Restricted

A.P.4700D—P.N.

PILOT'S NOTES
LIGHTNING T. MK. 4

Restricted

AMENDMENTS

Amendment Lists will be issued as necessary and should be inserted in the appropriate place in the Notes. New or amended paragraphs will be indicated by triangles thus ◀..................▶ to show the amount of amended text and thus ▶◀ to show where text has been deleted.

The number of the latest Amendment List affecting a page appears at the bottom of the page and any triangles therefore on the page refer to this amendment list. However if a page is issued in a revised form, or consists of completely new text, the triangles do not appear.

If a manuscript amendment is called for in an Amendment List the number of the Amendment List should be noted in the margin adjacent to the amended text.

Incorporation of an Amendment List must be certified below, and the Amendment List instruction sheet inserted at the end of the book.

Amendment List No.	Date of Incorporation	Signature	Amendment List No.	Date of Incorporation	Signature
1	INCORPORATED		7		
2	INCORPORATED		8		
3			9		
4			10		
5			11		
6			12		

Comments and suggestions regarding Pilot's Notes should be forwarded to the Officer Commanding, Royal Air Force Handling Squadron, Boscombe Down, Wiltshire.

June, 1963
(Amended by AL.9)

AP.101B-1004-15
(Formerly AP.4700D-P.N.)

PILOT'S NOTES
LIGHTNING T Mk 4

BY COMMAND OF THE DEFENCE COUNCIL

Ministry of Defence

Prepared by the Procurement Executive,
Ministry of Defence

NOTES TO USERS

1. These notes are complementary to AP.3456 Flying and reference should also be made to the Lightning Operating Data Manual.

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

3. The Notes are divided by marker cards into five Parts, each consisting of a number of chapters listed on the marker card. A Folio Sheet reference number is at the top left hand corner of each sheet, each Part starting at FS1. The following conventions also apply:—

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

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

4. The Flight Reference Cards are complementary to the Notes but are issued separately and are subject to separate amendment procedure. Reference is made to them, where necessary, throughout the Notes. Further copies of the cards can be obtained on demand.

5. When first published these Notes included information covering the following Special Flying Instructions, SFI/10, SFI/12, and each Amendment List instruction sheet includes a list of further Special Flying Instructions and a list of modifications covered by the Amendment.

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

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U.H.F. Standby T/R 10056 (A.R.I.23057)	2531N

MODIFICATION NUMBERS MENTIONED IN THE TEXT

Mod No	*Effect of modification*	*Location in text Pt*	*Ch*	*Para*
4241	Brushless AC and DC generators	1	1	3
4373	AC instrument isolation following phase failure	1	1	5
4398	Introduces 165 knot pressure switch	1	7	1
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SRIM 3772	IFF/SSR emergency coding on ejection	1	12	8
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0269/STC	Provides preset range of 500 yards in GUNS mode ...	1	16	1

INTRODUCTION

1. The Lightning T. Mk.4 is a two-seat, twin-engined, supersonic trainer, having highly swept, mid-mounted main planes and a slab tailplane. The ailerons, rudder and tailplane are fully power operated and incorporate artificial feel for each control; hydraulic supplies to these controls are duplicated. Hydraulically operated air brakes and trailing edge flaps are fitted. A braking parachute is housed in a compartment on the underside of the fuselage.

2. The power units are Avon Mk.210 axial-flow gas turbine engines, each developing approximately 11,200 lb. static thrust at sea level (14,400 lb. approximately with maximum reheat). The engines are mounted in the fuselage, No. 2 to the rear of and above No. 1.

3. Internal fuel is carried in integral wing tanks and in the flaps and additional fuel may be carried in a jettisonable ventral tank.

4. Electrical power is derived from a generator and an alternator, both driven by a single air turbine unit powered by air tapped from the engine compressors. Service and emergency batteries are fitted.

5. The armament, carried in an interchangeable armament pack fitted on the underside of the fuselage, consists of two 30 m.m. Aden guns internally or two pylon mounted guided missiles externally. The radar fire control system comprises A.I.23 equipment and Pilot Attack Sights. Displays and controls for this system are provided for both members of the crew.

6. The pressurised cockpit contains two ejection seats. The clam-shell canopy is hydraulically operated and electrically controlled and can be jettisoned by a canopy jettisoning flap, or, on ejection, by either of the ejection seat firing handles on either seat. ⧓ An external canopy jettison handle is provided.

7. Entry to the cockpit is gained from either side of the aircraft by access ladders which are part of the ground equipment. The canopy is opened from the outside by

means of a handle located behind a panel on the port side of the fuselage spine.

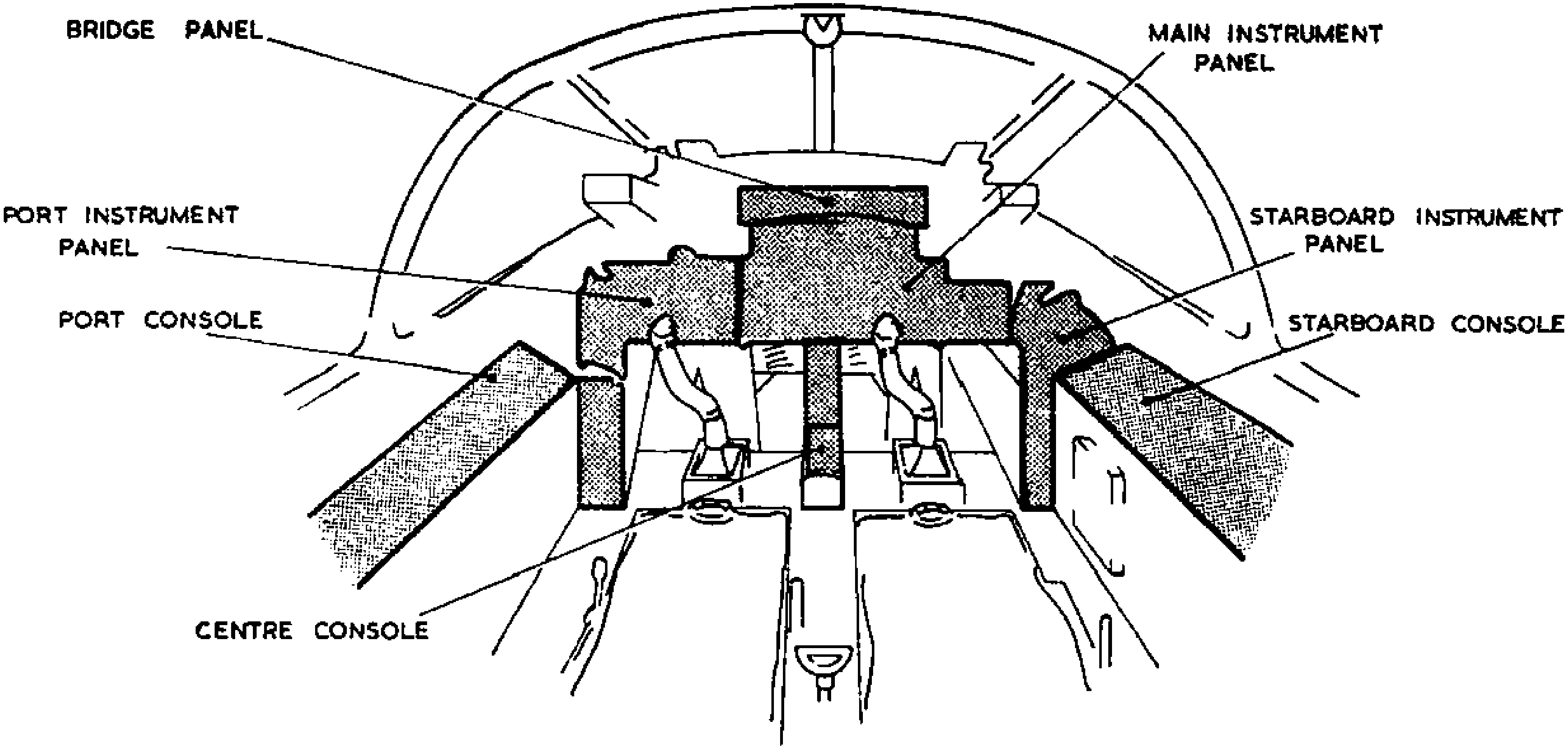
8. All emergency warning lights are grouped on a standard warning panel (SWP) and on an auxiliary warning panel (AWP) on the port and starboard sides of the cockpit respectively.

9. The various panels on which the pilots' controls and indicators are located are referred to in the Notes as follows:

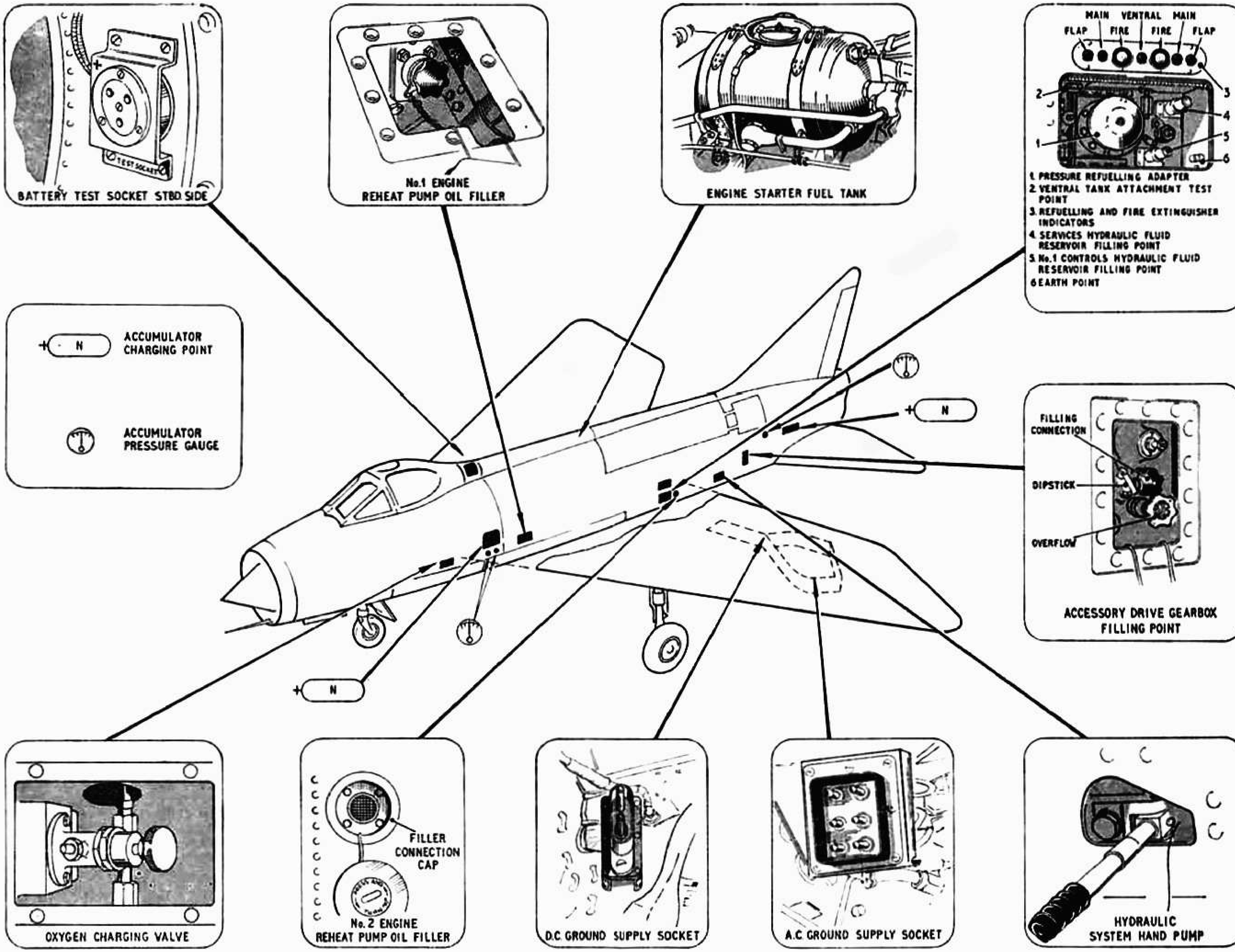
(a) The port console
(b) The port instrument panel
(c) The main instrument panel
(d) The bridge panel
(e) The centre console
(f) The starboard instrument panel
(g) The starboard console

10. The principal dimensions of the aircraft are:

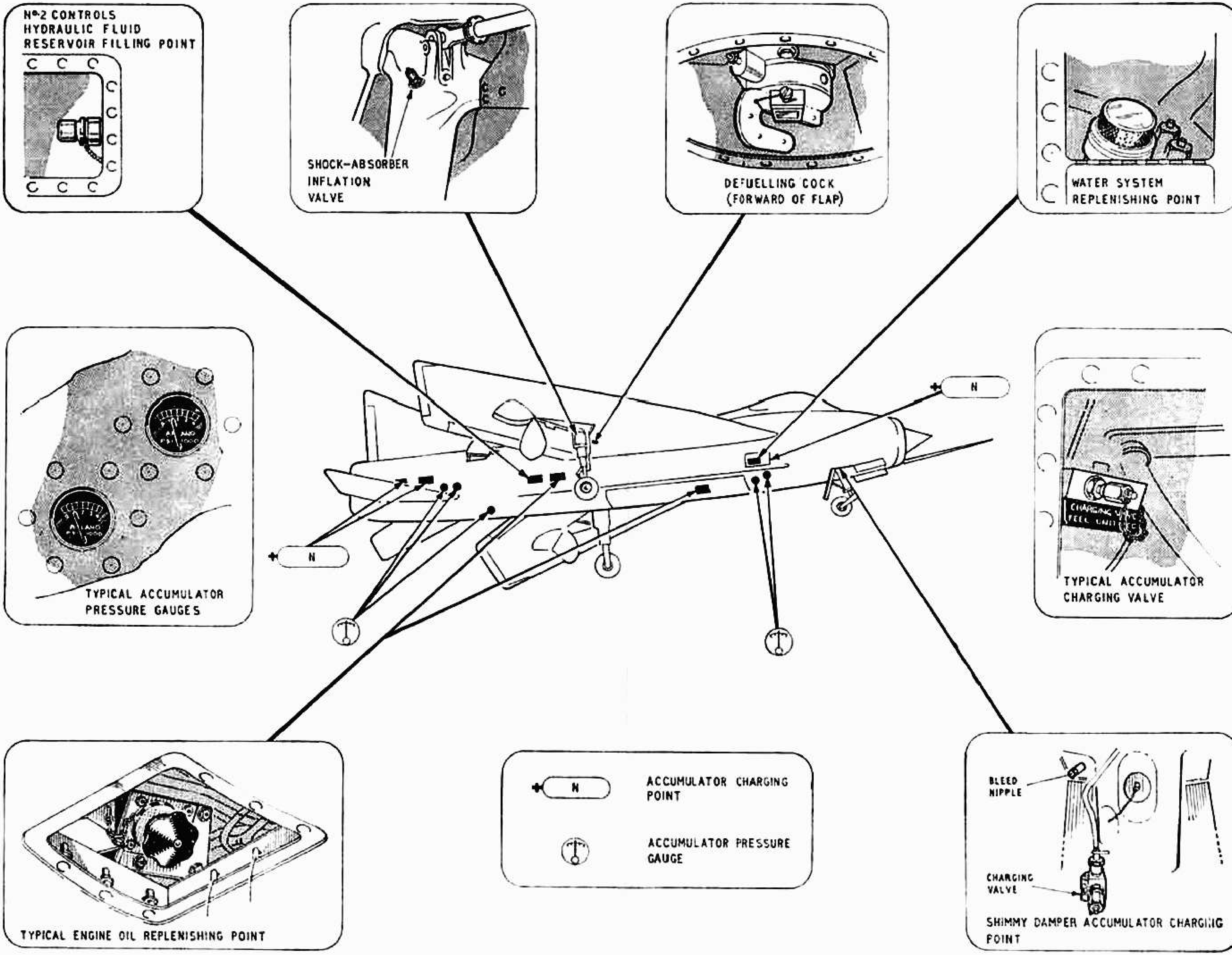
Length, overall	55 ft. 3 in.
Height, overall	19 ft. 7 in.
Wing span	34 ft. 10 in.
Tailplane span	14 ft. 6 in.
Canopy height	11 ft. 6 in.



Cockpit layout

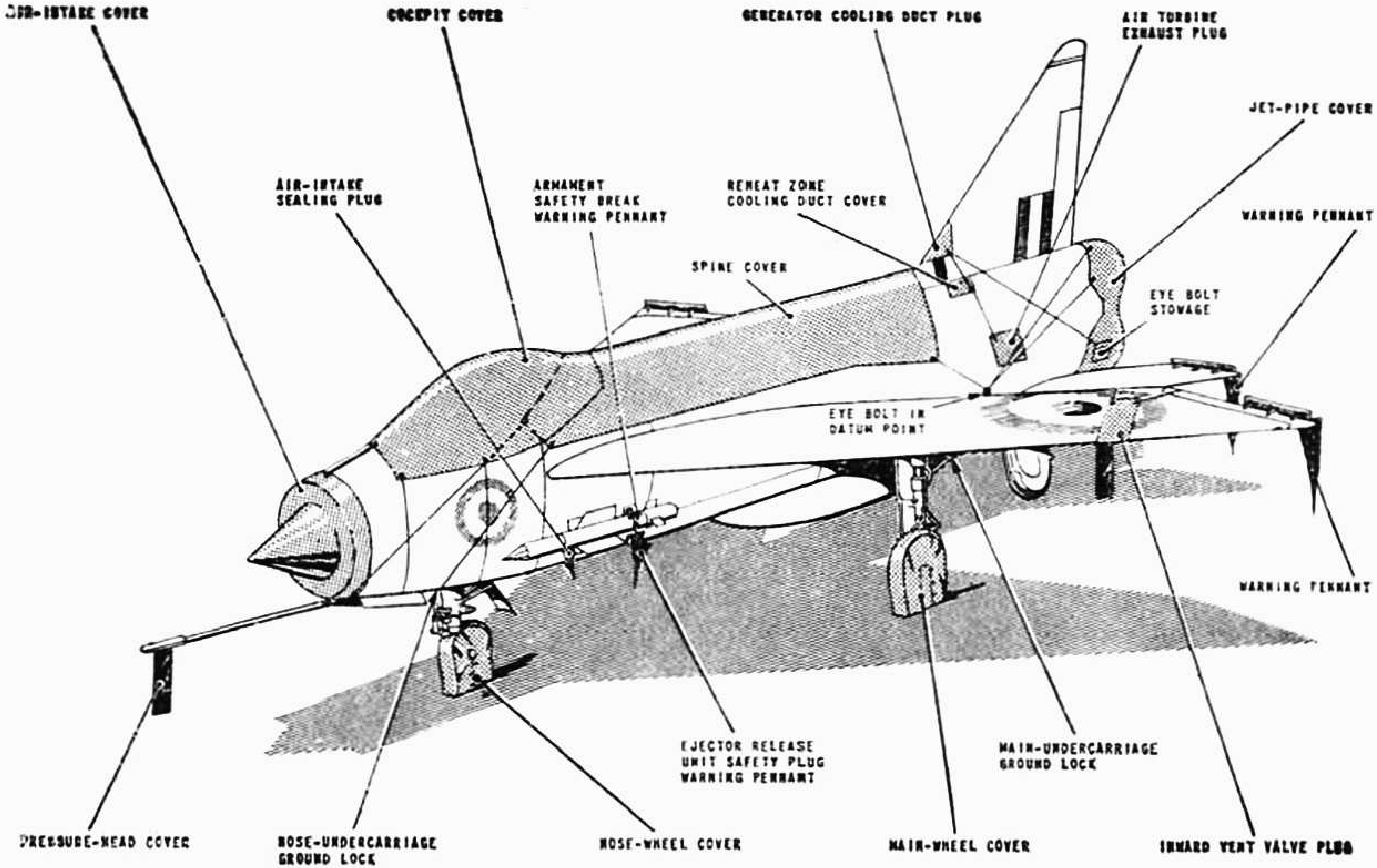


Servicing Points



Servicing Points

Covers, plugs and warning pennants



PART 1

DESCRIPTION AND MANAGEMENT OF SYSTEMS

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PART I—DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 1 — ELECTRICAL SYSTEM

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Description

1 General

(*a*) Power for the electrical services is normally obtained from an alternator and a generator mounted on an air turbine motor which is driven by air tapped from the engine compressors. The generator supplies DC at 28 volts to the DC busbar, and the alternator 3 phase AC at 200 volts, 400 CPS to the AC busbar.

(*b*) A 24-volt, 40 amp. hr. battery is connected to the DC busbar by an isolating switch and is charged by the generator when it is on line. The battery provides standby power for the DC operated services and, via an inverter, for certain of the AC operated instruments and services.

(*c*) *A* 22·8-volt 7 amp. hr. emergency battery supplies cockpit emergency lighting, standby artificial horizon, standby UHF and ⧓ the standby direction indicator. The battery is not connected to the DC busbar and is not charged from the aircraft system.

(*d*) Switching for both AC and DC operated services is 28 volt DC controlled.

2 Air turbine motor

The motor is supplied with air from a duct fed by both engine compressors. When the air supply is sufficient, motor speed is controlled by an integral governor so that alternator output is maintained at a constant frequency The unit incorporates three switches:

Overspeed switch: ⧓ the switch provides an over-frequency warning.

Nozzle stall switch: if air pressure falls below the minimum value to maintain turbine speed, the switch operates to bring on the TURB warning and open the alternator contactor (AC warning on). Resets when air pressure increases.

Underspeed switch: duplicates nozzle stall switch operation if that switch fails to operate as motor speed reduces.

3 Generator supply

(*a*) *Pre Mod.* 4241

(i) Power for the DC operated equipment is supplied by a 28-volt, 150 amp. generator; its output is automatically controlled by a carbon pile regulator and a voltage pick-up relay. The generator is protected by a differential relay and contactor from reverse current faults and a fuse protects the busbar from generator faults.

(ii) The generator comes on line automatically and the GEN warning on the SWP goes out when an engine is accelerated to approximately 40% RPM, and achieves full output at about 50% RPM. When the RPM of both engines falls below 35% approximately, or if the generator voltage falls appreciably for any other reason, the differential relay operates to take the generator off-line and light the GEN warning on the SWP.

(*b*) *Post Mod.* 4241

(i) When Mod. 4241 is embodied, a brushless, 28 volt, 200 amp. generator is fitted. Its output is automatically controlled by a control and protection unit. A fuse protects the busbar from generator faults.

(ii) When an engine is started, a current is initially generated by a pilot exciter to provide power for the main exciter field. When generator output exceeds 25·5 volts and current delivered by the generator reaches approximately 20 amps, the generator warning on the SWP goes out. It should be noted that, in this system, the generator takes over the full electrical load of the aircraft whenever the generator warning on the SWP is out, irrespective of engine RPM.

(iii) The DC equipment is protected by an overvoltage relay and an undervoltage relay. If either relay operates, the generator field is de-energised.

(iv) The generator can be reset by the pilot in the event of transient failure occurring.

(*c*) If an external DC supply is connected the generator may remain off-line after starting until the external supply is switched off.

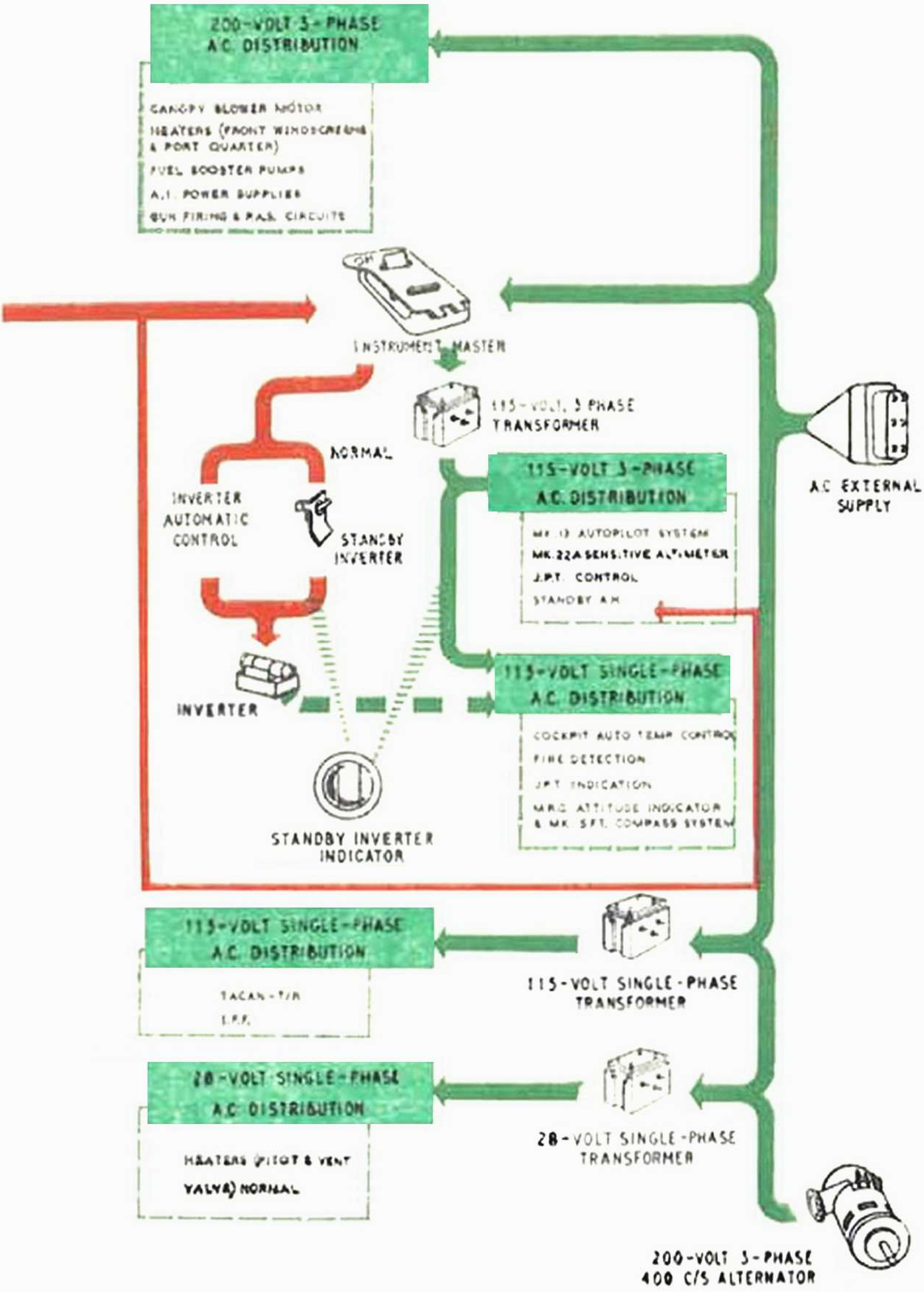
(*d*) Operation of both the inertia crash switches automatically isolates the generator field.

4 Alternator supply

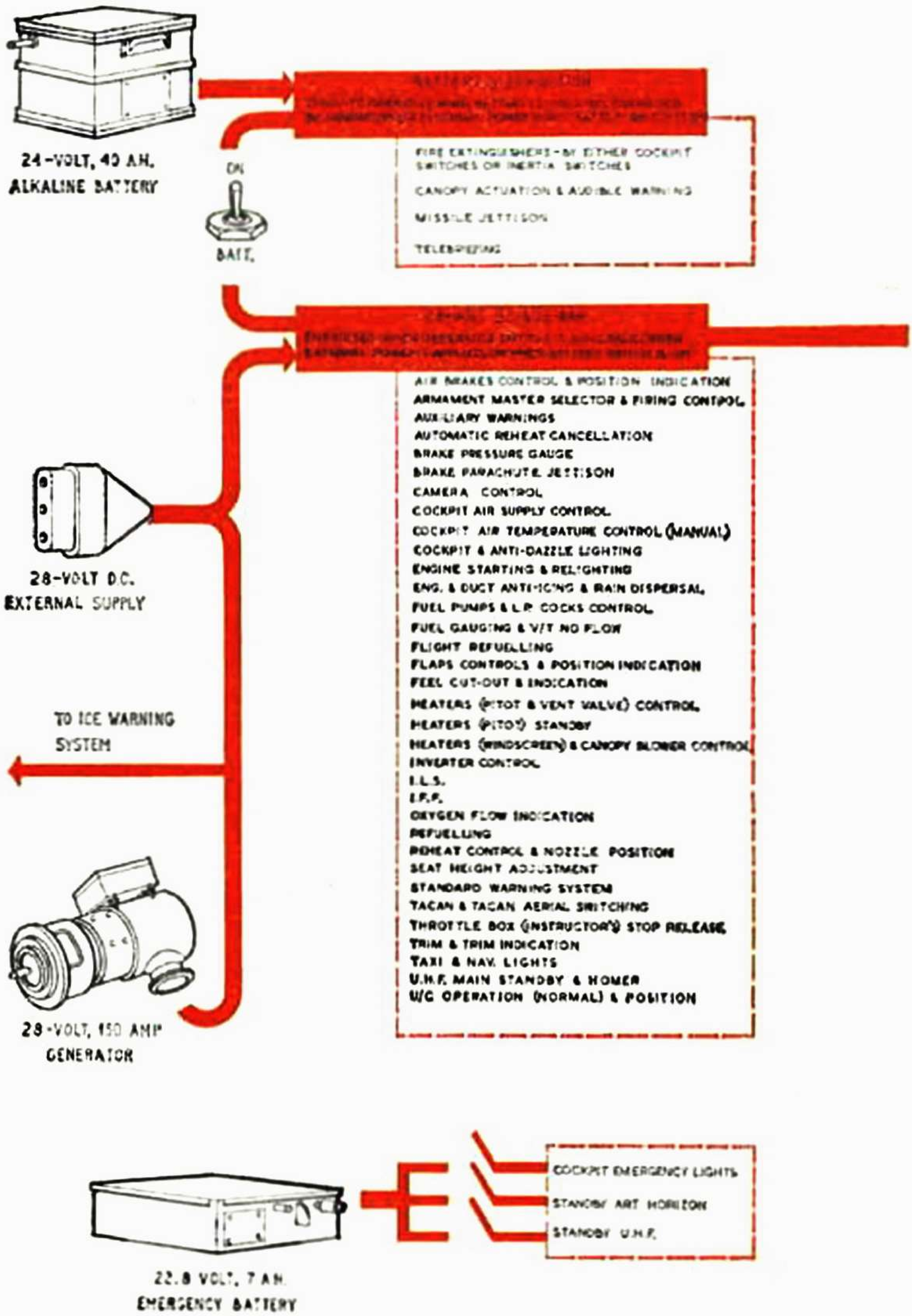
(*a*) Power for the AC operated equipment is provided by a 200 volt, 400 CPS, 3 phase alternator having a rated output of 20 KVA. Post Mod. 4241 the alternator is a brushless unit. Voltage control is automatic throughout. Output is maintained at a constant frequency by controlling the speed of the air turbine motor by a governor system which adjusts the position of the nozzle vanes of the motor.

(*b*) The supply is distributed either at 200 volts from the AC busbar, or modified via voltage changing transformers to 115 volts single and 3 phase and 28 volts single phase to operate the various groups of instruments and equipment.

(*c*) (i) An external AC supply may be connected to provide AC prior to the alternator coming on line after engine start.



Electrical Power Distribution



Electrical power distribution

(ii) Pre-Mod. 4241, if an external supply is connected, the alternator is isolated from the AC busbar by a hold-off relay. The relay, when energised by connecting and switching on the external supply, trips the alternator main contactor. Disconnection of the external supply after starting allows the alternator to come on-line provided the RPM of one engine is at 58% or above.

(iii) Post Mod. 4241, when the engine is started and RPM increased to air turbine control speed, the alternator main contactor closes to connect alternator output to the AC busbar provided phase sequencing is correct. At the same time, the external AC supply, if used, is automatically isolated. The alternator should remain on-line provided at least one engine is maintained at or above 58% RPM.

(*d*) The AC equipment is protected against overvoltage, undervoltage, earth faults and incorrect phase sequencing by:

(i) An overvoltage relay which de-energises the alternator field.

(ii) An undervoltage phase sequence unit which breaks the main contactor operating circuit. In this case, AC will be restored if conditions return to normal.

(*e*) ⧓ The pilot can reset the alternator in the event of transient failure occurring.

(*f*) Operation of both inertia crash switches automatically isolates the alternator field.

5 Instrument supply

(*a*) For supply purposes, the aircraft instruments are divided into two groups: one group has an alternative supply from a type 100A inverter, the other has no alternative AC supply (see (f) below).

(*b*) A 115v 3-phase transformer, fed from the aircraft AC supply normally supplies both groups of instruments and its output is monitored by an undervoltage/phase sequence unit.

(*c*) An INSTRUMENT MASTER switch controls switching of the instruments.

(*d*) If a transformer output fault is sensed by the under-voltage/phase sequence unit, the services listed in (f) (ii) are supplied by the Type 100A inverter which is started automatically. Post-Mod. 4373 the services listed in (f) (i) are isolated from the faulty supply. Pre-Mod. 4373 the services listed in (f) (i) remain connected to the faulty supply: in addition to these services giving unreliable indications, the standby artificial horizon and standby DI may not change over to the standby DC source.

(*e*) If required, the type 100A inverter may be switched on manually. With STANDBY INVERTER selected, those instruments which have a standby supply, (f) (ii), are fed by the inverter. Pre-Mod. 4373, the remaining services continue to be supplied from the transformer, Post-Mod. 4373 these services are isolated.

(*f*) (i) The following AC operated instruments and services, under the control of the INSTRUMENT MASTER switch, are supplied from normal sources and have no standby supply from the 100A inverter:—

Standby artificial horizon and standby DI (automatic changeover to DC if AC supply fails)
Mk. 13 autopilot
Jet pipe temperature control

(ii) The following AC instruments and services, under the control of the INSTRUMENT MASTER switch, are supplied from normal sources and are also supplied by the 100A inverter in standby conditions:—

Fire detection system
JPT indicators
Master reference gyro }
Attitude indicator } Dynamic reference system
Mk. 5 FT compass }
Cockpit temperature control (auto control)
Mk.22C altimeter

Controls and Indicators

6 Generator and alternator controls

(*a*) When Mod. 4241 is embodied, a resetting facility is provided in the generator and alternator circuits to enable them to be brought back on line following a transient failure. Control is by reset buttons, marked AC and GEN, on the port windscreen edge member.

(*b*) Pre-Mod. 4241, ⧓ an alternator resetting facility is provided by an AC RESET button on the starboard instrument panel.

(*c*) Additionally, ⧓ an O/F (over frequency) warning light on the starboard instrument panel comes on to indicate a 10% overfrequency of the AC supplies which is likely to result in loss of accuracy of the AC operated instruments. The light embodies a press-to-test facility and, on some aircraft, a light dimmer facility.

7 Instrument supply controls

(*a*) The instruments are controlled by a guarded ON (forward)—off (back) INSTRUMENT MASTER switch on the starboard console.

(*b*) The 100A inverter, which is switched on automatically in the event of failure of the normal AC supplies, can be switched on manually by a NORMAL/STANDBY INVERTER switch on the main instrument panel. With the switch at NORMAL the AC operated instruments are supplied as described in para. 5. When the switch is set to STANDBY INVERTER, the services listed at para. 5(f)(ii) are operated by a supply from the 100A inverter. The switch should only be used for testing or if the instruments are not functioning correctly on the normal supply.

(*c*) A magnetic indicator above the instrument panel marked STANDBY INVERTER shows black when the AC instruments are being supplied normally and white/ON when the change-over relay has operated to start up the 100A inverter.

8 Battery controls

(*a*) The main battery is connected to the DC busbar by setting the BATT switch to ON and is isolated from the busbar when the switch is set to off (back) or by operation of both inertia crash switches. With the generator and alternator off line and the battery switch off, the only services remaining operative are fire extinguisher control, canopy control, missile jettison control and the telebriefing facility.

(*b*) The emergency battery supplies the emergency lighting, the standby UHF, the standby artificial horizon and standby direction indicator, when the standby or emergency facility is brought into use.

9 Voltmeter

A voltmeter, fitted on the main instrument panel continually shows the DC busbar voltage. The indicator is divided into a red sector for voltages of 15-22 volts, an amber sector for voltages between 22 and 25, a white sector for voltages between 25 and 29 and a further red sector for voltages above 30 knots.

10 Supply failure warnings

Warnings on the SWP and AWP appertaining to electrical failures are as follows:

SWP	*AWP*	*Fault*
GEN	—	Generator off line
—	AC	Alternator off line
—	AC and TURB	Alternator main contractor tripped due to turbine underspeeding or operation of turbine nozzle stall switch (insufficient air)
GEN	AC and TURB	Failure of air turbine

Management of the System

11 Pre-flight and starting

(*a*) Normally, both external AC and DC supplies should be connected. In the operational role an AC supply is used to provide a 5 minute warm-up period for the AI equipment before take-off. Up to four minutes of this period can be supplied by the external AC, the remainder by the alternator after starting. If the alternator comes off-line after starting, however, the whole of the 5 minute period must be recommenced before the equipment becomes operational. Therefore, do not reduce both engine RPM simultaneously to below 58%.

(*b*) With no external AC supply connected, the 100A inverter will start up as soon as the DC busbar is energised if the INSTRUMENT MASTER switch is ON (see para. 5(f)).

NOTE: The standby artificial horizon and direction indicator will not erect on DC.

(*c*) If an external DC supply is not connected, the battery must support all the aircraft loads including engine starting and the 100A inverter load until the engine is accelerated to 50% RPM approximately (pre-Mod. 4241) or until the GEN warning on the SWP is extinguished (Post Mod. 4241), at which time the generator takes over the full load.

(*d*) When the external DC supply is disconnected after starting check that DC voltage is 28 volts. If voltage is 24 volts or less, operate the DC reset button, if fitted. If 28 volts (approx.) cannot be obtained, the aircraft must not be flown.

(*e*) Up to 70% RPM may be required to extinguish the TURB and AC warnings. Thereafter maintain 58% RPM on No. 2 engine.

12 In flight

(*a*) The air turbine maintains its governed speed at 58% RPM and above. This RPM corresponds to idling RPM at approximately 15,000 ft./250 knots. At idling RPM below this altitude and/or speed, the air turbine cannot maintain governed speed and the alternator comes off line.

(*b*) Check the voltmeter periodically in flight; voltage should be indicated in the white sector.

13 After landing and shut-down

(*a*) Maintain the No. 2 engine at the fast idling position when taxying, to keep AC on line.

(*b*) When shutting down, switch off all electrical services and then put the BATTery switch to off.

Malfunctioning

14 AC supply failure

(*a*) AC supply failure is indicated by the AC warning on the AWP. If this warning appears alone it indicates either failure of the alternator or the alternator control system or low engine speed. ⧓ An attempt to reset the system should be made by pressing the AC reset button; more than one attempt may be made. If power cannot be restored, a return to base should be made with the loss of AC-operated services except those provided for by the standby inverter. Flame-out may occur due to supplies being cut to the AC fuel booster pumps and reheat will be cancelled automaticaly if it is in use at the time of failure.

(*b*) If intermittent AC supply failure occurs, or the AC reset button is pressed to restore AC power, an output surge from the JPT controller may occur at JPT in excess of approximately 550°C. This could result in a reduction of fuel flow to the engines with a consequent transient loss of thrust. Therefore, if AC supply becomes intermittent or if repeated operation of the reset button is necessary, it is recommended that the JPT control switches are set to OFF.

(*c*) If ⧓ the OVERFREQ light illuminates, select STANDBY INVERTER. Pre-Mod. 4373, closely monitor those instruments which remain connected to the main AC supply.

15 Generator failure

(*a*) Failure of the generator is indicated by lighting of the GEN caption on the SWP. Post-Mod. 4241, attempt to reset the generator by pressing the DC reset button.

(*b*) Pre-Mod. 4241 or if the generator cannot be reset, the immediate effect of generator failure is that all DC loads are imposed on the main battery. Endurance of the battery depends on state of charge and loading at the time of failure and once the battery is discharged all DC supplied services (except emergency lighting), including AC services controlled by DC relays, will be lost.

(*c*) Following generator failure, reliance may be placed on the battery to supply DC services providing voltage is above 22 volts; below this voltage the battery discharges rapidly. Therefore, when the voltage falls to 23 volts, position the aircraft for landing while electrical power is still available.

