

SECRET



A. V. ROE & CO., LIMITED, MANCHESTER

AVRO VULCAN B.2

DEVELOPMENT
FOR INCREASED ENDURANCE

SCHEME 4

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SECRET

VULCAN B2

INCREASED ENDURANCE

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SUMMARY

Recently Bomber Command have demonstrated their capability to maintain an airborne alert using their present aircraft carrying free fall stores. Each aircraft achieved an eight hour sortie with one hour's fuel reserve with the help of in-flight refuelling. This exercise has demonstrated that if an eight hour endurance could be achieved without flight refuelling, then an airborne alert could be mounted much more economically and be a much simpler operational task.

This brochure shows that the required endurance can be achieved whilst carrying two Skybolt missiles by fitting additional fuel tanks in the bomb bay.

No modifications are required to meet the increased all up weight of 236,200 lb. other than the fitting of stronger, interchangeable tyres to the main undercarriage.

The endurance with these tanks is 8.1 hours, plus one hour's fuel reserve, i.e. 9.1 hours to dry tanks. If, in view of the special nature of the sorties, this allowance could be reduced then the endurance would be correspondingly increased.

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INTRODUCTION

The bomb bay tanks A & E at present being manufactured under cover of Mods. 527 and 528, give an endurance of 7 hours plus one hours fuel reserve. This is insufficient for the "airborne alert" role.

The limited capacity of these tanks is due to meeting the requirement to cater for the conventional, Blue Steel, and Skybolt stores, which necessitated complicated shapes. In order to achieve the lightest weight with such shapes the design of the tanks was based on the use of thin gauge stainless steel sheet fabricated by spot welding with consequent high costs.

Investigations into various tank shapes to further increased endurance have been made, and the findings given in our brochure "Development for Increased Endurance". Ref. DESIGN/698/464.

Scheme 4 of the brochure appears so attractive that further detailed study has been carried out and made the subject of this separate brochure.

The fuel is carried in two cylindrical tanks of the largest possible diameter.

By keeping to a true circular cross section, the tanks are the most economical shape for testing, manufacture, and installation and give the best weight capacity ratio. Routine servicing in the bomb bay is also facilitated by the shape and the large access panels which it is possible to provide in the fairings.

An appreciable background of design and operational experience also is available to support this proposal.

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Cylindrical tanks of the same basic design but of smaller dia. to permit installation wholly within the bomb bay were fitted in the first and second prototype aircraft, and also in a Vulcan B.1 for a special long range flight to Australia. The fuel supply and vent systems are also based on this previous experience and on the present Tank A & E systems.

Similarly the schemes for the fairings are based on those designed for the Tanker Version of the Vulcan.

From the General Arrangement shown in Figs.1 and 2, it will be noted that in order to fit tanks of the required capacity the bomb doors have been removed. The bottoms of the tanks project below the normal contour of the aircraft, and, together with fairings form the undersurface of the aircraft.

A more detailed description follows:-

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DESCRIPTION

1. GENERAL

The General Arrangement of the aircraft is shown in Fig. 1.

The basic configuration of the aircraft is to the present Skybolt standard, fitted with four Bristol Olympus 301 engines of 20,000 lb. T.O. thrust each.

In order to accommodate tanks of the required capacity the bomb doors are removed. The undersurface of the aircraft is formed by the false bottom of the tanks and forward, centre and aft fairings.

2. FUEL TANK INSTALLATION

The General Arrangement is shown in Fig. 2.

The tanks are of conventional aluminium alloy construction as shown in Fig. 3.

A false bottom is formed on the tank to complete the undersurface of the aircraft, to protect the tank proper from damage by stones, etc. thrown up by the wheels, to provide space for the fuel pump sumps, and to provide some protection in the event of a wheels up landing.

Fairings hinged to the false bottom complete the undersurface. These may be swung fully down to give access to the bomb bay, and when in the closed position provide a working platform - see Fig. 2.

The tanks are secured by wide steel straps and crutched

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to a pre-determined load against fixed pads by suitably torque-loading the turnbuckles, see Fig.4. Fore and aft loads are taken by longitudinal struts which are attached to diffusion members on the tank - see Fig.4.

The undersurface is completed by forward and aft fairings attached to the airframe, - see Fig.2, 3 and 4 for typical arrangements, and by a two piece central fairing attached to the airframe and Skybolt crate structure, see Fig.5. Adjustable swinging links are used for attachments to accommodate structural movement and align the fairings.

Four mini-lifts are used to hoist each tank as shown in Fig.8.

3. FUEL SYSTEM

Fig.6 shows the diagrammatic arrangement of the fuel system. The forward tank holds 1,855 gallons and rear tank 1,685 gallons - Total 3,540 gallons.

Each tank is fitted with three P. A. C. 1,200 fuel pumps which are identical to those used in the normal tanks. These work in parallel and deliver fuel into the normal cross feed pipe. Provision is made for isolating the pump compartment so that a faulty pump may be changed without defuelling the tank - see detail on Fig.3. A low pressure switch is fitted in each of the delivery lines operating warning doll's eyes on the bomb bay fuel system control panel - see Fig.7.

The tanks are refuelled simultaneously from a separate ground refuelling point at the forward end of the bomb bay, hence the overall refuelling time of the aircraft is unchanged. Flight Refuelling Mk.40 double acting refuelling valves, as fitted in the normal tanks are used. These are selected open by switches on a control panel adjacent to the ground refuelling point. A double level float switch is fitted to

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close the refuelling valves. The normal lower lever float switch also operates the green light on the control panel to show that the tank is full. If this fails the emergency high level float switch operates the red light on the panel.

The tank contents gauges are inserted from the bottom of the tank and can be removed without dropping the tank, see Fig.3. The contents are given on a single indicator fitted in a panel attached to the 1st Pilots seat member, see Fig.7. The contents for either tank can be read by selecting the appropriate switch position.

The fuel system control panel is a slight modification of the one at present fitted by Mod.526 at the rear of the main fuel system control panel on the centre retractable console for the present tanks A & E; see Fig.7.

The fuel in the bomb bay tanks must be used first. Selection of the Bomb Bay tank switches puts all the main fuel pumps to half speed and the pumps in the Bomb Bay tanks to full speed. The resultant pressure difference ensures that the Bomb Bay fuel is used until the low pressure doll's eyes indicate white. The main switches are then operated to main and the individual Bomb Bay tank pumps switched off. The main fuel system is then operating on the normal automatic sequencing system.

