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RDT&E PROJECT NO. 1F141807D174
USATECOM PROJECT NO. 4-6-0300-0
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U.S. ARMY
TEST & EVALUATION COMMAND

ENGINEERING FLIGHT EVALUATION OF THE BELL MODEL 209 ARMED HELICOPTER

FINAL REPORT

MAY 1966

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PROJECT PILOT

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

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ABSTRACT

This report presents the results of an engineering flight evaluation conducted to determine the technical engineering flight characteristics of the prototype Model 209, S/N N209J, HueyCobra weapons helicopter. This evaluation was conducted by the U. S. Army Aviation Test Activity (USAAVNTA), Edwards Air Force Base, California. Tests were conducted at Edwards Air Force Base, California. Twenty-nine flights were made for a total of 32 hours flying time during the period 13 November through 1 December 1965. The USAAVNTA was assigned responsibility for preparing the test plan, executing the test and preparing the test report.

Although the performance and flight characteristics did not conform with the values predicted by the contractor's technical reports, the results of these tests show that the Cobra design offered speed, maneuverability, good fields of vision from the cockpit, and other desirable armed aircraft characteristics not presently available from any helicopter in the U. S. Army inventory. The maximum (power limited) level flight airspeed at sea level with no external stores and the landing gear retracted was 162 knots true airspeed. Acceptable vibration levels and flight characteristics for a weapons platform were present during all test conditions which included the limit dive speed of 190 knots calibrated airspeed (KCAS).

The major problem areas included less-than-optimum high speed handling qualities, high noise levels in the aft cockpit, a front seat "sidearm" cyclic that was unsatisfactory because of the force arrangement, marginal cockpit ventilation and a cyclic force trim that was unsatisfactory because lateral forces could not be trimmed to zero.

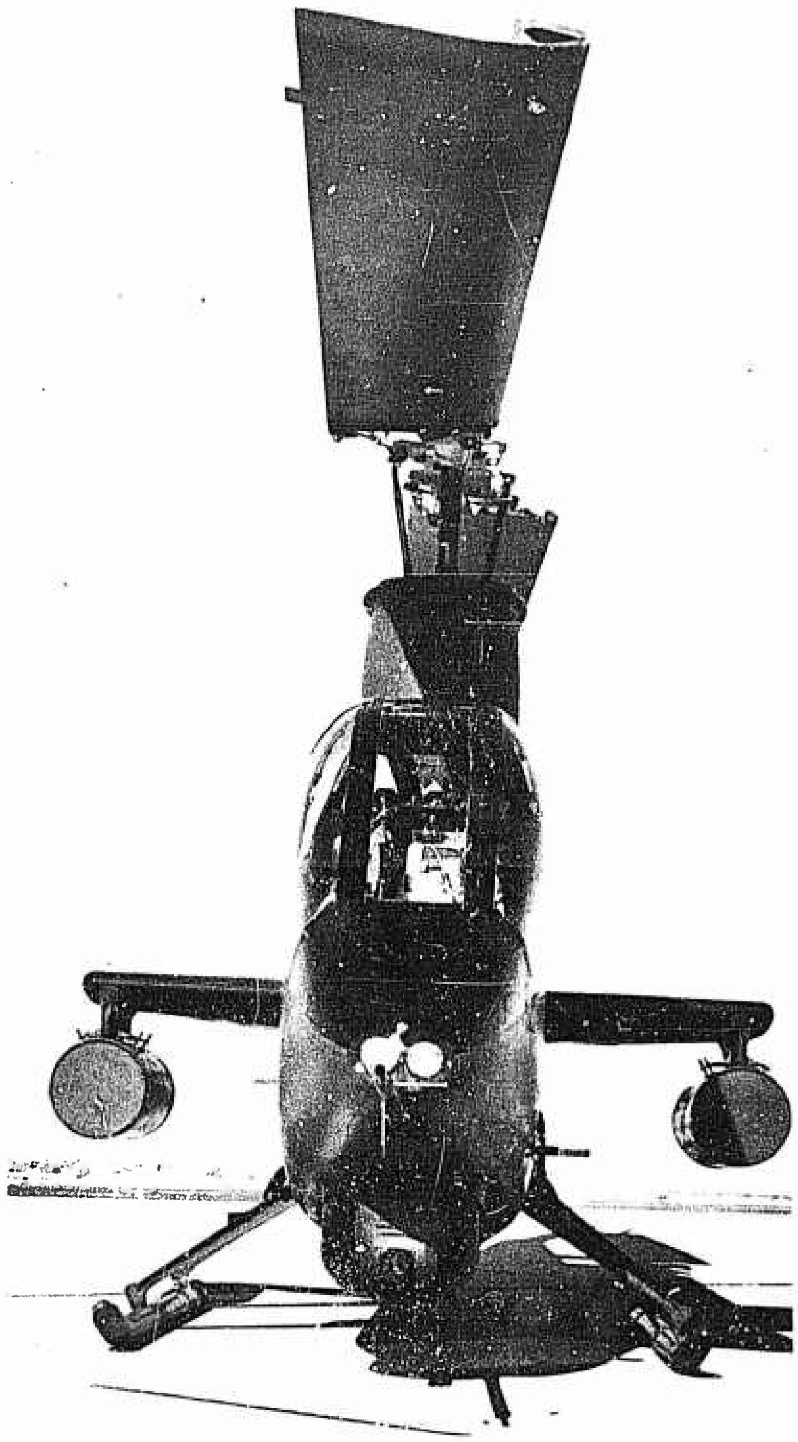
The limited contractor development program which preceded this evaluation resulted in limitations that did not allow evaluation of the design during weapons firing, touchdown autorotations, autorotation entries at speeds above 150 KCAS and flight at extreme center-of-gravity locations.

Additionally, the contractor's full structural demonstration was not complete. Development work remained to be accomplished in the areas of fatigue test and flight loads.

Generally, performance levels were somewhat less than the contractor's predicted values. Low speed performance, i.e., hover and climb flight, was similar to that of the UH-1 B/540 helicopters. High speed performance was, of course, considerably improved.

The tests showed that Automatic Stabilization Equipment (ASE) was required to provide adequate lateral-directional damping for a weapons platform at speeds above 120 KCAS. Safe flight was possible, however, in the event of ASE failure at high speed.

COBRA BELL 209



PART I General

A. REFERENCES

A list of references will be found in Part III, Annex A.

B. PURPOSE OF TEST

The purpose of this test was to quantitatively determine the flight and performance characteristics of the Bell Model 209 "Cobra" helicopter. In addition, maneuvers were performed to allow the comparison of agility characteristics with two other designs.

C. DESCRIPTION OF MATERIEL

1. Airframe

The test item airframe (S/N N209J) provided by the contractor was one of a kind and was specially configured for weapons carrying. The configuration featured a very narrow fuselage with small tapered wings (with two external store stations per wing) and an integral chin turret; accommodation was provided for a crew of two, pilot and gunner, with a tandem seating arrangement. The gunner accupied the forward station. During this evaluation, one station, the outboard, on each wing was utilized to carry a 19-round 2.75-inch FFAR rocket pod (LAU 3A/A).

Normal flight controls, similar to those in the UH-1 helicopter, were installed at the pilot's station. In the gunner's compartment, sidearm collective and cyclic controls allowed the central area of the cockpit to be used for the installation of weapons sighting systems.

A retractable skid gear was fitted to the test article. During this evaluation, the primary configuration tested was with the gear down and with fairings installed. Sufficient data was collected to determine the characteristics of the clean configuration with the gear up and with no external stores.

Two primary mission gross weights were used for the majority of this evaluation. Both included two unfaired 19-round rocket pods with the landing gear fixed down and faired. The light mission gross weight was 8100 pounds and the heavy mission gross weight was 8800 pounds.

At the time of this evaluation, the airframe was in a comparatively early stage of contractor test and development. A set of suggested flight limits that were the result of 68 hours of flight prior to these tests was provided (See Part III, Annex D).

2. Engine-Rotor System

The engine that was installed in the airframe for this evaluation was a prototype YT53-L-13, Serial Number 3. The engine did not conform to the T53-L-13 production configuration but did have similar power available characteristics.

The rotor system and dynamic components were similar to those procured with the FY 1966 UH-1B helicopters. The Model 540 main rotor system was 44 feet in diameter with 27 inch chord blades. The flight control system was considerably different from that of a standard UH-1B. No stabilizer bar was fitted and provisions were incorporated for electronic automatic stabilization equipment (ASE) for all three aircraft axes. Only the lateral and yaw channels were used during this evaluation because the longitudinal channel was not sufficiently developed for evaluation. None of the channels had been optimized for gain settings or other characteristics. The method of introducing cyclic inputs to the swash plate was different than in the standard UH-1B and was accomplished without mixing the longitudinal and lateral control commands.

D. BACKGROUND

The Department of the Army directed the U. S. Army Materiel Command (USAMC) to conduct an expedited flight test evaluation of a selected group of three helicopters to fulfill the immediate requirement for an armed helicopter. In October 1965, USAMC assigned this program to the U. S. Army Test and Evaluation Command (USATECOM) for testing by the U. S. Army Aviation Test Activity (USAAVNTA), under the technical direction of a USAMC appointed representative who had full responsibility for the conduct of the flight test program (References 9 and 10). The Plan of Test of the Armed Helicopters (Reference 11) was submitted by USAAVNTA 28 October 1965 and approved 8 November 1965. The test program was conducted at Edwards Air Force Base, California, from 13 November to 1 December 1965. An interim summary report of the combined armed helicopters test results (Reference 12) was submitted by USAAVNTA on 6 December 1965 to the Chairman, Improved Armed Helicopter Evaluation Group, Hq, USAMC. The contractor's UH-1 "Cobra" design, which had been developed under a company initiated program, was one of the three designs tested. This report presents the final results of the engineering flight evaluation of the Model 209, "Cobra" armed helicopter.

E. FINDINGS

1. General

The findings of this report can, to some degree, be related to the capability of the FY 1966 UH-1B helicopters equipped with the Model 540 rotor system. Comparison is valid, principally in the area of low speed performance, because the dynamic components are very similar. The Cobra, however, represents a considerable extension in speed capability using these components.

During this evaluation, several tests were conducted to investigate agility. Most of these tests were original efforts to provide the measurement of this characteristic. For this reason, both the test techniques and analysis methods were developed during the testing. Reflection on the results has indicated that modification of the techniques would have produced more meaningful results. The data presented, however, reasonably represents the characteristics of the helicopter during the maneuvers that were performed.

2. Cockpit

a. Pilot's Station - The pilot's cockpit was relatively easy to enter and exit using the handholds and steps that were provided on the right hand side of the aircraft. The steps, however, were configured to retract and extend with the landing gear. If the air-

craft were to be procured with a fixed gear, redesign of the step arrangement would be necessary.

The armored seat was adjustable up and down only. The seat adjustment for an average size pilot was satisfactory but it was doubtful that a large pilot would fit into the seat without having his head touch the top of the cabin. The seat was comfortable and would enhance the mission capability from a pilot fatigue standpoint. With the side panels of the armored seat raised, however, the seat was unsatisfactory because the pilot's cyclic control movements were restricted. This would increase pilot fatigue and limit maneuverability. Rudder pedals were adjustable fore and aft and the adjustment appeared to be adequate. Cyclic control position was not adjustable. For an average size pilot, the seat and control adjustments were satisfactory.

The canopy hold open and locking mechanism was less than optimum and a secondary positive lock had been provided. Canopy jettison capability was provided.

With the seat adjusted to the upper limit, the view of the warning lights along the top of the instrument panel was blocked by the instrument panel glare shield.

The caution panel was mounted on the right side quarter panel. This made it difficult to identify the caution lights with direct sunlight shining on the panel. The caution panel should be relocated.

The rest of the instrument panel presentation was adequate but should be optimized by a cockpit mock-up board if a configuration is finalized and procured.

Both cockpits were equipped with a tool for breaking plexiglass in case of a crash which would jam the canopy mechanism or if the helicopter rolled onto its side, block either the pilot's or copilot's exit.

A ventilation system was provided by a flush air inlet on the right side of the helicopter and ram air was boosted by an electrically driven blower. The pilot had an adjustable outlet on his instrument panel and deck outlets on each side of the cockpit. Air was exhausted out of the cockpit area into the compartment just aft of the pilot. This flight evaluation was conducted during the month of November at Edwards Air Force Base, California. Ambient temperatures were cool and the ventilation was satisfactory. Under summer conditions of higher ambient temperatures, however, it was doubtful that the present ventilation system would be adequate. The ventilation inlet was in close proximity to the rocket pods. During rocket firing, it is probable that gases from the rocket motors would be carried into the cockpit through the ventilation system. Defogging was rapid and adequate as configured. The heating system was not installed during the evaluation and could not be evaluated.

The majority of the avionics panels were located on the right hand console. This was unsatisfactory because avionics selection and tuning required the pilot to fly left handed while tuning radios. The pilot also had to turn his head to the right to locate the avionics. This distracted his attention from the instrument panel and flight path.

Due to the large glass area, the field of view from the pilot's cockpit was very good. The overhead structural members did not detract from the good field of view.

The noise level at the pilot's station was higher than that experienced at the gunner's station. Even with a form fitted helmet, there was a ringing sensation in the ears after a flight. A form fitted helmet and the use of issue ear plugs provided adequate ear protection. Using an issue helmet without additional ear protection, noise levels were unsatisfactory. The ventilation blower increased the noise level in the cockpit.

The circuit breaker panel as configured was unsatisfactory. The panel was located on the right side console at the rearmost position which was difficult or impossible to see or reach in flight. The circuit breakers should be relocated to allow easy access.

Every effort should be made to reconfigure the pilot's cockpit so that all frequently used functional switches and avionics can be manipulated with the left hand while in flight.

b. Copilot-Gunner's Station

Entry and exit from the gunner's station were satisfactory using the retracting steps and hatch on the left side of the fuselage once the proper technique was learned. No gunsight was installed; however, this may have had a direct bearing on the ease of entry and exit. The retracting steps should be redesigned if the aircraft is considered for procurement with fixed landing gear.

The armored seat was not adjustable in the gunner's cockpit. There was minimum head clearance for an average size individual. The front seat should be adjustable for head clearance. As configured the seat was comfortable but with the side panels raised movements of the gunner, while controlling the gunsight, will be restricted and may limit the useful travel. The copilot-gunner's seat should be designed to allow maximum unrestricted use of the sight.

The copilot-gunner's cyclic and collective controls were sidearm controls and were designed as emergency controls in case the pilot were wounded. Cyclic control travel was about one-half that of the pilot's and required twice the force to obtain the same control travel. Rudder pedals were conventional and adjustable fore and aft. The pedal travel and forces were the same as the pilot's controls. Rudder pedals at the copilot's station were satisfactory.

Comments on the canopy and ventilation system at the gunner's station are the same as those previously stated for the pilot's station.

The copilot-gunner's instrument panel had special instrumentation and was not representative. The copilot-gunner should be provided the basic engine and flight instruments and a means of communication in case of emergency.

The field of view from the copilot-gunner's station was excellent.

The noise level at the gunner's station was measured at 118 decibels and was considered satisfactory. A form fitted helmet provided adequate noise protection.

There were no circuit breakers located at the gunner's station. The gunner should be provided with some circuit breakers to increase his ability to handle certain emergencies without assistance from the rear cockpit. For instance, if the ASE circuit breakers were in the front cockpit, the ASE could be turnedoff without assistance from the rear seat. Those that are required could be determined from a mock-up board on the final configuration.

3. Starting and Rotor Engagement

The starting procedure was simple and basically the same as that of the UH-1 except for the relocation of switches in the cockpit.

4. Hovering

a. The handling qualities during hovering flight were similar to those of a standard UH-1B except for an increased rudder pedal sensitivity. The sensitivity was not objectionable and, once the pilot became accustomed to it, there was no tendency to overcontrol.

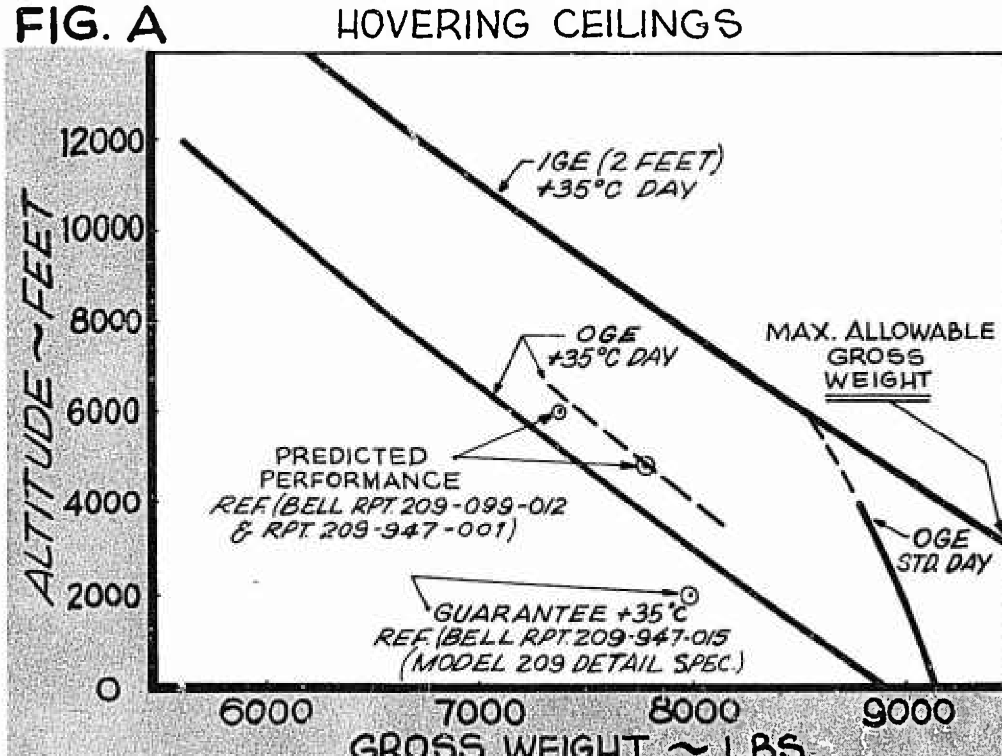
b. During the evaluation, the occurrence of favorable weather conditions made it possible to conduct some impromptu out-of-ground effect (OGE) hovering tests. While the data (See Figure No. 1, Part II) was not sufficient to establish the exact performance characteristics of the Cobra, it was sufficient to indicate that the hovering power-required characteristics were similar to those of the standard UH-1B/540 helicopter. Based on the power available as defined by Specification No. 104.33 (Reference 8), the hovering performance shown in Figure A should result.

Figure A shows that the hot day (+35 degree Centigrade (C)) OGE hovering performance was less than that predicted in Report No. 209-099-012 titled "Model 209 Technical Data Report," (Reference 7) Table II-2.

Additionally, the value offered by the contractor for a hot day OGE hovering guarantee in the proposed Model Specification (Report No. 209-947-010, Reference 4) was approximately 2000 feet lower than the value that was predicted in the Technical Data Report No. 209-099-012.

No hovering autorotation or sideward and rearward flight tests were conducted during this evaluation. These characteristics remain to be demonstrated and should be investigated if additional government tests are performed on the Cobra.

FIG. A HOVERING CEILINGS



5. Takeoff

Determination of the takeoff performance characteristics was not an objective of these tests. The handling qualities were qualitatively evaluated. The air taxi handling qualities were satisfactory and the helicopter could be accelerated through translational lift without collective manipulation and with little tendency to "sink through." The transition to forward flight from a hover produced the normal cyclic and rudder pedal trim changes. No adverse characteristics were noted.

6. Climbing Flight

a. Climb performance was briefly evaluated at altitudes from the surface to 12,000 feet. The climb schedule airspeed of 70 knots indicated airspeed (KIAS) was selected in the absence of a contractor-recommended climb schedule. Based on the level flight data, there was probably a performance penalty at the higher altitudes (i.e., above 7500 feet); but the data was adequate to indicate the magnitude of available climb performance.

The increased power available from the T53-L-13 engine accounted for most of the improvement in climb performance over that of the standard UH-1B/540 helicopters. Because of the engine difference, no direct comparison was valid. Generally, at a climb start gross weight of 8100 pounds, the Cobra demonstrated rates of climb of approximately 2200 feet per minute (FPM) up to the engine critical altitude of 10,000 feet. This level of performance was in reasonable agreement with the predictions of Bell Report No.209-099-012 (Reference 7). Service ceiling determination was not within the scope of the test objectives.

b. The handling qualities of the Cobra during climbing flight were satisfactory at the selected climb speed of 70 KIAS. Strong static longitudinal stability was present (Reference Paragraph E.15) and, once established, the climb airspeed was easy to maintain. No adverse trim changes with altitude were noted.

7. Level Flight

a. The level flight stability and control characteristics are discussed in depth later in this report. Only the performance comments, however, are presented here.

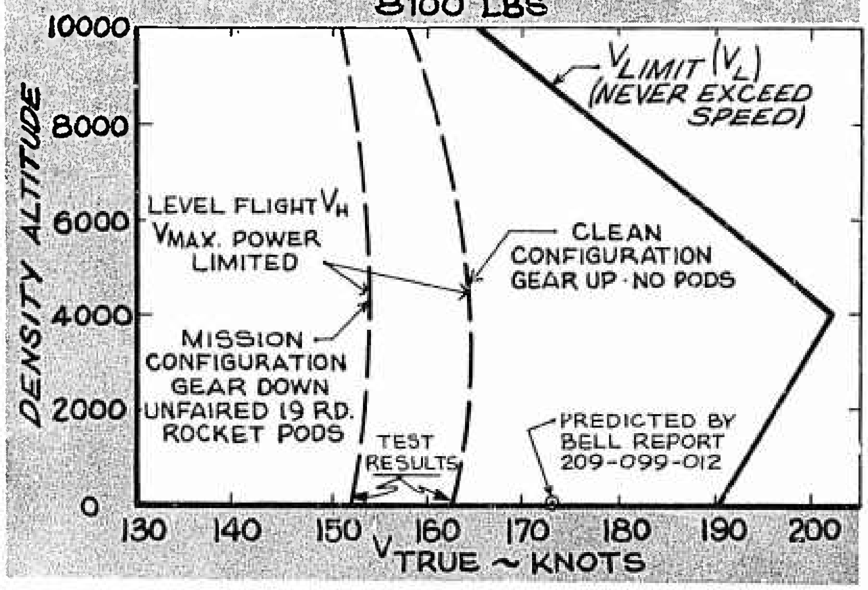
b. The results of the level flight tests revealed that the power required in level flight was more than was predicted by previously furnished contractor data. Tests were performed over a range of density altitudes from 2640 feet to 10,330 feet. The gross weight range was limited from 7460 pounds to 8760 pounds. All data was taken with a center-of-gravity (C.G.) location near station 193, which corresponded to a position 7 inches forward of the rotor mast centerline. There were four configurations tested. These are listed in Table I.

Table I - Level Flight Test Configurations		
Configuration No.	Landing Gear	Rocket Pods
1	Down & Faired	19-round (LAU 3A/A) rocket pod, no fairings
2	Down & Faired	19-round - nose and tail fairings
3	Up	19-round - nose and tail fairings
4	Up	No pods installed

The effect of the fuselage configuration on level flight performance was significant. The fuselage design was quite clean, aerodynamically, for a helicopter. In the optimum drag configuration, which was gear up and no rocket pods, the calculated sea level maximum speed at 8100 pounds, using the maximum allowable power (1100 shaft horsepower (SHP)), was 162 knots true airspeed (KTAS). This was approximately 10 knots less than predicted by Bell Report No. 209-099-012 (Reference 7). The maximum level flight true airspeed at 8100 pounds occurred at approximately 3500 feet. The relationship of the power limited speed (V_H) and the structural limited (V_L) boundaries is shown in Figure B.

FIG. B

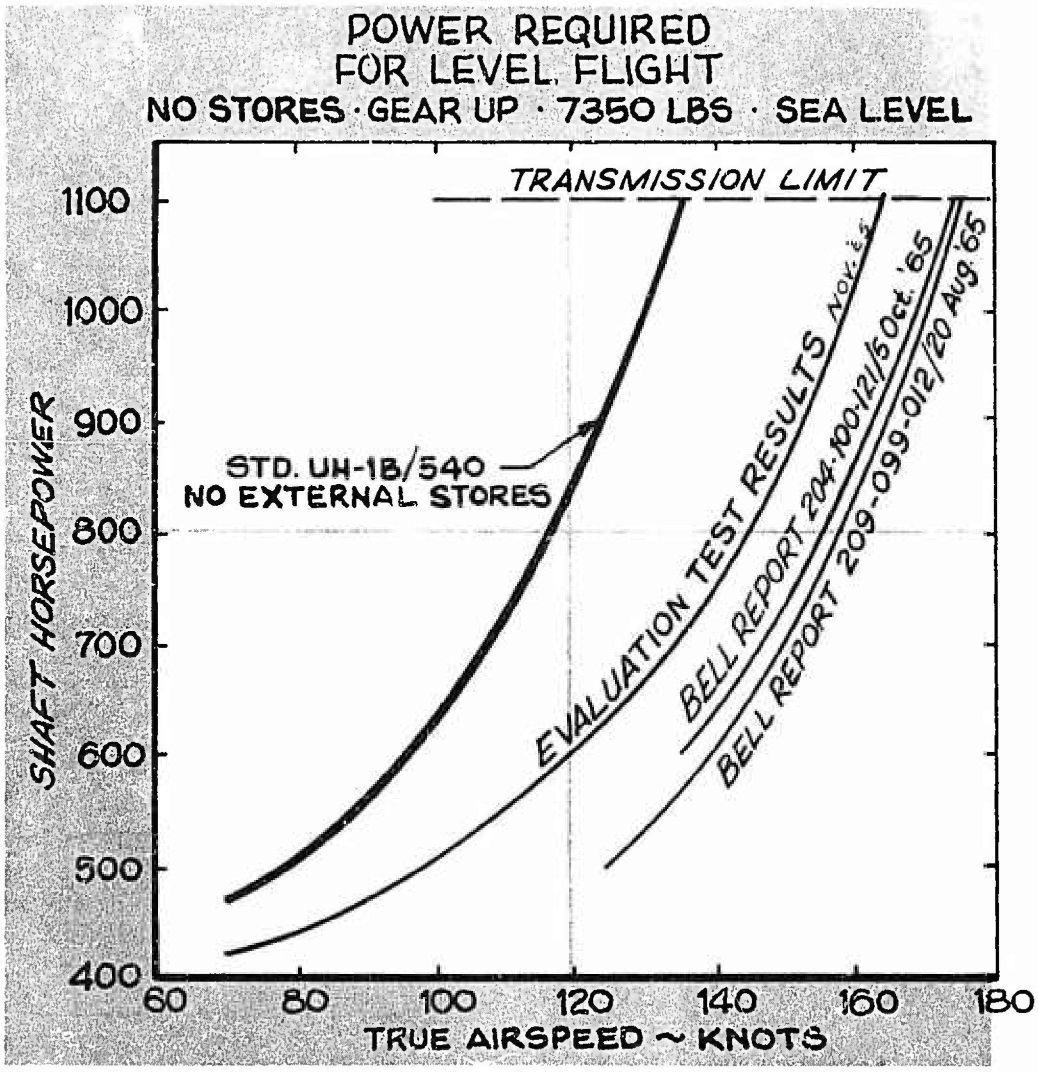
POWER LIMITED and MAXIMUM ALLOWABLE SPEEDS 8100 LBS



Additionally, the effect of the external stores on level flight maximum speeds is apparent from Figure B. Figure 6, Part II presents the effect of the various configuration changes in terms of equivalent flat plate drag area.

Figure C indicates the relationship between the results of this evaluation and previously furnished contractor data. A progressive decrease in the verified maximum level flight speed with calendar time is apparent. Most of the differences were attributed to the contractor's airspeed position error calibration which is discussed in Paragraph E.20.

FIG. C



The performance characteristics at speeds greater than V_H were investigated and the relationship of speed and rates of descent during high speed flight is shown in Figure D.

FIG. D

RATE OF DESCENT AT SPEEDS GREATER THAN MAXIMUM LEVEL FLIGHT SPEED
5000 FEET · 8100 LBS · 1100 SHP

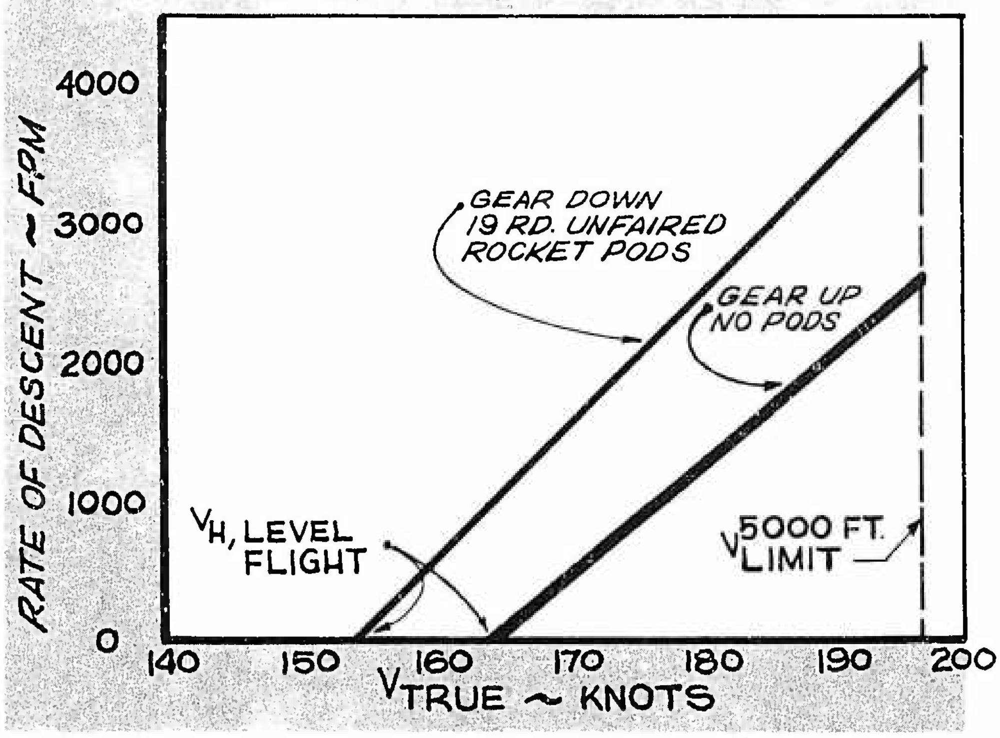


Figure D indicates the requirement to maintain a good aerodynamic configuration if high dive speeds are to be accompanied by acceptable rates of descent.

Optimum cruise speeds to obtain best range with the prototype test article varied between just over 140 knots KTAS for the clean configuration at light weights (sea level standard day) to 128 KTAS for the heavy weight "dirty" configuration with two unfaired 19-round rocket pods. The best cruise speeds for a production helicopter of this type would depend on the power and fuel flow characteristics of the production T53-L-13 engine. These characteristics are not presently available.

The approximate mission capability was calculated for three sample missions. The accuracy of these calculated missions was limited by the lack of definition of the exact engine characteristics. These missions should be a fair approximation of what could be expected of the design with the gear fixed down and with two 19-round LAU 3A/A unfaired rocket pods.

Approximate Mission Capability

Approximate combat radius, endurance and range capability at sea level. Based on:

a. 242.6 gallons (1576 pounds) usable fuel.

b. T53-L-13 Specification fuel flows 5 percent conservative (Reference 8, Lycoming Specification No. 104.33, 30 September 1964).

c. 8100 pounds average mission weight.

d. Gear down - Two 19-round rocket pods, no nose cones.

Table II - Combat Radius at Sea Level

Condition	Time	Fuel Used lb	Nautical Air Miles Traveled
Warm-up (2 min NRP)	.033	24	0
1 min T/O Power	.0163	13	0
Cruise Outbound (Max Cont Torque) 153 kt	.900	658	138
5 min Combat	.0833	65	0
Cruise Inbound (Max Cont Torque) 153 kt	.900	658	138
10% Fuel Reserve	0	158	0
TOTALS	1.93 hr	1576 lb	276 total 138 radius

Table III - Endurance at Sea Level

Condition	Time	Fuel Used lb	Nautical Air Miles Traveled
Warm-up (2 min NRP)	.033	24	0
1 min T/O Power	.0163	13	0
Cruise at Best Loiter Speed (65 kt)	3.29	1381	214
10% Reserve	0	158	0
TOTALS	3.34 hr	1576 lb	214 miles

Table IV - Range at Sea Level

Condition	Time hr	Fuel Used lb	Nautical Air Miles Traveled
Warm-up (2 min NRP)	.033	24	0
1 min T/O Power	.0163	13	0
Cruise @.99 max NAMPP, 133 kt, 575 lb/hr fuel flow	2.40	1381	320
10% Reserve	0	158	0
TOTALS	2.45 hr	1576 lb	320 miles

8. Acceleration and Deceleration Capability

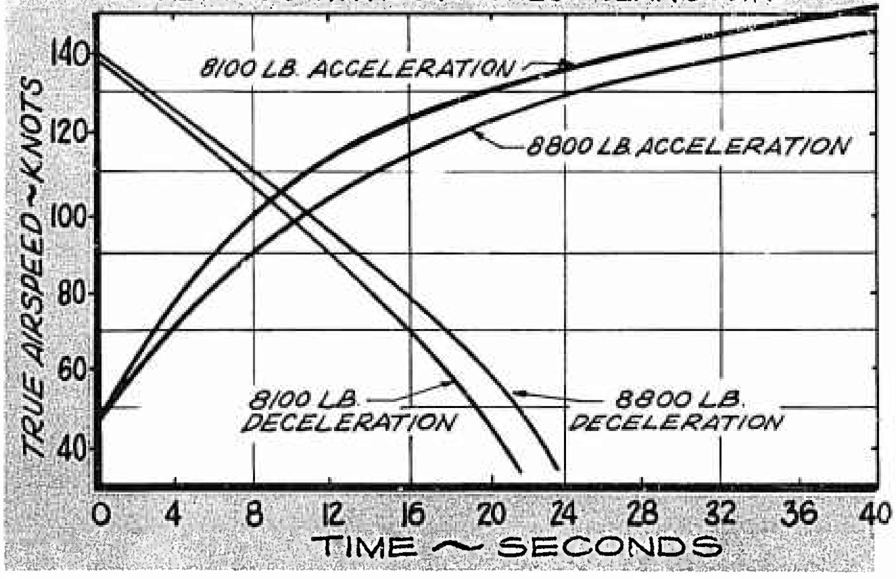
a. Tests were conducted to determine the acceleration and deceleration capability of the helicopter. These were performed over a surveyed course before a Fairchild Flight Analyzer which allowed the determination of true speeds without error being introduced by airspeed system lags.

b. The test data analysis and standardization were attempted using energy methods. The test data had considerable scatter. Application of the data analysis techniques did not appreciably improve the quality of the presentation.

For this reason, the "best fairings" of the test data are presented in Figure E as representative of the most useful information available.

FIG. E

ACCELERATION & DECELERATION PERFORMANCE
BELL MODEL 209 · N209J
NON-STANDARDIZED TEST DATA
ROCKET PODS WITHOUT CONES · GEAR DOWN

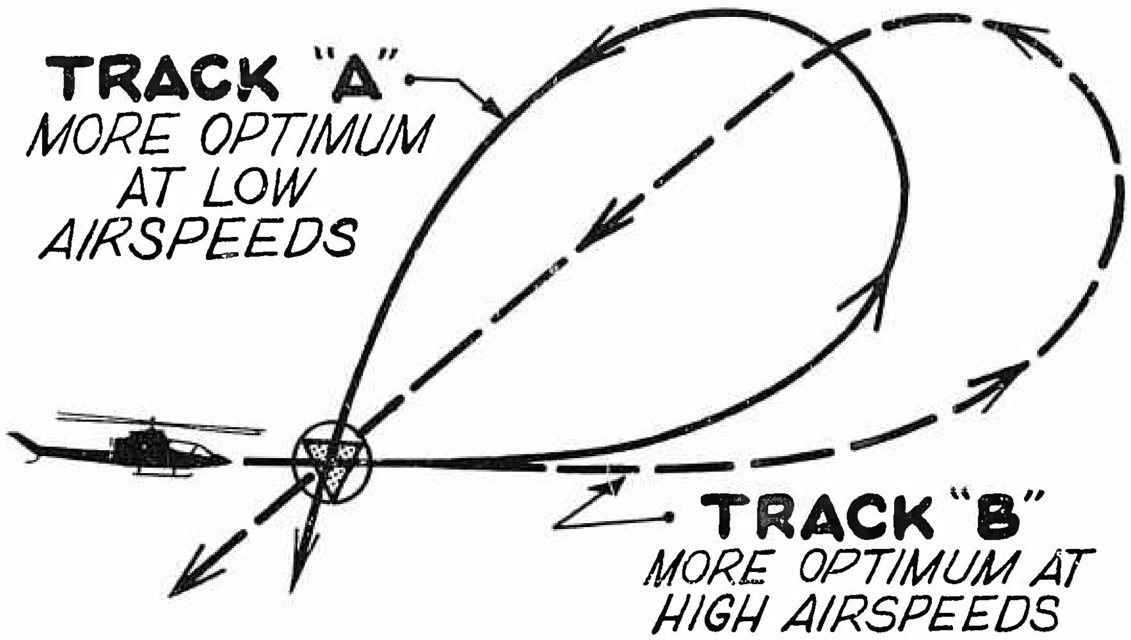


c. The deceleration capability of the helicopter was established by the rotor upper limit RPM (339). Once the level deceleration maneuver was commenced, the rate of cyclic flare was limited to that which resulted in a rotor RPM of 339.

9. Tear Drop Turn Capability

a. Tests were performed to establish the characteristics of the helicopter during the "return to target" or "tear drop turn" maneuver. The tests were performed by making a turn, either right or left, which minimized the time from passage over a target to return to the target. Altitude was held constant. The controls and power were varied as necessary. The tests were performed at three different maneuver entry speeds; 100 KIAS, 120 KIAS and V_H.

b. The results of these tests agreed reasonably with previously furnished contractor data. Tear drop turns are highly transient maneuvers and no attempt at performance standardization would be valid. The maneuver is a combination of performance, stability and control, dynamics and pilot proficiency. The timing of the maneuver is also important. A ground track similar to Track "A" below tended to minimize the time required to perform the maneuver at the lower speeds. At higher speeds, Track "B", which includes a slight delay after passing the target, before initiating a turn, tended to minimize times. The compromise track for the high speed flight path reduced at higher



speeds and thus reduced the time spent in turning flight. Minimizing the time spent in turning flight produced higher average speeds by reducing the time spent under conditions of high induced drag which caused high deceleration rates even with full power.

Figure F presents a "best fairing" of representative test data.

FIG. F

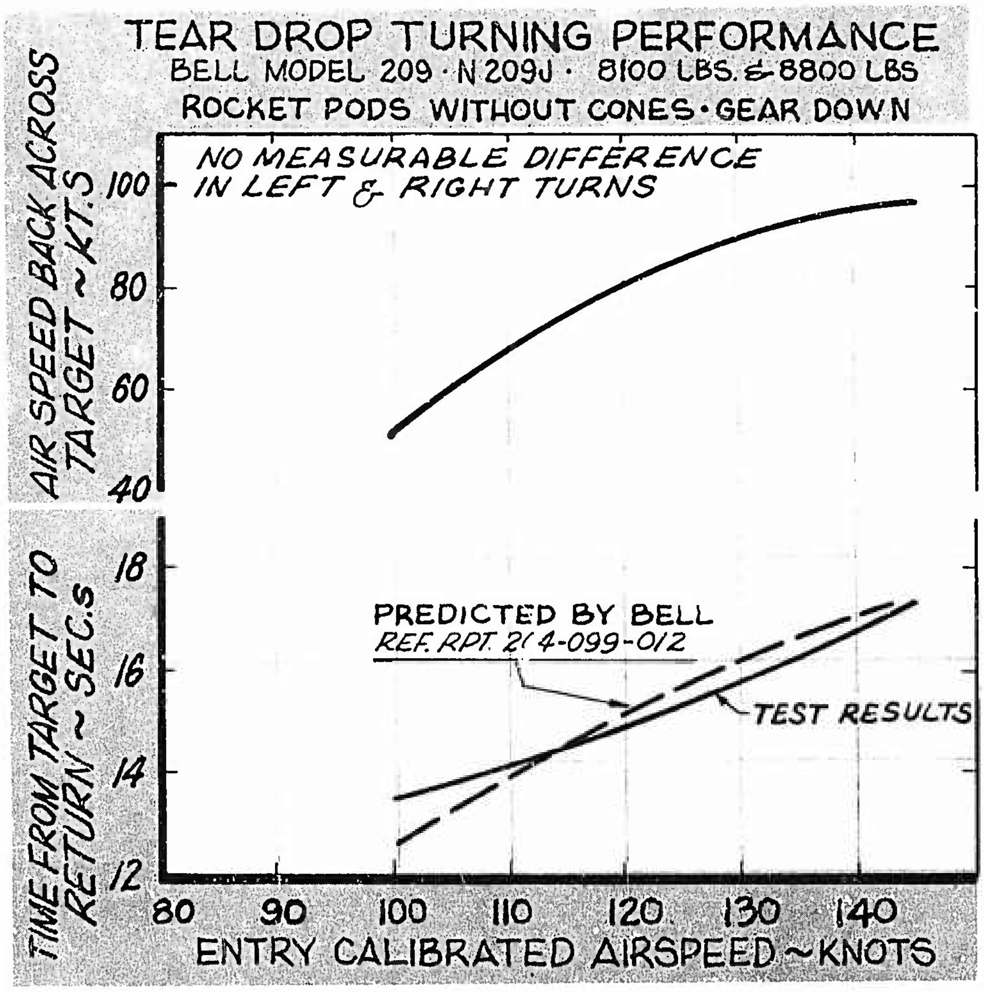


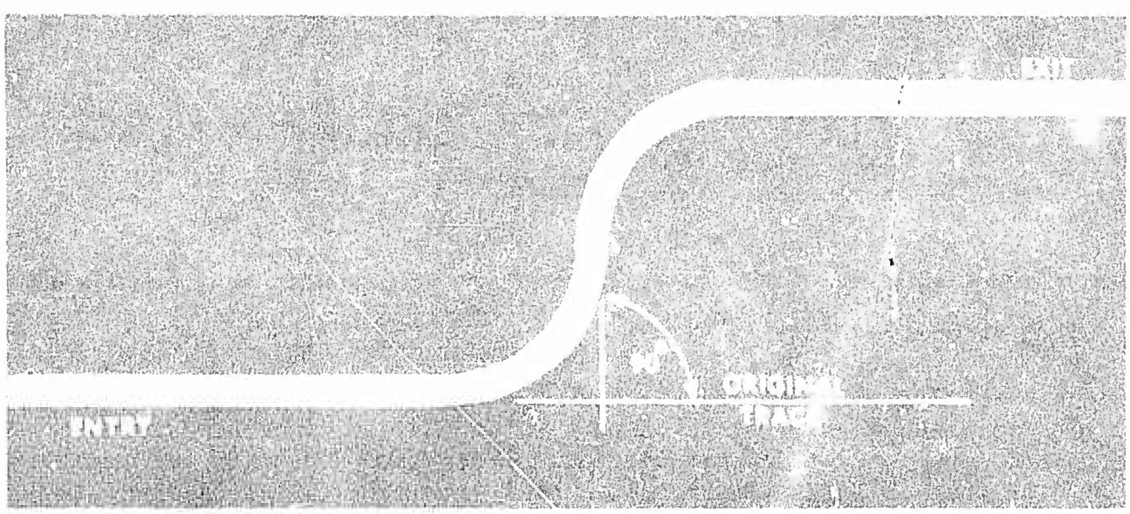
Table V presents some of the data collected with additional parameters of interest.

TABLE V
TEAR DROP TURNING PERFORMANCE
BELL MODEL 209

Entry V_{cal} kt	Airspeed Back Across Target kt	Time From Target to Return sec	Maximum g	Maximum Roll Rate deg/sec	Test Weight lb
117	52	14.76	2.10	26.0 Left	8100
117	56	15.09	2.18	30.0 Left	8100
116	84	14.87	2.42	36.5 Left	8100
121	71	15.03	2.36	34.0 Left	8100
101	53	13.77	2.00	28.0 Right	8100
104	57	13.28	2.10	40.0 Left	8100
116	79	15.40	2.25	43.0 Left	8100
111	82	14.08	2.20	33.0 Right	8100
119	85	15.60	2.25	41.5 Left	8100
140	96	17.96	2.25	40.5 Left	8100
140	95	16.73	2.25	31.5 Right	8100
139	89	16.78	2.23	43.0 Left	8100
119	77	15.09	2.10	40.0 Left	8800
119	77	15.40	2.20	34.5 Left	8800

10. Turn Reversal Capability

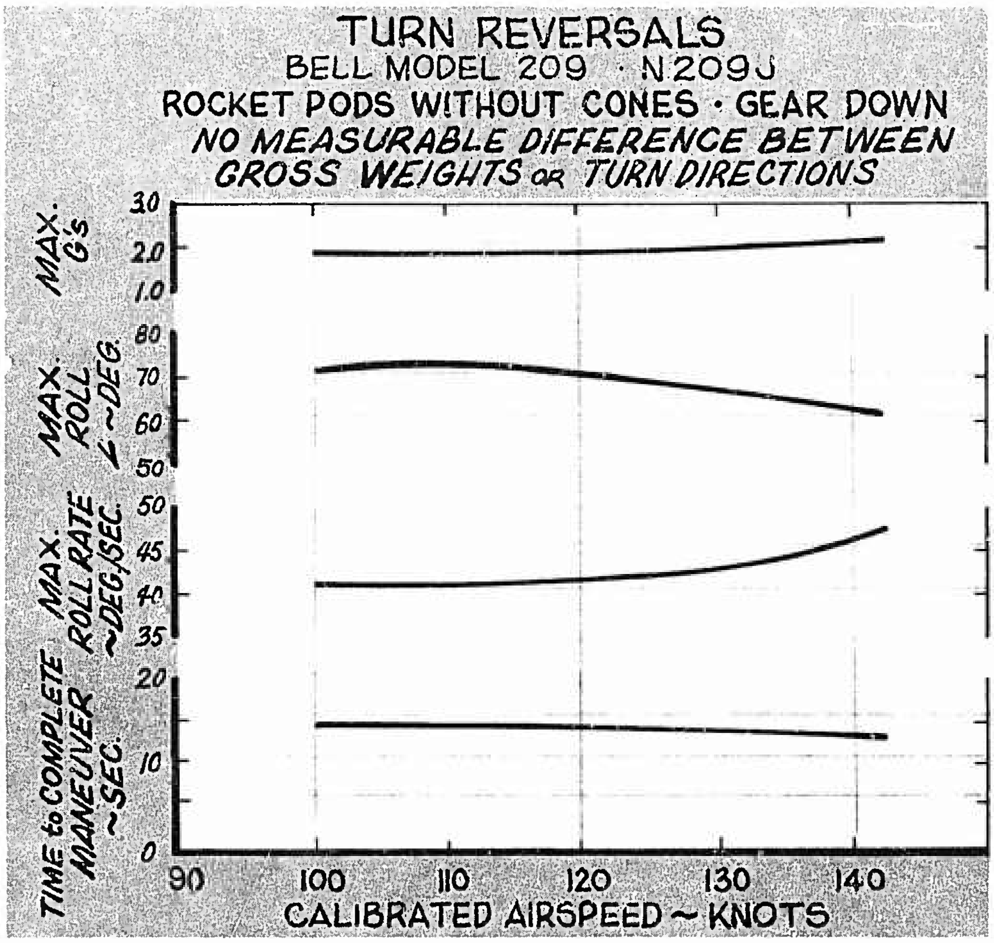
a. Turn reversals were performed as part of the effort to meet the agility test objectives. The maneuver was performed at constant altitude with a ground track similar to that shown below:



A 90-degree heading change was made as rapidly as possible and was followed by a second maximum effort 90-degree turn to return to the original heading. When performed to the limit of the helicopter's capability, these turns were more of a test of the structural integrity than an agility definition.

b. The data from this maneuver could not standardize with the available engineering analysis techniques. Most of the qualitative comments were expressions of amazement that something did not separate from the aircraft. Figure G presents a "best fairing" of representative test data. It is indicative of the maximum practical capability of the helicopter while performing the maneuver.

FIG. G

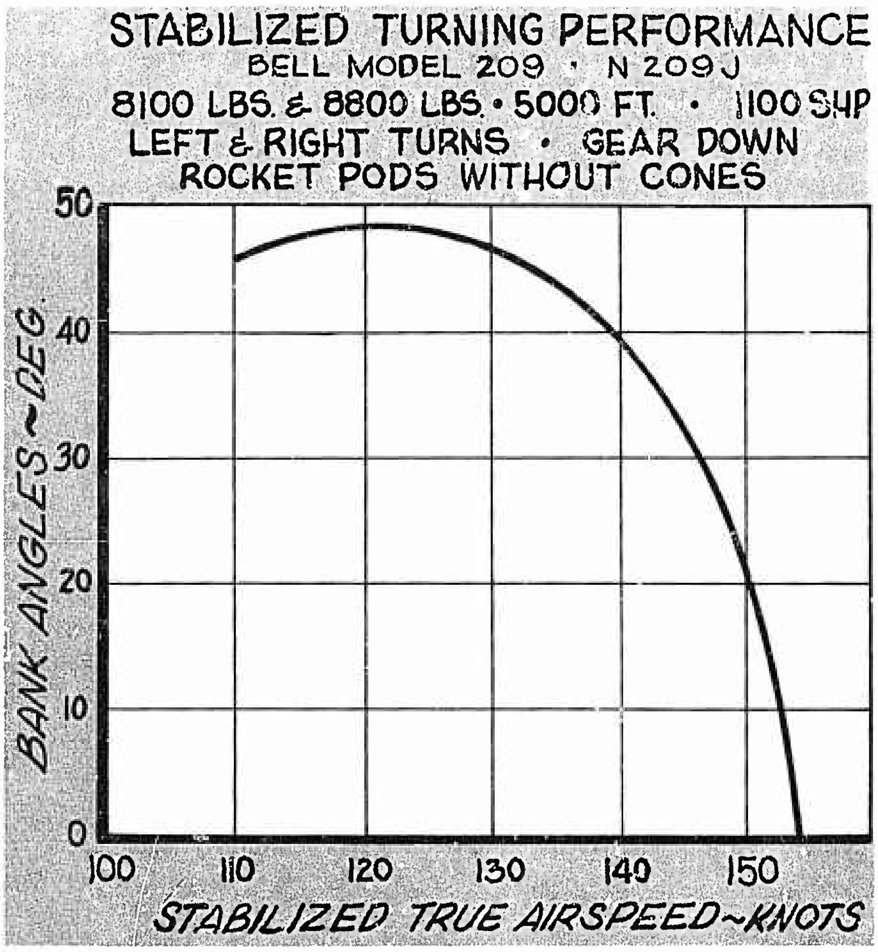


11. Stabilized Turning Flight

a. Stabilized level turning flight performance data was taken to establish the steady-state maneuvering characteristics. Tests were performed using two techniques. For one technique, indicated airspeed was held constant and power was increased for each incremental increase in stabilized bank angle. Another technique used was to hold constant power and allow indicated airspeed to decrease with each incremental increase in bank angle. Of the two techniques, the second seemed to be slightly the easier for data collection and analysis. Maintaining constant power in turning flight, however, required adjustment of collective position because of changing rotor inflow with bank angle and turn rate.

b. The reporting suspense date requirements precluded a thorough analysis of the turning performance data although the work which was accomplished indicated analysis was feasible. The test data "best fairing" is presented in Figure H. The bank angles were limited by the capability of the rotor to develop sufficient thrust to maintain a stabilized constant altitude turn. At bank angles quite near the maximum attainable, the vibration levels and airframe roughness became objectionable and practical maneuvering capability in stabilized turning flight would probably be slightly less than the values of Figure H.

FIG. H



12. Autorotational Entries

a. Autorotational entries were performed at speeds up to the limit that had been demonstrated by the contractor, 150 knots calibrated airspeed (KCAS). The higher speed autorotational entry characteristics had not been investigated during the limited development program.

b. With the exception of the technique change required to control rotor RPM, autorotational entries were characterized as generally mild maneuvers and no unacceptable rates or attitudes were encountered. Table VI is representative of the results obtained during the autorotational entry tests. At power settings in excess of those required for level flight at $.9V_H$ (approximately 130 KIAS), rotor decay rates following throttle chop were high. The minimum rotor speed observed after a 1 second delay was 283 RPM, and entry RPM was 324. Because of the flight regime, however, engine failure was an instantly recognizable condition and evaluation of the characteristics using a 1 second collective delay was considered a practical test technique.

At the higher airspeed, above 120 KIAS, the most desirable technique for maintaining rotor RPM control differed considerably from normal helicopter practice. At high airspeeds, i.e., lowered collective, increasing airspeed to increase autorotational rotor RPM, etc., produced effects opposite to those desired. In this flight regime, rotor speed control was complicated by increasing sensitivity to angle of attack, airspeed, and collective application. Large excursions in rotor RPM and extreme difficulty in RPM control resulted. The easiest of the variables to control was collective setting. The most desirable technique, following a throttle chop at high speed, was to maintain a fixed collective setting and execute a cyclic flare of sufficient abruptness to maintain the desired rotor RPM. The desired rotor RPM could be maintained accurately and it was practical to use cyclic flares which necessitated the application of additional collective to maintain RPM below the upper limit. These flares produced the desirable benefits of a rapid reduction of airspeed into the normal autorotational range, an increase in altitude, and allowed more convenient control of rotor RPM. At the lower airspeeds, normal helicopter autorotational flight procedures were adequate. These characteristics represent a pilot checkout and training consideration.

Table VI below summarizes the test results.

TABLE VI
AUTOROTATIONAL ENTRY TESTS
BELL MODEL 209

1 SECOND DELAY

Entry True Airspeed kt	Altitude Gained During Flare ft	Time From Entry to 70 Knots sec	Test Weight lb
107	18	9.00	8100
125	31	17.00	8100
146	97	21.00	8100
154	71	21.50	8100
152	228	15.50	8100
110	41	8.50	8800
126	71	17.00	8800
148	162	15.25	8800

13. Engine Inlet Characteristics

a. Data for the engine inlet temperature rise and pressure loss characteristics was taken with the instrumentation provided by the contractor. The results are presented in Figures 17 and 18, Part II.

b. The compressor inlet temperature rise was higher than that of a standard UH-1B (+2 degrees C) at speeds below 80 KCAS. The +5 degrees C measured during the limited OGE hovering tests should be decreased for improvement of the hovering performance under ambient conditions when engine power available is less than the transmission limit of 1100 SHP.

The engine inlet pressure recovery characteristics were found to be different than those established by the contractor in Bell Report No. 209-099-004 (Reference 6). These differences should be resolved during any future tests to allow accurate analysis of the installed engine power available characteristics.

14. Control Position Trim Stability

a. Control position trim stability data was taken during the level flight performance tests of the various configurations and is presented in Figures 27, 28, 30 and 31, Part II. Additionally, the data collected during the limited climb performance tests is presented to illustrate the effect of altitude during a constant-IAS, constant-power climb. (Reference Figure 29 of Part II).

b. Longitudinal trim stability was positive for all of the conditions tested and generally agreed with previous contractor test results. Both the lateral cyclic and pedal control positions tended to move to the left at high speeds and high power settings. These trim changes were not objectionable and wide margins of control travel remained.

Figure 29, Part II indicates a coupling between collective and longitudinal cyclic control that caused a nose down trim change as collective was increased. This trim change was not objectionable during climbing flight.

15. Static Longitudinal Speed Stability

a. Static longitudinal speed stability tests were conducted by establishing a trim airspeed and, with power fixed, investigating the speeds above and below trim by the use of longitudinal cyclic control. Tests were accomplished during level flight, high speed descending flight, climbing flight and autorotational flight. The results are presented in Figures 32 through 36 of Part II.

b. The static longitudinal speed stability was adequately positive for all of the conditions tested. The full range of C.G. locations could not be investigated because of the status of the contractor's development program. Any future testing should include an investigation of the static longitudinal speed stability at the most adverse C.G. (aft limit). Stability levels less positive than those shown by Figure 32, Part II should not be accepted as satisfactory. Weaker static stability characteristics in high speed flight would adversely affect trimmability and increase the pilot attention required to maintain constant airspeed in high speed descending flight.

No adverse coupling effects were noted during these tests. Any future tests should include establishment of the static longitudinal speed stability characteristics over a range of practical collective settings in high speed descending flight to verify the absence of coupling.

16. Static Lateral Directional Stability

a. Static lateral directional stability tests were conducted by establishing a zero sideslip trim condition at a selected airspeed and varying the sideslip angle while measuring the control positions required to maintain a a constant track over the ground.

b. For all conditions tested, strong positive dihedral characteristics were present. These characteristics became more apparent with increasing airspeed. The degree of dihedral effect provided was much greater than that of a standard UH-1B/540 helicopter which is only weakly positive at best. The strong dihedral effect was beneficial and contributed to the ease of accomplishing well coordinated maneuvering flight with minimum pilot attention to the directional controls. During any future testing, these characteristics should be investigated over the allowable C.G. range.

17. Dynamic Lateral-Directional Stability

a. Tests to determine the lateral-directional damping and dynamic stability characteristics were conducted by establishing trimmed zero sideslip flight at a selected airspeed. Without retrimming, the helicopter was placed in a stabilized sideslip. The controls were released to return to their zero sideslip position and the resulting aircraft motion was recorded. These tests were performed with the lateral and directional ASE channels both On and Off.

b. With ASE On, the lateral directional damping and short-period dynamic stability characteristics were adequate and complemented the other flight characteristics that contributed to the overall suitability of the design as a weapons platform.

With ASE Off, the helicopter did not exhibit the natural lateral-directional damping predicted by the contractor (Reference 7, Bell Report No. 209-099-012. The measured damping characteristics barely met the criteria of minimum required in the case of ASE failure and were considerably lower than the minimum requirements for armed aircraft.

