DIVISION OF AIRCRAFT PRODUCTION.
GOVERNMENT AIRCRAFT FACTORIES.

REPORT NO. 135

FLIGHT TESTS

GENERAL RECONNAISSANCE LINCOLN.

by H. K. Millicer, MSc.

Engineering Department,
July, 1952.

LIST OF CONTENTS.

LIST OF FIGURES.

---oOo---

FLIGHT TEST REPORT ON G.R. LINCOLN.

1. SUMMARY:

A series of instrumented flight tests on the G.R. Lincoln prototype has been carried out, and indicated that the lengthening of the fuselage by 6'6" and introduction of D.V. windows has not rendered the aircraft dangerous or difficult to control.

It has been shown that this aircraft within its C.G. limits of 46" to 61.6" aft of datum is stable and controllable in pitch and in yaw for all the configurations of flap and engine conditions tested and meets the appropriate A.P.970 conditions and R.A.A.F. recommendations. In fact the performance and aircraft behaviour are very much the same as the standard Lincoln aircraft, except for a much smaller position error at low airspeeds.

The pilots during their conversion to the modified aircraft should be aware of the 10 knots higher indicated stalling speeds.

Two large direct vision windows provide excellent visibility, much in excess of the R.A.A.F. requirements, but air deflectors in front of the windows, essential for their operation, cause a 3% loss in cruising speed.

2. INTRODUCTION:

From the wind tunnel tests at A.R.L. and the calculations done in our Department, it became evident that the intended modification was not drastic in its effects on stability, namely it was going to reduce the longitudinal static margin by 2" and the directional stability by some 10% without even producing a fin stall tendency. However, as there were some doubts as to the validity of wind-tunnel test results due to large scale effect expected, it was decided to instrument the prototype aircraft and carry out fairly extensive quantative flight tests in order to determine the new aircraft's behaviour in various configurations of flap and engine conditions.

3. EXTERNAL FEATURES OF THE NEW AIRCRAFT.

The standard production Lincoln aircraft A.73-48 has had the following external modifications, shown on the attached photograph:

(i) A parallel portion 6'6" long has been built in in front of the Pilot's Instrument Bulkhead and contained, for flight tests, the observer's seats and the automatic observer box.

(ii) This new compartment has two large side cut-outs, covered in normal flight by sliding-up window panels.

(iii) Each window opening has an air deflector manually rotatable about its vertical axis. When deflected about 35° to the air stream it creates a break-away and so reduces the velocities over the window area.

(iv) The Pitot head has been moved from its original side fuselage position, 30" down and 60" forward. After the second flight it was changed to the "chin" position as recommended by A.R.DU. Laverton.

4. INSTRUMENTATION:

A steel tube quadripod was installed on the aircraft nose to carry the yaw meter vane and a 'Desyn' transmitter. Three other 'Desyn' transmitters were installed on the elevator, the port aileron and the port rudder.

.../2...

4. INSTRUMENTATION (Contd.)

A stick force indicator with its 'Desyn' transmitters was installed on the second pilot's control column.

A hydraulic, dial type, pedal force indicator was fitted to the starboard first pilot's pedal.

An automatic observer box was mounted on the starboard observer's table in the new extended portion of the fuselage, containing:-

5 'Desyn' indicators for elevator, aileron, rudder and yaw angles and for the elevator stick force; a sensitive airspeed indicator; a "G" meter; a synchronising clock with large seconds hand; 4 fuel flow meters of the "gallons gone" type; F-73 type camera rigidly mounted in front of this instrument panel and operated electrically to take pictures every 2/3 secs; a small electric light for separate operation by the Technical Observer in charge, to be flashed on momentarily to mark an appropriate test phase on the film.

5. LOADING:

TABLE I indicates weights and C.G. positions for every flight carried out.

6. TESTS CARRIED OUT:

6.1 Instrument Calibration -

All the instruments carried in the observer box were calibrated on the ground against control deflections and hysterisis curves of the backlash were thus obtained.

6.2 Qualitative assessment of aircraft characteristics:

Two flights of total time of 1 hrs. 40 mins. were carried out to assess the new aircraft characteristics. These flights, although without the automatic observer working properly, indicated however that the G.R. Lincoln lateral static and dynamic stability and controllability is as good as the standard aircraft.

Times in partial climb from 1000 - 10,000 ft. were taken, and when reduced to standard conditions, proved to be no different from R/Cl. of standard aircraft.

Air deflectors and side windows were operated in the air and showed the need for obtaining firstly pressure distributions on the window panel and thus determining the best deflector angle. Without this information at the first attempt of opening the window, it blew in with high pressure, causing minor injury to one member of the crew.

The position of Pitot Head was found to be wrong; there was a large fluctuation of I.A.S. with sideslip.

6.3 Lateral and Directional Stability and Control -

Oscillatory dynamic stability with rudder free was checked in flights Nos. 2 and 3. The results taken from the automatic observer are shown in figures GR/13 and 14 and indicate that for both port and starboard rudder deflection, the G.R. Lincoln meets the requirements of A.P. 970 Chap. 6, para. 8.2. by having its oscillation amplitude halved in less than 1 cycle.

... / 3 ...

6.3 Lateral and Directional Stability and Control - (Contd.)

No snaking or hunting was found apparent with rudder fixed or free, engines on or off with deflectors in a streamline position. There is, however, some rudder and fuselage buffeting with air deflectors on at indicated speeds above 220 K i.e. in a dive.

No rudder locking was found to be present at any speeds between 100 K= 1.15 Vs and 150 K for conditions as specified in A.P.970. Angles of yaw as obtained from auto-observer were (for all symmetric engine conditions) smaller than the rudder angles required to produce them; the fin stall cannot be produced for full rudder or pedal forces of 180 lbs. or both.

MEASUREMENTS OF RUDDER power and obtainable rates of turn against live engines gave the following results, showing the rudder power to be adequate:

ENGINE CONDITIONS.	FLAPS:	U/C:	INDICATED SPEED KNOTS:	ANGLE OF BANK	RATE OF TURN	FOOT LOAD.
P.O.feathered Others + 7" 2650 r.p.m.	Up	Up	150	30°	170°/min.	moderate
P.O.feathered P.I.windmilling others + 7", 2650 r.p.m.	Up	Up	150	30°	160°/min.	medium
P.O.Wind-milling, others + 7". 2650 r.p.m.	Fully down	Down	90	small, full aileron	Just turning	180 lb.

6.4 Minimum Control Speeds, Dynamic & Static.

Dynamic minimum control speeds were obtained by cutting the Port outer engine suddenly, at different speeds with other engines developing full take-off power, flaps in take-off position, undercarriage down. The results were as follows:-

Port Outer Cut @ 125K IAS Pedal force 190 lb.
" " " 120K IAS " " 213 lb.
" " " 115K IAS " " 235 lb.

In the last case a lot of aileron was needed to hold off the bank developed and only just enough rudder was available to bring the aircraft back on its course.

Static minimum control speeds were also obtained with 2 engines inoperative on the port side, others @ + 12", 2850 r.p.m. The following results were obtained:

P.O. feath. P.I. windmill @ 138 K IAS Pedal force 157 lb.
" @ 130 K IAS " 180 lb.
" @ 120 K IAS " 202 lb.
" @ 110 K IAS " 224 lb.

At the lowest speed the lack of aileron power to hold off the bank became the limiting factor.

..... / 4 ...

6.5 Position Error.

Higher than usual Lincoln stalling speeds were observed quite early in the tests and confirmed later with the C.G. at 1/4 chord position (see para. 6.6). Therefore a change in position error of the static vent due to lengthening of the fuselage was suspected. In the course of tests done by tower aneroid method at A.E.D.U., Laverton, the difference on P.E. from the standard aircraft was confirmed. The curves of position error vs indicated speed for the modified standard aircraft are presented on Figs. G.R. L1 and 2. It can be observed that the G.R. Lincoln aircraft has a very small airspeed indicator position error.

6.6 Stalling Speeds.

The stalling speeds for all-up weight of 55,500 lb. C.G. @ 25.6% S.M.C. were:-

A/c. Configuration:	A.S.I.R. Knots	P.E. Knots	C_L max.
Flaps up, U/C up.	88	0	1.48
Flaps T.O. U/C down	82	-2	1.80
Flaps down, U/C down	75	-2.5	2.20

Lift coefficients and true stalling speeds appear to be the same as for the standard Lincoln. The indicated stalling speeds are however, much higher than standard aircraft, and this feature of the modified aircraft should be brought to service pilots' notice.

6.7 Longitudinal Stability - Neutral and Manoeuvre Points.

The neutral points engines on and off, flaps up and down were obtained from flights done at three different C.G. positions. Dummy concrete bombs and sand bags were used for ballast and C.G. and aircraft weight were calculated from gallons gone for every test. The filmed desyn results show very small scatter of untrimmed elevator angles vs C_L (fig. G.R. L13 and G.R.L11). The following table summarises the results from figures G.R. L4 and G.R. L12.

