Restricted

2nd Edition

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PILOT'S NOTES

VICTOR B. Mk.2

(Blue Steel)

2ND EDITION
December 1964

AP 4506B—PN

PILOT'S NOTES

VICTOR B Mk. 2 (Blue Steel)

NOTE

This publication is also applicable to the Victor B(SR) Mk. 2

PREPARED BY THE
MINISTRY OF TECHNOLOGY

BY COMMAND OF
THE DEFENCE COUNCIL

Henry Hardman

FOR USE IN THE ROYAL AIR FORCE

Notes to Users

1 These Notes are complementary to AP129 (6th Edition) Flying, and reference should also be made to the Operating Data Manual (AP4506B/OD), Victor B Mk. 2 (Blue Steel).

◀2 The Flight Reference Cards (AP 101B-1102-14) are an integral part of the Notes, but are issued separately and are subject to a separate amendment procedure. Reference to them is made throughout the Notes. Further copies of the Cards are available on demand.▶

3 These Notes are divided by marker cards into five Parts each consisting of a number of chapters listed on the marker card. ▶◀ The Folio Sheet reference number is at the top left-hand corner of each sheet, each Part starting at FS1.

4 Throughout the Notes 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 altitudes, mach numbers and accelerometer readings quoted are indicated values.

5 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.

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

SFI/Victor/47, SFI/Instruments/30

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

7 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 Modification numbers 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 2 (Blue Steel)

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Leading Particulars

DIMENSIONS

Length	114 ft. 11 in.
Height	26 ft. 9 in.
Span	120 ft.
Tail Span	32 ft. 8 in.
Track	33 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

(Dunlop Tubeless Tyres)

Main

Tyre size . . 27 in. x 6·5 in. x 15 in.

Pressure	*Aircraft weight (lb.)*	*Pressure* (PSI)
	160,000	194 $^{+6}_{-4}$
	160,000 to 175,000	218 $^{+7}_{-3}$
	175,000 to 195,000	240$\pm$5

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 Conway Mk. 201's .	Jet Turbine
Oil 34A/9100591 . .	(Oil Tank 24 pints excluding 3 pints air space)

Fuel 34A/179 AVTUR or 34A/251 AVTAG.

CONSTANT SPEED DRIVE

English Electric. Type AE8008 (Oil tank 12 pints excluding 4 pints air space.)

FUEL SYSTEM

Divided into three groups:

Port Wing Group . .	+ (Long Range Tanks)
Starboard Wing Group .	+ (Long Range Tanks)
Fuselage Group . . .	

Booster Pump pressure delivery: 11 PSI.

Fuel Tank pressurisation provided.

ELECTRICAL POWER SUPPLIES

DC supplies

28 volts. From alternators via transformer rectifier units.

AC Supplies

200 volt 3-phase 400 c/s .	From alternators
115 volt 3-phase 400 c/s .	From alternators via transformers
115 volt 1-phase 1,600 c/s .	From alternators via frequency changers

STANDBY SUPPLIES

Ram Air Turbo-alternators. (Supply for Flying Control Motors, No. 1 TRU and No. 2 Transformer (port RAT).)

Airborne Auxiliary Power Plant (AAPP). (Main Standby supplies.)

BATTERIES

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

Associated Air Publications

	AP
Aircraft hydraulic equipment	1803 series
Aircraft pneumatic equipment	4303 series
Aircraft pressurising and air-conditioning equipment	4340
Aircraft tanks	4117A
Aircrew equipment assemblies	1182 series
AYF installations	2533C
Conway Mk. 20100 series	4784A
Constant speed drives	4670A
Ejection equipment, aircraft	4288B
Electrical equipment manual	4343 series
Fire prevention and fire extinguishing equipment	957C
Hydraulic servicing trolley	2306B
IFF installation	2887D
Instrument landing system (ILS)	2543E
Instrument manual	1275 series
Lifting equipment and haulage accessories	2871A
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

Modifications mentioned in the Text

Mod. No.	Brief Title	Location in text Part	Chap.	Para.
2526	Delete bomb-bay tank pressurisation	I	2	7(*c*)
2825	Re-route oxygen pipe and introduce pull-off cable on 2nd pilot's PEC	I	11	11(*b*)
3008	Provision of guard for 1st pilot's canopy jettison gun sear	I	11	3
3125	Introduce new type hand fire extinguishers	I	14	7
3190	Vibrator for Mk. 19B or C altimeter	I	12	2(*b*)
3275	Provision of air intake heater mat indication	I	10	3(*b*)
3334	Standby (manual switching) for 1st pilot's MFS	I	8	10(*a*)(ii)
3427	Warning lights for MFS power supply failure	I	8	10(*a*)(iii)
3498	Independent switching of feel simulator heaters	I	12	1(*g*)
3636	External ground supply for RPU heater	I	1	6(*c*)
3698	De-ice position for windscreen heating	I	9	7(*a*)
3733	Circuit breakers for U/C circuits	I	4	6(*g*)
3736	Magnetic indicators for engine bleed valves	I	6	4(*c*)
3760A, B	Swivel seat static lines redesigned	I	11	15(*g*)
3760C	"Crew Gone" warning lights introduced	I	15	10
3815	Introduce VHF/UHF, PTR175	I	13	1
3816	Introduce cabin differential pressure gauge on panel BCB	I	9	2(*h*)
3882	Reposition UHF controller to AEO's station	I	13	2(*e*)
3883	Provide full I/C facilities at bomb aimer's station	I	13	6(*c*)
3902	Mk. 17F regulators introduced	I	11	22(*a*)
3904	Revised electrical supplies to booster pumps	I	2	11(*b*)
3926	Reposition brake parachute switch to panel AA	I	4	12(*a*)
3949	Guard over drop tank jettison switch	I	2	14
4020	Visual indicator for throttle gate trip lever	I	6	7(*e*)
4042	Introduction of Grimes beacon	I	1	20(*c*)
4130	Drop tanks jettison switch revised	I	2	14
4131	Underwing tank fuel jettison, fixed parts	I	2	9
4132	Underwing tank fuel jettison removable parts	I	2	9
4133	Fuselage tanks fuel jettison	I	2	9
4306	Modified MFS director horizon	I	8	4(*d*)
ES2424	Introduce demand emergency oxygen set to 3LS1 seats	I	11	24(*a*)
ES2425	Introduce demand emergency oxygen set to 3LS2 seats	I	11	24(*a*)
ES2986	Introduce Negative-G restraint	I	11	2(*e*)
BC039	Alterations to automatic hand line	I	15	9(*c*)
BC070	Introduction of undercarriage test switch	I	4	6(*b*)

INTRODUCTION

1 The Victor Mk. 2 (Blue Steel) is an all-metal mid-wing medium bomber powered by four Rolls-Royce Conway Mk. 201 jet turbine engines. The engines are started by a ground air starter unit, an Airborne Auxiliary Power Plant, which itself is started by means of a 28-volt electric starter motor, or by a combustor starter mounted on each engine. The power for the AAPP can be obtained from the aircraft internal batteries. By this means the aircraft is completely independent of conventional ground starting equipment.

2 The Victor B(SR) Mk. 2 is similar in nearly all respects to the Victor 2 (Blue Steel) except that

(a) The Blue Steel capability is withdrawn and in its place day or night photographic crates are fitted. Some Blue Steel switches remain in the aircraft but these are inoperable.

(b) The rapid start facility is deleted.

(c) The snatch disconnect facility, associated with rapid start, is rendered inoperative.

3 A crew of five is carried in the aircraft:

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

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

4 The crew cabin is the only section fully pressurised and air conditioned.

5 Conventional type mechanical flying control signalling systems operate Power Units installed adjacent to their associated control

6 A high-pressure hydraulic system operates the following:

(a) Tricycle undercarriage

(b) Wheelbrakes

(c) Flaps

(d) Bomb doors, which are withdrawn into the fuselage when open

(e) Airbrakes, in the rear fuselage

(f) Nosewheel steering

(g) Ram air turbine scoops

(h) Brake parachute door opening (post-Mod. 3300)

(j) Blue Steel doors.

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

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

8 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 underwing and bomb bay tanks can be installed as required.

9 All the instrument panels and electrical distribution boards on the aircraft are coded. Those located in the cabin are shown on

Key to distribution boards and control panels at pilots' station

Board	*Designation*
'A'	Pilots' Centre Instrument Panel
'AA'	1st Pilot's Instrument Panel
'AAF'	1st Pilot's Side Panel (rear)
'AAH'	1st pilot's coaming panel (SR aircraft only)
'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
'AR'	Visual Bomb-aimer's Control Panel
'AT'	Pilots' Centre Sliding Panel
'AU'	Distribution Board (Flying Control Trim Only)
'AV'	Circuit Breaker Panel
'AW'	Pilots' Upper Coaming Panel
'AZ'	Pilots' Coaming Board

Key to distribution boards and control panels at rear crew stations

Board	*Designation*
'BA'	AEO's LV Feeder Distribution Panel
'BB'	AEO's Side Panel
'BC' 'BCA' 'BCB'	AEO's Sloping Panel
'BD'	LV Bus-bars and Distribution Board
'BF'	AEO's Facia Panel (Generating System Controls)
'CA'	Navigator's Upper Panel
'CAH'	NBS Control Panel
'CAK'	Navigator's Switch Panel (Frequency Changer Control)
'CAG' 'CAJ'	Navigator's Instrument Panel
'CB'	Navigator's Side Panel (Bomb-bay Heating Control)
'CD'	Fuse and Distribution Panel
CC (Blue Steel) or CG (SR) CP	Navigator's side panel (Day camera panel)
'CE' 'CH'	Fuse and Distribution Panel
'CN'	Navigator's Side Panel
CZ CU or CL	Navigator's side panel (Bomb gear control) (BS aircraft) Night camera panel
'CK'	Fuse and Distribution Panel

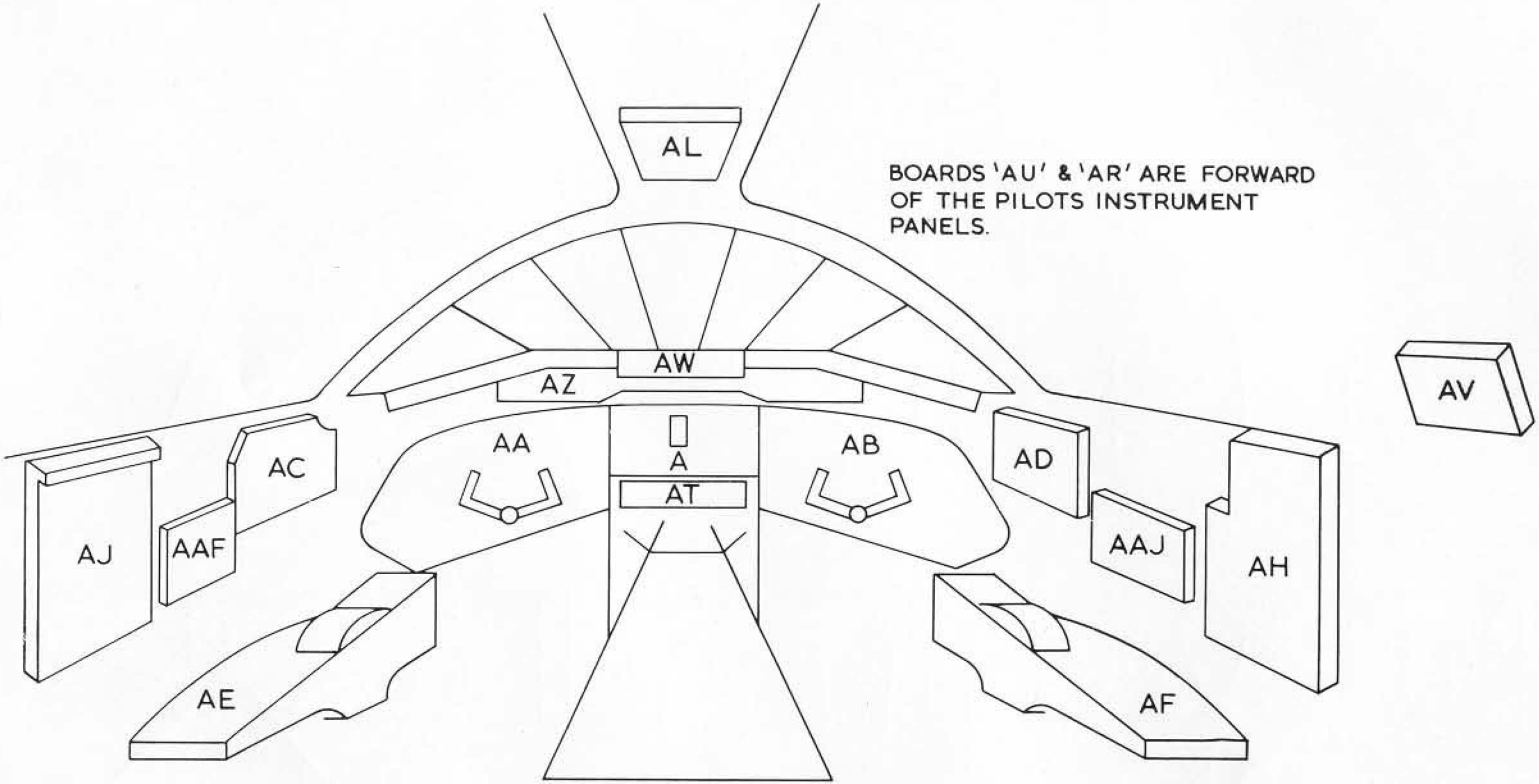

Fig. 1 Distribution boards and control panels at pilots' station

NOTE: AAH is above AA and to the left of AZ (SR aircraft only)

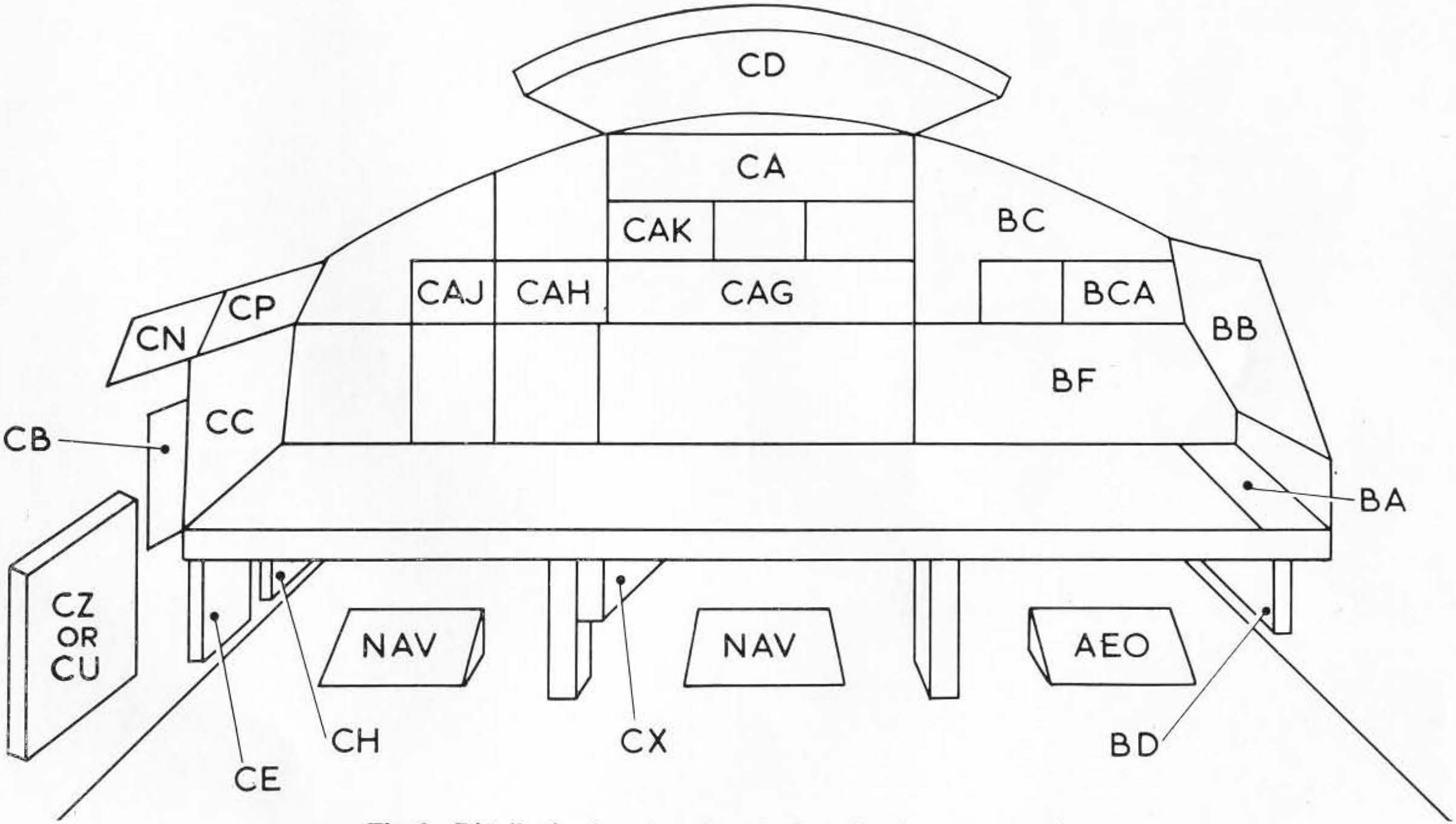

Fig. 2 Distribution boards and control panels at rear crew stations

NOTE: On SR aircraft CC is CG and CZ or CU is CL

Part I—Description and Management of Systems

List of Chapters

Part I

Chapter 1—Electrical System

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Description

1 Normal MV supplies

(*a*) The electrical power supply to the aircraft's bus-bars is obtained from four engine-driven alternators, each having a 3-phase 50 KVA output at 200 volts 400 CPS. A hydraulically-operated constant-speed drive unit is interposed between the engine and the alternator to ensure constant frequency output.

(*b*) Each alternator output is fed via a circuit breaker ("A" breaker) to its own bus-bar, thus providing four independent generating parallel the outputs of Nos. 1 and 2 alternators and the other to parallel the outputs of Nos. 3 and 4 alternators. These outputs are fed to the synchronising bus-bars via synchronising circuit breakers (" S " breakers).

(*c*) Provision is also made to connect the port and starboard synchronising bus-bars, via a paralleling contactor, should this become necessary.

2 Standby MV supplies

(*a*) The standby supply for the main generating system is provided by an airborne auxiliary power plant (AAPP) which is a Blackburn " Artouste " gas turbine driving a 3-phase 40 KVA, 200 volt 400 C/S alternator. The frequency in this case is kept constant by governing the speed of the gas turbine, to which the alternator is directly coupled by step down gearing.

(*b*) The output from the AAPP alternator is connected to the starboard synchronising bus-bar via a relay which can only be closed if the starboard synchronising bus-bar is dead. The supply can also be fed to the port synchronising bus-bar if the paralleling contactor is closed. The supply to the four bus-bars is then completed via the " S " breakers, if the main alternators have failed.

(*c*) The AAPP can also be used to provide electrical power for ground servicing, air pressure for starting the engines and air supplies for the jet pump.

3 Additional standby MV supplies (PFCU)

(*a*) To provide emergency MV supplies for the PFCU's two, ram air turbine (RAT) 15 KVA alternators are fitted in the rear fuselage. The port RAT supplies the No. 1 power control sub-units and the starboard RAT supplies the No. 2 PFCU's. Additionally the port RAT also supplies the No. 1 TRU and the No. 2 3-phase 115 volt 400 C/S

(*b*) The scoops for the RAT's are situated on top of the rear fuselage In flight they are normally held closed by hydraulic jacks, but should the speed of both engines on one side fall below 52% RPM the appropriate scoop opens and the turbine runs up to operating speed. As the speed of the engines falls still further the main alternator drive underspeed switches operate and the flying control power unit motors are transferred from the main bus-bars to the outputs of the RAT alternators. The scoops are normally open on the ground when the engines are not running or are operating at lower RPM than 52%.

(*c*) Provision is also made for manual switching at both the pilot's station and AEO's station.

4 Normal LV supplies

(*a*) To provide the 28 volt DC supplies necessary for control switching and actuators etc. two transformer/rectifier units (TRU's) are provided. The TRU input is normally derived from No. 1 and No. 4 200 volt bus-bars but provision is made for supplying No. 1 TRU from the port RAT.

(*b*) The output from the TRU's feed No. 1 and No. 2 LV bus-bars respectively and additionally the special feeder circuits.

(*c*) Provision is made for paralleling Nos. 1 and 2 LV bus-bars via a contactor.

5 Standby LV supplies

(*a*) Each LV bus-bar has a 24 volt 25 amp. hr. battery connected to it which will back up the output of the associated TRU.

(*b*) When the alternators are operating and the batteries and TRU's are connected to their bus-bars, as stated in para. 4(*b*), the special feeder circuits are fed from the TRU's but if the batteries are disconnected from the bus-bars for any reason, the special feeder

6 MV and LV ground supplies

(*a*) Three ground supply plugs are provided for 200 MV, 28 LV and 115v supplies (fuel gauges only).

(*b*) The MV supply is connected, via a circuit breaker to the port synchronising bus-bar and to the starboard synchronising bus-bar by the automatic closing of the paralleling contactor. The circuit breaker and the contactor will only close if the respective bus-bars are dead. From the synchronising bus-bars the supply to the main bus-bars is completed via the respective " S " breakers.

(*c*) The LV supply is connected via a contactor to No. 1 LV bus-bar and by the automatic closing of the paralleling contactor to No. 2 LV bus-bar. Post-Mod. 3636 the RPU heater switch on panel BF must be at NORMAL. To connect the ground supply to the special feeder circuits Nos. 1 and 2 batteries must be switched on.

(*d*) The 115v external supply is used during fuelling operations and, when connected, transfers the fuel gauge amplifiers from the aircraft main MV bus bars to the 115v external supply, provided that a 28v ground supply is in use. Thus no 200v MV supply is required during refuelling operations.

7 115 volt AC supplies

(*a*) 115 *volt* 3-*phase* 400 c/s *supplies*

Four transformers supplied from the main bus-bars and referred to as Nos. 1, 2, 3 and 4, 115 volt 400 c/s supplies, are provided. Nos. 1 and 2 transformers are normally supplied from No. 1 bus-bar and Nos. 3 and 4 transformers from Nos. 3 and 4 bus-bars respectively. Additionally No. 2 transformer can be supplied from the port ram air turbine.

(*b*) 115 *volt single-phase* 1600 c/s *supplies*

Two frequency changers are provided and referred to as 115 volt 1600 c/s supply No. 1 and supply No. 2. No. 1 supply is obtained

(*c*) The 115 volt supplies are used as follows:

Supply	*From bus-bar*	*Equipment supplied*
115 volt, 400 c/s 3 phase		
No. 1 Transformer . .	1	Green Satin only
No. 2 Transformer . .	1, or Port RAT	1st Pilot's MFS, standby yaw damper, Mk. 22 altimeter Additionally, via a change-over relay, the circuits normally supplied by No. 3 Transformer
No. 3 Transformer . .	3	NBS, IBS, RPU, standby horizon, TAS unit. Standby for 1st Pilot's MFS (post-Mod. 3334)
No. 4 Transformer . .	4	2nd Pilot's MFS, auto-pilot
115 volt, 1600 c/s 1 phase		
No. 1 Frequency changer .	1	Either supplies NBS, RPU and radio altimeter Mk. 6
No. 2 Frequency changer .	3	

Controls and Indicators

8 Main generating system control panel

(*a*) The main generating system control panel is panel BF at the AEO's station. The panel is laid out to represent a simple line diagram of the system, with indicators in positions occupied by circuit breakers or contactors in the system. These magnetic indicators are designed to provide line indications of circuits being made or broken.

(*b*) The panel illumination is by submerged lights, the routing

9 Alternator controls and indicators

(*a*) Each alternator has a four-position ON—OFF—RESET—ISOLATE switch, a POWER FAILURE warning light, a COOLING FAILURE warning light and a KW/KVAR meter.

(*b*) An alternator commences generating as soon as the engine is running; however with the control switch at OFF the power is not connected to its bus-bar. When ON is selected, provided the constant speed drive unit oil pressure is sufficient, the " S " breaker opens and the "A" breaker closes ; its indicator shows in line and the power failure light goes out.

(*c*) The RESET position is used to reset the exciter relay of the alternator.

(*d*) The ISOLATE position is used to disconnect an alternator from the synchronising bus-bar, whilst leaving it connected to its own bus-bar.

(*e*) A switch, labelled KW-KVAR is between each pair of KW-KVAR meters to enable the desired selection to be made.

(*f*) The cooling failure warning lights come on if the cock controlling the blast air from the engine compressors closes for any reason.

NOTE: This air supply is for engine bay cooling only.

10 Alternator synchronising controls and indicators

(*a*) Between each pair of A breaker indicators is a No. 1 (No. 3)—BUSBAR—No. 2 (No. 4) three position switch, below which is a SYNCHRONISING PUSH AND LIGHT. On either side of the panel is an AC voltmeter and a frequency meter.

(*b*) Setting the selector switch to No. 1 (or No. 3) or No. 2 (or No. 4) enables the volt and frequency meters to show the existing

(*c*) Pressing the synchronising push causes the output of the relevant alternator to come on to the synchronising bus-bar via the " S " breaker, the indicator for which will show in-line. The selector switch, when selected to other alternator then causes the light in the synchronising push to blink, if the frequency of the second alternator is not in phase with that of the first alternator. When the light is out, pressing the synchronising push brings the second alternator on to the synchronising bus-bar via its " S " breaker. The second " S " breaker indicator will now show in line. It is not possible to bring any alternator on to its sync. bar if the paralleling circuit breaker is closed.

(*d*) Once two alternators are running in parallel, should either one fail or be selected OFF, both " S " breakers will remain closed and the remaining alternator will supply both bus-bars.

11 MV bus-bar paralleling control and indicators

(*a*) If it is necessary to parallel the two synchronising bus-bars, the outputs must first be compared on the two sets of meters. The phase relationship of the two outputs is shown by the BUS-BAR PARALLELING SYNCHRONISING LIGHT, which when pressed, will show an intermittent light whenever the phases are not in harmony. When the light is out, setting the MV PARALLELING, NORMAL—PARALLEL switch to PARALLEL causes the paralleling circuit breaker to close and the magnetic indicator above the switch to show in line. A guard over the switch prevents inadvertent operation.

(*b*) The synchronising bus-bars are automatically paralleled when a ground supply is plugged in.

12 Ram air turbine controls and indicators

(*a*) Control of the RAT's is normally fully automatic (see para. 3(*b*)).

(*b*) Manual control of the RAT scoops can be effected by the pilots and by the AEO. A double-pole NORMAL—START switch on

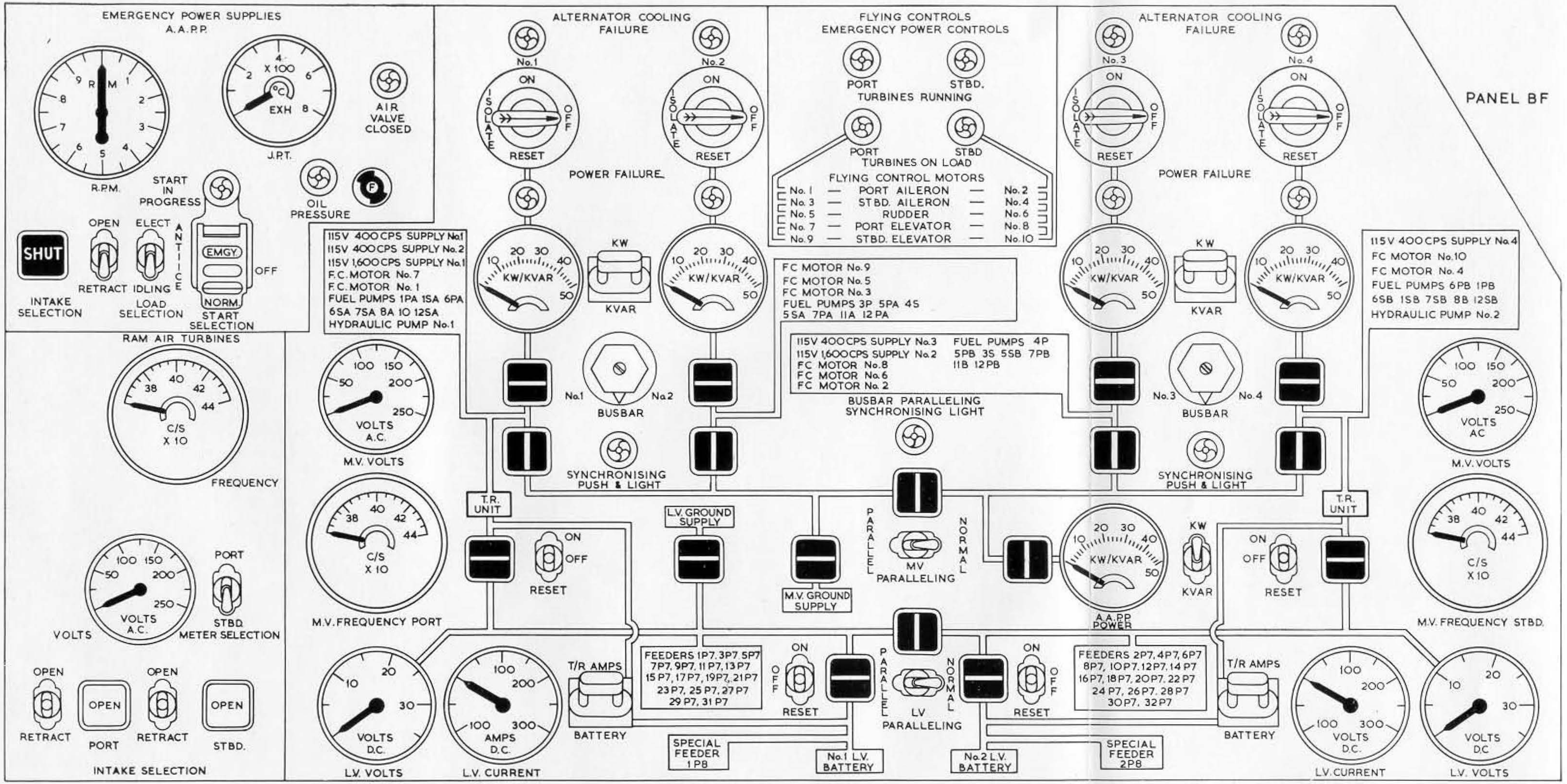


Fig. 1 Generating system, controls and indicators (Pre-Mod. 3904)

to START, both scoops open and remain open until control is returned to the AEO by setting the switch to NORMAL and a retract selection made by the AEO.

(*c*) At the bottom left-hand corner of the AEO's panel BF are two OPEN-Off—RETRACT switches and two OPEN—striped—SHUT magnetic indicators. Provided that the pilots' switch is at NORMAL the AEO has full control of the scoops. The magnetic indicators show striped when the scoops are in an intermediate position.

(*d*) Above the AEO's control switches are a frequency meter and a voltmeter; also a PORT-STBD., METER SELECTION switch by which the output of the appropriate RAT alternator can be checked.

(*e*) At the top of panel BF is a sub-panel labelled FLYING CONTROLS, EMERGENCY POWER CONTROLS. Four lights are provided, two TURBINES RUNNING lights and two TURBINES ON LOAD lights. The first pair come on when the alternator outputs have built up following opening of the scoops. The second pair come on either together or individually, only when one or more flying controls sub-unit motors are connected to the RAT bus-bars and the scoops are fully open.

13 RAT test switches and warning lights

(*a*) Four test push switches, each with an integral warning light are at the top left-hand corner of the navigator's panel CA and labelled RAM AIR TURBINES TEST, PO, PI. SI, SO. The contacts of the pushes are connected to the respective engine signalling units and when the push is operated it simulates flame-out conditions, thereby causing the light to come on.

(*b*) The appropriate light will also come on in flight if the engine flames out or electrical supply to the signalling unit fails.

(*c*) Should both pushes on one side be operated simultaneously the

14 AAPP alternator supply to MV bus-bars controls

(*a*) The AAPP alternator can only be effective if the frequency output is 400 ± 20 c/s. The alternator can be used to supply the main bus-bars in flight and on the ground.

(*b*) The LOAD SELECTION switch on panel BF must be set to ELECT to connect the AAPP alternator output to the starboard synchronising bus-bar via the AAPP relay, the magnetic indicator of which will show in line only if the bus-bar is dead.

(*c*) Adjacent to the magnetic indicator is a KW/KVAR meter which registers at all times when loads are being supplied. A KW/KVAR selection switch is alongside the meter.

15 LV bus-bars controls and indicators

(*a*) The two LV bus-bars are supplied by the two TRU's. When either ON—OFF—RESET switch is set to ON a relay is closed and a magnetic indicator adjacent to the switch shows in-line.

(*b*) The RESET position is for use should the reverse current cause the relay to trip. This position should not be used in flight.

(*c*) A voltmeter is provided for each LV bus-bar and gives a constant indication.

(*d*) An ammeter is also provided to indicate the TRU output current or battery current. An adjacent selector switch, T/R AMPS—BATTERY enables either to be read.

16 LV bus-bars paralleling control and indicator

(*a*) A single pole, LV PARALLELING, NORMAL-PARALLEL switch is provided to enable the LV bus-bars to be paralleled. A magnetic indicator above the switch shows in-line when this has (*b*) The LV bus-bars are automatically paralleled when an LV ground supply is plugged in or the AAPP start selector switch is selected to START and will remain so until the AAPP is running above 6,000 RPM.

17 Special feeders controls and indicators

(*a*) Two special feeder switches, NORMAL 1P8—OFF—1P8 EMERGENCY and NORMAL 2P8—OFF—2P8 EMERGENCY are on the forward face of the AEO's table. Two indicators on panel BB give ON—OFF indications.

(*b*) A direct supply is taken from No. 1 LV battery to the NORMAL 1P8 switch setting and to the 2P8 EMERGENCY switch setting. Similarly a direct supply is taken from No. 2 LV battery to the 1P8 EMERGENCY and NORMAL 2P8 settings of the switches.

18 LV battery controls and indicators

(*a*) The batteries are connected to the LV bus-bars by two ON—OFF—RESET switches on either side of the LV paralleling switch. The RESET position is for use should the reverse current coil disconnect a battery from its bus-bar and must *not* be used in flight. The special feeder switches must be on before these switches are operative.

(*b*) Adjacent to each switch is a magnetic indicator which shows in-line when a battery is connected to its bus-bar.

19 Internal lighting

(*a*) The internal lighting arrangements comprise four high intensity amber thunderstorm lights and six cabin lamps for general illumination. A system of combined pillar and bridge, panel, strip and floodlights are used for illumination of instruments and switches. In general, lamps are fitted to give duplicated illumination for each

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

Lights	*Control*
High intensity cockpit . .	Two switches on panel AZ
Cabin lights	Master switch on panel BB
Console AE red floods . . Oxygen regulator panel . . Plasteck & pillar lights on AC & AAF	Dimmer on console AE
Visual B/A control unit red floods . . . . . . Oxygen regulator panel . . Pillar lights on AR . . .	Dimmer on visual B/A switch panel
Console AF red floods . . Oxygen regulator panel . . Lights on AD and AAJ . .	Dimmer on console AF
Pilots' coaming panels strip-lights . . . . . . Lights on panel AW & AZ .	Dimmer on panel AB
P12 compass light . . . Lights on AL	Dimmer on panel AL
Chartboard lamp at AEO's position	Type R dimmer on panel BB
Chartboard lamp at Nav./Plotter's position	Type R dimmer on panel CAG
Chartboard lamp at Nav./Radar position	Type R dimmer on oxygen reg. panel
Striplights on panel CAG . .	Dimmer on panel CAG
Panel BB amber floods . .	Dimmer on panel BB
Panel BF lights	Dimmer on panel BCA
Panel AT lights	Dimmer on panel AT

(*c*) *Emergency lamps*
Two lamps are installed in the cabin roof and are automatically switched on, if a crash landing occurs, by the action of an inertia switch integral with each lamp. The power supply is from two independent dry batteries. The lamps may be tested by means of a TEST switch embodied in each. Each lamp also has a RESET switch by means of which the inertia switch can be reset.

20 External lighting

(*a*) *External lights master switch.* This switch, on panel AC, controls the supply to the individual lamp switches for the port and starboard landing lamps, flashing beacon and navigation lights. The extension and retraction of the landing lamps is by a separate supply controlled from the IN-TAXY-LAND switch on panel AC.
(*b*) Navigation lights ON-OFF switch is mounted on panel AC.
(*c*) Flashing beacon STEADY-OFF-FLASHING switch is mounted on panel AC. The switch is marked ON/OFF when the Grimes light is fitted (Mod. 4042).
(*d*) Landing lights ON—OFF switches on panel AC, control their respective port or starboard lamp filaments. In addition, there are two master circuit breakers on panel BA.
(*e*) Thirty-one lamps and nine two-pin sockets are provided for servicing use. The DC supply to the lamps and sockets is from an external socket type G fitted on board FE, together with a SERVICE LIGHTS MASTER, ON/OFF switch and a 20 amp fuse. With the master switch ON the supply is directed to a switch incorporated in each lamp.

Normal Management of the System

21 Before starting main engines

(*a*) *Special feeder and* LV *battery checks*
(i) On entering the aircraft and before connecting any external supplies, check that both LV batteries are switched OFF, AAPP start switch OFF and the required LV circuit breakers are made. Select No. 1 P.8 and No. 2P.8 special feeder switches to EMERGENCY and NORMAL in turn, checking that the indicators show ON. Leave both switches selected to NORMAL. Switch and after switching both LV ammeter switches to BATTERY, check that the battery voltages are not below 24 volts and that both LV ammeters are reading. Press the STOP buttons of both No. 1 and No. 2 frequency changers before connecting any MV supply.
(ii) If the charge state of the batteries is in doubt they may be checked when an MV supply is available and the TRU's switched ON. Switch the ammeter switch to BATTERY and check that the battery is charging at not more than 20 amps. This rate should fall to 10 amps within 1 minute, and to a maximum of 3 amps before taxying. If the charging rate is excessive it indicates that the batteries have been discharged and should be changed.

(*b*) *Use of external* MV *supply for functional checks*
(i) On completion of the above checks ensure that the MV paralleling switch is NORMAL. An external 200 volt 3-phase 400 cycles external supply may then be connected to provide power for functional checks of equipment.
(ii) Check that the MV GROUND SUPPLY indicator shows vertical, that the MV PARALLELING indicator shows horizontal (automatic parelleling) and that the MV bus-bar voltage and frequency indications are normal. Select both LV ammeter switches to T/R AMPS and switch ON No. 1 TRU, checking that its indicator shows vertical. Check that the port LV voltmeter and ammeter readings are normal, then select the LV PARALLELING switch to PARALLEL and check that the starboard voltmeter and ammeter readings are normal.
(iii) Return the LV PARALLELING switch to NORMAL, switch on No. 2 TRU and again check that the starboard voltmeter and ammeter readings are normal. The frequency changers may then be started if required and functional checks of equipment carried out in accordance with the aircraft check list.
(iv) On completion of the functional checks, and before starting the engines, press the STOP buttons of the frequency changers. Switch all alternator control switches to RESET and then OFF, and switch all KW/KVAR switches to KW. The engines may

(*c*) *Use of* AAPP *power for functional checks*

(i) On completion of the checks at (*a*) the AAPP may be started to supply electrical power for functional checks of equipment.

(ii) Check that the MV PARALLELING switch is at NORMAL and its indicator vertical.

(iii) When cleared with the crew chief start the AAPP (see para. 24(*a*)) using either the aircraft LV batteries or an external 28 volt supply. When the AAPP is running normally set the AAPP LOAD SELECTION switch to ELECT. The RPM should increase to 33,200—35,200 RPM and the indicator beside the AAPP POWER gauge should show horizontal.

(iv) Check that the port MV synchronising bus-bar volts and frequency read zero. Then select the MV PARALLELING switch to PARALLEL, check that its indicator shows horizontal and that the port MV voltage and frequency indicators read AAPP volts and frequency. If an external 28 volts supply has been used, this should now be removed.

(v) Check that the LV GROUND SUPPLY indicator shows horizontal and that the LV PARALLELING indicator shows vertical. Switch both LV ammeter switches to T/R AMPS and switch ON No. 1 TRU. Check that the port LV voltmeter and ammeter readings are normal, switch the LV PARALLELING switch to PARALLEL and check that the starboard LV voltmeter and ammeter readings are normal. Return the LV PARALLELING switch to NORMAL, switch ON No. 2 TRU and again check that the starboard LV voltmeter and ammeter readings are normal.

(vi) The frequency changers may then be started if required and the functional checks of equipment carried out in accordance with the Flight Reference Cards.

(vii) On completion of the functional checks and before starting the engines, press the STOP buttons of the frequency changers. Switch all alternator switches to RESET and then OFF, and switch all KW/KVAR switches to KW. The engines may then

22 Alternator control

NOTE: During engine starting with the appropriate synchronising selector meter switch set to the required alternator position, definite indications of alternator power output should be noticeable by the time the JPT is indicated. If no alternator output is indicated before the engine starter push-button springs out, the engine must be closed down immediately to avoid damage to the alternator drive mechanism. The engine may be restarted after a delay of two minutes but, should the alternator still fail to indicate power output, the engine must again be closed down and the CSDU oil system checked.

(*a*) *Bringing an alternator on to line*

When an engine is running with the alternator control switch set to OFF, the ALTERNATOR COOLING FAILURE warning light should be out, but the POWER FAILURE warning light should stay on until the alternator is brought on to line. Set the appropriate synchronising selector meter switch to the required alternator position and check on the MV VOLTS and MV FREQUENCY meters that the alternator output is normal (200 $\pm$ 5 volts and 400 $\pm$ 4 CPS). Select the alternator control switch to ON, check that the POWER FAILURE warning light goes out, that the appropriate "A" breaker indicator shows vertical (closed) and the appropriate " S " breaker indicator shows horizontal (open). The alternator's individual bus-bar will now be live and may be loaded as required.

(*b*) *Synchronising of alternators*

NOTE: The following procedure for synchronising the two port alternators is similar to the procedure for synchronising the two starboard alternators.

(i) Before connecting an engine-driven alternator to a synchronising bus-bar, any other supply from either the AAPP alternator or the MV ground supply must be disconnected, and the MV PARALLELING switch must be selected to NORMAL.

(ii) Select the port synchronising selector and meter switch to the No. 1 position; the output of No. 1 alternator will now be indicated on the port MV VOLTS and MV FREQUENCY

PUSH and LIGHT to close No. 1 " S " breaker and connect the alternator to the port synchronising bus-bar. Check that the pushbutton does not stay in when released. Select the synchronising selector meter switch to the No. 2 position and check that the voltage and frequency outputs of No. 2 alternator are similar to those of No. 1 alternator.

(iii) The synchronising light will now be connected between the two alternators and will provide an indication of their phase relationship by flashing on and off slowly. The period during which the alternator outputs are in phase will be indicated by the light being off, and it is during this period that the SYNCHRONISING PUSH and LIGHT should be pressed to synchronise the alternators. Pressing the light when it is on may result in one or both alternators coming off line, damage to the alternator drive mechanism or the rupturing of the 100 amp synchronising bus-bar protection fuses which are inaccessible from the cabin. Should the light remain on or off continuously, vary engine RPM or switch on a load to disturb the synchronism of the alternators. If the light flashes more than twice per second no attempt must be made to synchronise the alternators until the flashing rate decreases.

(iv) When the alternators are synchronised the synchronising selector and meter switch should be selected to BUS-BAR so that the voltage and frequency available at the synchronising bus-bar may be read from the gauges. Check that the KW/KVAR meters indicate that two alternators are on load ; under low load conditions variation in load sharing may be expected.

(v) If, after synchronising the alternators, any one of them should fail or be manually switched OFF, both " S " breakers will remain closed and the other alternator will supply the loads on both bus-bars.

(vi) To isolate an alternator and its individual bus-bar from the synchronising bus-bar, select the alternator control, switch to ISOLATE (for not more than 5 seconds) check that the " S "

(c) MV *bus-bar paralleling procedure*

Provision is made for connecting the port and starboard synchronising bus-bars in parallel whilst the alternators are connected to them. Check that the voltages and frequencies of both synchronising bus-bars are normal. Press the BUS-BAR PARALLELING SYNCHRONISING LIGHT. The light will now be connected between the two synchronising bus-bars and will provide an indication of the phase relationship by flashing on and off. The outputs on both sides will be in phase when the light is out, and it is at this time that the MV PARALLELING switch should be selected to PARALLEL. If it is subsequently desired to separate the bus-bars, select the MV PARALLELING switch to NORMAL.

> **WARNING.** Selection of the MV PARALLELING switch to PARALLEL when the BUS-BAR PARALLELING SYNCHRONISING LIGHT is illuminated may cause rupturing of the 100 amp bus-bar paralleling protection fuses which are not accessible from the cabin.

(d) Normal synchronising and paralleling procedure

Under normal conditions Nos. 1 and 2 alternators and Nos. 3 and 4 alternators should be synchronised as separate pairs. MV bus-bar paralleling should not normally be carried out when engine-driven alternators are connected to the synchronising bus-bars because of the risk of transferring a fault from one pair of alternators to the other pair.

23 Secondary supplies control

(a) 115 *volt* 3-*phase* 400 CPS *transformers*

The number 2, 3 and 4 transformers providing 115 volt 3-phase 400 CPS supplies operate automatically when the MV bus-bars are live. The No. 1 transformer is controlled by the Green Satin ON/OFF switch. The only indication of transformer serviceability is the normal operation of the associated equipment, which may be

(*b*) 115 *volt single-phase* 1600 CPS *frequency changers*
To prevent possible rupture of the frequency changer supply fuses, press the Nos. 1 and 2 frequency changer STOP buttons before any MV supply is connected to the main bus-bars. The NBS equipment must also be switched off. When MV supply is connected, select No. 1 position on the LOAD TRANSFER switch before pressing the NO. 2 START button, then move the LOAD TRANSFER switch to the No. 2 position and press the No. 1 START button. Check that the appropriate neon lights illuminate. Both frequency changers should normally be kept running during flight but, because the LOAD TRANSFER switch also controls the distribution of some loads between No. 2 and No. 3 transformers, the No. 2 position should normally be selected to assist even distribution of the transformer loads. If, for any reason, it is necessary to transfer the loads between frequency changers, provided that the other frequency changer is running with its neon light on, the LOAD TRANSFER switch may be operated without switching off the loads. However, should the MV input supply to the frequency changers be interrupted or removed for any reason, no matter how short the period of interruption, the frequency changer STOP buttons must be pressed before replacing the MV supply. If the frequency changers are used when the bus-bars are supplied by the AAPP or the MV ground supply, they must be switched OFF before the alternators are switched ON. Failure to take this precaution may result in rupture of the frequency changer input fuses.

NOTE: If at any time during flight the frequency changer LOAD–TRANSFER switch is moved to the No. 1 position, the captain should be informed that the 1st pilot's MFS and the standby artificial horizon will both be supplied from No. 2 transformer and both will be affected by any interruption in power supply.

24 Control and use of the AAPP

(*a*) *Ground starting of the* AAPP

(i) Electrical power for ground starting of the AAPP may be obtained from the aircraft LV batteries, or an external 200v supply providing 28-volts through an aircraft TRU, or an external 28-volt

(ii) Before starting the AAPP on the ground check with the crew chief that the external area is clear, check that the scoop opens and retracts when the appropriate selections are made, and that the OPEN and SHUT indications are correct.

