A.P. 4700 A and F—P.N.

RESTRICTED

Pilot's Notes
Lightning F. Mk I & F. Mk IA

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 positioned in the text thus: ◀ .... ▶ to show the extent of the amended text, and thus: ▶◀ to show where text has been deleted. When a page is issued or re-issued by amendment the number of the Amendment will appear at the bottom of the page. When a chapter is issued or re-issued in a completely revised form the triangles will not appear. Incorporation of an Amendment list must be certified by inserting the date of its issue, the date of incorporation and signature below.

Admt. list		Signature	Date of incorporation	Amdt. list		Signature	Date of incorporation
No.	Date			No.	Date		
1		MISSING		7			
2		MISSING		8			
3		MISSNG		9			
4				10			
5				11			
6				12			

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

February, 1962 A.P.4700A & F-P.N.

PILOT'S NOTES
LIGHTNING
F.MK.1 AND F.MK.1A

Prepared by Direction of the Minister of Aviation

Promulgated by Command of the Air Council

RESTRICTED

NOTES TO USERS

1. These notes are complementary to A.P.129 (6th Edition) Flying and should be read in conjunction with the Lightning Operating Data Manual. It is assumed that all concerned have a thorough knowledge of the Chapters of A.P.129 relevant to the operation of this type of aircraft.

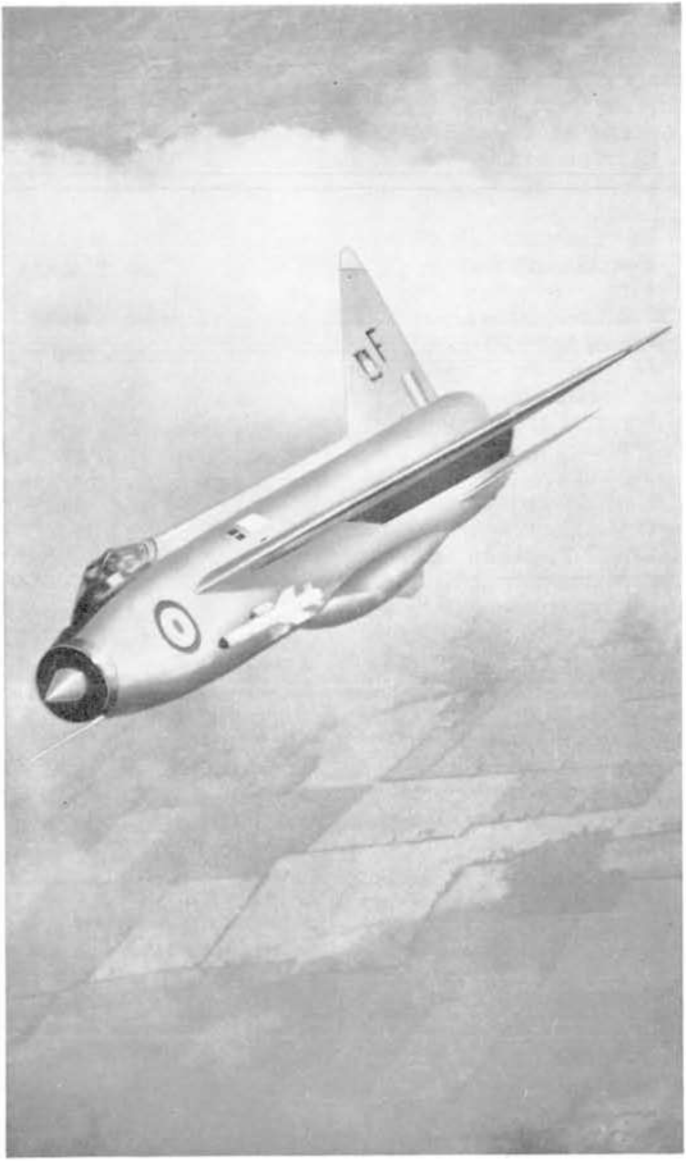
2. Throughout these Notes the following conventions apply :—

(a) Unless otherwise stated all speeds, mach numbers and accelerometer readings quoted are "Indicated".

(b) Words in capital letters in the text indicate the actual marking on the control concerned.

3. The limitations quoted in Part II are mandatory and must never be exceeded. The contents of other Parts of the book are mainly advisory, but instructions containing the word "must" are to be regarded as mandatory (A.M.F.O. 24 refers).

4. Comments and suggestions should be forwarded to the Officer Commanding, Handling Squadron, Royal Air Force, Boscombe Down, Wilts.



LIST OF ASSOCIATED AIR PUBLICATIONS

	A.P.
A.R.I. 18059	2534K
Avon Mk. 20900 and 21000 Series E.C.U. and associated jet pipes	4481 J & K
Cameras and accessories, air	1355C
Combustion starters for aero engines—Plessey	1181B
Ejection seats and escape equipment	4288
Electrical manual	4343 series
Fire prevention and fire extinguishing equipment in aircraft	957C
Guns, Aden 30 m.m.	1641S
Hydraulics and undercarriage equipment—British Messier	1803T
Hydraulic and undercarriage equipment, miscellaneous	1803P
Hydraulic equipment—Dowty	1803D
Hydraulic equipment—Dunlop	1803S
Hydraulic equipment—Integral	1803J
I.F.F. Mk. 10 (Airborne) A.R.I. 5848	2887N
I.L.S. airborne equipment (A.R.I. 18011)	2534E
Instrument manual	1275 series
Integrated flight instrument and control systems	4684 & 4685A
Pilot's attack sight, Mk. 1	4707A
Power flying control units—Hobson	4604G
Pressurising and air-conditioning equipment	4340
Pneumatic equipment—Hymatic	4303C
Rocket installation, sighting and ammunition	2802A
Rotol accessory gearbox and drives	2240A
Telebriefing (A.R.I. 18012 and F.G.R.I. 18013)	2876G
Tacan (A.R.I. 18107)	2534N
U.H.F. multi-channel T/R (A.R.I. 18124/1 and 2)	2531J
U.H.F. homing installations (A.R.I. 18120)	2531L
U.H.F., Standby, T/R (A.R.I. 23057)	2531N
V.H.F. TR. 1985/6/7 and TR. 11542 (A.R.I. 18064)	2528P

MODIFICATIONS MENTIONED IN THE TEXT

MOD NO.	EFFECT OF MODIFICATION
F.C.1	Introduction of Mk. 21A oxygen regulator.
165	Introduction of external intercomm.—Mk. 1 aircraft.
227	Introduction of external intercomm.—Mk. 1A aircraft.
244	Provision of vented blast tube sleeves in upper gun installation.
328	Wiring for external intercomm.
394	To introduce a modified top to the control column.
1522	Introduction of Mk. 20A oxygen regulator
1534	Introduction of a voltmeter.
1538	To replace Mk. 22A altimeter with Mk. 22C altimeter.
1556	To delete the Tacan aerial switch in the cockpit.
1569	Type 41A fire extinguisher bottles replaced by type 57A bottles.
1802	Introduction of services system hydraulic pressure gauge—Mk. 1 aircraft.
1803	Introduction of auxiliary hydraulic reservoir for No. 1 controls system—Mk. 1 aircraft.
1809	Introduction of services system hydraulic pressure gauge—Mk. 1A aircraft.
1823	Introduction of auxiliary hydraulic reservoir for No. 1 controls system—Mk. 1A aircraft.
1831	To enable telebriefing to be operated without battery switch being made—Mk. 1A aircraft.
1836	To enable telebriefing to be operated without battery switch being made—Mk. 1 aircraft.
1863	Introduction of Mk. 20B oxygen regulator.
1871	Mk. 4 machmeter to replace Mk. 3B.
1884	Mk. 16 air speed indicator to replace Mk. 15b.
Avon 2262	To introduce minicage fuel burner.

COMPLETE LIST OF CONTENTS

INTRODUCTION

PART 1—DESCRIPTION AND MANAGEMENT OF SYSTEMS

PART II—LIMITATIONS

PART III—HANDLING

PART IV—EMERGENCY PROCEDURES

PART V—OPERATING DATA

PART VI—ILLUSTRATIONS

INTRODUCTION

1. The Lightning F.Mk. 1 and F.Mk. 1A are single-seat, twin-engined, supersonic interceptor fighters, each 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 airbrakes 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, one to the rear of and above the other.

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 consists of two 30 m.m. Aden guns, one on either side of the cockpit, and an interchangeable armament pack fitted on the underside of the fuselage which carries two additional 30 m.m. Aden guns or forty-eight 2 inch air-to-air rockets internally or two pylon-mounted guided missiles externally. The radar fire control system comprises A.I.23 equipment and a Pilot Attack Sight.

6. The pressurised cockpit is equipped with an ejection seat. The clam-shell canopy is hydraulically operated and electrically controlled and can be jettisoned by a canopy jettisoning handle or, on ejection, by either of the ejection seat firing handles.

7. Entry to the cockpit is gained from the port side of the aircraft by an access ladder which is 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 (S.W.P.) and on an auxiliary warning panel (A.W.P.) on the port and starboard sides of the cockpit respectively.

9. 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.

10. The various panels on which the pilot controls and indicators are located are referred to in the Notes as shown on the diagram below.

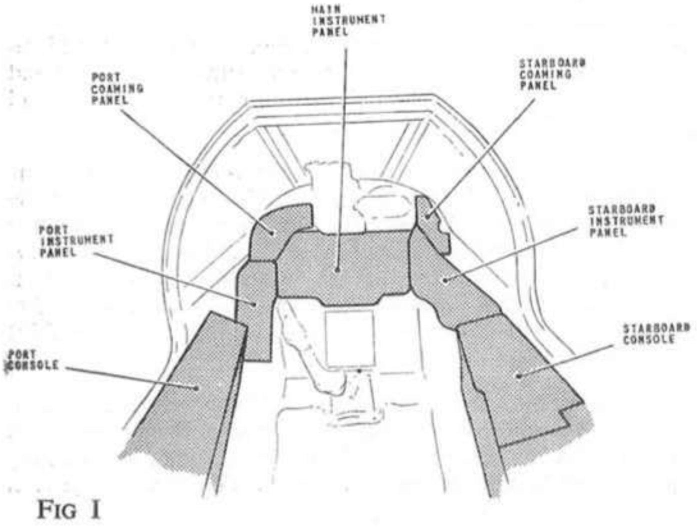
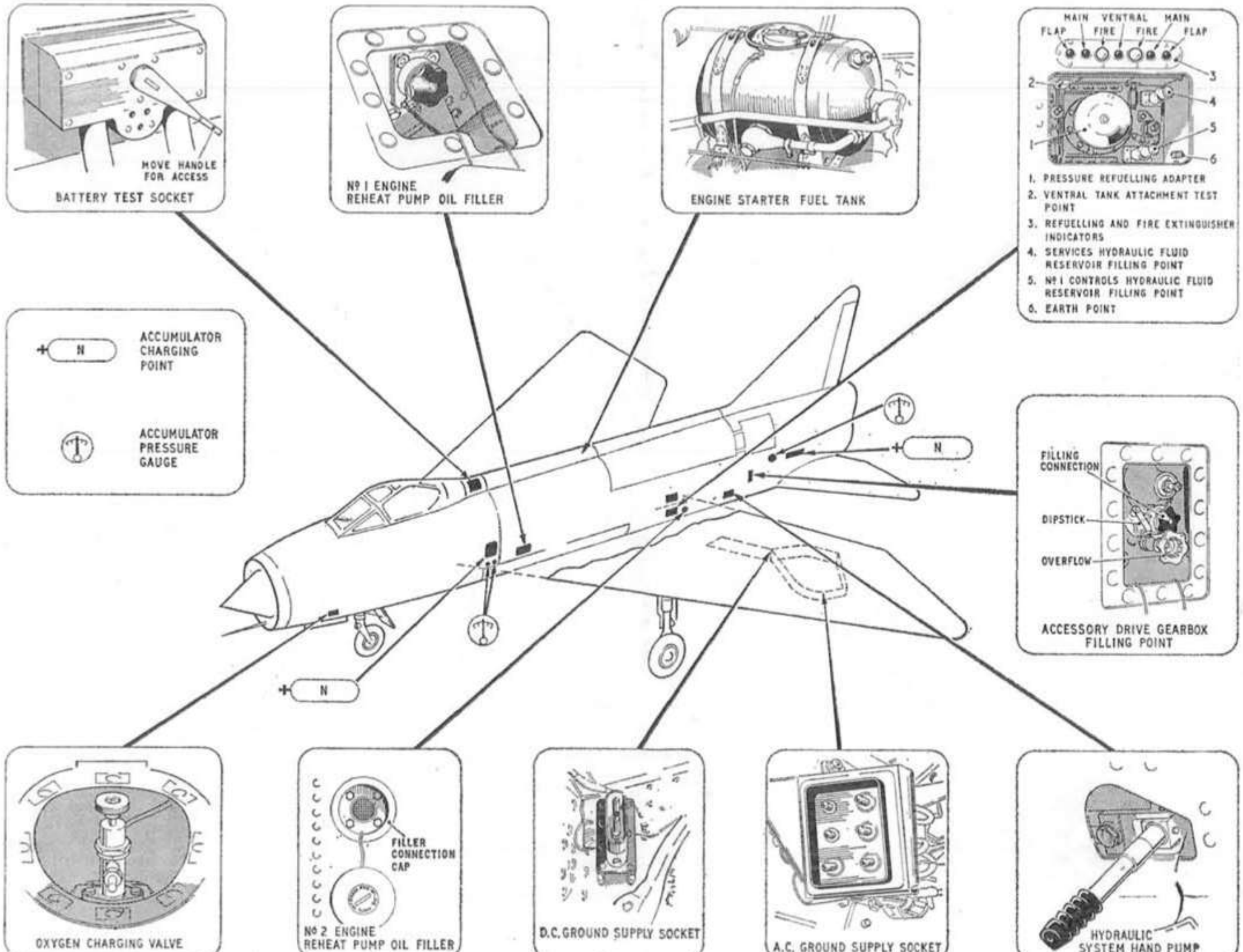
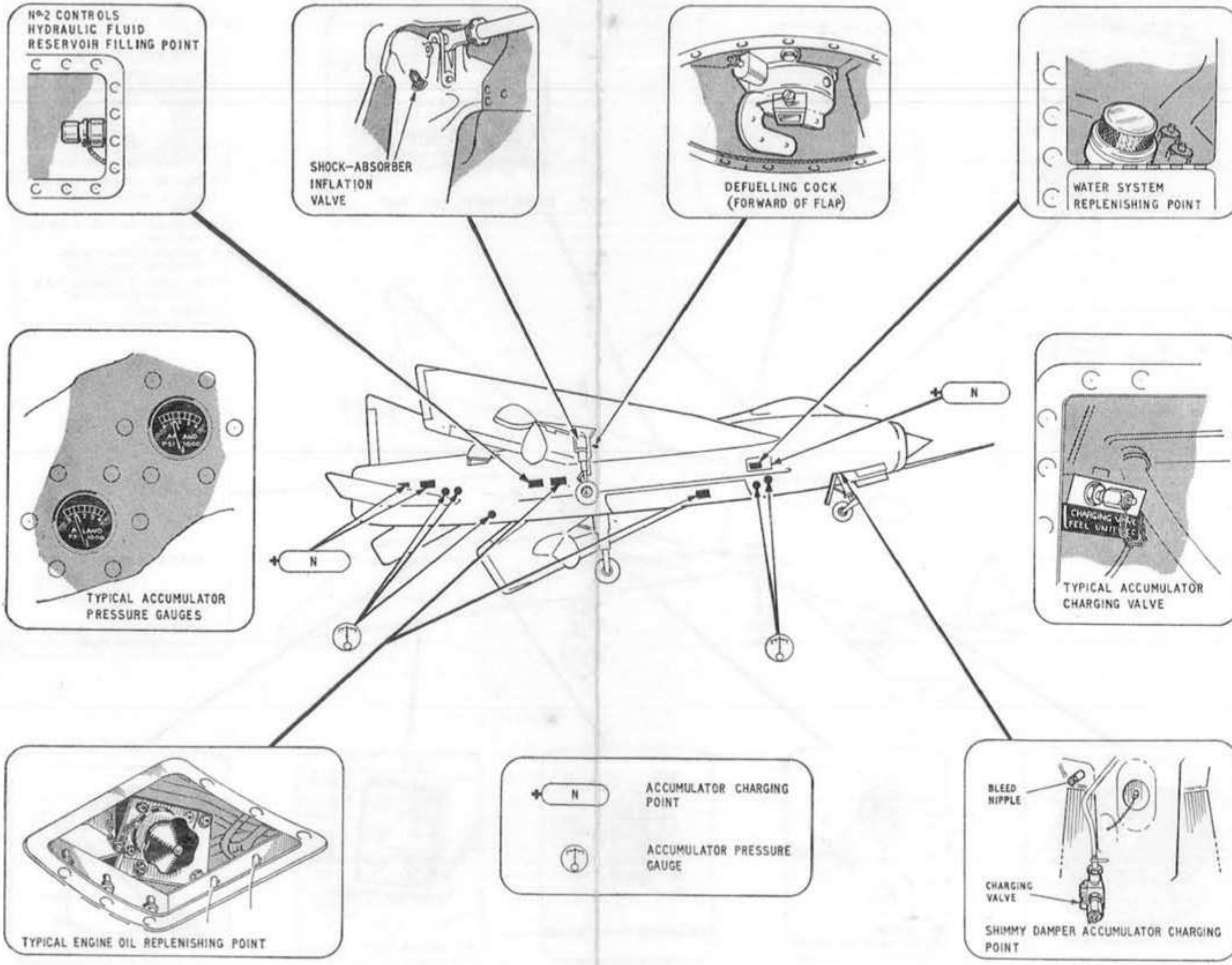


FIG I


MOVE HANDLE FOR ACCESS
BATTERY TEST SOCKET
Nº 1 ENGINE REHEAT PUMP OIL FILLER
ENGINE STARTER FUEL TANK
MAIN VENTRAL MAIN
FLAP FIRE FIRE FLAP
1. PRESSURE REFUELLING ADAPTER
2. VENTRAL TANK ATTACHMENT TEST POINT
3. REFUELLING AND FIRE EXTINGUISHER INDICATORS
4. SERVICES HYDRAULIC FLUID RESERVOIR FILLING POINT
5. Nº 1 CONTROLS HYDRAULIC FLUID RESERVOIR FILLING POINT
6. EARTH POINT
ACCUMULATOR CHARGING POINT
ACCUMULATOR PRESSURE GAUGE
N
FILLING CONNECTION
DIPSTICK
OVERFLOW
ACCESSORY DRIVE GEARBOX FILLING POINT
OXYGEN CHARGING VALVE
FILLER CONNECTION CAP
Nº 2 ENGINE REHEAT PUMP OIL FILLER
D.C. GROUND SUPPLY SOCKET
A.C. GROUND SUPPLY SOCKET
HYDRAULIC SYSTEM HAND PUMP


Nº2 CONTROLS
HYDRAULIC FLUID
RESERVOIR FILLING POINT
SHOCK-ABSORBER
INFLATION
VALVE
DEFUELLING COCK
(FORWARD OF FLAP)
WATER SYSTEM
REPLENISHING POINT
TYPICAL ACCUMULATOR
PRESSURE GAUGES
N
N
N
TYPICAL ACCUMULATOR
CHARGING VALVE
TYPICAL ENGINE OIL REPLENISHING POINT
N
ACCUMULATOR CHARGING
POINT
ACCUMULATOR PRESSURE
GAUGE
BLEED
NIPPLE
CHARGING
VALVE
SHIMMY DAMPER ACCUMULATOR CHARGING
POINT

PART I

DESCRIPTION AND MANAGEMENT OF SYSTEMS

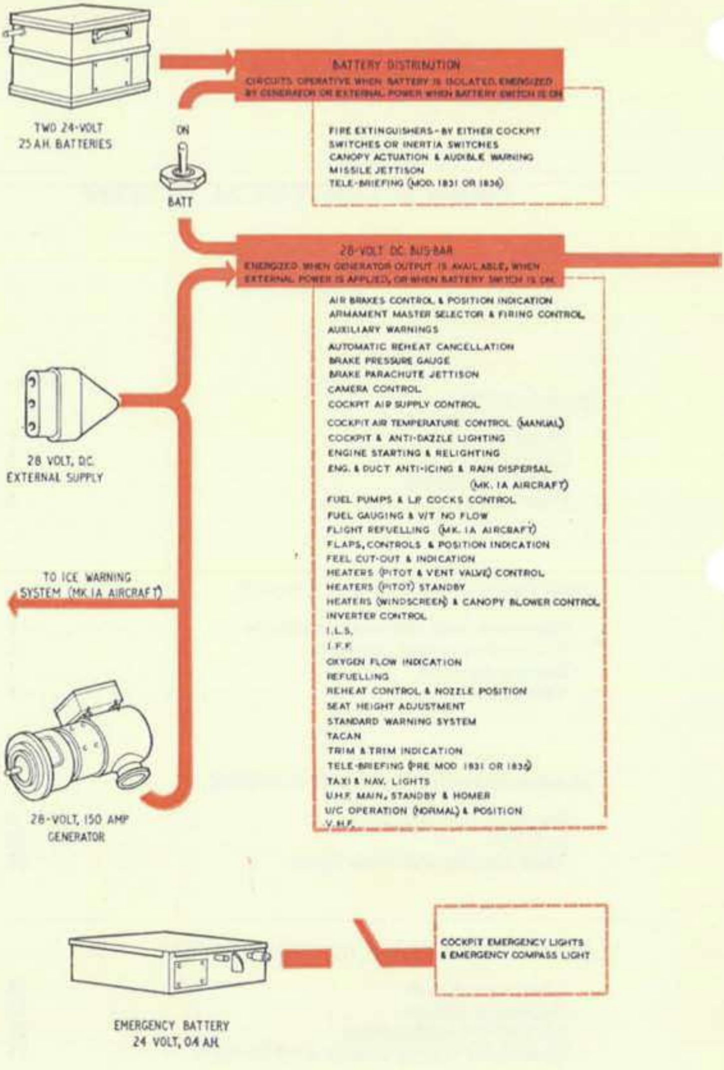
LIST OF CHAPTERS

PART I

Chapter 1. ELECTRICAL SYSTEM

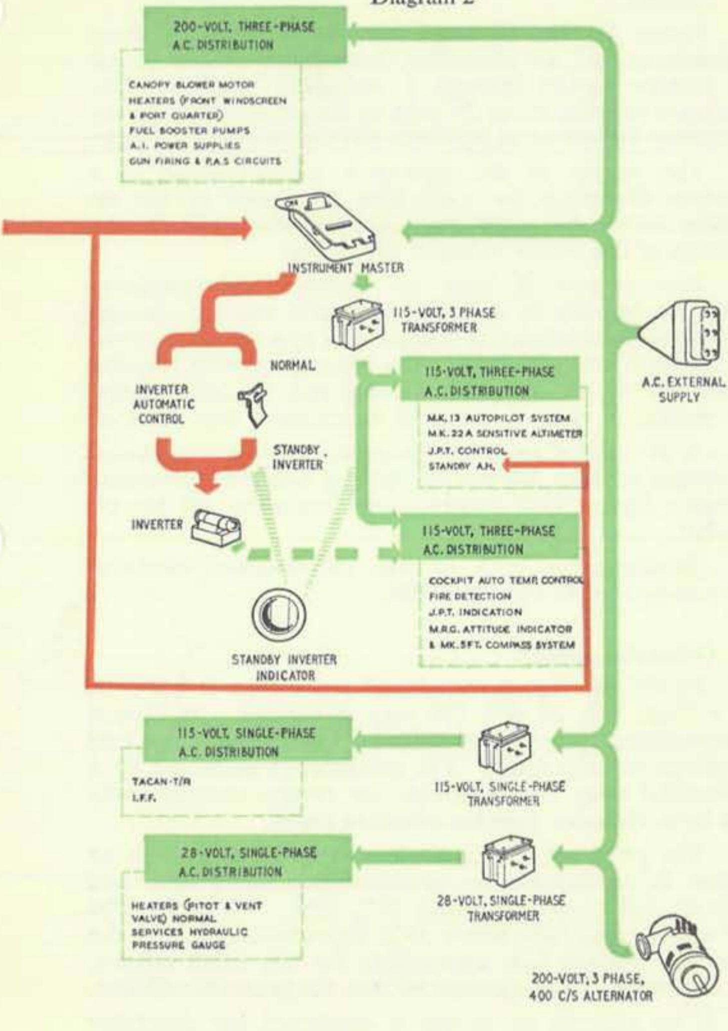
CONTENTS

Electrical Power Distribution
Diagram 1



ELECTRICAL POWER DISTRIBUTION

ELECTRICAL POWER DISTRIBUTION
Diagram 2



ELECTRICAL POWER DISTRIBUTION

DESCRIPTION

1. General

(a) Power for the electrical services is obtained from a generator and an alternator, both being driven by an air turbine motor through a reduction gearbox. The generator supplies DC at 28 volts to the DC bus-bar and the alternator 3 phase AC at 200 volts 400 CPS to the AC bus-bar.

(b) The output of the alternator 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.

(c) Two 24-volt 25 amp. hr. batteries are connected to the DC bus-bar by an isolating switch and are charged by the generator when it is operating or by a 28 volt external DC supply when connected. The batteries provide standby power for the DC operated services and, via an inverter, for certain of the AC operated instruments and services.

(d) A 24 volt 0.4 amp. hr. emergency battery is provided to supply cockpit emergency lighting and the emergency compass light. This battery is not connected to the DC bus-bar.

(e) Switching for both AC and DC operated electrical services is 28 volt DC controlled.

2. Generator supply

(a) Power for the DC operated equipment is supplied by a Type 522, 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 for reverse current faults and by a 150 amp. fuse for overload faults.

(b) The generator comes on line automatically 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.

(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.

3. 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. On start-up the alternator output voltage is initially regulated by a carbon pile regulator and then by a magnetic amplifier regulator. Voltage control is automatic throughout.

(b) Without an external AC supply connected, the alternator automatically comes on-line when an engine is accelerated to 58% RPM approximately, and will come off-line when both engines are brought below 58% RPM approximately.

(c) With an external AC supply connected, the alternator is isolated from the AC bus-bar 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.

(d) The supply is distributed either at 200 volts from the AC bus-bar, or modified via voltage changing transformers to 115 volts single and 3 phase and 28 volt single phase AC supplies to operate the various groups of instruments and equipment.

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

4. Instrument supply

(a) The supply to the aircraft instruments is normally taken from the AC bus-bar via a 3 phase transformer which converts the 200 volts AC to 115 volts 3 phase AC. The supply is controlled by a relay operated by the INSTRUMENT MASTER switch. This switch also controls the 28 volt DC supply required to operate certain of the instruments.

(b) In the event of failure of the normal AC supplies to the AC operated instruments a torque switch automatically operates to start up and bring into circuit a type 100A inverter which then supplies AC power to the more important AC operated instruments.

(c) The 100A inverter may be brought into use manually by selecting STANDBY INVERTER on the NORMAL/STANDBY INVERTER switch on the starboard console. Those instruments which have a standby supply will then operate via the inverter and the remaining instruments will continue to operate off the normal AC system. (The standby artificial horizon, however, has an independent and automatic DC standby facility if AC failure occurs).

