Chapter 3A

LOADING AND C.G. DATA

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Introduction

1. The data in this chapter is provided to enable the Centre of Gravity (C.G.) of a Mk.1A aircraft to be computed for any distribution of load. This enables investigation to be made into changes in the C.G. which may result from expenditure of fuel, bombs etc., and/or movement of crew immediately after take-off, or at any stage of the flight.

2. The C.G. is calculated with the aircraft in the rigging position i.e., the C.G. Datum Line horizontal

3. The Basic Weight and C.G. quoted in the following examples are average figures only and when computing a loading, the true Basic Weight and C.G. relative to the aircraft under consideration must be substituted.

DEFENITION OF THE C.G.

4. The C.G. is defined by its distance in feet, measured along the C.G. Datum Line, from a reference point known as the C.G. Datum Point. This distance is called the Moment Arm of the C.G. and is determined from the following expression:-

$$\frac{\text{(Basic weight x basic moment arm)} + \text{(Weight of loads x respective arms)}}{\text{Basic weight} + \text{Total weight of loads}}$$

$$= \frac{\text{Basic moment} + \text{Load moment}}{\text{Total weight}}$$

LOADING AND REFERENCE DATUMS (fig.1)

C.G. datum line

5. The line along which all longitudinal moment arms are measured is the front fuselage datum and makes an angle of 5 degrees with the rear fuselage datum.

C.G. datum point

6. The intersection of the front fuselage datum and the front spar datum.

Weighing reference point

7. Located on both port and starboard sides of the front fuselage by a removable plug which is situated 31·208 ft. (374·5 in.) forward of the C.G. datum point and 1·25 in. above the front fuselage datum. These locations are provided for the suspension of plumb lines when determining the C.G. by weighing the aircraft on platform scales.

Trim or computer datum

8. The slide rule computer datum is 12·00 ft. (144·0 in.) aft of the C.G. datum point. This is the middle of the C.G. range and only used for calculating the Index Unit for the initial setting on the C.G. computer (para.33).

MOMENT AND MOMENT ARMS

9. The moment of an item is the product of its weight (lb.) and its moment arm (ft.) measured along the C.G. datum line from the C.G. datum point. The moment arm of a load lying forward of the C.G. datum point is negative although the load itself is positive, therefore, the resultant moment is negative. The moment arm of a load lying aft of the C.G. datum point is positive and, therefore, the resultant moment is positive.

WEIGHT AND C.G. LIMITATIONS

10. Maximum all-up and landing weights

Maximum all-up weight	170,000 lb.
Maximum landing weight	170,000 lb.
Normal landing weight (no store)	99,300 lb.

Maximum forward C.G. limits

(a) Up to 110,000 lb.	11·42 ft.(137·0 in.)
(b) From 160,000 lb.	11·8 ft.(141·61 in.)

Maximum aft C.G. limit 12·58 ft. (151·0 in.)

C.G. MOVEMENT DURING FLIGHT

11. A loading which gives a satisfactory C.G. for take-off may be so affected by expenditure of fuel etc., that the C.G. passes beyond its limit. The possibility of this occurrence must always be considered (para.27). The effect of retracting the undercarriage has been taken into consideration in establishing the safe C.G. range and may, therefore, be neglected.

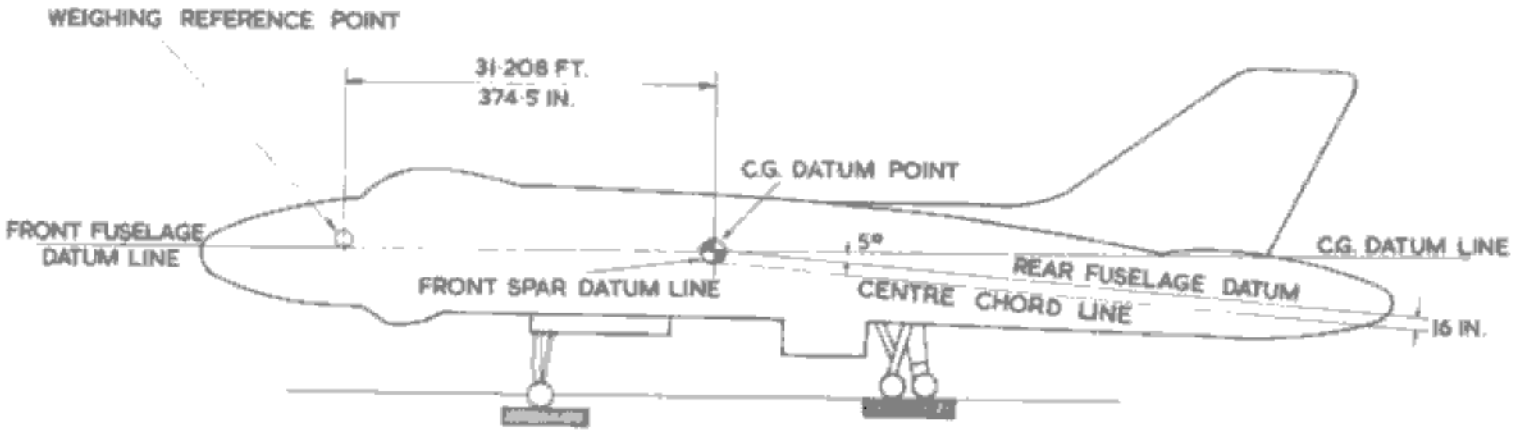
AIRCRAFT BASIC WEIGHT

12. The basic weight of an aircraft is by definition, the weight of the basic structure of the aircraft together with the weight of that non-expendable equipment that is common to all the roles for which the aircraft has been designed. It includes the weight of unusable fuel, oil and other fluids, i.e., the weight of fluids trapped in the systems after draining through the normal drain points, and the weight of the full coolant, hydraulic and pneumatic systems.

The average basic weight for Vulcan B Mk.1A aircraft with B.OL.104 engines = 88,200 lb.

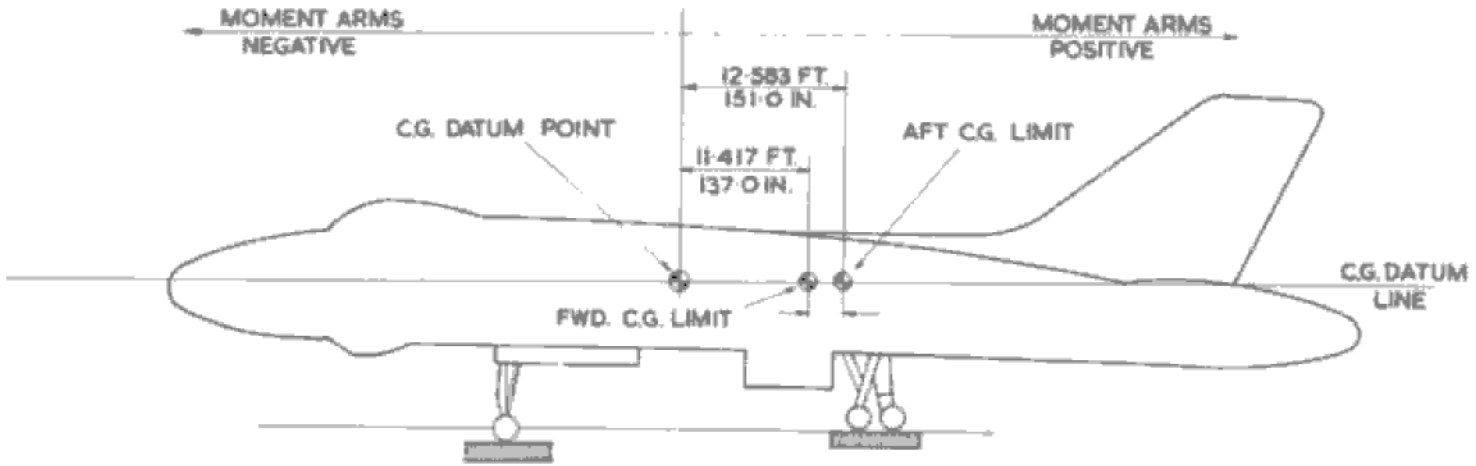
BASIC WEIGHT AND MOMENT RECORD CARD

13. This card is provided with each aircraft and is a continuous history of changes in structure or equipment affecting the weight and moment. It gives the current basic weight and moment to be used at the start of any loading calculation and shows the appropriate C.G. computer index unit to be used for C.G. checks in flight. The initial entry is the basic weight and moment of the aircraft with normal 'service fit' equipment, obtained from the C.G. report supplied with the aircraft upon delivery to the service (fig.4).



AIRCRAFT IN THE RIGGING POSITION i.e. C.G. DATUM LINE HORIZONTAL

Fig. 1. Loading and reference datums



AIRCRAFT IN THE RIGGING POSITION

Fig. 2. C.G. range

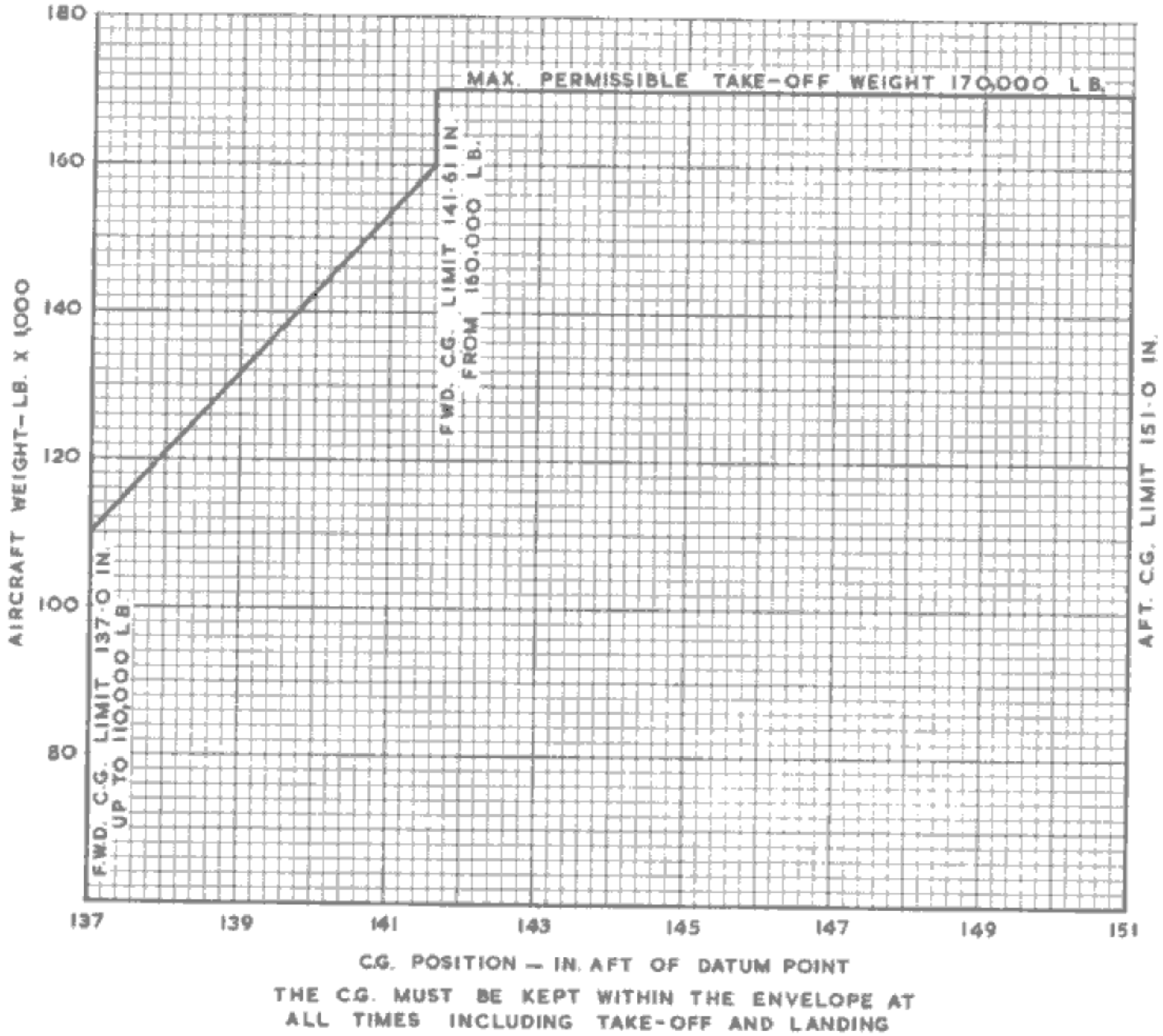


Fig. 3. Weight and C.G. envelope

XH.498	VULCAN B	Mk.1A	1	R.A.F. FORM 4908
Aircraft No.	Aircraft Type	Mark	Serial No.	