(iii) Test the AAPP fire detection, start in progress and oil pressure indications.

(iv) Select the INTAKE SELECTION switch to OPEN, the LOAD SELECTION switch to IDLE and the START SELECTION switch to NORMAL. The START IN PROGRESS light should illuminate and the LV bus-bar automatically parallel until 6,000 to 8,000 RPM. Check JPT not above 700°C, OIL PRESSURE light out and fire warning light out. The RPM should build up and idle at 23,000-25,000 RPM.

(v) When the AAPP is idling correctly, if electrical loading is required select ELECT, note that RPM increase to 33,200-35,200 RPM and the JPT falls below 500°C. Provided that no other supply is connected to the starboard synchronising bus-bar, the AAPP alternator output will be connected automatically to it and voltage and frequency output may be checked. Before paralleling the MV bus-bars ensure that no supply is connected to the port synchronising bus-bar.

(*b*) *In-flight starting of the* AAPP

(i) In-flight starting of the AAPP is certain up to 10,000 feet and ability to start at considerably greater altitude is also highly probable. The scoop must not be opened or closed at airspeeds in excess of 250 knots, but when the scoop is fully open speed may be increased to a maximum of 330 knots.

(ii) Before starting, test the fire warning detection system and check that the LOAD SELECTION switch is selected to ELECT. (On no account must IDLING be selected in flight as this will cause failure to light or flame extinction). Simultaneously select OPEN on the INTAKE SELECTION switch and

WARNING. *It is essential to check that the INTAKE SELECTION indicator changes from SHUT to striped indication within 5 seconds and that it indicates scoop fully OPEN within 45 seconds of selection. Should it fail to do so, the start selection must be cancelled immediately.*

(iii) Check that the START IN PROGRESS light illuminates, that the fire warning light does not illuminate and that the LV bus-bar is automatically paralleled. The engine windmilling speed will increase rapidly to above 20,000 RPM; light is indicated by a rise in JPT. The maximum JPT during starting is 700°C.

(iv) The START SELECTION switch must be left at EMERGENCY after starting and whilst the engine is running; ignition and oxygen enrichment will be switched off automatically at 30,000 RPM. In all cases if the AAPP fails to light-up before reaching 25,000 RPM or within 1 minute of selection, switch the START SELECTION switch to OFF, retract the scoop, and make a further attempt at a lower altitude if possible.

(v) If the AAPP starts normally, check that the amber START IN PROGRESS light goes out and LV bus-bars deparallel at 6,000 to 8,000 RPM and that the green OIL PRESSURE indicator light goes out by 23,000 RPM. RPM should increase steadily to the normal operating speed of 33,200-35,200 RPM, varying slightly with changes in aircraft speed and altitude. Provided that no other supply is connected to the starboard MV synchronising bus-bar, the AAPP alternator will automatically be connected to it and the voltage and frequency outputs may be checked.

(*c*) *Stopping the* AAPP

Before stopping the AAPP check that alternative electrical supplies are available if required. Select the START SELECTION switch to OFF. Before retracting the scoop ensure that speed is below 250 knots.

25 Ram air turbine scoop and alternator control

of the ram air turbine alternators on the ground, the system indications and operation of the scoop controls should be checked as follows before flight.

(*b*) (i) The green TURBINE ON LOAD lights should be illuminated when the special feeders are switched on and one or more of the appropriate PFCU's is switched off and the scoop is fully open.

(ii) The amber RAM AIR TURBINE TEST lights above the navigator's position should be illuminated when the appropriate engines are stopped or operating below 52% RPM. Check that the INTAKE SELECTION indicators show OPEN when any pair of lights is on.

(iii) After the engines are started, have each engine accelerated and check that the RAM AIR TURBINE TEST lights extinguish when the appropriate engine exceeds 52% RPM. Have the crew chief confirm all scoop movements. Select the INTAKE SELECTION switches to RETRACT and check that the indicators show SHUT 2-3 seconds after selection. Select START on the RAM AIR TURBINE SELECTOR SWITCH (at the pilot's panel AL), check that the indicators indicate OPEN 1-1½ seconds after selection, then return the switch to NORMAL.

(iv) Again select AEO's INTAKE SELECTION switches to RETRACT. Throttle back the engines, check that the RAM AIR TURBINE TEST lights illuminate as each engine reduces below 52% RPM, and that the intakes open and indicate OPEN as the second of each pair of lights illuminates. Throughout the checks note that the green TURBINE ON LOAD lights extinguish whenever the appropriate turbine intake moves from the fully open position.

(*c*) The RAT scoops should be selected to OPEN whenever the aircraft is on the ground and during take-off to prevent inadvertent opening caused by relay bounce interrupting the hold-in signal. By collected will be shed from the blades. The RAT scoops should be selected to RETRACT during the after take-off checks.

(*d*) During flight the scoops may be selected OPEN at the captain's discretion in order to carry out RAT alternator voltage and frequency checks at altitude. At 220 knots these should be approximately 185 volts and 370 CPS and will vary with changes in height and airspeed. During flight in inclement weather conditions, such as sandstorms or hailstorms, the scoop intake should be selected to RETRACT and, if necessary, held in during landing.

(*e*) When a RAT is in use, dutch rolling and side-slipping should be avoided, otherwise the changing air flow entering the turbine intake may cause variations of turbine speed with consequent fluctuations of alternator output.

26 Normal in-flight operation

(*a*) In order to cater for possible failure of electrical supplies to the pilots' instruments during a critical stage of flight shortly after take-off, and to make best use of the alternative supplies it is recommended that prior to take-off the AAPP is started and selected to ELECT, the engine-driven alternators are isolated from the synchronising bus-bars, and the AAPP alternator is connected to both synchronising bus-bars by paralleling. This will provide immediate and automatic take-over by the alternative supply in the case of total loss of MV supplies to either side (e.g. two-engine flame-out). On completion of the after take-off checks, the AAPP should be closed down, the synchronising bus-bars de-paralleled and the engine-driven alternators synchronised.

(*b*) During flight the voltages and frequencies of the MV bus-bars, the load sharing of the synchronised alternators, the voltages of the LV bus-bars, and all indicators and warning lights should be monitored frequently. If any malfunctions of the system occur, appropriate action should be taken as described in the subsequent paragraphs.

(*c*) The AAPP should be started prior to landing. At the captain's discretion the engine-driven alternators may be isolated from the

The AAPP may be kept running whilst taxying to provide an air supply for the jet pump until the Blue Steel is closed down and when closing down the main engines. The AAPP alternator must, however, be disconnected from the synchronising bus-bar if an external power supply is to be connected.

(*d*) Prior to closing down the engines, close down Blue Steel, switch off all heavy MV loads except fuel pumps. Having closed down the engines, switch off the alternators and booster pumps. Switch off the LV batteries and when the engines have stopped turning and the engine LP cocks are closed, switch off the special feeders.

Malfunctioning of the System

27 Alternator load sharing malfunction

In flight if the load sharing between two synchronised alternators differs by more than 8 KW/KVAR, with each alternator supplying load, the alternators should be isolated and the individual voltages and frequencies checked. Switch OFF the appropriate frequency changer, after transposing if necessary. If one alternator is found to be operating outside its limits, the other alternator should be reconnected to the synchronising bus-bar before the faulty alternator is switched OFF. If both alternators are found to be operating within their limits they may be resynchronised provided that neither alternator is overloaded ; restart the frequency changer. Under low-load conditions when the total load on two alternators is less than 10 KW the load sharing control circuits may not operate at their maximum efficiency and variation in load sharing may be expected.

28 Single alternator failures

(*a*) *Electrical faults*

If an alternator fails because of an electrical fault, this will be indicated by illumination of the appropriate POWER FAILURE warning light and opening of its "A" breaker. Select the appropriate RAT intake OPEN. Switch the alternator to RESET and then OFF. Stop any frequency changer supplied by the alternator. Check the voltage and frequency outputs. If the voltage and at OFF. Check the loading of the serviceable alternator and reduce loads if necessary. The RAT should be selected in again when the failure has been investigated.

NOTE: The alternator control switch must *not* remain at RESET for more than five seconds.

(b) Alternator drive failure

If the drive mechanism of an alternator fails, the POWER FAILURE warning light does not come on if the alternator is synchronised but failure will be indicated by complete out-of-balance of KW load sharing ▶◀ and possible deviation of bus-bar frequency from 400 CPS. Select the appropriate RAT intake OPEN and STOP any frequency changer supplied by the alternator. If a POWER FAILURE warning light illuminates, switch the alternator OFF, check its voltage and frequency, and check the loading of the serviceable alternator. If no POWER FAILURE warning light illuminates, check the frequency at the synchronising bus-bar. If this is low, switch OFF the alternator carrying zero KW load. If the frequency is higher than normal, switch OFF the alternator carrying all the KW load. Check the loading of the serviceable alternator and reduce loads if necessary. The RAT should be selected in again when the failure has been investigated.

(c) High CSDU *temperature*

(i) The normal CSDU temperature is 40°-60°C. Any increase in temperature up to the maximum continuous operating limit of 95°C indicates a possible fault.

(ii) Should 95°C be reached, select the appropriate RAT intake open, if necessary transpose the loads and stop the appropriate frequency changer. Load shed or switch off the appropriate alternator and monitor its temperature. When the temperature returns within limits, reload or switch on the alternator and close the RAT intake.

(iii) If this action does not result in the temperature remaining at ticable to minimise the fire risk and/or CSDU damage. If an electrical emergency exists or arises a CSDU oil temperature of 120°C may be accepted for up to 2 hours.

(iv) Operation of CSDU's at temperatures above 95°C results in a shorter life and must be reported on landing.

29 Double alternator failure on one side

NOTE: When both RAT's are extended the drag factor is such that range is cut by approximately 7%.

(a) Electrical faults on both alternators

(i) If two alternators on one system fail because of electrical faults, both POWER FAILURE warning lights will illuminate. The appropriate RAT scoop will open automatically and the opposite RAT should be selected open as a precautionary measure. The PFCU's supplied from the failed side will transfer to the RAT as its scoop opens, thus probably preventing it from running up to provide a useful output and resulting in the loss of use of these PFCU's. Check the voltage and current output of the LV battery on the failed side; if these are normal parallel the LV bus-bars to prevent excessive discharge.

(ii) In the event of failure of Nos. 1 and 2 alternators check that the frequency changer LOAD TRANSFER switch is on the No. 2 position and that the Standby Artificial Horizon supply is maintained. Switch the failed alternators to RESET and then OFF and check their individual outputs. If these are normal shed all switchable MV loads (e.g. hydraulic pump motors, fuel booster-pumps, frequency changer, ECM) before switching ON again. Reload as required, but do not re-synchronise.

(iii) If, on switching on again, one alternator re-trips, switch OFF and do not connect the serviceable alternator to the synchronising bus-bar. Re-load the serviceable alternator. Should one alternator show a fault condition on the voltage and frequency check, switch ON only the serviceable alternator, connect it to the synchronising

(iv) If both alternators show fault conditions leave their control switches selected to OFF. As soon as possible, descend to 20,000 feet, light the AAPP with the load selector selected to ELECT and connect to the bus-bars as required.

(v) The RAT's should be selected in again when the failure has been investigated.

(*b*) *Failure of two adjacent engines*

(i) If two adjacent engines fail, the appropriate RAT will open automatically as both engines decelerate below 52% RPM. However, if possible the RAT scoop should be manually selected open as a precautionary measure. The PFCU's will automatically be transferred to the RAT alternator bus-bar when the engine driven alternators come off line.

(ii) If the two port engines fail, the No. 1 T/R unit and No. 2 transformer will automatically be supplied from the port RAT alternator. Shed the appropriate switchable MV loads (e.g. frequency changer, hydraulic pump motors, fuel booster pumps, ECM, etc.) and, when the POWER FAILURE warning lights illuminate, switch off both the alternators.

(iii) If the two starboard engines have failed, the output of the starboard LV battery should be checked and the LV bus-bar paralleled.

(iv) If one or both engines are subsequently relit, switch ON the alternator(s), when the output is normal, reload as required and deparallel the LV bus-bars. Close the RAT intake as required.

(v) If neither is successfully relit, descend as soon as possible to a height at which the AAPP can be started. Start the AAPP with the load selector at ELECT, connect to the bus-bars as required.

(*c*) RAT *output*

The performance of the RAT's under their full electrical load is such that they will take over and support five PFCU's, one TRU and one

165 knots at 55,000 ft.
170 knots at 50,000 ft.
175 knots at 45,000 ft.
190 knots at 30,000 ft.

NOTE: The starboard RAT solely supports five PFCU's.

30 Failure of four alternators

(*a*) The chance of four-alternator failure is considered remote, and the RAT alternators are not designed to cater for such a failure if it is caused by electrical faults. If a four engine flame out occurs the alternators will eventually come off line in underspeed regardless of aircraft speed. However, they may be kept on line for a limited period by descending at the highest practicable IAS/MN.

(*b*) (i) On warning of engine flame-out, immediately select both RAT intakes OPEN. Check that the TURBINE RUNNING lights illuminate and that the voltage and frequency outputs are normal (185v 370 CPS). Select main yaw damper to STANDBY, and the standby yaw damper ON if required.

(ii) Shed all non-essential electrical loads, in particular the LV loads of STR18, NBS and the VHF box not in use.

(iii) As the alternator POWER FAILURE warning lights illuminate, check that the RAT TURBINES ON LOAD lights illuminate and the voltage and frequency outputs are normal. Switch OFF the alternators.

(iv) If immediate attempts to relight the engines are unsuccessfull check load shedding of No. 2 T/R unit, ECM, hydraulic pump motors, frequency changers, NBS, Green Satin, fuel booster pumps, auto-pilot and all other non-essential loads.

(v) If the main engines are relit above maximum AAPP lighting altitude, switch on the appropriate alternators when output is normal, and check that the TURBINES ON LOAD lights go out. Switch on MV and LV loads and retract RAT intakes as

(vi) If the engines cannot be started above maximum AAPP lighting altitude, start the AAPP, check that its alternator output is normal and that the starboard TURBINES ON LOAD light goes out when the AAPP power magnetic indicator is horizontal. Switch on No. 2 T/R unit, fuel booster pumps as required and No. 2 hydraulic pump motor.

(vii) If a main engine or engines are subsequently relit switch ON the appropriate alternator(s) when the output is normal. Check the MV PARALLELING switch is at NORMAL, synchronise alternators and switch on MV and LV loads as required. Select standby YAW DAMPER to STANDBY and main yaw damper ON. Retract RAT scoops as required.

31 Failure of 115-volt 3-phase 400 CPS supplies

Failure of Nos. 1 and 3 transformers will only be indicated by failure of their associated equipment. Nos. 1, 2 and 4 transformers have no standby supplies. If No. 3 transformer fails, its loads may be transferred to No. 2 transformer by selecting the frequency changer LOAD TRANSFER switch to the No. 1 position. (Before doing so ensure that No. 1 frequency changer is running and its neon light illuminated.) If No. 2 or 4 transformers fail, the MFS at the appropriate pilot's position will fail, the MFS power failure warning light will illuminate and both attitude fail flags will come down.

32 Failure of a frequency changer

Failure of a frequency changer will be indicated by a failure of its neon indicator light and, if the LOAD TRANSFER switch is selected to the failed frequency changer, by failure of its associated equipment. Check that the other frequency changer is running and its neon indicator light is illuminated, or if necessary START the other frequency changer. Then select the LOAD TRANSFER switch to the other position. No. 2 frequency changer is normally

FER switch to the No. 1 position will also cause the loads of No. 3 transformer to be transferred to No. 2 transformer. The pilots should be informed that both the 1st pilot's MFS and standby horizon are now being fed from No. 2 transformer.

33 Failure of a T/R unit

Failure of a T/R unit will be indicated by the voltage of the associated LV bus-bar falling to 24 volts or less and by the battery showing a discharge. The T/R unit magnetic indicator may be horizontal or vertical. If the indicator is horizontal switch OFF the T/R unit, check that battery voltage and amperage are consistent with its loads and select the LV PARALLELING switch to PARALLEL. Change the T/R unit control fuse and switch on. If the indicator remains horizontal switch OFF the T/R unit and leave it off. If the indicator returns to vertical, deparallel the LV bus-bar, switch ON the T/R unit and check its output is normal. If, when the failure occurred, the magnetic indicator was vertical, switch OFF the T/R unit, check that the battery output is normal and switch the LV PARALLELING switch to PARALLEL. For No. 1 TRU only, check fuse K1/CD to RAT supply c/o switch.

34 Failure of a special feeder

(*a*) Failure of a special feeder will be indicated by a number of the indicators on the generating panel BF changing to the striped indication. The appropriate special feeder indicator will show OFF and the associated LV VOLTS and LV CURRENT meters will read zero and the TRU and LV magnetic indicators will show cross-line. The appropriate RAT indicator will show a striped indication and the RAT scoop will extend automatically. Check the special feeder circuit breaker. If this is tripped switch OFF the associated LV battery and T/R unit. Switch off the affected services befor re-introducing the power supplies. Then reclose the circuit breaker. If the circuit breaker remains closed, the indicators should revert to their normal indications. Switch ON the battery and the T/R unit

RETRACT. However, if the 1P8 circuit breaker trips a second time, select the LV PARALLELING switch to PARALLEL and switch on loads as required. If the 2P8 circuit breaker trips a second time no LV paralleling action can be carried out.

(*b*) Under these conditions the inoperative indicators will remain striped, the POWER FAILURE warning lights of the two associated alternators will be inoperative and two engine fire-warning lights and fire-extinguisher systems will be inoperative.

(*c*) If the special feeder circuit breaker was found to be closed reduce loads and switch the special feeder control switch to EMERGENCY. This should make the indicators on panel BF operative, and the special feeder indicator should read ON. Check the appropriate battery indicator and LV voltmeter. If the battery indicator is vertical and the LV voltage low or zero. switch off the battery and T/R unit and retract the RAT intake. Do not parallel the LV bus-bars as a bus-bar fault is indicated. Should the battery indicator be horizontal and the LV voltage normal when checked, a battery or battery-lead fault is indicated. The battery should be switched off and the RAT intake retracted.

35 LV battery fault

An LV battery fault will be indicated by the associated magnetic indicator showing horizontal. Select the appropriate special feeder to EMERGENCY and switch OFF the failed battery. Change the battery control fuse (No. 1—AJ/L10, No. 2—AJ/L16) and switch the battery ON. If the battery indicator shows vertical return the special feeder switch to NORMAL. If the battery indicator remains horizontal, switch the battery OFF and leave OFF.

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

fuel system tankage can be increased by the carriage of a drop tank under each wing and 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 (*c*) All the fuel system controls are in the cockpit. 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 are the individual tank control switches and on side panel AAJ are the individual tank indicators for refuelling and defuelling.

2 Tank capacities

The following table shows the approximate usable fuel capacities, in pounds and calculated at 8lb/gallon.

Group	*Tank and Location*	*No. off*	*Galls per tank*	*Pounds total usable fuel*	*Booster pumps per tank*
Wing, port & stbd.	No. 1, centre section	2	608	9,728	2
	No. 3, inner plane .	2	261·5	4,184	1
	No. 4, inner plane .	2	321	5,136	1
	No. 5, inner plane .	2	338	5,408	2
	No. 6, outer plane .	2	472	7,552	2
Fuselage	No. 7 centre section	2	746·5	11,944	2
	No. 8A, centre section	1			
	No. 8B, bomb-bay roof . . .	1	621	4,968	2
	No. 10A & B, bomb-bay roof . .	1	388	3,104	1*
	No. 11, bomb-bay roof . . .	1	754	6,032	2
	No. 12, rear fuselage	2	621	9,936	2
	TOTAL INTERNAL TANKS			67,992	
Long range	Drop tanks . .	2	1,655	26,480	2
	Aft, bomb-bay .	1	988	7,904	2
	Forward, bomb-bay .	1	988	7,904	2
	TOTAL WITH LONG-RANGE TANKS			110,280	

* A second pump is provided exclusively for AAPP supply

3 Fuel proportioners

(*a*) Three air-driven fuel proportioners are provided, one for each wing and fuselage group. Fuel from the drop tanks, bomb bay tanks and No. 10 fuselage tank is not proportioned. The air for driving the proportioners motors is tapped from the high pressure stage of the engines.

(*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 pair of rotors, a combined NRV and surge valve, a pressure regulating valve and a bypass valve controlled by a electric actuator.

(*d*) Each proportioner motor is controlled by an air throttling valve and a centrifugal governor which prevents overspeeding by controlling the air supply.

(*e*) Additionally a mass valve is incorporated to shut off the proportioner motor under negative G conditions, in which case the engines are kept running by the recuperators.

4 Fuel recuperators

Four fuel recuperators are provided and are piped in pairs, each pair feeding two engines. Each recuperator is of 5-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.

5 Fuel feed to the engines

(*a*) *Fuselage group*

From the fuselage proportioner fuel is fed to the engine gallery line, between two electrically operated NRV's, to each pair of engines via the LP cocks. The fuel from No. 10 fuselage tank is fed direct

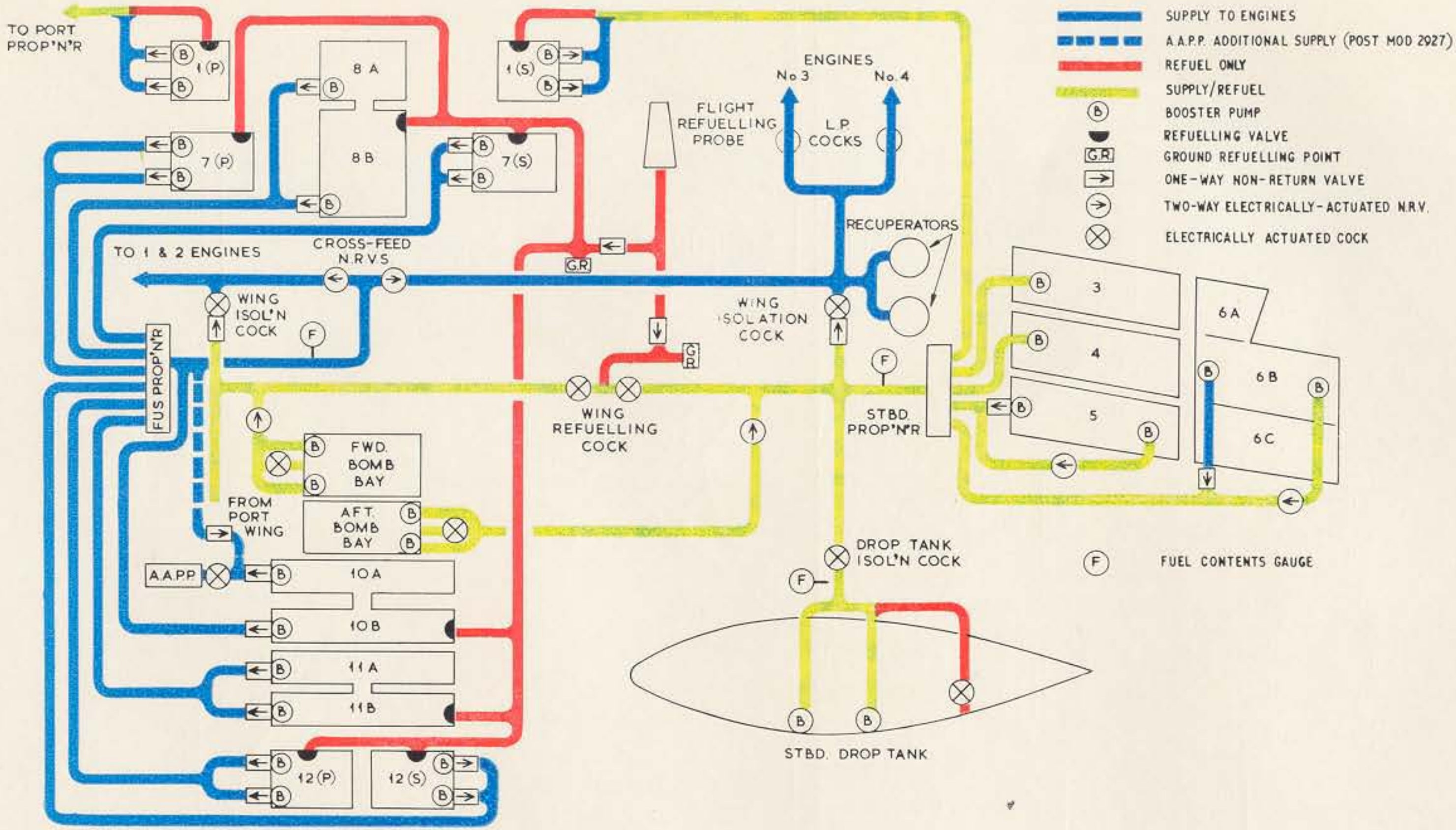
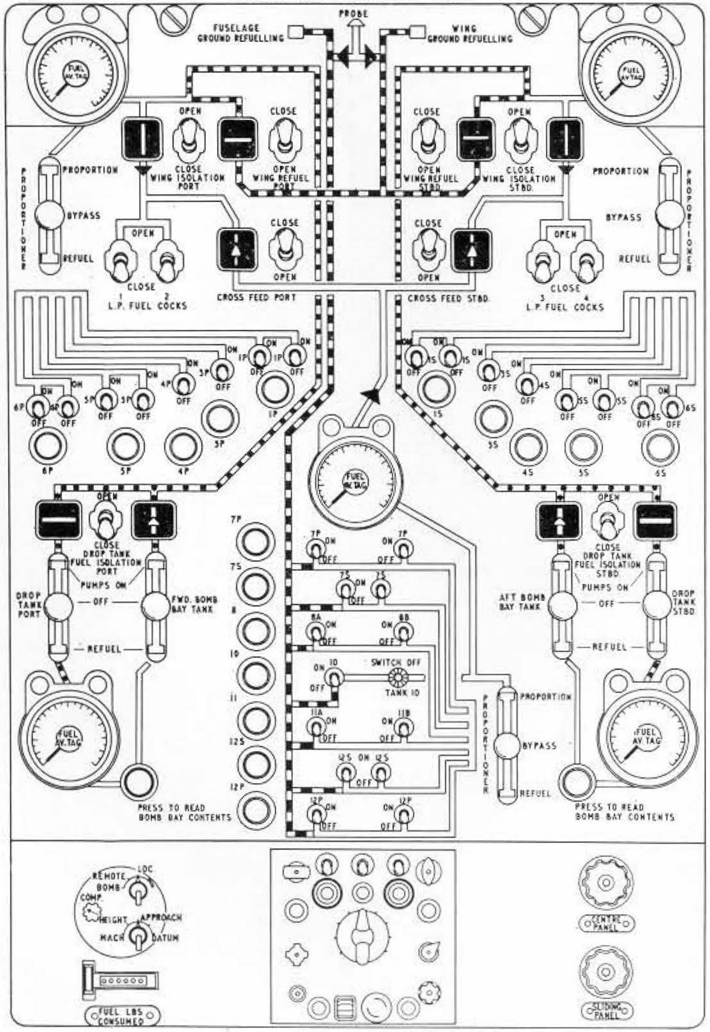
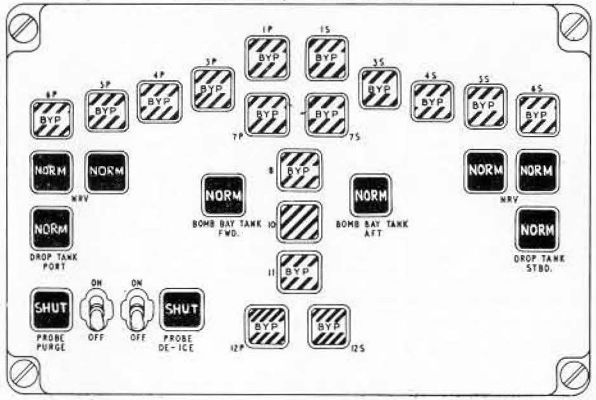


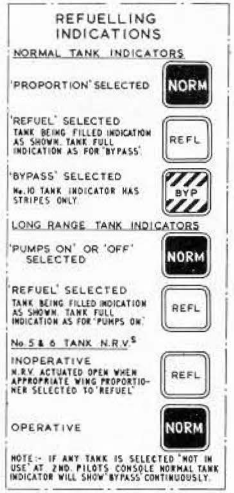
Fig. 1 Fuel system diagram

PILOTS' FUEL CONTROL PANEL

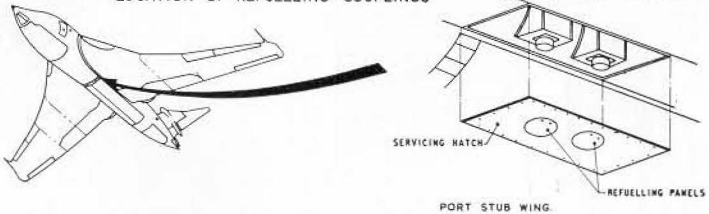


SECOND PILOT'S SIDE PANEL

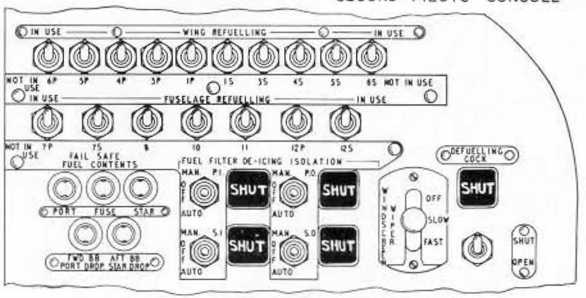


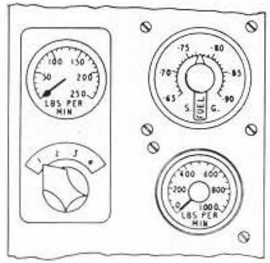


LOCATION OF REFUELLING COUPLINGS



SECOND PILOT'S CONSOLE





(*b*) *Wing groups*

(i) 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 an electrically-operated NRV and the aft bomb-bay tank into the starboard gallery line. Cross feeding from the wing groups is prevented by wing refuelling cocks in the wing gallery line and by the previously mentioned electrically-operated NRV's in the engine gallery line. These NRV's may be actuated should cross-feeding become necessary.

(ii) Fuel from each drop tank is fed through a drop tank isolation cock into the associated wing gallery line.

6 Fuel feed to the AAPP

(*a*) The normal fuel supply to the AAPP is tapped from the fuselage gallery line.

(*b*) When the fuselage booster pumps are OFF, or without MV power, a standby AAPP fuel supply is drawn from No. 10A tank by a 28v, 5 PSI booster-pump which operates automatically whenever the AAPP is in use.

(*c*) When using standard fuel handling procedures and the fuselage group becomes empty, i.e. total fuel state 6,000 lb., a reserve of 20 gallons is retained in No. 10 tank for AAPP supply. This is delivered by the 28v booster-pump and is sufficient for approximately 30 minutes running.

(*d*) If it is necessary to run the AAPP for a long period when the fuselage booster-pumps are normally off, see para. 28.

7 Tank pressurisation system

(*a*) The internal fuel tank pressurisation system automatically maintains a 2·5 to 4 PSI differential pressure between the fuel tanks and atmosphere for all conditions of flight. The system is divided into ducts of all four engines. One or more engines or the AAPP can pressurise all three groups. A vent valve gives both inward and outward venting should the normal control system malfunction, outward venting ocurring when the differential pressure exceeds $3\frac{1}{2}$ PSI and inward venting when differential falls below 0 PSI.

(*b*) *Drop tanks*

No drop tank pressurisation is provided.

(*c*) *Bomb-bay tanks*

When a forward bomb-bay tank only is fitted, it is vented via the fuselage system and is pressurised via the vent line to the same value as the fuselage system. When both bomb-bay tanks are fitted, only the forward tank is pressurised, provided that it is vented into the fuselage system, but not if it is vented into the aft tank. The aft tank is never pressurised. When Mod. 2526 is embodied the bomb-bay tank pressurisation system is deleted.

8 Ground refuelling system

(*a*) Two pressure refuelling connections are in the port wing root, one for refuelling both wing groups, bomb-bay tanks and the drop tanks and the other for refuelling the fuselage tanks.

(*b*) The wing groups are refuelled via the normal gallery lines and proportioners, but the fueselage 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.

◂ 9 Fuel jettison system

(*a*) When Mods. 4131, 4132 and 4133 are all incorporated a facility is provided whereby fuel may be jettisoned from the wing groups, the drop tanks and the fuselage group tanks simultaneously at a (*b*) With the jettison facility selected fuel is jettisoned from:

(i) Both drop tanks (and wing groups) by a combination of gravity and ram air intake pressure through a jettison cock at a total rate of approximately 2,500 lb/min.

(ii) The fuselage group by booster pump pressure, through the fuselage proportioner into the refuelling line via the defuelling cock and overboard through a jettison cock and pipe at a rate of approximately 2,000 lb/min. ▶

Controls and Indicators

10 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
Two wing refuel switches and indicators
Four LP cock control switches
Two crossfeed NRV switches and indicators
Twenty-nine booster pump switches
Two drop tank isolation switches and indicators
Two drop tank booster pump controls
Two controls, one for fwd and one for aft bomb-bay tank booster pumps, and NRV indicators
Five fuel contents gauges
Two drop tank/bomb-bay tank fuel gauge selector push switches
Seventeen individual tank contents push switches
Fuel consumed counter.

11 Internal tanks booster pumps controls

(*a*) Twenty-nine single-pole ON—OFF switches control the aircraft booster pumps. Eight are provided for each wing group and

(*b*) The switch toggle arms are coloured either red or green. This denotes that a pump is either supplied by the port (red) generating system or by the starboard (green) system. The breakdown of the various pumps supplied by individual busbars is as follows. (Where two pumps are installed in a tank these are referred to as A and B pumps.)

Bus-bar	*Pump*
No. 1 .	1(P)A, 6(P)B, 1(S)A, 6(S)A, 7(S)A, 8A, 10, 12(S)A
No. 2 .	3(P), 5(P)B, 4(S), 5(S)A, 7(P)A, 11(B), 12(P)A
No. 3 .	4(P), 5(P)A, 3(S), 5(S)B, 7(P)B, 11(A), 12(P)B
No. 4 .	1(P)B, 6(P)A, 1(S)B, 6(S)B, 7(S)B, 8B, 12(S)B

NOTE: The above table is consequent to the embodiment of Mod. 3904, which reversed the supplies for pumps 11(A) and 11(B), 5(P)A and 5(P)B, and 6(P)A and 6(P)B.

▶◀

12 Bomb-bay tanks booster pumps controls

(*a*) The FWD BOMB-BAY and AFT BOMB-BAY TANK gated control switches, PUMPS ON—OFF—REFUEL, are on the port and starboard side of the fuselage tank booster pump switches.

(*b*) A locking sleeve below each switch toggle must be raised before the switch can be moved from one of the gates to either of the other two gates.

(*c*) Forward of each switch is a magnetic indicator which shows the direction of flow through the electrically-operated NRV. Indications are as follows:

PUMPS ON . .	An arrow points away from the switch
OFF . . .	As above

(*d*) The refuelling cock indicators on panel AAJ show NORM with PUMPS ON or OFF selected and REFL with REFUEL selected until operation of the high level float switch, when the refuelling cock will close and the indicator return to NORM.

13 Drop tanks booster pumps controls

(*a*) Outboard of the two bomb bay tank switches are two similar DROP TANK, PUMPS ON—OFF—REFUEL switches which operate as described in para. 12(*b*) and (*d*).

(*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 or the cock is in an intermediate position.

14 Drop tanks jettison control

The DROP TANK RELEASE, SAFE-JETTISON switch is on 1st pilot's panel AC and is held up to jettison both drop tanks. ◀ Mod. 3949 introduces a guard over the switch. Post-Mod. 4130 the switch is operated in a fore and aft direction, moving it forward jettisons the drop tanks. ▶

15 Fuel proportioner controls

(*a*) Three PROPORTIONER, PROPORTION — BYPASS — REFUEL control gated switches are situated, one at each forward corner of the panel and one at the aft end of the panel. Each one has a locking sleeve which must be raised before the control switch can be moved to one of the three positions.

(*b*) The settings of the switch are:

PROPORTION . 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 "

BYPASS . . All cells in the particular proportioner are set

REFUEL . . The cells of the wing proportioners are set to the refuel position, but the cells of the fuselage proportioner are set to the by-pass condition. The solenoid operated refuelling valves are energised. The air motors are closed down

NOTE: Operation of a high level float switch during refuelling causes a wing tank proportioner cell to go to bypass or, in the case of the fuselage, a refuelling valve to close. In both cases the appropriate indicator on panel AAJ changes from REFL to BYP.

(*c*) Individual cell bypass selection switches, IN USE—NOT IN USE are on the second pilot's console AF and are set to NOT IN USE for any tank not required to be refuelled. Selections on these switches override any selection on the proportioner switches.

(*d*) Proportioner magnetic indicators which give NORM (proportion) REFL (refuel) BYP (by-pass) indications are on 2nd pilot's panel AAJ.

16 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. The gauges are fuel density compensated.

(*b*) A series of spring-loaded push buttons, one for each internal tank are adjacent to the booster pumps switches. When any one button is pressed the associated group contents gauge will indicate the contents of the selected tank. Two buttons in any one group must never be pressed simultaneously.

(*c*) Adjacent to each drop tank/bomb-bay tank contents gauge is a PRESS TO READ BOMB-BAY TANK CONTENTS button, since these gauges normally read drop tank contents.

(*d*) On the second pilots' console AF are five buttons, one of each fuel gauge, marked FAIL SAFE, FUEL CONTENTS. If a gauge reading is suspect pressing the relevant pushbutton will cause the gauge reading to decrease; releasing the button will cause the needle to return to the correct reading only if the gauge is service-

17 Wing isolation cocks switches and indicators

(*a*) An isolation cock in each wing-to-engine gallery line is controlled by a WING ISOLATION, OPEN-CLOSE switch. The cocks must always be open unless flight refuelling is taking place when it is essential that they be closed to prevent the possibility of air-contaminated fuel from the probe to pass into the engine gallery lines.

(*b*) A magnetic indicator outboard of each switch gives flow line indication of the position of the cock, or a striped indication if electrical supply is lacking.

18 Wing refuelling cocks and indicators

(*a*) Two isolation cocks are provided in the wing fuel gallery lines one either side of the refuelling connection. They are controlled by two WING REFUEL, OPEN-CLOSE switches inboard of the wing isolation cocks switches. The refuelling cocks are normally kept closed except during wing groups refuelling.

(*b*) A flow line magnetic indicator is adjacent to each switch. A striped indication is given when electrical supplies are lacking.

19 Cross-feed non-return valves and indicators

(*a*) The two cross-feed NRV's in the engine fuel gallery line are controlled by two CROSSFEED, OPEN-CLOSE switches. Normally the switches are left in the CLOSE position but should the port switch be set to OPEN the port wing groups will feed the starboard engines. Similarly setting the STBD switch to OPEN, with the PORT switch at CLOSE, will enable the port engines to be fed by the starboard wing groups.

(*b*) Two magnetic indicators show the direction of the setting of the NRV's by flow line indication. A striped indication is given when electrical supply is lacking.

20 LP cock controls

LP FUEL COCKS, OPEN-CLOSE control switches enable the

21 Fuel flowmeter

(*a*) Each engine is fitted with a flowmeter transmitter and electronic computer. On the second pilot's console AF is a density corrector selector switch by which the signals from the computer may be corrected for various fuel specific gravities.

(*b*) An indicator which shows instantaneous fuel flow in lb/min. (250 lb/min. maximum) of any one selected engine is also on panel AF. A four-position engine selector switch is adjacent.

(*c*) A total flow indicator gives the total instantaneous flow of all four engines. This indicator is also on console AF.

(*d*) A FUEL-LB consumed counter type indicator at the aft end of panel AT records the total fuel consumed by all four engines up to a reading of 999,999. A zeroing wheel is incorporated in the unit.

22 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 system gallery line and this must not be allowed to exceed 100°C.

(*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.

◂ 23 Fuel jettison controls

(*a*) At the bottom left-hand corner of panel AAF is a wire-locked FUEL JETTISON, OPEN/SHUT switch which operates all three

Adjacent to the switch are three FUEL JETTISON COCKS, PORT/FUSELAGE/STARBOARD magnetic indicators which display OPEN and SHUT indications according to the positions of their associated cocks.

(*b*) At the rear end of 1st pilot's panel AE is a new panel AEA which contains three FUEL JETTISON COCKS, PORT/FUSELAGE/STARBOARD circuit breakers. These control the electrical supplies to the individual jettison cocks.

(*c*) The ram air intakes of the drop tanks are provided with electric heater mats. The electrical supplies to these mats are controlled by the AUXILIARY HEATERS ON/OFF switch on panel AD. (See chap. 10 para. 3).

Normal Management of the System

24 General

The main aims of fuel system management are to ensure an adequate and reliable supply of fuel to all engines under all operating conditions and, at the same time to maintain a similar proportion of fuel in each tank so that the aircraft CG position remains reasonably constant within the laid down limits. With all the fuel booster pumps in operation, and all the fuel proportioner switches selected to PROPORTION, balancing should be achieved automatically. (Fuel from No. 10 tank does not feed through a proportioner, but as these tanks are situated close to the desired aircraft CG position, the use of fuel from them is governed by considerations other than the maintenance of CG position). 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 control the ratios of wing/fuselage loads.

25 Selection between fuel tank groups

(*a*) When changing from one source of fuel supply to another (i.e. making selections between fuel tank groups) it is essential to ensure

switching off the original supply. If a tank group proportioner is selected to PROPORTION and the booster pumps in that tank group are not operating, fuel supply from that group may be inadequate to supply the engine requirements. In order to avoid engine malfunction due to fuel starvation, when making selections between fuel tank groups the proportioner and booster pump switches must be selected in the correct sequence as follows:

(*b*) *Changing to Wing groups from Fuselage group*

Wing tank booster pump switches . .	ON
Wing groups proportioner switches . .	PROPORTION
Fuselage group proportioner switch . .	BYPASS
Fuselage tank booster pump switches .	OFF

(*c*) *Changing to Fuselage groups from Wing groups*

Fuselage tank booster pump switches . .	ON
Fuselage group proportioner switch . .	PROPORTION
Wing groups proportioner switches . .	BYPASS
Wing tank booster pump switches . .	OFF

(*d*) *Selecting bomb-bay tanks*

Both Tanks ;

FORWARD AND AFT BOMB-BAY TANK switches	Both PUMPS ON

One Tank only ;

CROSSFEED PORT AND STARBOARD switches	Both OPEN
Appropriate BOMB-BAY TANK switch .	PUMPS ON

The reverse switching order should be used to select bomb-bay tank(s) off.

(*e*) *Selecting Wing Drop Tanks*

PORT and STARBOARD DROP TANK ISOLATION switches	Both OPEN

PORT AND STARBOARD DROP

26 Fuel system control before flight

(*a*) 2,000 lb of fuel must always be loaded into the bomb-bay tank irrespective of the total fuel load. It can be used at the end of the sortie as detailed in para. 27.

(*b*) It is not considered advisable to start a flight with an unserviceable tank unless its fuel line is blanked off and its proportioner cell is set to NOT IN USE.

(*c*) If it is intended to fly with an unserviceable booster pump in any tank containing only one pump, the tank must be filled to a minimum of 50% of its capacity and its proportioner cell set to NOT IN USE. Amend the fuel drill to maintain the CG within limits. An unserviceable pump in a tank containing two pumps does not affect the fuel drill.

(*d*) Before starting the engines carry out the checks of fuel control indications in accordance with the aircraft check list. If, for any reason, any tanks do not contain fuel, or are not intended to be used during flight, the appropriate IN USE/NOT IN USE switches should be selected to NOT IN USE. All other tank switches should be selected to IN USE.

NOTE: Although No. 10 tank may not be used to supply the main engines, its switch should be selected to IN USE.

(*e*) The booster pump which supplies fuel from No. 10 tank to the AAPP will operate when the AAPP START SELECTOR switch is moved from the OFF position, and no selection by the pilots is required to supply fuel to the AAPP for starting.

(*f*) Start the main engines with the fuselage group booster pumps ON, and all proportioners selected to BYPASS (until a main engine is started there will be no air supply to drive the proportioner motors). When all engines have been started, select the fuselage proportioner to PROPORTION.

(*g*) Before taxying select wing group booster pumps ON and wing proportioner to PROPORTION. Select the fuselage proportioner

27 Fuel system control in flight

(*a*) Take-off with all proportioners selected to PROPORTION and booster-pumps for all tanks containing fuel ON.

(*b*) When the contents of No. 10 tank reach 500 lb switch its booster-pumps OFF.

(*c*) When a bomb-bay tank contents falls to 2,000 lb., switch the tank off.

(*d*) When the drop tanks are empty, select their isolation cocks CLOSED and switch their booster-pumps OFF.

(*e*) When the fuselage group contents fall to 6,000 lb, select the fuselage proportioner to BYPASS and switch the fuselage booster-pumps OFF.

(*f*) When the wing group contents fall to 3,000 lb per group switch on pumps for all tanks containing fuel, except No. 10 tank, and select all proportioners to PROPORTION.

(*g*) When the bomb-bay tanks are empty, i.e. total fuel state 12,000 lb, proceed as follows:

(1) All wing and fuselage booster-pumps ON

(2) Fuselage proportioner selected to BYPASS

(3) Wing proportioners selected to PROPORTION

(4) Start the Artouste and run at ELECT for the remainder of the sortie. If unable to start the Artouste, land as soon as practicable.

(*h*) If it becomes necessary to operate below the normal minimum fuel reserve of 8,000 lb proceed as follows:

(1) Select both crossfeed NRV's OPEN

(2) Restrict engine RPM to 90% maximum

(3) Use only shallow angles of climb or descent.

◄ (*j*) *Inadvertent emptying of a fuselage tank*

(i) If a fuselage tank is inadvertently emptied there is a risk of engine flame-out due to air ingress. To prevent flame-out, handle the fuel in the normal way until the fuselage group contents fall pumps ON. Carry out a manual fuel drill on the wing groups ensuring that not more than three pumps in each group are switched off at one time.

(ii) If the fuselage proportioner is serviceable it should be left in PROPORTION with the pumps ON. If unserviceable, it should be put to BYPASS with the pumps OFF.

(iii) When the wing group contents are down to 3,000 lb each, revert to the normal fuel drill.

NOTE: When at high level select the fuselage group to BYPASS and fuselage pumps OFF for 30 seconds in every 30 minutes until the fuselage group total falls to 6,000 lb. This is to exercise and warm up the wing proportioners.

28 Fuel system control during emergency use of the AAPP

Should it be necessary to use the AAPP after the fuselage group contents have fallen to 6,000 lb:

(i) Select wing proportioners to BYPASS and check all wing booster-pumps ON.

(ii) Switch all fuselage booster-pumps ON (except No. 10 tank) and select fuselage proportioner to PROPORTION.

(iii) When the total fuel state reaches 12,000 lb revert to normal fuel handling procedure.

29 Use of No. 10 tank

NOTE: The contents of No. 10 tank must be reduced early in the flight to eliminate bleed from the recuperators overfilling the tank and entering the vent trunk.

The fuel from No. 10 tank does not pass through the proportioner and it therefore overfeeds the remainder of the fuselage group. No. 10 booster-pump should be used as in para. 27, the contents being carefully monitored while the pump is ON.