16 Generator overvolting

If a voltmeter reading of 30 volts or more is sustained, select the BATT switch off to protect the battery. Return to base and select the battery switch on in the circuit prior to landing.

17 Air turbine malfunction

If the turbine wheel speed falls below the governed limits (under-frequency) a nozzle stall switch operates to energise the TURB warning on the AWP and open the alternator main contactor (AC warning on the AWP). If governed speed is regained, the alternator comes back on line and the warnings go out. Reduced turbine speed may result in low DC voltage indicated by the voltmeter and, Post-Mod. 4241, the GEN warning on the AWP.

18 Instrument supply change-over in flight

(*a*) If intermittent instrument supply change-over occurs, indicated by fluctuations of the STANDBY INVERTER magnetic indicator, set the NORMAL/STANDBY INVERTER switch to STANDBY. Pre-Mod. 4373 those services not supplied by the standby inverter should be closely monitored.

(*b*) Whenever the STANDBY INVERTER indicator changes to white/ON whilst autostabilisation or any mode of the autopilot is engaged, the autopilot should be switched off in the order, SUPPLIES switch, PITCH and ROLL and YAW switches and engage switch.

PART I

Chapter 2 — FUEL SYSTEM

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Description

1 Fuel tanks

(a) Internal fuel tanks

Internal fuel is carried in integral tanks in the wings and flaps. Each wing tank system comprises a leading edge tank and a two-compartment main tank. The outboard compartment of each main tank serves as the collector box from which all LP fuel is delivered to the engine HP pumps and reheat pumps. The flap tank fuel is transferred automatically by air pressure into the wing tank system. All tanks are vented outward and inward, but outward venting is prevented during negative-G flight.

(b) Ventral tank

A jettisonable ventral tank, divided into two interconnected compartments, may be fitted to the underside of the fuselage. Fuel from the ventral tanks is transferred automatically by air pressure into the wing tank system. A relief valve in the bottom of the tank permits automatic jettisoning of the fuel if the tank pressure exceeds 16·5 PSI above atmospheric pressure. Outward and inward venting is provided, but outward venting is prevented during negative-G flight.

2 Fuel feed

(a) General

Fuel is initially taken from the wing tank system. After 120—160 lb. of fuel has been delivered from the wing tanks, float switches and refuel/transfer valves control the sequence of fuel feed so that fuel is normally used in the order, ventral tank, flap tanks and wing tanks.

(b) Wing tanks feed

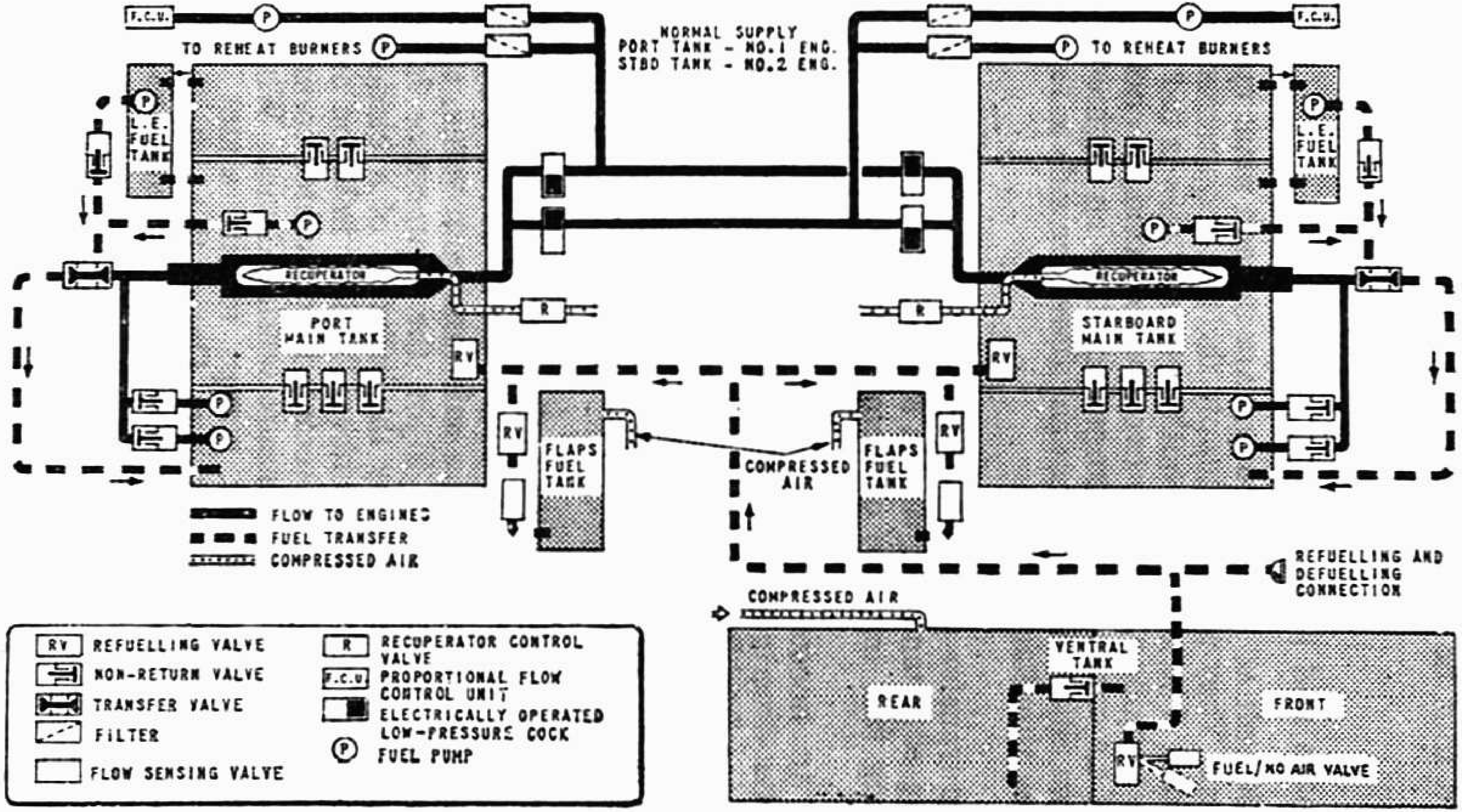
Fuel from the main compartment of the wing tanks is normally fed by gravity into the collector box, (outboard compartment). Additionally, DC transfer pumps feed fuel from the leading-edge tank and main compartment of the wing tank to maintain the collector box full. The collector box fuel is delivered to the engine HP pump and reheat pump by AC booster pumps via a recuperator.

(c) Ventral tank feed

The ventral tank fuel feeds automatically into the wing tank system by air pressure when the wing float tank float switches operate to open a Mk. 44 refuel valve in the wing tanks, i.e., when 120—160 lb of wing tank fuel has been used, when the ventral tank empties, a Mk. 7 valve in the tank closes, which operates electrically a Mk. 27 valve to permit transfer of fuel to commence from the flap tanks.

(d) Flap tanks feed

The flap tanks fuel automatically feeds into the wing tank system by air pressure when the Mk. 7 valve in the ventral



◀NOTE: The non-return valves shown fitted between the inner and centre compartments of each main tank have been removed by modification action. ▶

Simplified Fuel System

◀tank closes, i.e. ventral tank empty, provided that the Mk. 44 refuel valve is open. Flap transfer rate is slow and it should be noted that in the flaps-down configuration, any fuel remaining in the flaps up to 200 lb. per tank may be trapped and thus be unusable. ▶

3 Fuel cocks and pumps

(*a*) Two 200 volt AC booster pumps are in each main tank collector box. They normally supply the fuel requirements of the engines. The AC pumps outlet on each side is fed to either of two engine LP lines by two, two-position, LP cocks. Each set of LP cocks is so arranged to allow an engine to use fuel from either side but does not allow one side to feed both engines simultaneously.

(*b*) Two DC transfer pumps are fitted in each wing, one in ◀the leading-edge tank and one in the main wing tank, to▶ transfer wing fuel into the collector box.

(*c*) If the AC booster pumps fail a pressure sensitive transfer valve diverts the output of the DC transfer pumps into the engine feed line.

4 Fuel recuperators

A 40 lb. recuperator inside ▶◀ each main tank is fitted in the delivery line from the LP pumps to the LP cocks. Whenever fuel pressure drops below a safe minimum value, e.g. during inverted or negative-G flight, the recuperator fuel is discharged to the engines by the inflation of a bladder inside the recuperator fuel chamber. Bladder inflation and venting are controlled by an associated recuperator control valve which is also the fuel pressure sensing device. When fuel pressure is restored the pumps require about 10 seconds to recharge the recuperators. During this time they are able to supply the engines through a bypass annulus in each recuperator.

5 Fuel tank capacities

The usable fuel capacities are:—

Tank	Gallons Capacity	Capacity-Pounds	
		AVTUR 8·0 *lb/gall.*	*AVTAG* 7·7 *lb/gall.*
Main and leading edge	2 x 320	2 x 2560	2 x 2464
Flap ...	2 x 33	2 x 264	2 x 254
Recuperator	2 x 5	2 x 40	2 x 39
Ventral ...	1 x 250	1 x 2000	1 x 1925
Total fuel ...	966	7728	7439

6 Reheat fuel system

(*a*) Each of the two reheat pumps delivers fuel to the burners in its respective reheat jet pipe, the fuel intake to the pump being tapped from the appropriate LP line. When the throttle lever is advanced into the reheat section, an air shut-off cock opens to allow compressor air from the engine to drive a two-stage turbine. The turbine rotates a centrifugal fuel pump at high speed to deliver fuel to the burners.

(*b*) The rate of flow of the fuel to the burners is controlled by a reheat control unit. This unit senses the pressure ratio across the engine turbine and uses the resultant signal to influence the setting of the throttle valve in the fuel delivery line from the pump.

◀**7 Air-to-air refuelling system**

The aircraft may be fitted with a detachable air-to-air▶ refuelling probe positioned beneath the port mainplane. A refuelling pipe from the probe leads to the fuel system via a non-return valve. Refuelling is controlled by a switch in the cockpit which, when set to FLIGHT REFUEL, energises solenoid operated valves to release air pressure from the ventral and flap tanks and all refuelling valves are opened to refuelling flow until their respective tanks are full. Each refuelling valve closes when its "tank full" float switch operates and an appropriate light on the panel in the cockpit comes on.

8 Ground refuelling system

(*a*) A pressure refuelling point, under panel 63P on the port side of the fuselage, permits simultaneous refuelling of all tanks including the ventral tank when fitted. The act of opening panel 63P operates a micro-switch which changes the fuel electrical circuit from its flight condition to the ground refuelling condition. The micro-switch, together with fuel level switches in the tanks, controls the operation of the refuelling valves and the tank indicator lights.

(*b*) Above the refuelling panel are seven indicator lights, five of which, identified by a key on the panel, are tank full indicator lights. Of the five lights, two are red to indicate the port wing tank system and flap tank, two are green to indicate the starboard wing tank system and flap tank and the central amber light is for the ventral tank. Each light comes on when its associated tank is full, provided panel 63P is open.

(*c*) A gravity refuelling point is provided on the upper surface of each wing. This is a standby facility and it should be noted that the tanks cannot be filled to capacity by this method of refuelling.

Controls and Indicators

9 Fuel cocks and pump switches

(*a*) Two 3-position switches marked FUEL PUMPS, PORT and STBD are on the main instrument panel. Each switch controls the two AC and two DC LP fuel pumps and two LP fuel cocks in their respective systems. Each switch may be set to one of three positions, No. 1 ENG, OFF or No. 2 ENG, so that either tank system can be selected to either engine or both tank systems selected to one engine when the other is not running.

(*b*) Of the two LP cocks in each tank system one allows fuel to feed to No. 1 engine and the other to No. 2 engine. With a FUEL PUMP switch set to No. 1 ENG the cock to that engine is open and the cock to No. 2 engine closed and vice versa. With a FUEL PUMP switch at OFF both LP cocks on that side are closed. It is not possible for the tank system on one side to supply both engines simultaneously.

10 Fuel contents gauges

(*a*) Two capacitor type FUEL CONTENTS gauges are on the bridge panel. Marked PORT and STBD, each indicates the usable contents in pounds of its respective wing and leading-edge tanks. Indication of flap tank contents is given by the same gauges but only during transfer of the flap tank fuel. Before starting, therefore, each indicator will register only the contents of its associated wing tank and leading-edge tank.

(*b*) There is no contents gauge for the ventral tank. A magnetic SLIPPER TANK indicator on the main instrument panel shows black when fuel is transferring from the ventral tank and white when transfer ceases.

11 Fuel pressure warning lights

(*a*) A FUEL 1 and a FUEL 2 warning are on the AWP. Either warning will be illuminated if the fuel pressure in the associated LP delivery line falls to 3 PSI. The warnings are controlled by pressure switches in the delivery lines.

(*b*) Residual fuel pressure in the system may cause a fuel warning to remain out even when the associated fuel pump switch is selected OFF.

12 Ventral tank jettison

The ventral tank may be jettisoned by pulling the DROP TANK—PULL TO JETTISON handle which is located below the port instrument panel. The handle incorporates a switch for sideways jettisoning of the guided missiles. Both facilities may be operated independently or together.

13 Vent valve heating

The wing fuel tank vent valves are electrically heated. The heaters are controlled by a 3 position PITOT—NORMAL /OFF/STANDBY switch on the bridge panel. With the switch at NORMAL the vent valve heaters are supplied by AC from a 28 volt, single phase transformer. If AC failure occurs, or with the switch at OFF or STANDBY, the electrical supplies to the heaters are cut. The pressure head heater, however, which is also controlled by this switch has a standby feature when the switch is selected to STANDBY.

◀14 **Air-to-air refuelling controls**

(*a*) An air-to-air refuelling panel is on the port console.▶ It comprises five TANK FULL indicator lights, each of which comes on when the appropriate fuel tank is full.

(*b*) A FLIGHT REFUEL/OFF (guarded)/LAMP TEST switch, spring-loaded from LAMP TEST to OFF, is positioned on the port console. The switch, when set to FLIGHT REFUEL, controls the refuelling operation as described in para. 7. When set to LAMP TEST, the TANK FULL indicator lights can be tested prior to refuelling. Note that the ventral and flap fuel will not feed if the switch is inadvertently left at FLIGHT REFUEL during normal flying.

Normal use of the System

15 Use of the fuel switches

(*a*) Start the engines with the PORT and STBD FUEL PUMP switches up, i.e. PORT to NO. 1 ENG and STBD to NO. 2 ENG. Normally the fuel switches should be left at this position for the duration of the flight. If fuel asymmetry occurs, it should be corrected by use of differential throttle.

(*b*) *Single-engine flying*

When flying with one engine stopped set both fuel switches to the remaining engine. Some fuel asymmetry should be expected in this case and if it reaches a magnitude which may indicate an apparent unserviceability of the fuel system on one side, carry out the fuel emergency drill at Part IV, Chapter 1, para. 7.▸

16 Ventral tank transfer

(*a*) During taxying, particularly over an uneven surface, the ventral tank flow indicator may fluctuate from black to white because of intermittent operation of the wing tank float switches.

(*b*) In flight, if the transfer rate from the ventral tank exceeds the engine demand the wing tanks will fill and transfer will momentarily stop until the wing tank float switches once again operate.

(*c*) When the ventral tank is nearly empty some fluctuation in the flow indicator will occur until the unusable fuel in the tank settles. This may be accompanied by fuel contents gauge fluctuations as the flap tank fuel transfer cuts in and out.

(*d*) During operational climbs, the engine demand will be greater than the rate of transfer of the ventral tank fuel, therefore the fuel level in the wing tanks will have dropped considerably by the time that the ventral tank is empty.

17 Negative-G flight

Flame-out may occur under negative-G flight conditions once the recuperators have discharged. The discharge time of the recuperators will vary according to the power setting, speed, altitude and temperature. As a guide, in ISA conditions at sea level and maximum speed, the recuperator will discharge in 4 seconds with maximum reheat selected and in 9 seconds in maximum cold running. At 0·9M at 36000 ft these times increase to 15 seconds with maximum reheat and 33 seconds in cold running. However, for air turbine lubrication reasons, negative-G flight should not exceed 15 seconds.

18 Flight with low fuel contents

When landing with indicated fuel below 400 lb per side care should be taken to avoid side-slip as this can result in an increase in unusable fuel.

Malfunctioning of the System

19 Fuel pump failure

(*a*) Failure of all fuel pumps will result in cavitation of the engine HP pumps unless altitude is restricted to 10000 ft or below. At higher altitudes, i.e. above 17000 ft flame-out may also occur.

(*b*) If the AC fuel pumps are inoperative the DC pumps will supply the engines through the operation of the pressure sensitive transfer valves. In this case cavitation can be expected above 22000 ft approximately and flame-out may occur at heights above 27000 ft.

(*c*) A FUEL 1 or FUEL 2 warning may appear in flight conditions which prevent gravity flow into the collector box combined with failure of both DC pumps or failure of one

DC pump with the other uncovered. Emergency action, as given under FUEL EMERGENCIES in the Flight Reference Cards, should be taken to refill the collector box and maintain gravity flow.

(*d*) During prolonged, shallow, decelerating descents at speeds between 600 and 650 knots, whilst in minimum or near minimum reheat, it is possible for the collector box to empty, bringing on a FUEL warning. This occurs due to the high engine demand and flight conditions which prevent gravity flow supplementing fuel transfer from the DC pumps. The standard fuel pressure warning emergency actions should be taken which will reduce engine demand and promote gravity flow and the FUEL warning should disappear.

20 Ventral and flap tank fuel transfer failure

Failure of the ventral and flap tank fuel to transfer will result in a progressive aft movement of the CG as fuel is used in the wing tank systems. As soon as the failure is recognised, handling should be restricted to gentle manoeuvres. The aircraft should be landed before the CG moves beyond the aft limit.

⧓

21 LP cock failure

If the DC supply to the LP cocks fails, the cocks will remain in the last selected position before the failure occurred.

22 Fuel gauge malfunction

(*a*) When flying in a nose-down attitude, the fuel gauges may underread by as much as 200 lb/side. At the lower fuel states, however, the error is reduced.

(*b*) If generator failure occurs, the gauges will underread with declining battery voltage and then fall to zero.

PART I

Chapter 3 — ENGINE CONTROLS AND INDICATORS

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Description

1 Avon Mk. 210 engines

(*a*) Each of the two engines is a 15 stage axial flow gas turbine developing 11,200 lb. static thrust approximately at sea level without reheat and 14,400 lb. approximately with full reheat. The engines are mounted in the fuselage, the lower engine being designated No. 1 and the upper No. 2.

(*b*) The main engine systems include:

A high pressure fuel system
A reheat system
A liquid fuel starting system
Relighting facilities
A self-contained oil system
JPT control
Engine anti-icing system.

2 Engine fuel system

(*a*) *Fuel feed system*

Fuel from the main fuel system is delivered to the HP fuel pump through a filter and the pump output is fed to the burners through a fuel-cooled oil cooler and a proportional flow control unit; the latter unit incorporates the combined throttle valve and the HP cock which is controlled by the throttle lever.

(*b*) HP *fuel pump*

The HP fuel pump consists of two variable stroke pumps contained within a common housing. Either pump of the dual unit is capable of delivering sufficient fuel for approximately 100% RPM to be obtained. The output of the pump is controlled by a servo system in response to signals from the engine speed governor and the flow control unit.

(*c*) *Fuel control system*

The system contains the following controls:

(i) *Maximum* RPM *governor*

The maximum RPM of the engine is governed automatically. The governed speed may, however, vary with altitude and differing take-off conditions, and manual control may be necessary to prevent the operating limitations being exceeded.

(ii) *Altitude sensing unit*

The engine requirements at varying aircraft speeds and altitudes are regulated by the altitude sensing unit, which varies the pump delivery flow in accordance with intake air pressure.

(iii) *Altitude idling valve*

This valve provides a minimum limit to the fuel flow when the throttle is closed to the idling position thus preventing excessively low idling at altitude.

(iv) *Acceleration control*

This control automatically limits the rate of increase of the fuel flow to the engine during rapid throttle movements under all conditions.

(v) JPT *controller*

This control automatically prevents the JPT rising above the maximum limitation. Once the maximum JPT is attained and the temperature controller is in operation, the control, by trimming the fuel flow, prevents JPT rising above the maximum permissible value. Maximum RPM, therefore, will vary according to ambient air temperature, altitude and speed.

(vi) *Fuel flow limiter*

The maximum fuel flow is limited by means of an ACU back stop to prevent overstressing due to high intake pressure: this reduces maximum RPM, particularly at low altitude and high speed.

3 Reheat system

(*a*) Reheat is used to augment engine thrust by burning injected fuel in the jet-pipe. The temperature of the exhaust gases and hence their efflux speed from the jet-pipe nozzle is thereby increased, giving added thrust. The jet-pipe has a variable area propelling nozzle formed by a series of flaps designed to open or close and form a basically conical section. The flaps are moved by pneumatic rams operated by air from the compressor. The air supply to the rams is controlled by solenoids which are energised or de-energised depending on the setting of the pilot's throttle control, thereby selecting any one of three or four reheat positions (depending upon modification state) of the propelling nozzle flaps.

(*b*) Reheat is selected by moving the throttle into the reheat section of the throttle quadrant. This action closes appropriate micro-switches to select the degree of reheat required. Either three or four stages of reheat are provided. These are minimum reheat (if the appropriate jet pipe modifications are embodied), first and second intermediate reheat and maximum reheat, and occur in that order with progressive advancement of the throttle through the reheat section of the throttle quadrant.

(*c*) *Operation of reheat*

(i) When a throttle is moved into the reheat section an air shut-off cock is electrically actuated to open and start the turbine driven reheat pump. At the same time an igniter plug is energised and one of the nozzle control valves opens. The nozzle rams then move the nozzle to the pre-open position and the fuel pump, as its speed increases, delivers fuel to the burners. After 15 seconds the igniter plugs, having ignited the fuel, are de-energised by a time switch. Fuel delivery rate to the burners is automatically regulated by a reheat control unit.

(ii) After light-up, the rapid rise in exhaust unit pressure influences a micro-jet switch on the engine which senses compressor split/exhaust pressure differences. The switch operates to energise solenoids on the nozzle control unit and the nozzle moves to the selected reheat position.

(iii) The required stage of reheat is obtained by movement of the throttle within the reheat gate. The throttle control contacts micro-switches which energise solenoids to move the nozzle to correspond with the stage of reheat selected. The reheat control unit, sensing the changed pressure differential across the engine turbine adjusts the fuel flow accordingly.

(iv) When the throttle is moved out of the reheat section the nozzle control unit operates to move the nozzle to the first intermediate reheat position or, if four stages of reheat are provided, to the minimum reheat position. Reheat will remain lit, however, until the engine is decelerated to below 90% RPM.

(*d*) *Automatic reheat cancellation.*

A reheat trip automatically cancels reheat and closes the nozzle if any of five fault conditions occur; depending on the fault, reheat will be cancelled on one or both engines. A time switch incorporated in the trip circuit is energised on selection of reheat so that, if reheat fails to light, there will be a 10 seconds delay before the trip operates. The TTC warning on the AWP will illuminate following automatic cancellation and will remain until the throttles are returned past the reheat gate to reset the reheat trip relay. The fault conditions are as follows:

(i) If reheat fails to light the trip will operate 10 seconds after selection.

(ii) Immediate automatic cancellation occurs if reheat flames out.

(iii) Maximum JPT exceeded by 60°C when the JPT controller is at AUTO; immediate automatic cancellation occurs.

(iv) AC failure when running in reheat; immediate automatic cancellation occurs. Reheat cannot be relit unless AC is subsequently restored.

(v) DC electrical failure to the relays controlling the AC fuel booster pumps in either wing tank system; this results in two stopped booster pumps on one side. Immediate automatic cancellation occurs on both engines and reheat cannot be relit. Note that mechanical failure of two booster pumps on one side does not automatically cancel reheat.

4 Variable pitch guide vanes and air bleed valve

(*a*) The first row of stator blades in the engine consist of variable incidence guide vanes which assist in imparting swirl to the incoming air. At low RPM the first stage of the compressor delivers more air than is acceptable to the later stages. To prevent surge, the surplus air is bled off from the seventh stage of the compressor through an air bleed valve and the guide vanes are held at maximum swirl position. The guide vanes ram and the air bleed valve are both controlled by HP pump delivery fuel pressure, but the bleed valve cannot operate until the guide vanes start to move from the maximum swirl position. As the normal flight range of RPM is reached, the air bleed valve is closed and the guide vanes are moved progressively to the minimum swirl position.

(*b*) The guide vanes and bleed valve positions have no noticeable effect on RPM but until the guide vanes reach the minimum swirl position at about 92% RPM the engine is not operating at maximum efficiency.

5 Jet pipe propelling nozzle

To improve engine handling and to give a lower specific fuel consumption in the cruise range, the propelling nozzle orifice has two positions in cold running, automatically controlled by an engine mounted RPM sensitive switch. When accelerating an engine, the nozzle orifice will automatically close at approximately 94% RPM and will open on decelerating at approximately 86·5% RPM. This control should not be confused with the reheat nozzle control.

6 Engine starting system

(*a*) Each engine is started by an iso-propyl-nitrate (AVPIN) liquid fuel starter, which uses the gases from the decomposition of the fuel to drive the starter turbine which is connected to the engine by a reduction gear box. The starters use a common 3 gallon fuel tank installed in the fuselage spine. Normally, a total of six engine starts may be obtained.

(*b*) Pressing the starter button initiates a timed sequence of operations as follows:

(i) The starter motor combustion chamber is scavenged by compressed air.

(ii) A fuel charge is pumped into the combustion chamber.

(iii) The mixture of fuel and air is ignited by two high-frequency igniter plugs, and combustion sustained by decomposition of the injected fuel.

(iv) The starter turbine turns the engine and at the same time the engine HE ignition plugs are energised to light up the engine.

(v) When the engine reaches self-sustaining speed, a switch operates to shut down the starter system.

(*c*) If an engine fails to start, limitations on subsequent attempts to start that engine are imposed, depending on the type of failure. The limitations are as follows:

◀ (i) If, after pressing the starter button, starter combustion is not sustained (A or B type failures), a waiting period of at least one minute should be allowed before making a further attempt to start. This is to ensure that AVPIN fuel has drained from the starter combustion chamber. A maximum of three attempts only may be made.

(ii) If, after a normal starter combustion cycle, the main engine fails to reach self-sustaining speed, it is necessary to wait until the engine has stopped turning before making a further attempt. Additionally in this type of failure, heat soakage of the starter may prejudice the next start, therefore the interval between attempts should be as close as possible to one minute. A maximum of two such attempts to start may be made. A cooling period of 60 minutes must then be allowed before either investigation or a further starting attempt is made. The cooling requirement is considered satisfied if the final▶

◀ permitted starting cycle results in an engine start provided that the engine is allowed to run for a period of 15 minutes.

(iii) If, after a normal starter combustion cycle, the main engine fails to rotate, a further attempt to start must not be made. Examination or investigation must not be made in the vicinity of the engine starter until a cooling period of 60 minutes has elapsed. The starter must then be removed for investigation.

(*d*) If, for any reason, it is necessary to make successive normal starts on an engine, the time interval between shut-down and the next start must be as close as possible to one minute. As a guide, the starter may be operated again as soon as the engine RPM has reached 0%. Only two such starts may be made after which a cooling period of 60 minutes or an engine run of at least 15 minutes must precede a further start.

WARNING: On no account are the engine starter buttons to be pressed when the engine is rotating, either in the air or on the ground. ▶

7 Relighting

With the master starting switch on, pressing the relighting pushbutton by-passes the normal starting sequence and energises the ignition unit which in turn operates the high-energy igniter plugs to ignite the fuel spray. The system incorporates a time switch which holds on ignition for a period of 30 seconds approximately. Whenever the armament firing trigger is pressed with weapons selected on the master armament selector, the relighting circuits are automatically energised.

8 Oil system

Each engine has its own independent integral oil system of 9½ pints capacity. One pressure and four scavenge pumps maintain a continuous circulation through a fuel cooled oil cooler and filter to the engine bearings and gears.

9 Ice warning, engine and intake duct anti-icing system

(*a*) *Ice warning*

The ice warning system measures the temperature and moisture content of the air flow through the engine air intake duct. The moisture content is determined by comparing the electrical resistance of two identical heated sensing elements, the one exposed to an air flow containing free water and the other to an air flow from which the free water has been separated. The presence of free water causes differential cooling of the two elements since one of them is subject to additional cooling through water evaporation. Should icing conditions occur, a warning appears on the AWP. The system is supplied from the generator busbar. Therefore, whenever the generator is not running the system will be inoperative even though the 28 volt DC busbar is energised.

(*b*) *Engine and intake duct anti-icing*

Engine and duct anti-icing is selected by a switch on the bridge panel which controls both the engine anti-icing gate valves and the duct anti-icing valve. When the valves are open hot air from the engine compressor flows through the intake guide vanes and through the spars of the casing to the starter fairing. The air is then discharged into the air stream passing through the engine. In addition, the hot air supply is passed forward around the engine intake duct lip, the air escaping through numerous holes drilled in the duct.

Controls and Indicators

10 Throttles/HP cocks

(*a*) Two throttle boxes are provided. The pupil's unit is on the port console and the instructor's on the centre console. Both sets of throttles are mechanically linked and operation of any of the catch releases on one unit has a like effect on the other. The instructor's unit has no idling stop release.

(*b*) The throttle valve and HP cock of each engine are combined in one unit which is operated by its associated lever in the cockpit. With the lever in the fully aft position of the throttle quadrant both throttle valve and HP cock are closed. Progressive forward movement to the first gate opens the HP cock and sets the throttle to the idling position. Further movement through the throttle range opens the throttle from IDLING to OPEN. At the THROTTLE OPEN position a "feel" stop is provided which must be forced in order to move the throttles into the reheat section of the quadrant.

(*c*) Backward movement of the throttle is restricted by stops which prevent unintentional thrust reduction when:—

In reheat

At fast idling (No 2 engine only)

At idling

When the throttle is returned from the reheat section a stop prevents further rearward movement beyond 90% RPM approximately and reheat remains lit. To overcome the stop, it is necessary to press down on the PRESS STOP RELEASE catch on the No 2 throttle and then move both throttles out of the reheat section. A further stop is encountered on the No 2 throttle when it is moved back to the fast idling position: This stop is overcome by pressing down on the PRESS STOP RELEASE catch on the pupil's unit or the fast idling stop release on the instructor's unit, and moving the throttle rearward. The throttles have stops at the IDLING position which may be overcome by pressing the SHUT DOWN lever at the end of the pupil's throttle quadrant and moving the throttles to HP COCK CLOSED.

(*d*) (i) The PRESS STOP RELEASE catch will not overcome the reheat hold-in stop on No 1 throttle if No 2 engine is at less than 90% RPM approximately. To cancel reheat on No 1 engine in this case, depress the outboard of the two spring-loaded ramps which project above the top surface of the pupil's quadrant between the two throttle runs.

(ii) If No 1 throttle is still in reheat but at less than 100% RPM when reheat is cancelled on No 2 engine (by throttle movement only), the No 1 throttle reheat hold-in stop will also be released.

◀(*e*) When flying with the No 2 engine shut down the No 2 throttle lever is positively held in the HP cock closed position until cleared by operating the PRESS STOP RELEASE. This prevents inadvertent movement of the▶

◀ No 1 throttle into the HP cock closed position when throttling back. ▶

11 Engine starting and relighting controls

(*a*) The main starting controls are on the starboard console and comprise:

ENG. START MASTER switch
No 1 and No 2 ENGINE START pushbuttons
ENGINE STARTER ISOLATION SWITCH

The engine starting circuits are only operative when the ENG. START MASTER switch is on. The ENGINE STARTER ISOLATION SWITCH must be on before operating the ENGINE START buttons. After starting, the isolation switch must be set to ISOLATE — relighting is not affected.

(*b*) Relight buttons for the instructor's use are on the starboard console; those for the pupil are on the port console. Each pair is marked RELIGHT, No 1 and No 2. The ENG. START MASTER switch must be on to relight an engine in flight.

12 Jet pipe temperature control

(*a*) Jet pipe temperature control is brought into operation by two switches labelled JPT CONTROL, No 1 and No 2, above the port console. Each switch has an AUTO and OFF position. With a switch at AUTO maximum JPT control is in operation and reheat top temperature trip will occur if the maximum JPT is exceeded by 60°C. With a switch at OFF there is no JPT control and the TTC warning will not come on if excess JPT is experienced. The JPT control switches are normally wire-locked at AUTO.

(*b*) On some aircraft, the switches are labelled AUTO TEMP CONTROL CUT-OUT — IN/OUT.

13 Engine instruments

(*a*) Each engine has a percentage RPM gauge, a JPT gauge and a nozzle position indicator on the main instrument panel. The JPT gauge is operated from the 115 volt AC instrument supply and will function from the instrument inverter if normal AC supplies are not available.

(*b*) Each of the two dials of the jet pipe nozzle position indicators is marked with a 90° white arc and with scale marking 1 to 4 around 180° of the remaining arc of the circumference. The nozzle position corresponding to the various positions taken up by instrument pointer are:

Nozzle closed—6 o'clock end of white arc
Cruise position—9 o'clock end of white arc
Pre-open position—Between 6 o'clock and 9 o'clock
Minimum reheat—1 (not operative on some aircraft)
1st intermediate reheat—2
2nd intermediate reheat—3
Maximum reheat—4
Instrument de-energised—between 4 and 6 o'clock.

(*c*) *Oil pressure warning*

A pressure switch is fitted in the oil system of each engine. If the pressure falls below 20 PSI the pressure switch closes and an OIL 1 or OIL 2 warning as appropriate, appears on the AWP. The warning may remain after engine start until 45% RPM has been obtained.

14 Engine and intake duct anti-icing and ice warning

(*a*) Engine and intake duct anti-icing is controlled by an ENG. & INTAKE ANTI-ICING/OFF/RAIN CLEAR switch on the bridge panel. When the switch is set to ENG. & INTAKE ANTI-ICING, engine and duct anti-icing is in operation and a green indicator light, adjacent to the switch, illuminates. With the switch at OFF, anti-icing is cancelled. Anti-icing will also be automatically cancelled by the operation of any one of two temperature and pressure sensing switches in the intake duct anti-icing pipe. The temperature sensing switch is self-resetting and the system will therefore resume operation if the temperature drops and the switch resets. The pressure sensing switch however, is not self-resetting and anti-icing will not be operative again until the switch has been manually reset on the ground. The indicator light will cease to glow when anti-icing is cancelled. For use of the RAIN CLEAR setting, see Part I, Chapter 11.

(*b*) An ICE warning appears on the AWP whenever icing conditions are detected.

NOTE 1: The intake duct anti-icing facility is not yet cleared for use. At present, with ENG. & INTAKE ANTI-ICING selected, only engine anti-icing is operative. The temperature and pressure switches will not operate owing to the valve controlling hot air to the duct lip being inoperative.

NOTE 2: The ice warning system is not cleared for use and is inoperative.

PART I

Chapter 4 — ENGINE FIRE PROTECTION SYSTEM

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1 Fire zones

Each engine bay is divided into two fire zones by a firewall between the engine compressor section and the turbine and exhaust section. The engine compressor section is designated zone 1 and the turbine and exhaust section zone 2. The space surrounding the jet pipes of both engines is known as zone 3 and it is separated from the other zones by vertical and horizontal firewalls. Each fire zone has a separate ventilating system.

2 Fire extinguishers

(*a*) Two dual headed methyl bromide fire extinguishers are installed in the fuselage. The port extinguisher serves each zone 2 and the starboard extinguisher each zone 1. There is no extinguisher for zone 3. Extinguisher operation is effected by depressing either of two indicator switch units on the SWP. When either switch unit is depressed, both extinguishers are completely discharged into zones 1 and 2 of the appropriate engine bay. Tell-tale indicators, one on each side of the ventral tank refuelling light on the port side of the fuselage, shows a reddish-brown colour if the extinguishers are discharged.

(*b*) Each extinguisher bottle is fitted with an over-temperature safety device which causes the contents to spill overboard should the temperature in the vicinity of the bottle exceed 140°C approximately. Two indicators, one port and one starboard, located just aft of the No. 1 engine longeron show green when no spilling has occurred. If the contents of a bottle have been released overboard, the green indicator cover will have blown off exposing a red cone.

3 Fire detection

◀(*a*) An FFFD fire detection system is fitted in all fire zones. There is a separate Firewire circuit for each engine bay and two circuits, one to each jet-pipe in zone 3. The elements are connected to the input channels of a relay unit which controls the relevant warnings on the SWP. The INSTRUMENT MASTER switch must be ON for the detection circuits to be operative.

(*b*) The system is supplied with AC from the alternator output and has a standby supply from the type 100A inverter. Thus, a warning initiated on one AC source is continued if change-over to the other source occurs, with a momentary interruption at the instant of change-over. Because of this interruption, cancelled attention-getters will be re-activated if their originating warning is still present at the time of change-over. ▶

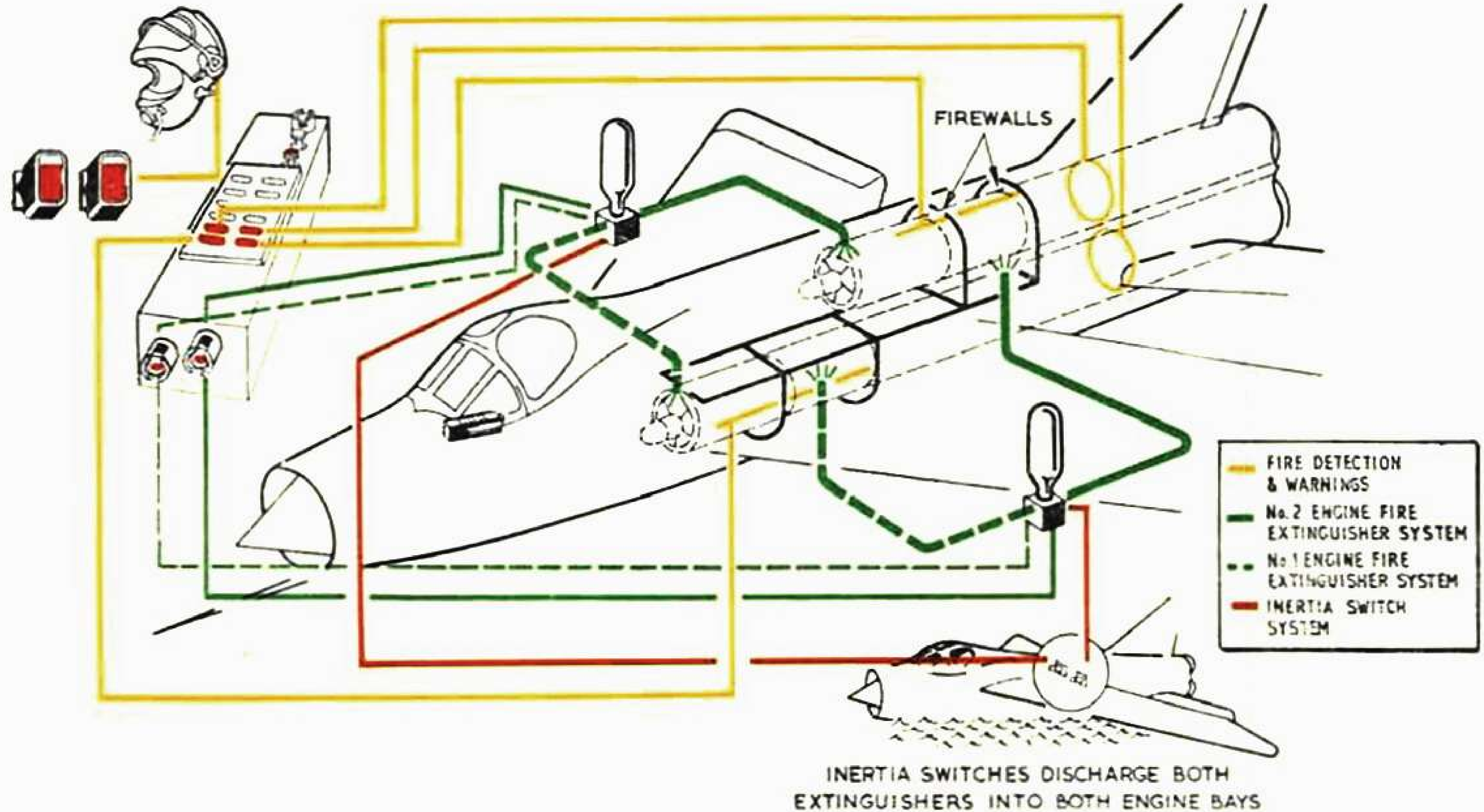
(*c*) Unserviceability of this system, when tested, is indicated by the warnings not illuminating or failing to extinguish when the test button of the SWP is released. Testing of the system should not be carried out in the air. Testing should be done before engine start and immediately after landing when optimum conditions for moisture contamination have been experienced.

