reduction gearing on the compressor end of the engine. This torquemeter is essentially a piston which supplies pressure, in proportion to the output torque, on the contained hydraulic oil. To obtain a more accurate indication of torque, the pressure of oil vapor behind this piston is also measured and the difference between this pressure and the hydraulic oil pressure is found. The conversion from torquemeter pressure to torque in inch-pound was obtained from the test cell run of engine S/N LE-06202.

The equation from which output shaft horsepower was determined from inflight torquemeter and rotor rpm readings was derived as follows:

$$SHP = \frac{2\pi}{12 \times 33{,}000} \times N_E \times T$$

where:

SHP = output shaft horsepower

N_E = output shaft rotational speed - rpm

T = output shaft torque, in-lb

The torquemeter calibration as obtained from engine calibration data indicated that torque could be determined as the following function of torque pressure:

$$T = 228.6\ \Delta P$$

where: ΔP= torque differential pressure - psi

Rotor speed was determined from output shaft rotational speed as follows:

$$N_R = \frac{N_E}{20.37}$$

where:

N_R = rotor rotational speed - rpm

Combining the above expressions results in the following expression for determining output shaft horsepower:

$$SHP = \frac{2\pi \times 228.6 \times 20.37 \times N_R \times \Delta P}{12 \times 33{,}000}$$

During the test program, engine characteristics were defined by the curve of:

$$\frac{SHP}{\delta_{t_2}\sqrt{\theta_{t_2}}} \quad \text{versus} \quad \frac{W_f}{\delta_{t_2}\sqrt{\theta_{t_2}}}$$

where:

SHP = output shaft horsepower

δ_{t_2} = ratio of compressor inlet total pressure to standard pressure at sea level

θ_{t_2} = ratio of compressor inlet total temperature to standard temperature at sea level

Compressor inlet pressure or temperature instrumentation was not installed in the test aircraft. Since no pressure loss was noted in FTC-TDR-62-21 (Reference s), the test ambient pressure was taken as the test compressor inlet pressure. Also, since the compressor inlet temperature noted in FTC-TDR-62-21 was consistently 2 degrees centigrade (C) above ambient, the test compressor inlet temperature was taken as 2 degrees C above the test ambient temperature.

Level Flight and Specific Range:

Level flight speed-power correction was derived from the C_p, C_T, μ method. Each speed power was flown at a pre-determined C_T holding rotor speed constant. To maintain W/ρ approximately constant, altitude was increased as fuel was consumed.

Test-day level flight power airspeed data was corrected to standard-day conditions by the following method: The test day speed-power point was defined by the dimensionless parameters, Cp_t, CT_t, and μ_t. Correction of test-day power to standard-day conditions was made holding these coefficients constant on the standard day. It follows from this that the relationships below are true between test-day and standard-day conditions:

$$C_{P_t} = C_{P_s}, \quad C_{T_t} = C_{T_s}, \quad \mu_t = \mu_s$$

From these relationships and definitions of the particular terms the following relationships hold:

$$W_t/\rho_t = W_s/\rho_s, \quad \rho_s = \rho_t\ (W_s/W_t)$$

This last relationship permits establishing the standard-day density, ρ_s, which is required for presenting the test-day data at a standard gross weight, W_s. W_s is the weight used in the computation of the target C_T for each individual level flight test.

From the definition of the power coefficient, Cp, the following relationships can be derived:

$$SHP_t/\rho_t = SHP_s/\rho_s$$

$$SHP_s = SHP_t\ (\rho_s/\rho_t)$$

This last relationship then defines the standard-day power required for flying at the same thrust, power and speed coefficient as on the test day but under standard-day conditions. Each level flight speed-power point was corrected in this fashion to standard-day conditions at the target gross weight.