30 Contents checks

Systematic checks should be made of all tank contents every thirty minutes when cruising at 40,000 ft. or above, and more frequently 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 gauge. 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 an attempt should be made to balance the fuel in a group of tanks by manual manipulation of the NOT IN USE switches. If a fuel tank gauge reading fault is suspected the appropriate FAIL SAFE switch on the 2nd pilot's starboard console should be pressed. The gauge reading should decrease by approximately 1,000 lb on the total contents scale, and return to its correct reading when the push-button is released. Failure of the needle to move indicates a faulty gauging system.

31 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 light 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 vent temperature exceeds 100°C the fuselage isolation switch must be set to ISOLATE until the temperature reduces below this figure.

32 Fuel jettisoning

(a) Before jettisoning

(i) As some fuel contamination of the rear fuselage may occur, all electrical equipment in the tail cone must be switched off. The airbrakes may be used; contamination is slightly reduced if the airbrakes are extended as fuel is being jettisoned.

(ii) To ensure that an adequate fuel supply is available to the engines, the wing groups must be on with their proportioners at BY-PASS.

(iii) The pumps of all fuselage tanks containing fuel must be on and the proportioner should be set to BYPASS for maximum fuel discharge or to PROPORTION for slightly reduced proportional discharge. The fuel tank pressurisation system should be on, otherwise the jettison rate is reduced.

(iv) The fuselage defuelling cock must be selected shut so that it closes automatically when the jettison switch is selected off or when the fuselage jettison circuit breaker is tripped, otherwise fuel is jettisoned if the fuselage jettison cock fails to shut.

(v) Check that the three fuel jettison circuit breakers are made; normally, they should be made before take-off. The fuselage circuit breaker should not be opened in flight but the drop tank circuit breakers should be opened when the tanks are empty to remove a standing positive in each tank circuit.

(vi) The drop tank isolation cocks must be closed to prevent wing fuel flowing to the drop tanks.

(*b*) *Jettisoning*

(i) Set the jettison switch to open and check that the fuselage defuelling cock indicates open.

(ii) Carefully monitor individual tank contents while fuel is being jettisoned to ensure that the CG remains within limits and to avoid excessive wing asymmetry.

(iii) Check that the jettison rate from the drop tanks is approximately equal and switch off the drop tank pumps.

(iv) Stop jettisoning when the fuselage group contents reach 6,000 lb; check that the fuselage defuelling cock indicates shut.

(*c*) *After jettisoning*

(i) Reset the fuel system as required and revert to the normal fuel handling procedure, switching off the bomb-bay tank pumps when they are empty. It may be necessary to proportion the fuel in all groups manually.

(ii) Electrical circuits in the drop tanks must not be used after fuel has been jettisoned.

(iii) To prevent a fire hazard, jettisoning must be stopped before landing. At all times, care is required to avoid striking the fuselage jettison pipe on the ground.

(iv) After landing the aircraft must be cleared of fuel contamination of the rear fuselage.

Malfunctioning of the System

33 Asymmetric wing contents

(*a*) Although it is possible to fly the aircraft with maximum fuel asymmetry (i.e. one wing group full and the other empty) the maximum permissible difference for landing is 8,000 lb and this should be regarded as the maximum acceptable asymmetry in flight. If this state is approached manual fuel balancing will be necessary. To balance the fuel:

(*b*) (i) Set both crossfeed control switches on the fuel control panel to OPEN.

(ii) Select the proportioner switch for the heavy wing to BY-PASS.

(iii) Monitor the contents gauges and when fuel balance is achieved select the proportioner to PROPORTION, select both cross-feed control switches to CLOSE.

(iv) Do not cross-feed if either wing group contents is less than 3,000 lb.

34 Booster pump failure

(*a*) Tanks 1P, 1S, 5P, 5S, 6P and 6S in the wing groups, and tanks 7P, 7S, 8, 11, 12P and 12S in the fuselage group have duplicated fuel booster pumps. Both bomb-bay tanks and both wing drop tanks also have duplicated booster pumps. Thus single pump failure in any of these tanks will not affect fuel proportioning.

(*b*) (i) Tanks 3P, 3S, 4P and 4S in the wing groups have only one pump per tank. A failure of any one of these booster pumps will be revealed by a constant tank contents reading on a series of tank contents checks. There is no safe method available for extracting fuel from these tanks following booster pump failure, and fuel remaining in the tank at the time of the failure must be considered unusable.

(ii) Owing to their position, this will have little effect on movement of the aircraft CG, but may cause unbalance between the wing groups total contents. Balance may be achieved by switching OFF the booster pump in the appropriate tank in the opposite wing, or by the method described at 33 above.

(*c*) No. 10B tank in the fuselage tank group also has a single booster pump for delivering fuel for use by the main engines. Failure of this booster pump will mean that fuel remaining in the tank at the time of pump failure will not be available to supply the main engines, but this fuel will still be available to supply the AAPP.

(*d*) 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 switched to NOT IN USE. Adjust 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.

35 Proportioner failure

(*a*) Complete failure of a proportioner whilst its control switch is selected to PROPORTION and associated booster pumps are ON will result in a total failure of the fuel supply from all tanks in its associated tank group to the engines. Indications of failure and actions to be taken are as follows:

(*b*) *Failure of fuselage group proportioner when fuselage group only is supplying the engines*

(i) *Indication*

Illumination of low pressure fuel warning lights for all four

(ii) *Immediate action*

Select all wing pumps ON.

(iii) *Subsequent action*

Select the fuselage proportioner switch to BYPASS, and the wing proportioners to PROPORTION. Check that the fuselage group is feeding, select the wing groups to BYPASS, pumps OFF and carry out manual balancing of fuselage fuel.

(*c*) *Failure of a wing group proportioner whilst wing groups only are supplying their respective engines*

(i) *Indication*

Illumination of the fuel low-pressure warning lights for the two engines supplied by the affected wing group.

(ii) *Immediate action*

Select all fuselage pumps ON.

(iii) *Subsequent action*

Select the failed proportioner switch to BYPASS. Check fuel control panel selections, e.g. for the accidental closing of a wing isolation cock. Select the fuselage group to PROPORTION, check that the affected wing group is feeding, select the fuselage group to BYPASS, pumps OFF and carry out manual balancing of wing fuel.

(*d*) *Failure of any one proportioner when there is an alternate supply of fuel to the engines (e.g. both wing groups and fuselage group in use)*

Failure will be revealed during routine tank contents checks by complete lack of flow from the tanks in the affected group. Select the failed proportioner to BYPASS and by selective use of the booster pumps maintain the individual tank contents in approximate proportion.

36 Proportioner air motor blanked off

When an air motor has been blanked off an appropriate *red* ink entry is to be made in F.700. In these circumstances operate the and conducted so as to preclude any possibility of landing with less than 8,000 lb of fuel.

37 Seized wing proportioner rotor

If an aircraft has to be operated with a seized proportioner rotor, make an appropriate entry in F.700 and operate the fuel system as follows:

(*a*) *Pre-flight*

Select the unserviceable proportioner to BYPASS and the associated IN USE/NOT IN USE switches to NOT IN USE. (Do not alter these selections during the sortie).

(*b*) *Pre Take-off*

Select both wing groups to BYPASS.

(*c*) *After Take-off*

On completion of the after take-off checks, switch OFF the booster-pumps of the wing group with the unserviceable proportioner and select the serviceable proportioner to PROPORTION.

(*d*) *Proportioning wing fuel*

If unequal feeding has occurred during take off,

(i) Operate the booster-pumps of the group with the U/S proportioner as necessary to achieve correct proportioning.

(ii) Correct proportioning for the group with the serviceable proportioner can be achieved by operation of the IN USE/NOT IN USE switches.

(*e*) *When fuselage group contents falls to* 6,000 *lb*

(i) Switch on all wing booster-pumps

(ii) Select fuselage group to BYPASS and switch off the fuselage booster-pumps.

(*f*) *When wing group contents fall to* 3,000 *lb each*

(i) Select all proportioners to BYPASS

(ii) Switch on all booster-pumps.

NOTE: If it is necessary to use the 2,000 lb. of fuel previously left in the bomb-bay tanks, serviceable proportioners must be set to PROPORTION and the booster-pumps of a wing group with a U/S proportioner must be

(*g*) *Planning*

The sortie is to be planned and conducted so as to preclude any possibility of landing with a fuel state below 8,000 lb.

38 Backing pump failure

Failure of a backing pump will be indicated by illumination of the fuel low pressure warning light of the affected engine. It may also be accompanied by fluctuating or reducing RPM. Throttle back the affected engine, reducing RPM until the warning light goes out. (If the light fails to go out before throttle is fully closed, check for accidental closing of LP cock switch.)

39 Engine failure

Following engine failure, if wing tank groups are in use, select both crossfeed control switches to OPEN and allow the remaining engines to feed from both sides. Make periodic checks of balance of wing contents and adjust if necessary.

40 Leaking tanks

(*a*) A leaking fuel tank will be indicated by a continous and disproportionate decrease in its fuel level relative to other tanks in the same group. It may be confirmed by switching OFF the booster pumps in that tank, with the proportioner selected to PROPORTION, and noting whether its fuel contents continue to decrease.

(*b*) To minimise fuel loss and reduce the amount of fuel available to leak into the airframe, the leaking tank should be used exclusively to feed two engines until it is almost empty.

(*c*) Select the appropriate group switch to PROPORTION, switch ON all fuel pumps and select the IN USE/NOT IN USE switch of the leaking tank to NOT IN USE, thus ensuring that this tank will feed more quickly than the other tanks in the group.

(*d*) When the leaking tank is empty switch OFF the booster pump and leave the IN USE/NOT IN USE switch at NOT IN USE.

(*e*) If it is necessary to fly with a fuel tank that is known to be unserviceable, the fuel line from that tank must be blanked off and

Part I

Chapter 3—Flight Refuelling System

List of Contents

Description

1 General

(*a*) A probe and drogue flight refuelling system is fitted. The 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
Port and starboard drop 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

(*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 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, starboard, 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.

Controls and Indicators

3 Flight refuelling controls

(*a*) During refuelling the proportioner switches of tank groups tanks to be refuelled are selected by seventeen IN USE—NOT IN USE switches on panel AF. Magnetic indicators on panel AAJ give NORM—REFL—BYP indications.

(*b*) The drop tanks and bomb-bay tanks are selected for the refuelling condition by setting their booster pump control switches to REFUEL.

4 Nitrogen purge control and indicator

The PROBE PURGE ON—OFF switch is also on panel AJ and when set to ON, purging takes place. A magnetic indicator shows white when this is taking place. When purging is complete and the float switch in the float chamber between the probe and tank 7(S) operates, the indicator reverts to black. This is an indication to switch off the system.

5 Probe lights

Two lights are 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.

Normal 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 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:

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

(ii) The minimum distance of the CG forward of the normal 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:

(i) Longitudinal CG—6 inches forward to 2 inches aft of the present limits.

(ii) Wing fuel asymmetry may be at the 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 lb/ft and this is exceeded when one drop tank is empty and the other is full.

(ii) If the CG or wing fuel asymmetry limits are exceeded they should be regained by selective use of fuel 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 a minimum of 6,000 lb of fuel in the fuselage group, the following restrictions apply:

(i) If the port wing refuelling cock fails to open, do not refuel the drop tanks and restrict the contents of the rear bomb-bay tank to 4,000 lb.

(ii) If the starboard wing refuelling cock fails to open, do not refuel the drop tanks.

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

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

(v) If any failure results in the forward bomb-bay tank failing to receive fuel, the rear bomb-bay tank contents should 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 wing refuelling 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 6,000 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, when the drop tanks are to be refuelled, select the drop tank isolation cocks open. The wing refuelling cocks must be closed to ensure that any air in the probe or the fuel lines is passed to the fuselage tanks and not to the engines during the intial 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. If pressure is above

(*c*) *In contact*

(i) After contact, the fuel gallery pressure gauge starts to register. With the tanker main pump operating and tanks receiving, the pressure should be 5—45 PSI; the fuel flow is approximately 4,000 lb/min., reducing slightly as the tanks fill. If the tanker main pump is not operating, the fuel flow is approximately 1,500 lb/min. Once fuel is seen to be flowing to the fuselage tanks, open the wing refuelling cocks.

(ii) While fuel is being received, ensure that the limits in para. 6 are not exceeded, particularly in cases of wing refuelling cock failure.

(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
13,700 lb each

Fuselage group
27,000 lb.

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 one bomb-bay tank only, stop refuelling it when its contents reach 7,000 lb.

(v) When filling both bomb-bay tanks, stop refuelling the first tank to reach 7,000 lb 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 7,000 lb. If fuel continues to flow to both tanks, break contact immediately.

(vi) When filling the drop tanks, stop refuelling each tank when its contents reach 10,000 lb; refuelling beyond 10,000 lb is safe but results in fuel venting.

(vii) If, at any time, the magnetic indicator of one proportioner refuelling the appropriate group. If a No. 5 or 6 tank, port or starboard NRV indicator shows striped, close the appropriate wing refuelling cock.

(viii) To stop refuelling, close off sequentially each group receiving fuel starting with the fuselage group, or close the wing refuelling cocks, or break contact. When still in contact with no tanks receiving fuel, the fuel gallery pressure may surge as high as 65 PSI.

(ix) When refuelling the fuselage group only, if the wing refuelling cocks are shut, refuelling must be stopped only by shutting off the tanks individually or by breaking contact.

(x) When refuelling the drop tanks only, refuelling must be stopped by shutting off the tanks one at a time.

(*d*) *After refuelling*

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

(ii) If necessary, use fuel selectively to achieve wing symmetry and transfer fuel internally to satisfy wing relief and CG 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 speed range is from 210 knots at AUW's up to 180,000 lb (increasing linearly to 225 knots at 210,000 lb) to 310 knots from sea level to 24,000 feet reducing linearly to 260 knots/0·85M at 40,000 feet. The recommended range is 240 to 270 knots.

(*b*) The recommended relative closing speed is 2 to 3 knots below and dead astern, keeping the signal lights in view at all times.

(*c*) When waiting to commence and 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 tanker's 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. 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 2nd pilot's instrument panel starts to indicate. Continue the approach until the recommended position is reached.

(*d*) Due to the line of trail of the hose it is difficult to see the yellow band unless it has been freshly painted; the correct refuelling carriage of the HDU is one-third of its travel in from the right-hand side.

10 In contact

Once in contact, make small control movements to hold the correct station, dead astern of the tanker, with the yellow hose markings 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 in-trim 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 which are marked with red and white stripes 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.

(iii) If the red and white stripes are difficult to see, it should be noted that the serving carriage of the HDU is at the left-hand end of its travel when the last few feet of the hose are being unwound.

(*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 is automatically applied, and contact is 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 occurs. 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 posittion; 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 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
Nose-wheel steering
Wheelbrakes
Flaps
Blue Steel doors
Airbrakes
Bomb doors (see Chap. 16)
RAT scoops (close only).

(*b*) The hydraulic fluid is drawn from a tank, divided into two 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
Flaps . . . DOWN
Airbrakes . . . CLOSED

(*d*) The electrical arrangement of the master selectors is such that when an emergency selection is originated the normal master selector closes and the emergency master opens. If the emergency condition 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 total capacity of the system is 20½ gallons of which 5 gallons are contained in the accumulators, when fully charged. The emergency level of the tank is 9½ gallons.

(*b*) Fluid returning to the hydraulic tank from the pumps and services is divided betwen the two compartments.

(*c*) 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 in the cockpit come on to indicate that the float switches have operated.

3 Accumulators

Accumulators are fitted in the main power circuit (one per pump), the wheelbrakes system, the nosewheel steering system and the brake parachute system. Charging details are as follows:

Accumulator	*No. off*	*Location*	*Air charge* PSI
Power .	2	Nosewheel bay . . .	3,000
Wheelbrakes .	4	Nosewheel bay . . .	1,800
Nosewheel steering .	1	Nosewheel bay . . .	350
Brake parachute	1	Rudder stbd fuselage fairing	1,800

Controls and Indicators

4 Hydraulic pump controls

(*a*) A switch for each pump is on the AEO's panel BB. Each switch has three positions, NORMAL—OFF—EMERGENCY. Two green pump contactor lights are above the switches and two pump ammeters are mounted on panel BC. Two red lights on pilots panel AW illuminate when the associated emergency float switches operate and an amber light on panel AZ illuminates if the system reverts to the emergency condition, or if an emergency selection is made.

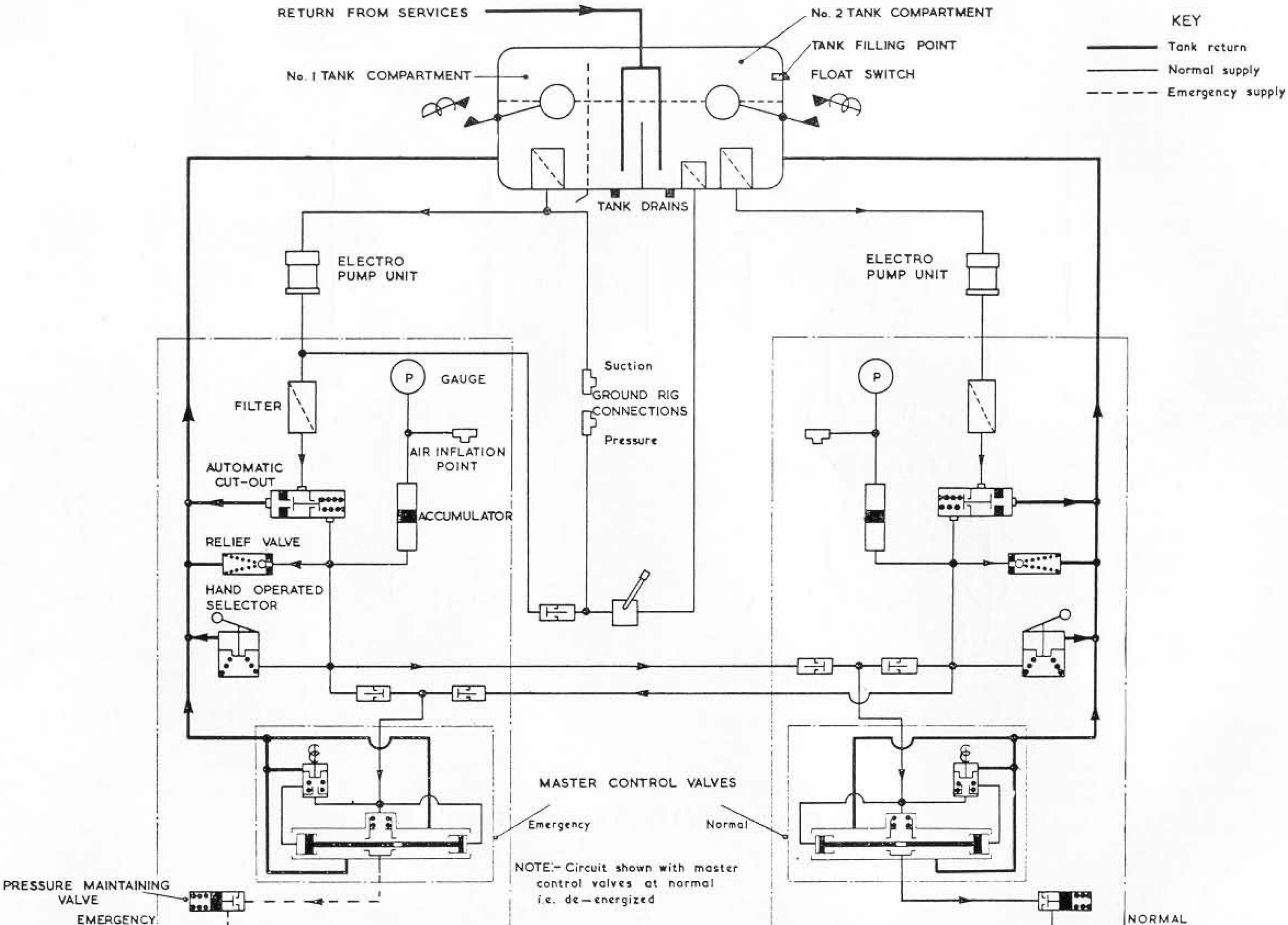
(*b*) When a switch is at NORMAL the green contactor light illuminates to indicate that electrical power is being supplied to the motor and the associated pump runs continuously. An automatic cut-out valve allows the pump to run off-load until pressure falls to 3,600 PSI ± 100 when the valve closes until pressure increases to 4,000 PSI ± 50. If the emergency level float switch operates the power supply to the associated pump motor is interrupted. When the switch is at EMERGENCY the float switch is bypassed.

5 Protection units

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

Undercarriage
Bomb doors
Flaps
Airbrakes.

The purpose of a unit is to isolate the normal supply to the circuit


RETURN FROM SERVICES
No. 2 TANK COMPARTMENT
KEY
Tank return
Normal supply
Emergency supply
TANK FILLING POINT
No. 1 TANK COMPARTMENT
FLOAT SWITCH
TANK DRAINS
ELECTRO PUMP UNIT
ELECTRO PUMP UNIT
Suction
GAUGE
GROUND RIG CONNECTIONS
FILTER
Pressure
AIR INFLATION POINT
AUTOMATIC CUT-OUT
ACCUMULATOR
RELIEF VALVE
HAND OPERATED SELECTOR
MASTER CONTROL VALVES
Emergency
Normal
NOTE:- Circuit shown with master control valves at normal i.e. de-energized
PRESSURE MAINTAINING VALVE
EMERGENCY
NORMAL

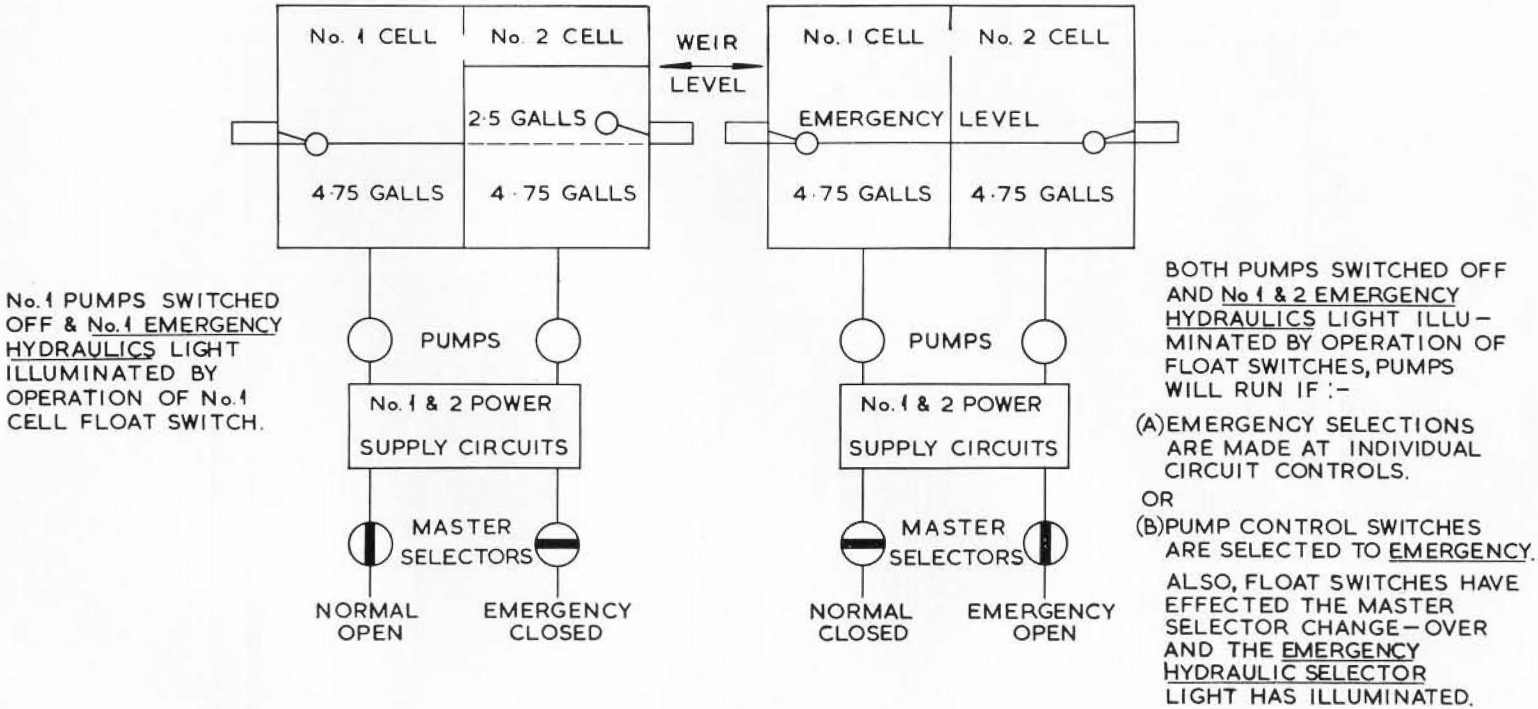


Fig. 2 Hydraulic fluid levels under fault conditions

(*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.

6 Undercarriage control

(*a*) The undercarriage is hydraulically operated and electrically selected by one of three pushbuttons, 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.

(*b*) When the aircraft is on the ground the undercarriage cannot be retracted since micro-switches on the bogie mechanism prevent the completion of the UP circuit until the weight of the aircraft is off the wheels. Additionally the UP button is electro-mechanically locked and cannot be depressed until a pitot switch operates at 105 knots to release the lock. Post-Mod. BC070 an undercarriage test switch is fitted at the rear of panel AE. A TEST selection overrides the 105 knot pressure switch.

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

(*c*) The brakes are automatically applied when an undercarriage UP selection is made 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 undercarriage UP line and the units are cocked, thus applying the brakes.

(*d*) When a DOWN selection is made, the UP line pressure is

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

(*f*) 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 and if the Blue Steel fin remains down when the undercarriage is lowered.

(*g*) Mod. 3733 introduces circuit-breakers on distribution board AJ (in lieu of sealed fuses) for the normal and emergency undercarriage operating circuits and for the undercarriage position indicator.

7 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) An independent system is fitted 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 first 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 starboard wing root, to pass to the undercarriage emergency lowering lines. Once the undercarriage is lowered in this way it cannot be raised

(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

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

(*d*) A hand-operated parking brake is fitted at the forward end of panel AE. A warning light alongside the undercarriage selector switch on panel A comes on whenever the parking brake is applied.

(*e*) *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. When the aircraft has come to rest, no further taxying should be attempted ; have the aircraft towed to dispersal.

9 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 to 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 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 ease of operation.

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

10 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 CLOSE.

(*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*) A two-position magnetic indicator on panel AZ shows IN, or striped according to the position of the airbrakes.

11 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.

12 Braking parachute control

(*a*) The SAFE-STREAM switch is on the 1st pilot's panel AE. When Mod. 3926 is embodied the switch is moved to panel AA.

(*b*) (i) The doors are unlocked by hydraulic pressure and opened by spring pressure. The system is controlled by two SAFE/STREAM selector switches, one for the normal and one for the emergency system, ganged together so that they operate simultaneously. 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 unlock the doors.

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

(iv) Should the parachute inadvertently stream, provided the switches are set at SAFE, it is automatically jettisoned.

13 Flaps control

(*a*) The three position UP, TAKE-OFF, DOWN control switch

selector switch. A position indicator which indicates the positions of both flaps, in divisions, is on panel AZ.

(*b*) When any position is selected, an electrically-operated selector valve allows fluid to flow to a hydraulic motor which mechanically drives the flaps through shafting. When the selected position is reached the selector valve is closed and the flaps are hydraulically locked in position.

14 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 flaps are lowered fully down ; they cannot be raised thereafter. (See para. 23(*d*)(ii)).

15 Ram air turbine scoops

(*a*) The appropriate scoop is held closed by normal hydraulic pressure, if the RPM of either or both engines on the side is above 50%. If the engine speed of both engines on one side is below 50% RPM the appropriate scoop is opened by spring pressure.

(*b*) Control of the scoops is dealt with in Chap. 1, para. 12.

Normal Management of the System

16 Functional and pre-flight checks

Prior to starting the engines, and when an MV supply is available, check the function of both hydraulic pumps and all hydraulic services in accordance with the check list. Check that both BRAKE SUPPLY gauges read 4,000 PSI, and that the pressure does not fall when both pumps are switched OFF. It is recommended that the switches are not moved from NORMAL to EMERGENCY or *vice versa* without pausing at the OFF position. Before taxying select

17 Normal in-flight management

Take-off with one pump at NORMAL and the other at EMERGENCY. On completion of the after take-off checks, and when all hydraulically-operated controls are retracted or closed, switch OFF the second pump and leave the other pump selected to NORMAL. It is recommended that the switching on and off of pump motors at altitude should be avoided except in cases of system failure or malfunction. All flying except during take-off and landing should be carried out with one hydraulic pump selected to NORMAL (and running continuously) and the other pump selected to OFF. The time for operation of some services will be slightly longer than when two pumps are running, but this should not affect the safe operation of the aircraft. Periodic checks must be made of the pump ammeter indications. During the checks before landing, switch the second pump to NORMAL. Both pumps should remain selected to NORMAL for final landings only and until the aircraft is dispersal with wheel chocks in position.

18 Approximate times of operation for hydraulic services

Service	*Time of Operation (seconds)*			
Undercarriage .	Up to down	12–16	Down to up	12–16
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
Air brakes . .	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 seven seconds but the times stated above include the period of time for

Malfunctioning of the System

19 Pump failure

If the pump which is selected to NORMAL fails, the sortie should be abandoned except in operational conditions. See Flight Reference Cards.

20 Overloading of pump motors

If the on-load indication on a pump motor ammeter exceeds 45 amps the pump should be switched OFF except in extreme emergency.

21 Excessive cut-in rate

If, during flight, the cut-in rate of the pump which is selected to NORMAL (as observed on its ammeter) increases to more than once per 30 seconds. See Flight Reference Cards.

22 Overheating of pump motors

If a pump ammeter reading exceeds 16 amps when the pump is idling overheating should be suspected. Switch OFF the pump as soon as possible. See Failed Pump procedure in Flight Reference Cards.

23 Loss of hydraulic fluid (tank 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 illuminate the appropriate HYDRAULIC WARNING light on the pilot's coaming panel, and will automatically switch off the associated pump motor if it is selected to 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 compartment contents fall to 4·75 gallons the second float switch will operate. The second pump motor will be automatically switched off (if it is selected to NORMAL) and the second HYDRAULIC WARNING light will illuminate. At the same time the EMERGENCY HYDRAULIC SELECTOR warning light will illuminate indicating that the Normal Master Selector has closed and the Emergency Master Selector has opened.

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

(*c*) If all three hydraulic warning lights are illuminated the pump motors will run only when a service Emergency selection is made with the pump motors selected to NORMAL, or if the pump motors are selected to EMERGENCY. (NOTE.—It is not necessary to select the pump motors to EMERGENCY in order to obtain Emergency operation of a service). The following Emergency selections only may be made:

Undercarriage . . .	EMERGENCY DOWN
Flaps	EMERGENCY DOWN
Airbrakes	EMERGENCY CLOSE
Bomb Doors . . .	OPEN or JETTISON, EMERGENCY CLOSE (open and close once only to avoid exces-

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

(ii) Whilst the 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 indicators show that the required position has been reached.

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

(iv) 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 NORMAL. However, following completion of an undercarriage EMERGENCY DOWN selection, the pump motors will continue to run until they are selected OFF, or a normal DOWN selection is made. As the undercarriage will normally be the first service to be operated under these emergency conditions, the pump motors must be switched OFF on completion of each Emergency selection to avoid unnecessary loss of fluid.

(*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 unnecessary 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

24 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 failure (e.g. float switch operation), those services which incorporate Emergency selections may be operated as described in the preceding paragraph. Make the appropriate Emergency selection of the service required. During the Emergency operation the EMERGENCY HYDRAULIC SELECTOR 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 SELECTOR light will go out. No further operation of the failed service can then be made, but the remaining services may be operated normally.

(*b*) If the undercarriage has been lowered by selecting EMERGENCY DOWN, reselect NORMAL down so that the pump(s) switch OFF automatically if a subsequent loss of fluid causes the float switch(es) to operate.

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. 10B electrically-operated auto-

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) To prevent injury during ejection both control columns are clear the pilots' knees. This is achieved automatically when the escape hatches are jettisoned when 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.

(ii) Control column retraction is achieved by gases from a cartridge fired by the action of pulling the face screen handle. A safety-pin, for the firing unit sear, must be removed before flight.

(iii) 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 wheel braking.

(*b*) Rudder pedal adjustment is achieved by rotating the crank handle beneath each control column tube. During flight it is possible that the handle may rotate, thus altering the adjustment.

4 Power control units

(*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

(*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 interconnects 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*

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 (*b*) In " Q " feel units pitot and static pressures are 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 forces transmitted to the pilot is approximately proportional 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 Roll damper system

(*a*) This is fitted to correct disturbances about the longitudinal axis by automatically applying aileron. A gyro senses any disturbance and via an amplification system signals two electric actuators in the aileron system. These actuators extend and retract in response to the signals and operate the PFCU reset levers to bring about the necessary aileron deflection.

(*b*) An altitude control is fitted which progressively increases the strength of the gyro signal with increasing altitude.

7 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.

8 Auto-mach trim system

(*a*) The purpose of the system is to counteract the nose-down trim 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 second 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, the servo begins to operate at approximately 0·80M. 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.

NOTE: A mach switch, set to operate at 0·79M, prevents inadvertent or runaway operation of the system at mach numbers below 0·79M.

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

(*d*) AC supply is obtained from No. 4 200 volt 3-phase bus-bar and DC supply from No. 2 LV bus-bar.

Controls and Indicators

9 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. These control, via change-over contactors, the 200 volt AC supplies to the respective sub-unit motors.

(*b*) Ten lights below the switches (duplicated at the AEO's station) come on if their associated sub-units suffer hydraulic pressure failure.

(*c*) A further ten lights at the AEO's station provide overheat warnings of the return fluid in the sub-units. The indication implies that

10 Roll damper control

(*a*) The roll damper ON/STANDBY/OFF switch is on the pilots' panel AZ.

(*b*) When STANDBY is selected from OFF any aileron deflection which may have remained is automatically cancelled.

(*c*) The roll damper must never be selected to ON if the PFCU sub-units are not running.

(*d*) Power supplies are from No. 4, 200 volt bus-bar and No. 2 LV bus-bar.

11 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 AC.

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

(*c*) Power supplies to the normal yaw damper are from No. 4, 200 volt bus-bar and No. 2 LV bus-bar.

(*d*) Power supplies to the standby yaw damper are from No. 2 transformer and No. 1 LV bus-bar. Thus if a main generating failure occurs these supplies will be available from the port RAT and the standby damper will be operative.

12 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

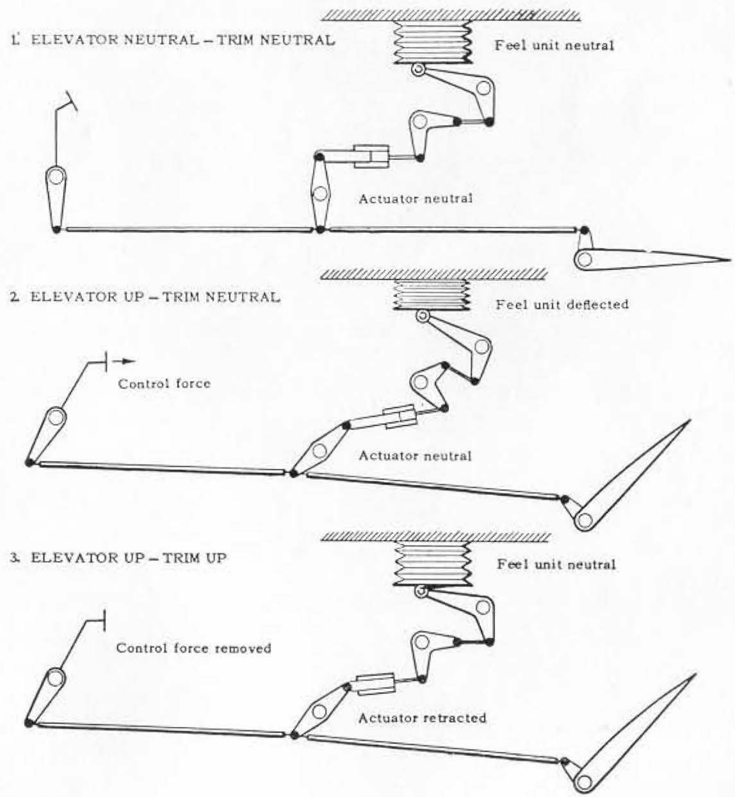


Fig. 1 Artificial feel and trim operation

13 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

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 rest 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.*

Normal Management of the Powered Controls and Trimmers

14 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 200 volt 3-phase 400 cycles AC supply must be available, either from an external supply source or from the AAPP. 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 in each direction and at least one set of controls must be tested over the full range of movement.

(i) *Console trim controls*

Without pressing the pushbutton, move the console trim control in each direction to check functioning of the cut-out. (If the trims move, the system is unserviceable). Then depress the button

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 the trims to neutral.

(ii) *Control column trim controls*

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 all the red power failure warning lights on the pilot's coaming panel (AZ) and at the AEO's station are illuminated. Start the No. 1 set (odd) by selecting the number 1, 3, 5, 7 and 9 switches (coloured red) to ON (up). Check that the appropriate red warning lights on the pilot's coaming and the AEO's station go out. Switch the main roll and yaw dampers to STANDBY. Test the controls for free, smooth and correct movement over their full travel (by ground crew observation). Jerky control surface movements or vibration may indicate unserviceability. Switch OFF the No. 1 (odd) set of controls (check that the red warning lights come on) and repeat the checks for the No. 2 (even) set of controls switches numbered 2, 4, 6, 8 and 10 (coloured green). 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 check the

NOTE: Rapid control movement may cause flickering of the power failure warning lights. This should cease when control movement ceases.

15 Dampers and auto-mach trimmer

(*a*) *Dampers*

The roll and yaw dampers should never be switched ON unless the appropriate PFCU's are running. Before take-off, and after starting the PFCU's, select the control switches of the roll damper, and the normal and standby yaw dampers to STANDBY. After a short pause select the roll damper and the normal yaw damper switches to ON. 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.

16 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 warning lights indicating power failure or overheating of the PFCU's should remain out.

(ii) The roll damper should be ON throughout flight. The main yaw damper should be selected on, and the standby yaw damper selected to STANDBY. Before engaging the auto-pilot select both yaw dampers to STANDBY.

(iii) Before reaching an altitude of 20,000 ft. or a speed of

is increased above 0·80M + 0·01M the auto-mach trimmer should provide a progressive nose-up trim force. The indicator may not indicate white (OUT) until 0·82—0·84M is reached. The auto-mach trimmer must be selected OFF before engaging the auto-pilot.

(*c*) (i) 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

17 "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 does occur the control forces will be light and all controls must be used with care to avoid over controlling. In the case of the ailerons, power units cannot apply enough deflection to cause over stressing as the hinge moments are too great. Over stressing could however result from over application of elevator or rudder at the higher speeds. The elevator must be moved slowly and cautiously with frequent reference to the accelerometer to avoid exceeding the G limitations. The rudder may be used as required in correcting a swing due to engine failure at low speed, or in a cross-wind landing, but must be moved slowly and cautiously at speeds over 200 knots.

18 Failure of a PFCU

If a power failure warning light for any PFCU illuminates during flight, its control switch should be selected to OFF. Selection to

19 Failure of 5 PFCU's

If the power failure warning lights of 5 PFCU's supplied from one synchronising bus-bar illuminate in flight, it is an indication of electrical failure of two alternators on one side. The RAT turbine alternator is not designed to cope with this type of failure and no PFCU selection will enable it to take over their supply. For restoration of electrical supplies see Part I, Chapter 1.

20 Overheating of a PFCU

If an overheat warning light illuminates during flight, switch OFF the affected PFCU. When the warning light goes out, wait approximately 5 minutes and re-select the PFCU to ON. If the warning light re-appears, switch OFF and leave OFF.

21 Failure of a control trimmer

If a control trimmer fails to respond to a trim selection, make no further selections of that control. Malfunction of individual switches or actuators still permits full trim travel using the alternative trim controller. If double failure of a control trim system (aileron, elevator or rudder) occurs leading to total loss of that system, it is still possible to fly the aircraft. However, in this case curtail the sortie because of the considerable pilot effort which may be required over a long period.

22 Damper failures

(*a*) Failure of the roll damper may be indicated by rolling oscillations, or by a wing low trim force. Switch OFF the roll damper and trim as necessary.

(*b*) 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.

23 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 change to a nose-down trim change 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 0·90M 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 0·90M and switch off.

Part I

Chapter 6—Engines

List of Contents

Power Plants—Description and Controls

1 General

(*a*) Four Conway Mk. 201 engines are installed, two in each wing adjacent to the fuselage. Each engine is an axial-flow by-pass turbo-jet incorporating a twin-spool compressor driven by turbines and has a turbo-annular combustion chamber.

(*b*) The drive shaft for the low-pressure compressor passes through the high-pressure compressor shaft and each compressor rotates independently of the other, and in the same direction. Provision is made for the HP shaft to drive ancillary units. The only drive from

(*c*) The output from the LP compressor is divided. Part goes to the HP compressor to provide the necessary air for fuel combustion whence it is ejected rearwards to drive the turbines; the remainder is directed through the annular by-pass duct, after which, it joins the hot gases from the turbines and the total flow is ejected through a propelling nozzle to atmosphere.

2 HP fuel pumps

(*a*) Fuel from the aircraft supply is fed through an engine-driven backing pump, through an LP filter to an engine-driven dual type HP fuel pump, the fuel delivery of which is limited to that required (*b*) The pump output is passed through a fuel-cooled oil cooler into a fuel control unit. A metered flow suitable to the engine conditions is then delivered to the burners.

3 Fuel control units

Each unit contains the following features to provide a correct flow of fuel to the engine.

(*a*) A steady running control system comprising a combined throttle valve and HP cock and an altitude sensing unit.

(*b*) A top temperature control, limiting exhaust gas temperature for take-off, climb and cruise.

(*c*) An LP shaft top-speed governor.

(*d*) An acceleration control.

(*e*) An idle speed governor.

(*f*) A maximum thrust governor.

4 By-pass duct bleed valve

(*a*) Each engine has an air bleed valve fitted in the by-pass duct casing in order to reduce the tendency for the LP compressor blades to stall at low RPM, thus leading to compressor surge.

(*b*) The bleed valve consists of a shuttle which operates a butterfly valve. Air tapped from the engine anti-icing supplies and controlled by a solenoid is used to operate the shuttle. The valve is open up to a given RPM to allow surplus air to escape from the by-pass duct; a P3 switch affects the fixed opening above 40000 ft. Above HP RPM of $88\pm1\%$ on the ground and $86{\cdot}5\pm1{\cdot}5\%$ at 52,000 ft. and 0·86M the valve is closed thereby improving compressor efficiency with a resultant lower specific fuel consumption.

(*c*) Mod. 3736 provides four magnetic indicators on the co-pilot's instrument panel to show the position of the bleed valve on each

5 Anti-icing system

To prevent ice formation on the LP compressor, hot air is bled from the HP compressor, via twin feeds, to the intake guide vane assembly, first row of stators. Two air regulator valves automatically prevent excess pressures developing in the system. Hot air is bled from the LP compressor to heat the articulated duct.

6 Fuel heater system

(*a*) Protection against fuel filter icing is provided by a hot air fuel heater just upstream of the main LP filter. The system is fully automatic and is operated by a pressure differential switch across the LP filter.

(*b*) On the 2nd pilot's console AF are four FUEL FILTER DE-ICING ISOLATION, AUTO/OFF/MAN switches, together with four ON (valve open)/OFF (valve closed) indicators. The system is normally operated with the switches at AUTO, the OFF and MAN positions are for after flight and flight-override purposes, respectively (see para. 19).

(*c*) Four test buttons are at the aft end of console AF.

7 Throttle/HP cock controls

(*a*) Two throttle boxes are provided, one for each pilot on the appropriate console. Each throttle lever can be moved freely from IDLING to FULLY OPEN and may be held in any selected position by operating the friction lock lever.

(*b*) At the IDLING position on the 1st pilot's throttle box is a gate mechanism which acts as the idling stop for the throttle levers. When the gate is disengaged the throttles may be moved back to the SHUT OFF position, at which position the throttle valves are fully closed and act as HP cocks.

(*c*) The idling gate may be disengaged by either pilot. A switch on the 1st pilot's throttle box operates the gate mechanism. A rotary solenoid on the gate mechanism; when the switch is operated the gate is disengaged. When the switch is released the gate is returned to its normal position under spring pressure.

(*d*) The gate mechanism must be operated before the throttles can be moved out of the SHUT OFF position or returned to that position from IDLING.

(*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 1st pilot that the gate is engaged.

8 Top temperature controls

Four JET PIPE TEMPERATURE ISOLATION, NORMAL/ ISOLATE switches are on 1st pilot's side panel. A three position CRUISE/CLIMB/TAKE-OFF switch is on panel AZ.

9 Anti-icing system controls

Four ENGINE ANTI-ICING-ON/OFF control switches are on 2nd pilot's panel AD, one for each engine.

10 LP turbine overspeed warning lights

Four OVERSPEED WARNING lights one for each engine, are on panel A. The appropriate light comes on if an LP turbine over speeds, in which case RPM should be reduced to the point where the light is extinguished.

11 Fuel heating control and indicator

(*a*) Although the system is designed for automatic operation, an AUTO/OFF/MAN override switch is provided on panel AF.

(*b*) With the switch set to AUTO the system operates automatically and a thermal switch prevents overheating. With the switch set to MAN the heater is under the pilot's control and no overheat

(*c*) The setting of the hot air valve is shown by an ON-OFF magnetic indicator also on panel AF.

12 Engine starting controls

(*a*) The engines are turned over for starting by air motors mounted on the engine starboard wheelcases and geared to the engine HP compressor shafts.

(*b*) The air supply to the starter motors can be supplied either from a ground supply or from the AAPP. All engines can be started from the AAPP supply; once any one engine is started the remaining three engines can be started from it. For rapid engine starting fuel/air combustors are fitted. (See para. 13).

(*c*) All engine starting control switches are on panel AL in the cockpit roof. These switches are:

(i) A starter master GROUND/FLIGHT/COMBUSTOR/ AAPP switch.

(ii) Four separate ENGINE SELECTOR switches by means of which individual engines may be selected for starting.

(iii) STARTER PUSH switch which completes the inter-connection between the main engine start circuits and air supply sources. The button locks in until the selected engine reaches self-sustaining speed.

(iv) Four START IN PROGRESS/LP STALL WARNING lights, one for each engine and which come on as soon as the associated LP compressor rotates. The light extinguishes as soon the starter button throws out. The light indicates that the LP compressor is turning; if no indication is given the start must be discontinued. The light operates within 180° of compressor rotation.