AIRCRAFT BASIC WEIGHT AND MOMENT RECORD

1	2	3				4		
		DETAILS OF CHANGE				CORRECTED BASIC FIGURES		
		WEIGHT	MOMENT					
			HORIZONTAL	~~VERTICAL~~				
DATE	REASON FOR CHANGE	+ LB.	+ LB.FT. ~~OR INDEX UNITS~~	+ ~~LB.FT. OR INDEX UNITS~~		WEIGHT LB.	HORIZONTAL MOMENT LB.FT. ~~OR INDEX UNITS~~	~~VERTICAL MOMENT LB.FT. OR~~ BASIC INDEX
13.3.62	From C.G. Report No. WTS/698/1168							
	Basic weight and moment					88,384	1,117,157	+ 5·657
	Remove:- "Service Fit" equipment as listed in C.G. Report							
	Add:- D.1 - Nose ballast + box 618 lb.							
	D.3 - E.C.M. ballast stn. 7 & 8 470 lb. and stn. 9 235 lb. + blanks 92.5 lb.							
13.3.62	"DELIVERY" WEIGHT & MOMENT					86, 227	1,069,133	+ 3·440
28.4.62	Remove:- D.1 Nose ballast + box							
	D.3 E.C.M. ballast and blanks as listed in C.G. report							
	Fit:- All "Service Fit" equipment							
28.4.62	Current basic weight and moment					88,384	1,117,157	+ 5·657

NOTE:- *Basic Index* = $\frac{\text{Basic weight (Arm in ft. about F/S datum - 12·0 ft.)}}{10,000}$

Fig. 4. R.A.F. Form 4908

REMOVABLE EQUIPMENT INCLUDED IN BASIC WEIGHT

Ref. No.	Description	Weight (lb.)	Arm (ft.)	Moment (lb.ft.)
	A.R.I.5874			
10D/19065	Transmitter S.T.18 Type 4188	17·0	-18·8	- 320
10D/19064	Receiver Type 4187	26·5	-18·8	- 499
10K/19067	Power and radio unit Type 4192	36·0	-18·8	- 678
5UC/6010	Voltnge regulator	10·8	-19·0	- 204
10L/16205	Control and drive unit Type 4190	17·0	-18·8	- 320
10D/19248	Aerial selector unit Type 7003	12·5	-19·0	- 238
	Total weight and moment A.R.I.5874 removable equipment	119·8	-18·9	- 2,259
	A.R.I.18064			
10D/17937	Transmitter receiver TR.1985	27·0	-28·2	- 761
10D/17938	Transmitter receiver TR.1986	27·0	-29·2	- 788
	Total weight and moment A.R.I.18064 removable equipment	54·0	-28·7	- 1,549
	A.R.I.18089			
10U/16596	Amplifier Type A.1961	6·25	-17·9	- 112
10U/16596	Amplifier Type A.1961	6·25	-21·9	- 137
	Total weight and moment A.R.I.18089 equipment	12·5	-19·9	- 249
	A.R.I.5810			
10B/16327	Scanner unit Type 121 } With connectors			
10B/17257	Reflector unit T.4033 } 280 lb.			
10D/19023	Frame assembly T.4032A }			
10U/16761	Amplifier Type 3703 40 lb.			
10D/18638	Modulator Type 2 50 lb.			
10AD/703	Analyser unit co-ordinate 52 lb.	489·0	-35·7	- 17,441
10D/18637	Transmitter receiver TR.3702 58 lb.			
6W/5	Gyro unit Mk.6 9 lb.			
10QB/6493	Indicating unit Type 301	64·3	-18·8	- 1,206
14A/4260	Camera Type R.88	12·3	-19·7	- 242
10L/16060	Control unit Type 626	1·8	-20·0	- 36
10LB/6376	Control unit Type 595	10·0	-18·8	- 188
19L/16154	Control unit Type 903	6·5	-19·7	- 128
10DB/8811	Power unit Type 729	33·0	-15·2	- 503
10VB/6250	Waveform generator Type 68	37·8	-13·0	- 491
10D/18640	Automatic calculator Type 5	41·3	-14·1	- 582
9D/1803	Navigation panel Mk.1B	36·0	-19·7	- 708
9D/756	Wind monitor unit	10·0	-18·8	- 188
9D/2	Calculator Type 1 Mk.1	50·0	-11·7	- 583

REMOVABLE EQUIPMENT INCLUDED IN BASIC WEIGHT (continued)

Ref.No.	Description	Weight (lb.)	Arm (ft.)	Moment (lb.ft.)
9D/3	Calculator Type 2 Mk.1	60·0	-29·1	- 1,745
9D/4	Calculator Type 3 Mk.1	95·0	-26·9	- 2,557
10LB/6366	Control unit Type 585	55·0	-18·8	- 1,036
9D/11	Power unit	55·0	-13·3	- 729
9D/12	Resistance unit	4·0	-17·3	- 69
10L/16493	Control unit Type 12558	8·2	-20·7	- 170
9D/1566	Variable air speed unit	0·8	-21·0	- 17
9D/1400	Forward throw indicator	1·0	-19·0	- 19
9D/757	Indicator unit	1·5	-19·3	- 29
9D/8	Directional indicator Mk.1	0·6	-30·0	- 18
10L/16495	Control unit Type 12580	2·8	-21·8	- 61
	Total weight and moment A.R.I.5810 removable equipment	1075·9	-26·7	- 28,746
	A.R.I.18011			
10L/263	Control unit Type 705	2·0	-22·0	- 44
10D/17819	Receiver Type R.1965 (Glide Path)	16·0	-23·6	- 378
10D/17818	Receiver Type R.1964 (Localiser Marker)	18·0	-23·1	- 416
	Total weight and moment A.R.I.18011 removable equipment	36·0	-23·3	- 838
	A.R.I.5816			
10V/16045	Waveform generator Type 72	21·5	-18·3	- 394
10D/16876	Receiver Type R.3673	21·5	-18·5	- 398
10Q/16058	Indicator unit Type 26	18·5	-19·0	- 352
	Total weight and moment A.R.I.5816 removable equipment	61·5	-18·6	- 1,144
	A.R.I.5378			
10D/2585	Trans/receiver Type 1576	27·0	-10·3	- 278
10K/17035	Power unit Type 814	10·8	- 9·4	- 101
10F/17565	Control unit Type 7231	2·0	-28·0	- 56
	Total weight and moment A.R.I.5378 removable equipment	39·8	-10·9	- 435
	A.R.I.18090			
10Q/93	Pulse altimeter indicator Type 7921	10·0	-19·5	- 195
10D/19806	Transmitter receiver Type 7923	28·7	-11·6	- 332
	Total weight and moment A.R.I.18090 removable equipment	38·7	-13·6	- 527

REMOVABLE EQUIPMENT INCLUDED IN BASIC WEIGHT (continued)

Ref.No.	Description	Weight (lb.)	Arm (ft.)	Moment (lb.ft.)
	A.R.I.23023			
10D/19598	Receiver Type AD.7092D	15·7	- 2·4	- 37
10L/16073	Control unit Type 1274	2·8	-19·2	- 54
	Total weight and moment A.R.I.23023 removable equipment	18·5	- 4·9	- 91
	A.R.I.5851			
10D/18843	Transmitter receiver Type TR.3710	116·0	+17·5	+ 2,030
10Q/16094	Tracking unit Type 100	48·0	+19·4	+ 932
10B/16389	Aerial Type 501	40·0	+18·1	+ 723
10B/17273	Waveguides Type T.529	1·1	+18·2	+ 20
10Q/16095	Electrical indicator Type 101	21·0	-18·8	- 394
6B/541	G.P. indicator Mk.4	25·0	-18·8	- 471
	Total weight and moment A.R.I.5851 removable equipment with G.P.I. Mk.4	251·1	+11·3	+ 2,840
	A.R.I.18124			
10D/5821-8542	Transmitter receiver Type 5	48·5	-10·2	- 497
10L/5821-8543	Control unit Type C/1607/ARC.52	2·76	-27·9	- 77
	Total weight and moment A.R.I.18124 removable equipment	51·26	-11·2	- 574
	E.C.M. equipment, including tail warning installation			
	A.R.I.5919			
10D/20974	Radar head c/w heat exchanger Type 6934	146·0	+53·4	+ 7,799
10Q/16420	Indicator unit(nav's station) Type 6935	13·5	-18·7	- 253
10J/214	Control unit	4·5	-19·3	- 87
	Total weight and moment A.R.I.5919 removable equipment	164·0	+45·5	+ 7,459
	A.R.I.18074			
10D/20533	Transmitter and P.U. T.7810 with base mounting T.4367	160·9	+43·4	+ 6,986
10L/16351	Control unit Type 7812	1·3	-20·0	- 26
	Total weight and moment A.R.I.18074 removable equipment	162·2	+42·9	+ 6,960

REMOVABLE EQUIPMENT INCLUDED IN BASIC WEIGHT (continued)

Ref.No.	Description	Weight (lb.)	Arm (ft.)	Moment (lb.ft.)
	A.R.I.18075			
10D/20530	No.1 Transmitter Type 9454 with P.U. and base mounting T.4367	164·3	+45·6	+ 7,492
10D/20530	No.2 Transmitter Type 9454 with P.U. and base mounting T.4367	164·3	+45·6	+ 7,492
10L/16349	Control unit Type 9456	2·2	-19·5	- 43
	Total weight and moment A.R.I.18075 removable equipment	330·8	+45·2	+ 14,941
	A.R.I.18105			
10D/20570	Blanking unit Type 9777	6·4	+51·6	+ 330
10D/21506	Blanking unit Type 11871	6·4	-39·5	- 253
10D/20567	Receiver Type R.9561	12·0	+51·6	+ 619
10D/20567	Receiver Type R.9561	12·0	+51·6	+ 619
10D/20567	Receiver Type R.9561	12·0	-39·5	- 474
10D/20567	Receiver Type R.9561	12·0	-39·5	- 474
10J/214	Control unit Type 9562	4·5	-19·6	- 88
	Total weight and moment A.R.I.18105 removable equipment	65·3	+ 4·3	+ 279
	A.R.I.18076			
10K/19874	No.1 Power unit T.9421 with base mounting	244·7	+47·5	+ 11,619
10K/19874	No.2 Power unit T.9421 with base mounting	244·7	+47·5	+ 11,619
10K/19874	No.3 Power unit T.9421 with base mounting	244·7	+49·5	+ 12,117
10D/20525	No.1 Transmitter T.9420 with base mounting T.4367	219·0	+41·4	+ 9,072
10D/20525	No.2 Transmitter T.9420 with base mounting T.4367	219·0	+41·4	+ 9,072
10D/20525	No.3 Transmitter T.9420 with base mounting T.4367	217·0	+43·4	+ 9,421
10L/16346	Control unit Type 9422	5·0	-19·6	- 98
	Total weight and moment A.R.I.18076 removable equipment	1,394·1	+45·1	+ 62,822
	Turbo alternator installation			
U.3711	Voltage control unit	23·0	+18·6	+ 427
CPS.3	Frequency control unit	6·5	+17·3	+ 112
37L/19000	Turbo-alternator	150·0	+19·0	+ 2,850
	Total weight and moment turbo-alternator removable equipment	179·5	+18·9	+ 3,389
	Total weight and moment E.C.M. removable equipment	2,295·9	+41·8	+ 95,850

