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ATTACK HELICOPTER EVALUATION, MODEL 309 KING COBRA HELIOCOPTER

Paul G. Stringer, et al

Army Aviation Systems Test Activity
Edwards Air Force Base, California

July 1972

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13. ABSTRACT

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Model 309 KingCobra						
Evaluated						
Provide data						
Desirable characteristics						
One deficiency						
Yaw excursion						
Twenty-three shortcomings						
Vibration						
Torque increase						
Excessive pilot compensation						
Heading and altitude control						

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MODEL 309 KINGCOBRA HELICOPTER

FINAL REPORT

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INTRODUCTION

BACKGROUND

1. The Model 309 KingCobra is a prototype attack helicopter designed and built by Bell Helicopter Company (BHC) under an in-house funded program independent of any military requirement. The design phase was completed and construction was begun in February 1971. The first flight of the Model 309 was on 27 January 1972. The US Army Aviation Systems Test Activity (USAASTA) was tasked by the US Army Aviation Systems Command (AVSCOM) to conduct an evaluation of the Model 309 helicopter to support the Attack Helicopter Requirement Evaluation (AHRE) performed by the US Army Combat Developments Command (ref 1, app A).

TEST OBJECTIVES

2. The objectives of the Model 309 attack helicopter evaluation were as follows:

a. To provide data for use in determining Advance Aerial Fire Support Systems (AAFSS) effectiveness model inputs.

b. To provide data for validating material need (MN) requirements.

c. To provide data for validating contractor claims.

DESCRIPTION

3. The BHC Model 309 KingCobra helicopter is essentially a growth version of the AH-1G. The configuration features two-place tandem seating, and two-bladed main and tail rotors. The main rotor system has double swept tips, a Wortmann airfoil, a wider chord and increased diameter as compared to the AH-1G. The automatic flight control stabilization (AFCS) system incorporates a three-axis stability and control augmentation system (SCAS) and an attitude retention unit (ARU). The power plant is a Lycoming T55-L-7C turboshaft engine rated at 2850 shaft horsepower (shp) at sea-level (SL), static conditions. The engine is limited to 2050 shp to conform to the helicopter main transmission limitation. The maximum gross weight of the BHC Model 309 is 14,000 pounds. A detailed description of the Model 309 can be found in appendixes B and C. Aircraft photographs are contained in appendix D.

SCOPE OF TEST

4. The BHC Model 309 was evaluated at the Arlington, Texas, plant of BHC from 5 June to 6 July 1972. During this flight program, 41 test flights were conducted for a total of 36 flight hours. Performance testing was conducted with the environmental control unit (ECU) OFF. Performance was calculated in accordance with MIL-C-5011A (ref 2, app A). Handling qualities and vibrations were evaluated with respect to the applicable requirements of military specification MIL-H-8501A (ref 3). Test configurations consisted of the following. clean (no external stores); external stores (two XM159 pods on each wing with rockets installed to achieve the desired gross weight); and TOW mission, simulated by the external stores configuration and a gross weight of 12,385 pounds. Test conditions are shown in table 1.

5. The flight restrictions and operating limitations applicable to this evaluation are contained in the pilot's checklist (ref 4, app A), as modified by the safety-of-flight release (app E).

METHODS OF TEST

6. Established flight test techniques and data reduction procedures were used (refs 5 and 6, app A). The test methods are briefly described in the Results and Discussion section of this report. A Handling Qualities Rating Scale (HQRS) was used to augment pilot comments relative to handling qualities (app F). Data reduction techniques utilized are described in appendix G.

7. The flight test data were obtained from test instrumentation displayed on the pilot and copilot/gunner panels, photopanel, and recorded on magnetic tape. A detailed listing of the test instrumentation is contained in appendix H.

CHRONOLOGY

8. The chronology of the BHC Model 309 attack helicopter evaluation is as follows:

Test directive received	9	March	1972
Test started	5	June	1972
Test suspended[1]	12	June	1972
Test resumed	19	June	1972
Test completed	6	July	1972

[1]The test was suspended due to the loss of a main rotor tip fairing and the subsequent investigation, redesign, fabrication, and qualification of the new rotor tip.

Table 1. Test Conditions.[1]

Type of Test	Nominal Gross Weight in the Clean Configuration[2] (lb)	Nominal Gross Weight in the External Stores Configuration[3] (lb)	Nominal Density Altitude (ft)	Nominal Trim Airspeed (KCAS)
Hover performance[4]		11,800 to 13,700	1670 to 1970	Zero
Level flight performance	10,320 to 11,460	11,430 to 13.410	3030 to 6620	48 to 174
Acceleration and deceleration performance		13,950 to 14,150	1710 to 2350	Zero to 155
Lateral flight performance and agility		12,600	1820	Zero to [5]39
Takeoff and landing	10,000 to 12,000	12,000 to 14,000	1650 to 2000	
Sideward and rearward flight		12,830 to 13,170	1460 to 1530	Zero to [5]35
Control positions in trimmed forward flight	10,320 to 11,460	11,480 to 13,410	3030 to 6620	48 to 174
Trimmability	10,320 to 11,460	11,480 to 13,410	3030 to 6620	48 to 174
Static longitudinal stability		13,450 to 13,760	5150 to 5330	68 to 151
Static lateral-directional stability		13,430 to 13,860	3730 to 4410	67 to 150
Dynamic stability		13,100 to 13,800	1950 to 5250	66 to 148
Controllability		12,970 to 13,870	2040 to 5800	Zero to 148
Maneuvering stability	11,200 to 11,470	13,420 to 13,880	3810 to 5320	69 to 159
Autorotational characteristics	10,000	13,400	3000	
Automatic stabilization system characteristics		12,970 to 13,810	2040 to 5800	69 to 159
Typical mission maneuvers[6]		13,500	1000 to 4000	Zero to 170

[1]Rotor speed: 311 rpm (also 294 rpm and 300 rpm at hover performance). SCAS ON. Not all variables tested at all weights, configurations, and speeds.
[2]Clean (no external stores). Center-of-gravity range: FS 196 to FS 199 (aft).
[3]External stores (two XM159 pods on each wing; rocket loading, 19 inboard, 12 outboard, each wing). Center-of-gravity range: FS 196 to FS 199 (aft).
[4]In ground effect (10-foot skid height). Out of ground effect (100-foot skid height). ECU: OFF.
[5]KTAS.
[6]Dives, pop-ups, simulated TOW launches and tracking maneuvers, and rolling pull-ups.

RESULTS AND DISCUSSION

GENERAL

9. A limited evaluation of the performance and handling qualities of the Bell Helicopter Company Model 309 KingCobra helicopter was performed. Specific mission suitability and miscellaneous tests were also conducted. Performance testing included hover and level flight performance, forward flight acceleration and deceleration, and lateral acceleration. Handling qualities were evaluated during takeoff and landing, forward flight, sideward and rearward flight, lateral acceleration, maneuvering flight, and autorotation. Static and dynamic stability and controllability tests were performed. Mission maneuver capability was evaluated during acceleration, deceleration, low-speed nap-of-the-earth flight, high-speed low-level flight, bob-up, target acquisition, target tracking, and rapid target shift maneuvers. The capability to move the aircraft over unimproved terrain was determined, and the maintenance characteristics were evaluated throughout the test. The hover ceiling of 5000 feet at maximum gross weight (14,000 pounds) on a 95°F day enhanced the aircraft capability to perform out-of-ground-effect tactical missions and slow-speed nap-of-the-earth flight and is highly desirable. Small lateral trim changes with airspeed reduced pilot workload requirements. Minimal changes of aircraft attitude occurred during takeoff and landing. The inability to correct for large and rapid yaw excursions within the tail rotor power limits was the only deficiency determined. Numerous undesirable characteristics of the flight control system degraded the aircraft handling qualities. A total of 23 shortcomings was noted. The most significant shortcomings were an excessive two-per-revolution vibration during maneuvering flight, and excessive torque increase with increased steady-state load factor. In addition, excessive pilot effort was required for target tracking, for precise heading and attitude control in turbulence, and for performing lateral agility maneuvers.

PERFORMANCE

General

10. Hover performance testing was conducted in ground effect at a 10-foot skid height and out of ground effect at a 100-foot skid height. Level flight performance was evaluated at gross-weight-to-density-altitude ratios of 11,350 to 15,495 pounds. Forward flight acceleration and deceleration performance was evaluated at an approximate 2000-foot density altitude in the airspeed range from hover to the maximum airspeed in level flight. At maximum power, the extrapolated standard-day, out-of-ground-effect hover ceiling at a 14,000-pound gross weight was 11,850 feet. The potential capability to hover out of ground effect at 14,000 pounds on a 95°F day at 5000 feet is highly desirable. In addition, the large power margin available to terminate a deceleration at a hover is desirable. The sea-level maximum level flight airspeed was 178 knots true airspeed at 10,000 pounds, decreasing to 170 knots true airspeed at 14,000 pounds. The

difference in equivalent flat plate area between the clean helicopter and the armed helicopter (four XM159 pods) was 6.8 square feet, which decreased maximum level flight airspeed, specific range, and the long-range cruise airspeed by approximately 7 percent. Maximum left lateral acceleration was 0.39g. Maximum right lateral acceleration (0.21g) was limited by the tail rotor 90-degree gearbox shaft horsepower limitation (350 horsepower).

Hover Performance

11. The hover performance tests were conducted at skid heights of 10 feet (in ground effect (IGE)) and 100 feet (out of ground effect (OGE)). The free-flight hover method was utilized to determine hover performance. A measured weighted cord attached to the front of the right skid was used to establish skid height above the ground. The test conditions are presented in table 1. The summary hover capability comparison is presented in figure 1, appendix I. The aircraft nondimensional hover performance data are presented in figures 2 and 3. Nondimensional tail rotor performance is persented in figures 4 and 5. Extrapolated data indicate that the OGE hover ceiling at the maximum allowable gross weight of 14,000 pounds on a standard day is 11,850 feet, and on a 95°F day is 5000 feet, and that the standard-day OGE hover ceiling at the TOW mission gross weight of 12,385 pounds is 15,600 feet.

Level Flight Performance

12. Level flight performance tests were conducted to determine power required and associated fuel flow as a function of airspeed. In addition, specific range, cruise airspeed (V_{CR}), endurance, and maximum airspeed in level flight (V_H), as well as level flight engine performance characteristics were determined. A constant ratio of gross weight to density altitude (W/σ) was maintained by increasing altitude as fuel was consumed. The test conditions are presented in table 1. The results of the tests are presented in figures 6 through 12, appendix I. The long-range summary for the clean configuration is presented in figure 13. Maximum endurance for both the clean and external stores configurations is shown in figures 14 and 15.

13. The increase in equivalent flat plate area for the external stores configuration is presented in figure A. End plates were placed over the front of each rocket pod when determining the external stores configuration increase in equivalent flat plate area. The addition of external stores caused an increase of 6.8 square feet of equivalent flat plate area.

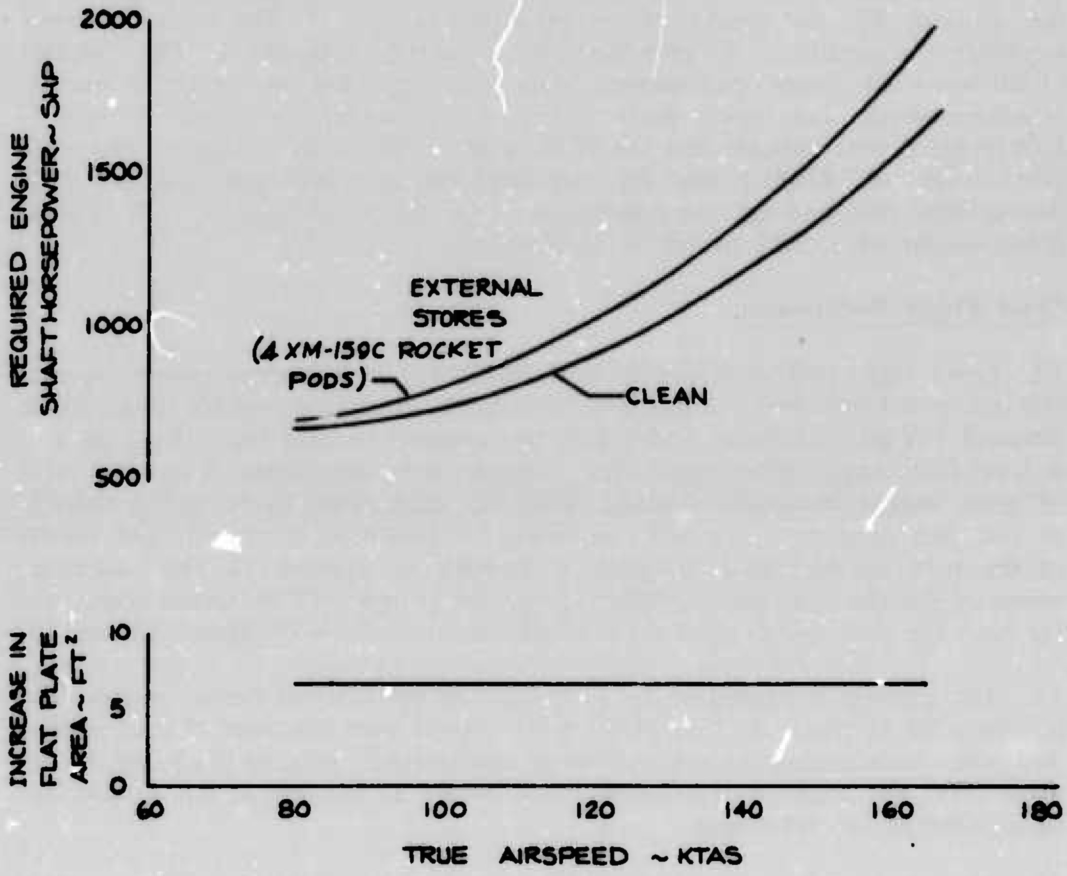
14. The long-range summary for standard-day conditions is presented in figure 13, appendix I. At sea level, V_H decreased essentially linearly from 178 knots true airspeed (KTAS) at a 10,000-pound gross weight to 170 KTAS at a 14,000-pound gross weight in the clean configuration. The increased drag of external stores decreased V_H, specific range, and long-range cruise airspeed by approximately 7 percent, as shown in figures 15 and 16. Throughout the gross weight range, the engine fuel flow at sea level for the best endurance airspeed is essentially unchanged by the addition of external stores.

FIGURE A

EQUIVALENT FLAT PLATE AREA INCREASE DUE TO EXTERNAL STORES

AVG GROSS WEIGHT ~ LBS	AVG CG LOCATION ~ IN.	AVG DENSITY ALTITUDE ~ FT	AVG OAT ~ °C
11430	196.6(FWD)	3030	25

ROTOR SPEED = 311 RPM



Forward Flight Acceleration and Deceleration Performance

15. Forward flight constant-altitude accelerations and decelerations were performed in the external stores configuration at an average gross weight of 14,000 pounds. Tests were conducted in the airspeed range from hover to V_H at maximum power (transmission limit). Time histories of representative accelerations and decelerations are presented in figures 17 and 18, appendix I. Acceleration and deceleration times are summarized in table 2.

Table 2. Acceleration-Deceleration Performance.[1]

Flight Condition	Time (sec)
Zero to 146 KCAS	35
132 to 150 KCAS	6
151 KCAS to zero	40
150 to 132 KCAS	12

[1]Gross weight: 14,000 pounds.
Center of gravity: 198.3 (aft).
Density altitude: 2000 feet.
Rotor speed: 311 rpm.
Configuration: external stores.

16. Accelerations were accomplished by rapid application of maximum power while coordinating flight controls to maintain constant altitude and steady heading. Less than 2-percent transient droop was noted, and there was no permanent droop. Droop characteristics during level accelerations were satisfactory.

17. Entry into the deceleration maneuver required reduction of the rotor speed followed by a rapid collective control reduction and a flare to maintain constant altitude. During decelerations, the main rotor speed required constant attention to prevent an overspeed. Rotor speed was very sensitive to collective pitch position and load factor. Decelerative performance was limited by this characteristic.

18. The pilot's forward field of view was unrestricted during accelerations. However, during decelerations, forward field of view was restricted by the forward cockpit due to the nose-high attitude. Below 120 knots indicated airspeed (KIAS), all forward vision was blocked, and ground orientation could only be maintained by looking out to the sides.

Lateral Acceleration Performance

19. The lateral acceleration performance was evaluated by conducting lateral accelerations and reversals IGE (skid height, approximately 40 feet) in the TOW mission configuration. Acceleration was accomplished by rolling the aircraft to a predetermined bank angle with a rapid lateral control motion while adding power to maintain constant altitude, and control as necessary to 37, maintain constant attitude and heading. Bank angle to the left was limited maintain constant altitude and heading. Bank angle to the left was limited by engine torque. Bank angle to the right was limited by tail rotor shaft horsepower (current inspection limit, 350 shp). Performance data, shown in figures 18 and 19, appendix I, were recorded with a ground-positioned grid camera. A ground pacer vehicle was used to determine limit sideward speed. The data are summarized in table 3.

Table 3. Maximum Lateral Flight Performance.[1]

Roll Angle (deg)	Maximum Acceleration (g)	Airspeed (kt)	Time[2] (sec)	Distance[2] (ft)
30 left	0.39	10	1.6	35
		20	3.1	47
		25	3.8	73
		30	4.5	105
		35	5.3	152
12 right	0.21	10	2.9	30
		20	6.2	115
		25	7.9	180
		30	10.6	305

[1]Gross weight: 12,610 pounds.
Configuration: TOW.
Center of gravity: 196.7 (fwd).
Density altitude: 1820 feet.
Outside air temperature: 25.5°C.
Rotor speed: 311 rpm.
[2]Time and distance measured from start of lateral motion.

20. The maximum bank angle in left sideward flight was approximately 30 degrees, as limited by maximum power. It was necessary to closely monitor engine torque to preclude an overtorque condition. The maximum bank angle in right sideward flight was approximately 12 degrees. The tail rotor shaft horsepower required close monitoring to preclude exceeding the current inspection limit. The maximum acceleration achieved to the left was 0.39g, and 0.21g to the right. The corresponding time from start of lateral motion to limit speed (35 KTAS left, 30 KTAS right) was 5.4 and 10.6 seconds, respectively. There was no cue, other than judgment of ground speed, to alert the pilot of reaching limit sideward velocity.

HANDLING QUALITIES

General

21. The handling qualities of the Bell Helicopter Company Model 309 KingCobra were evaluated under a variety of operating conditions. The gust response was heavily damped in all axes. The small change of lateral control trim positions with airspeed is highly desirable. Cross-slope landings were accomplished to 10.2 degrees (left skid upslope) and 15.0 degrees (right skid upslope) with minimal pilot compensation (HQRS 3). One deficiency was found: the inability to correct for large and rapid yaw excursions within tail rotor power limits. Numerous undesirable characteristics of the flight control system degraded the aircraft handling qualities. There were 23 shortcomings. The most significant shortcomings were the excessive torque increase with increased steady-state load factor and excessive two-per-revolution vibration in maneuvering flight. In addition, moderate pilot compensation was required for target tracking, for maintaining precise heading and attitude control in turbulence, and for performing lateral agility maneuvers.

Control Systems Characteristics

22. Control system characteristics were measured on the ground with the engine and rotor stopped. Electrical and hydraulic power were furnished from external sources. Both hydraulic systems were pressurized. Control forces were measured using a hand-held force gage, and control displacements were taken from control position indicators mounted on the instrument panel. Cyclic and directional control forces were measured with force trim ON. Collective forces were measured with the adjustable friction set to prevent control creep. Control system characteristics in flight were qualitatively evaluated and determined to be essentially the same as those observed on the ground. Cyclic control pattern and longitudinal, lateral, and collective control force characteristics are presented in figures 20 through 23, appendix I, and are summarized in table 4.

Table 4. Control System Characteristics.

Control	Breakout Force Including Friction (lb)		Control Force Gradient (lb/in.)		Maximum Control Force (lb)		Free Play (in.)	Trim Slippage
	Test Results	MIL-H-8501A Maximum	Test Results	MIL-H-8501A Maximum	Test Results	MIL-H-8501A Maximum		
Longitudinal	1.5	1.5	2	2	11	8	1/8	No
Lateral	1.4	1.5	1	2	6.5	7	1/8	No
Directional	10.0	7	10	N/A	32	15	1/8	Yes
Collective	9.5	3	1.2	N/A	13.5	7	None Observed	N/A

23. Lateral and longitudinal cyclic control force gradients and breakout force including friction met the requirements of MIL-H-8501A and were satisfactory. Two degrading features were observed during this test with the force trim OFF. The cyclic control motored to the forward or left lateral stop when a 1/4-pound force was momentarily applied to the cockpit control. Motoring of the cyclic control is a shortcoming. In addition, an inconsistent and erratic force resisted cyclic control movement laterally or longitudinally. This erratic force was described as a "ratchety" feeling and was apparent in flight whenever large control movements were made with the force trim OFF and minimum adjustable friction applied. The erratic cyclic control force was objectionable and is a shortcoming.

24. The directional control breakout force including friction was 10 pounds, which exceeded the 7-pound limit of paragraph 3.3.13 of MIL-H-8501A by 3 pounds (43 percent). In addition, the maximum force of 32 pounds exceeded the 15-pound limit of paragraph 3.3.11 by 17 pounds (113 percent). The pedal force gradient was essentially linear within 2 inches of trim. When the pedals were displaced more than 2 inches from trim, a sudden release of force would occasionally occur. This sudden change in pedal force appeared to have been caused by slippage of the force trim magnetic brake. This trim slippage was observed in flight on two occasions and also occurred during ground operations. The sudden release of pedal forces in flight resulted in abrupt control inputs that were very objectionable. Slippage of the directional pedal force trim is a shortcoming, correction of which is desirable.

25. The collective control force data presented in figure 23, appendix I, was obtained with the friction set at a level that was sufficient to prevent collective creep during high-power, high-load-factor maneuvers. With this friction setting, the collective breakout force including friction was 9.5 pounds of pull. This high breakout force was objectionable, in that excessive pilot effort was required to make small collective control adjustments. The 9.5-pound collective control breakout force exceeded the 3-pound limit of paragraph 3.4.2 of MIL-H-8501A by 6.5 pounds (217 percent). The excessive collective control breakout force is a shortcoming, correction of which is desirable.

Takeoff and Landing Characteristics

26. Takeoff and landing characteristics were qualitatively evaluated throughout the test with SCAS ON and OFF at gross weights from 10,000 to 14,000 pounds and over the center-of-gravity (cg) range of fuselage station (FS) 196 (fwd) to FS 199 (aft). Surface winds ranged from calm to maximum gusts of 20 knots. Hover landings and takeoffs were started and ended at a 3-foot skid height.

27. Liftoff to a hover was accomplished with minimal control displacement and forces and with practically no changes in pitch or roll attitude. Liftoff to a hover at a constant level attitude is a desirable characteristic. Although landings required minimal effort in light winds (HQRS 3), moderate pilot compensation was required in gusty winds due to small roll excursions, up to ±4 degrees from level attitude (HQRS 4). Very small feedback forces could be felt in the cyclic control which

appeared to be related to the roll excursions. These random roll excursions and forces are shortcomings which should be corrected. These excursions and forces were not noticeable with SCAS OFF.

28. Nose-up and nose-down slope landings had not been accomplished by the contractor, therefore, were not accomplished during this evaluation. Cross-slope landing characteristics were evaluated in calm winds in the clean configuration at a 10,500-pound gross weight and a forward cg. The test area was a grassy slope. Landings were accomplished up to the 15-degree safety-of-flight-release limit (app E) with the right skid upslope. Sufficient lateral control remained to positively control aircraft roll attitude. Landings were made to 10.2 degrees with the left skid upslope, as limited by maximum lateral cyclic control. Mininial pilot compensation was required (HQRS 3). When landings were made on slopes over 10.2 degrees (up to 13.2 degrees), sideward slippage occurred, and moderate compensation was required (HQRS 4).

29. Vibration levels were annoying during cross-slope landings. As lateral cyclic displacement increased with the lowering of the downslope skid, a one-per-revolution (1/rev) vibration developed. The 1/rev vibration decreased as the aircraft stabilized with both skids down. A 2/rev vibration became noticeable as the collective was lowered to the full-down position with the cyclic displaced. When the cyclic control was centered, all annoying vibrations ceased.

Lateral Acceleration Handling Qualities

30. The lateral acceleration handling qualities were evaluated during the lateral acceleration performance testing at the conditions outlined in table 1. Representative time histories of lateral accelerations are presented in figures 24 through 26, appendix I. During the acceleration, engine torque had to be closely monitored to prevent overtorquing. There was no means of determining sideward velocity, and a calibrated ground pace vehicle was used to determine when limit airspeed was reached. Because of the 350-shp tail rotor gearbox current inspection limit, only 12 degrees of bank angle could be reached during accelerations to the right. This restriction precluded an effective evaluation of the acceleration and the deceleration maneuver to the right. Reversals were not evaluated from right lateral flight. During acceleration to the left, moderate pilot effort was required to maintain heading and altitude (HQRS 4). At the limit left sideward velocity (35 KTAS), a rapid reversal was accomplished while attempting to maintain heading and altitude. The aircraft tended to yaw left, and considerable pilot effort was required to maintain heading during the rapid reversal from left sideward flight (HQRS 5). The excessive pilot effort required during maximum accelerations to the left and during the subsequent rapid reversal from limit left sideward velocity are shortcomings which should be corrected.

Sideward and Rearward Flight Characteristics

31. Sideward, rearward, and slow-speed forward flight tests were conducted to determine control margins and handling qualities while hovering in winds. The

airspeed range varied from hover to the sideward and rearward limits, and to 40 KTAS in forward flight. Each airspeed was determined using a calibrated ground pace vehicle. The helicopter was in the external stores configuration with an aft cg at a 15-foot skid height at conditions shown in table 1.

32. Sideward flight test results are presented in figure 28, appendix I. Lateral control position changes with airspeed were small and not detectable by the pilot. Directional control position changes were essentially linear with airspeed changes, except for an abrupt discontinuity between 10 and 20 KTAS in left sideward flight. This discontinuity was noticeable to the pilot but was not distracting, and only minimal pilot compensation was required to maintain heading during left sideward translation. Aft longitudinal control displacement was required as trim airspeed increased, left and right. Above 30 KTAS in left sideward flight, a reversal of longitudinal control displacement occurred but was not objectionable. During this test, control trim shifts were small, and control margins were adequate. The 30-KTAS limitation of right sideward velocity (app E) prevented investigation to the 35-knot sideward flight requirement of MIL-H-8501A. Within the scope of this test, the trim control position characteristics in sideward flight are satisfactory.

33. Rearward and slow-speed forward flight test results are presented in figure 28, appendix I. As is shown in this figure, cyclic and pedal control position changes from 5 KTAS in rearward flight to 20 KTAS in forward flight were very small. From 5 to 20 KTAS in rearward flight, the longitudinal control position changes were linear and very stable (aft control for increasing rearward speed). From 20 to 35 KTAS in rearward flight, the control position variation was slightly unstable but was not objectionable. Lateral trim shifts during this test were small and were not objectionable. Directional control in rearward flight required constant attention. Control margins were adequate and are satisfactory.

34. Hovering in gusty winds required frequent directional control inputs to stabilize heading. On several occasions, when hovering at maximum gross weight in winds with a gust spread of approximately 10 knots, the tail rotor current inspection limit of 350 horsepower was reached. The inability to correct rapid and large yaw excursions within the current tail rotor horsepower limit is a deficiency, correction of which is mandatory.

Control Positions in Trimmed Forward Flight

35. Control positions in trimmed forward flight were evaluated from 50 knots calibrated airspeed (KCAS) to V_H with SCAS ON. Tests were conducted at the conditions listed in table 1 in the clean and external stores configurations at a forward cg. Figures 29 through 33, appendix I, present the results of this test. The longitudinal control trim position gradient in level flight was positive (increasing forward displacement with increasing airspeed) and essentially linear. The lateral control trim position variation from 50 KCAS to V_H was approximately 0.5 inch and was not noticeable to the pilot. The lack of a noticeable lateral trim shift with airspeed is a desirable characteristic. The directional control trim position variation with airspeed was approximately 0.6 inch left from 100 to 160 KCAS. Within the scope of this test, the control trim characteristics evaluated are satisfactory.

Trimmability

36. The trimmability characteristics were evaluated concurrently with other testing. Aircraft trim was established by either of two independent systems. The first system used magnetic brakes in the force trim system, in all three axes, which were released and reset at a new trim position by a trim release button on the cyclic control grip. Pressing the trim release button removed all forces from the controls. The second system utilized the attitude trim actuators of the ARU to move the cyclic control laterally and longitudinally. With the ARU engaged, the cyclic control could be moved to any desired trim position with the vernier switch.

37. The trim release button normally was depressed prior to displacing the controls and then released to reengage the force trim system when the new trim position was established. This method was satisfactory, although control movements with all forces released occasionally resulted in minor overcontrolling. When the force trim button was depressed after the controls had been moved from trim, the sudden release of forces generally resulted in an undesired control input. The resulting abrupt aircraft disturbance was objectionable. Sudden release of control forces following force trim release is a shortcoming, correction of which is desirable.

38. The vernier trim of the ARU had an extremely slow trim rate (approximately 1 degree per second). Control system friction was strong enough to oppose the movement of the attitude trim actuators and hold the cyclic control until it was disturbed by vibrations or a control input, preventing precise trimming. This trim system could only be operated when no force was applied to the cyclic control. This precluded use of the vernier trim to reduce control forces to zero. Use of the vernier trim was a time-consuming and tedious operation, which rendered it ineffective in trimming the aircraft. This is a shortcoming, correction of which is desirable.

Static Longitudinal Stability

39. Static longitudinal stability characteristics were evaluated from trim conditions of 68, 124, and 147 KCAS at an aft cg, and at 151 KCAS at a forward cg. Tests were conducted in the external stores configuration at an average gross weight of 13,760 pounds and 13,450 pounds, respectively. The aircraft was trimmed in steady-heading, zero-sideslip level flight. With the collective control held fixed at the trim setting, the aircraft was stabilized at incremental speeds greater and less than the trim speed. Test results are presented in figures 34 and 35, appendix I.

40. Static longitudinal stability, as indicated by the variation of longitudinal control position with airspeed, was neutral to slightly positive at all test airspeeds. The aircraft was slow to return to trim airspeed when displaced; however, the trim airspeed, once established, could be maintained with minimal effort. The static longitudinal stability characteristics are satisfactory.

Static Lateral-Directional Stability

41. Static lateral-directional stability characteristics were evaluated at level flight trim airspeeds of 67, 124, and 150 KCAS at an average density altitude of 4000 feet. Tests were conducted in the external stores configuration at an average gross weight of 13,600 pounds and an aft cg. The aircraft initially was trimmed at zero sideslip at the desired airspeed. With the collective control fixed and maintaining a steady-heading at the trim airspeed, the aircraft was stabilized at incremental sideslip angles from zero to the limits of the sideslip envelope. Test results are presented in figures 36 through 38, appendix I.

42. Static directional stability, as indicated by the variation of directional control position with sideslip, was positive and essentially linear at all test airspeeds. This gradient increased slightly with increasing airspeed. Dihedral effect, as indicated by the variation of lateral control position with sideslip, was positive and essentially linear at all test airspeeds. The lateral control gradient increased with increasing airspeed. Pitch with sideslip occurred at all trim airspeeds. Increasing aft displacement of the longitudinal control was required with increasing sideslips, left and right. In all cases, the maximum longitudinal control requirement at the sideslip limit was 0.5 inch or less and was not objectionable. The side-force characteristic, as indicated by the variation of bank angle with sideslip, was positive for right sideslips and large left sideslips, but was neutral at small left sideslip angles. This characteristic slightly increased pilot effort to stabilize in balanced flight at all airspeeds. The static lateral-directional characteristics are satisfactory.

Dynamic Stability

43. Dynamic stability characteristics were evaluated in OGE hover and in level flight at 65, 120, and 145 KCAS with SCAS ON. The long-term response was also evaluated with SCAS OFF at 120 KCAS. Tests were conducted at the conditions listed in table 1.

44. Short-period gust response characteristics were evaluated by rapidly displacing the desired control 1 inch from trim for a duration of 0.5 second and returning the control to trim position while recording subsequent aircraft response. Time histories of representative simulated gust responses are presented in figures 39 through 42, appendix I. The short-period response of the helicopter was similar for all test conditions and was essentially deadbeat in all axes. The normal acceleration reached a maximum of 1.15g at 150 KCAS and a minimum of 0.97g following longitudinal pulse inputs. In forward flight in turbulent conditions with SCAS ON, small pitch excursions occurred which were not present with the SCAS OFF.

45. Lateral-directional gust response was also evaluated by inducing directional control doublets. Aircraft response was essentially deadbeat about all axes, and there were no residual lateral-directional oscillations. In turbulent conditions with SCAS ON, objectionable random yaw and roll excursions occurred which were not present with SCAS OFF. These resulted in considerable pilot compensation

being required for precise heading and bank attitude control in turbulent conditions (HQRS 5). The tendency of the aircraft, with SCAS ON, to develop undesirable random roll and yaw excursions is a shortcoming, correction of which is desirable.

46. Turns with lateral cyclic only were qualitatively evaluated at airspeeds above 65 KCAS with SCAS ON. A lateral cyclic control input sufficient to generate a 30-degree roll displacement in 6 seconds resulted in no noticeable adverse yaw. Pedal-fixed turns could be easily accomplished.

47. The long-term aircraft response was excited by release from off-trim airspeed and by longitudinal pulse inputs of 1 inch for 0.5 second. At 65 KCAS with SCAS ON, the long-term motion was oscillatory and slightly divergent with a period of 48 seconds, as shown in figure 41, appendix I. Turbulence prevented accurate determination of long-term response at 120 KCAS. Qualitatively, the long-term response was damped to slightly divergent with a period of approximately 42 seconds with SCAS ON. With SCAS OFF at 120 knots, the long-term response was deadbeat. Long-term response was easily excited, but the very long period would require minimal pilot compensation during instrument flight conditions (HQRS 3). The long-term dynamic characteristics met the requirements of paragraph 3.2.11 of MIL-H-8501A.

Controllability

48. Controllability characteristics with SCAS ON were evaluated in forward flight and hover at an approximate 13,600-pound gross weight and an aft cg. Single-axis control step inputs were applied to the longitudinal and lateral controls using mechanical fixtures to obtain the desired control input size. The size of directional control inputs were estimated. Control inputs were held constant, and the subsequent angular displacement, angular rate (response), and angular acceleration (sensitivity) were measured. The results of these tests are presented in figures 43 through 51, appendix I. The control power characteristics during OGE hover are summarized in table 5 and compared with the requirements of MIL-H-8501A.

49. Longitudinal, lateral, and directional controllability characteristics are presented in figures 43 through 51, appendix I. Control sensitivity, response, and control power at airspeeds above 100 KCAS and at a hover provided adequate cues that the aircraft responded to the control input without a tendency to overcontrol. No control coupling was noted during longitudinal controllability testing.

50. Lateral controllability characteristics are shown in figures 46 through 48, appendix I. Following a lateral step input, initial roll rate increased within 0.2 second and roll damping was adequate, and without tendency toward overcontrol. The roll response in maneuvering airspeed range was only 10 deg/sec per inch of the lateral control displacement.

Table 5. Out-of-Ground-Effect Hover Control Power and Damping.[1]

Axis	Direction	Control Power (deg in 1 sec)		Damping (ft-lb/rad/sec)	
		Test Results	MIL-H-8501A Minimum	Test Results	MIL-H-8501A Minimum
Pitch	Forward	[2]4.0	1.8	36,180	9,985
	Aft	[2]4.0			
Roll[3]	Left	2.0	1.1	15,400	8,848
	Right	1.5			
Yaw	Left	[2]16	4.5	28,300	29,584
	Right	[2]16			

[1]Gross weight: 13,700 pounds.
Center of gravity: FS 198 (aft).
Density altitude: 2040 feet.
Outside air temperature: 26°C.
Rotor speed: 311 rpm.
Configuration: external stores.
[2]Extrapolated data.
[3]Degrees in 1/2 second.

51. Directional controllability characteristics are presented in figures 49 through 51, appendix I. Directional control sensitivity was essentially invariant with airspeed in forward flight. The aircraft responded in the proper direction for all directional inputs without hesitation or cross-coupling. The directional control damping failed to meet the requirement of paragraph 3.6.1.1 of MIL-H-8501A, in that damping was 28,300 foot-pounds per radian per second (ft-lb/rad/sec), 1284 ft-lb/rad/sec (4.4 percent) below the requirement. The controllability characteristics were satisfactory. The hover controllability evaluation was limited to an approximate 1/2-inch left directional control input due to high tail rotor horsepower required, which approached the limit of 350 horsepower.

Maneuvering Stability

52. Maneuvering stability characteristics were evaluated at the conditions shown in table 1 at an aft cg with SCAS ON. The variation of longitudinal control position and control force with normal acceleration was determined by initially trimming the aircraft in coordinated level flight at the desired airspeed and then stabilizing

the aircraft at incremental bank angles, both left and right. During the test, trim collective setting and trim airspeed were maintained. Data were recorded at each stabilized bank angle. Data were also recorded during steady pull-ups and pushovers at the trim airspeeds. Maneuvering stability characteristics are presented in figures 52 through 58, appendix I.

53. The variation of longitudinal control position with normal acceleration (stick-fixed stability) was positive and essentially linear at all trim airspeeds. The longitudinal control position gradient varied from approximately 2.3 inches per g (in./g) at 69 KCAS to 1.1 in./g at 142 KCAS. The variation of longitudinal control force with normal acceleration (stick-free stability) was positive and linear. The longitudinal control force gradient varied from approximately 4 pounds per g (lb/g) for all airspeeds tested above 119 KCAS to 9.2 lb/g at 70 KCAS. The stick-fixed and stick-free maneuvering stability characteristics are satisfactory.

54. High-g maneuvers at low power settings, below 52-percent engine torque, were conducted to the envelope limit (1.7g) (app E). Vibration levels were satisfactory. During maneuvering flight with engine power above 52 percent, significant 2/rev vertical vibrations occurred as load factor increased above 1.4g. The vibration level increased with increasing load factor and limited the usable load factor to 1.6g, thus decreasing mission effectiveness. Excessive vibration levels during high-g maneuvers at high power settings are a shortcoming, correction of which is desirable.

55. At 140 KIAS, engine torque increased above trim setting at 1.4g and increased further with increased load factor. At 1.6g in a right turn (approximate 55-degree bank angle), engine torque reached the limit (79 percent). The steady-state torque increase signficantly detracted from the maneuverability of the aircraft during high-speed turns and required excessive attention to monitor the engine torque (HQRS 5). The excessive torque increase with increased load factor is a shortcoming, correction of which is desirable.

Autorotational Characteristics

56. Simulated engine failures (throttle chops) were prohibited by the safety-of-flight release (app E) and were therefore not evaluated during this test.

57. A limited evaluation of steady-state autorotational characteristics was conducted in the external stores configuration at a gross weight of approximately 13,400 pounds and at an aft cg at bank angles up to 15 degrees. Rotor speed tended to build rapidly in turns and decelerations, and required very close monitoring by the pilot, but was easily controlled. Additionally, touchdown autorotations were performed in the clean configuration at a gross weight of approximately 10,000 pounds. A wide range of flare heights could be used. Sufficient rotor inertia was available to make smooth touchdowns. The steady-state autorotational descent and landing characteristics are satisfactory.

Automatic Stabilization System Characteristics

58. Failure of the SCAS was qualitatively evaluated throughout the flight envelope. Failure was simulated by disengaging the SCAS using the SCAS DISENGAGE button located on the cyclic grip, and observing aircraft response with controls fixed and free. Aircraft response to a complete SCAS disengagement was mild and easily controlled. The aircraft tended to roll right with no pitching or yawing. Within the scope of the test, aircraft response to SCAS failure is satisfactory.

59. When engaging the SCAS, a noticeable transient motion occurred in both longitudinal and lateral controls. This characteristic was objectionable and did not meet the requirements of paragraph 3.5.9 of MIL-H-8501A. This is a shortcoming, correction of which is desirable.

60. During flights in turbulent air, with SCAS ON, inputs could be felt in the flight controls, and small, rapid excursions of the aircraft occurred. These inputs and excursions were disconcerting and slightly annoying. These inputs and excursions were not noticeable with SCAS OFF.

61. The ARU was qualitatively evaluated in hover and in forward flight at 65, 120, and 140 KCAS. In relatively stable air, the ARU maintained aircraft attitude and heading essentially without deviation. In turbulence at airspeeds below 80 KCAS, the ARU caused large roll excursions, a shortcoming which should be corrected. When maneuvering the aircraft with the ARU engaged, small force variations could be felt in the controls. Force variation in the cyclic control with ARU engaged is a shortcoming, correction of which is desirable. Pedal inputs deactivated the heading-hold mode and required manual reengagement when established on a new heading.

MISCELLANEOUS ENGINEERING TESTS

Cockpit Evaluation

62. A qualitative evaluation of the cockpit was conducted throughout the test program. The DC circuit breaker panel is mounted vertically on the right side of the cockpit near the pilot's right elbow. This location requires the pilot to turn his head to the rear and down to check circuit breakers, and reduces the circuit breaker accessibility. The AC circuit breakers are hidden by the collective control lever during ground operations. In flight, the AC circuit breakers were readily visible but difficult to reach because of the position of the collective lever. Dual temperature/pressure gages are installed to display engine and transmission parameters. These gages are easier to read than are the gages installed in the AH-1G.

63. The aircraft was equipped with an environmental control unit (ECU) which provided heating and cooling for the crew stations. Flights were conducted with ambient temperatures exceeding 90°F, and the unit provided adequate cooling. The unit had an annoying and distracting characteristic of cycling on and off during

low-power descents such as the approach to a landing. The sound associated with this cycling gave a momentary impression of an engine failure. This distraction during approach is a shortcoming and should be corrected.

Weight and Balance

64. The aircraft weight and longitudinal cg were determined prior to testing. The empty aircraft weight, including instrumentation, was 8572 pounds with the cg located at FS 202.1 (aft). The instrumentation was estimated to weigh 325 pounds. The resulting aircraft empty weight was estimated to be 8247 pounds with the cg at FS 204.1 (aft). The aircraft weight breakdown is presented in table 6.

Table 6. Weight and Balance.

Item	Weight (lb)	Arm
Basic aircraft	8247	FS 204.1
Aircraft with test instrumentation	8572	FS 202.1
XM159C pod without rockets	76	FS 191.7 (inboard)
		FS 198.7 (outboard)
XM159C pod with 19 rockets	[1]608	FS 191.7 (inboard)
XM159C pod with 12 rockets	[1]412	FS 198.7 (outboard)

[1]Per pod.

65. The external stores configuration had a total of four XM159C rocket pods, two mounted on each wing. Each inboard rocket pod was loaded with nineteen 28-pound inert rockets, and each outboard rocket pod was loaded with twelve 28-pound inert rockets (maximum allowable load).

Ground Operation Characteristics

66. Engine start and ground run-up procedures were easily accomplished. Throttle advance from idle to governed range required approximately 20 degrees of throttle grip turn. This small sector required close attention by the pilot to prevent torque surge. The remaining travel of the throttle grip was approximately 90 degrees.

67. During engine shutdown, with throttle friction OFF, it was necessary to hold the grip throttle closed to prevent fuel from flowing to the engine and causing a hot shutdown. The requirement to hold the throttle closed during shutdown is a shortcoming and should be corrected.

68. Main rotor coast down was accomplished without mast bumping. In gusty winds with another helicopter hover-taxiing in close proximity upwind, the maximum tip-path deviation was less than 18 inches. Compared with the AH-1G, main rotor coast-down characteristics are improved, primarily because of the absence of mast bumping.

Engine Characteristics

69. Lycoming computer source deck number 19.00.46.00 was used to determine power-available and fuel-flow data at a power turbine speed of 13,408 rpm (311 rotor rpm). Referred engine characteristics were based on test-stand green-run calibrations (figs. 59 through 61, app I). Engine shaft horsepower available is shown in figures 62 through 64. Engine inlet temperature and inlet pressure characteristics were determined by the airframe manufacturer and are presented in figure 65. Installed fuel flow for standard-day conditions is shown in figure 66.

70. Power turbine speed and rotor speed were displayed by a dual-needle tachometer. Within the operating range of the engine, main rotor and engine speed remained matched and were easily controlled by the pilot. Engine/rotor speeds were displayed in percent and could be readily selected by the pilot by the use of the engine beeper trim switch located on the collective control grip. Rotor speed variation with normal power changes was less than 2 percent.

Airspeed System Calibration

71. A ship's pitot-static system was not installed in the test aircraft. The test instrumentation pitot-static system (boom) was calibrated using an F-51 pace aircraft. The results of this calibration test are presented in figure 67, appendix I.

Vibration Characteristics

72. Vibration data were gathered during level flight performance tests. The following fuselage stations were instrumented with vibration sensors: center of gravity, pilot seat, pilot instrument panel, gunner seat, and gunner instrument panel. The vibration instrumentation allowed vertical, lateral, and fore-and-aft vibration characteristics to be evaluated. The vibration characteristics are presented in figures 68 through 82, appendix I, for harmonics of 1/rev, 2/rev, 4/rev, and 6/rev.

73. With the active vibration suppression system (VSS) ON, the highest single-amplitude 2/rev vibration levels were encountered at high airspeeds near maximum power. The pilot seat maximum vibration level was 0.18g vertical and 0.18g lateral; the gunner seat maximum vibration level was 0.25g vertical and 0.18g

lateral. The vibration levels were unpleasant at high power settings but not objectionable; however, during testing, frequent high-amplitude random and sporadic impulse-type inputs, described as thuds, were observed. These inputs were attributed to the VSS and were highly distracting and objectionable. The random inputs from the VSS are a shortcoming, correction of which is desirable.

74. During tests with the VSS inactive (failure mode), very high 2/rev vibration levels were experienced at high airspeeds at maximum power settings (figs. 70 and 72). These vibrations did not limit attainment of maximum level flight airspeeds but were objectionable.

MISSION MANEUVERS

75. The mission maneuver capability was evaluated by conducting accelerations, decelerations, slow-speed nap-of-the-earth flight, pop-ups, bob-ups, high-speed low-level flight, target acquisition, target tracking, and rapid target shift maneuvers. The helicopter was configured with external stores at an average gross weight of 13,500 pounds and an aft cg.

76. The acceleration of the helicopter from hover to 60 KIAS required no large control motions or forces. A nose-low attitude of 20 degrees was required for rapid acceleration, and minimal pilot attention was devoted to maintaining ground clearance. Rotor speed control was satisfactory. The acceleration from hover to 60 KIAS was accomplished with minimal pilot compensation (HQRS 3). The large margin of power available to rapidly terminate at a hover is an enhancing quality. Minimal pilot compensation was required to decelerate from 60 KIAS to hover (HQRS 3). Deceleration was limited by the tendency of the main rotor to overspeed when power was reduced and load factors were applied. Moderate pilot effort was required to control the rotor speed. Forward field of view was blocked by the forward cockpit structure while in the deceleration flare attitude. This poor field of vision degrades the mission effectiveness and is a shortcoming.

77. Low slow-speed nap-of-the-earth flight was evaluated by flying at low altitude (less than 50 feet) over rolling wooded terrain at airspeeds from 30 to 70 KIAS. With force trim ON, the cyclic control force harmony was good, but slightly high compared to the directional control forces. With force trim OFF, the cyclic control was more responsive and in close harmony with the pedals. In both cases, minimal pilot effort was required to achieve the desired rates necessary to accomplish turns, accelerations, and decelerations (HQRS 3). Response of the aircraft to the abrupt collective inputs required for the mission was excellent. Adequate power margin was available. The canopy door support members limited the pilot's lateral field of view at bank angles of 30 to 45 degrees. In level flight, lateral field of view was excellent, and the forward field of view was only slightly restricted by the canopy door supports. The slow-speed nap-of-the-earth flight characteristics are satisfactory.

78. The pop-up and bob-up maneuvers are illustrated in figure B. The pop-up maneuver was accomplished from 40 KIAS in nap-of-the-earth flight. Collective and cyclic were used to climb over a masking object, and target acquisition was simulated. Breakoff and reversal of direction were accomplished at approximately 70 KIAS. Target acquisition was accomplished with minimal effort (HQRS 3). The response at the breakoff was good, and the helicopter was easily and quickly maneuvered back to an area behind the entry position. A hover-up (bob-up) maneuver was accomplished to evaluate handling characteristics during simulated mask breaking and target acquisition. Vertical control was good, and only light control forces were required. Slight yaw oscillations were detectable but did not degrade target acquisition. Pilot effort was not a factor in accomplishing this task (HQRS 2). Within the scope of this test, the pop-up and bob-up maneuver characteristics are satisfactory.

79. High-speed low-level flight was evaluated by flying over wooded rolling terrain at less than 100 feet and speeds between 100 and 140 KIAS with the force trim ON. Low lateral response resulted in reduced agility and required an excessive amount of air space to turn toward obstacles and follow the terrain, thereby increasing vulnerability (para 52). Because of the low lateral response characteristics, moderate pilot effort was required to accomplish turns during high-speed, low-level maneuvers (HQRS 4). Low lateral response is a shortcoming which should be corrected to improve mission effectiveness. Pushover maneuvers were accomplished to 0.5g, and no trim shifts or coupling was observed. The engine exhibited excessive transient torque in turns (increasing torque in left turns and decreasing torque in right turns). This characteristic is also present in the AH-1G. At 130 KIAS and 58-percent torque, the helicopter was rolled at a moderate rate from a 30-degree right bank to a 30-degree left bank. During the roll, the engine torque increased to the limit torque. Considerable pilot compensation was required to prevent an overtorque while maneuvering at high power settings (HQRS 5. The excessive torque increase in a left roll is a shortcoming which should be corrected.

80. Target acquisition and tracking were evaluated by rolling into a simulated firing dive, both left and right, from approximately 90 KIAS. In all cases, initial acquisition was easily accomplished (HQRS 3). Tracking and maintaining the target during the airspeed increase required moderate pilot compensation to keep ball-centered (coordinated) flight and damp out directional oscillations (HQRS 4). Rapid buildup of airspeed combined with the difficulty in maintaining balanced flight during dives reduced the time available for weapons fire delivery. The excessive pilot effort required for target tracking is a shortcoming and should be corrected.

81. During rapid target shifts and diving flight, undesirable sideslips and oscillations occurred Stabilizing on the new target required moderate pilot compensation (HQRS 4). The excessive pilot effort required for rapid target shifts is a shortcoming and should be corrected.

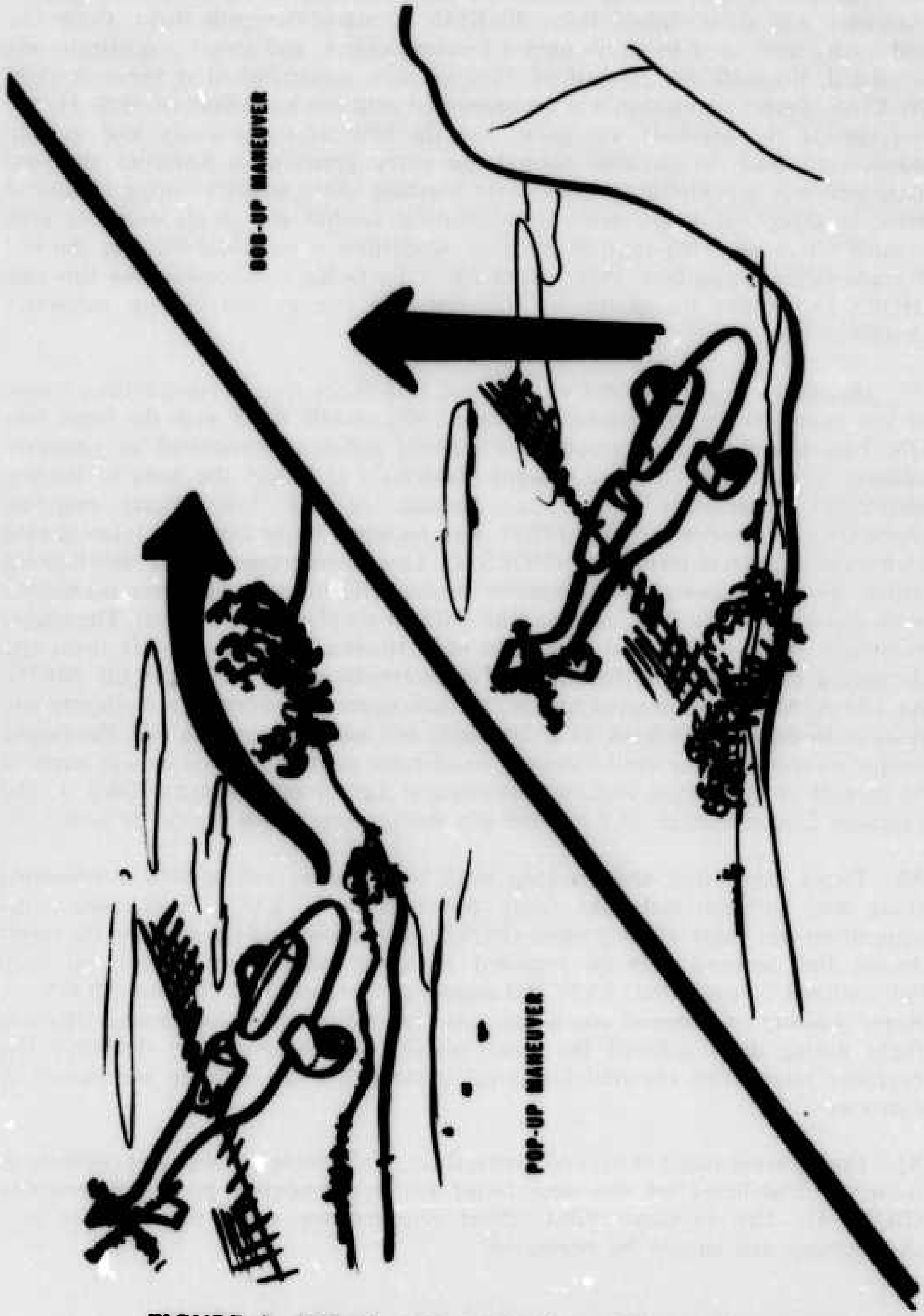


FIGURE B. POP-UP AND BOB-UP MANEUVERS.

FORWARD AREA CONCEALMENT

82. The capability to move the KingCobra across unimproved areas was evaluated by towing an aircraft-towing simulator with standard tactical 1/4-ton and 3/4-ton vehicles using the standard military tow bar. Manual pushing of the aircraft was prohibited by the contractor because the push points had not been designed on the test aircraft. The towing simulator had the same gross weight, cg, undercarriage, and tow-bar attaching points as the aircraft. The gross weight was 13,594 pounds, and the cg was FS 196 (fwd). The area used for the test was a clay type of soil with sparse vegetation and was free of rocks. The average airfield index was 4.0 which converts to a California bearing ratio of 2:3 at a depth of 2 feet.

83. The towing kit consisted of four sets of four detachable wheels mounted in tandem on each skid, a total of 16 wheels. Each set of four wheels weighed 140 pounds. A cable was also attached between the skids just forward of the forward cross tubes during towing. Preparation for towing required four men and took 3 minutes and 6 seconds. The aircraft could be towed on the soft, level, unprepared areas; however, on slightly rolling terrain, the ground clearance was inadequate (2-1/4 to 3 inches), and the skids would hang up and stall the 1/4-ton tow vehicle. The 3/4-ton vehicle could pull the aircraft over uneven terrain. The minimum ground clearance was 11.5 inches for an antenna; clearance to the gun turret was 13.5 inches.

84. The long tandem arrangment of the wheels required a turning radius of 19 feet, 7 inches at the skids, thus giving the aircraft an overall turning radius of the farthest point aft (the tail rotor in a horizontal position) of 55 feet, 4 inches.

MAINTENANCE CHARACTERISTICS

85. The maintainability characteristics of the Model 309 helicopter were evaluated throughout conduct of the flight test program. Evaluated characteristics included ground support equipment, accessibility, interchangeability, identification, servicing, fasteners, cables/connectors, and safety. Failures and maintenance actions also were recorded. Available contractor technical documents, historical data, and current maintenance procedures were reviewed. This review was a limited noninterference evaluation. Only a qualitative evaluation was performed because of the minimal number of program flight hours provided which limited the opportunity to observe component repair and replacements. No formal remove or replace tests were conducted. The aircraft was fully instrumented, a condition that resulted in maintenance complications which should not exist on an operational aircraft. The observations were divided into five categories: (1) airframe, landing gear, fuel system; (2) engine; (3) flight controls, main rotor, power train; (4) hydraulics; and (5) instruments, cockpit, electronics.

86. The following items of airframe, landing gear, and fuel system maintenance characteristics are shortcomings:

a. Lack of work platforms and footholds for forward-airframe, rotor-head, engine areas.

b. Poor accessibility in the interior tail boom area.

c. Tail rotor drive shaft covers permit accumulation of dirt and moisture.

d. Location of components behind removable stress panels. Removal of these panels requires excessive maintenance time and tends to damage the panels and fasteners.

e. Four ground-handling wheel sets which increase maintenance requirements and storage problems.

87. The following flight control, main rotor, and power train maintenance characteristics are shortcomings:

a. Main rotor blade design subject to indetectable moisture leakage and corrosion.

b. Main rotor repair would be difficult in the field.

88. Servicing the two hydraulic systems required special ground support equipment which is not included in Army aviation tables of organization and equipment.

89. The following instrument, cockpit, and electronics maintenance characteristics are shortcomings:

a. Susceptibility to damage of the pilot and copilot hatch seals.

b. Lack of work platforms for maintenance in crew station areas.

c. Limited accessibility to electronics equipment.

d. Electronic equipment stacking which required removal of operable equipment.

90. The following additional maintenance characteristics were observed which required frequent inspections or maintenance:

a. The rear mounts for the engine tended to loosen which caused engine deck bonding separation and loosening of rivets in the engine compartment.

b. Present inspection requirements for hydraulic-boost ball connections are for 20 operating hours between inspection. This inspection required approximately 16 manhours and direct support maintenance facilities. The transmission must be removed to accomplish this inspection. The frequency of inspection and time required to conduct the inspection would impose excessive workloads on maintenance facilities and significant loss of aircraft availability.

c. The elastomeric transmission mounts are prone to permanent distortion during maneuvering flight at high-g loads. Twice during the test the mounts were changed due to distortion. Mount change required transmission removal at direct support maintenance facilities and approximately 12 manhours.

d. The transmission mount rubber lining was deformed or penetrated during high-g maneuvers. Lining replacement requires transmission removal and required approximately 16 manhours for replacement of field maintenance.

e. Daily flight inspection of the main rotor blades required approximately 0.5 manhour. This extended the normal day-to-day requirements of the daily inspection.

f. Tail rotor pitch change bell-crank bearing appeared to wear rapidly and required frequent changing.

g. Rivets in synchronized elevator, tail rotor vertical fin, and engine deck installation to airframe tended to loosen.

CONCLUSIONS

GENERAL

91. The following conclusions were reached upon completion of testing:

a. The following highly desirable features were identified:

(1) Capability to hover OGE at maximum gross weight at 5000 feet on a 95°F day (para 11).

(2) Liftoff to a hover at a constant level attitude (para 27).

(3) The lack of noticeable lateral trim shift with airspeed (para 35).

(4) Large margin of power available to rapidly terminate at a hover (para 76).

b. Numerous undesirable characteristics of the flight control system degraded the aircraft handling qualities.

c. One deficiency and 23 shortcomings were noted.

DEFICIENCY AND SHORTCOMINGS AFFECTING MISSION ACCOMPLISHMENT

92. Correction of the following deficiency is mandatory: inability to correct rapid and large yaw excursions within the allowable tail rotor horsepower limit (para 34).

