2nd Edition

Restricted

A.P. 4506 A and C-P.N.

PILOT'S NOTES

VICTOR B. Mks. I and Ia

2ND EDITION
May 1963

AP 4506A & C—PN

PILOT'S NOTES

VICTOR Mk. 1 & 1A

Prepared by Direction of the Minister of Aviation

Henry Hardman

Promulgated by Command of the Air Council

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Notes to Users

1 These Notes are complementary to AP129 (6th Edition) Flying, and reference should also be made to the Operating Data Manual (AP4506A/OD), Victor B. Mk. 1.

2 The limitations quoted in Part II are mandatory and are not to be exceeded except in emergency. The contents of the other Parts are mainly advisory but instructions containing the word "must" are also mandatory.

3 The Notes are divided by marker cards into six Parts each consisting of a number of chapters listed on the marker cards. A Folio Sheet reference number is at the top left-hand corner of each sheet, each Part starting at FS/1. The following conventions also apply:

(a) Words in large capital letters in the text indicate the actual markings on the controls concerned.

(b) Unless otherwise indicated, all airspeeds, mach numbers and accelerometer readings quoted are indicated values.

4 When first published these Notes included information covering the then current Special Flying Instructions:

SFI/Victor/23, 30, 33, 39, 41, 42

and each Amendment List instruction sheet includes a list of further Special Flying Instructions and a list of Modifications covered by the Amendment.

5 Modification numbers are only referred to in these Notes when it is necessary to differentiate between pre- and post-Mod. states. For ease of reference a list of Modifications mentioned in the text is included after the main contents list, with a cross reference to the position in the text where details of the modification are given.

Victor B Mk. 1A

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	AP
Aircraft hydraulic equipment	1803 Series
Aircraft pneumatic equipment	4303
Aircraft pressurizing and air conditioning equipment	4340
Aircraft tanks	4117 Series
Aircrew equipment assemblies	1182 Series
AYF installations	2533C
Sapphire Mk. 20200 and 20700 series	4543 C & H
Ejection equipment, aircraft	4288B
Electrical equipment manual	4343 Series
Fire prevention and fire extinguishing equipment	957C
Gee installation	2557M
Hydraulic servicing trolley	2306B
IFF installation	2887N
Instrument manual	1275 Series
Lifting equipment and haulage accessories	2817A
Powered flying control units and equipment, Hobson	4604B, C & D
Pressure cabin testing trolleys	2306G
Pressure refuelling equipment	4511
RAF engineering	1464 Series
Rotol accessory gearboxes and drives	2240A
Signals manual	1186 Series
Starting systems for aero engines	1181
Wheels, tyres and brake systems, aircraft	2337
Wireless installations	2538AH

Leading Particulars

DIMENSIONS

Length	114 ft. 11 in.
Height	26 ft. 9 in.
Span	110 ft.
Tail span	32 ft. 8 in.
Track	30 ft. 2 in.

ALIGHTING GEAR

Type	Electro-Hydraulic

Main Shock Absorber

Fluid	Oil, hydraulic OM.15 34B/9100572
Fluid capacity	311·0 cu. in.
Air pressure	1,400 PSI (with leg extended)

Dash Pot

Fluid	Oil, hydraulic OM.15 34B/9100572
Fluid capacity	9·5 cu. in.
Air pressure	1,930 PSI (extended)

Nose Shock Absorber

Fluid	Oil, hydraulic OM.15 34B/9100572
Fluid capacity	486·0 cu. in.
Air pressure	Upper 210 PSI Lower 1,450 PSI

WHEELS

Main (Dunlop Tubeless Tyres)

Tyre size	27 in. x 6·5 in. x 15 in.
Pressure	Aircraft weight 160,000 lb: $194 {+6 \atop -4}$ PSI Aircraft weight 180,000 lb: $240 {+5 \atop -5}$ PSI

Nose (Dunlop Tubeless Tyres)

Size	30 in. x 9 in. x 15 in.
Pressure	170 PSI all weights

Tail Bumper (With Tube)

Type	AH 8864
Size	7 in. x 4·75 in.
Pressure	35 PSI

BRAKES

Dunlop, hydraulic Maxaret

Pressure	1,600 PSI

HYDRAULIC SYSTEM

Type	High pressure 4,000 PSI
Components	Electro Hydraulic with certain Dowty and British Messier
Fluid	OM.15 34B/9100572

ANTI-ICING

Thermal and Electrical .

ENGINES

Four Sapphire Mk. 202 (Mk. 1)
or 207 (Mk. 1A) Jet Turbine
Oil 34A/9100591 . . (Oil tank 18 pints excluding 3 pints air space)
Fuel 34A/179 AVTUR or 34A/251 AVTAG

FUEL SYSTEM

Divided into three groups

Port Wing Group . . + (Long Range Tanks)
Starboard Wing Group . + (Long Range Tanks)
Fuselage Group . . .
Booster Pump delivery pressure 11 PSI
Fuel Tank pressurisation provided

ELECTRICAL POWER SUPPLIES

DC *supplies*

112 volts. From alternators via transformer rectifier units.
28 volts. From alternators via transformer rectifier units.

AC *supplies*

208 volt 3-phase 400 c/s . From alternators
115 volt 3-phase 400 c/s . From motor generators supplied by 112V bus-bars
115 volt 1-phase 1,600 c/s . From motor generators supplied by 112V bus-bars

BATTERIES

Varley Type J.24 volt. 25 Amp/Hr. (Ten installed.)

List of Modifications mentioned in the Text

Mod. No.	Brief Title	Location in Text		
		Part	Chap.	Para.
591	AN/ARC 52 introduced	I	12	2
656	Canopy unlocking lever and stowage	I	14	3(c)
745	Tone-modulated VHF introduced	I	12	3
769	Thermal ice detector introduced	I	9	2
813	Changes to anti-icing system	I	9	3
820	Interconnect tanks 7 P&S and duplicate pumps in tanks 12 P&S	I	2	2(b)
828	Pressure-off brakes for PFCU's	I	5	4(d)
864	Twin-pointer ASI for 1st pilot	I	11	2(a)
891	Automatic cabin depressurisation	I	8	13
908	CAU bypass introduced	I	8	5
2007	Automatic opening of CAU valves and wing air exit shutters	I	6	1(d)
2023	Protective screens for aircrew	I	8	8(b)
2154	Magnetic indicators for MV and LV paralleling	I	1	14
2163	Automatic operation of brakes	I	4	10(c)
2348	Hydraulic pump ammeters introduced	I	4	5(b)
2352	Droop leading edge introduced	I	4	17
2357	Alcohol spray for 1st pilot's windscreen	I	8	8(d)
2529	Changes to hydraulics control system	I	4	6(a)
2545	Guards for fire detection test switches	I	13	2
2548	High pressure ducting revised	I	8	9
2598	Additional lock at canopy gas gun release	I	14	3(b)
2657	Override for roll error excess torque cut-out	I	7	7(d)
2690	Lights for flight refuelling probe	I	3	5
2744	Engine-mounted alternators (Mk. 1 aircraft)	I	1	1(a)(ii)
2789	Control column automatic release mechanism	I	5	2(b)
2802	Ducting insulation revised	I	8	9
2820	Render ice-protection system inoperative	I	9	1
2842	Nylon studs to identify port fuel pump switches	I	2	9(c)
2866	Continuous running hydraulic pumps	I	4	5(a)
2910	Reposition boathook	I	14	8
2979	Engine-mounted alternators (Mk. 1A aircraft)	I	1	1(a)(ii)
2987	Twin-pointer ASI for 2nd pilot	I	11	2(a)
3008	Guard over 1st pilot's canopy jettison gun sear	I	10	3
3031	Independent switching of ECM pumps	I	1	11(b)
3079	Nitrogen system for undercarriage emergency lowering	I	4	9(c)
3125	Hand fire-extinguishers altered	I	13	6
3144	Delete radio altimeter Mk. 5	I	12	10

Mod. No.	Brief Title	Location in Text		
		Part	Chap.	Para.
3149	Guard for auto-pilot power button	I	7	3(*a*)
3190	Vibrators for Mk. 19B or C altimeters	I	11	2(*b*)
3248	Brake parachute system revised	I	4	14(*d*)
3295	Swivel seats introduced	I	10	11
3326	Automatic hand line for rear crew escape	I	14	9
3583	Direct reading of bomb-bay tank contents	I	2	14(*c*)
3486	Vibrators for 19F altimeters	I	11	2(*b*)
3589	Pressure gauge for nitrogen purging	I	3	2(*b*)
3606	Cross-feed cock wiring revised	I	2	17(*l*)
3645	Guard on 1st pilot's throttle box	I	6	2(*c*)
3646	Mk. 17F regulator in lieu of Mk. 17D	I	10	13(*a*)
3817	Cabin differential pressure gauge	I	8	2(*g*)
3881	Reposition UHF controller	I	12	2(*b*)
3886	Fitment of 7th oxygen regulator	I	10	13(*a*)
3925	Repositioning of brake parachute switch	I	4	14(*d*)
3929	Cabin differential pressure gauge	I	8	2(*g*)
3955	" Crew gone " indication	I	14	10
3996 3997	Provision for bomb-bay tank fuel jettison	I	3B	2(*c*)
4020	Visual indicator for throttle trip lever	I	6	2(*c*)
BC 039	Alterations to automatic hand line	I	14	9(*c*)

Introduction

1 The Victor B. Mk. 1 is an all metal mid-winged medium bomber powered by four Sapphire Mk. 202 jet turbine engines. The B. Mk. 1A aircraft is powered by four Sapphire Mk. 207 engines ; both marks are rated at 11,000 lb static thrust at sea level. ECM equipment is carried in the rear fuselage compartment and below the cabin floor.

2 *These notes are based primarily on the Mk. 1A aircraft, but where differences occur between the two marks specific mention is made.*

3 A crew of five is carried in the aircraft:

1st Pilot
2nd Pilot
Air Electronics Officer
Navigator/Radar Plotter
Navigator/Bomb Aimer

Provision is made for the fitment of a sixth seat should this be required, i.e., for a crew chief.

4 Conventional type mechanical flying control signalling systems operate Power Units installed adjacent to their associated control surfaces.

5 A high-pressure hydraulic system operates the following:

(a) Tricycle undercarriage
(b) Wheel brakes
(c) Main flaps
(d) Wing nose flaps
(e) Bomb-doors, which are withdrawn into the fuselage when open
(f) Airbrakes, in the rear fuselage
(g) Nosewheel steering

6 (*a*) Thermal and electrical anti-icing systems are fitted, the hot air for thermal anti-icing is derived from the engine compressors and diluted with ram air, ducted from auxiliary ram air intakes, before being passed to the areas to be anti-iced.

(*b*) A thermal heating system is also provided for the bomb-bay this air being derived from the starboard engine compressors.

7 A pressurised fuel system is installed in the wings and fuselage. Although consisting of a number of fuel tanks it is greatly simplified by the use of fuel proportioners. The fuel system is adapted for "Flight Refuelling" and bomb-bay tanks can be installed as required.

8 (*a*) Mk. 1 and 1A aircraft converted to the tanker role are designated (K)1 and (K)1A. All Mk. (K)1 aircraft are three-point tankers. The majority of Mk. (K)1A aircraft are three-point tankers, the remainder being an interim two-point version.

(*b*) All (K)1 aircraft are brought up to (K)1A (three-point) standards in the following respects:

1 Flight refuelling (receiver) facility
2 Ice protection and pressurisation systems
3 Fixed droop leading edges
4 Sapphire Mk. 207 engines, but excluding top temperature control
5 New radio and intercomm. facilities
6 Individual fuel tank gauging

9 All the instrument panels and electrical distribution boards on the aircraft are coded. Those located in the cabin are shown on Figures 1 and 2 ; the codings and designations are listed overleaf.

Key to distribution boards and control panels at pilots' station

Board	*Designation*
'A'	Pilots' Centre Instrument Panel
'AA'	1st Pilot's Instrument Panel
'AAJ'	2nd Pilot's Side Panel (rear)
'AB'	2nd Pilot's Instrument Panel
'AC'	1st Pilot's Side Panel
'AD'	2nd Pilot's Side Panel
'AE'	1st Pilot's Console
'AF'	2nd Pilot's Console
'AH'	Fuse and Distribution Board
'AJ'	Fuse and Distribution Board
'AL'	Engine Starting Panel
'AU'	Visual Bomb-Aimer's Control Panel
'AT'	Pilots' Centre Sliding Panel
'AV'	Circuit Breaker Panel
'AW'	Pilots' Upper Coaming Panel
'AZ'	Pilots' Coaming Panel

Key to distribution boards and control panels at rear crew stations

Board	*Designation*
'BA'	AEO's Fuse and Distribution Board
'BB'	AEO's Side Panel (Generating System Controls)
'BC'	AEO's Sloping Panel
'BD'	LV Bus-Bars and Distribution Board
'BF'	AEO's Facia Panel
'BG'	Nose Flap Signalling Panel
'CA'	Navigator's Radar Switch Panel
'CAC'	Bomb-Gear Control and VG Recorder Cock
'CB'	Navigator's Side Panel (Bomb-Bay Heating Control)
'CD'	Radar Relay and Distribution Board
'CC'	Navigator's Side Panel (Normal Bomber Role)
'CP'	Camera Door Circuit Breaker Panel
'CE'	Fuse and Distribution Board (PR Role)
'CH'	Bomb Fuse and Distribution Board
'CN'	Bomb Jettison Circuit Breaker Board

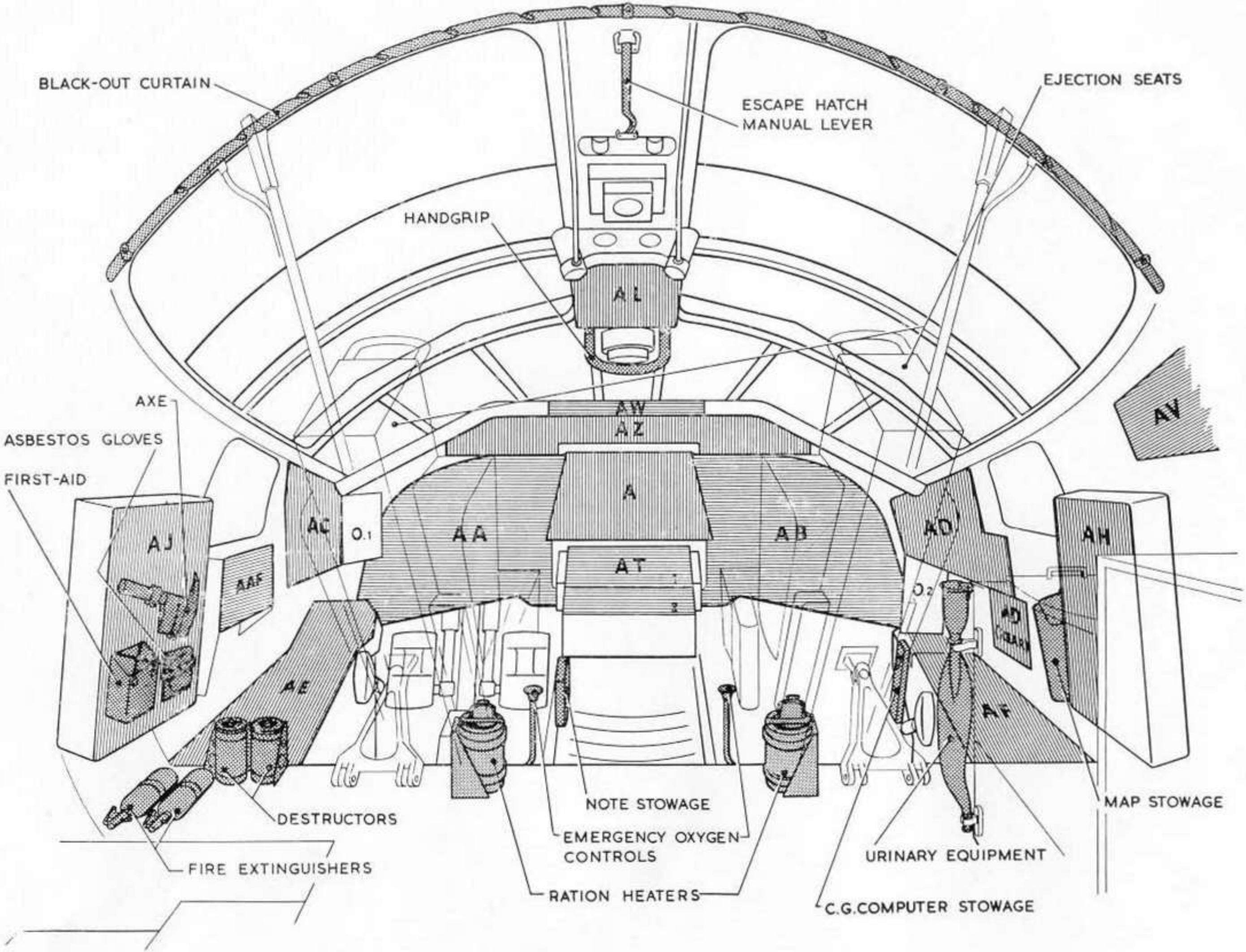

Fig. 1 Pilots' panels

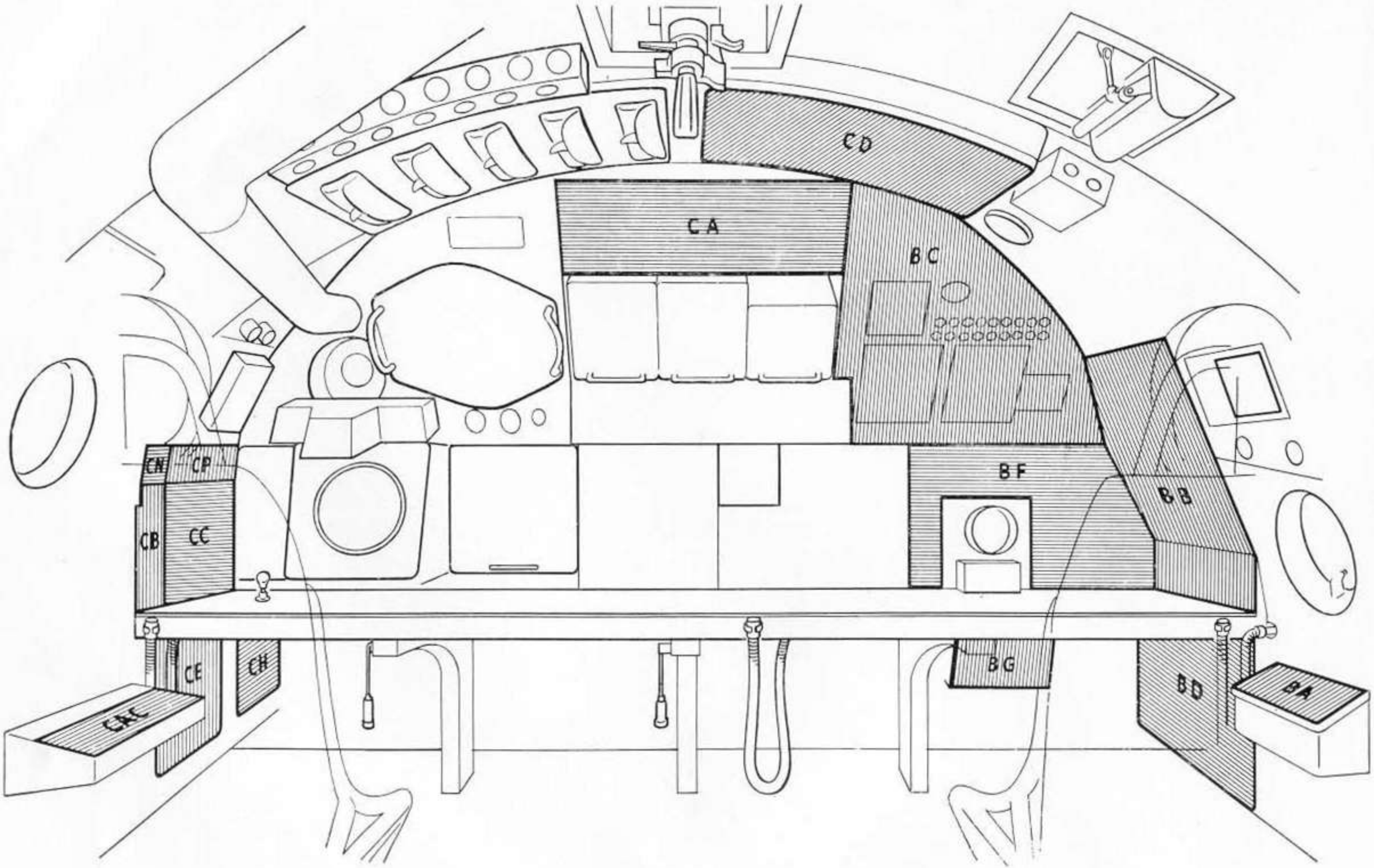

Fig. 2 Crew panels

Part I—Description and Management of Systems

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Part I

Chapter 1—Electrical System

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Description

1 General

(*a*) (i) Power for the electrical services is derived from separate port and starboard generating systems via two independent but identical distribution points. Each system consists of two 3-phase 73 KVA alternators, one driven by each engine. Each alternator produces two outputs, one delivering three phase, variable frequency AC at a nominal 208 volts for electrical anti-icing equipment and battery and feel simulator compartment heating; the other at 104 volts which is transformed and rectified to produce power for the DC services, at 112 volts and 28 volts. Constant frequency 3-phase and single-phase alternating current at 115 volts 400 cycles and 115 volts, 1,600 cycles respectively is obtained by rotary inverters operated from the 112-volt DC bus-bars.

(ii) *Engine mounted alternators*

When Mods 2744(B1) or 2979 (B1A) are embodied the mountings and drives of the alternators are changed to engine-mounted direct drives. This greatly minimises the risk of secondary damage occurring to surrounding components if drive failure occurs.

(*b*) *Bus-bars*

(i) Nine bus-bars are provided as follows:

Two three-phase 208 volts variable frequency AC
Two 112 volts, port and starboard, DC (medium voltage)
Two 28 volts, port and starboard, DC (low voltage)
Two 28 volts, port and starboard special feeders.
One ECM bus-bar (Mk. 1A only)

(ii) One 112-volt and one 28-volt DC bus-bar is fed from each of the distribution points. In an emergency each port 112-volt and 28-volt bus-bar can be connected to its starboard counterpart by a paralleling system which, when manually operated, provides a single source of supply for each voltage. The 208-volts bus-bars do not have paralleling facilities.

(*c*) *Batteries*

(i) Ten 24-volt 25 a.h. batteries are fitted in an electrically-heated ventilated compartment on the port side of the aircraft just aft of the nosewheel bay and accessible through a door.

(ii) Two banks of four batteries are each wired in series to form two 96-volt units. One unit connects to the port medium voltage bus-bar and the other to the starboard bus-bar. The remaining two 24-volt batteries are each connected to the appropriate low voltage bus-bar and special feeders.

(*d*) *Inertia switches*

Four inertia switches are fitted two port and two starboard, which automatically shut down the alternators and disconnect the batteries from the bus-bars if the aircraft decelerates at more than 3G.

NOTE: If the inertia switches operate after a crash landing the LV battery switches must be switched OFF before the MV. If the reverse procedure is adopted the LV battery will be reconnected.

2 DC supplies to bus-bars

(*a*) The 112-volt DC bus-bars are fed from the transformer rectifiers through a reverse current relay and a contactor. The 28-volt DC bus-bars are similarly fed through a combined reverse current relay/contactor. A 350-amp fuse is incorporated between each 112-volt bus-bar and the contactor.

(*b*) If a short circuit develops in the output lines from the transformer rectifier units the reverse current relays prevent total power supply failure by disconnecting the short circuited line from the bus-bar.

(*c*) Voltage trimmers are mounted on panel BA.

(*d*) The electrical equipment in the plenum chamber is normally cooled by ram air in flight or by two plenum chamber cooling fans when the aircraft is on the ground with the nose-wheel oleo depressed. (On Mk. 1 aircraft pre-modification 716 the cooling fan switching is controlled by pressure switches within the nostril

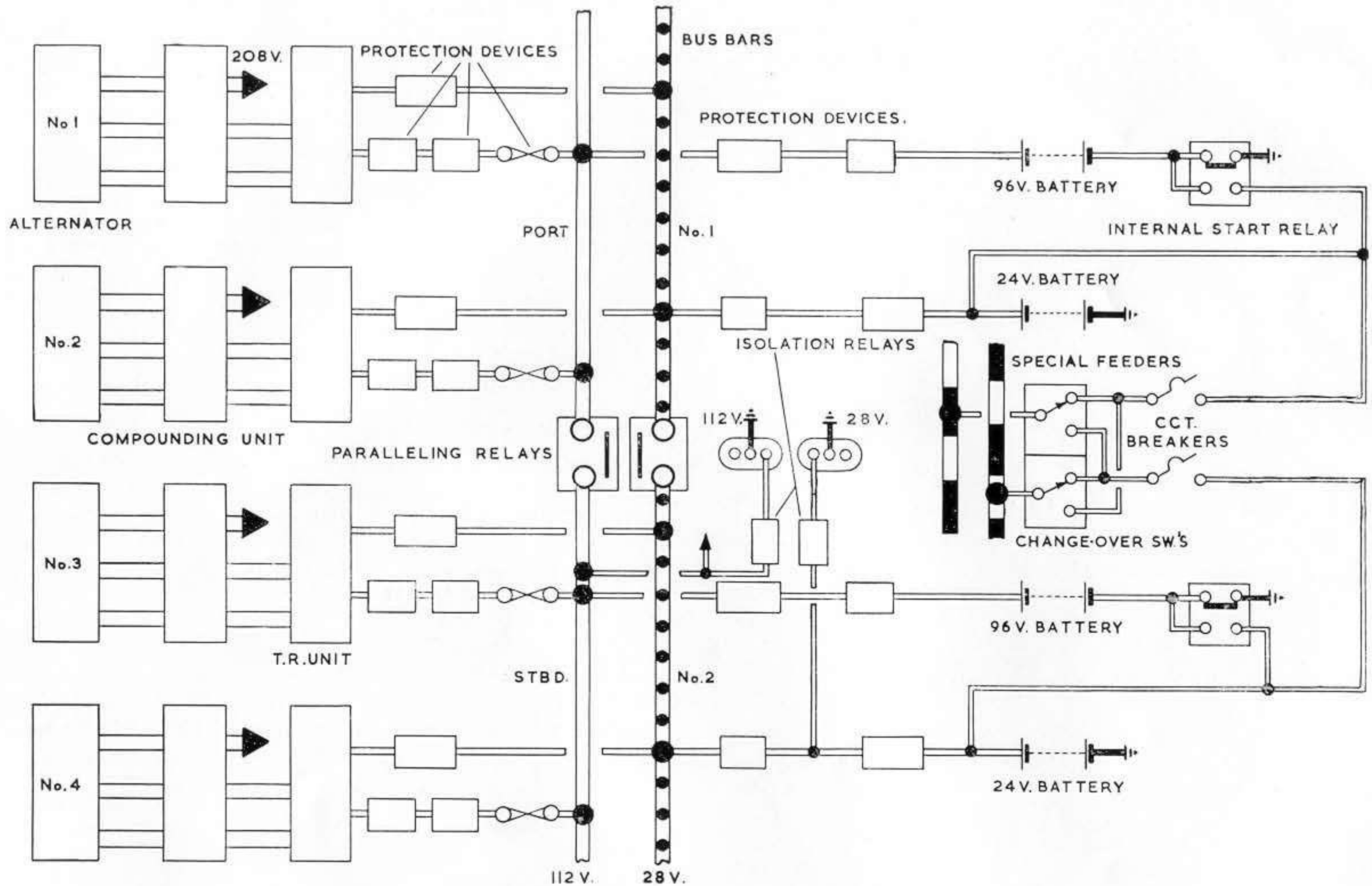

Fig. 1 Alternator system

intake ducting and not by nosewheel micro switch action.) Two red warning lamps, PORT COOLING FAN FAIL and STARBOARD COOLING FAN FAIL will come on if insufficient air pressure is provided for adequate cooling.

(*e*) LV and MV multi-position indicating ammeters are fitted, at panel BA, to indicate the current flow in the generator circuits.

3 Bus-bar paralleling

(*a*) A split bus-bar system divides the aircraft electrical system and ensures that a supply is readily available for the duplicated essential control services should bus-bar or power failure occur.

(*b*) The arrangement of supplies for essential services is as follows:

(i) On each 112-volt bus-bar:

One hydraulic pump feeder

One sub-unit of each powered flying control unit

Half of the booster pumps in each wing and half of the fuselage booster pumps.

(ii) On each 28-volt bus-bar:

One VHF/UHF set

(iii) One special feeder from each 24-volt battery.

(*c*) As the aircraft will continue to operate normally with one half of the electrical system inoperative the need to parallel the bus-bars will only arise in emergency. Careful thought must be taken before deciding to parallel the bus-bars since any fault in one bus-bar will be transferred to the other and could cause complete electrical failure. A combined voltmeter and ammeter is provided for each bus-bar to provide sufficient information for the AEO to decide whether the bus-bar to be transferred is serviceable.

4 DC ground supply

A medium voltage and a low voltage ground supply socket are located adjacent to the battery compartment. When a supply is connected to either voltage socket, the respective bus-bars are paralleled.

5 DC flight instruments supply

The DC supply for the turn and slip indicators and Mk. 4B compass is obtained through circuit breakers 1F4 and 2F4 on panel BB. Normally No. 1F4 only is required but should the supply routed through this circuit breaker fail, an alternative supply is routed through circuit breaker 2F4. Feeder 8P7 on panel BB supplies the No. 1 flight instrument inverter.

6 Low voltage DC special feeders

Two special feeder 28V bus-bars capable of operating independently of the LV battery master switches are installed to ensure a separate 24V supply for essential control circuits and are fed directly from the internal batteries (one battery for each bus-bar). To connect external power to the special feeder bus-bars the LV battery switches must be ON.

7 Low voltage DC distribution

(*a*) From the 28-volt bus-bars power is transferred to the various distribution boards through feeders protected by circuit breakers, on panel BB coded for the distribution board they protect.

(*b*) Inside each fuse and distribution panel is a list of the various fuses contained therein.

8 AC supplies

(*a*) The 208-volt variable frequency AC supply is required for the anti-icing heater mats and battery and feel simulator compartments heating. When the low power warning light is on, e.g. if engine speed is below 51%, the 208-volt supply is not available at the AC bus-bars. The 208-volt AC bus-bars supply the following services:

No. 1 bus-bar	*No. 2 bus-bar*
*Port engine air intake heaters	*Starboard engine air intake heaters
*Port alternator and jet pump air intake heaters	*Starboard alternators and jet pump air intake heaters
Front fuselage port air intake heaters	Front fuselage starboard air intake heaters
*Port aileron power unit air duct heater	*Starboard aileron power unit intake heaters
Battery compartment heaters	Artificial feel unit compartment heaters
	*Rudder power unit air duct heaters

* (Mk. 1A only)

(*b*) When the alternators are in high power, i.e. the low power warning lights are out, the 208-volt AC supply of only two alternators is used, the others being automatically held in reserve in the event of a fault occurring.

(*c*) Normally Nos. 1 and 4 alternators supply the port and starboard AC bus-bars respectively, Nos. 2 and 3 being held in reserve. If two alternators on one side fail, no paralleling facilities are available.

9 AC inverter supplies

(*a*) *Type* 153 *inverters*

Two type 153 inverters are fitted. One inverter supplies the Green Satin system, via two ON/OFF switches on panel CA. The other, which is the primary flight instruments inverter, is controlled by any one alternator switch and the No. 1 flight instrument circuit breaker 1F4 on panel BB. This inverter supplies the following:

Mk. 4B Compass	Artificial horizons
Bomb relay unit	Fuel flowmeters
Bomb calculator	Bomb spacing unit
Yaw damper (electric)	JPT gauges
Tank fire warning	Zero reader.
Jet pipe temperature control (Mk. 1A only)	UHF D/F

If this inverter fails, a standby supply is automatically obtained from the No. 3 type 350 inverter, provided that it is switched on. No standby supply is available for the Green Satin installation. The starboard 112V bus-bar supplies the Green Satin inverter and the port 112V bus-bar supplies the flight instruments inverter.

(*b*) *Type* 350 *inverters*

(i) Three type 350 inverter sets supply the equipment listed below. The available output from each inverter is 1 KVA 115V—3-phase 400 CPS and 2 KVA 115V—single-phase 1,600 CPS.

"A" Group No. 1 set	*"B" Group No. 2 set*	*"C" Group No. 3 set*
NBC		
H2S	IFF Mk. 10	(Standby)
Bomb sight	Auto Mach trimmer	
	GEE Mk. 3 (Mk. 1 and 1A only)	
	Tail warning	
	Cabin and bomb-bay temp. control	
	Anti-icing control	
	Yaw damper (hydraulic)	
	Auto Pilot	
	ADF supply (DF only)	

(ii) Nos. 1 and 2 inverters are fed from the port 112-volt bus-bar and No. 3 from the starboard 112-volt bus-bar. In the supply line to each inverter is a fuse and a circuit breaker.

(*c*) *Tacan inverter*

A separate inverter, fed from No. 1 LV bus-bar, provides the electrical supplies for Tacan. It is controlled by an ON/OFF switch at the nav./plotters position.

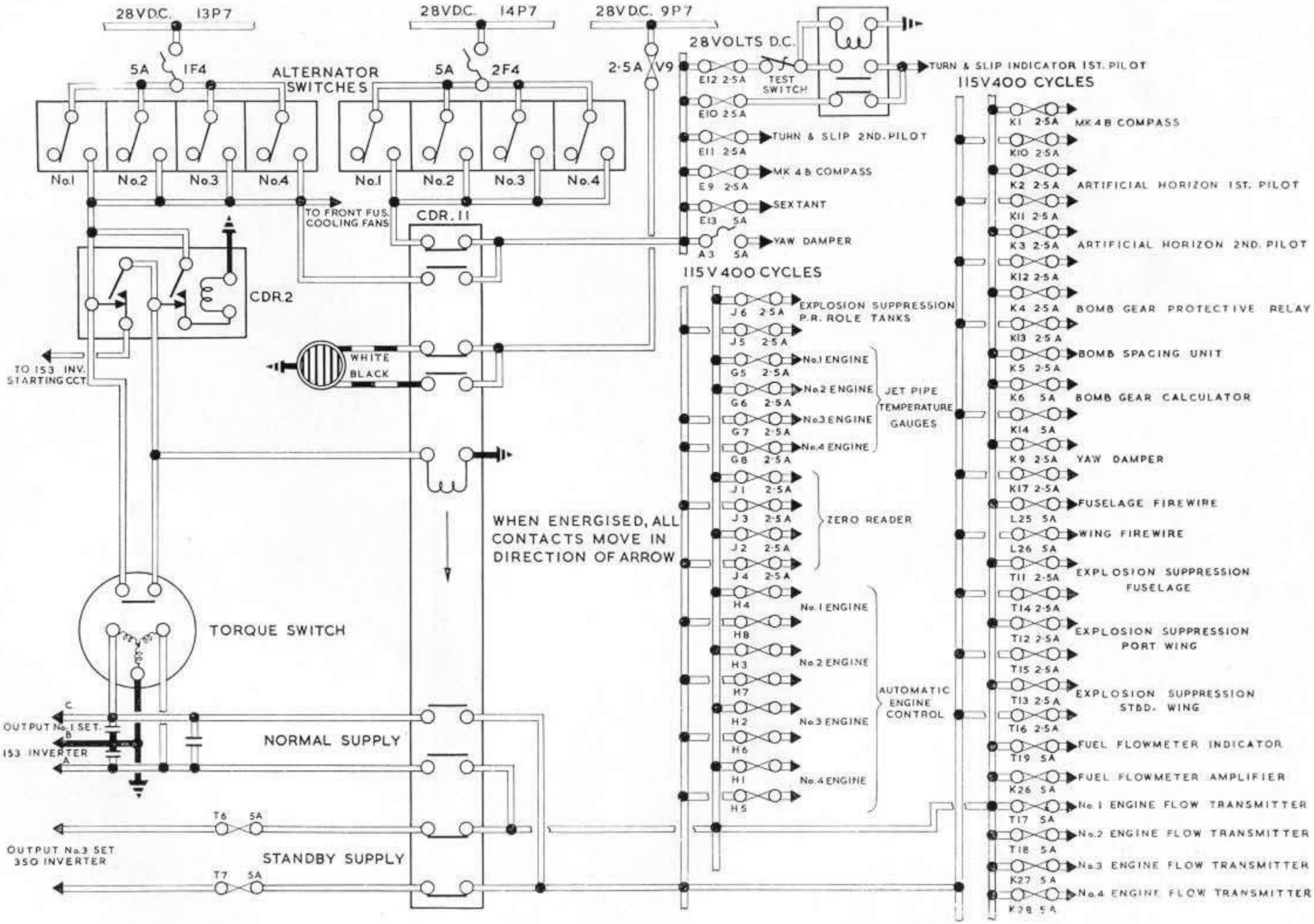

Fig. 2 Inverter supplies

10 ECM AC power supplies (Mk. 1A aircraft only)

AC power for the ECM equipment is supplied by either No. 2 or No. 3 alternator. When either of these is supplying the ECM equipment it cannot be used to supply the normal bus-bars. Thus if No. 1 or No. 4 alternator fails when No. 2 or No. 3 is supplying the ECM equipment, the appropriate bus-bars will be dead except for battery power or unless the bus-bars are paralleled. The Nos. 2 and 3 alternators run at engine speed, but Nos. 1 and 4 alternators run at 1·1 : 1 engine speed.

11 ECM cooling (Mk. 1A aircraft only)

(*a*) The ECM equipment is cooled by a water-glycol mixture which is circulated by two pumps from a separate water-glycol container in the rear compartment, through a freon cooling pack and then to the canisters. A constant circulation then obtains.

(*b*) The system is controlled by an ON/OFF switch on panel BC. The switch controls the electrical supplies to the water-glycol pumps, the rotor compressor and amplifier of the freon cooling pack. Post-Mod. 3031 the glycol pumps and rotor compressor are controlled by separate switches.

(*c*) An adjacent magnetic indicator shows HIGH (above 26°C) or LOW (below 1°C) if unsatisfactory water-glycol temperatures exist and striped under all other conditions (between 1°C and 26°C).

(*d*) Post-Mod. 3031, a red warning light beside the control switches comes on when a high pressure condition is detected in the compressor. The compressor must then be switched off for two minutes before switching on again.

(*e*) Supply to the ECM bus-bar is from the 208V AC output of the alternator.

Controls and Indicators

12 Battery controls

(*a*) Battery circuit breakers and supply indicators for each MV and LV battery supply are on panel BB together with battery master switches for control of each battery.

(*b*) The LV batteries may be reset after a disconnection from a bus-bar by means of a two-way, spring-loaded to OFF, battery reset switch on panel BD. This switch should only be used in extreme emergency when all LV supplies to that bus-bar have been lost. The MV batteries have no resetting facility.

13 Alternator controls and indicators

(*a*) Four ON/START/OFF switches, one for each alternator are mounted on the AEO's side panel BB. The switch positions function as follows:

OFF . . The alternator is inoperative

START . . The alternator is still inoperative, but the start circuit of the TRU is energised. This eliminates damage to the voltage regulator during initial voltage surge when the alternator is switched on

NOTE: The switch must not be left in the START position for more than 15 seconds or damage will be caused to a resistance in the TRU.

ON . . The power supplies are automatically connected to the bus-bars. The 208-volt AC supply will also be connected to the appropriate bus-bar provided that engine speed is above approximately 50%.

(*b*) Four low power warning lights, one for each alternator are mounted on the AEO's panel BB. If the control switches are set to ON, the appropriate amber light comes on whenever its alternator is in the low power condition, i.e. when engine speed is below approximately 50%.

(*c*) Four press-to-test red warning lights adjacent to the amber warning lights come on when alternator failure has occurred.

(*d*) A feeder circuit breaker supply for each alternator control switch is also fitted on panel BB.

14 Bus-bar paralleling control

The two low voltage bus-bars may be interconnected by operating an ON/OFF paralleling switch on panel BB: a similar switch is also on panel BB to parallel the two medium voltage bus-bars. Mod. 2154 introduces a magnetic indicator for each bus-bar paralleling switch which show black when the bus-bars are split and white when they are paralleled.

15 LV special feeders controls and indicators

(*a*) Two switches NORMAL/OFF/1P8 and NORMAL/OFF/2P8 control the routing to the two special feeders. Two magnetic indicators one above each switch show black when current is being fed to the special feeders. The first switch when set to NORMAL, supplies the 2P8 special feeder and the second similarly supplies the 1P8 special feeder. Should the electric supply to either special feeder fail, shown by its magnetic indicator going white, the switch below the indicator can, in emergency, be set to 1P8 or 2P8 respectively. This enables both special feeders to be supplied from the same battery.

(*b*) When the switches are at NORMAL a supply is routed through the appropriate circuit breakers on panel AJ to the following circuits:

Engine fire extinguishers
LP cocks
HP cocks
Fuel proportioners

and through fuses on distribution board BA to the following circuits:

Plenum chamber cooling fans warning
Tank fire extinguishers and warning lights
Battery warning
Bus-bar paralleling
Alternator warning

16 AC bus-bars controls and indicators

(*a*) At the top of panel BB are four CONTROL circuit breakers, together with four magnetic indicators which show pictorially which alternators are supplying AC POWER to the AC BUS-BARS. The supply indicators show a vertical line when energised.

(*b*) The indicators are energised when their respective alternators are either " working " or " running and available if required ".

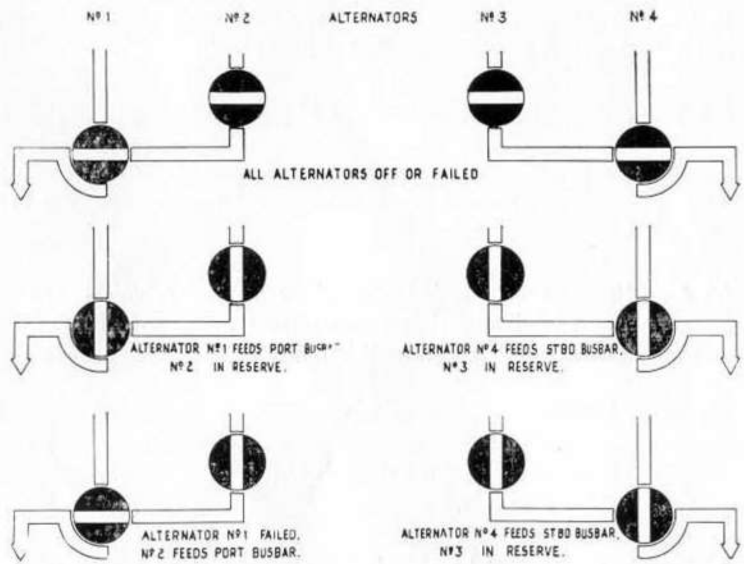

Fig. 3 Alternator indicators

17 AC type 350 inverters controls and indicators

The inverter circuit breakers are remotely controlled by three ON/OFF switches on panel CA. Six neon indicators, adjacent to the switches, glow when the inverters are operating correctly at 400 c/s and 1,600 c/s.

18 ECM controls and indicators (Mk. 1A aircraft only)

(*a*) The ECM switch panel CAL is at the left of panel BF. At the top right hand corner of the panel is a five-position No. 2 ALTR/RUN/START/OFF/START/RUN/No. 3 ALTR switch. This switch is inoperative whenever the No. 2 and No. 3 alternator switches are away from the OFF position. To supply the ECM equipment, No. 2 or No. 3 alternator must first be switched OFF and the appropriate engine RPM set to 93 + $4\frac{1}{2}$%. The alternator should then be selected to START on the five-position switch for a few seconds and then to RUN. Adjacent to the five-position switch is a frequency meter, which should read 400 ± 20 cps and a volt meter which should read 200 volts while supplies are being made. Two voltage trimmer controls are provided on panel BF.

(*b*) Whenever ECM is selected engine RPM must be kept constant within the range of 93 ± $4\frac{1}{2}$% in order that the correct frequency of 400 ± 20 cps can be maintained. If the frequency is not maintained the supply of the ECM bus-bars is lost and the equipment must be reset. If the supply is lost the alternator supply does not automatically revert to the normal bus-bars.

(*c*) Whenever ECM equipment is in use all the normal alternator " switched off " indications are given at the AEO's station.

(*d*) At the right of panel AZ, at the pilot's station are two ECM frequency indicators which show as follows:

Striped .	No power at indicator, generator switch not at OFF
Black .	ECM selected and available at bus-bars, within correct frequency range
White .	ECM supplies not available at the bus-bars

19 Ration heaters

(*a*) A ration heater is fitted at each pilot and crew station (except the downward observation station).

(*b*) Two circuit breakers are fitted, one on panel AF (AD-Mk. 1) controlling the two pilots' ration heaters and one on panel BB controlling the three crew ration heaters.

(*c*) When using the ration heaters it is imperative that a hole is made in each food tin before it is placed in a heater and that no tin is heated continuously for a period of more than two hours.

20 Internal lighting

(*a*) Miniature pillar lighting is installed throughout the pilots' cockpit, illuminating all panels with the exception of fuse and circuit breaker panels AJ, AH and AV.

(*b*) The following switches control the lights as follows:

Location	*Controls lights on panels*
Aft of panel AC	AC, AE
Left-hand side of panel AB	AB
Aft of panel AT	AT
Aft of panel AT	A
Right of panel AZ	AW, AZ
Left of panel AL	AL
Bottom of panel AB	AB
Outboard of quadrant on panel AF . .	AD, AF

21 External lighting

(*a*) *External lights control*

The EXTL. LIGHTS MASTER CIRCUIT BREAKER is on panel AC and controls the navigation lights, and, via the port and starboard light circuit breakers, the filaments of the landing lamps. The navigation lights ON/OFF switch is on panel AC. (The navigation lights have no flashing facility.) The beacon switch is independent of the external lights master circuit breaker.

(b) Anti-collision beacon

The anti-collision beacon is controlled by a three position switch on panel AC. The switch positions are FLASHING/OFF/STEADY.

(c) Landing and taxying lights

(i) Two master circuit breakers one for the PORT and STBD. lights are on panel AC. Adjacent is a three-position IN/TAXY/LAND switch. Setting the switch to TAXY or LAND selects the appropriate position. When set to IN the lights are retracted and switched off.

(ii) A further two circuit breakers are on panel AJ.

Normal Management of the System

22 Before starting engines

(a) Electrical checks

(i) On entering the aircraft check that all alternator switches are OFF and their circuit breakers tripped. When the external power supply is on, switch on the Special Feeders checking that the magnetic indicators are black. Make all LV circuit breakers on the lower part of panel BB with the exception of the following:

Window dispensers Nos. 1, 2, 3 and 4

Ration heaters

Flight Instrument No. 1

The external supply voltages will be indicated on the bus-bar voltmeter and the paralleling indicators (Mod. 2154) show white.

(ii) Ensure that the MV battery switches are off and the indicators white then switch on the LV battery switches and check that the indicators show black. Make all four AC circuit breakers at the top of the panel, the indicators should be horizontal. The No. 1 LV volt meter/ammeter should read a charge rate of 0-10 amps thus indicating a normal battery condition, but No. 2 will show a discharge reading of 50-60 amps. This is not a fault in the electrical system but is due to the ammeter being so placed in the external power circuit as to read all current being supplied to the aircraft LV bus-bar.

(iii) Make the crash switch circuit breaker and check that the warning lights are out.

(iv) Re-check that the No. 1 Alternator circuit breaker is tripped and switch the alternator to START then ON; this connects a 28v DC supply via No. 2 Flight Instrument circuit breaker to the Mk. 4B compass, the 1st and 2nd pilot's Turn and Slip indicators and the sextant.

NOTE: An alternator must never be switched ON with its circuit breaker made if the engine is stationary, or severe damage will result.

(v) Trip circuit breaker 1P25 and watch for a flicker on the total contents gauge at the Navigator Plotter's station (this indicates that the alternative electrical supply has taken over), then remake it.

(vi) Switch ON No. 3 type 350 inverter to supply the Mk. 4B compass and engine instruments.

(vii) Make all circuit breakers on panels AJ and AV.

(b) Functional checks

On commencing the functional checks prior to the use of hydraulic pumps make the No. 1 Flight Instrument circuit breaker and check that the cooling fan warning lights are out. The Plenum Chamber pressure gauge should now read a minimum of 0·07 PSI and the Flight Instrument Inverter indicator on panel CA show black. When the hydraulic pumps are no longer required for functional checks, trip the No. 1 Flight Instrument circuit breaker and check that the cooling fan warning lights are illuminated.

(c) Normal starting procedure

Immediately prior to starting the engines switch OFF No. 1 alternator switch and make the No. 1 Flight Instrument circuit breaker.

(d) Internal start procedure

When the aircraft batteries are used to start the engines the alternator switches must be OFF and the No. 1 Flight Instrument circuit breaker made. Switch ON the LV batteries and parallel the LV bus-bars, then switch ON the MV batteries. It is not necessary to parallel the MV bus-bars as this is done automatically on selecting INTERNAL on the Start Master Switch.

23 After starting engines on external power

(a) Battery control

When all engines are running at idling speed switch ON the MV batteries and ensure that the charge rate is normal (0-10 amps after one minute). The maximum permissible charge rate is 20 amps for 30 minutes.

(b) Alternator control

When the MV batteries are on, make all the alternator field circuit breakers and switch on the first alternator as follows: Select the START position, pause for a period of five seconds then switch to ON. The alternator Power Failure Warning light (red) should now go out and the Low Power (amber) light illuminate. Simultaneously the cooling fan warning lights should be extinguished and the Flight Instrument Inverter indicator show black. Repeat the above switching procedure for the remaining three alternators and check that their individual ammeters show LV and MV output when external power is removed.

(c) Bus-bar de-paralleling check

When the alternator output is stabilised remove external power and check that the paralleling indicators show black. A further check may be made by loading each bus-bar and observing the

24 After starting engines on internal power

(a) Alternator control

When the first engine is running at idling speed, switch on its alternator as described in 23(*b*). As the engine is run up to 75% check that the alternator Low Power (amber) warning light goes out at 51% power and its AC magnetic indicator becomes vertical. As each engine is started repeat the switching procedure.

(b) Bus-bar de-paralleling

With all engines started and the Start Master Switch at FLIGHT, place the LV paralleling switch OFF and check that the LV and MV paralleling indicators are black.

(c) Battery control

After an internal start the battery charge rate will be higher than usual but should soon settle down to a figure of 10 amps or less.

25 Pre take-off electrical checks

When all engines are at full power prior to take-off ensure that all electrical power circuits are functioning normally, as follows:

(i) Alternator Failure Warning Lights out.

(ii) Alternator Low Power Warning Lights out.

(iii) Alternator Cool Close Lights out.

(iv) AC Power Supply indicators vertical.

(v) MV and LV voltages and current within limits.

26 Control in flight

(a) Alternators

(i) Switching of alternators in flight should be restricted to a

(ii) In normal flight with all the alternator Low Power Warning lights out, all AC magnetic indicators should be vertical, with Nos. 1 and 4 alternators supplying the AC bus-bars.

N.B.—If the AC output of two alternators on one side fails, no cross-feeding facilities are available and all the 208V AC supplies will be lost on the affected side.

(b) Batteries and bus-bars

Check periodically that the MV and LV battery indicators are black and bus-bar voltages normal (112V, 28V). If the battery is switched off in flight and switched on again before landing a charge rate of up to 80 amps for 30 seconds may occur until the TRU settles down.

(c) Special feeders

During flight periodic checks should be made to ensure that the Special Feeder indicators are black, as if either indicator changes to white the special feeder together with its associated battery is lost.

(d) DC bus-bar paralleling

Before paralleling the bus-bars in the event of a fault care should be taken to ensure that:

(i) No earth fault is present on the dead bus-bar (as indicated by the volt/ammeter).

(ii) All loads are switched off the dead bus-bar.

WARNING : *If a wrong decision is made it is possible to transfer a fault to the live bus-bar thus losing all electrical supplies.*

27 Inverter control

(*a*) The Flight Instrument Inverter indicator on panel CA will normally show black in flight. In the event of its failing, No. 3 Type 350 Inverter will automatically take over its loads; for this reason No. 3 350 Inverter should always be switched ON in flight.

(*b*) When switching Type 350 Inverters on and off the loads must always be switched off first. This also applies when use is made of

28 Limitations on electrical power

Loading of each alternator must be limited to a sustained MV load of 200 amps and an LV load of 100 amps. Normal in-flight loads with four alternators in use will be approximately 50 amps MV and 25 amps LV per alternator.

Malfunctioning of the System

29 Loss of an LV battery

(*a*) If during flight an LV magnetic indicator changes to white, that battery is then disconnected from the bus-bar. Put the appropriate battery switch to OFF, allow time for the thermal trip to reset (approximately 30 secs.) then switch the battery ON again. If the magnetic indicator changes to black then white switch OFF and leave off.

(*b*) If an LV battery becomes disconnected and cannot be reset, care must be taken not to throttle back both engines on that side in such a manner that both alternators change into low power at the same time. Failure to take this precaution may result in failure of both associated alternators and loss of resetting facilities. This situation is caused by the frequency sensing units in the transforming rectifier units moving to the low power condition simultaneous with the throttle movement, thus momentarily breaking the TRU LV supply to the bus-bar. As no LV battery supply is available on the bus-bar the subsequent loss of alternator field current will cause both alternators to fail. Non-synchronous movement of the throttles will prevent this by ensuring that one TRU is supplying field current to both alternators whilst the frequency sensing unit of the other is moving to the low power position.

(*c*) If the disconnection of the battery is accompanied by the loss of alternators, load shedding must be carried out and action taken to reset the LV battery as in (a) above. If this action is unsuccessful the LV bus-bar reverse current reset switch at the edge of the in flight to recover a failed battery but, in the event of failure of battery and alternator supplies, range considerations or subsequent faults may justify its use.

30 Loss of an MV battery

(*a*) Should an MV battery indicator show white indicating disconnection from the bus-bar, switch OFF then ON. If the indicator shows black no further action is necessary.

(*b*) If after switching OFF then ON the indicator goes black then white no further action is possible.

(*c*) Should the indicator remain white after reset action the battery is connected but the indicator is unserviceable and the fuse should be checked.

31 Loss of a special feeder

(*a*) If either magnetic indicator changes to white indicating a failure it is inadvisable to use the alternative supply except in the case of an engine fire on the failed side. The special feeder switch should in this event be put over to the alternative position whilst the fire button is being pressed.

(*b*) All other actions as for loss of an LV battery.

32 Single alternator failure

(*a*) The loss of an alternator will be indicated by the illumination of the Power Failure Warning Light (PFWL) on panel BB and nil readings on the appropriate ammeter. If the field circuit-breaker has tripped, switch OFF, reset the circuit-breaker and switch ON via the START position. If the alternator Power Failure Warning Light comes on again switch OFF and leave OFF.

(*b*) If an alternator PFWL comes on whilst engine RPM is less than

has tripped off line due to a temporary overload condition. Switch the alternator OFF, shed the appropriate MV loads and switch the alternator ON again after a minimum period of 30 seconds. If the alternator then operates satisfactorily the MV bus-bar loads may be reconnected, but if the PFWL comes on again switch OFF and leave OFF.

(*c*) If both the low power light and the PFWL come on whilst engine RPM is above 51% it is an indication of a sheared drive shaft, in this case switch the alternator OFF and leave OFF. Consideration should be given to flaming out the engine.

33 Double alternator failure

(*a*) Should two alternators fail on one bus-bar both Power Failure Warning Lights will illuminate. Switch OFF the MV battery switch thus removing all heavy loads from it immediately, and reduce LV loads by selective switching. The MV loads can then be individually switched OFF by use of the appropriate switches. Restore the MV battery to its bus-bar by switching ON and check its ammeter for any discharge. Reset the alternators as in para. 32 above and switch ON MV services again. If neither alternator can be reset the MV and LV voltmeter/ammeters must be checked before any decision to parallel the bus-bars is made.

NOTE: *No attempt is to be made to recover an alternator if the bus-bars have been paralleled.*

(*b*) In the event of the loss of two alternators accompanied by the disconnection of an LV battery and loss of special feeder, the MV battery latched contactors will interlock due to the lack of supplies to open them. The MV bus-bars may in this instance be paralleled at the captain's discretion.

(*c*) In all instances where two alternators fail on one side or are switched off, load shedding should be carried out as listed in the Double Alternator Failure Drill. However, the LV battery should not be switched off immediately such an emergency occurs as it is important of these being, Engine Fire Warning, PFCU indicators, Hydraulic control and indicators and Abandon Aircraft lights. If it is not possible to reset the alternators and a decision is made not to parallel the bus-bars the LV battery will become discharged if left on. Therefore after the immediate emergency is over it is advisable to switch it off and trip the LV feeder circuit breakers on the failed side. If the battery voltage is kept above 19 volts it can be used for important control and indicator circuits as although some indicators will work at very low voltage, control circuits become useless below 17 volts. In the event of the loss of two alternators on one side being accompanied by the disconnection of the LV battery, the MV latched loads cannot be switched off the bus-bar. Therefore consideration must be given to paralleling the MV bus-bars or switching off the MV battery.

34 Four alternator failure

The chance of four alternator failure due to an electrical fault is considered remote in a split bus-bar system, but in the event of its happening the following procedure must be carried out:

(i) Shed loads as in sub-paras. (v) to (xix)

(ii) Trip all alternator field circuit breakers and remake individually

(iii) If unable to regain alternators trip circuit breakers and, if safe to do so, parallel the bus-bars

(iv) Airbrakes as required

(v) Switch OFF both hydraulic pumps

(vi) Switch OFF half Power Flying Control Units

(vii) Select all proportioners to BYPASS

(viii) Leave three fuel pumps ON, all others OFF

(ix) NORMAL yaw damper STANDBY—standby yaw damper as required

(x) Switch OFF all inverters except the (153) Flight Instrument

(xi) Trip NBC and H2S circuit breakers

(xii) Switch OFF scanner stabilisation

(xiii) Switch OFF the VHF/UHF set not in use

(xiv) Minimum use of the HF then trip the circuit-breaker

(xv) Switch all lighting to minimum requirements

(xvi) Switch OFF all heater and anti-icing switches except pitot head heaters

(xvii) Trip ILS and ADF circuit breakers

(xviii) Trip ration heater circuit breaker

(xix) Switch OFF conference inter-comm. and UHF (Mk. 1A and Tanker aircraft only)

(xx) IFF to EMERGENCY if required. (No. 2 350 Inverter must be ON for same)

NOTE 1: The MV bus-bar voltage must be monitored continuously, as the power flying controls will be inoperative at below 75v and the aircraft must be abandoned when this figure is reached.

NOTE 2: If the alternator failure is due to a four-engined flame-out the alternator field circuit breakers should not be tripped until the Transformer Rectifier Unit LV outputs fall to 5 amps as the alternators will continue to give an output under windmilling conditions. In this event the air-brakes should not be extended.

35 LV or MV bus-bar overvolting

If an overvolting condition of more than 35v on an LV bus-bar or 125v on an MV bus-bar occurs check the ammeters to find the generating system carrying the heaviest load. Switch OFF the alternator with the highest output and if the voltage returns to normal no further action is necessary. If the overvolting persists switch this alternator back ON again and switch OFF the second alternator. If the voltage is now normal no further action is necessary but if the overvolting condition persists switch OFF both alternators, shed the appropriate loads and consider paralleling

36 High or low voltage on LV or MV bus-bars

Should an LV or MV bus-bar voltage increase to 30-35v or 115-120v respectively or should voltage fall to 24-26v or 105v respectively, switch OFF either alternator and trim the remaining alternator to 28v. Switch both alternators ON again and then switch OFF the alternator which has been trimmed. Trim the second alternator to 28v and switch both alternators ON again. If unable to trim any one alternator, switch OFF and leave off, but if unable to trim both alternators switch both ON, leave on and monitor the voltmeter/ammeter for excessive charge or discharge.

37 Failure of cooling fans whilst taxying

(*a*) The failure of one cooling fan whilst taxying will be indicated by the illumination of the red warning light on panel BB. Load shedding must be carried out on the appropriate bus-bars, the MV and LV bus-bars paralleled to distribute the Transformer Rectifier Unit loads evenly, and the aircraft taxied back to dispersal.

(*b*) Two cooling fan warning lights illuminating on panel BB will indicate the failure of both fans. Check the No. 1 Flight Instrument circuit breaker on panel BB and its associated magnetic indicator on panel CA. If the indicator is white and the circuit breaker tripped, reset the latter and if the cooling fan warning lights go out and plenum chamber pressure as indicated on panel BC is above 0·07 PSI, no further action is necessary. If the cooling fans remain unserviceable the engines should be closed down as quickly as possible and all services switched OFF. Fuse E20 in panel CD over the Navigator/Radar station can now be checked, also the appropriate HRC fuses in the plenum chamber.

38 Loss of plenum chamber pressure in flight

Any loss of plenum chamber pressure in flight will be indicated by a negative reading on the gauge on panel BC, and is usually indicative of the loss of a hatch, i.e. dinghy hatch, plenum chamber hatch. All Transformer Rectifier Unit loads should be reduced to a minimum consistent with safety and the bus-bars paralleled if safe to do so. It is considered that where flight conditions necessitate, a further 90 minutes flying time is permissible without undue overheating but where possible the aircraft should be landed and closed down.