With ASE Off, at speeds greater than 120 KCAS, the low level of natural damping caused the helicopter to exhibit lateral directional oscillations that were easily excited and could not be damped by the pilot. Figures J and K summarize the results and Figures 40 and 41, Part II present time histories of representative tests.

FIG. J
SUMMARY ~ LATERAL - DIRECTIONAL DYNAMIC STABILITY
○ ASE ON · □ ASE OFF

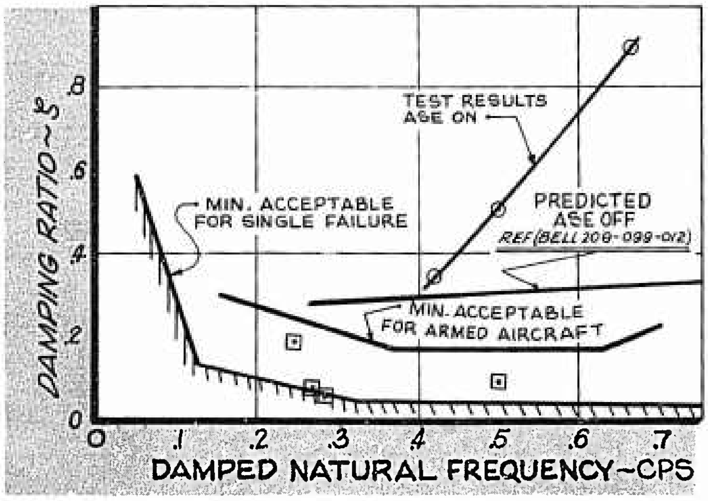
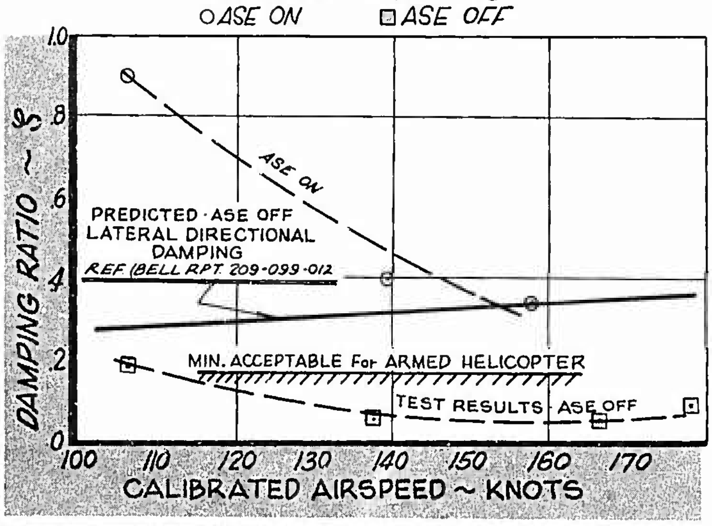


FIG. K
LATERAL-DIRECTIONAL DAMPING CHARACTERISTICS
○ ASE ON □ ASE OFF



Figures J and K illustrate the requirement for ASE for this helicopter in order to meet the minimum characteristics required for an acceptable weapons platform. The natural lateral directional characteristics allowed safe flight at all airspeeds up to V_L in the event of an ASE failure at high speed. Deceleration to a speed where the characteristics were satisfactory (120 KCAS) was uncomfortable and was accompanied by roll excursions of ± 10 degrees but could be accomplished without unusual skill or corrective action by the pilot.

18. Maneuvering Flight

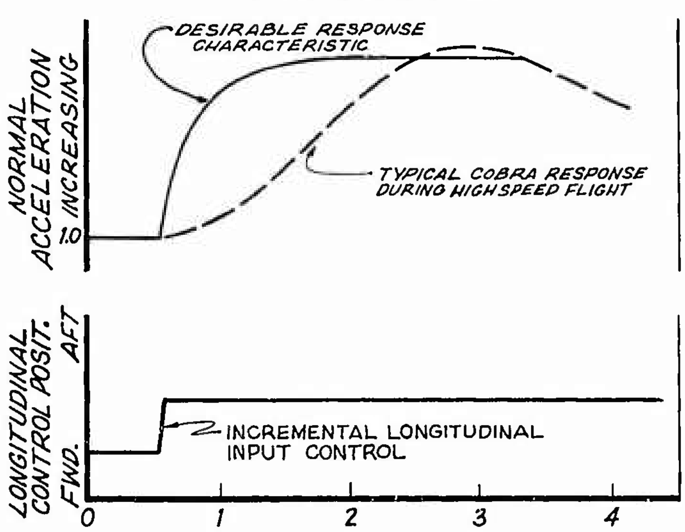
a. Longitudinal Characteristics

Data from symmetrical pull-ups and stabilized turning flight was used to evaluate the longitudinal characteristics during maneuvering flight. The symmetrical pull-up tests were performed by establishing a level flight trim airspeed, altitude and power setting. Without disturbing the trim settings a cyclic climb to a slightly higher altitude was initiated. Following the climb, a pushover to trim airspeed allowed the aircraft to be maneuvered so that it was level at the trim altitude and airspeed, with some amount of normal acceleration, depending upon the amount of aft cyclic applied. Tests were conducted for each trim airspeed over a range of normal acceleration values.

The stabilized turning flight data was accumulated during the performance tests.

Figures 42, 43 and 44, Part II present the data collected during the symmetrical pull-up maneuvers. As tested, without longitudinal ASE, the helicopter exhibited undesirable characteristics which became increasingly objectionable with increasing airspeed. Specifically, the control power and damping characteristics were related in a manner which resulted in considerable "apparent overshoot" and excessive time required following the cyclic input to reach peak normal acceleration. These characteristics, illustrated below in Figure L, coupled with increasing pitch sensitivity with airspeed and

FIG. L
LONGITUDINAL RESPONSE
TO STEP INPUTS



a light gradient of stick force per g (approximately 4 pound/g) made the pilot task of maneuvering the helicopter more difficult than is acceptable for a weapons platform. Additionally, these characteristics caused reluctance to utilize fully the maneuvering capability of the helicopter because of the difficulty in controlling pitch rate and normal acceleration accurately. More desirable characteristics would be present if the stick force per g (F_S/g) were increased and the damping improved to provide reduced time constants (inertia/control power ratio) for the transient responses to cyclic inputs. Suggested target values are a F_S/g value of 10 pounds/g and a time constant of .3 seconds as presented in U. S. Army Aviation Materiel Laboratories (USAAVNMLABS) Report TR-65-45 (Reference 2).

Figures 46 and 47 present the longitudinal control position data collected during stabilized turning flight. For most conditions tested, the stick-fixed maneuvering stability gradients were adequately positive in that an aft displacement was required to produce an increase in load factor. The stick-free gradients could have been improved by an increase in force/g.

At the lowest airspeed tested (102 KCAS, See Figure 47, Part II) the data indicates that the stick-fixed (and stick-free) maneuvering gradients were negative. The data was collected using a constant airspeed, increasing power test technique. This should be investigated further by the contractor to define accurately the areas of negative longitudinal cyclic maneuvering stability. At a minimum, positive stick-free maneuvering stability should be provided.

b. Lateral Maneuverability

Lateral Maneuverability was evaluated by applying step inputs, both left and right, of various sizes and measuring the helicopter reactions. The lateral and directional ASE systems were ON for most of these tests.

The results of these tests are presented in Figures 48, 49 and 50, Part II. With the ASE damping characteristics as tested, more than enough lateral control power was available. During the turn reversal and tear drop maneuvers, the practical maximum usable rates of roll were on the order of 40-45 degrees/second. Roll rates of this magnitude were easily obtained without encountering control stops.

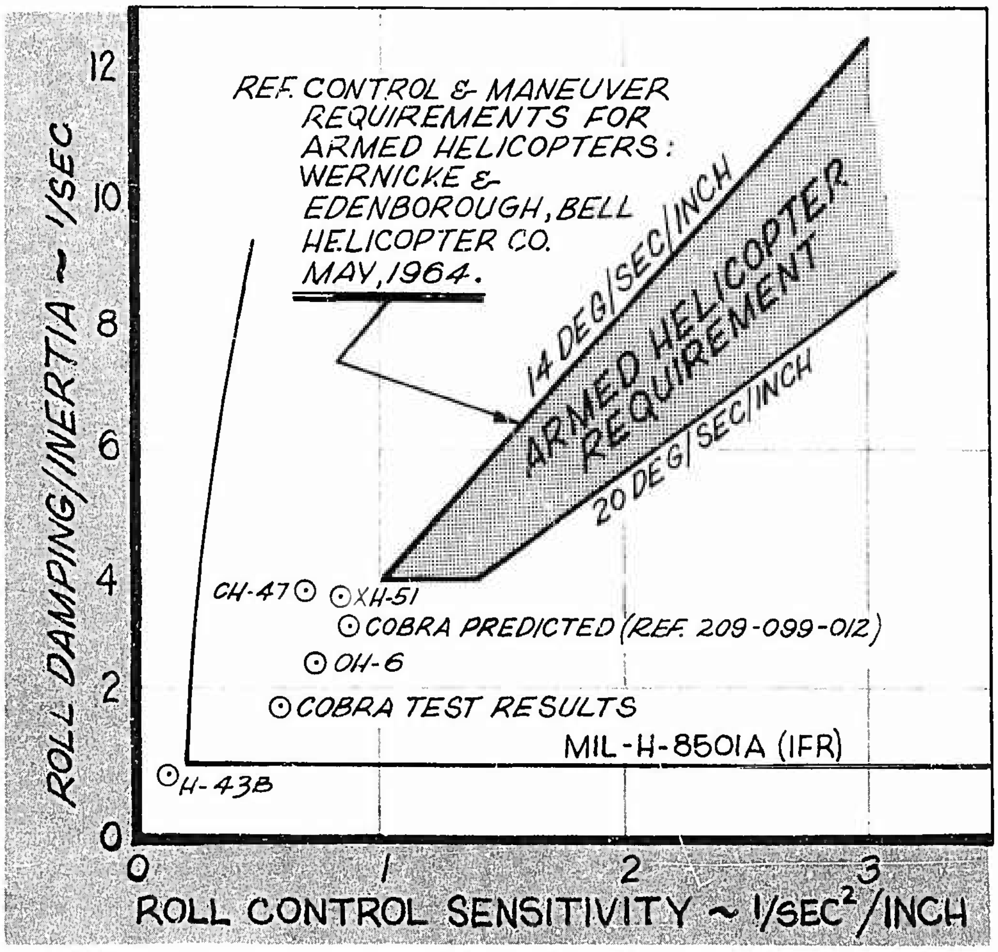
The maneuvering requirements of the armed helicopter mission have been widely recognized as demanding lateral controllability and transient response characteristics more rigorous than those available from the present generation of helicopters. As tested, the Cobra did not represent any progress in the improvement of lateral characteristics. Figure M was taken from a 1964 paper titled "Control and Maneuver Requirements for Armed Helicopters" by Mr. Wernecke and Mr. Edenborough of the Bell Helicopter Company. It identifies a zone of desirable lateral response characteristics for the armed mission.

It was recognized that the lateral ASE characteristics were not optimized and Figure M included the contractor's predicted characteristics. This improvement was expected to be achieved by proper tailoring of ASE damping, quickening, and washout signals. While the lateral transient maneuvering flight characteristics were not as objectionable as those for the longitudinal axis, the parameters of Figure M and the pilot's comments both indicate the flying qualities could have been improved by increasing both the roll damping and roll sensitivity. The criteria of Figure M were verified by the similar requirements of USAAML TR-65-45, "Suggested Flying Qualities for V/STOL Aircraft," (Reference 2).

c. Cyclic Force Harmony (Aft Cockpit)

As tested, the Cobra had cyclic forces in the ratio of 1:1, longitudinal and lateral, from the trimmed position. These forces were provided by standard geometry UH-1 force-feel hardware. During high speed maneuvering flight, improved harmony would result from the use of force for equal displacement ratios which are between 2:1

FIG. M
ROLL RESPONSE



and 4:1, for the longitudinal and lateral controls.

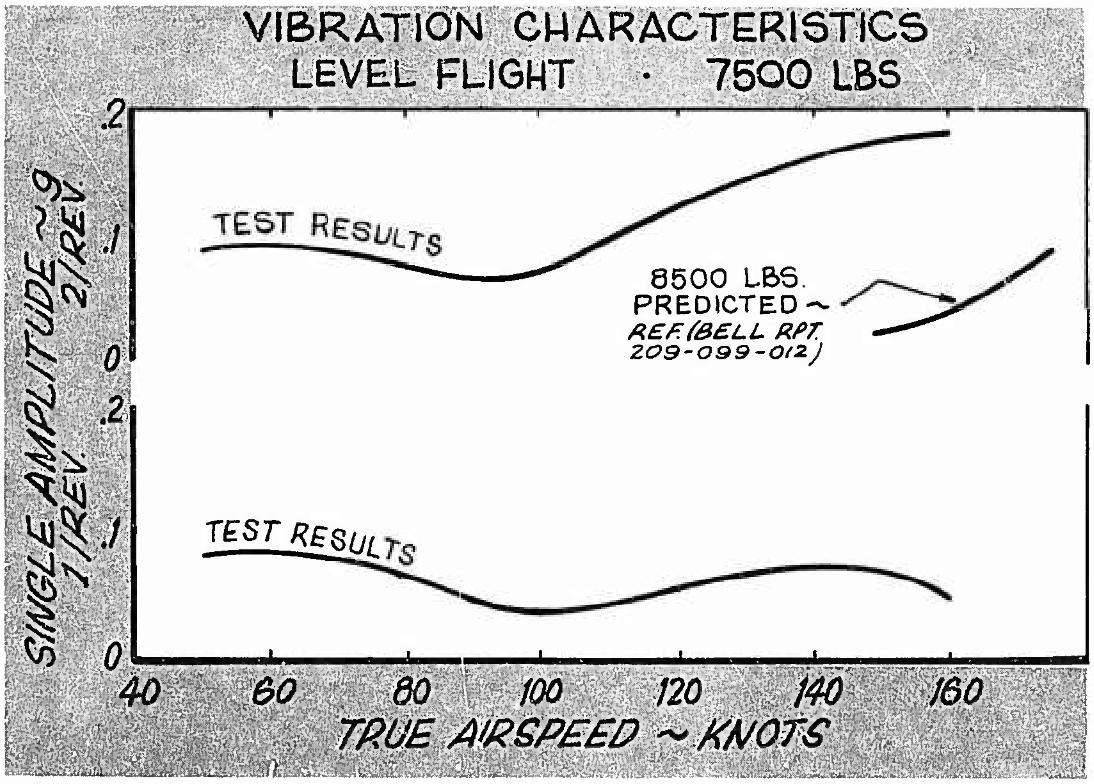
19. Vibration Characteristics

a. Vibration data was collected during tests which included: the level flight performance tests, the stabilized turning flight performance tests, and test conducted at speeds greater than 155 KTAS in descending flight using a cross section of power settings. Data was recorded at the pilot's station, both laterally and vertically. Analyzed data is presented in Figures 53 through 62, Part II.

b. The armed helicopter mission demands lower vibration levels, especially for the low frequencies (0-10 cycles per second (CPS)), than are presently allowed by Paragraph 3.7 of MIL-H-8501A (Reference 1). The basis of the more stringent requirement is the effect of low frequency vibration on the ability of a gunner to use a gunsight effectively.

Previous armed UH-1 test programs have indicated that .1g single amplitude is an acceptable maximum value for 1-per-rev (5.4 CPS) vibrations. Although the test results indicated the presence of vibration levels in excess of those predicted by the contractor, the vibration levels were acceptable over the entire flight envelope. One-per-rev components of the vibration waveform were usually under .1g single amplitude in level flight, increasing during turning flight and in high speed descents. The 2-per-rev levels stayed under .2g single amplitude except in high speed descending flight at the higher power settings, (i.e., high collective pitch angles).

FIG. N



Higher order harmonics 6, 8, and 10 per rev were present. Below 160 KCAS, the higher frequencies were predominantly 6 and 8 per rev. Above 160 KCAS, 10 per rev was the dominant high frequency. In the cockpit, the higher harmonics were detectable but not objectionable. Although no gunsight was fitted and no firing tests were conducted, the flight crew was of the opinion that the composite vibration levels encountered would not have limited the mission capability. Improvement in the vibration levels, however, would enhance crew comfort and effectivity and indirectly improve mission capability.

20. Airspeed Calibration

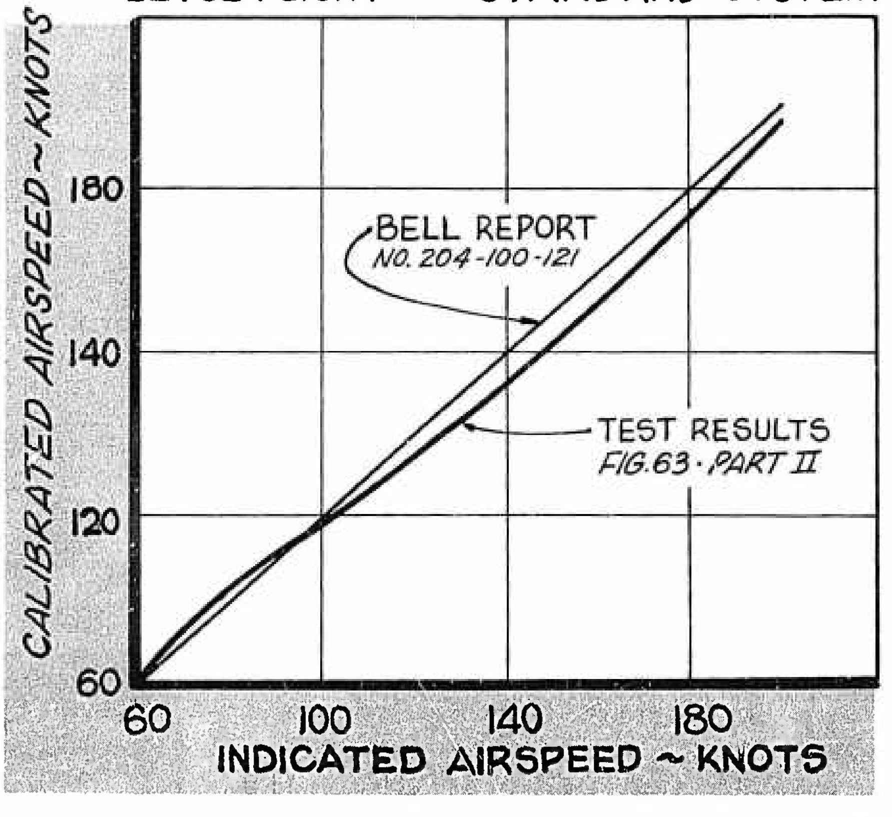
a. An airspeed position error calibration was performed using a helicopter pacer (trailing bomb) in the low speed range (below 100 knots), and a fixed wing pacer for the higher speed range.

b. The results of the airspeed calibration are presented in Figure 63, Part II. This calibration differed considerably from the characteristics presented in Bell Report 204-100-121, Reference 5, Figure 4. The Bell data indicated a zero position error for all speeds and Figure 63 of this report indicated a negative position error at indicated speeds above 100 knots. The net effect was to reduce the predicted maximum and cruise airspeeds in level flight by 4 to 5 knots, the amount of the difference. Figure 0 illustrates the calibration results.

FIG. O

AIRSPEED CALIBRATION

LEVEL FLIGHT · STANDARD SYSTEM



21. Control System Static Friction and Force

a. The rear cockpit cyclic control system was tested to establish the relationship of force and friction versus displacement. These tests were accomplished with the rotor static and with electrical and hydraulic power provided by auxiliary ground power equipment. The results are presented in Figures 64 through 67, Part II. The front cockpit cyclic characteristics were not determined because of a lack of test equipment small enough to work in the confined area around the sidearm cyclic control position. The gearing ratio between the front and rear cockpit controls was arranged as shown by Table VII, which is an excerpt from Bell Report 209-099-012 (Reference 7). For a given control force input, displacement at the swashplate was slightly less than half as much for the sidearm control compared to the aft cockpit cyclic.

b. Figures 64 and 65 of Part II show the longitudinal cyclic control characteristics, force trim both off and on. Figure 65 is of interest because it shows that some amount of positive stick centering was present even with the force trim off. The centering force gradient, however, was quite small or non-existent near the mid position of the control travel but became quite positive near the extreme positions.

Table VII

Control	Pilot in	Gunner in	Rotor Control deg
Longitudinal Cyclic	+4.9,-4.8	±2.1	+14.0 to -13.5
Lateral Cyclic	+4.8,-4.8	±2.1	±7
Directional	±2.75	±2.75	-7 to +20
Collective (75%R)	9.7	6.5	0 to 22

Figures 66 and 67, Part II present the lateral cyclic control characteristics. Figure 66 shows a unique friction band characteristic during cyclic displacements to the right of the neutral point. This condition was caused by a static imbalance of the control system mechanisms and was manifested in flight by a tendency to roll gradually to the left after the helicopter was trimmed for hands-off level flight.

22. Miscellaneous

a. With the control system configuration of the test article, flight from the front seat was practical only with the force trim off and with a minimum friction adjustment on the aft cyclic. Otherwise, the combination of limited leverage with the side-arm cyclic placement and the forces made maneuvering forces unacceptably high. With force trim off, friction and residual centering caused forces that were still high enough to be annoying but were flyable. The static imbalance of the lateral control system mentioned in Paragraph E.21, which created a constant left roll input was more noticeable and objectionable with the sidearm cyclic. A constant right force had to be held and created a very noticeable out-of-symmetry force and roll rate response characteristic. Left rolling inputs could be made with relatively light forces but a right input or an input to arrest a left roll rate required forces which were disconcertingly high. This insecure feeling was heightened by the leverage problem caused by arm position which allowed better mechanical advantage to the wrist and hand for left inputs than for right inputs. Longitudinally the sidearm control was stiffer than was considered desirable.

The sidearm collective and rudder pedals in the front cockpit were quite acceptable and no particular problem was noticed while adapting to their characteristics.

After some practice with the controls in forward flight, the observer, was able to complete an approach to a hover followed by a touchdown. This was accomplished under favorable atmospheric conditions of very light wind and no turbulence. The hovering characteristics were satisfactory once the approach had been completed. The problems of the approach centered around the normal trim changes with airspeed and the sidearm cyclic characteristics mentioned above.

As tested, the front seat control system would be unsuitable for service use based solely on the requirement for assistance from the pilot to remove friction and turn off the force trim in order for control to be assumed at the gunner's station. In a combat environment, the effort required to accomplish these two tasks may suddenly be beyond the capability of the occupant of the rear cockpit. Additionally, improvement in the cyclic control system friction and forces would be necessary to provide satisfactory control for normal, not maneuvering flight.

b. The lateral force trim system, as tested, was unsatisfactory for the reasons mentioned in Paragraphs E.21 and E.22A, which pointed out that a left rolling input was always present due to the static balance of the control system. The inability to remain in stable, hands off, trimmed level flight was very annoying.

c. Flight during turbulent air conditions produced the opinion that maneuvering flight airspeeds and control input rates should be tailored to the atmospheric conditions. One hund-

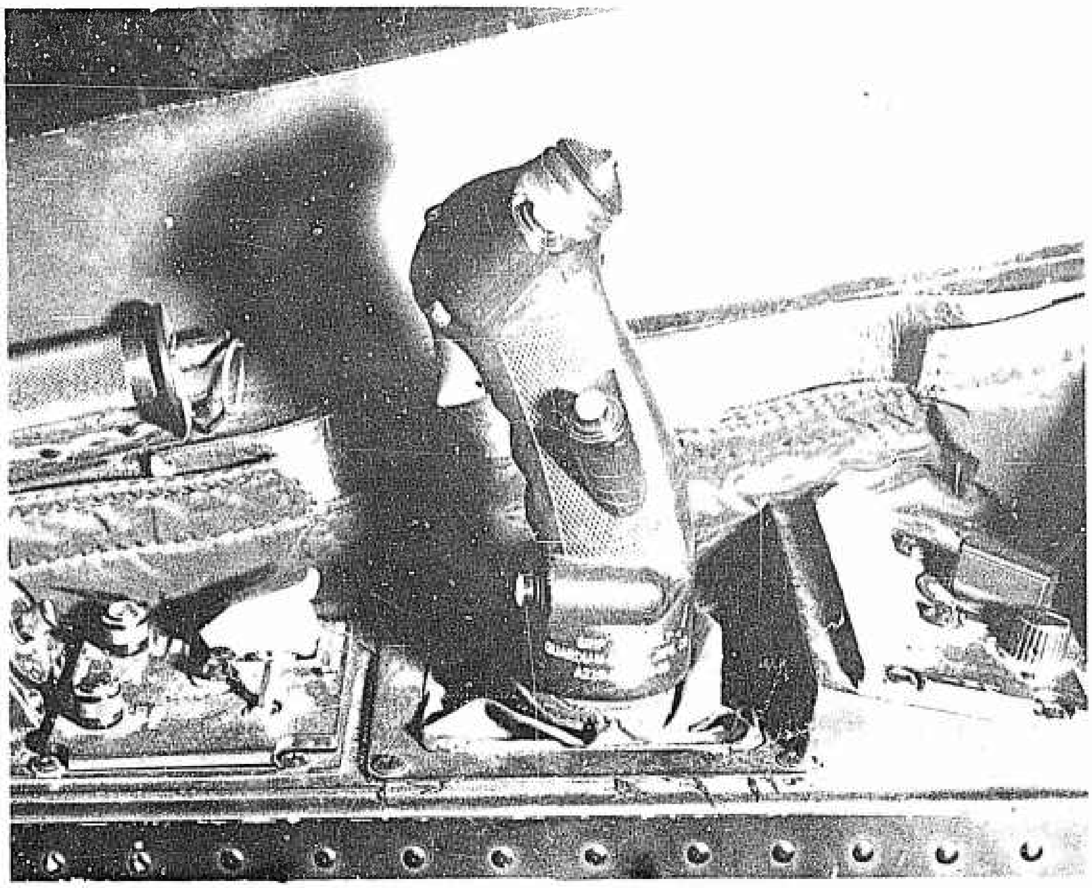


PHOTO 3 – SIDEARM CYCLIC CONTROL

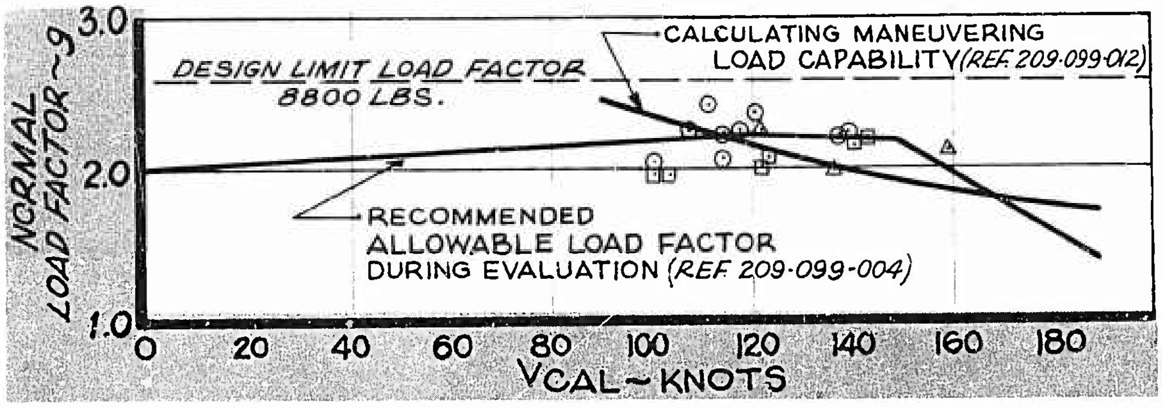
red and twenty KIAS was determined to be a reasonably comfortable maneuvering airspeed under conditions of moderate to severe turbulence. The roll rates and load factors used for maneuvering under these conditions were more limited by common sense than by aircraft capability. Sufficient documentation was accomplished to indicate, not too surprisingly, that the helicopter can be flown in turbulent air.

d. Nap-of-the-earth flight was conducted over some rather demanding terrain. The helicopter was capable of good terrain following. The maneuvering flight characteristics as tested were enhanced by the excellent field of vision from both cockpits. Improvement in the maneuvering flight characteristics in accordance with the discussion of Paragraph E.18 of this report should result in very acceptable nap-of-the-earth flight characteristics.

e. The structural demonstration and flight loads survey for the test article were incomplete. Complete knowledge of the structural integrity and a fatigue life substantiation was, therefore, not available. Prior to further Army engineering flight tests, these areas should be expanded by the contractor so that a more complete evaluation can be conducted. It is doubtful that the dynamic components would have the same fatigue life as when used for the UH-1B application.

The allowable load factor-airspeed relationship recommended by the contractor for this evaluation is shown in Figure P.

FIG. P
HUEYCOBRA
VARIATION OF NORMAL LOAD FACTOR WITH AIRSPEED
8800 LBS.
O *TEAR DROP MANEUVERS* □ *TURN REVERSALS* △ *SYMMETRICAL PULL UPS*



Also presented are the design limit load factor, the calculated maneuvering capability and some of the peak load factors observed during these tests. The values observed indicate that the agility maneuvers were performed using the maximum maneuvering capability of the design. The maneuvering test results, therefore, can be presumed to be representative of the maximum capability; and no additional maneuvering capability would be realized when the contractor has developed a full structural envelope.

f. Rocket and machine gun firing capability had not been established for the test article. Prior to further Army engineering tests, the contractor should demonstrate the aircraft characteristics during rocket and machine gun firing under all flight conditions.

g. Under some flight conditions of low "g," primarily pushovers from the climbs following dive recoveries, natural frequency pylon motion was encountered. This motion was of the same type and frequency (1/2 - 3/4 per rev) previously encountered and reported as objectionable during tests of the UH-1B/540 helicopter. In this case, damping was quick and positive following an increase in load factor to 1.0 g. Future effort should include the verification of good pylon damping over the allowable load factor and airspeed envelope. Based on the earlier UH-1B/540 undamped pylon motion problems, future Army engineering tests of this design should include investigation of the ASE and pylon stability compatibility under all flight conditions.

h. The limit airspeeds recommended by the contractor for the evaluation are presented in Part III, Annex D and included 190 KCAS from sea level to a density altitude of 4000 feet. The helicopter was capable, in an armed configuration, of a power limited level flight speed of approximately 155 KCAS. The speed range between 155 and 190 KCAS was quite usable in shallow dives. Vibration levels were tolerable and acceptable flight characteristics were present. The high never exceed speed (V_{NE}) would offer the opportunity to develop tactics that would take advantage of the high speeds. If procurement of this helicopter type is initiated, the procuring agency should specify that the V_{limit} speed should not be less than 190 KCAS and an increase in this value is desirable.

i. During the evaluation, the helicopter was maintained by contractor personnel. At least once during the program the helicopter was turned over to the contractor flight personnel for retracking the rotor because of excessive 1-per-rev vibrations. Considering the experience with the standard UH-1B/540 helicopters, difficulty in maintaining good track would seem to be an inherent 540 rotor system problem. If procurement of this type helicopter is initiated, the procuring agency should require the contractor to demonstrate consistency of rotor track and vibration levels when the helicopter is operated with a normal level of maintenance effort.

j. The T53-L-13 engine provided power available considerably in excess of the rated transmission limit of 1100 SHP. If procurement of this type helicopter is initiated, the procuring agency should investigate the possibility of increasing the allowable transmission torque limits to take advantage of the installed power. An increased SHP "short-time" 5 minute rating would be of value during takeoff and landing and during high speed maneuvering flight.

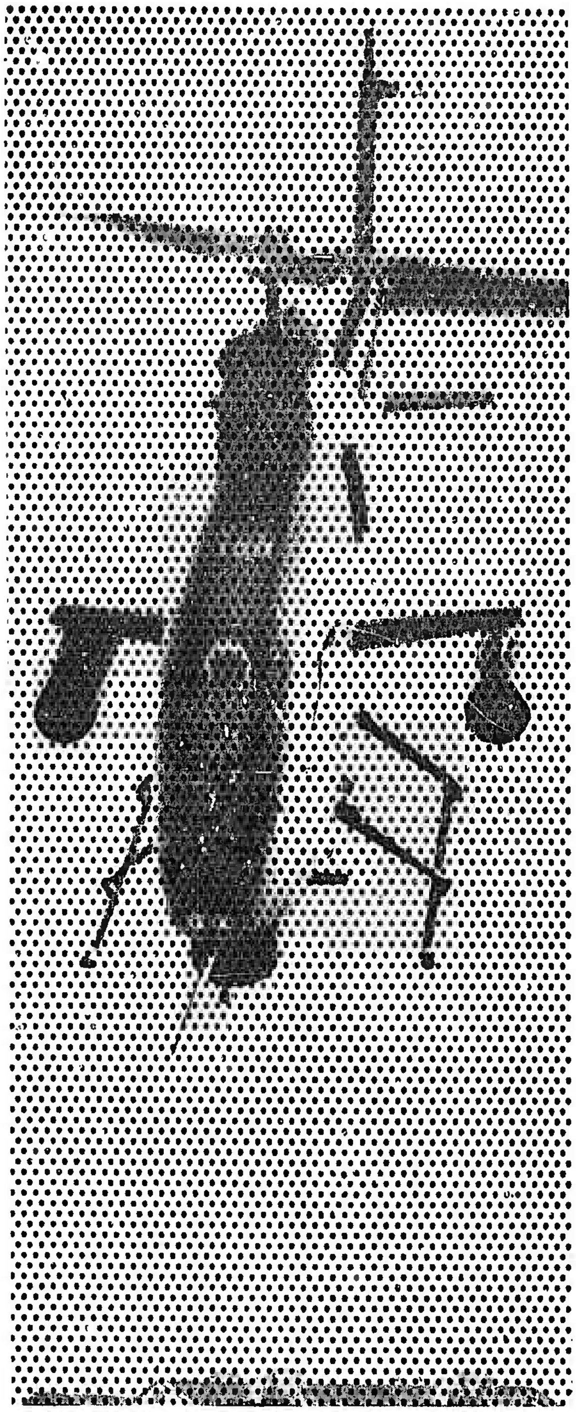
k. Finally, it should be recognized that the test article provided for the evaluation was in a relatively early stage of contractor development and test. At the beginning of the evaluation, the helicopter had accumulated only 68 hours since roll-out. A large percentage of that time had been accumulated during demonstrations of the dive speed capability as part of a sales effort.

This evaluation included some of the most structurally severe maneuvers and tests ever attempted by a government helicopter test agency. The fact that the test article withstood the treatment was a tribute to the contractor and the people of his staff responsible for its design and construction.

The actual parts replacement during the evaluation consisted of an oil pressure warning light switch and a forward fuel boost pump. Non-routine maintenance included the rotor retracking already mentioned and attempts to improve the ASE operation, which was recognized as not being optimized at the beginning of the tests.

Considering the manner in which the helicopter had to be operated to meet the test objectives, maintenance was remarkably low for a prototype aircraft.

F. Conclusions



The HueyCobra test article provided for the evaluation demonstrated acceptable flight characteristics over an airspeed envelope that was considerably larger than that for a standard armed UH-1B/540 helicopter. Although most of the flight characteristics were less optimum than predicted by the contractor, tactical use of airspeeds during dives up to the limit of the test vehicle (190 KCAS) appeared to be feasible with characteristics which would allow effective weapons delivery.

The use of an existing set of dynamic components matched to a new fuselage design with improved drag characteristics resulted in improved level flight performance in terms of speed and range for comparable power settings and fuel loads. The contractor's performance estimates were found to be optimistic with most of the optimism apparently caused by an erroneous airspeed position error calibration. Test results indicated that the hovering and climb performance characteristics of the design were similar to those of a standard UH-1B/540 helicopter, excluding the difference in performance that could be attributed to the more powerful T53-L-13 engine.

The helicopter accomplished the agility maneuvers satisfactorily although improved handling qualities during transient maneuvering flight would reduce the pilot effort and attention required to utilize the full design capability.

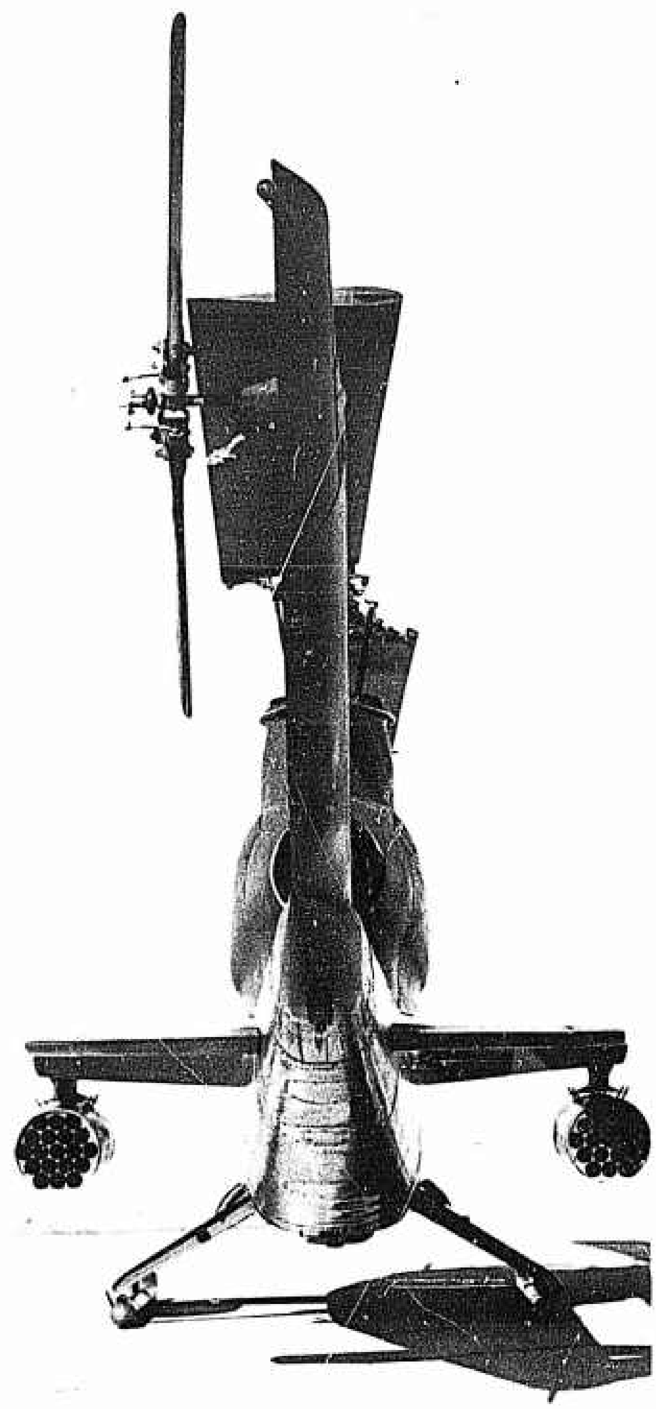
The vibration characteristics were adequate for the anticipated mission over the flight envelope investigated.

The cockpit configuration provided an excellent field of vision for both the gunner and pilot. Cockpit ventilation was marginal. The sidearm cyclic control provided for the gunner's station was characterized by excessive and asymmetric lateral forces and would have to be improved to be considered satisfactory. Noise level in the aft cockpit was considered to be excessive.

High speed autorotational entries required a rotor RPM control technique that was different from a normal helicopter maneuver and would represent a pilot checkout and training requirement.

Flight to the limit airspeed, 190 KCAS, was possible with the ASE off, although the natural airframe lateral directional damping characteristics would limit effective use as a weapons platform to speeds below approximately 120 KCAS.

The fatigue life and structural integrity of the design remains to be substantiated by a contractor demonstration.



G. Recommendations

1. Improvements in the following areas should be accomplished prior to further Army engineering tests of this design:

a. Improve maneuvering flight characteristics, both laterally and longitudinally. The following suggestions are presented in the areas where improvement is desired:

(1) Provide a stick force per g gradient during stabilized turning flight and during pull-up turning flight and during pull-up maneuvers. A minimum gradient of 10 pounds/g is suggested.

(2) Reduce the time required to achieve 63 percent of the maximum normal acceleration during step inputs. The present time constant is 1.2 seconds; a desirable target is .3 seconds.

(3) Reduce the time required to achieve 63 percent of the maximum steady rolling rate following step inputs. The present time constant is .5 seconds; a desirable maximum is .25 seconds.

(4) Maintain a force harmony ratio between the longitudinal and lateral controls which is between 2:1 and 4:1 throughout the speed range of the helicopter while satisfying items (1) through(3).

b. Establish the usable center-of-gravity range of the design and at the most adverse combination of gross weight and center of gravity, provide longitudinal static stability gradients that are at least as stable as the least stable conditions presented in this report.

c. Measure the aft cockpit noise level and reduce to meet requirements of the appropriate military specifications.

d. Investigate the negative maneuvering stability below 100 KIAS in stabilized turning flight and, if present, provide positive longitudinal position vs force g gradients

e. Eliminate the longitudinal trim change in left sideslips and match with the desirable lack of longitudinal trim change during right sideslips.

f. Eliminate left rolling control input caused by configuration of control system and which could not be trimmed out.

g. Improve front seat cyclic control to provide acceptable control forces and harmony. Control transition to the front seat must be accomplished without assistance presently required from the pilot to turn off force trim and remove cyclic friction.

h. Demonstrate autorotational entries at all speeds to V_{NE} and develop recommended entry technique.

i. Demonstrate low g (down to 0.0 g) pylon stability and helicopter controllability over the usable speed range to V_{NE}.

j. Complete structural demonstration and establish structural integrity and structural margins over the weight range to include the proposed maximum allowable gross weight.

k. Demonstrate and establish the requirements of Paragraphs a, b, e, h, i and j for the most adverse external stores configurations.

l. Investigate the engine inlet pressure recovery characteristics and resolve differences between government and contractor measurements.

m. Demonstrate autorotation touchdown at maximum gross weight and develop recommended touchdown techniques.

n. Demonstrate ASE and pylon stability compatibility for all allowable flight conditions, gross weights and approved maneuvers.

2. The following items are recommended for accomplishment prior to release of the design for possible service and logistical test:

a. Establish the fatigue life of the dynamic components based on criteria applicable to the armed helicopter mission.

b. Complete a "firing" structural and handling qualities demonstration to be followed by government verification of the handling qualities during weapons firing.

c. Demonstrate consistency of rotor track and vibration levels when helicopter is operated with a normal level of maintenance effort. The government should establish the acceptable level of maintenance effort to be termed "normal."

d. Provide improved canopy operation and canopy "hold-opens."

e. Provide adequate cockpit heating and ventilation.

f. Complete the correction of deficiencies reported during government engineering tests. Verification of the corrections or deviations from the requirements must be accomplished by the engineering test agency prior to release of the full flight envelope for service and logistical test.

g. Provide armored seats for both cockpits which do not restrict the usable travel of the aft cockpit flight controls or a front cockpit gunsight.

h. Relocate switches, circuit breakers and instruments in a more logical manner as determined by a mockup board.

3. The following items are recommended for study or action to provide an improved capability for the weapons system.

a. Increase the present

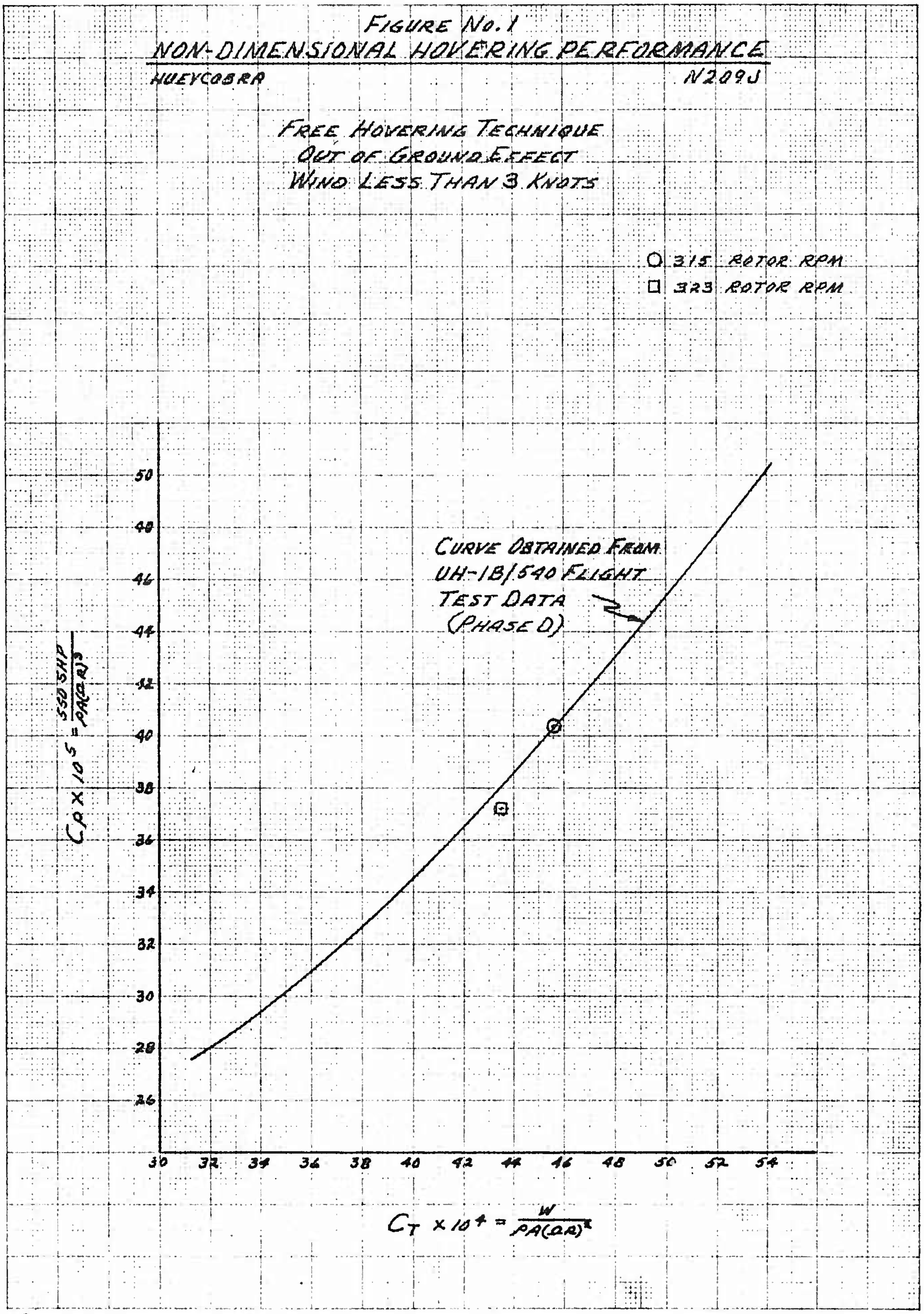
V_{NE} limit of 190 KCAS to the maximum value consistent with the safe capability of the design. Under no circumstances should the government consider acceptance of flight limits more restrictive than those provided during this evaluation.

b. Investigate the possibility of increasing the allowable takeoff and continuous torque limits in order to take advantage of the power which will be available from the T53-L-13 engine under favorable atmospheric conditions. The characteristics of the rotor at high speeds and high collective settings should be considered when increasing these limits.

c. Initiate a study to provide improved vibration characteristics. While the vibration levels of the prototype were generally acceptable, degradation with flying time in a manner similar to that presently being experienced by the UH-1B/540 helicopters will result in a significant reduction in mission capability.

PART II GRAPHICAL ANALYZED TEST DATA

FOR OFFICIAL USE ONLY



FOR OFFICIAL USE ONLY

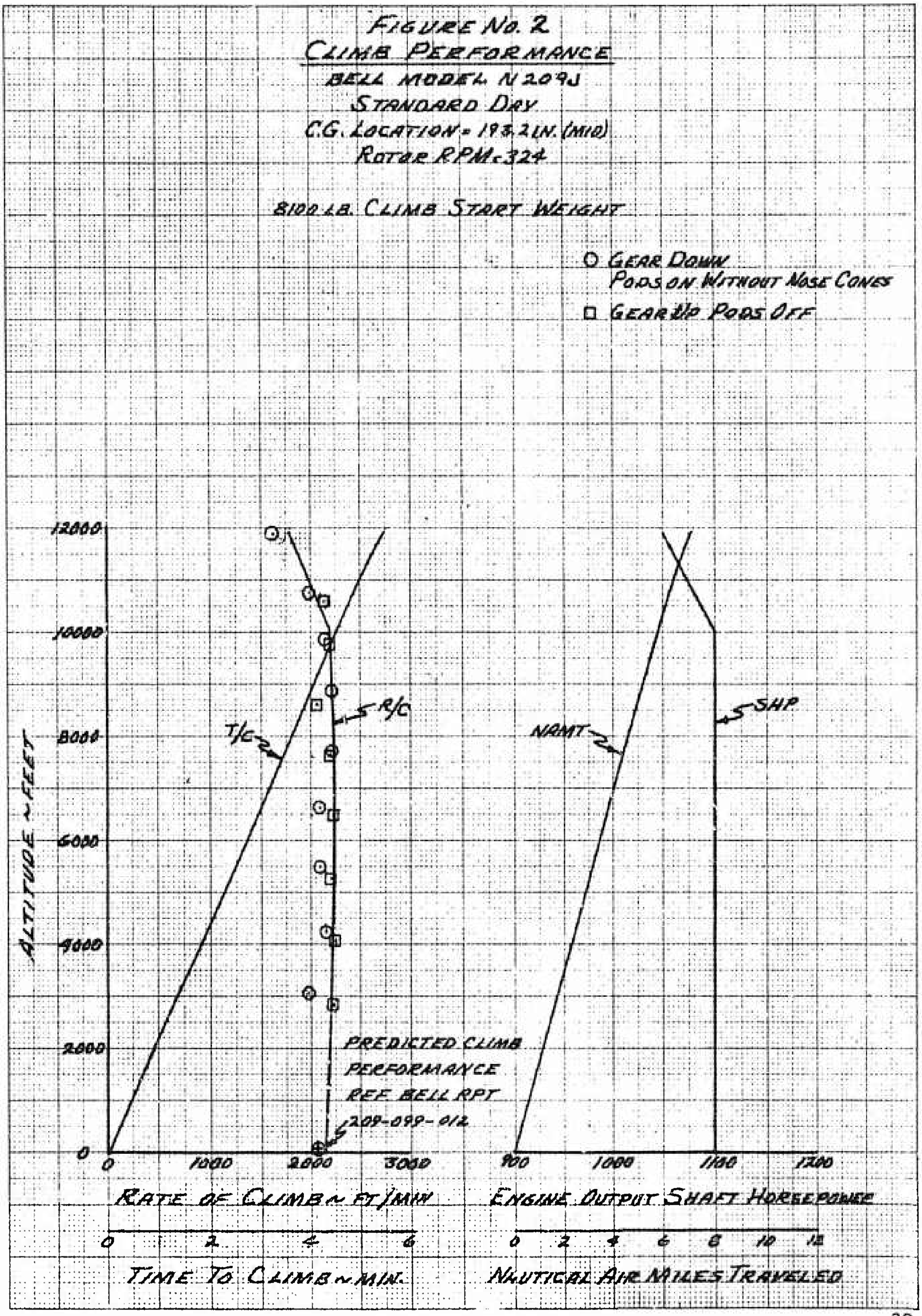


FIGURE No. 2
CLIMB PERFORMANCE
BELL MODEL N209J
STANDARD DAY
C.G. LOCATION = 193.2 IN. (MID)
ROTOR RPM = 324
8100 LB. CLIMB START WEIGHT
O GEAR DOWN
PODS ON WITHOUT NOSE CONES
□ GEAR UP PODS OFF
ALTITUDE ~ FEET
12000
10000
8000
6000
4000
2000
0
T/C
R/C
NAMT
SHP
PREDICTED CLIMB
PERFORMANCE
REF. BELL RPT
209-099-012
0
1000
2000
3000
900
1000
1100
1200
RATE OF CLIMB ~ FT/MIN
ENGINE OUTPUT SHAFT HORSEPOWER
0
2
4
6
0
2
4
6
8
10
12
TIME TO CLIMB ~ MIN.
NAUTICAL AIR MILES TRAVELED

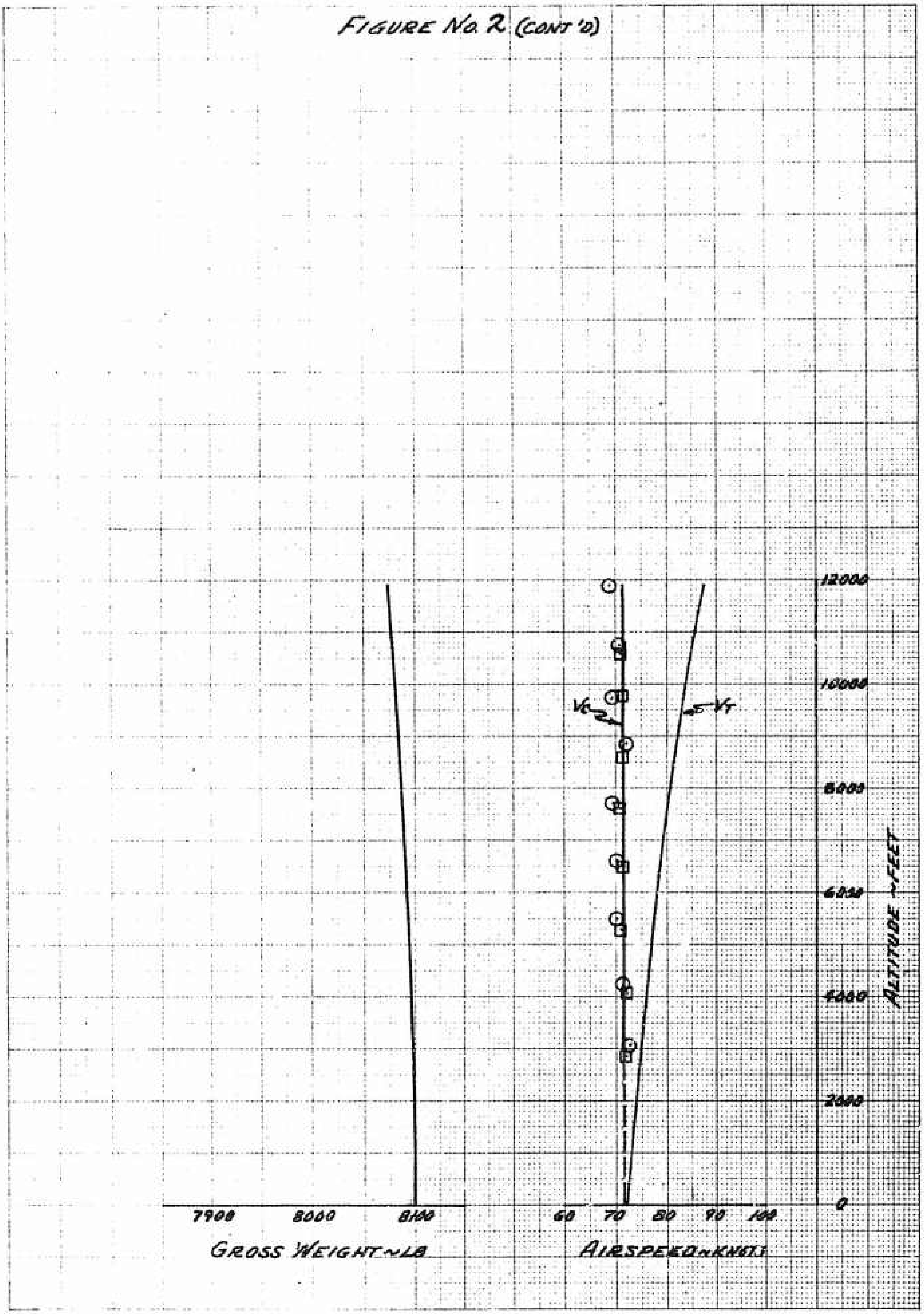


FIGURE No. 2 (CONT'D)
12000
10000
8000
6000
4000
2000
0
ALTITUDE ~ FEET
V_C
V_T
7900
8000
8100
GROSS WEIGHT ~ LB
60
70
80
90
100
AIRSPEED ~ KNOTS

FIGURE NO. 3

CLIMB PERFORMANCE

BELL MODEL N 209 J

STANDARD DAY

C.G. LOCATION = 193.2 IN. (MID)