(v) IGNITION ISOLATION switch which completes the circuit to the HE igniter units of the engine being started. After all engines are started the switch must be set OFF. It should

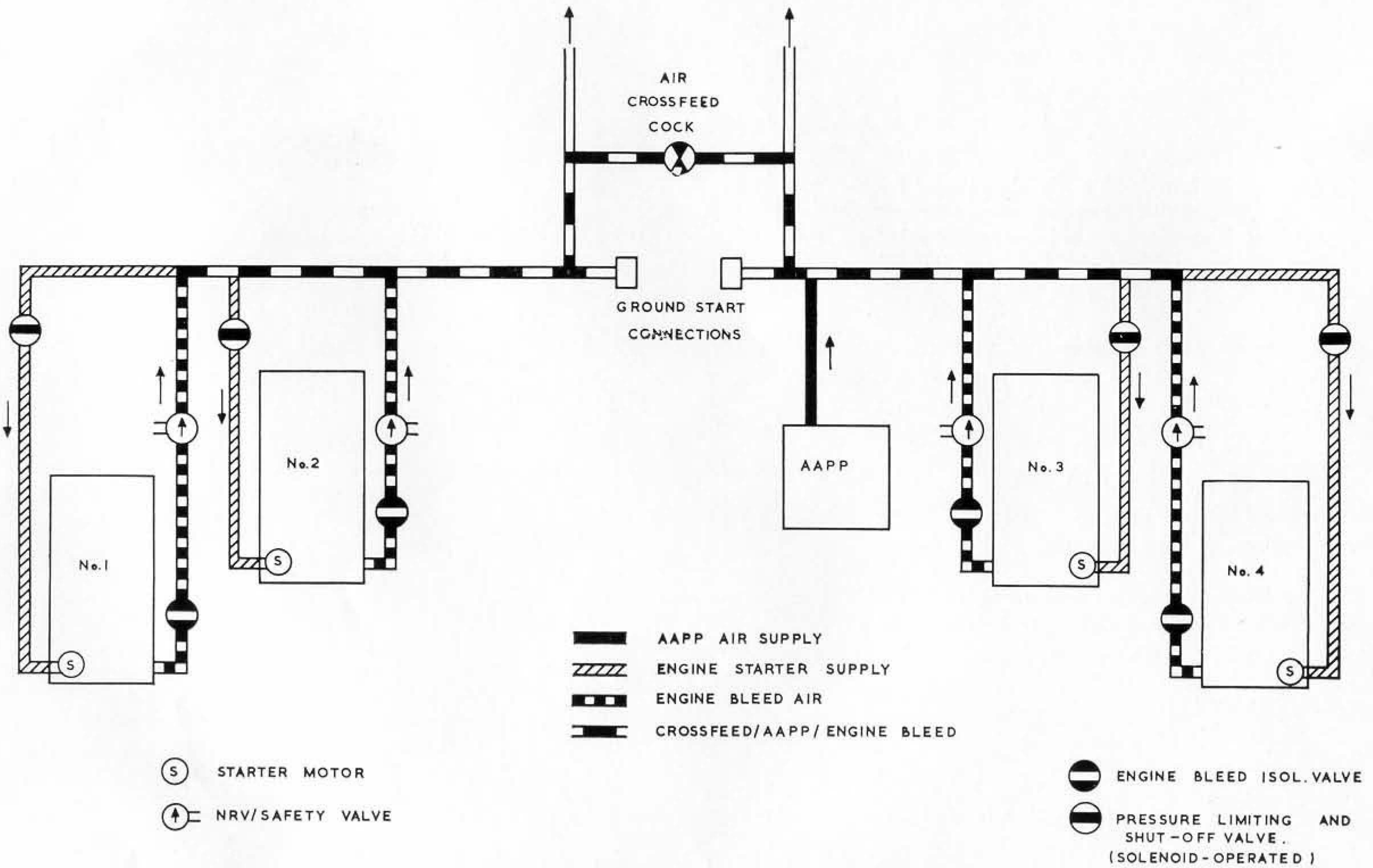


Fig. 1 Normal engine starting system

(vi) CROSSFEED COCK, OPEN-CLOSE switch which controls the crossfeed cock between the port and starboard high pressure air starting systems so that when any engine has been started, air may be crossfed to the other engines. An amber warning light indicates when the cock is open.

(*d*) The RELIGHT buttons for starting an engine in the air are in the tops of the throttle levers, on each pilot's throttle box.

13 Rapid engine starting

(*a*) *Introduction*

(i) In order that more than one engine can be started at one time a fuel/air combustor starting system is provided.

(ii) A combustor mounted on the underside of each engine provides low pressure air for the associated starter motor when the engine start selection is made. This is achieved by burning fuel, taken from the fuel tanks, with air from storage bottles, and directing the gaseous products from the combustor to the turbo starter motor.

(*b*) *Air supplies*

Five air storage bottles carried in each mainplane supply high pressure air at 3,300 PSI for the combustors in the associated wing. Sufficient air is contained in the bottles for two engine starts per side provided that the bottles are initially fully charged.

The air from the five storage bottles is collected in a common manifold and fed via a charging point and gauge to the combustors in that wing. Control of the air is achieved by an On/Off valve and a pressure reducing valve in each combustor supply line. On opening the On/Off valve the high pressure air flows through the pressure reducing valve which controls the air supply to the combustor at 240 PSI. This air pressurises the fuel reservoir in the combustor and also mixes with the spray from the atomiser in the

(*c*) *On/Off valve*

This is an electrically operated differential pressure type valve and is used to control the air supplies to the combustor. The unit consists of a main piston valve which is subjected to inlet pressures. A small drilling through the valve allows inlet pressures to the back of the valve, this in conjunction with a bias spring holds the valve on its seat isolating the air supplies. A solenoid operated bleed valve at the back of the main piston valve, when energised vents the back of the valve to atmosphere such that the inlet pressure felt on the head of the valve forces the valve off its seat allowing air to the pressure reducing valve and combustor. When the bleed valve closes, a pressure build up at the back of the main piston valve in conjunction with the spring, forces the valve back onto its seat so isolating the air supplies.

(*d*) *Pressure reducing valve*

This valve is fitted immediately upstream of the combustor and reduces the air supply pressure from 3,300 PSI to 240 $^{+2}_{-3}$ PSI. A bursting disc assembled on the valve protects the combustor against high supply pressure should the PRV fail in the open position.

(*e*) *Fuel/air combustor*

The combustor assembly consists basically of a steel cylinder divided by a web at its approximate mid-position to form two chambers, one a combustion chamber, containing an igniter plug and pressure switch, and the other a fuel reservoir.

(i) *Combustion chamber*

Mounted on the web and extending into the combustion chamber is a cylindrical flame tube. This tube forms an annular cavity between itself and the cylinder that forms the combustor casing, so protecting the area around the combustor from radiant heat. A burner head mounted on the web, carries a diffuser plug which bustion chamber a conical tube, carried on the exhaust outlet, extends into the flame tube forming a flame trap so protecting the ducting against a naked flame.

An air inlet is provided on the combustion chamber close to the web, and directs a portion of the incoming air through drillings in the web, into the reservoir on one side of the floating piston.

(ii) *Igniter plug*

An igniter plug, mounted on the wall of the combustion chamber, extends into the flame tube to ignite the atomised fuel when an engine start selection is being made.

(iii) *Pressure switch*

A pressure switch carried on the wall of the combustion chamber and sensitive to combustion pressures locks in the starting cycle when ignition has taken place.

(iv) *Fuel reservoir*

The reservoir comprises an annular chamber which contains a fully floating piston. A fuel transfer tube is located in the reservoir and passes down its axis through the floating piston to make its attachment on one end of the web, while the other end picks up with a drilling on the end wall of the reservoir. The end wall of the reservoir provides the fuel inlet which incorporates an NRV to the reservoir, a drilling to connect the stored fuel to the transfer tube, and a bleed screw, that permits initial priming of the reservoir.

(*f*) *Operation*

(i) On initiating a rapid engine start, high pressure air passes through the ON/OFF valve and pressure reducing valve to the combustor. A proportion of this air is fed into the reservoir and impinges on the separator piston, pressurising the fuel. The fuel the delivery valve, and to the atomiser mounted in the burner ring in the combustion chamber. An NRV located in the fuel inlet feed line prevents fuel from the reservoir back tracking to the aircraft fuel system. The remainder of the air passing to the combustor is directed into the combustion chamber to mix with the fuel spray from the atomiser. At the time of the engine start selection, a time switch is set to function the igniter mounted in the combustor chamber and control the time of combustor operation.

(ii) The igniter is functioned for a period of 2 seconds to fire the mixture in the combustion chamber, while the pressure switch sensitive to combustor pressures operates and locks in the starting cycles. Heated gases at a pressure of 36 PSI and at a temperature of 1,000°C now pass into the starter and are brought to impinge on the turbine wheel in the starter motor to rotate the engine rapidly to engine self-sustaining speed.

(iii) Incorporated in the starter is a speed sensitive device which will terminate the starting cycle when the engine reaches a predetermined speed. This is achieved by breaking the electrical supplies to the on/off valve so shutting the valve and isolating the air supply from the combustor.

(iv) In the event of the engine not starting first time, the starting cycle is automatically stopped by the time switch after 15 seconds.

(v) A second attempt to start an engine can be made after 30 minutes. The combustor reservoir contains 400 CC of fuel catering for approximately 200 CC of fuel to be used per start before it is subsequently recharged in flight for further engine starts.

(*g*) *Combustion fuel supplies*

Fuel is taken from the engine's fuel system just upstream of the backing pumps. The combustor reservoir, once primed, is subse-

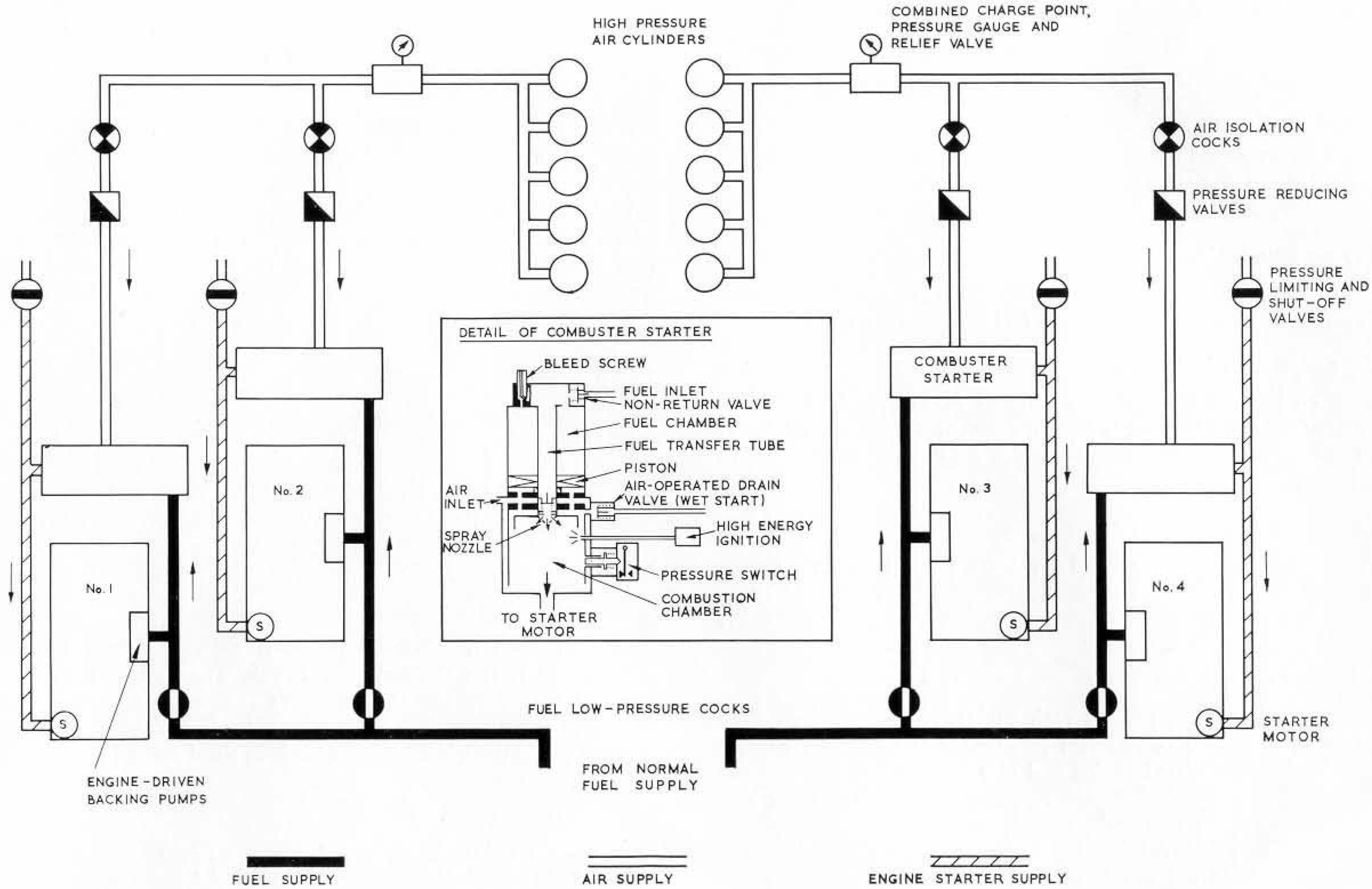


Fig. 2 Rapid start system

14 Engine instruments

(*a*) EGT *gauges*

Four EXHaust gas temperature (EGT) gauges, one for each engine, are on panel A.

Each measures the temperature of the gases in the exhaust unit of its associated engine. The exhaust unit is upstream of the junction of the by-pass flow and the gas stream.

(*b*) HP RPM *indicators*

Four percentage-calibrated RPM indicators are on panel A and each is driven by a tachometer generator on its respective engine.

(*c*) *Oil pressure indicators*

Four oil pressure indicators are on panel A. The required 200 volt 400 c/s single phase AC is from the 200 volt bus-bars and is fed to individual auto-transformers which step the voltage down to 26 volts.

(*d*) CSDU *oil temperature gauge*

A temperature gauge is fitted on AEO's panel BC. An adjacent selector switch enables the oil temperature of any constant speed drive unit to be obtained. Electrical supplies are from feeder 12P7.

15 Fuel LP warning lights

Four warning lights, one for each engine, are on panel A. Each gives an indication of low fuel pressure as it leaves the backing pump of the associated engine and also indicate low fuel pressure at the inlet to the engine backing pump ; two lights on one side illuminating while using wing groups will indicate a proportioner failure on that side. All four lights illuminating while the fuselage group only is in use will indicate a fuselage proportioner failure. The lights are of the press-to-test type, and the electrical supplies are from feeder 3P7 for the port lights and 2P7 for the starboard

Airborne Auxiliary Power Plant (AAPP) Description and Controls

16 AAPP—general

(*a*) The AAPP is a gas-turbine engine, housed in the lower section of the starboard wing root, Air for the operation of the engine is ducted into the unit via a forward-facing retractable intake.

(*b*) The AAPP drives a 200-volt 3-phase 400 c/s 40 KVA alternator, which can supply the electrical system, up to an altitude of 45,000 feet. It also provides low pressure air for starting the engines and for ground running of the Blue Steel vapour cooling pack.

(*c*) A self-contained oil system is provided of 5 pint capacity.

17 AAPP controls and indicators

(*a*) All controls are on the AEO's panel BF.

(*b*) *Intake control*

This is operated by an INTAKE SELECTION OPEN-CLOSED switch with an adjacent magnetic indicator which shows SHUT in white-on-black, OPEN in black-on-white and striped when the intake is in an intermediate position, or electrical supply is lacking.

(*c*) *Electrical load control*

The distribution of electrical power is controlled by a LOAD SELECTION, IDLING-ELECT switch. The IDLING position causes the AAPP to run at idling RPM except when main engine starting is in progress. The ELECT position is used when electrical supplies to the main bus-bars and/or Blue Steel ground cooling are required.

(*d*) AAPP *starting controls*

(i) AAPP starting is controlled by a START SELECTOR, NORMAL-OFF-EMERGENCY switch. Adjacent to the switch are an RPM indicator, a JPT gauge, an oil pressure light, a start in progress warning light and a combined fire extinguisher

(ii) When the start selector switch is set to NORMAL the AAPP starter motor is energised, the booster pump in tank 10 starts up, the ignition system operates and the start in progress light comes on. As RPM build up the oil pressure light should go out. When the AAPP reaches 6,000 to 8,000 RPM the starting system is de-energised and the start in progress light goes out. The starter switch should be left at NORMAL.

NOTE: NORMAL starting should not be attempted unless the intake is fully open.

(iii) An EMERGENCY start can be made in the air before the intake is fully open.

(iv) An OFF selection should only be made to stop the AAPP.

Normal Management of the Engine Systems

18 Management of engine anti-icing system

(*a*) If icing is encountered in flight, the engine anti-icing system must be switched on immediately and the aircraft should be climbed or descended out of icing as quickly as possible.

(*b*) Anti-icing may be used for take-off, but the aircraft should be climbed out of icing as quickly as possible.

(*c*) On the ground at air temperatures below $+ 8°C$ and in conditions of high humidity such as fog or mist reducing the visibility to less than 1,000 yards, anti-icing must be used on take-off.

(*d*) The affect of engine anti-icing is:

(i) The air flow through the combustion chamber and turbines is reduced, giving decreased thrust for a given EGT.

(ii) The air entering the intake is heated slightly causing a decrease in air density and a further decrease in thrust.

(*e*) To maintain engine thrust during anti-icing operation the engine RPM may be increased, if necessary, to give greater air flow through the engine.

19 Management of the engine fuel filter de-icing system

NOTE: When fuel with an anti-icing additive is used the system is rendered inoperative by removal of the fuses. Before flight using fuel without an anti-icing additive the system is to be ground serviced and used as

(*a*) If, prior to starting the engines, the settings of the de-ice selector switches and indicators disagree, this should be disregarded until the post start-up checks have been performed. Since the de-icing control valve is servo-operated, it can only function when the engine is running; thus, if the switches are set at OFF, the indicators should change to OFF during start-up.

(*b*) During the after take-off checks select the FUEL FILTER DE-ICING ISOLATION switches for each engine system to AUTO. Check that the associated magnetic indicator shows OFF (valve closed).

(*c*) During flight the four magnetic indicators must be monitored frequently and in any case at intervals of not more than 30 minutes. If an indicator shows ON (valve open) for a period in excess of 3 minutes (i.e. de-ice period plus time switch run-down) it signifies possible malfunction of the system and the appropriate selector switch must be set to OFF. The flight may continue. If the ON indication persists the engine should function normally for up to 10 hours. However, if any signs of engine malfunction occur, the engine should be shut down as soon as possible.

(*d*) If, with the switches set at AUTO, two or three indicators show ON, the switches of the other systems should be set to MAN for 2 minutes and then returned to AUTO. This is because it is unlikely that icing conditions will occur at one filter and not at another; failure of an indicator to show ON in these circumstances indicates possible failure of the automatic side of the system.

(*e*) During descent from a flight where the systems have been used, operate the test facility or set the selector switches of serviceable systems to MAN for a period of 2 minutes and then return them to AUTO. This procedure should be carried out before reaching the check height (where opening of the throttles will demand the higher fuel flow rates) and if possible should be completed not more

Part I

Chapter 7—Auto-pilot Mk. 10B

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. The roll error cut-out and rudder torque limiter are inhibited when the flaps are more than 1° down.

2 Controls

(a) Flight control panel

The auto-pilot control panel is at the rear of fuel panel AT. It carries the following components:

POWER switch
READY magnetic indicator
IN magnetic indicator
ENGAGE switch
Rudder (R), aileron (A) and elevator (E) channel switches
Auto-land PRIME switch
GLIDE path switch
TRACK switch
BOMB switch
IAS/ALT lock switch

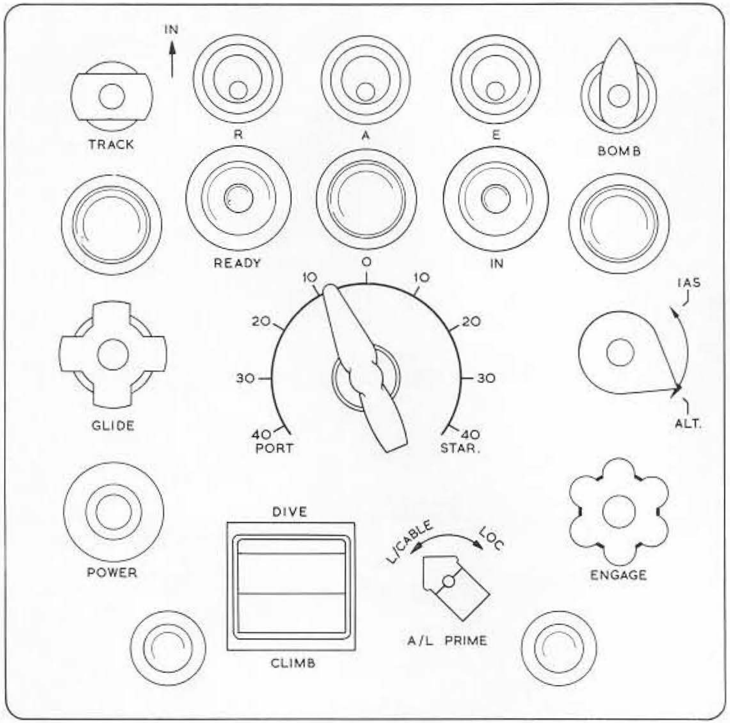


Fig. 1 Auto-pilot controller

(b) Trim indicator

A trim indicator is on each pilot's instrument panel. The indicator, is marked TRIM, NOSE-HEAVY/TAIL HEAVY and shows degrees of out of trim. Trim should be kept in the green sector otherwise auto-pilot disconnect may occur on the elevator torque limiter.

(c) Track switch

(d) Turn and pitch control

The turn and pitch controller is on panel AT. A rotary switch, turning over a scale marked from 0 to 40 degrees on either side, provides turn control, while a DIVE-CLIMB switch provides pitch control.

(e) Cut-out switches

There is an instinctive cut-out switch on each control column. When either is operated, the three auto-pilot control channels are disengaged from the aircraft control surfaces. Re-engagement can then be effected by pulling the ENGAGE switch.

(f) Bomb aimer's control

To enable the bomb aimer to control the aircraft in azimuth during a visual bombing run, a further turn control is provided at the bomb aimer's station.

(g) Interlocks

Various interlocks are operative.

(h) G *cut-out*

A G cut-out prevents auto-pilot operation if G outside the limits of + 0·5 or + 1·5 is present (i.e. ± 0·5 of level flight conditions and is mounted below the crew table. A pushbutton is fitted on the unit to allow the operation of the cut-out to be checked on the ground.

(j) Mach compensator unit

The mach compensator unit automatically adjusts the auto-pilot to compensate for the changes of pitch attitude when varying the speed in the range 0·85M to 0·95M.

3 Use of controls

(a) POWER switch

When the POWER switch is pulled out and provided that the master switch is on, AC at 115 volts and 28 volt DC are fed to the auto-pilot. After approximately 45 seconds, the READY indicator will show white, indicating that the auto-pilot is ready for (*b*) *ENGAGE switch*

Provided that the rudder, elevator and aileron channel switches are in the IN position (forward), pulling out the ENGAGE switch will couple the auto-pilot to all three control surfaces; the READY indicator will turn black and IN indicator will turn white.

(*c*) *Channel switches*

If any channel switch is put to the out position, its particular control surface will be disengaged from the auto-pilot and the READY indicator will show white. To re-engage the channel, move the switch to the IN position. If all three channel switches are disengaged, the auto-pilot will disengage.

(*d*) *Pitch and turn controls*

(i) The pitch and turn controls are used to alter the setting of the gyro platform relative to the aircraft, thus causing the servos to change the aircraft attitude. For example, if a nose-down change of pitch is required, operation of the pitch control rotates the gyro platform tail-down relative to the aircraft; the resultant gyro signal then actuates the elevator servo-motor to bring the nose of the aircraft down until release of the pitch control causes rotation of the gyro platform to cease and the new pitch attitude to remain in force. In effect, the aircraft rotates round the platform, which remains horizontal in space.

(ii) *Pitch control*

The pitch control switch is spring-loaded to the central (neutral) position. It is moved forward to produce nose-down pitch change. Switch movement is opposed by two spring rates, so that initial movement against a weak spring produces a slow rate of change of attitude, while further movement against a strong spring will cause a fast rate of change. The slow rate is inoperative when ALT/IAS lock is being used—the fast rate overrides the IAS/ALT

(iii) *Turn control*

The aircraft can be turned at a selected angle of bank by moving the turn control round to the required bank angle. The control will remain at the selected position and the aircraft will remain at that angle of bank, until the control is moved to a new position, when the aircraft will follow the new selection. A spring-loaded ball catch is provided to locate the pointer in the neutral position. The turn control overrides any pre-selected heading on the Beam Compass, provided that the TRACK switch is not pulled.

(*e*) *Auto-land prime switch*

The switch is marked AL PRIME, L. CABLE (leader cable)/LOC (ILS localiser); it is operated by turning it to the appropriate position and then pulling it up, only after GLIDE has been selected. In the L. CABLE position, the aircraft uses leader cable signals for directional steering below about 320 feet ; in the LOC position, ILS signals are used throughout the approach. This switch must not be used at present.

(*f*) *TRACK and GLIDE switches*

(i) The TRACK switch can be used to slave the auto-pilot to heading error signals from the MFS.

(ii) When an ILS facility is selected and the auto-pilot is engaged with the TRACK switch pulled out, the Beam Compass set up as described in Chapter 8, para. 15, and the MFS selector set to LOC, the ILS error signal and the heading error signal derived from the beam compass will be fed to the auto-pilot and the aircraft will be manoeuvred to follow the ILS localiser centre plane. When on an ILS approach, with the Beam Compass set up for the approach, pulling out the GLIDE switch will feed the glide path signals to the auto-pilot. A 3° nose-down pitch change is introduced at the same time. With the TRACK switch pulled, the turn control is inoperative and, with the GLIDE switch pulled, the height lock is inoperative.

WARNING. The MFS should not be selected to LOC at speeds

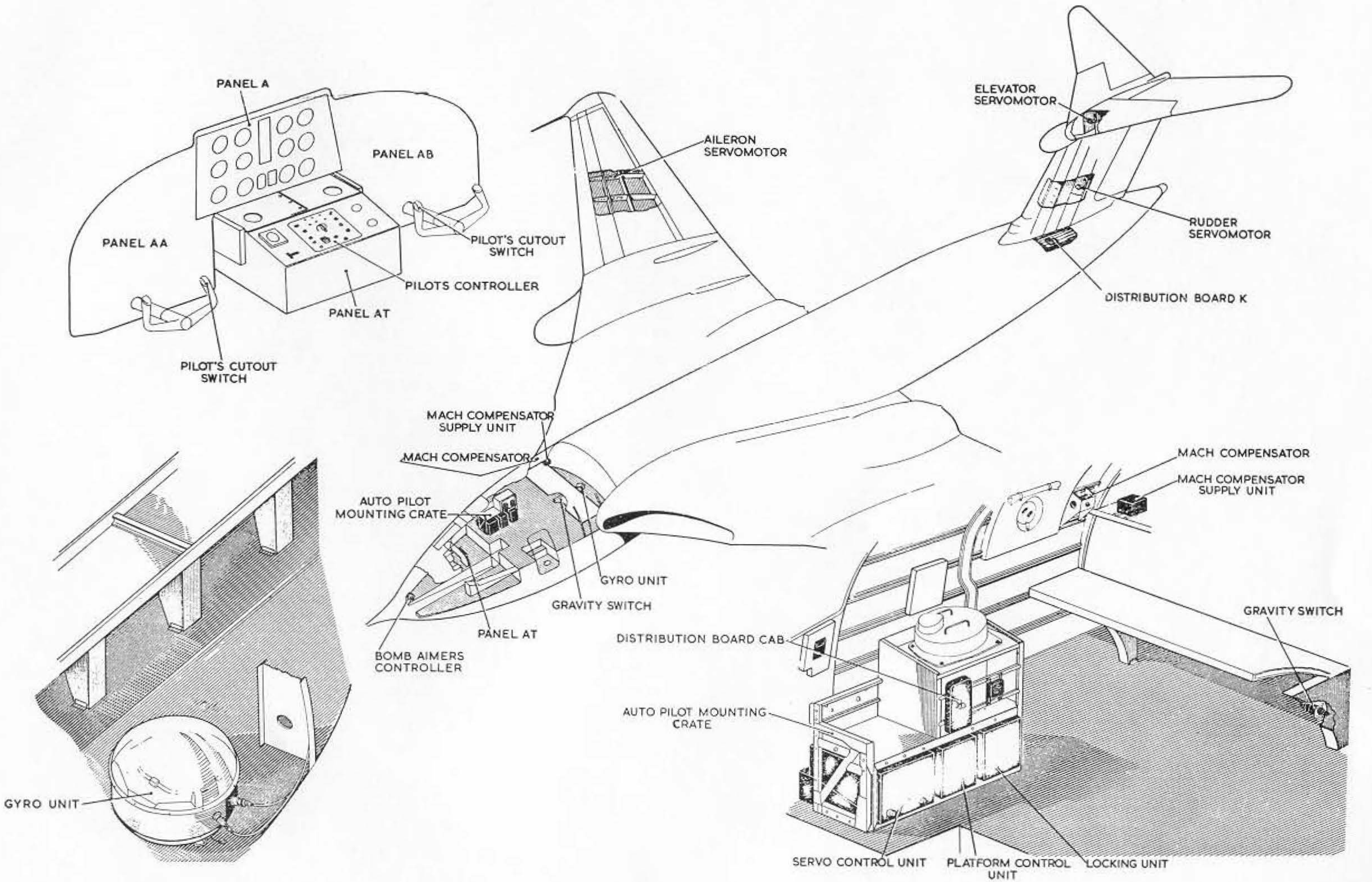


Fig. 2 Auto-pilot components location

(g) Airspeed/altitude lock switch

The IAS/ALT lock switch will control the aircraft to maintain a given airspeed or pressure height, whichever is selected. When the switch is operated, the aircraft will maintain the height or speed at which it is flying at the moment of selection. The height and speed locks can be overriden by operating the fast rate of the pitch control; the slow rate is inoperative when the height lock is in operation. The height/airspeed lock will be disconnected if the GLIDE switch is pulled or if the elevator channel is switched off.

(h) BOMB switch

When the BOMB switch on the controller is pulled out (on), signals from the NBS (blind selected) are fed to the bank platform motor, to maintain the aircraft on the desired bombing track.

Normal Management of the Auto-pilot

4 Full functional checks

After 100 hours flying, or after malfunctioning of the auto-pilot, the following checks should be made:

(a) Engagement

With power supplies on, the yaw dampers at STANDBY and one set of the power controls running, pull out the POWER switch and check that the READY indicator shows white after about 45 seconds. Set the R, A and E switches IN (forward) Check that both beam compasses are synchronised and that the flying controls are centralised and then pull out the ENGAGE switch. Check that the READY indicator shows black and that the IN indicator turns white.

(b) Disengagement

Check in turn the operation of the instinctive cut-out switches on the control columns, noting that the controls become free, the

(c) Trim indicators and torque limiters

Re-engage the auto-pilot and push the elevator control forward; check that the out of trim indicator shows nose heavy. Increase the push force when the torque limiter should operate and fully dis-engage the auto-pilot. Re-engage and repeat the check in the opposite sense. The rudder control torque limiter will fully dis-engage the auto-pilot (flaps UP) if a strong push force is applied to the rudder controls in either direction.

(d) Roll error cut-out

Re-engage the auto-pilot (flap UP) and after 10 seconds, move the turn control quickly to full travel. The ailerons should move, in the correct sense, to about one quarter of full travel and after a slight delay the auto-pilot should dis-engage fully. Repeat the check in the opposite direction.

(e) Limiters

Re-engage the auto-pilot and select flaps to TAKE-OFF. Check that the roll error cut-out and rudder torque limiter are inhibited by:

(i) Applying a full-scale bank control movement.

(ii) Applying rudder against the auto-pilot.

In both cases the auto-pilot should not disengage. Select flaps UP.

(f) Compass monitoring

Engage the aileron channel only. If the aileron control is moving slowly either way rotate the heading pointer with the synchronising knob in the correct sense to stop this movement. Disengage the auto-pilot, resynchronise the compass and re-engage the auto-pilot. The aileron controls should now be stationary but rotating the heading pointer with the synchronising knob either way will start the aileron control moving in the appropriate sense. Resynchronise the compass *(g) Individual channels*

Check the operation of each channel switch in turn. With any channel switched off, the READY indicator should show white and the appropriate control should be free. Ensure that returning the individual switches to the IN position re-engages the appropriate control. Then select all three channel switches off and check auto-pilot and control disengagement. Return the switches to the IN position and check that the auto-pilot does not re-engage until the ENGAGE switch is pulled out.

(h) Turn control

Move the turn control slowly from the detent, making sure that the aileron control moves in the correct sense. Set the heading index under the heading pointer and pull TRACK. Check that the turn control is inoperative and leave the turn control fully deflected. Push the TRACK switch in and check that the turn control is inoperative until it has been returned to its detent.

(j) Pitch control

Engage the auto-pilot and check that forward movement of the pitch control moves the elevator control forwards and that rearward movement moves the control rearwards. Pull ALT and check that the pitch control is inoperative on slow rate but that on selection of fast rate the ALT switch drops in and the control is once more operative. Repeat the check with the ASI switch.

(k) Heading error steering

With MFS navigational selector central and the heading pointer over the heading index, select TRACK. Check that rotating the heading index to the left moves the aileron control to the left and similarly to the right.

Check that GLIDE cannot be selected. Select LOC on the MFS navigator selector and the TRACK switch will drop in. Reselect cannot be selected. Select LOC & GP on the MFS navigational selector and the TRACK switch should stay out. Recheck the heading index operation. Select GLIDE and check that the ailerons do not respond to movements of the heading index. Select the navigational selector to central when the TRACK and GLIDE switches should drop in.

(l) GLIDE interlocks

Select LOC & GP on the MFS navigational selector and pull TRACK. Select ALT and then GLIDE. The ALT switch should drop in, the elevator control should move forward and then the torque limiter may operate, disengaging the auto-pilot. Repeat the check with the ASI switch. With GLIDE selected, check that the pitch control is inoperative. The torque limiter may operate when GLIDE is selected.

(m) REMOTE interlock

With the MFS navigational selector central and TRACK pulled, select REMOTE on the selector and the TRACK switch should drop in. Reselect TRACK and, by moving the heading pointer with the Track Control Unit, check that the ailerons move in the correct sense.

(n) Disengage the auto-pilot, switch the channel switches off and push the POWER switch in.

5 Pre-flight checks

The following checks should be made before flight:

(a) With power supplies on, the yaw dampers at STANDBY and having started one set of the powered flying controls, set the R, A and E channel switches in, pull out the POWER switch and check that the READY indicator shows white after approximately 45

(*b*) Centralise the controls, check the trim indicator is within ± 1 division and pull out the ENGAGE switch. Check that the READY indicator turns black and the IN indicator turns white.

(*c*) Check the operation of the pitch and turn controls. Check the operation of the roll error cut-out (flaps UP) by putting the turn control to maximum deflection.

(*d*) Check the operation of the elevator torque limiter in each direction, by applying a steadily increasing pressure to the control until the auto-pilot disengages. Similarly, check the rudder torque limiter (flaps UP).

(*e*) Switch off the rudder channel and check that the rudder control is free. Switch on again and check that the rudder control is re-engaged. Similarly, check the aileron and elevator channels.

(*f*) Move the elevator control backwards and forwards and check that the trim force indicator moves in the correct sense.

(*g*) Re-engage the auto-pilot and check the operation of each pilot's cut-out switch.

(*h*) Select all three channel switches out and push in the POWER switch.

6 Normal flight control

(*a*) Having checked that the mach trimmer is OFF, the yaw dampers are at STANDBY, the roll damper is ON and that the trim indicator is central, set up and engage the auto-pilot as in para. 5(*a*) but with the controls as required when the aircraft is fully trimmed for the existing condition of flight. The auto-pilot maintains the flight condition existing at the moment of engagement. Whilst the auto-pilot is in use the trim indicator should be kept approximately central by use of the aircraft elevator trimmer.

(*b*) *To turn the aircraft*:

(i) The turn control may be used to select the required angle of bank (up to 45°). As the required heading is approached, the

(ii) The aircraft may be controlled using the heading index of the beam compass selected, providing TRACK is pulled. With the MFS navigational selector central, no ILS localiser signals are fed into the auto-pilot but, if LOC is selected and TRACK reselected, radio signals are fed in unless the beam compass sense switch is used to suppress the radio signals. When LOC & GP is selected on the navigational selector low speed auto-pilot gearings become operative (see para. 7(*a*)), the aircraft still follows the heading index as long as the radio signals are suppressed and TRACK is pulled.

(iii) It is recommended that method (i) above be used at high altitudes when small angles of bank are required and method (ii) be used for instrument let downs and approaches when up to 25° of bank may be achieved.

(*c*) To climb or descend, move the pitch control forward or back until the required pitch attitude is achieved. Do not use the elevator trimmer to alter the pitch attitude.

(*d*) If the ALT lock is to be engaged, this should be done when the aircraft is in an approximately level attitude. ▶◀

(*e*) At maximum altitudes, if it is desired to carry out a cruise climb, trim the aircraft carefully and then engage the auto-pilot. The aircraft may take several minutes to settle down to a constant mach number. If the speed is not quite right, very small adjustments to the pitch controller correct the speed but the effect is not immediately apparent. Alternatively, a stepped cruise climb can be made, using the speed lock, by disengaging and then re-engaging the lock at the new speed.

(*f*) The auto-pilot must not be used above 0·88M/300 knots if the mach compensator is inoperative or above 0·9M/300 knots when the mach compensator is operative. Outside these limits a pitch oscillation can develop. The auto-pilot must not be used below

7 Auto-ILS approach

(*a*) To make an auto-ILS approach, set up the MFS as described in Chapter 8, para. 15(*a*). Follow the instructions in para. 15(*b*), suppressing the radio coupling, if required, with the sense switch, then pull TRACK. When the aircraft is in a suitable position downwind, couple onto the localiser by rotating the sense switch and/or by moving the heading index to the QDM of the ILS localiser beam, plus the expected drift at break-off height. When the aircraft is closer than about 15 miles to the airfield and the speed is below 180 knots, LOC & GP should be selected on the navigational selector to introduce low speed auto-pilot gearings, ensuring a smooth intercept of the localiser. Also, when the auto-pilot height lock is in use, if the LOC & GP selection is not made, the height lock performance will be poor.

(*b*) Just before the glide path needle, which is descending, reaches the centre dot of the pitch scale, set flaps, air brakes and throttles as required, select GLIDE on the auto-pilot and APPROACH and DATUM on the MFS selector. Switch the main yaw damper ON. The aircraft will couple onto the glide path. On overshoot, when the pitch scale setting knob is pressed in, the APPROACH setting on the MFS navigational selector is cancelled.

(*c*) The MFS and auto-pilot both have auto-wind-drift facilities, which are brought into use when APPROACH is selected on the MFS navigational selector and GLIDE is selected on the auto-pilot. Consequently the beam bar and azimuth director pointer should be central when on the auto-ILS approach.

(*d*) If a race track pattern is to be followed for subsequent auto-approaches, leave the sense switch pointing upwards but, if the beam QDR is to be flown followed by a procedure turn, the sense switch should be left horizontal.

NOTE: If, for any reason, after GLIDE has been selected, the auto-pilot should be fully disengaged and then re-engaged and GLIDE be reselected,

8 Asymmetric flight

(*a*) Following engine failure, carry out the following drill:

Physically pre-load the rudder pedals and switch off channel R. Retrim the rudder as required to keep the aircraft straight; then re-engage channel R.

This drill must be repeated after any further change of asymmetric power.

(*b*) Alternatively, disengage the whole auto-pilot, retrim the aircraft and re-engage the auto-pilot.

Malfunctioning of the Auto-pilot

9 Engagement faults

Should there be an unselected engagement of the auto-pilot, or if the auto-pilot fails to disengage, the cut-out must be held in while the POWER switches are pushed in and the channel switches are set off. The auto-pilot must then be regarded as unserviceable.

10 Torque limiters and roll error cut-out

(*a*) (i) The elevator and rudder torque limiters will fully disengage the auto-pilot if too great a load is applied to either of the controls.

(ii) If the auto-pilot should disengage due to operation of the torque limiters and the aircraft was thought to be out of trim, thus causing the disengagement, it may be re-engaged after retrimming the aircraft. If there is no apparent reason for the disengagement, the auto-pilot should be considered unserviceable and switched off.

(*b*) If the auto-pilot should disengage due to the operation of the roll error cut-out it should be considered unserviceable and switched off.

Part I

Chapter 8—Military Flight System

List of Contents

Description

1 General

(*a*) The Military Flight System (MFS) consists of:

(i) Twin aircraft systems.

(ii) Twin compass systems.

(iii) Certain common data sources with the auto-pilot Mk. 10B.

(*b*) Basic information is displayed on the Director Horizon and the Beam Compass at each pilot's station. These two instruments, which replace the normal artificial horizon, gyro-magnetic compass, ILS indicator, PDI, Zero Reader indicator and selector and the auto-pilot heading selector, provide flight director signals for the pilots.

(*c*) ILS signals can be fed into the system, the ILS localiser information being presented on the Beam Compass and the ILS

(*d*) Flight director signals are fed into the Director Horizon, telling the pilot the attitude required to achieve the desired condition of flight. If the auto-pilot is in use, it is supplied with heading signals from the system.

(*e*) Track control facilities enable the navigator to apply drift and variation signals to the heading signals. The heading signals can also be linked to the NBS.

(*f*) The two halves of the system function independently but are monitored by comparator units.

2 Twin vertical gyros

(*a*) A unit in the pressure cabin, consists of port and starboard gravity-monitored vertical gyros, driven by the 115-volt AC supply.

Director Horizons respectively. The gyros have freedom in pitch of 85° and complete freedom in roll.

(*b*) Each system measures the aircraft attitude independently but the two are so monitored by a comparator unit that warning flags will show on both horizons if their signals differ by more than the equivalent of 10° in roll and 3½° in pitch, due either to faults within the MFS or to power failure.

3 Twin azimuth gyro unit

Port and starboard horizontal gyros in a rack beside the vertical gyros, driven by the 115-volt AC supply, provide azimuth signals for the port and starboard compass systems. They are normally magnetically monitored and, when monitoring is taking place, the arrows in the annunciators will pulsate. If the DG facility is selected on a Beam Compass, monitoring is disconnected on that side, and the DG flag shows and the annunciator arrows centralise and remain locked. Monitoring is automatically disconnected during turns but the annunciator arrows continue to indicate monitoring current.

4 Director horizons

(*a*) Each Director Horizon is, basically, an artificial horizon on which the pitch and roll elements have been separated. The instrument indicates up to ± 40° of pitch and 60° of bank but, however, the horizon bar and bank ringsight have complete freedom in roll.

(*b*) The various components consist of:

A horizon bar
A bank ringsight pointer and bank scale
A pitch ringsight pointer
A pitch scale
A glidepath pointer
An azimuth director pointer
BEAM and glidepath (GP) flags and a pitch director indicator (P) flag
An attitude warning flag

(*c*) Roll signals from the remote vertical gyro are fed to the horizon bar, which rotates in a conventional sense to indicate bank. At the same time, the bank ringsight, operating at right-angles to the horizon bar, moves over a scale to indicate the precise angle of bank; the scale is marked in 10° intervals up to 30° and then at 60°. The azimuth director pointer, moving over the same scale, is normally controlled by a heading error signal, given by the difference between the actual aircraft heading and the setting of the heading index on the Beam Compass. When ILS is selected, the pointer is controlled by the resultant of heading error and beam displacement signals. In the PDI function, track error only is given (see para. 7(*c*) (ii)). The relationship between error signal and bank displacement angle is such that a 10° error signal demands a 20° bank angle, except when ILS is selected ; in this case, a 10° heading error demands a 10° bank angle. The maximum bank angle demanded is 30°. The demand is satisfied by applying bank in the indicated direction until the ringsight pointer is over the azimuth director pointer.

(*d*) Pitch signals from the vertical gyros are fed to the ringsight pitch pointer, which moves vertically over the pitch scale. The pitch indication is non-linear and pitch scale markings indicate approximately 6° and 13° of dive or climb either side of the centre dot. The pointer displacement is less sensitive as pitch displacement increases from the neutral datum. The maximum pointer deflection is 40°; between this angle and 85°, the pointer is held in the fully deflected position.

(*e*) The glidepath pointer, which moves over the pitch scale, is controlled by the ILS glidepath signals. Both the pointer and the pitch scale can be moved up and down together behind the pitch path signals, the needle remains over the centre dot on the pitch scale. When the pitch scale is being servo-driven and/or a selection other than central is made on the pitch selector switch, the P flag will show.

(*f*) The BEAM flag is permanently visible when adequate ILS localiser signals are being received; the GP flag shows when adequate ILS glidepath signals are being received. Inadequate radio signals are indicated by a pulsing of the appropriate flag.

5 Beam compasses

(*a*) Each Beam Compass is basically the remote indicator of its gyromagnetic compass system, being fed with signals from the detector units.

In addition, the Beam Compass:

(i) Acts as the heading monitor for the auto-pilot.

(ii) Acts as the heading selector for both Director Horizons and for the auto-pilot.

(iii) Shows the displacement from a selected radio beam and the aircraft heading relative to that beam.

(iv) Can provide directional gyro information.

(*b*) The various components consist of:

A rotatable compass scale
A heading pointer, with a miniature aircraft in the centre and a ringsight pointer at the tip
A heading index
Top and bottom datum marks
Radio-coupled range marks
Radio beam displacement bar and scale
DG flag
Sense switch
Setting knob

(*c*) Both compass warning lights will come on, after a delay varying from 20-45 seconds, if the two heading indicators differ by more than 5°. Certain power failures may make a light come on (see para. 10(b)).

(*d*) The DG flag shows when the directional gyro function is selected on the annunciator unit.

(*e*) In order to avoid undue running of the compass system on the ground, two compass isolation switches are provided at the nav./plotter's position, for use when ground testing other equipment.

Controls and Indicators

6 Annunciator units

An annunciator unit is provided for each half of the twin compass system. The controls on the unit consist of a COMP-DG switch, a synchronising knob and a window showing the annunciating arrows. To synchronise, the knob should be turned in the direction of the annunciating arrow until the arrow pulsates. The synchronising knob is also used to set the compass when it is being used as a DG.

7 MFS selector

(*a*) One MFS selector is provided on panel AT for both pilots and carries the following switches:

A COMP switch, for compass selection
A navigational selector switch
A pitch selector switch.

(*b*) The COMP switch is engraved with an arrow, to indicate which compass system, port or starboard, has been selected to supply heading control signals to the azimuth director pointers of both Director Horizons and to the auto-pilot. All heading selections (*c*) (i) The navigational selector switch has five positions:

BOMB, REMOTE, central (normal), LOC and GP.

(ii) With BOMB selected, azimuth directions are supplied from the NBS and normal heading error signals are suppressed.

(iii) With REMOTE selected, the heading information is controlled by the navigator, who can feed in variation and/or drift information, thus making it possible for the beam compass to read magnetic heading, magnetic track, true heading or true track.

(iv) With the switch at the normal centre position, only the heading error (magnetic) from the beam compass is supplied to the azimuth director.

(v) With LOC selected, and provided that the ILS is tuned in and operating, localiser beam signals will be fed into the system. The BEAM flag on the director horizon will show and the beam bar on the beam compasses will indicate the aircraft position relative to the beam. Whether ILS is tuned in or not, selecting LOC will give 1: 1 bank demand.

(vi) With GP selected, both localiser and glide-path signals will be fed into the system. Both the BEAM and the GP flags will show on the Director Horizons and the glidepath pointer will indicate the aircraft's position relative to the glidepath.

(*d*) (i) The pitch selector switch controls the servo-driven functions of the Director Horizon pitch scales and has five positions:

MACH, HEIGHT, central (normal), APPROACH and DATUM. The MACH position is at present inoperative. With any of these selections, other than central, the pitch (P) flag will show on the Director Horizons.