93. Correction of the following shortcomings is desirable. These shortcomings are listed in the order that they appear in the text and not necessarily in the order of importance.

a. Motoring of cyclic control with friction and force trim OFF (para 23).

b. Erratic cyclic control forces (para 23).

c. Slippage of directional pedal force trim (para 24).

d. Excessive collective control breakout force (para 25).

e. Feedback forces in cyclic control during hover with SCAS ON (para 27). (para 27).

f. Random roll excursions during a hover with SCAS ON (para 27).

g. Moderate pilot effort required to maintain heading and attitude in left lateral accelerations (HQRS 4) (para 30).

h. Considerable pilot effort required to maintain heading during lateral flight reversals (HQRS 5) (para 30).

i. Control forces released suddenly following force trim release (para 37).

j. Vernier trim operation was ineffective (para 38).

k. Considerable pilot effort was required for precise heading and attitude control in turbulence (HQRS 5) (para 45).

l. Excessive 2/rev vibration levels were observed in high power maneuvering flight (para 54).

m. Engine torque increased excessively with increased load factor (para 55).

n. Transient motion in cyclic controls occurred during SCAS engagement (para 59).

o. Roll excursions occurred in turbulence with ARU ON (para 61).

p. Cyclic control forces varied with ARU ON (para 61).

q. The environmental control unit was distracting (para 63).

r. Engine shutdown required holding throttle closed (para 67).

s. Random inputs were observed in the vibration suppression system (para 73).

t. Low lateral response degraded mission effectiveness (para 79).

u. Excessive transient engine torque was observed in left rolls (para 79).

v. Moderate pilot effort was required for target tracking (HQRS 4) (para 80).

w. Moderate pilot effort was required for target shifts (HQRS 4) (para 81).

SPECIFICATION CONFORMANCE

94. Within the scope of this test, the Model 309 helicopter failed to meet the following requirements of the military specification, MIL-H-8501A:

a. Paragraph 3.2.8 - Transient forces in the longitudinal cyclic control (para 23).

b. Paragraph 3.3.11 - Directional control maximum force of 32 pounds exceeded the 15-pound requirement by 17 pounds (113 percent) (para 24).

c. Paragraph 3.3.13 - Directional control breakout including friction force of 10 pounds exceeded the 7-pound limit by 3 pounds (43 percent) (para 24).

d. Paragraph 3.3.14 - Transient forces in the lateral cyclic control (paras 23 and 27).

e. Paragraph 3.3.19 - Directional control damping of 28,300 ft-lb/rad/sec was less than the minimum requirement of 29,584 ft-lb/rad/sec, by 1284 ft-lb/rad/sec (4.3 percent) (para 22).

f. Paragraph 3.4.2 - Collective control breakout of 9.5 pounds exceeded the 3-pound limit by 6.5 pounds (217 percent) (para 25).

g. Paragraph 3.5.4.1 - Satisfactory vertical takeoffs and landings could not be accomplished in gusty winds (para 34).

h. Paragraph 3.5.9(a) - Switching transient when engaging the SCAS (para 59).

RECOMMENDATIONS

95. The deficiency identified during this evaluation must be corrected (para 92).

96. The shortcomings, correction of which is desirable, should be corrected (para 93).

APPENDIX A. REFERENCES

1. Letter, AVSCOM, AMSAV-EF, 9 March 1972, subject: Attack Helicopter Evaluation of the Model 309 Helicopter, Project No. 72-10.

2. Military Specification, MIL-C-5011A, *Charts; Standard Aircraft Characteristics and Performance, Piloted Aircraft*, 5 November 1951.

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

4. Checklist, Bell Helicopter Company, "Model 309 Pilot's Checklist" (undated).

5. Flight Test Manual, Naval Air Test Center, FTM No. 101, *Helicopter Stability and Control*, 10 June 1968.

6. Flight Test Manual, Naval Air Test Center, FTM No. 102, *Helicopter Performance Testing*, 28 June 1968.

7. Military Standard, MIL-STD-810B, *Environmental Test Methods*, 15 June 1967.

APPENDIX B. AIRCRAFT DESCRIPTION

FUSELAGE

1. The fuselage of the Model 309 KingCobra has the general structural and space arrangement of the AH-1G. Compared with the AH-1G, the following significant improvements are incorporated. The pylon suspension system incorporates a four-point, focused, elastomeric arrangement to minimize vibration. The main beams are stiffened to improve fuselage frequency response. The canopy has additional frames to stiffen it and to simplify the construction and interchangeability of the hinged entrance doors.

WINGS

2. Stub wings mounted on the fuselage supply some additional lift at high speeds and provide mounting accommodations for weapons pylons. The wing structure is built up with aluminum alloy spars and ribs covered with sheet aluminum skin.

TAIL BOOM

3. The semimonocoque tail boom is similar to that of the AH-1G, but is 35 inches longer. It supports the cambered fin, the ventral fin with tail skid, the elevator, the tail rotor, the tail rotor drive system, and necessary controls.

LANDING GEAR

4. The landing gear is similar to that of the AH-1G, but is 3 inches higher to provide ground clearance.

ROTOR SYSTEM

5. The door-hinged hub main rotor assembly is a two-bladed, semirigid, underslung pitch change (feathering axis) type rotor. The blades are attached to the grip by a retaining bolt and drag brace. The blade centrifugal loads are carried by a tension torsion strap between the grip and the yoke spindle. Elastomeric seals are used between the grip and spindles. The yoke flexure is attached to the trunion by means of two elastomeric flapping axis bearings which require no lubrication. The blades are primarily all-aluminum bonded construction, except the leading edge stainless steel abrasive strips, the forward sweep tip section, and the steel grip plates. The blade employs a Wortmann airfoil with a double swept tip incororating an approximate 7.7-degree negative twist. Each blade has a 40-pound tip weight. Control horns for cyclic and collective control input are mounted on the trailing edge of the blade grip.

TAIL ROTOR

6. The tail rotor is a two-bladed, controllable pitch tractor assembly mounted on the right side of the vertical fin. The blades are of all-metal construction with a stainless steel spar and aluminum skin bonded to an aluminum honeycomb core. Pitch horns are located on the trailing side of the blade. The yoke is a steel flex beam type with an approximate 1.5-degree precone with six self-aligning uniball bearings. The yoke is mounted to the output shaft of the 90-degree gearbox by two trunion halves, the inner half providing the flapping stop.

TRANSMISSION AND SUSPENSION SYSTEM

7. Compared to the AH-1G, the transmission was improved to permit operation at increased torque. The transmission provides output to the main and tail rotor speed by means of a three-stage reduction: one spiral-bevel gear stage and two planetary stages. The transmission incorporates a free-wheeling clutch unit at the input drive. This provides a disconnect from the engine and allows the rotor to autorotate in the event of an engine failure. The transmission is suspended at each of its four corners by two laminated elastomeric mounts inclined so that the stiff axes of the four are focused at a point below the mounting plane, near the center of gravity. This mounting system is designed to reduce the tranmission inplane rotor forces and to improve the pylon stability characteristics. A torque shaft is mounted to the rear of the transmission with links attached to the transmission adapter assembly to absorb the twisting torque of the assembly during operation.

ENGINE

8. The Lycoming T55-L-7C shaft turbine engine is derated to a maximum continuous rating of 1850 shaft horsepower (shp) and a takeoff rating of 2050 shp. This reduction in operating shaft horsepower reduces compressor speed, and turbine inlet temperature. The installation is similar to that of the T53 in the AH-1G, but includes a speed-reducer gearbox which reduces the governed output of the power turbine to 6475 rpm.

ENGINE POWER CONTROL SYSTEM

9. The collective levers at both crew stations have twist-grip throttles and engine-rpm control switches. The interconnected twist grips activate push-pull controls that lead to the engine power control. The engine-rpm control switch is a three-position momentary-contact beeper switch. Engaging the switch increases or decreases engine speed by powering an electric actuator attached to the engine speed control lever. A cam in the collective pitch control system compensates for droop by moving the complete electric actuator and, in turn, the rpm control, thus tending to keep engine speed constant with changes in power settings.

FUEL SYSTEM

10. The fuel system controls are located on the pilot engine/power control panel just forward of the collective control lever. The fuel system consists of two interconnected rubber fuel cells, each with a sump and submerged fuel boost pump, capacitor-type fuel quantity probe, and a low-fuel-level warning switch. Also included in the system are a shutoff valve, fuel pressure switches and transmitter, quantity gage, and caution lights. The fuel system is serviced by a filler cap located on the right side of the helicopter just above and forward of the wing. Drain and defueling valves are located inside access panels on the lower fuselage.

BASIC AIRCRAFT INFORMATION

11. Additional aircraft descriptive data are shown in the following listing and three-view drawing:

Airframe

Height over highest point of helicopter	13.9 ft
Length:	
Maximum, rotor blades extended (rotating and positioned)	59.3 ft
Minimum, main rotor blades removed	48.74 ft
Width:	
Main fuselage	36 in.
Canopy	38 in.
Ground angle, nose-up	Zero deg
Overturn angle about skid contact line	27 deg
Tread of skid gear	6.67 ft
Length of skid gear	11.1 ft
Inclination of main rotor shaft:	
Longitudinal	Zero deg
Lateral	Left 1-1/2 deg

Minimum clearance between rotors	1.13 ft
Static ground clearance of rotor blades (main)	6.6 ft
Span, maximum, main rotor blades turning	48 ft
Wing:	
Span	10.33 ft
Chord (tip)	2.63 ft
Exposed panel area	19.6 ft^2
Effective area	26.6 ft^2
Aspect ratio	3.76
Horizontal stabilizer:	
Span	6.83 ft
Chord	33 in.
Root	29.38 in.
Taper ratio (includes carry-through)	1.54
Tip	21.38 in.
Thickness	11.6 percent
Area (includes carry-through)	15.1 ft^2
Airfoil section	Clark Y (inverted) (modified)
Gearing to longitudinal cyclic	Nonlinear
Aspect ratio	3.09
Vertical stabilizer (includes ventral fin):	
Span	8.67 ft
Taper ratio	2.0

Airfoil section	Cambered
Area	26.0 ft^2
Aspect ratio	2.89

<u>Main Rotor</u>

Number of blades	2
Diameter	48 ft
Disc area	1809.6 ft^2
Blade chord	33 in.
Rotor solidity	0.073
Metal blade area	132 ft^2
Blade airfoil	FX098
Leading edge tip sweep:	
0.82 right to 0.90 right	36 deg (fwd)
0.90 right to 1.00 right	52 deg (aft)
Linear blade twist	-7.68 deg
Normal tip speed (311 rpm)	782 ft/sec

<u>Antitorque Rotor</u>

Number of blades	2
Diameter	9.97 ft
Disc area	73.43 ft^2
Blade chord	11.5 in.
Rotor solidity	0.126
Total blade area	9.67 ft^2

Blade airfoil	BAS00T003 (sym 10.5-percent thick)
Linear blade twist	Zero deg
Pitch-flap coupling (δ_3)	45 deg
Normal tip speed (1615 rpm)	818 ft/sec
Tail rotor arm	29.68 ft

<u>**Engine-to-Transmission Fixed-Drive Ratios**</u>

Engine output shaft to main rotor	21.228:1
Engine output shaft to tail rotor	4.088:1

APPENDIX C. FLIGHT CONTROL DESCRIPTION

GENERAL

1. Flight control in the KingCobra is provided by conventional helicopter cyclic, collective, and pedal controls. The linkages and boost system are similar to those of the AH-1 helicopter. The pilot and gunner controls are mechanically interconnected. The pilot collective and cyclic controls have adjustable friction devices. Both sets of pedals have provisions for fore-and-aft adjustment.

HYDRAULIC SYSTEM

2. The KingCobra incorporates two independent hydraulic systems, with separate mechanical drives, to power the flight controls and the automatic flight control system (AFCS). The hydraulic system is illustrated in figure 1.

3. Each system contains its own reservoir, transmission-driven pump, filter module, pressure-operated valve, self-sealing quick-disconnect fittings for ground test, and fluid conduit lines. The main rotor hydraulic flight control system has three irreversible servo-actuator packages: one for collective pitch, one for longitudinal cyclic pitch, and one for lateral cyclic pitch. Each package consists of a dual-tandem actuator, a dual-tandem manually operated valve assembly, two bypass check valves, an isolation check valve, a thermal relief valve, and a pressure-operated return shutoff valve. Each hydraulic system supplies hydraulic pressure to one-half of each dual-tandem actuator, and normal operation of the main rotor hydraulic flight controls uses both hydraulic systems simultaneously. The entire flight control system may be operated with either hydraulic system inoperative. In this case, the remaining system powers its corresponding portion of each flight control actuator. The unpowered half of each servo actuator idles in bypass. The electrical control circuitry is arranged to preclude turning both systems OFF simultaneously. The directional control system does not have tandem actuators and is connected to only one hydraulic system. The actuator package consists of a steel cylinder, a manually operated valve assembly, two bypass check valves, two relief valves set to limit the actuator output loads, and a pressure-operated return shutoff valve. The pilot controls the actuator through the manually operated servo valve. When the hydraulic system is lost or turned off the return passage in the actuator is automatically blocked and an irreversible valve reacts to external loads applied to the actuator.

ELEVATOR CONTROL

4. The elevator control system consists of a series of bell cranks, levers, and push-pull tubes similar to those of the AH-1G.

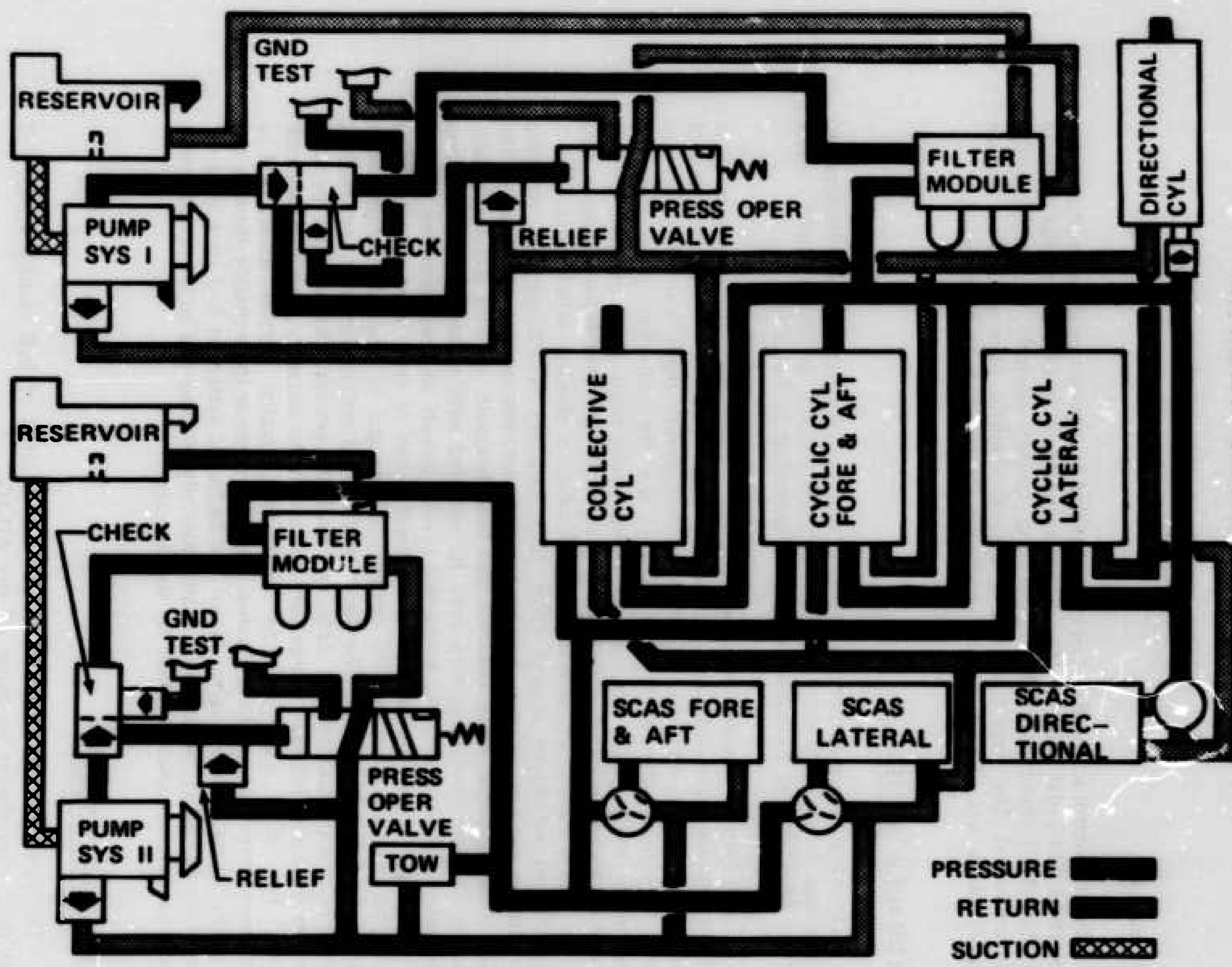


Figure 1. Hydraulic System.

FORCE TRIM

5. A magnetic brake and spring system is used in the longitudinal, lateral, and directional control systems. The springs hold the cyclic and pedals in any selected position and provide control force feel. The system is disengaged by depressing the trim release button on the cyclic. The force-feel system may be turned OFF by means of a switch on the left-hand console panel.

CYCLIC CONTROL GRIP

6. The cyclic grip has control switches for the force trim, stability and control augmentation system (SCAS), and the AFCS. With the attitude retention unit (ARU) engaged, a beeper switch on the cyclic grip allows trimming of the aircraft to a new attitude. Figure 2 shows the cyclic grip.

COLLECTIVE CONTROL

7. The collective pitch control is located to the left of the pilot and has a rotating grip-type throttle. A hydraulic actuator in the control linkages is used to amplify the command forces and prevent control loads from feeding back to the collective stick. In the case of loss of hydraulic pressure, the actuator forms a direct mechanical linkage. A series of bell cranks, push-pull tubes, and levers link the collective control to the collective lever on the mast.

TAIL ROTOR PITCH CONTROL PEDALS

8. The directional pedals control the pitch of the tail rotor through a series of mechanical linkages which, unlike the AH-1G, include no cable or pulley linkages.

AUTOMATIC FLIGHT CONTROL SYSTEM

9. The AFCS is a three-axis, multi-mode stabilization system. The system has two basic modes of operation: SCAS and ARU. The SCAS provides rate damping in all axes. The ARU provides three-axis attitude stabilization and includes a trim-through/fly-through capability. The AFCS schematic is presented in figure 3.

10. The SCAS is a three-axis, limited-authority, rate-referenced stability augmentation system. The system uses three electro-hydraulic servo actuators, control motion transducers, and a sensor/amplifier unit. As shown in figure 4, a control linkage from the SCAS actuator pivots about the cockpit control linkage which is mounted to the airframe. The linkage is intended to permit SCAS to operate without affecting the cockpit linkage while differentially mixing the actuator output with pilot control inputs.

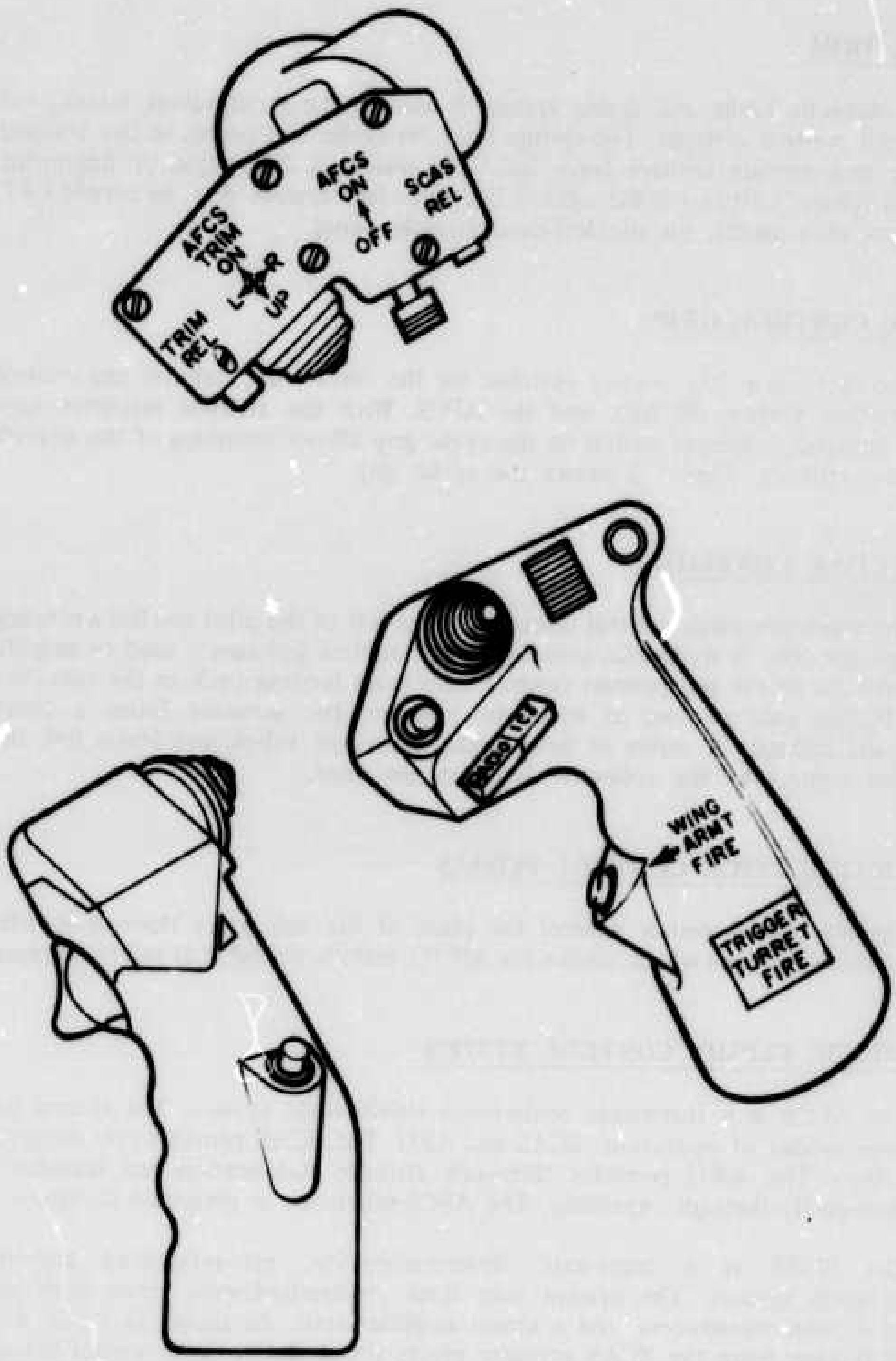


Figure 2. Cyclic Control Grip.

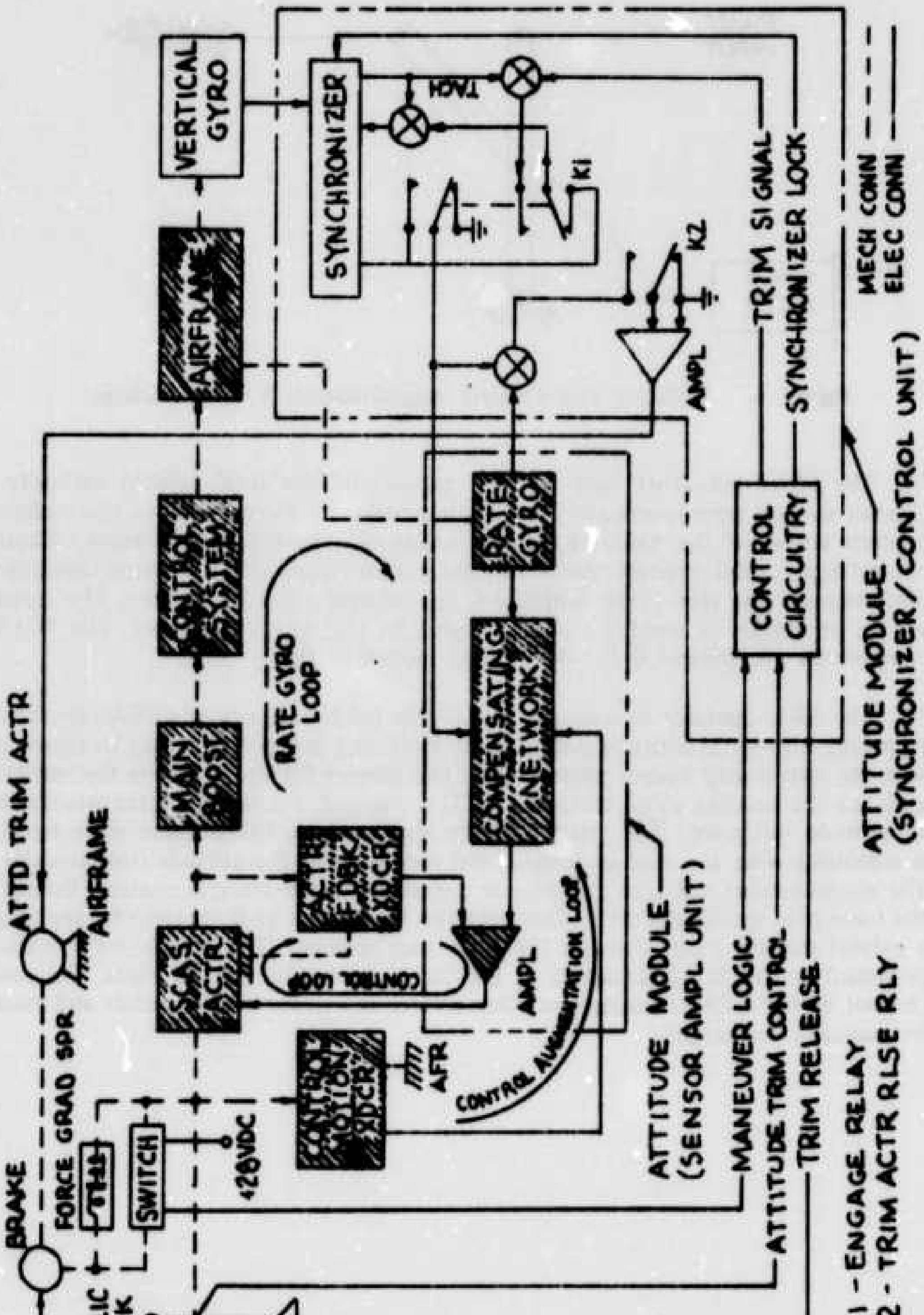


Figure 3. Stability and Control Augmentation System.

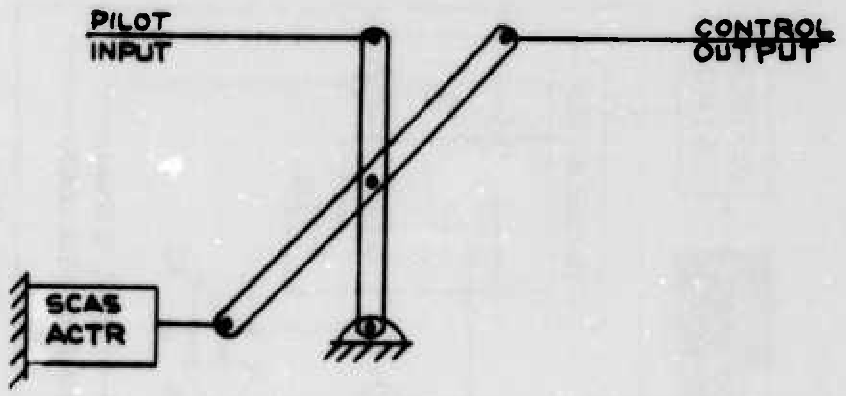


Figure 4. Stability and Control Augmentation System Linkage.

11. The SCAS actuators have ±12-1/2 percent of the total control authority. Control motion transducers are film-type potentiometers connected to the cockpit controls ahead of the electro-hydraulic actuators. The transducers sense cockpit control inputs and process them into the sensor/amplifier. The sensor/amplifier unit contains the rate gyros, amplifiers, and general control circuitry. The signal to the amplifiers is used to send a signal to the SCAS actuators. The SCAS components are indicated by the shaded blocks in figure 3.

12. The ARU operates in conjunction with the pitch, roll, and yaw SCAS circuitry to provide three-axis attitude stabilization. Pitch and roll attitudes may be trimmed with the cyclic grip beeper switch. The basic sensors for the ARU are the vertical gyro and the heading gyro. When the ARU is engaged, the synchronizer establishes an attitude reference. The output of the synchronizer, the attitude error signal, is combined with the rate gyro signal and processed to the attitude trim actuator. The electromechanical trim actuator is connected to the cockpit controls through the force trim spring assembly. This actuator corrects an attitude error by applying a parallel control input through the force trim springs. The attitude error is also processed to the SCAS actuators to provide supplemental control input. The yaw channel of the ARU is disengaged when a force is exerted on the pedals and must be manually reengaged.

APPENDIX D. PHOTOGRAPHS

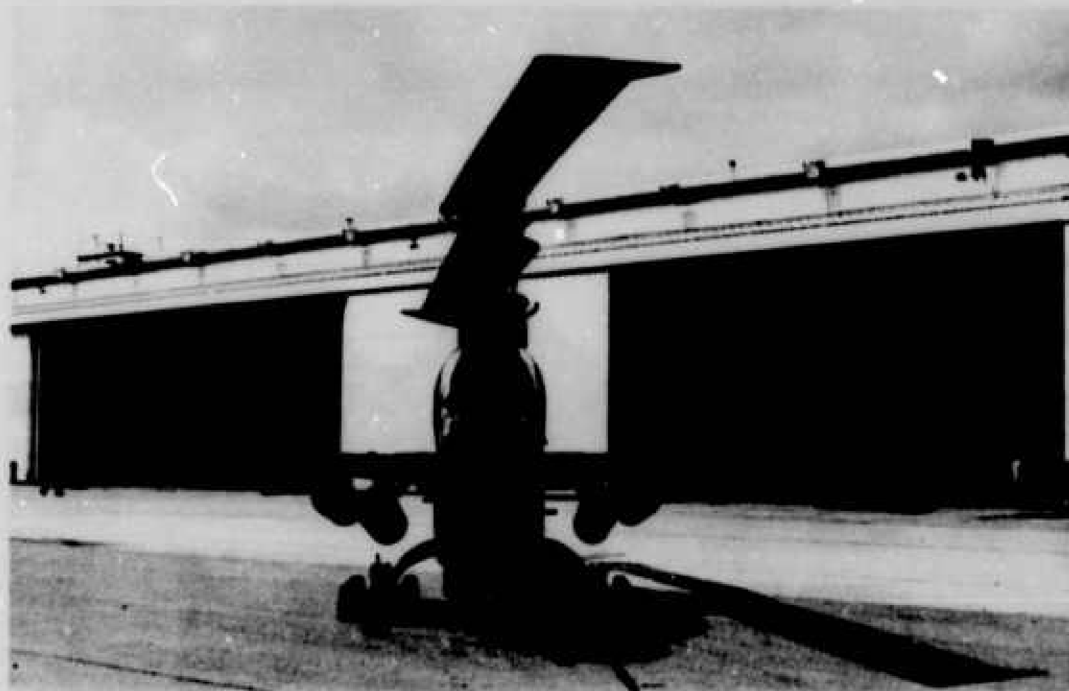


Photo 1. Model 309 KingCobra, Front View, External Stores Configuration.

Photo 2. Model 309 KingCobra, Right Front View, External Stores Configuration.

Photo 3. Model 309 KingCobra, Right Side View, External Stores Configuration.

Photo 4. Model 309 KingCobra, Rear View, External Stores Configuration.

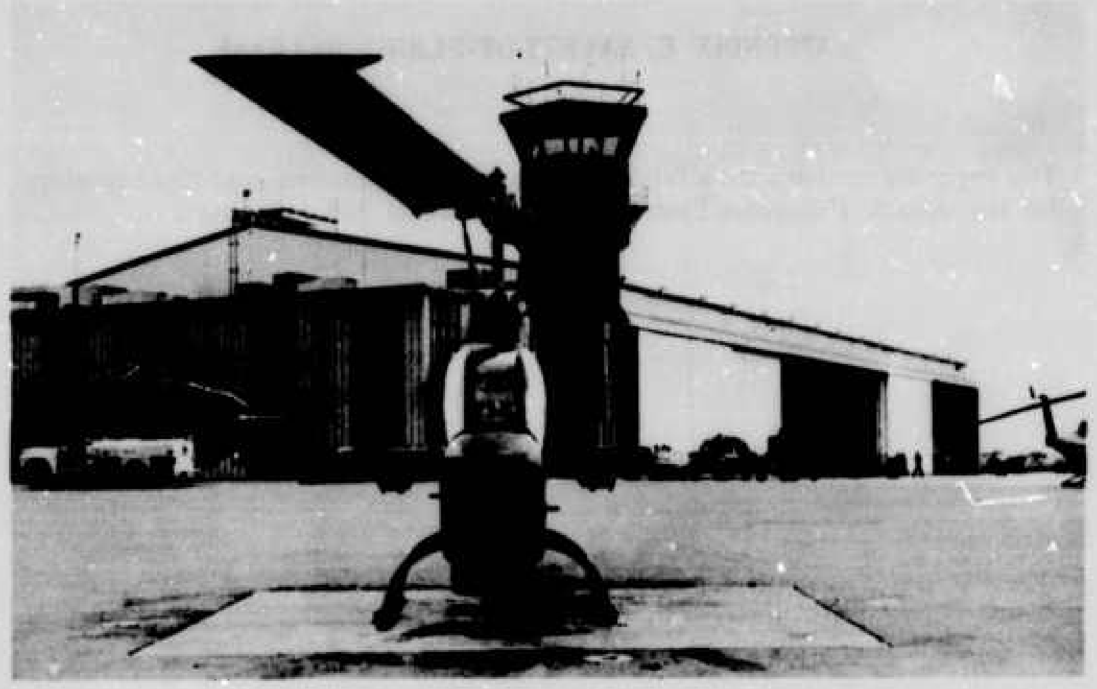


Photo 5. Model 309 KingCobra, Front View, Clean Configuration.

Photo 6. Model 309 KingCobra, Left Side View, Clean Configuration.

APPENDIX E. SAFETY-OF-FLIGHT RELEASE

This appendix contains the safety-of-flight release, amendments, and flight envelope for the Attack Helicopter Evaluation of the Model 309 helicopter.

DEPARTMENT OF THE ARMY
HEADQUARTERS, US ARMY AVIATION SYSTEMS COMMAND
PO BOX 209, ST. LOUIS, MO 63166

AMSAV-EF

2 JUN 1972

SUBJECT: Safety of Flight Release for the Bell Model 309 KingCobra Flight Evaluation

Commanding Officer
US Army Aviation Systems
Test Activity
ATTN: SAVTE-P

1. This letter constitutes a safety of flight release for day VFR flight of the Bell Model 309 KingCobra for conduct of the ASTA flight evaluation.

2. Operating Limitations are as follows:

a. Airspeed Limitations:

(1) Forward Flight

(a) The maximum authorized forward flight airspeed versus density altitude is shown in Figure 1.

(b) The maximum authorized airspeed for shaft horsepowers (SHP) greater than 1350 is that maximum level flight airspeed (V_H) obtainable with not more than 2050 SHP.

(2) Sideward Flight and Rearward Flight.

(a) The maximum authorized airspeeds for sideward flight are:

Gross Weight	
10,000 lb	40 knots left or right
14,000 lb	35 knots left 30 knots right

(b) The maximum authorized rearward flight speeds are:

Gross Weight	
10,000 lb	40 knots
14,000 lb	35 knots

(3) Stabilized Autorotation . . . 60 to 120 KCAS

b. Sideslip. The maximum authorized sideslip angle versus calibrated airspeed is shown in Figure 2.

c. Load Factor. The maximum authorized load factor versus calibrated airspeed is shown in Figure 3.

d. Gross Weight and Center of Gravity. The gross weight - center of gravity envelope is shown in Figure 4.

e. Altitude.

(1) The maximum authorized density altitude for maneuvering flight to the load factor limits of Figure 3 is 4,000 feet.

(2) Density altitudes up to 8,000 feet are authorized for this test subject to:

(a) The normal load factor shall be limited to one "g" to the maximum extent practicable for all density altitudes above 4,000 feet.

(b) The airspeed reduction shown in Figure 1.

f. Autorotation.

(1) Intentional autorotational touchdown landings are not authorized.

(2) Gradual power reduction to an intentional autorotative condition is authorized, however, intentional rapid power reductions (throttle chops) to an autorotative condition are not authorized.

g. Slope Landings. Slope landings shall be limited to cross slope landings on slopes not to exceed 15 degrees.

h. External Stores.

(1) External store configurations are limited to symmetric configurations only.

(2) Jettisoning of external stores is not authorized except in the case of an emergency.

i. Stability and Control Augmentation System (SCAS).

(1) SCAS shall be fully functional for all flights. This does not preclude turning the system off as necessary for test and evaluation.

(2) In the event of an in-flight SCAS failure terminate test and land as soon as practical.

(3) Intentional SCAS hardover failure evaluation is not authorized.

j. Rotor Speed Limits.

(1) Maximum power off . . . . 326 rpm (108% N_2)

(2) Maximum power on . . . . 311 rpm (100% N_2)

(3) Minimum power on . . . . 306 rpm
(Hover only) 290 rpm

(4) Minimum power off . . . . 295 rpm

(5) Gauge Markings.

(a) Red radial at 326 rpm

(b) Red radial at 311 rpm

(c) Green arc from 306 to 311 rpm

(d) Red radial at 295 rpm

(e) Yellow arc from 290 to 306 rpm

k. Transmission Limits.

(1) Torque

(a) Maximum (5 minutes) 80%

(b) Maximum (continuous) 72%

(c) Continuous at airspeeds greater than V_H 50%

(d) Gauge Markings:

1 Red radial at 80%

2 Red radial at 50%

3 Green arc to 72%

4 Yellow arc 72% to 80%

(2) Oil Temperature

(a) Maximum . . . . 110°C

(b) Gauge marking - red radial at 110°C

(3) Oil Pressure

(a) Maximum . . . . . 70 psi

(b) Minimum . . . . . 30 psi

(c) Gauge markings:

1 Red radial at 70 psi

2 Green arc from 40 psi to 60 psi

3 Red radial at 30 psi

1. Engine Limits.

(1) Measured Gas Temperature

(a) Transient (5 seconds) . . . . 815°C

(b) Maximum (10 minutes) . . . . 665°C

(c) Military (30 minutes) . . . . 645°C

(d) Normal (continuous) . . . . 620°C

(e) Gauge markings:

1 Red radial at 815°C

2 Red radial at 665°C

3 Blue arc from 645°C to 665°C

4 Yellow arc from 620°C to 645°C

5 Green arc from 400°C to 620°C

(2) Oil Pressure

(a) Minimum at ground idle . . . . . 10 psi

(b) Minimum at 70% N_1 . . . . . . 40 psi

(c) Maximum . . . . . 110 psi

(d) Gauge markings:

1 Red radial at 110 psi

2 Green arc from 50 psi to 90 psi

3 Yellow arc from 40 psi to 50 psi

4 Red radial at 10 psi

(3) Oil Temperature

(a) Maximum . . . . 135°C

(b) Gauge marking, red radial at 135°C

(4) Gas Producer Speed (N_1)

(a) Transient (3 second) . . . . 18,769 rpm (100%)

(b) Maximum (10 minutes) . . . . 18,300 rpm (98%)

(c) Military (30 minutes) . . . . 17,900 rpm (96%)

(d) Normal (continuous) . . . . 17,500 rpm (93%)

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SUBJECT: Safety of Flight Release for the Bell Model 309 KingCobra Flight Evaluation

(c) Gauge markings:

1 Red radial at 100%

2 Red radial at 98%

3 Blue arc from 96% to 98%

4 Yellow arc from 93% to 96%

5 Green arc from 70% to 93%

(5) Fuel Pressure

(a) Maximum . . . . 35 psi

(b) Minimum . . . . 5 psi

(c) Gauge markings:

1 Green arc from 5 psi to 35 psi

2 Red radial at 5 psi

FOR THE COMMANDER:

4 Incl
as

ROBERT D. HUBBARD
Acting Chief, Flt Std & Qual.Div
Directorate for RD&E

Copy furnished:
ASTA Test Team
Ft. Worth, Texas

Commanding Officer
US Army Bell Plant Activity
P.O. Box 1605
Ft. Worth, Texas 76101

AMSAV-EF
SUBJECT: Safety of Flight Release for the Bell Model 309 KingCobra Flight Evaluation

Copy furnished con't
Commanding General
US Army Materiel Command
ATTN: AMCRD-FQ
AMCSF-A

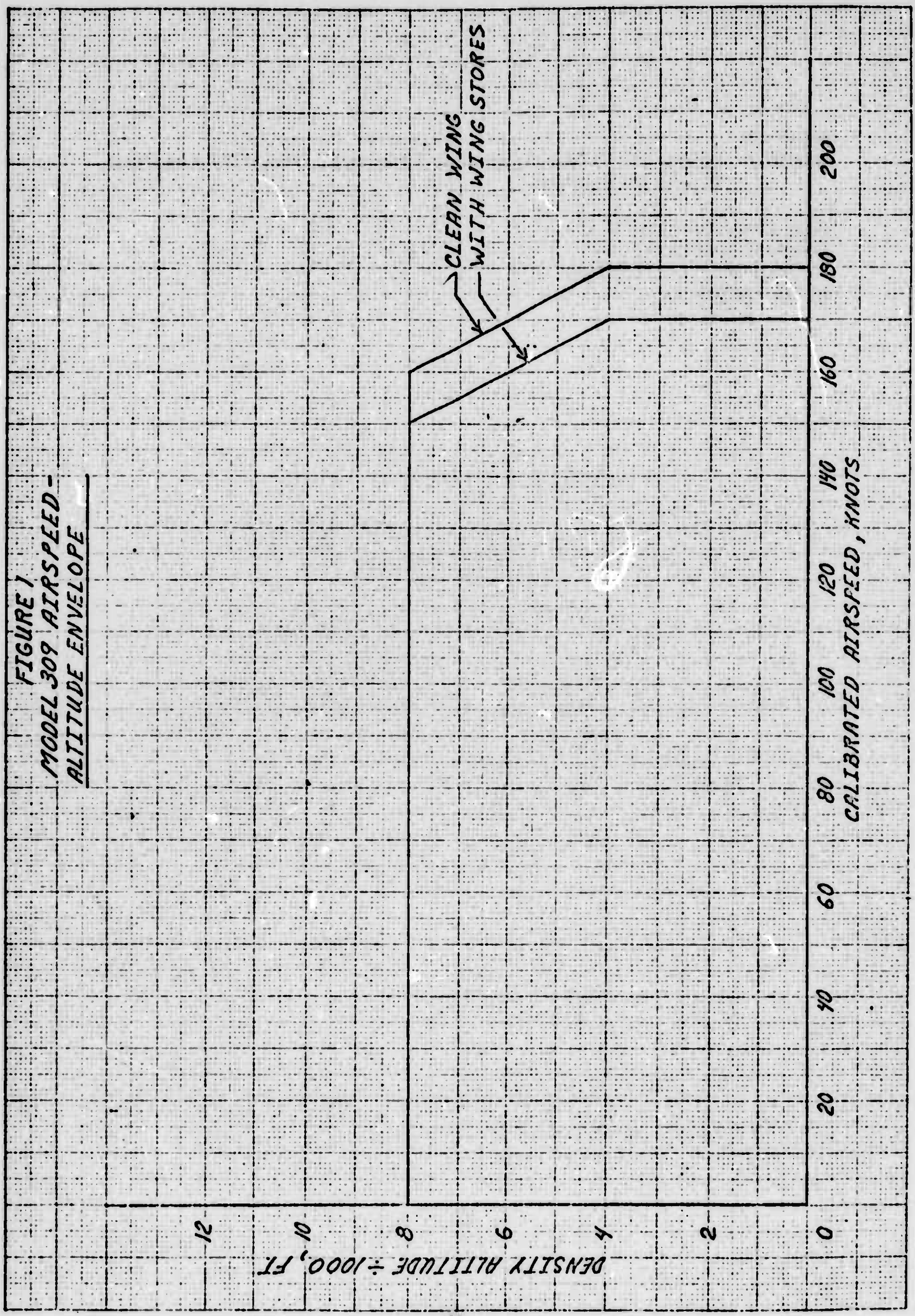


FIGURE 1
MODEL 309 AIRSPEED-ALTITUDE ENVELOPE

FIGURE 2
MODEL 309 AIRSPEED – SIDESLIP ENVELOPE

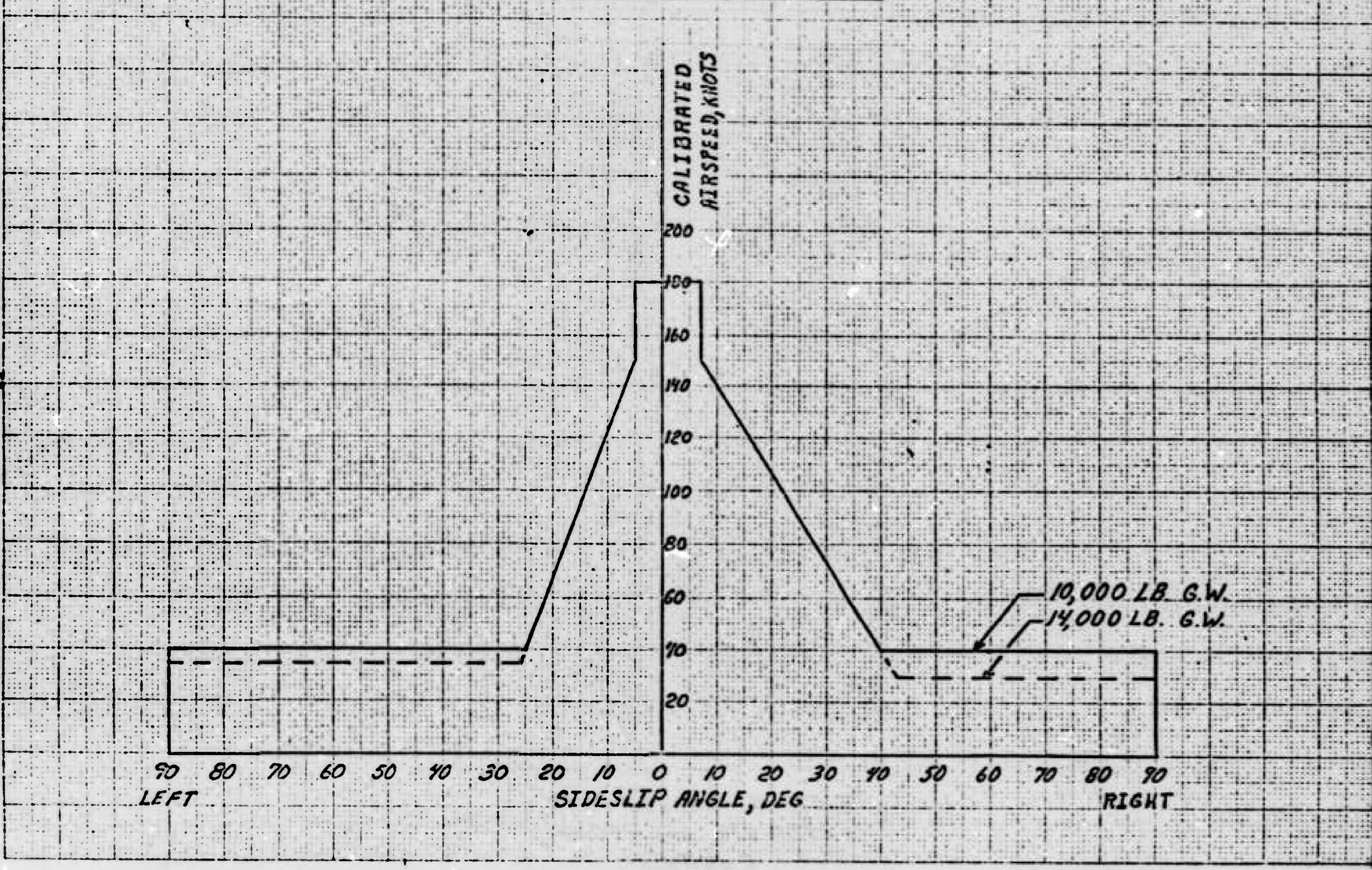


FIGURE 3
MODEL 309 AIRSPEED-
LOAD FACTOR ENVELOPE

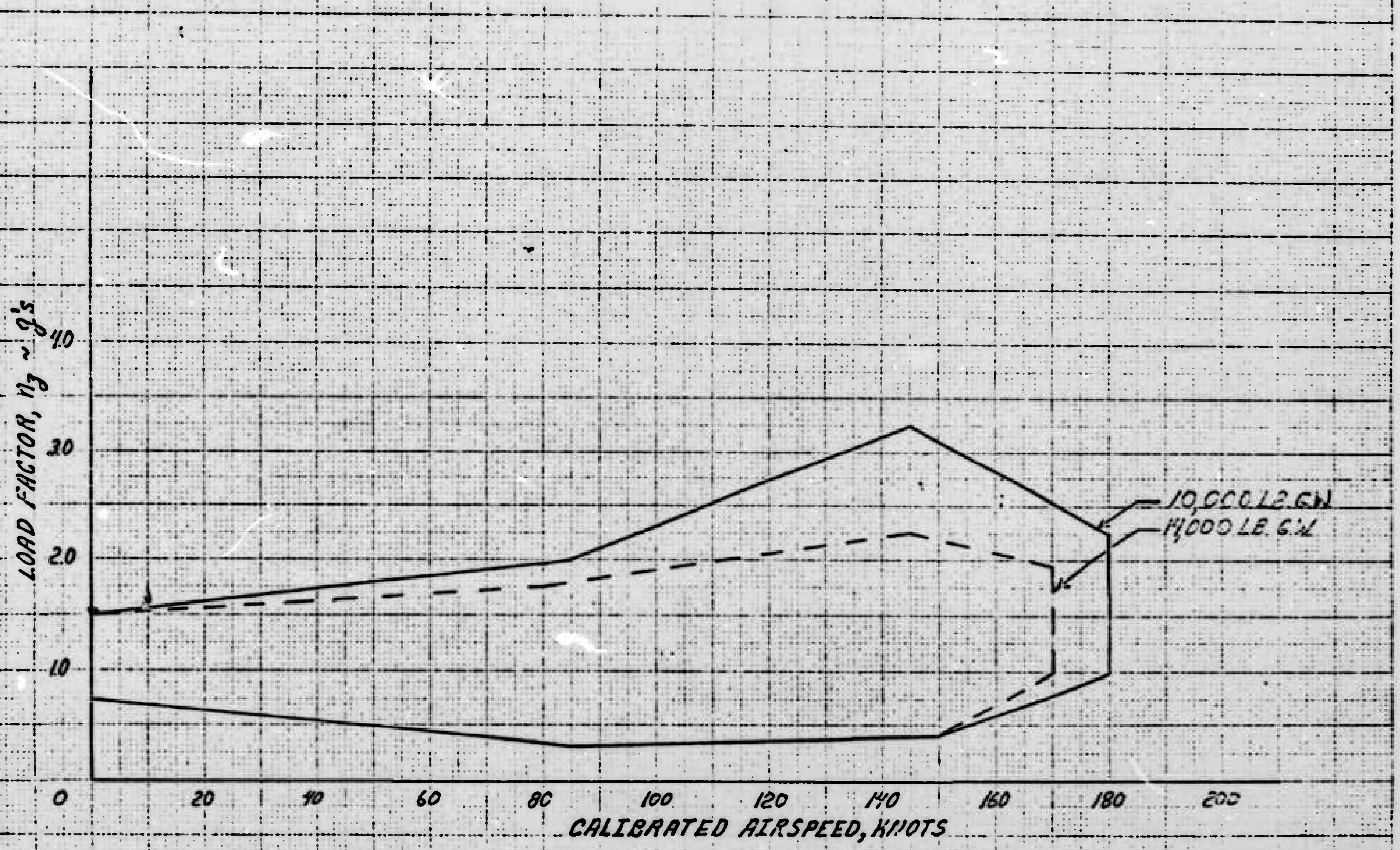
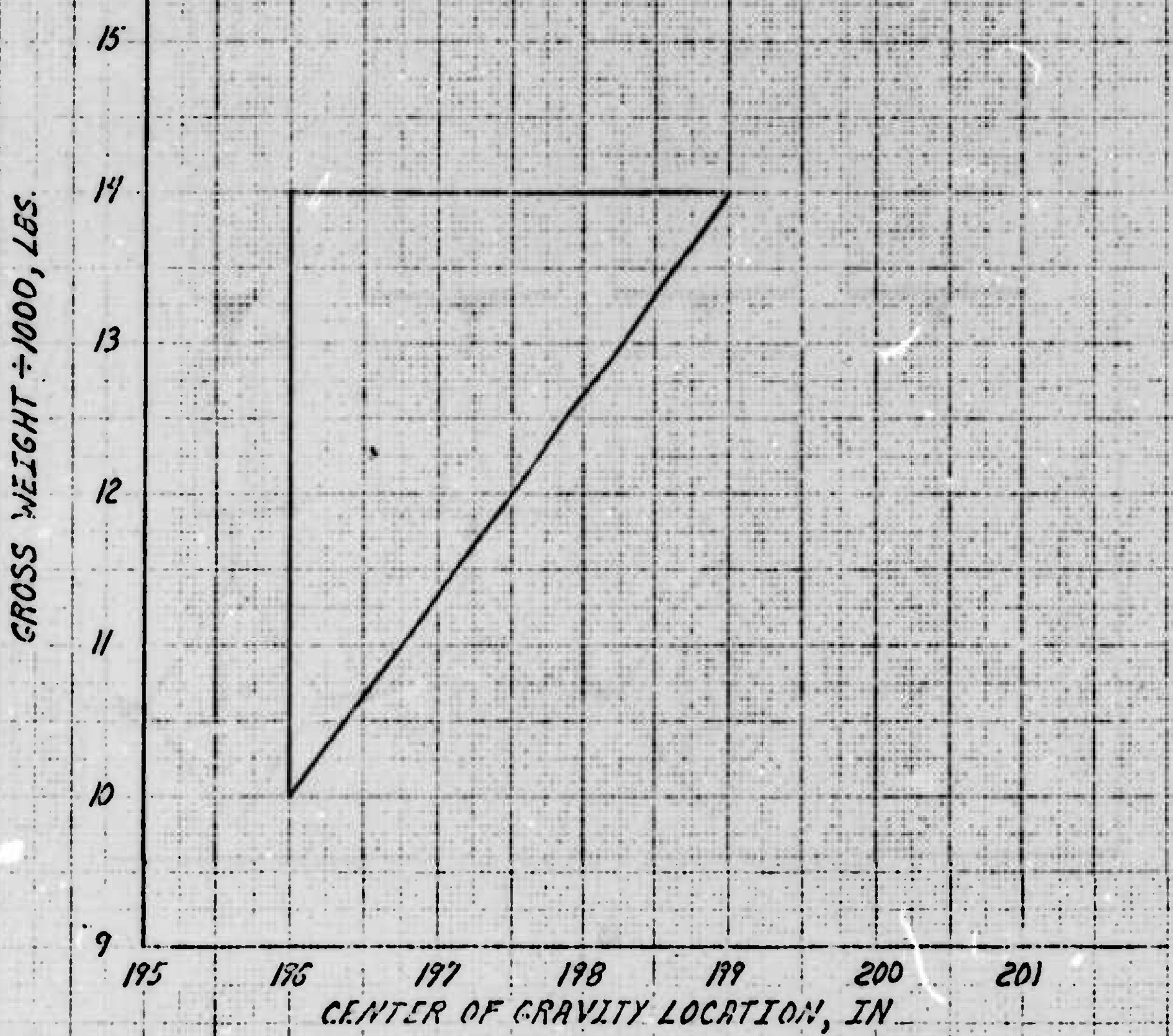
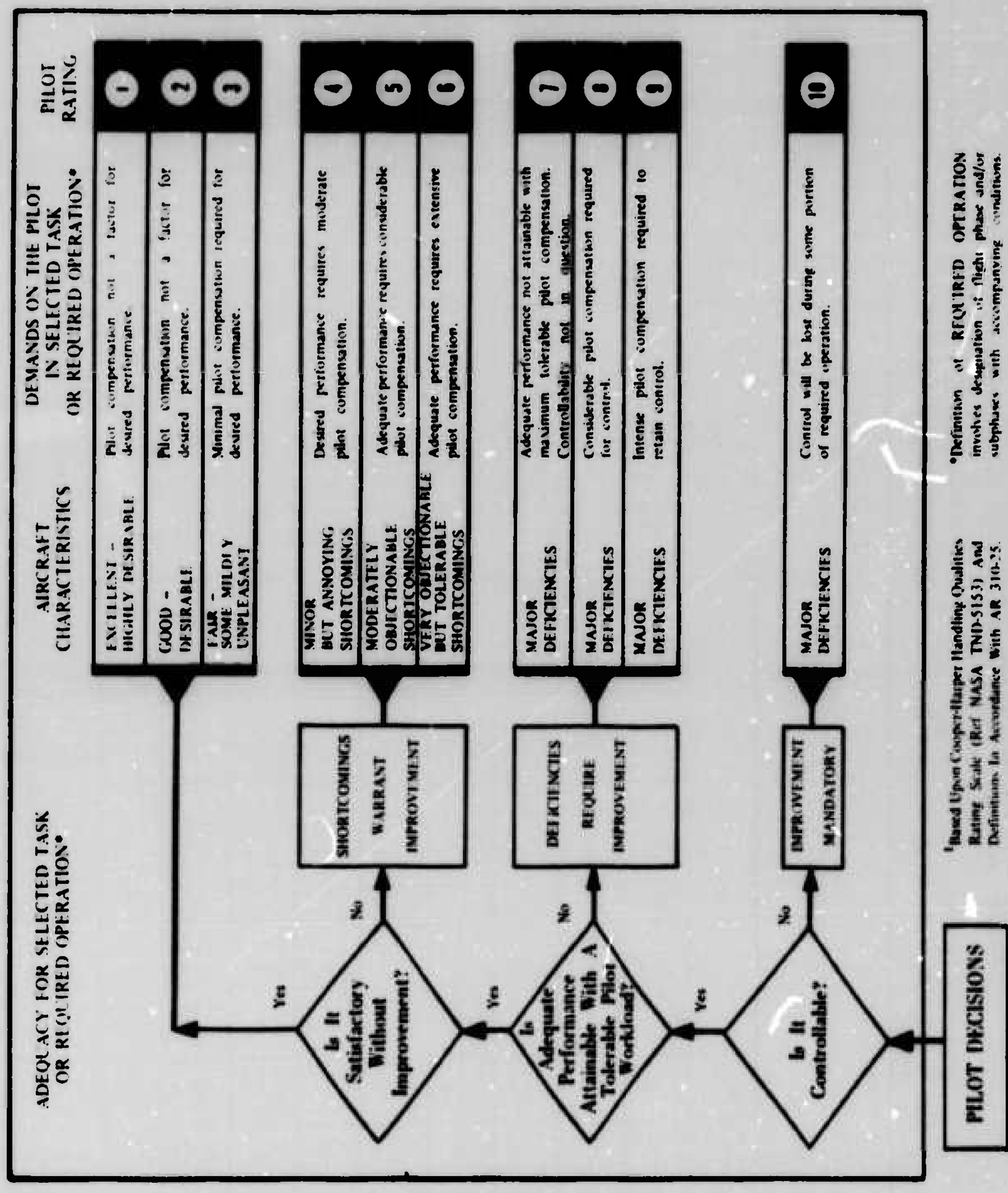


FIGURE 4
MODEL 309 GROSS WEIGHT-
CENTER OF GRAVITY ENVELOPE



APPENDIX F. HANDLING QUALITIES RATING SCALE



APPENDIX G. DATA ANALYSIS METHODS

INTRODUCTION

1. This appendix contains some of the data reduction and analysis methods used to evaluate the Bell Helicopter Company's Model 309 KingCobra helicopter. The topics discussed include:

a. Shaft horsepower required.

b. Shaft horsepower available.

c. Tail rotor performance.

d. Level flight performance and specific range.