REMOVABLE EQUIPMENT INCLUDED IN BASIC WEIGHT (continued)

Ref.No.	Description	Weight (lb.)	Arm (ft.)	Moment (lb.ft.)
-	Oxygen charge - 8 bottles in bomb bay	56·0	+ 4·5	+ 254
-	Entrance ladder	28·0	-21·4	- 600
27N/299	Hand fire extinguishers (5 off)	27·5	-24·8	- 683
6B/2838	Periscopic sextant Mk.2B c/w case	11·5	-23·0	- 265
27C/2425	Dinghy Type M.S.5	116·0	-22·3	- 2,586
7B/1484	Signal pistol 1·5 in. Mk.1	4·1	-20·7	- 85
-	Signal pistol cartridges (12 off)	4·1	-22·3	- 91
12K/1314	Ejector seat cartridges set No.3 Mk.3	3·0	-26·8	- 80
9A/02450	First aid outfit cabin	6·0	-26·7	- 160
-	Gloves, first aid kit - D.1	4·5	-32·1	- 144
34B/9100475	Windscreen de-icing fluid (12 gall.)	97·8	-32·2	- 3,146
-	Tail parachute c/w shackle	200·0	+48·5	+ 9,693
5UB/5748	Amplidyne	39·5	-34·1	- 1,347
5J/3483	Batteries in power compartment (4 off)	300·0	+34·5	+ 10,350
5J/3483	Battery in power compartment (1 off)	75·0	+32·6	+ 2,444
	E.C.M. cooling			
-	Vapour cycle cooling pack	109·5	+49·6	+ 5,429
-	Glycol in manifold and pipes	35·4	+46·9	+ 1,659
-	Glycol in reservoir	10·2	+47·3	+ 482
-	Freon	8·0	+50·0	+ 400
-	Unusable fuel to bring to basic weight	154·0	+16·1	+ 2,477

15. **VARIABLE LOAD**

Ref.No.	Description	Weight (lb.)	Arm (ft.)	Moment (lb.ft.)
	Bomb gear			
	Role A - Red Beard			
-	Carriers and pintles (343 lb. + 26 lb.)	369	+12·11	+ 4,467
	Role B - 6,000 lb. store			
	Carriers and pintles	473	+12·11	+ 5,726
	Role C - 7,000 lb. M.C.			
-	Carriers and pintles	218	+12·11	+ 2,639
-	Crutches	23	+11·70	+ 269
-	Fuzing units	6	+ 8·17	+ 49
-	Rear steady	48	+25·92	+ 1,244
	Total weight and moment carriers, pintles etc.	295	+14·24	+ 4,201

VARIABLE LOAD (continued)

Ref.No.	Description	Weight (lb.)	Arm (ft.)	Moment (lb.ft.)
	Role D - Blue Danube			
-	Carriers and pintles	186·0	+12·11	+ 2,252
-	AT.81913 Forward cable retractable winch	14·7	+ 4·08	+ 60
-	AT.81857/8 Forward crutches	9·5	+ 8·32	+ 79
-	AT.62778 Buffer stop assembly	13·2	+12·12	+ 160
-	AT.81855/6 Rear crutches	11·5	+14·87	+ 171
-	AT.82079 Mounting forward snatch and fuzing unit	5·9	+ 4·07	+ 24
-	AT.81914 Rear latch bolt bracket assembly	5·3	+14·72	+ 78
-	AT.62992 Assembly attachment channels	2·0	+21·00	+ 42
-	AT.62980 Rear winches and mountings	27·8	+14·78	+ 411
	Total weight and moment carriers, crutches etc.	276·0	+11·87	+ 3,277
	Role E - 21 x 1,000 lb. store			
11A/4146	Carrier and pintles forward AT.81718	275·0	+ 4·46	+ 1,227
11A/4146	Carrier and pintles centre AT.81718	275·0	+13·41	+ 3,686
11A/4146	Carrier and pintles rear AT.81718	275·0	+22·43	+ 6,140
	Total weight and moment carrier and pintles	825·0	+ 13·4	+ 11,053
	Role F - 24 x 25 lb. smoke flashes or 24 x 100 lb. practice bombs			
	Carriers and pintles	1,050·0	+13·37	+ 14,042
	E.C.U. carrier			
FS1072 999H	E.C.U. carrier c/w adapter sets	1,145	+11·8	+ 13,565
FS1072 1319E	Equipment stowage rack c/w 4 minihoists and trolley jacks	577	+22·2	+ 12,788
-	E.C.U. carrier c/w BOL.101 engine and engine blanks	5,062	+11·9	+ 60,977
-	E.C.U. carrier c/w BOL.102 engine and engine blanks	5,215	+11·8	+ 61,564
-	E.C.U. carrier c/w BOL.104 engine and engine blanks	5,280	+11·8	+ 62,197
-	E.C.U. carrier c/w BOL.201 engine and engine blanks	5,568	+11·9	+ 66,107
-	E.C.U. carrier c/w BOL.301 engine and engine blanks	5,968	+11·6	+ 69,437
	Freight pannier			
27H/3346	Freight pannier (empty)	446	+ 9·0	+ 4,014
26DC/6177	Suspension	273	+ 9·0	+ 2,457

VARIABLE LOAD (continued)

Ref.No.	Description	Weight (lb.)	Arm (ft.)	Moment (lb.ft.)
	Pannier case			
27H/3346	Freight pannier (full)	4,000	+ 9·0	+ 36,000
26DC/6177	Suspension	273	+ 9·0	+ 2,457
	Total, pannier case	4,273	+ 9·0	+ 38,457
	T4 Bombsight, removable equipment			
9/4482	Computer	50·0	-27·3	- 1,365
9/4566	Sighting head	15·0	-29·3	- 439
9/4579	Amplifier	11·5	-26·8	- 308
	Total T 4 bombsight installation	76·5	-27·6	- 2,112
	A.R.I.18051 - removable equipment			
26DC/8925	Container in wing (2 off)	98·6	+24·6	+ 2,424
26DC/8927	Container in power compartment	29·5	+32·5	+ 959
Z.8302	Stripper unit in wing (2 off)	74·0	+21·3	+ 1,573
Z.8279	Stripper unit in power compartment (2 off)	74·0	+30·6	+ 2,263
Z.8277	Installation of window launch units.	15·3	+24·4	+ 374
10L/291	Control units	15·8	-20·2	- 319
	Total window launching	307·2	+23·7	+ 7,274
	A.R.I.5848 - removable equipment			
10D/20334	Transmitter receiver Type 4535	38·4	-15·0	- 574
16K/1660/ 03629 0932	Coding unit KY95A/A.P.K. - 25	10·4	-14·2	- 148
16K/1660/ 03629 0584	Control unit Type C1158/APK - 6A	1·4	-18·9	- 26
16K/1660/ 03629 0585	Coder control unit C1128/APX-25	1·2	-19·2	- 23
	Total A.R.I.5848	51·4	-15·0	- 771
	Special flight containers (Mod.630 and 842)			
	10,000 lb. - Blue Danube			
-	Container Type 'A'	181·0	+32·7	+ 5,920
26DC/9830	Cradle Z.9815	19·3	+32·6	+ 630
-	Container Type 'B'	115·0	+13·5	+ 1,552
26DC/9831	Cradle Z.9827	11·4	+13·5	+ 154
	Total	326·7	+25·3	+ 8,256

VARIABLE LOAD (continued)

Ref.No.	Description	Weight (lb.)	Arm (ft.)	Moment (lb.ft.)
	2,000 lb. - Red Beard			
-	Container Type 'A'	181·0	+32·7	+ 5,920
26DC/9830	Cradle Z.9815	19·3	+32·6	+ 630
-	Container Type 'B'	115·0	+13·5	+ 1,552
26DC/9831	Cradle Z.9827	11·4	+13·5	+ 154
	Total	326·7	+25·3	+ 8,256
	7,000 lb. M.C.			
-	Container Type 'A'	181·0	+32·7	+ 5,920
26DC/9830	Cradle Z.9815	19·3	+32·6	+ 630
-	Container Type 'C'	123·0	+13·5	+ 1,661
-	Cradle Z.10046	18·7	+13·5	+ 252
	Total	342·0	+24·7	+ 8,463
	Bomb fuzing			
-	Bomb fuzing in bomb bay	44·3	+ 0·8	+ 37
-	Bomb fuzing in cabin	9·7	-20·4	- 198
	Total bomb fuzing	54·0	- 3·0	- 161
-	Aircraft destructors M.E. No.1 Mk.1 (2 off)	6·5	-32·0	- 208
-	Survival packs (5 off)	170·0	-33·9	- 5,766
-	Miscellaneous appendix 'A' items including binoculars, watches, navigational aids etc.	47·1	-22·7	- 1,067
-	V.G. recorder I.T. 4.3.18	4·2	-19·8	- 83
-	C. of G. computor	1·25	-26·4	- 33

EXPENDABLE LOAD

16.

Ref.No.	Description		Weight (lb.)	Arm (ft.)	Moment (lb.ft.)
	Bombs				
	Role A				
-	Red Beard Target marker	2,000 lb.	1,680	+12·10	+ 20,339
	Role B				
-	6,000 lb. store		3,175	+12·10	+ 38,285

EXPENDABLE LOAD (continued)

Ref. No.	Description		Weight (lb.)	Arm (ft.)	Moment (lb.ft.)
-	Role C 7,000 lb. M.C.	6,200 lb. + 1,000 lb.	7,200	+11·90	+ 85,968
-	Role D Blue Danube		10,225	+11·77	+120,382
-	Role E 21 x 1,000 lb.				
	Forward station	7 x 1,000 lb. stores	7,000	+ 4·421	+ 30,951
	Centre station	7 x 1,000 lb. stores	7,000	+ 13·364	+ 93,548
	Rear station	7 x 1,000 lb. stores	7,000	+ 22·285	+156,000
	Total Role E 21 x 1,000 lb. stores		21,000	+ 13·357	+280,499
	Practice bombs				
-	Role F				
-	Smoke flashes	24 x 25 lb.	600	+13·37	+ 8,024
		or			
	24 x 100 lb. H.A.		2,400	+13·37	+ 32,096
	Window - example loadings				
	Primary containers in wing - port and starboard				
10AV/125	Window Type 23	(1,920 packets)	851·0	+24·4	+ 20,779
	Container below power compartment				
10AV/125	Window Type 23	(360 packets)	160·0	+33·0	+ 5,280
	Total window		1,011·0	+25·8	+ 26,059
	Primary containers in wing - port and starboard				
10AV/123	Window Type 21	(3,744 packets)	698·0	+24·4	+ 17,043
	Container below power compartment				
10AV/125	Window Type 23	(360 packets)	160·0	+33·0	+ 5,280
	Total window		858·0	+26·0	+ 22,323

SPECIFICATION ROLES

17. The following are the specification roles as listed in Vol.3, Part 2 of this Air Publication:-

Role A	Bomber	1 x 2,000 lb.	Red Beard
Role B	Bomber	1 x 6,000 lb.	
Role C	Bomber	1 x 7,000 lb. M.C.	Yellow Sun
Role D	Bomber	1 x 10,000 lb.	Blue Danube
Role E	Bomber	21 x 1,000 lb.	Variants (Including clusters, target indicators and mines)
Role F	Bomber	24 x 100 lb. or 25 lb.	Practice

FUEL LOADING DATA

18. Details of fuel tank capacities, weight and moment for varying fuel Specific Gravities are as follows:-

Tank No. P. & S.	Fuel S.G. 0·8 Gall.	Arm (ft.)	Weight (lb.)	Moment (lb.ft.) Positive	Moment (lb.ft.) Negative
1	1,242	-11·027	9,936	-	109,566
2	1,888	- 3·0	15,104	-	45,314
3	1,248	13·316	9,984	132,945	-
4	1,248	19·055	9,984	190,244	-
5	1,006	21·937	8,048	176,547	-
6	1,458	25·616	11,664	298,783	-
7	1,074	28·538	8,592	245,196	-
-	-	-	-	1,043,715	154,880
Total	9,164	12·124	73,312	888,835	-