Specific range calculations were performed using the level flight performance curves presented in Figures 1 through 3, Appendix I and the specification fuel flow characteristics at 5-percent conservative presented in Report No. 204-099-712 (Reference v).

$$NAMPP = \frac{V_T}{W_f}$$

where:

NAMPP = nautical miles per pound of fuel

V_T = true airspeed in knots

W_f = fuel flow, pounds per ~~force~~ hours

APPENDIX III

TEST INSTRUMENTATION

1.0 Sensitive, calibrated instrumentation was installed and maintained in UH-1B, S/N 60-3589, by personnel of the Logistics Division of USAAVNTA. The following parameters were recorded:

a. Pilot's Panel

(1) Boom Airspeed

(2) Rotor Tachometer

(3) Angle of Sideslip

(4) Rate of Climb

(5) Boom Altitude

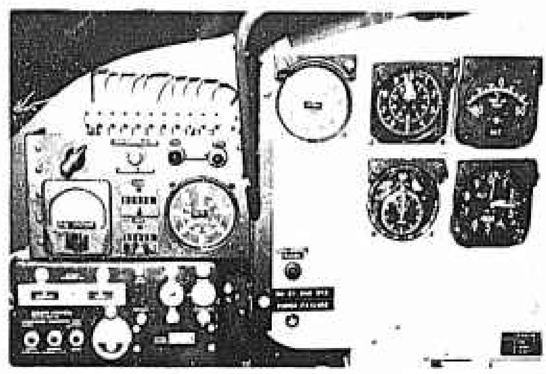


Photo 4- Engineer's Panel

b. Engineer's Panel

(1) Torquemeter (High and Low)

(2) Free Air Temperature

(3) Standard Airspeed

(4) Standard Altitude

(5) Fuel Flow (Stepper Motor System)

(6) Fuel Totalizer

c. Oscillograph

(1) Longitudinal Cyclic Control Position

(2) Lateral Cyclic Control Position

(3) Directional Control Position

(4) Collective Control Position

(5) Angular Pitch Acceleration

(6) Angular Roll Acceleration

(7) Angular Yaw Acceleration

(8) Rate of Pitch

(9) Rate of Roll

(10) Rate of Yaw

(11) Angle of Pitch

(12) Angle of Roll

(13) Angle of Yaw

(14) Angle of Attack

(15) Angle of Sideslip

(16) Normal C.G. Acceleration

(17) Vertical Vibration

(18) Lateral Vibration

(19) Rotor RPM (Blip)

(20) Pilot's Event Marker

(21) Engineer's Event Marker

(22) Voltage Monitor

(23) Longitudinal Cyclic Force

(24) Lateral Cyclic Force

2.0 The aircraft was equipped with an airspeed boom incorporating a swiveling pitot-static source and vanes for angle of attack and sideslip.

APPENDIX IV

GENERAL AIRCRAFT INFORMATION

1.0 AIRCRAFT PRINCIPAL DIMENSIONS - MAXIMUM

a. Length

(1)	Overall (main rotor fore and aft and tail rotor horizontal)	52.9 ft
(2)	Overall (main rotor fore and aft and tail rotor vertical) to end of tail skid	49.8 ft
(3)	Nose of cabin to tail skid	39.5 ft
(4)	Nose of cabin to tail rotor horizontal	42.9 ft
(5)	Skid gear	10.8 ft

b. Width

(1)	Skid gear	8.4 ft
(2)	Synchronized elevator	9.3 ft
(3)	Stabilizer bar	9.0 ft

c. Height (to static ground line)

(1)	Tip of main rotor forward blade to ground	8.4 ft
(2)	Tip of main rotor blade static position	13.2 ft
(3)	Tip of forward main rotor blade, tied down position	18.8 ft
(4)	Tip of tail rotor blade, vertical position	14.6 ft
(5)	Tail skid to ground	3.9 ft
(6)	Top of cabin	6.8 ft
(7)	Cabin base to ground	1.0 ft

d. Diameters

(1) Main rotor	44.0 ft
(2) Tail rotor	8.5 ft
(3) Stabilizer bar	9.0 ft

e. Miscellaneous

(1) Main rotor airfoil	NACA 0012
(2) Main rotor chord	21 in
(3) Swept disc area	1520.5 ft^2
(4) Gear ratio (engine to main rotor)	20.37 to 1
(5) Gear ratio (engine to tail rotor)	3.97 to 1
(5) Solidity ratio	.0506
(7) Tail rotor airfoil	NACA 0012
(8) Tail rotor chord	0.7 ft

