ISRAEL AIRCRAFT INDUSTRIES LTD. התעשיה האוירית לישראל בע"מ
ENGINEERING DIVISION חטיבת הנדסה

SECURITY CLASSIFICATION סווג בטחוני

REPORT No. 4820/10483 **דו"ח מס'**

RELEASED BY E.O. NO.: A93-772 :שוחרר לפי הוראה הנדסית

SUBJECT: WESTWIND MODEL 1124 - DYNAMIC AIRCRAFT RESPONSE TO INADVERTENT INFLIGHT THRUST REVERSER DEPLOYMENT :נושא

REFERENCE: :סימוכין

PREPARED: NAME: L. Sternfield L. Beiner :שם :הוכן
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APPROVED: NAME: I. Darel :שם :אושר
SIGNATURE: [redacted] :חתימה

DATE: 25.3.1976 :תאריך

לשמוש תעוד הנדסי

תפוצה: עותק ___ מתוך ___ עותקים

הנמען: ___

אות הוצאה הדו"ח-ראה בכותרת דף הישימות.
אות הוצאה בתחתית הדף מתיחסת לכל דף בנפרד.

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DYNAMIC AIRCRAFT RESPONSE STUDY

A study was conducted to determine the effect of thrust reverser deployment in flight on the motion of the aircraft. This study included both an analytical phase and flight tests.

Longitudinal - Lateral Coupled Motions

At the outset of the investigation, 6 degree-of-freedom calculations were made assuming that the airplane was disturbed from its trimmed flight condition at an altitude of 15,000 feet and M = 0.35 (V_C = 175 Knots) by deployment of the thrust reverser on one engine. Full deployment of the thrust reverser from its stowed condition occurred in 1.0 second. The disturbance moments introduced into the equations of motion, C_{m_o} = .081, C_{n_o} = -.008, C_{ℓ_o} = -.002 were obtained from Appendix A and the stability derivatives used in all the calculations are given in reference 1. For this calculation, $X_{c.g.}$ = .28 $\bar{c}$ and $X_{a.c}$ = .36 $\bar{c}$ for a static margin of .08. The computed time histories shown in figure 1 indicate that the sideslip angle, β roll velocity, P, and yaw velocity, R, are of small magnitude and thus the coupling between the lateral and longitudinal motions is negligible. This point was checked further by independent calculations of the lateral and longitudinal motions. A comparison of these results with the 6 degree-of-freedom results confirmed the fact that the lateral and longitudinal motions are in essence not coupled and that the aircraft's lateral motions are only slightly affected by thrust reverser deployment and readily controllable by the pilot and

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/or autopilot.

On the basis of the foregoing plus the fact that there are obvious constraints on the airplane's angle of attack, α , and normal acceleration, g, all subsequent analyses and calculations of the effect of thrust reverser deployment were made for the aircraft's longitudinal motions.

Pre-Flight Test Calculations

Prior to the flight tests, it was decided that the tests would be made at the following flight condition :

Mach = 0.3

Altitude = 15,000 feet

Weight = 15,500 lbs

c.g. = .23 $\bar{c}$

Flaps Deflected 12°

α trim = 5.3°

The results of the calculations are shown in figure 2 for the cases of engine cut and engine idle. Once again the thrust reverser is assumed to be fully deployed in 1.0 second. With the resultant pitching moment disturbances obtained from wind tunnel tests (Appendix A) of C_{m_0} = .027 and .081 for the cut and idle cases, respectively. For engine idle, $\Delta\alpha \sim 6°$ corresponding to $\Delta g \sim 1.2$ whereas for engine cut $\Delta\alpha \sim 2°$ with $\Delta g \sim 0.4$. The ability of the pilot to control the disturbed motion was investigated by assuming that at the time the thrust reverser was fully deployed the pilot pushed the stick forward. The elevator was deflected to a magnitude sufficient to oppose the disturbed C_{m_0} = .081, in our case a δ_e = 6.3°, in two and three seconds, respectively. The results presented in figures 3a and 3b show a reduction in the peak $\Delta\alpha$ between 23 to 30% and the airplane returns to its trimmed flight condition. This result is conservative since :

a) The pilot would probably apply control when he senses the airplane's pitching velocity of 1.0 to 2.0°/sec, which occurs before t = 1.0 second (assumed in the calculations)

b) The rate of control deflection applied by the pilot would be much greater than the rate assumed in the calculations.

<u>Correlation of Flight Tests with Calculations</u>

Figures 4 - 6 compare the flight tests (discrete points on the figures) with calculations (continuous curves). The flight conditions are given on each figure. The case of figure 6 referred to as Burst represents an increase in engine RPM (from 33% RPM to 45% RPM) from the aircraft's trimmed flight (engine at 33% RPM) with thrust reverser deployed. Suffice to state that the agreement between flight tests and calculations is excellent, the differences being greatly exaggerated in view of the expanded scale used in the figures.

Detailed time histories of the flight records, including the effect of noise on the instrumentation measurements, are shown in figures

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4a, 5a, and 6a. Relative to the comments made earlier about the pilot's ability to control the motion, note in figures 4a and 5a that the pilot applied elevator control when the pitching velocity was in the order of 1°/sec. Also, the rate of control deflection was about 6°/sec. in figure 5a.

The pitching moment disturbance, C_{m_0}, due to thrust reverser deployment was determined from the flight tests and is presented in figure 7. These values of C_{mo} were used in the calculations made in figures 4 - 6. Note the excellent agreement for the cut case for the wind tunnel value and flight determined value of C_{m_0}. Basically,

$$C_{m_o} = - C_{m_{\delta_e}} \left[(\delta_{steady\ state})_{After\ Deployment} - (\delta_{trim})_{Before\ Deployment} \right]$$

For the Burst case, the (δ_{trim}) before deployment was determined by satisfying the condition of zero pitching moment with a stabilizer position known from the flight test.

Calculations for Proposed Flight Conditions

Two flight conditions, take-off and cruise, were selected to predict the airplane's flight behaviour in response to the thrust reverser deployment.

1) Take off - Flaps 12°

Gross weight = 15,000 lbs

c.g. = 28% MAC

ISA, SEA LEVEL

$V = V_2 = 120$ KCAS

Take off forward thrust = 3044 lb

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ii) Cruise

gross weight = 15,000 lbs

mid c.g. = 25% MAC

ISA, 41,000 FT altitude

M = .70

Thrust as required for level flight = 1332 lb

Figure 8 shows time histories of thrust reverser deployment, Thrust and C_{m_0} for take off and cruise. The C_{m_0} was based on the data obtained from the flight tests (figure 7).

The variation of the thrust with time results from the fact that, in case of unwanted deployment of the thrust reverser at power greater than idle, an automatic system enters into operation 1/2 second after the onset of thrust reverser and reduces the power to idle in 4 seconds. The idle thrust is 226 lbs for cruise condition and 93 lbs for take off condition, respectively. Then, by using the time-history of thrust in conjunction with $C_{m_0} = f\left(\sqrt{T/q_0 S}\right)$ from figure 7, the time history of C_{m_0} is obtained.

To be conservative for the take-off calculation, the dashed curve of figure 8 labeled $C_{m_0\,T/O}$ was used. Also, it was assumed that the pilot would apply elevator to control the motion as pitch velocity reached about 1°/sec. Figure 9 shows that the pilot controls the perturbed motion in α to less than 4°, corresponding to a $\Delta g \sim 0.5$ (α_{TRIM} = 9°). A sketch of δ_e is also shown in figure 9.

For cruise flight, the calculations included the effect of the autopilot on the airplane's motions. However in this flight condition it was assumed that the pilot did not apply any elevator inputs throughout the flight. In actual flight, the pilot would probably apply some elevator control in about 3 or more seconds after the disturbance occurs. The autopilot in attitude hold activates both the elevator and stabilizer in response to the C_{m_0} disturbance. An analysis of the closed-loop system, including the autopilot's servo torque capability and stabilizer trim speed, indicated that an effective elevator deflection, δ_e (deg.) = 0.73 + 0.2t would be generated to oppose the perturbed motion. This effective δ_e is based on wind tunnel results showing that $\frac{\delta_e}{\delta_{stabilizer}} = \frac{1}{3}$

The pertinent data for this flight and the resultant motions are shown in figure 10. The peak total angle of attack is about 7.5° which corresponds to a C_L of 0.85. At this Mach number of 0.7 with a C_L of 0.85, the flight test results indicate that the airplane is on the boundary of buffet onset.

REFERENCES

1. IAI Report 4220/3009 Commodore Jet - Lateral and Longitudinal Stability Derivatives - Lateral and Longitudinal Stability.

2. IAI Report 4490/10563 Westwind 1124 - Wind Tunnel Tests with T/R Stowed and Deployed.

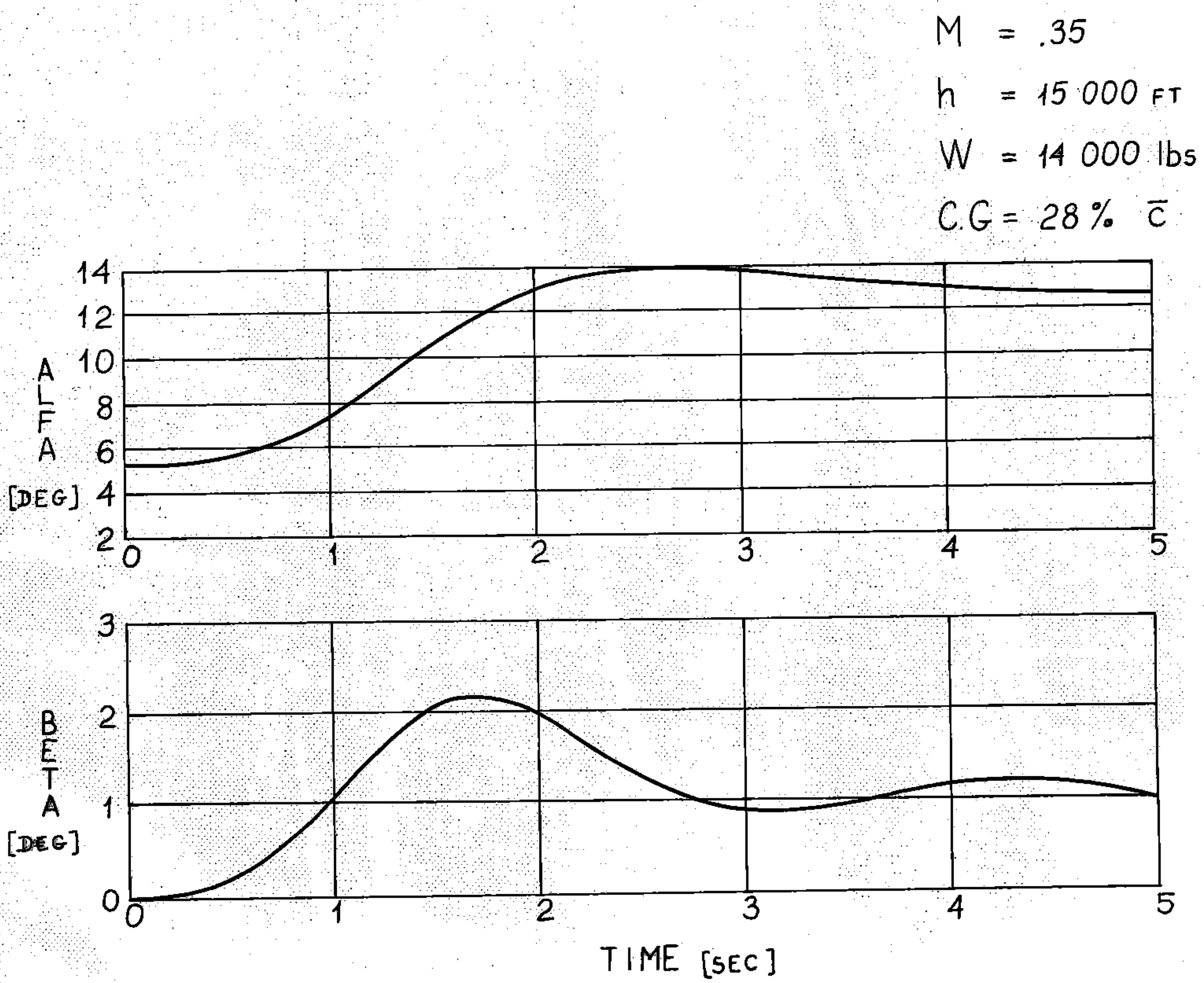

FIG. 1

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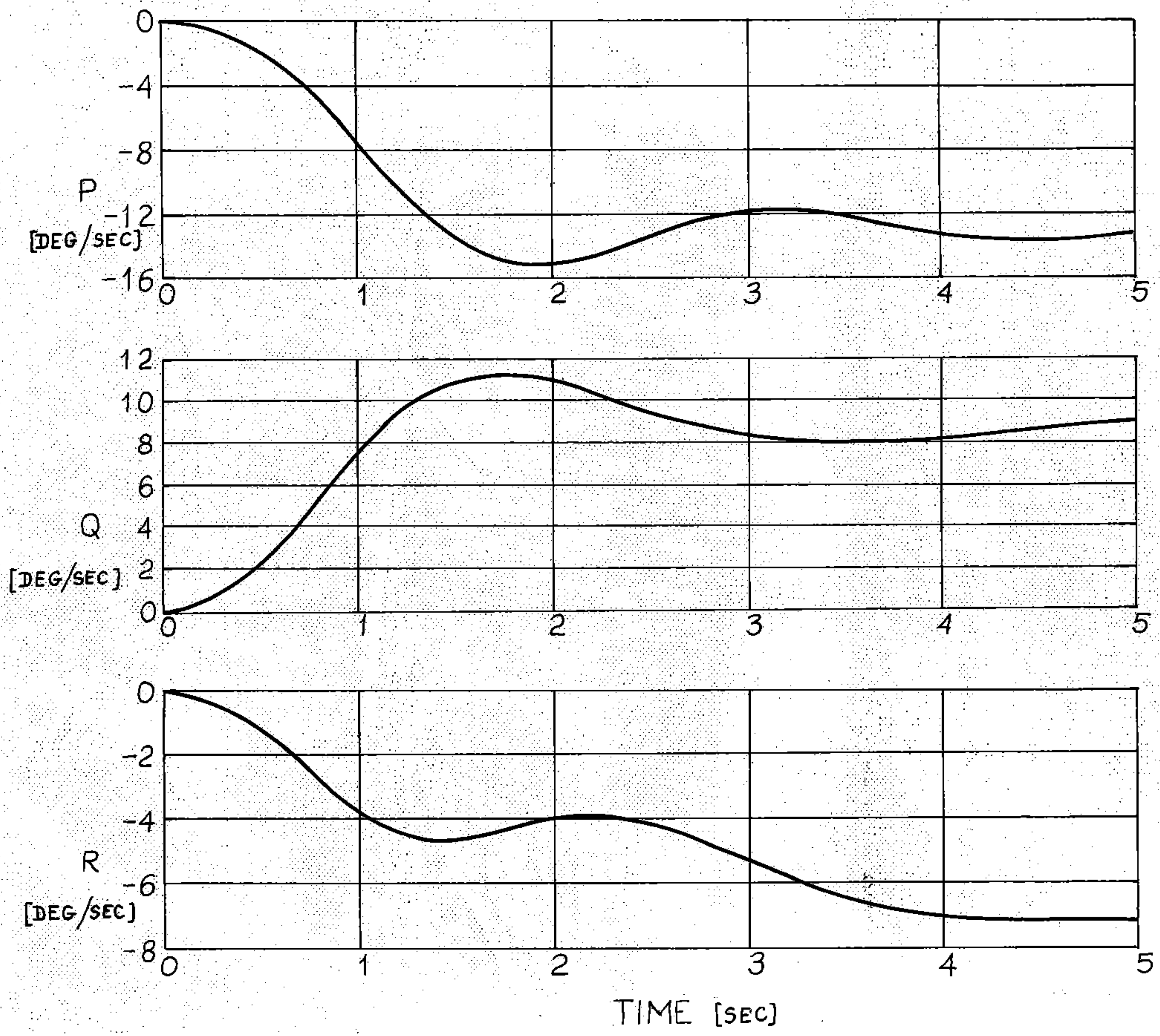
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[DEG/SEC]
0
-4
-8
-12
-16
Q
[DEG/SEC]
12
10
8
6
4
2
0
R
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0
-2
-4
-6
-8
0
1
2
3
4
5
TIME [SEC]

FIG. 1

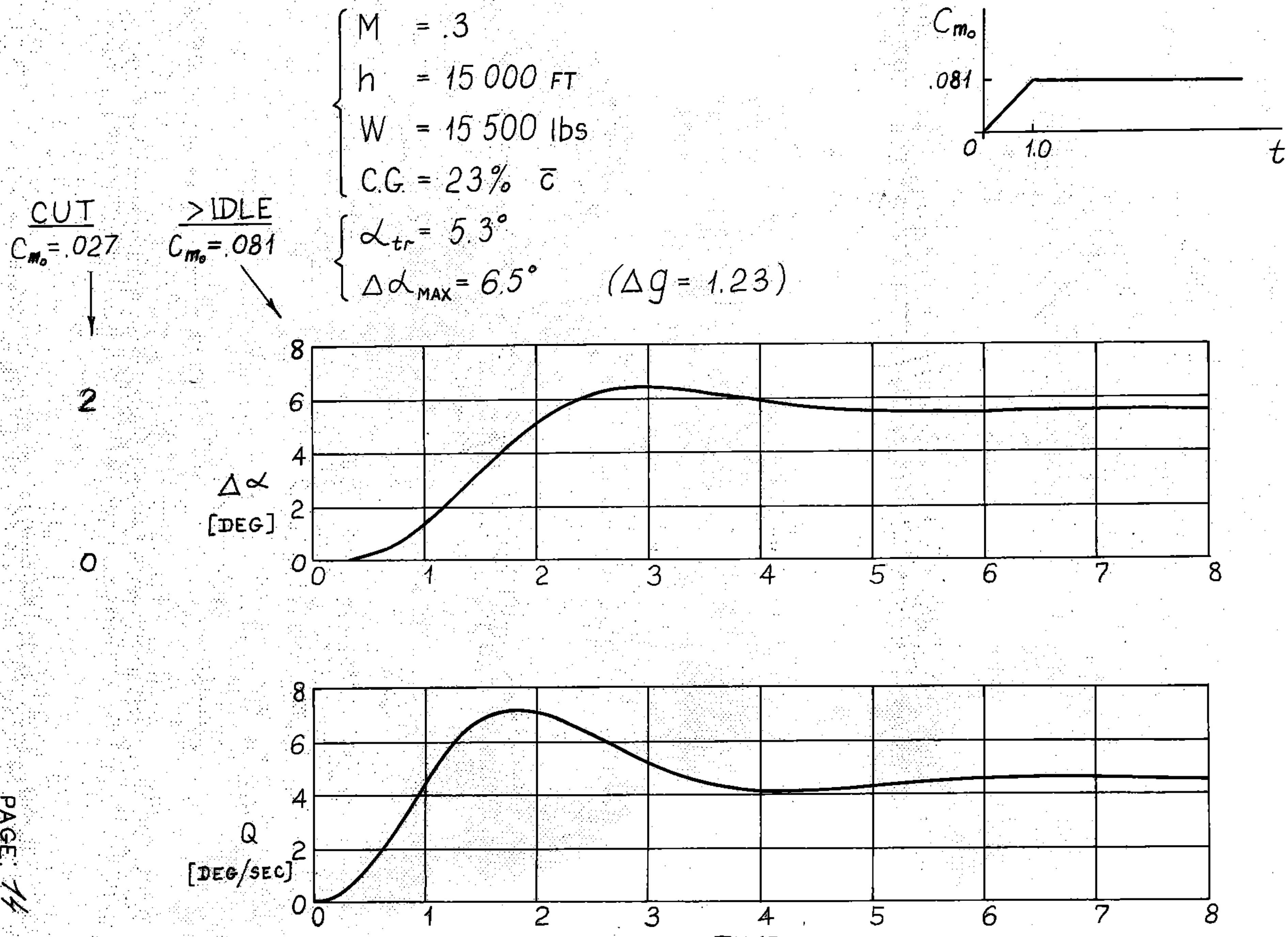

FIG. 2

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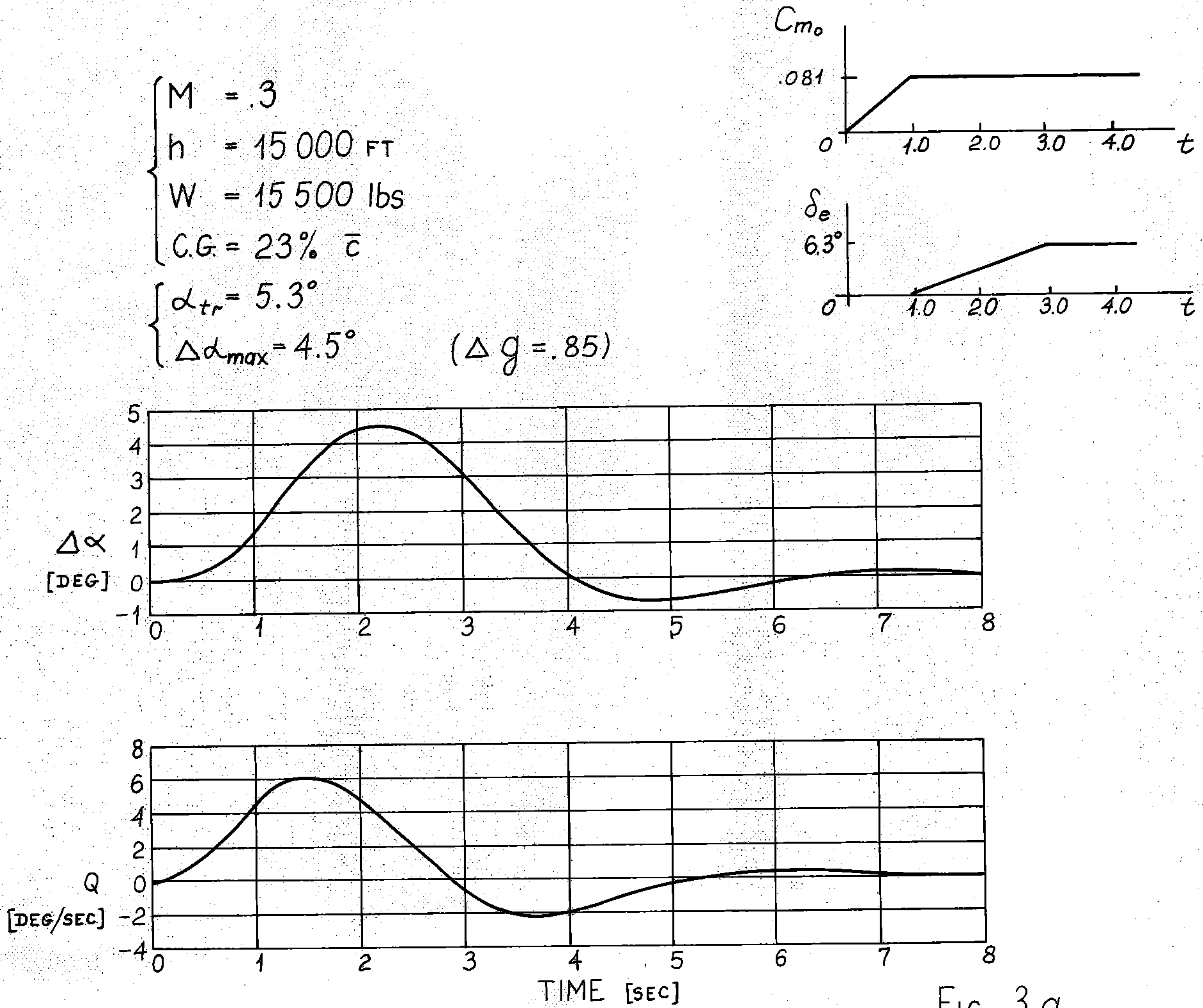
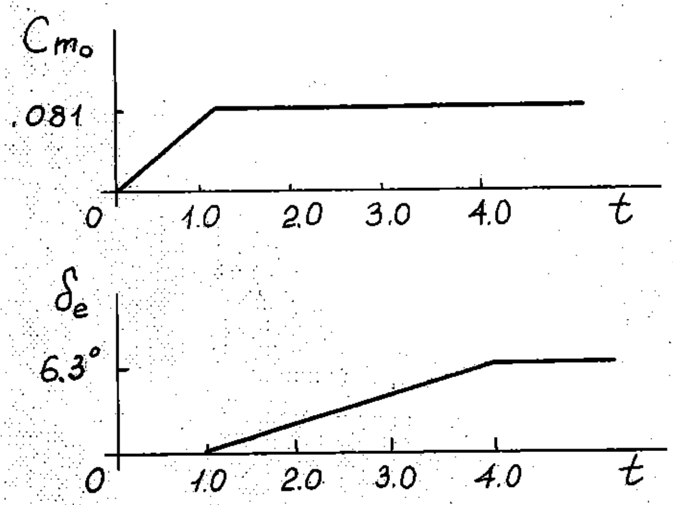

M = .3
h = 15 000 FT
W = 15 500 lbs
C.G. = 23% c̄
α_{tr} = 5.3°
$\Delta\alpha_{max}$ = 4.5°
(Δg = .85)
C_{m_0}
.081
0
1.0
2.0
3.0
4.0
t
δ_e
6.3°
$\Delta\alpha$ [DEG]
Q [DEG/SEC]
TIME [SEC]

FIG. 3 a

$$\begin{cases} M = .3 \\ h = 15\,000 \text{ FT} \\ W = 15\,500 \text{ lbs} \\ C.G. = 23\% \ \bar{c} \end{cases}$$

$$\begin{cases} \alpha_{tr} = 5.3° \\ \Delta\alpha_{max} = 5.0° \end{cases} \quad (\Delta g = 0.94)$$