(d) (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 (automatic change-over to DC supply if AC supply fails)
Mk. 22A sensitive altimeter
Mk. 13 auto-pilot system
Jet pipe temperature control

(ii) The following AC operated 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 :—

Centre windscreen temperature control (not heaters)
Fire detection system
JPT indicators
Master reference gyro } Dynamic
Attitude indicator } reference
Mk. 5FT compass } system
Cockpit temperature control (Auto control)

CONTROLS AND INDICATORS

5. Generator and alternator controls

(a) Both the generator and alternator are brought on to line automatically at 40% and 58% RPM respectively, provided external supplies are disconnected. When both engines are brought below 58% RPM the alternator will automatically come off-line, and if brought below 35% RPM the generator will automatically come off-line. The RPM figures are approximate. There is no provision for pilot control of the generator or alternator apart from throttling the engines.

(b) If the generator fails or is brought off-line a GEN warning appears on the standard warning panel (S.W.P.).

(c) If the alternator fails or is brought off-line an AC warning will appear on the auxiliary warning panel (A.W.P.).

(d) If the turbine wheel speed falls below the governed limits the alternator main contactor is tripped and the AC and TURB warnings will appear on the A.W.P.

6. 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, for use in the event of failure of the normal AC supplies, can be switched on manually by a NORMAL/STANDBY INVERTER switch on the starboard console. With the switch at NORMAL the AC operated instruments are supplied from the AC bus-bar. When the switch is set to STANDBY INVERTER, the normal AC supplies are cut to those services listed at para. 4(d)(ii) which are then operated by a supply from the 100A inverter.

(c) A magnetic indicator on 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.

7. Battery controls

(a) The main batteries are connected to the DC bus-bar by setting the BAT switch to ON, and are isolated from the bus-bar when set to off (back) or through the operation of the inertia crash switches. If the alternator and generator are not feeding their respective bus-bars and the batteries are isolated, the only services remaining operative are the fire extinguisher control, canopy control, the missile jettison control and, when Mod. 1831 or 1836 is embodied, the telebriefing facility.

(b) The emergency battery supplies only the cockpit emergency lighting and the emergency compass light and is brought into use by selecting the EMERGY LIGHTS switch on the instrument panel to ON.

8. Voltmeter

When Mod. 1534 is embodied a voltmeter is fitted on the cockpit starboard shroud. The voltmeter continually shows the DC bus-bar 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 volts.

MANAGEMENT OF THE SYSTEM

9. Pre-flight and starting

(a) Normally, both external AC and DC supplies should be connected. In the operational role an external AC supply is used to provide a 5 minute warm-up period for the A.I. equipment prior to switch-on after take-off. 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 minutes period must be re-commenced. The throttle setting on the No. 2 engine, therefore, must not come below 58 % RPM after starting the engines.

(b) With no external AC supply connected the 100A inverter will start up as soon as the DC bus-bar is energised, to operate the flight instruments listed at para. 4(d)(ii), provided the INSTRUMENT MASTER switch is ON. The standby artificial horizon, however, will not erect in this case.

(c) If an external DC supply is not connected, the main batteries will have to bear the 100A inverter load until an engine is accelerated to 50% RPM at which engine speed the generator will take over the full load.

(d) (i) During engine starting, check the serviceability of the DC generator 150 amp. fuse by starting the No. 1 engine first and checking that the GEN light on the S.W.P. remains on. The No. 2 engine must not be started first with its throttle at the fast idling position. If this is done, the 150 amp. fuse may rupture when the remaining engine is started and no warning of failure would be given by the GEN warning light. Therefore, if it is necessary to start the No. 2 engine first, it should be done with the throttle at the slow idling position and the GEN warning checked to be on when the engine has started.

(ii) When the external supply is disconnected, check that the voltmeter reading is 28 volts ; if at 24 volts or below, the aircraft must not be flown. If no voltmeter is fitted, switch off the battery switch and check that the undercarriage green lights remain illuminated. If the lights go out, the aircraft must not be flown. Re-select the battery switch on when the check is complete.

(e) When all external supplies have been disconnected, maintain No. 2 engine at 58% RPM or above otherwise the AC operated services will be inoperative except those under the control of the 100A inverter.

10. In flight

(a) The air turbine will maintain its governed speed at 58% RPM or above. This RPM corresponds approximately to idling RPM at 10,000 ft./250 Kts. At idling RPM below this altitude the air turbine speed will reduce and the alternator will be brought off-line.

(b) The reading of the voltmeter (if fitted) should be checked frequently in flight and should indicate in the white sector.

11. After landing and shut-down

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

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

MALFUNCTIONING OF THE SYSTEM

12. Alternator failure

(a) Alternator failure is indicated by the illumination of the AC light on the A.W.P. It may be accompanied by flame-out of the engines due to supplies being cut to the AC fuel booster pumps. Reheat will be automatically cancelled if it is in use at the time of the failure.

(b) Overvoltage on the alternator will cause the overvoltage relay to operate to trip the main contactor. The alternator will remain off-line for the duration of the flight.

(c) Alternator failure will necessitate emergency action as listed in Part 4, Chapter 2, para. 1.

13. Generator failure

(a) Generator failure is indicated by the illumination of the GEN light on the S.W.P.

(b) (i) The immediate effect of generator failure is that all DC loads will be borne by the main batteries. The life of the batteries depends on their capacity, charge and rate of discharge. If a voltmeter is not fitted the discharge rate is not known. Complete failure of all electrically operated services, except emergency lighting, will occur once the battery has discharged.

(ii) With a voltmeter fitted reliance may be placed on the battery to supply DC power to all relevant services provided the reading is above 22 volts. Electrical services will begin to fail when the voltage comes below 22 volts and the battery will rapidly discharge. Action should be taken, therefore, when the voltage falls to 23 volts and whilst electrical power is still available, to commence a descent and to place the aircraft in a position for landing.

(c) If the DC generator 150 amp. fuse ruptures, the generator will be isolated from the DC bus-bar and the main batteries will have to bear all DC loads. The GEN warning will not appear and the only indication of the fault will be a reading of 24 volts or below on the voltmeter, or, if a voltmeter is not fitted, by the gradual failure of the electrical services. The voltmeter reading must, therefore, be monitored frequently during flight.

(d) Emergency actions to be taken in the case of generator failure or malfunctioning of the system is given in Part IV, Chap. 2, para. 1.

14. Air turbine malfunction

(a) *Overspeeding*. If the air turbine wheel speed increases above a certain datum RPM, a governor in the wheel shaft operates a switch to close off a shut-off valve in the air duct to the turbine which stops the turbine for the duration of the flight. In this case both alternator and generator will come off-line and emergency action as listed at Part IV, Chap. 2, para. 1 must be taken.

(b) *Underspeeding*. If the turbine wheel speed falls below the governed limits a mechanically operated switch operates to trip the alternator main contactor. AC supplies are lost and the AC and TURB warnings will appear on the A.W.P. If the turbine wheel regains governed speed the alternator supply will be restored and the warnings will disappear.

15. Instrument supply change-over in flight

(a) On Mk. 1 aircraft only, if instrument supply change-over occurs whilst AI is in operation the AI must be switched off immediately to prevent damage to the equipment.

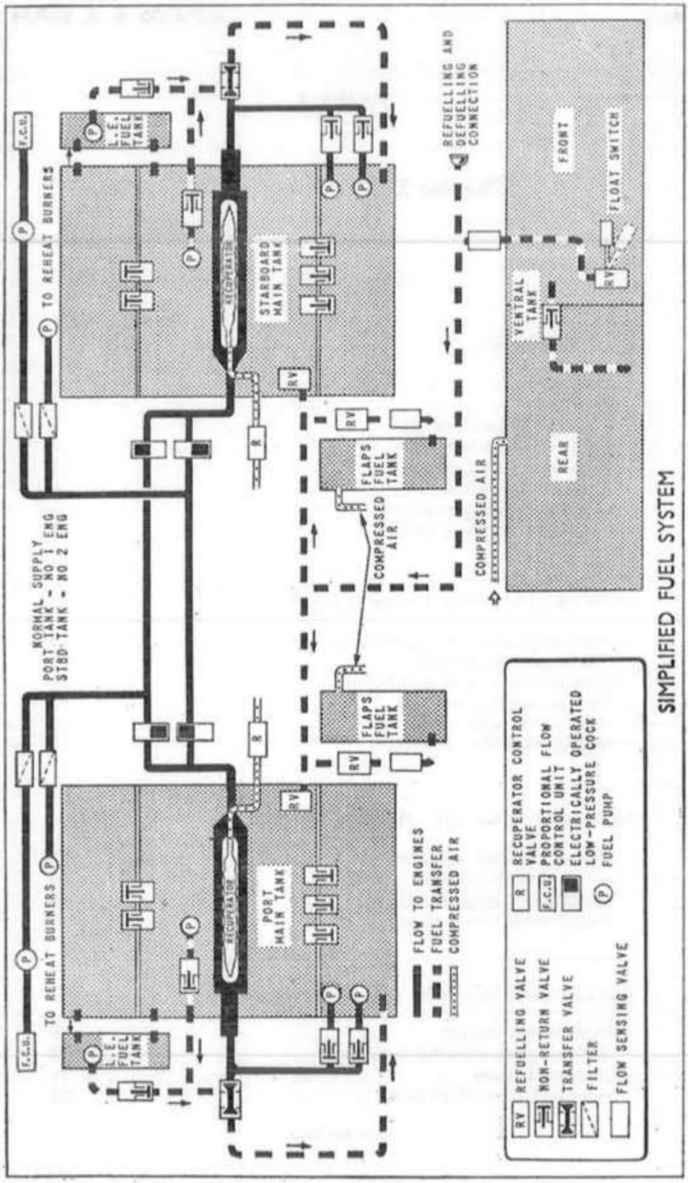
(b) If an aircraft oscillation occurs co-incident with an instrument supply change-over whilst flying with auto-stabilisation on, switch off the auto-pilot master switch and then the pitch and the roll and yaw switches. The probable fault is a ruptured fuse controlling one phase of the 3 phase supply. In this condition the instrument change-over would take place but the autostabilisers would remain connected to the faulty supply.

(c) If intermittent instrument supply change-over occurs, indicated by fluctuations of the STANDBY INVERTER magnetic indicator, set the NORMAL/STANDBY INVERTER switch to STANDBY.

PART I

Chapter 2. FUEL SYSTEM

CONTENTS



SIMPLIFIED FUEL SYSTEM

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 three-compartment main tank. The outboard compartment of each main tank serves as the collector box from which, normally, 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 inverted or 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 tank 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 or inverted flight.

2. Fuel feed

Fuel is initially taken from the wing tank system. After 120-160 lb. of fuel has been delivered from the wing tanks, float switches in the tanks operate to open a valve to allow the ventral tank fuel to be transferred under air pressure into the wing tank system. The aft compartment of the ventral tank empties before the forward compartment commences to feed. When the ventral tank transfer ceases a flow sensing valve operates electrically to open transfer valves at the flap tanks, allowing fuel from these tanks to be delivered into the wing system by air pressure.

Fuel from the inboard and centre compartment of each wing system is fed by gravity into each collector box. In addition, DC transfer pumps feed fuel from the leading edge tank and the centre compartment to maintain the collector box full. The fuel in the collector box is delivered by AC booster pumps, through a recuperator, to the engine driven HP pump and to the reheat pump.

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 centre compartment of the main 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 the centre compartment of 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	Capacity Gallons	Capacity—Pounds	
		AVTUR 8.0 lb./gall.	AVTAG 7.7 lb./gall.
Main and leading-edge	2 x 312	2 x 2496	2 x 2402
Flap	2 x 33	2 x 264	2 x 254
Recuperator	2 x 5	2 x 40	2 x 39
Ventral	1 x 247	1 x 1976	1 x 1902
Total fuel	947	7576	7292

6. Reheat fuel system

(a) Each of the two reheat pumps delivers fuel to the burner 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. Flight refuelling system

To be issued by amendment.

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 is illuminated when its associated tank is full.

(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 cock and pump switches

(a) Two 3-position switches marked FUEL PUMPS, PORT and STBD. are on the starboard console. Each switch controls the four 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 gauges are on the starboard instrument 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 NO FLOW indicator on the starboard instrument panel shows black when fuel is transferring from the ventral tank and white when transfer ceases.

11. Fuel pressure warning lights

A FUEL 1 and a FUEL 2 warning are on the A.W.P. 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.

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 trigger 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 HEATER, ON-OFF - STANDBY switch on the starboard console. With the switch at ON the vent valve heaters are supplied by the 28 volt, single phase, AC 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. Flight refuelling controls

To be issued by amendment.

NORMAL USE OF THE SYSTEM

15. Use of the fuel switches

(a) Start the engines with the PORT and STBD FUEL PUMP switches forward, 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.

(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, Chap. 2, para. 3.

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. Inverted or negative-G flight

Flame-out may occur under inverted or 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 I.S.A. 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 36,000 ft. these times increase to 15 seconds with maximum reheat and 33 seconds in cold running.

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 10,000 ft. or below. At higher altitudes, i.e. above 17,000 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 22,000 ft. approximately and flame-out may occur at heights above 27,000 ft.

(c) Failure of only the DC transfer pumps should not affect engine performance as fuel will drain into the collector box by gravity from the leading-edge tank and the wing centre compartment. It is possible, however, that during descents the DC pump in the main compartment of each wing may be uncovered, in which case only the DC pump in the leading-edge tank supplies the collector box. If this pump should have failed, the collector box may completely empty and the associated fuel pressure warning light would appear and, if no action were taken, the engine may flame-out.

(d) Emergency actions in the event of fuel pump failures are given in Part IV, Chap. 2, para. 2.

20. Ventral tank transfer failure

A partial or complete failure of the ventral tank to transfer can result in a progressive movement of the C.G. beyond the aft limit as fuel is used in the wing and flap tank systems. A landing should be made as soon as possible after the failure has become evident ; gentle manoeuvres only should be carried out, especially when at low altitude with guided missiles fitted.

21. L.P. 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

CONTENTS

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 HP cock which is controlled by the pilot's throttle lever.

(b) *H.P. 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 r.p.m. governor*

The maximum RPM of the engine is governed automatically. The governor 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 idling extinction at altitude.

(iv) *Acceleration control*

This control automatically limits the rate of increase of the fuel flow to the burners during throttle movements.

(v) *J.p.t. 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 down the fuel flow, prevents JPT rising above the permissible value. Maximum RPM therefore, will vary according to ambient air temperature, altitude and forward 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 reheat positions 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. Three stages of reheat are provided, first and second intermediate 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) Variable stages of reheat are 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. Reheat will remain lit, however, until the engine is decelerated to below 90% RPM.

(v) Reheat is automatically cancelled if the JPT increases to 60°C above maximum. The TTC warning light on the A.W.P. will come on to indicate that top temperature control has operated. Reheat remains cancelled until the throttle is moved out of the reheat section and then reselected.

(vi) Automatic reheat cancellation on both engines will occur in the event of failure of the AC electrical supply to the fuel booster pumps, or the failure of the DC electrical supply to the booster pump control relays in one wing. The TTC warnings will come on. When the throttles are moved out of the reheat gate the warnings will go out. Reheat cannot subsequently be relit after this type of failure.

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 air bleed valves and the guide vanes are held at the maximum swirl position. The guide vanes ram and the air bleed valve are both controlled by HP pump delivery fuel pressure, but the bleed valves 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.

(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 H.E. 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, there is no indication on the RPM gauge of engine rotation, 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. As no heat factor is involved, there is no limit to the number of attempts which can be made following failures of this type, but the fault should be investigated after about six attempts.

(ii) If engine rotation has occurred, however, 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. Two such attempts to start may be made. Once these attempts have been used, a waiting period of at least 45 minutes must be observed to allow the starter to cool. Otherwise, there is a possibility of damage occurring to components of the starter through overheating. Further single attempts may then be made at intervals of 45 minutes.

(d) (i) 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 three such starts may be made after which a cooling period of 45 minutes or an engine run of at least 15 minutes must precede a fourth or further single start.

(ii) During successive starts of an engine, if a failure of the type described in (c)(ii) above occurs, then the restrictions therein described will apply to subsequent attempts, any normal start which has been made counting as an attempt to start.

7. Relighting

With the master starting and ignition switches 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. Engine anti-icing—Mk. 1 aircraft

Hot air, tapped from the engine compressor, is directed through an electrically-actuated gate valve and fed to an annular manifold. Some of the air then flows through the intake guide vanes and some through the spars of the casing to the starter fairing. The air is then discharged into the air stream passing through the engine. The system is not intended for prolonged use in flight.

10. Ice warning, engine and intake duct anti-icing system—Mk. 1A aircraft

(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 light on the starboard console automatically illuminates. The system is supplied from the generator bus-bar. Therefore, whenever the generator is not running or is off-line the system will be inoperative even though the 28 volt DC bus-bar is energised.

(b) *Engine and intake duct anti-icing*
Engine and duct anti-icing can be selected by a switch on the starboard console, which controls both the engine anti-icing gate valve and the duct anti-icing valve. When the valves are open, hot air from the engine compressor flows to de-ice the engine, as described for Mk. 1 aircraft in para. 9. In addition, the hot air supply is passed forward to a spray ring around the engine intake duct, the air entering the intake through numerous holes drilled in the spray ring.

CONTROLS AND INDICATORS

11. Throttles/H.P. cocks

(a) The throttle valve and HP cock of each engine are combined in one unit which is operated by its associated lever on the port console. 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 valve 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.

(b) 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 and moving the throttle rearward. Both throttles have stops at the IDLING position which may be overcome by pressing the SHUT DOWN lever at the end of the quadrant and moving the throttles to HP COCKS CLOSED.

(c) (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 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.

12. Engine starting and relighting controls

(a) The main starting controls are on the starboard console and consist :—

ENG. START MASTER switch
No. 1 and No. 2 IGNITION switches
No. 1 and No. 2 ENGINE START pushbuttons

The engine start and ignition switches are only operative if the ENG. START MASTER switch is ON.

(b) Two, No. 1 and No. 2, RELIGHT pushbuttons are on the port console. The ENG. START MASTER and IGNITION switches must be on to relight an engine in flight.

13. Jet pipe temperature control

Jet pipe temperature control is brought into operation by two switches on the port instrument panel labelled J.P.T. CONTROL, No. 1 and No. 2. 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.

14. Engine instruments

(a) Each engine has a percentage RPM gauge and a JPT gauge on the starboard instrument panel, and a nozzle position indicator on the starboard console. 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 markings 1 to 4 around 180° of the remaining arc of the circumference. The nozzle position corresponding to the various positions taken up by the 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 (inoperative)
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 A.W.P. The warning may remain after engine start until 45% RPM has been obtained.

15. Anti-icing controls—Mk. 1 aircraft

A single DE-ICE switch on the starboard console controls the anti-icing systems of both engines. With the switch forward, anti-icing is in operation and a green light adjacent to the switch illuminates. When the switch is moved back anti-icing is cut off and the green light is extinguished.

16. Engine and intake duct anti-icing and ice-warning—Mk. 1A aircraft

(a) Engine and intake duct anti-icing is controlled by a DE-ICE—OFF—RAIN DISPL switch on the starboard console. When the switch is set to DE-ICE, engine and duct anti-icing is in operation and a DE-ICE ON 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 DE-ICE ON light will cease to glow when anti-icing is cancelled. For use of the RAIN DISL setting, see Part I, Chap. 11.

(b) An ICE WARN light, adjacent to the DE-ICE—OFF—RAIN DISPL switch, illuminates when icing conditions are detected.

NOTE: 1. The intake duct anti-icing facility is not yet cleared for use. At present, with DE-ICE selected, engine anti-icing is operative as described in para. 15. The temperature and pressure switches will not operate owing to the valve controlling hot air to the duct lip being inoperative.

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

PART I

Chapter 4. ENGINE FIRE PROTECTION SYSTEM

CONTENTS

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 type 41A 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 S.W.P. 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, show a reddish-brown colour if the extinguishers are discharged.

(b) When Mod. 1569 is embodied, the type 41A fire extinguisher bottles are replaced by type 57A bottles. The type 57A 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.

3. Fire detection

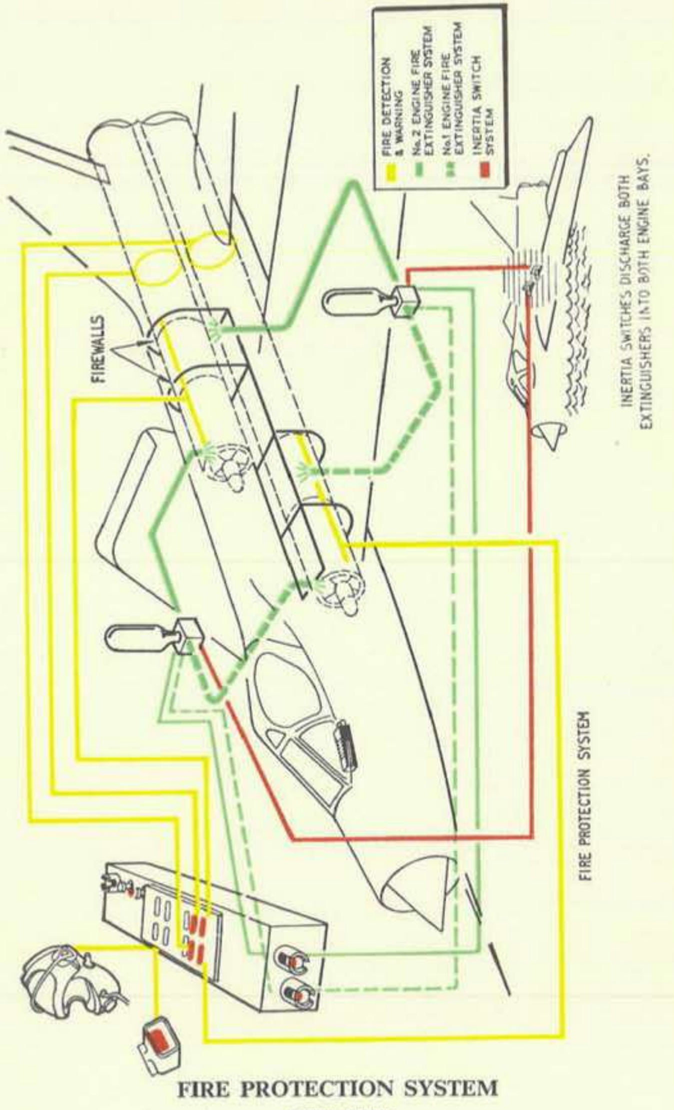
Firewire elements, which at normal temperatures behave as semi-conductors and when heated become conductive, are fitted in all fire zones. There is a separate Firewire circuit for each engine bay and two circuits, one to each jet-pipe, in zone 3. The elements are connected to the input channels of a relay unit which controls the relevant warnings on the S.W.P. The INSTRUMENT MASTER switch must be ON for the detection circuits to be operative.

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 S.W.P. 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 S.W.P. and the illumination of the light in the fire extinguisher switch unit. Warning of excessive temperature or fire in zone 3 is given by a RHT 1 or RHT 2 warning on the S.W.P.

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 I, Chap. 1).



FIRE PROTECTION SYSTEM

PART I

Chapter 5. HYDRAULIC SYSTEM

CONTENTS

DESCRIPTION

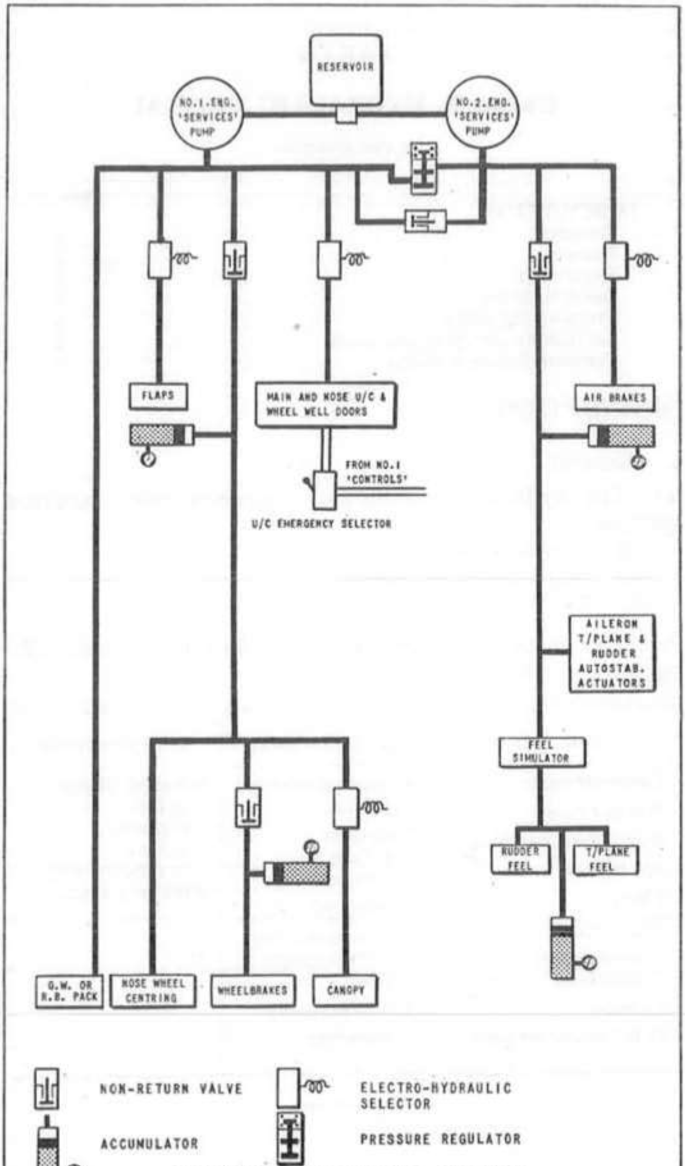
1. General

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

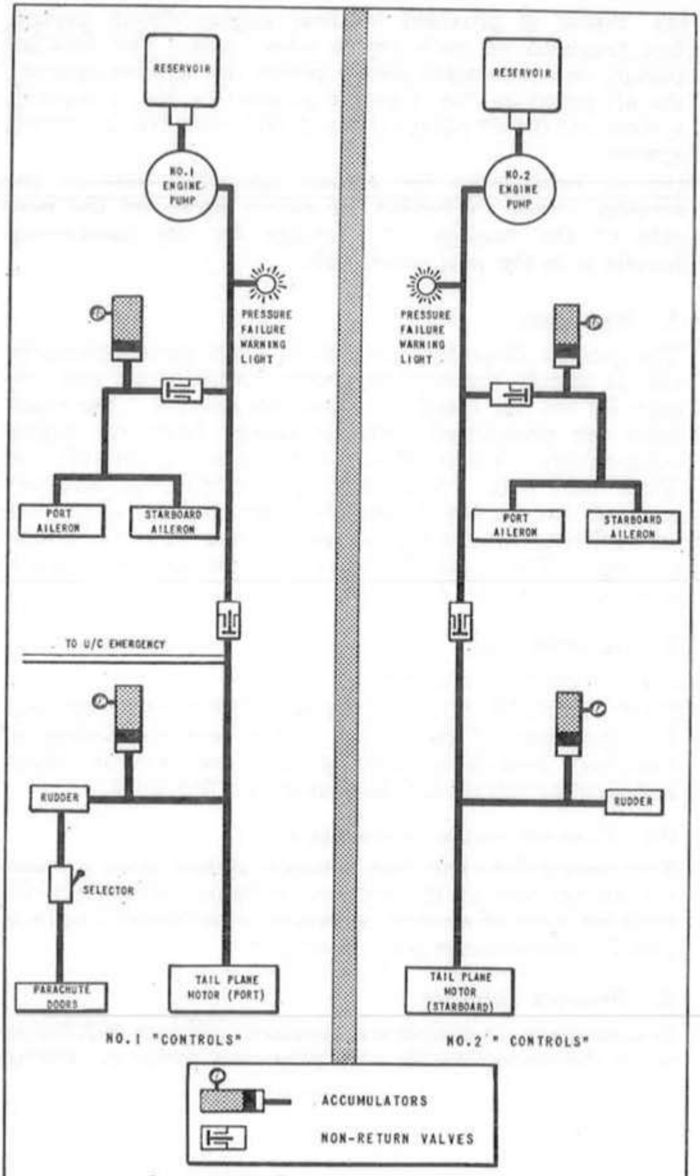
(i) Services system
(ii) No. 1 controls system
(iii) No. 2 controls system

(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	Rudder p.f.c.u.	Rudder p.f.c.u.
Air brakes	Brake parachute compartment door	
Flaps	U/C emergency lowering	
Feel system		
Autostabiliser actuators		
Canopy		
G.W. or rocket pack		



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 three 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. When Mod. 1803 (Mk. 1 aircraft) or Mod. 1823 (Mk. 1A aircraft) is embodied, 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

When Mod. 1802 (Mk. 1 aircraft) or 1809 (Mk. 1A aircraft) is embodied a pressure gauge on the cockpit port shroud indicates services system pressure. When the pumps are running the pressure reading should be approximately 3,000 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 approximately.