Engines	Flaps	Neutral Point S.M.C.	Inches aft Datum.
Off	Up	62%	100
+12" 2850 rpm	Up	42%	75.5
"	Down	37%	68.5

The above tables show that theoretically this aircraft could be flown with C.G. at 75.5". However, the fact that the pilot needed only 2° of elevator to change speed from 140 - 240K indicates that without discomfort this aircraft could not be flown with C.G. beyond 62-63" aft at datum.

Manoeuvre points, stick fixed and free, engines on +12" 2850 r.p.m. were obtained from analysis of flights done at extreme C.G. positions. Elevator angles, the "G" meter, the A.S.I., the stick force indicator and fuel gauges were filmed, every 2/3 sec. during untrimmed pull-outs, whilst the observer

.../5...

6.7 Longitudinal Stability - Neutral and Manoeuvre Points (Contd.)

in charge of camera operated a flash bulb to mark clearly on the film the moment when the aircraft was horizontal. Again the C.G. position and aircraft weight were calculated for every test and the results in terms of elevator angles per "G" and stick force per "G" were plotted on figs. G.R. L.5,6,7,8 and 9. The summary of it appears in the table below:-

Condition	Engine	Flaps	Manoeuvre Point	
			% S.M.C.	Inches aft Datum.
Stick free	On	Up	42	72.5
Stick free	On	Up	48	84.0

The tests with C.G. in the intermediate (58") position as a further check could not be carried out owing to a minor structural damage to the aircraft suffered during pull-outs; but the results as presented have shown a small scatter of points.

A couple of tests in a simulated baulked landing configuration were made with C.G. at 59.6", flaps and undercarriage down. The results indicated that there was just enough down elevator angle still available to climb away @ 130K on opening the power. On opening up the engines from + 3", 2650 r.p.m. to take-off power, with the aircraft in the trimmed out condition @ 110K. the required stick force and displacement were 20 lb. and 11° down respectively.

Summing up the longitudinal stability, it appears that the C.G. limits flaps up, undercarriage up should stay at 63" aft of datum as stipulated before, but the former 58" limit imposed in the design stage by this department for the landing condition could be relaxed to read now 59" as tested.

6.8 Performance.

The C.R. Lincoln performance as compared with standard aircraft appears to be identical as far as the top speed and rate of climb are concerned. The R/C. from three separate tests as reduced to I.C.A.N. and weight of 61,600 lb. are shown here on Fig. G.R.L.10.

The indicated level speeds with appropriate engine conditions were measured with deflectors shut or open at 8000' in order to compare them directly with speeds taken by A.R.D.U., Laverton, at the same height and powers. The speeds as quoted below were reduced to I.C.A.N. conditions and an all up weight of 61,600 lbs.

Engine Condition	Defl. streamlined. TAS KNOTS	Deflectors Open TAS KNOTS	Defl. Open - Window Open TAS KNOTS	True speed loss with deflectors & window open.
+ 3" 2650 RPM	187	182	181	3%
+ 7" 2650 RPM	212	203	201	5%
+12" 2850 RPM	235	225	223	5.4%

The reduction of speed due to deflectors & windows open is noticeable, but apparently acceptable to R.A.A.F. who consider that the deflectors and windows may have to be operated only for about 1/10 of their flight duration, consequently the approximate loss of max. range would be only .3%.

... / 6 ...

6.9 Operation of D.V. Windows and Deflectors.

The large, sliding, direct vision windows were designed to be shielded by the air deflectors in front of them, and have been found in the course of flight trials to be dangerously powerful when treated without due care. The deflectors should be fully open before an attempt is made to release the window locks.

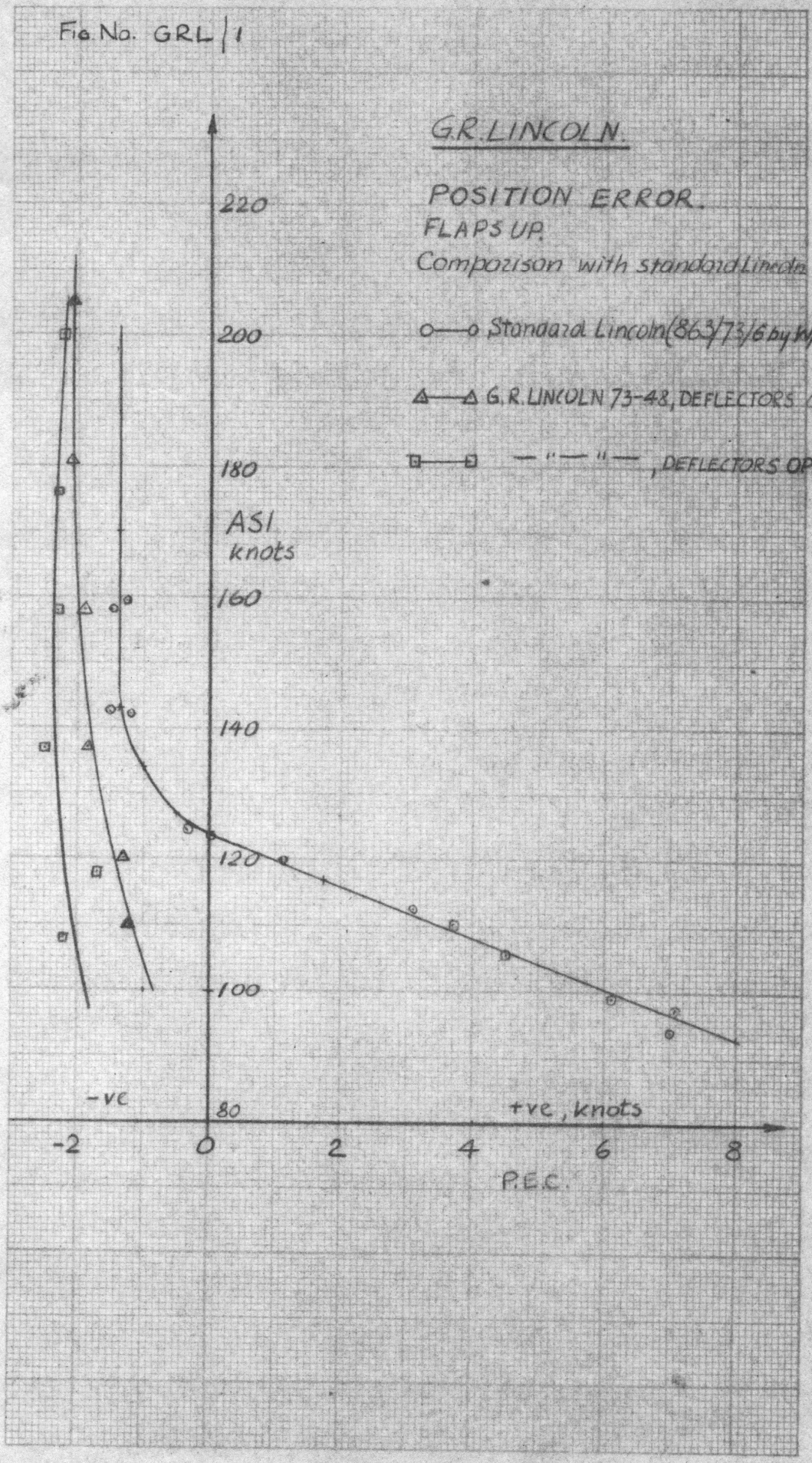
The window apertures with deflectors fully open offer an excellent visibility, and are nearly draught free. They permit the observers to put their heads right outside the fuselage contour without any discomfort at speeds up to 200K. Above that speed, at about 220K in a dive, some structural buffet appears in the fuselage and empennage, therefore prolonged dives with deflectors opened may not be permissible.

With windows open, an air circulation is set up inside the fuselage with a resulting draught about the pilot's legs. A black-out type curtain with a zip fastener in front of the cat-walk is hoped to eliminate the draught by sealing off the front observer's compartment from the rest of the aircraft. As an alternative to the deflectors, just in case the reduction in speed and range was unacceptable to R.A.A.F., the small blister type cover was built and tried. In the course of flight tests the blister was shown to cause no visible reduction in speed and proved to be draught free, but very noisy. It also offered much worse visibility than the window - deflector combination, although still within R.A.A.F. requirements. A R.A.A.F. Service inspecting group headed by S/L. Nichols has decided against the blister and agreed to adopt the window - deflector solution to the direct window problem.

A.C. 1305

PREPARED BY HKM	GOVERNMENT AIRCRAFT FACTORIES	PROJECT G.R. LINCOLN
DATE 22.5.52	DIVISION OF AIRCRAFT PRODUCTION	WEIGHT 59'000 lb.