4 Fire warnings

Warning of a fire in zone 1 or 2 of the No. 1 engine is given by a FIRE 1 warning on the SWP and the illumination of the light in the fire extinguisher switch unit; warning of a fire in zone 1 or 2 of the No. 2 engine is by a FIRE 2 warning on the SWP and the illumination of the light in the fire extinguisher switch unit. Warning of excessive temperature or fire zone 3 is given by a RHT 1 and/or RHT 2 warning on the SWP.

5 Inertia crash switches

Two inertia crash switches are in circuit with the fire extinguisher system. If both crash switches operate, both extinguishers are discharged into zones 1 and 2 of each engine. The crash switches also operate to isolate certain electrical supplies (see Part 1, Chapter 1).



Fire protection system

PART I

Chapter 5 — HYDRAULIC SYSTEM

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Operation of Firestreak and airbrakes	8

Description

1 General

(*a*) The hydraulic installation comprises three separate systems: —

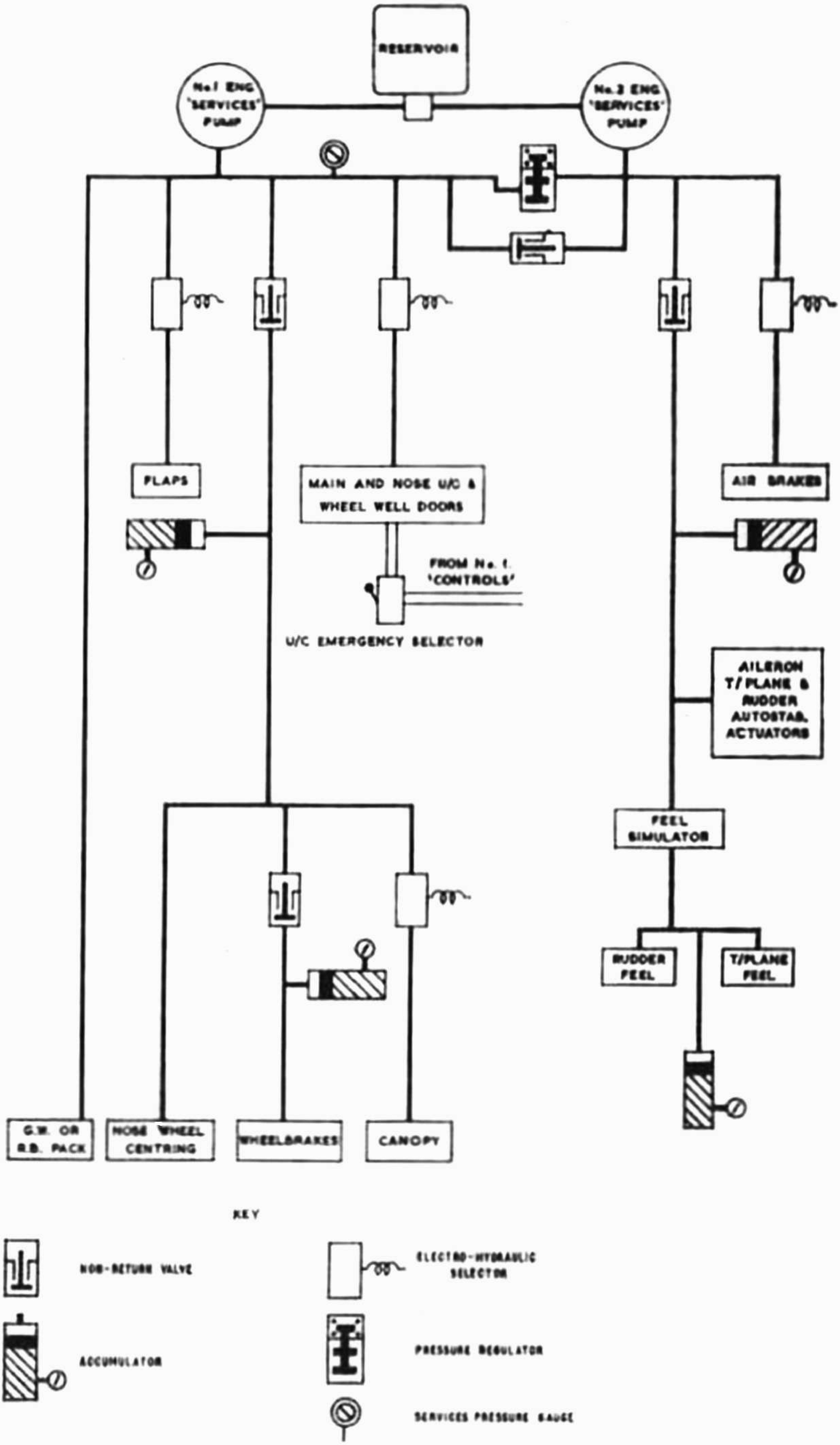
(i) Services system

(ii) No. 1 controls system

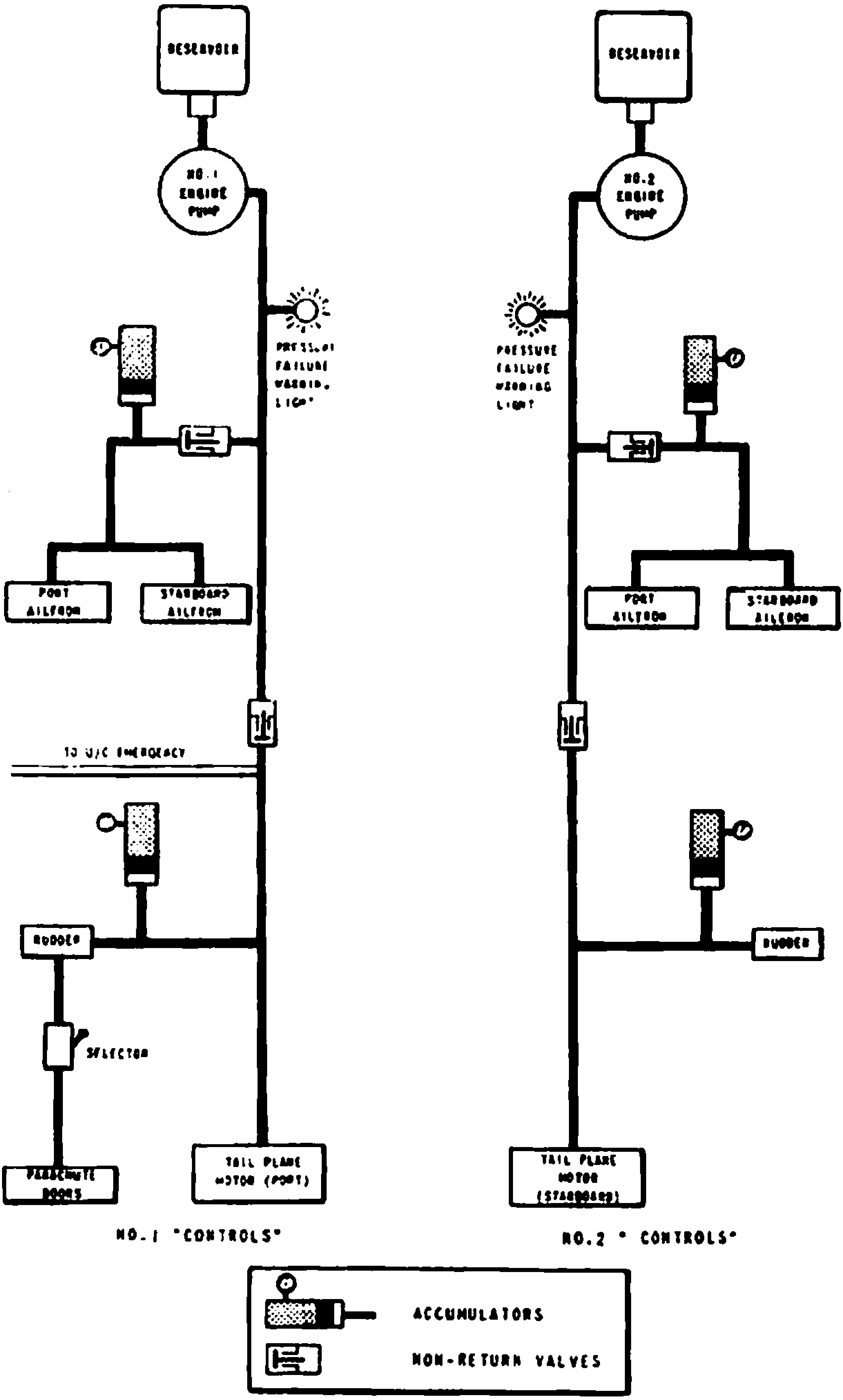
(iii) No. 2 controls system

(*b*) The systems provide for the following hydraulically operated services.

Services	*No. 1 Controls*	*No. 2 Controls*
Undercarriage	Outboard aileron p.f.c.u.	Inboard aileron p.f.c.u.
Wheel brakes	Tailplane p.f.c.u. (port motor)	Tailplane p.f.c.u. (starboard motor)
Nose-wheel centring and anti-shimmy		
Air brakes	Rudder p.f.c.u.	Rudder p.f.c.u.
Flaps	Brake parachute compartment door	
Feel system		
Autostabiliser actuators	U/C emergency lowering	
Canopy		
G.W.		



Services hydraulic supply



Controls hydraulic supply

2 Pumps

(*a*) Power is provided by four engine driven pumps, two mounted on each engine wheel case. The forward pumps on each engine jointly power the services system; the aft pump on No. 1 engine powers the No. 1 controls system and the aft pump on No. 2 engine the No. 2 controls system.

(*b*) A hand-pump for ground operation only of the services system is behind an access panel on the port side of the fuselage. A stowage for the hand-pump handle is in the port wheel well.

3 Reservoirs

The pumps draw hydraulic fluid from reservoirs, one to supply the services system requirements and one each for the No. 1 and No. 2 controls systems. The reservoirs are pressurised with air tapped from the engine compressors. An auxiliary reservoir for the No. 1 controls system is fitted to provide an additional reserve for emergency lowering of the undercarriage. The auxiliary reservoir operates in parallel with the main No. 1 controls reservoir.

4 Accumulators

(*a*) *Services accumulators*

Four accumulators in the services system store pressure for operation of the wheel brakes, canopy raising or lowering, nosewheel centring and anti-shimmy, autostabiliser actuators, feel simulator and feel units.

(*b*) *Controls system accumulators*

Two accumulators in each controls system store pressure for all services in the controls systems. These provide for high rates of normal operation of the control surfaces and for limited emergency operation.

5 Pressure regulator

It is necessary to maintain a minimum pressure of 2,700 PSI when the guided missile pack alternator motor is running. If the airbrakes are selected the pressure may come below 2,700 PSI. A pressure regulator and non-return valve are therefore interposed between the delivery lines of the No. 1 and No. 2 services system pumps. If the No. 2 pump delivery pressure falls through selection of airbrakes the pressure regulator operates and the non-return valve closes, thus ensuring that the No. 1 pump output pressure is not reduced. The pressure at the missile pack alternator motor, which is supplied from the No. 1 pump, is therefore protected.

6 Services system pressure gauge

A pressure gauge fitted above the bridge panel indicates services system pressure. When the pumps are running the ◀pressure reading should be 3,000 ± 250 PSI. When▶ a service is selected which has a high fluid demand, the reading will fall rapidly and then gradually rise to 3,000 PSI.

7 Pressure failure warning

(*a*) A pressure switch is fitted in the pressure line of both No. 1 and No. 2 controls system. If line pressure falls to 1,750 PSI the switch closes and a HYD 1 or HYD 2 warning as appropriate, appears on the AWP. If both pressure switches close, an additional HYD warning appears on the SWP.

(*b*) Failure of the services system is indicated when the reading of the services pressure gauge falls to zero (red sector of gauge). The gauge requires a 28 volt single phase AC supply and if this fails the needle on the gauge will fall below zero into the white sector of the gauge.

8 Operation of Firestreak and airbrakes

(*a*) To ensure that the required electrical output for satisfactory operation of Firestreak is maintained, one engine must always be run at or above fast idling speed.

(*b*) To obtain satisfactory operation of airbrakes when Firestreak is armed, No. 1 engine must be maintained at or above fast idling speed.

(*c*) If flying on No. 2 engine only, loss of Firestreak electrical supply will result due to reduction in missile alternator RPM if airbrakes are used.

(*d*) If flaps or undercarriage are operated at any time with Firestreak armed, loss of Firestreak electrical supply will result due to reduction in missile alternator RPM.

PART I

Chapter 6 — POWER FLYING CONTROLS AND TRIMMERS

Contents

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Description

1 General

The ailerons, tailplane and rudder are fully power operated flying controls. The ailerons and rudder are moved by jack-type powered flying control units (PFCU) and the tailplane by a twin screw-jack PFCU. PFC units are mechanically actuated from the control column and rudder bar. Hydraulic power for the operation of the control surfaces is duplicated so that failure of one controls system does not result in loss of aircraft control. As the controls are irreversible, artificial feel is provided in each system. Trimming is effected by electrically operated actuators which, by moving the control runs, displace the PFCU and adjust the cockpit controls to the required position.

2 Ailerons

(*a*) Each aileron is moved by two jack-type PFC units. The outboard PFCU is powered by No. 1 controls system hydraulic pressure and the inboard by the No. 2 controls system. Lateral movement of the control column displaces the control valves of each PFCU simultaneously which in turn moves the control surface. When the desired deflection of the surface is reached the control valve of the PFCU is centred by follow-up movement of the valve input linkage and no further movement of the surface takes place until the control column is once again moved laterally. If the hydraulic supply to one PFCU fails the unit will be motored by the other PFCU; this results in a slight reduction in the maximum operating rate.

(*b*) ⧓ The aileron movement is limited to $\pm 7°$ (approximately half-travel) whenever the undercarriage is up. A restrictor in the control run in the port wing engages with the undercarriage wheel-well door as it closes.

3 Rudder

The rudder is moved by a jack-type PFCU which incorporates twin piston assemblies in tandem. One of the pistons is operated by the No. 1 controls hydraulic system and the other by the No. 2 controls system. Movement of the rudder bar displaces the control valve of the PFCU which in turn moves the rudder surface. Follow-up movement of the valve input linkage centralises the control valve in a similar manner to that of the ailerons. Failure of the hydraulic system to one piston does not affect the rate of operation.

4 Tailplane

The slab tailplane is moved by a twin screw-jack PFCU powered by two independent reversible hydraulic motors through a common gearbox. The port hydraulic motor is supplied from the No. 1 controls hydraulic system and the starboard from the No. 2 controls system. Fore and aft movement of the control column displaces the control valves of the PFCU which in turn moves the control surfaces simultaneously. The control valves are centred when the tailplane angle is equal to the demanded angle in a similar manner to that of the ailerons and rudder. Failure of the hydraulic supply to one of the motors will reduce the rate of operation but this will not cause any embarrassment at 2G or below, to which manoeuvring is restricted following such a failure.

5 Artificial feel system

(*a*) *Aileron feel*

Artificial feel on the aileron control is provided by a torsion bar acting on the linkage between the control columns and the control rod. Feel force is directly proportional to control column movement and does not vary with speed.

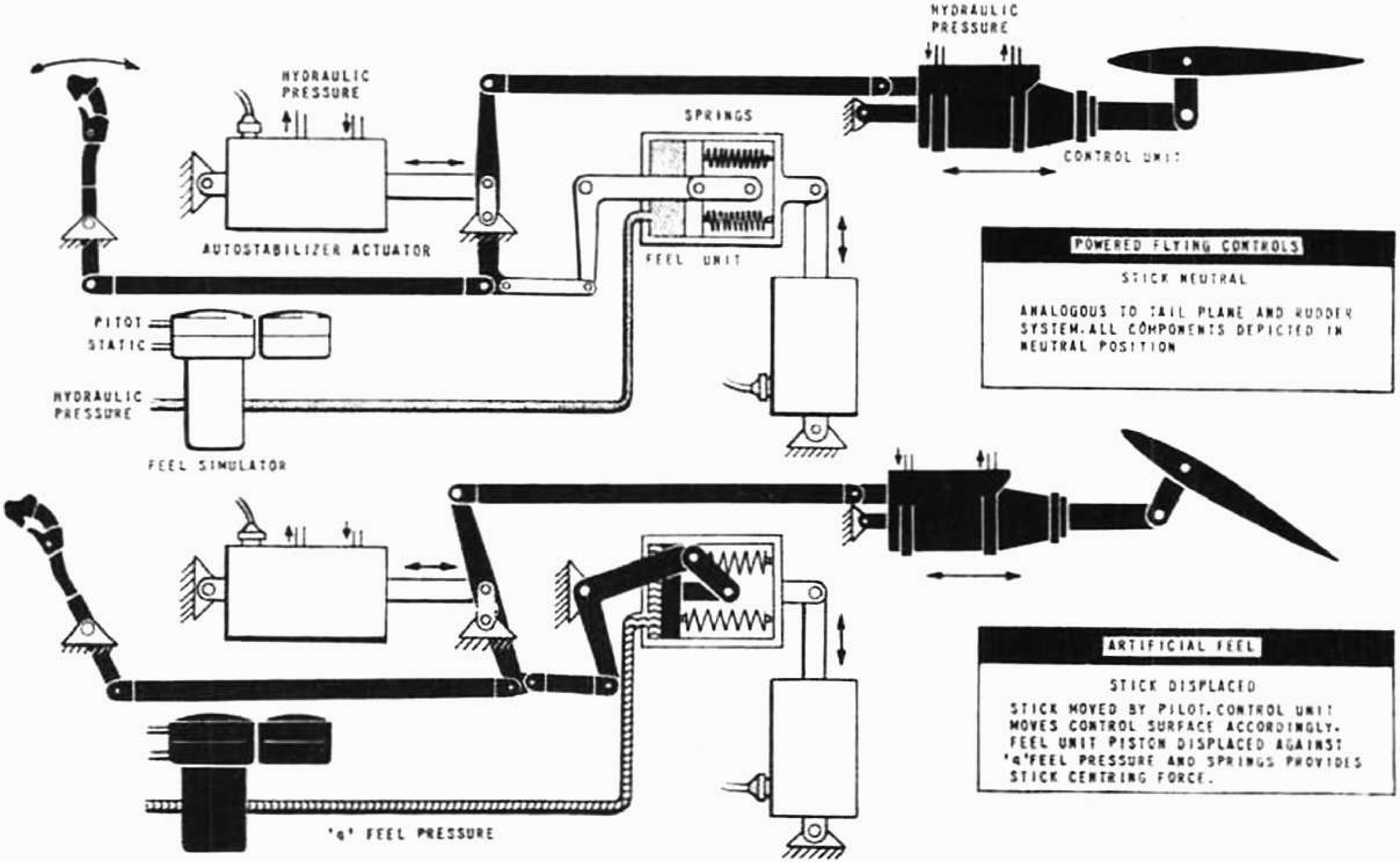
(*b*) *Tailplane and rudder feel*

(i) Artificial feel on the rudder and tailplane control is provided primarily by a hydraulic feel unit linked in the control run. When the control column or rudder bar is moved, a piston in the feel unit is displaced against hydraulic pressure. Relaxing the force on the control column allows the piston to move back to neutral, returning the control column or rudder bar to its trimmed position. Additionally, spring feel is provided to assist the hydraulic feel and to act as a stand-by system in the event of failure of the hydraulic feel system.

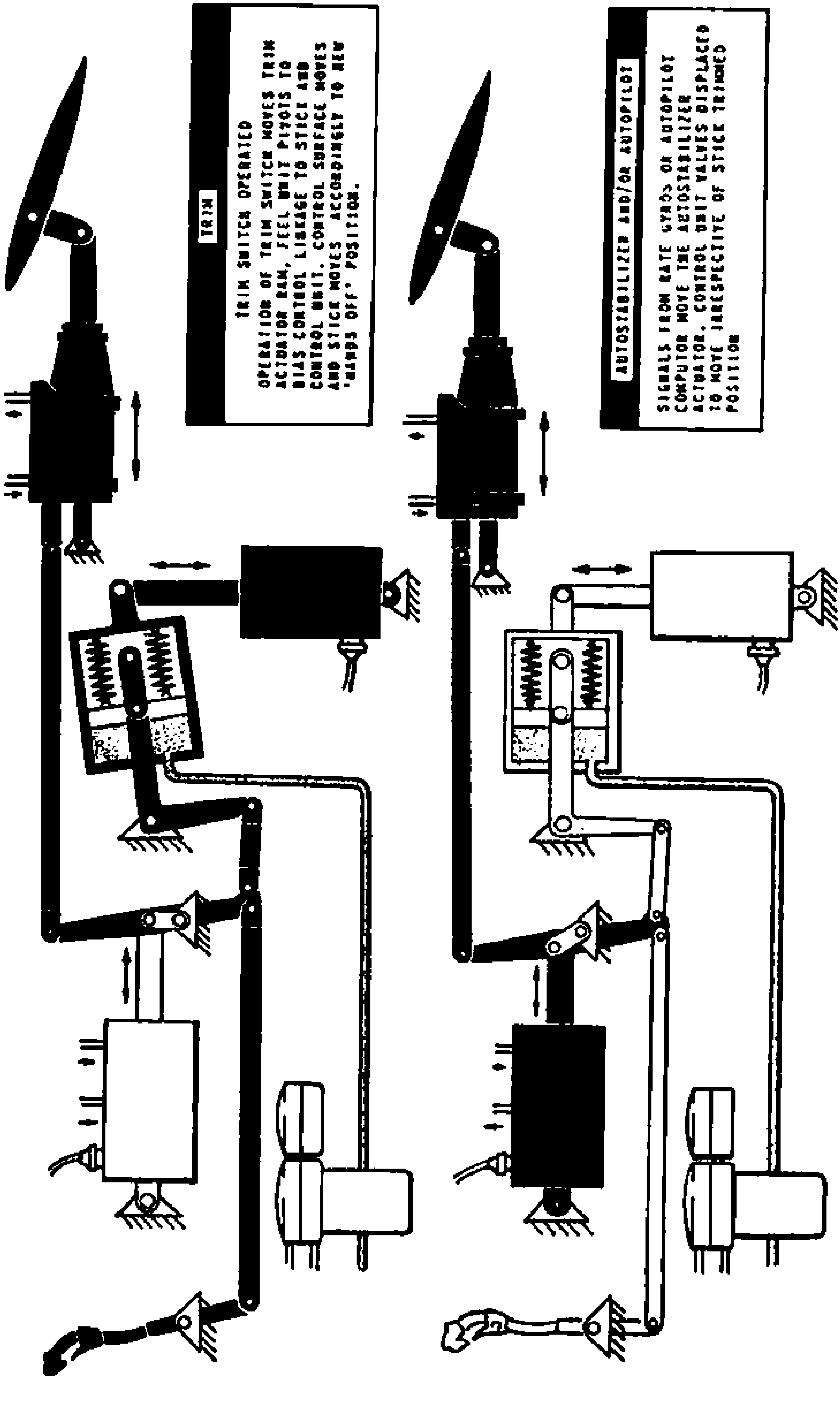
(ii) The hydraulic feel units are designed to give a linear increase in feel force with rudder or control column movement. They also give an increasing feel force with increase in pitot/static differential pressure controlled by a feel simulator control unit which meters the hydraulic pressure to the feel units. If the pitot/static pressure is increased, e.g. by increasing airspeed, the feel simulator control increases the hydraulic pressure at the feel units providing a greater pressure opposing movement of the piston in the feel unit. At speeds above 0·9M, however, feel is maintained at a constant value for a given altitude, per degree of control movement, irrespective of any further increase in dynamic pressure. Differences in static pressure will continue to affect feel force i.e. decrease in altitude will increase the feel force.

(iii) To reduce foot load in the circuit, hydraulic feel to the rudder is cancelled when the undercarriage is in the DOWN position. It is restored when an UP selection is made.

(iv) Hydraulic feel may be cancelled manually by a switch under the canopy sill on the port side of the cockpit.



Power control system



Power control system

(v) Two accumulators are in the hydraulic feel system, the smaller to act as a damper between the feel units to prevent rapid operation of the controls causing interaction between the rudder and tailplane units and to prevent reaction on the simulator valve which would otherwise cause the flight instruments to fluctuate. The larger accumulator prevents changes in feel occuring when the general services are being operated. It also provides for the continued operation of the feel units for a limited period after failure of the services hydraulic system.

6 Trimming

Trimming is effected by an electrically-operated actuator in each system which is connected to the hydraulic feel unit or, in the case of the ailerons, to the torsion bar. Movement of the actuator displaces the feel unit or aileron torsion bar which in turn displaces the control columns and the control valve of the p.f.c.u. The actuators are operated by double pole switches. A combined aileron and tailplane switch is on each control column; the pupil's rudder trim switch is to the left of his AI display and the instructor's is on the starboard console.

Controls and Indicators

7 Controls

(*a*) The controls are operated by dual, pistol grip control columns and rudder bars. Each control column carries on it an aileron/tailplane trimming switch, G90 and PAS recorder camera operating button, armament firing trigger and safety catch, auto-pilot engage switch, press-to-transmit switch, a wheel brake lever, a nosewheel steering switch (inoperative) and, on the pupil's control column only, a parking catch.

(*b*) Each rudder bar may be adjusted individually for leg reach by RUDDER BAR ADJUST handles, one to each station at the bottom of the instrument panel. Pulling out a handle and turning it clockwise moves the appropriate rudder pedals aft; turning anti-clockwise reverses the process. After adjustment the handle must be pushed in and located in the retaining clip.

8 Trim switches and indicators

(*a*) *Rudder trim*

Twin, 3 position, ganged switches marked RUDDER TRIM, spring loaded to the central off position, control the rudder trim in the natural sense. The ganged switches for the pupil are located to the left of his AI display.

Those for the instructor are on the starboard console. Both halves of a RUDDER TRIM switch must be selected together before trimming can be obtained.

(*b*) *Aileron/tailplane trim*

A four-way, spring-loaded to off, ganged dual switch on each control column, when operated in the natural sense, controls the aileron and tailplane trim. To test the functioning of a dual switch the ganging bar can be raised and pivoted to one side by squeezing or pulling the pin at the top of the ganging bar; the two switches revealed may then be tested individually.

(*c*) *Trim indicators*

A combined TRIM INDICATOR on the main instrument panel shows the trim position on three scales for the RUDder, TAILplane and AILeron. A fourth scale on the indicator shows the position of the airbrakes.

(*d*) *Feel selector and indicator*

A two-position FEEL—ON/OFF switch is under the port canopy sill. When the switch is at ON the hydraulic feel units are brought into operation. In the OFF position, hydraulic feel is cancelled and only spring feel remains. A magnetic FEEL indicator on the port instrument panel shows black and ON when the feel switch is ON, and white and OFF with the switch at OFF. Note that it indicates only the switch position and does not indicate feel failure.

9 Power control failure warnings

No 1 or No 2 controls system hydraulic failure warning is given by the illumination of the HYD 1 or HYD 2 warnings respectively on the AWP. Failure of both systems is indicated by a HYD warning appearing on the SWP in addition to the two warnings on the AWP.

Normal use of the System

10 Pre-flight checks

(*a*) Check the trim switches at each station independently as follows:

(i) Test the rudder trim for a "live" circuit by operating each of the two rudder switches separately. If any movement of the rudder trim occurs the aircraft must not be flown. Test the rudder trim over its full range by operating both switches together and then set to neutral. Replace the ganging bar.

(ii) Test the aileron and tailplane trim for a "live" circuit by raising the ganging bar and operating each switch separately. If any movement of either aileron or tailplane trim occurs the aircraft must not be flown. Replace the ganging bar and check that it is locked by attempting to lift it. Test the aileron and tailplane trim over the full range and then set the ailerons to neutral and the tailplane to T.O.

(*b*) Check the operation of the FEEL switch by selecting OFF and then ON. Note that the FEEL magnetic indicator corresponds to selections of the switch. Leave the switch at ON.

(*c*) Prior to take-off, operate the controls over the full range for freedom of movement. If excessive rate of movement of the tailplane is made it is possible that the control valve in the p.f.c.u. will bottom. This will be noticed by an increase in feel force. No mechanical damage should occur, however, due to this condition.

(*d*) Check that the HYD 1 and HYD 2 warnings on the AWP and the HYD warning on the SWP are out prior to take-off.

11 In-flight

Limitations are imposed on the use of the ailerons. These are given at Part 2 Chapter 1 Para 11.

Malfunctioning of the System

12 Power control failure

(*a*) Failure of one hydraulic controls system is indicated by a HYD 1 or HYD 2 warning appearing on the AWP. A slight reduction in the maximum operating rate of the ailerons will occur but there will be no noticeable effect on the other controls below 2G.

(*b*) Failure of both hydraulic controls systems is indicated by a HYD warning appearing on the SWP in addition to the two warnings on the AWP. The accumulators in the systems will provide for limited operation for a short period before the controls become immovable. If the failure is caused by double engine flame-out the accumulator supply may be supplemented from the pumps by windmilling the engines at a speed of 250 knots or above.

◀(*c*) Aeration followed by pump cavitation (usually after negative-G) is the most probable cause of double hydraulic controls system failure. A period of straight and level flight is likely to recover the pumps and restore hydraulic power. This has been known to take up to eight minutes. ▶

PART 1

Chapter 7 — OTHER AIRCRAFT CONTROLS

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Braking parachute	6

Description

1 Undercarriage controls and indicators

(*a*) The hydraulically operated undercarriage comprises two main wheels retracting rearward and outward into the wings and a nose wheel retracting forward into a well in the fuselage nose.

(*b*) The undercarriage is controlled by two pushbuttons on the port instrument panel, one for UP, and one for DOWN. The pushbuttons are in circuit with the undercarriage electro-hydraulic selector and are mechanically inter-locked so that depressing one pushbutton releases the other. A pitot static switch prevents an UP selection being made at airspeeds below 165 knots (150 knots pre mod 4398). In an emergency this switch can be overridden by turning the UP pushbutton clockwise to its fullest extent and then pushing in the button normally. There is no undercarriage control at the instructor's station.

(*c*) Standard undercarriage position indicators are fitted, one on the port instrument panel and the other on the starboard instrument panel.

(*d*) The limiting speed for undercarriage up selection is 250 knots and for lowering, 220 knots. Flight with the undercarriage down is limited to 250 knots normally and 280 knots for emergency locking down.

2 Undercarriage emergency lowering control

(*a*) The undercarriage emergency lowering control is a yellow and black striped T-handle situated on the cockpit floor at the left of the pupil's seat. The spring-loaded button, marked U/C, on the T-handle must be pushed in before the handle can be pulled. The handle must be pulled to its full extent and just prior to full travel it will fall away as it leaves its guide. The handle is wired to indicate that it has not been disturbed and the aircraft should not be flown if the wire is found to be broken.

(*b*) When the T-handle is operated, No 1 control system hydraulic pressure is directed to close a valve in a protection unit to isolate services pressure from the normal selector and to open a valve in the protection unit to connect all the up lines to return, irrespective of the setting of the normal selector. At the same time, shuttle valves and relay valves are operated to direct the No 1 controls system pressure to lower the undercarriage.

(*c*) Once the emergency system has been used it is not possible to retract the undercarriage until the system has been ground serviced.

(*d*) After an emergency selection, ensure that the normal selector is in the down position to render the armament circuits safe.

3 Flap control and indicators

(*a*) The flaps, which are utilised as fuel tanks, are hydraulically operated from the services hydraulic system and electrically controlled by flap selector switches, one to each station. The flaps are not interconnected. The pupil's switch is on the ⧓ port shroud panel adjacent to the pupil's rudder trim switch; the instructor's flap selector is on the starboard instrument panel. The pupil's switch is a two-position fully UP or fully DOWN switch while the instructor's is a three position UP/centre/DOWN switch. There is no supply to the pupil's switch unless the instructor's switch is in the centre position; the instructor, therefore, can override any selection made by the pupil.

(*b*) A pitot-pressure switch, set to close at 250 knots, automatically selects the flaps up if they have been inadvertently left in the down position and speed increased to 250 knots. When speed is again reduced below 250 knots, the flaps will take up the position as determined by the flap selector switch; however, the flap selector lever should be set to the up position whenever automatic retraction occurs.

(*c*) No provision is made for in-flight operation of the flaps in the event of services system failure or DC electrical failure.

(*d*) A flap position indicator is on the port instrument panel. Each of the two needles on the instrument shows the position of its respective flap.

(*e*) The limiting speed for operation of the flaps is 250 knots.

4 Airbrakes control and indicator

(*a*) The airbrakes are hydraulically operated from the services hydraulic system and electrically controlled by a 3-position IN/OUT switch, spring-loaded to off, on each No. 2 engine throttle lever. Synchronous operation of the airbrake doors is achieved by a valve in the hydraulic lines to the airbrakes which throttles the supply to either door should it tend to lead in operation. A mach switch set to operate at 1·2M, causes the airbrakes to be automatically closed if this speed is exceeded; when speed is reduced below the setting of the mach switch the airbrakes will remain in until the next OUT selection is made. The airbrakes can only be selected to fully out and fully in. When guided weapons are 'armed' the rate of operation of the airbrakes is reduced and in this case they must not be used unless No. 1 engine is at fast idle RPM or above.

(*b*) A combined trim and airbrake indicator is on the main instrument panel. One of the four scales on the indicator shows the position of the airbrakes and has a special provision for the locked-in position.

(*c*) The limiting speed for operation of the airbrakes is 1·2M.

5 Wheelbrake control

(*a*) The hydraulically operated disc-type wheel brakes are fitted with Maxaret anti-skid units and are controlled by a lever on the front of each control column. The brake lever is connected to a differential control valve which is mechanically linked to the rudder bar to give differential braking in the conventional manner. A parking catch is fitted on the port brake lever only.

(*b*) The accumulator pressure available for brake operation is shown on a gauge on the starboard instrument panel. The normal reading is 3,000 ± 100 PSI, but in flight the pressure may build up above this figure to as much as 3,600 PSI. Should the brake pressure during flight reach 3,600 PSI, operate the wheelbrakes to relieve the pressure.

6 Braking parachute

(*a*) A ribbon-type braking parachute is housed in a compartment on the underside of the rear fuselage. The pupil's and instructor's parachute stream handles, marked TAIL CHUTE PULL are above the port and starboard instrument panels respectively. Pulling either handle to its fullest extent mechanically operates a selector to hydraulically open the parachute doors from No. 1 controls system pressure. As the doors open the parachute streams.

(*b*) Two CHUTE JETTISON pushbuttons are fitted. The pupil's button ⧓ is on the port shroud panel adjacent to the pupil's rudder trim switch. The instructor's button is on the starboard instrument panel. When either button is depressed an electro-magnetic release unit opens to jettison the parachute. The release unit can be operated only after the parachute has been streamed.

(*c*) If the parachute is inadvertently streamed at excessive speed it will become detached from the aircraft through the rupturing of a shear-pin in the parachute cable.

(*d*) The TAIL CHUTE PULL lever, if reset by the pilot after streaming the parachute, should be held and returned slowly, otherwise damage to the cable will result.

(*e*) The limiting speeds for operation of the braking parachute are:

Normal operation — 150 knots.
Emergency operation — 170 knots.

◀NOTE: Whenever the parachute is streamed at speeds above 150 knots, the fact must be reported after flight, so that the parachute can be assessed for re-use. ▶

(*f*) If the No. 1 engine is shut down but is windmilling, ◀the hydraulic supply should be sufficient to operate the▶ parachute doors.

PART I

Chapter 8 — FLIGHT INSTRUMENTS

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◀ Altimeter (Mk. 22C)	6
Altimeters (Mk. 26 and Mk. 21)	7 ▶
Pitot and static pressure instruments	8
Miscellaneous instruments	9

Description

1 Interim dynamic reference system

The dynamic reference system uses a master reference gyro (MRG) to supply continuous flight attitude and heading information to the attitude indicator (roller blind), the Mk. 5FT compass, the Mk. 13 autopilot system, the AI and the pilot attack sight (PAS). The system is controlled by the INSTRUMENT MASTER switch on the starboard console. Both 28 volt DC and 115 volt 3-phase 400 CPS AC power are required to operate the system.

2 Master reference gyro (MRG)

(*a*) The MRG comprises a gyroscopically stabilised, servo-operated platform assembly. Two platforms, an inner and an outer, are stabilised to the vertical by an earth gyro, which in turn is monitored for drift, any tendency to precess being corrected by servo-motors which re-align the platforms. The platforms are therefore slaved to the gyro gimbal rings and any relative movement between the aircraft and the two platforms induces bank and pitch signals which are fed to the attitude indicator, the autopilot system, the AI and the PAS. Acceleration errors are catered for by cutting the monitoring signals to the gyro at a predetermined rate.

(*b*) An azimuth gyro is mounted on the inner platform to feed heading information to the Mk. 5FT compass and the autopilot system. This gyro is normally monitored by a compass detector unit, but compass monitoring is cut off whenever DG is selected on the Mk. 5FT compass or when flight accelerations and attitudes would cause errors during compass detection.

(*c*) The MRG is brought into use by the INSTRUMENT MASTER switch which when set to ON, causes the platforms to servo to their datum position (i.e. approximately level) during the first 3 seconds and then rapidly erects the gyros during the next 17 seconds. Off flags on the attitude indicator and the Mk. 5FT compass disappear when the system is functioning normally. If these flags still remain 35 seconds after switch-on, the INSTRUMENT MASTER switch must be set to OFF and the fault investigated.

(*d*) If it is necessary to switch the system OFF immediately after it has been switched ON, an interval of 4 minutes must elapse before switching ON again.

(*e*) ⧓ An MRG NORMAL—FAST ERECTION switch, spring-loaded to NORMAL, and an MRG, ON-OFF pushswitch are on the main instrument panel.

(i) When the MRG—NORMAL/FAST ERECTION switch is set to NORMAL, the vertical gyro erects at a rate of 3°/min. and at FAST ERECTION at 17°/min. FAST ERECTION should be selected if it is necessary to remove false errors in attitude indications which may have occurred through sustained accelerations below the limits catered for by the monitoring cut-out devices. The selection should be made in straight and level unaccelerated flight.

(ii) The MRG—ON/OFF pushswitch may be used to switch off the MRG even though the INSTRUMENT MASTER switch is on. Its main use is to take the MRG load off the aircraft battery in conditions where the battery is the sole means of electrical power, e.g. during engine starts with no external power. It may also be used to cage a spinning instrument display whenever the MRG has failed or toppled. The switch must be pushed in to select MRG ON, and pulled out to select OFF. A light in the switch illuminates when OFF is selected, provided the INSTRUMENT MASTER switch is ON.

3 Attitude indicator, Mk. F1M

(*a*) The attitude indicator which is operated by signals from the MRG gives a continuous indication of pitch by a roller blind presentation and of roll by a pointer at the bottom of the blind frame. The blind is half-white and half-black and the dividing line represents the natural horizon. When the horizon is not visible on the display at high climbing or diving angles a zenith or nadir star is shown, the long tails of which point in the direction of the horizon. Looping manoeuvres which pass the zenith or nadir result in a rapid rotation of the blind through 180°. Two concentric circles on the face of the instrument represents 20° and 40° of pitch and, in the vertical plane only, are additional marks representing 10°, 30° and 50°. Roll markings are 10°, 20°, 30°, 60° and 90° port and starboard. An OFF flag is at the top of the instrument. The flag retracts 20 seconds after MRG switch-on.

(*b*) The instrument indicates pitch and roll attitudes throughout 360° in either plane to an accuracy of within 1°.

4 Mk. 5FT compass system

(*a*) Signals from the azimuth gyro of the MRG are fed to the Mk. 5FT compass on the instrument panel. When the INSTRUMENT MASTER switch is set to ON an off-flag on the face of the instrument is retracted after 20 seconds to indicate completion of the starting cycle. The flag remains retracted as long as power is being supplied to the instrument.

