NASA CONTRACTOR REPORT

NASA CR-2337

NASA CR-2337

FLIGHT TEST DATA FOR A CESSNA CARDINAL

by David L. Kohlman

Prepared by
THE UNIVERSITY OF KANSAS CENTER FOR RESEARCH, INC.
Lawrence, Kansas
for Langley Research Center

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C. • JANUARY 1974

1. Report No. NASA CR-2337	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle FLIGHT TEST DATA FOR A CESSNA CARDINAL		5. Report Date JANUARY 1974 6. Performing Organization Code
7. Author(s) DAVID L. KOHLMAN		8. Performing Organization Report No. FRL 72-001
9. Performing Organization Name and Address UNIVERSITY OF KANSAS LAWRENCE, KANSAS		10. Work Unit No. 736-60-01 11. Contract or Grant No. NGR 17-002-072
12. Sponsoring Agency Name and Address NATIONAL AERONAUTICS AND SPACE ADMINISTRATION WASHINGTON, D.C. 20546		13. Type of Report and Period Covered CONTRACTOR REPORT 14. Sponsoring Agency Code

15. Supplementary Notes

This is a topical report.

16. Abstract

THIS REPORT CONTAINS THE RESULTS OF A FLIGHT TEST ANALYSIS OF THE PERFORMANCE OF A STANDARD CESSNA 177B CARDINAL AIRPLANE. THE AIRPLANE WAS FULLY INSTRUMENTED TO OBTAIN STEADY STATE PERFORMANCE, STICK-FIXED DYNAMIC STABILITY CHARACTERISTICS, AND ROLL RESPONSE DATA. RESULTS OBTAINED INCLUDE GRAPHS OF C_L VERSUS α, C_D VERSUS C_L, AND SPEED-POWER RELATIONSHIPS. DYNAMIC DATA INCLUDE PHUGOID AND DUTCH ROLL CHARACTERISTICS, AND ROLL RESPONSE CHARACTERISTICS.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
HIGH-WING LIGHT PLANE PERFORMANCE STABILITY AND CONTROL	UNCLASSIFIED - UNLIMITED

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
UNCLASSIFIED	UNCLASSIFIED	34	$3.00

*For sale by the National Technical Information Service, Springfield, Virginia 22151

TABLE OF CONTENTS

NOMENCLATURE

Symbol	Definition	Units
α	Airplane Angle of Attack	Deg.
β	Sideslip Angle	Deg.
σ	Density Ratio, ρ/ρ_o	-
ρ_o	Standard Sea Level Density	0.002378 Slugs/Ft^3
ζ_d	Dutch Roll Damping Ratio	-
δ_{flap}	Flap Deflection	Deg.
δ_{stab}	Stabilizer Deflection	Deg.
AR	Aspect Ratio	-
CAS	Calibrated Airspeed	MPH
C_{d_p}	Zero Lift Drag Coefficient	-
C_L	Airplane Lift Coefficient	-
C_D	Airplane Drag Coefficient	-
e	Induced Drag Efficiency Factor	-
R/C	Rate of Climb	Ft/Min
S_w	Wing Area	Ft^2
THP	Thrust Horsepower	Horsepower
THP_e	Equivalent Thrust Horsepower	Horsepower
V_e	Equivalent Velocity	MPH
W	Gross Weight	Lbs.

SUMMARY

This report contains the results of a flight test analysis of the performance of a standard Cessna 177B Cardinal airplane. The airplane was fully instrumented to obtain steady state performance, stick-fixed dynamic stability characteristics, and roll response data. Results obtained include graphs of C_L versus α, C_D versus C_L, and speed-power relationships. Dynamic data include phugoid and dutch roll characteristics, and roll response characteristics. Flight test data agree quite well with handbook cruise data for the production airplane.

INTRODUCTION

In July, 1970, a Cessna 177B Cardinal airplane was donated to the Flight Research Laboratory of the University of Kansas Center for Research, Inc. by the Cessna Aircraft Company. This airplane, N1910F, serial number 17700002, was the second Cardinal manufactured, and was subsequently modified for use as a 1970 model prototype. Aerodynamically, it is almost identical to a production 1970 Cardinal, and it has the same type of engine. The only external differences are the presence of an instrumentation boom on each wing tip and a slight permanent deformation of the wings due to a previous structural integrity test.

The purpose of the tests reported herein is to provide a set of base data on the Cardinal to compare with the performance of the same airplane after advanced technology wings have been installed. The new wings were designed and manufactured as a part of a program to investigate aerodynamic improvements in the design of light aircraft. The program is being conducted under NASA Grant NGR 17-002-072 by the staff of the Flight Research Laboratory.

Results of flight tests of the modified Cardinal will be reported in a subsequent document.

INSTRUMENTATION SYSTEM

The instrumentation system was designed, fabricated, installed, and calibrated by the Cessna Aircraft Company according to specifications of the Flight Research Laboratory. The instrumentation was designed as a complete unit module to facilitate easy installation and removal. It consists of a baseplate on which is mounted an oscillograph, attitude gyro, static inverter, signal conditioning box, accelerometer, airspeed-altitude recorder, intervalometer, and 24-volt batteries. The signal conditioning box provides bias and balance controls for the transducer outputs.

The control surface transducers (linear potentiometers) are connected directly to the surfaces to eliminate the effect of cable stretch.

The airspeed transducer consists of a swivel-head airspeed boom on the left wing tip and a differential pressure transducer. Sideslip and angle of attack are measured by vanes mounted on a boom on the right wing tip and attached to precision potentiometers.

Manifold pressure is sensed by an absolute pressure transducer connected with the existing indicator plumbing. Engine speed is measured with a magnetic sensor.

Photographs of the instrumentation module and wing tip booms are shown in Figures 1, 2, and 3. Table I lists the parameters which are recorded on film strips in the two recorders.

Table I Measured Parameters and Design Specifications for Cardinal Instrumentation System

Variable	Range	Accuracy
Airspeed, V	40 - 170 mph	± 1 %
Altitude, h	0-10,000 ft.	± 1 %
Angle of attack, α	-4° - +20°	± 0.5°
Sideslip, β	-15° - +15°	± 0.5°
Pitch angle, θ	-15° - +15°	± 0.5°
Roll angle, ϕ	-75° - +75°	± 0.5°
Rudder deflection, δ_r	-24° - +24°	± 0.5°
Stabilator deflection, δ_e	-20° - + 5°	± 0.5°
Right aileron deflection, δ_R	-20° - +20°	± 0.5°
Left aileron deflection, δ_L	-20° - +20°	± 0.5°
Normal load factor, n_z	- 1 - + 3	± 0.01
Engine speed, RPM	500 - 2800	± 1 %
Manifold pressure, p_M	5 - 30 in. Hg	± 1 %

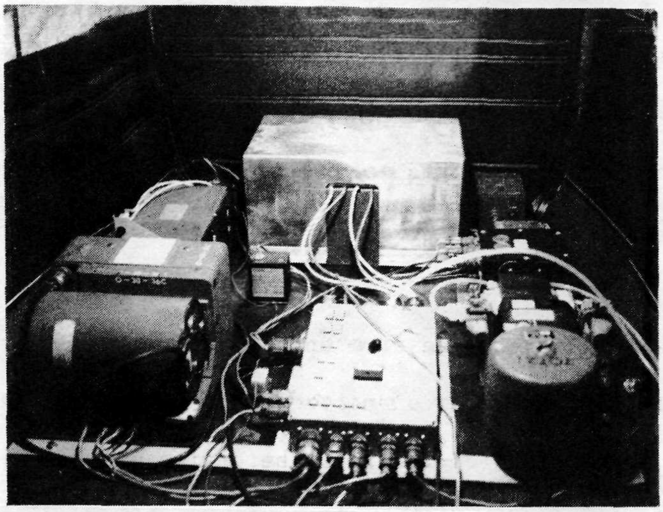


Figure 1
Cardinal Data
Sensing and Recording
Instrumentation System

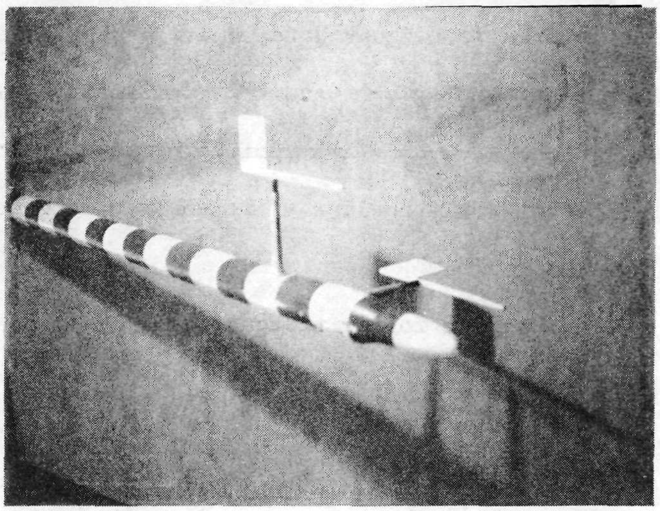


Figure 2
Angle of Attack
and Sideslip Vanes,
Right Wingtip Boom

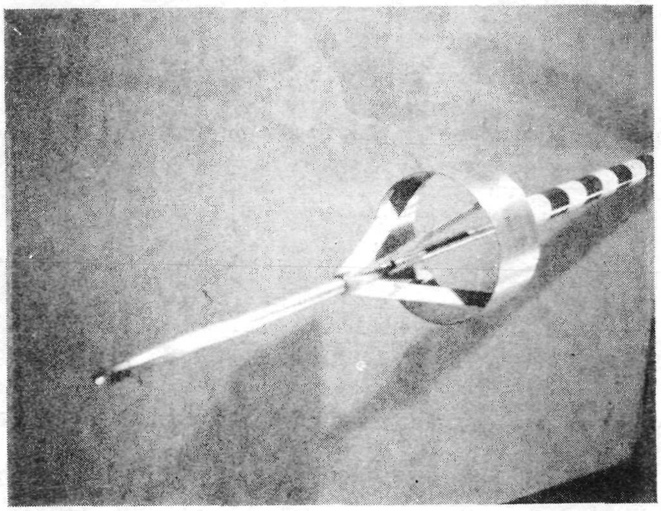


Figure 3
Weathervaning Pitot-
Static Tube, Left
Wingtip Boom

LIFT AND DRAG CHARACTERISTICS

The lift and drag characteristics of the Cardinal were determined from a series of steady, level flight data points conducted at two altitudes, 2500 ft. and 7500 ft. MSL pressure altitude. Two different center of gravity locations were tested.

Engine brake horsepower was determined from engine manifold pressure, rpm, pressure altitude, ambient temperature, and the power chart supplied by the engine manufacturer. The power predicted from the engine chart was then reduced by 5% to account for losses from inlet temperature rise and miscellaneous losses.

Thrust horsepower was determined from brake horsepower, propeller rpm, air density, true airspeed and propeller performance charts. The actual calculations were performed with the aid of a computer program supplied by Cessna Aircraft Company. The program output consists of propeller efficiency, horsepower, and thrust.