Tank No. P. & S.	Fuel S.G. 0·78 Gall.	Arm (ft.)	Weight (lb.)	Moment (lb.ft.) Positive	Moment (lb.ft.) Negative
1	1,262	-11·027	9,844	-	108,548
2	1,908	- 3·0	14,882	-	44,646
3	1,268	13·316	9,890	131,701	-
4	1,268	19·055	9,890	188,454	-
5	1,026	21·937	8,004	175,590	-
6	1,478	25·616	11,528	295,306	-
7	1,094	28·538	8,533	243,518	-
-	-	-	-	1,034,569	153,194
Total	9,304	12·145	72,571	881,375	-

FUEL LOADING DATA (continued)

Tank No. P. & S.	Fuel S.G. 0·77 Gall.	Arm (ft.)	Weight (lb.)	Moment (lb.ft.) Positive	Moment (lb.ft.) Negative
1	1,262	-11·027	9,717	-	107,147
2	1,908	- 3·0	14,692	-	44,076
3	1,268	13·316	9,764	130,023	-
4	1,268	19·055	9,764	186,053	-
5	1,026	21·937	7,900	173,307	-
6	1,478	25·616	11,380	291,513	-
7	1,094	28·538	8,424	240,407	-
-	-	-	-	1,021,303	151,223
Total	9,304	12·145	71,641	870,080	-

Tank No. P. & S.	Fuel S.G. 0·76 Gall.	Arm (ft.)	Weight (lb.)	Moment (lb.ft.) Positive	Moment (lb.ft.) Negative
1	1,262	-11·027	9,591	-	105,757
2	1,908	- 3·0	14,501	-	43,503
3	1,268	13·316	9,637	128,333	-
4	1,268	19·055	9,637	183,633	-
5	1,026	21·937	7,797	171,050	-
6	1,478	25·616	11,233	287,748	-
7	1,094	28·538	8,314	237,269	-
-	-	-	-	1,008,033	149,260
Total	9,304	12·145	70,710	858,773	-

Tank No. P. & S.	Fuel S.G. 0·75 Gall.	Arm (ft.)	Weight (lb.)	Moment (lb.ft.) Positive	Moment (lb.ft.) Negative
1	1,262	-11·027	9,465	-	104,367
2	1,908	- 3·0	14,310	-	42,930
3	1,268	13·316	9,510	126,638	-
4	1,268	19·055	9,510	181,213	-
5	1,026	21·937	7,695	168,808	-
6	1,478	25·616	11,085	283,958	-
7	1,094	25·124	8,205	234,158	-
-	-	-	-	994,775	147,297
Total	9,304	12·145	69,780	847,478	-

For design calculation use:-

Capacity (gall.)	Specific Gravity	Weight (lb.)	Mean Arm (ft.)	Moment (lb.ft.)
9,304	0·77	71,641	12·145	870,080

FUEL TRANSFER

19. To trim the aircraft C.G. by fuel transfer between No.1 and 7 tanks:-

$$\frac{\text{All up weight} \times \text{C.G. shift required}}{474{\cdot}78} = \text{Weight of fuel to be transferred.}$$

e.g., $\frac{145{,}000 \times 1}{474{\cdot}78} = 305$ lb.

i.e. To move the aircraft C.G. forward or aft by one inch at an All Up Weight of 145,000 lb. a total weight of 305 lb. fuel must be transferred.

FUEL C.G. INDICATOR

20. This instrument is mainly for use during flight refuelling, to aid the pilot to keep the aircraft in longitudinal trim. It shows any variation in the mean fuel C.G. due to uneven distribution. The gauge is calibrated about the mean C.G. of the fuel and is connected to the tank contents transmitters via a computer box which takes into consideration the moment arm of each tank. The limit of each tail heavy, green, sector represents 30,000 lb.ft. out of balance moments, giving a total of 60,000 lb.ft. and the limit of each nose heavy, green, sector represents 15,000 lb.ft. out of balance moments, giving a total of 30,000 lb.ft. When the fuel is correctly distributed the needles are in the horizontal position (i.e., number of out of balance moments zero).

NOTE . . .
This instrument does not give the aircraft C.G. position.

UNUSABLE FUEL

21. Unusable fuel is the fuel remaining after the contents gauges register zero. This fuel is included in the Basic Weight and must be added to the weighed weight of the aircraft.

The weight and moment of fuel to bring to 'Basic Weight'

Weight	=	154 lb.
Moment Arm	=	+ 16·1 ft. (193 in.)
Moment	=	+ 2,477 lb.ft.

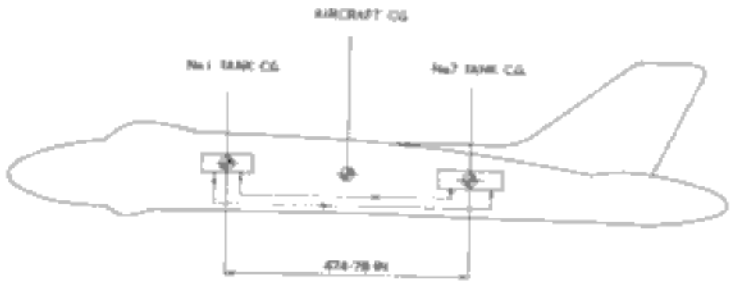


Fig. 5. Fuel transfer

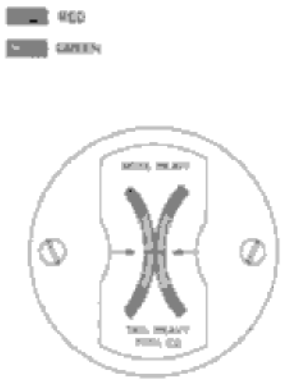


Fig. 6. Fuel C.G. indicator

NOTE . . .
Although all the fuel indicated on the fuel contents gauges is usable the recommended minimum for final landing is 8,000 lb. total, because of the wide distribution of fuel between tanks and the possibility of uncovering pumps while manoeuvring the aircraft.

CREW LOADING DATA

22.

Description	Weight lb.	Arm ft.	Moment lb. ft.
1st and 2nd pilot	360	- 27·3	- 9,828
3 crew members	540	- 21·6	- 11,664
Total weight and moment - 5 crew	900	- 23·88	- 21,492
Safety equipment			
1st and 2nd pilots chutes and dinghies	102	- 27·3	- 2,785
3 crew members chutes and dinghies	131	- 21·7	- 2,843
Total weight and moment of chutes and dinghies	233	- 24·15	- 5,628
Total weight and moment - 5 crew with chutes and dinghies	1,133	- 23·94	- 27,120
6th crew member	180	- 25·2	- 4,536
6th crew member's chute and dinghy	43	- 25·2	- 1,084
Total weight and moment - 6 crew with chutes and dinghies	1,356	- 24·14	- 32,740

ENGINE C.G. DATA

23. To find $\overline{X}$ engine C.G. from aircraft C.G. datum point.

$C = \cos 10^{0} \times A$
$= 0{\cdot}9841 \text{ in.} \times A$
$\overline{X}$ = C.G. of trunnion - C
$= 164{\cdot}9841 \text{ in.} - C$

Example :

A = C.G. of engine from trunnion - 5·5 in. obtained from engine Air Publication

To find X:

$C = 0{\cdot}98481 \times 5{\cdot}5 \text{ in.}$
$= 5{\cdot}4165 \text{ in.}$
$\overline{X} = 164{\cdot}9841 - 5{\cdot}4165 \text{ in.}$
$= 159{\cdot}5676 \text{ in. aft of aircraft C.G. datum point}$

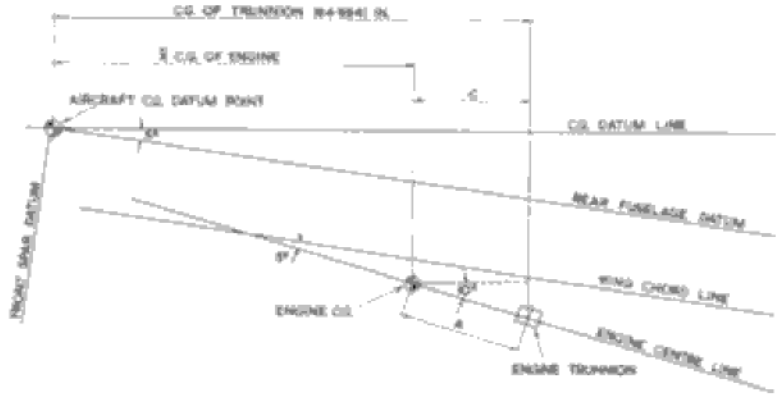


Fig. 7. Engine C.G. data

TYPICAL LOADING CALCULATION

24. Role C 7,000 lb. M.C.

Current Basic Weight and Moment			
(Obtained from Record Sht. - Form 4908)	88,384	1,117,157	-
ADD : Variable Load			
Carriers and pintles	295·0	4,201	-
T.4 bombsight - removable equipment	76·5	-	2,112
Window launching - removable equipment	307·2	7,247	-
I.F.F. Mk.10 removable equipment	51·4	-	771
Bomb fuzing	54·0	-	161
Aircraft destructors H.E. No.1, Mk.1 (2 off)	6·5	-	208
Survival packs (5 off)	170·0	-	5,766
Miscellaneous Appendix 'A' items including binoculars, watches, navigational aid etc.)	47·1	-	1,067
V.G. recorder 1T 4.3.18	4·2	-	83
C. of G. computor	1·25	-	33
Crew (5 off) complete with chutes and dinghies	1133·0	-	27,120
		1,128,632	37,321
Weight and moment less expendable load	90,530	1,091,311	Index Unit + 0·498
ADD : Expendable Load			
Store, 7,000 lb. M.C.	7,200	85,968	-
Window disposable	858	22,323	-
Fuel 99·6% at 7·7 lb./gall.	71,412	867,305	-
All-Up Weight	170,000	2,066,907	Index Unit + 2·686

The C.G. position = $\frac{2,066,907}{170,000}$ = 12·158 ft. = 145·9 in. aft of datum point