It is not proposed to pressurise the tanks since with the flight plan envisaged - Fig.13, it is extremely unlikely that fuel boiling will occur. However, the vent system shown on Fig.2 will cater for this eventuality. The forward tank is vented via a 3 in. dia. pipe to the two existing N.A.C.A. vents for Tanks A & E, and the aft tank via a separate 3 in. dia. pipe to an additional N.A.C.A. vent. The vent positions have already been proved by flight tests carried out for previous installations.

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4. BOMB BAY PROTECTION

The Bomb Bay is already protected by the methyl bromide system introduced by Mod. 526 for the present tanks A & E. Fire detection is by the firewire system.

5. WEIGHT & C.G. DATA

The weight summary and proposed C.G. envelope are shown in Figs. 9 and 10 respectively. It will be noted that the removal of the bomb doors and mechanism to accommodate the tanks saves 1,746 lb. A further weight saving of 1,000 lb. by removal of redundant equipment has been assumed. A detailed explanation of this is given in Brochure Design/698/464. To meet the A. U. W. of 236,202 lb. stronger main wheel tyres will be required and 50 lb. has been added for this.

At maximum A. U. W. the C.G. is approx. in the mean position, therefore the aft limit which governs the stressing cases has been reduced to 152.0 inches aft of the DATUM, increasing linearly to the original 156.861 inches as the weight is reduced to 210,000 lb.

6. STRUCTURE

The Structural Test Programme has shown that the basic airframe structure will satisfactorily meet the full specification flight envelope up to an A. U. W. of 195,000 lb.

The permissible normal acceleration factor (n) will be reduced at the higher A. U. W. of 236,202 lb. at take-off and during the climb, but this factor will improve as fuel is consumed and weight progressively reduced. This is illustrated in Figs. 11 and 12.

The stressing of the undercarriage and its supporting structure is acceptable, as the loading is reduced by the reduced factor and the trend of the C.G. at the higher A. U. W. This will prove no

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embarrassment in Service as the additional weight is virtually on the C.G.

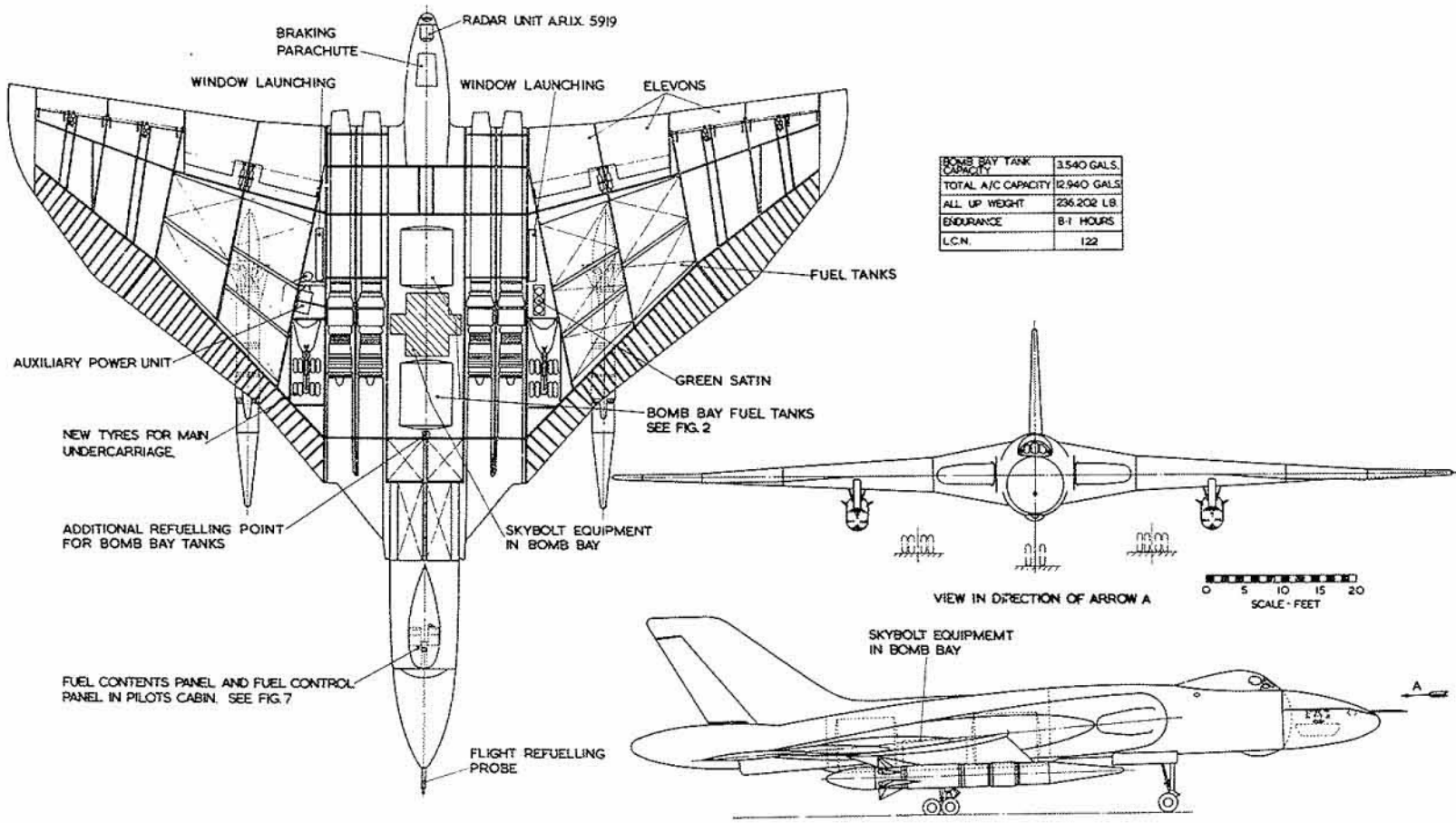
7. PERFORMANCE

The proposed flight plan to achieve the maximum endurance is shown in Fig. 13. The initial part of the climb is carried out at 250 kts. I. A. S. From 20,000 ft. up to the commencement of the cruise at 30,000 speed is increased to 290 kts. A speed of $M = 0.6$ is maintained for the cruise and as weight is reduced altitude increases to 36,000 ft. The aircraft held at this height until the descent is commenced, this is carried out at 180 kts. E. A. S.

Endurance is 8.1 hours plus one hours fuel reserve.