39 Failure of a type 350 inverter

The failure of a type 350 inverter will be indicated by one or both neon indicators on panel CA failing to glow. Before attempting to reset the inverter its loads must be switched OFF, then the inverter switch held in the trip position for one second. Switch the inverter ON and if the neon indicators are normal, reload. In the event of failure to re-establish the inverter a transpose facility exists to enable its group of services to be transferred to another inverter. This facility is controlled by the POWER EMERGENCY TRANSPOSE SWITCH on panel CA at the Navigator's station. Before operating the switch both the unserviceable inverter and the inverter to which the group is to be transferred must be unloaded and switched OFF to prevent arcing of the relay contacts. After transposition the serviceable inverter must be switched ON again and the loads re-introduced. The table below summarises the operations involved in effecting transposition.

U/S Inverter	*Group*		*Switch OFF Inverters*	*Select*	*Switch ON Inverter*
	Reqd.	*Not Reqd.*			
1	A	B	1 and 2	A/B	2
1	A	C	1 and 3	A/C	3
2	B	A	2 and 1	A/B	1
2	B	C	2 and 3	B/C	3

40 Failure of a type 153 Inverter

Loss of type 153 inverter supplies will be indicated as follows:

(*a*) No. 1 Flight Instruments Inverter—the magnetic indicator on panel CA will indicate white but the services supplied will be automatically taken over by No. 3 350 inverter. The reset action is to trip and remake the No. 1 Flight Instrument circuit breaker (*b*) The Green Satin Inverter — the only indication of loss of Green Satin inverter supplies will be the failure of the Green Satin equipment. The reset procedure is to switch OFF the Green Satin equipment and the inverter, then switch ON in the reverse order. If the inverter remains on no further action is necessary but if it fails again no alternative supply is available.

41 Load shedding

The following tables list all the MV loads and the main LV loads which may be shed

MV *loads*

Switch off appropriate MV Battery to ensure complete load shedding.

Port MV *Bus-bar*	*Starboard* MV *Bus-bar*
Nos. 1 and 2—350 Inverters	No. 3—350 Inverter
Flight Instrument Inverter	Green Satin Inverter
No. 1 Hydraulic Pump	No. 2 Hydraulic Pump
Odd PFCU's	Even PFCU's
Red Fuel Pumps	Green Fuel Pumps
H2S Amplidyne	H2S Scanner
Ration Heaters	Ration Heaters
TR Cooling Fan	TR Cooling Fan

Attention is drawn to the small H2S load on both bus-bars which will preclude the use of H2S when either bus-bar has completely shed its loads.

Main LV *Loads*

No. 1 LV *Bus-bar*	*No.* 2 LV *Bus-bar*
Landing lamps	UHF
HF	Panel lights
No. 1 VHF/UHF	No. 2 VHF/UHF
Starboard pitot head heater	Port pitot head heater
Panel lights	Cabin lights
NBC	Trim control
H2S	Main Alternator control
IFF Mk. 10	Cabin Temperature Control
Radio Altimeter	ADF
Navigation lights	Engine anti-icing
Main Alternator Control	Tail anti-icing
Trim control	Port wing anti-icing
PFCU control	Starboard wing anti-icing
Cabin ventilation	Bomb-bay heating
Tail anti-icing	Wing air exit shutters
Engine anti-icing	Controlled AC supplies and flight instruments standby DC
Starboard wing anti-icing	Flying controls
Port wing anti-icing	Bombing controls and indicators
Wing air exit shutters	
Trip circuit breaker 1P25	
Tacan	

NOTE: In the event of double engine or double alternator failure where it is decided not to parallel, the LV battery will be switched off to conserve it after the immediate emergency is over. The hydraulic, fuel, PFCU and inverter control circuits will be affected as detailed under these sections.

Part I

Chapter 2—Fuel System

List of Contents

Description

1 Introduction

(*a*) Fuel is stored in a series of flexible bag-type tanks, in three groups, one group in the fuselage and one in each wing. The basic fuel system tankage can be increased by the carriage of two tanks in the bomb-bay.

(*b*) The tanks of each fuel tank group are pressurised by a group pressurisation system all three of which operate from a common air supply system tapped from the final stage of the compressor of all four engines.

(*c*) (i) The controls for fuel system usage are on a sliding panel AT between the two pilots and which slides forward under the centre instrument panel when not in use. On the second pilot's console AF (Mk. 1) or side panel AAJ (Mk. 1A) are the fuel proportioner indicators.

(ii) Individual IN USE/NOT IN USE tank control switches are on panel FE on the port side of the fuselage and are not accessible in flight.

2 Tank capacities

(*a*) The following table shows the approximate usable fuel capacities, in pounds and calculated at 7·7 lb/gallon.

Tank and location	*No. off*	*Gallons usable fuel per tank*	*Pounds total usable fuel*	*Booster pumps per tank*
WING				
No. 1 Centre section .	2	467	7,192	1
No. 2 Inner plane .	2	295	4,542	1
No. 3 Inner plane .	2	263·5	4,058	1
No. 4 Inner plane .	2	323·5	4,981	1
No. 5 Inner plane .	2	340·5	5,244	2
No. 6 Outer plane .	2	475	7,315	2
FUSELAGE				
No. 7 Centre section .	2	589	9,071	1
No. 8 Bomb-bay roof	1	342	2,634	1
No. 9 Bomb-bay roof .	1	529	4,073	1
No. 10 Bomb-bay roof .	1	773	5,952	1
No. 11 Bomb-bay roof .	1	382	2,941	1
No. 12 Rear fuselage .	2	524	8,069	1 (2 post-Mod. 820)
		Total, internal .	66,072	
LONG RANGE				
Bomb-bay . . .	2	988	15,216	2
		Total with long-range tanks .	81,288	

(*b*) When Mod. 820 is embodied No. 7 P. & S. Tanks are inter-connected, thus for operational purposes the two tanks become one. This ensures a continued supply of fuel from both tanks should either tank booster pump fail.

(*c*) Mod. 820 also makes provision for additional booster pumps in No. 12P and 12S tanks thereby ensuring a continued supply should a single pump failure occur. The pumps are controlled by two circuit breakers on Sliding Panel AT, the switching being arranged so that one circuit breaker controls the No. 1 pumps in each tank whilst the other circuit breaker controls the No. 2 pumps in each tank. The control switches on panel AT are identified by the annotations 12P AND S NO. 1 PUMPS and 12P AND S NO. 2 PUMPS.

3 Fuel proportioners

(*a*) Three mechanical vane type fuel proportioners are provided, one for each wing and fuselage group. Fuel from the bomb-bay tanks is not proportioned.

(*b*) The proportioners provide the desired ratio of fuel flow from individual tanks.

(*c*) Each proportioner consists of a number of cells each connected to a particular tank. Each cell contains a set of rotors, a bypass valve and a fuel outlet valve. Both valves of the wing groups proportioners are electrically controlled; only the bypass valve of the fuselage group proportioner is controllable.

4 Fuel recuperators

Four fuel recuperators are provided and are piped in pairs, each pair feeding two engines. Each recuperator is of $2\frac{1}{2}$ gallon capacity and ensures that the engines are supplied with fuel under negative G conditions. The recuperators are re-charged from the main fuel feed system when negative G conditions no longer exist.

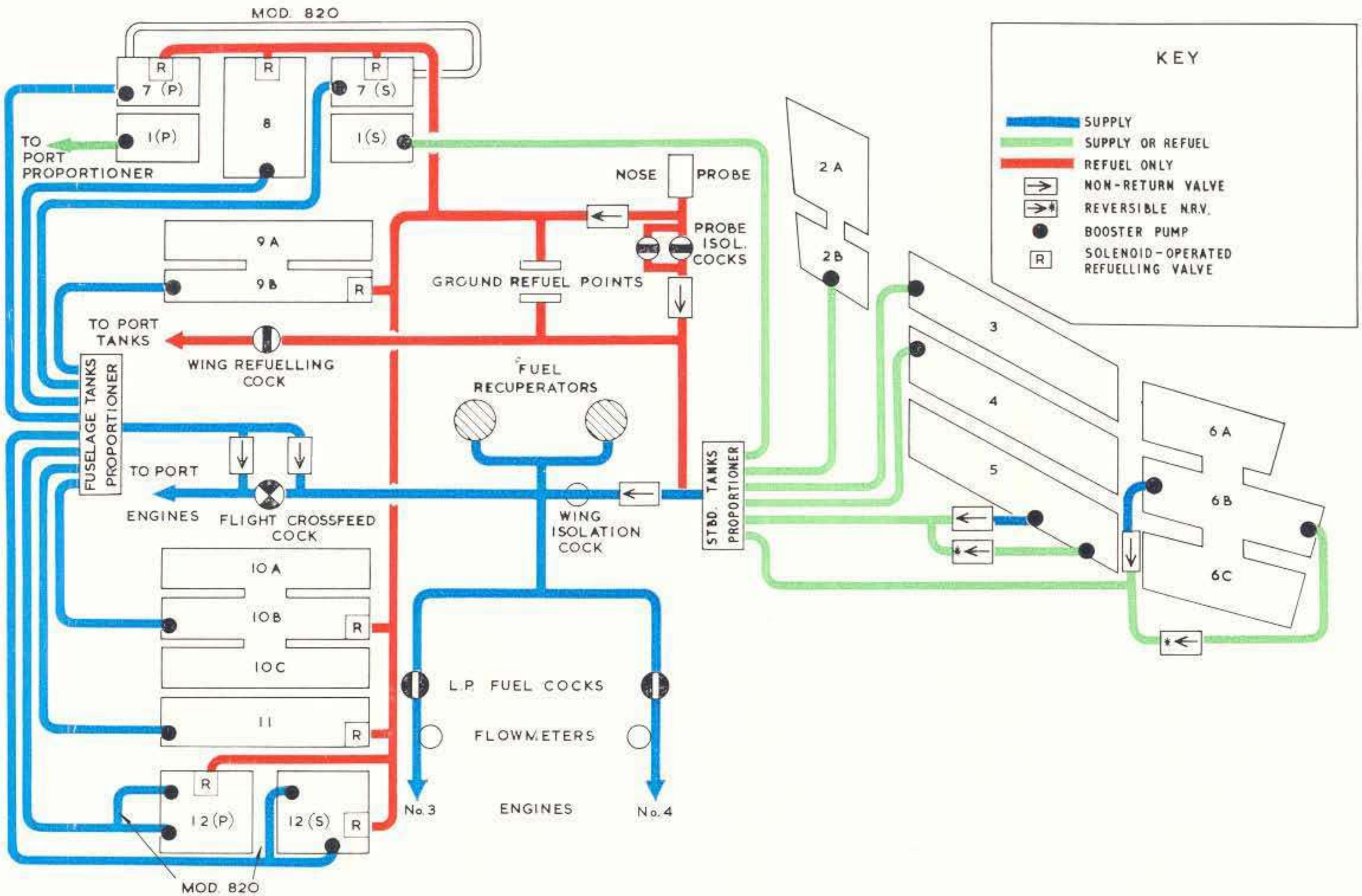

Fig. 1 Fuel system diagram

5 Fuel feed to the engines

(*a*) *Fuselage group*

From the fuselage proportioner fuel is fed to the engine gallery line, either side of the crossfeed cock and then to each of engines via the LP cocks.

(*b*) *Wing groups*

From each wing group proportioner fuel is fed to the wing gallery line and then through wing isolation cocks to the engine gallery line on the associated side. The forward bomb-bay tank feeds into the port wing gallery line via long range isolation cock and the aft bomb-bay tank into the starboard gallery line. Cross-feeding can be actioned by the use of the flight cross-feed cock, or, in emergency, by the wing refuelling cock.

6 Tank pressurisation system

The internal fuel tank pressurisation system automatically maintains a 2·75 PSI differential pressure between the fuel tanks and atmosphere for all conditions of flight. The system is divided into three groups with a common air supply tapped from all four engines. One or more engines can pressurise all three groups. A vent valve gives both inward and outward venting should the normal control system malfunction, outward venting occurring at 4 PSI and inward venting at 0·14 PSI.

7 Ground refuelling system

(*a*) Two pressure refuelling connections are on the starboard side of the fuselage, one for refuelling both wing groups and bomb-bay tanks and the other for refuelling the fuselage tanks.

(*b*) The wing groups are fuelled via the normal gallery lines and proportioners, but the fuselage group is provided with separate refuelling lines.

(*c*) All tanks are fitted with high level float switches which control either the proportioner cells (wing groups) or the refuelling valves (fuselage group) to cut off the supply to the affected tank.

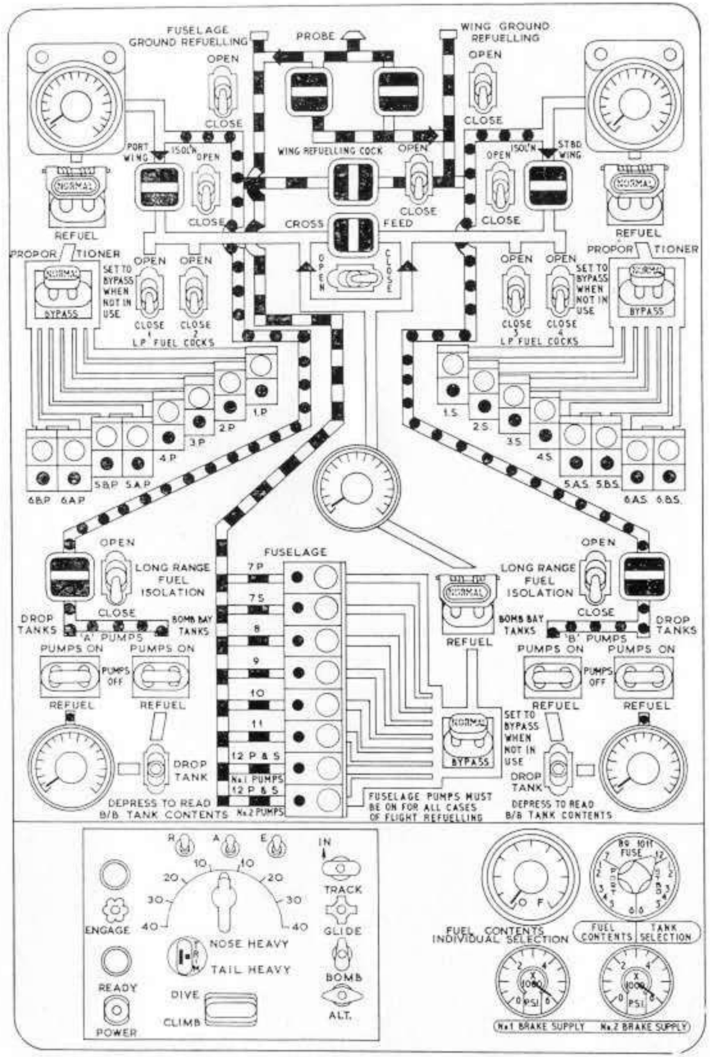

Fig. 2 Sliding panel AT

Controls and Indicators

8 Sliding panel AT

(*a*) This is the main fuel control panel and slides in runners below the centre instrument panel. The panel is in the form of a mimic diagram of the fuel system and is transilluminated.

(*b*) On the panel are the following controls:

Three proportioner controls
Two wing isolation switches and indicators
One wing refuel switch and indicator
Four LP cock control switches
One cross-feed cock switch and indicator
Twenty-four booster pump circuit breakers
Two long range isolation cock switches and indicators
Two drop tank booster pump controls
Two controls, one for fwd. and one for aft bomb bay tank booster pumps
Five fuel contents gauges
Two bomb-bay tank fuel gauge selector switches
Tank contents selector
Two probe isolation cocks switches

9 Internal tanks booster pumps controls

(*a*) Twenty-four circuit breaker switches control the aircraft booster pumps. Eight are provided for each wing group and eight for the fuselage group.

(*b*) Post Mod. 820 each No. 12 tank circuit breaker controls one pump in each tank, so that failure of one pump, or its electrical supply does not affect full delivery rate.

(*c*) When Mod. 2842 is embodied twelve nylon studs are fitted adjacent to and for ease of identification of those circuit breakers which control fuel pumps supplied from the port bus bar.

10 Bomb-bay tanks booster pumps controls

The FWD BOMB-BAY and AFT BOMB-BAY TANK controls switches, PUMPS, ON/OFF/REFUEL, are on the port and starboard side of the fuselage tank booster pump switches. Since each controls one pump in each tank, both switches must be on if only one tank is fitted in order that both pumps in that tank are operative.

11 Drop tanks booster pumps controls (not in use)

(*a*) Outboard of the two bomb-bay tank switches are two similar DROP TANK, PUMPS ON/OFF/REFUEL switches which operate in an identical fashion to the bomb-bay tank switches.

(*b*) Forward of each DROP TANK SWITCH is a DROP TANK FUEL ISOLATION, OPEN/CLOSE switch which must be set to OPEN before fuel will flow to the wing gallery lines. A magnetic indicator adjacent to each switch gives "flow line" indication of the position of the cock, or striped indication if electrical supply is lacking.

12 LP warning lights

(*a*) Four red warning lights, one for each engine are mounted on the lower edge of the pilots centre engine instrument panel A. The light is controlled by a pressure switch mounted on the corresponding engine and connected to the fuel supply line between the low pressure filter and the engine driven pump ; the switch contacts close if the pressure in the line falls below 2½ PSI.

(*b*) When Sapphire Mod. 1099 is embodied an additional 9 PSI absolute pressure switch is fitted. This gives a positive indication of low fuel pressure at altitude.

13 Fuel proportioner controls

(*a*) Three PROPORTIONER, NORMAL / BYPASS control switches are situated, one at each forward corner of the panel and one at the aft end of the panel.

(*b*) The settings of the switch are

NORMAL .	Proportioned fuel from all tanks containing fuel in the respective group is fed to the engines, provided that the individual tank control switches are selected to " in-use." This setting is also used for refuelling
BYPASS .	All cells of the proportioner set to bypass

(*c*) Above each proportioner switch is a NORMAL/REFUEL switch. When the switch for the fuselage group is set to REFUEL the refuelling valves solenoids are energised ; when the wing groups switches are set to REFUEL, the wing proportioner cells are activated to the refuel condition and the reversible NRV's in tanks 5 and 6 are operated.

(*d*) Individual cell bypass selection switches, IN USE/NOT IN USE are on panel FE on the port side of the fuselage and are set to NOT IN USE for any tank not required to be refuelled. Selection of NOT IN USE places that cell in BYPASS regardless of the setting of the proportioner switch on panel AT; the appropriate magnetic indicator will show striped.

(*e*) Proportioner magnetic indicators are on the 2nd pilot's side panel AAJ (Mk. 1 a/c panel AF), they give the following indications:

NORMAL . . .	Black
BYPASS . . .	Striped
REFUEL . . .	White (if tank is not full) Striped (tank full)

14 Fuel contents gauges

(*a*) Five fuel contents gauges are provided which give total contents indications of the three internal and the two long range groups. A further total contents gauge is situated on the navigator's panel; this gauge does not include the bomb-bay and drop tank fuel.

(*b*) A further contents gauge and a selector switch are situated on the aft sloping portion of the sliding panel. By appropriate switch selection this indicator may be used to ascertain the contents of individual tanks or the aggregate contents of two or more adjacent tanks.

(*c*) Adjacent to each drop tank/bomb-bay tank contents gauge is a DEPRESS TO READ B/B TANK CONTENTS button, since these gauges normally read drop tank contents. When Mod. 3583 is embodied the switch function is reversed and the bomb-bay tank contents can be read direct.

(*d*) *Fuselage tanks low level warning*

(i) A magnetic indicator (400 GALS. FUS RESERVE WARNING) on the aft sloping portion of the centre sliding panel AT shows white when the contents of the fuselage tanks group have fallen to 3,080 lb. The indicator is operated by float switches in the Nos. 11 and 12 tanks, therefore the stated amount of fuel is available only when correct fuel proportioning has been maintained.

(ii) When Mod. 820 is embodied the indicater is deleted.

15 Wing isolation cocks switches and magnetic indicators

Each wing group has an isolation cock controlled by an OPEN/CLOSE switch on panel AT. Adjacent to each switch is a flowline magnetic indicator. The cocks isolate the wing tanks from the engines.

16 Wing refuelling cock and indicator

(*a*) An electrically-actuated crossfeed cock is provided to isolate the port and starboard wing groups, and is controlled by an OPEN/CLOSE switch on panel AT. Normally the cock is only opened during refuelling and defuelling but can be used in the air in conjunction with the flight crossfeed cock to use trapped fuel in the event of a wing isolation cock failing in the closed position.

(*b*) A flowline magnetic indicator is adjacent to the switch.

17 Crossfeed cock and indicator

(*a*) The flight crossfeed cock in the engine fuel gallery line is controlled by a CROSSFEED, OPEN/CLOSE switch. Normally the switch is left in the CLOSE position. A flowline magnetic indicator is above the switch.

(*b*) When Mod 3606 is embodied, the electrical supply to the cross-feed cock is derived from No. 1 LV bus-bar (feeder 3P7) instead of No. 2. Since the electrical supply for the wing refuelling cock is derived from No. 2 LV bus-bar, in the event of a single LV bus-bar failure, cross-feeding of fuel can be carried out by use of the appropriate cock.

18 LP cock controls

LP FUEL COCKS, OPEN/CLOSE control switches enable the LP fuel cocks of Nos. 1, 2, 3 and 4 engines to be actuated as desired.

19 Fuel flowmeter

A fuel flow indicator controlled by a five-way switch on the co-pilot's side panel AD gives the fuel flow reading for any particular engine. A " Fuel Gone " meter is situated on the navigator's centre panel.

20 Fuel tanks pressurisation controls

(*a*) The controls are mounted on 1st pilot's panel AAF and comprise of three FUEL VENT PRESSURE ISOLATION, NORMAL/ISOLATE switches, three pressure gauges and a temperature gauge.

(*b*) With the switches set to NORMAL all tank groups are pressurised when the engines are running. Setting any switch to ISOLATE causes that group to be depressurised.

(*c*) The pressure gauges read 0 to 10 PSI and are marked in red at 5 PSI which pressure must not be exceeded.

(*d*) The temperature gauge reads the temperature in the fuselage

(*e*) A red warning light is on the pilots coaming panel and comes on if the pressure differential in any group falls below 0·14 PSI.

21 Fuel filter de-icing system controls (Mk. 1A only)

(*a*) The fuel filter in each engine supply line is de-iced by hot air tapped from that engine compressor and passed to a heat exchanger through which the fuel flows. The hot air from each engine enters the associated system through a solenoid-operated gate valve which may be manually or automatically controlled by four MAN/OFF/AUTO switches, one for each engine, on 2nd pilot's panel AF. A warning light for each gate valve indicates that the gate value is open.

(*b*) When MAN is selected the gate valves are opened and the associated warning lights come on. When AUTO is selected, the solenoids are actuated when both the fuel temperature drops to 10°C and the pressure differential across the filter rises to $2\frac{1}{2}$ PSI. The solenoid remains activated and the warning lights remain on until either fuel temperature rises above 25°C or the pressure differential falls.

(*c*) The electrical supply to the systems is from the 28-volt bus-bars.

Normal Management of the System

22 General

The main aims of fuel system management are to ensure an adequate and reliable supply of fuel to the engine under all operating conditions, and at the same time, to control the proportion of fuel in each tank so that the aircraft CG position remains reasonably constant within the laid down limits. With all fuel booster pumps in operation and all the proportioners selected to NORMAL, these requirements should be achieved automatically. However, in practice, one of the wing groups may feed more slowly than the other. It is also desirable to reduce the stresses on the airframe and therefore selective use of the wing and fuselage fuel tank groups must be made to achieve even loading and to control

23 Selection between fuel tank groups

(*a*) If a group proportioner is selected to NORMAL and all the booster pumps in that group are not operating, fuel supply from that group may be inadequate to supply engine requirements. In order to avoid engine malfunction due to fuel starvation, proportioners and booster pump circuit breakers must be selected in the correct sequence as follows :

(*b*) *Changing to wing groups from fuselage group*

Wing tank booster pump circuit breakers . .	Closed (on)
Wing proportioner switches	NORMAL
Fuselage proportioner switch	BYPASS
Fuselage tank booster pump circuit breakers .	Tripped (off)

(*c*) *Changing to fuselage group from wing groups*

Fuselage tank booster pump circuit breakers .	Closed (on)
Fuselage proportioner switch	NORMAL
Wing proportioner switches	BYPASS
Wing tank booster pump circuit breakers . .	Tripped (off)

(*d*) *Selecting forward bomb-bay tank*

Flight crossfeed	OPEN
Port LONG RANGE FUEL ISOLATION switch	OPEN
A & B bomb-bay tank switches	Both ON

Use the reverse order to switch off the bomb-bay tank.

24 Fuel system control

(*a*) Before flight ensure that all IN USE/NOT IN USE switches at Panel FE are selected IN USE for all serviceable fuel tanks. It is not considered safe to take-off with an unserviceable and empty tank unless its fuel line to the proportioner is physically blanked off in addition to selecting its proportioner cell to NOT IN USE at panel FE.

(*b*) Before starting the engines carry out the checks of fuel control indications in accordance with the aircraft check list. Open the LP cocks, select the fuselage proportioner to NORMAL, switch on all fuselage booster pumps and check that all LP warning lights are out.

(*c*) Before taxying switch on all wing group booster pumps and select both wing proportioners to NORMAL. Switch off the fuselage booster pumps but leave the fuselage proportioner selected to NORMAL.

(*d*) Take-off with all booster pumps on (except bomb-bay tanks) and all proportioners selected to NORMAL.

(*e*) After take-off select the wing proportioners to BYPASS and the wing booster pumps OFF.

(*f*) When the fuselage group contents indicate 10,000 lb. select the wing groups on and the fuselage group off. The wing cross-feed cock may be opened as required to maintain balance of fuel contents but when either wing group indicates 5,000 lb. the cross-feed cock should be closed and should remain closed for the rest of the flight.

(*g*) When either wing group contents indicate 5,000 lb. select the wing proportioners to BYPASS, leaving the booster pumps on. Select the fuselage proportioner to NORMAL and the fuselage booster pumps on. Switch off all the booster pumps in one wing group to prove that the fuselage proportioner is working properly; then switch the pumps on again. With these selections fuel should continue to be supplied from the wings rather than from the fuselage. Monitor the individual wing tank contents and, as each tank indicates empty the booster pump must be switched off within 30 minutes. When the fuselage group gauge indicates that the fuselage tanks have started to feed, select the fuselage proportioner to BYPASS.

(*h*) The minimum fuel state recommended for final landing is 8,000 lb. Regardless of fuel state it is recommended that during the final approach to land, roll or overshoot, the booster pumps of all wing and fuselage tanks containing fuel are switched on. The proportioners may be selected to NORMAL or BYPASS according to the fuel state but, in the event of any fuel low pressure light illuminating, all proportioners should be selected to BYPASS. On completion of an overshoot the fuel controls may be re-selected as required.

25 Fuel control with bomb-bay tank operable

(*a*) When a bomb-bay fuel tank is fitted and operable the wing and fuselage groups should be controlled as in para. 24. In addition, at 20,000 feet, select the CROSS-FEED cock OPEN, switch *both* BOMB-BAY TANK switches to PUMPS ON, and the port LONG RANGE FUEL ISOLATION cock OPEN. When the bomb-bay tank contents fall to 700 lb. CLOSE the LONG RANGE FUEL ISOLATION cock, select the BOMB-BAY TANKS switches to PUMPS OFF and CLOSE the CROSS-FEED cock.

(*b*) 700 lb. of fuel must be held in reserve in the bomb-bay tank to prevent the possibility of the booster pumps dry-running for an excessive period, with an attendant fire hazard (the pumps must not be dry-run for more than 30 mins.). The possibility of pumps continuing to run after being switched off exists if a fuse in the LV supply to the booster pump blows when the pumps are running.

(*c*) If a bomb-bay tank is fitted and its booster pumps operable, 700 lb. fuel must be loaded in the tank regardless of the fact that the tank may not be used.

26 Contents checks

Systematic checks should be made of all tank contents every thirty

when operating at lower levels. Check the individual tank contents for a given group and ensure that their total equals the amount indicated on the group contents scale. The individual tank contents of a group not in use should be checked in case a booster pump has failed to switch off. The various fuel tank readings should also be checked against the fuel calculator chart to ensure that the fuel is proportioning correctly. If the fuel is not proportioning correctly and an attempt is made to balance the fuel in a group of tanks by manipulation of the booster pumps, the associated proportioner should be switched to BYPASS as a precautionary measure and returned to NORMAL as soon as balancing is completed.

27 Booster pump control

(*a*) To avoid the possibility of low pressure warning lights flickering or engines flaming out, the minimum number of usable booster pumps to be switched on is given below.

Group	*State*	*Attitude*	*No. of pumps to avoid*	
			L.p. lights	*Flame-out*
Fuselage	Normal	Climb	6	5
	Normal	Dive	2	2
	Bypass	Climb	5	4
	Bypass	Dive	2	2
Each wing	Normal	Climb	4	4
	Normal	Dive	2	2
	Bypass	Climb	3	3
	Bypass	Dive	2	2

NOTE 1: The above figures are for flight at sea level at 100% RPM with no fuel tank pressurisation.

NOTE 2: Should delivery pressure from the system drop suddenly due to uncovering of pumps, a full recuperator will delay the onset of flame-out (*b*) (i) If bus-bar failure occurs and paralleling action is not taken, the proportioners must be set to BYPASS since only four pumps will be available in any one tank group. Post-Mod. 2842 the circuit breakers controlling pumps supplied by the port bus-bar are identified with illuminated studs.

(ii) If an MV bus-bar failure occurs, an immediate check of all fuel gauge readings must be carried out and logged. Reference to the table below will establish the amount of unusable fuel trapped within a group at the time of failure. This quantity remains constant for the remainder of the flight and must be subtracted from all subsequent group readings to establish the approximate amount of available fuel.

Group contents at time of bus-bar failure	*Port MV failed* Constant Unusable fuel		*Stbd MV failed* Constant Unusable fuel	
	Per Wing	*Fuselage*	*Per Wing*	*Fuselage*
2,000	1,000	600	1,000	300
4,000	2,000	1,200	2,000	700
6,000	2,900	1,800	3,100	1,000
8,000	3,800	2,400	4,200	1,300
10,000	4,800	3,000	5,200	1,700
12,000	5,700	3,600	6,300	2,000
14,000	6,600	4,200	7,400	2,300
16,000	7,600	4,800	8,400	2,700
18,000	—	5,400	—	3,000
20,000	—	6,000	—	3,300
25,000	—	7,500	—	4,200
30,000	—	9,000	—	5,000
Unusable tanks	2, 3, 6	9, 10	1, 4, 5	8, 11

(iii) Each special feeder supplies LV control power to half the cells in each proportioner. Should a special feeder fail, operation of the proportioner control will affect only three cells in each wing proportioner and four cells on the fuselage proportioner. The other cells will remain in the position selected at the time of the failure.

(*c*) *Low fuel states*

Because tanks 8 and 9 tend to empty very quickly with the fuselage proportioner in BYPASS, if the flight is to be continued below a total fuselage fuel state of 8,000 lb. the pumps in tanks 8 and 9 must be switched off until the total fuel contents fall to 7,000 lb. If possible under these conditions maximum RPM should be avoided by using only as much power as is necessary. Extreme attitudes and large accelerations should also be avoided.

◀(*d*) (i) When flight is to be continued below a total fuel state of 8,000 lb. and a bomb-bay fuel tank is fitted and operable, the normally unusable fuel remaining in the wing groups can be transferred to the bomb-bay tank and then delivered to the engines.

(ii) When the fuselage group begins to overfeed the wing groups, indicating that no more fuel can be obtained from the wing groups, check that the fuselage group is feeding correctly and select the fuselage proportioner to BYPASS (para. 24(g)).

(iii) Transfer the fuel remaining in the wing groups to the bomb-bay tank by making the following selections :

Wing isolation cocks . . CLOSED
Refuelling cross-feed cock . OPEN
Long range isolation cock . OPEN
Bomb-bay pumps switches . REFUEL
Wing booster pumps . . ON

(iv) When the fuel has been transferred, it is delivered to the engines by making the following selections :

Wing booster pumps . . OFF
Refuelling cross-feed cock . CLOSED
Bomb-bay tank pumps . ON
Port wing isolation cock . OPEN

(v) When the contents of the bomb-bay tank fall to 100 lb. select :

Bomb-bay pumps . .	OFF
Long range isolation cock .	CLOSED
Wing isolation cocks . .	CLOSED
Refuelling cross-feed cock .	CLOSED

(v) Throughout these procedures the flight cross-feed cock must remain CLOSED and frequent checks should be made to ensure that the low pressure warning lights remain out.

28 Management of the fuel tanks pressurisation system

Before starting the engines, and in accordance with the aircraft check list, check that the three tank pressure gauges indicate zero and that the temperature gauge reading is normal. Select the FUEL VENT PRESSURE ISOLATION switches to NORMAL. Under certain conditions the red FUEL TANK LOW PRESSURE warning lamp on the pilot's coaming panel may be illuminated when the engines are stationary. After starting the engines check that this light is out, and that the tank pressures and temperatures are normal. In flight the three tank pressure gauges and the temperature gauge must be checked periodically. If the reading of any pressure gauge exceeds 5 PSI, the appropriate isolation switch should be switched to ISOLATE, until the pressure reduces to below this figure. If the fuselage vent temperature exceeds 100°C its isolation switch must be set to ISOLATE until the temperature reduces below this figure.

29 Management of the fuel filter de-icing system (Mk. 1A aircraft)

(*a*) Normally all four switches should be selected to AUTO. However if flying with only six booster pumps in operation and the fuel low pressure warning lights come on and remain on after the proportioner has been set to BYPASS, thus indicating possible icing conditions, select the de-icing switches to MAN for a period not exceeding three minutes and return the switches to AUTO. This time limit is necessary since the systems are not protected by the temperature switches when selected to MAN.

(*b*) The selection of MAN in the conditions above is advantageous since the systems are brought into operation earlier than under AUTO control and any possible filter icing is cleared and fuel pressure increased before possible flame-out occurs.

(*c*) If, with the switches at AUTO, less than four warning lights come on, the systems associated with the lights which are not illuminated should be selected to MAN. This is because it is unlikely that icing conditions can occur at one filter and not at another; failure of a light to come on in these circumstances indicates possible failure within the automatic side of that system.

(*d*) MAN must never be selected for a period exceeding three minutes for the reason stated in (*a*) above.

(*e*) It has been found that at low fuel flow conditions e.g. during descent, the pressure differential may be insufficient to operate the automatic switch of the fuel filter de-icing system. If the system has operated during a sortie, it is to be selected to MAN for periods of up to 3 minutes during the descent.

30 Management of the ground refuelling system

(*a*) *Refuelling—internal tanks*

(i) Before refuelling internal tanks, all booster pumps circuit breakers must be tripped, the proportioner control switches set to NORMAL, the LP cocks closed and the flight cross-feed cock closed. Ensure that the WING REFUELLING CROSSFEED COCK switch is set to OPEN. Set the WING ISOLATION COCKS to CLOSED.

(ii) During refuelling of tanks 5 and 6, port and starboard, the four NRV indicators on panel AAJ (AF, Mk. 1) should show white.

(iii) Delivery to each tank automatically ceases when the tank is full. However, if the tanks are to be partially filled, they should first be filled and then defuelled until the correct amount remains.

(*b*) *Refuelling—bomb-bay tanks*

(i) The bomb-bay tanks, though refuelled through the wing tanks couplings, are independent of the wing tanks. Either bomb-bay tank may be isolated by leaving the appropriate tank switch at PUMPS OFF, and closing the long range isolation cock.

(ii) Before refuelling the bomb-bay tanks, ensure that all booster pumps circuit breakers are tripped, all LP cocks closed, TANKER MASTER switch NORMAL (Mk. 1 only) and the WING REFUELLING COCK magnetic indicator shows " in line ". Set the WING REFUELLING COCK to OPEN.

(iii) The port and starboard wing LONG RANGE FUEL ISOLATION switches should be set to OPEN and their indicators should then show " in line ".

(iv) The FWD or AFT BOMB-BAY TANKS pump switch should then be set to REFUEL, as appropriate. The associated electrically-operated refuelling cocks should then be open, indicated by the appropriate magnetic indicators on panel AAJ (AF, Mk 1) showing white. Fuel delivery may then commence.

(*c*) When refuelling has been completed as indicated by the contents gauges and magnetic indicators reset the switches as follows:

NORMAL/REFUEL switches .	NORMAL
WING REFUELLING COCK magnetic indicator . .	Cross-line. Switch to CLOSE
PROPORTIONER switches .	NORMAL

Malfunctioning of the System

31 Asymmetric wing contents

(*a*) Although it is possible to fly with one wing group full and the other one empty, the maximum permissible difference for landing is 8,000 lb and this should be considered the maximum practical asymmetry. If this difference is reached it will be necessary to balance fuel as follows:

(i) Select CROSS-FEED cock OPEN.

(ii) Select the proportioner switch for the lighter wing group to BYPASS.

(iii) Switch off the booster pumps in the lighter wing group. Check that the fuel LP WARNING lights remain out.

(iv) Monitor the contents gauges and when fuel balancing is achieved switch on the booster pumps, select the proportioner switch to NORMAL and CLOSE the CROSS-FEED cock.

(*b*) Except in cases of extreme asymmetry, do not cross-feed if either wing group contents indicate less than 5,000 lb.

32 Booster pump failure

(*a*) Tanks 5P, 5S, 6P and 6S in the wing groups and the bomb-bay fuel tank each contain two fuel pumps. Post-Mod. 820 tanks 12P and 12S in the fuselage group also contain two fuel pumps and in addition, tanks 7P and 7S are interconnected. Thus single booster pump failures in any of these tanks will not affect fuel proportioning.

(*b*) If a booster pump fails in any tank containing only one booster pump, the fuel proportioner will not ensure correct fuel delivery from that tank regardless of whether fuel tank pressurisation is on or off. Depending on the particular tank affected, varying reduced rates of delivery can be expected as follows:—

Tank group	*Tank pump failed*	*Percentage reduction in delivery rate*
WING . . .	1	100%
	2	63%
	3	23%
	4	26%
FUSELAGE . .	7 (Pre-Mod. 820)	61%
	9	58%
	10	48%
	12 (Pre-Mod. 820)	100%

Practically, these figures may be regarded as a measure of non-available fuel ; expressed as a percentage of the fuel remaining in the tank when the pump fails. In extreme cases, e.g. failure of a pump in a No. 1, 7 or 12 tank at an early stage in the flight, it may subsequently be necessary to resort to fuel balancing to maintain the CG within limits. If fuel balancing becomes necessary it can be best done by leaving unused an appropriate amount of fuel, as shown by the CG calculator, in the No. 12 or No. 1 tanks. Similarly it may be necessary to leave fuel in a wing tank in order to maintain symmetry. This will obviously increase the amount of non-available fuel, which must not be included in the reserve for landing. The provisions of paragraph 27 must also be borne in mind.

(*c*) If it is necessary to fly with an unserviceable booster pump in any tank containing only one booster pump, the tank must be filled to at least 50% of its capacity and its proportioner cell selected to NOT IN USE at panel FE. Amend the fuel drill to maintain the CG within limits. One unserviceable booster pump in a tank containing two pumps will not affect the fuel drill.

33 Proportioner failure

(*a*) The complete failure of a proportioner will be indicated by the failure of the affected tank group to feed when its proportioner switch is at NORMAL and its booster pumps are on. However, fuel may still be supplied to the engines through the action of the engine-driven HP pumps drawing fuel from the other groups, provided their switches are at BYPASS. Some loss in engine speed may be experienced however until a serviceable tank group is selected to feed the affected engines.

(*b*) If a fuselage proportioner fails while it is in use, select the wing groups on and proportioners NORMAL. Decide by the fuel and CG calculators how the fuel should be extracted from individual fuselage tanks to maintain the correct CG. Then select the fuselage proportioners to BYPASS, ensure all fuselage booster pumps are on and select off the wing groups. Control the fuel flow from individual fuselage tanks as calculated, by selective use of the fuselage booster pumps.

(*c*) If a wing proportioner fails while it is in use, select the fuselage group on and proportioner NORMAL. Decide by the fuel and CG calculators how the fuel should be extracted from the affected wing group individual tanks to maintain correct CG. Then select the failed proportioner's switch to BYPASS, ensure all the booster pumps for that group are on, and select off the fuselage groups. Control the fuel flow from the individual tanks of the affected group as calculated, by selective use of that group's booster pumps.

34 Engine failure

If an engine fails, open the flight cross-feed cock, and allow the three remaining engines to feed from both sides.

35 Fuel tank pressure failure

In flight the three tank pressure gauges and the vent temperature gauge should be checked periodically. If the reading of any pressure gauge exceeds 5 PSI the appropriate isolation switch should be switched OFF or altitude must be reduced to return the pressure below this figure. If the fuselage vent temperature exceeds 100°C, its isolation switch must be set to OFF.

36 Other failures

Stores hang-up may necessitate departure from the normal management in which case CG position should be maintained by selective use of the fuel tanks in accordance with the fuel and CG calculators.

Part I

Chapter 3—Flight Refuelling System (Receiver)

List of Contents

Description

1 General

(*a*) A probe and drogue flight refuelling system is fitted. The system has its own controls and allows fuel to flow into the normal fuel system, whilst the aircraft engines are run on fuel delivered under pump pressure from the fuselage group.

(*b*) Refuelling is controlled from the cockpit by the second pilot. Individual selection of the following groups is possible:

Port and starboard wing tanks

Fuselage tanks

Forward and aft bomb-bay tanks

(*c*) The probe is positioned between the pilots' escape hatches and extends forward so that the pilot can comfortably see the probe head whilst flying on to the drogue. The fuel delivery pipe runs through the starboard side of the crew compartment until it passes through the pressure bowl behind the navigator's table. The pipe is then divided between the wing and fuselage refuelling lines.

(*d*) A non-return valve is in each of these lines and a third NRV is in the probe line aft of the cabin to prevent fuel flowing back through the probe.

2 Nitrogen purging system

(*a*) This system is provided to empty the refuelling line passing through the cabin after refuelling thereby minimising the fire risk.

(*b*) Two high pressure nitrogen bottles charged to 1,800 PSI provide the supply which is reduced to 10 PSI in the probe line. With the system in operation the nitrogen forces fuel from the probe line to No. 7 tank, port, via a float chamber. This float chamber is normally full during initial purging but as the fluid level falls towards the end of purging a float switch operates to indicate that purging may be discontinued. Mod. 3589 introduces a pressure gauge to give an indication of system pressure.

Controls and Indicators

3 Flight refuelling controls

(*a*) When refuelling, the proportioner switches of the groups to be refuelled should be set to NORMAL and the NORMAL/REFUEL switches to REFUEL. Magnetic indicators on panel AAJ show white when the controls are set for refuelling.

(*b*) The bomb-bay tank is selected to the refuelling condition by setting its booster-pump control switch to REFUEL.

4 Nitrogen purge control and indicator

The PROBE PURGE ON/OFF switch is on panel AAJ and when set to ON, purging takes place. A magnetic indicator shows white when this is taking place. This indicator may take up to one minute to turn white after purging has been selected. When purging is complete and the float switch in the float chamber between the probe and tank 7(P) operates, the indicator reverts to black. This is an indication to switch off the system.

5 Probe lights

Mod. 2690 introduces two lights mounted on a fairing below and focussed on the probe. A double pole switch on panel AB can be used to select either light and the light intensity is controlled by a dimmer switch on panel AT.

Management of the System

6 CG control and wing fuel asymmetry

(*a*) It has been assumed that pre-flight planning has ensured that the CG will remain within normal limits throughout the flight including landing with stores and 10,000 lb. of fuel. It has also been assumed that the fuel quantities to be transferred in flight have been planned to conform with normal loading conditions. The flight plan must be examined to establish the following for reference in the event of action being necessary due to malfunction:

1 The minimum distance of the CG aft of the forward limit at any time during the flight. To be recorded as CG margin forward.

2 The minimum distance of the CG forward of the normal aft limit at any time during flight. To be recorded as CG margin aft.

(*b*) The failures allowed for in the drill will in some cases cause the CG to move outside the normal limits and/or asymmetrical fuel distribution to occur; in these circumstances the following extended limits are permissible:

1 Longitudinal CG—6 inches forward to 3 inches aft of present limits.

2 Wing fuel asymmetry may be at a maximum in flight, but must be less than 8,000 lb for landing.

◂ When use is made of these extended limits, gentle manoeuvres only are permitted, speed must not exceed 0·85M and the auto-pilot must not be used.

(*c*) (i) The maximum rolling moment is 320,000 ft. lb. but, as this is achieved only when one wing group and its associated wing pod are full of fuel and the opposite wing group and pod are empty, it is unlikely to occur.

(ii) Selective use of fuel should be used to restore the CG to within normal limits as soon as possible and to reduce wing fuel asymmetry to less than 8,000 lb before landing. Adequate aileron control exists at maximum fuel asymmetry in flight and for landing with asymmetry less than 8,000 lb.

(*d*) To keep the CG within limits in certain cases of failure, when full refuelling is intended starting with the minimum of 8,000 lb. of fuel in the fuselage group, the following restrictions apply:

(i) *Three-point tanker*

1 If No. 7 tank port or starboard fails to receive fuel, the total contents of the remaining fuselage tanks must not exceed 18,500 lb.

2 If any valve failure results in the forward bomb bay tank failing to receive fuel, the total contents of the fuselage tanks must not exceed 17,500 lb. or, if the fuselage tanks are already full, the rear bomb bay tank contents must not exceed 8,400 lb.

(ii) *Two-point tanker*

1 If No. 1 tank port or starboard fails to receive fuel, the rear bomb bay tank contents must not exceed 5,500 lb. ; if both bomb bay tanks are to be filled, the total contents of the fuselage tanks must not exceed 21,000 lb.

2 If No. 7 tank port or starboard fails to receive fuel, the total contents of the remaining fuselage tanks must not exceed 22,500 lb. and the contents of the rear bomb bay tank must not exceed 2,800 lb. ; if both bomb bay tanks are to be filled, the total contents of the fuselage tanks must not exceed 13,000 lb.

3 If any failure results in the forward bomb bay tank failing to receive fuel, the rear bomb bay tank contents must not exceed 2,800 lb.

7 Transfer procedure

(*a*) *General*

The drills for refuelling and malfunctioning procedure are contained in the Flight Reference Cards and must be used at all times. These drills allow for any single failure case. If a double failure occurs, refuelling may still be carried out but care is required.

(*b*) *Before contact*

(i) Before carrying out dry contacts, select the wing or fuselage groups as required, keeping the probe isolation cocks closed.

(ii) Before carrying out wet contacts switch off the fuel tank pressurisation 15 minutes before contact, check and note the fuel gauge readings and the amount of fuel to be received, ensure that the fuselage group contents are not less than 8,000 lb., fly on the fuselage group with its proportioner at BYPASS and switch off the wing groups.

(iii) Immediately before contact, select all groups that are to receive fuel to REFUEL and, in the case of the 2-point tanker, when the bomb bay tanks are to be refuelled, select the long range isolation cocks open. The probe isolation cocks must be closed to ensure that any air in the probe or the fuel line is passed to the fuselage tanks (fuselage and bomb bay tanks in 3-point tanker) and not to the engines during the initial transfer of fuel. The wing isolation cocks must be closed before commencing refuelling to prevent high fuel pressures reaching the engines and recuperators.

(iv) If the fuel tank pressurisation gauges indicate a pressure of 2·75 to 5 PSI, refuelling may be carried out but the gauges must be monitored continually during transfer and, if the pressure rises above 5 PSI, refuelling of the affected group or groups must be stopped.

(*c*) *In contact*

(i) After contact, the fuel gallery pressure gauge will start to register. With the tanker main pump operating and tanks receiving, the pressure should be 20-45 PSI. The initial contact pressure, no tanks receiving, may be as high as 55 PSI with surge to 65 PSI. If the pressure remains below 30 PSI, there may be unserviceability in the tanker aircraft. For emergency transfer, tanker main pump not operating, the pressure will be approximately 8 PSI falling even lower as fuel transfer continues. In these circumstances an average refuelling contact time is 20 to 25 minutes. Once fuel is seen to be flowing to the fuselage tanks (fuselage and bomb bay tanks in 3-point tanker) open the probe isolation cocks.

(ii) While fuel is being received, ensure that the limits in para. 6(*b*) are not exceeded, particularly in cases of valve failure that result in tanks failing to receive fuel.

(iii) To prevent high fuel pressures rupturing a fuel tank following the failure of two or more high level float switches, tanks are not to be filled completely and the maximum permissible group contents are as follows:

Wing groups
14,700 lb. each

Fuselage group

1 30,000 lb. when receiving up to 5,000 lb. of fuel into the group.
2 27,500 lb. when receiving 5,000-10,000 lb. into the group.
3 25,000 lb. when receiving 10,000-15,000 lb. into the group.

If before contact, a tank is more than 400 lb. out of proportion, the appropriate maximum permissible group contents must be decreased by the same amount.

(iv) When filling both bomb bay tanks together, stop refuelling the first tank to reach 14,000 lb. (3-point tanker) or 7,000 lb. (2-point tanker) then, provided that fuel flow ceases, allow the other tank to fill completely. If fuel flow to the first tank does not cease, stop refuelling the other tank at 14,000 lb. (3-point tanker) or 7,000 lb. (2-point tanker). If the forward tank fails to fill, the rear tank contents must not exceed 8,400 lb. (3-point tanker) or 2,800 lb. (2-point tanker).

(v) If, at any time, the magnetic indicator of one proportioner cell in any fuel group flickers or shows steady striped, stop refuelling the appropriate group. If a No. 5 or 6 tank, port or starboard, NRV indicator shows striped, carry out an emergency break (2-point tanker) or close the probe isolation cocks (3-point tanker).

(vi) To stop refuelling, carry out an emergency break or close off sequentially each group receiving fuel starting with the fuselage group or close the probe isolation cocks. In the case of the 2-point tanker, when fuel is being received into the wing and bomb bay tanks together, the probe isolation cocks must not be closed otherwise high surge pressures are produced in the fuel lines.

(*d*) *After refuelling*

(i) When refuelling is complete, break contact, close the probe isolation cocks, open the wing isolation cocks, operate the probe nitrogen purge system and then switch the fuel tank pressurisation on.

(ii) Revert to the appropriate fuel handling procedure, transfer or transit. On a transit flight, if the contents of the wing tanks are less than the maximum permissible, transfer fuel from the bomb bay tanks to the wing tanks ; the maximum permissible group contents must not be exceeded.

(iii) In all cases, if necessary, use fuel selectively to achieve wing symmetry and transfer fuel internally to satisfy wing relief requirements.

Normal Procedures and Handling

8 Initial approach

WARNING : When a red or green light, or no lights are showing on the hose drum unit, contacts must not be attempted. Contacts are only permissible if amber light(s) are showing. If, when in contact, a red light comes on or all lights go out contact must be broken immediately.

(*a*) The recommended speed range is 250-290 knots and an initial relative closing speed of 2 to 3 knots (maximum of 5 knots) should be used approaching from below and dead astern, keeping the signal lights in view at all times.

(*b*) When waiting to commence an approach, the receiver should be positioned behind and to the starboard of the tanker in case the hose becomes detached while being trailed or wound in.

9 Final approach and contact

(*a*) Make the final approach from dead astern and below the drogue, so that the pilot is looking along the line of the hose. Set power to maintain the correct closing speed and from about 40 feet adjust speed by visual judgment rather than by reference to the ASI. Accurate and steady flying is required and over controlling must be avoided. To this end it is important that the seat is adjusted to a comfortable position so that the pilot does not have to lean forward to get an adequate view of the probe. When about 5 to 10 feet short of the drogue a moderate buffet is felt, accompanied by a slight nose-up change of trim as the tail unit of the aircraft enters the tankers slipstream. At this point a small increase of power may be needed to maintain the closing speed. As the probe enters the drogue, mild buffeting is experienced, accompanied by considerable noise.

(*b*) Once contact has been made and the probe is positively coupled to the drogue, fly the aircraft gradually up the line of the hose until the refuelling position is reached; keep the curve of the hose concave to the receiver. A slight reduction of power is then needed to maintain the refuelling position.

(*c*) The recommended refuelling position is achieved when the forward edge of a 10 feet long yellow band on the hose is just entering the serving carriage of the HDU. Aft of this band, the hose is marked with white stripes at 10 feet intervals and the 5 feet forward of the yellow band is marked with red and white stripes. Seven feet of the hose must be wound in before the tanker fuel valve opens. When the valve is open, the tanker lights change from amber to green and the fuel gallery pressure gauge on the co-pilot's instrument panel starts to indicate. Continue the approach until the yellow band is just visible, as this is the optimum position for aircraft control.

(*d*) Due to the line of trail of the hose it is difficult to see the markings unless they have been freshly painted. In this event, if the hose is wound in until approximately two-thirds of the drum unit is covered by the coiled hose, the correct refuelling position is reached.

10 In contact

Once in contact, make small control movements to hold the correct station, dead astern of the tanker, with the yellow hose marking showing and the signal lights visible and guard against any tendency to over-correct. Avoid carrying the hose excessively downwards or sideways or probe damage may occur; carrying the hose higher than the normal line of trail may induce a sharp nose-up change of trim. It is difficult to achieve a permanent intrim condition. Coarse throttle movement may be necessary to hold station but, normally, make small movements only. With the throttle friction damper fully off, throttle movement is comfortable.

11 Breaking contact

(*a*) *Normal procedure*

(i) To break contact, reduce power slightly and allow the aircraft to fall astern gradually. Hose unwinding should be controlled at a slow rate by throttle movement. When the last seven feet of the hose is coming off the drum, the signal lights change to amber if the tanker valve has not already been closed. Aim to break contact with the drogue in its natural position so that it can be watched as it draws away. If contact is broken in any other position the drogue will oscillate over a wide area about its normal position.

(ii) If contact is broken with the receiver aircraft riding high, it is possible that the drogue may strike the feel intake. To reduce this possibility and to avoid the danger of being struck by an oscillating drogue, when the last few feet of the hose are being unwound, close the throttles to the idling gate. This ensures a swift deceleration once contact has been broken, but, providing that it is not done too soon, should not cause the hose drum brake unit to operate.

(*b*) *Emergency procedure*

If a red light comes on, or if all lights go out, or if it is necessary to break contact quickly for any other reason, close the throttles fully and select airbrakes out to ensure that the deceleration rate is sufficient for the hose to reach a speed of 5 ft./sec. when its brake will be automatically applied, and contact will be broken. This method should only be used in emergency conditions or for training purposes as it throws a heavy load on the hose drum unit.

(*c*) *Clearing the tanker*

When contact is broken some fuel splash will occur. This causes no embarrassment to the pilots, since it passes above the line of vision, striking the fuselage at a point above the pilot's head.

12 Incorrect contact

(*a*) If the probe misses the drogue, close the throttles and withdraw to a safe distance along the approach path as the aircraft decelerates.

(*b*) If the probe hits the outer rim of the drogue, the hose may wind in. If this occurs, withdraw behind and to starboard of the tanker while the hose is retrailed.

(*c*) If the probe penetrates the canopy or spokes of the drogue, withdraw along the approach path to break contact with the drogue in the natural position. If necessary, wait for the hose to be retrailed.

(*d*) If the probe appears to enter the drogue but fuel does not flow, a soft contact may have occurred due to the closing speed being too low in the final stages of the approach; the hose may wind in. Withdraw and, if necessary, wait for the hose to be retrailed.

Part I

Chapter 3A—Two-point Tanker Installation Mk. (K) 1A Aircraft

List of Contents

Description, controls and indicators

1 Description

(*a*) The two-point tanker installation on the Victor 1A is comprised of two Mk. 20B flight refuelling pods, one carried under each wing. Each pod is controlled from a separate control panel CI on the rear crew compartment starboard wall.

(*b*) The pods, which each have a fuel capacity of approximately 1,000 lb., are supplied with fuel transferred from the bomb bay tanks and from the wing tank groups. The port wing group and forward bomb bay tank normally supply the port pod and the starboard wing group and aft bomb bay tank supply the starboard pod.

(*c*) The flight refuelling pods are automatic in operation once certain settings and switch selections have been made by the panel operator. The control panels contain indicators and lamps to give visual evidence of the progress of the operation and warning of abnormal conditions necessitating special action. Such action may happen automatically or require further switch selections by the operator.

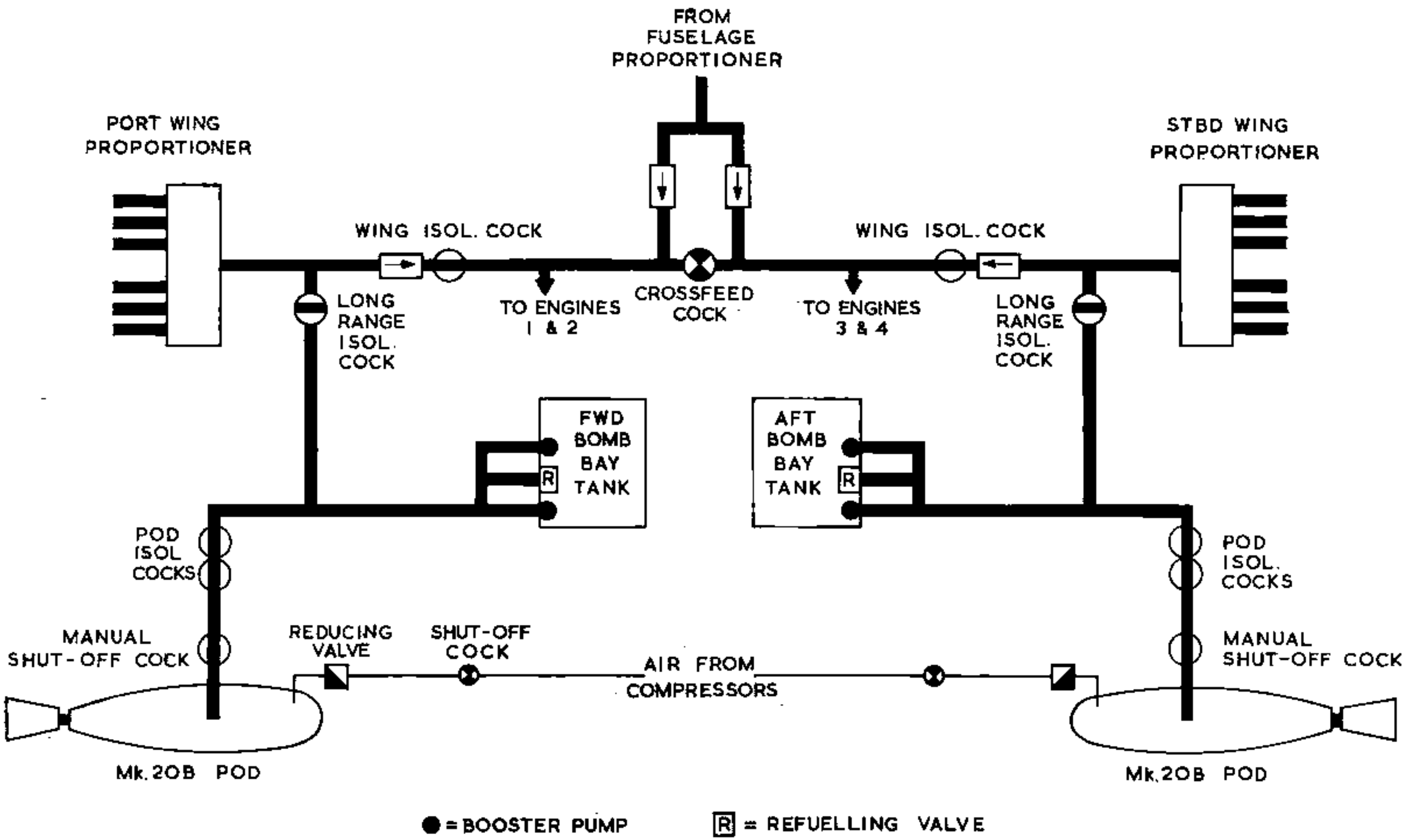

Fig. 1 Fuel system

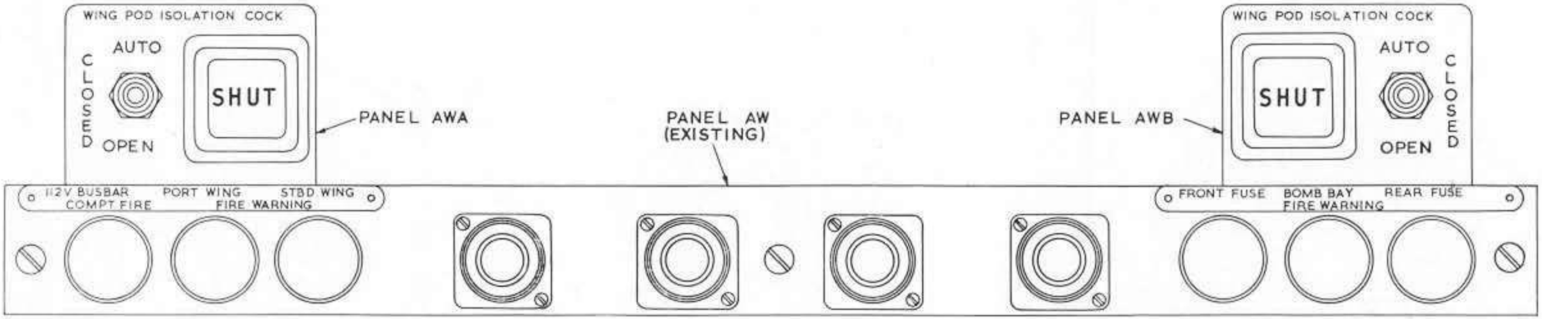

Fig. 2 Pilots' controls

2 Pilot's switch panels

(*a*) Above panel AW are two switch panels AWA and AWB. Each contains a WING POD ISOLATION COCK, AUTO-CLOSED-OPEN switch and and OPEN-striped-SHUT magnetic indicator. Panel AWA controls the fuel transfer to the port pod and AWB to the starboard pod.