GENERAL

2. The helicopter performance test data were generalized through the use of nondimensional coefficients. The purpose was to accurately obtain performance at conditions not specifically tested. The following coefficients were used to generalize test results obtained during the test program:

a. Coefficient of Power (C_P):

$$C_P = \frac{SHP \times 550}{\rho A \; (\Omega R)^3} \qquad (1)$$

b. Coefficient of Thrust (C_T):

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

c. Advance Ratio (μ):

$$\mu = \frac{1.6889 \times V_T}{\Omega R} \qquad (3)$$

d. Advancing Tip Mach Number (M_{tip}):

$$M_{tip} = \frac{1.6889\ V_T + \Omega R}{a} \qquad (4)$$

Where: SHP = Engine output shaft horsepower

550 = Conversion factor (ft-lb/sec per shp)

ρ = Air density (slug/ft^3)

A = Main rotor disc area (ft^2)

Ω = Main rotor angular velocity (radian)

R = Main rotor radius (ft)

W = Gross weight (lb)

1.6889 = Conversion factor (ft/sec per kt)

V_T = True airspeed (kt)

a = Speed of sound (ft/sec)

SHAFT HORSEPOWER DETERMINATION

3. Engine output shaft horsepower was determined from the following equation:

$$SHP_{ENG} = \frac{\left[\left(\frac{Q_{MR}\ N_{MR}}{K_{MR}} + \frac{Q_{TR}\ N_{TR}}{K_{TR}}\right)\frac{2\pi}{12 \times 33,000} + 25\right]}{0.9956} \qquad (5)$$

Where: Q_{MR} = Main rotor shaft torque (ft-lb)

N_{MR} = Main rotor rotational speed (rpm)

Q_{TR} = Tail rotor shaft torque (ft-lb)

N_{TR} = Tail rotor rotational speed (rpm)

K_{MR} = Efficiency factor = 0.9895

K_{TR} = Efficiency factor = 0.9820

33,000 = Conversion factor (ft-lb/min per shp)

25 = The constant, an average shp loss which includes the following:

17-shp loss due to main rotor, tail rotor and speed decreaser gearbox

5-shp loss due to hydraulic loads

3-shp loss due to electrical loads

0.9956 = The constant, an overall efficiency factor

SHAFT HORSEPOWER AVAILABLE

4. Shaft horsepower available for a specification engine was derived from the Lycoming engine computer source deck number 19.00.46.00. Inlet characteristics were based on data from Bell Helicopter Company. The other assumptions were zero airspeed, 0.6-percent air bleed, anti-ice OFF, environmental control unit OFF, and 5-horsepower extraction.

TAIL ROTOR PERFORMANCE

5. During the hover performance tests, tail rotor performance parameters were recorded. Terms in equations 1, 2, and 5 which apply to the main rotor were replaced by the tail rotor performance. The terms are redefined as follows:

SHP = Tail rotor shaft horsepower (equation 5)

A = Tail rotor disc area (ft^2)

Ω = Tail rotor angular velocity (rad/sec)

R = Tail rotor radius (ft)

T_{TR} = Tail rotor thrust (lb)

Q_{TR} = Tail rotor torque (ft-lb)

Tail rotor thrust was determined from the following equation:

$$T_{TR} = \frac{Q_{MR}}{\ell_t} \tag{6}$$

Where: Q_{MR} = Main rotor shaft torque (ft-lb)

ℓ_t = Perpendicular distance between center lines of main and tail rotor shafts (29.68 ft)

LEVEL FLIGHT PERFORMANCE AND SPECIFIC RANGE

6. Level flight performance was defined by measuring the shaft horsepower required to maintain level flight throughout the airspeed range of the helicopter. The results of each level flight were presented as shaft horsepower standard, tip Mach number, and specific range.

7. Test-day level flight power was corrected to standard-day conditions by assuming that the test-day dimensionless parameters, C_{P_t}, C_{T_t}, and μ_t, are independent of atmospheric conditions. Consequently, the standard-day dimensionless parameters, C_{P_s}, C_{T_s}, and μ_s, are identical to C_{P_t}, C_{T_t}, and μ_t, respectively. From the definition of equation 1, the following relationship can be derived:

$$SHP_s = SHP_t \times \frac{\rho_s}{\rho_t} \tag{7}$$

Where: SHP = Engine output shaft horsepower

ρ = Air density (slug/ft^3)

t = Test day

s = Standard day

8. Specific range was calculated using the level flight performance curves and the specification installed-engine fuel-flow characteristics at 5-percent conservatism:

$$NAMPP = \frac{V_T}{W_f} \tag{8}$$

Where: NAMPP = Nautical air miles per pound of fuel (naut mi/lb)

V_T = True airspeed (kt)

W_f = Fuel flow (lb/hr)

APPENDIX II. TEST INSTRUMENTATION

All instrumentation was installed in the test helicopter by Bell Helicopter Company prior to the start of the test program. The following test parameters were presented:

PILOT PANEL

Airspeed (boom system)
Altitude (boom system)
Rate of climb
Rotor speed
Gas producer speed
Engine torque
Longitudinal control position
Lateral control position
Pedal control position
Angle of sideslip
Center-of-gravity normal acceleration
Exhaust gas temperature
Tail rotor torque
Collective control position
Outside air temperature

GUNNER PANEL

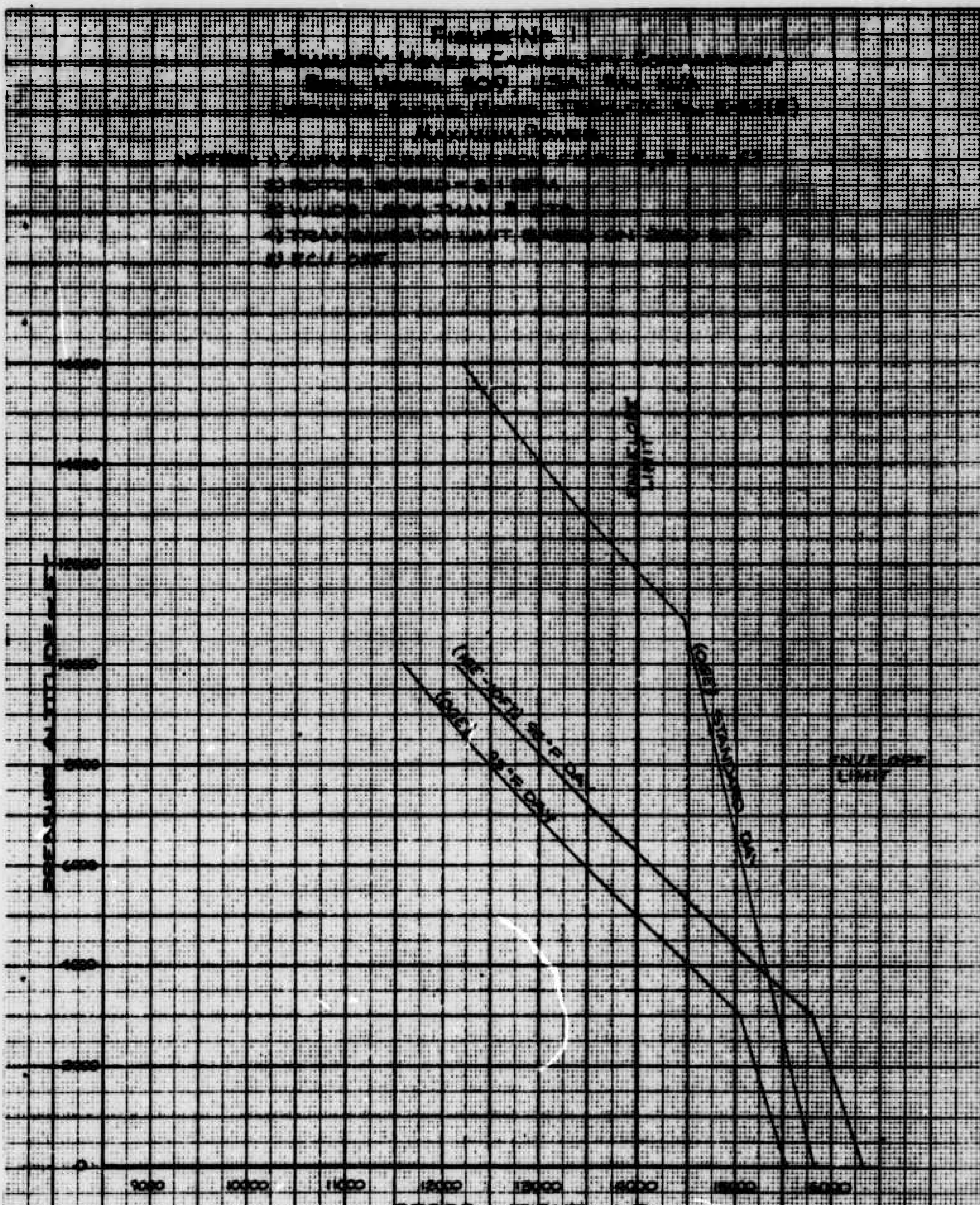
Airspeed (boom system)
Altitude (boom system)
Outside air temperature
Rotor speed
Angle of sideslip
Exhaust gas temperature
Fuel counter
Magnetic tape correlation counter
Photopanel correlation counter

MAGNETIC TAPE

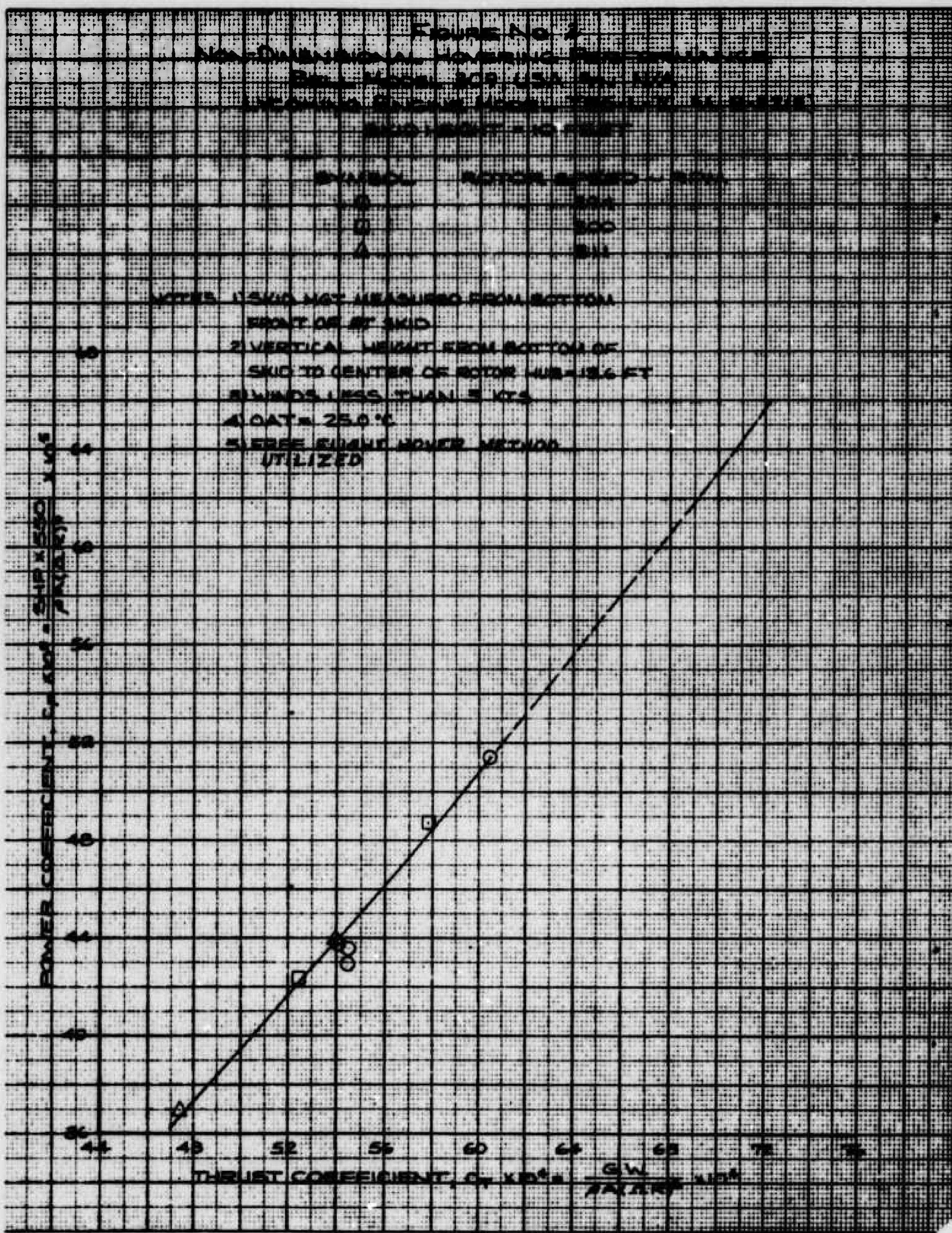
Airspeed (boom system)
Altitude (boom system)
Angle of sideslip
Angle of attack
Roll attitude
Pitch attitude
Yaw attitude
Roll rate
Pitch rate
Yaw rate
Longitudinal control position
Lateral control position
Pedal control position
Collective control position
Magnetic tape correlation counter
Engine delta torque
Main rotor torque
Main rotor blade angle
Tail rotor torque
Tail rotor blade angle
Longitudinal control force
Longitudinal SCAS actuator position
Lateral SCAS actuator position
Directional SCAS actuator position
Pilot seat vertical vibration
Pilot seat vibration (forward)
Pilot seat vibration (aft)
Gunner seat vertical vibration
Gunner seat lateral vibration
Gunner seat vibration (forward)
Gunner seat vibration (aft)
Pilot panel vertical vibration
Pilot panel lateral vibration
Pilot panel vibration (forward)
Pilot panel vibration (aft)
Gunner panel vertical vibration
Gunner panel lateral vibration
Gunner panel vibration (forward)
Gunner panel vibration (aft)
Main rotor rotor speed
Center-of-gravity vertical vibration
Center-of-gravity lateral vibration
Event markers
Engine fuel flow
Gas producer speed

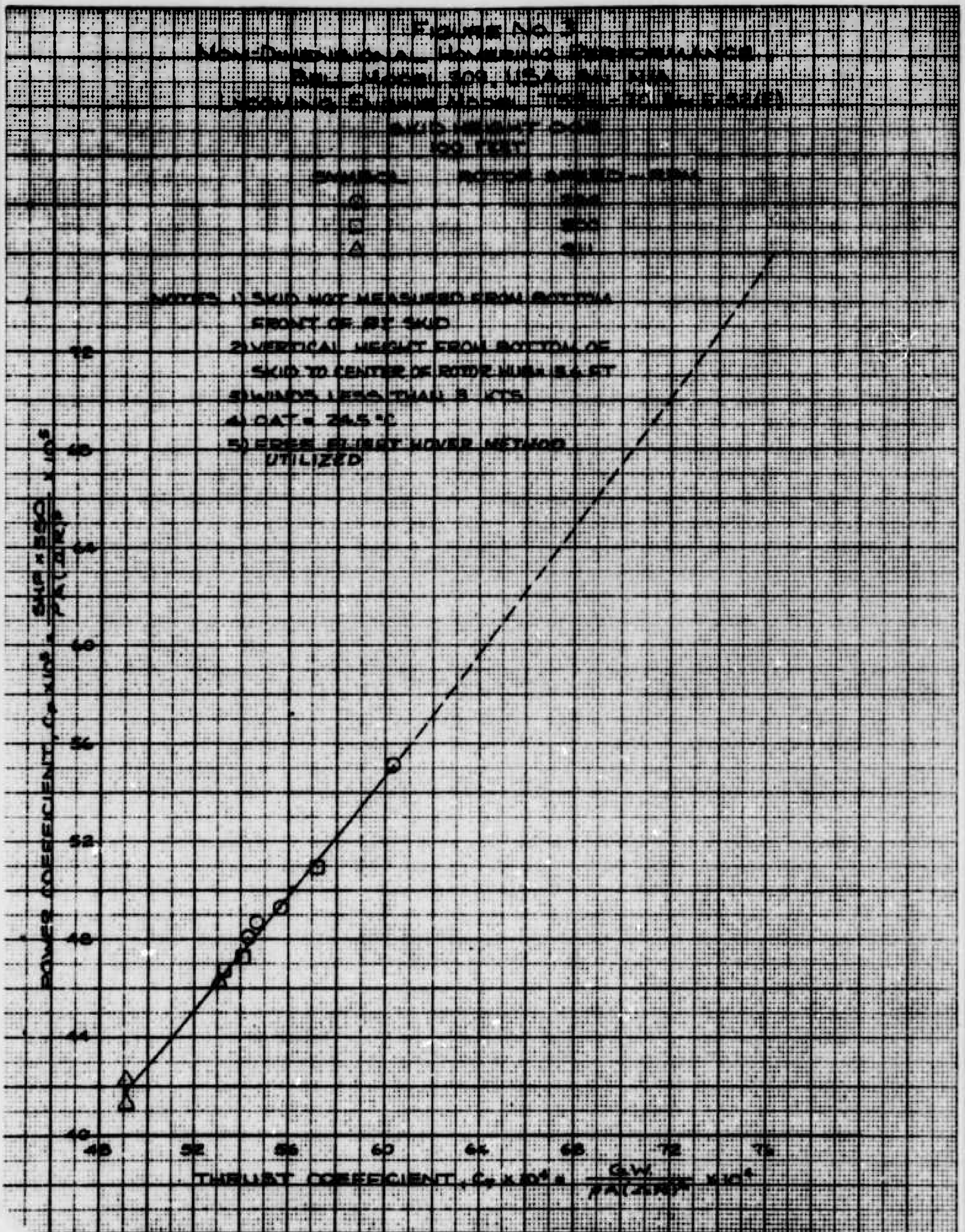
APPENDIX I. TEST DATA

INDEX



PRESSURE ALTITUDE ~ FEET
GROSS WEIGHT ~ LB
9000
10000
11000
12000
13000
14000
15000
16000
0
2000
4000
6000
8000
10000
12000
14000
16000
LIMIT
STANDARD DAY
95°F DAY
ENVELOPE LIMIT
5) ECU OFF


SYMBOL ROTOR SPEED ~ RPM
NOTES: 1) SKID HGT MEASURED FROM BOTTOM FRONT OF LEFT SKID
2) VERTICAL HEIGHT FROM BOTTOM OF SKID TO CENTER OF ROTOR HUB = 12.6 FT
3) WINDS LESS THAN 3 KTS
4) OAT = 25.0 °C
5) FREE FLIGHT HOVER METHOD UTILIZED
POWER COEFFICIENT, $C_P \times 10^6$
THRUST COEFFICIENT, $C_T \times 10^4$
36
40
44
48
52
56
60
64
68
44
48
52
56
60
64
68
72
76


100 FEET
SYMBOL
ROTOR SPEED – RPM
2) VERTICAL HEIGHT FROM BOTTOM OF
SKID TO CENTER OF ROTOR HUB
3) WINDS LESS THAN 3 KTS
4) OAT = 24.5 °C
5) FREE FLIGHT HOVER METHOD
UTILIZED
POWER COEFFICIENT
THRUST COEFFICIENT
40
44
48
52
56
60
64
68
72
48
52
56
60
64
68
72
76

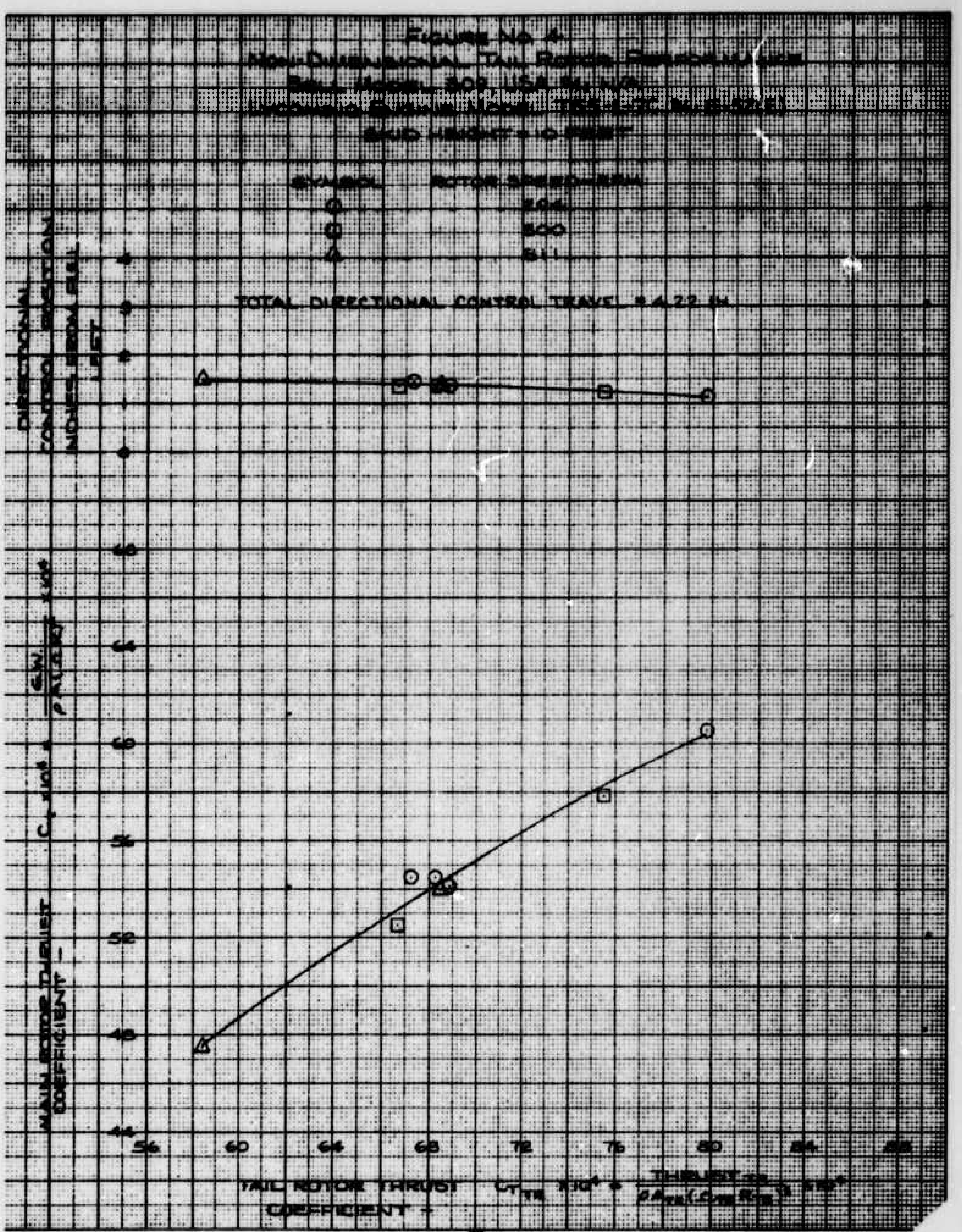
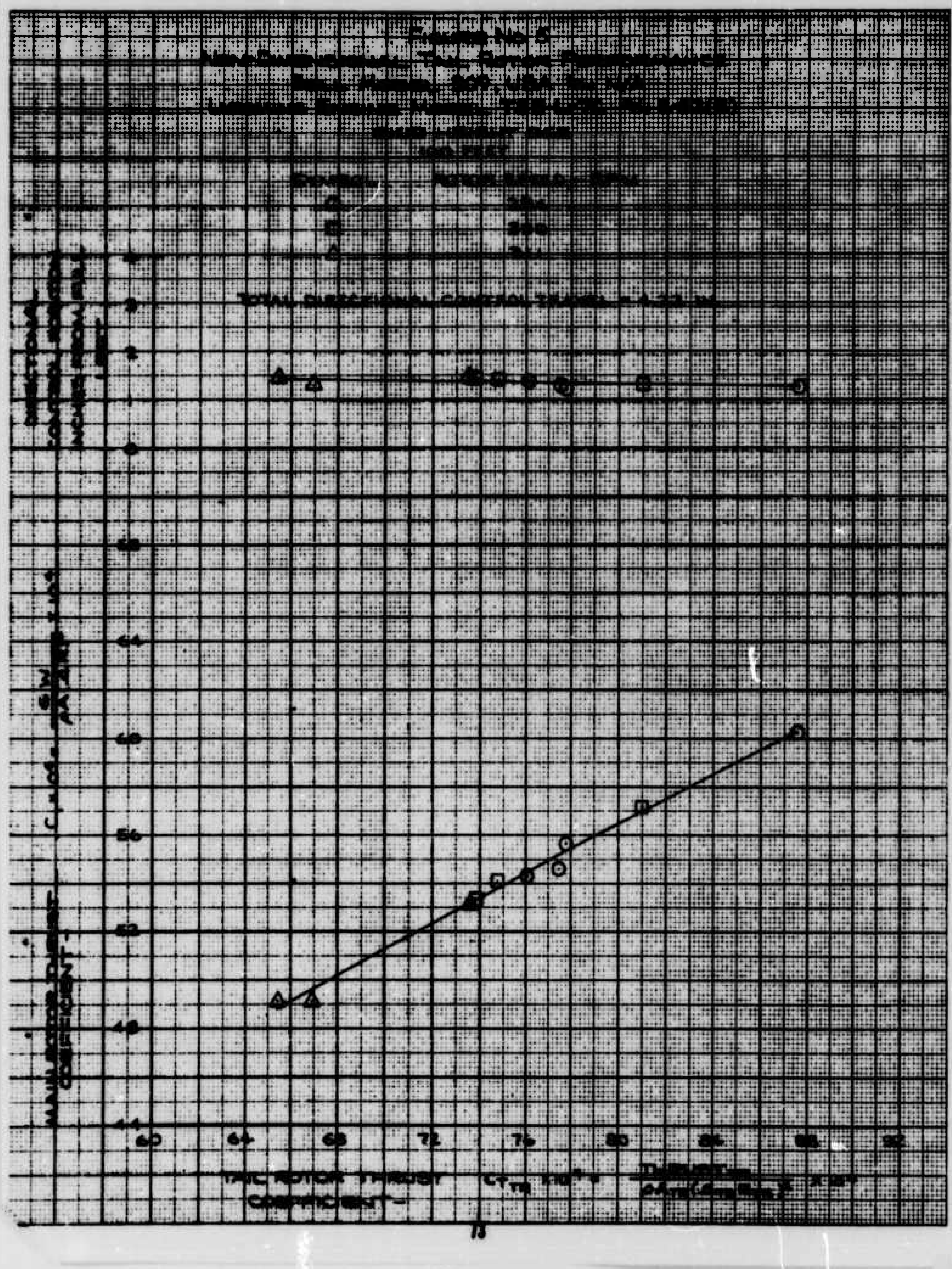
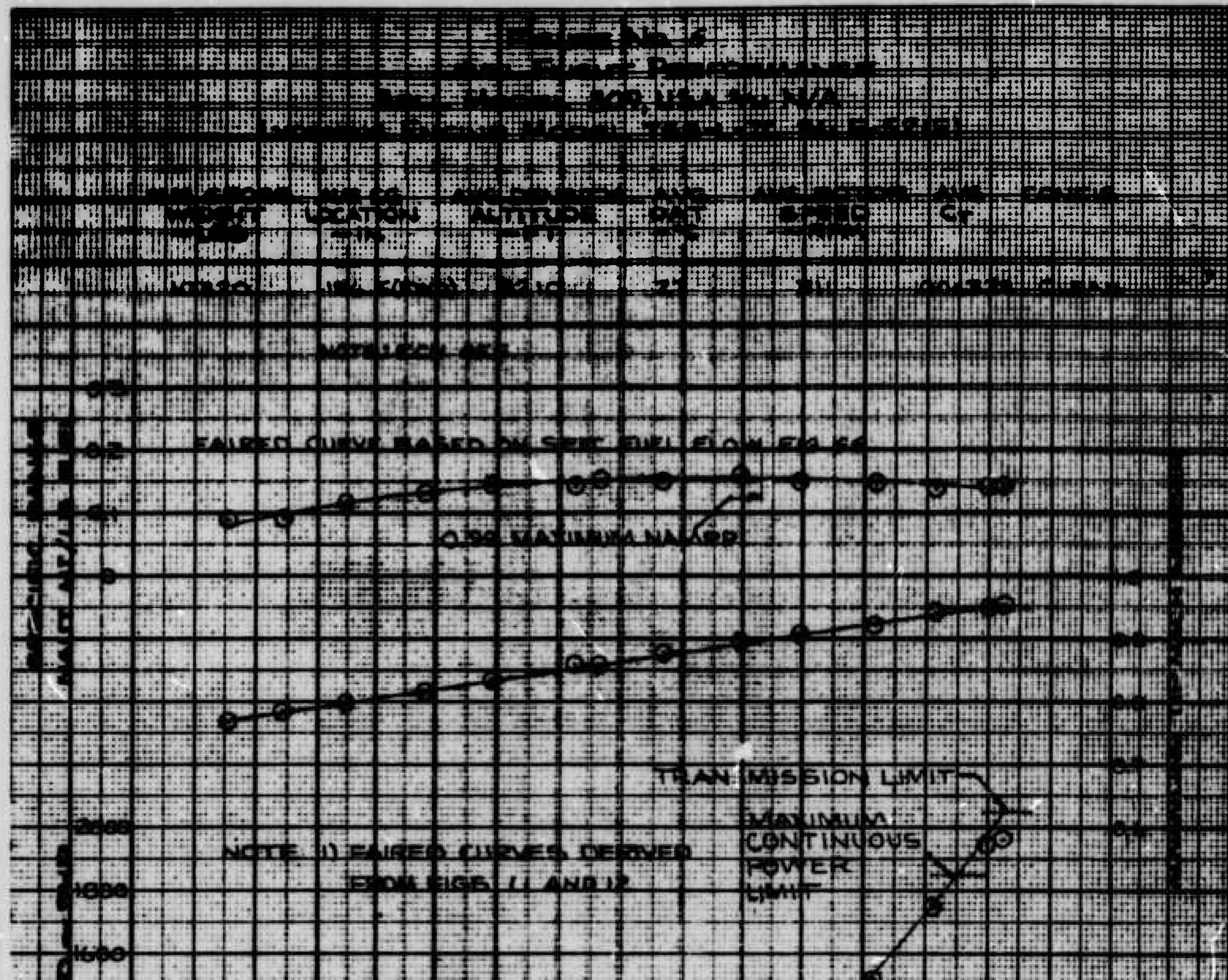
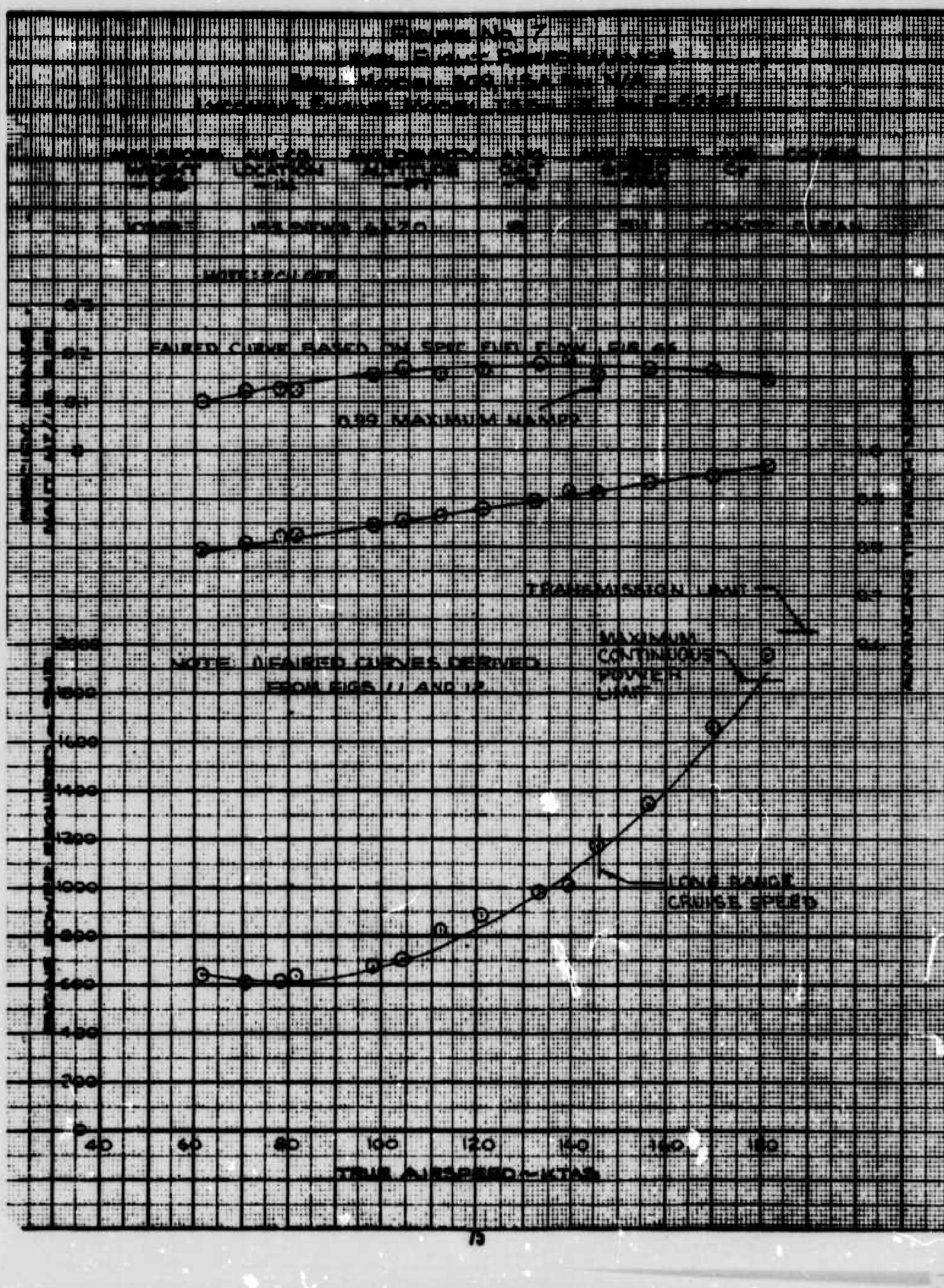


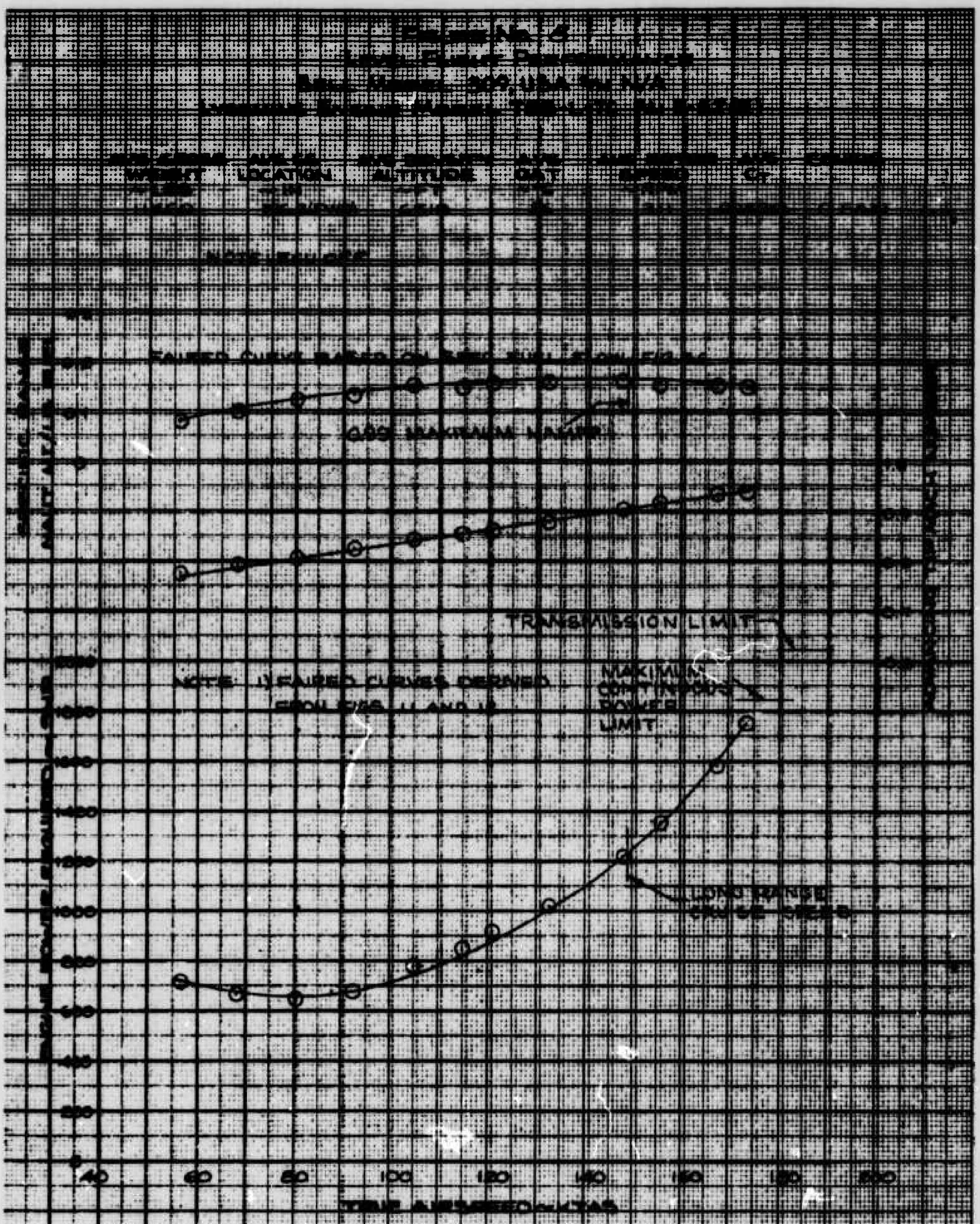
FIGURE NO. 4
NON-DIMENSIONAL TAIL ROTOR PERFORMANCE
SKID HEIGHT = 10 FEET
SYMBOL
ROTOR SPEED ~ RPM
TOTAL DIRECTIONAL CONTROL TRAVEL = 4.22 IN
DIRECTIONAL CONTROL POSITION INCHES FROM FULL LEFT
MAIN ROTOR THRUST COEFFICIENT
TAIL ROTOR THRUST COEFFICIENT
56
60
64
68
72
76
80
84
88
44
48
52
56
60
64
68


100 FEET
TOTAL DIRECTIONAL CONTROL TRAVEL
TAIL ROTOR THRUST
COEFFICIENT
60
64
68
72
76
80
84
88
92
48
52
56
60
64
68


WEIGHT
LOCATION
ALTITUDE
OAT
SPEED
TRANSMISSION LIMIT
MAXIMUM CONTINUOUS POWER LIMIT
NOTE: 1) FAIRED CURVES DERIVED FROM FIGS. 11 AND 12
LONG RANGE CRUISE SPEED
2000
1800
1600
1400
1200
1000
800
600
400
200
0
40
60
80
100
120
140
160
180
200
TRUE AIRSPEED ~ KTAS



LOCATION
ALTITUDE
FAIRED CURVE BASED ON SPEC FUEL FLOW FIG 46
0.99 MAXIMUM NAMPP
TRANSMISSION LIMIT
MAXIMUM CONTINUOUS POWER LIMIT
NOTE: 1) FAIRED CURVES DERIVED FROM FIGS 11 AND 12
LONG RANGE CRUISE SPEED
0.2
0.1
0
2000
1800
1600
1400
1200
1000
800
600
400
200
0
40
60
80
100
120
140
160
180
TRUE AIRSPEED ~ KTAS


WEIGHT
LOCATION
ALTITUDE
OAT
CG
TRANSMISSION LIMIT
NOTE: 1) FAIRED CURVES DERIVED
FROM FIGS. 11 AND 12
MAXIMUM
CONTINUOUS
POWER
LIMIT
LONG RANGE
CRUISE SPEED
40
60
80
100
120
140
160
180
200

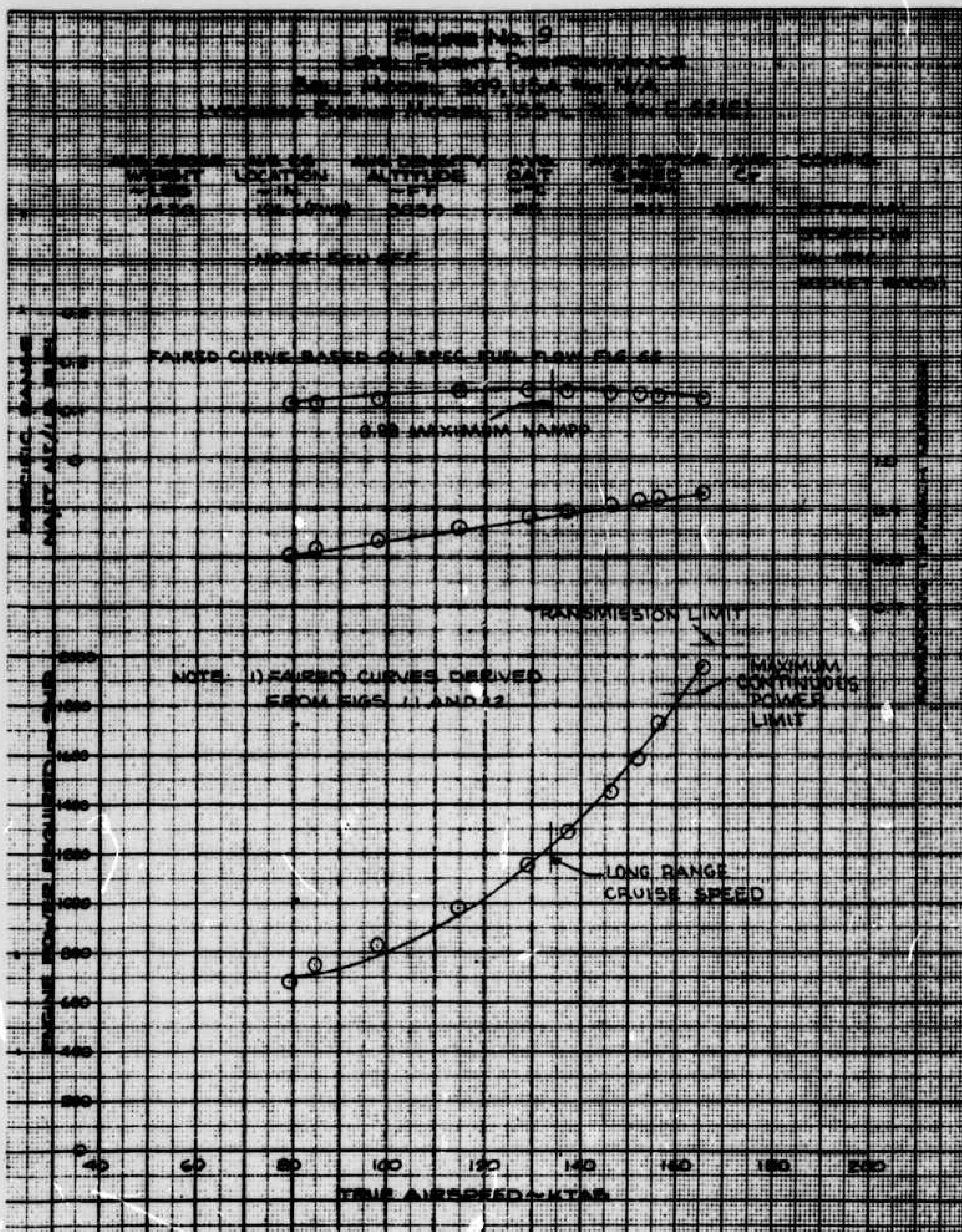
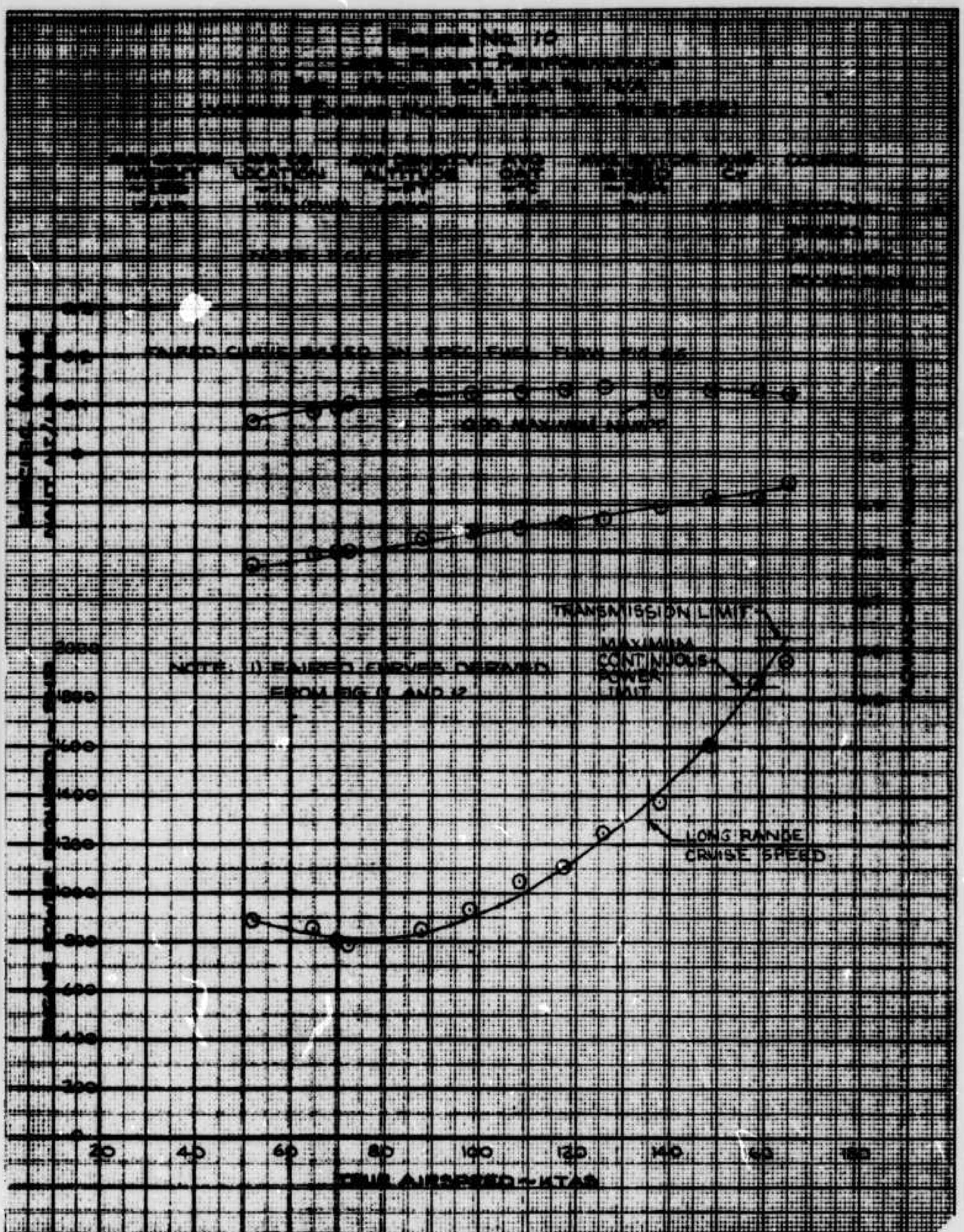


FIGURE No. 9
WEIGHT
LOCATION
ALTITUDE
OAT
SPEED
FAIRED CURVE BASED ON SPEC. FUEL FLOW
TRANSMISSION LIMIT
NOTE: 1) FAIRED CURVES DERIVED FROM FIGS. 11 AND 12
MAXIMUM CONTINUOUS POWER LIMIT
LONG RANGE CRUISE SPEED
TRUE AIRSPEED ~ KTAS
40
60
80
100
120
140
160
180
200
0
200
400
600
800
1000
1200
1400
1600
1800
2000



NO. 10
WEIGHT
LOCATION
ALTITUDE
OAT
SPEED
TRANSMISSION LIMIT
MAXIMUM CONTINUOUS POWER LIMIT
NOTE: 1) FAIRED CURVES DERIVED FROM FIG 11 AND 12
LONG RANGE CRUISE SPEED
2000
1800
1600
1400
1200
1000
800
600
400
200
0
20
40
60
80
100
120
140
160
180

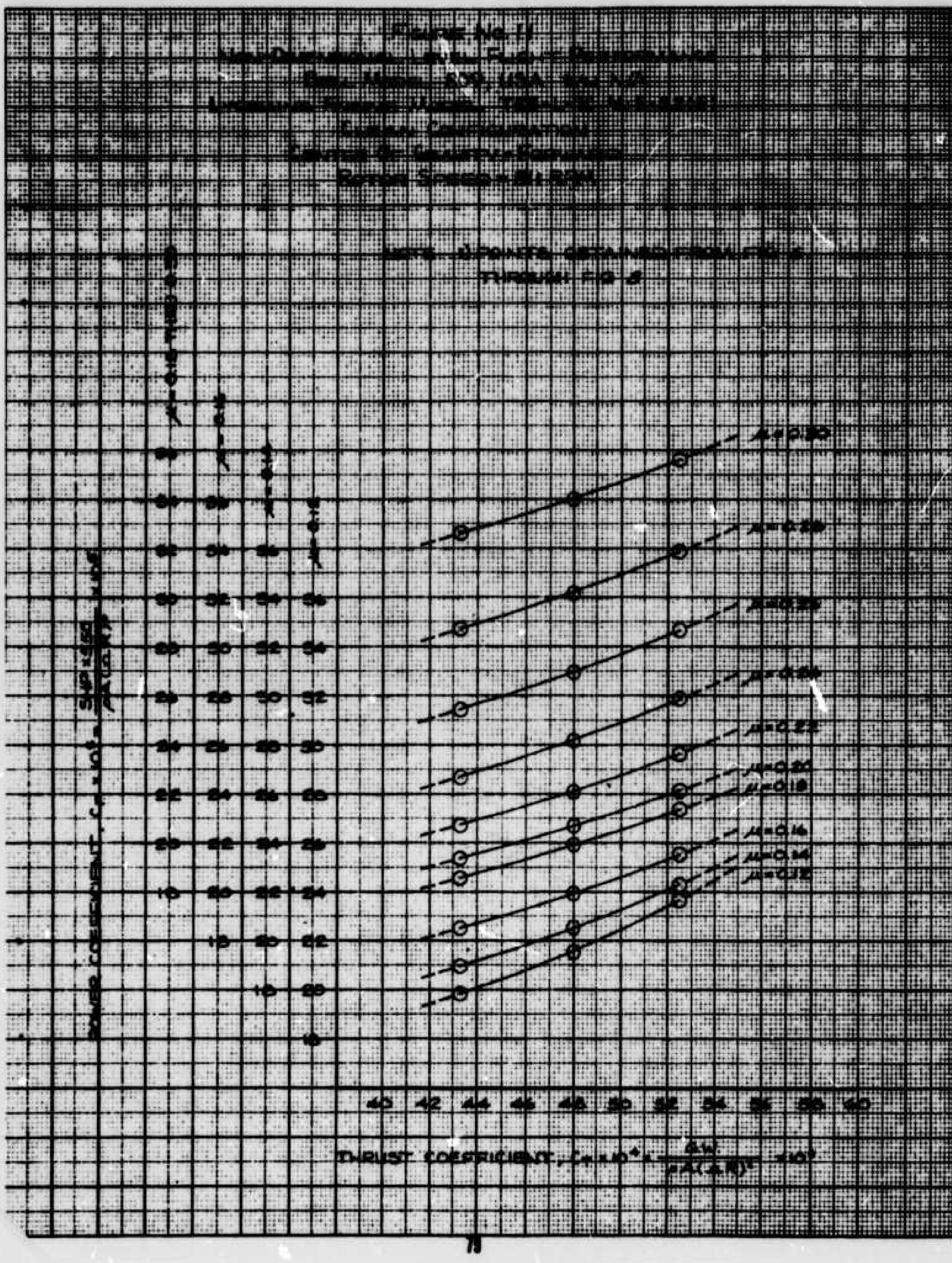


FIGURE NO. 11
CLEAN CONFIGURATION
THRUST COEFFICIENT
POWER COEFFICIENT
40 42 44 46 48 50 52 54 56 58 60
μ = 0.30
μ = 0.28
μ = 0.26
μ = 0.24
μ = 0.22
μ = 0.20
μ = 0.18
μ = 0.16
μ = 0.14
μ = 0.12

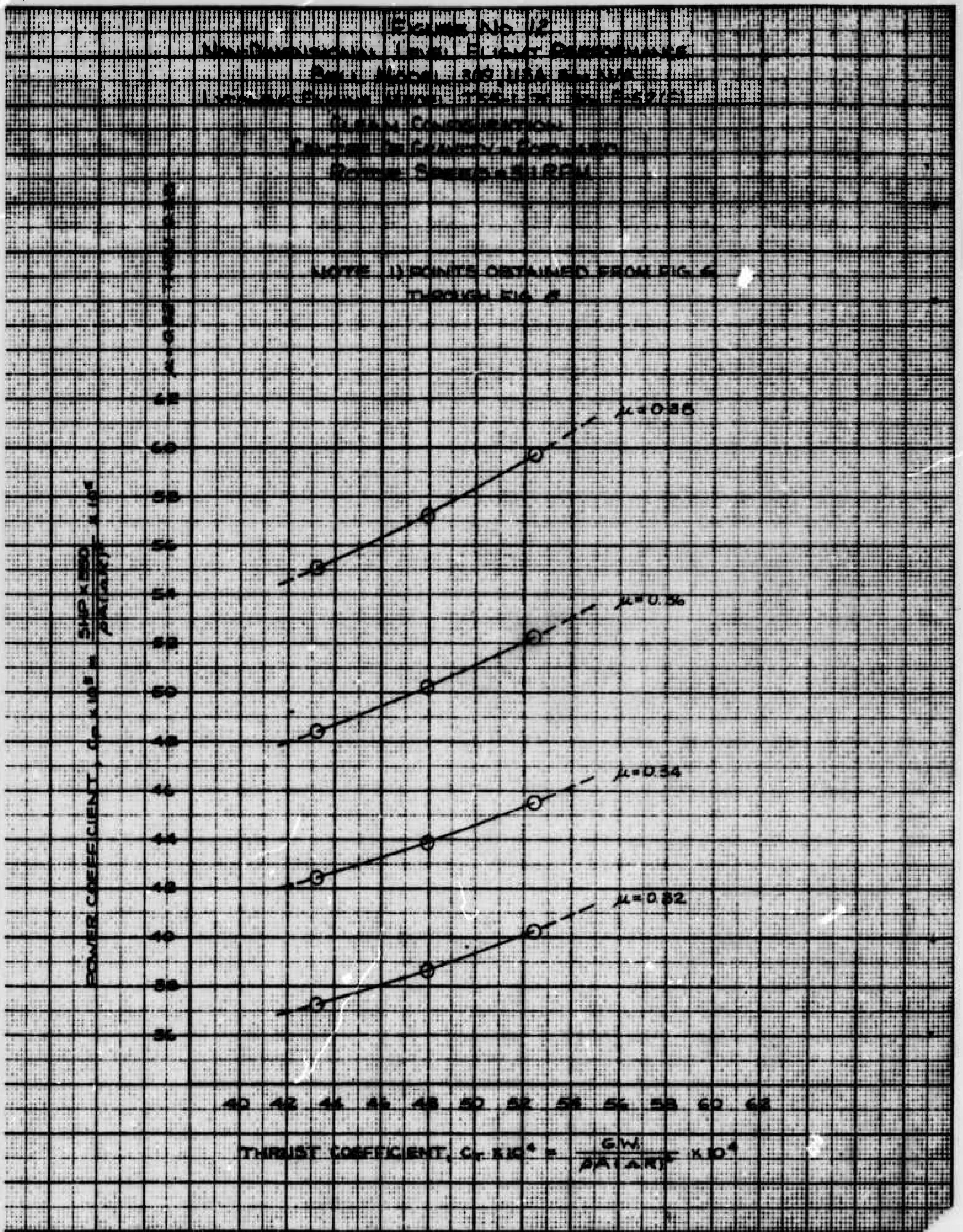
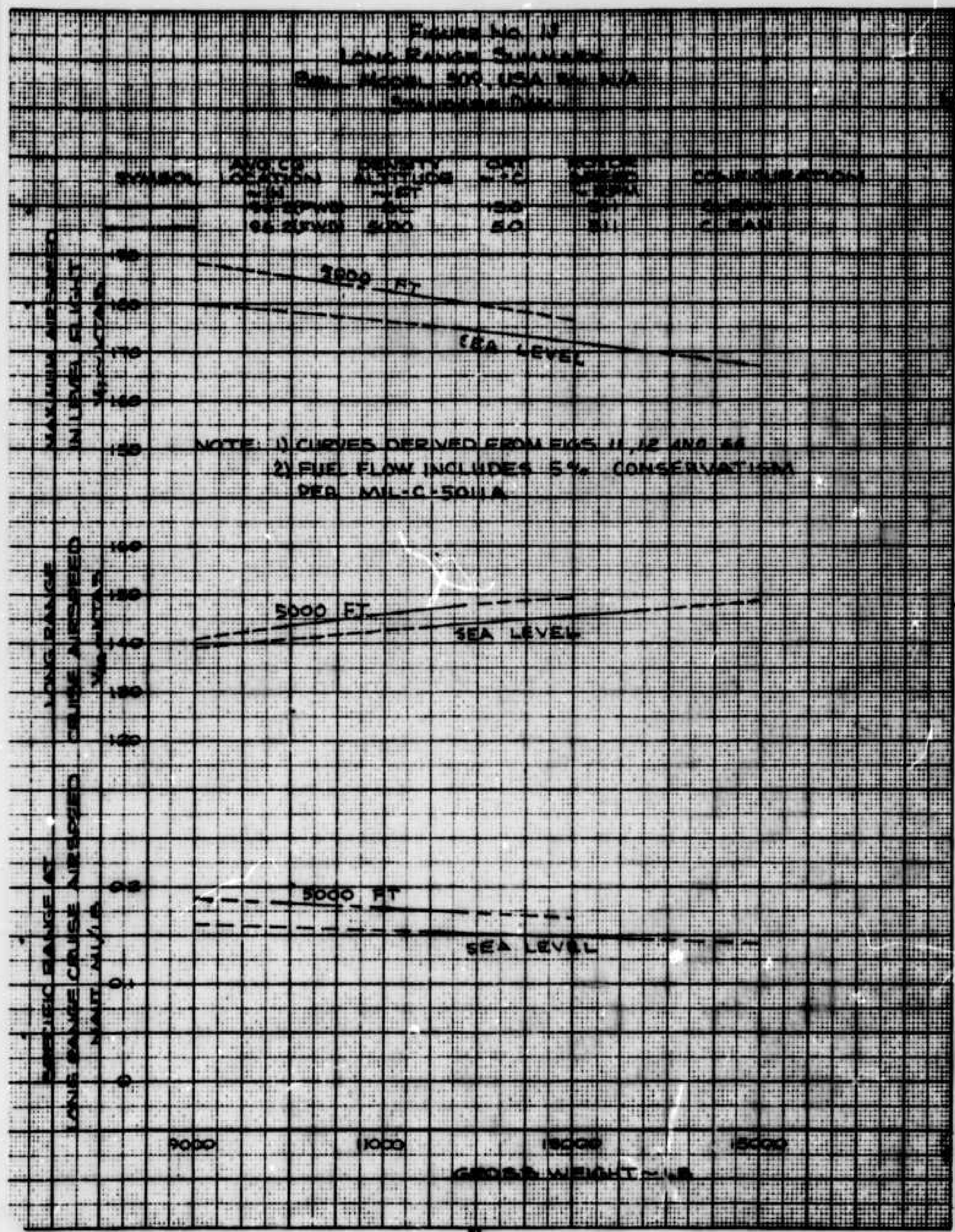
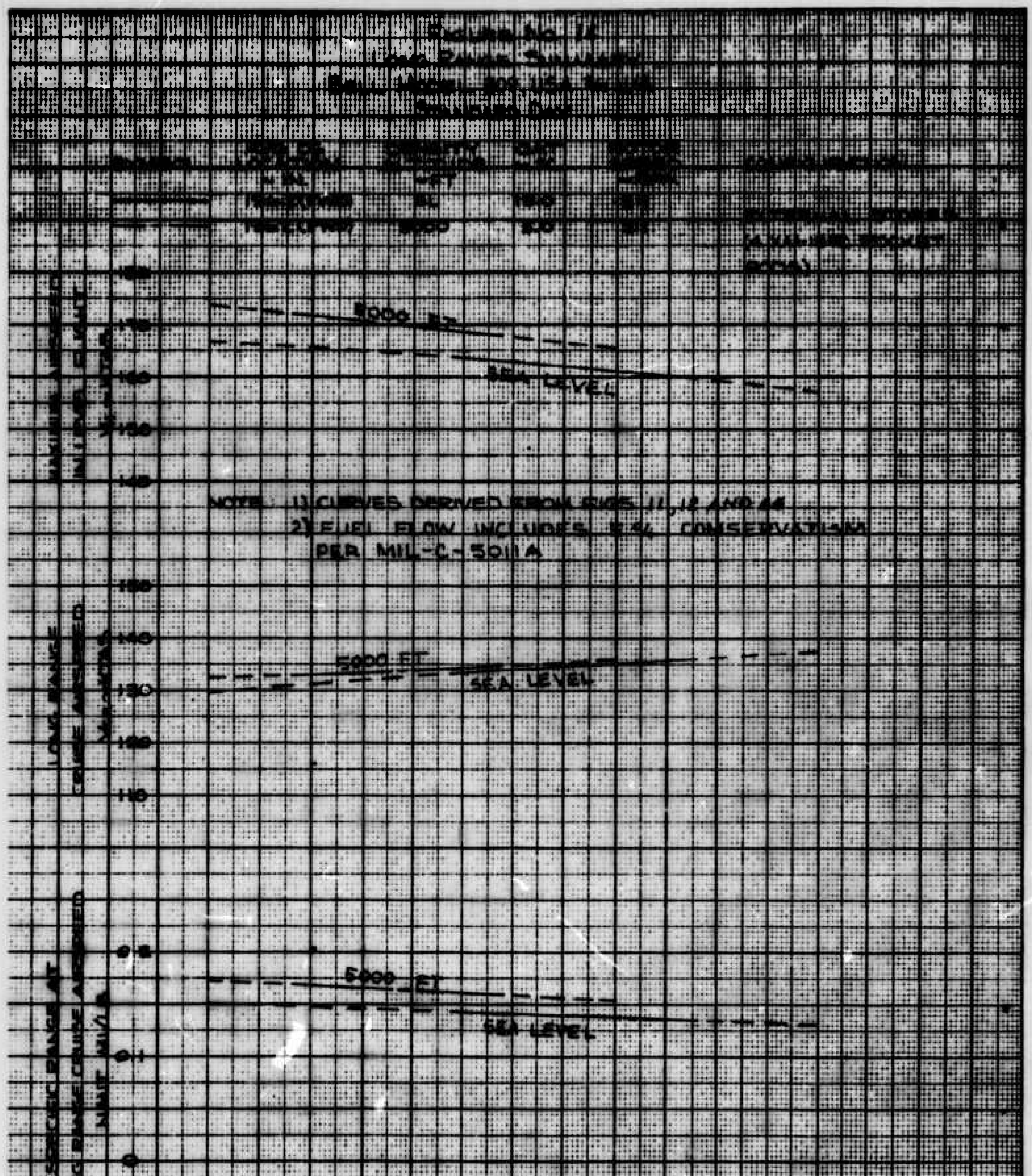