(ii) With HEIGHT selected, pitch directions are given to maintain the aircraft at the altitude at which it was flying at the

down, the position of the centre dot indicating to the pilot the corrections needed to maintain the pressure altitude. As the variation of the pitch scale will be relative to its position at the time of selection, the aircraft should be allowed to settle to the required cruise conditions before selecting HEIGHT. In order to avoid undue attitude changes, the height facility will disconnect automatically if the deviation from the selected altitude exceeds 13 millibars (400 feet at sea level). The selector will then return to the centre position.

NOTE: If HEIGHT is selected *before* the aircraft has settled to its cruising attitude, any signals followed in the interim will result in a distorted flight path.

(iii) With the switch in the centre position, no pitch director signals will be fed to the Director Horizons and the pitch scale can be adjusted to any required attitude datum.

(iv) The APPROACH and DATUM positions are interconnected, the switch being spring-loaded to return to APPROACH when released after selecting DATUM. The selection will only be attained if the navigational selector switch is selected to LOC and GP (See 9(*b*)(ii)).

8 Navigator's controls

In addition to a compass repeater, fed from the port compass system, a track control unit is provided at the navigator's station. Both variation and/or drift values can be fed into the compass system automatically or manually. A compass selector switch enables the navigator to select which of the compass systems is to supply information to the unit and to other navigational equipment (GPI, NBS). It is essential that the compass selected by the navigator has not been selected to DG by the pilot, unless gyro steering is in progress and the navigator is fully aware of the selection made. The navigator can also check magnetic heading at any time by

9 Pitch director function controls

(*a*) With the pitch selector switch in the central position, there are no pitch director signals and the pitch scale remains as a fixed datum. It can be adjusted, however, by the pitch scale setting knob. There are three methods of operation:

(i) *Emergency setting*. With the pitch scale knob pulled out, the pitch scale can be manually adjusted up or down to indicate a required attitude. Only the scale of the instrument so operated will move, the other instrument being unaffected. If the knob is left pulled out, the scale cannot be servo-driven on that instrument.

(ii) *Trimming setting*. With the knob in its normal position, it has restricted movement against a spring in either direction Rotation of the knob will cause the scale to move up or down slowly, until the knob is released. While the scale is moving, the pitch flag will appear. Operation of the knob in this fashion affects both instruments.

(iii) *Fast setting*. With the knob pushed in, against spring tension, both scales will move rapidly to align the centre dot with the pitch pointer ; the knob must be held in until alignment is complete. While the scale is moving, the P flag will appear. This facility is not accurate if the aircraft angle of climb or dive is greater than 10°. This method of operation is particularly useful when climbing away from an overshoot ; it overrides any pitch selection on the MFS selector, releasing the selector switch to its central position.

(*b*) Pitch director functions are fed into the system when the pitch control on the MFS selector is moved from its central position. The functions are as follows:

(i) With HEIGHT selected, the pitch scale is servo-driven to indicate corrections required to maintain the altitude at which the aircraft was at the time of selection (the pitch flag will show). at the time of selection, the aircraft should be trimmed to the speed and attitude required, with the pitch pointer over the centre dot of the scale, before selecting HEIGHT.

(ii) The DATUM position of the switch, used in conjunction with LOC and GP, selects the pitch scales to centre, which is the approximate aircraft attitude on the ILS glidepath. When released, the switch returns to APPROACH and the pitch scales move slowly, if the aircraft is not on the ILS glidepath, in such a direction as to bring the aircraft back onto the glidepath. With the switch at APPROACH, a drift unit in the pitch computor unit compensates for drift except for wind shear.

10 Power supplies and failure indications

(*a*) (i) The main system is operated by 115 volt AC at 400 CPS, the 1st pilot's by No. 2 and the co-pilot's by No. 4 transformer.

(ii) *Post-Mod*. 3334

A NORMAL/EMERGENCY change over switch is fitted on the 1st pilot's instrument panel. When EMERGENCY is selected the 1st pilot's MFS power supplies are obtained from No. 3 instead of No. 2 transformer. There is no alternate power source for the co-pilot's MFS.

(iii) *Post-Mod*. 3427

Two power failure warning lamps are fitted, one on each pilot's instrument panel. In the event of a power supply failure, the appropriate lamp will illuminate.

(*b*) Complete power failure to the system will be indicated by:

(i) The failure warning flags showing on both Director Horizons.

(ii) No compass annunciation and the system going dead.

(iii) No ILS BEAM or GP flag indications.

(iv) MFS pitch selector reverting to the central position.

(c) Power failure to one side of the system is indicated by:

(i) Attitude warning flags on both Director Horizons.

(ii) No compass annunciation on dead side.

(iii) Starboard compass warning light if failure is in port system (no compass warning light if failure is in starboard system until there is 5° discrepancy between indicated headings).

(iv) No BEAM and GP flags.

(v) Reversion of pitch selector to central position if failure is in the starboard system.

(vi) Post-Mod. 3427 the appropriate PFWL illuminating.

(*d*) Partial power failure within the systems may be indicated as well by:

(i) The failure warning flags on both Director Horizons when a power failure leads to a discrepancy between the signals to the horizons (see 2(*b*)). Certain power failures can lead to an immediate appearance of the failure warning flag on one or both Director Horizons, before the failure has led to a signal discrepancy.

(ii) Compass warning lamp indication on one or both Beam Compasses, either immediately or when compass indications differ by more than 5° for more than 20-45 seconds.

(iii) ILS BEAM or GP flag behaviour.

(iv) Faulty flight direction facilities indicated by failure to achieve the selected manoeuvre.

NOTE: Mod. 2967 introduces an A/P/GYRO NORMAL-STANDBY switch at the navigator's station. When the switch is set to STANDBY and an external 28 volt supply is connected, the MFS 115 volt power supplies are interrupted to prevent prolonged ground running of the gyros during periods of readiness. When the switch is set to NORMAL, or the 28 volt

Normal Management of the MFS

11 Full functional checks

(*a*) Before power is switched on check that the attitude failure warning flags are visible on both Director Horizons, and that these disappear when power is switched on. Have both COMPASS ISOLATION switches at the navigator's position selected to ON, and the airfield variation value set on the TRACK CONTROL UNIT.

(*b*) On the MFS selector set the navigation and pitch selector switches to the central positions. Check that the pitch and roll attitude indications on both Director Horizons settle down as the gyroscopes erect, and that both show similar indications depending on the aircraft ground attitude. Check that both setting knobs are not in the fully out positions.

(*c*) Select both compass annunciator switches to COMPASS. Synchronise both beam compasses by turning the synchronising knobs in the direction of the annunciator arrows until the arrows pulsate. Both amber compass warning lights should go out. Push and turn the setting knob of each Beam Compass to set each compass card with the aircraft heading pointer at the top compass datum. Pull and turn the setting knobs to align the heading indices under the heading pointers. Compare the heading pointer readings with the P.12 compass reading.

NOTE: Some disparity in readings may be expected if there is magnetic material in the area of the aircraft wing tips.

(*d*) At the MFS selector move the navigation selector to REMOTE. Check that the heading pointer of each Beam Compass moves in the correct direction and value of the variation set on the track control unit. Return the switch to the central position and note that the compass heading pointers return to their original positions.

(*e*) At the MFS selector turn the COMPASS selector switch to port. On the port beam compass move the heading index to port and starboard and check that the azimuth directors on both full range of movement. Check that 15° displacement of heading index demands 30° bank demand of azimuth directors. Turn the compass selector switch to starboard and repeat the check on the starboard compass.

(*f*) Set both compass annunciator switches to DG and check that the DG flags appear on both Beam Compasses. Turn the synchronising knob on the starboard annunciator unit to set the starboard heading pointer at least 20° clockwise from the port heading pointer. Set both annunciator switches to COMP and check that both compass warning lights come on within 45 seconds. Set the port annunciator switch to DG, check that the lights go out, and come on again when the port annunciator switch is returned to COMP. Slowly rotate the starboard synchronising knob to bring the starboard heading pointer towards the same indication as the port heading pointer. Check that the warning lamps remain on while the readings differ by at least 7° but go out before the difference is reduced to 3°. Repeat the check after displacing the starboard heading pointer at least 20° anti-clockwise from the port heading pointer.

(*g*) Turn the compass selector to port and displace the port compass heading pointer sufficiently to illuminate the warning lights. Turn both compass annunciator knobs simultaneously in a clockwise direction, check that both warning lights go out while the heading pointers are moving, and illuminate again when the heading pointers stop. Repeat the check in the reverse direction. Re-synchronise both compasses.

(*h*) Turn the radio sense switches at the side of each Beam Compass with the arrows pointing upwards. Check that the radio beam bars on both Director Horizons are central on their scales and that no flags are visible.

(*j*) Check the operation of the pitch scale on the port Director Horizon by means of the setting knob as follows:

(i) Pull the knob fully out and check that, by rotating it, the pitch scale can be manually adjusted both up and down ; leave

(ii) Push the knob and release it, allowing it to return to its mid position. Rotate the knob clockwise against spring pressure, note that the pitch scales on both Director Horizons move slowly to the top of their travel and that the Pitch flags appear. Release the knob.

(iii) Push the knob fully in, note that the pitch scale centre dots on both Director Horizons move rapidly to a position directly under the pitch pointers and that the Pitch flags appear. Release the knob.

(iv) Rotate the knob anti-clockwise against spring pressure, note that the pitch scales on both Director Horizons move slowly to the bottom of their travel and that the pitch flags appear. Release the knob.

(v) Push the knob fully in, note that the pitch scale centre dots of both Director Horizons move rapidly to a position directly under the pitch pointers and that the Pitch flags appear. Release the knob.

(vi) Repeat the checks on the starboard Director Horizon.

(*k*) Displace the pitch scales slightly from the pitch pointers. Select HEIGHT on the MFS pitch selector switch and check that the Pitch flags appear on both Director Horizons ; the pitch scale should move slowly towards the pitch pointer. Pull out the setting knobs on each horizon in turn and note that the Pitch flags on the respective instruments disappear. Return both setting knobs to their mid-positions and return the pitch selector switch to its central position.

(*l*) With the ILS switched OFF, select the MFS navigational switch to LOC. Check that the BEAM flags on both Director Horizons pulse fully in and out. Select LOC and GP position and check that both BEAM and GP flags pulse. If ILS signals are available, switch ON the ILS. Check that the heading index is within the radio coupling range markers and rotate the BEAM COMPASS

As the ILS signals are fed to the MFS system the BEAM and GP flags should stop pulsing and remain steadily in view. The radio beam bars, azimuth directors and glidepath directors should be displaced but the direction and magnitude of their displacement will vary according to the displacement of the aircraft from the ILS beams.

(*m*) Select and hold the DATUM position on the pitch selector switch, check that both pitch scales move rapidly to the centre of the instruments and that the Pitch flags appear. Release the pitch selector switch and note that it locks on the APPROACH position. The pitch scale should move slowly towards the pitch pointer. If the heading pointer is offset from the heading index, the azimuth director pointers should move towards zero bank (drift unit function). Select the navigational switch to its central position, check that the pitch selector switch releases to its central position and that the Pitch flags disappear. Switch OFF the ILS.

(*n*) If the NBS is functioning, select BOMB on the navigational selector switch and check this function in accordance with the Navigator Radar's manipulation of the NBS equipment. On completion of the check return the navigational selector switch to its central position.

12 Pre-flight checks

(*a*) Check that the attitude failure warning flags of both director horizons are not visible, and that the pitch scale setting knobs are not in the fully out position. Select the navigation and the pitch selector switches to the central positions. Check that the pitch and roll attitude indications on both horizons are similar. Switch ON the ILS.

(*b*) By use of the pitch scale setting knob check all three modes of operation of the pitch directors on each director horizon in turn. On completion of the checks leave the pitch director set approximately

(*c*) Select both compass annunciation switches to COMPASS and synchronise the compasses by turning the synchronising knobs in the direction of the annunciator arrows until the arrows pulsate. Check that both amber compass warning lights go out. Align the heading pointer and heading index over the top datum on both compasses. Set the compass selector switch to PORT, ensure that the azimuth directors are central and compare the port compass heading with the P.12 compass. Check that the azimuth directors move in the correct sense when the heading index is moved port and starboard, and return to central. Set the compass selector switch to STARBOARD and repeat the compass checks using the starboard beam compass. Leave the compass selector switch selected to the compass required.

(*d*) Set the radio sense switches of both beam compasses as required (normally pointing up) and check that the heading index is within the radio coupling range. Set the ILS QDM under the heading index. Select the navigation selector switch to LOC, check that the BEAM flags appear on both director horizons and that the beam bars and azimuth directors move in the correct sense. Then select the navigation selector switch to LOC & GP, check that the GP flags appear on both director horizons and that the glide-path directors move up. Select the pitch selector switch through APPROACH to DATUM, check that both pitch flags appear and that both pitch scales move rapidly to the centre of the instruments. Release the pitch selector switch and ensure that it springs back and remains at the APPROACH selection. Centralise the navigation selector switch and check that the pitch selector switch automatically moves to the central position. Switch off the ILS.

(*e*) If the NBS equipment is functioning select BOMB on the navigation selector switch and check this funtcion in accordance with the Navigator Radar's manipulation of the NBS equipment. Return navigation selector to central.

(*f*) Select navigation selector switch to REMOTE, note the change of heading shown on the beam compasses and confirm with

13 Normal flight control and en-route flying

NOTE: The Beam Compass should not be regarded as a steering compass but as an instrument for setting up courses which will be steered by obeying the direction of the Director Horizon.

(*a*) *General*

Select the required compass on the MFS selector. The heading index may be set to any position around the Beam Compass but, for normal en-route flying, it is more convenient to set the index to the top datum and rotate the compass card so that the required course is in line with the index. For course changes, rotate the compass card to bring the new course against the heading index. The azimuth director pointer on the Director Horizon will indicate the necessary bank required to turn the aircraft onto the new heading ; when this has been reached the azimuth director pointer will be vertical and the compass heading pointer will be over the heading index.

(*b*) *Navigational control*

(i) To fly magnetic headings, set the MFS navigational selector to the centre position.

(ii) To fly true track, magnetic track or true heading, set the navigational selector switch to the REMOTE position. The navigator can then feed in magnetic variation and/or drift (from the Green Satin) to the Beam Compass heading pointers. Any changed selection by the navigator will cause the heading pointer to move relative to the compass card and will necessitate resetting the heading index if the previous course is to be maintained.

(*c*) *Selection between compasses*

Before altering the selection of the compass selector switch, the heading index of the compass to be selected should be set to the aircraft heading. Failure to do this will result in an indication of bank demand on the azimuth director pointers as soon as the

(*d*) *Use of pitch datum facilities*

The pitch scale of the Director Horizons may be adjusted to any desired position and the aircraft then flown so as to maintain the ring of the pitch pointer over the centre dot of the pitch scale. If HEIGHT lock facility is selected on the MFS pitch selector switch, the aircraft may then be maintained at the height at which the facility was selected by maintaining the pitch pointer over the centre dot of the pitch scale.

14 Visual circuits and landings

Select the required compass on the compass selector switch and set the navigational selector switch to the central position. Before take-off set the compass card with the runway QDM at the top datum ; set the heading index at the top datum also and leave the setting knob out. All changes of heading after take-off can be made by setting the index to the required course and following the azimuth director pointer indications.

15 ILS approach

(*a*) On approach to the overhead or " gate " position switch ON the ILS and select whichever compass is required. ▶◀

(*b*) Before commencing the let-down, on the MFS selector set the navigational selector switch central (to fly magnetic headings) and the pitch selector switch central (to cancel the HEIGHT facility). Set both radio sense switches upwards. On the selected compass set the outbound heading to the top datum, and on the other compass set the localiser or runway QDM to the top datum.

(*c*) On commencement of the inbound turn, rotate the compass in use in two stages to bring the localiser or runway QDM to the top datum. Select LOC on the navigational selector switch, check that the BEAM flags appear, and follow the indications of the azimuth (*d*) In the presence of a cross-wind, the aircraft will be directed to adopt a drift angle at which the heading error signal balances the beam displacement signal. There will be no demand signal displayed on the azimuth director, but the aircraft will be established on a track displaced from the beam centre line, and this will be indicated by the radio beam displacement bar on the Beam Compass. Reset the heading index under the heading pointer, and check that the drift angle thus set coincides with the drift information from the Green Satin. Adjust the drift angle as required to maintain the aircraft on the localiser beam centre line.

(*e*) When level and approaching the interception with the glide-path beam, select HEIGHT on the pitch selector switch and GP on the navigational selector switch. Check that the GP flags appear and are steady.

(*f*) When the glidepath pointer is over the centre dot of the pitch scale, select APPROACH & DATUM. This will cause the pitch scales to move rapidly to the approximate correct indication for the approach. Select flap and reduce power as required to follow the indications of the glidepath director.

(*g*) On overshoot, move the navigational selector switch to the central position (the pitch selector switch will automatically move to the central position), align the pitch scales using the fast setting, and align the heading index with the heading pointer if necessary. For further low-level instrument procedures rotate the heading index or compass card as required.

16 GCA approach

(*a*) *Without* ILS

Set the heading index to the top datum and rotate the compass card to the heading given by the GCA controller. Follow the indica- approach centre line, the runway QDM may be set to the top datum and the setting knob pulled out so that new courses may be set by adjustment of the heading index. Alternatively, the heading index may be left vertical and the compass card rotated to set up the controllers' courses.

(*b*) *With* ILS *monitoring*

If it is desired to use the ILS beam for standby or monitoring information, set the compass card with the QDM of the ILS beam against the top datum. Set the heading index to the courses given by the GCA controller and follow the directions of the azimuth director pointer. As the ILS is only to be used to give beam displacement information on the Beam Compasses, set the radio sense switch arrows pointing in the opposite direction to the heading index in order to suppress radio displacement signals to the azimuth director pointer.

Malfunctioning of the MFS

17 Attitude failure

If there is a power supply failure, or if there is a difference of 10° of roll or $3\frac{1}{2}$° of pitch signals between the port and starboard system, warning flags will show on both Director Horizons. Check each Director Horizon against other flight instruments.

18 Heading failure

If the heading indications on the Beam Compasses vary by more than 5° both amber warning lights will come on after approximately 30 seconds. Check both annunciator units and, if both are functioning correctly, check each Beam Compass reading with the P.12 compass. Select the serviceable compass on the MFS selector and select DG on the faulty compass. Inform the navigator and

19 Director horizon faults

(a) Reduced sensitivity

(i) A director horizon can, although being supplied with the correct input signals, develop a fault causing reduced sensitivity of the pitch, glidepath and azimuth director pointers. Any one, two or three of the pointers can be affected. This fault causes:

The pitch pointer to indicate a smaller pitch attitude than actually exists.

The glide path or azimuth pointer to demand a smaller correction than is actually required.

(ii) During flight, cross reference should be maintained between the two director horizons and the other flight instruments and, if the fault occurs, reference be made to the serviceable instrument, i.e. the director horizon that presents the greater demand or pitch indication.

(iii) If the fault occurs during an ILS approach, the approach should be broken off and a subsequent one made using a ground interpreted aid instead, whilst reference is made to the serviceable director horizon.

(iv) As the demand signals to the auto-pilot are unaffected, an auto-ILS approach can be successfully carried out although the defective horizon will present false indications.

◀ *(b) Pitch pointer fluctuation*

The pitch pointer may fluctuate slightly at times. These fluctuations are acceptable provided that the vertical gyros are erect and that the movement is less than half of the width of the pitch pointer bar. ▶

Part I

Chapter 9—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 ground test lever, which must be set fully down for flight conditions.

2 Controls and indicators

The controls and indicators for the system with the exception of circuit breakers on panel AV are all on the 2nd pilot's side panel AD as follows:

(*a*) Four OPEN-CLOSE ENGINE BLEED ISOLATION VALVES switches one for each engine, control the supply of air

(*b*) Two OPEN-CLOSE PORT and STBD. CABIN AIR ISOL. 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 8,000 feet until a maximum differential pressure of 9 PSI is reached (47,000 feet 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 8,000 feet cabin altitude until a maximum differential of 4 PSI is reached (19,500 feet). When set to UNPRESS a dis-

(*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 off (central), MANUAL COOL or WARM (down), or AUTO (up). 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 temperature. 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 CAU BYPASS—CAU IN switch, adjacent to the ISOLATION VALVES switches enables the cold air unit to be completely by-passed by setting the switch to CAU BYPASS.

(*f*) 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 ½ PSI from the selected value. Red warning lights are at each crew station except the 2nd pilot's and prone bomb aimer's.

(*g*) In addition to the warning light a warning horn sounds if cabin altitude exceeds 42,000 feet. The warning can be silenced by operation of the HORN OVERRIDE switch on the 2nd pilot's side panel AD.

(*h*) Mod. 3816 introduces a cabin differential pressure gauge on panel BCB to provide an indication 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 matically 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

The starboard ram air intake nostril supplies air for ventilation in unpressurised flight at low altitude. The ram air valve may be opened by a bowden-cable, operated by a lever at the Nav./Radar operator's station.

5 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.

6 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 the 2nd pilot's console are two test switches for testing the cabin temperature balance bridges.

7 Windscreen de-icing and demisting

(*a*) The pilot's windscreen panels are heated electrically by gold film inlays. A switch on panel AC, marked WINDSCREEN HEATING PO & SI/OFF/DE-MIST controls the electrical supplies to the port outer and starboard inner panels. On the right of panel AZ is a second WINDSCREEN HEATING PI & SO/OFF/DE-MIST switch, controlling the supplies to the port inner and starboard outer panels. A magnetic indicator beside each switch shows the condition of the system. Mod. 3698 introduces a DE-ICE position to both switches.

(*b*) *Demisting*

A WINDSCREEN DEMISTING OPEN/SHUT control lever on panel AB can be used to supply demisting air either to the pilots' centre windscreens (up) or to the downward observation windows (down) and provides reduced supplies to both in the HALF OPEN position.

(*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 2nd pilot's console, AF and one on 1st pilot's side panel.

8 Bomb-bay heating system

(*a*) *General*

The bomb-bay heating system is designed to maintain a temperature of +20°C but provision is made to allow manual control within variable limits dependent upon the type of store carried. The system will operate only if the starboard ENGINE BLEED ISOLATION COCKS switches are set to OPEN.

(*b*) *Controls and indicators*

The controls are mounted on the navigator's side panel and consist off:

(i) An OFF/AUTO/MANUAL switch.

(ii) A COOL/OFF/WARM control switch.

(iii) A COOL/NORMAL/WARM rotary TEMP. SETTING CONTROL switch.

(iv) A bomb-bay TEMPERATURE INDICATOR.

(v) A bomb-bay OVERHEAT RESET switch.

(vi) An OVERHEAT warning light.

(vii) 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 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.

(*c*) *Carriage of Blue Steel*

When Blue Steel is carried the bomb-bay heating must not be switched on. Prior to Mod. 3167 the warm air supply to the missile

Normal Management of the System

9 Before flight

(*a*) Before starting the engines, in accordance with the check list, carry out the following checks and selections:

Nos. 1 and 2 pressure controller levers	Down and flush
Cabin pressure dump valve . .	Up and wired
Circuit breakers at panel AV . .	Closed
Crew door accumulator pressure .	Normal
Hatch seal pressures . . .	Normal (both sides)
Hatch seal clips	In position
CABIN TEMP. BRIDGE TEST switches	Both central
Bomb-aimer's demist selector .	OFF
Ram air valve	CLOSE
ENGINE BLEED ISOLATION VALVES	CLOSE (4)
MASTER FLOOD FLOW switch	AUTO
Flood flow reset switch . .	Central
Flood flow indicator . . .	Black
Warning HORN OVERRIDE switch	Up
CAU selector switch . . .	CAU IN
CABIN AIR ISOL. COCKS .	CLOSE PORT & STBD.
CABIN PRESSURE selector .	CRUISE or as required
MAX. HEAT and OVERHEAT warning lights	Out: push to test
CABIN TEMPERATURE control switch	AUTO
CABIN TEMPERATURE SETTING selector	As required

(*b*) When the engines are started and the entrance door closed, set:

AIR CROSS-FEED cock . .	CLOSE
ENGINE BLEED ISOLATION VALVES	All to OPEN (RPM below 60%)
DV windows	Closed before take-off

(*c*) After take-off select the CABIN AIR ISOL. COCKS switches OPEN in turn with a minimum 10-second interval.

10 Control of cabin temperature

(*a*) The cold-air unit should be selected IN prior to engine starting and remain so until airborne. During flight the CAU should be selected to BYPASS, so as to give increased CAU life, and only selected IN if the cabin temperature becomes excessively hot. It should be selected IN prior to landing.

(*b*) The cold air unit control switch must be selected to CAU IN if cabin air conditioning is required on the ground. Select the CABIN AIR ISOL. COCKS open at 10 second intervals, but ensure that the ENGINE BLEED ISOLATION VALVES are open first or overspeeding of the cold air unit turbine may result. At least one engine should be at 70—75% RPM. The CABIN AIR ISOL. COCKS should be closed for take-off.

(*c*) With the CABIN TEMPERATURE control switch set to AUTO the temperature may be adjusted by means of the SETTING selector. If the red OVERHEAT warning light illuminates, the temperature control valve will automatically move to the fully cold position (indicated on the WARM-COOL indicator). Subsequent cooling of the thermal switch will allow the temperature control valve to open and a small movement of the SETTING selector towards COOL may help to prevent further overheating. If the OVERHEAT warning light illuminates again, a failure of the automatic temperature control system is indicated and all subsequent control must be made by manual selection.

(*d*) Manual control is achieved by judicious use of the control switch between the COOL and WARM positions. Movement of the temperature control valve is indicated on the COOL—WARM indicator when the switch is at COOL or WARM, and movement ceases when the switch is released. If the amber MAX HEAT warning light comes on, the temperature should be reduced by holding the control switch at COOL until the amber light goes out. If, when the amber light is on, further overheating occurs, the red OVERHEAT warning light will illuminate and the system will automatically go to fully cold. When the OVERHEAT warning light goes out, further manual selections may be made.

(*e*) Only sufficient hot air should be allowed on to the windscreen panels to prevent misting. Surplus air should be directed to the pilots' feet heating by setting the windscren demisting control to BOMB AIMER OPEN. Particular care must be taken to avoid excessive heating of the panels whenever the anti-flash screens are fitted.

(*f*) At low altitudes the RAM AIR VALVE may be selected OPEN to assist in cabin cooling.

(*g*) Air conditioning is marginal in conditions of high humidity where the OAT is above +25°C. Before descent to low level the cabin should be refrigerated for about 20 minutes using the CAU. During the descent close the cabin air isolation cocks at 10,000 ft. to trap the cold air. Resume normal cabin conditioning after about ½ hour of low level flight.

11 Control of cabin pressure

The pressure control selector should normally be set to CRUISE or COMBAT as required. If air conditioning only is required, select UNPRESS. Periodic checks of the cabin altimeter should be made throughout flight to ensure that cabin altitude is correct for

CRUISE to COMBAT or vice versa the times to stabilise the new condition are as follows:

CRUISE to COMBAT . . .	36 seconds
COMBAT to CRUISE . . .	5½ to 6¼ minutes

Some internal misting may occur when selecting COMBAT from CRUISE.

12 Control of gold film windscreen heating

(*a*) Both heater switches should be selected to DE-MIST before take-off and maintained there throughout flight. DE-ICE (Mod. 3698) should only be selected when it is required to clear ice or heavy misting.

(*b*) To avoid delamination of windscreen panels, DE-ICE should never be selected without having first selected DE-MIST, nor should the aircraft be flown with the system OFF.

Malfunctioning of the System

13 Loss of cabin pressure

(*a*) If the cabin pressure falls below the correct pressure for the selection in use, red LOSS OF CABIN PRESSURE warning lights on the 1st pilot's coaming and at the 3 rear crew stations will illuminate. The cabin pressure warning horn will sound if the cabin pressure falls to that equivalent to 42,000 ft. cabin altitude.

(*b*) With the MASTER FLOOD FLOW switch selected to AUTO, the flood flow system should automatically operate if the cabin altitude reaches 27,000 ft. and the indicator will show white (OPEN) when the flood flow valve is fully open. The mass-flow

26,500 ft. and will cycle open and closed to maintain these conditions while the switch is selected to AUTO. This cycling effect may be prevented by assuming manual control of the mass-flow valve. Move the MASTER FLOOD FLOW SWITCH to the mid (OFF) position, and then increase or decrease the mass flow by judicious selection between the FLOOD and LESS AIR positions until comfortable conditions exist in the cabin.

(*c*) When flood flow is no longer required select the flood-flow reset switch to RESET until the indicator goes black.

14 Emergency de-pressurisation of the cabin

(*a*) In an emergency the cabin can be depressurised by any of the following selections:

1st pilot's ABANDON AIRCRAFT switch	ABANDON AIRCRAFT
1st pilot's EMERGENCY DECOMPRESSION switch .	EMERGENCY DECOMPRESSION
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 12,000 ft. and with CRUISE selected, the appropriate time must elapse between selecting depressurisation of the cabin and opening the door. (See Part IV, Chap. 3, para. 1). All crew members should be strapped in their seats before the door is opened.

Part I

Chapter 10—Airframe and Engine Air Intakes Anti-icing Systems

List of Contents

Description, Controls and Indicators

1 General description

(*a*) A hot air anti-icing system augmented by electrically heated mats, is provided for the engine intakes, the alternator CSDU oil-cooler air intake, Blue Steel vapour cooling pack air intake, ECM heat exchanger intake, 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 approximately 80°C.

(*b*) Engine anti-icing (as opposed to engine air intake anti-icing) is covered in Part I, Chap. 6, paras. 5 and 18.

2 Controls and indicators—hot air system

NOTE: The electrical supply to the ice detectors and heater mats is inoperative until the airspeed is above 105 knots, since the 28 volts supply from feeder 21P7 is controlled by the undercarriage pitot switch.

(*a*) In order that the hot air system may function the ENGINE BLEED ISOLATION VALVES OPEN-CLOSE switches should all be set to OPEN. The system is then controlled by the following

(i) An icing conditions indicator which shows black when not in icing conditions or ICE if such conditions are encountered. Below the indicator is a notice: SWITCH OFF ANTI-ICING IF INDICATOR REMAINS BLACK FOR OVER TWO MINUTES.

(ii) Three OFF-ON ANTI-ICING CONTROL switches for the PORT and STBD. wings and TAIL, together with three OVERHEAT WARNING lights and three RESET-OFF switches. Also fitted are four WING AIR EXIT SHUTTERS magnetic indicators.

(*b*) When the 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 and the indicators show OPEN. Conversely an OFF selection automatically closes the shutters.

(*c*) If an overheat warning is given by any one of the three lights a hot-air valve is moved to the fully closed position and a 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

(d) 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 use again.

3 Controls and indicators—electrical system

(*a*) Two electrical anti-icing bus-bars are provided, the PORT supplied by No. 2, 200 volt bus-bar and the STBD. supplied by the No. 3. These supplies are controlled by an AUXILIARY HEATERS, ON/OFF switch. This switch is only effective at airspeeds above 105 knots, as the 28 volt supply to feeders 33P7 and 34P7 is controlled by a pitot-pressure switch.

(*b*) Post-Mod. 3275, two green press-to-test lights are fitted on the co-pilot's side panel AD to provide visual indication of the operation of the port and starboard air intake heater mats.

(*c*) Post-Mods 4131, 4132 the heaters ON/OFF switch also controls the supplies to the port and starboard drop tanks ram air intakes heater mats.

Normal Management of the Systems

4 General

(*a*) The effect of continuous operation in icing conditions has yet to be established and thus operation in icing conditions is to be avoided where possible and limited to a minimum when unavoidable. It is possible that with the current mod. state, large pieces of ice may form on and be shed from the air intake anti-surge vanes after 5-10 minutes in icing conditions with the possibility of damage to the engines.

(*b*) Heating of the air intake leading edge in the region of the inner engines is negligible at engine speeds below 80% RPM.

(*c*) If rapid throttle movements are made, slight engine surging may occur when the systems are in use.

5 Control of the hot air system

(*a*) To switch on the system the following procedure should be used:

Appropriate circuit breakers on panel AV	Closed
Engine isolation cocks . .	OPEN
Anti-icing control switches .	ON. Exit shutter indicators OPEN

(*b*) The systems should be switched on in any of the following circumstances:

1 For take-off in conditions where the air temperature is below +8°C and visibility is reduced to less than 1,000 yards in fog or mist.

2 If the icing indicator shows ICE.

3 If icing conditions are forecast.

4 If visual inspection shows ice formation on the windscreen and build-up of ice on the wing leading edges.

The system should be switched off above 40,000 feet.

(*c*) 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 three overheats occur successively, the system must be switched off. There is a possibility of overheat indication during climb at high RPM before the system has stabilised.

6 Control of the electric heater mats

The heater mats may be switched on before take-off, the airspeed switch keeping them inoperative until a speed of 105 knots is attained.

Part I

Chapter 11—Aircrew Equipment Assembly and Oxygen System

List of Contents

WARNING. The ejection seats must be rendered safe whenever the aircraft is on the ground, by ensuring that the safety pins are inserted in the ejection gun sears and in the delay mechanisms. It is emphasised that pins should not be inserted in

1 General

The aircrew 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

Ejection Seats

2 Seats, general

(*a*) The ejection seats, Type 3LS1 Mk. 1 for the 1st pilot and Type 3LS2 Mk. 1 for the 2nd pilot, are similar but partially handed Each seat carries a Mk. 33 parachute assembly with a horseshoe-shaped pack, combined harness, a back pad (incorporating an adjustable kidney pad) and a personal survival pack type R. The seats become Type 3LS1 and 2 Mk. 2 upon the embodiment of a demand emergency oxygen set. (See para. 24(*a*)).

(*b*) The seat pan is adjustable for height, by means of a lever on the inboard 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 " go-forward " lever, forward on the port 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.

(*e*) When Mod. ES2986 is embodied a negative-G strap is fitted to the seat pan. It is adjusted by a downward pull.

3 Ejection gun and firing handles

Each seat is fitted with an 80 ft./sec. telescopic ejection gun, which can be fired by either of two handles ; the face screen handle, is above the occupant's head and B-shaped. The seat pan firing handle, for use in conditions of high G or when it is otherwise impossible to reach the screen handle, is in the front of the seat pan. 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

4 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. The ejection gun time delay firing unit cannot be operated until an interference pin is withdrawn by a lanyard attached to the canopy.

5 Drogue gun

The drogue gun has a time-delay mechanism and fires half a second after the ejection gun has fired, withdrawing the duplex drogues to stabilise the seat. The time-delay mechanism is operated by a static 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).

6 Back-type parachute assembly, Mk. 33

The parachute pack rests on a support behind the shoulders and is secured by two retaining straps, running between the upper harness lock and the headbox. The harness serves both to restrain the pilot in the seat in normal flight and as a parachute harness. For the former purpose it is attached to the seat by one upper and two lower locks. At the appropriate part of the ejection sequence, the harness locks, together with the pack retaining straps, the face screen, the man portion of the PEC and the leg-restraint lines are released, allowing the pilot to separate from the seat. At the same moment the seat stabilising drogues are detached from the seat, but remain attached to the apex of the parachute, thus opening it

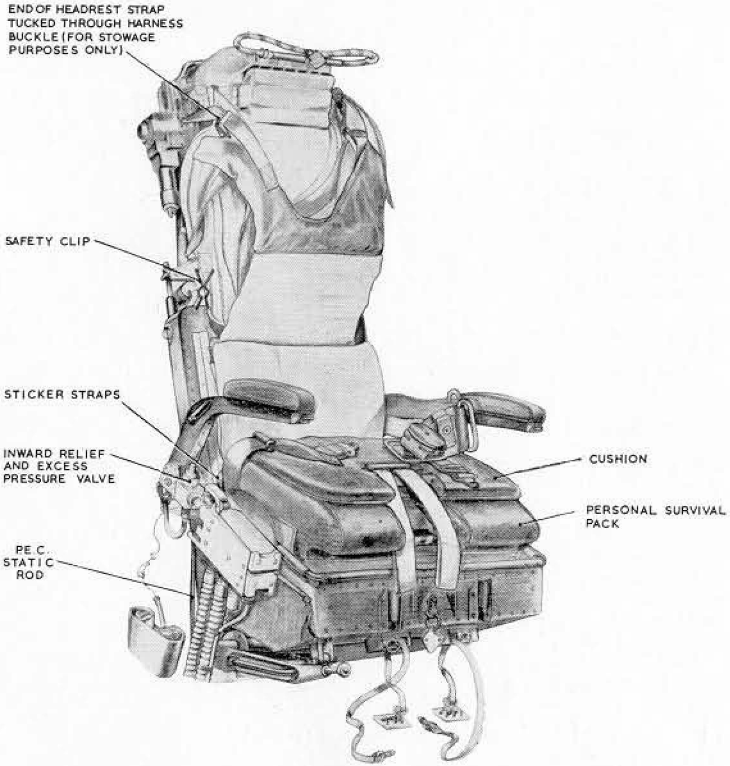


Fig. 1 Mk. 3LS seat equipped (1)

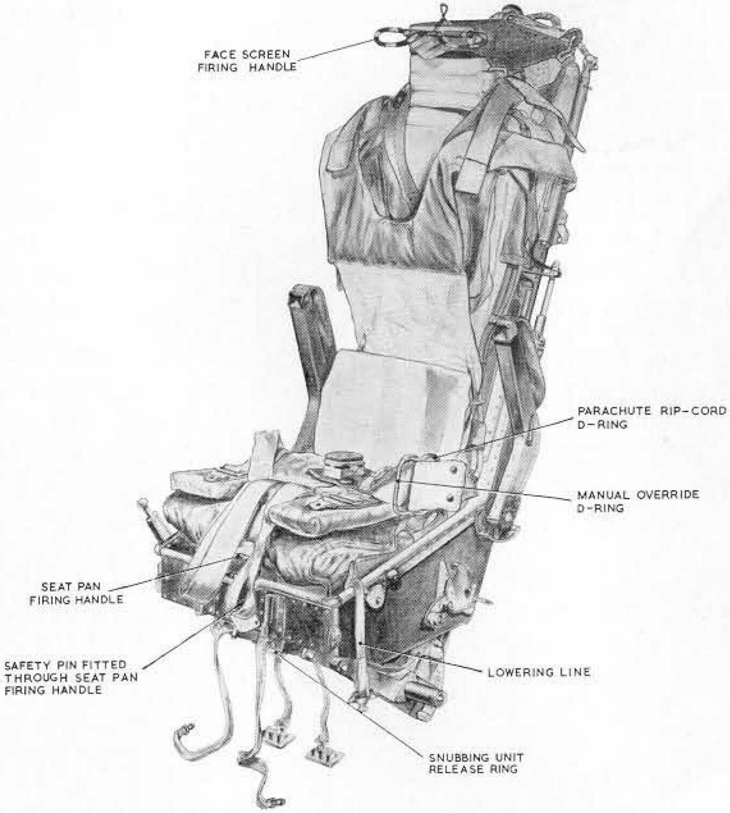


Fig. 2 Mk. 3LS seat equipped (2)

7 R-type survival pack

The survival pack is stowed in the seat pan and attached by quick release fasteners to the outside of the combined harness. A third connection is made (while strapping-in) to the pilot's lifejacket. This embodies a 15 ft. " lowering line ", so that while parachuting the pilot can detach the side connections to the harness and allow the pack to suspend from his lifejacket. It is important that the pack be thus lowered: otherwise difficulties are likely to ensue after alighting, when the harness is discarded.

8 Barostat/G-stop time-delay

NOTE: A barostat operating at 5,000 metres can be fitted for flights over mountainous country.

(*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, personal equipment connector 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.

(*b*) A G-stop is also incorporated 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.

9 Leg restraint

(*a*) Leg restraint cords are provided to prevent the legs flailing during ejection. From the cockpit floor these pass upwards, then forwards through snubber units. During strapping in the free ends sockets on the front of the seat pan, the right cord crossing to the left leg and back to the right socket, and *vice versa*. When more cord is required for this operation, the snubber can be temporarily released by pulling on the ring on its front.

(*b*) As the seat rises on ejection, the cords are drawn through the snubbers until the legs are tightly restrained. The floor attachment then shears, but the snubbers prevent the cord running back. When the man separates from the seat during the later ejection sequence, the sockets release the upper ends of the cords. This end may also be released manually, at the end of a normal flight by pulling the man-portion of the PEC away from the seat portion. (Unless the PEC is mated, the leg cord sockets will not grip.)

10 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 waist-belt is pulled to disconnect the parachute withdrawal line from the automatic gear. This action also uncovers the second (rip-cord) D-handle.

(*c*) After operating the first D-handle, the harness, the parachute retaining straps, the leg restraint cords and the man-portion of the PEC are released by pushing out and pulling up the manual separation lever to the rear of the seat pan on the left side. After leaving the seat, the parachute can be opened by pulling the rip-cord D-handle on the harness.

Clothing and Personal Equipment Connectors

11 Personal equipment connectors (PEC)

(*a*) The pilots' PEC's are in three portions, the aircraft portion, the seat portion and the man portion. The aircraft portion is attached seat. The man portion, an integral part of the clothing, is attached (during strapping in) to the top of the seat portion. When not in use, the seat portion is protected by a dust cover, for which a stowage is also provided on the back of the pilots' seats.

(*b*) The PEC connects all the personal services to the man. The aircraft supplies (main system oxygen, ventilating air, mic./tel.) are fed into the aircraft portion. As the seat ascends the guide rails on ejection, a static rod causes the seat portion to break away. Mod. 2825 replaces the static rod on the 2nd pilot's seat by a pull-off cable.

(*c*) To prevent loss of emergency oxygen, the lower orifices of the seat portion are closed by valves when the aircraft portion is removed.

(*d*) The man and seat portions are mated by sliding the nose of the man portion into hooks at the front of the seat portion and then pressing the handle at the rear downwards. Correct engagement should be checked by tugging smartly on the oxygen hose.

(*e*) To release, press down on the thumb button in the handle and lift the handle. (This also releases the leg-restrain cords).

(*f*) *Rear crew*

Each rear crew member has an oxygen, AVS and mic./tel. connector. No PEC's are fitted.

12 Pressure jerkins and anti-G suits (high altitude)

Pressure jerkins (Mk. 1 or Mk. 4 for pilots and Mk. 3 for rear crew) are worn in conjunction with anti-G suits Mk. 5A when flying at high altitudes. These two items form a pressure suit to protect the crew member if cabin pressure fails and inflate automatically if the cabin altitude reaches 40,000 feet. They are inflated from the oxygen supply, via a hose assembly which is permanently attached to the jerkin. The oxygen mask and anti-G suit are connected to this before flight. The Pressure Jerkin Hose Assembly used by the pilots (Mk. 6) has a lower end consisting of the PEC man portion: the rear crew's (Mk. 9) terminates in a single bayonet-type oxygen connector. The pressure jerkin also includes a life-jacket stole and is provided with a personal locator beacon, etc.

13 Mask and helmet

A G-type helmet is worn with either a P2A 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.

14 Low-altitude clothing assembly

For flights below 40,000 feet, it is not essential to wear pressure clothing. In such cases, normal flying clothing is worn, with a separate life-jacket. A special mask hose assembly, Mk. 2 for pilots and Mk. 7 for rear crew, has to be worn to connect to the aircraft hose assembly.

Rear Crew Safety Equipment

15 Rear crew seats

(*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 cusion. 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 compressed air 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 air 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 lever incorporates a handle into which the individual parachute static line is clipped when leaving the seat prior to abandoning aircraft.

(*g*) When Mod. 3760, part A, is embodied static line strong points are fitted as follows:

(i) Port seat point, on front face of desk.

(ii) Centre and stbd. seat points, at front ends of centre seat

(iii) Sixth crew seat point, at frame 63. The static lines (Mod. 3760, part B) include mic/tel. lead, oxygen hose and electric wiring for the " crew gone " warning signals (see Chap. 15, para. 10). This permits the static lines to remain connected at all times.

▶◀

16 Back-type parachute assembly Mk. 40 or Mk. 46

(*a*) 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 flight. In either case when the occupant abandons the aircraft, the static line 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.

(*b*) 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.

(*c*) For use of the EO see para. 24(*b*) to (*d*) and 29(*b*).

17 Survival pack type S

Although its size and scale of contents differ, this survival pack is fitted to the parachute harness and lifejacket in a similar way to the

(iii) If the 110°C switch in the sensing duct operates, an emergency cooling selection is automatically made and maintained until RESET is selected. An amber warning light below the selector comes on once the switch has operated. Should the temperature still rise, an 115°C switch operates to switch on the emergency cooling and a red light comes on.

Oxygen System

21 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 inter-connections enables one half of the system to supply oxygen should the other half fail.

(*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. From the regulators, oxygen at breathing pressure is fed on demand.

22 Oxygen regulators, general

(*a*) An oxygen regulator Mk. 21B is supplied for each crew member's normal station and one additional regulator feeds the bomb-aimer's position. The 1st and 2nd pilots' regulators are at the forward ends of the port and starboard consoles. When Mod. 3902 is embodied the Mk. 21B regulators are replaced by Mk. 17F regulators.

(*b*) The regulator is designed to provide the following facilities:

(i) An oxygen supply in direct relation to the rate and strength

(ii) The correct ratio of air and oxygen according to cabin altitude. Above 32,000 feet cabin altitude, 100% oxygen is provided. 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 and pressure clothing when the cabin altitude is between 39,000 feet and 56,000 feet.

(*c*) *Limitations*

(i) When used with a P-mask and pressure clothing, the regulation will provide protection against loss of cabin pressure up to a cabin altitude of 56,000 feet, provided that a descent is started within 30 secs. 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 ¼ of the total capacity.

(ii) When pressure clothing it not worn, protection is given up to 45,000 feet, provided that 40,000 feet cabin altitude is reached within two minutes of the failure.

(iii) When Mk. 17F regulators are fitted the aircraft must not be flown above 48,750 feet to take into account the aerodynamic suck effect of 1,250 feet should the hatch or crew door be jettisoned.

23 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

(iii) JERKIN TEST — MASK TEST — EMERGENCY — NORMAL lever. When this lever is set to NORMAL, oxygen or a mixture of oxygen and air as selected by (ii), is fed to the mask at the required pressure when the user breathes in. When the lever is set to EMERGENCY the pressure of oxygen to the mask is, at low altitude, slightly increased (to the same extent as the safety-pressure which automatically occurs in any case above 12,000 feet—above this height safety pressure is approximately doubled). To reach the MASK TEST position, the knob in the end of the lever must be pulled out ; in this position the mask can be tested under pressure for leaks before take-off. The JERKIN TEST position gives an appreciably higher pressure and is used to test mask, jerkin and G-suit simultaneously for leaks; it must not be used unless all these items are worn.

(*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 oxygen is flowing. 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.

24 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 system at the seat portion of the PEC, via an RV51 valve ; this valve provides the correct amount of pressurisation for height from the emergency oxygen and allows the user to breathe in cabin air when the emergency oxygen is finished (some effort is required to breathe in cabin air, as a valve spring has to be over-

(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. The set cannot inflate the pressure garments although it can maintain pressure after inflation by the main oxygen system. As the bottle is attached to the seat, emergency oxygen is not available after separation from the seat.

(iii) Mods. ES2424 and 2425 introduce a demand emergency oxygen set to the Type 3LS1 and 3LS2 seats respectively. This provides a more effective emergency system in case of ejection at extreme altitude.