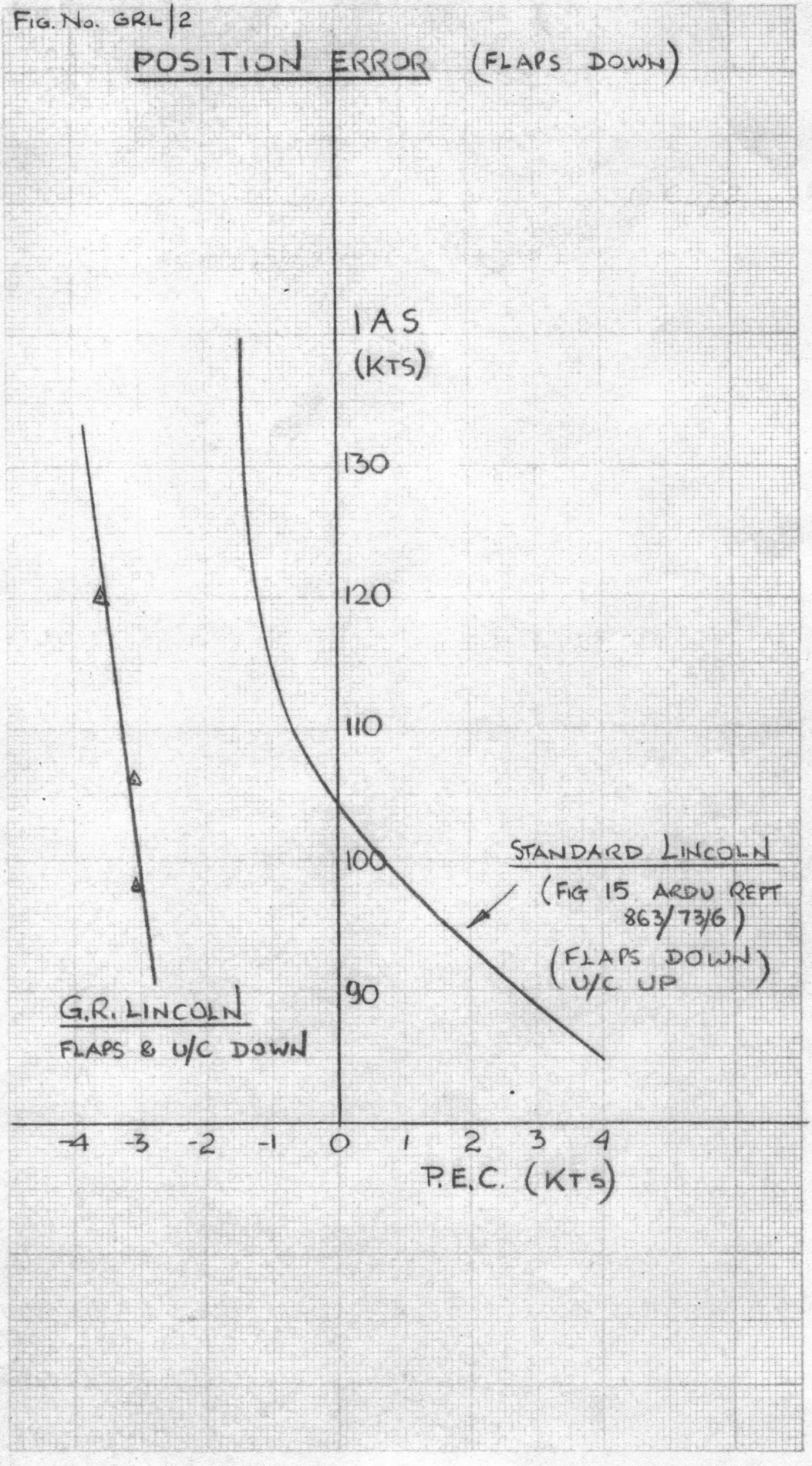
Fig. No. GRL/1



A.C. 1305

PREPARED BY SSS	GOVERNMENT AIRCRAFT FACTORIES	PROJECT GR LINCOLN
DATE 30. 5. 52	DIVISION OF AIRCRAFT PRODUCTION	WEIGHT 59,000 lb.

FIG. No. GRL/2

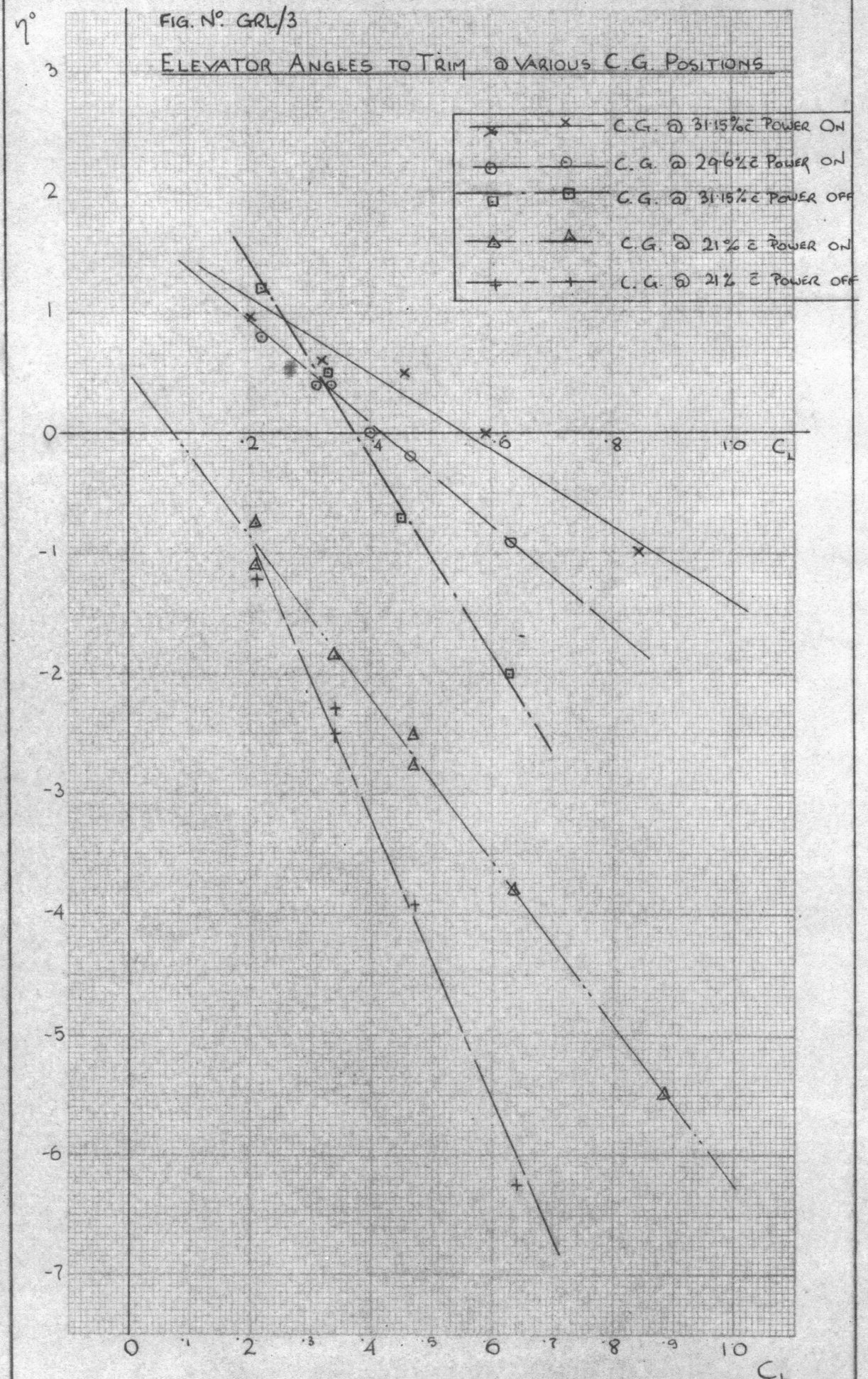


A.C. 1305

PREPARED BY SSS/TW	GOVERNMENT AIRCRAFT FACTORIES	PROJECT G.R. LINCOLN
DATE 6.6.52	DIVISION OF AIRCRAFT PRODUCTION	WEIGHT

FIG. N°. GRL/3

ELEVATOR ANGLES TO TRIM @ VARIOUS C.G. POSITIONS



A.C. 1305

PREPARED BY T. Webb	GOVERNMENT AIRCRAFT FACTORIES	G.R. LINCOLN PROJECT FLIGHT TEST
DATE 11-6-52	DIVISION OF AIRCRAFT PRODUCTION	WEIGHT