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 A.W.P. If both pressure switches close, an additional HYD warning appears on the S.W.P.

(b) Pre-Mod. 1802 or 1809 there is no indication of services system failure other than a service failing to operate. When a pressure gauge is fitted, however, failure of the services system is indicated when the reading 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 on the gauge.

PART I

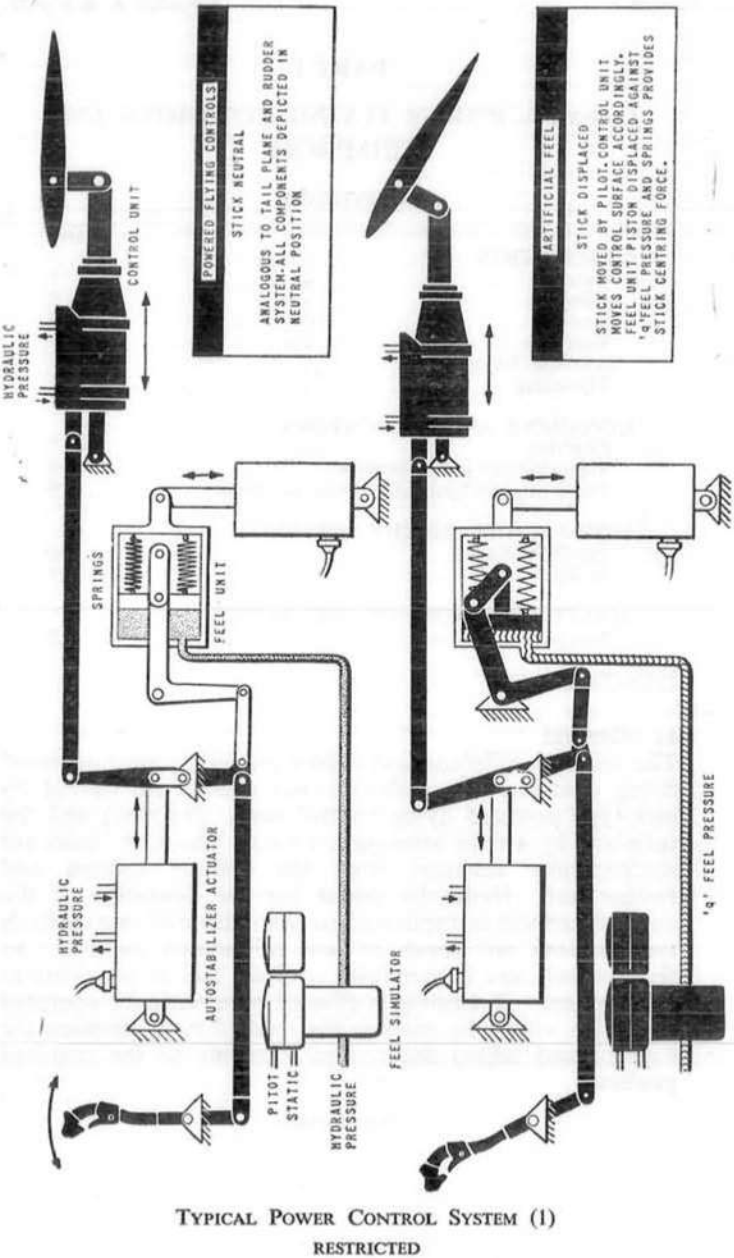
Chapter 6. POWER FLYING CONTROLS AND TRIMMERS

CONTENTS

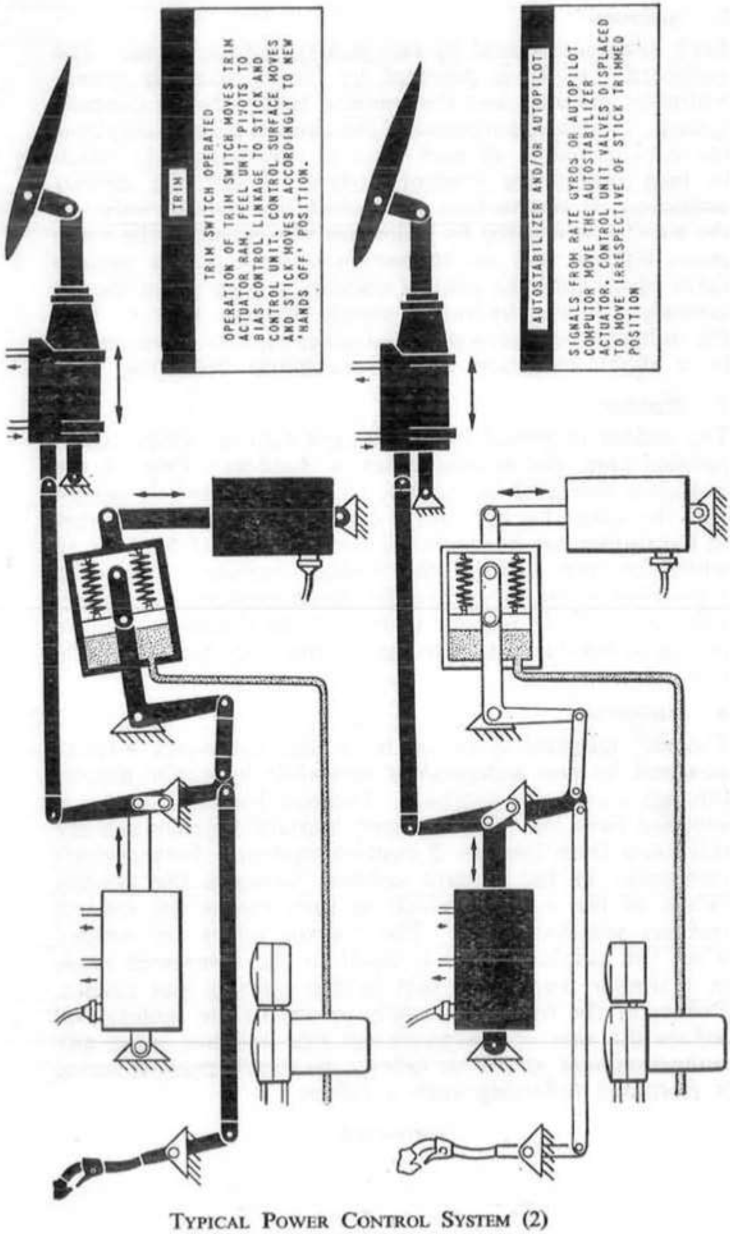
DESCRIPTION

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 (P.F.C.U.) and the tailplane by a twin screw-jack P.F.C.U. The P.F.C. 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 P.F.C.U. and adjust the cockpit controls to the required position.



TYPICAL POWER CONTROL SYSTEM (1)



TYPICAL POWER CONTROL SYSTEM (2)

2. Ailerons

Each aileron is moved by two jack-type P.F.C. units. The outboard P.F.C.U. 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 P.F.C.U. simultaneously which in turn moves the control surface. When the desired deflection of the surface is reached the control valve of the P.F.C.U. 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 P.F.C.U. fails the unit will be motored by the other P.F.C.U. ; this results in a slight reduction in the maximum operating rate.

3. Rudder

The rudder is moved by a jack-type P.F.C.U. 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 P.F.C.U. 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 P.F.C.U. 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 P.F.C.U. 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 manoeuvering 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 connecting the control column and the control run. 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) Hydraulic feel to the rudder is cancelled when the undercarriage is in the DOWN position and is restored when an UP selection is made.

(iv) Hydraulic feel may be cancelled manually by a switch on the port instrument panel.

(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 occurring 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 column and the control valve of the P.F.C.U. The actuators are operated by double-pole switches, that for the rudder being on the port console and the combined aileron and tailplane switch is on the control column.

CONTROLS AND INDICATORS

7. Controls

(a) The controls are operated by a pistol grip control column and a rudder bar. The control column carries on it an aileron/tailplane trimming switch, G.90 and P.A.S. recorder camera firing button, armament firing trigger and safety catch, auto-pilot engage switch, press-to-transmit switch and a wheel brake lever and parking catch.

(b) The rudder bar may be adjusted for leg reach by a RUDDER BAR ADJUST handle situated at the bottom of the instrument panel or, on Mk. 1A aircraft, above the instrument panel. When the handle is pulled out a toothed plunger is withdrawn from the rudder rack allowing the rudder bar to move aft under the action of a compression spring, or to be pushed forward against the pressure of the spring. When the desired position is reached, releasing the handle allows the toothed plunger to re-engage the rack.

8. Trim switches and indicators

(a) *Rudder trim*

Twin, 3 position, switches marked RUDDER TRIM, spring loaded to the central off position, on the port console, control the rudder trim in the natural sense. Both switches must be selected together before the trimmer will operate.

(b) *Aileron/Tailplane trim*

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

(c) *Trim indicators*

A combined TRIM INDICATOR on the port 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 on the port instrument panel. 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.

9. Power control hydraulic 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 A.W.P. Failure of both systems is indicated by a HYD warning appearing on the S.W.P. in addition to the two warnings on the A.W.P.

NORMAL USE OF THE SYSTEM

10. Pre-flight checks

(a) Test the rudder trim for a 'live' circuit by operating each of the two rudder switches separately. If any movement of the rudder trim actuator 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.

(b) Test the aileron and tailplane trim for a ' live ' circuit by raising the ganging bar and operating both switches 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.

(c) 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.

(d) 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.

(e) Check that the HYD 1 and HYD 2 warnings on the A.W.P. and the HYD warning on the S.W.P. are out prior to take-off.

11. In-flight

Limitations are imposed on the use of the ailerons. These are given in Part II, Chap. 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 A.W.P. A slight reduction in the maximum operating rate of the ailerons will occur but there will be no noticeable effect on the other controls.

(b) Failure of both hydraulic controls systems is indicated by a HYD warning appearing on the S.W.P. in addition to the two warnings on the A.W.P. 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) Emergency actions for control system failures is given at Part IV, Chap. 2, para. 4.

PART I

Chapter 7 OTHER AIRCRAFT CONTROLS

CONTENTS

DESCRIPTION

1. Undercarriage controls and indicator

(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 interlocked so that depressing one pushbutton releases the other. A pitot static switch prevents an UP selection being made at airspeeds below 150 knots. In an emergency this switch can be overriden by turning the UP pushbutton clockwise through 60° and then pushing in the button normally.

(c) A standard undercarriage position indicator is fitted on the lower port instrument panel.

(d) The limiting speed for undercarriage operation is 250 knots (280 knots for emergency locking down).

2. Undercarriage emergency lowering control

(a) The undercarriage emergency lowering control is a yellow and black striped lever at the left of the seat pan.

Depressing the plunger at the top of the lever and pulling rearward, directs No. 1 controls system hydraulic pressure 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.

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

(c) The lever is normally wired to indicate that it has not been inadvertently operated. On Mk. 1A aircraft, a spring clip is fitted over the plunger to prevent inadvertent operation. The aircraft should not be flown if the wire on the lever is broken (Mk. 1 aircraft) or if the spring clip is not in position (Mk. 1A aircraft).

(d) The lever must on no account be pulled without first operating the plunger, otherwise the plunger locking mechanism may be damaged which may prevent an emergency undercarriage selection being made.

3. Flap control and indicator

(a) The flaps, which are utilised as fuel tanks, are hydraulically operated from the services hydraulic system and electrically controlled by a two-position, fully UP or fully DOWN, switch on the port coaming panel. The flaps are not interconnected. A pitot-pressure switch, set to close at 250 knots, automatically selects the flaps to 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 selected by the flap switch.

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

(c) An indicator on the port instrument panel shows the position of the flaps.

(d) 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, spring-loaded to off, switch on the 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 1.35 to 1.4M, 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 55% RPM or above.

(b) A combined trim and airbrake indicator is on the port 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 speeds for operation of the airbrakes are :—

(i) Normal operation . . 650 knots/1.4M
(ii) In rolling manoeuvres 650 knots/1.2M

5. Wheelbrakes 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 the 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. Full differential pressure at the brakes is achieved at half-pedal displacement.

(b) The accumulator pressure available for brake operation is shown on a gauge on the starboard console.

6. Braking parachute

(a) A ribbon-type braking parachute is housed in a compartment on the underside of the rear fuselage. The parachute is streamed by pulling to the fullest extent a handle marked TAIL CHUTE—PULL on the port coaming panel. This action mechanically operates a selector to hydraulically open the parachute doors from No. 1 controls system pressure. As the doors open, the parachute rip-pins are withdrawn and the parachute streams.

(b) Depressing a push-button TAIL CHUTE JETTISON on the port coaming panel, operates an electro-magnetic release unit which 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 220 knots or above it will become detached from the aircraft through the rupturing of a shear-pin in the parachute cable.

(d) The TAIL CHUTE—PULL lever should not be reset after streaming the parachute until after the parachute pack is refitted.

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

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

PART I

Chapter 8. FLIGHT INSTRUMENTS

CONTENTS

DESCRIPTION

1. Interim dynamic reference system

The dynamic reference system uses a master reference gyro (M.R.G.) to supply continuous flight attitude and heading information to the attitude indicator (roller blind), the Mk. 5FT compass, the Mk. 13 auto-pilot system, the A.I. and the pilot attack sight (P.A.S.). 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 (M.R.G.)

(a) The M.R.G. 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 auto-pilot system, the A.I. and the P.A.S. 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, the auto-pilot system and the A.I. This gyro is normally monitored by a compass detector unit, but compass monitoring is cut off whenever D.G. is selected on the Mk. 5FT compass or when flight accelerations and attitudes would cause errors during compass detection.

(c) The M.R.G. 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 M.R.G., NORMAL-FAST ERECTION switch, spring loaded to NORMAL, is on the main instrument panel. In the NORMAL position 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.

3. Attitude indicator, Mk. F1M

(a) The attitude indicator which is operated by signals from the M.R.G. 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 represent 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 M.R.G. 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 M.R.G. 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, D.G. appears in the window above the button. If compass is selected the window remains blank.

(c) A 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 D.G. 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 bottom 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 Chap. 14, para. 4).

(e) The compass indicates accurately irrespective of aircraft attitude.

5. Standby artificial horizon (Mk. 6A or 6G)

(a) The standby artificial horizon is fitted to meet the case of failure of the attitude indicator. It is controlled by the INSTRUMENT MASTER switch and by an ART. HORIZON, NORMAL/EMERGENCY switch on the port coaming panel. With the ART. HORIZON switch at NORMAL, the instrument is operated by 115 volts AC from the alternator or, on alternator failure, by 28 volt DC power reduced to 24 volts by a dropping resistor, the changeover being automatic. With the switch selected to EMERGENCY, the dropping resistor is bypassed, allowing the instrument to be run at the battery voltage. If failure of both alternator and generator occurs, therefore, the switch should be set to EMERGENCY and the instrument will operate from the battery supplies while they last. EMERGENCY must only be used on combined alternator/generator failure. The instrument cannot be erected by DC power alone and no attempt should be made to test it on the ground by this method, otherwise damage to the instrument may occur.

(b) The instrument incorporates a fast erection button. A flag indication shows whenever power supplies to the instrument are cut.

6. Altimeter (Mk. 22A)

(a) A Mk. 22A servo altimeter is on the main instrument panel. It is operated by 115 volts, 400 CPS, single phase AC from the alternator. There is no standby source of power to the instrument if AC failure occurs. An off-flag appears on the instrument if power supplies to it are cut.

(b) When Mod. 1538 is embodied the Mk. 22A altimeter is replaced by a Mk. 22C altimeter.

7. Pitot and static pressure instruments

(a) The following flight instruments are served by the pitot/static system :—

Mk. 22A altimeter
Standby altimeter, Mk. 24
Machmeter, Mk. 3B (Mk. 4 when Mod. 1871 is embodied)
A.S.I., Mk. 15B (Mk. 16 when Mod. 1884 is embodied)
V.S.I., Mk. 3P.

(b) An electrically heated pressure head is on the nose of the aircraft. A PITOT HEATER, ON-OFF-STANDBY switch on the starboard console controls the power supplies to the heater. With the switch at ON 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.

8. Miscellaneous instruments

(a) An E2B standby compass is on the starboard frame member of the centre windscreen. If reliance is to be placed on this compass then the A.I. C.R.T. visor must be in the normal viewing position or folded at the aft hinge only. If folded vertically at the forward hinge, excessive compass deviation can occur.

(b) A Mk. 3 accelerometer is fitted on the port coaming panel.

(c) A Mk. 21 altimeter on the starboard console indicates the cockpit altitude.

(d) A slip indicator is on the port coaming panel.

PART I

Chapter 9. GENERAL EQUIPMENT AND CONTROLS

CONTENTS

DESCRIPTION

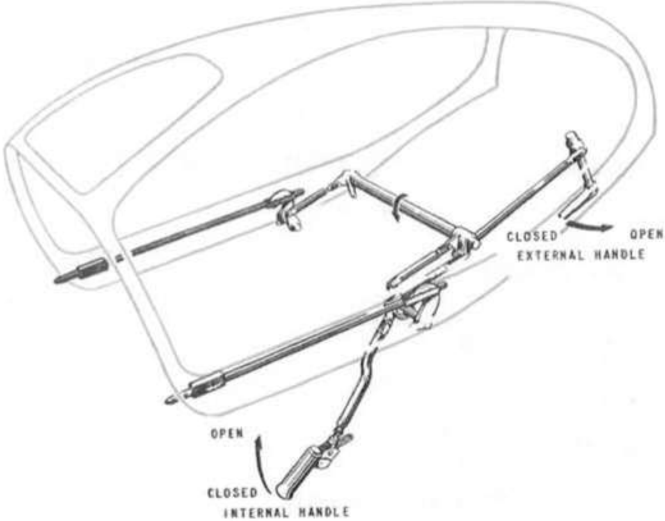
1. Canopy control and operation

(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 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.

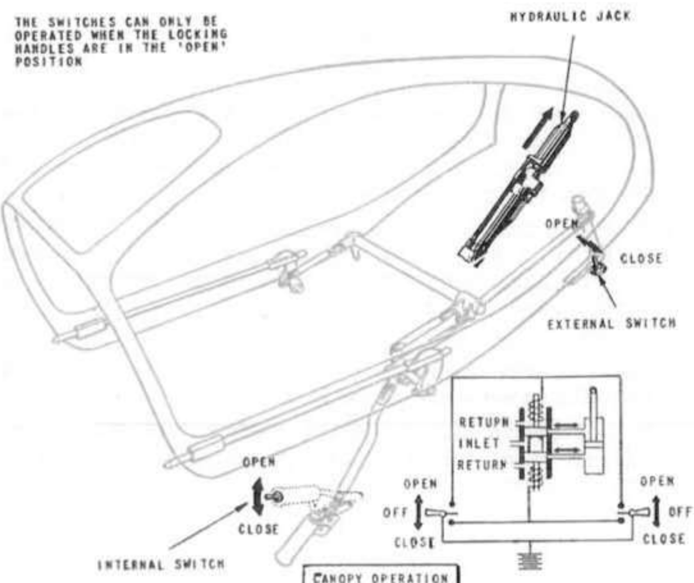
(b) For external canopy operation a similar CANOPY LOCKING HANDLE is behind a panel on the port side of the fuselage spine. The handle, in this case, must be rotated rather than pulled up or down.

(c) When closing and locking the canopy, the last few degrees of downward movement of the CANOPY handle causes the canopy seal to be inflated.

(d) An electric buzzer on the starboard of the canopy bulkhead gives audible warning whenever the canopy is being operated.

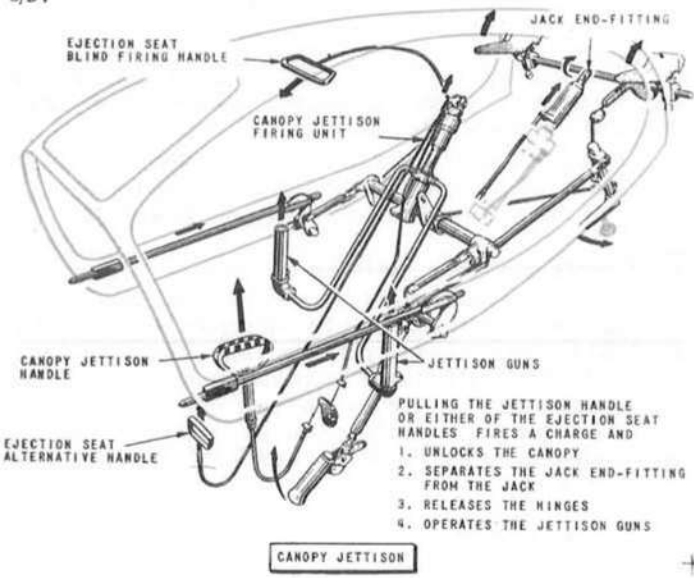


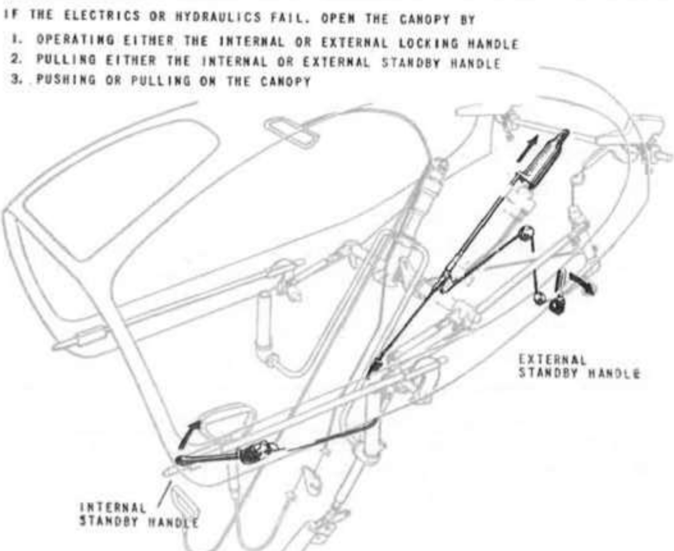
CANOPY LOCKING/UNLOCKING



CANOPY OPERATION

CANOPY MECHANISM AND OPERATION





CANOPY MECHANISM AND OPERATION

(e) Two CANOPY UNLOCKED indicator lights are on the windscreen starboard frame member. The lights illuminate whenever the canopy is unlocked.

(f) Two mechanical indicators marked CANOPY FREE-LOCKED, are on each inside face of the lower canopy-frame to show the position of the canopy shoot-bolts.

2. Canopy emergency operation

In hydraulic or electrical failure conditions, the canopy may be opened on the ground by pulling up the CANOPY HANDLE and then operating the EMERGENCY CANOPY JACK RELEASE lever located below the standard warning panel on the cockpit port wall. The canopy can then be pushed upwards. A similar control for external use is adjacent to the CANOPY LOCKING HANDLE in the port spine.

3. Canopy jettison

The canopy may be jettisoned by pulling a yellow and black striped CANOPY JETTISON handle at the left of the seat pan or, on ejection, by pulling the primary or secondary firing handles of the ejection seat. Pulling any one of these handles 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 jettisons the canopy by means of two jettison jacks.

4. Internal lighting

Normal internal lighting is supplied by the DC electrical system and controlled by the following switches :—

(a) A MAIN PANEL LIGHTS dimmer switch on the starboard instrument panel controls the forward instrument panel pillar lamps and lamp bridges, attention light and armament control panel lighting.

(b) Two, PORT AND STARBOARD LIGHTING, dimmer switches on the starboard instrument panel control the red floodlighting for the port and starboard consoles respectively and the supplementary panel lighting from the auto-pilot, V.H.F. and radar control panels and pillar lamps aft of the Tacan control unit.

(c) An E2B COMPASS DIMMER switch on the starboard coaming panel controls the E2B standby compass lighting. This lighting has a standby facility from the emergency battery (see para. 5 below).

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 to illuminate the instrument panel and consoles by a distribution of amber floodlamps. The electrical supply is taken from the emergency battery. With the switch at ON, the E2B compass lighting supply is transferred from the DC bus-bar to the emergency battery.

(b) Two high intensity white anti-dazzle lamps are fitted to the windscreen arch, port and starboard, and are controlled by a BRIGHT—OFF—DIM switch on the port coaming panel.

6. External lighting

The external lighting is taken from the DC supply and is controlled by the NAV. LIGHTS and TAXI LTS. switches on the starboard console. The NAV. LIGHTS switch is a 3-position STEADY-OFF-FLASH switch.

PART I

Chapter 10. PRESSURISATION AND AIR CONDITIONING

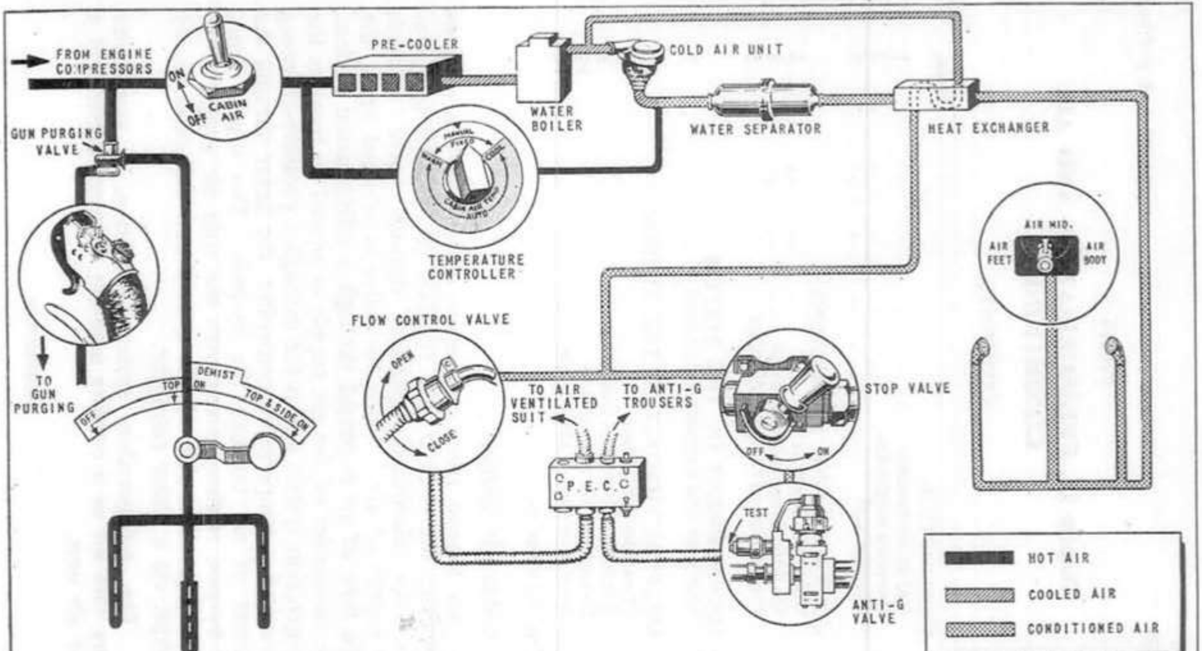
CONTENTS

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.