ROTOR R.P.M. = 324

GEAR DOWN

PODS ON WITHOUT NOSE CONES

8800 LB. CLIMB START WEIGHT

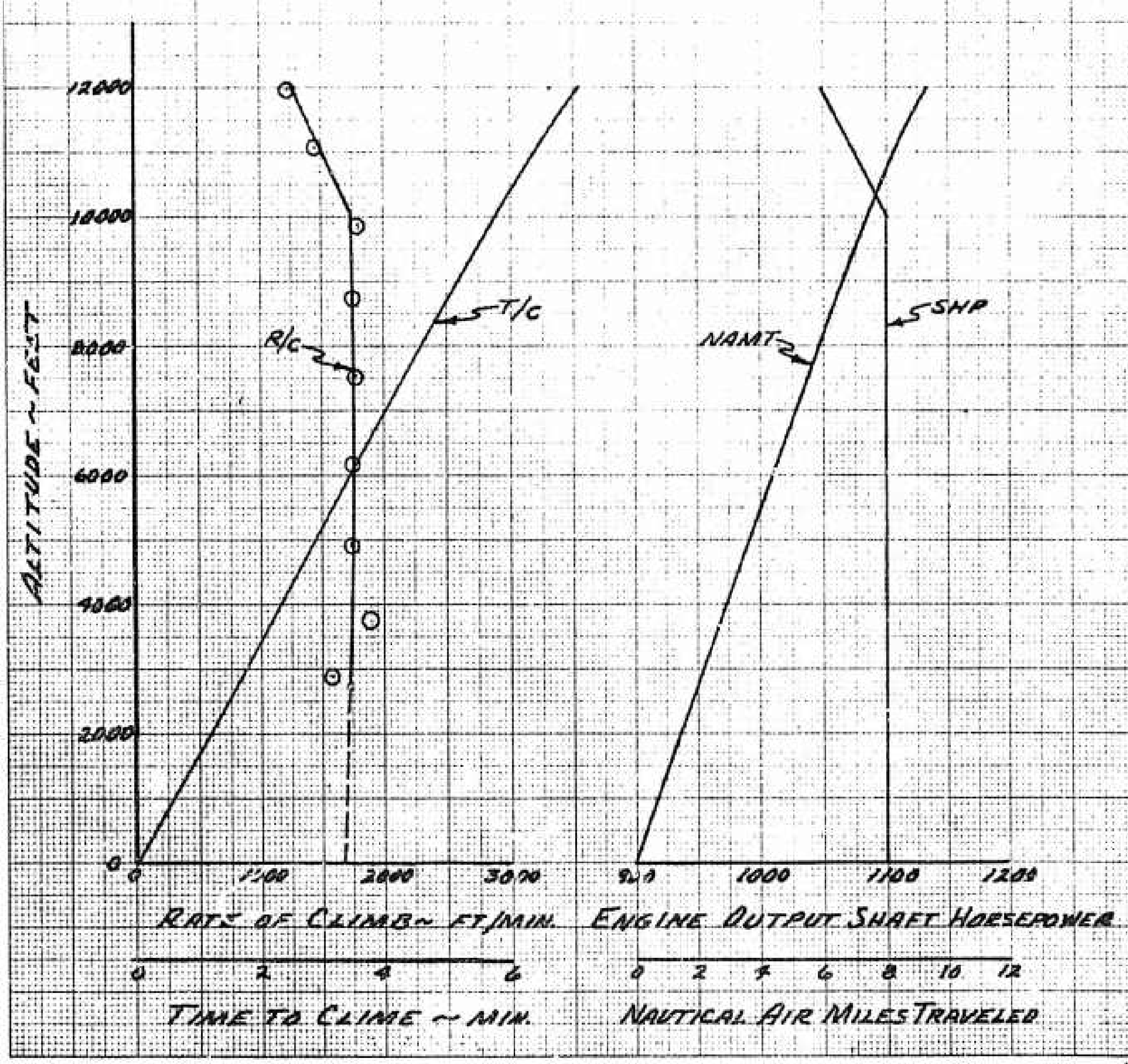
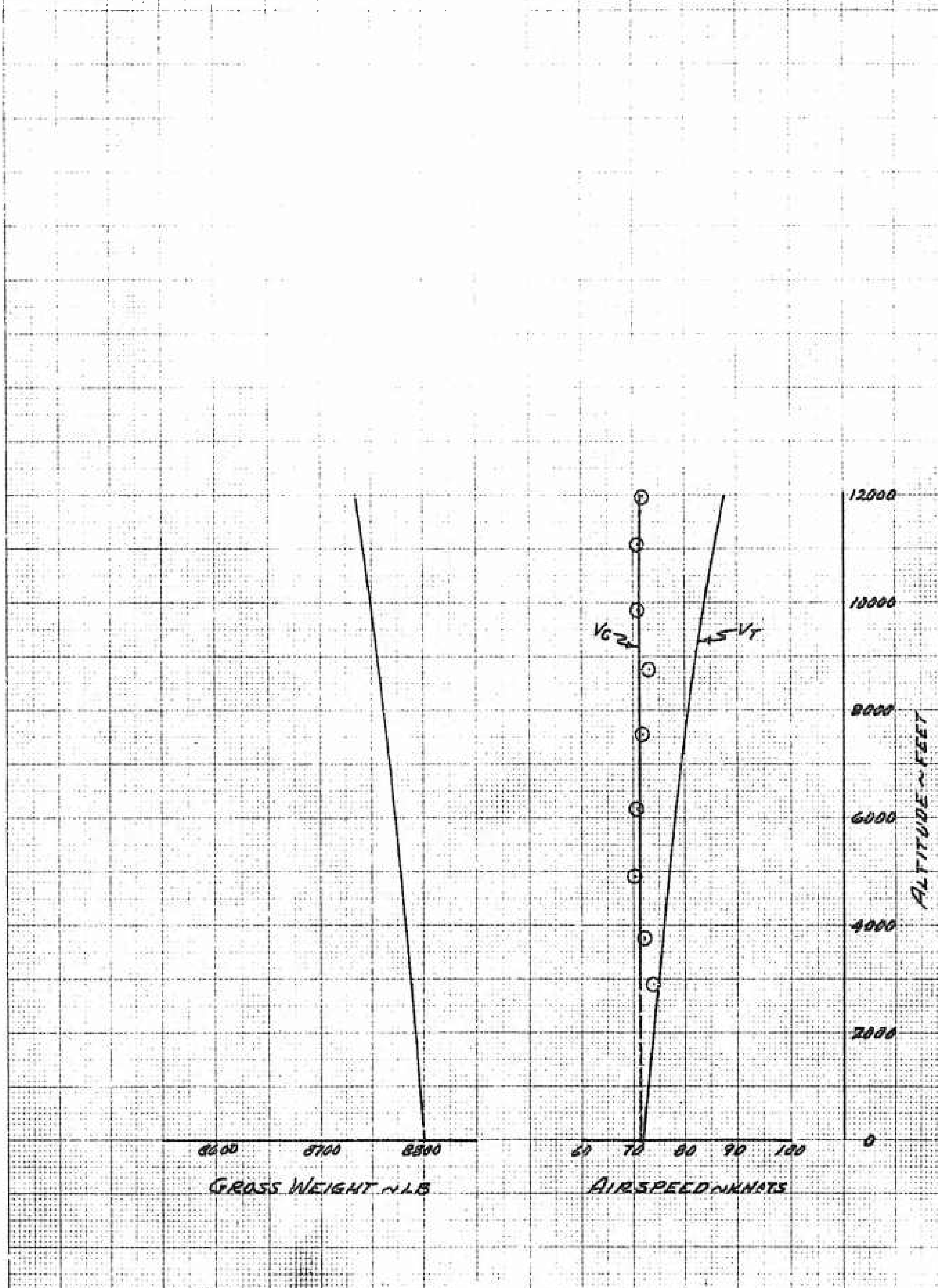


FIGURE No 3 (CONT'D)



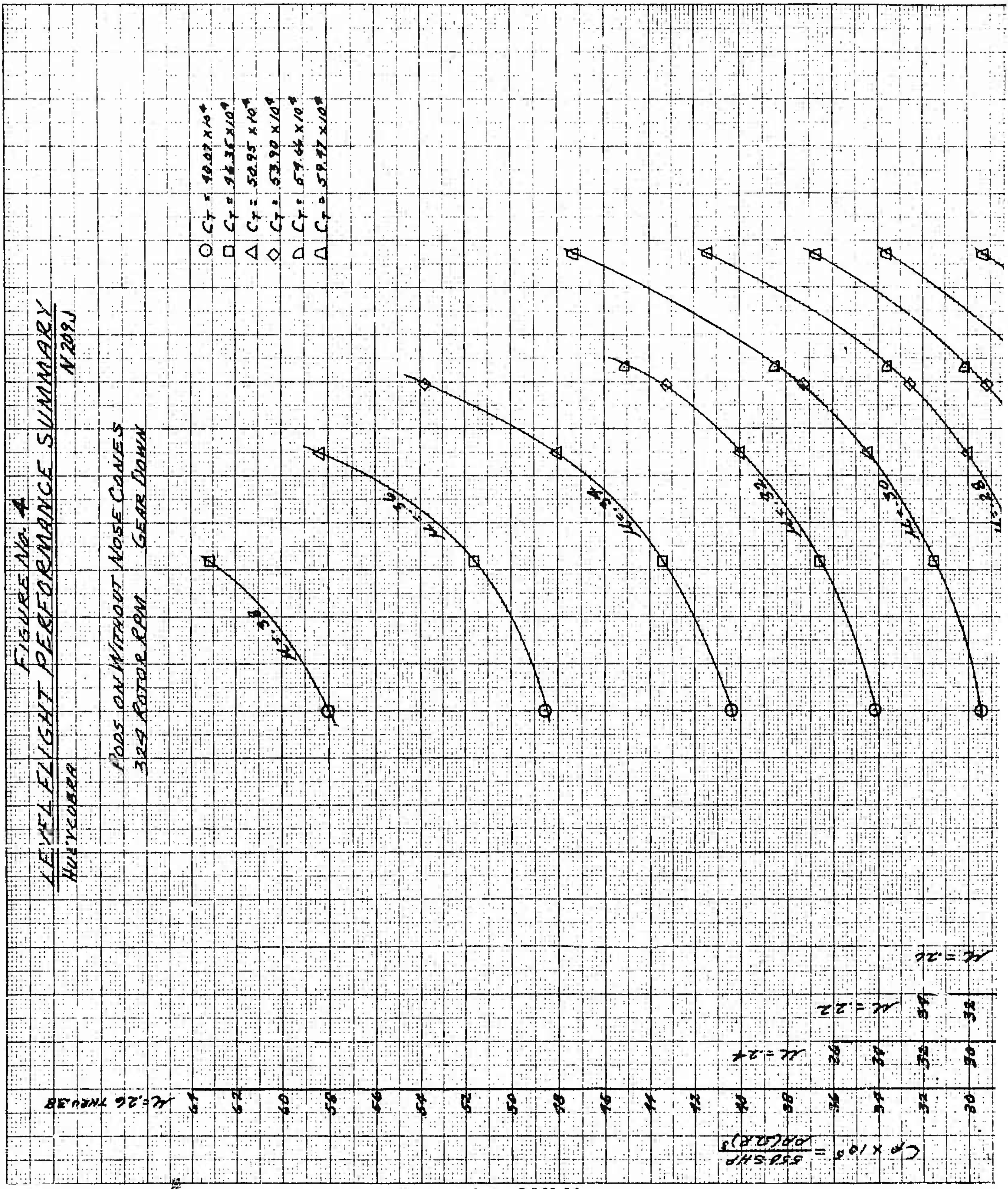
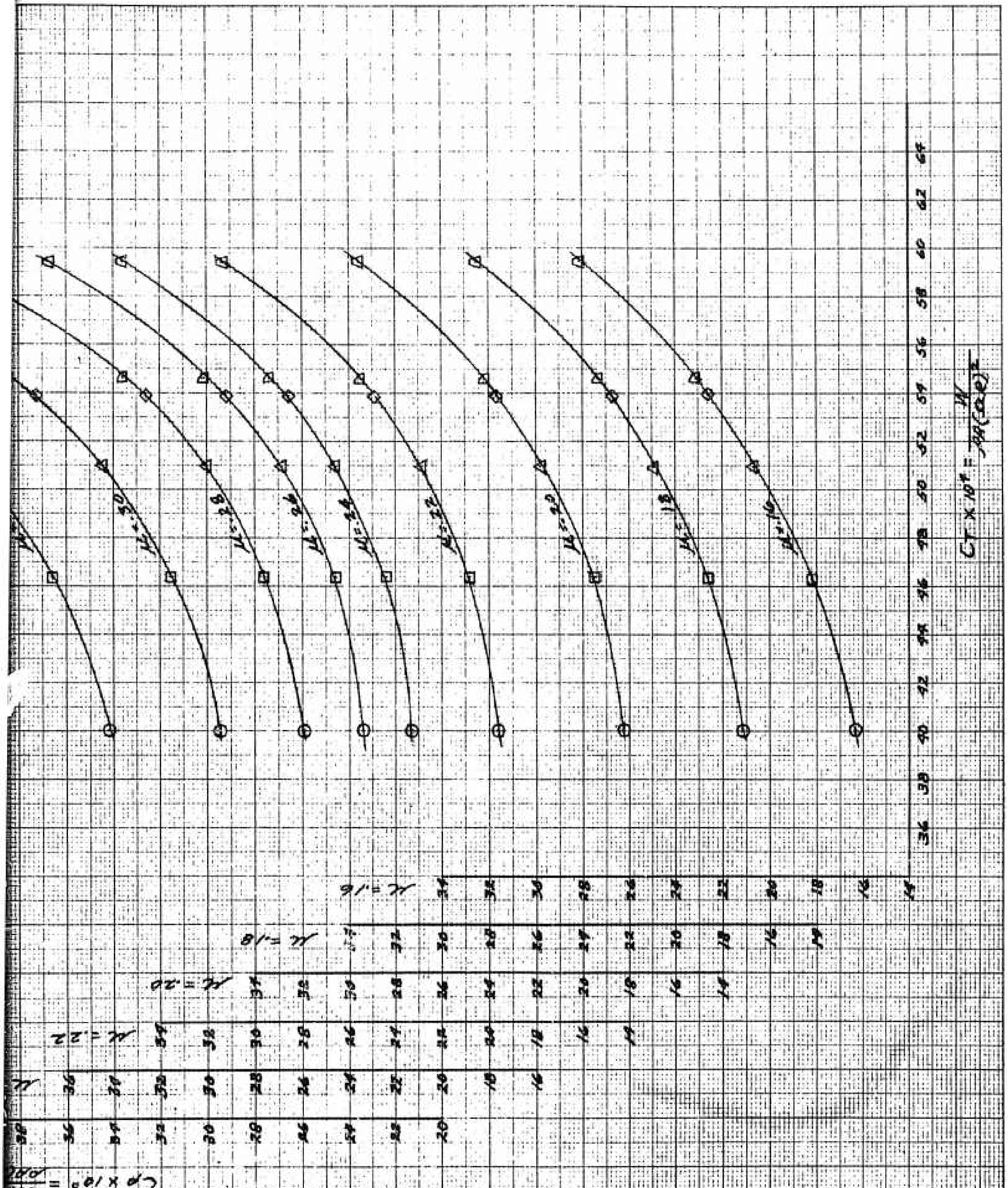


FIGURE No. 4
LEVEL FLIGHT PERFORMANCE SUMMARY
HUEYCOBRA
N209J
PODS ON WITHOUT NOSE CONES
324 ROTOR RPM
GEAR DOWN


μ=.30
μ=.28
μ=.26
μ=.24
μ=.22
μ=.20
μ=.18
μ=.16
μ = .16
μ = .18
μ = .20
μ = .22

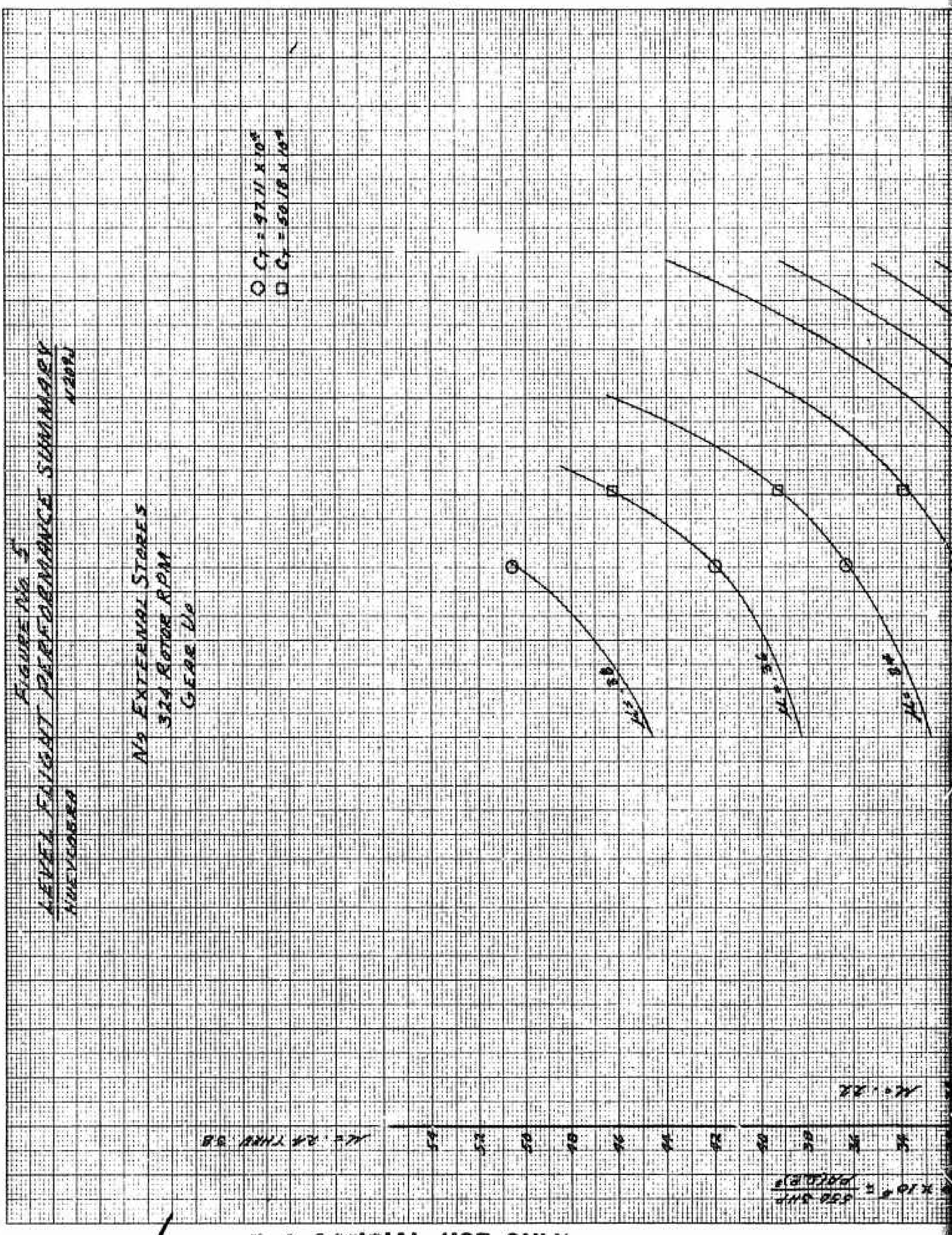
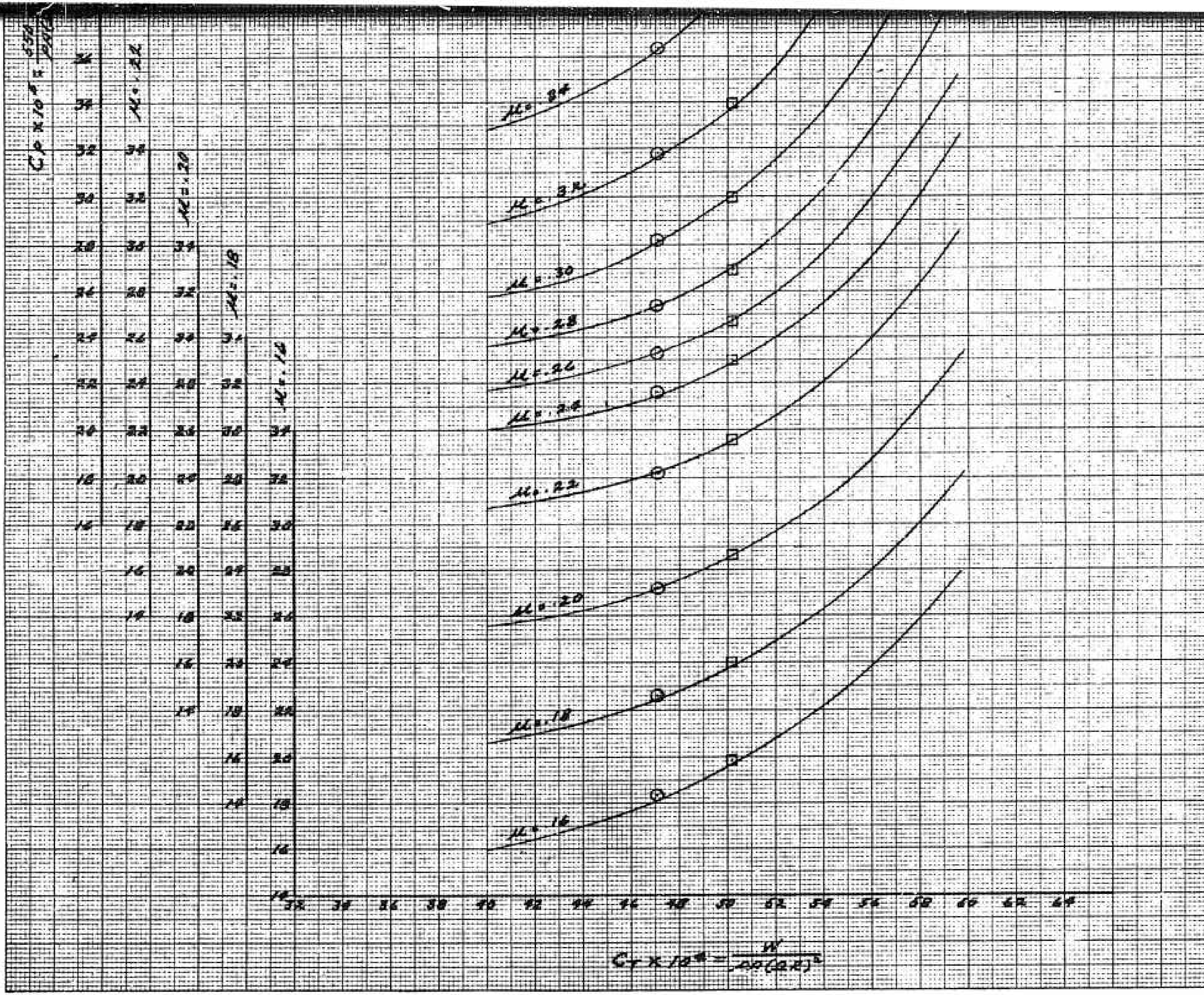


FIGURE No. 5
LEVEL FLIGHT PERFORMANCE SUMMARY
HUEYCOBRA
N209J
No EXTERNAL STORES
324 ROTOR RPM
GEAR UP
○ C_T = 47.11 X 10^{-4}
□ C_T = 50.18 X 10^{-4}



$\mu = .34$
$\mu = .32$
$\mu = .30$
$\mu = .28$
$\mu = .26$
$\mu = .24$
$\mu = .22$
$\mu = .20$
$\mu = .18$
$\mu = .16$
32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64
$C_T \times 10^4 = \frac{W}{\rho n^2 (2R)^4}$

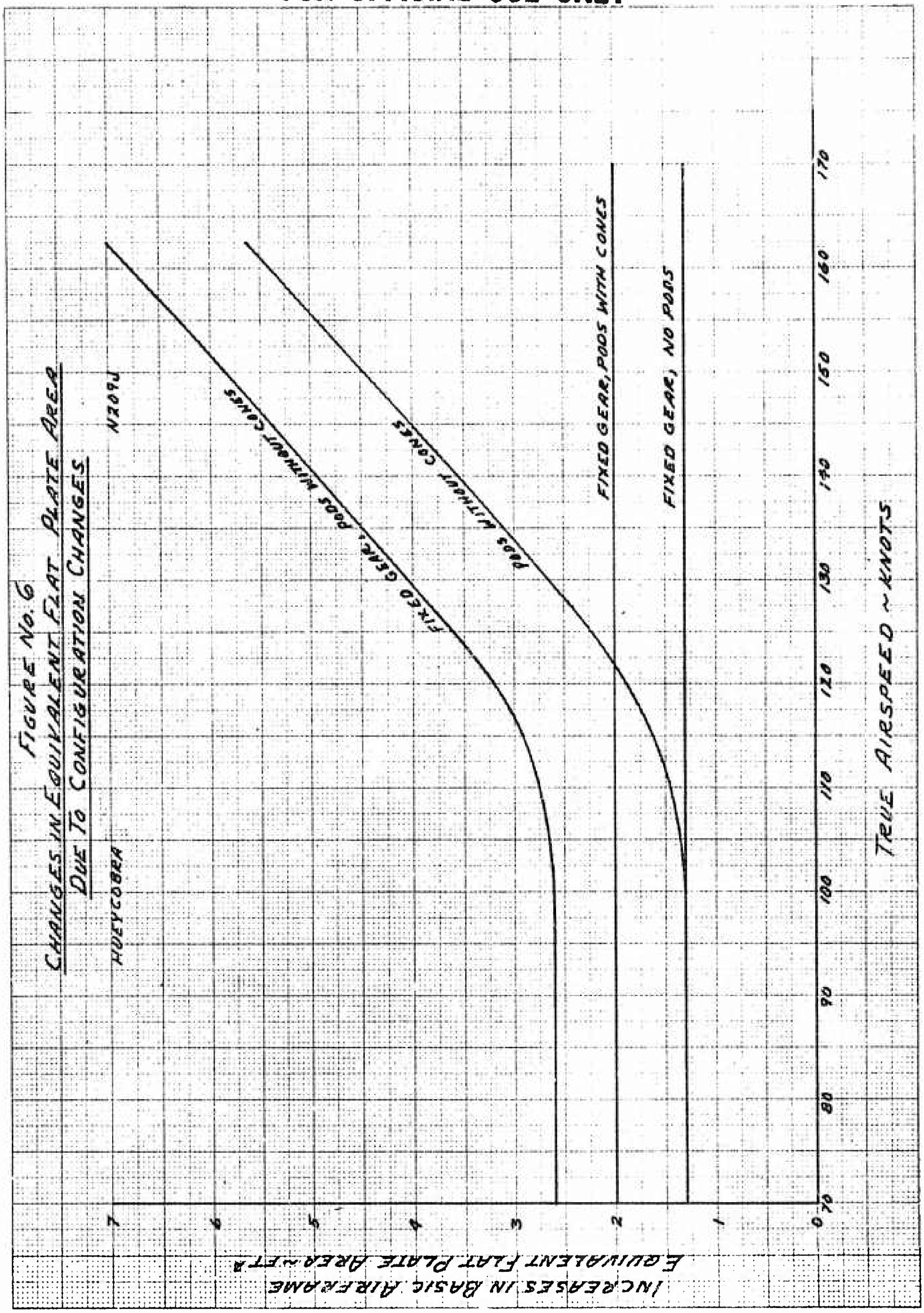


FIGURE No. 6
CHANGES IN EQUIVALENT FLAT PLATE AREA
DUE TO CONFIGURATION CHANGES
HUEYCOBRA
N209J
FIXED GEAR, PODS WITHOUT CONES
PODS WITHOUT CONES
FIXED GEAR, PODS WITH CONES
FIXED GEAR, NO PODS
70
80
90
100
110
120
130
140
150
160
170
TRUE AIRSPEED ~ KNOTS
0
1
2
3
4
5
6
7
INCREASES IN BASIC AIRFRAME
EQUIVALENT FLAT PLATE AREA ~ FT²

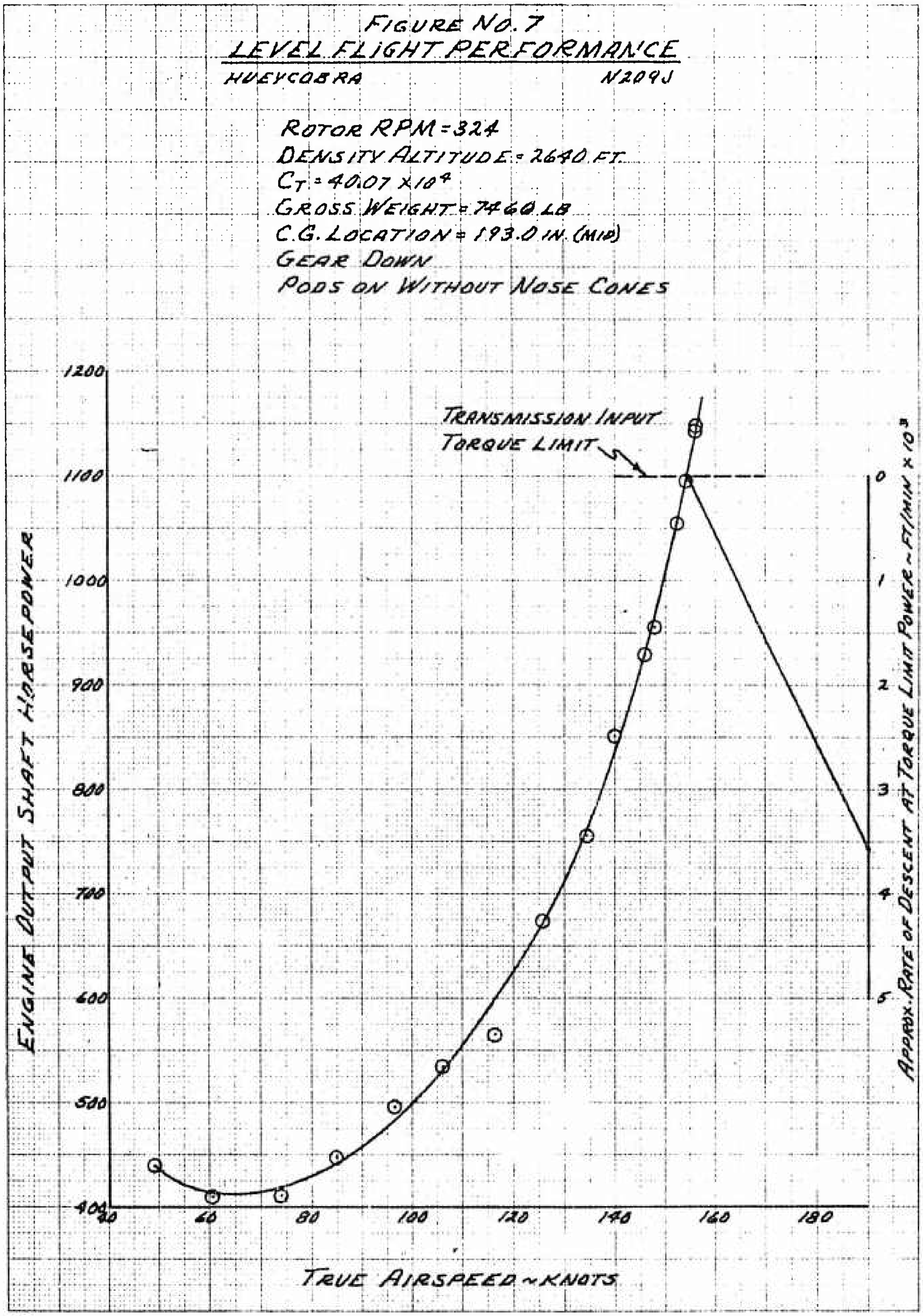


FIGURE NO. 7
LEVEL FLIGHT PERFORMANCE
HUEYCOBRA
N209J
ROTOR RPM = 324
DENSITY ALTITUDE = 2640 FT.
C_T = 40.07 x 10^4
GROSS WEIGHT = 7460 LB
C.G. LOCATION = 193.0 IN. (MID)
GEAR DOWN
PODS ON WITHOUT NOSE CONES
TRANSMISSION INPUT TORQUE LIMIT
ENGINE OUTPUT SHAFT HORSEPOWER
1200
1100
1000
900
800
700
600
500
400
40
60
80
100
120
140
160
180
TRUE AIRSPEED ~ KNOTS
APPROX. RATE OF DESCENT AT TORQUE LIMIT POWER ~ FT/MIN x 10^3
0
1
2
3
4
5

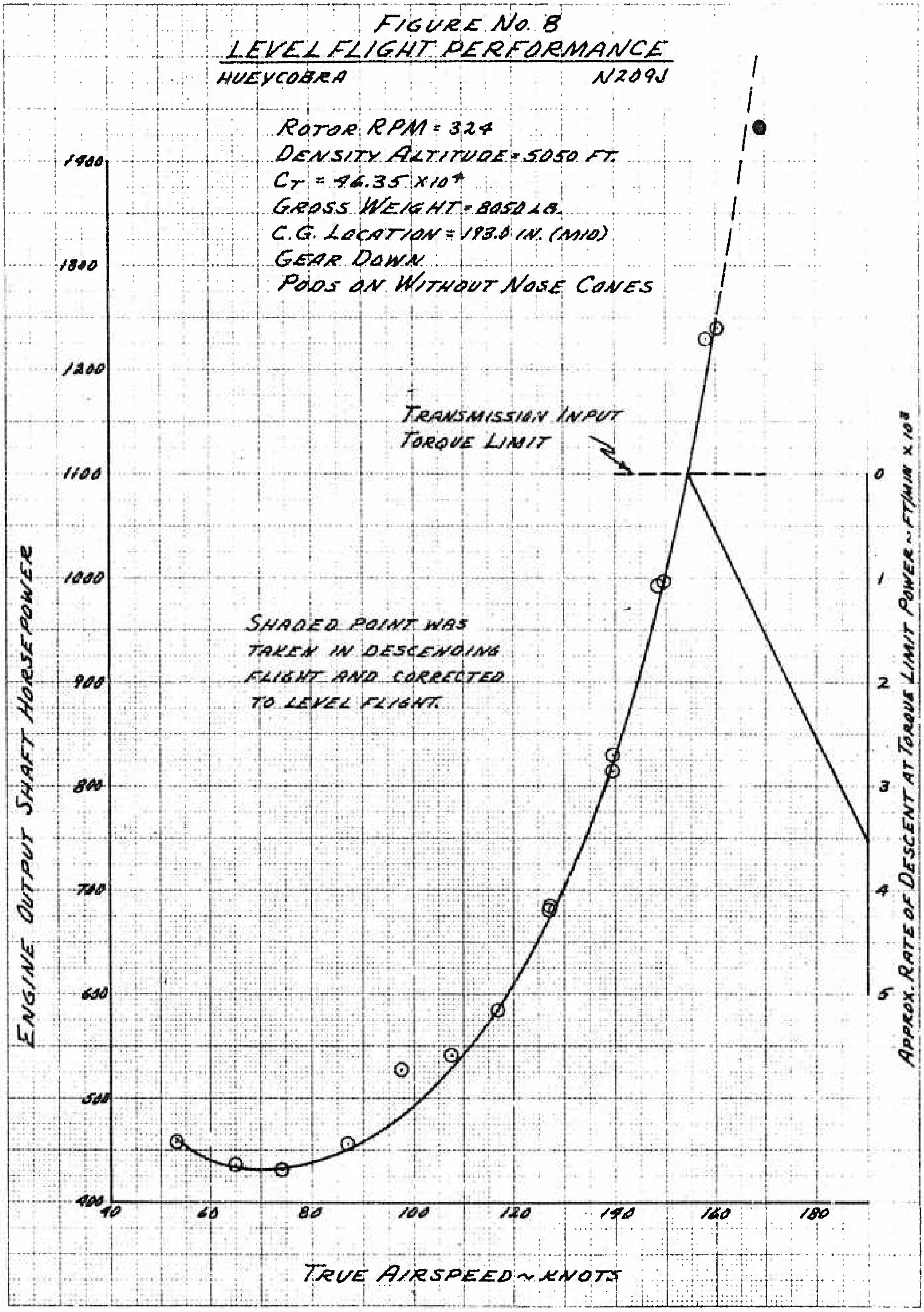


FIGURE No. 8
LEVEL FLIGHT PERFORMANCE
HUEYCOBRA
N209J
ROTOR RPM = 324
DENSITY ALTITUDE = 5050 FT.
C_T = 46.35 X 10^4
GROSS WEIGHT = 8050 LB.
C.G. LOCATION = 193.0 IN. (MID)
GEAR DOWN
PODS ON WITHOUT NOSE CONES
TRANSMISSION INPUT TORQUE LIMIT
SHADED POINT WAS TAKEN IN DESCENDING FLIGHT AND CORRECTED TO LEVEL FLIGHT.
ENGINE OUTPUT SHAFT HORSEPOWER
TRUE AIRSPEED ~ KNOTS
APPROX. RATE OF DESCENT AT TORQUE LIMIT POWER ~ FT/MIN x 10^3
1400
1300
1200
1100
1000
900
800
700
600
500
400
40
60
80
100
120
140
160
180
0
1
2
3
4
5

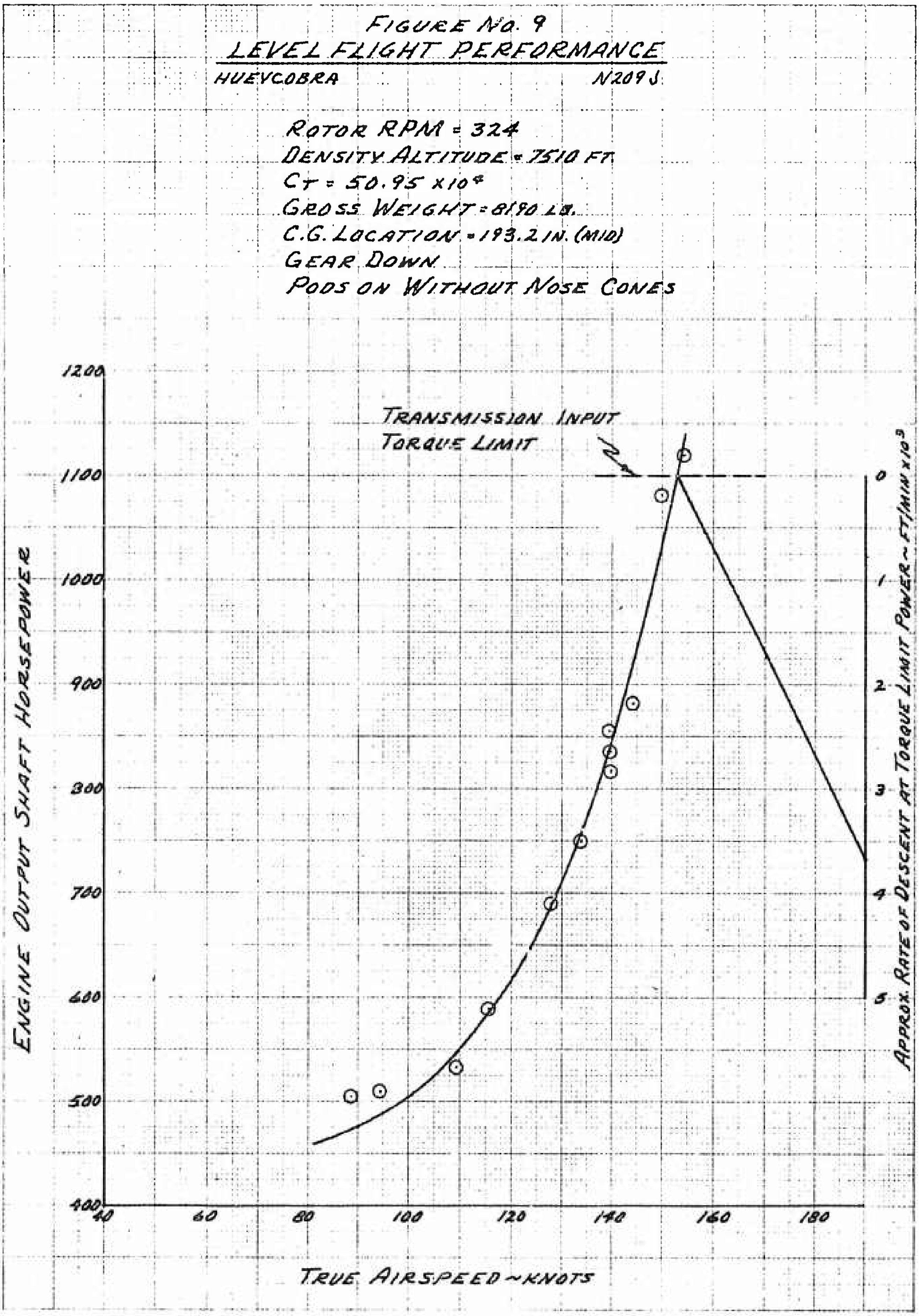


FIGURE NO. 9
LEVEL FLIGHT PERFORMANCE
HUEYCOBRA
N209J
ROTOR RPM = 324
DENSITY ALTITUDE = 7510 FT.
CT = 50.95 x10⁴
GROSS WEIGHT = 8190 LB.
C.G. LOCATION = 193.2 IN. (MID)
GEAR DOWN
PODS ON WITHOUT NOSE CONES
TRANSMISSION INPUT
TORQUE LIMIT
ENGINE OUTPUT SHAFT HORSEPOWER
APPROX. RATE OF DESCENT AT TORQUE LIMIT POWER ~ FT/MIN x10³
TRUE AIRSPEED ~ KNOTS
400
500
600
700
800
900
1000
1100
1200
0
1
2
3
4
5
40
60
80
100
120
140
160
180

FIGURE No. 10
LEVEL FLIGHT PERFORMANCE

HUEYCOBRA N209J

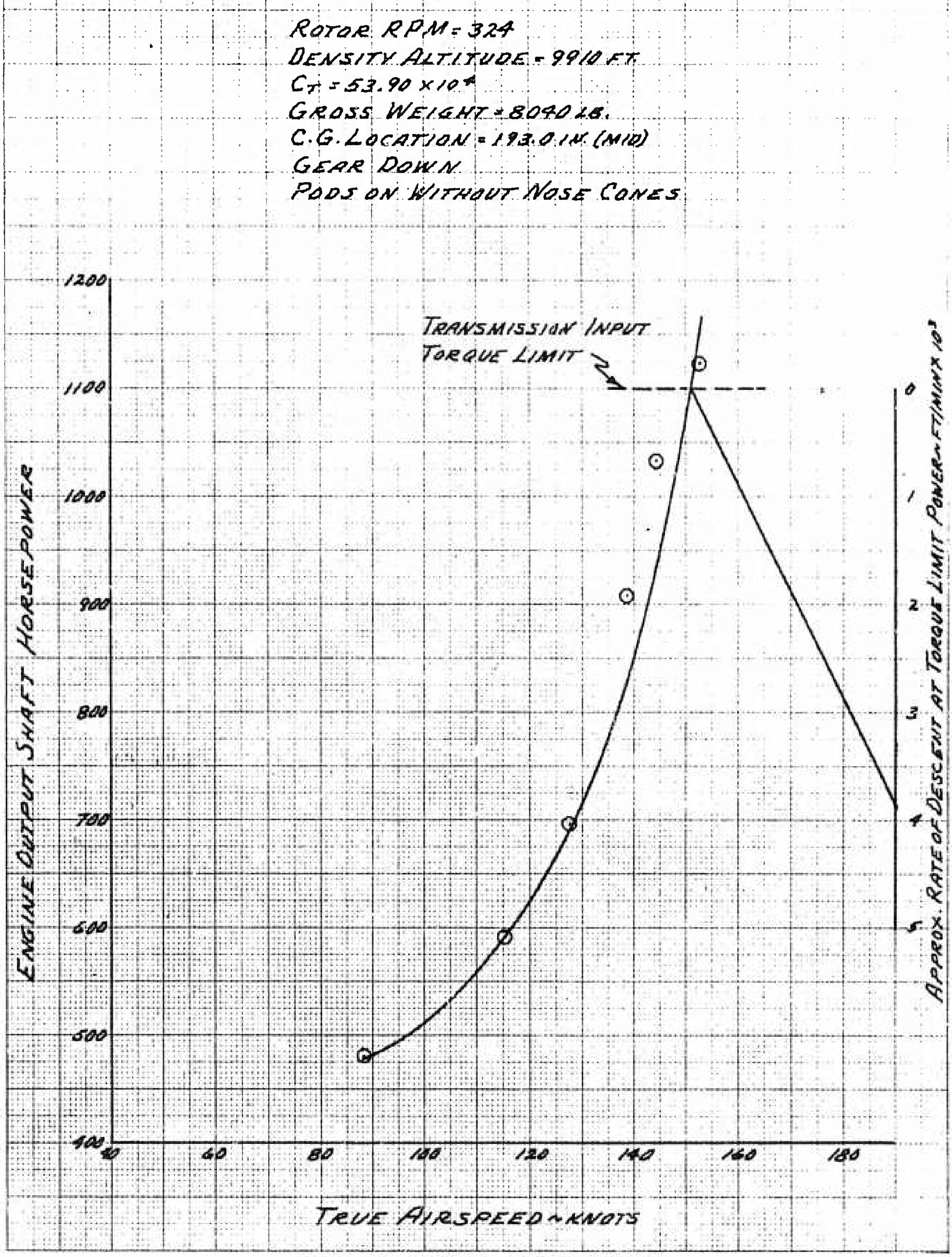
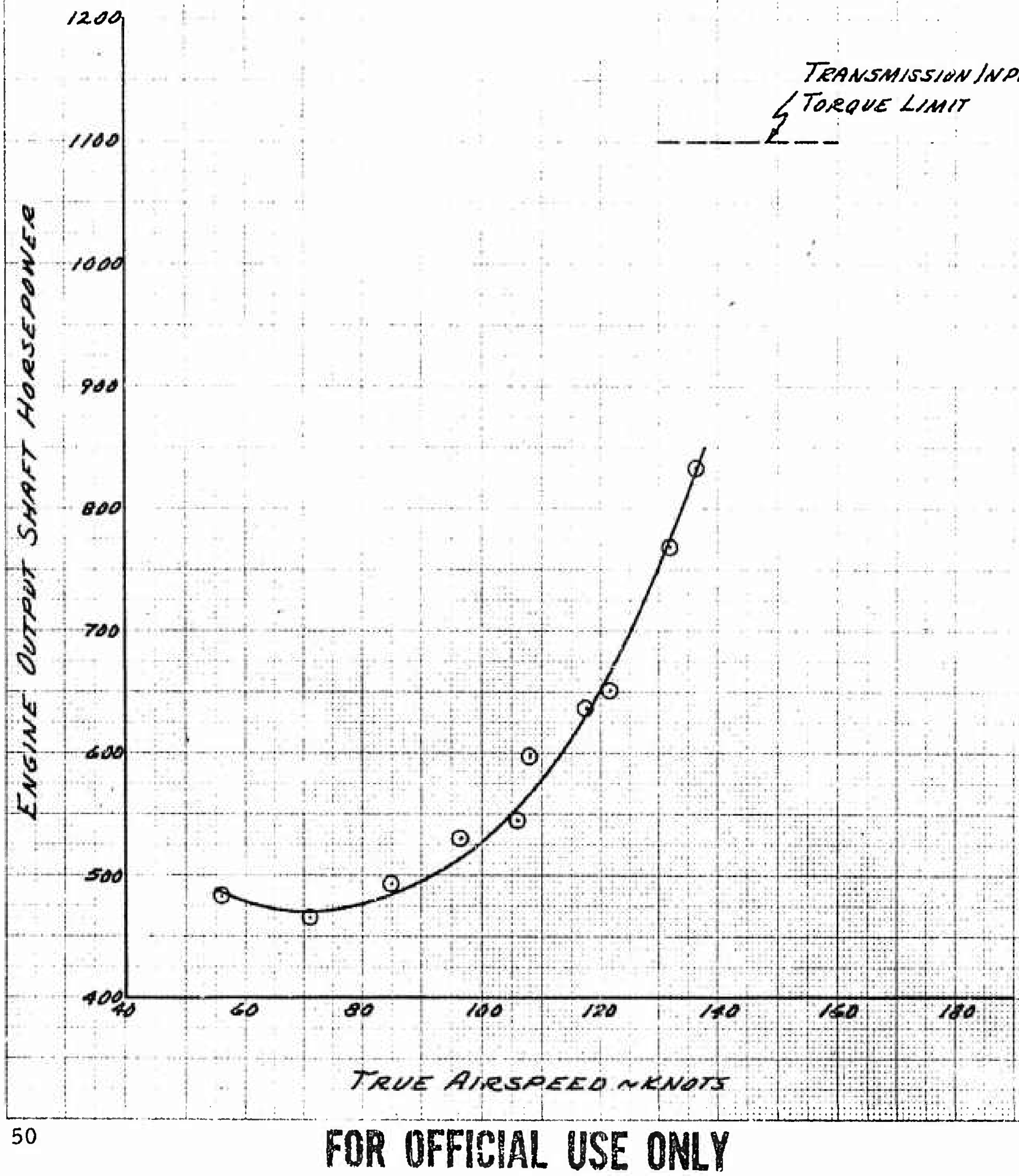


FIGURE No 11

LEVEL FLIGHT PERFORMANCE

HUEYCOBRA N209J

ROTOR RPM = 324
DENSITY ALTITUDE = 9580 FT.
C_T = 54.66 X10⁴
GROSS WEIGHT = 8240 LB.
C.G. LOCATION = 193.2 IN. (MID)
GEAR DOWN
PODS ON WITHOUT NOSE CONES



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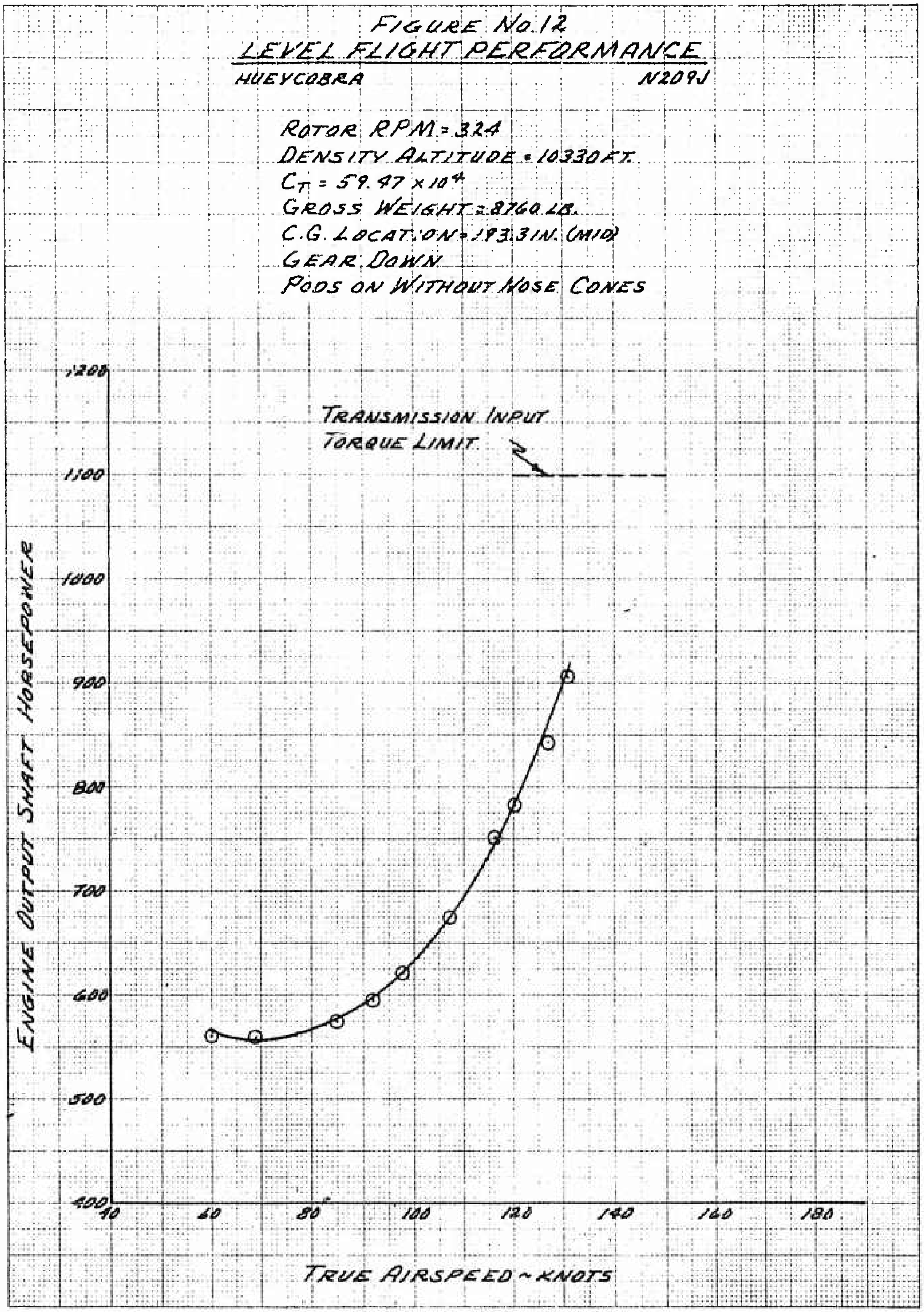
FIGURE NO.12
LEVEL FLIGHT PERFORMANCE
HUEYCOBRA
N209J
ROTOR RPM = 324
DENSITY ALTITUDE = 10330 FT.
C_T = 59.47 x 10^4
GROSS WEIGHT = 8760 LB.
C.G. LOCATION = 193.3 IN. (MID)
GEAR DOWN
PODS ON WITHOUT NOSE CONES
TRANSMISSION INPUT
TORQUE LIMIT
ENGINE OUTPUT SHAFT HORSEPOWER
1200
1100
1000
900
800
700
600
500
400
40
60
80
100
120
140
160
180
TRUE AIRSPEED ~ KNOTS

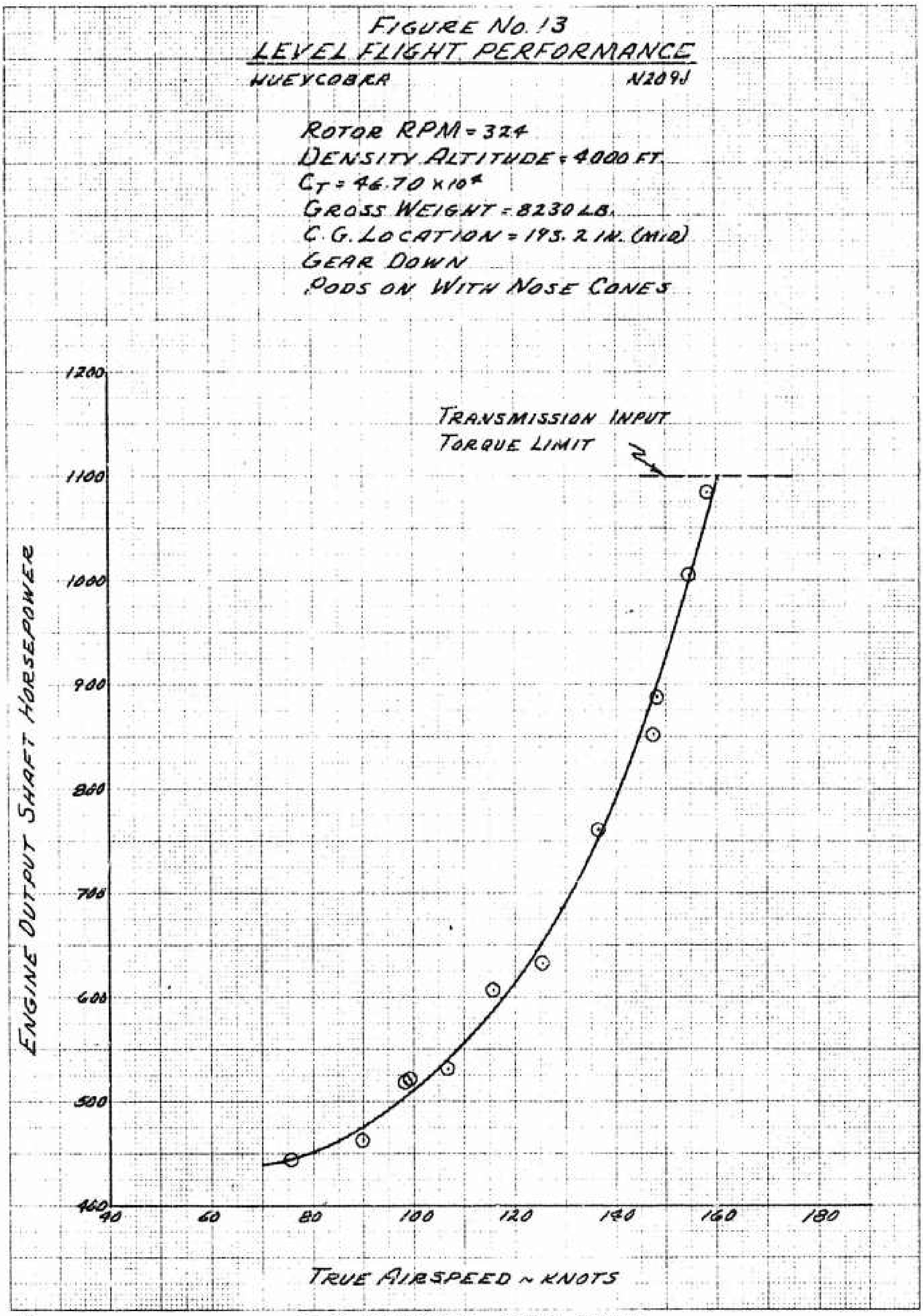
FIGURE NO. 13
LEVEL FLIGHT PERFORMANCE
HUEYCOBRA
N209J
ROTOR RPM = 324
DENSITY ALTITUDE = 4000 FT.
C_T = 46.70 x 10⁴
GROSS WEIGHT = 8230 LB.
C.G. LOCATION = 193.2 IN. (MID)
GEAR DOWN
PODS ON WITH NOSE CONES
TRANSMISSION INPUT TORQUE LIMIT
ENGINE OUTPUT SHAFT HORSEPOWER
1200
1100
1000
900
800
700
600
500
400
40
60
80
100
120
140
160
180
TRUE AIRSPEED ~ KNOTS

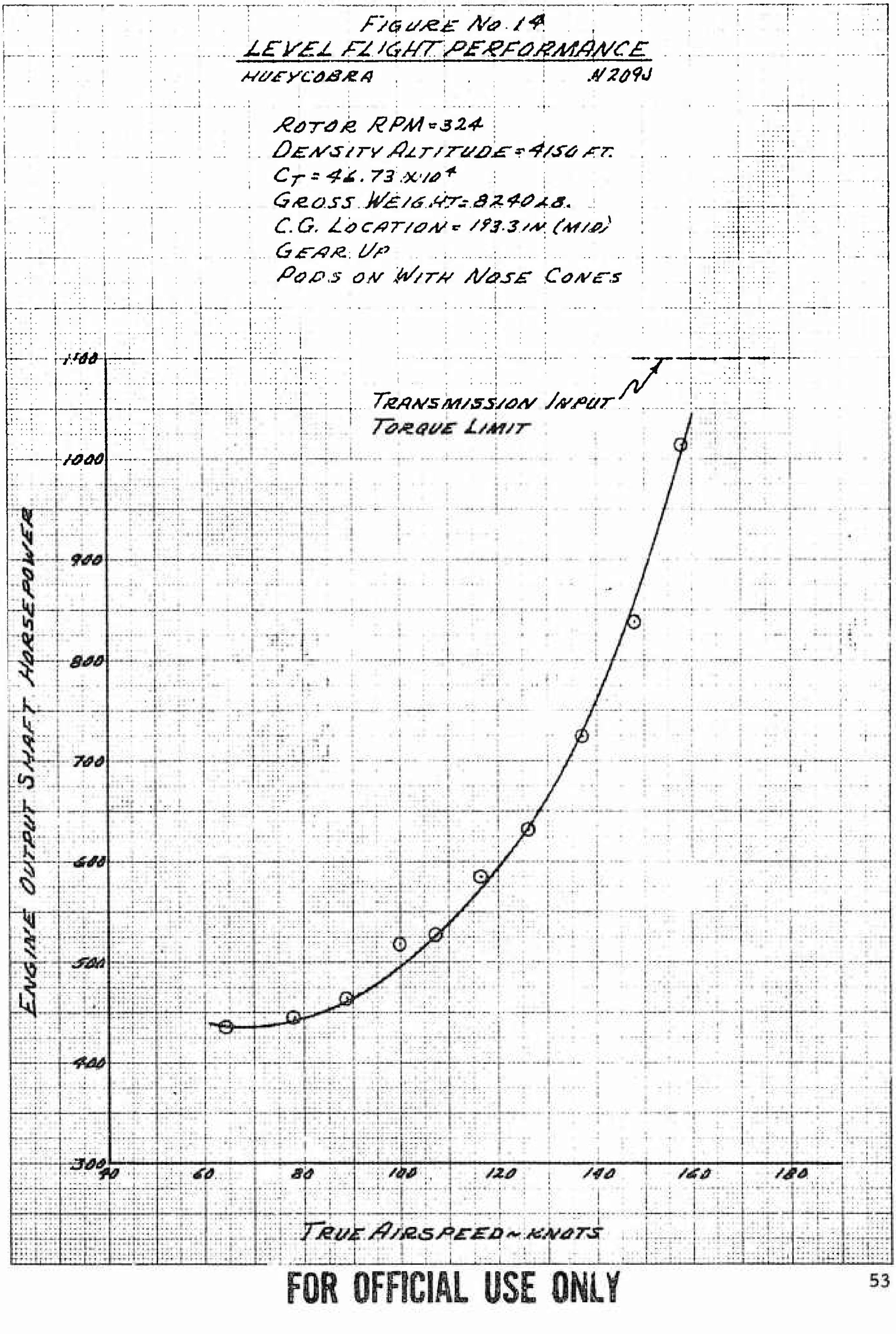
FIGURE No. 14
LEVEL FLIGHT PERFORMANCE
HUEYCOBRA
N209J
ROTOR RPM = 324
DENSITY ALTITUDE = 4150 FT.
C_T = 46.73 X 10⁻⁴
GROSS WEIGHT = 8240 LB.
C.G. LOCATION = 193.3 IN. (MID)
GEAR UP
PODS ON WITH NOSE CONES
TRANSMISSION INPUT TORQUE LIMIT
ENGINE OUTPUT SHAFT HORSEPOWER
300
400
500
600
700
800
900
1000
1100
40
60
80
100
120
140
160
180
TRUE AIRSPEED ~ KNOTS

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FIGURE NO. 15

LEVEL FLIGHT PERFORMANCE

HUEYCOBRA N209J

ROTOR RPM = 324

DENSITY ALTITUDE = 4270 FT.