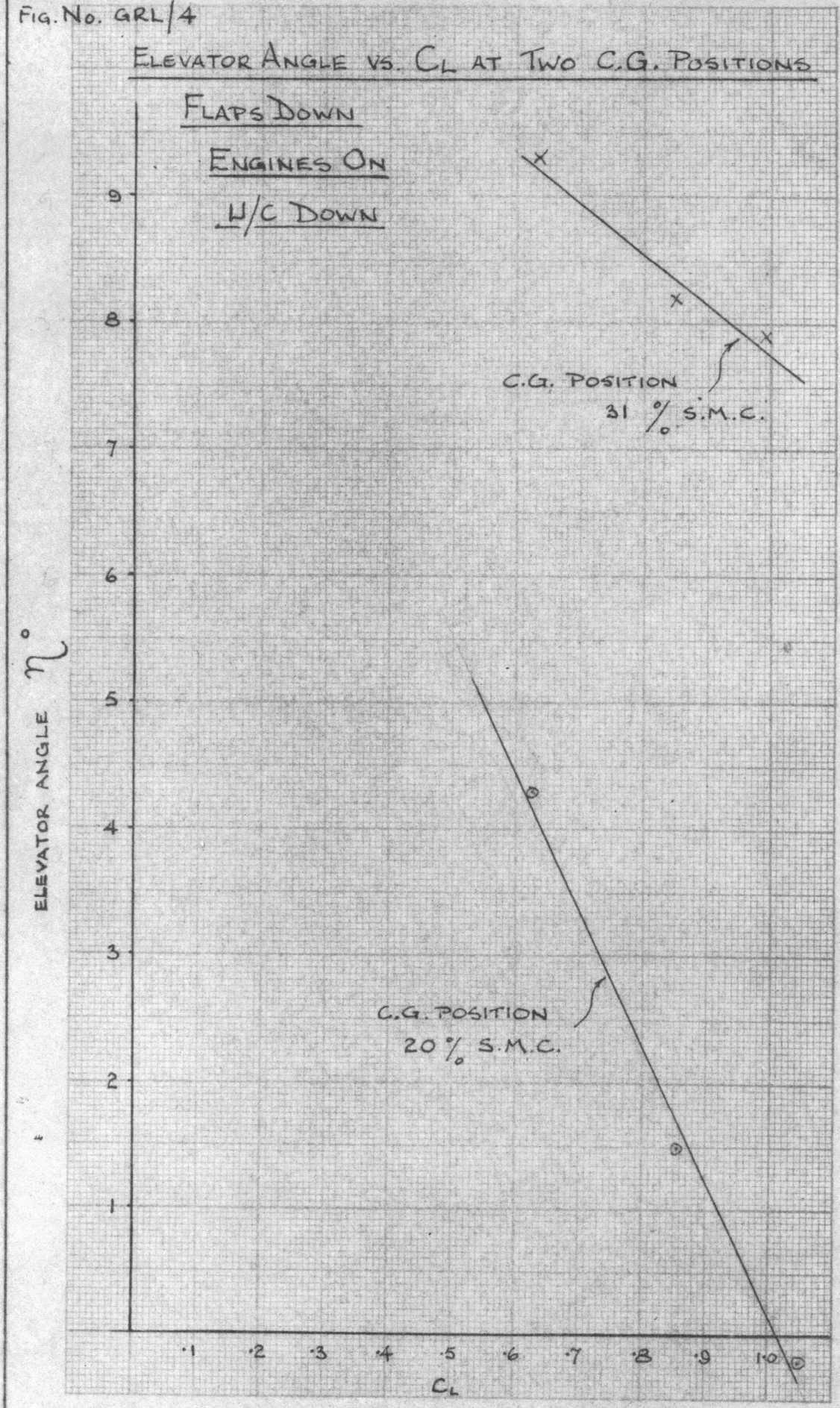
FIG. No. GRL/4

ELEVATOR ANGLE VS. C_L AT TWO C.G. POSITIONS

FLAPS DOWN

ENGINES ON

U/C DOWN



A.C. 1305

PREPARED BY SSS/TW	GOVERNMENT AIRCRAFT FACTORIES	PROJECT G.R. LINCOLN
DATE 6. 6. 52	DIVISION OF AIRCRAFT PRODUCTION	WEIGHT

FIG No. GRL/5

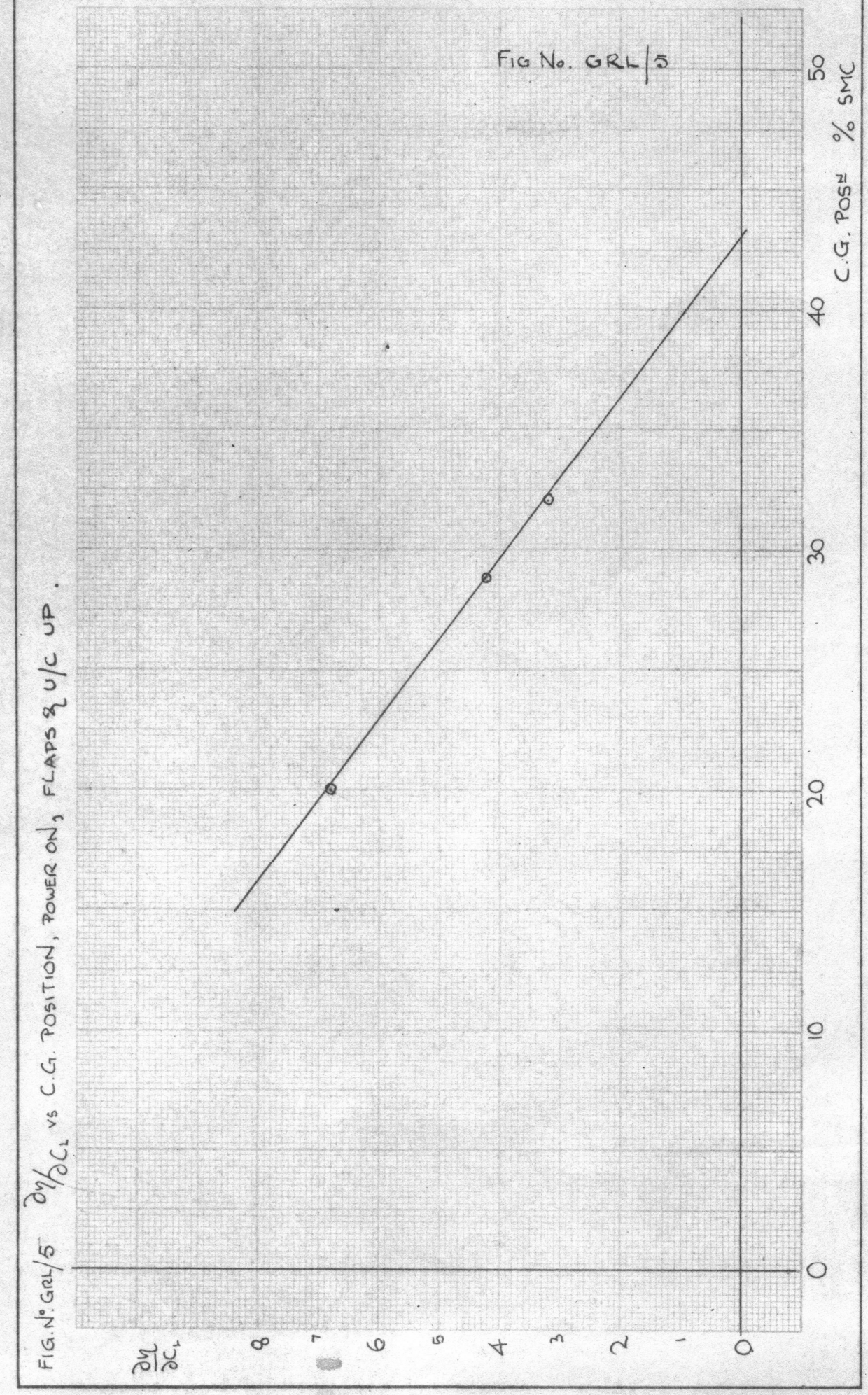


FIG. No. GRL/5 $\partial\eta/\partial C_L$ vs C.G. POSITION, POWER ON, FLAPS & U/C UP.

A.C. 1305

PREPARED BY T. Webb	GOVERNMENT AIRCRAFT FACTORIES	G.R. LINCOLN FLIGHT PROJECT TEST RESULTS
DATE 11-6-52	DIVISION OF AIRCRAFT PRODUCTION	WEIGHT