(*b*) A pushbutton centrally below the instrument selects either compass monitoring or directional gyro. If the latter is selected, DG appears in the window above the button. if compass is selected the window remains blank.

(*c*) Compass monitoring annunciator window is on the face of the instrument. With compass selected and synchronised, a dot/cross annunciator slowly oscillates in the window. If DG is selected the annunciator is rigid in the de-energised central position. Fast synchronisation is achieved by the use of a SYN knob at the botton right of the instrument. The knob must be depressed and turned. The correct direction of turn is indicated by the ease with which the knob can be turned. Resistance to turn indicates turning in the wrong direction and if turned sufficiently in this way, a slipping clutch comes into action.

(*d*) At the bottom left of the instrument is a HDG knob which, when depressed and turned, moves a heading selection pointer on the instrument. This control, when used in conjunction with the Mk. 13 auto-pilot in the ILS mode, causes the aileron control of the auto-pilot to turn the aircraft on to the heading selected by the HDG knob. The heading selection pointer rotates with the compass card except when a new heading is being selected by the HDG knob (see Part I, Chapter 14, para. 4).

5 Standby artificial horizon (Mk. 6A or Mk. 6H) and direction indicator system

◀(*a*) The standby artificial horizon and the direction indicator are fitted to meet the case of failure of the MRG. The system is controlled by the INSTRUMENT MASTER switch on the main instrument panel. The system is operated by 115 volts AC from the transformer, or on alternator failure, by 28 volts DC, the changeover being automatic. If failure of both alternator and generator occurs, the system is automatically switched to the DC supply which is at the highest voltage, i.e. main busbar at▶ battery voltage or emergency battery. The system cannot be started by DC power and no attempt should be made to test the system on the ground unless power is being supplied from an AC source.

(*b*) The standby artificial horizon incorporates a fast erection button and an orange and black striped off-flag. The off-flag disappears on switch-on and the instrument is ready for use after approximately 20 seconds in the case of the Mk. 6A and 40 seconds for the Mk. 6H. To restore the gyro axis, depress the FAST ERECTION button this need only be done momentarily for the Mk. 6A instrument but must be held depressed for the Mk. 6H. FAST ERECTION should only be used in straight and level unaccelerated flight.

(*c*) ▶◀ A direction indicator is fitted above the E2B compass. The turn button of this instrument is also a fast erection push switch. When used for fast erection, a blue light in the indicator comes on. If the blue light goes out on releasing the button, the instrument is ready for use. If the blue light remains, auto fast erection takes place and the blue light will go out when the instrument is ready for use.

6 Altimeter (Mk 22C)

A Mk 22C servo altimeter is on the main instrument panel. It is operated by 115 volts, 400 HZ, single phase AC from the alternator. The altimeter continues to operate from the standby inverter if the normal supply fails. An OFF flag or a black and yellow striped flag appears on the instrument if all power supplies to it are cut.

7 Altimeters (Mk 26 and Mk 21)

(*a*) A Mk 26 altimeter is fitted on the port instrument panel. It is a conventional instrument operating on the aneroid principle and is used as a standby altimeter.

(*b*) A Mk 21 cabin altimeter is on the starboard console.

8 Pitot and static pressure instruments

(*a*) The following flight instruments are served by the pitot-static system:

Mk 22C altimeter
Standby altimeter Mk 26
Cabin altimeter Mk 21
Machmeter Mk 3B or Mk 4
ASI Mk 15B, Mk 16 or Mk 20
VSI Mk 3P

(*b*) An electrically heated pressure head is on the nose of the aircraft. A PITOT — NORMAL/OFF/STANDBY switch on the bridge panel controls the power supplies to the heater. With the switch at NORMAL the heater is supplied by 28 volts single phase AC. If AC failure occurs the heater can be supplied by DC power by setting the switch to STANDBY.

9 Miscellaneous instruments

(*a*) An E2B standby compass is on the frame member between the two front windscreens.

(*b*) A Mk 3 accelerometer is fitted below the instructor's AI display. Post mod 4662 the accelerometer is re-positioned on the centre windscreen strut.

(*c*) A slip indicator is on the main instrument panel.

PART I

Chapter 9 — GENERAL EQUIPMENT AND CONTROLS

Contents

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Canopy emergency operation	2
Canopy jettison	3
Internal lighting	4
Emergency internal lighting	5
External lighting	6
First-aid kit	7
Hand operated fire extinguisher	8

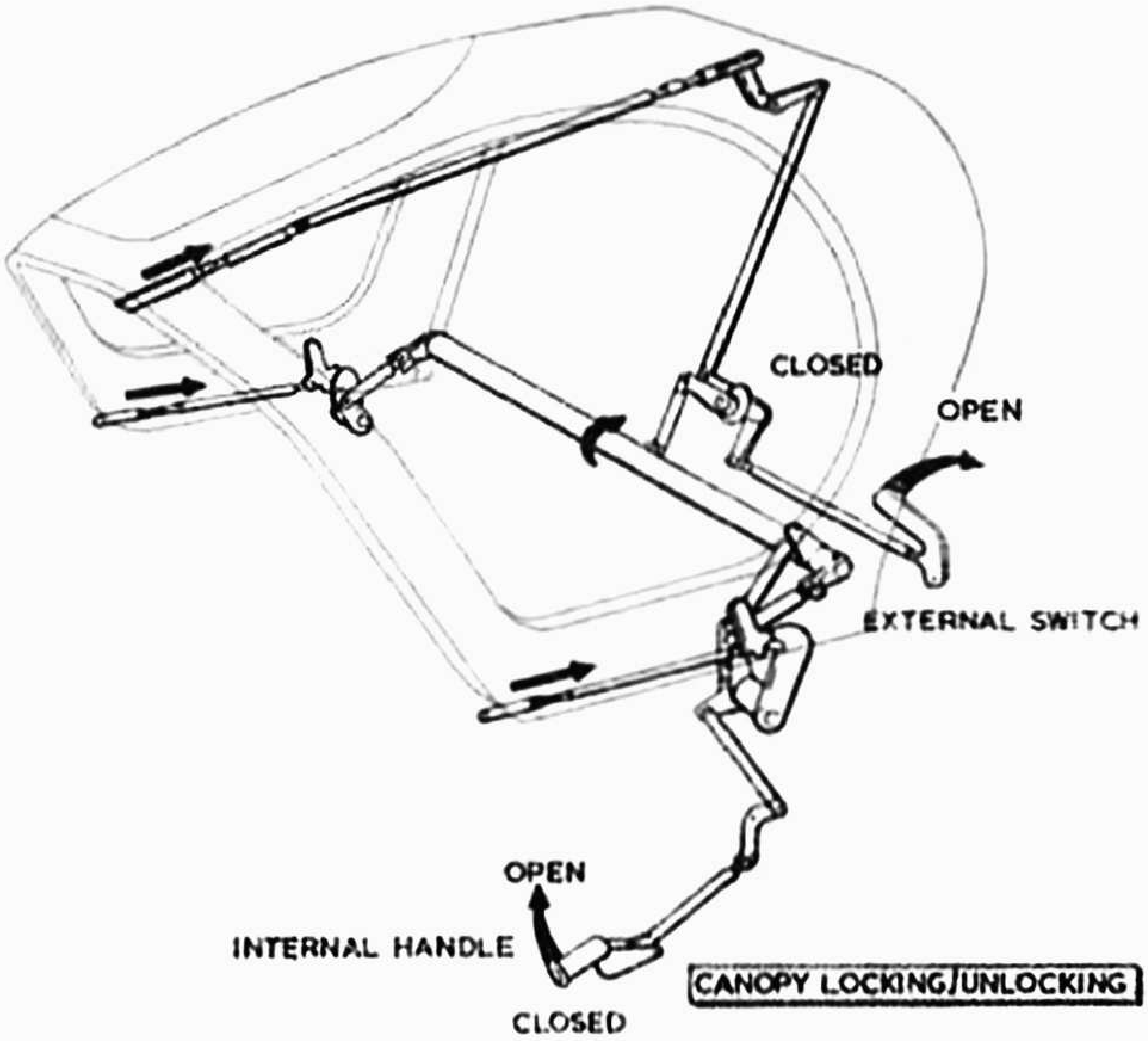
Description

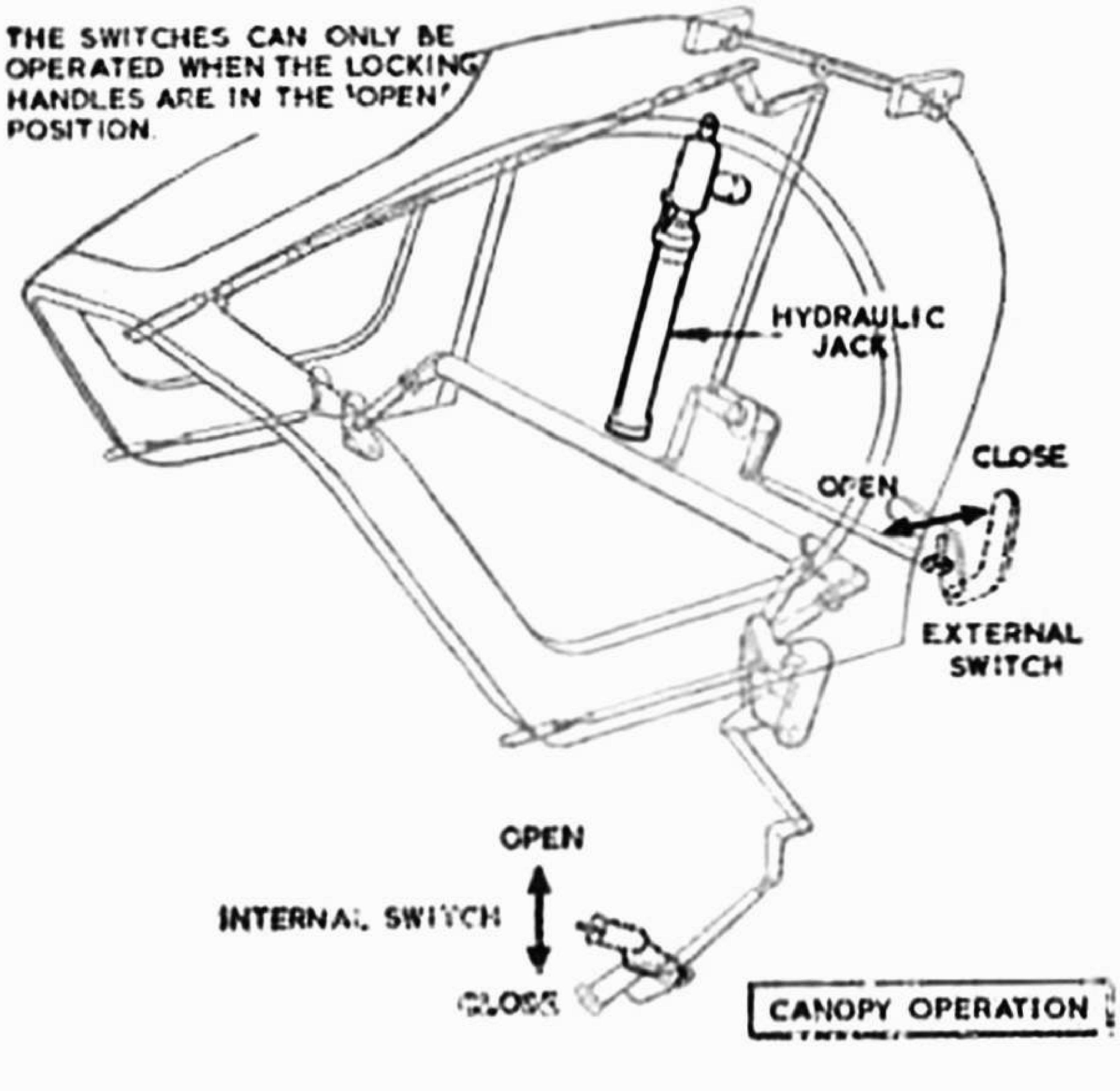
1 Canopy control and operation

(*a*) The jettisonable clam-shell canopy is hydraulically operated and electrically controlled. The canopy is opened or closed from inside the cockpit by a CANOPY handle and toggle switch at the left of the pupil's seat pan. When the handle is pulled up, the canopy is unlocked and a toggle switch is exposed in the head of the handle. When the switch is moved to OPEN, the canopy hydraulic jack operates to open the canopy. To close the canopy, set the toggle switch to CLOSED and when the canopy has closed push the handle down to lock the canopy. The toggle switch is spring-loaded to a central off position allowing intermediate positions between fully open and fully closed to be selected.

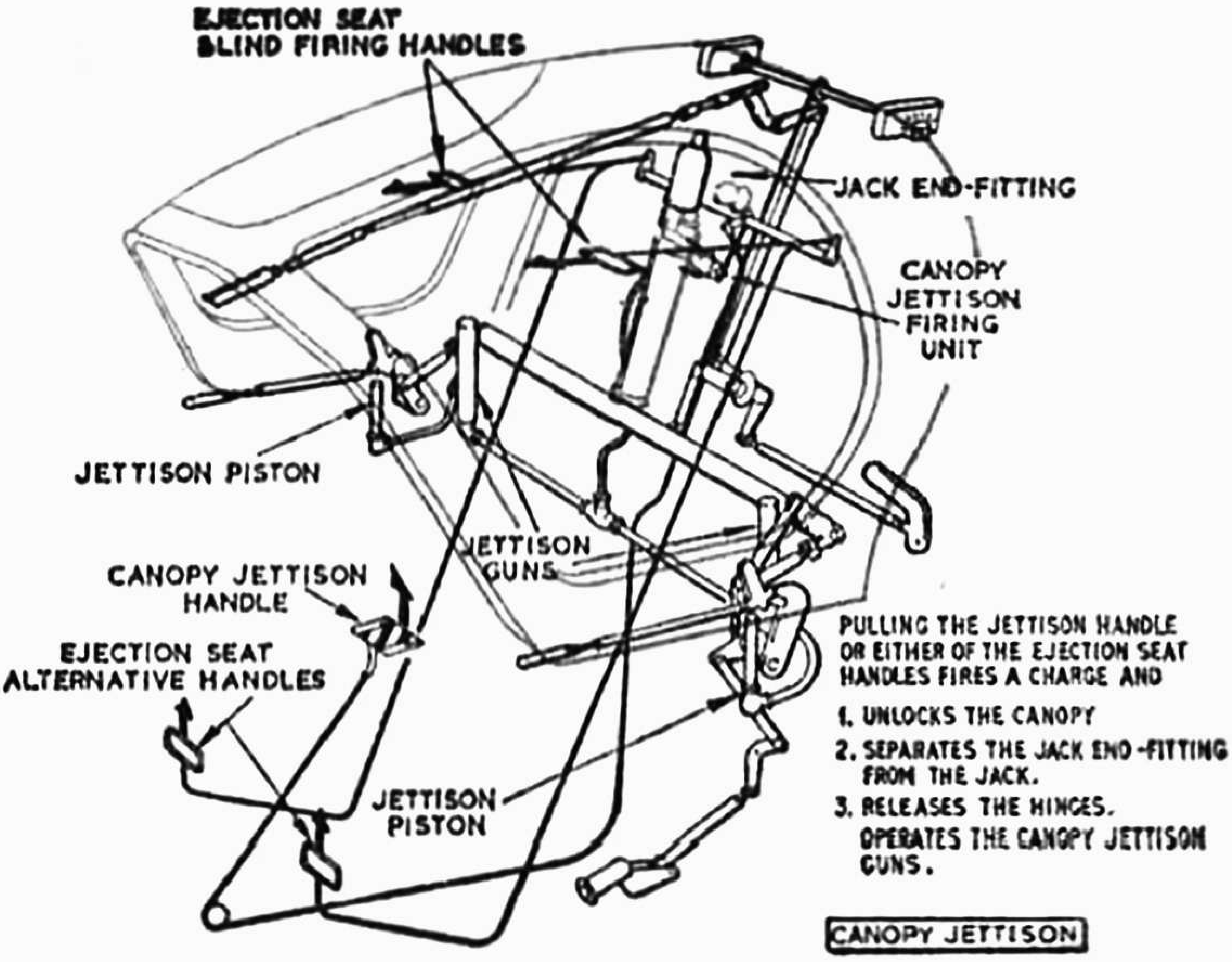
(*b*) For external canopy operation a similar CANOPY LOCKS handle is behind a panel on the port side of the fuselage spine. The toggle switch, in this case, is behind the CANOPY LOCKS handle and is inaccessible until the handle is pulled out to unlock the canopy.

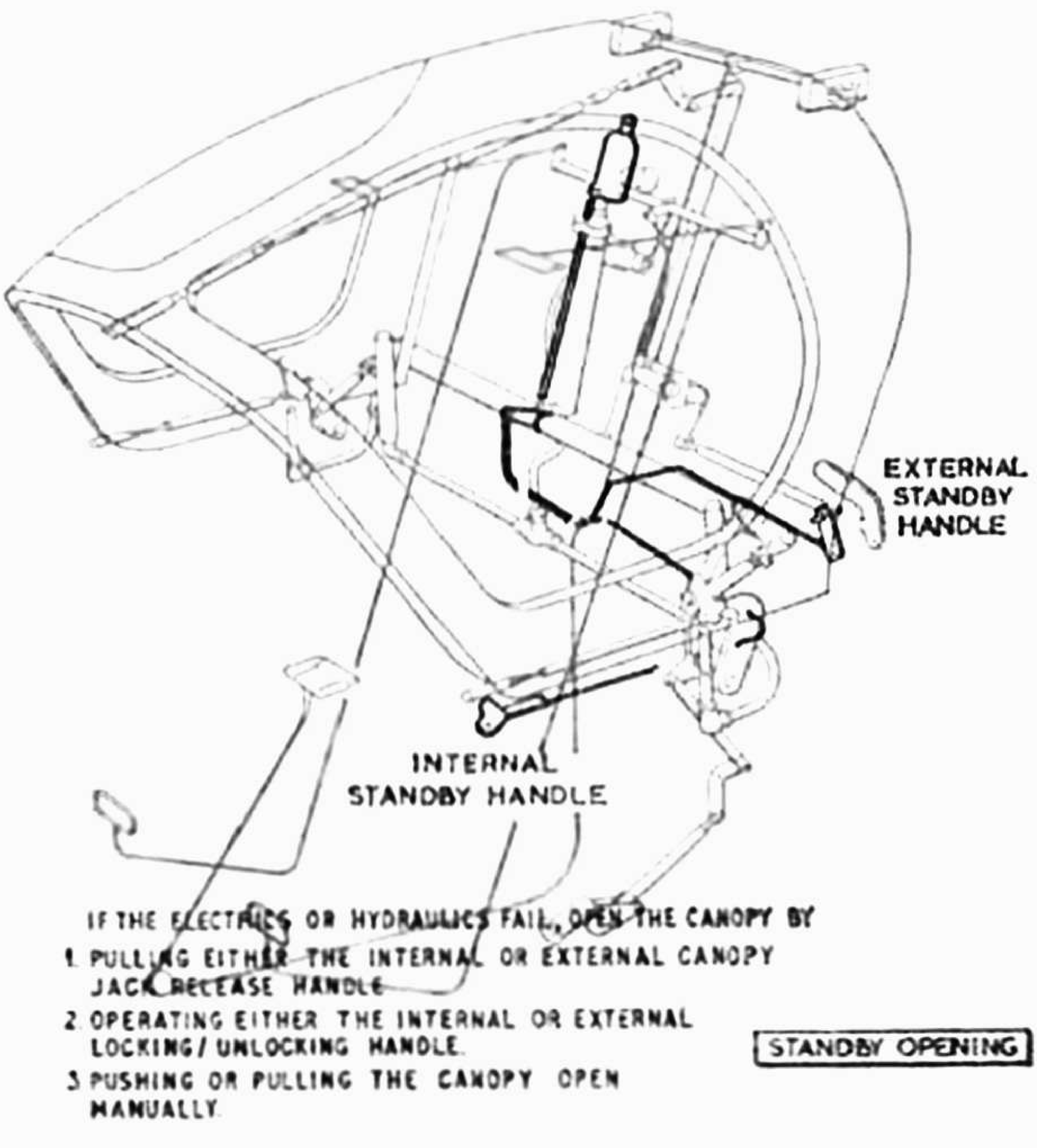
(*c*) When closing and locking the canopy, the last few degrees of downward movement of the CANOPY handle





Canopy mechanism and operation





Canopy mechanism and operation

or the external CANOPY LOCKS handle causes the canopy seal to be inflated (see Part I, Chapter 10, para. 3).

(*d*) An electric buzzer on the rear pressure bulkhead gives audible warning whenever the canopy is being operated.

(*e*) Whenever the canopy is not locked a CANOPY warning will appear on the AWP provided a DC electrical supply is available.

(*f*) Three mechanical indicators, one on each inside face of the lower canopy frame and one at the top frame, show the position of the canopy shoot-bolts. Each indicator on the lower canopy frame is marked CANOPY — FREE/LOCKED.

2 Canopy emergency operation

(*a*) A CANOPY JACK RELEASE lever, located on the cockpit port wall, may be used to open the canopy on the ground if the normal system fails. To prevent inadvertent operation, the lever is retained in its unoperated position by a thin copper wire. The lever should be pulled inboard to free the jack-head, the normal CANOPY handle pulled up and the canopy pushed upwards physically (from the outside, as it is almost impossible to raise the canopy while sitting in the seat.) A similar release lever for external use is adjacent to the CANOPY LOCKS handle in the port spine.

(*b*) If, in hydraulic or electrical failure conditions, the canopy opens only slightly after a normal selection, it may not be possible to free the jack-head either by use of the CANOPY JACK RELEASE or by the canopy jettison system. Proceed as follows:

(i) Close the canopy by selecting and holding CLOSED on the OPEN/CLOSED switch (manual assistance may be necessary to close the canopy).

(ii) Push the CANOPY handle down to lock.

(iii) Operate the CANOPY JACK RELEASE.

(iv) Pull the CANOPY handle upwards taking care not to operate the OPEN/CLOSED switch.

(v) With external aid, physically lift the canopy.

(*c*) If it is vital to vacate the aircraft quickly, do not attempt to unlock the canopy. Use the CANOPY JETTISON flap, but see para. 3(b).

3 Canopy jettison

(*a*) The canopy may be jettisoned by lifting through 90° to the vertical position, a yellow and black striped flap located at the aft end of the centre console, or on ejection, by pulling the face-screen or seat-pan firing handle of either ejection seat. An external jettison handle, labelled EMERGENCY CANOPY JETTISON, is fitted flush with the skin on the port side of the fuselage below the cockpit. Operating any one of these controls withdraws the sear of the canopy jettison firing unit which fires a charge to unlock the canopy, free the hinges and the hydraulic jack end-fitting and jettison the canopy by means of two jettison jacks.

(*b*) If the nosewheel has collapsed and the canopy is jettisoned, there is a danger of the canopy falling back on the cockpit.

4 Internal lighting

(*a*) The internal cockpit lighting is divided into four groups, each controlled by a rotary dimmer switch located above the port console. The DIMMERS switches are labelled PORT, E2B & BRIDGE, FLYING INSTS., and STBD and control the lighting for the port console, bridge panel and E2B compass, main instrument panel, and starboard console respectively. Contacts in the FLYING INST. switch effect automatic dimming of the attention lights when this switch is selected on.

(*b*) The lighting for the main instrument panel and bridge panel is mainly provided by pillar lamps. The port and starboard consoles are illuminated by red floodlighting.

5 Emergency internal lighting

(*a*) If the normal cockpit lighting fails, cockpit emergency lighting may be selected by switching ON the EMERGY LIGHTS switch on the main instrument panel. Emergency lighting is supplied from a lampholder, fitted with an amber filter, located on the canopy top centre member. The electrical supply is taken from the emergency battery.

(*b*) Two high intensity white anti-dazzle lamps are mounted on the canopy top centre member and are controlled by an adjacent BRIGHT/off/DIM switch.

6 External lighting

The external lighting is taken from the DC supply and is controlled by the NAVN. LTS.—STEADY/OFF/FLASH switch and by the TAXY LIGHTS switch. Both switches are on the main instrument panel.

7 First-aid kit

A first-aid kit is mounted in the cockpit on the left side of the rear bulkhead.

8 Hand operated fire extinguisher

◀Pre mod 0244/STC a hand operated, water glycol, fire▶ extinguisher is fitted on the pressure bulkhead behind and above the port seat.

PART 1

Chapter 10 — PRESSURISATION AND AIR CONDITIONING

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MANAGEMENT OF THE SYSTEM	
Cabin air and temperature control	7
MALFUNCTIONING OF THE SYSTEM	
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Emergency decompression	10

Description

1 Cabin air system

(*a*) Air tapped from the engine compressors is used to pressurise the cockpit and regulate the cockpit temperature. An electrically-operated shut-off valve controls the supply of air. When the valve is selected open, the main flow of air is passed through a refrigeration system. The remainder of the air supply is routed to by-pass the refrigeration system and is fed through a pressure-reducing valve and a temperature controller, the latter varying the amount of air through the by-pass. The supply from the by-pass is then mixed with the cold air supply from the refrigeration side of the system and delivered to the cockpit via a water extractor.

(*b*) The refrigeration system comprises a pre-cooler using ram air as a cooling medium, a water boiler and a cold air unit.

(*c*) At the cockpit, the conditioned air is fed to a spray pipe on the rear pressure bulkhead and to two dual nozzle valves below the main instrument panel, one to each station. The efflux from each of the valves can be directed to the pilots' bodies or legs as desired by selecting FACE or FEET at the valves. If the valve is set to the vertical position, air will be directed through both nozzles of the valve.

(*d*) A ram air valve is on the cockpit port wall; when the valve is selected open it allows air at atmospheric pressure and temperature to enter the cockpit.

2 Pressure controller

(*a*) A pressure controller on the forward pressure bulkhead controls the cockpit pressure automatically by regulating the action of an air discharge valve. At about 7,500 ft. the unit commences to control the discharge of air and as height is increased the cockpit pressure builds up until the full differential of 4 PSI is reached at about 32,000 ft., above which it is maintained constant.

◀(*b*) Severe overpressurisation is normally prevented by relief valves built into the air discharge valve ,which open if cabin pressure exceeds approximately 4·5 PSI. If overpressurisation occurs, the following action must be taken:

(i) At cabin differential pressures above 4·0 PSI but below 6 PSI, restrict speed to 1·3M/500 knots.

(ii) At cabin differential pressures of 6 PSI or above, reduce speed to below 1·3M/500 knots and return to base and land.

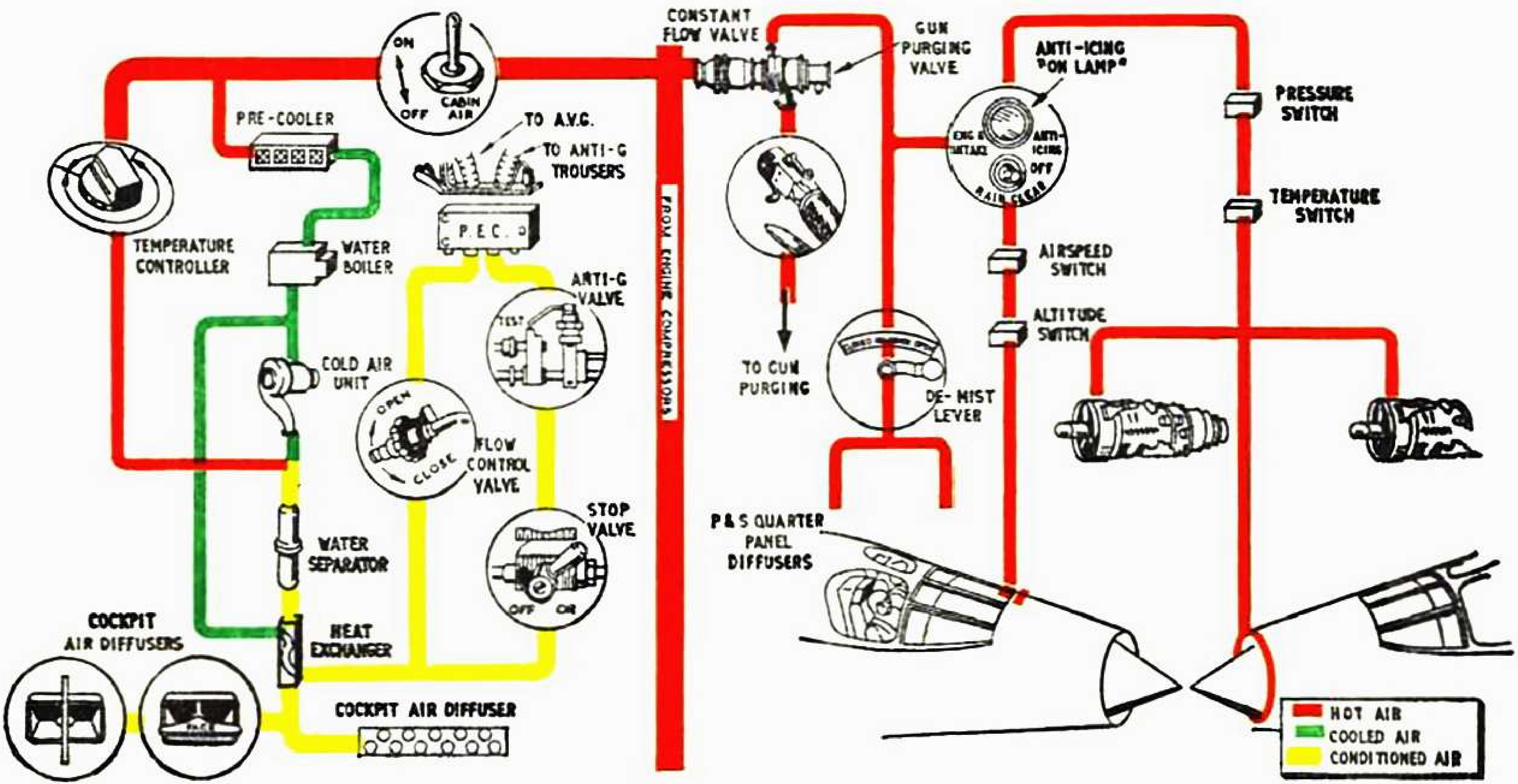
(*c*) Corresponding values of aircraft altitude and cabin altitude are as follows: —

Aircraft altitude	*Cabin altitude at 4PSI*	*Cabin altitude at 6PSI*
35,000 ft.	17,750 ft.	11,500 ft.
45,000 ft.	22,500 ft.	15,500 ft.
55,000 ft.	26,500 ft.	18,000 ft. ▶

3 Canopy seal

(*a*) When the canopy is closed, final movement of either the internal or external canopy locking handles operates a pneumatic valve to allow air to inflate the canopy seal. Similarly, initial movement of either handle when unlocking the canopy will cause the seal to deflate.

(*b*) If the canopy handle is not fully home during locking, the canopy seal may not fully inflate and pressurisation may be lost.



Air system controls

4 Cabin air controls

(*a*) Air conditioning of the cockpit is controlled by a CABIN AIR switch on the bridge panel. With the switch selected ON the electrically-operated shut-off valve is opened to allow air to pass to the cockpit.

(*b*) Two duel nozzle valves are located below the main instrument panel, one at each station. The controls on the valve are marked FACE and FEET.

(*c*) A ram air OPEN/CLOSED control is on the cockpit port wall. To operate the valve the spring-loaded handle must first be pulled out to disengage the lock.

◀(*d*) A Mk. 21 cabin altimeter is on the starboard console. It indicates the cockpit pressure in terms of altitude. ▶

5 Cockpit temperature control

(*a*) A CABIN AIR TEMP controller is located on the main instrument panel. The controller is divided into a black AUTO sector and a red MANUAL sector. COOL and WARM are marked at opposite ends of each sector and a central FIXED position is marked on the MANUAL sector.

(*b*) When the temperature control selector is in the MANUAL sector it is self-centring to the FIXED position. The control must be held to either WARM or COOL until the desired temperature is attained. The valve takes about 20 seconds to move from full warm to full cool and a time delay of about one minute will occur before the full effect of a temperature change is felt.

(*c*) When the temperature control selector is in the AUTO sector is remains in the position selected and the temperature is automatically regulated by the temperature control valve.

6 Pressurisation failure indication

A serious reduction in cockpit pressure is indicated by the illumination of the CPR warning on the SWP.

Management of the System

7 Cabin air and temperature control

(*a*) During the internal checks, set the CABIN AIR switch to ON. The switch should normally be left in this position for the duration of the flight. Before take-off ensure that the ram air valve is closed.

(*b*) Set the CABIN AIR TEMP controller into the AUTO sector as required. Variations in the selected temperature can be expected with large changes in speed or altitude. If a new temperature is selected there will be a delay of about one minute before it is obtained.

(*c*) The MANUAL sector of the CABIN AIR TEMP. controller is not normally used. If the AUTO facility fails, however, the selector should be moved into the MANUAL sector and held at either COOL or WARM as required. There will be a similar delay between selecting and obtaining a new temperature.

Malfunctioning of the System

8 Pressurisation failure

Pressurisation failure is indicated by the CPR warning appearing on the SWP and can be confirmed by the cabin altimeter. If the failure occurs at high altitude, an immediate descent must be made to 35,000 feet cabin altitude and the oxygen mask toggle set to the down position. 100% OXYGEN should be selected, the regulator test lever set to EMERGENCY and the DEMIST control set to OPEN. The descent must then be continued to a cabin altitude of 25,000 feet or below for decompression sickness reasons and a return to base made at the lowest practicable altitude. Ram air may be used as necessary for ventilation.

9 Temperature control failures

If excessive overheating or overcooling occurs, select MANUAL on the temperature controller and hold at COOL or WARM as necessary for 10-15 seconds. If the temperature responds, leave the controller in the MANUAL sector making manual adjustments as required. If the overheating or overcooling persists, however, proceed as for a pressurisation failure and select CABIN AIR to off.

10 Emergency decompression

If it is necessary to decompress the cockpit, e.g. prior to ejection, set the CABIN AIR switch to off and open the ram air valve.

PART 1

Chapter 11 — WINDSCREEN DEMISTING AND RAIN DISPERSAL

Contents

DESCRIPTION	Para
Windscreen and canopy demisting	1
Canopy interspace demisting	2
Rain dispersal	3

Description

1 Windscreen and canopy demisting

(*a*) The port and starboard front windscreens and the port sidescreen are electrically heated by inter-laminar elements fed from the AC supply system. A temperature control unit in each circuit prevents overheating by automatically interrupting the supply to the elements. Three NESA switches on the bridge panel, marked PORT, STBD, and SIDE control the heating to the port main windscreen, the starboard main windscreen and the port sidescreen respectively. The electrical supply to the front windscreens is additionally controlled by the 165 knots pressure switch associated with the undercarriage so that only half heat is applied below this speed and full heat above it.

(*b*) The port and starboard sidescreens are fitted with hot-air diffusers controlled by the DE-MISTER lever below the port console. With the lever at OPEN, hot air is supplied to the sidescreens through two spray pipes at the base of the sidescreens. This facility should only be used if electrical demisting fails or is inadequate. As soon as demisting is complete select the DE-MISTER to CLOSED.

2 Canopy interspace demisting

Air in the canopy interspace is dried by passing it through chemical air driers. The air is circulated by a blower motor controlled by the SIDE nesa switch on the bridge panel.

3 Rain dispersal

(*a*) The system improves forward visibility through the port windscreen in rain. A centre strip is completely cleared and an area surrounding the strip is partially cleared. The cleared area is larger in moderate rain than in heavy rain. Air trapped from both engine compressors is directed to a nozzle assembly located in the fuselage skin upstream of the windscreen. This assembly has two angled nozzles away from the windscreen and a wiper nozzle at the base of the windscreen; the efflux from the angled nozzles creates high turbulence of the airflow breaking up large rain droplets, whilst the jet of hot air from the wiper nozzle keeps an area of the windscreen free from moisture.

(*b*) The system is controlled by the ENG & INTAKE ANTI-ICING/OFF/RAIN CLEAR switch, when set to RAIN CLEAR, on the bridge panel. Two pressure operated switches automatically limit its operation to below 10000 ft altitude and 350 knots airspeed.

◀(*c*) The system should be exercised before each flight during the "Checks after starting" thus reducing the possibility of valve seizure due to corrosion. ▶

(*d*) Limitations on the use of rain dispersal are given at Part 2 Chap 1.

PART 1 — DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 12—AIRCREW EQUIPMENT ASSEMBLY AND ASSOCIATED SYSTEMS

(Completely revised by AL10)

Contents

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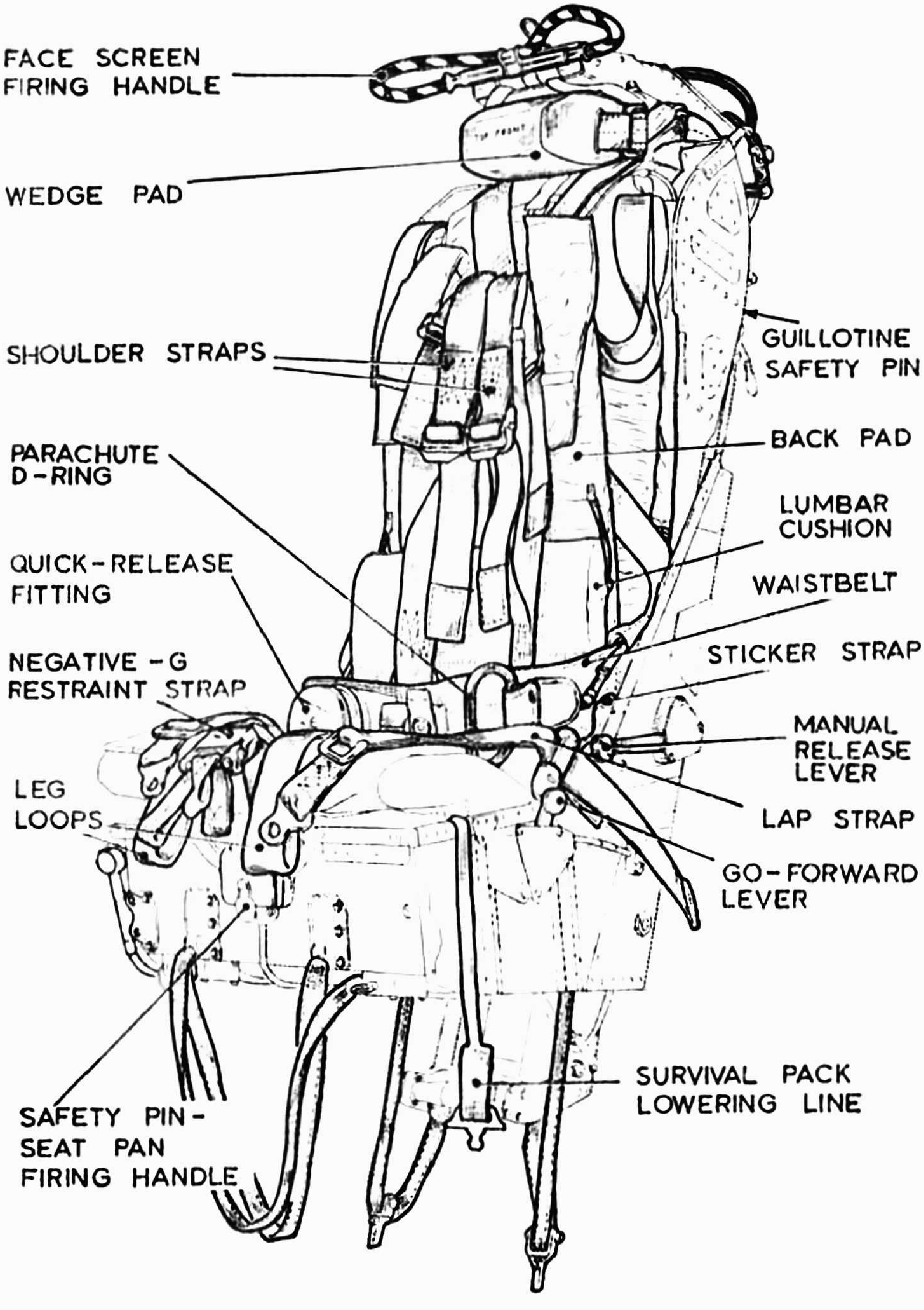
WARNING: Whenever the aircraft is on the ground, the ejection seat must be "safe for parking", i.e. the safety pins must be fitted to the face-screen firing handle, to the seat-pan firing handle and in the guillotine unit sear.

