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RDTE PROJECT NO.
USAAVSCOM PROJECT NO. 70-03
USAASTA PROJECT NO. 70-03

ARMY PRELIMINARY EVALUATION II PRODUCTION OV-1D (MOHAWK)

PERFORMANCE AND HANDLING QUALITIES

FINAL REPORT

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MARCH 1971

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US ARMY AVIATION SYSTEMS TEST ACTIVITY

EDWARDS AIR FORCE BASE, CALIFORNIA 93523

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ABSTRACT

Performance and stability and control testing was conducted on a production model OV-1D airplane (Mohawk), S/N 68-16990, to evaluate its ability to perform the manned aerial surveillance mission and to determine military specification compliance. Testing was performed by the US Army Aviation Systems Test Activity, Edwards Air Force Base, California, between 14 and 24 July 1970. The testing was conducted at the Grumman Aerospace Corporation Facility at Calverton, New York. Nine flights were accomplished for a total of 20.5 hours. The stability and control portion of the testing is presented in this report. The performance test results will be contained in an addendum. The flying qualities of the OV-1D were satisfactory for mission accomplishment. One deficiency was reported: the possibility of an operating engine feathering created by a malfunction in the torque gage during takeoff. In addition, there were seven shortcomings noted. Airworthiness and flight characteristics testing on the OV-1D is recommended in order to provide current handbook data.

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APPENDIXES

INTRODUCTION

BACKGROUND

1. The OV-1D airplane is a growth version of the OV-1 model manufactured by the Grumman Aerospace Corporation (GAC), Bethpage, New York, for the US Army. Four preproduction aircraft were used in contractor flight tests to evaluate performance, flying qualities, structural integrity and electronic compatibility of new electronic surveillance mission equipment. An Army Preliminary Evaluation (APE I) on the preproduction OV-1D airplane was conducted by the US Army Aviation Systems Test Activity (USAASTA) in May 1969 (ref 1, app I). The evaluation of the production OV-1D airplane (APE II) was directed by the US Army Aviation Systems Command (USAAVSCOM) by test request number 70-03 (ref 2).

TEST OBJECTIVES

2. The following is the list of test objectives as outlined in the test directive:

a. To quantitatively and qualitatively evaluate the airplane performance and handling qualities, and to verify compliance with the requirements of the military specification (mil spec), MIL-F-8785(ASG), Amendment 2 (ref 3, app I) and the detail specification (ref 4).

b. To determine if the shortcomings reported in the preproduction APE were adequately corrected.

c. To spot-check performance data provided by GAC.

DESCRIPTION

3. The OV-1D airplane (photo 1) tested during the APE II was the production OV-1D, S/N 68-16990. The OV-1D is a two-place, triple-vertical-stabilizer, mid-wing, twin-engine turboprop airplane. The airplane is powered by two Lycoming T53-L-701 turbine engines, each rated at 1400 shaft horsepower (shp) with Hamilton standard 53C51-27 three-bladed propellers. Martin-Baker ejection seats are provided for the crew. The missions of the OV-1D are visual, photographic, infrared (IR), and side-looking airborne radar (SLAR) surveillance. A detailed description of the airplane and mission equipment is contained in reference 4, appendix I.

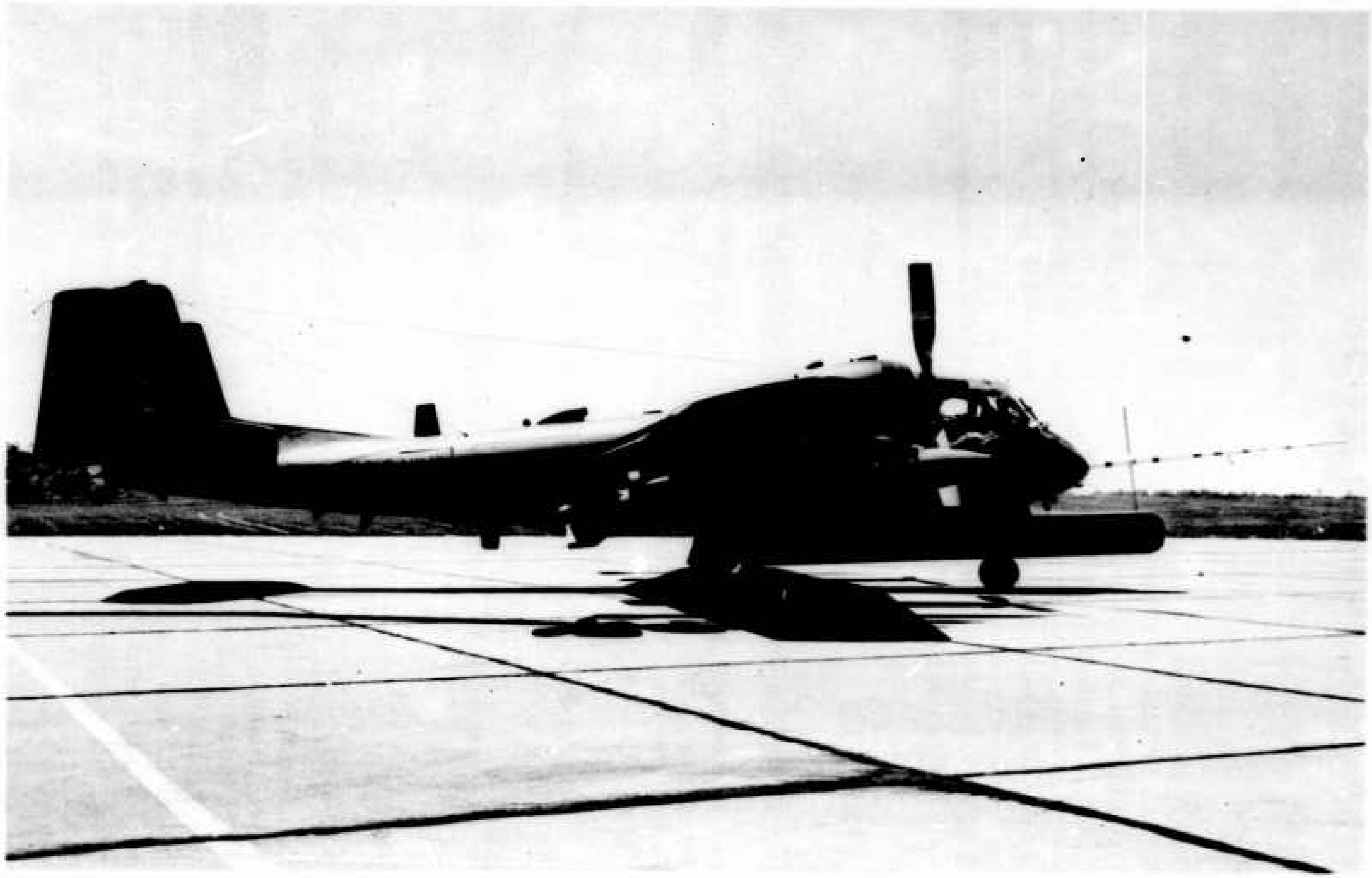


Photo 1. Production OV-1D Airplane.

4. The flight control system is reversible, incorporating ailerons, rudders and elevators. In addition to the outboard ailerons, there are hydraulically powered inboard ailerons interconnected to the flaps. When the flaps are retracted, the inboard ailerons remain retracted. When the flaps are lowered, the inboard ailerons are automatically extended and act as lateral control surfaces. This provides additional lateral control at low airspeeds with flaps extended. All control surfaces are controlled from the cockpit through mechanical linkages from the rudder pedals and stick. A detailed description of the flight control system is contained in reference 5, appendix I.

5. The test instrumentation installed in the airplane is listed in appendix II and includes a photopanel, airborne tape system and telemetry. Calibrated engines were used in this evaluation.

6. The external stores configurations for the OV-1D are listed in table 1. The applicable airplane configurations used in APE II are listed in table 2.

Table 1. External Stores Configurations.

Configuration	External Stores Arrangement	
A	ALQ-80 radar jammer	Right wing, station 237
	LS-59A flasher pod	Right wing, station 213
	150-gallon drop tank	Left and right wings, station 185
	ALQ-67 fuze jammer	Left wing, station 237
	APS-94 (D) SLAR	Lower right fuselage
B	ALQ-80 radar jammer	Right wing, station 237
	150-gallon drop tank	Left and right wings, station 185
	ALQ-67 fuze jammer	Left wing, station 237
	APS-94 (D) SLAR	Lower right fuselage
C	ALQ-80 radar jammer	Right wing, station 237
	150-gallon drop tank	Left and right wings, station 185
	ALQ-67 fuze jammer	Left wing, station 237

Table 2. Airplane Configurations.

Configuration[1]	Symbol	Landing Gear Position	Flap Setting (deg)	Power
Takeoff	TO	Down	15	Takeoff
Power	P	Up	0	Normal rated (NRP)
Cruise	CR	Up	0	For level flight (PLF)
Land	L	Down	45	Flight idle
Power approach	PA	Down	45	For level flight[2]
Wave-off	WO	Down	45	Takeoff
Combat	CO	Up	0	Takeoff

[1]Configurations are defined in the mil spec MIL-F-8785(ASG) Amendment 2 (ref 3, app I).
[2]Power for level flight at 1.15 calibrated landing stall speed (V_{S_L}) or normal approach speed, whichever is less.

SCOPE OF TEST

7. The flying qualities of the OV-1D were evaluated against the requirements of the mil spec as amended by the detail specification. Ratings were assigned in accordance with the Handling Qualities Rating Scale (HQRS) contained in appendix III. The flying qualities and performance of the airplane were evaluated within the limitations of the flight envelope and the restrictions of the safety-of-flight release (ref 6, app I).

8. The APE II testing was conducted at GAC test facility at Peconic Airport, Calverton, New York, from 14 to 24 July 1970. Nine test flights were conducted for a total of 20.5 hours. The center of gravity (cg) was varied from 23.8 to 29.3 percent mean aerodynamic chord (MAC). Gross weights ranged from 15,920 to 18,000 pounds. The testing was primarily conducted in the maximum drag stores configuration A. The one exception was a test conducted in the symmetric stores configuration C to compare the effect of parasite drag.

METHODS OF TEST

9. The test methods used are outlined in the test plan (ref 7, app I) and are discussed in detail in the Results and Discussion section of this report. Performance data reduction methods and engine characteristics will be discussed in the Performance section of this report which is to be published as an addendum at a later date.

CHRONOLOGY

10. The chronology of the OV-1D is as follows:

Test directive received	12	February	1970
Pre-APE conference	30	June through	
	1	July	1970
Test airplane received	13	July	1970
First APE flight	14	July	1970
Last APE flight	24	July	1970
Advance copy of report submitted		November	1970

RESULTS AND DISCUSSION

PERFORMANCE

11. The Performance section of this report will be published as an addendum at a later date.

STABILITY AND CONTROL

Static Longitudinal Stability

12. The level-flight static longitudinal stability of the OV-1D was evaluated at density altitudes ranging from 4180 to 6380 feet in the CR and PA configurations. Tests were conducted at the forward, mid, and aft cg at gross weights ranging from 16,720 to 18,000 pounds with all external stores installed. The single-engine static longitudinal stability was also evaluated in the PA configuration at the aft cg. Test results are presented in figures 1 through 7, appendix IV, as plots of elevator position and force versus calibrated airspeed and lift coefficient. Table 3 summarizes the static longitudinal stability test conditions.

13. Static longitudinal stability tests were conducted to determine if the variations of elevator control force and position with airspeed were smooth, and the local gradients stable. After the aircraft was trimmed in level flight, the airspeed was varied in the increments of approximately 5 knots about trim, using only the elevator control while maintaining constant power and trim settings. The elevator control force and position were recorded for each stabilized speed. All elevator force and position variations with airspeed were smooth curves, and their gradients indicated that the airplane had positive static longitudinal stability for the conditions tested, *ie*, a forward motion and increasing push force of the longitudinal control were required to maintain airspeeds higher than trim, and an aft movement and pull force were required to maintain airspeeds lower than trim. In the CR configuration, the effect of varying the cg was negligible. In the PA configuration, however, flying with an aft cg resulted in a much weaker force gradient than did the forward cg (as can be seen in figures 4 and 6, appendix IV).

14. The force and position gradients for the PA configuration were slightly more positive than for the CR configuration which indicated that flying with the flaps and gear down has a stabilizing effect. The results of the single-engine test indicated weak but positive static longitudinal stability.

Table 3. Static Longitudinal Stability Test Conditions.

Configuration A (Full Stores)

Configuration	Average Gross Weight (lb)	Center of Gravity (% MAC)	Trim Airspeed (KCAS)	Average Density Altitude (ft)
CR	17,920	24.5 (fwd)	157	4,740
CR	17,960	27.3 (mid)	157	6,380
CR	18,000	29.3 (aft)	157	5,810
PA	17,710	24.3 (fwd)	88	4,180
PA	17,400	27.2 (mid)	90	5,860
PA	17,725	29.2 (aft)	93	5,690
PA[1]	16,720	29.0 (aft)	91	5,480

[1]Single engine: left engine at ground idle, left propeller feathered, right engine at military rated power (MRP).

15. Control force cues were adequate for satisfactory airspeed control, even at the aft loading test condition and during the single-engine testing (HQRS 2). The elevator-fixed neutral points are plotted in figure 8, appendix IV, and were well aft of the aft cg limit of 29.3 percent MAC. The longitudinal stability requirements of the mil spec were met.

Static Lateral-Directional Stability

16. The static lateral-directional stability of the airplane was tested at the conditions presented in table 4. The tests were conducted at the mid cg and at trim airspeeds ranging from 89.5 KCAS to 165 KCAS.

17. The steady-heading sideslip method was used for this testing. The airplane was first stabilized at zero sideslip at the desired trim airspeed. The sideslip angle was then varied in increments of approximately 5 degrees up to the maximum limit of 15 degrees (left and right) while maintaining trim airspeed and a constant heading. In the P configuration, it was not possible to sustain large sideslip angles

because of the high pedal forces, *ie*, 260 pounds for 14 degrees of left sideslip and 350 pounds for 14.5 degrees of right sideslip. Control positions, forces and airplane attitude were recorded for each sideslip. The results of the static lateral-directional stability tests are presented in figures 9 through 13, appendix IV.

Table 4. Static Lateral-Directional Stability Test Conditions.

Configuration	Average Gross Weight (lb)	Average Center of Gravity (% MAC)	Trim Calibrated Airspeed (kt)	Average Density Altitude (ft)
P	17,740	27.3 (mid)	165	6,580
WO	16,780	27.1 (mid)	89.5	2,920
WO	17,110	27.2 (mid)	92	6,340
PA	17,200	27.2 (mid)	92	6,030
PA	16,380	26.8 (mid)	90	1,240

18. The data indicate that the airplane has positive rudder-fixed static directional stability, in that right rudder pedal deflections were required for left sideslips, and left deflections were required for right sideslips. The variation of sideslip angle with rudder pedal deflection was essentially linear, and the requirements of the mil spec for rudder position stability were met. In a like manner, the rudder force stability requirements of the mil spec were met. The plots indicate a greater measure of static directional stability, or tendency to return to an equilibrium sideslip angle when disturbed, as airspeed increased.

19. The airplane exhibited positive control-fixed and control-free dihedral effect for all configurations tested, including WO, in that left aileron deflection and force were required for left sideslips, and vice versa. The requirements of the mil spec for dihedral effect were met.

20. The airplane exhibited strong positive side-force characteristics in the P configuration, *ie*, increased left bank angle was required for increased left sideslips, and right bank angle was required for right sideslips. The pilot was provided with strong cues as to the amount of sideslip in the airplane. In the PA configuration, the airplane exhibited somewhat weaker positive side-force characteristics but did comply with the requirements of the mil spec. The bank angle versus sideslip gradients were still linear and, qualitatively, were not objectionable to the pilot. The overall lateral-directional flying qualities of the OV-1D are satisfactory.

Maneuvering Stability

21. The maneuvering stability characteristics of the airplane were evaluated at a density altitude of approximately 6480 feet and stores configuration A under the conditions shown in table 5.

Table 5. Maneuvering Stability Test Conditions.

Configuration	Normal Load Factor Range (g)	Calibrated Airspeed (kt)	Gross Weight (lb)	Center of Gravity Location (% MAC)
CO	1.0 to 3.2	200, 226, 249 and 278	16,278 to 17,418	24.0 to 24.5 (fwd)
WO	1.0 to 2.0	119, 131 and 141	15,846 to 16,123	23.8 (fwd)

22. The windup turn method was used with turns in both directions for each test condition. The airplane was trimmed at the desired test condition, after which it was slowly banked in the desired direction of turn. The trim airspeed was maintained as the bank angle was gradually increased until the desired normal load factor was reached. The time histories of longitudinal stick force and normal load factor were recorded during the maneuver. The plots of longitudinal stick force versus normal load factor were obtained by cross-plotting points from the time histories.

23. The maneuvering stability test results are presented in figures 14 through 18, appendix IV. Figure 14 is a summary of the results. The force gradients were positive and linear for all test conditions and would permit accurate normal load factor control by the average pilot (HQRS 2). It is noteworthy that the gradient of stick force was approximately 20 lb/g for all conditions tested. The gradients met the requirements of paragraph 3.3.9 of the mil spec. Based on the relatively light stick force gradient in the WO configuration at a forward cg, the gradient at an aft cg in PA configuration may not meet the mil spec requirements. This gradient would not be considered a shortcoming because of the maneuvering required with landing gear and flaps down. In addition, the stick force gradient is not considered a primary pilot cue to load factor control at low airspeeds and low load factors. The maneuvering stability of the OV-1D airplane is satisfactory for mission accomplishment.

24. The production OV-1D does not have a normal load factor indicator. During maneuvering flight, such as might be required to evade enemy aircraft or missiles, it would be easily possible to exceed the airplane normal acceleration limits during rolling pullouts of 3.2g's (ref 6, app I). A normal load factor indicator is required if unintentional overstresses are to be prevented or monitored. The lack of a normal load factor indicator is a shortcoming which should be corrected at the earliest possible time.

Spiral Stability

25. The spiral stability of the OV-1D was evaluated at a density altitude of 7900 feet and an airspeed of 124 KCAS in the CR configuration and stores configuration A. Data were obtained after trimming the airplane in straight and level flight, displacing a prop lever to obtain a 5-degree bank angle, returning the prop lever to the trim position, and by observing the resultant bank angle for approximately 15 seconds. The spiral stability for the configuration tested was neutral, *ie*, the bank angle remained constant. The spiral stability of the OV-1D for the condition tested met the requirements of the mil spec and is satisfactory for mission use.

Stalls

26. Stalls and associated flying qualities were investigated by slowly decelerating until the stall occurred. The rate of decrease in airspeed was less than 1 knot per second in all cases. Stalls were investigated in stores configuration A over a density altitude range between 5800 and 8000 feet. Test conditions and results are presented in table 6. Time histories of two stalls are presented in figures 19 and 20, appendix IV.

Table 6. Stall Warning Airspeed Characteristics.

Configuration	Gross Weight (lb)	Center of Gravity Location (% MAC)	Trim Calibrated Airspeed (kt)	Warning Calibrated Airspeed (kt)	Stall Calibrated Airspeed (kt)
PA	18,150	27.2 (mid)	89.5	75	73
	17,300	27.3 (mid)	88	72	70
	16,300	26.9 (mid)	87	71	68
L	17,900	27.3 (mid)	102	90	85
	17,100	27.2 (mid)	105	84	82
	16,200	26.9 (mid)	94	83	81
PA[1]	16,600	26.9 (mid)	109.5	85	84

[1]Single engine: left engine ground idle, left propeller feathered.

27. Control about all axes during the approach to the stall was good. The aircraft was responsive to all control inputs with no noticeable changes in control responses from ordinary flight conditions (HQRS 2). Stall warning in all cases was a light airframe-and-control-system buffet commencing approximately 2 knots above the stall speed. The buffet level was such that a pilot might not realize that he was operating near the stall speed. Also, the narrow (approximately 2 knots) stall warning margin is insufficient to provide the pilot with an adequate stall warning. During slow airspeed operations, the pilot could stall the aircraft without realizing that he was operating near a stall until it occurred. This situation would be hazardous during a short field landing approach and could result in the loss of an aircraft and crew. The stall warning margin in the PA and L configurations failed to meet the requirements of paragraph 3.6.3 of the mil spec. The warning in the PA configuration occurred at 1.03 times the stall speed; whereas, the mil spec requires that warning occur between 1.05 and 1.10 times the stall speed. The warning in the L configuration occurred at 1.02 times the stall speed; whereas, the mil spec requires the warning to be between 1.05 and 1.15 times the stall speed. The inadequate stall warning in the PA and L configurations is a shortcoming that should be corrected as soon as possible (HQRS 5). Installation of an artificial stall warning device is recommended.