AIR SYSTEM CONTROLS

(c) At the cockpit, the conditioned air is fed to two perforated spray nozzles and, on Mk. 1 aircraft only, to a centrally mounted diffuser. The diffuser is provided with a 3-position control which enables the air to be directed onto the pilot's body or legs as selected. On Mk. 1A aircraft, the diffuser and its control is deleted and the air enters from the side of the control column housing in addition to the entry from the spray nozzles.

(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. It is used to provide an emergency air supply should the main system fail.

2. Pressure controller

A pressure controller on the forward pressure bulkhead controls the cockpit pressure automatically by regulating the action of an air discharge valve. At about 10,000 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 34,000 ft., above which it is maintained constant. Overpressurisation is prevented by relief valves built into the air discharge valve which open if the cabin pressure exceeds 4.5 PSI approximately.

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.

4. Cabin air controls

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

(b) On Mk. 1 aircraft only, a lever marked AIR BODY-MID-AIR FEET is at the bottom of the instrument panel. Conditioned air can be directed to the pilot's body or legs as selected by the lever.

(c) A ram air OPEN-CLOSED control is on the cockpit port wall below the seat pan. 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 starboard console. 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 it 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 S.W.P.

MANAGEMENT OF THE SYSTEM

7. Cabin air and temperature control

(a) After closing the canopy, 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 S.W.P. and can be confirmed by the cabin altimeter. If the failure occurs at altitude an immediate descent must be made to 30,000 ft. or below and, if fuel permits, a return to base should be 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.

11. Smoke or mist in the cockpit

(a) If smoke occurs in the cockpit and appears to be coming from the air diffusers, select the CABIN AIR switch to OFF until the smoke disappears. If the smoke is coming from any other source open the ram air valve. In both cases cockpit pressure will be lost whilst the CABIN AIR switch is OFF or the ram air valve open and the pilot will therefore be required to proceed as for pressurisation failure. The oxygen regulator should be selected to EMERGENCY whilst smoke persists.

(b) If misting occurs select the DEMIST control to ALL ON. When misting disappears reselect to OFF or TOP ON (see Chap. 11, para. 1(c)).

PART I

Chapter 11 WINDSCREEN DEMISTING AND RAIN DISPERSAL

CONTENTS

1. Windscreen and canopy demisting

(a) The front windscreen is heated electrically by inter-laminar elements fed from the AC supply system. With the FRONT WINDSCREEN switch on the starboard console selected ON the heating to the windscreen is automatically controlled and regulated. The electrical supply to the elements is controlled by the 150 knot pressure switch associated with the undercarriage circuit, so that only half heat is applied below this speed and full heat above it.

(b) The port windscreen panel is electrically heated by inter-laminar elements fed from the AC system and controlled by the SIDE WINDSCREEN switch on the starboard console. A temperature control unit in the circuit automatically regulates the heating of the panel.

(c) (i) The port and starboard side windscreen panels and the canopy top panel are fitted with hot-air sprays. Hot air from the engine compressors is passed by two pipes, one for the side windscreen sprays and one for the canopy spray. Each pipe has a stop valve and the canopy hot air passes through a pressure reducing valve. A 3-position DEMIST control handle is on the port console. The selected positions are :—

ALL ON	Full flow to the canopy and to the side windscreens
TOP ON	Full flow to the canopy and partial flow to the side windscreens
OFF	Heating supply shut off.

(ii) Hot-air demisting of the side windscreens should only be used if the electrical demisting is not adequate or fails. As soon as demisting is complete, select OFF or TOP ON on the DEMIST control.

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 WINDSCREEN switch on the starboard console.

3. Rain dispersal (Mk. 1A aircraft only)

(a) The system improves forward visibility by completely clearing a centre strip of the windscreen from top to bottom in light continuous rain, or by completely clearing the lower area of the strip and partially clearing the upper area in heavy rain. Air, tapped 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 DE-ICE—OFF—RAIN DISPL switch on the starboard console, and by two pressure-operated switches which automatically limit operation to below 10,000 ft. altitude and 350 knots airspeed.

(c) With rain dispersal switched on, engine RPM should be restricted to 85% RPM. Use of the system above 85% RPM should be limited as follows :—

85—90% RPM—4 minutes
90—100% RPM—1 minute.

Its use at RPM higher than 85% may lead to softening of the sealant between the glass laminations, impaired vision and making the windscreen unserviceable but not rendering it unsafe.

(d) If the windscreen heating system fails, the outer laminations of the windscreen will crack if the rain dispersal system is switched on following a cold soak at altitude, but this will not seriously reduce the strength of the windscreen.

PART I

Chapter 12 AIRCREW EQUIPMENT ASSEMBLY AND ASSOCIATED SYSTEMS

CONTENTS

EJECTION SEAT

1. Ejection seat Mk. 4BS—General

(a) A Mk. 4BS ejection seat is fitted. The seat has a combined safety and parachute harness which is fastened by a single quick-release box. The back type Mk. 28 parachute assembly embodies a horse-shoe type parachute pack and a combined safety and parachute assembly, which is fastened by a single quick-release box. The pack is secured by two restraining straps at the upper end. The seat pan accommodates a personal survival pack Type V (complete with comfort cushion) containing a dinghy and survival equipment. Two leg restraint cords are fitted at the front of the seat pan. An emergency oxygen bottle is mounted on the starboard seat beam.

(b) At the rear of the seat is the 80 ft./sec. ejection gun and a drogue gun is mounted on the port seat beam. The seat has two firing handles, one on the drogue container attached to the face blind and the other on the front of the seat pan. Both handles are provided with safety pins.

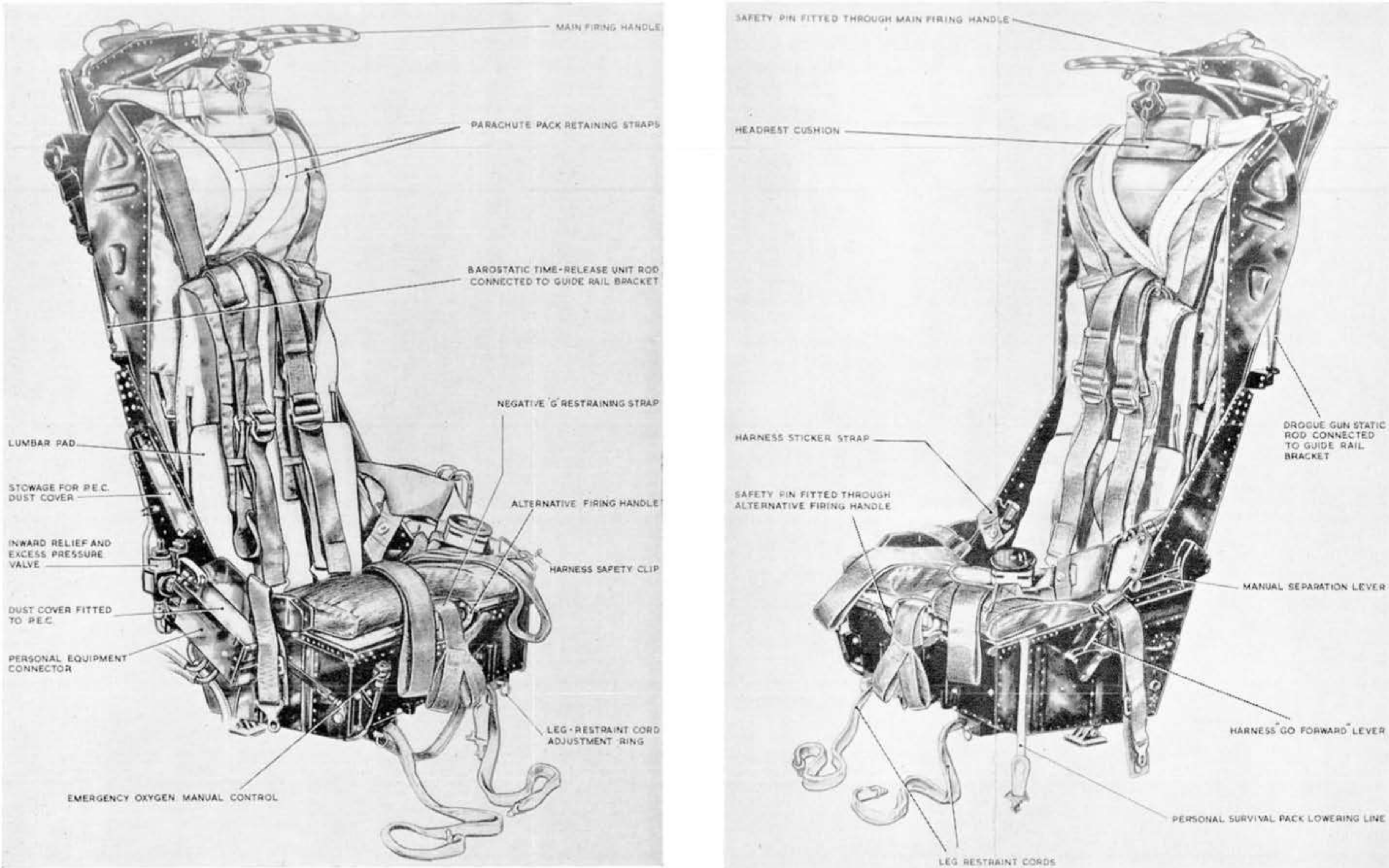
(c) A G-stop is incorporated to prevent separation from the seat if the speed of the seat after ejection is too high for safe deployment. The switch prevents the operation of the barostatic time-release unit until the speed has fallen to a safe figure. The seat has a ground-level ejection capability provided the aircraft's flight path is parallel to the ground and the speed is a minimum of 90 knots. If the aircraft is descending the minimum safe altitude is increased.

2. Seat adjustment and lean-forward release

The seat height may be adjusted by an electric motor controlled by a switch positioned just above and forward of the personal equipment connector on the right of the seat. The switch, which is spring loaded to the central (off) position operates in the natural sense, i.e. a downward movement of the switch lowers the seat and vice-versa. The spring-loaded harness lean-forward release lever is on the port side of the seat pan. To lean forward the lever must be moved forward. When the lever is released the harness is prevented from going further forward. As the wearer leans back, the harness is locked in any position and to lean forward again he must operate the lever.

3. Personal equipment connector (P.E.C.)

The P.E.C. is on the starboard side of the seat and provides intercomm. and R/T, oxygen, air ventilated suit and anti-G supplies. On ejection these services are auto-



EJECTION SEAT
AIRCREW EQUIPMENT ASSEMBLY AND ASSOCIATED SYSTEMS

matically disconnected by static line. Emergency oxygen is supplied through the P.E.C. but is not turned on until ejection or when selected. Disconnecting the man portion of the P.E.C. frees the leg restraint cords.

4. Combined harness quick-release box

The quick-release box, when fastened, secures the occupant to the seat. *The box must not be operated when carrying out manual separation in the air since this will free the occupant from both seat and parachute.*

5. Manual override D-ring

The manual override D-ring is mounted on the waistbelt of the parachute harness and is the one nearest the quick-release box. If manual separation from the seat is necessary the override D-ring should be pulled to its fullest extent before operating the manual separation lever. The parachute withdrawal line is then disconnected from the seat automatic mechanism and the protective canvas flap over the rip-cord D-ring is removed.

6. Manual separation lever

The lever at the rear of the port side of the seat pan, when pulled out of the gate and upward, releases the combined harness from its three attachment points and also releases the parachute restraining straps. At the same time the man portion of the P.E.C. and the leg restraint cords are released. The occupant is then free to leave the seat wearing his parachute.

WARNING : During a manual separation, the manual separation lever must only be operated *after* pulling the override D-ring otherwise the seat will remain attached to the apex of the parachute. If the lever is inadvertently operated the seat must subsequently be serviced by suitably qualified maintenance personnel.

7. Rip-cord D-ring

The rip-cord D-ring is normally covered by a canvas flap retained in position by two press studs. The flap is removed by the action of pulling the manual override 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.

8. Leg restraint cords and adjusting controls

(a) The cords ensure that the occupant'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 occupant 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 the seat harness portion of the combined harness is released or until the manual separation lever has been operated. The restraint cords are free to pull through the garter D-rings as separation from the seat occurs.

9. Normal operation of the seat

(a) When either firing handle is operated the canopy is jettisoned immediately and removes a restrictor from the time-delay firing unit. After a delay of one second the seat is ejected and the drogue gun, which is operated by a static rod, fires half a second later. If G conditions necessitate the use of the seat pan alternative firing handle the occupant should press his head firmly back against the head rest cushion to minimise the risk of spinal injury on ejection.

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

(b) On ejection the aircraft portion of the P.E.C. is disconnected from the seat portion and on separation the man portion of the P.E.C. disconnects from the seat.

(c) As the seat is ejected a static rod readies the barostatic time-release mechanism. When the seat has descended on the drogue to 10,000 ft., 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 connecting lifting line, the face screen is disconnected and the parachute deployed. The occupant is momentarily prevented from leaving the seat by two restraining straps until deployment of the parachute lifts him clear of the seat.

ANTI-G AND A.V.S. SYSTEMS

10. Anti-G system

(a) Partially cooled air from the cockpit 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 P.E.C. to the pilot's anti-G suit. On this aircraft the anti-G suit is inflated when positive accelerations are applied or if the cockpit altitude exceeds 35,000 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 1.9G applied) and, when set to L, at 1.05 PSI per G applied (but not below 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 cockpit 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 on the starboard console permits the system to be tested provided an engine is running, the P.E.C. is connected and the stop valve switched ON. Pressure should be felt in the suit.

11. Air ventilated suit system

(a) Partially cooled air tapped from the cockpit air conditioning system is used to provide the air ventilated suit supply. A flow control selector is on the starboard console. 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 A.V.S. ground air supply connection is on the starboard side of the fuselage.

OXYGEN SYSTEM

12. General description

Oxygen is stored in two cylinders, of 400 and 750 litres capacity, in the forward equipment compartment. An oxygen contents gauge is on the starboard instrument panel. A pressure reducing valve reduces the pressure to 200-400 PSI before the oxygen is fed to the regulator. The regulator delivers the oxygen to the pilot via the P.E.C. The regulator may be a Mk. 20, a Mk. 20A (Post Mod. 1522), Mk. 20B (post Mod. 1863) or, if Fighter Command Lightning

Mod. 1 is embodied, a Mk. 21A. On Mk. I aircraft the regulator is positioned below the instrument panel and on Mk. 1A aircraft on the side face of the starboard console.

13. Pressure demand regulator

(a) Any of the regulators which can be fitted have similar controls. The height limitations for the various types of regulator and clothing worn are listed at (c)(iii) below. The regulator controls and indicators are as follows :—

(i) An 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 ON-OFF 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 is on the port coaming panel.

(iv) An air dilution switch marked NORMAL—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, partial pressure helmet and associated clothing as listed at para. 15. 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 garments when cockpit altitude exceeds 39,000 ft. approximately. At cockpit altitudes below 10,000-12,000 feet, oxygen is delivered at ambient pressure and above this height, up to 39,000 feet, it is delivered under a slight ' safety pressure ' to ensure that any leakages downstream of the regulator do not dilute the oxygen with air.

(ii) Above 39,000 feet approximately, the pressure is progressively increased above ambient so that the pressure in the lungs remains at the equivalent of about 39,000 feet in the case of Mk. 20 Series regulators and about 41,000 feet for Mk. 21 series regulators, thus preventing anoxia.

(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 the maximum rate, must be initiated to a cockpit altitude of 40,000 feet, and if possible continued to a cockpit altitude of less than 30,000 feet. The limits of protection afforded by the various combinations of regulator and personal equipment are :—

	Mk.20 type regulators			Mk.21A type regulator		
Personal Equipment	Limiting altitude	Total time from loss of cabin pressure to 40,000 ft. cockpit altitude	Initiate descent in:—	Limiting altitude	Total time from loss of cabin pressure to 40,000 ft. cockpit altitude	Initiate descent in:—
A13A/4, P or Q mask	45,000 ft.	1½ min.	1 min.	45,000 ft.	1½ min.	1 min.
P or Q mask with sleeveless jerkin and anti - G trousers	50,000 ft.	2 min.	½ min.	56,000 ft.	2 min.	½ min.
Partial pressure helmet with sleeveless jerkin and anti-G trousers	66,000 ft.	4 min.	1 min.	56,000 ft.	2 min.	½ min.

NOTE : Aerodynamic suck will cause the cockpit altitude to exceed aircraft altitude by up to 8,000 feet if the canopy is lost.

(c) (i) With the air dilution switch at NORMAL, an air/oxygen mixture of appropriate proportions is delivered up to a cockpit altitude of about 32,000 feet. 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 and lack of flow will be instantly recognised by difficulty in inhaling.

(iii) The NORMAL setting must not be used with Mk. 20 regulators. If the cockpit 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 switch is at NORMAL. When this switch is set to EMERGENCY, oxygen is delivered at a slightly greater pressure than normal, i.e. approximately safety pressure up to 10-12,000 ft. cockpit altitude and approximately double safety pressure above this height. EMERGENCY should be selected whenever smoke or noxious fumes fill the cockpit.

(ii) The MASK TEST and JERKIN TEST positions of the test switch 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.

14. 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 P.E.C. 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 P.E.C. breaks the emergency oxygen supply and allows air to be breathed. Between the emergency oxygen set and the P.E.C. an inward relief and excess pressure valve (RV.51) is fitted.

(b) The RV.51 regulates the flow of emergency oxygen so that ' safety pressure ' is produced up to 39,000 feet. Above 39,000 feet a barometric capsule in the RV.51 causes the pressure to increase, producing a similar mask pressure as would be given by the main system. As the emergency oxygen flow reduces with reducing altitude and increase in time, the inlet element of the RV.51 allows air to be drawn in to dilute the oxygen. The opening of the inlet element will be noticed by increasing difficulty in breathing. This can be relieved by setting the airmix control to NORMAL or by disconnecting the oxygen mask when below 10,000 feet cockpit altitude ; after ejection, separation of the P.E.C. after deployment of the parachute will allow full ingress of air. The endurance of the oxygen set is about 10 minutes provided cockpit altitude is reduced. An immediate descent to a cockpit altitude of 10,000 feet should therefore be made once the emergency oxygen is selected.

(c) If ejection is made at heights above 40,000 feet, the flow from the emergency oxygen set will be inadequate to inflate the pressure jerkin and anti-G suit rapidly. It will only top up the garments already inflated by the main regulator before the seat leaves the aircraft. Thus, if escape is necessary above 40,000 ft. the cockpit should, if possible, be depressurised prior to ejecting.

15. Clothing

(a) *Low altitude assembly*

For flights below 40,000 ft. the following equipment must be worn :—

A13/A4 or P2A or Q2A oxygen mask
Suits flying Mk. 2A or appropriate suit with leg restraint garters
Helmet, Flying, Type G
Helmet, Protective, Mk. 1A
Oxygen mask hose assembly, Mk. 1

Other items of equipment are optional, e.g. life jacket, anti-G suit, etc., depending on the flight conditions.

(b) *High altitude assembly*

For flights above 40,000 ft., the following equipment must be worn :—

P2A or Q2A oxygen mask or partial pressure helmet
Suits flying Mk. 2A or appropriate suit with leg

restraint garters
Helmet, Flying, Type G } If partial pressure
Helmet, Protective, Mk. 1A } helmet is not worn
Suits anti-G, Mk. 5A
Pressure jerkin hose assembly Mk. 2
Pressure jerkin, Mk. 1 or Mk. 4

Air ventilated suit Mk. 2A is optional.

USE OF THE AIRCREW EQUIPMENT ASSEMBLY

16. Strapping-in procedure

(a) Before entering the seat, ensure that the harness is securely attached to the seat by pulling on the straps individually at each attachment point.

(b) Ensure that the main and alternative firing handle safety pins are fitted.

(c) Ensure that there is no safety pin fitted in the canopy jettison sear and the drogue gun safety lock pin is removed.

(d) Ensure that the drogue and time-delay 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.

(f) Check that the canopy/ejection seat connecting cable is attached to the rear base of the canopy and is routed correctly through the eyelet on the top of the electrical distribution box. Also ensure that the safety catch is locked in the position at the connection of the cable to the seat and that the safety catch at the other end of the cable is properly fitted between the jaws of the firing unit restrictor.

(g) Sit in the seat and adjust its height to approximately the mid-position. (This is to enable the secondary firing handle safety-pin to be removed at a later stage without fouling the control column.)

(h) Remove the dust cover from the seat component of the P.E.C. and fit into the stowage on the right-hand side of the seat pan. Connect the ' man ' portion of the P.E.C. to the seat portion ensuring that it is locked.

(i) Connect the survival pack lanyard to the life-jacket or pressure jerkin ensuring that it passes outside the left leg.

(j) Pass the left-hand leg restraint cord through the right leg garter D-ring and plug into the socket above the left-hand snubbing unit. Pass the right-hand leg restraint cord through the left-hand garter D-ring and plug into the socket above the 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 P.E.C. is locked to the seat component, the leg restraint cords cannot be secured. It is not important which cord is secured first so long as the cords 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 backward through the snubbing units.

(k) Pull up the parachute back pad and adjust the height of the lumbar cushion, then proceed as follows depending on whether or not a negative G strap is fitted.

(i) If the negative G strap is not fitted, connect and tighten the harness lap straps ensuring that the right hand strap passes outside the hoses from the P.E.C. with the excess of the hoses below the lap strap.

(ii) If the negative G strap is fitted, 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 P.E.C. and tighten the straps. Tighten the adjustable part of the negative G strap and stow the end in the elastic loop provided.

NOTE :—Whether or not a negative G strap is fitted the lap straps must be as tight as possible. To tighten these straps fully it is necessary to relieve the tension in the ' standing end ' of each strap otherwise the buckles become stiff. Pull on the ' running end ' with one hand and push the webbing of the ' standing end ' towards the buckle with the other. It may be necessary to do this several times before the straps are really tight and while it is being done the occupant should push himself well back into the seat.

(l) 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.

(m) Fit the spring safety clip to the quick-release box.

(n) Remove the alternative firing handle safety-pin and insert it in its stowage.

(o) Adjust the sitting height to the desired position.

(p) Ensure that the shoulder straps pass under the folds of the life jacket 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.

(q) Put on the helmet and connect the oxygen supply and Mic/Tel lead.

(r) Check function of the lean-forward harness release.

(s) 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.

(t) Have the main firing handle safety-pin removed and placed in its stowage.

17. Leaving the seat after landing

(a) Remove the safety pins from their stowage and fit the short pin through the alternative firing handle. Hand the long pin to the ground crew member who will fit it to the main firing handle. If a ground crew member is not available, the pilot must fit the pin to the main firing handle before leaving the cockpit. In this condition, the ejection seat is now 'safe for parking'.

(b) Remove the safety clip from the harness quick-release fitting. Unlock the harness quick-release fitting, free the straps and return the fitting to the locked position.

(c) Disconnect the man portion of the P.E.C. 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.

(f) Disconnect the Mic/Tel lead.

(g) Leave the aircraft.

18. Abandoning the aircraft in flight

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

(b) If above 40,000 ft. and circumstances permit, depressurise the cockpit to ensure that the pressure clothing is fully inflated prior to ejection.

(c) Pull the face blind 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 blind handle cannot be reached, pull up the alternative firing handle.

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

(e) If the ejection seat fails to eject, pull the override D-ring and operate the manual separation lever and proceed as on an aircraft without an ejection seat. The emergency oxygen system will be disconnected when separation takes place.

(f) When the parachute has developed, disconnect the survival pack 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. If a partial pressure helmet is worn, remove it and throw it away whether landing in water or not, otherwise the parachute canopy cannot be seen. To do this easily, unplug the helmet hose first and then use the helmet emergency release.

19. Ditching

To be issued by amendment.

PART I

Chapter 13 WARNING SYSTEMS

CONTENTS

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 ENG. MASTER START and the INSTRUMENT MASTER switches are ON. The fire warnings, however, are still operative with the ENG. MASTER START switch at OFF, but they require the INSTRUMENT MASTER switch to be ON.

(b) The windows in the standard warning panel (S.W.P.), 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	Oxygen failure (inoperative)

(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) A red attention light which flashes whenever a warning appears, is on the port coaming 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 S.W.P.

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

The attention light flashes.
The audio warning sounds.
The appropriate window on the S.W.P. lights up.
The C pushbutton light flashes.
If an engine fire has occurred, the appropriate fire extinguisher switch unit lights.

(f) The warning may be cancelled by depressing the C button. All warnings will cease except for the light in the appropriate window and, if a FIRE 1 or FIRE 2 warning, the fire extinguisher switch unit light.

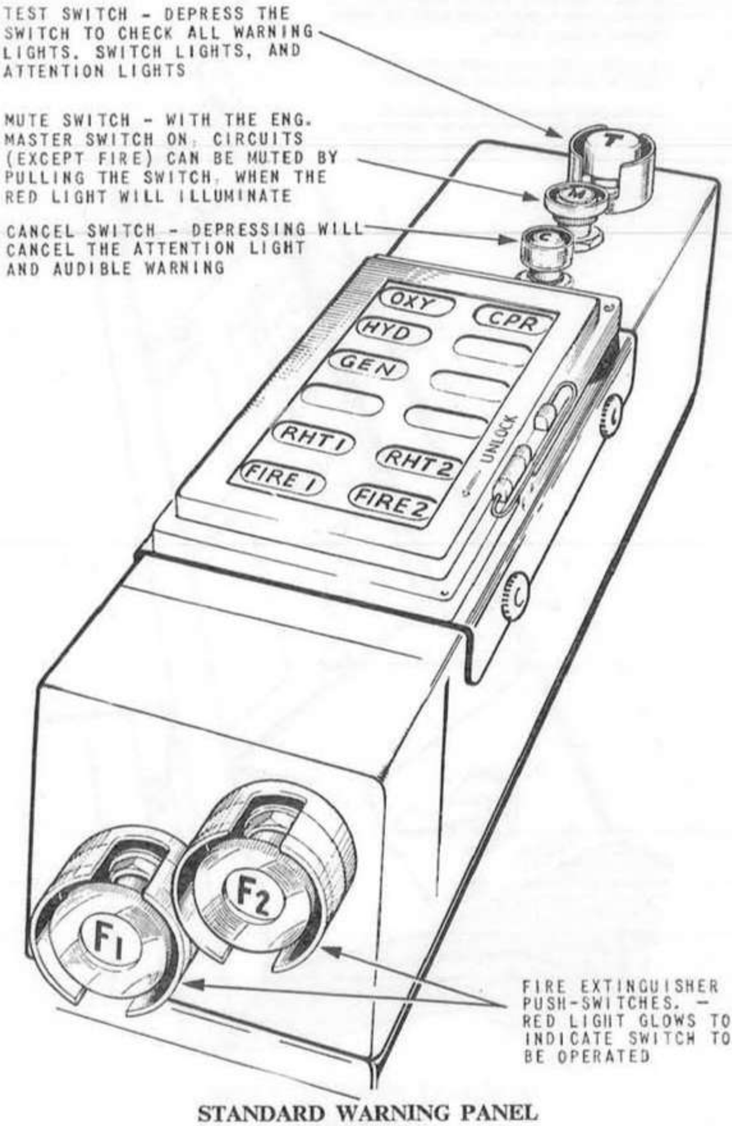
(g) When the M button is pulled out (integral light on) all warnings are rendered inoperative except for the fire warnings. The M button must always be in during flight.