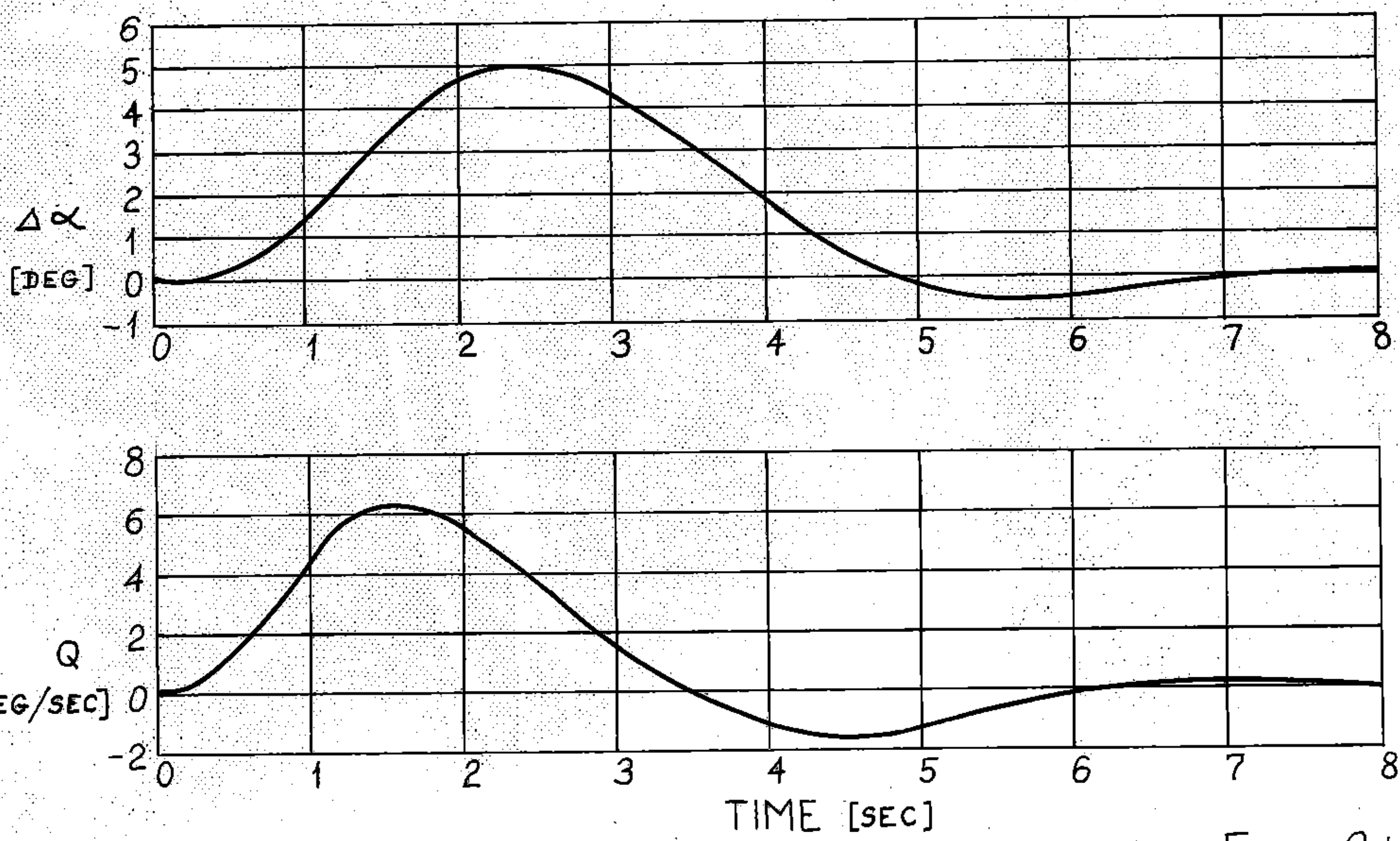


FIG. 3b

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CUT

$M = .3$
$h = 14\,000$ FT
$W = 15\,965$ lbs
$C.G. = 22.8\,\%\ \bar{c}$

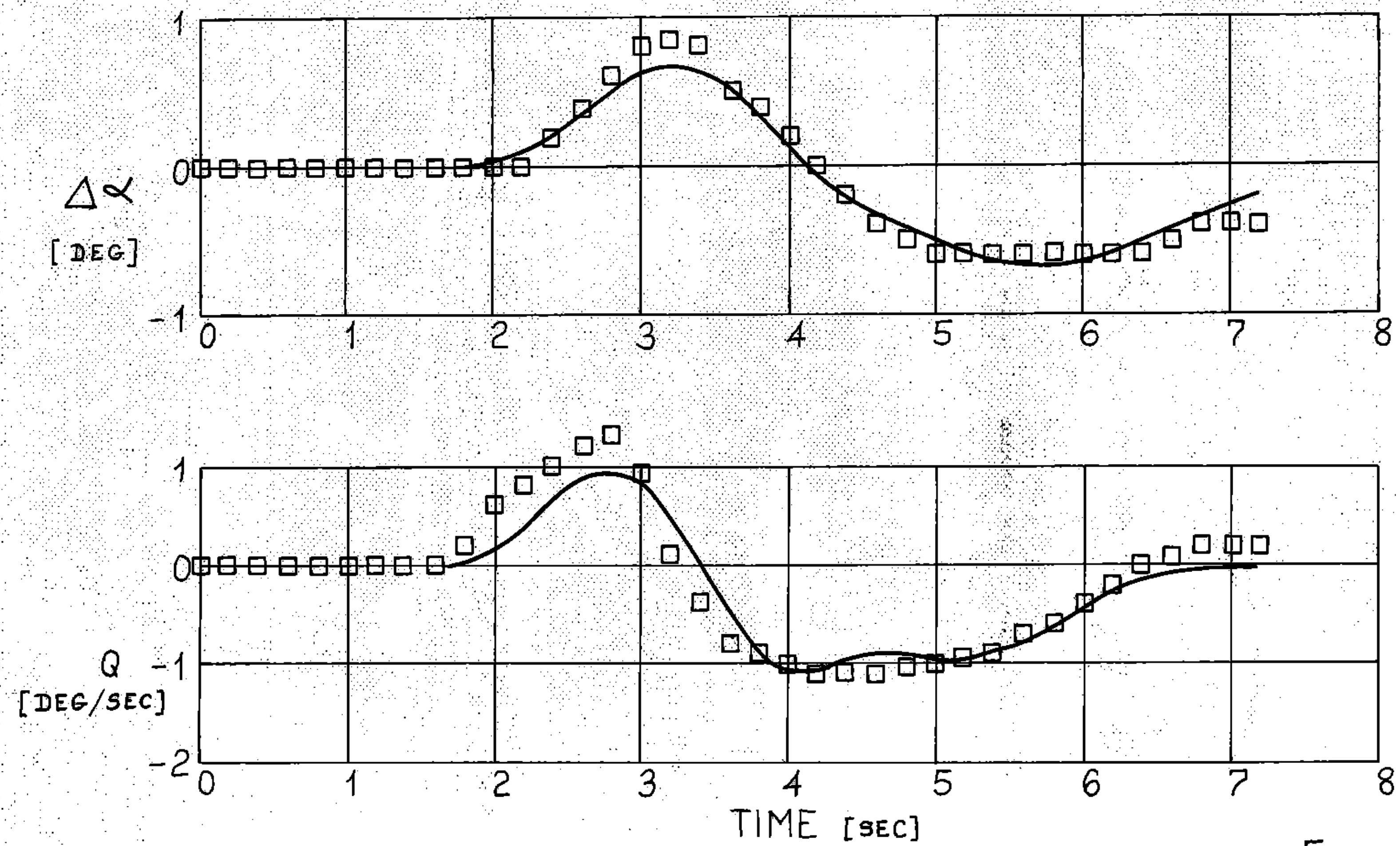

FIG. 4

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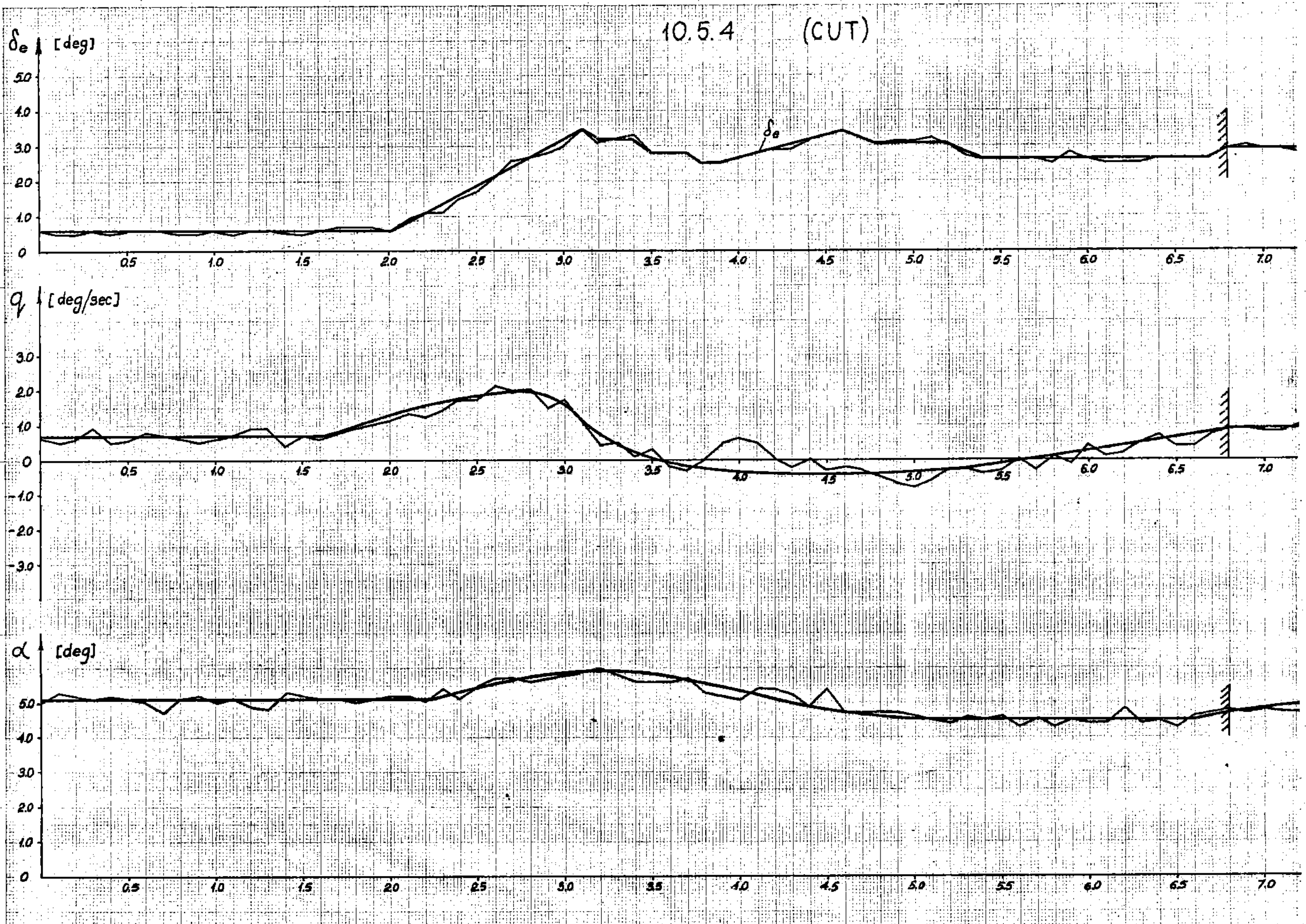

FIG. 4a

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IDLE

M = .29
h = 14 600 FT
W = 15 415 lbs
C.G = 22.4% $\bar{c}$

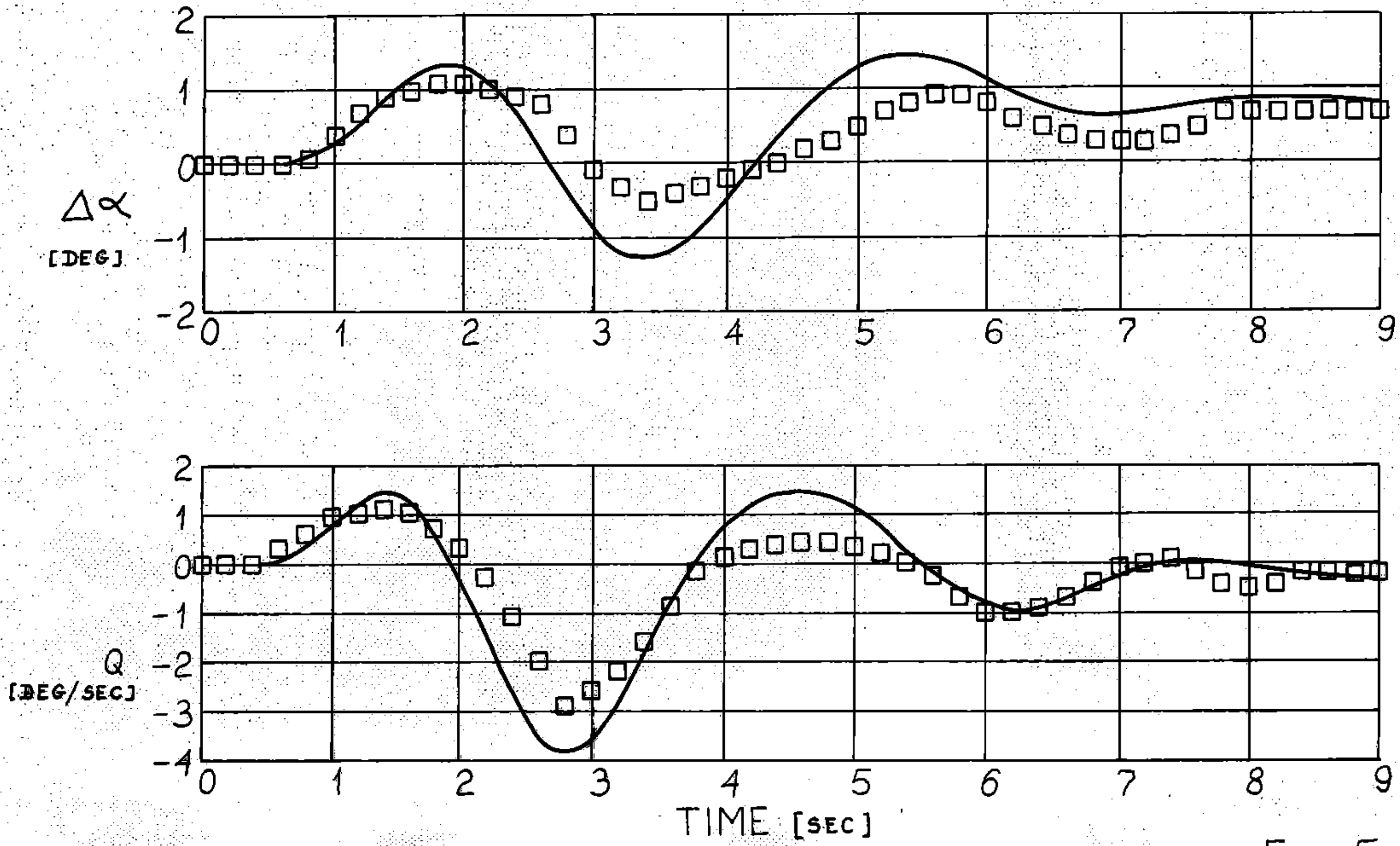

FIG. 5

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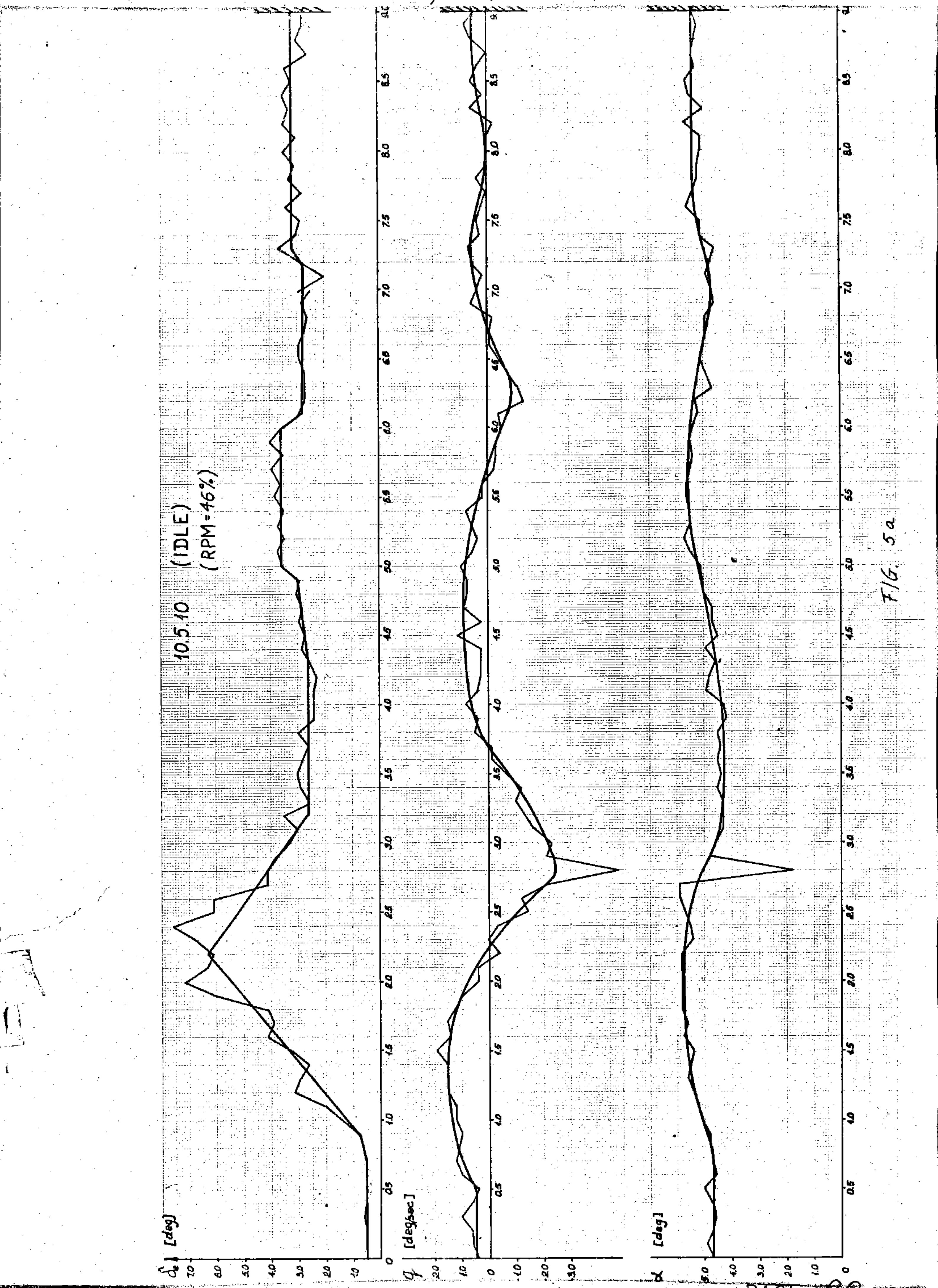

FIG. 5a

BURST (RPM = 33% - 45%)

M = .28
h = 9000 FT
W = 15 265 lbs
C.G = 22.3 % $\bar{c}$

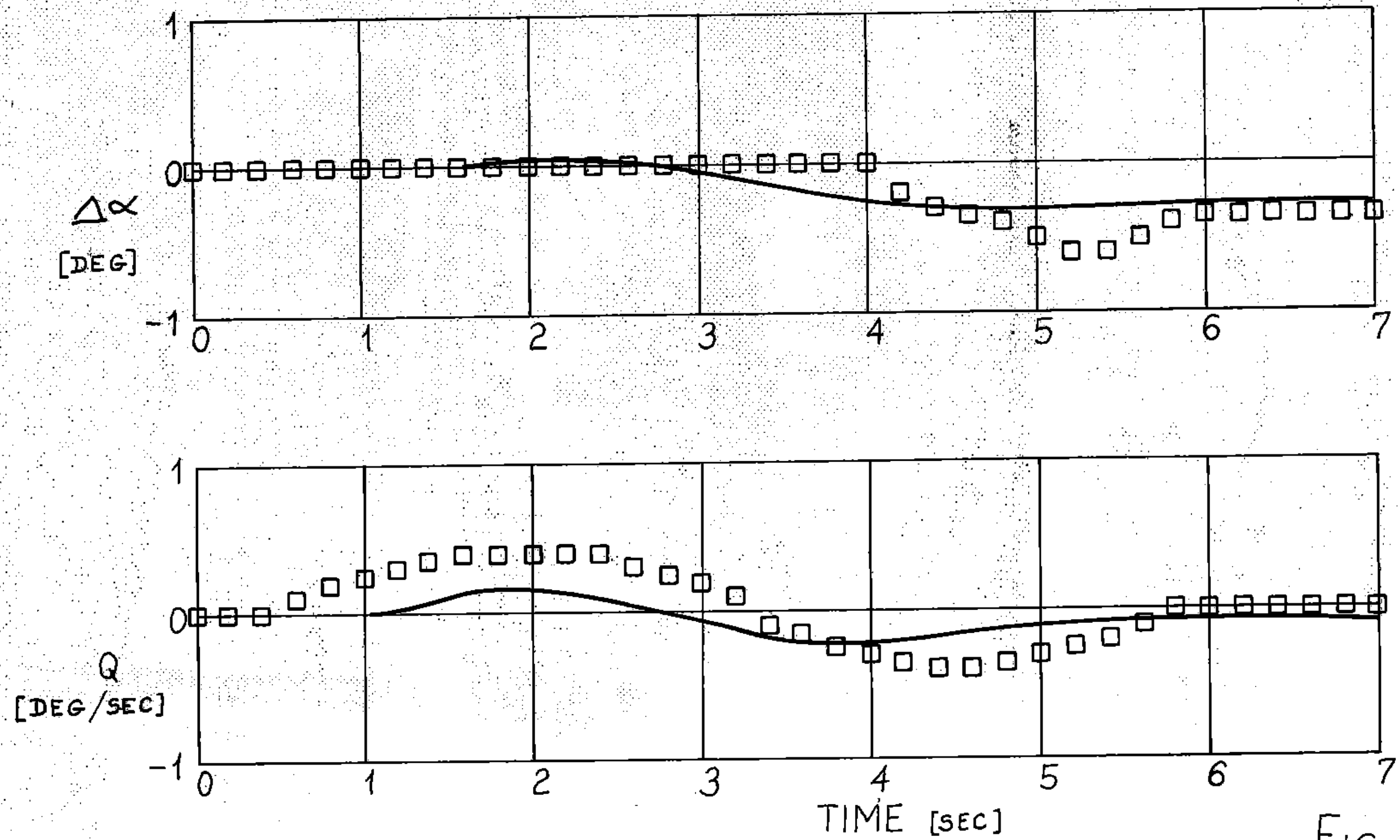

FIG. 6

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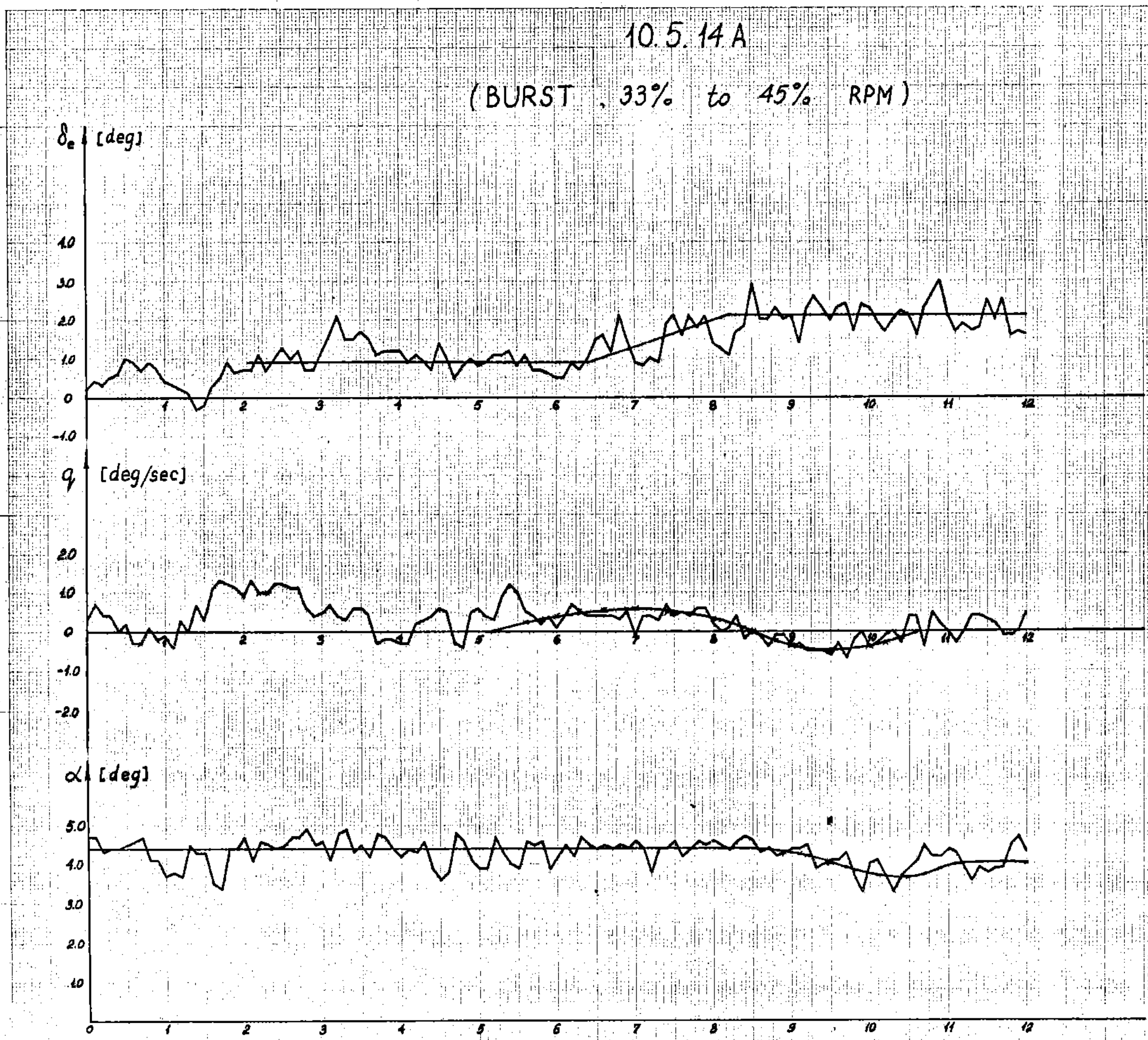
10.5.14 A
(BURST , 33% to 45% RPM)
δ_e [deg]
4.0
3.0
2.0
1.0
0
-1.0
q [deg/sec]
2.0
1.0
0
-1.0
-2.0
α [deg]
5.0
4.0
3.0
2.0
1.0
0
1
2
3
4
5
6
7
8
9
10
11
12