Lift and drag were determined by the following equations:

$$D = T \cos\theta \qquad (1)$$
$$L = W - T \sin\theta$$

Weight was determined for each point by plotting the approximate fuel consumed versus time using the known fuel consumption characteristics and approximate power settings, and the initial and final weight of the airplane.

Drag characteristics were determined as follows. As shown in Reference 1, thrust horsepower may be expressed in the following manner:

$$THP_e = THP\sqrt{\sigma} = \frac{C_{d_p}\rho_o S_w V_e^3}{1100} + \frac{W^2}{275\pi e A R \rho_o S_w V_e} \qquad (2)$$

$$THP_e(V_e) = \frac{C_{d_p}\rho_o S_w}{1100} V_e^4 + \frac{W^2}{275\pi e A R \rho_o S_w} = K_1 V_e^4 + K_2 \qquad (3)$$

Thus if $THP_e(V_e)$ is plotted as a function of V_e^4, a normal drag polar will appear as a straight line, and C_{d_p} and e can be determined from the slope,

K_1 and intercept, K_2 of the line. (Note that V_e is converted to ft/sec in Equations 4 and 5).

$$C_{d_p} = \frac{K_1 \; 348.4}{\rho_o S_w} \tag{4}$$

$$e = \frac{W^2}{403.4 \pi AR \rho_o S_w K_2} \tag{5}$$

Data from flights 5, 7, 9, 10, 11 and 13 were plotted in Figures 4 through 9. A straight line approximation was drawn using the least squares method. An average slope and intercept for all flights were then computed to determine C_{d_p} and e for both the clean and full flap configurations.

The Cessna 177 Handbook cruise performance was developed by Cessna from their flight test data. For comparison, the specified altitude, manifold pressure, rpm, and airspeed in the Handbook were treated as flight test data and THP_e was obtained in the same manner as all other flight test data in this report. The resulting Handbook points are plotted in Figure 10 along with data from flights 9, 10 and 13, converted to a 2500 lb. gross weight. The agreement is very close.

Table II shows a comparison of e and C_{d_p} calculated from flight test data for Cardinal N1910F and the Handbook data.

Table II Drag Characteristics Determined From Flight Test and Handbook Data

	C_{d_p}	e
Handbook - Clean	0.0258	0.564
Flight Test - Clean	0.0267	0.564
Flight Test - Full Flaps	0.0462	0.545

Clearly the agreement is quite good for the clean airplane. As might be expected, the induced drag efficiency factor, e, is identical, but the zero lift drag of the test airplane is slightly higher than indicated in the

