

CHAPTER 1

LOADING AND C.G. DATA

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LIST OF CONTENTS

	Para.		Para.
Introduction	1	Typical service load	6
Datum point	2	Tare weight	7
Positive and negative moments	3	Typical examples	8
Method of calculating the C.G. position	4	Normal load	9
The C.G. range	5	Load movements	10

LIST OF ILLUSTRATIONS

	Fig.
Loading and C.G. diagram	1

INTRODUCTION

1. This chapter deals with the effect of different loads upon the fore and aft positions of the centre of gravity (C.G.) of this aircraft. The C.G. position is determined with the aircraft in the rigging position (fuselage datum line horizontal and alighting gear lowered) and is found by taking moments about a fixed point known as the C.G. datum point.

DATUM POINT

2. The position of the datum point is arbitrarily selected by the manufacturers

and, on this aircraft, is indicated by a peg on the port side of the fuselage, as illustrated in fig. 1.

POSITIVE AND NEGATIVE MOMENTS

3. The distance of each load from the datum point is known as its moment arm. The loads are measured in pounds, and the moment arms in feet. If a load lies forward of the datum point, its moment arm is taken as negative and, therefore, the resultant moment is negative. Conversely, the moment arms and moments of loads aft of the datum point are taken as positive.

METHOD OF CALCULATING THE C.G. POSITION

4. The C.G. position is determined from the following expression:—

$$\frac{\text{(Tare weight} \times \text{Tare moment arm)}}{\text{Tare weight}} + \frac{\text{(Weight of loads} \times \text{Respective moment arms)}}{\text{Total weight of loads}}$$

$$= \frac{\text{Tare moment and load moments}}{\text{Total weight}}$$

THE C.G. RANGE

5. Approved limits of travel of the C.G. are shown in fig. 1 and the tables. The C.G. must always be kept within this range, even if the load or fuel is partially or wholly expended.

TYPICAL SERVICE LOAD

6. The positions of all the items of equipment to complete the typical service load

F.S./1

(T.S.L.) are given in fig. 1. The items in the tables, given in the key to fig. 1, follow Appendix "A" order.

TARE WEIGHT

7. The tare weight and moment given include all fixed fittings and equipment not listed in the table, and take account of airframe modifications 1-25, 30-74, 76-86, 89-149, 153-160, 162-170, 174-188, 202-236,

239-255, 258-267, 270-339, 356, 358-429, 441, 479-485, 489-512, 542, 610-611, and power plant modifications 1-6, 8, 10, 15-21. Should subsequent modifications affect the tare weight and moment, details will be given in an amendment to this chapter.

TYPICAL EXAMPLES

8. In the following examples, calculations are given for the C.G. position (alighting gear down) under possible conditions of loading. All examples refer to the standard version with drop tanks (*see table*), and incorporating Mods. 202 and 611 (extra ballast in nose).

Normal load

	Weight (lb.)	Moment (lb. ft.)
Tare weight	6,726	6,889
Add the effect of load items No. 7-33	5,591	-823
Total	12,317	6,066
C.G. position = $\frac{6,066}{12,317} = 0.492$ ft. (5.90 in.) aft of datum		

Load movements

10. The consumption of all fuel and ammunition modifies the C.G. position as follows:—

	Weight (lb.)	Moment (lb. ft.)
Normal weight as at para. 9	12,317	6,066
Deduct the effect of load items No. 10, 28-33	4,669	2,326
Total	7,648	3,740
C.G. position = $\frac{3,740}{7,648} = 0.489$ ft. (5.87 in.) aft of datum		

11. Aircraft which have full internal fuel tanks, drop tanks fitted but empty, and carry no ammunition, may not, as shown in the example below, be safely flown:—

	Weight (lb.)	Moment (lb. ft.)
Normal weight as at para. 9	12,317	6,066
Deduct the effect of load items No. 10 and 33	1,995	161
Total	10,322	5,905
C.G. position = $\frac{5,905}{10,322} = 0.572$ ft. (6.86 in.) aft of datum		

The C.G. is beyond the aft limit of 0.488 ft. This may be corrected by placing weight (either ballast or ammunition) in the ammunition tanks in order to bring the C.G. within the limits:—

	Weight (lb.)	Moment (lb. ft.)
Total (as above)	10,322	5,905
Add the effect of ballast (375 lb. in ammo. tanks)	375	-1,125
Total	10,697	4,780
C.G. position = $\frac{4,780}{10,697} = 0.447$ ft. (5.36 in.) aft of datum		