$C_T = 47.11 \times 10^{4}$

GROSS WEIGHT = 8250 LB.

C.G. LOCATION = 193.3 IN. (MID)

GEAR UP

PODS OFF

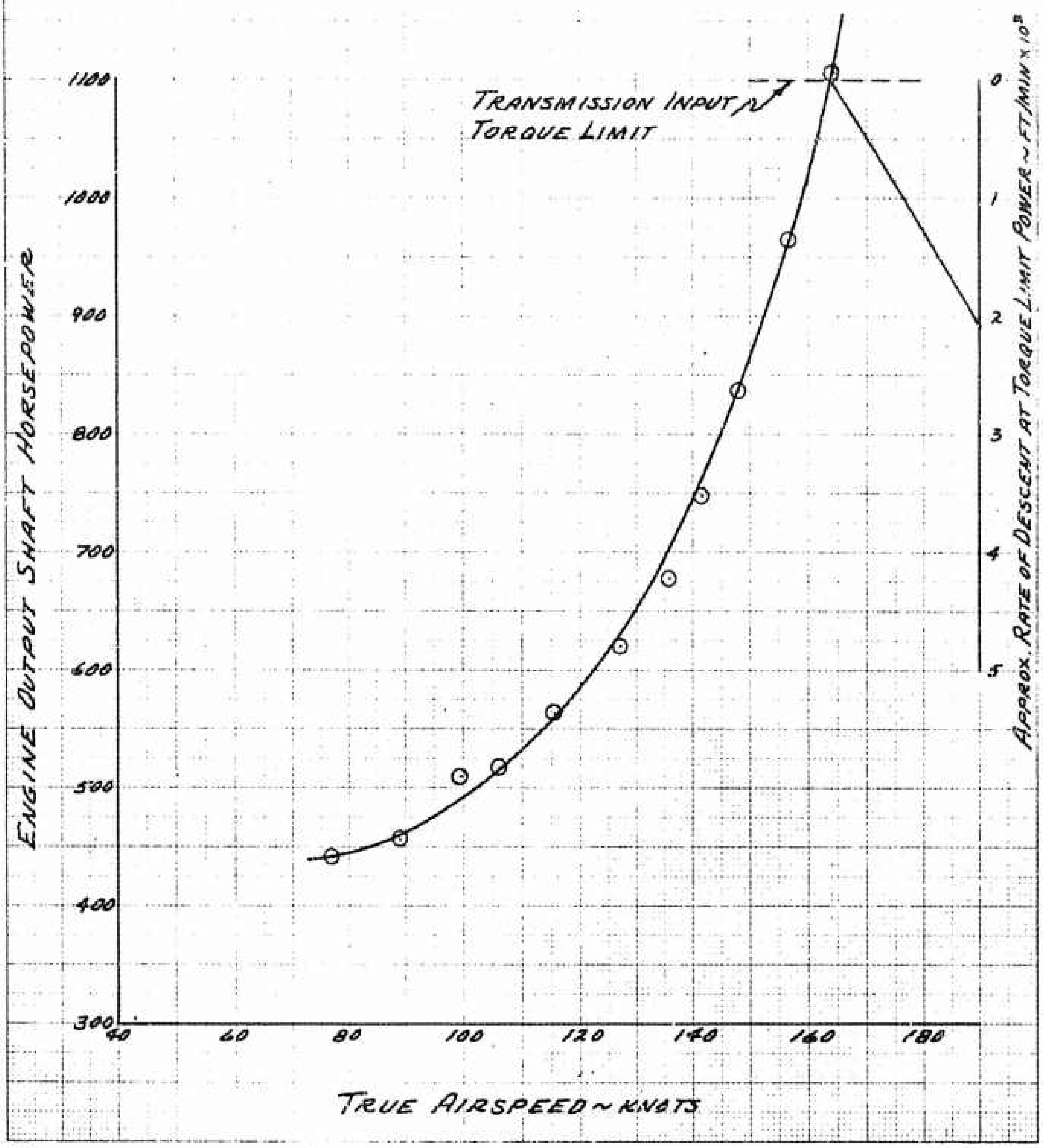

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FIGURE NO. 16
LEVEL FLIGHT PERFORMANCE
HUEYCOBRA N209J

ROTOR RPM = 324
DENSITY ALTITUDE = 6640 FT.
$C_T = 50.18 \times 10^{4}$
GROSS WEIGHT = 8180 LB.
C.G. LOCATION = 193.3 IN. (MID)
GEAR UP
PODS OFF

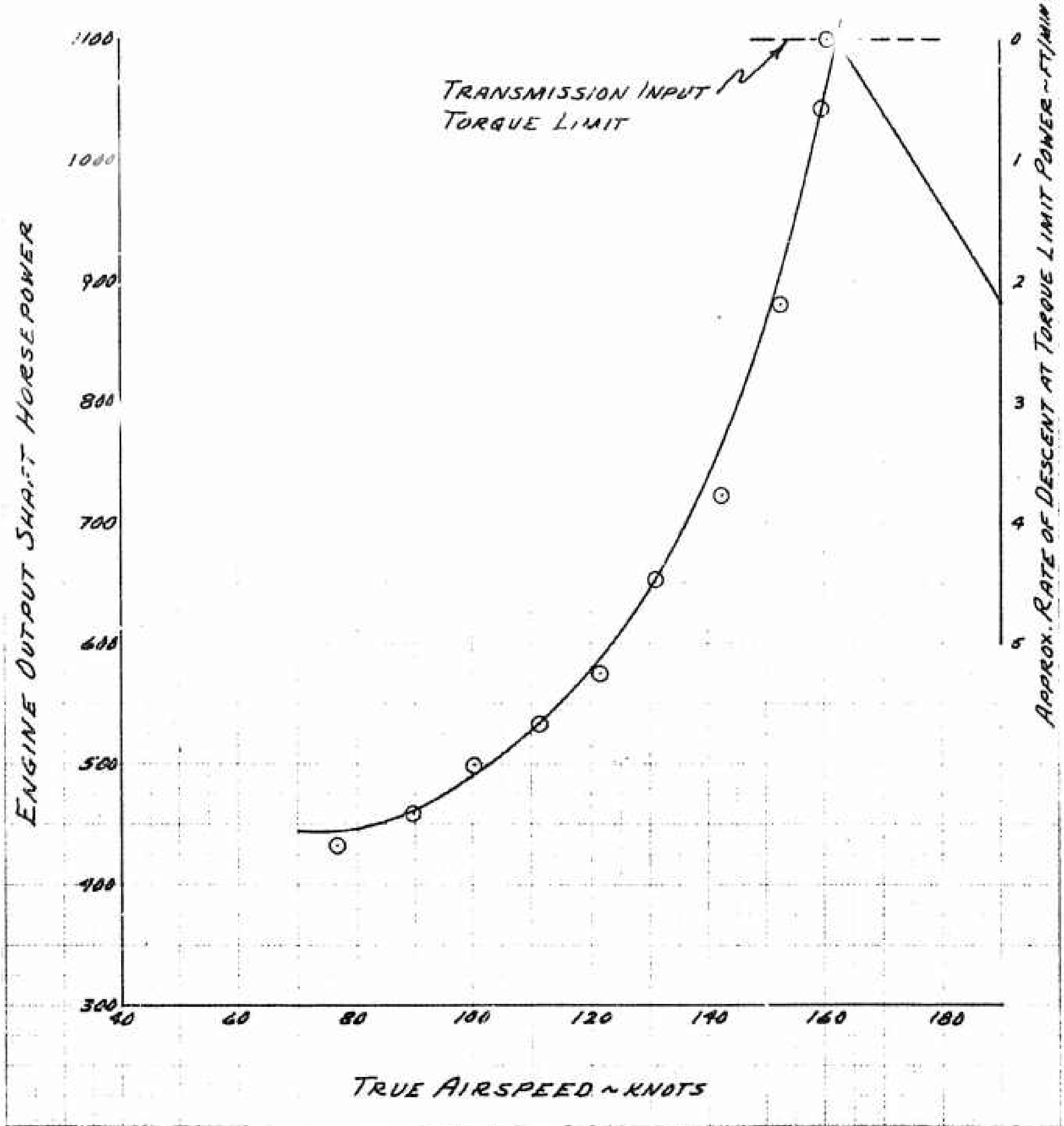
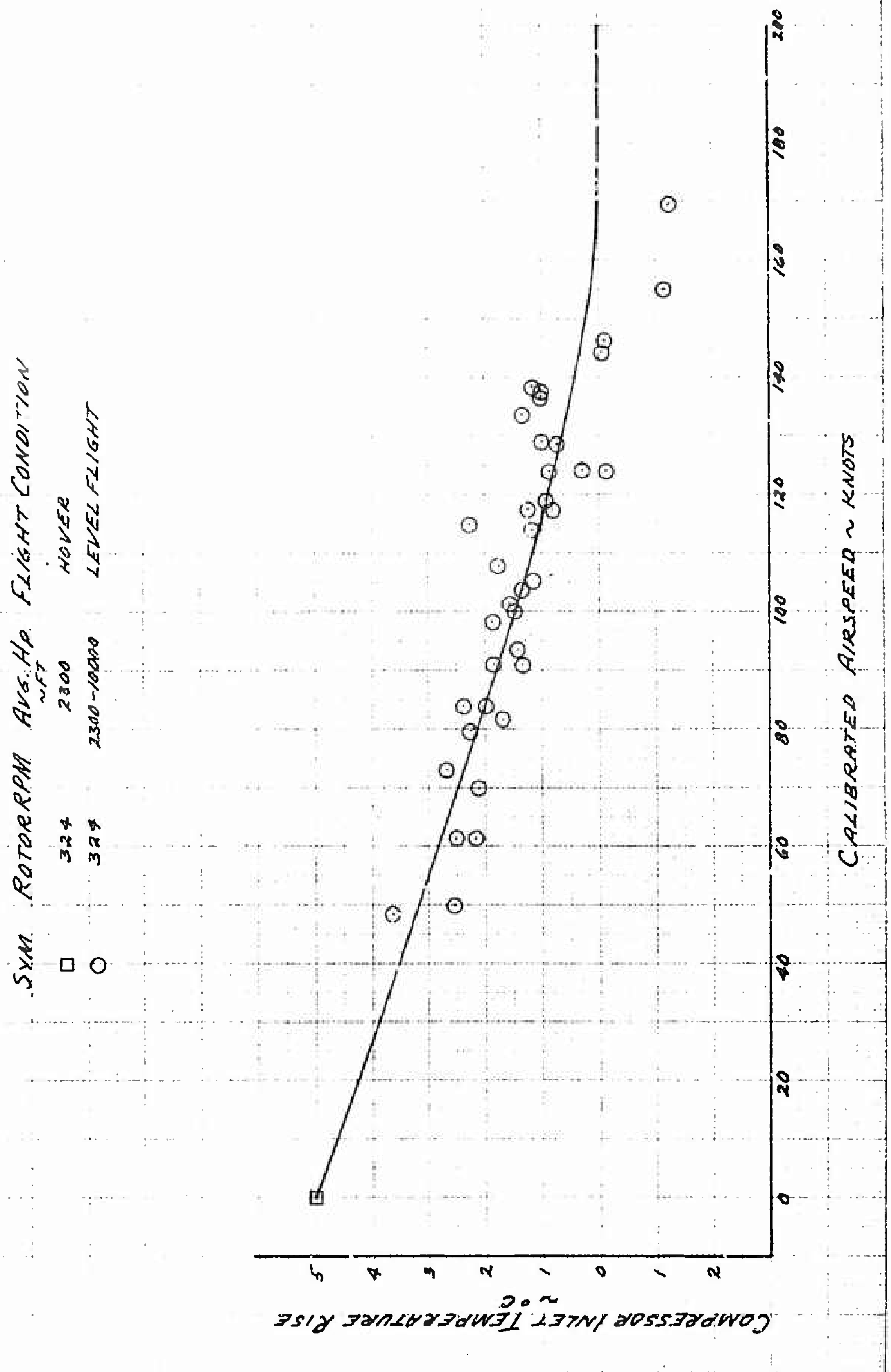


FIGURE NO. 17
ENGINE CHARACTERISTICS



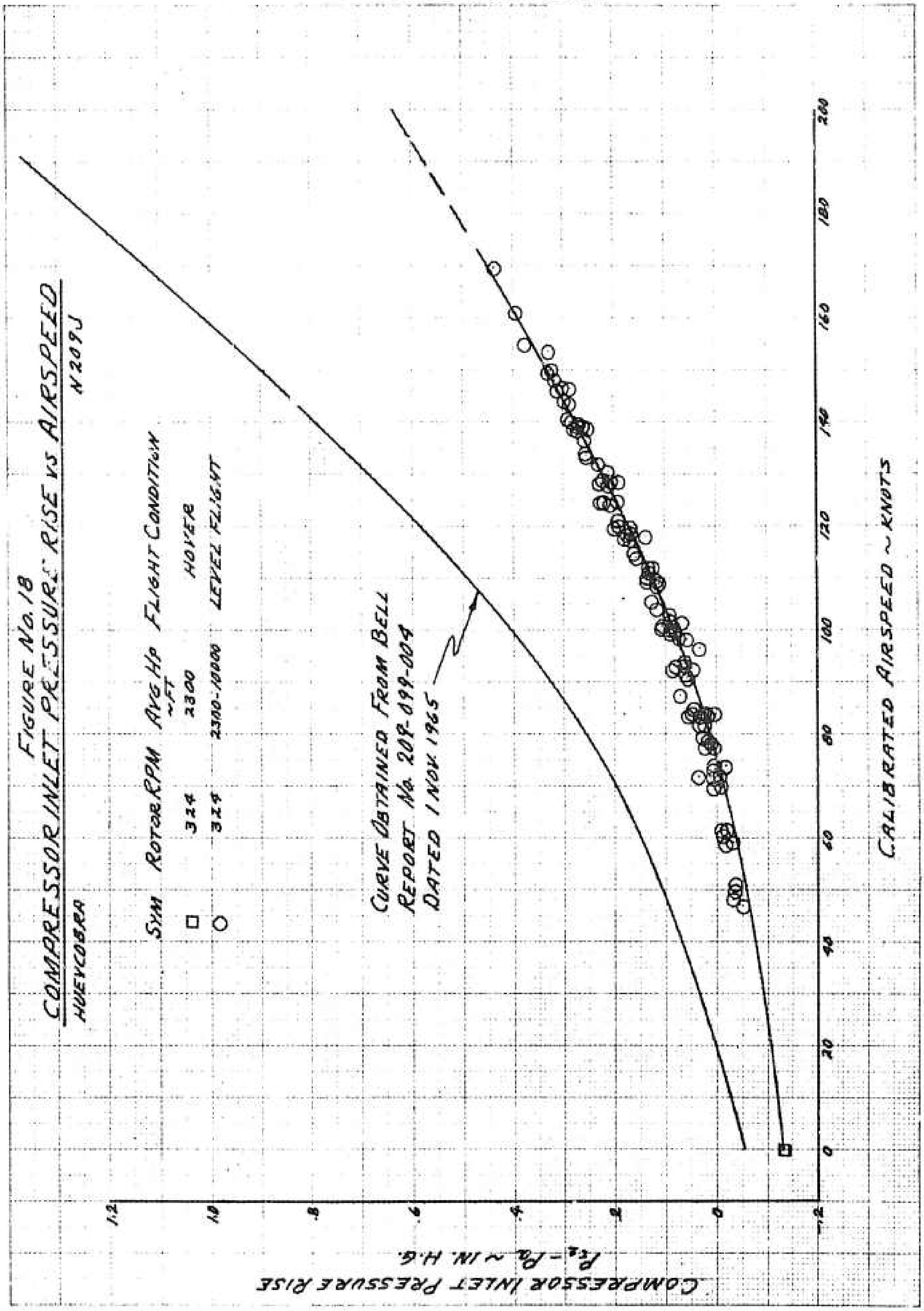


FIGURE NO. 18
COMPRESSOR INLET PRESSURE RISE VS AIRSPEED
HUEYCOBRA
N209J
SYM ROTOR RPM AVG Hp ~FT FLIGHT CONDITION
324 2300 HOVER
324 2300-10000 LEVEL FLIGHT
CURVE OBTAINED FROM BELL
REPORT No. 209-099-004
DATED 1 NOV 1965
COMPRESSOR INLET PRESSURE RISE
$P_{t_2} - P_a$ ~ IN. H.G.
CALIBRATED AIRSPEED ~ KNOTS
1.2
1.0
.8
.6
.4
.2
0
-.2
0
20
40
60
80
100
120
140
160
180
200

FIGURE NO. 19

SHAFT HORSEPOWER AVAILABLE

HUEYCOBRA N 209J

HOVERING

BASED ON LYCOMING SPEC. 104.33 AND THE INLET CHARACTERISTICS OF FIGURES 17 AND 18.

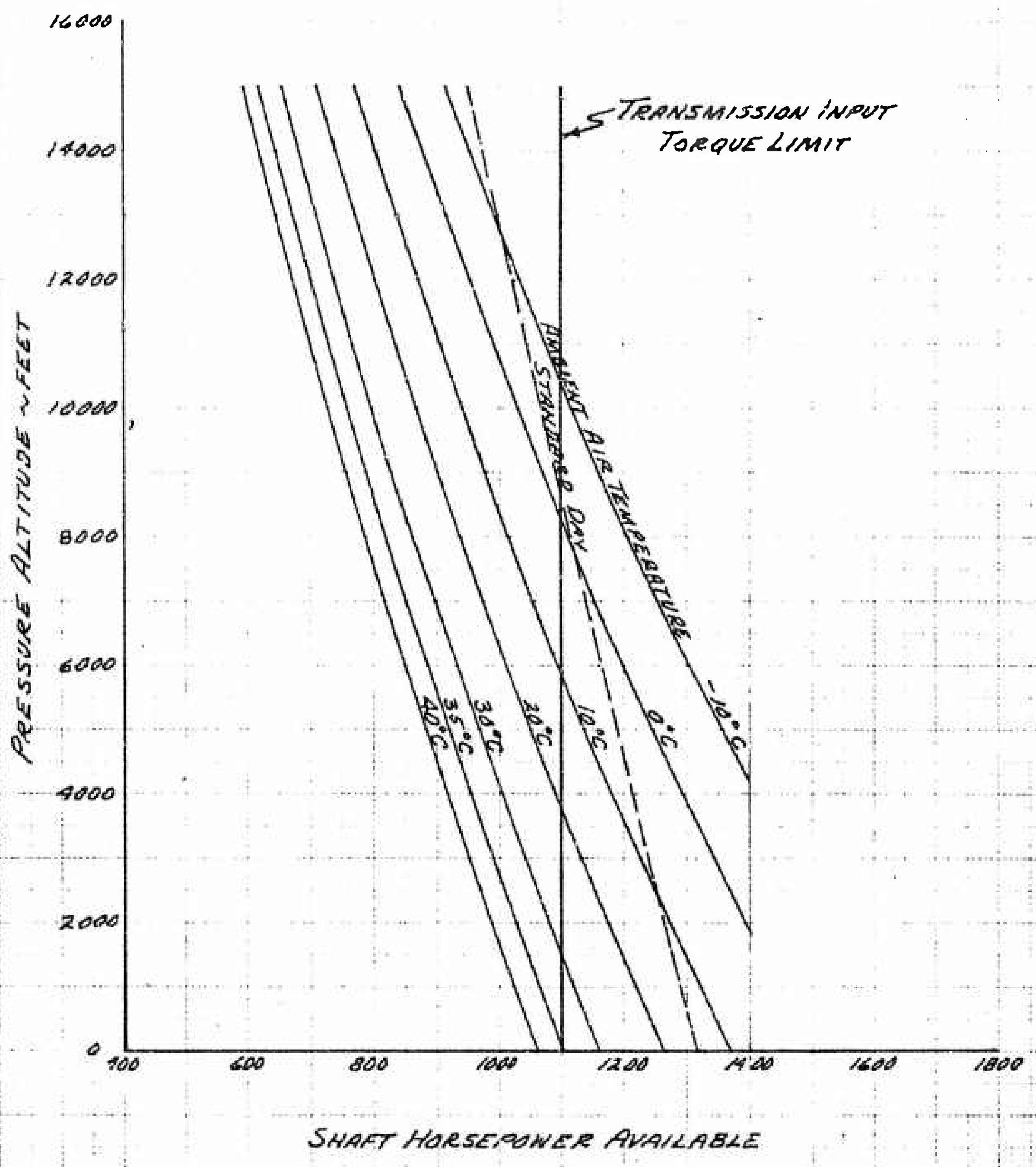


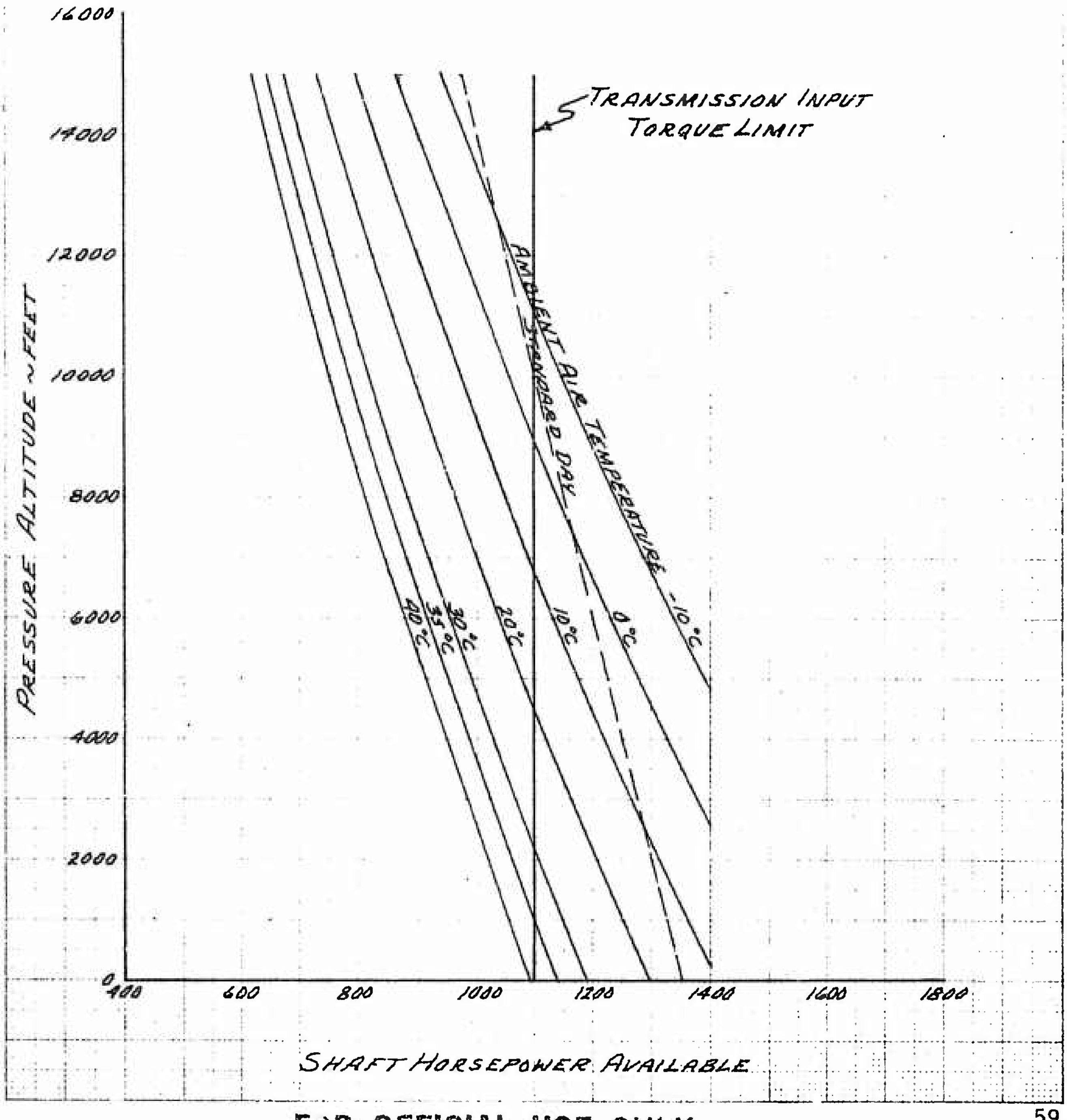
FIGURE NO. 20

SHAFT HORSEPOWER AVAILABLE

HUEYCOBRA N209J

LEVEL AND CLIMBING FLIGHT AT 70 KCAS

BASED ON LYCOMING SPEC. 104.33 AND THE INLET CHARACTERISTICS OF FIGURES 17 AND 18.



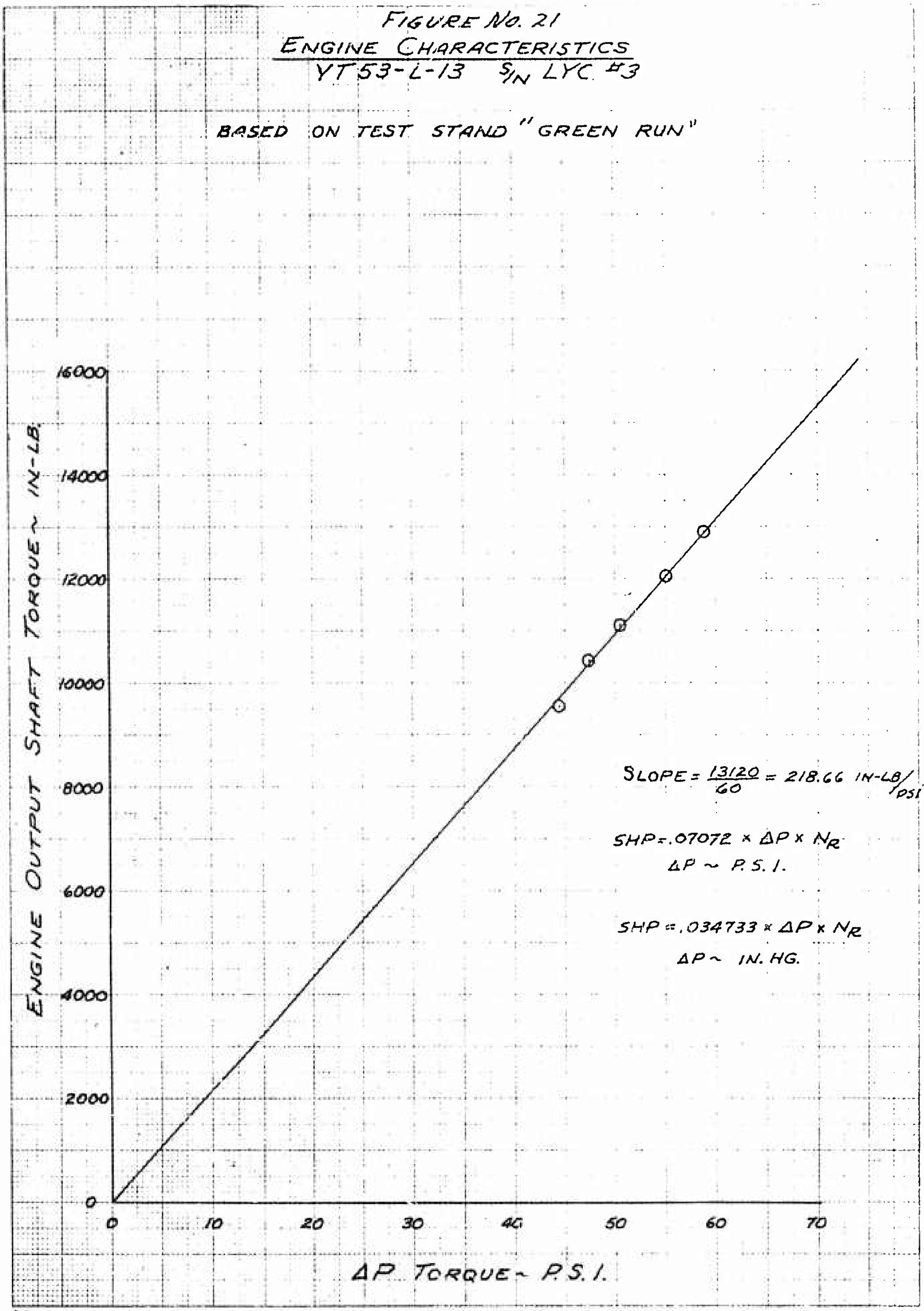


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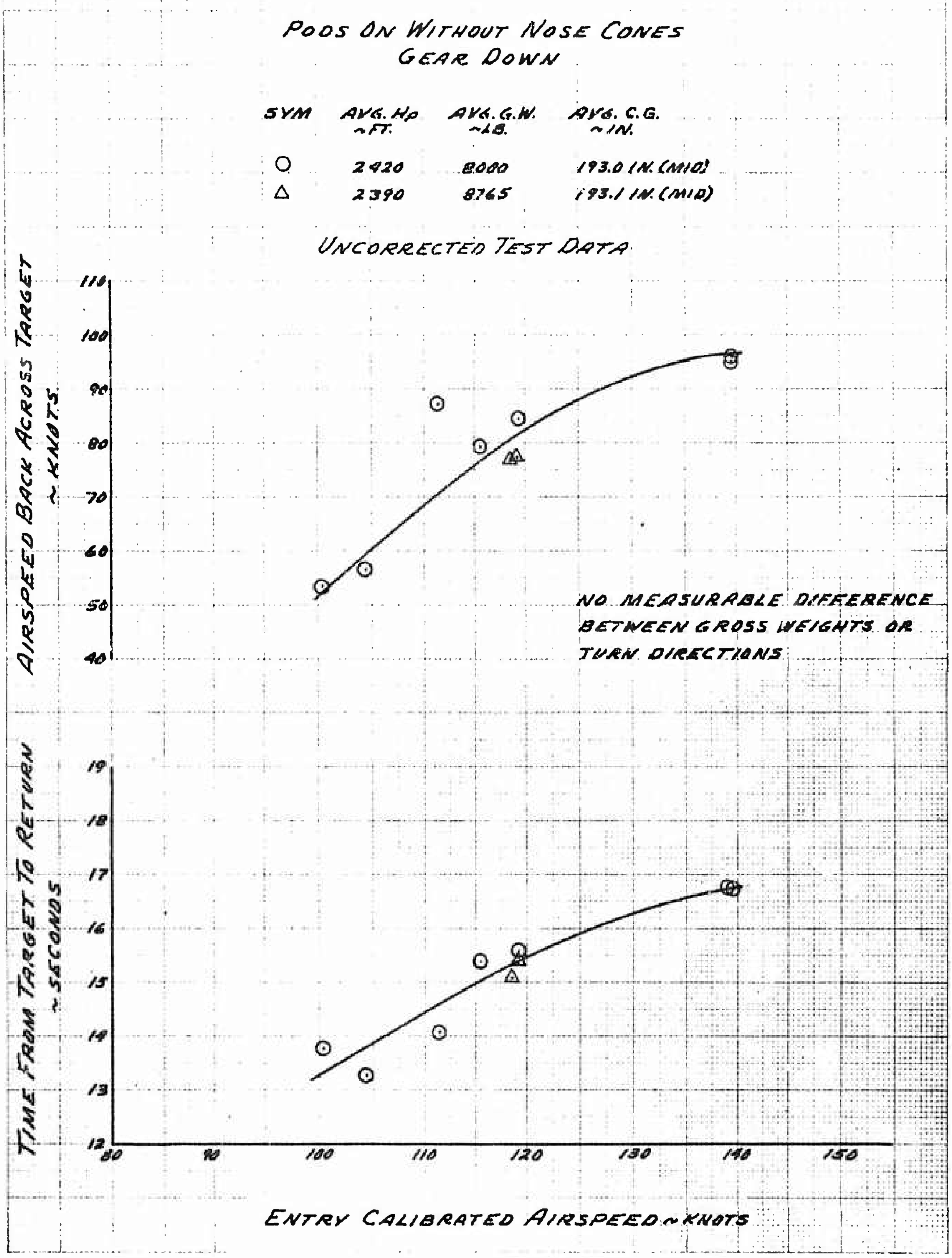
FIGURE NO. 22
TEAR DROP TURNING PERFORMANCE
HUEYCOBRA N209J



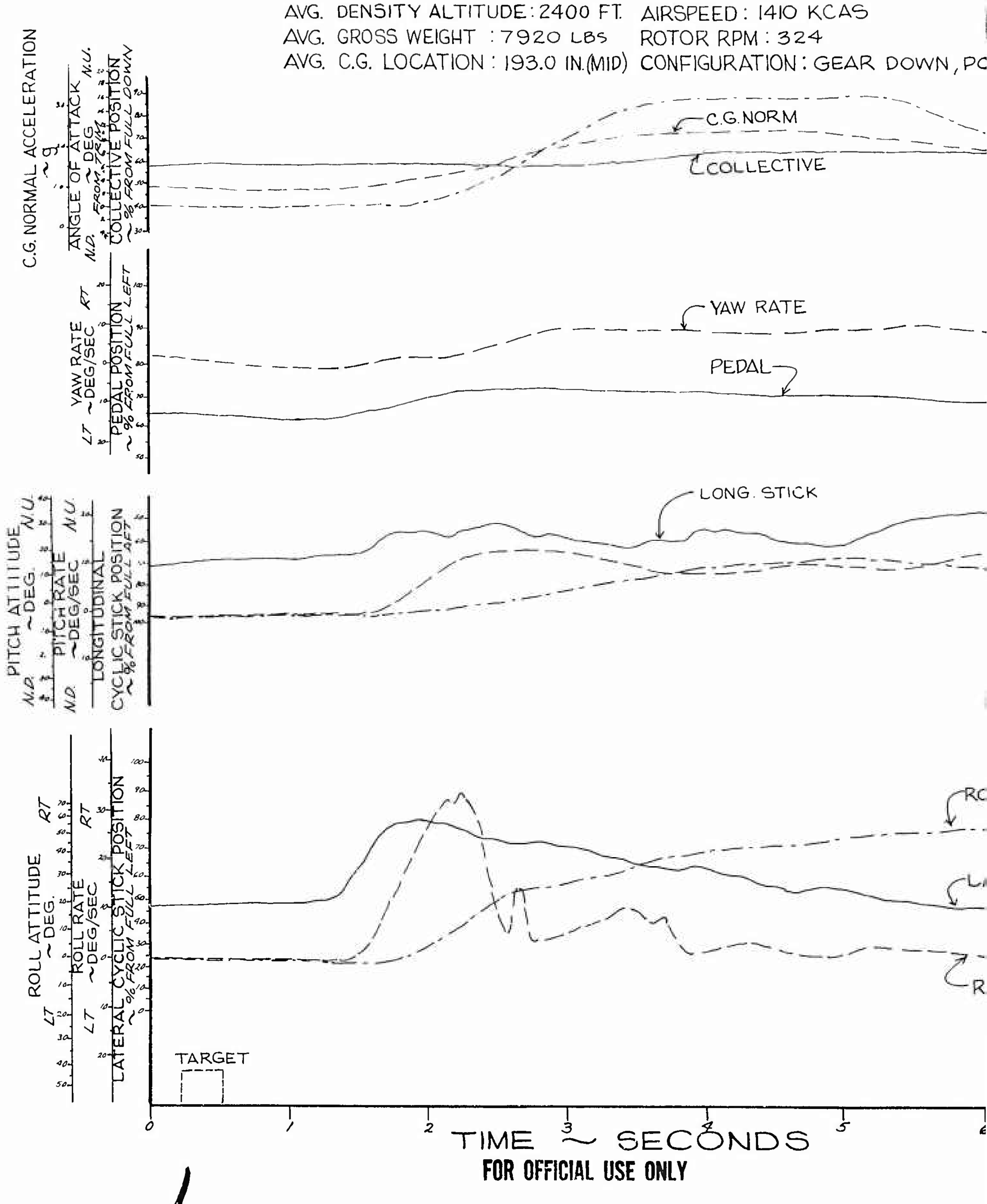
FOR OFFICIAL USE ONLY

FIGURE NO. 20

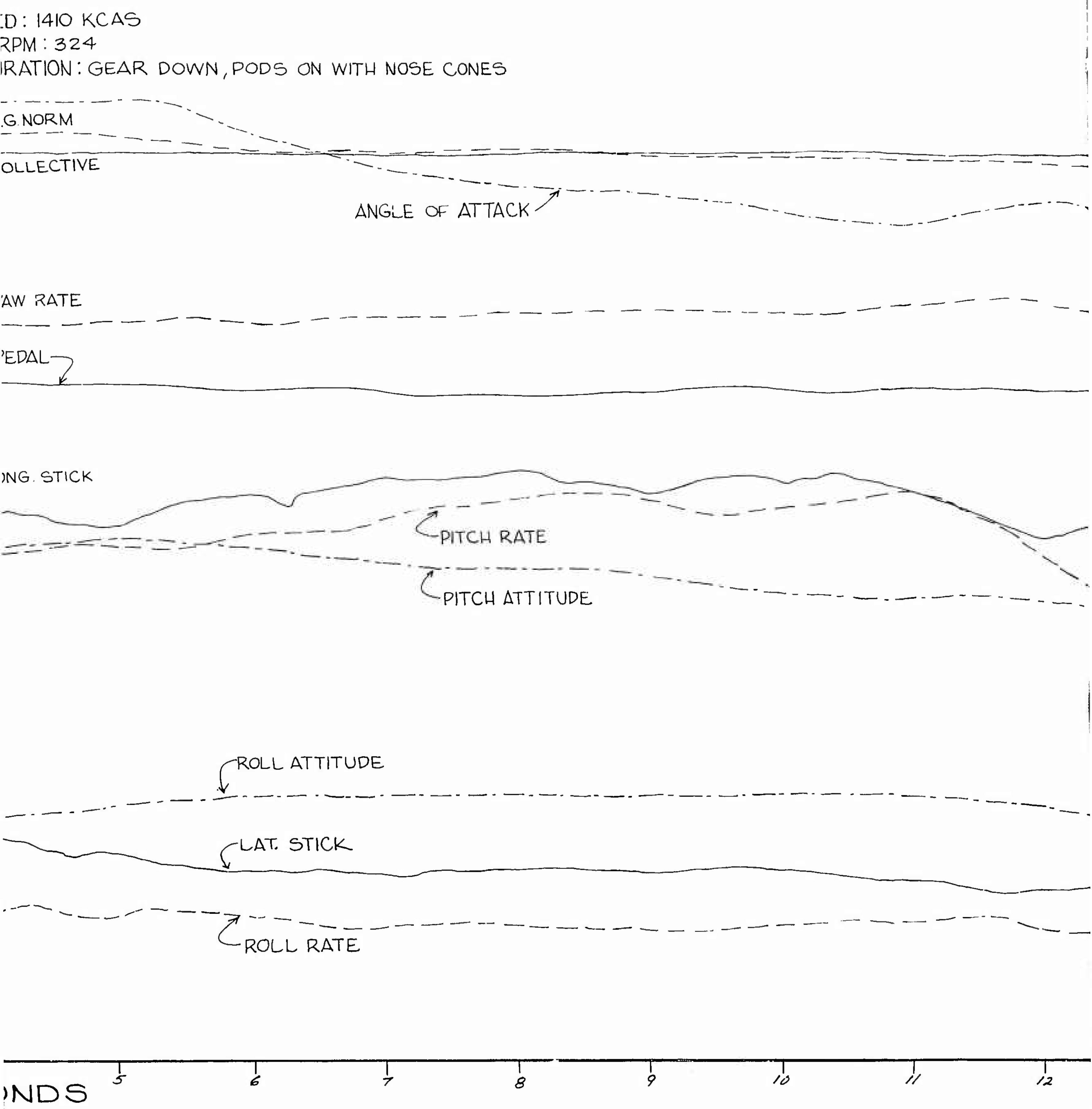
TEAR DROP TURN

HUEY COBRA - N209J

AVG. DENSITY ALTITUDE: 2400 FT. AIRSPEED: 141.0 KCAS
AVG. GROSS WEIGHT: 7920 LBS ROTOR RPM: 324
AVG. C.G. LOCATION: 193.0 IN. (MID) CONFIGURATION: GEAR DOWN, PC

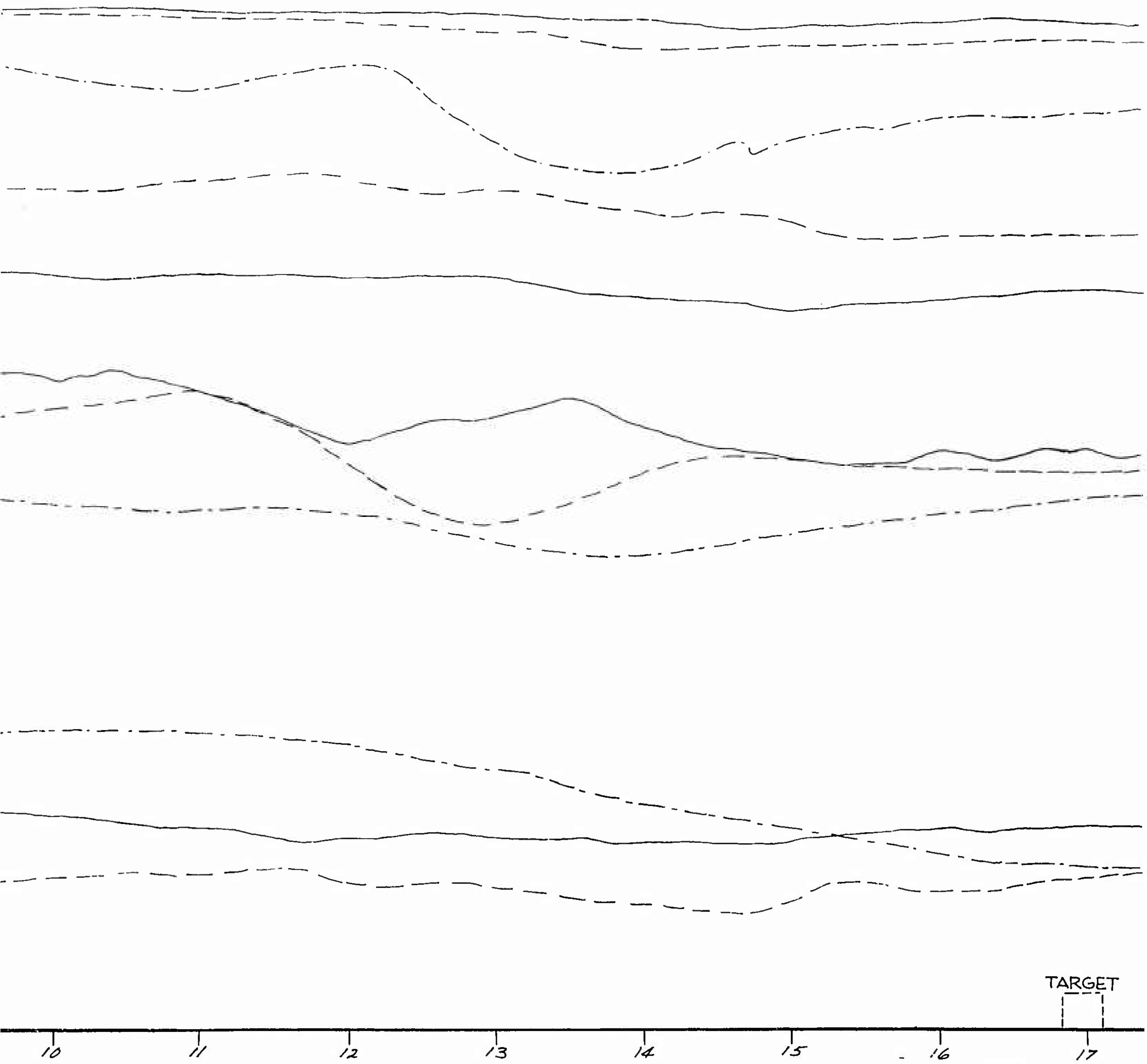


FOR OFFICIAL USE ONLY



D : 1410 KCAS
RPM : 324
RATION : GEAR DOWN, PODS ON WITH NOSE CONES
G. NORM
OLLECTIVE
ANGLE OF ATTACK
AW RATE
EDAL
NG. STICK
PITCH RATE
PITCH ATTITUDE
ROLL ATTITUDE
LAT. STICK
ROLL RATE
5
6
7
8
9
10
11
12
NDS

2



3

FIGURE NO. 24
TURN REVERSALS
HUEYCOBRA N209J

PODS ON WITHOUT NOSE CONES
GEAR DOWN

SYM	AVG. Hp ~FT.	AVG. G.W. ~LB.	AVG. C.G. ~IN.
○	2420	8021	193.1 (MID)
△	2310	8263	193.2 (MID)

UNCORRECTED TEST DATA

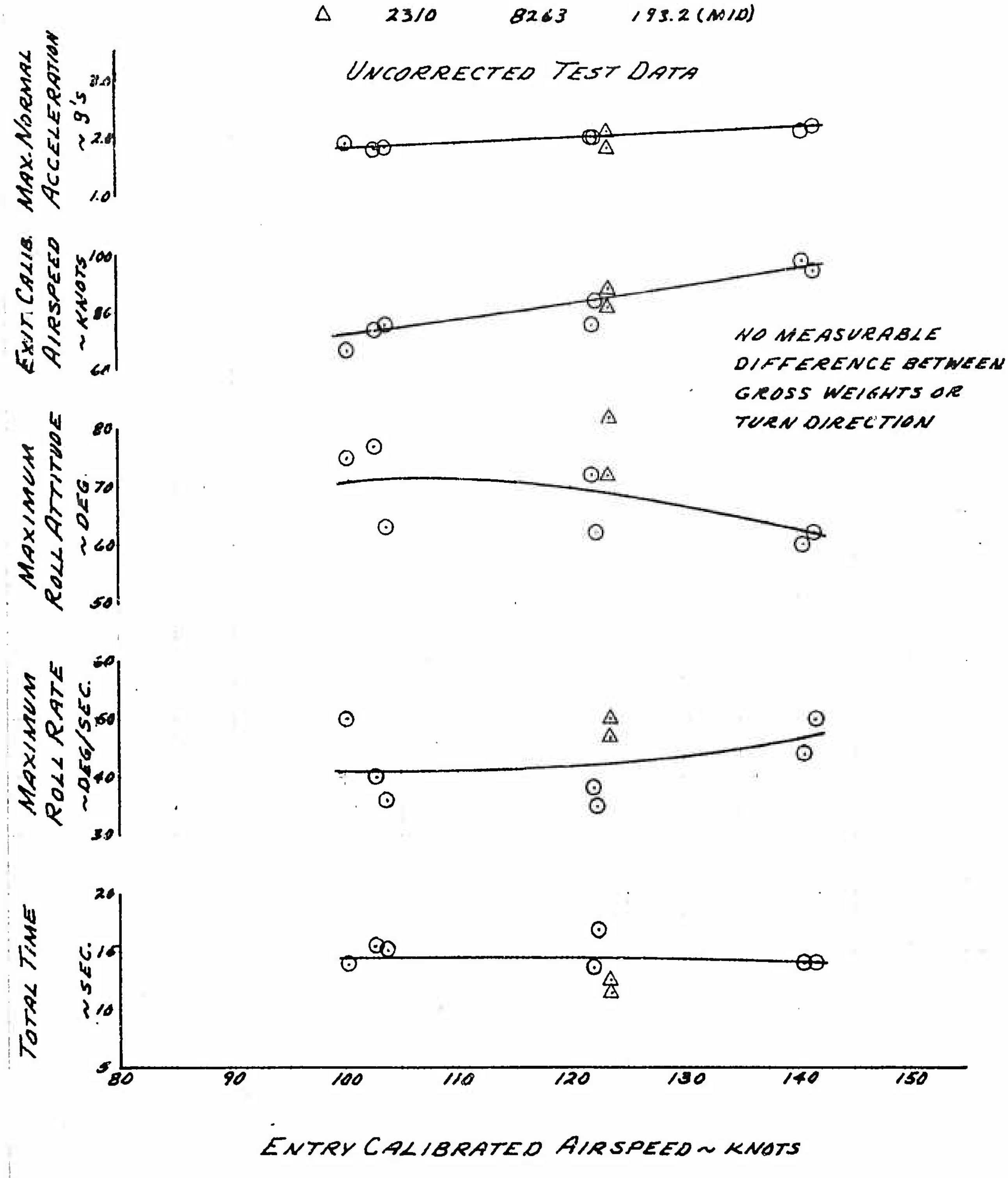


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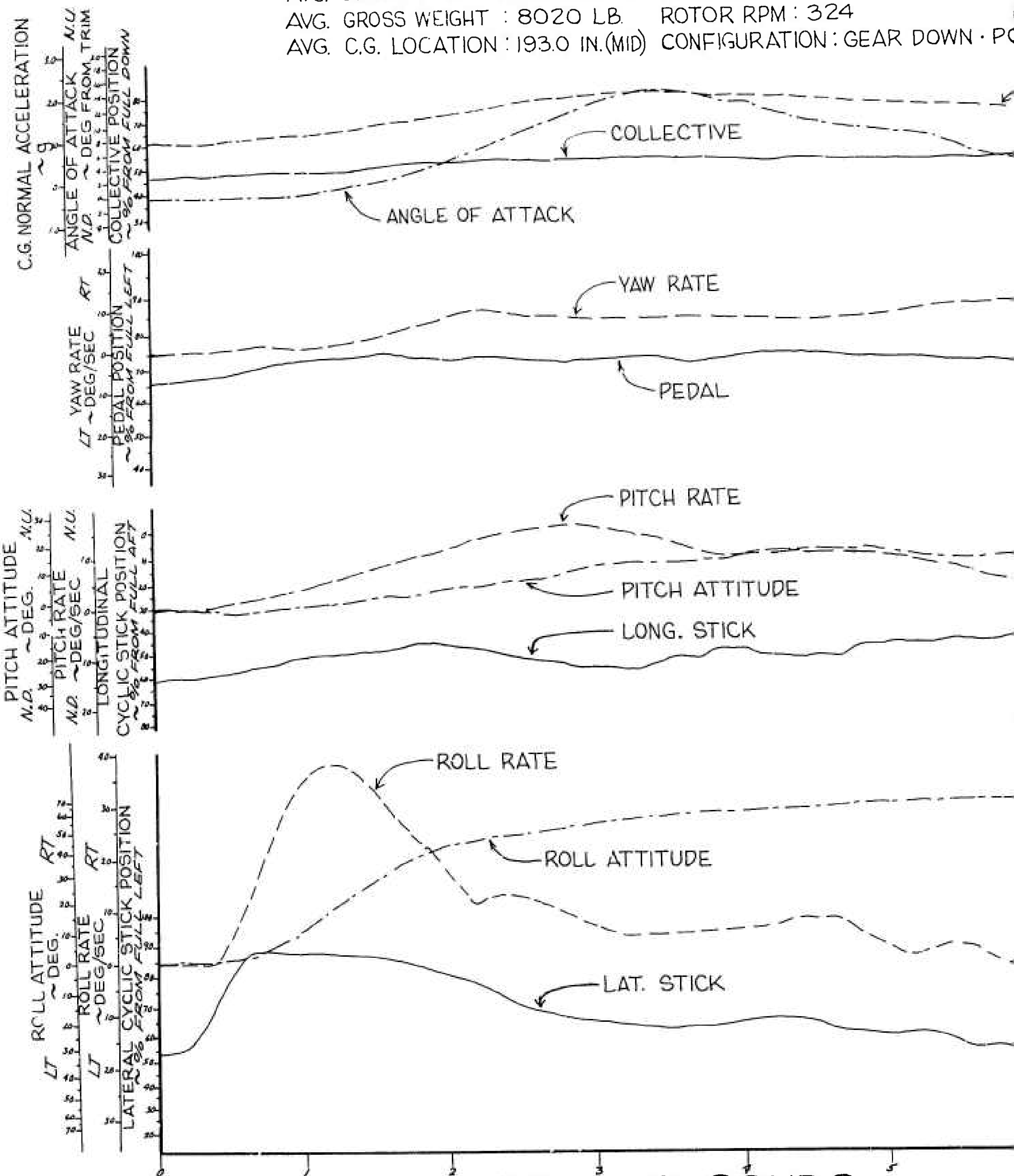
FIGURE NO. 25

TURN REVERSAL

HUEYCOBRA N209J

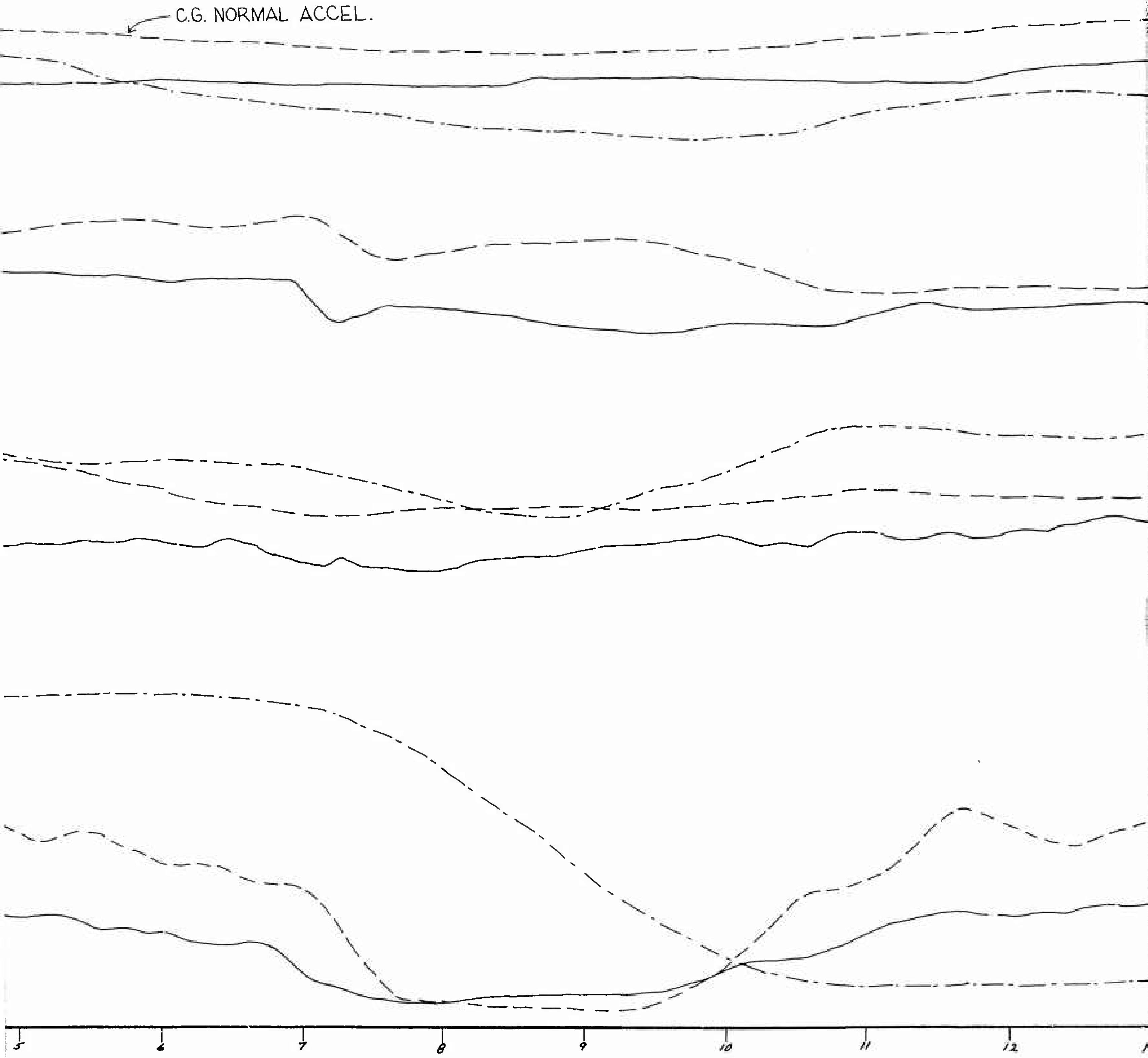
AVG. DENSITY ALTITUDE: 1200 FT   AIRSPEED: 122 KCAS
AVG. GROSS WEIGHT: 8020 LB.   ROTOR RPM: 324
AVG. C.G. LOCATION: 193.0 IN. (MID)   CONFIGURATION: GEAR DOWN · PO



