PART I

DESCRIPTION AND MANAGEMENT OF SYSTEMS

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PART I—DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 1—ELECTRICAL SYSTEMS

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Description and Controls

1 Electrical supplies general description

(*a*) *AC supplies*

(i) The primary electrical power supplies are 200v, 3-phase AC at 400 c/s, provided hy two generators, one on each engine. Normally each supply channel feeds a separate 200v busbar but provision is made for linking both channels. Warning of generator failure is given on the SWP (Standard Warning Panel).

(ii) A 115v AC supply is ohtained from a step-down transformer supplied from the starboard 200v channel. A magnetic indicator gives warning of 115v supply failure.

(*b*) *DC supplies*

(i) The normal DC power supplies are ohtained from two 4·5 KW transformer-rectifier units (TRU) each supplied from one cbannel of the 200v AC system. The output of each transformer-rectifier unit (28v nominal) is supplied to tbe DC normal husbar. From this busbar, fused supplies are fed to secondary busbars. Warning of douhle TRU failure is given on tbe SWP, and a voltmeter indicates the voltage at the busbar.

(ii) A limited 22·8v supply is provided by a battery connected to the normal husbar and, although a battery switch is provided, certain circuits are supplied direct from the battery busbar. Provision is also made for connecting a 28v ground supply.

(iii) An additional 22·8v battery is provided for emergency use. There is no control of this battery other than by the individual circuit switches. There is no interconnection between the normal and emergency husbars.

2 Electrical supplies controls and indicators

Control or indicator	*Location*	*Markings*
200V. AC supplies		
Generator control switches (two) ...	Port control panel ...	PORT & STBD GENERATORS—ON/OFF/RESET
Generator failure warnings (two) ...	SWP	GEN. P. & GEN. S
Busbars-connected magnetic indicator	Stbd. switch panel ...	AC BUS-TIE
115V AC supply		
Supply failure magnetic indicator	Instrument panel ...	115 VOLTS AC FAILURE
DC supplies		
Voltmeter	Stbd. switch panel ...	DC
Double TRU failure warning	SWP	DC
TRU test switch ...	Stbd. switch panel ...	DC TEST
Battery switch ...	Port control panel ...	BATTERY MASTER—ON/OFF

3 200 Volt AC supplies

(*a*) Each generator is driven from the HP compressor and comes on-line automatically as its respective engine is started; it comes off-line when the engine is shut down. To ensure that the generators have a stahilised output, they have a constant-speed drive. When each engine and associated generating equipment is operating normally, the 200v channels are entirely separate. If one generator fails, it is taken off-line and the main husbars of hoth channels are automatically paralleled hy the bus-tie contactor, so that the demands of hoth channels are met hy the serviceahle generator. If a fault occurs on the main hushars of one channel, the generator serving the faulty channel is locked off-line and the hus-tie contactor remains open, until the engine is shut down. Generator failure is indicated by the appropriate GEN P or GEN S warning on the SWP. The AC BUS-TIE magnetic indicator shows a vertical white bar when the contacts are open (bushars not paralleled), a horizontal white har when the contacts are closed (busbars paralleled), and cross-hatched when the system is off.

(*b*) The generators are regulated and controlled via their respective control and protection units. Pilot control is hy operating the generator switches on the port control panel. The switches are locked in the ON position hy a clip which is pulled to unlock, and are spring-returned to OFF from the RESET position.

4 115 Volt AC supply

For certain equipment, notably the IFIS, a 115v, 3-phase AC supply is required. This is obtained from the starboard 200v AC channel through a step-down transformer. Two of the three phases are taken to twelve-way fuse hlocks; the third phase is earthed. The failure magnetic indicator, operated hy a torque switch, is incorporated in the circuit and shows hlack when the supply is availahle and cross-hatched when there is no supply.

5 External AC supply

A 200v, 3-phase AC supply from an external source can be connected through a plug on the port side of the aircraft. The external supply and the generators are interlocked so that the latter cannot be brought on-line if the external supply is already connected. Similarly the external supply cannot be brought on-line if a generator is already on-line.

6 AC distribution

(*a*) *200V, 3-phase*

AC from each generator is fed to its associated busbar assembly through a contactor. Each assembly is in the accessories and radio bays and comprises three groups of fuses; one phase of the respective generator output is connected to each group. The bus-tie contactor automatically interconnects the busbar assemblies in the event of generator failure or engine shut-down, but not if a fault occurs on one busbar.

(*b*) *115V, 3-phase*

The distribution of the 115V AC supply is from two twelve-way fuse blocks and an earth bar located in the AC distribution box R–A in the radio bay.

7 DC distribution

DC from each TRU is fed to a single busbar which supplies fused secondary busbars in the two cockpits and in the radio bay. Supply failure at the main busbar is indicated on the SWP.

8 TRU test switch

The TRU test switch, when set ON, prevents the AC bus-tie contactor closing when a generator switch is selected OFF, tbus allowing the output of each TRU to be tested separately. With the engines running, the battery master switch OFF and the TEST switch ON, each TRU can be tested by switching OFF eacb generator switch, in turn, and noting that the voltmeter reads 28 volts and that the DC light on the SWP remains out.

9 Main battery

(*a*) A nickel-cadmium 22·8V, 15 ampere/hr. battery is connected to the normal busbar through a contactor controlled by the battery on/off switch. Located in the radio bay, the battery helps to stabilise the busbar under normal conditions and, in emergency, gives the pilot time to change the services over to tbe emergency supply.

(*b*) Certain circuits are supplied direct from the battery busbar; these are listed in para. 18.

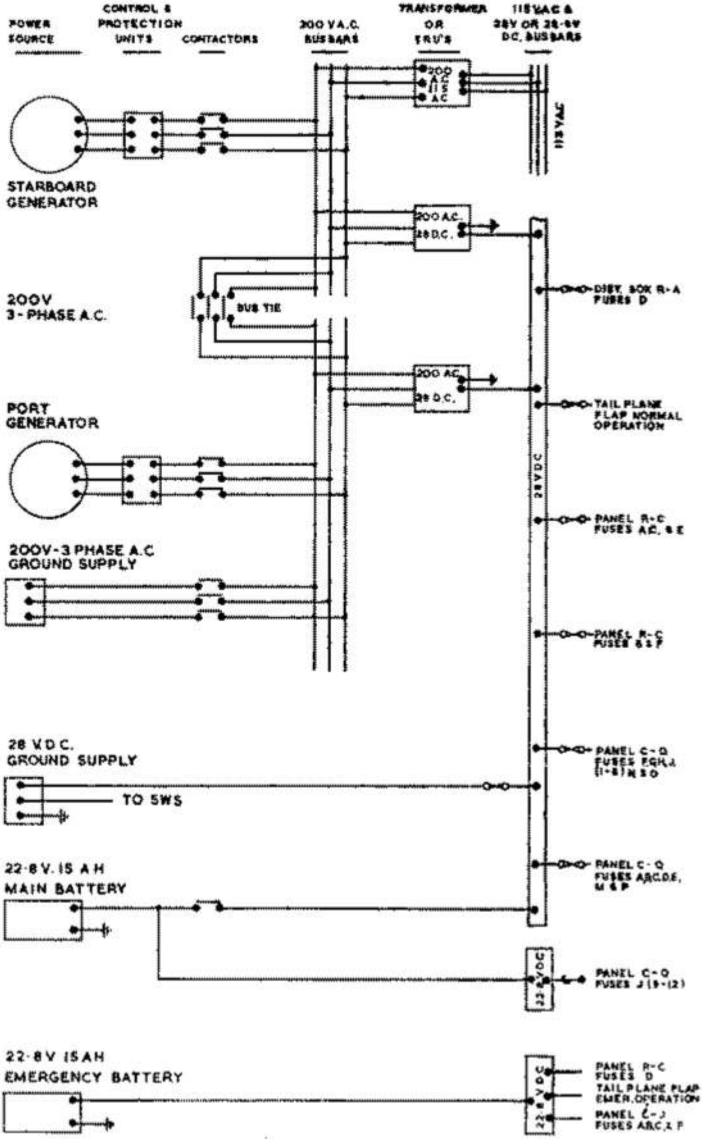

Fig. A—Electrical supply and distribution

10 Emergency battery

An emergency DC supply is available from a 22·8V, 15 ampere/hr. nickel-cadmium battery in the radio bay. The battery supplies two fuse panels, one in the pilot's cockpit and the other in the radio bay. Refer to para. 17 for the circuits supplied by this battery.