Fig. 6 a

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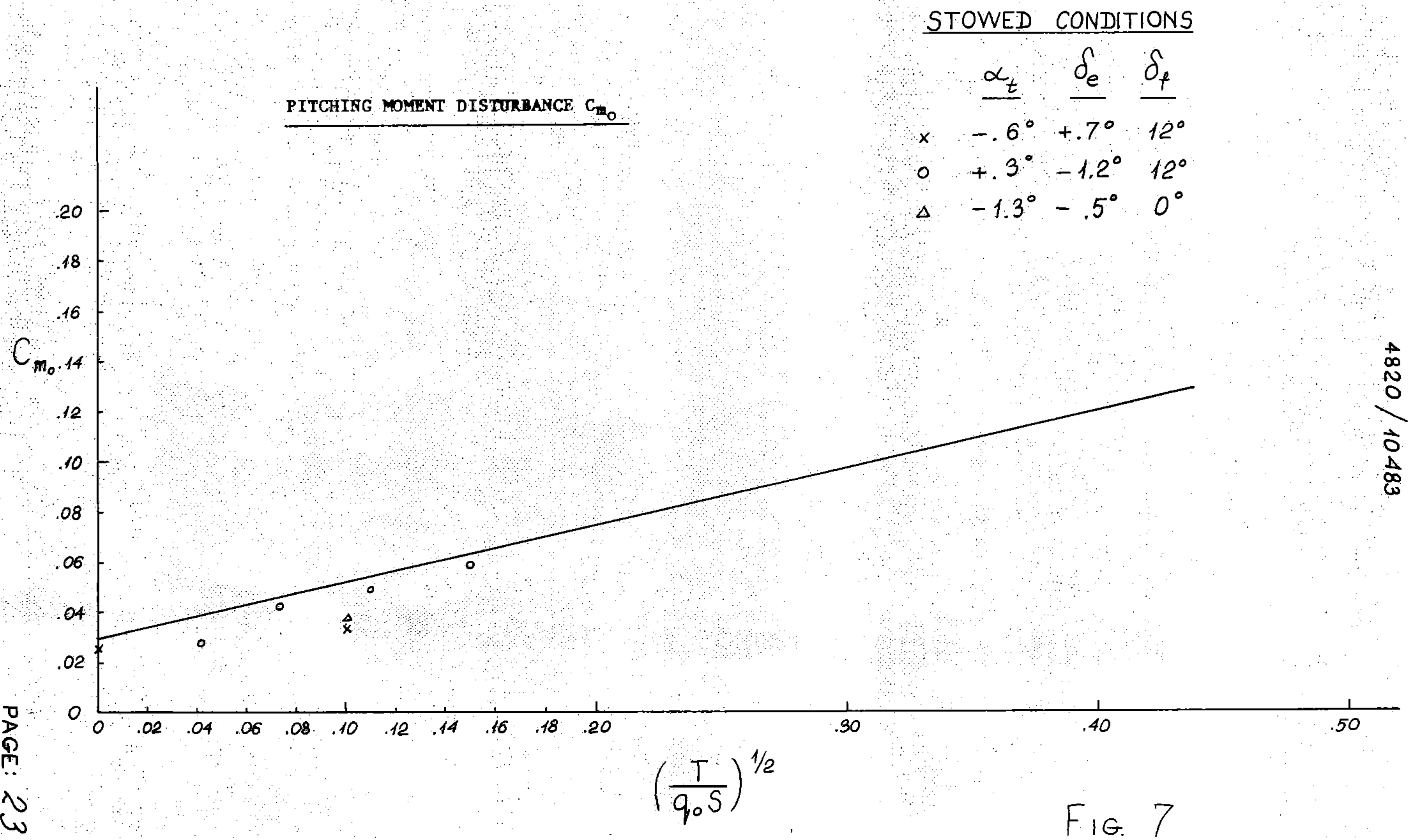

FIG. 7

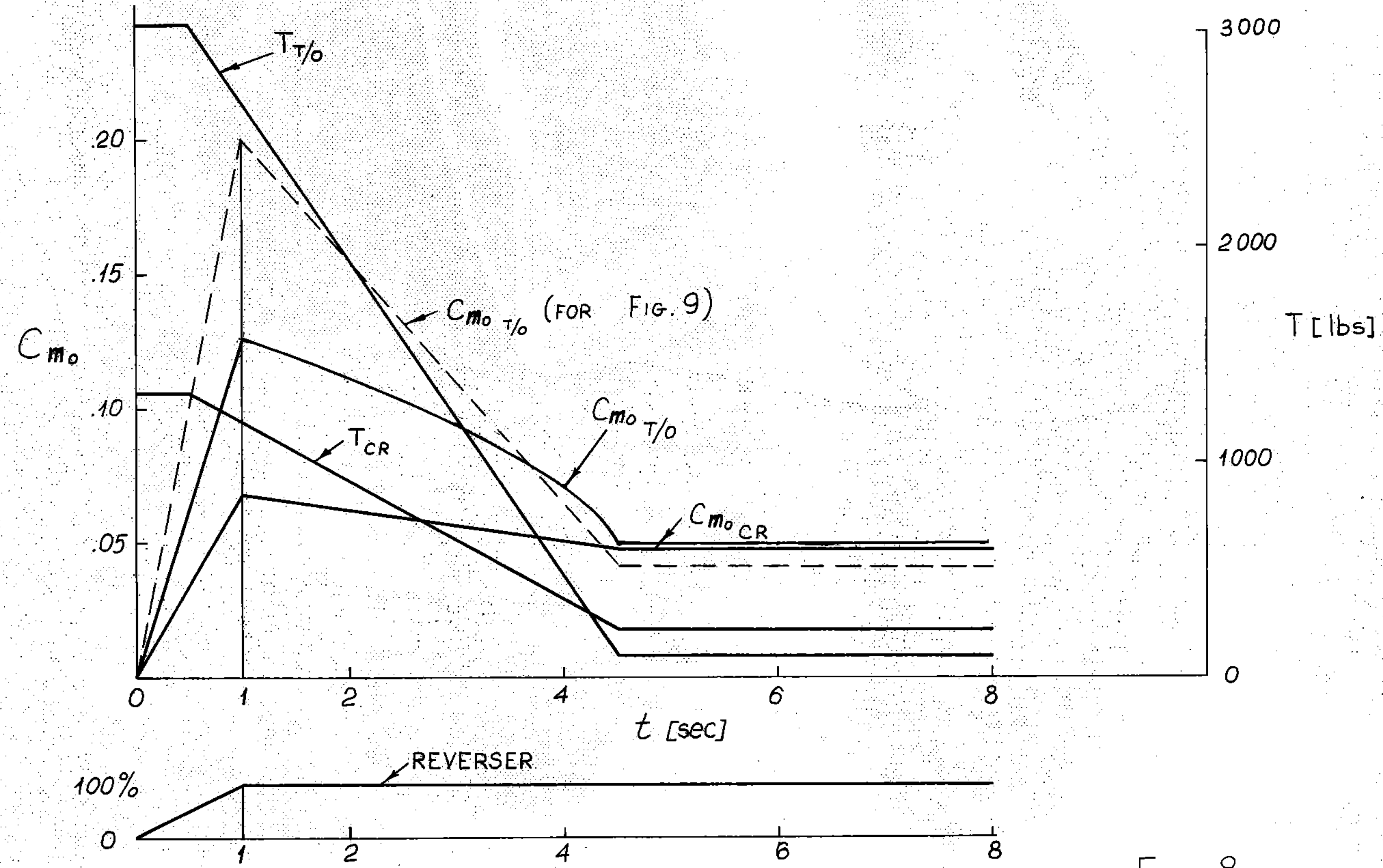

FIG. 8

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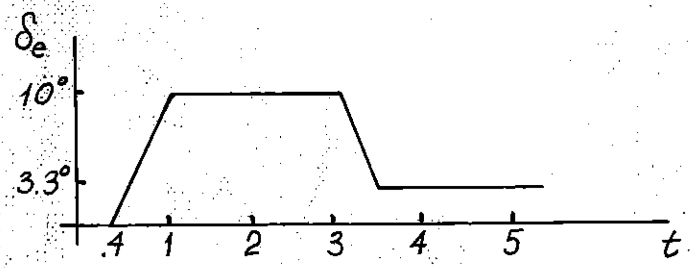
TAKE-OFF (WITH PILOT RESPONSE)

$$\begin{cases} M = .18 \\ h = 0 \\ W = 15\,000 \text{ lbs} \\ C.G = 28\,\%\ \bar{c} \end{cases}$$



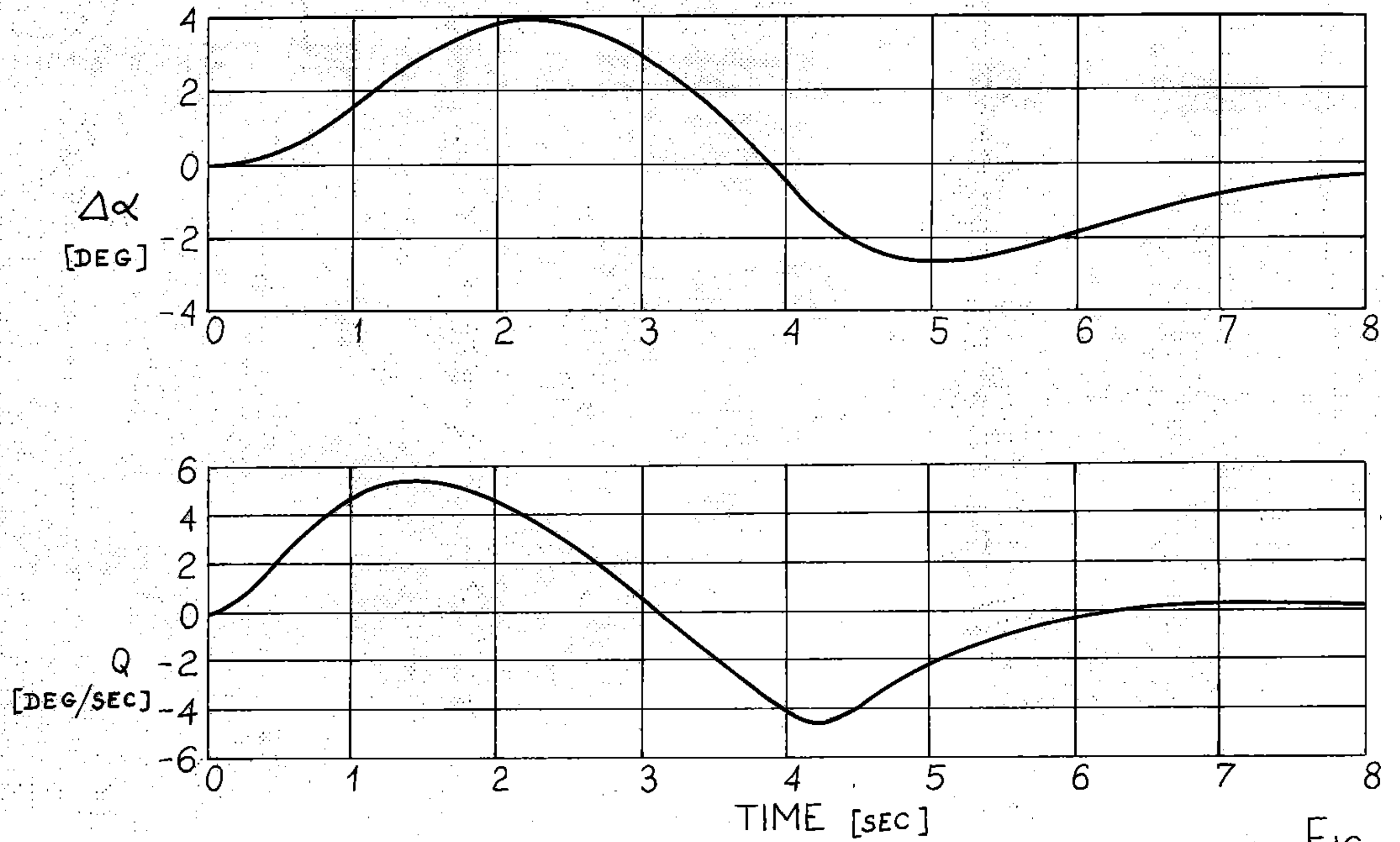


FIG. 9

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CRUISE deriv.

WITH AUTOPILOT

$M = .7$
$h = 41\,000$ FT
$W = 15\,000$ lbs
C.G $= 25\%\ \bar{c}$

$\alpha_{t_n} = 3.34''$
$\Delta\alpha_{MAX} = 4.17°$ $(\Delta g = 1.25)$

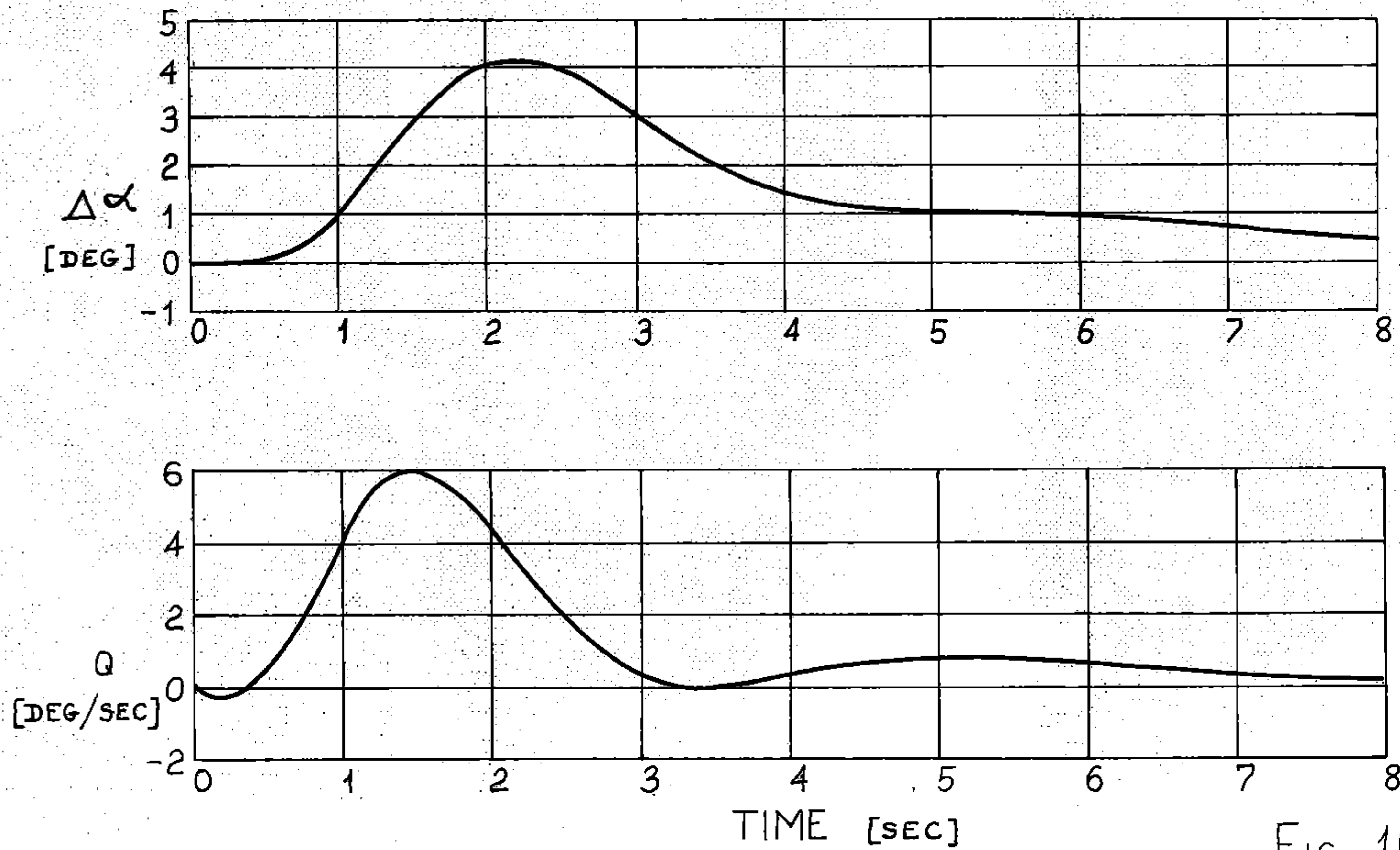

FIG. 10

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ISRAEL AIRCRAFT INDUSTRIES

No.3189/102

FLIGHT TEST REPORT

Time of departure: 1415 Flight time: 1:20 Number of landings: 1

A T/O WEIGHT: 16165 lb T/O C.G. 23% EXTERNAL CONDITION: wing tip camera in right tip tank

METEO: Wind D/F 270/08 R/W 30 Pr ground 1011 mb θ ground 24° C.

Units Used ___ V: ___ Z ___ O: ___ Time: GMT/LOCAL ___

DATE: 28 Jan 76

AIRCRAFT: 1124/154

CREW: Pilot Levine

Shapira

PURPOSE OF FLIGHT: In-flight deployment of thrust reversers

OBSERVATIONS ON AIRCRAFT AND EQUIPMENT:

1. See Flight Test Discrepancies Report for this flight. It is recommended to perform a general integrity check of the flight control system, aft control surfaces, engine installation and aft fuselage structure due to excessive vibrations encountered during extended period with deployed thrust reverser while airborne.

TEST AS CARRIED OUT:

2. Prior to the flight, an extensive checkout was performed on the ground with the right engine thrust reverser system to verify normal system operation, in particular operation of the special in-flight deployment switch and methods of closing the buckets once deployed. Max reverse thrust was checked to be 75% N_1 on both engines.

3. When airborne, at 15,000 ft, one stall was performed with 12 deg flaps and idle thrust to verify the vibration level and obtain a basis of comparison with vibration levels anticipated during deployed operation.

4. At 15,000 ft, 150 KIAS, with 12 deg flaps, left engine idle and right engine cut, the right thrust reverser was deployed. Deployment was photographed with a wing tip camera and other cameras, including TV, from a chase airplane. Windmill rpm on the right engine prior to deployment was N_1=11.4%, N_2=6.0%. The deployment was normal and the airplane reacted with a mild pitchup, slight yaw and roll to the right and sudden increase in vibration level. The pitchup was countered by normal pilot reaction with the controls....2 to 3 deg nose down elevator, 2 deg right rudder and slight right aileron. The configuration was eventually trimmable, with approx. 0.6 deg nose down pitch trim. Vibration level was unpleasant but not alarming, being of a low frequency and random nature, and felt through the controls as well as throughout the airplane. Windmill rpm decayed on the right engine to N_1=6.8%, N_2= 0.8%. This was exercise 10.5.4 on the flight cards.

5. Ex. 10.5.5 With the right engine cut and its thrust reverser deployed, and the left engine at idle, the airplane was decelerated to 130 KIAS and returned to 150 KIAS. Throughout this speed range the airplane was easily controlled and probably even trimmable. No change in buffet level was noted.

6. Ex. 10.5.6 At 150 KIAS, the power on the left engine was brought up to maintain level flight at 15,000 ft. Required N_1 was approx. 92%. The airplane was still easily controlled though more left rudder deflection and force were required to maintain balanced flight and max left rudder trim was not quite sufficient to keep the ball in the middle. The pitch change if any, was negligible. Buffet level was unchanged.

7. Ex. 10.5.7 With power for level flight at 150 KIAS (92% N_1 on left engine), the airplane was decelerated to 130 KIAS. Again, it was easily controlled with no significant change in pitch or yaw or buffet level.

8. Ex. 10.5.8 The airplane was returned to 150 KIAS and then accelerated to 180 KIAS, followed by application of approx. climb thrust rating on the left engine (98% N_1). As speed increased from 170 KIAS, the buffet changed, with a slight reduction in the random low frequency noise and the introduction of higher constant frequency, coming in waves as in a node. This additional vibration was more noticeable through the airframe rather than throu[gh] the control system.

9. Ex. 10.5.9 At 150 KIAS, with the right engine still cut, the thrust reverser was stowed. Wing tip camera was operated during stowage. The stow was normal and the airplane reacted with a very mild pitchdown which was easily corrected by slight nose up elevator. All buffeting ceased.

10. Ex. 10.5.10 At 15,000 ft, 150 KIAS, 12 deg flaps and <u>both</u> engines at idle, the right thrust reverser was again deployed. Right engine N_1 dropped approx. 1.5% and ITT rose appro[x.] 30° C. The deployment was normal and the airplane reaction was similar to the deployment with the cut engine. Pitchup was slightly greater, as was yaw and roll, but again the airpl[ane] was easily controlled by normal pilot reaction of a little forward wheel and left rudder. Approx. 5 deg of nose down elevator was required....6 to 8 kg force....and 3 to 4 deg of rud[der]. Vibration level was increased but still was not cause for alarm. Frequency content was proba[bly] unchanged. The airplane was trimmed in pitch and the controls released......the wheel could be seen to be vibrating fore and aft with an amplitude of approx. 2 to 3 cm peak to peak.

11. Ex. 10.5.11 thru .14 The airplane was decelerated to 130 KIAS and accelerated to 200 KIAS with application of thrust on the left engine up to 98% N_1. In all cases it was controllable and probably trimmable about all axes. Again, as speed increased above 170 KIAS, low frequency noise diminished and the higher frequency node appeared.

12. Ex. 10.5.14a At 150 KIAS, throttle bursts were performed with the right engine. The right power lever was advanced to approx. 50% N_1 and then chopped to idle, simulating the action of the throttle retarder mechanism. This burst technique was repeated to peaks of 63% and 72% N_1, with momentary stabilizations at peak rpm and sudden chops to idle. Airplane reaction to all bursts and chops was mild, with pitchup during the burst and nose drop during the chop. In all cases it was easily controlled by normal pilot reactions via the controls. The only significant change was a noticeable increase in buffet level observed via the control wheel as thrust level was increased. Buffet at 72% N_1 was quite strong.

13. Ex. 10.5.15 At approx. 165 KIAS, the right engine still at idle, the pilot attempted to stow the buckets, by selecting STOW position of the in-flight deploy switch. The chase pilot reported that the buckets did not stow completely, closing very slightly away from the fully deployed condition. As airspeed was slowly reduced, the buckets traversed more and mo[re] towards the stowed position and finally at 153 KIAS, complete stow was achieved. This, by the way, was exactly the speed indicated by Grumman as the max closure speed with idle thrust. Airplane reaction during this slow stowage was normal and thoroughly controllable.

14. Ex. 10.5.15a At 150 KIAS and with flaps fully up, right engine at idle, the right reverser was deployed. Airplane reaction was again normal, with essentially no change in reaction compared to its behavior with 12 deg flaps. Buffet level might have been slightly increased with the 0 flap configuration.

15. Ex. 10.5.20 thru .22 During this series of exercises the problem of landing with one deployed bucket was explored. The airplane was flown with 12, 20 and 40 deg flaps and left engine power up to climb rating (98%) at speeds down to 115 KIAS (approx. 1.2 V_s). During slow speed flight, rolling and pitching control was evaluated. No controllability problem was encountered during these runs at approx. 8,000 ft to 10,000 ft and it was decide[d] to attempt a landing with the right reverser deployed and 40 deg flaps, speed to be held at 125 KIAS minimum, equivalent to 1.3 Vs plus 10 kt.

16. Ex. 10.5.23 and .24 At 3,000 ft and 150 KIAS, 20 flaps, an idle deploy was made. A relatively normal single engine landing was completed, using 40 deg flaps on final approac[h] and 135 KIAS decelerating into 125 KIAS on short final. The glideslope was held with 90 to 95% N_1 on the left engine. A left crosswind of approx. 5 kt at 90 deg prevailed at the time. On touchdown, both thrust reversers were deployed for a normal rollout without brakes applie[d]. As an abnormal procedure, it might be wise to use not more than 20 deg flaps and an "on speed" approach, in order to avoid possible high sink rates which would be more difficult to correct with available thrust on the operating engine with 40 deg flaps than with 20 deg.

 [redacted]

התעשיה האוירית לישראל בע"מ
ISRAEL AIRCRAFT INDUSTRIES LTD.
LOD AIRPORT ISRAEL נמל תעופה, לוד

REPORT No. 4820/10483 דו"ח מס

SUBJECT: נושא:

סווג בטחוני

APPENDIX A

SUMMARY OF WIND TUNNEL DATA WITH THRUST REVERSER STOWED AND DEPLOYED

The aerodynamic coefficients obtained during the wind tunnel test described in the Wind Tunnel Report 4490/10563 (Reference 2) with the thrust reverser stowed and deployed were plotted in the following figures versus the pressure of the ejector p_t .

The data are given for 0, 6 and 12 degrees angle of attack and -8, 0 and 8 degrees sideslip angle and for flaps up and down at 12°.

The moment coefficients C_m, C_ℓ and C_n are given around the balance vitual center 9.4558" forward and .58" below the aircraft cg at 30% MAC and in the wing reference plane. (Dimensions are given above for the 1/10 scale model).