28. Stall was defined as the loss of aircraft control about some axis. Control was lost in the pitch axis for the stalls using symmetric power. The stall was characterized by an abrupt decrease in aircraft pitch attitude that was not controllable through use of the elevators. Control about the roll and yaw axis remained effective throughout the stall (HQRS 2). For single-engine operation, the stall was characterized by an abrupt roll toward the inoperative engine as well as a decrease in the airplane pitch attitude.

29. Stall recovery was effected by decreasing the back pressure on the control stick. The stall recovery was effected immediately with no progressive stall tendencies noted. Control during the stall recovery was normal (HQRS 2). Except for the inadequate stall warning previously noted, the stall characteristics of the OV-1D are satisfactory for mission accomplishment.

Trimmability

30. Trimmability was qualitatively assessed throughout the test program. In addition, quantitative data were obtained in the TO configuration at a gross weight of 16,364 pounds, a cg of 29.0 percent MAC, and a density altitude of 7193 feet. The results of this test are presented graphically in figure 21, appendix IV. The lateral trim limit was reached at an airspeed of 82 KCAS. The longitudinal and directional trim rate and sensitivity were well matched to the trim task encountered during normal operation. The lateral trim control was not as sensitive

as desired; however, it is satisfactory (HQRS 3). The lateral trim of the airplane is greatly affected by airspeed changes. Maintaining lateral trim during airspeed changes requires almost constant trim control manipulation. This complicates the trim task required to attain trimmed cruising flight. The lateral trim change caused by airspeed change (autopilot OFF) is undesirable for instrument flight (HQRS 5). However, since instrument flying will normally be conducted with the autopilot engaged, lateral trimmability is not a shortcoming. The trimmability of the OV-1D airplane is satisfactory for mission accomplishment. It is recommended that a caution note be placed in the operator's manual to indicate that large lateral trim changes (associated with small airspeed changes) will be required during instrument approaches with the autopilot inoperative.

SINGLE-ENGINE TRIMMABILITY AND MINIMUM CONTROL SPEED

31. The single-engine trimmability and minimum control speed (V_{MC}) of the OV-1D were evaluated in the CR configuration at a gross weight of 17,200 pounds, an aft cg, and a density altitude of 4810 feet. The test was accomplished with the left engine operating at ground idle and the propeller feathered. The right engine was operating at military power. Trimmability and V_{MC} were determined with the wings level and for a 5-degree bank angle toward the operating engine.

32. The minimum trim speed was evaluated by stabilizing the airplane at a given airspeed with one engine feathered and reducing the airspeed in increments of approximately 5 knots. The airplane was retrimmed at each new airspeed until a trim limit was reached.

33. Single-engine trimmability data are presented in figure 22, appendix IV. The minimum speed at which the airplane could be trimmed in a wings-level condition was 147 KCAS. When the airplane was banked 5 degrees toward the operating engine, it was possible to maintain zero control forces at all speeds above 131 KCAS. Right rudder trim limits were reached in each case. The single-engine trimmability of the OV-1D airplane met the requirements of the mil spec and was satisfactory.

34. The static minimum single-engine control speed was determined by slowly reducing airspeed until full control displacement was reached in the lateral or directional axis, and straight flight could no longer be maintained. Trim was used to reduce control forces until trim limits were reached. The minimum single-engine control speed was 96 KCAS for the wings-level condition and 91 KCAS when the airplane was banked 5 degrees toward the operating engine. The rudder was the limiting control in both cases. Pedal forces averaged 170 pounds for the wings-level condition and 150 pounds when the airplane was banked toward the operating engine. The static V_{MC} of the OV-1D was satisfactory and met the requirements of the mil spec.

35. Dynamic V_{MC} was evaluated by stabilizing at the desired airspeed and power setting with recommended takeoff trim settings and then rapidly reducing the power on the left engine to idle. After 1 second, recovery to straight flight was initiated. The airspeed was reduced in increments of approximately 5 knots, and the test was repeated at each incremental airspeed until an airspeed was reached at which straight flight could no longer be achieved and maintained. Using this method, the dynamic V_{MC} was found to be identical to the static V_{MC}. The dynamic V_{MC} of the OV-1D was satisfactory and met the requirements of the mil spec.

CONTROL SYSTEM MECHANICAL CHARACTERISTICS

36. The mechanical characteristics of the flight control system were evaluated in flight, and the results are presented in table 7.

Table 7. Control System Mechanical Characteristics.

Control Axis	Breakout Including Friction Force		Centering	Control Oscillation Response
	Measured (lb)	Specification Limits (lb)		
Longitudinal	±1	±1/2 to ±3	Positive	Damped Oscillatory
Lateral	±1	±1/2 to ±2	Positive	Damped Oscillatory
Directional	±18	±1 to ±7	Positive	Damped Oscillatory

37. The breakout force (including friction) was determined by applying a gradually increasing force on a particular control and recording the force when the control first moved. This procedure was then repeated for control motion in the opposite direction. The breakout force of the longitudinal and lateral control systems met the requirements of the mil spec; however, the control force of the directional control system failed to meet the requirement of paragraph 3.2.1 of the mil spec, in that the 7-pound limit of the mil spec was exceeded by 11 pounds. The breakout force in all controls was sufficient to prevent undesired control motion caused by normal aircraft vibration or turbulence, yet not so great as to interfere with precise aircraft control. The breakout force in the longitudinal and lateral control systems was not sufficient to prevent slight control motions when using the intercommunications system (ICS) or radio switch on the control stick; however,

the resultant control motion and aircraft response was not objectionable. The breakout force of the OV-1D control system is satisfactory for mission accomplishment (HQRS 3).

38. Control centering was determined by displacing the desired control from trim, releasing it and noting the position to which it returned as well as any change in the airplane's trim condition. The centering of all controls was positive within the sensitivity of the measuring and recording devices used. Moving the controls and allowing them to return to center produced no apparent changes in the airplane's trim condition. The centering of the OV-1D control system is satisfactory.

39. The dynamic response of the OV-1D control system was determined by striking the desired control sharply and observing the resultant motion of the control. All the responses were damped oscillatory and did not produce any undesirable aircraft responses. Normal aircraft vibrations or turbulence did not tend to excite motion in any control. The dynamic response of the OV-1D control system met the requirements of the mil spec and was satisfactory.

GROUND HANDLING

40. The taxi speed of the OV-1D on a level hard surface is too fast for safe operation in confined spaces. To keep the taxi speed within limits, intermittent use of thrust reversal, operation with one propeller feathered, or braking is required. This causes unnecessary wear on aircraft components and increases maintenance requirements. The high taxi speed of the OV-1D airplane is a shortcoming which should be avoided in future designs.

41. A simulated single-engine landing was made, and the runway distance markers were used to aid in estimating landing distance. This test indicated that the landing roll, using only brakes to stop, would be approximately 2500 feet. This distance is greater than the runway length required for tactical operation. This landing distance requirement could result in the inability to land at the takeoff site under circumstances wherein reverse thrust could not be used. If a suitable alternate landing site were not available, severe aircraft damage could result. The poor braking action of the OV-1D is a shortcoming which should be avoided in future designs.

42. Except for the shortcomings mentioned above, the ground handling characteristics were excellent. Winds had little effect upon the ground handling characteristics. Directional control while taxiing was excellent. The ground handling qualities of the OV-1D are satisfactory for mission accomplishment (HQRS 3).

COCKPIT EVALUATION

43. The vertical tape display indicators installed in the production OV-1D airplane (photo 2) are a significant improvement over the round dials installed in previous models of the OV-1. The tape indicators are easily read and interpreted during a rapid scan. Ease of engine power matching is greatly improved over the aircraft with the round dials.

44. The environmental control system (ECS) is highly desirable and is effective during all airborne operations. In order to have effective ECS, it was necessary to feather one engine while taxiing in order to prevent excess taxi speed and still have an adequate power setting. Improvement of ECS effectiveness at low power settings is desirable.

45. The circuit breaker panel for the autopilot is located in the equipment compartment and is not accessible during flight. Reengagement of the system while in flight is impossible, though only a transient condition could cause disengagement. The loss of the autopilot causes loss of SLAR mission capability. The inaccessibility of the autopilot circuit breakers is a shortcoming which should be corrected as soon as possible.

46. The OV-1D has no warning system to alert the pilot when the speed brakes are extended. Since aerodynamic warning is transient in nature, inadvertent operation with the speed brakes extended is easily possible. Such operation significantly affects aircraft performance and could result in aircraft loss during single-engine operation. The lack of a warning system to alert the pilot when the speed brakes are extended is a shortcoming which should be corrected as soon as possible. Installation of a speed brake warning light similar to the AUTOFEATHER ARMED warning light is recommended.

47. The pilot ICS control panel is located in a relatively inaccessible position at the rear of the center console (photo 3). It is extremely difficult for the pilot to see the panel and thus determine which receivers and transmitters are selected. In-flight manipulation of the ICS control panel by the pilot is conducive to vertigo. In addition, the six receiver switches on the panel can be inadvertently turned ON or OFF merely by placing a helmet bag, map case, or other loose item on the rear of the console. The inaccessible location of the pilot ICS control panel is a shortcoming which should be corrected as soon as possible. Relocation of the panel to a more accessible position and the installation of guards to protect the receiver switches are recommended.

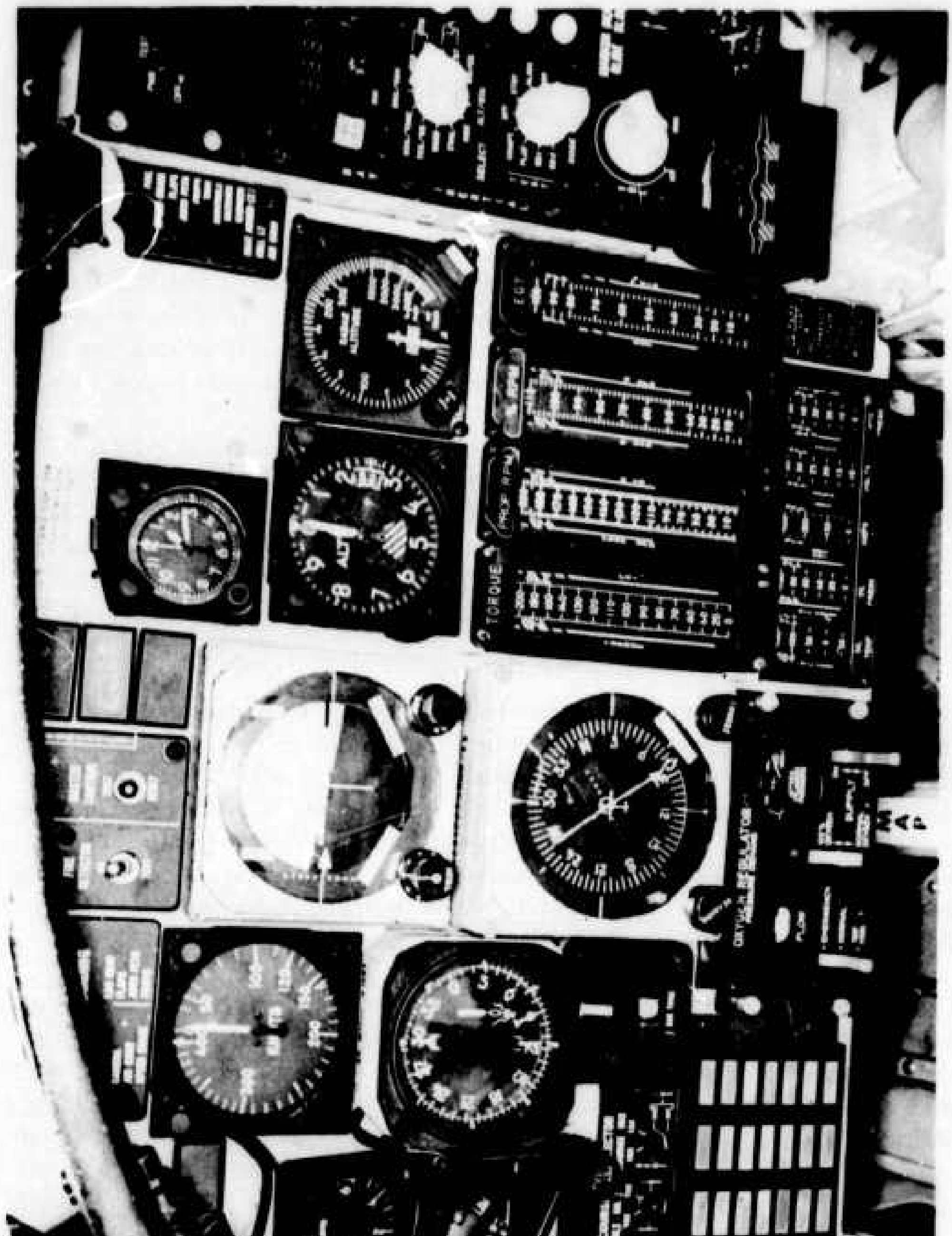


Photo 2. Cockpit instrument panel showing vertical tape display indicators.

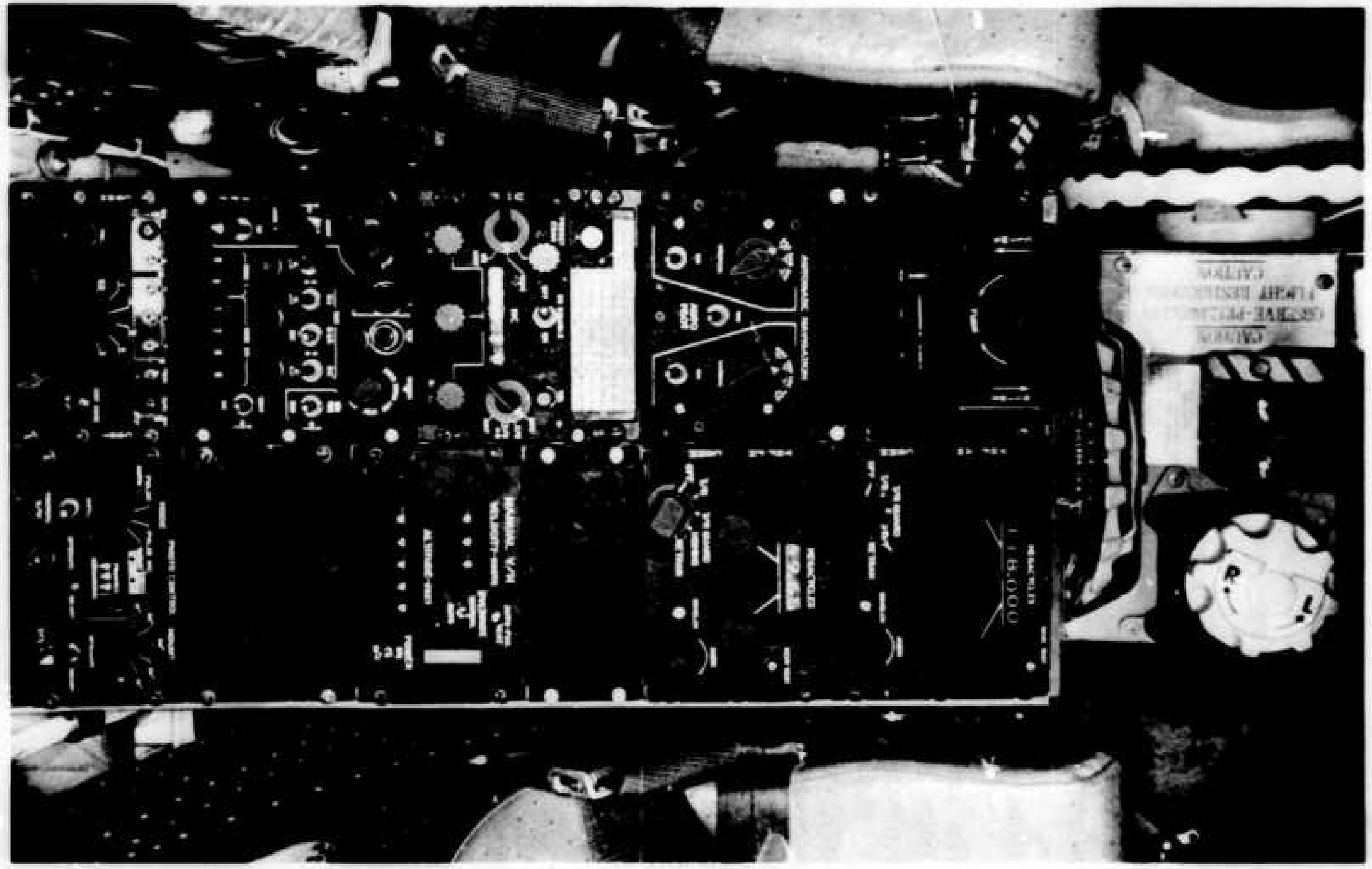


Photo 3. Center console showing pilot's ICS control panel.

MISCELLANEOUS

48. The Lycoming Division of Avco Corporation recommends that the ECS not be used when operating above normal rated power (NRP) (ref 9, app I) because of excessive turbine inlet temperature. NRP is defined in terms of turbine inlet temperature for the T53-L-701 engine. Each turbine inlet temperature corresponds to a particular position of the fuel control lever. For NRP, this position is 94 degrees from the closed position. Because the aircraft does not have a turbine inlet temperature gage, the pilot has no means of determining when the engines are operating at or below NRP. Installation of a NRP detent in the fuel control or power lever linkage is recommended in order for the pilot to determine when the engines are operating at or below NRP.

49. The autofeather system in the OV-1D airplane receives engine power information from the torque pressure gage in the cockpit. An electrical failure of the torque pressure gage would cause the propeller on an operating engine to feather. This could result in loss of the aircraft and crew if it occurred during a takeoff. The possibility of having the propeller on an operating engine feather unintentionally is a deficiency for which correction is mandatory. As an interim measure, leaving the autofeather switch OFF during takeoff is recommended. In the event of an actual engine failure during takeoff, immediate arming of the autofeather system is recommended to insure rapid feathering of the inoperative engine. It is recommended that the OV-1D be restricted from short field operations until correction of the autofeather deficiency is accomplished.

CONCLUSIONS

GENERAL

50. The flying qualities of the OV-1D airplane are satisfactory for mission accomplishment.

DEFICIENCIES AND SHORTCOMINGS AFFECTING MISSION ACCOMPLISHMENT

51. During flight with the autopilot OFF, large lateral trim changes are required for small airspeed changes (para 30).

52. The possibility of having the propeller of an operating engine autofeather during takeoff is a deficiency for which correction is mandatory (para 49).

53. Correction of the following shortcomings is desirable for improved operation and safety:

a. The lack of a cockpit normal load factor indicator (para 24).

b. The inadequate stall warning in the PA and L configurations (para 27).

c. The high taxi speed (para 40).

d. The poor braking action (para 41).

e. The inaccessibility of the autopilot circuit breakers (para 45).

f. Lack of a speed brake extended warning system (para 46).

g. Inaccessible location of the pilot ICS control panel and lack of guards to protect the receiver switches (para 47).

RECOMMENDATIONS

54. The deficiency discussed in paragraph 49 should be corrected at the earliest practicable date.

55. The shortcomings listed in paragraph 53 (a, b, e, f and g) should be corrected as soon as possible.

56. The shortcomings listed in paragraph 53 (c and d) should be avoided in future designs.

57. Restrict the OV-1D airplane from short field operations until correction of the autofeathering system deficiency has been accomplished (para 49).

58. Install a normal rated power detent in the fuel control or in the power lever linkage (para 48).

59. Until the autofeather deficiency is corrected, operate with the autofeather system OFF and only arm it in the event of an actual engine failure during takeoff (para 49).

60. Place a caution note in the operator's manual to indicate that large lateral trim changes (associated with small airspeed changes) will be required during instrument approaches with the autopilot inoperative.

61. Airworthiness and flight characteristics testing should be conducted on the OV-1D in order to produce current data for Army technical manuals and other publications.