Ejection Seat

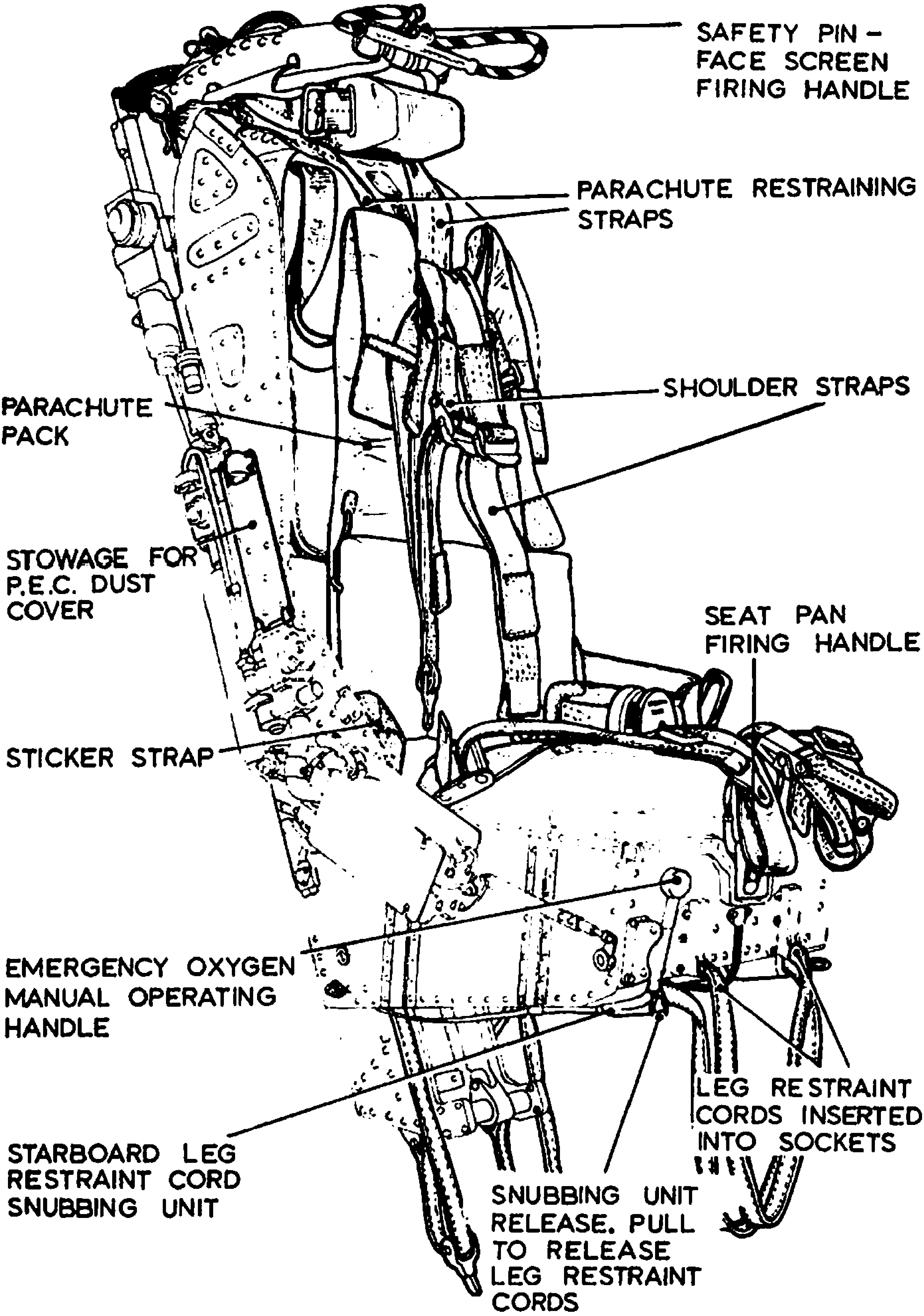
1 Ejection Seat Type 4BST Mk 2 — General

(*a*) A Type 4BST Mk 2 ejection seat is fitted in the aircraft. The associated parachute assembly is a Back Type Mk 45: this embodies a horseshoe parachute pack and a



Type 4BST Mk 2 Ejection Seat

Port Side



Type 4BST Mk 2 Ejection Seat

Starboard Side

combined safety and parachute harness fastened by a quick release box, the pack being held in position by two restraining straps at the upper end. A back pad and lumbar cushion are included in the harness for comfort and support. A negative-G restraint strap is fitted to restrain the pilot against vertical movement when subjected to negative-G forces; this strap should be tensioned during strapping-in. A Type V personal survival pack (PSP), complete with cushion, containing a dinghy and survival equipment, is housed in the seat pan. Two leg restraint cords are fitted to the front of the seat pan. An emergency oxygen bottle is mounted on the starboard seat beam. A guillotine unit is incorporated to assist in manual separation.

(*b*) A pack restraint spreader system is incorporated. This consists of two arms mounted just beneath the parachute support arch which swivel forward giving quicker release of the parachute pack restraining straps during separation after an ejection.

(*c*) At the rear of the seat is the 80 ft/sec ejection gun. The seat has two firing handles, both of which are provided with safety pins. One, which has an integral face screen, projects from the front of the drogue container; the other is positioned centrally on the front face of the seat pan.

(*d*) A drogue gun is mounted on the port seat beam. For ejection at high speed below 10000 ft a G-controller switch is fitted. This delays operation of the barostat time-release unit until the forward speed of the seat and pilot has been sufficiently reduced to ensure safe parachute deployment. The seat has a ground-level ejection capability provided the aircraft's flight path is parallel to the ground with a minimum forward speed of 90 knots.

2 Seat adjustment and lean-forward release

◀(*a*) On each seat, height may be adjusted by an electric motor controlled by a switch unit marked SEAT — UP/off/DOWN positioned on the port and starboard cockpit walls. The seat pan moves relative to the headrest and▶ can therefore accommodate different body lengths, at the same time ensuring that the occupant's head is correctly located whatever the position of the seat pan. The switch is spring-loaded to the central (off) position and operates in the natural sense, i.e. a downward movement of the switch lowers the seat and vice-versa.

(*b*) An inertia-reel go-forward system is fitted. It is controlled by a three-position spring-loaded lever on the port side of the seat pan. When the lever is moved fully forward and then allowed to return to the central position the pilot can lean forwards or backwards at will. An automatic inertia device locks the harness during an ejection or if more than 2½G in the forward plane is experienced. Movement of the lever to the rear position brings into action the snubbing unit in the top harness lock thus preventing further forward movement: as the wearer leans back the harness is locked in the rearward position.

3 Personal equipment connector (PEC)

The PEC is fitted to the starboard side of the seat pan and provides R/T, intercomm, oxygen and supplies to both the air ventilated and anti-G suits. It consists of three components; a seat portion which is fitted permanently to the starboard side of the seat pan; a man portion which is fitted to the flying clothing; and an aircraft portion which disconnects automatically on ejection. The system allows the services to be either connected or disconnected in one action. On ejection the services are automatically disconnected. Emergency oxygen is supplied through the PEC but is only provided on ejection or when selected. The leg restraint system is also interlinked; disconnecting the man portion of the PEC releases the restraint cords.

4 Combined harness quick-release box

The quick-release box, when fastened, secures the combined restraint and parachute harness and therefore secures the pilot to the seat. *On no account must this box be operated when carrying out manual separation in the air since this will free the pilot from both seat and parachute.*

5 Manual separation

(*a*) Manual separation of the parachute from the seat is effected by a guillotine unit. The unit is positioned on the port side of the drogue container and incorporates a sear safety pin for use during servicing. The parachute withdrawal line passes through the guillotine unit, the sear of which is connected to the parachute pack by a static line. The parachute withdrawal line is severed by the guillotine unit firing as a result of forward movement of the pilot in the seat during manual separation.

(*b*) A manual separation lever is at the port side of the seat pan. When pulled out of its gate and upwards, the combined harness is released from its three attachment points and the parachute restraining straps are also released; at the same time the man portion of the PEC and the leg restraint cords are released. As the pilot leaves the seat, the guillotine unit operates.

NOTE: If the lever is inadvertently operated, the seat must subsequently be serviced by suitably qualified maintenance personnel.

6 Rip-cord D-ring

The rip-cord D-ring is provided for manual opening of the parachute should the ejection seat fail to fire or the automatic opening of the parachute fail after ejection.

7 Leg restraint cords and adjusting controls

(*a*) The cords ensure that the pilot's legs are drawn back automatically and restrained close to the seat pan during ejection thus providing clearance and preventing the legs being blown apart after ejection. The cords are attached to the aircraft structure at their lower ends and pass through the snubbing units beneath the front of the seat pan, which allow the cords to pass freely down through the units but prevent them passing upwards. An adjusting ring on each snubbing unit, when pulled forward, allows the pilot to adjust the cords to give sufficient leg movement for application of full rudder. The ends of the cords plug into units on the forward face of the seat pan.

(*b*) After ejection, the legs are held in position until auto or manual separation occurs; the restraint cords are then free to pull through the garter D-rings.

8 Normal operation of the seat

(*a*) When either firing handle is operated the canopy is jettisoned immediately: this in turn removes an interdictor from the time-delay firing unit (TDFU). Continued pressure on the firing handle is necessary however, to remove the sear on the TDFU after the canopy has gone: after a delay of 0·4 seconds the seat is ejected. The drogue gun, which is operated by a static rod, fires ½ second later. The 'double pull' effect is unlikely to be noticed if the system operates normally. The main purpose of this system is to ensure that the seat is not in a 'live but unfired' condition if the canopy fails to jettison. If the seat pan firing handle is used, press the head firmly back against the head rest cushion to minimise the risk of spinal injury on ejection. Leave the feet on the rudder pedals; drawing the feet back could lead to injury.

NOTE: The seat cannot eject if the canopy fails to jettison.

(*b*) On ejection the aircraft portion of the PEC is disconnected from the seat portion; on separation the man portion of the PEC disconnects from the seat.

◀(*c*) When SRIM 3772 is embodied, provided the IFF/SSR transponder is operating, the emergency coding signal is automatically triggered on pilot ejection. The facility is fitted to both seats. ▶

(*d*) As the seat is ejected a static rod readies the barostatic time-release mechanism. When the seat has descended on the drogue to 10000 ft (or 5000 metres, depending upon modification state) or at once if ejection has taken place below that height and provided the G-stop has not operated, the barostat removes an obstruction to the gear train of the mechanism allowing it to operate. After 1¼ seconds the combined harness is released from the seat, the seat-stabilising drogues are freed and, by a drogue link line, the face screen is disconnected and the parachute deployed. The pilot may momentarily be prevented from leaving the seat by two restraining straps until deployment of the parachute lifts him clear of the seat.

Anti-G and AVS Systems

9 Anti-G system

(*a*) Partially cooled air from the cabin air conditioning system is fed via a stop valve to the barometric/anti-G valve. When the latter operates, air at controlled pressure is admitted via the PEC to the pilot's anti-G suit. On this aircraft the anti-G suit is inflated when positive accelerations are applied or if the cabin altitude exceeds 35000 ft.

(*b*) The stop valve is controlled by a handle on the starboard console, and is provided with a spring-loaded catch retaining it in the OFF (forward) or ON (aft) positions. The stop valve is for emergency use only and should normally be in the ON position. In the event of failure of the barometric/anti-G valve and a build-up of pressure in the anti-G suit the stop valve should be placed in the OFF position when the suit will deflate. If the stop valve is inadvertently left at OFF there will be no protection to the lower part of the body in the event of loss of cabin pressure at high altitude.

(*c*) (i) Under G conditions the barometric/anti-G valve applies a pressure to the anti-G suit according to the severity of the G force applied. A selector valve on the starboard console, when set to H, admits pressure to the suit at 1·25 PSI per G applied (but not below approximately 1·9G applied) and, when set to L, at 1·05 PSI per G applied (but not below approximately 2·25G applied). The setting of the valve is determined by individual requirements; it should not be necessary to change from one setting to the other in flight.

(ii) If loss of cabin pressure occurs at high altitude, the barometric/anti-G valve applies pressure to the anti-G suit at a value of approximately 0·5 PSI greater than the oxygen system applies pressure to the lungs and pressure jerkin.

(*d*) A test button at each anti-G valve permits the system to be tested provided an engine is running, the PEC is connected and the stop valve switched ON. Pressure should be felt in the suit.

10 Air ventilated suit system

(*a*) Partially cooled air tapped from the cabin air conditioning system is used to provide the air ventilated suit supply. The flow controllers for pupil and instructor are between the ejection seats and on the starboard console inboard face respectively. The rotary control is turned clockwise to OPEN. The temperature of the air supply to the suit is controlled by the CABIN AIR TEMP controller.

(*b*) An AVS ground air supply connection is on the starboard side of the fuselage.

Oxygen System

11 General description

Oxygen is stored in four cylinders, each of 750 litres capacity, in the equipment compartment aft of the rear pressure bulkhead. An oxygen contents gauge is on the starboard instrument panel. A pressure reducing valve reduces the oxygen pressure to 200-400 PSI before the oxygen is fed to the regulators, one for each station, positioned below the main instrument panel; these deliver oxygen on demand to the pilots via the PEC.

12 Pressure demand regulator

(*a*) The height limitations for the Mk 21B regulator and various types of flying clothing worn are listed at (*b*) (iii) below.

The regulator controls and indicators are as follows: —

(i) An OXYGEN SUPPLY — ON/OFF cock, wired to ON, controls the oxygen entering the regulator.

(ii) A pressure gauge indicates the input pressure. This should read between 200-400 PSI when the OXYGEN SUPPLY cock is ON.

(iii) An OXYGEN FLOW INDICATOR shows a white vertical bar when oxygen is being drawn from the regulator on breathing in and black when no flow is taken on expiration or if there is no electrical supply to the regulator. A repeater indicator for each station is on the port and starboard sides of the main instrument panel respectively.

(iv) An air dilution switch marked NORMAL OXYGEN/100% OXYGEN (see (*c*) below).

(v) A lever marked NORMAL/EMERGENCY/MASK TEST/JERKIN TEST (see (*d*) below).

(*b*) (i) The pressure demand regulator must only be used with the types of oxygen mask and associated clothing as listed at paras 17 and 18. Other types of oxygen mask are not compatible, even at low altitudes. Oxygen is supplied to the pilot on demand under all operating conditions and is used to provide inflation of the pressure garment when cabin altitude exceeds 40000 ft approximately. At cabin altitudes below 10000-12000 feet, oxygen is delivered at ambient pressure and above this height, up to 40000 feet, it is delivered under a slight "safety pressure" to ensure that any mask leakage, perhaps due to a badly fitting or wrongly adjusted mask, is outward.

(ii) Above 40000 feet a pressure of oxygen will be maintained in the lungs adequate to prevent hypoxia so that an emergency descent may be performed.

(iii) Following loss of cabin pressurisation at high altitude, the harness toggle of the oxygen mask must be moved to the down position and an immediate descent at maximum rate made to a cabin altitude of below 40000 feet. Continue a rapid descent to below 25000 feet (cabin altitude). The limits of protection afforded by the various combinations of regulator and personal equipment are: —

Mk 21 regulators

Personal Equipment	*Limiting altitude*	*Total time from loss of cabin pressure to 40000 ft cabin altitude*	*Initiate descent in:*
P or Q mask	45000 ft	2 min	½ min
P or Q mask with sleeveless jerkin and anti-G trousers	56000 ft	2 min	½ min

NOTE: Aerodynamic suck will cause the cabin altitude to exceed aircraft altitude by up to 11000 ft. if the canopy is lost.

(*c*) (i) With the air dilution switch at NORMAL OXYGEN, an air/oxygen mixture of appropriate proportions is delivered up to a cabin altitude of about 32000 ft. Above this altitude only 100% oxygen is supplied. This conserves the oxygen supply but makes recognition of low flow delivery from the regulator difficult.

(ii) With the air dilution switch at 100% OXYGEN, neat oxygen only is delivered at all altitudes. If the cabin becomes filled with smoke or noxious fumes, 100% OXYGEN should always be selected.

(*d*) (i) The regulator characteristics described at (*c*) above are obtained when the test lever is at NORMAL. When this lever is set to EMERGENCY, oxygen is delivered at a slightly greater pressure than normal, i.e. approximately safety pressure up to 10-12000 ft cabin altitude and approximately double safety pressure above this height.

(ii) The MASK TEST and JERKIN TEST positions of the test lever are intended only for ground checks prior to take-off. To select either of these positions the knurled knob on the end of the lever must first be pulled out. The JERKIN TEST position must not be used unless a pressure jerkin is worn.

13 Emergency oxygen

(*a*) The emergency oxygen set is located on the back of the ejection seat and feeds its supply into the rear of the seat portion of the PEC and thence into the oxygen mask tube. If failure of the main oxygen system occurs emergency oxygen may be manually selected by pulling up the yellow and black striped knob on the front of the ejection seat. On ejection, the operation is entirely automatic, the movement of the seat up the rails initiating the supply. When the pilot separates from the seat after ejection the separation of the man and seat portion of the PEC breaks the emergency oxygen supply and allows air to be breathed. An emergency oxygen demand regulator is fitted between the emergency oxygen set and the PEC.

(*b*) The function of the demand regulator is to control the supply from the emergency oxygen cylinder and to regulate the delivery in accordance with the physical requirements of the user at altitude. A pressure/contents gauge is fitted at the starboard rear of the ejection seat; the reading on the gauge should indicate in the white sector before flight.

14 Normal management of the oxygen system

With the regulator cock set to ON, oxygen is supplied to the pilot on demand once the man portion of the PEC is connected to the seat portion.

15 Pre-flight checks

NOTE: Comprehensive pre-flight checks of all personal equipment should be carried out on a Godfrey Test Cabinet with the assistance of a Safety Equipment Worker. The following checks are necessary to check aircraft equipment.

(*a*) Check that the oxygen contents gauge shows a minimum of $\frac{7}{8}$ths.

(*b*) Check that the main ON/OFF cock on the regulator is wired to ON.

(*c*) Check that the input pressure gauge indicates a supply pressure of 200-400 PSI.

(*d*) Set the air dilution switch marked NORMAL/100% OXYGEN to NORMAL.

(*e*) Check that both OXYGEN FLOW INDICATORS annunciate during breathing.

(*f*) Using the lever marked NORMAL/EMERGENCY/MASK TEST/JERKIN TEST check as follows: —

(i) Setting the lever to EMERGENCY check that an increase in safety pressure is felt. Check the flow indicators show BLACK when the breath is held.

(ii) Having moved the harness toggle on the oxygen mask into the down position select MASK TEST. Oxygen will now be fed under pressure into the mask. Holding breath check that the flow indicators show BLACK. Return both toggle and lever to normal positions.

16 Oxygen system malfunctions

In the event of a system malfunction warn the other crew member and proceed as follows:—

(*a*) *Suspected hypoxia*

Check oxygen connections and mask fit
Operate emergency oxygen
Descend to a cabin altitude of 10000 feet or below

(*b*) *Difficulty in breathing in*
Oxygen Flow Indicator malfunction
Low pressure on regulator gauge

Check oxygen connections, mask hose and mask fit
Select 100% OXYGEN

If able to breathe normally	If unable to breathe normally or white oxygen flow indicator persists
Continue sortie with frequent checks of oxygen contents and pressure	Operate emergency oxygen Descend to a cabin altitude of 10000 feet or below

(*c*) *Difficulty in breathing out*
Check cabin altitude

If cabin altitude below 40000 feet

Mask off face momentarily
Set regulator lever to MASK TEST

If difficulty persists

Ease mask off face
Descend to a cabin altitude of 25000 feet

No further difficulty
Continue with sortie

If cabin altitude above 40000 feet

Mask toggle down
Descend at maximum rate through 40000 feet
Continue a rapid rate descent to a cabin altitude of 25000 feet

(*d*) *Toxic fumes*
Select 100% OXYGEN
Set regulator test lever to EMERGENCY

NOTE: If the emergency oxygen set is used and exhausted, inhalation will become difficult, this can be relieved by setting the dilution lever to NORMAL OXYGEN or by disconnecting either the mask or helmet hose.

Flying Clothing

17 Low altitude assembly

For flights below 36000 feet aircraft altitude the following equipment should be worn: —

Air ventilated suit Mk 2A or 2C
Anti-G suit Mk 7B

Coveralls Mk 7 (summer) or
Immersion coverall Mk 10 (winter) and
Inner coverall Mk 1 (winter)
Boots flying, lightweight
Garters — leg restraint
Helmet flying type G } or Helmet protective Mk 3B
Helmet protective Mk 1A }
Oxygen mask P2A or Q2A
Oxygen mask hose assembly Mk 1
Life preserver Mk 14 or 14A

18 High altitude assembly

For flights above 36000 feet aircraft altitude the following equipment should be worn: —

Air ventilated suit Mk 2A or 2C
Anti-G suit Mk 7B
Coveralls Mk 7 (summer) or
Immersion coverall Mk 10 (winter) and
Inner coverall Mk 1 (winter)
Boots flying 1965 pattern
Garters — leg restraint
Helmet flying type G } or Helmet protective Mk 3B
Helmet protective Mk 1A }
Oxygen mask P2A or Q2A
Pressure jerkin hose assembly Mk 2
Pressure jerkin Mk 1 or Mk 4

Flight Procedures

19 Pre-flight checks

(*a*) Ensure that the face-screen and seat-pan firing handle safety pins are fitted and that the manual separation lever is fully down.

(*b*) Check that the harness is securely attached to the seat by pulling on the straps individually at each attachment point.

(*c*) Ensure that there is no safety pin fitted in the canopy jettison sear and that the drogue gun safety lock pin has been removed. Remove and stow the safety pin from the guillotine unit sear. Check that the parachute guillotine cable is attached to the guillotine sear.

(*d*) Ensure that the drogue gun and barometric time-release mechanism trip rods are connected to their brackets.

(*e*) Check that the drogue withdrawal line is routed over the top of all other lines and is connected to the top of the drogue gun piston by shackle pin. Check that the drogue link line is routed outside the parachute restraint strap. Ensure that the parachute withdrawal line is routed through the guillotine unit (yellow flap) and is connected to the drogue link line.

(*f*) Check that the centre pin and the top latch plunger are flush with the latch housing.

(*g*) Check that the face-screen firing cables are connected to the canopy gun sear and to the time-delay firing unit (TDFU) sear. Check that the seat-pan firing cable ring is threaded over the cable to the TDFU sear.

(*h*) Ensure that the scissor shackle is closed and flat.

(*j*) Ensure that the safety catch is fitted between the jaws of the TDFU restrictor. Check that the canopy/ejection seat static line is routed correctly through the rubber eyelet and is connected at one end to the rear base of the canopy and at the other end to the restrictor safety catch.

(*k*) Check that the emergency oxygen contents/pressure gauge is indicating in the white sector.

20 Strapping-in procedures

(*a*) Remove the dust cover from the seat component of the PEC and fit into the stowage on the right-hand of the seat pan. Connect the man portion of the PEC to the seat portion ensuring that it is locked.

(*b*) Connect survival pack lanyard to life preserver or pressure jerkin ensuring that it passes outside the left leg.

(*c*) Pass left-hand leg restraint cord through right leg garter D-ring and plug into the socket above the left-hand snubbing unit. Pass right-hand leg restraint cord through left-hand garter D-ring and plug into socket above right-hand snubbing unit. Pull sharply on each cord to ensure that they are securely locked in their sockets, remembering that unless the man portion of the PEC is locked to the seat component, the leg restraint cords cannot be secured. It is not important which cord is secured first provided that they are not interlaced. If the cords are not long enough to provide the required range of leg movement pull the ring of each snubbing unit and ease the cord forward; slack should be taken up by pulling the cords backwards through the snubbing units.

(*d*) Pull up the parachute back pad and adjust the height of the lumbar cushion. Pass the looped ends of the blue 'Y' section of the negative-G strap over their respective lap strap lugs and connect the lugs to the harness quick-release box; ensure that the right lap strap passes outside the hoses from the PEC and tighten the straps. Tighten the adjustable part of the negative G strap.

NOTE: The lap straps must be as tight as possible.

(*e*) Pass the left leg loop upwards over the inside of the thigh and through the D-ring on the left lap strap (from the inside of the ring towards the outside of the leg). Bring the end of the leg loop over towards the quick-release box and pass the lug of the left shoulder strap through the leg loop (from the top downwards) and insert the lug into its appropriate slot in the quick-release box. Snug the loop over the lug. Repeat these operations with the right leg loop and shoulder strap.

(*f*) Adjust the sitting height to the desired position.

(*g*) Ensure that the shoulder straps pass under the lobes of the life preserver or pressure jerkin stole. Tighten the inner (blue) straps and then the outer (khaki) straps.

NOTE: It is undesirable to tighten these straps excessively since this action may arch the back and lead to spinal injury if ejection becomes necessary. The inner straps should not press down unduly on the shoulders but equally there should be no slack. The outer straps should be adjusted similarly to provide a comfortable fit.

(*h*) Operate the lean-forward lever and lean forward. Move the lever fully back, lean fully back and re-tighten the khaki straps. Failure of the harness to re-engage and lock back indicates that the harness is not secure.

(*j*) Put on helmet and connect oxygen supply and Mic/Tel lead.

(*k*) Check that the face-screen firing handle is resting on top of the protective helmet. Check that the firing handle can be reached with both hands.

(*l*) Have the face-screen and seat-pan firing handle safety-pins removed and placed in their stowages.

21 Leaving the seat after landing

(*a*) Have the safety pins removed from their stowage and fitted in the seat-pan and face-screen firing handles and in the guillotine unit sear. In this condition, the ejection seat is now "safe for parking".

(*b*) Unlock the harness quick-release fitting, free the straps and return the fitting to the locked position.

(*c*) Disconnect the man portion of the PEC and replace the dust cover on the seat portion.

(*d*) Free the leg restraint cords from the garters.

(*e*) Disconnect the personal survival pack lanyard.

22 Abandoning the aircraft in flight

(*a*) If possible, reduce speed to 250 knots and fly in straight and level or climbing flight.

(*b*) Pull the face-screen firing handle fully down over the face ensuring that the elbows are kept well in and that the head and back are pressed firmly against the seat. If the face-screen firing handle cannot be reached, pull up the seat-pan firing handle.

(*c*) If automatic separation fails, operate the manual separation lever and fall clear of the seat. When clear, pull the rip-cord D-ring.

(*d*) *Seat fails to eject*:

(i) If the seat fails to eject, pull the firing handle again. If this fails, pull the other firing handle.

(ii) If the seat still fails to eject, jettison the canopy using the jettison system or, if proved necessary, by use of the CANOPY handle to effect opening; then pull either the face-screen or seat-pan firing handle again.

(iii) If the canopy has left the aircraft and the seat still fails to eject, operate the manual separation lever and abandon the aircraft. When clear, pull the rip-cord D-ring. The emergency oxygen system will be disconnected when separation takes place.

(*e*) When the parachute has developed, check that the survival pack lowering line is connected, disconnect the side quick-release couplings and allow the pack to hang on its lowering line. If descending into water remove the helmet and oxygen mask, but not if descending onto land.

(*f*) The method of initiating ejection must depend upon conditions. Use the seat pan handle *always* if conditions are or are becoming critical — ie below 3000 feet AMSL, or below 5000 feet in an air dive. Use the face-screen if at high altitude and, if you prefer, when time is *not* critical.

NOTE: The time delay which occurs between pulling a seat firing handle and ejection of the seat, applies to both seats.

PART I

Chapter 13 — WARNING SYSTEMS

Contents

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Standard warning system	1
Auxiliary warning system	2

1 Standard warning system

(*a*) The standard warning system ensures that all important emergencies are brought to the notice of the pilot and groups the warnings on a standard warning panel above the port console. All warnings are operative whenever an AC and DC supply is available and the ENGINE START MASTER and the INSTRUMENT MASTER switches are ON. The fire warnings however, are still operative with the ENGINE START MASTER switch at OFF, but they require the INSTRUMENT MASTER switch to be ON.

(*b*) The windows in the standard warning panel (SWP), when illuminated, give warning of the following emergencies.

FIRE 1	Fire in No. 1 engine bay (zones 1 and 2)
FIRE 2	Fire in No. 2 engine bay (zones 1 and 2)
RHT 1	Fire in No. 1 jet pipe area (zone 3)
RHT 2	Fire in No. 2 jet pipe area (zone 3)
GEN	Generator failure
HYD	Failure of No. 1 and No. 2 controls hydraulic systems
CPR	Cockpit pressurisation failure
OXY 1 / OXY 2	Oxygen failure (inoperative)

For night use, a blue translucent panel can be slid over the windows if required.

(*c*) Also on the panel are three buttons, T(test), M(mute) and C(cancel). The M and C buttons contain integral lights. To the rear of the panel are two, F1 and F2, fire extinguisher indicator switch units.

(*d*) Two red attention lights which flash whenever a warning appears, are on the port and starboard sides of the bridge panel. Additionally, an audio warning is heard on the R/T whenever a warning occurs. The audio warning may be attenuated by pulling out the AUDIO WARNING PULL MUTE switch just forward of the SWP.

(*e*) When a warning is received the following indications are given:

(i) The attention lights flash.

(ii) The audio warning sounds.

(iii) The appropriate window on the SWP lights up.

(iv) The C pushbutton light flashes.

(v) If an engine fire has occurred, the appropriate fire extinguisher switch unit lights.

◀(*f*) The audio and flashing warnings can be cancelled by pressing the C button. All warnings cease except for the appropriate SWP caption and, if a FIRE 1 or FIRE 2 warning, the fire extinguisher switch unit light. If AC change-over now occurs, and the warning is FIRE or RHT, the attention getters will be re-activated. Also, if after pressing the C button another warning is received, the audio and attention light warnings operate to draw attention to the new warning. ▶

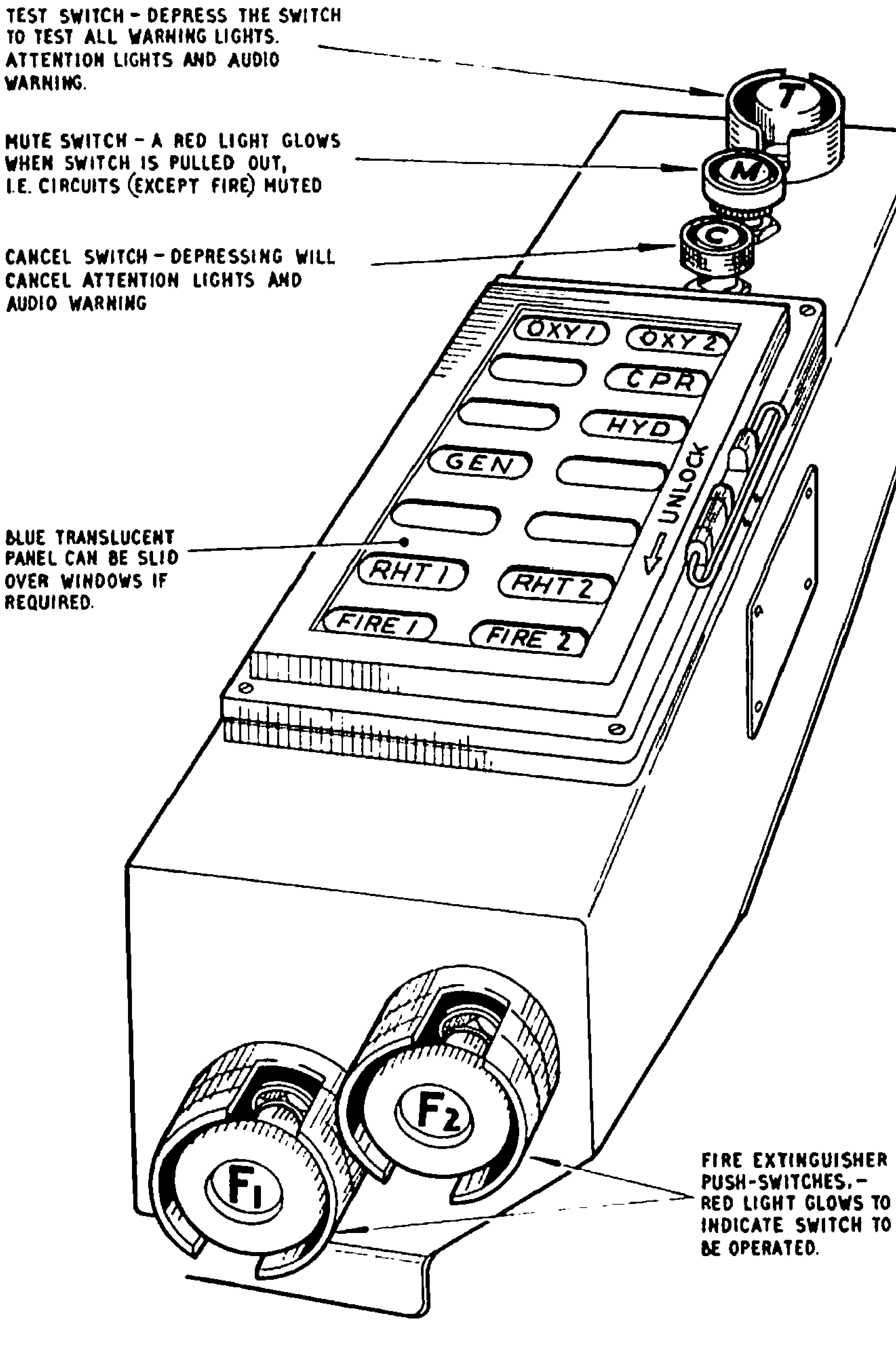
(*g*) ▶◀ If any warning appears transiently but triggers the attention lights and audio warning, these will be removed automatically when the warning disappears.

(*h*) When the M button is pulled out (integral light on) all warnings are rendered inoperative except for the fire warnings. The M button must always be in during flight.

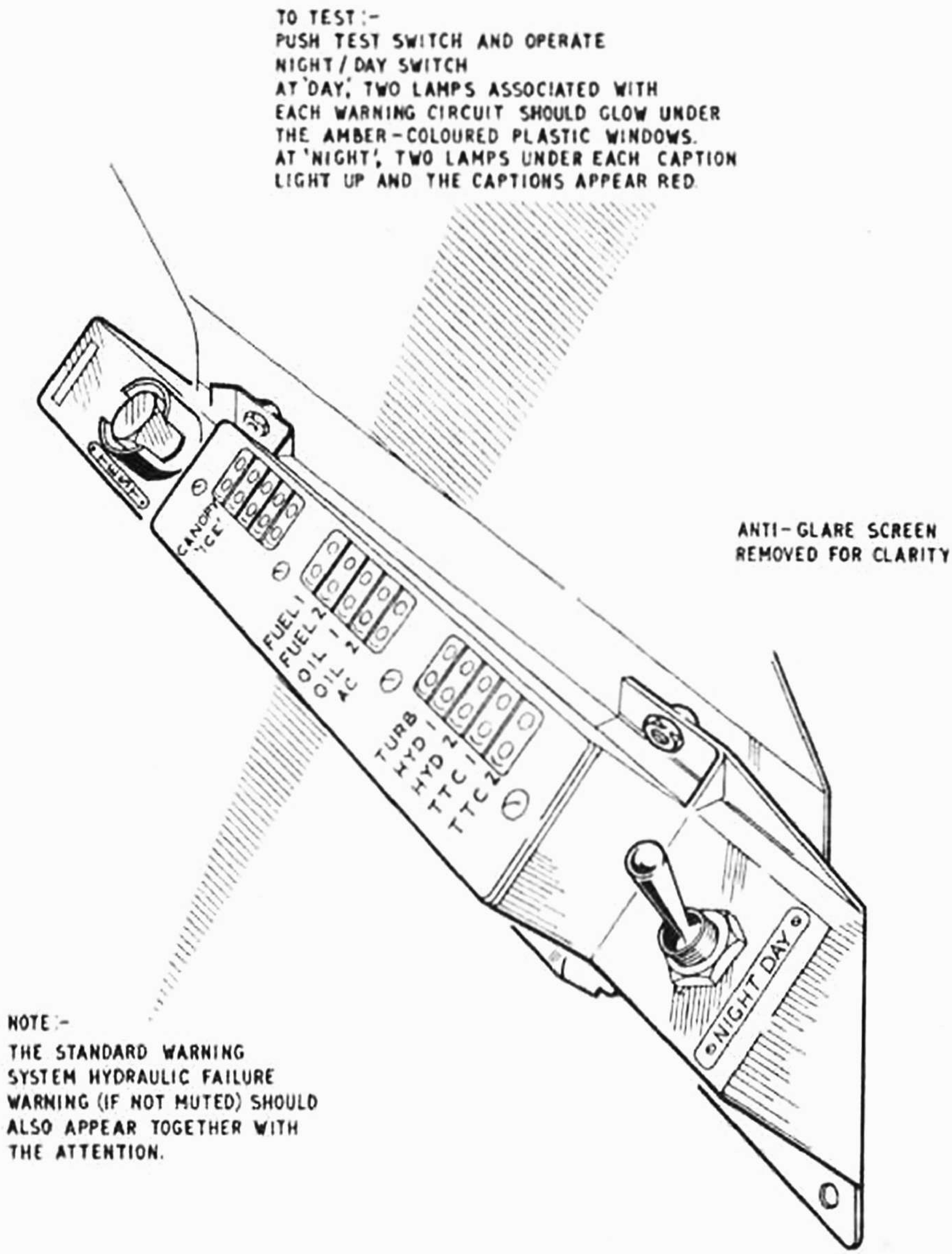
(*j*) The T button, when pressed, causes all indicator lights and warnings to operate providing the M button is in, AC and DC power is available, the UHF is switched on and the ENGINE START MASTER and INSTRUMENT MASTER switches are ON. When the T button is released all warnings will disappear except for the attention lights, the audio warning and any warning which would normally be energised due to the aircraft condition in which the testing was done.

2 Auxiliary warning system

(*a*) The auxiliary warning panel (AWP) groups the less important warnings on a panel mounted above the star-



Standard warning panel



Auxiliary warning panel

board console. All warning circuits on this panel are DC operated.

(*b*) The panel windows when illuminated, give warning of the following failures: —

CANOPY	Canopy unlocked warning
ICE	Icing conditions warning (not operative)
FUEL 1	Fuel pressure warning (No 1 engine)
FUEL 2	Fuel pressure warning (No 2 engine)
OIL 1	Oil pressure warning (No 1 engine)
OIL 2	Oil pressure warning (No 2 engine)
AC	Alternator supply failure warning
TURB	Air turbine underspeed warning
HYD 1	Hydraulic failure warning (No 1 controls system)
HYD 2	Hydraulic failure warning (No 2 controls system)
*TTC 1	Top temperature control warning (No 1 engine)
*TTC 2	Top temperature control warning (No 2 engine)

* but see Part 1 Chapter 3 para 3(d)

(*c*) The warning indications can be tested by depressing the TEST pushbutton forward of the panel.

◀(*d*) The panel contains two sets of captions, each individual caption being lit from beneath by two lamps: Those for use by day are etched on amber windows. A DAY/NIGHT selector switch is at the aft end of the panel. ▶

(*e*) Whenever the HYD 1 and HYD 2 warnings appear together, the HYD warning on the SWP will light up and consequently the attention light will flash and the audio warning will be heard.

PART I

Chapter 14 — AUTO-PILOT

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◀ MALFUNCTION	
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Description and Controls

1 General

The Mk. 13 auto-pilot system provides three-axis auto-stabilisation, bank attitude holding and auto-ILS coupling. The system is used in conjunction with the MRG and the Mk. 5FT compass and the ILS localiser and glide path receivers.

2 Auto-pilot control unit

The auto-pilot control unit is mounted on the main instrument panel and comprises the following controls:

(*a*) A master SUPPLIES switch controls the 28 volt DC and 3-phase 400 CPS 115 volt AC power supplies required to operate the system.

(*b*) A magnetic indicator above the SUPPLIES switch shows black when power supplies are available and white/OFF when the system is switched off.

(*c*) Two, PITCH and ROLL & YAW, switches when set to on (up) bring into operation the three-axis autostabilisation.

(*d*) An ATTITUDE HOLD/ILS switch selects either of the two modes of the auto-pilot. Both auto-pilot engage switches must be off to change selection.

(*e*) A GLIDE switch, spring loaded to OFF, removes the height lock and initiates the glide phase when the switch is momentarily held at GLIDE.