FOR OFFICIAL USE ONLY

.AS

EAR DOWN · PODS ON WITH NOSE CONES



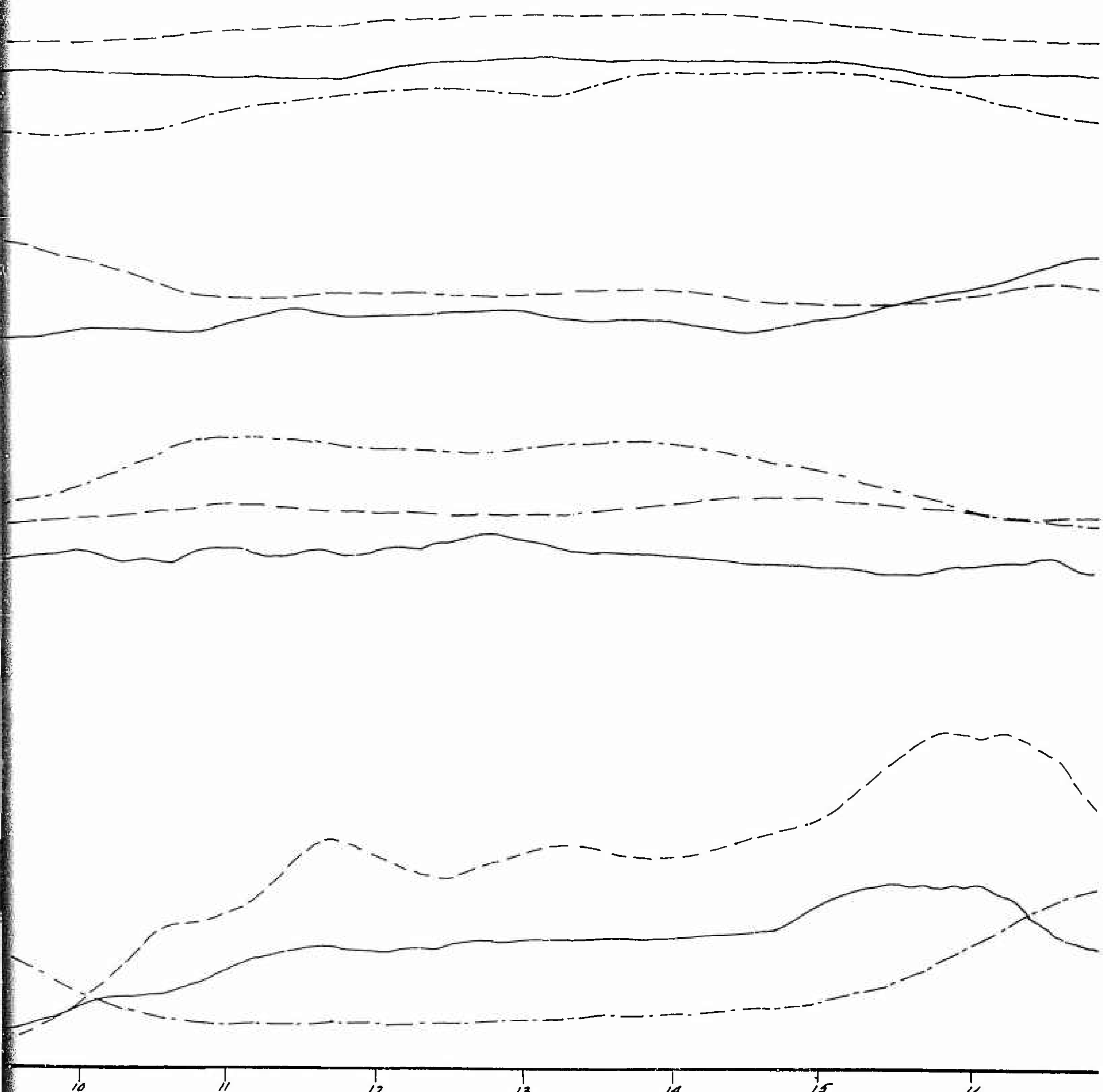
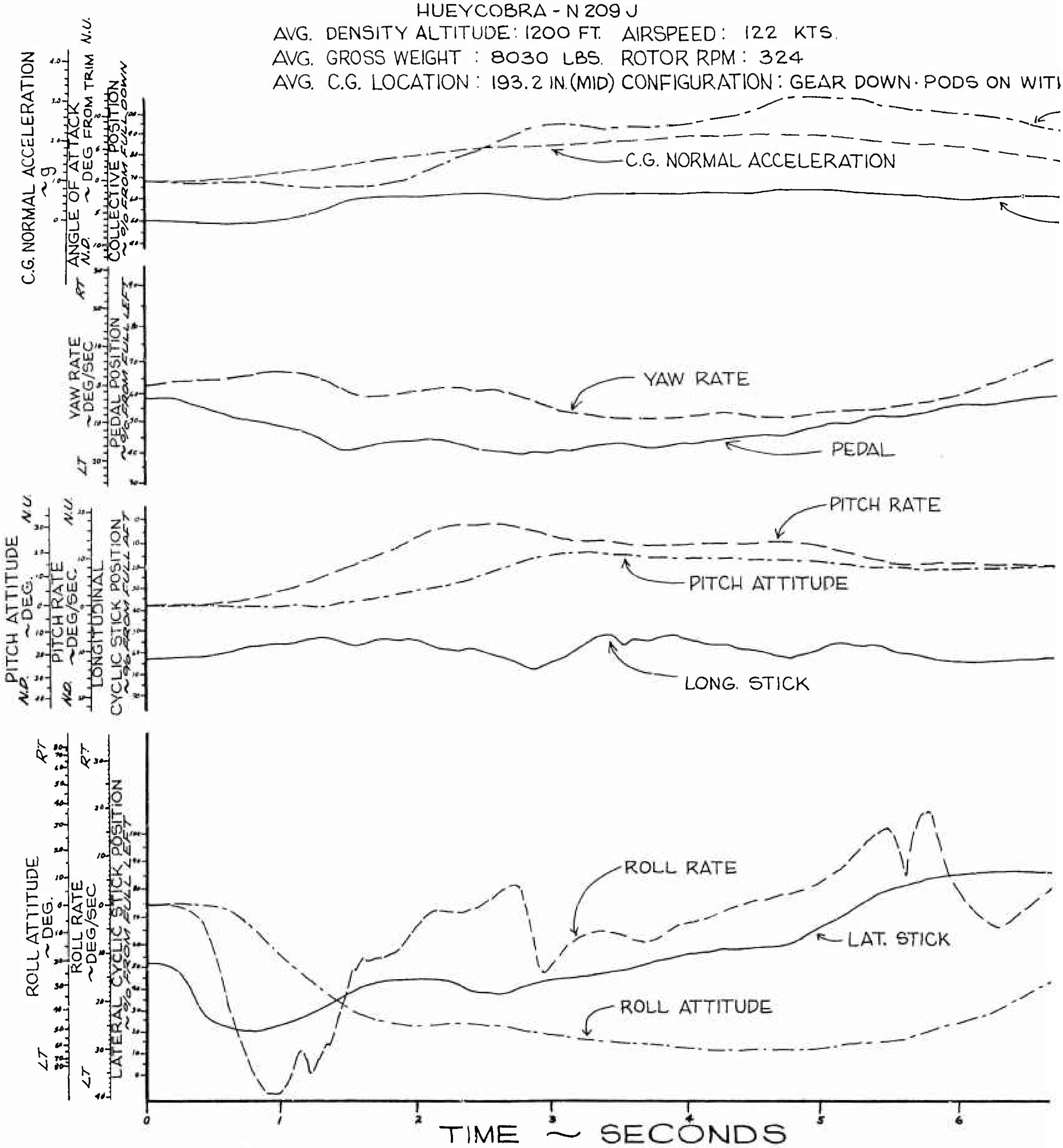

10
11
12
13
14
15
16

FIGURE NO. 26

TURN REVERSAL

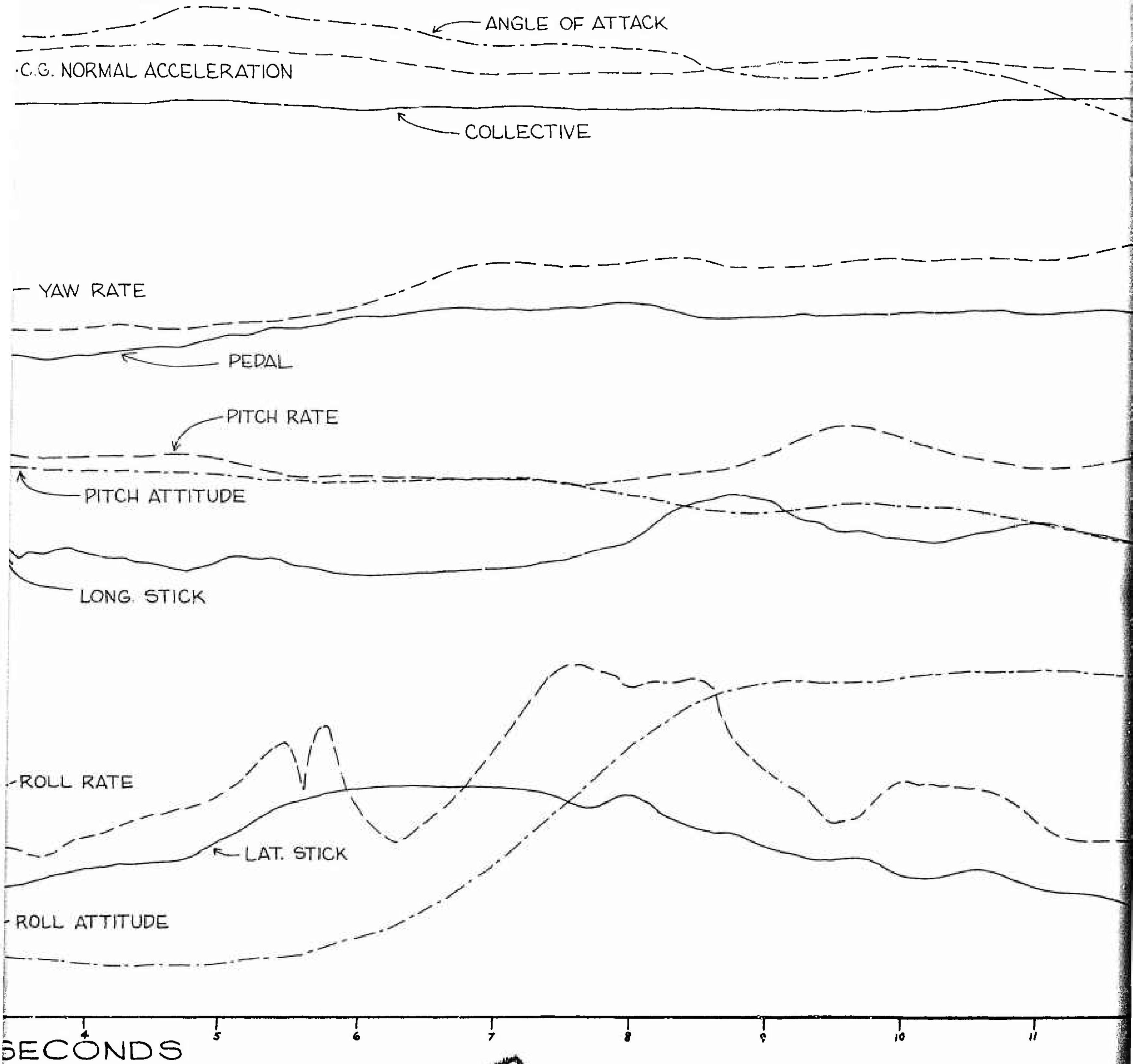
HUEYCOBRA - N 209 J

AVG. DENSITY ALTITUDE: 1200 FT. AIRSPEED: 122 KTS.
AVG. GROSS WEIGHT : 8030 LBS. ROTOR RPM : 324
AVG. C.G. LOCATION : 193.2 IN.(MID) CONFIGURATION : GEAR DOWN · PODS ON WIT



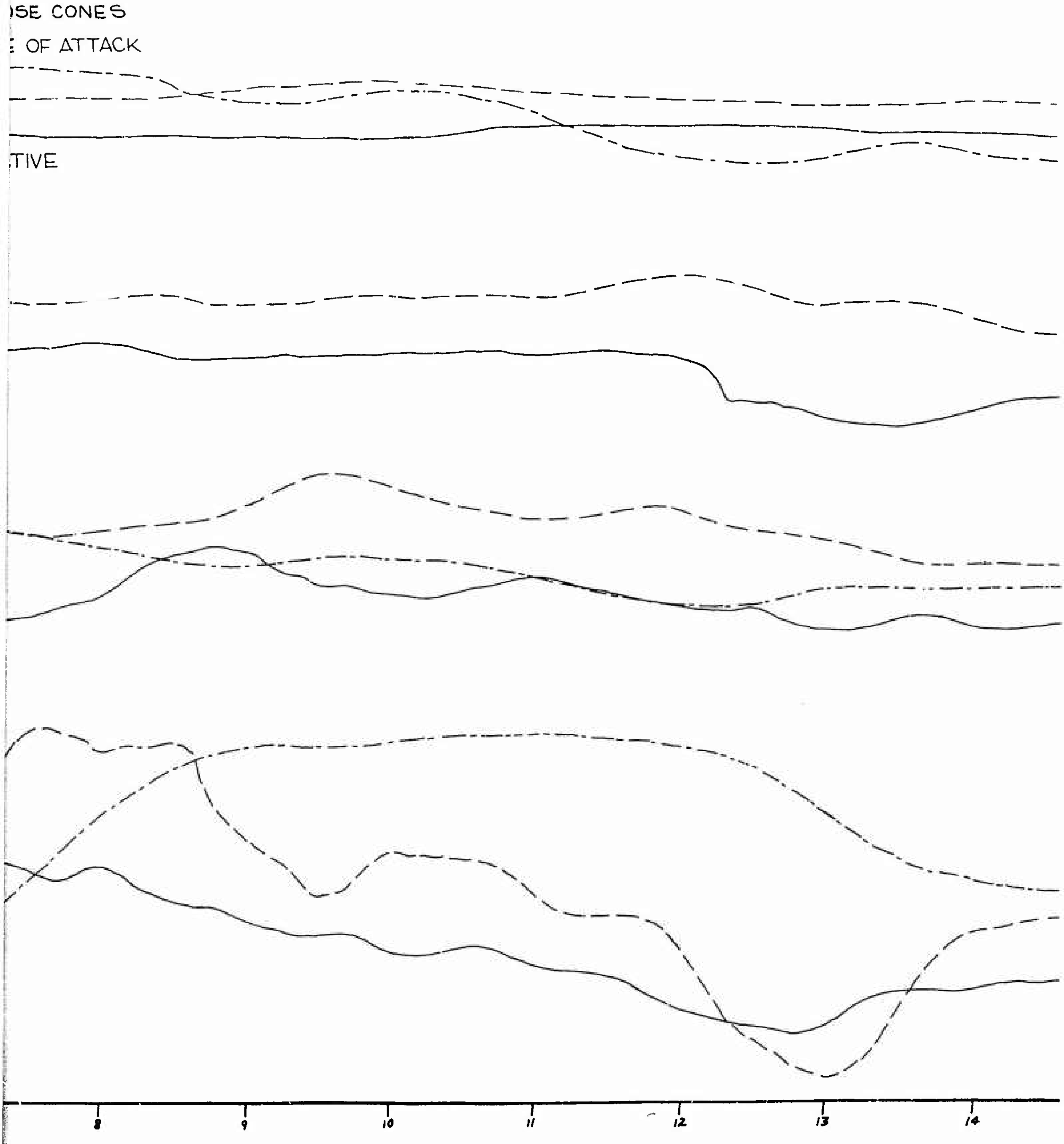
NLY
6
L
J

AIRSPEED: 122 KTS.
ROTOR RPM: 324
CONFIGURATION: GEAR DOWN· PODS ON WITH NOSE CONES

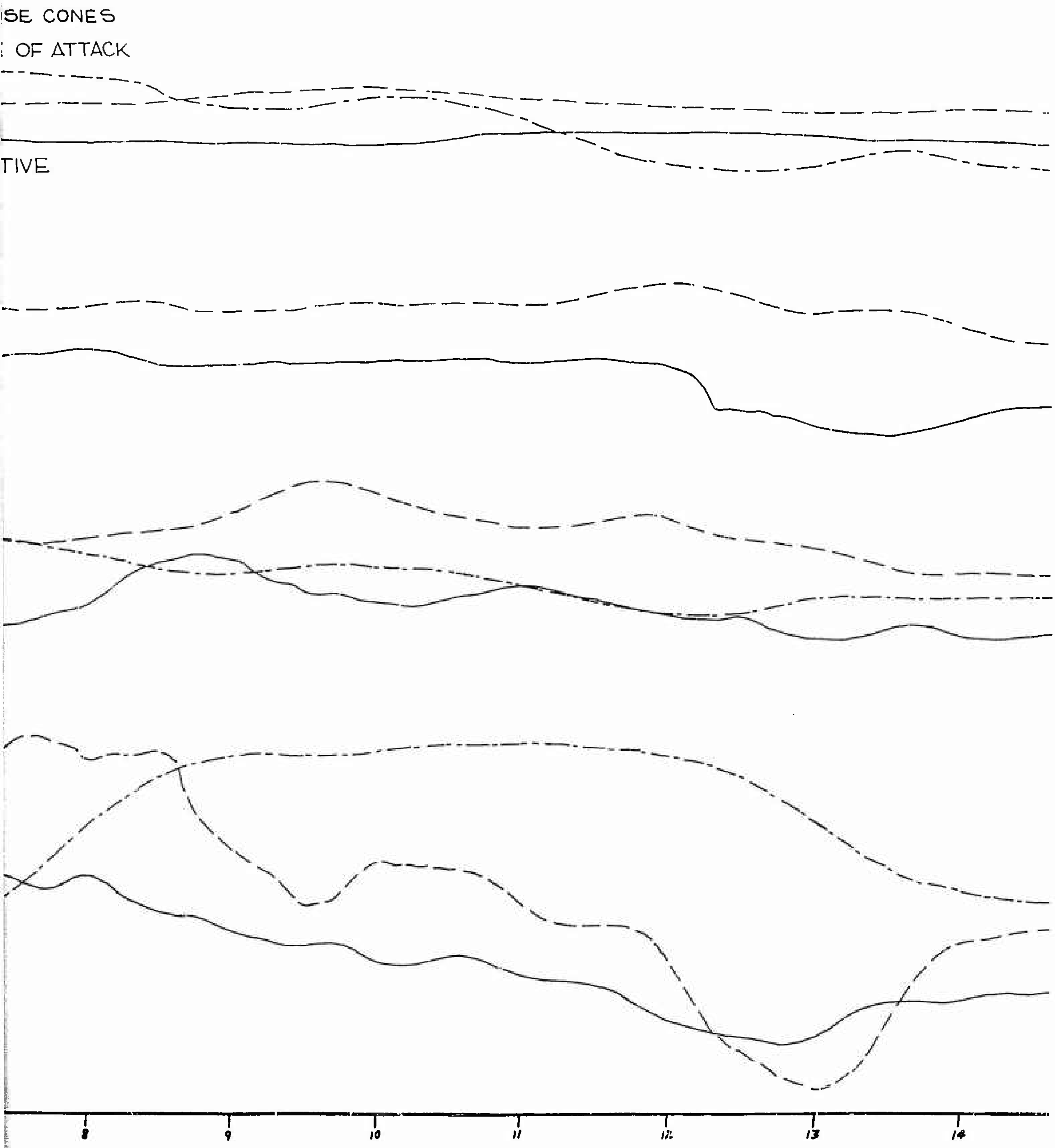


ONLY

2



OSE CONES
E OF ATTACK
TIVE
8
9
10
11
12
13
14


SE CONES
OF ATTACK
TIVE
8
9
10
11
12
13
14

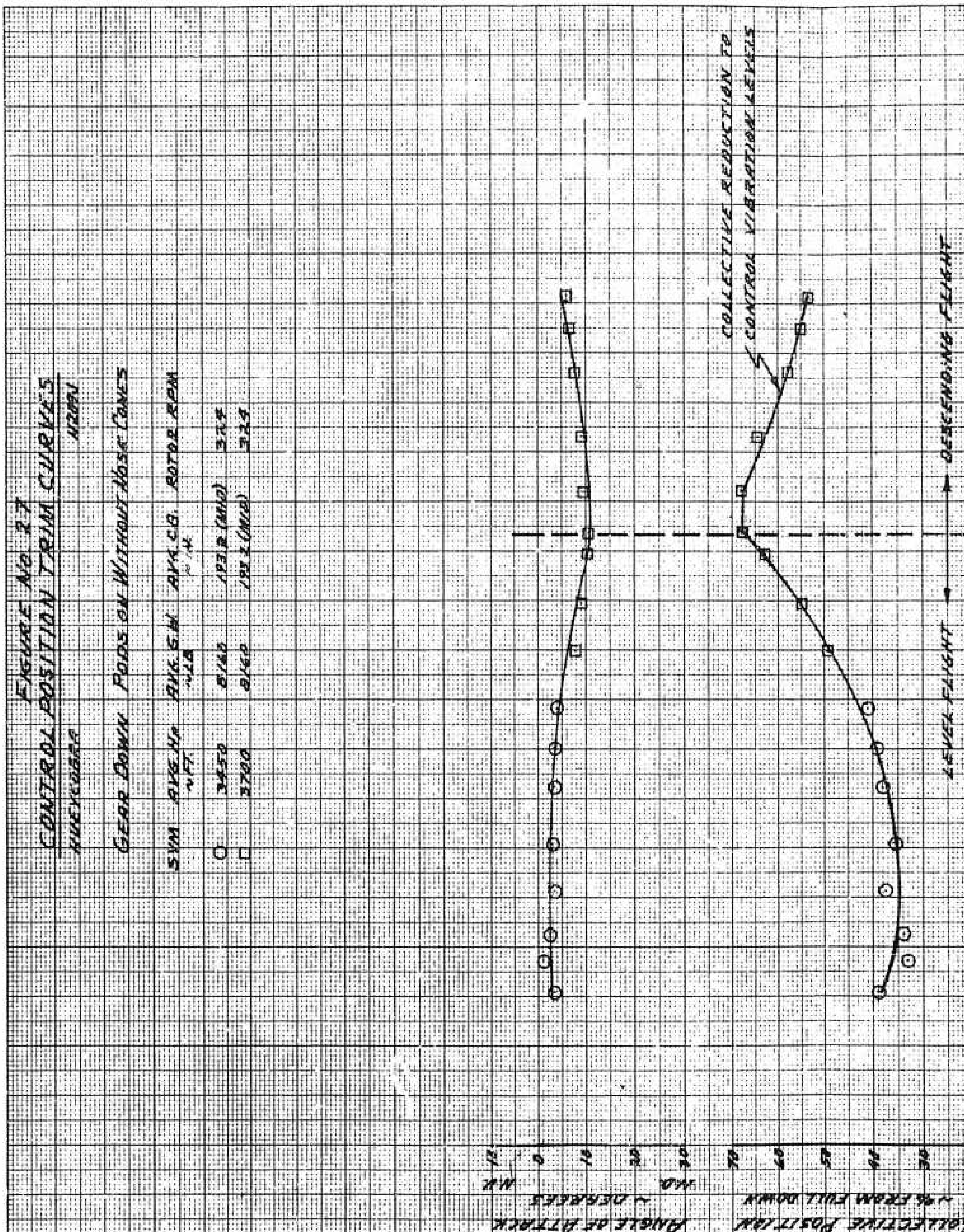
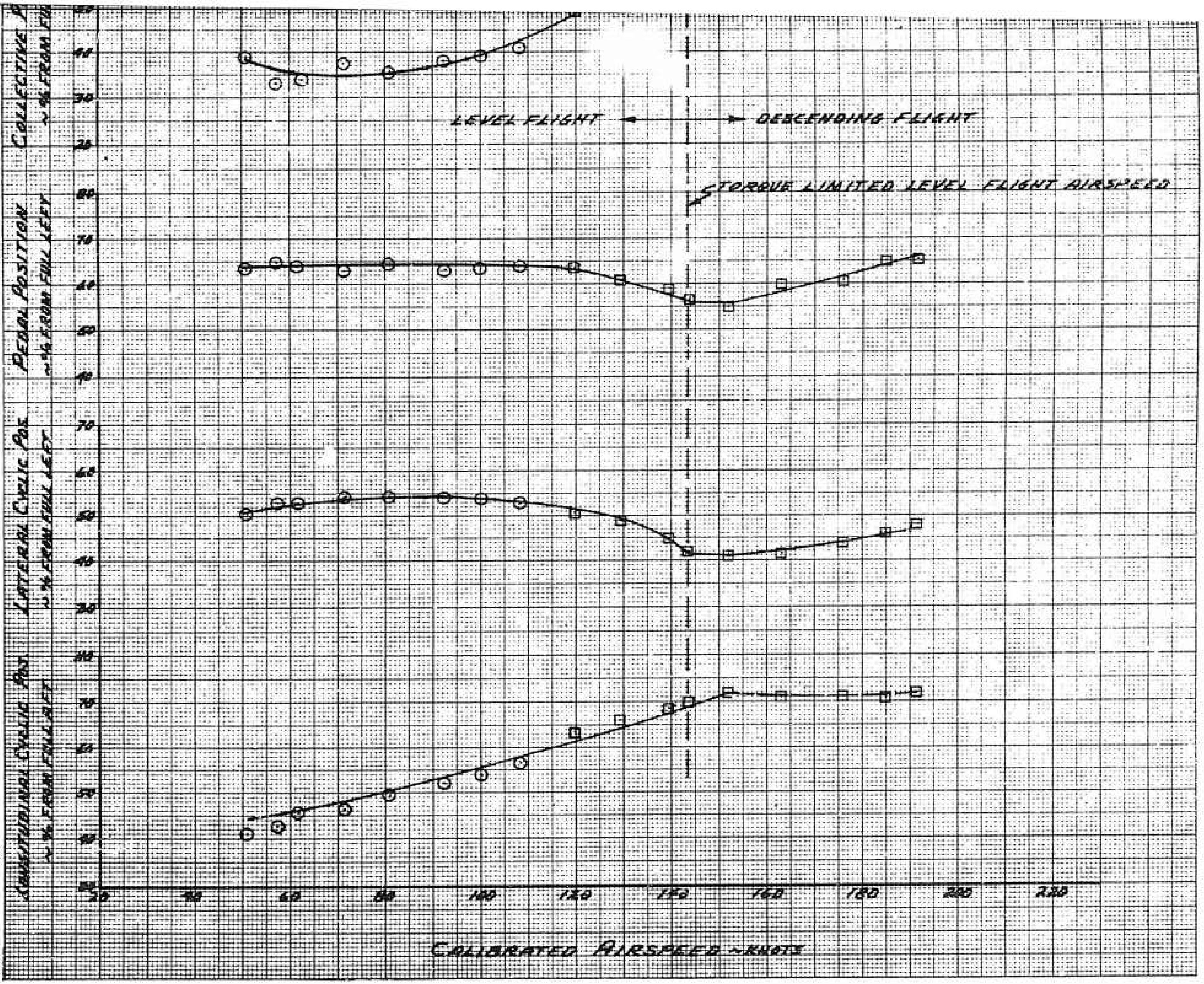


FIGURE No 27
CONTROL POSITION TRIM CURVES
HUEYCOBRA
N209J
GEAR DOWN PODS ON WITHOUT NOSE CONES
SYM AVG. Hp ~FT. AVG. G.W. ~LB AVG. C.G. ~IN. ROTOR RPM
3450 8160 193.2 (MID) 324
3700 8160 193.2 (MID) 324
ANGLE OF ATTACK ~ DEGREES
N.U.
N.D.
COLLECTIVE POSITION ~% FROM FULL DOWN
COLLECTIVE REDUCTION TO CONTROL VIBRATION LEVELS
LEVEL FLIGHT
DESCENDING FLIGHT


Collective P ~ % from Fu
Pedal Position ~ % from Full Left
Lateral Cyclic Pos ~ % from Full Left
Longitudinal Cyclic Pos ~ % from Full Aft
Level Flight
Descending Flight
Torque Limited Level Flight Airspeed
20
40
60
80
100
120
140
160
180
200
220
Calibrated Airspeed ~ Knots

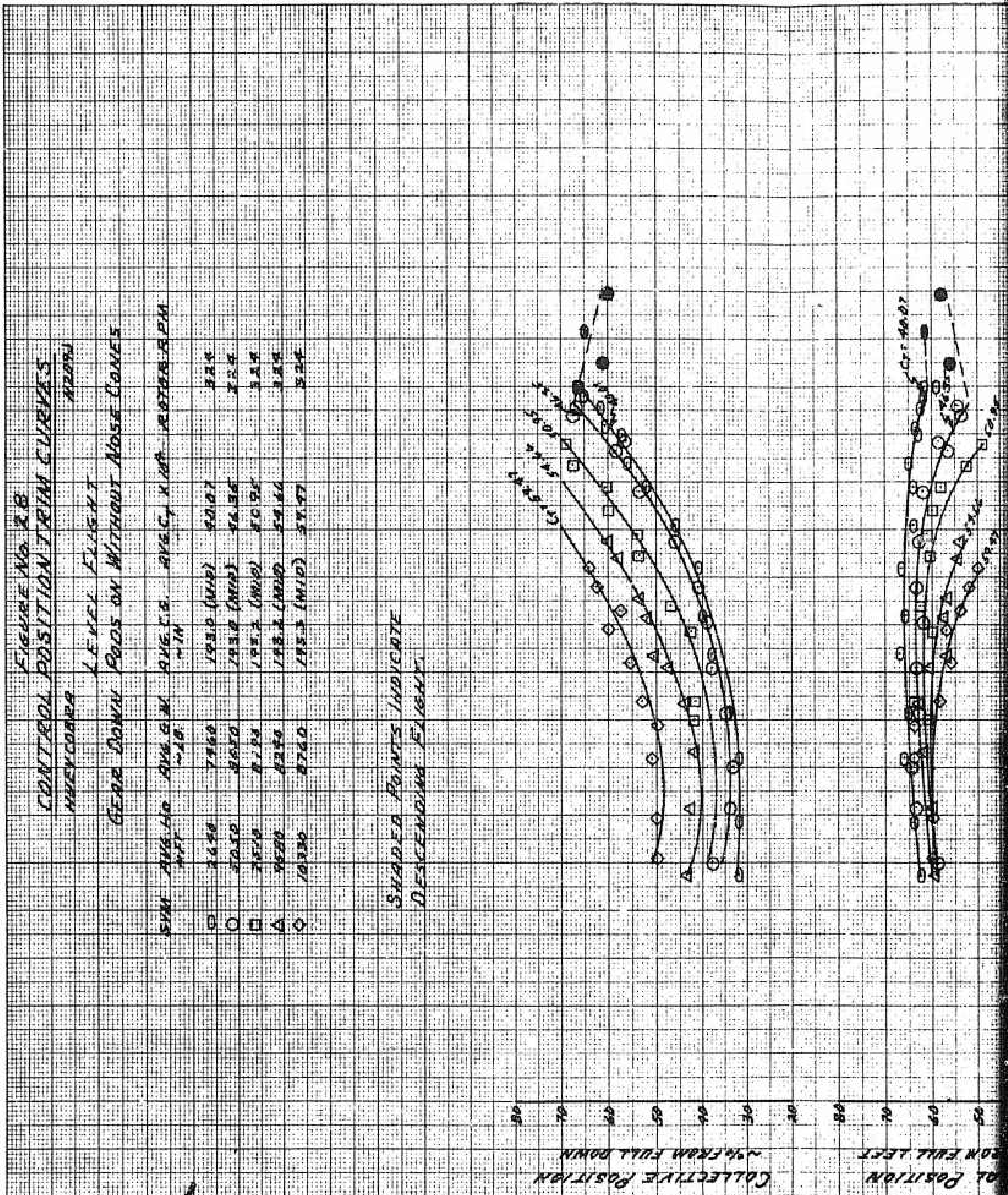


FIGURE No. 28
CONTROL POSITION TRIM CURVES
HUEYCOBRA
N209J
LEVEL FLIGHT
GEAR DOWN PODS ON WITHOUT NOSE CONES
SYM AVG. Hp ~FT AVG. G.W. ~LB. AVG. C.G. ~IN AVG. $C_T \times 10^4$ ROTOR RPM
2650 7960 193.0 (MID) 40.07 324
5050 8050 193.0 (MID) 46.35 324
7510 8190 193.2 (MID) 50.95 324
9580 8290 193.2 (MID) 54.66 324
10330 8760 193.3 (MID) 59.47 324
SHADED POINTS INDICATE DESCENDING FLIGHT.
COLLECTIVE POSITION ~% FROM FULL DOWN
C_T=59.47
54.66
50.95
46.35
40.07
C_T=40.07
46.35
54.66
59.47
50.95

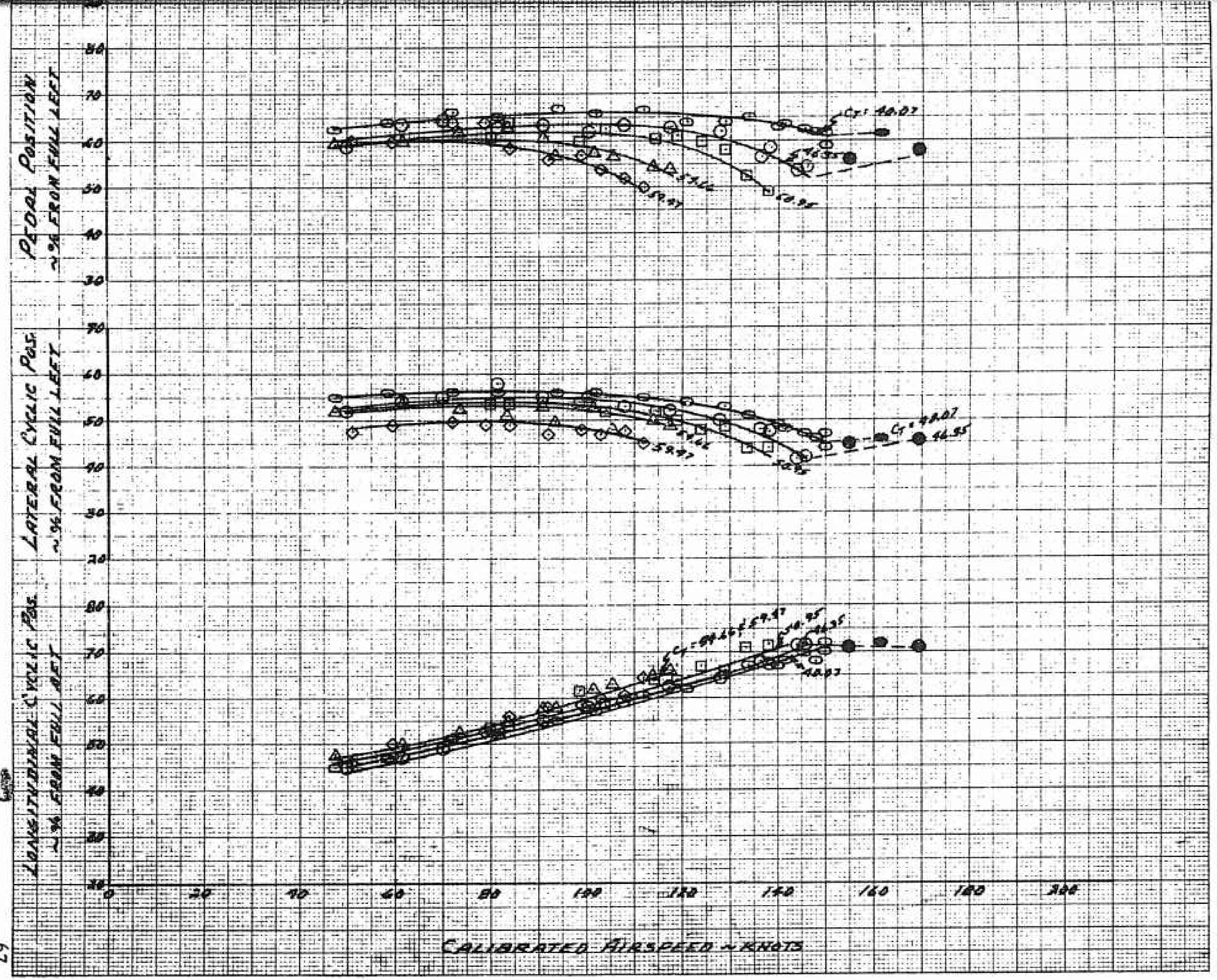

PEDAL POSITION
~% FROM FULL LEFT
LATERAL CYCLIC POS.
~% FROM FULL LEFT
LONGITUDINAL CYCLIC POS.
~% FROM FULL AFT
CALIBRATED AIRSPEED ~ KNOTS

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FIGURE No. 29
CONTROL POSITIONS IN CLIMBING FLIGHT

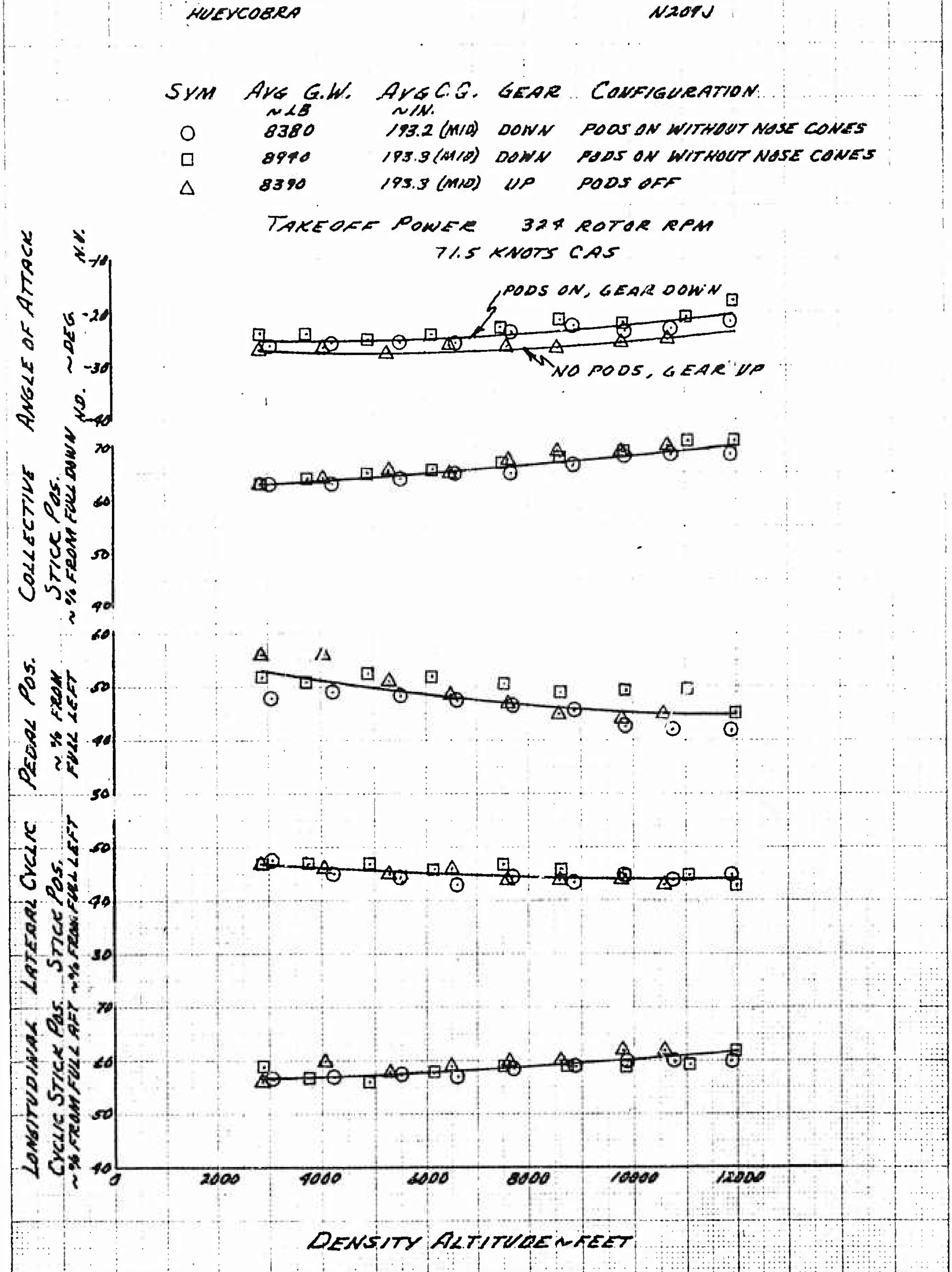

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FIGURE NO. 30
CONTROL POSITION TRIM CURVES

HUEYCOBRA N209J

GEAR UP PODS ON WITH NOSE CONES

SYM	AVG. Hp ~FT.	AVG. G.W. ~LB.	AVG. C.G. ~IN.	ROTOR RPM
○	4350	8290	193.2 (MID)	324

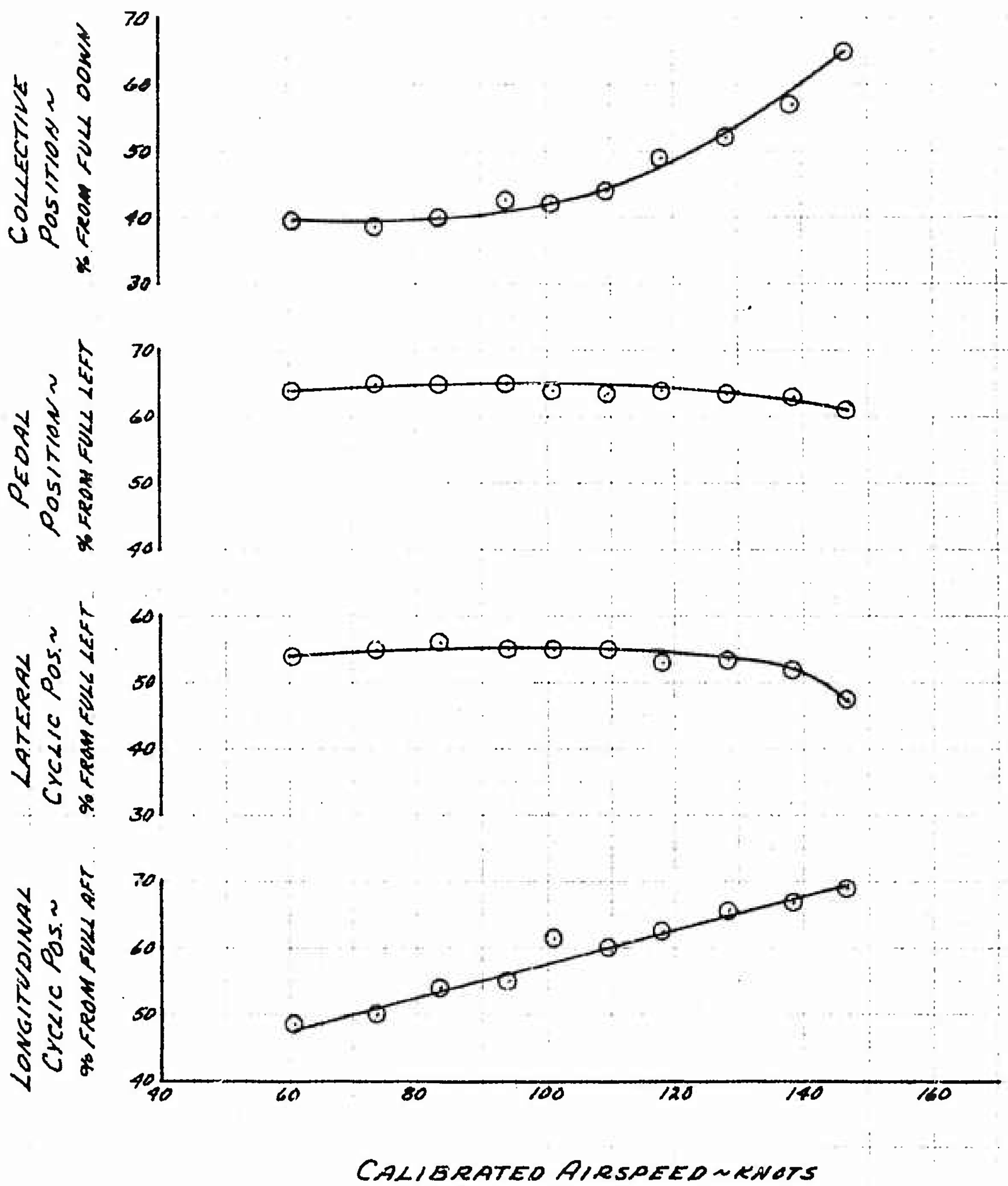


FIGURE NO. 31

CONTROL POSITION TRIM CURVES

HUEYCOBRA N209J

GEAR UP PODS OFF

SYM	AVG Hp ~FT	AVG. G.W. ~LB	AVG. C.G. ~IN.	ROTOR RPM
○	4440	8250	193.2 (MID)	324
□	6690	8180	193.3 (MID)	324

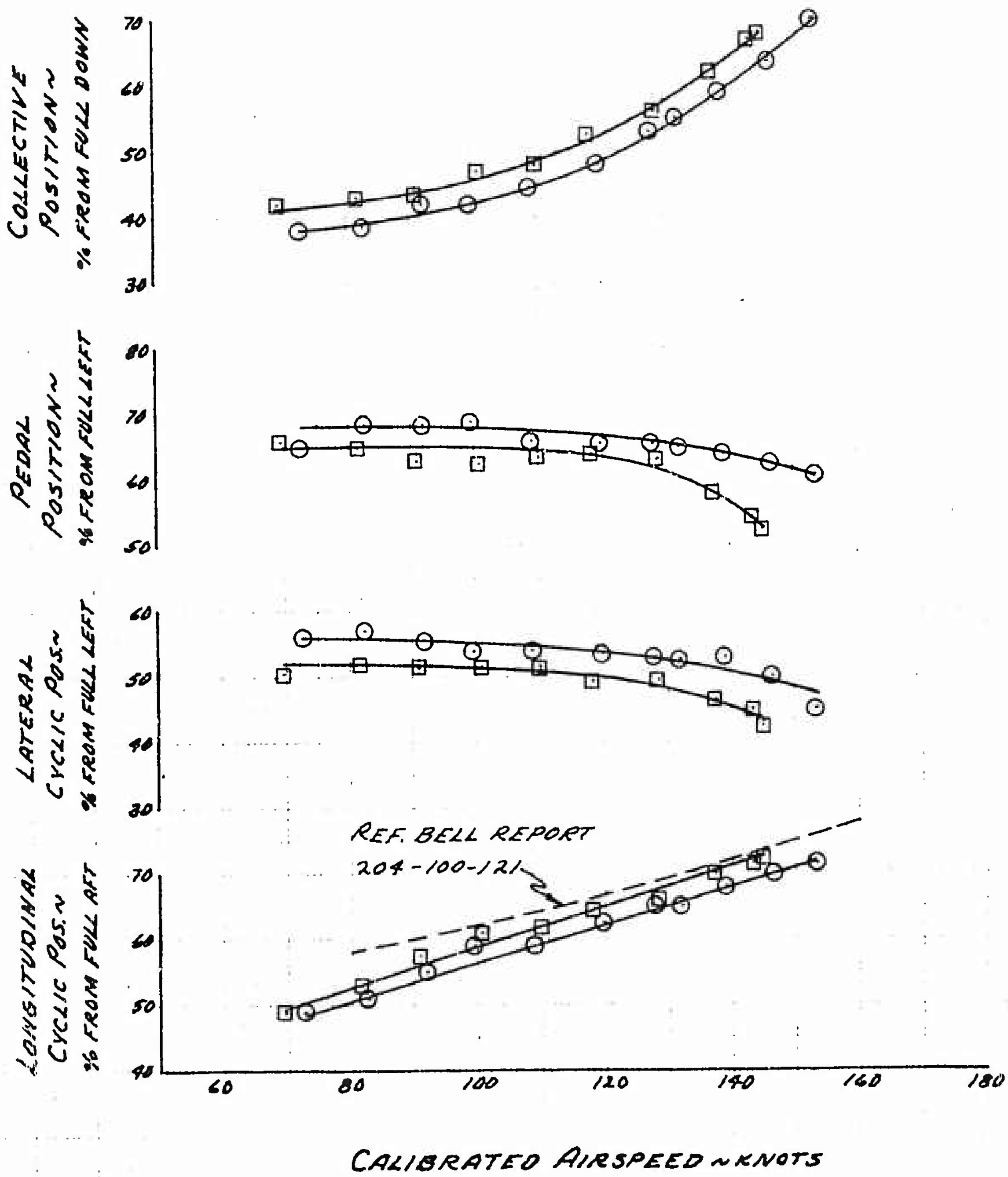


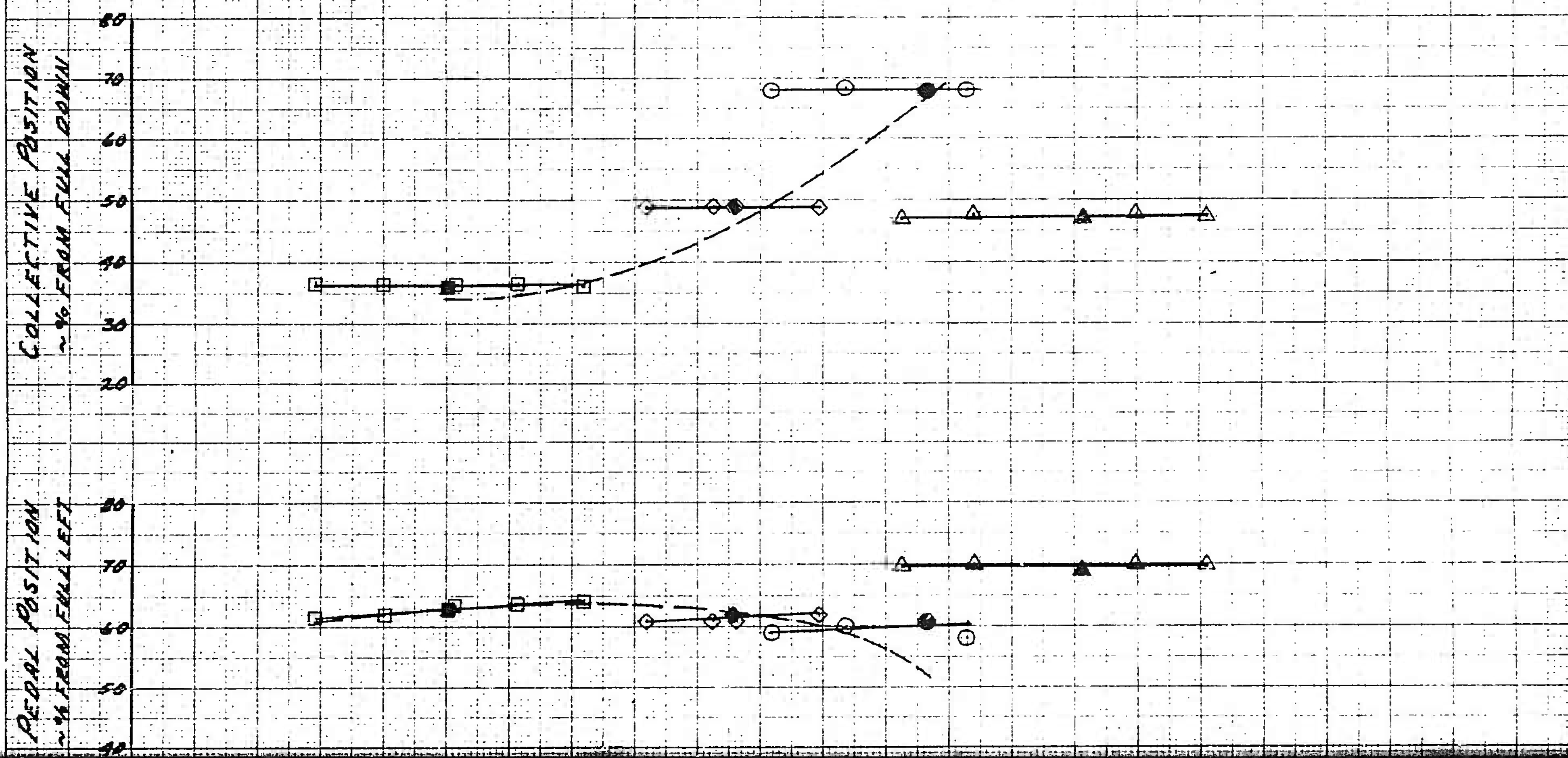
FIGURE No. 32

STATIC LONGITUDINAL SPEED STABILITY

HUEYCOBRA N209J

SYM	AVG HP ~FT.	AVG G.W. ~LB.	AVG C.G. ~IN	ROTOR RPM	CONFIGURATION
○	5680	7470	193.1 (MID)	324	GEAR DOWN PODS ON WITHOUT NOSE CONES
□	2780	8350	193.2 (MID)	324	GEAR DOWN PODS ON WITHOUT NOSE CONES
◇	2490	8340	193.2 (MID)	324	GEAR DOWN PODS ON WITHOUT NOSE CONES
△	5370	7790	193.2 (MID)	324	GEAR UP PODS OFF

SHADED SYMBOLS DENOTE TRIM POINTS



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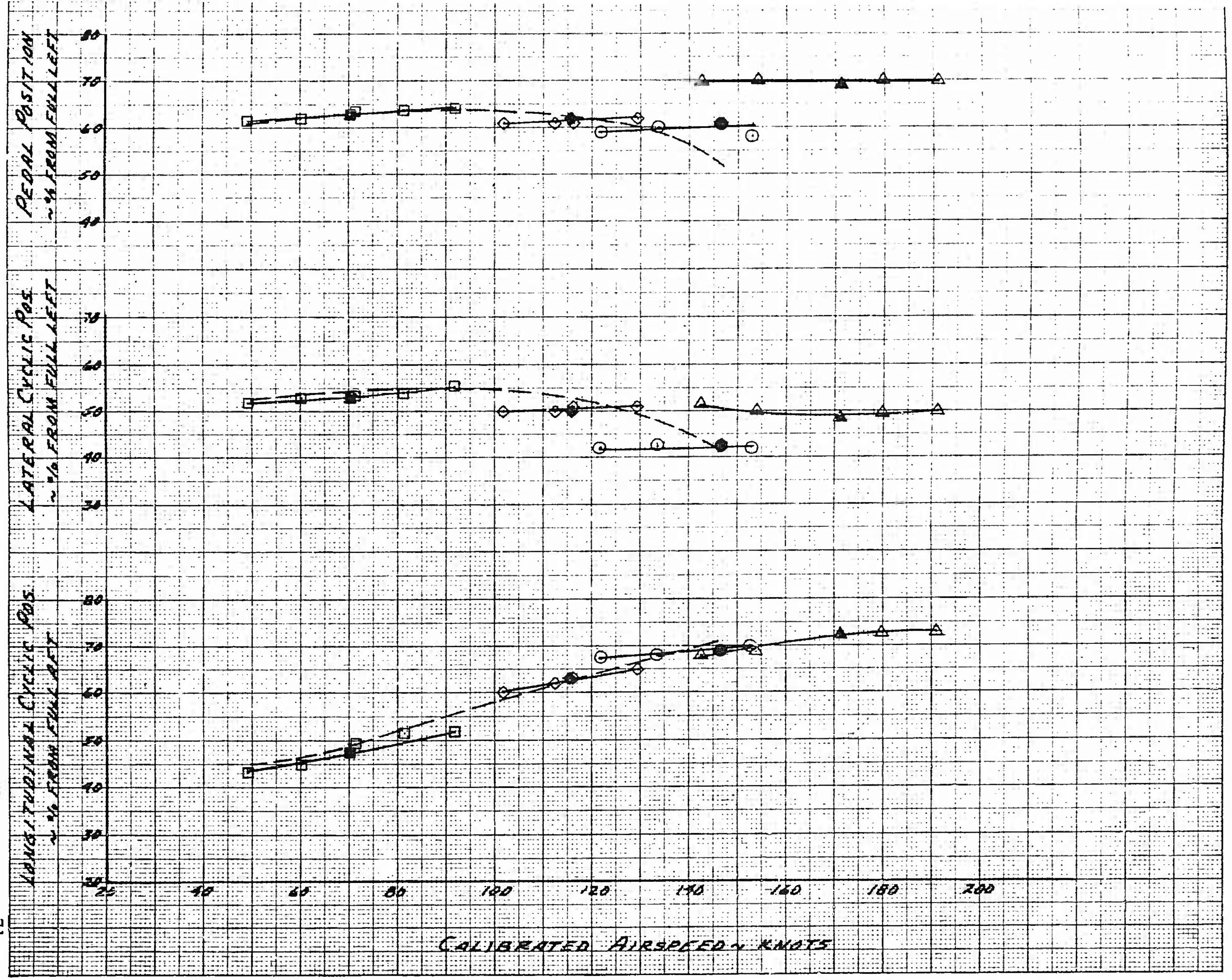


PEDAL POSITION ~% FROM FULL LEFT
LATERAL CYCLIC POS ~% FROM FULL LEFT
LONGITUDINAL CYCLIC POS ~% FROM FULL AFT
CALIBRATED AIRSPEED ~ KNOTS
80
70
60
50
40
30
20
100
120
140
160
180
200