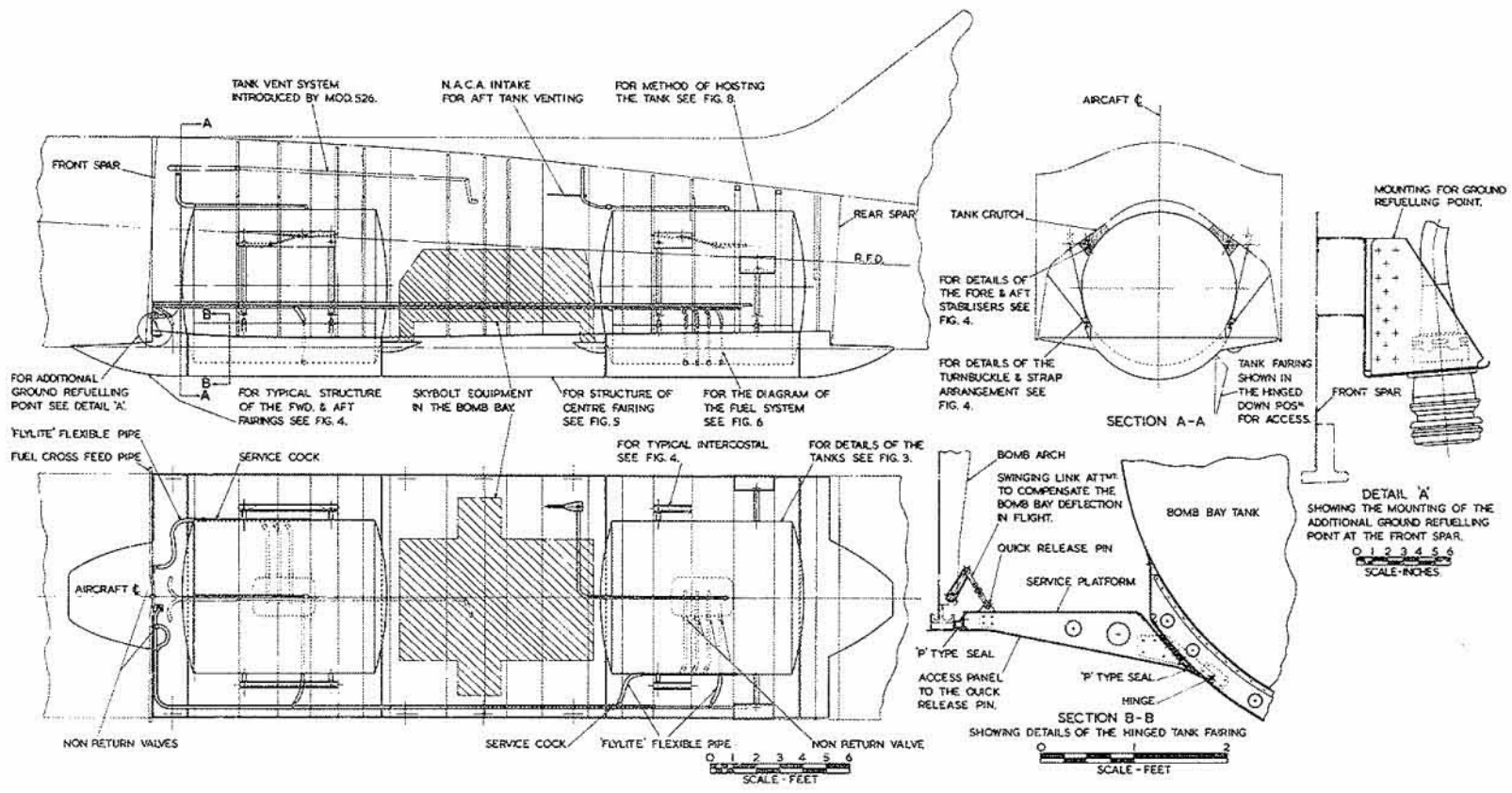
Take-off distance to clear 50 ft. is estimated to be 5,730 ft.

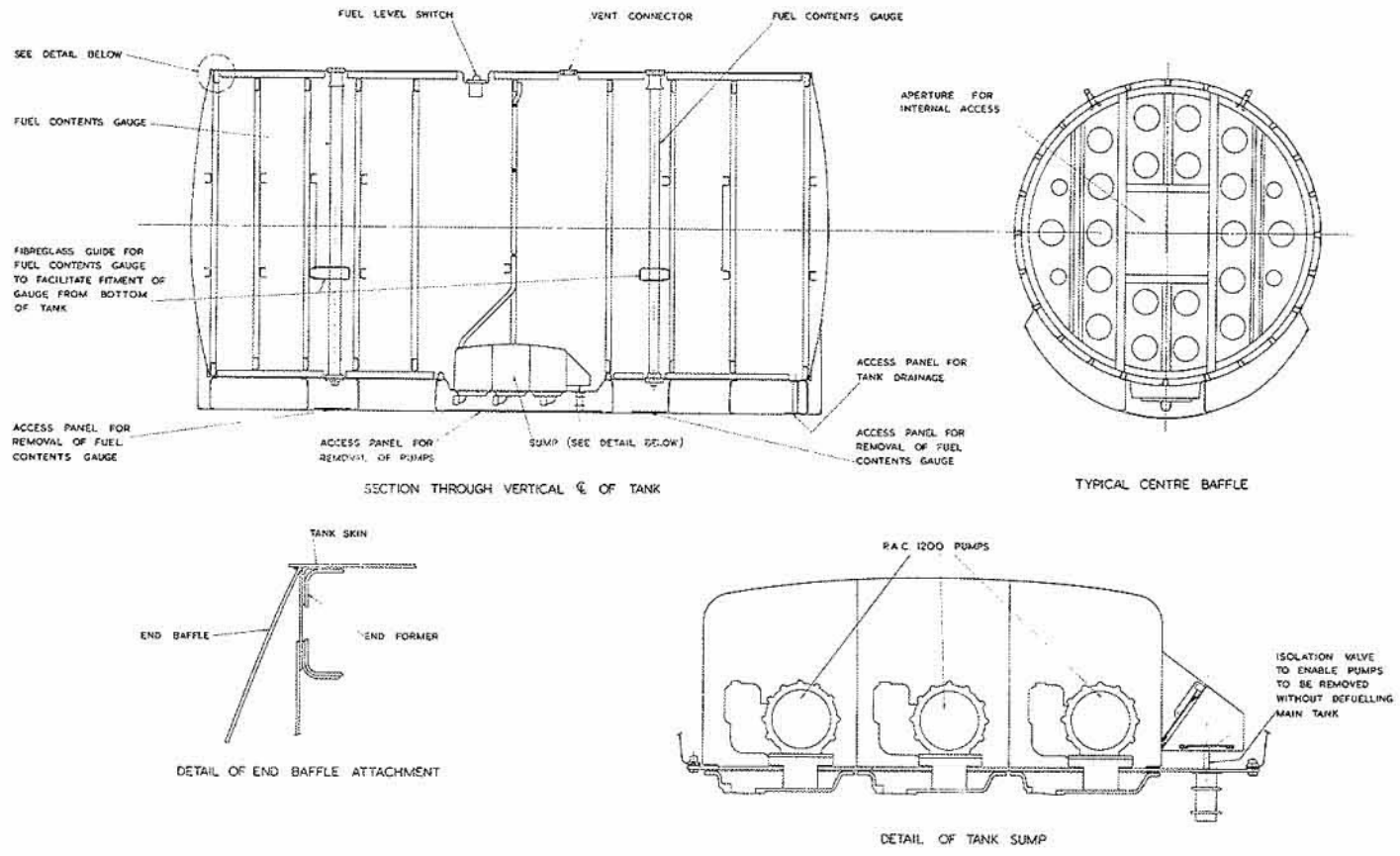
The estimated L. C. N. is 122.