3 Auto-pilot engage switch

A three-position AP/OFF/FD switch is on each control column. The switch controls the pre-selected attitude hold or ILS outputs to the aileron and tail-plane autostabilisers when AP is selected. The FD position is inoperative.

4 Heading selector

An HDG selector and selected heading pointer is on the Mk. 5FT compass. Used in the ILS mode it transmits heading information to the auto-pilot computer to modify the bank demand of the ILS localiser receiver in such a manner that the aircraft turns on to the convergence heading and intercepts the localiser with the minimum of overshoot.

5 Throttle servo

A THROTTLE SERVO — ENGAGED/DISENGAGED control is located on the inboard face of the port console. ◀The control, when set to ENGAGED couples an▶ electrically operated actuator into the control run via a clutch mechanism. The position of the actuator is controlled by signals from the auto-pilot computor, when ILS is selected on the auto-pilot control unit, in such a manner as to maintain the correct aircraft approach speed (175-180 kts.). Small manual adjustments can be made with the clutch engaged and in emergency the servo can be over-ridden by direct movement of the throttle levers.

6 Trim indicator

(*a*) An AUTO-PILOT TRIM indicator is on the main instrument panel. The indicator may have either a moving bar or a model aircraft presentation, depending on which type is fitted. The indicator shows the auto-pilot pitch demands in the ILS mode only although deflections occur in other modes. A sustained deflection of the bar or the model aircraft after engagement indicates that a normal trim change is required. If a sustained deflection of the indicator occurs before engagement, a malfunction of the system is the probable cause and engagement should not be made.

◀(*b*) With the power supply off, the trim pointer moves off-scale. ▶

7 Autostabilisers

(*a*) In each axis, rate gyros sense the rate of change of pitch, roll or yaw angles associated with short period oscillations and feed amplified correcting signals to the appropriate autostabiliser actuator in the control run to move the control surfaces in response to the signals. Four electro-hydraulic actuators are fitted, two for the aileron and one each for the tail-plane and rudder, and they are brought into operation by means of the PITCH and ROLL & YAW switches on the auto-pilot control unit.

(*b*) Each actuator is interconnected with the control linkage to the PFCU and is so arranged that movement of the actuator moves the control valve of the PFCU without causing movement of the pilot's controls. Conversely, movement of the pilot's controls displaces the PFCU control valve without affecting the position of the actuator.

(*c*) The autostabiliser actuators are fitted with two-position stroke restrictors controlled by a solenoid. The solenoid must be energised before full stroke of the actuator can take place. With electrical supplies on, the solenoids of the aileron and rudder actuators are energised (aileron ± 2° 24′, rudder ± 3°) and with supplies off are de-energised (0° stroke in each channel). The solenoid of the tailplane actuator, however, is normally de-energised and the stroke restrictor limits movements in this channel to ± 1°. Whenever the undercarriage is selected down in the auto-ILS mode, the solenoid of the actuator is energised, allowing full stroke of the tailplane actuator (3° 18′).

(*d*) If AC failure occurs, the rudder and aileron actuators will centralise and the tail-plane actuator will move to either end of its restricted stroke. Resultant out of trim forces can be corrected on the normal tail-plane trim.

(*e*) If hydraulic failure occurs the autostabilisers will remain in the position occupied when failure occurred. Out-of-trim rudder forces may be required to be held by foot load, but aileron and tail-plane out-of-trim forces can be corrected on the normal trim.

8 Bank attitude hold

The bank attitude hold system is used to maintain the aircraft, within limits, in any bank attitude initially set by the pilot. It is brought into operation by selecting ATTITUDE HOLD on the pilot's controller, flying the aircraft into the desired position, trimming out all loads on stick and rudder pedals and engaging the auto-pilot by selecting AP on the engage switch.

9 Auto/ILS coupling

(*a*) When the ILS mode is selected and the auto-pilot engaged, the ILS auto-coupler flies the aircraft automatic ally from the point of engagement down to the break-off height, from which position the approach is completed manually.

(*b*) Auto/ILS is selected by setting the ATTITUDE HOLD/ILS switch to ILS, selecting the desired heading on the Mk. 5FT compass heading selector, selecting the correct engine speed and moving the throttle servo to ENGAGED and engaging the auto-pilot. Prior to the interception of the glide path, the GLIDE switch must be momentarily held to GLIDE to initiate this phase of the approach.

(*c*) The detailed procedure for Auto/ILS is given at Part III, Chapter 3, para. 6.

Malfunction

10 Autostabiliser/autopilot malfunction

(*a*) If any suspicious wander of the aircraft from its expected performance in the autostabiliser/autopilot mode occurs even if no failure warning has been given, switch off the SUPPLIES switch and then the PITCH and ROLL & YAW switches.

NOTE: Following a malfunction, it is recommended that the autopilot is switched off for the duration of the flight, but if it is necessary, for investigation purposes, to switch on, only the SUPPLIES switch should be selected on. This should be done at low IAS, well clear of the ground and other aircraft, anticipating a severe trim change and possible recurrence of the malfunction.

(*c*) The following types of autostabiliser malfunction may occur depending upon the switch positions of the master and autostabiliser switches: —

(i) With the system not in use, i.e. SUPPLIES switch and PITCH and ROLL & YAW switches off, there can be no malfunction in the aileron and rudder channels but the tailplane autostabiliser actuator is likely to drift to, and remain at, one end or the other of its restricted stroke.

(ii) With the SUPPLIES switch on and the Pitch and ROLL & YAW switches off, a hard over actuator malfunction within the limits of the actuator stroke in any one of the control channels is possible.

(iii) With the SUPPLIES switch and the PITCH and ROLL & YAW switches on, with or without an auto-pilot mode engaged, hard over or oscillatory actuator malfunctions may occur.

(*d*) A summary of the effects of power supply failure and action to be taken is given below: —

Failure	*Defect*	*Action*
DC supply failure	Actuators remain centred, stroke restrictors close.	Disengage auto-pilot and autostabiliser channels.
AC supply failure	Stroke restrictors close. Tailplane actuator drifts to limited authority	Correct aircraft response with controls. Switch off SUPPLIES switch and disengage auto-pilot and autostabilisers. Re-trim tailplane if required.
Partial (internal) AC failure	Actuator drifts to extent of relevant authority either singly or in pairs: (a) Two ailerons (b) Tailplane and rudder.	As for AC supply failure, above
Service hydraulic power failure	Actuators are friction locked in the position pertaining when the accumulators exhaust.	As for AC supply failure, above

PART I

Chapter 15 — RADIO AND RADAR CONTROLS

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1 UHF

(*a*) *General*

(i) The UHF equipment comprises two UHF sets, one for normal use and the other for standby use. When the normal set is in use any one of 1,750 channels can be selected. The standby set provides two channels, one of which is pre-tuned to 243 mcs. The normal set may be used to provide homing facilities in conjunction with the vertical pointer of the ILS indicator; the standby set cannot be used in this way.

(ii) Power supplies are normally taken from the 28 volt DC bus-bar but in generator failure conditions, the emergency battery provides the power supply for the standby set when standby power is selected.

(iii) Four aerials are fitted, the upper forming the entire tip of the fin, the lower below the nose and two whip aerials for the homing facility are on the top skin of the spine.

(*b*) *Controls*

The UHF control panel is located on the port instrument panel. On it are the following controls:

(i) Four tuning knobs with which any one of 1,750 frequencies may be manually selected. The knobs from left to right select hundreds, tens, units and tenths of mcs., the appropriate digits appearing in windows above the knobs.

(ii) A 20-position selector switch with which any one of 18 pre-tuned frequencies may be selected plus the guard frequency. The 20th position selects manual tuning.

(iii) An OFF/T.R./T.R.+G/ADF function switch. When T.R. is selected, only the frequency selected is in operation. With T.R.+G selected, the guard frequency is monitored in addition to normal communication on the channel selected. For homings using the vertical pointer of the ILS indicator, ADF should be set. At the OFF position the normal set and the homing facility are switched off. In generator failure conditions, if the standby set only is to be used, the main set function switch should be set to OFF to reduce the load on the aircraft battery.

(iv) A VOLume control is between the pre-tuned channel selector and the function selector.

(*c*) The remaining UHF controls are as follows:

(i) A NORMAL/STANDBY switch selects the set required. When STANDBY is selected, the set may take up to 1 minute to warm up.

(ii) A, NORMAL/STANDBY, POWER switch is for use in conjunction with the standby UHF set. When NORMAL is selected at the POWER switch, the 28 volt DC supply to the standby set is reduced, by a dropping resistor, to the 24 volts required to operate the set. In generator failure conditions, the POWER switch should be set to the STANDBY position, which switches the power supply to the emergency battery; this allows the set to be run at 24 volts and reduces the load on the main battery.

(iii) An AERIAL—UPPER/LOWER switch selects the aerial required. However, with the standby set selected, the lower aerial is connected irrespective of the setting of the AERIAL SWITCH.

(iv) A VP/I.L.S.INDR. switch selects the mode of operation of the ILS indicator.

(v) A VP SENS—MIN/MAX switch selects the sensitivity of the homing indications when VP is in use.

(vi) ⧓ A UHF STBY—GUARD/CHANNEL A switch on the main instrument panel permits the second channel of the standby set to be selected. The CHANNEL A position is used for ground test purposes only and should not be used in the air.

◀The nosewheel steering push button on the instructor's control column is utilised as a mute switch to allow interference-free intercomm. between the two occupants. ▶

(*e*) Four press-to-transmit switches are provided. At each pilot's position one switch is fitted on the control column handle and the other on the No. 2 engine throttle lever. Any one of the four switches may be used to transmit.

(*f*) *Violet picture* (*homing*)

The vertical pointer of the ILS indicator may be used to provide homing directions, provided the required frequency is set, ADF is selected and VP/ILS switch is at VP.

2 Intercommunication

(*a*) Intercommunication is provided by an A.1961 amplifier controlled by two INTERCOM switches on the starboard instrument panel. The switches are labelled ON/OFF and NORMAL/EMERGY respectively. When ON and NORMAL are selected, normal intercomm. service is ◀operated through the A.1961 amplifier. If the power supply to the intercomm. amplifier fails, intercomm. facilities are automatically provided via the side-tone of whichever UHF set is in use. If the amplifier itself fails, both intercomm. and UHF reception are lost until the amplifier is switched off or emergency intercomm is selected. ▶

(*b*) An external intercomm. socket for communication between the cockpit and the ground crew is in the starboard wheel well.

3 Telebriefing

A telebriefing installation can be connected to a socket in the starboard wheel bay. Two TELEBRIEFING indicator switch units, on the starboard instrument panel and on the port console, are illuminated when the connection is made. The equipment is normally in the receive condition; to transmit, the indicator switch unit must be depressed.

4 ILS

Standard ILS equipment is fitted. The control unit is mounted at the bottom of the port instrument panel. The MASTER switch and VOLUME control are adjacent to the control unit. An ILS indicator, marker lamp and VP/ILS changeover switch are on the instrument panel. The VP/ILS switch must be set to ILS when ILS is required otherwise false indications will be presented. The glide-path and localiser aerials are fitted in the starboard and port leading edges of the wing respectively and the marker aerial is in the skin on the underside of the rear fuselage.

5 Tacan

(*a*) A Tacan navigational system, which provides distance and magnetic bearing information, is fitted. The control unit is located on the port instrument panel and the Tacan indicator is on the main instrument panel. The system requires 28 volt DC and 115 volt single phase AC power supplies.

(*b*) The control unit comprises the following controls and switches:

(i) An ON/OFF master switch.

(ii) A BRG/DIST.BRG switch. With BRG selected, only the receiver is operating and bearings are given on the indicator. With DIST.BRG selected, both receiver and transmitter are operating and distance and bearing information is presented.

(iii) Four Tacan channel selector pushbuttons by which any one of 126 channels may be selected.

(iv) A VOLume control.

(*c*) The Tacan aerial is on the underside of the rear fuselage and the upper is in the skin on the top of the fuselage forward of the cockpit.

6 AI.23

(*a*) AI.23 equipment is installed. Two hand controllers are fitted, the pupil's on the port console and the instructor's on the centre console. The hand controllers have identical controls except that the AI main on/off switch is fitted on the port controller only. Change-over from one hand controller to the other is effected by an AI CH/O — INSTRUCTOR/PUPIL switch on the starboard console.

(*b*) Two AI display units are mounted above the port and starboard instrument panels respectively. The units have identical controls except that the computer selector is fitted to the port display unit only.

(*c*) In addition to its normal functions the AI supplies range and bearing information to the Pilot Attack Sights after radar 'lock on', and information to the guided weapons homing circuits to assist them to 'lock on'.

(*d*) Both 28 volt DC and 200 volt AC electrical power are required for the operation of the AI.

7 IFF/SSR

A Cossor 1520 IFF/SSR transponder unit is fitted in the aircraft allowing interrogation by civil or military ground radar, and making an automatic identifying response. The controller is positioned on the floor below the port console and incorporates the controls detailed in the table overleaf.

(*b*) An IFF FAILURE light and a panel lighting switch are located adjacent to the controller. The failure light has a press-to-test facility which also tests the self-test light on the controller.

(*c*) The operating modes and codes to be used are normally established before flight, but ground radar stations may request particular selections. Codes 7600 and 7700 are selected only in emergency to give a particular alarm as follows:

7600 ... Radio failure (normally loss of voice contact in a controlled airspace)

7700 ... Aircraft emergency

Control	*Function*
Code number selectors MODE 1—MODE 3/A/B	Four selectors and indicators for each. Indicators show 0000 to 7777, allowing 4096 codes to be selected
Two-position emergency coding switch: CIVIL/MIL	Used in conjunction with EMGY PUSH MIL: Normal setting. Response codes (Military modes 1, 2 or 3) modulated to emergency form CIVIL: Code 7700 automatically selected for response to civil interrogation
Two-position switch (spring-loaded to off): I/P	Momentary operation triggers an identification pulse for 20 seconds, added to selected code
Self-test push button incorporating a double filament green light: TEST	With equipment switched on, pressing button checks receiver sensitivity, transmitter power output and mode serviceability. Set NORM, press TEST: if check satisfactory TEST light comes on (IFF FAILURE light out) Unsatisfactory test indicated by IFF FAILURE light and no TEST light. Flashing IFF FAILURE light can occur if rotary switch at SBY: steady light if switch to LOW

PART 1

Chapter 16 — ARMAMENT AND CAMERA CONTROLS

Contents

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1 Pilot attack sight (PAS)

(*a*) The PAS is basically a gyro sight working in conjunction with the AI 23 radar equipment. Provision is made for the sight to be manually controlled. Two PAS display units are mounted above the port and starboard instrument panels respectively.

(*b*) The PAS units are switched on whenever the master armament selector switch is set to weapons (GUNS/GW/RB).

(*c*) The pupil's No 2 engine throttle lever twist grip determines whether the radar or the manual ranging mode is in operation. Normally locked in the radar position, the grip must be lifted and turned anti-clockwise to allow manual ranging of the gyro graticule. Mod 0269/STC provides an indent in the throttle lever twist grip enabling a range of 500 yards to be preset for use in the GUNS mode. A wing span setting control is on the starboard of the pupil's sight for use when manually ranging.

(*d*) The brilliance of the sight display can be adjusted by dimmer controls at the base of the sight.

(*e*) Warning that an attack must be broken off is given by the illumination of a break-off light adjacent to the target indicator reflector.

(*f*) The PAS requires both DC and AC electrical supplies for its operation.

(*g*) A holder for spare bulbs for the PAS is fitted on the bridge panel.

2 Armament — general

(*a*) The armament of the aircraft consists of an interchangeable armament pack fitted on the underside of the fuselage, carrying either two 30 mm Aden guns or a missile pack for two guided weapons.

(*b*) A four position, OFF/GUNS/GW/RB, master armament selector switch is on the bridge panel. The switch selects the weapons to be used and, in any position other than OFF, switches on the PAS.

(*c*) An armament safety break under the Firestreak pack, when disconnected, prevents any armament stores being fired when the aircraft is on the ground.

(*d*) The armament circuits are inoperative until the undercarriage UP pushbutton has been selected.

(*e*) All stores are fired by the armament trigger on either control column. The trigger incorporates a safety catch. Depressing the armament trigger automatically energises both engine relight systems.

3 Guns

With GUNS selected at the master armament selector, pressing the armament trigger fires the guns. A solenoid operated gun purging valve opens to allow engine air to scavenge the gun bays of dangerous concentrations of gases during firing and for two seconds after. A GUN PURGING — ON light on the bridge panel illuminates to indicate purging system pressure and the completion of the firing circuit. If the gun purging valve remains in the closed position, the guns will not fire nor will the GUN PURGING light illuminate. If the light remains for longer than 2 seconds after firing has ceased, select OFF at the master armament selector switch. This will close the valve and the light will go out if the fault is electrical. If the light does not go out a purging valve failure in the open position is indicated and all the remaining rounds should be fired without delay. The return to base should be made at the lowest practicable RPM to avoid structural damage.

4 Guided weapons

(*a*) With GW set on the master armament selector switch, pressing the armament trigger initiates the firing cycle of the guided weapons. The armament trigger should be kept pressed until the missile has been launched, this period should not normally exceed 3 seconds. Premature release of the trigger may cause a misfire. The trigger must be depressed by the crook of the finger as finger tip pressure only may cause a side loading which will prevent full depression of the trigger.

(*b*) The setting of the GW/PAIRS/SINGLE switch on the bridge panel determines whether one or both missiles are to be fired. When SINGLE is selected, the starboard missile will always be released first, provided it has 'acquired'.

(*c*) An arming switch on the bridge panel, when set to ARMED, controls the guided missile pack alternator, provides power for the missile electronic control equipment and supplies the missile cooling air during the armed period.

(*d*) Two ARMING GW indicator lights are on the bridge panel. The left hand light is coloured blue and the other is green.

(i) The blue indicator illuminates for a period of two minutes when ARMED is selected on the arming switch; the light is extinguished at the end of the two minute period. Neither missile can be fired until the two minute period has elapsed. Additionally, the light will flash if the missile supplies are interrupted or if the arming switch remains at ARMED after the second missile has been fired.

(ii) The green indicator is associated with the armed time indicator (see (*e*) below) and lights up when the arming switch is selected to ARMED. Missile cooling and refrigerator supplies are exhausted after approximately 15 minutes of elapsed armed time; this is indicated by the flashing of the green indicator. Selecting the arming switch off extinguishes the light.

(*e*) An armed time indicator is on the port instrument panel. It gives an indication of the elapsed armed time from the moment the arming switch is moved to ARMED. The indicator is an electrically controlled clock showing the period of elapsed time up to 30 minutes. The indicator may be reset to zero by a resetting knob on the face of the indicator.

(*f*) A FIRE CONTROL RESET switch, spring loaded to off, is on the bridge panel. The GW acquisition system may be returned to normal after a simulated firing by setting the switch to ON.

(*g*) The missiles can be jettisoned by either the pupil or the instructor. The pupil's jettison control is a guarded button on the ventral tank jettison handle. The instructor's control is a guarded EMERGENCY JETTISON—JETTISON/GW switch on the starboard instrument panel. When the pupil's trigger is operated or the instructor's switch set to JETTISON, the missiles and their shoes are jettisoned laterally.

(*h*) Missile acquisition lights are fitted adjacent to each PAS. These lights are additional to the indication given by the PAS. The lights are shrouded to prevent glare during night flying.

5 Cameras

(*a*) A G.90 camera is fitted in the radome strut. It is controlled by a MASTER CAMERA switch on the bridge panel and runs whenever this is set to ON and either the camera pushbutton is pressed or the armament trigger pressed when weapons are selected at the master armament selector. Above the MASTER CAMERA switch is an IRIS — DULL/BRIGHT switch to control the lens aperture setting.

(*b*) (i) A PAS camera recorder is mounted on a bracket at the port of the pupil's pilot attack sight. A switch unit for the recorder is above the port instrument panel. The camera idles whenever the PAS is switched on, and then runs when the ON pushbutton of the switch unit is pressed, the armament trigger or camera pushbutton is pressed, or when AI.23 radar is locked on and firing bracket signals are received.

(ii) A light in the switch unit illuminates whenever the recorder is running under the control of the switch unit ON pushbutton or AI.23. When the armament trigger or camera pushbutton is in use, the light will only illuminate during the 3 second period of camera over-run which occurs at the end of the firing cycle.

(iii) The camera recorder may be adjusted for shutter speed by a spring-loaded push-in knob on the camera. Adjustments for frames per second, 2 or 16 is by an FPS control on the camera.

◀(*c*) An AI RECDR — PULL ON switch is fitted adjacent to the instructor's PAS. The switch allows selective▶ use of the automatic film record which is taken of the AI display.

Control	*Function*
Four-position rotary switch with a fifth 'push to turn' position: OFF/SBY/LOW/NORM/EMGY PUSH	OFF: Equipment switched off. IFF FAILURE light on steady. When switch set from OFF to any other position, 50 sec required for warm-up SBY: Power to equipment. After warm-up transponder accepts interrogations on selected modes but cannot respond — IFF FAILURE light flashes LOW: Equipment functioning but with reduced sensitivity. Used at request of ground station to reduce clutter NORM: Equipment functioning normally, accepting interrogations and responding on selected modes EMGY PUSH: When switch pressed and turned to EMGY, transponder transmits immediate replies with emergency coding on modes 1, 2, 3A or B (see also CIVIL/MIL switch) irrespective of settings of mode switches
Four on/off MODE switches (up for on): 1/2/C/D	MODE 1: Transponder replies to mode 1 interrogations using mode 1 code MODE 2: Transponder replies to mode 2 interrogations using a preset code unique to aircraft MODE C: Transponder replies to mode C interrogations transmitting coded altitude signals (encoding altimeter not yet fitted) MODE D: Not in use
Three-position rotary switch: 3A/OFF/B	OFF: Transponder isolated from mode 3A or B interrogations 3A: Transponder replies to mode 3A interrogations using mode 3 code B: Transponder replies to mode B interrogations using mode 3 code

PART II

LIMITATIONS

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PART 2

Chapter 1 — AIRFRAME LIMITATIONS

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1 General

The Lightning T Mk 4 is designed for duties appropriate to an interceptor fighter trainer. Intentional stalling and spinning are prohibited. The aircraft is cleared for use in temperate and semi-tropical conditions.

2 Maximum speeds

Maximum IMN	1·7M
Maximum IAS: —	
No missiles	650 knots
One missile	600 knots
Two missiles	600 knots below 25000 ft 650 knots above 25000 ft
Undercarriage down selection	220 knots
Undercarriage up selection	250 knots
With undercarriage down	250 knots (normally) 280 knots (emergency)
Airbrake operation ...	1·2M

Flap operation
and with flaps down ... 250 knots
Parachute stream ... 150 knots (normal)
170 knots (emergency)

NOTE: Streams in excess of 150 knots must be reported.

3 Minimum speeds

Flaps and undercarriage up 180 knots

Flaps and undercarriage down 140 knots

In all configurations higher minimum speeds must be maintained with G applied.

4 G limitations

(*a*) The maximum permissible normal accelerations are as follows: —

Configuration	*Up to 0·9M*	*0·9 or above*
With empty or no ventral	6G	5·5G
With fuel in ventral	5·5G	5G
With single missile	3G	3G

or the onset of buffet, if earlier.

(*b*) The maximum permissible negative acceleration is minus 3G. Negative G should not be applied for longer than 15 seconds.

5 Weight limitations

The maximum permissible weight for take-off and all forms of flying, including landing, is 35000 lb.

6 CG limits

The take-off CG limits are contained in AP101B-1004-1A Volume 1, Book 1, Section 2, Chapter 3.

7 Aircraft approach limitations

(*a*)

Approach Aid	*3° glide-path*		*2½° glide-path*	
	Indicated	*True*	*Indicated*	*True*
GCA	300 ft	350 ft	250 ft	300 ft
Manual ILS	350 ft	400 ft	300 ft	350 ft
Auto ILS	300 ft	350 ft	250 ft	300 ft

(*b*) In the event of main altimeter failure, the AAL is 500 feet indicated, if VSI failure has occurred, it is preferable that an ILS approach is made.

(*c*) It is recommended that all ILS approaches are monitored by GCA.

8 Crosswind limitations

(*a*) The maximum crosswind component for take-off is 25 knots.

(*b*) The maximum crosswind component for landing on dry runways is 25 knots, on wet runways 20 knots, and on flooded runways 15 knots.

9 Runway length

The aircraft should be operated from runways of not less than 2500 yards in length. The aircraft LCN is 24 at 34500 lb AUW.

10 Altitude limitations

The aircraft should not be flown above 60000 ft. The maximum altitude for which the oxygen regulator and personal equipment have been cleared are as follows: —

◀ *Personal equipment*	*Mk 21*
P or Q mask	45000 ft
P & Q mask with sleeveless jerkin and anti-G trousers	56000 ft ▶

NOTE: These altitudes do not take into account aerodynamic suck. Cockpit altitude will exceed aircraft altitude by up to 11000 ft if the canopy is lost.

11 Rolling manoeuvres

(*a*) *General*

(i) At less than 1G, the use of aileron should be kept to a minimum. Transient use of aileron for target tracking at less than 1G is permitted.

(ii) In moderate buffet or other signs of the approach to the stall, particularly at high subsonic speeds above 20000 feet, coarse use of aileron must be avoided.

(iii) Airbrake position must not be varied during rapid rolling manoeuvres.

(iv) Before rolling, especially with a single missile fitted, sideslip should be minimised.

(*b*) *Rolls up to* 360°

(i) *Special restrictions*

For rolls through more than 180°, the configuration must be two or no missiles.
Rolls through more than 180° must be executed smoothly from the upright attitude in 1G flight and must be fully completed before any other manoeuvre is started.
Rolls in excess of 360° are prohibited.

(ii) *Normal flight envelope*

1G aileron rolls are permitted between 300 knots and 1·7M/600 knots using low rates of roll.

(iii) *Aerobatic rolling manoeuvres*

Aerobatic rolling manoeuvres are permitted between 300 knots and 0·9M/550 knots below 15000 feet subject to the following: —

Rapid rolls are permitted using aileron control only.
Classic slow rolls involving less than 1G are permitted.
Derry turns and hesitation rolls are prohibited.

(*c*) *Rolls up to* 180°

Rapid rolls through not more than 180° are permitted using full available aileron (7°) up to 1·7M/600 knots within the range 1G to the lesser of 4G (3G with single missile) or the onset of moderate buffet.
With accelerometer readings greater than 4G, co-ordinated turns using only low rates of roll are permitted.

◀(*d*) Rapid rolling with the probe fitted is prohibited. ▶

12 Carriage and jettison of ventral tank

The aircraft may be flown with or without the ventral tank. The tank may be jettisoned but because of the severe nose-down trim change which may occur in certain flight conditions, it should not be done at speeds in excess of 500 knots.

13 Auto-pilot limitations

(*a*) The use of the auto-pilot is permitted in the auto-stabiliser mode subject to the following restrictions:

◀(i) The autostabiliser may be engaged throughout the▶ flight, from before take-off to landing but it is recommended that, with the autostabiliser engaged, speeds above 400 knots should not be used at heights less than 1,000 ft. above ground level.

(ii) If the autostabiliser is selected on in flight, the selection should not be made whilst the aircraft is in close proximity to another aircraft or the ground, lest there may be a latent malfunction which will then become effective.

(iii) The autostabiliser may be used during air-to-air refuelling.

(*b*) ▶◀ The auto-pilot is cleared for use in the bank attitude hold mode, subject to the following conditions:

(i) Before bank attitude hold is engaged autostabilisers must be engaged and operating.

(ii) Bank attitude hold may be used down to, but not below, 1,000 ft. above ground level.

(iii) Bank angle must not exceed 75° at any time.

(iv) Below 10,000 ft., the pilot should have his hand on the control column and monitor the aircraft's behaviour continuously so that immediate recovery action can be guaranteed in the event of a malfunction.

(*c*) ▶◀ The system is cleared for use in the auto ILS mode subject to the following conditions:

(i) The recommended approach speed bracket is 175 to 180 knots.

(ii) The mode may not be engaged above 8,000 feet (1,013 mb. altimeter setting). Engagement above this height causes full nose-down tail-plane control to be applied. The use of the track phase as a height and heading lock is therefore impracticable.

(iii) All approaches should be CGA monitored.

14 Firestreak installation

(*a*) Carriage is permitted throughout the flight envelope, subject to the Firestreak service release.

(*b*) Firing is permitted between 0·6M and 1·7M at up to 3G or the onset of moderate buffet at heights up to 55,000 feet, subject to Firestreak service release.

(*c*) In the event of a misfire, the missile fins may operate and if one or both missiles remain, 3G should not be exceeded for a period of 30 seconds after the misfire.

(*d*) Jettisoning is permitted at speeds up to 300 knots/0·7M (250 knots with the undercarriage down) between 1 and 2G. Sideslip should be minimised before jettisoning.

(*e*) Mk. 1 ammonia bottles should be used. These give a maximum armed time of 15 minutes.

(*f*) Prolonged dives with missiles armed should be avoided.

(*g*) The rolling limitations should be strictly observed during any breakaway manoeuvre following the firing of one or two missiles.

15 Gun firing

(*a*) Carriage of live ammunition is permitted up to 1·7M.

(*b*) Firing is permitted up to 600 knots and 4·5G from sea-level to 10,000 feet and to 600 knots/1·7M and 4·5G from 10,000 feet to 60,000 feet.

(*c*) After landing from a low level flight in which guns have been fired and when ground ambient temperature is 35°C or more, approximately 30 minutes should be allowed to elapse before re-loading.

16 Battery limitations

◀The battery installation may be used for engine starting without external supplies; *simultaneous* double engine starts without external supplies are prohibited. Temperature limits for the battery at take-off are +10°C to +40°C.▶

17 Rain dispersal system

(*a*) The system may be used for take-off.

(*b*) Rain dispersal may be selected on at any stage of the approach and left on for any subsequent overshoot, circuit and landing. With two engines operating, the number of normal overshoots with rain dispersal switched on is unlimited.

(*c*) If the system is used during a single-engine approach overshoot and landing, the fact should be reported after landing and an inspection of the windscreen made for bubbling of the vinyl layer.

18 Air-to-air refuelling

Air-to-air refuelling sorties of up to 2 hours duration are permitted with Victor KC135 and Buccaneer tanker aircraft. The aircraft should remain not more than 20 minutes flying time away from landing at a suitable airfield. The following limits should be observed:

(*a*) Maximum speed with the probe fitted is 1·7M/525 knots.

(*b*) The autostabiliser may be used.

(*c*) Rapid rolling with the probe fitted is prohibited.

(*d*) One or two missiles may be carried, but missile firing with the probe fitted is prohibited except in operational necessity.

(*e*) The use of reheat should be avoided during refuelling; if reheat is considered necessary, it should be selected and adjusted prior to contact. Selection of reheat whilst in contact with the tanker is prohibited.

(*f*) En route refuelling at night may be carried out provided that the probe light is fitted. Practice refuelling at night may be attempted without the probe light fitted.

(*g*) The maximum speed for contact with a Mk 20B drogue trailed by a Victor tanker is 290 knots up to 37000 feet and 0·88M above 37000 feet up to 43000 feet.

19 Formation flying

See Part 3 Chapter 2 para 11 for limitations imposed on high speed formation flying.

20 ILS

ILS is not to be switched on above 30000 feet nor above 400 knots (see also para 21).

21 Equipment temperatures

Certain components of the Fire Control System and radio equipment may become unreliable or give false indications in sustained high speed, low altitude flight at high ambient temperatures. Normally, therefore, speed should be restricted so as not to exceed the ram temperature limit for the equipment as given below:

(*a*) *ILS*

ILS should not be switched on when the ram temperature exceeds 50°C. A practical limit is 400 knots, further reducing speed below 5000 feet.

(*b*) *AI23*

For continuous operation, a ram temperature of 50°C should not be exceeded. As a guide, if the following speeds are not exceeded, operation of the equipment need not be impaired:

(i) North Europe — 400 knots below 10000 feet
450 knots between 10000 and 15000 feet

(ii) Mediterranean — 250 knots below 5000 feet
400 knots between 5000 and 15000 feet

Speeds in excess of these should not be exceeded for periods longer than 5 minutes.

(*d*) *Other equipment*

Ram temperature should not exceed 70°C in sustained flight.

NOTE: Ram temperatures for various speeds, altitudes and ambient temperatures are given in the Lightning ODM.

22 Arrester barrier engagement

The aircraft is cleared for engagement with Mk 6, 12 and 12A arrester barriers.

23 Trampling of arrester wires

◀The aircraft is cleared to trample the rigged and supported centre span of the following arrester gear hookwires at any speed: —

RHAG, SPRAG, CHAG, PUAG, BLISS BAK 9, BAK 12 and 500 S.

NOTE: The fin under the central tank may occasionally be struck by the wire support. ▶

PART 2

Chapter 2 — ENGINE LIMITATIONS

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1 Engine limitations Avon Mk 210

Power Rating	*Time Limit per flight OR per hour*	RPM *per cent*	JPT °C (*max*)
Maximum cold power (or any degree of reheat)	15 mins (combined)	100 ± ·5 max	775
Intermediate	30 mins	97·5 max	740
Max continuous ...	Unrestricted	95 max	705
Approach	Unrestricted	60 min	—
Slow idle	Unrestricted	31-34	625
Ground fast idle ...	Unrestricted	58 min	625

NOTE 1: 700°C must not be exceeded during starts.

NOTE 2: Under adverse conditions of hot day and/or tailwind running, the ground idling, ground fast idling and taxying temperatures may be allowed to exceed the limit up to 675°C.

NOTE 3: During climbs at maximum conditions the governed speed may be permitted to rise to 102·5% RPM, but the maximum JPT must not be exceeded. Below ISA conditions, down to minus 30°C, governed speed will be maintained.

NOTE 4: During certain engine accelerations, temperatures in excess of the limiting JPT may be experienced. Full control to 775°C should be established by the JPT controller within 5 seconds. If, due to JPT controller malfunction, control is not established within this period, temperatures up to 800°C may be tolerated for a further 10 seconds whilst manual control is being taken.

NOTE 5: The maximum continuous reheat running time is 15 minutes; if further time is required the reheat must be cancelled and re-selected. This applies to all degrees of reheat and included in this period is any time spent with maximum cold power selected.

2 Oil pressure

The oil pressure warning lights must be extinguished at 45% RPM.

3 Minimum starting temperature

The minimum ambient temperature for engine starting is:

Pre-mod Avon 3707 ... ... minus 40°C

◀ Post-mod Avon 3707 ... ... minus 15°C ▶

In temperatures below these values, the engine must be heated as necessary before starting.

◀4 Fuel

The following fuels (containing FSII) are approved for use:

AVTUR—NATO Code F34—JP Equivalent: JP 1

AVTAG—NATO Code F40—JP Equivalent: JP 4

NOTE 1: The following emergency substitute fuels (NATO Codes F35, F42, F44 and F45) may also be used, in which case FSII should, if possible, be added. The content should be 0·10% to 0·15% by volume.

NOTE 2: Use of the emergency substitute fuels without the addition of FSII may lead to the formation of ice in the fuel system and fungus in the fuel tanks. ▶

PART III

HANDLING

LIST OF CHAPTERS

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NOTE

All Check Lists referred to in this Part are detailed on the Flight Reference Cards.

PART 3 — HANDLING

Chapter 1 — STARTING, TAXYING AND TAKE-OFF

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1 Preparation for flight

(*a*) Carry out the "external and internal checks".

(*b*) Carry out the "engine start procedure".

(*c*) Carry out the "checks after starting".

2 Engine handling on the ground

(*a*) With one engine at maximum RPM, 60% or above must be maintained on the other engine to prevent over-heating of the slower running engine.

(*b*) Single engine running of No 1 engine must be kept to a minimum and should not exceed 60% RPM to avoid severe stress on the compressor blades and intake damage.

3 Taxying

(*a*) If the OAT is below +5°C and the runways are wet or visible moisture reduces visibility to 1000 yards or less, anti-icing must be switched on immediately after starting and left on for taxying.

(*b*) Have the chocks removed and release the wheel brakes parking catch. Idle/fast idle is usually sufficient power, but in some circumstances, up to 60% RPM on both engines may be required to get the aircraft moving. Under adverse conditions of hot day and/or tailwind, extra care must be taken to keep the JPT within limits when accelerating the slower running engine. Move forward and check the brakes. Once taxying speed is reached, set the throttles to idle/fast idle. Full rudder must be applied to gain full differential braking. Avoid harsh braking and sharp turns because vented fuel may enter the auxiliary air intakes. The ventral tank flow indicator may flicker between white and black, particularly when the brakes are applied.

(*c*) Keep No 2 throttle at fast idle, or above if necessary, to ensure continuous AC supply.

(*d*) The canopy may be left open but off the top stop provided the airstream against the canopy does not exceed 65 knots (i.e. taxying speed plus wind component). If canopy vibration occurs, either close the canopy or reduce speed until the vibration stops.

(*e*) Fuel consumption at idle/fast idle is approximately 55 lb/minute.

4 Take-off performance considerations

(*a*) V STOP and V GO speeds are contained in the Lightning ODM. If speed is at or below V STOP, the take-off may be abandoned and the aircraft brought to rest by the use of maximum braking techniques in the remaining length of runway. If speed is at or above V GO, the take-off may be continued after the failure of an engine; the aircraft will become airborne in the remaining distance.

(*b*) Provided V STOP is greater than V GO, only V STOP need be considered. If V GO is greater than V STOP, however, a speed band would occur between the two speeds in which engine failure would result in the aircraft running into the overshoot area irrespective of whether the take–off was continued or not; in these circumstances, reheat should be used from the start of the take-off run and, if either reheat fails to light, the take-off should be abandoned. V GO is likely to exceed V STOP only if the runway length is less than 2500 yards.

(*c*) Examples of V STOP speeds are given below. They assume that there is no runway slope, no wind, that full braking is in use with the brake parachute streamed and that pilot reaction time is normal. If any one of these factors is invalidated a barrier engagement may result.

Temperature	Runway length from start of ground roll	Runway surface	V STOP
+15°C	2500 yards	Wet	136 knots
+15°C	2500 yards	Dry	153 knots
+30°C	2400 yards	Wet	129 knots
+30°C	2400 yards	Dry	148 knots

◀(*d*) If an emergency occurs which would make it unsafe to become airborne, the take-off should be abandoned even if V STOP has been exceeded. If there is no arrester barrier, the decision whether or not to eject from the aircraft will depend on the circumstances.

(*e*) If a failure occurs which is not included in (*b*) or (*d*), the pilot's actions will depend on the circumstances. If the speed is above V STOP, the take-off should be continued and a precautionary landing made.

(*f*) If a cold power take-off is continued after an engine failure, reheat should not be selected because a successful engagement of reheat will be of little benefit in shortening the take-off run. Furthermore, if the nozzle opens but the reheat fails to light, the resultant thrust reduction will aggravate the emergency. Both throttles should be left at the position selected for take-off because there is no yaw to assist the pilot in determining which engine has failed. When the aircraft is safely airborne, the undercarriage should be raised and then the failed engine identified and the HP cock closed. ▶

(*g*) If a "rotation" is to be performed after a reheat take-off it must be started at a minimum of 250 knots and the acceleration limited to +3G.

5 Take-off in icing conditions

(*a*) Anti–icing should always be used for take-off in icing conditions, but if runway length is limiting, switch on anti-icing and run the engines at not less than 85% for 1 minute, then switch off and take off immediately. This removes any ice already formed but affords no further protection, therefore anti-icing should be switched on again as soon as practicable after take-off.

(*b*) The use of anti-icing adversely affects take-off performance by up to 4%.

6 Take-off

CAUTION: The flaps should not be used for take-off owing to the risk of one flap blowing up if a services system hydraulic failure occurs.

(*a*) Carry out the "checks before take-off".

(*b*) Align the aircraft on the runway with the nose wheel straight and apply the brakes. Parallel No 1 throttle with No 2 and then open both throttles to 85% RPM. Check that the brakes hold at this setting. If required, switch on rain dispersal unless committed to take-off in icing conditions. Release the wheel brakes and increase both throttles to maximum cold thrust. At this setting, check that: —

(i) The nozzles have moved to the closed position.

(ii) The JPT increase to at least 650°C.

If these conditions are not satisfied, abandon the take-off.

NOTE: Take-off RPM may vary between 97% and 100·5% depending on the ambient temperature, use of reheat, use of anti-icing, JPT controller operation and intake effects.