FIG. No. GRL/6

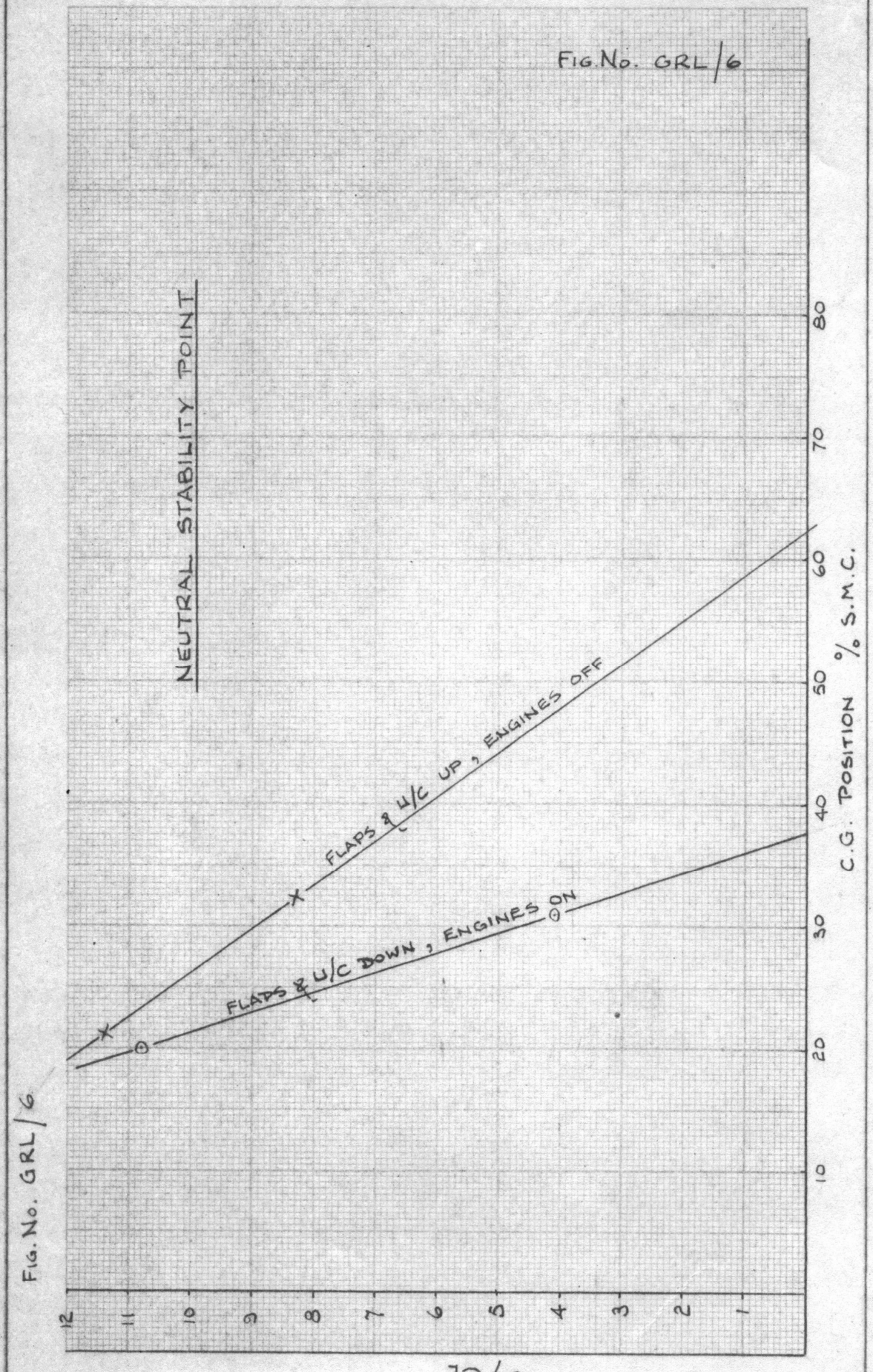


FIG. No. GRL/6

FIG. N° GRL/7

ELEVATOR ANGLE PER G vs SPEED. TEST N° 7.

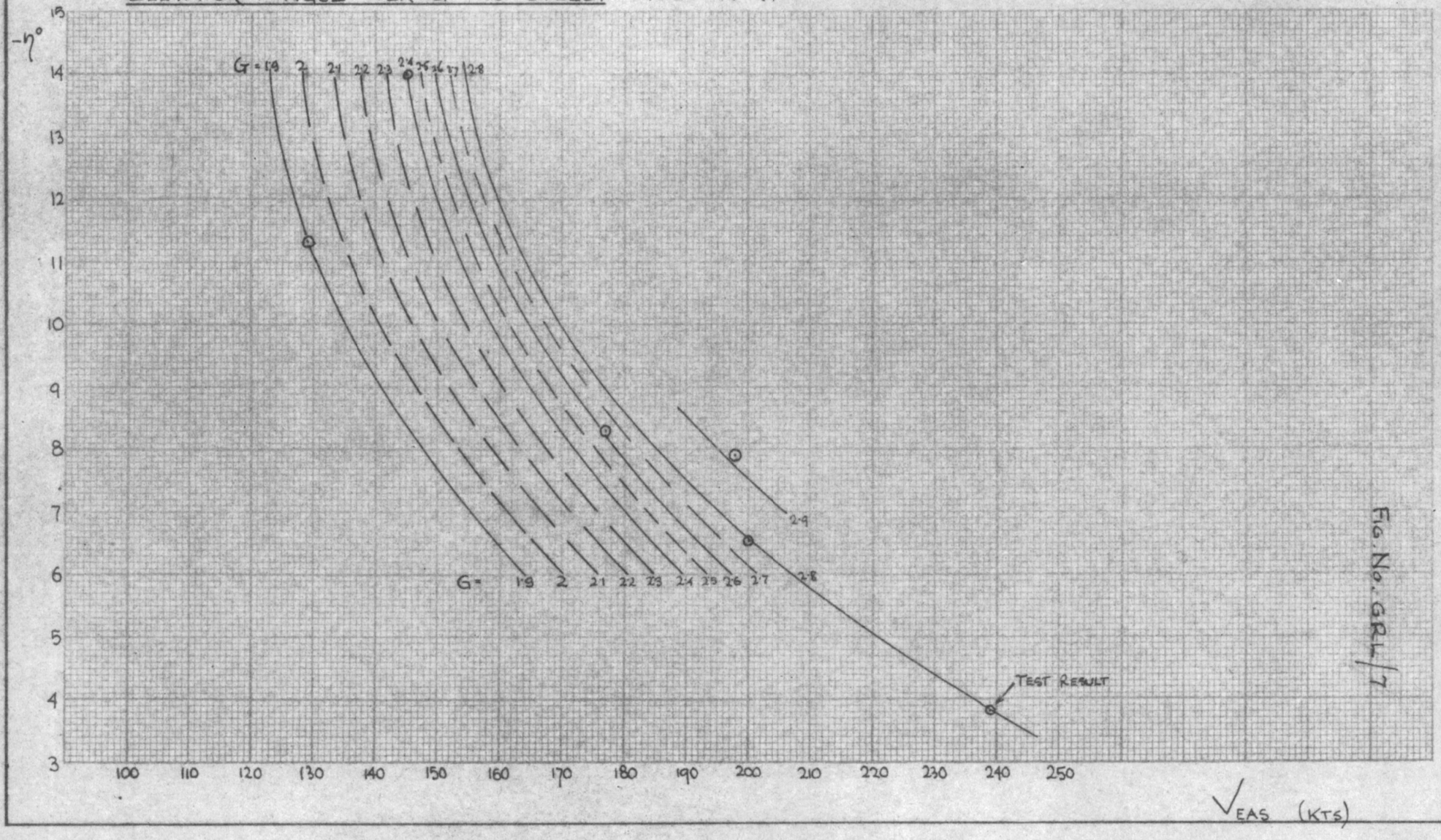


Fig. No. GRL/7

PREPARED BY 555	GOVERNMENT AIRCRAFT FACTORIES
DATE 6. 6. 52	DIVISION OF AIRCRAFT PRODUCTION
	PROJECT G.R. LINCOLN
	WEIGHT

A.C. 1305

A.C. 1305

PREPARED BY S.S.S.	GOVERNMENT AIRCRAFT FACTORIES	PROJECT G.R. LINCOLN
DATE 6. 6. 52	DIVISION OF AIRCRAFT PRODUCTION	WEIGHT