(*b*) *Rear crew's emergency oxygen*

(i) In the case of failure of a main oxygen regulator, rear crew should normally transfer, if possible, to sixth crew member's regulator, rather than use the EO set. This will enable the flight to be continued without reducing altitude.

(ii) For bale-out conditions an emergency oxygen set is carried in the rear crew parachute assemblies, and is automatically initiated by operation of the parachute static line. If necessary direct manual initiation can be effected by pulling a black/yellow knob just below the QRB.

(iii) This set delivers oxygen " on demand " and can produce sufficient flow and pressure to inflate the jerkin and G-suit, at the rapidity required, at altitudes above 40,000 feet. Unlike the main system regulator, " Safety pressure " is provided from ground level (up to 40,000 feet). There is no Air Mix.

(iv) The set consists of a small storage cylinder fitted with an operating head which (a) turns on the supply when the release is operated and (b) reduces the output to a steady medium pressure. This is stowed at the top of the parachute pack. A tube leads the medium pressure oxygen to the demand regulator stowed in the pocket at the back of the right half-belt. From the regulator, a breathing pressure hose is led forward and connected to the

(v) The endurance of the set is approximately 10 minutes. It should be noted that although this is a demand set, the cylinder will fairly rapidly exhaust itself if it is accidentally initiated and the outlet is not connected to a mask worn by a man. The set will discharge itself in an attempt to produce safety-pressure. The set must therefore be replaced if accidentally initiated while strapping-in.

Use of Aircrew Equipment Assemblies

25 Clothing assembly

(*a*) When wearing pressure clothing, the air-ventilated suit and anti-G suit are put on beneath the shirt and trousers and the jerkin is put on top of the flying overalls. The hoses from the anti-G suit and AVS are fed through the outer clothing; the AVS hose is connected to the PEC (pilots) or the AVS socket (rear crew). The anti-G hose is connected to the main oxygen hose.

(*b*) When pressure clothing is not worn, the mask hose assembly is used in place of the jerkin hose assembly.

26 Strapping-in procedure

(*a*) *Pilots*

Prior to entering the seat, grasp each lap and shoulder strap in turn and tug smartly to test for security.

(i) Enter the seat and adjust the height.

(ii) Connect the lanyard of the personal survival pack to the pressure jerkin or life-jacket.

(iii) Remove the PEC cover and connect the man portion to the seat portion, checking that it is correctly locked. With low-altitude clothing, connect the oxygen hose clip to the D-ring on the life-jacket.

(iv) Reach towards the face screen handle to adjust clothing

(v) Pass the left leg restraining cord through the D-ring on the right garter and insert the plug on the end of the cord into the housing on the left snubbing unit. Do up the right cord in the same manner, ensuring that the cords are not interlaced. Adjust the cords for adequate rudder pedal movement by pulling out the toggles in the front of the units and moving the cords as required.

Fig. 4 Leg restraint

NOTE: The sockets will not grip the cord plugs unless the man portion of the PEC has first been locked into position.

(vi) Pull up the back pad and adjust the kidney pad.

(vii) Bring the waistbelt of the combined harness in front of the body, adjust the position of the quick-release box and to the PEC. Pull down any excess hose below the lap strap. Tighten the lap straps fully, ensuring that the body is well back in the seat. When a negative-G strap is fitted, thread each blue lap strap through the appropriate loop of the negative-G strap before connecting it to the quick release box.

(viii) Thread the crutch loops through the D-rings on the lap straps, ensuring that the loops are so twisted that they lie flat against the thighs. Pass the right shoulder strap through the right crutch loop and the left strap through the left loop and attach the straps to the quick-release box, both shoulder straps of the parachute should be under life-jacket (jerkin) stole. Engage the safety clip under the locking plate of the quick-release box. If necessary tuck the left crutch loop behind the front D-handle on the waist-belt.

(ix) Sit up straight and tighten the inner (blue) shoulder straps, followed by the outer (khaki) ones. These straps should not be tightened to such an extent that the back is bent, as this may cause a hazard on ejection. Tighten the negative-G strap, if fitted.

(x) Operate the "go-forward" lever, lean forward, release the lever and lean back. Check that the harness springs back and locks. This provides a check that the manual override lever has not been inadvertently operated. Retighten the khaki shoulder straps if necessary.

(xi) Put on the helmet and connect the mask tube to the bayonet socket in the hose assembly. Plug in the mic./tel. lead.

(xii) Check the intercomm. and oxygen regulator.

(xiii) Ensure there is no slack in the harness straps of the personal survival pack.

(*b*) *Rear crew members*

(i) Check the contents of the assister cushion bottle and insert pins. The pressure should be 1,200 PSI.

(iii) Slacken all the parachute straps fully and stow them in their stowages before getting in the seat.

(iv) Check that the side harness straps of the personal survival pack are connected to the parachute harness.

(v) Connect the emergency oxygen supply to the oxygen mask hose or pressure jerkin assembly.

(vi) 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.

(vii) 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.

(viii) Connect the personal survival pack lowering line to the life-jacket.

(ix) Connect the oxygen mask hose or pressure jerkin assembly to the aircraft assembly and make the mic/tel. connection.

(x) Connect the static line to the aircraft hose assembly (Pre-Mod. 3760 to the swivelling lever).

(xi) Fasten the seat lap strap.

(xii) 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.

(xiii) Connect the AVS to its separate supply point.

(xiv) Put on the helmet and connect the mask tube to the mask hose or pressure jerkin assembly.

(xv) Connect the mic/tel. lead.

Fig. 5 Mk. 3LS seat occupied (1)

Fig. 6 Mk. 3LS seat occupied (2)

27 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 PEC ; this also releases 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*

(i) Remove helmet and mask, disconnecting mask tube and mic./tel. lead.

(ii) Disconnect 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 PSP lanyard.

(vi) Disconnect the static line.

(vii) Disconnect the mask hose or pressure jerkin assembly from the aircraft hose assembly, placing the aircraft assembly in its stowage.

(viii) Remove pins.

28 Pressurisation failure

If the cabin pressure fails, each crew member should immediately depress the lever on the P-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, the pressure jerkin and anti-G suit will inflate and oxygen will be delivered under pressure. A descent must be made to 40,000 feet cabin altitude within two minutes of the failure, with a subsequent descent to below 25,000 feet, to avoid the effects of decompression sickness.

29 Regulator failure

(*a*) *Pilots*

If a pilot's regulator fails above 10,000 feet cabin altitude, he should transfer to a spare regulator if available. A spare mask hose assembly should be carried for this purpose. Flights should be restricted to below 40,000 feet since there will be no pressure jerkin connection. If no spare regulator is available he should immediately select emergency oxygen, by pulling up the handle beside his seat. The regulator should be switched off. 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 a spare regulator (if available) otherwise he may use his emergency oxygen bottle, but use of the latter will involve a reduction in the aircraft altitude.

Part I

Chapter 12—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*
Bombsight computer

(*c*) The starboard wing pressure head system supplies both pitot and static pressure to the following:

2nd pilot's machmeter, ASI, altimeter* and rate of climb indicator*
Master navigator's ASI and altimeter*
VG recorder
Undercarriage switch
Auto-mach trim switch
Mach compensator (Auto-pilot)
Flight data unit and amplifier unit (Autostabiliser)
Bomb fusing switch
Fatigue meter switch
Auto-pilot pressure unit*
Mk. 3 calculator*
True airspeed unit

(*d*) The nose pitot head supplies pitot pressure for the " Q " feel units.

(*e*) The large diameter vents on the fuselage supply static pressure for the " Q " feel units. The small vents at Stn. 191 supply static pressure for the auto-pilot pressure unit, altitude cut-out switch and manometric height unit.

(*f*) The port and starboard pressure heads and the nose pitot head are electrically heated. The controlling on/off switches for the heater elements are on panel AZ.

(*g*) Post-Mod. 3498 the feel simulator compartment heaters are controlled by a FEEL SIMULATOR, ON/OFF switch on panel AZ. Pre-Mod. 3498 they are controlled by the nose pitot heater switch.

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. The 2nd pilot's ASI is 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 and also if the Blue Steel fin fold switch is not selected UP before the undercarriage is lowered.

(*b*) *Altimeters*

Three altimeters are fitted, one on each pilot's instrument panel and one at the navigator's station. When Mod. 3190 is embodied vibrators are fitted to the Mk. 19B or C altimeter at the 2nd pilot's station.

(*c*) *Machmeters*

A machmeter is fitted on each pilot's instrument panel.

3 Other instruments

(*a*) *Electrically-operated instruments*

See Part 1, Chap. 6, para. 14 and Chap. 8.

(*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. Also its greater volume may cause some instrument lag.

(*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.

Part I

Chapter 13—Radio and Radar

List of Contents

Radio Communication

1 VHF/UHF, PTR 175 (Mod. 3815)

(*a*) A VHF/UHF PTR 175 set is fitted. 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 control unit is situated on panel BQ at the AEO's position and has the following controls.

(i) A 20-position rotary switch giving selection of 18 preset channels, the guard frequency (channel G) and MANUAL.

(ii) Three manual control switches. The first switch selects the

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

(DL, DL/T, T/R ON—DL OFF: inoperative)

(*c*) 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 number to be selected is indicated on the resetting panel (this will not correspond to the selector switch indicators). The resettting pins are then moved to the required positions and the cover plate replaced.

(*d*) *Power supplies*

The 28-volt DC supplies for the installation are derived from special feeder 2P8.

2 UHF ARC/52

(*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 channel. MCW transmission is available if required.

(*b*) The remote control unit on the port console (pre-Mod. 3882), operated by the 1st pilot, 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, normal transmission and reception
T/R + G, with the guard frequency superimposed on reception
ADF, inoperative.

(*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*) Mod. 3882 repositions the control unit at the AEO's station.

(*f*) *Power supplies*

The UHF uses 200-volt AC, from No. 2 bus-bar, and 28-volt DC, from feeder 9P7 Post-Mod. 3815 the UHF uses DC only, supplied from No. 1 LV bus-bar (feeder 9P7).

3 Tone release

Tone release facilities are available for simulated bombing practice and may be obtained from either VHF or UHF. The controls are on panel CF and consist of a 3-position UHF—OFF—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. Tones may be obtained with the NBS isolation panel switches set at NORMAL or ISOLATE.

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.

(*a*) The intercomm. system operates through an A1961 amplifier, controlled by a NORMAL—EMERGENCY—OFF switch at the for conference intercomm. and is controlled by an ON—OFF switch at the AEO's position. If the normal intercomm. system fails, setting the control switch to EMERGENCY will provide intercomm. facilities through the amplification stage of the PTR 175.

(*b*) A master volume control, at the AEO's station, is in the line between the amplifier and the main distribution junction box to maintain compatibility between the volume level of VHF and intercomm.

(*c*) An external intercomm. point is provided on the port side of the nose, the system being controlled by two switches at the AEO's position, panel BC.

NOTE: The bomb-aimer's lead and pre-Mod. 3760 the transfer leads have their mic/tel. connections wired direct to the A1961. No other method of communication is available. (But see para. 6(*c*)).

6 Station boxes

(*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

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 members, 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. Mod. 3883 provides full intercomm. facilities at the bomb-aimer's position *(d) Control of services*

The control of the various services fed to the station boxes is as follows:

(i) *Pilot*

UHF (Pre-Mod. 3882 and Post-Mod. 3815) and VHF (Pre-Mod. 3815) selection
ILS ON/OFF switch
ILS/ADF/TACAN audio selection
VHF BOX selector switch (Pre-Mod. 3815)
ILS channel selection

(ii) AEO

Airborne warning
HF
I/C NORMAL/EMERGENCY/OFF switches
Conference I/C ON/OFF switch
ADF power switch
UHF (Post-Mod. 3882 and Pre-Mod. 3815)
VHF/UHF (Post-Mod. 3815)

(iii) *Nav./plotter*

ADF

(iv) *Nav/radar*

VHF-UHF tone switch

Navigational Radio and Radar

7 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 or ADF audio signals is controlled by a switch on the 1st pilot's console. A repeater indicator is on the 2nd pilot's instrument panel. A circuit breaker on the AEO's panel BA controls the 28-volt supply.

8 ILS

The ILS channel selector is on the spine between the pilots' escape audio selector switch are on the 1st pilot's side panel. A marker light is provided on each pilot's instrument panel. There is no separate ILS indicator the signals being fed into the MFS when the ILS is selected on and the MFS selector switches are set to LOC & GP and APPROACH. The localiser signals are then shown on the Beam Compasses and the glidepath signals on the Director Horizons. ILS signals will be fed to the auto-pilot when the TRACK and GLIDE switches are pulled out.

9 Tacan

Tacan is fitted; the controls are at the navigator's station at panel BCE. A repeater indicator is above pilots's panel AW. The equipment takes about 1½ minutes to warm up.

▸◂

10 Green Satin and GPI

(*a*) Green Satin Mk. 2 is installed. The control unit and associated GPI Mk. 6 are at nav/plotter's position. Heading information is fed from either port or starboard compass systems, the selection being controlled by a switch on the MFS track control unit, which also carries the VSC. The Green Satin signals can be fed into the MFS when the pilots' selector is at REMOTE.

(*b*) The system uses 200-volt, 3-phase, 400 CPS AC from No. 1 transformer.

11 Radar altimeter Mk. 6A

The radar altimeter Mk. 6A indicator/control unit is on the nav/radar's panel CAJ and CAH. The system uses 28-volt DC from feeder 3P7 and 115-volt, single phase, 1,600 CPS AC from No. 1 or No. 2 frequency changer.

Operational Radio and Radar

12 NBC, H2S and RPU

(*a*) The navigational bombing system (NBS Mk. 1A or Mk. 2) is

NBC calculator type 7 and the bombing control unit, all of which have their controls and indicators at the nav/radar's position. The RPU is located at the rear of the nav/radar seat.

(*b*) The system uses 200-volt AC from No. 2 MV bus-bar, 115-volt 400 CPS AC from No. 3 or 2 transformer, 115-volt 1,600 CPS from No. 2 or 1 frequency changer and 28-volt DC. AC from No. 3 or 2 transformer is rectified within the equipment to give 112-volt DC.

(*c*) Signals from the NBS are fed into the MFS when BOMB is selected on the MFS navigational selector and into the auto-pilot when the BOMB switch is pulled out.

13 ECM

(*a*) The ECM installation is controlled by the AEO. Audio signals can be superimposed on the intercomm. by selection of the appropriate switch on the station boxes. Facilities for monitoring the ECM warning are at the AEO's and 2nd pilot's stations by selecting MONITOR-ALARM.

(*b*) The power supplies required for the installation are 200-volt, 3-phase, 400 CPS from all four alternators and 28-volt DC from feeder 17P7.

(*c*) ECM equipment temperatures are controlled by the circulation of water-glycol. Heaters and ram air heat exchangers in the coolant circuits maintain the coolant temperatures between 6°C and 10°C. The pumps and heaters are fed from No. 1 bus-bar (aft system) and No. 4 bus-bar (forward system).

14 IFF Mk 10

IFF Mk. 10, with SIF and I/P facilities, is installed and the controls are at the AEO's position. The system uses 200-volt AC from No. 4 bus-bar and 28-volt DC from feeder 3P7.

▸◂

Part I

Chapter 14—Fire Warning and Protection Systems

List of Contents

1 General

Visual warning of fire in the engine bays, fuselage plenum chamber and fuel tank areas is given by 10 warning lights and four combined extinguisher pushbutton/warning lights, all on panel AW. Six independent extinguishing installations are fitted comprising a total of 13 electrically-discharged methyl-bromide extinguishers, which are discharged simultaneously by the action of inertia switches if a crash landing is made (see para. 6). 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
Engine bays	Four
AAPP bay	One

2 Engines fire protection systems

(*a*) *Engine bays*

A triple FD system is in each engine bay. A combined extinguisher button and warning light for each engine is on panel AW. When the operating temperature of any sensing element is reached, the associated warning light comes on. If the button is then pressed the alternator cooling shutter closes, the LP fuel cock closes and the fire bottle discharges.

(*b*) *Internal engine fire system*

Part of the engine air is tapped off the main flow to cool certain internal components. A fire detector is fitted in this cooling air outlet duct and if the air temperature rises abnormally the detector operates to illuminate an amber warning light on panel AW.

3 AAPP bay system

(*a*) A triple FD system is in the AAPP. If the fire occurs the system causes a warning light integral with the extinguisher pushbutton, on panel BF to come on.

(*b*) Operation of the pushbutton causes

(i) The extinguisher to discharge

(ii) The AAPP bay cooling shutter to close

(iii) The AAPP fuel valves to close

(iv) The AAPP booster pump in tank 10 to stop running

4 Fuel tanks fire protection system

(*a*) Five separate continuous Firewire 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 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.

5 Plenum chamber fire protection system

(*a*) A Firewire 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.

6 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. A circuit breaker is 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
Nos. 1 and 2 engines extinguishers

(*d*) The starboard inertia switches cause the following extinguisher systems to discharge:

Starboard mainplane extinguisher
Nos. 3 and 4 engines extinguishers
Fuselage fuel tanks extinguishers
Plenum chamber extinguishers
AAPP bay extinguisher.

7 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 15—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 doorstep 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

(*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

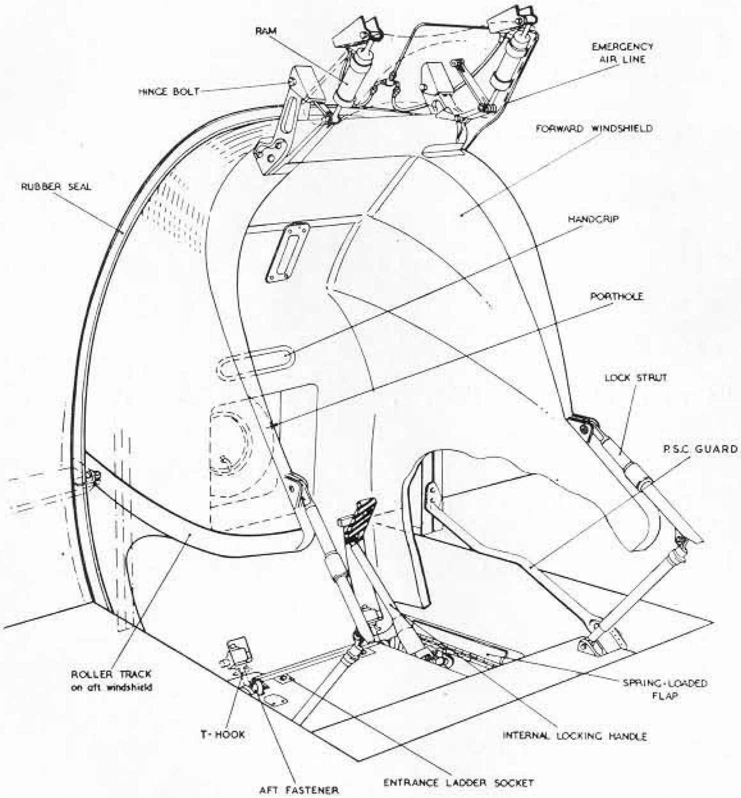


Fig 1 Crew door

2 Door emergency opening system

WARNING. Above 12,000 feet the door must not be opened before the appropriate time has elapsed since selecting the ABANDON AIRCRAFT switch, or any other depressurising

(*a*) The crew door can be opened in emergency by a PARACHUTE EXIT EMERGENCY RELEASE lever on the underside of the crew table. The lever 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

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 or seat pan handle 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.

4 Escape hatch seals

(*a*) An inflatable seal is attached to the lower surface of each hatch and is supplied with air from an air bottle in the inside of the hatch. Each bottle is normally charged to 1,800 PSI and supplies the seal, through a reducing valve, at 10 PSI. A pressure gauge is adjacent to the bottle.

(*b*) The seal is deflated by screwing a plug into a three-way valve and is inflated by unscrewing the plug. If an air bottle fails in flight the seal may be inflated by cabin pressure if the deflation

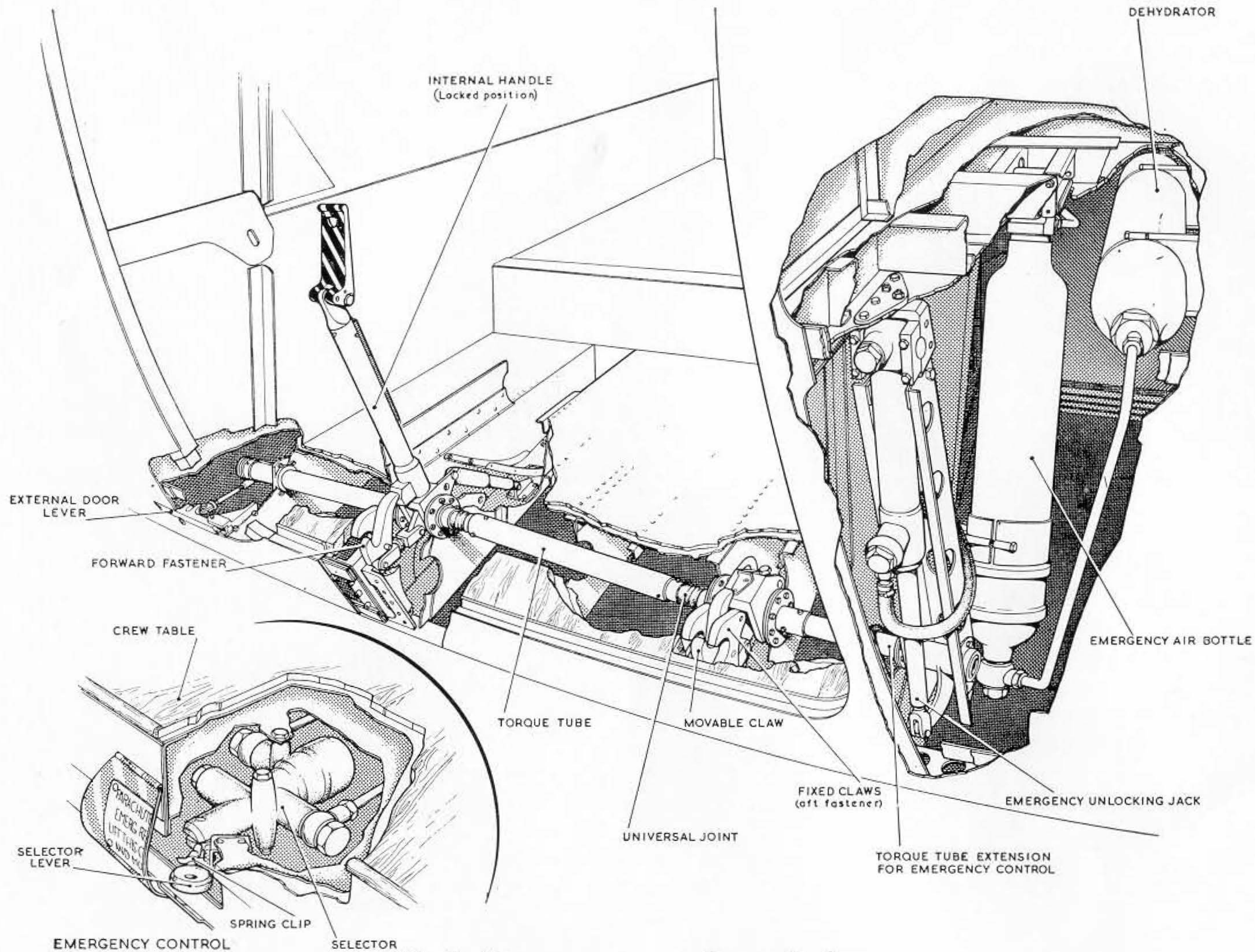


Fig. 2 Door emergency opening mechanism

5 Crash axe and asbestos gloves

The axe is secured in a stowage forward of the first-aid kit on fuse panel AJ. A pair of asbestos gloves is stowed below the head of the axe.

6 First-aid kit

This is stowed on panel AJ forward of the entrance door.

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. The dinghy can then be inflated by pulling the handle attached to the fabric covering on top of the dinghy.

9 Automatic hand line

(*a*) A guide rope 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.

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.

(*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.

10 "Crew gone" warning lights

(*a*) Mod. 3760, part C (see also Chap. 12, para. 15(*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 I

Chapter 16—Armament and Operational Equipment

List of Contents

1 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 SHUT 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.

(*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.

2 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

Following a JETTISON selection, the doors must be closed by an EMERGENCY CLOSE selection.

(*c*) If the bomb doors fail to close when the normal selector is set to CLOSE, 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 then set to AUTO or CLOSE, the doors will re-open after 3 seconds.

(*d*) If 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.

3 Bomb release safety lock

A bomb release safety lock prevents inadvertent weapon release. The lock is controlled by a guarded double pole switch on panel AAF. The switch is marked LOCK IN/off/LOCK OUT and has an amber light at the LOCK OUT position, which comes on if the safety lock is released, and a green light at the LOCK IN position, to show the lock is engaged.

4 Window launchers

(*a*) Twin window installations are installed one above each main-plane and are operated by the AEO.

(*b*) There are two control panels, one for the port and one for the the starboard installation.

Part I

Chapter 17—Strategic Reconnaissance Equipment

List of Contents

1 General

(*a*) *Day role*

(i) The day crate is carried in the bomb-bay with either bomb-bay fuel tanks or with a flash crate replacing the forward bomb-bay tank.

(ii) In the day crate may be carried up to eight F96 cameras, three F89 cameras with three PE units and an F49 survey camera.

(*b*) *Night role*

(i) The night crate is carried in the bomb-bay with either three flash crates or with one flash crate and the aft bomb-bay tank.

(ii) In the night crate may be carried up to five F89 cameras with five PE units.

2 F96 camera installation

(*a*) The F96 cameras are controlled from panel CG at the nav/radar position (see Fig. 1). A further panel ASA is at the prone bomb-

(*b*) Electrical supplies for the cameras are as follows:

Cameras 1-5: 28 volt DC from feeder 23P7
200 volt AC from No. 2 bus-bar

Cameras 6-8: 28 volt DC from feeder 24P7
200 volt AC from No. 4 bus-bar

(*c*) The intervalometer for the cameras is supplied with 28 volt DC from feeder 23P7.

3 F89 camera installation

(*a*) The F89 cameras are controlled from panel CL (see Fig. 3) at the nav/radar position. Additional controls are on panel ASA at the prone bomb-aimer's position.

(*b*) Electrical DC supplies are from feeder 23P7. There are no AC

4 Photo-flash installation

(*a*) The photo-flash installation is controlled from panel CL, with additional controls on panel ASA.

(*b*) 28 volt DC electrical supplies for the installation are from feeder 23P7 for the front and rear crates and from feeder 24P7 for the centre crate.

5 F49 camera installation

(*a*) The F49 camera is controlled from panel CG (see Fig. 1); a warning light is on panel ASA.

(*b*) On 1st pilot's panel AAH is an amber warning light which comes on three seconds before the camera is pulsed and remains on until after the camera has pulsed as a warning to the pilot to level the wings, since the camera can be corrected for drift and pitch but not for bank.

(*c*) Electrical DC supplies to the camera are from feeder 23P7 and to the warning lights from feeder 24P7.

6 F96 cameras operation

(*a*) The following is the recommended sequence of operation of the cameras:

(i) AC supplies selected ON.

(ii) Master and individual camera circuit-breakers closed.

(iii) Ratio selector selected and reset.

(iv) Exposure control selected.

(v) Image compensation and intervalometer time interval set.

(vi) Bomb doors open.

(vii) Intervalometer changeover selected. Start cameras by intervalometer ON/OFF switch.

(*b*) The intervalometer pulses all selected cameras through relays and directly operates a magnetic indicator and counter. The indications that the cameras are functioning correctly are by individual counters on panel CL and flashing lights on panel ASA.

7 F89 cameras operation

(*a*) The following is the recomended sequence of operation of the cameras:

(i) Master circuit-breakers closed.

(ii) Flash container selected on crate selector switch.

(iii) Cameras and height/speed setting ON.

(iv) Ground speed and aircraft height set on V/H controller.

(v) Master camera selected.

(vi) Required number of flashes selected.

(vii) Bomb doors open.

(viii) Flash LIVE/ISOLATE switch to LIVE. Flash armed indicators ARM.

(ix) Start cameras and flash release either by camera start/flash release pushbutton or NBS bomb release pulse.

(x) The IMC supply light on the V/H controller then comes on, the flashes gone lights pulse, the flashes remaining counters subtract and the flash selector moves to the next position.

(*b*) If the height/speed setting supply is not made only one flash is released and the IMC light does not come on ; the flashes gone light remains on.

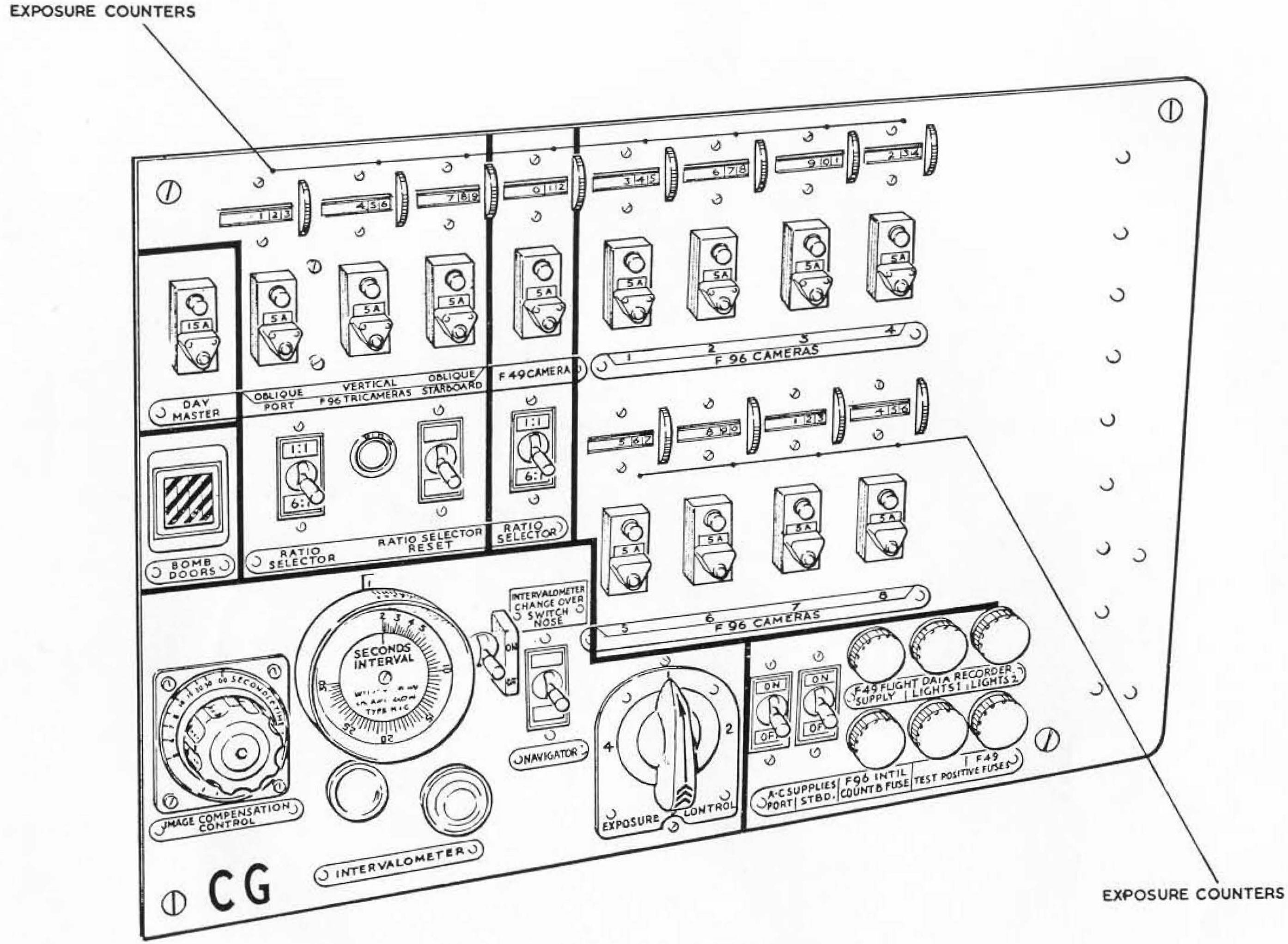


Fig. 1. Panel CG

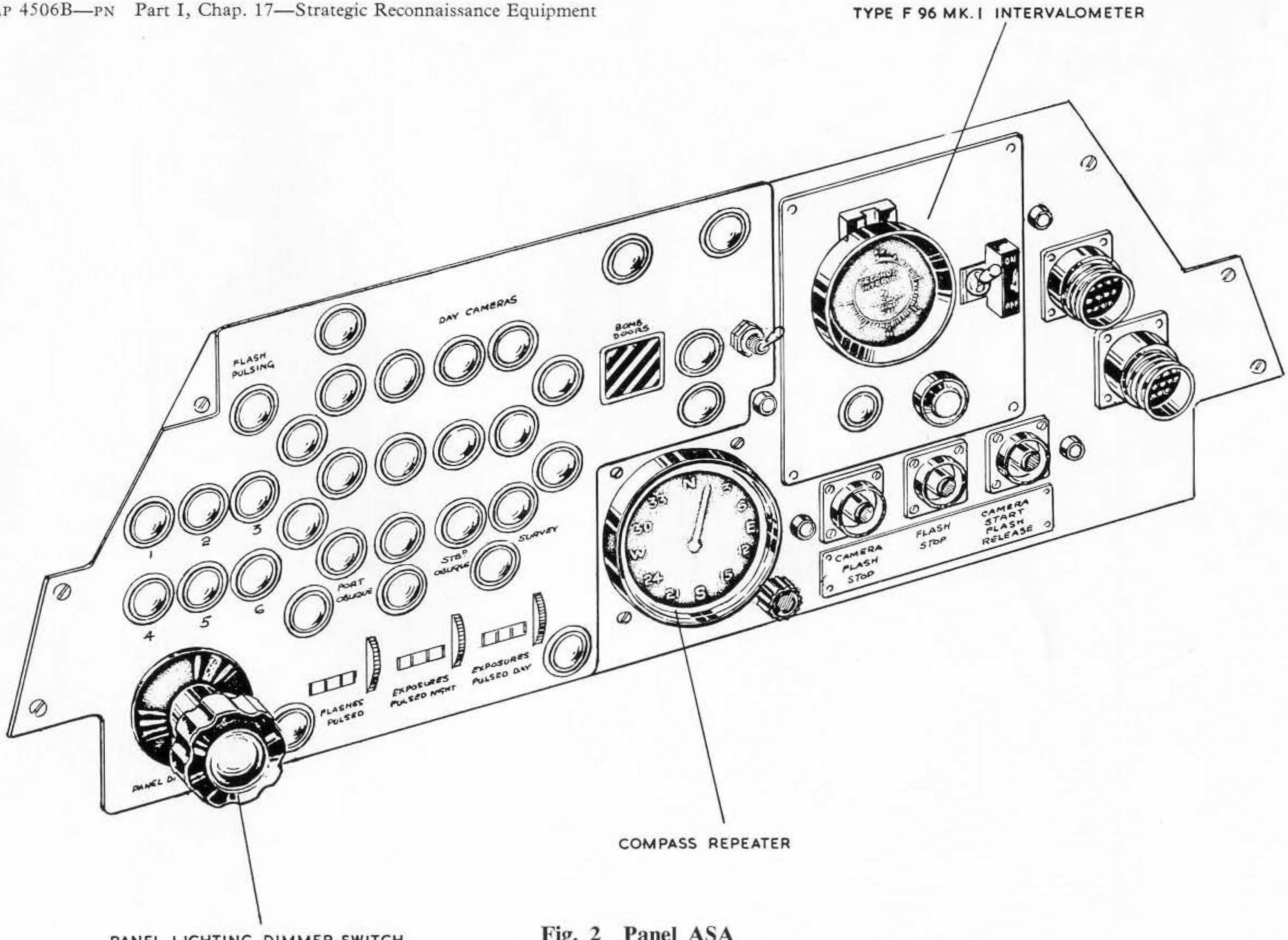
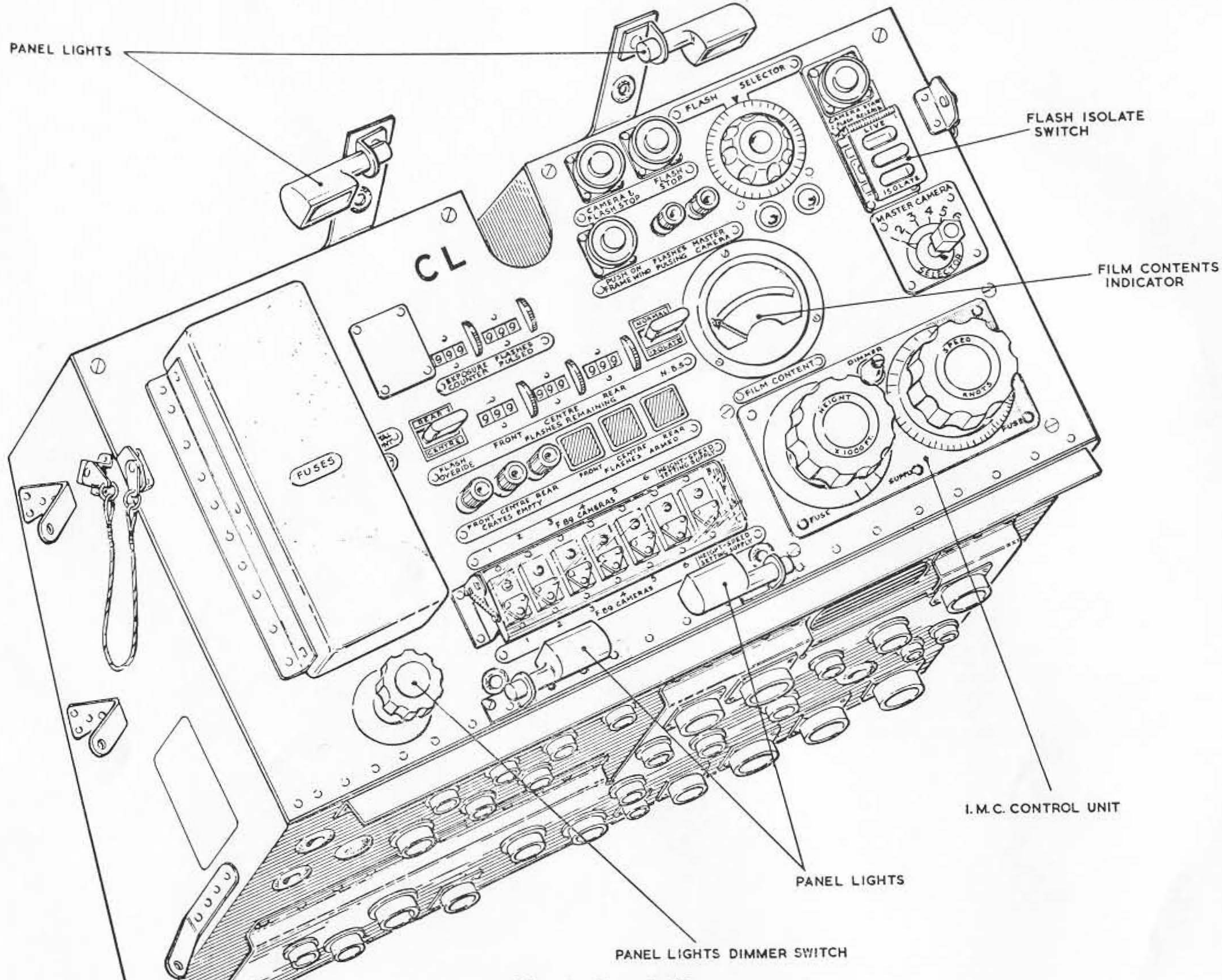


Fig. 2 Panel ASA


PANEL LIGHTS
FLASH ISOLATE SWITCH
FILM CONTENTS INDICATOR
I.M.C. CONTROL UNIT
PANEL LIGHTS
PANEL LIGHTS DIMMER SWITCH

Part II—Limitations

List of Chapters

Part II

Chapter 1—Engine and AAPP Limitations

List of Contents

1 Limitations—Conway Mk. 201

(*a*)

Power rating	*Time-limit (per flight)*	RPM %	EGT °C
Maximum	5 mins.	104	690
Intermediate	2 hours	103	665
Max. Continuous . . .	—	101·5	630
Ground idling	—	48±1	430
During starts:			
Normal start	Moment-	—	600
Operational rapid start	arily	—	690

(*b*) *Oil pressures*

Minimum at ground idling . . . 12 PSI

Minimum at 80% and above . . . 28 PSI

2 Limitations—Artouste AAPP Mk. 112 and Mk. 113

Condition		RPM	*Max.* JPT °C	*Duration*
Air load	*Elect. load*			
Max. . .	10 KW	33,200/35,200	595	1 min.
Blow-off .	48 KW (60 KVA)	33,200/35,200	570	5 mins.
Blow-off .	32 KW (80 KVA)	33,200/35,200	530	5 secs.
Blow-off .	32 KW (40 KVA)	33,200/35,200	525	Continuous
Blow-off .	Nil	33,200/35,200	500	Continuous
Blow-off .	Nil	23,000/25,000	500	Continuous

Max. JPT during starts or accelerations is 700°C

3 Engine anti-icing

Engine and engine intake anti-icing is cleared for use when flight in

Part II

Chapter 2—Airframe Limitations

List of Contents

1 General

(*a*) The aircraft is cleared for use by day and night in temperate conditions subject to the observance of the limitations imposed in this chapter. Operation above 50,000 feet is not recommended.

(*b*) Aerobatics, stalling and spinning are prohibited. Speed must not be reduced below that for the onset of pre-stall buffet nor below the recommended threshold speed.

(*c*) In manoeuvres the aircraft must not be taken beyond the onset of buffet if this occurs below the permitted G limits.

(*d*) Above 0·90M a bank angle of 30° must not be exceeded, in order to avoid adverse lateral control characteristics i.e. a diminution of aileron control effectiveness and a reversal in the sense of

2 Weight and CG limitations

Max. take-off	
With U/W tanks	223,000 lb.
Without U/W tanks	204,000 lb.
Max. landing (normal)	145,000 lb.
Max. landing (emergency)	200,000 lb.

NOTE 1: For emergency landings vertical velocity at touchdown must be minimised and taxying should be cautious. The brakes and tyres must be thoroughly inspected subsequently. If 1·9G is exceeded at touchdown, a heavy landing check must be carried out.

NOTE 2: Ground manoeuvres at weights above 204,000 lb. should be cautious.

CG limits (undercarriage down)	*Clean*	*With U/W tanks*
*Forward	140 ins.	140 ins. AOMD
Aft	160 ins.	156 ins. AOMD

* Progressive at 0·5 in. per 10,000 lb. at weights above 130,000 lb.

3 Speed limitations

(*a*) *With all* PFCU's *operative and auto-mach trim ON*

	0—19,000 *ft.*	*Above* 19,000 *ft.*
Clean	350K	325K/0 92M
With empty underwing tanks .	350K	325K/0 92M
With full or part full underwing tanks	305K	305K/0 92M

(*b*) *With auto-mach trim inoperative*

No further restrictions but 0·90M should only be exceeded when essential. (See also para. 1(*d*)).

(*c*) *With any one rudder* PFC *sub-unit, roll damper or yaw damper inoperative*

No additional limitation.

(*d*) *With any one aileron or elevator sub-unit inoperative*

Gentle manoeuvres only . 0·90M or 250 knots
Further failures do not impose further limitation.

(*e*) The minimum speed at altitudes above those obtainable with 87% RPM is 0·82M.

(*f*) *Use of the following services*

With airbrakes and bomb doors open . . No limit
With flaps down to TAKE-OFF . . . 225 knots
With flaps fully down . . . . . 195 knots
▶◀
For operating AAPP scoop . . . . . 250 knots
With AAPP scoop extended . . . . 330 knots
(but see para. 3(*a*))
With Blue Steel doors open, following release of weapon, pre-Mod. 3674 . . . . . 235 knots
(see also para. 16(*a*))
When operating Blue Steel fin fold system . . 235 knots

◀(*g*) *Brake parachute*

(i) The normal maximum speed for streaming the brake parachute is 140 knots up to a maximum all-up weight of 160,000 lb. (chute life 25 streams).

(ii) In emergency the following maximum speeds for various all-up weights may be used.

Weight (lb)	*Streaming Speed (Knots)*	
	Chute age 5 streams or less	*Chute age 6 to 24 streams*
140,000	160	153
145,000	158	150
150,000	155	148
160,000	151	144
180,000	143	136
200,000	135	129

(iii) Once a parachute has been streamed at emergency speeds

4 G limitations

(*a*) *Positive* G

Speed	*Up to* 170,000 *lb.*		170,000 *to* 195,000 *lb.*		*Above* 195,000 *lb.*	
	With negligible aileron	*With max. aileron*	*With negligible aileron*	*With max. aileron*	*With negligible aileron*	*With max. aileron*
Below 0·90M	2·0G*	1·8G	1·6G	1·5G	1·5G	1·3G
Above 0·90M	1·8G	1·8G	1·6G	1·5G	1·5G	1·3G

NOTE: Above 170,000 lb, the ailerons should be used with care

* 1·8G when bomb-bay load exceeds 23,000 lb.

(*b*) *Negative* G

Below 275 knots . . . . −0·8G
Above 275 knots . . . . −0·25G
Zero G conditions must be avoided.

(*c*) The onset of buffet overrides all the above G limitations.

5 Aircraft approach limitations

GCA/Precision radar . . 250 ft. AGL (300 ft. indicated)
MFS/ILS and ILS . . 250 ft. AGL (300 ft. indicated)
4 PPI . . 500 ft. AGL (550 ft. indicated)

6 MFS and auto-pilot

(*a*) The following settings must be used on the MFS:

Height lock gearing . . . . . . 0·025°/feet
Height lock time constant . . . . . 30 seconds
Wind drift time constant . . . . . 30 seconds
Pitch integrator time constant . . . . 30 seconds
Bombing system selector . . . . . 2·6° error

(*b*) The auto-pilot is cleared for use, subject to the following limitations:

(i) *Altitude*

Maximum . . . Cruise ceiling at 97% RPM
Minimum . . . 1,500 feet
300 feet indicated (Auto-ILS)

(ii) *Speeds*

1 *Maximum*

Mach compensator operative . . 300 knots/0·9M (whichever is the lower)

Mach compensator inoperative . . 300 knots/0·88M (whichever is the lower)

2 *Minimum* 210 knots/0·82M (whichever is the lower). Speeds as necessary for auto-ILS.

(iii) The auto-pilot must not be used when engine RPM are higher than 97%.

(iv) Both pilots must be strapped in at all times.

(v) Trim must be maintained within ± 1 division on the auto-pilot trim indicator.

(vi) The mach trimmer must be switched OFF

(vii) Both yaw dampers must be selected to STANDBY; one must be selected ON for an ILS approach.

(viii) All three channels must be operating.

(ix) The roll damper must be switched ON.

(x) Auto-trim must not be used.

NOTE: The airspeed lock and attitude hold are unsatisfactory at high altitude.

7 Radio and navigation

The following are cleared for use but their reliability cannot be guaranteed:

ILS (see para. 5)
VHF/UHF
IFF Mk. 10*
Radio compass
Intercomm.
Green Satin
INS Mk. 1
Radio altimeter Mk. 6A
NBS Mk. 1A (in manual flight control)
NBS Mk. 2 (as high level fixing aid in temperate climates only)
MFS compass system
True airspeed unit
Variable air speed unit
ARI 5874 HF STR 18B
TACAN

* Operation of the

8 Fuel system

(*a*) Carriage and use of both bomb-bay tanks is permitted. It is essential to switch off the tank pumps when 2,000 lb fuel remain, to obviate the pumps being uncovered in a 30° climb or dive. This fuel may be included in the landing reserve.