(*b*) The CLOSED-OPEN settings of the switch are self-explanatory ; the AUTO setting controls, via float switches, the fuel level in the pod to maintain the pod between mid-level and full by automatically opening and closing the pod isolation cocks. There are two cocks, No. 1 and No. 2, for each pod.

(*c*) *Test switches*

On the forward face of Panel AJ are two lights, PORT No. 1 and STBD. No. 1, PRESS TO TEST No. 2. These are for checking the position of the pod isolation cocks. When the No. 1 cock of each pod is closed the light comes on. Pressing each light individually causes the light to go out and then come on again provided that the associated No. 2 cock is closed. Failure of a light to come on when the pod isolation cock switch is set to CLOSED

3 Tanker operator control panels

(*a*) On each pod control panel are the following controls :

(*b*) *Switches*

(i) *Master switch*

The MASTER (ON-OFF) SWITCH controls all electrical circuits to the pod except those controlled by the turbine overspeed switch.

(ii) *Fuel jettison switch*

The FUEL JETTISON ON-OFF controls the jettison valve in the pod. A guard on the switch must be rotated through 90° before the switch can be operated.

(iii) *Wind/trail switch*

The WIND-TRAIL switch controls the winding or trailing of the hose.

(iv) *Emergency trail switch*

The EMERGENCY TRAIL/OFF/HOSE RELEASE switch permits the hose to be extended to the full trail position from

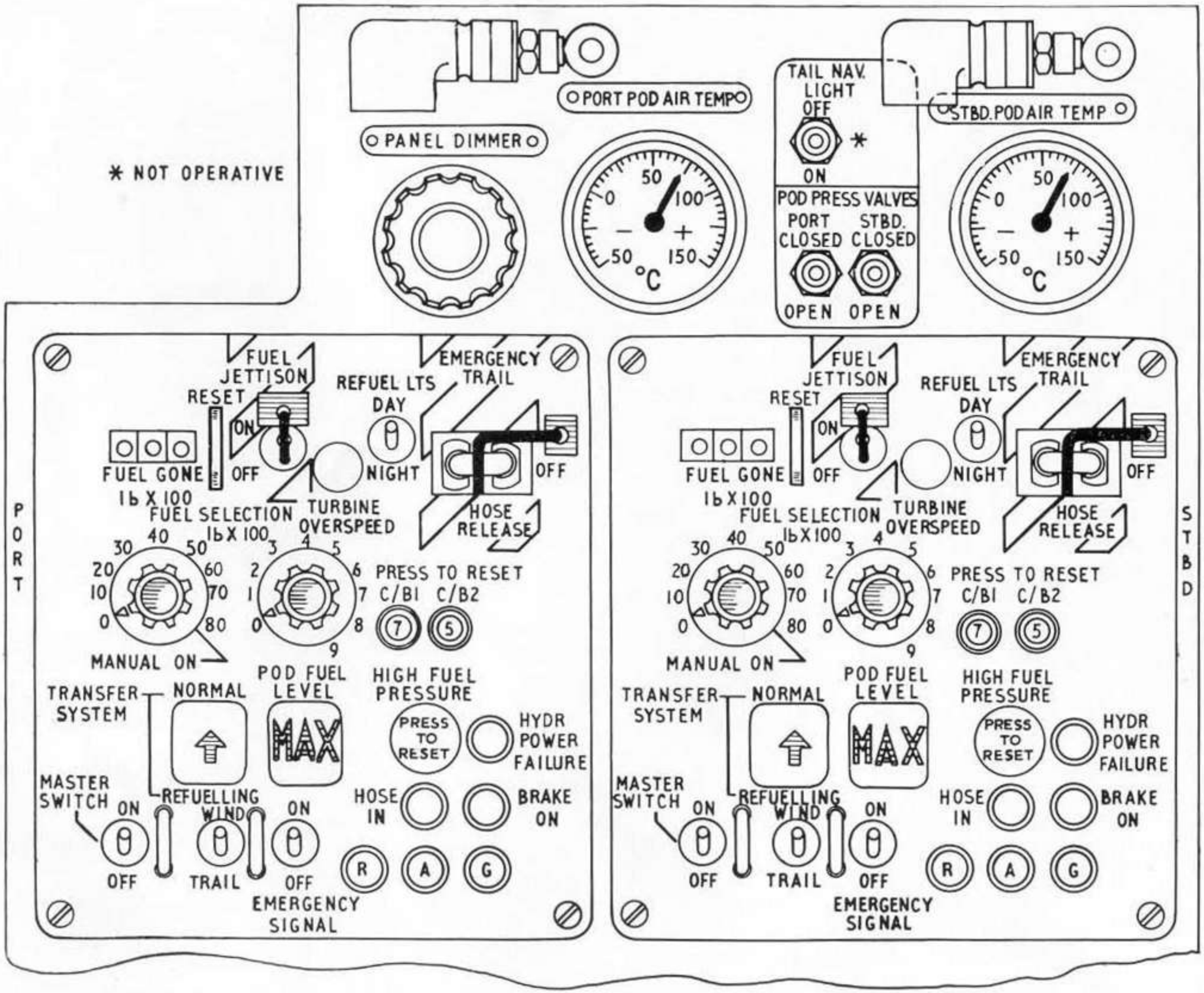

Fig. 3. Tanker operator's controls

(v) *Refuelling lights switch*

The REFUEL LTS, DAY-NIGHT switch controls the choice of brightness of the signal lights in the pod.

(vi) *Emergency signal switch*

The EMERGENCY SIGNAL ON-OFF switch causes the red signal lights to come on irrespective of any other lights which may be illuminated.

(*c*) *Fuel selection controls*

(i) *Fuel selector switches*

Two fuel selector rotary switches, one reading in tens of hundreds and the other reading in hundreds are preset to the amount of fuel required to be transferred. Passage of fuel causes the switches to rotate anti-clockwise giving an indication of the amount still to be transferred. At the end of transfer the fuel selector valve automatically closes. However the left-hand switch has a MANUAL ON position and with the switch thus set an unrestricted amount of fuel may be transferred without preset limitation.

(ii) *Fuel totaliser*

A veeder counter is mounted above the selector switches giving a reading of FUEL GONE in hundreds of pounds.

(*d*) *Magnetic indicators*

(i) *Refuelling indicator*

An arrow indication points either to NORMAL or REFUELLING. The REFUELLING indication is given whenever the pod isolation cocks are open. The NORMAL indication is given when the cocks are closed. The indicator shows black when the aircraft power supplies are off and is independent of the master switch.

(ii) *Fuel level indicator*

The POD FUEL LEVEL indicator shows MIN or MAX according to the amount of fuel in the pod. The indicator shows black at intermediate conditions.

(*e*) *Warning lights*

(i) Warning lights are fitted to provide indication of HIGH FUEL PRESSURE (amber) HYDR POWER FAILURE (red), HOSE IN (white), BRAKE ON (blue) and TURBINE OVERSPEED (red). Additionally the HOSE IN light pulsates while the hose is being trailed or wound in.

(ii) Three signal lights operate automatically once a refuelling operation has commenced. The red light comes on when the hose is being trailed or wound in, but not at full trail. The amber light comes on when the hose is at full trail (or full trail less 6 feet). The green lights comes on when the receiver aircraft has engaged the drogue, the hose has wound in by six feet and the necessary components have functioned to permit passage of fuel.

(*f*) *Circuit breakers*

Two PRESS TO RESET circuit breakers protect the normal (CB1) and emergency (CB2) circuits in the pod.

4 Pod air pressure valves

The PORT and STBD. POD PRESS VALVES, OPEN-CLOSE switches control the supply of air from the engine compressors to pressurise the refuelling pods. Additionally an AIR TEMP. gauge is provided for each pod ; the air temperature must not exceed 100°C in use.

Management of refuelling pods

5 Preparing for contact and trailing hose

(*a*) Pilot set pod isolation cocks at AUTO. If non-feathering turbine blades are fitted to the pod, speed must first be reduced to 200 knots and then increased to the appropriate refuelling speed. This is to overcome the hysteresis of this type of turbine.

(*b*) When the tanker operator has initiated the refuelling operation the hose will take approximately 20 seconds to trail ; during this time faint jerking of the aircraft may be experienced and some shift in directional and lateral trim occurs. The HOSE IN light flashes during hose unwinding. As the hose reaches the fully trailed position the amber light comes on. The emergency signal light should be left ON until the tanker is ready for contact. Accurate trimming and smooth flying of the tanker is now essential to ensure the minimum delay in establishing a successful contact.

6 During contact and transferring fuel

(*a*) The contact is normally felt in the aircraft and some directional and lateral trim changes occur which should be corrected as gently as possible. Shortly afterwards, when the hose has wound in by about 5 feet, the amber light goes out, the green refuel light comes on and fuel starts to flow.

(*b*) *Co-pilot*

When contact is made record total fuel in aircraft.

(*c*) *Operator*

During fuel transfer monitor the high pressure fuel light. This may " flicker " in the initial stages of transfer the fault is probably caused by the receiver aircraft but in the later stages the fault is usually within the pod. If the light remains on, press and hold for two seconds to cancel signal. Three attempts should be made, pressing for two seconds each time. If the light cannot be cancelled then the flight refuelling must be abandoned. During the fuel transfer check that it is registered on the Fuel Gone counter, and that the Fuel Selector Switches are " ticking off " the required amount. Any hose movement during the transfer may be accompanied by a " flash " of the HOSE IN light.

(*d*) During multi-contact sorties, reset the fuel selector switches between engagement. The Fuel Gone counter totalises all fuel transferred. The theoretical maximum amount of transferable fuel is 50,000 lb.

(*e*) The pods should be topped up at the completion of each refuelling ; if the pod pressurisation is not switched off, the rate of flow to the pod is reduced by about 60%.

Management of the aircraft fuel system

7 Normal control in flight

(*a*) Take-off and climb with all proportioners selected to NORMAL and all wing and fuselage booster pumps ON.

(*b*) After take-off switch off the wing groups booster pumps.

(*c*) When the fuselage group contents reduce to 13,000 lb. select wing group booster pumps ON, fuselage proportioner to BY PASS, and fuselage group booster pumps OFF, except during transfers.

(*d*) When all transfers have been completed continue as per para. 10.

8 Control when transferring to a receiver

(*a*) When ready to transfer to a receiver select all proportioners to NORMAL and switch all wing and fuselage booster pumps ON.

(*b*) Open the long range tanks isolation cocks, open the pod isolation cocks, check that the wing isolation cocks are open and when the receiver is in contact switch on all bomb bay tank pumps.

(*c*) If only one pod is in use the long range tank isolation cock on the other side should be kept closed.

9 Internal transfer of fuel

(*a*) When transferring fuel from wing groups to bomb bay tanks, fly on the fuselage group with its proportioner in BYPASS and control out-of-balance by selective switching of tanks 8 and 9 booster pumps.

(*b*) Set the appropriate wing group proportioner to NORMAL, pumps ON, long range tank isolation cocks OPEN, wing and pod isolation cocks CLOSED and open the bomb bay tank refuelling valves.

(*c*) At the end of transfer revert to the appropriate method of fuel system control.

(*d*) See also para. 11(a).

10 Control after completion of all receiver transfers

(*a*) When all receiver transfers have been completed, any fuel remaining in the pods and wings should be transferred to the bomb bay tanks when possible, pod fuel being transferred first. Whenever possible the contents of each bomb bay tank should be similar.

(*b*) To transfer fuel from a pod to its associated bomb bay tank, close the appropriate long range tank isolation cock, open the pod isolation cocks, switch on the pressure air and open the bomb bay tank refuelling valve. As soon as all fuel is transferred, close the pod isolation cocks and open the long range tank isolation cock.

(*c*) To transfer fuel from a wing group to its associated bomb bay tank, ensure the pod isolation cocks closed, close the wing isolation cock, switch on the wing group pumps and open the bomb bay tank refuelling valve. Set the wing proportioner to BYPASS when a low fuel state is reached.

(*d*) When all fuel is transferred switch on all bomb bay tank and fuselage booster pumps ; set the fuselage group proportioner to BYPASS. The bomb bay tanks should overfeed the fuselage system until empty. To assist this, switch off the fuselage tanks pressurisation until the bomb bay tanks are empty.

(*e*) When the total fuel in the bomb bay and fuselage tanks is below 8,000 lb. an overshoot should not be attempted unless the fuselage contents are above 5,000 lb. or each bomb bay tank contains a minimum of 2,500 lb.

11 Use of the wing refuelling cock

(*a*) If a wing isolation cock fails to open it may be bypassed by opening the wing refuelling cock.

(*b*) To transfer fuel to the port pod from the aft bomb bay tank or to the starboard pod from the forward bomb bay tank open the appropriate pod isolation cock and bomb bay tank refuelling valve, set both long range tank isolation cocks open and open the wing refuelling cock. Revert to normal control on completion of transfer.

12 Aircraft handling

(*a*) *Taxying*

A careful watch must be kept for obstructions because the wing refuelling pods are 85 ft. apart and have a small ground clearance.

(*b*) *Take-off and landing*

(i) Care must be taken to keep the wings level during take-off and landing particularly in gusty cross-wind conditions because, with the mainwheels on the ground, application of approximately 8° of bank causes the appropriate wing refuelling pod to touch the ground.

(ii) After take-off at maximum AUW, when raising the flap below the limiting speed, slight pre-stall buffet may occur until speed is increased.

(*c*) *In flight*

(i) At all times, the pilot is to be kept informed of the progress of refuelling by the operator.

(ii) As a hose is trailed, small directional and lateral trim changes occur and, before a contact is made, the tanker should be accurately trimmed at the flight refuelling speed.

(iii) When ready for contact, the tanker must be flown as steadily as possible to create a stable platform for the benefit of the receiver. Abrupt control movements and coarse use of the throttle should be avoided. Particular care is required when handling the elevators since short period pitching oscillations can be induced causing the hose to oscillate.

(iv) When the receiver closes in, the tanker tends to roll away from the pod being used ; after contact speed tends to increase unless power is reduced by 1 to 2% RPM.

(v) Power has to be reduced and the aircraft re-trimmed as fuel is transferred to the receiver to maintain the refuelling speed and level flight.

Malfunctioning of the refuelling pods

13 Failure of pod isolation cocks to open

If this occurs the only fuel available for transfer will be that already in the pod. Diagnosis of this condition can only be made by reference to the pod isolation cocks indicator or fuel contents guages. Additionally the REFUELLING indication will not be given.

14 Hydraulic failure (Hose stowed)

The hose must not be trailed if the HYDRAULIC POWER FAILURE warning light is on.

15 Hydraulic failure (Hose trailed)

(*a*) If failure occurs during contact, fuel stops flowing. The green light goes out, the emergency red, hydraulic failure and amber lights come on. (The Blue brake light comes on if the hose is not at full trail.)

(*b*) Attempt to wind in the hose normally. If the hose fails to wind in, select the master switch to OFF : depending upon the actual failure that has occurred the hose may wind in. A reduction of airspeed may be of assistance.

(*c*) If the hose cannot be wound in, reselect the master switch to ON and jettison the hose when safe to do so.

16 Drogue breaks off

(*a*) If his occurs the hose is quickly wound in (approx. 3 secs.).

(*b*) Provided the reception coupling is retained the hose stows normally, the BRAKE ON light appearing on completion. Select all switches OFF.

(*c*) If the complete drogue assembly breaks off, or the hose parts, the hose will probably wind in before any action can be taken. Immediately the failure is apparent select the Master Switch to OFF.

(*d*) Partial breakdown of the drogue may cause hose instability. Reduce speed prior to rewind in an attempt to stabilise ; when stabilisation occurs rewind the hose. If it remains unstable the hose must be jettisoned.

17 Receiver probe lodged in coupling

(*a*) Close the pod isolation cocks. Select fuel counters to " Zero " to minimise loss of fuel from the pod.

(b) Check with Receiver aircraft whether :

(i) Nozzle.

(ii) Nozzle and fuel tube is lodged in coupling, causing hose gyrations.

(*c*) In case (i) wind in hose normally. In case (ii) the hose must be jettisoned.

18 Hose fails to wind in

If the hose fails to wind in, increase airspeed to maximum then progressively reduce airspeed with WIND selected. Rewind should commence at 240 knots. The application of sideslip may be of assistance.

19 Hose jettison (over clear area)

If the HYDRAULIC POWER FAILURE and BRAKE lights come on when the hose is trailed or being trailed, it cannot then be wound in and must be jettisoned if possible before landing. Reduce speed to 230 knots. Set the fuel selection switches to zero. Set the WIND/TRAIL switch to TRAIL and the emergency switch to EMERGENCY TRAIL. The BRAKE light cycles until the hose is full extended (amber light on) when it remains off. The hose may now be jettisoned by selecting HOSE RELEASE. After jettisoning select all panel switches to off.

20 Pod fuel jettison (Hose stowed)

(*a*) Close the pod isolation cocks, set the Master Switch on and operate the jettison switch. When the pod tank fuel indicator shows MIN. switch off the jettison and Master Switches.

(*b*) If it is required to jettison aircraft fuel, this can be done, with hose stowed, by repeating the cycle of (*a*) with the pod isolation cocks open.

21 Failure of fuel to flow following a normal contact

If, following an apparently normal contact and appearance of the green light, no fuel is transferred to the receiver—proceed as follows:

(*a*) Receiving aircraft checks all relevant switches.

(*b*) Tanker checks all relevant switches.

(*c*) The fault may have been a " soft " contact, therefore receiver withdraws and makes a further contact.

(*d*) If fuel still fails to transfer, a fault in the pod is probable and no remedial action is possible.

22 Failure of a high level float switch

If the high level float switch fails, fuel streams from a vent about fifteen feet inboard of the pod at a rate of approximately 40 gallons/minute. The pattern of flow passes above the receiver and should cause no hazard if the receiver does not fly too high above his normal station.

Part I

Chapter 3B—Three-point Tanker Installation Mk. (K) 1 and Mk. (K) 1A Aircraft

List of Contents

Description, Controls and Indicators

1 Description

(*a*) The three-point tanker installation is comprised of two wing-

unit (HDU) carried in the bomb-bay. Each pod and the HDU are controlled from panel CI on the rear crew compartment starboard wall. The fuel system is controlled by the pilots. Both (K) 1 and (K) 1A aircraft are fitted with the Sapphire 207 engines but (K) 1

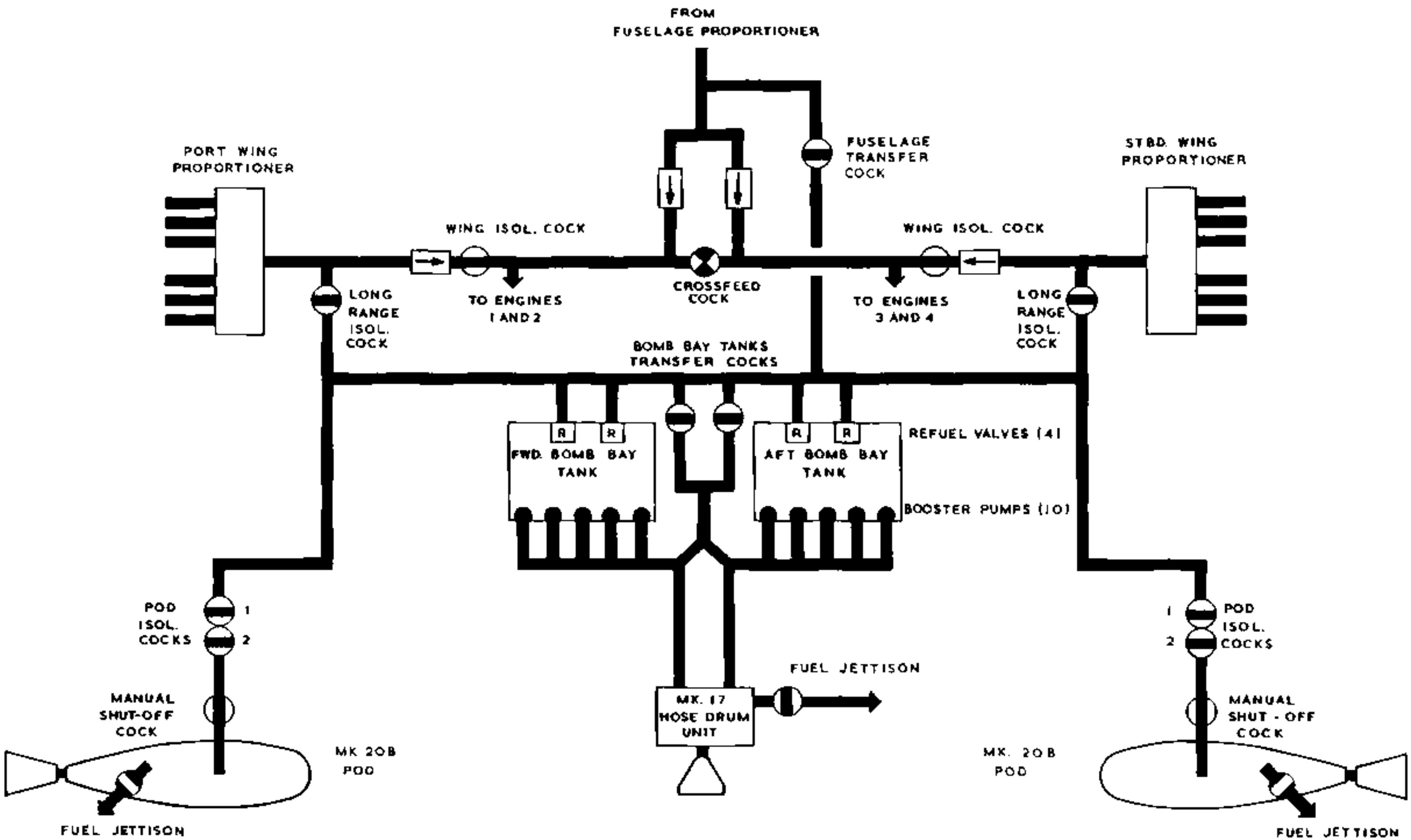

Fig. 1 Fuel system

(*b*) The pods each have a capacity of approximately 1,000 lb. of fuel. Normally each pod is supplied by the bomb-bay tanks, but it is possible to supply either or both pods from any suitable combination of tank groups by appropriate switching.

(*c*)(i) The HDU is supplied with fuel from the bomb-bay tanks. The HDU fuel pump is driven by an air turbine fed from the hot air supply to the tail anti-icing jet pumps.

(ii) The HDU hydraulic supplies, for raising and lowering the unit, and for brake applications, are obtained from the old bomb-bay doors pipelines, since bomb doors are not fitted.

(*d*) (i) Each bomb-bay tank contains five booster pumps. Two refuelling valves in each tank permit fuel to be transferred from any combination of wing/fuselage groups.

(ii) The electrical supply to the booster pumps in the bomb-bay tanks is arranged so that single bus-bar failure does not affect all pumps in one tank. Three pumps in the forward tank and two in the aft are supplied by the port MV bus-bar, the remainder being served by the starboard MV bus-bar.

(*e*) The pods and HDU are automatic in operation once certain settings have been made by the panel operator. The panels contain indicators and lights to give visual evidence of the progress of the refuelling operation and warning of abnormal conditions necessitating special action. Such action may happen automatically or require further switch selections by the operator.

(*f*) A periscope is mounted between the two navigators for rearward and downward viewing of the receiver contacting the hose.

2 Pilots' switch panel

(*a*) *Panel AT*

(i) Panel AT for both the Mk. 1 and Mk. 1A aircraft has been similarly revised to cater for the additional switches required, as follows:

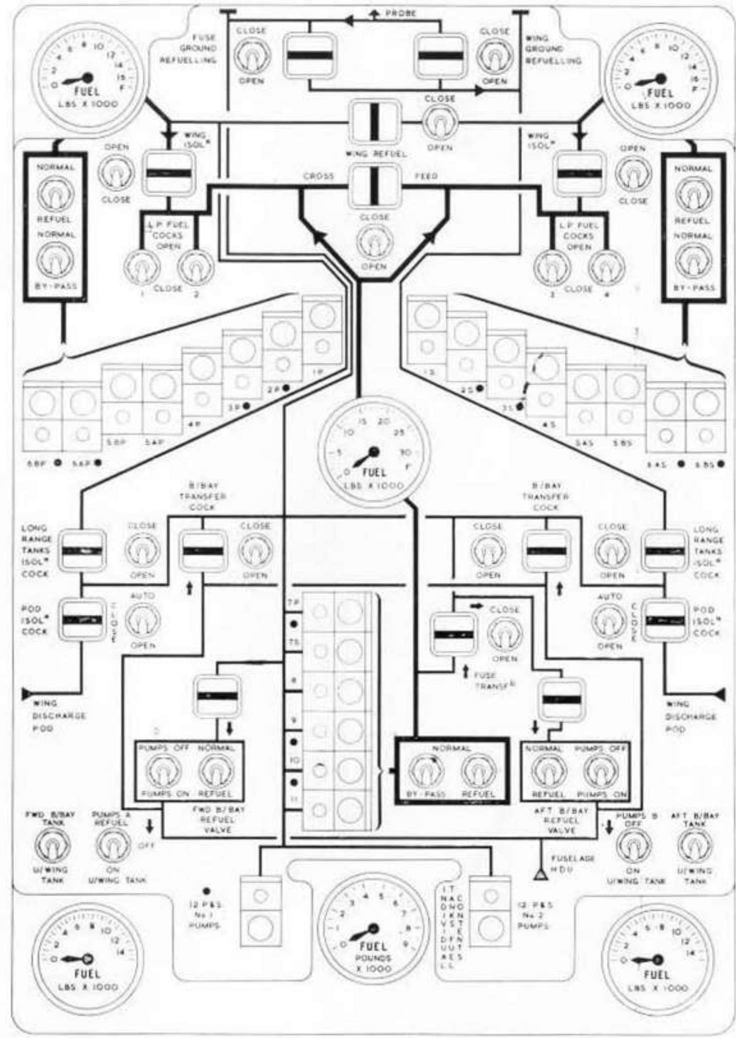

Fig. 2 Pilots' panel AT

1 Two B/BAY TRANSFER COCK, CLOSE/OPEN switches each with an adjacent magnetic indicator which gives an in-line indication when its associated cock is open. Circuit breakers are on board AJ. Either cock controls the flow of fuel from the bomb-bay tanks to the Mk. 20B pods and/or to the engines. Normally both cocks should be operated.

2 Two POD ISOLN COCK, AUTO/CLOSE/OPEN switches each with an adjacent magnetic indicator which gives an in-line indication when the two isolation cocks for the associated pod are open. The AUTO (normal) setting of the switches controls, via float switches, the pod fuel level to maintain it between mid-level and full by automatically opening and closing the cocks as necessary. Circuit breakers are on board AJ.

3 One FUSE TRANSFER OPEN/CLOSE switch with an adjacent magnetic indicator which gives an in-line indication when the transfer cock is open. A circuit breaker is on board AJ and electrical supply is from the starboard MV bus-bar. The cock controls the flow of fuel from the fuselage group to the bomb-bay tanks or to the Mk. 20B pods.

(ii) The following changes have been made to existing switches:

1 The fuselage proportioner NORMAL/BYPASS and NORMAL/REFUEL switches have been repositioned side-by-side.

2 The bomb-bay tanks PUMPS ON/OFF/REFUEL switches have been replaced by NORMAL/REFUEL and PUMPS ON/PUMPS OFF switches. Each PUMPS switch controls all five pumps in its associated tank. Electrical supplies to the REFUEL switches are from the starboard MV bus-bar.

3 The bomb-bay tanks/drop tanks contents gauge switches have been re-annotated FWD (AFT) B'BAY TANK/U'WING TANK.

(*b*) *Test switches*

On the forward face of Panel AJ are two lights, PORT No. 1 and STBD No. 1 PRESS TO TEST No. 2. These are for checking the position of the pod isolation cocks. When the No. 1 cock of each pod is closed the light comes on. Pressing each light individually causes the light to go out and then come on again provided that the associated No. 2 cock is closed. Failure of a light to come on when the pod isolation cock switch is set to CLOSED means that the appropriate cock has not fully closed.

(*c*) *Fuel jettison switch (post-Mods.* 3997 *and* 3998)

A caged BOMB BAY TANKS FUEL JETTISON VALVE switch on panel AC when set to JETTISON enables fuel to be pumped out of the bomb-bay tanks, via the HDU fairing, at the rate of approximately 4,000 lb/min.

3 Tanker operator's pod control panels

(*a*) On each pod control panel are the following controls:

(*b*) *Switches*

(i) *Master switch*

The MASTER (ON/OFF) SWITCH controls all electrical circuits to the pod except those controlled by the turbine overspeed switch.

(ii) *Fuel jettison switch*

The FUEL JETTISON, ON/OFF controls the jettison valve in the pod. A guard on the switch must be rotated through 90° before the switch can be operated.

(iii) *Wind/trail switch*

The WIND/TRAIL switch controls the winding or trailing of the hose.

(iv) *Emergency trail switch*

The EMERGENCY TRAIL/OFF/HOSE RELEASE switch permits the hose to be extended to the full trail position from which it can be jettisoned by selecting HOSE RELEASE.

(v) *Refuelling lights switch*

The REFUEL LTS, DAY/NIGHT switch controls the choice of brightness of the signal lights in the pod.

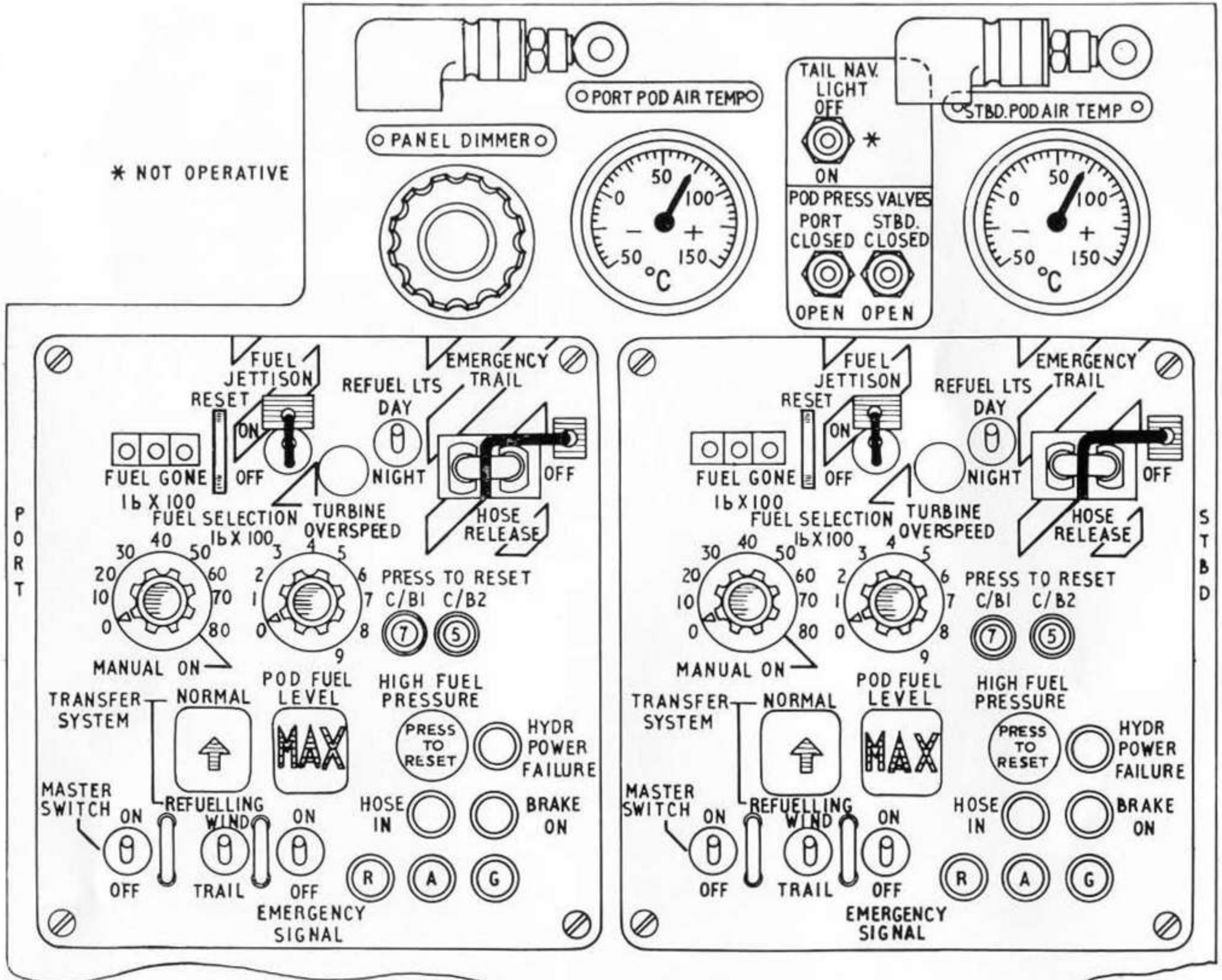

Fig. 3 Tanker operator's pod controls

(vi) *Emergency signal switch*

The EMERGENCY SIGNAL, ON/OFF switch causes the red signal lights to come on irrespective of any other lights which may be illuminated.

(*c*) *Fuel selection controls*

(i) *Fuel selector switches*

Two fuel selector rotary switches, one reading in tens of hundreds and the other reading in hundreds are preset to the amount of fuel required to be transferred. Passage of fuel causes the switches to rotate anti-clockwise giving an indication of the amount still to be transferred. At the end of transfer the fuel selector valve automatically closes. However, the left-hand switch has a MANUAL ON position and with the switch thus set an unrestricted amount of fuel may be transferred without preset limitation.

(ii) *Fuel totaliser*

A veeder counter is mounted above the selector switches giving a reading of FUEL GONE in hundreds of pounds.

(*d*) *Magnetic indicators*

(i) *Refuelling indicator*

An arrow indication points either to NORMAL or RE-FUELLING. The REFUELLING indication is given whenever the pod isolation cocks are open. The NORMAL indication is given when the cocks are closed. The indicator shows black when the aircraft power supplies are off and is independent of the master switch.

(ii) *Fuel level indicator*

The POD FUEL LEVEL indicator shows MIN or MAX according to the amount of fuel in the pod. The indicator shows black at intermediate conditions.

(*e*) *Warning lights*

(i) Warning lights are fitted to provide indication of HIGH FUEL PRESSURE (amber), HYDR POWER FAILURE (red), HOSE IN (white), BRAKE ON (blue) and TURBINE OVER-SPEED (red). Additionally the HOSE IN light pulsates while the hose is being trailed or wound in.

(ii) Three signal lights operate automatically once a refuelling operation has commenced. The red light comes on when the hose is being trailed or wound in, but not at full trail. The amber light comes on when the hose is at full trail. The green light comes on when the receiver aircraft has engaged the drogue, the hose has wound in by six feet and the necessary components have functioned to permit passage of fuel.

(*f*) *Circuit breakers*

Two PRESS TO RESET circuit breakers protect the normal (CB1) and emergency (CB2) circuits in the pod.

(*g*) *Pod air pressure valves*

The PORT and STBD. POD PRESS VALVES, OPEN/CLOSE switches control the supply of air from the engine compressors to pressurise the refuelling pods. Additionally an AIR TEMP. gauge is provided for each pod; the air temperature must not exceed 100°c in use.

4 Tanker operator's HDU control panel

(*a*) The HDU control panel at the bottom of panel CI has the following controls.

(*b*) *Switches*

(i) *Master switch*

The MASTER, ON/OFF switch controls the turbine pump and the hose circuits.

(ii) *Retraction switch and indicator*

The RETRACTION, UP/DOWN switch controls the raising and lowering of the HDU. Above the switch is a RETRACT INDicator which shows:

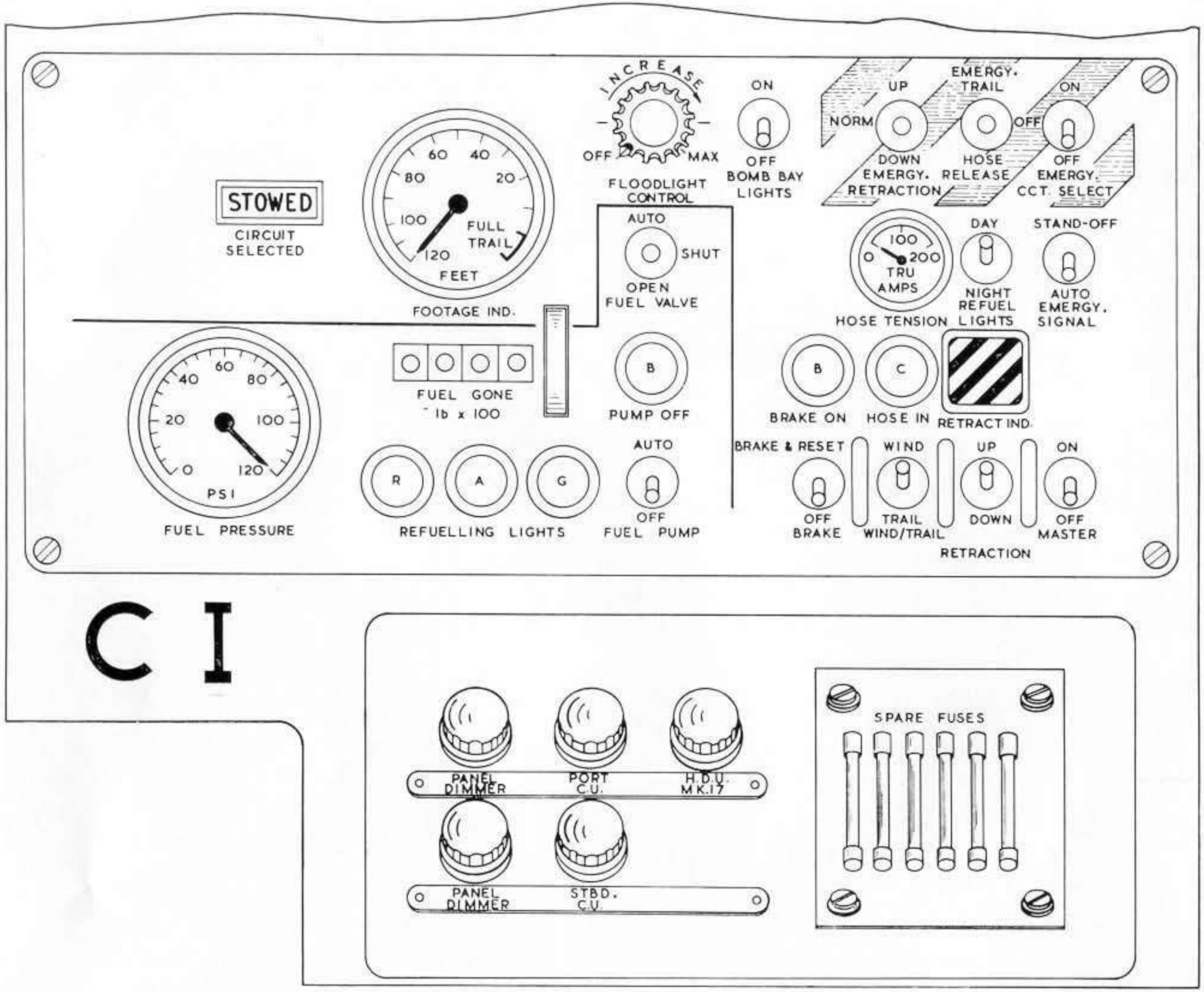

Fig. 4 Tanker operator's HDU controls

UP	HDU raised
Striped	Circuit de-energised or HDU at an intermediate position
DOWN	HDU lowered

(iii) *Wind/Trail switch and light*

The WIND/TRAIL switch controls the hose to be trailed or wound in. Above the switch is a HOSE IN white warning light which comes on when the hose is fully stowed.

(iv) *Brake switch and light*

The BRAKE, OFF/BRAKE & RESET switch can be used to apply the HDU brake if necessary or to reset the brake to off if it has been applied by the overspeed control unit. The blue warning light comes on when the brake is applied.

(v) *Fuel pump switch and warning light*

The FUEL PUMP, AUTO/OFF switch controls the air turbine driven delivery pump. With the switch at AUTO the pump runs when the receiver is in contact, provided that 6 feet of hose has wound in and the fuel valve switch is set to AUTO. Above the pump switch is a blue warning light which comes on when the pump is not running. The fuel pump is automatically switched off if fuel pressure exceeds 75 PSI.

(vi) *Fuel valve switch*

The FUEL VALVE, AUTO/SHUT/OPEN switch controls the valve in the fuel delivery line. With the switch at AUTO the valve opens after the receiver is in contact and about 6 feet of hose is wound in.

(vii) *Emergency circuit selector*

The EMERGENCY CCT SELECT ON/OFF switch enables the next circuit to be selected if this does not occur automatically.

(viii) *Hose jettison switch*

The EMERGY TRAIL/OFF/HOSE RELEASE when set to EMERGY TRAIL causes the hose to trail fully, from which position it may be jettisoned by selecting HOSE RELEASE.

(ix) *Emergency retraction switch*

The EMERGY RETRACTION, UP/NORM/DOWN switch enables the HDU to be operated UP or DOWN if the normal circuit fails.

(*c*) *Indicators*

(i) *Circuit selection indicator*

A seven-position CIRCUIT SELECTED indicator shows the following indications according to the progress of the operation: TRAIL, GEAR H (high), REFUEL, GEAR L (low) WIND, PRE-STOW, STOWED.

(ii) *Footage indicator*

The FOOTAGE IND, marked in FEET from 120 clockwise to FULL TRAIL indicates the amount of hose wound on the drum.

(iii) *Fuel gone indicator*

The FUEL GONE, lb × 100, veeder counter indicates the total amount of fuel passed to the receiver. A knurled wheel is provided to reset the counters to zero.

(iv) *Fuel pressure indicator*

The FUEL PRESSURE indicator shows the fuel pressure in PSI at the venturi throat.

(v) *Hose tension indicator*

The HOSE TENSION indicator shows the current in amps being consumed by the torque drive to the hose drum. It is calibrated 0, 100, 200 with a red mark at the 150 amp position. This position indicates the maximum torque to be applied to the motor. With the hose trailed the reading is normally 120 amps. A lower (50-60 amps) reading is indicated when the hose is being trailed. Hose tension is controlled automatically.

(*d*) *Lighting*

(i) *Floodlight control*

The floodlight OFF/INCREASE/MAX rheostat switch although on the HDU control panel is to control the brilliance of the under-wing floodlights.

(ii) HDU *floodlights*

The BOMB BAY LIGHTS, ON/OFF switch controls the two floodlights on the HDU fairing which illuminate the hose drum and serving unit.

(iii) *Signal lights*

A row of coloured lights, two red, two amber and two green, on the HDU are used for signalling to the Receiver aircraft. The duplication is simply a safeguard against failure. The red lights warn the Receiver not to attempt contact, or to break away if in contact. They are controlled by an EMERGY SIGNAL AUTO/STAND-OFF switch. When set to AUTO the red lights go out at full trail and the amber lights come on to indicate that the aircraft is ready for contact to be made. When the fuel valve is open, the lights change from amber to green. The green lights then remain on all the time that the fuel valve is open. The STAND-OFF position switches on the red lights irrespective of the progress of the operation. The three pairs of signal lights each have a REFUELLING LIGHTS repeater on the Tanker panel, and their intensity is controlled by a DAY/NIGHT REFUEL LIGHTS switch.

(iv) At the top of Panel CI is a TAIL NAV LIGHT, OFF/ON switch by means of which the tail navigation light may be switched off when necessary.

(*e*) *Circuit breakers*

NORMAL SUPPLY and EMERGENCY SUPPLY circuit breakers control the 28v supplies and are on Panel BB.

Normal Procedures and Handling

5 Taxying

A careful watch must be kept for obstructions as the wing pods are 85 feet apart and have a small ground clearance.

6 Take-off and landing

(*a*) Care must be taken to keep the wings level during take-off and landing, particularly in gusty cross-wind conditions; with the main wheels close to the ground, approximately 10° of bank can cause the appropriate wing pod to touch the ground.

(*b*) When raising the flaps, after take-off at maximum AUW, slight pre-stall buffet may occur in turbulence until speed is increased above 200 knots. Under these conditions, turns and abrupt nose-up changes of attitude are to be avoided.

7 In flight

(*a*) *Preparing for contact and trailing the hose*

(i) The operator should carry out the pre-contact checks contained in the Operators Check List and keep the pilot informed of the progress of all in-flight refuelling operations.

(ii) Before a wing hose is trailed, when non-feathering turbine blades are fitted to the pod, speed must be reduced to 200 knots and then increased to the flight refuelling speed to overcome the hysteresis of this type of turbine.

(iii) After the initiation of a refuelling operation, a wing hose will take approximately 20 seconds, and the centre hose 32 seconds, to reach the trail position. When a wing hose is trailed, small directional and lateral trim changes occur; trailing the centre hose has little noticeable effect on the aircraft. Before a receiver makes contact, the tanker should be accurately trimmed at the flight refuelling speed. The optimum speed range for flight refuelling is 250-270 knots.

(iv) When ready for contact, the tanker must be flown as steadily as possible to create a stable platform for the benefit of the receiver. Abrupt control movement and coarse use of the throttle should be avoided. Particular care is required when handling the elevators since short period pitching oscillations can be induced, so causing the hose to oscillate.

(*b*) *Approach and contact*

(i) When a receiver approaches and contacts a wing hose, the tanker tends to roll away from the hose in use. When a receiver approaches and contacts the centre hose, the tanker experiences a nose-down change of trim which must be counteracted by very careful, progressive use of the elevators. In both cases, the speed of the tanker increases slightly and power should be reduced by 1 to 3% RPM to maintain the refuelling speed after contact is established.

(ii) As fuel is transferred to the receiver, power should be reduced to maintain level flight and the refuelling speed.

(iii) To reduce the effects of cold soaking, the hose should be wound in and the HDU raised as soon as the transfer of fuel to a receiver is complete and the pod master switches should be selected ON for 5 minutes in every half hour.

Management of the Aircraft Fuel System

8 Fuel loading

(*a*) *Transfer flights*

(i) Load the amount of fuel to be transferred into the bomb-bay tanks. If this exceeds the capacity of the bomb-bay tanks, they should be filled.

(ii) Load 16,000 lb. of fuel into the fuselage tanks.

(iii) Load the remaining fuel required into the wing tanks. When the wing tanks are full, load any further fuel required into the fuselage tanks up to the maximum AUW of the aircraft.

(iv) Fill the pods from the wing tanks.

(*b*) *Transit flights*

(i) Fill the wing and fuselage tanks as required.

(ii) When the wing and fuselage tanks are full, load any further fuel required into the bomb-bay tanks up to the maximum AUW of the aircraft.

(*c*) *Wing relief limitations*

The total contents of the fuselage and bomb-bay tanks must not exceed:

(i) 44,000 lb. when the wing tanks are empty.

(ii) 52,000 lb. when the wing tanks are half full.

9 Internal transfer of fuel

(*a*) *Wing tanks to bomb-bay tanks*

To transfer fuel from the wing tanks to the bomb-bay tanks select:

(i) All wing and fuselage pumps ON.

(ii) All proportioners NORMAL.

(iii) Long range isolation cocks OPEN.

(iv) Pod isolation cocks CLOSED.

(v) Bomb-bay tanks refuelling switches REFUEL.

(vi) Appropriate bomb-bay tank refuelling switch NORMAL or REFUEL as required to maintain equal amounts of fuel in the two bomb-bay tanks.

(vii) Fuselage proportioner BYPASS and wing isolation cocks CLOSED when the wing contents fall to 5,000 lb. each.

(viii) Pumps in tanks 8 and 9 ON or OFF as required to control any out of balance condition.

(ix) Wing proportioners BYPASS when the wing contents fall to 2,000 lb. each.

(x) Individual wing tank pumps OFF as the tanks empty.

(xi) Wing isolation cocks OPEN when all the wing tanks are empty.

The long range isolation cocks must remain open when all the wing tanks are empty.

(*b*) *Wing pods to bomb-bay tanks*

To transfer fuel from the wing pods to the bomb-bay tanks select:

(i) Wing and fuselage pumps and proportioners as required.

(iii) Pod isolation cocks OPEN.
(iv) Bomb-bay refuelling switches REFUEL.
(v) Pod pressure valves OPEN.
(vi) Pod isolation cocks and pressure valves CLOSED when the pod fuel level indicator shows MIN.

After transferring pod fuel to the bomb-bay tanks, a small amount of fuel must be transferred from the wing tanks to the bomb-bay tanks to purge the fuel lines of air.

(c) *Wing tanks to wing pods*

To transfer fuel from the wing tanks to the wing pods select:

(i) Wing and fuselage pumps ON and proportioners NORMAL.
(ii) Long range isolation cocks OPEN.
(iii) Pod isolation cocks AUTO.

(d) *Bomb-bay tanks to wing pods*

To transfer bomb-bay fuel to the wing pods select:

(i) Wing and fuselage pumps and proportioners as required.
(ii) Long range isolation cocks CLOSED.
(iii) Bomb-bay tanks transfer cocks OPEN.
(iv) Pod isolation cocks AUTO.
(v) Bomb-bay tank pumps ON.

(e) *Bomb-bay tank to bomb-bay tank*

To transfer fuel from one bomb-bay tank to the other select:

(i) Wing and fuselage pumps and proportioners as required.
(ii) Long range isolation cocks CLOSED.
(iii) Bomb-bay tanks transfer cocks OPEN.
(iv) Refuelling switch of bomb-bay tank to receive fuel REFUEL.
(v) Pump switch of the other bomb-bay tank ON.

(f) *Fuselage tanks to bomb-bay tanks*

To transfer fuel from fuselage tanks to bomb-bay tanks select:

(i) Wing and fuselage pumps ON and proportioners NORMAL.
(ii) Fuselage transfer cock OPEN.
(iii) Bomb-bay tanks refuelling switches REFUEL.
(iv) Appropriate bomb-bay tank refuelling switch NORMAL or REFUEL as required to maintain equal amounts of fuel in the bomb-bay tanks.

10 Bomb-bay tanks feeding the engines

(a) To feed fuel from the bomb-bay tanks to the engines select:

(i) Fuselage pumps ON and proportioner NORMAL.
(ii) Wing proportioners to BYPASS and pumps OFF.
(iii) Long range isolation cocks OPEN.
(iv) Bomb-bay tanks transfer cocks OPEN.
(v) Bomb-bay tank pumps ON.
(vi) Fuselage proportioner to BYPASS.
(vii) Fuselage pumps OFF.

(b) When feeding fuel from the bomb-bay tanks to the engines after the pod fuel and wing fuel has been transferred to the bomb-bay tanks, the fuselage pumps should be ON and the fuselage proportioner should be at BYPASS.

11 Transferring to a receiver

(a) *Transfer from the* HDU

To transfer fuel from the bomb-bay tanks to a receiver through the HDU select:

(i) Wing and fuselage pumps and proportioners as required.
(ii) Long range isolation cocks as required.
(iii) Bomb-bay tank pumps ON when ready for contact, after trailing the hose.

When transferring more than 25,000 lb. of fuel, as soon as fuel is flowing to the receiver, commence transferring wing fuel to the bomb-bay tanks (see para. 9(*a*)). If contact is broken during transfer, stop the internal transfer of fuel from the wing tanks to the bomb-bay tanks until contact is re-established.

(b) *Transfer from the wing pods*

To transfer fuel from the bomb-bay tanks to a receiver through the wing pods select:

(i) Wing and fuselage pumps and proportioners as required.

(ii) Long range isolation cocks CLOSED.
(iii) Bomb-bay tanks transfer cocks OPEN.
(iv) Pod isolation cocks AUTO.
(v) Pod pressure valves OPEN.
(vi) Bomb-bay tank pumps ON when ready for contact, after trailing the hose.

If it is necessary to transfer more than 25,000 lb. of fuel, wing tank fuel should be transferred to the bomb bay tanks between receiver transfers.

12 Bomb-bay tank contents

(*a*) The contents of the two bomb-bay tanks should normally be kept equal but, when both tanks are delivering fuel at the same time, one tank feeds faster than the other, i.e. one tank still contains up to 3,000 lb. of fuel when the other tank becomes empty.

(*b*) To keep the contents equal:

(i) When transferring fuel from the bomb-bay tanks through the HDU, transfer fuel from the wing tanks to the appropriate bomb-bay tank.

(ii) When feeding the engines from the bomb-bay tanks, switch the bomb-bay tank pumps selectively.

(iii) Transfer fuel from one bomb-bay tank to the other when transfer to a receiver is not being carried out.

13 Fuel jettison

(*a*) *Via wing pods*

(i) To jettison pod fuel only, select the pod isolation cocks CLOSED, pod pressure valves OPEN and the pod fuel jettison switches ON.

(ii) To jettison aircraft fuel, select transfer to the pods as required, pod isolation cocks AUTO, pod pressure valves OPEN and pod fuel jettison switches ON.

(iii) When jettisoning from the wing groups, fly on the fuselage group with its proportioner at BYPASS. When jettisoning from the bomb bay tanks, fly on the wing or fuselage groups as required. After jettisoning is complete, revert to the appropriate normal fuel handling drill.

(*b*) *Via Mk.* 17 HDU

(i) In emergency, fuel may be jettisoned from the bomb bay tanks, or from the wing tanks by transfer to the bomb bay tanks, via the Mk. 17 HDU.

(ii) Jettisoning may be carried out at all altitudes at speeds up to 300 knots.

(iii) As some fuel contamination of the rear fuselage may occur, the Green Satin and Mk. 6 altimeter must be switched off while fuel is being jettisoned.

(iv) To jettison fuel from the bomb bay tanks only, fly on the wings or fuselage groups as required, select the bomb bay tank pumps on and open the bomb bay tanks jettison valve.

(v) To jettison fuel from the wing tanks, fly on the fuselage group with its proportioner at BYPASS, establish fuel transfer from the wing groups to the bomb bay tanks and jettison fuel from the bomb bay tanks. Careful consideration is required before jettisoning wing fuel in an emergency that involves the failure of an MV busbar (see Chapter 2, para. 27(*b*)).

(vi) When the required amount of fuel has been jettisoned, revert to the appropriate fuel handling procedure; jettisoning must be stopped before landing.

(vii) If a landing has to be made with the HDU down, the jettison pipe is likely to contact the runway.

14 Wing isolation cocks

(*a*) The wing isolation cocks should normally be open at all times, except as in para. 9(*a*)(vii).

(*b*) If a wing isolation cock fails to open, it may be bypassed by opening the wing refuelling cock.

15 CG and wing relief limits

If, at any time, the CG or wing relief limitations should inadvertently be exceeded, internal transfer of fuel or selective switching of fuel pumps must be carried out to regain normal conditions.

16 Fuel handling procedure

The fuel handling procedure is designed to keep as much fuel as possible in the wing tanks at all times and to reduce the total contents of the fuselage and bomb-bay tanks to a minimum before the remaining wing fuel is transferred to the bomb-bay tanks.

(*a*) *Transfer flights*

(i) Start and taxy as normal.

(ii) Take-off with all wing and fuselage booster pumps ON and all proportioners NORMAL.

(iii) After take-off:

1 If the fuselage tank contents have fallen to 14,000 lb., select the fuselage proportioner to BYPASS and the fuselage booster pumps OFF.

2 If the fuselage tank contents are more than 14,000 lb. select the wing proportioners to BYPASS and the wing booster pumps OFF.

(iv) When the fuselage tank contents fall to 14,000 lb. select the wing booster pumps ON, wing proportioners NORMAL, fuselage proportioner BYPASS and the fuselage booster pumps OFF.

(v) During transfer to a receiver, fly on the wing or fuselage groups as in (iii) or (iv), above. When either wing group contents fall to 5,000 lb. select the wing proportioners to BYPASS and leave the wing booster pumps ON. Select the fuselage proportioner to NORMAL and the fuselage booster pumps ON. Switch off all the booster pumps in one wing group to prove that the fuselage proportioner is working; then switch the pumps on again. When the fuselage group starts to feed, select the fuselage proportioner to BYPASS.

(vi) Whenever fuel is transferred from the wing tanks to the bomb-bay tanks proceed as in para. 9(*a*).

(vii) After all transfers to receivers are complete, where necessary, reduce the contents of each bomb-bay tank to 2,000 lb.

(viii) Transfer the pod fuel and then the wing tank fuel to the bomb-bay tanks.

(ix) When the wing tanks are empty, leave the fuselage pumps ON and the proportioner BYPASS and, at the same time feed the bomb-bay tank fuel to the engines. Maintain balance by the selective switching of the pumps in tanks 8 and 9.

(x) If a flight has to be continued when the total contents of the fuselage and bomb-bay tanks are below 8,000 lb., maximum engine RPM, extreme attitudes and large accelerations should be avoided; an overshoot should not be carried out unless the fuselage tanks contain a total of at least 5,000 lb. of fuel or the bomb-bay tanks contain a total of at least 4,000 lb.

(*b*) *Failure to transfer*

If, during a flight when transfer to a receiver is planned, a failure to transfer all or part of the fuel occurs, continue the fuel handling from the appropriate point in para. 17 reducing the contents of the bomb-bay tanks, the fuselage tanks and finally the wing tanks before transferring the pod fuel and then the wing fuel to the bomb-bay tanks.

17 Transit flights

(*a*) Start and taxy as normal.

(*b*) Take-off with all wing and fuselage booster pumps ON and all proportioners NORMAL.

(*c*) After take-off select the wing proportioners to BYPASS and the wing booster pumps OFF.

(*d*) At 20,000 feet:

(i) If the bomb-bay tanks total contents are 4,000 lb. or less, continue to fly on the fuselage tanks.

(ii) If the bomb-bay tanks total contents exceed 4,000 lb., feed the bomb-bay fuel to the engines.

(*e*) When the bomb-bay tank contents fall to 2,000 lb. each select the fuselage booster pumps ON, fuselage proportioner NORMAL (*f*) When the fuselage tank contents fall to 14,000 lb., select the wing booster pumps ON, wing proportioners NORMAL, fuselage proportioner BYPASS and the fuselage booster pumps OFF.

(*g*) When the wing group contents fall to 5,000 lb. each, select the fuselage tank booster pumps ON and transfer the pod fuel and then the wing tank fuel to the bomb-bay tanks.

(*h*) Continue as in para. 16(*a*) (ix) and (x).

18 Tanker refuelling

(*a*) When the tanker is to be refuelled in flight, adjust the fuel tank contents so that the fuselage and bomb-bay tanks can receive the greater part of the fuel to be transferred. This ensures that the wing relief limitations cannot be exceeded and that a high rate of fuel flow is achieved. During transfer, fly on the fuselage group.

(*b*) After contact, to reduce the possibility of pressure build up in the fuel lines and to open the bomb-bay/fuselage NRV, pass fuel to the wing, fuselage and bomb-bay tanks ; as soon as fuel is flowing, stop refuelling the wing tanks.

(*c*) When filling a fuel tank group completely, stop refuelling that particular group when:

(i) *Bomb-bay tanks*
The gauges show full.

(ii) *Fuselage group*
Two magnetic indicators show striped.

(iii) *Wing groups*
One magnetic indicator shows striped.

Malfunctioning of the Pods and HDU

NOTE: In this section only those procedures necessitating action or consideration by the pilot are given. Other malfunctions which rely entirely on Tanker Operator actions have been omitted.

19 Failure of pod isolation cocks to open

If this occurs the only fuel available for transfer will be that already in the pod. Diagnosis of this condition can only be made by reference to the pod isolation cocks indicator or fuel contents gauges. Additionally the REFUELLING indication is not given.

20 Pod hydraulic failures

(*a*) *Hose stowed*

The hose must not be trailed if the pod HYDRAULIC POWER FAILURE warning light is on.

(*b*) *Hose trailed*

(i) If failure occurs during contact, fuel stops flowing.

(ii) Attempt to wind in the hose normally.

(iii) If the hose cannot be wound in, it should be jettisoned when safe to do so.

21 Failure of a pod high level float switch

If the high level float switch in a pod fails, fuel streams from a vent about fifteen feet inboard of the pod at a rate of approximately 40 gallons/minute. The pattern of flow passes above the receiver and should cause no hazard if the receiver does not fly above his normal station.

22 Failure of fuel to flow following a normal contact

If, following an apparently normal contact and appearance of the green light, no fuel is transferred to the receiver, proceed as follows:

(*a*) Receiving aircraft checks all relevant switches.

(*b*) Tanker checks all relevant switches.

(*c*) The fault may have been a " soft " contact, therefore receiver withdraws and makes a further contact.

(*d*) If fuel still fails to transfer, a fault in the pod or HDU is probable and no remedial action is possible.

23 Drogue failures

(*a*) During transfer in turbulent conditions if a hose becomes unstable the receiver aircraft should withdraw. Both tanker and receiver should then adjust height to another level where turbulence is not experienced and establish a fresh contact.

(*b*) (i) In severe turbulence there is a risk of loss of or damage to the drogue.

(ii) If the drogue is lost the hose quickly winds in.

(iii) Partial breakdown of the drogue may cause hose instability. Reduce speed prior to rewind in an attempt to stabilise ; when stabilisation occurs rewind the hose. If it remains unstable the hose must be jettisoned.

24 Receiver probe lodged in coupling

(*a*) If the pod is in use close the isolation cocks and select fuel counters to " Zero " to minimise loss of fuel from the pod. If the HDU is in use switch OFF the master switch and the bomb-bay tank pumps.

(*b*) Check with receiver aircraft whether:

(i) Nozzle, or

(ii) Nozzle and fuel tube is lodged in coupling, causing hose gyrations.

(*c*) In case (i) wind in hose normally. In case (ii) the hose must be jettisoned.