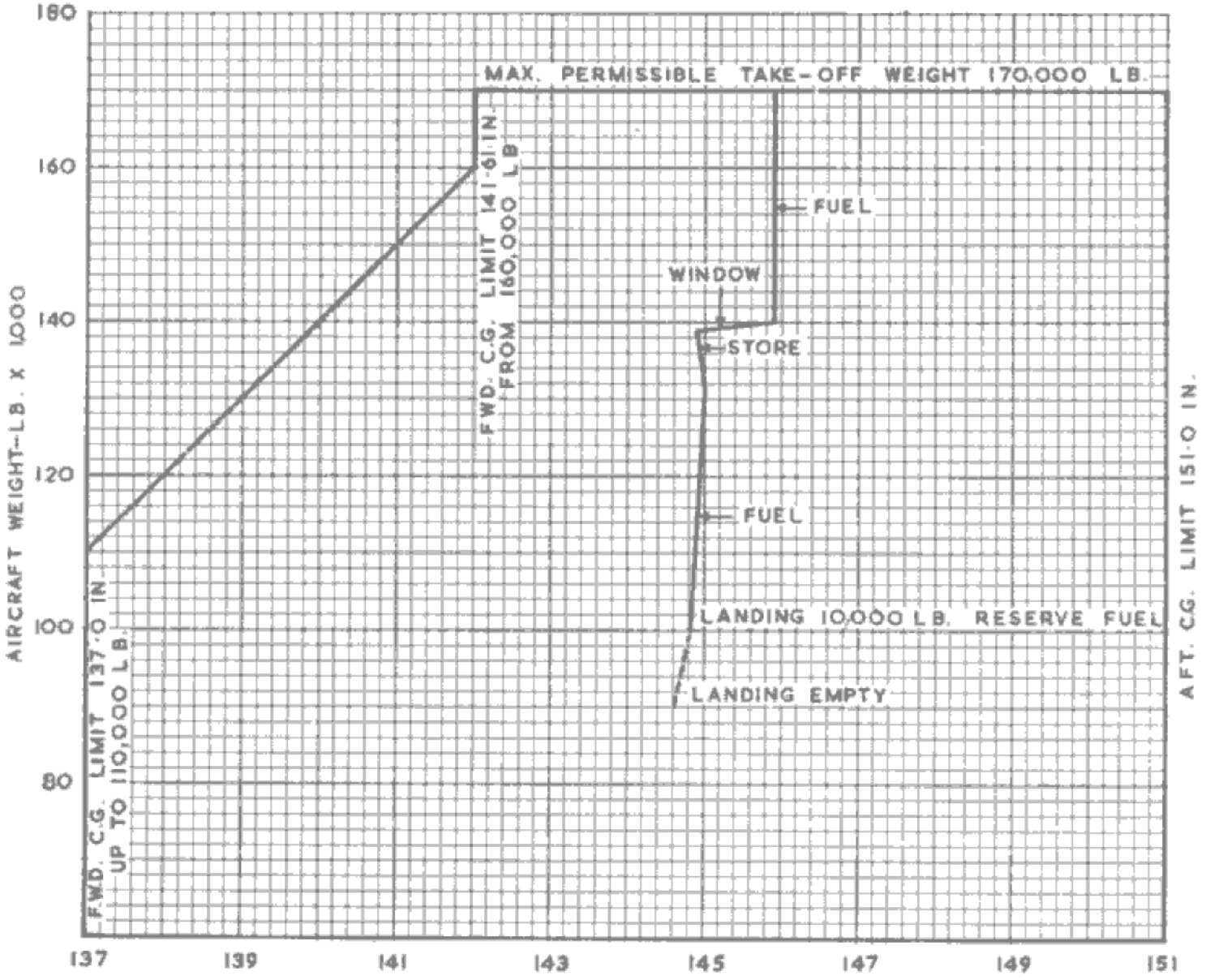


Fig. 8. C.G. movement during flight - Role C

TYPICAL LOADING CALCULATION (continued)

25. Role D. Blue Danube

Description	Weight (lb)	Positive	Negative
Current Basic Weight and Moment			
(Obtained from Record Sht. - Form 4908)	88,384	1,117,157	-
ADD : Variable Load			
Carrier and pintles	276·0	3,277	-
T.4 bombsight - removable equipment	76·5	-	2,112
Window launching - removable equipment	307·2	7,274	-
I.F.F. Mk.10 - removable equipment	51·4	-	771
Bomb fuzing	54·0	+	161
Aircraft destructors H.E. No.1, Mk.1 (2 off)	6·5	-	208
Survival packs 5 off	170·0	-	5,766
Miscellaneous Appendix 'A' items including binoculars, watches, navigational aid etc.	47·1	-	1,067
V.G. recorder 1T 4.3.18	4·2	-	83
C. of G. computer	1·25	-	33
Crew (5 off) c/w chutes and dinghies	1133·0	+	27,120
		1,127,708	37,321
Weight and moment less expendable load	90,511	1,090,387	Index Unit + 0·425
ADD : Expendable Load			
Store Blue Danube	10,225	120,382	-
Window disposable	858	22,323	-
Fuel 95% at 7·6 lb./gall.	68,406	830,797	-
All-Up Weight	170,000	2,063,889	Index Unit + 2,397

C.G. position = $\frac{2,063,889}{170,000}$ = 12·140 ft = 145·7 in. aft of datum point

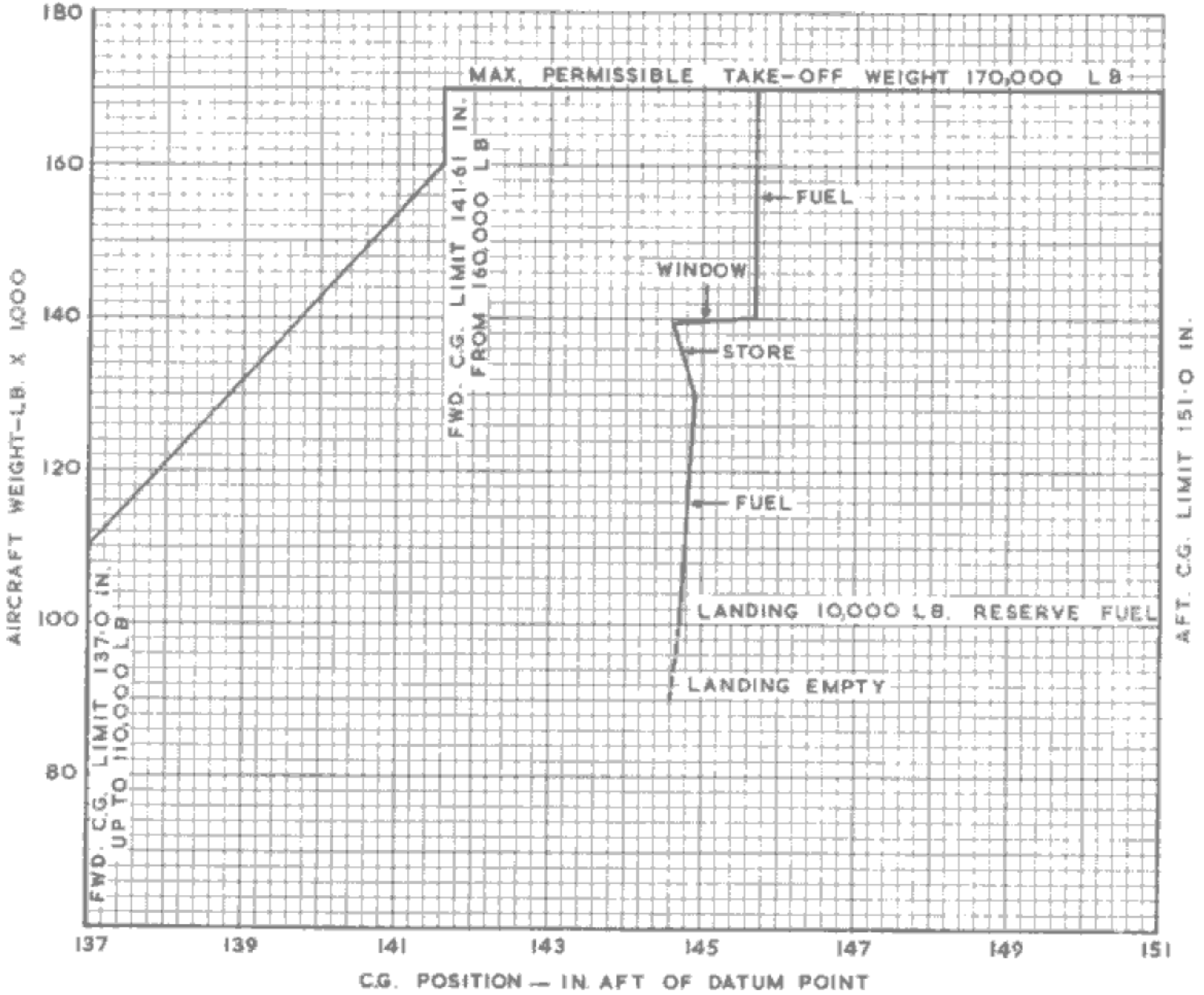


Fig. 9. C.G. movement during flight - Role D

CALCULATION OF EXPENDABLE LOAD

26. Case C 7,000 lb. M.C.

Description	Weight (lb.)	Moment (lb.ft.) Positive	Negative
Drop ; Window	858	22,323	-
Store	7,200	85,968	-
Use : Fuel less 10,000 lb. reserve	61,412	745,855	-
Oxygen 8 bottles	56	254	-
Windscreen de-icing fluid 12 gall.	97.8	-	3,146
		854,400	3,146
Total weight and moment of expendable load.	69,624	851,254	-

CALCULATION OF C.G. FOR LANDING

27. Case C 7,000 lb. M.C.

Landing Weight = 170,000 - 69,624 = 100,276 lb.

Moment = 2,006,907 - 851,254 = 1,215,653 lb. ft.

Landing C.G. = $\frac{1,215,653}{100,376}$ = 12·111 ft. (145·332 in.) aft of C.G. datum point

EFFECT OF UNDERCARRIAGE RETRACTION

28. The moment effect of undercarriage retraction = - 19,640 lb.ft.

Example:-

Case C - 7,000 lb. M.C. (para.27)

Weight 100,376 lb. C.G. 12·111 ft. (145·332 in.)

Moment 1,215,653 lb. ft. (undercarriage down

Change in moment due to undercarriage retraction -19,640 lb.ft.

Moment 1,196,013 lb. ft. (undercarriage up)

C.G. position (undercarriage up) = $\frac{1,196,013}{100,376}$ = 11·915 ft. (142·98 in.)

The C.G. shift due to undercarriage retraction at a weight of 100,376 lb. is 2·352 in. forward, at the A.U.W. of 170,000 lb. this effect is reduced to 1·392 in.

NOTE . . .
All C.G.'s, moments and limits in this chapter are quoted with the undercarriage down

BALLAST

29. Ballasting of this aircraft in the operational condition is unnecessary. Provision has been made however to fit ballast to compensate for substantial equipment shortages. Ballasting positions are situated in the nose and the E.C.M. rear fuselage.

Nose Ballast

Ballast is fitted in the nose as replacement weight for the H_2S scanner. This consists of a box 90 lb. and 12 ballast weights of approximately 40 lb. each.

12 x 40 = 480 + Box 90 = 570 lb.

Moment arm = - 35.66 ft. (-428 in.)

Maximum capacity of nose ballast box = 18 Weights.

Maximum weight 18 x 40 = 720 + Box 90 = 810 lb.

Maximum permissible weight to be fitted at this station = 810 lb.

E.C.M. Ballast

Introduced by Mod.949 E.C.M. ballasting is in two parts. Part A used for 'delivery' loading to the 'Service' and Part B for replacement of E.C.M. sets, when all other 'Service Fit' equipment is fitted.

As the aircraft C.G. in the fully equipped condition approaches the forward C.G. limit (fig.9) due to modifications, it becomes more important to replace equipment removed in the rear fuselage by ballast weights.

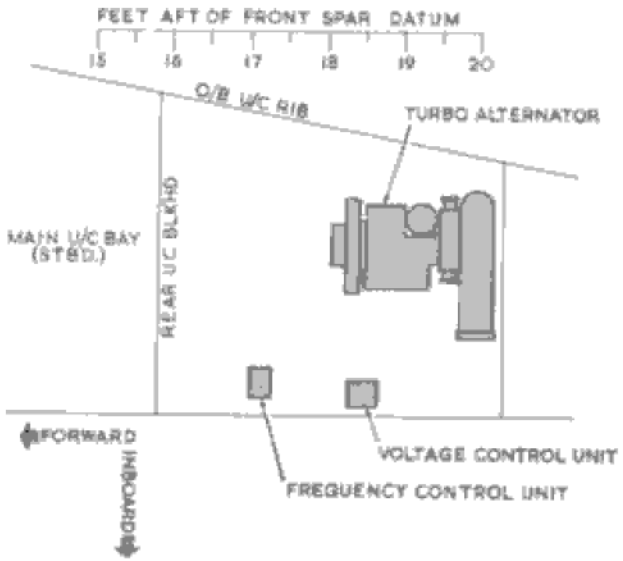


Fig. 10. E.C.M. equipment in starboard main plane

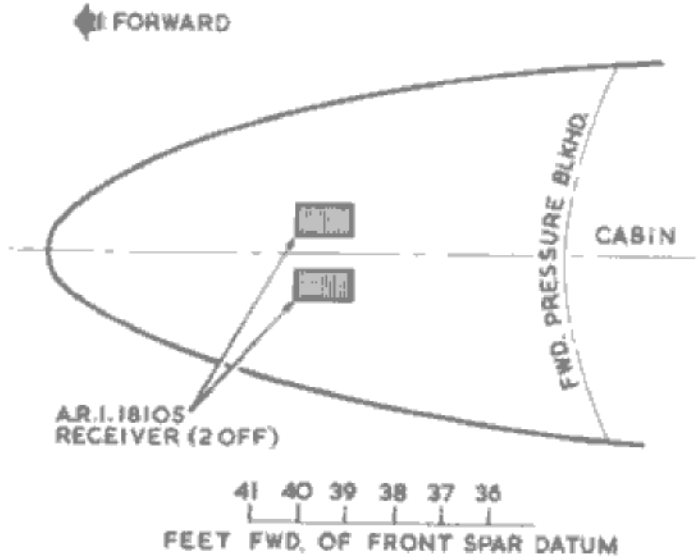


Fig. 11. E.C.M. equipment in nose section

Station No.	Description	Weight lb.	Arm ft.	Moment lb. ft.
	Average weight of one ballast plate complete with mounting = 240 lb.			
	Part A.E.C.M. delivery ballast			
1 & 2	Socket plate Ref.No. 26DC/9664 (2 off)	30·0	+41·4	+ 1,243
3	Socket plate Ref.No. 26DC/9664	15·0	+43·4	+ 651
4	Socket plate Ref.No. 26DC/9665	15·0	+43·4	+ 651
5 & 6	Socket plate Ref.No. 26DC/9666 (2 off)	30·0	+45·6	+ 1,368
	Transportation plate Part No. 1/Z10109	2·5	+52·0	+ 130
	Total socket plates	92·5	+43·7	+ 4,043
7 & 8	Ballast plate Ref.No. 26DC/9860 (2 off)	480·0	+47·5	+22,792
9	Ballast plate Ref.No. 26DC/9860	240·0	+49·5	+11,884
	Total ballast	720·0	+48·2	+34,676
	Total delivery ballast and socket plates	812·5	+47·7	+38,719