FIG No. GRL/8

ELEVATOR ANGLE PER G VS SPEED TEST No 8

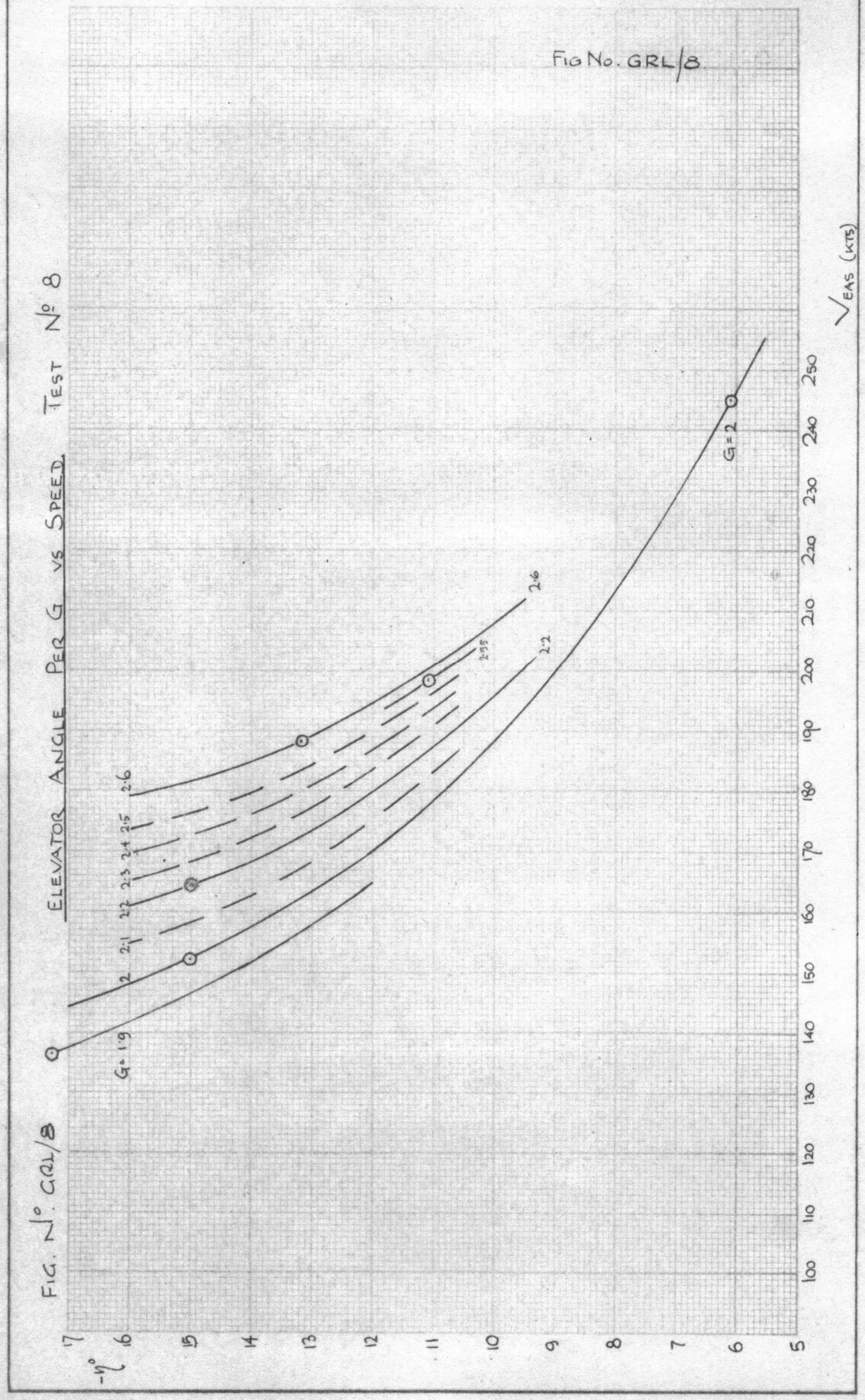


FIG. No. GRL/8

A.C. 1305

PREPARED BY T.D. Lobb	GOVERNMENT AIRCRAFT FACTORIES	G.R. LINCOLN PROJECT
DATE 10-6-52	DIVISION OF AIRCRAFT PRODUCTION	WEIGHT