(h) (i) 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 V.H.F. or U.H.F. is switched on and the ENG. START MASTER and INSTRUMENT MASTER switches are ON. When the T button is released all warnings will disappear except for the attention light, the audio warning and any warning which would normally be energised due to the aircraft condition in which the testing was done. To remove the attention light and audio warning, depress the C button.

(ii) The system should be tested after starting the engines and when all warnings have cleared. If done before engine start or whilst a warning remains lit the test circuit will appear to operate normally even though the test circuit supply fuse has ruptured.

(2. Auxiliary warning system

ia) The auxiliary warning panel (A.W.P.) groups the less mportant warnings on a panel mounted above the starboard console. All warning circuits on this panel are DC operated.



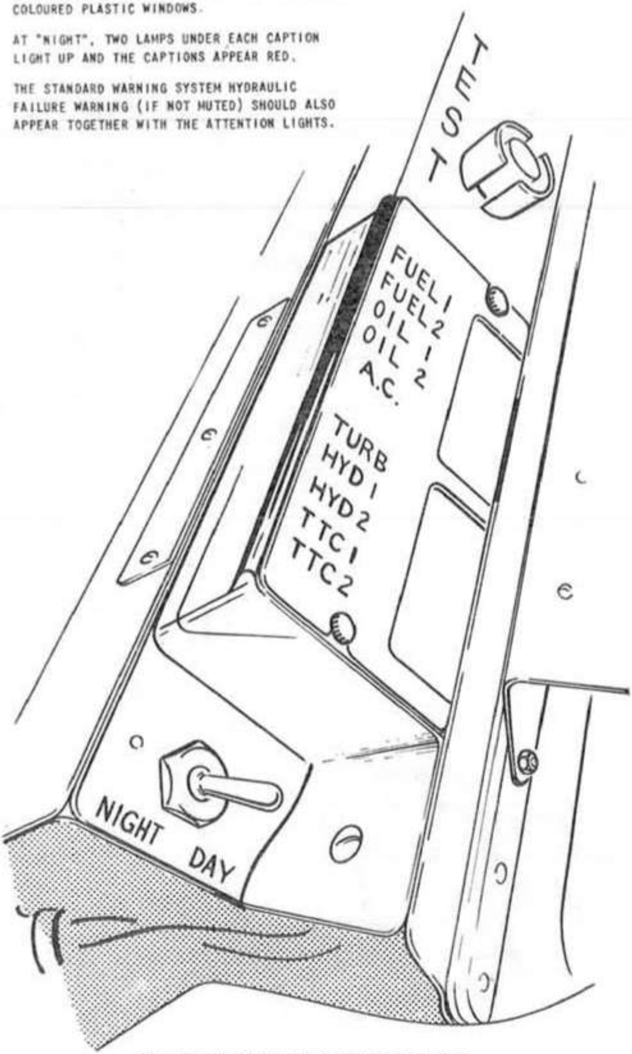
STANDARD WARNING PANEL

TO TEST:-
PUSH TEST SWITCH AND OPERATE NIGHT/DAY SWITCH

AT "DAY", TWO LAMPS ASSOCIATED WITH EACH WARNING CIRCUIT SHOULD GLOW UNDER THE AMBER COLOURED PLASTIC WINDOWS.

AT "NIGHT", TWO LAMPS UNDER EACH CAPTION LIGHT UP AND THE CAPTIONS APPEAR RED.

THE STANDARD WARNING SYSTEM HYDRAULIC FAILURE WARNING (IF NOT MUTED) SHOULD ALSO APPEAR TOGETHER WITH THE ATTENTION LIGHTS.



AUXILIARY WARNING PANEL

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

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)
A.C.	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)
TTC1	Top temperature control warning (No. 1 engine)
TTC2	Top temperature control warning (No. 2 engine)

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

(d) A DAY-NIGHT selector switch is at the aft end of the panel. When DAY is selected, the two lamps under each amber window are in circuit. When NIGHT is selected the two lamps under each caption are in circuit.

(e) Whenever the HYD 1 and HYD 2 warnings appear simultaneously, the HYD warning on the S.W.P. will light up and consequently the attention light will flash and the audio warning will be heard.

PART I

Chapter 14 AUTO-PILOT

CONTENTS

DESCRIPTION AND CONTROLS

1. General

The Mk. 13 auto-pilot system provides three-axis auto-stabilisation, bank attitude holding and auto-I.L.S. coupling. The system is used in conjunction with the M.R.G., the Mk. 5FT compass and the I.L.S. localiser and glide path receivers.

2. Auto-pilot control unit

The auto-pilot control unit is mounted on the starboard console 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 forward of the SUPPLIES switch shows black when power supplies are available and white/OFF when the system is switched off.

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

(d) An ATTITUDE HOLD—ILS switch selects either of the two modes of the auto-pilot.

(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 A.P. ON—OFF—F.D. ON switch is on the control column. The switch controls the pre-selected attitude hold or I.L.S. outputs to the aileron and tailplane autostabilisers when A.P. ON is selected. The F.D. ON position is inoperative.

4. Heading selector

An HDG selector and selected heading pointer is on the Mk. 5FT compass. Used in the I.L.S. mode it transmits heading information to the auto-pilot computor to modify the bank demand of the I.L.S. localiser receiver in such a manner that the aircraft turns on to the convergence heading at the required angle and the minimum of over-shoot.

5. Throttle servo

A THROTTLE SERVO. LOCK-UNLOCK control is located below the engine throttle levers. The control, when set to LOCK in the I.L.S. mode, 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 I.L.S. is selected on the auto-pilot control unit in such a manner as to maintain the correct aircraft approach speed. Small manual adjustments can be made with the clutch engaged and in emergency the servo can be overriden by direct movement of the throttle levers.

6. Trim indicator

An AUTO-PILOT TRIM indicator is on the port 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 I.L.S. mode only. A sustained deflection of the bar or the model aircraft after engagement indicates that a normal pitch trim change is required. If a sustained deflection of the indicator occurs before auto-pilot engagement a malfunction of the system is the probable cause.

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 P.F.C.U. and is so arranged that movement of the actuator moves the control valve of the P.F.C.U. without causing movement of the pilot's controls. Conversely, movement of the pilot's controls displaces the P.F.C.U. 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 allowing full stroke of the actuators in these channels (aileron $\pm 2^\circ\ 24'$, rudder $\pm 3^\circ$). The solenoid of the tailplane actuator, however, is normally de-energised and the stroke restrictor limits movement in this channel to $\pm 1^\circ$. Whenever the undercarriage is selected down in the auto-I.L.S.

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 A.P. ON on the engage switch.

9. Auto/I.L.S. coupling

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

(b) Auto/I.L.S. is selected by setting the ATTITUDE HOLD—I.L.S. 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 LOCK, 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.

LIMITATIONS

10. Auto-pilot limitations

(a) The use of the auto-pilot is permitted in the autostabiliser mode, subject to the following restrictions :—

(i) The autostabiliser may be engaged throughout the flight, from take-off to landing but it is recommended that, with the autostabiliser engaged, speeds above 400 knots I.A.S. 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 (e.g. formation flying) or the ground, lest there be a latent malfunction which will then become effective.

(iii) The autostabiliser must always be used above 1.6M.

(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 must have his hand on the stick and monitor the aircraft's behaviour continuously so that immediate recovery action can be guaranteed in the event of a malfunction.

(v) Mod. 394 (modified stick top) must be embodied in the aircraft.

USE OF THE AUTO-PILOT

11. To be issued by amendment.

PART I

Chapter 15 RADIO AND RADAR CONTROLS

CONTENTS

1. V.H.F. (Mk. 1 aircraft)

(a) Twin V.H.F. sets, TR1985/86, each having ten channels, are installed in the fuselage spine and are designated set 1 and set 2 respectively. The channel selector switches are located below the port console. A set selector switch, labelled SET 1—SET 2 is adjacent to the channel selectors. Two, V.H.F., CHANNEL SET 1—SET 2, remote indicators are on the starboard instrument panel. The V.H.F. aerial forms the entire tip of the aircraft fin.

(b) Two press-to-transmit switches are provided, one on the control column hand grip and the other on the No. 2 engine throttle lever.

(c) Power supplies for the V.H.F. sets are taken from the 28 volt DC bus-bar.

2. U.H.F. (Mk. 1A aircraft)

(a) *General*

On Mk. 1A aircraft, the V.H.F. is replaced with U.H.F. equipment. This comprises two U.H.F. sets installed in the fuselage spine, 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 only one channel, normally pre-tuned to 243 mcs. The normal set may be used to provide homing facilities in conjunction with the vertical pointer of the I.L.S. indicator; the standby set cannot be used in this way. 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 in the top skin of the spine.

(b) *Controls*

The U.H.F. control panel is located below the 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 twentieth 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 I.L.S. indicator, A.D.F. 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 batteries.

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

(c) Below the U.H.F. control panel the remaining 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) An UPPER—LOWER AERIAL switch selects the aerial required. However, with the standby set selected, the lower aerial is connected irrespective of the setting of the AERIAL switch.

(iii) A V.P.—I.L.S. INDR. switch selects the mode of operation of the I.L.S. indicator.
(iv) A V.P. SENS., MIN-MAX switch selects the sensitivity of the homing indication when V.P. is in use.

(v) A, NORMAL—STANDBY, POWER switch is for use in conjunction with the standby U.H.F. 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 eliminates the dropping resistor and allows the standby set to be run at the battery voltage (i.e. 24 volts approx. initially).

(d) The two press-to-transmit switches associated with the U.H.F. are positioned as described in para. 1.

(e) *Violet picture* (*homing*)

The vertical pointer of the I.L.S. indicator may be used to provide homing directions, provided the required frequency is set, A.D.F. is selected and V.P./I.L.S. switch is at V.P. The V.P. SENS MIN-MAX switch selects the sensitivity of the indications.

3. External intercomm.

When Mod. 165 and 328 are embodied on Mk. 1 aircraft and Mod. 227 and 328 on Mk. 1A aircraft, provision is made for external intercomm. via a socket in the starboard wheel well. When an external headset is plugged in to the socket, intercomm. between the pilot and the groundcrew is available on the V.H.F. (Mk. 1 aircraft) or on either normal or standby U.H.F. set (Mk. 1A aircraft).

4. Telebriefing

A telebriefing installation can be connected to the aircraft at a socket in the starboard wheel bay. The light in the telebriefing pushbutton on the starboard console illuminates when the connection is made. The equipment is normally in the receive condition ; to transmit, the pushbutton must be depressed. The aircraft battery switch must be on to operate the system unless Mod. 1836 (Mk. 1 aircraft) or Mod. 1831 (Mk. 1A aircraft) is embodied.

5. I.L.S.

Standard I.L.S. equipment is fitted. The control unit is mounted below the port console. The MASTER switch and VOLUME control are located adjacent to the control unit. An I.L.S. indicator and marker lamp are on the instrument panel. On Mk. 1A aircraft, the VP/I.L.S. switch must be set to I.L.S. when I.L.S. is required. 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.

6. Tacan

(a) Tacan navigational system, which provides distance and bearing information, is fitted. The control unit, which may be type 7750 or 9273, is located below the starboard console on Mk. 1 aircraft and below the port console on Mk. 1A aircraft. The Tacan indicator is on the main instrument panel. The system requires 28 volt DC and 115 volt single-phase AC power supplies.

(b) (i) The type 7750 control unit has an OFF-REC-T/R switch, a TACAN AERIAL, UPPER-LOWER switch, two channel selector switches and a VOLume control. With the unit selected to REC, only bearing information is given on the indicator. Both bearing and distance information is presented with the switch at T/R.

(ii) The type 9273 control unit has an ON-OFF switch and a BRG—DIST.BRG. switch in place of the single OFF-REC-T/R switch of the earlier control unit. Four push switches are provided to operate the channel selections, in place of the two rotary switches of the type 7750 control unit.

(iii) When Mod. 1556 is embodied the TACAN AERIAL, UPPER-LOWER switch is removed and the Tacan is permanently connected to the lower aerial. The lower 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.

7. I.F.F. Mk. 10

The I.F.F. controls are on the starboard console. They consist of :—

(a) An I.F.F. MASTER switch.

(b) An OFF-STANDBY-LOW SENSITIVITY-ON control

(c) An OUT-MODE 2-EMERGENCY control. To select EMERGENCY the knob must be pushed in before turning.

(d) An OUT-MODE 3 switch.

(e) A coder control unit.

(f) An I/P switch.

Two aerials are installed, the upper on the top of the canopy and the lower in the skin on the underside of the rear fuselage.

8. A.I. 23

(a) A.I. 23 equipment is installed. The hand controller is on the port console and the display unit is above the instrument panel. In addition to its normal function, the A.I. supplies range and bearing information to the Pilot Attack Sight after radar ' lock on ', and information to the guided weapons homing circuits to assist them to ' lock on '.

(b) Both 28 volt DC and 200 volt AC electrical power are required for the operation of the A.I.

PART I

Chapter 16 ARMAMENT AND CAMERA CONTROLS

CONTENTS

1. Pilot attack sight (P.A.S.)

(a) The P.A.S. is basically a gyro sight working in conjunction with the A.I.23 radar equipment. Provision is made for the sight to be manually controlled. The P.A.S. display unit is mounted above the instrument panel.

(b) The P.A.S. is switched on whenever the master armament selector switch is set to weapons (GUNS-G.W.-R.B.)

(c) The 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. A wing span setting control is on the starboard of the 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 P.A.S. requires both DC and AC electrical supplies for its operation.

2. Armament—General

(a) The armament of the aircraft consists of two 30 m.m. Aden guns in the upper nose position of the fuselage.

Additionally an interchangeable armament pack is fitted on the underside of the fuselage. The pack may be a gun pack carrying two 30 mm. Aden guns, a rocket pack containing forty eight 2 inch rockets or a missile pack for two guided weapons.

(b) A four position, OFF-GUNS-GW-RB, master armament selector switch is below the starboard console. The switch selects the weapons to be used and, in any position other than OFF, switches on the P.A.S.

(c) An armament safety break on the port side of the fuselage, 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 the 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 energises a solenoid operated gun purging valve which 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 starboard coaming 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 on 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 remaining rounds should be fired without delay. The return to base should be made at the lowest practicable RPM to avoid structural damage.

4. Rockets

(a) With RB selected at the master armament selector, pressing the armament trigger energises a hydraulic selector valve in the rocket pack to extend the launchers. When the launchers are fully extended the rockets are fired and two seconds after firing has ceased the launchers retract.

(b) An R.B. DOORS UNLOCKED warning light is on the starboard console. The light illuminates whenever the launchers are not fully retracted. The light has a press to test facility.

(c) An R.B. EMGY RETRACT switch on the starboard console is for use when the rocket launchers fail to retract normally at the end of the firing cycle. Setting the switch forward retracts the launchers.

5. 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 for at least 2½ seconds.

(b) The setting of the G.W. PAIRS-SINGLE switch on the starboard console 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 starboard console, 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) A GW ARMING INDR light on the starboard console 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 minutes period. Neither missile can be fired until the two minute period has elapsed. Additionally, the light will flash if failure of the missile alternator occurs or if the arming switch remains at ARMED after the second missile has been fired.

(e) A GW ARMED TIME indicator and light are on the starboard coaming panel. They give 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. Missile cooling and refrigerant supplies are exhausted after approximately 15 minutes of elapsed armed time ; this is indicated by the flashing of the light. Selecting the arming switch off extinguishes the light.

(f) A G.W.F.C.R. (fire control reset) switch spring-loaded to off, is on the starboard console. The G.W. acquisition system may be returned to normal after a simulated firing by setting the F.C.R. switch to ON. On Mk. 1A aircraft, the switch is replaced by a pushbutton.

(g) A MISSILE JETT. LIFT AND SQUEEZE trigger is on the ventral tank jettison handle. When the trigger is operated the missiles and their shoes are jettisoned laterally.

6. Cameras

(a) A G.90 camera is fitted in the radome strut. It is controlled by a MASTER CAMERA switch on the starboard console and runs whenever this is set to ON and either the camera push-button is pressed or the armament trigger pressed when weapons are selected at the master armament selector. Forward of the MASTER CAMERA switch is an IRIS. DULL-BRIGHT switch to control the lens aperture setting.

(b) (i) A P.A.S. camera recorder is mounted on a bracket at the port of the pilot attack sight. A switch unit for the recorder is adjacent to the master armament selector switch. The camera idles whenever the P.A.S. is switched on, and then runs when the ON push-button of the switch unit is pressed, the armament trigger or camera push-button 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 push-button or AI 23. When the armament trigger or camera push button 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.

PART II—LIMITATIONS

LIST OF CHAPTERS

PART II

Chapter 1 AIRFRAME LIMITATIONS

CONTENTS

1. General

The Lightning F. Mk. 1 and F. Mk. 1A are designed for duties appropriate to an interceptor fighter. Intentional stalling and spinning are prohibited. The aircraft are cleared for use in temperate climates only.

2. Maximum speeds

Clean aircraft, or with ventral tank and/or missiles	1.7M/650 knots, whichever is first attained
Airbrake operation (normal)	1.4M/650 knots, whichever is first attained
Airbrake operation (rolling manoeuvres)	1.2M/650 knots, whichever is first attained
Undercarriage operation	250 knots 280 knots for emergency locking down (see Part IV, Chap. 2, para. 5)

Recommended speed for undercarriage lowering	220 knots
Flap operation	250 knots
Parachute stream	150 knots (normal)
	170 knots (emergency)

The maximum speed for operating a service also applies with the service in the extended position.

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

The maximum permissible normal acceleration at mach numbers up to 1.6 is 4.5 G with ventral tank full, 5G with ventral tank empty, or that corresponding to the onset of buffet. In some circumstances, missile limitations may impose more severe restrictions (see paragraph 14). Above 1.6M the normal acceleration is not to exceed 3G.

5. Weight limitation

The maximum permissible weight for take-off and all forms of flying, including landing, is 34,000 lb.

6. C.G. limitations

The take-off C.G. limits are contained in A.P.4700 A & F, Volume 1, Book 1, Section 2, Chapter 3.

7. Aircraft approach limitations

To be issued by amendment.

8. Cross-wind landings

The maximum cross-wind component for landing with a braking parachute 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 2,500 yards in length, preferably having the Boscombe Down type of surface.

10. Altitude limitations

The aircraft should not be flown above 60,000 ft. The maximum altitude for which the oxygen regulator and personal equipment have been cleared are as follows :—

Personal equipment	*Mk.* 20	*Mk.* 21
A13A/4, P or Q mask ..	45,000 ft.	45,000 ft.
P & Q mask with sleeveless jerkin and anti-G trousers	50,000 ft.	56,000 ft.
Partial pressure helmet with sleeveless jerkin and anti-G trousers	66,000 ft.	56,000 ft.

NOTE :—These altitudes do not take into account aerodynamic suck. Cockpit altitude will exceed aircraft altitude by up to 8,000 ft. if the canopy is lost.

11. Rolling manoeuvres

Rolling manoeuvres are restricted to the following :—

(a) At speeds up to 550 knots or 1.6M

(i) Half-aileron rolls through 90° with application of positive G up to the lesser of 4G or the onset of G stall buffet.

(ii) Half-aileron rolls through 180° between 1 and 2G.

(b) At speeds above 550 knots or 1.6M, or with accelerometer readings greater than 4G :—

Co-ordinated turns using low rates of roll only.

(c) The minimum use of aileron with accelerometer readings less than 1G at any speed.

(d) Normal use of ailerons for correction in take-off or landing including the circuit phase.

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 large trim change which may occur in certain conditions, jettisoning should not be carried out at speeds exceeding 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 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, e.g. formation flying, or near the ground, lest there be a latent malfunction which then becomes effective.

(iii) The autostabiliser must always be used above 1.6M.

(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 must have his hand on the stick and monitor the aircraft's behaviour continuously so that immediate recovery action can be guaranteed in the event of a malfunction.

(v) Mod. 394 must be embodied in the aircraft (modified stick top).

14. Firestreak installation

(a) Carriage of the missiles and acquisition functioning exercises are permitted throughout the flight envelope but firing is only permitted up to the limit of 1.3M. Dispersion becomes excessive at accelerometer readings above 3G.

(b) Two consecutive sorties are permissible. In the case of low altitude sorties, the cruising altitude should not be less than 5,000 feet. After a first low altitude sortie, ground cooling will be required if the return cruise has been omitted and the ground ambient temperature exceeds 25°C.

(c) In the event of a misfire (which might actuate the missile fins) the aircraft should not exceed 3G for a period of 30 seconds after the misfire.

(d) Jettisoning is permitted at speeds between 150 and 300 knots below 5,000 ft. at between 1 and 2G.

(e) Mk. 1 refrigerant containers (unbaffled) should be used. These give a maximum armed time of 15 minutes.

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

15. Gun firing

(a) When un-vented upper gun blast tubes are fitted, carriage of live ammunition is permitted up to 1.3M. Firing is permitted with upper guns only, up to 1.3M at heights between 20,000 and 45,000 ft. and 3G should not be exceeded.

(b) With vented upper gun blast tubes (Mod. 244), carriage of live ammunition is permitted up to 1.6M and firing with upper guns only up to 1.3M at heights between 20,000 ft. and 45,000 ft. and 3G should not be exceeded.

(c) In circumstances when H.E. ammunition is carried and 0.8M is exceeded below 5,000 feet for longer than 5 minutes, any ammunition which has been subjected to these conditions whilst in the upper guns and feed chutes must be discarded after flight.

(d) With either type of blast tube, a total of 2,000 rounds per gun position must not be exceeded pending completion of structural integrity firing trials.

16. Air to air rocket installation

Carriage of 2 inch air to air rockets is not permitted pending completion of development trials.

17. Flight refuelling limitations

Flight refuelling is not yet cleared pending flight trials.

18. I.L.S.

I.L.S. must not be switched on at altitudes above 10,000 ft.

19. Rain dispersal system

With the rain dispersal system switched on, 85% RPM should not be exceeded except in the overshoot case. Use of the system above 85% RPM. should be limited as follows :—

85 to 90% RPM	..	4 minutes
90 to 100% RPM	..	1 minute.

PART II

Chapter 2 ENGINE LIMITATIONS

CONTENTS

1. Engine limitations, Avon Mk. 210

Power Rating	Time limit per flight	R.P.M. per cent	JPT °C (max)
Take-off and operational necessity (with or without reheat)	15 mins. (combined)	100±0.5 max.	775
Intermediate	30 mins.	97.5 max.	740
Max. continuous ..	Unrestricted	95 max.	705
Approach	Unrestricted	60 min.	—
Slow idle	Unrestricted	31-34 min.	625

NOTES : 1. The use of AVTAG or AVTUR is permitted.
2. 700°C must not be exceeded during starts.
3. During climbs at maximum conditions the governed speed may be permitted to rise to 102.5% r.p.m. but the maximum j.p.t. must not be exceeded.
4. In sub I.S.A. conditions the maximum r.p.m. at sea level may vary as follows :—
—10°C : 99% —25°C : 98%
Full I.C.A.O. thrust will still be maintained.
5. The maximum period for which reheat may be used at any one time is 15 minutes.
6. Reheat may be used throughout the flight envelope but is not to be selected above 0.9M below 10,000 ft.
7. Slam throttle movements must be avoided between 15,000 ft. and 25,000 ft.

2. Oil pressure

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

PART III—HANDLING

LIST OF CHAPTERS

PART III

Chapter 1 PREPARATION FOR FLIGHT

CONTENTS

1. External checks

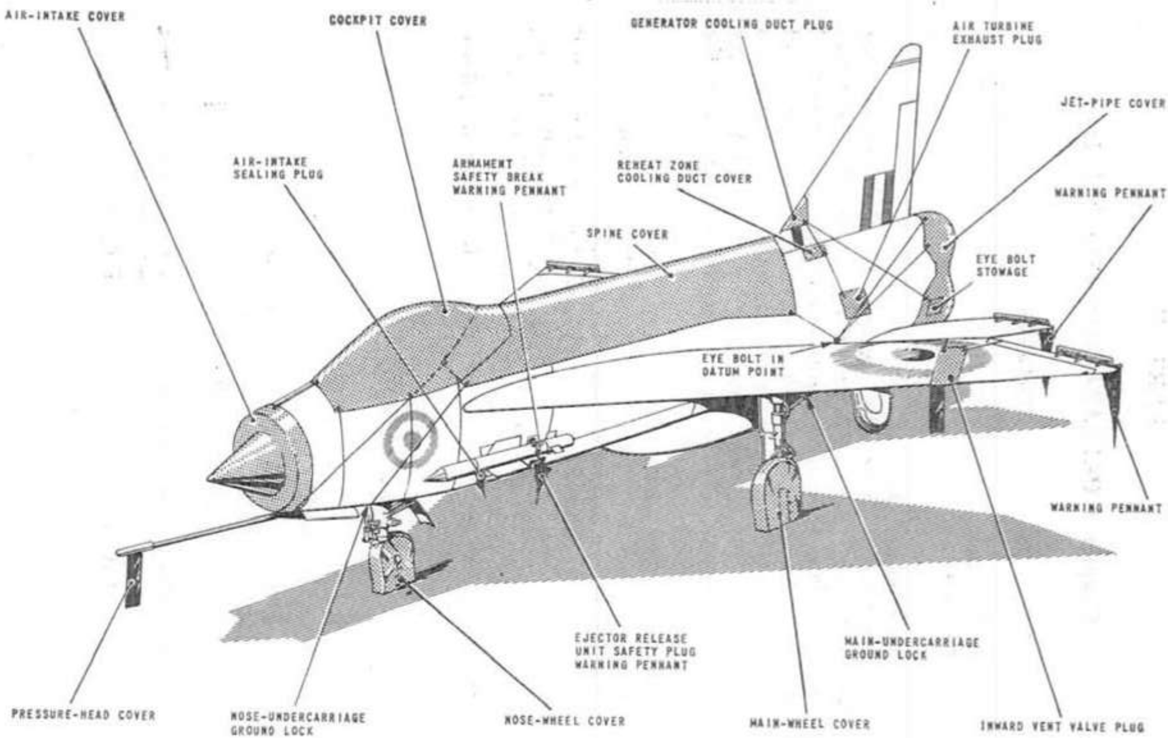
Systematically check the outside of the aircraft for obvious signs of damage and for security of panels and doors. Have all covers, plugs, intake and flying control guards removed. Check that the main and nose-wheel undercarriage locks are removed and check the oleos for extension and leaks, the tyres for cuts and the brake leads for security and leaks. In addition, carry out the following specific checks :—

Feel units accumulator ..	115 PSI minimum
Hydraulic accumulators ..	1,500 PSI minimum
Armament safety break plug	Disconnected
Firestreak (if fitted) ..	Check ejector release unit safety plugs stowed and that the panels are fitted to the pack.
Fire extinguishers	Check lights for discoloration
Fire extinguisher over-temperature discharge indicators (Mod. 1569)	Green

2. Internal checks

(a) Before entering the cockpit, check :—

G.W. arming switch ..	OFF
Armament trigger safety catch	SAFE
Undercarriage down button	In (UP button override knobs horizontal)
Ejection seat	Safe for parking



COVERS, PLUGS AND WARNING PENNANTS

(b) On entering the cockpit, carry out the strapping-in procedure (see Part I, Chap. 12), and then carry out the following cockpit checks :—

* Applies to Mk. 1 aircraft only
† Applies to Mk. 1A aircraft only.