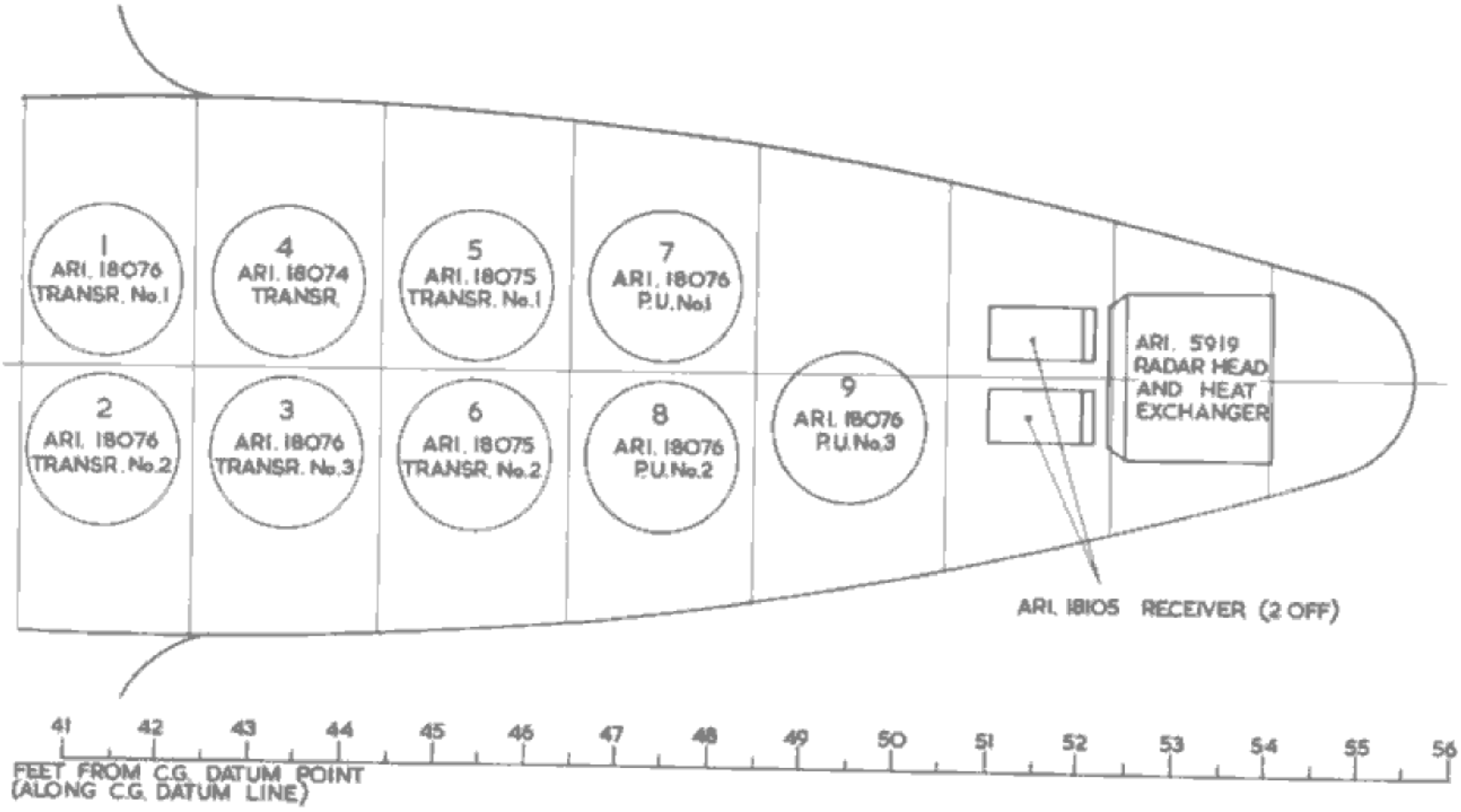


Fig. 12. E.C.M. equipment and ballast in rear fuselage

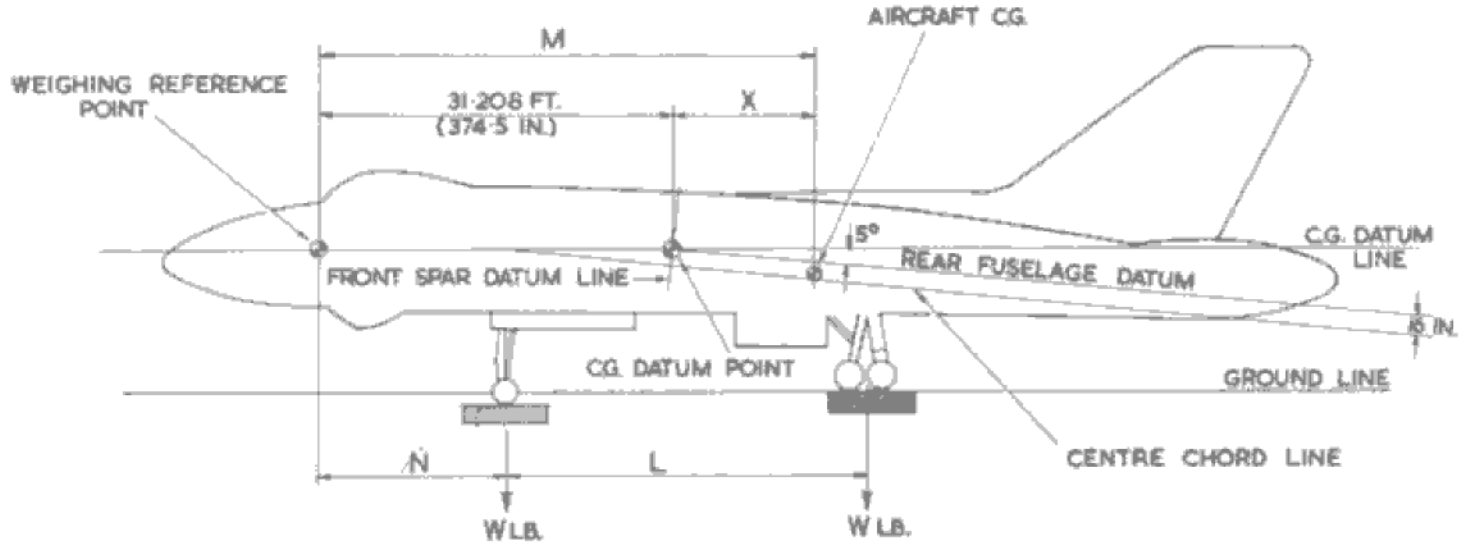


Fig. 13. Weighing on platform scales

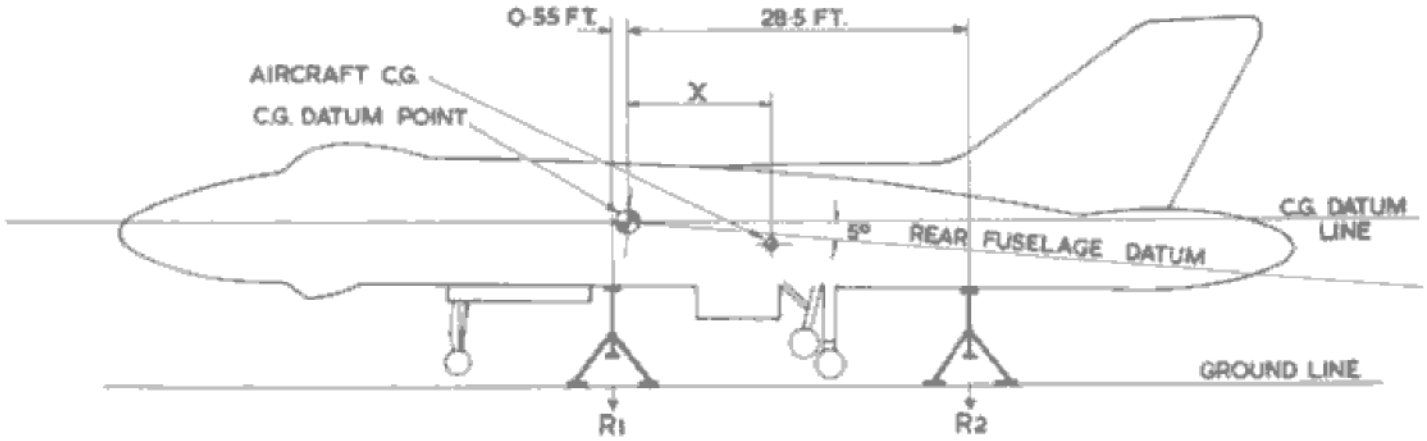


Fig. 14. Weighing on hydrostatic units

Station No.	Description	Weight (lb.)	Arm (ft.)	Moment (lb.ft.)
	Part B, E.C.M. additional ballast			
1 & 2	29Z9980 Ballast Plates 2 off	480·0	+41·4	+19.884
3 & 4	29Z9980 Ballast Plates 2 off	480·0	+43·4	+20,840
5 & 6	29Z9980 Ballast plates 2 off	480·0	+45·6	+21,880
	Total additional ballast	1,440·0	+43·5	+62,604

WEIGHING PROCEDURE

30. The aircraft should be checked for any deviation in equipment from that defined as included in the Basic Weight (para.12, 14 and 15). Defuelling is carried out in the normal manner as laid down in Section 4, Chapter 2 of this book to unusable fuel level (i.e., contents gauge zero). The aircraft is then rigged so that the C.G. datum line is horizontal. This can be done by either using a clinometer set at 5 deg. in the main undercarriage bay or by using a star plate and plumb line in the cabin (Sect.2, Chap.4). The remaining fuel in each tank must then be drained via the sump plug. The aircraft external surfaces must be dry, the wheel brakes off, when on platform scales, and the hangar doors closed.

Weighing on platform scales

Measurements

N (ft.) - Weighing reference point to nose wheel centre
L (ft.) - Nose wheel centre to bogie centre line

Calculations

To determine the aircraft centre of gravity in relation to the C.G. datum point (dimension X).

Take Moments about the Weighing Reference Point.

$$(W + w) \times M = (w \times N) + W(N + L)$$

$$M = \frac{(w \times N) + W(N + L)}{(W + w)}$$

$$X = M - 31{\cdot}208 \text{ ft.}$$

Example

W = 84,405 lb. L = 30·156 ft.
w = 4,621 lb. N = 15·229 ft.