FIGURE No. 12
CLEAN CONFIGURATION
NOTE: 1) POINTS OBTAINED FROM FIG. 6 THROUGH FIG. 8
$\mu = 0.38$
$\mu = 0.36$
$\mu = 0.34$
$\mu = 0.32$
36
38
40
42
44
46
48
50
52
54
56
58
60
62
40 42 44 46 48 50 52 54 56 58 60 62
POWER COEFFICIENT, $C_P \times 10^5 = \frac{SHP \times 550}{\rho A (\Omega R)^3} \times 10^5$
THRUST COEFFICIENT, $C_T \times 10^4 = \frac{G.W.}{\rho A (\Omega R)^2} \times 10^4$


LONG RANGE SUMMARY
SYMBOL
CONFIGURATION
CLEAN
5000 FT
SEA LEVEL
NOTE: 1) CURVES DERIVED FROM FIGS 11, 12 AND 64
2) FUEL FLOW INCLUDES 5% CONSERVATISM
PER MIL-C-5011A
MAXIMUM AIRSPEED IN LEVEL FLIGHT
LONG RANGE CRUISE AIRSPEED
SPECIFIC RANGE AT LONG RANGE CRUISE AIRSPEED
9000
11000
GROSS WEIGHT ~ LB



5000 FT
SEA LEVEL
NOTE: 1) CURVES DERIVED FROM FIGS. 11, 12 AND 44
2) FUEL FLOW INCLUDES 5% CONSERVATISM
PER MIL-C-5011A
5000 FT
SEA LEVEL
5000 FT
SEA LEVEL
GROSS WEIGHT ~ LB

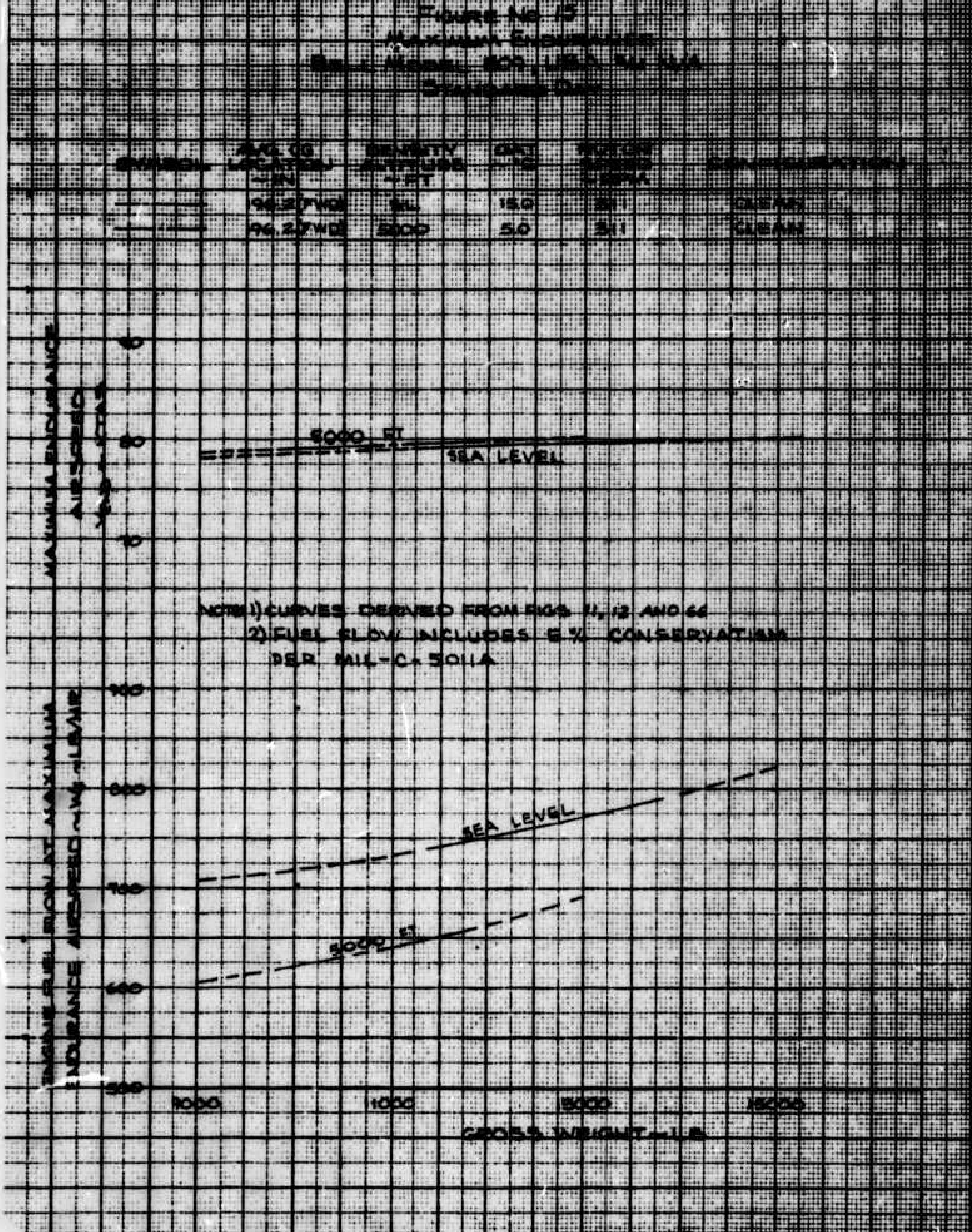
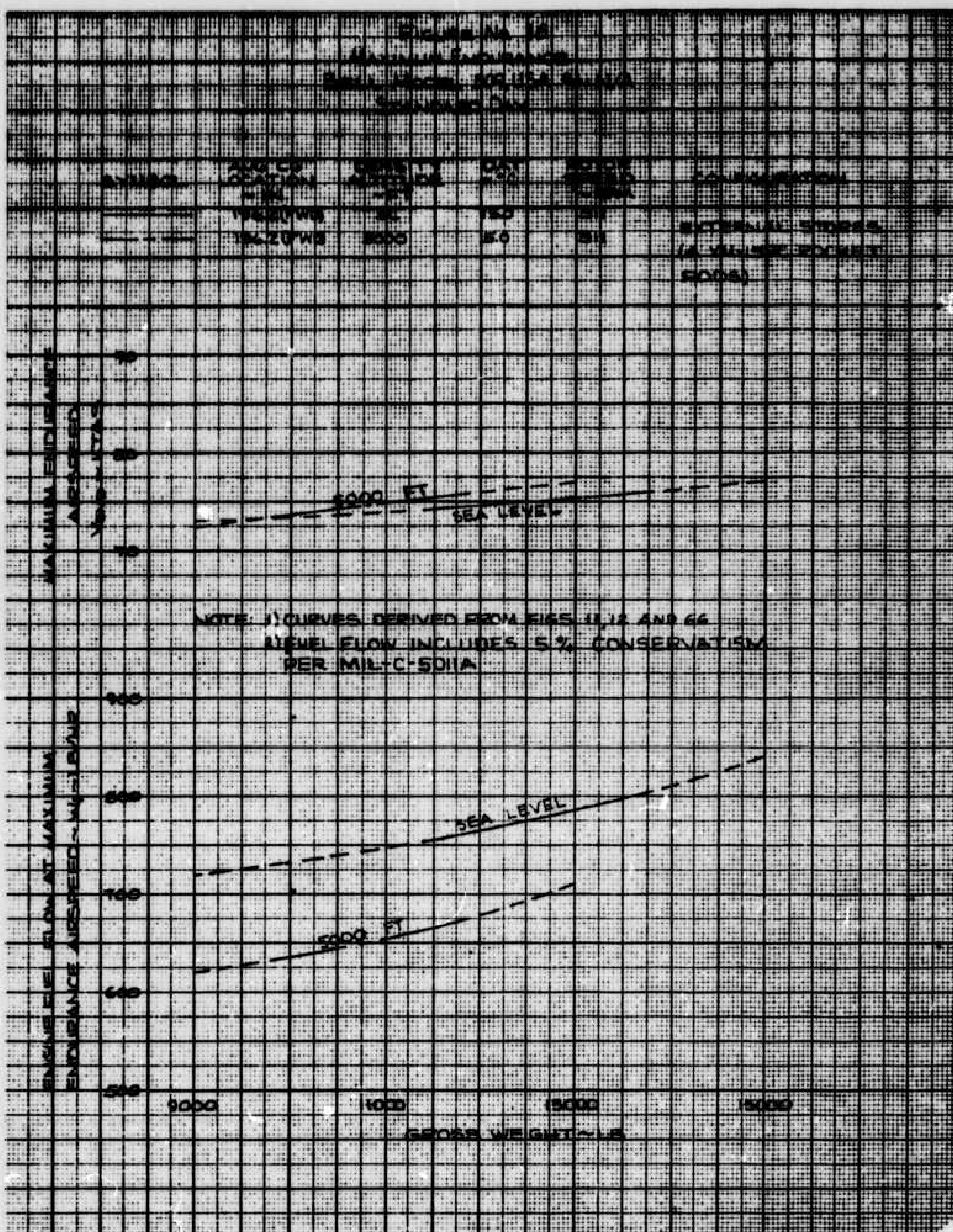


FIGURE NO. 15
MAXIMUM ENDURANCE
STANDARD DAY
SYMBOL
AVG CG LOCATION ~IN
DENSITY ALTITUDE ~FT
OAT ~°C
ROTOR SPEED ~RPM
CONFIGURATION
96.2(FWD)
S.L.
15.0
CLEAN
96.2(FWD)
5000
5.0
CLEAN
5000 FT
SEA LEVEL
NOTE: 1) CURVES DERIVED FROM FIGS 11, 12 AND 66
2) FUEL FLOW INCLUDES 5% CONSERVATISM PER MIL-C-5011A
MAXIMUM ENDURANCE AIRSPEED
ENGINE FUEL FLOW AT MAXIMUM ENDURANCE AIRSPEED ~ LB/HR
900
800
700
600
500
GROSS WEIGHT ~ LB



5000 FT
SEA LEVEL
NOTE: 1) CURVES DERIVED FROM FIGS. 11, 12 AND 66
2) FUEL FLOW INCLUDES 5% CONSERVATISM
PER MIL-C-5011A
SEA LEVEL
5000 FT
GROSS WEIGHT ~ LB

FIGURE No. 17

ACCELERATION FROM HOVER TO V_H

BELL MODEL 309, USA S/N N/A

LYCOMING ENGINE MODEL T55-L-7C S/N E-52(E)

GROSS WEIGHT ~LB	C.G. LOCATION ~IN.	DENSITY ALTITUDE ~FT.	OAT ~°C	ROTOR SPEED ~RPM	TRIM AIRSPEED ~KCAS	C_T	CONFIGURATION
13950	198.3	2350	28.5	311	HOVER	.005692	EXTERNAL STORES (4 XM-159C ROCKET PODS)

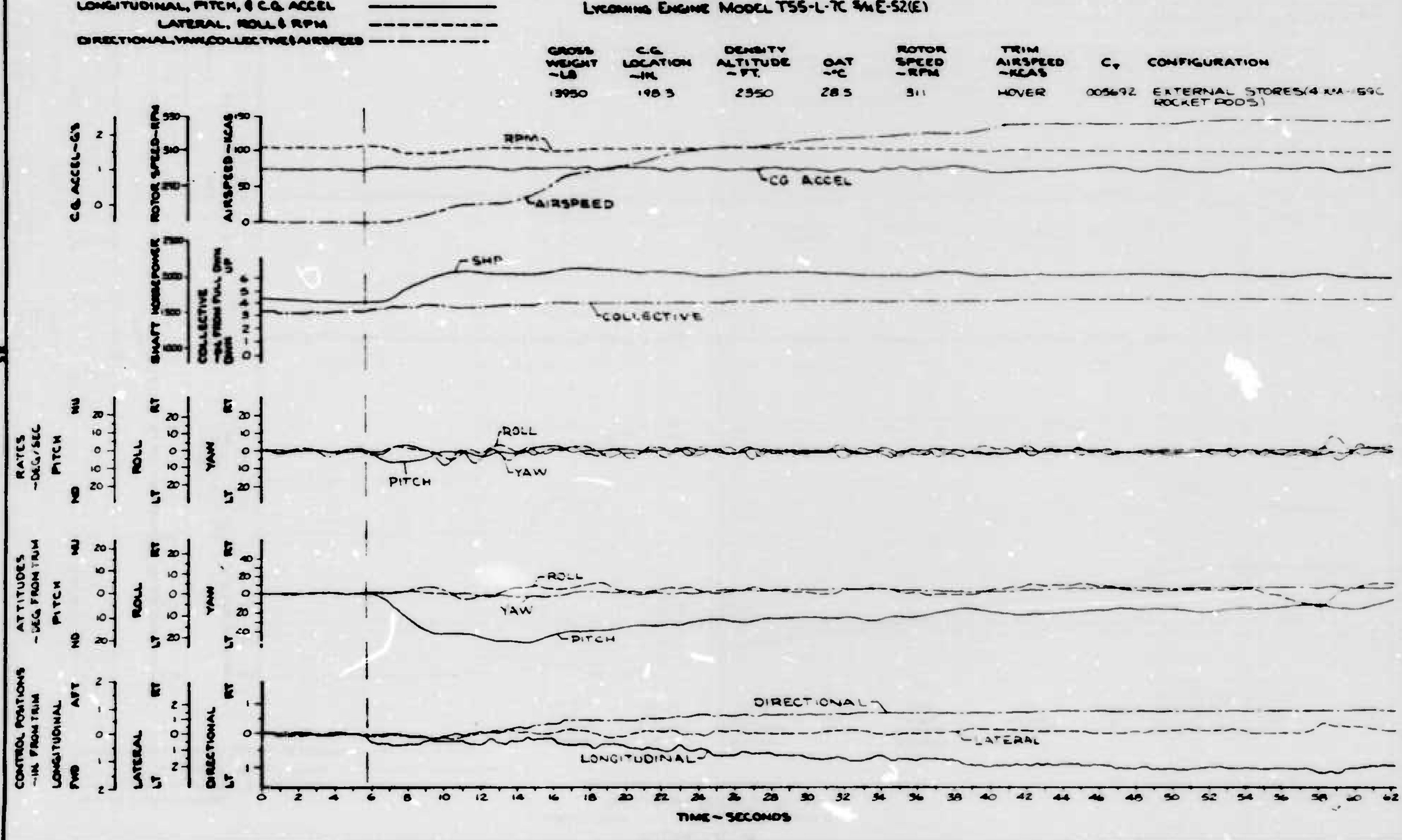
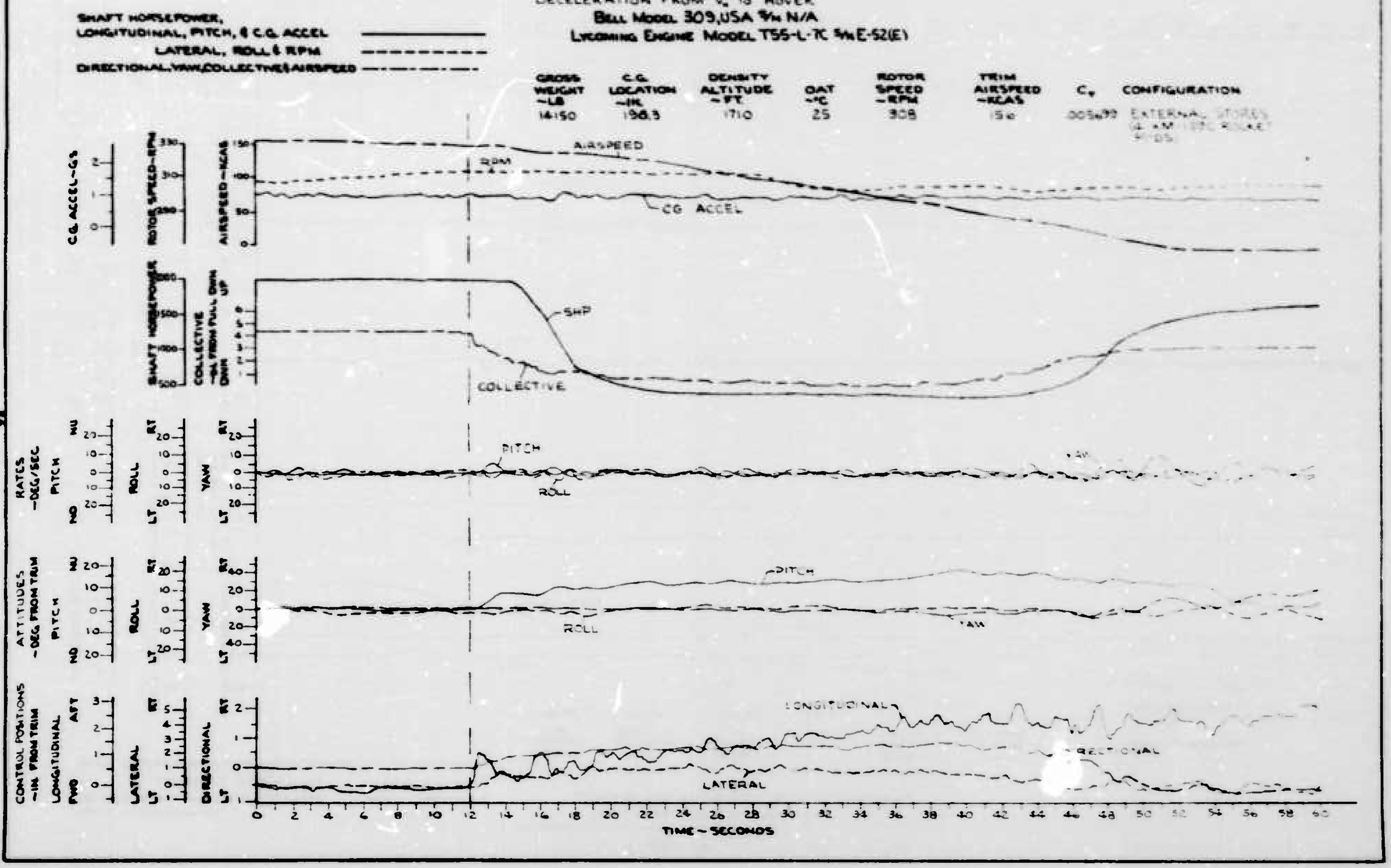
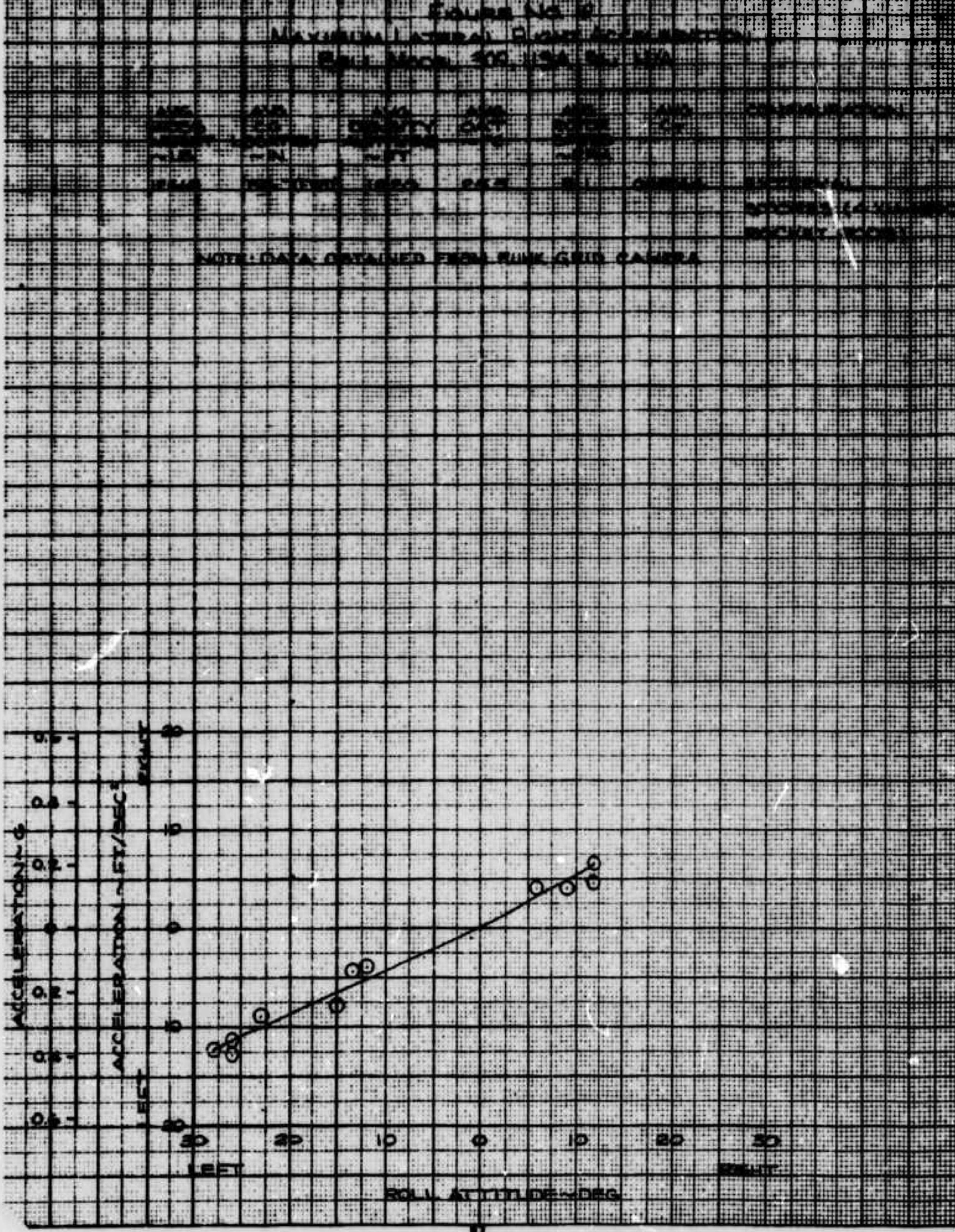


FIGURE No. 18
DECELERATION FROM V_H TO HOVER
BELL MODEL 309, USA S/N N/A
LYCOMING ENGINE MODEL T55-L-7C S/N E-52(E)





ACCELERATION ~ G
ACCELERATION ~ FT/SEC²
RIGHT
LEFT
30
20
10
0
10
20
30
LEFT
RIGHT
ROLL ATTITUDE ~ DEG

FIGURE NO. 20
CYCLIC STICK CONTROL PATTERN
BELL MODEL [illegible]

NOTES: 1) [illegible]
2) [illegible] AND ELECTRICAL POWER [illegible]
SOURCE
3) ALL PERTINENT SWITCHES AND SYSTEMS SET TO [illegible]
NORMAL IN-FLIGHT CONDITION
4) [illegible] CONTROL AUGMENTATION [illegible]
5) TOTAL [illegible] CONTROL [illegible]
6) TOTAL LATERAL CONTROL TRAVEL [illegible] IN.
7) COLLECTIVE CONTROL POSITION DID NOT ALTER CYCLIC
MOVEMENT LIMITS

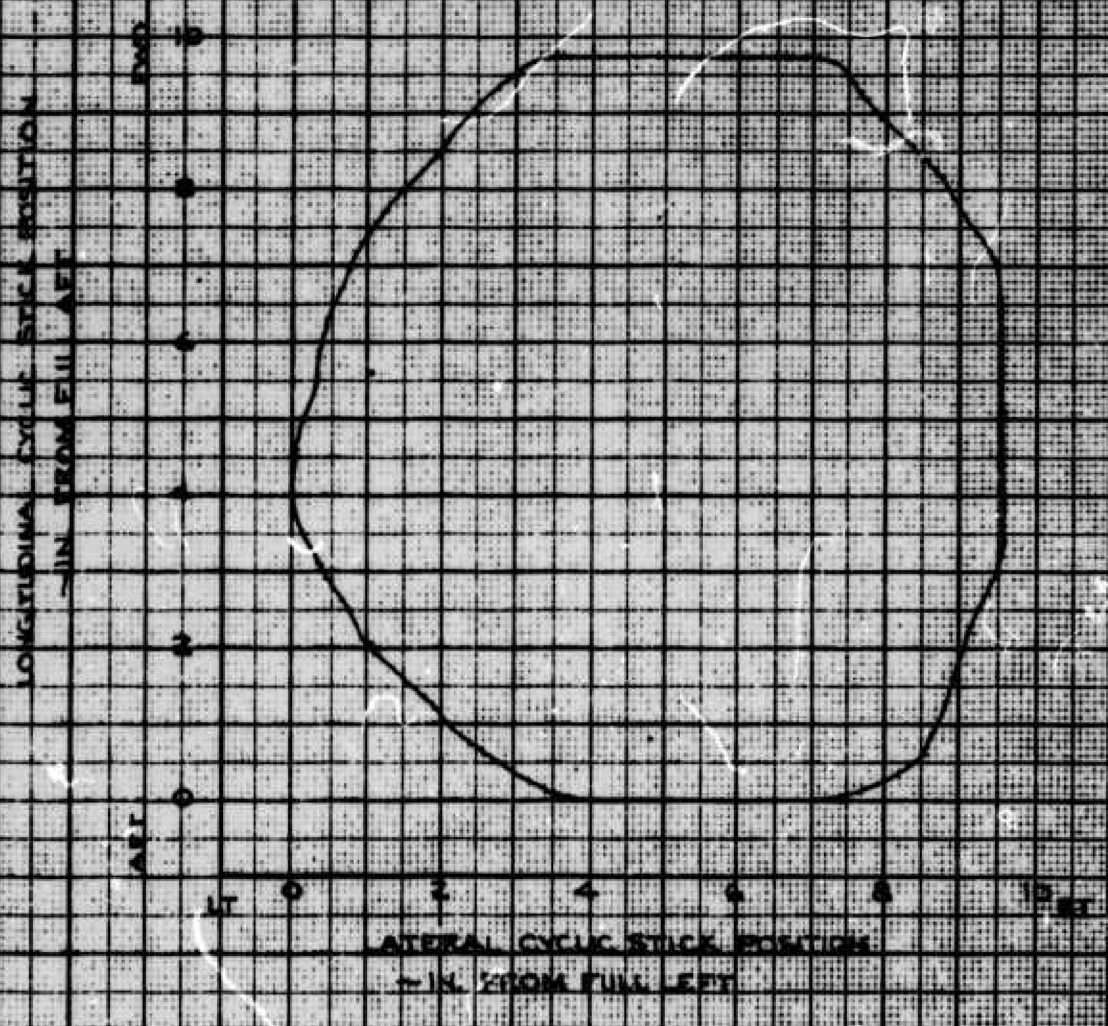
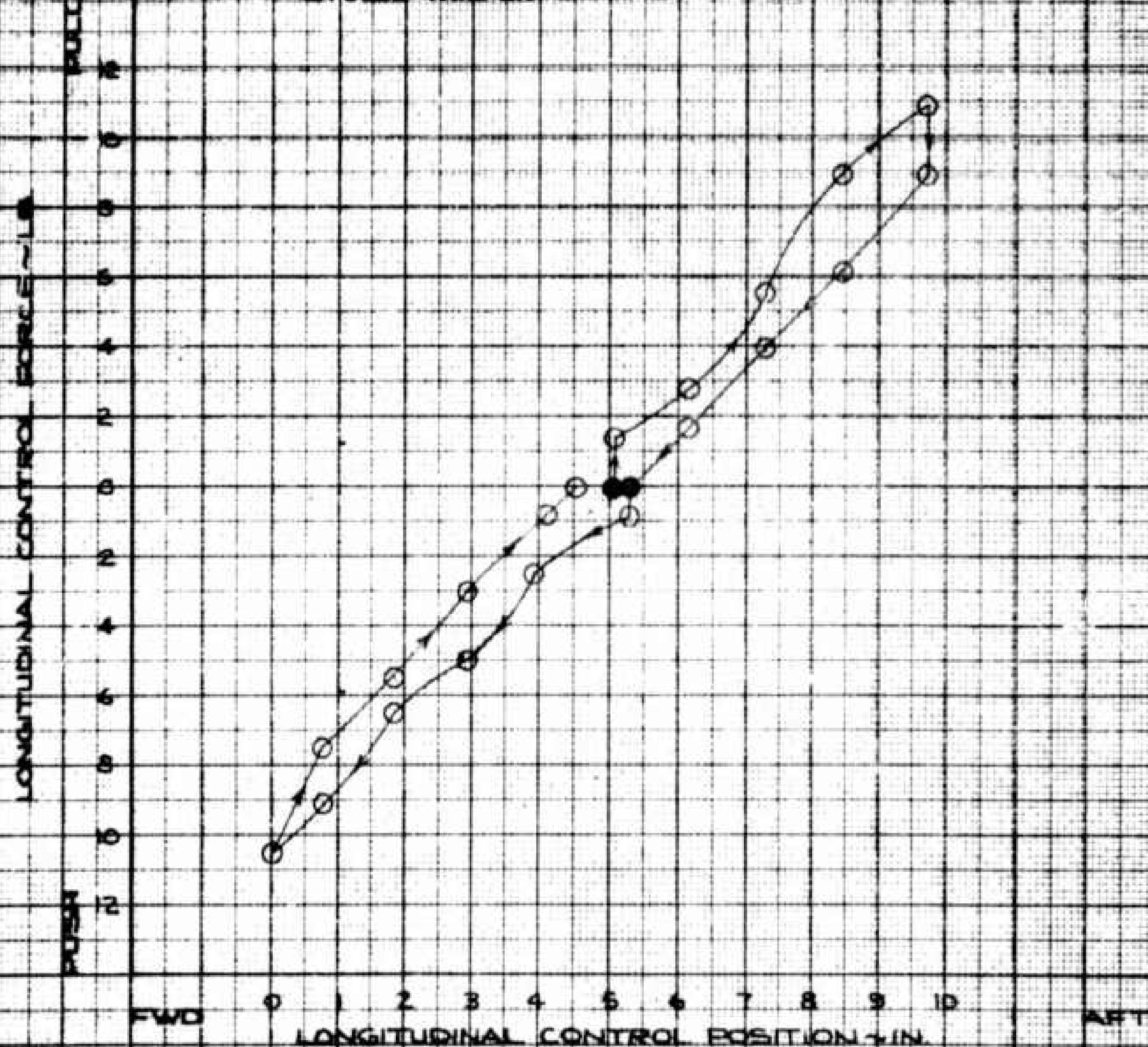


FIGURE NO. 21

LONGITUDINAL CONTROL SYSTEM CHARACTERISTICS

BELL MODEL 309, USA S/N N/A

NOTES: 1) ROTOR STATIC AND CYCLIC FRICTION AT ZERO
2) FORCES MEASURED AT CENTER OF GRIP
3) HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS
4) NO. 1 AND NO. 2 BOOST SYSTEMS ON
5) SOLID SYMBOL DENOTES TRIM POINT
6) LATERAL CONTROL POSITION 4.76 INCHES FROM FULL LEFT
7) TOTAL LONGITUDINAL CONTROL DISPLACEMENT = 9.75 INCHES
8) FORCE TRIM ON



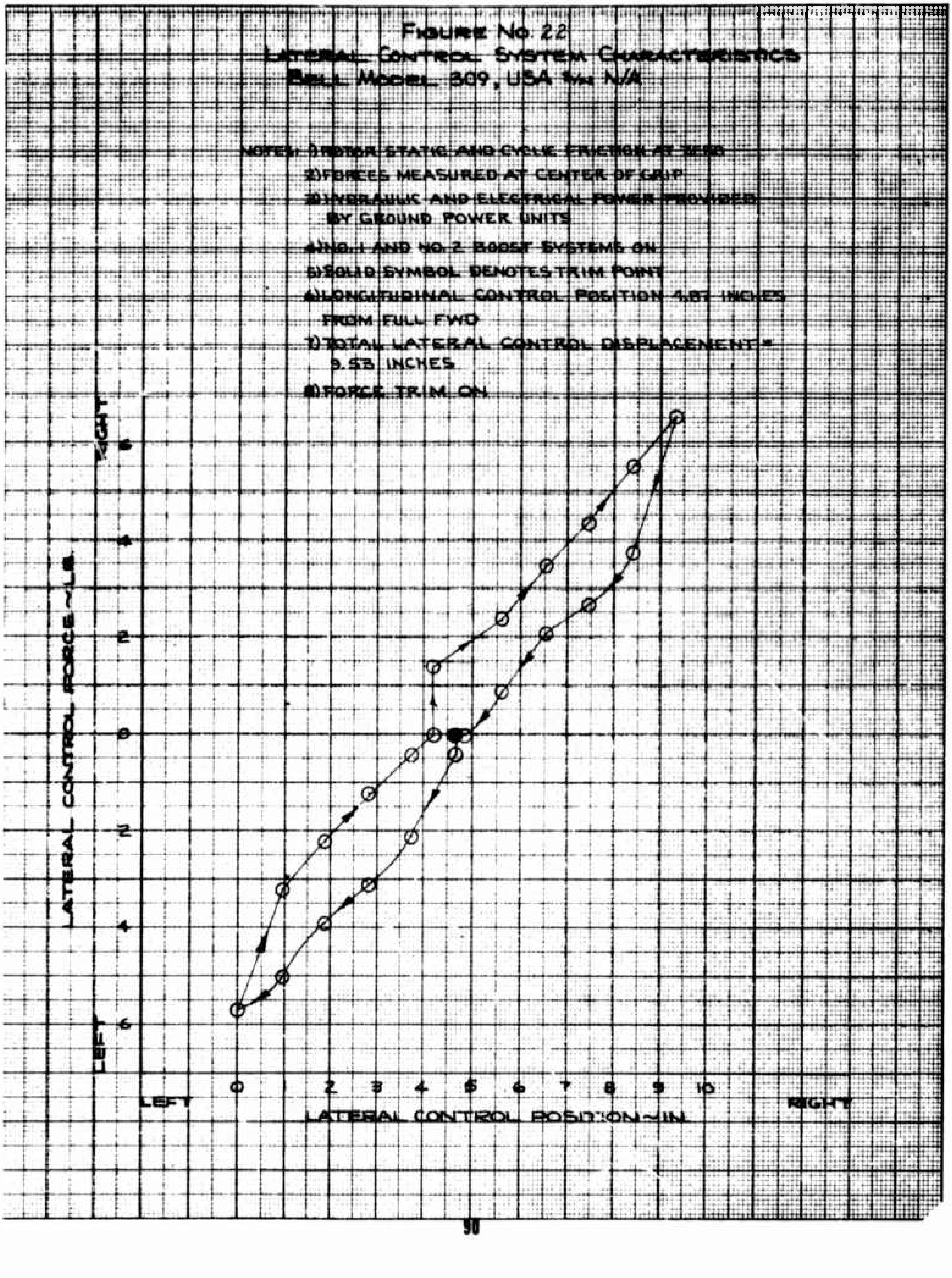


FIGURE No. 22
LATERAL CONTROL SYSTEM CHARACTERISTICS
BELL MODEL 309, USA S/N N/A

NOTES: 1) ROTOR STATIC AND CYCLIC FRICTION AT ZERO
2) FORCES MEASURED AT CENTER OF GRIP
3) HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS
4) NO. 1 AND NO. 2 BOOST SYSTEMS ON
5) SOLID SYMBOL DENOTES TRIM POINT
6) LONGITUDINAL CONTROL POSITION 4.87 INCHES FROM FULL FWD
7) TOTAL LATERAL CONTROL DISPLACEMENT = 9.58 INCHES
8) FORCE TRIM ON

FIGURE NO. 83
COLLECTIVE CONTROL SYSTEM CHARACTERISTIC
BELL MODEL 309 USA S/N N/A

NOTES: 1. TEST CONDUCTED ON GROUND WITH EXTERNAL HYDRAULIC AND ELECTRICAL POWER.
2. ROTOR STATIONARY.
3. TOTAL CONTROL TRAVEL = 6.10 IN.

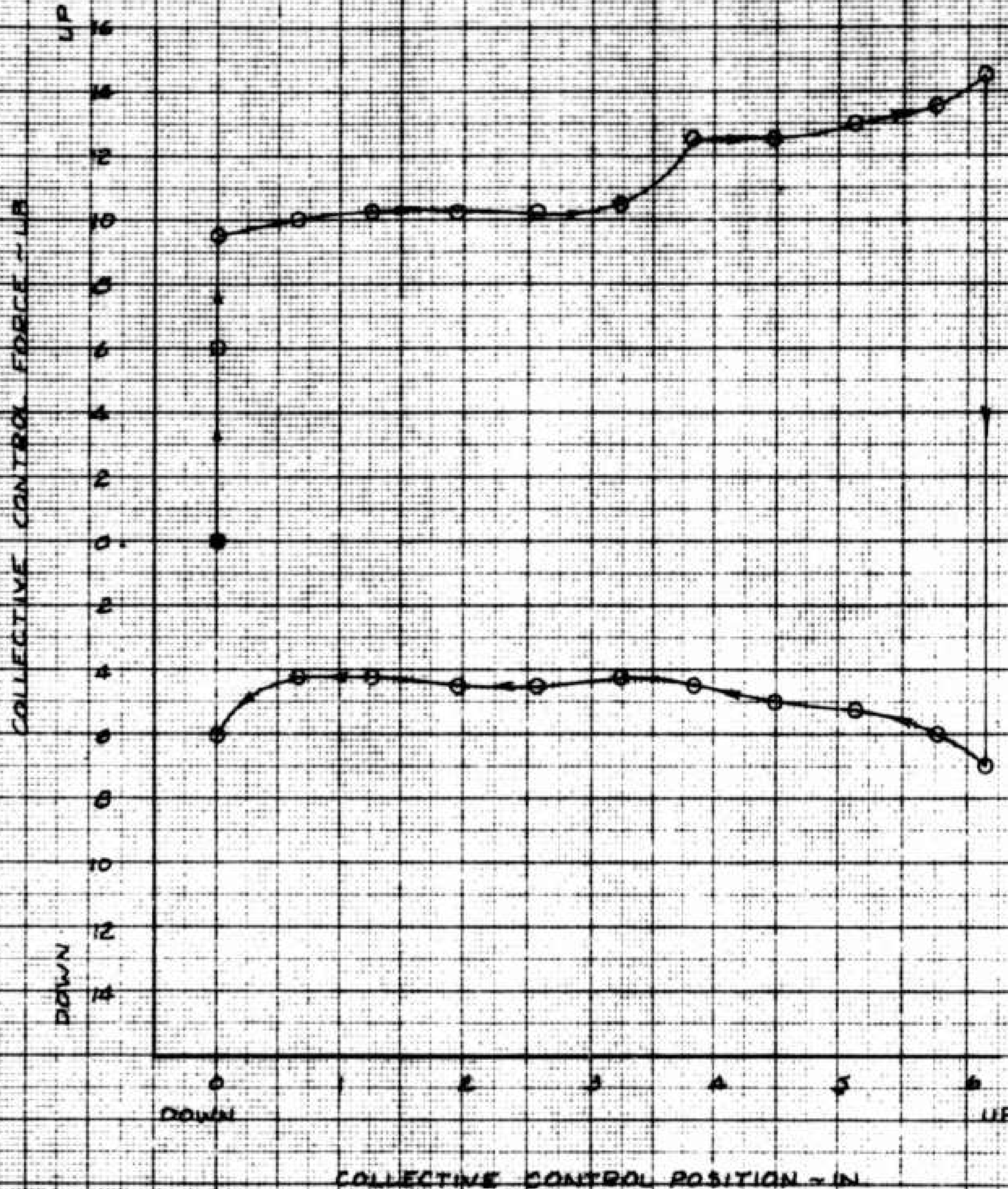


FIGURE NO. 24

TIME HISTORY OF LEFT SIDEWARD FLIGHT (AGILITY TEST)

BELL MODEL 309, USA S/N N/A

LYCOMING ENGINE MODEL T55-L-7C S/N E-52(E)

GROSS WEIGHT -LB	C.G. LOCATION -IN.	DENSITY ALTITUDE -FT	OAT -°C	ROTOR SPEED -RPM	C_T	CONFIGURATION
12530	196.7	1950	26.5	311	.004837	EXTERNAL STORES (4 XM-159C ROCKET PODS)

ACCEL, LONGITUDINAL, PITCH & MAIN ROTOR RPM ————
VEL, LATERAL, ROLL & MAIN ROTOR POWER – – – – –
DISPL, DIRECTIONAL, YAW & TAIL ROTOR POWER —·—·—

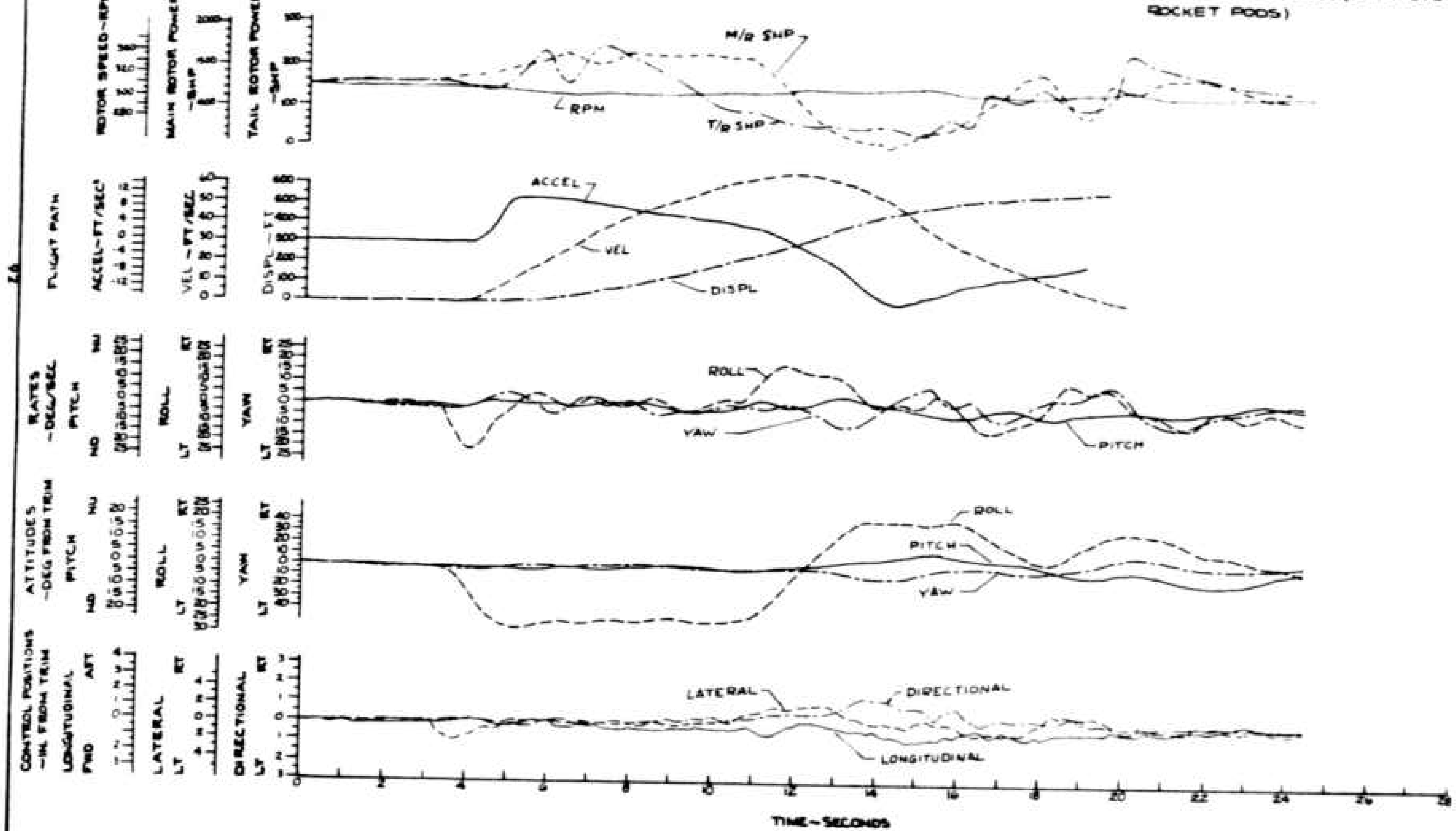


FIGURE NO 25

TIME HISTORY OF LEFT SIDEWARD FLIGHT (AGILITY TEST)

BELL MODEL 309, USA S/N N/A

LYCOMING ENGINE MODEL T55-L-7C S/N E-52(E)

GROSS WEIGHT ~LB	CG LOCATION ~IN	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T	CONFIGURATION
12550	196.7	1950	26.5	311	.004846	EXTERNAL STORES ... ROCKET PODS

ACCEL, LONGITUDINAL, PITCH & MAIN ROTOR RPM ————

VEL, LATERAL, ROLL & MAIN ROTOR POWER – – – – –

DISPL DIRECTIONAL, YAW & TAIL ROTOR POWER — · — · —

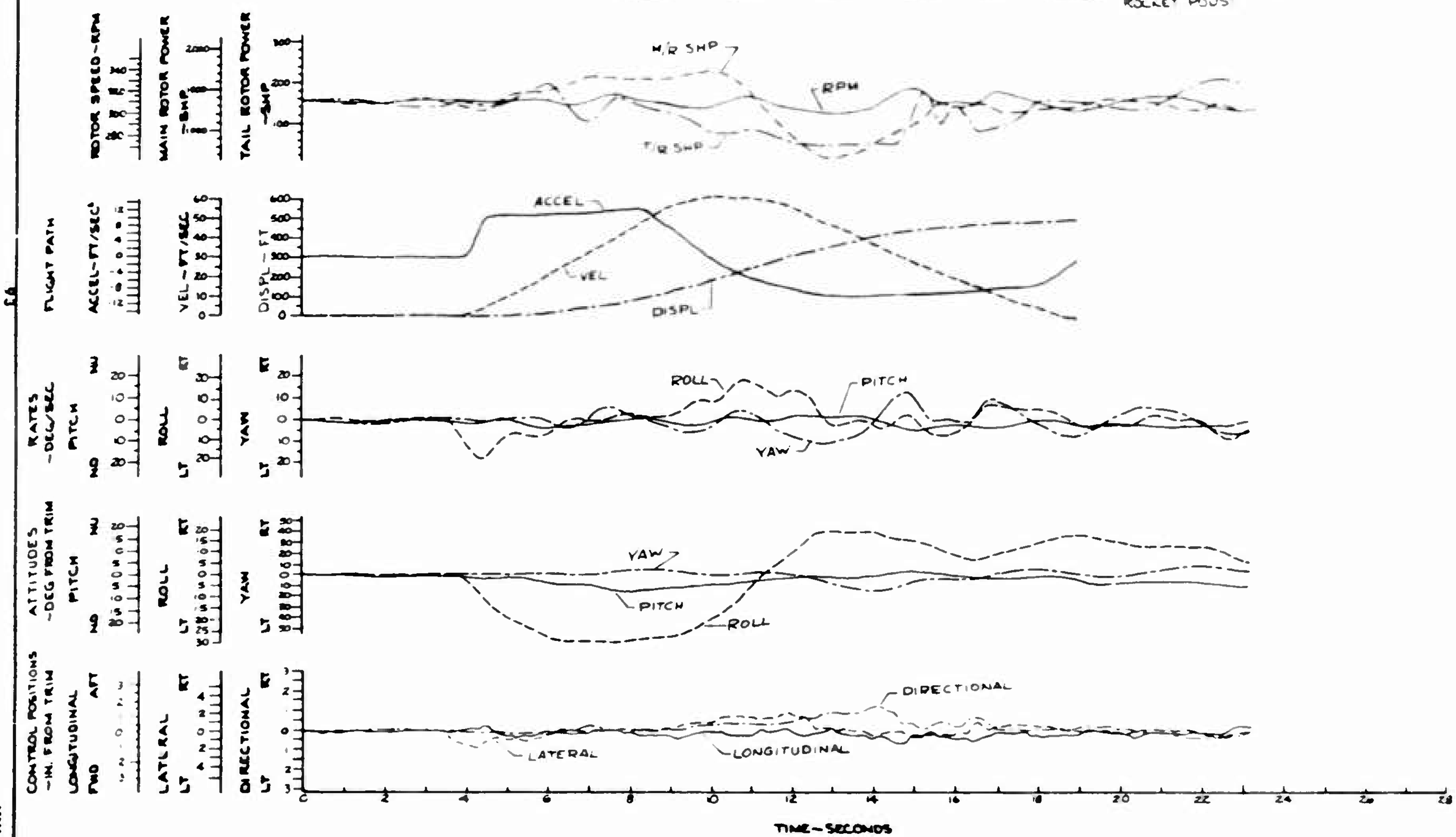


FIGURE NO 26

TIME HISTORY OF RIGHT SIDEWARD FLIGHT (AGILITY TEST)

BELL MODEL 309, USA S/N N/A

LYCOMING ENGINE MODEL TSS-L-7C S/N E-52(E)

GROSS WEIGHT ~LB	C.G. LOCATION ~IN.	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T	CONFIGURATION
12580	196.7	1950	26.5	311	.004781	EXTERNAL STORES: 4 XM-59 ROCKET PODS

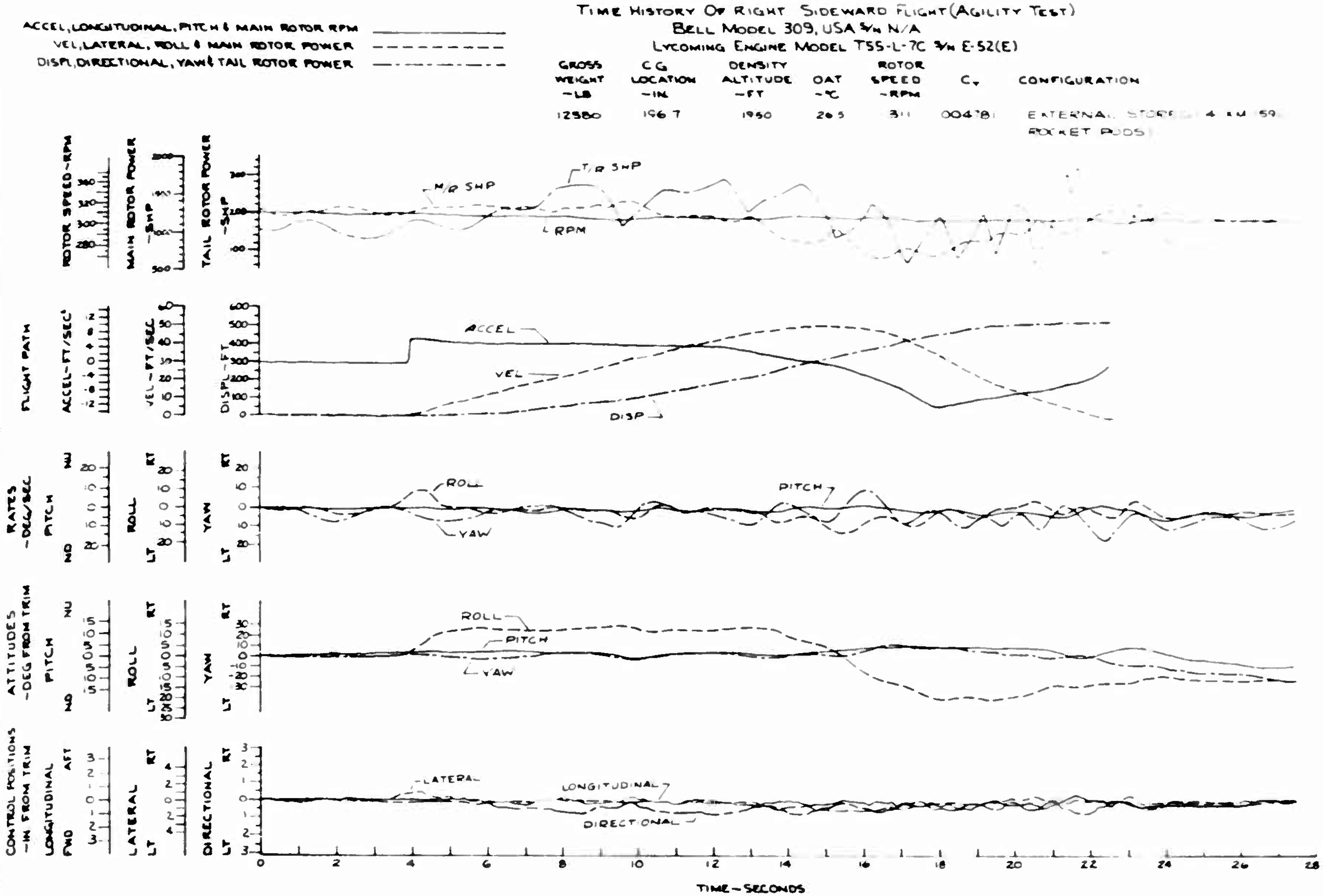
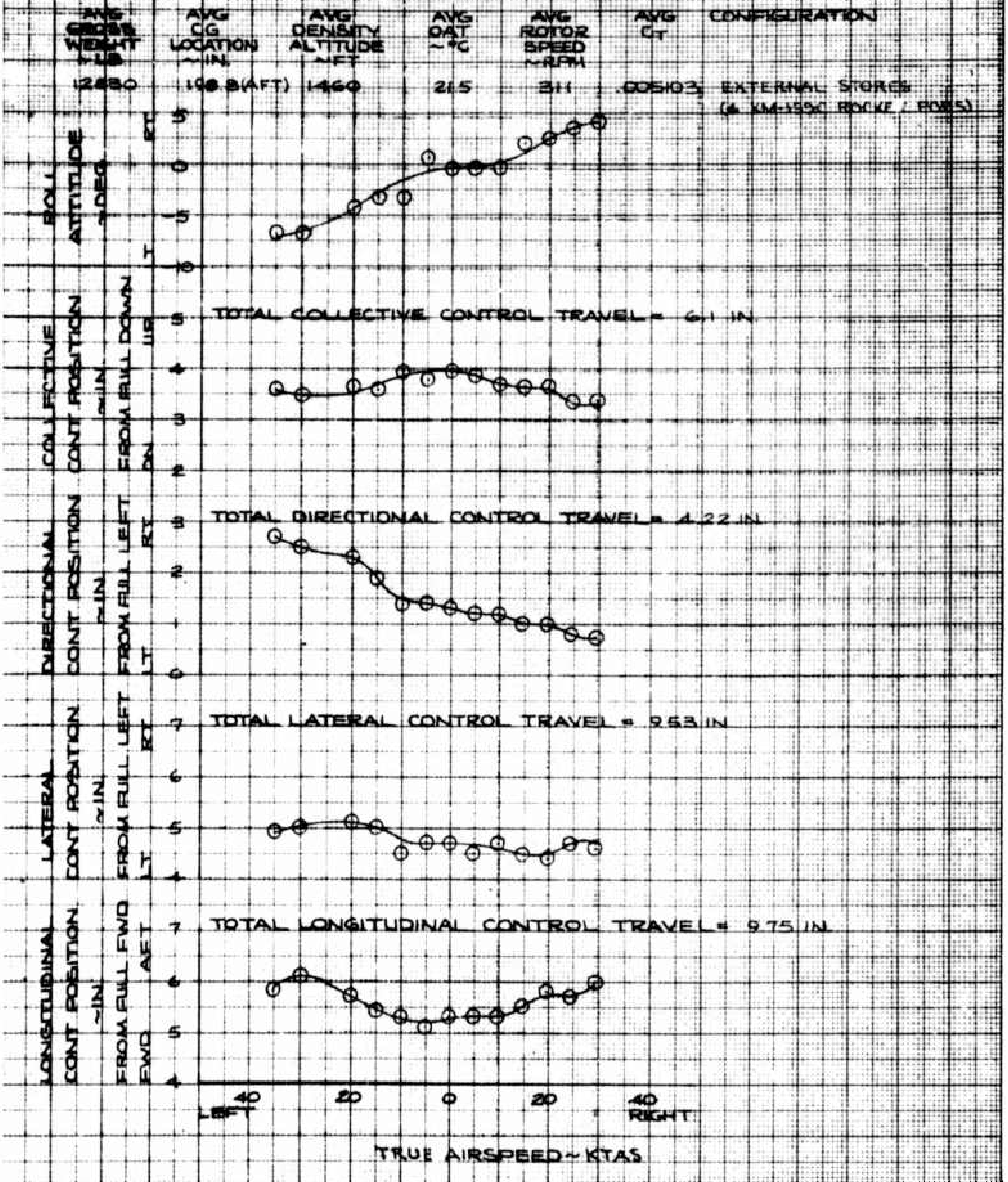