The mass flow through the nacelle varies with the ejector total pressure point when the thrust reverser is stowed :

pt (PSI)	Mass flow measured in the nacelle inlet (Kg/sec)
30	.150
50	.165
76	.195

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When the thrust reverser is deployed the mass flow during the test was constant equal to .100 kg/sec no matter what was the ejector pt. Therefore we draw one line through all the points for the stowed configuration at pt = 0,30, 50 and 76 PSI and one line parallel to the horizontal axis for the deployed configuration for all the points where pt was not zero, assuming that if the mass flow is constant the aerodynamic coefficient should be also constant.

Substracting the values of the coefficients with the thrust reverser deployed from the values with the thrust reverser stowed we find the aerodynamic coefficients increaments that represent the aero-dynamic interference due to the jet deflection.

Two conditions were considered :

i) when pt = 0 that will simulate a condition with the engine cut

ii) when pt = 76 PSI that will simulate a condition when the engine is working. It is difficult to know what power setting was simulated but we believe that something more than idle power was obtained.

The matrices of the aerodynamic interference for flaps up and 12 with engine cut and power on at α = 0, 6 and 12 degrees and β = -8, 0 and 8 degrees, are given. The moments coefficients were recalculated for the a/c c.g.

This coefficients represent only the aerodynamic interference between the engine jet with the thrust reverser deployed and the airframe.

The moment coefficients due to the reversed thrust were added to the interference coefficients after being computed by formulas

$$\Delta C_{m_o} = \frac{T}{qS}\,\frac{h}{c}$$

$$\Delta C_{n_o} = \frac{T}{qS}\,\frac{e}{b}$$

where h and e are the vertical/lateral distance between the thrust line and aircraft cg, c is the mean aerodynamic chord, b the wing span, S wing area, q the dynamic pressure and T the reversed thrust. A conservative large thrust value was used in the calculations of the final perturbation coefficients :

$$C_{m_o} = .0081 \text{ or } .0027$$

$$C_{n_o} = -.008$$

$$C_{\ell_o} = -.002$$

at the beginning of the dynamic simulation.

The coefficient C_{m_o} was plotted in Figure 7 versus the parameter $\sqrt{\frac{T}{qS}}$ that is approximately proportional to the ratio of the jet velocity v_j to the aircraft velocity V_o. This because the ratio v_j/V_o is a measure of the downwash at the aircraft tail due to free air inflow into the engine jet. This downwash is the main source of the aerodynamic interference.

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TEST DATA SHEET — גליון נתוני נסיון

TEST No. — נסוי מס׳

SUBJECT: — נושא:

4820/10483

INSTRUMENTATION DATA — נתוני מיכשור:

AERODYNAMIC COEFFICIENTS

DUE TO T/R DEPLOYEMENT

$P_t = 0$

δ_F		α	β		ΔC_L	ΔC_D	ΔC_y	ΔC_m	ΔC_n	ΔC_R
0°		0°	0°		-.005	.0260	-.001	.0248	+.0003	-.00049
↓		6°	↓		-.030	.0237	.001	.0235	-.0010	-.00071
		12°			-.045	.0210	.004	.0228	-.0016	-.00104
		0°	-8°		0	.0240	-.003	.0350	-.0028	-.00067
		6°	↓		-.015	.0215	-.004	.0443	-.0042	-.00136
		12°			-.020	.0176	-.002	.0490	-.0028	-.00218
		0°	8°		-.020	.0250	.001	-.0010	-.0024	-.00101
		6°	↓		-.025	.0230	.001	.0288	-.0035	-.00111
		12°			-.050	.0190	.004	.0176	-.0053	-.00144
12°		0°	0°		0	.0255	.001	.0170	-.0012	-.00031
↓		6°	↓		0	.0240	-.002	.0400	-.0014	-.00098
		12°			-.020	.0210	.003	.0440	-.0020	-.00103
		0°	-8°		-.015	.0255	-.006	.0093	+.0016	-.00104
		6°	↓		-.020	.0230	-.007	-.0010	-.0006	-.00192
		12°			-.030	.0195	-.005	.0035	-.0025	-.00145
		0°	8°		-.003	.0250	.005	.0249	-.0010	-.00035
		6°	↓		-.020	.0220	.006	.0440	-.0024	-.00106
		12°			-.037	.0165	.008	.0462	-.0084	-.00059

נכון בביצוע ראשון - אפס ליקויים 6031-פ

PERFORMED BY: — הוכן ע"י:

DATE: — תאריך:

ISRAEL AIRCRAFT INDUSTRIES LTD. התעשיה האוירית לישראל בע"מ

TEST DATA SHEET גליון נתוני נסוי

TEST No. נסוי מס'

SUBJECT: נושא:

4820/10483

INSTRUMENTATION DATA נתוני מיכשור:

AERODYNAMIC COEFFICIENTS

DUE TO T/R DEPLOYEMENT

P_t = 75 PSI

δ_F		α	β		ΔC_L	ΔC_D	ΔC_Y	ΔC_m	ΔC_n	ΔC_l
0°		0°	0°		-.017	.0485	.0120	.0322	-.0037	-.00013
↓		6°	↓		-.030	.0460	.0126	.0685	-.0042	-.00194
		12°			-.050	.0400	.0180	.0676	-.0074	-.00179
		0°	-8°		0	.0440	.0040	0	+.0003	-.00004
		6°	↓		-.030	.0440	.0040	-.0065	-.0025	-.00234
		12°			-.035	.0430	.0047	.0133	-.0005	-.00385
		0°	8°		-.030	.0465	.0185	.0285	-.0054	-.00070
		6°	↓		-.052	.0430	.0186	.0555	-.0069	-.00070
		12°			-.050	.0360	.0200	.0726	-.0062	-.00192
12°		0°	0°		-.030	.0455	.0126	-.0314	-.0065	.00016
↓		6°	↓		-.025	.0446	.0145	.0018	-.0052	-.00076
		12°			-.030	.0383	.0140	.0325	-.0050	-.00185
		0°	-8°		-.005	.0460	0	.0048	-.0007	-.00200
		6°	↓		-.018	.0430	0	-.0189	-.0004	-.00300
		12°			-.037	.0405	0	-.0068	0	-.00230
		0°	8°		-.040	.0463	.0186	.0031	-.0075	.00150
		6°	↓		-.050	.0415	.0220	.0225	-.0091	.00056
		12°			-.060	.0330	.0200	.0401	-.0088	.00018

נכון בביצוע ראשון - אפס ליקויים 6081-ט

PERFORMED BY: הוכן ע"י:

DATE: תאריך:

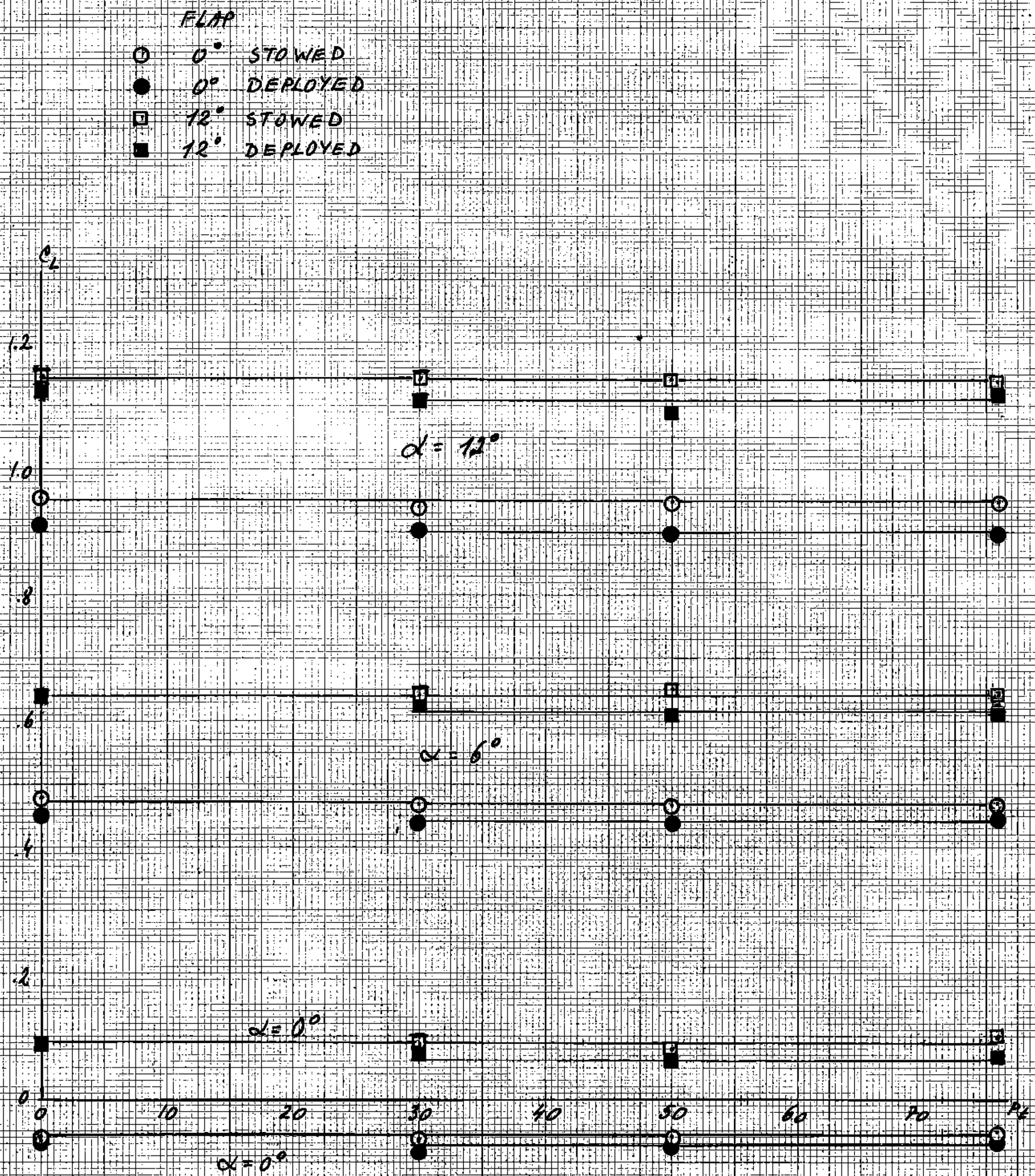
4820/10483

WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_L VS P_t

$\beta = 0^\circ$

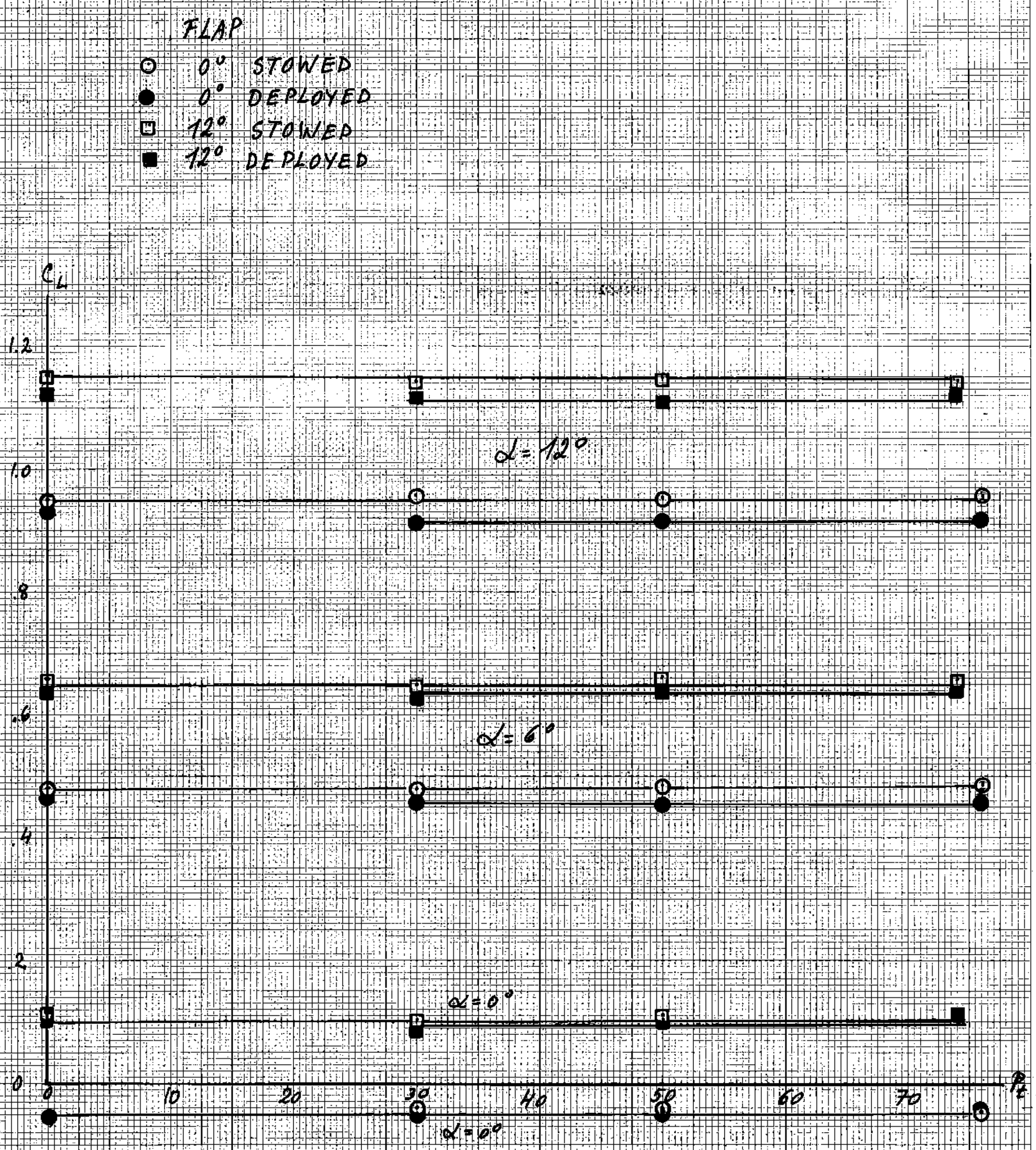


WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_L VS P_t

$\beta = -8°$



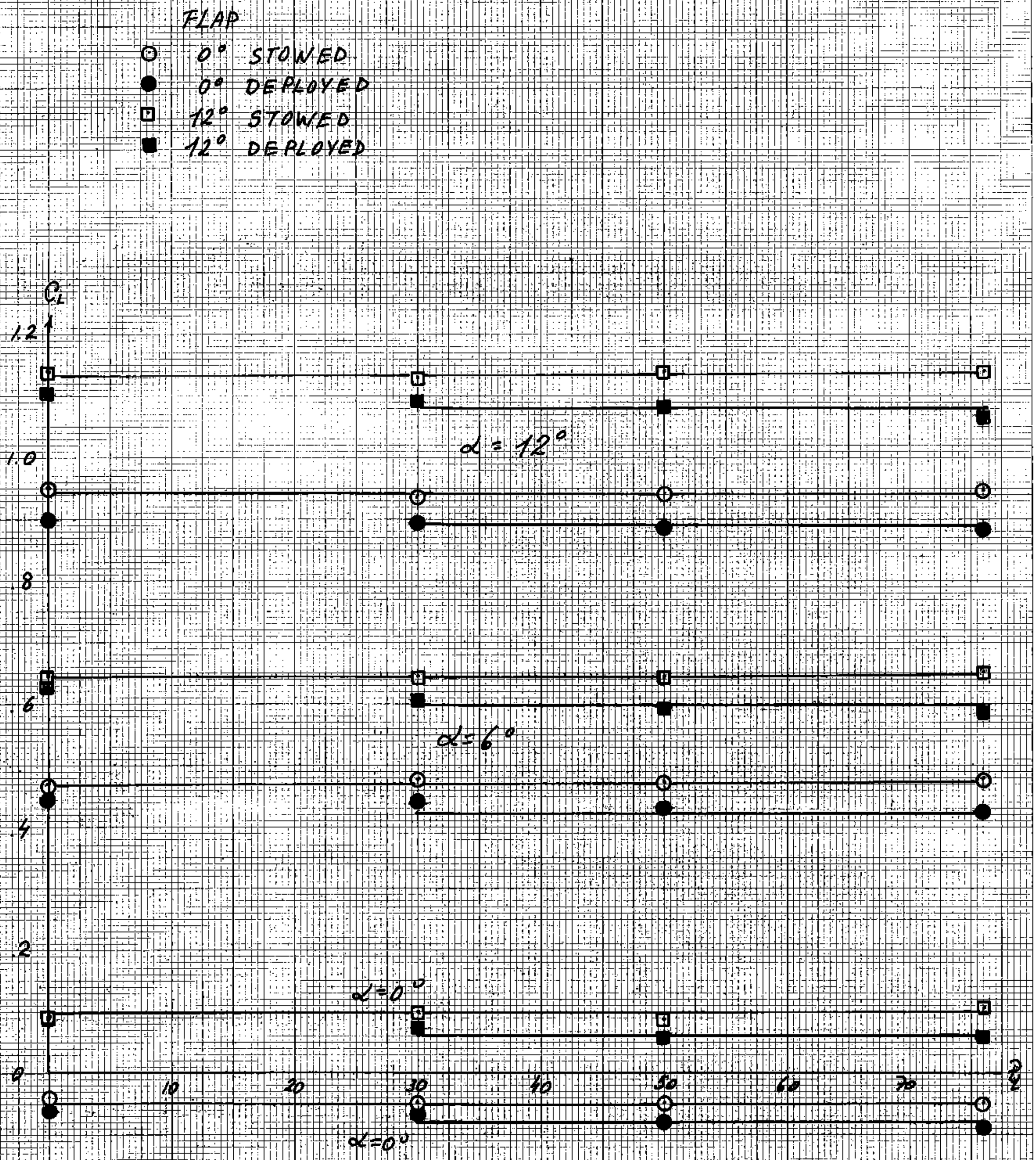
4820/10483

WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_L vs P_t

$\beta = +8^\circ$



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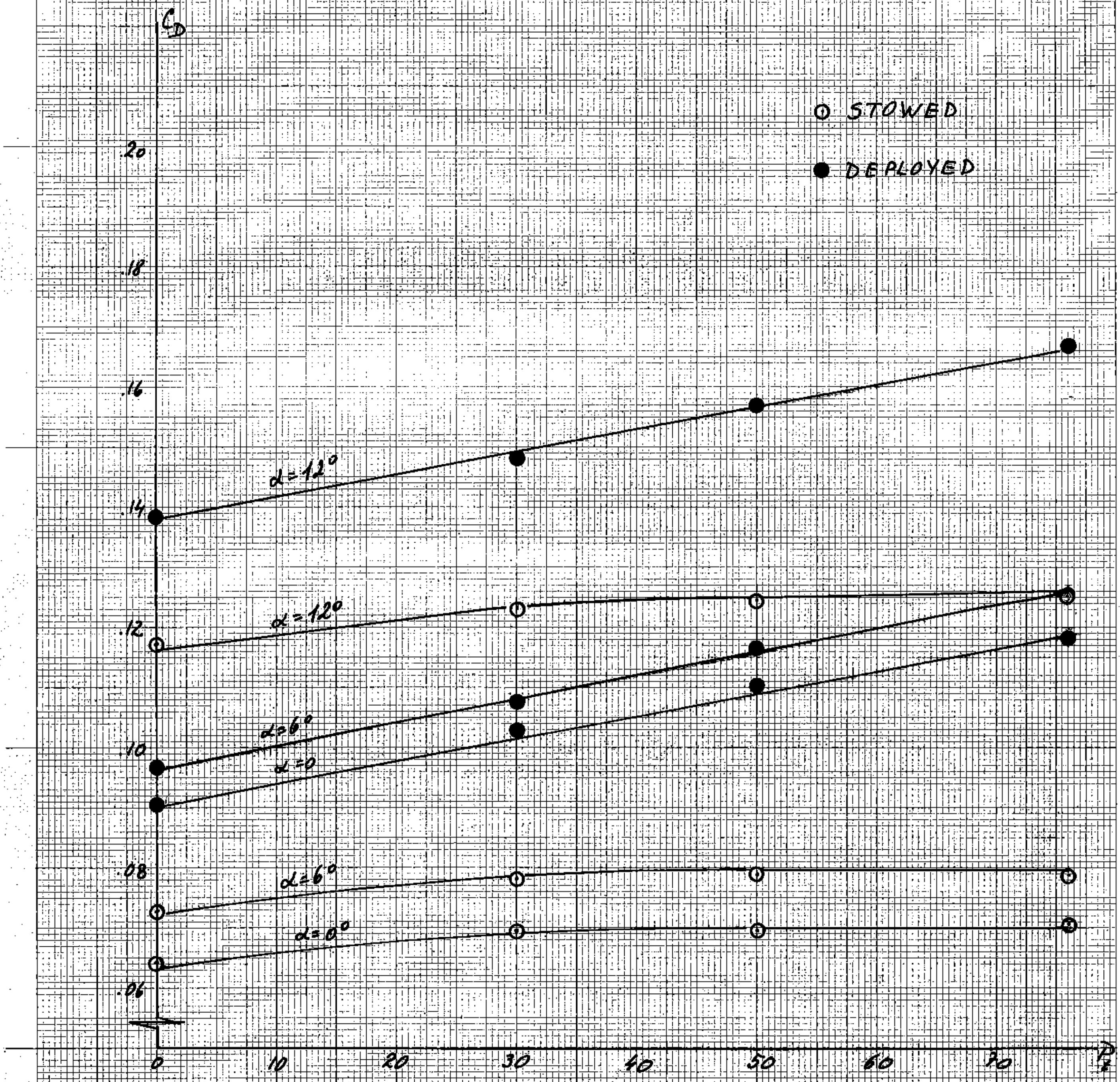
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_D vs P_t

$\delta_F = 0°$

$\beta = 0°$



4820/10483

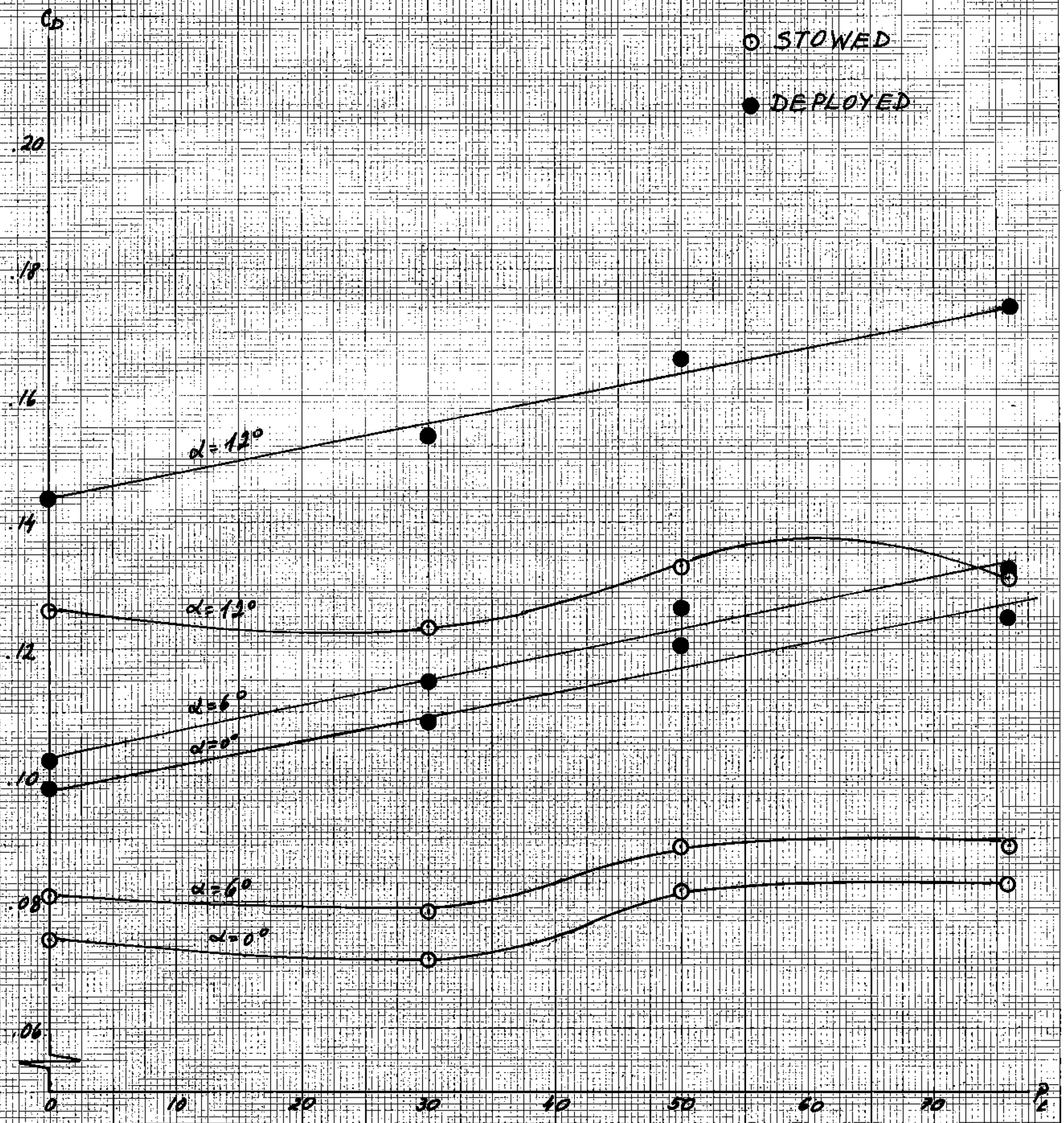
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_D VS P_t