$W + w$ = 89,026 lb. $N + L$ = 45·385 ft.

$$M = \frac{(4{,}621 \times 15{\cdot}229) + (84{,}405 \times 45{\cdot}385)}{89{,}026} = 43{\cdot}820 \text{ ft.}$$

X = 43·820 - 31·208 = + 12·612 ft.

Weight = 89,026 lb.

Moment arm X = + 12·612 ft. (datum point)

Moment (W x X) = + 1,122,796 lb.ft.

Weighing on hydrostatic units

Calculations

To determine the aircraft centre of gravity in relation to the C.G. datum point (dimension X).

Take moments about the C.G. datum point

$$(R.1 + R.2)\,X = (R.2 \times 28{\cdot}5) - (R.1 \times 0{\cdot}55)$$

$$X = \frac{(R.2 \times 28{\cdot}5) - (R.1 \times 0{\cdot}55)}{(R.1 + R.2)} \text{ ft.}$$

Example

R.1 = 48,690 lb.
R.2 = 40,336 lb.

R.1 + R.2 = 89,026

$$X = \frac{(40{,}336 \times 28{\cdot}5) - (48{,}690 \times 0{\cdot}55)}{89{,}026} = +\ 12{\cdot}612 \text{ ft.}$$

Weight	=	89,026 lb.
Moment Arm X	=	12.612 ft. (aft of C.G. datum point)
Moment (W x X)	=	+ 1,122,796 lb.ft.

TO OBTAIN THE BASIC WEIGHT AND MOMENT FROM A SERVICE WEIGHING

31.

Description	Weight lb.	Moment lb. ft. Positive	Moment lb. ft. Negative
Example			
Aircraft as weighed	89,026	1,122,796	-
Remove:- Equipment not included in basic weight			
Carrier and pintles, 7,000 lb. M.C.	- 295·0	-	4,201
T.4 bombsight - removable equipment	- 76·5	2,112	-
Window launching - removable equipment	- 307·2	-	7,274
I.F.F. MK.10 - removable equipment	- 51·4	771	-
Bomb fuzing	- 54·0	161	-
Aircraft destructors H.E. No.1, Mk.1 (2 off)	- 6·5	208	-
V.G. recorder IT/4.3.18	- 4·2	83	-
C.G. computer	- 1·25	33	-
Add:-			
Unusable fuel included in basic weight	+ 154·0	2,477	
		5,845	11,475
Aircraft basic weight and moment	88,384	1,117,166	-

REMOVABLE MILITARY LOAD - BOMB BAY

32.

Removable load	Case A Red Beard 1 x 1,680 lb. target marker	Case B 6,000 lb. store	Case C 7,000 lb. MC (1 x 6,200 + 1,000 lb.) Store	Case D Blue Danube	Case E 21 x 1,000 lb. H.E. stores	Case F 24 x 25 lb. smoke or flashes	Case F 24 x 100 lb. practise bombs
Variable load							
Carriers	343		192		684	684 + 288 * = 972	684 + 288 * = 972
Crutch assemblies		473	Crutches 23) Fuzing units 6) 77 Rear steady 48)	276 (para. 15)			
Pintles	26		26		78	78	78
Total	369	473	295	276	†762	1,050	1,050
Expendable load							
Store	1,680	3,175	7,200	10,225	21,000	600	2,400
Total weight of stores carriers, crutches and pintles	2,049	3,648	7,495	10,501	21,762	1,650	3,450

† Carrier weight = 228 lb.
Pintles 2 off 26 lb.
3 x 254 = 762 lb.

* Adapters fitted to one normal carrier = 96 lb. (4 off)
Total for 3 carriers = 288 lb.

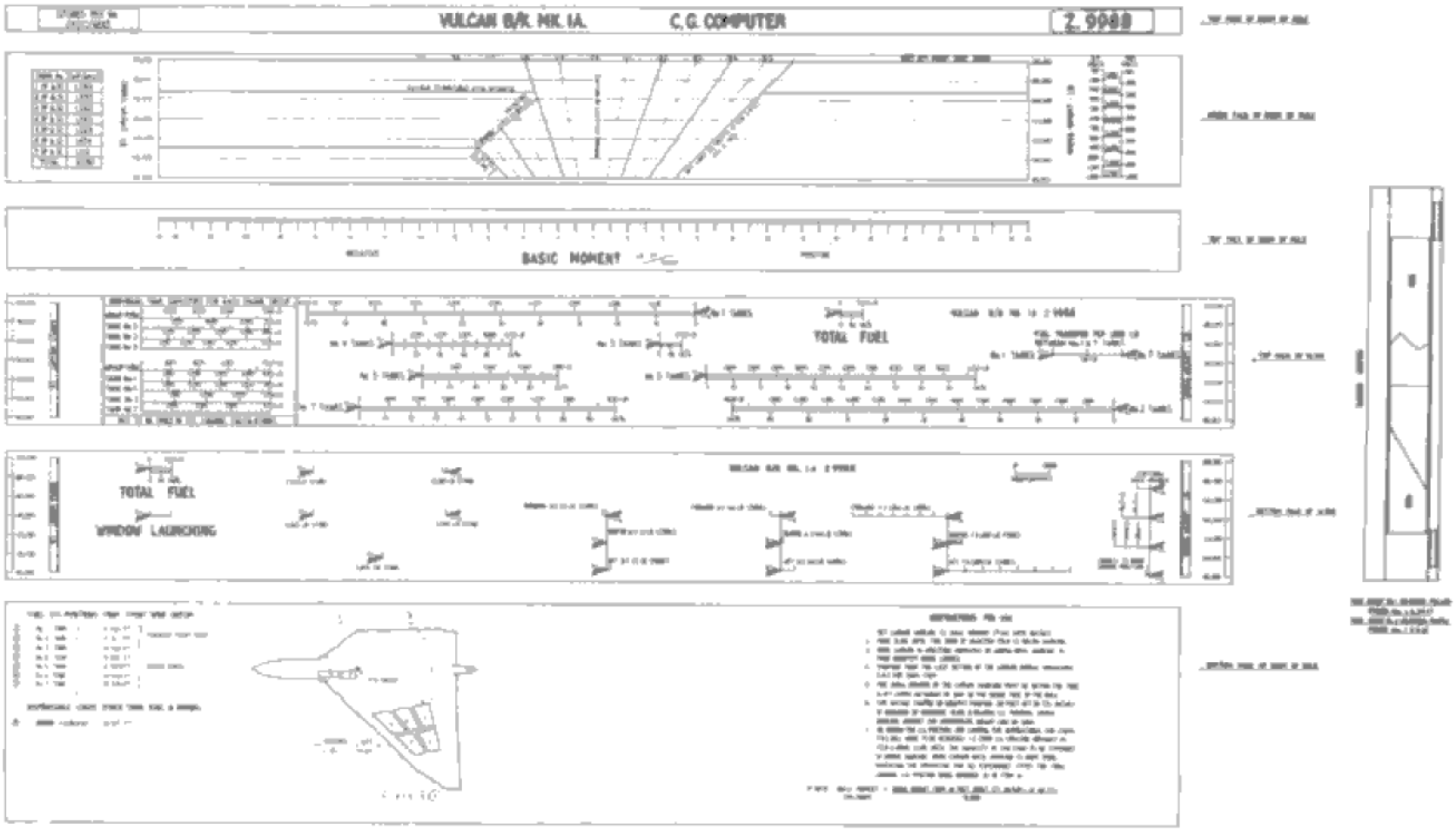


Fig. 15. C.G. computer

C.G. COMPUTER

33. The aircraft C.G. computer consists of a stock, slide and cursor. Two scales A and B are marked on the stock and two scales C and D on the slide (fig.15). Scale A is a grid made up of three scales showing:-

1. The C.G. position measured in feet from the aircraft C.G. datum point.
2. The Gross weight in lb.
3. The C.G. limits.

Scale B is the Basic Moment (index units) scale and shows the aircraft moment in $\frac{\text{lb.ft.}}{10{,}000}$ about the computer datum. The graduated scale lines on the slide referred to as scales C and D represent various items of load and their lengths are determined by the value of their moment in lb.ft. about the computer datum.

Trim or Computer Datum

A nominal C.G. position 12·00 ft. aft of the aircraft C.G. datum point has been selected as the computer datum, i.e., centre of C.G. range. This reduces the moment and gives a suitable scale to fit the computer dimensions.

Basic Moment (Index Units)

The Basic Moment is the aircraft moment converted to the computer datum and is obtained thus:-

$$\text{Basic moment} = \frac{\text{Basic weight} \times (\text{arm in feet about C.G. Datum Point} - 12{\cdot}00 \text{ ft.})}{10{,}000}$$

This gives the initial setting when using the C.G. computer.

NOTE...
The Vulcan computer was designed prior to the introduction of standard terminology. Consequently the term Basic Moment shown on Scale B and referred to in this paragraph represents the moment about the Trim Datum (A.P.4747A).

Instructions for use

1. Set cursor hairline to basic moment.
2. Move slide until the zero of selected item is below hairline.
3. Move cursor in direction indicated by arrow until hairline is over quantity being loaded.
4. Starting from the last setting of the cursor, repeat operations 2 and 3 for each item.
5. The final position of the cursor hairline must be within the fore and aft limits as shown on grid on the inside face of the rule.
6. The actual centre of gravity position (in feet, aft of front spar datum) is obtained by removing slide and reading C.G. position under the hairline against the appropriate weight line on grid.
7. To obtain the C.G. position for landing, the instructions for items 2 and 3 will have to be reversed, i.e., from the C.G. position obtained in item 6, move slide until the quantity of the load to be expended is under hairline, move cursor until hairline is over zero, repeating the operations for all expendable items, the final landing C.G. position being obtained as in item 6.

Conclusion

The computer gives the summation of moments only, it does not give the gross weight or record the operations carried out.

For this reason it is suggested that the user, when computing an aircraft loading should first list all the items of load required with their associated weights.

MODIFICATIONS

34. When an aircraft is weighed by the manufacturer its Basic Weight and Index are quoted, together with the modifications embodied at the time of weighing. Before a particular aircraft Basic Weight is used, it must be ascertained if further modifications have been added. If so, the Basic Weight and Index must be raised on the Record Card, R.A.F. Form 4908.