AC and DC external supply ..	Connected and switched on
Engine master switch ..	ON
Battery switch	ON
Instrument master switch ..	ON and gated (roller blind erects after 20 seconds)

COCKPIT—LOWER LEFT SIDE

Canopy operating lever ..	UP
Ram air valve	CLOSED and locked
Canopy jettison handle ..	Fully down
Demist lever	OFF (rear)
Throttle SERVO control ..	UNLOCK
Undercarriage emergency lever	Fully forward (Safety wire unbroken) (Mk. 1A, spring clip in position)
*V.H.F. sets	On
†U.H.F.	Channel selected. Function switch T/R Power switch—NORMAL Aerial switch — UPPER NORMAL/STANDBY switch — NORMAL Volume control — As required V.P./I.L.S.—As required
I.L.S. master switch	OFF
I.L.S. channel switch ..	As required
†Tacan	ON Channel selected Aerial as required DIST/BRG or BRG as required
Ventral tank and missile jettison handle	Fully in. Trigger wired or guarded

COCKPIT—MIDDLE LEFT SIDE

†Flight refuelling panel ..	Test lights, leave switch central

A.I. hand controller	Ground test switch inboard
Emergency canopy jack release	Outboard
Throttles	Fully forward into reheat, then idle/fast idle

COCKPIT—UPPER LEFT SIDE

S.W.P.	Test. Check lights, audio, mute and cancel.

COCKPIT—FRONT

Feel switch	ON
Feel indicator	ON
Undercarriage selector ..	DOWN
Undercarriage position indicator	3 green lights — alternate bulbs day/night switch
J.P.T. controller switches ..	AUTO—wired
Combined trim indicator ..	Test trim switches individually for live circuit, then operate combined trim switches over full range. Set : rudder neutral, aileron neutral, tailplane T.O.
Braking parachute selector ..	Fully in
Slip indicator..	Central
Anti-dazzle light switch ..	OFF
Accelerometer	Reset
Flaps	UP (indicating UP)
Standby art. horizon switch	NORMAL
Standby art. horizon ..	Flag not visible, erect if necessary
M.R.G. NORMAL/FAST ERECTION switch	NORMAL
Standby inverter indicator ..	Black
Flight instruments	Visual check
Emergency lamps switch ..	OFF
*Air diffuser control lever ..	As required
Oxygen regulator	Contents — FULL, 200—400 PSI
NORMAL/100% switch	100%
Mask jerkin	TEST, return to NORMAL
Flow indicators ..	Annunciating

*V.H.F. indicators	Indicating channel selected
R.P.M. indicators	Normal
J.P.T. indicators	Normal
Fuel gauges	Contents
Ventral flow indicator ..	White

COCKPIT — LOWER RIGHT SIDE

*Tacan	ON, channel selected, aerial switch (if fitted) as required
Camera control unit ..	OFF
Armament selector switch ..	OFF
A.V.S. flow control	As required
Anti-G cock	ON, set L or H as required

COCKPIT—UPPER RIGHT SIDE

E2B compass	Check
Canopy unlock warning lights	On
Armed time clock	Zero
Arming warning lights ..	Out
R.B. doors unlock light ..	Out
R.B. emergency retract switch	Off
G.W. arming switch ..	Off
G.W. PAIRS/SINGLE switch	As required
A.W.P.	All lights on except TTC Test for TTC lights NIGHT/DAY switch as required
Voltmeter (if fitted) ..	28 volts

COCKPIT—RIGHT CENTRE SIDE

Navigation light switch ..	As required
Taxy lamps	OFF
Camera iris switch	As required
Camera master switch ..	As required
*De-ice switch	OFF (warning light out)

†De-ice/Rain-dispersal switch	OFF (warning light out)
Pitot heater switch	ON (forward)
Front and side wind-screen heating switch	ON
Engine starter master switch	ON
Standby inverter switch ..	NORMAL-indicator black. Select STANDBY-indicator white. Check off flag does not appear on attitude indicator. Reset to NORMAL-indicator black.
Ignition switch	ON
Cabin air switch	ON
Battery switch	ON
Cockpit lamps	As required
Nozzle position indicators ..	Check
I.F.F. master switch ..	ON
I.F.F. control panel	Standby
Auto-pilot :	
Master switch	ON, SUPPLIES magnetic indicator black
Auto-stabilisers	ON
I.L.S./ATT. HOLD ..	ATT. HOLD
Fuel switches	Both back (A.W.P.—fuel lights out). Both forward (lights remain out)
Cabin temperature selector	As required
Cabin altitude	Check altimeter
Brake accumulator pressure gauge	2,000 PSI (min.)
Instrument master switch ..	ON (gated)

CONTROL COLUMN

Auto-pilot	OFF (central)
Armament trigger safety catch	Safe
Brake lever	On, parking catch engaged.

PART III

Chapter 2 STARTING, TAXYING AND TAKE-OFF

CONTENTS

1. Starting the engines

(a) Confirm or set :—

AC and DC external ground supply	Connected
Brakes	On
Instrument master switch ..	ON (Inverter indicator black)
S.W.S. M button	Down
HP cocks/throttles	Idle/Fast idle
Battery switch	ON
Fuel switches	PORT—No. 1 ENGINE STBD—No. 2 ENGINE (Both switches forward)
Engine start master switch ..	ON
No. 1 and 2 ignition switches	ON
No. 1 engine start button ..	Press for 2 seconds and release

(b) Checks after starting No. 1 engine :—

JPT	700°C max. during start 625°C max. when idling
Fire warning	Out
Oil pressure warning ..	Out above 45% RPM
Hydraulic warning (No. 1 and S.W.P.)	Out above 40% RPM
Flaps and airbrakes	Test

GEN warning	On (Reduce to idling, if necessary, to bring on warning)

(c) Starting No. 2 engine :—

No. 2 engine starter button	Press for 2 seconds and release

(d) Checks after starting No. 2 engine :—

JPT	700°C max. during start 625°C max. when idling
Fire warning	Out
Oil pressure warning ..	Out above 45% RPM
Hydraulic warning (No. 2) ..	Out above 40% RPM
Ground AC and DC supply ..	Disconnect
Voltmeter (if fitted) ..	28 volts. If voltmeter not fitted, switch off battery switch and check undercarriage lights still illuminated. Reselect battery switch on.
AC and TURB failure warning	Out at 58% RPM
S.W.P. and A.W.P. ..	Increase RPM if necessary on No. 1 engine and check all warnings out

NOTES : 1. With an engine at maximum R.P.M., 50% or above must be maintained on the other engine to avoid excessive J.P.T. on the slower running engine.

2. Single engine running on No. 1 engine must be kept to a minimum as the aircraft intake configuration produces high compressor blade stresses particularly at high R.P.M.

3. Maintain No. 2 engine at fast idling for A.C. electrical supplies.

2. Failure to start

(a) *Engine does not rotate*

If, after pressing the starter button, there is no indication on the RPM gauge of engine rotation, wait for one minute to allow the AVPIN to drain from the starter, repeat the starting checks and press the starter button again. There is no limit to the number of attempts to start after this type of failure, but investigate the fault after about six abortive attempts.

(b) *Engine rotates but fails to light*

If engine rotation has occurred but the engine fails to reach self-sustaining RPM, shut the HP cock immediately it is apparent that the engine will not light. If this is done before the RPM reduces to 10%, fuel is unlikely to accumulate in the jet pipe. Repeat the starting checks and press the starter button again as close as possible to one minute after the first attempt to start. If the engine again rotates but fails to light up a waiting period of 45 minutes must be observed before a further single attempt to start is made.

3. Checks after starting

Canopy	Check both lights on. Select closed. Shoot bolts LOCKED. Lights out.
Standby inverter indicator ..	Black
Flight instruments	Attitude indicator and standby art. horizon erected. Mk. 5FT compass set. Both altimeters set.
Auto-pilot magnetic indicator	Black
Brake accumulator pressure	3,000 PSI ± 50
Services pressure gauge (if fitted)	3,000 PSI ± 50
Anti-G	Test
S.W.P.	Test—cancel, all warning lights out
A.W.P.	Test, release, all warning lights out
Ice warning light	Out
Armament safety break ..	Have ground crew replace plug.

4. Taxying

(a) Have the chocks removed and release the wheel brakes parking catch. About 60% RPM will be required to get the aircraft under way, but once taxying speed has been attained, the throttles may be set to idle/fast idle. Check the operation of the brakes as soon as possible. Avoid sudden heavy braking or sharp turns otherwise venting of fuel into the auxiliary intakes may occur.

(b) The No. 2 throttle should not be reduced below fast idling to ensure continued electrical supply.

(c) Taxying with the canopy open in any position is permissible provided the airstream against the canopy is not greater than 65 knots (i.e. aircraft speed plus wind component). If canopy nodding occurs either close the canopy or reduce taxying speed until the nodding stops.

5. Checks before take-off

Trim	Rudder neutral Aileron neutral Tailplane—T.O.
Airbrakes	In and locked
Auto-pilot	SUPPLIES magnetic indicator black Autostabilisers—ON I.L.S. ATT. HOLD—ATT. HOLD Control column switch—OFF Throttle servo—UNLOCK
Fuel	Contents Fuel switches forward
Flaps	UP (indicated UP)
Feel switch	ON. Magnetic indicator black
Instruments	Mk. 5FT compass synchronised Attitude indicator and standby art. horizon erected Other instruments—normal Inverter indicator—black Pitot heater—ON S.W.P. and A.W.P. warning lights out

Oxygen	Contents 100% Pressure Flow indicator—operation Flow check
Hood	Closed, locking handle fully down. Shoot bolts LOCKED Warning lights out
Harness	Tight and locked
Hydraulics	Warnings out. Check controls for full and free movement.
Voltmeter	28 volts

6. Take-off

(a) Take-off with flap extended should not be attempted due to the possibility of one flap blowing up following services system hydraulic failure.

(b) Align the aircraft on the runway ensuring that the nose-wheel is 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 this setting on a dry runway surface. Increase both throttles to maximum cold thrust and release the wheel brakes. Check that the nozzles move to the closed position at 94% RPM approximately and that there is no evidence of swirl vane malfunction, indicated by overspeeding of an engine and a JPT less than 650°C. If these conditions are not satisfied, abandon the take-off.

(c) Speed increases quickly during the take-off run and there is no difficulty in keeping straight even in strong cross-winds. Keep the nose-wheel on the ground until 145 knots approximately, and then smoothly ease the control column back to raise the nose-wheel and unstick the aircraft at about 165-170 knots. Violent backward movement of the control column at the unstick speed must be avoided otherwise the tail bumper area may strike the runway.

(d) In strong cross-wind conditions, either wing may drop when the aircraft unsticks. Retract the undercarriage as soon as the aircraft is safely airborne keeping the speed below 250 knots until the wheels are locked up.

7. Take-off performance considerations

(a) V STOP and V GO speeds are contained in the Lightning O.D.M. The take-off may be abandoned and the aircraft brought to rest in the remaining length of runway if speed is at or below V STOP. If speed is at or above V GO, the take-off may be continued and the aircraft will become airborne in the remaining distance. Provided V STOP is greater than V GO, only V STOP should be considered. If V GO is greater than V STOP, however, a speed band occurs 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, consideration should be given to the use of reheat from the start of the take-off run. V GO is only likely to exceed V STOP if the runway length is less than 2,500 yards.

(b) If an engine failure occurs during the take-off run at above V STOP, the take-off should be continued without the use of reheat. Selection of reheat after the failure is not recommended as there will be little benefit in shortening the take-off run, and if reheat fails to light but the nozzle opens, a thrust reduction will occur on that engine which will aggravate the emergency.

(c) Examples of V STOP speeds are given below.

TEMPERATURE	RUNWAY LENGTH	RUNWAY SURFACE	V STOP
+15°C	2,500 yds.	Wet	140 kts.
+15°C	2,500 yds.	Dry	160 kts.
+30°C	2,400 yds.	Wet	129 kts.
+30°C	2,400 yds.	Dry	150 kts.

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.

8. Abandoning the take-off

(a) If, during the take-off run, an emergency occurs which would make it perilous to become airborne, the take-off should be abandoned even if V STOP has been exceeded. If the aircraft cannot be stopped in the remaining distance, engage the runway safety barrier. If this is not possible, the decision whether or not to abandon the aircraft by ejection will depend upon the circumstances.

(b) If the emergency is of a lesser degree, e.g. engine failure, the considerations stated in para. 7 should apply. The take-off should always be abandoned if the speed is at or below V STOP ; there is little point in taking an unserviceable aircraft into the air if it can be brought to rest on the ground without damage.

(c) To abandon the take-off, proceed as follows :—

(i) Move the throttles to idle/fast idle
(ii) Stream the brake parachute
(iii) Apply maximum pressure at the wheel brakes
(iv) Select throttles to idle/idle
(v) Have the runway safety barrier raised and if necessary, engage it.

9. Checks after take-off

Brakes	Apply momentarily
Undercarriage	UP (before 250 knots)
Ventral tank (if fitted) ..	Feeding.

PART III

Chapter 3 HANDLING IN FLIGHT

CONTENTS

1. Climbing

(a) The aircraft accelerates rapidly after take-off if the climbing angle is shallow. Allow speed to increase to 450 knots increasing the climbing angle to about 22° to maintain this speed initially.

(b) At altitudes below 35,000 ft. approximately, the best rate of climb is obtained at 450 knots/0.9M. Above this height the best rate of climb is obtained at about 1.5M. The optimum altitude for changing from subsonic to supersonic speed in the climb is dependent mainly upon air temperature and is generally between 30,000 ft. and 40,000 ft. For specific details of the best altitude for accelerating to supersonic flight refer to the Lightning O.D.M.

(c) The climbing flight profile will depend upon the operational technique required. Details of climb profiles are contained in the Lightning O.D.M.

(d) During the subsonic part of the climb, any deviation above or below 0.9M will result in a loss of climbing performance. The aircraft holds the trimmed speed of 0.9M without difficulty but care should be taken to avoid exceeding 0.94M which will result in the aircraft entering the transonic drag region ; this will be noticed by slight buffet occurring as the mach number approaches 0.96M.

2. Engine handling on the climb

(a) Provided the J.P.T. CONTROL is selected to AUTO for both engines, the throttles may be left in the maximum cold thrust position or in reheat during the climb. Maximum RPM may vary according to the ambient air temperature, altitude and forward speed.

(b) If the J.P.T. CONTROL for an engine becomes unserviceable or is switched to OFF, manual throttling of the affected engine will be necessary to prevent the JPT and the RPM exceeding the limits, and the reheat top temperature trip will be inoperative.

3. Engine handling in flight

(a) Operate the throttles smoothly at all times and avoid slam accelerations. If required, however, rapid throttle movement can be made at any altitude except between 15,000 ft. and 25,000 ft., in which height band surging may occur.

(b) At low altitudes acceleration to maximum cold thrust from 60% RPM can be achieved within five seconds.

(c) Below 10,000 feet approximately and 250 knots, the RPM of the engines will fall below 58% if both throttles are at idling. The RPM should be kept at 58% or above to prevent the air turbine underspeeding causing loss of electrical supplies.

(d) Reheat may be used throughout the flight envelope but it is not to be selected above 0.9M below 10,000 ft. The recommended reheat lighting range is shown on the graph opposite. The possibility of failure of reheat through flame extinction increases at the higher altitudes. Successful reselection of reheat under these circumstances is affected by altitude and mach number.

4. Engine handling in icing conditions

(a) If visible moisture reduces visibility to 1,000 yards or less and the O.A.T. is below + 5°C, anti-icing must be

Reheat Lighting Range

Graph. To be issued

by amendment.

REHEAT LIGHTING GRAPH

switched ON immediately after starting and left ON for taxying.

(b) Anti-icing should always be used for take-off in icing conditions.

(c) Climb at the maximum practical rate of climb. If an alteration in RPM is necessary move the throttles smoothly.

(d) If icing conditions are met in level flight, switch ON anti-icing and climb or descend out of the icing as continued flight in icing conditions may result in flame extinction. Should an engine flame-out, relight immediately. If this is unsuccessful make a further attempt within one minute; if this second attempt is unsuccessful any further attempt may damage the engine.

(e) (i) During descent and landing 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 practical 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 required to overshoot, open the throttles smoothly.

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

5. General flying

(a) *Ailerons*

The ailerons are light and effective throughout the speed range. Aircraft response to aileron increases with speed and at high subsonic and at supersonic speeds high rates of roll can be achieved. However, to avoid inertia coupling effects the rolling limitations (see Part II, Chapter 1, para. 11) must not be exceeded. Large rapid aileron movements will cause adverse yaw which is more pronounced at low indicated airspeeds.

(b) *Tailplane*

The tailplane is effective throughout the speed range and aircraft response to small stick movements is generally satisfactory. However, at speeds below about 200 knots, longitudinal response is poor and large stick movements are necessary to manoeuvre. This is particularly apparent during the roundout to land. At supersonic speeds response to tailplane is decreased due to the increased longitudinal stability of the aircraft and relatively large stick movements are necessary to manoeuvre and stick forces become moderately heavy.

(c) *Rudder*

The rudder is effective throughout the speed range and the aircraft response to small rudder deflection is generally satisfactory. 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 trim out any asymmetry. 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 reduced to a comfortable magnitude.

(d) *Harmonisation of controls*

The aileron and tailplane controls are well harmonised over the speed range except that in manoeuvres at supersonic speed large tailplane movements are required in comparison with aileron movements. Small rudder deflections to co-ordinate manoeuvres are only necessary at low indicated airspeeds and at high supersonic speeds.

(e) *Trimmers*

The trimmers are effective in operation throughout the speed range. The rates of operation are relatively slow, especially the tailplane trimmer, and consequently there is no tendency to overtrim. At supersonic speeds large amounts of rudder trim may be required on some aircraft to correct directional trim changes. Also, when flying with one missile at supersonic speed large amounts of rudder trim are necessary to trim to zero side-slip. Where large amounts of rudder trim have been used in supersonic flight care is needed when decelerating through the transonic region to avoid excessive yaw as the response to rudder increases suddenly. Heavy foot loads may be required to correct or prevent the yaw until the trim can be applied.

(f) *Airbrakes*

The deceleration obtained with airbrakes extended is only moderate over the speed range. Extension of airbrakes causes slight buffet at all speeds and at high speed a slight nose-down trim change occurs which is easily controllable.

(g) *Changes of trim*

Increase in power	Slight nose-up
Decrease in power	Slight nose-down
Undercarriage down ..	Slight nose-down
Undercarriage up	Slight nose-up
Flaps down	Slight nose-down
Flaps up	Slight nose-up
Airbrakes out	Slight nose-down at high speed
Airbrakes in	Slight nose-up at high speed
Increase in speed	Very slight nose-up to about 0.96M then increasing nose-down to about 1.4M. Slightly nose-up between 1.4M and 1.7M.
Decrease in speed	Reverse of trim changes under ' Increase in speed '.

6. Inertia coupling

(a) The aircraft can, under certain conditions, be affected by inertia coupling ; for this reason rolling limitations are imposed on the aircraft (see Part II, Chap. 1, para. 11).

(b) The subject of inertia coupling is too complex to be dealt with fully within the scope of these notes, but if the rolling limitations are exceeded either of the following effects may be produced :—

(i) Rapid rolling under positive G produces sideslip which can easily become large enough to overstress the fin ; the amount of sideslip increases with higher rates of roll and higher G.

(ii) 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, theory suggests that 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.

7. Handling with only one missile

(a) Considerable asymmetric forces can develop if G is applied when carrying only one missile. The asymmetric force increases directly with applied G and, particularly at high I.A.S. at supersonic speeds, may give rise to dangerously high fin loads if sideslip is not trimmed. Indications that asymmetry is becoming excessive are given by :—

(i) The inability to trim to zero sideslip despite large rudder pedal force.

(ii) The need to apply large aileron deflection to prevent the aircraft rolling.

If these symptoms occur, therefore, the applied G must be relaxed.

(b) Whenever one missile only is fitted, the following manoeuvres must not be attempted :—

(i) The unnecessary rapid application of G. Otherwise a considerable rolling and yawing tendency will develop before the aircraft can be trimmed.

(ii) Any unnecessary rapid rolling manoeuvre with G applied or with sideslip, since the resulting asymmetric forces adds to the inertia coupling characteristics in a fast roll.

(c) If, whilst carrying two missiles, one missile only is fired under G, sudden asymmetry will develop.

8. Stalling

NOTE: Intentional stalling is prohibited. The following information is given to cover the case of an inadvertent stall.

(a) *Clean aircraft with and without Ventral tank fitted*

Stalling tests have shown that the aircraft is prone to enter an incipient spin from the 1G stall but that adequate warning is available. At an altitude of 40,000 ft. the characteristics appear as follows :—

225 knots	Slight buffet begins
170 knots	Buffet becomes moderate
145 knots	Buffet is considerably reduced. Sink rate increases.
135-115 knots	Lateral and directional wallowing becomes more pronounced as speed is further reduced. Up to this point recovery is immediate on moving stick forward.
115-110 knots	Yaw develops rapidly to the point where it cannot be held with rudder.
110-100 knots	Stall marked by wing drop.

Due to high rate of sink at low I.A.S. and the comparatively large height losses incurred in recovery, speed should not normally be reduced below the minimum speed limitations (see Part II, Chap. 1, para. 3). In all manoeuvring flight below 200 knots, care should be taken to maintain sufficient engine RPM to enable maximum rate application of full power as required.

(b) *Aircraft with Ventral tank fitted and airbrakes OUT*

Tests indicate that the characteristics are similar to those described in sub-para. (a) with some increase in buffet amplitude and with the sink rate developing at a speed approximately 10 knots higher.

(c) *Undercarriage and flaps down—airbrakes OUT*
Stall approaches down to 115 knots have shown essentially similar characteristics with a large region of moderate buffet and slightly more pronounced lateral and directional behaviour giving a " knife edge " feeling to control. Considerable sink at a rate of approximately 4,000 ft. per minute occurs below 130 knots. There is every indication that the aircraft is prone to spin from the stall in this configuration.

9. Stalling under G

(a) *Aircraft clean with Ventral tank fitted*
Commencing at 45,000 ft./0.9M, even using maximum cold thrust, speed loss is rapid with application of G. A good buffet margin exists and some lateral rocking occurs as G is increased. At the stall the aircraft rolls fairly smoothly into, or out of the turn, and recovery is immediate on relaxing G.

(b) *Aircraft with Ventral tank fitted and airbrakes OUT*
Under similar conditions to (a) above, a good buffet margin exists and the lateral rocking characteristics are present. However, there is little warning of the rather violent " flick " manoeuvre which typifies the G stall with airbrakes OUT. Although recovery is rapid on relaxing controls the aircraft should not be flown beyond the lateral rocking stage.

10. Stalling with missiles fitted

Stalls with missiles fitted have not been investigated.

11. Spinning

NOTE : Intentional spinning is prohibited. The following information is given to cover the case of an inadvertent spin.

Sufficient is known of the spin and recovery characteristics from 1 G entry to give the following information and recommendations :—

(a) The spin is very oscillatory in yaw, pitch and roll and is comparatively slow (approx. 6 seconds per turn).

Initially, however, the aircraft yaws and rolls rapidly for about ½ a turn and the nose drops sharply. Approximately every ¾ of a turn the rate reduces considerably as the nose rises above the horizon. Using the technique below, recovery has been effected from erect spins in periods varying from immediate to 2 turns. The aircraft becomes fully unstalled as speed increases above 140-150 knots and exact recovery behaviour is dependent to some extent on the I.A.S. when rotation ceases. If yaw is checked at about the unstall speed and controls are centralised quickly, recovery will normally be clean and positive. About 1 cycle of a dutch roll motion can occur with possibly a slight nose down pitch if yaw is stopped at a lower speed or there is residual sideslip. Total height loss during a 2 turn spin and recovery can exceed 10,000 feet.

(b) *Recovery action*

(i) Apply *full* anti-spin rudder, centring the ailerons and moving the stick slightly forward of neutral. Allow adequate time for controls to take effect.

(ii) If rotation does not stop after maintaining this action for at least 2 turns, application of up to ¼ in-spin aileron should assist recovery but there is a risk that this will induce a continuing roll and may mask recognition of recovery.

(iii) When rotation ceases centralise all controls. Check that I.A.S. is building up rapidly and ease the aircraft out of the dive. It should be noted that there is a possibility that the M.R.G. will have toppled giving large errors on the attitude indicator and loss of compass annunciation.

(iv) In the case of an inverted spin, no experience has been obtained. Recovery action as in sub-para. (i) above should be taken but with the stick slightly aft of neutral.

(v) Spinning characteristics with missiles and with flaps and/or undercarriage down are unknown but it is recommended that the same recovery action be used and that flaps and undercarriage should be retracted as soon as possible. Due to the 150 kts. pressure switch it may be necessary to operate the undercarriage override in this case.

(c) Normal recovery has been shown to be quite positive, and in fact, slightly more delayed recoveries have been achieved by simply releasing all controls. Tests have proved that ¼ out-spin aileron or more is detrimental to recovery ; the recommendation of ailerons neutral is, therefore, important and in cases of disorientation or doubt, releasing the control column will achieve this.

(d) If still in the spin at 15,000 feet the aircraft should be abandoned.

12. High speed flying

(a) The aircraft is easily capable of exceeding its airspeed and Mach number limitation of 650 knots/1.7M and care must be taken to avoid flying beyond these limits. With airbrakes extended the limits are reduced to 650 knots/ 1.4M and for rolling manoeuvres with airbrakes extended, 650 knots/1.2M within the rolling limitations.

(b) As speed is increased beyond 0.94M there is a slight nose-down trim change and very slight buffet in the speed range 0.94M to 0.98M. This is barely noticeable in normal 1G flight but becomes more pronounced under increased accelerations and/or with a ventral tank fitted. Transition from subsonic to supersonic flight can be achieved in maximum cold thrust from sea level to 45,000 feet, and up to 52,000 feet in reheat. There are no other mach characteristics in the transition stage apart from a slight deterioration in controllability and a reduction in damping (but see (d) below). Above 1.0M, control is improved and normal accelerations within the limitations are limited only by a gradual decrease in tailplane effectiveness with increase in mach number. A slight nose-down trim change occurs with increasing speed between 1.0M and 1.4M approximately.

(c) When reducing speed, a small nose-up trim change will occur in the transonic region.

(d) On some aircraft, directional trim changes may occur in the transonic region which may require increasing amounts of rudder trim as mach number is increased (see para. 5 (e)).

(e) 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 limitation in rolling maneouvres.

13. Formation flying

Formation flying should only be carried out in the subsonic speed range. If formation flying is attempted in the transonic or supersonic range shock waves from the aircraft in formation may cause control difficulties or structural failure.

14. Flight refuelling

To be issued by amendment.

15. Descent procedures

(a) *Fast descent*

Speed	1.1M/450 knots
Airbrakes	Out
Throttles	Idle/Idle

(b) *Normal descent*

Speed	0.9M/350 knots
Airbrakes	Out
Throttles	Idle/Fast Idle

(c) *Range 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 to fast idle and descend as for a two-engine descent.

(e) *Descent in icing conditions*

If icing conditions require the use of engine anti-icing, maintain engine RPM at 80% or above.