11 External DC supply

A 28V DC supply from an external source can be connected through a three-pin plug on the port side of the aircraft, forward of the bomb bay. A third pin of the plug completes the circuit to the mute relay of the standard warning system, thereby cancelling all indications on the SWP, except fire-warning and wing-fold.

12 Circuit protection relays

(*a*) Relays whose contacts are in various circuits are energised by microswitches when the port and starboard oleos extend on take-off. They remain energised until landing, although the undercarriage is shortened for retraction, by a supply switched through the undercarriage 'locked-down' microswitches. The relays, when energised:

1. Prevent movement of the wing-fold selector lever by de-energising the locking solenoid.
2. Energise the nosewheel automatic centring circuit.
3. Energise the undercarriage 'up' button locking solenoid, allowing an up selection to be made.
4. Allow full, instead of reduced, voltage to be available to the windscreen heater elements.
5. Permit the transfer of fuel from overload tanks if fitted.
6. Switch off ground cooling of jet pipe and CSDU oil.
7. By-pass the engine anti-icing selection switch, where upon the engine anti-icing magnetic indicator indicates for both engines irrespective of switch selection.
8. ◀Prepare stores fuzing, release and jettison circuits.▶

(*b*) Setting a key in a GROUND TEST microswitch in the starboard wheel bay and turning it to TEST simulates the operation of the circuit protection relays, for ground test purposes.

Normal Operation

13 Management of the electrical system

(*a*) *Before starting*

Ensure that an external 200V AC supply is connected. Switch on the battery master switch and the generator control switches; check that the GEN lights are showing and then cancel the standard warning system. Check that the 115v, AC failure magnetic indicator shows black, and that the bus-tie magnetic indicator shows a horizontal white bar.

NOTE: If the aircraft battery voltage is to be checked, it must be done by switching on the battery switch before any external supply is connected.

(*b*) *After starting*

When both engines are running and the external power supplies are disconnected, check that the GEN P and S lights are out and that the 115v, AC failure magnetic indicator remains black. If a GEN warning is on, operate the appropriate reset switch. With both engines running, the bus-tie indicator should change to show a vertical white bar (contactor open) immediately the external power supply is disconnected; if this does not occur, generator failure may be indicated.

Malfunctioning

14 Single generator failure

If one generator fails, the busbar contactor automatically closes to parallel the 200v busbars of both channels; the combined loads of both channels are then supplied by the remaining generator.

15 Double generator failure

(*a*) If both generators fail, all AC is lost and the main DC supplies are from the main battery. Shed all non-essential loads quickly and monitor the voltmeter.

(*b*) The main battery fails at approx. 19 volts. The emergency battery should, if fully charged, last at least 30 minutes; this life can be prolonged by restricting the use of those circuits which require a heavy current.

16 TRU failure

(*a*) If one TRU fails it is unlikely to be noticed. If both TRUs fail the DC warning is given on the SWP; the voltmeter then indicates main battery voltage. If circumstances permit, the battery master switch should be selected off until all unnecessary DC services have been switched off.

When the switch is set on again, all AC services are available while the main battery lasts, i.e. down to approx. 19 volts.

(*b*) If the main battery fails, both TGT reset relays are de-energised and the TGT controllers reset to the high datum; both TGT's must then be manually controlled to the lower datum figure. If the blow DC supply switch is then set to EMGY, the starboard TGT reset relay is energised and the starboard TGT controller is reset to the low datum, leaving only the port engine TGT to be manually controlled. Subsequent selection of blow, by drooping the ailerons, de-energises the starboard TGT reset relay, therefore both TGT controllers are then set to the high datum.

17 Circuits supplied from the emergency battery busbar

Panel C-J, fuses A, B, C, & F, on pilot's starboard wall. Panel R-C fuses D, in radio bay.
Services, other than those marked with an asterisk, are normally supplied from the main busbar.

Fuses	*Service*
A1, A3, D8	Mainplane flaps
A5	Aileron droop and tailplane flap
B1, B2, B10	Undercarriage (less tail bumper)
A6, A12	Arrester hook
A11, C8	Airbrakes
A10, C1	Bomb door
A9, B5	*GS system valves change-over and indicator
C6	BLC control
C11	*BLC pressure gauges (post-mod 961)
C7, F3	Fuel jettison (fuselage tanks)
A7	Fuel jettison (overload tanks)
A8	Cabin air conditioning and pressurisation
B11, B12	Cabin pressure failure warning (pre-mod. 1011)
C2, C3	Armament jettison
A4	Tailplane trim
B6	Pilot's instrument lighting
C4	Artificial horizon and DI
C5	Standby UHF
C9	*UHF auto-tone
F1	ADD (audio only from emergency supply)
◀F2	Cabin pressure failure warning (post-mod. 1011) ▶
D1	*Crash relays (fuse removed by STI BUCC/ 151B)

D2 *Fire protection (stbd engine)
D3 *Fire protection (port engine)
D4, D5, (D9 post-mod 899) *Fire protection (fuel and bomb bay)
D12 or C12 (post mod 1067) *Fire protection (wing tanks) (fuse removed by STI BUC/151B)

18 Circuits supplied from the main battery busbar

Panel C-Q, fuses J, on observer's rear bulkhead, port.

J9	Refuel/defuel/jettison test
J11	Battery contactor
◀ J10, J12	Canopy operation and control ▶

19 Circuits normally supplied from the 28 volt DC busbar

Services marked with an asterisk also require 200V AC. Services marked with a dagger also require 115V AC.

FLYING CONTROLS AND INSTRUMENTS

Flying controls, pumps failure on SWP
Integration valves
BLC controls, indicators
Rudder, aileron and tailplane trim
†IFIS
*IFIS lighting
†Standby gyro instruments
ADD (normal operation)
OAT indicator
◀Tailplane flap selection, operation and indication ▶

HYDRAULIC SERVICES

◀Undercarriage, selection, indication and warning
Flaps, Aileron droop, Bomb door, Airbrakes, Arrester hook — Selection and indication ▶
GS system pump failure MI's
GS system, normal control
Nosewheel steering
Wheelbrakes anti-skid
◀Wingfold and wing and nose fold operation and warnings ▶

FUEL SYSTEM

Fuel proportioners, controls and MI's
Inter-tank transfer valves

Cross-feed cock operation and MI
FNA valves, control
Overload fuel transfer
†Explosion suppression, main tanks (fuse removed by STI BUCC/151B)
Tank pressurisation failure
◀Fuel pressure warning ▶

AUTOPILOT SYSTEM

*†Autopilot and autostabilisers
*Yaw damper

RADIO AND RADAR

*Main UHF and homer
Standby UHF (normal operation)
*HF
*Radio altimeter
*Tacan
*Wide-band homer
*IFF
CASS unit
*Blue Jacket
◀*Blue Parrot
Voice recorder (mod 1258) ▶

WEAPONS AND PHOTOGRAPHIC

*Attack system
†Weapon protective relays
Armament selection, release and normal jettison
VT fuzing
*Bullpup and RP's
Camera installation
*Camera crate blower/heater
◀†Rate of pitch indicator (mod 1162) ▶

LIGHTING

Downward identification light
Formation, rendezvous and nav. lights
Instrument and floodlighting
Radio and accessories bay
In-flight refuelling
Refuel/defuel
*Fuel flowmeter
Fuel pressure warning

ENGINE SERVICES

LP compressors rotation light
Engine starting, relighting and auto-relighting

Fuel pressure MI's
Oil pressure MI's
Fuel filter ice warning MI's
Engine intakes anti-icing control and MI
Ice detector
*Thrustmeter
Engine overheat warning

MISCELLANEOUS ITEMS

Circuit protection relays
SWS operation and test
TRU failure
Oxygen contents and flow MI's
Canopy ▶◀ lock indication
Cabin air conditioning controls
*Cabin and radio bay air intakes anti-icing
*Windscreen heating
Windscreen rain clearance control
Pressure heads heating
Radio bay overheat protection
Miscellaneous temperature indicator
Outside air temperature indicator
115V AC indicator
Ejection seats
Circuit protection relays
GEN failures on SWP
115V AC failure MI
DC power failure on SWP and voltmeter
Airspeed contactor/fatigue meter

20 Circuits supplied from the AC busbars

Fuses for these circuits are in the accessories bay and radio bay and are not therefore listed individually.