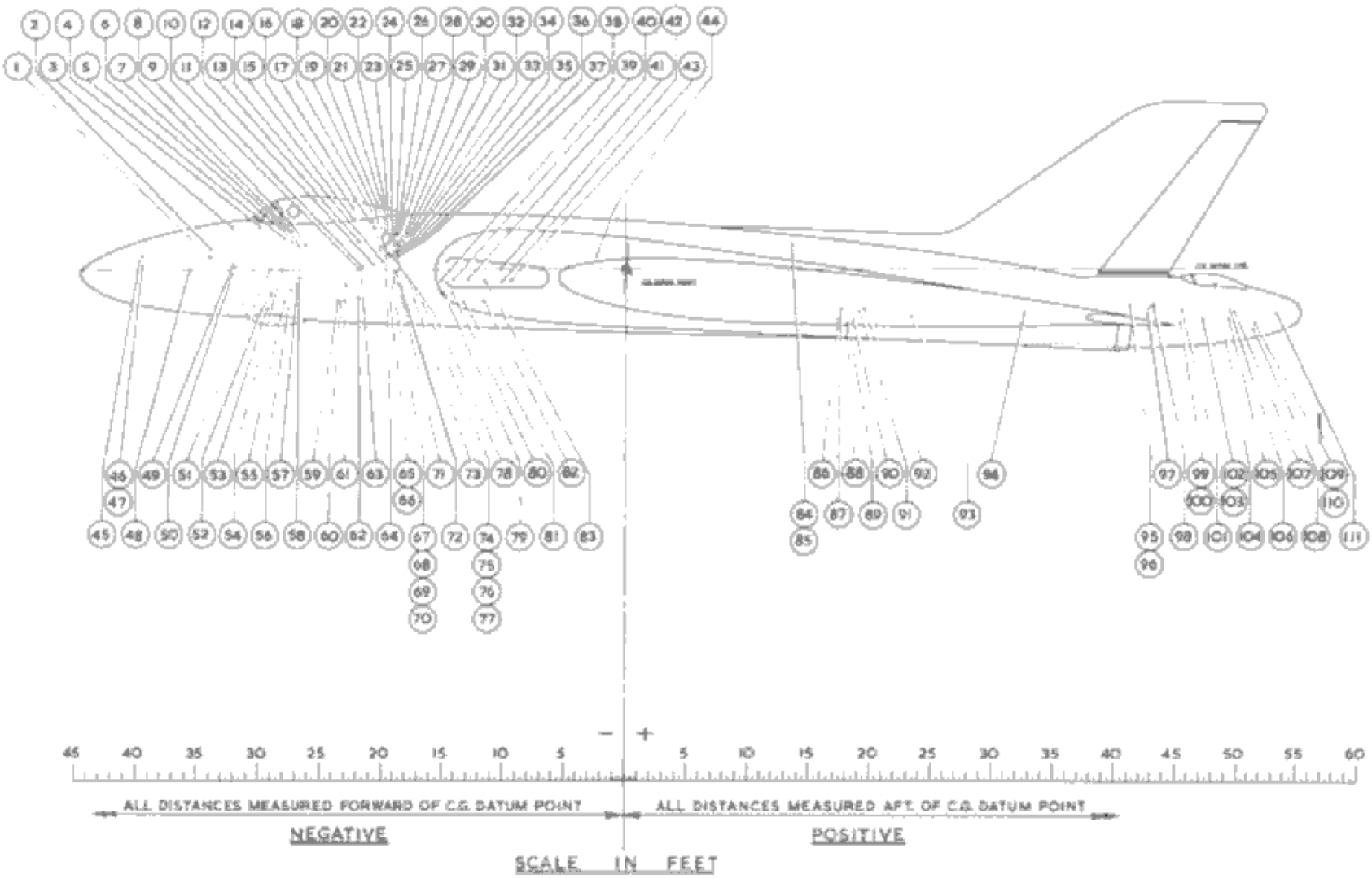


Fig. 16. Loading and C.G. diagram - electrical, radio and radar removable equipment

KEY TO FIG.16

Item No.	Ref. No.	Description	Weight lb.	$\bar{x}$ Arm ft.	$W\bar{x}$ Moment lb. ft.
1	5UB/5748	Amplidyne	39·5	- 34·1	- 1,347
2	-	Survival packs	170·0	- 33·9	- 5,766
3	34B/9100475	Windscreen de-icing fluid (12 gall.)	97·8	- 32·2	- 3,146
4	9D/8	Directional indicator Mk.1	0·6	- 30·0	- 18
5	10F/17565	Control unit Type 7231	2·0	- 28·0	- 56
6	-	1st and 2nd pilot's chutes and dinghies	102·0	- 27·3	- 2,785
7	9A/02450	First Aid Outfit - cabin	6·0	- 26·7	- 160
8	-	1st and 2nd pilot	360·0	- 27·3	- 9,828
9	-	C. of G. computor	1·25	- 26·4	- 33
10	10L/16495	Control unit Type 12580	2·8	- 21·8	- 61
11	-	3 crew members	540·0	- 21·6	- 11,664
12	10L/16493	Control unit Type 12558	8·2	- 20·7	- 170
13	10L/263	Control unit Type 705	2·0	- 22·0	- 44
14	10L/16060	Control unit Type 626	1·8	- 20·0	- 36
15	-	Signal pistol cartridges (12 off)	4·1	- 22·2	- 91
16	270/2425	Dinghy Type M.S.5	116·0	- 22·3	- 2,586
17	9D/1566	Variable air speed unit	0·8	- 21·0	- 17
18	7B/1484	Signal pistol 1·5 in. Mk.1	4·1	- 20·7	- 85
19	10L/291	Control unit	15·8	- 20·2	- 319
20	10L/16351	Control unit Type 7812	1·3	- 20·0	- 26
21	-	V.G. recorder I.T.4.3.18	4·2	- 19·8	- 83
22	9D/1803	Navigation panel Mk.1B	36·0	- 19·7	- 708
23	10Q/93	Pulse altimeter indicator Type 7921	10·0	- 19·5	- 195
24	14A/4260	Camera Type R.88	12·3	- 19·7	- 242
25	9D/757	Indicator unit	1·5	- 19·3	- 29
26	9D/1400	Forward throw indicator	1·0	- 19·0	- 19
27	9D/756	Wind monitor unit	10·0	- 18·8	- 188
28	10L/16073	Control unit Type 1274	2·8	- 19·2	- 54
29	10Q/16058	Indicator unit Type 26	18·5	- 19·0	- 352
30	10U/16596	Amplifier Type A1961	6·25	- 17·9	- 112
31	10QB/6493	Indicator unit Type 301	64·3	- 18·8	- 1,206
32	10Q/16420	Indicator unit navigator's station Type 6935	13·5	- 18·7	- 253
33	16K/1660/ 03629/0584	Control unit Type C1158/APK-6A	1·4	- 18·9	- 26
34	10LB/6366	Control unit Type 585	55·0	- 18·8	- 1,036
35	10LB/6376	Control unit Type 595	10·0	- 18·8	- 188
36	10O/16095	Electrical indicator Type 101	21·0	- 18·8	- 394
37	6B/541	G.P. indicator Mk.4	25·0	- 18·8	- 471
38	10DB/8811	Power unit Type 729	33·0	- 15·2	- 503
39	10D/18640	Automatic calculator Type 5	41·3	- 14·1	- 582
40	10VB/6250	Waveform generator Type 68	37·8	- 13·0	- 491
41	10D/2585	Trans/receiver Type 1576	27·0	- 10·3	- 278
42	10D/5821	Trans/receiver Type 5	48·5	- 10·2	- 497
43	10K/17035	Power unit Type 814	10·8	- 9·4	- 101

KEY TO FIG.16 (continued)

Item No.	Ref. No.	Description	Weight lb.	x Arm ft.	Wx Moment lb. ft.
44	10D/19598	Receiver Type A.D.7092D	15·7	- 2·4	- 37
45	10D/21506	Blanking unit Type 11871	6·4	- 39·5	- 253
46	10D/20567	Receiver Type R.9561	12·0	- 39·5	- 474
47	10D/20567	Receiver Type R.9561	12·0	- 39·5	- 474
48	10B/19090	Scanner unit Type 121 including amplifier, modulator, gyro unit etc.	489·0	- 35·7	- 17,441
49	-	Gloves, first aid kit	4·5	- 32·1	- 144
50	-	Aircraft destructors M.E. No.1, Mk.1 (2 off)	6·5	- 32·0	- 208
51	10D/17938	Transmitter/receiver TR.1986	27·0	- 29·2	- 788
52	9D/3	Calculator Type 2 Mk.1	60·0	- 29·1	- 1,745
53	9/4566	Sighting head	15·0	- 29·3	- 439
54	10D/17937	Transmitter receiver TR.1985	27·0	- 28·2	- 761
55	10L/5821	Control unit Type C/1607/ARC 52	2·76	- 27·9	- 77
56	9/4482	Computer	50·0	- 27·3	- 1,365
57	9D/4	Calculator Type 3 Mk.1	95·0	- 26·9	- 2,557
58	9/4579	Amplifier	11·5	- 26·8	- 308
59	10D/17819	Receiver Type R.1965 (glide path)	16·0	- 23·6	- 378
60	6B/2838	Periscopic sextant Mk.2B c/w case	11·5	- 23·0	- 265
61	10D/17818	Receiver Type R.1964 (localiser marker)	18·0	- 23·1	- 416
62	10U/16596	Amplifier Type A.1961	6·25	- 21·9	- 137
63	-	3 crew members chutes and dinghies	131·0	- 21·7	- 2,843
64	19L/16154	Control unit Type 903 (camera)	6·5	- 19·7	- 128
65	5UC/6010	Voltage regulator	10·8	- 19·0	- 204
66	10D/19248	Aerial selector unit Type 7003	12·5	- 19·0	- 238
67	10D/19065	Transmitter S.T.18 Type 4188	17·0	- 18·8	- 320
68	10D/19064	Receiver Type 4187	26·5	- 18·8	- 499
69	10K/19067	Power and radio unit Type 4192	36·0	- 18·8	- 678
70	10L/16205	Control and drive unit Type 4190	17·0	- 18·8	- 320
71	10V/16045	Waveform generator Type 72	21·5	- 18·3	- 394
72	10D/16876	Receiver Type R.3673	21·5	- 18·5	- 398
73	9D/12	Resistance unit	4·0	- 17·3	- 69
74	10J/214	Control unit Type 9562	4·5	- 19·6	- 88
75	10L/16346	Control unit Type 9422	5·0	- 19·6	- 98
76	10L/16349	Control unit Type 9456	2·2	- 19·5	- 43
77	10J/214	Control unit	4·5	- 19·3	- 87
78	16K/1660/03629/0585	Coder control unit C1128/APX-25	1·2	- 19·2	- 23
79	10D/20334	Transmitter/receiver Type 4535	38·4	- 15·0	- 574
80	16K/1660/03629/0932	Coding unit KY95A/A.P.K.-25	10·4	- 14·2	- 148
81	9D/11	Power unit	55·0	- 13·3	- 729
82	9D/2	Calculator Type 1 Mk.1	50·0	- 11·7	- 583
83	10D/19806	Transmitter receiver Type 7923	28·7	- 11·6	- 332
84	-	Type 'B' special flight container	115·0	+ 13·5	+ 1,552
85	-	Type 'C' special flight container	123·0	+ 13·5	+ 1,661
86	CPS.3	Frequency control unit	6·5	+ 17·3	+ 112

KEY TO FIG.16 (continued)

Item No.	Ref. No.	Description	Weight lb.	x̄ Arm ft.	Wx̄ Moment lb. ft.
87	10D/18843	Transmitter receiver Type TR.3710	116·0	+17·5	+ 2,030
88	10B/16389	Aerial Type 501	40·0	+18·1	+ 723
89	10B/17273	Waveguides Type T.529	1·1	+18·2	+ 20
90	U.3711	Voltage control unit	23·0	+18·6	427
91	TGA.30	Turbo alternator	150·0	+19·0	+ 2,850
92	10Q/16094	Tracker unit Type 100	48·0	+19·4	+ 932
93	-	Window launching installation	281·4	+27·0	+ 7,593
94	-	Type 'A' special flight container	181·0	+32·7	+ 5,920
95	10D/20525	No.1 transmitter T.9420 with base mounting T.4367	219·0	+41·4	+ 9,072
96	10D/20525	No.2 transmitter T.9420 with base mounting T.4367	219·0	+41·4	+ 9,072
97	10D/20525	No.3 transmitter T.9420 with base mounting T.4367	217·0	+43·4	+ 9,421
98	10D/20533	Transmitter and power unit T.7810 with base mounting T.4367	160·9	+43·4	6,986
99	10D/20530	No.1 transmitter T.9454 with power unit and base mounting T.4367	164·3	+45·6	+ 7,492
100	10D/20530	No.2 transmitter T.9454 with power unit and base mounting T.4367	164·3	+45·6	+ 7,492
101	-	Glycol in reservoir	10·2	+47·3	+ 482
102	10K/19874	No.1 power unit T.9421 with base mounting	244·7	+47·5	+11,619
103	10K/19874	No.2 power unit T.9421 with base mounting	244·7	+47·5	+11,619
104		Tail parachute c/w shackle	200·0	+48·5	+ 9,693
105	10K/19874	No.3 power unit T.9421 with base mounting	244·7	+49·5	+12,117
106	-	Pack - vapour cycle cooling	109·5	+49·6	+ 5,429
107	-	Freon	8·0	+50·0	+ 400
108	10D/20570	Blanking unit Type 9777	6·4	+51·6	+ 330
109	10D/20567	Receiver Type R.9561	12·0	+51·6	+ 619
110	10D/20567	Receiver Type R.9561	12·0	+51·6	+ 619
111	10D/20974	Radar head c/w heat exchanger Type 6934	146·0	+53·4	+ 7,799