AVRO VULCAN B2 -G.A. OF AIRCRAFT

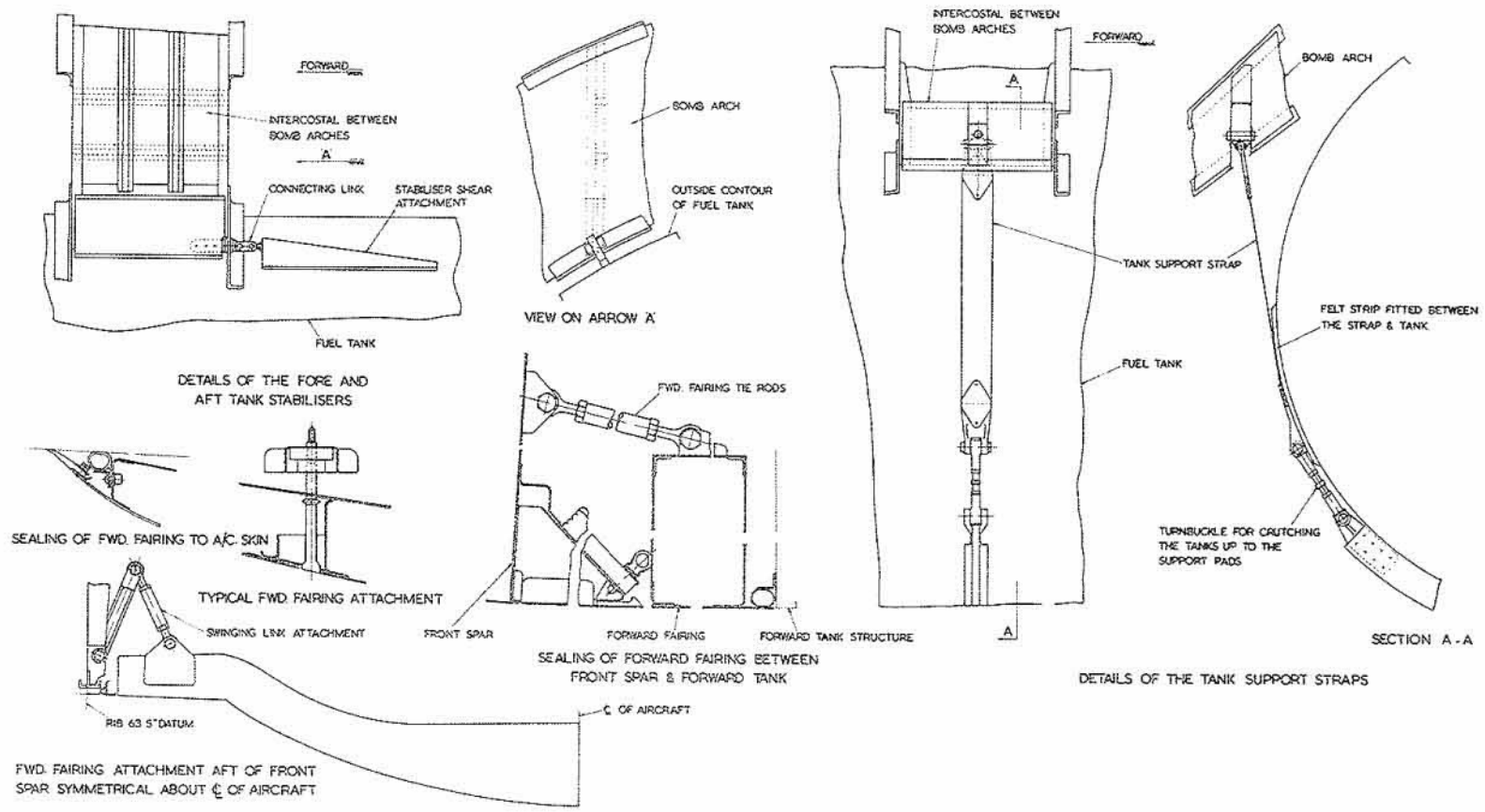
BOMB BAY TANKS





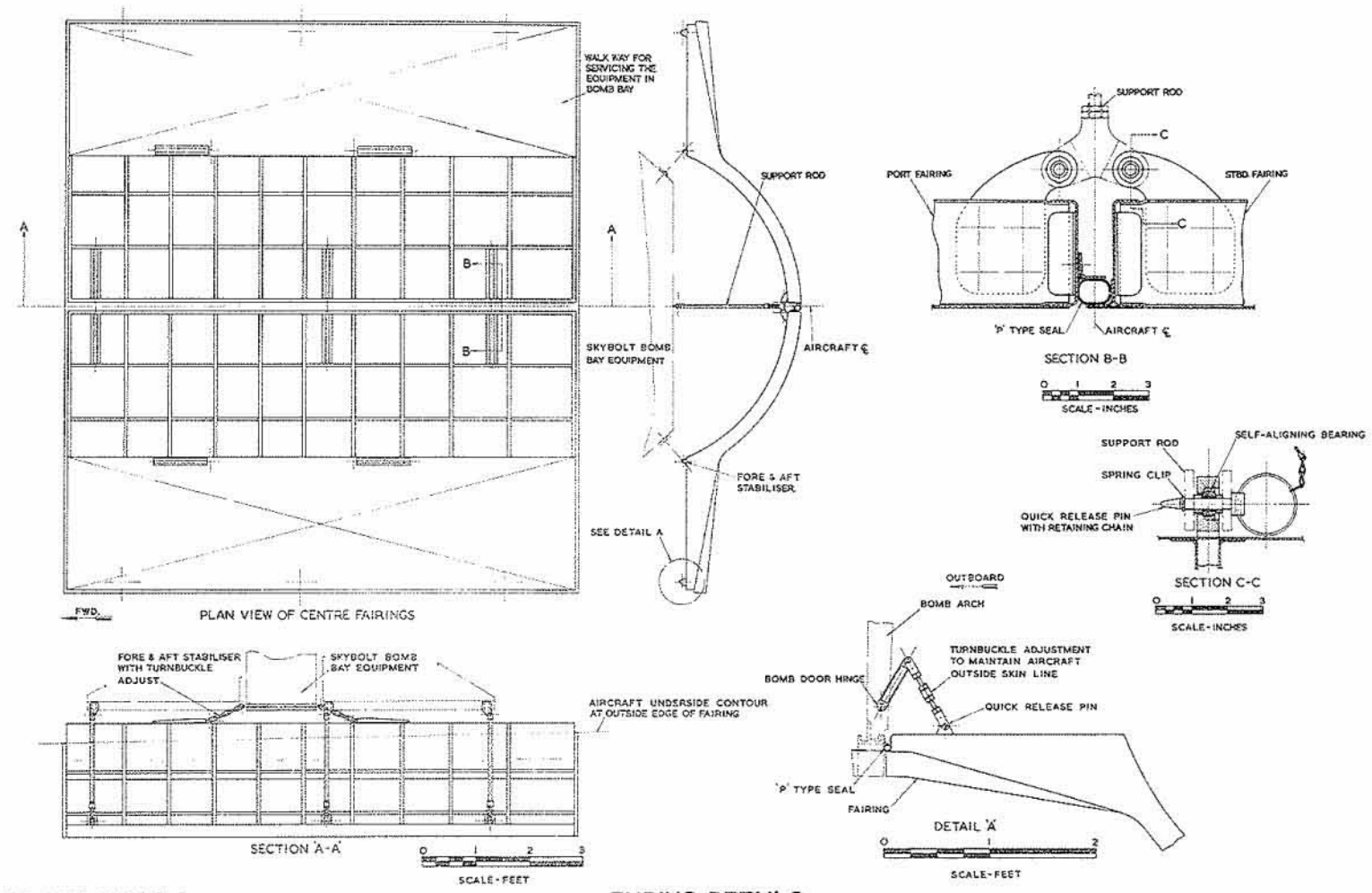
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TANK