APPENDIX I. REFERENCES

1. Final Report, USAASTA, Project No. 68-43, *Army Preliminary Evaluation, Preproduction OV-1D (Mohawk)*, March 1970.

2. Test Request, USAAVSCOM, No. 70-03, *OV-1D (Production) Army Preliminary Evaluation (APE) II*, February 1970.

3. Military Specification, MIL-F-8785(ASG) Amendment 2, *Flying Qualities of Piloted Airplanes*, 17 October 1955.

4. Specification, AMC-SS-2682, *Detail Specification for Model OV-1D Airplane (Two Turboprop Engines), Fiscal 1968 Procurement*, 10 June 1969.

5. Technical Manual, TM 55-1510-204-35, DS, GS, *Depot Maintenance Manual, OV-1 Aircraft*, 28 October 1968, with Change 2, 28 July 1969.

6. Message, AMSAV-R-F, USAAVSCOM, 13 July 1970, subject: Safety-of-Flight Release for Conduct of OV-1D APE II.

7. Test Plan, USAASTA, Project No. 70-03, *Army Preliminary Evaluation II, OV-1D Airplane*, May 1970.

8. Report, Grumman Aerospace Corporation, FAD 134-5D-3.4, *OV-1D Production Pre-APE Report*, 30 June 1970.

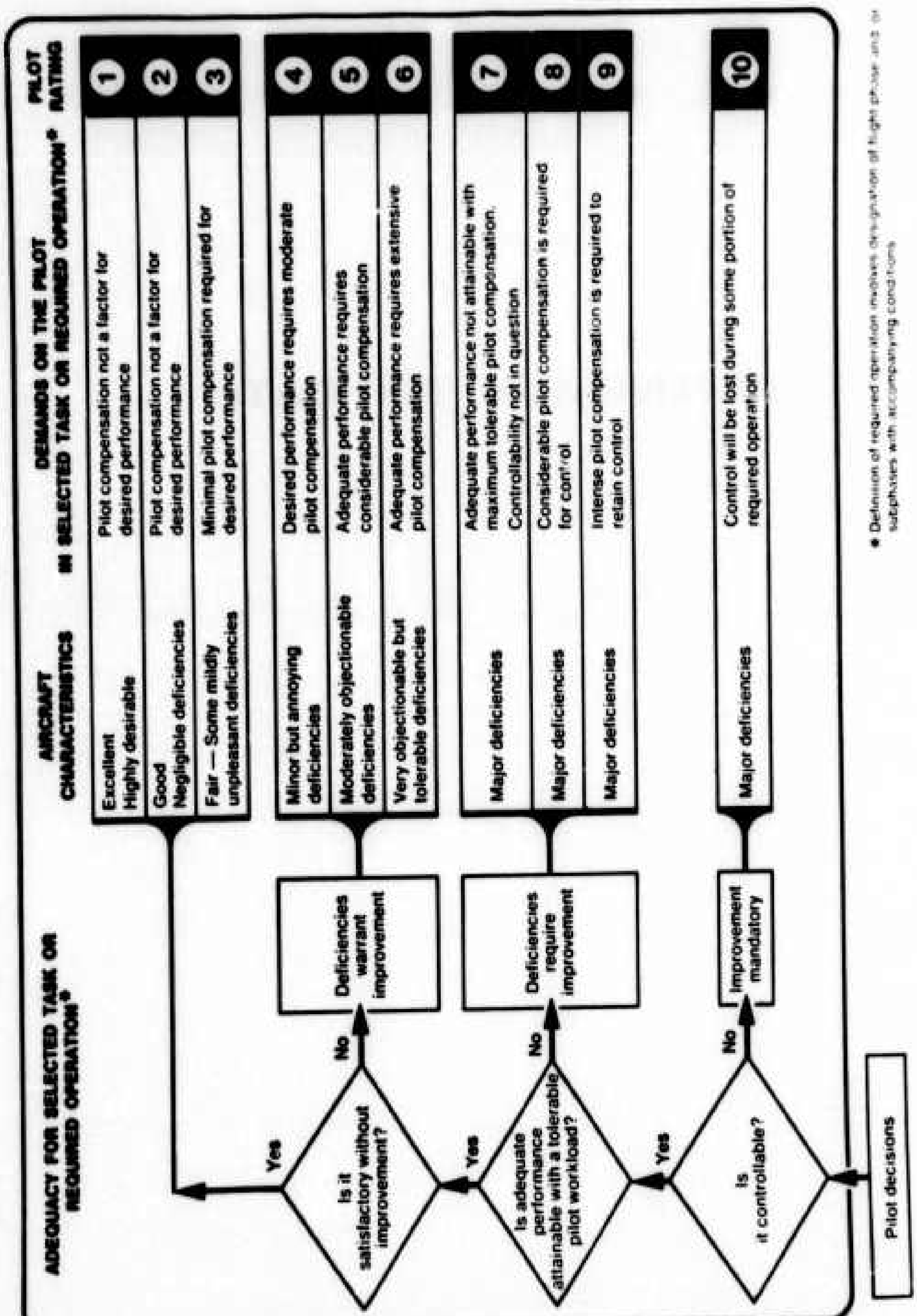
9. Letter, Lycoming Division of Avco Corporation, 13 April 1970, Robert B. Magnuson, T53 Project Engineer, Stratford, Conn. to GAC, Stuart, Florida, ATTN: Mr. B. Capone.

APPENDIX II. INSTRUMENTATION

Parameter	Cockpit	Photopanel	Magnetic Tape
Mach number (test system)	X		
Airspeed (test system)	X	X	
Altitude (test system)	X	X	
Rudder pedal force	X		X[2]
Angle of sideslip (nose boom)	X		X[2]
Visual acceleration	X		
Time correlation	X	X	X[2]
Frame counter	X	X	
Angle of attack	X		X[2]
Fuel quantity	X[1]	X	
Outside air temperature	X[1]	X	
Left/right torque pressure	X[1]	X	
Left propeller rpm	X[1]	X	
Right propeller rpm	X[1]	X	
Left/right fuel flow	X[1]	X	
Left/right engine EGT	X[1]	X	
Left/right gas producer speed (N_1)	X[1]	X	
Lateral stick position			X[2]
Lateral stick force			X[2]
Longitudinal stick force			X[2]
Yaw rate			X[2]
Pitch rate			X[2]
Roll rate			X[2]
Bank angle			X[2]
Pitch attitude			X[2]
Center rudder position			X[2]
Elevator position			X[2]
Left outboard aileron position			X[2]
CG normal acceleration			X[2]
Pilot's voice			X[2]
Fairchild camera pulse			X

[1] Production system.
[2] Recorded at the ground station when telemetry was selected.

APPENDIX III. HANDLING QUALITIES RATING SCALE



* Definition of required operation involves designation of flight phase and/or subphases with accompanying conditions.

APPENDIX IV. TEST DATA

FIGURE 1
STATIC LONGITUDINAL STABILITY (STICK FIXED & FREE)
OV-1D USA S/N 68-16990
CRUISE CONFIGURATION

SYM	AVG. GR. WT. - LB	AVG. C.G. - %MAC	AVG. DENS. ALT. - FT.	STORE CONFIG.
O	17920	24.5	4740	A

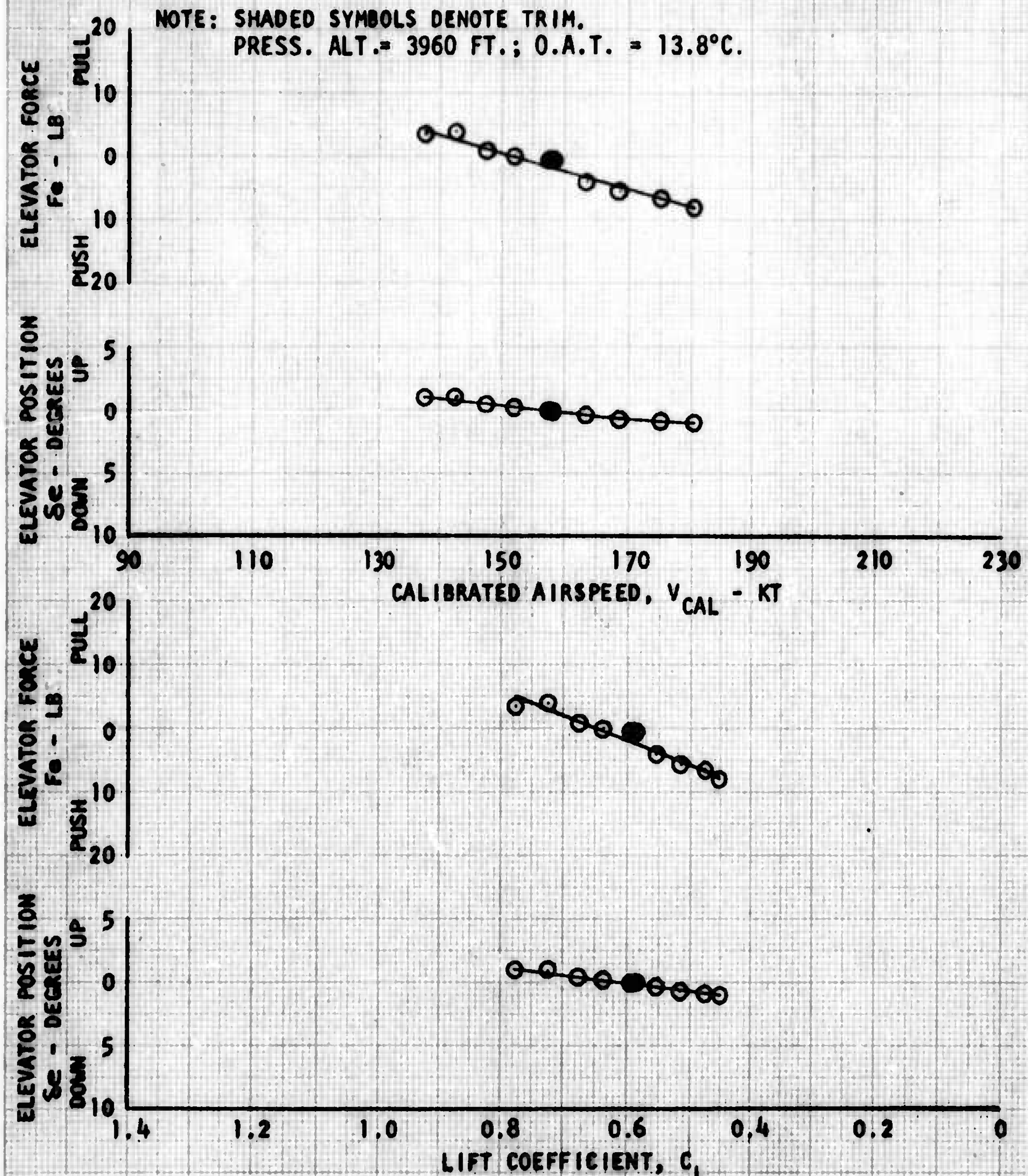


FIGURE 2
STATIC LONGITUDINAL STABILITY (STICK FIXED & FREE)
OV-1D USA S/N 68-16990
CRUISE CONFIGURATION

SYM	AVG. GR. WT. - LB	AVG. C.G. - %MAC	AVG. DENS. ALT. - FT.	STORE CONFIG.
O	17960	27.3	6380	A

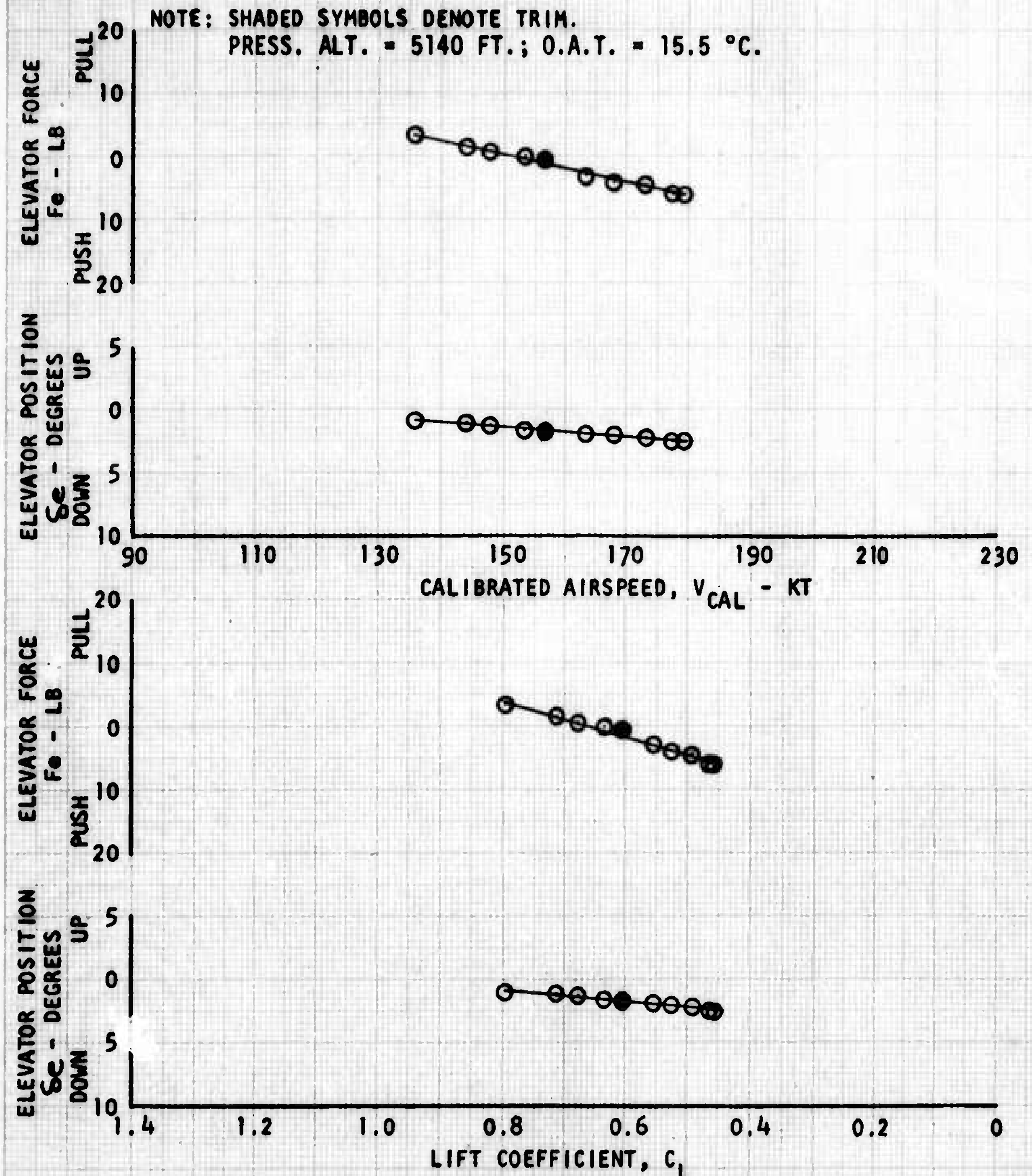


FIGURE 3
STATIC LONGITUDINAL STABILITY (STICK FIXED & FREE)
OV-10 USA S/N 68-16990
CRUISE CONFIGURATION

SYM	AVG. GR. WT. - LB	AVG. C.G. - %MAC	AVG. DENS. ALT. - FT.	STORE CONFIG.
O	18000	29.3	5810	A

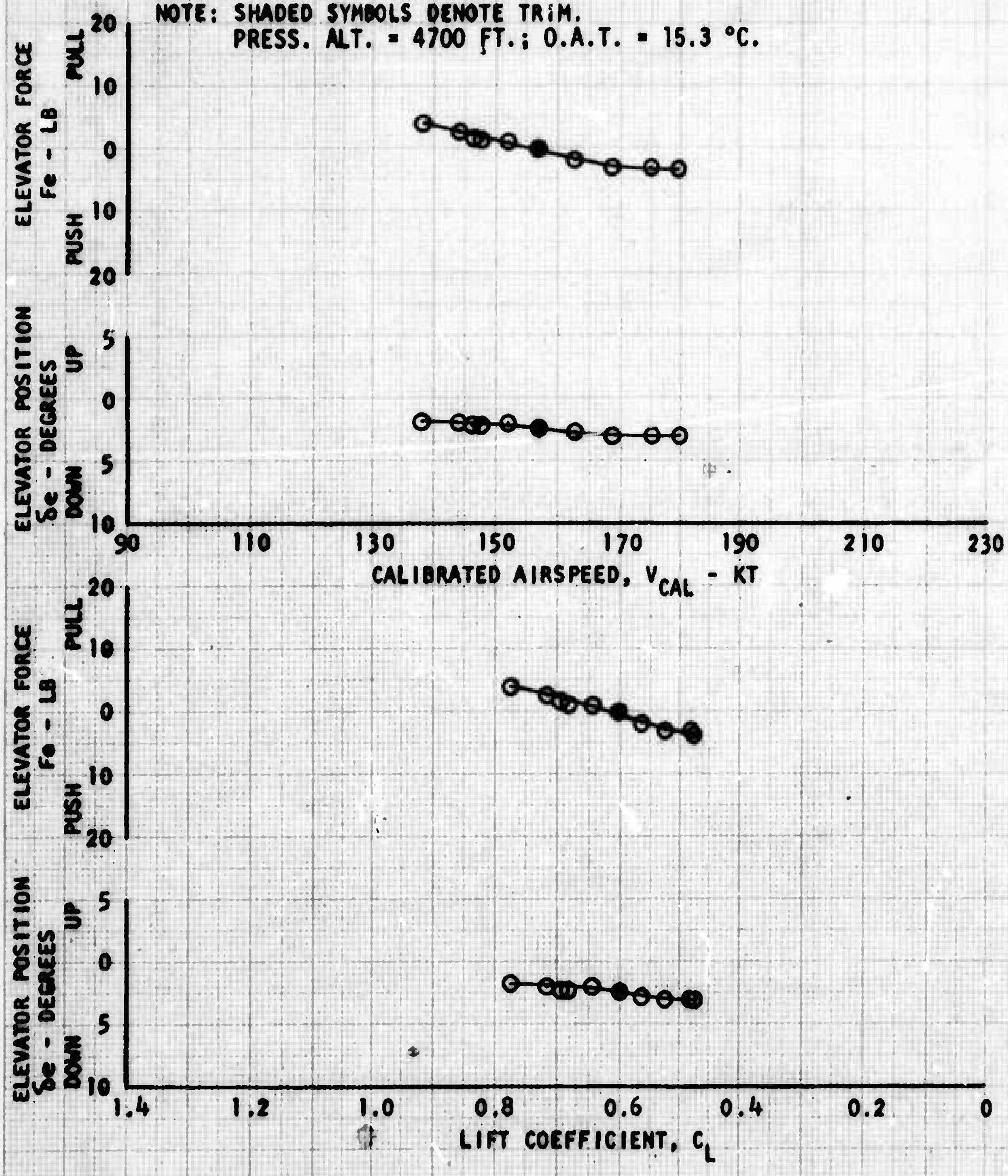


FIGURE 4
STATIC LONGITUDINAL STABILITY (STICK FIXED & FREE)
OV-1D USA S/N 68-16990
POWER APPROACH CONFIGURATION

SYM	AVG. GR. WT. —LB	AVG. C.G. —%MAC	AVG. DENS. ALT. —FT.	STORE CONFIG.
O	17710	24.3	4180	A

NOTE: SHADED SYMBOLS DENOTE TRIM.
PRESS. ALT. = 3380 FT.; O.A.T. = 15.1 °C.