Figure No. 27
Control Positions in Sideward Flight
Bell Model 309, USA S/N N/A



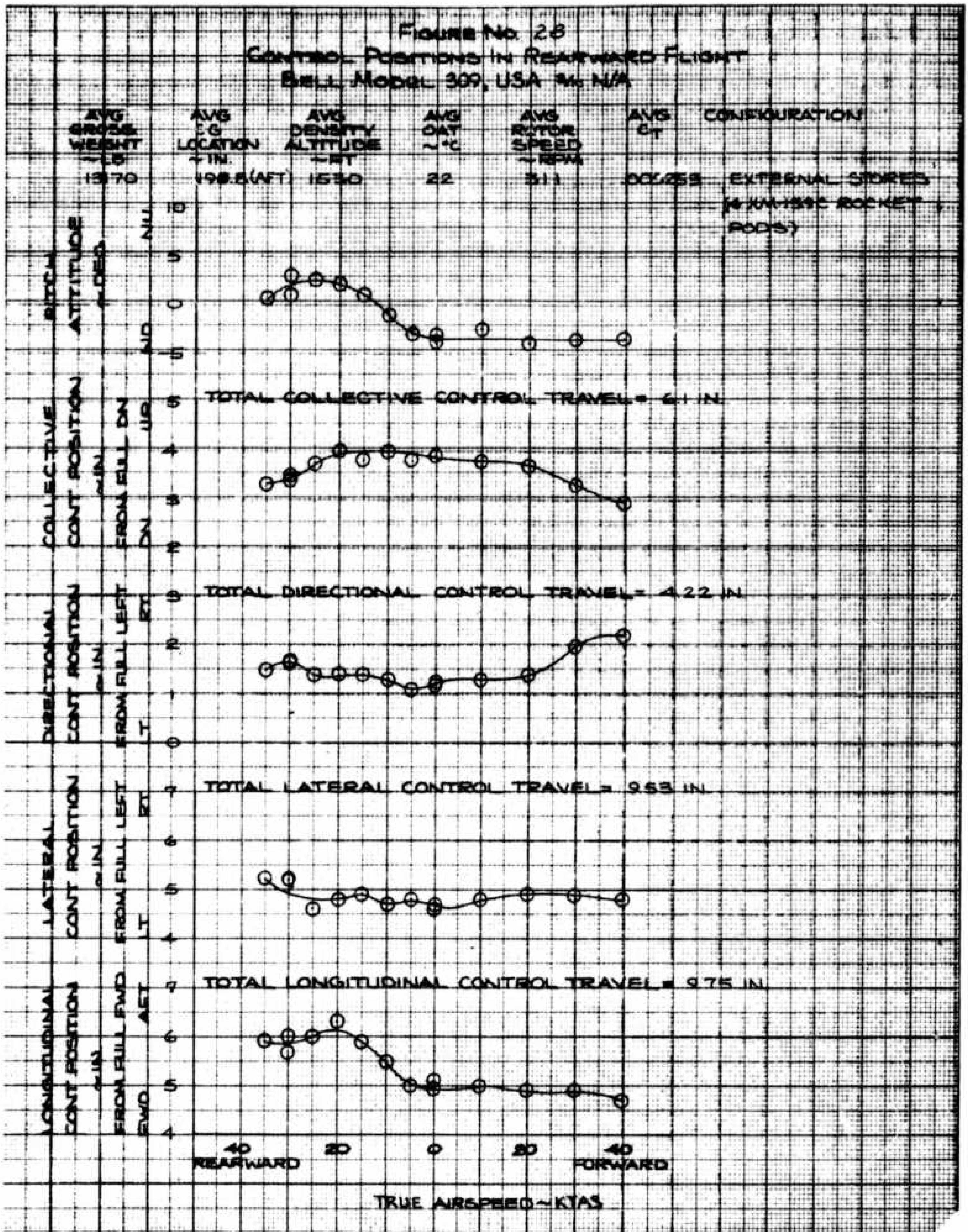


FIGURE No. 28
CONTROL POSITIONS IN REARWARD FLIGHT
BELL MODEL 309, USA S/N N/A
AVG GROSS WEIGHT ~LB
AVG C.G. LOCATION ~IN.
AVG DENSITY ALTITUDE ~FT
AVG OAT ~°C
AVG ROTOR SPEED ~RPM
AVG C_T
CONFIGURATION
22
EXTERNAL STORES
ROCKET PODS)
PITCH ATTITUDE ~DEG
NU
ND
COLLECTIVE CONT POSITION ~IN FROM FULL DN
UP
DN
TOTAL COLLECTIVE CONTROL TRAVEL = 6.1 IN.
DIRECTIONAL CONT POSITION ~IN FROM FULL LEFT
RT
LT
TOTAL DIRECTIONAL CONTROL TRAVEL = 4.22 IN.
LATERAL CONT POSITION ~IN FROM FULL LEFT
RT
LT
TOTAL LATERAL CONTROL TRAVEL = 9.53 IN.
LONGITUDINAL CONT POSITION ~IN FROM FULL FWD
AFT
FWD
TOTAL LONGITUDINAL CONTROL TRAVEL = 9.75 IN.
40
REARWARD
20
0
20
40
FORWARD
TRUE AIRSPEED ~KTAS

Figure No. 29

Control Positions in Trimmed Forward Flight

Bell Model 309, USA S/N N/A

AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T	CONFIGURATION
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

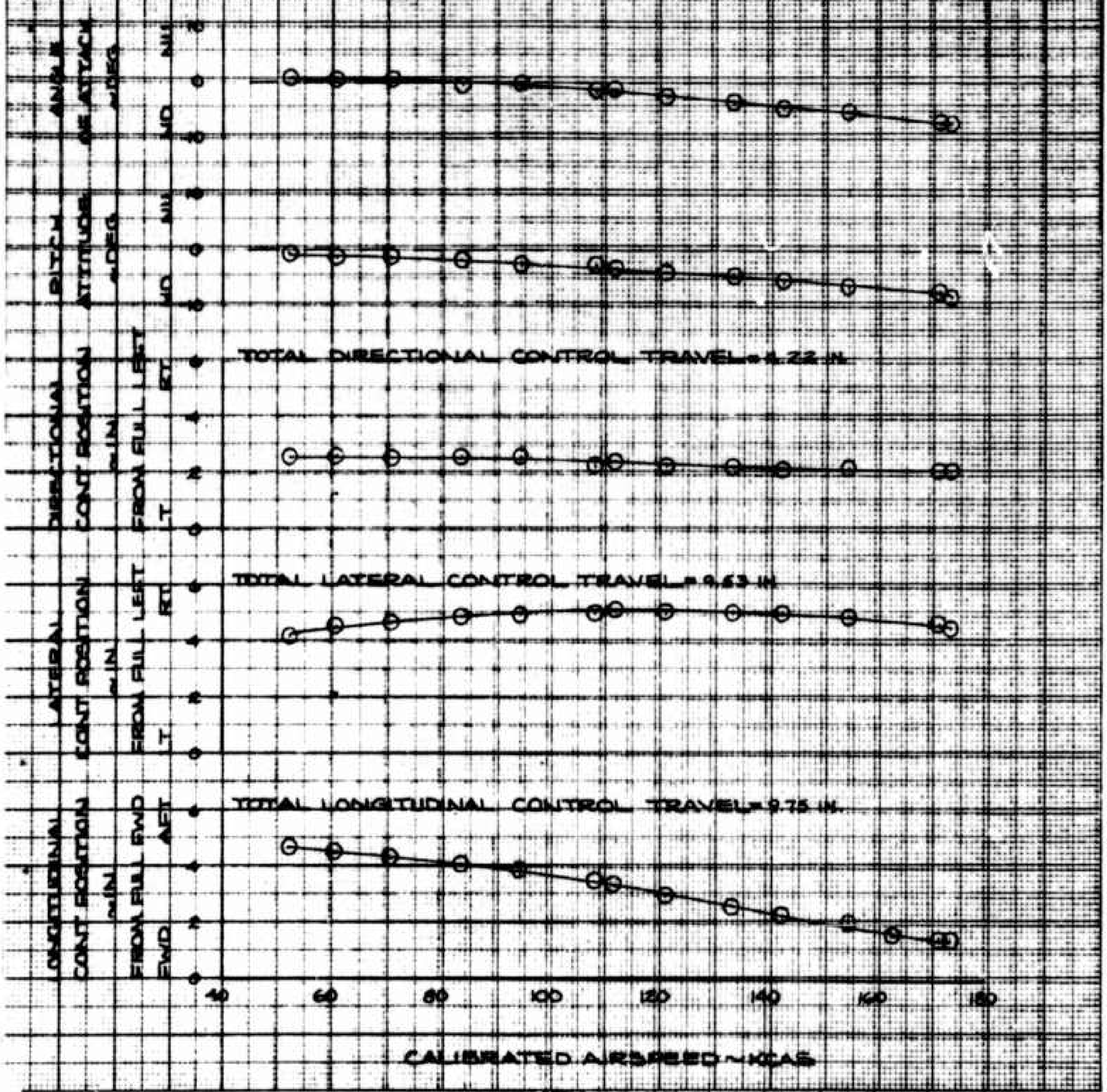
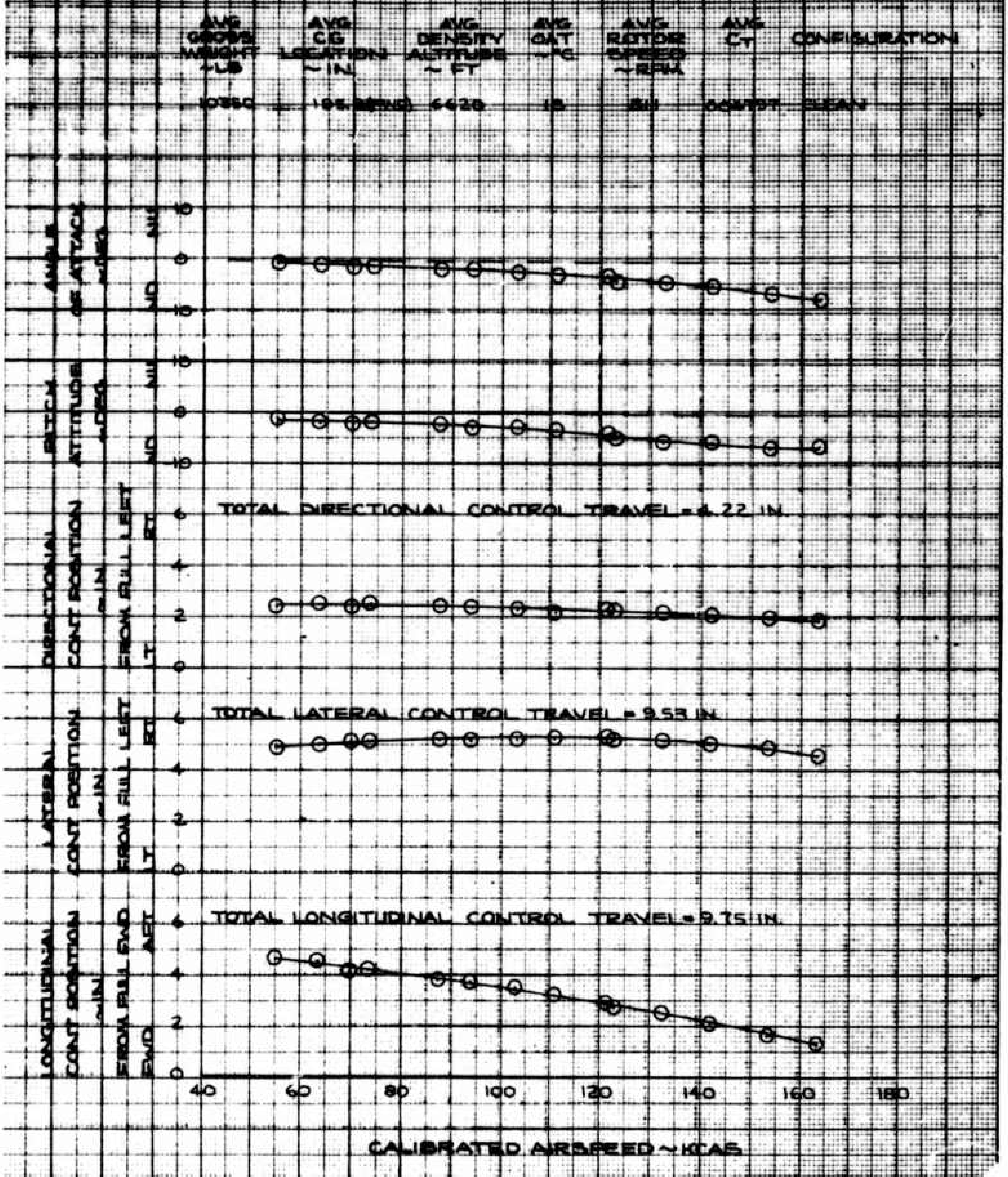


FIGURE NO 30
CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT
BELL MODEL 309, USA S/N N/A



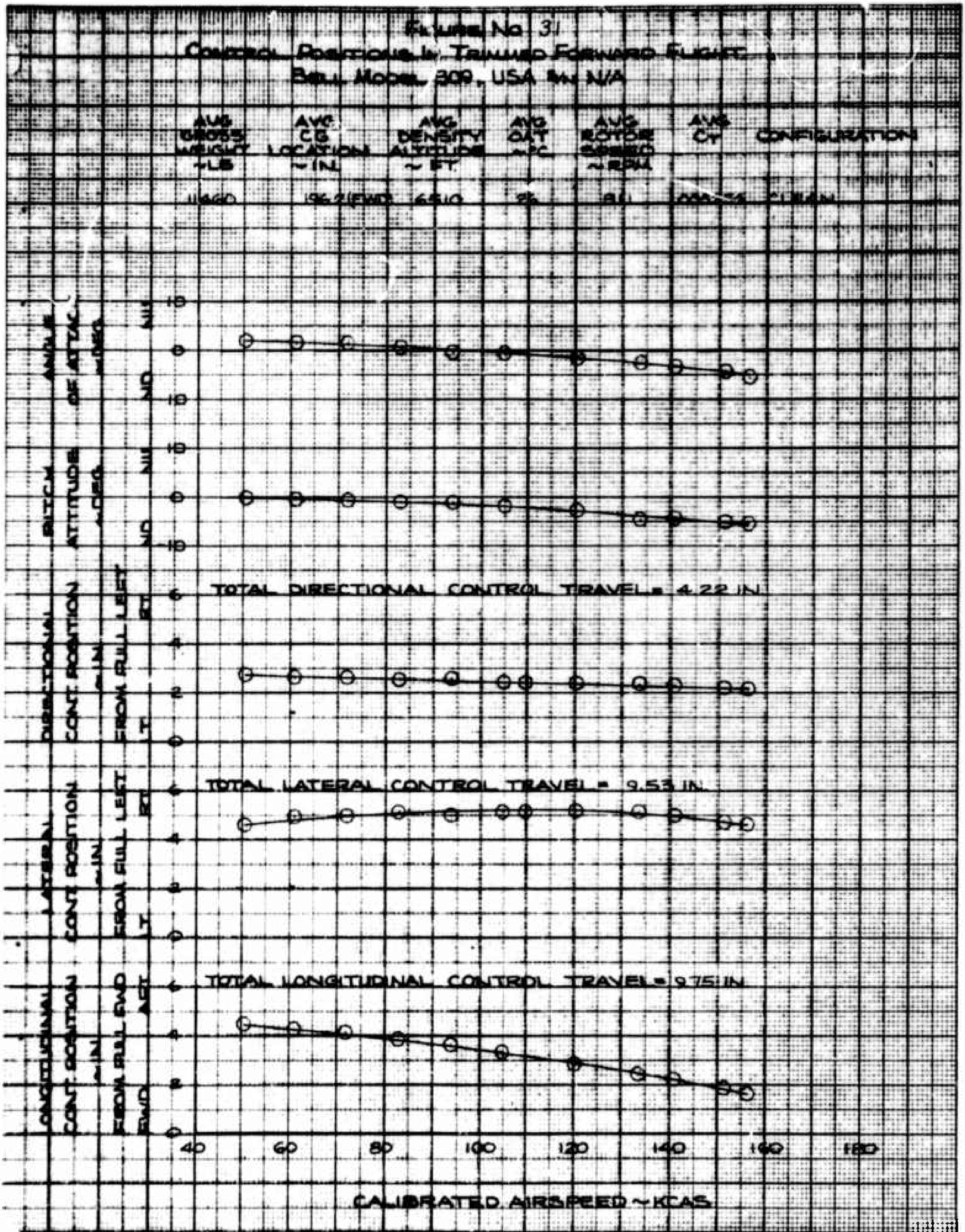


FIGURE No. 31
CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT
BELL MODEL 309, USA S/N N/A
AVG GROSS WEIGHT ~LB
AVG CG LOCATION ~IN.
AVG DENSITY ALTITUDE ~FT.
AVG OAT ~°C
AVG ROTOR SPEED ~RPM
AVG C_T
CONFIGURATION
11460
196.2(FWD)
6510
CLEAN
ANGLE OF ATTACK ~DEG.
PITCH ATTITUDE ~DEG.
NU
ND
DIRECTIONAL CONT. POSITION ~IN. FROM FULL LEFT
RT
LT
TOTAL DIRECTIONAL CONTROL TRAVEL = 4.22 IN.
LATERAL CONT. POSITION ~IN. FROM FULL LEFT
TOTAL LATERAL CONTROL TRAVEL = 9.53 IN.
LONGITUDINAL CONT. POSITION ~IN. FROM FULL FWD
AFT
FWD
TOTAL LONGITUDINAL CONTROL TRAVEL = 9.75 IN.
40
60
80
100
120
140
160
180
CALIBRATED AIRSPEED ~KCAS

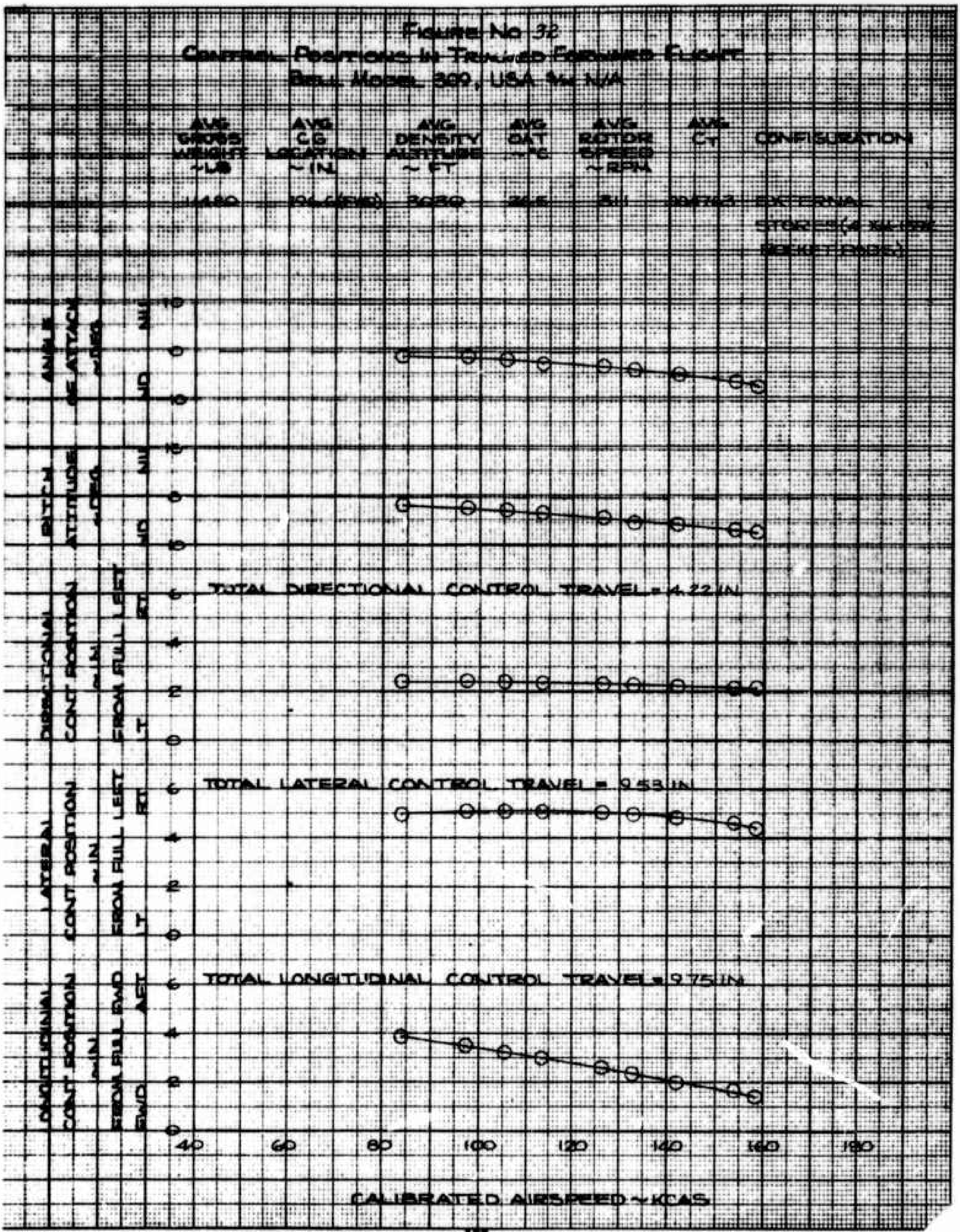


FIGURE NO 32
CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT
BELL MODEL 309, USA S/N N/A
AVG GROSS WEIGHT ~LB
AVG CG LOCATION ~IN
AVG DENSITY ALTITUDE ~FT
AVG OAT ~°C
AVG ROTOR SPEED ~RPM
AVG C_T
CONFIGURATION
EXTERNAL STORES (4 XM-159C ROCKET PODS)
ANGLE OF ATTACK ~DEG
PITCH ATTITUDE ~DEG
NU
ND
DIRECTIONAL CONT POSITION ~IN FROM FULL LEFT
RT
LT
TOTAL DIRECTIONAL CONTROL TRAVEL = 4.22 IN.
LATERAL CONT POSITION ~IN FROM FULL LEFT
TOTAL LATERAL CONTROL TRAVEL = 9.53 IN.
LONGITUDINAL CONT POSITION ~IN FROM FULL FWD
AFT
FWD
TOTAL LONGITUDINAL CONTROL TRAVEL = 9.75 IN.
40
60
80
100
120
140
160
180
CALIBRATED AIRSPEED ~ KCAS

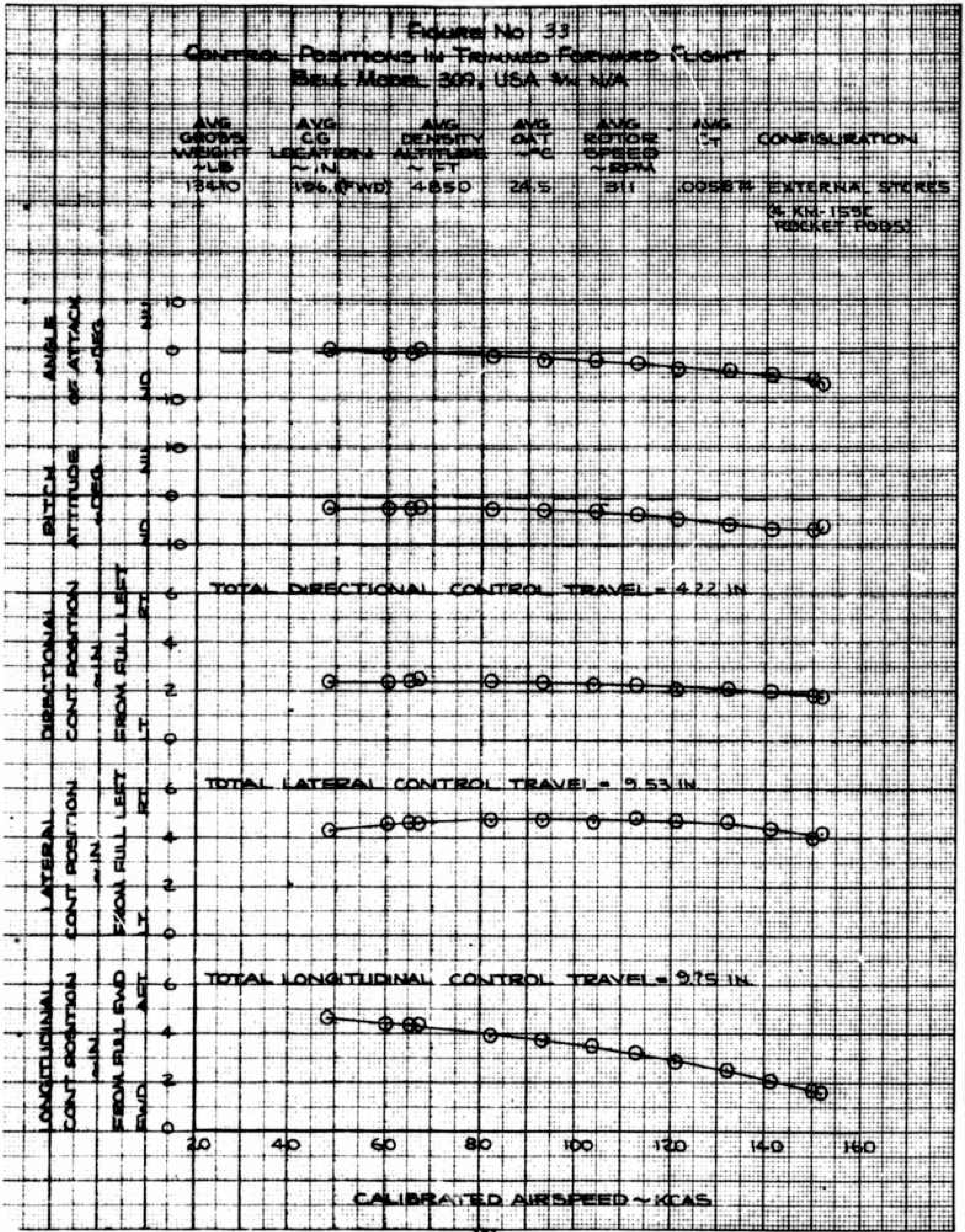


Figure No 33
Control Positions in Trimmed Forward Flight
Bell Model 309, USA S/N N/A
AVG GROSS WEIGHT ~LB
AVG CG LOCATION ~IN
AVG DENSITY ALTITUDE ~FT
AVG OAT ~°C
AVG ROTOR SPEED ~RPM
AVG C_T
CONFIGURATION
13410
196.(FWD)
4850
24.5
311
.00587
EXTERNAL STORES (4 XM-159C ROCKET PODS)
ANGLE OF ATTACK ~DEG
PITCH ATTITUDE ~DEG
NU
ND
DIRECTIONAL CONT POSITION ~IN FROM FULL LEFT
TOTAL DIRECTIONAL CONTROL TRAVEL = 4.22 IN
LATERAL CONT POSITION ~IN FROM FULL LEFT
TOTAL LATERAL CONTROL TRAVEL = 9.53 IN
LONGITUDINAL CONT POSITION ~IN FROM FULL FWD
TOTAL LONGITUDINAL CONTROL TRAVEL = 9.75 IN
RT
LT
AFT
FWD
10
0
10
10
0
10
6
4
2
0
6
4
2
0
6
4
2
0
20
40
60
80
100
120
140
160
CALIBRATED AIRSPEED ~ KCAS

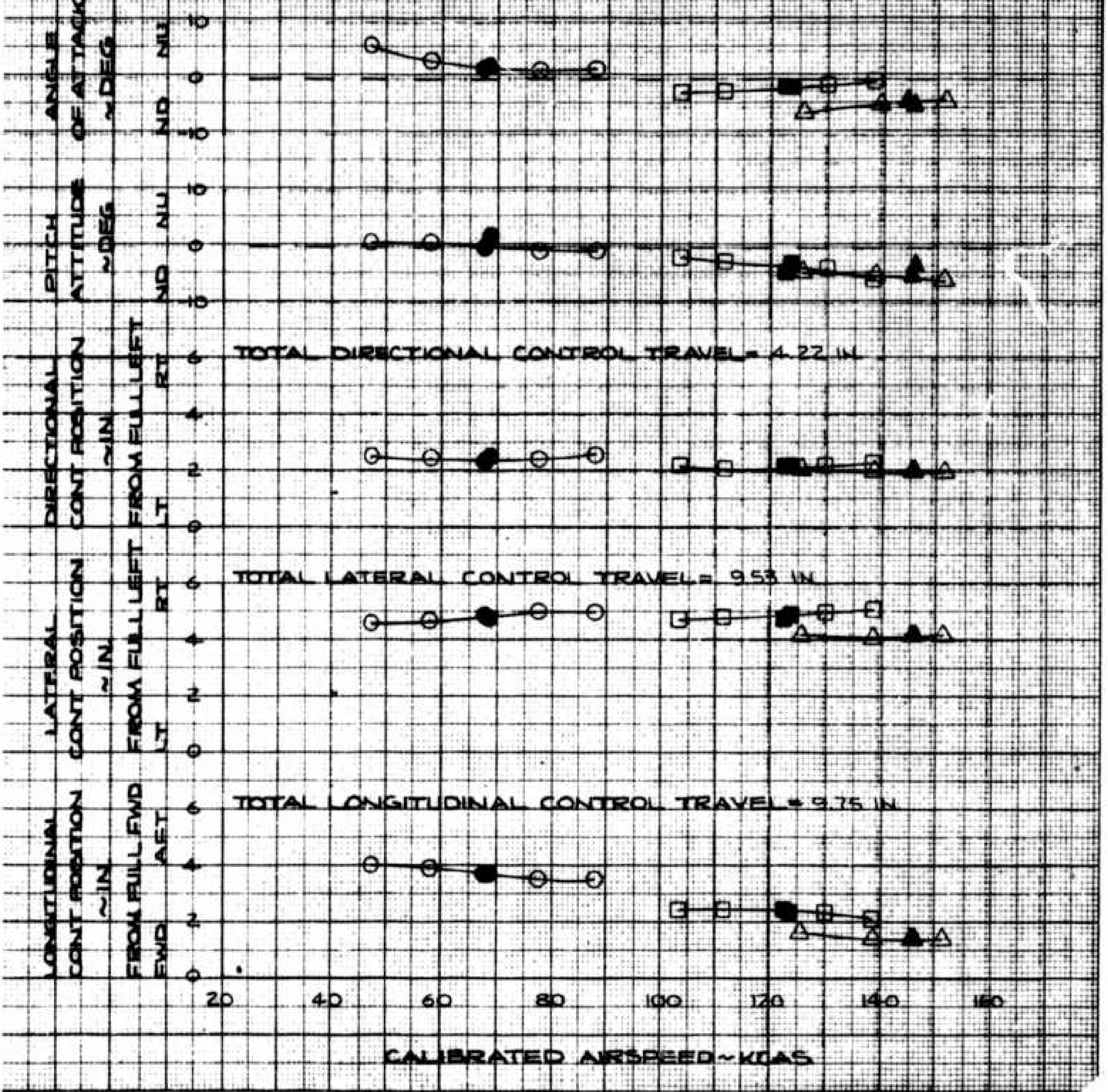
FIGURE NO. 34

STATIC LONGITUDINAL STABILITY

BELL MODEL 309, USA S/N N/A

AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T	CONFIGURATION	FLIGHT CONDITION
13760	198.3(AFT)	5530	25.5	311	.006481	EXTERNAL STORES (4 XM-159C ROCKET PODS)	LEVEL FLIGHT

NOTES: 1. SOLID SYMBOLS ARE TRIM POINTS
2. COLLECTIVE HELD FIXED DURING TEST



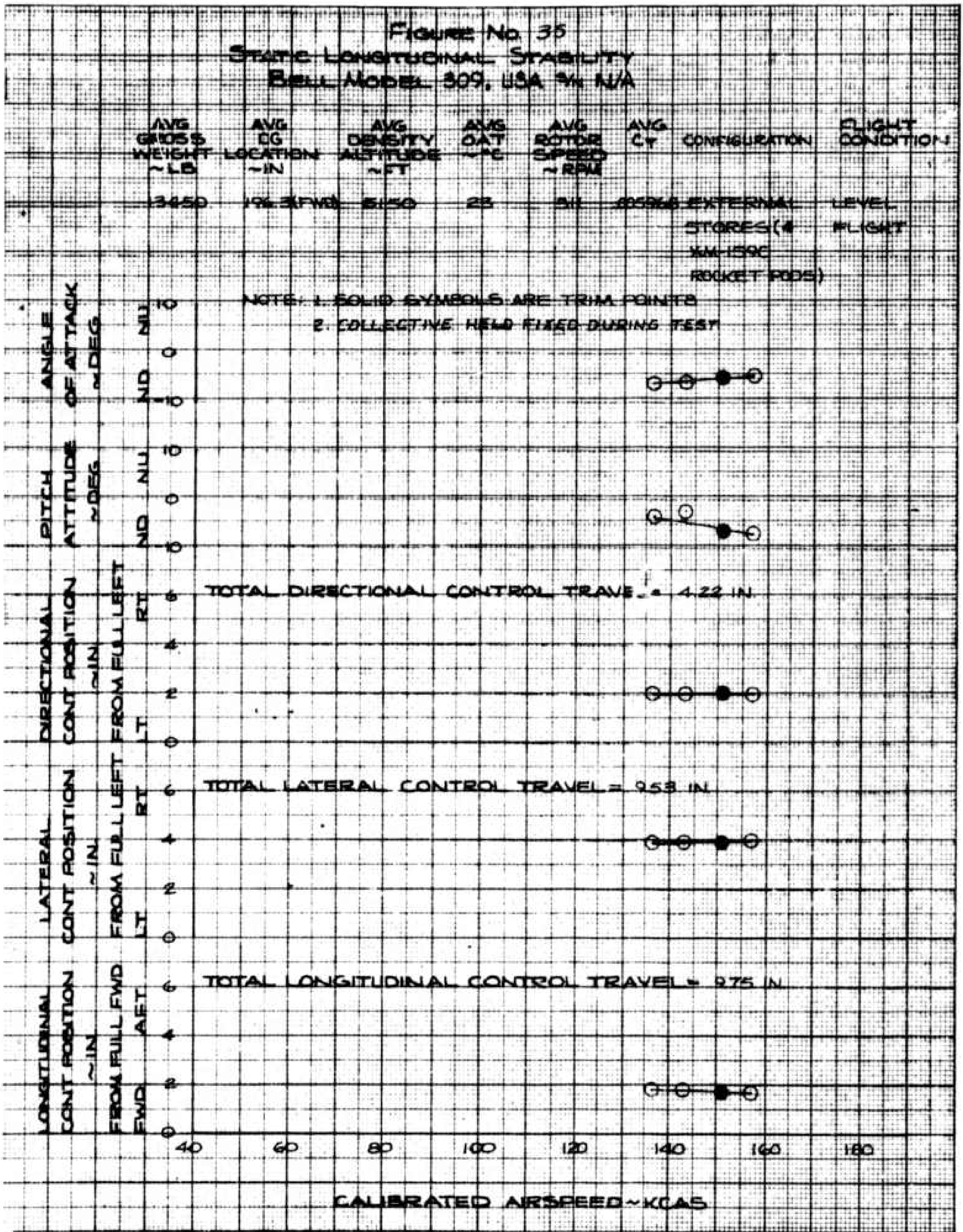
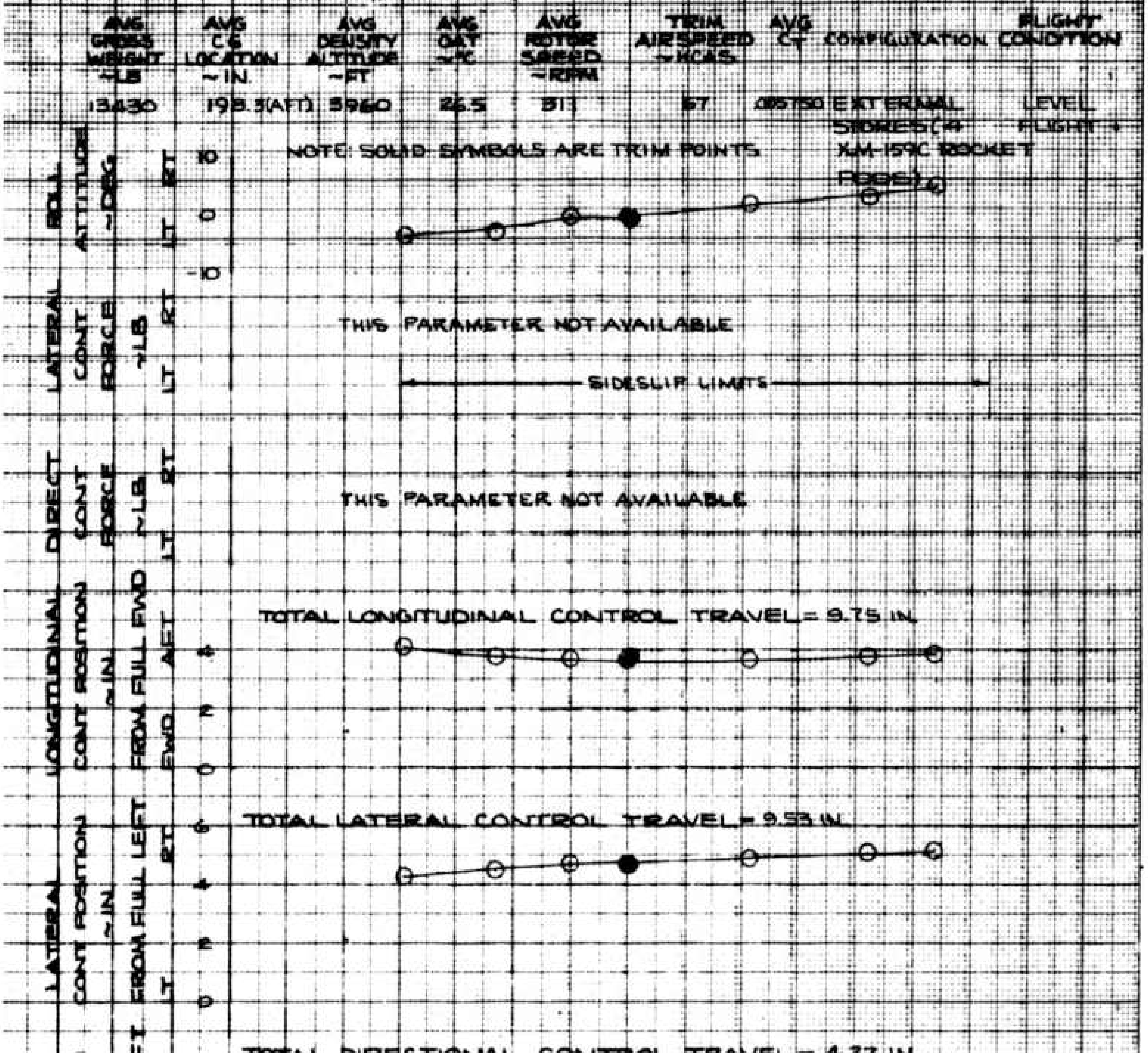


FIGURE NO. 35
STATIC LONGITUDINAL STABILITY
BELL MODEL 309, USA S/N N/A
AVG GROSS WEIGHT ~LB
AVG CG LOCATION ~IN
AVG DENSITY ALTITUDE ~FT
AVG OAT ~°C
AVG ROTOR SPEED ~RPM
AVG C_T
CONFIGURATION
FLIGHT CONDITION
13450
196.3(FWD)
5150
23
311
.005968
EXTERNAL STORES(4 XM-159C ROCKET PODS)
LEVEL FLIGHT
NOTE: 1. SOLID SYMBOLS ARE TRIM POINTS
2. COLLECTIVE HELD FIXED DURING TEST
ANGLE OF ATTACK ~DEG
NU
ND
PITCH ATTITUDE ~DEG
DIRECTIONAL CONT POSITION ~IN FROM FULL LEFT
RT
LT
TOTAL DIRECTIONAL CONTROL TRAVEL = 4.22 IN.
LATERAL CONT POSITION ~IN FROM FULL LEFT
TOTAL LATERAL CONTROL TRAVEL = 9.53 IN.
LONGITUDINAL CONT POSITION ~IN FROM FULL FWD
AFT
FWD
TOTAL LONGITUDINAL CONTROL TRAVEL = 9.75 IN.
40
60
80
100
120
140
160
180
CALIBRATED AIRSPEED ~KCAS

Figure No. 36
Static Lateral Directional Stability
Bell Model 309, USA S/N N/A



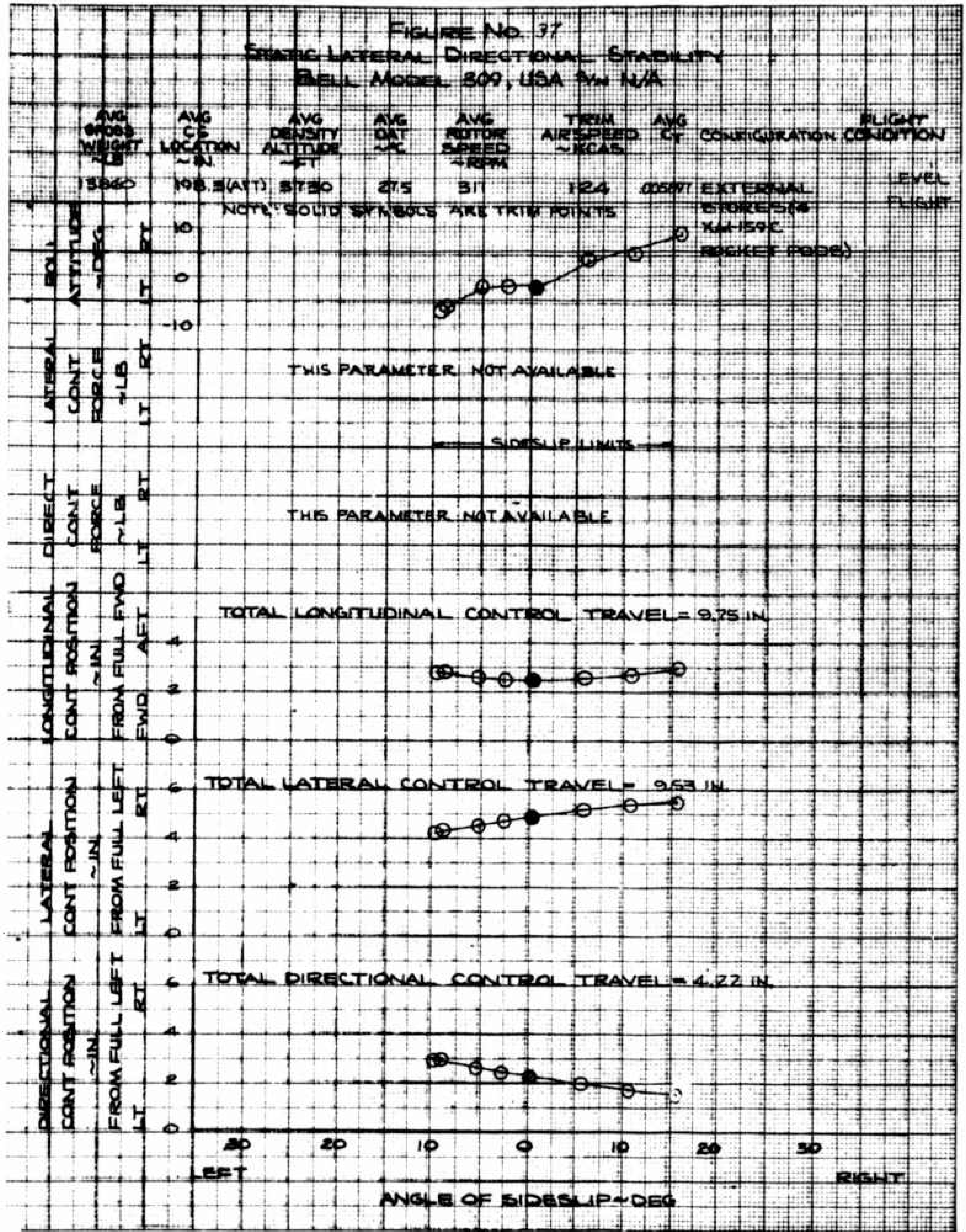


FIGURE NO. 37
STATIC LATERAL DIRECTIONAL STABILITY
BELL MODEL 309, USA S/N N/A

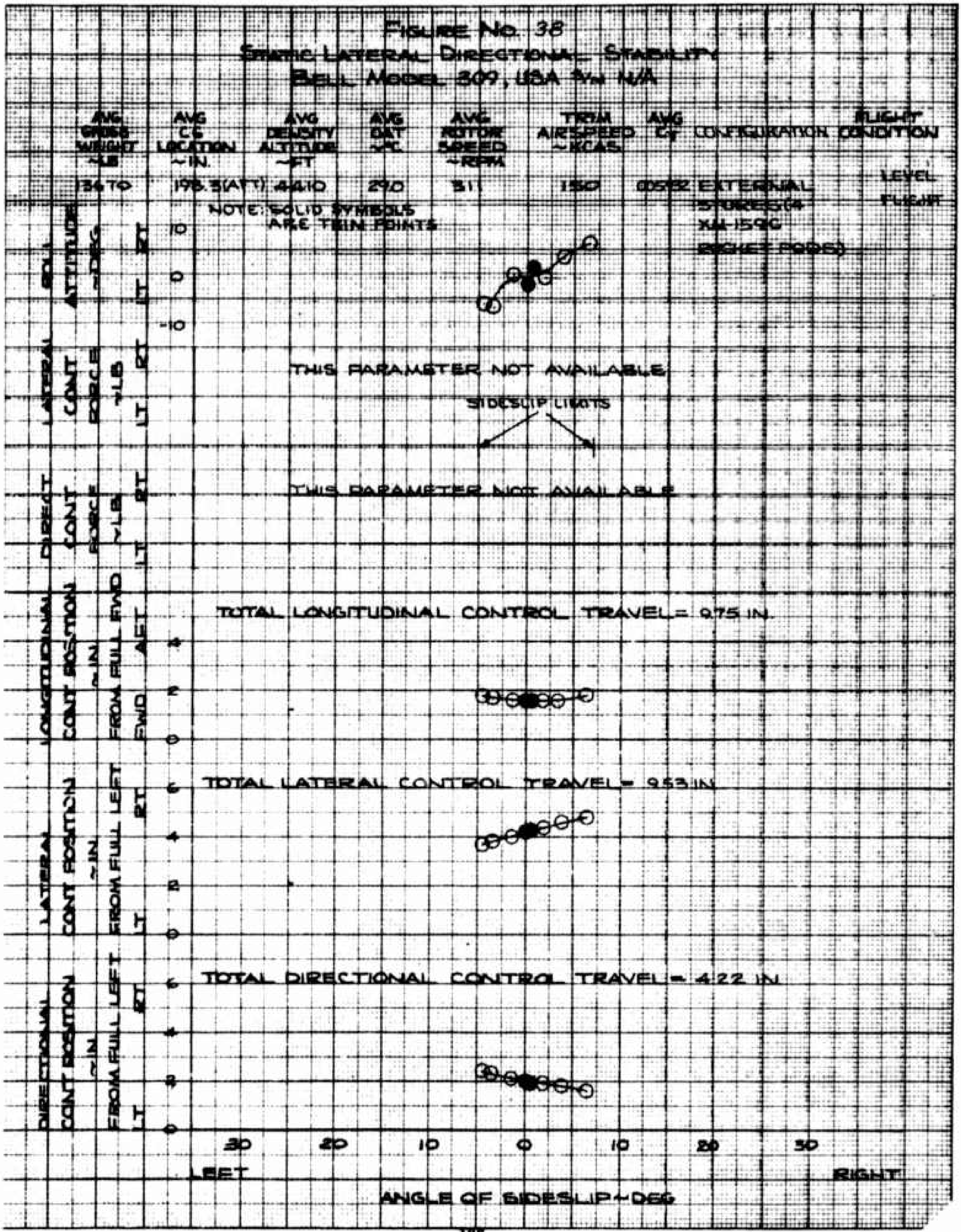


FIGURE No. 38
STATIC LATERAL DIRECTIONAL STABILITY
BELL MODEL 309, USA S/N N/A
AVG GROSS WEIGHT ~LB
AVG CG LOCATION ~IN.
AVG DENSITY ALTITUDE ~FT
AVG OAT ~°C
AVG ROTOR SPEED ~RPM
TRIM AIRSPEED ~KCAS
AVG CT
CONFIGURATION
FLIGHT CONDITION
13470
198.3(AFT)
4610
29.0
311
150
.00592
EXTERNAL STORES(4 XM-159C ROCKET PODS)
LEVEL FLIGHT
NOTE: SOLID SYMBOLS ARE TRIM POINTS
ROLL ATTITUDE ~DEG
LATERAL CONT FORCE ~LB
DIRECT CONT FORCE ~LB
LONGITUDINAL CONT POSITION ~IN. FROM FULL FWD
LATERAL CONT POSITION ~IN. FROM FULL LEFT
DIRECTIONAL CONT POSITION ~IN. FROM FULL LEFT
THIS PARAMETER NOT AVAILABLE
SIDESLIP LIMITS
THIS PARAMETER NOT AVAILABLE
TOTAL LONGITUDINAL CONTROL TRAVEL = 9.75 IN.
TOTAL LATERAL CONTROL TRAVEL = 9.53 IN.
TOTAL DIRECTIONAL CONTROL TRAVEL = 4.22 IN.
LEFT
RIGHT
ANGLE OF SIDESLIP ~ DEG

FIGURE NO. 39
AFT LONGITUDINAL PULSE
BELL MODEL 309, USA S/N N/A

GROSS WEIGHT ~LB	C.G. LOCATION ~IN	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	TRIM AIRSPEED ~KCAS	C_T	CONFIGURATION
13650	198.3	1950	25	311	HOVER	.005503	EXTERNAL STORES (4 XM-159C ROCKET PODS)

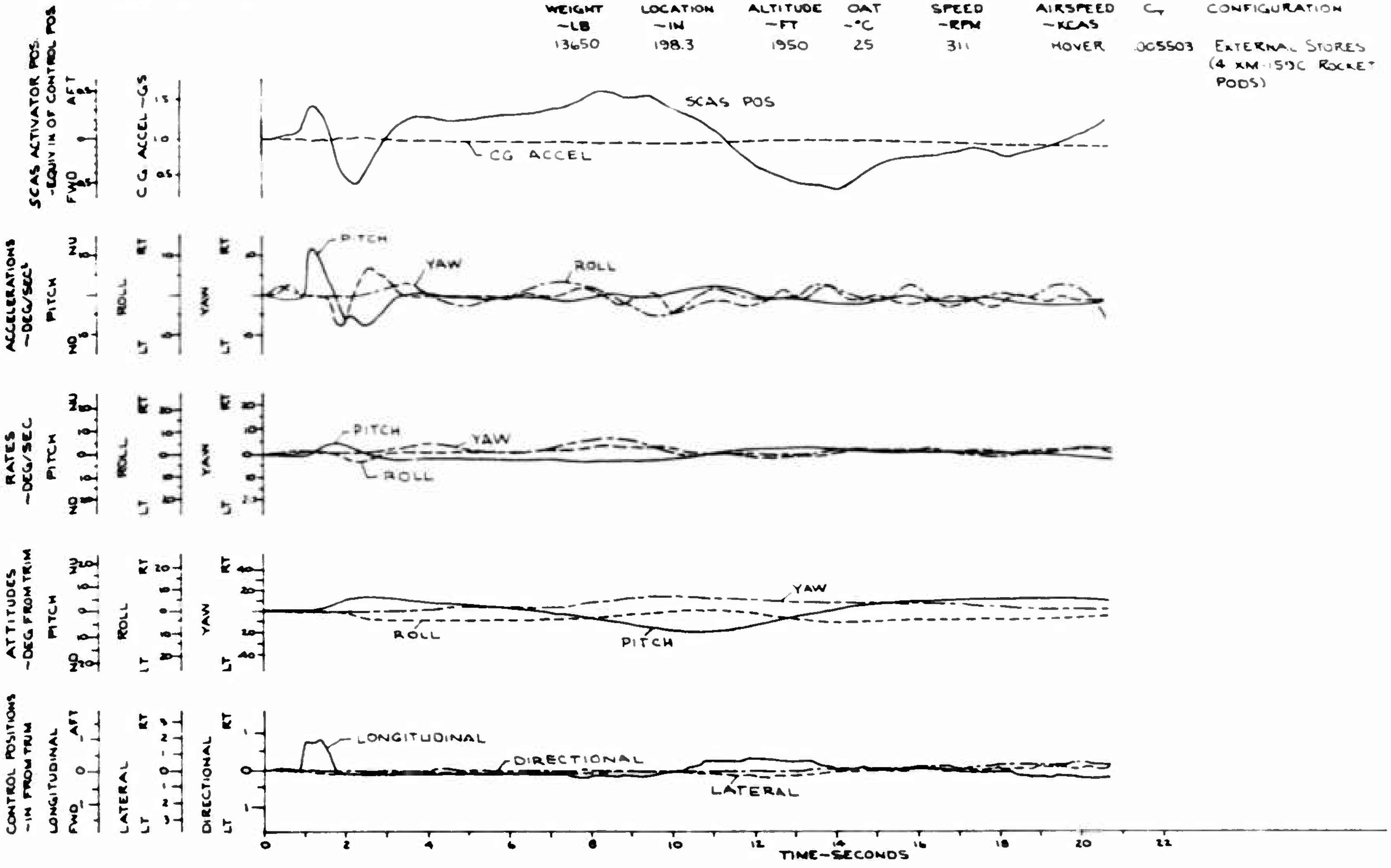


FIGURE NO. 40
RIGHT LATERAL PULSE
BELL MODEL 309, USA S/N N/A

LONGITUDINAL, PITCH & SAS ————
C.G. ACCEL, LATERAL & ROLL - - - - -
DIRECTIONAL, YAW —·—·—·—

GROSS WEIGHT ~LB	C.G. LOCATION ~IN.	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	TRIM AIRSPEED ~KCAS	C_T	CONFIGURATION
13100	198.3	1950	25	311	HOVER	.005280	EXTERNAL STORES (4 XM-159C ROCKET PODS)

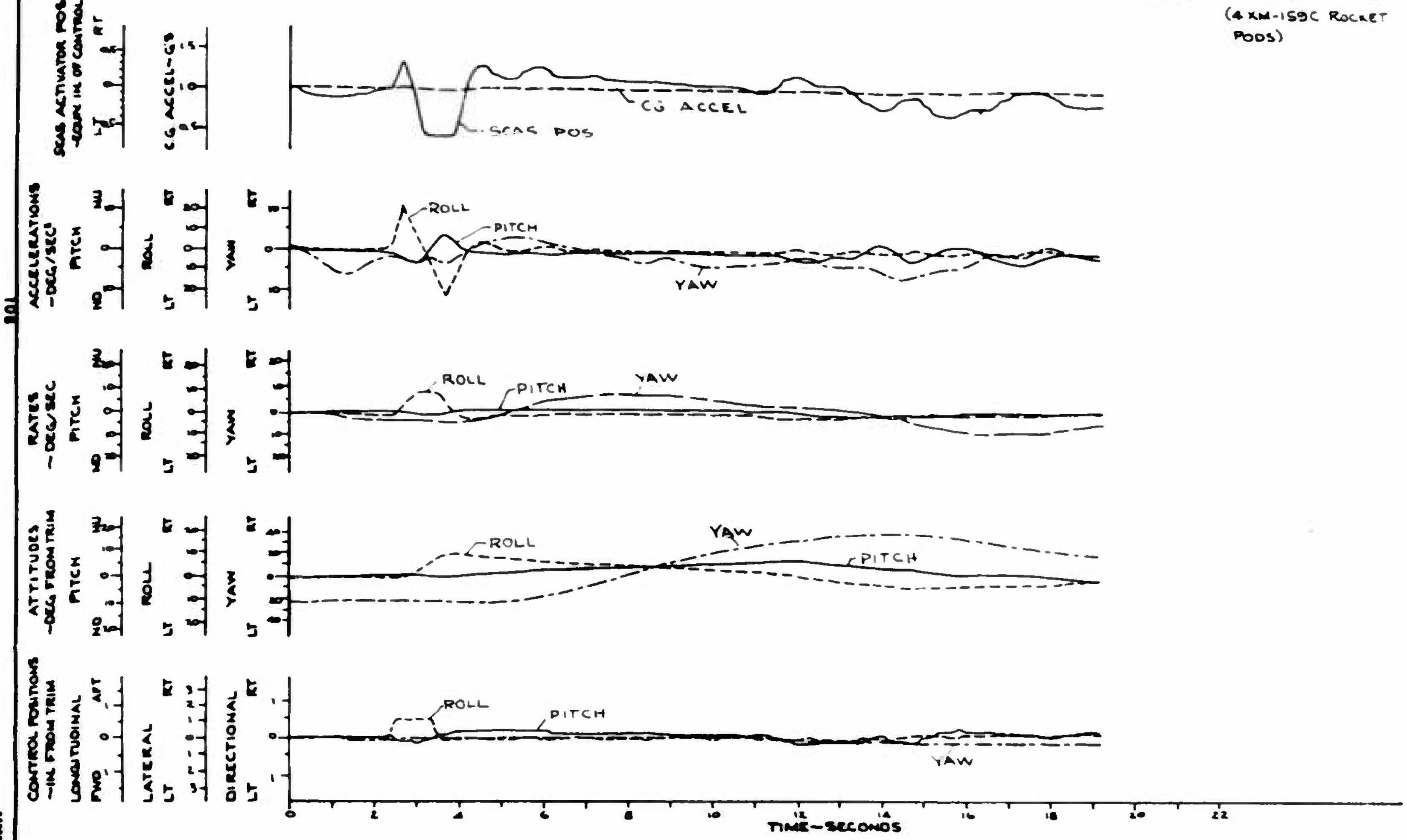
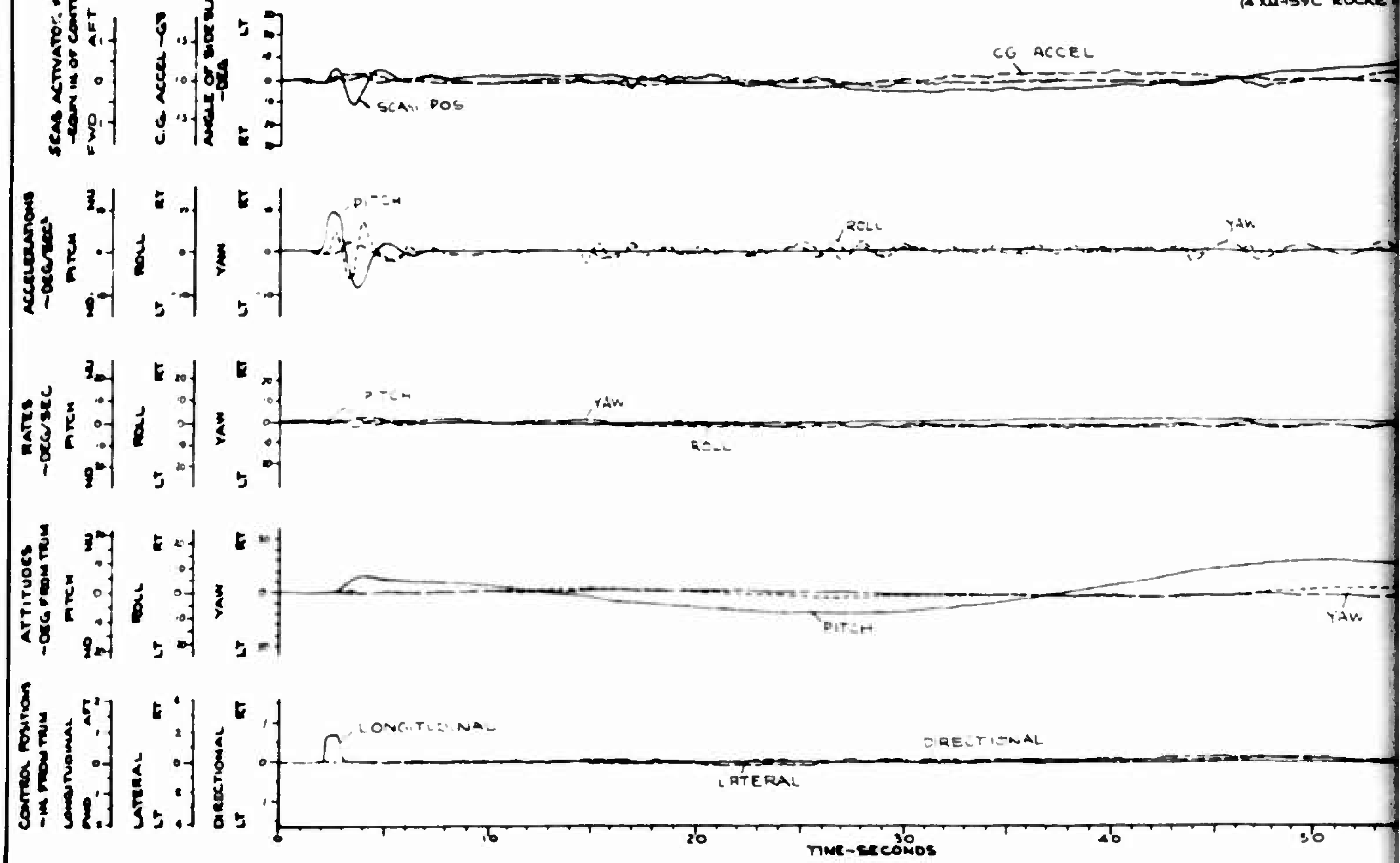