200V, AC (PORT)

Main UHF
HF cooling
Radio altimeter
*Windscreen wiper
Fuel contents indicators (Master)
*TGT control (Port)
Thrustmeter (DC is only required to achieve port selection)
IFIS lighting
Wide-band homer

Armament (Bullpup)
Windscreen heating
Port TRU
Ice detector (post-mod 630)
Yaw damper (post-mod 1216)

200V, AC (STBD)

IFF
HF
Tacan
Blue Jacket
*Windscreen wiper
Fuel contents (slave)
Windscreen heating
*TGT control (stbd)
Flowmeter
Autopilot
Starboard TRU
Camera blowers
Bomb distributor
◀Weapons system and recorder ▶
Strike sight
Blue Parrot
Cabin and radio bay intake anti-icing
Yaw damper (pre-mod 1216)
Air to air refuelling pod
200/115v transformer

115V AC

Weapons protective relay units
Artificial horizon and DI (DC is only required for emergency operation)
IFIS
Fire detection
Explosion suppression (DC is only required for reset)
◀Rate of pitch indicator (mod 1162) ▶
†Autopilot

*Services, other than those marked with an asterisk also require DC

†Also requires 200v AC

21 Load shedding table

(*a*) Standard loads on the DC busbbars, which cannot be switched off:

	Busbars (Amps)	
	Normal	*Emergency*
Normal conditions	12·5 plus	nil

In emergency conditions the following loads are transferred to the emergency busbar:

General services hydraulic system on emergency	4·0 amps
Blowing system on emergency	4·4 amps

(*b*) Loads under the control of the aircrew.

	DC busbars (amps)		AC busbars (v. amps)		
			200v		
	Normal	Emergy	Port	Stbd	115v
Cabin/Radio bay intakes anti-icing				2000	
Cameras	60·0			1019	
Main UHF and homer					
Transmit	1·5		430		
Receive	1·1		275		
Autopilot/autostabilisers	13·0		150		
Pressure head heaters (including ADD probe)	12·8				
Blow control	11·2	or 4·0			
Bullpup	15·0				
HF					
Transmit	2·5			685	
Receive	1·8			104	
EL/EA fuzing	10·0				120
Tailplane flap operation	14·0	or 12·0			
Engine intake anti-icing	8·0				
Blue Parrot					
Transmit	8·0			2575	
Receive	8·0			2435	
Cockpit lighting	6·6				
Rendezvous light	6·0				
Engine relighting (each engine)	5·0				
EP fuzing	10·0				150
Standby UHF					
Transmit	1·5	or 1·5			
Receive	0·08	or 0·08			
Inter-tank transfer valves	3·0				
Radio altimeter	3·0		58		
Strike sight	3·0				
Ice detector (pre-mod. 630)	2·5				
Ice detector (post-mod. 630)	0·03		34		
Standby gyro instruments	0·1	or 2·6			
TGT control				50	

	DC busbars (amps)		AC busbars (v. amps)		
	Normal	Emergy	200v Port	200v Stbd	115v
IFF and SIF	2·0				
Navigation lights	2·0				
Aileron droop	1·2	or 0·6			
Rudder trim	1·3				
Tailplane trim	1·4	or 1·4			
Aileron trim	1·3				
Downward ident. lamp	1·2				
Wide-band homer	1·07		30		
Tacan	0·71			460	
Formation lights	0·7				
Attitude light	0·6				
Cross-feed cock	0·43				
Blue Jacket					
HT on				400	40
HT off				275	40
Airbrakes operation	0·4	or 0·75			
IFIS lighting			30		
Yaw damper				50	
Windscreen heating (high power)				1250	
Windscreen wipers			430	430	
Bomb door	0·8	or 2·2			
Stores jettison	2·0	or 2·0			
Fuel jettison		2·2			
Cabin pressurisation	2·7	or 2·3			
ADD	3·0	or 0·2			
Undercarriage	1·2	or 1·2			
Flaps	0·4	or 0·3			

PART I—DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 2—STANDARD WARNING AND FIRE PROTECTION SYSTEMS

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Standard warning system

1 General description

(*a*) The standard warning system provides visual and audible warning of an emergency, and visual warning of the particular service concerned. Warnings given are of excessive temperatures in the vicinity of the engines, fuel tanks, bomb bay or radio bay, or failure of the following services:—

Autopilot
Cabin pressurisation
Flying controls hydraulic systems
Generators
Wing and nose-fold locks
DC (TRU) failure

(*b*) Visual warning, in general, is by two attention warning lights, one each side of the pilot's instrument panel coaming, and a light in a cancel pushbutton on the standard warning panel (SWP). Visual warning, in particular, is by illumination of a service light on the SWP. Audio warning (fire-bell) is given through the mic/tel circuits. The attention warning circuit can be rendered inoperative by pulling out the mute (M) switch. A warning caused by a fault of short duration is automatically cancelled.

(*c*) When operating, the system is supplied from the relevant warning circuit(s) except for the test circuit which is supplied from the DC normal busbar.

2 Standard warning panel

The SWP, on the starboard console in the pilot's cockpit. contains the following service lights and switches:—

Service lights	*Services failed*
DC	DC supplies (both TRU's)
R. BAY	Radio bay cooling
C. PR	Cabin pressure
GEN P	Port generator
GEN S	Starboard generator
CON P	Powered flying controls, port
CON S	Powered flying controls, starboard
AP	Autopilot and autostabilisers
WF	Wing and nose-fold locks
FIRE P	Fire in port engine
FIRE S	Fire in starboard engine
FIRE F	Fire in fuel tanks bay
FIRE B	Fire in bomb or accessories bays

Switches	*Function*
T (test) pushbutton	For testing the whole warning system
M (mute) push-pull	Normally left in the pushed (on) position. When pulled, the audio warning and the attention warning facility is rendered inoperative. A light in the top of the switch is then illuminated.
C (cancel) pushbutton	For cancelling a warning, but does not extinguish the service light which remains on until the cause of warning is removed.

GT (ground test) pushbutton	For testing the warning system when a ground AC/DC supply is connected.
	NOTE: To avoid excessive lamp temperatures all warnings, other than fire and wing and nose-fold locks are automatically disconnected when a ground supply is connected, unless the battery master switch is ON.
Two F (fire) pushbuttons	One for the fire extinguisher system of each engine. A warning light is in the head of each pushbutton

3 Standard warning system, operation

Excessive temperatures in the vicinity of the engines, fuel tanks, radio bay or bomb bay, or failure of any service listed in para 2, cause a warning circuit to operate in the appropriate system. This connects DC to a flasher and excitation unit and the appropriate lights in the standard warning panel. The flasher and excitation unit provides a steady DC supply to the audio warning unit and an intermittent supply to the two attention warning lights and the cancel pushbutton.

Fire protection systems

4 General description

Three fire protection systems are provided, identical systems for each engine and one combined system for the fuel tanks, bomb bay and accessories bay. The systems detect and give warning of fire or high temperature round the engines or in the vicinity of the fuel tanks and bomb bay and provide for either manual extinguishing (engine bays) and automatic extinguishing of the fuel tanks, bomb and accessories bays. An independent system provides fire protection for the overload fuel tanks when fitted. The normal electrical requirements are AC from the 115V busbar and 24V DC from the emergency battery. For test purposes a supply from the DC busbar is available when the test button on the standard warning panel is pressed, but a 115V AC supply is still required.