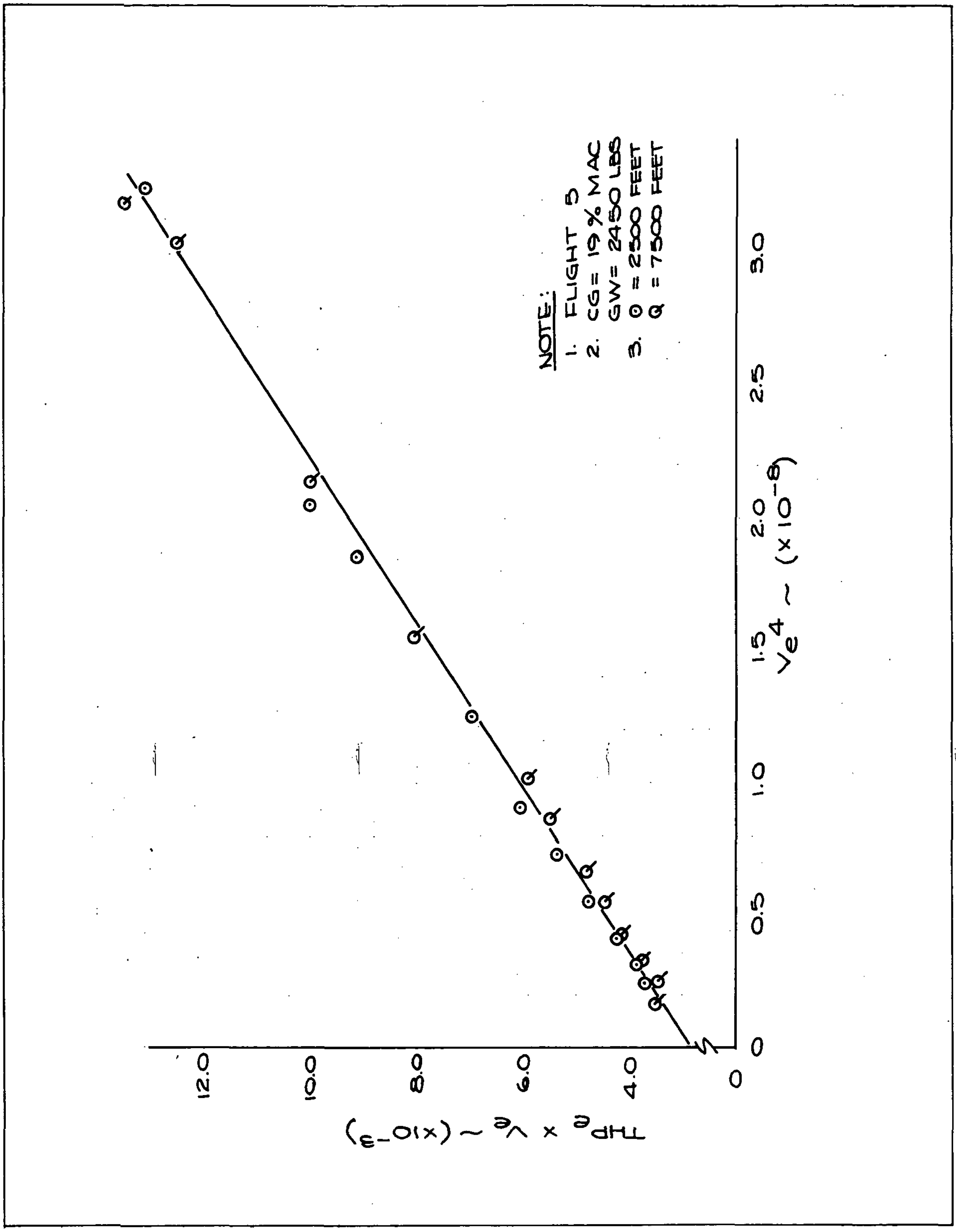


FIG. 4 ~ STEADY STATE PERFORMANCE ~ FLIGHT 5

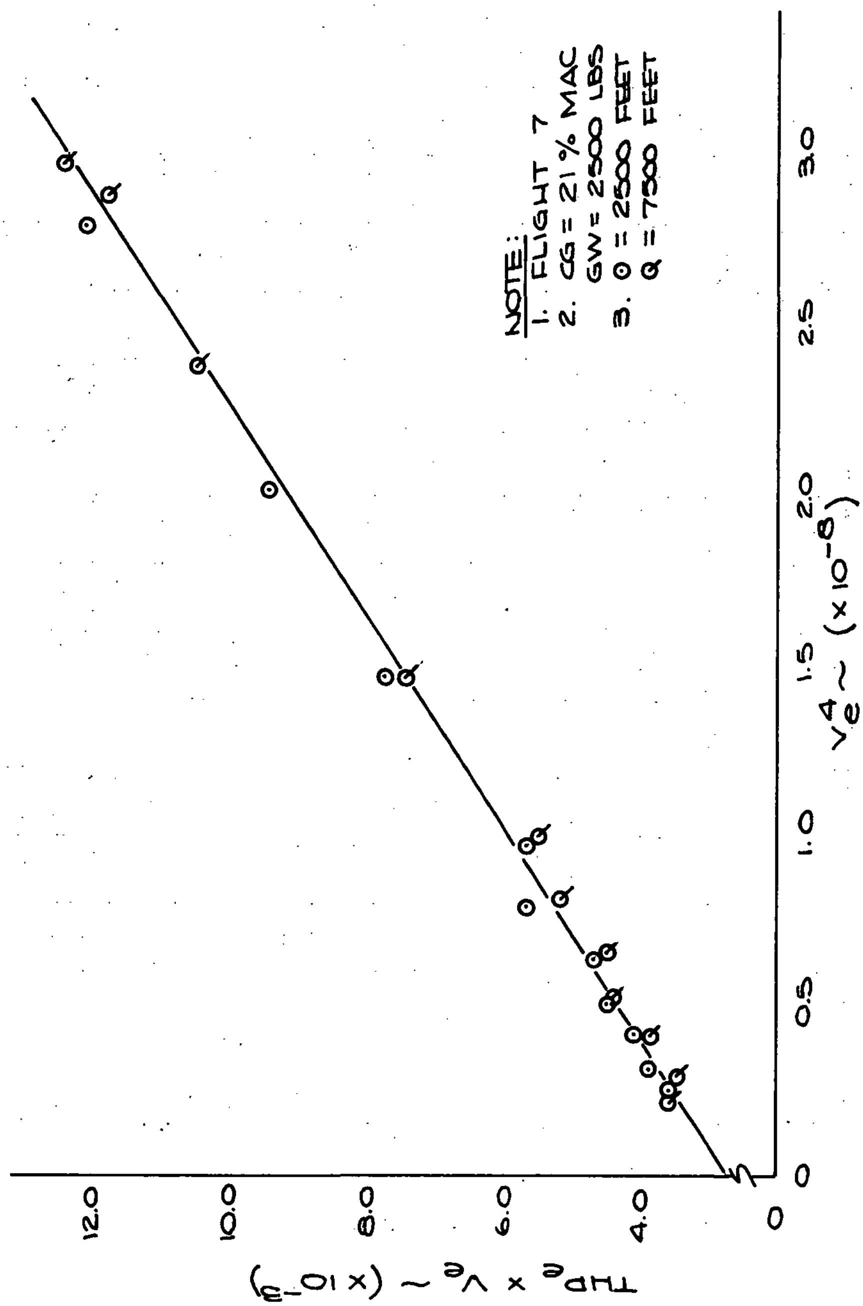


FIG. 5 ~ STEADY STATE PERFORMANCE ~ FLIGHT 7

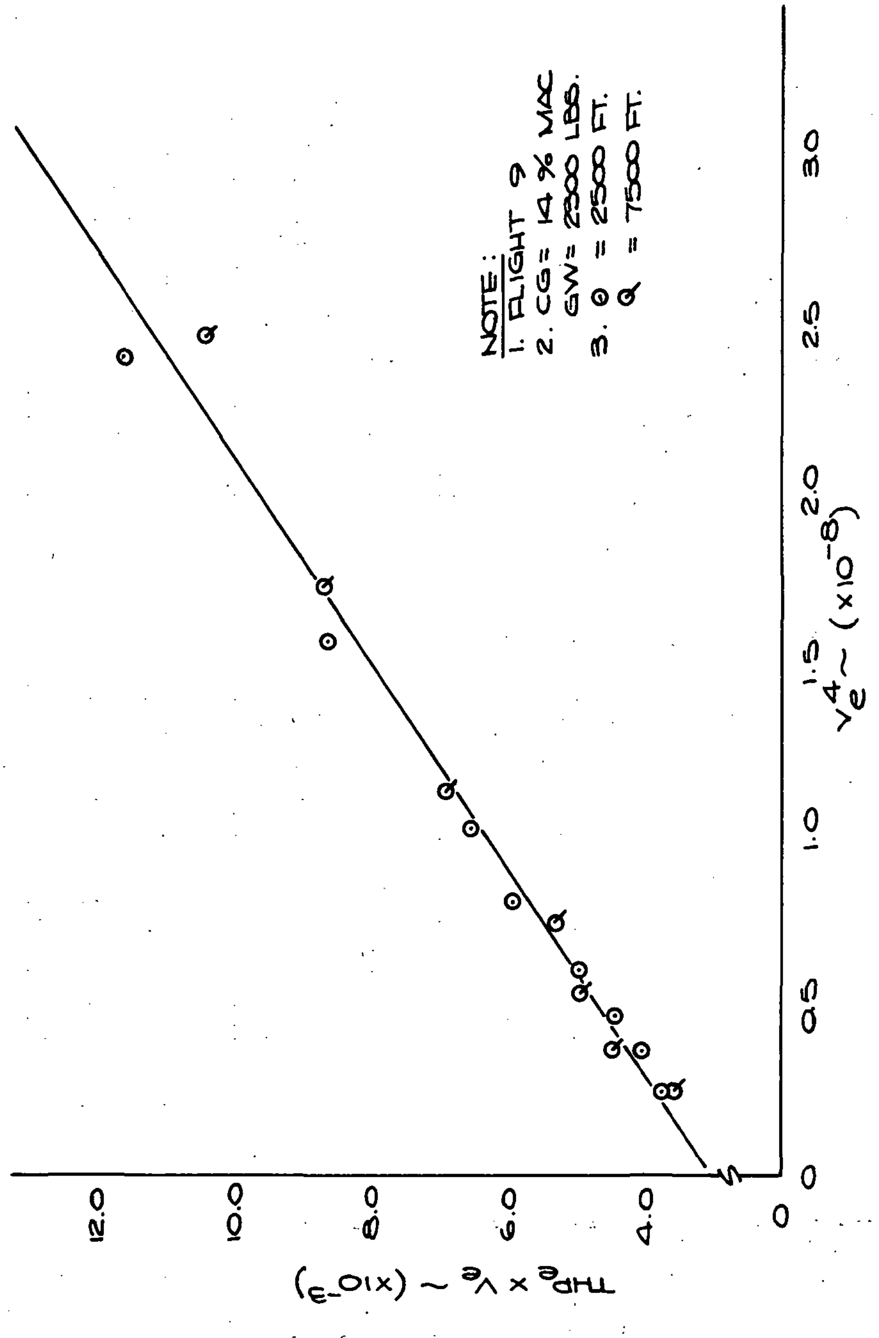


FIG. 6 ~ STEADY STATE PERFORMANCE ~ FLIGHT 9

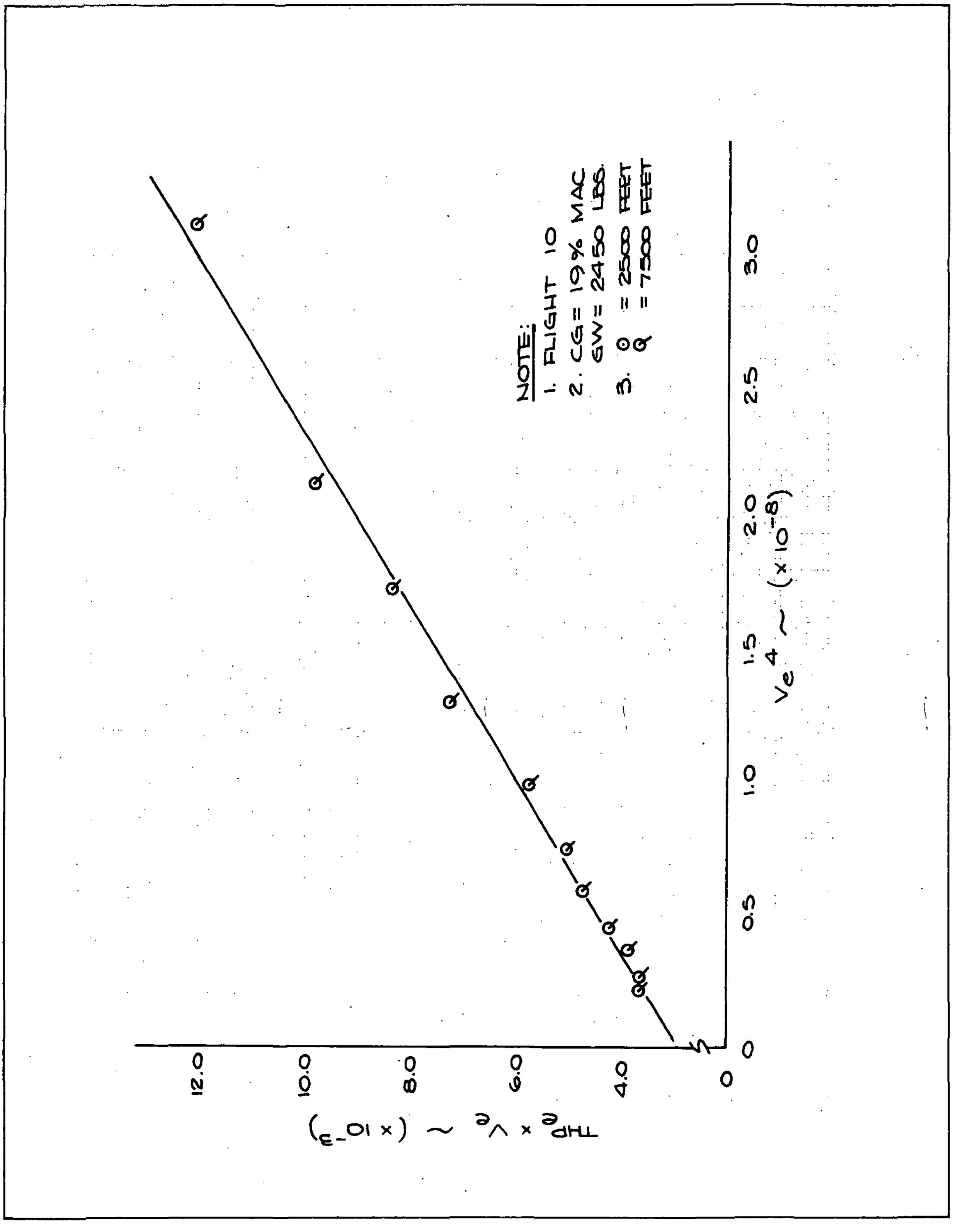


FIG. 7 ~ STEADY STATE
PERFORMANCE ~ FLIGHT 10

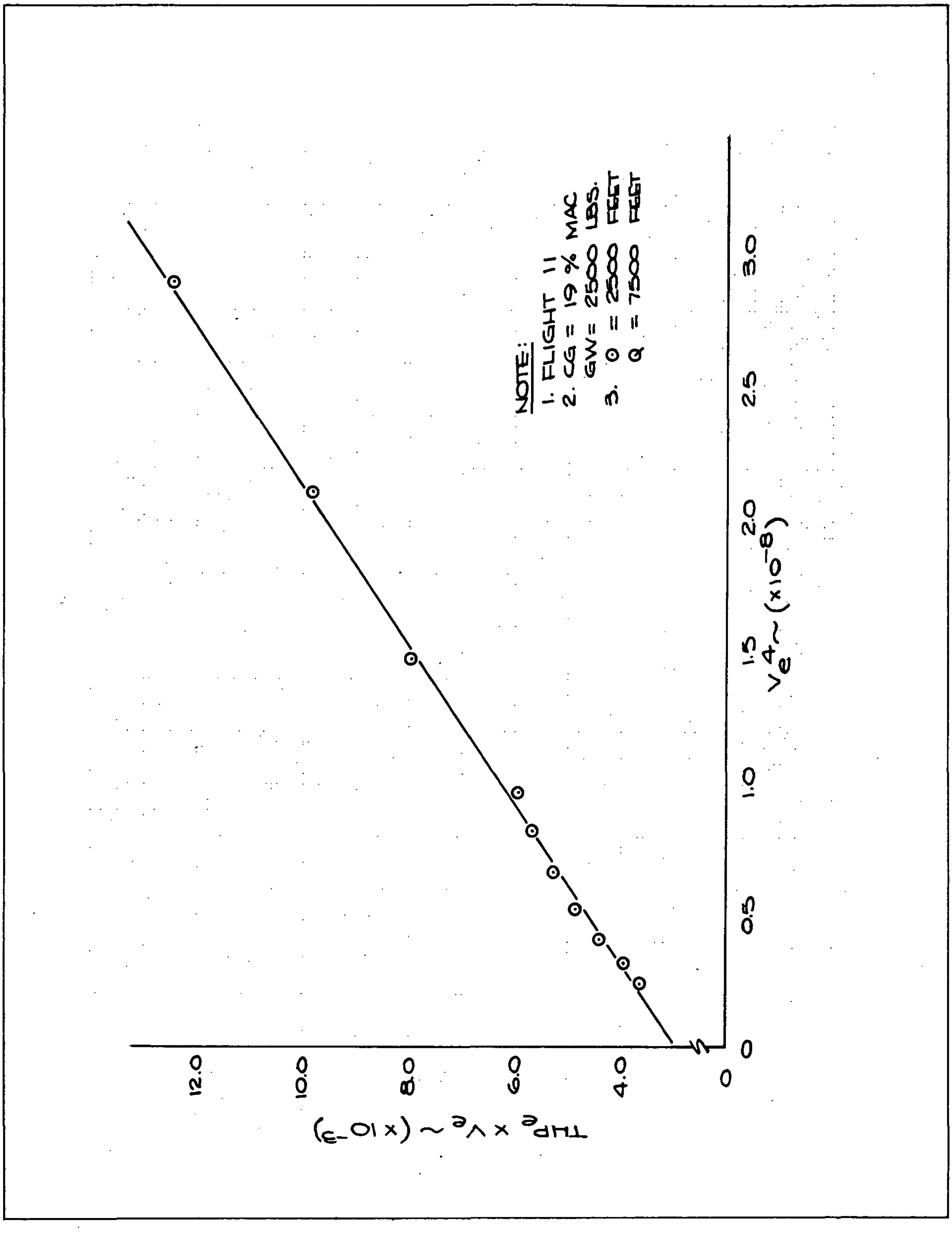


FIG. 8 ~ STEADY STATE
PERFORMANCE ~ FLIGHT 11

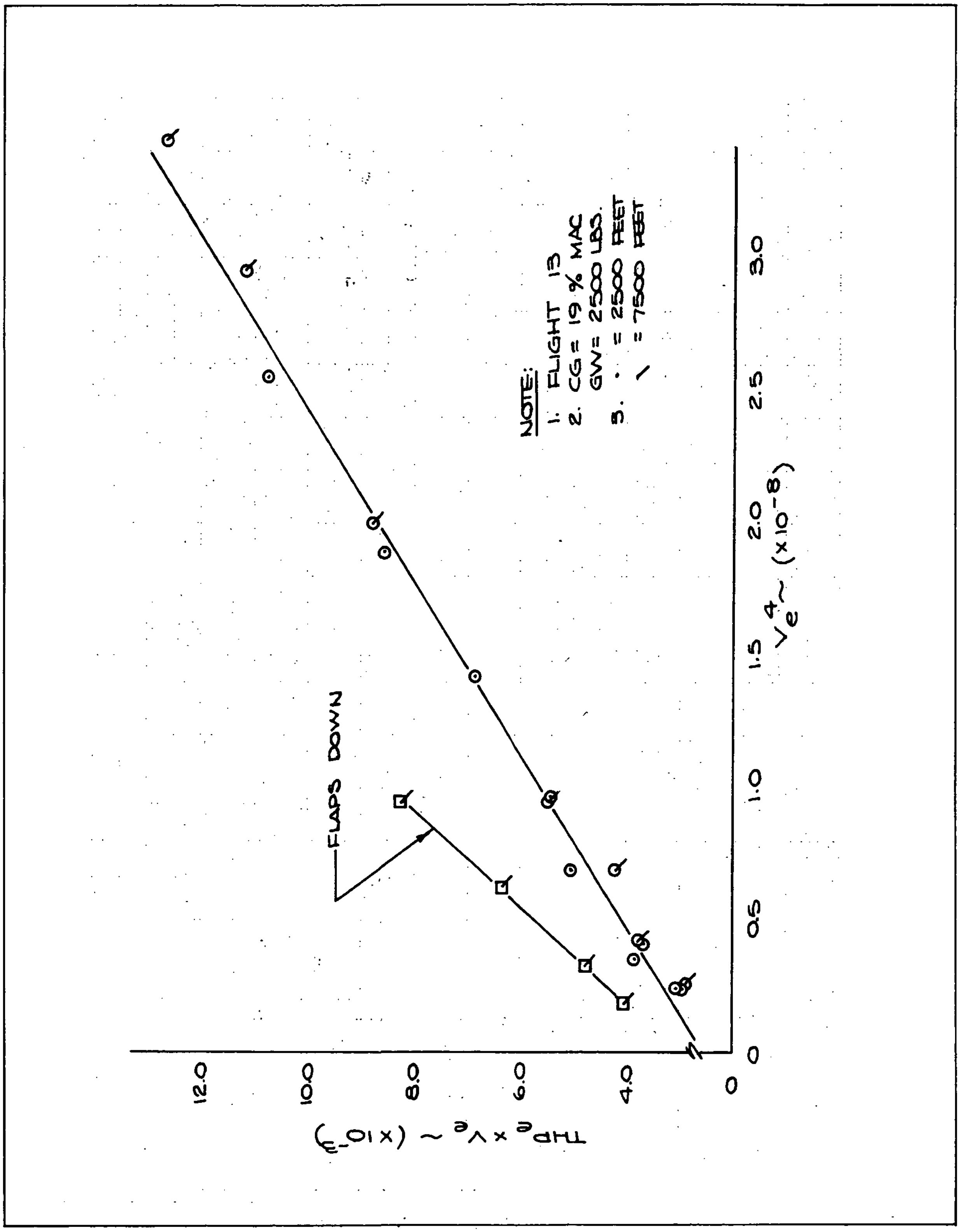


FIG. 9 ~ STEADY STATE PERFORMANCE ~ FLIGHT 13

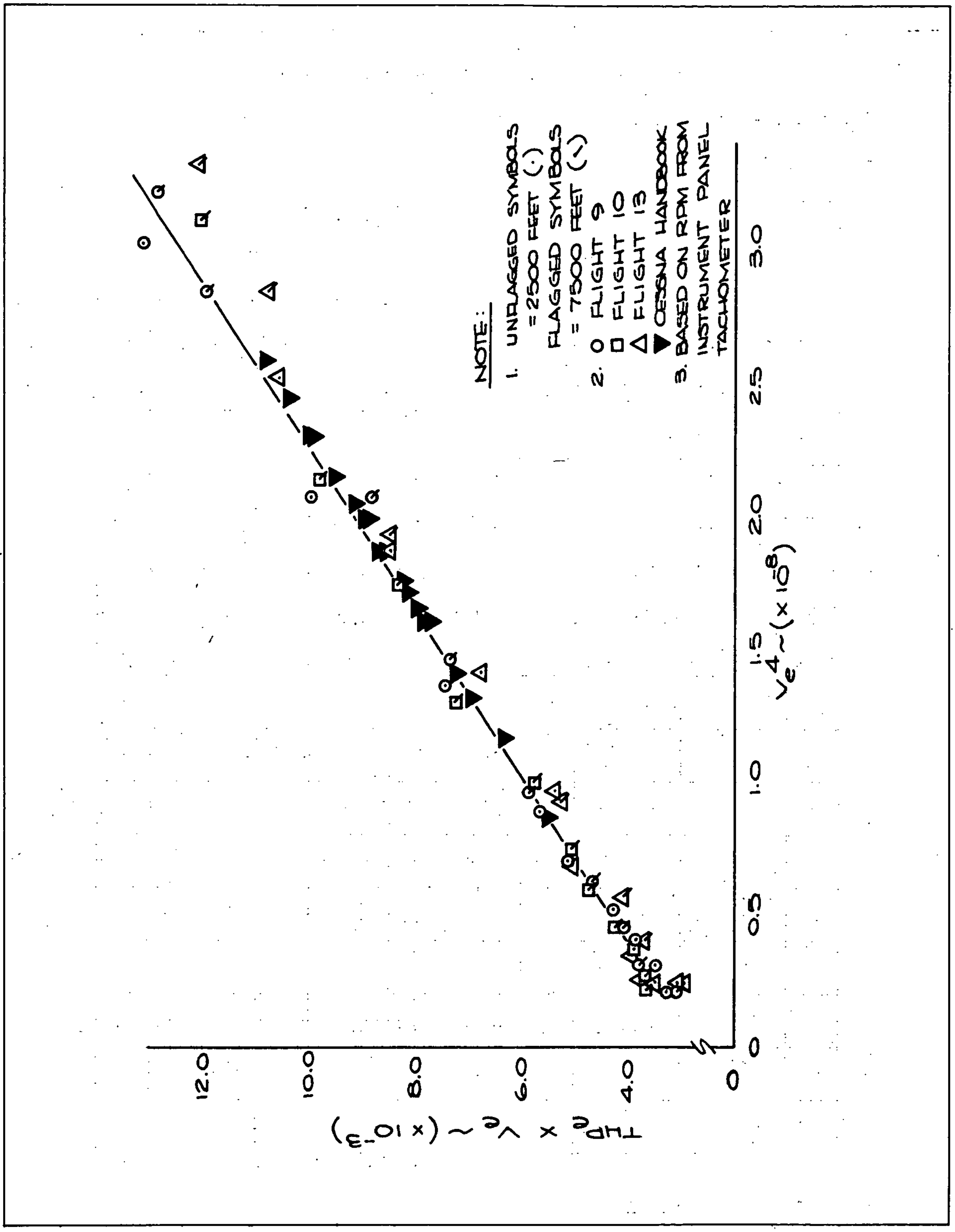


FIG. 10 ~ COMPARISON OF FLIGHT TEST AND HANDBOOK CRUISE PERFORMANCE

Handbook. However, the test airplane had instrumentation booms on each wing and was not in the brand new condition of the airplanes used for the Handbook data. Furthermore, the wings on the test airplane had a slight permanent deformation due to a previous structural integrity test.

The full flaps configuration increased C_{d_p} substantially and reduced e slightly, as would be expected.

The final averaged drag polar and horsepower-velocity curves for the test Cardinal are presented in Figures 11 and 12. These will be the basis of comparison with the modified Cardinal. Note that in the clean configuration the maximum lift to drag ratio is $L/D_{max} = 11.0$.

As a further check on the data recorded and the accuracy of the thrust horsepower program, the maximum rate-of-climb and corresponding airspeed were calculated using the curve in Figure 12 for two altitudes. The results are shown in Table III. The computed rates of climb are slightly lower than Handbook values because of the higher zero lift drag coefficient, and the speed for maximum rate-of-climb is in perfect agreement.

Table III Cardinal Climb Performance

Altitude		Computed From Flt. Test Data	Cardinal Handbook
2500 Ft.	Max. R/C	706 Ft/Min	712 Ft/Min
	Best R/C Speed V_e	90 MPH	90 MPH
7500 Ft.	Max. R/C	416 Ft/Min	457 Ft/Min
	Best R/C Speed V_e	85 MPH	85.5 MPH

Note that the computed maximum airspeed at 2500 ft. and 7500 ft. are 146.5 mph and 130 mph CAS respectively. These are very close to observed values.

Figure 13 is a plot of lift versus angle of attack for the clean and full flaps configurations. The data is in good agreement except for the low C_L data of flight 13 which showed a consistent deviation for which no expla-