(*c*) If reheat is required, advance the throttles through the reheat gate. Check that the nozzles move immediately to the pre-open position and then, on light-up, to the stage of reheat selected. Confirm that reheat has lit by checking that the JPT's are between 650°C and maximum.

(*d*) Speed increases quickly during the take-off run and there is no difficulty in keeping straight even in strong crosswinds. Differential braking may be necessary until the rudder becomes effective by 100 knots. Raise the nose wheel at 125 knots, avoiding an excessive attitude; at 160 knots, move the control column smoothly rearwards aiming to unstick the aircraft at 165 to 170 knots. Coarse backward movement of the control column at the unstick speed must be avoided otherwise the tail bumper area may strike the runway.

(*e*) In a strong crosswind the up-wind wing may rise slightly and, when the aircraft unsticks, either wing may drop. The wing-drop can be corrected easily by use of aileron.

(*f*) As soon as the aircraft is safely airborne, apply the brakes and retract the undercarriage, keeping the speed below 250 knots and the brakes applied until the wheels are locked up. This operation causes noticeable jolting of the airframe and, if main undercarriage retraction is unsynchronised, slight irregular lateral rolling.

(*g*) Carry out the "checks after take-off".

7 Abandoning the take-off

◀ (*a*) *Actions*

Move the throttles to idle/idle
Stream the brake parachute (may not deploy if the speed is below 100 kt)
Employ maximum wheel braking technique (Part 3 Chap 3 para 3).

(*b*) *Considerations*

Failure of the services pumps will not be indicated to the pilot since AC is off-line. If a double failure occurs, the wheel brakes accumulator will usually meet the braking requirements of the aircraft. However, if frequent 'maxaretting' and/or differential braking occurs, the accumulator may be exhausted. ▶

PART 3 — HANDLING

Chapter 2 — HANDLING IN FLIGHT

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1 Climbing

(*a*) The aircraft accelerates rapidly after take-off if the climbing angle is shallow. Allow the speed to increase to 420 knots and then increase the climbing angle to about 18° to establish the recommended speed of 450 knots.

(*b*) The optimum climb in the troposphere is obtained at 450 knots/0·9M. If a climb to greater heights is required, the recommended technique is to accelerate the aircraft near the tropopause and then employ the energy climb. For specific details of climb profiles and the best altitude for accelerating to supersonic flight refer to the Lightning ODM.

(*c*) During a reheat climb, internal fuel contents will decrease, because the ventral fuel transfer rate is inadequate below approximately 15000 ft. Above this height, transfer is equal to demand and the internal contents should remain constant.

2 Engine handling in flight

(*a*) (i) The JPT control switches should be set to AUTO and, providing the control is serviceable, the JPT is prevented from exceeding the maximum limitation. Maximum RPM varies according to the ambient air temperature, altitude and airspeed. Throttle back if necessary to keep within RPM limitations.

(ii) If the JPT control for an engine becomes unserviceable or is switched to OFF, manual throttling of the engine is necessary to prevent the JPT exceeding the limitations; the excessive temperature component of the reheat trip system is inoperative.

(*b*) Operate the throttles smoothly at all times and, particularly, avoid rapid re-acceleration of the engines after cancellation of reheat or reduction from high RPM. Surging may occur above 20000 feet and should be corrected by throttling back. At low altitude, acceleration from 60% RPM to maximum cold thrust can be achieved within 5 seconds.

(*c*) Maintain at least one engine above 58% RPM to ensure continuous AC electrical supplies. Engine RPM fall below 58% if both throttles are left at idling below approximately 15000 feet and 250 knots.

(*d*) To conserve fuel, operate the engines in the cruise nozzle position whenever practicable.

3 Reheat handling in flight

(*a*) All selections of reheat must be made within the flight envelope shown in Fig 1. To provide the maximum chance of successful engagement at all permitted heights and speeds, pause momentarily with maximum cold power selected, and then ease the throttles forward into the reheat section. After light-up, reheat may be used within the envelope shown in Fig 2.

(*b*) If, within the recommended lighting range, reheat fails to light within 10 seconds cancel the selection, wait 2 seconds and then re-select. If reheat again fails to light, further attempts are unlikely to be successful and the system should be regarded as unserviceable.

(*c*) When using maximum reheat with the correct nozzle position indications, the JPT should be stable at or near the operating limit; the RPM may possibly be reduced by the TTC. If a reheat extinction occurs and the nozzle remains open, the resultant change in pressure across the turbine causes an increase in RPM and a drop in JPT. The temperature drop is more marked at low altitude and the RPM

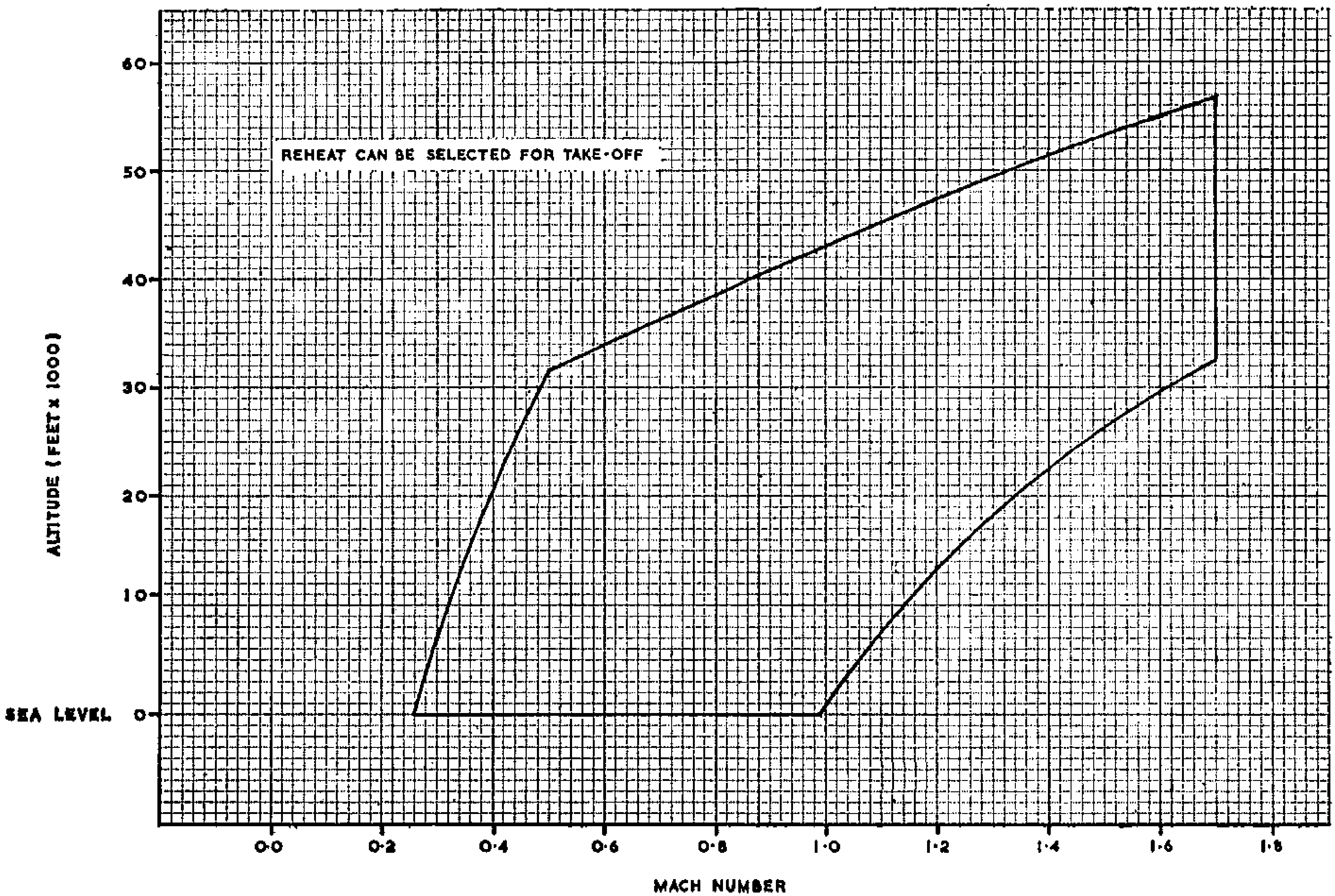

Fig. 1. Reheat lighting range

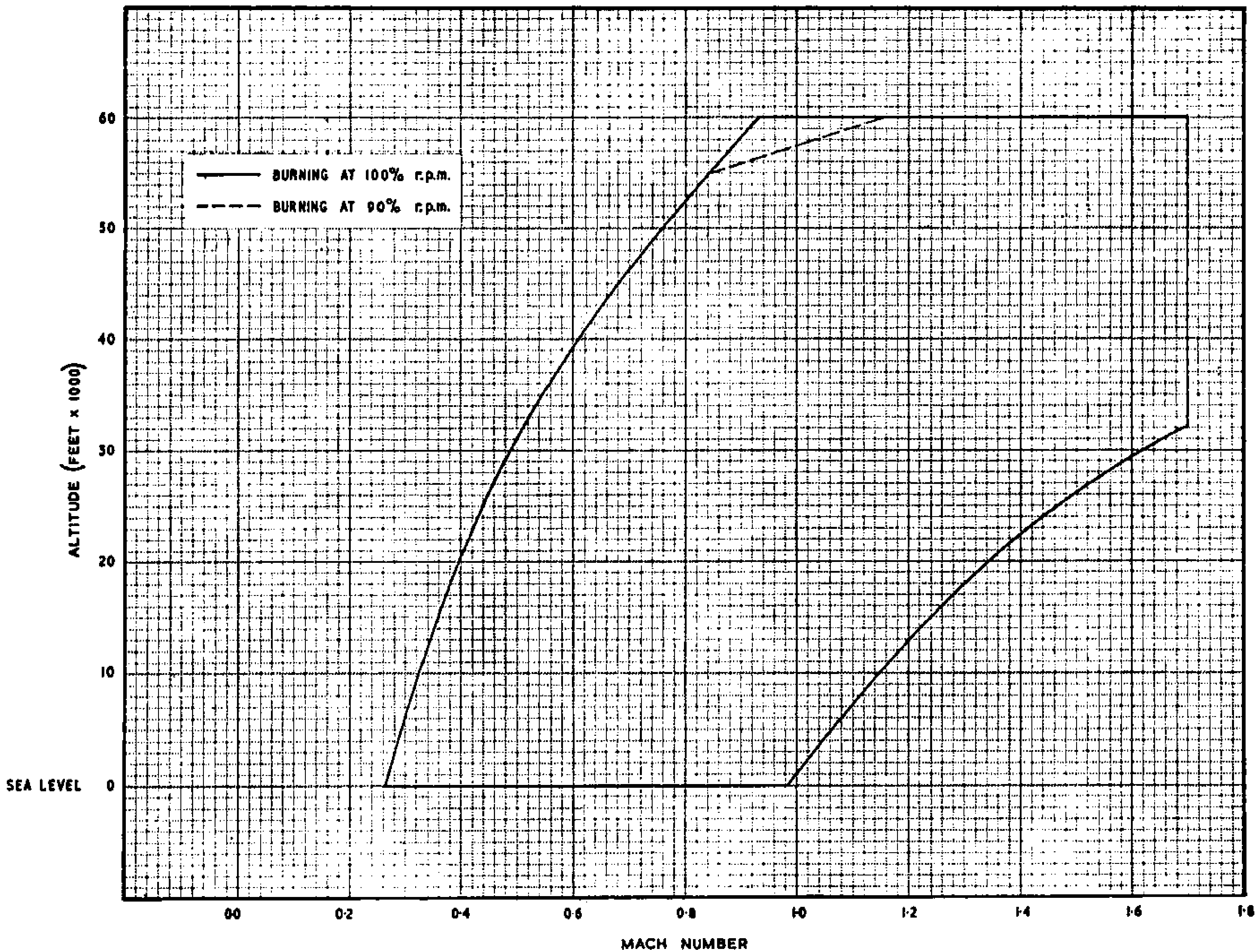

Fig. 2. Reheat burning range

rise more marked at high altitude, where the 102·5% limitation may be exceeded. Although, at higher altitudes, the JPT may not drop below 700°C, it drops sufficiently below the steady reheat running condition to be taken as a positive indication of reheat extinction when occurring in conjunction with a sudden increase in RPM. The reheat selection must be cancelled and the engine RPM maintained within the limitations.

(*d*) (i) If automatic cancellation occurs, one re-selection of reheat may be made except in the case of AC failure or a FUEL warning. If auto-cancellation occurs again, no further attempt to light reheat should be made.
(ii) The possibility of reheat cancellation through flame extinction increases at higher altitudes. Successful re-selection of reheat under these circumstances is affected by altitude and mach number.

(*e*) If, after cancellation of reheat, the nozzle remains fully open, there is a thrust loss of approximately 50% at maximum cold power. A subsequent selection of reheat is permissible only in emergency.

(*f*) If a throttle should seize in the reheat range, causing excessive fuel consumption, the reheat can be tripped and the nozzle closed by selecting one fuel switch, momentarily OFF, then on again. This simulates failure of the booster-pump relays in one wing tank system and trips both reheat systems. The possibility of flaming-out one engine exists but circumstances may make this acceptable.

4 Engine handling with anti-icing in operation

(*a*) When anti-icing is switched on there is usually a rise in JPT of approximately 20°C and, at full throttle, RPM fall if the JPT controller comes into operation.

(*b*) If climbing, employ the maximum practicable rate of climb. When an adjustment of RPM is necessary, move the throttles slowly.

(*c*) If icing conditions are met in level flight, switch on anti-icing and climb or descend out of the icing as continued flight in these conditions may result in flame extinction. Should an engine flame out, attempt an immediate relight. If this is unsuccessful, the second attempt should be made after $1\frac{1}{2}$ minutes, if this fails, any further attempt may damage the engine.

(*d*) (i) During descent in icing conditions, maintain engine RPM at 80% or above and switch on anti-icing. The maximum anti-icing protection is obtained with the highest practicable RPM. Descend at the maximum practicable rate.

(ii) If icing persists down to airfield level, check the engine response before approaching to land and keep the engine speed above 80% RPM, if possible, until finally committed to a landing. If it is necessary to overshoot, open the throttles smoothly.

(*e*) After leaving icing conditions, allow a period of two minutes before switching the anti-icing OFF.

5 General flying

(*a*) *Ailerons*

The ailerons are effective and the control forces light throughout the speed range. Aircraft response to aileron increases with speed and, at high subsonic speed, high rates of roll can be achieved. Care must be taken to observe the rolling limitations (see Part II, Chapter 1, para. 11) in order to avoid inertia coupling. Large, rapid aileron movements will cause adverse yaw which is more pronounced at low indicated airspeeds and in high speed flight (see Part III, Chap. 2, para. 11).

(*b*) *Tailplane*

(i) Below about 200 knots, longitudinal response is poor and large control movements are necessary during the roundout to land.

(ii) At higher airspeeds, the tailplane is more effective and response is good.

(iii) At supersonic speeds, aircraft response to tailplane movement decreases and relatively large control movements are necessary to manoeuvre.

(*c*) *Rudder*

(i) At subsonic speeds, aircraft response to rudder movement is satisfactory. Foot loads are heavy at all speeds with the undercarriage up. With the undercarriage down, however, the hydraulic component of feel is automatically removed and the rudder forces are moderate. At circuit speed, relatively small applications of rudder will induce a marked roll.

(ii) At supersonic speeds the response to rudder deteriorates and this, combined with a reduction in aerodynamic damping, necessitates larger deflections to co-ordinate manoeuvres or to trim out any asymmetry.

(*d*) *Harmonisation of controls*

The aileron and tailplane controls are well harmonised at subsonic speeds. Manoeuvres at supersonic speed require large tailplane movements in comparison with aileron movements. Rudder deflections to co-ordinate manoeuvres are necessary only at low indicated airspeeds and at supersonic speeds, particularly in the region 1·2M to 1·4M.

(*e*) *Trimmers*

(i) The tailplane and aileron trimmers are effective throughout the speed range.

(ii) On some aircraft, a directional trim change occurs at supersonic speed which may require the application of full rudder trim to correct.

(iii) The rates of operation, especially of the tailplane trimmer, are slow.

◀(iv) With the air-to-air refuelling probe fitted, more marked directional trim changes with speed can be expected above 500 knots. Therefore careful attention should be paid to rudder trim. ▶

(*f*) *Airbrakes*

The deceleration obtained with airbrakes extended is moderate over the speed range. Extension of airbrakes causes slight buffet at all speeds. At high speed, a nose-down trim change occurs and is accompanied by slight lateral displacement.

(*g*) *Changes of trim*

Increase in power ...	Slight nose-up
Undercarriage down ...	Slight nose-down
Flaps down	Slight nose-up on selection, then slight nose-down
Flaps up	Slight nose-up
Airbrakes out	Slight nose-down at high speed; slight lateral displacement

6 Flight conditions involving high structural loads

(*a*) *General information*

High structural loads are incurred in certain manoeuvres and flight conditions. The aircraft has been designed to withstand these but excessive repetition of high loads will reduce its useful life through fatigue damage. Therefore, the aircraft should not be subjected unnecessarily to the following flight conditions:

(i) Repeated application of high G.

(ii) High speed flight at low altitutde, particularly in turbulence.

(iii) Certain rolling manoeuvres (see sub. paras. (*b*) to (*e*)). For this reason, rolling limitations are imposed.

NOTE: At high G, the slip-ball is less sensitive to sideslip than at 1G and even small displacements of the ball should be corrected.

(*b*) *Aircraft with two or no missiles*

(i) During rapid rolls at high G, roll-yaw inertia coupling tends to produce higher than normal loads. This is particularly true at the speed/height combination of 0·8M to 0·95M and 20,000 to 35,000 feet where the high angle of attack, signified by buffet, produces sideslip and hence fin load; the amount of sideslip increases with higher rates of roll and higher G.

(ii) In the region of 1·2M to 1·4M, particularly at 500-600 knots and with G applied, application of aileron induces pronounced adverse yaw. This produces sideslip and, therefore, high fin loads and appreciably reduces the normal rolling capability of the aircraft. Extension of the airbrakes aggravates the situation; their use (within the limitations) should be kept to a minimum in these circumstances. Rudder should be used to decrease sideslip; if G is reduced, rolling response will be improved and the fin loads further reduced.

(*c*) *Aircraft with single missile*

(i) High load regions are similar to those in sub-para. (*b*) with an additional fin load due to the yawing moment of the single missile; this is particularly marked at high G. If the sideslip loads due to the single missile and full aileron rolling are additive, i.e. rolling away from the missile, particularly high fin loads can be produced in the region of 1·2M to 1·4M. The situation will be aggravated if the airbrakes are extended; their use in these circumstances (within the limitations) should be kept to a minimum.

(ii) Indications that asymmetry is becoming excessive are given by: —

The inability to correct the yaw, despite a heavy rudder pedal force.

A marked change of lateral trim.

(iii) The loads should be reduced by minimising side-slip and reducing G.

(*d*) *Firing and breakaway*

(i) If only one of two missiles is fired and then a rapid breakaway performed, high fin loads will be produced. The aircraft will yaw and, due to the sweep-back, will have a strong rolling tendency. If aileron is applied to oppose this roll, even higher fin loads may result.

(ii) The loads should be minimised by correcting side-slip with rudder and reducing normal acceleration to between 1G and 3G.

(*e*) *Auto-rotation due to inertia coupling*

Moderate rates of roll at less than 1G can produce auto-rotation; that is, rotation which does not cease on centralising the controls. Should this condition occur, only the minimum amount of aileron should be used to stop the rotation with the rudder kept central and the control column in the position for 1G flight.

(*f*) *Transonic yaw divergence*

Supersonic manoeuvrability is restricted by the G limitation but, at high altitudes, the use of full tailplane may not achieve these limits. If full or nearly full tailplane is applied or maintained at supersonic speeds below 1·3M above 30000 feet, there is a danger of achieving a large angle of attack with little or no pre-stall buffet warning. In this situation a reduction of lateral and/or directional stability may cause the aircraft to roll and/or yaw; if this occurs, G should be relaxed immediately. These conditions must be avoided because the yaw may be severe and can induce high fin loads. Furthermore, the high angle of attack causes a rapid loss of speed which, combined with the yaw, may induce a spin as the aircraft becomes subsonic. Accordingly, when decelerating transonically above 30000 feet, applications of large tailplane angles should be avoided until the aircraft is subsonic, when buffet will provide pre-stall warning. However, because of the large stick travel and heavy force required, a determined effort is needed to sustain these large tailplane angles.

NOTE 1: For the same tailplane angle, the G will increase markedly when decelerating through Mach 1.
NOTE 2: Airbrakes will aggravate the reduced stability.
NOTE 3: With a single missile the additional yawing and rolling effects may conceal the onset of the symptoms.

◀7 **Stalling in 1G flight**

WARNING: Intentional stalling is prohibited and speed should not be reduced below the minimum speed limitations (Part 2 Chap 1 para 3). During any manoeuvres below 200 kt, engine RPM should be maintained above 60% to ensure rapid acceleration to full power.

(*a*) 1*G stall sequence*
The 1G stall sequence outlined below applies to an aircraft carrying two missiles with undercarriage and flaps up. The minor differences to this sequence if missiles are removed are given in sub para b:—

220 kt (approx) ..	Slight buffet begins.
180 kt	Gentle wing rock may occur.
170 kt	Buffet increases in intensity.
140 kt decreasing to 115 kt	Aircraft begins to wander in roll, yaw and pitch. The wander becomes more pronounced as speed is reduced. The rate of descent can increase to over 6000 ft/min as the stall is approached. The IAS at which sink commences varies according to the rate at which the control column is moved aft. Up to this point, recovery is immediate on centralising the control column but coarse use of aileron or rudder could easily result in a spin.
115 kt (approx) ...	Aircraft yaws rapidly followed by wing drop and entry to a spin. At this stage, centralising the control column may not prevent a spin developing.

(*b*) 1*G stall sequence — missiles not carried*
With missiles off, the buffet level is higher and there is some stick force lightening as speed is reduced below 125 kt which gives a "knife edge" feeling. ▶

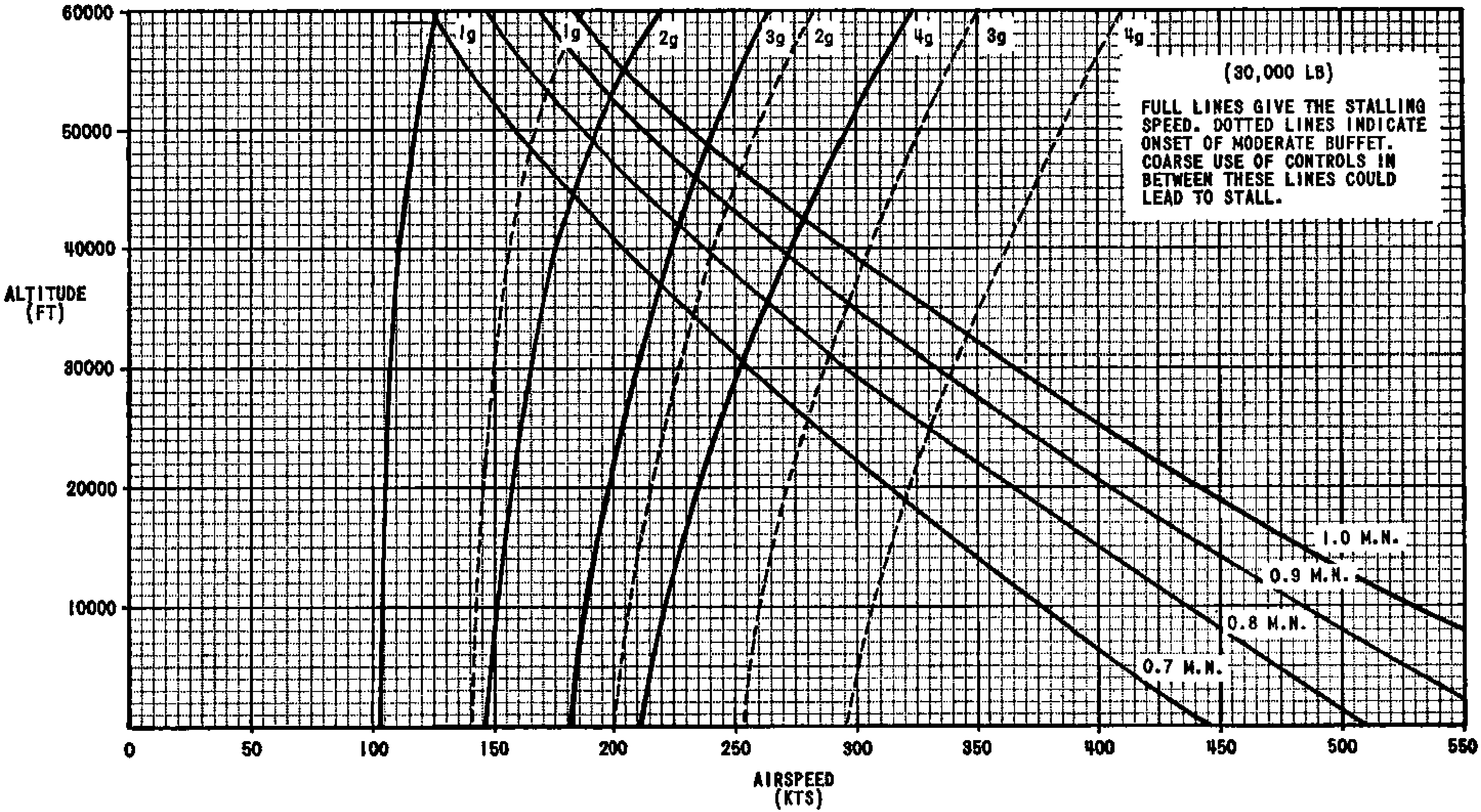

Fig. 3 Stalling speeds and buffet boundaries

◀8 G-Stalling

Speed can be lost rapidly as G is applied. With a gradual application of G, the onset of moderate buffet occurs well before the stall (see Fig 3). Further evidence may be provided in the form of gentle wing rocking and directional wandering. If the aircraft fails to respond normally to control movements or starts to deviate from its flight path without pilot action, the controls must be immediately centralised or the aircraft is likely to flick roll. Instinctive use of aileron to oppose any roll will aggravate the situation and probably cause the aircraft to roll and yaw in the opposite direction to the applied aileron. (With airbrakes OUT, the flick manoeuvre is less predictable and usually more severe). If G is applied suddenly by a harsh control movement, the aircraft may pass rapidly through the buffet zone into the flick manoeuvre. Coarse use of the controls should be avoided when manoeuvring in the buffet zone.

9 Spinning

WARNING: Intentional spinning is prohibited. The following information is to acquaint pilots with spin characteristics and recovery from inadvertent spins.

(*a*) *Spin entry and characteristics*

The spin entry and *initial* characteristics vary considerably and depend upon the type of manoeuvre and position of the controls at the moment of entry. Generally, at the stall, the aircraft yaws rapidly and then begins to roll. The nose tends to drop after the first half turn and then rise above the horizon at the end of the first turn. The second turn is generally steeper and the spin remains oscillatory in roll, yaw and pitch. Rate of rotation is quite slow, being about 6 to 8 seconds per turn. The rate of descent in a spin is approx 20000 ft/min (2-2500 ft/turn). The ASI will fluctuate between off-scale and up to 140 knots, once per turn.

(*b*) *Spin recovery*

Actions	Considerations
1. Centralise the control column and rudder	—
2. Positively confirm that aircraft is spinning	2. Confirmed by sustained rotation in yaw with ASI fluctuating between off-scale and 140 kt. ▶

Actions	Considerations
3. Positively assess direction of rotation	3. The aircraft has no turn needle and external references must therefor be used. If the direction of spin is in doubt (e.g. at night, IMC, or pilot confused) there is a high probability that the aircraft will recover within 3-4 turns (approx 8,000 ft) if both the rudder and control column are kept central; rudder should therefore NOT be applied unless the direction of spin is definitely established.
4. Apply FULL rudder against the direction of rotation. Keep control column centralised	4. A force of 200 lb is needed to apply full rudder.
5. Monitor height and airspeed	5. The aircraft may be slow to respond initially but will recover within 2 turns (4-5000 ft: 15 secs) after applying full rudder. THE BEST SIGN OF THE AIRCRAFT RECOVERING IS THE AIRSPEED INCREASING THROUGH 150 KNOTS.
6. Centralise the rudder when airspeed rises through 150 kt	6. —
7. Allow the airspeed to increase to 200 kt BEFORE opposing any residual roll with aileron	7. Residual roll will probably be present after the spin has been broken. If the pilot attempts to counter this before 200 kt. is reached, there is a chance that the aircraft will re-enter a spin.
8. Recover from the unusual position and then pull out from the dive at 270-300 kt using 2½-3G	8. Total altitude loss from entry to recovery to level flight from a fully developed spin is likely to be 10000-15000 ft. Altitude loss in pulling out of a 90° dive at 270-300 kt using 2½-3G reduces from 7000 ft at the tropopause to 5000 ft at 10000 ft. The MRG may topple during a spin and therefore the attitude indicator and compass should be regarded as unreliable until they can be checked after recovery.
9. EJECT at 10000 ft AGL if the aircraft is not under control	9. 'Under control' means that the aircraft is responding normally to control inputs and is accelerating through 200 kt.

(c) *General spinning information*

(i) *General.* Particularly prior to air combat flights, pilots should ensure on the ground that they can achieve

◀ full rudder travel even though this might result in a slightly knee-high sitting position.

(ii) *Engine effects.* The engines should not flame out or surge in a spin although reheat (if in use) may extinguish. Varying the power setting in a spin has negligible effect on recovery and therefore the throttles should be left in the pre-spin setting until recovery is accomplished.

(iii) *Aileron effects.* Full out-spin aileron will prevent recovery. More than ½ in-spin aileron results in an extremely rapid recovery which can easily reverse into a spin in the opposite direction; neutral aileron is therefore recommended for spin recovery. The 'feel' in the aircraft's control system helps to achieve the neutral position.

(iv) *Tailplane effects.* Fore and aft control column position has no effect on recovery time but with the column fully forward, an uncomfortable bunt results after rotation ceases; a too far aft control column position could result in a further stall following recovery.

(v) *Air-to-air refuelling probe and airbrakes.* The effects of the probe and airbrakes are so small they can be ignored. ▶

10 High speed flying

(*a*) The aircraft is capable of exceeding its airspeed and mach number limitations and care must be taken to avoid flying beyond these limits. The mach number must not exceed 1·2M when the airbrakes are in operation.

(*b*) Transition from subsonic to supersonic flight can be achieved in cold thrust from sea level to 43000 feet and up to 50000 feet in reheat. As speed is increased beyond 0·9M there is a slight nose-up trim change and very slight buffet in the speed range 0·94M to 0·98M. The buffet is barely noticeable in 1G flight but becomes more pronounced under increased G and/or with a ventral tank fitted. The trim change increases nose-up with increase in mach number to about 1·1M, and then becomes increasingly nose-down between 1·2M and 1·6M.

(*c*) In the transonic range, a reduction in damping causes a slight deterioration in stability. Above 1·0M control improves and application of G, within the limitations, is restricted only by a gradual decrease in tailplane effectiveness with increase in mach number.

(*d*) The handling characteristics change appreciably in the region 1·2M to 1·4M above 550 knots, particularly when missiles are fitted and when G is applied. In this region, application of aileron induces pronounced adverse yaw, causing reduced roll response and a feeling of control heaviness. Difficulty may be experienced in accurate lateral trimming. Therefore, close rudder co-ordination is important during all manoeuvres.

(*e*) On some aircraft, directional trim changes may occur in the transonic region, particularly when reducing speed. These may require the application of up to full rudder trim as mach number is increased and heavy foot loads as mach number is reduced.

NOTE: Some aircraft have an angled metal strip fitted to the rudder to reduce the severity of these trim changes.

(*f*) Airbrake operation at high speed is accompanied by a small nose-down trim change and slight buffeting. Directional stability is reduced with the airbrakes extended, hence the more severe limitations in this configuration.

(*g*) As speed is reduced a progressive nose-up trim change occurs down to the transonic region.

11 Formation flying

(*a*) (i) There is a possibility of the structural limitations of the aircraft being exceeded during formation flying due to airflow interference between aircraft.

(ii) The following speed and manoeuvre limitations are to be observed. When mach number limitations are too low to be indicated on the machmeter, they are to be converted to IAS for the conditions of flight concerned.

(*b*) *Operational close formation flying (excluding aerobatics)*

(i) Speeds should normally be restricted to 450 knots or 0·92M, whichever is the less. Normal acceleration should not exceed 2G. Lateral clear separation should not normally be less than half wing-span and must never reduce to less than a quarter span. The wing-man's overtaking speed should be low enough to allow correction for any lateral disturbances due to the lead aircraft's airflow pattern.

(ii) If it is required to fly at higher subsonic speeds or higher normal accelerations a minimum clear lateral separation of two wing-spans (70 feet) must be maintained.

(iii) Aircraft must not fly directly behind another aircraft at speeds greater than 0·7M and below this mach number, the fin-tip should be kept clear of the other aircraft's jet-stream.

(*c*) *Formation aerobatics and formation display flying*

(i) In close formation no aircraft is to exceed 0·87M.

(ii) At speeds less than 0·7M, or 450 knots indicated, maintenance of lateral separation consistent with avoidance of collision is satisfactory.

(iii) Between 0·7M and 0·87M no aircraft should exceed 3G and clear lateral separation should be one half span (18 feet). It is essential that this is not reduced to less than one quarter span (9 feet) even momentarily.

(iv) Aircraft must not fly directly behind another aircraft at speeds greater than 0·7M and below this mach number, the fin-tip should be kept clear of the other aircraft's jet-stream.

(v) If it is required to make high subsonic speed low level runs in formation, aircraft must be flown in echelon only, and are to have a minimum lateral separation of twenty-five yards between aircraft.

(*d*) *Supersonic manoeuvres*

Especial care is required to avoid the pressure field of an aircraft flying at supersonic speed. In any passing manoeuvre between aircraft, one or both of which are travelling supersonically, a clear separation of at least two spans (of the larger aircraft if different) must be allowed in any direction normal to the line of flight.

13 Air-to-air refuelling

(*a*) *Considerations*

The following information is based on refuelling from a

Victor tanker aircraft but applies equally to air-to-air refuelling operations with KC135 or Buccaneer tankers except that in the latter case, minor differences exist which are covered in (*c*) (i) and (ii) below. Reheat should not be used unless absolutely necessary. If refuelling in conditions where cold power is inadequate, reheat must not be engaged whilst in contact with the drogue. The recommended technique is to establish lateral separation from the tanker and engage one reheat only. When speeds are synchronised, refuelling can be effected as described in (*c*).

(*b*) *Actions before refuelling*

(i) Check autostabilisers on and functioning correctly.

(ii) Check fuel contents.

(iii) Test "tanks full" indicator lights.

(iv) Select the air-to-air refuelling switch to FLIGHT REFUEL.

(v) Move into line astern formation on the appropriate drogue, maintaining 10-15 yards probe/drogue longitudinal clearance.

(iv) Note natural trail angle of hose.

(*c*) *Refuelling*

(i) *Making contact*
Establish position 4-6 feet astern of the drogue, with speeds synchronized. Once this position is established, the drogue should be steady and the aircraft control forces may now be trimmed to zero. When using a wing drogue with Victor and KC135 tankers, it is necessary to apply about $\frac{2}{3}$ available aileron trim away from the tanker fuselage; some rudder trim away from the tanker may also be required. With a Buccaneer tanker $\frac{3}{4}$ aileron and $\frac{3}{4}$ rudder trim away from the tanker are required; as the tip of the probe is about to enter the drogue, a small amount of right rudder is required to prevent a minor yaw displacement; rudder is not required once contact is made. Increase power to accelerate and, as soon as contact is established, reduce power to maintain an overtaking speed of 2-4 knots.

(ii) *Speed limitations*
The maximum speed for contact with a Mk. 20B drogue

trailed by a Victor tanker is 290 knots up to 37,000 ft. and 0·88M above 37,000 ft. up to 43,000 ft.

(iii) *In contact*

Continue to overtake the tanker at 2-4 knots until the amber section of the hose reaches the Hose Drum Unit (HDU); reduce power slightly so that speeds are synchronised when the amber section is wound on the HDU. Maintain position during refuelling by keeping the hose at its natural trail angle and the amber section steady on the HDU. Slight variations in aircraft position result in noticeable changes of trim, particularly when refuelling from a wing drogue, but control effectiveness is adequate to cope with these changes. Monitor the fuel gauges and the 'tanks full' indicator lights; the latter will illuminate ◀ when their respective tanks are full. With the Buccaneer tanker, a small amount of fuel may vent from the tanker pylon during refuelling and may spray onto the receiver's windscreen, but this does not present any difficulty. ▶

(iv) *Breaking contact*

Reduce power slightly and withdraw the hose at a low rate, less than 5 feet per second, keeping the hose at its natural trail angle. If the hose is withdrawn at an excessive rate, the HDU safety brake will operate and cause immediate disconnection of probe and drogue; this may delay the refuelling of accompanying receiver aircraft.

(v) *Emergency break*

Move the throttles to idle/fast idle and extend the air-brakes. When the rate of hose withdrawal exceeds 7 feet per second, disconnection of the probe and drogue will occur.

(vi) *Hose/drogue malfunction*

Structural failure of the hose or drogue may result in excessive fuel spillage; the fuel may enter the air intakes and cause engine flame-out. If this occurs, an immediate relight should not be attempted. Close the appropriate HP cock and wait as long as possible but for at least 1½ minutes before carrying out the relight drill.

(*d*) *Actions after refuelling*

(i) Select the air-to-air refuelling switch OFF.

(ii) Check that the ventral tank is feeding.

WARNING: If the air-to-air refuelling switch is left at FLIGHT REFUEL, the ventral and flap tanks fuel will not transfer.

◀(*e*) *Broken probe*

If the end of the probe is broken or bent, restrict speed to below 350 knots. ▶

14 Aerobatics

(*a*) *General*

The IAS, G and rolling limitations given in Part II must be strictly observed. Within these limitations aerobatics are easy and pleasant to perform.

(*b*) *Rolling manoeuvres*

The recommended speed is 350 knots which, below 15,000 feet, affords the greatest scope within the rolling limitations.

(*c*) *Looping manoeuvres*

(i) Considerable height is covered in looping manoeuvres and small variations in technique will significantly affect recovery.

(ii) Reheat or maximum cold power should be used for loops. If it is intended to use reheat, it should be operating before the loop is started. Similarly, reheat should not be selected during an intended cold power loop because the initial opening of the nozzle causes a marked reduction in thrust.

(iii) The recommended minimum entry speed for loops is 400 knots. Until experience is gained, it is recommended that loops are started in the 7,000-12,000 feet height band at a speed of 450 knots. An initial acceleration of about 4G should be applied and it should be expected that slight buffet will occur during part of the manoeuvre.

(iv) For a half-roll off the top of a loop, an initial speed of 500 knots is recommended.

(*d*) *Inverted flying*

(i) The recommended speed is 350 knots.

(ii) Negative G must not be sustained longer than 15 seconds. Fuel starvation should not occur but the oil pressure will reduce causing OIL lights to illuminate.

If it is required to perform successive prolonged negative-G manoeuvres, a minimum period of 10 seconds positive G must be established between each manoeuvre to prevent oil starvation of the air turbine gearbox.

14 Flight in turbulence

The recommended speed for flight in severe turbulence is the lesser of 350 knots/0·9M.

15 Range and endurance

(*a*) Maximum range and endurance are obtained at approximately the following heights: —

(i)	On two engines ...	Range: 36000 feet Endurance: 30000 feet
(ii)	On one engine ...	Range: 36000 feet Endurance: 20000 feet

(*b*) For details of cruise performance, refer to the ODM.

16 Descent procedures

(*a*) *Fast descent*

Speed	0·95M/550 knots
Airbrakes	Out
Throttles	Idle/Idle

(*b*) *Normal descent*

Speed	0·9M/375 knots
Airbrakes	Out
Throttles	Idle/Fast Idle

(*c*) *Slow descent*

Speed	0·9M/250 knots
Airbrakes	In
Throttles	Idle/Idle (No 2 engine to fast idle before RPM fall to 58%)

(*d*) *Single-engine descent*

◀ Move the live engine throttle to fast idle and descend as for a two-engine descent. Increase attitude to 7° nose-up for at least 15 secs half-way down the descent. ▶

PART III — HANDLING

Chapter 3 — CIRCUIT AND LANDING PROCEDURES

Contents

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1 Approach and landing

◀(*a*) An overshoot followed by a circuit and landing uses up to 250 lb./side. An overshoot followed by a normal GCA/ILS to landing uses up to 500 lb./side. ▶

(*b*) After joining the circuit, carry out the "checks before landing".