25 Hose fails to wind in

If the hose fails to wind in, increase airspeed to maximum then progressively reduce airspeed with WIND selected. Rewind should commence at 240 knots. The application of sideslip may be of assistance.

26 Hose jettison

(*a*) If, because of electrical or hydraulic failure, a hose cannot be wound in it must be jettisoned, if possible, before landing.

(*b*) Before jettisoning the hose, speed should be reduced to 200 to 230 knots depending on AUW. The operator then selects EMERGENCY TRAIL, with repeated selections until panel indications show the hose to be at full trail. In the case of a Mk. 17 HDU hose, during trailing the EMERGENCY HYDRAULIC WARNING light on panel AZ indicates the aircraft hydraulic system is operating in the emergency condition.

(*c*) With the hose at full trail, speed should be adjusted to 230 knots and then the operator instructed to select HOSE JETTISON.

27 Landing with a hose trailed

(i) If the aircraft has to be landed with a hose trailed, to ensure that the hose does not contact the undershoot area, a normal approach should be made to the instrument touchdown point, approximately 300 yards in from the runway threshold.

(ii) When landing with the centre hose trailed, to prevent the HDU striking the ground, the threshold speed should be increased by 5 knots. The hold-off must be kept to a minimum as a nose-up attitude is to be avoided and the touchdown should be as gentle as possible. On a short runway make an early touchdown, accepting the possibility of the hose contacting the undershoot area.

(iii) The aircraft should be positioned so that the trailing hose is as near the centre of the runway as possible at touchdown.

Part I

Chapter 4—Hydraulic System and Aircraft Controls

List of Contents

Description

1 General

(*a*) Hydraulic power, supplied by two electrically-driven pumps operates the following services:

Undercarriage	Airbrakes
Nosewheel steering	Nose flaps (pre-Mod. 2352)
Wheelbrakes	Bomb-doors
Main flaps	

(*b*) The hydraulic fluid is drawn from a tank, divided into two equal halves, each half of which feeds one pump. The pressure output from each pump (4000 PSI) is fed to two electrically-operated selectors, the normal master and the emergency master. With a serviceable system the normal master selector is open and supplies the individual circuits, each having its own selector, (*c*) The emergency Master Selector is normally closed but is opened under emergency conditions and feeds pressure through pipelines independent of the normal system, to selectors for the emergency operation of

Undercarriage	DOWN
Main flaps	DOWN
Airbrakes	CLOSED
Bomb-doors	OPEN and CLOSE

(*d*) The electrical arrangement of the Master Selector is such that when an emergency selection is originated the normal Master Selector closes and the emergency master opens. If the Emergency Selection is due to an individual circuit fault the master selectors revert to their normal settings after the affected circuit has been operated, but if the emergency is due to loss of hydraulic fluid, all systems have to be operated on emergency.

2 Hydraulic reservoir

(*a*) The hydraulic tank is at the rear of the nosewheel bay together with the hydraulic pumps. The contents of the tank when at the normal level with the system fully charged are 15½ gallons. The emergency level of the tank is 9½ gallons (4¾ gallons per side).

(*b*) A float switch in each half of the tank operates when the fluid level in the respective compartment has fallen to 4¾ gallons and switches off the associated pump. Additionally warning lights at the AEO's station come on to indicate that the float switches have operated.

3 Accumulators

Accumulators are fitted in the main power circuit (one per pump) and in the wheelbrakes and nose-flap systems. Charging details are as follows:

Accumulator	*No. off*	*Location of gauges and inflation valves*	*Air charge pressure* PSI	
Power . .	2	Nose-wheel bay	3,000	
Wheelbrakes .	4	Nose-wheel bay	2,000	
			°C OAT	± 25 PSI
Nose flaps .	8	Access panels beneath nose flaps	−40	1,270
			−20	1,380
			0	1,490
			+20	1,600
			+40	1,710
			+70	1,870

Controls and Indicators

4 Hydraulic pump controls—pre-Mod. 2866

(*a*) Each of the two electrically-driven pumps draws its supply from its associated hydraulic tank compartment. Each pump is controlled by a manual switch. No. 1 pump switch is a three-position AUTO/OFF/ON type; No. 2 pump switch is a four-position GROUND TEST/AUTO/OFF/ON type. Both switches are situated in the crew compartment at the AEO's station on panel BB.

(*b*) With both switches at AUTO, during flight the pumps switch on and off according to the position of the hydraulically-operated services.

If all services are in the flight position, i.e.:

Undercarriage . . .	UP
Nose flaps	IN and accumulators fully charged
Main flaps	UP
Airbrakes	IN
Bomb-doors	CLOSED

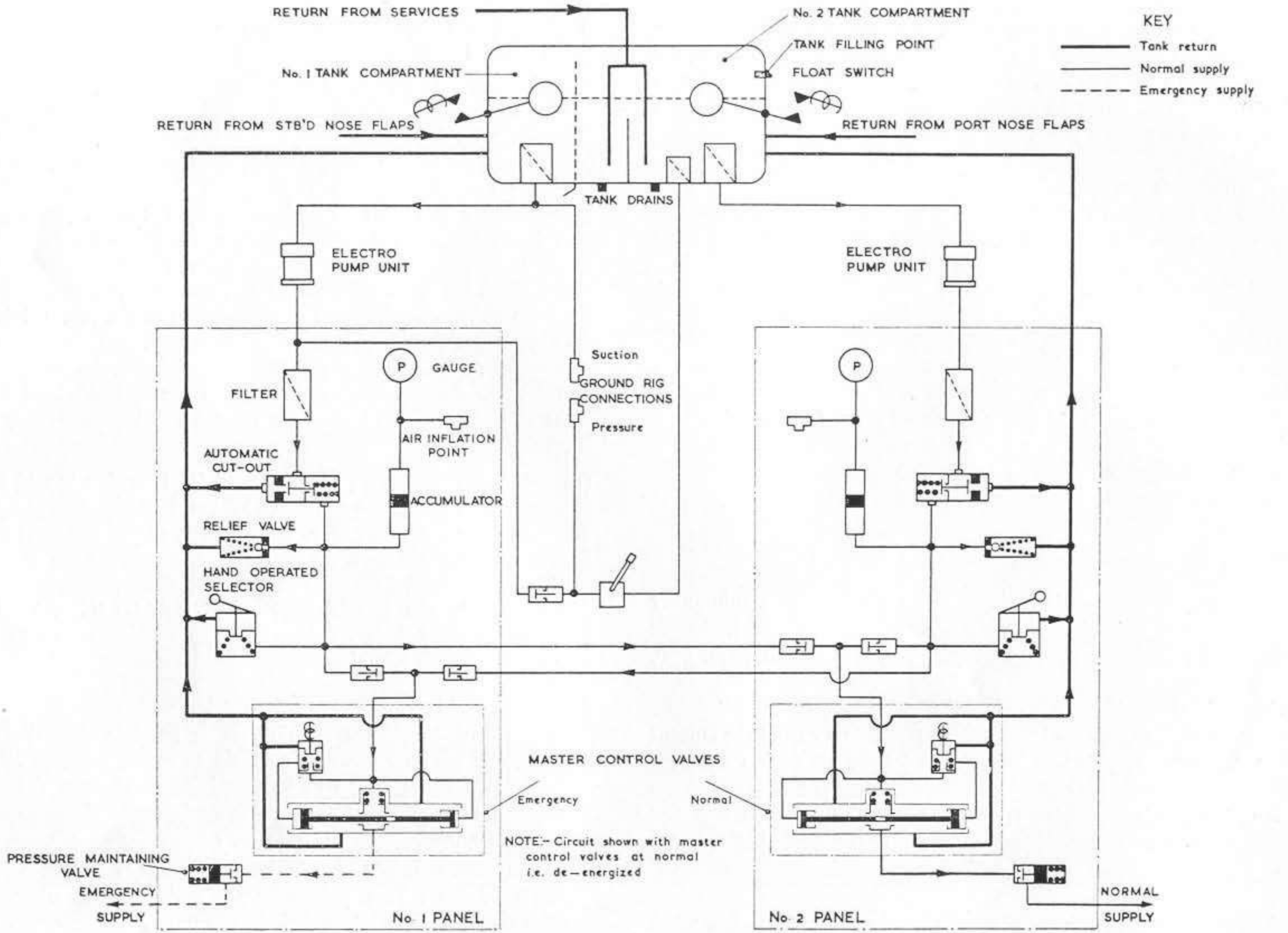

Fig. 1. Hydraulic power supplies

the pumps do not run. If any service is not in the position mentioned above both pumps run but when the pressure reaches 4,000 $^{+50}_{-0}$ PSI the pumps are off-loaded until the pressure falls again to 3,600 $^{+100}_{-0}$ PSI. Once all services are in the flight position again the pumps are automatically switched off.

(*c*) With both pump switches set to ON the pumps run continuously irrespective of the position of any of the services. The pumps run on and off load according to line pressure. With the switches in this position, the pumps are not switched off if the fluid level in the tanks falls.

(*d*) The GROUND TEST position permits the testing of No. 2 pump simultaneously with No. 1 pump. If this position is not selected only No. 1 pump runs when a ground servicing truck is plugged in, thus ensuring that the ground generating equipment is not overloaded. If both switches are at AUTO when the electrical supply is plugged in, both pumps run.

5 Hydraulic pump controls, post-Mod. 2866

(*a*) When Mod. 2866 is embodied the pumps run continuously when selected to ON or AUTO. The effect of loss of hydraulic fluid and emergency selections remains as detailed in para. 6(*a*).

(*b*) Essential to Mod. 2866 is Mod. 2348 which introduces an ammeter at the AEO's station, for each pump to measure the current in the pump motor earth lines. Additionally Bomber Command Mod. 28 provides, a green pump running light for each pump, on panel BB; their indication is that the pumps have been switched on and their main contactors are closed. They do not indicate that the pumps are actually running.

(*c*) The brake pressure gauges indicate the system pressure when this exceeds brake accumulator pressure.

6 Emergency operation of the system with the pumps at AUTO

(*a*) A failure causing loss of fluid from one power panel will cause the fluid level to drop in the tank compartment feeding that panel. When the level in that compartment, drops to the 4¾ gallons (emergency level), the compartment float switch will operate and stop the associated pump feeding the faulty panel. Hydraulic power supply will then be maintained by the other power panel, still feeding normal service lines via the normal power circuit selector. Services operation will, however, be at a reduced speed as only one pump is effective. If services continue to be selected with the power circuit in this condition, half of the return fluid will flow into the failed circuit compartment. This flow will cause intermittent operation of the float switch, allowing the pump to run and causing further loss of fluid. As a result, fluid level in the other compartment will drop until the 4¾ gallon emergency level is reached.

(*b*) When the other compartment fluid level reaches the 4¾ gallon level as in the above condition, associated float switch will operate and stop the remaining pump. Immediately the second float switch operates, the solenoids on the power circuit selectors are energised, closing the normal selector and opening the emergency selector. Simultaneously the EMERGENCY HYDRAULIC WARNING light on Panel AZ is illuminated. Any service selections must now be emergency selections.

(*c*) (i) On making an emergency selection with this condition, the pumps will commence running. It is possible that the failed panel will pump its remaining fluid to waste, consequently the serviceable panel only will be supplying fluid from the power circuit via the emergency selector to a selected service.

(ii) If a failure causing loss of fluid is experienced downstream of the power supply circuit, i.e. in a normal service line, the levels of both tank compartments will drop simultaneously. Consequently, both float switches will operate together, energising the power circuit selector solenoids to emergency open-normal closed, stopping the pumps and illuminating the EMERGENCY HYDRAULIC WARNING light. Any service selections must again be emergency selections but this time, as the fault may be in a normal service line, further fluid loss may not occur.

(iii) If an emergency selection is made due to an electrical or a hydraulic fault on a service but with the power supply circuit in a normal state, then the emergency service selection will not only energise the emergency selector for that service but will also energise the power circuit selector solenoids, changing those selectors to emergency open, normal closed for the duration of operation of that service. Upon completion of operation of that service the power circuit solenoid is de-energised and the power circuit returns to normal open, emergency closed. The emergency hydraulic warning light is then extinguished.

NOTE 1: The power supply circuit will not revert to Normal after a bomb-door emergency OPEN selection. With the doors selected open, no normal selections of other services, with the exception of nose-flaps, are available until the bomb-doors have been closed using an emergency selection.

NOTE 2: When airbrakes have been closed using an emergency selection, the 1st Pilot's control lever must be brought out of the emergency gate to the normal closed position before the power supply circuit reverts to normal and the emergency hydraulic warning light goes out.

NOTE 3: The float switch will not switch OFF its associated pump when that pump is switched to ON. Mod. 2529 introduces a warning light for each float switch on panel BB.

NOTE 4: When the undercarriage is selected by emergency selection the pumps will continue to run until the normal down button is pressed.

7 Protection units

(*a*) Protection units are fitted in the normal supply lines to the selectors of the following services:

Undercarriage
Bomb-doors
Main flaps
Airbrakes

The purpose of a unit is to isolate the normal supply to the circuit and provide an alternative path for the return fluid.

(*b*) Normally pressure fluid has an unrestricted path through the protection unit to the selector, but when an emergency selection is made emergency circuit pressure is connected to the piston of the associated protection unit to close the normal supply line. Once a protection unit has been operated, normal selection of its associated service cannot be made again in flight since the units must be manually reset and are inaccessible in flight.

8 Undercarriage control

(*a*) The undercarriage is hydraulically operated and electrically selected by one of three push-buttons, UP, DOWN and EMERGENCY-DOWN, in the centre of panel A. The buttons are mechanically interlocked, so that when any one button is pressed in, the button left in by a previous selection is released. On Mk. 1 aircraft the buttons are forward on the port console, AE.

(*b*) When the aircraft is on the ground the undercarriage cannot be retracted since the UP button is electro-mechanically locked and cannot be depressed until a pitot-switch operates at 105 knots to release the lock. Although the button can then be depressed, micro-switches on the bogie mechanism prevent the completion of the selection circuit until the weight of the aircraft is off the wheels and the tip hooks are engaged.

NOTE: The electro-mechanical lock can be overridden, for servicing purposes, by *twisting the UP button 60° clockwise.*

(*c*) On Mk. 1A aircraft the brakes are automatically applied when the UP selection circuit is completed and before the retraction cycle commences. To achieve this there is a 3 second delay before fluid is allowed to pass to the undercarriage circuit ; during this three seconds the maxaret spill line is pressurised from the under carriage UP line and the units are cocked, thus applying the brakes.

(*d*) When a DOWN selection is made, the up lines pressure is relieved and the brake units are depressurised and released.

(*e*) A standard position indicator is on panel AZ.

(*f*) Pre-Mod. 2987 the 2nd pilot's ASI incorporates an undercarriage warning device. This consists of a window in the face of the instrument in which a flag marked U/C oscillates if any undercarriage unit is not locked down at speeds below 160 knots.

9 Undercarriage emergency control

(*a*) When an EMERGENCY DOWN selection is made, the pressure supply from the pumps is changed from the normal to the emergency circuit, the protection unit is closed and the emergency selector valve opens to feed fluid to the lowering jacks.

(*b*) When the undercarriage is locked down the pressure supply reverts to normal provided that the float switches have not operated, but further undercarriage selection will not be possible and nosewheel steering will not be available.

(*c*) *Independent emergency lowering nitrogen system*

(i) Mod. 3079 introduces an independent system for emergency lowering of the main and nosewheel undercarriage. The system operates from an independent nitrogen supply and caters for the case of complete hydraulic failure.

(ii) At the rear of the second pilot's seat, facing inboard, is a control unit which incorporates a pressure gauge and a charging point. When the flap at the top of the unit is lifted a lever is revealed. When the lever is pushed fully down a valve is opened which permits nitrogen, stored in a single bottle in the plenum chamber, to pass to the normal undercarriage lowering lines. Once the undercarriage is lowered in this way it cannot be raised again until the system has been ground-serviced.

(iii) The following table lists the nitrogen bottle charging pressures, which are also given on a plate on the control unit.

Temp. °C	−40	−20	0	20	40	70
PSI . .	2,380	2,590	2,800	3,000	3,200	3,510

Tolerances in pressure are ± 25 PSI

10 Wheelbrakes control

(*a*) A maxaret braking system controlled by the rudder pedals is fitted. Four hydraulic accumulators are included in the system to provide a reserve of pressure in an emergency.

(*b*) Two separate pressure supplies feed the inboard and outboard brakes respectively of the port and starboard wheel units. Depression of either pilot's rudder pedals feeds pressure to both the inboard and outboard brakes associated with the rudder pedal which is depressed.

(*c*) (i) When Mod. 2163 (*Not* B.1 aircraft) is embodied the brakes are automatically applied when an undercarriage UP selection is made before the retraction cycle commences. To achieve this there is a 3 second delay before fluid is allowed to pass to the undercarriage circuit ; during this period the maxaret spill line is pressurised from the undercarriage UP line and the units locked, thus applying the brakes.

(ii) When a DOWN selection is made, the up line pressure is relieved and the brake units depressurised and released.

(*d*) Two pressure gauges, one for the inboard brakes and one for the outboard brakes, indicate the supply pressure of 4,000 PSI to the wheelbrakes reducing valves.

(*e*) A hand-operated parking brake is fitted at the forward end of panel AE. A warning light (MK. 1A only) alongside the undercarriage selector switch on panel A comes on whenever the parking brake is applied and either main undercarriage leg is locked down.

(f) Emergency operation

With the hydraulic circuit in EMERGENCY, only accumulator pressure will be available for braking. The brake parachute must always be streamed and maxaretting and unnecessary brake application avoided. The brake pressure gauges should be carefully monitored. When the aircraft has come to rest, no further taxying should be attempted; have the aircraft towed to dispersal.

11 Nosewheel steering

(*a*) The GROUND STEERING MASTER switch and the steering control wheel are on panel AA. Hydraulic pressure to the circuit is only available after the undercarriage has been selected down on the normal system.

(*b*) Nosewheel steering is effected by two opposed steering jacks of which hydraulic pressure is electrically controlled following movement of the handwheel. The handwheel may be operated clockwise or anti-clockwise to give a steering range of approximately 45° in either direction. When the handwheel is stopped and held in any position the nosewheel is held at a similar position giving a constant turning radius.

(*c*) When the handwheel is released a centring spring returns it to neutral at which setting the nosewheel is free to caster.

(*d*) No emergency system is incorporated, i.e. no steering power is available if the undercarriage has been lowered on emergency or if both hydraulic tank float switches have operated.

(*e*) The handwheel may be pulled out from its normal position by up to 3 inches for greater pilot comfort.

(*f*) A ground test switch is on Console AE.

(*g*) Nosewheel steering is inoperative when the aircraft is being towed with an external MV supply connected and when the nose-

12 Airbrakes control

(*a*) The airbrakes, which are fitted in the tail cone, are operated by a single hydraulic jack which is electrically controlled by interconnected levers one on each pilot's throttle quadrant, inboard. Control is of the "follow-up" type and airbrake selection is infinitely variable between the OPEN and CLOSE positions. The 1st pilot's lever only has a third (gated) position—EMERGENCY IN.

(*b*) Movement of either lever causes the hydraulic jack to operate. When the selected position is reached electrical supply is terminated and the brakes are then hydraulically locked.

(*c*) Airbrakes movement is shown on an indicator on Panel AZ. A magnetic indicator below shows black with the airbrakes in and white with the airbrakes other than fully in.

13 Airbrakes emergency control

(*a*) The emergency system is for use only to close the airbrakes.

(*b*) When the 1st pilot's selector is set into the EMERGENCY IN gate, the hydraulic system operates in the emergency condition until the airbrake is fully closed. The airbrakes are then inoperative and no further selection can be made. The power circuit will remain in emergency (warning light on) and the airbrakes magnetic indicator will remain at white until the selector lever is returned to CLOSE when the selection is completed.

14 Braking parachute control

(*a*) The SAFE/STREAM switch is on the 1st Pilot's panel AE. When set to STREAM the parachute is ejected. When the switch is returned to SAFE it is jettisoned.

(*b*) Should the parachute stream inadvertently in flight it is automatically jettisoned, provided that the switch is at SAFE.

(*d*) (i) When Mod. 3248 is embodied the doors are unlocked by hydraulic pressure and opened by spring pressure. If hydraulic failure occurs an accumulator provides adequate pressure for unlocking the doors. The system is controlled by two SAFE/STREAM selector switches, one for the normal and one for emergency system, ganged together so that they operate simultaneously, fitted on the 1st pilot's panel AE. (Post Mod. 3925 panel AAP). When they are set to STREAM the parachute is ejected. When they are returned to SAFE the parachute is jettisoned.

(ii) If there is no pressure available from the aircraft's normal hydraulic system, emergency accumulator pressure will stream the parachute.

(iii) Unless there is prior knowledge of hydraulic system failure, there is no indication that the emergency accumulator pressure has been used to stream the parachute.

15 Main flaps control

The three po ition UP/TAKE-OFF/DOWN control switch is on panel A (AE, Mk. 1) together with a gated EMERGENCY Selector switch. A position indicator which indicates the positions of both main flaps, in divisions, is on panel AZ.

16 Main flaps emergency control

When the EM DOWN selector is operated after first raising the locking guard, the hydraulic system is switched to emergency and the main flaps are lowered fully down only; however intermediate positions can be obtained by reselecting OFF when the position indicator shows that the flaps have reached the required position. The flaps cannot subsequently be raised.

17 Nose flaps control

◀ NOTE: Mod. 2352 introduces fixed droop leading edges in lieu of nose flaps to Mk. (K) 1, Mk. 1A and Mk. (K) 1A aircraft. The following

(*a*) *Power supply circuit operation*

(i) With the hydraulic pumps at AUTO, whenever nose flaps move out, pumps commence running and remain running until the nose flaps are moved in.

(ii) A drop in any one nose flap accumulator pressure to 2900 PSI causes the pumps to run, if set to AUTO. Then they recharge that accumulator to 3500 PSI and automatically stop. (Post Mod. 2866 — continuously running pumps — this recharging is indicated by pump ammeters showing pumps working on load.)

(iii) There is no emergency supply of hydraulic fluid to the nose flaps. They are always moved out by their accumulator pressure, and moved in by normal power circuit pressure once the accumulators have been recharged.

(*b*) *Control and indications*

(i) A three position rotary switch (IN-AUTO-OUT) is provided on Panel AC.

(ii) Two magnetic indicators on Panel AZ show positions of inner and outer nose flap sections. They indicate as follows:

Black	.	Both sections locked in
White	.	Both sections out
Striped	.	In any position other than above and when electrical power is lacking

(iii) Two amber lights, on Panel AZ, in circuit with the CL detector system and the accumulator pressure switches.

(*c*) *Nose flaps selected to AUTO*

(i) Whenever main flaps leave the up position, nose flaps automatically move out. When main flaps return to the up position and providing all eight nose flaps accumulators are re-

(ii) At speeds below 0·7M, when a high CL condition exists on either wing, all nose flap sections move out. When the CL condition disappears the nose flaps move in.

(iii) At speeds below 0·7M when the pressure in any one nose flap accumulator drops to 2800 PSI all nose flap sections move out and remain out until all accumulators are recharged.

(*d*) *Nose flaps selected to IN*

(i) Nose flaps move out automatically whenever the main flap leaves the up position. Each nose flap section moves in when main flap returns to the up position, providing one of its pair of accumulators is fully charged.

(ii) Other automatic functions of nose flap are cancelled.

(*e*) *Nose flaps selected to OUT*

An OUT selection of nose flaps moves them out providing sufficient pressure exists in the accumulators. This selection must not be made above 0·75M.

(*f*) CL *Warning Lights*

(i) *Nose flaps at AUTO*. CL warning lights illuminate whenever a high CL condition exists and the nose flaps have not moved out. At speeds below 0·7M, only a brief flicker is apparent. Above 0·7M, mach switches prevent the nose flaps moving under high CL conditions. In this case a steady amber is apparent during a a high CL condition.

(ii) *Nose flaps at IN*. A CL condition above 0·7M gives a constant amber indication. Below 0·7M however, not only does amber indicate a high CL condition but also a pressure drop in one or more nose flap accumulators. The pressure dropping to 2800 PSI in any one nose flap accumulator causes its associated CL warning light to illuminate. The forward four accumulator pressure switches are in circuit with the starboard amber, the rear four with the port amber.

(*g*) *Pre-Mod.* 214

British Messier nose flaps have identical control and indications except that there is no automatic out selection of nose flaps with a drop of any one accumulator pressure to 2800 PSI.

NOTE: Because of the pressure switch system, if the aircraft is parked with electrical power ON and nose-flaps selected AUTO, any release of pressure from one of the eight accumulators causes the nose-flaps to move out without warning.

18 Bomb-bay doors control

(*a*) The bomb-bay doors are controlled by a three-position OPEN/AUTO/CLOSE switch on panel AZ. A three-position magnetic indicator is situated adjacent, which shows black when the doors are closed, striped when they are moving or if no electric power is available and OPEN (white) when they are open.

(*b*) If the bomb-bay doors do not open within a predetermined time with the switch set to OPEN, the hydraulic system is automatically switched to emergency and the doors are opened on the emergency circuit.

(*c*) When the switch is at AUTO automatic door opening is achieved on receipt of a signal from the NBC equipment. In addition, when Mod. 930 is embodied the doors can be opened in emergency by a signal from the NBC equipment.

(*d*) The doors can be closed following an OPEN or AUTO open selection by setting the switch to CLOSE.

(*e*) Circuit breakers on panel AJ protect the supply to both the normal and emergency circuits.

19 Bomb-bay doors emergency control

(*a*) Located on panel AC are an EMERGENCY BOMB three-position JETTISON/OFF/EMERGENCY CLOSE switch and a LOWER CARRIERS JETTISON two-position JETTISON/OFF switch.

(*b*) If the EMERGENCY BOMB switch is set to JETTISON the doors are automatically opened and the stores are jettisoned. Following a JETTISON selection, the doors must be closed by an EMERGENCY CLOSE selection.

(*c*) If the bomb doors fail to close, first set the normal selector to CLOSE and then set the EMERGENCY BOMB switch to EMERGENCY CLOSE to set the hydraulic system to emergency and close the doors. If the normal selector is not set to CLOSE, the doors will re-open after 3 seconds.

(*d*) If the bombs hang up on the lower carriers, the carriers can be jettisoned by opening the bomb doors and selecting JETTISON on the LOWER CARRIERS JETTISON switch.

◀ 20 Bomb release safety lock

The bomb release safety lock prevents inadvertent weapon release. The lock is controlled by a guarded double pole switch on panel AAF marked LOCK IN/off/LOCK OUT. Two lights are fitted above the switch, one green and one amber. The amber light comes on when the safety lock is released and the green light when the lock is engaged. ▶

Management of the System

21 Hydraulic pump management

(*a*) *Pre-flight functional checks*

Prior to starting the engines, and when an LV AND MV supply is available, check the function of both hydraulic pumps in all selector positions and of all hydraulic services, in accordance with the check list. When changing pump selections a pause of at least 5 seconds should be made at the OFF position. Check that both BRAKE-SUPPLY gauges indicate 4,000 PSI and that the pressure

(*b*) *Pump selection*

Taxy with one pump selected to AUTO (green pump running light on) and the other pump OFF. Take off with one pump ON and the other pump at AUTO (both pump running lights on). On completion of the after take-off checks, and when all hydraulically-operated controls are retracted, switch one pump (normally No. 1 pump) OFF and leave the other pump selected to AUTO. All flying, except during take-off and landing, should be carried out with one pump selected to AUTO and the other one OFF. It is recommended that the switching on and off of pump motors at altitude should be avoided except in cases of malfunction. Pre-Mod. 2866, with a pump selected to AUTO it will only run when a hydraulically operated control is not fully retracted, or when re-charging of hydraulic accumulators on the main hydraulic system is necessary. The green PUMP RUNNING light will indicate when the pump is switched on. Post-Mods. 2866 and 2348, a pump will run continuously when selected to AUTO and variations in the pump ammeter indications will indicate whether the pump is running on or off load. During the checks before landing switch both pumps to AUTO and maintain these selections throughout roller landings and overshoots. Before final landing select one pump ON and the other to AUTO.

(*c*) A pump should not be switched to ON or AUTO within 5 seconds of switching it OFF.

22 Approximate times of operation for hydraulic services

Service	*Time of Operation (seconds)*			
Undercarriage .	Up to down	12–16	Down to up	12–16
Nose-flaps . .	In to out	0·7–1	Out to in	12–15
Main-flaps . .	Up to take-off	14–16	Take-off to up	14–15
	Take-off to Down	4½–5	Down to take-off	3½–4
	Up to down	18–20	Down to up	17–18
Airbrakes . .	Close to open	4–5	Open to close	2–3
Bomb doors	Close to open	3–4	Open to close	6–8

NOTE 1: The above times are valid when both hydraulic pumps are in operation. When only one hydraulic pump is in operation the times may be increased by up to 100%.

NOTE 2: The undercarriage lowers and retracts in flight in approximately 7 seconds but the times stated above include the period of time for the doors to close and the jack to lock.

Malfunctioning of the System

23 Pump failure

If a hydraulic pump fails, the sortie should be abandoned except in operational conditions. If possible reduce height before switching the other pump to AUTO and lower the undercarriage and flaps as soon as possible.

24 Overloading of pump motors

If the steady indication on a pump motor ammeter exceeds 60 amps the pump should be switched OFF. Intermittent peaking up to 100 amps may normally be expected.

25 Excessive cut-in rate

If, during flight, the cut-in rate of a pump motor increases to more than once per 30 seconds switch OFF the pump and use only when required.

26 Overheating of pump motors

If a pump ammeter reading is beyond the white sector (i.e. exceeds 45 amps) when the pump is idling, overheating should be suspected. Switch OFF the pump as soon as possible.

27 Loss of hydraulic fluid (float switch operation)

(*a*) If a hydraulic leak occurs causing loss of fluid in one system, the float switch in the appropriate hydraulic tank compartment will operate when the fluid level in that compartment reaches 4.75 gallons. This will automatically switch off the associated pump motor if it is selected to AUTO, and Post-Mod. 2529, will illuminate the associated HYDRAULIC WARNING light at panel BB. If the pump motor is selected to ON it will continue to run and must be switched OFF manually. Approximately 2·5 gallons of fluid will be available in the other tank compartment to allow normal operation of services. However, during operation of services return fluid will be divided between the tank compartments allowing further loss of fluid, and when the second tank compartments contents fall to 4·75 gallons the second float switch will operate. The second pump motor will automatically be switched off (if it is selected to AUTO) and the second HYDRAULIC WARNING light at panel BB will illuminate. At the same time the EMERGENCY HYDRAULIC warning light at panel AZ will illuminate indicating that the Normal Master Selector has closed and the Emergency Master Selector has opened.

(*b*) If a hydraulic leak occurs downstream of the Normal Master Selector both tank float switches will operate and the EMERGENCY HYDRAULIC warning light and both HYDRAULIC WARNING lights (if fitted) will illuminate simultaneously.

(*c*) If the Emergency Master Selector has opened, the pump motors will only run when an Emergency service selection is made with the pump motors selected to AUTO, or if the pump motors are selected to ON. The following Emergency selections only can be made:—

Undercarriage .	EMERGENCY DOWN
Main Flaps . .	EMERGENCY DOWN
Nose Flaps . .	OUT
Airbrakes . .	EMERGENCY CLOSE
Bomb Doors . .	OPEN or JETTISON, EMERGENCY CLOSE (open and close once only to avoid excessive loss of fluid)

(*d*) (i) The order of service selection will be at the captain's discretion but normally the undercarriage should be lowered as soon as possible.

(ii) Operation of the nose flaps will use the fluid in the nose flap accumulators.

(iii) Whilst the main flaps emergency selector has only NORMAL and EMERGENCY DOWN selection positions, intermediate flap positions may be obtained by selecting EMERGENCY DOWN and then cancelling the selection by selecting NORMAL when the flap position indicator shows that the required position has been reached.

(iv) If bomb door operation is necessary it is essential to check that the normal bomb selector is at CLOSE before selecting EMERGENCY CLOSE. Failure to do so will cause automatic re-cycling of the bomb doors with consequent loss of hydraulic fluid.

(v) When an Emergency selection of any service, except undercarriage EMERGENCY DOWN, is completed, the pump motors will be switched off automatically provided that they are selected to AUTO. However, following completion of an undercarriage EMERGENCY DOWN selection the pump motors will continue to run until they are selected OFF. As the undercarriage will normally be the first service to be operated in the emergency condition, the pump motors must be switched OFF on completion of each Emergency selection to avoid unnecessary loss of fluid. After the emergency retraction of airbrakes return the selector lever to NORMAL CLOSE to obtain correct indication of the magnetic indicator (see para. 13(*b*)).

(*e*) Nosewheel steering will not be available and only accumulator pressure will be available for operation of the wheelbrakes. This should provide adequate pressure for one full stop landing, but unnecessarily harsh braking causing operation of the maxaret units must be avoided. When the brake pressure gauges indicate 2,000 PSI, further brake application will cause the gauge reading to fall to zero.

28 Hydraulic service failure

(*a*) If a hydraulic service fails to operate following a normal selection and the failure is not apparently caused by a main system (e.g. float switch operation), those services which incorporate Emergency selections may be operated as described in the preceding paragraph without causing hydraulic system as a whole to operate permanently in an Emergency condition. Make the appropriate Emergency selection of the service reauired. During the Emergency operation the EMERGENCY HYDRAULIC warning light will illuminate indicating that the hydraulic system is in the Emergency condition. On completion of the operation the main hydraulic system will revert to its normal condition and the EMERGENCY HYDRAULIC warning light will go out. No further operation of the failed service (except the bomb doors) can then be made, but the remaining services can be operated normally.

(*b*) If the undercarriage has been lowered by selecting EMERGENCY DOWN, and the pump motors have then been stopped by selecting OFF, the pumps may only be restarted by one of the following procedures:

(i) Selecting ON at the pump control switches.

(ii) By depressing the normal undercarriage DOWN button *after* the undercarriage is indicated down and locked, and then selecting AUTO at the pump control switches.

Part I

Chapter 5—Powered Flying Controls and Trimmers

List of Contents

Description

1 General

(*a*) Dual controls are fitted for side-by-side seated pilots. Electro-hydraulic power units are provided to operate the ailerons, rudder and elevators. There is no manual reversion.

(*b*) Provision is made for a Mk. 10 electrically-operated auto-pilot.

2 Control columns

(*a*) The control columns are of the horizontal sliding type and are free both to rotate and slide. Each control column incorporates an elevator trim switch and an auto-pilot instinctive cut-out switch, on the inboard handgrip. The control columns operate push-pull rods to the powered flying controls units.

(*b*) (i) Post-Mod. 2789, if the aircraft is to be abandoned using the ejection seats, both control columns are disconnected from the elevator control and moved forward to clear the pilots' knees. This is achieved automatically when the escape hatches are jettisoned as the ejection seat firing handle is pulled. If only one hatch is jettisoned its associated handwheel will be disconnected, but the other will remain effective until the second hatch is jettisoned. Pre-Mod. 2789 the red handle on each pilot's console must be operated to retract the control column.

(ii) If either escape hatch is jettisoned by means of the ditching handle, the associated control column does not slide forward.

3 Rudder pedals

(*a*) In addition to normal fore-and-aft pedal movement for rudder control each pair of rudder pedals is used for wheelbrakes application. Depressing the pedals by toe action actuates the brake cylinders, the amount of toe movement controlling the pressure and differential wheelbraking.

(*b*) Rudder pedal adjustment is achieved by rotating the crank handle beneath each control column tube.

4 Powered flying control units (PFCU)

(*a*) The power unit for the rudder, each elevator and each aileron consists of two self-contained sub-units. Each sub-unit comprises an electric motor driving an hydraulic pump, a reversible hydraulic motor, a self-contained hydraulic fluid supply and a valve gear. The hydraulic motors of both sub-units drive a single screw jack which transmits control column input to the associated control surface by means of skew levers.

(*b*) When the valve gear is moved by the control column in either direction hydraulic fluid is passed to the hydraulic motor to drive the screw jack, and thus the control surface. When control column movement ceases the screw jack continues to move until the valve is reset to the neutral position by means of a reset lever which inter-connects the screw jack with the valve gear. When the valve reaches a neutral position, hydraulic flow is cut off and control surface movement ceases until the control column is again displaced.

(*c*) Two sub-units are incorporated in each power unit so that if failure of one sub-unit occurs control movement can still be achieved. With one sub-unit out of action the maximum rate at which the control can be operated remains the same but for a given rate the hinge moment against which the control surface can be moved is reduced.

(*d*) *Pressure-off brakes* (*Mod.* 828)

Each PFCU is fitted with a pressure-off brake designed to prevent the flying control surfaces from tramping under gusting wind loads when the aircraft is parked. Two brake shoes, spring-loaded to the " brake-on " position, apply a load to the output drive of the PFCU when the complete unit is switched off. As each sub-unit is switched on, its associated brake shoe is lifted from the output drive by hydraulic pressure. To gain complete freedom from brake effect both sub-units must be switched on and operating correctly. If sub-unit failure occurs the attendant brake shoe will be applied.

5 " Q " feel units

(*a*) Since there is no feed back of control surface hinge moments to the pilots' controls, synthetic feel, which varies with airspeed and control displacement, is given in the controls signalling systems by " q " feel units. Each unit is connected in parallel with its associated controls system and embodies a duplicated motor actuator for trim control.

(*b*) In " q " feel units pitot and static pressure is fed to the inside and outside respectively of a bellows so that the difference in pressure, i.e. dynamic pressure, is measured. Movement of the pilot's control compresses the bellows by means of a toggle mechanism so that the force transmitted to the pilot is approximately proportioned to the dynamic pressure and the displacement of the control. Each feel unit contains in addition a double-acting centralising spring unit which in addition to giving a force proportional to control displacement also assists in returning the feel unit to neutral when the controls are centralised.

6 Yaw damper system

(*a*) This is fitted to correct disturbances about the normal axis by automatically applying rudder. Two yaw dampers are fitted, the normal and the standby and each functions in a similar manner. A gyro senses and signals any disturbance to an electric actuator in the rudder system. This actuator extends and retracts to operate the PFCU reset lever.

(*b*) An airspeed unit is fitted which progressively decreases the gyro signals with increasing airspeed.

7 Auto-mach trim system

(*a*) The purpose of the system is to counteract the nose-down trim changes encountered at high mach number. This is achieved by introducing a servo jack into the elevator PFCU signalling system between the " q " feel unit and the PFCU. The operation of the servo jack is controlled by the 2nd pilot's machmeter, the output signals of which are amplified to operate a relay unit to supply power to the servo jack which moves in proportion to the output signal. The effective length of the particular portion of the signalling system is then altered.

(*b*) When switched ON and above 20,000 feet, the servo begins to operate at approximately 0.85M. A further increase in mach number results in upward movement of the elevator without altering the stick position, the amount increasing with increase of mach number. At approximately 0.95M and above the servo jack is fully extended.

(*c*) G cut-outs prevent servo movement if the normal acceleration of the aircraft exceeds 1·8 G or is less than 0·6 G.

(*d*) AC supply is obtained from No. 2 Type 350 inverter and DC supply from No. 2 LV bus-bar.

Controls and Indicators

8 Power controls switches and indicators

(*a*) An individual ON/OFF control switch for each sub-unit, i.e. 10 in all, is on panel AZ in the pilots' cockpit.

(*b*) Ten lights below the switches come on if their associated sub-units suffer hydraulic pressure failure.

(*c*) On the AEO's panel BC are twenty magnetic indicators, two for each sub-unit. If overheating of the hydraulic fluid in a sub-unit occurs the appropriate indicator in the upper row will show white. Warning of hydraulic pressure failure will be given by the appropriate sub-unit indicator in the lower row showing white.

9 Yaw damper controls

(*a*) Two ON/STANDBY/OFF switches are fitted for the yaw dampers, that for the normal damper being on panel AZ and for the standby damper on panel AE.

(*b*) Only one yaw damper should be ON in flight, the other being selected to STANDBY. Neither should be selected ON or STANDBY if the PFCU sub-units are not running.

(*c*) Power supplies to the normal yaw damper are from No. 2 Type 350 inverter and No. 2 LV bus-bar.

(*d*) Power supplies, AC and DC, to the standby yaw damper are from the flight instrument supplies.

10 Auto-mach trimmer control and indicator

(*a*) An ON/OFF/RESET switch is on panel AZ with an adjacent magnetic indicator.

(*b*) When RESET is applied the electric actuator retracts fully and thus removes any applied auto-mach trim.

(*c*) The indicator shows black (in) with the actuator fully retracted, and white (out) with the actuator anywhere but fully retracted.

11 Trimmer controls

A standard trim switch, for the ailerons elevators and rudder is located on each pilot's console, AE and AF : before either trim

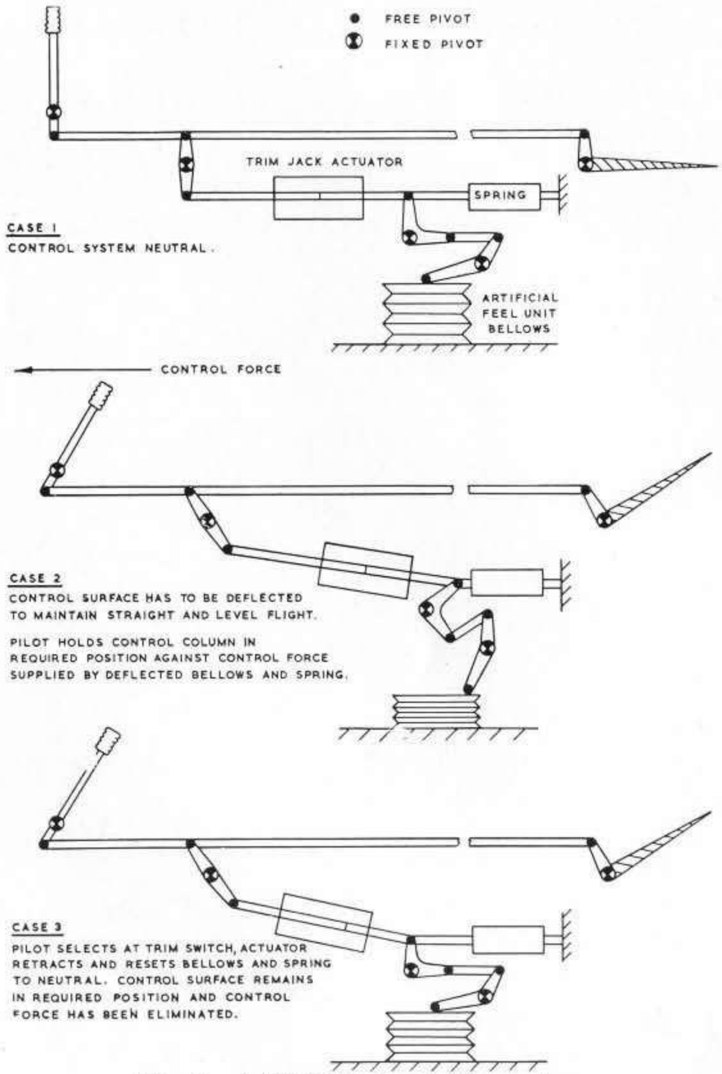

Fig. 1 Artificial feel and trim system

switch can be operated a central push-button must first be depressed. An alternative trim switch for the elevators is situated on the inboard handgrip of each pilot's control column, beneath a protective guard. When either guard is lowered its associated trim switch circuit is " dead." No trim tabs are fitted to the control surfaces ; the trim system operates the main controls signalling systems through electric actuators and will trim the stick forces out while keeping the pilots' control columns stationary. Operation of the trim switch for any of the controls extends or retracts an actuator to reset the feel simulator. Each actuator is driven by one of two electric motors through a differential gear box. The 1st pilot's controls operate one motor and the 2nd pilot's controls operate the other. In the case of the elevator trim circuit, the 1st pilot's control column alternative switch operates the motor normally controlled by the 2nd pilot's console switch and vice versa.

Management of the Powered Controls and Trimmers

12 Ground checks and starting

(a) General

The powered flying controls and the control trimmers must be checked before starting the engines. A 28 volt DC supply and a 112 volt external supply must be available. Before starting any of the PFCU's check with the crew chief that all ground personnel are clear of the control surfaces.

(b) Testing trimmer controls

The trimming controls of both pilots must be tested over the full range of movement.

(i) *Console trim controls*

Without pressing the pushbutton, move the console trim in each direction to check functioning of the cut-out. (If the trims move, the system is unservicable). Then depress the button and move the trimmer control in each direction to check the correct movement of the aileron, rudder and elevator controls. Watch the trim indicators for smooth travel over the whole range of movement. At full travel the indicators will normally move beyond the extreme marks on the indicator face. The control column and rudder pedals will normally move some distance in the direction of applied trim. When elevator trim is applied, the elevator trim-load indicator on each pilot's instrument panel will move in the appropriate direction but its rate of movement is not directly proportional to the trim movement applied. Repeat the checks on the other pilot's console trimmer control and return to neutral.

(ii) *Control column trim control*

Operate the control column trimmer control switch through the hole in the flap and check that the elevator trim does not move. (If the trim moves, the system is unserviceable). Then raise the flap and operate the trimmer over its full range of movement in each direction. Repeat the checks on the other pilot's trim controls and return the trim to neutral.

(*c*) *Starting and testing* PFCU's

Check that the ten red power failure warning lights on the pilot's coaming panel (AZ) are on, and that the ten power failure magnetic indicators are white and the ten overheat magnetic indicators at the AEO's station are black. Start the No. 1 set by selecting the number 1, 3, 5, 7 & 9 switches to ON (up). Check that the appropriate red warning lights on the pilot's coaming go out and the indicators at the AEO's station are black. Test the controls for free, smooth and correct movement over their full travel (by ground crew observation). Jerky control movements or vibration may indicate unserviceability. Switch OFF the No. 1 set of controls (check that the red warning lights come on) and repeat the checks for the No. 2 set of controls switches numbered 2, 4, 6, 8 and 10. On completion of checks switch OFF all PFCU's until ready for take-off. Before take-off, switch on all PFCU's, check that all warning lights go out and magnetic indicators are black. Check the controls for freedom of movement over their full travel.

NOTE: Rapid control movement may cause flickering of the power failure warning lights. This should cease when control movement ceases.

13 Auto-stabilisers and auto-mach trimmer

(*a*) *Auto-stabiliser*

The yaw dampers should never be switched to STANDBY or ON unless the appropriate PFCU's are running. Before take-off, and after starting the PFCU's select the normal and standby yaw dampers to STANDBY. ▶ ◀ There is no indicator to show that the units are operating.

NOTE: Only one yaw damper should be selected to ON. The other should be selected to STANDBY.

(*b*) *Auto-mach trimmer*

The auto-mach trim indicator should be IN and black when the aircraft is on the ground. If the indicator shows white (out), after starting the elevator PFCU's select the control switch to RESET and check that the indicator changes to black (in). If it fails to do so, the aircraft must not be flown. The auto-mach trim should be selected to OFF for take-off.

14 In-flight management of the powered controls

(*a*) If any component of the flying control system is found to be faulty before take-off, the aircraft must not be flown.

(*b*) (i) Throughout flight the red power failure warning lights should remain out and the overheat magnetic indicators should remain black.

◀ (ii) Throughout flight the hydraulic yaw damper should be selected ON and the standby yaw damper should be selected to STANDBY.

(iii) Once above 20,000 feet if the mach trimmer is required it should be switched ON between 0·84 and 0·85M before speed is increased further. If, when the mach strut is selected on, its ▶

magnetic indicator has not turned white by the time 0·87M is reached the speed should be reduced to 0·84M and the mach trimmer switched off. If during normal use the magnetic indicator remains white after the speed has decreased below 0·84M then the reset switch should be used until the magnetic indicator reverts to black. As speed is increased above 0·85M ± 0·01M the auto-mach trimmer should provide a progressive nose-up trim force. The indicator should indicate white (OUT).

(*c*) (i) Depending on orders in force, up to five PFCU's may be selected OFF during flight for training purposes only. It is recommended that only one PFCU to each control surface is switched OFF at any time.

(ii) The auto-mach trim may be switched off for training purposes but speed should not exceed 0·90M whilst it is selected to OFF.

Malfunctioning of the Powered Controls and Trimmers

15 " Q " feel unit failure

Feel failure warning is not incorporated since the system is mechanical and it is unlikely that failure will occur. If failure occurs, the control forces will be light and overstressing of the aircraft by over-application of elevator or rudder could easily result. At the higher speeds and mach numbers the aileron jacks will stall and so limit the amount of aileron that can be applied irrespective of the movement of the handwheel. The controls must be used with care above 180 knots, and large deflections must be avoided at any speed. The elevator must be moved slowly and cautiously with frequent reference to the accelerometer to avoid exceeding the G limitations.

16 PFCU failures

(*a*) If a sub-unit failure warning light on panel AZ comes on and/or the associated magnetic indicator at the AEO's station shows white, the associated switch should be put off.

(*b*) If a sub-unit failure is caused by a valve jamming, the first subsequent movement of the control will require the application of more force than usual. The additional force applied will operate a " break-link " to isolate the jammed valve and thereafter the control forces required will be normal.

(*c*) Pre-Mod. 828 (PFCU's fitted with pressure-off brakes) no significant effects will be noticed on the handling characteristics at any speed within the limitations if a sub-unit fails. On aircraft fitted with pressure-off brakes, rudder or elevator sub-unit failure will have no noticeable effect on the handling of the aircraft, but in the case of aileron sub-unit failure the aileron angle which can be applied will be progressively reduced as mach number increases. At the maximum permitted mach number, 0·95M, only very small aileron angles will be achieved, and above this limit, the ailerons will be virtually immovable. Additional aileron control can be obtained by compressing an over-travel spring link, but the forces involved are extremely high and if the wing with the inoperate sub-unit is allowed to drop, it may require the maximum combined effort of both pilots to raise it. Control at high airspeed (low mach number) and on the circuit and landing is normal. Handling characteristics with two aileron sub-units inoperative are similar. If an aileron sub-unit fails, therefore, speed must be reduced to below 0·9M.

(*d*) *Complete aileron or elevator power unit failure*

(i) If a complete aileron or elevator power unit fails, adequate control remains for gentle manoeuvres, approach and landing. Control forces are higher than normal and it is advisable to have both hands on the control column for approach and landing.

(ii) If an aileron unit has failed, the landing may be made using normal technique provided that due caution is exercised and that conditions are favourable, but some increase in approach speed is advisable if appreciable turbulence or crosswind exists.

(iii) If an elevator unit has failed only gentle manoeuvres should be performed. The landing should be made using take-off flap and the normal threshold speed for the AUW should be increased by 20 knots.

17 Overheating of a PFCU

If an overheat magnetic indicator goes white during flight, switch OFF the affected PFCU. When the indicator goes black, wait approximately 5 minutes and re-select the PFCU to ON. If the indicator again goes white, switch OFFand leave OFF.

18 Failure of a control trimmer

If a trimmer fails to respond to a trim selection, make no further selections of that control, until the appropriate circuit breakers have been checked. The alternative elevator trim actuator may be used if necessary, i.e. if the 1st pilot's control column trim control or the 2nd pilot's console trim control has failed, use the 1st pilot's console trim control or the 2nd pilot's control column trim control, and vice-versa.

19 Yaw damper failure

Failure of a yaw damper may be indicated by yawing oscillations or by a yawing trim force. Switch OFF the yaw damper, trim as required and switch ON the standby yaw damper.

20 Auto-mach trim failure

The auto-mach trimmer may fail by sticking in one position of actuator extension, or by the actuator moving to its full travel of extension or retraction. The first failure will be indicated by a gradual change from a nose-up trim force to a nose-down trim force as speed is increased in the operative speed range. The second failure will be indicated by a sudden nose-up or nose-down trim change.

Reduce speed to 0·85M or below, and if necessary retract the actuator in small increments by selecting the control switch to RESET in short " blips ". If the Mach trim indicator remains black (in) when flying in the operative speed range, do not increase speed above 0·85M.

Part I

Chapter 6—Engines

List of Contents

1 General

(*a*) The Sapphire Mk. 202 or Mk. 207 engines are each rated at 11,000 lb. static thrust at sea level. The main engine systems include:—

Electric starting (see para. 3)

Relighting facilities (see para. 4)

High-pressure fuel system (see sub-para. (*b*))

Self-contained oil system (see sub-para. (*c*))

Anti-icing (see sub-para. (*d*) and Part I, Chap. 9, Para. 5 which deals with air intake anti-icing)

Automatic JPT controls (see sub-para. (*e*))

(*b*) *High pressure fuel pumps*

A single variable-output HP pump is fitted to each engine. Delivery from each pump is regulated by a maximum speed governor, a barometric flow control unit and an air/fuel ratio control. The maximum speed governor is sensitive to jet pipe pressure and with reducing pressure reduces max. engine speed to prevent the JPT exceeding the limits. The BFCU maintains selected engine speed under conditions of varying altitude and airspeed. The A/FRC comes into action only during periods of rapid throttle opening to prevent the possibility of compressor stall.

(*c*) *Oil system*

Each engine has one pressure and three scavenge pumps which maintain a continuous circulation through an oil cooler to the engine bearings and gears. The engine oil tank capacity is 18 pints of oil with 6 pints air space.

(*d*) *Engine anti-icing*

(i) The inlet guide vanes, air intake struts and starter motor fairing of each engine are heated by hot air from the engine centre section. Control of the hot air supply to each engine is by means of 4 four-position OPEN/CLOSE/HALF-OPEN/AUTO switches, on panel AD, which actuate the hot air valve shutters. When Mod. 2007 is embodied the AUTO switch position is inoperative.

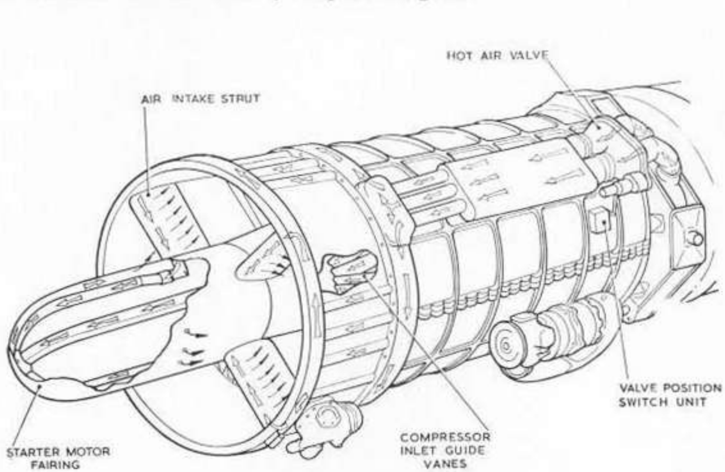

Fig. 1 Engine Anti-icing

(ii) With the switch in the AUTO position control of the system is by the ice detector relays which, when energised, cause the hot air valve shutter to move from the closed to the half-open position. When icing conditions no longer exist it will be necessary to select CLOSE to switch off the system.

(iii) The 28-volt DC supplies to the systems are from feeders 7P7 (Port engines) and 10P7 (starboard engines) on panel AH.

(iv) The leading edges of the engine air intakes are kept free of ice by the airframe anti-icing system.

(*e*) *Automatic* JPT *control system* (*Mk.* 1*A only*)

(i) A three datum JPT control system is embodied to maintain constant JPT at the Intermediate (98%) and Maximum Continuous (96%) engine speed ratings and to limit the maximum JPT to 660°C. A three-position TAKE-OFF/CLIMB/CRUISE, ratings selector switch is fitted on panel AZ and four NORMAL/OFF isolating switches, one for each engine, are fitted below the 1st pilot's side window.

(ii) With the selector switch set to TAKE-OFF the system will limit the maximum JPT to 660°C $^{+0}_{-10}$ and engine speed at full throttle is controlled by a fuel governor trimmed as necessary by the JPT control. Any other desired operating condition can be obtained by normal movement.

NOTE: With the isolating switches set to OFF or if the jpt control system fails, engine speed is controlled entirely by the fuel pump governor and take-off power is ensured by a 'fail safe' device.

(iii) After take-off, with the isolating switches all ON, selection of the switch to CLIMB trims the fuel governor to ensure that the JPT is maintained at 625°C $^{+0}_{-10}$. Engine speed is thereby adjusted without any throttle movement from fully open. Similarly, subsequent selection of CRUISE further trims the fuel governor to maintain 600°C $^{+0}_{-10}$, again without throttle adjustment.

NOTE: In both CLIMB and CRUISE conditions, throttle control is normal if power settings below those selected are required.

(iv) Setting any of the isolating switches to OFF isolates the JPT control of the associated engine which must then be controlled by throttle manipulation.

2 Throttle/HP cock controls

(*a*) A throttle quadrant, containing 4 interconnected combined throttle lever/HP cock controls is fitted on each pilot's console. A throttle damper mechanism is fitted only to the 1st pilot's control box, but it can be operated by the 2nd pilot through a system of cables. A damper-operating lever is outboard of each throttle quadrant.

(*b*) Each throttle lever has two stages of travel ; the initial 5° movement forward actuates a micro-switch to open the electrically-actuated HP cock. Before any forward movement can be obtained a gate must be released. Once forward of the gate if it is desired to close the HP cock the gate must again be released before the lever can be returned.

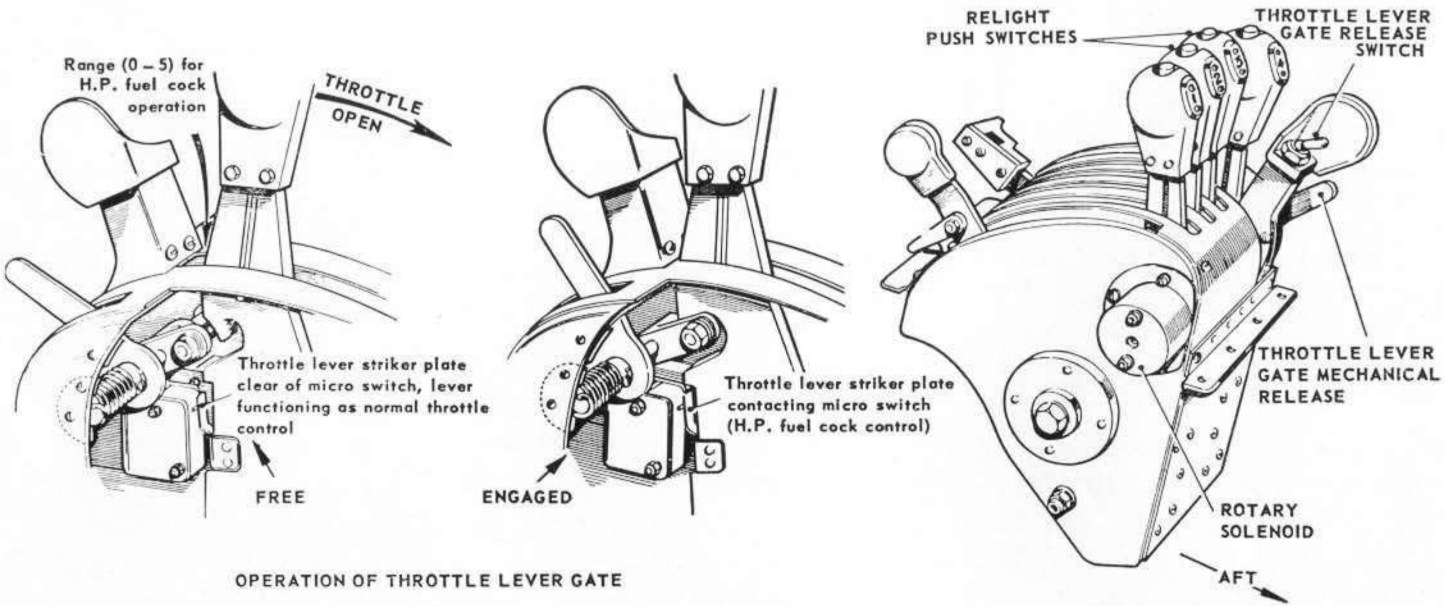

Fig. 2 Throttle controls

(*c*) The gate release mechanism is fitted only to the 1st pilot's quadrant but is controllable from either quadrant by means of a spring-return switch at the rear of each throttle box. A manual override lever, on the 1st pilot's quadrant, is fitted to meet the case of electrical failure. Mod 3645 introduces a guard to the mechanical trip lever to prevent inadvertent operation.

(*d*) Circuit breakers, one for each engine HP cock, are on panel AJ.

(*e*) Mod. 4020 introduces a visual indicator for the throttle gate lever. A white knob replaces the black knob on the lever and a second knob is provided at the inner face of the sleeve guard. When aligned the knobs provide visual and feel indication to the

3 Starting system

(*a*) The starting controls are all grouped on the roof panel AL. The starter master circuit breaker is on panel AJ. Starting is effected by an electric starter motor which rotates its associated engine until light-up occurs and the engine becomes self-sustaining. For ground starting an external electrical supply is normally to be used.

(*b*) The starting controls comprise:

(i) An ignition isolation switch
(ii) A starter motor isolation switch
(iii) An engine start selector
(iv) A 3-position starter master switch; INT/GROUND/

(v) A starter pushbutton

(vi) A starter warning light

(vii) A starter circuit breaker

(*c*) With the battery master, ignition and starter motor isolation switches ON, the appropriate engine selected, the starter master switch set to GROUND (INT for starting without an external electrical supply) the HP and LP cocks OPEN and booster pumps ON, the starter warning light will come on 3 seconds after the starter pushbutton is pressed.

(*d*) Initially the starter motor runs at low speed to ensure smooth engagement. The electrical current also causes the time switch to wind up and run. The speed of the starter motor is then progressively increased until it reaches full speed. After about 20 seconds the starter pushbutton hold-in solenoid is de-energised, at which time the engine should have reached a speed of about 17·5%. When the engine speed reaches approximately 30% RPM the next engine can be selected and started provided that a time of 36 seconds has elapsed from first pressing the starter pushbutton. The STARTER WARNING light then goes out.