(*b*) The carriage and use of underwing tanks is permitted provided that Mods. 19, 800, 853, 2041, 2064, 2139, 2500, 2689, 3494, 3811, 3949 and 4048 are all embodied. If Mods. 853, 2139, 2500 and 3949 are not embodied fuel must not be carried in these tanks. Mod. 3949 is essential for drop tank jettison.

(*c*) Fuel filter de-icing is cleared for use, but must be switched off if it malfunctions.

(*d*) Fuel tank pressurisation is cleared for use.

(*e*) The system operates satisfactorily in negative G conditions.

9 Air conditioning and bomb-bay heating

(*a*) The air-conditioning system is cleared for operation to a maximum differential of 9 PSI. Flood flow facility is cleared for use.

(*b*) The AVS system may be switched on to obtain ventilation. Full use is not yet permitted.

(*c*) The high pressure ducting system is cleared provided that the engine bleed isolation cocks are not opened at engine RPM above 60%.

(*d*) Bomb-bay heating is cleared provided that bomb-bay temperatures are monitored to ensure that the limitation for any store carried is not exceeded.

10 Airframe and engine intake anti-icing

(*a*) The hot air anti-icing system is cleared for use provided Mods. 3850 and 3315 are embodied.

(*b*) The electrical anti-icing system is cleared for use.

(*c*) Flight in icing conditions should be avoided or kept to a minimum.

11 Hydraulic system

Both pumps must be on for take-off and landing. One pump only must be run continuously in flight. If it fails at altitude the other pump must not normally be switched on but should be kept in reserve for lowering undercarriage and flaps.

12 ECM and Window

(*a*) The ECM installation is cleared for use in temperate climates. Armament stores fitted with radio/radar fuses are not to be carried on flights when ECM is to be operated.

(*b*) Window launching is cleared for use of types 26, 28, 100 and DAW.

(*c*) Flaps must be up when launching window.

13 Electrical system

(*a*) The system is cleared for operation in the 2-2 configuration.

(*b*) Starting of the Mk. 112 or Mk. 113 AAPP is certain up to 10,000 feet and ability to start at considerably greater altitude is also highly probable. A guaranteed start can be obtained in flight, off load, from 160 to 250 knots.

(*c*) The RAT's are cleared for use.

(*d*) Normal CSDU oil temperature is 95°C. In emergency a maximum temperature of 120°C is permitted for a period not exceeding 2 hours. Negative G is to be avoided pending further trials of the oil tank.

(*e*) At high ambient temperatures neither TRU is to be loaded above 205 amps, to avoid overheating and failure.

14 Signal pistol

The signal pistol installation is cleared for firing throughout the operating range of the aircraft.

15 Gold film windscreen heating

(*a*) Pre-Mod. 3698 the system is cleared for use in the " Demist " position only. This position may only be selected in flight, or within five minutes of take-off. The system must be switched off immediately after landing.

(*b*) Post-Mod. 3698 the system is fully cleared for use. DE-ICE must not be selected without first selecting DE-MIST.

(*c*) The aircraft must not be flown with the system OFF.

16 Blue Steel

(*a*) The HC Mk. 1 or Practice Inert Trainer missile may be loaded, carried and released in operations or jettisoned in emergency. The maximum speed for release or jettisoning is 290 knots. Pre-Mod. 3674 the doors are to be closed immediately after separation if speed exceeds 235 knots. ECM must not be operated during loading and unloading of the missile.

(*b*) When a weapon is not carried the Blue Steel doors are not to be operated to the open position in flight. They are to be closed as soon as possible following release of a weapon.

(*c*) The lower fin is not to be extended in flight, unless release is planned. The following additional G limitations apply when carrying the weapon.

Missile Condition		*M*	IAS (*knots*)	G *limitations*
Fin	*Controls*			
Up	Free	Up to 0·75	Up to 290	As para. 4(*a*)
		Above 0·75	Up to 235	1·8G
			235 to 270*	1·6G
Up	Locked	Up to 0·92	Up to 290	As para. 4(*a*)
Down	Free	Up to 0·75	Up to 290	As para. 4(*a*)
		Above 0·75	Up to 235	2·0G
			235 to 290	1·6G
Down	Locked	Up to 0·92	Up to 290	As para. 4(*a*)

NOTE: The G limitations of para. 4(*a*) apply in all cases where they are *lower* than those given above.

* This restriction is pending embodiment of Mod. 4067.

17 SR aircraft limitations

The limitations of paras. 1-15 also apply to SR aircraft. No additional limitations are imposed.

◄18 RHAG and SPRAG trampling

The aircraft is cleared to trample the rigged RHAG and SPRAG up to take-off speed. However, on aircraft fitted with a fuselage fuel jettison pipe extreme care must be used to avoid excessive rotation angles during the take-off run. ►

Part III—Engine and Aircraft Handling

List of Chapters

NOTE

All Check Lists referred to in this Part are detailed on the Flight Reference Cards

Part III

Chapter 1—Engine Starting and Handling

List of Contents

1 General

Throughout, it should be remembered that the relevant checks must be carried out.

2 Normal start

(*a*) *Starting—air supplies*

Air supplies for starting the engines should normally be obtained from either the AAPP or the combustor. If the AAPP is unserviceable the aircraft should not be flown. If for any reason it is desired not to use the AAPP, air supplies may be obtained from a Ground Air Supply Unit (Palouste). The air hose for this supply should be connected to the coupling behind a panel in the starboard inner engine door. Either the AAPP or the ground air supply may be used to start any engine, the air CROSSFEED COCK must be opened to allow No. 1 or No. 2 engine to be started. Also, when necessary, the air supplies of any one or more running engines can be used to start the remaining engines. The recommended starting order is 4, 3, 2, 1.

(*b*) *Starting the* AAPP

Before starting carry out the following checks:

(i) Check that the ground area is clear for starting and the AAPP

(ii) Ensure that an internal 24-volt LV supply, or external 28-volt supply is available.

(iii) INTAKE SELECTION switch	Test OPEN and RETRACT operation and indications Leave OPEN
(iv) Fire warning	Test
(v) LOAD SELECTION switch	IDLE
(vi) START SELECTION switch	NORMAL

The AAPP will start automatically. During the start check:

(vii) START IN PROGRESS light	On, then out at 6,000 — 8,000 RPM
(viii) Fire warning light	Out
(ix) OIL PRESSURE light	On

The RPM should increase and idle at 23,000—25,000 RPM. If the AAPP is required for engine starting only, leave LOAD SELECTION switch at IDLE. If the AAPP is required for electrical supplies also, select LOAD SELECTION switch to ELECT, check that engine speed increases to 33,200—35,200 RPM and that the JPT does not exceed 515°C. If, during starting, the AAPP fails to light, or if the JPT exceeds 700°C select the START SELECTION switch to OFF. The max. JPT during air delivery for main engine starting is 585°C for one minute.

(c) *Engine start using* AAPP *air supply*

(i) Before starting each engine, check with the crew chief that the ground area is clear. Start No. 4 engine first. Check:

Fuselage booster pumps . .	ON
Fuselage Proportioner switch	BYPASS
LP cocks	OPEN
EGT isolation switches . .	NORMAL
EGT controller switch . .	TAKE-OFF
Throttle levers . . .	HP cock closed
Engine bleed isolation cocks .	OPEN
Ignition isolation switch .	ON
Air crossfeed cock . . .	OPEN
Start master switch . .	AAPP
Engine selector switches . .	No. 4 ON
Start button	PRESS until No. 4 START IN PROGRESS light illuminates

(d) When the light illuminates, release the gate mechanism and open No. 4 throttle to the IDLING position (just beyond the gate). Engine light up should occur in 8 to 10 secs. after opening the HP cock. During the start check:

Fire warning light . . .	Out
Oil pressure . . .	Registering (12 PSI min. at ground idle RPM)

When the engines reaches 38% RPM the engine starter button should spring out and the START IN PROGRESS light extinguish. The engine should accelerate to a ground idling speed of approximately 48% RPM. If the starter button has not released when 38% RPM is reached, move the STARTER MASTER switch to FLIGHT and back to AAPP. If, during the start, the EGT exceeds 600°C, close the HP cock immediately and monitor the fire warning light.

(e) After starting No. 4 engine, return the No. 4 selector switch to OFF. Start Nos. 3, 2, and 1 engines, using the same procedure.

(f) When all engines have been started, check:

Air crossfeed cock . . .	CLOSED
Starter master switch . .	FLIGHT
Ignition isolation switch . .	ISOLATE
Alternator switches . .	ON

3 Rapid start

(a) This paragraph deals only with engine starting using the wing mounted air bottle supplies and combustor starters. To gain full benefit from the rapid start the Rapid Take-Off check list should be followed. A combustor start must not be attempted at air temperatures below −15°C. To start a pair of engines the minimum air bottle pressure on the appropriate side is 2,900 PSI (1,500 PSI is sufficient to start one engine of a pair). Should an engine fail to start a 30 min. period must elapse before attempting a second *combustor* start.

(b) *Engine starting using combustor starters*

(i) Before starting the engines check with the crew chief that the ground area is clear. Check:

Fuselage booster pumps .	ON
Fuselage proportioner switch .	BYPASS
LP cocks	OPEN
EGT isolation switches . .	NORMAL

Throttle levers . . .	OPEN
Engine bleed isolation cocks .	OPEN
Ignition isolation switch .	ON
Start master switch . .	COMBUSTOR
Engine start selector switches	ALL ON
Air crossfeed cock . . .	OPEN

Press the starter button, check that four START IN PROGRESS lights illuminate and keep a careful watch on EGT's. The engines should reach self-sustaining speed in approximately 11 seconds and the starting cycle terminated by the operation of an engine speed sensitive switch. If an engine fails to start, the starting cycle is terminated by a time switch after 15 seconds. Should the EGT exceed 600°C (690°C operational) or should the rate of rise of EGT indicate that 600°C (690°C) is likely to be exceeded, the throttle lever must be closed to the HP shut-off position immediately. EGT should normally fall below 600°C but if 690°C is reached a fault in the system is indicated.

(ii) If an engine fails to start there may be insufficient air pressure remaining to attempt a second combustor start after 30 minutes. With the air crossfeed cock and engine bleed valves open, however, the fastest restart will be obtained by using the air supplies of the running engines. Check:

Running engines . . .	Accelerating through 40% RPM
Throttle lever of affected engine	Closed to idling gate
Start master switch . .	GROUND
Engine selector switches . .	Failed engine ON, others OFF

Press the starter button until the START IN PROGRESS light illuminates and monitor EGT carefully.

(iii) When all engines have started check:

Air crossfeed cock . .	CLOSED
Starter master switch . .	FLIGHT
Ignition isolation switch . .	ISOLATE

NOTE: Should it not be intended to carry out a scramble take-off, the throttles may be closed to the idling gate when the engines reach normal idling speed.

4 Ground handling

The ground idling speed should be 48% RPM, the maximum EGT at idling is 430°C and the minimum oil pressure 12 PSI.

5 Engine handling in flight

(*a*) Throughout flight the engine limitations must be observed. If at any time the EGT limitations are exceeded the throttle must be retarded to maintain the EGT within limits. This is particularly important above 50,000 feet and the EGT must be monitored closely. Any instance of the limitations being exceeded must be recorded and reported.

(*b*) At high altitudes, to prevent surge and flame-out, the throttles should be handled gently at all times, although rapid accelerations and decelerations are permissible in cases of necessity provided that, above 45,000 feet, the inboard engines are maintained at 90% RPM or more. To reduce the possibility of surge or flame-out at very high altitudes (above 55,000 feet), if it is necessary to re-accelerate the engines after the throttles have been closed, ensure that the RPM and EGT are stabilised at flight idling before re-opening the throttles.

(*c*) *Use of the* EGT *controller*

The EGT isolation switches should be selected to NORMAL under all normal flight conditions, and the EGT controller switch should be selected to TAKE-OFF, CLIMB or CRUISE as required. The EGT controller must not be used to reduce engine power at low altitude. When selecting a lower EGT controller setting, close the throttles until all engines are slightly below the appropriate EGT, select the EGT controller switch as required and then open the throttles fully. When selecting a higher EGT controller setting, make the appropriate selection and then open the throttles as required. If an engine fails to accelerate to the EGT appropriate to the EGT is indicated, select the appropriate EGT isolation switch to ISOLATE, and advance the throttle carefully. If the required EGT can now be obtained, a EGT controller fault is indicated; the isolation switch should be left at ISOLATE and the EGT maintained within limits by careful use of the throttle. Great care must be taken with the switch at ISOLATE, particularly at high altitudes, as the LP overspeed governor is also isolated.

(*d*) LP *compressor overspeed*

If any LP compressor overspeed warning light illuminates the appropriate throttle must be retarded until the warning light goes out. Subsequent throttle opening must be made slowly.

6 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 only be closed if the engine actually stops turning or if there is a risk of fire.

7 Relighting in flight

(*a*) *Hot relighting*

An engine flame-out can generally be recognised by falling RPM. A hot relight can normally be obtained under any flight conditions (possibly up to 55,000 feet) if the following action is taken soon after the flame-out occurs and before the RPM fall below the flight idling values:

(i) *Below* 35,000 *feet*

Press the relight button without moving the throttle until a relight is obtained; this is recognised by the RPM ceasing to fall. If a relight is not obtained immediately, progressively close the throttle to the idling gate as the RPM continue to fall. If a relight is obtained after a large drop in RPM has occurred, it may be difficult to accelerate the engine and surging may occur. In this case, keep the relight button pressed and advance the throttle to

(ii) *Above* 35,000 *feet*

Press the relight button and, at the same time, close the throttle to the idling gate. When a relight is obtained, recognised by the RPM and EGT stabilising at the flight idling value, allow 30 to 60 seconds to elapse before opening the throttle to set the required RPM. This procedure provides the best chance of achieving a relight without surge occurring at high altitudes. At very high altitudes, to prevent any surging affecting the adjacent engine, its relight button should be pressed during the hot relight, to reduce the possibility of a sympathetic flame-out.

(iii) *High* JPT

During a hot relight, keep a careful watch on the EGT. If, at any time, the EGT approaches the limit or rises without a corresponding increase of RPM, shut the HP cock immediately.

(iv) *Failure to relight*

If a relight is not obtained within 20 seconds of pressing the relight button, close the HP cock and wait at least 1 minute before attempting a cold relight.

(*b*) *Cold relighting*

NOTE 1: No oil pressure indication will be obtained until the bus-bar supplying the associated engine is energised.

NOTE 2: A cold relight can reasonably be expected up to 40,000 feet at any airspeed, but the band 210 to 240 knots is recommended ; if a relight is unsuccessful descend to 35,000 feet or below before making any further attempt.

Ensure that a fuel supply is available to the engine. Press the relight button and open the HP cock. When the RPM or EGT start to increase release the relight button and, when the engine is running satisfactorily, open up to the desired RPM. Under normal conditions a relight should be obtained within 15 seconds. If an engine fails to relight within 20 seconds, close the HP cock and wait one minute

8 Low oil pressure

The normal oil pressure is 40 PSI at 90% RPM and above and the minimum oil pressure is 28 PSI at 80% RPM and above. If the oil pressure falls below the minimum pressure, the engine should be stopped as soon as possible. However, if emergency conditions exist which would be made more hazardous by closing down the engine, the minimum oil pressures for continual use of the engine until the earliest possible landing are 24 PSI at 86% RPM and *pro-rata* to 28 PSI at 99% RPM.

9 In-flight starting of the AAPP

In-flight starting of the AAPP is described under Management of the Electrical System, Part I, Chap. 1, para. 24.

10 Stopping the engines

Carry out the closing down checks in the Flight Reference Cards and stop the engines by closing the HP cocks. Do not close the LP cocks or switch off the special feeder switches until the engines are below 10%.

Part III

Chapter 2—Taxying, Take-off and Handling in Flight

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1 Taxying

(*a*) As visibility from the cockpit is restricted it is advisable to inspect the area before entering the aircraft, particularly if it is intended to taxy in confined spaces. Particular note should be taken of objects likely to be blown by the jet efflux. The forward view from the cockpit is very good, but it is impossible to see the wing tips. However, it is possible to see the wing tips from the windows of the rear cabin, and whenever possible the rear crew members should maintain observation whilst taxying.

(*b*) Before taxying the checks in the Flight Reference Cards must be carried out. In particular, the H2S scanner must be stabilised or secured, the brake pressure gauges must be checked and the GROUND STEERING MASTER switch must be selected ON.

(*c*) The thrust required to overcome the inertia of the aircraft in order to start taxying varies with the AUW and the surface. At normal operating weights and on level surfaces approximately 60-65% RPM will be required. Once the aircraft is in motion sufficient thrust for normal taxying on level surfaces will be obtained with all engines idling but slight increases of thrust will be required on

pilots' wheelbrake controls, and also the nosewheel steering. The nosewheel steering control handwheel should be pulled out to its most comfortable position, and control will be effected by turning the handwheel in the desired direction. A moderate hand-force is required and the maximum deflection of the nosewheel is approximately 45° in either direction. Any intermediate deflection may be obtained by off-setting the steering handwheel by the requisite amount and holding it there. When the handwheel is released a centring spring returns it to the neutral position and the nosewheel will be free to caster. Differential braking may be used to assist in tight turns but care must be taken to avoid scuffing of the inner undercarriage tyres. It is possible to turn 180° on a 50 yard wide runway fairly comfortably. However, at heavy weights, sharp or fast turns must be avoided. Very little assistance can be gained by using asymmetric thrust in turns.

(*d*) The brakes are effective but care should be taken to avoid overheating by excessive use. This applies particularly when prolonged or repeated differential braking is required. Frequent checks of the brake pressure gauges must be made whenever the

the throttles apply even and increasing pressure to the brake pedals, and do not operate the parking brake lever until the aircraft has been brought to rest. Check the illumination of the PARKING BRAKE ON light whenever the parking brake is applied.

2 Take-off

(*a*) Complete the pre take-off checks shown in the Flight Reference Cards, before entering the runway.

(*b*) Align the aircraft with the runway and hold it stationary by applying even pressure to the brake pedals. Open the throttles evenly, noting that all engines accelerate normally. If the throttles are opened quickly one or more engines may lag initially. The brakes should be capable of holding the aircraft stationary until all four engines reach 88% RPM and must be considered unserviceable if they do not. At 88% RPM release the brakes and, as the engines reach maximum power, check:

RPM	Not exceeding 104%
EGT	Not exceeding 690°C
Oil pressure	Not less than 28 PSI (normal 40 PSI)
CSDU oil temperature . .	Not exceeding 95°C
LP overspeed warning light .	Out
Electrical power circuits . .	Functioning normally

(*c*) At all weights the acceleration when the brakes are released is impressive and there is a slight tendency to swing into any cross-wind. This can easily be controlled by use of the nosewheel steering. When the brakes are released, the weight on the nosewheel is reduced (the nosewheel rises if the CG is appreciably aft) and the control column should be held half forward to improve the effectiveness of the nosewheel steering until the rudder becomes effective at 90 knots. During the later stages of the take-off run acceleration becomes very rapid, especially at the lighter weights. The aircraft is not to be rotated until 20 knots below the recommended unstick tion and consequent lengthening of the take-off run will result. A light pull force is normally required to raise the nose although this will vary with the CG and elevator trimmer setting. A further slight backward movement of the control is required to fly the aircraft cleanly off the ground.

(*d*) *Recommended unstick speeds*

Take-off weight (lb)	Unstick speed (knots)
120,000	120
130,000	125
140,000	130
150,000	135
160,000	140
170,000	145
180,000	150
190,000	153
200,000	157
223,000	167

3 Safety speeds

(*a*) *Single engine failure during take-off*

Using rudder alone 105 knots is the minimum speed at which the aircraft can be kept straight should an outboard engine fail during the take-off run. A small amount of aileron should be applied as the aircraft subsequently becomes airborne to prevent a roll towards the dead engine. As safety speed will always be below unstick speed, the decision to abandon or to continue the take-off will depend on the results of previous calculations made using the Operating Data Manual.

(*b*) *Failure of two engines during take-off*

The safety speed with two engines on one side flamed out is 155 knots. At this speed full rudder and approximately one quarter aileron is required to hold the aircraft straight. Should a single engine fail during take-off, a minimum speed of 155 knots should be attained before consideration is given to stopping the adjacent

4 Accelerated stop procedure

(*a*) In all cases where the take-off run has to be aborted the following actions are to be taken:

(i) Close the throttles.

(ii) Select airbrakes out.

(iii) Stream the tail brake parachute at or below maximum streaming speed.

(iv) Apply maximum continuous braking at or below pre-calculated speed.

(v) Inform ATC " aborting ".

(*b*) A further take-off is not to be attempted until the brakes and tyres have been allowed to cool, checked and recorded as serviceable in the F700 and the reason for aborting the take-off has been fully investigated.

5 After take-off

At normal operating weights, using maximum power on all four engines, the aircraft climbs away after take-off at a steep angle, and the speed increases rapidly to 200 knots. It is recommended that, when safely airborne and clear of any obstructions, all engines are throttled back sufficiently to enable CLIMB to be selected on the EGT controller and then the throttles re-opened fully. The initial climb-away should be made at 200 knots. When safely clear of the ground retract the undercarriage (manual application of wheel-brakes is not required) and select the flaps UP, taking care not to exceed the appropriate limiting speeds before they are retracted. (The limiting speeds are 235 knots for the undercarriage and 225 knots for the flaps). The change of trim as these controls retract is negligible. While carrying out the after-take-off checks the speed may be increased to 240 knots but should not exceed 250 knots until the AAPP intake has been retracted. As speed increases there is a slight nose-up change of trim which may be easily countered by normal use of the elevator trimmer.

6 Climbing

(*a*) Climb at 250 knots increasing to 300 knots at 10,000 ft. From the height at which 300 knots coincides with 0·84M, climb at this mach no. until 45,000 ft. is reached at which height speed should be increased to 0·86M. Fuel selections and in-flight checks should be carried out as required.

(*b*) When maximum rate of climb is required the engines should be left at full throttle with the EGT control selected to TAKE-OFF (5 mins. limit) and the aircraft climbed at the speeds recommended in (*a*) above.

(*c*) If a cruise climb is to be carried out, the engines should be adjusted to the settings computed for the prevailing conditions. The maximum intermediate power setting is 103·0% RPM and 665°C for 2 hours. The maximum continuous power setting is 101·5% RPM and 630°C EGT.

7 Cruising flight

(*a*) The aircraft cruises comfortably at 0·86M at which speed, even at high altitude, about 20° bank is available for manoeuvring purposes before the onset of buffet. The engines are fitted with compressor bleed valves which open automatically to improve engine handling at the lower RPM but at the cost of increased fuel consumption. Hence, if it is important to conserve fuel, the valves must remain closed, and this can be achieved by operating all engines at a minimum of 87% RPM at altitudes up to 51,000 feet, thereafter increasing by 1% RPM per 1,000 feet.

(*b*) Aircrew should ensure that the flying clothing and personal safety equipment worn is of a standard to allow for an increase of 2,000 feet in cabin altitude caused by the loss of a pilot's escape hatch. Throughout the flight periodic checks should be made of each crew member's oxygen supply equipment and the functioning of all systems in use.

8 Flying controls

(a) Ailerons

The ailerons are effective throughout the permitted speed range. The stick forces required increase with increase of airspeed and with increase of control deflection. Although there is a gradual deterioration throughout the speed range, adequate control is available under all normal approach conditions. The aileron trimmer is effective in use and provides more than adequate trim for all normal flight conditions.

(b) Rudder

The rudder is effective at all speeds above about 80 knots but response is noticeably poor below 90 knots. The rudder pedal forces are heavy compared with the forces required for movement of the ailerons and elevators. Pedal forces increase with speed and deflection and at the maximum permissible speeds the forces are heavy. Response to rudder trimmer selections is quick and effective and at high airspeeds the rudder trimmer should be used with care. Adequate trim control is available for all normal flight conditions.

(c) Elevators

The elevators are effective with good response throughout the speed range. Response to elevator trimmer selections is quick and the trim should be selected in small " blips ". Due to poor longitudinal stability at the extremes of the performance envelope the aircraft is difficult to trim. The trim load indications on each pilot's panel may be used to assist in fine trimming.

(d) Auto-stabilisers

(i) *Roll and yaw dampers*

With the roll damper and either yaw damper on, lateral and yawing oscillations following any disturbance in level flight are quickly and effectively damped. If the roll damper is inoperative, damping is still effective but slightly slower in effect. With both yaw dampers and the roll damper inoperative, any lateral or yawing disturbance may be followed by dutch rolling. At low mach numbers, particularly below 0.85M, this may be divergent and take some time to damp out manually. At high mach numbers, dutch rolling may be reduced in amplitude due to the aircraft's stability characteristics, but small oscillations may persist for a considerable time. At high altitudes, dutch rolling is more likely to occur and be more pronounced. It is therefore recommended that at all times in flight the roll damper and one yaw damper are selected to ON and the other yaw damper selected to STANDBY.

(ii) *Auto-mach trimmer*

As speed is increased above 0·83M, a progressive nose-down trim change will occur, requiring increasing nose-up trim selections by the pilot. If the auto-mach trimmer is selected ON, above 20,000 feet and as speed increases above 0·8M, ±0·01M the auto-mach trimmer will cause a progressive up-elevator selection to be made requiring a progressive push-force by the pilot to maintain level flight. The push force may be held reasonably comfortably by the pilot throughout most of the speed range and may be trimmed out easily. If the auto-mach trimmer is not operative, an increasing pull-force is required as speed increases, and this becomes quite heavy at the higher mach numbers. Therefore it is recommended that the auto-mach trimmer is switched ON at all times above 20,000 feet and before speed is increased above 0·79M. If the auto-mach trimmer is not operative, speed must not be increased above 0·90M.

NOTE: No pitch damper is fitted.

(e) Airbrakes

The airbrakes may be extended at any airspeed, and to any extent from the fully closed to the fully open position. There is no immediate change of trim associated with their extension, but the ensuing reduction in airspeed causes the characteristic nose-down trim changes. They are very effective at high airspeeds and remain sufficiently effective at low airspeeds to permit drag control at approach speeds. Extension at high airspeeds or high power settings produces light aircraft buffet.

(f) Flaps

The limitations, of 225 knots when the flaps are selected to TAKE-OFF and 195 knots when the flaps are selected to DOWN must be observed. Following the selection of flaps from UP to TAKE-OFF or DOWN there will be a delay of approximately 10 seconds, during which time the flaps are travelling rearwards, before any change of trim is noticed. Changes of trim are slight except when full flap is lowered. In this case, a moderate nose-up trim change occurs.

(g) Bomb doors

The bomb doors may be opened or closed at any airspeed within the permitted speed range. The time for opening or closing will depend on whether one or two hydraulic pumps are operating. During bomb door travel, slight pitching oscillations may be experienced but the ultimate trim change is negligible. Moderate airframe buffet which will vary considerably with bomb-bay configuration, will be felt whenever the bomb doors are open particularly at higher airspeeds. If constant power is maintained there will be a slow reduction in speed of 0·01 to 0·02M.

(h) Undercarriage

The airspeed limitation of 235 knots must be observed whenever any component of the undercarriage is not fully retracted. Raising or lowering of the undercarriage produces no significant trim change. There is a " thump " as each undercarriage unit locks down and slight airframe buffet may be felt whenever the undercarriage is extended. The undercarriage should not be lowered when the aircraft is side-slipping to avoid possible damage due to sideloads on the undercarriage door mechanism.

9 High speed flight

(a) Auto-mach trimmer operative

With the auto-mach trimmer operative, when the speed is increasing a progressively heavier push force is required on the stick to maintain altitude without re-trimming, i.e. the aircraft behaves as if it were stable throughout. The stick force can be held or trimmed out as desired, but trimming above 0·90M is not recommended because, if the auto-mach trimmer should fail and the actuator retract fully, a strong nose-down moment would occur. However, during an emergency descent, elevator trimming is permitted up to 0·92M, to lessen the high stick forces which would otherwise occur with reduction of altitude. The aircraft is pleasant to fly at high mach number, but accelerates rapidly in dives and in response to increased thrust, and care must be taken to avoid exceeding the maximum speed of 0·92M. Lateral control is good within the permitted speed limitations, but deteriorates beyond them (see para. 9(*c*) below) and to allow a margin for inadvertent increase of mach number, bank angles must not exceed 30° at speeds greater than 0·90M.

(b) Auto-mach trimmer inoperative

If an auto-mach trimmer failure occurs in flight, retract the actuator if necessary, by blipping the control switch to RESET until IN is indicated, then switch off to prevent a sudden nose-up moment occurring should the actuator extend again. With the auto-mach trimmer inoperative, pitch instability occurs between about 0·83M and 0·92M at all positions, and with increasing speed a progressively heavier pull force is required to control the aircraft without retrimming. The stick force may be trimmed out if desired, but the speed must not be allowed to exceed 0·90M unless exceptional circumstances require it. In the latter event, elevator trimming is allowed up to the maximum permissible speed of 0·92M. With the auto-mach trimmer inoperative, the aircraft is safe and not difficult to fly at high mach number, but the machmeter must be watched continuously to avoid exceeding the limitations; bank angles must not exceed 30° at speeds greater than 0·90M.

(c) Flight outside limitations

Because of the ease with which the aircraft may be accelerated, care must be taken not to exceed 0·92M. However, in case this speed is exceeded inadvertently the following description of flight at higher mach numbers is given. Beyond 0·92M the aircraft is stable in pitch, but the pilot is unlikely to be aware of the fact, unless the auto-mach trimmer is inoperative and even then, only when the aircraft has been trimmed at about 0·92M. Light airframe buffet commences in level flight at 0·91 to 0·92M, increasing initially to moderate intensity then reducing as 0·95M is approached. The buffet may decrease or disappear in gentle turns, though further application of G will result in onset of a different kind of buffet, harsher in character and increasing in intensity with G. Above 53,000 feet the onset of buffet may be delayed. At all altitudes, there is a decrease of aileron effectiveness as speed increases. The deterioration becomes more rapid with increasing mach number and decreasing altitude, particularly below 40,000 feet. At 0·95 to 0·96M, the amount of aileron deflection which the PFCU's are capable of applying becomes very limited and the entire PFCU output may, in some instances, be required to hold the wings level. The benefit derived from forcing the control wheel against the over-travel spring is only small. Above 0·93M, the sense of roll induced by side slip is reversed and application of top rudder lowers a depressed wing instead of raising it. In certain conditions, the rolling movement resulting from application of top rudder can completely counteract that produced by the ailerons. To avoid the possibility of instinctive and unwitting application of top rudder at high mach number, the rudder pedals should be freed if 0·92M is exceeded with any bank applied. If the limiting speed is exceeded it is important to reduce speed as rapidly as possible by throttling back, extending the airbrakes and carefully applying up-elevator. If any degree of bank is present, corrective aileron should be applied as soon as the mach number has fallen sufficiently for this to be possible.

(*d*) *Manoeuvring*

When manoeuvring the aircraft, reference must be made to the accelerometer to avoid exceeding permitted values of G. At speeds above 0.80M and altitudes up to 40,000 feet, maximum permitted values of G may be reached at any AUW without encountering buffet, G limitations. At onset, buffet is generally light, but between 0·82 and 0·85M, it occurs more suddenly and is harsher in character than at other speeds. Below 0·85M, buffet onset is often accompanied or closely followed by a rolling tendency in either direction; this is controllable by use of the ailerons. Above 0·85M, the rolling tendency is not present at buffet onset. At all mach numbers, up to tht maximum permitted, recovery from the buffet onset conditions is simple and straightforward. Penetration into the buffet is not permitted, but in case this region is entered inadvertently, the following description of the behaviour is given. Buffet intensity increases with further application of G and, if penetration continues, heavy or very heavy buffet will be experienced. At all mach numbers this may be accompanied by stick lightening i.e. successive equal increments of G require smaller pull-force increments to apply them. The rolling tendency also becomes more marked and may be experienced at speeds above 0·85M once buffet has reached a moderate level. For reasons of lateral control, bank angles must not exceed 30° at speeds above 0·90M, and pilots must be prepared for a reduction in aileron effectiveness above 0·92M, particularly at altitudes below 40,000 feet. The rudder pedals should be freed if 0·92M is exceeded with any bank applied.

◀ (*e*) *Flight at high* IAS *and low altitude*

At low altitudes speed may be increased rapidly in level flight up to the limiting airspeed and care must be taken to avoid exceeding this speed. The airbrakes provide an extremely effective control at high IAS.

(*f*) *Use of flying controls during manoeuvres at low altitude*

(i) Rapid entry to and exit from turns (ie simultaneous application of elevator and aileron) at any speed causes significant amounts of sideslip with consequent high fin loading. Coarse use of rudder to assist either entry to or recovery from such turns must be avoided because rudder application increases this sideslip

(ii) At speeds in excess of 300 knots the ailerons become progressively heavier and less effective hence the available rate of roll is reduced due to aeroelastic effects. The elevator, however, remains powerful and the aircraft responds to elevator movements more rapidly. Therefore, when manoeuvring at high speeds extreme care must be exercised to avoid over-controlling in pitch. Coarse use of elevator can cause substantial elevator angles to be applied which together with any sideslip present and any coarse aileron application can cause high fin loading with the attendant risk of structural failure.

(iii) Additionally, in flight above 250 knots care must also be taken to avoid " check manoeuvres " in which excessive tail loads can be produced by the pilot making a large movement of the control column in pitch and then returning it to neutral before G builds up.

(iv) At higher speeds, extreme care must be exercised to avoid exceeding the G limitations, particularly during turns.

10 Handling at high altitudes at low mach numbers

NOTE: For the purposes of this paragraph " flight at high altitude " may be defined as flight above an altitude at which 0·82M can be maintained in level flight with 87% RPM set.

(*a*) At very high altitudes the IAS is less for a given IMN, so that stick forces are less, the incremental G which can be pulled before encountering buffet is less, and the aircraft is closer to the stall. Hence coarse application of the controls must be avoided when operating the aircraft near its ceiling at low IAS. This is particularly necessary in the case of the elevator where large forward stick movements can quickly result in negative G limitations being exceeded, and large rearward movements in rapid penetration to heavy buffet, and possibly into the region of longitudinal instability. Special care should, therefore be taken during flight at high altitude and low IAS.

(*b*) If the above precautions are observed, the aircraft will not however, due to mishandling or severe turbulence when flying near the critical condition, instability is encountered, an incipent pitch-up may occur. This can be corrected by positive but not violent forward movement of the stick, and subsequent control movements should be gentle until the normal flight condition is regained. If, however, the nose continues to rise against the forward movement of the stick, a full pitch-up may develop. To correct a full pitch-up (a pitch change of up to 50° may be experienced) the stick must be held fully forward until the nose has fallen below the horizon and the IAS has increased above the value prior to the incident. After this, recovery from the ensuing dive should be carried out as gently as possible, thereby avoiding the possibility of a second pitch-up. The likelihood of the latter is greatly increased if it is attempted to catch the nose on the horizon, and no such attempt must be made. If the above 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 recovery action is ineffective, the braking parachute should be 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 as described above.

11 Approach to the stall

NOTE: Stalling is not permitted, and speed must not be reduced below the onset of pre-stall buffet or threshold speed, whichever is the higher.

(*a*) *Clean configuration*

With wings level, pre-stall buffet will occur at 10 to 25 knots above the threshold speed for the weight. This buffet is barely discernable speed is reduced by a further 10 knots, when light buffet commences. From 5 knots below to 5 knots above threshold speed a third stage of buffet becomes apparent, this consists of occasional moderate to heavy thumps superimposed on the high frequency light buffet. Elevator forces remain very light throughout the approach to the stall and a recovery may be made immediately by gently pushing the control column forward.

(b) Undercarriage down. Full flap extended

In the landing configuration, slight variation caused by the undercarriage and flaps may mask the onset of buffet until the speed is reduced to 10 knots below the threshold speed. At this point, heavier buffet will occur, changing to a spasmodic vertical shaking as speed is further reduced.

(*c*) Flight tests at 125,000 lb. AUW at speeds of 120 knots clean and 115 knots in the landing configuration have shown that all controls remain effective but aircraft response, especially to rudder movement, is greatly reduced. During the light buffet stage recovery is immediate if the control column is moved forward and power increased.

(d) 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.

12 Descending

(a) Normal QGH *descent*

Close the throttles, ensuring that if above 45,000 feet, the inboard engines are maintained at 90% RPM, select airbrakes fully out and descend at 0·84M/240 knots. The rate of descent is approximately

(b) Cruise descent

Close the throttles, ensuring that the inboard engines' RPM does not fall below 90% above 45,000 feet, and descend at 210 knots.

(c) Maximum rate descent

If it is necessary to make a maximum rate descent, close the throttles, extend the airbrakes fully and descend at 0·92M/290 knots. The descent angle is steep and care must be taken to avoid exceeding the maximum speed limitations. Under instrument conditions it may be found advantageous to monitor the standby artificial horizon as well as the Director Horizon. During flight tests a descent from 53,400 feet to 40,000 feet took about 2 minutes at 160,000 lb.

13 Flying in turbulent conditions

The recommended speeds for flight in turbulent conditions are 220-250 knots or 0·87M. At these speeds, in moderate or severe turbulence, large aileron deflections may be required. Care should be taken that these deflections are applied slowly and smoothly. It is possible that lateral control could be marginal under these conditions.

14 Handling with underwing tanks fitted

The handling is generally the same as in the clean configuration with the following exceptions:

(*a*) Except near the maximum altitude, buffet may occur in straight flight as early as 0·88M, increasing in intensity with speed, and being particularly marked below 40,000 feet. Buffet may decrease or disappear in turns, though further application of G will result in onset of a different kind of buffet, harsher in character and (*b*) At speeds below 0·88M, buffet onset occurs in turning flight somewhat earlier than in the clean configuration, and the intensity increases much more rapidly with increasing G. The rolling tendency and stick lightening are again apparent but only above 0·84M after the onset of buffet. Both effects are particularly marked in the region 0·84 to 0·86M, and are accentuated when G is being applied rapidly.

(*c*) Flight tests have shown the existence of an early buffet onset, sometimes accompanied by a rolling tendency, considerably below 0·88M which occurs only when flying near the maximum altitude for the AUW in straight and level flight or in very gentle turns below 0·85M. The effect is noticeable only when attempting to cruise under the conditions in which it occurs; it disappears if altitude is reduced, and the aircraft may then be manoeuvred up to the buffet referred to in (*b*) without encountering early buffet at all.

(*d*) With fuel in the underwing tanks, the rolling inertia is increased and a given rate of roll takes longer to build up and longer to correct, thus giving the impression of a reduced rate of roll.

(*e*) With one tank full and the other empty adequate aileron trim is available to hold wings level at speeds above 170 knots. At lower speeds corrective aileron, in addition to full aileron trim is necessary, but control is adequate. In this configuration, corrective rudder is also necessary if a slam acceleration is made when taking overshoot action. It must be remembered that with asymmetric fuel, the direction of swing reverses on changes from decelerating to accelerating flight and *vice versa*.

(*f*) On approaches to the stall at any flap setting, it has been found that the wing rocking tendency which some aircraft exhibit is likely to be more pronounced when underwing tanks are fitted.

Part III

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 MFS as required (Part I, Chapter 8). When level at circuit height reduce speed to 225 knots and lower the flaps to the TAKE-OFF position. Carry out the pre-landing checks and reduce to the recommended speed, which is 20 knots above the threshold speed for the weight. A slight buffet or burble may be felt below 200 knots when underwing tanks are fitted. The relevant speeds in knots for various aircraft weights are given below:

Weight lb.	*Pattern*	*Approach*	*Threshold*
120,000	147	137	127
130,000	152	142	132
140,000	157	147	137
150,000	162	152	142
160,000	167	157	147
170,000	172	162	152
180,000	177	167	157
190,000	182	172	162
200,000	186	176	166

2 Visual circuit

When carrying out a visual circuit, maintain the recommended pattern speed until suitably positioned at approximately 90° to the runway. Select flaps DOWN and reduce power as required, aiming, whenever possible, to be approximately lined up with the runway at about 600 ft. on the glide path 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, select and control the MFS as required (see Part I, Chapter 8, paras. 15 and 16). Maintain the recommended pattern speed until interception with the glide path. Select flaps DOWN and reduce power as necessary to maintain speed on the glide path at the recommended approach 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 for all approaches.

4 Landing

WARNING. When landing at or above the maximum normal weight the recommended threshold speed should be closely adhered to and tail wind conditions avoided. The rate of descent at touchdown should be kept to a minimum.

Provided that a good approach has been made, landing the aircraft presents no difficulties. Cross the theshold at the recommended speed, gradually closing the throttles. Round-out by steadily easing back on the control column, 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, select STREAM when the nosewheel is firmly on the runway. Wheel braking may be commenced once the nosewheel is down, provided the speed is below the maximum braking for the conditions prevailing.

5 Use of the brake-parachute

(*a*) The normal maximum speed for streaming the brake-parachute is 140 knots at weights up to 160,000 lb. In emergency, at weights between 140,000 lb. and 200,000 lb., dependent on the past usage of the parachute, other speeds are permissible. (See Part II, Chap. 2, para. 2(*g*)). Whenever possible, use of the brake parachute is recommended to reduce the landing run. When the mainwheels are below the required streaming speed, select the brake-parachute to STREAM. Full deployment usually occurs 4-5 seconds after selection. 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 kts. but very little advantage is gained from using it below that speed.

(*b*) The maximum permissible crosswind component for streaming the brake parachute is 25 kts. When the parachute deploys in crosswind conditions, a marked nose-into-wind yawing effect occurs, the degree of yaw increasing with increase in crosswind component. The aircraft must be 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 below 10 kts. When it is certain that the aircraft can be stopped comfortably with normal use of wheelbrakes, 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-and applying heavy brake pressure continuously. On dry surfaces the maxaret units will 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 will 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*) *Wet surfaces*

Depending upon the degree of wetness and type of runway surface, retardation may be considerably reduced. Maximum braking efficiency is obtained by making a firm touchdown, then applying light brake pressure as soon as the aircraft is firmly on the runway and the wheels have had time to spin up. Brake pressure may be increased progressively as aircraft speed is reduced, in order to bring the aircraft to rest using the full length of the runway. Although the maxaret units are designed to prevent skidding, under the worst conditions even light braking may cause the wheels to spin down and, eventually, to lock. If this is suspected, the brakes must be released and the wheels given time to spin up before they are re-applied.

(*d*) *Flooded or icy surfaces*

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 firm touchdown at the beginning of the runway. The brakes must be

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 kts. 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 approach should be flown at 10 kts. above the normal recommended speeds. A normal approach path should be flown, using airbrakes as required. Avoid a prolonged hold-off as this may result in the rear-fuselage striking the ground. Therefore practice flapless landings are not recommended.

9 Overshooting

The engines can be accelerated from approach idling (70% RPM) to full power within 5 secs. If all throttles are opened rapidly, power increases suddenly as the levers reach the fully open position. Slight varying engine acceleration times may cause asymmetric thrust components. More than adequate power is normally available and engine speed may be reduced as required when the overshoot has been initiated, in order to avoid climbing away at an excessively

Part III

Chapter 4—Asymmetric Flying and Flight with PFCU's Failed

List of Contents

1 Handling in flight

Flight with one engine stopped presents little difficulty and from handling considerations may be indistinguishable from four-engine flying. Any slight rudder loads may be easily trimmed out. With two engines on one side stopped the amount of trim required for normal cruising is small. The loss of one or two engines will have an obvious effect on performance. The closing down or loss of two engines will also cause the associated RAT scoop to extend. The management of the electrical system under such conditions is described at Part I, Chapter 1.

2 Approach and landing

(*a*) The minimum approach speed, with or without drop tanks fitted, is 145 knots. If Blue Steel is fitted the minimum approach speed is 155 knots.

(*b*) As long as the necessary total power can be obtained from the operative engines, the technique for approach and landing using

(*c*) When on two engines if the calculated approach speed is *less* than minimum approach speed, the latter should be maintained until the decision height of 350 feet has been reached.

3 Overshooting

(*a*) With one engine stopped, it is possible to climb away with full flap and undercarriage down, airbrakes in, at all weights. The slow and varying acceleration times of the engine may increase the asymmetric effect considerably if the throttles are opened rapidly and, until experience of a particular engine installation is gained, the decision to overshoot should be made early enough for the throttles to be opened slowly.

(*b*) With two engines stopped the aircraft will climb away witn take-off flaps and undercarriage down, airbrakes in, at the normal landing weight. Climb straight ahead to a minimum height of 1,000 ft. AGL maintaining at least minimum approach speed. The power required will vary with AUW. If the throttles are moved rapidly to the fully open position the sudden increase of power as engines. Full rudder and half aileron will be needed to control the aircraft and it is recommended that power is increased initially to 92% RPM and the remaining power fed on more slowly. The over-shoot, must be commenced at or above the decision height and the approach speed. (See para. 2).

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 permitted manoeuvres, but landing in this condition requires considerable concentration, as control forces are higher 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 flap only and the threshold speed increased by 20 kts.

(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 permitted manoeuvres and, in calm weather conditions, a landing may be made using 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 kts.

Part IV—Emergency Handling Procedures

List of Chapters

NOTES

All Check Lists referred to in this Part are detailed on the Flight Reference Cards.

Part IV

Chapter 1—Engine Emergency Procedures

List of Contents

NOTE: The following emergency drills are contained in the Flight Reference Cards.

Engine fire drill

Engine overheat warning

Four engine flame-out

1 Engine mechanical failure

If an engine fails under conditions which indicate a mechanical failure, immediately stop the engine by closing the HP cock. ▶◀ Select the appropriate RAT intake OPEN. Keep close observation for warning of engine bay fire. Switch OFF the alternator.

2 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 cock. ▶◀ The RAT intakes will normally be extended

(*c*) Should a double engine failure occur at a speed lower than safety speed but above the " stop " speed the live engines should be throttled back momentarily to stop the yaw, and then power re-applied as required.

3 Two-engine failure in flight

(*a*) If two adjacent engines fail in flight, the appropriate RAT intake will automatically open as the RPM decrease, but in order to ensure that the RAT alternator is capable of accepting its electrical loads, the intake should be manually selected OPEN as soon as possible. Depending on the circumstances of engine failure attempts may be made to relight the engines as soon as possible or stop them by closing the HP cocks. ▶◀ If an attempt is made to relight, relight the inboard engine first.

(*b*) If the engines are stopped, or if immediate attempts to relight the engines are unsuccessful, the PFCU's will automatically be transferred to the RAT alternator busbar when the engine-driven alternators come off line. If the two port engines have failed, the transferred to the RAT alternator busbar. Switch off the motor-operated loads (e.g. frequency changer, hydraulic pump motors, booster pumps) and, when the POWER FAILURE warning lights illuminate, switch OFF the alternators. If the two starboard engines have failed the output of the starboard LV battery should be checked and the LV busbars paralleled. Switch the frequency changer load transfer switch to the No. 1 position to maintain the Stand-by Horizon supply, then switch OFF No. 2 frequency changer.

(*c*) If one or both engines are subsequently relit switch ON the appropriate alternators when the outputs are normal. Reload the alternator as required and deparallel the LV busbar. Close the RAT intakes as required. If neither engine is successfully relit, descend and light the AAPP as soon as possible. Connect the AAPP alternator to the busbars as required.