AND FAIRING DETAILS



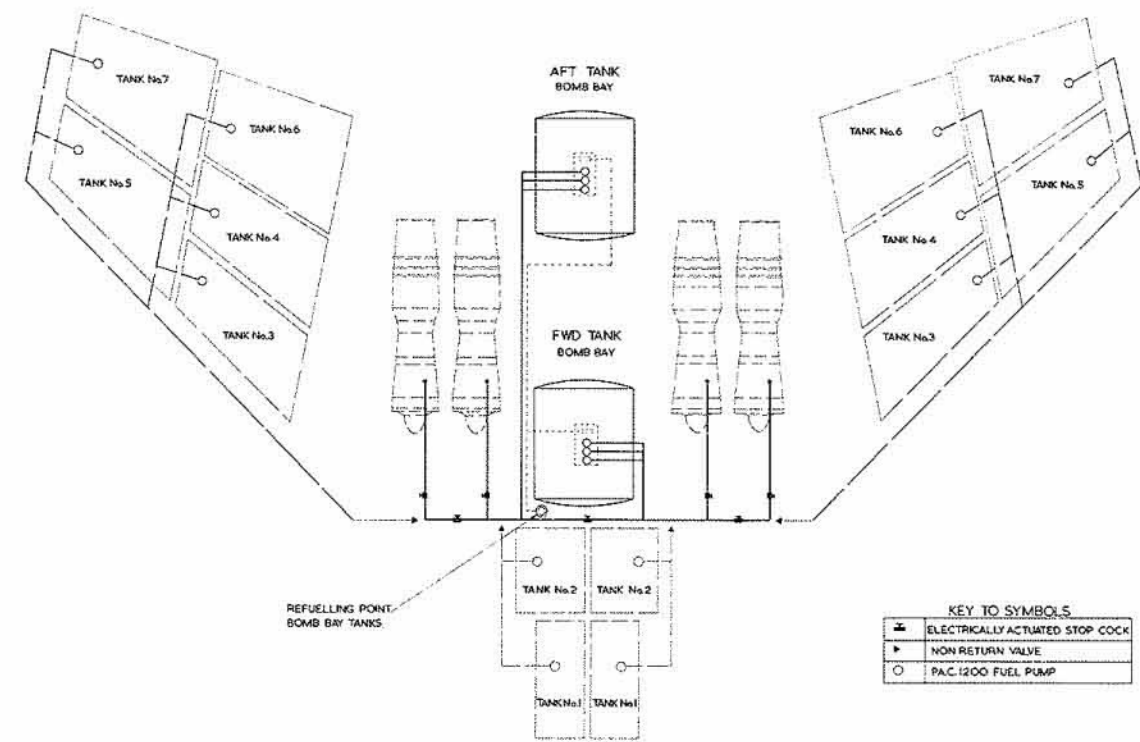
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TANK AND FAIRING DETAILS.