5 Engine fire detection and warning

Each engine fire protection system incorporates a firewire sensing element comprising varying lengths of firewire which are joined together hy coupling units. The element is routed around the inner surface of the lower engine cowling door, around the auxiliary spar ring and then rearward ahout the inner nacelle structure. If anywhere along the firewire a critical temperature is reached it alters the impedance sufficiently to cause a flow of current large enough to energise a relay in the control box. This operates the standard warning system. The fire warning remains in force until the sensing element has cooled sufficiently to de-energise the relay.

6 Engine fire extinguishing

The two 6 lb hottles of methyl-bromide are on the rear face of the accessories hay dividing hulkhead. The single outlet of each bottle supplies a pipeline which is routed into the front compartment of the accessories hay and then through the bodyside into the appropriate engine hay. At this point the pipeline hranches two ways; from the upper hranch a spray pipe is routed upwards and then rearwards along the bodyside as far as the front spar ring; a spray pipe connected to the lower hranch extends rearwards to a point just forward of the auxiliary spar ring. The bottles are operated manually hy pressing the appropriate fire-extinguisher pushbutton, and automatically hy operation of any pair of the crashtrip element switches located in the extremities of the aircraft.

NOTE: The fire extinguisher is not to be used as a result of an engine overheat warning (Chapter 5).

7 Engine fire protection controls and indicators

(*a*) Two fire-extinguisher pushhuttons, one for the port engine and one for the starboard engine, are aft of the standard warning system panel. Each hutton incorporates a warning light. In addition, FIRE P and FIRE S warning lights are on the panel.

(*b*) The sensing elements and the warning system are tested when the standard warning test (T) pushhutton is pressed, providing 115V AC is availahle.

Fuel tanks and bomb bay

8 Fuel and bomb bay fire detection

Three sensing elements are provided; one is clipped to the spray pipes of the extinguisher system, one projects into the lower half of the bomb bay at the aft end and one is clipped to the accessories bay door. Each element is connected to a relay unit in the radio bay.

9 Fuel and bomb bay fire warning and extinguishing

If a current flows in any of the elements sufficient to energise its associated relay unit, it operates the standard warning system and gives the fuel bay or bomb bay fire warning as appropriate. Energising either relay also operates two 12 lb methyl-bromide fire extinguishers in the radio bay, one port and the other starboard, and a single 12 lb bottle in the front accessory bay. A spray pipe from each of the former bottles is carried along their respective sides of the bomb and accessories bays and the fuel tanks, and nine connections to each pipe carry the fluid upwards between the fuel tanks. The latter bottle discharges through two pipes, along each side of the accessory bays. The warning is cancelled when the elements have cooled sufficiently.

10 Fuel and bomb bay fire, controls and indicators

A FIRE F (fuel bay) and FIRE B (bomb bay) lights are on the SWP. The complete fire-detection and warning system is tested when the test pushbutton in the standard warning system is pressed. A relay in this circuit prevents operation of the fire extinguishers.

11 Overload fuel tanks fire

Explosion suppression of the overload fuel tanks is auto-◀matic by operation of the crashtrip switches (but see NOTE to para. 13). The extinguishing system cannot be▶ operated manually.

12 Explosion suppression, fuel tanks

(*a*) An explosion suppression system is incorporated in the fuselage tanks, although in peace-time the system is ◀rendered inoperative by removing the DC supply fuses.▶ The system utilises the time interval between commencement of a flame and development of an explosion, to fill the tank with a mixture of fuel and an extinguishing agent, thus preventing development of an explosion. Simply, each tank has two suppressor units, fitted with detonators which are fired on receipt of a signal from a photo-electric cell. The system is supplied with AC from the 115V busbar and DC from the normal busbar.

(*b*) When AC is first applied, a neon MAIN TANKS EXPLOSION SUPPRESSION—RESET indicator, on the pilot's starboard console, is illuminated. Pressing an adjacent PRESS TO RESET guarded pushbutton, resets the system and extinguishes the light. Eight indicator fuses, in the starboard wheelbay, show if the system has operated.

(*c*) The external tanks system is similar to that in the internal tanks, except that it is only operated by the crash relays. There are no indicators or controls in the cockpit but an indicator fuse is in the fairing of each tank.

Crash Switches

13 General description

◀NOTE: When STI/Buccaneer/151 is satisfied, this system is rendered inoperative by removing the DC supply fuses. ▶

Pairs of crashtrip elements are located one forward of the nosewheel, one each on the port and starboard wing tip fairing, and one aft of the bomb bay; all the switches are on the undersurfaces. Four elements, one in each pair, are wired in parallel to a crashtrip relay unit; the remaining elements, also wired in parallel, are connected to a second crashtrip relay unit. If both relay units are energised, they complete the circuits to energise two relays which:

1. Discharge the engine fire extinguishers
2. Discharge the fuel tanks and bomb-bay fire extinguishers
3. Isolate the generators and main battery from their respective busbars
4. Discharge the fire extinguishant contained in the suppressor units within each overload fuel tank, if fitted.

PART I—DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 3—HYDRAULIC SYSTEMS

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1 General description

(*a*) Two main hydraulic systems are fitted. One system is used to operate the flying controls and consists of two independent systems each operating its appropriate half of the twin jacks in the powered flying control units. The second main system, known as the General Services system, consists of two semi-independent systems which combine to power various services for both normal and emergency operation, and other services for normal operation only. Two fuel proportioners, however, are driven by their respective General Services systems before these become one.

(*b*) Provision is made for emergency operation of the flying controls by the General Services system through integration valves.

(*c*) A windscreen wiper has its own independent electro-hydraulic system.

2 Flying controls hydraulic systems

Each flying controls hydraulic system supplies hydraulic power for operation of its appropriate jack in the rudder, tailplane and aileron powered flying control units (PFCU). In addition, the starboard system also supplies the tailplane and rudder artificial feel units and the yaw damper actuator.

3 Flying controls systems components

(*a*) The port system is supplied by a pump on the port engine and the starboard system by a pump on the starboard engine; since both systems are similar, only one is described below.

(*b*) A pump draws fluid from a reservoir and delivers it to the system. When a pressure of 3,300 PSI is reached the pump is internally off-loaded and fluid is returned to the reservoir via a fuel-cooled heat exchanger. The reservoir is pressurised to 28 PSI by system pressure to ensure delivery under negative-G conditions; provision is also made for returning excess fluid to the general services system if an integration valve has been opened.

(*c*) An accumulator, incorporated in the system to act as a pulse damper, is charged with air to 2,000 PSI. In the delivery line from the pump there are tappings for a connection to a pressure gauge on the cockpit starboard wall, a pressure switch for operation of the SWS and a ground connection. An additional tapping and a non-return valve are provided for the integration valve.

4 General services hydraulic systems

The two hydraulic systems which form the General Services system each supply power for operation of a fuel proportioner. The systems then combine to form one system for normal and emergency operation of the undercarriage, arrester hook, flaps, airbrakes, bomb door and, for normal operation only, of the tailskid, wheelbrakes, nosewheel steering and wing fold.