(*e*) Irrespective of whether the engine has lit or not the time switch de-energises the circuit after 30 seconds running time and then runs for a further 6 seconds to reset the starting circuit.

(*f*) A mechanical interlock between the engine start selector switch and the pushbutton ensures that a further engine selection cannot be made until the existing starting cycle is completed.

4 Relighting system

A relight button is incorporated in the top of each throttle lever on both quadrants. When pressed, with the starter master switch at FLIGHT, each one completes the circuit to the igniter plugs of the associated engine.

5 Engine instruments

Oil pressure gauges, one for each engine, are fitted on panel A. A percentage calibrated engine speed indicator for each engine, together with its associated jpt gauge below it, are also on panel A.

Part I

Chapter 7—Auto Pilot Mk. 10

List of Contents

Description, Controls and Indicators

1 General

Disturbances to the aircraft flight path are picked up by three rate gyros, mounted at right angles to each other on a platform. The gyro signals pass through amplifiers to the servo-motors in each control run. As a safety measure a torque limiter is fitted in the elevator and rudder circuits and this automatically disengages the whole auto-pilot if too great a load is applied to either control. A roll error cut out disengages the auto-pilot when a certain undemanded bank angle is reached, excepting when flaps are 1° or more down when it is inhibited.

2 Controls

(*a*) *Mk. 1A aircraft*

(i) The auto-pilot is operated from a control unit on panel AT and is monitored from the Mk. 4B compass master indicator. The heading selector is on the 1st pilot's console AE and a trim indicator is fitted on the 1st and 2nd pilot's panels AA and AB respectively.

(ii) The control unit has the following switches and indicators located on it:

POWER switch and associated READY magnetic indicator

ENGAGE switch and associated IN magnetic indicator

Rudder, aileron and elevator channel switches

Trim indicator

BOMB switch (NBS)

TRACK switch

GLIDE switch

Height lock switch marked ALT

Turn control switch

Pitch control switch marked CLIMB-DIVE

(*b*) *Mk.* 1 *aircraft*

(i) The heading selector is on the pilots' centre panel A and there are two control units, one on the 1st pilot's console AE and the other on panel AT. A remote trim indicator is also on panel AT.

(ii) The control unit on console AE has the following switches and indicators:

POWER switch and READY magnetic indicators
ENGAGE switch and IN magnetic indicator
Rudder, aileron and elevator channel switches
Trim indicator
Bomb switch
Track switch
Height lock switch
Glide switch

(iii) The control unit on panel AT has the following switches:

Turn control switch
Pitch control switch

(*c*) In each aircraft the rudder, aileron and elevator switches are conventional two position (IN forward) toggle switches. The pitch control switch is a multiple switch, spring-return to centre-off and the turn control switch is a pointer knob which operates the wiper arm of a potentiometer. The remainder of the switches are of the pull (on)—push (off) type electromagnetically held in when operated.

3 Control unit function

(*a*) *POWER switch*

When the POWER switch is pulled " on " the READY magnetic indicator shows white after a period of approximately 60 seconds, indicating that the auto-pilot is ready to be engaged with the aircraft controls. The power switch should be pulled ON as soon as possible after take-off to allow the maximum time for the auto-pilot to stabilise before being used. Mod. 3149 (BC Mod/Victor/04) provides a guard to prevent inadvertent tripping of the button when panel AT is in the extended position.

(*b*) *ENGAGE switch*

When the ENGAGE switch is pulled " on " and all three channel switches are IN, the white indication disappears from the READY indicator and a black and white striped disc shows at the IN indicator ; this confirms that the auto-pilot is engaged. If any control channel remains disengaged, the READY indicator remains exposed and both READY and IN discs are visible.

(*c*) *Channel switches*

If one channel remains engaged (IN), the remaining channel(s) may be engaged by setting the appropriate channel switch(es) to the IN position. If all three channels are disengaged, the auto-pilot is disengaged completely, the ENGAGE switch returns to the " off " position, the IN disc disappears and the READY disc is visible. To re-engage the auto-pilot, set at least one of the channel switches to IN and pull " on " the ENGAGE switch.

(*d*) *Pilot's cut-out switches*

If either the 1st pilot's or 2nd pilot's cut-out switch is operated, the auto-pilot is disengaged and the ENGAGE switch returns to the " off " position, the IN indication disappears and the READY indication is visible.

(*e*) *Turn control switch*

The aircraft can be turned at a pre-set bank by selecting the angle on the control knob. The knob remains at the selection and the aircraft maintains the bank until a different angle is selected, or the control knob is returned to the central position.

(*f*) *Pitch control*

The pitch control is operated in a natural sense, i.e. moving the switch forward produces nose-down pitch and vice-versa. The toggle is spring-loaded to the centre (off) position and movement is opposed by two spring rates. Initial movement against a weak spring produces a slow rate of change of aircraft attitude and further movement which is against a stronger spring causes a fast rate of attitude change.

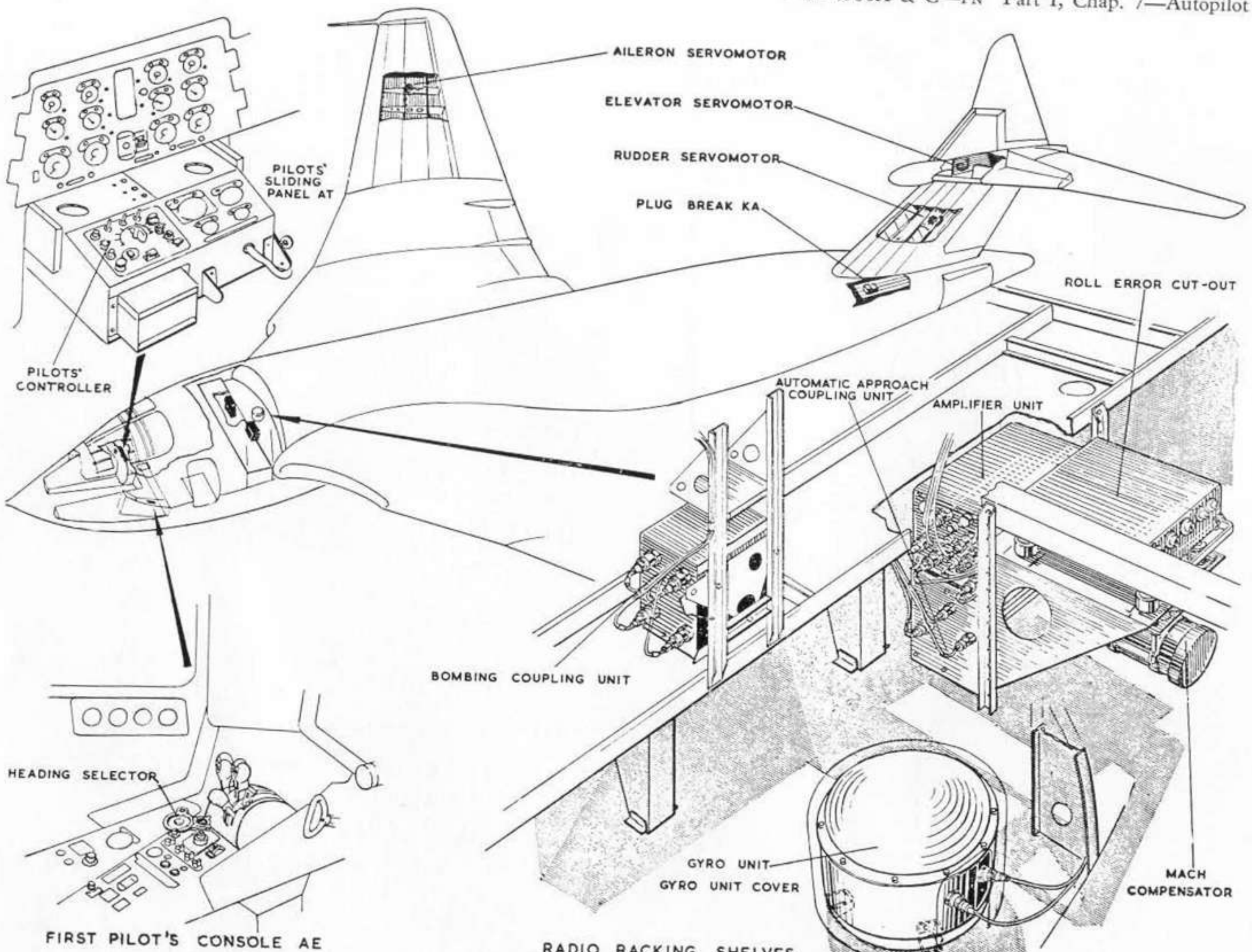

Fig. 1 Auto-pilot equipment

4 G switch

The G switch is on the centre leg of the navigator's table and, when operated, disengages the auto-pilot from the main control systems. The switch incorporates test and reset buttons for manual operation during functional testing of the auto-pilot system.

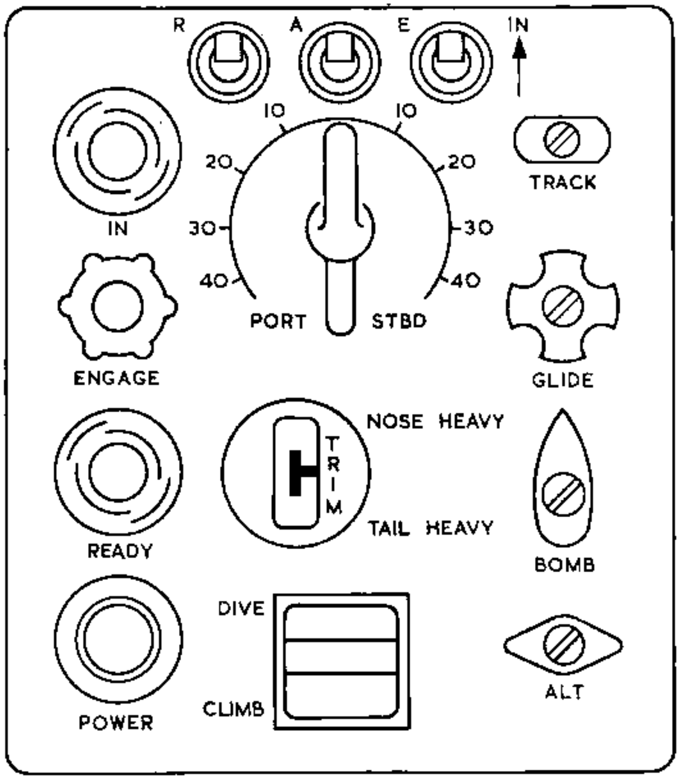

Fig. 2 Auto-pilot control panel

5 Heading selector

The heading selector comprises a compass repeater and a pre-select

OFF, courses are pre-selected on the heading selector and the aircraft turns to the heading when the pre-select turn button is depressed. The angle of bank is restricted to 30 degrees. With ILS on, the runway heading corrected for drift is pre-selected before pulling the track switch on.

Management and Malfunctioning of the Auto-Pilot

6 Auto-pilot limitations

Provided Mods. 666, 781 and 957 are incorporated the auto-pilot is cleared for use, but the following limitations must be observed:

(*a*) *General*

(i) The auto pilot must not be used below 1,500 feet above ground level except on the ILS glide path.

(ii) Maximum speed: 330 knots/0·9M.

NOTE: If short period oscillations (2 seconds) occur above 0·85M the auto-pilot must be disengaged and is not to be re-engaged above 0·85M.

(iii) Minimum speed:

Above 30,000 feet	0·83M
Below 30,000 feet	No limit

(iv) The maximum bank angle must not exceed 30°.

(v) One pilot must be firmly strapped in at all times when the auto-pilot is in control.

(vi) Longitudinal trim must at all times be maintained within ± 1 division of neutral on the special trim indicator.

(vii) Before engaging the auto-pilot, the auto-mach trimmer must be switched OFF, the Newark stand-by yaw damper must be switched to STANDBY and the Hobson main yaw damper must lieu of the main yaw damper; if the latter is unserviceable the auto-pilot may be used without yaw damper assistance with some deterioration in performance.

(viii) Coupled ILS approaches may be made to an AAL of 250 feet above runway level.

(*b*) *NBS coupling*

Direct and offset coupled NBS bombing attacks may be made provided that the speed does not exceed 330 knots or 0·85M.

7 Pre-flight checks

Ensure that the Nos. 2 and 3 type 350 inverters are on, that one set of PFCU's are operating and that the yaw dampers are at STANDBY. Set the R, A and E channel switches to IN, pull up the POWER knob and check that the READY indicator shows white after approximately 45 seconds. Check that the flying controls are central, that the trim load indicators are in the green sector, that the flaps are fully retracted and that the auto-pilot turn control switch is central. Pull the ENGAGE switch and check that the IN indicator shows black and white stripes and the READY indicator shows black. Press lightly on all three controls to check proper engagement. Carry out the following checks of operation:

(*a*) Check for aileron drift and neutralise by turning the Mk. 4B compass. Disengage the auto-pilot, re-synchronise the Mk. 4B compass and re-engage.

(*b*) Switch out each channel in turn and check that the READY indicator shows white in addition to the IN indicator showing black and white stripes. Check the freedom of control of the disengaged channel and that the other channels remain firm. Re-engage and check that the READY indicator shows black.

(*c*) Check the operation of each pilot's instinctive cut-out ; re-engage.

(*d*) Check the operation of the elevator and rudder torque cut-outs by applying steadily increasing force to the elevator and rudder controls in each direction in turn. Re-engage after each operation. Post-Mod. 2657 movement of the flaps away from the fully-up position inhibits the operation of the roll-error cut-out and the rudder excess torque cut-out.

(*e*) Check that movement of the pitch control produces movement of the control column in the correct sense, and corresponding movement of the trim indicator. The control column may continue to move very slowly for a short time after releasing the pitch control switch.

(*f*) Check that operation of the bank control in each direction in in turn causes corresponding movement of the control column. Check that maximum movement in each direction causes disengagement through operation of the roll-error cut-out. Re-engage.

(*g*) Switch off all three channels and press in the POWER switch. Re-set all controls to the take-off position. Switch off PFCU's.

8 Use in flight

(*a*) *To engage the auto-pilot*

(i) Pull on the POWER switch and wait approximately 60 seconds for the READY magnetic indicator to show white. Check that the three-channel switches R, A and E are switched IN. Check that the trim indicators are within the green sectors. Trim the aircraft to fly hands and feet off in the desired flight attitude and then pull the engage switch.

NOTE: If the trim indicators are outside the green sectors, the auto-pilot must not be engaged.

(ii) Check that the IN magnetic indicator shows black and white stripes and the ready indicator shows black.

(b) To turn the aircraft

Rotate the turn control knob to the bank figure required; return the knob towards the central position as the new heading is reached. During prolonged turns there will probably be some loss of datum, with the result that when the turn knob is returned to the central position, the aircraft may over or under bank before finally assuming level flight. It is not necessary to re-set the heading selector, except where specified in (*e*).

NOTE: If the auto-pilot is engaged whilst the bank control knob is in any position other than central, this control will be inoperative until it has first been returned to the central position.

(c) Climb or descent

Move the pitch control fore or aft as required to achieve a change of pitch attitude, release the control to maintain the new pitch attitude, then re-trim the aircraft. Two rates of change of attitude are available. Initial movement of the pitch control against a weak spring will bring a slow rate into operation, while further movement against a stronger spring will bring a fast rate into operation.

(d) Manual operation of one or more control surfaces

The rudder and aileron channels may be temporarily disengaged, in straight and level flight only, in order to permit the trim of the control surfaces to be checked but in no circumstances should a turn be initiated with the aileron channel disengaged. Should any one of the channels of the auto-pilot become inoperative due to some unknown defect, all channels should be immediately disengaged and the POWER switch set off. Disengage the channel or channels required by selecting off the appropriate switch or switches. To resume automatic control of the disengaged channels (if not more than two) select the appropriate channel or channels IN by the channel switch or switches. If all three channel switches have been selected off it will be necessary to re-engage by pulling out the ENGAGE switch when all three channel switches are IN.

(e) Use of the heading selector

The heading selector can be used for:

(i) Executing pre-selected turns. A desired heading can be pre-selected by the course setting pointer and the aircraft can be turned on to that heading by pressing the pre-select turn button for at least one second.

(ii) Monitoring the aircraft heading in the TRACK and GLIDE phase of an automatic approach. The heading of the runway should be pre-selected with drift allowance and the TRACK switch on the control unit then pulled. When the track switch is pulled the bank control is inoperative.

NOTE: The bank control will override a pre-selected turn at any time.

(f) Barometric height control

To engage the height lock pull the ALT switch at the desired altitude. With the height lock selected the pitch control will be rendered inoperative at the slow-rate position in either direction. To remove the barometric height control push off the ALT switch.

NOTE: When engaged, the height lock switch will automatically release to off if the elevator channel switch is selected off, or if the pitch control is moved to the fast-rate position in either direction.

(g) Disengaging the auto-pilot

To disengage, press either cut-out button on the control columns. Do not push off the power switch if the auto-pilot is to be used again, otherwise it will be necessary to carry out the procedure as in (a) above, instead of merely re-selecting the ENGAGE switch on. Alternative means of disengaging the auto-pilot is to push off the ENGAGE switch on the control unit, or to switch off the three channel switches.

9 Auto ILS approach

(*a*) The initial ILS approach is assumed to commence at a point approximately 10 to 15 miles from the runway threshold. Approach to this position may be from a high level or low level pattern;

either may be flown manually or on normal auto-pilot control as required. Select the required ILS frequency, and identify the beacon. If the auto-pilot is not already in use, press the POWER knob, check that the READY indicator shows white and select the R, A and E switches IN before reaching the check height.

(*b*) At check height, or on the downwind leg, lower the undercarriage and flap as required and trim the aircraft at the pattern speed for the AUW. Engage the auto-pilot and pull *the* ALT switch. Set the runway heading corrected for drift on the heading selector. Check that the ILS indicator warning flags have disappeared. When at an angle of less than 170 degrees from the final approach heading pull the TRACK knob on the auto-pilot. The aircraft should approach the beam at an angle up to 70 degrees to the QDM and turn gradually onto the centre line, possibly with one slight overshoot. Make any corrections to drift setting on the heading selector necessary to maintain the aircraft on the beam centre line.

(*c*) As the aircraft approaches the glidepath and the glidepath needle indicates half deflection, select full flap, retrim and set the power required to maintain the correct speed on the final approach. When the glidepath needle reaches the top of the circle pull the GLIDE switch. The speed should be held constant by use of throttles throughout the approach and the trim indicators monitored frequently. The flight instruments and the ILS meter should be scanned as for normal instrument approaches to detect any malfunction of the auto-pilot. Should any malfunction be suspected, the auto-pilot should be tripped immediately, and the approach continued manually or broken off as required. The approach must be discontinued if the glidepath or localiser needles reach full scale deflection before the break-off height.

(*d*) When the break-off height is reached the auto-pilot must be tripped and the approach completed manually. If the recommended approach speeds have been used, no difficulty will be experienced in landing normally on the ILS touch-down point.

10 Use of the auto-pilot under asymmetric conditions

Disengage the auto-pilot, retrim the aircraft and re-engage the auto-pilot.

11 Unselected engagement

Should there be an unselected engagement of the atuo-pilot, or if the auto-pilot fails to disengage, the cut-out must be held in while the channel switches are set off and the POWER switch pushed in. The auto-pilot must then be regarded as unserviceable.

Part I

Chapter 8—Air Conditioning System

List of Contents

Description, Controls and Indicators

1 General

Air for pressurising and conditioning the cabin is tapped from each engine compressor. All components of the system are installed beneath the cabin floor. Two pressure controllers are mounted in the cabin. On top of each is a wire-locked pressure adjusting knob and a ground test lever. The latter must be set fully down for flight conditions.

2 Controls and indicators

The controls and indicators for the system with the exception of a circuit breaker on panel AJ are all on the 2nd pilot's side panel

(*a*) Four OPEN/CLOSE ENGINE BLEED ISOLATION COCKS switches, one for each engine, control the supply of air for the system and for the anti-icing system.

(*b*) Two OPEN/CLOSE PORT AND STBD. CABIN AIR ISOLATION cocks, one for each pair of engines control the supply to the pressure ratio control valve and the temperature control valve and thence to the cabin.

(*c*) The CABIN PRESSURE control switch has three positions, CRUISE/COMBAT/UNPRESS. With it set to CRUISE the pressure controllers, one of which has two different settings, maintain a constant cabin altitude of 8,000 feet at all altitudes above

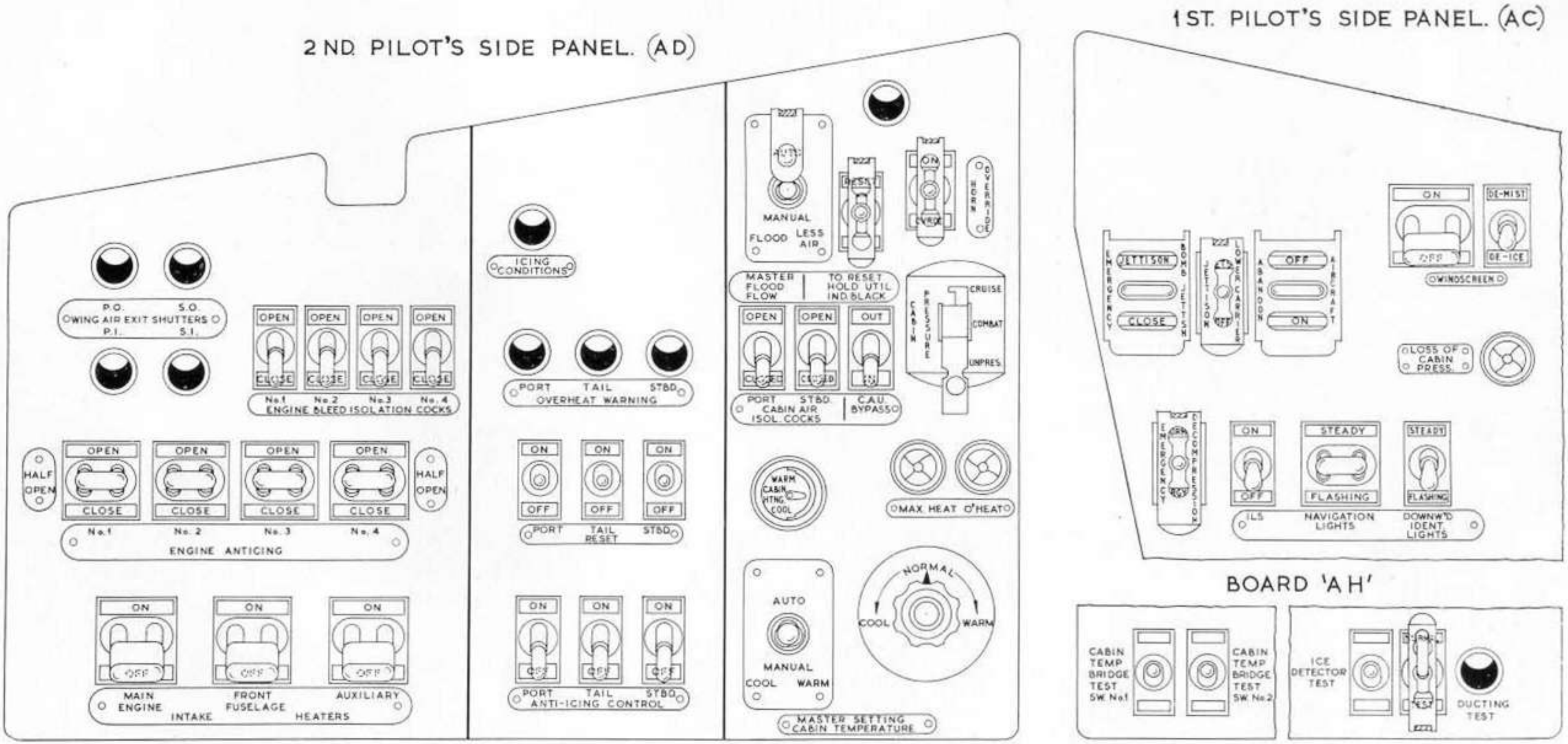

Fig. 1 Air conditioning controls and indicators

or pre-Mod. 2368 Mk. 1A aircraft is reached (23,000 feet approximately). Post-Mod. 2368 the maximum differential pressure is 8 PSI (38,500 ft. approximately). Above that height the pressure differential remains constant and the cabin altitude will increase. With the switch at COMBAT the variable controller is set to maintain 25,000 feet cabin altitude; at altitudes below 25,000 feet ambient conditions are maintained. When set to UNPRESS a discharge valve is opened to dump cabin pressure.

(*d*) The temperature of the cabin air is controlled by two switches, the CABIN TEMPERATURE MASTER and SETTING switches. The Master switch permits the selection of AUTO, off and MANUAL, COOL or WARM, and the SETTING switch, which is for use with the MASTER switch at AUTO, automatically varies the temperature between COOL, NORMAL and WARM. The MANUAL COOL and WARM positions may be used for manual control of cabin temperatue. The switch must be held to either position; when released it reverts to the off position. Above the MASTER switch is an indicator which shows the position of the temperature control valve between WARM and COOL. Above the SETTING switch are two warning lights, an amber one marked MAX. HEAT and a red one marked OVERHEAT.

(*e*) A cabin altimeter is provided on the second pilot's instrument panel AB. A warning light on the 1st pilot's side panel comes on if cabin pressure falls by approximately $\frac{1}{2}$ PSI from the selected value when the control switch is set to CRUISE only. Red warning lights are at each crew station except the 2nd pilot's and prone bomb aimer's.

(*f*) In addition to the warning light a warning horn sounds if cabin pressure exceeds 42,000 feet. The warning can be silenced by operation of the HORN OVERRIDE switch on the 2nd pilot's side panel AD.

◀ (*g*) Mod. 3817 (B.1A and B(K)1A) or Mod. 3929 (B(K)1) provides a cabin differential pressure gauge on panel BF or CAG respectively to give an indication of prevailing conditions to rear crew members. ▶

3 Flood flow control

(*a*) The MASTER FLOOD FLOW AUTO/MANUAL switch controls the flood flow system. The switch is held at AUTO by a spring-loaded gate. With the switch at AUTO flood flow is automatically selected should cabin altitude rise above 27,000 feet. When the gate is raised the switch may be set to OFF (central). The MANUAL setting of the switch is either to FLOOD (left) or LESS AIR (right). By judicious use of these two positions the cabin pressure can be maintained to a reasonable degree. The switch must be held to either position, if released it springs to the off position.

(*b*) A magnetic indicator shows white whenever the flood flow system is in operation.

(*c*) A guarded RESET switch is provided to reset the flood flow control after use, with the flood flow switch OFF.

4 Ram air ventilation—unpressurised flight

(*a*) Two ram air intakes are on the port and starboard sides of the nose respectively. The port intake is primarily for supplying air to the heat exchanger unit in the air-conditioning system and the starboard one for cabin ventilation.

(*b*) *On Mk. 1A aircraft* ram air for unpressurised flight is introduced by a manually-operated lever, fitted on the structure outboard of the Nav./Radar operator, which controls the starboard ram air valve via a bowden cable.

(*c*) *On Mk.* 1 *aircraft,* ram air may be introduced by setting the RAM AIR VALVE OPEN/CLOSE switch to OPEN. A position indicator is situated above the switch and shows all positions between OPEN and CLOSE. The cabin cannot be pressurised unless the switch is at CLOSE.

5 Cold air unit bypass (Mk. 1A aircraft)

When Mod. 908 is embodied a cold air unit bypass is fitted and controlled by a CAU BYPASS, IN/OUT switch on panel AD, adjacent to the cabin air isolation cocks switches. When the switch is set to OUT, the CAU is bypassed.

6 Cabin decompression

In an emergency, and if the aircraft is to be abandoned, cabin pressure can be released by any one of the following controls:

(*a*) The EMERGENCY DECOMPRESSION switch on the 1st pilot's panel AC when moved upwards.

(*b*) The cabin pressure control switch when set to UNPRESS.

(*c*) The crew dump control above the main entrance door when pulled downwards.

(*d*) The ABANDON AIRCRAFT warning switch when set ON, if Mod. 891 is embodied.

7 Circuit breakers

Circuit breakers for the cabin ventilation control, cabin temperature control, cabin temperature overheat warning, air-conditioning isolation and ram air valve circuits are positioned on panel AV. On panel AH are two test switches for testing the cabin temperature balance bridges.

8 Windscreen de-icing and de-misting

(*a*) *De-icing*

The 1st and 2nd pilots' windscreens and DV panels are electrically heated. Each pilot has an OFF/AUTO switch, a DEMIST/DE-ICE switch and a NORMAL/OVERHEAT/DE-ENERGISED magnetic indicator.

(*b*) *Demisting*

A WINDSCREEN DEMISTER OPEN/SHUT control on panel AB can be used to supply de-misting air either to the pilots' windscreen (up) or to the downward observation windows (down) and provides reduced supplies to both in the intermediate position. Additionally Mod. 2023 introduces a control lever beneath 2nd pilot's panel AB which can be used to divert hot air to the pilots' feet or to the windscreen for heating purposes.

(*c*) *Windscreen wipers*

A windscreen wiper is on each pilot's front panel. Each wiper is actuated by a hydraulic pump driven by an electric motor, through suitable reduction gears. The speed of each electric motor is controlled by its associated OFF/SLOW/FAST switch, one on each pilot's console, AE, AF, aft.

(*d*) *Alcohol spray*

When Mod. 2357 is embodied an alcohol spray unit is provided for the 1st pilot's windscreen panels. Alcohol, sufficient for 30 minutes continuous use, is contained in a 1·5 gallon reservoir. It is forced out by air pressure, controlled by a switch on the 2nd pilot's panel AF.

Management of the System

9 Controls selection

(*a*) *Before flight*

(i) Before starting the engines set the pressurisation and air-conditioning controls as follows:

Cabin pressure master (panel AJ) and all circuit breakers on panel AV .	Closed
Cabin pressure selector switch . . .	Set to CRUISE or COMBAT as required
Flood flow switch . .	AUTO. Reset switch OFF. Magnetic indicator black.

Ram air valve switch (Mk. 1) or lever (Mk. 1A)	Operate ram air valve and leave as required (In hot weather the ram air valve may be put in the OPEN position while taxying)
Cabin temperature master switch	MANUAL
Cabin temperature setting switch	Mid-position
Cabin air isolation cock switches . . .	CLOSED
CAU bypass (Mk. 1A) .	IN

(ii) After the entrance door has been closed, check or set:

Emergency decompression switch	NORMAL, safety lock engaged
Dump valve control . .	Up

(iii) After the engines have been started set:

Engine bleed isolation cocks	OPEN (these selectors also control the supply of air to the anti-icing and bomb-bay heating systems and should normally be left on at all times during flight) *Pre-Mods.* 2548 *and* 2802*B* & *C these cocks must remain closed until above* 20,000 *feet in the climb,* unless a lower rate of climb is acceptable in which case air conditioning may be achieved below 20,000 feet by restricting one engine to 85% RPM with its bleed isolation cock open.

(*b*) *Before take-off*

DV windows . . .	Closed
Ram air valve . . .	CLOSE

(*c*) *After take-off*

Cabin air isolation switches	OPEN (one during the two thousand feet checks, the second during the ten thousand feet checks)
Cabin Temp. master switch	AUTO at ten thousand feet
Cold air unit bypass switch (Mk. 1A aircraft only) .	OUT (it should only be switched IN if the cabin temperature becomes excessively hot)

(*d*) *Descent*

Pre-Mods. 2548 and 2802B & C no engine is to exceed 85% RPM when descending below 20,000 feet unless the associated engine bleed isolation cock has first been closed.

(*e*) *Low flying*

Pre-Mods. 2548 and 2802B & C, to provide cabin air conditioning for low level flying it is recommended that one engine is restricted to 85% RPM and its bleed isolation cock is opened. The other three engines can be used normally, but if the fourth engine has to be accelerated above 85% RPM the bleed cock must first be closed.

(*f*) *Before landing* (*Mk.* 1*A aircraft only*)

Cold air unit bypass switch IN

NOTE: When the temperature control valve indicator needle has stablilised, the temperature setting switch may be used to adjust the cabin temperature. Movement of the control before the needle has stabilised will not assist in establishing the desired condition.

10 Control of cabin temperature

(*a*) Normally the temperature control switch should be at AUTO and the temperature adjusted by means of the setting control. If the red OVERHEAT warning light comes on, the temperature control valve will automatically revert to fully cool. The indication of the light is a failure of the automatic system. All subsequent control must then be by manual selection.

(*b*) Manual control is achieved by judicious use of the control switch between the COOL and WARM positions. If the amber MAX. HEAT warning light comes on, the temperature may be reduced by inching the control switch to COOL until the amber light goes out. If, when the amber light is on, further overheating occurs, the red light will come on and the system will automatically go to fully cold and remain there.

(*c*) Only sufficient hot air to prevent misting should be directed onto the windscreen panels. Excessive heating may cause panel de-lamination. Surplus air should be directed away from the panels by selecting the WINDSCREEN DEMISTING control lever towards BOMB AIMER OPEN, and the PILOTS' WINDSCREEN HEATING control lever towards PILOTS' FEET HEATING. It may be necessary to adjust the control settings whenever engine power settings are altered, and particularly after a prolonged descent. Particular care must be taken to avoid excessive heating of the panels whenever the anti-flash screens are fitted.

(*d*) During a descent the heating should be controlled to avoid transparency misting and not switched to full heat when misting occurs as this may crack the transparencies. Until Mod. 779 is embodied do not descend through cloud with fully cold selected as this may cause failure of the cold air unit. During a descent the DV panel heating should be switched on.

(*e*) Before descending to low level, in conditions of high humidity and temperature, the cabin should be refrigerated for about 20 minutes using the CAU.

11 Control of cabin pressure

The control switch should normally be set to either CRUISE or COMBAT. UNPRESS. should be selected if air-conditioning only is required. When the switch is set from COMBAT to CRUISE or vice versa the times taken to stabilise the new conditions are as follows:

CRUISE to COMBAT . . .	36 seconds
COMBAT to CRUISE	5½ to 6½ minutes

Malfunctioning of the System

12 Loss of cabin pressure

(*a*) (i) When operating in CRUISE conditions, a red light at the crew stations (see 2(*e*)) gives indication if the cabin altitude increases by more than 2,000 feet.

(ii) When operating in COMBAT conditions the red lights do not illuminate but the flood flow system is automatically brought into use, controlling cabin altitude between 26,400 and 27,000 feet.

(iii) If the flood flow system is unsuccessful in preventing cabin pressure loss, the cabin altitude will continue to increase. When it reaches an equivalent to 42,000 feet the warning horn sounds. This warning may be silenced by operation of the cut-out switch on panel AD. A descent should then be made to a cabin altitude of 30,000 feet at which height the flight may be continued.

(*b*) *Control of the flood flow system*

(i) Normally the master flood flow switch should be set at AUTO, the FLOOD and LESS AIR settings providing a MANUAL means of operating the flood flow system. When the system is in operation a magnetic indicator adjacent to the switch shows white.

(ii) To reset the system after use, or if it has operated inadvertently, set the master switch to OFF and hold up the RESET switch until the indicator shows black. Then reset the master switch to AUTO.

13 Automatic cabin depressurisation (post-Mod. 891)

When the ABANDON AIRCRAFT warning light switch on the 1st pilot's side is operated the dump valve solenoids are energised and the cabin depressurises, at the same time the flood flow circuit is rendered inoperative.

14 Emergency de-pressurisation

(*a*) In an emergency the cabin can be de-pressurised by any of the following selections:

1st Pilot's ABANDON AIRCRAFT switch (Post Mod. 891)	ON
1st Pilot's EMERGENCY DECOMPRESSION switch	EMERGENY DE-COMPRESSION
CABIN PRESSURE selector	UNPRESS
Rear crew Dump Valve operating handle .	Break wire and pull down

(*b*) The time taken to depressurise the cabin will vary according to the aircraft's altitude and the pressure differential selected. Above 40,000 feet and with CRUISE selected (post-Mod. 2368), at least 6 seconds should elapse between selecting depressurisation and opening the cabin door. All crew members should remain strapped in their seats until the door is open.

Part I

Chapter 9—Airframe and Engine Air Intakes Anti-icing Systems

List of Contents

1 General

NOTE: Mod. 2820 renders the thermal anti-icing system inoperative on Mk. 1 aircraft. However, Mk. (K) 1 aircraft are fitted with ice protection systems to the Mk. 1A and (K) 1A standard.

A thermal anti-icing system, augmented by electrically heated mats, is provided for the engine air intakes and for the leading edges of the mainplane, tailplane, fin and elevators. The hot air supply is from the same source as the cabin pressurising and temperature supply. The engine air intakes electric heating mats are thermostatically controlled by sensing units to ensure that the temperature of the area which they cover does not exceed 150°C.

2 Control and indicators—anti-icing system

NOTE: The electrical supply to the ice detectors and heater mats is inoperative until airspeed is above 105 knots, since the 28 V supply from

(*a*) In order that the system may function the ENGINE BLEED ISOLATION COCKS switches should all be set to OPEN. The system is then controlled by the following switches and indicators under the second pilot's control:

1. An ICING CONDITION magnetic indicator which indicates when icing conditions are encountered.

2. Three OFF/ON switches for the PORT and STBD. wing and TAIL, together with three OVERHEAT WARNING magnetic indicators and three RESET-OFF switches. When Mod. 769 is embodied the OVERHEAT warning indicators are replaced by warning lights.

3. A magnetic indicator for each wing air exit shutter, which

4. Three OFF/ON switches for the MAIN ENGINE air intake heater mats, the FRONT FUSELAGE HEATERS and the AUXILIARY (fin and wing) HEATERS. Each engine intake boundary layer and saddle heater has a temperature sensing device and amplifier, which, when the switch is ON, cause the associated boundary layer heater to be switched on provided that the temperature is sufficiently low and switched off when the temperature reaches a satisfactory level. The other two systems must be manually switched OFF.

(*b*) (i) The ICING CONDITIONS magnetic indicator shows white when icing conditions are encountered. This is an indication to switch on the systems. When icing conditions cease to exist the ICING CONDITION indicator reverts to black and indicates that the system may be switched OFF.

(ii) When the PORT, TAIL and STBD. ANTI-ICING CONTROL switches are set ON, conditioned hot air is fed to the thermal anti-icing system. In order to make the hot air supplies from the starboard engines available at the tailplane for anti-icing purposes, the navigator's bomb-bay heating switch must be selected to TAIL ANTI-ICING, BOMB-BAY HEATING. The ON selection of the PORT and STBD. switches also opens the wing air exit shutters. Conversely an OFF selection automatically closes the shutters.

(iii) If an overheat warning is given by any one of the three magnetic indicators the hot air valve is moved to the fully closed position and the cold air valve is fully opened. All air exit shutters remain open. Also, in the case of a TAIL overheat warning, the port isolation cock, in the supply lines to the tail, closes.

(iv) To reset any part of the system following an overheat warning, hold up the appropriate RESET switch. This action closes the cold air valve and the system is brought back into

(*c*) A test switch for the ice detector on panel AH, may be used to test the system when the aircraft is on the ground. When held at TEST the switch provides a 28V supply from feeder 10P7.

(*d*) Circuit breakers on panel AV are as follows:

Tailplane anti-icing	1, normal control
	1, reset system
	2, isolation cocks
Mainplane anti-icing	1, per side, normal
	1, per side, reset

3 DV window de-misting (Mod. 813)

(*a*) The DV window demisting system is operative and the electrical supplies for the heater elements are taken from the 28V. DC pitot controlled feeders.

(*b*) The switches labelled WINDSCREEN HEATING on the pilots' coaming panel AZ and the associated magnetic indicator have nothing to do with DV window demisting and *do not* control this system.

(*c*) Circuit breakers on panel AV control the supplies to the DV windows, these must be made and the aircraft flying above 105 kts. before DV window demisting is operative.

4 Bomb-bay heating system

(*a*) *General*

The bomb-bay heating system is designed to maintain a temperature of +2°C. but provision is made to allow manual control within variable limits depending upon the type of store carried. The system will operate only if the starboard ENGINE BLEED ISOLATION COCKS switches are set to ON.

(*b*) *Controls and indicators*

The controls are mounted on the navigator's side panel and consist of:

(i) An OFF/AUTO/COLD/HOT, HEATING CONTROL

(ii) A COOL/NORMAL/WARM rotary TEMP. SETTING CONTROL switch.

(iii) A bomb-bay TEMPERATURE INDICATOR.

(iv) A TAIL ANTI-ICING BOMB-BAY HEATING/BOMB-BAY ISOLATED switch. The switch must be selected to TAIL ANTI-ICING, BOMB-BAY HEATING. With the switch thus set tailplane anti-icing is also in use; with the switch set to BOMB-BAY ISOLATED the starboard isolation cock is closed, bomb-bay heating is inoperative and tail anti-icing is fed from the port engines only.

(v) A magnetic indicator which shows white when the heating is off and black when it is on.

5 Management of the systems

(a) Control of the thermal anti-icing system

(i) To switch on the system the following procedure should be used:

Appropriate circuit breakers on panel AV . . .	Closed
Engine isolation cocks . .	ON
Anti-icing control switches .	ON. Exit shutter indicators white

(ii) The thermal anti-icing system should be switched on in the following circumstances:

1 During taxying and for take-off in conditions where the air temperature is below +3°C and the relative humidity exceeds 90%.

2 If visual inspection shows ice formation on the windscreen and build-up of ice on the wing leading edges.

(iii) If an OVERHEAT WARNING is given the affected section is automatically switched off. To bring the section back into use, hold up the RESET switch when the indication should be cancelled. If a further warning is given switch OFF the affected system.

(b) Control of the electric heater mats

In conditions of *(a)* (ii) 1, the heater mats may be switched on prior to take-off, the airspeed switch keeping them inoperative until a speed of 105 knots is attained.

(c) Flying procedure during icing conditions

NOTE: See also Part IV, Chap. 1, para. 8.

(i) *Climb*

Partial protection only is to be expected by climbing at 300 knots at 98% RPM. Optimum protection is achieved at 250 knots at 98% RPM. Decrease in forward speed will result in some range loss. A greater range loss may ensue from the increased drag, caused in severe icing conditions by the ice accretion on the outer wing.

(ii) *Descent*

1 The 208v variable-frequency power for the electrically-heated mats is normally supplied by the outboard engines and during descent under icing conditions it is important to keep No. 1 and No. 4 alternators in high power, and to keep RPM as high as possible to give maximum amount of heat for anti-icing the aircraft structure. During a descent under icing conditions where OAT is above −10°C, descent should be made with Nos. 2 and 3 engines throttled fully back and Nos. 1 and 4 engines maintained at 80% RPM with air-speed controlled to 240 knots by use of air brakes. For temperatures below −10°C the maximum continuous icing conditions will not extend through a layer of more than 10,000 ft. Under these conditions a rapid descent at 300 knots should be made through the icing layer, so that time spent under these conditions should not exceed 1½ to 2 mins. Again Nos. 1 and 4 engines should be kept at maximum power

consistent with a forward speed at 300 knots, and Nos. 2 and 3 engines throttled fully back. During a rapid descent under conditions below −10°C some ice may build up on the outer wings and in the engine intake. Run back, due to incomplete evaporation, is likely to occur down the engine intake and refreeze in rivulet form, which may break away and pass through the engine. After the descent, OAT should be approaching −10°C at let-down height of 2,500 feet, and a normal landing should be made.

2 The above procedures are recommended using power on outboard engines to provide heat for wing de-icing and to use the normal 208V supply for heating mats. If an outboard engine fails, the inboard engine should be used, at as high power as possible, to provide the maximum amount of heat for anti-icing. Under these conditions the inboard alternator, which is normally at standby, will provide AC power for the electric heater mats.

3 Cold weather icing tests carried out on Sapphire engines indicate that the engine can accept limited quantites of ice through the compressor without affecting running, but after descent through severe icing conditions inspection of compressor blades should be carried out.

(iii) Pre-Mods. 2548 and 2802B & C if thermal anti-icing is an operational necessity during climb to or descent below 20,000 feet normal drills should be followed and the occurrence reported in F.700.

(*d*) *Control of the bomb-bay heating system*

(i) All bomb-bay heating controls are at the navigator's station. The system should normally be operated at AUTO with a temperature setting suitable for the stores carried. Should the automatic system fail, the temperature can be controlled manually by moving the heating control switch to HOT or COLD as necessary.

(ii) Pre-Mods. 2548 and 2802B & C if bomb-bay heating is required either No. 3 or No. 4 engine bleed valve must be opened but that engine must not exceed 85% RPM.

Part I

Chapter 10—Aircrew Equipment Assembly and Oxygen System

List of Contents

WARNING: Both ejection seats must be rendered safe for parking, whenever the aircraft is on the ground, by inserting safety pins in the :

Seat pan handle (Post-Mod. ES2158)

Ejection gun firing unit sear

Canopy jettison and time delay unit trip lever

Canopy jettison firing unit sear

Control column snatch unit firing unit sear (Post-Mod. CJ 44)

1 General

The aircraft equipment assemblies consist of the seats, the flying and safety clothing and associated equipment, including oxygen connections. The description of these items and their use is covered in the following paragraphs. Ejection seats are provided for the pilots and static seats for the rear crew members. Post-Mod 3295, swivel seats are fitted for the rear crew members and the sixth seat is fitted with an assister cushion.

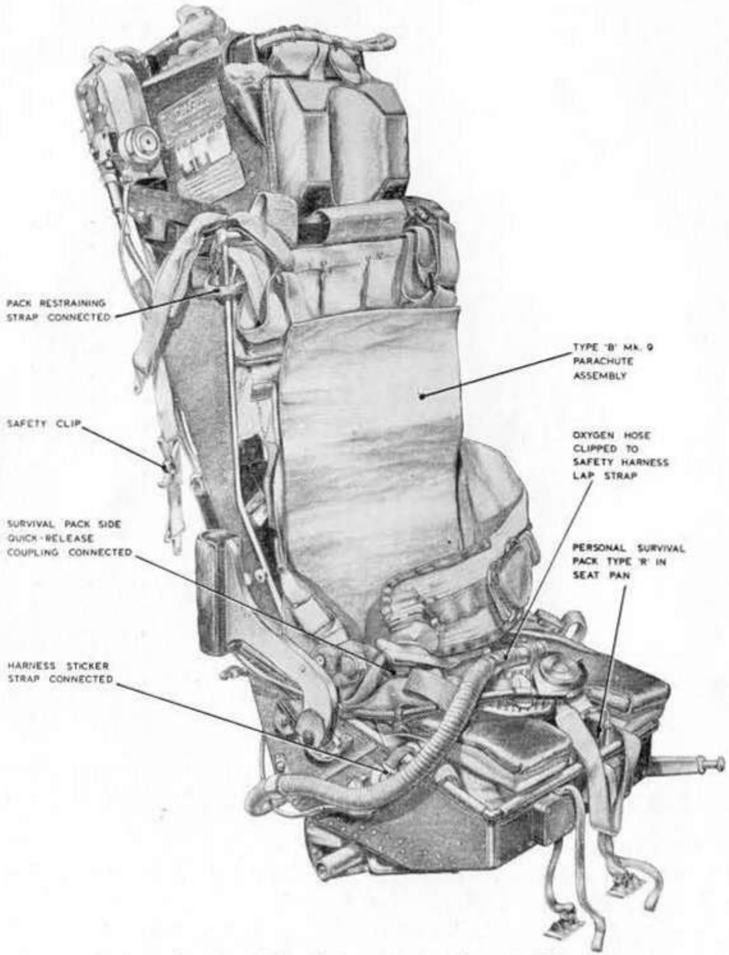

Fig. 1 Ejection seat equipped (1)

Ejection seats

2 Seats, general

(*a*) The ejection seats, Mk. 3L1 for the 1st pilot and Mk. 3L2 for the 2nd pilot, are similar but partially handed. Each seat carries a Mk. 9 parachute assembly, Type ZF harness, a personal survival pack type R and emergency oxygen bottle.

(*b*) The seat pan is adjustable for height, by means of a lever on the outboard side of the seat. The trigger in the end of the lever must be depressed before the height can be adjusted and, when released, locks the seat in the selected position.

(*c*) A lean-forward lever, forward on the inboard side of each seat, allows the occupant to lean forwards, by unlocking the attachment between the shoulders and the back of the seat. If the lever is released, the forward position can be held but, on sitting back again, the slack is automatically taken up and locked against renewed forward movement.

(*d*) The adjustable armrests are controlled by either of two levers on each rest, one at the forward end and one at the rear, on the side of the rest.

3 Ejection gun and firing handles

Each set is fitted with an 80 ft./sec. telescopic ejection gun, which can be fired by either of two handles; the face screen firing handle, to which is attached a face blind, is above the occupant's head and is B-shaped. The seat pan firing handle, for use in conditions of high G or when it is otherwise impossible to reach the blind handle, is in the front of the seat. Either handle must be pulled to its full extent to fire the gun. Safety pins are provided, one for each firing handle. Mod. 3008 introduces a guard over the canopy jettison gun sear on the 1st pilot's ejection seat.

4 Drogue gun

The drogue gun has a time-delay mechanism and fires half a second after the ejection gun has fired

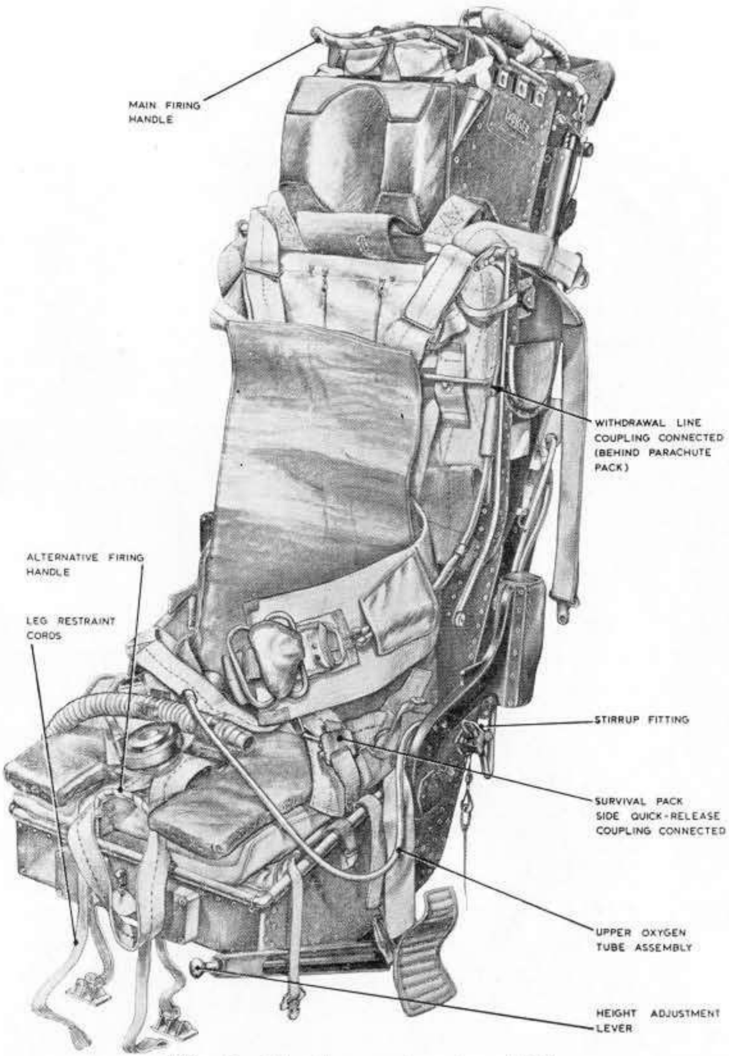

Fig. 2 Ejection seat equipped (2)

drogues to stabilise the seat. The time-delay mechanism is operated by a static trip rod, which withdraws a sear from the gun as the seat rises on the rails.

NOTE: Before flight, check that the drogue withdrawal line (between the gun and the flap securing pin) passes *over* the black lifting line (between the scissors shackle and securing pin on the side of the head-box).

5 Barostat/G-stop time-delay

(*a*) A barostat-controlled mechanism delays automatic separation from the seat until it is below 10,000 feet. Below this height, the mechanism operates after a delay of $1\frac{1}{4}$ seconds, releasing the harness, and leg restraint cords from the seat. Simultaneously, the drogues are detached from the top of the seat and the parachute pack and top of the face blind are also released. The drogues, however, remain connected to the apex of the parachute and withdraw it upwards. A 5,000 metre capsule can be fitted for flights over mountainous territory.

(*b*) A G-stop is also incorporation in the barostat mechanism so that, in ejections made at high aircraft speeds, the mechanism does not function until the speed of the seat has fallen to a safe value for parachute deployment. Ejection can be made from ground level upwards, provided that the aircraft's flight path and attitude are horizontal and that the speed is at least 90 knots. If the aircraft is descending or nose-down, more height will be required.

6 Hatch/seat connection

An interconnection between the seat-firing mechanism and each pilot's hatch enables the hatch to be jettisoned automatically when any firing handle is pulled. After operating the handle, there is a delay of one second before the ejection gun fires.

7 Leg restraint

Leg restraint cords are provided, to ensure that the legs are drawn back and held close to the seat pan during and after ejection. The cords pass through snubbing units below the front of the seat pan and are then fastened to the cockpit floor with rivets which shear at a pull of 400 lb. The snubbing units allow the cords to pass freely down through the unit but prevent them passing upwards, except when released by the spring-loaded toggle at the front of each snubbing unit.

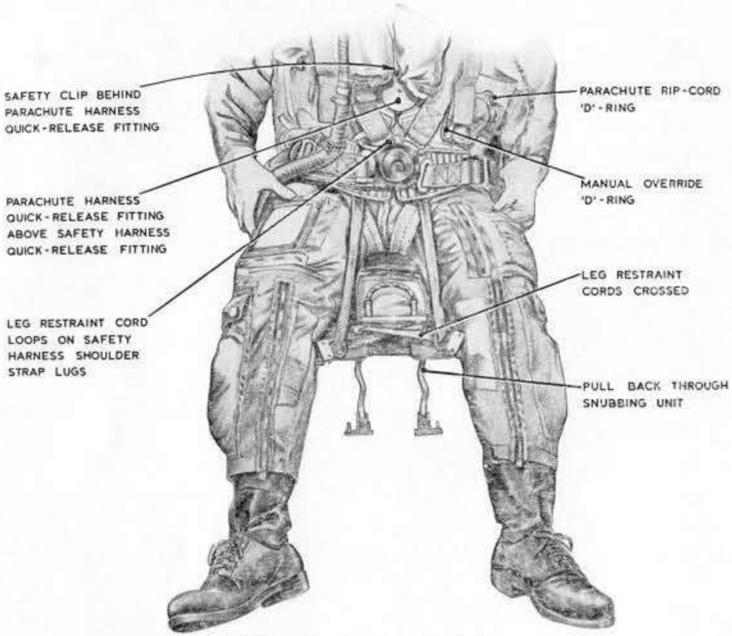

Fig. 3 Leg restraint

8 Manual separation

(*a*) To allow the occupant to release himself from the seat, should the automatic devices fail to operate, means of manual separation are embodied.

(*b*) The first (manual override) D-handle on the parachute waistbelt is pulled to disconnect the parachute from the drogue link line.

(*c*) After operating the first D-handle, the seat harness may then be operated to enable the occupant to leave the seat. After leaving the seat, the parachute can be opened by pulling the rip-cord D-handle on the parachute harness.

Rear Crew Safety Equipment

9 Mask and helmet

A G-type helmet is worn with either a P1A or Q2A oxygen mask. These masks are of the chain-toggle, pressure-breathing type with a bayonet hose connection ; they are identical apart from size. The mask should be tested before flight and the knurled screws adjusted so that there is no leakage under pressure. A lever on the front of the toggle harness is normally in the up position, should pressurisation failure occur, the lever is put to the down position, to clamp the mask more tightly on the face for pressure breathing. Post-Mod 3295 a mask hose assembly must be worn to connect to the aircraft assembly and the emergency oxygen hose.

10 Parachute assembly

(*a*) *Pre-Mod.* 3295

The rear crew members wear back-type parachutes Mk. 20 and personal survival pack type S. The parachutes have a barostat control which, when the static line is used, delays deployment of the parachute until below 13,000 feet. This can be overridden by the yellow and black knob on the left shoulder strap. The left shoulder strap also carries a red loop for operating the emergency oxygen and a snaphook for attachment to the static line. Four static lines are at the back of the AEO's seat.

(*b*) *Post-Mod.* 3295

(i) The Mk. 40 parachute is normally operated by the crew member attaching its static line to the hook on the appropriate swivel seat before leaving the aircraft. The Mk. 46 parachute static line remains connected throughout the flight. In either arms the barostat unit, which delays deployment until either the escaper has fallen freely to 13,000 feet or if already below that height, for two seconds so as to be clear of the aircraft. This unit can be overridden by pulling the plastic sheathed tag attached to the parachute end of the static line. Static line operation should always be chosen as it automatically ensures deployment, even if the escaper is knocked out during the escape : the override is a safeguard in case of failure of the automatics, or of inability to hook on the static line for any reason. To override the automatics the handle on the crutch strap should be pulled.

(ii) The parachute embodies a demand EO set, normally initiated automatically by the static line. A knob on the crutch strap provides direct manual initiation if required.

11 Swivel seats—Mod. 3295

(*a*) Each rear crew member is provided with a swivel seat incorporating an assister cushion and a Mk. 40 or Mk. 46 parachute with a demand emergency oxygen set. The two navigators' seats swivel clockwise, the AEO's seat swivels anti-clockwise. The sixth crew seat is a non-swivelling seat fitted with an assister cushion. It must always be fitted facing rearwards.

(*b*) The seats are mounted on rails which allow them to be slid fore and aft as required. The seat rails are reinforced to take crash landing loads. Fore and aft movement of the seats is controlled by either a lever at the base of the rear of each seat (move to the right to unlock) or by the rearward movement (in relation to occupant) of the yellow/black lever on the left of the seat.

(*c*) Swivelling of the seats is controlled by either a lever at the top of the rear of each seat (move right to unlock) or by forward movement of the yellow/black lever on the left of the seat. These movements also unlock the valve of the seat back, which is spring-loaded, to a forward position necessary to clear obstacles when swivelling. Once either motion of the seat has commenced, the handle may be released and will spring back into its central position to lock the seat again, when the seat has reached the opposite end of the travel.

(*d*) (i) The assister cushion is inflated by CO_2 stored in a bottle at the back of the seat at a pressure of 1,200 PSI. A pressure gauge is incorporated in the bottle.

(ii) The CO_2 is released to the cushion by pulling up a yellow/black knob, at the right of the seat, to the full extent of its travel. Additionally this action also releases the harness lap strap anchorages thereby freeing the occupant from the seat.

(*e*) The seat thigh supports can be adjusted for individual comfort by means of a star wheel mounted under the supports centrally.

(*f*) The yellow/black swivelling level incorporates a handle into which the individual parachute static line is clipped when leaving the seat prior to abandoning aircraft.

(*g*) When Mod. 3955, Part A, is embodied static line strong points are fitted as follows :

(i) Port seat point, on front face of desk.

(ii) Centre and starboard seat points, at front ends of centre seat lower rails.

(iii) Sixth crew seat points, at frame 63. The static lines (Mod. 3955, Part B) include mic/tel. lead, oxygen hose and electric wiring for the "crew gone" warning signals (see Chapter 14, Para. 10).

This permits the static lines to remain connected at all times.

Oxygen System

12 Description of oxygen system

(*a*) Oxygen is carried in ten 2,250-litre bottles. The bottles are all charged through a connection aft of the radome ; the correct charging pressure is 1,800 PSI. Two pressure gauges on the AEO's panel BB show the pressure in each half of the system, indicating it as a fraction of the full charge contents. These gauges normally read the same but a system of non-return valves and interconnections enables one half of the system to supply oxygen should the other half fail. Mod. 3646 replaces the Mk. 17D regulators with Mk. 17F.

(*b*) From the oxygen bottles, the high pressure supply lines pass into the pressure cabin. Master valves, one for each side of the system, are below the pressure gauges.

(*c*) The supply is fed to four pressure-reducing valves, which reduce the pressure to 400 PSI. The medium pressure lines pass from each pressure-reducing valve to the regulators.

13 Oxygen regulators, general

(*a*) An oxygen regulator Mk. 17D or 17E (Mod. 2503—Mk. 1A only) is supplied for each crew member's normal station and one additional regulator is at the bomb-aimer's position. The 1st and 2nd pilots' regulators are at the forward ends of the port and starboard consoles. Mod. 3886 introduces a seventh Mk. 17F regulator at the sixth crew member's position. To operate the regulator the seat must be in the fully aft position.

(*b*) The regulator is designed to provide the following facilities:

(i) An oxygen supply in direct relation to the rate and strength of the user's respiration.

(ii) The correct ratio of air and oxygen according to cabin altitude. Above 32,000 feet cabin altitude, 100% oxygen is provided and 100% oxygen may be selected at any time.

(iii) A safety pressure, slightly higher than the normal delivery pressure, when cabin altitude exceeds 12,000 feet, and full pressurisation of the oxygen supply when the cabin altitude is between 39,000 feet and 56,000 feet.

(*c*) *Limitations*

The regulators will provide protection against loss of cabin pressure up to a cabin altitude of 50,000 feet, provided that a descent is started within 30 seconds of the pressure loss and that a cabin altitude of 40,000 feet is reached within two minutes of the failure and that the oxygen contents have not fallen below $\frac{3}{8}$ of the total capacity.