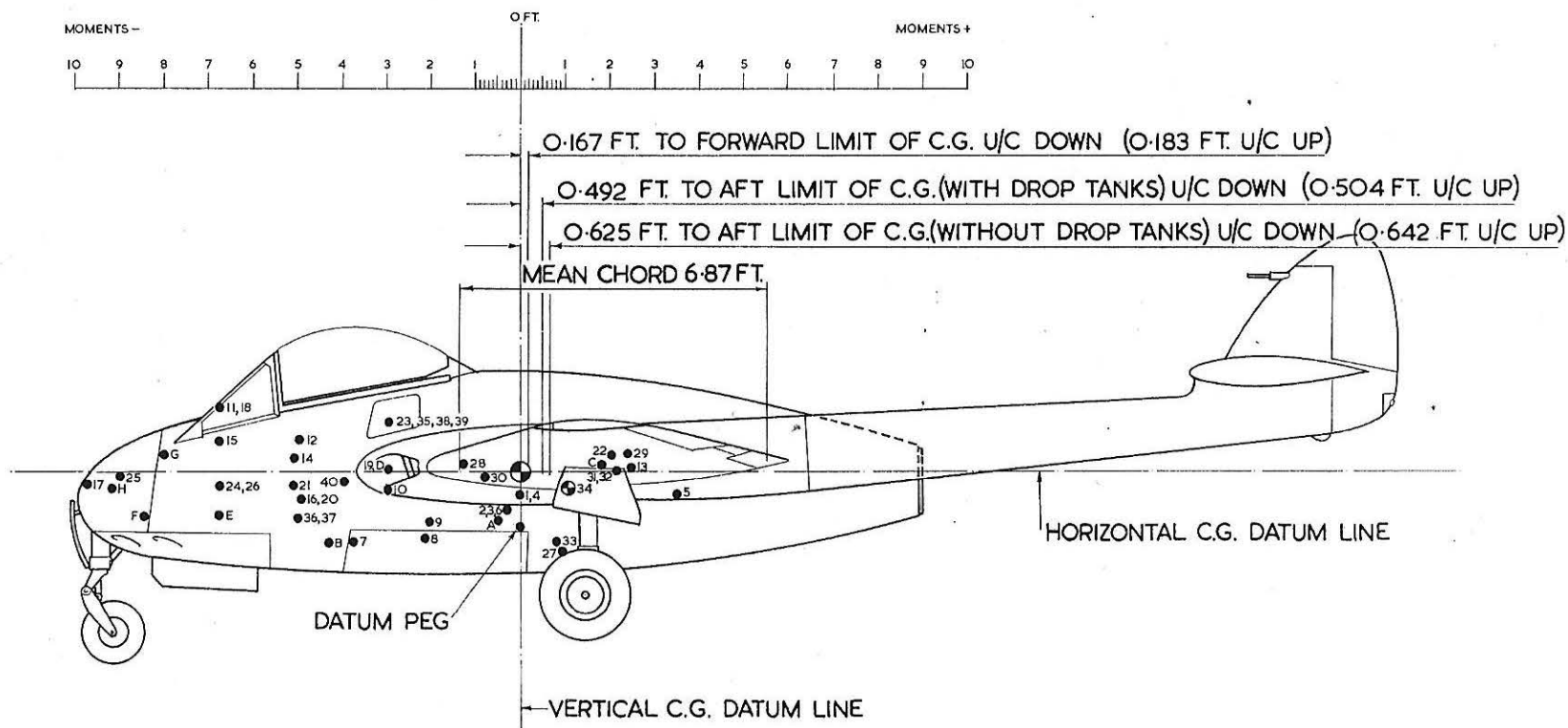


FIG. 1. LOADING AND C.G. DIAGRAM

Reference	Item No.	REMOVABLE ITEMS OF MILITARY LOAD	Standard version with 2 x 100 gall. capacity drop tanks			Standard version with 8 x 60 lb. R.P. & 2 x 500 lb. bombs			Standard version with 2 x 1,000 lb. bombs		
			Weight (lb.)	Arm (ft.)	Moment (lb. ft.)	Weight (lb.)	Arm (ft.)	Moment (lb. ft.)	Weight (lb.)	Arm (ft.)	Moment (lb. ft.)
Note 1		BOMBS—R.P. :—									
	1	Bomb carrier and fairings	—	—	—	80	0	0	80	0	0
	2	2 x 500 lb. bombs	—	—	—	1,000	-0.271	-271	—	—	—
	3	2 x 1,000 lb. bombs	—	—	—	—	—	—	2,200	-0.225	-495
	4	Front tier carriages	—	—	—	10	-0.1	-1	—	—	—
	5	Rear tier carriages	—	—	—	10	-3.4	34	—	—	—
	6	8 x 60 lb. R.P.	—	—	—	749	-0.447	-335	—	—	—
		ARMAMENT :—									
	7	4-20 mm. Hispano Mk. 5 guns	352	-3.89	-1,369	352	-3.89	-1,369	352	-3.89	-1,369
	8	4 Feed mechanisms	76	-2.2	-167	76	-2.2	-167	76	-2.2	-167
	9	4 Firing units	21.2	-2.1	-45	21.2	-2.1	-45	21.2	-2.1	-45
	10	20 mm. gun ammunition—600 rounds	375	-3.0	-1,125	375	-3.0	-1,125	375	-3.0	-1,125
Note 2	11	Gyro gunsight Mk. 2 D	8.5	-6.8	-58	8.5	-6.8	-58	8.5	-6.8	-58
	12	Throttle ranging controls	0.9	-5.0	-5	0.9	-5.0	-5	0.9	-5.0	-5
		MISCELLANEOUS									
	13	Landing lamp	5.0	2.3	12	5.0	2.3	12	5.0	2.3	12
	14	Torch type "O" and battery	1.5	-5.1	-8	1.5	-5.1	-8	1.5	-5.1	-8
	15	Clock Mk. 2A	0.5	-6.8	-3	0.5	-6.8	-3	0.5	-6.8	-3
	16	Map case	0.5	-5.0	-3	0.5	-5.0	-3	0.5	-5.0	-3
	17	G-45B Camera and accessories	7.6	-9.8	-74	7.6	-9.8	-74	7.6	-9.8	-74
	18	Gyro gunsight recorder	2.2	-6.8	-15	2.2	-6.8	-15	2.2	-6.8	-15
	19	Charge for 2 oxygen cylinders	4.7	-3.0	-14	4.7	-3.0	-14	4.7	-3.0	-14
	20	Crowbar	1.0	-5.0	-5	1.0	-5.0	-5	1.0	-5.0	-5
	21	CREW :— Pilot, parachute and "K" type dinghy	218	-5.12	-1,116	218	-5.12	-1,116	218	-5.12	-1,116
Note 3		RADIO :—									
	22	Aerial, type "62"	2.0	2.0	4	2.0	2.0	4	2.0	2.0	4
	23	Transmitter-receiver T.R.1464	34.5	-2.9	-100	34.5	-2.9	-100	34.5	-2.9	-100