(*c*) (i) At circuit speeds, slight buffet is present and, during the final turn, aileron must be held on to maintain bank. These characteristics are noticeable for only a few flights.

(ii) It is recommended that a shallow approach is used, maintaining at least 60% RPM to ensure rapid engine acceleration if this becomes necessary. Steep approaches should be avoided due to the danger of striking the tail bumper area at the round-out.

(iii) Make the initial turn on to finals at 190 knots. As the runway heading is approached, reduce the bank angle and the airspeed progressively to line-up at 175 knots. Reduce speed slowly to cross the threshold at ◀165 knots aiming to touch down at 155 knots. When landing in turbulent conditions, add 5-10 knots to the threshold and touchdown speeds. Nearly full backward▶ movement of the control column is necessary for the round-out which should be performed smoothly with power on, to prevent the tail striking the ground. When the main wheels are on the ground, close the throttles to idle/fast idle and lower the nose-wheel to the ground.

At 150 knots, pull the brake parachute handle to its full extent. To prevent damage to the parachute during streaming, hold the control column fully forward; when the parachute has deployed, move the No. 2 throttle to idle. If the brake parachute is streamed at speeds below 100 knots, the airflow may be insufficient to assist the pilot chute to deploy the main canopy.

(iv) The braking effect of the parachute is high and it should always be used. The parachute will normally reduce the aircraft speed to 20 knots in approximately 2,000 yards without use of wheelbrakes and irrespective of runway surface conditions. Use the wheel brakes as necessary to supplement the braking effect of the parachute and to keep straight. If wheel brakes only are used, the landing ground roll is increased by approximately 40% on a dry runway and approximately 60% on a wet runway.

NOTE: The speeds quoted above apply to AUW of 30,000 lb. and below. At weights above 30,000 lb. the speeds should be increased by 5 knots for every 2,000 lb. increase in weight. The AUW with a full armament load, empty ventral tank and 1,500 lb./side internal fuel remaining is approximately 30,000 lb.

2 Failure of the brake parachute

(*a*) Failure of the brake parachute to stream will considerably increase the landing run and/or place a heavy demand upon the wheel-brakes. In the most adverse conditions it may not be possible to stop the aircraft in the runway length available. The action to be taken in the event of a brake parachute failure will be governed by prevailing conditions and must be decided upon before commencing the final approach.

(*b*) If the fuel state, weather, etc. permit:

(i) Overshoot action should be taken and the aircraft landed on a runway long enough to meet the ground roll ◀ requirements. If landing at the same airfield, leave the undercarriage down to cool the main tyres. It is very ▶ important that the correct threshold speed should be used on the subsequent landing.

(ii) Carry out a normal approach and touchdown. Move the throttles to idle/idle. After lowering the nosewheel to the ground employ maximum wheel braking technique and close one HP cock.

(iii) However, if both services hydraulic pumps have failed, wheel braking will be provided only by the accumulator. This will usually meet the braking requirements of the aircraft but, particularly if frequent maxaretting occurs, its capability may be marginal. Failure of a services pump is not indicated to the pilot.

(*c*) If circumstances make an overshoot inadvisable, the possibility of brake parachute failure should be anticipated and the following precautionary landing technique adopted:

(i) Carry out a normal approach and touchdown, move the throttles to idle/idle. After lowering the nosewheel to the ground employ maximum wheel braking technique and simultaneously pull the brake parachute handle to its full extent.

(ii) If the brake parachute deploys, the wheelbrakes should be released and a normal landing run completed. If the brake parachute fails to deploy, maximum wheel braking technique should be used as necessary.

(*d*) Should the parachute stream and then collapse, overshoot action should be considered. The decision will depend upon the initial deceleration obtained, the length of runway available and the prevailing runway surface conditions. If overshoot action is taken, the parachute jettison button must always be operated; once the parachute has collapsed the pilot will be unaware whether or not the parachute is still attached. If landing at the same airfield, leave the undercarriage down for tyre cooling.

(*e*) After landing without a brake parachute, the aircraft should not be taxied because damage to the brakes and tyres may have occurred.

(*f*) Landing ground roll distances and airborne distance to clear 50 feet are contained in the Lightning ODM.

3 Use of the wheel brakes

(*a*) After the nose-wheel has been lowered on to the runway the brakes can be used, dependent upon runway conditions, as follows:

(i) *Dry surfaces*

On dry surfaces the maxaret units will normally prevent the wheels from locking when excessive brake pressure is applied but, unless the shortest possible run is required, more gentle use of the brakes is recommended. The aircraft must be firmly on the ground before the brakes are applied as the maxaret units do not operate unless the wheels are rotating. As a safeguard against locking the wheels during a bounce, the maxaret units remain operative for several seconds. If a slip or skid is felt or if difficulty is experienced in keeping straight, release the brakes momentarily.

(ii) *Wet surfaces*
Braking effect may be greatly reduced and will depend directly upon the amount of water and on the type of runway surface. Generally, under wet conditions it is recommended that light continuous braking action be commenced after the aircraft is firmly on the ground and the wheels have had time to spin up. The brake application may then be progressively increased as the speed falls off. If a slip or skid is suspected the pressure should be released, to allow time for the wheels to spin up and then re-applied gradually.

(iii) *Flooded or icy runways*
Whenever possible these conditions should be avoided due to the certainty of a reduction in braking effectiveness. If a landing has to be made, employ the technique described in (ii) above, using extreme caution.

(*b*) Every effort should be made to use the brakes judiciously according to the length of the runway, thus avoiding overheating.

◀(*c*) If maximum braking is necessary the following technique should be used: the nosewheel should be lowered on to the runway as soon as possible after touchdown. With the stick held fully forward firm brake pressure should be applied, simultaneously streaming the brake parachute. Progressively move the stick rearward and increase the brake pressure as the aircraft slows, aiming to avoid "maxaretting". In inclement conditions observe the caution as described in (a)(ii) above. ▶

4 Overshoot procedure

Normally, 90% RPM will be sufficient for overshooting from the approach. Open the throttles smoothly, retract the airbrakes and jettison the brake parachute if streamed. Do not raise the undercarriage if a further circuit is to be flown immediately. Delay selection of flaps to UP until 180 knots has been attained.

5 Instrument approach

(*a*) *Speeds and power settings*

The following speeds and power settings are recommended for use during instrument approaches. The figures apply to aircraft fitted with ventral tank and two missiles:—

TWO ENGINES

	U/C	Flap	A/brake	Approx. % RPM	Speed (Kts.)
◀ Level	Up	Up	In	75	230
Level	Down	Down	In	84	190
Glide-path	Down	Down	Out	83	175 ▶

SINGLE ENGINE

	U/C	Flap	A/brake	Approx % RPM	Speed (Kts.)
◀ Level	Up	Up	In	86	230
Level	Down	Down	In	93	190
Glide-path	Down	Down	Out	90	175 ▶

(*b*) *Missed approach procedure*

(i) It is recommended that the undercarriage, flaps and airbrakes should be retracted during the overshoot. The subsequent approach pattern should be flown at the same speeds and settings as shown in (*a*) above, lowering the undercarriage at the end of the downwind leg.

(ii) If the fuel state is marginal for dealing with a subsequent undercarriage malfunction, leave the wheels down during and after the overshoot.

6 Auto-ILS approach

(*a*) The let-down should be planned so that on reaching check height the aircraft is suitably positioned within the engagement area (see Fig. 1). Do not descend to less than 1,000 feet AGL until the glide-path is intercepted.

(*b*) During or after the let-down, set or confirm:—

(i) Auto-stabilisers selected and functioning satisfactorily.

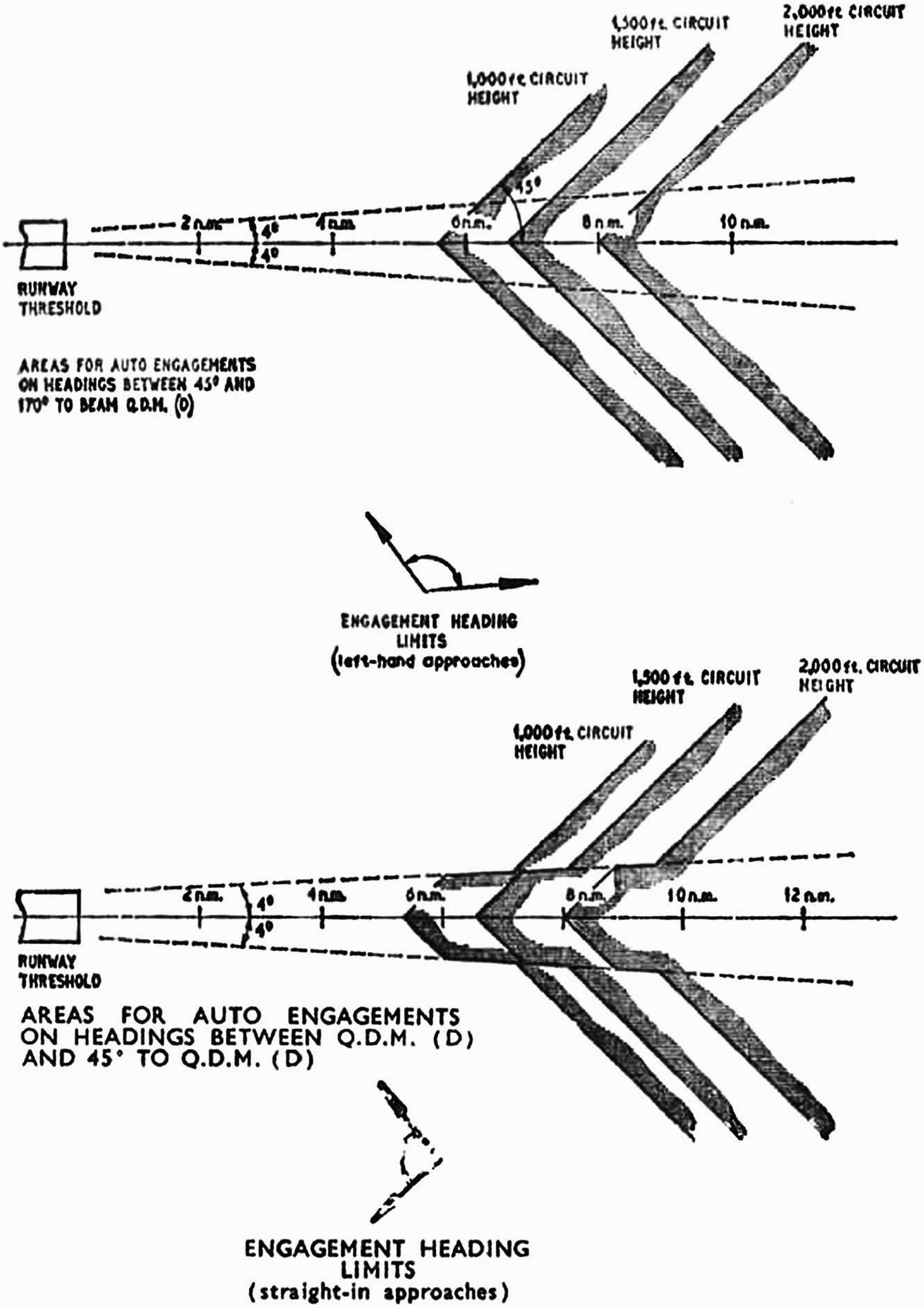

Fig. 1 Auto-ILS engagement areas (3° glide-path)

(ii) ILS master switch ON (below 30,000 feet/400 knots); select appropriate channel and check beacon identification signal.

(iii) VP/ILS switch at ILS.

(iv) Heading selector set to QDM(D). (See Note 1.)

(v) Localiser and glide-path flags not showing.

(vi) Control column auto-pilot switches OFF.

(vii) Select ILS on the auto-pilot control unit.

(*c*) With airbrakes out and throttles set to idle/fast idle, reduce speed at circuit height for checks before landing.

(*d*) As the speed falls through 250 knots, set both engine RPM at 75% and select the throttle servo to ENGAGED.

(*e*) Lower the flaps and, at 220 knots, the undercarriage. Select airbrakes IN.

(*f*) Continue flying the aircraft manually at constant height and allow the speed to stabilise at 175 knots to 180 knots under throttle servo control. It may be necessary to make small adjustments to the power setting to achieve this speed; the servo clutch may be overridden, without having to disengage it, by manually moving the throttles.

(*g*) Trim the aircraft. The autopilot trim indicator should fluctuate about the central position (see Note 2).

(*h*) When suitably positioned within the engagement area and on a correct heading (less than 170° from the QDM(D)), check that the ILS indication is logical and that the auto-pilot trim indicator is central. Select control column auto-pilot switch to AP.

(*j*) The auto-pilot will immediately apply up to 30° of bank to turn the aircraft towards the localiser beam and fly an interception heading of up to 45° to the QDM(D). During this turn, the aircraft may descend as much as 400 feet. This height loss may either be accepted or it may be corrected by the pilot; if it is to be corrected it is preferable to do so by overriding the auto-pilot rather than by using the trimmer, otherwise the aircraft will need re-trimming when the turn is completed.

(*k*) The auto-pilot will align the aircraft with the localiser beam after one overshoot. At short interception ranges, this overshoot may cause full-scale deflection on the ILS indicator.

◀(*l*) When the glide bar begins to move down, extend the airbrakes and press the GLIDE switch. The aircraft will pitch down and follow the glide-path (see Note 3). ▶

(*m*) Throughout the approach, carefully monitor auto-pilot trim and approach speed and keep them correct by trimming and overriding the throttle servo clutch as appropriate. The small corrections that may be necessary should be followed by a delay of about 30 seconds, where practicable, to allow the system to stabilise.

(*n*) Continue the approach until visual contact is gained or until break-off height is reached.

(*o*) Select throttle servo DISENGAGED, control column switches OFF and then land or overshoot as appropriate.

NOTE 1: QDM(D) is the heading required at ground level to track the beam centre-line and is the beam QDM corrected for drift due to the surface wind. In cases of strong cross-winds or large wind shear, the aircraft will tend to "sit-off" the beam at the start of the approach and progressively converge with the centre-line as height decreases during the glide phase. It is important that an accurate value of QDM(D) is obtained since the final approach accuracy depends on it.

NOTE 2: The auto-pilot trim indicator registers error signals in the pitch channel. The direction of displacement on the indicator shows the direction in which the aircraft would pitch if the auto-pilot were to be disengaged. Prior to engagement it should indicate zero and, if this is not the case after 10 seconds of steady flight, the auto-pilot should not be engaged in case of a latent malfunction.

NOTE 3: Selection of GLIDE reduces the auto-pilot authority in bank angle. Therefore, GLIDE should not be selected with a heading error of greater than 10° from QDM(D) or with a localiser error of greater than 3 dots. If necessary, transition to glide may be delayed until a half-scale "fly-down" glide signal is indicated.

7 Flapless landing

◀(*a*) All stages of a flapless circuit and landing should be flown at speeds 10 knots faster than for a normal landing. Whenever practicable, therefore, the AUW should be reduced to 30,000 lb. in order to achieve the minimum touchdown speed of 165 knots. The absence of flap▶

results in a marked nose-up attitude throughout the circuit and, unless the seat position is raised, difficulty may be experienced in retaining an unobstructed view of the runway when lined up on the final approach.

(*b*) A flatter approach than normal is recommended. The high angle of attack reduces tail bumper clearance when rounding-out and extra care is necessary at this stage of landing. The higher touchdown speed may cause the aircraft to bounce; this should be prevented by moving the control column forward as the main wheels touch the ground. The minimum landing run will be about 200 yards longer than that for a normal landing.

8 Crosswind landing

◀(*a*) The crab technique is recommended for approaches in crosswind conditions. When rudder is used to eliminate drift, a rolling moment due to yaw will result and should be anticipated.

(i) Lower the nosewheel immediately after touchdown and stream the brake parachute, anticipating the weather-cock effect by use of rudder as necessary to keep the aircraft on or parallel to the centre line. Aileron into wind should be applied to keep the wings level and equalise weight distribution on the wheels as far as possible. Maximum use of rudder is recommended for directional control until asymmetric wheel braking becomes necessary as the rudder begins to lose effectiveness. Total available tyre/runway adhesion is divided between braking and opposition to sideways movement (drift), and therefore, delaying the use of wheel brake reduces the tendency to drift.

(ii) The most critical part of the landing run is between 125 and 100 knots and in strong crosswinds the aircraft will assume a noticeable nose-into-wind angle and down-wind wing-low attitude. Below 100 knots, normal wheel braking up to maximum may be used as required without significant adverse effect on directional control. Landing distances will be longer than normal.

(iii) The above recommendations and those in sub. para. (*b*) below remain valid in the event of parachute

◀ failure. The degree of wheel braking practicable will depend on the conditions and there will be an increased risk of engaging the airfield barrier.

(*b*) If an uncontrollable drift to the downward side of the runway occurs in extreme circumstances such as an unavoidable landing outside normal crosswind limits, the following actions are recommended:—

(i) Release brakes, allowing maximum use of restoring force provided by tyre/runway friction to oppose drift.

(ii) Allow weathercock effect to yaw aircraft nose into wind and restore tracking towards or parallel to the upwind side of the runway.

(iii) Delay use of brakes until rudder control becomes insufficient or until directional control ceases to be critical.

(iv) Do not jettison the brake parachute unless retaining it is likely to cause the aircraft to leave the side of the runway. ▶

9 Roller landings

Roller landings are not normally permitted due to the possibility of overheating the tyres.

10 Checks after flight

(*a*) Carry out the "checks after landing".

(*b*) Carry out the "shut-down checks".

PART 3 — HANDLING

Chapter 4 — SINGLE-ENGINE FLYING AND RELIGHTING

Contents

	Para
Stopping an engine	1
Single-engine flying	2
Single-engine landing and overshoot	3
Relighting an engine in flight	4
Relighting in icing conditions	5

1 Stopping an engine

(*a*) Shutting down an engine in flight is to be restricted to the following occasions: —

(i) Appropriate emergency procedures.

(ii) When specifically required on an air test.

(iii) When there is an operational necessity to conserve fuel.

(*b*) Practice single engine flying should be carried out by throttling back No 2 engine whenever possible, to alleviate high compressor blade stresses in No 1 engine. As No 1 engine has no fast idle stop, manual control must be used to prevent inadvertent selection of RPM below 58%.

(*c*) If an engine is to be shut down, consideration should be given to stopping No 2 engine in preference to No 1 for the reason at (*b*) above and so that the undercarriage emergency system and brake parachute are available if the shut down engine fails to relight. Carry out the following procedures: —

(i) Select the throttle/HP cock to HP COCK CLOSED.

(ii) Select both fuel pump switches to the live engine.

2 Single-engine flying

(*a*) There are no asymmetric handling problems associated with single-engine flying.

(*b*) Flight through icing conditions should be avoided owing to lack of protection on the shut down engine.

(*c*) Both fuel switches should be set to the live engine. Some fuel asymmetry can be expected but no attempt should be made to balance the fuel by selective switching of the fuel switches. If such an attempt is made, a flame-out of the live engine may occur if the booster pumps on one side are unserviceable. If it is suspected that failure of the fuel system on one side has occurred, adopt the fuel ◀ emergency drill given in the Flight Reference Cards. ▶

(*d*) Halfway down the descent on recovery, aircraft attitude should be increased to 7° nose-up for at least 15 seconds to replenish the fuel collector boxes.

3 Single-engine landing and overshoot

(*a*) A single-engine landing presents no difficulty and the approach and landing should be carried out at the normal speeds.

(*b*) Provided the speed is above 145 knots, an overshoot with the undercarriage and flaps down can be achieved in maximum cold thrust. Raise the undercarriage when safely airborne and the flaps, at not less than 180 knots.

4 Relighting an engine in flight

(*a*) (i) If a flame-out occurs, an immediate relight may be attempted at any altitude and airspeed/mach number by pressing the appropriate relight button for 2 seconds, leaving the throttle at its set position (but see (ii), below). A successful relight will be indicated by the RPM stabilising and then commencing to rise. Ensure, by throttling back if necessary, that the maximum JPT is not exceeded. If no relight occurs within 20 seconds, select HP cock OFF and wait 1½ minutes before attempting a normal relight as in (*b*).

(ii) If flame-out occurs whilst in reheat, cancel the reheat selection before proceeding as in (i) above.

(*b*) Normal relights are practicable up to 40000 feet and 0·9M. Relighting becomes progressively more certain at lower altitudes. For normal relighting proceed as follows:—

(i) Maximum speed, 0·9M.

(ii) Maximum altitude, 40000 feet.

(iii) Check HP cock closed on the dead engine.

◀ (iv) Check engine starting master switch is on. ▶

(v) Appropriate fuel switch on for that engine.

(vi) Press the appropriate relight button for 2 seconds.

(vii) Without delay, open the throttle slowly to the half-open position.

(viii) When the RPM and JPT have stabilised, the RPM may be increased as required.

(ix) If the RPM and JPT fail to rise within 20 seconds of pressing the relight button, close the HP cock and wait ◀ for at least 1½ minutes before making a further attempt▶ at a lower altitude and with airspeed as low as practicable.

5 Relighting in icing conditions

If an engine flames-out when flying in icing conditions an ◀immediate attempt to relight, as described in para. 4(*a*) above, may be made. If this is unsuccessful the second attempt should be made after 1½ minutes. If this also fails, any further attempt may damage the engine. ▶

PART 4

EMERGENCIES INDEX

PART 4

EMERGENCIES

1 Index

The following table shows the location of all emergency procedures in the text of the Notes and in the Flight Reference Cards (FRC):

Emergency	*Text* *Pt*	*Ch*	*Para*	*FRC*
Abandoning aircraft	1	12	22	Card 26
Air turbine malfunctions	1	1	17	Card 15
Alternator failure	1	1	14	Card 15
Autostabiliser/autopilot malfunction	1	14	10	—
Canopy emergency operation ...	1	9	2	—
Canopy jettisoning	1	9	3	Card 24
Cockpit heating failure	1	10	9	Card 22
Cockpit pressure failure	1	10	8	Card 22
Engagement with arrester barrier ...		—		Card 26
Engine failure	3	1	4	Card 18
Engine fire	4	—	2	Card 16
Engine relighting	3	4	4	Card 18
Fuel contents gauge failure	1	2	22	—
Fuel asymmetry during single-engine flying		—		Card 19
Fuel pressure warning	1	2	11	Card 19
Fumes in cockpit		—		Card 22
Generator failure	1	1	15	Card 15
Generator overvolting	1	1	16	—
Hazardous landings		—		Card 25
Hydraulic failures	1	5	7	Card 21
Instrument supply changeover in flight	1	1	18	—
Missile jettisoning	1	16	4	Card 24
Oil pressure failure	1	3	13	Card 18
Oxygen failure	1	12	16	Card 23
◀Radio failure		—		Card 24▶
Reheat failure	1	3	3	—
Reheat fire	4	—	2	Card 17
Reheat relighting	3	2	3	—
Undercarriage emergency operation	1	7	2	Cards 24 & 25
Ventral and flap tank fuel transfer failure	1	2	20	Card 20
Ventral tank jettison	1	2	12	Card 24

42 Fire in the air

(*a*) *Damage to elevator control rods*

A fire of sufficient severity in a reheat or engine zone can affect the elevator control rods so that elevator control is reduced or lost. The most likely result is control stiffening caused either by structural distortion or by grease carbonisation in the control system bearings; it is stressed that in this condition the aircraft can still be manoeuvred. All evidence available suggests that it is most unlikely that complete loss of control will occur from fire causes alone, before other significant happenings which would necessitate ejection: these are total electrical failure, fuel system warnings, hydraulic problems and loss of rudder control. Even with these associated failures the aircraft is likely to be fully controllable until the point of ejection. There is also evidence to suggest that the symptoms of fire damage to the controls are progressive and, provided they are not accompanied by warnings of other system failures or malfunctions, it is likely that the aircraft will remain flyable. No additional danger will be placed on the pilot by staying with the aircraft until it is either deemed to be recoverable or ejection is necessary for reasons of fuel state, operational necessity or danger to civilian population. It is advisable, therefore, to fly at a low IAS, turning where necessary at a low rate, not attempting to look for external signs of fire which, in any case, may be indiscernable. Although the steel control rods are resistant to the most severe fire, the surrounding structure could fail with similar results to control rod failure. Symptoms of fire damage are:

(i) Increase in friction or stiffening of elevator control.

(ii) Loss of effectiveness about the centre position of the control column.

(iii) Loss of feel.

To detect the symptoms, make small fore and aft movements of the control column. Investigation has shown that in the case of a persistent fire, it is very likely that the symptoms will appear within 5 minutes.

(*b*) *Fire warning at low level*

The rate at which control damage can arise is such that there may be insufficient time to land safely even though the warning occurs at low level near an airfield. Unless a warning occurs during the last stages of an approach, from which position a landing is likely to be safer than any overshoot, the pilot's primary considerations should be to shut down the affected engine and to attain a minimum safe height of 5000 feet AGL.

(*c*) *Minimum safe height*

The recommended minimum safe height at which to perform subsequent actions is 5000 feet AGL. This assumes automatic parachute deployment and caters for:

(i) All aircraft attitudes.

(ii) A rate of descent of 20000 feet/minute.

(iii) The time interval between a pilot deciding to eject and initiating the ejection sequence.

(*d*) *Persistent warning*

If the fire drill extinguishes the fire, the firewire should cool and the warning should go out; a persistent warning would indicate either a continuing fire or a spurious warning. As stated in (*a*) above, if elevator control is going to be lost, it is most likely to occur within 5 minutes. If loss of control has not occurred at the end of 15 minutes it is virtually certain that the warning is spurious. Thus, to diagnose whether a persistent warning is real or spurious, a minimum of 5 minutes should be spent above 5000 feet and longer than this if the fuel state permits. A continued double warning must be taken as an indication of persistent fire and the aircraft should not be landed; a persistent single warning without any other signs of fire or system warnings can be assumed to be spurious. The decision to land if all warnings go out must be taken individually and will depend on what other symptoms have occurred.

(*e*) *Firewire reset times*

Dependent on the type of overheating experienced by the firewire, and the level beyond the warning threshold to which the firewire has been heated, a certain time will be required for the system to fall to the reset level. In many cases this reset time could extend up to 2 minutes and even beyond.

(*f*) *Engine fire*

The importance of immediately shutting down an engine following a fire warning cannot be overstressed. This quickly lowers the temperature of the engine and its surrounds, and cuts off supplies of inflammable fluids. A

◀speed reduction is recommended before discharging the extinguisher. However, the pilot should not wait deliberately for speed to reduce but rather effect the speed reduction as circumstances permit whilst carrying out the actions which precede operating the extinguisher. It should be noted that optimum cooling of the external surfaces of a live engine is obtained at flight idle. Whenever possible the live engine should be brought back to this condition at the time of shut down of the affected engine.

(*g*) *Reheat fire*

Present data suggests that a double reheat fire warning will result in the loss of the aircraft. However, it is stressed that even in this condition, immediate ejection is not essential. In all cases the No 1 engine should be immediately shut down and a controlled climb initiated to at least 5000 feet AGL. The aircraft may then be manoeuvred into the most suitable area for an ejection, unless further symptoms necessitate otherwise. In the case of a single reheat warning it is possible for the warning to originate from either engine and the drill requires shut down of the engine associated with the warning while minimum practicable RPM is used on the other (the drill represents minimum practicable RPM as 250 knots). It is also possible for only one warning to be given when, but for some unusual circumstance or malfunction, two warnings would have appeared. Thus, even though a single reheat warning goes out, a safe height should be maintained for at least 5 minutes.

(*h*) *Fire drills*

Engine and reheat fire drills are given in the Flight Reference Cards. These recommend that a similar pattern be followed involving immediate shut-down of the affected engine (No 1 engine in the case of a double reheat warning), a climb to a minimum safe altitude of 5000 feet AGL, gentle manoeuvres only without negative-G, operation of the extinguisher followed by checks (both from a visual source and functional) to try to establish the seriousness of the fire. If fuel permits, flying may be continued until the real situation can be established so as to permit landing, or until the aircraft is in the most suitable position for abandonment.▶

PART VI

ILLUSTRATIONS

PART VI

ILLUSTRATIONS

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Cockpit — port side	1
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KEY TO FIG. 1

1. Anti-G stop valve selector.
2. Demist control.
3. Ram air valve control.
4. Canopy control handle.
5. Throttle servo control
6. Pupil's relight pushbuttons.
7. Reheat/fast idling stop release lever.
8. Flight refuelling control panel.
9. Flight refuelling selector switch.
10. Hydraulic feel cut-out switch.
11. Emergency canopy jack release lever.
12. Pupil's AI hand controller.
13. Fire extinguisher indicator switches.
14. Pupil's telebriefing indicator switch.
15. Standard warning panel.
16. SWP cancel button.
17. Pupil's rudder trim switch.
18. SWP mute button.
19. SWP test button.
20. Cockpit lighting dimmer switches.
21. JPT control switches.
22. Pupil's flap selector switch.
23. PAS camera recorder switch unit.
24. Pupil's brake parachute stream handle.
25. Tacan control unit.
26. Undercarriage selector pushbuttons.
27. Instructor's AI hand controller.
28. Pupil's brake parachute jettison pushbutton.
29. Feel switch position indicator.
30. Ventral tank/missile jettison handle.
31. ILS master switch.
32. Canopy jettison flap.
33. Pupil's undercarriage position indicator.
34. ILS control unit.
35. ILS volume control.
36. IFF control unit (not shown).
37. Undercarriage emergency selector.
38. IFF master switch.

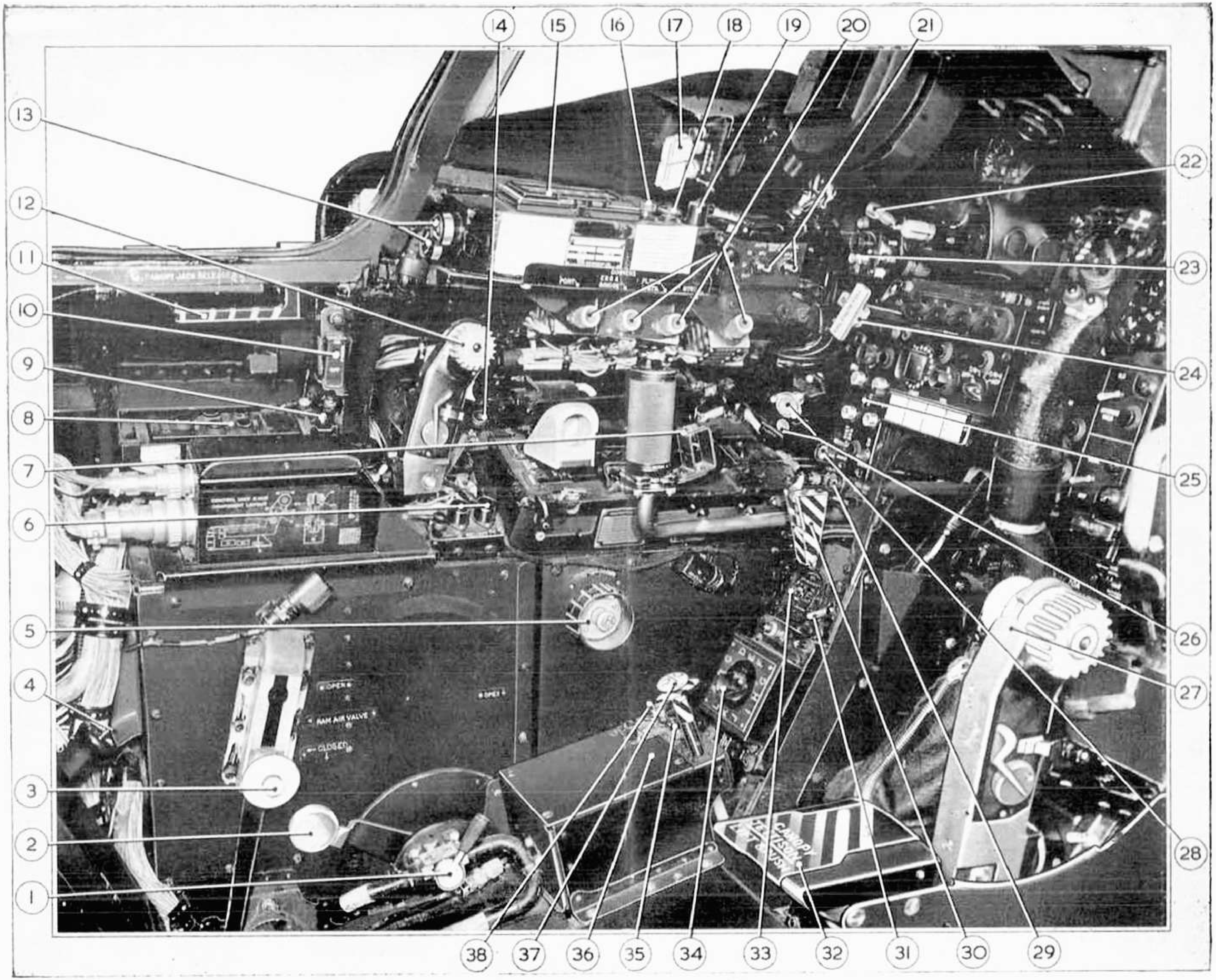

Fig. 1. Cockpit — port side

KEY TO FIG. 2

1. UHF power switch.
2. UHF control unit.
3. Brake parachute stream handle.
4. Standby/cabin altimeter.
5. Armed time indicator.
6. Flaps position indicator.
7. Artificial horizon NORMAL/STBY switch.
8. Auto-pilot trim indicator.
9. Pupil's remote oxygen flow indjcator.
10. Standby inverter magnetic indicator.
11. Port attention light.
12. Camera master switch.
13. Rocket doors unlocked warning light.
14. Camera iris switch.
15. GW pairs/single switch.
16. Rocket battery emergency retract switch.
17. GW fire control reset switch.
18. Gun purging warning light.
19. GW arming switch.
20. GW arming indicator light-blue.
21. Master armament selector.
22. GW arming indicator light-green.
23. E2B compass.
24. Hydraulic services pressure gauge.
25. Fuel contents gauges
26. Port windscreen heater switch.
27. Cabin air switch.
28. Starboard windscreen heater switch.
29. Pitot and vent valve heater switch.
30. Side windscreen heater and canopy blower switch.
31. Engine anti-icing warning light.
32. Engine anti-icing switch.
33. Starboard attention light.
34. ILS marker.
35. Instructor's remote oxygen flow indicator.
36. R/T mute switch.
37. Combined trim and airbrake position indicator.
38. Accelerometer.
39. Voltmeter.
40. Brake parachute stream handle.
41. Ventral tank no flow indicator.
42. Nozzle position indicator.
43. Navigation lights switch.
44. Instructor's oxygen regulator.
45. Taxy lights switch.
46. Fuel pumps and cocks switches.
47. Instructor's airbrakes switch.
48. VP/ILS switch.
49. VP sensitivity switch.
50. Emergency lights switch.
51. Standby artificial horizon.
52. Pupil's oxygen regulator.
53. Nosewheel steering switc (inoperative).
54. Two-axis trim switch.
55. Camera pushbutton.
56. Auto-pilot control unit.
57. Auto-pilot engage switch.
58. UHF set selector switch.

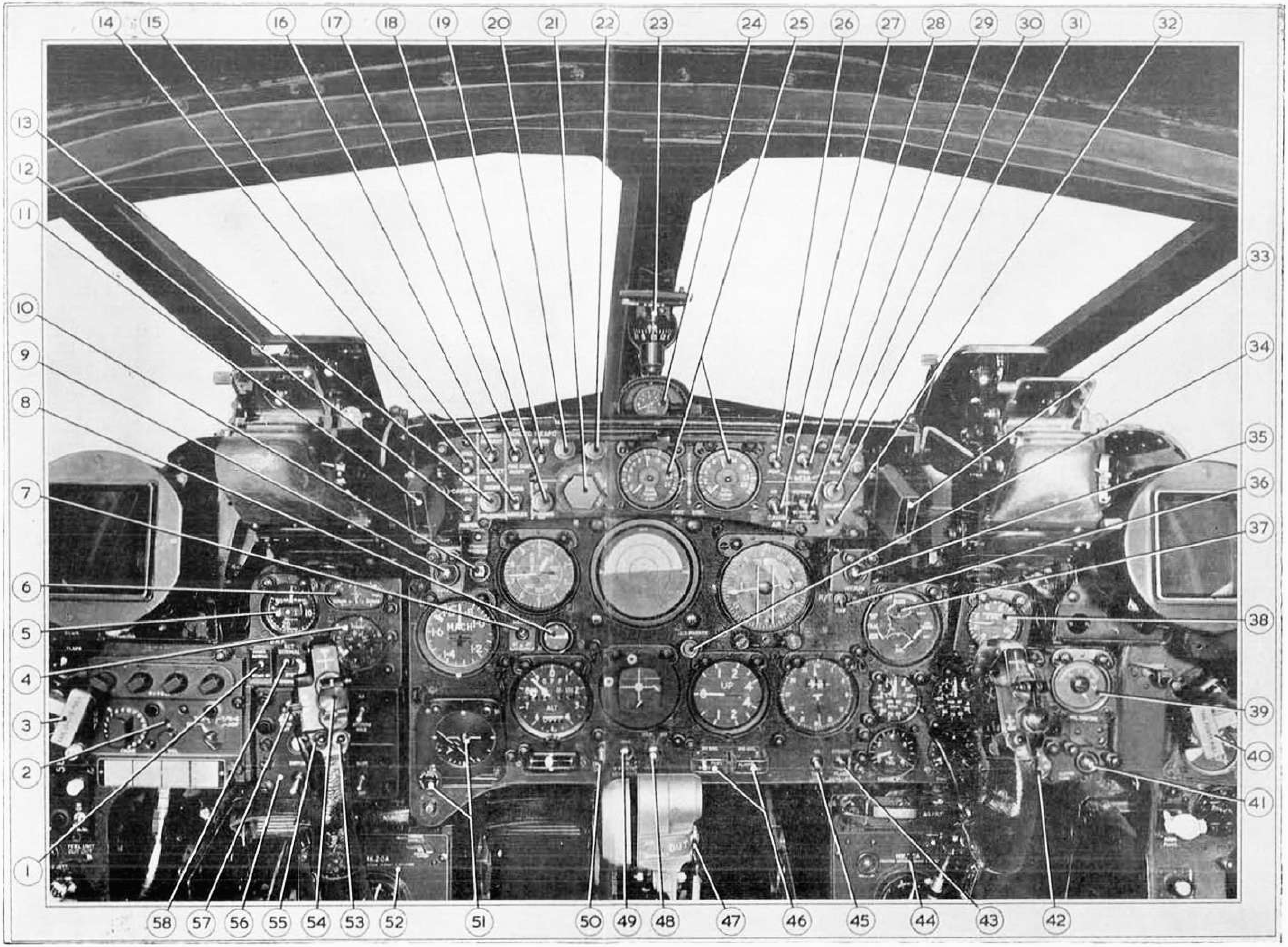

Fig. 2 Cockpit — forward view

KEY TO FIG. 3

1. Brake parachute jettison pushbutton
2. Instructor's flap selector switch.
3. Undercarriage position indicator.
4. Brake accumulator pressure gauge.
5. Oxygen contents gauge.
6. Brake parachute stream handle.
7. Ignition switch, No. 1 engine.
8. Ignition switch, No. 2 engine.
9. Engine start master switch.
10. AWP test pushbutton
11. Engine start pushbuttons.
12. Auxiliary warning panel.
13. AWP day/night selector switch.
14. Ejection seat up/down switch.
15. Anti-G H/L selector switch.
16. Anti-G test button.
17. Instrument master switch.
18. AVS flow control selector.
19. Instructor's rudder trim switch
20. Instructor's relight pushbuttons.
21. Battery isolation switch.
22. AI changeover switch.
23. GW emergency jettison switch.
24. Instructor's telebriefing indicator switch.
25. Intercomm. normal/emergency switch.
26. Intercomm. on/off switch.

Fig. 3 Cockpit — starboard side