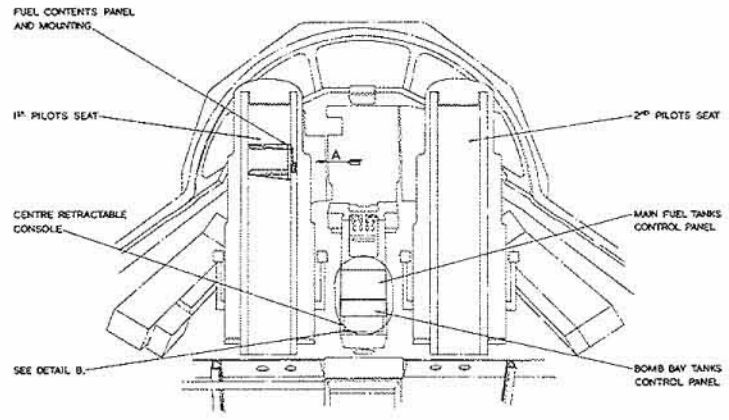
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FAIRING DETAILS

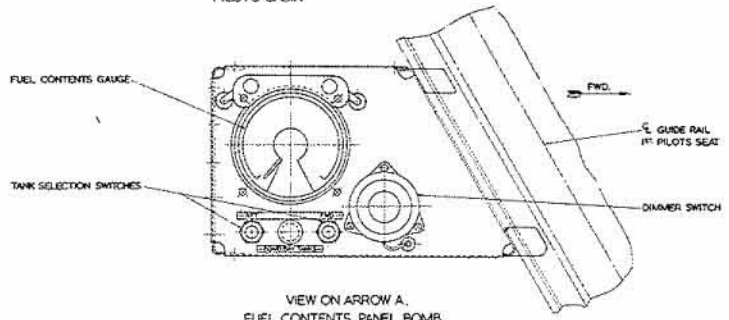


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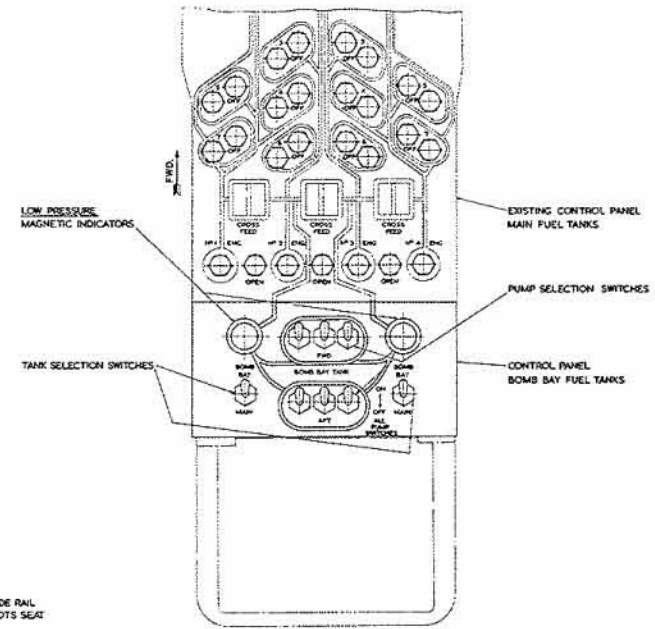
DIAGRAM OF FUEL SYSTEM



VIEW LOOKING FORWARD INTO PILOTS CABIN



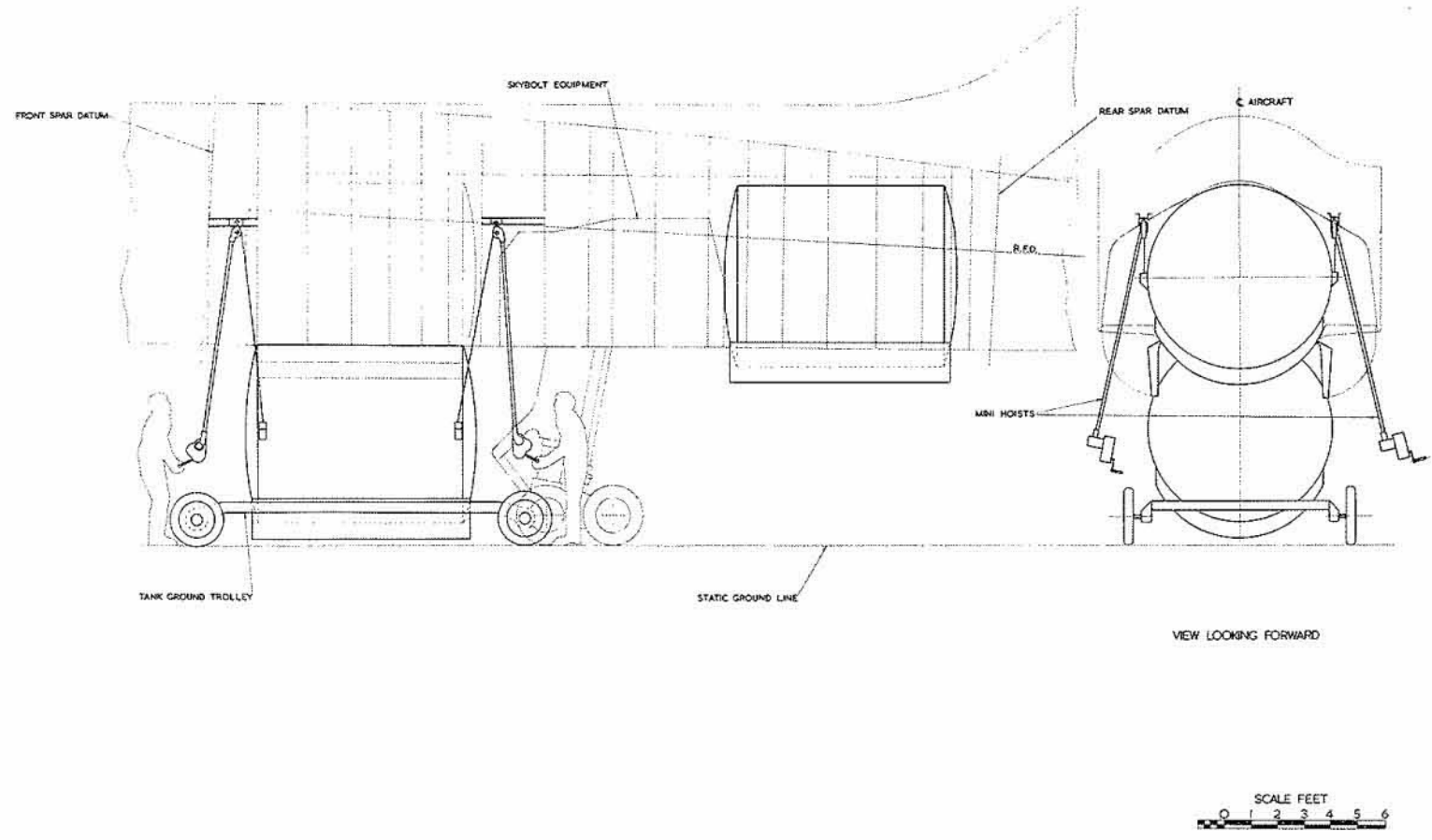
VIEW ON ARROW A. FUEL CONTENTS PANEL BOMB BAY TANKS