PART III

Chapter 4 CIRCUIT AND LANDING PROCEDURES

CONTENTS

1. Approach and landing

(a) After joining the circuit reduce speed to 220 knots and check :—

Airbrakes	OUT
Undercarriage	DOWN. Three green lights
Fuel	Contents. 500 lb./side min.
Flaps	DOWN
Harness	Tight and locked
Brake accumulator pressure	3,000 PSI min. ± 50

(b) Turn across wind at about 190 knots, maintaining this speed until lined up with the runway. Make the final approach at 170 to 175 knots reducing speed slowly to cross the threshold at 165 knots aiming to touch down at 155 knots. When the main wheels are on the ground close the throttles to idle/fast idle, lower the nose-wheel and stream the brake parachute. When it is certain that the parachute has streamed, shut the HP cock of the No. 1 engine.

NOTE : The speeds quoted above apply to all-up weights of 30,000 lb. and below. At weights above 30,000 lb. the speed should be increased by 5 knots for every 2,000 lb. increase in weight. The all-up weight with a full armament load, empty ventral tank and 1,700 lb./side internal fuel remaining is approximately 30,000 lb.

(c) 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.

(d) The braking effect of the brake parachute is high and it should always be used. If wheel brakes only are used the landing ground roll is increased by 40% approximately on a dry runway and 55% approximately on a wet runway.

2. Use of the wheel brakes

(a) After the nose-wheel has 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 of 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*
Retardation may be greatly reduced and will depend directly upon the degree of wetness of the runway surface. Generally, under wet conditions it is recommended that light intermittent braking action be commenced as soon as the aircraft is firmly on the ground and the wheels have had time to spin up. The brake pressure may then be progressively increased and can be held continuously as the speed falls off. If a slip or skid is suspected the pressure should be released momentarily and re-applied gradually.

(iii) *Flooded or icy runways*

Whenever possible these conditions should be avoided due to the certainty of the reduction in braking effectiveness on flooded or icy runways. However, if a landing has to be made, extreme caution is required.

(b) Every effort should be made to avoid overheating the brakes by using them judiciously according to the length of the runway.

3. Failure of the brake parachute

(a) Failure of the brake parachute to stream will considerably increase the landing ground roll and in the most adverse conditions it may not be possible to bring the aircraft to rest in the runway length available. Unless circumstances dictate otherwise, therefore, overshoot action should always be taken and a landing made at an airfield with a runway long enough to meet the ground roll requirements in the prevailing conditions. The subsequent approach and landing will require extra care to ensure that the correct threshold speed is not exceeded. Close one of the HP cocks after touch-down. Both HP cocks must not be closed in the landing run, otherwise the brake accumulator may become exhausted. The runway barrier should be raised to prevent running into the overshoot area.

(b) Should the parachute stream and then collapse overshoot action should be considered. This 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.

(c) Landing ground roll distances and airborne distance to clear 50 feet are contained in the Lightning O.D.M.

4. Overshoot procedure

(a) As much as 400 lb./side fuel may be required for ı overshoot, circuit and landing. Open the throttles smoothly and jettison the brake parachute if streamed. Raise the undercarriage when safely airborne, but if wheel brakes have been used during the landing run, leave the undercarriage down to dissipate residual heat at the brakes. Delay selection of flaps to UP until 180 knots has been attained.

(b) If, on the subsequent circuit, the fuel state is very low, carry out the final crosswind turn at not less than 200 knots, delaying selection of the flaps until the turn has been completed.

5. Instrument approach

The following speeds and power settings are recommended for use during instrument approaches with the undercarriage and flaps down and the airbrakes out :—

TWO ENGINES WITH VENTRAL TANK AND MISSILES

	% RPM	Speed
Level	.. 82	250—190 Kts.
Glide-path ..	.. 80	190—175 Kts.

SINGLE ENGINE

	% RPM	Speed
Level	.. 95	250—190 Kts.
Glide-path ..	.. 93	190—175 Kts.

6. Flapless landing

A flatter approach than normal should be made, increasing the approach and threshold speeds by 10 knots. In these conditions tail bumper clearance is reduced and extra care is necessary at the round out. The landing run will be about 200 yards longer than that for a normal landing.

7. Crosswind landing

The crab technique is recommended for approaches in crosswind conditions. When streaming the brake parachute in a crosswind the yawing effect should be anticipated and the aircraft kept straight by using rudder and wheel brakes. In very strong crosswinds, if directional control is lost, jettison the parachute.

8. Roller landings

Roller landings are not normally permitted due to the possibility of overstressing the tyres by excessive rolling speeds.

9. Checks after landing

(a) Brake parachute ..	Jettison above 10 Knots. (The parachute may be damaged if retained at lower speeds).

(b) After clearing the runway :—

No. 2 engine	Fast idle
Flaps	UP
Airbrakes	IN
Electrical services ..	Switch off non-essential services.

Taxy back with No. 2 engine at fast idle.

10. Shut-down checks

Brakes	Parking brake on
No. 2 throttle/HP cock	HP cock closed
Fuel switches	OFF
All electrical services ..	Off
Ejection seat	Safe for parking
Battery switch	OFF
Cockpit lighting ..	Off

PART III

Chapter 5 SINGLE-ENGINE FLYING AND RELIGHTING

CONTENTS

1. Stopping an engine

(a) Single-engine flying should be practised by throttling back one engine. If necessary, however, an engine may be shut down ; consideration should be given to shutting down the No. 2 engine in preference to the No. 1 so that the undercarriage emergency system is always available if the shut down engine fails to relight. Carry out the following procedure :—

(i) Select the throttle/HP cock to HP cock closed.

(ii) Select both fuel pump switches to the live engine.

(iii) Do not attempt to correct fuel asymmetry.

2. Single-engine flying

(a) There are no asymmetric problems associated with single-engine flying and as long as the necessary power can be obtained with the live engine all manoeuvres should be as normal.

(b) 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 this is done 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 at Part IV, Chapter 2, para. 3.

3. Single-engine landing and overshoot

(a) A single-engine landing presents no difficulty and the approach and landing should be as normal. Selection of flaps to down may be delayed if necessary, to conserve engine power.

(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 raise the flaps at 180 knots.

4. Relighting an engine in flight

(a) (i) If a flame extinction occurs an immediate relight may be attempted at any altitude and airspeed/mach number by pressing the relight button for 2 seconds, leaving the throttle at its set position. 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, close the HP cock.

(ii) If flame extinction occurs whilst in reheat, cancel the selection before proceeding as in (i) above.

(b) Normal relights are practicable up to 40,000 feet and 0.9M (30,000 feet, 0.9M pre-Avon Mod. 2262). Relighting becomes progressively more certain at lower altitudes and airspeeds. For normal relighting proceed as follows :—

(i) Maximum speed, 0.9M.

(ii) Altitude 40,000 feet max. (30,000 feet max. pre-Avon Mod. 2262.)

(iii) Check HP cock closed on the dead engine.

(iv) Check engine master and ignition switches are 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 engine may be opened up to the desired RPM.

(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 one minute before making a further attempt at a lower altitude and with airspeed as low as possible.

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 a further attempt may be made within one minute. If this also fails, any further attempt may damage the engine.

PART IV

EMERGENCY PROCEDURES

LIST OF CHAPTERS

PART IV

Chapter 1 ENGINE EMERGENCY PROCEDURES

CONTENTS

1. Engine failure on take-off

(a) The take-off should be abandoned if an engine failure occurs at or below the V STOP. Proceed as follows :—

(i) Move the throttles to idle/fast idle

(ii) Stream the brake parachute

(iii) Apply maximum pressure at the wheel brakes.

(iv) Select throttles to idle/idle.

(v) Have the runway safety barrier raised.

(b) If an engine fails above the V STOP speed, continue the take-off ensuring that maximum cold thrust is selected on both engines. Do not engage reheat. Raise the undercarriage as soon as possible when safely airborne and select HP cock closed for the failed engine. Set both fuel switches to the live engine and return to base and land.

2. Engine failure during flight

(a) *Mechanical failure*

If an engine fails due to obvious mechanical causes carry out the following drill immediately :—

(i) Close the HP cock of the affected engine.

(ii) Select the fuel switches to the live engine.

(iii) *Do not attempt to relight the failed engine.*

(iv) Return to base and land.

(b) *Flame-out*

If an engine flames-out an immediate relight may be attempted at any speed and altitude. (See Part III, Chapter 5, para. 4 (a)). If this fails, close the HP cock, wait one minute and proceed as for normal relighting, as described in Part III, Chapter 5, para. 4 (b).

(c) *Double flame-out*

Make an immediate attempt to relight the engines. If this fails, proceed as follows :—

(i) Maintain speed in excess of 250 knots so that windmilling RPM can provide hydraulic power for the operation of the flying controls.

(ii) Commence a fast rate descent to the maximum relighting altitude, restricting flying control operation to a minimum.

(iii) Shed all non-essential DC loads as soon as possible.

(iv) When at the recommended relighting altitude carry out the normal relighting drill on one engine only. When that engine has relit, switch on the required electrical supplies and relight the other engine.

3. Action in the event of engine fire (F1 or F2 warning)

(a) Carry out the following immediate actions :—

(i) Close the appropriate throttle/HP cock.

(ii) Switch fuel to the remaining engine.

(iii) Reduce speed if practicable.

(iv) Press the appropriate fire extinguisher button.

(v) Land as soon as possible.

(b) If the fire warning disappears :—

Test the S.W.P. system and if unserviceable proceed as for a persistent fire.

(c) If the fire warning persists :—

(i) If an F1 warning, jettison the ventral tank.

(ii) Look for signs of fire.

(iii) If signs of fire are apparent such as smoke, flame, control system malfunction or instrument indication, abandon the aircraft.

NOTE : 1. A visual check by another aircraft will be of assistance.

2. If the other fire warning comes on no extinguishant will be available and the aircraft must be abandoned.
3. Do not attempt to relight after a fire warning.

4. Reheat warnings (RHT 1, RHT 2)

Carry out the following immediate actions :—

(a) Cancel reheat on both engines.

(b) If the warning or warnings go out :—

(i) Test the S.W.P. system (if unserviceable proceed as for a persistent warning).

(ii) Continue the flight using minimum power on both engines.

(iii) Land as soon as possible.

(c) If one warning persists :—

(i) Close the appropriate throttle/HP cock.

(ii) Switch fuel to the remaining engine.

If that warning still persists :—

(iii) Check that there are no signs of fire.

(iv) Use minimum power necessary for the remainder of the flight.

(v) If the warning is a RHT 1 warning, jettison the ventral tank.

(d) If signs of fire are apparent such as smoke, flame, control system malfunction or instrument indication, or if a double reheat warning persists, abandon the aircraft.

5. Reheat failure

(a) If reheat fails to light within ten seconds or flames-out whilst in use, cancel the selection, wait for two seconds and re-select. Should reheat fail to light after several selections within the recommended reheat lighting range, the cause should be investigated. Flight may be continued without the use of reheat.

(b) If the JPT exceeds the top temperature trip setting, reheat will be automatically cancelled and the nozzles will close. Indication will be given by the illumination of the TTC warning on the A.W.P. The reheat selection should be cancelled. A second selection may be made but if automatic cancellation again occurs, no further attempts to light reheat should be made.

(c) If, after cancellation of reheat, the nozzles remain in the open position, there will be a substantial loss of thrust in cold power. Subsequent selection of reheat is permissible though a successful lighting is unlikely.

PART IV

Chapter 2 AIRFRAME EMERGENCY PROCEDURES

CONTENTS

1. Electrical failures

(a) *A.C. failure*

(i) AC failure will be indicated by the AC warning appearing on the A.W.P. The most important feature of AC failure is the failure of the AC fuel booster pumps and the Mk. 22A altimeter. Immediate action must be taken to descend to an acceptable altitude to obviate cavitation of the engine HP pumps and the possibility of flame-out of the engines (see Part I, Chapter 2, para. 19). The standby altimeter must be used throughout the period of AC failure.

(ii) The standby inverter should automatically start up to provide AC to the flight instruments listed at Part I, Chapter 1, para. 4 (d)(ii). To prevent intermittent operation of the inverter, set the NORMAL/STANDBY INVERTER switch to STANDBY.

(iii) Immediately AC failure occurs carry out the following procedure :—

Cancel reheat (if not automatically cancelled)

Throttle back smoothly
Descend to 27,000 ft. using the standby altimeter
Select the pitot heater to STANDBY
Select the standby inverter to STANDBY
Switch off the auto-pilot master SUPPLIES switch
Switch off A.I.
Restrict engine RPM to 85% if possible
Continue the descent to 22,000 ft., or lower if fuel permits. Use the standby altimeter throughout.

(iv) The following services will be inoperative during AC failure :—

AC fuel booster pumps
Mk. 22A altimeter
Normal pitot heater
A.I.
Armament circuits
Tacan
Fuel vent valve heaters
Windscreen heaters and canopy blower
Jet pipe temperature control
I.F.F.
Auto-pilot
Services system hydraulic gauge

(b) *Generator failure*

(i) If the generator comes off-line, indicated by a GEN warning on the S.W.P., the main batteries will have to bear all DC loads. Immediate action must be taken, therefore, to conserve the life of the batteries and to land the aircraft or place it in a position for landing before battery exhaustion occurs. Immediately the failure is apparent, carry out the following procedure :—

Cancel reheat
Throttle back smoothly
If no voltmeter is fitted :—

Descend at maximum rate to 10,000 ft. or V.M.C. below cloud, whichever is lower
Shed non-essential DC loads

If a voltmeter is fitted and is reading more than 23 volts:—

Shed non-essential DC loads and monitor the voltmeter

Descend and then cruise at 0.9M/36,000 feet

When voltmeter falls to 23 volts, descend at maximum rate to 10,000 feet or V.M.C. below cloud, whichever is lower

Maintain 85% RPM or lower on both engines

Select U.H.F. (if fitted) to STANDBY, power switch to STANDBY and function switch to OFF

If fuel permits, select undercarriage down and check green lights before the battery is exhausted.

(ii) Non-essential DC loads which should be shed in generator failure conditions are as follows :—

I.L.S.	11 amps.
Non-essential V.H.F./U.H.F. ..	6/11 amps.
A.I.	3 amps.
Navigation lights	2.7 amps.
Auto-pilot	2.7 amps.
I.F.F.	2 amps.
Master armament selector ..	2 amps.
Camera heater	2 amps.
Cockpit lighting	1.2 amps.
Tacan	1 amp.

NOTE :—The fuel switches must *not* be selected off to reduce electrical loads. If this is done flame-out of the engines will occur, since these switches also control the L.P. cocks.

(c) *Air turbine or generator and alternator failure*

(i) Failure of the alternator and generator will be shown by the AC and GEN warnings appearing on the A.W.P. and S.W.P. respectively and if these failures are the result of air turbine malfunction, a TURB warning will also appear on the A.W.P.

(ii) Immediately the failure occurs, carry out the following actions :—

Cancel reheat (if not cancelled automatically)

Throttle back smoothly

If no voltmeter is fitted :—

Descend at maximum rate to 10,000 ft. or V.M.C. below cloud whichever is lower using the standby altimeter.

Shed non-essential DC loads

If a voltmeter is fitted and is reading more than 23 volts :-

Descend at maximum rate to 27,000 feet

Shed non-essential DC loads and monitor the voltmeter

When the voltmeter falls to 23 volts continue the descent at maximum rate to 10,000 feet or V.M.C. below cloud whichever is lower using the standby altimeter.

Maintain 85% RPM or lower on both engines

Select U.H.F. (if fitted) to STANDBY, power switch to STANDBY and function switch to OFF

Select pitot heater to STANDBY

Select the standby artificial horizon to EMERGENCY

Select the standby inverter to STANDBY

If fuel permits, select undercarriage down and check green lights before the battery is exhausted.

(d) *Battery failure*

Exhaustion of the battery after generator failure will cause the complete failure of all electrically operated services except emergency lighting. Electrical services will begin to fail when the battery voltage falls below 22 volts and the battery will rapidly discharge. It is important to land the aircraft or be in a position to land before the battery has discharged. Flame-out of the engines through cavitation must be avoided, otherwise it will not be possible to relight once the battery is exhausted. A list of actions to be taken after battery failure and the effect of battery failure is given below.

(i) Maintain 85% RPM or lower on both engines and fly at 10,000 feet or V.M.C. below cloud whichever is lower.

(ii) The only available flight instruments will be the E.2 compass, the standby altimeter, the air speed indicator, the machmeter and the rate of climb indicator.

(iii) The fuel gauges will underread with declining voltage and then fall to zero.

(iv) Use the emergency system to lower the undercarriage.

(v) The brake parachute can be streamed but will not be jettisonable.

(vi) The flaps will be inoperative.

(vii) The trimmers will be inoperative.

(viii) If an engine flames out it will not be possible to relight it.

(ix) The fuel switches will be inoperative.

(x) The S.W.P. and the A.W.P. will be inoperative.

(xi) The brake pressure gauge will not read.

2. Fuel pressure warning

If a FUEL 1 or FUEL 2 warning appears on the A.W.P. carry out the following procedure depending upon the altitude at which the warning occurs :—

(a) *Below* 10,000 *ft.*

(i) Cancel reheat, restrict engine RPM and reduce speed until warning is cancelled.

(ii) If warning remains on, do not accelerate engine above 85% RPM. Reduce speed to a practicable minimum.

(iii) Do not run the affected engine above 10,000 ft.

(b) *Above* 10,000 *ft.*

(i) *Range critical*

Continue normal recovery on two engines

If engine flames out :—

Close HP cock of the affected engine and continue recovery on one engine.

During the descent a relight may be attempted when below 10,000 ft.

If relight unsuccessful, switch fuel to the good engine.

If fuel warning appears on the good engine side restrict engine RPM and speed to a practicable minimum and remain below 10,000 ft.

(ii) *Range not critical*

Close the HP cock of the affected engine

Continue recovery on one engine

Do not switch fuel to remaining engine nor attempt a relight above 10,000 ft.

(c) *Fuel pressure warning during descent*
If the fuel pressure warning first appears during a descent, and is not associated with electrical failure, the probable fault is the failure of the leading-edge DC transfer pump. If this pump fails and the DC transfer pump in the main compartment is uncovered, the collector box will empty. Action should be taken as follows :—

(i) Reduce power to idling RPM.

(ii) Increase the aircraft attitude to 7° nose-up and hold this attitude for 10 to 15 seconds to allow the collector box to fill.

(iii) Continue the descent at 250 knots with the airbrakes IN to ensure a continuous supply of fuel to the collector box. If time and fuel do not permit such a descent, make a normal descent with airbrakes out ; the collector box will, however, empty again in approximately 3 minutes and the fuel pressure warning light will re-appear.

If the engine flames-out, do not relight until action is taken to refill the collector box as described above.

3. Fuel asymmetry during single-engine flying

(a) Fuel asymmetry should not be corrected during single-engine flying. If it is suspected that the pumps of the non-feeding side are unserviceable, carry out the following drill. This should only be done if the fuel on the non-feeding side is essential for recovery.

(i) Fly below 30,000 ft. and 0.9M.

(ii) Check ignition switches and engine start master switch—ON.

(iii) Check that the fuel switches are both selected to the live engine.

(iv) Press the relight button of the live engine for 2 seconds and release.

(v) Switch off the fuel switch on the feeding side.

(vi) Wait for 5 seconds with the switch at OFF or until the fuel pressure warning light appears, then return the switch to its former position.

(b) If a fuel warning does not appear all fuel will be available to the live engine.

(c) If a fuel warning appears, it will not be known if the fuel on the non-feeding side will be available to the live engine. Before attempting to feed the fuel, reduce height to 10,000 feet or below and switch off the feeding side just before it empties.

4. Failure of the hydraulic system

(a) *Services system failure*

(i) Failure of the services system will be indicated either by failure of a service to operate or, when Mod. 1802 or 1809 is incorporated, by the services system pressure gauge reading zero. If the reading on the gauge falls below zero into the white sector of the gauge, an electrical fault at the gauge is the cause. The services listed below will be inoperative following services system hydraulic failure. Where indicated, accumulator pressure may be available :—

Undercarriage normal system
Flaps
Airbrakes
G.W. and R.P.

Canopy operation	Accumulator pressure may be available. (Brakes, check brake pressure gauge).
Nose-wheel centring and anti-shimmy	
Feel simulator	
Autostabilisers and auto-pilot	
Brakes	

(ii) After services system failure carry out the following actions :—

Return to base and set up approach for flapless landing
Use emergency system to lower undercarriage
Increase threshold speed by 10 knots
Stream brake parachute and close HP cocks immediately on touch-down
Apply continuous pressure without maxaretting in one application of wheel brakes
Do not taxy.

NOTE :—The landing should be made at an airfield with a long runway (minimum 7,500 ft.) equipped with a safety barrier.

(b) *Controls system failure*

(i) Failure of one of the controls systems is indicated by a HYD. 1 or HYD. 2 warning appearing on the A.W.P. No noticeable effect will be felt on the flying controls except for a slight reduction in the maximum operating rate of the ailerons. Immediately the failure is apparent :—

Reduce speed if practicable
Do not exceed 2G
Return to base and land
Carry out a normal approach and landing.

If the failure is in the No. 1 controls system, the emergency undercarriage system will be inoperative ; accumulator pressure may be available for streaming the brake parachute, but it should not be relied on.

(ii) Failure of both controls systems will be indicated by a HYD. 1 and a HYD. 2 warning on the A.W.P. and by a HYD warning on the S.W.P. If the failure is due to double-engine flame-out, immediately increase speed if necessary to 0.9M or 250 knots so that the windmilling engines can supplement the controls system accumulator supply. Limit control operation to a minimum and relight an engine as soon as possible. If the failure is not due to double-flame-out or if the engines cannot be relit, abandon the aircraft.

5. Undercarriage emergency operation

(a) The following actions are to be taken if the undercarriage fails to unlock or lock down. A fuel state of 800 lb./side should allow sufficient time to carry out the drill.

(b) Check the serviceability of the services hydraulic system at once by operating the airbrakes and then leaving them in.

(c) *Undercarriage fails to unlock—All u/c lights out*

If several selections are unsuccessful, select undercarriage emergency down whether the services system is serviceable or not. If the undercarriage still fails to unlock it is recommended that the aircraft is abandoned.

(d) *Undercarriage unlocks but fails to lock down—One or more u/c red lights*

If the services system is unserviceable, use emergency down immediately. If the services system is serviceable, proceed as follows :—

(i) Try reselection.

(ii) Ascertain from the control tower or another aircraft the position of the undercarriage legs.

(iii) If an undercarriage leg is within 20° approximately of fully down yaw the aircraft for periods of at least 20 seconds favourable to that leg (i.e. yaw to starboard to lock port leg) increasing speed into the range 270-280 knots. In this speed band the maximum benefit of yaw is obtained. If the leg has stopped at a higher position, use roll first and then yaw.

(iv) If still unsuccessful, select emergency down.

(e) *Use of emergency selection*

(i) Before using the emergency selector, maintain level or climbing flight with minimum use of the control column at 180 knots. The No. 1 engine should be running at the highest practicable power commensurate with configuration and speed, and at least at 70% RPM, until the undercarriage is locked down.

(ii) If the emergency system fails to lock the undercarriage down proceed as in (d) (ii) and (d) (iii) above.

6. Hydraulic feel failure

Failure of the hydraulic feel is indicated by marked lightening of the stick and rudder forces. The spring forces remaining after hydraulic failure will be adequate at low speeds but low at high I.A.S./mach number, and gentle maneouvres only should be undertaken. Speed should be reduced to below 400 knots. If the feel failure is caused by pitot failure, malfunction of the flight instruments will also be apparent.

7. Trimmer malfunction

(a) If the tailplane or the rudder trimmers fail to function control forces may be relieved, if necessary, by switching off the hydraulic feel. If the tailplane trimmer has stuck in a nose-down trim position, the hydraulic feel should, in any case, be switched off during the approach and landing.

WARNING :— When flying with the feel switched off, control forces are light and care must be taken not to exceed the airframe limitations ; speed should not normally exceed 400 knots.

(b) If the aileron trimmer fails the stick forces can be easily held even if the trimmer has failed at the extreme end of its travel.

8. Action in the event of autostabiliser/auto-pilot malfunction

If a malfunction occurs to the autostabilisers or the auto-pilot, immediately :—

(a) Correct the aircraft response by control application. If it is an oscillatory malfunction, do not chase it.

(b) Switch off the auto-pilot SUPPLIES switch, anticipating a change of trim in the tailplane channel.

(c) Re-trim the aircraft.

(d) Disengage the auto-pilot and switch off the autostabiliser switches.

(e) Leave the auto-pilot switched off for the duration of the flight.

NOTE : If it is necessary, for investigation purposes, to switch on the auto-pilot after a malfunction, only the master SUPPLIES switch should be selected ON ; all other switches must be off. This should be done at a low I.A.S., well clear of the ground and other aircraft, anticipating a sharp trim change and possible recurrence of the malfunction.

(f) A summary of the effects of power supply failure are listed in the table 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 tail-plane 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 above
Services hydraulic power failure	Actuators are friction locked in the position pertaining when the accumulators exhaust.	As above

9. Ventral tank transfer failure

If fuel in the ventral tank fails to transfer, the aircraft C.G., will progressively move aft and may exceed the aft limit. Following the failure, gentle maneouvres only and turns up to 60° bank and 2G are permitted. Rolling maneouvres are not permitted. Additionally, if missiles are carried, reduce speed to 250 knots on descending below 35,000 feet. Land as soon as possible.

10. Ventral tank jettisoning

To jettison the ventral tank, carry out the following actions :

(a) Position over a safe area if possible.

(b) Reduce speed to 500 knots or below.

(c) Pull the ventral tank jettison handle.

NOTE : If 500 knots is exceeded during jettisoning violent nose-down pitching could exceed the negative G structural limits.

11. Missile jettisoning

(a) If possible, reduce to below the limits 300 knots/2G and below 5,000 ft.

(b) Position over a safe area if possible.

(c) Lift the safety catch on the ventral tank jettison handle and squeeze the exposed lever. *Do not pull the ventral tank jettison handle unless the tank also has to be jettisoned.*

12. Canopy jettisoning

(a) Reduce speed to 300 knots or below.

(b) Lower the seat.

(c) Keep the head down.

(d) Pull the canopy jettison handle to its fullest extent.

(e) If the canopy fails to jettison after pulling the normal canopy jettison handle, or after pulling the primary or secondary firing handles, operate the emergency canopy jack release lever and then pull up the normal canopy unlocking handle. If this is done after the ejection seat firing handle is pulled, the ejection seat will fire after a delay of one second.

13. Emergency use of oxygen

SYMPTOMS	ACTION
A—Inhalation difficult. Blinker inoperative or erratic.	1. Check regulator pressure gauge (200—400 P.S.I.) 2. Select EMERGENCY on selector lever. If breathing is still restricted : 3. Pull emergency oxygen knob. 4. Descend to 10,000 ft. cockpit altitude or below and return to base. **N.B.** Exhaustion of the emergency oxygen is indicated by increased difficulty in breathing in. This can be relieved by setting the air-dilution lever to NORMAL or by disconnecting the oxygen mask when below 10,000 ft. cockpit altitude.
B—Blinker inoperative. Breathing unrestricted.	1. Select 100% OXYGEN. 2. Check mask connection. 3. Check P.E.C. connection. 4. Check regulator pressure gauge (200—400 P.S.I.). *If breathing still unrestricted* : Regulator is serviceable and delivering oxygen ; blinker *only* is U/S and sortie may be continued on 100% OXYGEN. *If breathing becomes restricted* : 5. Pull emergency oxygen knob. 6. Descend to 10,000 ft. cockpit altitude or below and return to base.
C—Toxic fumes or smoke in the cockpit.	1. Select 100% OXYGEN. 2. Move regulator selector lever to EMERGENCY. 3. If necessary to prevent leaks, move mask toggle to high pressure position.