4 Four-engine flame-out

(*a*) If four engines flame out, the RAT intakes automatically open when the engine speeds fall below 52% RPM. The engine-driven alternators may be kept on line for a limited period by descending at the highest practicable IAS/MN. The RAT intakes should be selected open manually. Carry out the appropriate drills in the check list.

(*b*) *If alternators come off line*

(i) As the POWER FAILURE warning lights illuminate check that the RAT TURBINE ON LOAD lights illuminate and that the RAT alternator frequency and voltage outputs remain normal. Switch OFF the alternators.

(ii) Check that No. 2 T/R unit, ECM, hydraulic pump motors, frequency changers, NBS, Green Satin, fuel booster pumps, auto-pilot and all other non-essential loads are switched off. Switch the main yaw damper to STANDBY and standby yaw damper ON if required.

(*c*) *If main engine(s) are relit*

If the main engine(s) are successfully relit, switch ON the alternator(s) when the engine(s) reach flight idling RPM. Check that the RAT TURBINE ON LOAD lights go out. Switch on MV and LV loads as required. Standby yaw damper STANDBY, main yaw damper ON.

(*d*) *If main engines are not relit*

Whilst attempting to relight the engines, descend as soon as possible to a height at which the AAPP can be started. Start the AAPP and check that its alternator frequency and voltage outputs are normal. Check that the starboard TURBINES ON LOAD light goes out when the AAPP magnetic indicator is horizontal. Parallel the MV synchronising busbars and check that the port TURBINES ON LOAD light goes out. Switch on No. 2 T/R unit, No. 2 hydraulic pump motor and fuel booster pumps as required.

(*e*) *If main engine(s) relit after* AAPP

When the engine(s) reach flight idling RPM, switch ON the alternator(s) and check voltage and frequency output. Select MV paralleling switch to NORMAL, ▶◀ switch on MV and LV loads as required and resynchronise alternators.

Part IV

Chapter 2—Airframe Emergency Procedures

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NOTE: The following emergency drills are contained in the aircraft check lists (Flight Reference Cards)

Cabin pressure failures
Oxygen failures
Hydraulic malfunction drills
Double alternator failure

1 Escape hatch jettisoning

(*a*) Automatic jettisoning occurs when the associated ejection seat face screen or seat pan handle is pulled.

(*b*) To jettison manually, pull up the associated ditching handle.

2 Underwing tank jettisoning

(*a*) Full or empty drop tanks may be jettisoned, in straight and level flight only, at all speeds up to 350 knots.

(*b*) Flaps must be fully raised otherwise serious damage may be caused to them by the tanks on jettison.

(*c*) If one tank fails to jettison, speed must not exceed 0·9M and gentle manoeuvres only are to be carried out.

3 Electrical system failures

Failure	*Indication*	*Immediate action*	*Subsequent action*
LOAD SHARING MALFUNCTION	Load between two alternators differs by more than 8 KW/KVAR with each alternator supplying some load	1 Isolate the alternators 2 Check individual voltages and frequencies 3 Check CSDU oil temperature	1 If one alternator outside its limits, reconnect the other alternator to the sync. busbar 2 Switch off the faulty alternator and appropriate frequency changer 3 If both alternators within limits, re-synchronise if neither is overloaded Restart the frequency changer
SINGLE ALTERNATOR FAILURE (a) Electrical	1 Power failure warning light 2 'A' breaker opens	1 Select appropriate RAT open 2 Switch alternator to RESET for not more than 5 secs., then OFF 3 Stop any frequency changer supplied by it	1 Check voltage and frequency outputs and CSDU oil temperature 2 If normal select alternator ON and re-synchronise 3 If out of limits leave alternator OFF 4 Reduce loads as necessary 5 Select RAT closed when failure investigated
(b) Drive failure	1 Complete out-of-balance of KW load sharing if synchronised 2 Deviation of busbar frequency from 400 c/s 3 Power failure warning light may come on	1 Select appropriate RAT open 2 Stop any frequency changer affected	1 If PFW light comes on switch alternator OFF, check alternator voltage and frequency and check loading of serviceable alternator and CSDU oil temperature 2 If no PFW light, check frequency of sync. busbar If normal or low switch off alternator with zero KW load If high switch off alternator with all the KW load 3 Check loading of serviceable alternator and reduce loads if necessary 4 Select RAT closed when failure investigated
DOUBLE ALTERNATOR FAILURE (a) Electrical	1 Both PFW lights come on 2 RAT scoop opens automatically 3 PFCU's on affected side fail	1 Select opposite RAT open	1 Check LV battery output on affected side 2 If normal, parallel the LV busbars 3 (a) If the port alternators fail check the frequency changer load transfer switch to No. 2 (b) If the starboard alternators fail switch the frequency changer load transfer switch to No. 1 4 Switch failed alternators to RESET then OFF and check individual output 5 If outputs normal shed all switchable MV loads and switch on again. Do not re-

Failure	*Indication*	*Immediate action*	*Subsequent action*
DOUBLE ALTERNATOR FAILURE (a) Electrical—*contd.*			6 If one alternator retrip switch OFF. Do not connect serviceable alternator to sync. busbar 7 Reload serviceable alternator 8 If both alternators are faulty leave OFF, descend to AAPP light-up altitude, start AAPP ▶◀ and connect it to busbars as required 9 Select RAT's closed
(b) Engine flame-out	1 Engine RPM decelerate 2 RAT opens below 52% RPM 3 PFCU's remain operating on RAT 4 PFW lights come on	1 Select RAT manually (precautionary measure)	1 Switch off all switchable MV loads 2 Switch off alternators when PFW lights come on 3 If failure on Starboard side check output of stbd. LV battery. Parallel LV busbar 4 Switch frequency changer load transfer switch to No. 1 5 If the failure is on the port side check Frequency Changer Load Transfer switch to No. 2 6 If any engine subsequently relit switch on appropriate alternator, reload and deparallel LV busbar. Close RAT 7 If neither engine relit descend to AAPP light-up altitude, start AAPP ▶◀ and connect to busbars as required
FOUR ENGINE FLAME-OUT	1 Alternators come off line in underspeed ▶◀	1 Select both RATS open 2 Check RAT running lights come on 3 Check RAT voltages and frequencies normal 4 Select standby yaw damper on, main yaw damper to standby	1 Shed all non-essential loads 2 As the PFW lights come on, check RAT load lights come on and, outputs normal 3 Switch off alternators 4 If no immediate relight check load shedding is complete 5 If engines relit above AAPP light up altitude: Switch on appropriate alternators When output normal, check RAT load lights go out Switch on MV and LV loads Close RATS as required

Failure	*Indication*	*Immediate action*	*Subsequent action*
FOUR ENGINE FLAME-OUT —*contd.*			6 If engines not relit above AAPP light up altitude start AAPP and connect to stbd. bus-bar. Check stbd. RAT load light goes out when AAPP m.i. is horizontal Switch on 2 TRU, booster pumps as required, and No. 2 hydraulic pump 7 If main engines subsequently relit: Switch on appropriate alternators Check MV bus-bar deparalleled Synchronise alternators Switch on MV and LV loads Retract RAT scoops Select standby yaw damper to standby and main yaw damper on
3-PHASE TRANSFORMER FAILURE	Failure of associated equipment	None in the case of 1 and 4 transformers *No. 2 Transformer* Select 1st Pilot MFS change-over switch to EMERGENCY *No. 3 Transformer* Transfer to No. 2 by selecting No. 1 frequency changer (No. 1 FC must be running)	If No. 1 fails, switch off Green Satin
FREQUENCY CHANGER FAILURE	Neon light goes out	Check other FC is running, otherwise start it	Select LOAD TRANSFER Switch to serviceable FC
TRU FAILURE	LV busbar volts fall to below 24v Battery shows discharge. TRU m.i. vertical or horizontal	1 Switch off TRU, check LV loads and parallel LV bus-bar (Check fuse K1/CD in case of No. 1 TRU)	1 If MI was horizontal change TRU fuse and switch on. If MI remains horizontal switch OFF and leave OFF. If MI returns to vertical deparallel ▶◀ and check output normal 2 If MI was vertical no further action should be taken

Failure	*Indication*	*Immediate action*	*Subsequent action*
SPECIAL FEEDER FAILURE	Some indicators on BF show striped Special feeder indicator shows OFF LV volts and current meters read zero Appropriate RAT indicator striped. RAT scoop extends	Check circuit breaker If tripped switch off appropriate LV battery and TRU Switch off NBS, STR18 and VHF	1 Reset circuit breaker 2 If it stays closed, indicators revert to normal, switch on the battery and TRU and reselect services required Select RAT closed 3 If 1P.8 CB retrips parallel LV supplies and switch loads as required (paralleling inoperative if 2P.8 retrips). Two PFW lights and fire warning lights will be inoperative 4 If the CB was not tripped reduce loads and set control switch to EMERGENCY. Check appropriate battery (a) If indicator vertical and voltage low, switch off battery and TRU and close RAT. ◀ *DO NOT* parallel LV busbars nor start AAPP ▶ (b) If battery indicator horizontal and voltage normal switch off battery and close RAT
LV BATTERY FAULT	Magnetic indicator horizontal	Special feeder to EMERGENCY Switch off failed battery	Change fuse and switch on battery. If MI shows vertical return special feeder to NORMAL, otherwise switch off battery and leave off

4 Fuel system failures

Failure	*Indication*	*Immediate action*	*Subsequent action*
BOOSTER PUMP FAILURE	None for duplicated pumps in tanks 1, 5, 6, 7, 8, 11 and 12 Tanks 3 and 4: contents gauge reading stays constant	None	If unbalance occurs due to failure of 3 and 4 tank pumps, switch off the appropriate pump in the opposite wing If tank 10B pump fails, fuel available for AAPP only
PROPORTIONER FAILURE (a) Fuselage prop. when fus. group only in operation	LP warning lights of all four engines	Select all wing pumps ON	Select fuselage proportioner to BYPASS. Select wing proportioners to PROPORTION. Check that the fuselage group is feeding, select wing groups to BYPASS, pumps OFF and manually balance fuselage fuel
(b) Wing prop. When wing groups only in operation (no cross-feed)	LP warning lights of two affected engines	Select all fuselage pumps ON	Select failed proportioner to BYPASS. Check fuel control panel selections. Select fuselage group to PROPORTION. Check that affected wing group is feeding, select the fuselage group to BYPASS, pumps OFF and manually balance wing fuel
(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
BACKING PUMP FAILURE	LP warning light of affected engine Fluctuating or reducing RPM	Throttle engine until warning light goes out	If light fails to go out before throttle fully closed, check for accidental closure of LP cock
ENGINE FAILURE	Various	If wing groups in use, open both cross-feed cocks	Check wing contents balance and adjust if necessary

Failure	*Indication*	*Immediate action*	*Subsequent action*
Leaking Tank	Continuous and disproportionate decrease in fuel level relative to other tanks in same group Confirm by switching off pumps in that tank, with proportioner at PROPn and note if contents still decrease	Select appropiate group to PROPORTION Switch ON all fuel pumps Select leaking tank IN USE/NOT IN USE switch to NOT IN USE	When leaking tank is empty switch OFF fuel pump Leave IN USE/NOT IN USE switch at NOT IN USE

Part IV

Chapter 3—Abandoning, and Emergency Landing Procedures

List of Contents

NOTE: The following emergency drills are contained in the Flight Reference Cards.

Undercarriage malfunction drills
Abandoning the aircraft
Crash landing
Ditching

1 Abandoning the aircraft

WARNING. At high altitude, time must be allowed to depressurise the cabin before operating the door opening lever as the maximum safe differential pressure for opening the door is 1·5 PSI. The following table gives the approximate time taken to reduce from cruise pressure to this figure.

Ht. (ft.)	Time to depressurise to 1·5 PSI diff. press. (secs.)
12,000	0
20,000	4
25,000	7
30,000	9
35,000	11
40,000	13
45,000	14
50,000	15

The maximum safe speed for rear crew members to abandon the aircraft is 250 knots, the recommended speed is approximately 200 knots.

(*a*) *Preparatory actions*

(i) Before abandoning the aircraft, speed should be reduced as much as possible and the aircraft should be as clean as conditions permit. Flaps and undercarriage should be raised, although experience indicates that successful escape is not precluded if these conditions cannot be achieved.

(ii) The normal order for leaving the aircraft is nav. plotter, AEO, nav. radar, second pilot, first pilot. When a sixth crew member is carried he must leave the aircraft after the Nav/Plotter. Rear crew members should avoid placing bags and other equipment in positions to impede the swivelling of the seats or the escape routes.

(iii) The manual override must not be used above 20,000 feet. However it must be used below 1,000 feet (below 250 knots) *(b) Abandoning the aircraft*

1st Pilot	*2nd Pilot*	*Nav/Plotter*	*6th Crew Member*	AEO	*Nav/Radar*
Orders "Prepare to abandon aircraft, ht. ....ft."	Acknowledges	Acknowledges	Acknowledges	Acknowledges	Acknowledges
Sets mask toggle down	Sets mask toggle down	Sets mask toggle down	Sets mask toggle down	Sets mask toggle down	Sets mask toggle down
If above 40,000 ft. awaits calls of "READY" from rear crew members	If above 40,000 ft. selects COMBAT PRESSURE	*Swivels seat (first)* Puts on parachute and reports "READY"	Puts on parachute and reports "READY"	Puts on parachute and reports "READY"	Puts on parachute and reports "READY"
On last call of "READY" or immediately if below 40,000 ft., selects EMERGENCY DECOMPRESSION	On last call of "READY" or immediately if below 40,000 ft. selects NO PRESSURE	Ensures static line connected	Ensures static line connected	Ensures static line connected Transmit Distress Call Sets IFF to EMERGENCY When cabin is depressurised opens door	Ensures static line connected *Swivels seat (third)*
Operates ABANDON AIRCRAFT switch and orders "Jump, Jump, Jump." (If below 1,000 ft. orders "Low level Jump, Jump, Jump")		Pulls demand emerg. ox. control Disconnects from aircraft systems, operates assister cushion	Pulls demand emerg. ox. control Disconnects from aircraft systems, operates assister cushion	*Swivels seat (second)* Pulls demand emerg. ox. control Disconnects from aircraft systems operates assister cushion	Pulls demand emerg. ox. control Disconnects from aircraft systems, operates assister cushion
Checks "Crew gone" lights	Checks "Crew gone" lights and informs 1st pilot when all rear crew members have left.				
Operates ejection seat	Operates ejection seat	Leaves aircraft first	Leaves aircraft second	Leaves aircraft third	Leaves aircraft fourth

(*c*) *Abandoning aircraft at low altitude*

NOTE: Wherever possible convert speed to height.

Should it be necessary to abandon the aircraft at low altitude (below 1,000 feet) reduction of the time interval between the moment at which the order to abandon aircraft is given 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 normally the parachute is left in the seat when a crew member is moving around the cockpit, should the parachute be worn it will be necessary to disconnect the static line to leave the seat, pre-Mod. 3760. In this event an attempt should be made to reconnect the static line, but 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 a static line is connected or not, the manual override should always be pulled as soon as possible after abandoning the aircraft below 1,000 feet and 250 knots.

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

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 have the aircraft towed away.

3 Crash landing on an airfield

The following drill is recommended in conjunction with the appropriate Check List :

(*a*) Reduce weight as much as is practicable.

(*b*) Jettison bombs and underwing tanks at captain's discretion. Ensure bomb-doors are closed.

(c) 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.

(*d*) 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.

(*e*) Ensure that the crew are strapped in and that their seats are at the crash position.

(*f*) At 500 ft. jettison the pilots' hatches and close the HP cocks just before touch-down.

(*g*) After touch-down the crew should escape through the nearest exit.

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 in conjunction with the appropriate Check List.

(*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 crew are firmly strapped in, with their seats at the crash position.

(*f*) Land using normal landing flap, with sufficient speed to ensure a touchdown at 125 kts.

(*g*) Lower the nose wheel and simultaneously apply aileron to hold the wings level.

(*h*) As the speed falls to 110 kts. lower the wing-tip gently onto the ground, and simultaneously apply rudder and wheel brakes 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.

(*k*) Aileron effectiveness is lost at approximately 105 kts. 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: 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 which the wing-tip is expected to strike will reduce friction and enable the aircraft to be held straight down to a lower speed.

5 Ditching

NOTE: 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.

(*a*) The following drill is recommended in conjunction with the appropriate Check List.

(*b*) 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 touch-down. The touch-down should be made parallel to the swell. If the swell is not steep and the wind across it is above 25 kts., it may be preferable to land into wind.

(*c*) At the touchdown, if the bomb doors hold and the procedure in (*b*) is carried out correctly, the ditching should be gentle. If the impact is severe enough to collapse the bomb doors, the deceleration is increased but the ditching is still satisfactory.

(*d*) Just before touch-down, close the HP cocks. All crew members should operate the dinghy release handle in turn and the crew leave the aircraft through the pilots' escape hatches carrying personal dinghies.

Part V—Illustrations

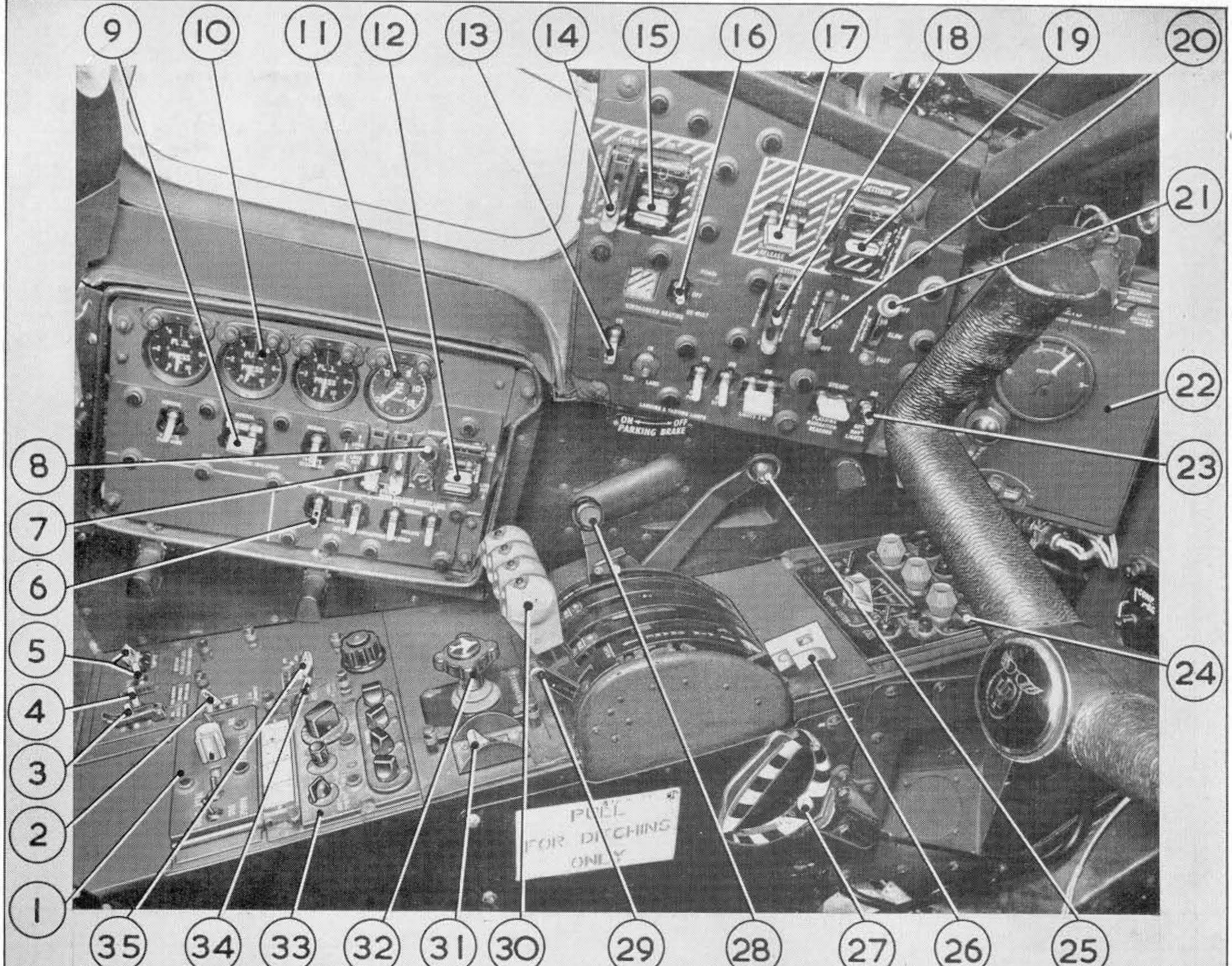
Part V

Illustrations

List of Figures

Key to Fig. A

1 Radio altimeter control unit
2 Radio altimeter on/off switch
3 Bomb doors emergency test switch
4 Nosewheel steering ground test switch
5 Brake parachute test switches and indicator
6 EGT isolation control switches
7 Blue Steel safety lock normal and emergency switches
8 Bomb release locked/unlocked warning lights
9 Fuel vent pressure switches
10 Fuel vent pressure gauges
11 Fuel vent temperature gauge
12 IBS bomb release safety lock switch
13 ILS switch
14 Emergency decompression switch
15 Abandon aircraft switch
16 Windscreen demist de-ice switch
17 Drop tanks release switch
18 Lower carrier jettison switch
19 Emergency bomb jettison switch
20 Yaw damper switch
21 Windscreen wipers control
22 Oxygen regulator
23 External lights switches
24 1st Pilot's station box
25 Parking brake control
26 Airbrakes control
27 Ditching handle
28 Throttles friction control
29 Engine cut-off lock release
30 Throttles/HP cocks
◀31 Brake parachute switch ▶
32 Trimmer switch
33 UHF controller
34 UHF tone switch
35 ILS/ADF/TACAN switch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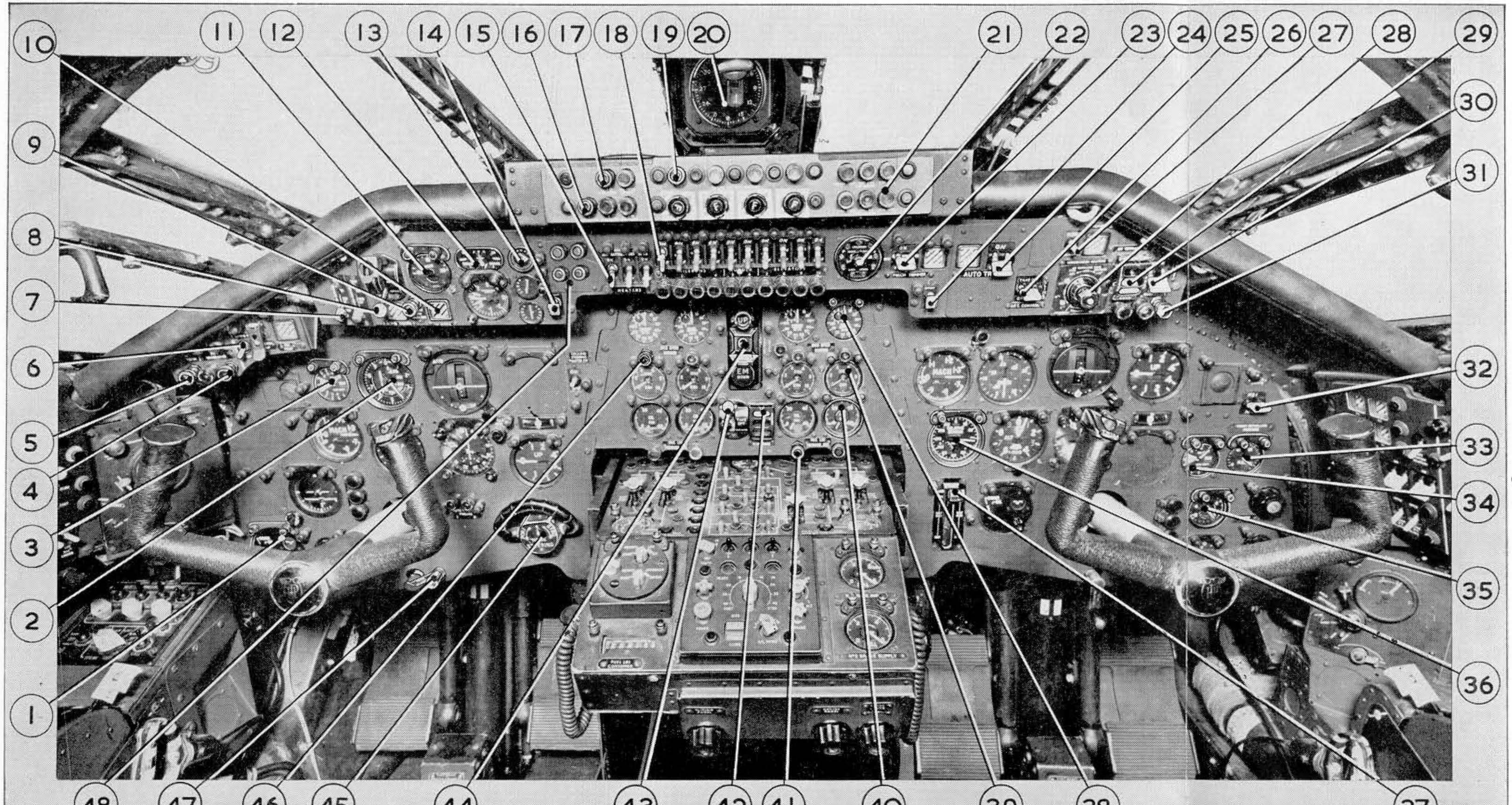
ON ← → OFF PARKING BRAKE
PULL FOR DITCHING ONLY

Key to Fig. B

1 MFS annunciator
2 ASI
3 Trim force indicator
4 Blue Steel fire warning lights (red)
5 Blue Steel HTP temperature warning light (amber)
6 Blue Steel fin switches and indicator
7 Roll and yaw damper switches
8 Bomb doors control switch and indicator
9 Emergency hydraulics selected warning light
10 Airbrakes position indicator
11 Bombing indicator
12 Flaps position indicator
13 Trim position indicators
14 Thunderstorm lamps switch
15 Pitot head heater switches
16 Emergency hydraulics and loss of electrics warning lights
17 Loss of cabin pressure and low pressure warning lights
18 PFCU switches and power failure lights
19 Engine fire warning lights and extinguisher pushbuttons
20 TACAN indicator
21 Airframe fire warning lights
22 Undercarriage position indicator
23 Mach trim switch and indicator
24 Thunderstorm light switch
25 Auto-trim switch and indicator
26 JPT control switch
27 Windscreen demist de-ice switch and overheat indicator
28 AVS temperature control
29 AVS isol-cock control switch
30 AVS auto-reset-manual switch
31 AVS warning lights
32 Probe lights switch
33 Flight refuelling pressure gauge
34 Trim force indicator
35 OAT gauge
36 Relative bearing indicator
37 Windscreen demist control
38 Tachometers (four)
39 EGT gauges (four)
40 Oil pressure gauges (four)
41 Fuel low pressure warning lights (four)
42 Flaps emergency selector switch
43 Flaps selector switch
44 Undercarriage selector switch
45 Nosewheel steering control
46 Engine overspeed warning lights (four)
47 Rudder pedals adjuster
48 " Crew gone " warning lights



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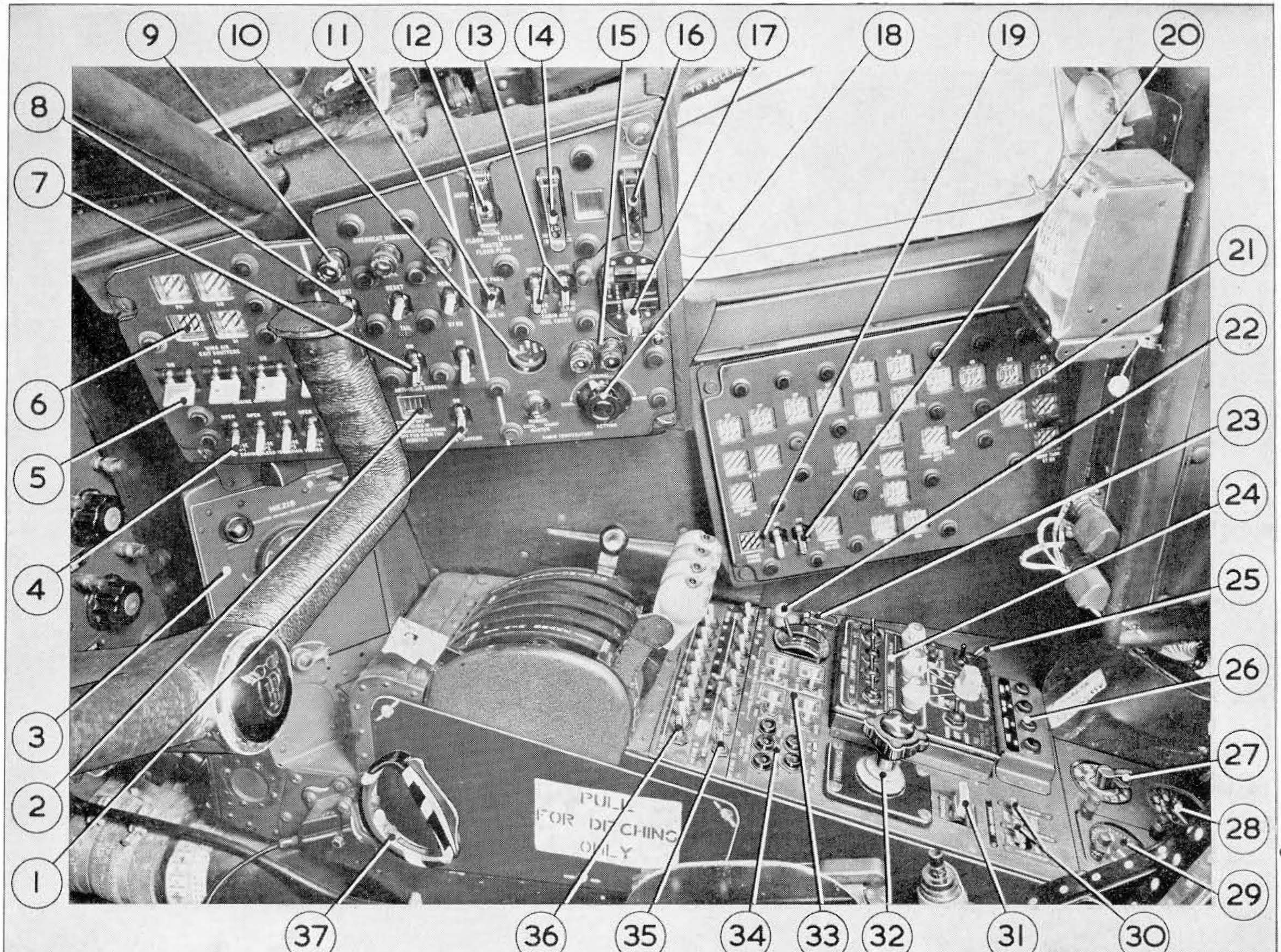
Key to Fig. C

1 Auxiliary heaters switch
2 Icing conditions indicator
3 Oxygen regulator
4 Engine bleed isol. switches
5 Engine anti-icing switches
6 Air exit shutters indicators
7 Anti-icing control switches
8 Anti-icing reset switches
9 Anti-icing overheat warning light
10 Cabin temp. indicator
11 CAU bypass switch
12 Flood flow master switch
13 Cabin air isol. cock switches
14 Flood flow reset switch
15 Max. heat and overheat warning lights
16 Warning horn override switch
17 Cabin pressure control
18 Cabin temp. selector
19 Probe purge indicator
20 Probe purge and de-ice switches
21 Fuel indicators
22 Windscreen wipers control
23 Defuelling cock switch and indicator
24 Station box
25 Blue Saga switch
26 Fuel filter de-ice test switches
27 SG control
28 Rate of flow meter
29 Flowmeter and selector switch
30 Auto throttle supplies switches
31 Auto throttle master switch
32 Trimmer switch
33 Fuel fiter de-icing switches and indicators
34 Fail safe fuel contents push switches
35 Fuselage refuelling switches
36 Wing refuelling switches
37 Ditching handle



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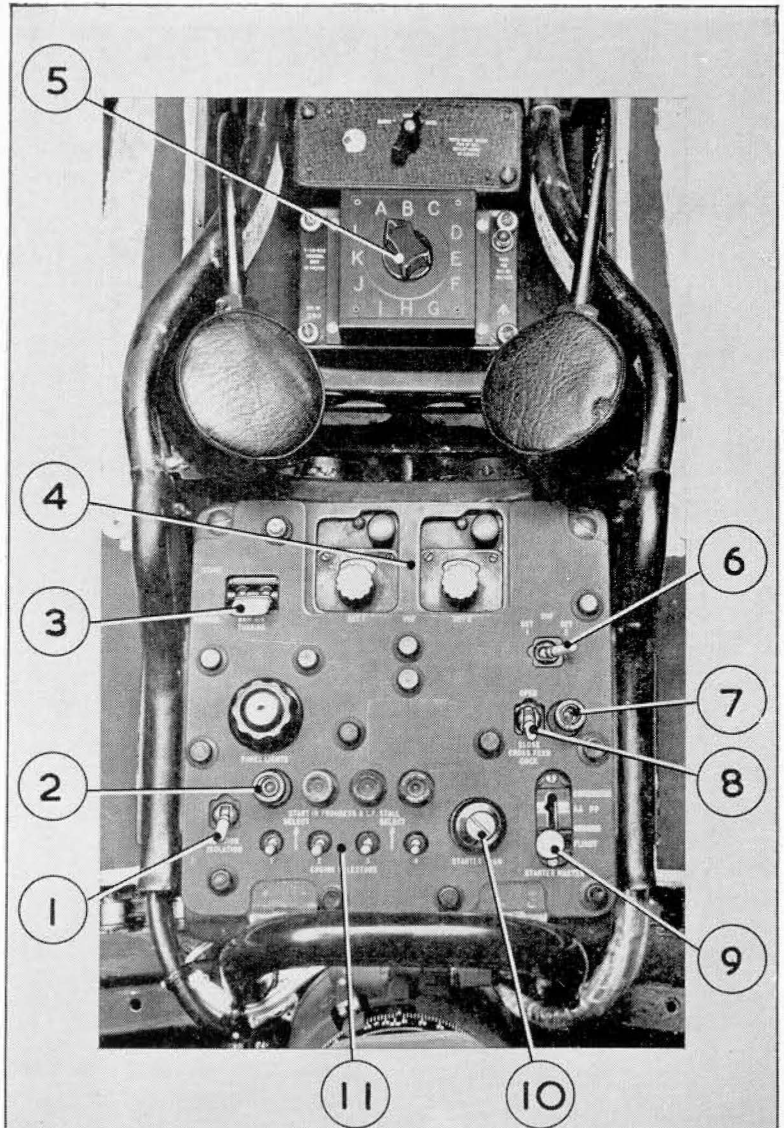
PULL
FOR DITCHING
ONLY

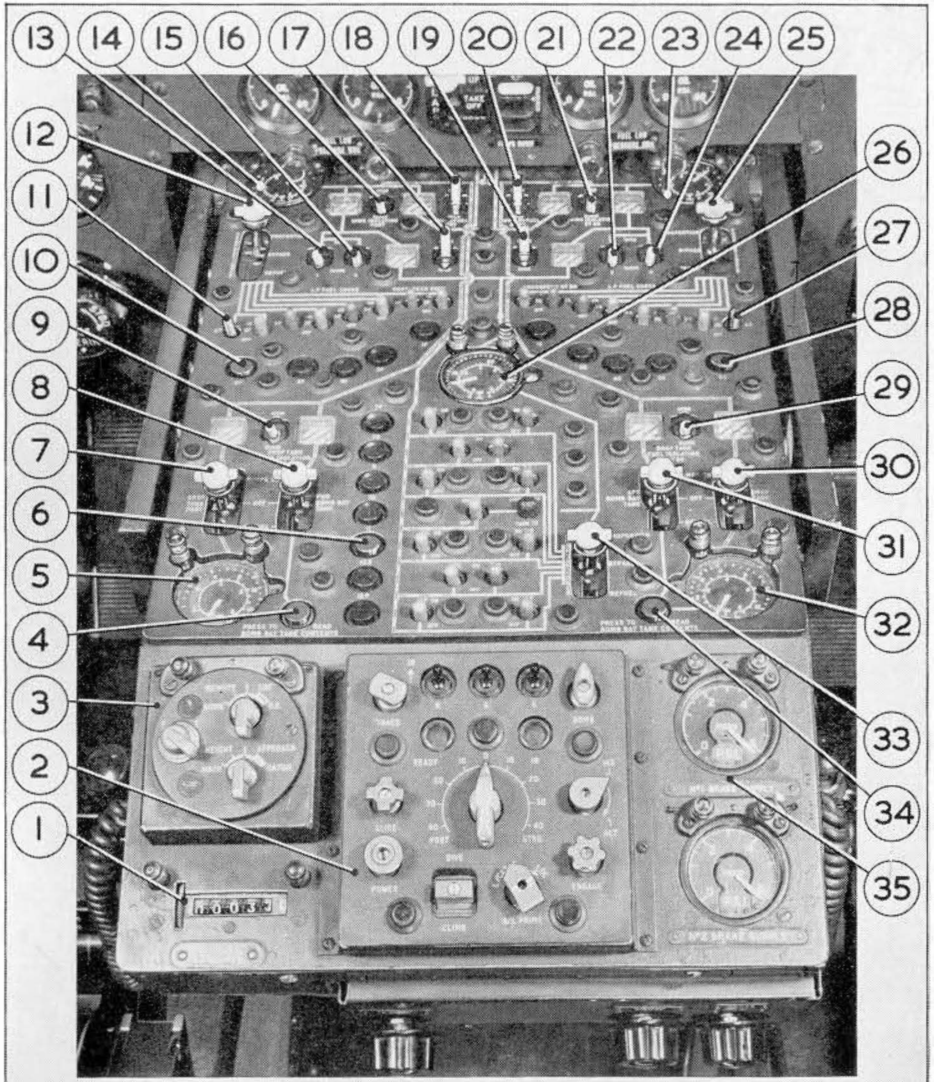
Key to Fig. D

1 Ignition isolation switch
2 Start in progress lights
3 RAT control switch
4 VHF controls
5 ILS control unit
6 VHF set selector switch
7 Crossfeed position indicator
8 Crossfeed cock switch
9 Starter master switch
10 Starter push switch
11 Engine selector switches



Key to Fig. E

1	Fuel consumed indicator
2	Auto-pilot control
3	MFS selector
4 & 34	Bomb bay tanks contents pushbutton
5 & 32	Drop tanks contents gauge
6	Fuselage individual tank contents pushbuttons
7 & 30	Drop tanks pumps switch
8 & 31	Forward and aft bomb bay tanks pumps switch
9 & 29	Drop tank isol. switch and indicator
10 & 28	Wing individual tank contents pushbuttons
11 & 27	Wing pump switches
12 & 25	Wing proportioners controls
13, 15, 22, 24	LP cocks switches
14 & 23	Wing groups contents gauges
16 & 21	Wing isol. cocks switches and indicators
17 & 19	Crossfeed cocks switches and indicators
18 & 20	Wing refuel cocks switches and indicators
26	Fuselage group contents gauge
33	Fuselage proportioner control
35	Brakes pressure gauges

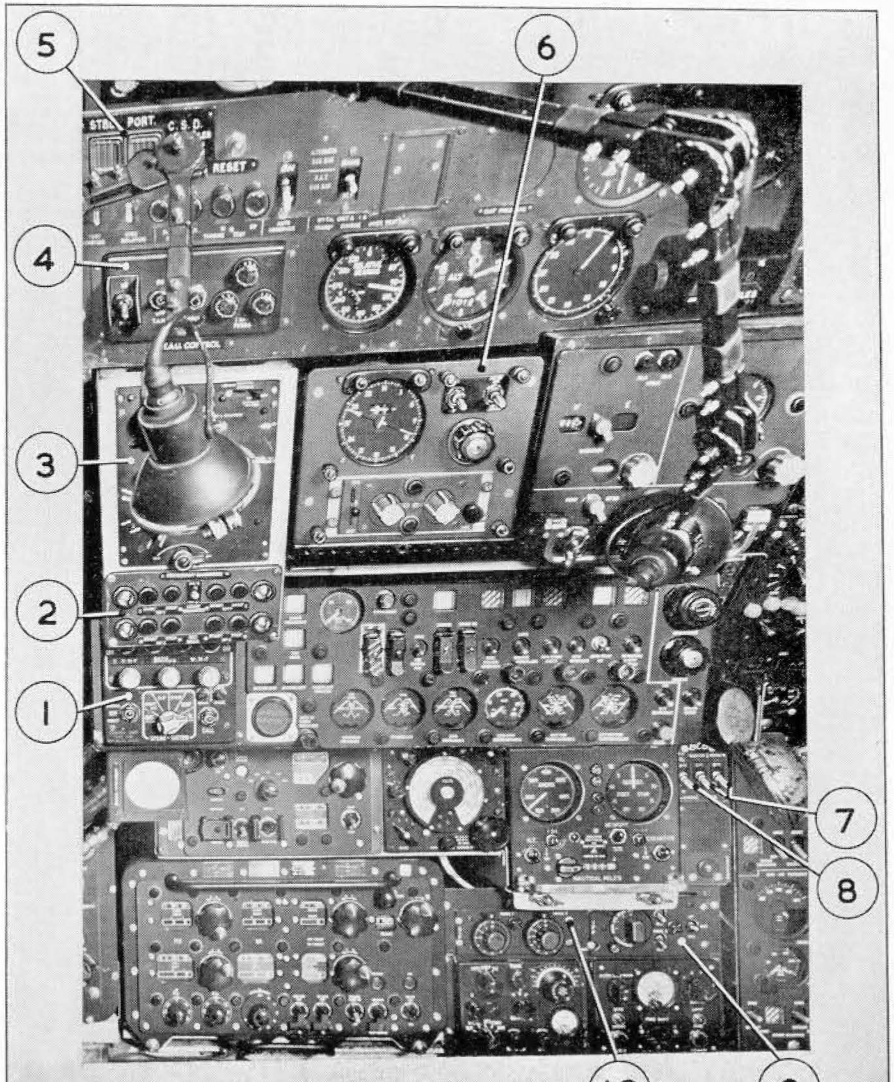


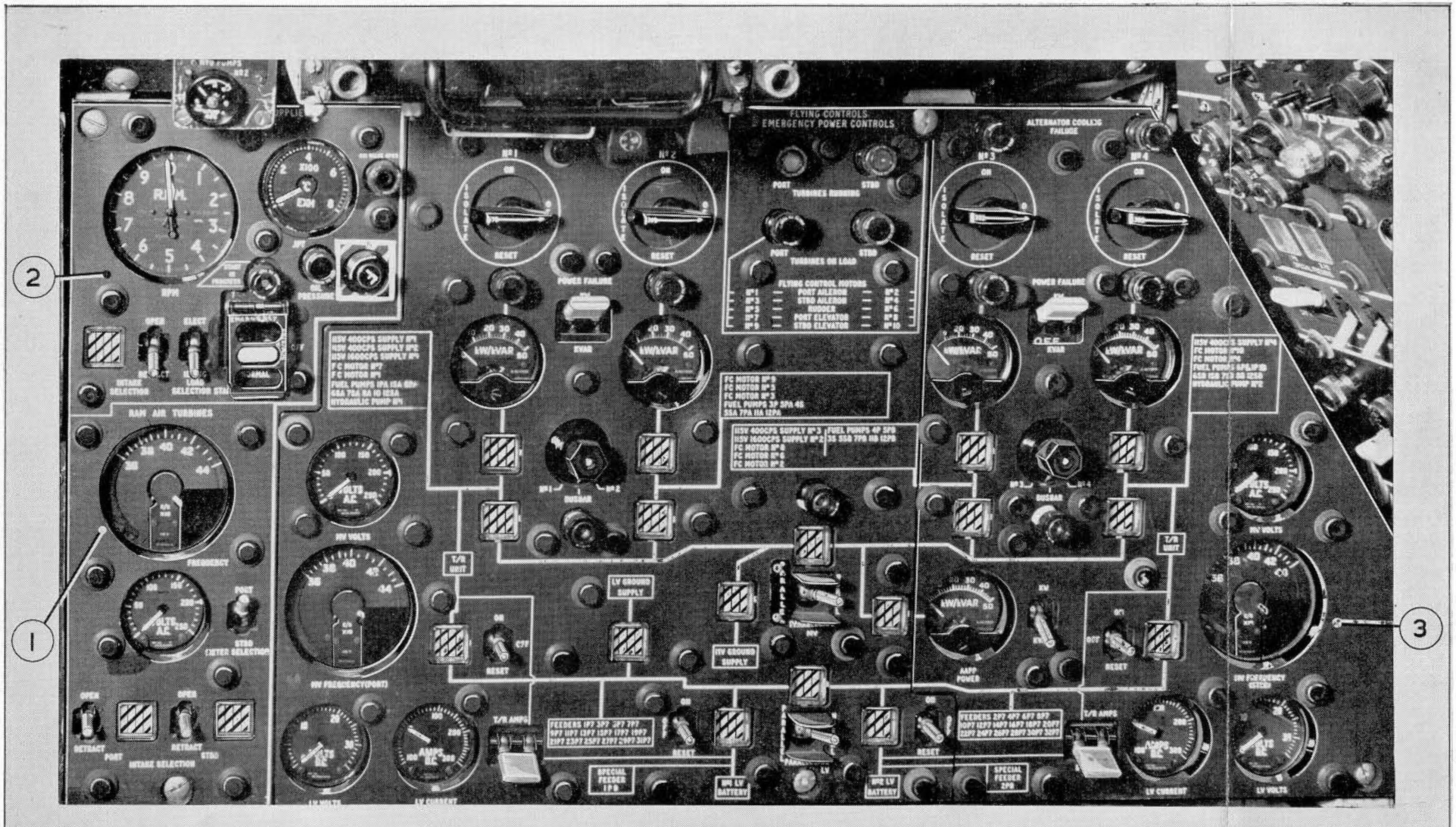
Key to Fig. F

1 Station box
2 Frequency changers controls
3 Oxygen regulator
4 TAS control unit
5 CSD oil cooler de-icing indicators
6 TACAN control unit
7 INS switches
8 MFS gyro switch
9 IFF control
10 SIF control

Key to Fig. G

1 RAT control panel
2 AAPP control panel
3 Generating system control panel




FLYING CONTROLS
EMERGENCY POWER CONTROLS
RAM AIR TURBINES
R.P.M.
KW/KVAR
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2
3

Key to Fig. H

1 Not in use
2 Hydraulic pump switches
3 Hydraulic pumps run lights
4 Intercomm switches
5 HF output switch
6 Special feeder indicators
7 Crash switch master circuit breaker
8 Crash switch warning lights
9 Service lights master switch
10 Fire warning lamps test switch
11 Fire warning detectors test switch
12 AAPP detector/lamp switch
13 ECM L band control unit
14 Station box
15 Oxygen system contents gauges
16 Oxygen regulator
17 Oxygen system supply valves
18 ECM X band control unit
19 ECM communications jammer
20 ECM metric jammer
21 ECM S band control unit


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CONN I/C WARNING
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ON
OFF
UHF
VHF
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SPEAK - LISTEN
MK.21B
FULL
OXYGEN SUPPLY VALVE
OXYGEN SUPPLY VALVE
UNIFIED THREADS