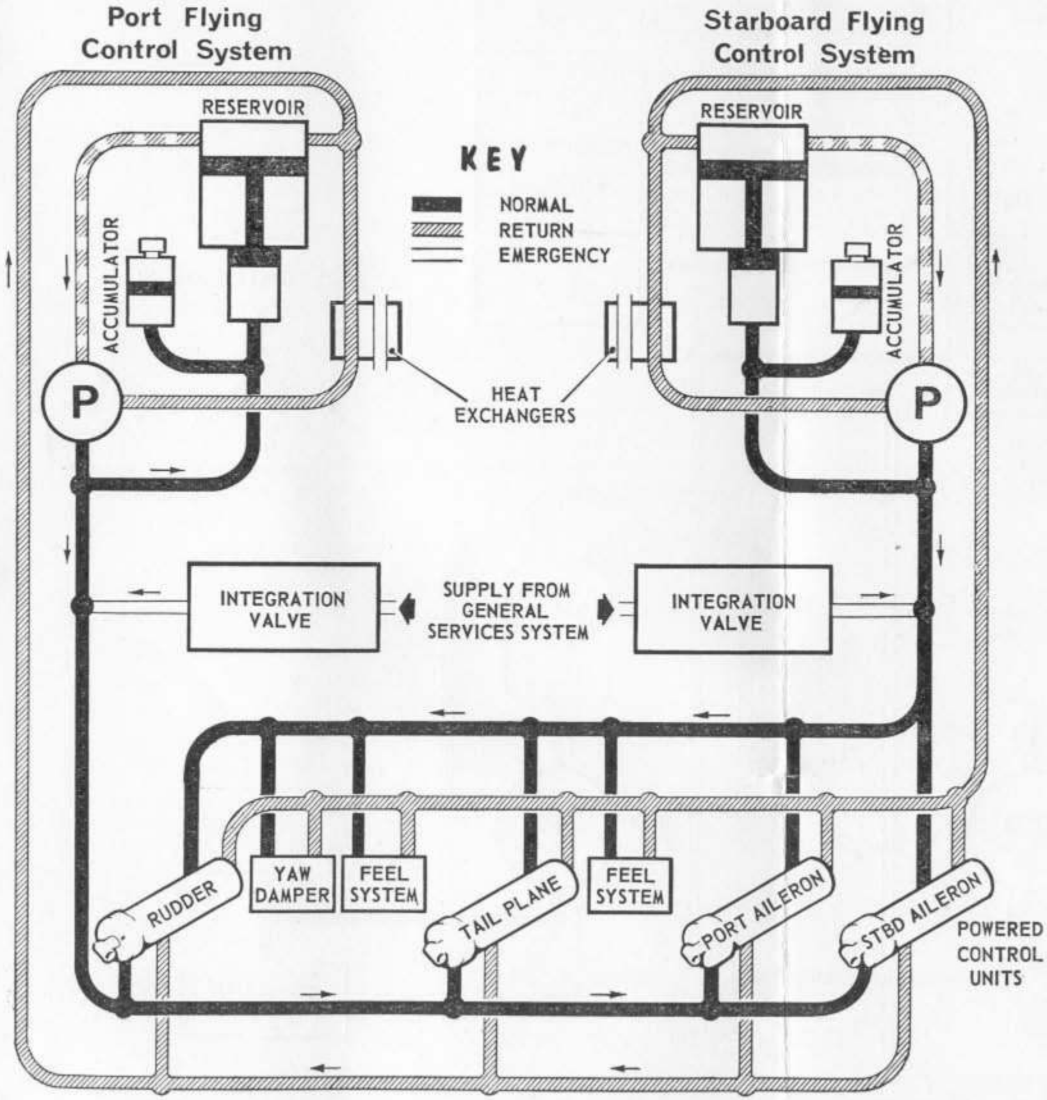

Fig. A—Flying controls hydraulic system

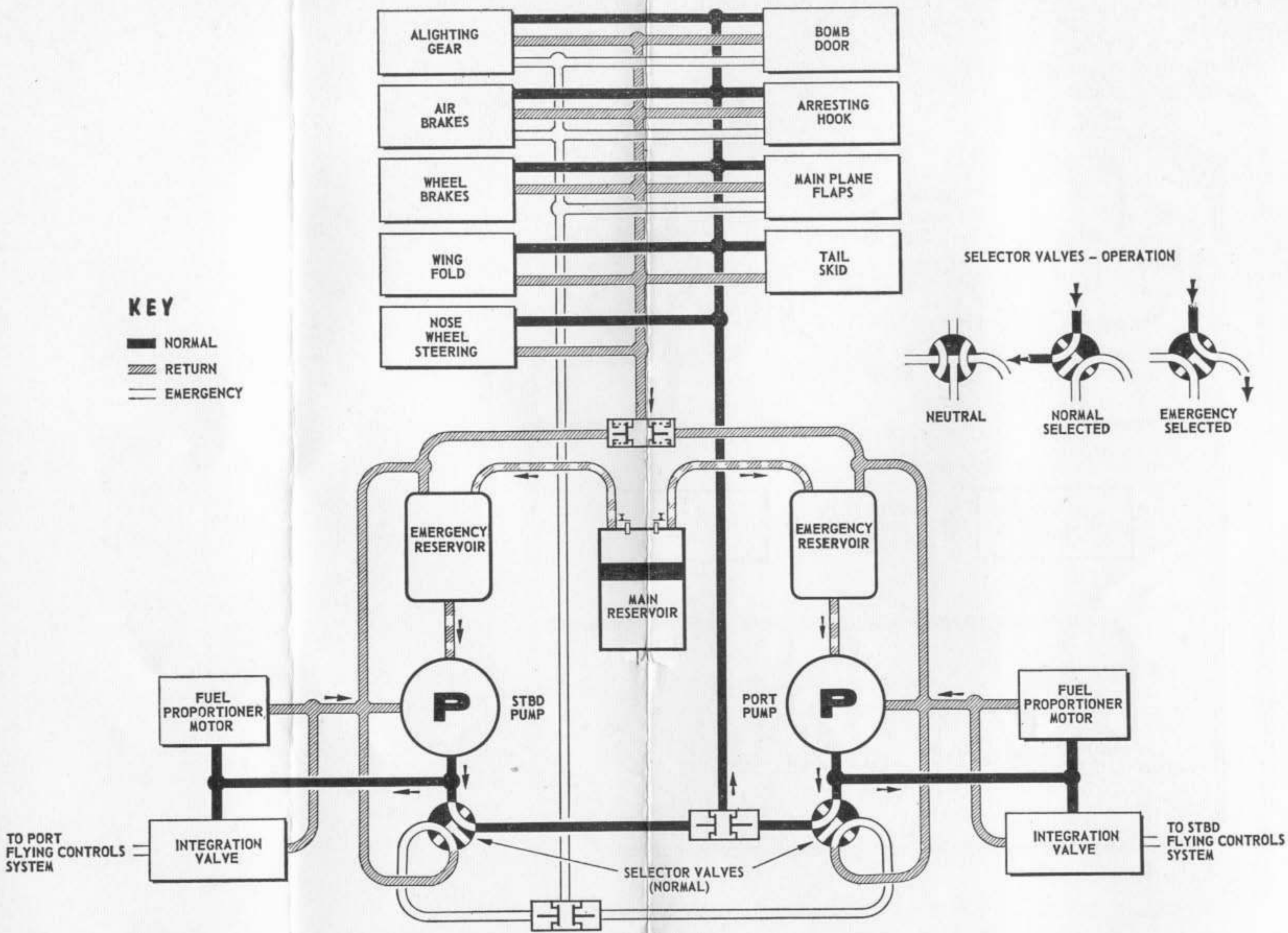

Fig. B—General services hydraulic system

5 General services systems components

(*a*) The port and starboard systems are supplied from pumps on the port and starboard engines respectively. The pumps draw fluid from separate emergency reservoirs and supply power to the system at 4,000 PSI. When this pressure is reached the pumps are internally off-loaded and fluid is returned to the reservoir via a heat-exchanger. The emergency reservoirs are themselves fed from a main reservoir which is pressurised by compressor air. A piston separates the air from the fluid and if, due to loss of fluid, this piston bottoms, it operates two microswitches in the control valves circuits.

(*b*) Each pump delivery line incorporates a filter through which the fluid passes before reaching its control valve. Between the filters and the control valves, tappings are taken which supply the fuel proportioners, flying controls integration valves and flow indicator (pump failure) transmitters.

(*c*) The control valves each have three positions, normal, neutral and emergency; operation of the valves is automatic, as described in para. 6. The system incorporates switches for controlling a 3-position magnetic indicator. Adjacent to each valve are two pressure indicators which indicate the position of the valve. When the valves are in the normal position, fluid is passed to a double non-return valve which combines the supplies to form a single power supply for normal operation of the general services; at the same time the emergency lines are connected to return. In the emergency position the valves pass fluid to another double non-return valve which combines the supplies to form a single power supply for emergency operation of certain of the General Services; the normal lines are connected to return. When the valves are in the neutral position each pump's delivery is returned to its own reservoir.