FIG. No. GRL/9

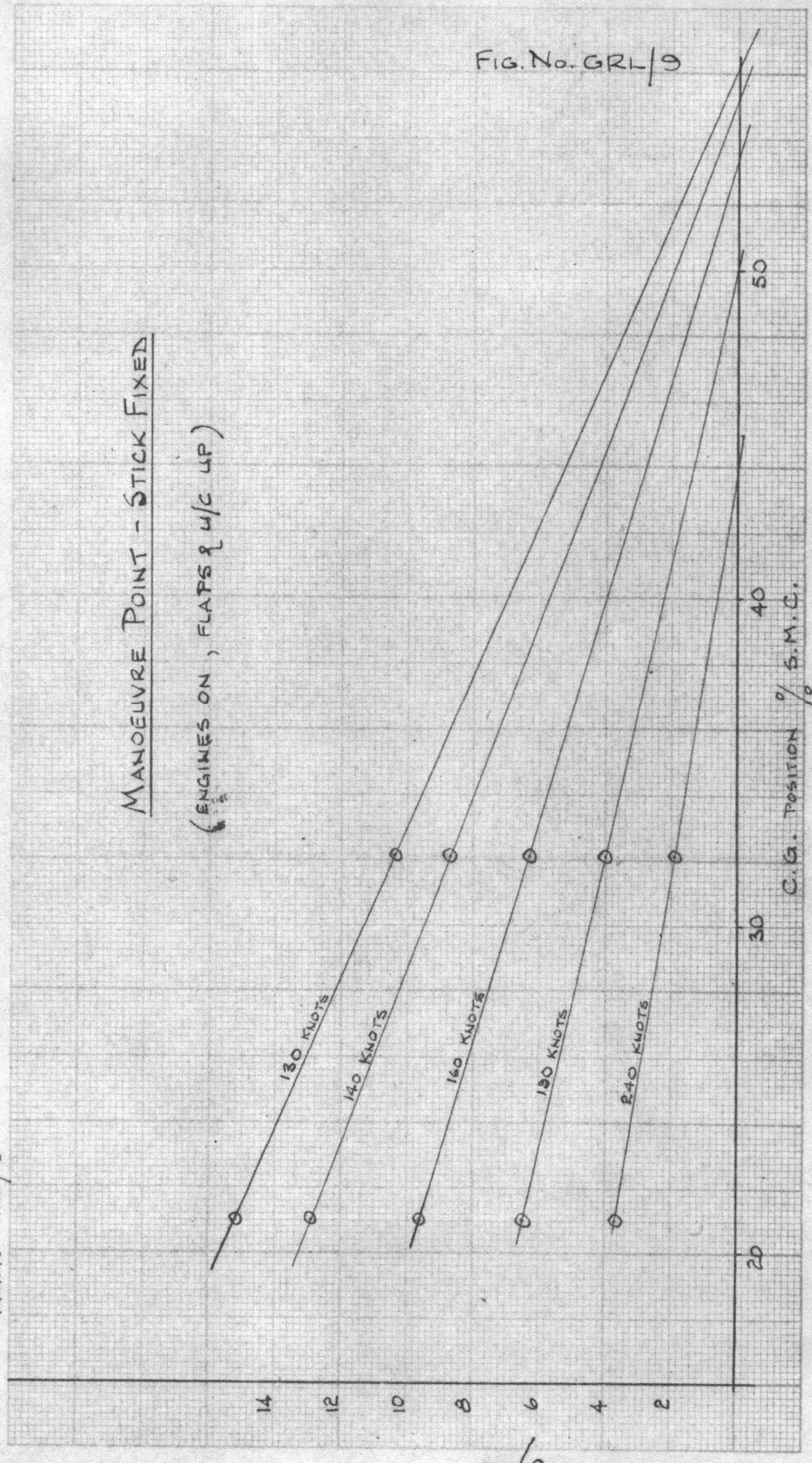


FIG. N°: GRL/9

5/12

A.C. 1305

PREPARED BY SSS	GOVERNMENT AIRCRAFT FACTORIES	PROJECT G.R. LINCOLN
DATE 6. 6. 52	DIVISION OF AIRCRAFT PRODUCTION	WEIGHT

FIG. No. GRL/10

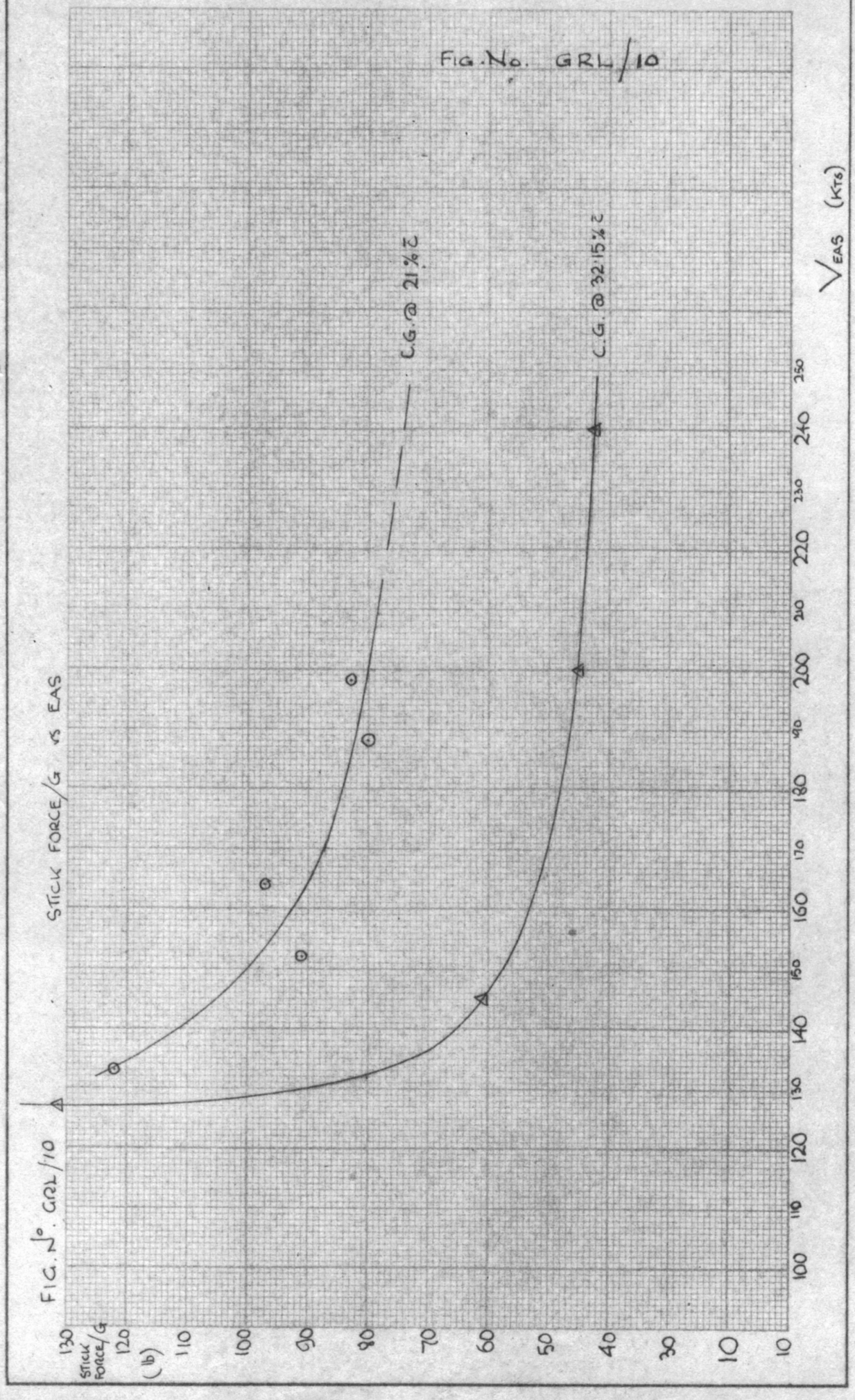


FIG. No. GRL/10

A.C. 1305

PREPARED BY SSS	GOVERNMENT AIRCRAFT FACTORIES	PROJECT G.R. LINCOLN
DATE 6.6.52	DIVISION OF AIRCRAFT PRODUCTION	WEIGHT

FIG. No. GRL/11

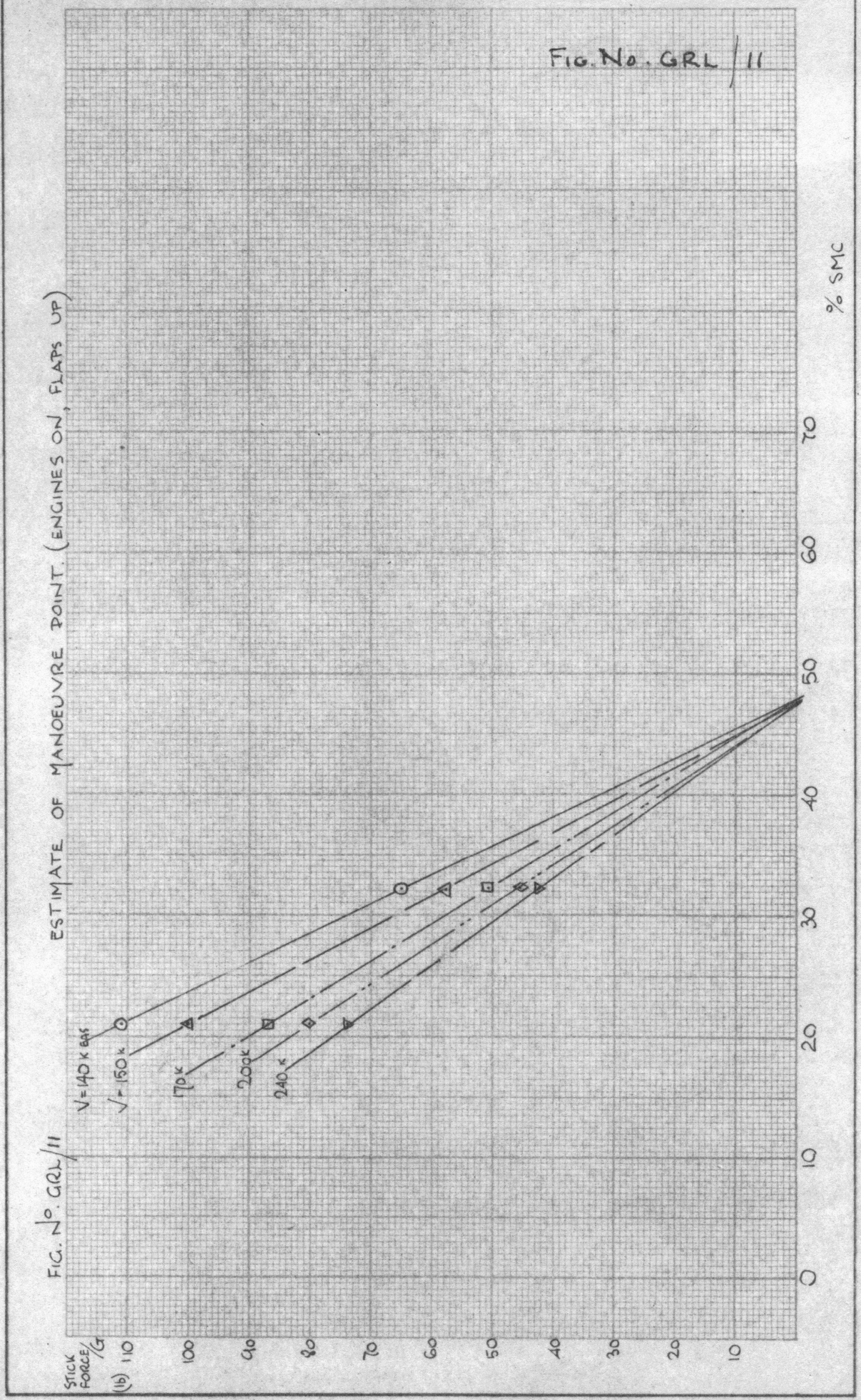


FIG. No. GRL/11

A.C. 1305

PREPARED BY SSS	GOVERNMENT AIRCRAFT FACTORIES	PROJECT GR LINCOLN
DATE 10. 6. 52	DIVISION OF AIRCRAFT PRODUCTION	WEIGHT 61 160 # T.O.

FIG. No. GRL/12

FIG. No GRL/12

COMPARISON OF TIME TO HEIGHT : G.R. & STANDARD LINCOLN. ICAN CONDITIONS.

{T.O. WT.: 61,160 lb.
{2850 R.P.M. +12" BOOST.

G.R. LINCOLN @ 61,160 lb T.O. WT. (FLT 11)
G.R. LINCOLN @ 62,000 T.O. WT (FLT No 2)

STANDARD LINCOLN
REDUCED TO SAME CONDITION
(i.e. 61,160 lb)

ALTITUDE (FT)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0

0 1 2 3 4 5 6 7 8 9

TIME TO HEIGHT (MINUTES)

A.C. 1305

PREPARED BY T. Webb	GOVERNMENT AIRCRAFT FACTORIES	G.R. LINCOLN PROJECT FLIGHT TEST
DATE 12-6-52	DIVISION OF AIRCRAFT PRODUCTION	WEIGHT

FIG. No. GRL/13

Lateral Damping
- Rudder Free

(STBD. RUDDER DEFLECTED, ENGINES ON
SPEED 150 KNOTS I.A.S.)