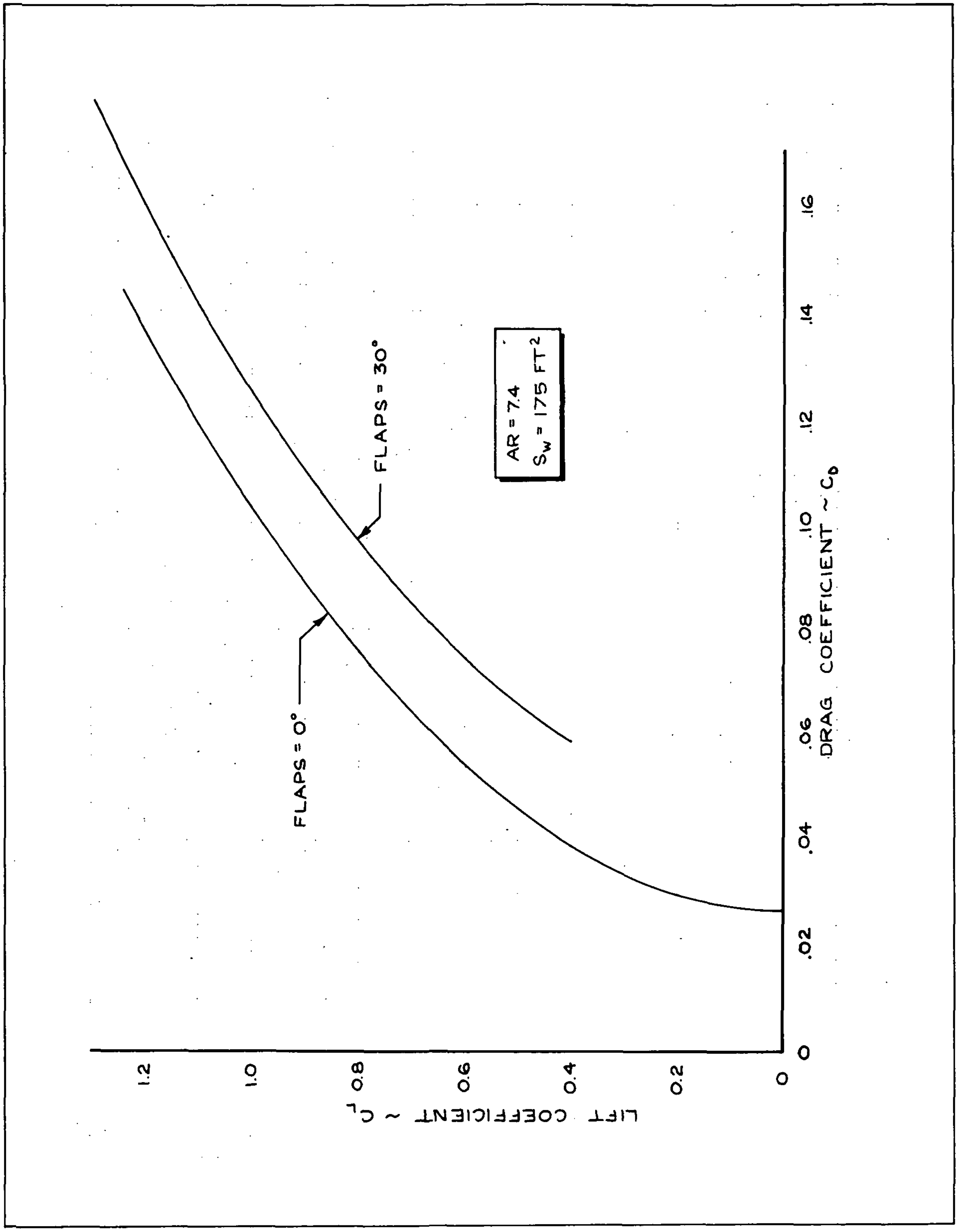
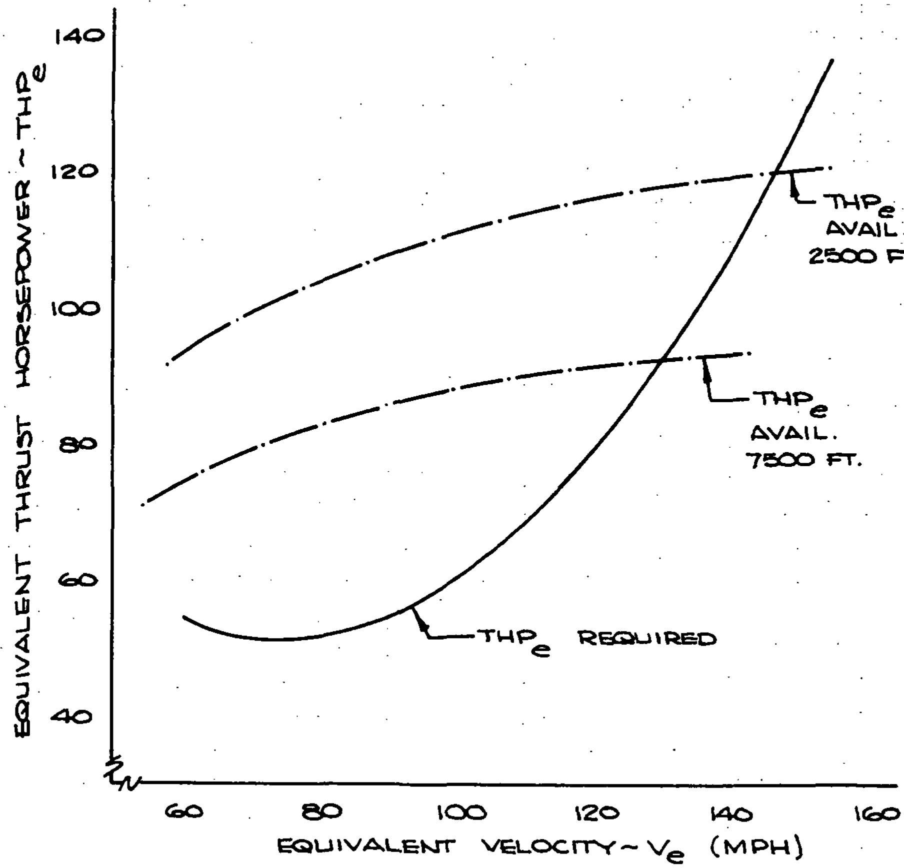


FIG. 11 ~ FLIGHT TEST
DRAG POLARS



NOTE:

1. GROSS WEIGHT = 2500 LBS.

FIG. 12 ~ FLIGHT TEST POWER REQUIRED AND AVAILABLE

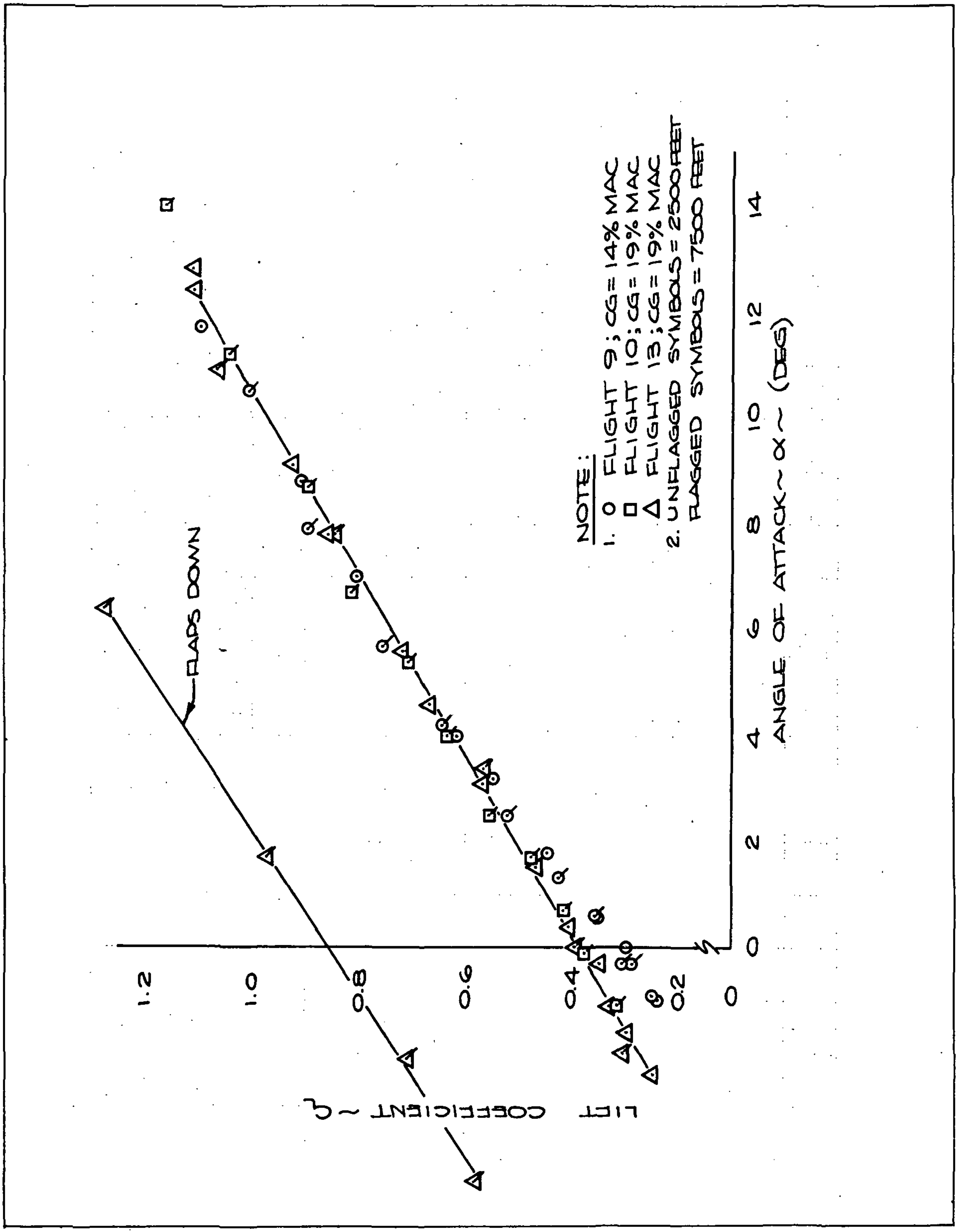


FIG. 13 ~ CARDINAL TRIMMED LIFT CURVES

nation could be found.

The trimmed lift curve slopes are as follows:

Clean $\quad C_{L_\alpha} = 0.0582$ per deg.

Full Flaps $\quad C_{L_\alpha} = 0.0651$ per deg.

The shift in angle of attack caused by full flap deflection at constant C_L is approximately 7.5° at $C_L = 0.6$.

TRIM CHARACTERISTICS

Horizontal stabilizer angle as a function of airspeed was measured. The results are shown in Figures 14 and 15 for the clean and full flaps configurations. The stick-fixed speed stability is positive over the entire speed range but decreases with the flaps down. As expected, there is a linear relationship between δ_{stab} and C_L. While the stability decreases with an aft shift in center of gravity, the difference was not large enough to extrapolate to the neutral point with acceptable accuracy.

Stability derivatives obtained from the data were as follows:

Clean $\quad C_{L_{\delta_{stab}}} = -0.126 \text{ deg}^{-1}$

Full Flaps $\quad C_{L_{\delta_{stab}}} = -0.235 \text{ deg}^{-1}$

CG = 19% MAC

ROLL PERFORMANCE

Roll data were obtained by two methods. In the first, the airplane was stabilized in level flight. The ailerons were then given a full deflection as rapidly as possible and held until the roll angle reached 60°. The rudder pedals were held fixed. Data were recorded for two airspeeds, 80 mph and 120 mph CAS. In the second, the airplane was rolled past a bank angle of 45°, then rolled with full aileron deflection through an opposite bank angle of 45°. Rudder pedals were held fixed and the initial airspeed was 120 mph CAS.

The data are summarized in Table IV. In addition, Figures 16 and 17 show time histories of rolls from 0° through 30° for 80 mph and 120 mph CAS.