FIGURE NO 41
LONG PERIOD CHARACTERISTICS
BELL MODEL 309, USA S/N N/A

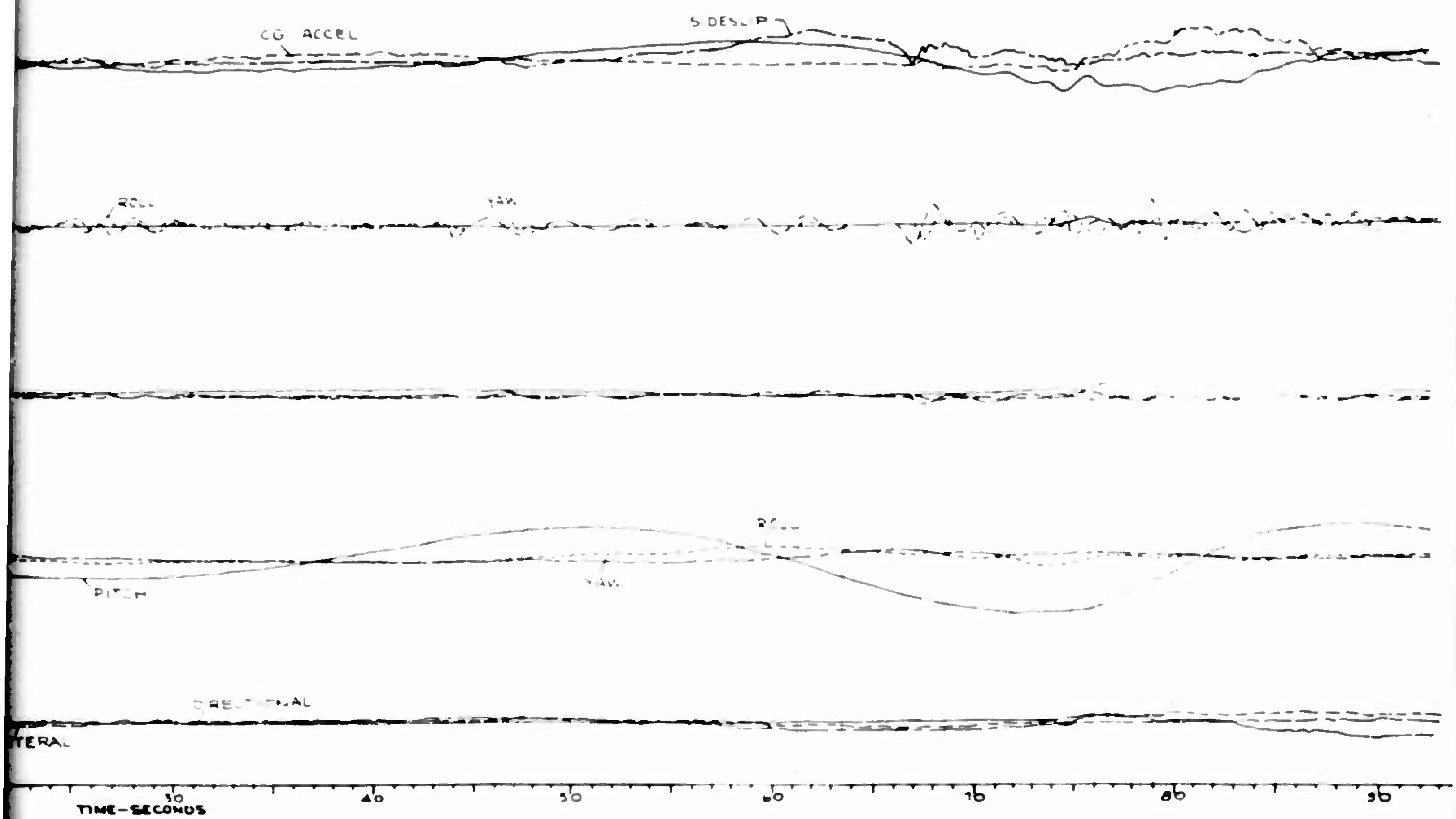
LONGITUDINAL, PITCH & SAS ————
C.G. ACCEL, LATERAL & ROLL - - - - - -
DIRECTIONAL, YAW & SIDESLIP — - — - —

GROSS WEIGHT ~LB	C.G. LOCATION ~IN.	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	TRIM AIRSPEED ~KCAS	C_T	CONFIGURATION
15800	198.5	5250	25.5	311	66	.006145	EXTERNAL STORES (4 XM-159C ROCKET



RE NO. 41
OD CHARACTERISTICS
EL 309, USA S/N N/A

DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	TRIM AIRSPEED ~KCAS	C_T	CONFIGURATION
5250	25.5	311	66	.006145	EXTERNAL STORES (4 XM-159C ROCKET PODS)



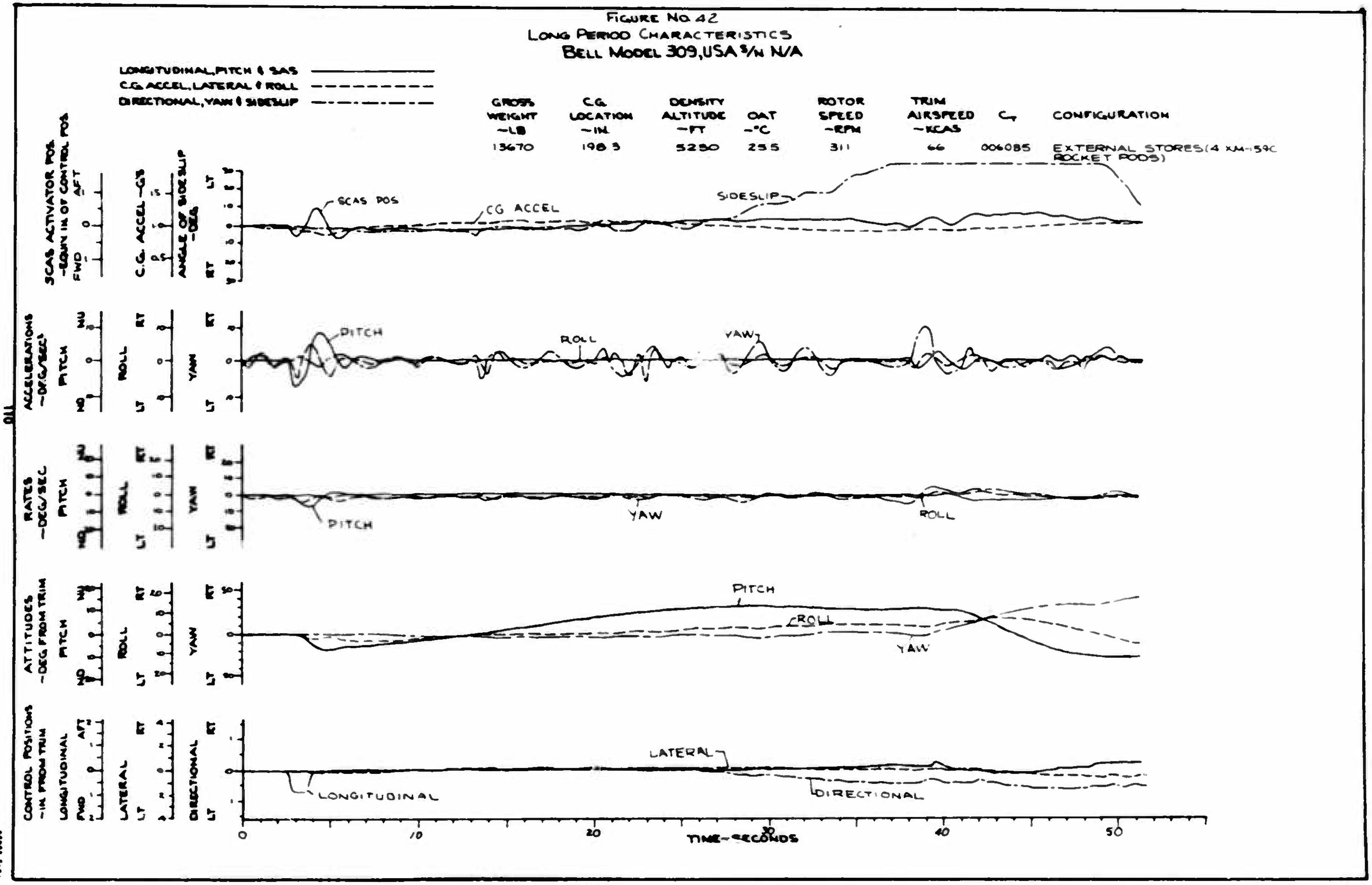


FIGURE NO. 42
LONG PERIOD CHARACTERISTICS
BELL MODEL 309, USA S/N N/A
LONGITUDINAL, PITCH & SAS
C.G. ACCEL, LATERAL & ROLL
DIRECTIONAL, YAW & SIDESLIP
GROSS WEIGHT ~LB 13670
C.G. LOCATION ~IN. 198.5
DENSITY ALTITUDE ~FT 5250
OAT ~°C 25.5
ROTOR SPEED ~RPM 311
TRIM AIRSPEED ~KCAS 66
C_T .006085
CONFIGURATION EXTERNAL STORES (4 XM-159C ROCKET PODS)
SCAS ACTIVATOR POS. ~EQUIV IN. OF CONTROL POS
FWD
AFT
C.G. ACCEL ~G'S
ANGLE OF SIDESLIP ~DEG
LT
RT
SCAS POS
CG ACCEL
SIDESLIP
ACCELERATIONS ~DEG/SEC²
PITCH
ROLL
YAW
NU
ND
RATES ~DEG/SEC
ATTITUDES ~DEG FROM TRIM
CONTROL POSITIONS ~IN. FROM TRIM
LONGITUDINAL
LATERAL
DIRECTIONAL
0
10
20
30
40
50
TIME ~ SECONDS

Figure No. 43
Summary Longitudinal Control Response And Sensitivity
Bell Model 309, USA S/N N/A

AVG GROSS WEIGHT ~LB	AVG C.G. LOCATION ~IN	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T	CONFIGURATION
13780	138.3(AFT)	2040 TO 5320	28.0	311	.005595 TO .006326	EXTERNAL STORES(4 XM-159C ROCKET PODS)

NOTE: 1) CURVES DERIVED FROM FIGS 44 AND 45
2) SCAS ON

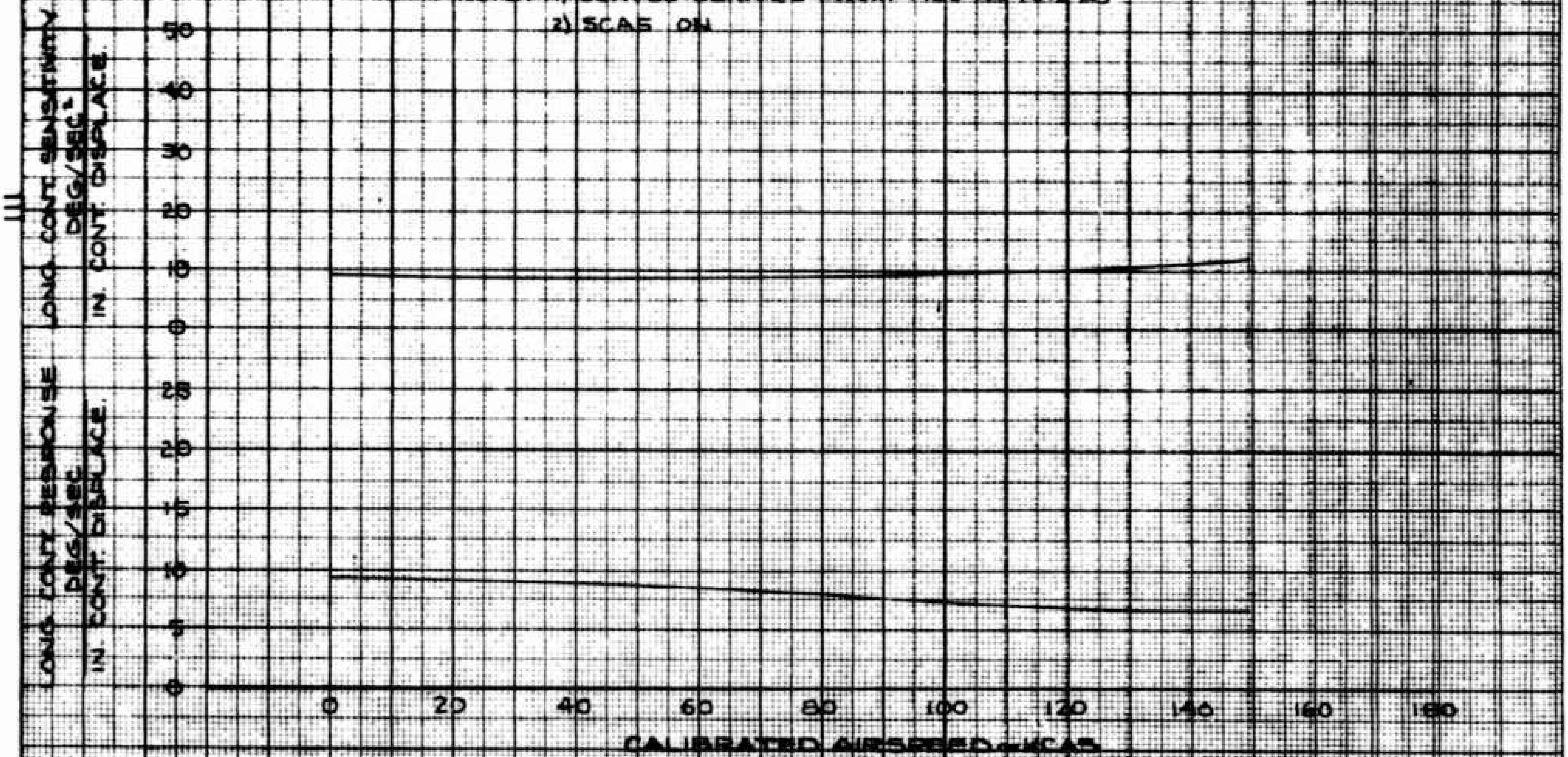


FIGURE NO. 64
LONGITUDINAL CONTROL RESPONSE AND SENSITIVITY
BELL MODEL 309, USA S/N N/A

SYMBOL	AVG GROSS WEIGHT ~LB.	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T	TRIM A/S ~KCAS	CONFIGURATION
○	[illegible]	[illegible]	[illegible]	[illegible]	311	[illegible]	HOVER	EXTERNAL [illegible]
□	[illegible]	19[illegible] (AFT)	5650	27.5	311	[illegible]	[illegible]	STORED [illegible]
◇	[illegible]	176.3 (FWD)	[illegible]	[illegible]	311	[illegible]	HOVER	[illegible]

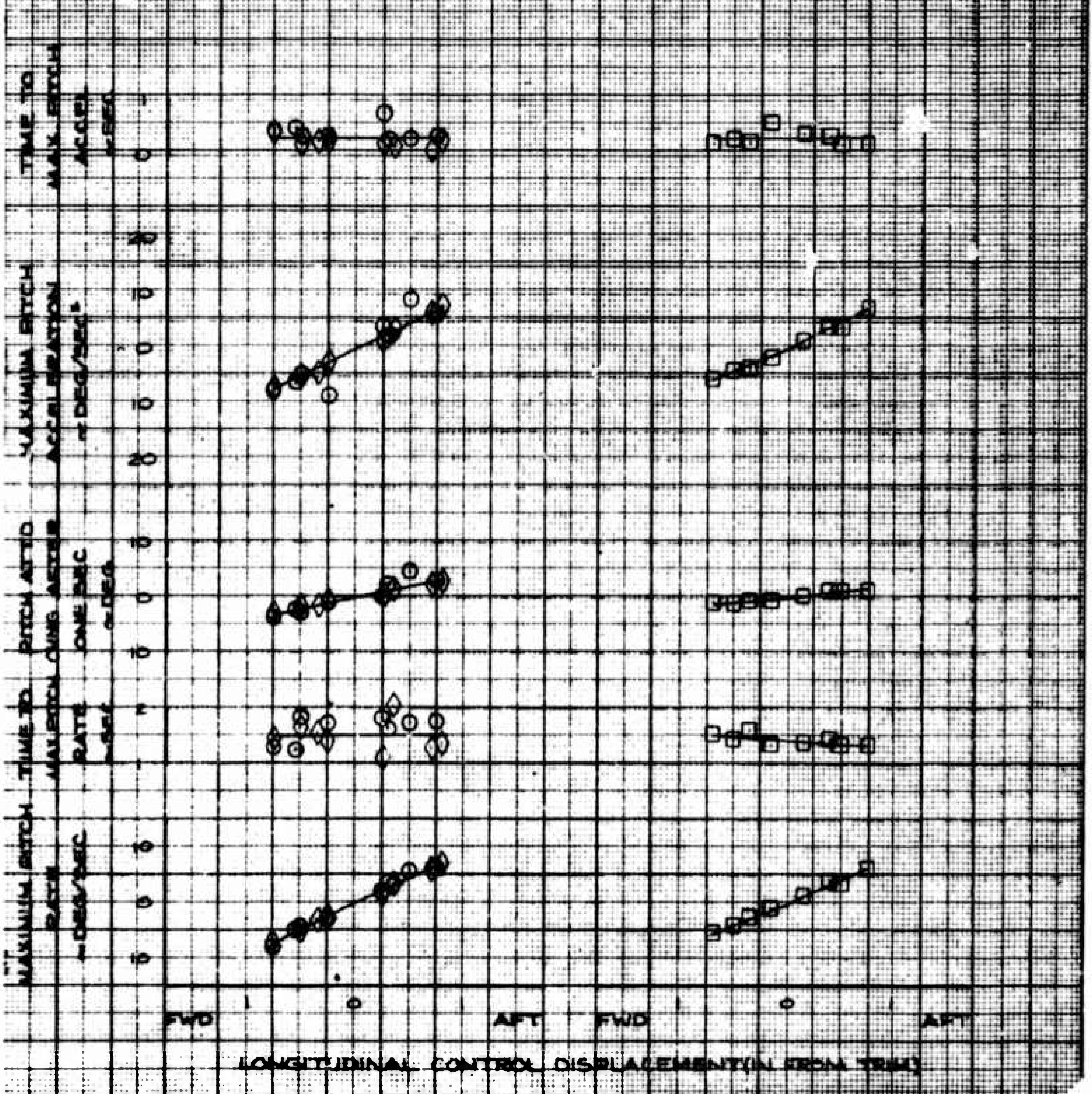


FIGURE NO. 45
LONGITUDINAL CONTROL RESPONSE AND SENSITIVITY
BELL MODEL 309, USA S/N N/A

SYMBOL	AVG GROSS WEIGHT ~LB	AVG C.G. LOCATION ~IN	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T	TRIM A/S ~KCAS	CONFIGURATION
○	15710	198.5(AFT)	[illegible]	[illegible]	311	[illegible]	[illegible]	EXTERNAL
□	15700	198.5(AFT)	4710	29.5	311	.005996	160	STORES([illegible] ROCKET PODS)

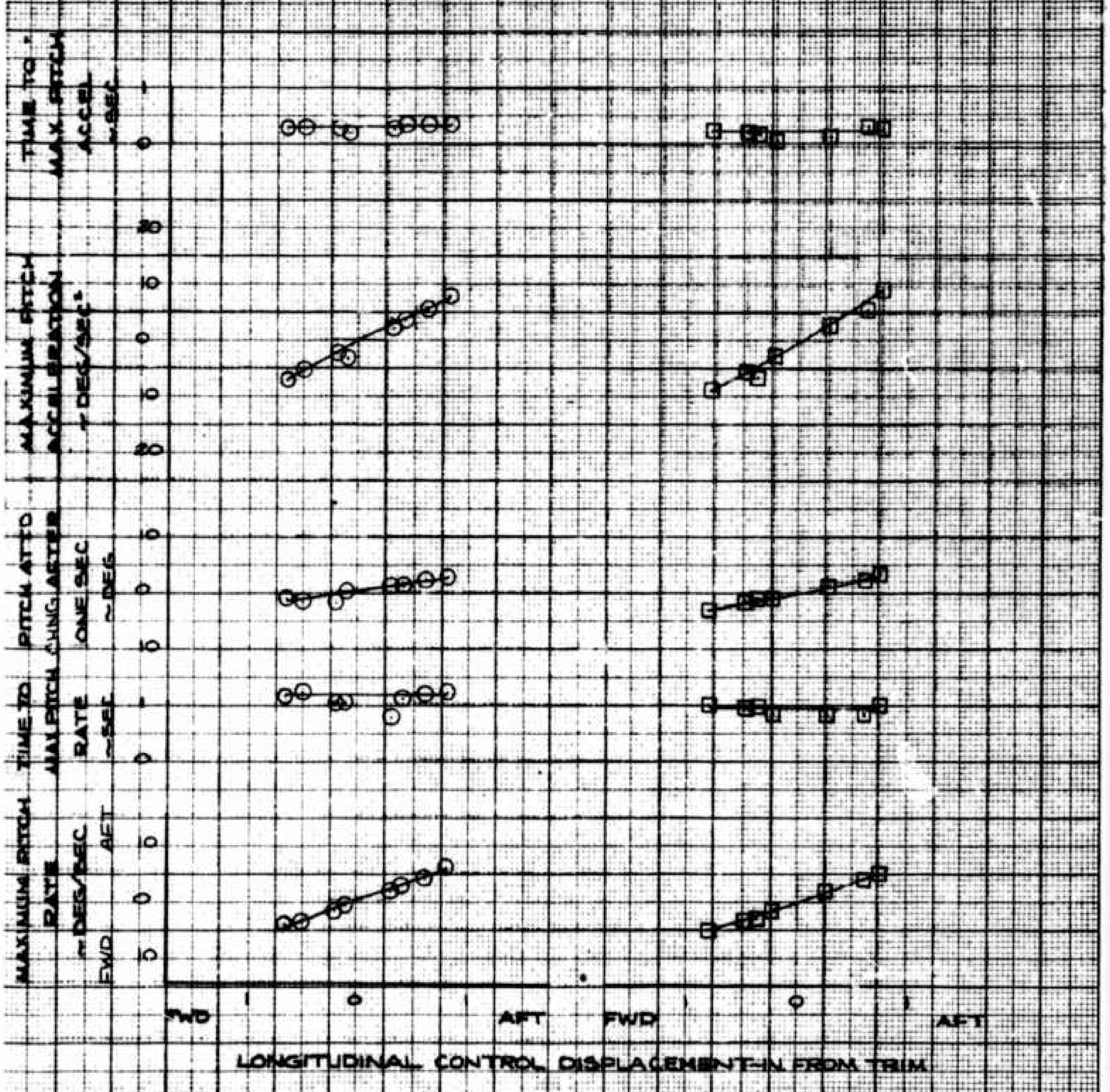


FIGURE NO. 46
SUMMARY LATERAL CONTROL RESPONSE AND SENSITIVITY
BELL MODEL 309, USA S/N N/A

AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T	CONFIGURATION
13370	192.3(AFT)	2040 TO 5455	27.5	311	.005489 TO .005904	EXTERNAL STORES (4 XM-159C ROCKET PODS)

NOTE: 1) CURVES DERIVED FROM FIGS 47 AND 48
2) SCAS, ON

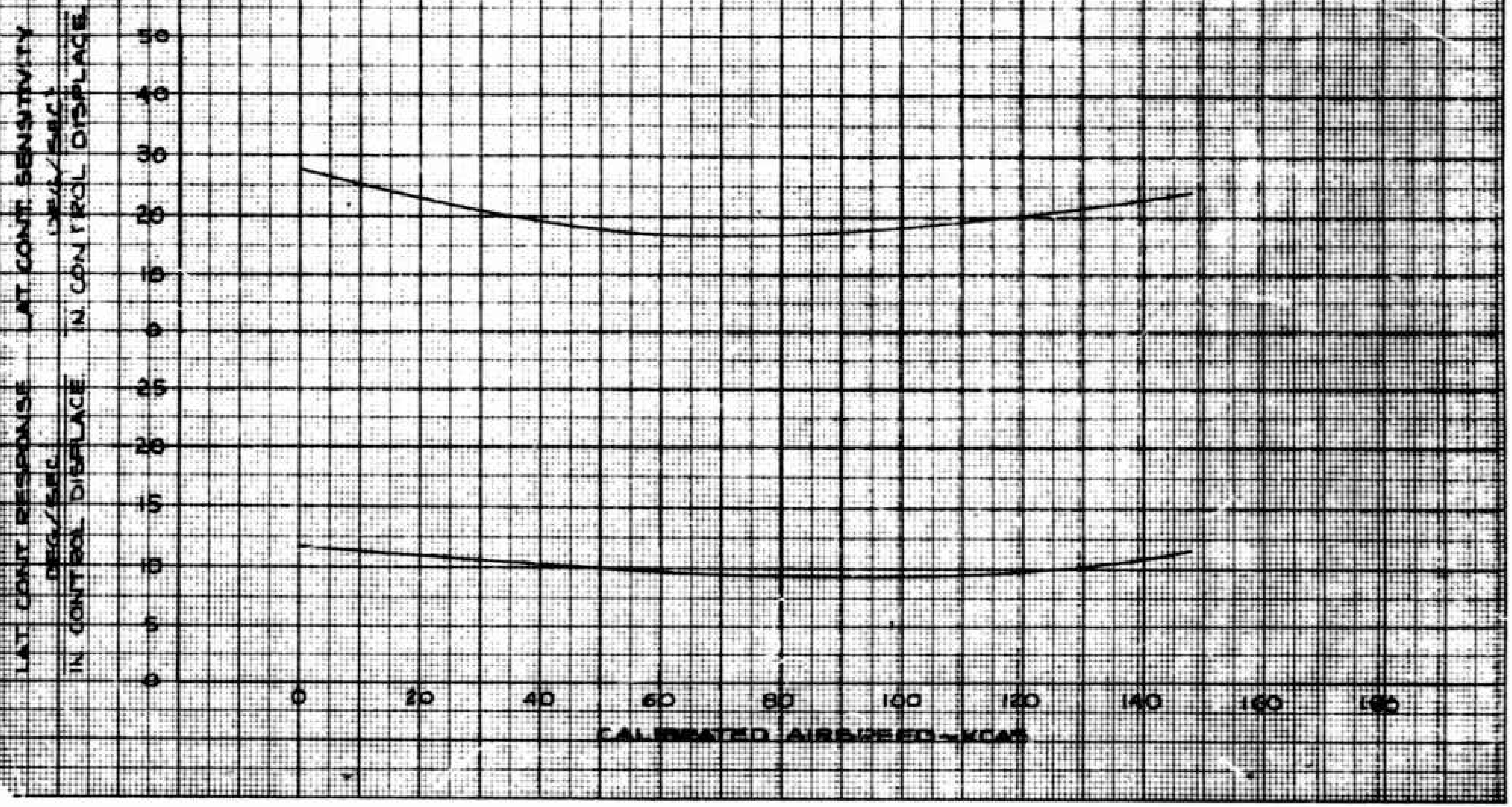


FIGURE NO. 47
LATERAL CONTROL RESPONSE AND SENSITIVITY
BELL MODEL 309, USA S/N N/A

SYMBOL	AVG. GROSS WEIGHT ~LB	AVG CG LOCATION ~IN	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T	TRIM A/S ~KCAS	CONFIGURATION
○	13570	198.3(AFT)	2040	25.5	311	.005480	NONE	EXTERNAL
□	13450	198.3(AFT)	5800	27.5	311	.00508	67	STORES(4 XM-157C ROCKET PODS)

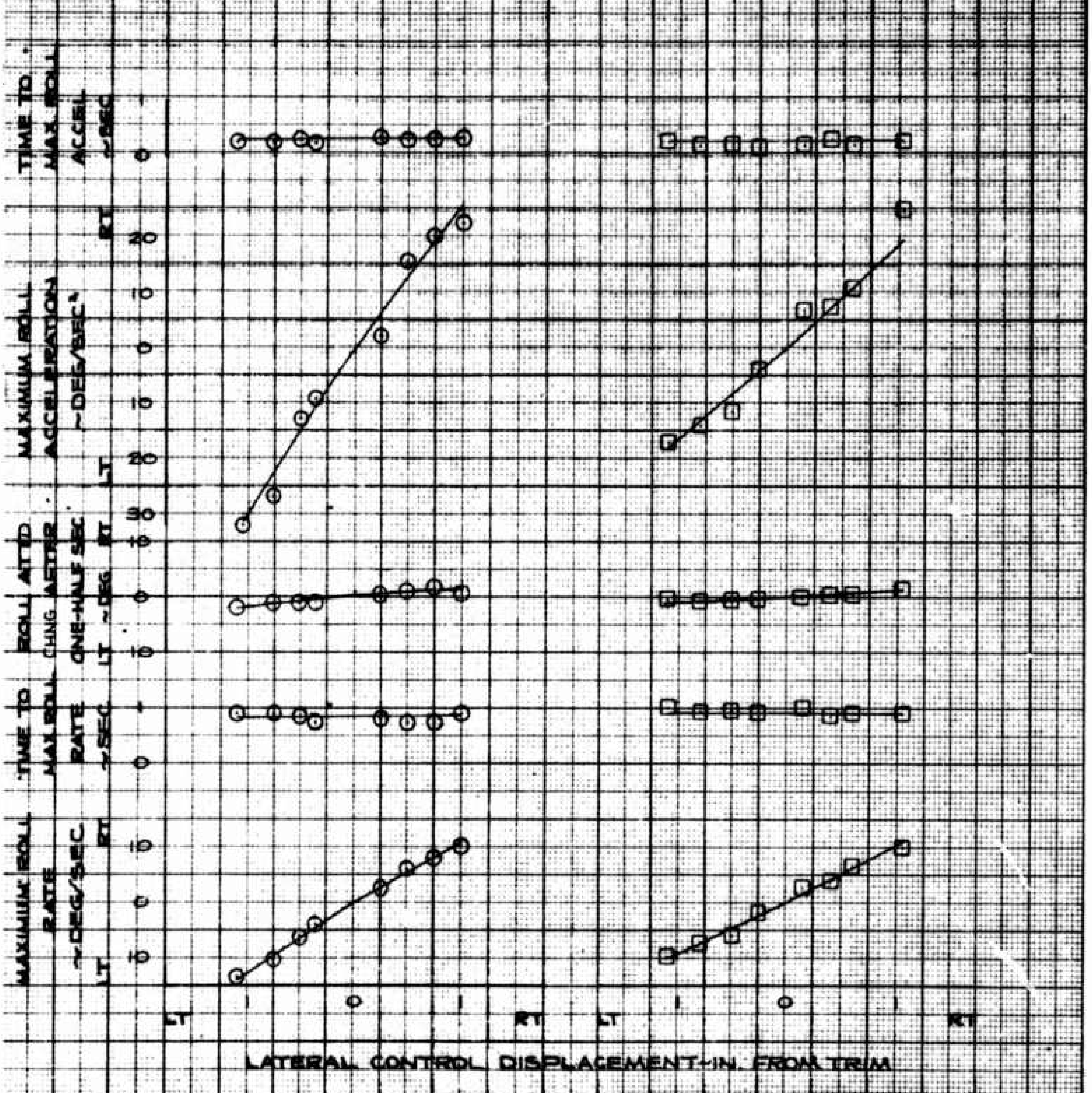


Figure No. 48

Lateral Control Response and Sensitivity

Bell Model 309, USA S/N N/A

SYMBOL	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T	AVG CAL A/S ~KCAS	CONFIGURATION
○	13120	198.2(AFT)	5680	31.5	31	.005912	124	EXTERNAL
□	12970	198.3(AFT)	4935	30.5	31	.005720	143	STORES (4 XM-159C ROCKET PODS)

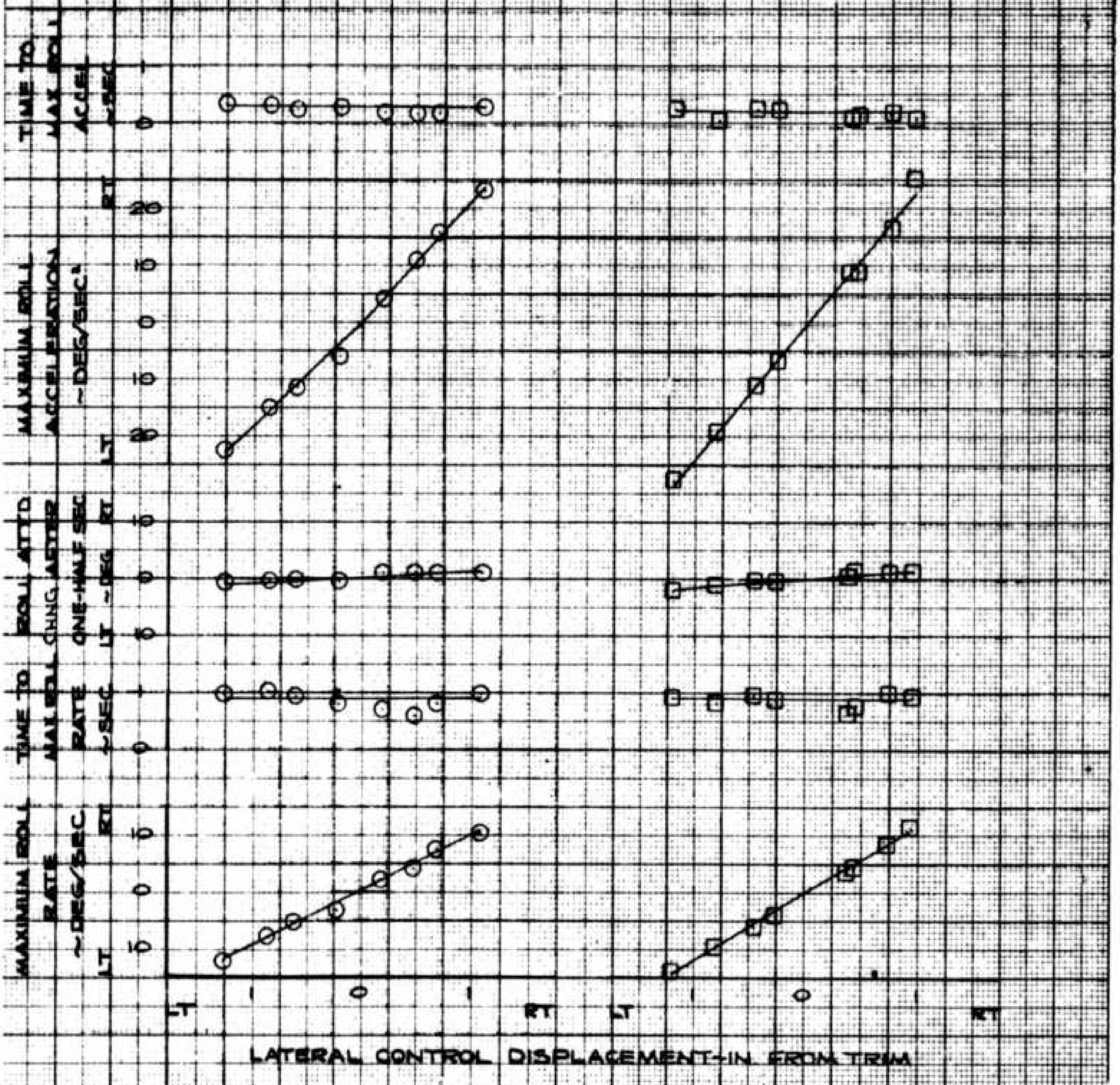


FIGURE No 40

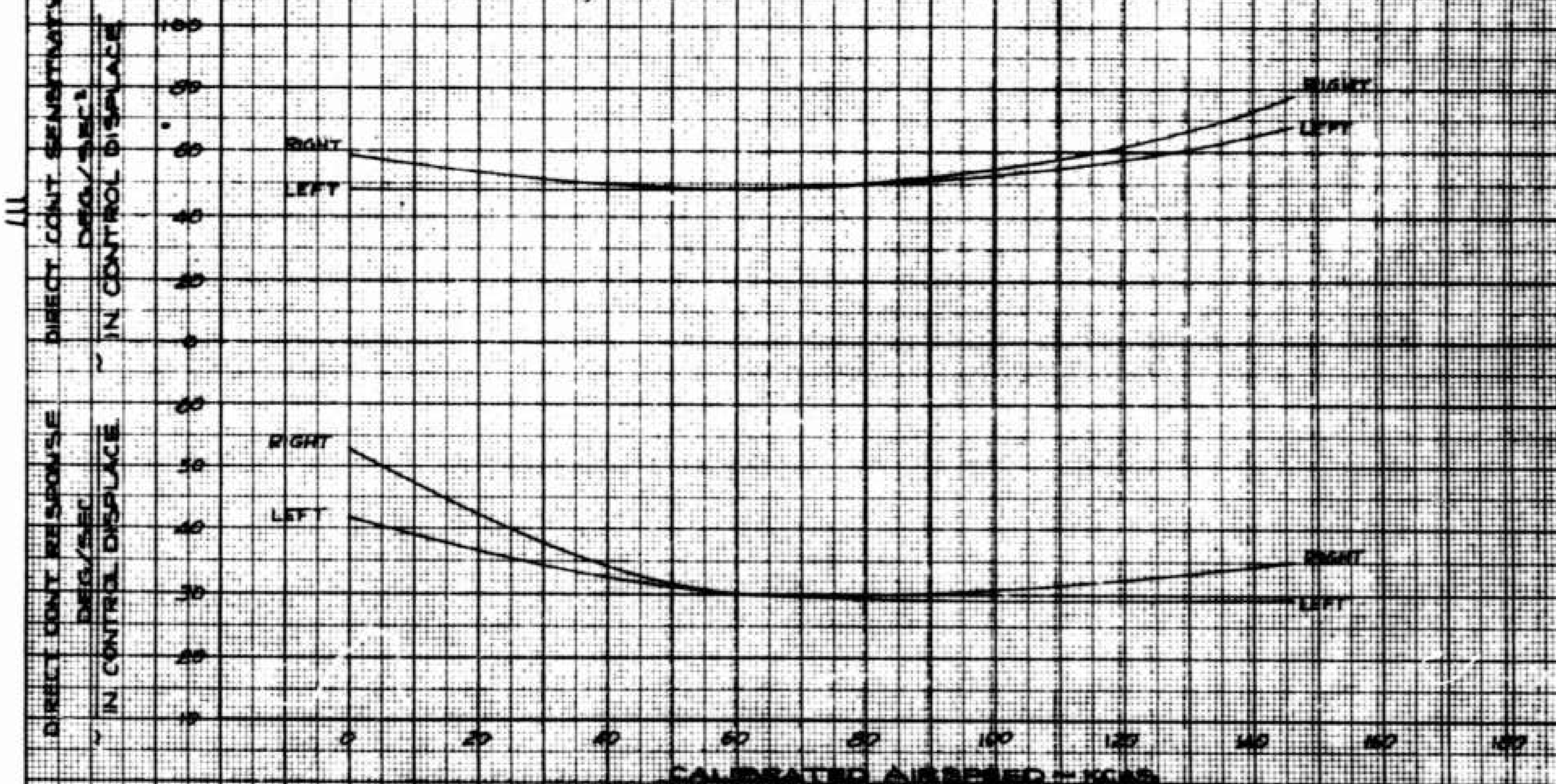
SUMMARY DIRECTIONAL CONTROL RESPONSE AND SENSITIVITY

BELL MODEL 309, USA S/N N/A

AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG. C_T	CONFIG.
13400	198.3 (AFT)	2050 TO 5520	27.0	311	.005383 TO .006087	EXTERNAL STORES (4 XM-159C ROCKET PODS)

NOTE: 1) CURVES DERIVED FROM FIG 50 AND 51

2) SCAS ON



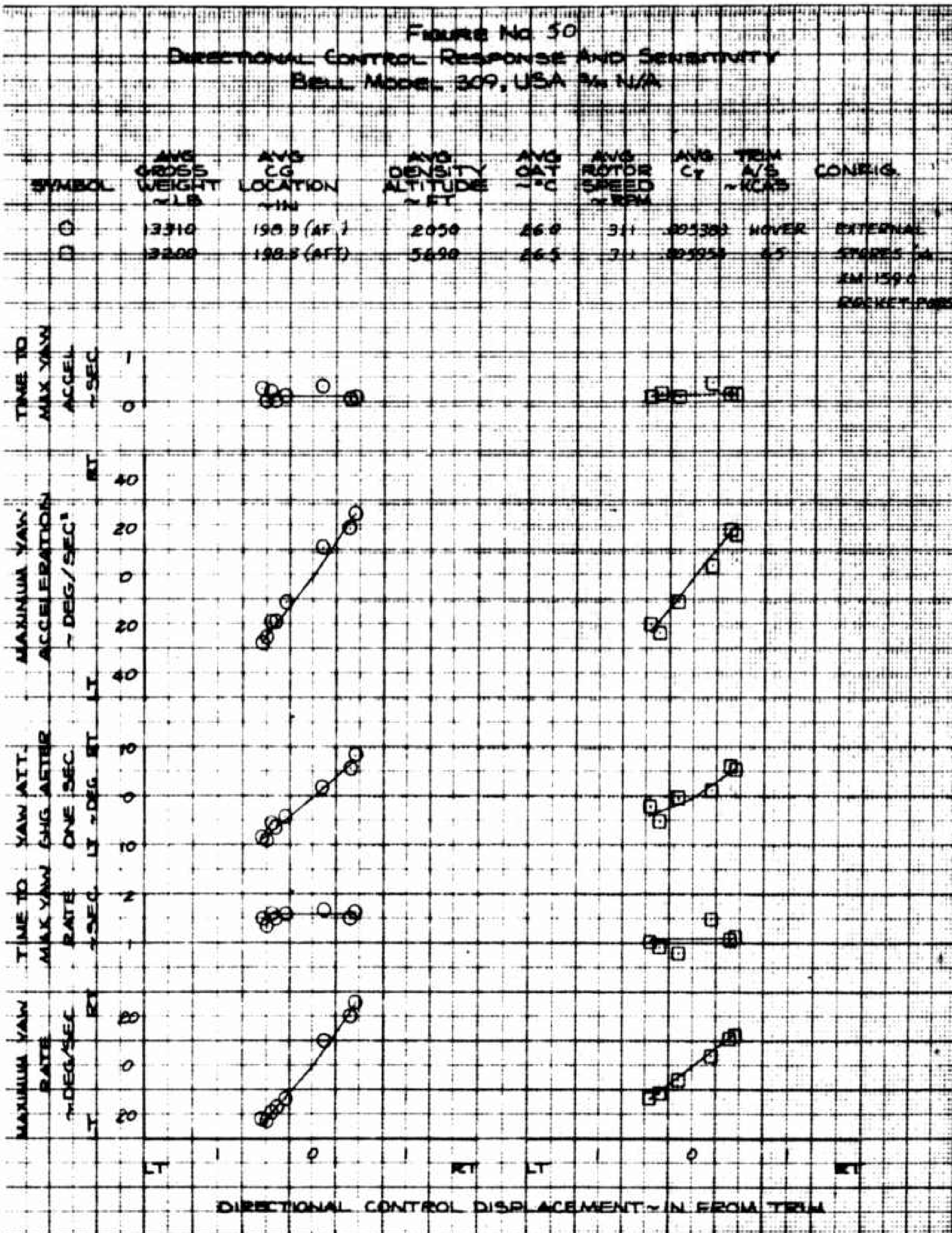


FIGURE NO 50
DIRECTIONAL CONTROL RESPONSE AND SENSITIVITY
BELL MODEL 309, USA S/N N/A
SYMBOL
AVG GROSS WEIGHT ~LB
AVG CG LOCATION ~IN
AVG DENSITY ALTITUDE ~FT
AVG OAT ~°C
AVG ROTOR SPEED ~RPM
AVG C_T
TRIM A/S ~KCAS
CONFIG.
○ 13310 198.3 (AFT) 2050 26.0 311 .005380 HOVER
□ 13200 198.5 (AFT) 5690 26.5 311 .005958 65
EXTERNAL STORES (4 XM-159C ROCKET PODS)
TIME TO MAX YAW ACCEL ~SEC
1
0
MAXIMUM YAW ACCELERATION ~DEG/SEC²
RT
40
20
0
20
40
LT
YAW ATT. CHG AFTER ONE SEC LT ~DEG RT
10
0
10
TIME TO MAX YAW RATE ~SEC
2
1
MAXIMUM YAW RATE ~DEG/SEC
RT
20
0
20
LT
LT
1
0
1
RT
LT
1
0
1
RT
DIRECTIONAL CONTROL DISPLACEMENT ~ IN FROM TRIM

Figure No. 51
Directional Control Response and Sensitivity
Bell Model 309, USA S/N N/A

Symbol	Avg. Gross Weight ~LB	Avg. CG Location ~IN	Avg. Density Altitude ~FT	Avg. OAT ~°C	Avg. Rotor Speed ~RPM	Avg. C_T	Trim A/S ~KCAS	Config.
⊖	13820	198.3(AFT)	5340	28.0	311	.006166	124	EXTERNAL STORES (4 XM-159C ROCKET PODS)
□	13460	198.3(AFT)	5530	29.5	311	.006040	147	

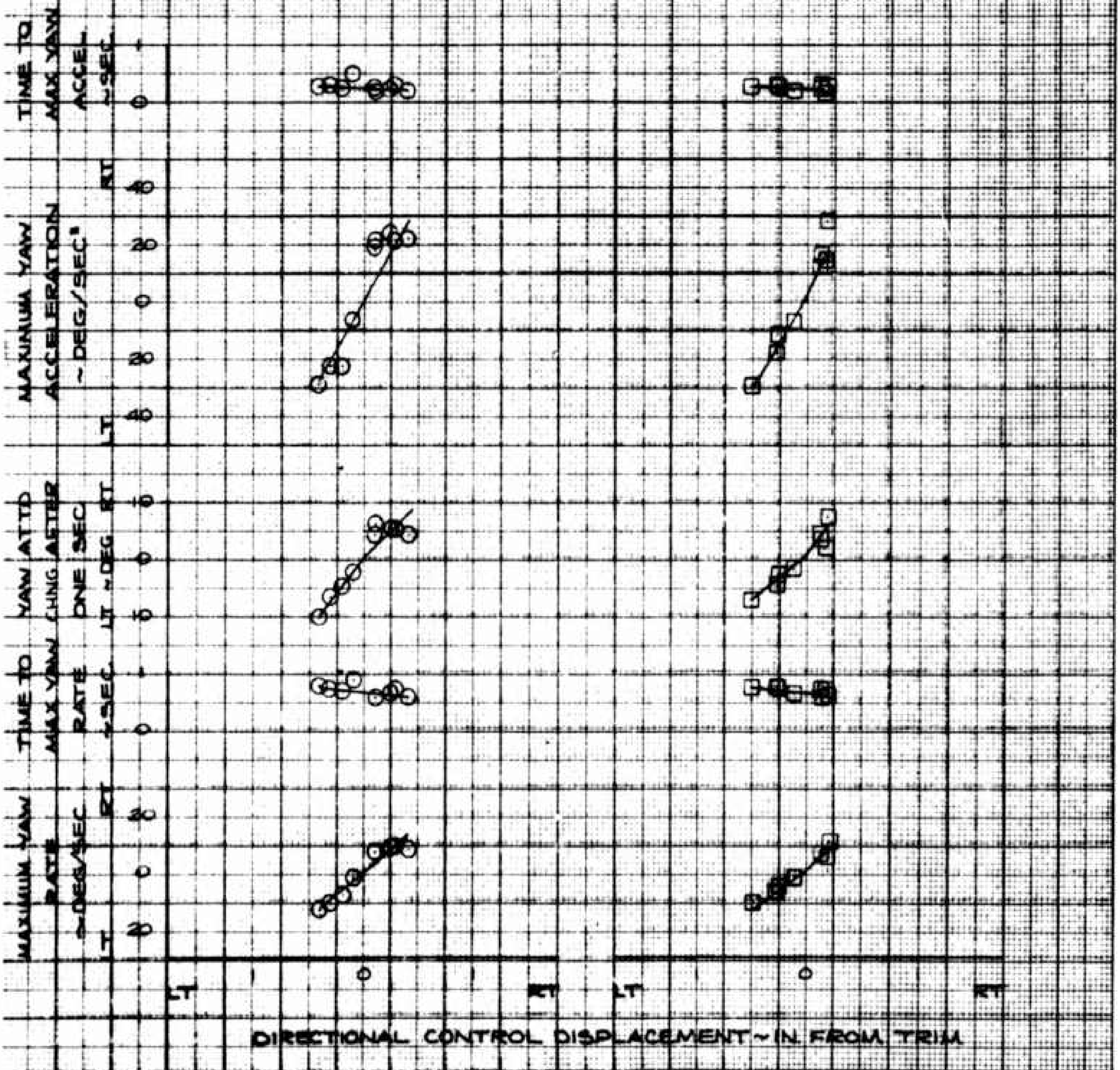


FIGURE NO. 52
MANEUVERING STABILITY SUMMARY
BELL MODEL 309, USA S/N N/A

AVG. GROSS WEIGHT ~LB.	AVG. CG LOCATION ~IN.	AVG. DENSITY ALTITUDE ~FT.	AVG. OAT ~°C	AVG. ROTOR SPEED ~RPM	CONFIGURATION
11240	196.2 (FWD)	3920	26.0	311	CLEAN
13750	198.3 (FWD) TO 198.6 (AFT)	4170	24.5	311	EXTERNAL STORES (4 XM 159C ROCKET PODS)

NOTE: CURVES DERIVED FROM FIGS 53 THROUGH 58

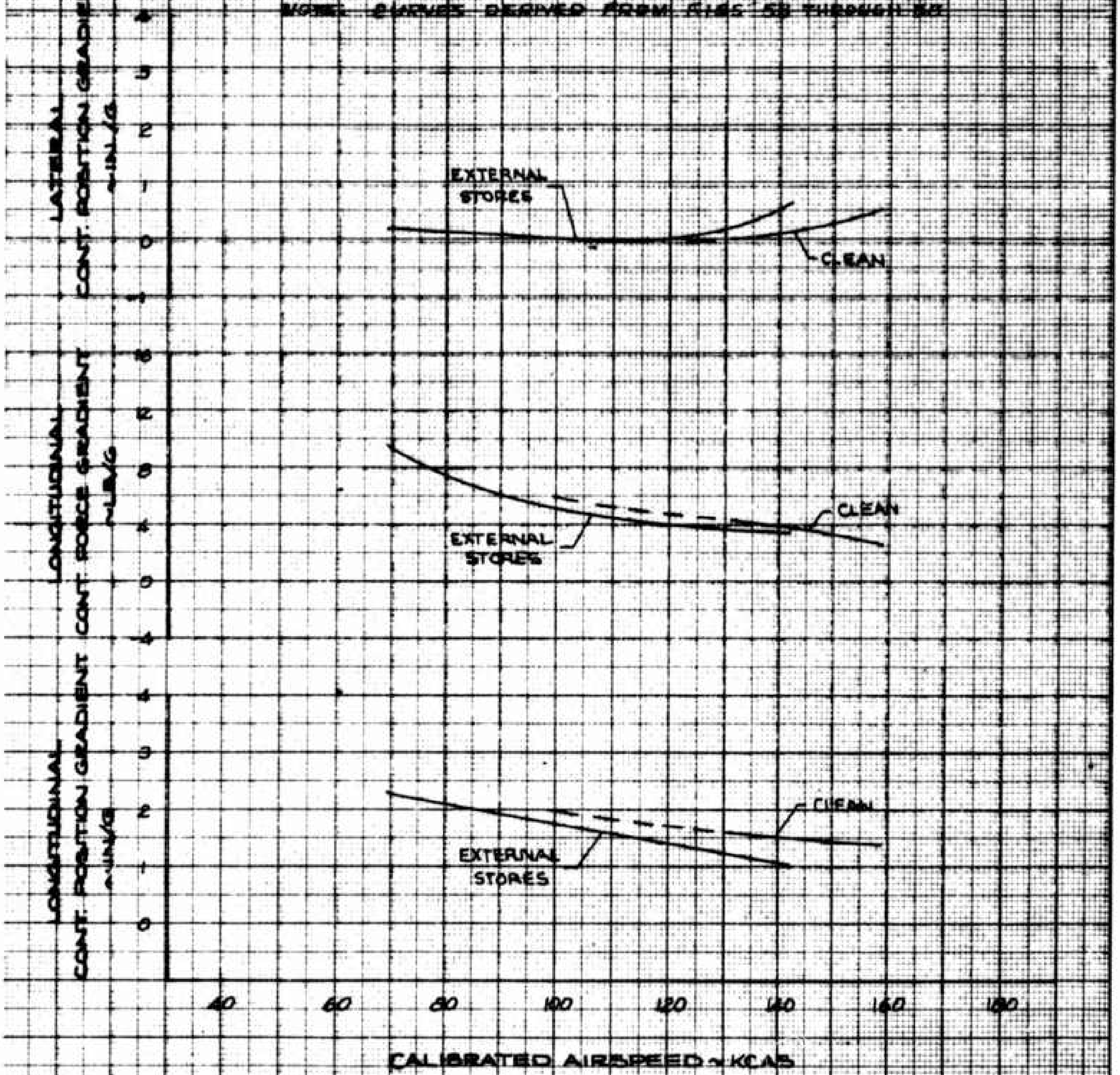
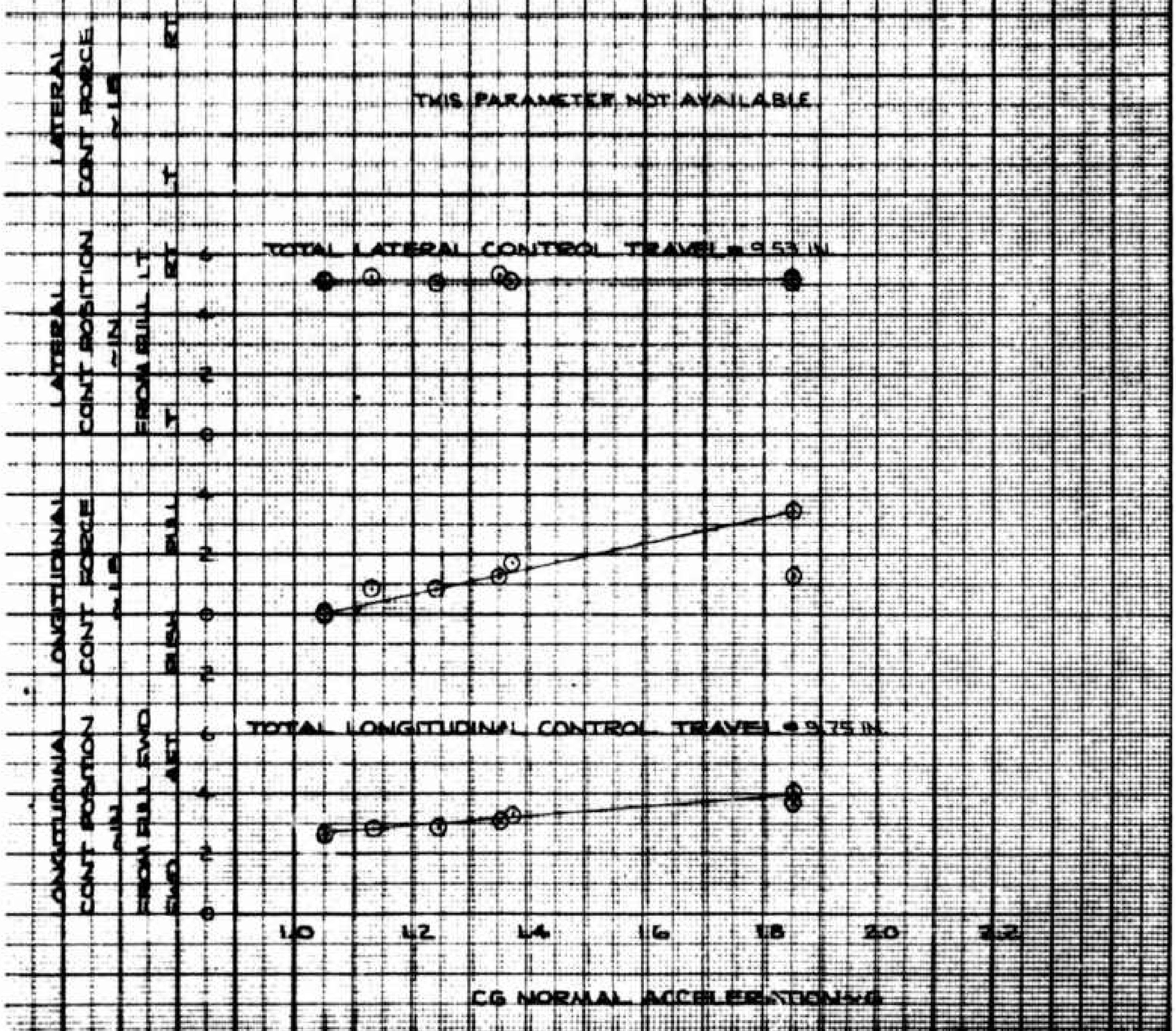
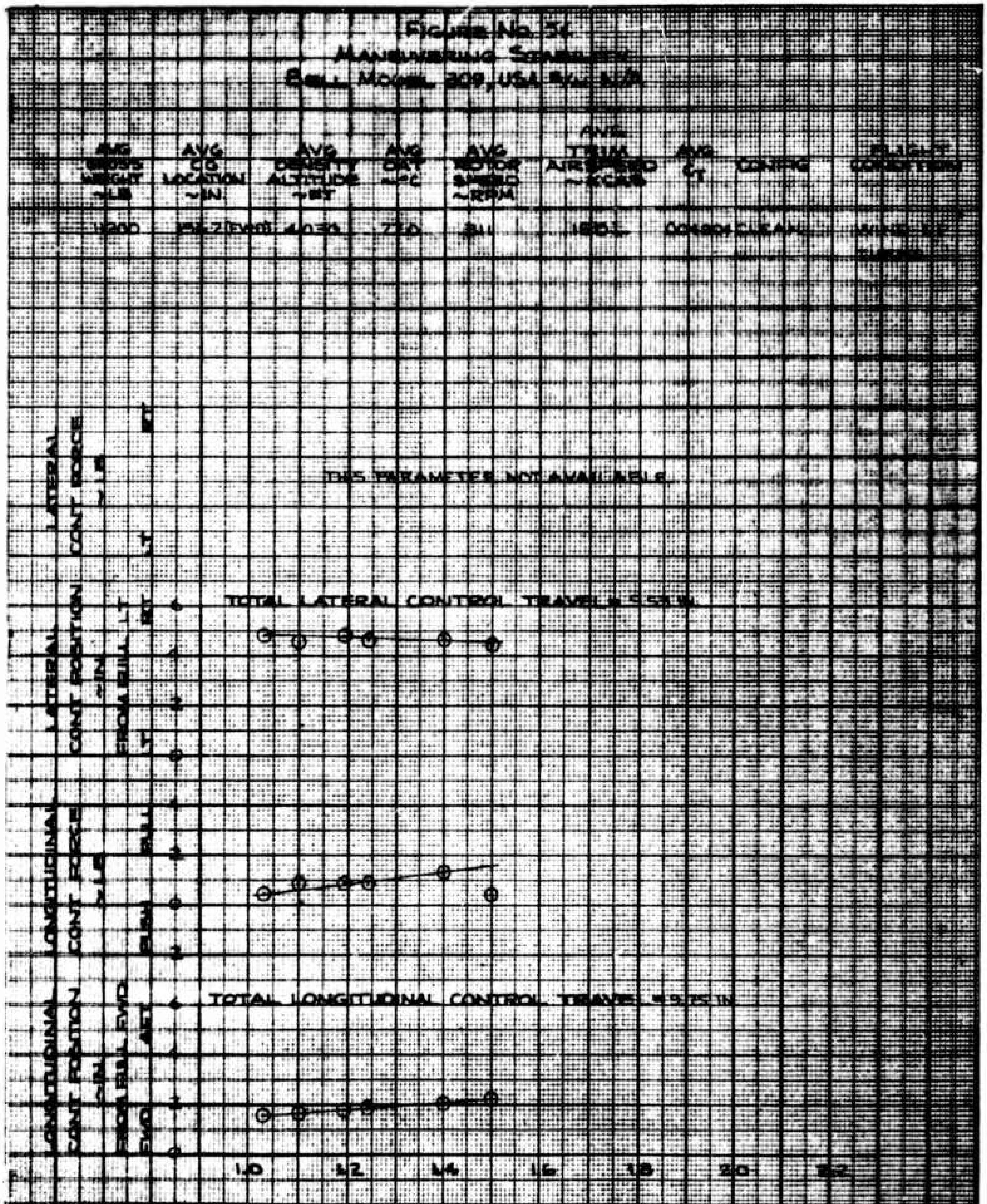


FIGURE No. 53
MANEUVERING STABILITY
BELL MODEL 309, USA S/N N/A

AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG TRUE AIRSPEED ~KCAS	AVG C_T	CONFIG	FLIGHT CONDITION
11870	196.2(FWD)	2810	25.0	311	132.1	.004887	CLEAN	WIND-UP TURNS





AVG GROSS WEIGHT ~LB
AVG CG LOCATION ~IN.
AVG DENSITY ALTITUDE ~FT
AVG OAT ~°C
AVG ROTOR SPEED ~RPM
AVG TRIM AIRSPEED ~KCAS
AVG C_T
CONFIG
FLIGHT CONDITION
CLEAN
THIS PARAMETER NOT AVAILABLE
TOTAL LATERAL CONTROL TRAVEL
TOTAL LONGITUDINAL CONTROL TRAVEL
LATERAL CONT FORCE ~LB
LATERAL CONT POSITION ~IN FROM FULL LT
LONGITUDINAL CONT FORCE ~LB
LONGITUDINAL CONT POSITION ~IN FROM FULL FWD
1.0
1.2
1.4
1.6
1.8
2.0
2.2
CG NORMAL ACCELERATION