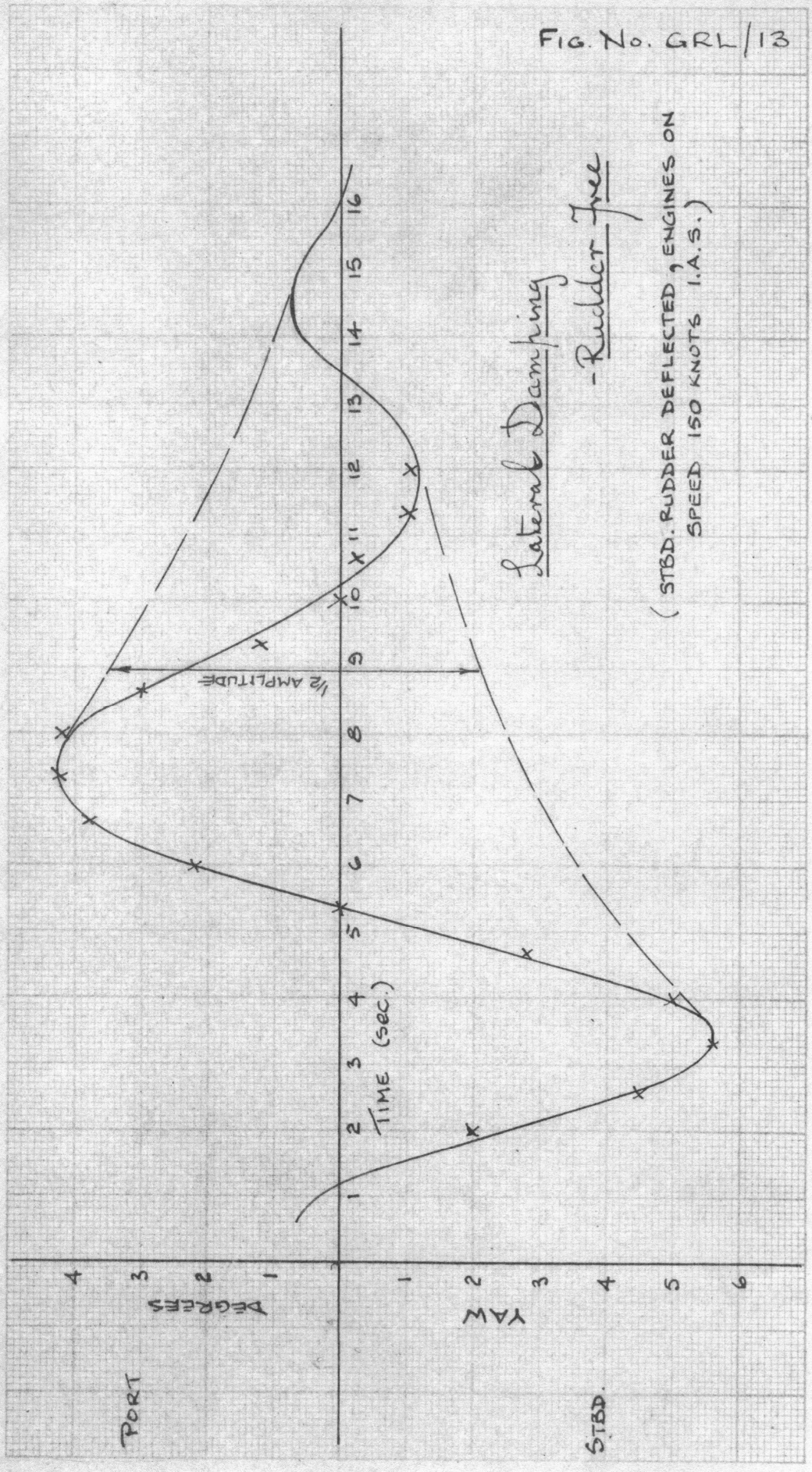
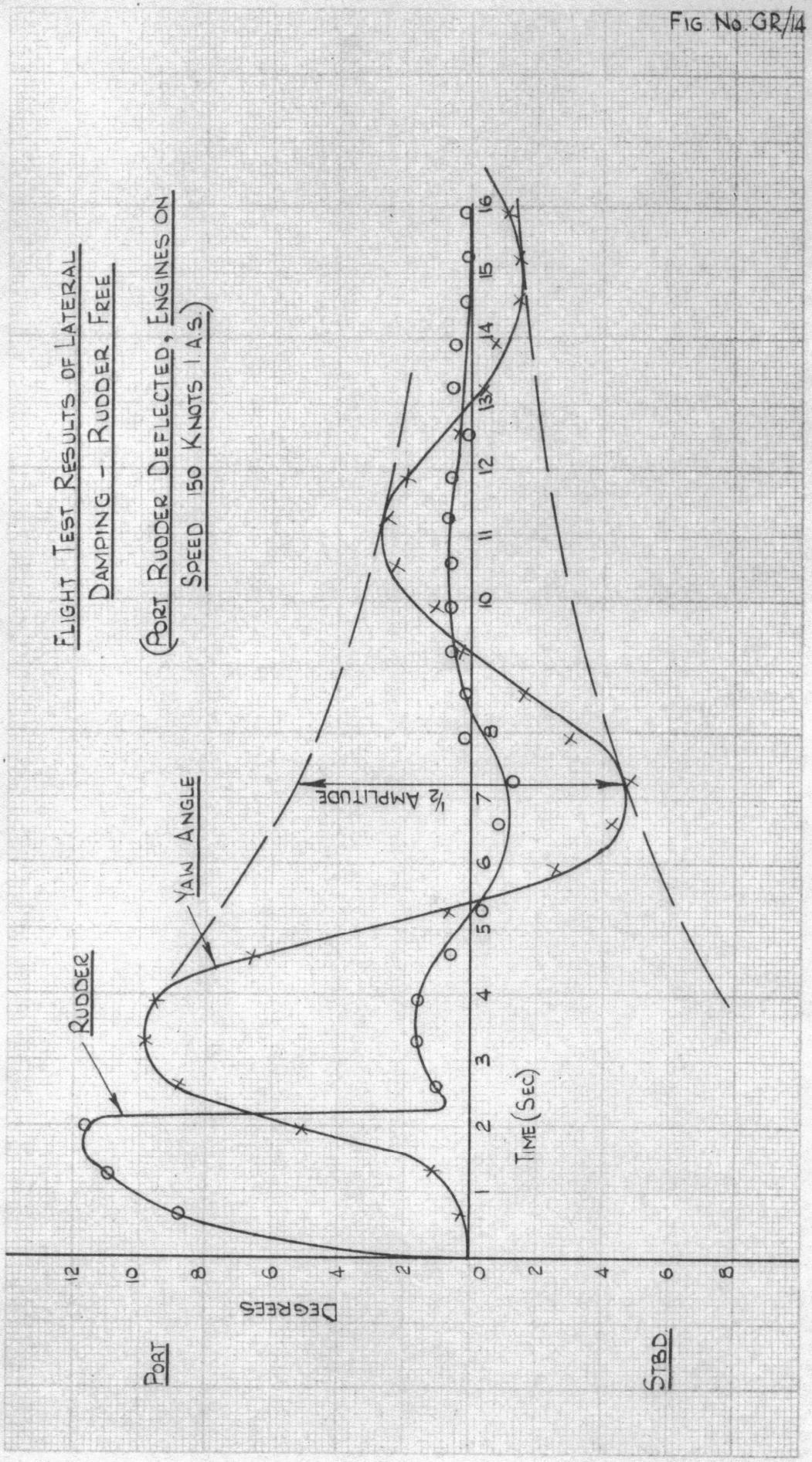


FIG. No. GR/13

A.C. 1305

PREPARED BY T. WEBB	GOVERNMENT AIRCRAFT FACTORIES	PROJECT G.R. LINCOLN
DATE 23. 5. 52.	DIVISION OF AIRCRAFT PRODUCTION	WEIGHT

FIG. No. GR/14



SUMMARY OF C.G. POSITIONS FOR G.R. LINCOLN TEST FLIGHTS.

TEST FLIGHT NO	DATE	DESCRIPTION		WEIGHT (lb)	C.G. POSITION U/C DOWN (IN)	% OF S.M.C. U/C DOWN	C.G. POSITION U/C UP (IN)	% OF S.M.C. U/C UP	DEFLECTOR INSTALLATION.
1.	5.5.52	PROVING FLIGHT		62,174	50.64	24.44	52.30	25.67	BOTH
2.	6.5.52.	RATE OF CLIMB		62,000					BOTH
3.	19.5.52	LATERAL STABILITY AND PRESSURE DISTRIBUTION FOR OBERVER'S WINDOW:	TAKE-OFF CONDITION.	59,325	48.01	22.58	49.82	23.85	BOTH
			LANDING CONDITION	56,841	47.44	22.19	49.36	23.54	BOTH
4.	20.5.52	ASYMMETRIC:	TAKE-OFF CONDITION	56,409	47.34	22.12	49.27	23.48	BOTH
			LANDING CONDITION. (FUEL GONE 270)	54,465	46.85	21.77	48.85	23.18	BOTH
5.	22.5.52	POSITION ERROR RUNS (AT LAVERTON)	TAKE-OFF CONDITION (FROM FISHERMEN'S BEND)	59,344	52.79	25.95	54.63	27.25	
		RADIO OPERATOR IN AFT POSITION		57,600	55.58	27.92	57.47	20.25	BOTH
		(FUEL USED 815G. AT FISHERMENS BEND)	LANDING CONDITION	53,476	51.88	25.31	53.19	26.23	
6.	22.5.52	LEVEL SPEEDS WITH DEFLECTORS. (TOOK OFF FROM LAVERTON)		57,184	53.09	26.00	55.0	27.50	BOTH
7.	26.5.52	*ELEVATOR ANGLES & PULL-OUTS:	TAKE-OFF CONDITION	62,113	59.83	30.91	61.58	32.14	BOTH
8.	29.5.52	*ELEVATOR ANGLES, PULL-OUTS & LEVEL SPEEDS:	TAKE-OFF CONDITION	63,389	44.27	19.96	45.98	21.16	
			AFTER TAKE-OFF (RE-POSITION OF CREW.)	63,389	44.56	20.16	46.28	21.37	BOTH
			LANDING CONDITION (FUEL USED 465G.)	60,041	43.62	19.50	45.43	20.77	
9	29.5.52	*ELEVATOR ANGLES AND LEVEL SPEEDS:	TAKE-OFF CONDITION	63,308	56.3	28.4	58.0	29.6	
			LANDING CONDITION (FUEL USED 395G)	60,464	56.01	28.22	57.81	29.49	BOTH
10.	2.6.52	LEVEL SPEEDS WITH PORT BLISTER INSTALLED:	TAKE-OFF CONDITION	58,602	49.51	23.64	51.37	24.95	STBD. ONLY.
			LANDING CONDITION (FUEL USED 355G.)	56,048	49.00	23.29	50.94	24.65	(PORT BLISTER)
11.	3.6.52	LEVEL SPEEDS AND RATE OF CLIMB WITH PORT BLISTER INSTALLED:	TAKE-OFF CONDITION	61,158	50.02	24.00	51.80	25.26	STBD. ONLY.
			LANDING CONDITION (FUEL USED 555G)	57,162	49.21	23.43	51.11	24.77	(PORT BLISTER)
12.	5.6.52	STANDARD LINCOLN (A73-56) RATE OF CLIMB TEST:	TAKE-OFF CONDITION	58,535	52.67	25.87	54.53	27.18	NIL
			BEFORE CLIMB CONDITION (FUEL USED 73.1G)	58,009	52.57	25.8	54.45	27.12	NIL
			AFTER CLIMB CONDITION (FUEL USED 120.2G.)	57,670	52.51	25.76	54.39	27.08	NIL
			LANDING CONDITION (FUEL USED 224G.)	56,922	52.36	25.65	54.27	26.99	NIL

* GRAPH OF C.G. FUEL GONE DRAWN FOR THESE TESTS.