$\delta_F = 0°$

$\beta = -8°$



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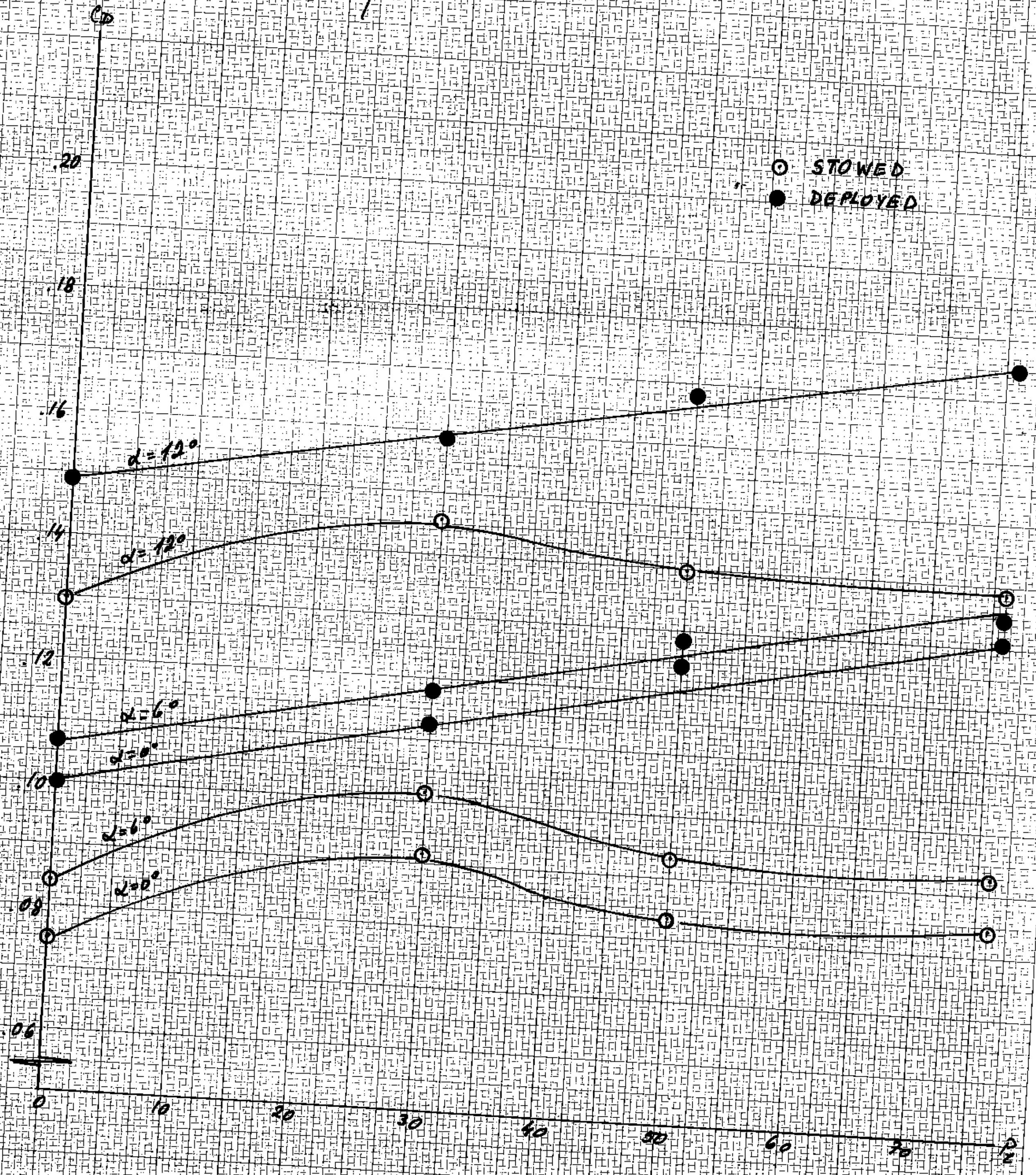
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_D vs P_t

$\delta_F = 0°$

$\beta = +8°$



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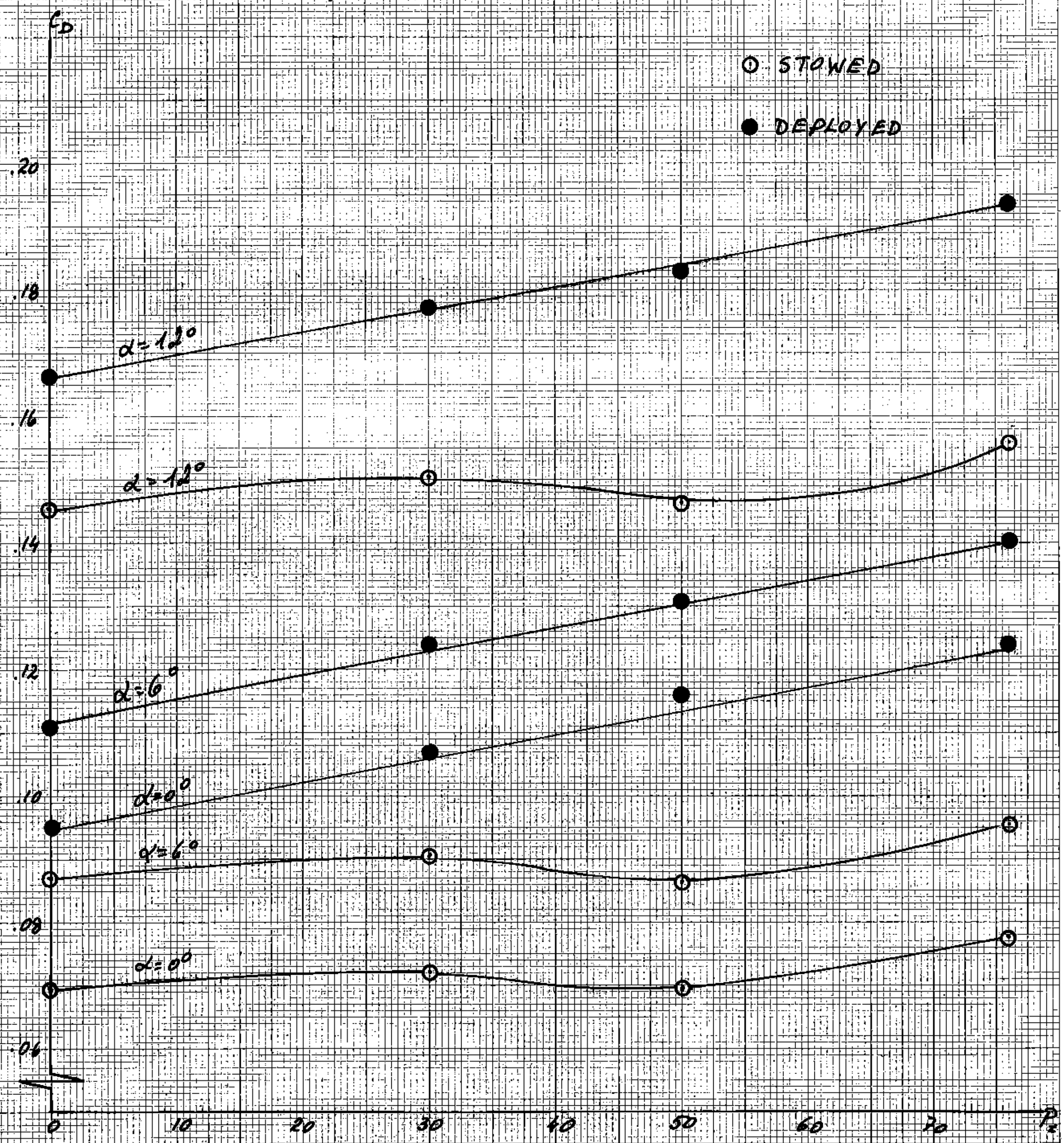
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_D VS P_t

$\delta_F = 12^\circ$

$\beta = 0^\circ$



4820/10483

WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_D vs P_t

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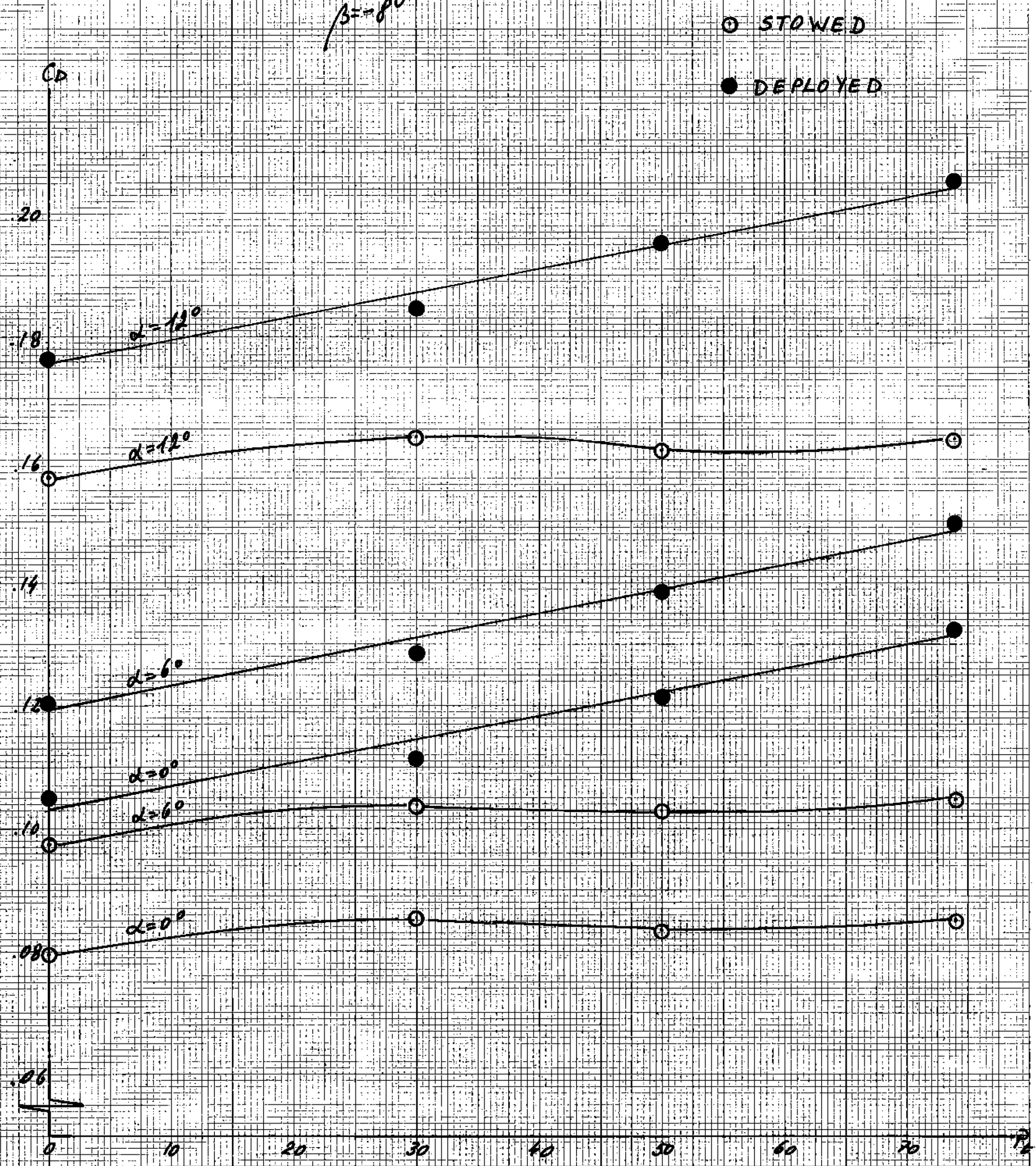
$\beta = -8^\circ$



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WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_D vs P_t

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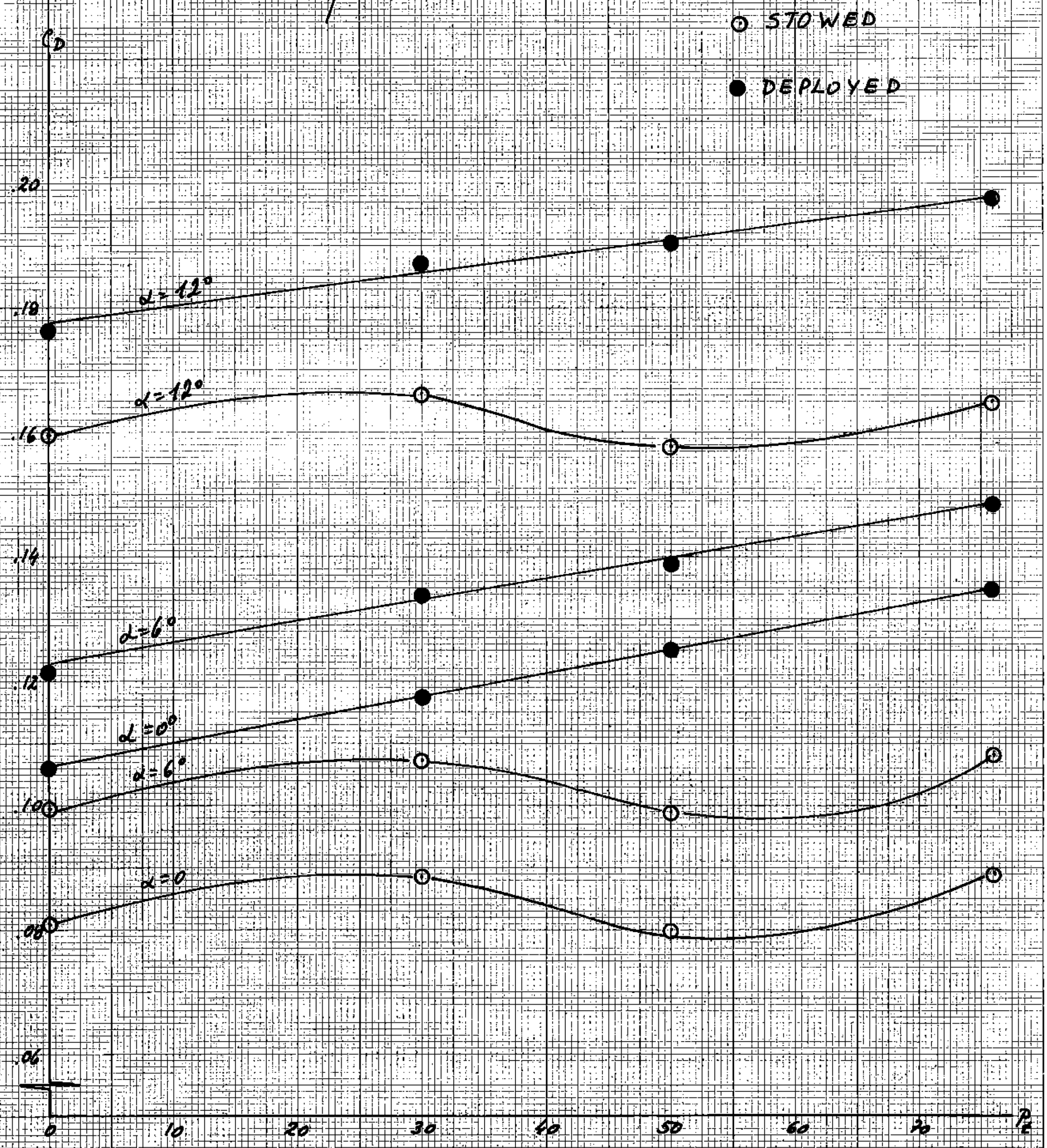
$\beta = +8°$



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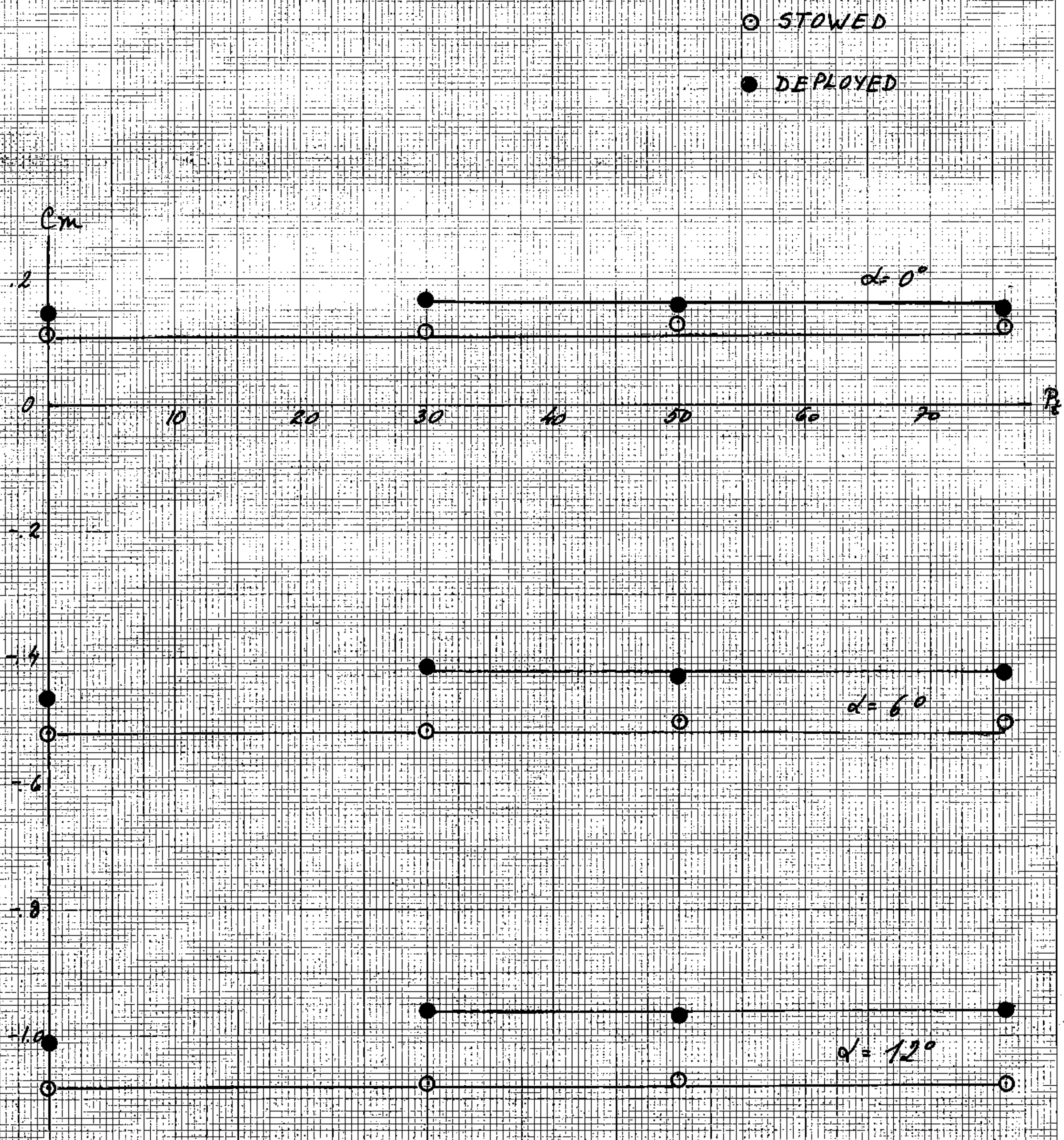
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_m VS P_t

$\delta_F = 0°$

$\beta = 0°$



WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_m VS P_t

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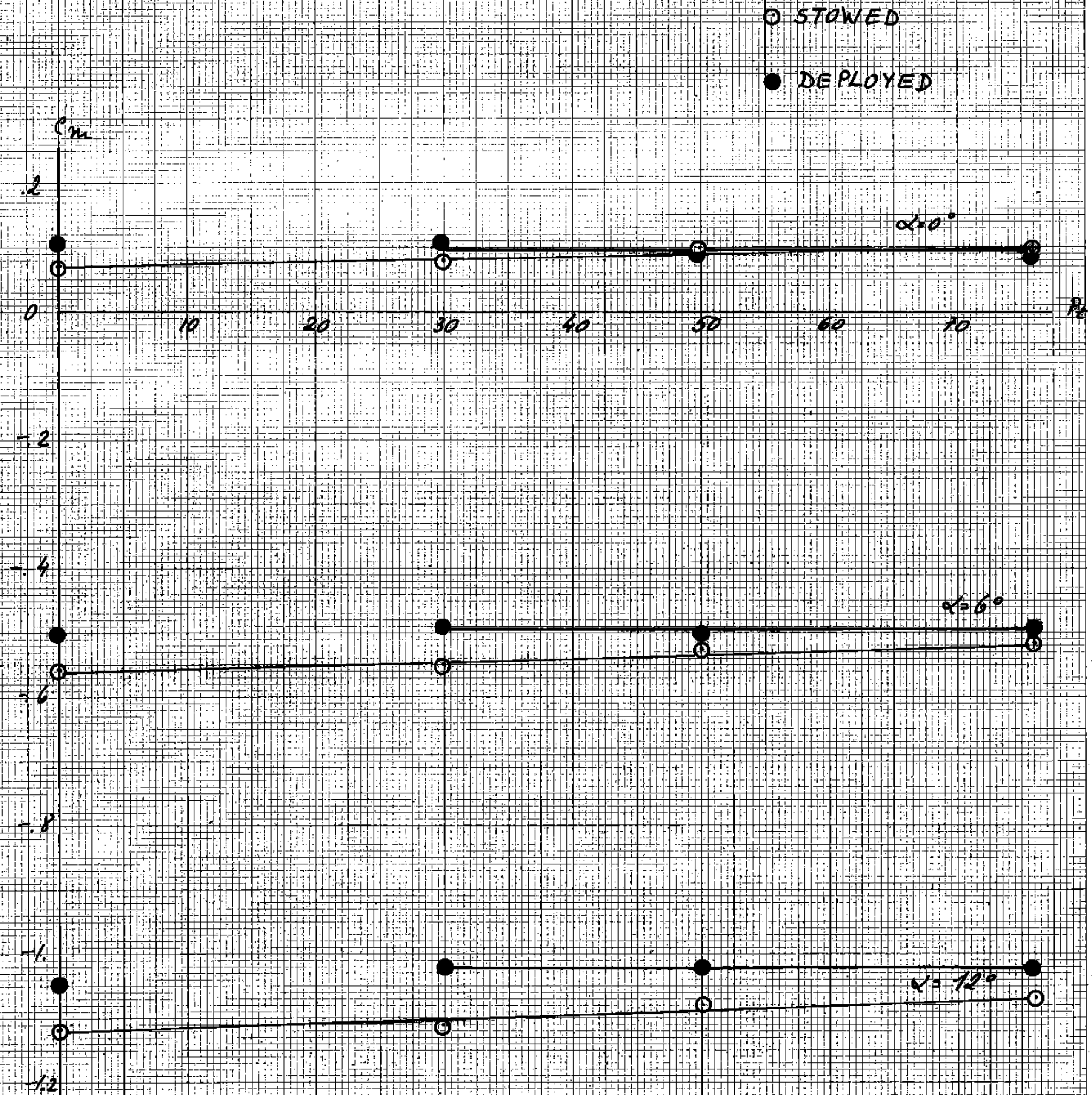
$\beta = -8°$



4820/10483

WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_m VS P_t

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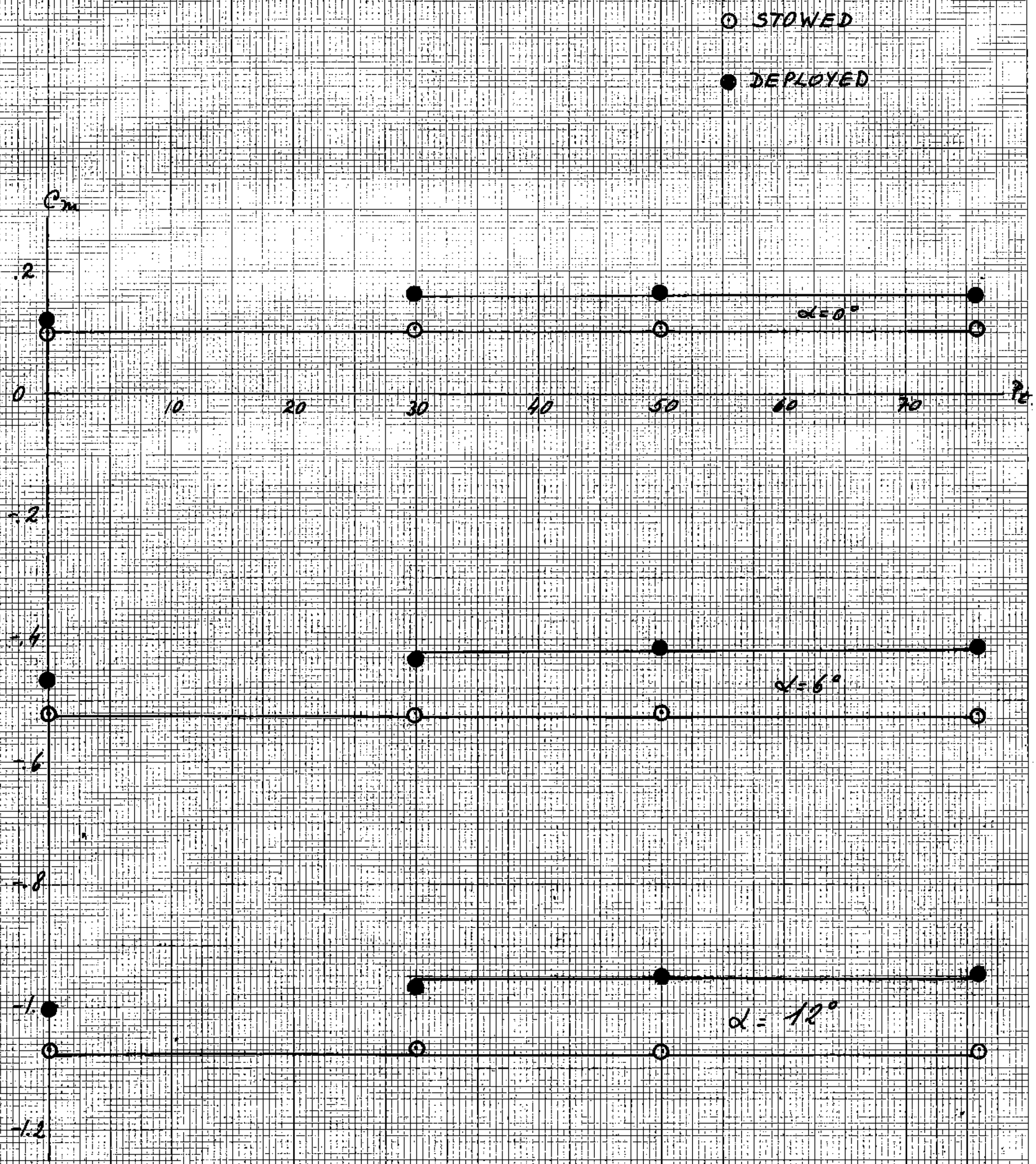
$\beta = +8°$



WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_m vs P_t

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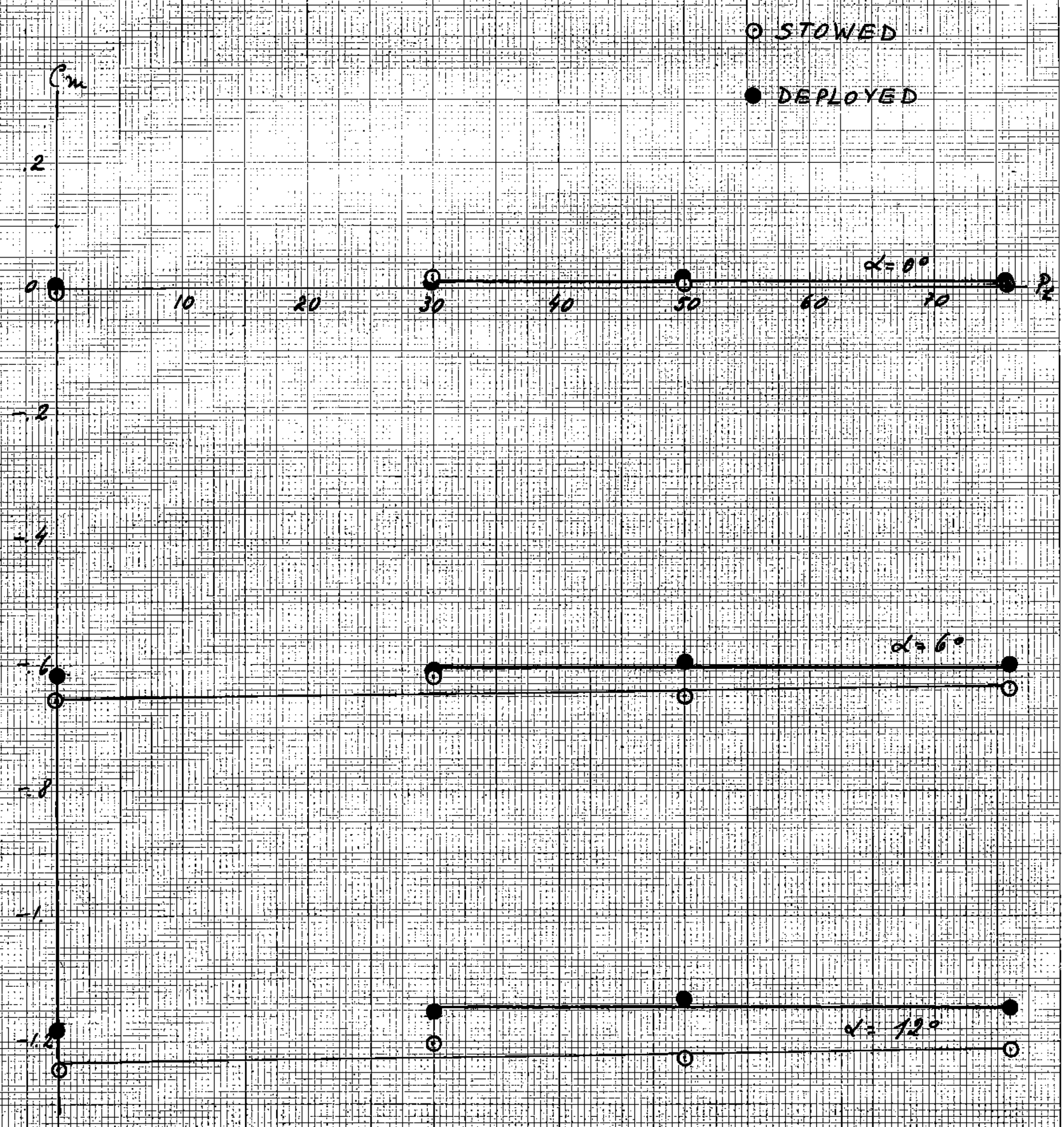
$\beta = 0°$



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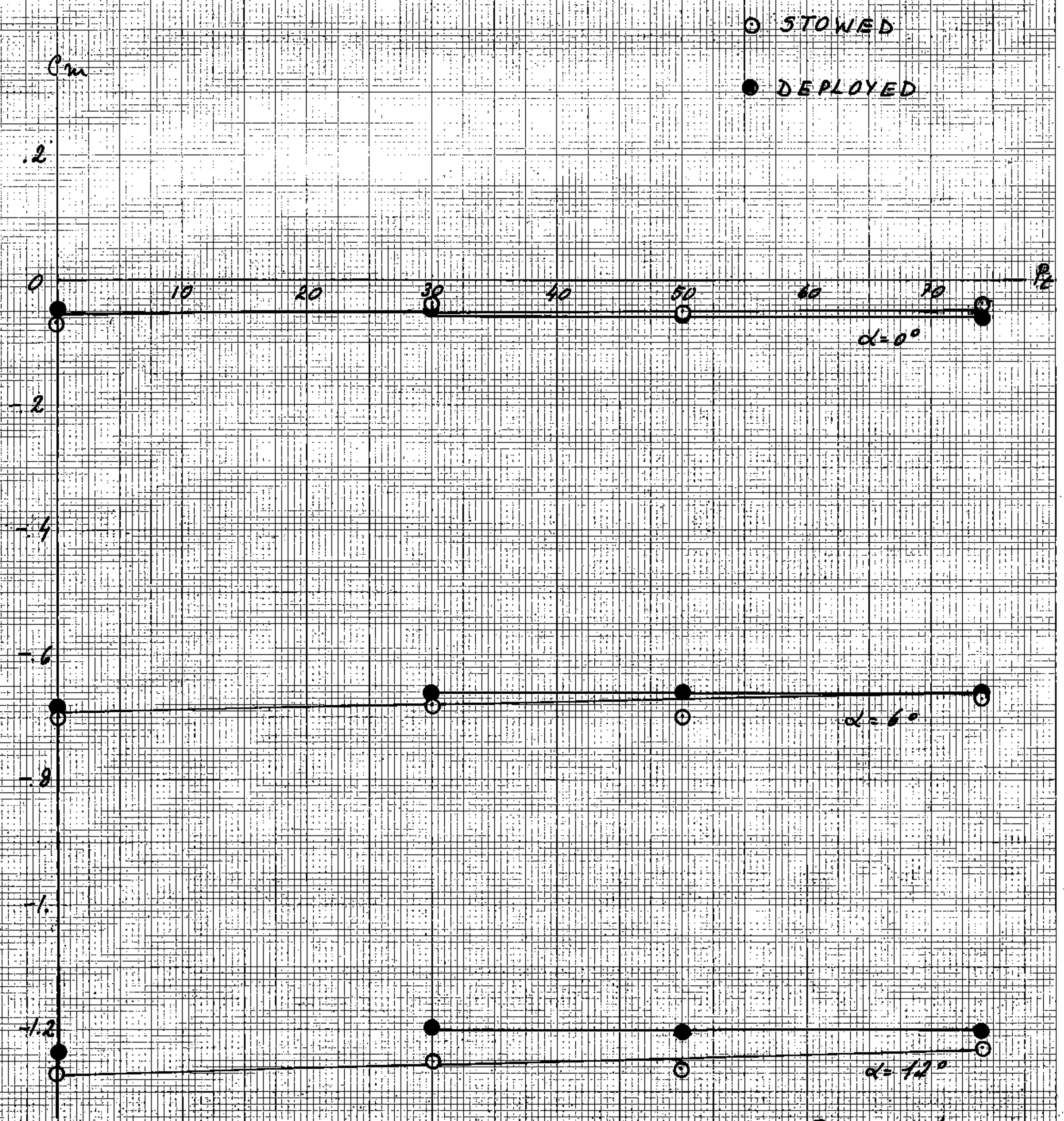
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_m vs P_t

$\delta_F = 12°$

$\beta = -8°$



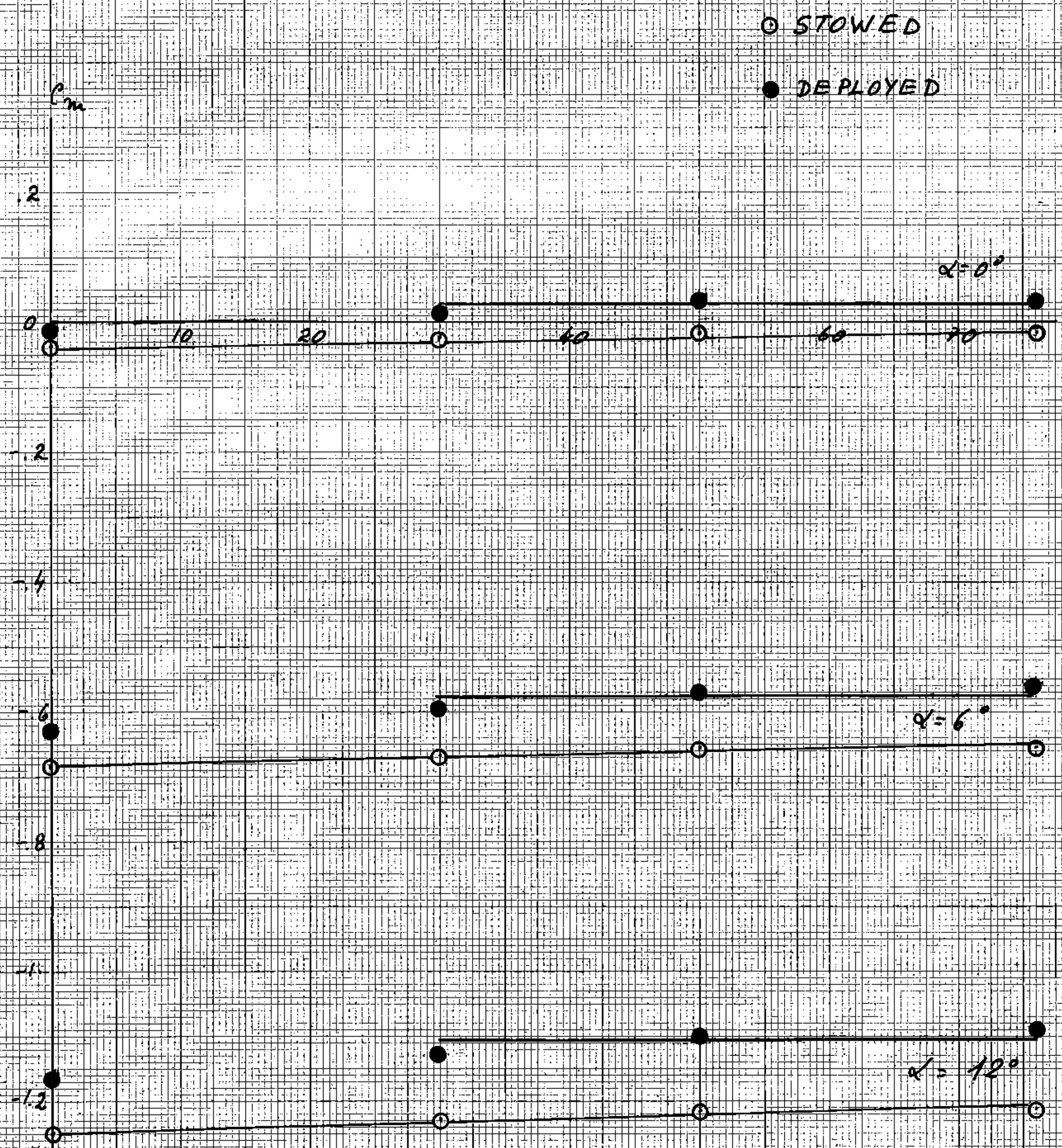
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_m VS P_t

$\delta_F = 12°$

$\beta = +8°$



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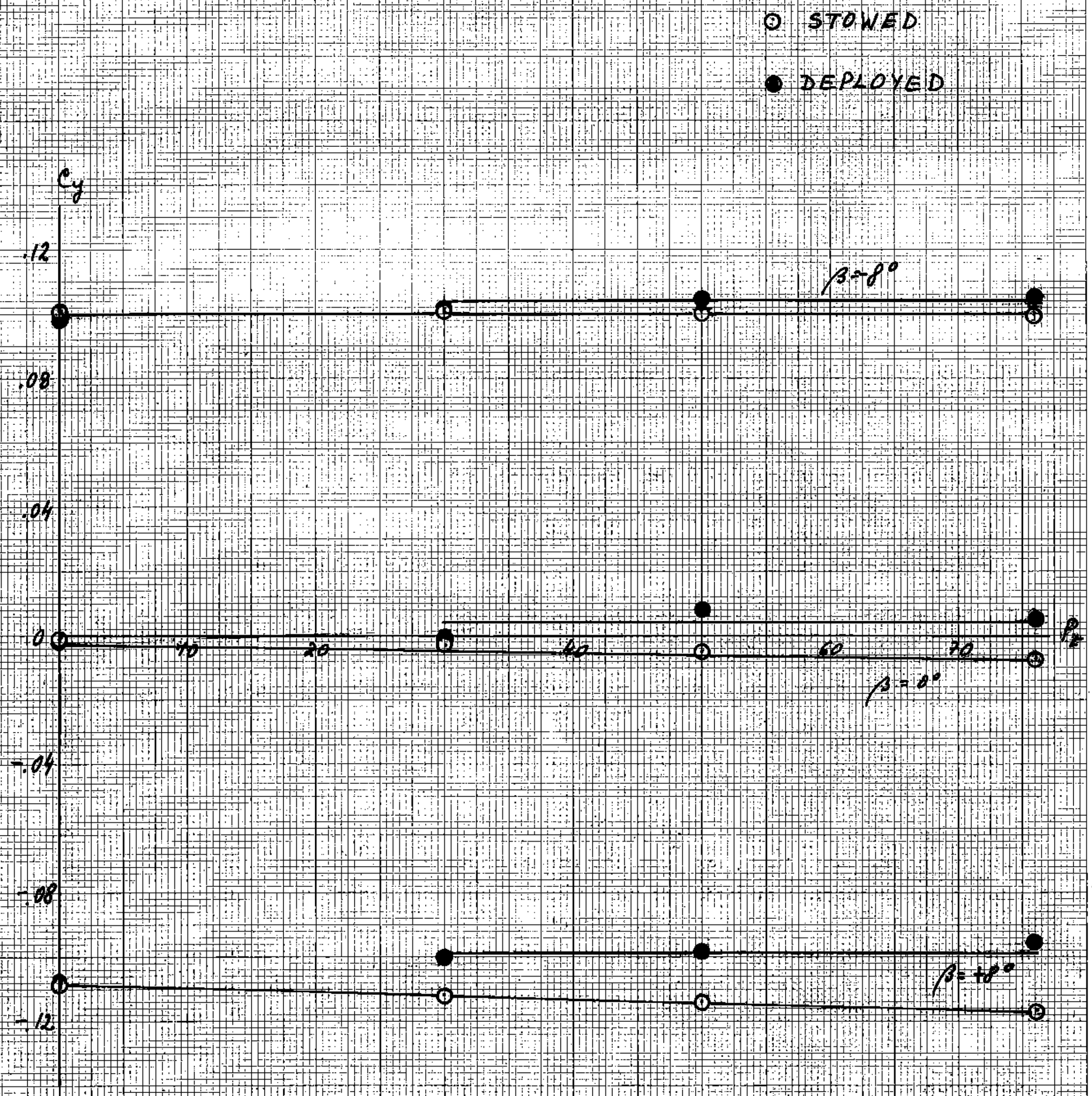
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_y vs P_t

$\delta_F = 0°$

$\alpha = 0°$



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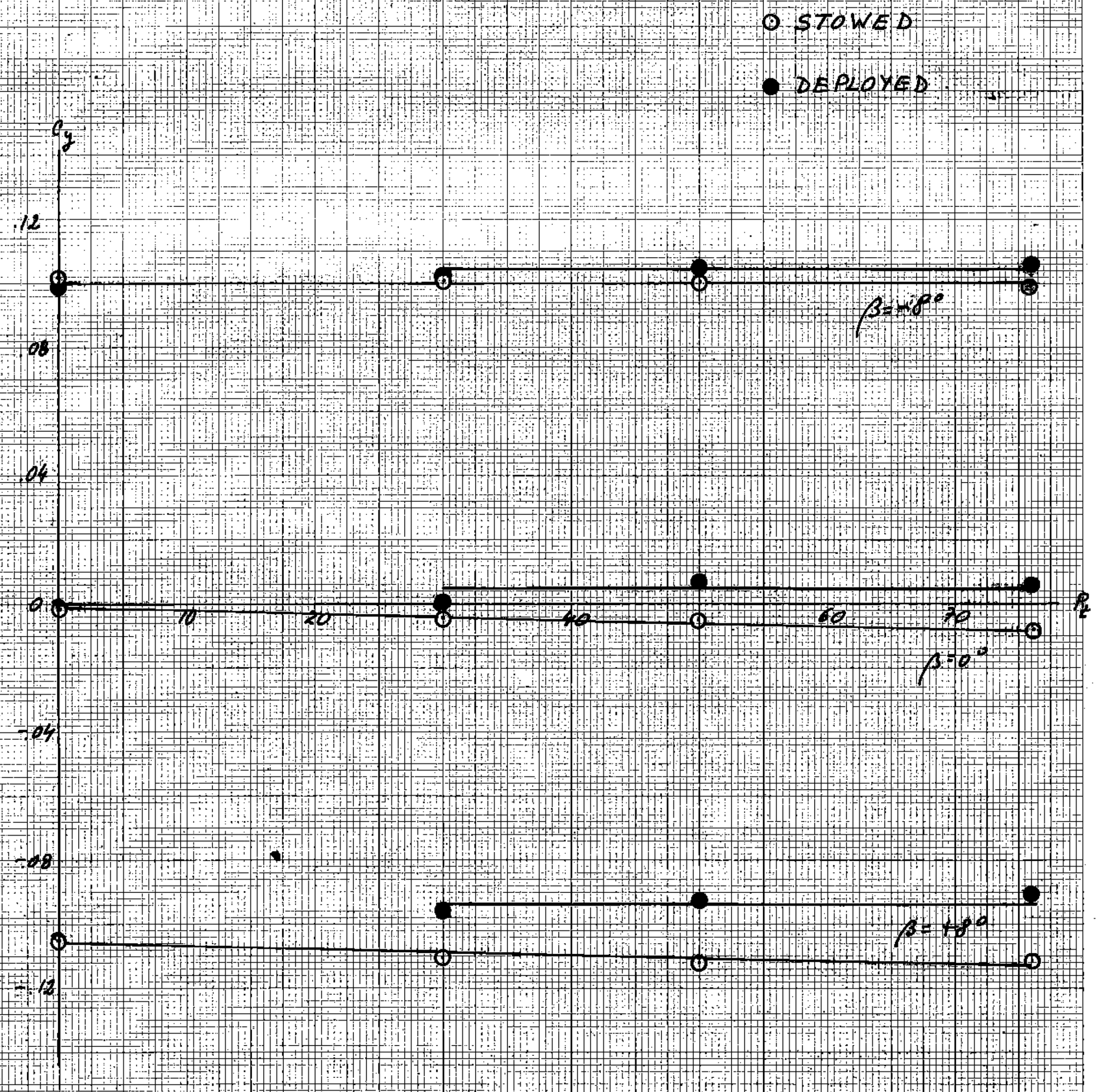
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_y vs P_t

$\delta_F = 0°$

$\alpha = 6°$



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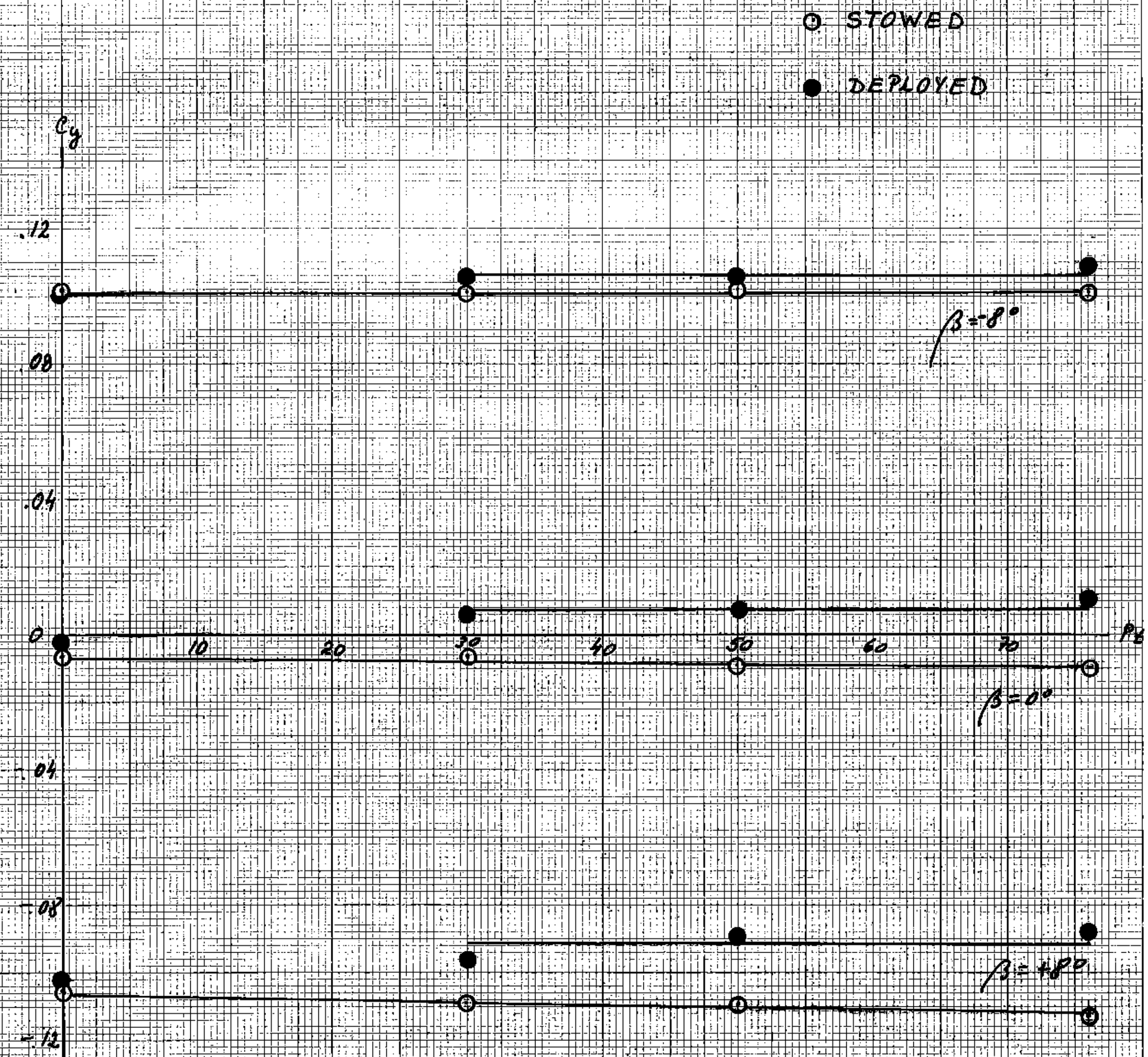
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_y VS P_t

$\delta_F = 0°$

$\alpha = 12°$



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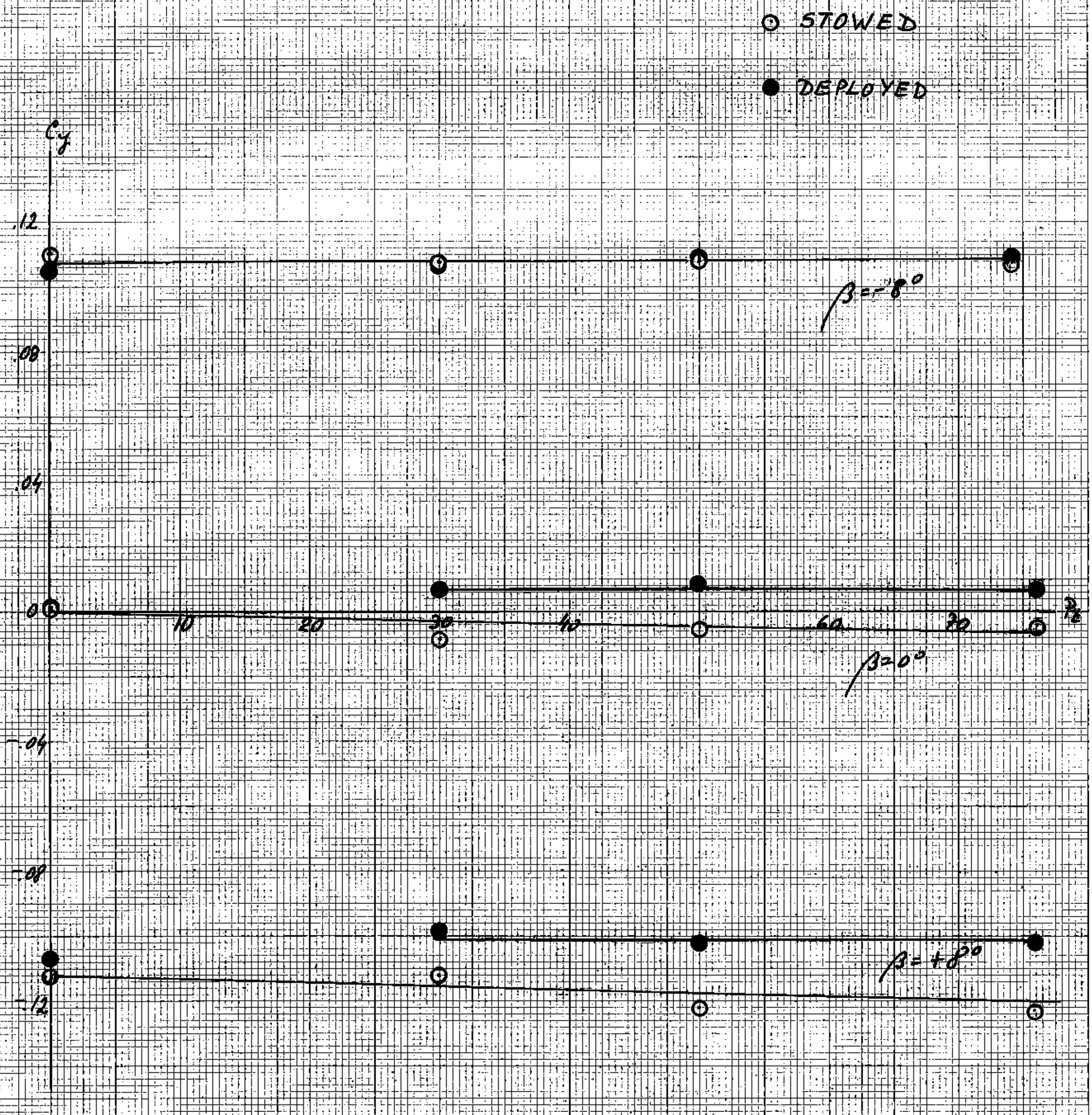
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_y VS P_t