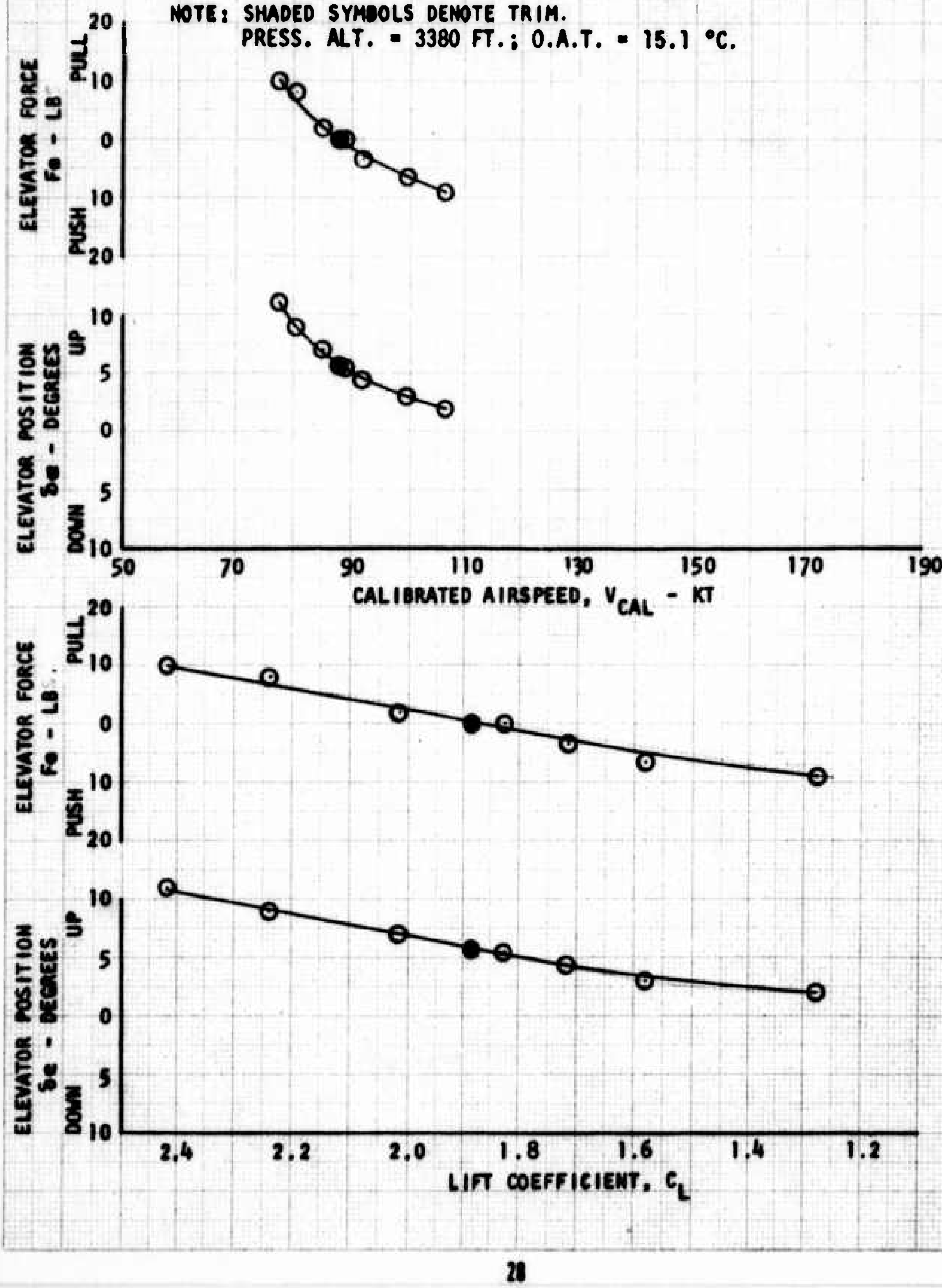


FIGURE 5
STATIC LONGITUDINAL STABILITY (STICK FIXED & FREE)
OV-1D USA S/N 68-16990
POWER APPROACH CONFIGURATION

SYM	AVG. GR. WT. —LB	AVG. C.G. -%MAC	AVG. DENS. ALT. - FT.	STORE CONFIG.
O	17400	27.2	3960	A

NOTE: SHADED SYMBOLS DENOTE TRIM.
PRESS. ALT. = 4820 FT.; O.A.T. = 14.4 °C.

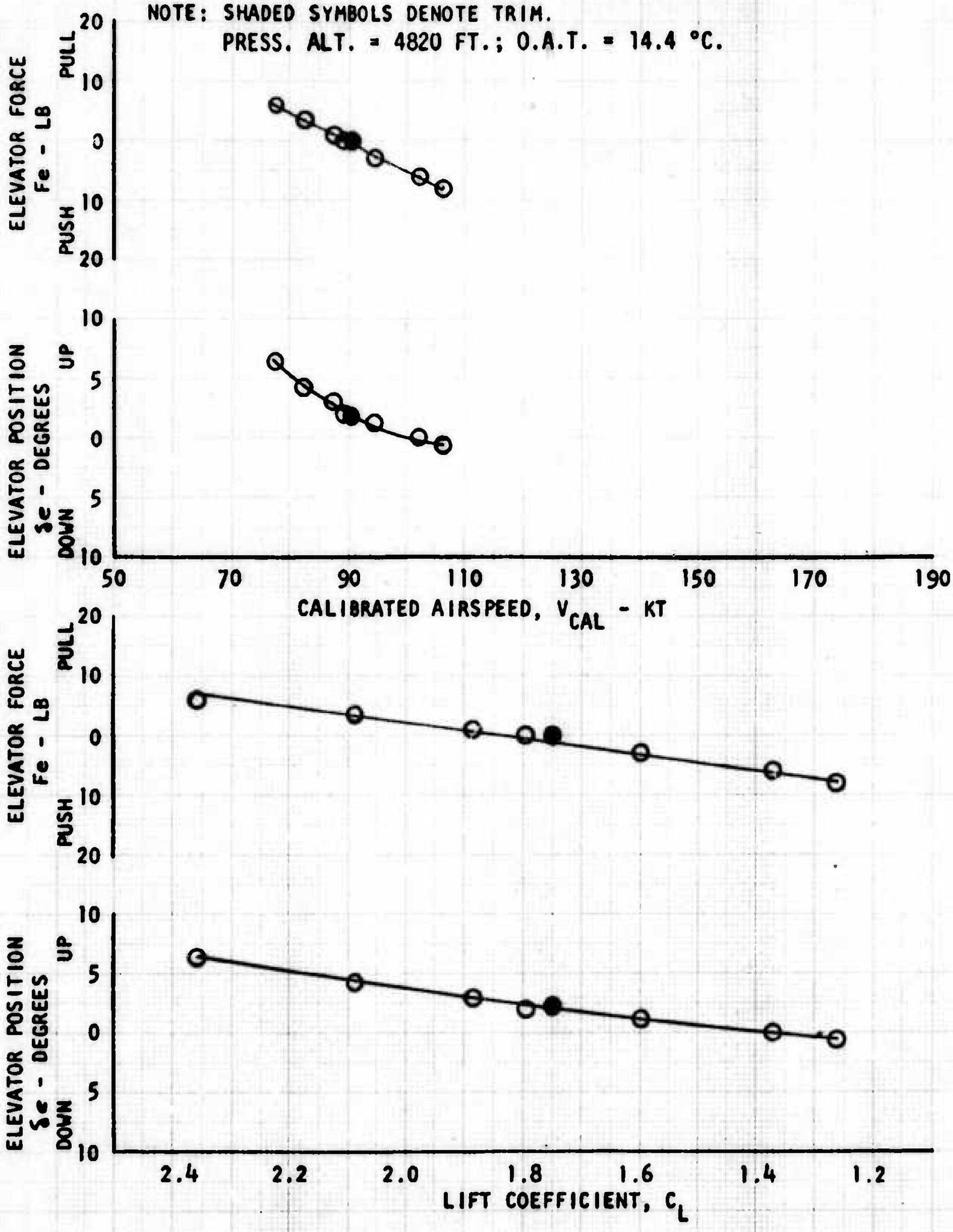


FIGURE 6
STATIC LONGITUDINAL STABILITY (STICK FIXED & FREE)
OV-1D USA S/N 68-16990
POWER APPROACH CONFIGURATION

SYM	AVG. GR. WT. – LB	AVG. C.G. – %MAC	AVG. DENS. ALT. – FT.	STORE CONFIG.
O	17725	29.2	5690	A

NOTE: SHADED SYMBOLS DENOTE TRIM.
PRESS. ALT. = 4800 FT.; O.A.T. = 13.1 °C.

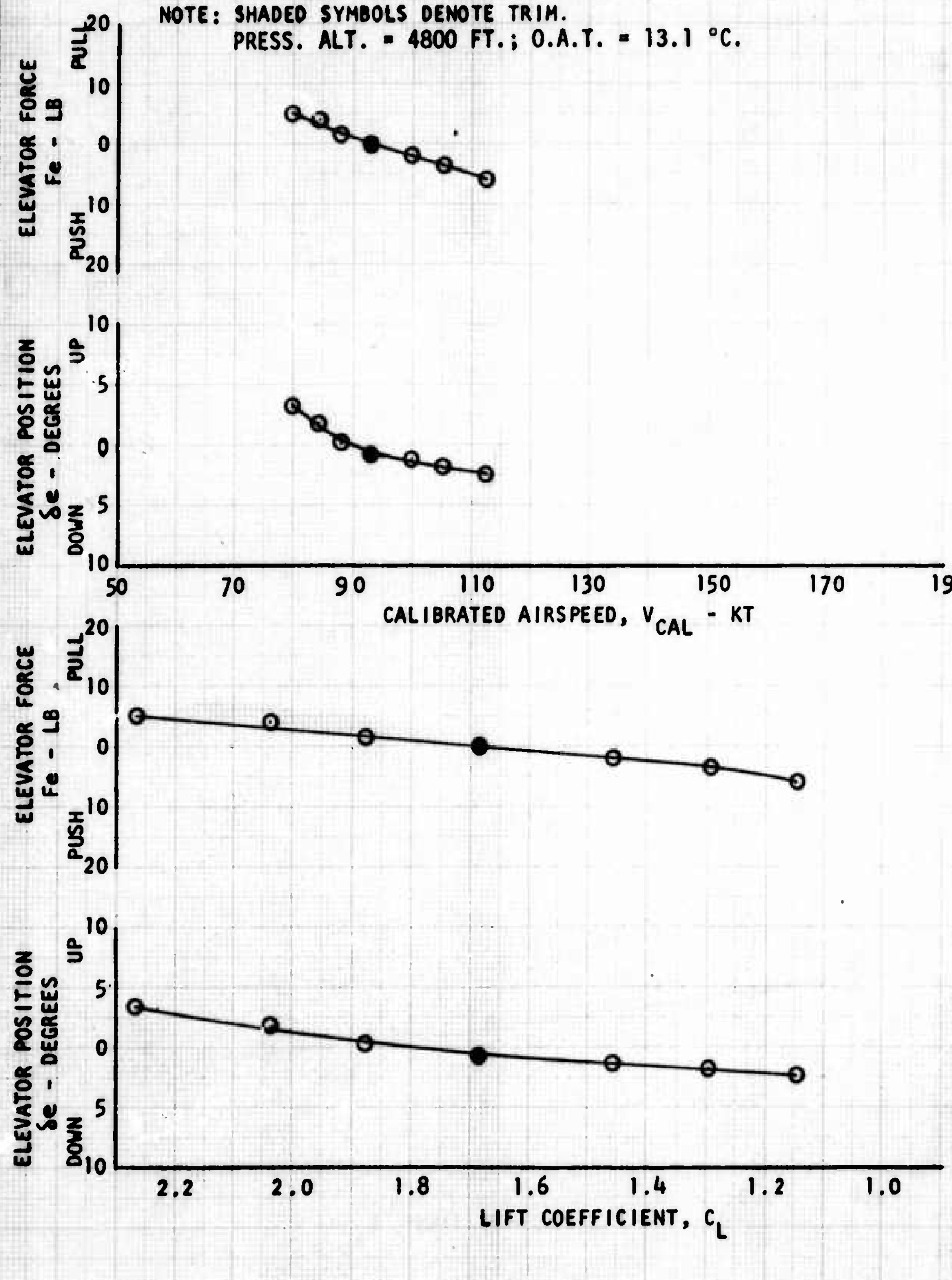


FIGURE 7
STATIC LONGITUDINAL STABILITY (STICK FIXED & FREE)
OV-1D USA S/N 68-16990
POWER APPROACH - SINGLE ENGINE CONFIGURATION

SYM	AVG. GR. WT. -LB	AVG. C.G. -%MAC	AVG. DENS. ALT. -FT.	STORE CONFIG.
O	16720	29.0	5480	A

NOTE: SHADED SYMBOLS DENOTE TRIM.
PRESS. ALT. = 4310 FT.; O.A.T. = 16.5 °C.

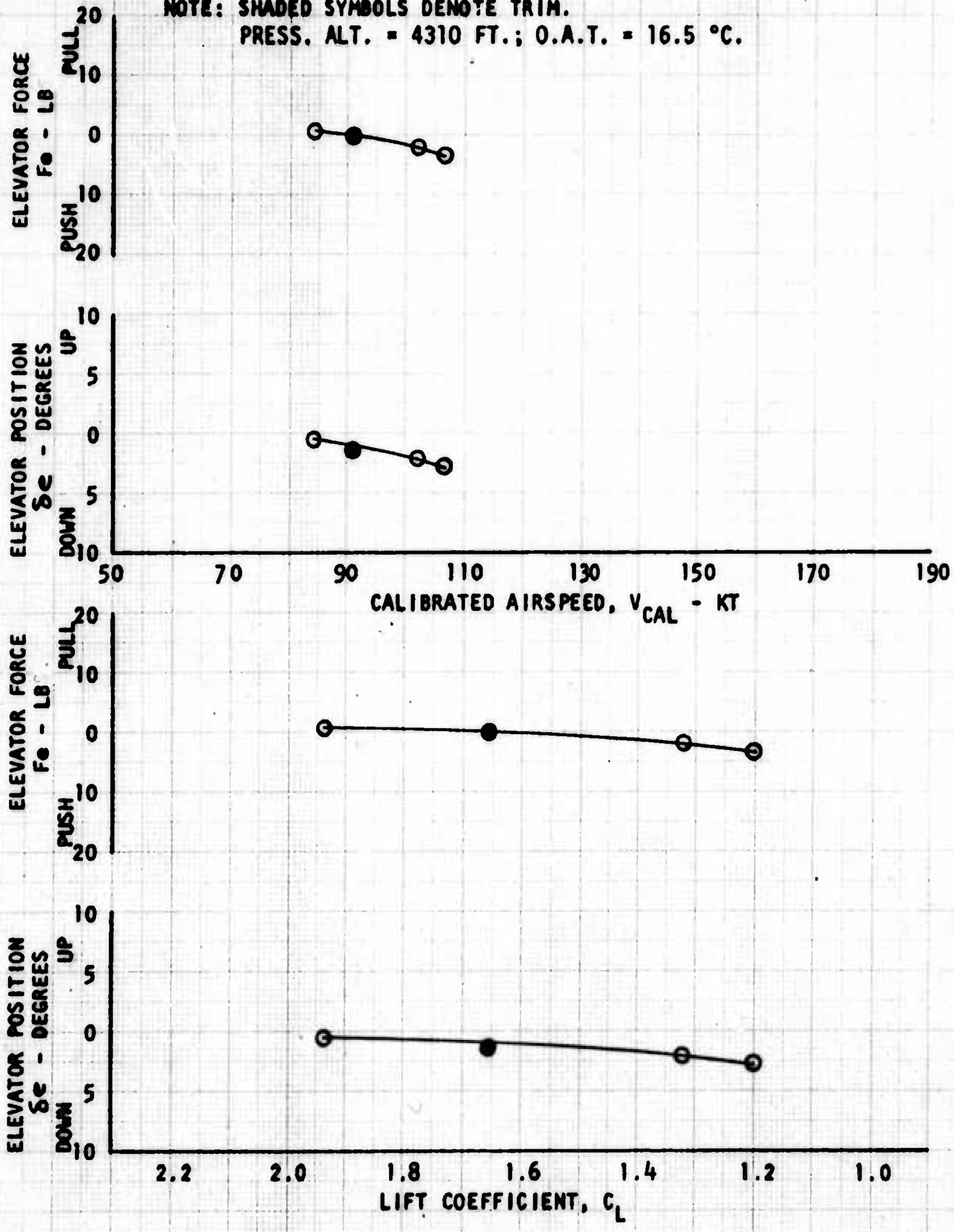
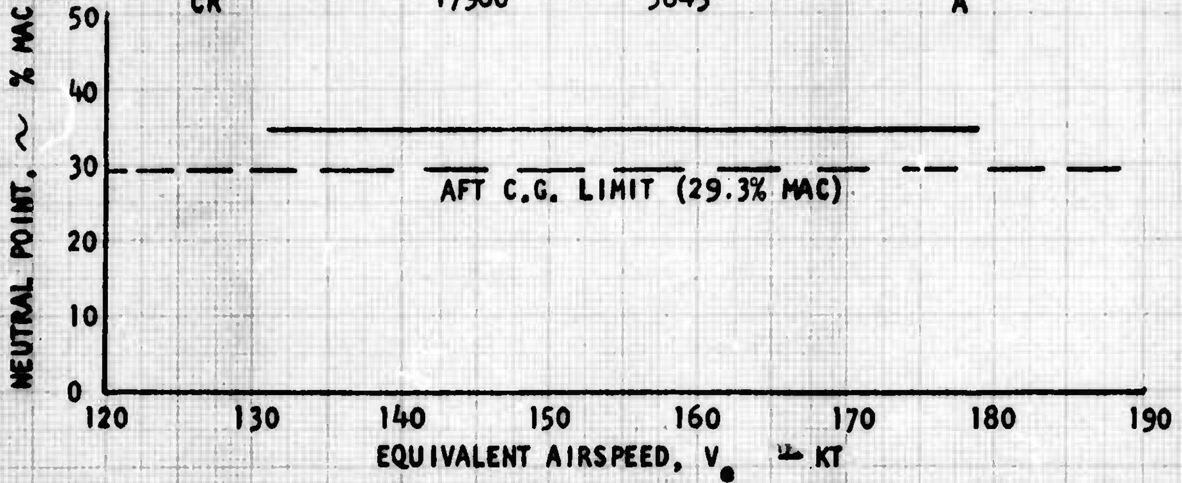


FIGURE 8
STICK FIXED NEUTRAL POINT
OV-1D USA S/N 68-16990

NOTE: RESULTS DERIVED FROM FIGS. 1 THROUGH 6.
CR CONFIG: PRESS. ALT. = 4600 FT.; O.A.T. = 14.9 °C.
PA CONFIG: PRESS. ALT. = 4330 FT.; O.A.T. = 14.2 °C.

ACFT CONFIG.	AVG. GR. WT. - LB	AVG. DENS. ALT. - FT	STORE CONFIG.
CR	17960	5643	A



ACFT CONFIG.	AVG. GR. WT. - LB	AVG. DENS. ALT. - FT	STORE CONFIG.
PA	17550	5243	A

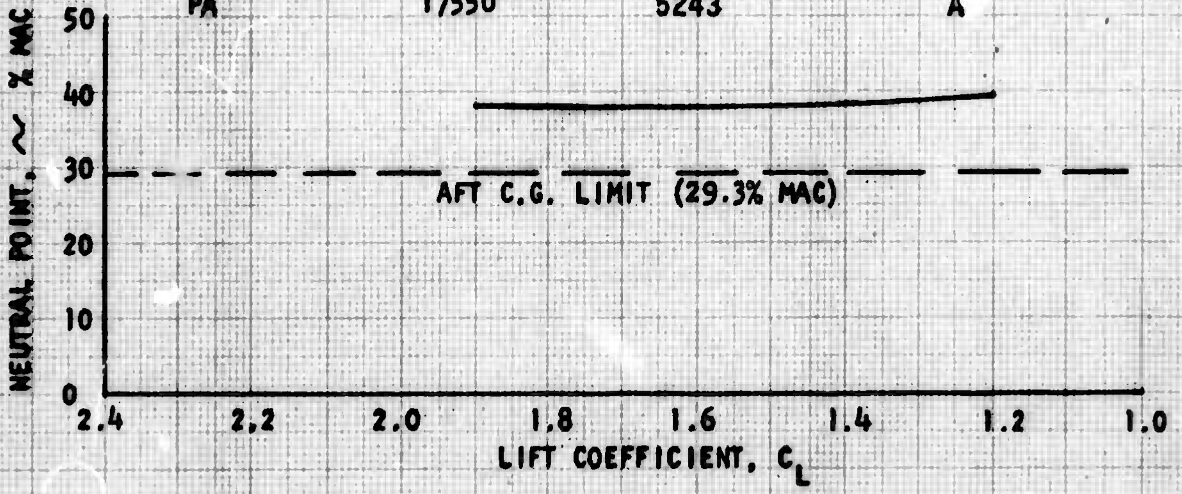


FIGURE 9
STATIC LATERAL-DIRECTIONAL STABILITY
OV-1D USA S/N 68-16990
POWER CONFIGURATION

AVG. CAL. A/S -KT	AVG. GR. WT. -LB.	AVG. C.G. -%MAC	AVG. DENS. ALT. -FT.	STORE CONFIG.
165	17740	27.3	6580	A

NOTE: PRESS. ALT. = 5000 FT.; O.A.T. = 18.8 °C.