14 Oxygen regulators, controls and indicators

(*a*) *Controls*

On the face of the regulator are three levers, whose operation and function is as follows:

(i) OXYGEN SUPPLY, ON/OFF lever. This lever controls the supply of oxygen to the regulator and must be ON at all times in flight.

(ii) NORMAL OXYGEN/100% OXYGEN lever. When in the normal position, this lever allows air to mix with the oxygen in suitable proportions, up to a cabin altitude of 32,000 feet. Above this altitude, the air inlet is closed and 100% oxygen is delivered in the mask. With the lever at 100% OXYGEN, the air inlet is closed regardless of the altitude ; this position should always be used if toxic fumes are present.

(iii) An EMERGENCY three-position switch. When this is pushed in, in the central position, oxygen is supplied under pressure. The firmer the switch is pushed in, the greater the pressure. The mask can be adjusted so that no leaks are present. Movement of the switch to either side position causes oxygen to be delivered at a slight continuous pressure and should be so set if toxic fumes or anoxia are present.

(*b*) *Indicators*

(i) A gauge on the regulator shows the pressure of oxygen being delivered to the regulator and should indicate 200-400 PSI at all times ; two gauges at the AEO's station show the main storage cylinder pressures as a fraction of the full charge contents.

(ii) A magnetic indicator on the regulator shows white when the user is breathing in. A repeater indicator is provided in the rear cabin for the bomb-aimer's regulator so that the other rear crew members can monitor this isolated station.

Fig. 4 Ejection seat occupied (1)

(*c*) *Dual oxygen feed coupling*

To provide a " walk around " facility for rear crew members from the main oxygen supply, and for use in the event of a regulator failure by any crew member a dual oxygen feed coupling has been introduced. It is stowed in a polythene bag on panel BD and consist of a dual feed coupling and flexible extension three feet in length. When in use two adjacent crew members can be supplied from any one oxygen connection except in the case of the visual bombing position.

15 Emergency oxygen

(*a*) *Pilot's emergency oxygen*

(i) An emergency oxygen bottle is installed on the starboard beam of each ejection seat and feeds into the main oxygen tube.

(ii) The emergency oxygen is operated automatically on ejection. It can also be selected manually by pulling up the knob on the inboard side of each seat. As the bottle is attached to the seat, emergency oxygen is not available after separation from the seat.

(*b*) *Rear crew's emergency oxygen* (*pre-Mod.* 3955)

An emergency oxygen bottle is in the top of each rear crew member's parachute pack and is operated automatically when the parachute static line is operated, or manually by a red loop on the left shoulder strap of the harness.

(*c*) *Rear crew's emergency oxygen* (*post-Mod.* 3955)

(i) The oxygen is passed through a demand regulator stowed in a pocket at the back of the parachute right half-belt. From the regulator, a breathing pressure hose is connected to the mask hose assembly when " strapping in ". Safety pressure is provided from ground level to 40,000 feet and there is no Air Mix facility.

(ii) The endurance of the set is approximately 10 minutes but, if it is accidentally operated when not connected to a mask worn by a crew member, the oxygen is rapidly exhausted in an attempt to maintain safety pressure. The manual over-ride knob is on the crutch strap.

Fig. 5 Ejection seat occupied (2)

Use of Aircrew Equipment Assemblies

16 Strapping-in procedure—pilots

(*a*) When seated, connect the PSP lowering line to the life-saving waistcoat.

(*b*) Secure the parachute harness and fit safety-clip to quick-release box.

(*c*) Secure the seat harness and leg-restraint cords as follows:

(i) Fasten the leg-restraint garters below the knees with the D-rings to the rear (if not permanently embodied in the flying suit).

(ii) Fasten the lap straps of the seat harness, but do not tighten them.

(iii) Pass the left nylon cord through the right leg D-ring, under the right safety-harness lap strap and insert the right shoulder safety-harness eyepiece through the loop on the cord. Secure the shoulder safety-harness in the quick-release box.

(iv) Repeat for the other cord, passing the right cord through the left leg D-ring, under the left safety-harness lap strap and insert the left shoulder safety-harness eyepiece through the loop on the cord. Secure the safety-harness.

(v) Adjust the leg-restraint cords to give full rudder movement.

(vi) Sit well back in the seat and tighten the lap straps.

(vii) Take up all the slack in the shoulder straps but do not over-tighten them.

(*d*) Connect the main oxygen and emergency oxygen supply tubes to the oxygen mask tube, ensuring that the emergency oxygen tube passes under the left shoulder strap. Attach the oxygen tube assembly locating chain to the LSW.

(*e*) Connect the intercomm. lead.

(*f*) Adjust the height of the seat.

(*g*) Check that the face screen firing handle can be reached with both hands together.

(*h*) Have all the safety pins removed an stowed.

17 Strapping-in procedure—rear crew static seats

Prior to entering the seat, ensure that the safety-pins have been removed from the EO cylinder.

(*a*) When seated, connect the lanyard of the personal survival pack to the left webbing strap of the life-jacket, adjusting the length of the latter so that the quick-release fitting will lie clear below the harness lap strap when subsequently connected.

(*b*) Fasten the parachute harness:

(i) Pass the left half of the waist-belt over the life-jacket/survival pack landyard connection.

(ii) Pass the right lap strap over the right thigh, thread it up through the right crutch loop and connect to the quick-release box on the waist-belt.

(iii) Connect the left lap strap similarly, ensuring that it passes over the survival pack landyard.

(iv) Fasten the right shoulder strap into the quick-release box, ensuring that it lies under the stole of the life-jacket.

(v) Clip the hook of the right half of the waist-belt over the end fitting just connected.

(vi) Fasten the left shoulder strap into the quick-release box, ensuring that this strap passes over the " valley " between the cylinder and stole of the life-jacket.

The objectives are:

1 To leave the parachute static line hook, emergency oxygen control and override knob completely unobstructed.

2 To obscure the life-jacket cylinder red cap as little as as possible.

3 To trap as little as possible of the life-jacket stole.

(vii) Fit the safety-pin between the disc and the body of the quick-release box. Ensure that its webbing safe-tie is clear so that the clip can be rapidly disengaged.

(viii) Tighten the lap straps.

(*c*) Connect the quick-release couplings of the PSP to the parachute harness and tighten the restraining straps.

(*d*) Put on helmets and connect mask tube. Connect the emergency oxygen and attach the tube-locating chain to the life-jacket D-ring. Plug in the mic/tel lead.

(*e*) Fasten the safety-harness and adjust the seat position.

(*f*) Check the intercomm. and oxygen regulator.

18 Strapping-in procedure—rear crew swivel seats

WARNING: Post-Mod. 3886 the sixth crew member's oxygen hose and static line must be routed between the back of his legs and his seat. Premature deployment of the parachute could occur within the cabin if an attempt to bale out was made with the hose routed in front of the legs.

(*a*) Check the contents of the assister cushion bottle. The pressure should be 1,200 PSI. Insert the pip-pin.

(*b*) Remove the demand emergency oxygen pin.

(*c*) Slacken all the parachute straps fully and stow them in their stowages before getting in the seat.

(*d*) Check that the side harness straps of the personal survival pack are connected to the parachute harness.

(*e*) Connect the emergency oxygen supply to the oxygen mask hose.

(*f*) Adjust the parachute quick-release box in front of the body. Pass the thigh straps through the crutch loops and connect them to the quick-release box.

(*g*) Connect the shoulder straps to the quick-release box, ensuring that the hose assembly is beneath the right shoulder and leg straps. Tighten the harness.

(*h*) Connect the personal survival pack lowering line to the life-jacket.

(*j*) Connect the oxygen mask hose to the aircraft assembly and make the mic/tel. connection.

(*k*) Connect the static line to the aircraft hose assembly (Pre-Mod. 3955 to the swivelling lever).

(*l*) Fasten the seat lap strap.

(*m*) Check the seat swivelling and sliding actions and make sure that the personal survival pack lowering line does not foul on any portion of the seat.

(*n*) Put on the helmet and connect the mask tube to the mask hose.

(*o*) Connect the mic/tel. lead.

(*p*) Check the intercomm. and oxygen.

19 Normal exit procedure

(*a*) *Pilots*

(i) Remove helmet and mask, disconnecting mask tube and mic/tel lead.

(ii) Remove safety clip from quick-release box and undo harness.

(iii) Disconnect dinghy lanyard.

(iv) Disconnect the leg restraint cords.

(v) Move out of the seat, seeing that the leg restraint cords pass through the garter D-rings.

(*b*) *Rear crew members (static seats)*

(i) Remove helmet and mask, disconnecting mask tube and mic/tel lead.

(ii) Disconnect safety harness and parachute harness.

(iii) Disconnect dinghy lanyard.

(iv) Disconnect emergency oxygen.

(v) Leave seat.

(*c*) *Rear crew members (swivel seats)*

(i) Remove the helmet and mask, disconnecting the mask tube and mic-tel lead.

(ii) Disconnect the safety harness and parachute harness.

(iii) Disconnect the emergency oxygen supply.

(iv) Slacken the parachute straps and stow them in their stowages.

(v) Disconnect the personal survival pack lanyard.

(vi) Disconnect the static line.

(vii) Disconnect the mask hose assembly from the aircraft hose assembly, placing the aircraft assembly in it stowage.

(viii) Replace the emergency oxygen safety pin.

(ix) Remove the assister cushion pip pin.

20 Pressurisation failure

If the cabin pressure fails, each crew member should immediately depress the lever on the mask toggle harness. This will clamp the mask tightly against the face to prevent leakage of oxygen. If the cabin altitude is above 40,000 feet, a descent must be made to 40,000 feet cabin altitude within two minutes of the failure, with a subsequent descent to below 20,000 feet, to avoid the effects of decompression sickness.

21 Regulator failure

(*a*) *Pilots*

If a pilot's regulator fails above 10,000 feet cabin altitude, he should immediately select emergency oxygen, by pulling up the handle beside his seat. The regulator should be switched off. Post-Mod. 3955 he should transfer to any other available regulator. A spare mask hose assembly should be carried for this purpose. The emergency oxygen is only sufficient for 10 minutes and descent should therefore be made to an altitude where oxygen is not required. When this altitude has been reached, if the main regulator has been on 100% OXYGEN, switch over to NORMAL so that cabin air can be freely breathed, while maintaining mic/tel, etc.

(*b*) *Crew members*

If a crew member's regulator fails, he can transfer to the dual oxygen feed coupling or, post-Mod. 3955, to any other available regulator. It is not operationally practicable to use the emergency oxygen set except when abandoning the aircraft or whilst reducing to a safe altitude.

Part I

Chapter 11—Pitot-static System and Flight Instruments

List of Contents

1 Pitot-static system

(*a*) The pitot-static system may be divided into the following five separate systems:

(i) Port wing pressure head.

(ii) Starboard wing pressure head.

(iii) Nose pitot head.

(iv) Fuselage static vents.

(v) Wing static vents.

(*b*) The port wing pressure head system supplies both pitot and static pressure to the following:

1st pilot's machmeter, ASI, altimeter* and rate of climb indicator*
AMU
Bombsight computor

(* = Static pressure only)

(*c*) The starboard wing pressure head system supplies both pitot and static pressure to the following:

(i) 2nd pilot's machmeter, ASI, altimeter* and rate of climb indicator*

(ii) Master navigator's ASI and altimeter*.

(iii) CL *Warning Detector Panel*. This panel is mounted at the AEO's station and contains the stall warning detector switches and contacting machmeters used to automatically control the operation of the wing nose flaps.

(iv) *Auto Height and Auto Mach Units*. These units are mounted on the pressure bowl in the cabin and are the controlling units for the elevator auto mach trim.

(v) *Undercarriage Pressure Switch*. This switch is mounted on the NBC crate behind the co-pilot's seat. Its purpose is to automatically release the lock on the undercarriage UP button when a speed of 105 knots is attained. This allows a normal undercarriage UP selection to be made. It also completes the circuit to the following:

1H15	Auxiliary intake heaters	Port wing
2H15	Auxiliary intake heaters	Stbd. wing
1H24	Engine intake heating	Port
2H24	Engine intake heating	Stbd.
1H25	Front fuselage intake heating	Port
2H25	Front fuselage intake heating	Stbd.
H31	Ice detector test	
H33	Cold air unit control valves	
5H14	DV window heating	Port
6H14	DV window heating	Stbd. wing

(vi) *Vertical Gust Recorder.* When a vertical gust recorder is carried it is mounted at the starboard side of the bomb-bay, and is connected to the pressure and static supply through a cock located in the cabin adjacent to the navigator's position.

(vii) *Bomb Gear Circuit Pitot Switch.* This switch is mounted in the cabin adjacent to the VG recorder cock and operates in conjunction with the bomb gear.

(viii) *Fatigue Meter Switch.* This switch is mounted in the cabin near the VG recorder cock and controls the switching ON and OFF of the RAE Fatigue Meter.

(ix) *Auto-pilot coupling unit.* This unit is located under the navigator's table and is connected to the static supply only.

(x) *Pitot Head Heaters.* Two switches are located on panel AZ, one of the two switches controls the port pitot head heater while the other controls the starboard. The nose pitot head heater is switched on with the Front Fuselage Heater Switch on panel AD, but the heater does not actually come on until a forward speed of 105 knots is reached.

(*d*) *Nose pressure head.* This protrudes from the nose of the aircraft and is provided to supply pressure during flight to the bellows of the artificial feel unit.

(*e*) *Fuselage Static System.* The static vents are on either side of the fuselage below the line of the cabin floor and are interconnected by a $1\frac{1}{2}$ in. dia. pipe. Tappings are taken from the pipe for:

(1) The artificial feel unit compartment

(2) The fuel pressure venting system

2 Pitot-static operated instruments

(*a*) *Airspeed indicators*

Three ASI's are fitted, one on each pilot's instrument panel and one at the navigator's station. Both pilots' ASI's are fitted with a flag which appears and oscillates in the face of the dial if speed is reduced below 160 knots with the undercarriage up. When Mod. 864 (1st pilot—Mk. 1A) and Mod. 2987 (2nd pilot) are embodied both ASI's are replaced by two-pointer instruments not incorporating warning flags.

(*b*) *Altimeters*

Three altimeters are fitted, one on each pilot's instrument panel and one at the navigator's station. Mod. 3190 provides vibrators for the Mk. 19B or C altimeters on the co-pilot's instrument panel. Mod. 3486 replaces the Mk. 19B or C altimeters at all three stations with Mk. 19F altimeters and additionally provides vibrators at the 1st pilot's and navigator's stations.

(*c*) *Machmeters*

A machmeter is fitted on each pilot's instrument panel.

3 Other instruments

(*a*) *Electrically-operated instruments*

See Part I, Chap. I.

(*b*) *Accelerometer*

The accelerometer is mounted in front of the 1st pilot on AZ and indicates all normal accelerations imposed on the aircraft in the pitching plane by means of three concentrically-mounted pointers. One pointer indicates instantaneous G and automatically reverts to 1G reading when the aircraft is in straight level flight. The other two register the maximum positive and negative G readings respectively until reset manually.

(*c*) *Outside air temperature gauge*

An outside air temperature gauge is fitted on panel AB and at the navigator's station.

4 Malfunctioning of the pitot-static system

(*a*) The starboard system contains a greater number of pipe joints than the port system and is therefore more susceptible to a leak developing.

(*b*) If a discrepancy occurs between the readings of the 1st and 2nd pilots' pressure instruments it is more likely that the instruments fed from the starboard system are in error.

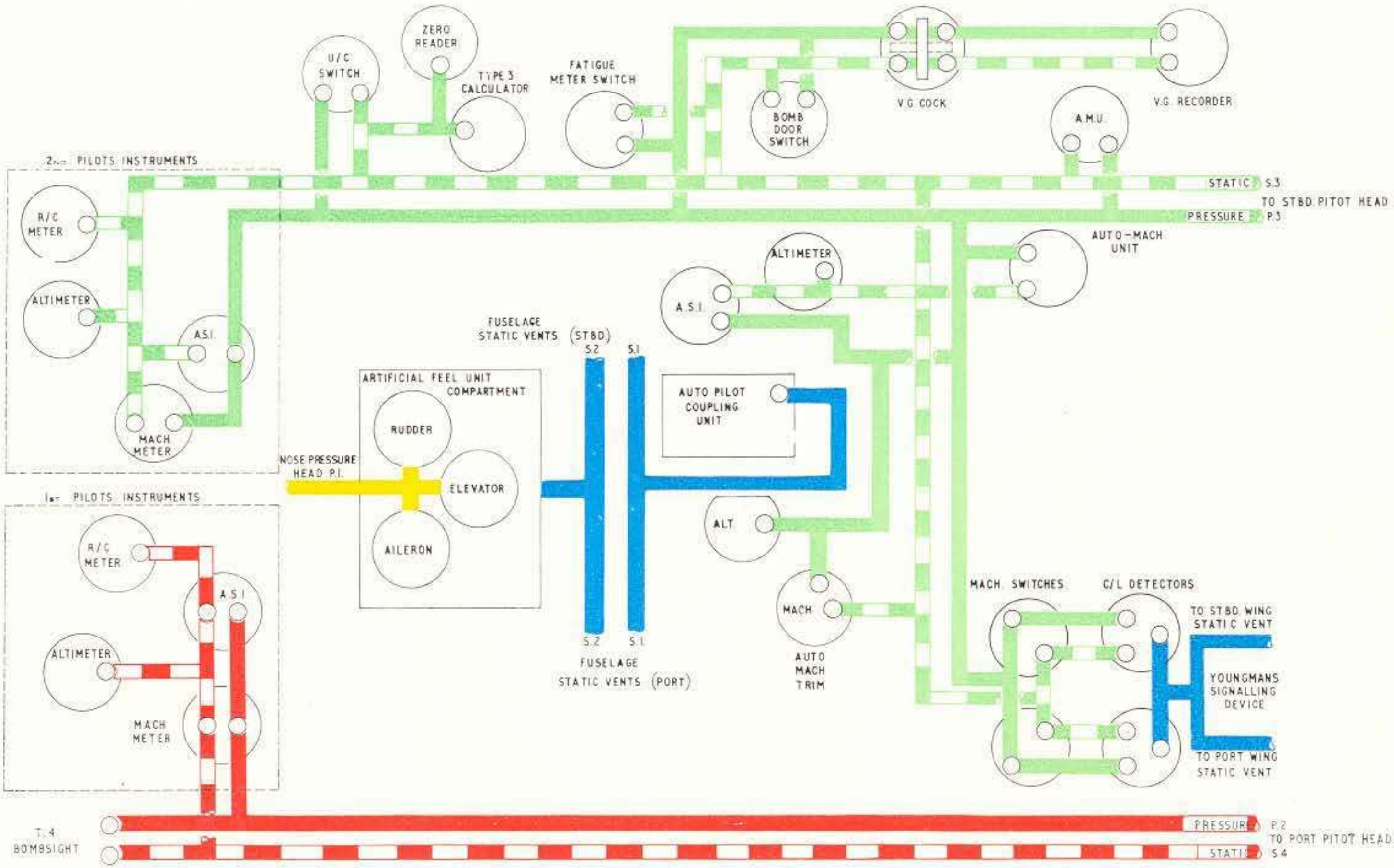

Fig. 1 Pitot-static system

Part I

Chapter 12—Radio and Radar

List of Contents

Radio Communication

1 VHF TR1985/86

(*a*) Twin VHF sets, TR1985/86, each having ten channels, are installed. The controls are on the roof panel, together with a changeover switch.

(*b*) Power for the VHF is from the 28-volt system. Selection of No. 2 VHF by the pilot energises the change-over relays.

2 UHF ARC/52 (Mod. 591—Mk. 1A only)

(*a*) The UHF transmitter/receiver is in the floor of the fin compartment and the selector on panel AE. It is possible to select 1,750 channels at 0·1 mc/s intervals or 19 preset channels, one of which is tuned to 243 mc/s. In addition, a separate receiver allows a guard frequency of 243 mc/s to be superimposed on any selected

(*b*) The remote control unit on panel AE or, post-Mod. 3881 on panel BF, carries the following controls:

(i) A 20-position rotary switch, giving selection of 18 preset channels, the guard frequency (channel G) and MANUAL.

(ii) Four manual control switches. The first selects either 200 or 300 mc/s, the second selects 0 to 90 mc/s in tens, the third selects 0 to 9 mc/s and the fourth 0 to 0·9 mc/s. These switches are only operative when MANUAL is selected on the 20-position switch.

(iii) A volume control.

(iv) A four-position function switch, giving selection of:

OFF

T/R + G, as TR with the guard frequency superimposed on reception

ADF (inoperative)

(*c*) On panel AE is a tone switch.

(*d*) It is possible to reset the preset channels in the air, if necessary. To do so, the cover plate on the control unit is removed by undoing the milled screws. The channel selector is then turned until the number to be selected is indicated on the resetting panel (this will not correspond to the selector switch indication). The resetting pins are then moved to the required positions and the cover plate closed.

(*e*) *Power supplies*

The UHF uses 28-volt DC, from feeder 10P7.

3 Tone release

Tone release facilities are available, post-Mod. 745, for simulated bombing practice and may be obtained from either VHF or UHF. The controls are on panel CP and consist of a 2-position UHF/VHF switch, start switch and a light. When the start switch is pressed, the service selected radiates a continuous 1 kc/s note until the bomb is supposedly released.

4 HF STR 18B2

(*a*) HF communication is by STR 18B2, the control unit being at the AEO's position. The control unit carries a function switch, a channel selector, volume and fine tuning controls. R/T transmission can be made on HF, if required. Also at the AEO's position are the HF SUPPLY circuit breaker and OUTPUT control switch.

(*b*) The STR 18B2 uses 28-volt DC.

5 Intercomm. general

(*a*) The intercomm system operates through an A1961 amplifier,

position. In addition, a separate A1961 amplifier is provided for conference intercomm and is controlled by an ON-OFF switch at the AEO's position (Panel BF). If the normal intercomm system fails, setting the control switch to EMERGENCY will provide intercomm and call facilities through the amplification stage of the VHF.

(*b*) Additional intercomm points are provided in the front fuselage, plenum chamber, rear compartment and on the underside of the port side of the nose. These are controlled by two ON/ISOLATE switches at the AEO's position, panel BF.

6 Intercomm. controls (Mk. 1 aircraft)

(*a*) Normal intercomm. is available between all crew stations providing that:

(i) Ist and 2nd Pilots select VHF on VHF/HF switches and I-C on I-C/ADF switches.

(ii) Navigators select NORMAL/CONFERENCE switch to NORMAL and I-C/ADF switch to I-C.

(iii) AEO selects both VHF and I-C on his VHF/HF and I-C/VHF switches respectively.

(*b*) *Pilots' controls*

(i) *VHF/HF*. These switches are located on panels AE and AF for the 1st and 2nd pilots respectively. The VHF selection provides normal intercomm. with the rest of the crew whilst permitting transmit-receive operation of the VHF installation. On HF the microphone, telephone and PTT leads are transferred to the STR 18 B2 HF equipment for HF/RT.

(ii) *I-C/ADF*. These switches in the cabin roof positioned aft of panel AL provide the pilots with a means of listening to the radio compass receiver. It is important to note that an ADF selection overrides any other switch position hence it is normally

(iii) *Call Switch*. This switch, also located aft of panel AL, is commen to both pilots. It is a spring-loaded three-position control with CALL NAV. and CALL AEO selections.

CALL NAV. This superimposes intercomm. to the navigators when they are isolated on the conference circuit

CALL AEO. Intercomm. is superimposed to the AEO irrespective of which service he is operating.

(*c*) *Navigators' Controls*

(i) NORMAL/CONFERENCE. The NORMAL and CONFERENCE selections of this switch provide alternative intercomm. systems for the navigators. The CONFERENCE position isolates the navigators on to a separate intercomm. amplifier. On the NORMAL position the navigators can also hear the VHF output.

(ii) *I-C/ADF*. The ADF position provides the plotter with radio compass receiver output and is similar to the pilots I-C/ADF switch in that it over-rides other selections. When switched to ADF the plotter's mic. is still connected to intercomm.

(iii) *Call Switch*. This is a spring-loaded switch which enables the plotter to call either pilot when the latter are on ADF. It superimposes intercomm. on to the ADF circuit.

(*d*) AEO's *Controls*

(i) *VHF/HF*. On VHF the AEO has normal intercomm. and can monitor the VHF output. The HF selection isolates the AEO from the rest of the crew and he has control of the STR 18 B2.

(ii) *I-C/VHF*. The VHF position isolates the AEO from the intercomm. circuit and connects a separate PTT switch and volume control to the approriate VHF box. The AEO thus controls transmission and reception of the VHF and no other crew member can monitor the VHF. However it is possible for the pilots, by selecting CALL AEO, to listen through to the VHF if necessary.

(iii) *Call Pilot*. This is a spring-loaded switch which enables the AEO to superimpose intercomm. on to the ADF circuit.

7 Intercomm. controls (Mk. 1A aircraft)

(*a*) All crew members have identical station boxes, the controls on which allow any crew member to:

(i) Select any one of five SPEAK/LISTEN services.

(ii) Mix incoming radio and intercomm. signals without interfering with selections made by other crew members.

(iii) Call all other crew members on intercomm. irrespective of the services they may have selected.

(*b*) The type 7681 station boxes carry the following controls:

(i) Four ON/OFF switches at the top of the box. These provide a mixer service for listening only. They consist of:

HF
Conference I-C
Airborne warning
Normal I-C

(ii) Three volume controls below the ON/OFF switches. These provide further listening services on UHF, ADF or ILS, and VHF. The VHF or UHF volume control must also be turned up when using the appropriate SPEAK LISTEN service (see (iii) below).

(iii) A rotary SPEAK LISTEN switch at the bottom of the box. This switch allows selection of the following five services:

Conference I-C
HF
UHF
VHF
NORMAL I-C

With this switch OFF and the I-C listening switch OFF, a crew member can isolate himself from the rest of the crew when listening to incoming signals.

(iv) A spring-loaded CALL switch on the right of the SPEAK/LISTEN switch.

This switch is used, in conjunction with the I-C position of the SPEAK/LISTEN switch, to call all crew member, regardless of their selections.

(v) A NORMAL/OFF/DIRECT switch, to the left of the SPEAK/LISTEN switch.

On NORMAL, incoming signals are fed through a two-valve amplifier, powered by a fused 28-volt supply. The fuse and a spare are on the front of the box. If fuse or valve failure occurs, selection of DIRECT will by-pass the amplifier and switch it off. Only the selected SPEAK LISTEN facility will be available (at reduced volume) and the LISTEN ONLY switches will be inoperative.

(*c*) Both pilots have press-to-transmit buttons on their control columns. The AEO has a press-to-transmit button and a morse key. No transmission facilities are provided for the navigators.

(*d*) *Control of services*

The control of the various services fed to the station boxes is as follows:

(i) *Pilot*

HF control but no selection
UHF (pre-Mod. 3881) and VHF selection
ILS switching and selection
ILS/ADF/TACAN audio selection
UHF tone selector switch

(ii) AEO

Airborne warning /monitor
HF
ECM
I-C/NORMAL/EMERGENCY/switch
Conference I-C ON/OFF switch
UHF (pre-Mod. 3881) and VHF but no selection

(iii) *Nav./plotter*

ADF

(iv) *Nav./radar*

Tone release

Navigational Radio and Radar

8 Radio compass (ADF)

The radio compass controller and the manual loop controller are at the nav./plotter's position, while the selection of either ILS, ADF or TACAN audio signals is controlled by a switch on the 1st pilot's console. A repeater indicator is on the 1st pilot's instrument panel. A circuit breaker on panel BB controls the 28-volt supply.

9 ILS

The ILS channel selector is on the spine between the pilot's escape hatches, the master ON/OFF switch is on the 1st pilot's side panel. Two marker lights are provided on pilot instrument panels AA & AB. The indicator is on panel A (Mk. 1 only).

10 Radio altimeter Mk. 5

NOTE: Mod. 3144 deletes the installation.

A radio altimeter Mk. 5 is on the 2nd pilot's panel AB, with limit lights ; limit lights are also provided on 1st pilot's panel AA. The limit switch is on the port console and the supply switch is

11 Green Satin and GPI

(*a*) Green Satin is installed. The control unit and associated GPI Mk. 4 are at the nav./plotter's position.

(*b*) The system is supplied by the Green Satin type 153 inverter.

12 Gee Mk. 3

The control unit for the Gee Mk. 3 is at the nav./plotter's position. The electrical supply ON/OFF switch is on panel BC. The system uses 28-volt DC from feeder 8P7 and Phase A of No. 2 Type 350 inverter.

13 Radio altimeter Mk. 6A

The radio altimeter Mk. 6A indicator/control unit is on the nav./radar's panel CAJ. The system uses 28-volt DC from feeder 8P7 and Phase A of No. 2 Type 350 inverter. The supplies are controlled by a switch on panel CA.

Operational Radio and Radar

14 NBC and H2S

(*a*) The navigational bombing systems (NBS Mk. 1) is installed. The system basically consists of the H2S Mk. 9A installation and the navigation and bombing computer Mk. 2. The controls and indicators for the system are at the nav./radar's position and the pilots' centre panel A.

(*b*) The system is supplied from No. 1 Type 350 inverter and the 28 volt DC and 112 volt DC bus-bars. The supplies are controlled by switches and circuit breakers on panel CA.

15 IFF Mk. 10

IFF Mk. 10, with SIF and I/P facilities, is installed. The controls are on the AEO's facia panel. The system uses 115-volt AC 1600 c/s from No. 2 Type 350 inverter, 28-volt DC from feeder 8P7.

◂16 Tacan

Tacan is fitted; it has an AIR/GROUND or AIR/AIR capability and is controlled by an ON/OFF switch at the nav./plotter's position. A repeater indicator is fitted on the co-pilot's front panel. The power supplies are from a 28-volt inverter fed from No. 1 LV bus-bar and controlled by an INVERTER ON/OFF switch also at the plotter's position.

17 UHF D/F

UHF D/F equipment is fitted which provides the ADF facility of the PTR 175 or ARC 52. When used in conjunction with the Tacan installation it indicates the range and relative bearing of the receiver aircraft from the tanker. The bearing indicator is fitted at the nav./plotter's station adjacent to the AIR/GROUND bearing indicator. Power supplies for the D/F circuits are 115-volt AC, from the Flight Instrument inverter and 28-volt DC.

Radio Equipment—Three-point Tanker

18 VHF/UHF, PTR 175

(*a*) Twin VHF/UHF PTR 175 sets are fitted in Mk. (K) 1 aircraft and one ARC/52 and one PTR 175 in the Mk. (K) 1A. These are located on the floor of the fin compartment and the plenum chamber respectively and known as RT1 and RT2. It is possible to select 370 channels between 115 and 135·95 MC/S (VHF) and 3,500 channels between 225 and 399·95 MC/S (UHF) or 19 preset channels two of which are tuned to 243 MC/S and 121·5 MC/S respectively. In addition a separate receiver allows a pre-set guard frequency between 238 and 248 MC/S to be superimposed on any selected channel. MCW transmission is available if required.

(*b*) The two control units which are situated on panel AT (RT1) and at the AEO's position (RT2) have the following controls.

(i) A 20-position rotary switch giving selection of 18 preset

(ii) Three manual control switches. The first switch selects the first two figures (hundreds and tens) of the desired frequency in tens, the second selects the third figure (units) and the third selects the decimals. These switches are only operative when MANUAL is selected on the 20-position switch.

(iii) A volume control.

(iv) A seven-position function switch giving selection of:

OFF
T/R (normal transmission and reception)
T/R & G (normal transmission and reception plus the guard frequency superimposed)
ADF (used with direction finding equipment)
DL, DL/T, T/R ON—DL OFF } inoperative

(*c*) Tone switches marked RT1, RT2, are on the port console and panel CP.

(*d*) It is possible to reset the preset channels in the air if necessary. To do so the cover plate on the control unit is removed by undoing the milled screws. The channel selector is then turned until the number to be selected is indicated on the resetting panel (this will not correspond to the selector switch indicators). The resetting pins are then moved to the required positions and the cover plate replaced.

(*e*) *Power supplies*

The 28-volt DC supplies for the twin installation are derived from the LV bus-bars via the VHF1/VHF2 circuit breakers on panel BB.

19 HF, Collins 618-T3

(*a*) Collins HF radio is fitted. It provides 21,750 channels spaced 1 K/C apart in the frequency range 2·75 to 24·5 MC/S. The remote

(i) Four knobs which select the required frequency in MC/S and to three decimal places of a megacycle.

(ii) A six-position function switch giving selection of:

OFF	
USB .	. Upper Side Band R/T
LSB .	. Lower Side Band R/T
AM .	. Amplitude Modulation (Double Side Band) R/T
DATA	. Inoperative
CW .	. W/T using the AEO's morse key.

(iii) A volume control marked RF SENS.

(*b*) An antenna control unit is mounted adjacent to the controller, its purpose is to enable the transmitter output to be matched to the suppressed aerial in the wing root.

20 Intercomm, general

(*a*) The intercomm. system operates through type UA60 station boxes at all crew stations including the sixth seat and prone bombing positions. Each station box incorporates its own amplifier and the whole system is controlled by a NORMAL—I/C—ON/OFF switch at the AEO's position. The power supply is 28-volt DC and each station box has its own fuse. Two additional amplifiers, types UA6070 and UA563A provide external and conference intercomm, the ON/OFF switches for these are also at the AEO's position.

(*b*) Additional intercomm. points are provided in the external network at the front fuselage, plenum chamber, rear compartment, underside of the port side of the nose, snatch disconnect point, radio rack and airbrake position.

21 Intercomm, controls

(*a*) All crew members have identical station boxes which provide the following facilities.

(ii) Mixing of incoming radio and intercomm. signals without interference with other crew members' selections.

(iii) The ability to call other crew members on intercomm. irrespective of the services they may have selected.

(*b*) The station boxes have the following controls:

(i) Push on/push off facility switches incorporating a rotary volume control, which allow reception of the following services:

RT1 and RT2
HF
CONFERENCE intercomm.
I/C
ADF (Voice and Range)
RADAR WARNING (Monitor and Alarm)
ILS
TACAN
OVERRIDE (To speak to all other crew members irrespective of the services they may have selected).

(ii) A rotary TRANSMITTERS switch located at the bottom of the box permits selection of the following services:

RT1 . .	No. 1 PTR 175 set (or ARC 52 Mk. (K) 1A)
RT2 . .	No. 2 PTR 175 set
HF . .	Collins 618-T3
CONF .	Conference intercomm.

(iii) A call light which when pressed illuminates the call lights at all other stations thus attracting the attention of any crew member off intercomm.

(iv) A NORMAL/EMGY switch which when selected to EMGY on a faulty station box, maintains intercomm. provided the offending box is also selected to RT1 or RT2. It should be noted that selection of any other service on the box operating on EMGY causes that service to be heard by all crew members.

(*c*) Both pilots have press-to-transmit buttons on their control columns. Press-to-transmit switches are also fitted at the nav./plotter and prone bombing positions, whilst the AEO has a press-to-transmit switch and a morse key.

(*d*) *Control of services*

The control of the various services fed to the station boxes is as follows:

(i) *Pilot*

HF control but no selection
RT1 control and selection
RT2 control but no selection
ILS control and selection
Tone selection
RADAR WARNING (co-pilot only)

(ii) *AEO*

RADAR WARNING control and selection
HF control and selection
RT2 control and selection
RT1 control but no selection
NORMAL intercomm. } ON/OFF switches
CONFERENCE intercomm. } ON/OFF switches
EXTERNAL intercomm. } ON/OFF switches

(iii) *Nav./plotter*

ADF control and selection
TACAN control and selection
RT1 control but no selection
RT2 control and selection (controller is situated between AEO and plotter).

(iv) *Nav./radar*

TONE RELEASE control and selection
Navigational Radio and Radar.

Part I

Chapter 13—Fire Warning and Protection Systems

List of Contents

1 General

Visual warning of fire in the engine bays, fuselage plenum chamber and fuel tanks is given by six warning lights and four combined extinguisher pushbutton/warning lights, all on panel AW. Nine independent extinguishing installations are fitted comprising a total of twenty electrically-discharged methyl-bromide extinguishers, which are discharged simultaneously by the action of inertia switches if a crash landing is made (see para. 5). They are located as follows:

Wing tank group, port	One
Wing tank group, starboard	One
Fuselage tank group, front	Two
Fuselage tank group, rear	Two
Plenum chamber	Two
Engines, zones 1 forward of firewall	Four
Engines, zones 2, annular space between jet pipe and surrounding shroud	Four
Engines, zones 3, rear of firewall	Four

2 Engine fire protection system

(*a*) Each engine bay is divided into three zones. Twenty-three resetting fire detectors are fitted in each engine bay and one fire extinguisher is in each engine zone.

(*b*) An abnormal temperature rise affecting any fire detector causes its associated warning light to come on. When the pushbutton is pressed the extinguishers in zones 2 and 3 are discharged first, and the HP and LP cocks for that engine are turned off. In addition the generator cooling air supply is cut off and finally the extinguisher in No. 1 zone is discharged. When the cooling air supply is cut off an ALT. COOLING CLOSE warning light on the AEO's side panel comes on.

(*c*) If the fire is extinguished, the warning light goes out as the flame switches cool.

(*d*) *Master control units*

(i) Two master control units are provided, one for the port engines and one for the starboard engines. When energised by a detector circuit they cause the illumination of the associated warning lights. A pulse circuit, which makes a ticking noise when operating, is incorporated in each control unit and regularly interrupts the supply to each control unit relay thus preventing false fire warning due to vibration of the relay contacts.

(ii) Three guarded (post-Mod. 2545) test switches on panel BF may be used to test the port and starboard detector circuits and to light the warning lamps.

(*e*) Circuit breakers for the extinguisher circuits are on panel AJ.

3 Fuel tanks fire protection system

(*a*) Five separate continuous fire-wire detector installations are fitted, one for each wing tank installation, one for the rear fuselage fuel tanks, one for the tanks over the bomb-bay and, one for the front fuselage tanks. A warning light for each system is provided on panel AW.

(*b*) Four extinguishing systems are provided, one for each set of wing tanks and one for the rear and front fuselage fuel tanks. There is no extinguishing system for the tanks above the bomb-bay.

(*c*) Each mainplane system has one extinguisher bottle and each fuselage system has two bottles.

(*d*) If the operating temperature (180° C—250°C) of any sensing element is reached the associated warning light comes on and the extinguisher(s) is discharged automatically. When the temperature reverts to normal the circuit is de-energised and the warning light goes out.

4 Plenum chamber fire protection system

(*a*) A fire-wire detector installation is fitted in the plenum chamber. A warning light for the system is on panel AW.

(*b*) If the warning light comes on two extinguisher bottles discharge their contents automatically. When the temperature in the chamber returns to normal, the warning light goes out.

5 Inertia switches

(*a*) Four inertia switches are fitted, two port and two starboard, which automatically bring the fire extinguisher installations into operation if the aircraft decelerates at a rate exceeding 3G. A warning light for each inertia switch is located on the AEO's side panel BB and comes on when its inertia switch is tripped. Circuit breakers are fitted adjacent.

(*b*) Operation of any one inertia switch does not affect any extinguisher circuit. Both switches on one side must operate before the extinguisher circuits are energised.

(*c*) The port inertia switches cause the following extinguisher systems to discharge:

Port mainplane extinguisher

Zone 2 and 3 extinguisher for Nos. 1 and 2 engines (thereby closing HP and LP cocks and cooling air supply to the generators)

Zone 1 extinguishers for Nos. 1 and 2 engines

(*d*) The starboard inertia switches cause the following extinguisher systems to discharge.

Starboard mainplane extinguisher

Zone 2 and 3 extinguishers for Nos. 3 and 4 engines

Zone 1 extinguisher for Nos. 3 and 4 engines

Fuselage fuel tanks extinguishers

Plenum chamber extinguishers

6 Hand fire-extinguishers

Three hand fire-extinguishers ($\frac{2}{3}$ distilled water $\frac{1}{3}$ glycol) are provided in the cockpit. Mod. 3125 replaces these with ones filled with bromochlorodifluoromethane. These are more suitable for use against all classes of fire.

Part I

Chapter 14—Entrance, Emergency Exits and Emergency Equipment

List of Contents

1 Entrance to aircraft

(*a*) Entry to the aircraft is via the crew door on the port side of the fuselage; the door is hinged on its top edge and opens outwards. Two telescopic struts support the door in the open position. Two sockets are fitted to the door step for the entrance ladder. A windshield is fitted to both edges of the door to protect the crew when abandoning the aircraft.

(*b*) The door is opened from the outside by means of a lever, flush with the skin, fitted slightly forward at the bottom of the door. The skin below the lever incorporates a yale lock enabling the entrance door to be positively locked. When the unlocking handle is operated the action opens the door sufficiently for the edges to be grasped from the outside and pulled open.

(*c*) In the centre of the door above a porthole is a handgrip by means of which the door can be pulled shut. Two door fasteners are engaged by operating either the internal or external lever. The door periphery is sealed by an extruded beading on the doorway which bears against sheet rubber web on the door.

(*d*) The door is normally opened from inside by means of a lever, which lies in a slot in the doorway when not required, and covered by a spring-loaded flap. To open the door the lever is pulled down and swung inboard flush with the cabin floor. The door should then be pushed open.

(*e*) An indicator plate, over the door aft fastener, is slotted to accept a stop plate to the locking claw. When the door is closed and locked the stop plate must abut within $\frac{1}{16}$ in of the line on the indicator plate.

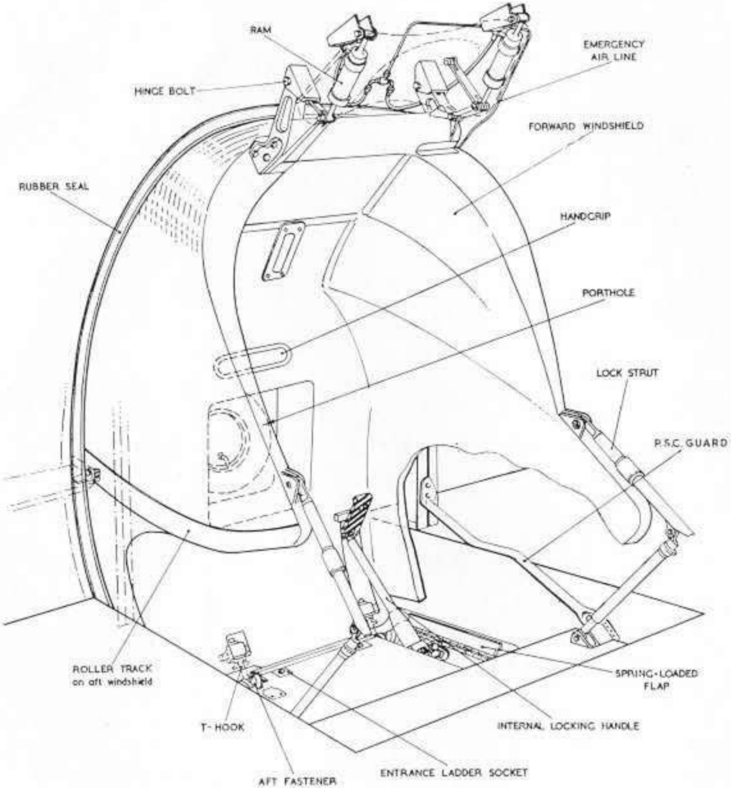

Fig. 1 Crew door

(*f*) *Mod.* 2013

To prevent the crew door lock freezing in flight, warm air from the air conditioning system is fed into each fastener channel through a nozzle and exhaust through lock mechanism into the cabin.

2 Door emergency opening system

WARNING: Above 40,000 ft. the door must not be opened until 6 seconds after the ABANDON AIRCRAFT notice is given. (Post-Mod. 3817 when the cabin differential pressure gauge indicates $1\frac{1}{2}$ PSI).

(*a*) The crew door can be opened in emergency by a PARACHUTE EXIT EMERGENCY RELEASE lever on the underside of the crew table. The level is covered by a spring flap.

(*b*) When the lever is moved fully to the left, air from an accumulator under the floor aft of the step is admitted to the latch jack and to the door rams, forcing the door open.

(*c*) The accumulator is charged via a valve in the aft face of the step, the air passing through a dehydration cell before entering the accumulator. A pressure gauge, which should read 2,500 PSI at 20°C, is included in the circuit and can be read through a window in the aft side of the step.

3 Pilots' escape hatches

(*a*) Each pilot has an escape hatch above his head. A ditching handle, by means of which each hatch may be jettisoned is situated on each pilot's console AE, AF. A hatch is also jettisoned when its associated ejection seat face blind is pulled. In either case a hatch is jettisoned by gas pressure from a cartridge operating on two ejection guns which force the front of the hatch upwards about two hinges at the rear end. These hinges disengage after the hatch has swung upwards.

(*b*) An external release is fitted outboard of each pilot's escape hatch. When the release lever is pulled fully up, the hatch is raised

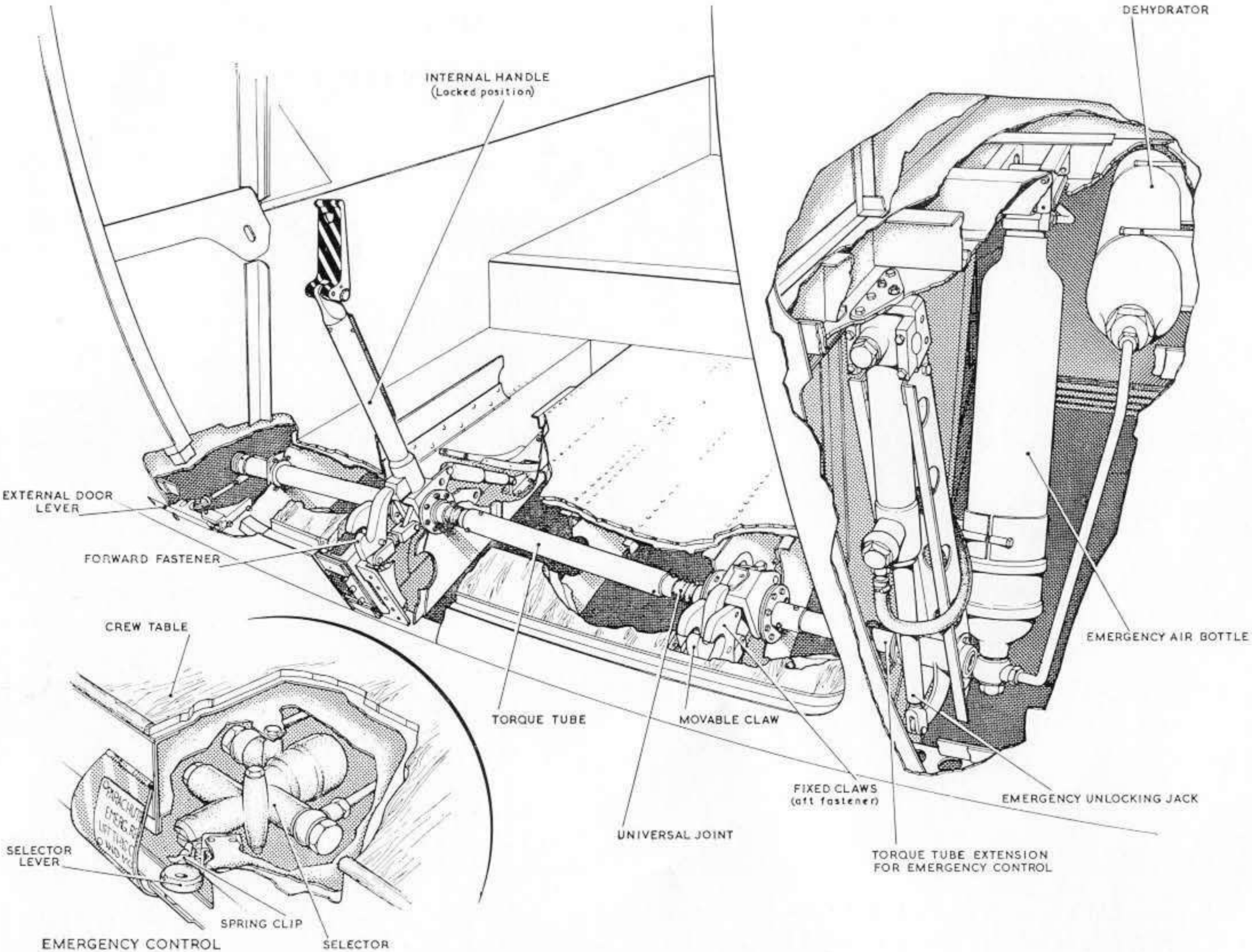

Fig. 3. Door fastening mechanism

outboard. When Mod. 2598 is embodied the release lever is rendered inoperative. On later aircraft embodying this modification the lever is not fitted.

(*c*) Mod. 656 introduces an unlocking lever, and stowage, to enable each pilot's escape hatch to be unlocked for servicing purposes. The chain clip must be detached and the lever pulled down before it can be rotated after the insertion of a tommy bar. (This system could also be used in emergency).

4 Escape hatch seals

(*a*) An inflatable seal is on the lower edge of each escape hatch and can be inflated to a pressure of 10 PSI by air stored in a bottle mounted on each escape hatch. Each bottle is charged to 1,800 PSI and feeds through a pressure reducing valve. The pressure in the bottles is shown by adjacent pressure gauges.

(*b*) Alternative and interchangeable systems may be fitted. One system is controlled by an ON/OFF lever (ON to inflate) and the other by a deflation plug which is removed to inflate the seal.

(*c*) In the latter sytem, if an air bottle fails in flight, screw the deflation plug into its valve thereby allowing cabin pressure to inflate the seal.

5 Crash axe and asbestos gloves

The axe is secured in a stowage forward of the first-aid kit at the side of calc. 3. A pair of asbestos gloves is stowed below the head

6 First-aid kit

This is stowed at the side of calc. 3.

7 Signal pistol

A signal pistol and a cartridge stowage are located in the starboard side of the cabin roof. In the stowed (or forward) position the pistol may be loaded. A spring-loaded plunger, which holds it in this position, may be withdrawn by finger pressure enabling it to be swung vertically to the firing position where it is again retained in position by a similar plunger. It is not possible for the pistol to be accidentally fired in the stowed position.

8 Dinghy installation

(*a*) The dinghy is carried in a compartment aft of the cabin in the starboard upper surface of the fuselage and is covered by a positive lock hatch. The dinghy release handle, in the cabin, is pulled to release the hatch and to operate the CO_2 bottle which inflates the dinghy.

(*b*) Should the CO_2 bottle become overheated a safety device permits the escape of CO_2 to an indicator in the dinghy hatch. The gas blows out a sealing disc and perspex cover causing red streamers to trail from it.

(*c*) The dinghy hatch can be released from outside by pulling a handle beneath a " break-in " panel. Once the hatch is open, the dinghy inflation handle can be pulled to inflate the dinghy.

(*d*) A boat hook is positioned (post-Mod. 2910) on the cable duct below panel AJ and a nylon rope is below the starboard escape

9 Automatic hand line

(*a*) When Mod. 3326 is embodied a guide rope is installed. It is connected to a point above the rear of the 2nd pilot's seat and to the entrance door. Its purpose is to assist rear crew members to escape under adverse flight conditions.

(*b*) The rope, which is permanently attached to the roof, is fastened with a shackle to the closed crew door before take-off. If the door is opened the rope is automatically pulled taut. Clips are provided in the roof to stow the rope when not in use.

◀ (*c*) BC Mod. 039 alters the attachment point from the crew door to a position forward of the lower edge of the door, on the aircraft structure. The position of the roof stowage is also altered.

WARNING: This facility must not be used when a 6th crew member is carried as he may sustain injury or have his escape restricted when the entrance door opens.

10 "Crew gone" warning lights

(*a*) Mod. 3955, Part C (see also Chapter 10, para. 11(*g*)) introduces a "crew gone" warning system to provide indication to the pilot, by four blue warning lights on panel AZ, of each rear crew member's emergency evacuation of the aircraft. The lights have a press-to-test facility.

(*b*) As each crew member leaves the aircraft, provided that his static line is correctly attached, a switch built in to the static line operates to switch on the appropriate warning light. ▶

Part II—Limitations

List of Chapters

Part II

Chapter 1—Engine Limitations

List of Contents

1 Limitations—Sapphire Mk. 202 or Mk. 207

Condition	*Time limit (mins.)*	*Engine speed % (100%=8,600* RPM	JPT °C *(max.)*
Take-off and Operational Necessity .	10	100·5 (see NOTE 1)	660
Intermediate . .	30	98 (see NOTE 2)	625
Max. Continuous .	None	96 (see NOTE 2)	600
Ground Idling . .	None	37·5±2·5	650
Ground Starting .	—	—	875*

*(800°C if modified gauges not fitted)

NOTE 1: Without top temperature control in use, great care must be taken not to exceed 660°C especially in high ambient temperatures.

NOTE 2: If the three datum JPT control is fitted, it maintains constant JPT at Take-off, Intermediate and Max. Continuous rating to 660° $^{+0}_{-10}$ 625° $^{+0}_{-10}$ and 600° $^{+0}_{-10}$ respectively. Therefore engine speed will change with altitude and up to 20,000 feet the RPM for Intermediate and Max. continuous may be allowed to increase to 98·5% and 96·5% respectively.

NOTE 3: Below 10,000 feet, above 300 knots, the engines are not to be operated in the RPM band 80% to 85%, although they may be accelerated or decelerated through it.

2 Oil pressures

Minimum at Ground Idling .	8 PSI
Normal at Max. Continuous .	30-38 PSI
Minimum at Max. Continuous .	25 PSI

Part II

Chapter 2—Flying Limitations

List of Contents

1 General

(*a*) The Victor B Mk. 1 and Mk. 1A aircraft are designed for manoeuvres appropriate to the role of a high altitude medium bomber. Some Mk. 1A aircraft are equipped as tankers and are designated K Mk. 1A—Two-point. Other Mk. 1A aircraft and some Mk. 1 aircraft are equipped as three-point tankers and are designated K Mk. 1 and K Mk. 1A—Three-point.

(*b*) Aerobatics, stalling and spinning are prohibited. Speed must not be reduced below that for the onset of pre-stall buffet. (See also para. 8).

2 Speed and mach number limitations

(*a*) *With all* PFC*'s working and with both yaw dampers and auto-mach trimmer in operation*

From sea level to 34,000 feet	330 knots
Above 34,000 feet	0·93M

NOTE: No further limitations are imposed for flight with any of the following inoperative:

Artificial feel unit
Auto-mach trimmer
One yaw damper
Any one rudder PFC sub-unit

(*b*) *With any one or two aileron or elevator sub-units inoperative*

Gentle manoeuvres only are permitted . . . . 0·90M

(*c*) *For the operation of the following services and flight with them in the extended position*

Bomb doors, Mks. 1 and 1A	No limit with Mods. 447, 862, 943 and 2053 all embodied, otherwise 300 knots or 0·90M
Airbrakes	No limit
Undercarriage	235 knots
Flaps, at TAKE-OFF position	190 knots (200 knots, post-Mod. 4206)
at DOWN position	185 knots
Nose-flaps	0·75M

(*d*) *Brake parachute streaming*

(i) Normal . . . . 140 knots maximum at landing weight of 135,000 lb.

(ii) Emergency . . .

Weight (lb.)	Max. streaming speed (knots)	
	Chute age 5 streams or less	Chute age 6 to 24 streams
135,000 .	162	155
140,000 .	160	153
145,000 .	158	150
150,000 .	155	148
160,000 .	151	144
180,000 .	143	136

NOTE: Chutes which have been used at emergency speeds must not be re-used.

(*e*) Max. crosswind for take-off, landing and streaming the brake parachute . . . . 25 knots

3 Weight limitations

(*a*) For take-off, and landing in an emergency . . . 185,000 lb.

If Mod. 3152 is not embodied, the oleo leg pressures are to be increased to 1,500 PSI.

(*b*) After refuelling in flight . 195,000 lb.

(*c*) For normal landings . . 135,000 lb.

Brakes are not to be applied above 125 knots if landing without a brake parachute.

4 G limitations

(*a*) The following acceleration factors are not to be exceeded, with negligible aileron:

(i) *B Mk.* 1 (*Mods.* 879, 935 *embodied*) *and B Mk.* 1*A aircraft*

All up weight not exceeding	*Up to* 0·9M	*Above* 0·9M
195,000 lb. Flight refuelled weight	1·7G	1·5G
180,000 lb.	1·9G	1·7G
147,000 lb.	2·3G	2·1G

(ii) *K Mk.* 1 *and K Mk.* 1*A aircraft*

All up weight not exceeding	*Up to* 0·9M	*Above* 0·9M
195,000 lb. Flight refuelled weight	1·65G	1·5G
180,000 lb.	1·75G	1·65G
147,000 lb.	2·0G	1·9G

(*b*) If buffet is experienced before the above readings are reached, a further increase in G is not permitted.

(*c*) (i) The following acceleration factors are not to be exceeded with maximum aileron:

All up weight	G *limit*
Above 170,000 lb. . . .	Gentle manoeuvres only are permitted
Not exceeding 170,000 lb. .	1·3G
Not exceeding 147,000 lb. .	1·5G

These limitations must be borne in mind when entering and leaving turns, particularly during evasive manoeuvres.

(ii) Rapid application of aileron with G is prohibited.

(*d*) The undue application of negative G is to be avoided.

5 CG limits

Aft limit, at all weights	161 in. aft of datum
Forward limit	
Up to 100,000 lb.	140 in. aft of datum
At 160,000 lb.	142·5 in. aft of datum
At 165,000 lb.	142·75 in. aft of datum
At 170,000 lb.	143 in. aft of datum
At 175,000 lb.	143·3 in. aft of datum
At 180,000 lb.	143·7 in. aft of datum
At 185,000 lb.	144·0 in. aft of datum
At 190,000 lb.	144·3 in. aft of datum
At 195,000 lb.	144·7 in. aft of datum

and linear variation between these limits.

6 Flight refuelling

(*a*) Mk. 1A aircraft are cleared for flight refuelling by day and night from KB50J tanker aircraft at 22,000 feet and 230 knots and from KC135 tanker aircraft up to 30,000 feet at 250 to 260 knots.

(*b*) Mk. 1A, (K) 1 and (K) 1A aircraft are cleared for flight refuelling from (K) 1 or (K) 1A tankers subject to the limitations of para. 7.

(*c*) The maximum refuelled weight is not to exceed 195,000 lb.

7 Tanker limitations

(*a*) (i) Tanker aircraft are not to be flown in the low level role.

(ii) The normal aircraft limitations apply when the hoses and drogues are stowed.

(iii) Only gentle manoeuvres are permitted when the hoses are trailed. Refuelling in icing conditions is not recommended.

(iv) Pending embodiment of Mods. 4262 and 4263, refuelling by night is permitted only by three-point tankers in the case of small highly manoeuvrable aircraft or if the receiver provides adequate lighting, since the inadequate tanker lighting could lead to receiver pilot disorientation.

(v) In the training role, dry contacts are permitted, by day only unless the receiver is cleared for night contacts. Blanking plates are to be fitted to the hoses to ensure that no fuel is passed.

(vi) The aircraft may be flown without pods provided that blanks are fitted on the pylons which are left in position on the wing. Flight with the Mk. 17 HDU removed is prohibited.

(vii) If Mod. 4171 is not embodied in the Mk. 20 B pod pressurisation system the rate of descent must not exceed 5,000 ft./min. when the pods are not full.

(viii) Pending further trials the auto-pilot is not to be used during flight refuelling, except in the case of Lightning aircraft.

(*b*) *Trailing and trailed speeds—Mk. 20 B pods*

Under all conditions the minimum and maximum speeds are to be observed. The speed range is as follows:

Height	*Speed*	
	Min.	*Max.*
Sea level to 24,000 ft.	230 kts.	310 kts.
24,000 ft. to 40,000 ft.	230 kts.	310 kts. decreasing linearly to 260 kts./0·85M at 40,000 ft.

(*c*) *Wind-in speeds—Mk. 20 B pods*

Hoses should normally be wound in at the following speeds:

Height	*Speed*
Sea level to 35,000 ft.	Below 275 kts.
35,000 ft. to 40,000 ft.	Decreasing linearly to 260 kts./0·85M

(*d*) *Trailing, trailed and wind-in speeds—Mk.* 17 HDU

(i) *High-speed drogue*

1 *Training role*

Max. speed. 270 knots up to 35,000 feet, decreasing linearly to 260 knots at 40,000 feet.

Min. speed. 230 knots.

2 *Tanker role*

Max. speed. 270 knots up to 25,000 feet, decreasing linearly to 260 knots at 40,000 feet.

Min. speed. 230 knots.

(ii) *Intermediate-speed drogue*

Max. speed. 280 knots up to 34,000 feet, decreasing linearly to 260 knots (0·85M) at 40,000 feet; 0·85M up to 43,000 feet.

Min. speed. 210 knots up to 40,000 feet, increasing linearly to 230 knots at 43,000 feet.

(iii) *Low-speed drogue*

Not yet cleared for service use.

(*e*) *Emergency—pods and HDU*

(i) The recommended speeds for selecting EMERGENCY TRAIL are as follows:

AUW	*Speed*
Up to 150,000 lb.	200 kts.
150,000 lb. to 195,000 lb.	Increasing linearly to 230 kts.

(ii) The recommended hose jettison speed is 230 knots.

(*f*) The following aircraft are cleared for both wet and dry contacts from the positions stated:

Receiver	*Tanker*	*Positions*	*Day or Night*
Victor K1, B1A, K1A, 2 (BS), 2 (SR)	3-pt.	HDU	D
Vulcan 1A, 2 . . .	3-pt.	HDU	D
VC10 C1	3-pt.	HDU	D/N
Belfast *	3-pt.	HDU	D
F100	2/3-pt.	All	D
Buccaneer 1 and 2 . .	2/3-pt.	All	D
Lightning . . . . 1A, 2, 3, 5, interim 6, 6	2/3-pt. †	All	D/N‡
Javelin 9	2/3-pt.	HDU, port pod (emergy only)	D
Sea Vixen 1 and 2 . .	2/3-pt.	HDU, stbd pod	D

* Low-speed drogue clearance required.
† The auto-pilot may be used.
‡ Night contacts, 3-point tankers only.