FIGURE No. 33

STATIC LONGITUDINAL SPEED STABILITY

HUEYCOBRA N209J

GEAR DOWN PODS ON WITHOUT NOSE CONES

SYM	AVG Hp ~FT	AVG. G.W. ~LB.	AVG C.G. ~IN.	ROTOR RPM	FLIGHT CONDITION
○	5690	8370	193.2 (MID)	324.0	CLIMB

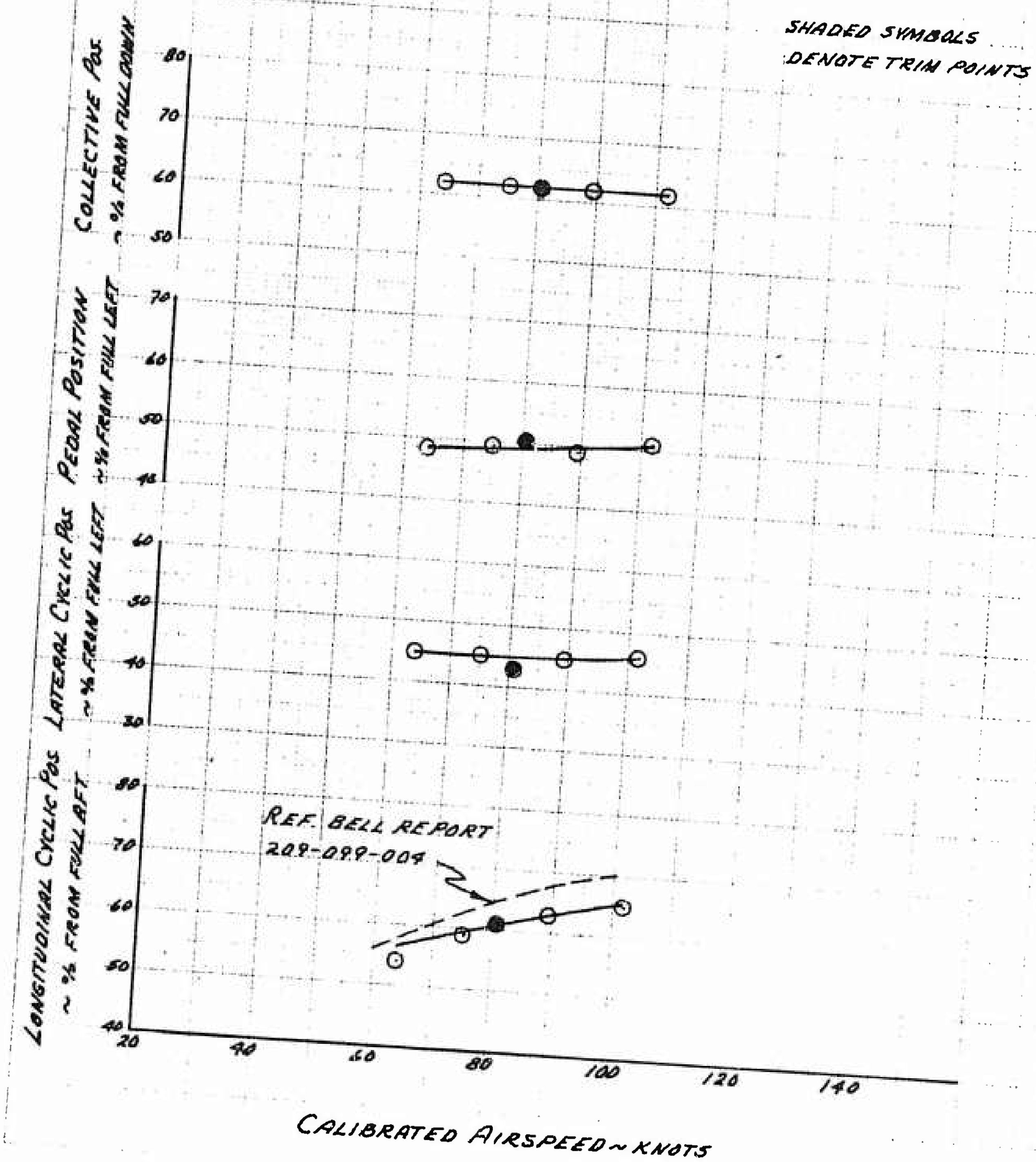


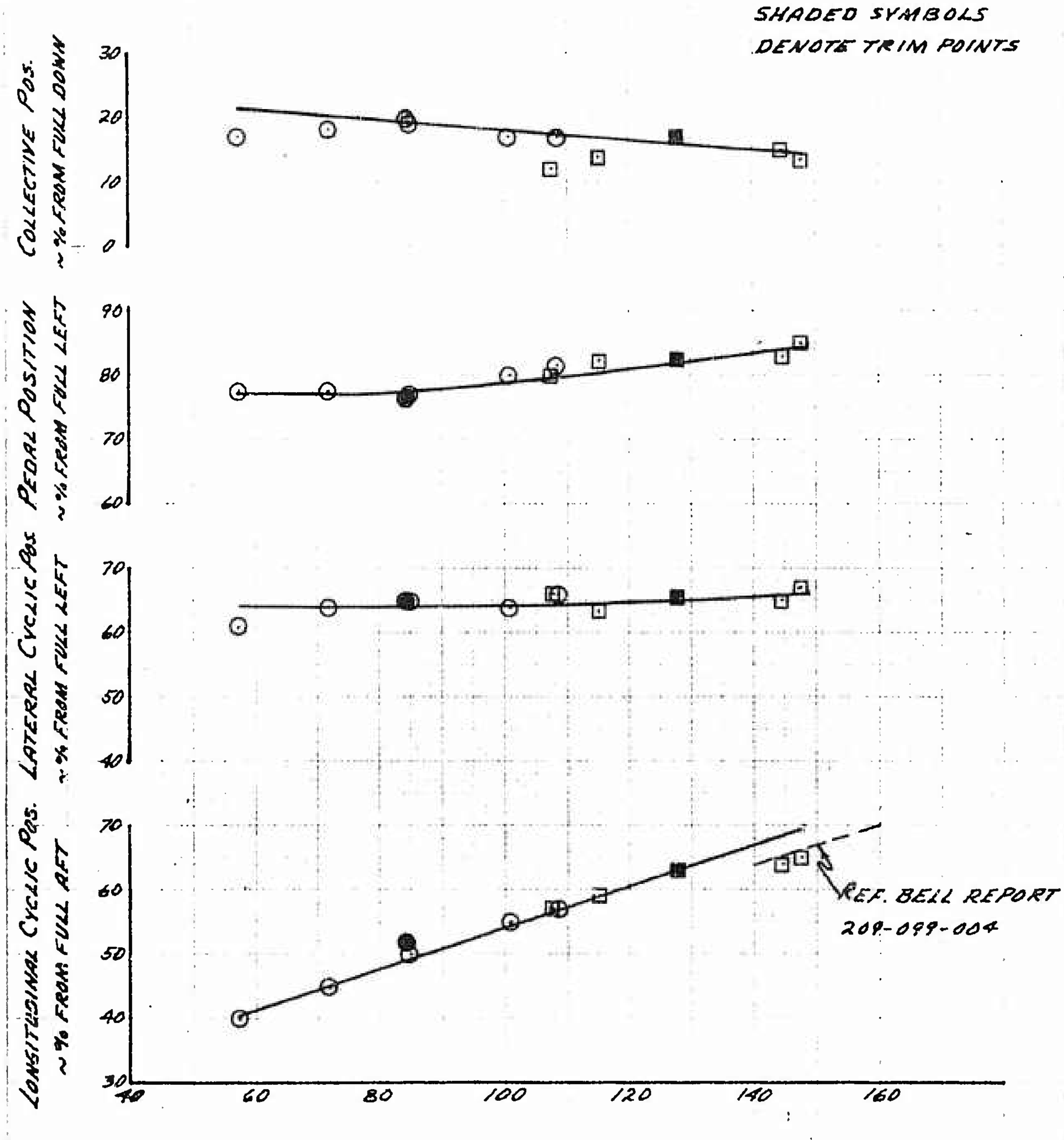
FIGURE NO. 34

STATIC LONGITUDINAL SPEED STABILITY

HUEYCOBRA N209J

GEAR DOWN PODS ON WITHOUT NOSE CONES

SYM	AVG. Hp ~FT.	AVG. G.W. ~LB.	AVG C.G. ~IN.	ROTOR RPM	FLIGHT CONDITION
○	5570	8010	193.2 (MID)	315.4	AUTOROTATION
□	4820	8150	193.2 (MID)	314.0	AUTOROTATION



CALIBRATED AIRSPEED ~ KNOTS

FIGURE No. 35

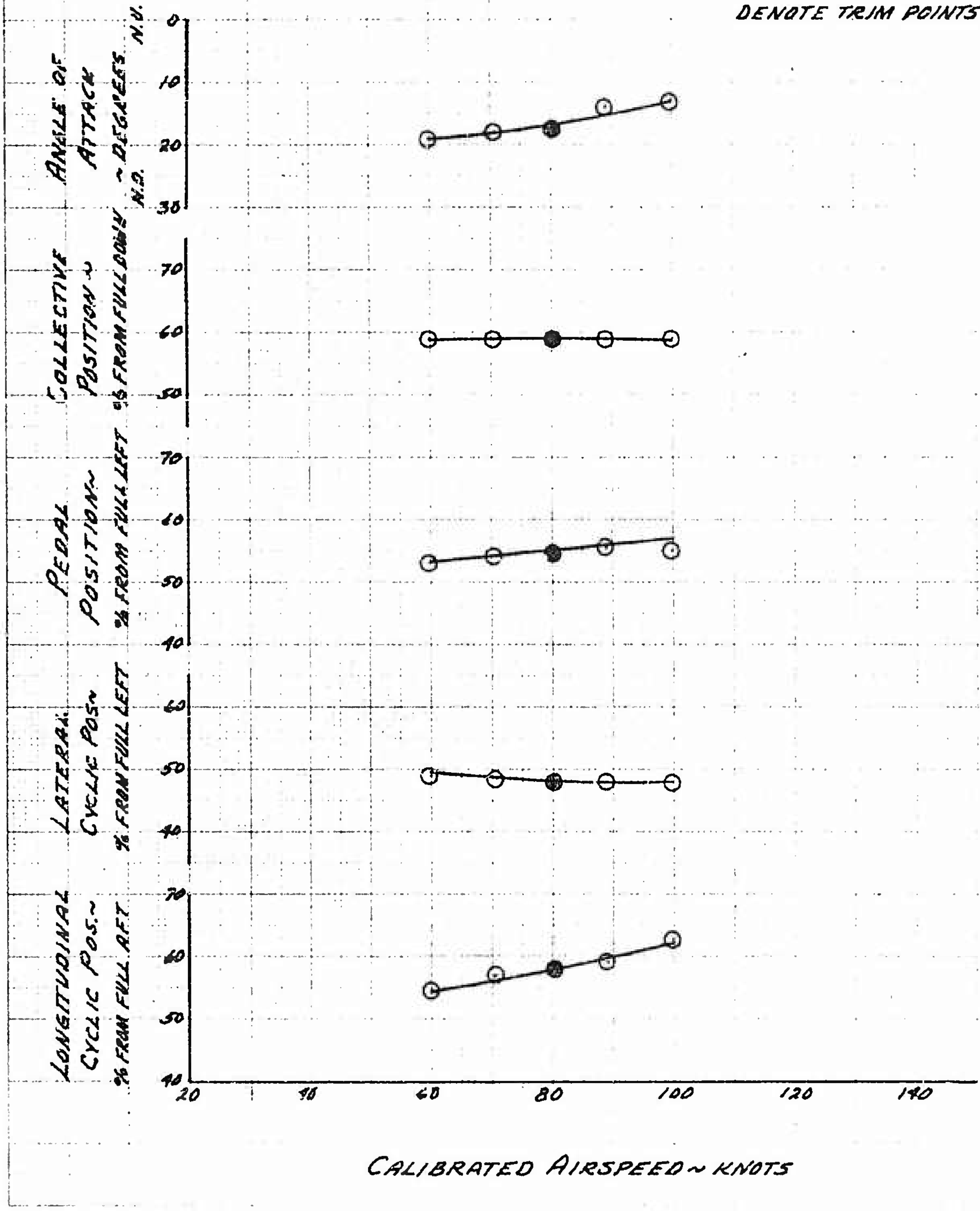
STATIC LONGITUDINAL SPEED STABILITY

HUEYCOBRA N209J

GEAR UP PODS ON WITH NOSE CONES

SYM	AVG H_p ~FT.	AVG G.W. ~LB.	AVG. C.G. ~IN.	ROTOR RPM	FLIGHT CONDITION
○	5620	8380	193.2(MID)	329	CLIMB

SHADED SYMBOLS DENOTE TRIM POINTS



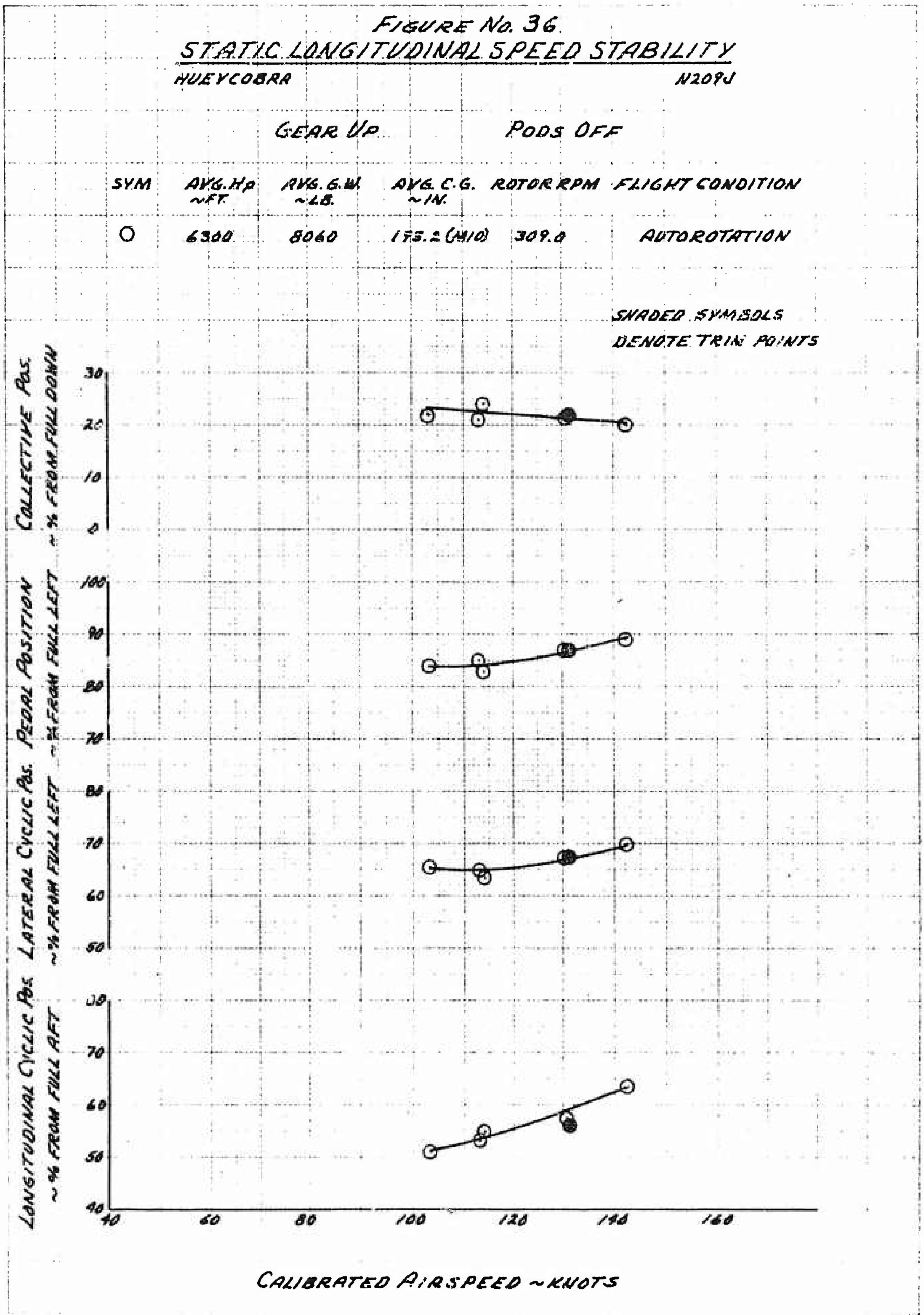


FIGURE No. 36
STATIC LONGITUDINAL SPEED STABILITY
HUEYCOBRA
N209J
GEAR UP
PODS OFF
SYM
AVG. Hp ~FT.
AVG. G.W. ~LB.
AVG. C.G. ~IN.
ROTOR RPM
FLIGHT CONDITION
6300
8060
193.2 (MID)
309.0
AUTOROTATION
SHADED SYMBOLS DENOTE TRIM POINTS
COLLECTIVE POS. ~% FROM FULL DOWN
PEDAL POSITION ~% FROM FULL LEFT
LATERAL CYCLIC POS. ~% FROM FULL LEFT
LONGITUDINAL CYCLIC POS. ~% FROM FULL AFT
CALIBRATED AIRSPEED ~KNOTS

FIGURE No. 38
STATIC LATERAL-DIRECTIONAL STABILITY

HUEYCOBRA N209J

GEAR DOWN PODS ON WITHOUT NOSE CONES

AIRSPEED ~KCAS	AVG Hp ~FT.	AVG. G.W. ~LB.	AVG. C.G. ~IN.	ROTOR RPM	COLLECTIVE POS. ~% FROM FULL DOWN
118	3790	8070	193.2(MID)	324	50

SHADED SYMBOLS DENOTE TRIM POINTS

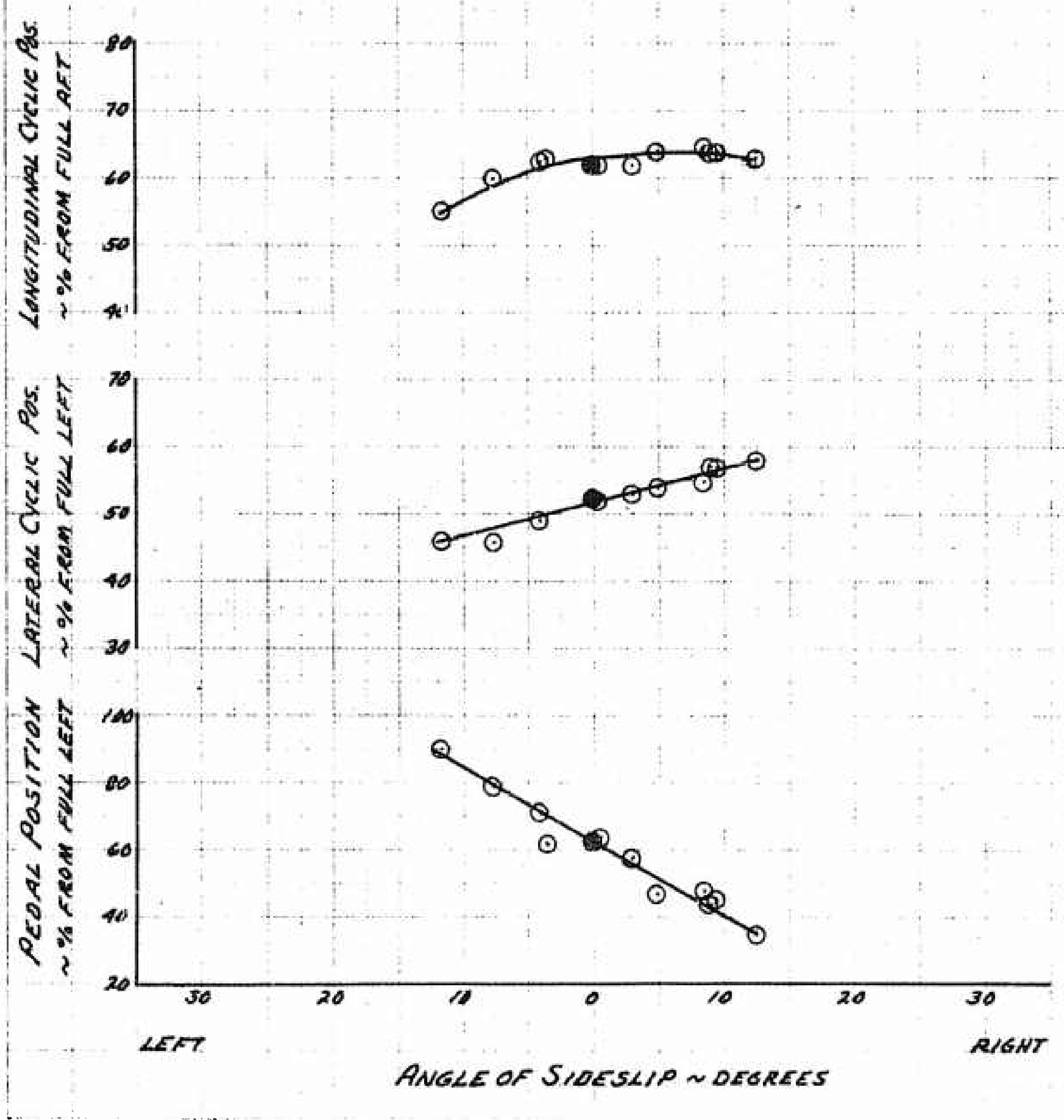


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FIGURE NO. 39

STATIC LATERAL-DIRECTIONAL STABILITY

HUEYCOBRA N209J

GEAR DOWN POD ON WITHOUT NOSE CONES

AIRSPEED ~KCAS	AVG. Hp ~FT.	AVG. G.W. ~LB.	AVG. C.G. ~IN.	ROTOR RPM	COLLECTIVE POS. ~% FROM FULL DOWN
139	5300	8390	193.2 (MID)	324	60

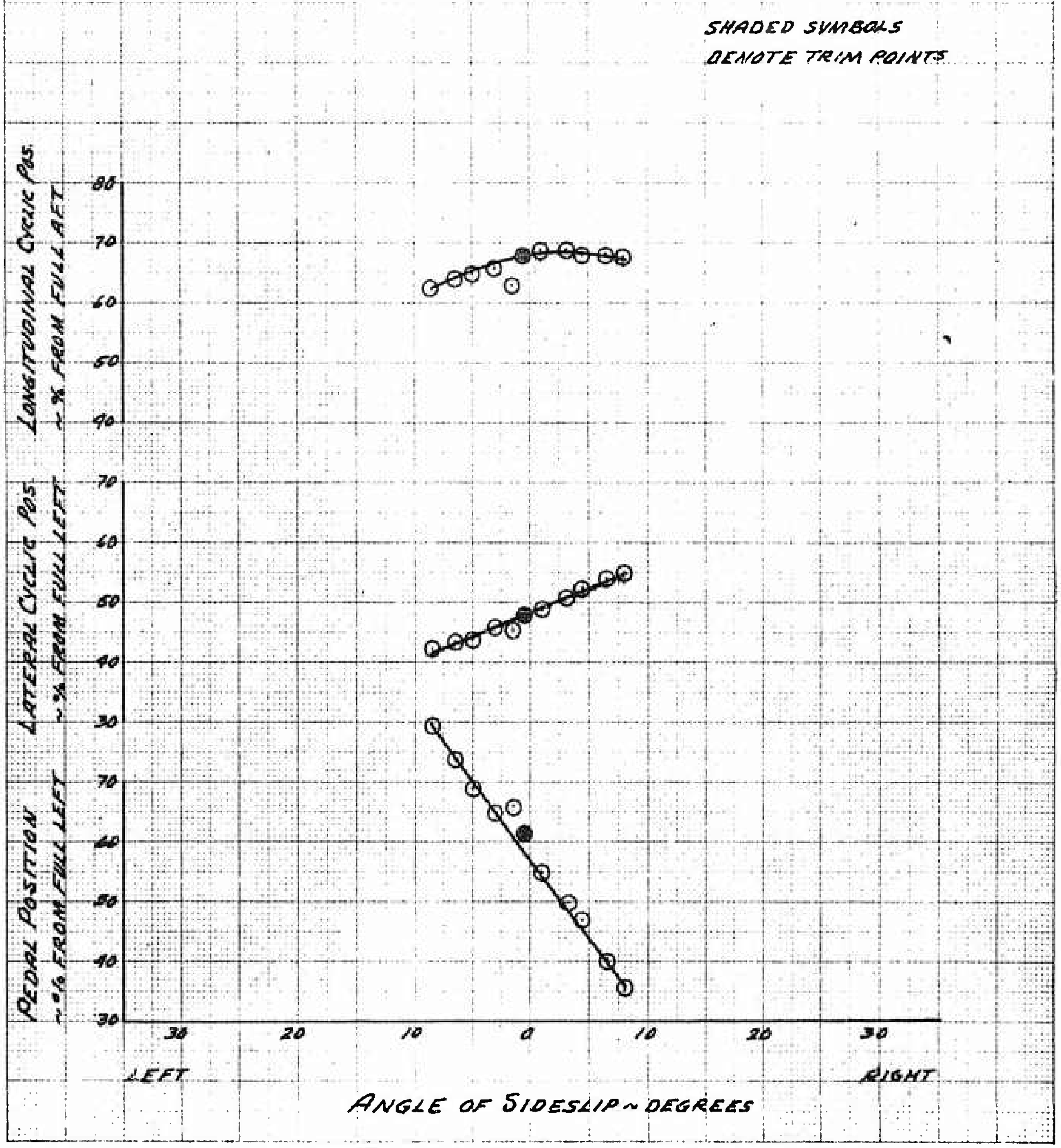

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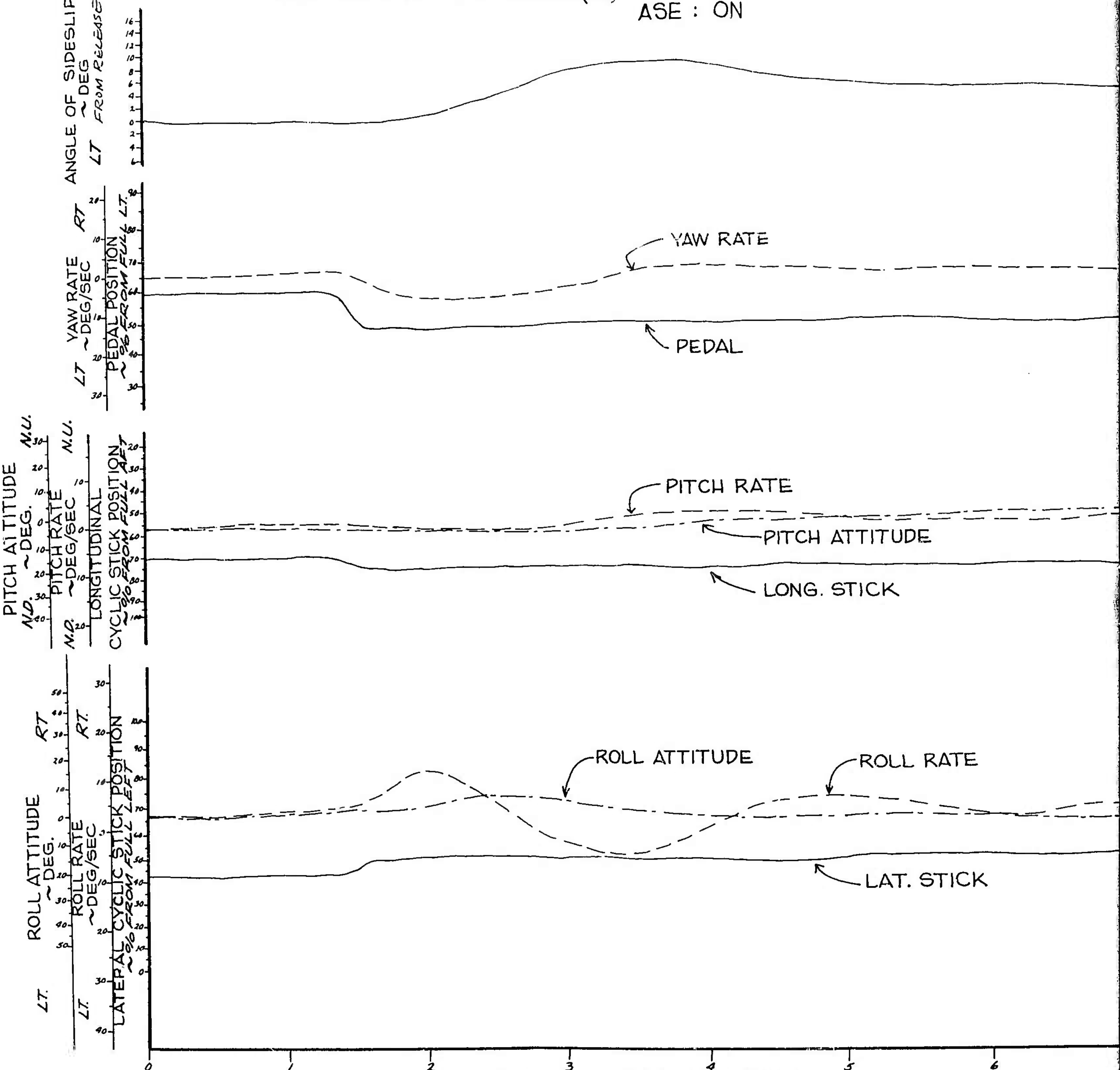
FIGURE NO. 40

RELEASE FROM STEADY SIDESLIP

HUEYCOBRA N 209 J

AVG. DENSITY ALTITUDE: 5700 FT. AIRSPEED: 166.0 KCAS
AVG. GROSS WEIGHT : 8010 LB ROTOR RPM: 324
AVG. C.G. LOCATION: 193.0 IN. (MID) CONFIGURATION: GEAR UP · PODS OFF
ASE : ON



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RE NO. 40

STEADY SIDESLIP

RA N 209 J

5700 FT. AIRSPEED : 166.0 KCAS

0 LB ROTOR RPM : 324

.0 IN.(MID) CONFIGURATION : GEAR UP · PODS OFF

ASE : ON

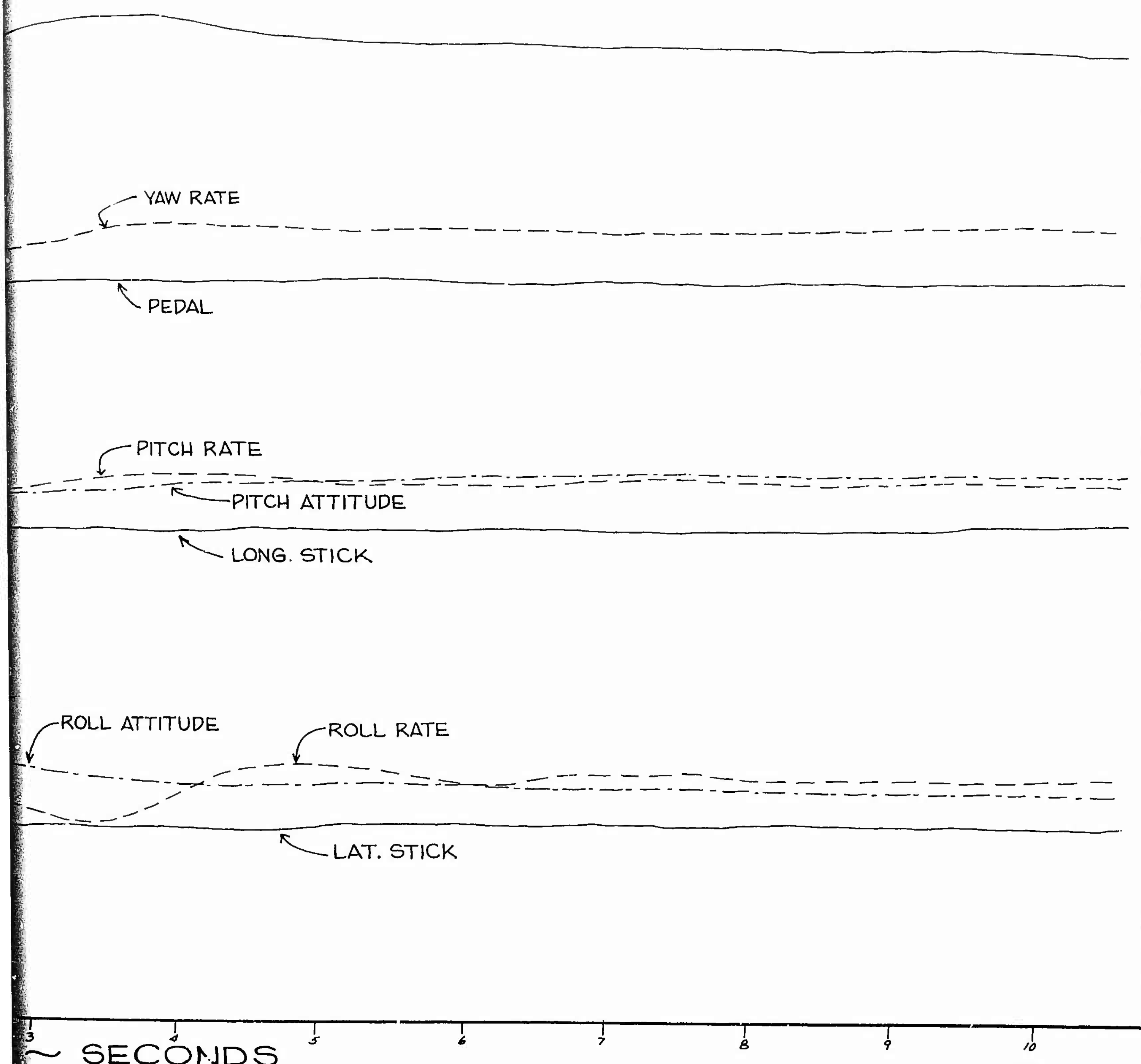
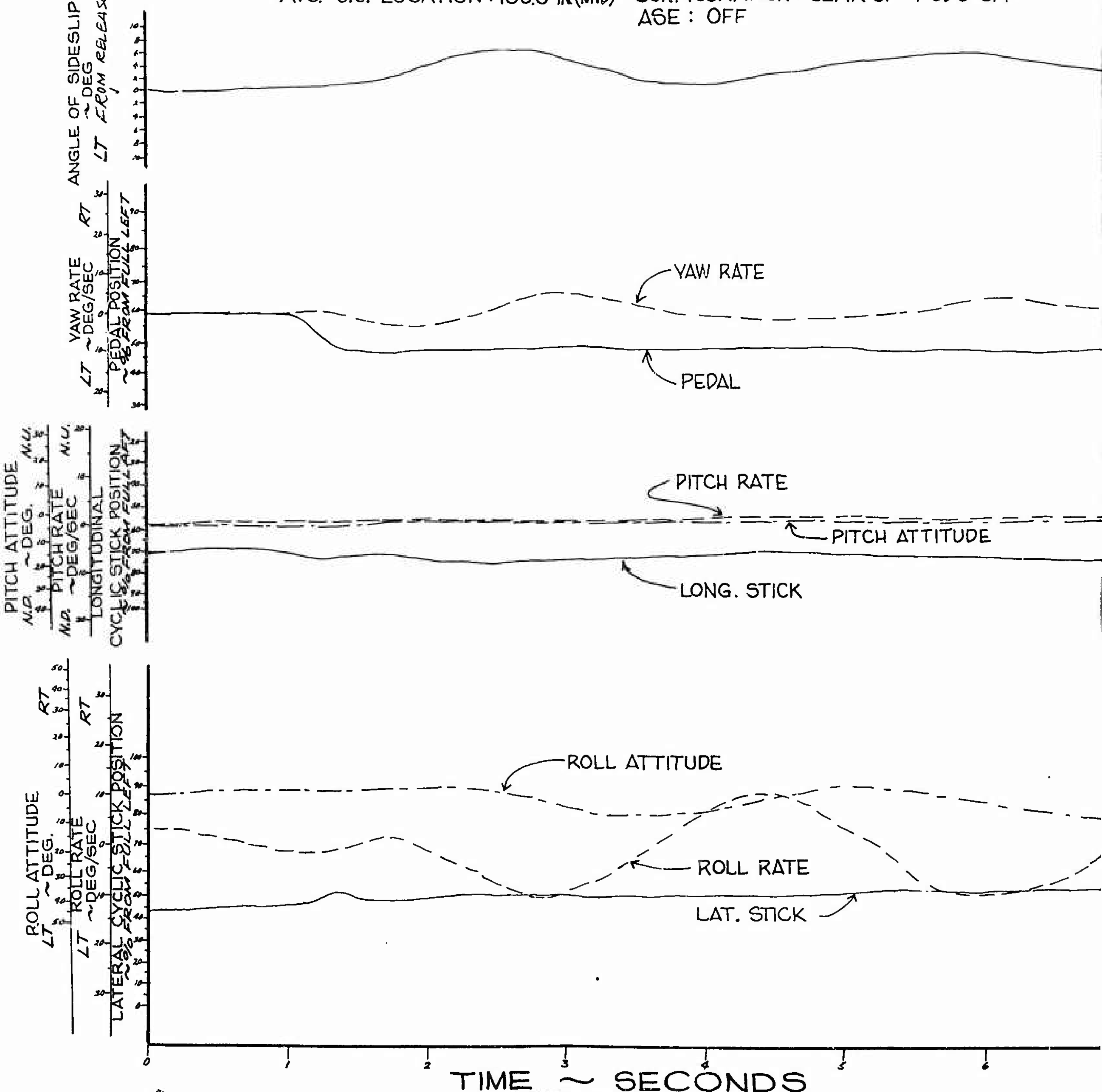


FIGURE NO. 41

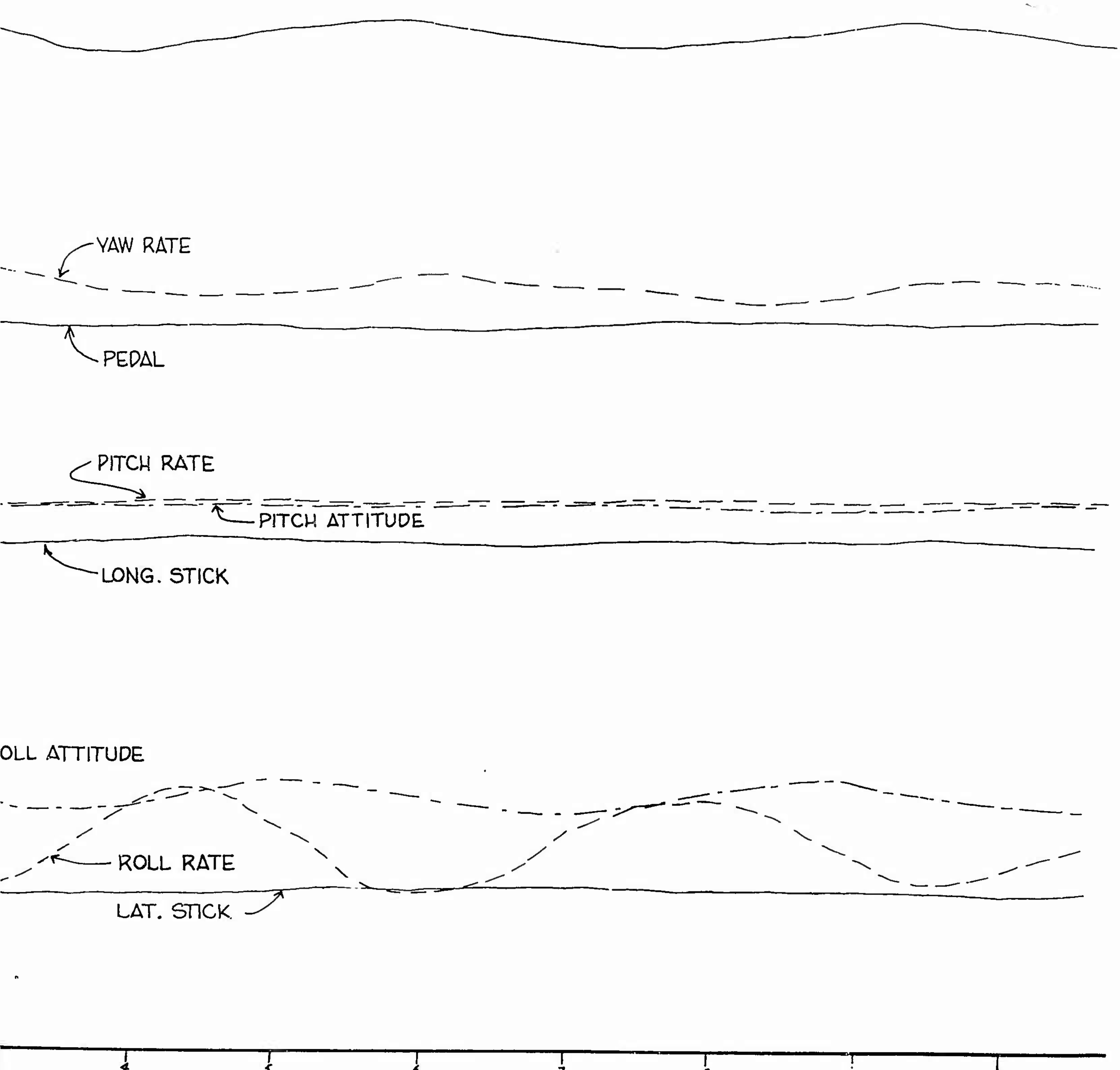
RELEASE FROM STEADY SIDESLIP

HUEYCOBRA - N 209J

AVG. DENSITY ALTITUDE: 5700 FT. AIRSPEED: 166.0 KCAS
AVG. GROSS WEIGHT: 8010 LB. ROTOR RPM: 324
AVG. C.G. LOCATION: 193.0 IN (MID) CONFIGURATION: GEAR UP · PODS OFF
ASE: OFF



USE ONLY
NO. 41
I STEADY SIDESLIP
- N 209J
FT. AIRSPEED: 166.0 KCAS
. ROTOR RPM: 324
(MID) CONFIGURATION: GEAR UP · PODS OFF
ASE: OFF



- SECONDS
USE ONLY

2

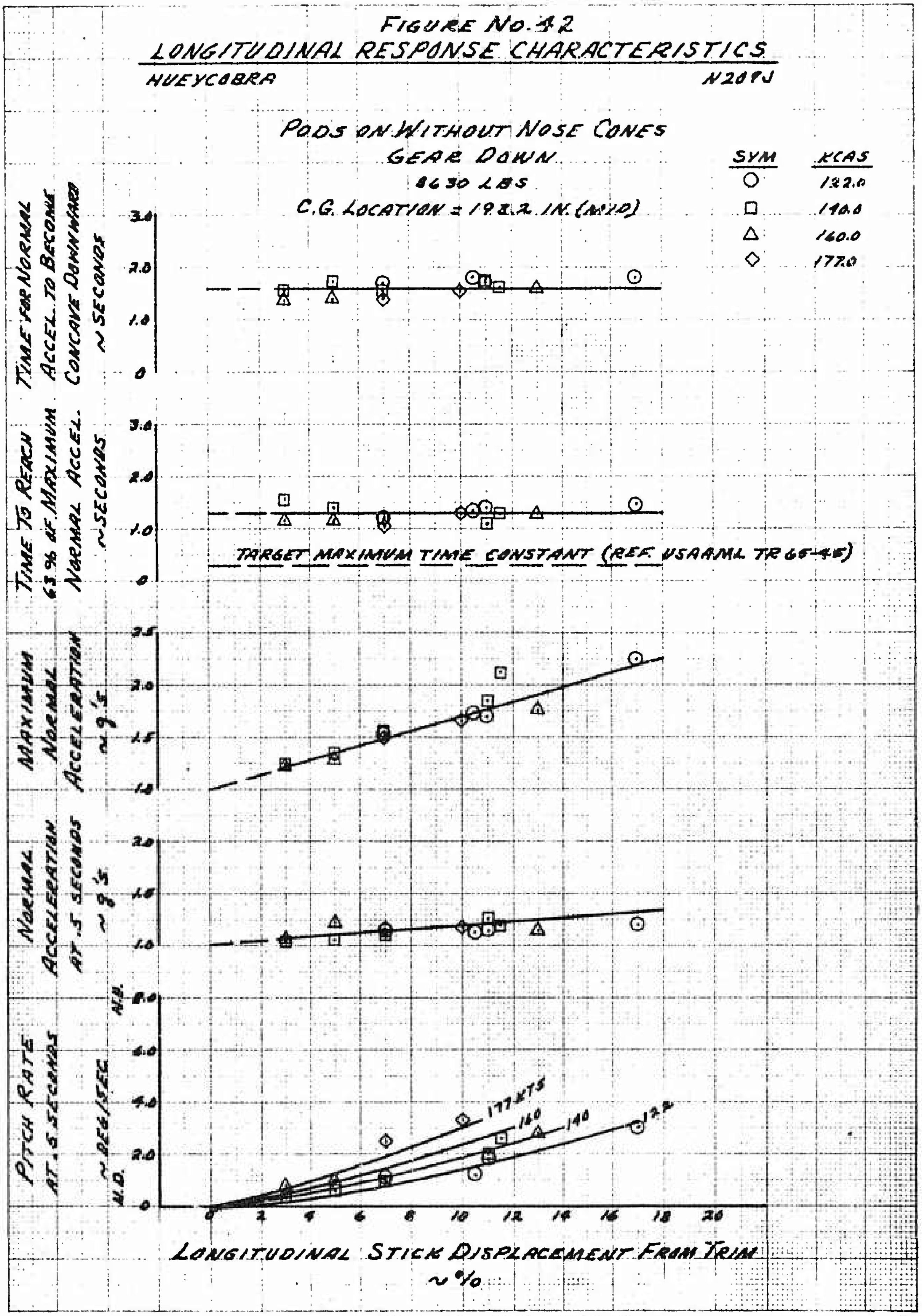


FIGURE No. 42
LONGITUDINAL RESPONSE CHARACTERISTICS
HUEYCOBRA
N209J
PODS ON WITHOUT NOSE CONES
GEAR DOWN
8630 LBS
C.G. LOCATION = 193.2 IN. (MID)
SYM
KCAS
132.0
140.0
160.0
177.0
TIME FOR NORMAL ACCEL. TO BECOME CONCAVE DOWNWARD ~ SECONDS
TIME TO REACH 63% OF MAXIMUM NORMAL ACCEL. ~SECONDS
TARGET MAXIMUM TIME CONSTANT (REF. USAAML TR 65-45)
MAXIMUM NORMAL ACCELERATION ~g's
NORMAL ACCELERATION AT .5 SECONDS ~g's
PITCH RATE AT .5 SECONDS ~DEG/SEC
N.U.
N.D.
177 KTS
160
140
132
LONGITUDINAL STICK DISPLACEMENT FROM TRIM ~%

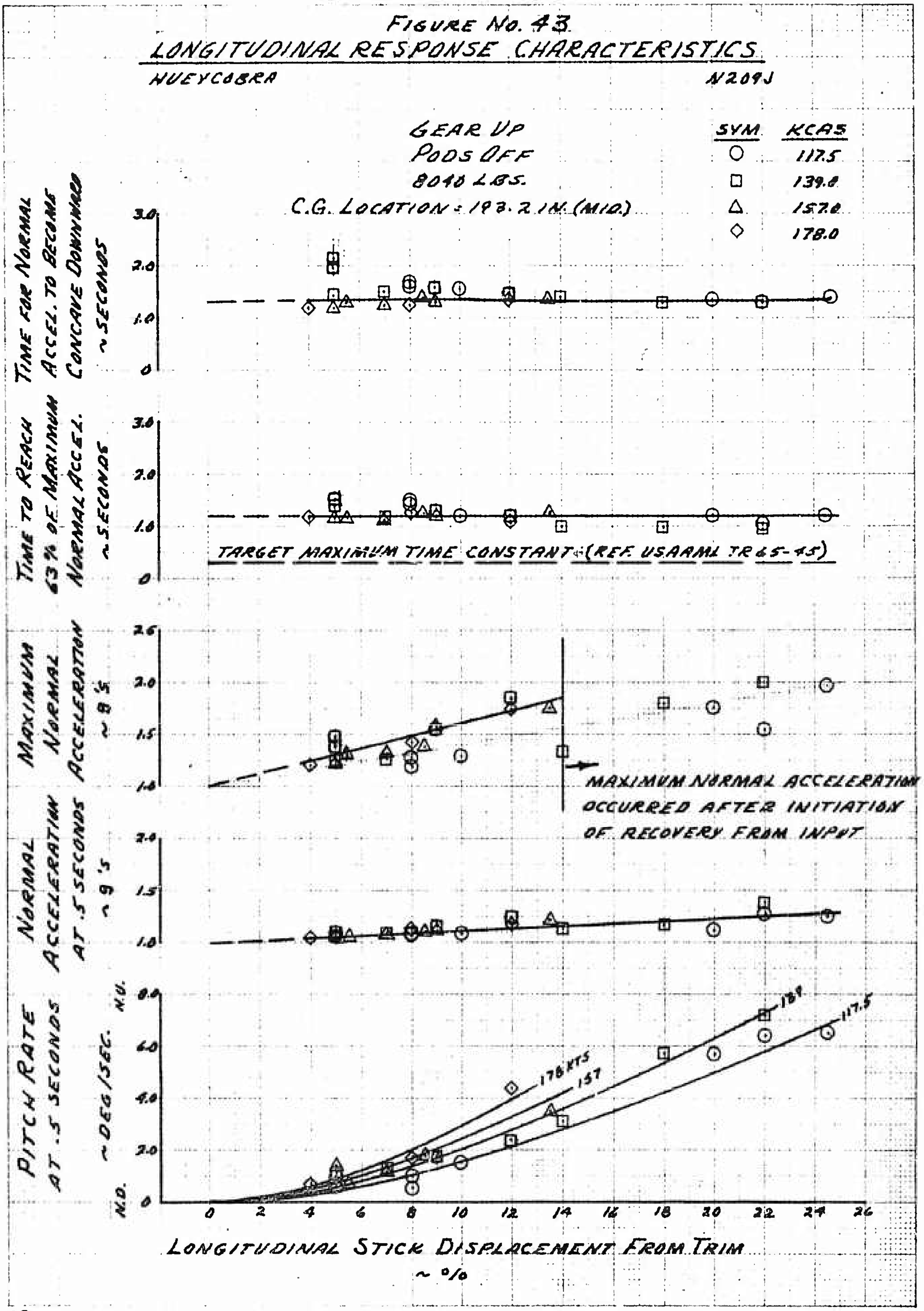


FIGURE NO. 43
LONGITUDINAL RESPONSE CHARACTERISTICS
HUEYCOBRA
N209J
GEAR UP
PODS OFF
8040 LBS.
C.G. LOCATION = 193.2 IN. (MID)
SYM.
KCAS
117.5
139.0
157.0
178.0
TIME FOR NORMAL ACCEL. TO BECOME CONCAVE DOWNWARD ~ SECONDS
TIME TO REACH 63% OF MAXIMUM NORMAL ACCEL. ~ SECONDS
TARGET MAXIMUM TIME CONSTANT (REF. USAAML TR 65-45)
MAXIMUM NORMAL ACCELERATION ~ g's
MAXIMUM NORMAL ACCELERATION OCCURRED AFTER INITIATION OF RECOVERY FROM INPUT
NORMAL ACCELERATION AT .5 SECONDS ~ g's
PITCH RATE AT .5 SECONDS ~ DEG/SEC. N.U.
N.D.
178 KTS
157
139
117.5
LONGITUDINAL STICK DISPLACEMENT FROM TRIM ~ %

FIGURE No. 44
MANEUVERING STICK FORCE
HUEYCOBRA N209J

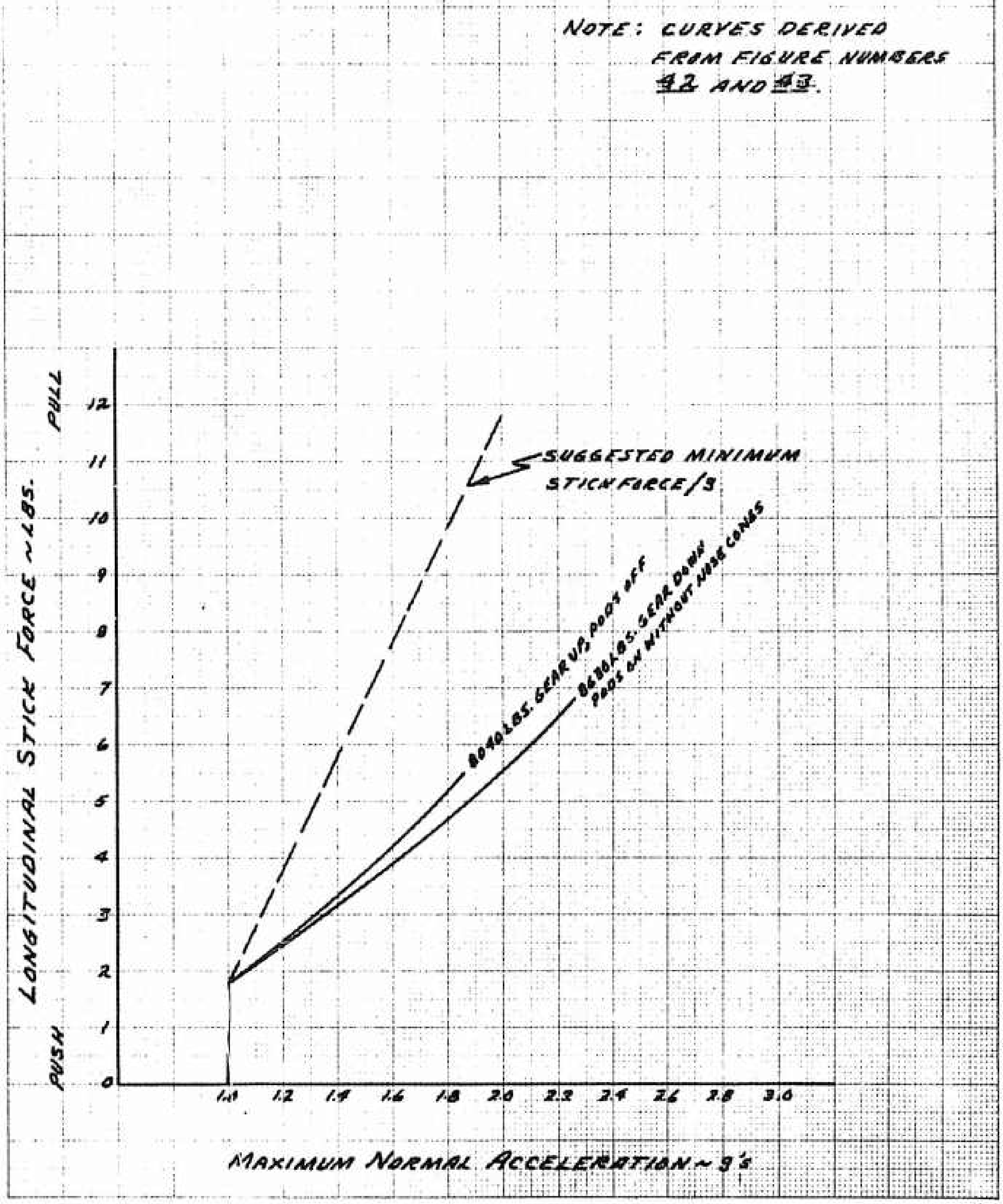


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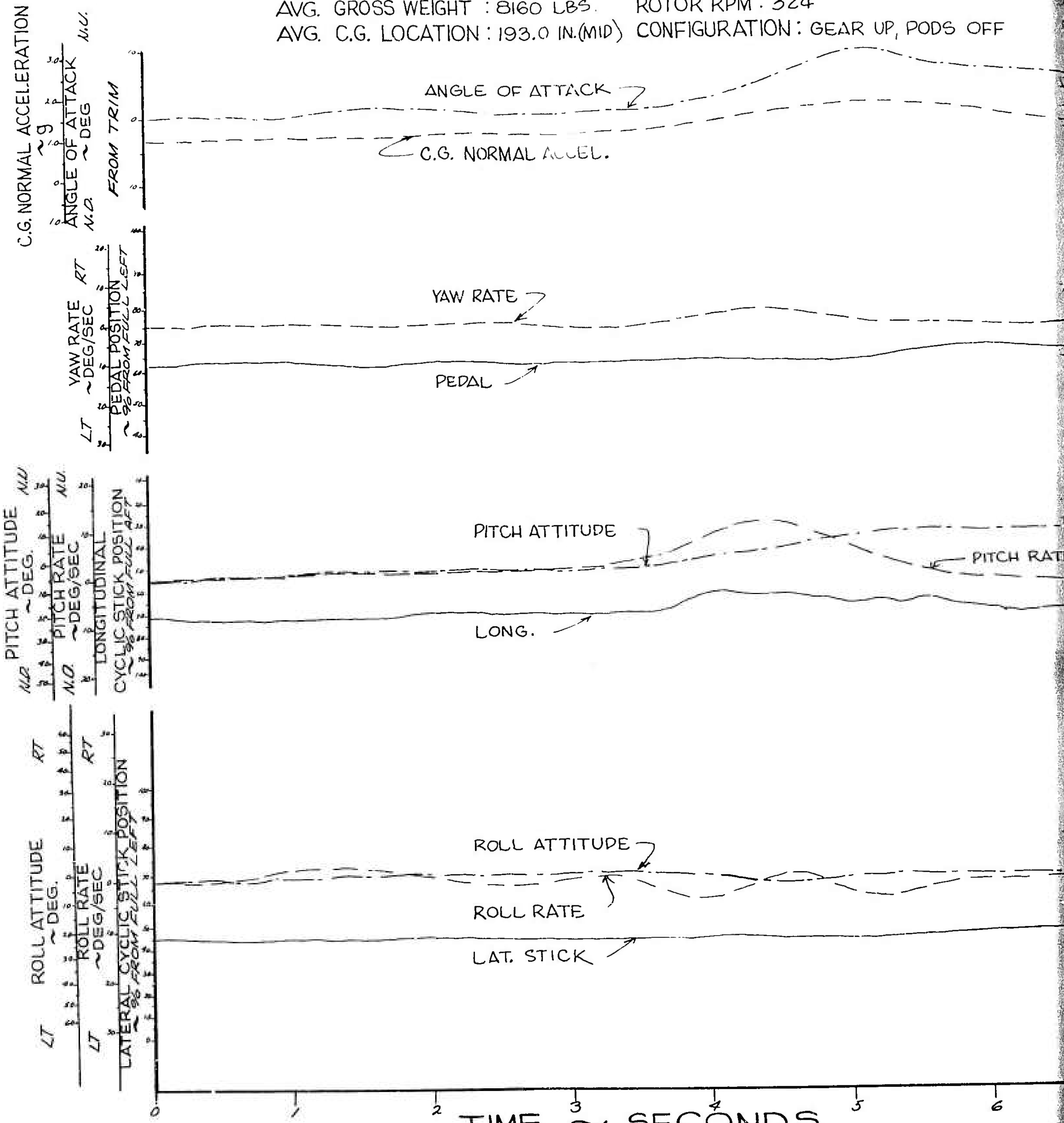
FIGURE NO. 45