$\delta_t = 12°$

$\alpha = 0°$



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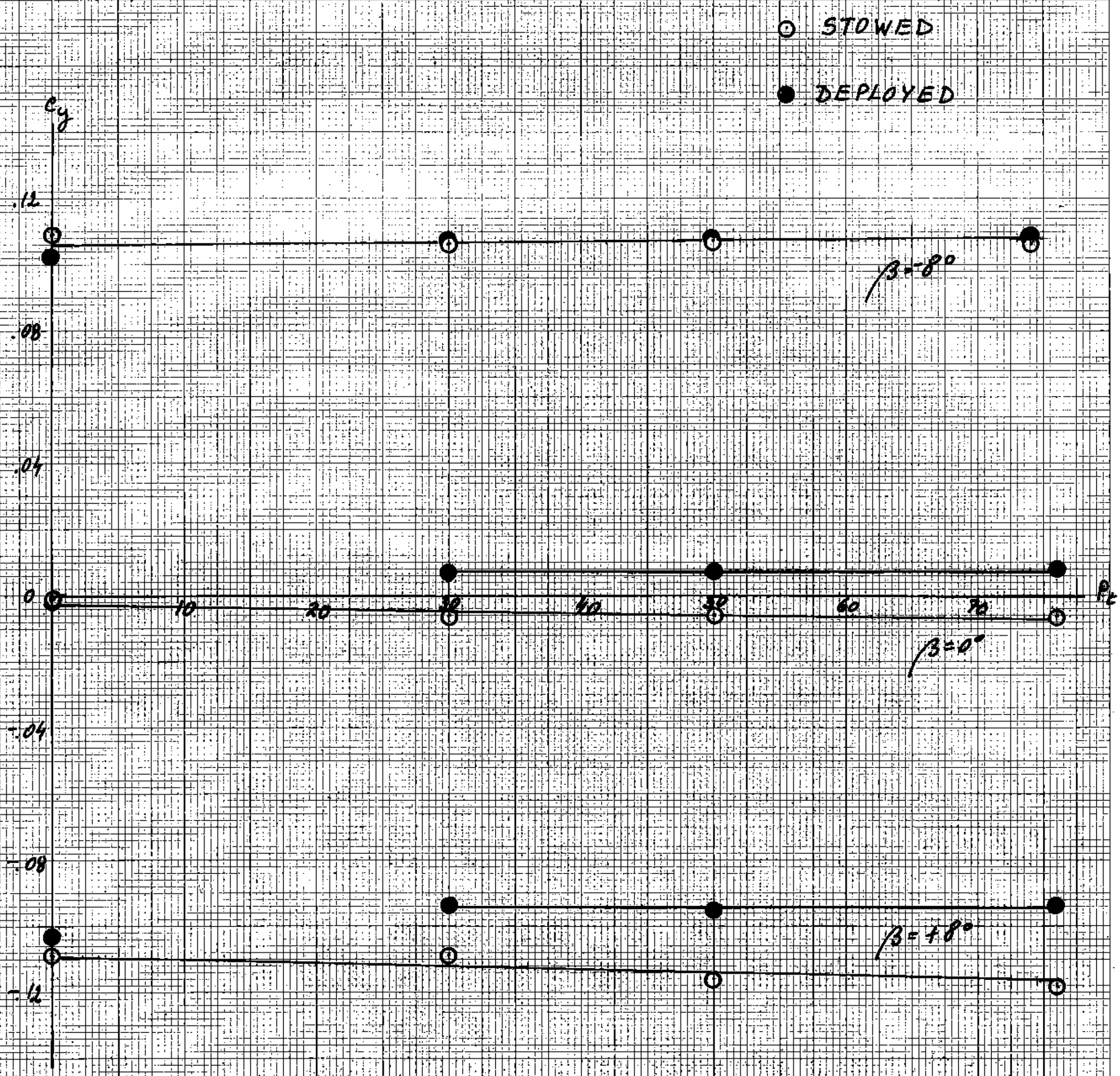
WESTWIND 1124

WIND TUNNEL WITH THRUST REVERSER

C_y vs P_t

$\delta_f = 12°$

$\alpha = 6°$



4820/10483

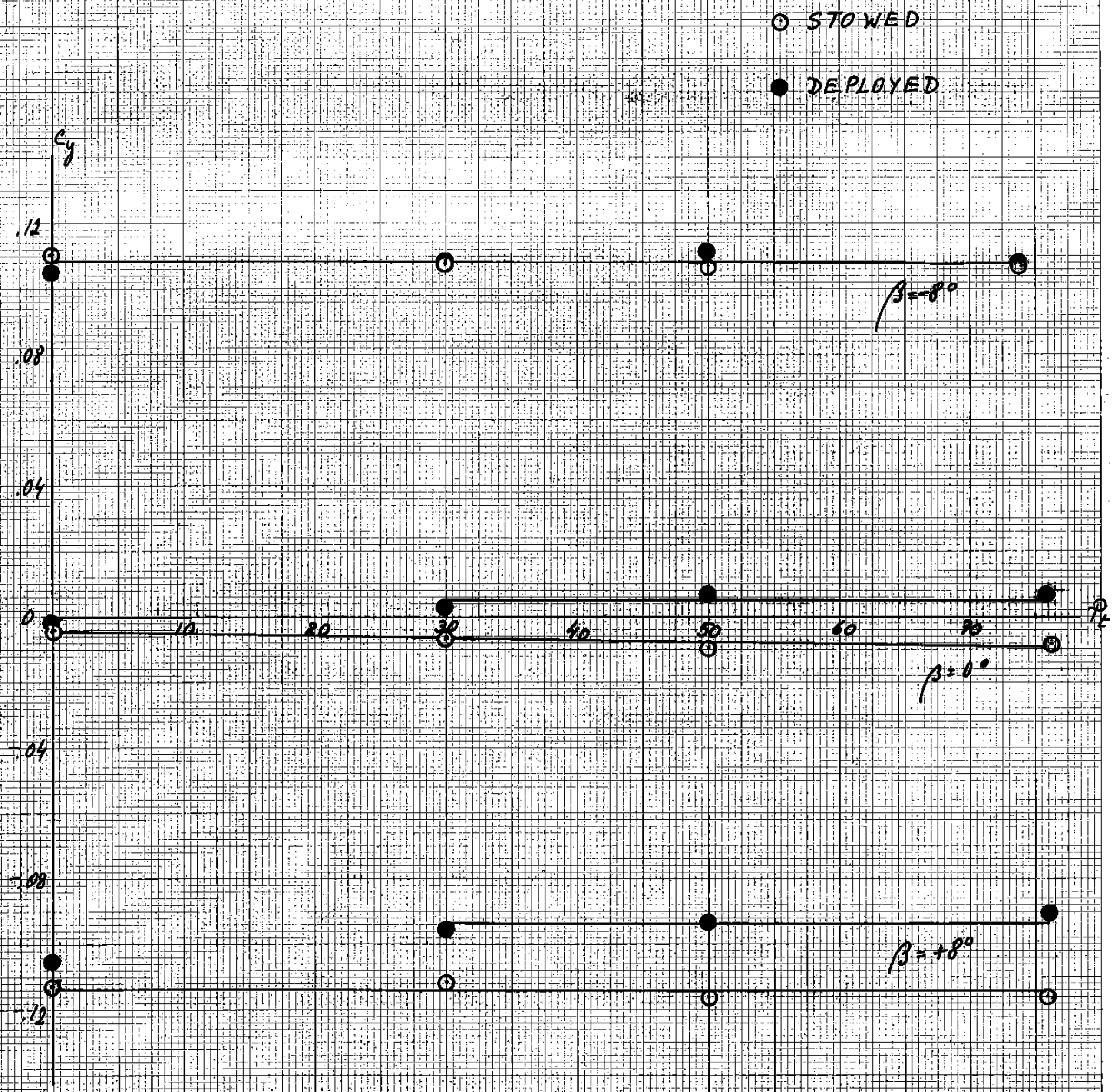
WESTWIND 1124

WIND TUNNEL WITH THRUST REVERSER

C_y vs P_t

$\delta_F = 12°$

$\alpha = 12°$



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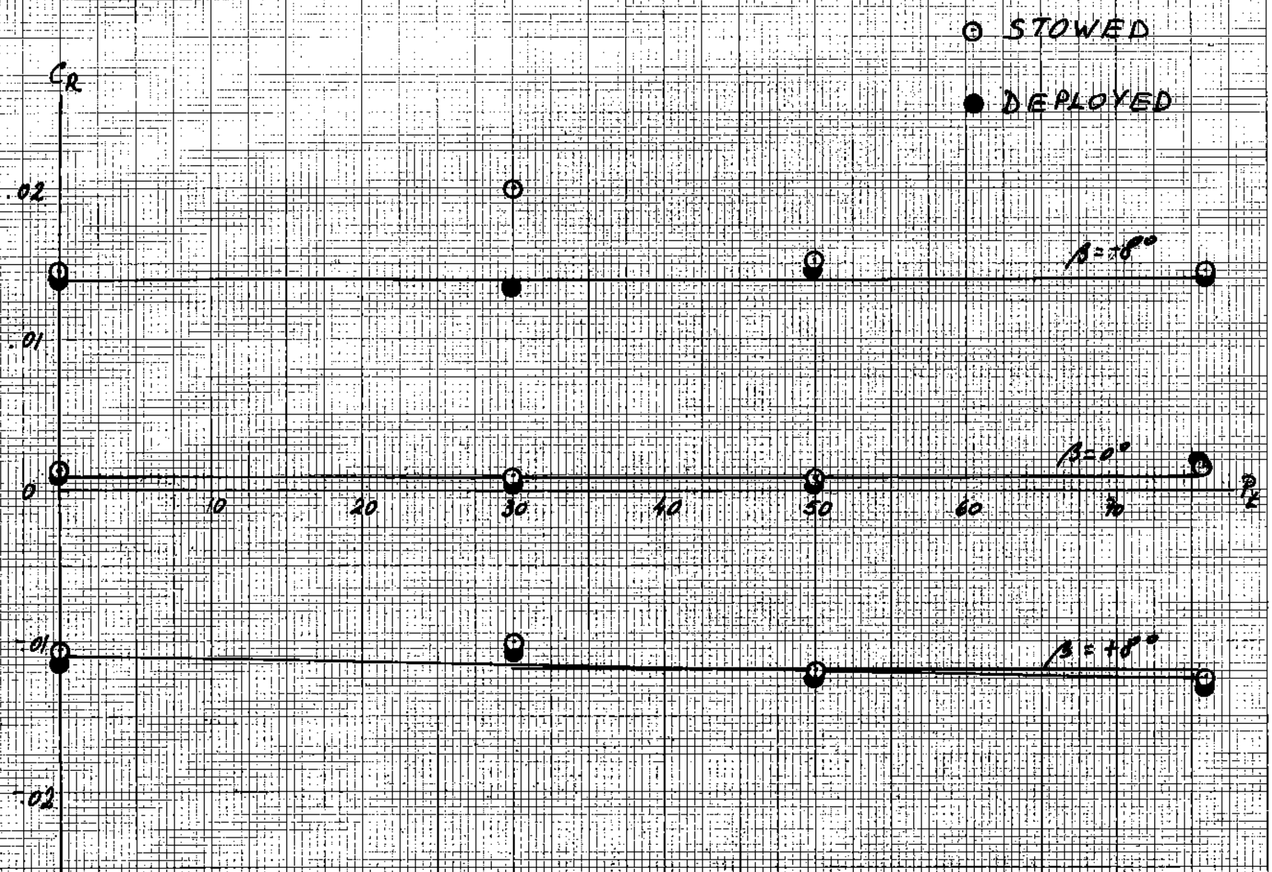
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_R vs P_t

$\delta_F = 0°$

$\alpha = 0°$



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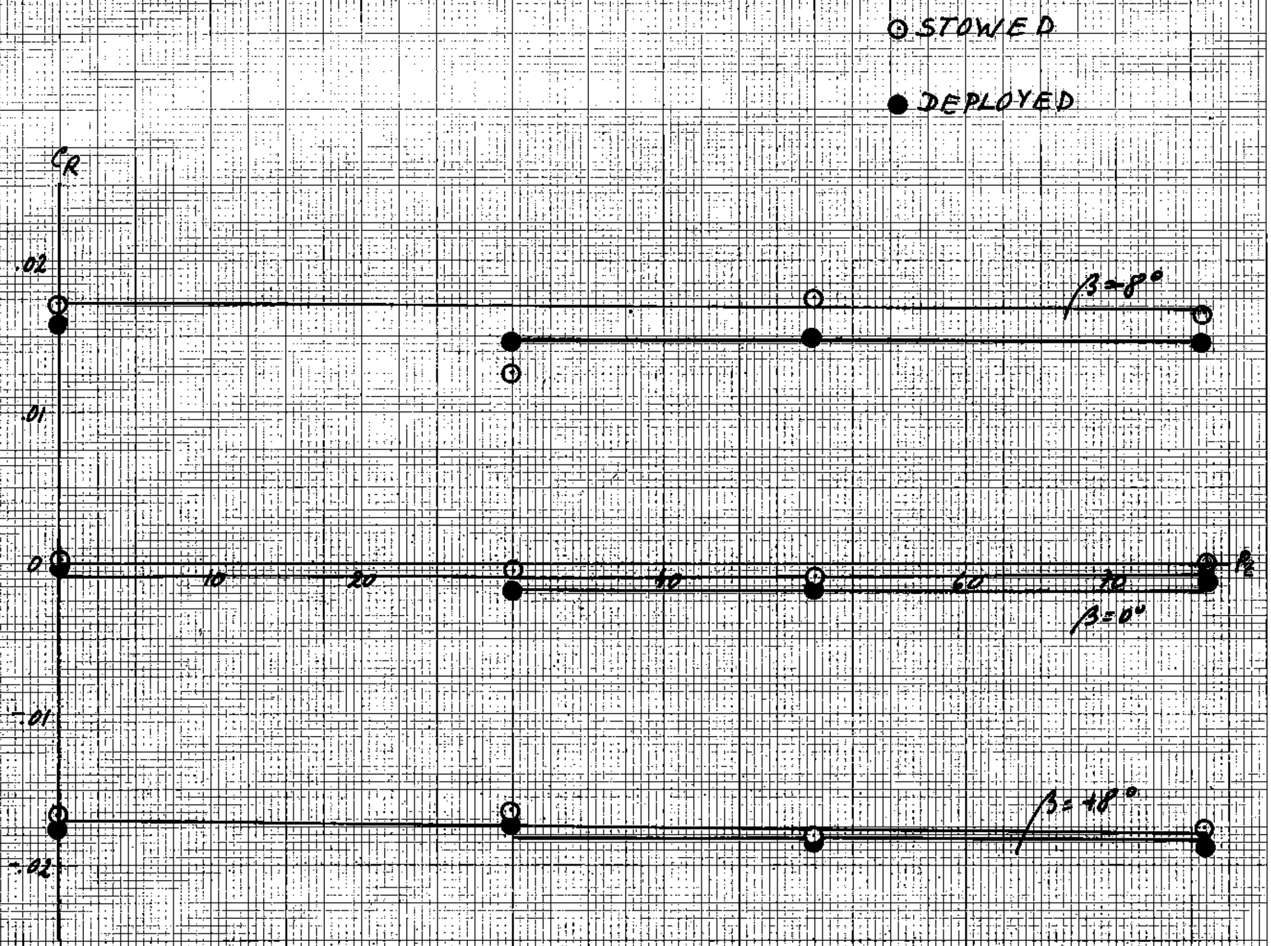
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_R vs P_t

$\delta_F = 0°$

$\alpha = 6°$



4820/10483

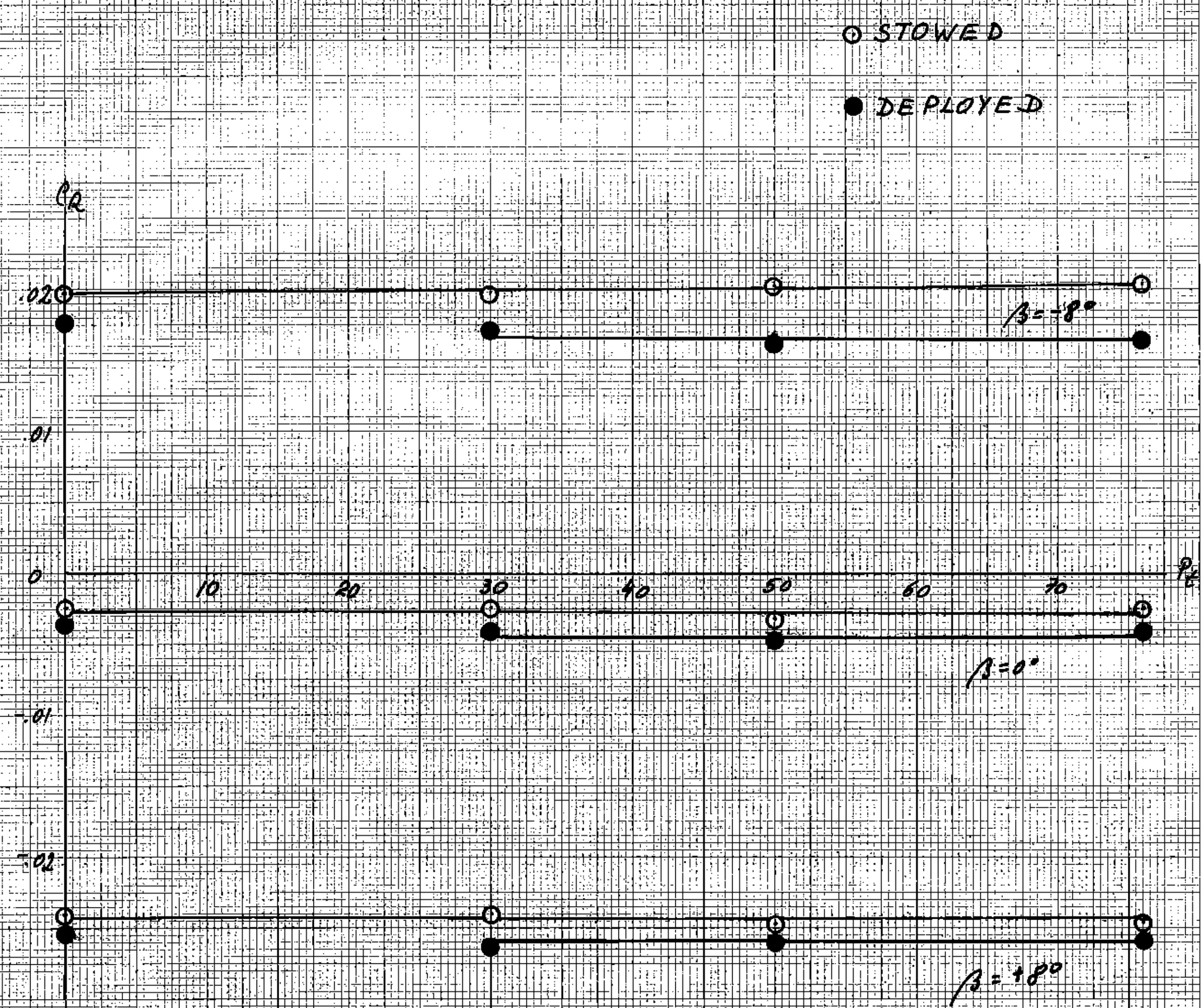
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_R vs P_t

$\delta_F = 0°$

$\alpha = 12°$



4820/10483

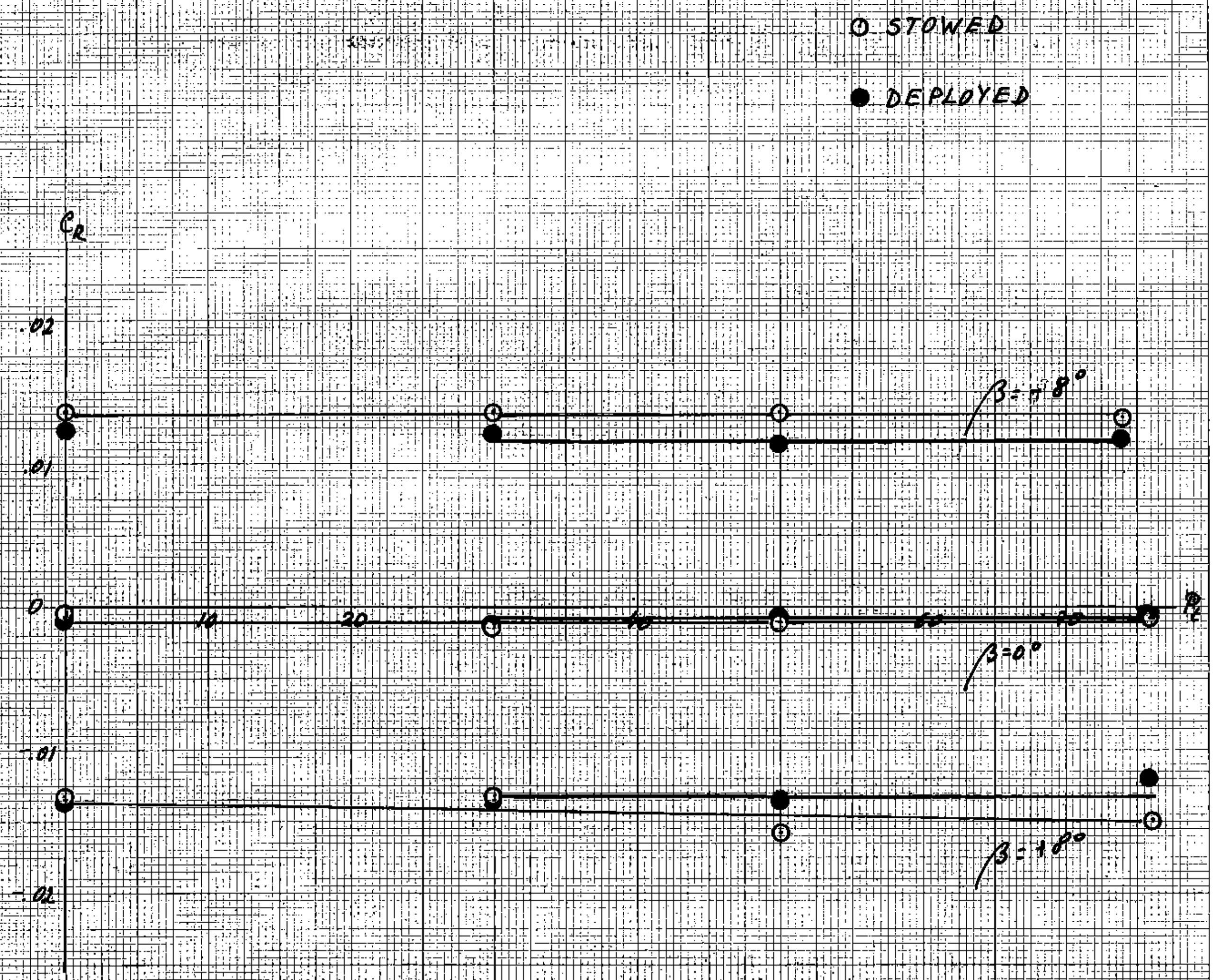
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_R vs P_t