(*d*) The return lines from the services culminate in a flow-divider, comprising a double non-return valve, which divides the fluid, one half to each emergency reservoir. If integration has taken place, the return from the flying controls system is directed into the appropriate emergency reservoir.

6 Operation of the control valves

(*a*) Whenever DC from the normal busbar is available, the normal solenoids of the control valves are energised and the three-position magnetic indicator shows NORM. The supply to the valves is, however, routed through the micro-switches on the main reservoir and through the bomb-door safety switch so that, if the switch is set safe, or if sufficient fluid has been lost from the main reservoir, the DC supply is broken and the valves de-energised to their neutral position. The magnetic indicator then shows cross-hatched.

(*b*) If any of the General Services standby selectors are operated, they not only select the service but also supply DC from the emergency battery to energise the emergency solenoids of the control valves and de-energise the normal solenoids if the valves were at normal. The magnetic indicator then shows EMGY.

(*c*) The system remains on emergency after a standby selection until that selection is cancelled. Two exceptions, provided no other standby selection has been made, are:

1. When the airbrakes reach their fully-in position.
2. When the bomb door reaches its locked open or locked closed position.

7 Integration of the flying controls and general services systems

In an emergency the port and starboard flying controls systems can be separately supplied from the general services systems through the integration valves. The port general services system supplies the starboard flying controls system and the starboard general services system supplies the port flying controls system. The port valve is the valve connecting the starboard general services system to the port flying controls system.

WARNING 1: If loss of fluid causes a flying controls failure, opening the associated integration valve causes a loss of fluid in the general services system.

WARNING 2: If one flying controls system is operating satisfactorily an integration valve should not normally be opened except for landing. In the latter case it may be opened as a precaution against the good system's engine failure.

Controls and indicators

8 Flying controls system, controls and indicators

(*a*) There are no controls for normal operation of the flying controls hydraulic system. If system failure occurs, PORT and STBD, FLYING CONTROLS INTEGRATION VALVES—OPEN/CLOSE switches are provided on the standby switch panel (see para. 7).

(*b*) Two (PORT and STBD) FLYING CONTROL PRESSURE gauges are on the starboard wall.

(*c*) CON P or CON S warnings on the SWP give warning of system failure.

9 General services system, control and indicators

(*a*) Control of the general services system is fully automatic.

(*b*) Two HYDRAULIC GENERAL SERVICES, PORT and STBD magnetic indicators are on the starboard console; they show black when the flow from respective pumps is sufficient for effective operation of the system, and cross-hatched at other times.

(*c*) A three-position magnetic indicator, between the magnetic indicators in (*b*) above, shows the state of the general services system. When the control valves are in their normal position, the indicator shows NORM. If the valves move to the neutral position (para. 6 (*a*)), the magnetic indicator shows cross-hatched. If a standby selector is operated, the valves move to the emergency position (para. 6 (*b*)) and the indicator shows EMGY.

(*d*) Two pressure indicators, for use by the ground crew, are associated with each system control valve. The indicators take the form of a pin which protrudes from a housing if the valve is in the position it indicates (either normal or emergency). When both pins associated with one valve are retracted, the valve is in the neutral position.

Normal Operation

10 Before starting the engines

With the normal DC busbar energised, the general services three-position indicator shows NORM and the two-position magnetic indicators show cross-hatched, the CON P and CON S lights on the SWP are on and the flying controls system port and starboard pressure gauges read zero.

11 After starting the first engine

The appropriate flying controls system pressure gauge indicates the pump delivery pressure. The appropriate CON light goes out. The general services three-position indicator remains at NORM and the appropriate pump magnetic indicator turns black.

12 After starting the second engine

The appropriate pressure gauge indicates the delivery pressure of the second pump in the flying controls system, the appropriate CON light goes out and the appropriate two-position indicator in the general services system turns black.

13 Testing the systems

The flying controls system can be tested by functioning the controls, checking that the indications remain normal.

Malfunctioning

14 Flying controls single system failure

If one system fails, the appropriate pressure gauge shows zero pressure and the appropriate CON warning on the SWP comes on. The flying controls continue to operate satisfactorily, but possibly at a reduced rate. The integration valve should not be opened except for landing, and not then if it is suspected that fluid loss, as opposed to a pump failure, is the cause of failure, as the general services system will eventually lose all its fluid.

15 Flying controls double system failure

If both systems fail e.g., one system failure and the other engine failed, both pressure gauges show zero and both CON lights in the SWP come on. Set the INTEGRATION switch associated with the inoperative engine to OPEN, i.e., port engine stopped, set PORT switch OPEN; the port flying controls system is then operated by pressure from the starboard general services system. If the failure is due to leaks (such as splitting of a tandem jack) some of the flying controls may continue to function while fluid remains in the general services system.

16 General services system, single pump failure

If one pump fails, the appropriate magnetic indicator shows cross-hatched; the control valves remain at normal and the system continues to be supplied by the remaining pump. All the general services, except the fuel proportioner supplied by the failed pump (and one side of the flying controls system if the integration valve has been opened), continue to operate satisfactorily, although at a reduced rate.

17 General services system, double pump failure

If both pumps fail, the system is completely inoperative and the only hydraulically-operated services available are the flying controls.

18 Loss of fluid from the main reservoir

If the main reservoir empties, the piston bottoms and the control valves move to the neutral position and shut down the system, except for the fuel proportioners, which continue to operate until the respective emergency reservoir is empty, the three-position magnetic indicator shows cross-◀hatched. The system cannot be reverted to normal and all subsequent selections must be made using the standby controls. Fluid remaining in either emergency reservoir is sufficient to operate the following services: ▶

*Airbrakes	one complete cycle
*Bomb door	one complete cycle
Undercarriage	down only
Flaps	down only
Arrester hook	down only

◀NOTE 1: The wheelbrakes continue to operate until their accumulator is discharged. ▶

*If a flying control integration valve has been opened, the bomb door should not be operated and operation of the airbrakes must be restricted to one 'out' selection if it is required to operate the remainder of the emergency services.

~~NOTE 2: If, due to loss of fluid, the piston in the main reservoir has bottomed, causing the control valves to move to the neutral position (MI cross-hatched) the system cannot be reverted to normal.~~ AL 9

◀19 Failure of an individual service to operate

If an individual service fails to operate on normal selection, the standby control should be used. This operates a release valve for that selector, which prevents normal selection until it has been reset on the ground. When a standby selector is used, the GS hydraulic system remains on emergency until that selection is cancelled, except as shown in para. 6(*c*). If the aircraft is to be landed with the GS system on emergency, the undercarriage EM DOWN button must be pressed so that hydraulic pressure ensures that the undercarriage is safely locked down.

NOTE: If the GS system is on emergency because the undercarriage EM DOWN button has been used, the system can be reverted to normal by pressing the normal DOWN button. This leaves the undercarriage in an unsafe condition and should not normally be used on the ground. ▶

20 DC power failure

If the normal DC supply fails, the general services system selector valves move to the neutral position and the three-position magnetic indicator shows cross-hatched. It is not possible to tell if the failure is due to the reservoir piston bottoming (para 5(*a*)) or to fuse failure. The emergency services quoted in para. 18 should be used with discretion in order to preserve the emergency battery. If the emergency battery also fails, the general services system, except for the fuel proportioners, is completely inoperative.

PART I—DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 4—FUEL SYSTEM

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Description and Controls

1 Fuel system general description

(*a*) (i) Fuel in eight internal tanks, four for each engine, is fed by two hydraulically-operated proportioners to their respective engines, via the LP cocks. The tanks are pressurised by air from both engines, and two recuperators, one for each engine, provide a supply of fuel under negative-G conditions. To cater for various failures, two inter-tank transfer valves and a cross-feed cock can be opened so that one proportioner can draw fuel from all tanks and deliver it to both engines. Pressure refuelling/de-fuelling is employed; the control panel and hose coupling are on the starboard side of the nose. The tanks can also be gravity refuelled through filler caps at the top of each tank. Provision is also made for rapid defuelling using the proportioners. Setting ON a RAPID DEFUELLING switch on the fuel control panel, opens the forward jettison valves and an additional valve which connects the jettison gallery to the refuel-defuel gallery, to allow the proportioners to pump out fuel through the ground coupling. Provision is also made for air-to-air refuelling.