Figure No. 55
Maneuvering Stability
Bell Model 309, USA S/N N/A

AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	TRIM AIRSPEED ~KCAS	AVG C_T	CONFIG	FLIGHT CONDITION
13650	198.5(AFT)	3400	22.5	311	69	.005759	EXTERNAL STORES(4 XM-159C ROCKET PODS)	WIND-UP TURNS

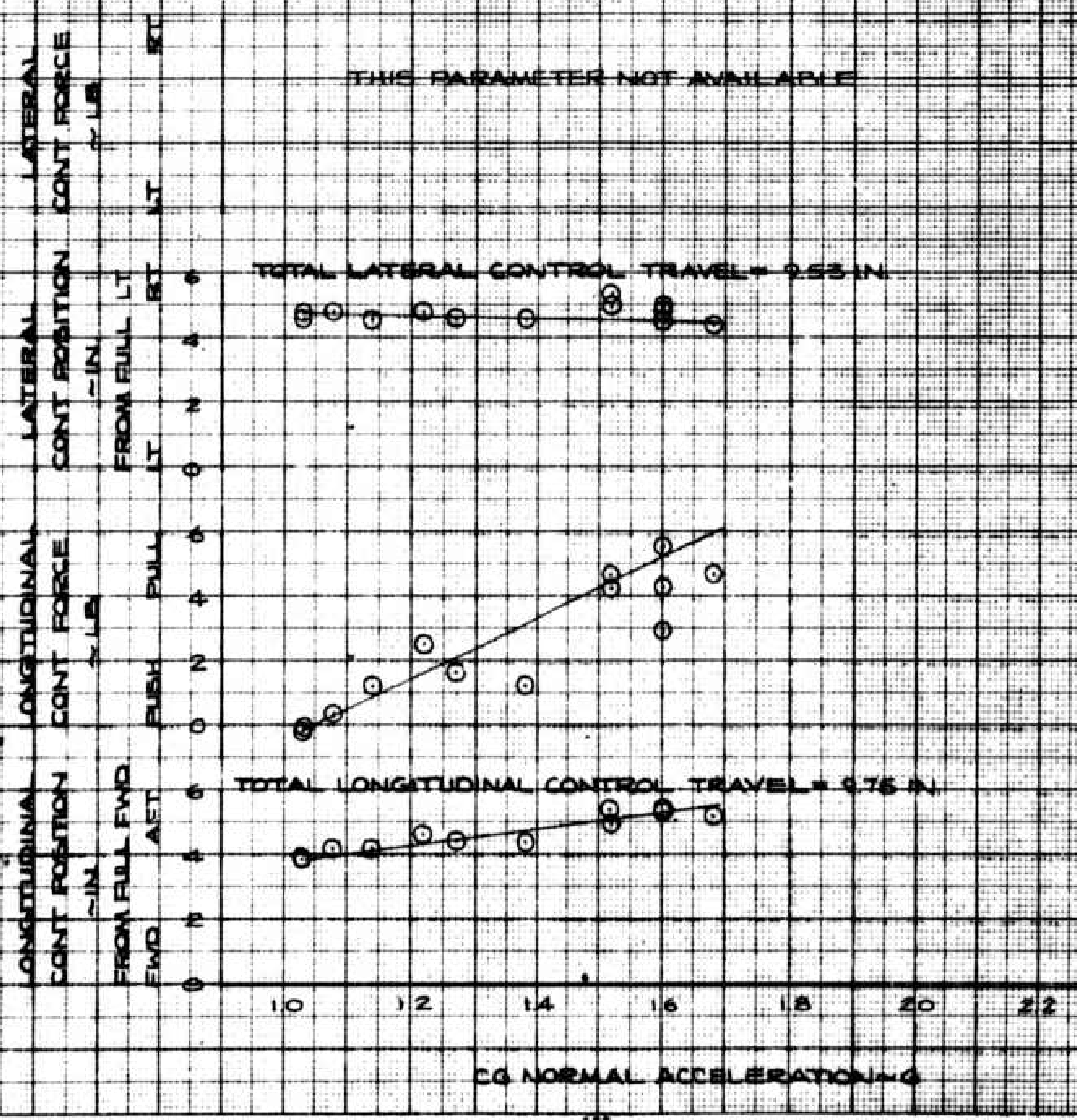


FIGURE NO. 56
MANEUVERING STABILITY
BELL MODEL 309, USA S/N N/A

AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	TRIM AIRSPEED ~KCAS	AVG C_T	CONFIG	FLIGHT CONDITION
10320	198.8(AFT)	4820	24	311	110	.005845	EXTERNAL STORES(4 XM-159C ROCKET PODS)	WIND-UP TURNS

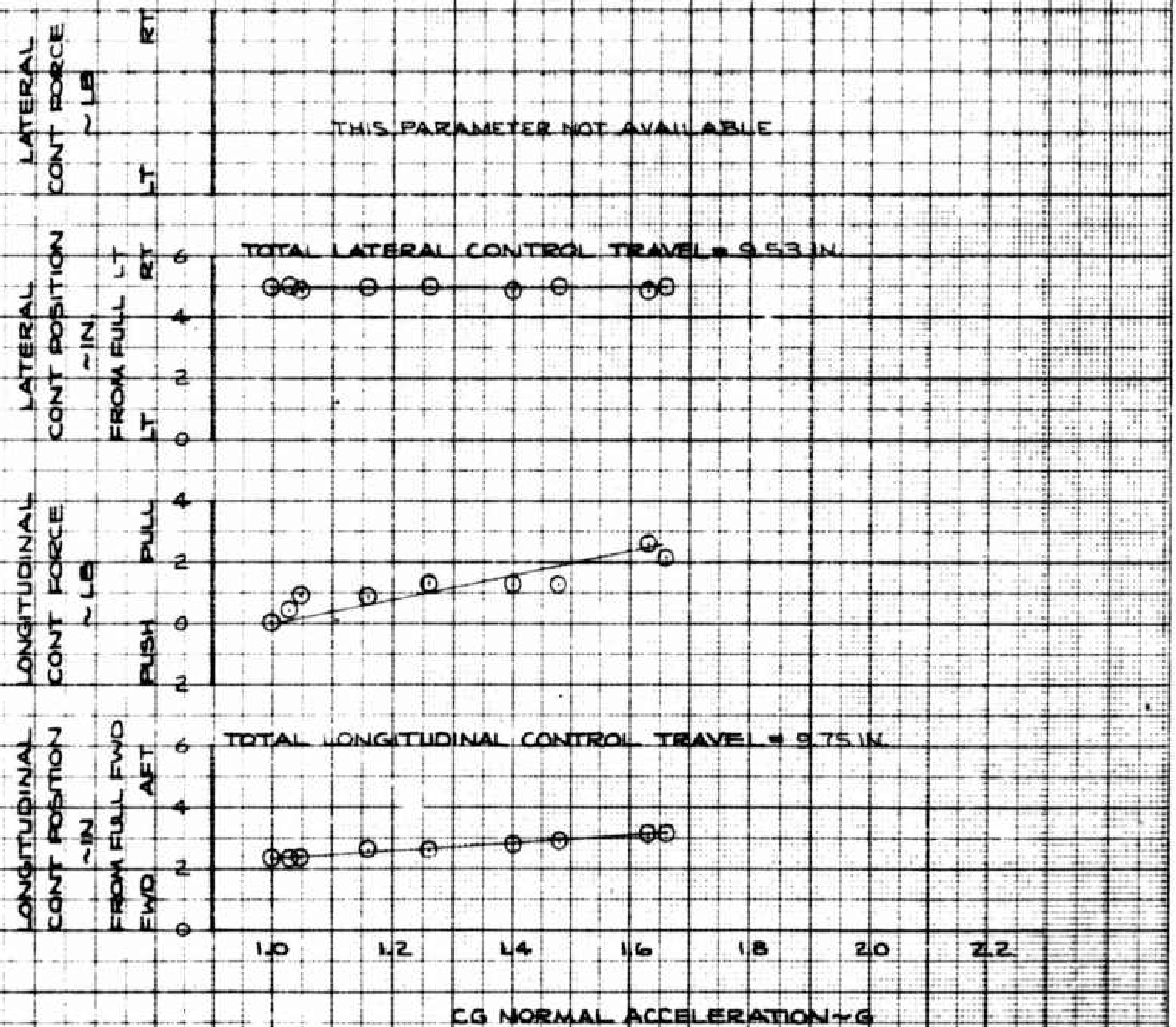
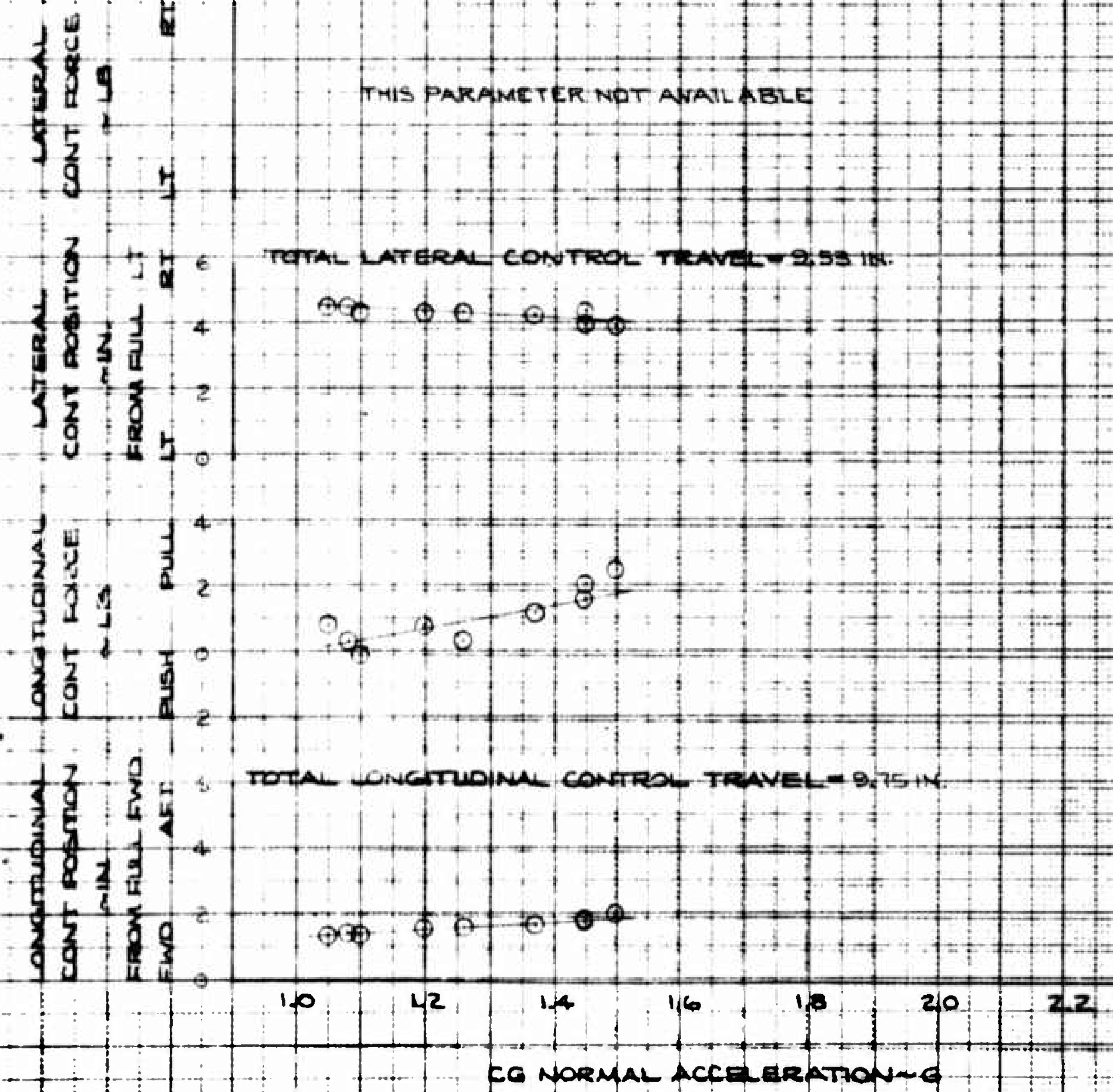


FIGURE NO 57
MANEUVERING STABILITY
BELL MODEL 309, USA S/N N/A

AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	TRIM AIRSPEED ~KCAS	AVG C_T	CONFIG	FLIGHT CONDITION
13420	198.8(AFT)	5320	24	311	142	.005757	EXTERNAL STORES(4 XM-159C ROCKET PODS	WIND-UP TURNS



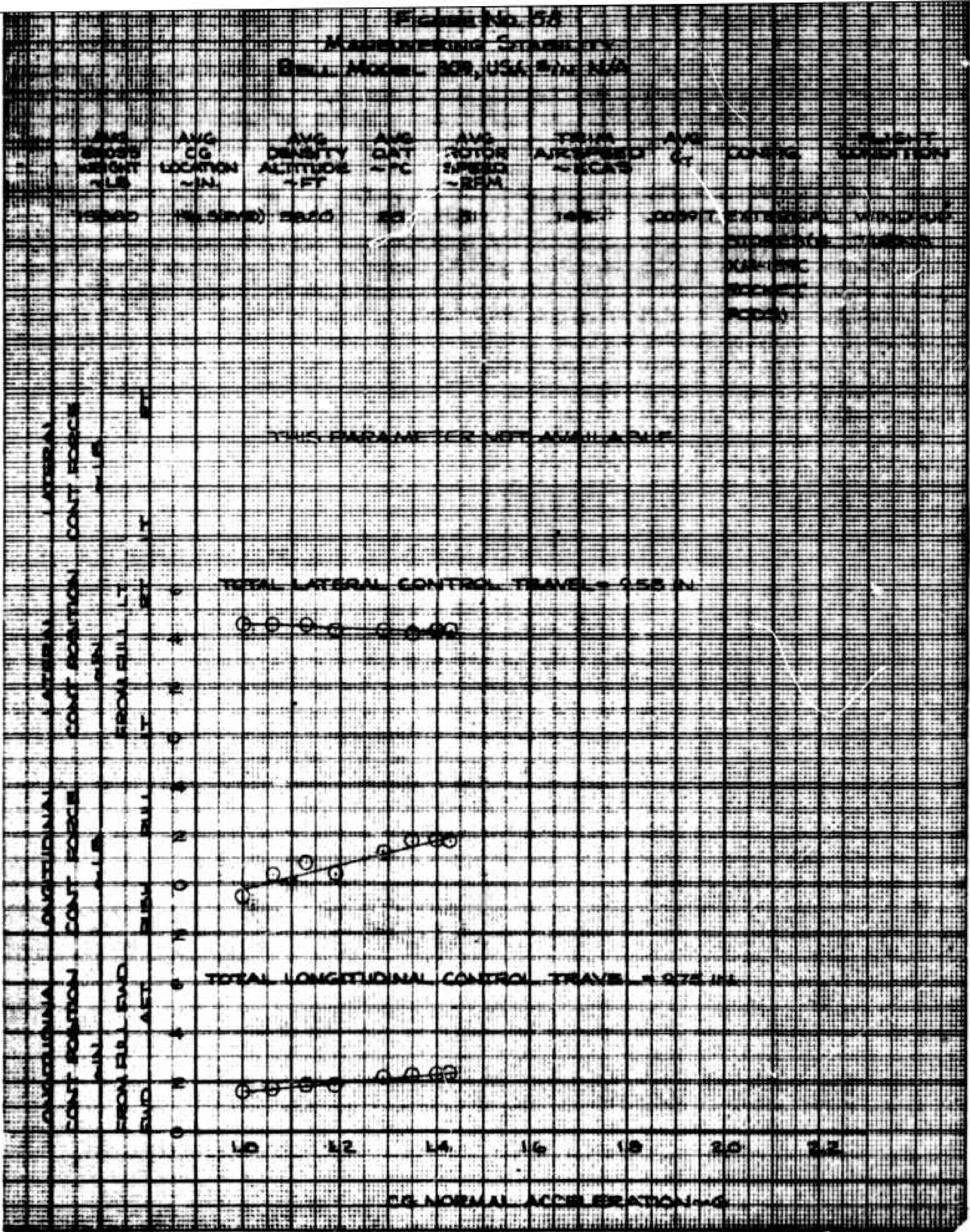


Figure No. 58
Bell Model 309, USA S/N N/A
AVG. CG LOCATION ~IN.
AVG. DENSITY ALTITUDE ~FT
AVG. OAT ~°C
AVG. ROTOR SPEED ~RPM
TRIM AIRSPEED ~KCAS
CONFIG.
FLIGHT CONDITION
EXTERNAL
PODS)
LATERAL CONT FORCE ~LB
THIS PARAMETER NOT AVAILABLE
LATERAL CONT POSITION ~IN. FROM FULL LT
TOTAL LATERAL CONTROL TRAVEL = 9.58 IN.
LONGITUDINAL CONT FORCE ~LB
LONGITUDINAL CONT POSITION ~IN. FROM FULL FWD
TOTAL LONGITUDINAL CONTROL TRAVEL = 9.75 IN.
1.0
1.2
1.4
1.6
1.8
2.0
2.2
CG NORMAL ACCELERATION ~G

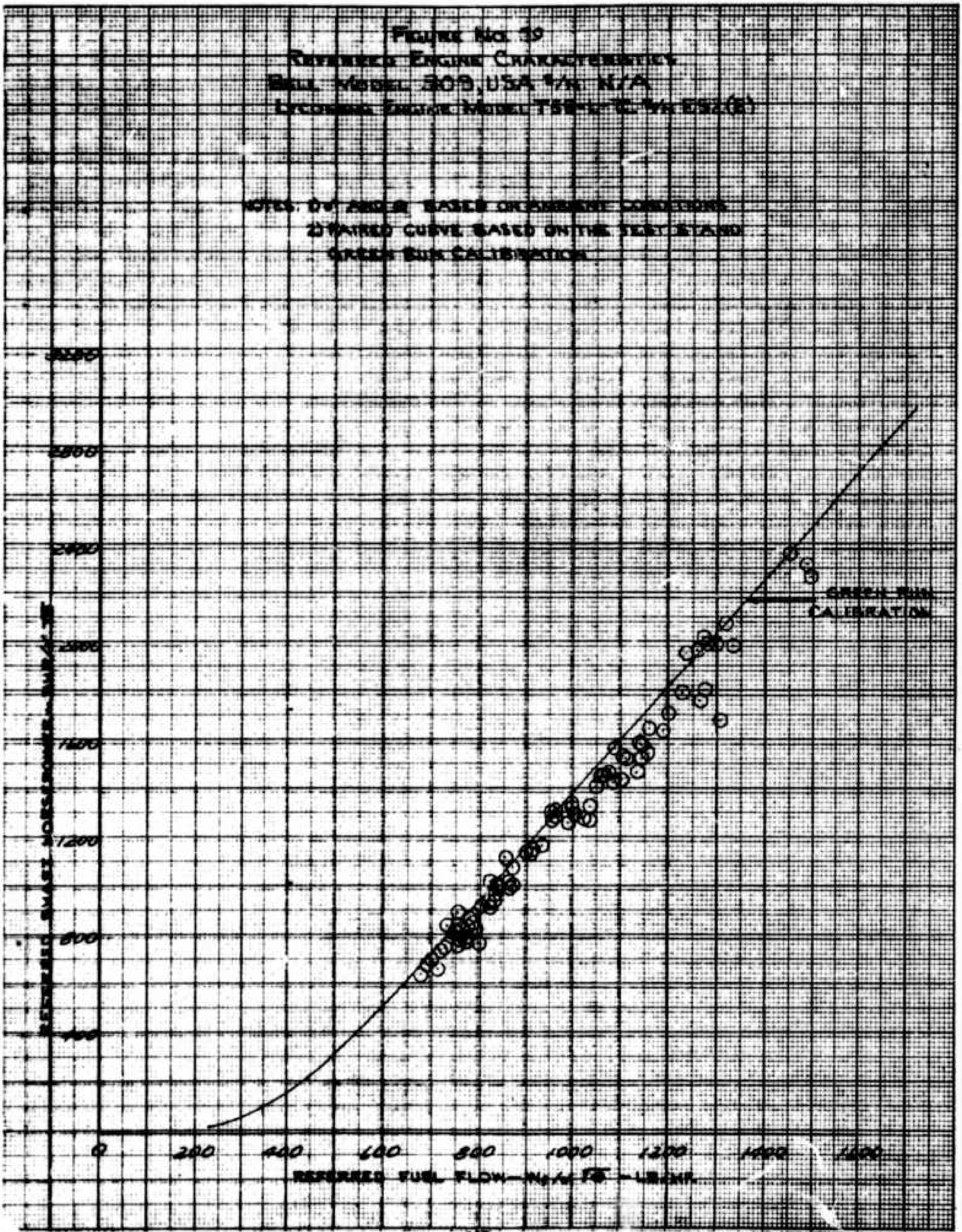


FIGURE NO. 39
GREEN RUN
CALIBRATION
0
200
400
600
800
1000
1200
2000
2800
1600
1200
800

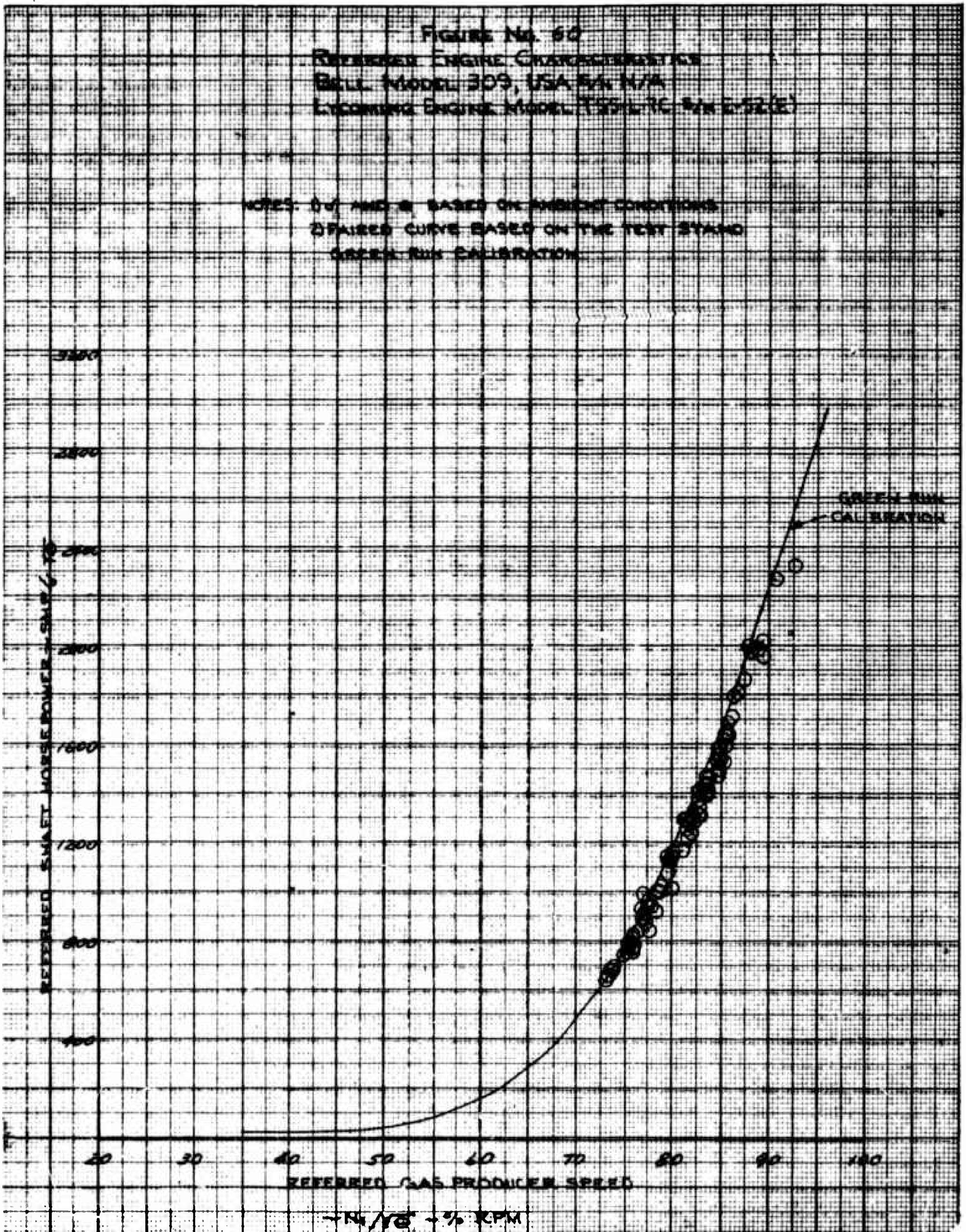


FIGURE NO. 60
REFERRED ENGINE CHARACTERISTICS
BELL MODEL 309, USA S/N N/A
NOTES: 1) δ AND θ BASED ON AMBIENT CONDITIONS
2) FAIRED CURVE BASED ON THE TEST STAND GREEN RUN CALIBRATION
GREEN RUN CALIBRATION
3200
2800
2400
2000
1600
1200
800
400
20
30
40
50
60
70
80
90
100
REFERRED GAS PRODUCER SPEED
REFERRED SHAFT HORSEPOWER

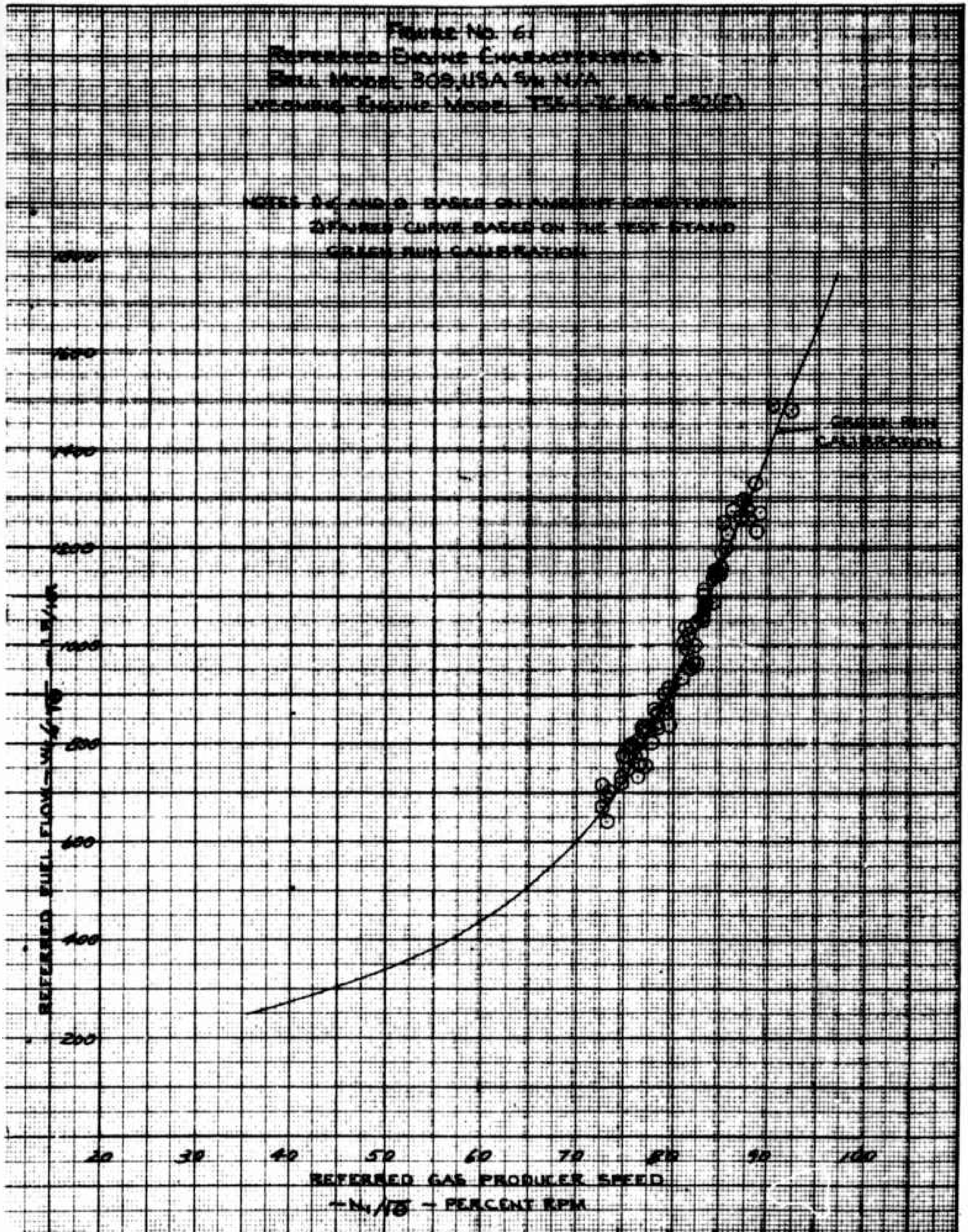
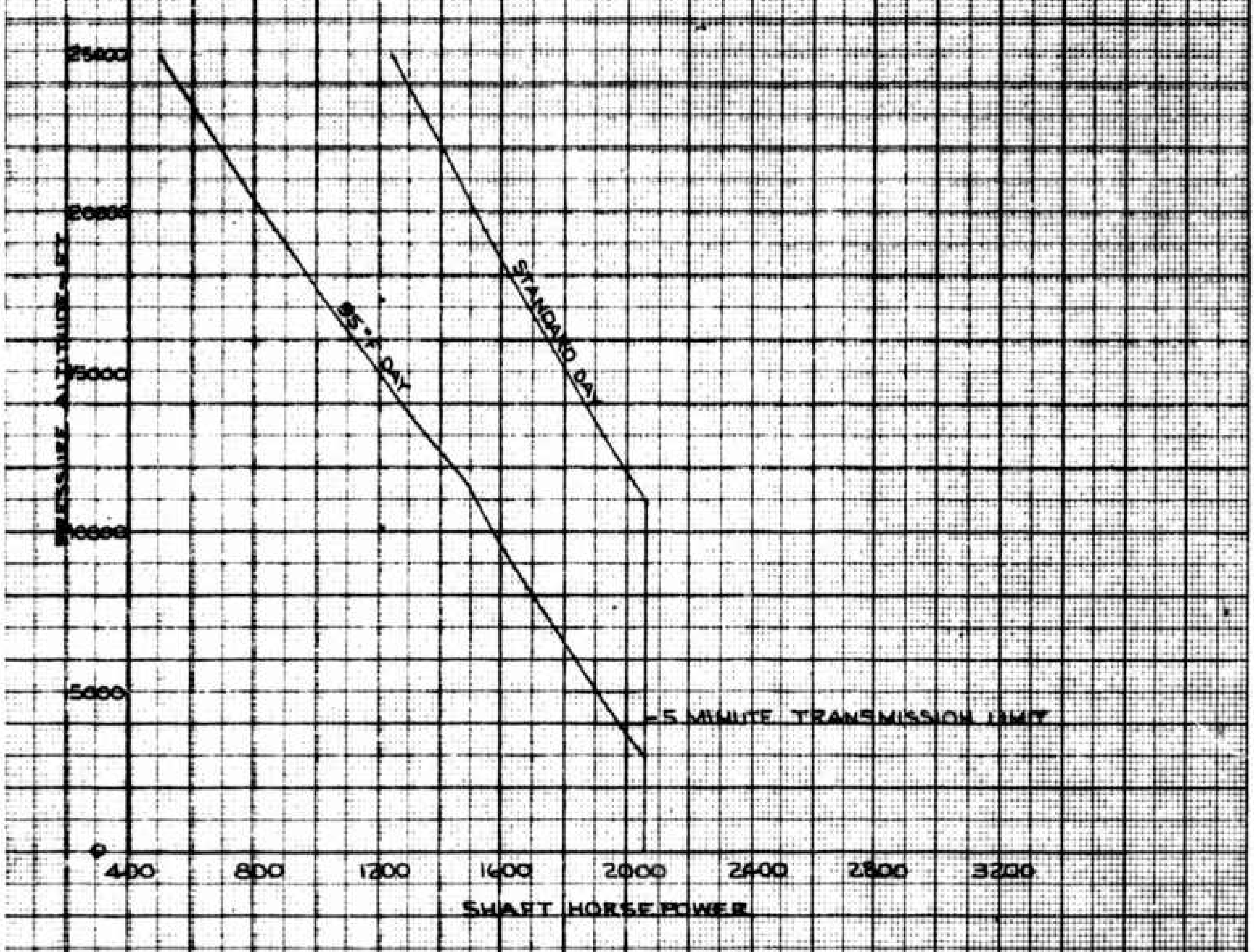


FIGURE NO. 61
REFERRED ENGINE CHARACTERISTICS
BELL MODEL 309, USA S/N N/A
GREEN RUN CALIBRATION
GREEN RUN CALIBRATION
REFERRED FUEL FLOW — LB/HR
200
400
600
800
1000
1200
1400
1600
1800
20
30
40
50
60
70
80
90
100
REFERRED GAS PRODUCER SPEED
— PERCENT RPM

FIGURE NO. 62
SHAFT HORSEPOWER AVAILABLE
BELL MODEL 309,USA S/N N/A
LYCOMING ENGINE MODEL T53-L-7C
PLOT FOR MAXIMUM POWER
N_R = 311

NOTES: 1) 0 AIRSPEED
2) AIR BLEED 6% (ECU OFF)
3) ANTI ICE OFF
4) COMPRESSOR INLET TEMP RISE 0°C
5) COMPRESSOR INLET PRESSURE RATIO .998
6) EXHAUST PRESSURE LOSS +1.0 IN. H_2O
7) HP EXTRACTION 5.0
8) SOURCE OF DATA: LYCOMING ENGINE COMPUTER DECK NO. [illegible]



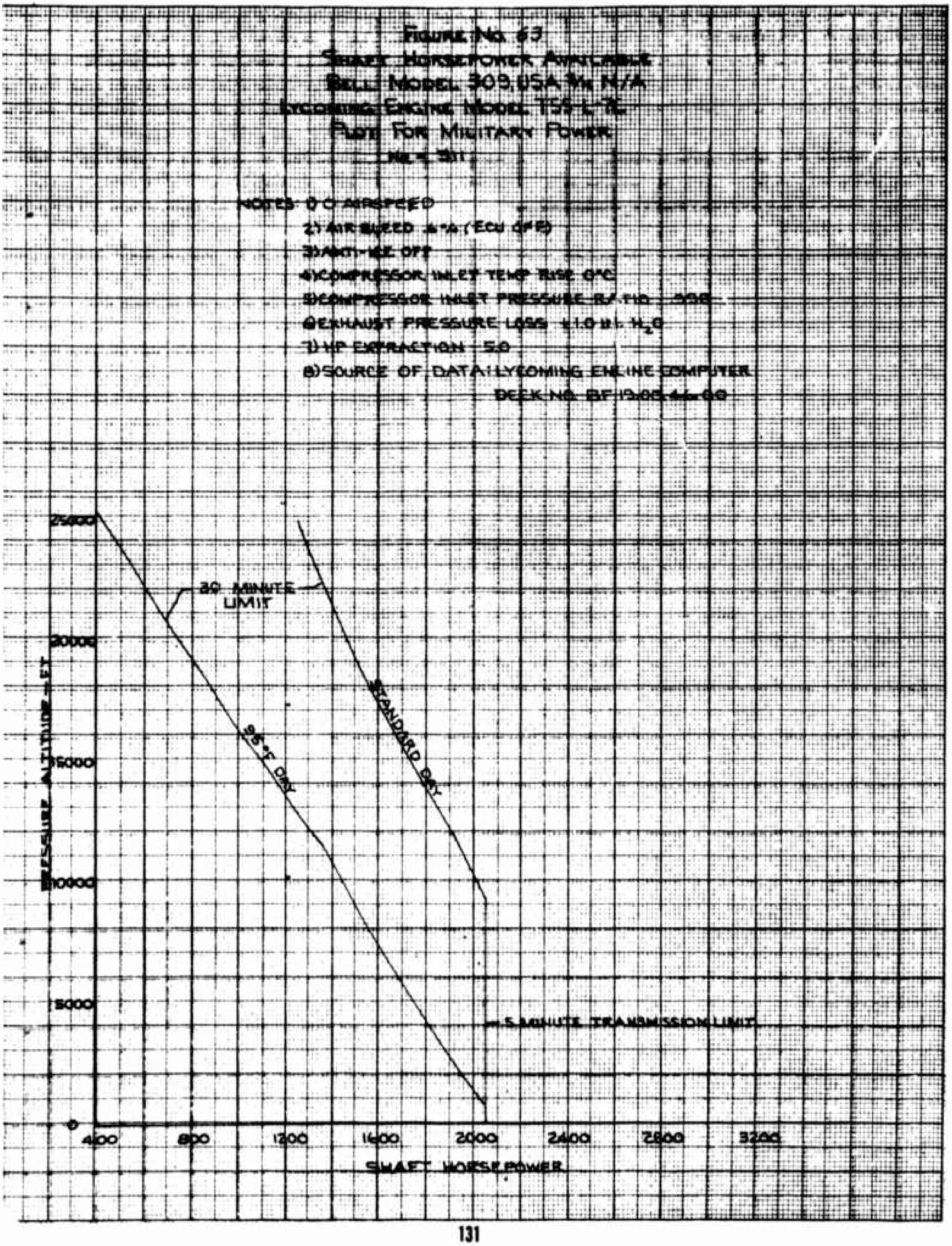
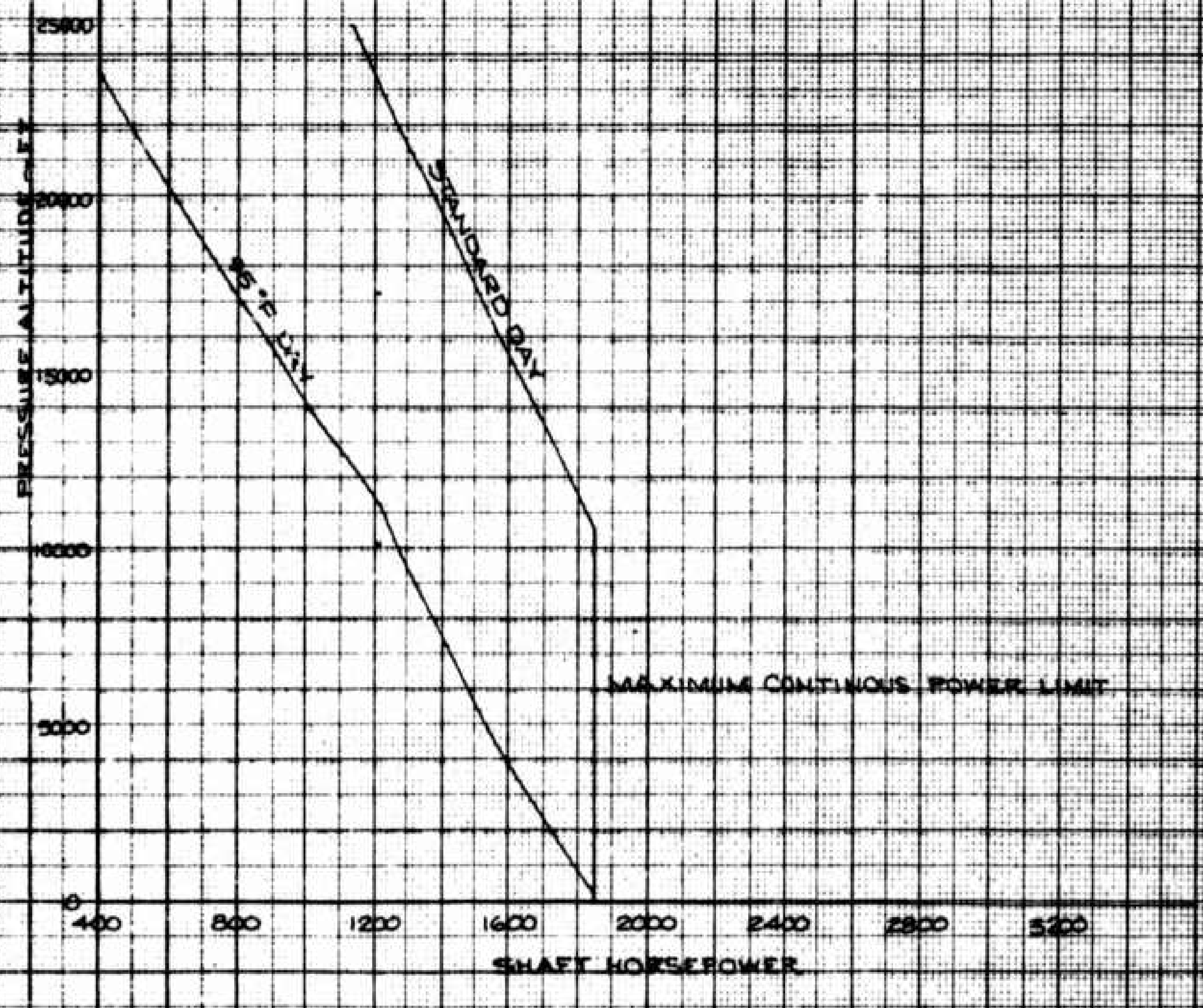


FIGURE NO. 63
SHAFT HORSEPOWER AVAILABLE
PLOT FOR MILITARY POWER
NOTES: 1) 0 AIRSPEED
3) ANTI-ICE OFF
4) COMPRESSOR INLET TEMP RISE 0°C
7) HP EXTRACTION 5.0
8) SOURCE OF DATA: LYCOMING ENGINE COMPUTER
30 MINUTE LIMIT
STANDARD DAY
95°F DAY
5 MINUTE TRANSMISSION LIMIT
25000
20000
15000
10000
5000
0
PRESSURE ALTITUDE — FT
400
800
1200
1600
2000
2400
2800
3200
SHAFT HORSEPOWER

FIGURE No. 64
SHAFT HORSEPOWER AVAILABLE
BELL MODEL 309, USA S/N N/A
LYCOMING ENGINE MODEL T55-L-7C
PLOT FOR NORMAL POWER (MAXIMUM CONTINOUS POWER)
NG = 311

NOTES: 1) 0 AIRSPEED
2) AIR BLEED .6 % (ECU OFF)
3) ANTI-ICE OFF
4) COMPRESSOR INLET TEMP RISE 0°C
5) COMPRESSOR INLET PRESSURE RATIO .992
6) EXHAUST PRESSURE LOSS +1.0 IN. H_2O
7) HP EXTRACTION 5.0
8) SOURCE OF DATA: LYCOMING ENGINE COMPUTER DECK NO. BE 19.00.46.00



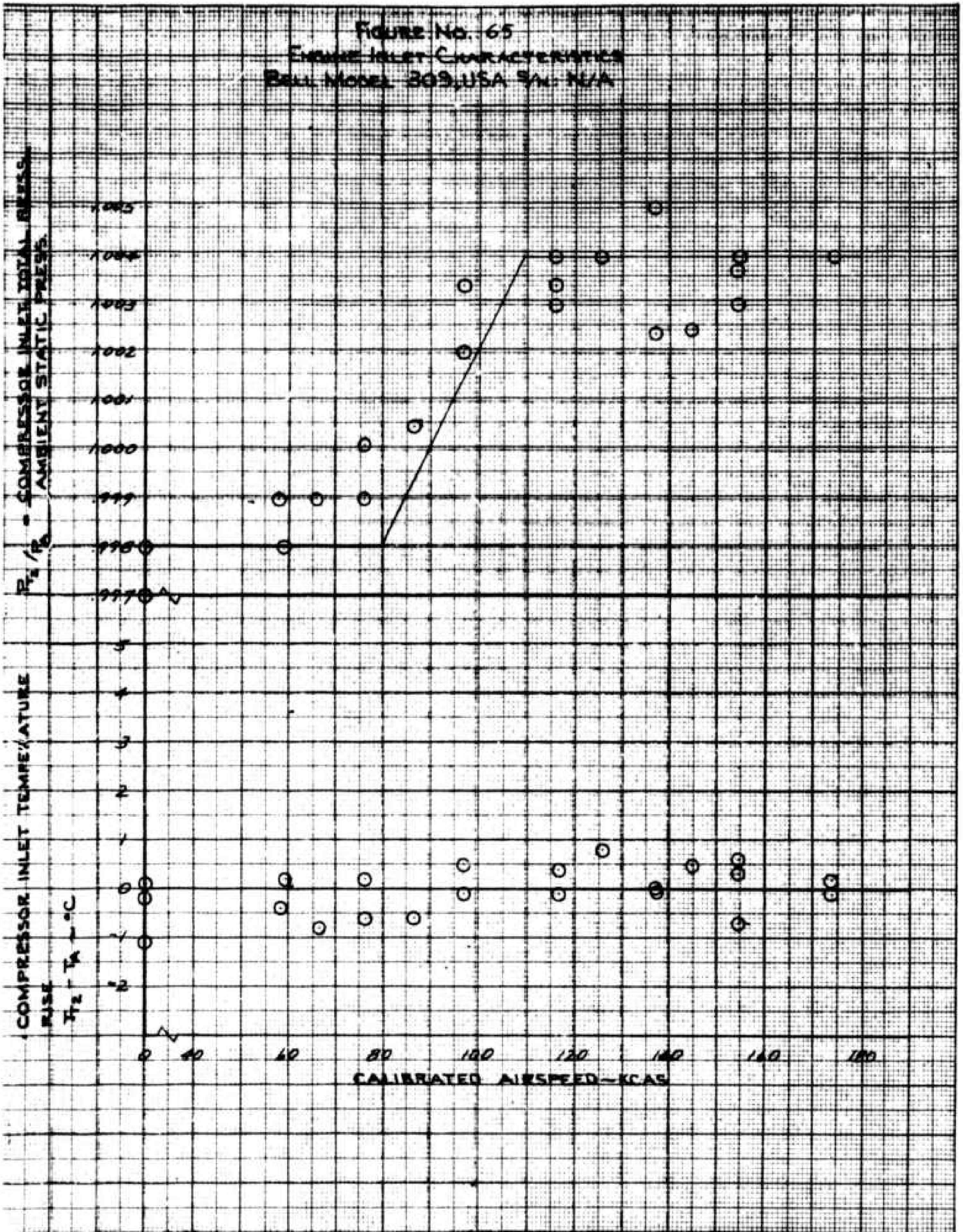


FIGURE NO. 65
ENGINE INLET CHARACTERISTICS
BELL MODEL 309, USA S/N: N/A

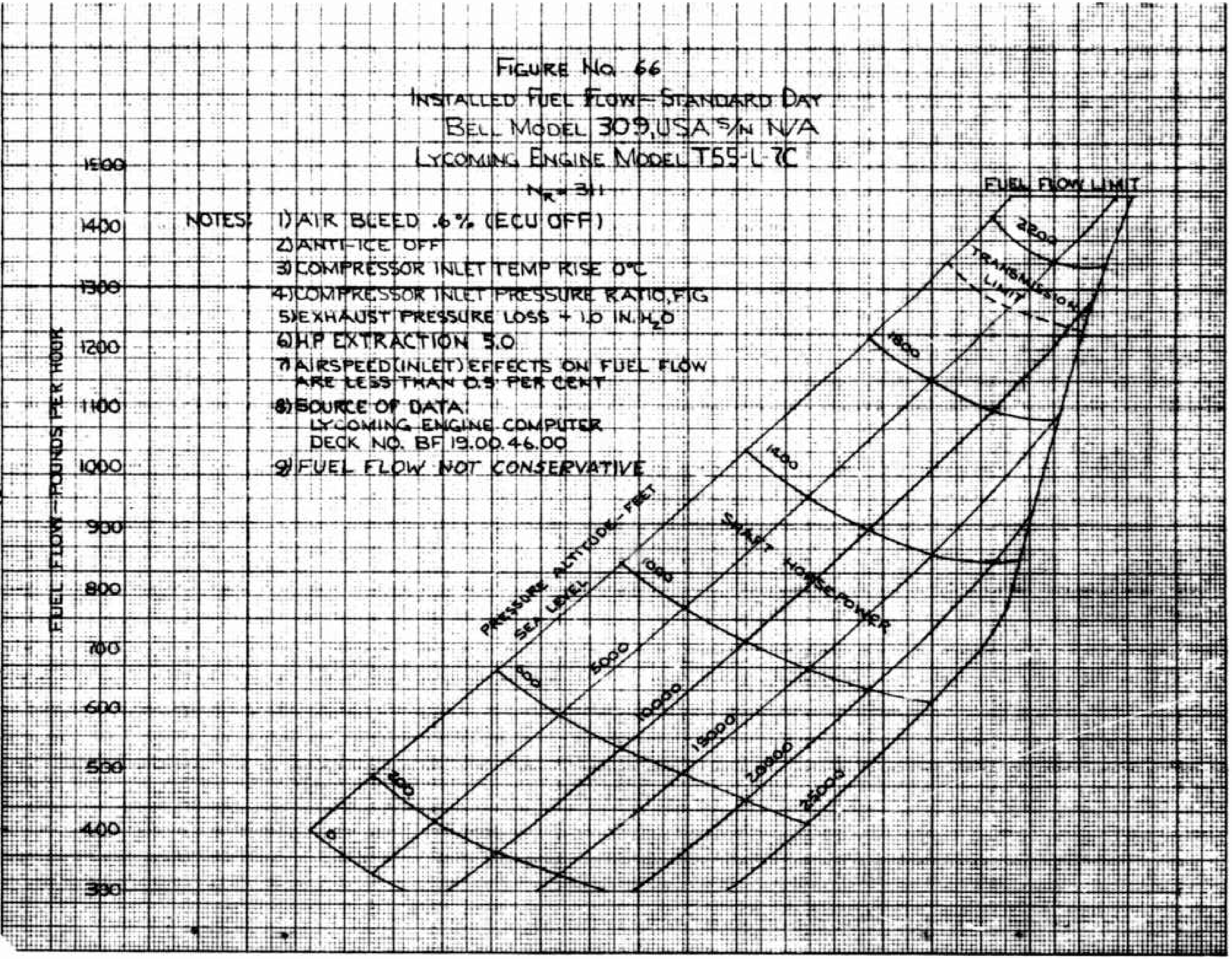


FIGURE NO. 66
INSTALLED FUEL FLOW – STANDARD DAY
BELL MODEL 309, USA S/N N/A
LYCOMING ENGINE MODEL T55-L-7C
$N_R = 311$
NOTES: 1) AIR BLEED .6% (ECU OFF)
2) ANTI-ICE OFF
3) COMPRESSOR INLET TEMP RISE 0°C
4) COMPRESSOR INLET PRESSURE RATIO, FIG
5) EXHAUST PRESSURE LOSS + 1.0 IN. H_2O
6) HP EXTRACTION 5.0
7) AIRSPEED (INLET) EFFECTS ON FUEL FLOW ARE LESS THAN 0.5 PER CENT
8) SOURCE OF DATA: LYCOMING ENGINE COMPUTER DECK NO. BF 19.00.46.00
9) FUEL FLOW NOT CONSERVATIVE
FUEL FLOW – POUNDS PER HOUR
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
FUEL FLOW LIMIT
TRANSMISSION LIMIT
SHAFT HORSEPOWER
2200
1800
1400
1000
600
200
0
PRESSURE ALTITUDE – FEET
SEA LEVEL
5000
10000
15000
20000
25000

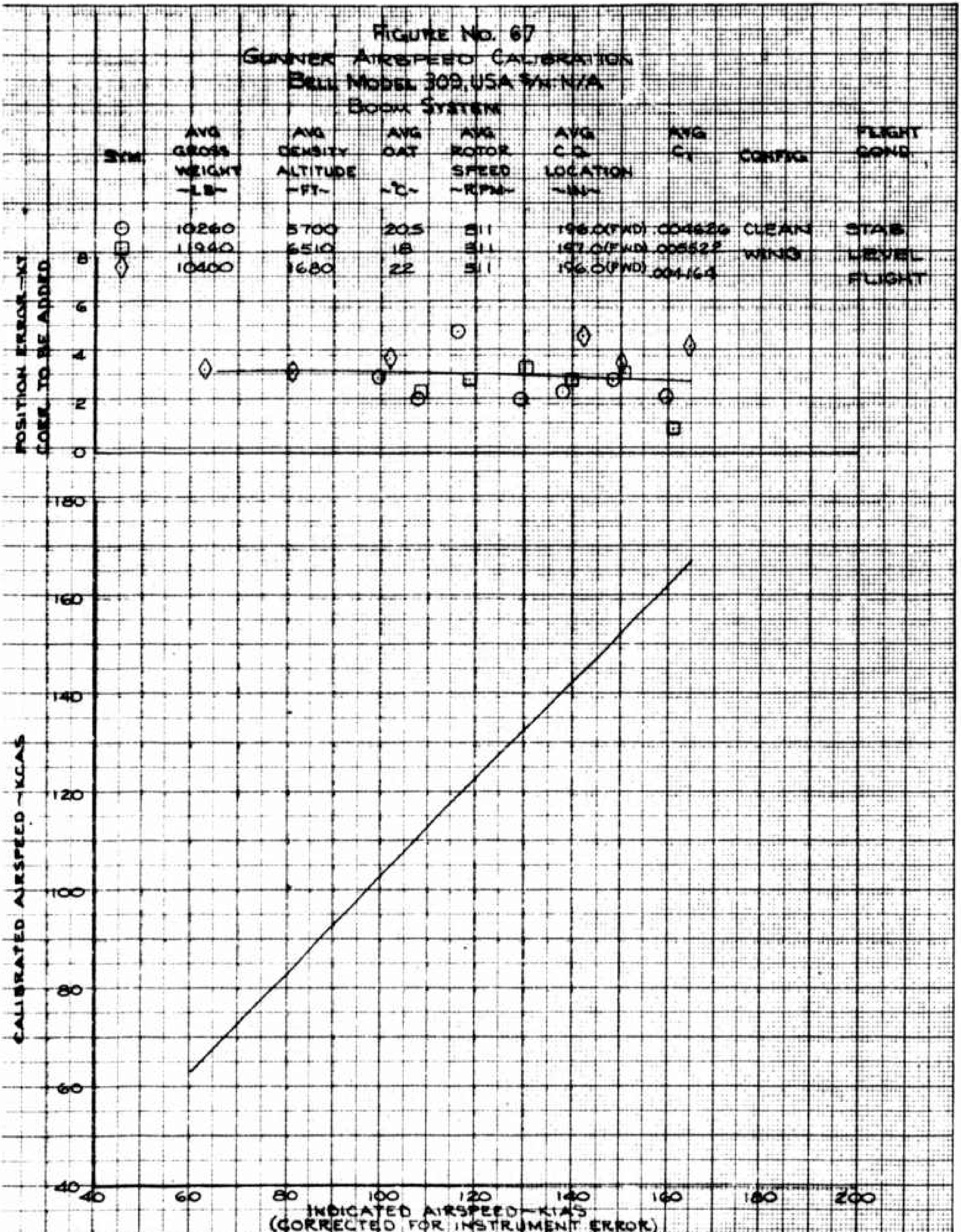
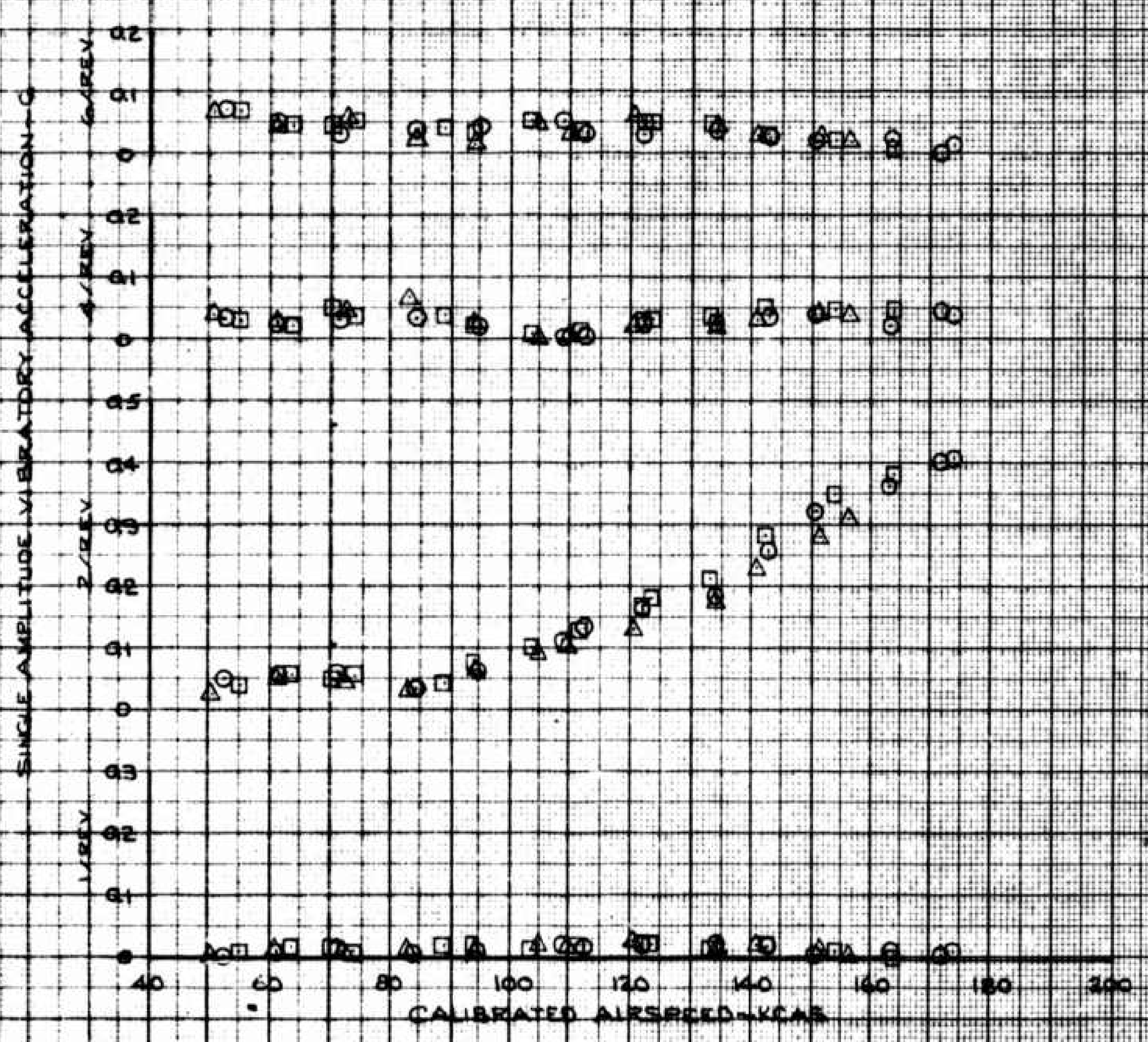


FIGURE NO. 67
GUNNER AIRSPEED CALIBRATION
BELL MODEL 309, USA S/N N/A
BOOM SYSTEM
SYM.
AVG GROSS WEIGHT ~LB~
AVG DENSITY ALTITUDE ~FT~
AVG OAT ~°C~
AVG ROTOR SPEED ~RPM~
AVG C.G. LOCATION ~IN~
AVG C_T
CONFIG.
FLIGHT COND.
10260 5700 20.5 311 196.0(FWD) .004626
11940 6510 18 311 197.0(FWD) .005622
10400 1680 22 311 196.0(FWD) .004164
CLEAN WING
STAB. LEVEL FLIGHT
POSITION ERROR~KT
CORR. TO BE ADDED
8
6
4
2
0
180
160
140
120
100
80
60
40
CALIBRATED AIRSPEED~KCAS
40
60
80
100
120
140
160
180
200
INDICATED AIRSPEED~KIAS
(CORRECTED FOR INSTRUMENT ERROR)

FIGURE No. 68
VIBRATION CHARACTERISTICS
BELL MODEL 309, USA S/N N/A
C.G. VERTICAL

SYM	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T	CONFIGURATION	FLIGHT CONDITION
○	10820	194.5	5210	21	311	.004528	CLEAN	STABILIZED
▣	10860	195.9	6620	18	311	.004797		LEVEL FLIGHT
△	11460	196.2	6510	26	311	.005264		