2.0 POWER PLANT

The test aircraft was powered by a T53-L-9A gas turbine engine, Serial Number LE-06202. The engine is comprised of an inlet and reduction gear section, an axial-contrifugal compressor, an angular vaporizing combustor, a gas producer turbine, a free power turbine, and an exhaust diffuser. The compressor consists of five axial stages and one centrifugal stage. The engine installation is rated to an output torque valve equivalent to 1100 horsepower at 6600 rpm for takeoff and 900 horsepower at 6400 to 6600 rpm for continuous operations.

3.0 OPERATING LIMITS WITH XM-16 AND XM-21 ARMAMENT SUBSYSTEMS INSTALLED

a. Operating instructions were obtained from Technical Manual TM 55-1520-211-10.

b. Maximum airspeed was 100 KCAS.

c. Engine speeds were 6400 - 6600 rpm.

d. Gross weight limits were 6000 pounds minimum and 8500 pounds maximum.

e. C.G. limits were Fuselage Station 125 maximum forward and Station 133 maximum aft.

f. Jettison limits of the LAU-32A/A rocket pods were symmetrical both left and right and were as follows:

Airspeed - KCAS	Sideslip Angle - deg
60	10.0
70	6.5
80	5.0
90	4.0
100	3.5

4.0 ARMAMENT SUBSYSTEM

4.1 GENERAL

The UH-1B airframe can sustain a total load of 750 pounds on each side external stores mount. This occurs at Fuselage Station (F.S.) 136 inches, butt line (B.L.) 65 inches, water line (W.L.) 21 inches. The limit load factors that may be applied are: 4g down, 2g up, 1.5g lateral, and 4g forward. The MA-4A bomb rack has a maximum load capability of 10,000 pounds and can carry a load up to 1600 pounds, on the UH-1B.

4.2 DESIGN CRITERIA

a. External Stores

Item	XM-16	XM-21
Gun mount	2	2
Machine guns	4 (M-60C)	2 (XM-20)
Ammunition chutes	4	2
Rack assemblies	2	2

a. External Stores (Cont'd)

Item	XM-16	XM-21
Cables	2	2
Rocket launchers (LAU-32A/A)	2	2
Rocket (2.75-inch FFAR)	14	14
Total Weight (pounds)	640.6	648.3

b. Internal Stores

Item	XM-16	XM-21
Sighting station	1	1
Control panel	1	1
Intervalometer	1	1
Ammunition boxes with covers	12	12
Ammunition box rack	1	1
Rounds of linked ammunition	6000	6000
Total weight (pounds)	460.6	523.9

c. Machine Guns

Characteristic	XM-16	XM-21
Weight	21.0 lb	50.0 lb
Length	43.5 in	31.5 in
Rate	550 rd per min	2000 to 4000 rd/min
Maximum depression	66 deg	90 deg
Maximum elevation	+9 deg	+10 deg
Maximum traverse		
Inboard	12 deg	12 deg
Outboard	70 deg	70 deg

d. LAU-32A/A Rocket Launcher

Characteristic	XM-16 and XM-21
Diameter	9.8 in
Length-overall	49.9 in
Capacity (2.75-in FFAR)	7
Weight - empty	47.5 lb
Weight - loaded	170.0 lb
Suspension	14 in and centered

e. 2.75-inch FFAR (Rocket)

Characteristic	XM-16 and XM-21
Length	48.0 in
Diameter	7.0 in
Motor length	39.4 in
Weight	17.5 lb
Warhead length	8.5 in
Loaded C.G.	19.5 in. from nose
First rocket pair fired	200 milliseconds after triggers energized
Ripple fired complement time	1.167 sec