(ii) Two external tanks, one under each wing, can also be carried and provision is also made for installing a tank in the bomb bay.

(*b*) When required, the aircraft can be converted into an air to air refuelling tanker by the carriage of a flight refuelling pod, Mk. 20C or E, on a special pylon beneath the starboard inner wing (station 2).

(*c*) Provision is made for fire detection, for warning and suppression in the fuel tank bay and the bomb bay.

2 Fuel system controls and indicators

The following table shows the location and markings on all the fuel system controls and indicators except those peculiar to the air to air refuelling installation which is covered in Ch. 4A. The controls are on the pilot's starboard console unless otherwise stated.

Control or Indicator	*Markings*	*Location*
Normal operation		
LP cocks (two)	ENGINE MASTER COCK—ON/OFF (PORT & STBD)	At rear of pilot's port console
Fuselage tanks contents indicators (two banks)	FUSELAGE TANKS (PORT ENGINE & STBD ENGINE)	
Contents indicators supply change-over switch	FUEL IND SUPPLY—NORMAL/CHANGEOVER	
Recuperator check button	RECUPERATOR CHECK	

Control or Indicator	*Markings*	*Location*
Malfunctioning		
Proportioner failure magnetic indicators (two)	PROPORTIONER FAILURE (port and starboard)	
HP pump inlet pressure failure magnetic indicators (two)	PUMP INLET FUEL PRESSURE (PORT ENG & STBD ENG)	
Tank pressurisation failure magnetic indicator	FUEL TANK PRESS	
Cross-feed cock switch and magnetic indicator	CROSS-FEED COCK—CLOSE/OPEN	
Inter-tank transfer valves switch	FUSELAGE INTER TANK TRANSFER—ON/OFF	
Fuel/no-air valve switches (four)	FUEL NO AIR VALVES PORT ENGINE TANK 2—NORMAL/CLOSE TANK 6—NORMAL/CLOSE STBD ENGINE TANK 3—NORMAL/CLOSE TANK 5—NORMAL/CLOSE	
Overload tanks		
Tanks contents indicators (three)	PORT WING STBD WING BOMB BAY	Observer's auxiliary panel
Fuel transfer switches (two)	OVERLOAD TANKS FUEL TRANSFER WINGS—ON/OFF BOMB BAY—ON/OFF	Observer's auxiliary panel
Fuel jettisoning		
Fuselage tanks jettison control	FUEL JETTISON PULL AND TURN	
Overload tanks jettison switch	OVERLOAD TANKS FUEL JETTISON—ON/OFF	

3 Internal tanks

The eight internal tanks are integral with the upper half of the fuselage. The tanks are paired 1 & 3, 2 & 4, 5 & 7 and 6 & 8, the odd and even number tanks supplying the starboard and port engines respectively. Numbers 1, 4, 7 and 8 tanks are slave tanks, the contents of which are fed into their respective master tanks, through internal connections, under the influence of the pressurisation system. Each master tank has two fuel/no-air (FNA) shut-off valves in parallel, operated by General Services air and controlled by ◀their own float switch. Each pair of FNA valves is also controlled by a switch on the starboard console. ▶

4 Overload tanks

Provision is made for the installation of a bomb bay fuel tank and for the carriage of one slipper-type jettisonable wing tank under each inner plane. When fitted, the tanks are connected to the main systems in the bomb bay by transfer pipes. Fuel from the overload tanks is transferred to the main tanks under the influence of the pressurising system.

5 Fuel tank capacities

The capacities of the tanks are:—

Fuselage tanks	*Gallons*	*lb. (AVCAT)* SG.0·83	*lb. (AVTUR)* SG.0·8
No. 1	214*	1776	1712
No. 2	224	1859	1792
No. 3	174	1444	1392
No. 4	169	1403	1352
No. 5	191	1585	1528
No. 6	192	1594	1536
No. 7	193	1602	1544
No. 8	203	1685	1624
Total internal	1,560	12,948	12,480

*Does not include 10 gallons in the recuperators.

Overload tanks			
Bomb bay	440	3652	3520
Port wing	250	2075	2000
Stbd. wing	250	2075	2000
Total	2,500	20,750	20,000
Refuelling pod	140	1162	1120

Fig. A *overleaf*

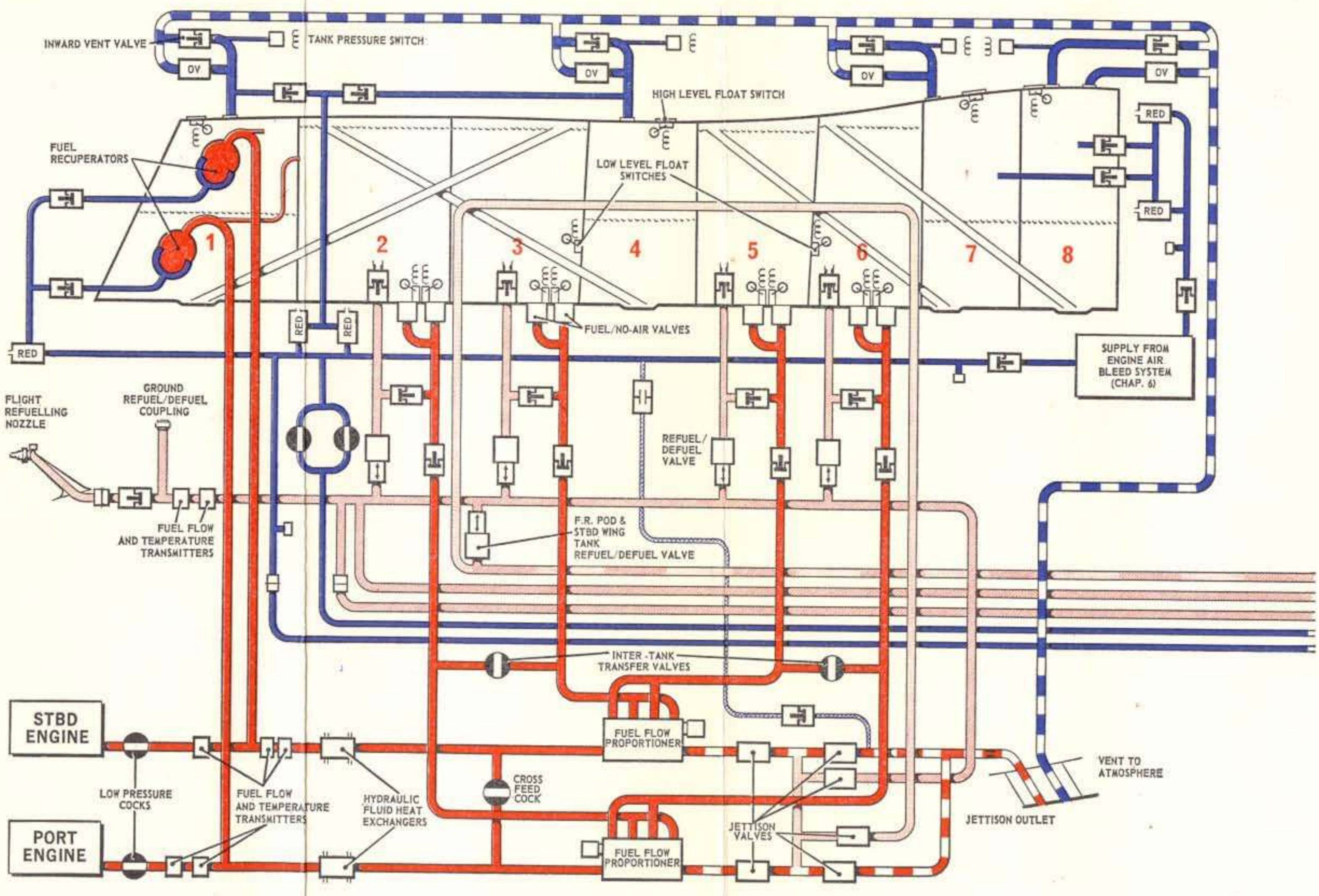

Fig. A—Fuel system—Part 1 (rapid defuelling valve mod 953 added)