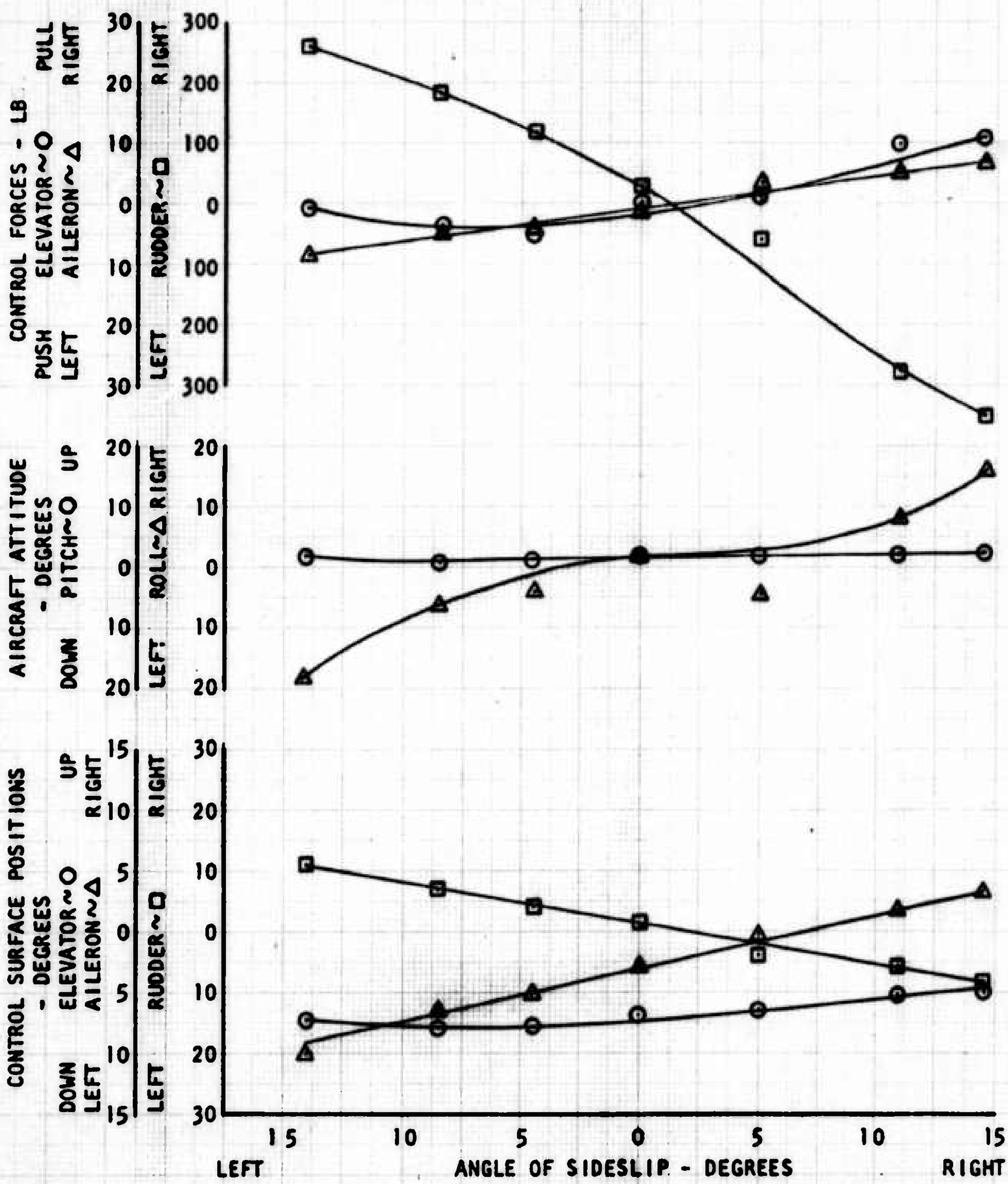


FIGURE 10
STATIC LATERAL-DIRECTIONAL STABILITY
OV-1D USA S/N 68-16990
WAVE-OFF CONFIGURATION

AVG. CAL. A/S -KT	AVG. GR. WT. -LB.	AVG. C.G. -%MAC	AVG. DENS. ALT. -FT.	STORE CONFIG.
89.5	16780	27.1	2920	A

NOTE: PRESS. ALT. = 1900 FT.; O.A.T. = 20.0 °C.

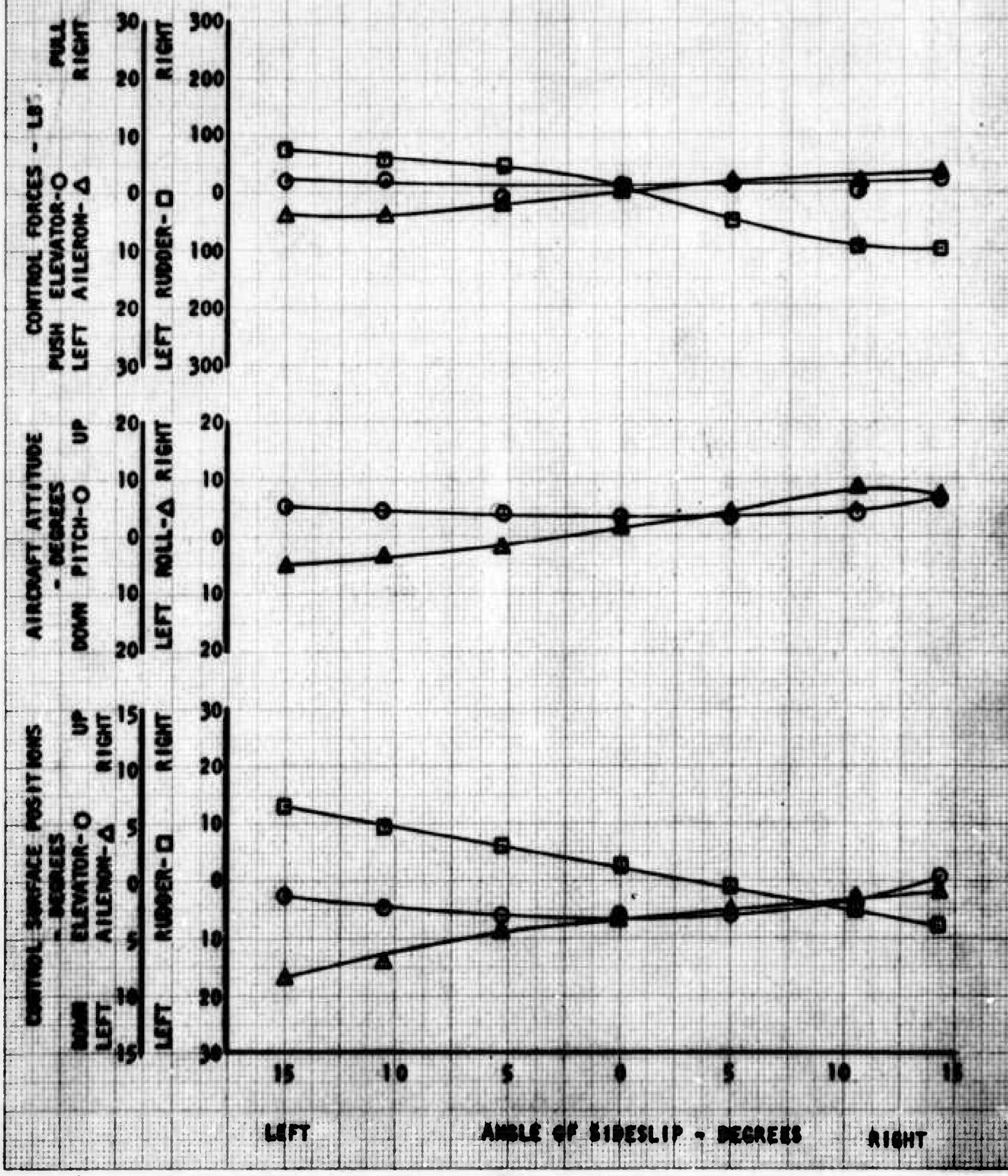


FIGURE 11
STATIC LATERAL-DIRECTIONAL STABILITY
OV-1D USA S/N 68-16990
WAVE-OFF CONFIGURATION

AVG. CAL. A/S -KTS	AVG. GR. WT. -LB.	AVG. C.G. -%MAC	AVG. DENS. ALT. -FT.	STORE CONFIG.
92	17110	27.2	6340	A

NOTE: PRESS. ALT. = 4800 FT.; O.A.T. = 18.9 °C.

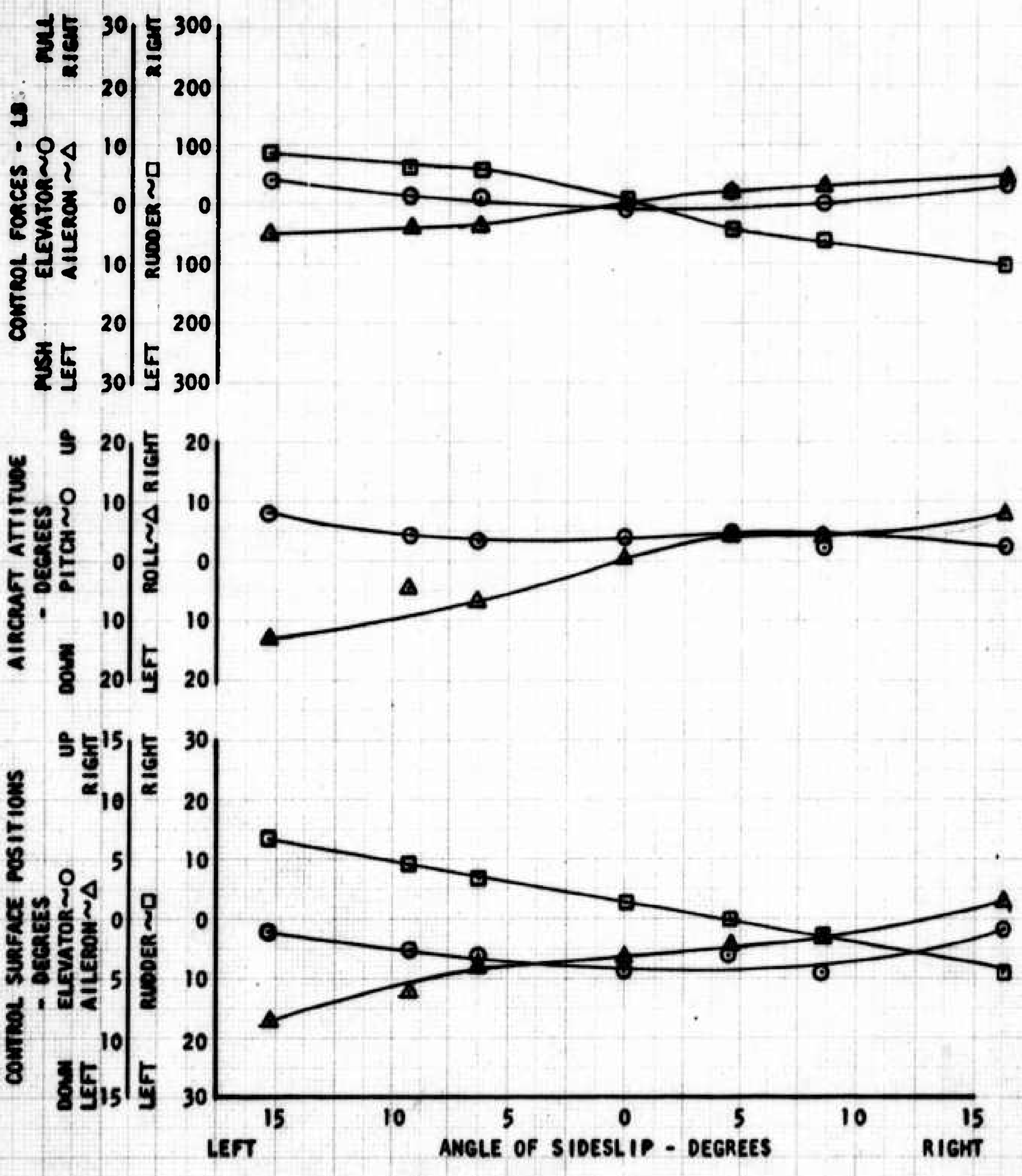


FIGURE 12
STATIC LATERAL-DIRECTIONAL STABILITY
OV-1D USA S/N 68-16990
POWER APPROACH CONFIGURATION

AVG. CAL. A/S -KTS	AVG. GR. WT. -LB	AVG. C.G. -%MAC	AVG. DENS. ALT. -FT	STORE CONFIG.
92	17200	27.2	6030	A

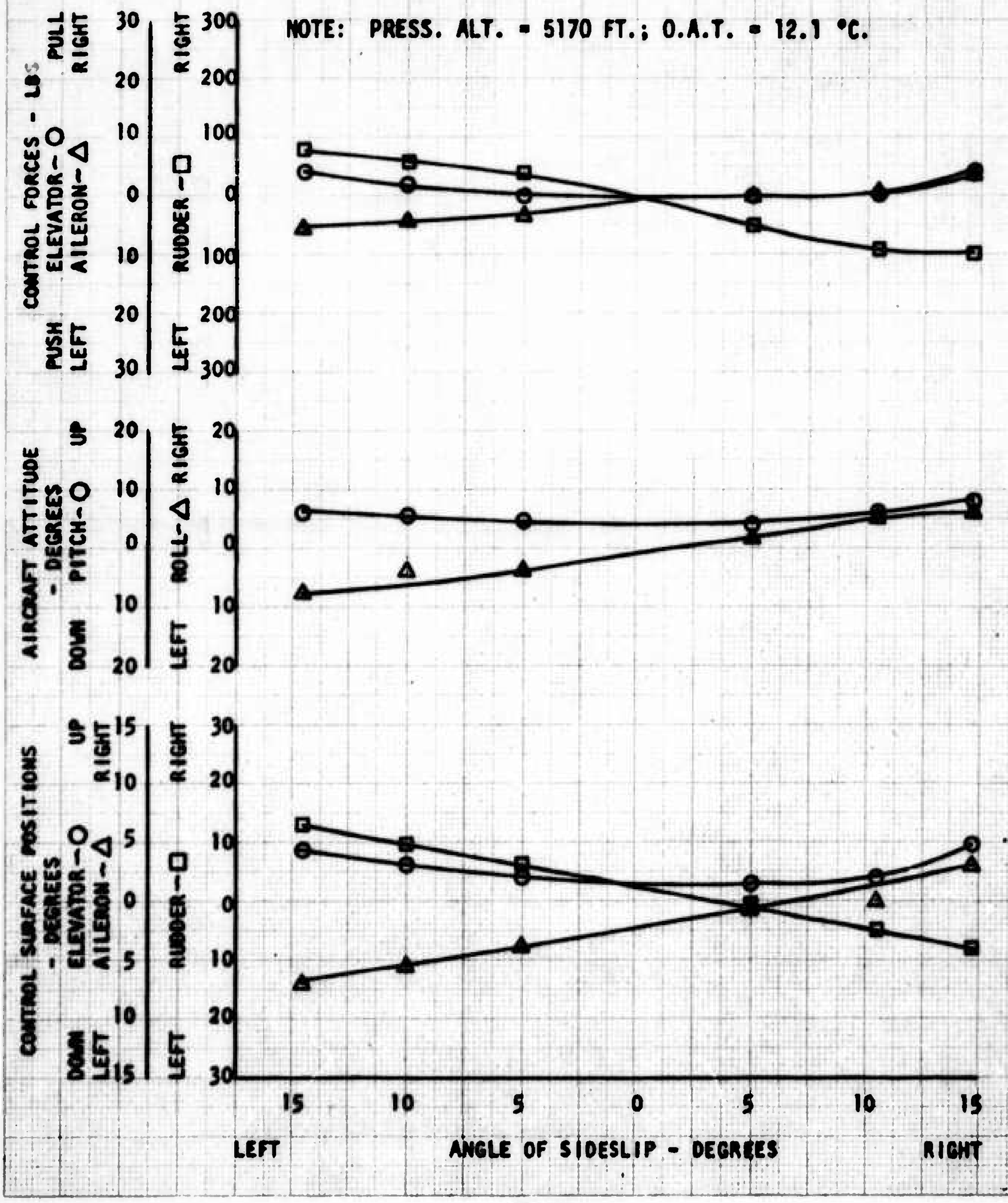


FIGURE 13
STATIC LATERAL-DIRECTIONAL STABILITY
OV-1D USA S/N 68-16990
POWER APPROACH CONFIGURATION

AVG. CAL. A/S - KT	AVG GR. WT - LB.	AVG. C.G. - %MAC	AVG. DENS. ALT. - FT.	STORE CONFIG.
90	16380	26.8	1240	A

NOTE: PRESS ALT. = 880 FT.; O.A.T. = 16.3 °C.