$\delta_F = 12^\circ$

$\alpha = 0^\circ$



4820/10483

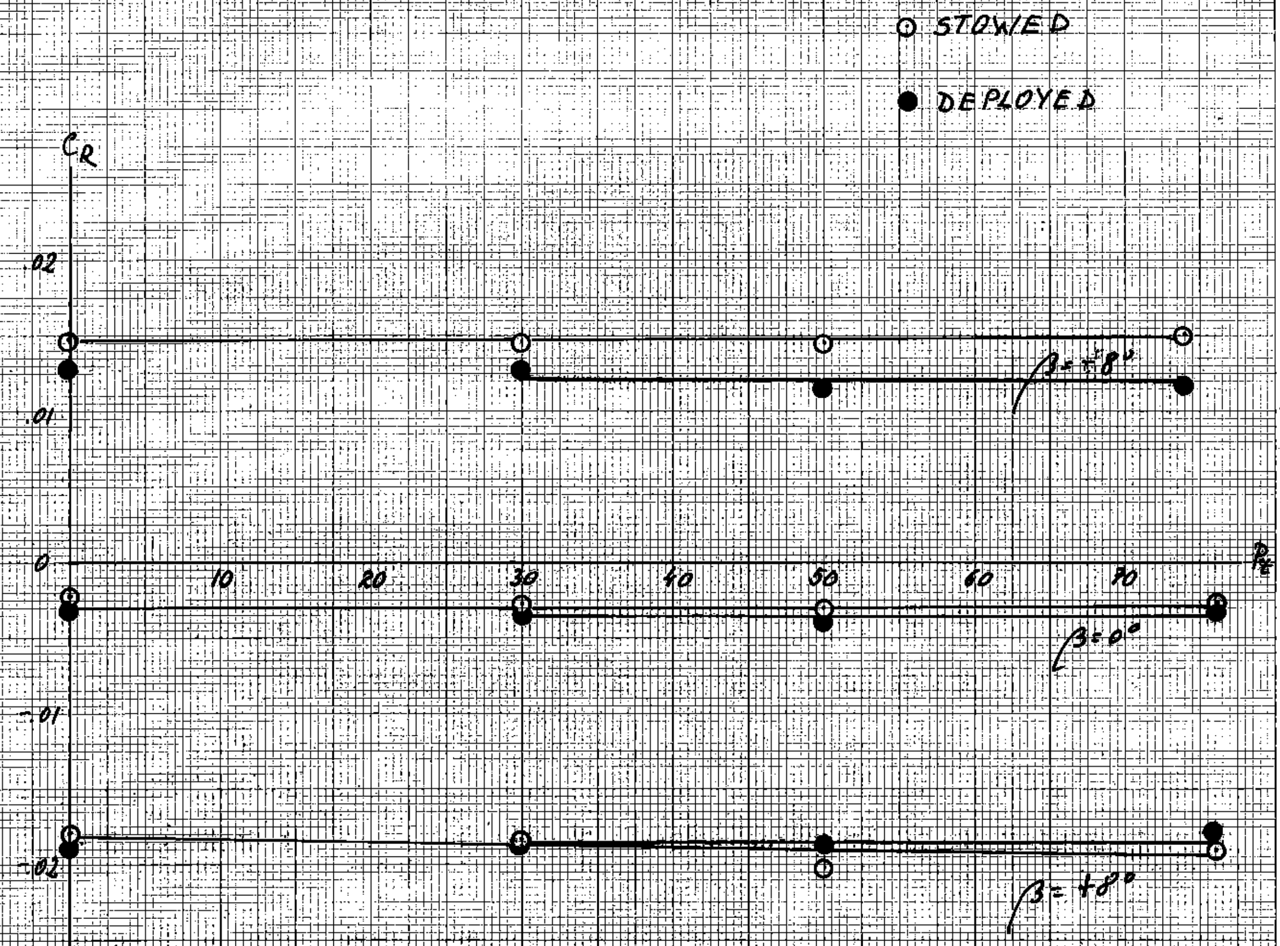
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_R VS P_t

$\delta_F = 12°$

$\alpha = 6°$



4820/10483

WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_R vs P_t

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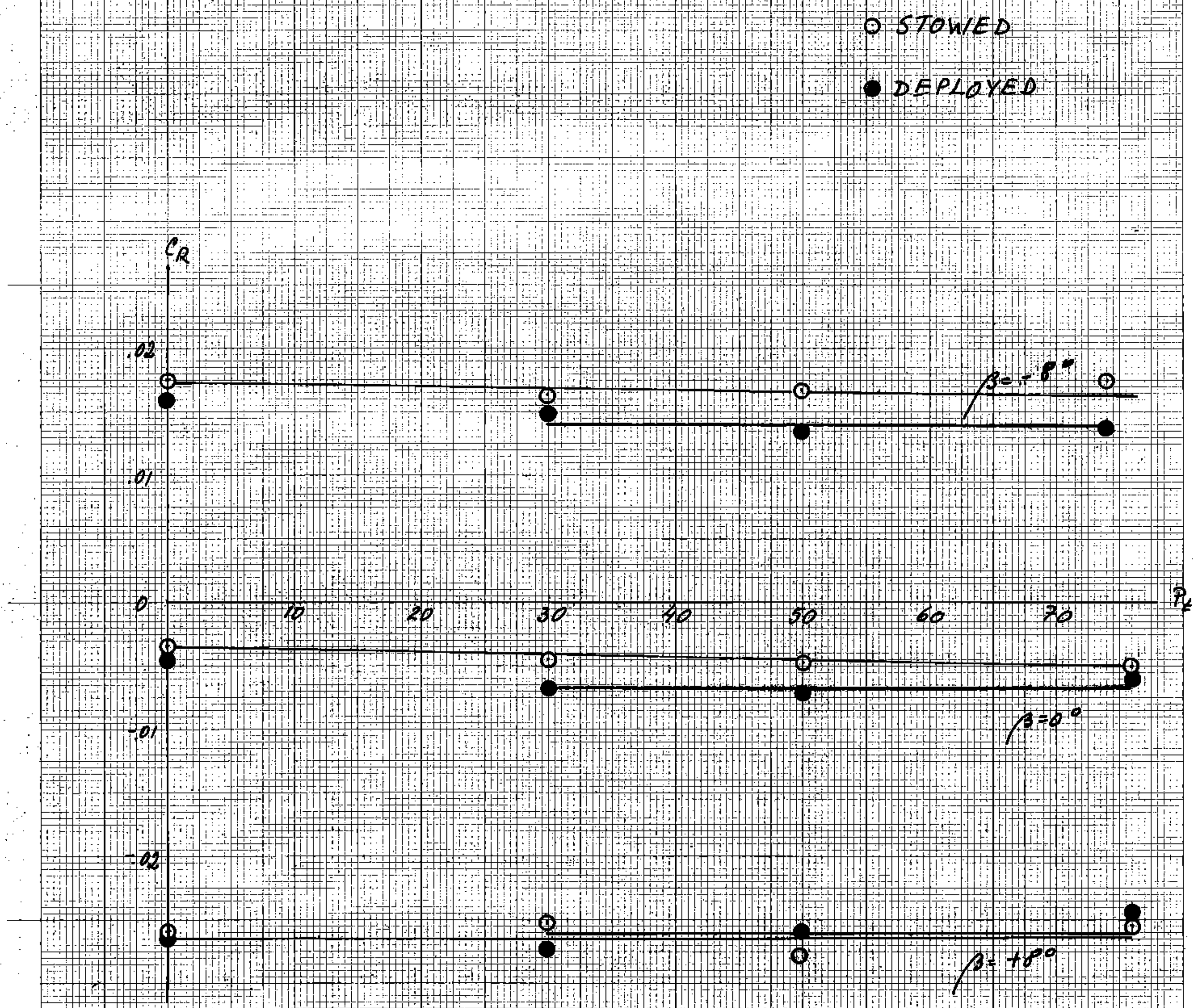
$\alpha = 12°$



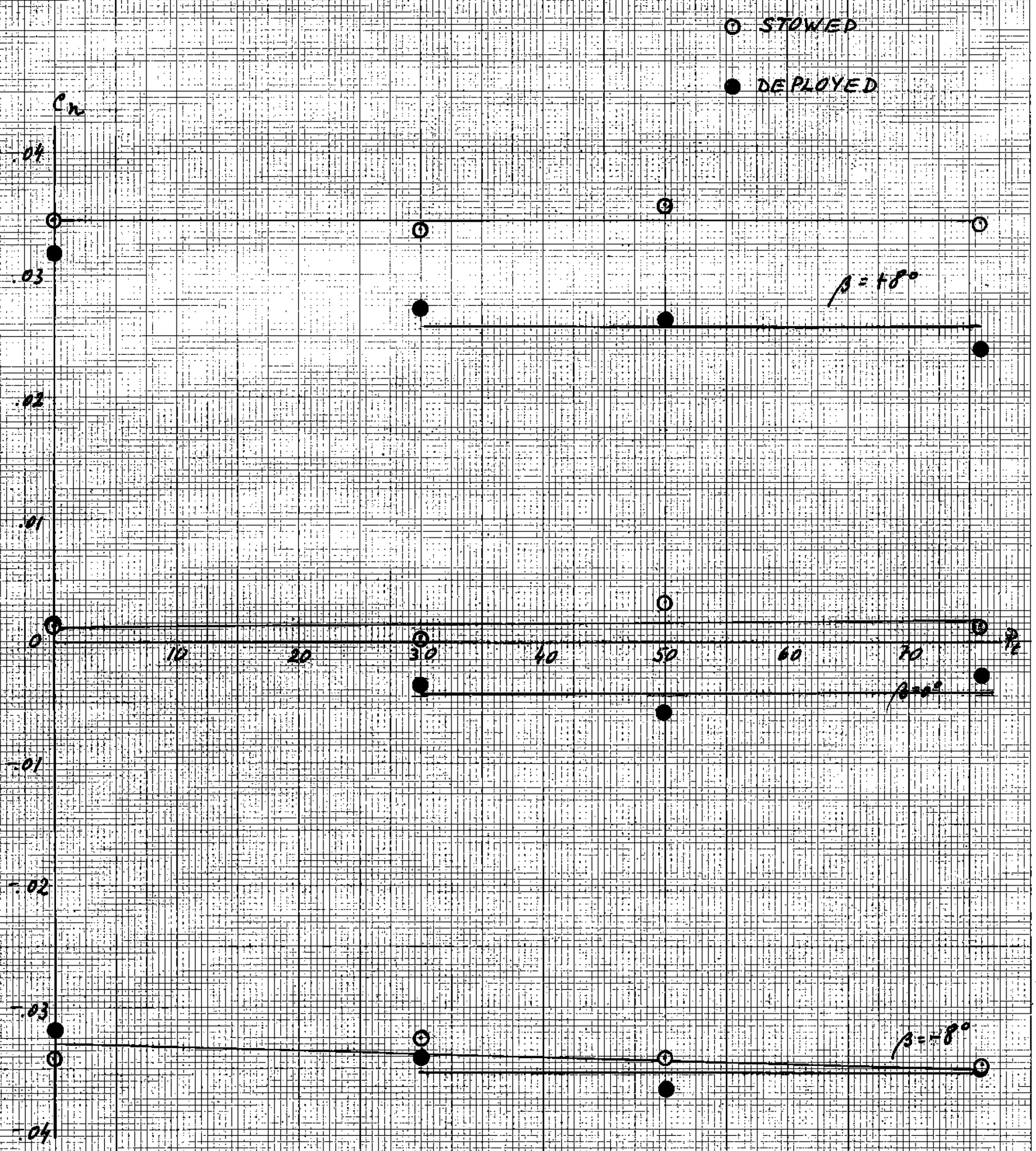
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_n VS P_t

$\delta_F = 0°$

$\alpha = 0°$



4820/10483

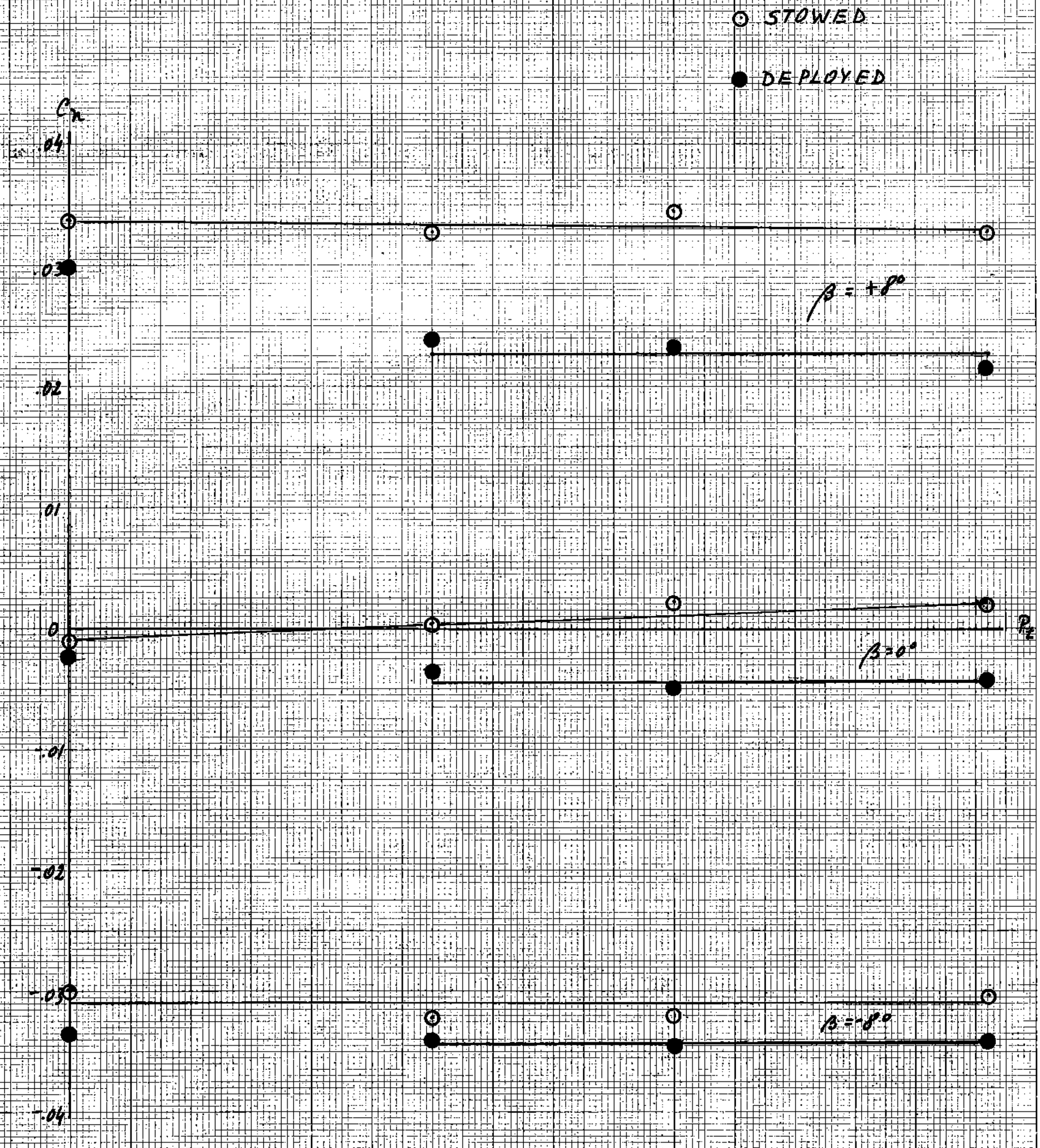
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_n VS P_t

$\delta_F = 0°$

$\alpha = 6°$



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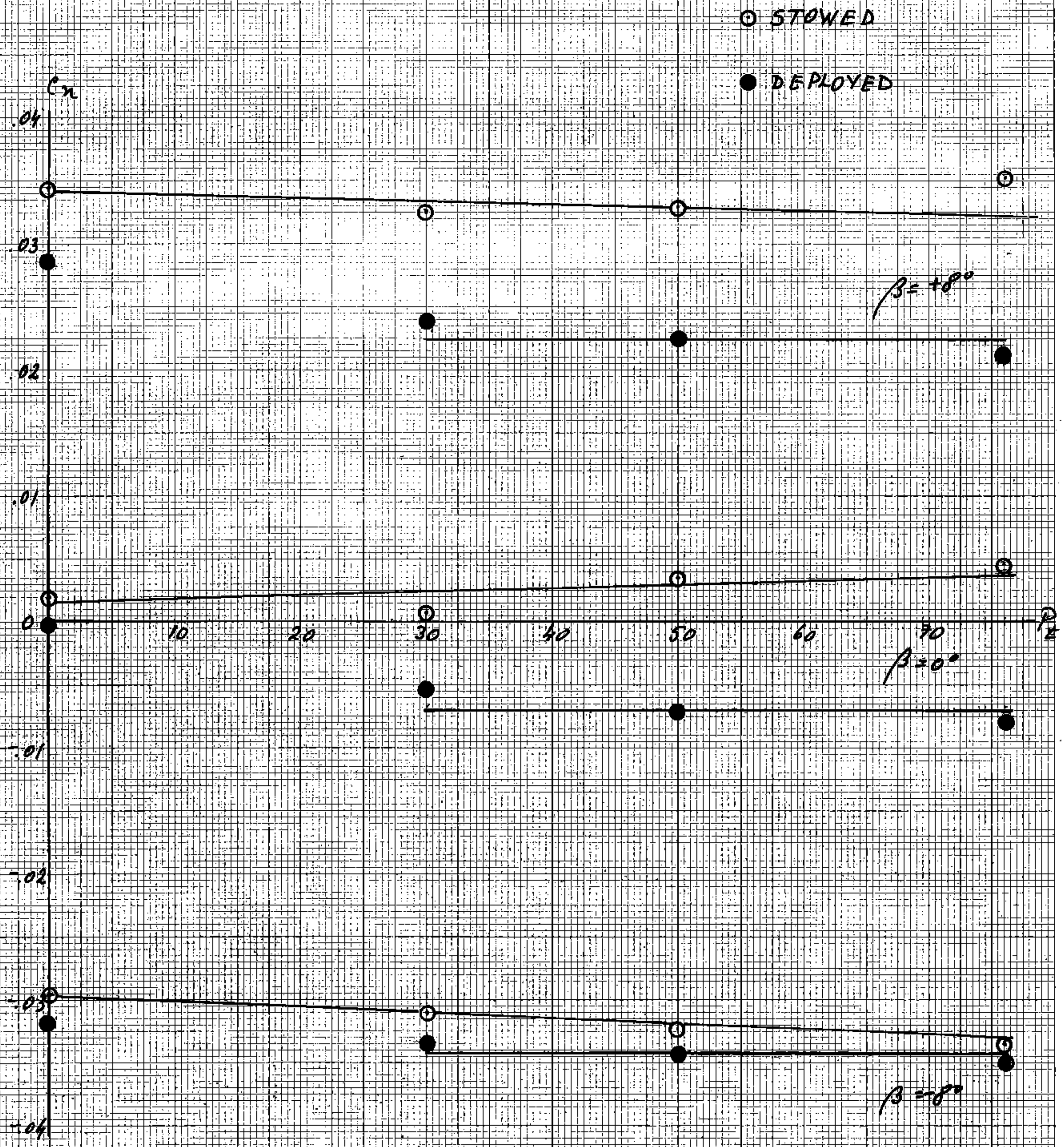
WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_n VS P_t

$\delta_F = 0°$

$\alpha = 12°$



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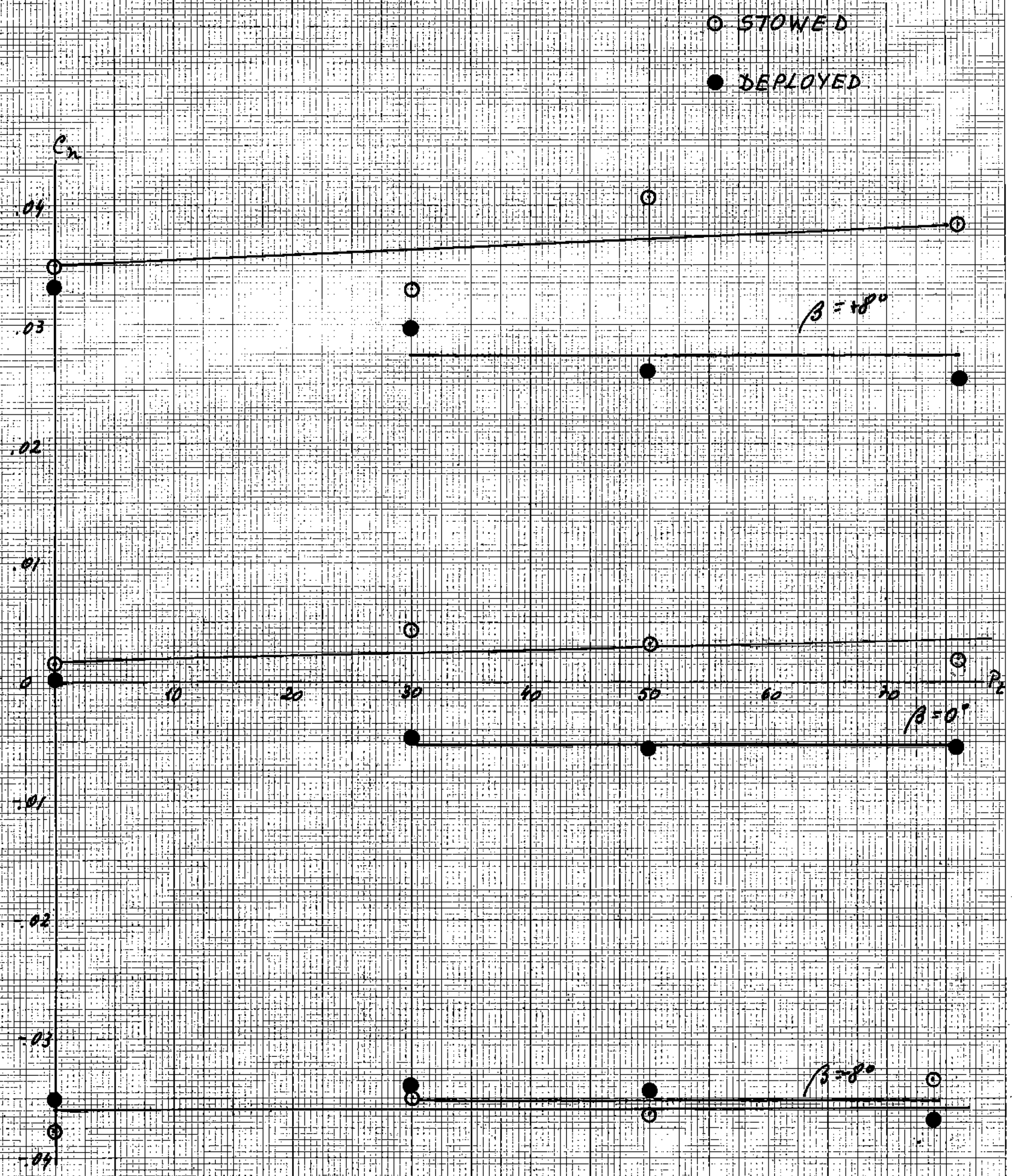
WESTWIND 1124

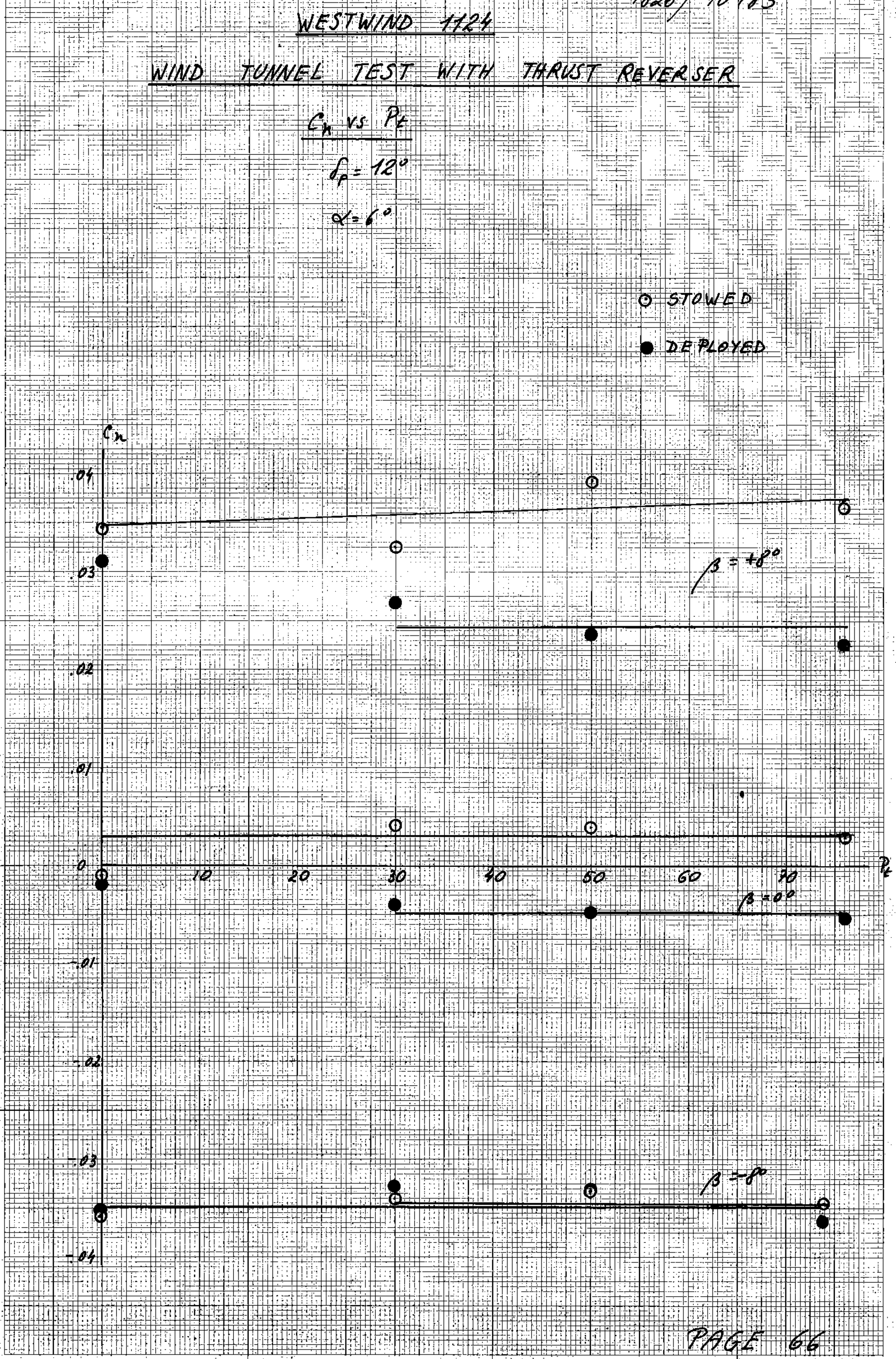
WIND TUNNEL TEST WITH THRUST REVERSER

C_n vs P_t

$\delta_F = 12°$

$\alpha = 0°$




WESTWIND 1124
WIND TUNNEL TEST WITH THRUST REVERSER
C_n vs P_t
$\delta_p = 12°$
$\alpha = 6°$
STOWED
DEPLOYED
C_n
.04
.03
.02
.01
0
-.01
-.02
-.03
-.04
10
20
30
40
50
60
70
P_t
$\beta = +8°$
$\beta = 0°$
$\beta = -8°$

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WESTWIND 1124

WIND TUNNEL TEST WITH THRUST REVERSER

C_n VS P_t

$\delta_f = 12°$

$\alpha = 12°$