14. Cockpit pressure failure

If a CPR warning appears on the S.W.P. :—

(a) Move mask toggle to the high pressure (down) position.

(b) Descend immediately to 30,000 feet cockpit altitude or below.

(c) Switch off A.I.

(d) Return to base at the lowest possible altitude commensurate with reaching destination with adequate fuel reserve.

(e) Use ram air as necessary for ventilation.

15. Excessive cockpit heating or cooling

If excessive overheating or overcooling occurs in the cockpit :—

(a) Select MANUAL on the temperature controller and hold at COOL or WARM as necessary for 10 to 15 seconds.

(b) If successful, leave at MANUAL.

(c) If the overheating or overcooling persists, proceed as for cockpit pressure failure and switch the CABIN AIR switch to OFF.

16. Smoke or mist in the cockpit

(a) If smoke is coming from the air diffusers select the CABIN AIR to OFF. If smoke is coming from another source select the ram air valve open. In both cases, proceed as for pressurisation failure. Select 100% OXYGEN and EMERGENCY at the oxygen regulator.

(b) If mist occurs in the cockpit select the DEMIST control to ALL ON. When the mist clears set to TOP ON or OFF.

PART IV

Chapter 3 ABANDONING AND EMERGENCY LANDING PROCEDURES

CONTENTS

1. Abandoning the aircraft

NOTE : The seat limitations are as follows :—

Minimum speed	90 knots
Minimum altitude	Ground level in level or climbing flight.

(a) *Controlled ejections*

(i) Reduce speed to 250 knots if possible.

(ii) Fly in straight and level or climbing flight if possible.

(iii) If above 40,000 ft. and circumstances permit, depressurise the cockpit before ejecting.

(iv) Pull the primary or secondary firing handle.

(b) *Action should the automatic system fail after ejection*

(i) Discard the face blind.

(ii) Pull the override D-ring to the full length of its travel to isolate the parachute auto-device.

(iii) Grasp the rip-cord handle.

(iv) Operate the manual separation lever on the port side of the seat pan and then fall out of the seat.

(v) When clear of the seat, pull the rip-cord handle.

(c) *Action should the ejection seat fail to eject*

(i) Pull the override D-ring to the full length of its travel to isolate the parachute auto-device.

(ii) Operate the manual separation lever on the port side of the seat pan and proceed as on an aircraft not fitted with an ejection seat. The emergency oxygen system will be disconnected when separation takes place.

(d) When the parachute has developed, disconnect the survival pack 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 on to land. If a partial pressure helmet is worn, remove it and throw it away whether landing in water or not, otherwise the parachute canopy cannot be seen. To do this easily, unplug the helmet hose first and then use the helmet emergency release.

2. Landing on an unprepared surface

(a) A crash landing will be a hazardous operation and the aircraft should always be abandoned if time and circumstances permit.

(b) If a crash landing is inevitable, it should be made with the undercarriage and flaps down and the airbrakes extended. Make a normal approach, jettisoning the canopy at a speed above 200 knots whilst the flaps are up. Lower the flaps on the final approach. When the wheels touch, stream the brake parachute and close the HP cocks.

3. Landing with the undercarriage in abnormal positions

(a) *Landing with a main wheel or wheels unlocked or with the undercarriage locked up*

A landing should not be attempted. Abandon the aircraft.

(b) *Landing with both main wheels locked down, but nose-wheel unlocked*

(i) Jettison the ventral tank and all jettisonable stores and on the final approach to land, at a speed above 200 knots and with flaps up, the canopy.

(ii) Select flaps if available

(iii) When the main wheels touch, stream the brake parachute, holding a nose-high attitude for maximum aerodynamic braking.

(iv) Shut the HP cocks.

(v) Lower the nose on to the runway before tailplane control is lost.

(vi) Apply the brakes to keep straight.

(vii) If a barrier is in use on the runway have it in the lowered position.

4. Landing with a burst tyre

To be issued by amendment.

5. Landing into a barrier

To be issued by amendment.

6. Landing with asymmetric flaps

A landing with asymmetric flaps is not recommended. A flapless landing should be made.

7. Ditching

To be issued by amendment.

PART VI—ILLUSTRATIONS

PART VI — ILLUSTRATIONS

Key to Fig. A

1. Ram air valve control.
2. Demist control.
3. Canopy control handle.
4. I.L.S. master switch.
5. Throttle servo control.
6. Rudder trim switch.
7. Relight pushbuttons.
8. A.I. hand controller.
9. Emergency canopy jack release lever.
10. Fire extinguisher indicator switches.
11. Idling stop release lever.
12. Standard warning panel.
13. S.W.P. cancel button.
14. S.W.P. mute button.
15. S.W.P. test button.
16. Audio warning mute switch.
17. Feel selector switch.
18. Undercarriage selector switch.
19. Press-to-transmit switch.
20. Airbrakes selector switch.
21. Reheat/fast idling stop release lever.
22. Flap position indicator.
23. Ventral tank/missile jettison handle.
24. I.L.S. control unit.
25. Undercarriage emergency lowering lever.
26. I.L.S. volume control.
27. V.H.F. control panel.
28. Canopy jettison handle.

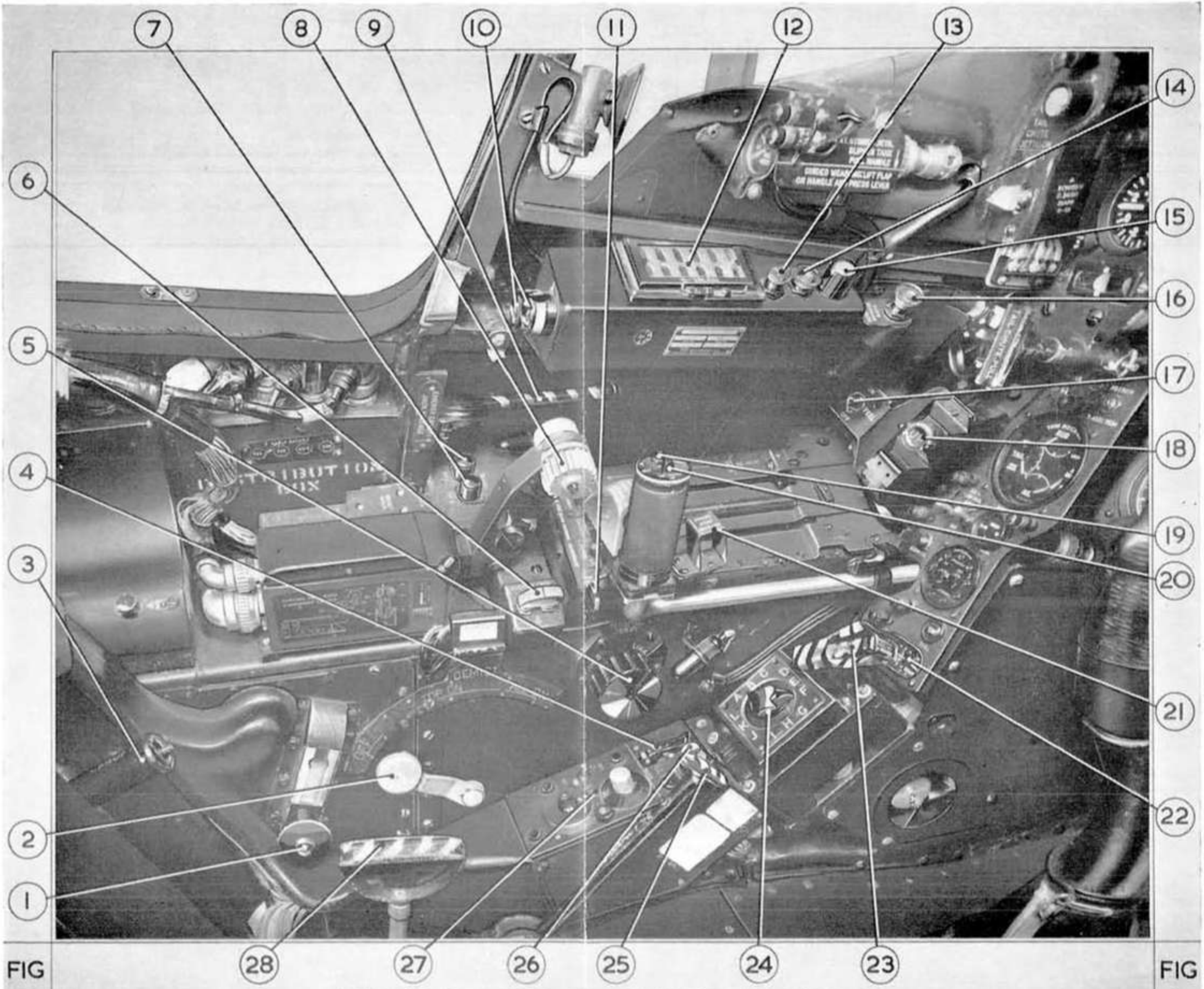


FIG A

LIGHTNING F. MK. I. COCKPIT—PORT SIDE

FIG A

Key to Fig. B

1. Feel indicator.
2. Undercarriage position indicator.
3. Auto-pilot trim indicator.
4. J.P.T. control switches.
5. Trim and airbrakes position indicator.
6. Standby inverter indicator.
7. Brake parachute stream handle.
8. Slip indicator.
9. Services hydraulic pressure gauge.
10. High intensity anti-dazzle lamps switch.
11. Accelerometer.
12. Brake parachute jettison pushbutton.
13. Remote oxygen flow indicator.
14. Attention light.
15. Flap selector switch.
16. Standby artificial horizon normal/emergency switch.
17. M.R.G. normal/fast erection switch.
18. Standby artificial horizon.
19. Standby altimeter.
20. Air speed indicator.
21. Attitude indicator.
22. Mk. 5 FT compass indicator.
23. G.W. armed time indicator.
24. Gun purging light.
25. G.W. armed time light.
26. V.H.F. channel indicators.
27. R.P.M. gauges.
28. J.P.T. gauges.
29. Fuel contents gauges.
30. Oxygen contents gauge.
31. Ventral tank flow indicator.
32. I.L.S. marker light.
33. I.L.S. indicator.
34. Emergency lights switch.
35. Tacan indicator.
36. Rudder bar adjusting handle.
37. Aileron/tailplane trim switch.
38. Camera switch.
39. Oxygen regulator.
40. Press-to-transmit switch.
41. Auto-pilot engage switch.
42. Main altimeter.
43. Machmeter.

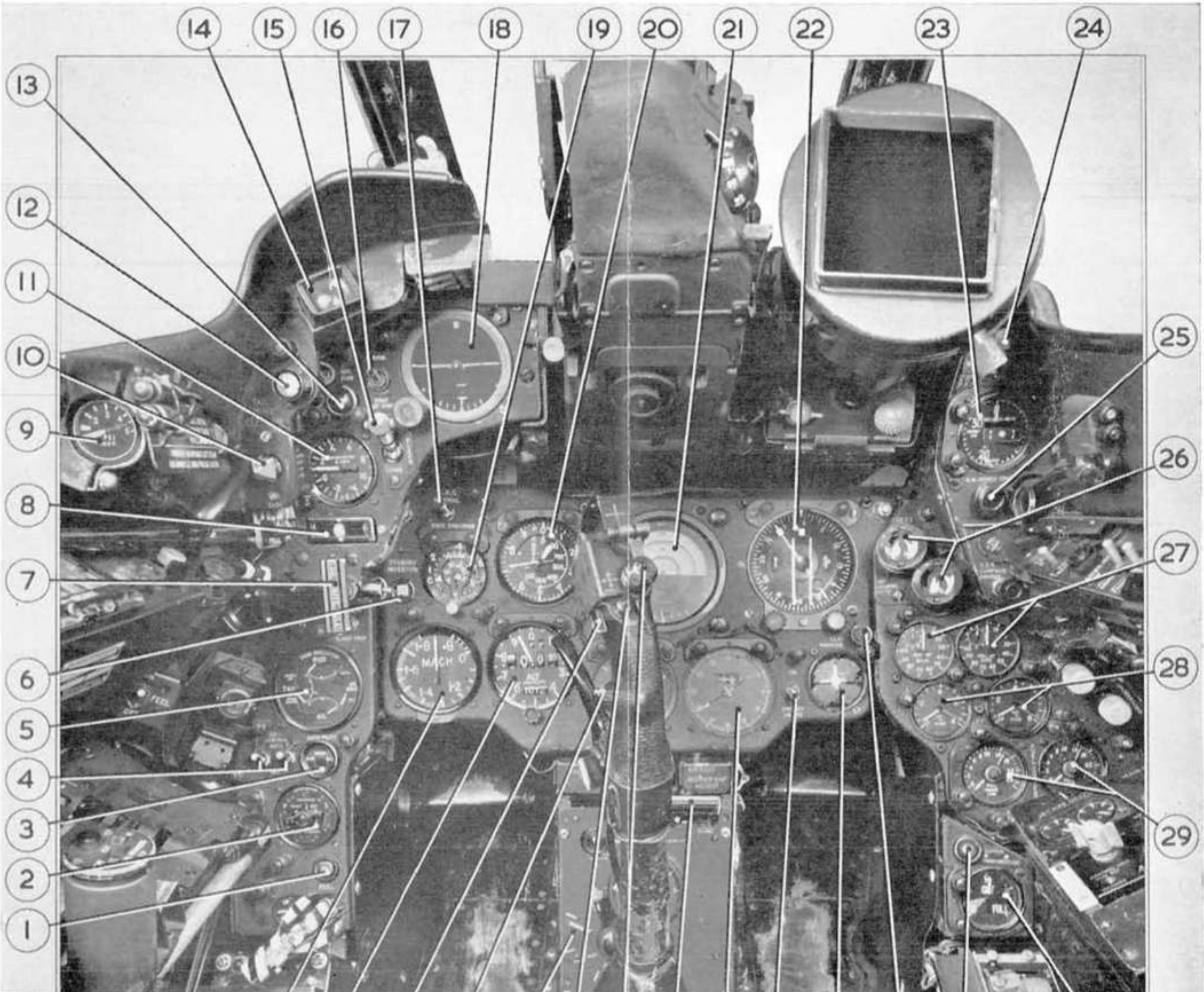


FIG B LIGHTNING F. MK. I. COCKPIT – FORWARD VIEW FIG B

Key to Fig. C

1. Main panel lights dimmer switch.
2. Navigation lights switch.
3. Port and starboard cockpit lights dimmer switches.
4. E.2.B. compass light dimmer switch.
5. R.B. doors unlocked light.
6. R.B. doors emergency retract switch.
7. G.W. arming indicator light.
8. G.W. arming switch.
9. G.W. pairs/single selector switch.
10. A.W.P. test pushbutton.
11. G.90 camera iris switch.
12. Auxiliary warning panel.
13. G.90 camera master switch.
14. Engine anti-icing indicator.
15. Engine anti-icing switch.
16. A.W.P. day/night switch.
17. G.W. fire control reset pushbutton.
18. Vent valve and pitot heater switch.
19. Side windscreen heater switch.
20. Front windscreen heater switch.
21. Standby inverter manual selector switch.
22. Engine start master switch.
23. Ignition switches.
24. Engine start pushbuttons.
25. Battery switch.
26. Cabin air switch.
27. Instrument master switch.
28. Cabin altimeter.
29. Anti-G H/L selector switch.
30. Brake pressure gauge.
31. Anti-G test button.
32. Cockpit temperature selector.
33. Anti-G stop valve selector.
34. Fuel pumps/cocks switches.
35. Telebriefing indicator switch.
36. A.V.S. flow control selector.
37. Auto-pilot controller.
38. Master armament selector switch.
39. P.A.S. camera recorder switch unit.
40. Tacan control unit.
41. I.F.F. control unit.
42. Taxy lights switch.
43. Jet pipe nozzle indicators.

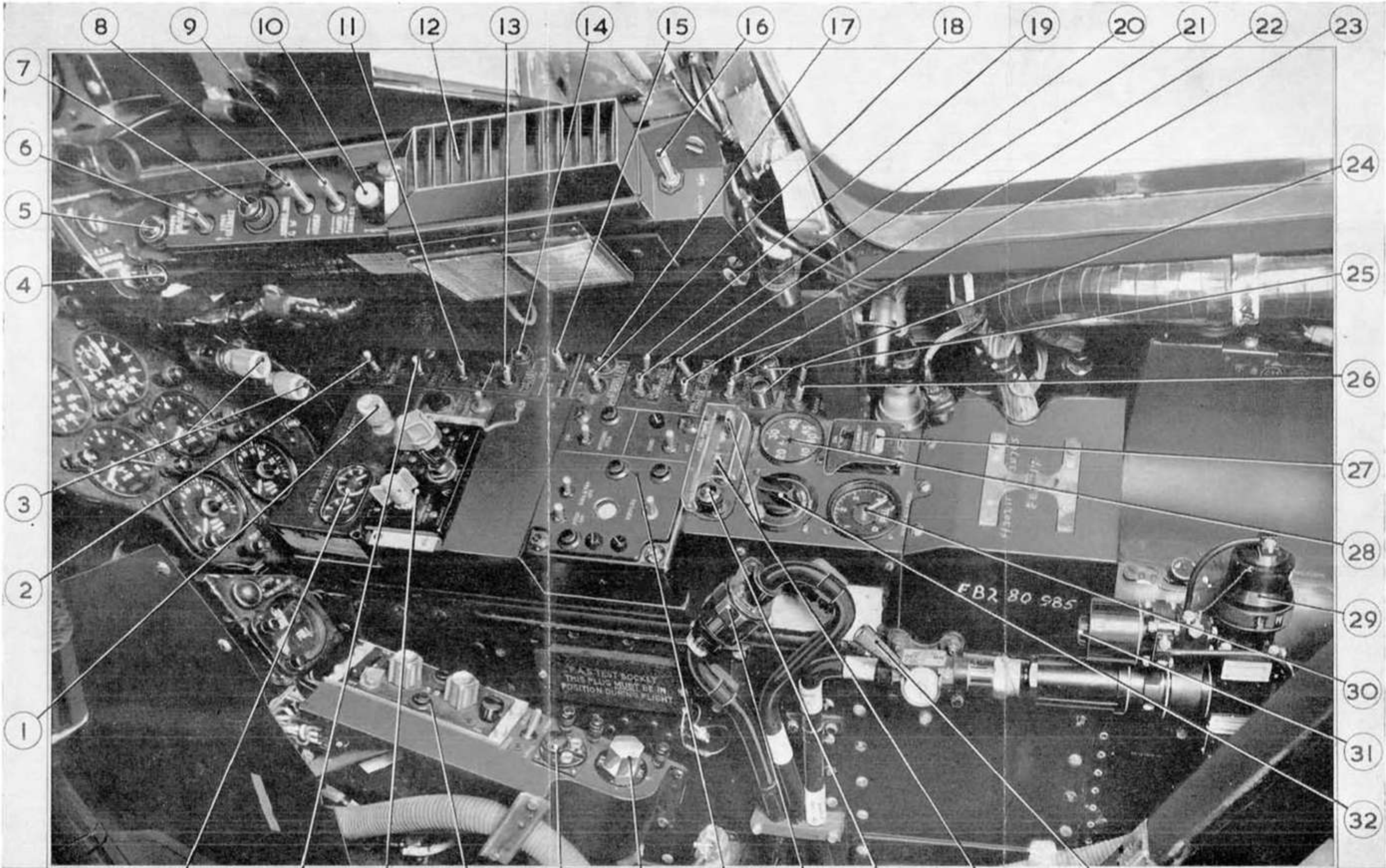


FIG C

LIGHTNING F. MK. I. COCKPIT — STARBOARD SIDE

FIG C

Key to Fig. D

1. Canopy control handle.
2. Demist control.
3. Rudder trim switch.
4. Flight refuelling control panel.
5. Flight refuelling lights test switch.
6. Relight pushbuttons.
7. A.I. hand controller.
8. Emergency canopy jack release lever.
9. Fire extinguisher indicator switches.
10. Idling stop release lever.
11. Throttle servo control.
12. Standard warning panel.
13. S.W.P. cancel button.
14. S.W.P. mute button.
15. S.W.P. test button.
16. Audio warning mute switch.
17. Feel selector switch.
18. Undercarriage selector switch.
19. J.P.T. control switches.
20. Press-to-transmit switch.
21. Undercarriage position indicator.
22. Reheat/fast idling stop release lever.
23. Feel indicator.
24. Flap position indicator.
25. Airbrakes selector switch.
26. Ventral tank/missile jettison handle.
27. Tacan aerial selector switch.
28. I.L.S. master switch.
29. I.L.S. volume control.
30. Tacan control unit.
31. Undercarriage emergency lowering lever.
32. I.L.S. control unit.
33. Canopy jettison handle.
34. Ram air valve control.

FIG D

LIGHTNING F. MK. IA. COCKPIT – PORT SIDE

Key to Fig. E

1. Auto-pilot engage switch.
2. Main altimeter.
3. Auto-pilot trim indicator.
4. Machmeter.
5. Trim and airbrakes position indicator.
6. Brake parachute stream handle.
7. Standby inverter indicator.
8. Slip indicator.
9. High intensity anti-dazzle lamps switch.
10. Accelerometer.
11. Brake parachute jettison pushbutton.
12. Flap selector switch.
13. Remote oxygen flow indicator.
14. Attention light.
15. Standby artificial horizon normal/emergency switch.
16. M.R.G. normal/fast erection switch.
17. Standby altimeter.
18. Standby artificial horizon.
19. Air speed indicator.
20. Pilot attack sight.
21. Aileron/tailplane trim switch.
22. Attitude indicator.
23. Mk. 5FT compass indicator.
24. Canopy unlocked warning lights.
25. E.2.B. compass.
26. A.I. display unit.
27. Gun purging light.
28. G.W. armed time indicator.
29. G.W. armed time light.
30. E.2.B. compass light dimmer switches.
31. R.P.M. gauges.
32. J.P.T. gauges.
33. Fuel contents gauges.
34. Oxygen contents gauge.
35. Ventral tank flow indicator.
36. I.L.S. marker light.
37. I.L.S. indicator.
38. Emergency lights switch.
39. Tacan indicator.
40. U.H.F. control panel.
41. Press-to-transmit switch.
42. Camera switch.

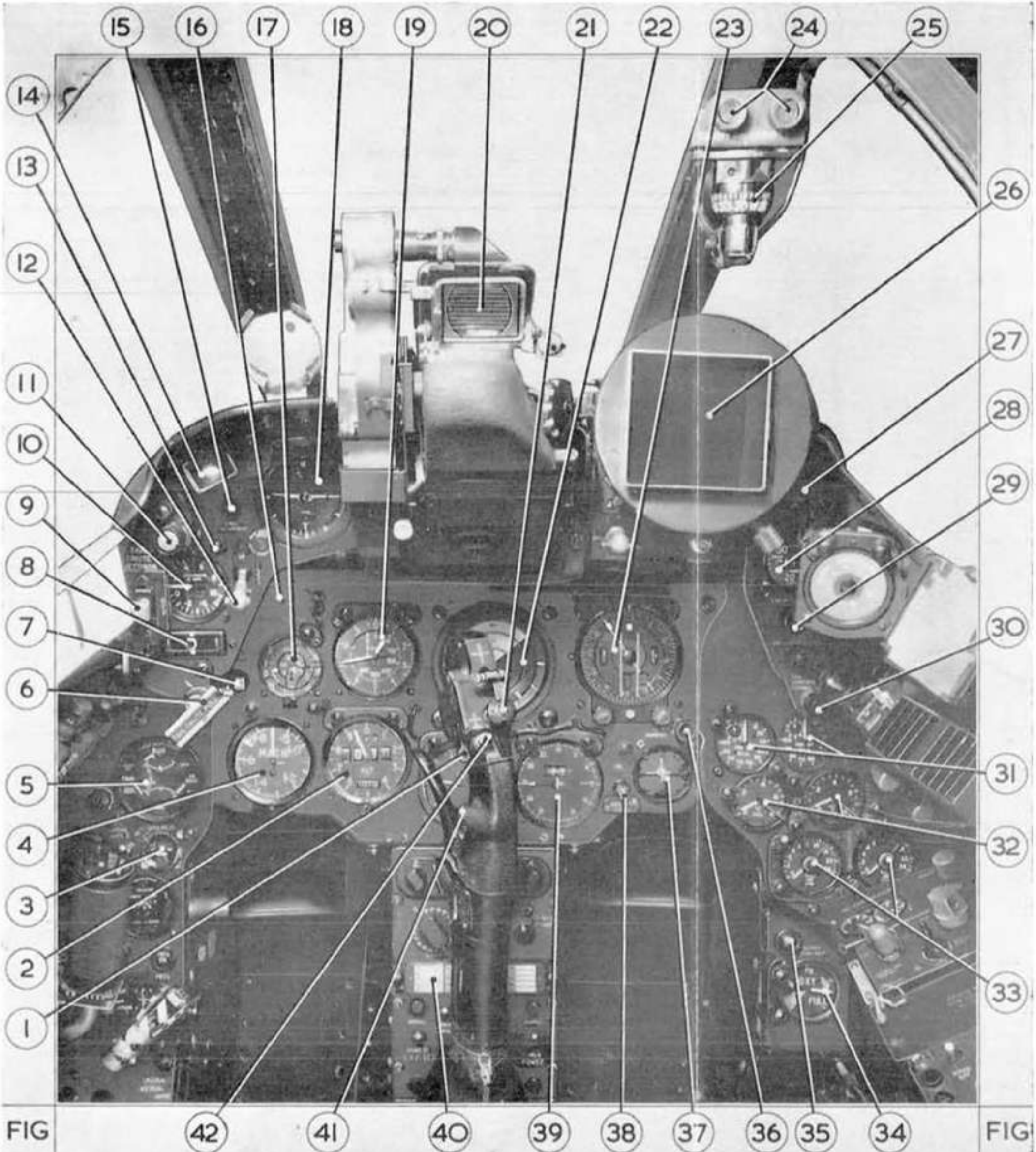


FIG E

LIGHTNING F. MK. IA. COCKPIT - FORWARD VIEW

FIG E

Key to Fig. F

1. I.F.F. control unit.
2. Jet pipe nozzle indicators.
3. Main panel lights dimmer switch.
4. Port and starboard cockpit lights dimmer switches
5. R.B. doors emergency retract switch.
6. R.B. doors unlocked light.
7. G.W. arming indicator light.
8. Navigation lights switch.
9. G.W. arming switch.
10. Voltmeter.
11. G.W. pairs/single selector switch.
12. A.W.P. test pushbutton.
13. Taxi lights switch.
14. G.90 camera iris switch.
15. Auxiliary warning panel.
16. G.90 camera master switch.
17. Engine anti-icing indicator.
18. Ice warning indicator.
19. Engine anti-icing/rain dispersal switch.
20. Vent valve and pitot heater switch.
21. G.W. fire control reset pushbutton.
22. A.W.P. day/night switch.
23. Side windscreen heater switch.
24. Front windscreen heater switch.
25. Standby inverter manual selector switch.
26. Engine start master switch.
27. Ignition switches.
28. Engine start pushbuttons.
29. Battery switch.
30. Cabin air switch.
31. Instrument master switch.
32. Cabin altimeter.
33. Anti-G test button.
34. Brake pressure gauge.
35. Anti-G stop valve selector.
36. Cockpit temperature selector.
37. Telebriefing indicator switch.
38. A.V.S. flow control selector.
39. Fuel pumps/cocks switches.
40. Master armament selector switch.
41. P.A.S. camera recorder switch unit.
42. Auto-pilot controller.
43. Oxygen regulator.

FIG F

LIGHTNING F. MK. IA. COCKPIT—STARBOARD SIDE

FIG F