8 Fixed droop leading edges

Mk. 1A, (K) 1A and (K) 1 aircraft embodying Mod. 2352 must not be flown at speeds below the onset of pre-stall buffet or the recommended threshold speed, whichever is higher.

9 Aircraft approach limitations (AAL)

The AAL's are:

GCA/Precision Radar .	250 feet above airfield level
GCA/Search Radar .	400 feet above airfield level
Manual ILS . . .	350 feet above airfield level
ILS/Zero Reader . .	250 feet above airfield level
Auto ILS	250 feet above airfield level

10 Miscellaneous limitations

(*a*) The engines are cleared for use with AVTUR fuel. AVTAG fuel may be used, provided that silica-gel ¼ in. plus crystals are used in the fuel tank pressurising system air drier and the silica-gel desiccant is inspected during primary star servicing.

◀ (*b*) (i) Engine anti-icing is cleared for use.

(ii) Airframe anti-icing is cleared for use provided that the following modifications are embodied:

B Mk. 1A . . .	2548A, B, C, 2774, 2802
K Mk. 1, K Mk. 1A . .	2802

(*c*) The Auto-Mach trimming system is only to be switched on when deliberate flight beyond 0·85M is intended and is to be switched off before reducing speed below 0·84M.

(*d*) Dry running of booster pumps should be avoided. The pumps may be dry run for up to 30 minutes without damage but beyond that limit serious deterioration will occur. There is no fire risk. In the 3-point tanker role bomb bay tank booster pumps can be dry run for up to two hours without damage. ▶

Part III—Check Lists

List of Chapters

Part III

Chapter 1—Crew Check Lists

Chapter 2—Checks Away from Base

NOTE: These chapters are deleted. The current Bomber Command check lists are to be used.

Part IV—Engine and Aircraft Handling

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Part IV

Chapter 1—Engine Starting and Handling

List of Contents

1 General

Throughout it must be remembered that the relevant checks in Part III must be carried out at the appropriate times.

2 Starting the engines using an external power supply

(*a*) The recommended starting order is 3 —2 — 1 — 4.

(*b*) The following selections and checks must be made before engine starting:

External electrical supply	112v and 28v DC connected and ON
LV batteries	ON
MV batteries	OFF
Inverters	No. 3 ON, No. 2 OFF, No. 1 as required
Alternators	OFF
No. 1 Flight instruments circuit breaker	Made
Fuel proportioners	All NORMAL
Fuselage booster pumps	All on
LP cocks	OPEN
JPT control switches	OFF
IGNITION and MOTOR ISOLATION switches	ON
ENGINE SELECTOR	No. 3
START MASTER switch	GROUND

(*c*) Open the HP cock to the idling position (just beyond the gate) and press the STARTER PUSH button. The STARTER PUSH button should lock in until released by the overspeed relay (or on completion of the starting cycle after 30 seconds) and the AEO may monitor the stages of the starting cycle by watching for movements of the MV voltmeter needles. Engine light-up will be indicated by increasing RPM and JPT. When the spill-valve closes at 22% RPM a sharp increase in JPT may be noticed. During the start the JPT may rise above the idling limit of 660°C and, if it rises to 875°C (800°C on unmodified gauges) before engine speed reaches 18·5% RPM, the HP cock must be closed immediately. If the engine is still accelerating at 18·5% RPM with the JPT below 800°C the start may be continued, even though the JPT rises to 875°C (800°C on unmodified gauges) later in the starting cycle. The JPT should be below 660°C when the engine reaches idling speed (37·5 ± 2·5% RPM). If, during the start, the JPT exceeds 875° or, if the fire warning light illuminates, close the HP cock immediately.

(*d*) When the engine reaches idling speed check:

Engine fire warning lights .	Out
JPT	66O° C maximum
Oil pressure	8 PSI minimum

NOTE: The oil pressure may take several seconds to build up, especially if the engine has not been run for some time. If the oil pressure fails to build up within 30 seconds of initiating the start, stop the engine and carry out a dry motoring cycle. If the oil pressure fails to build up a second time, the fault must be investigated.

(*e*) Start the remaining engines in a similar manner and, when all engines are running, put the START MASTER switch to FLIGHT, switch OFF the IGNITION and MOTOR ISOLATION switches and complete the after-starting checks.

(*f*) *Precautions*

The STARTER PUSH button must not be held in manually if it fails to be retained electrically after it has been pressed and has held momentarily. Failure to observe this precaution may result in damage to the starter drive mechanism.

3 Starting when external power supply is available for starting only one engine

Start No. 3 (or No. 4) engine in the normal manner. When it is running satisfactorily switch ON its alternator and switch on the MV and LV batteries. Disconnect the ground supply and increase the engine speed to 75% RPM. Subsequent engines may then be started in the manner laid down for starting on internal power.

4 Starting on internal power

(*a*) When it is necessary to use the aircraft internal batteries for starting engines, use of electrical services should be limited to those essential for engine starting and for the aircraft's safety, until all engines are running and their alternators switched on.

(*b*) No. 3 (or No. 4) engine should be started first.

When it is running satisfactorily, its alternator should be switched ON and engine speed increased to ensure that alternator output is sufficient for starting the remaining engines. Because of the airflow patterns in the combined engine intakes the engines on the opposite (port) side of the aircraft must be started next, the adjacent engine on the starboard side being started only when the first engine has been brought back to idling RPM.

(*c*) Make the following selections and checks:

All alternator switches . .	OFF
Flight instrument circuit breakers	Made
Port and starboard special feeders	ON
LV batteries	ON
LV BUSBAR PARALLELING switch	EMERGENCY (ON) Indicator white
Intercomm. switches . .	ON
Engine fire warning system .	Test
HYDRAULIC WARNING .	Out
Brake pressures . . .	2000 PSI minimum
Undercarriage indicator . .	3 green lights
MV batteries	ON
Fuel proportioners	BYPASS

Booster pumps . . .	One fuselage pump on
LP cocks	No. 3 OPEN, LP fuel warning light out
IGNITION and MOTOR ISOLATION switches	ON
ENGINE SELECTOR . .	No. 3
START MASTER switch .	INTERNAL
No. 3 type 350 inverter . .	ON
MV PARALLELING indicator	White

Open No. 3 HP cock to the idling position and press the STARTER PUSH button.

(*d*) When No. 3 engine reaches idling RPM check :—

Alternator circuit breakers . .	All made
No. 3 alternator . . .	ON, light out, output normal
Cooling fan warning lights .	Out
Fuselage booster pumps . .	All on
Fuselage proportioner . .	NORMAL
LP cocks	All OPEN

Increase No. 3 engine speed to 75% RPM, open Nos. 1 and 2 HP cocks and start Nos. 1 and 2 engines in turn.

(*e*) When Nos. 1 and 2 engines are started, switch ON their alternators and check that output is normal. Increase Nos. 1 and 2 engine speeds to 75% RPM and throttle back No. 3 engine to idling RPM. Open No. 4 HP cock, start No. 4 engine and, when at idling speed, switch ON No. 4 alternator. Throttle back all engines to idling RPM and check:—

IGNITION and MOTOR ISOLATION SWITCHES .	OFF
START MASTER switch .	FLIGHT
MV PARALLELING indicator	Black
LV BUSBAR PARALLELING switch	NORMAL (OFF)
LV PARALLELING indicator	Black

Complete checks and selections as required.

5 Failure to start

(*a*) If an engine fails to light-up, the HP cock must be closed immediately. The engine must be allowed to come to rest and may then be motored over to clear excess fuel before the next attempt to start. If the surrounding ground becomes soaked with fuel the aircraft must be moved before attempting a restart.

(*b*) After three consecutive operations of the starter motor, wait 15 minutes for cooling before using the starter again. This allows only two attempts to start, with a dry motoring cycle in between.

(*c*) Following a failure to start or a dry motoring cycle, ensure that the engine has come to rest before the STARTER PUSH button is pressed again.

6 Dry motoring cycle

The procedure for a dry motoring cycle is similar to a normal start except that the IGNITION ISOLATION switch is left OFF and the HP cock is left CLOSED. The STARTER PUSH button will release after 30 seconds, and engine speed should reach at least 10.5% RPM.

7 Engine handling

(*a*) At all times the engine handling limitations must be observed. Any instance of the limitations being exceeded must be reported.

(*b*) The throttles may be opened or closed rapidly under any flight conditions but, except in emergency, more gentle handling of the throttles is recommended.

(*c*) *Running a single engine above 52·5%* RPM

When running any engine above 52·5% RPM the speed of the other engine on the same side should be increased to a minimum of 52.5%. This is necessary because the engine being run at high speed will partially starve the other engine of air if it is left at idling speed. This will result in a decrease in speed on the idling engine and an excessive rise in JPT; the engine may flame out and an engine fire result.

(*d*) *Take-off and climb*

(i) If the initial climb to 20,000 feet is made at full power, engine speed may increase to 100.5% RPM but, above this height, a negative creep device gradually reduces engine speed with height to maintain the JPT within limits. As a result, full throttle engine speed at 45,000 feet will be about 97.5% RPM. However, irrespective of the engine speed obtained at full throttle, the throttle settings must be reduced to intermediate power within 10 minutes of take-off.

(ii) Without automatic jet pipe temperature control, when climbing at engine speeds above 93% RPM but below full power, it is necessary to adjust the throttle settings to maintain the selected engine speed or to keep the JPT within limits.

(iii) When the 3-datum automatic jet pipe temperature control is fitted, the throttles may be left in the fully open position after take-off and, with the JPT isolation switches ON, the selected JPT, as determined by the JPT controller, is maintained at all altitudes with corresponding changes in engine speed.

NOTE: Failure or isolation of the JPT controller on an engine whilst CRUISE or CLIMB is selected, will result in a slow rise in engine speed and JPT. In this case, control the engine speed and JPT by normal throttle manipulation.

8 Use of the engines anti-icing system

(*a*) The system should be brought into use during the pre-take-off checks when the OAT is below +3°C and the relative humidity exceeds 90% or the visibility is less than 1,000 yards in fog or mist. Reference is to be made to the Operating Data Manual for take-off performance corrections. The system may be used for take-off and during all conditions of flight when icing conditions are encountered.

(*b*) When the system is in use the available take-off thrust varies with OAT. The following are the relative figures, expressed as a percentage of ISA take-off thrust:

+ 5°C	94·5%
0°C	97%
− 5°C	99·5%
−10°C	102%
−20°C	107%

(*c*) The use of the anti-icing system causes the JPT to rise by approximately 25° to 30°C, if the system is fully OPEN and by approximately half that figure if the HALF-OPEN position is selected. If automatic JPT control is not fitted it may be necessary to reduce the throttle setting to avoid exceeding the max. permissible JPT. Where automatic JPT control is fitted, engine speed will be reduced automatically.

NOTE: HALF-OPEN should be selected whenever the engine speed is above 82%. OPEN should be selected at engine speeds below 82%.

9 Stopping an engine in flight

To stop an engine in flight, or if an engine fails, close the throttle and bring it back through the gate to shut off the HP cock. The alternator must be switched OFF. The LP cock must be closed only if the engine actually stops turning or if there is a risk of fire.

10 Relighting in flight

(*a*) Relighting is progressively more certain with decrease in altitude and the chances of a successful relight are greater if the engine is warm.

(*b*) If an engine flames out for reasons other than mechanical failure or deliberate shut-down, a relight may be attempted immediately, while engine speed is decreasing, by pressing the relight button with the throttle at its set position. A successful relight will be indicated by the engine speed stabilising and then commencing to rise. The likelihood of a successful relight is reduced if height is above 40,000 feet.

(*c*) For relighting a cold engine the following procedure should be used:

(i) Adjust airspeed until the failed engine is windmilling at 23·2% RPM—the optimum windmilling speed for relighting. The minimum windmilling RPM for a successful relight varies from 11·5% at 10,000 feet to 17·5% at 35,000 feet. Above 36,000 feet it is necessary to maintain a windmilling RPM as near to 17·5% as the minimum flight speed will permit.

(ii) Check the following:

Booster pumps	ON
LP cock	OPEN
Starter master switch	FLIGHT

(iii) With the HP cock shut, press and hold the relight button. After 3 seconds release the HP cock gate and move the throttle on to the IDLING stop, continuing to press the relight button. When the engine speed has increased by 3%, release the relight button. If the JPT rises to 66°C and continues to rise, the HP cock should be closed immediately. This action should also be taken if the engine has not lit within 15 seconds of initially pressing the relight button.

(iv) After an abortive relight attempt, the engine and jet pipe must be drained of unburned fuel over a period of three minutes before a further relight is attempted. If circumstances permit, the second attempt to relight should be made at a lower altitude after checking the igniter fuse. Not more than three unsuccessful attempts to relight should be made on any one engine in one sortie. One of the attempts should be made using the other relight button.

(v) If time permits, all unnecessary electrical loads should be taken off the affected bus-bar before the relight button is pressed. The alternator should be switched ON when the RPM have stabilised. As soon as the voltage and current is stable, the normal loads may again be placed on the bus-bar.

11 Stopping the engines

When all MV electrical loads have been switched off, switch OFF the alternators and stop the engines by closing the HP cocks. Do not close the LP cocks or switch off the special feeders until the engines have stopped rotating.

Part IV

Chapter 2—Taxying, Take-Off and Handling in Flight

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1 Taxying

(*a*) At the normal operating weight and on level concrete, about 47%—58% RPM will be required to start the aircraft moving, thereafter sufficient thrust for taxying is obtained with all engines idling. Very little turning effect is achieved by the use of asymmetric thrust, and the throttles should be moved symmetrically. Care should be taken not to increase the power on one engine above 52·5% while the other engine on the same side is below this figure. As soon as the aircraft has begun to move, check that the brakes are operating evenly and efficiently and then at the earliest opportunity test the nose wheel steering.

(*b*) Differential braking may be used with the nosewheel steering to initiate turns, but thereafter the nosewheel steering system alone should be sufficient. The aircraft can be steered by using the toe brakes independently but this procedure should not normally be used since the force required to caster the nosewheel results in harsh changes in direction with resultant strain on undercarriage components.

(*c*) The minimum turning circle can be achieved at full steering lock. However when small radius turns are essential it may be necessary to assist the nosewheel steering with slight application of brake.

(*d*) The total fuel consumption when taxying with all engines idling is 95lb./min.

(*e*) The wing tips cannot be seen from the pilot's seats, but the crew members can give guidance for clearance. Ground crew surveillance should always be given when taxying in confined spaces.

2 Take-off

(*a*) Carry out the pre take-off checks.

(*b*) Align the aircraft on the runway and apply foot brakes. With maximum brake pressure at the wheels, open up the engines

Depending on their condition, the brakes may slip before maximum engine speed is achieved. If brake slip occurs at an engine speed of less than 93% RPM, the brakes must be considered unserviceable. As soon as full throttle is applied the following checks should be made:

Engine speed	99% to 100·5% RPM
JPT	660°C max.
Oil pressure	25-38 PSI
Electrical power circuits . .	Functioning normally

(*c*) When the brakes are released the initial acceleration is slow, particularly at the heavier all-up weights, and the aircraft will swing into any cross-wind. At forward and mid CG loadings the aircraft can be kept straight with nosewheel steering initially and then by rudder as this becomes effective at 90 knots. At aft CG, nosewheel steering is less effective, and it may be necessary to use the wheel brakes to hold a straight run until the rudder becomes effective. The nosewheel should not be raised until 10 knots below the unstick speed, when slight backward pressure of the control column should be applied and the aircraft flown off.

(*d*) *Table of unstick speeds*

Take-off weight (lb.)	*Unstick speed (kts.)*
100,000	115
110,000	120
120,000	125
130,000	130
140,000	135
150,000	140
160,000	145
170,000	150
180,000	155

3 Safety speeds

If an engine fails with the remaining engines at take-off power, the aircraft can be held straight using nosewheel steering until at about 80 knots, assuming no cross-wind, rudder alone may be used. The safety speed therefore will always be below the unstick speed and the decision to continue or abandon the take-off will depend on the aircraft weight and prevailing runway conditions as determined by the Operating Data Manual. Longitudinal trim is not affected by engine failure.

4 After take-off

(*a*) When safely airborne select undercarriage UP. In Mk. 1 aircraft apply the parking brake and wait 5 seconds before retracting the undercarriage. Speed must not exceed 185 knots until the undercarriage and main flaps are fully retracted. To avoid a steep angle of climb, RPM should be reduced to maintain 625°C JPT (or slightly less at low AUW's) immediately after the undercarriage has been selected UP.

(*b*) At a safe height, and when the undercarriage is fully retracted, select main flaps UP, and select nose flaps to AUTO. When the main flaps are fully retracted select climbing power and accelerate to climbing speed. The nose flaps will retract automatically when the main flaps are fully retracted provided that the aircraft is not in a high CL condition.

(*c*) Complete the after take-off checks.

5 Climbing

(*a*) The recommended climbing speed is 300 knots. However, from considerations of aircraft fatigue life, speed should not be increased above 250 kts. until reaching 10,000 ft. Thereafter climb at 300 kts. until this speed is coincident with 0·83 M, and then continue to climb at 0·83M.

(*b*) When maximum rate of climb is required the engines should be left at take-off power for up to 10 minutes. Normally climbing power (98% RPM, 625°C JPT) should be selected and CLIMB selected on the JPT controller (if fitted).

(*c*) For the cruise climb the engines should be set as computed for prevailing conditions, but the maximum continuous power setting is 96% RPM. The maximum permissible JPT at this power setting is 600°C. With JPT control fitted the engine speed will decrease as altitude is increased.

6 Flying controls

(*a*) *Ailerons*

The ailerons are effective and forces are light throughout the speed range. The stick forces increase with speed and also with aileron control surface movement. At speeds above 150 knots, the ailerons give very good response. Below 150 knots, response deteriorates, but control in the approach configuration is still good.

(*b*) *Elevators*

The elevators are effective throughout the speed range with good response. Stick forces increase with speed and with increased elevator angle but remain reasonable.

(*c*) *Rudder*

The rudder is effective throughout the speed range down to approximately 80 knots. The pedal forces increase with speed and deflection and at high speed are very heavy.

(*d*) *Effect of airbrakes*

The airbrakes may be extended at any speed. Extension at high power settings produces light airframe buffet. They are very effective at high speeds and remain sufficiently effective at low

(*e*) *Changes of trim*

Lowering and raising the undercarriage	Negligible
Main flaps from fully up to fully down .	Moderate nose-down
Main flaps up from fully down . .	Moderate nose-up
Main flaps up from take-off . . .	Slight nose-up
Main flaps from up to take-off . .	Slight nose-down

NOTE: The main flaps are of the Fowler type which, when selected down, first travel rearwards and then rotate downwards. Following the selection of take-off or landing flap there is a delay of about 13 seconds, during which time the flaps are moving rearward, before any trim change is felt.

Nose flaps out or in	Negligible
Airbrakes in and out . . .	Negligible
Bomb-doors open or closed . . .	Negligible with moderate buffet at high IAS

(*f*) *Fixed droop leading edges* (*post-Mod.* 2352)

The handling characteristics of aircraft fitted with fixed droop leading edges are similar to those of aircraft fitted with nose flaps. A slight reduction in longitudinal stability is noticeable when flying with an aft CG, and this characteristic is more pronounced when flying at low indicated airspeeds. Speed must not be reduced below the recommended threshold speeds or the onset of pre-stall buffet which occurs at approximately 5 knots lower than with nose flaps when main flaps are retracted and at the same speed as with nose flaps when main flaps are extended.

7 Stalling

(*a*) Stalling is not permitted and speed must not be reduced below the onset of pre-stall buffet. With wings level, an exaggerated nose-up attitude will be apparent before the onset of pre-stall buffet. If it is intended to approach the buffet region the nose-flaps should be selected OUT. With nose-flaps selected IN, and parand mild pitch-up may occur some 5-10 knots before the onset of pre-stall buffet. With the aircraft in the clean configuration (or with nose-flaps lowered) the initial pre-stall buffet is an unmistakable light buffet of moderate frequency. With undercarriage and flaps lowered the initial pre-stall buffet may be masked by general airframe buffet. If the initial buffet is felt, recovery must be made immediately by lowering the nose and opening the throttles to increase speed. If recovery action is not taken and speed is further reduced, the buffet will become moderate before changing to a heavier and more irregular " lumpy " buffet. However, the controls should remain effective and the aircraft remain controllable, though with some difficulty. On aircraft with fixed droop leading edges the onset of pre-stall buffet may occur at airspeeds some 5 knots lower than on unmodified aircraft when main flaps are retracted, but the rate of increased of buffet intensity with further reduction in speed will be greater.

(*b*) *Stalling in turns*

Approach to the stall in turning flight is indicated by the onset of light buffet which is followed by moderate buffet. It is possible for buffet to be encountered before the G limitations are reached. Recovery action, which is effected by reducing the backward pull on the control column, must be taken as soon as buffet is experienced.

(*c*) *Recovery from a stall or superstall*

If recovery action is not taken early enough, the aircraft may stall and then possibly enter a spin or a stable stalled glide (Superstall). The latter condition is most easily recognised by the extremely high rate of descent (up to 10,000 or 15,000 fpm) combined with low IAS, with the nose remaining on or near the horizon, and with all controls apparently useless. In either event, the stick should be held fully forward and full rudder applied against any rotation. Ailerons should remain about neutral and power should be reduced. The aircraft should then recover. If, however, the above

streamed. Because of the very high aircraft incidence, this will produce a large nose-down moment and unstall the aircraft. The parachute is likely to break away during the ensuing dive, recovery from which should be made as gently as possible.

8 High-speed flight

(*a*) *At high indicated airspeeds*

The IAS limitation is 330 knots. Flight at high indicated airspeeds presents no special difficulties. At low altitude the aircraft is easily capable of exceeding the limiting speed in level flight. Therefore, when accelerating to the limiting speed care must be taken to throttle back early to avoid exceeding this speed. Elevator movements should be made smoothly and deliberately, otherwise pitching will develop and accurate speed control will become difficult.

(*b*) *At high mach numbers*

▸◂

(i) *Auto-mach trimmer operative*

The auto-mach trimmer provides a progressive nose-up trim change as speed is increased above 0·85M, although the trimmer magnetic indicator may not go white until 0·87M is reached. If the magnetic indicator does not show white when 0·88M is reached, speed should be reduced to 0·85M and the auto-mach trimmer switched OFF. Careful trimming is required to maintain a steady speed in the region of 0·85M, but at slightly higher speeds trimming is easier. The aircraft should not ◂ normally be trimmed at speeds in excess of 0·92M. Flight at high mach numbers should be carried out with the wings reasonably level and in any case bank angles should not exceed 30° at speeds above 0·90M.

(ii) Because of the ease with which the aircraft may be accelenumber. However, in case this speed should be exceeded inadvertently, the following description of flight at mach numbers above 0·93M is given. Above 0·93M slight buffet occurs and and there is a decrease in control effectiveness. This decrease in effectiveness is most marked on the ailerons, particularly below 40,000 ft. and is due to aileron jack stalling. (Rapid heavying of the control hinge movements restricting the aileron deflection which can be achieved with the full output of the power control units). A moderate push force is required to maintain 0·95M. Above 0·95M a slight wing drop may occur; this can be checked with the ailerons although aileron control, particularly below 40,000 ft., is then very limited. Above 0·97M aileron control is negligible and there is little benefit to be gained by forcing the control wheel against the over-travel spring. Above 0·93M to 0·94M the sense of roll induced by side-slip is reversed (i.e. application of top rudder lowers a depressed wing rather than raises it) and in certain conditions the rolling moment resulting from application of top rudder can completely counteract that produced by the ailerons. In order to avoid the possibility of instinctive and unwitting applications of top rudder when rolling the aircraft at high mach number the rudder pedals should be freed if 0·93M is exceeded with any bank applied. Recovery from high mach number is best accomplished by closing the throttles, extending the airbrakes and applying up-elevator, maintaining the wings level or rolling level with aileron and leaving the rudder pedals free.

(c) *Auto-mach trimmer inoperative*

As speed is increased beyond 0·87M a slight, though progressive, nose-down trim change occurs and speed must only be allowed to exceed 0·90M when exceptional circumstances require such higher speeds. As speed increases above 0·90 M an increasing pull-force is required to control the aircraft.

9 Descent

(a) *Cruise descent*

Close the throttles and with airbrakes, flaps and undercarriage retracted, descend at a constant speed of 210 kts. The nose flaps should be selected to AUTO and allowed to extend when the speed decreases below 0·70M. The descent from 50,000 ft. to sea level will take about 35 minutes.

(b) *Other descents*

In all other descents the airbrakes should be out, with undercarriage and all flaps retracted. With the throttles closed, select the speed appropriate to the type of descent:

Normal QGH . . .	0·84M/240 knots (4000 fpm)
Rapid descent . . .	0·90M/300 knots (7000 fpm)
Max. rate descent . .	0·93M/330 knots

WARNING: A max. rate descent should only be made in extreme emergency; the rate of descent must be reduced if the fuel tank pressure warning light comes on.

10 Flying in turbulent conditions

The recommended speed for flight in conditions of severe turbulence is 220-250 knots or 0·87M, whichever speed is achieved first.

Part IV

Chapter 3—Circuit and Landing Procedures

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1 Joining the landing pattern

Before descending to join the circuit or approach pattern, carry out the pre-descent checks and select the ILS as required. When level at the circuit or pattern height, select nose flaps OUT at 220 kts. and lower the main flaps to the TAKE-OFF position at 185 kts. Carry out the pre-landing checks and reduce to the recommended speed, which is 20 knots above the threshold speed for the weight. The recommended pattern (or circuit) speeds, final approach speeds and runway threshold speeds for various aircraft weights are shown on the accompanying graph.

2 Visual circuit

When carrying out a visual circuit, maintain the recommended pattern speed until suitably positioned at approximately 90° to the runway. Select main flaps DOWN and reduce power as required, aiming, whenever possible, to be approximately lined up with the runway at about 600 ft. at the recommended approach speed. When the decision to land has been made, reduce speed progressively aiming to round-out over the runway threshold at the recommended threshold speed. If a steep approach is made and a large change of attitude is necessary to round out, buffet and a tendency to sink may be experienced ; in this case the threshold speed should therefore be increased by approximately 5 knots.

3 Instrument approaches

When carrying out ILS or GCA approaches, maintain the recommended pattern speed until ½ mile before interception with the glidepath. Select main flaps DOWN and reduce power as necessary to maintain speed on the glidepath at the recommended approach speed. During the final stages of the approach and when in visual contact with the runway, reduce speed progressively aiming to round-out over the runway threshold at the recommended threshold speed.

◀ NOTE: Variable airbrake procedure is recommended during the approach. ▶

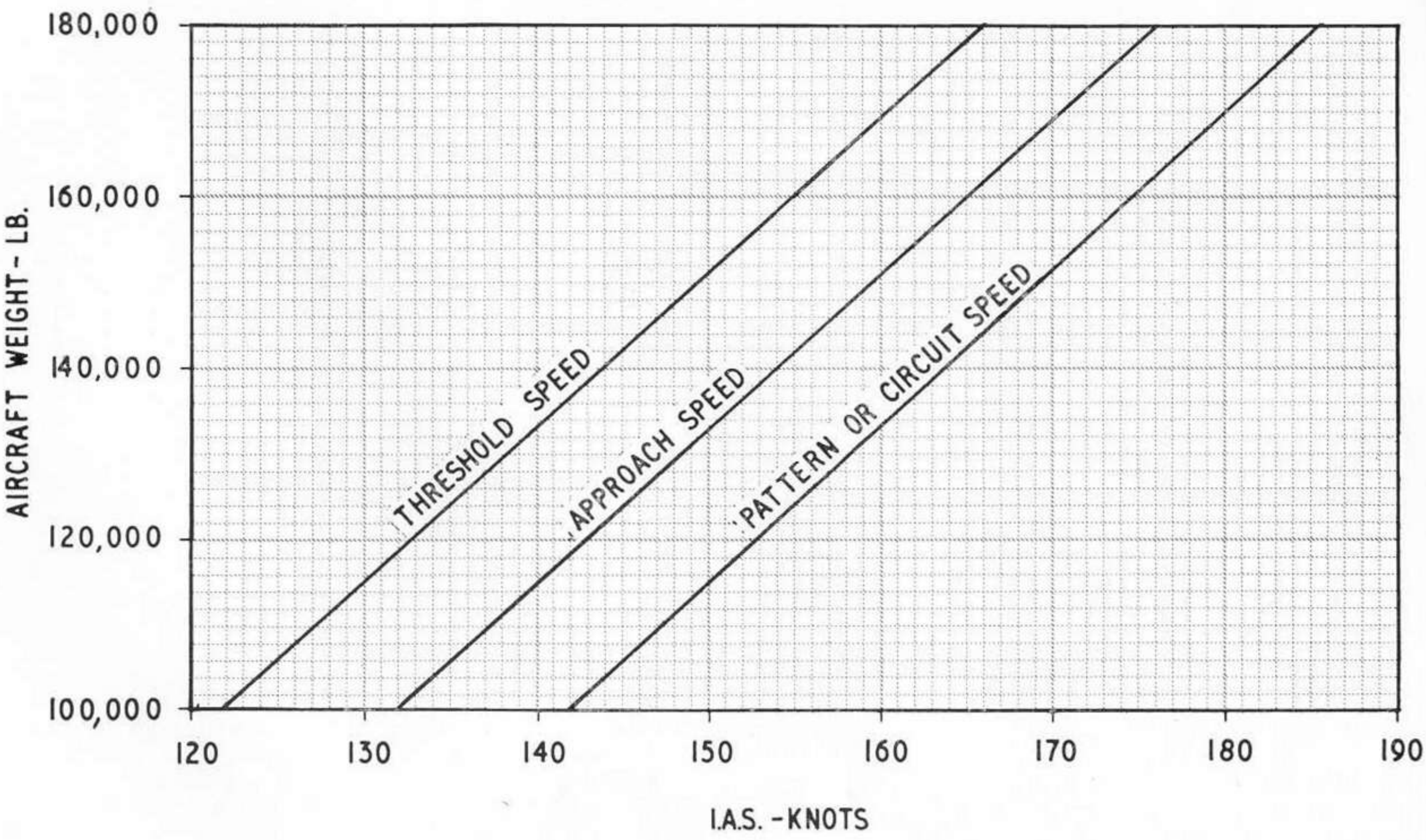

Fig. 1 Circuit, approach and threshold speeds

4 Landing

Provided that a good approach has been made, landing the aircraft presents no difficulties. Cross the threshold at the recommended speed, gradually closing the throttles. Round-out and allow the aircraft to sink gently but firmly onto the runway, a prolonged hold-off is not recommended. When the main wheels are firmly on the ground, lower the nosewheel onto the runway. A slight push force may be required and throughout the landing run the 2nd pilot should maintain a moderate push force on the control column to assist nosewheel steering effectiveness. If it is intended to use the brake-parachute, this should be selected to STREAM when the main wheels are on the runway and the nosewheel lowered whilst the parachute is deploying. Wheel braking action may be commenced when the nosewheel is firmly on the runway, provided that the speed is below the maximum braking speed for the conditions prevailing.

5 Use of the brake-parachute

(*a*) The maximum permissible speed for streaming the brake-parachute is 140 knots. Under normal conditions, use of the brake-parachute to reduce the landing run is recommended. When the mainwheels are firmly on the runway, and when the speed is below 140 knots, select the brake-parachute to STREAM and lower the nosewheel onto the runway whilst the parachute is deploying. Full deployment usually occurs 4-5 seconds after selection. If the airbrakes have been extended during the approach they should be closed before the brake-parachute is streamed. When the parachute deploys fully, retardation is marked. Maximum retardation is achieved by streaming the brake-parachute as early in the landing run as possible. The retarding effect is noticeable down to approximately 70 knots but very little advantage is gained from using it below that speed.

(*b*) The maximum permissible crosswind component for streaming the brake-parachute is 20 knots. When the parachute deploys in crosswind conditions, a marked nose-into-wind yawing effect occurs, the degree of yaw increasing with increase in cross-wind component. The yawing effect must be anticipated and the aircraft kept straight by using rudder, differential braking and nosewheel steering as required. If directional control cannot be maintained with full use of these controls, the brake-parachute must be released by selecting the switch to SAFE, and wheelbrakes used to stop the aircraft.

(*c*) To achieve a clean jettisoning of the brake parachute it should normally be released at the end of the landing run before reducing to taxy speed. When it is certain that the aircraft can be stopped comfortably with normal use of wheel-brakes, select the brake-parachute to SAFE. If the parachute should fail to jettison, no further selections should be made but the aircraft should be stopped when clear of the runway and the fault investigated.

6 Use of the wheelbrakes

(*a*) Before landing check that the brake pressure gauges indicate 4,000 PSI, that the parking brake is off and that the pilot's feet are clear of the brake pedals. Brake pressure must not be applied before the wheels have touched the runway and are rotating.

(*b*) The shortest landing run (with or without streaming the brake-parachute) is obtained by lowering the nose onto the runway and applying heavy brake pressure continuously. On dry surfaces the maxaret units normally prevent the wheels from locking if excessive brake pressure is applied but, unless the shortest possible landing run is required, more gentle use of the brakes is recommended. As a safeguard against locking the wheels during a bounce the maxaret units remain inoperative for several seconds. When the nosewheel is firmly on the runway, provided that the speed is below the maximum braking speed for the conditions prevailing, apply light pressure to both brake pedals. As speed decreases, gradually increase the pressure until, when the aircraft speed is very low maximum pressure may be applied to stop the aircraft.

(*c*) On wet surfaces, retardation may be considerably reduced according to the degree of wetness of the runway surface. Generally, under wet runway conditions it is recommended that light intermittent braking action be commenced as soon as the nosewheel is firmly on the runway. The brake pressure may be progressively increased and may be held continuously as speed reduces. If slip or skid is felt the pressure should be released momentarily and then re-applied gradually.

(*d*) On flooded or icy runways a drastic reduction in brake effectiveness must be expected and, whenever possible, such conditions should be avoided. However, if a landing on a flooded or icy runway has to be made, it is essential to achieve the recommended threshold speed and make an accurate touchdown at the beginning of the runway. The brakes must be used carefully throughout the landing run. Because of the possible decreased effectiveness of the wheelbrakes in assisting maintenance of directional control, careful consideration must be given to the desirability of streaming the brake-parachute in crosswind conditions.

7 Crosswind landings

A crosswind landing presents no special difficulty, and the crab technique is recommended. The maximum crosswind component for safe landing is 25 knots. See paragraph 5(*b*) for use of the brake-parachute after landing.

8 Flapless landing

If the flaps fail to lower when either normal or emergency selections are made, the normal pattern speed for the weight should be flown and when commencing the descent for landing this speed should be maintained and decreased by 10 knots at the threshold. The 2 degrees glide path technique should be employed giving a flat approach and care should be taken on the round out since heavy elevator movements may result in the rear fuselage striking the ground. Practice flapless roller landings are not recommended.

9 Overshooting

Overshooting from any height presents no problems. Select airbrakes in and open the throttles to the required power setting. More than adequate power should normally be available, and engine speed may be reduced as required when the overshoot has been initiated in order to avoid climbing away at an excessively steep angle. At a safe height complete the overshoot checks.

10 Roller landings

(*a*) When carrying out roller landings it is not necessary to lower the nosewheel on the runway. However, if it is intended to reduce speed during the roll to below 90 knots, or in strong cross-wind conditions, the nosewheel may be lowered to assist maintenance of directional control.

(*b*) When opening the throttles, pilots should be prepared for some difference in response from each engine. Care must be taken to avoid adopting an exaggerated nose-up attitude as the aircraft accelerates, and to avoid lifting off the ground at too low a speed. The aircraft may be flown off comfortably at the threshold speed for the AUW.

◀ (*c*) After an asymmetric approach and landing, all throttles are to be closed to the idling position before power is re-applied to all four engines ▶

Part IV

Chapter 4—Asymmetric Flying and Handling with PFCU's Failed

List of Contents

1 Handling in flight

(*a*) Flight with one engine stopped presents no unusual handling problems and under certain conditions may be indistinguishable from four-engine flying. Any rudder loads may easily be trimmed out. With two engines on one side stopped it is possible to trim out all loads in cruising flight. However, if two engines on the same side are stopped at high altitude at speeds above 0·75M severe buffet is experienced due to the choking of the stopped engines air intake. This buffet is less marked at lower altitudes and lower airspeeds.

(*b*) The stopping of any engines entails loss of electrical supply from the associated alternaters, and the electrical system should be managed in accordance with the relevant instructions in Part I and Part V. If two engines on one side are stopped and the bus-bars are not paralleled, one sub-unit in each PFCU is inoperative. Only gentle manoeuvres are permitted under these conditions and the aircraft should be landed as soon as possible.

2 Approach and landing

(*a*) As long as the necessary total power can be obtained from the operative engines, the techniques for approach and landing using three engines should be as normal, except that the lowering of full-flap should be deleayed until it is certain that a landing can be made.

(*b*) During an approach using two engines, the calculated approach speed for the weight should be maintained down to the decision height of 200 feet above the airfield level. Full flap should then be lowered when required.

3 Overshooting

(*a*) With one engine stopped it is possible to climb away after a baulked landing with the main flaps and undercarriage down at all weights. The airbrakes should be closed as soon as the overshoot is initiated.

(*b*) With two engines stopped the aircraft can climb away with full flap and undercarriage down, airbrakes in, at the normal landing weight. The overshoot must be commenced at or above the decision height and the approach speed. During the climb away to a safe height the speed should be maintained at or above the pattern speed.

4 Flight with PFCU's failed

(*a*) *Failure of any one* PFC *sub-unit*

The failure of a PFC sub-unit has a negligible effect upon aircraft handling within the flight limitations stated in Part II.

(*b*) *Failure of a complete elevator* PFCU

The degree of control available following the failure of a complete elevator PFCU is sufficient for all normal manoeuvres, but landing in this condition requires considerable concentration, as control forces are higher than normal and response is less. The most critical period occurs during the round out and, to ensure that sufficient control is retained to accomplish this manoeuvre, it is recommended that the landing is made using take-off flaps only and the threshold speed increased by 20 knots.

(*c*) *Failure of a complete aileron* PFCU

The failure of an aileron PFCU produces considerable disharmony of the controls and results in a much reduced maximum rate of roll. Despite these effects the degree of control remaining is sufficient for all normal manoeuvres and, in calm weather conditions, a landing may be made using the normal technique and threshold speed. The increased control force and reduced aircraft response, however, demand that special care is taken to avoid having to make large rolling corrections at a late stage on the approach. In gusty or cross-wind conditions the threshold speed should be increased by 20 knots.

Part V—Emergency Handling Procedures

List of Chapters

Part V

Chapter 1—Engine Emergency Procedures

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1 Engine fire

NOTE: If a fire occurs in one engine it is recommended that the adjacent engine is also closed down. Depending upon the stage of flight this may not always be practicable and aircraft captains must base their decision upon the circumstances at the time of the incident.

(*a*) *Indication*

Fire in an engine is indicated by the illumination of the appropriate red ENGINE FIRE WARNING light.

(*b*) *Immediate actions*

(i) Warn crew.

(ii) Press ENGINE FIRE WARNING button. (This action should automatically close the appropriate HP COCK, LP cock and alternator cooling close shutter).

(iii) Close both HP and LP cocks on the affected side.

(iv) Select ECM alternator to main bus-bar.

(v) Check that the ALTERNATOR COOL CLOSE light has illuminated.

(*c*) *Subsequent actions*

(i) Reduce speed.

(iii) Switch ON unaffected wing and fuselage pumps.

(iv) Select unaffected wing and fuselage proportioners to BY-PASS.

(v) CLOSE both crossfeed cocks.

(vi) Switch OFF affected wing fuel pumps.

(vii) Select affected proportioner to NORMAL.

(viii) CLOSE affected WING ISOLATION COCK.

(ix) If the fire is in the port side CLOSE the LONG RANGE ISOLATION cock and switch OFF bomb-bay tank pumps.

(x) Switch OFF affected alternators.

(xi) Complete load shedding drill.

(xii) Parallel bus-bars at captain's direction.

(xiii) Check externally by use of the periscope.

(*d*) If the fire fails to go out, prepare to abandon the aircraft.

(*e*) If a fire occurs on or soon after take-off, and a heavy weight circuit and landing is carried out, it may be sufficient to switch off the MV battery and monitor the LV supply rather than to carry out the full load-shedding procedure. If the port engines are flamed-out,

2 Engine mechanical failure

If an engine fails under conditions which indicate a mechancial failure, immediately stop the engine by closing the HP cock and LP cock. Keep close observation for warning of engine fire. Switch OFF the alternator.

3 Flame extinction

If an engine fails under circumstances in which it is unlikely to have suffered mechanical damage, and is not showing signs of mechanical damage but is windmilling at a reasonable speed for the flight conditions prevailing, an attempt may be made to relight it. During the relight attempt a careful watch must be kept on the engine fire warning indications and the JPT, oil pressure and RPM gauges. At the slightest sign of malfunction, close the HP cock and LP cock and make no further attempt to relight the engine.

4 Engine failure during take-off

(*a*) If a single engine fails during take-off while below the "stop" speed, the take-off must be abandoned. Throttle back all engines, stream the brake-parachute and use wheelbrakes as required.

(*b*) If an engine fails above the "stop" and "go" speeds, continue with the take-off. The safety speed will always be below the unstick speed. As soon as possible, depending on the circumstances of the failure, attempt to relight the failed engine, or stop it by closing the HP cocks and LP cock.

(*c*) If two engines fail during take-off, it may be necessary to throttle back the two remaining engines to assist in maintaining directional control.

5 Two engine failure in flight

(*a*) If two adjacent engines fail in flight, pilot's actions must be in

(*b*) *No indication of mechanical failure*

(i) Throttle back.

(ii) Select alternative fuel supply.

(iii) Attempt immediate relight on each engine in turn.

(iv) Descend, continuing to attempt relights

Recheck fuel selections.

(*c*) *Indications of mechanical failure*

(i) Close HP and LP cocks.

(ii) Monitor the engine fire warning lights but do not press unless fire is indicated.

(iii) CLOSE cross-feed cock and wing isolation cock. Switch off booster pumps in affected wing and select proportioner to NORMAL. Ensure fuel supply to other engines by switching on fuselage booster pumps and selecting fuselage and unaffected wing proportioners to BYPASS.

(*d*) In both cases the AEO should take the appropriate action for double alternator failure. Bus-bar paralleling action may be taken at the captain's discretion.

6 Four engine flame-out

(*a*) *Indications of failure*. Indications should be obvious, engine instruments and loss of thrust.

(*b*) *Actions*

(i) Attempt hot relights immediately.

(ii) Captain orders "load shedding".

(iii) Crew carry out actions as detailed in Table 1.

This is an attempt to maintain generation by high windmilling RPM.

(v) At 25,000 feet put any additional fuel pumps ON (minimum 3 pumps in any one group) reduce to optimum relighting conditions and attempt relights.

(vi) Continue attempts to relight and if unsuccessful abandon aircraft.

NOTE: During this drill the AEO must monitor the TRU/LV ammeter and, if the readings fall to within 5 amps of the zero point the field circuit breaker of the associated alternator must be tripped. This is to prevent discharge to the alternator field at low windmill RPM.

If the MV bus-bar voltage falls to 75 volts at any time during the drill the aircraft must be abandoned immediately.

Table 1

FOUR ENGINE FLAME-OUT DRILLS

	1 *Captain*	2 *Co-pilot*	3 *A.E.O.*	4 *Navs. P & B*
Immediate Actions	1. Warn crew "Load shed" 2. Descend, attempting hot relight	1. Proportioners to BYPASS 2. Load shed	1. Parallel bus-bars if safe 2. Load shed	1. Load shed
Subsequent Actions	1. Attempt further relight 2. Adjust speed and attitude for rear crew escape 3. If no relight order "Prepare to abandon aircraft"	1. Inform A.E.O. when each engine falls below 25% RPM 2. Reduce booster pumps to absolute minimum 3. Transmit distress call	1. Switch off alternators when associated engine falls below 25% RPM	1. Take up abandon aircraft positions 2. Pass position to co-pilot

NOTE 1: It is assumed that the alternators will not come off line immediately, and, therefore, the immediate actions will take place with alternators ON.

NOTE 2: This drill assumes the emergency happens when the aircraft is at height. At low level the actions would be modified for immediate rear crew escape.

NOTE 3: "Load shed" implies *all* loads OFF except:—

(*a*) Booster pumps as required
(*b*) Minimum PFCU's
(*c*) Flight instrument 153 inverter
(*d*) Standby yaw damper if required
(*e*) VHF/UHF set when in use

Part V

Chapter 2—Airframe Emergency Procedures

List of Contents

1 Failure of a PFCU

(*a*) *Indication*

Warning light comes on.

(*b*) *Immediate action*

Switch off the affected sub-unit. This action does *not* cancel the warning light.

(*c*) *Subsequent action*

One attempt may be made to restart the sub-unit. If the warning light stays on, switch off the sub-unit and leave it off.

2 Overheating of a PFCU

(*a*) *Indication*

Overheat warning indicator shows white.

(*b*) *Immediate action*

Switch off the affected PFCU.

(*c*) *Subsequent action*

When the magnetic indicator shows black, wait five minutes and switch on the PFCU. If the magnetic indicator again shows white, switch OFF and leave OFF.

3 Control surface trim runaway

(*a*) *Indication*

Marked change of aircraft trim.

(*b*) *Immediate action*

(i) Release trimmer and call "Trim runaway".

(ii) Take stick force and alert other pilot to assist if necessary.

(iii) Reduce speed if necessary.
(iv) Retrim on alternative switch.

(*c*) *Subsequent action*

AEO trips circuit breaker of faulty trimmer on panel AJ or AV.

Circuit Breaker	*1st Pilot Panel*	*Co-Pilot Panel*
Console Selector Trim Switch Master .	AV	AJ
" " " " Rudder .	AV	AJ
" " " " Aileron .	AV	AJ
" " " " Elevator .	AV	AJ
Control Column Elevator Trim Switch .	AJ	AV

NOTE: The Master circuit breaker cuts out the associated console switch only, leaving the other pilot's spectacle switch operative.

4 Control surface trim failure

(*a*) *Indication*

No response to trim selection.

(*b*) *Action*

(i) Make no further selections of the affected control until its circuit breaker has been checked.

(ii) If tripped, reset the circuit-breaker.

(iii) Make a trial operation of the trim at low airspeed.

(iv) If the control still fails to operate, or again causes the circuit-breaker to trip, break the circuit and use the alternative trim.

NOTE: If a trim runaway occurs, the circuit breaker must be tripped immediately and the alternative trim used for the remainder of the flight.

5 Yaw damper failure

(*a*) *Indications*

Yawing oscillations or yaw trim force.

(*b*) *Action*

Switch hydraulic yaw damper to STANDBY and standby yaw damper ON. If the indications continue switch the hydraulic yaw damper OFF, this action cuts the feedback circuit and allows the rudder to run 4° in one direction or the other. The standby yaw damper should be switched to STANDBY and the rudder trim used to neutralise the rudder; this will slightly offset the rudder pedals; the standby yaw damper should then be switched ON and hydraulic yaw damper left OFF.

6 Auto-mach trim failure

(*a*) *Indications*

(i) *Sticking in one position of extension*

Gradual change from nose-up to nose-down trim force as speed is increased in the operative speed range.

(ii) *Moving to fully extended or retracted*

Sudden nose-up or nose-down trim change.

(*b*) *Immediate action*

Reduce speed to below 0·85M and switch off.

(*c*) *Subsequent action*

(i) Retract the actuator in small increments by selecting control switch to RESET in short "blips".

(ii) If the indicator remains black do not increase speed above 0·87M.

7 Cabin pressure failures

(*a*) *Loss of cabin pressure*

(i) *Indications*

Warning lights come on. Horn sounds if cabin altitude exceeds 42,000 feet.

(ii) *Immediate action*

NOTE: Flood flow, if set to AUTO, operates automatically, but will cycle once cabin altitude reduces to below 26,500 feet.

Warn crew assume manual control by switching off master flood flow switch and increase or decrease mass flow by selections between FLOOD and LESS AIR.

(iii) *Subsequent action*

Check for leaks and that all cabin pressurisation system switch selections are correct. When no longer required, select the flood flow reset switch to RESET until the indicator goes black.

(*b*) *Over-pressurisation*

(i) *Indications*

Cabin altimeter reads lower than correct figure for altitude.

(ii) *Immediate actions*

1 Warn crew.
2 Level out, if climbing.
3 Do not exceed 30,000 feet.
4 Dump excess pressure to obtain correct cabin altimeter reading.
5 Select COMBAT, if on CRUISE.

(iii) *Subsequent actions*

If over-pressurisation persists switch off the starboard isolation cock and then maintain cabin pressure by alternate on/off switching of the port isolation cock. The port engines bleed isolation cocks may be switched off and the cabin pressure maintained by alternate on/off switching of either one of these switches.

NOTE 1: If over-pressurisation is caused by *inadvertent* operation of flood flow, switch off the flood flow system and RESET.

NOTE 2: If over-pressurisation is caused by *normal* operation of the flood flow system, manually control pressure by LESS AIR selection.

NOTE 3: If cabin pressurisation occurs at low altitudes, check that the pressure controller ground test lever is flush.

(*c*) *Rapid or explosive depressurisation*

(i) *Indications*

Warning lights illuminate. Horn sounds if cabin altitude exceeds 42,000 ft. Noise of decompression and cabin misting.

(ii) *Immediate action*

Warn crew "Emergency Descent, toggles down." Crew acknowledge. Throttle back, extend airbrakes, descend at 0·93M/330 knots until cabin height is 30,000 ft. or below. Check flood flow is operating ; if necessary select manually.

(iii) *Subsequent actions*

Check selections of ABANDON AIRCRAFT switch, EMERGENCY DECOMPRESSION switch, ENGINE BLEED ISOLATION switches, CABIN AIR ISOLATION switches. Select alternate setting on cabin pressure selector switch. If depressurisation is due to incorrect switching, RESET flood flow.

If the failure is due to puncturing of the cabin walls, use leak stoppers if possible.

NOTE: Maximum cabin height is 42,000 ft. in emergency only.

8 Escape hatch jettisoning

(*a*) *Post-Mod.* 2789

Automatic jettisoning occurs when associated ejection seat *face blind* handle is pulled.

(*b*) To jettison manually, pull up associated ditching handle.

9 Flight with escape hatches jettisoned

(*a*) Flight tests have shown that at speeds of 250 knots and over, with one or both pilots' escape hatches removed, normal intercommunication will be extremely difficult if not impossible. Cabin altitude may exceed actual altitude by up to 2,000 feet.

(*b*) Airflow conditions and buffet level at the pilots' station for speeds in excess of 180 knots are not uncomfortable, but below 180 knots the buffet level and airflow in the cockpit increase abruptly and will become increasingly more severe with a further reduction of speed. Difficulty will be experienced in seeing due to the dust and airflow unless the eyes are protected by the use of goggles. The loss of one or both hatches will not affect the stalling speed, and the normal approach speeds should be used.

(*c*) The inadvertent loss of the pilots' escape hatches may result in damage to the airframe, especially the rear fuselage. Therefore the aircraft should be flown at an airspeed as low as is practicable, i.e. 220 knots and below and only gentle manoeuvres performed until the extent of the damage, if any, is confirmed.

10 Action in the event of complete loss of plenum chamber pressure

(*a*) There is no immediate danger of overheating and this drill should be carried out with care and attention. The object of the load shedding is to reduce all TRU loading evenly. No excessive overheating should take place if the TRU loading is reduced to a maximum of 30A per MV channel and 20A per LV channel, and there is no restriction on flight duration if these maxima are achieved. If the plenum/dinghy hatch is missing airspeed should be restricted to a max. of 240 knots with an optimum of 210 knots or less to avoid possible damage to the airframe aft of the hatch.

(*b*) *Action*

(i) ECM equipments all OFF. Return alternator to main electrical system.

(ii) Load shed selectively, Port and Stbd., as follows, monitoring ammeters:

1 Hydraulic pumps—both OFF—use one when required
2 PFCU's—switch OFF numbers 1, 4, 6, 7, 10
3 Proportioners—BYPASS
4 Fuel pumps—minimum of 3 in a group
5 Inverters—all OFF except flt. instruments
6 NBC and H2S—circuit breaker tripped
7 Scanner stabilisation—OFF
8 VHF/UHF—either set OFF
9 Yaw dampers—Normal to STANDBY/Standby as required
10 Anti-icing—As required
11 External and Internal lights—Minimum
12 ILS—OFF
13 ADF—OFF
14 HF—minimum use then—OFF
15 Ration heater CB's tripped

(iii) Check plenum hatches with periscope.

(iv) If panel BA ammeter loading excessively uneven then parallel at captain's discretion.

11 Nose flap failure

(*a*) *Failure to lower*

(i) If the nose flaps fail to lower at any time when AUTO is selected and the lift co-efficient is high, or when the main flaps are lowered, try lowering by selecting nose flaps OUT. If the nose flaps still will not lower, take action as in (ii) and (iii) below.

(ii) *Manoeuvring*

The speeds at which the CL warning lights will come on may vary due to the tolerance in the setting of the pressure ratio switch, and to extraneous aerodynamic effects such as rolling motion or rate of increase of incidence. Pre-stall buffet will occur at approximately 15-25 knots below the CL warning speed. Whilst manœuvring, therefore, maintain speed above that at which the CL lights operate.

The table on next page lists the ranges of speeds at which the CL warning lights will come on with the undercarriage, nose flaps and main flaps retracted.

Wt. (*lb*)	*IAS—1G Flight*	*IAS—1½G Flight*
100,000	155–170	185–200
110,000	160–175	195–210
120,000	165–180	200–220
130,000	170–190	210–230
140,000	175–195	215–240
150,000	185–205	225–250
160,000	190–210	230–255
170,000	195–215	240–265
180,000	200–220	245–270

(iii) *Circuit and landing*

For the circuit and landing, 10 knots must be added to the recommended speeds shown on the approach speed chart. Gentle turns with as little acceleration as possible must be used, therefore the downwind leg must be wide and the turn to the cross-wind leg delayed. If lower speeds are used pitch-up may be experienced as the aircraft nears the ground if a complete failure of the nose flaps to lower has occurred, or a combined pitch-up and severe wing drop if both nose flaps on one side only have failed to lower.

(*b*) If the nose flaps fail to retract automatically proceed as follows:

(i) Select nose flaps IN.

(ii) If they fail to retract, the aircraft must not be flown at speeds above 0·75M and the limiting IAS.

(iii) Flight with the nose flaps extended will increase the drag and have a corresponding effect on range characteristics.

12 Hydraulic system failures

NOTE 1: This drill lays down the action to be taken in the event of known hydraulic malfunctions. Other faults due to extraordinary causes, i.e. stray earths, loose leads, etc., cannot be covered by check list drills.

NOTE 2: The order in which the drill is written is considered to indicate the most probable sequence of events. By referring to the index below the drill may be started at the appropriate paragraph and, should subsequent faults develop, followed to its logical conclusion.

NOTE 3: The following is a list of situations as nominated in the drill:—

(*a*) During take off
(*b*) No. 1 pump peaking (Sortie U.K. Area)
(*c*) No. 1 pump peaking (Overseas Flights)
(*d*) No. 1 pump failure or float switch operation before let-down
(*e*) Aircraft unclean—range considerations
(*f*) No. 1 pump fails or float switch operates during let-down procedure
(*g*) Airbrakeless let-down procedure
(*h*) No. 2 pump fails/float switch operates during let-down procedure
(*j*) Cold soak procedure

(*a*) *During take off*

If either float switch light illuminates or either pump fails:—

1. Both pumps OFF at once
2. Reduce to circuit speed, select unaffected pump—AUTO
3. Undercarriage—DOWN (leave down)
4. Nose flaps—OUT
5. Flaps—TAKE OFF—Pumps—OFF
6. Reduce to landing weight, serviceable pump AUTO for final landing

If unaffected pump fails or float switch operates (see sub-para. (*h*))

(*b*) *No.* 1 *pump peaking* (*Sortie U.K. Area*)

1. No. 1 pump OFF
2. *Do not try No.* 2 *pump*
3. Aim to complete planned sortie
4. No. 1 pump may be selected to AUTO whenever hydraulic services are required throughout the flight
5. If No. 1 pump fails or its float switch operates:—
   (i) Before let-down (see sub-para. (*d*))
   (ii) During let-down (see sub-para. (*f*))

(*c*) *No.* 1 *pump peaking* (*Overseas flights*)

1. No. 1 pump OFF
2. *Do not try No.* 2 *pump*
3. If possible proceed to home base

4. Reduce height to appropriate flight level below 42,0000 feet
5. Do not operate bomb doors or airbrakes (unless vital for aircrew safety). Select nose flaps—IN
6. If No. 1 pump fails or its float switch operates: —
   (i) Before let-down (see sub-para. (*d*))
   (ii) During let-down (see sub-para. (*f*))

(*d*) *No.* 1 *pump failure or float switch operation before let-down*

1. Switch pump OFF
2. *Do not use No.* 2 *pump*
3. Descend to a flight level below 40,000 feet
4. Abandon sortie
5. Return to base or select suitable airfield
6. Plan airbrakeless descent to approx. 25,000 feet (see sub-para. (*g*))
7. If the aircraft is unclean at the time of failure (see sub-para. (*e*))

(*e*) *Aircraft unclean—range considerations*

1. No. 1 pump OFF—*do not select ON*
2. With both pumps OFF, attempt to clean up aircraft by selecting: —
   Airbrakes—NORMAL IN
   Bomb doors—NORMAL CLOSED
3. If aircraft remains unclean calculate fuel required to reach destination
4. If essential to reduce drag select: —
   No. 2 pump—AUTO
   When aircraft is clean, pump—OFF
5. When approaching destination (see sub-para. (*g*)) for airbrakeless let-down

(*f*) *No.* 1 *pump fails or float switch operates during let-down procedure*

Before airbrakes extended

1. No. 1 pump OFF
2. (See sub-para. (*g*) 3)

After airbrakes extended

1. Both pumps OFF until ready for undercarriage DOWN
2. Select nose flaps—IN
3. No. 2 pump AUTO—undercarriage DOWN
4. Power—as required
5. Nose flaps OUT
6. Flaps TAKE OFF
7. Airbrakes IN
8. No. 2 pump OFF
9. For final landing No. 2 pump AUTO
10. Select full flap. Pump OFF
11. On touch-down select usable pumps to AUTO

(Items 3–11: No. 2 pump fails or float switch operates (see sub-para. (*h*)))

(*g*) *Airbrakeless let-down procedure*

1. Calculate position at which to commence slow descent to approx. 25,000 feet in area of descent point
2. Inform controlling authority of intentions
3. At 25,000 feet select nose flaps IN, reduce to 185 kts.
4. No. 2 pump AUTO—undercarriage DOWN—pump OFF. (The effect of cold soaking on micro switches may delay the indication of 3 greens (see sub-para. (*j*) for cold soak procedure))
5. At descent point No. 2 pump AUTO
6. Main flap TAKE OFF—nose flaps OUT—pump OFF
7. Commence descent at 180 kts.
8. Leave pumps OFF until final approach

(Items 4–8: No. 2 pump fails or float switch operates (see sub-para. (*h*)))

9. When full flap required—No. 2 pump AUTO—when flap down switch OFF
10. On touch-down select usable pumps to AUTO

(*h*) *No. 2 pump fails/float switch operates during let-down procedure*

1. Continue airbrakeless let-down
2. Inform A.T.C. " Unable to taxy, require towmaster "
3. Select one serviceable pump to AUTO, leave other pump OFF until landing
4. *Make emergency selections only*
5. When U/C locked down select—NORMAL DOWN
6. When flaps are at TAKE OFF, select nose flaps—OUT
7. If possible reduce fuel state to 8,000 lb. for landing
8. If the U/C was lowered before the system went into emergency the effect of return fluid may make nosewheel steering available for landing. This fluid would be put to better use in topping up the brake accumulators
   Plan not to use nosewheel steering
9. On touch-down co-pilot will call out brake pressures. At 3,000 PSI the AEO will select usable pumps to AUTO
10. *Do not taxy*

(*j*) *Cold soak procedure*

If three greens are not obtained: —

1. When the hydraulic pump in use goes " off load " select it OFF
2. Continue descent without flap
3. At check height select one serviceable pump to AUTO
4. When three greens are obtained, make flap selections as appropriate to the hydraulic situation.

13 Oxygen failures

(*a*) *Anoxia*

This can occur at any altitude in excess of 10,000 ft. In the event of anoxia:

(i) Check regulator (doll's eye and pressure gauge). Select

(ii) Check mask tube and connections.

(iii) If in doubt change to alternative supply.

(iv) If there is still no oxygen supply, operate the emergency oxygen set and descend to a cabin altitude of 10,000 feet.

(v) On training flights, if alternative supply used, reduce aircraft altitude to 45,000 ft.

(*b*) *Decompression sickness*

In the event of decompression sickness:

(i) Immediately reduce cabin altitude to below 10,000 ft.

(ii) Check oxygen regulator and connectors and select EMERGENCY pressure.

(iii) Land as soon as possible.

(iv) Arrange for Medical Officer to meet the aircraft on landing.

(*c*) *Hyperventilation*

This can occur at any altitude. The commonest cause of hyperventilation is anoxia.

(i) Check that anoxia is not present.

(ii) Select EMERGENCY pressure, to check oxygen flow and return to normal.