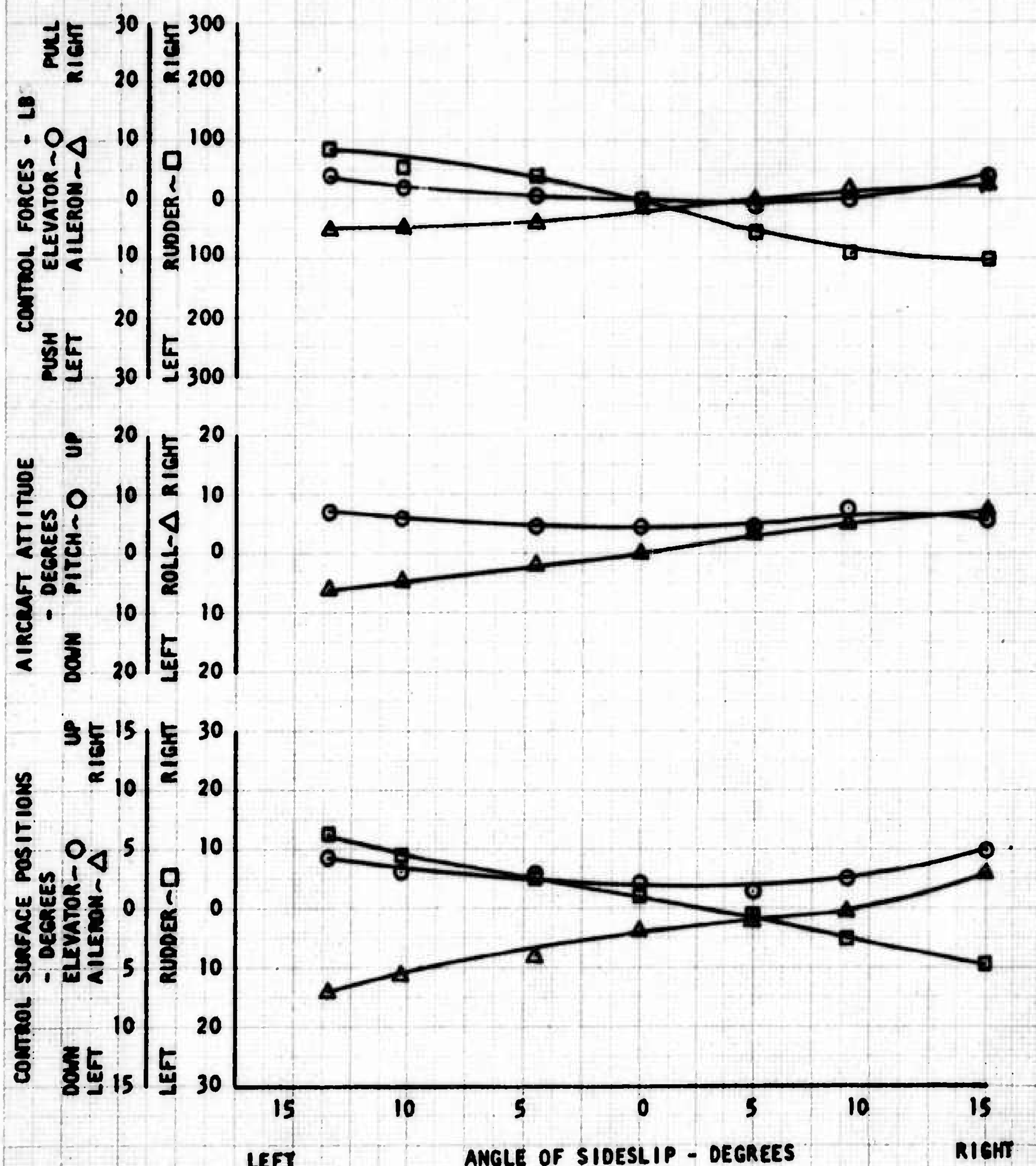
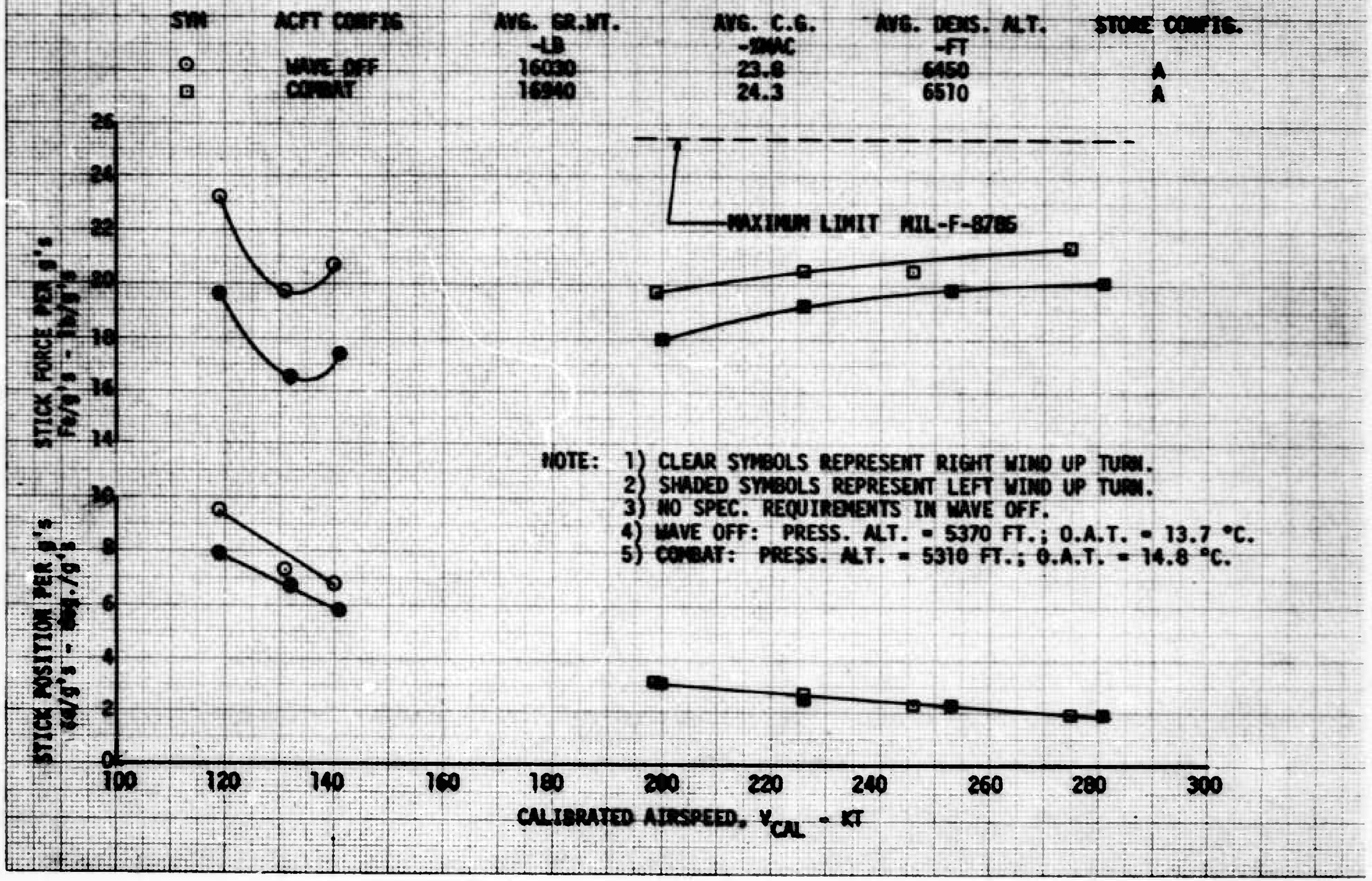


FIGURE 14
MANEUVERING STABILITY SUMMARY
OV-1D USA S/N 68-16990



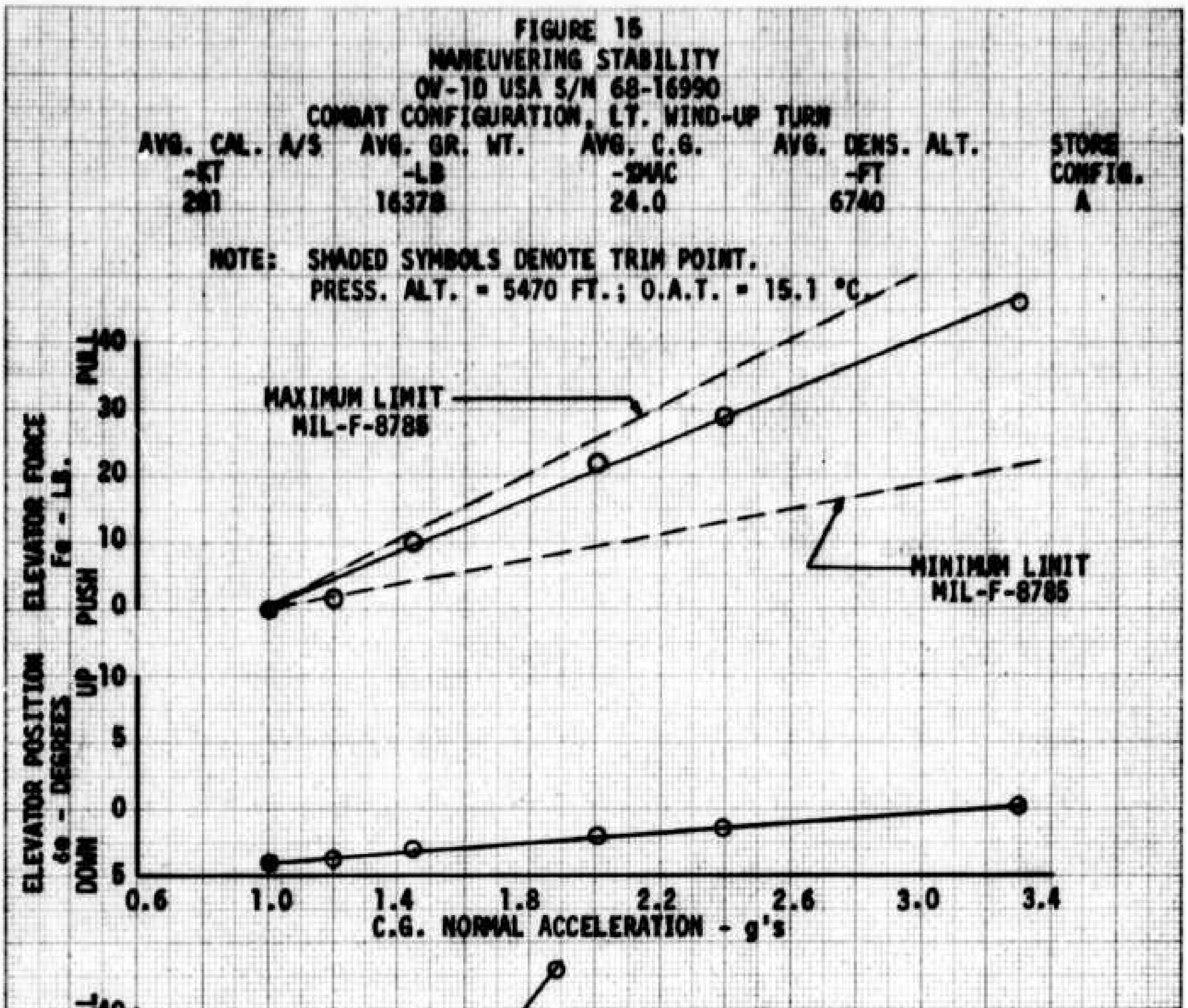


FIGURE 15
MANEUVERING STABILITY
OV-1D USA S/N 68-16990
COMBAT CONFIGURATION, LT. WIND-UP TURN
AVG. CAL. A/S -KT 201
AVG. GR. WT. -LB 16378
AVG. C.G. -%MAC 24.0
AVG. DENS. ALT. -FT 6740
STORE CONFIG. A
NOTE: SHADED SYMBOLS DENOTE TRIM POINT.
PRESS. ALT. = 5470 FT.; O.A.T. = 15.1 °C.
MAXIMUM LIMIT MIL-F-8785
MINIMUM LIMIT MIL-F-8785
ELEVATOR FORCE Fe - LB.
PUSH
PULL
ELEVATOR POSITION δe - DEGREES
UP
DOWN
C.G. NORMAL ACCELERATION - g's
LIFT COEFFICIENT - C_L

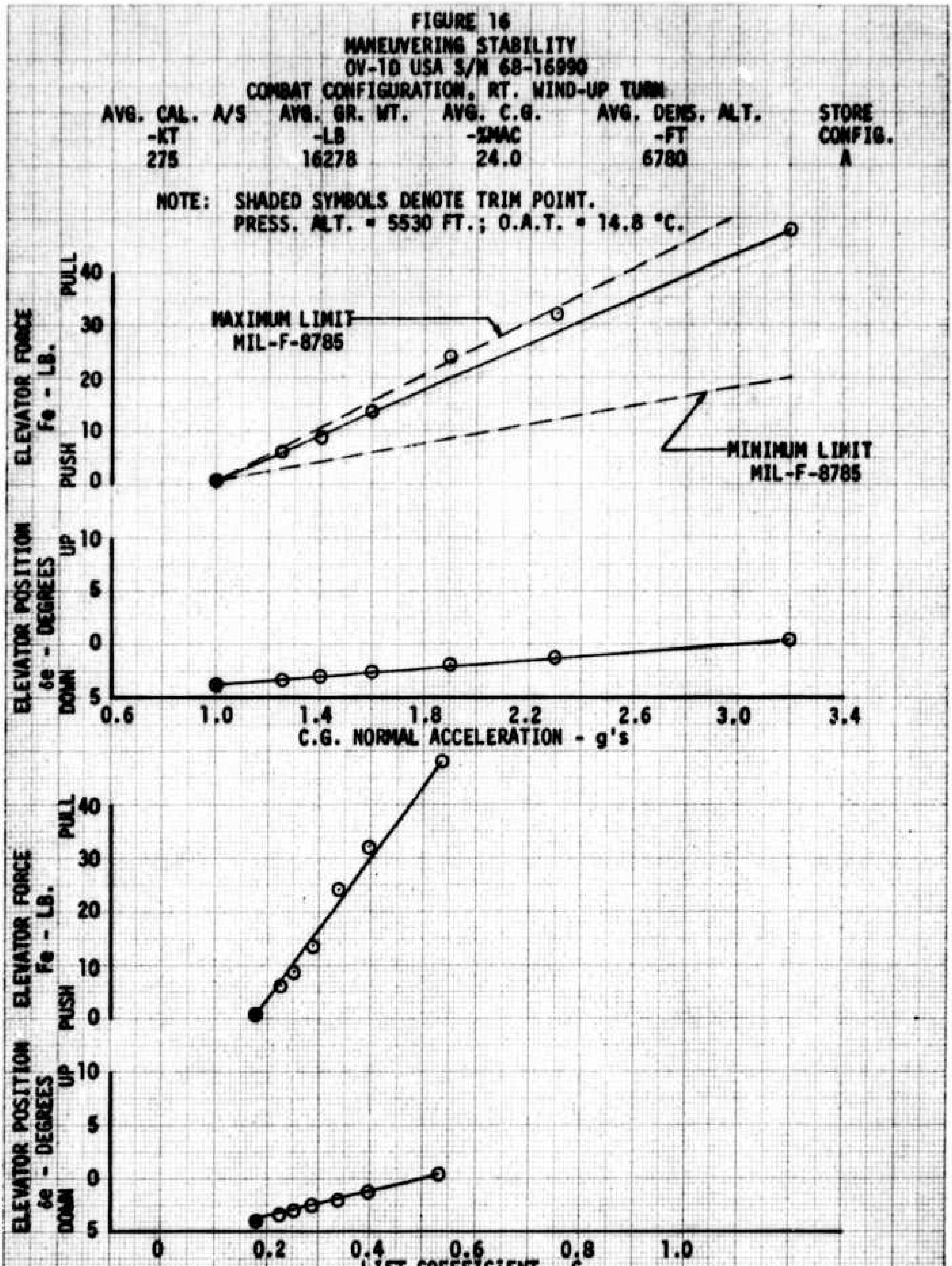


FIGURE 16
MANEUVERING STABILITY
OV-10 USA S/N 68-16990
COMBAT CONFIGURATION, RT. WIND-UP TURN
AVG. CAL. A/S -KT 275
AVG. GR. WT. -LB 16278
AVG. C.G. -%MAC 24.0
AVG. DENS. ALT. -FT 6780
STORE CONFIG. A
NOTE: SHADED SYMBOLS DENOTE TRIM POINT.
PRESS. ALT. = 5530 FT.; O.A.T. = 14.8 °C.
MAXIMUM LIMIT MIL-F-8785
MINIMUM LIMIT MIL-F-8785
ELEVATOR FORCE Fe - LB.
PUSH
PULL
ELEVATOR POSITION δe - DEGREES
DOWN
UP
C.G. NORMAL ACCELERATION - g's
LIFT COEFFICIENT - C_L

FIGURE 17
MANEUVERING STABILITY
OV-10 USA S/N 68-16990
WAVE OFF CONFIGURATION, LT. WIND-UP TURN

AVG. CAL. A/S -KT	AVG. GR. WT. -LB	AVG. C.G. -%MAC	AVG. DENS. ALT. -FT	STORE CONFIG.
119	16055	23.8	6880	A

NOTE: SHADED SYMBOLS DENOTE TRIM POINT.
PRESS. ALT. = 5700 FT.; O.A.T. = 13.9 °C.

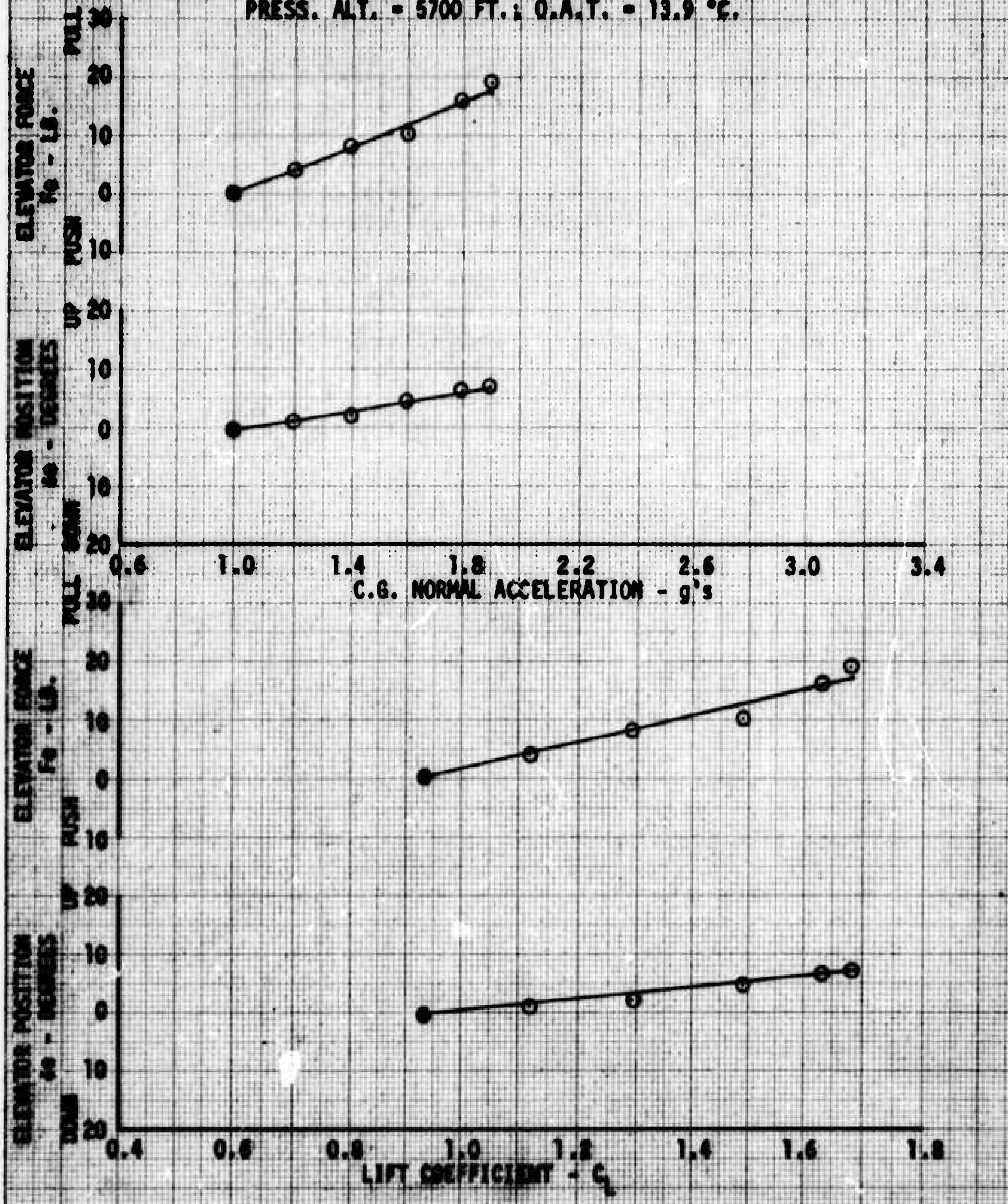


FIGURE 18
MANEUVERING STABILITY
OV-1D USA S/N 68-16990
WAVE OFF CONFIGURATION, RT. WIND-UP TURN

AVG. CAL. A/S -KT	AVG. GR. WT. -LB	AVG. C.G. -%MAC	AVG. DENS. ALT. -FT	STORE CONFIG.
119	16100	23.8	6440	A

NOTE: SHADED SYMBOLS DENOTE TRIM POINT.
PRESS. ALT. = 5340 FT.; O.A.T. = 13.9 °C.