DETAIL B PART PLAN VIEW ON THE CENTRE RETRACTABLE CONSOLE

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FUEL SYSTEM CONTROL PANELS



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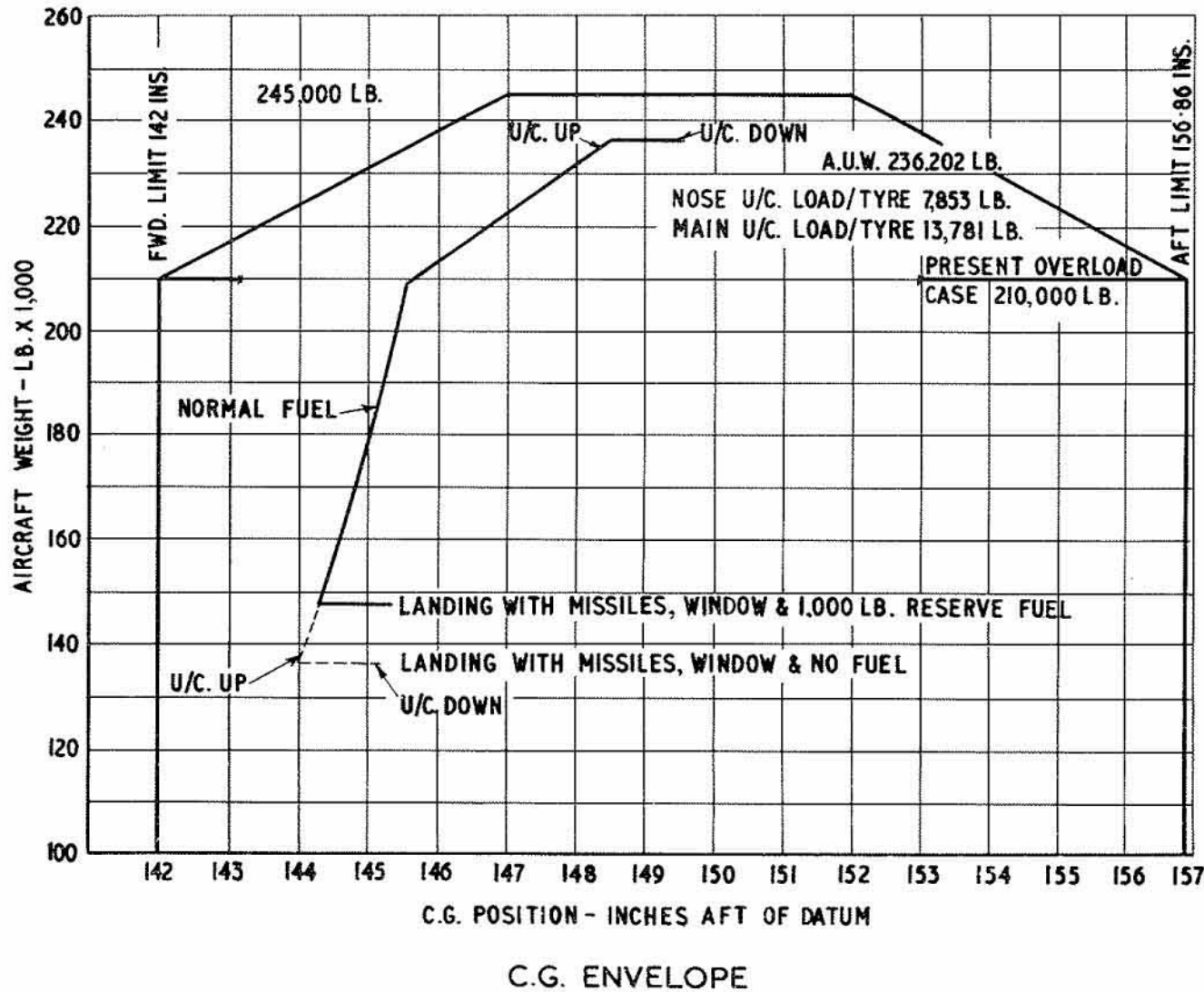
TANK HOISTING

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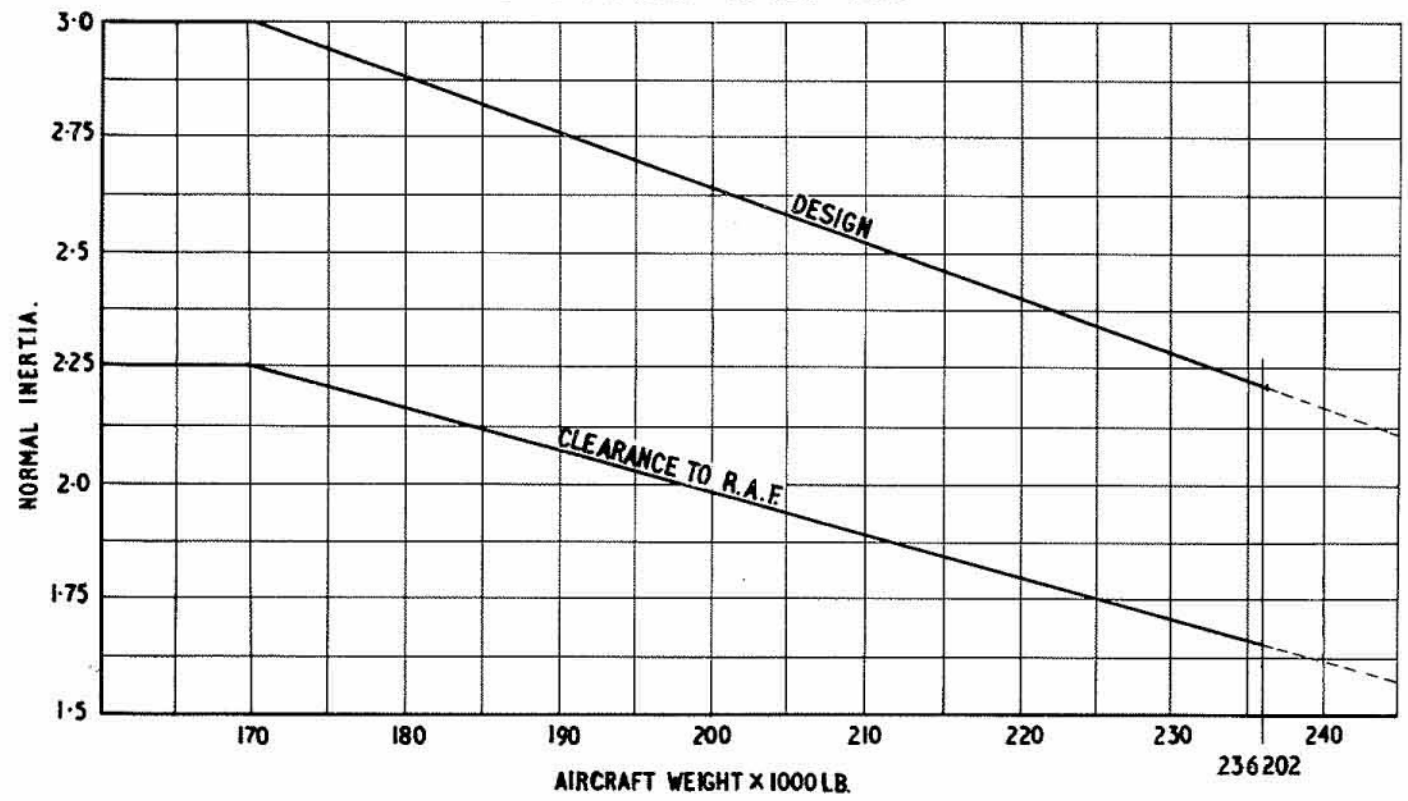
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WEIGHT SUMMARY