(iii) Control the rate and depth of breathing.

(*d*) *Oxygen magnetic indicator failure*

If the oxygen magnetic indicator fails to operate, but breathing is not impeded, check that the pressure regulator valve indicates normal pressure (200-400 PSI) and select 100% oxygen. If breathing remains unimpeded the magnetic indicator only is at fault and the sortie may be continued. A further check may be made by pressing in the EMERGENCY switch and checking that breathing pressure is increased.

(*e*) *Oxygen supply failure*

If the oxygen magnetic indicator fails to operate and breathing becomes impeded, check the oxygen connections. If connections are

If this fails to clear the fault, operate the emergency oxygen supply if cabin altitude is above 10,000 ft. If cabin altitude is below 10,000 ft. loosen the mask from the face and do not operate emergency oxygen supply. The emergency oxygen supply will last for approximately 10 minutes. To continue flight at cabin altitude above 10,000 ft. connect mask to an alternative regulator (sixth seat or bomb aimer prone position).

14 Notes on electrical malfunctions

(a) Bus-bar paralleling

The split bus-bar system is a major safety factor in the electrical system, therefore bus-bars should only be paralleled when they have been proved safe by the use of the appropriate battery and associated volt/ammeter.

(b) The LV *bus-bar reverse current reset switch*

This switch should not normally be used in flight to recover a failed battery but in the event of a complete loss of alternator and battery LV supplies, range considerations or subsequent faults might create an extreme emergency which might justify its use.

(c) Loss of an LV *battery*

If an LV batery is lost and cannot be reset avoid throttling back both engines simultaneously on that side or both alternators may fail also. This is due to the Frequency Sensing Units in the Transformer Rectifier Units moving to the Low Power condition simultaneous with the throttle movement, thus momentarily breaking the TRU LV supply to the bus-bar. As no LV battery supply is available on the bus-bar the subsequent lack of alternator field current will cause both alternators to fail. Non-synchronous movement of the throttle will prevent this by ensuring that one TRU is supplying field current to both alternators whilst the frequency

(d) Double alternator failure

In all instances where two alternators fail on one side or are switched off, load shedding should be carried out as listed in the double alternator failure drill. However, the LV battery should not be switched off immediately such an emergency occurs as it is important to retain various indicators and control circuits, the most important of these being, Engine Fire Warning, PFCU indicators, Hydraulic control and indicators and Abandon Aircraft lights. If it is not possible to reset the alternators and a decision is made not to parallel the bus-bars the LV battery will become discharged if left on. Therefore after the immediate emergency is over it is advisable to switch it off and trip the LV feeder circuit breakers on the failed side. If the battery voltage is kept above 19 volts it can be used for important control and indicator circuits as although some indicators will work at very low voltage, control circuits become useless below 17 volts.

15 Load shedding

The following tables list all the MV loads and the main LV loads, which may be shed.

MV *loads*

Switch off appropriate MV Battery to ensure complete load shedding

Port MV *Bus-bar*	*Starboard* MV *Bus-bar*
Nos. 1 and 2—350 Inverters	No. 3—350 Inverter
Flight Instrument Inverter	Green Satin Inverter
No. 1 Hydraulic Pump	No. 2 Hydraulic Pump
Odd PFCU's	Even PFCU's
Red Fuel Pumps	Green Fuel Pumps
H2S Amplidyne	H2S Scanner
Ration Heaters	Ration Heaters
TR Cooling Fan	TR Cooling Fan

Attention is drawn to the small H2S load on both bus-bars which will preclude the use of H2S when either bus-bar has completely

Main LV *Loads*

No. 1 LV *Bus-bar*

Landing lamps
HF
No. 1 VHF/UHF
Starboard Pitot head heater
Panel lights
NBC
H2S
IFF Mk. 10
Radio Altimeter
Navigation lights
Tacan

Main Alternator control
Trim control
PFCU control
Cabin ventilation
Tail anti-icing
Engine anti-icing
Starboard wing anti-icing
Port wing anti-icing
Wing air exit shutters
Trip circuit-breaker 1P 25

No. 2 LV *Bus-bar*

UHF
Panel lights
No. 2 VHF/UHF
Port Pitot head heater
Cabin lights
Trim control
Main Alternator control
Cabin Temperature control
ADF
Engine anti-icing

Tail anti-icing
Port wing anti-icing
Starboard wing anti-icing
Bomb-bay heating
Wing air exit shutters
Controlled AC supplies and flight instruments standby DC
Flying controls
Bombing controls and indicators

NOTE: In the event of double engine or double alternator failure where it is decided not to parallel, the LV battery will be switched off to conserve it after the immediate emergency is over. The hydraulic, fuel PFCU and inverter control circuits will be affected as detailed under these sections.

16 Electrical system failures

Failure	*Indication*	*Action*
SINGLE ALTERNATOR FAILURE (Electrical)	1 Power Failure Warning Light ON 2 Appropriate ammeter on panel BA reads zero	1. Check alternator field circuit-breaker (*a*) *If tripped*: (i) Switch OFF (ii) Reset circuit-breaker (iii) Switch ON (*b*) *If not tripped*: 2. *Check* AC *indicators* (*a*) If AC indicator for serviceable alternator on the same bus-bar is horizontal (i) Switch OFF, then ON (ii) If PFWL relights, switch OFF and take no further action (line to line fault) (iii) *Do not trip* AC *circuit-breaker*

Failure	*Indication*	*Action*
SINGLE ALTERNATOR FAILURE (Electrical)—*cont.*		(*b*) If AC indication for *unserviceable* alternator is horizontal, check feeder circuit breaker on panel BB *If tripped*: (i) Switch OFF (ii) Reset the circuit-breaker (iii) Switch ON once only (*c*) *If both* AC *indicators are normal*: 3. Switch OFF the U/S alternator and wait for a period of 30 seconds 4. Switch ON once only (*a*) PFW light goes out and remains out. No further action (*b*) PFW light goes out and immediately comes back on, switch OFF and leave OFF (*c*) PFW light goes out and comes back on after a delay, switch OFF and leave OFF (*d*) PFW light remains on, switch OFF and leave OFF
SINGLE ALTERNATOR FAILURE (Electrical)—*cont.*	1 Low Power Light ON 2 Power Failure Warning Light ON 3 Ammeters on panel BA read zero	1. *If engine* RPM *below 51%* (*a*) Switch OFF and wait for a period of 30 seconds (*b*) Switch ON (i) If PFWL goes out and remains out, no further action (ii) If PFWL relights, switch OFF and leave OFF 2. *If engine* RPM *above 51%* Switch OFF and leave OFF (sheared alternator drive)
DOUBLE ALTERNATOR FAILURE	1 Both Power Failure Warning Lights ON 2 Ammeters on panel BA read zero	1. AEO warns captain 2. Switch OFF the failed alternators 3. Switch OFF appropriate MV battery 4. Select the fuel proportioners in use to BYPASS and reduce LV loads on failed bus-bar where possible as follows: *No. 1* LV: Tacan; HF; No. 1 VHF/UHF; IFF, ILS; Landing lamps; Lighting; Starboard Pitot head heater; Trip circuit breaker 1P 25 *No. 2* LV: UHF; No. 2 VHF/UHF; ADF; Lighting; Port Pitot head heater

Failure	*Indication*	*Action*
DOUBLE ALTERNATOR FAILURE —*cont.*		4. Switch OFF MV loads on failed bus-bars as follows *Port* MV: Odd PFCU's; No. 1 Hydraulic Pump; Nos. 1 and 2—Type 350 Inverters; Flight Instrument (153) Inverter; Red fuel pumps; Bomb-bay " A " pumps; Trip H2S circuit-breaker; Pilots' ration heaters *Starboard* MV: Even PFCU's; No. 2 Hydraulic Pump; No. 3 Type 350 Inverter; Green Satin (153) Inverter; Green fuel pumps; Bomb-bay " B " pumps; Trip H2S circuit-breaker; Crew ration heaters 5. Switch on MV battery and check for zero discharge 6. Reset action on each alternator 7. If unable to recover either alternator, check bus-bars safe to parallel 8. Switch off LV battery and trip LV feeder circuit breakers on that side 9. Use LV battery as required 10. Bus-bars may be paralleled at Captain's discretion NOTE: *No attempt is to be made to recover an alternator with the bus-bars paralleled.*
FOUR ALTERNATOR FAILURE	1 Power failure warning lights on 2 Ammeters on panel BA read zero 3 A fall in all voltmeter readings	1. Shed loads as in items 4 to 17; trip all alternator field circuit breakers and remake individually 2. If unable to regain alternators trip field circuit breakers and, if safe to do so, parallel bus-bars 3. Select airbrakes *as required* 4. Switch OFF both hydraulic pumps 5. Switch OFF half PFCU's 6. Select all proportioners to BY-PASS 7. Leave three fuel pumps ON, all others OFF 8. NORMAL yaw damper STANDBY—standby yaw damper *as required* 9. Switch OFF all inverters except the Flight Instruments (153) inverter 10. Trip NBC and H2S circuit-breakers 11. Switch OFF scanner stabilisation 12. Switch OFF the VHF set not in use 13. Minimum use of HF then trip circuit-breakers 14. Switch all lighting to minimum requirements

Failure	*Indication*	*Action*
FOUR ALTERNATOR FAILURE—*cont.*		15. Switch OFF all heater and anti-icing switches except pitot head heaters 16. Trip ILS and ADF circuit-breakers 17. Trip ration heater circuit-breakers 18. IFF to emergency if required No. 2 type 350 inverter ON *N.B. 1* The Captain must be prepared to order "Abandon Aircraft" at any time
FOUR-ENGINE FLAME-OUT		*N.B. 2* If the emergency is due to four-engine flame-out item 1 should not be actioned until the engine speed has decreased to 25% RPM. The airbrakes should not normally be extended whilst attempting to maintain alternator output under low windmill RPM
LV BATTERY FAULT	1 Magnetic indicator goes white	1. Warn pilot not to throttle back engines on failed side simultaneously 2. Check the appropriate Battery Master circuit-breaker 3. Switch OFF battery, wait 30 seconds, switch ON again. Observe LV volt/ammeter (*a*) If indicator goes black then white switch OFF and leave OFF (*b*) If indicator remains white no further action possible, magnetic indicator unserviceable
MV BATTERY FAULT	1 Magnetic indicator goes white	1. Switch OFF then ON (*a*) If indicator remains white, no further action, presume battery on line, check fuse (*b*) If indicator goes black then white no further action possible, suspect excessive charge
SPECIAL FEEDER FAILURE	1 Magnetic indicator white 2 LV Battery magnetic indicator white	1. Check LV and MV battery indicators 2. All proportioners to BYPASS (*a*) If battery indicators black, continue as normal, indicator unserviceable (*b*) If battery indicators white warn pilot to avoid simultaneous throttle movement on failed side, no further action possible 2. *Emergency use of 1P8/2P8 switch* The emergency position of the special feeder switch may only be used as follows: (*a*) In the event of engine fire on failed side (1P8 PORT 2P8 STARBOARD), the fire button should be pressed whilst the failed special feeder switch is selected to the alternative position

Failure	*Indication*	*Action*
SPECIAL FEEDER FAILURE—*cont.*		(*b*) Immediately prior to touch-down if crash landing (*c*) In dispersal, if no external supplies available, select alternative position on special feeder switch in order to close HP cocks of engines on failed side
LOSS OF PLENUM CHAMBER PRESSURE IN FLIGHT	1 A negative reading on the pressure gauge 2 Cooling fan light(s) illuminate or flicker 3 Possible noise if hatch strikes aircraft	1. ECM equipments all OFF. Return alternator to main electrical system 2. Load shed selectively, Port and Stbd., as follows, monitoring ammeters: (*a*) Hydraulic pumps—both OFF—use one when required (*b*) PFCU's—switch OFF numbers, 1, 4, 6, 7, 10 (*c*) Proportioners—BYPASS (*d*) Fuel pumps—minimum of three in a group (*e*) Inverters—all OFF except flt. instruments (*f*) NBC and H2S—circuit breaker tripped (*g*) Scanner stabilisation—OFF (*h*) VHF/UHF—either set OFF (*j*) Yaw dampers—Normal to STANDBY/Standby as required (*k*) Anti-icing—As required (*l*) External and Internal lights—Minimum (*m*) ILS—OFF (*n*) ADF—OFF (*o*) HF—minimum use then—OFF (*p*) Ration heater C/B's tripped 3. Check plenum hatches with periscope 4. If panel B.A. ammeter loading excessively uneven then parallel at captain's discretion
OVERVOLTING ON MV OR LV BUS-BARS (more than 125V or 35V)	1 MV Voltmeter reads more than 125V 2 LV Voltmeter reads more than 35V	1. Check on ammeters which alternator is carrying the heaviest load 2. Switch OFF the alternator with the greatest load (*a*) If voltage returns to normal no further action (*b*) If still overvolting, switch ON the first alternator, switch OFF the other. If voltage now normal no further action 3. If overvolting persists: (*a*) Switch OFF both alternators (*b*) Carry out load shedding drill as for double-alternator failure (*c*) Reset each alternator individually once only (*d*) For subsequent action see para. 14

Failure	*Indication*	*Action*
HIGH OR LOW VOLTAGE ON LV AND MV BUS-BARS	1 LV Voltmeter reads 29V to 34V or 24V to 26V 2 MV Voltmeter reads 115V to 120V or 105V	1. Switch OFF either alternator 2. Trim remaining alternator to 28V LV or 112V MV 3. Switch ON first alternator again 4. Switch OFF the alternator which has been trimmed 5. Trim other alternator to 28V LV or 112V MV 6. Switch ON other alternator N.B.—If unable to trim any one alternator, switch OFF and leave OFF; if unable to trim either, switch both ON and monitor volt/ammeter for overvolting.
FAILURE OF FLIGHT INSTRUMENT INVERTER	1 Magnetic Indicator on panel CA shows white	1. Trip and remake No. 1 Flight Instrument circuit-breaker on panel BB (*a*) If indicator changes to black no further action necessary (*b*) If indicator remains white no further action need be taken as the No. 3 Type 350 Inverter automatically takes over the loads
FAILURE OF A TYPE 350 INVERTER	1 Neon indicator(s) on CA flicker or fail	1. Switch OFF the group of services supplied by the inverter 2. Switch OFF the appropriate inverter (hold in the OFF position for 1 second only) 3. Switch ON the inverter 4. Switch on the associated group of services (*a*) If the inverter remains on line no further action is necessary (*b*) If the inverter fails again proceed as follows: (i) Switch OFF services of, and the unserviceable inverter (ii) Switch OFF the services of, and the alternative inverter to which the load is to be transferred (iii) Switch the POWER EMERGENCY TRANSPOSE SWITCH to the group required (iv) Switch ON the serviceable inverter and group of services required The table below summarised the operations involved in affecting transposition:

U/S Inverter	*Group*		*Switch OFF Inverters*	*Select*	*Switch ON Inverter*
	Reqd.	*Not Reqd.*			
1	A	B	1 and 2	A/B	2
1	A	C	1 and 3	A/C	3
2	B	A	2 and 1	A/B	1
2	B	C	2 and 3	B/C	3

Failure	*Indication*	*Action*
LV AND POSSIBLY MV FLUCTUATIONS WITH TWO ALTERNATORS ON BUS-BAR	Fluctuation on LV and MV voltmeters and alternator ammeters	1. Increase loading of affected alternators (e.g. hydraulic pump ON) 2. If fault clears reduce load 3. If fault persists when in LOW power condition increase engine RPM 4. Reduce RPM when fluctuations cease
CHANGING FROM HIGH TO LOW POWER, LV BUS-BAR FALLS TO 23V	LV bus-bar voltmeter reads 23V	1. Increase RPM to HIGH power condition 2. If undesirable to increase RPM continue to use LV at 23V N.B.—This fault is caused by a frozen tap change contact which may clear after a period at low level.

17 Fuel system failures

Failure	*Indication*	*Immediate action*	*Subsequent action*
BOOSTER PUMP FAILURE	Contents remain almost constant in tanks with one pump only. No indication in tanks with two pumps	Check sufficient pumps selected to prevent flame-out	Adjust CG or wing balance by switching off pumps in other tanks
PROPORTIONER FAILURE (*a*) Fuselage prop. when fus. group only in operation	LP warning lights of all four engines	Wing pumps ON	Wing props. NORMAL Check fuselage group for leak/proportioner failure Fuselage prop. to BYPASS All fuselage pumps ON Wing groups OFF, one at a time Maintain individual fuselage contents in approx. proportion
(*b*) Wing prop. when wing groups only in operation (no cross-feed)	LP warning lights of two affected engines	Fuselage group ON	Fuselage prop. NORMAL Check for cause Select failed prop. to BYPASS All pumps ON in affected group Select fuselage group OFF Maintain individual tank contents in approx. proportion
(*c*) Any one prop. when all groups in use	Lack of flow from tanks in affected group	Select affected prop. to BYPASS	Maintain individual tank contents in approximate proportion

Part V

Chapter 3—Abandoning and Emergency Landing Procedures

List of Contents

1 Abandoning the aircraft

(*a*) *Preparatory actions*

(i) Whenever possible, altitude should be reduced to below 40,000 ft. Before abandoning aircraft, speed should be reduced as much as possible (at least below 250 knots, the recommended speed is approximately 200 knots) and the aircraft should be as clean as conditions permit. Bomb-doors should be closed and main flaps and undercarriage raised, although trials show that dummies pass well inboard, of the main undercarriage in straight and level flight.

(ii) The manual override must not be used above 20,000 feet. However, it must be used below 1,000 feet (below 250 knots) although this does not preclude the use of the static line.

(*b*) *Abandoning drill*

(i) Warn crew, reduce speed if appropriate.

(ii) Select oxygen mask toggles down.

(iii) Transmit distress calls. Clamp key and set IFF to EMERGENCY.

(iv) Navigator at prone position returns to his seat. Other crew members assist in putting on his parachute.

(v) "Clean" aircraft—close bomb-doors, retract flaps, undercarriage and airbrakes if possible. Co-pilot selects NO PRESSURE.

(vi) Check personal safety equipment. Parachutes on, dinghy attached, protective helmets on. Rear crew seat harness release.

(vii) Operate ABANDON AIRCRAFT switch and order "*Jump, Jump*". Cabin depressurisation should take about 6 seconds after operating abandon aircraft switch. (Post-Mod. 3817 when the cabin differential pressure gauge indicates $1\frac{1}{2}$ PSI).

(viii) Nav. Plotter opens the door not less than seven seconds after illumination of ABANDON AIRCRAFT light if cabin has been pressurised.

(ix) Rear crew members should abandon aircraft in the following order:

Navigator Plotter (centre crew member)
Sixth seat member
AEO (port crew member)
Navigator Radar (starboard crew member)

On leaving their seats, each rear crew member should disconnect his main oxygen supply and operate his emergency oxygen supply.

(x) In turn, leave seat and on reaching the door, connect to static line, if above 1000 ft.

(It is essential that the line be passed over the shoulder and not under the left arm after it has been attached to the snap hook). Sit on the top step, right foot braced against the front of the step, and left foot braced against the centre step. The body should be hunched up as much as possible, head tucked in and hands grasping the trouser legs below the knees, in order to ensure a clean exit. The exit is made by rolling forward in a "balled up" position, assisting the roll forward by a push from the right foot. The compact position should be held as tightly as possible on meeting the airstream. Static lines should be pulled in by each following man if time permits.

(xi) Last crew member taps 2nd pilot before leaving aircraft.

(xii) 2nd pilot operates control snatch unit* and ejects.

(xiii) 1st pilot operates control snatch unit* and ejects.

* Unless Mod. 2789 is embodied

(*c*) *Swivel seats*

WARNING: Post-Mod. 3886 the sixth crew member must ensure that before leaving his seat his oxygen hose and static line are routed between the back of his legs and his seat.

(i) When swivel seats are fitted (Mod. 3295), the assister cushion should be operated to assist the crew member to his feet, after swivelling the seat.

(ii) When using the Mk. 40 parachute, the static line should be connected to the swivelling lever handle before abandoning the aircraft if time permits.

(iii) Post-Mod. 3955 (aircraft oxygen hose assembly) a Mk. 46 parachute is used. The static line is connected at all times when the parachute is worn and operates the crew gone light in front of the 1st Pilot. Thus there is no requirement for the last crew member to tap the co-pilot before leaving the aircraft."

(*d*) *Abandoning aircraft at low altitude*

Should it be necessary to abandon the aircraft at low altitude (below 1,000 feet and 250 knots) reduction of the time interval between the moment at which the order is given to abandon the aircraft and the moment at which the parachute is deployed can be of overriding importance, and the following points should be borne in mind.

(i) Whilst it is highly desirable to connect a static line, time should not be wasted if this proves troublesome.

(ii) The static line arms the parachute barostat, which then withdraws the pack pins after a delay of 2 seconds. Therefore, irrespective of whether the static line is connected or not, the manual override should always be pulled as soon as possible after abandoning the aircraft below 1,000 ft.

2 Landing with the hydraulic system in the emergency condition

If an EMERGENCY HYDRAULIC SELECTOR warning light has illuminated it must be anticipated that, during the landing run, wheelbrake pressure will be limited to accumulator pressure and nosewheel steering will not be available. The use of flaps will be available but airbrakes will not be available. A normal approach and landing should be made at the correct speeds. In normal wind conditions the brake-parachute should be streamed, but if cross-wind conditions exist, consideration must be given to the lack of directional control aids which exist. It is suggested that the parachute should be streamed to gain the initial deceleration, but jettisoned before excessive brake pressure is required to maintain directional control. Sufficient brake pressure should be available for a normal full-stop landing. Apply the brakes steadily and continuously, increasing pressure as the speed reduces, but avoiding excessive pressure which may cause the maxaret units to operate and cause intermittent brake application. When the brake pressure gauge readings fall to 2,000 PSI, further brake application will cause the readings to fall to zero. When the aircraft is stopped make no attempt to taxy further but close down the engines and

3 Undercarriage malfunction drills (hydraulic system normal)

(*a*) *Up selection, 3 green lights remain on*

(i) Check undercarriage control and pressure head control fuses (change each one once only).

(ii) If no effect, select undercarriage DOWN and leave down.

(iii) Modify sortie.

(*b*) *Undercarriage not fully retracted*

(i) Check control fuse.

(ii) If no effect select NORMAL DOWN leave down and modify sortie (if necessary replace control fuse again).

(iii) If control fuse is serviceable suspect protection unit operation.

(iv) Inform ATC and request a visual check.

(v) See para. (*d*)(v).

(*c*) *Down selection—Failure to lower—No travel lights*

(i) Check undercarriage indicator and day/night screen.

(ii) If hydraulic system normal switch both pumps to AUTO.

(iii) AEO reports on pump ammeters:

1 No load indication—check undercarriage control fuse
2 Normal load indication—check the indicator fuse

(iv) If no effect select EMERGENCY DOWN, when 3 greens select NORMAL DOWN (see para. (*d*)(vii)).

(*d*) *Failure to lower fully, any combination of lights*

(i) Check undercarriage indicator changeover.

(ii) If hydraulic system normal, select both pumps AUTO.

(iii) Inform ATC and request a visual check.

(iv) Allow as much time as possible to overcome the effect of cold soak in micro switches.

(v) Depending on fuel state, orbit, or divert as necessary.

(vi) Reduce to landing weight—select EMERGENCY DOWN, if 3 greens available—select NORMAL DOWN.

(vii) If unsuccessful:

1 Check undercarriage emergency control fuse.
2 Check main selector changeover relay fuse.
3 Check fuses to main emergency selector.

(viii) Operate nitrogen lowering system (post-Mod. 3079).

(ix) In instances of 2 green lights and 1 red, but undercarriage leg appearing down on visual check, consideration should be given to a light roller landing at *approach* speed with a view to making the micro switch for the third green. In all cases this action must be preceded by operating the emergency hydraulic and nitrogen lowering systems.

(x) If three greens are not obtained, a landing should be made using a foam strip whenever possible.

(xi) *Do not attempt to taxy.*

4 Landing with one main leg retracted

Should it become necessary to land with one main undercarriage unit not locked down the following drill is recommended:

(*a*) Reduce weight as much as is practicable.

(*b*) Render ejection seats safe.

(*c*) Disconnect parachutes, dinghies, leg-restraining straps and emergency oxygen tubes.

(*d*) Operate the pressurisation dump valve, jettison the pilots' canopies and open the entrance door.

(*e*) Ensure that the crew are strapped in, with their seats at the crash position.

(*f*) Land using normal landing flap, with sufficient speed to ensure a touchdown at 125 knots.

(*g*) Lower the nosewheel and simultaneously apply aileron to hold the wings level.

(*h*) As speed falls to 110 knots, lower the wing-tip gently on to the ground, and simultaneously apply rudder and wheelbrakes to hold the aircraft straight.

(*j*) Stream the braking parachute as soon as the wing-tip touches the ground. Continue to apply aileron to reduce the ground reaction at the wing-tip and so delay the start of the ground loop.

NOTE 1: Aileron effectiveness will be lost at approximately 105 knots. To reduce the possibility of major damage to the wing it is important that the wing-tip is lowered to the ground at a controlled rate whilst aileron control is still available.

NOTE 2: A ground loop imposes a heavy strain upon the undercarriage, and should be delayed until speed is as low as possible. A foam strip laid along the side of the runway where the wing-tip is expected to strike will reduce friction and enable the aircraft to be held straight, down to a lower speed.

5 Crash landing

The following drill is recommended if a crash landing becomes necessary:

(*a*) Reduce weight as much as is practicable.

(*b*) Jettison bombs at captain's discretion. Ensure bomb-doors are closed.

◀ (*c*) At 10,000 feet have the nav.plotter place the safety pins in the ▶ ejection gun sears on the pilots' seats.

(*d*) Between 5,000 and 2,000 ft. when committed to a landing disconnect parachutes, dinghies, leg-restraining straps and emergency oxygen tubes.

(*e*) If, in the opinion of the captain, there will be a danger of the navigators and AEO being trapped in the aircraft after landing, they should be ordered to abandon the aircraft.

(*f*) Have the pressurisation dump valve operated and, below 5,000 ft., the entrance door opened.

(*g*) Make a normal approach with the undercarriage up or down as required. The advantages of reducing impact load with the undercarriage down, however, should be carefully considered.

(*h*) Ensure that the crew are strapped in and that their seats are

(*j*) At 500 ft. jettison the pilots' hatches and close the HP cocks just before touchdown.

(*k*) After touchdown the crew should escape through the nearest exit.

6 Ditching

Model tests indicate that the ditching characteristics should be satisfactory there being no tendency to dive under the surface provided the vertical rate of descent is low at the moment of ditching. The following drill is recommended:

(*a*) Warn the crew. Crew acknowledges.

(*b*) Jettison bombs. Ensure bomb-doors are closed.

(*c*) At 10,000 ft. or below, depressurise and have the nav./plotter place the safety pins in the ejection gun sears on the pilots' seats.

(*d*) Between 10,000 ft. and 5,000 ft., when committed, disconnect parachutes, dinghies, leg-restraining straps and emergency oxygen tubes.

(*e*) Ensure that the crew are strapped in and that their seats are at the crash position.

◀ (*f*) At 500 ft. jettison the co-pilot's hatch. Lower flap as required. ▶

(*g*) During the final stages of the approach, the airspeed should be the minimum consistent with satisfactory control. The round out should be made as accurately as possible to obtain the minimum rate of descent at touchdown. The touchdown should be made parallel to the swell. If the swell is not steep and the wind across it is above 25 knots, it may be preferable to land into wind.

(*h*) At the touchdown, if the bomb-doors hold and the procedure in (*g*) is carried out correctly, the ditching should be gentle. If the impact is severe enough to collapse the bomb-doors, the deceleration will be increased but the ditching will still be satisfactory.

◀ (*j*) Just before touchdown, close the HP cocks. After touchdown, jettison the 1st pilot's hatch. A rear crew member should operate ▶ the dinghy release handle and the crew leave the aircraft through

Part VI—Illustrations

List of Figures

Part VI—Illustrations

Key to Fig. A

1 Windscreen wiper control
2 Yaw damper control
3 Panel lamps dimmer
4 Drop tanks jettison control
5 Auto-pilot heading selector
6 Jet pipe temperature control switches (4)
7 Port wing fuel vent pressure switch
8 In-flight safety lock switch
9 In-flight safety lock lights
10 Fuel vent pressure gauges
11 Fuselage fuel vent pressure switch
12 Starboard wing fuel vent pressure switch
13 Fuel vent temperature gauge
14 Taxy and landing lamps switch
15 Emergency decompression switch
16 ILS switch
17 Bomb jettison switch
18 Lower carriers jettison switch
19 Flashing beacon switch
20 Abandon aircraft switch
21 Navigation lights switch
22 Windscreen heating switches and indicator
23 Bomb door emergency OPEN/CLOSE switch
24 1st pilot's oxygen regulator
25 1st pilot's station box
26 Throttle friction lever
27 Throttles/HP cocks
28 Control column retraction handle (1st pilot)
29 Airbrakes control
30 Throttle gate lever release
31 Ditching handle
32 Rudder/Aileron/Elevator trimmer
33 Brake parachute control switch
34 UHF control box
35 UHF tone switch
36 ADF/ILS switch


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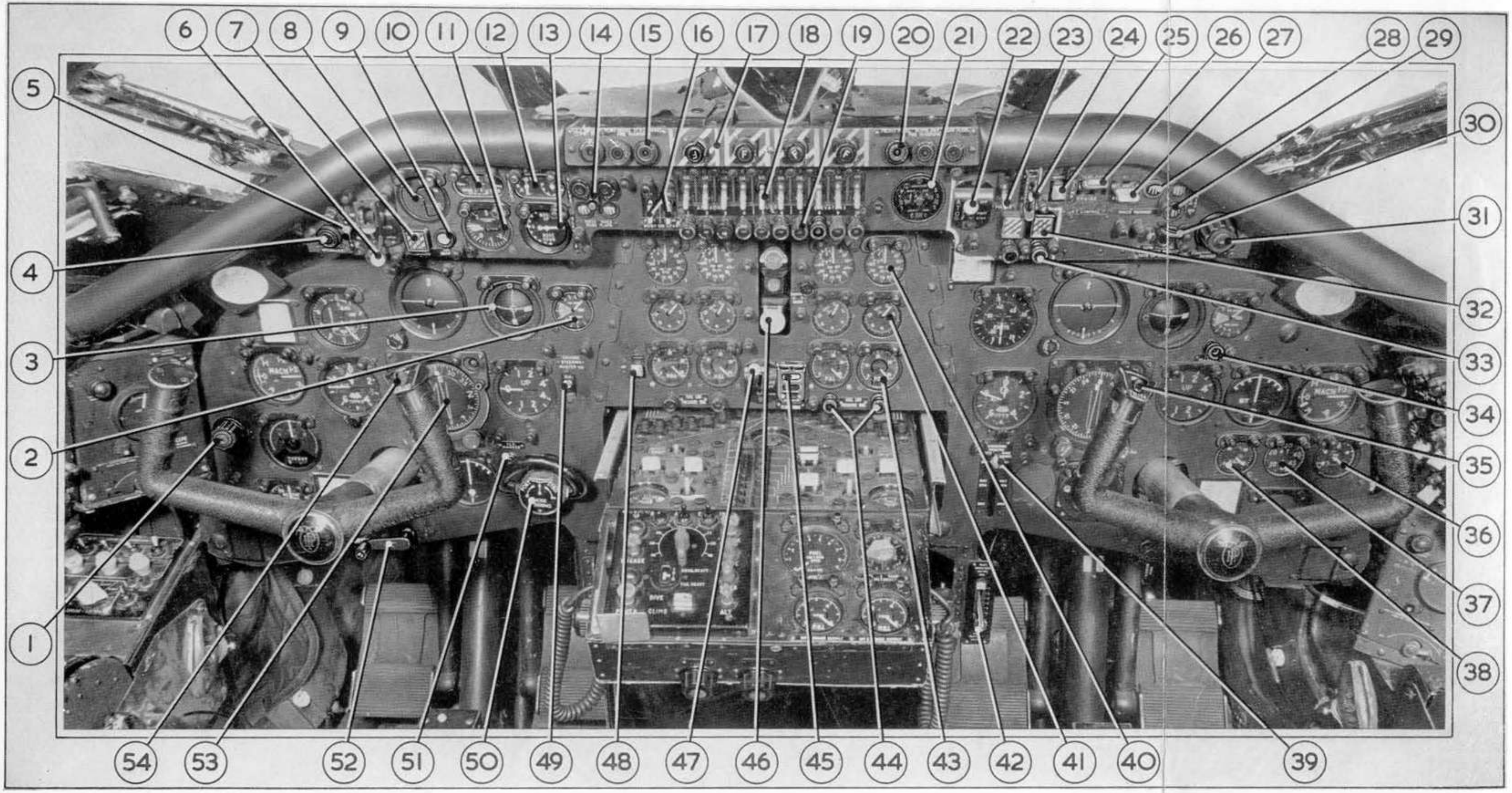
Key to Fig B

1 Panel lamps dimmer switch
2 Feel trim indicator
3 Zero reader
4 Emergency hydraulic warning light
5 Yaw damper control
6 Bomb-bay doors control
7 Bomb-bay doors position indicator
8 Airbrakes position indicator
9 Airbrakes magnetic indicator
10 Flaps position indicator
11 Accelerometer
12 Aileron/rudder trim indicator
13 Elevator position indicator
14 Nose flaps indicators and warning lights
15 Fire warning lights (3)
16 Pitot head heater switches
17 Engine fire warning pushbuttons
18 PFCU control switches
19 PFCU warning lights
20 Fire warning lights (3)
21 Undercarriage position indicator
22 RATOG control switch } inoperative
23 RATOG master switch } inoperative
24 RATOG jettison switch } inoperative
25 Thunderstorm light switch
26 JPT control switch
27 Mach trim switch
28 Mach trim indicator
29 ECM Frequency indicators
30 Fuel tank pressure warning light
31 Panel lamps dimmer
32 RATOG indicators } inoperative
33 RATOG warning lights } inoperative
34 ILS marker light
35 Elevator trim control
36 Outside air temperature gauge
37 Cabin pressure altimeter
38 Fuel pressure gauge
39 Windscreen demisting control
40 RPM indicators
41 JPT gauges
42 Pilots' feet heating control
43 Oil pressure gauges
44 Fuel LP warning lights (4)
45 Flaps emergency control
46 Undercarriage selector buttons
47 Flaps control
48 Thunderstorm light switch
49 Ground steering master switch
50 Nosewheel steering control
51 ILS marker light
52 Rudder pedals adjuster
53 Mk. 4B compass
54 Elevator trim control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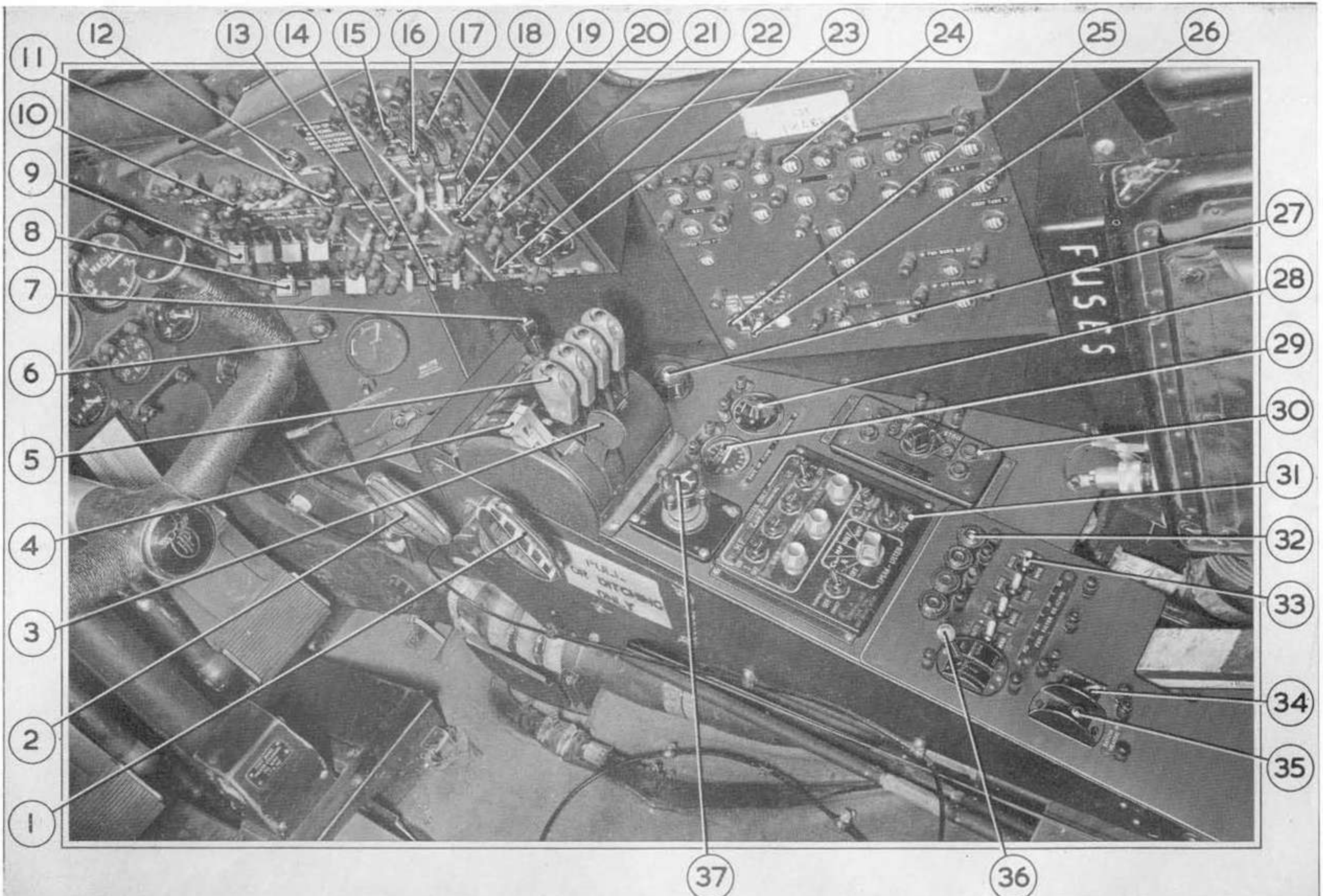
MACH

Key to Fig. C

1 Ditching handle
2 Control column retraction handle (co-pilot)
3 Throttle gate release switch
4 Airbrakes control
5 Throttles/HP cocks
6 2nd pilots oxygen regulator
7 Throttle friction lever
8 Intake heaters switches
9 Engine anti-icing switches
10 Engine bleed isolation cocks switches (4)
11 Anti-icing overheat warning indicators
12 Icing conditions indicator
13 Anti-icing reset switches
14 Anti-icing on/off switches
15 Flood flow switch
16 Flood flow reset switch
17 Warning horn over-ride switch
18 Cabin pressure switch
19 CAU bypass switch
20 Cabin temperature control valve position indicator
21 Max. heat warning light
22 Cabin temperature selector switch
23 Cabin temperature setting control
24 Proportioner and NRV indicators
25 Windscreen spray switch
26 Probe purge switch
27 Panel lamps dimmer
28 Flowmeter selector switch
29 Flowmeter
30 Mk. 4B compass control panel
31 2nd pilot's station box
32 Fuel filter de-icing lights (4)
33 Fuel filter switches (4)
34 Blue Saga switch
35 Ration heaters switch
36 Windscreen wiper control
37 Aileron/Rudder/Elevator trimmer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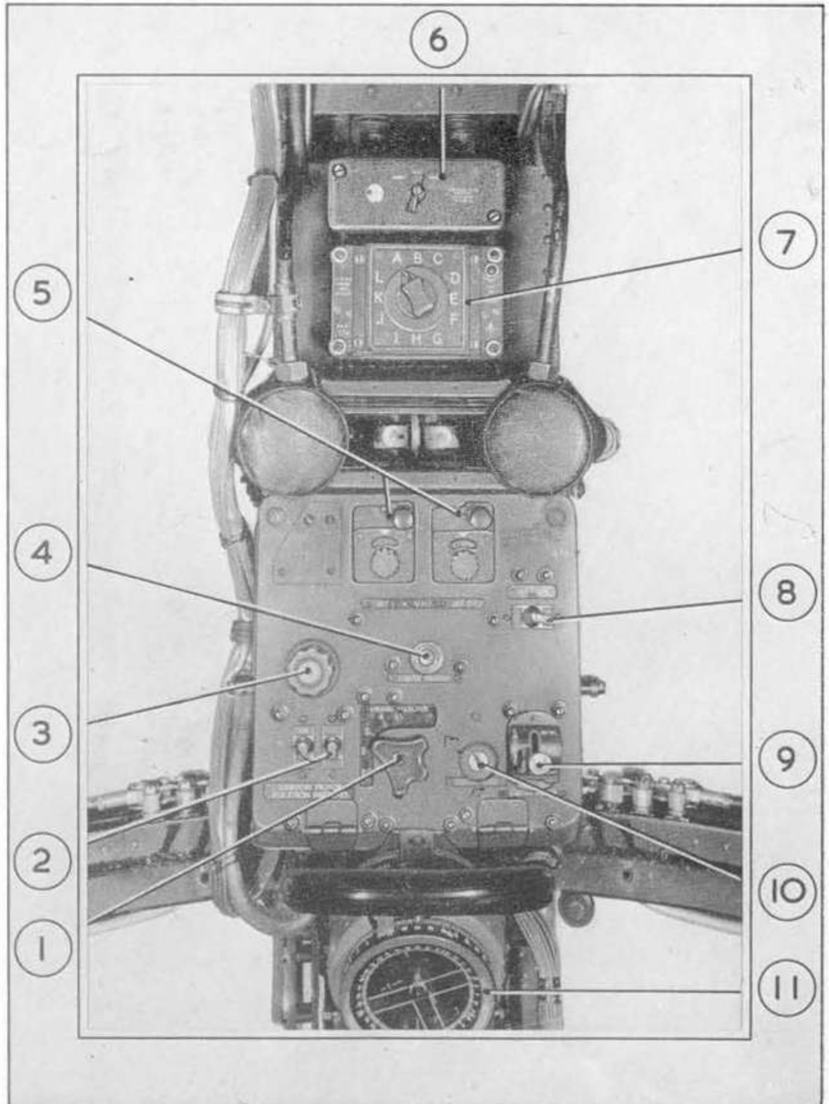
FUSES

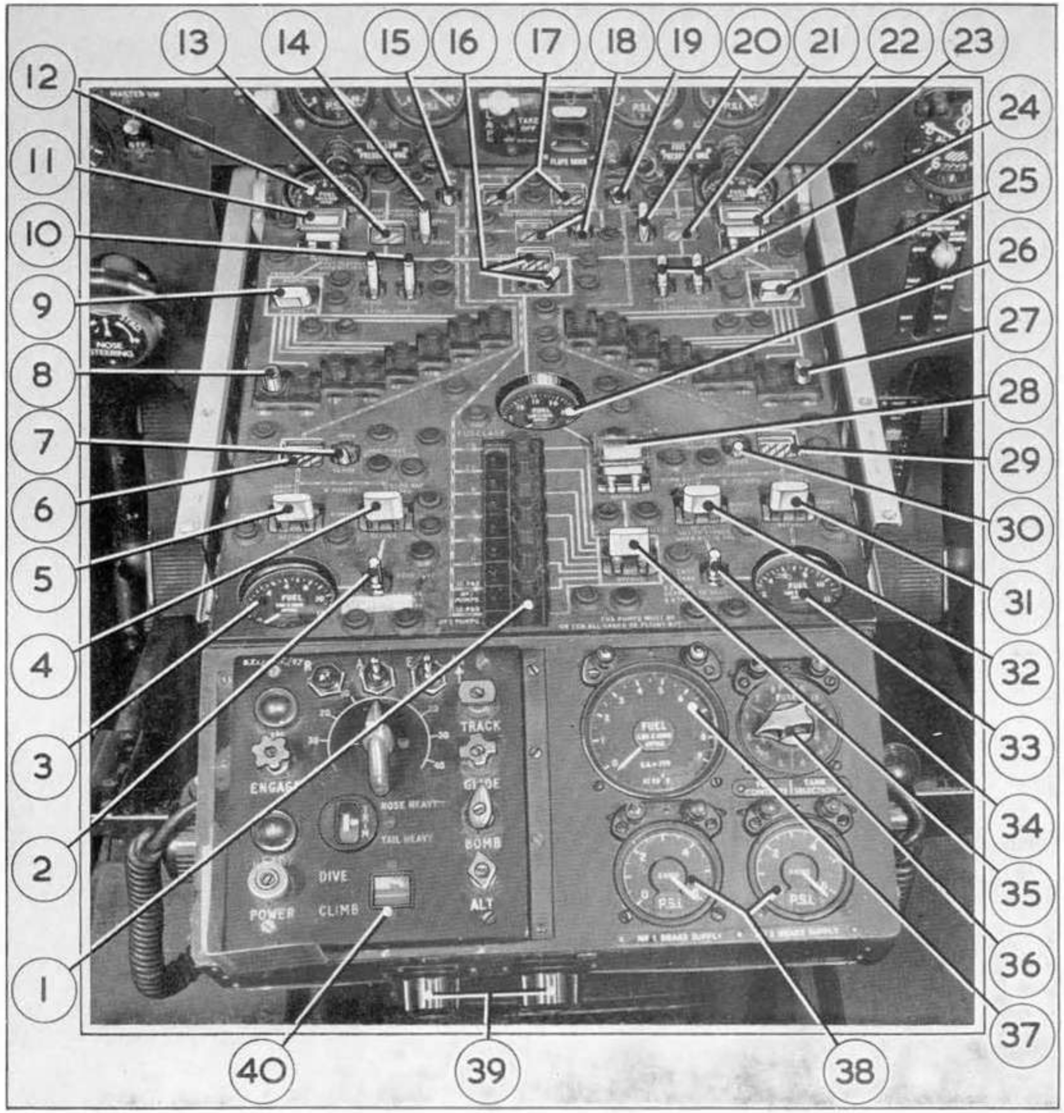
Key to Fig. D

1 Engine selector switch
2 Ignition and motor isolation switches
3 Panel lamps dimmer
4 Starter warning light
5 VHF selector boxes
6 Voice range filter control
7 ILS control unit
8 VHF set changeover switch
9 Engine starter master switch
10 Engine starter pushbutton
11 P.12 compass



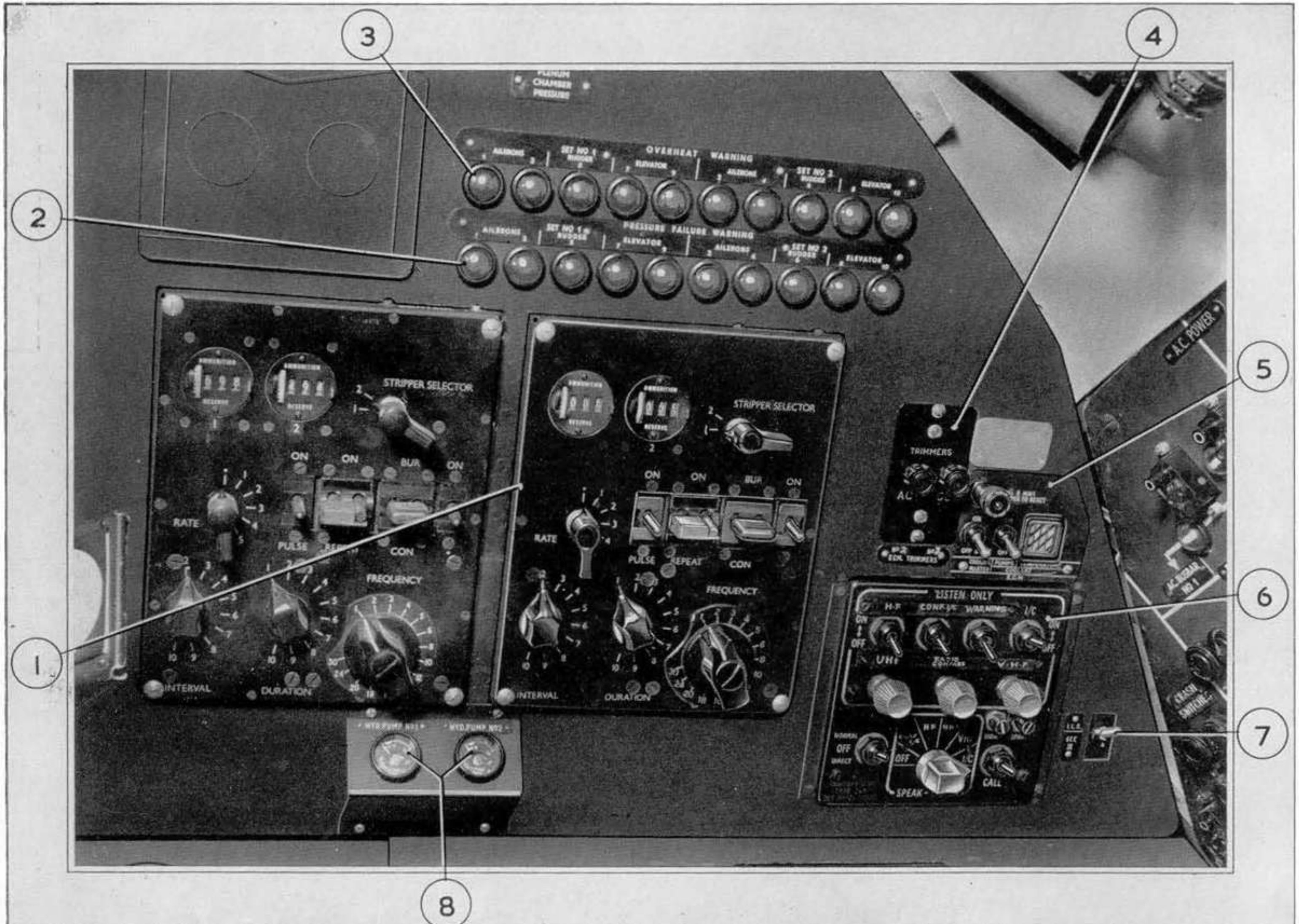
Key to Fig. E

1 Fuselage tanks pumps circuit-breaker switches
2 Bomb-bay tanks/drop tank contents selector switch
3 Bomb-bay tank/drop tank contents gauge (port)
4 Bomb-bay tank pump switch ('A' pumps)
5 Drop tank pumps switch ('A' pumps)
6 Long-rang tanks isolation cock indicator (port)
7 Long-range tanks isolation cock switch (port)
8 Wing tanks pumps circuit-breaker switches (port)
9 Wing tanks proportioner switch (port)
10 LP cocks switches, 1 and 2 engines
11 Wing NORMAL/REFUEL switch
12 Wing tanks contents gauge (port)
13 Port wing isolation cock indicator
14 Port wing isolation cock switch
15 Probe isolation cock switch
16 Cross-feed open/close switch and indicator
17 Flight refuelling probe isolation cocks indicators
18 Wing refuelling crossfeed cock switch and indicator
19 Probe isolation cock switch
20 Stbd. wing isolation cock switch
21 Stbd. wing isolation cock indicator
22 Wing tanks contents gauge (stbd.)
23 Wing NORMAL/REFUEL switch
24 LP cocks switches, 3 and 4 engines
25 Wing tanks proportioner switch (stbd.)
26 Fuselage tanks contents gauge
27 Wing tanks pumps circuit breakers (stbd.)
28 Fuselage tanks refuel switch
29 Long-range tanks isolation cock indicator
30 Long-range isolation cock switch
31 Drop tank pumps switch ('B' pumps)
32 Bomb-bay tank pumps switch ('B' pumps)
33 Bomb-bay tank/drop tank contents gauge (stbd.)
34 Bomb-bay tank/drop tank contents selector switch
35 Fuselage tanks proportioner switch
36 Individual tanks contents selector switch
37 Individual tanks contents gauge
38 Brake pressure gauges
39 Panel lamps and probe lights dimmers
40 Auto-pilot control unit



Key to Fig. F

1 Window control units
2 PFCU pressure warning indicators
3 PFCU overheat warning indicators
4 ECM trimmers
5 ECM pumps control unit
6 AEO's station box
7 ILS/Gee switch
8 Hydraulic pumps ammeters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OVERHEAT WARNING
PRESSURE FAILURE WARNING
STRIPPER SELECTOR
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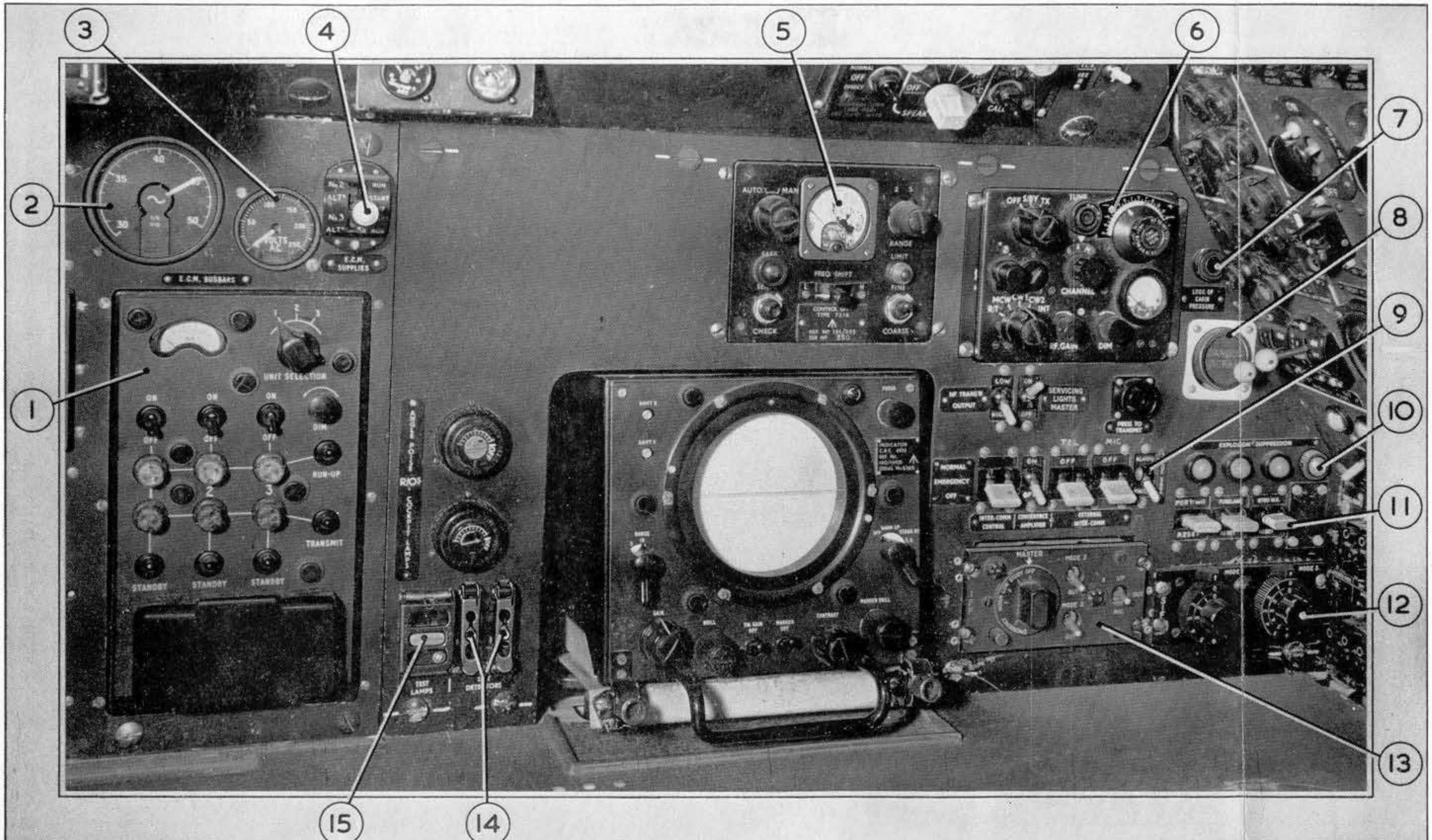
REPEAT
CON
FREQUENCY
INTERVAL
DURATION
TRIMMERS
LISTEN ONLY
SPEAK
CALL
A.C. POWER

Key to Fig. G

1 ECM control panel
2 ECM frequency meter
3 ECM voltmeter
4 ECM alternator control switch
5 ARI 5874 control unit
6 ARI 5874 control unit
7 Cabin pressure warning light
8 Abandon aircraft warning light
9 Blue Saga switches
10 Explosion protection indicators
11 Explosion protection switches
12 IFF SIF control
13 IFF control panel
14 Fire warning detector test switches
15 Fire warning lights test switch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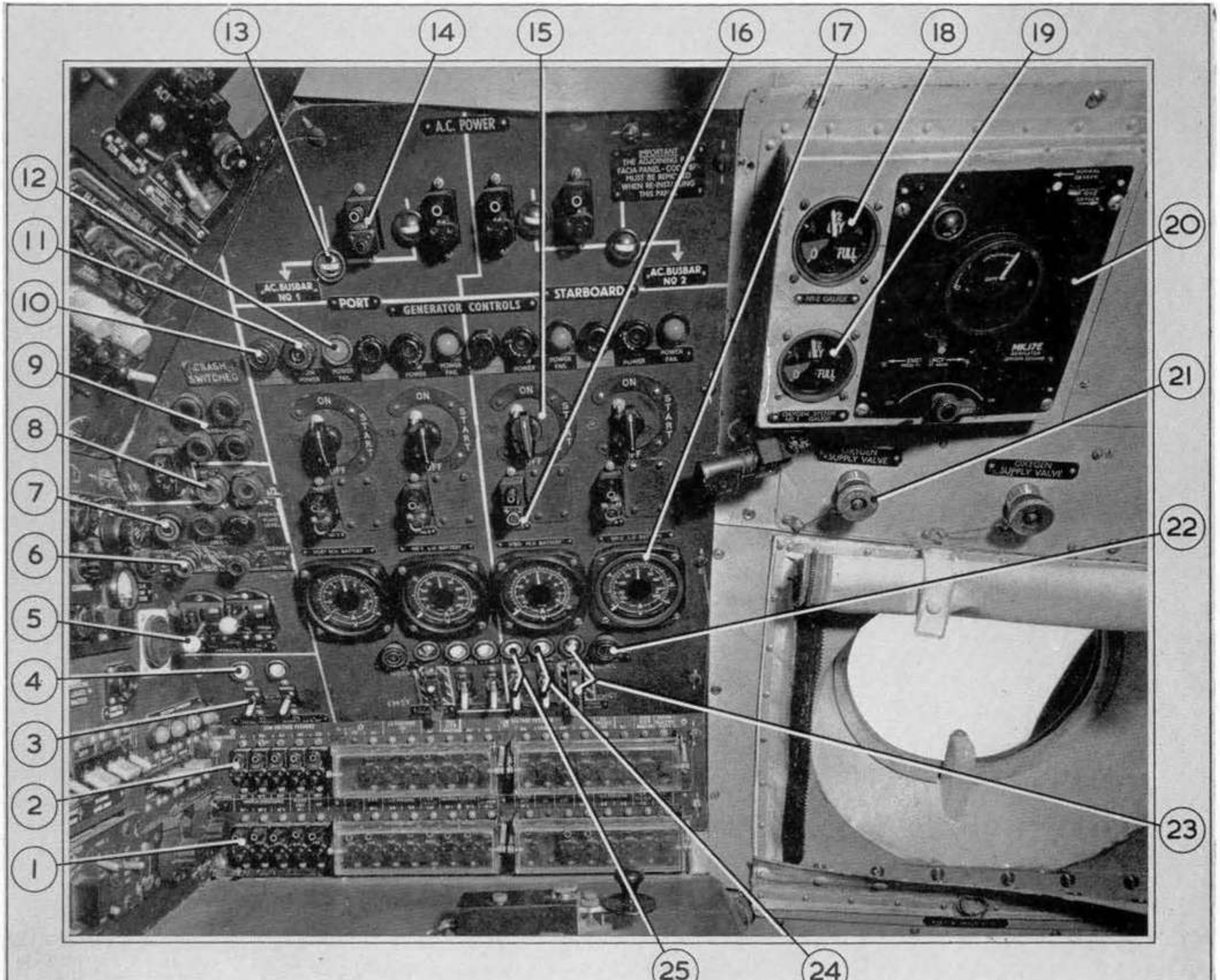
UNIT SELECTION
STANDBY
TRANSMIT
RUN-UP
FREQ. SHIFT
CHECK
COARSE
CHANNEL

Key to Fig. H

1 Circuit-breaker panel
2 Circuit-breaker panel
3 Special feeders switches
4 Special feeders indicators
5 Hydraulic pumps switches (2)
6 Hydraulic pumps overheat warning lights (2)
7 Hydraulic emergency level lights (2)
8 Hydraulic pumps running lights (2)
9 Inertia switches warning lights
10 Alternator cooling close light (4)
11 Alternator low power light (4)
12 Alternator failure indicator (4)
13 Alternator feeding indicator (4)
14 208-volt circuit-breaker (4)
15 Alternator control switch (4)
16 Alternator circuit-breaker (4)
17 MV ammeters/voltmeters (4)
18 Oxygen system contents gauge
19 Oxygen system contents gauge
20 AEO's oxygen regulator
21 Oxygen system supply valves
22 Cooling fan failure light (2)
23 MV bus-bar paralleling switch and indicator
24 LV battery master switch and indicator (2)
25 MV battery master switch and indicator (2)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A.C. POWER
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PORT
GENERATOR CONTROLS
STARBOARD
A.C. BUSBAR NO 2
CRASH SWITCHES
ON
START
OXYGEN SUPPLY VALVE
OXYGEN SUPPLY VALVE
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