SYMMETRICAL PULLUP

HUEY COBRA · N209J

AVG. DENSITY ALTITUDE: 4520 FT. AIRSPEED: 178.0 KCAS
AVG. GROSS WEIGHT: 8160 LBS. ROTOR RPM: 324
AVG. C.G. LOCATION: 193.0 IN.(MID) CONFIGURATION: GEAR UP, PODS OFF



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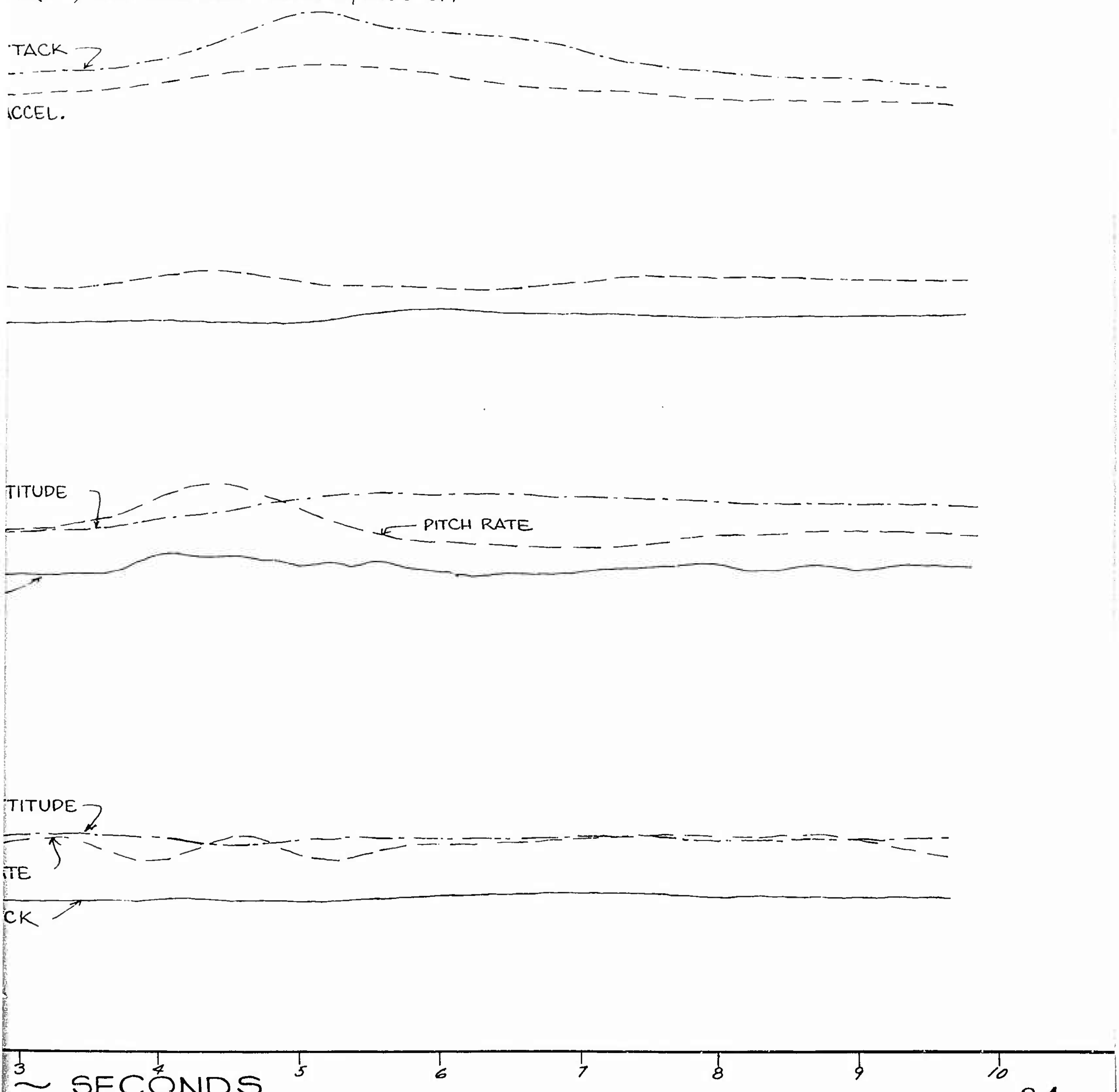
AL USE ONLY
E NO. 45
AL PULLUP
RA · N209J
520 FT. AIRSPEED: 178.0 KCAS
LBS. ROTOR RPM: 324
IN.(MID) CONFIGURATION: GEAR UP, PODS OFF



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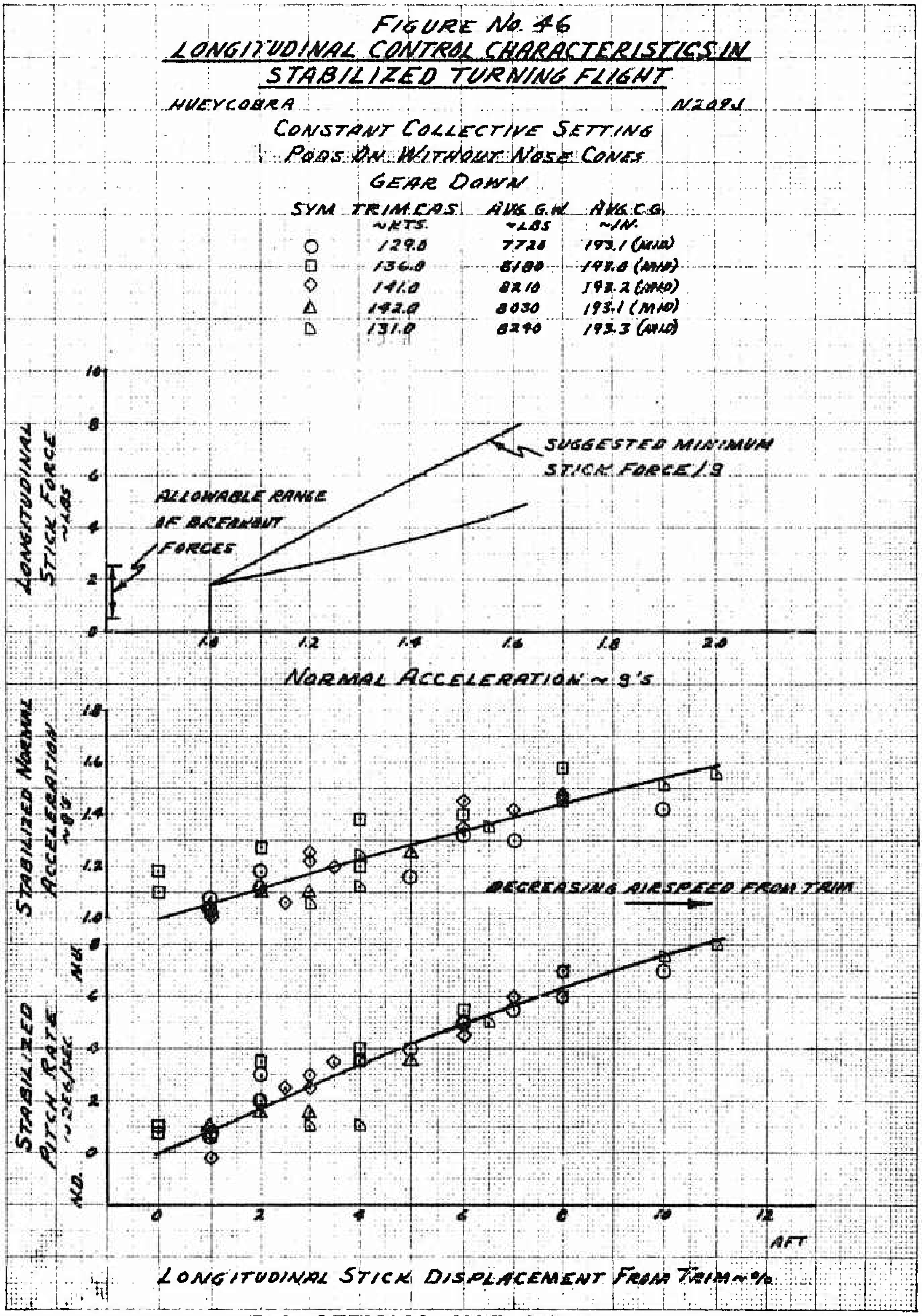


FIGURE No. 46
LONGITUDINAL CONTROL CHARACTERISTICS IN STABILIZED TURNING FLIGHT
HUEYCOBRA
N209J
CONSTANT COLLECTIVE SETTING
PODS ON WITHOUT NOSE CONES
GEAR DOWN
SYM TRIM CAS ~KTS AVG G.W. ~LBS AVG C.G. ~IN.
129.0 7720 193.1 (MID)
136.0 8180 193.0 (MID)
141.0 8210 193.2 (MID)
142.0 8030 193.1 (MID)
131.0 8290 193.3 (MID)
LONGITUDINAL STICK FORCE ~LBS
SUGGESTED MINIMUM STICK FORCE/g
ALLOWABLE RANGE OF BREAKOUT FORCES
NORMAL ACCELERATION ~ g's
STABILIZED NORMAL ACCELERATION ~g's
DECREASING AIRSPEED FROM TRIM
STABILIZED PITCH RATE ~DEG/SEC
N.U.
N.D.
AFT
LONGITUDINAL STICK DISPLACEMENT FROM TRIM ~%

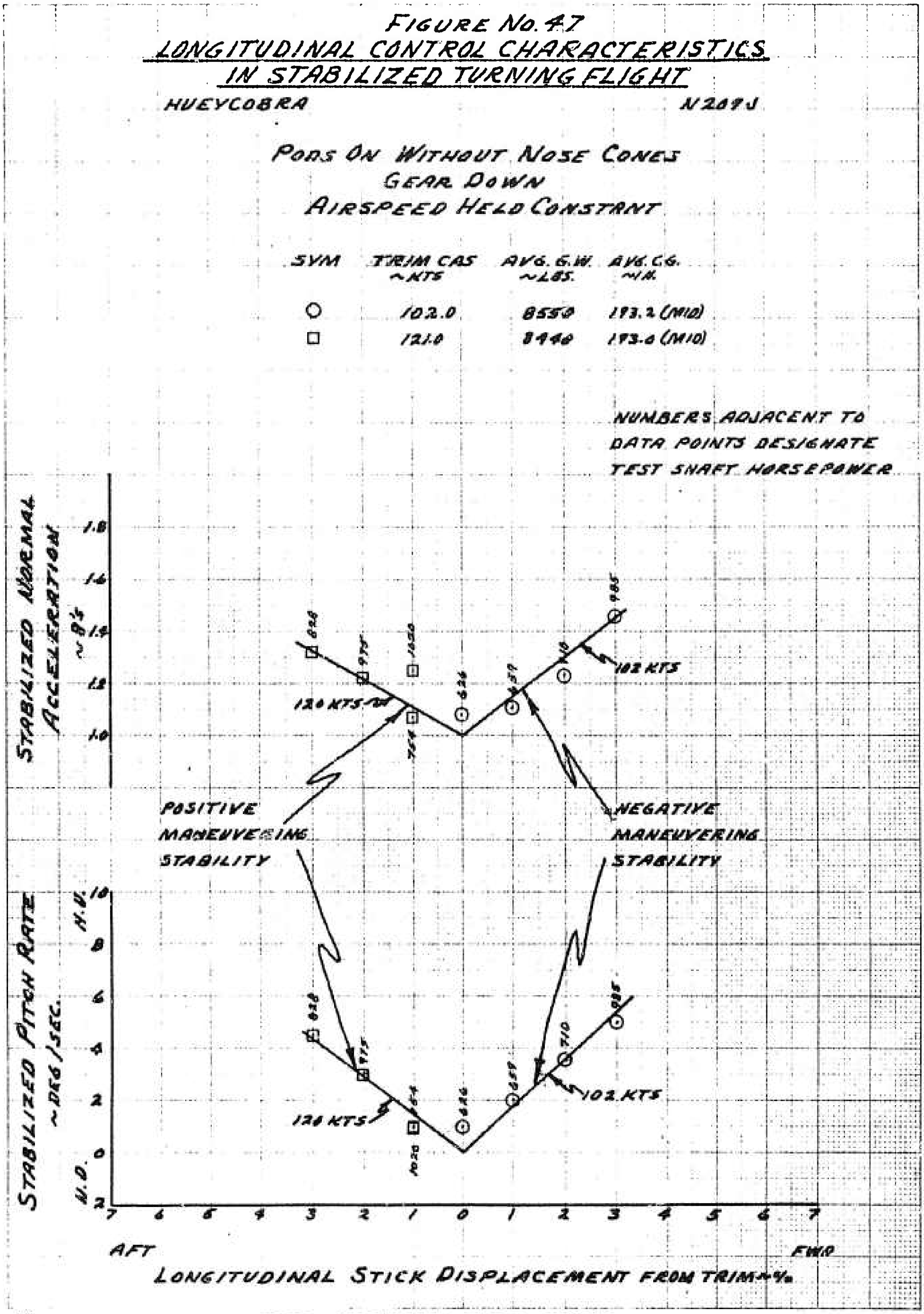
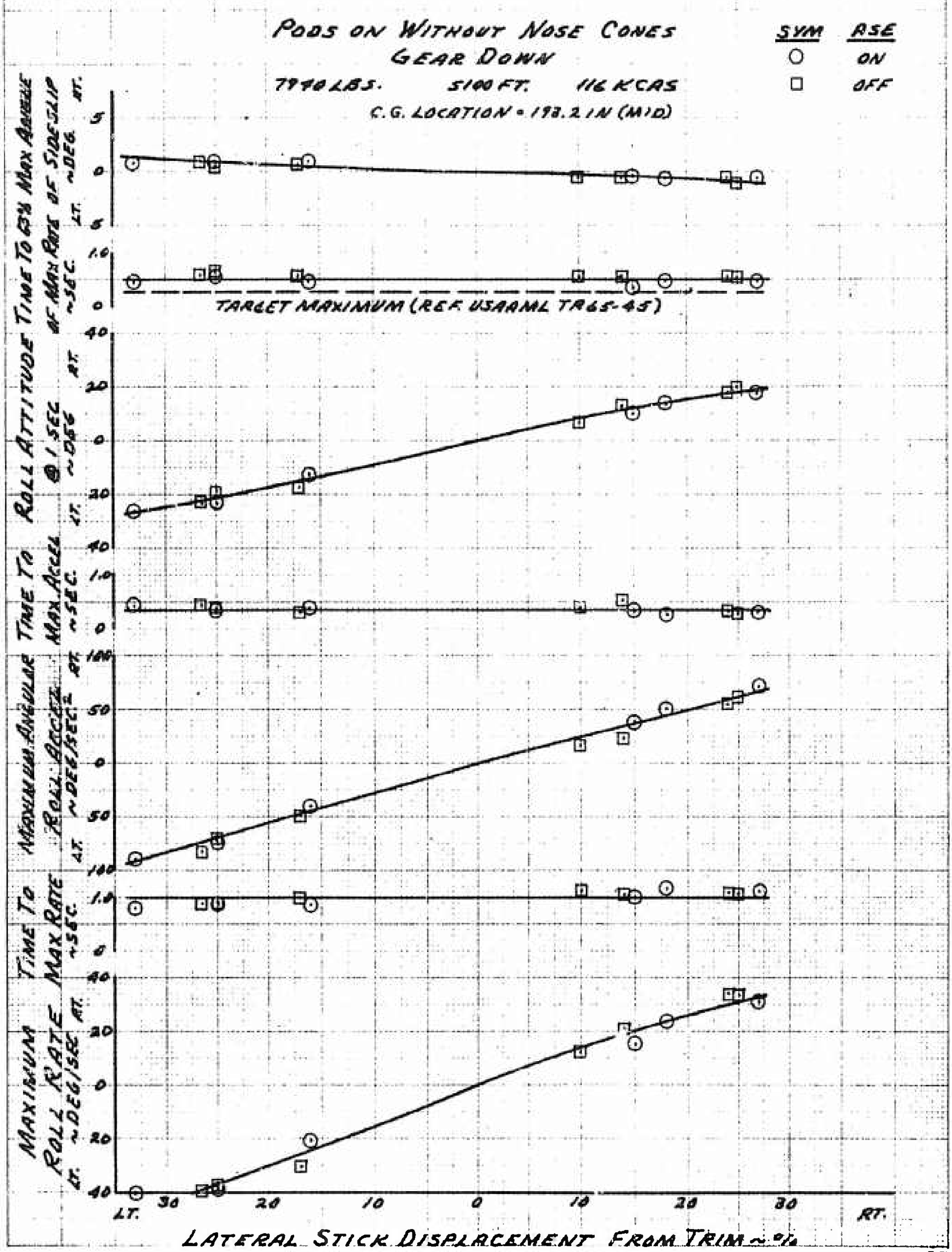


FIGURE NO. 47
LONGITUDINAL CONTROL CHARACTERISTICS
IN STABILIZED TURNING FLIGHT
HUEYCOBRA
N209J
PODS ON WITHOUT NOSE CONES
GEAR DOWN
AIRSPEED HELD CONSTANT
SYM
TRIM CAS ~KTS
AVG. G.W. ~LBS.
AVG. C.G. ~IN.
102.0
8550
193.2 (MID)
121.0
8440
193.0 (MID)
NUMBERS ADJACENT TO DATA POINTS DESIGNATE TEST SHAFT HORSEPOWER
STABILIZED NORMAL ACCELERATION ~g's
120 KTS
102 KTS
POSITIVE MANEUVERING STABILITY
NEGATIVE MANEUVERING STABILITY
STABILIZED PITCH RATE ~DEG/SEC.
N.U.
N.D.
AFT
FWD
LONGITUDINAL STICK DISPLACEMENT FROM TRIM ~%

FIGURE No. 48
LATERAL CONTROLLABILITY
HUEYCOBRA N209J



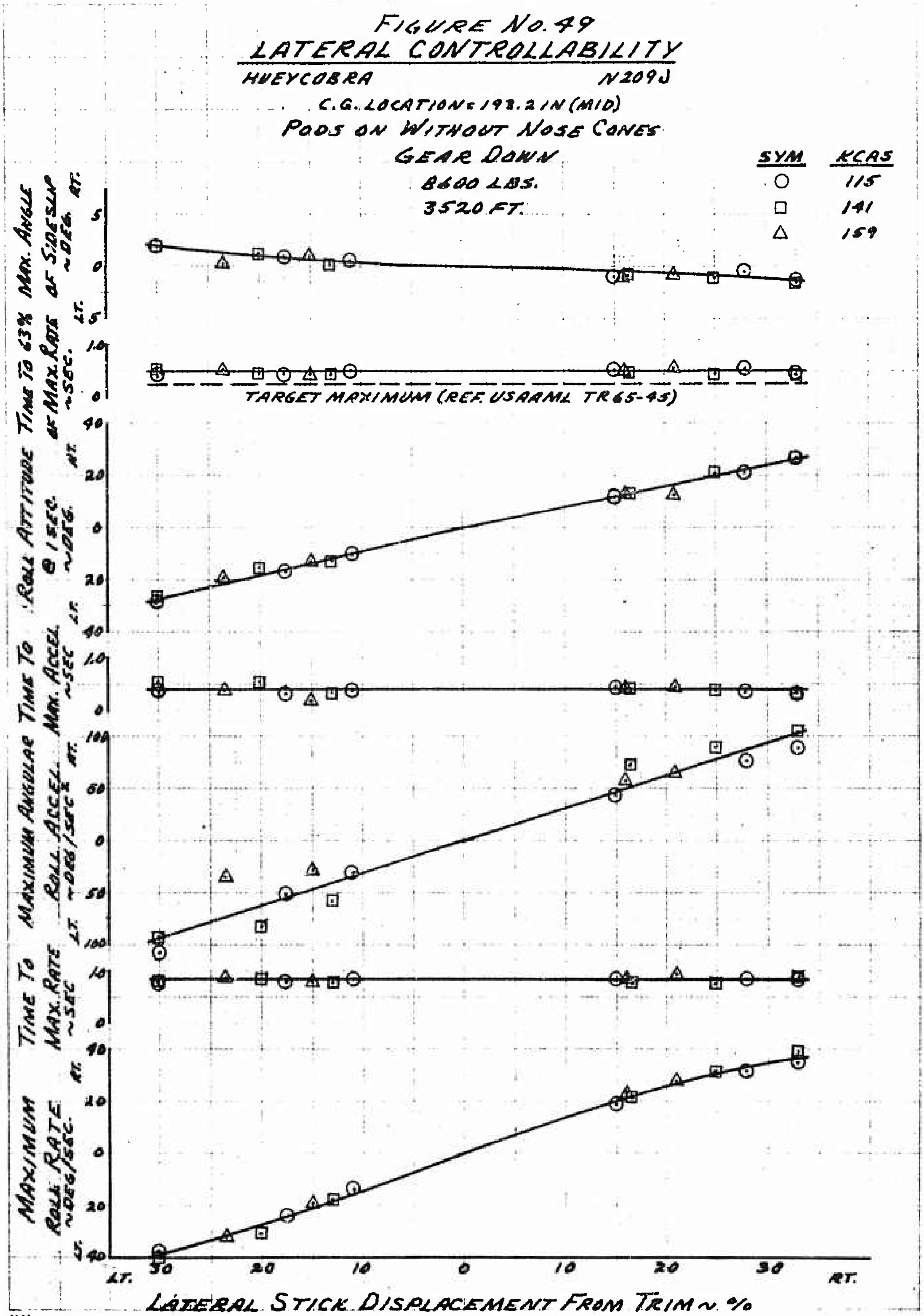


FIGURE NO. 49
LATERAL CONTROLLABILITY
HUEYCOBRA
N209J
C.G. LOCATION = 193.2 IN (MID)
PODS ON WITHOUT NOSE CONES
GEAR DOWN
8600 LBS.
3520 FT.
SYM
KCAS
115
141
159
MAX. ANGLE OF SIDESLIP ~DEG.
TIME TO 63% OF MAX. RATE ~SEC.
TARGET MAXIMUM (REF. USAAML TR65-45)
ROLL ATTITUDE @ 1 SEC. ~DEG.
TIME TO MAX. ACCEL ~SEC
MAXIMUM ANGULAR ROLL ACCEL. ~DEG/SEC²
TIME TO MAX. RATE ~SEC
MAXIMUM ROLL RATE ~DEG/SEC.
LT.
RT.
LATERAL STICK DISPLACEMENT FROM TRIM ~ %

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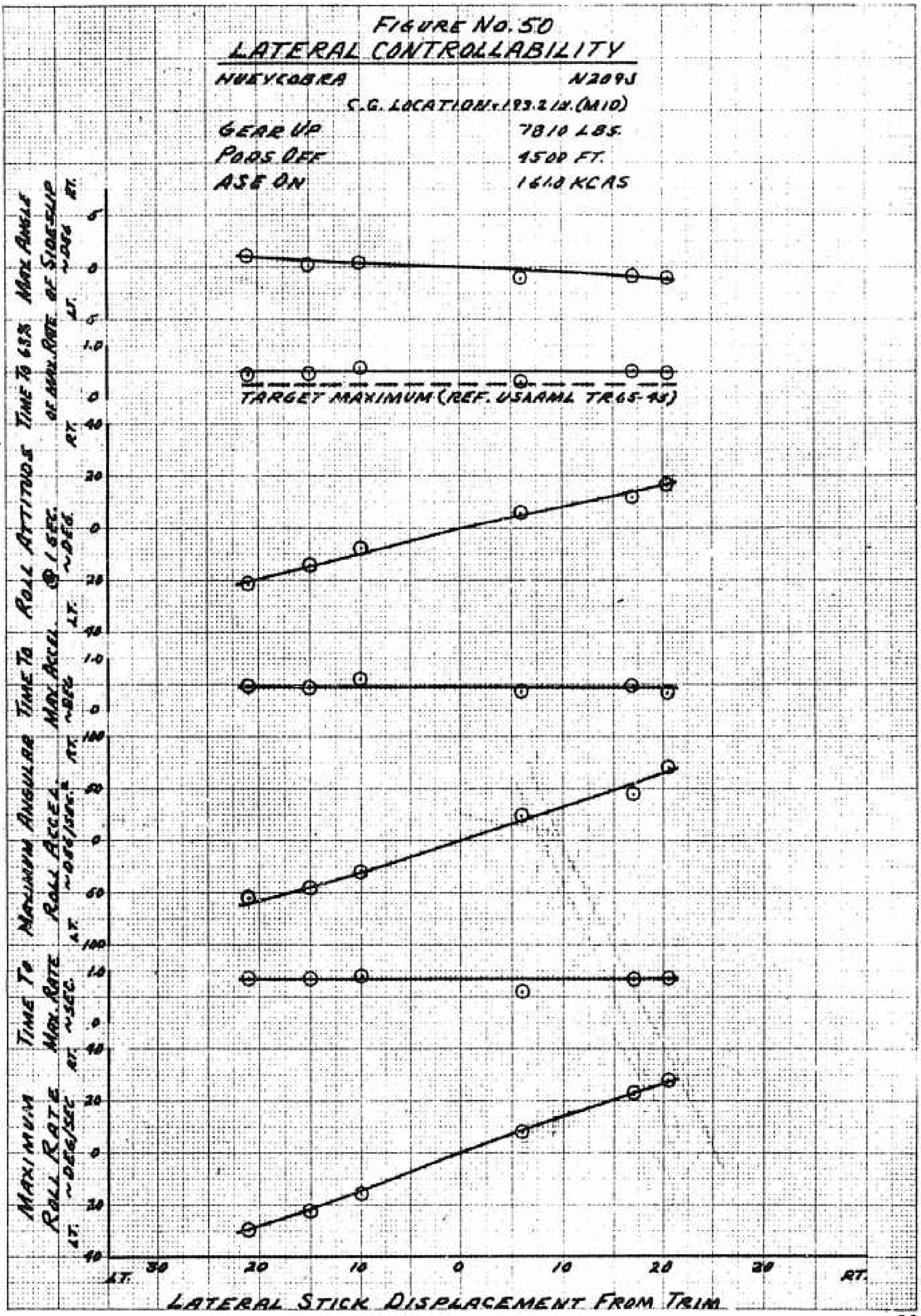

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FIGURE NO. 51

LATERAL STEP

HUEYCOBRA - N209J

AVG. DENSITY ALTITUDE: 6960 FT. AIRSPEED: 112. KCAS
AVG. GROSS WEIGHT : 7900 LBS ROTOR RPM: 324
AVG. C.G. LOCATION: 193.0 IN.(MID) CONFIGURATION: PODS ON WITHOUT NOSE CONES GEAR DOWN
ASE: ON

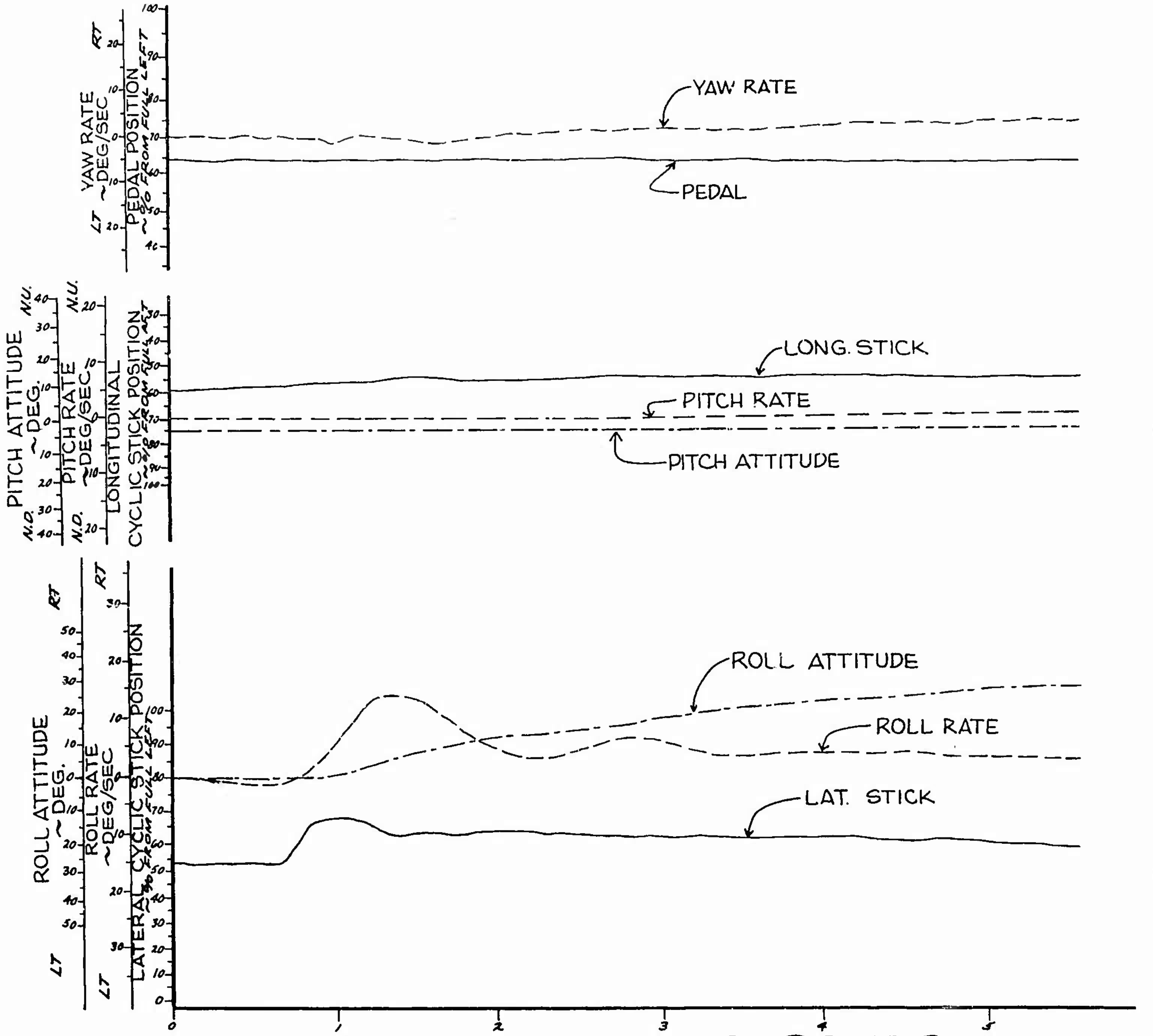

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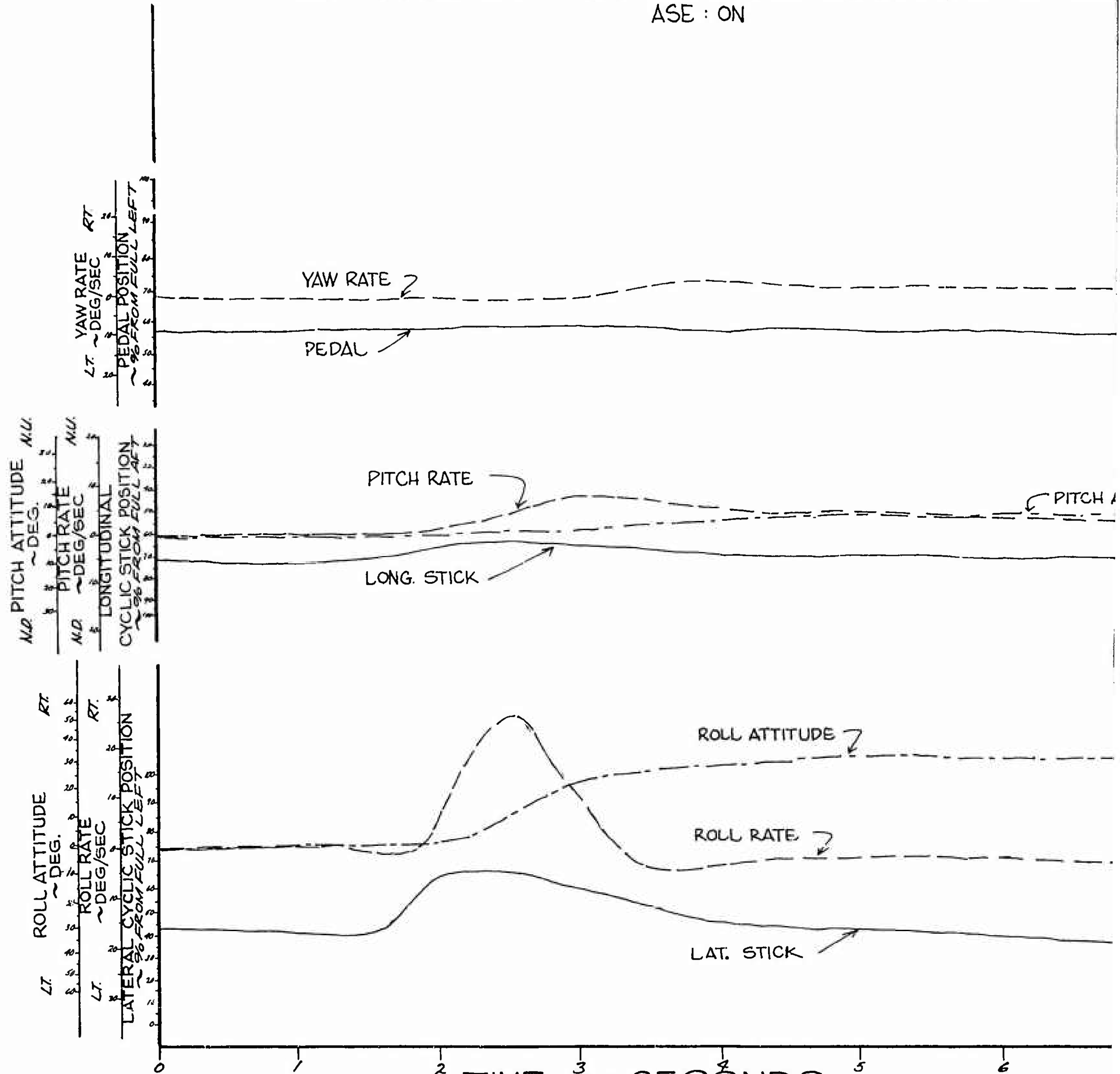
FIGURE NO. 52

LATERAL STEP

HUEY COBRA N 209J

AVG. DENSITY ALTITUDE: 3390 FT. AIRSPEED: 159 KCAS
AVG. GROSS WEIGHT : 8450 LB. ROTOR RPM: 324
AVG. C.G. LOCATION: 193.0 IN (MID) CONFIGURATION: GEAR DOWN, PODS ON WITHOU
ASE : ON



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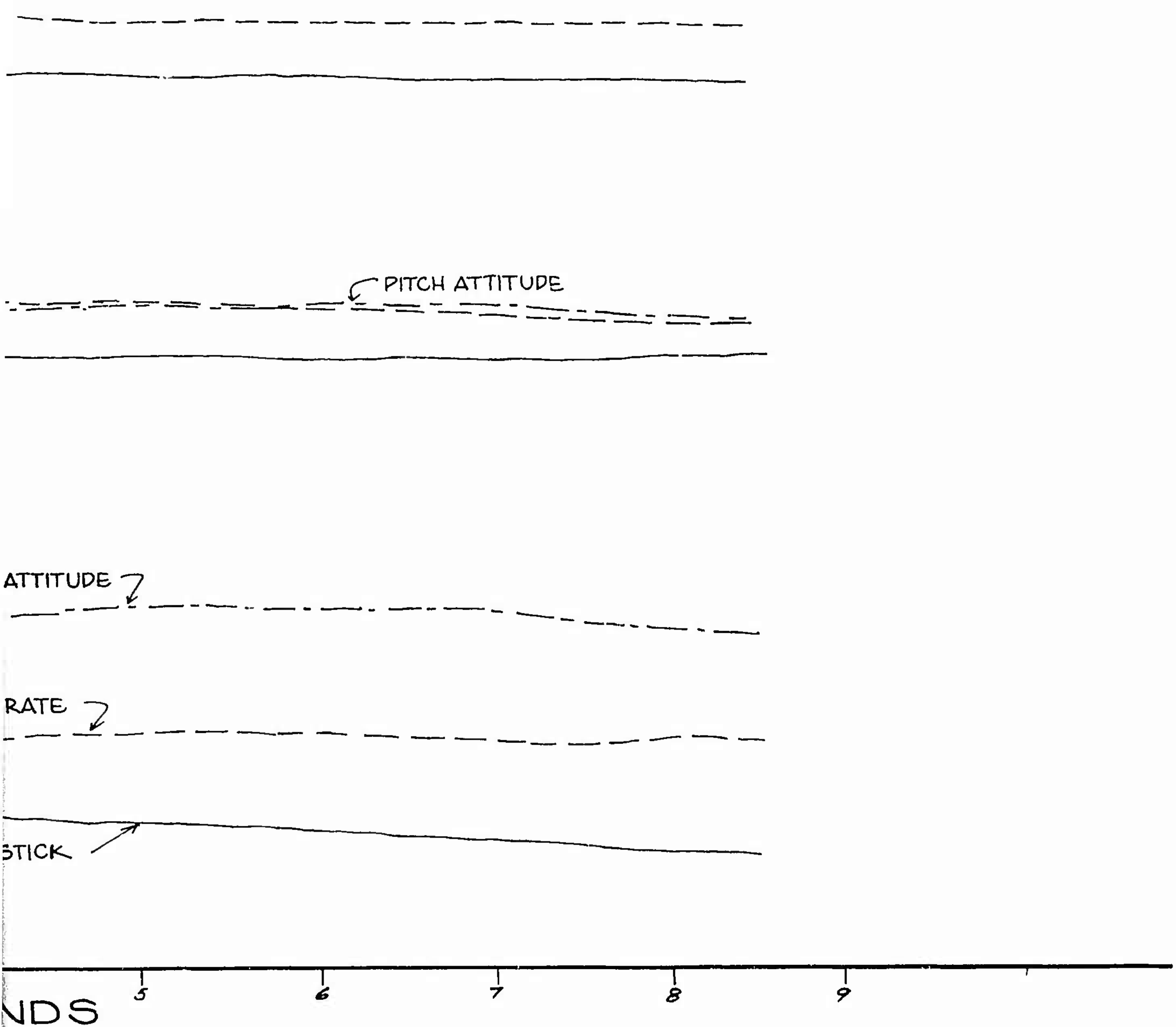
159 KCAS
M : 324
ATION : GEAR DOWN, PODS ON WITHOUT NOSE CONES



2

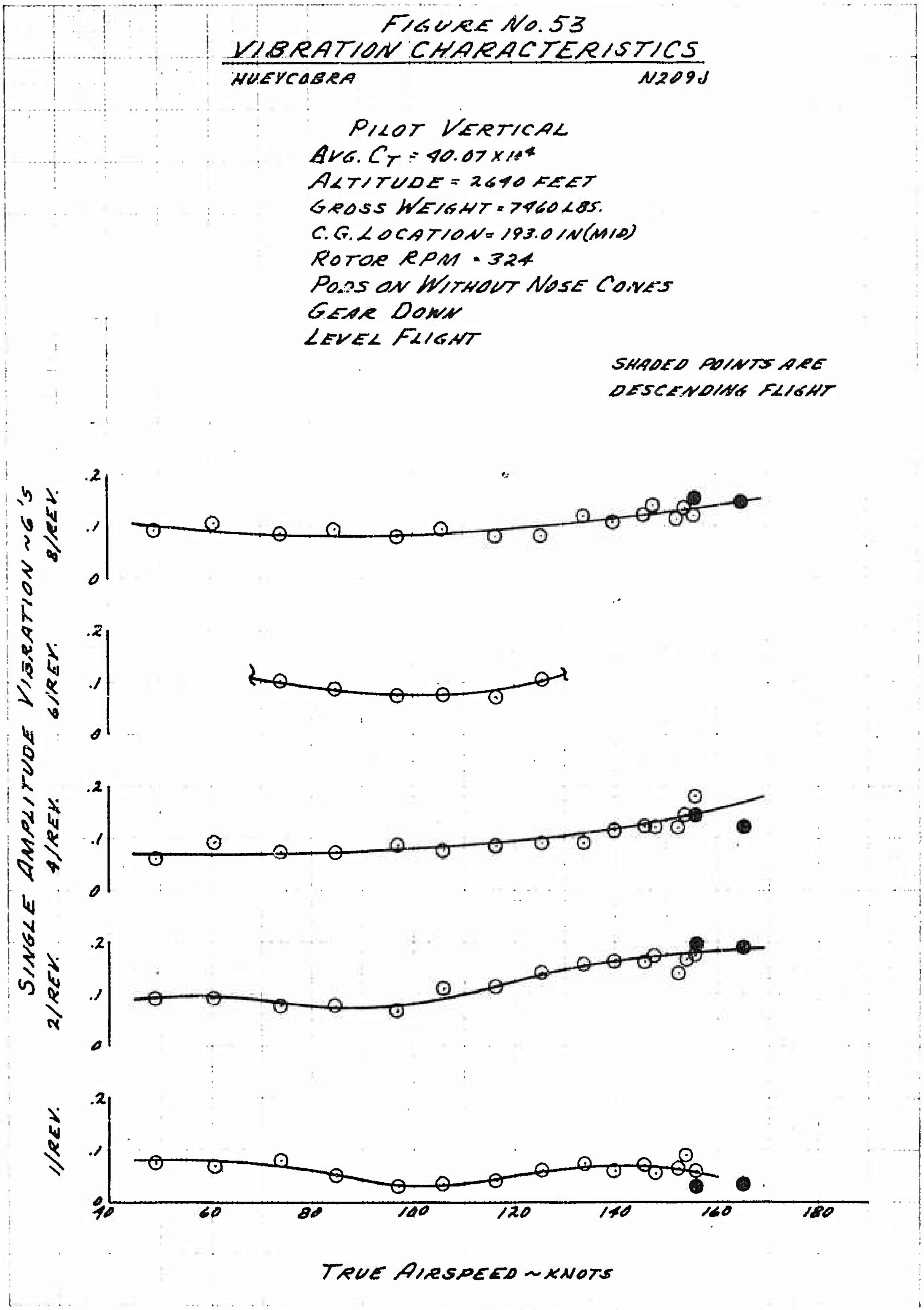


FIGURE NO. 53
VIBRATION CHARACTERISTICS
HUEYCOBRA
N209J
PILOT VERTICAL
AVG. C_T = 40.07 X 10^{-4}
ALTITUDE = 2690 FEET
GROSS WEIGHT = 7960 LBS.
C.G. LOCATION = 193.0 IN (MID)
ROTOR RPM = 324
PODS ON WITHOUT NOSE CONES
GEAR DOWN
LEVEL FLIGHT
SHADED POINTS ARE DESCENDING FLIGHT
SINGLE AMPLITUDE VIBRATION ~ G'S
8/REV.
6/REV.
4/REV.
2/REV.
1/REV.
.2
.1
0
40
60
80
100
120
140
160
180
TRUE AIRSPEED ~ KNOTS

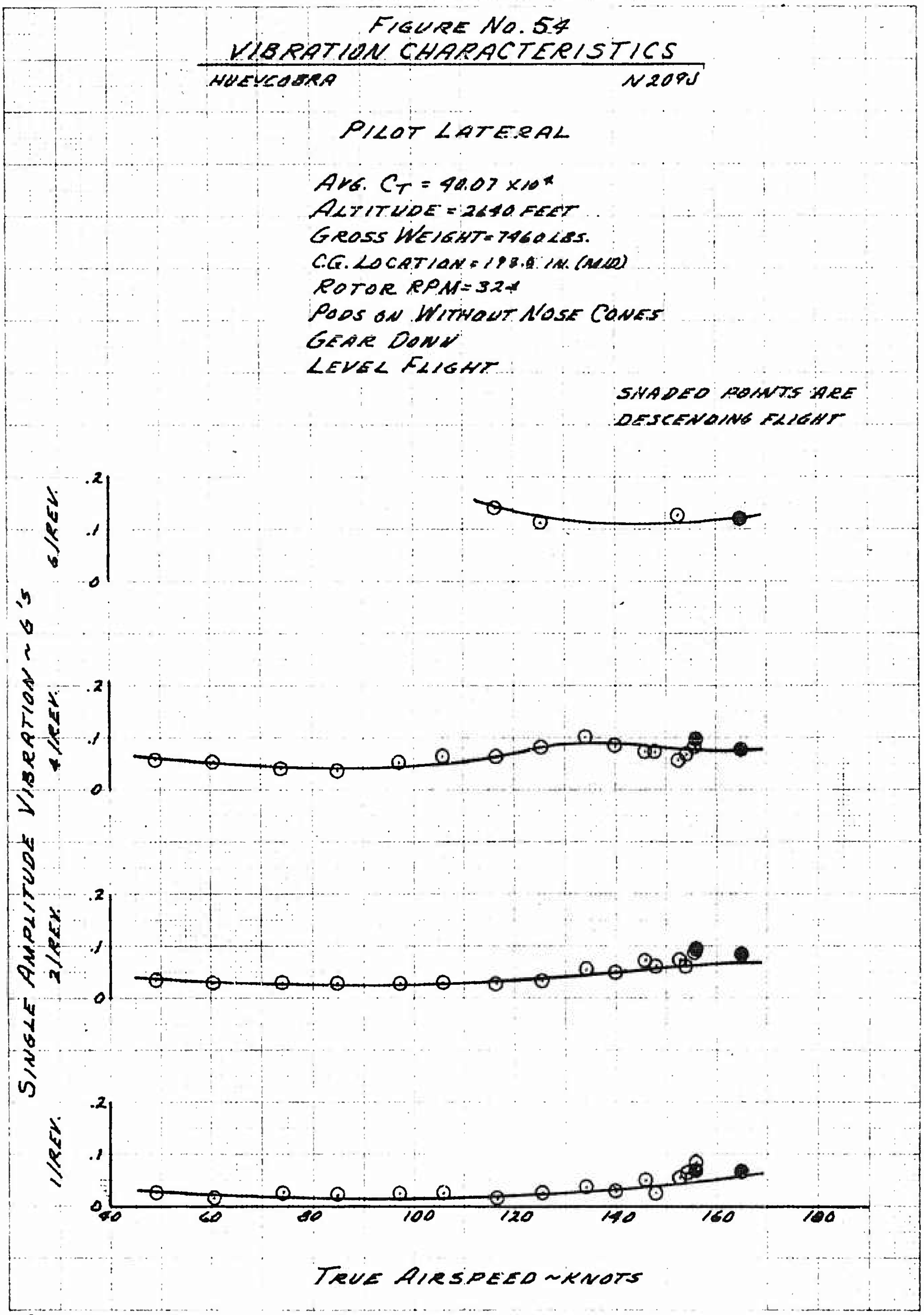


FIGURE NO. 54
VIBRATION CHARACTERISTICS
HUEYCOBRA
N209J
PILOT LATERAL
AVG. C_T = 90.07 x10^4
ALTITUDE = 2640 FEET
GROSS WEIGHT = 7460 LBS.
C.G. LOCATION = 198.6 IN. (MID)
ROTOR RPM = 324
PODS ON WITHOUT NOSE CONES
GEAR DOWN
LEVEL FLIGHT
SHADED POINTS ARE
DESCENDING FLIGHT
SINGLE AMPLITUDE VIBRATION ~ G'S
6/REV.
4/REV.
2/REV.
1/REV.
.2
.1
0
40
60
80
100
120
140
160
180
TRUE AIRSPEED ~ KNOTS

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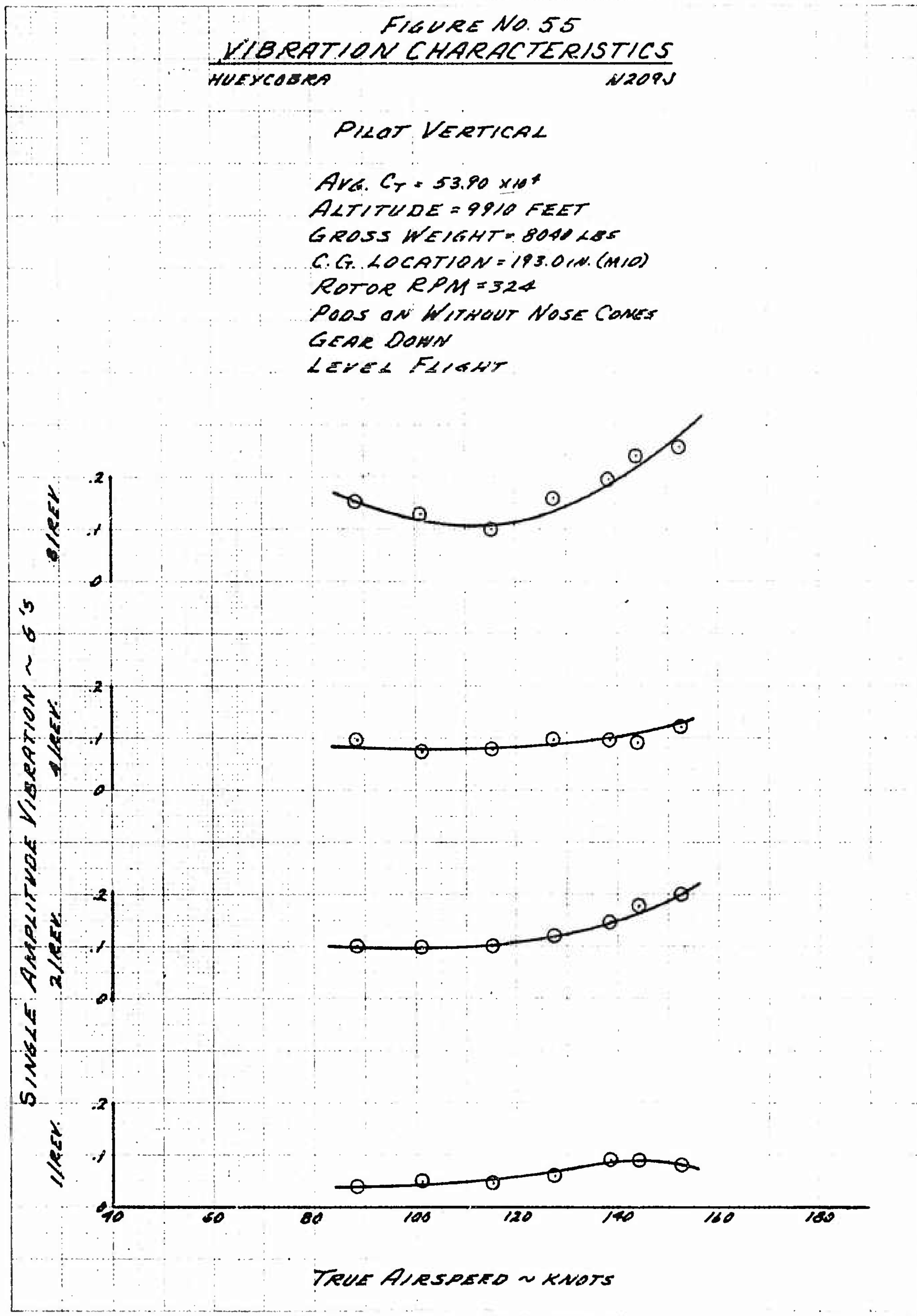

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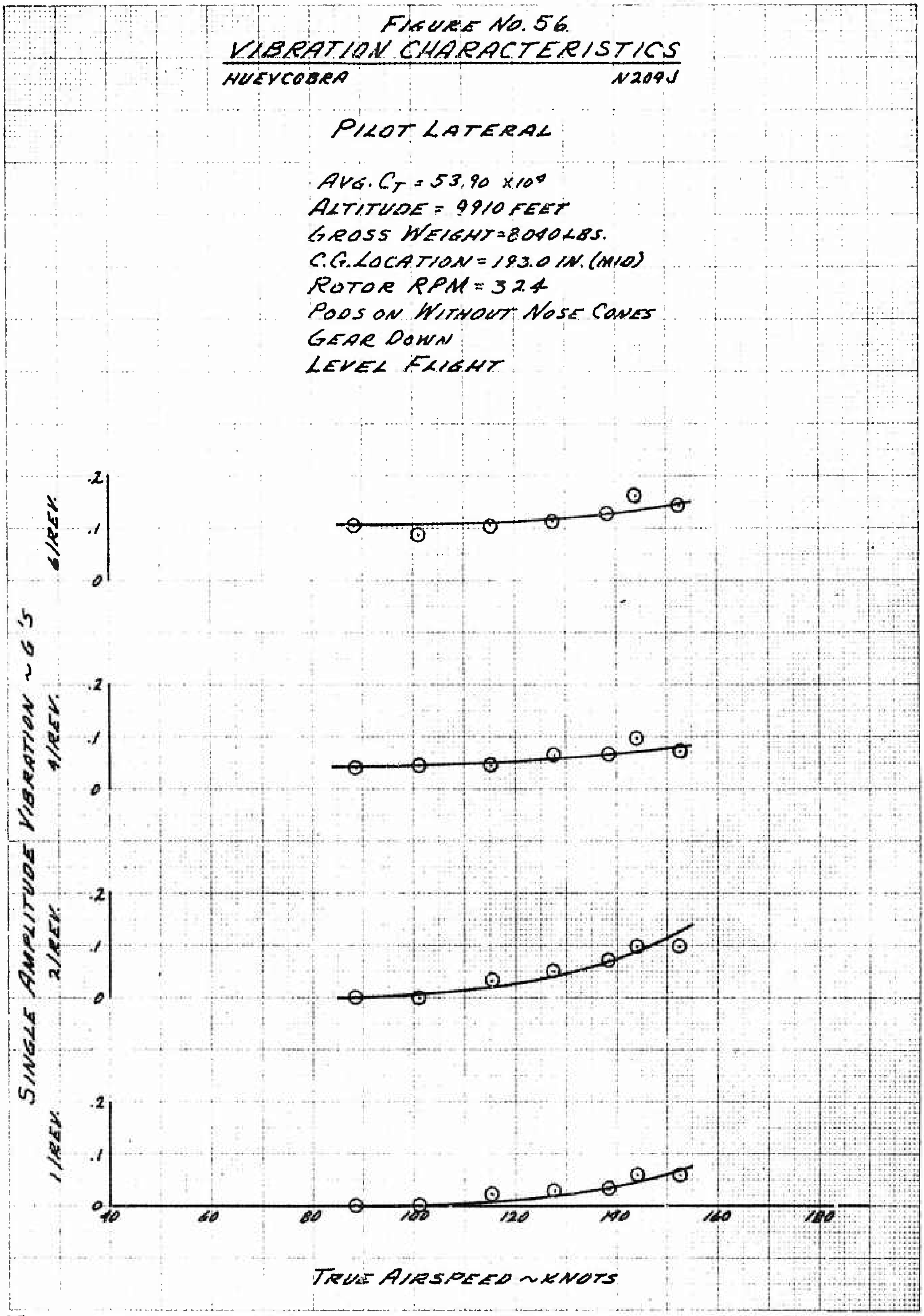


FIGURE NO. 56
VIBRATION CHARACTERISTICS
HUEYCOBRA
N209J
PILOT LATERAL
AVG. C_T = 53.90 x10⁴
ALTITUDE = 9910 FEET
GROSS WEIGHT = 8040 LBS.
C.G. LOCATION = 193.0 IN. (MID)
ROTOR RPM = 324
PODS ON WITHOUT NOSE CONES
GEAR DOWN
LEVEL FLIGHT
SINGLE AMPLITUDE VIBRATION ~ G'S
6/REV.
4/REV.
2/REV.
1/REV.
.2
.1
0
40
60
80
100
120
140
160
180
TRUE AIRSPEED ~ KNOTS

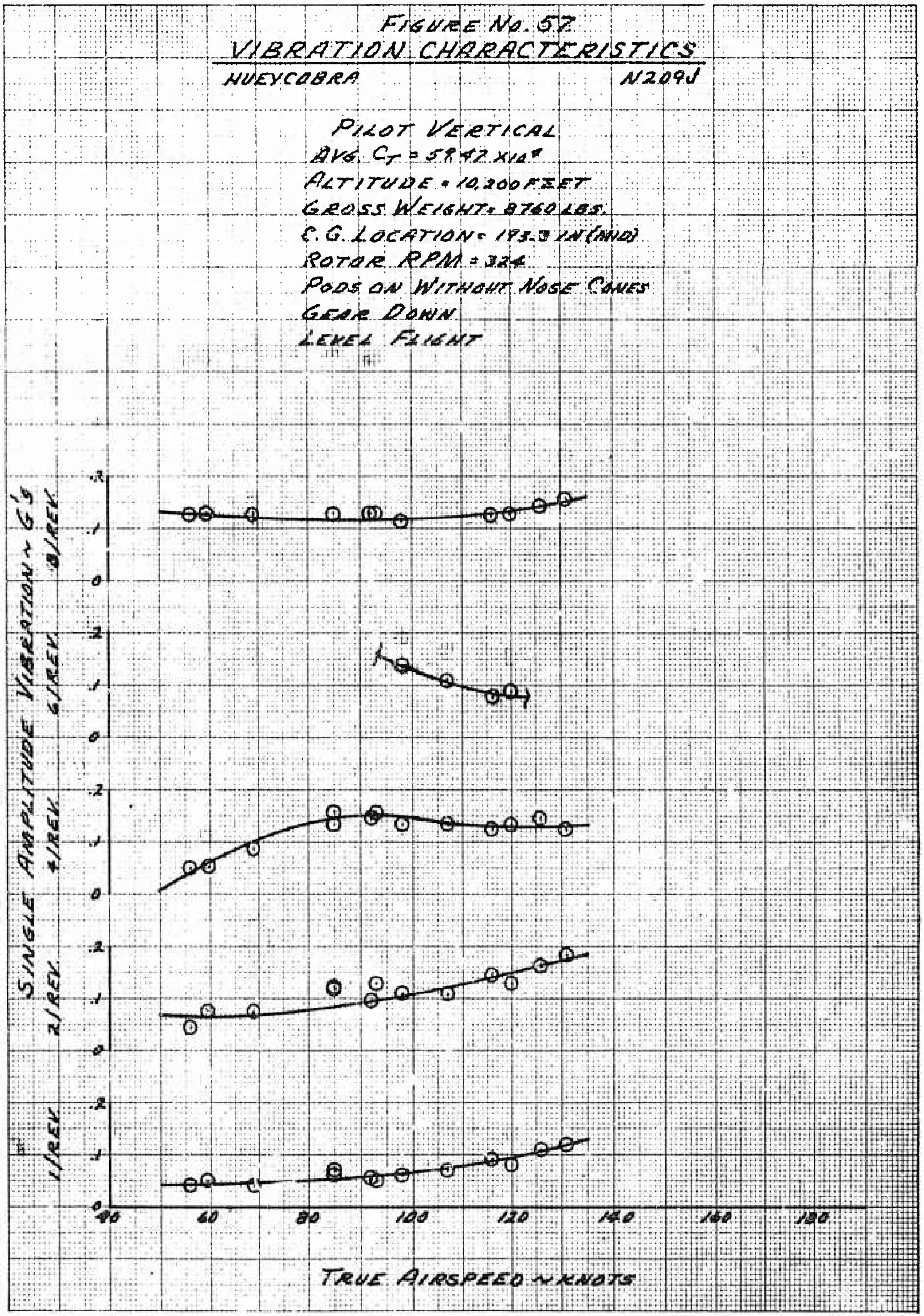


FIGURE NO. 57
VIBRATION CHARACTERISTICS
HUEYCOBRA
N209J
PILOT VERTICAL
AVG. C_T = 59.42 x10⁻⁵
ALTITUDE = 10,200 FEET
GROSS WEIGHT = 8760 LBS.
C.G. LOCATION = 193.3 IN (MID)
ROTOR RPM = 324
PODS ON WITHOUT NOSE CONES
GEAR DOWN
LEVEL FLIGHT
SINGLE AMPLITUDE VIBRATION ~ G's
8/REV.
6/REV.
4/REV.
2/REV.
1/REV.
TRUE AIRSPEED ~ KNOTS
40
60
80
100
120
140
160
180