PRESENT AIRCRAFT BASIC WEIGHT	111,163
Weight saving schemes (See Brochure: DESIGN/698/464)	- 1,000
Remove bomb doors and mechanism	- 1,746
Bomb bay fuel tanks and system	+ 2,654
Bomb bay fairings	+ 1,085
Weight penalty-tyres	+ 50
	<u>112,206</u>
	BASIC WEIGHT
5 crew members with parachutes and dinghies	<u>1,133</u>
	BASIC OPERATIONAL WEIGHT
	<u>113,339</u>
Rapid blooming window	425
Stores 2 x G. A. M. 87A missiles	<u>22,800</u>
	A. U. W. LESS FUEL
	<u>136,564</u>
Bomb bay fuel - fwd. tank 1855 gallons @ .77 SG.	14,283
Bomb bay fuel - aft tank 1685 gallons	12,975
Normal fuel 100% 9400 gallons	<u>72,380</u>
	A. U. W.
	<u>236,202</u>



BOMB BAY FUEL TO BE USED FIRST.

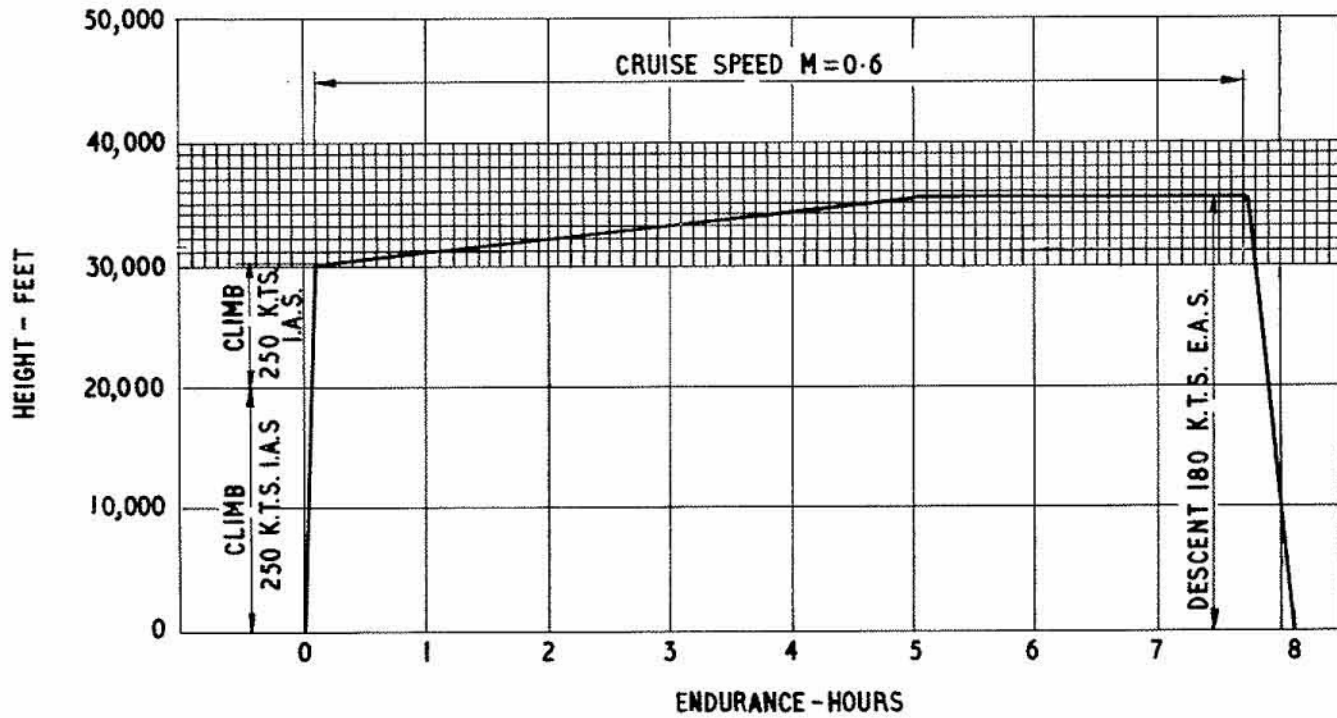


VARIATION OF NORMAL INERTIAS WITH WEIGHT.


CASE	WEIGHT LB.	PERMISSIBLE NORMAL INERTIAS FOR SYMMETRIC PULLOUTS I.M.N. \neq 0-87		GUST SPEED FT./SEC.
		DESIGN	R.A.F. CLEARANCE.	
4	236,202	2-2	1-65	31-5
PRESENT OVERLOAD.	210,000	2-25	1-89 ANTICIPATED	36
SPECIFICATION	195,000	2-7	2-02	38
SPECIFICATION	170,000	3-0	2-25	42

BOMB BAY FUEL TO BE USED FIRST.

VARIATION OF NORMAL INERTIAS WITH WEIGHT.



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