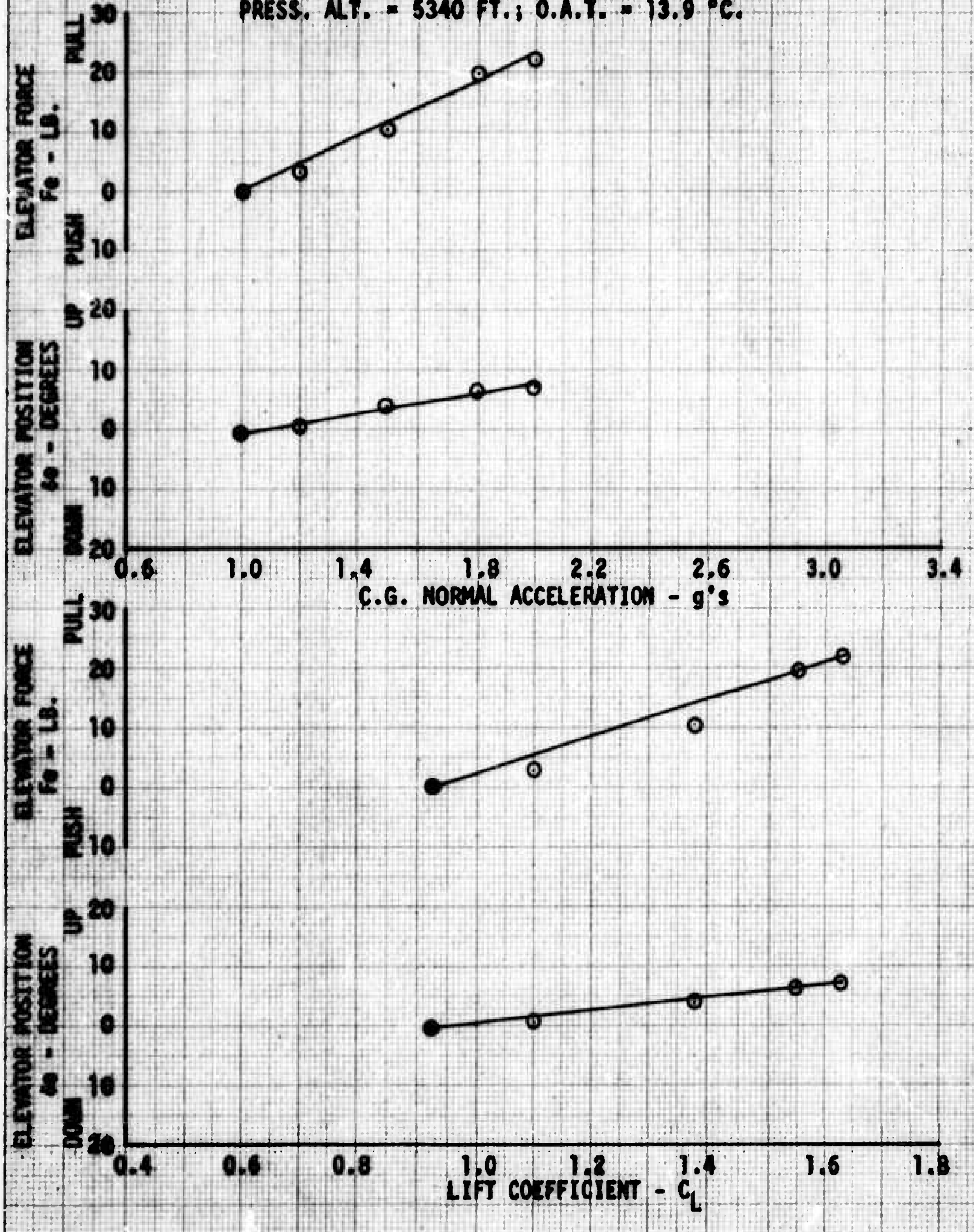


FIGURE 19a

STALL CHARACTERISTICS

OV-10 USA 68-16990

LANDING CONFIGURATION

TRIM AS. - KCAS	AVG. GR. WT. - WEIGHT	AVG. CG - % MAC	AVG. DENS. ALT. - FT	STORE CONFIG.
102	18060 LB.	27	7620	A

NOTE: PRESS. ALT.= 6860 FT., O.A.T.= 7.9°C

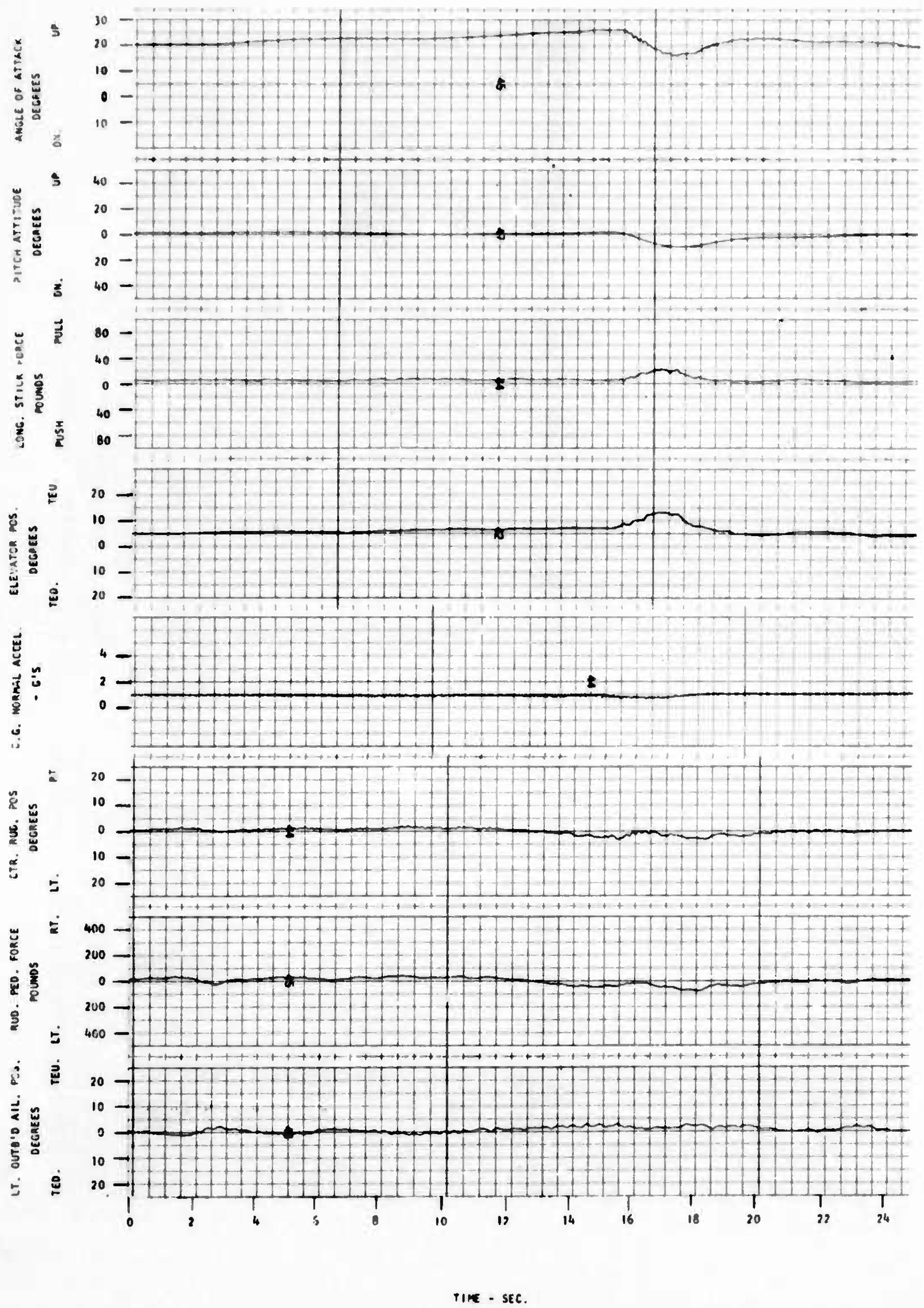


FIGURE 196

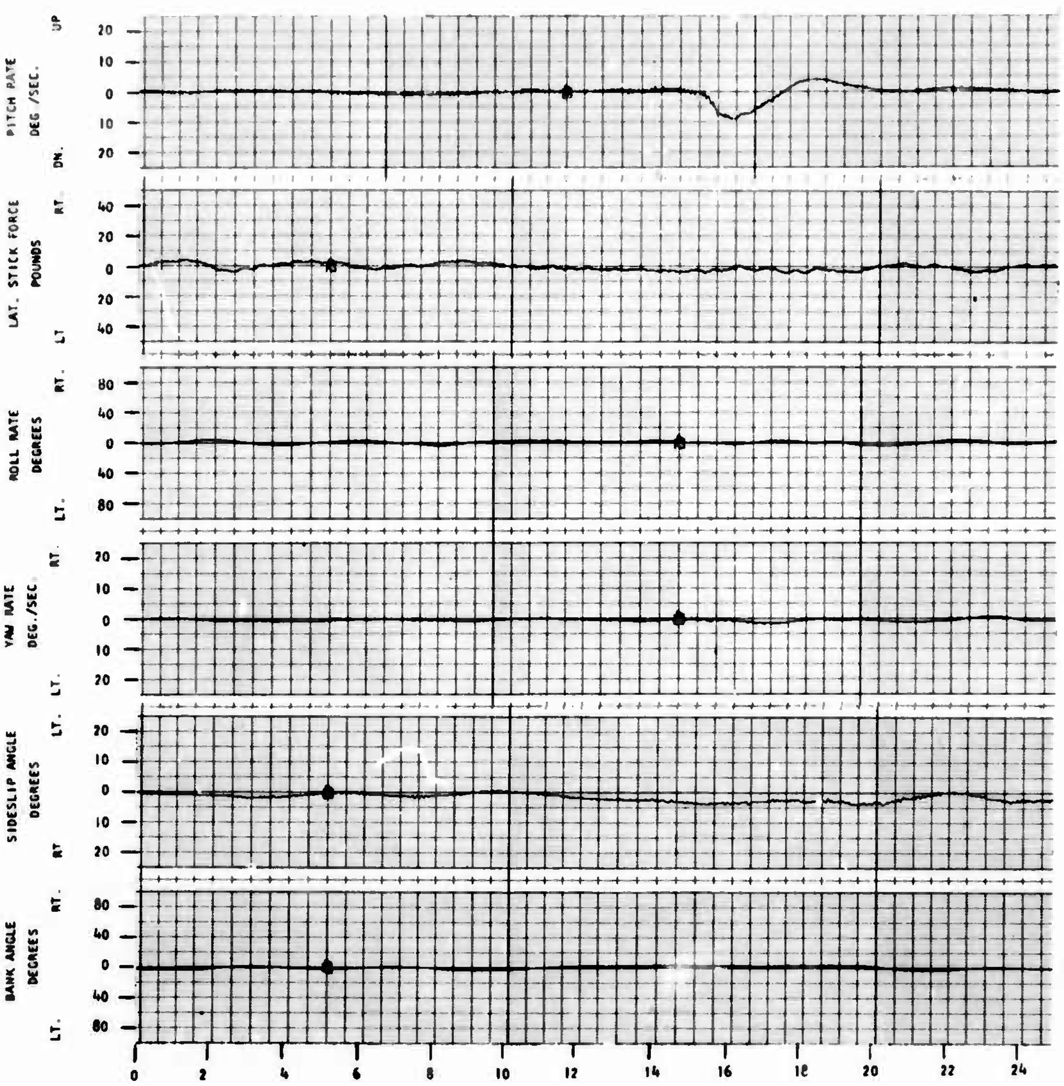
STALL CHARACTERISTICS

OV-1D USA 68-16990

LANDING CONFIGURATION

TRIM AS. - KCAS	AVG. GR. WT. - WEIGHT	AVG. CG - % MAC	AVG. DENS. ALT. - FT	STORE CONFIG.
102	18060 LB.	27	7620	A

NOTE: PRESS. ALT.= 6860 FT., O.A.T.= 7.9°C



TIME - SEC

FIGURE 20a

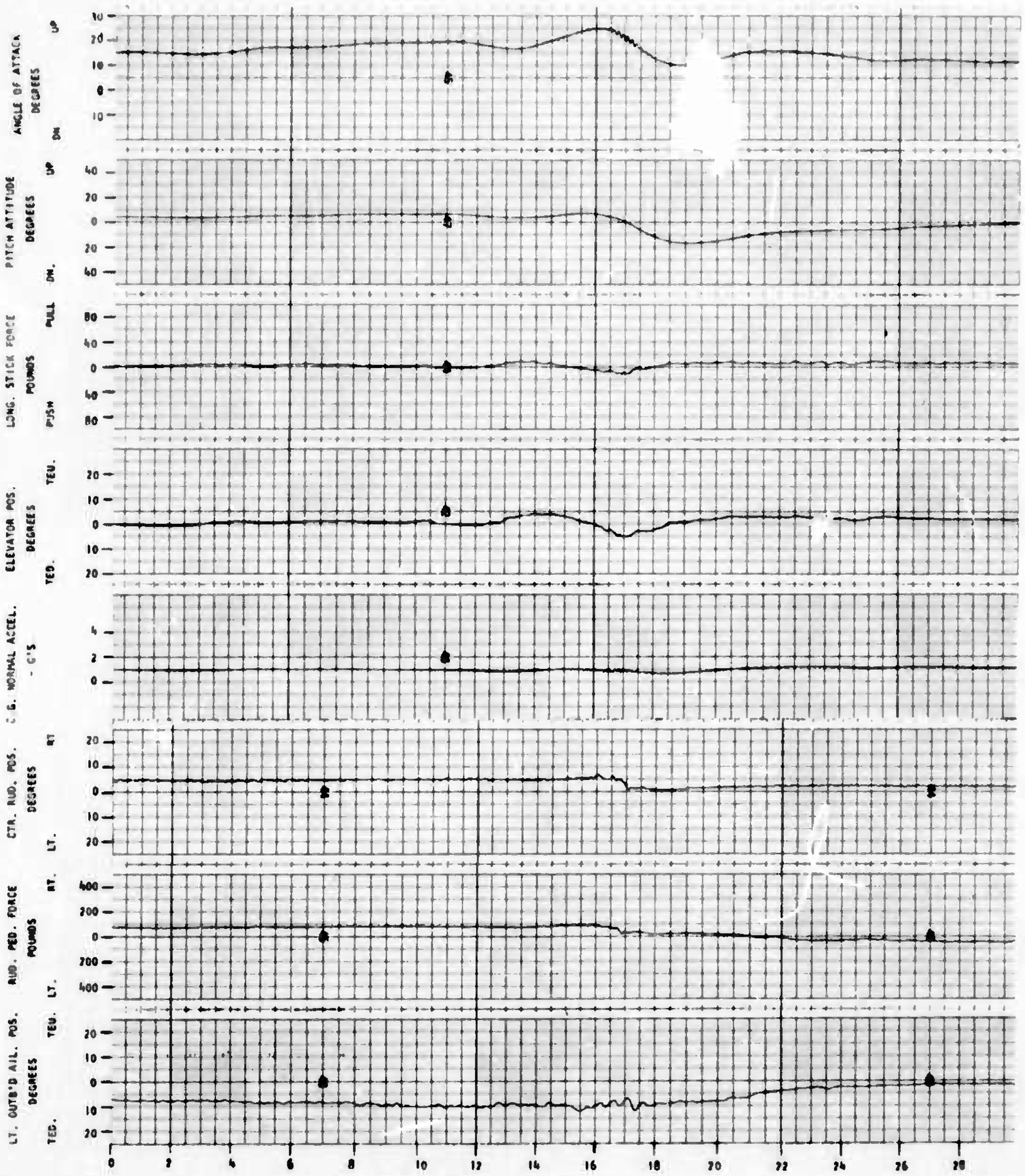
STALL CHARACTERISTICS

OV-10 USA 68-16990

POWER APPROACH SINGLE ENGINE

TRIM AS. - KCAS	AVG. GR. WT. - WEIGHT	AVG. CG - % MAC	AVG. DENS. ALT. - FT	STORE CONFIG.
109	16640 LB.	27	7970	A

NOTE: PRESS. ALT.= 7260 FT., O.A.T.= 6.7°C



TIME - SEC.

FIGURE 20b

STALL CHARACTERISTICS

OV-1D USA 68-16990

POWER APPROACH SINGLE ENGINE

TRIM AS. - KCAS	AVG. GR. WT. - WEIGHT	AVG. CG - % MAC	AVG. DENS. ALT. - FT	STORE CONFIG
109	16640 LB.	27	7970	A

NOTE: PRESS. ALT.= 7260 FT., O.A.T.= 6.7°C

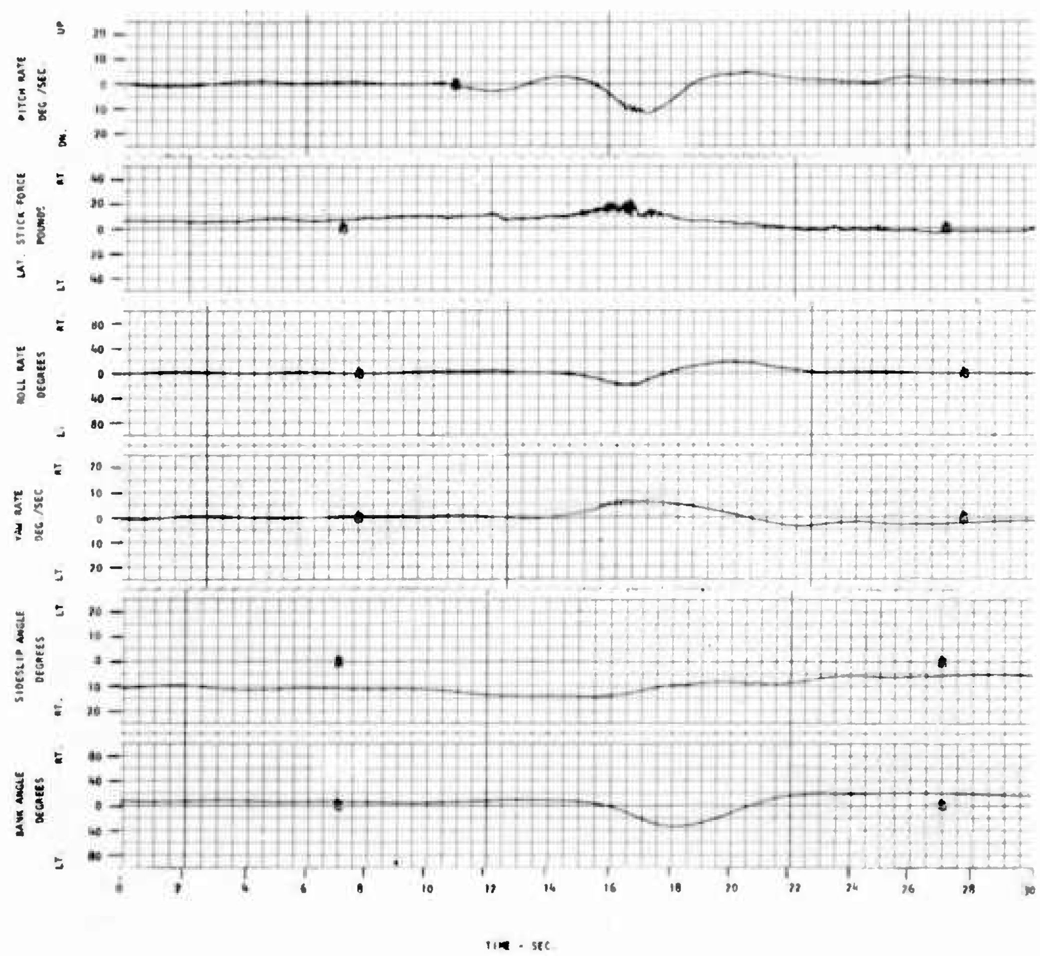


FIGURE 21
TRIMMABILITY
OV-10 USA S/N 68-16990
TAKE-OFF CONFIGURATION

AVG. GR. WT. -LB	AVG. C.G. -%MAC	AVG. DENS. ALT. -FT	STORE CONFIG.
16364	29.0	7193	A

NOTE: PRESS. ALT. = 6030 FT.; O.A.T. = 13.1 °C.

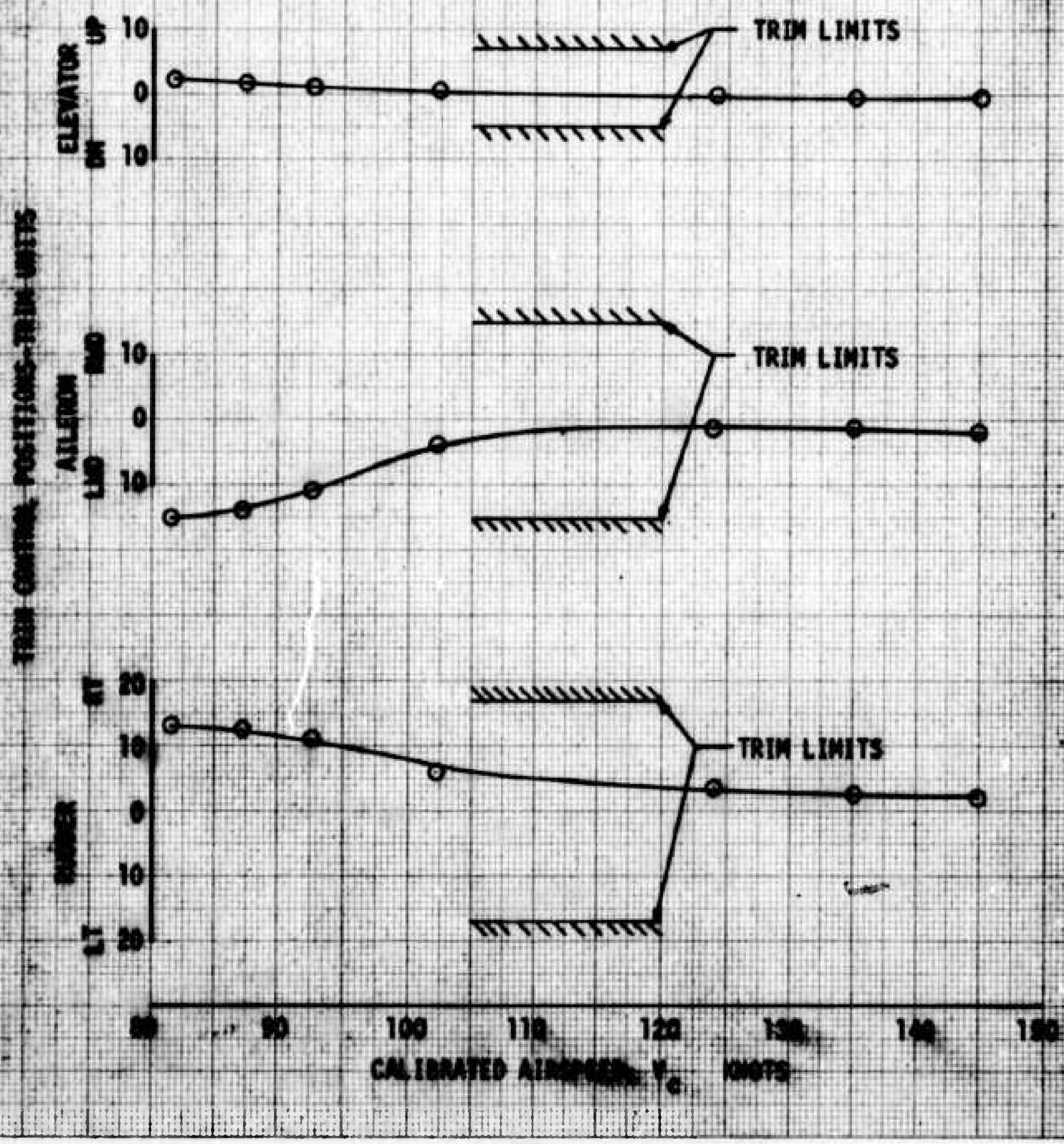


FIGURE 22
TRIMMABILITY
OV-1D USA S/N 68-16990
P CONFIGURATION (SINGLE ENGINE)

LEFT ENGINE	AVG. GR. WT. -LB	AVG. C.G. -%MAC	AVG. DENS. ALT. -FT	STORE CONFIG.
GROUND IDLE (FEATHERED)	17350	29.3	4810	A

NOTE: 1) SHADED SYMBOLS DENOTE 5° OF BANK INTO THE LIVE ENGINE.
2) OPEN SYMBOLS DENOTE WINGS LEVEL.
3) PRESS. ALT. = 3580 FT.; O.A.T. = 18.5 °C.