	24	Control, type "12"	1.6	-6.8	-11	1.6	-6.8	-11	1.6	-6.8	-11
	25	Receiver R.3121	32.8	-9.0	-295	32.8	-9.0	-295	32.8	-9.0	-295
	26	Control, type 1	1.8	-6.8	-12	1.8	-6.8	-12	1.8	-6.8	-12
	FUEL SYSTEM :— 2 x 100 gall. drop tanks	150	0.902	135	—	—	—	—	—	—	
		TOTAL WEIGHTS AND MOMENTS, REMOVABLE ITEMS OF MILITARY LOAD	1,297	—	-4,274	2,996	—	-5,064	3,427	—	-4,906
		FUEL at 8.1 lb./gall. :—									
28	96 gall. main fuselage tank	778	-1.3	-1,012	778	-1.3	-1,012	778	-1.3	-1,012	
29	106 gall. wing stub tanks	859	2.23	1,916	859	2.23	1,916	859	2.23	1,916	
30	39 gall. leading edge tanks	316	-0.8	-253	316	-0.8	-253	316	-0.8	-253	
31	7 gall. inboard wing tanks	381	2.1	800	381	2.1	800	381	2.1	800	
32	42 gall. outboard wing tanks	340	2.1	714	340	2.1	714	340	2.1	714	
34	2 x 100 gall. drop tanks	1,620	0.794	1,286	—	—	—	—	—	—	
	Aircraft tare to Col. 10, Appendix "A" (alighting gear down)	6,726	1.024	6,889	6,726	1.024	6,889	6,726	1.024	6,889	
		TOTAL ALL-UP WEIGHT AND MOMENT—alighting gear down (less desert equipment)	12,317	0.492 (5.904in.)	6,066	12,396	0.328 (3.936in.)	4,072	12,827	0.324 (3.888in.)	4,150
	retract alighting gear			136			136			136	
	alighting gear up	12,317	0.504 (6.048in.)	6,202	12,396	0.339 (4.068in.)	4,208	12,827	0.334 (4.008in.)	4,286	
		DESERT EQUIPMENT :—									
35	Covers	5.0	-3.0	-15	5.0	-3.0	-15	5.0	-3.0	-15	
36	Sundry gear	1.5	-5.0	-8	1.5	-5.0	-8	1.5	-5.0	-8	
37	Tool kit	1.8	-5.0	-9	1.8	-5.0	-9	1.8	-5.0	-9	
38	Water bottle and carrier	3.7	-3.0	-11	3.7	-3.0	-11	3.7	-3.0	-11	
39	Emergency flying rations and container	6.1	-3.0	-18	6.1	-3.0	-18	6.1	-3.0	-18	
40	Signal gear	11.9	-4.0	-48	11.9	-4.0	-48	11.9	-4.0	-48	
I		TOTAL ALL-UP WEIGHT AND MOMENT—alighting gear down (with desert equipment)	12,347	0.482 (5.784in.)	5,957	12,426	0.319 (3.828in.)	3,963	12,857	0.314 (3.768in.)	4,041
	retract alighting gear			136			136			136	
	alighting gear up	12,347	0.493 (5.916in.)	6,093	12,426	0.330 (3.960in.)	4,099	12,857	0.325 (3.905in.)	4,177	