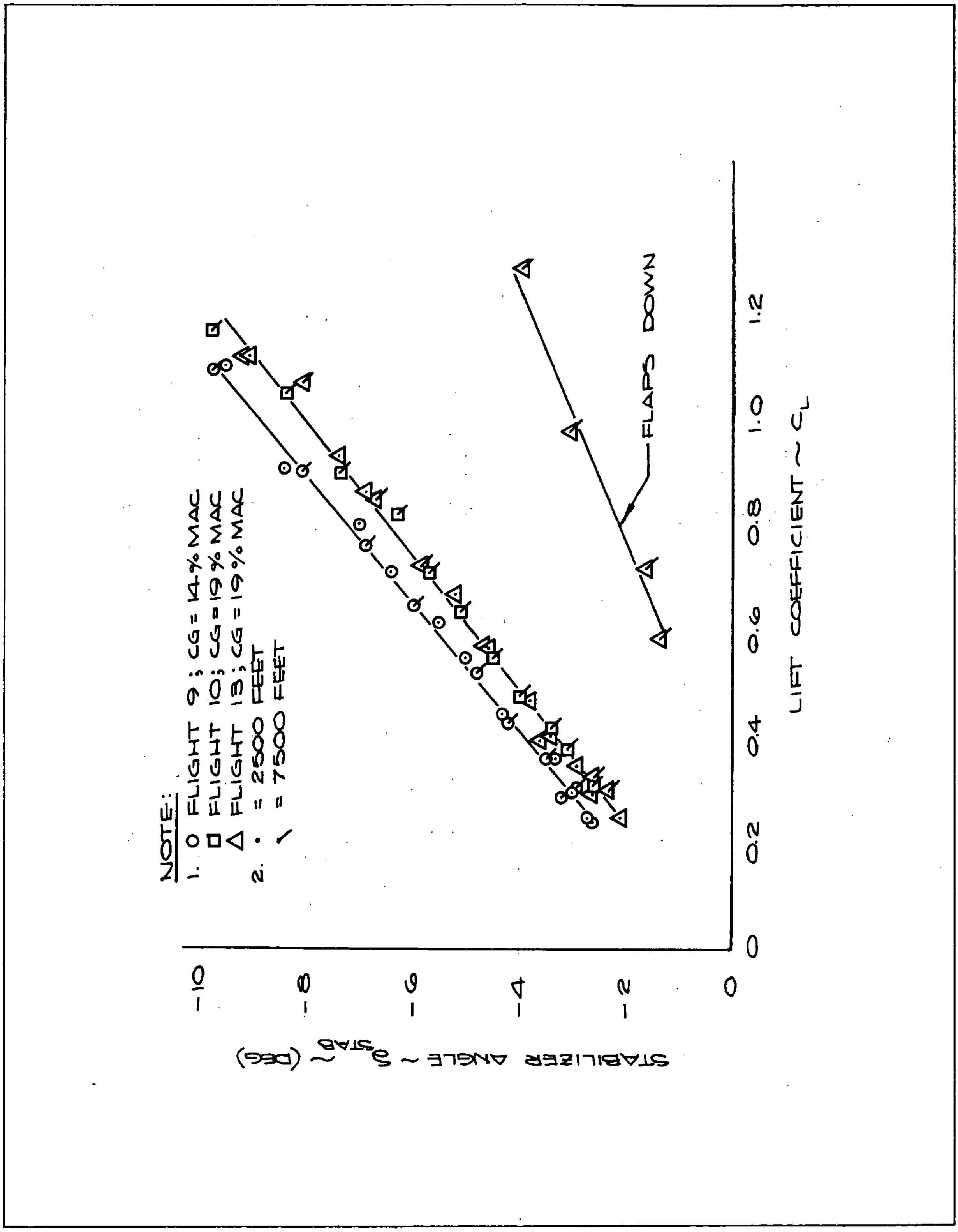


FIG. 14 ~ STABILIZER
TRIM DATA

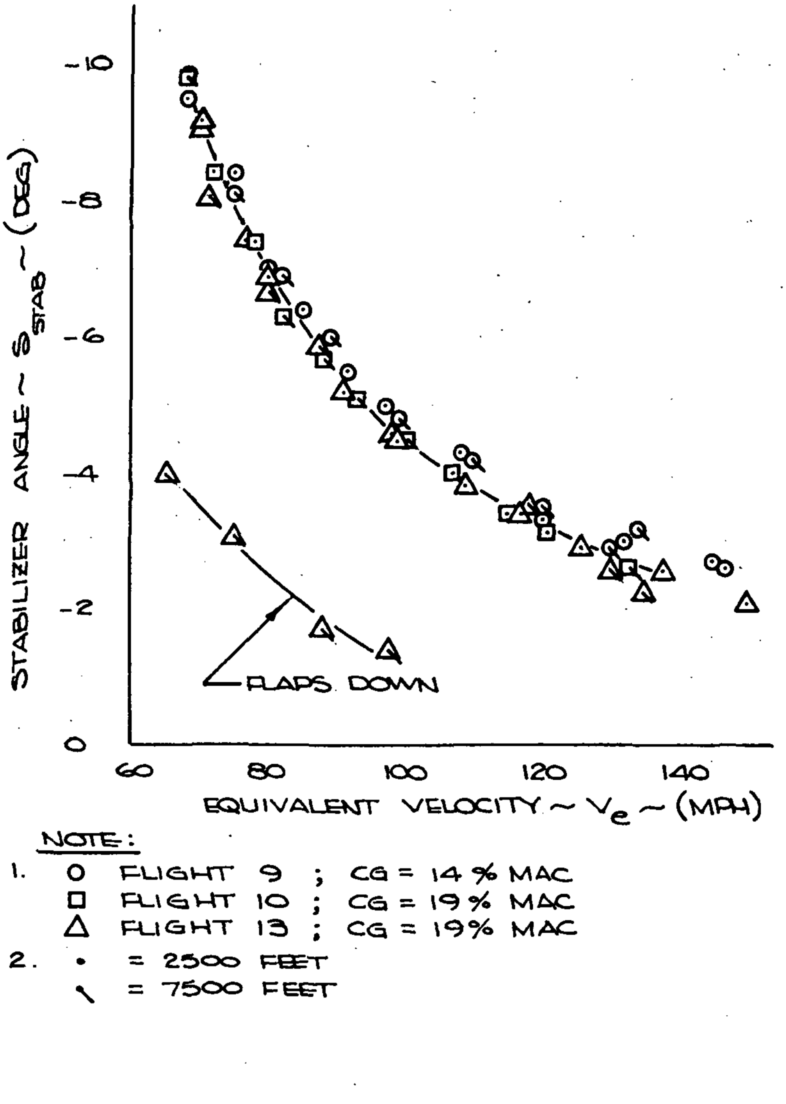


FIG. 15 ~ SPEED STABILITY AND STABILIZER TRIM

Table IV Summary of Roll Data - Flight 8

Point No.	Direction	Altitude	Airspeed (IAS)	Time to ϕ=30°	$\dot{\phi}_{MAX}$	β at ϕ=30°	β_{MAX}	$\dot{\beta}_{MAX}$	$(\frac{pb}{2V})_T$
4	Left	4000	80	1.41 SEC	-35.9°/SEC	-8.5°	-18.6°	-16°/SEC	0.0896
	Left		80	1.02	-35.9	-	-20°	-17°/SEC	0.0896
5	Right	4000	80	1.12	+34.1	+11°	+24°	+15	0.0851
	Right		80	1.03	+33.2	+ 9°	+25°	+15	0.0828
6	Left	4100	120	0.73	-54.7	- 3°	-7.4°	-11	0.0909
	Left		120	0.70	-54.7	-3.5°	-8.8°	-11	0.0955
7	Right	4100	120	0.74	+54.7	+3.5°	+11.0°	+10	0.0909
	Right		120	0.70	+53.8	+ 3°	+12.2°	+11	0.0895
8	45°Rto45°L	4000	120	-	-58			-12	0.0980
9	45°Lto45°R	4000	120	-	+53			+13	0.0894