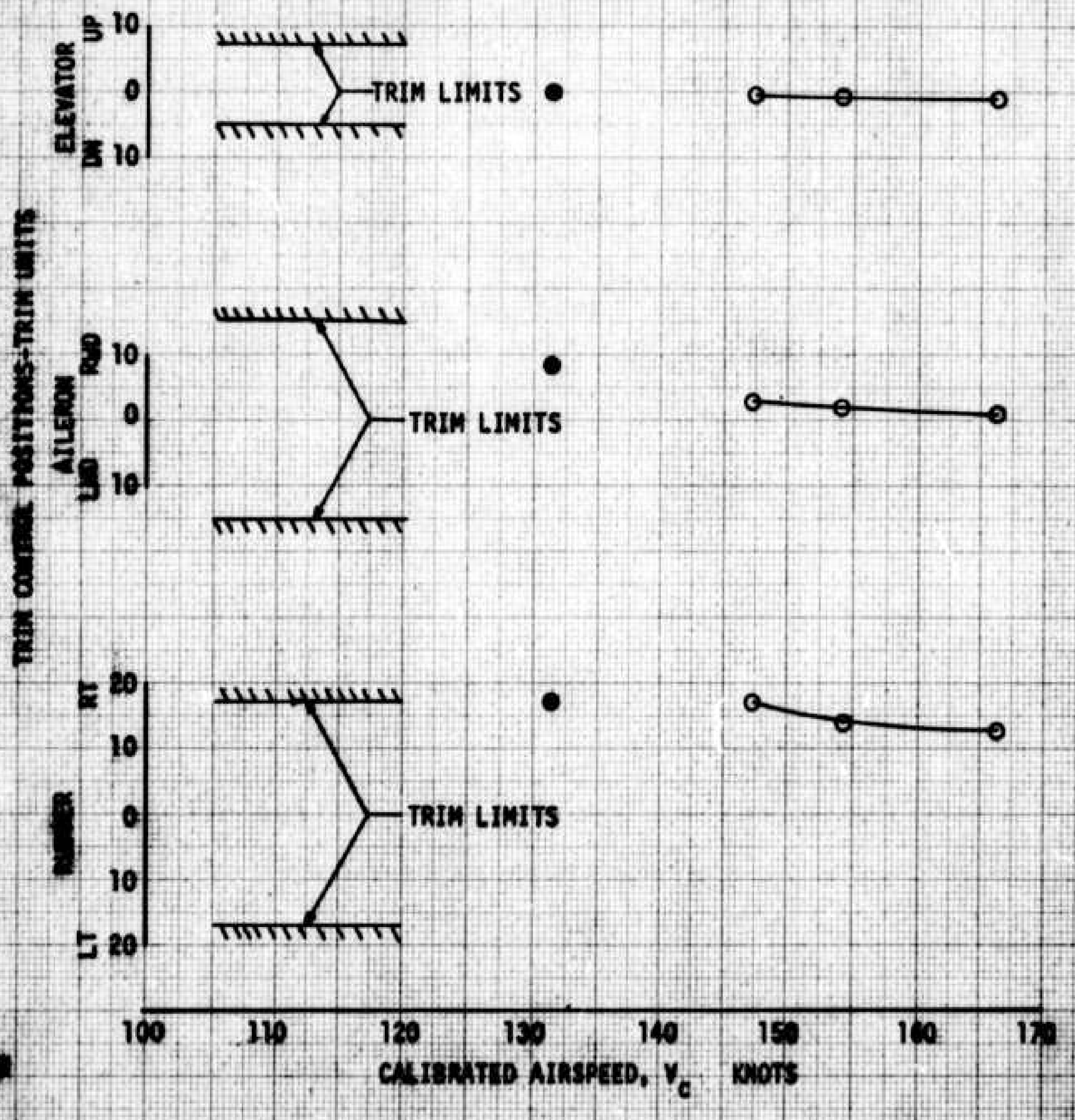


FIGURE NO. 23

AIRSPEED CALIBRATION

OV-1D USA S/N 68-16990

TEST NOSEBOOM SYSTEM

CRUISE CONFIGURATION

DATA FURNISHED BY G.A.C.

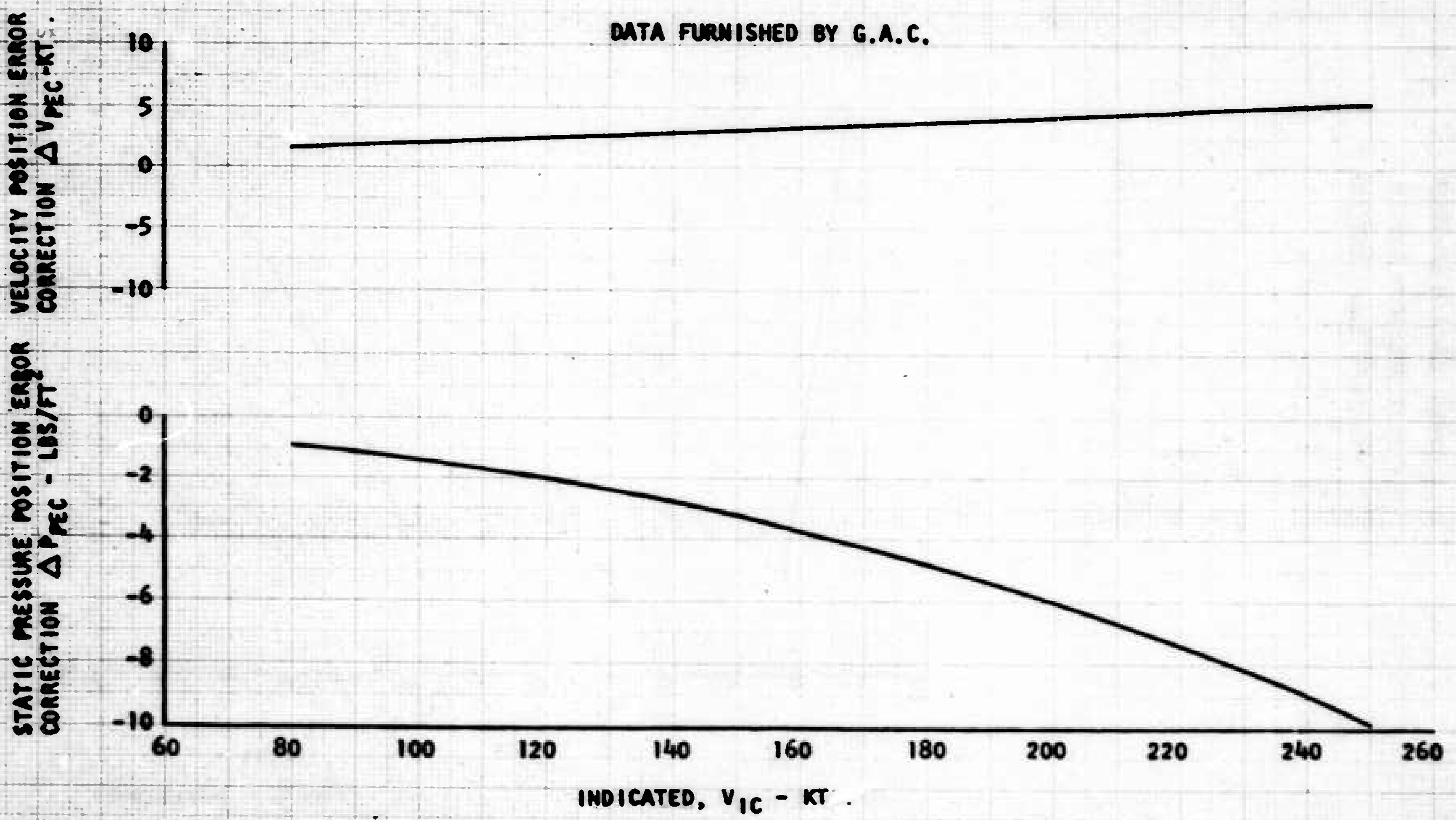


FIGURE NO. 24

AIRSPEED CALIBRATION

OV-1D USA S/N 68-16990

TEST NOSEBOOM SYSTEM

TAKEOFF CONFIGURATION

DATA FURNISHED BY G.A.C.

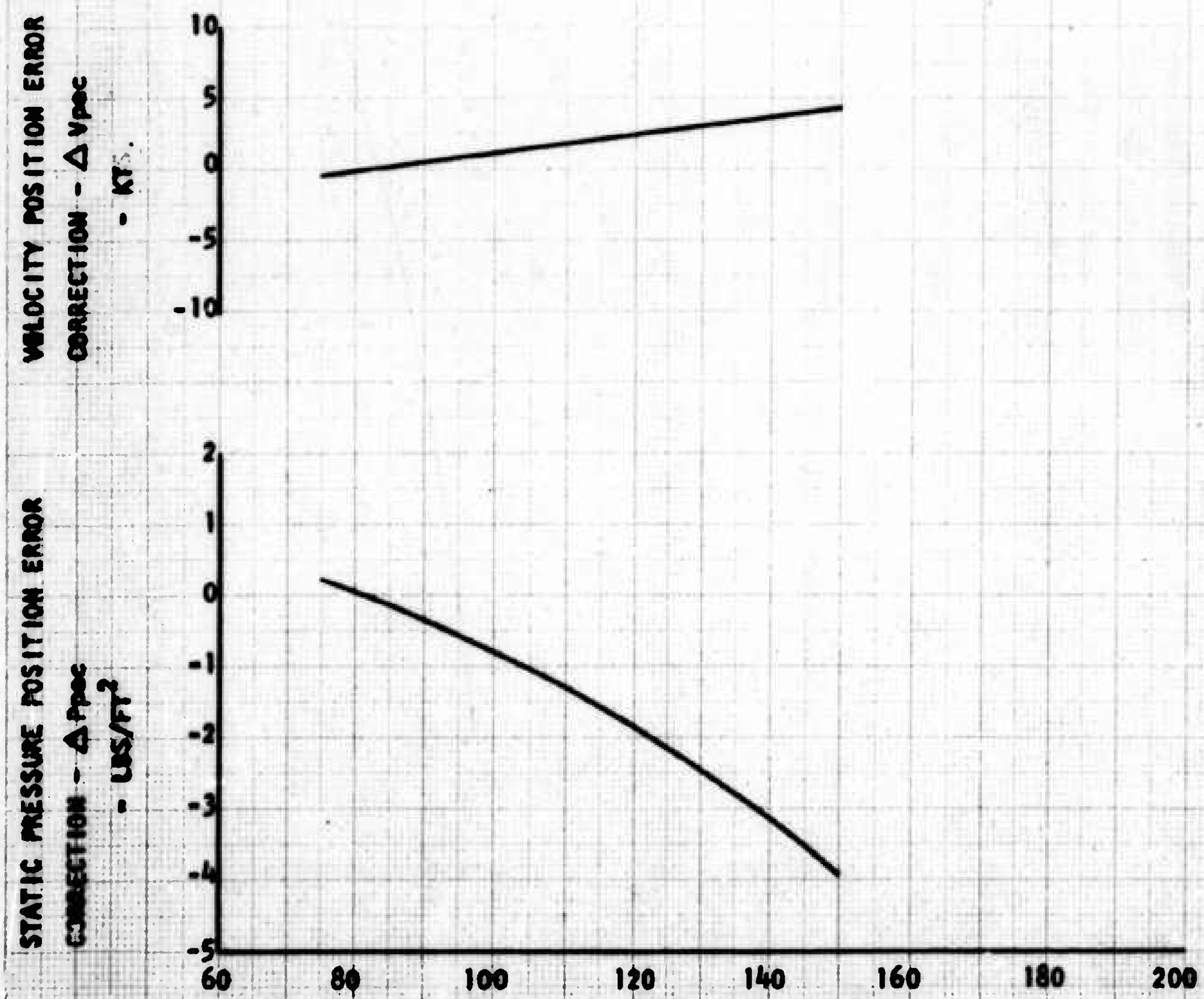


FIGURE NO. 25

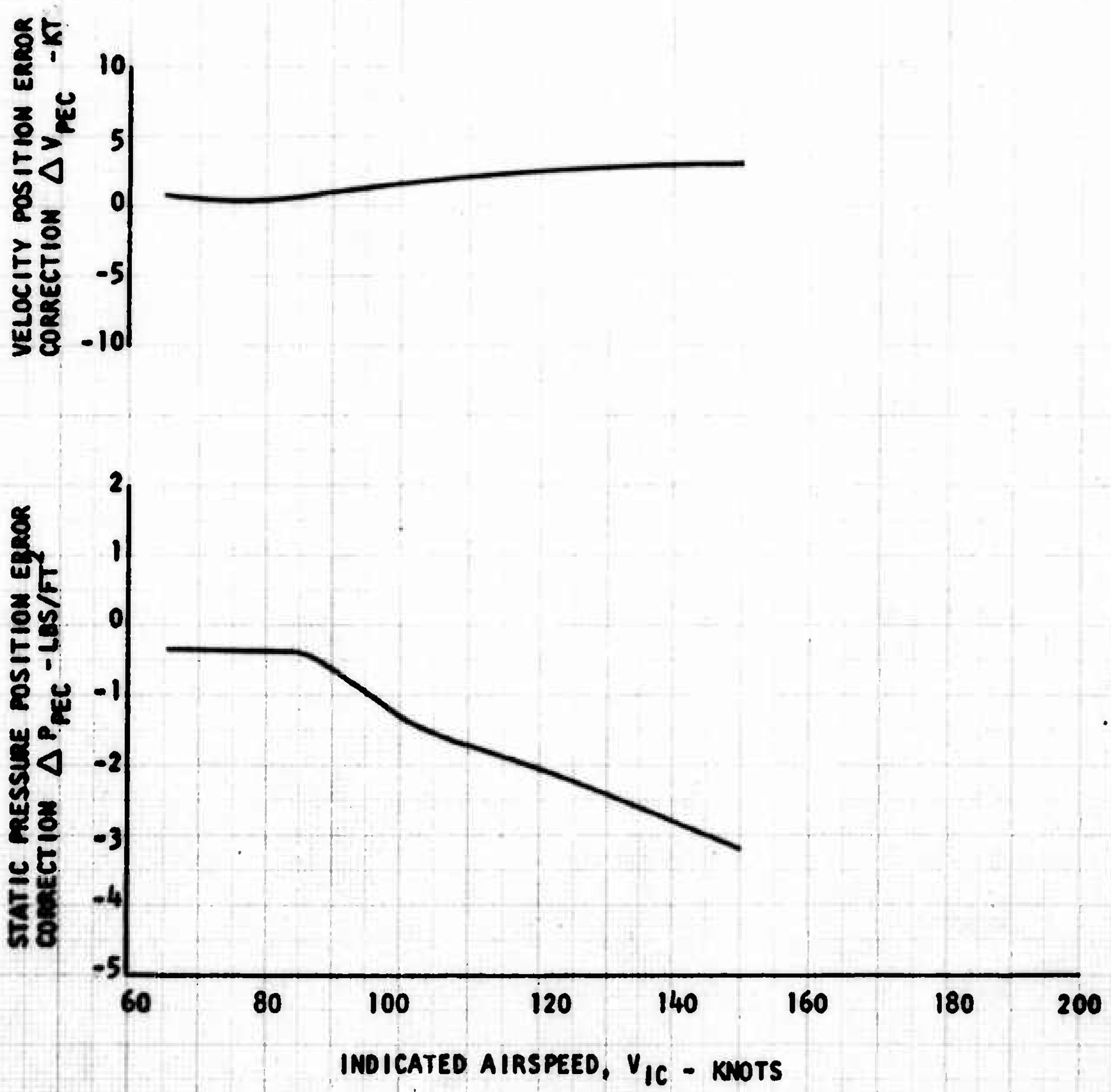
AIRSPEED CALIBRATION

OV-1D USA S/N 68-16990

TEST NOSEBOOM SYSTEM

POWER APPROACH CONFIGURATION

DATA FURNISHED BY G.A.C.



APPENDIX V. ABBREVIATIONS AND SYMBOLS

ITEM	DEFINITION
APE	Army Preliminary Evaluation
°C	Degree(s) Centigrade
C_D	Drag coefficient
C_L	Lift coefficient
CG, cg	Center of gravity
CO	Combat
CR	Cruise
ECS	Environmental control system
EGT	Exhaust gas temperature
°F	Degree(s) fahrenheit
g	Acceleration of gravity
g's	Acceleration expressed as a multiple of gravity
GAC	Grumman Aerospace Corporation
GRWT, grwt	Gross weight
H_P	Pressure altitude
HQRS	Handling Qualities Rating Scale
ICS	Intercommunications system
°K	Degree(s) Kelvin
KCAS	Knot(s) calibrated airspeed
KTAS	Knot(s) true airspeed

L	Land
LWD	Left wing down
M_0	Corrected ideal inlet airflow at engine compressor face
M_1	Corrected inlet airflow at engine compressor face
MAC	Mean aerodynamic chord
mil spec	Military specification
MRP	Military rated power
NAMPP	Nautical air miles per pound of fuel
NRP	Normal rated power
P	Power
PA	Power approach
PLF	Power for level flight
P_{T_0}	Free stream total pressure
P_{T_1}	Total pressure at engine compressor face
S	Planform area
SLAR	Side-looking airborne radar
T	Thrust
THPiw	Thrust horsepower corrected to standard day, standard weight
TO	Takeoff
Viw	Velocity corrected to standard day, standard weight
V_{MC}	Minimum control speed
V_T	True airspeed

WO	Wave-off
W_S	Standard weight
W_t	Test weight
δ_{T_1}	Compressor face total pressure ratio
θ_{T_1}	Relative total air temperature at engine compressor face
ρ	Air density
σ	Ratio of test air density to standard-day, sea-level air density
σ_s	Ratio of standard-day test density altitude to standard-day sea-level density

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13. ABSTRACT

Performance and stability and control testing was conducted on a production model OV-1D airplane (Mohawk), S/N 68-16990, to evaluate its ability to perform the manned aerial surveillance mission and to determine military specification compliance. Testing was performed by the US Army Aviation Systems Test Activity, Edwards Air Force Base, California, between 14 and 24 July 1970. The testing was conducted at the Grumman Aerospace Corporation Facility at Calverton, New York. Nine flights were accomplished for a total of 20.5 hours. The stability and control portion of the testing is presented in this report. The performance test results will be contained in an addendum. The flying qualities of the OV-1D were satisfactory for mission accomplishment. One deficiency was reported: the possibility of an operating engine feathering created by a malfunction in the torque gage during takeoff. In addition, there were seven shortcomings noted. Airworthiness and flight characteristics testing on the OV-1D is recommended in order to provide current handbook data.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
OV-1D airplane						
Performance						
Stability and control						
Aerial surveillance mission						
Flying qualities						

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