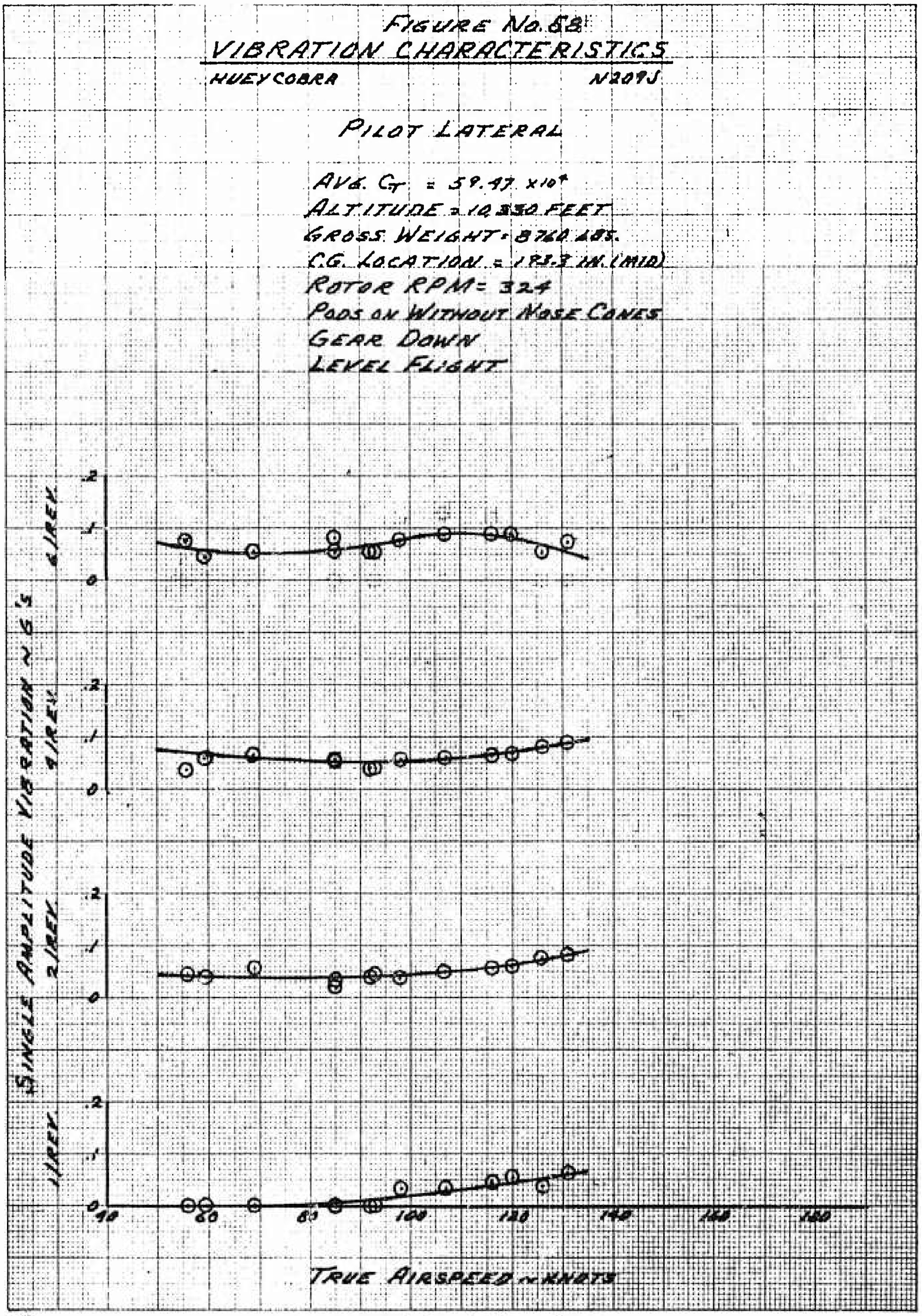


FIGURE No. 68
VIBRATION CHARACTERISTICS
HUEYCOBRA
N209J
PILOT LATERAL
AVG. C_T = 59.47 x10⁴
ALTITUDE = 10,330 FEET
GROSS WEIGHT = 8760 LBS.
C.G. LOCATION = 193.3 IN. (MID)
ROTOR RPM = 324
PODS ON WITHOUT NOSE CONES
GEAR DOWN
LEVEL FLIGHT
SINGLE AMPLITUDE VIBRATION ~ G'S
6/REV.
4/REV.
2/REV.
1/REV.
.2
.1
0
40
60
80
100
120
140
160
180
TRUE AIRSPEED ~ KNOTS

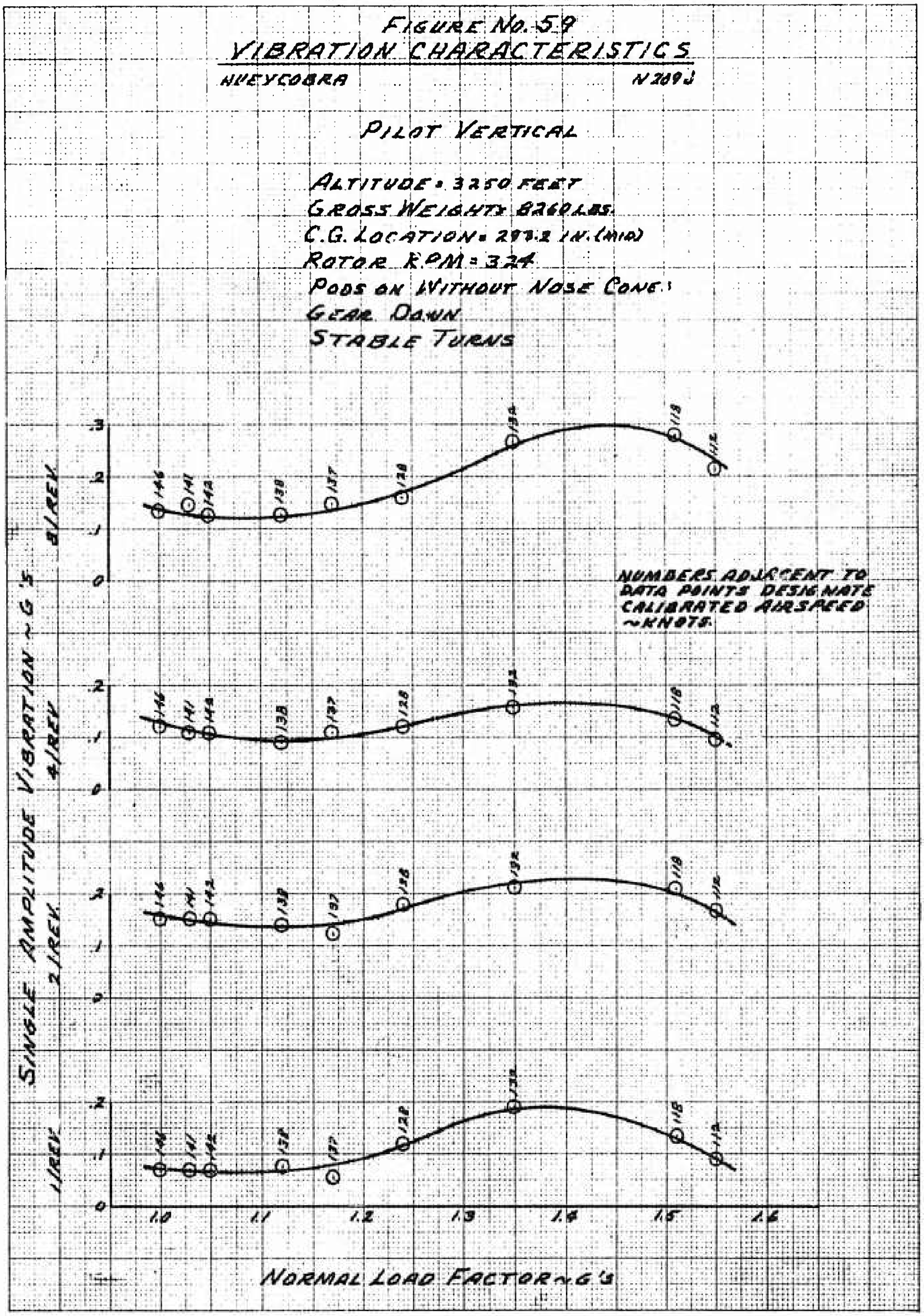


FIGURE No. 59
VIBRATION CHARACTERISTICS
HUEYCOBRA
N209J
PILOT VERTICAL
ALTITUDE = 3250 FEET
GROSS WEIGHT = 8260 LBS.
C.G. LOCATION = 293.2 IN. (MID)
ROTOR RPM = 324
PODS ON WITHOUT NOSE CONE
GEAR DOWN
STABLE TURNS
NUMBERS ADJACENT TO DATA POINTS DESIGNATE CALIBRATED AIRSPEED ~KNOTS
SINGLE AMPLITUDE VIBRATION ~ G'S
8/REV
4/REV
2/REV
1/REV
NORMAL LOAD FACTOR ~ G'S
1.0
1.1
1.2
1.3
1.4
1.5
1.6

FIGURE NO. 60
VIBRATION CHARACTERISTICS

HUEYCOBRA N209J

PILOT LATERAL

ALTITUDE = 3250 FEET
GROSS WEIGHT = 8260
C.G. LOCATION = 293.2 IN (MID)
ROTOR RPM = 324
PODS ON WITHOUT NOSE CONES
GEAR DOWN
STABLE TURNS

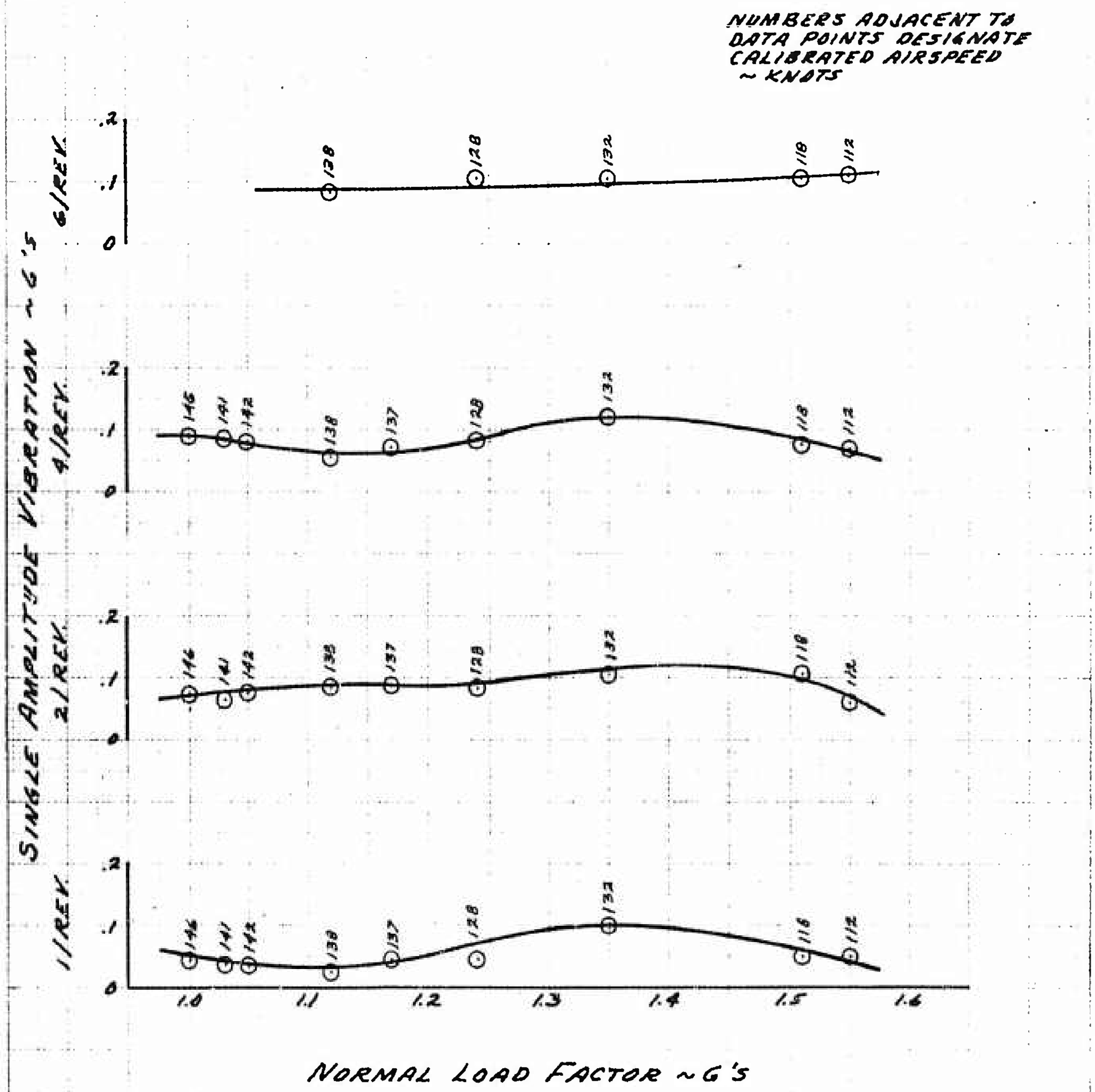


FIGURE NO. 61

VIBRATION CHARACTERISTICS IN HIGH SPEED DESCENDING FLIGHT

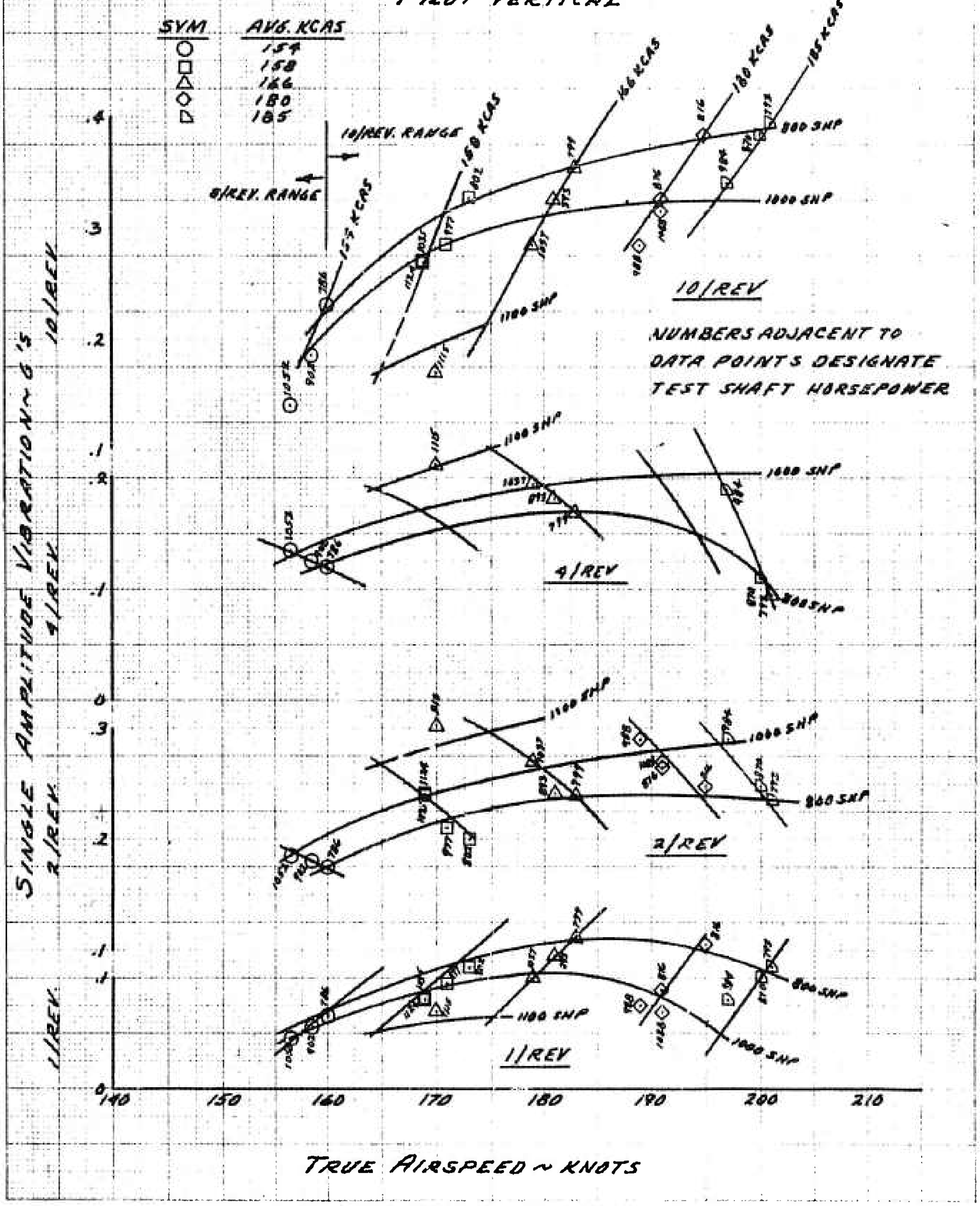
HUEYCOBRA N209J

No Rocket Pods

Landing Gear Retracted

8080 LBS

Pilot Vertical



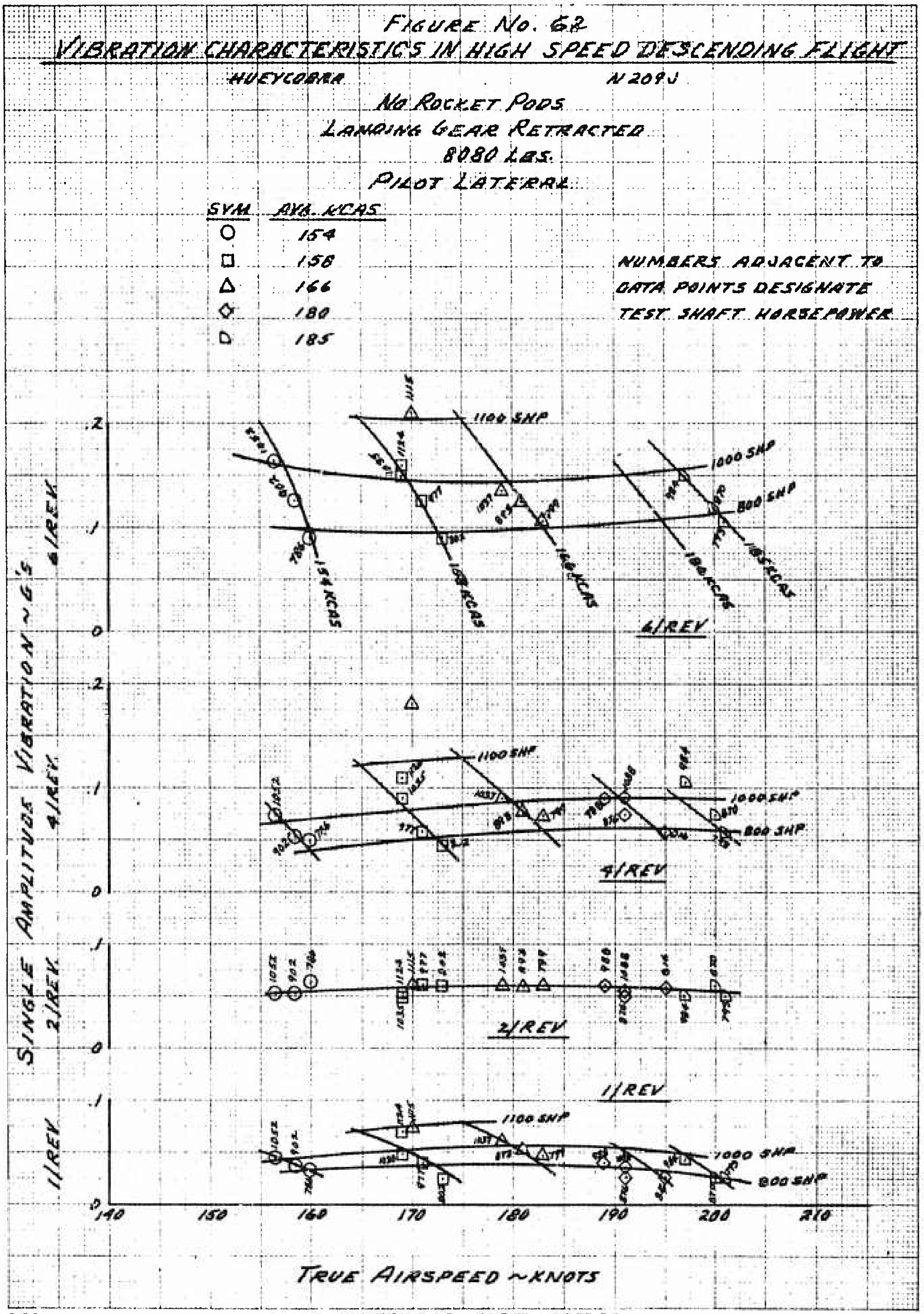


FIGURE NO. 62
VIBRATION CHARACTERISTICS IN HIGH SPEED DESCENDING FLIGHT
HUEYCOBRA
N 209J
NO ROCKET PODS
LANDING GEAR RETRACTED
8080 LBS.
PILOT LATERAL
SYM AVG. KCAS
154
158
166
180
185
NUMBERS ADJACENT TO DATA POINTS DESIGNATE TEST SHAFT HORSEPOWER
1100 SHP
1000 SHP
800 SHP
154 KCAS
158 KCAS
166 KCAS
180 KCAS
185 KCAS
6/REV
4/REV
2/REV
1/REV
SINGLE AMPLITUDE VIBRATION ~ G'S
140
150
160
170
180
190
200
210
TRUE AIRSPEED ~ KNOTS

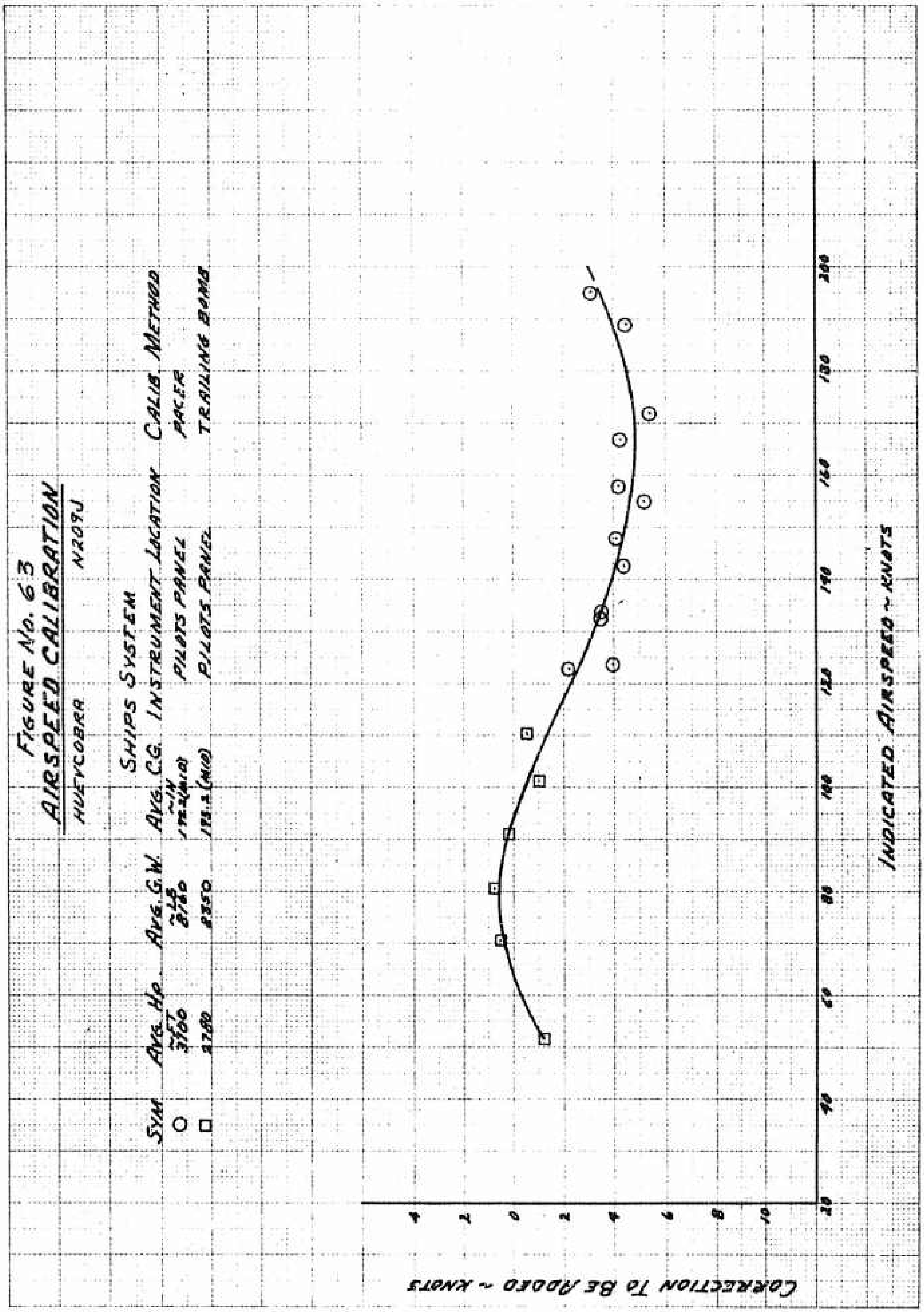


FIGURE NO. 63
AIRSPEED CALIBRATION
HUEYCOBRA
N209J
SHIPS SYSTEM
SYM
AVG. Hp ~FT
AVG. G.W. ~LB
AVG. C.G. ~IN
INSTRUMENT LOCATION
CALIB. METHOD
○ 3700 8180 172.2(MID) PILOTS PANEL PACER
□ 2780 8350 173.1(MID) PILOTS PANEL TRAILING BOMB
CORRECTION TO BE ADDED ~ KNOTS
INDICATED AIRSPEED ~ KNOTS

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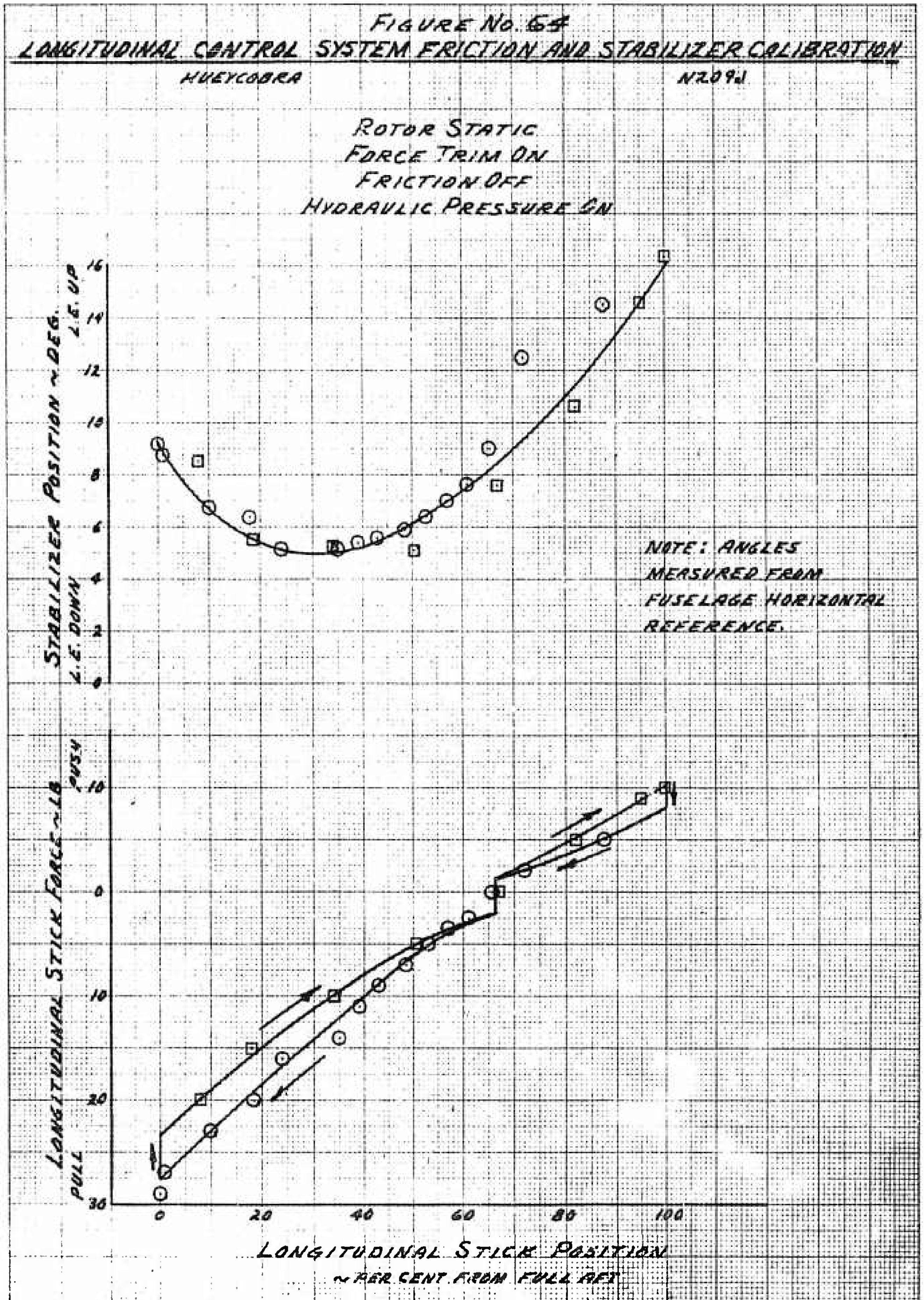

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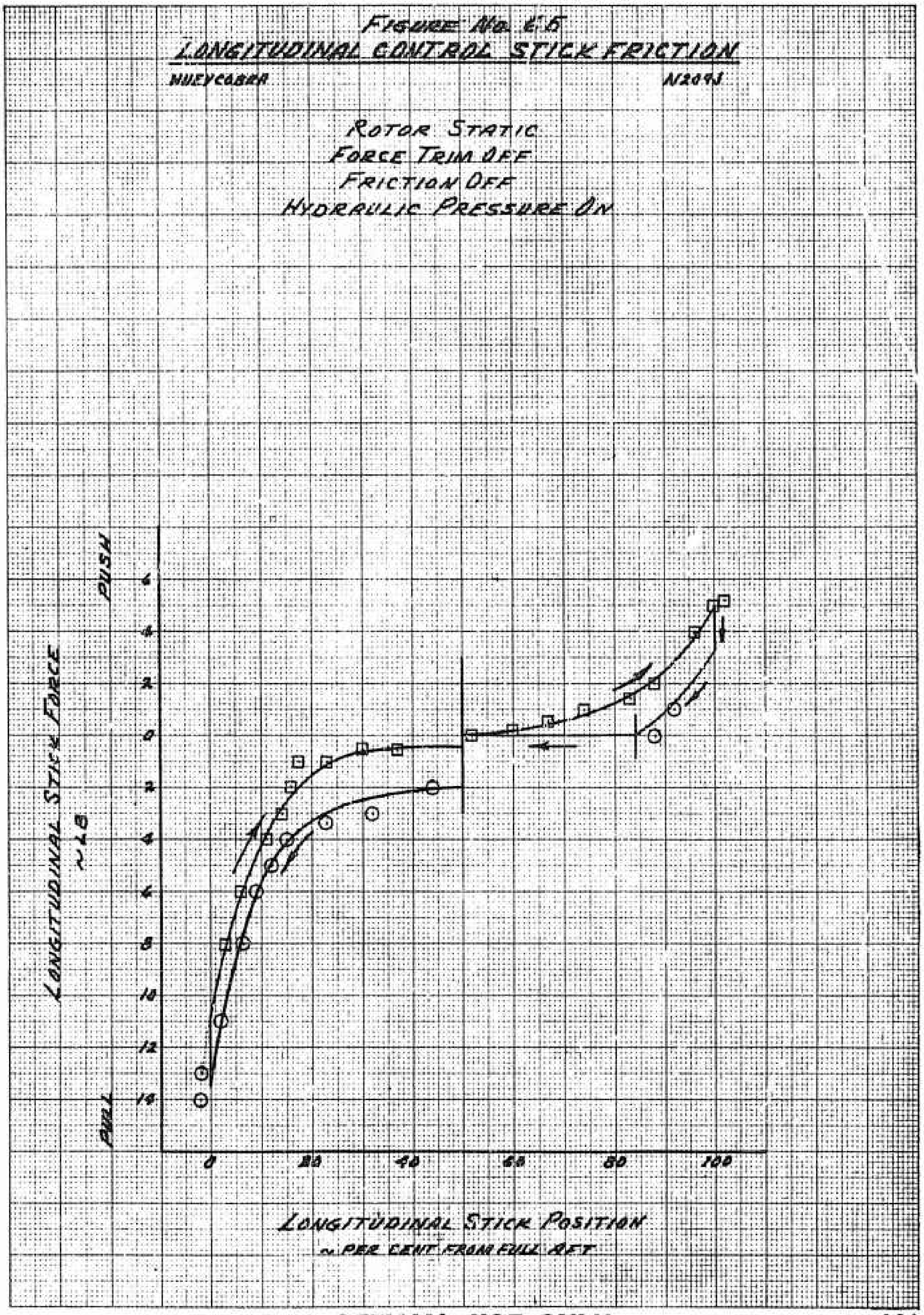


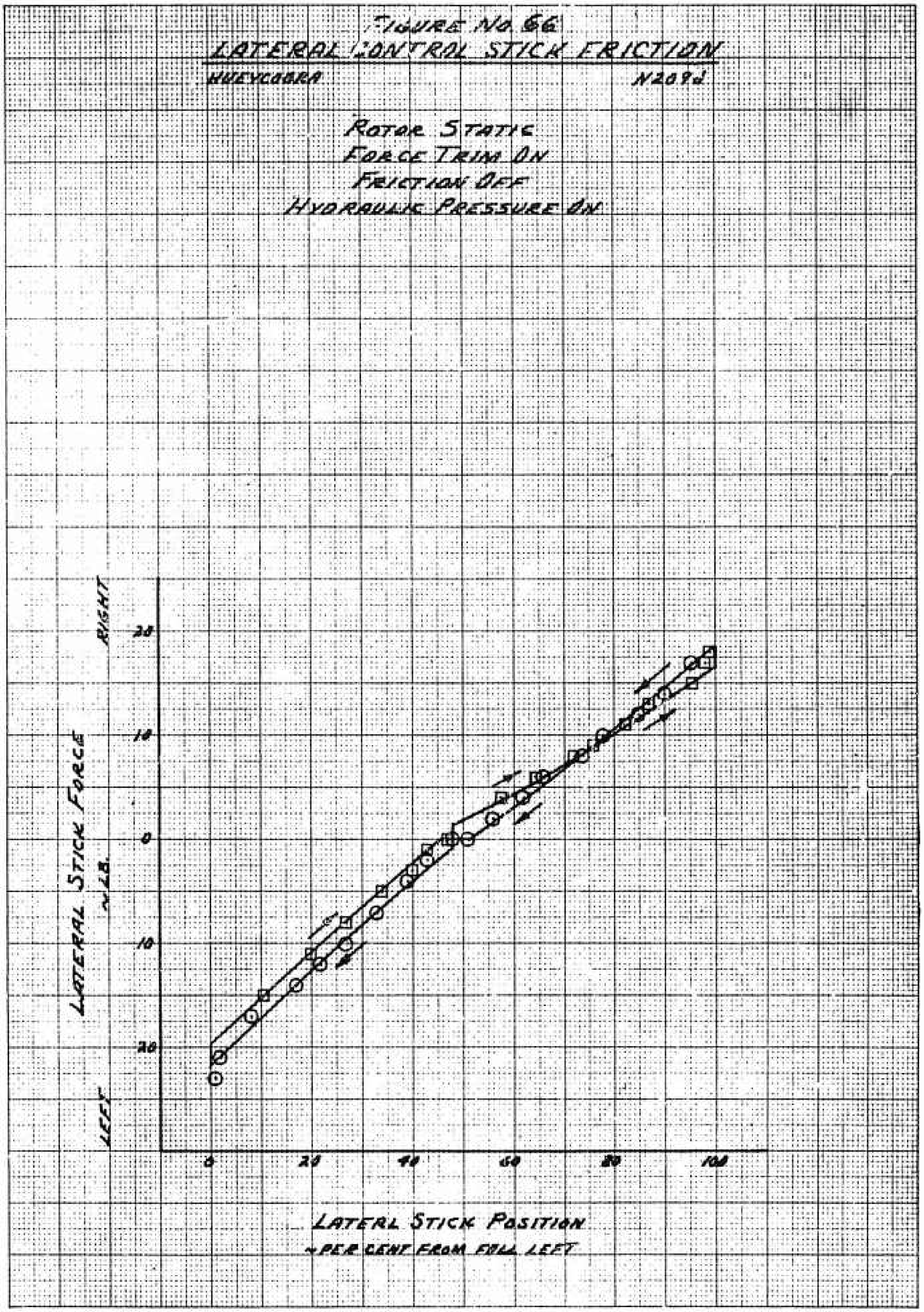


FIGURE NO. 66
LATERAL CONTROL STICK FRICTION
HUEYCOBRA
N209J
ROTOR STATIC
FORCE TRIM ON
FRICTION OFF
HYDRAULIC PRESSURE ON
LATERAL STICK FORCE
~ LB.
RIGHT
LEFT
20
10
0
10
20
0
20
40
60
80
100
LATERAL STICK POSITION
~ PER CENT FROM FULL LEFT

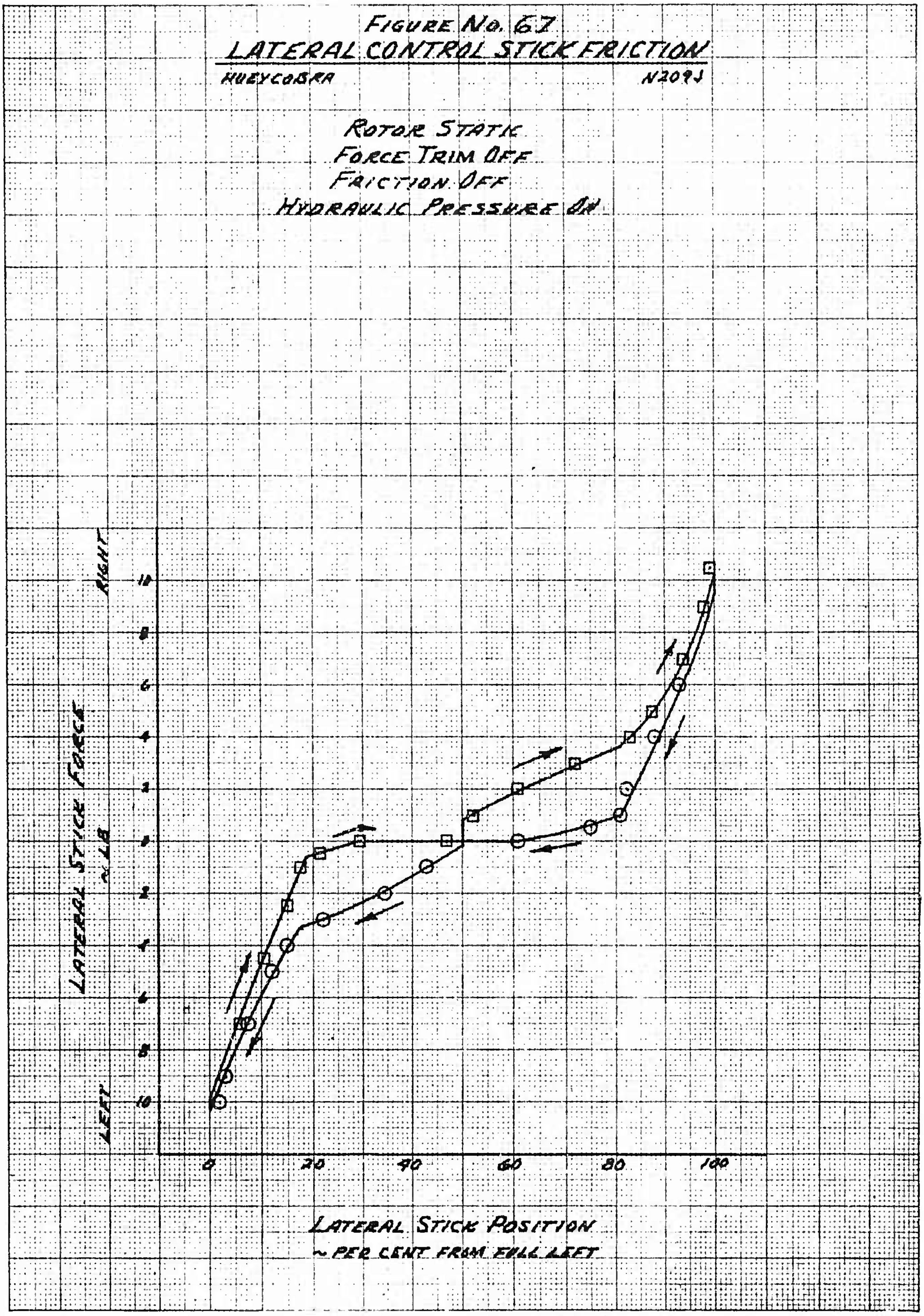


FIGURE NO. 67
LATERAL CONTROL STICK FRICTION
HUEYCOBRA
N209J
ROTOR STATIC
FORCE TRIM OFF
FRICTION OFF
HYDRAULIC PRESSURE ON
LATERAL STICK FORCE ~ LB
RIGHT
LEFT
10
8
6
4
2
0
2
4
6
8
10
0
20
40
60
80
100
LATERAL STICK POSITION
~ PER CENT FROM FULL LEFT

PART III ANNEXES

ANNEX A. References

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

2. USAAVLBS Technical Report 65-45, "Suggested Requirements for V/STOL Flying Qualities," U. S. Army Aviation Materiel Laboratories, June 1965.

3. Paper, "Control and Maneuver Requirements for Armed Helicopters," Bell Helicopter Company, May 1964.

4. Report No. 209-947-010, "Detail Specification for Model 209 Tactical Helicopter," Bell Helicopter Company, March 1966.

5. Report No. 204-100-121, "Huey-Cobra Interim Flight Test Progress Report, Model 209," Bell Helicopter Company, October 1966.

6. Report No. 209-099-004, "Preliminary Operational Envelope Model 209 Helicopter," Bell Helicopter Company, November 1965.

7. Technical Data Report No. 209-099-012, "Model 209 Improved UH-1 Weapons Helicopter," Bell Helicopter Company, August 1965.

8. Model Specification No. 104.33 for T53-L-13 Turbine Engine, Lycoming, Division of AVCOM Corporation, September 1964.

9. (C) Message 13923, AMCRD, Hq, U. S. Army Materiel Command (USAMC), 23 October 1965, subject: Expedited Flight Test Evaluation (U).

10. (C) Message 14297, AMCRD, Hq, USAMC, 28 October 1965, subject: Addition of UH-2 to Expedited Flight Test Evaluation (U).

11. (C) Plan of Test of Armed Helicopters (U), U. S. Army Aviation Test Activity, 28 October 1965.

12. (C) Report, "Early Engineering Confirmatory Flight Test Evaluation Improved Armed Helicopter," (U), Hq, USAMC, undated.

13. Military Specification MIL-A-8806, "General Specification for Acoustical Noise Level in Aircraft," 25 October 1956.

ANNEX B. Calculations and Analysis Methods

The following calibrated instrumentation was installed and maintained by contractor and U. S. Army Aviation Test personnel:

1. Front Cockpit (Gunner's Station)

   Altitude (Boom)

   Airspeed (Boom)

   High Torque Pressure

   Low Torque Pressure

   Outside Air Temperature

   Engine Inlet Temperatures (4 Stations)

   Fuel Used Counter

   Oscillograph and Photo Panel Correlation Counter

2. Rear Cockpit (Pilot's Station)

   Collective Position Indicator

   Lateral Cyclic Position Indicator

   Longitudinal Cyclic Position Indicator

   Rudder Pedal Position Indicator

   Angle of Sideslip

   Sensitive Rotor Tachometer

   Ship's Rotor and Engine (N_2) Tachometer

   Sensitive Airspeed (Ship's System)

   Altimeter (Ship's System)

   Normal Acceleration

   Standard Torquemeter

   Correlation Counter

Standard Engine RPM (N_1)

Standard Exhaust Gas Temperature

Other Standard Aircraft Instrumentation

3. Photo Panel

Compressor Inlet Pressure (4 Stations)

Airspeed (Boom)

Altitude (Boom)

Clock

Correlation Counter

Fuel Counter

Low Torque Pressure

High Torque Pressure

Engine RPM (N_1)

Rotor RPM

Outside Air Temperature

Exhaust Gas Temperature

4. Oscillograph

Event Marker

Rotor Marker

Pilot Vertical Vibration

Collective Position

Angle of Sideslip

Yaw Rate

Yaw Angular Acceleration

Roll Rate

Roll Angular Acceleration

Lateral Cyclic Position

Rudder Pedal Position

Roll Angle

Longitudinal Cyclic Position

Pitch Angle

Pitch Rate

Angle of Attack

Pitch Angular Acceleration

C.G. Normal Acceleration

Pilot Lateral Vibration

ANNEX C GENERAL TECHNICAL INFORMATION

1. Dimensions and Areas

Overall Length (Rotors Turning)	637.00 in
Overall Width (Rotor Trailing)	112.0 in
Overall Height @ 6600 Pounds (Design Gross Weight)	145.6 in
℄ Main Rotor to ℄ Tail Rotor	321.31 in
℄ Main Rotor to Elevator Hinge Line	198.4 in
Elevator Area	15.0 sq ft
Elevator Airfoil Section	Clark Y

Vertical Stabilizer Area for Aerodynamic Data	31.24 sq ft
Vertical Stabilizer Airfoil Section	Special Camber
Vertical Stabilizer Aerodynamic Center	FS 476.8, WL 76.0
Wing Area	
Total	24.7 sq ft
Outboard of B.L. 18	15.0 sq ft
Wing Span	9.0 ft
Airfoil Section	NACA 64A-421
Angle of Incidence	11 deg

2. Main Rotor

Number of Blades	2
Diameter	44 ft
Disc Area	1520 sq ft
Disc Loading @ 6600 Pounds	4.35 lb/sq ft
Power Loading @ 1100 hp and 6600 Pounds	6.00 lb/hp
Blade Chord	27 in
Rotor Solidity	.0650
Blade Area	99 sq ft
Blade Airfoil	9-1/3% Symm Section Special
Blade Twist	-.455 deg/ft
Hub Precone Angle	2-3/4 deg
Tip Speed	
324 Rotor RPM, 6600 Engine RPM	746 ft/sec
294 Rotor RPM, 6000 Engine RPM	677 ft/sec

3. <u>Anti-Torque Rotor</u>

Number of Blades	2
Diameter	8.5 ft
Disc Area	56.8 sq ft
Blade Chord	10.0 in
Rotor Solidity	.125
Blade Area	7.08 sq ft
Blade Airfoil	10% Symm Section Special
Blade Twist	0 deg
Tip Speed	
1655 Rotor RPM, 6600 Engine RPM	735 ft/sec
1505 Rotor TPM, 6000 Engine RPM	669 ft/sec

4. <u>Transmission Drive Ratios</u>

Engine to Main Rotor	20.383:1
Rotor Speed at 6600 Engine RPM	324 RPM
Rotor Speed at 6000 Engine RPM	294 RPM
Engine to Antitorque Rotor	3.990:1
Rotor Speed at 6600 Engine RPM	1655 RPM
Rotor Speed at 6000 Engine RPM	1505 RPM
Engine to Antitorque Rotor Drive System	1.535:1
Shaft Speed at 6600 Engine RPM	4310 RPM
Shaft Speed at 6000 Engine RPM	3910 RPM

5. <u>Engine</u>

Lycoming Aircraft Gas Turbine	LTCIK-4
U. S. Army Designation	T53-L-13

The flight limits used for this evaluation were established by Reference 6, Bell Report No. 209-099-004. A summary of the limits are presented below:

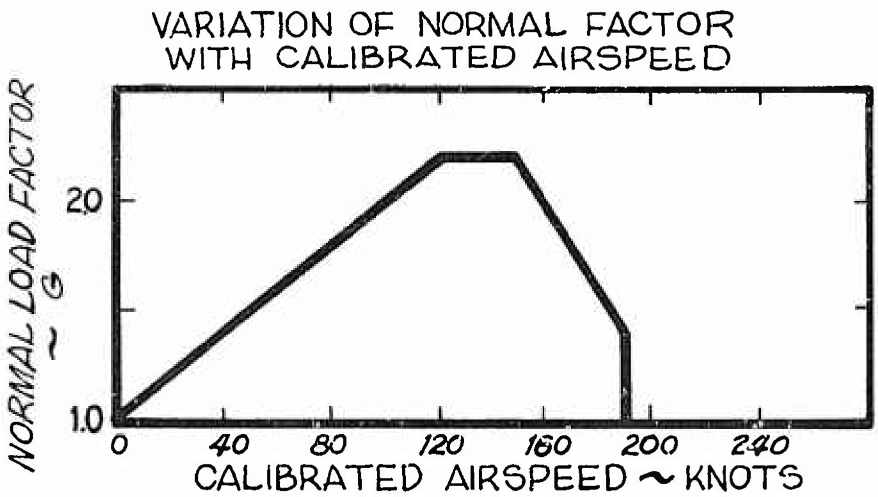
1. Airspeed

190 KCAS from sea level to 4000 feet (density altitude). Decreasing 8 KCAS/1000 feet above 4000 feet.

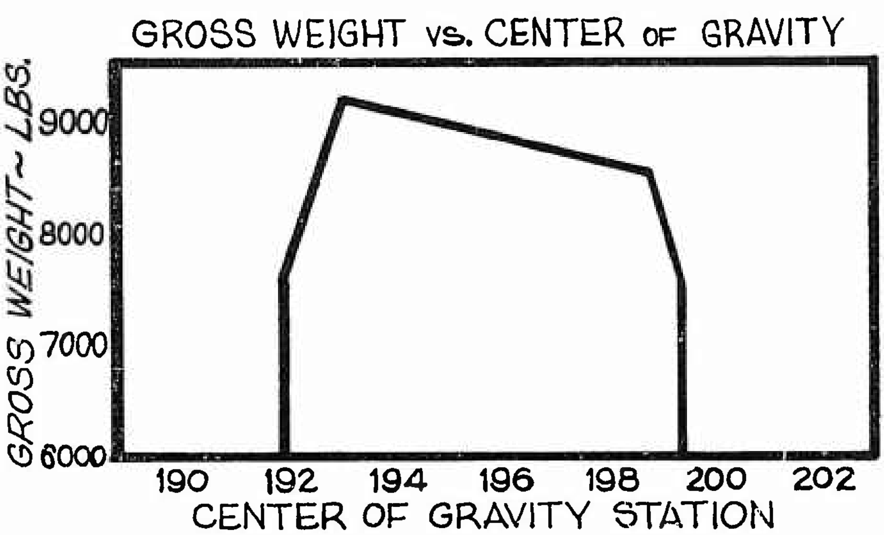
2. Altitude

Sea level to 10,000 feet (no oxygen equipment installed).

3. Center of gravity - gross weight envelope.



4. Variation of normal load factor with airspeed.



5. Sideslip angle limits ± 20 degrees of sideslip allowed at 60 KCAS with a linear decrease to ± 5 degrees at 190 KCAS.

6. Intentional autorotational entry speed maximum - 150 KCAS.

7. Gross Weight

9200 pounds maximum

8. RPM Limits

Power On - 6600 to 6400 Engine RPM

324 to 314 Rotor RPM

Power Off 304* to 339 Rotor RPM

* Transient Lower Limit = 250 RPM

Power On During Dives and Maneuvers - 324 Rotor RPM

9. Temperature and Pressure Limits

Engine Oil Temperature	200 deg F
Transmission Oil Temperature	225 deg F
90 deg Gear Box Oil Temperature	225 deg F
42 deg Gear Box Oil Temperature	225 deg F
Engine Oil Pressure	20-80 PSI
Transmission Oil Pressure	30-70 PSI
Fuel Pressure	5-20 PSI

10. Transmission Power Limit

1100 SHP continuous

ANNEX E. Weight and Balance

The test helicopter was weighed prior to the first evaluation flight. Because of the instrumentation and special equipment installations, the weights were not representative of a production airframe.

Basic Weight	5590 lbs
Included Unusable Fuel	
Full Oil and Hydraulic Reservoirs	
Rocket Pods Installed	
Instrumentation Film Onboard	
Fuel Weight (242.6 gallons)	1576 lbs
TOTAL (Without Crew or Payload)	7166 lbs

Ballast was added as required to obtain the desired test gross weight and C.G. locations.

UNCLASSIFIED
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DOCUMENT CONTROL DATA - R&D

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

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3. REPORT TITLE

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4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report, 13 November 1965 through 1 December 1965

5. AUTHOR(S) (Last name, first name, initial)

John C. Kidwell, Project Engineer
John K. Foster, Major, U. S. Army TC, Project Pilot

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
May 1966	122	13

8a. CONTRACT OR GRANT NO. b. PROJECT NO. RDT&E Project No. 1F141807D174 c. USATECOM Project No. 4-6-0300-01 d. USAAVNTA Project No. 65-30	9a. ORIGINATOR'S REPORT NUMBER(S) N/A 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Iroquois Project Manager U. S. Army Materiel Command 20315

13. ABSTRACT This report presents the results of an engineering flight evaluation conducted to determine the technical engineering flight characteristics of the prototype Model 209, S/N N209J, Huey Cobra weapons helicopter. This evaluation was conducted by the U. S. Army Aviation Test Activity (USAAVNTA), Edwards Air Force Base, California. Tests were conducted at Edwards Air Force Base, California. Twenty-nine flights were made for a total of 32 hours flying time during the period 13 November through 1 December 1965. The USAAVNTA was assigned responsibility for preparing the test plan, executing the test and preparing the test report. Although the performance and flight characteristics did not conform with the values predicted by the contractor's technical reports, the results of these tests show that the Cobra design offered speed, maneuverability, good fields of vision from the cockpit, and other desirable armed aircraft characteristics not presently available from any helicopter in the U. S. Army inventory. The maximum (power limited) level flight airspeed at sea level with no external stores and the landing gear retracted was 162 knots true airspeed. Acceptable vibration levels and flight characteristics for a weapons platform were present during all test conditions which included the limit dive speed of 190 knots calibrated airspeed (KCAS). The major problem areas included less-than-optimum high speed handling qualities, high noise levels in the aft cockpit, a front seat "sidearm" cyclic that was unsatisfactory because of the force arrangement, marginal cockpit ventilation and a cyclic force trim that was unsatisfactory because lateral forces could not be trimmed to zero. The limited contractor development program which preceded this evaluation resulted in limitations that did not allow evaluation of the design during weapons firing, touchdown autorotations,

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(See continuation sheet)

UNCLASSIFIED
Security Classification

14 KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
Engineering Flight Evaluation						
Bell Model 209 Armed Helicopter						
Huey Cobra Weapons Helicopter						
Performance Characteristics						
Flight Characteristics						

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U. S. Army Aviation Test Activity (USAAVNTA)
Edwards Air Force Base, California 93523

Engineering Flight Evaluation of the Bell Model 209 Armed Helicopter

RDT&E Project No. 1F141807D174
USATECOM Project No. 4-6-0300-01
USAAVNTA Project No. 65-30

autorotation entries at speeds above 150 KCAS and flight at extreme center-of-gravity locations. Additionally, the contractor's full structural demonstration was not complete. Development work remained to be accomplished in the areas of fatigue test and flight loads. Generally, performance levels were somewhat less than the contractor's predicted values. Low speed performanne, i.e., hover and climb flight, was similar to that of the UH-1 B/540 helicopters. High speed performance was, of course, considerably improved. The tests showed that Automatic Stabilization Equipment (ASE) was required to provide adequate lateral-directional damping for a weapons platform at speeds above 120 KCAS. Safe flight was possible, however, in the event of ASE failure at high speed.