5.0 WEIGHT AND BALANCE

The test aircraft was weighed and balanced in a closed hangar with the armament subsystems installed. A typical service loading for the two subsystems was as follows:

a. XM-16 Armament Subsystem Installed

Item	Weight-lb
Operating weight	4787
Pilot and copilot @ 200 lb per man	400
155 gallons of fuel (fuel weight = 6.50 lb/gal)	1008
External and internal components installed including 6000 rounds of ammunition and 14 rockets	1101
Total Weight	7296 lb

b. <u>XM-21 Armament Subsystem Installed</u>

Item	Weight-lb
Operating weight	4787
Pilot and copilot @ 200 lb per man	400
155 gallons of fuel (fuel weight = 6.50 lb/gal)	1008
External and internal components installed including 6000 rounds of ammunition and 14 rockets	1172
Total Weight	7367 lb

APPENDIX V

SYMBOLS AND ABBREVIATIONS

Symbol	Definition	Units
C_P	Power coefficient	non-dimensional
C_T	Thrust coefficient	non-dimensional
μ	Rotor tip speed	non-dimensional
SHP/shp	Shaft horsepower	ft-lb/min
ρ	Air density	slugs/ft^3
A	Rotor disc area	ft^2
Ω	Angular velocity	radians/sec
R	Rotor radius	ft
W, GW	Gross weight	lb
V_t	True airspeed	kt
N_E	Output shaft rotational speed	rpm
T	Output shaft torque	in-lb
ΔP	Torque differential pressure	psi
N_R	Rotor rotational speed	rpm
δ	Pressure ratio	--
θ	Temperature ratio	--
W_f	Fuel flow	lb/hr
KIAS	Knots indicated airspeed	kt
KCAS	Knots calibrated airspeed	kt
KTAS	Knots true airspeed	kt
NAMPP	Nautical air miles per pound of fuel	--

Symbol	Definition	Units
1/rev	Cycles per revolution	cycles/rev
C.G.	Center of gravity	in
rpm	Revolution per minute	rpm
V_{NE}	Airspeed not to exceed	kt
S.A.	Single amplitude	g
freq	Frequency	cycles/sec
IGE	In ground effect	--
rd/min	Rounds per minute	--
Subscript		
s	Standard-day conditions	
t	Test conditions	

APPENDIX VI

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	Iroquois Project Manager U. S. Army Materiel Command

13 ABSTRACT Engineering flight tests of the UH-1B helicopter equipped with the XM-16 and XM-21 armament subsystems were conducted by the U.S. Army Aviation Test Activity (USAAVNTA). The overall objective was to determine the effect of the installation of the subsystems on the UH-1B, including the existence of any safety-of-flight conditions and performance losses. Performance data showed that both armament subsystems caused an appreciable drag increase. The XM-16 caused a greater reduction in specific range than the XM-21. Compared with performance of clean UH-1B at 8000 pounds gross weight, 5000 feet altitude, and 324 rotor rpm, the installation of the XM-16 and XM-21 resulted in specific range reductions of 15 percent and 12 percent respectively. Compared with clean UH-1B data (Report FTC-TDR-62-13), stability and control data showed no appreciable changes in flying characteristics of the UH-1B equipped with either armament subsystem. Firing tests showed that both armament systems could be fired safely within the flight envelope established by the contractor. Vibration characteristics were satisfactory under all conditions tested except for the lateral 4 cycles-per-revolution vibration with the XM-21 armament subsystem installed. The vibration level at all forward airspeeds slightly exceeded the 0.15-g limitation of MIL-H-8501A. Hydraulic boost-off tests in hover, takeoff, climb, level flight, and landing were investigated. Qualitative pilot comments describing the helicopter's flying qualities with the boost off with either armament subsystem indicated that collective forces were high and could not be maintained for an extended period. The only practical method of landing was to execute a run-on landing. Attempting to transition to a hover resulted in over control and incipient loss of control due to high cyclic forces. The performance data generated in this evaluation should be incorporated in the Operator's Manual.

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