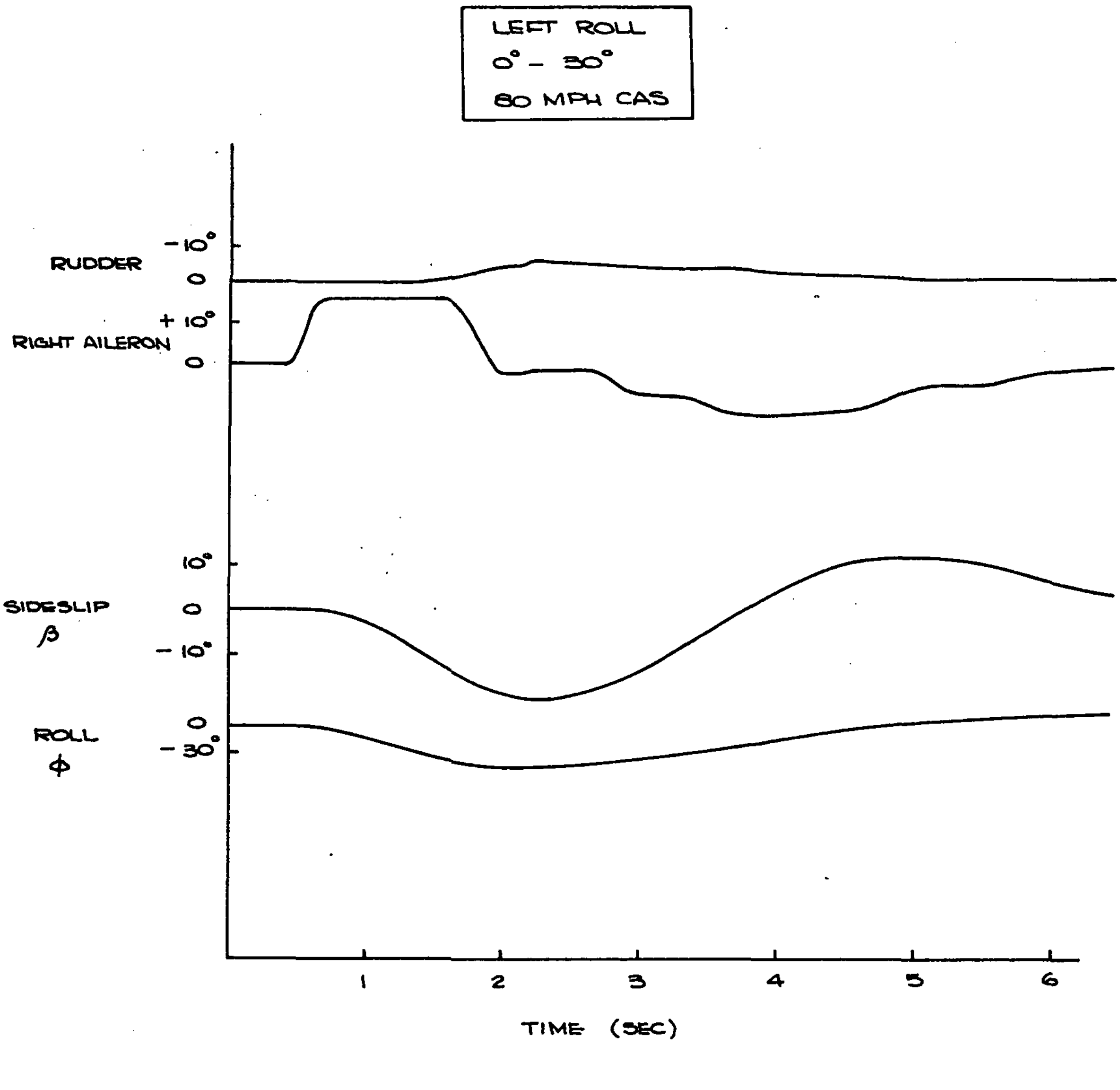


FIG. 16 ~ LOW SPEED ROLL TIME HISTORY

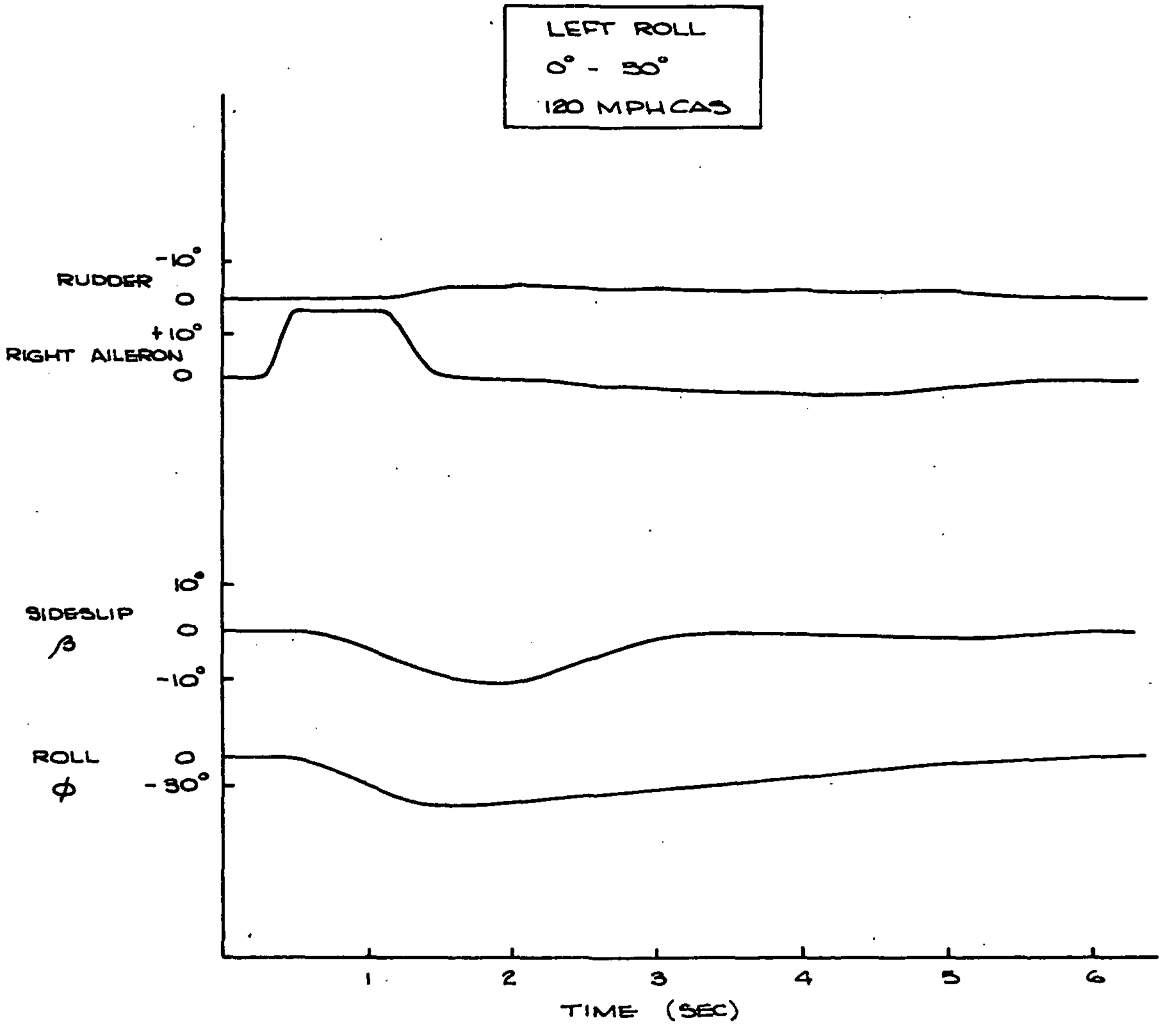


FIG. 17 ~ HIGH SPEED ROLL TIME HISTORY

Note that there are two roll criteria used in handling quality specifications, time to $\phi = 30°$ and steady state helix angle, pb/2V. For light aircraft, the normally specified criteria are: time to roll to 30° should be less than 1.0 sec. as a desirable level, with the minimum acceptable level being a roll to 30° in 2.0 seconds or less (Reference 2); roll helix angle, pb/2V should be greater than 0.07.

At low speed, the time to roll to 30° is just slightly above the minimum desirable level. At high speed, this criteria is easily met. The pb/2V criterion is satisfied easily at all speeds.

At low speed the average maximum roll rate is 34.8°/sec. At high speed, the average maximum roll rate is 54.5°/sec. There is good agreement in the steady state roll rates achieved in the 0° to 30° rolls and the 45° to 45° roll maneuvers.

Also of interest is the amount of adverse yaw generated by aileron inputs. As shown in Table IV, at low speed the slideslip angle ranges from 8.5° to 11° at $\phi = 30°$ with sideslip rates exceeding 15°/sec. At high speed the sideslip magnitude is reduced because of the higher roll rate, but sideslip rates are approximately 11°/sec. During the recovery maneuver the sideslip angle increased to over 20° at low speed. As can be seen in Figures 16 and 17, the large sideslip angle caused some rudder deflection due to cable stretching, even though the rudder pedals were held fixed.

LONGITUDINAL DYNAMIC CHARACTERISTICS

Longitudinal dynamic data were taken in the following manner. The airplane was stabilized and trimmed in level flight. The elevator was deflected to provide a longitudinal disturbance, then returned to the original trimmed position. The resulting phugoid mode was then allowed to oscillate through several cycles. Lateral inputs were made as required to keep the wings level.

The results are summarized in Table V. Frequency and damping ratios

Table V Phugoid Mode Characteristics of the Cardinal

Run No.	Flap Position	Period (SEC)	Freq. (RAD/SEC)	Damping Ratio	Trim Airspeed (MPH)	CG (%MAC)	WT. (LBS)	Initial Condition α (DEG)	δ_{STAB} (DEG)
17	0°	19.0	0.330	0.061	80	18.99	2464	6.6	1.1
18	0°	17.6	0.357	0.047	80	18.99	2463	6.6	1.1
19	30°	18.5	0.339	0.045	80	18.99	2560	10.8	-2.5
20	30°	19.4	0.324	0.044	80	18.99	2459	10.0	-2.5

were determined from analysis of the oscillograph data assuming a standard second order dynamic system model. Note that there is only a slight difference in characteristics with flaps deployed, with both frequency and damping appearing to decrease with increased flap deflection.

DUTCH ROLL CHARACTERISTICS

As is usually the case with light, single engine aircraft, the dutch roll mode was highly damped. A time history of a typical dutch roll excitation is shown in Figures 18 and 19. The maneuver was initiated by inducing a large sideslip angle with the rudder, then centering the rudder and aileron quickly while allowing the oscillation to damp. The high damping ratio makes it extremely difficult to extract accurate quantitative results from the data, but the frequency appears to be approximately 1.60 rad/sec and the damping ratio ζ_d in excess of 0.5 at 80 mph CAS. At 120 mph CAS, the frequency is approximately 2.1 rad/sec and the damping ratio in excess of 0.4.

STALL PERFORMANCE

A total of 21 stalls were performed to determine the stall speeds for both the clean and flaps down configurations. Stalls were initiated by reducing the power to idle and decelerating at approximately one knot per second from an airspeed of about 10 to 15 knots above anticipated stall speed. Stall speed was defined as the calibrated airspeed at which the nose of the airplane pitched down involuntarily.

Table VI summarizes the stall data. The measured stall speeds of 64.7 and 55.0 mph for the clean and full flap configurations compare with Handbook values of 63 and 53 mph respectively. Note that $C_{L_{max}}$ was somewhat higher for flights with a rearward c.g. location as would be expected.

REFERENCES

1. Petersen, F. S., "Aircraft and Engine Performance"; Naval Air Test Center, Patuxent River, Maryland 1958.

2. Ellis, David R., "Flying Qualities of Small General Aviation Airplanes, Part 4"; Report No. FAA-RD-71-118, Dept. of Transportation, FAA, December 1971.