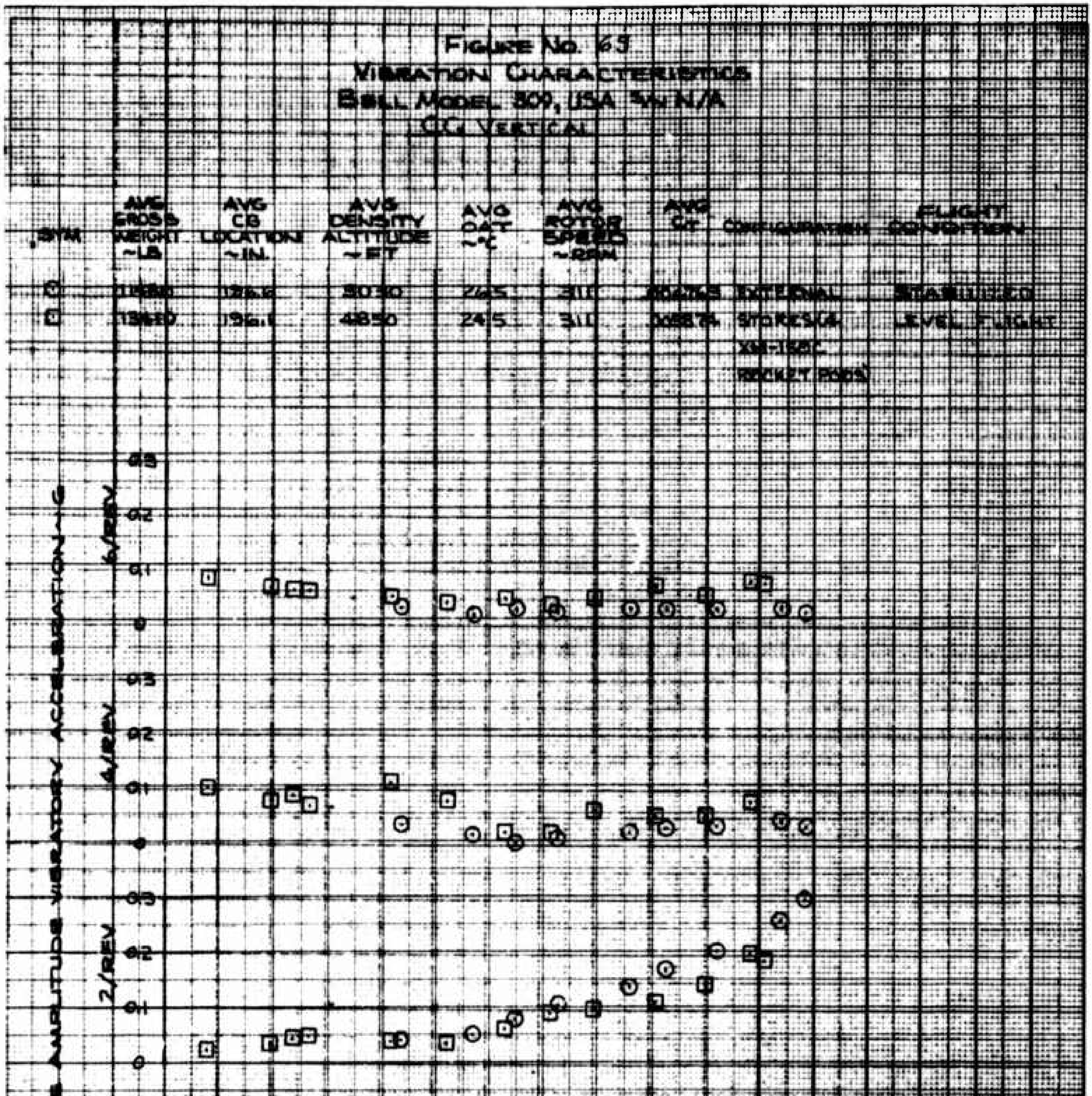
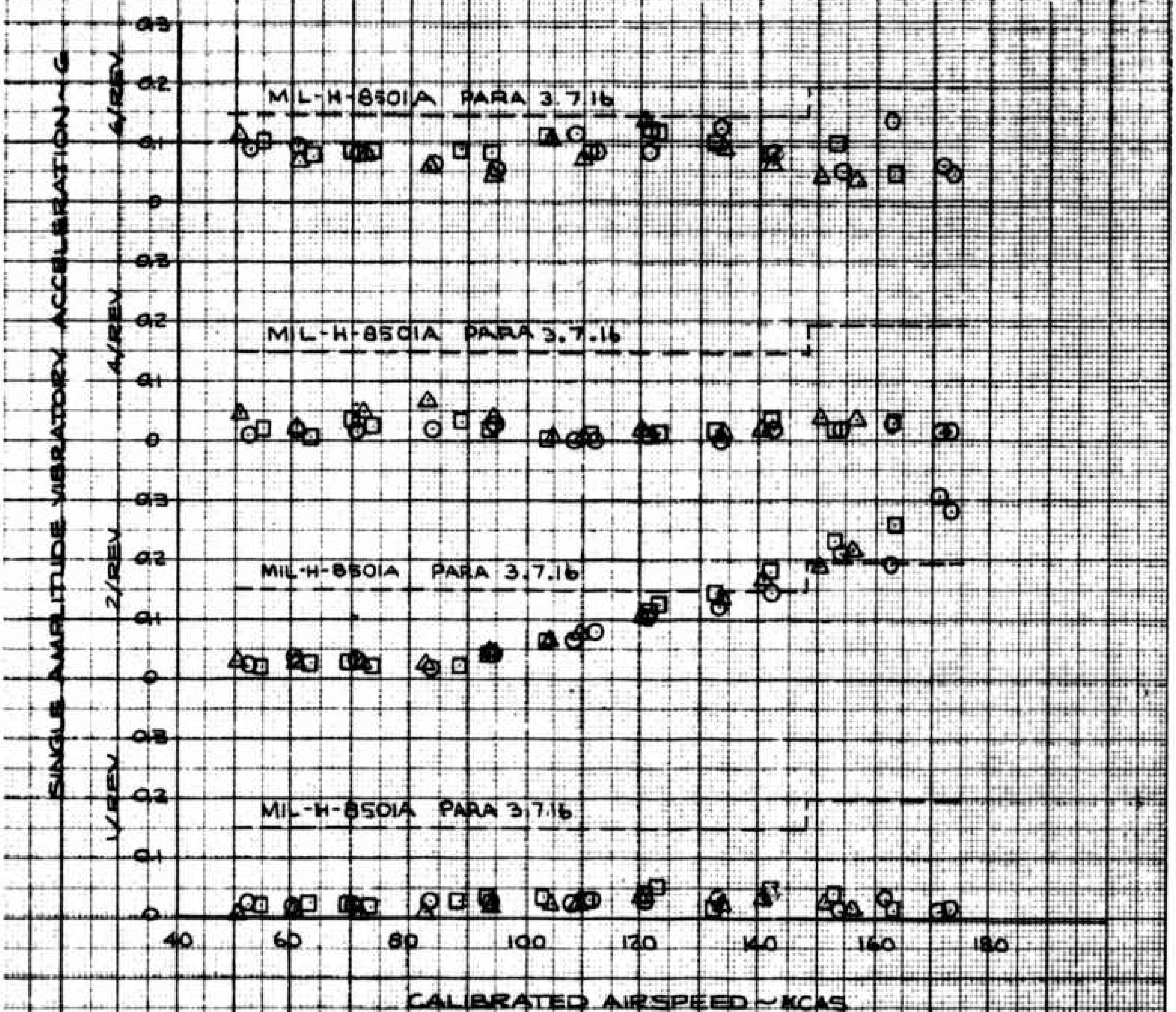


FIGURE No. 65
VIBRATION CHARACTERISTICS
BELL MODEL 309, USA S/N N/A
C.G. VERTICAL
SYM
AVG GROSS WEIGHT ~LB
AVG CB LOCATION ~IN.
AVG DENSITY ALTITUDE ~FT
AVG OAT ~°C
AVG ROTOR SPEED ~RPM
AVG CT
CONFIGURATION
FLIGHT CONDITION
4850
24.5
311
EXTERNAL
STORES (4 XM-158C ROCKET PODS)
STABILIZED
LEVEL FLIGHT
SINGLE AMPLITUDE VIBRATORY ACCELERATION ~ G
6/REV
4/REV
2/REV
1/REV
0.3
0.2
0.1
0
40
60
80
100
120
140
160
180
200
CALIBRATED AIRSPEED ~ KCAS

FIGURE NO. 70
VIBRATION CHARACTERISTICS
BELL MODEL 309, USA S/N N/A
PILOT SEAT VERTICAL

SYM	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG CT	CONFIGURATION	FLIGHT CONDITION
○	10220	196.5	5210	27	311	.004338	CLEAN	STABILIZED
□	10350	196.9	6620	18	311	.004757		LEVEL FLIGHT
△	11460	196.2	6510	26	311	.005256		



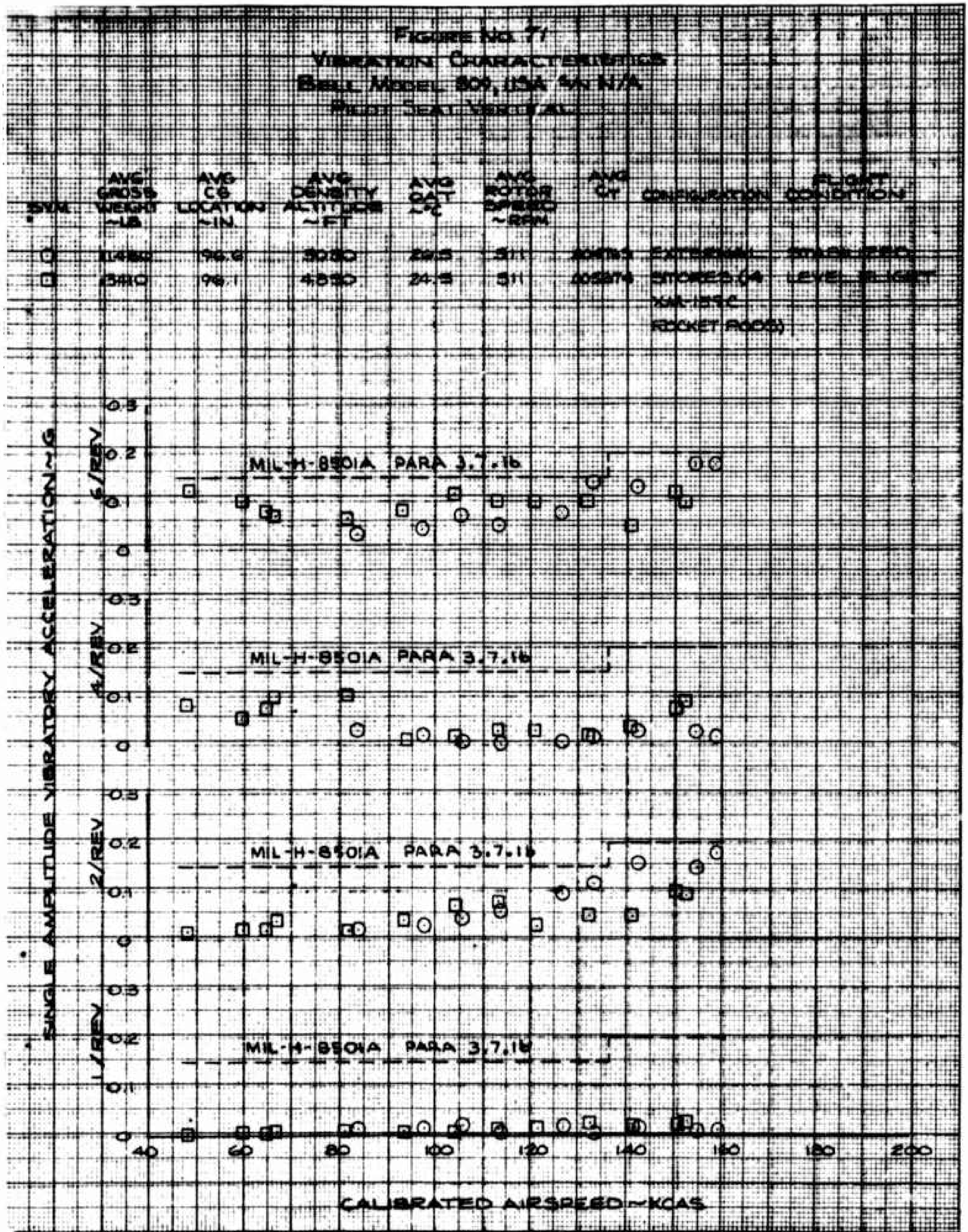


FIGURE NO. 71
VIBRATION CHARACTERISTICS
BELL MODEL 309, USA S/N N/A
PILOT SEAT VERTICAL
SYM
AVG GROSS WEIGHT ~LB
AVG CG LOCATION ~IN.
AVG DENSITY ALTITUDE ~FT
AVG OAT ~°C
AVG ROTOR SPEED ~RPM
AVG CT
CONFIGURATION
FLIGHT CONDITION
EXTERNAL STORES (4 XM-159C ROCKET PODS)
LEVEL FLIGHT
MIL-H-8501A PARA 3.7.1b
SINGLE AMPLITUDE VIBRATORY ACCELERATION ~G
6/REV
4/REV
2/REV
1/REV
CALIBRATED AIRSPEED ~KCAS

Figure No. 72
Vibration Characteristics
Bell Model 309, USA S/N N/A
Gunner Seat Vertical

SYM	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T	CONFIGURATION	FLIGHT CONDITION
○	10320	196.5	3210	27.0	311	.004328	CLEAN	STABILIZED
□	10350	195.9	4620	18.0	311	.004797		LEVEL FLIGHT
△	11460	196.2	6510	26.0	311	.003254		

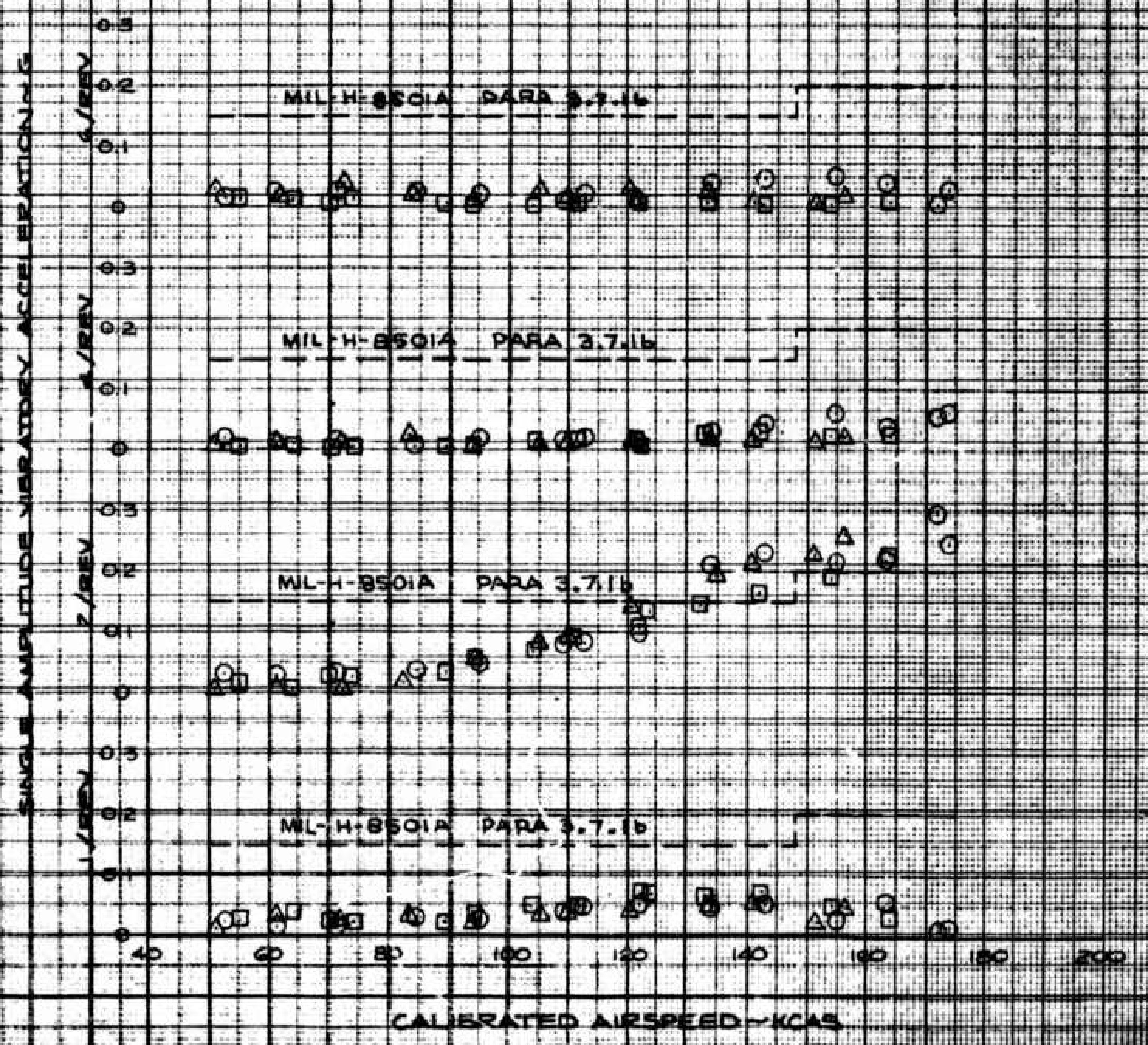
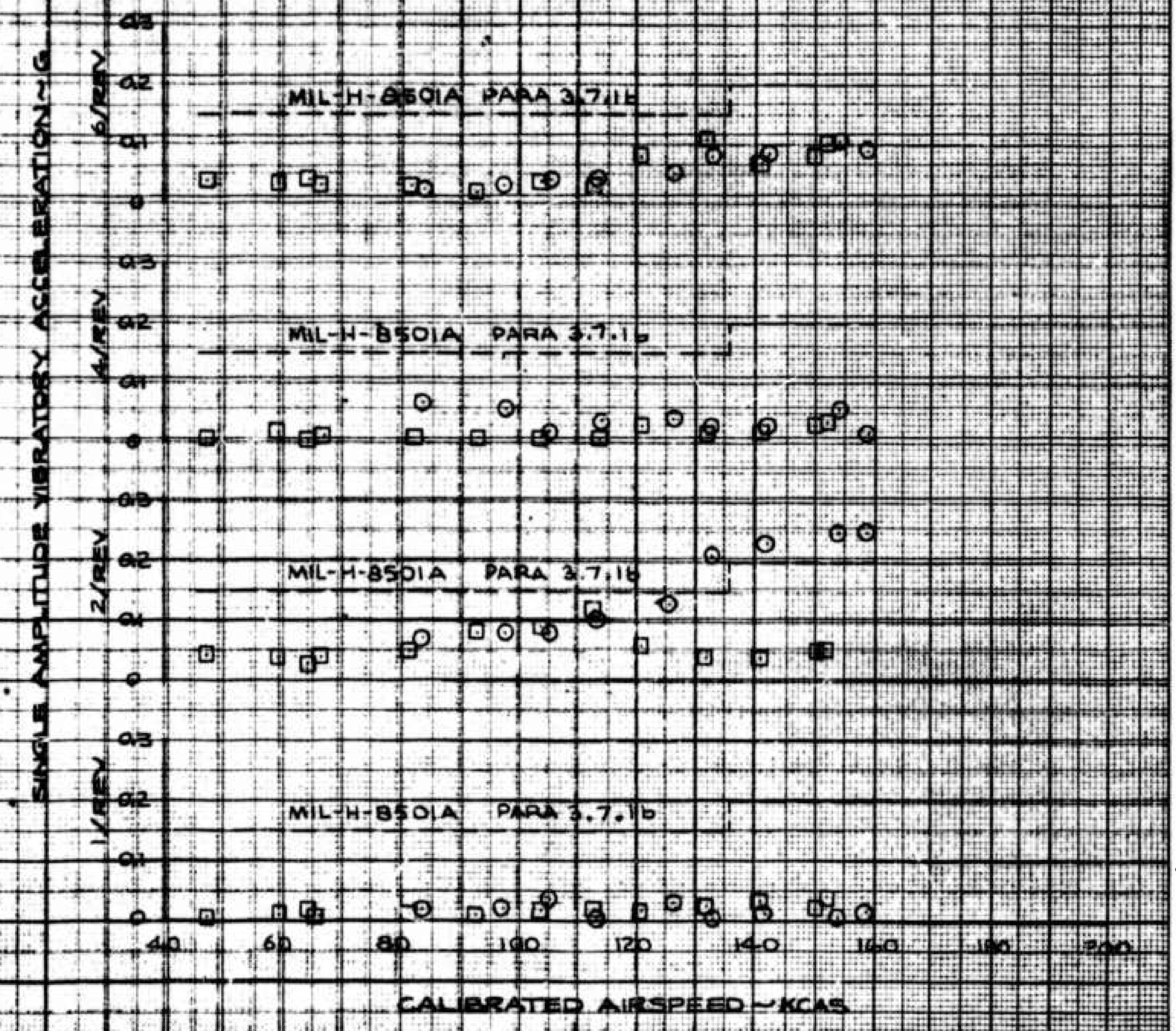


FIGURE No. 73
VIBRATION CHARACTERISTICS
BELL MODEL 309, USA S/N N/A
GUNNER SEAT VERTICAL

SYM	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG CT	CONFIGURATION	FLIGHT CONDITION
⊙	11490	196.6	3030	26.5	311	.002665	EXTERNAL STORES (6 XM159C ROCKET PODS)	STABILIZED LEVEL FLIGHT
⊡	13410	196.1	4850	24.5	311	.002876		



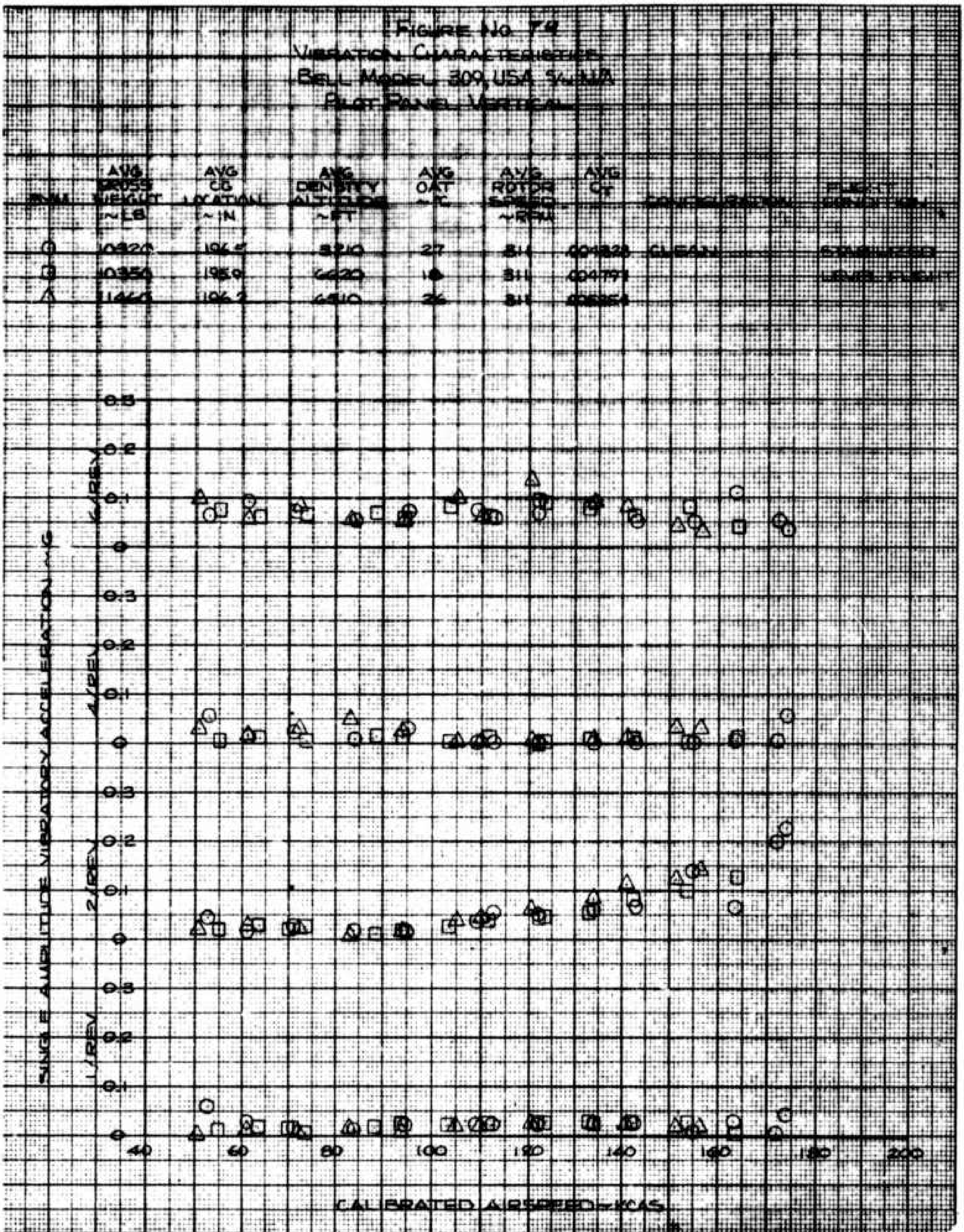
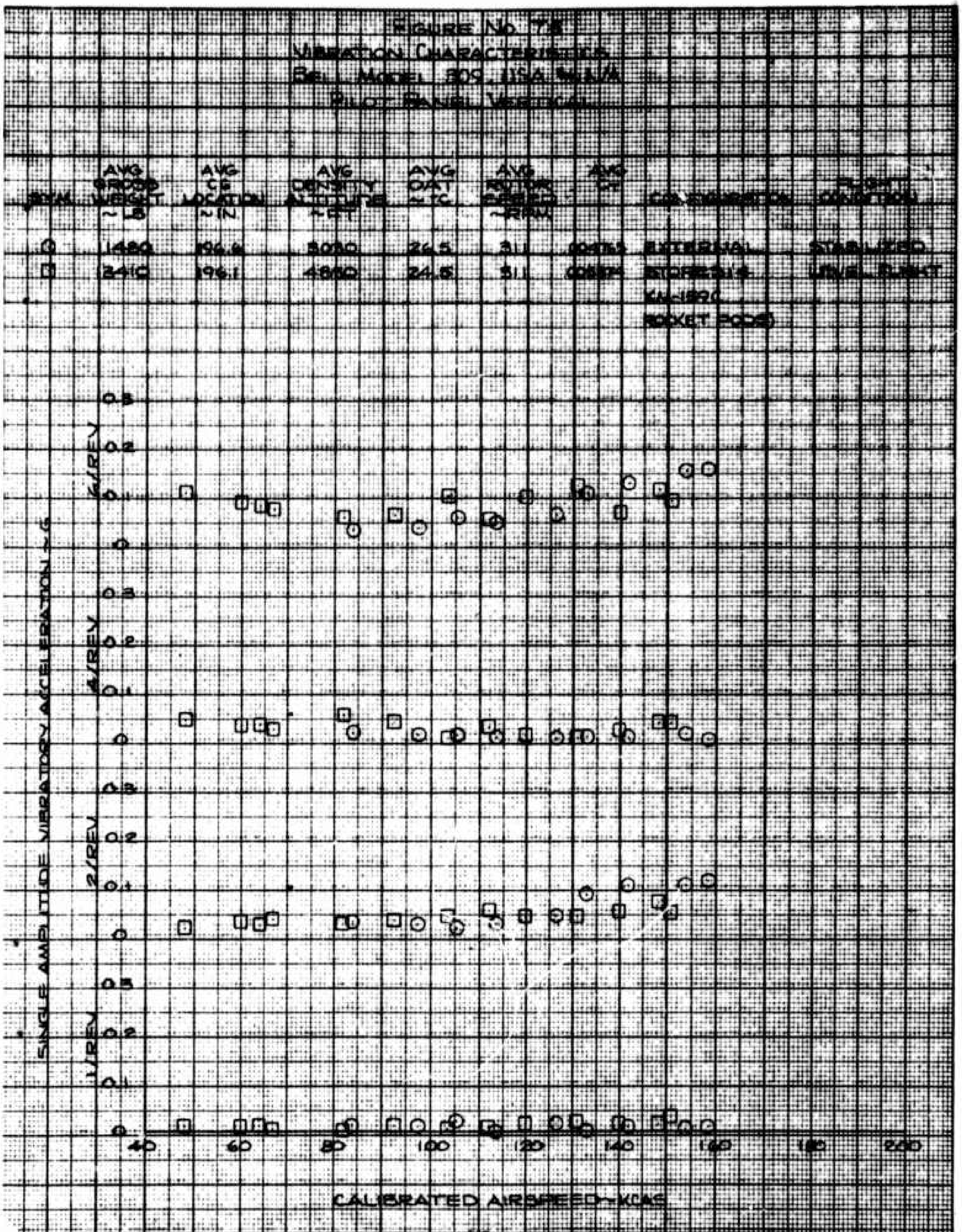


FIGURE NO. 79
VIBRATION CHARACTERISTICS
BELL MODEL 309, USA S/N N/A
PILOT PANEL VERTICAL
AVG GROSS WEIGHT ~LB
AVG CG LOCATION ~IN
AVG DENSITY ALTITUDE ~FT
AVG OAT ~°C
AVG ROTOR SPEED ~RPM
AVG CT
CONFIGURATION
FLIGHT CONDITION
10920
196.5
5210
27
311
CLEAN
10350
195.9
6620
311
LEVEL FLIGHT
11460
196.2
6510
26
311
SINGLE AMPLITUDE VIBRATORY ACCELERATION ~G
6/REV
4/REV
2/REV
1/REV
0.3
0.2
0.1
0
40
60
80
100
120
140
160
180
200
CALIBRATED AIRSPEED ~ KCAS


VIBRATION CHARACTERISTICS
BELL MODEL 309
PILOT PANEL VERTICAL
SYM
AVG GROSS WEIGHT ~LB
AVG CG LOCATION ~IN
AVG DENSITY ALTITUDE ~FT
AVG OAT ~°C
AVG ROTOR SPEED ~RPM
AVG
CONFIGURATION
FLIGHT CONDITION
1480
196.6
5030
26.5
311
EXTERNAL
STABILIZED
2410
196.1
4860
24.5
311
STORES
LEVEL FLIGHT
XM-159C
ROCKET PODS
SINGLE AMPLITUDE VIBRATORY ACCELERATION ~G
6/REV
4/REV
2/REV
1/REV
0.3
0.2
0.1
0
40
60
80
100
120
140
160
180
200
CALIBRATED AIRSPEED ~KCAS

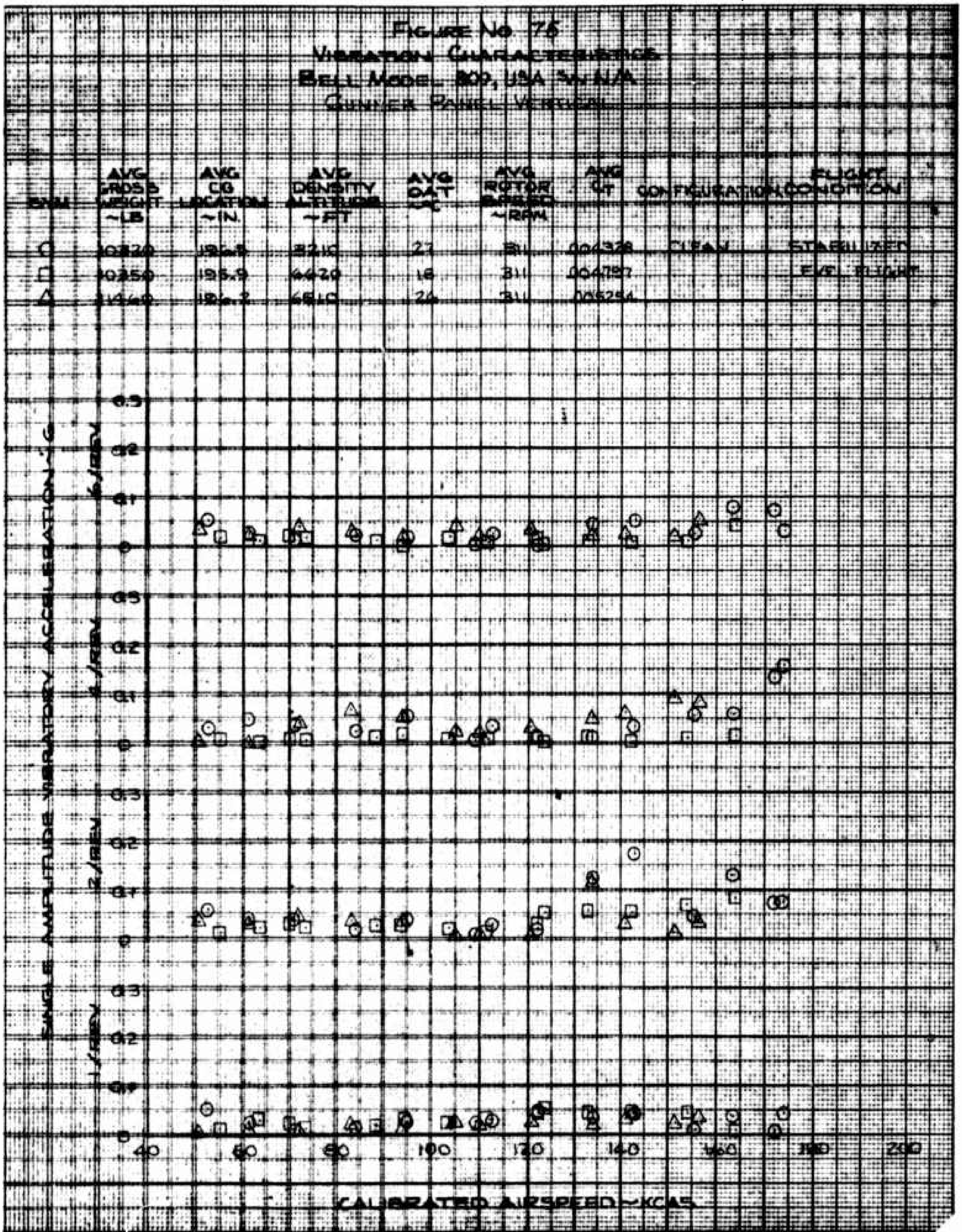


FIGURE NO 75
VIBRATION CHARACTERISTICS
BELL MODEL 309, USA S/N N/A
GUNNER PANEL VERTICAL
SYM | AVG GROSS WEIGHT ~LB | AVG CG LOCATION ~IN. | AVG DENSITY ALTITUDE ~FT | AVG OAT ~°C | AVG ROTOR SPEED ~RPM | AVG CT | CONFIGURATION | FLIGHT CONDITION
○ 10220 196.5 5210 27 311 .004328 CLEAN STABILIZED LEVEL FLIGHT
□ 10250 195.9 6620 18 311 .004797
△ 11460 196.2 6510 26 311 .005254
SINGLE AMPLITUDE VIBRATORY ACCELERATION ~ G
6/REV
4/REV
2/REV
1/REV
0.3
0.2
0.1
0
40
60
80
100
120
140
160
180
200
CALIBRATED AIRSPEED ~ KCAS

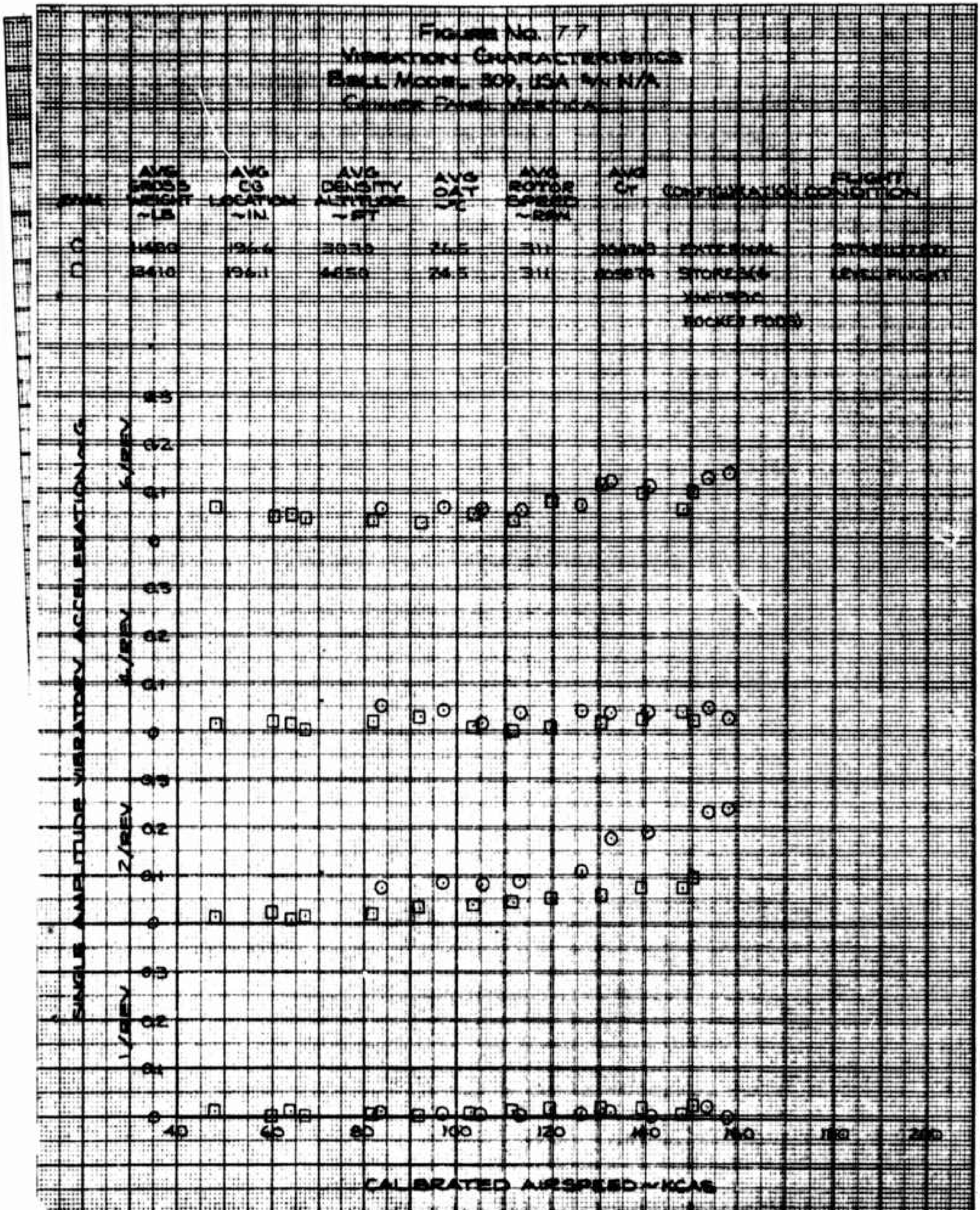
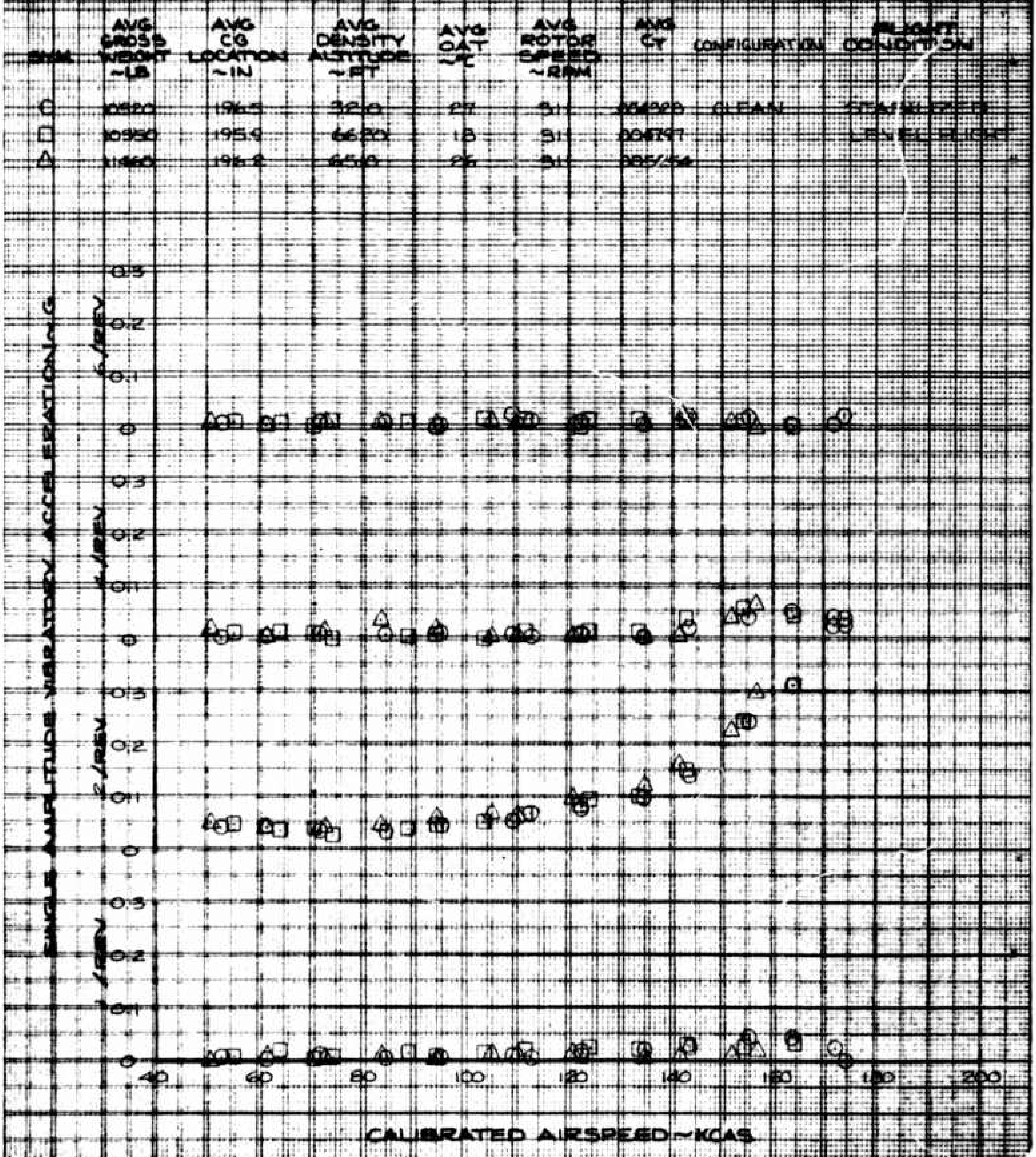


FIGURE No. 77
VIBRATION CHARACTERISTICS
BELL MODEL 309, USA S/N N/A
AVG GROSS WEIGHT ~LB
AVG CG LOCATION ~IN.
AVG DENSITY ALTITUDE ~FT
AVG OAT ~°C
AVG ROTOR SPEED ~RPM
AVG CT
CONFIGURATION
FLIGHT CONDITION
SINGLE AMPLITUDE VIBRATORY ACCELERATION ~G
6/REV
4/REV
2/REV
1/REV
CALIBRATED AIRSPEED ~ KCAS

FIGURE NO. 78
VIBRATION CHARACTERISTICS
BELL MODEL 309, USA S/N N/A
CG LATERAL



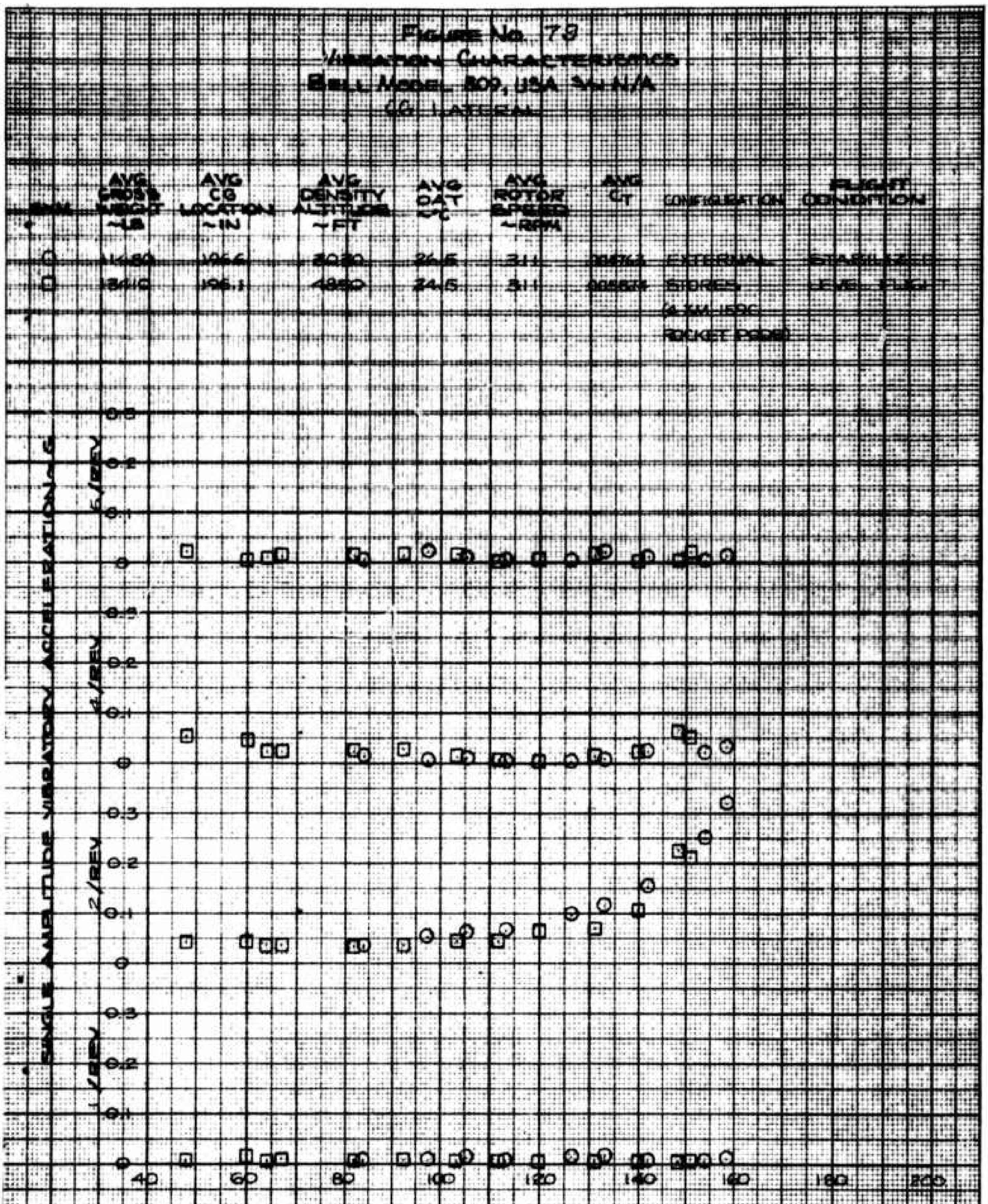


FIGURE NO. 73
VIBRATION CHARACTERISTICS
BELL MODEL 209, USA S/N N/A
CG LATERAL
SYM
AVG GROSS WEIGHT ~LB
AVG CG LOCATION ~IN
AVG DENSITY ALTITUDE ~FT
AVG OAT ~°C
AVG ROTOR SPEED ~RPM
AVG C_T
CONFIGURATION
FLIGHT CONDITION
○ 196.6 26.5 311 EXTERNAL STABILIZED
□ 196.1 4850 24.5 311 STORES LEVEL FLIGHT
(4 XM-159C
ROCKET PODS)
SINGLE AMPLITUDE VIBRATORY ACCELERATION ~ G
6/REV
4/REV
2/REV
1/REV
0.3
0.2
0.1
0
40
60
80
100
120
140
160
180
200
CALIBRATED AIRSPEED ~ KCAS

Figure No. 60
Vibration Characteristics
Bell Model 309, USA S/N N/A
Pilot Seat, Lateral

SYM	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T	CONFIGURATION	FLIGHT CONDITION
○	10520	196.5	3210	27	311	[illegible]	CLEAN	STABILIZED
□	10550	195.9	6680	18	311	[illegible]		LEVEL FLIGHT
△	11460	196.2	6510	26	311	[illegible]		

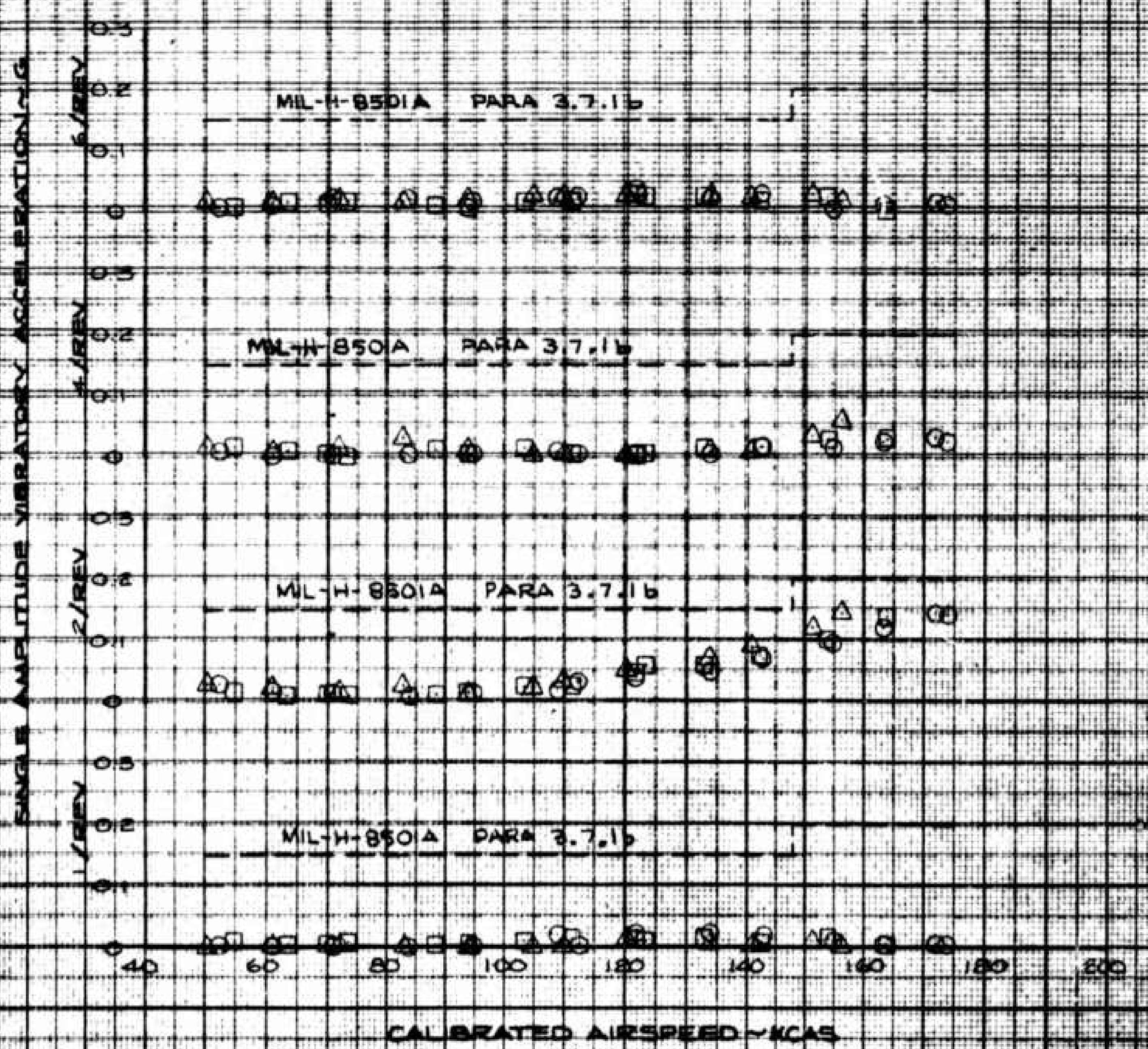
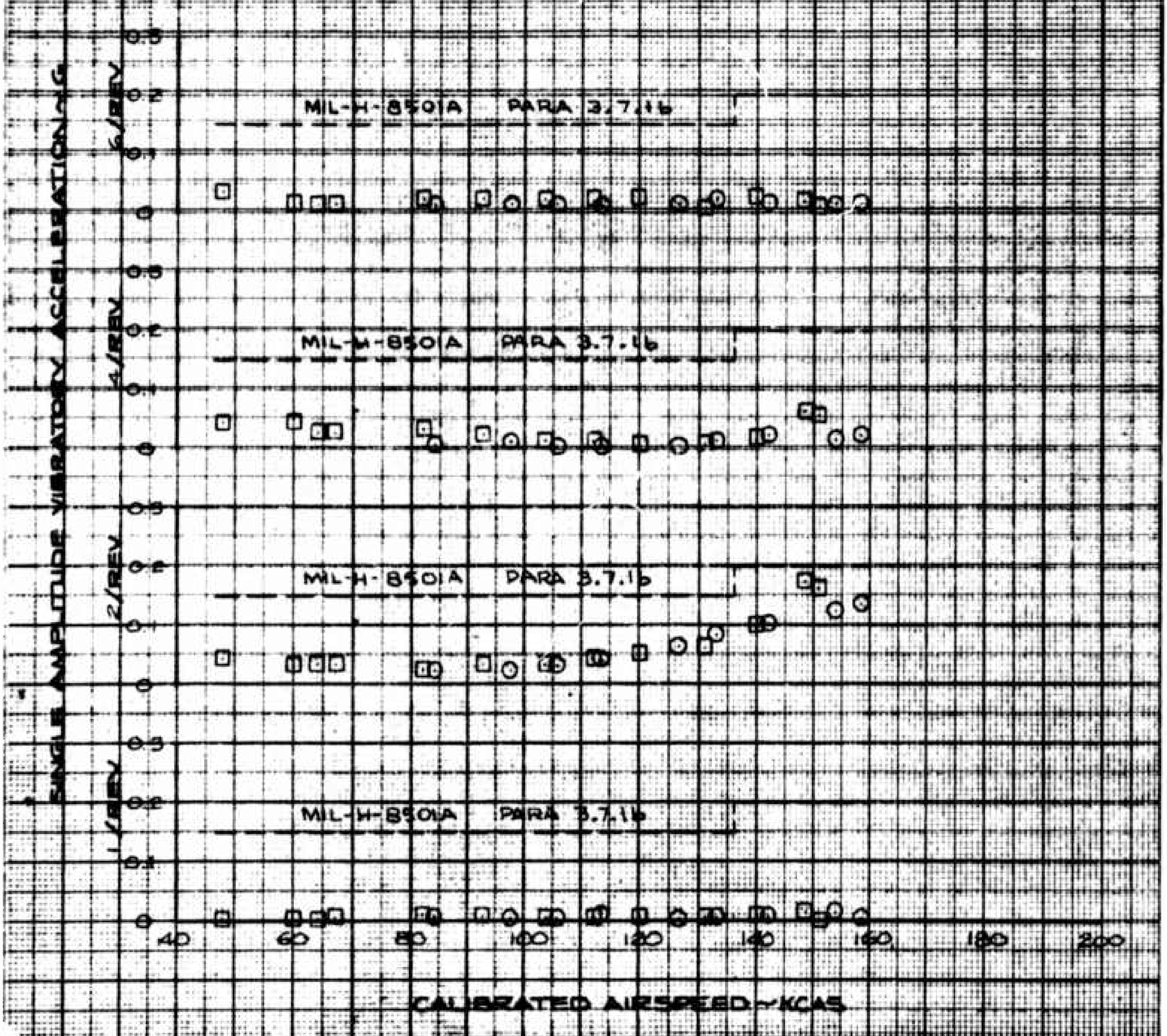


FIGURE NO. 81
VIBRATION CHARACTERISTICS
BELL MODEL 309, USA S/N N/A
PILOT SEAT LATERAL

SYM	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T	CONFIGURATION	FLIGHT CONDITION
○	1480	196.6	3030	26.5	31	.004763	EXTERNAL STORES (4 XM 159C ROCKET PODS)	STABILIZED LEVEL FLIGHT
□	3410	196.1	4850	24.5	31	.005874		



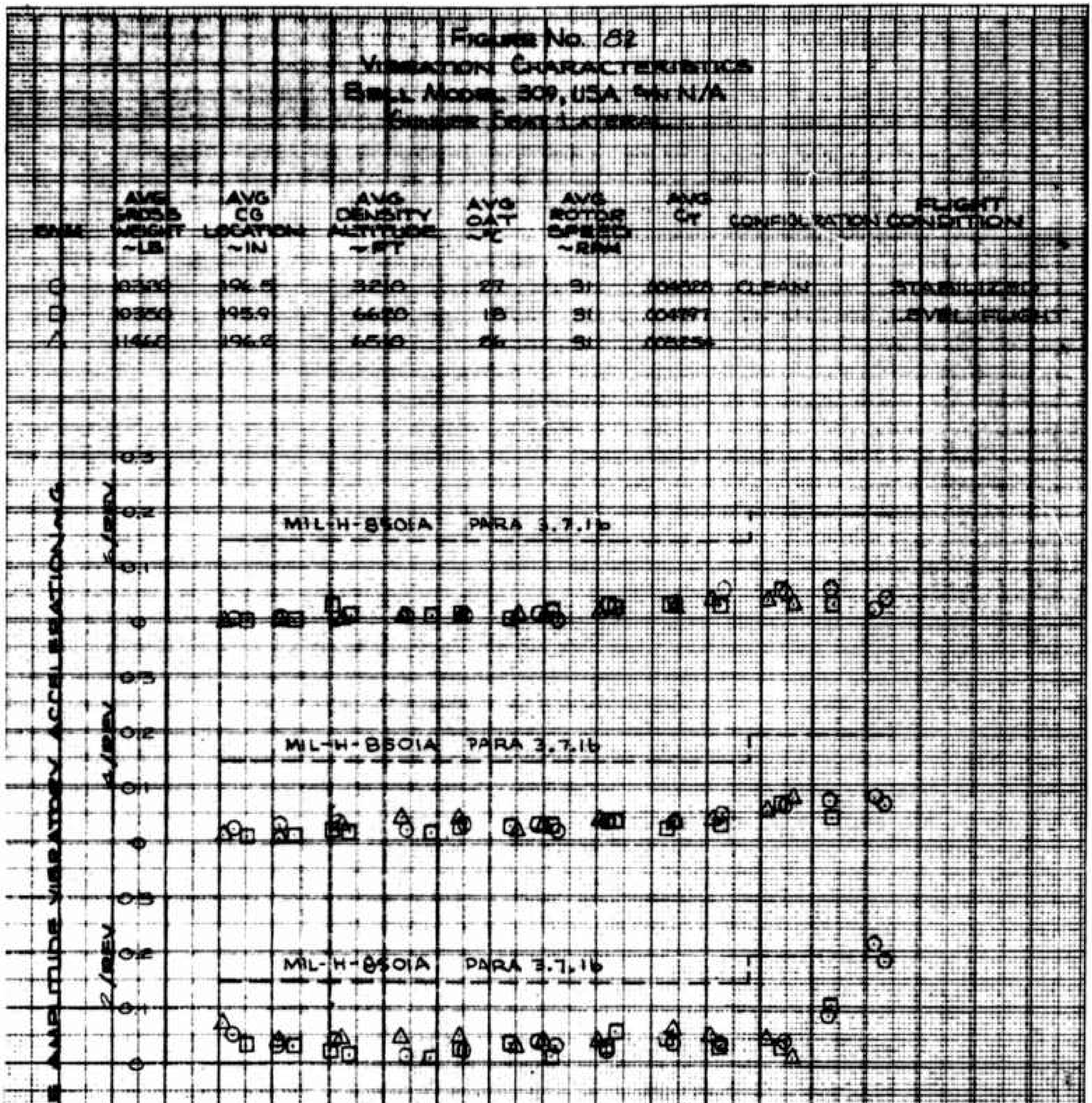


FIGURE No. 82
VIBRATION CHARACTERISTICS
BELL MODEL 309, USA S/N N/A
MIL-H-8501A PARA 3.7.1b
MIL-H-8501A PARA 3.7.1b
MIL-H-8501A PARA 3.7.1b
MIL-H-8501A PARA 3.7.1b
SINGLE AMPLITUDE VIBRATORY ACCELERATION ~ G
40
60
80
100
120
140
160
180
200
CALIBRATED AIRSPEED ~ KCAS

FIGURE NO. 83
VIBRATION CHARACTERISTICS
BELL MODEL 309, USA S/N N/A
GUNNER SEAT LATERAL

SYM	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T	CONFIGURATION	FLIGHT CONDITION
○	1480	196.4	8030	26.5	311	004763	EXTERNAL STORES (4 XM-159C ROCKET PODS)	STABILIZED LEVEL FLIGHT
□	13410	196.1	4850	24.5	311	005874