Item No.	REMOVABLE ITEMS OF MILITARY LOAD NOT INCLUDED IN TYPICAL LOADINGS	Standard version less drop tanks		
		Weight (lb.)	Arm (ft.)	Moment (lb. ft.)
	TARE WEIGHT 6,726 lb. This weight includes the following items :—			
A	Accumulators, 12 volt, 25 amp. hr.	77.2	-0.5	-39
B	Air cylinder	10.4	-4.3	-45
C	R.I. Compass	6.0	1.8	11
D	2 Oxygen cylinders, less charge	30.0	-3.0	-90
E	Inertia weight in elevator circuit	20.5	-6.8	-139
F	Ballast in nose—156 lb. (fixed to front face front armour)	156.0	-8.4	-1,310
G	Ballast in nose—58 lb. (fixed to front	58.0	2.1	122

Note 3	21	CREW :— Pilot, parachute and "K" type dinghy	218	—5.12	—1,116	218	—5.12	—1,116	218	—5.12	—1,116
	22	RADIO :— Aerial, type "62"	2.0	2.0	4	2.0	2.0	4	2.0	2.0	4
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	27	FUEL SYSTEM :— 2×100 gall. drop tanks	150	0.902	135	—	—	—	—	—	—
		TOTAL WEIGHTS AND MOMENTS, REMOVABLE ITEMS OF MILITARY LOAD	1,297	—	—4,274	2,996	—	—5,064	3,427	—	—4,906
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	34	2 × 100 gall. drop tanks Aircraft tare to Col. 10, Appendix "A" (alighting gear down)	1,620 6,726	0.794 1.024	1,286 6,889	— 6,726	— 1.024	— 6,889	— 6,726	— 1.024	— 6,889
		TOTAL ALL-UP WEIGHT AND MOMENT—alighting gear down (less desert equipment)	12,317	0.492 (5.904in.)	6,066	12,396	0.328 (3.936in.)	4,072	12,827	0.324 (3.888in.)	4,150
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	36	Sundry gear	1.5	—5.0	—8	1.5	—5.0	—8	1.5	—5.0	—8
	37	Tool kit	1.8	—5.0	—9	1.8	—5.0	—9	1.8	—5.0	—9
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E	Inertia weight in elevator circuit	20.5	—6.8	—139
F	Ballast in nose—156 lb. (fixed to front face front armour)	156.0	—8.4	—1,310
G	Ballast in nose—58 lb. (fixed to front armour door)	58.0	—8.1	—470
H	Ballast in nose—44 lb. (fixed to nose cowl)	44.0	—9.2	—405
	ALSO THE FOLLOWING :—			
	Instruments	47.0		
	Hydraulic gear	68.0		
	Pneumatic gear	40.0		
	Wireless equipment, fixed fittings, etc.	32.0		
	All armour plating	160.0		
	Electrical equipment with wiring	254.0		
	Gun gear	170.0		

NOTE 1 : 4-20 mm. Mk. 5 guns comprising :—Empty case and link chutes, 4 electric firing units, cocking unit No. 6, 2 left-hand and 2 right-hand belt feed mechanisms.

NOTE 2 : G.45 camera comprising :—Adapter, type 32, indicator, type 45, relay unit and wedge plates.

NOTE 3 : All radio units include valves.

WEIGHTS AND CENTRE OF GRAVITY RESTRICTIONS

MAXIMUM ALL-UP WEIGHT :—12,860 lb.

MAXIMUM PERMISSIBLE LANDING WEIGHT :—10,560 lb.

MAXIMUM PERMISSIBLE ALL-UP WEIGHT FOR AEROBATIC FLYING :—10,560 lb.

NOTE : AEROBATICS MAY ONLY BE PERFORMED WHEN STORES OR DROP TANKS HAVE BEEN JETTISONED.

LIMITS OF PERMISSIBLE C.G. TRAVEL (ALIGHTING GEAR DOWN)

Forward limit : 0.167 ft. (2.0 in.)

Aft limit :—Without drop tanks, 0.625 ft. (7.5 in.)

With drop tanks, 0.492 ft. (5.904 in.).

All the above limits are measured aft of vertical C.G. datum and parallel to the fuselage datum line. (These correspond to 0.183 ft. (2.2 in.) and 0.642 ft. (7.7 in.) less drop tanks, or, with drop tanks, 0.504 ft. (6.05 in.) alighting gear up.)

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