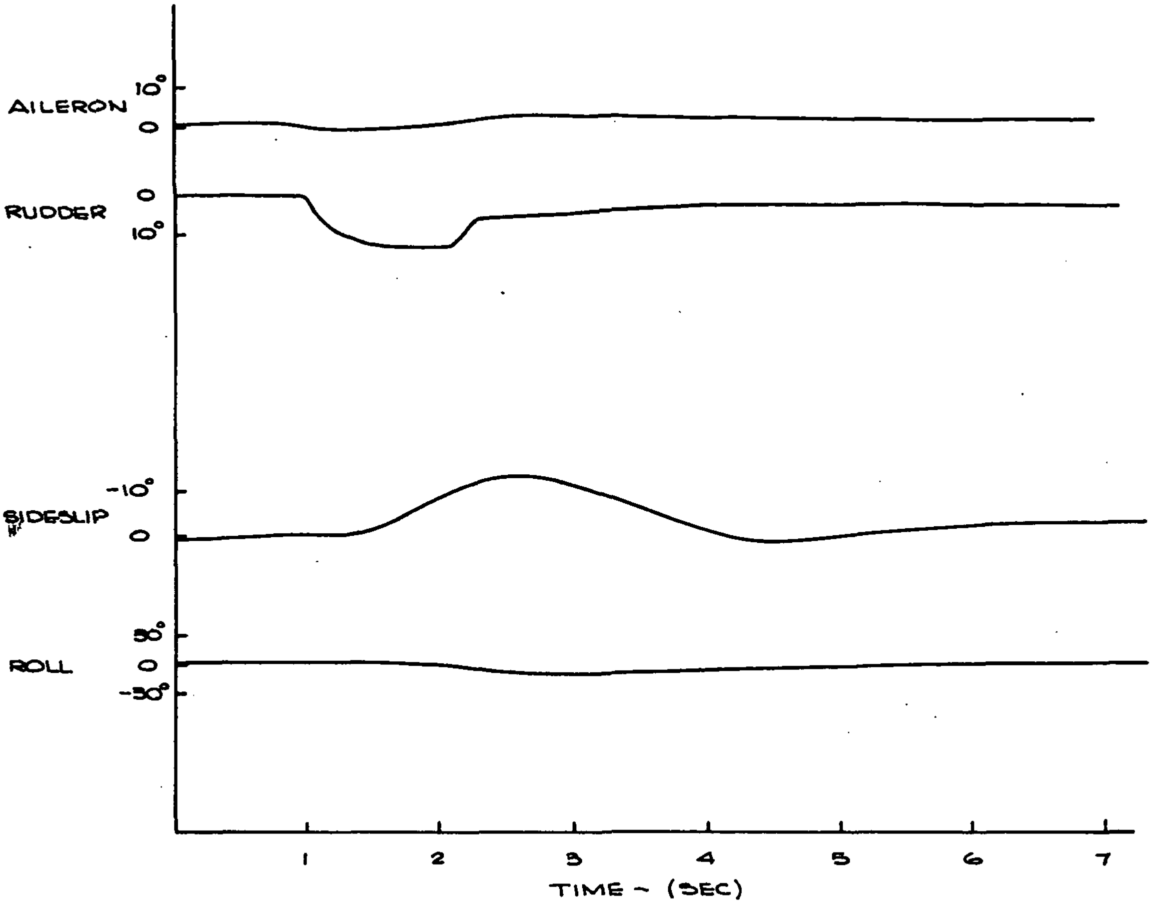


FIG. 18 ~ LOW SPEED DUTCH ROLL EXCITATION
80 MPH CAS

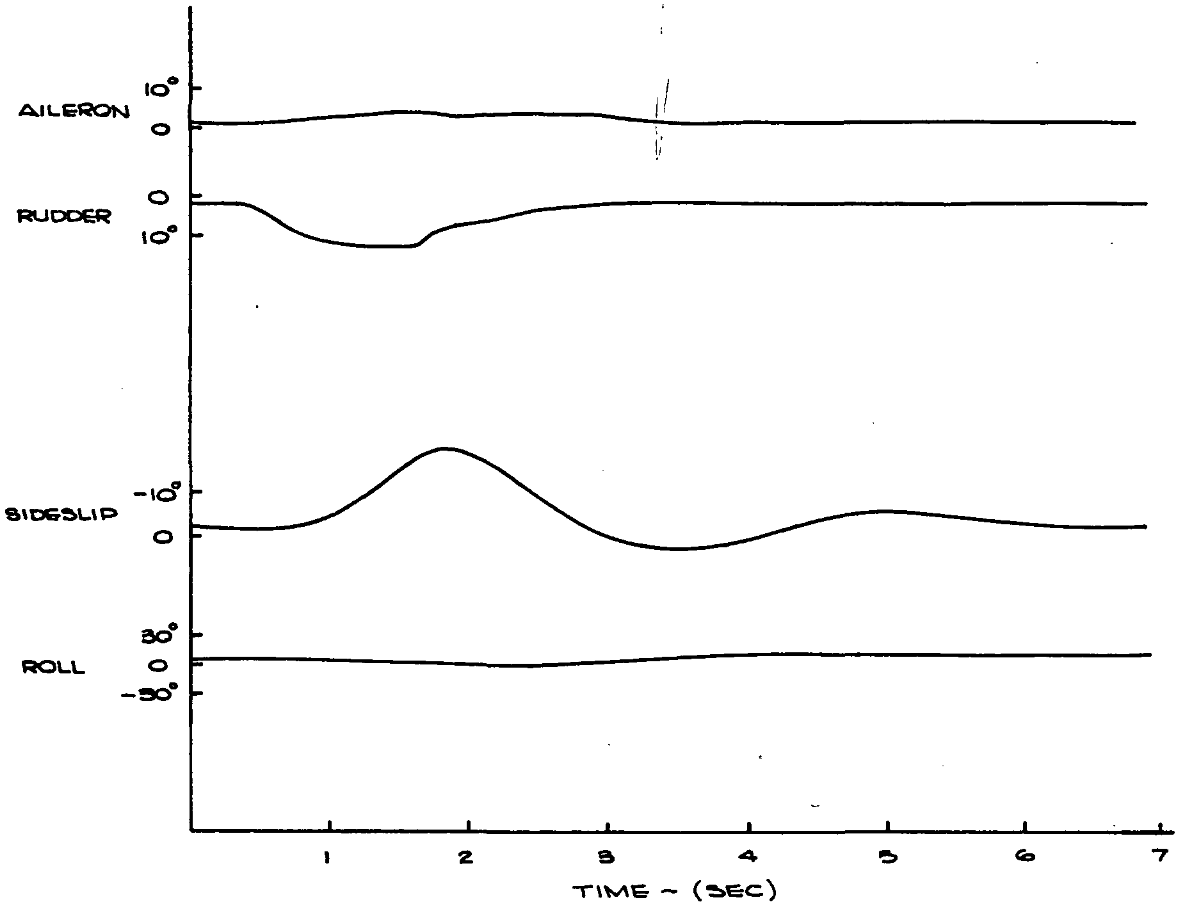


FIG. 19 ~ HIGH SPEED DUTCH ROLL EXCITATION
120 MPH CAS

Table VI Summary of Cardinal Stall Data

Flt.	Run	IAS-MPH	Weight	C.G. Location	Flaps	Alt.	$C_{L_{MAX}}$
5	14	65	2440	19% $\bar{c}$	0°	7500	1.28
	15	65	2400	19%	0°	7500	1.28
	16	55	2400	19%	30°	7500	1.80
	17	55	2400	19%	30°	7500	1.80
7	26	65	2500	21%	0°	7500	1.32
	27	65	2500	21%	0°	7500	1.32
	30	53	2500	21%	30°	7500	1.98
	31	53	2500	21%	30°	7500	1.98
9	21	65	2290	14%	0°	7500	1.21
	22	65	2290	14%	0°	7500	1.21
	25	54	2290	14%	30°	7500	1.75
	26	53	2290	14%	30°	7500	1.82
	27	54	2290	14%	30°	7500	1.75
10	12	62	2460	19%	0°	7500	1.42
	13	63	2460	19%	0°	7500	1.38
	14	62	2460	19%	0°	7500	1.42
	18	55	2460	19%	30°	7500	1.82
	19	55	2460	19%	30°	7500	1.95
	20	53	2460	19%	30°	7500	1.95
13	25	55	2450	19%	30°	7500	1.80
	26	65	2450	19%	0°	7500	1.29

Average $C_{L_{MAX}}$ (Flaps=0) = 1.35

Average $C_{L_{MAX}}$ (Flaps=30°) = 1.84

For Wt. = 2500 LBS.

Stall Speed = 64.7 MPH
(δ_F = 0)

Stall Speed = 55.0 MPH

APPENDIX

Configuration Details of the Cessna Cardinal

Configuration Details of the Cessna Cardinal

The following data on the Cessna Cardinal are taken from the Cessna Aircraft Co. Drawing No. 1703001, "General Arrangement Model 177".

WING	
Total Wing Area	175 ft.^{2}
Wing Span	36 ft.
Aspect Ratio	7.4
Taper Ratio	0.7
Dihedral Angle	1.5°
Incidence:	
Root	3.5°
Tip	.5°
FLAP	
Area (both)	29.5 ft.^{2}
Type	Single Slot
Deflection	0° up; 30° down
% of Wing at L.E.	70
Span (each)	116 in.
HORIZONTAL STABILATOR	
Area	35 ft.^{2}
Tab Area	2.59 ft.^{2}
Span	11.83 ft.
Aspect Ratio	4.0
Taper Ratio	1.0
Deflection	20° up; 5° down ±1°
Tab Deflection	2° up; 7° down ±1°
VERTICAL STABILIZER	
Area (including rudder)	18.81 ft.^{2}
Span	4.78 ft.
Aspect Ratio	2.031
Taper Ratio	.553
L.E. Sweep Angle	39°42'
Rudder Area	6.41 ft.^{2}
Rudder Travel	24°L; 24°R ±1°

Table VI Summary of Cardinal Stall Data

Flt.	Run	IAS-MPH	Weight	C.G. Location	Flaps	Alt.	$C_{L_{MAX}}$
5	14	65	2440	19% $\bar{c}$	0°	7500	1.28
	15	65	2400	19%	0°	7500	1.28
	16	55	2400	19%	30°	7500	1.80
	17	55	2400	19%	30°	7500	1.80
7	26	65	2500	21%	0°	7500	1.32
	27	65	2500	21%	0°	7500	1.32
	30	53	2500	21%	30°	7500	1.98
	31	53	2500	21%	30°	7500	1.98
9	21	65	2290	14%	0°	7500	1.21
	22	65	2290	14%	0°	7500	1.21
	25	54	2290	14%	30°	7500	1.75
	26	53	2290	14%	30°	7500	1.82
	27	54	2290	14%	30°	7500	1.75
10	12	62	2460	19%	0°	7500	1.42
	13	63	2460	19%	0°	7500	1.38
	14	62	2460	19%	0°	7500	1.42
	18	55	2460	19%	30°	7500	1.82
	19	55	2460	19%	30°	7500	1.95
	20	53	2460	19%	30°	7500	1.95
13	25	55	2450	19%	30°	7500	1.80
	26	65	2450	19%	0°	7500	1.29

Average $C_{L_{MAX}}$ (Flaps=0) = 1.35

Average $C_{L_{MAX}}$ (Flaps=30°) = 1.84

For Wt. = 2500 LBS.

Stall Speed = 64.7 MPH
(δ_F = 0)

Stall Speed = 55.0 MPH

Configuration Details of the Cessna Cardinal Cont'd

AILERON

Area (both)	
Aft of hinge line	14.09 $ft.^2$
Forward of hinge line	4.77 $ft.^2$
Deflection	20° up; 15° down ±2°

NASA-Langley, 1974 —— 2 CR-2337

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

SPECIAL FOURTH-CLASS RATE
BOOK

POSTAGE AND FEES PAID
NATIONAL AERONAUTICS AND
SPACE ADMINISTRATION
451

U.S.MAIL

POSTMASTER : If Undeliverable (Section 158 Postal Manual) Do Not Return

"The aeronautical and space activities of the United States shall be conducted so as to contribute . . . to the expansion of human knowledge of phenomena in the atmosphere and space. The Administration shall provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

—NATIONAL AERONAUTICS AND SPACE ACT OF 1958

NASA SCIENTIFIC AND TECHNICAL PUBLICATIONS

TECHNICAL REPORTS: Scientific and technical information considered important, complete, and a lasting contribution to existing knowledge.

TECHNICAL NOTES: Information less broad in scope but nevertheless of importance as a contribution to existing knowledge.

TECHNICAL MEMORANDUMS: Information receiving limited distribution because of preliminary data, security classification, or other reasons. Also includes conference proceedings with either limited or unlimited distribution.

CONTRACTOR REPORTS: Scientific and technical information generated under a NASA contract or grant and considered an important contribution to existing knowledge.

TECHNICAL TRANSLATIONS: Information published in a foreign language considered to merit NASA distribution in English.

SPECIAL PUBLICATIONS: Information derived from or of value to NASA activities. Publications include final reports of major projects, monographs, data compilations, handbooks, sourcebooks, and special bibliographies.

TECHNOLOGY UTILIZATION PUBLICATIONS: Information on technology used by NASA that may be of particular interest in commercial and other non-aerospace applications. Publications include Tech Briefs, Technology Utilization Reports and Technology Surveys.

Details on the availability of these publications may be obtained from:

SCIENTIFIC AND TECHNICAL INFORMATION OFFICE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Washington, D.C. 20546