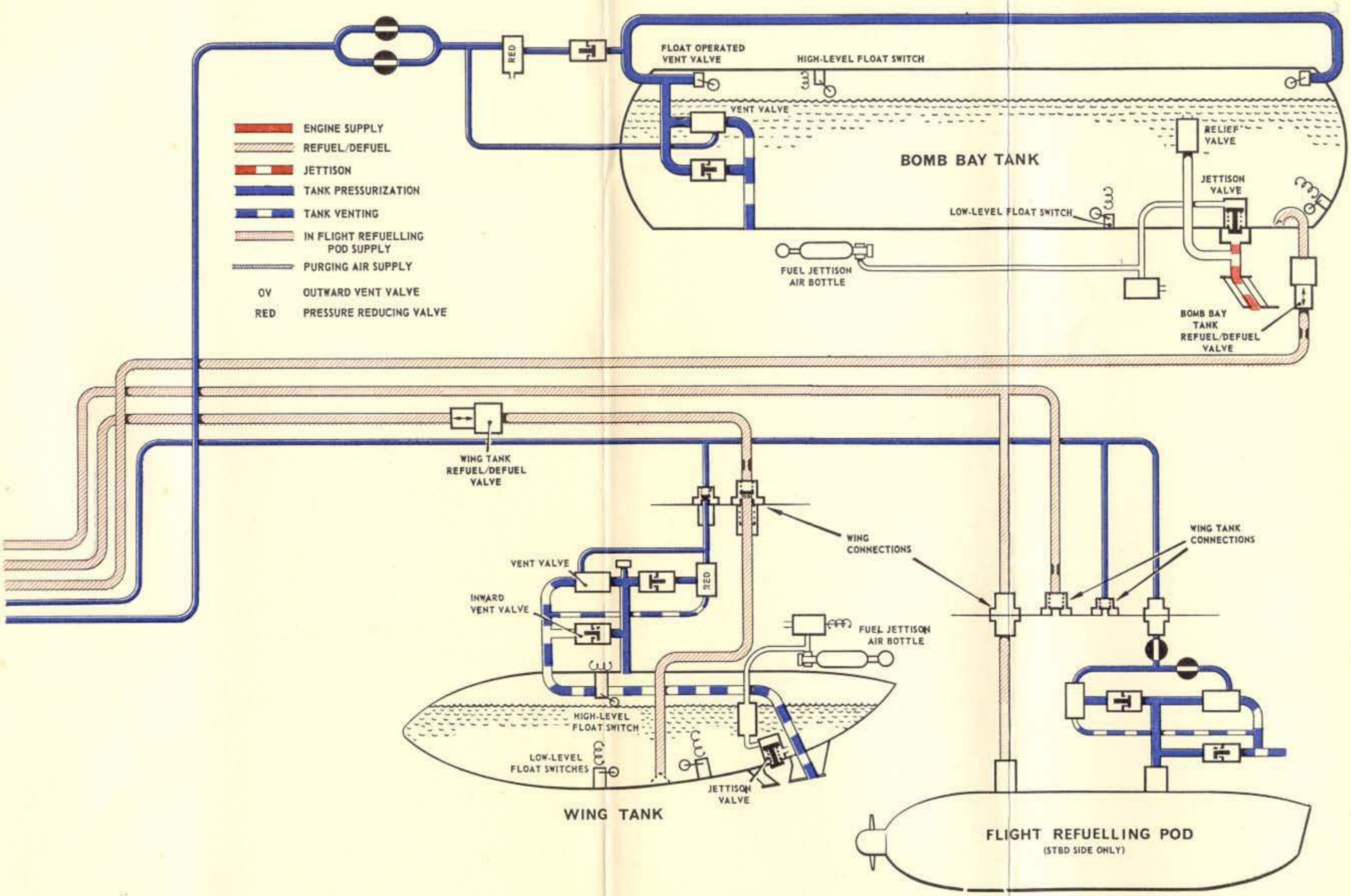

Fig. B—Fuel system—Part 2

6 Unusable fuel

(a) Fuselage tanks
Unusable fuel should be considered to be 300 lb. This is distributed between the four master tanks and allows for variations between aircraft and for gauge readability and accuracy. A tank should be considered to be empty if its gauge indicates 75 lb. or less.

(b) Wing tanks
In level flight between 20 and 56 lb. is unusable in each tank.

(c) Bomb bay tank
In level flight approximately 80 lb. is unusable.

7 Fuel tank pressurising and venting

(a) Pressurisation
Air from the engine air-bleed system (Chapter 6) is ducted, through non-return valves and pressure-reducing valves, to the slave tanks and the fuel recuperators. Pressurisation is controlled by the outward-vent valves (sub-para. (*b*)). Four pressure switches, one in the line to each pair of fuselage tanks, are wited in series to a magnetic indicator which shows black when all tanks are correctly pressurised. Pressurisation of the overload tanks is governed by shut-off valves, two for the wing tanks and two for the bomb bay tank, which are controlled by the OVERLOAD TANKS FUEL TRANSFER—ON/OFF switches at the observer's station.

(b) Venting
As all fuselage tanks are paired, only the slave tanks require venting. For outward venting, the line from each slave tank is connected to a common vent which terminates under the fuselage; four vent valves, one in each vent line, lift when the tank pressure rises to 7¾ PSI. The common vent line is also used for inward venting, the outward vent valves being by-passed in this case; outward venting through these by-pass pipes is prevented by non-return valves. To prevent fuel aeration after refuelling, a small bleed hole in each non-return valve allows the tanks to become depressurised when the aircraft is standing. This takes approximately 25 minutes. Venting of the overload tanks takes place through an independent system in each overload tank.

8 Overload fuel transfer

(*a*) During normal operation, fuel from the wing tanks and bomb bay tank is transferred to the main tanks via transfer pipes which feed into the refuel/defuel gallery. Fuel transfer is controlled by OVERLOAD TANKS FUEL TRANSFER WING and BOMB BAY—ON/OFF switches in the observer's cockpit. Selection of these switches to ON energises, to open, the overload tanks pressurisation valves, and prepares the refuel/defuel valves for fuel transfer. The switches should be returned to OFF when transfer is complete. They should also be off during flight refuelling, although this is done automatically when probe/drogue contact is made. To prevent the transfer of fuel when the aircraft is on the ground, the electrical circuits are linked to the circuit protection relays.

◀(*b*) *Ground testing*

To enable fuel transfer to be tested when on the ground, a FUEL TRANSFER TEST—NORMAL/TEST switch is provided in the starboard wheelbay ~~when mod. 1037 is embodied~~. Holding the switch to TEST opens the tanks transfer air pressure valves. ▶ AL 9

9 Fuel proportioners

The two hydraulically-operated fuel proportioners, one for each engine are supplied with power from the general services hydraulic system. Normally each proportioner draws fuel from two of the master tanks when its associated engine is running; the proportioner magnetic indicators show black. When negative G is experienced, two switches operate to close a shut-off valve in each hydraulic supply line and stop the proportioners, causing the magnetic indicators to change to cross-hatched. The proportioners automatically restart as soon as the negative-G switches open. The speed of a proportioner is normally controlled by the back-pressure of the fuel between the proportioner and the engine but, when fuel jettisoning is taking place, the maximum speed is restricted by a hydraulic flow control valve.

10 Fuel proportioner operation

(*a*) Each proportioner is divided into four separate metering cells, each containing a rotor driven by a common shaft. Two cells are fed from the same master tank and, as the width of a cell depends on the capacity of the tank by which it is fed, it follows that the flow from each tank is proportional to its capacity; balance is, therefore, maintained. A non-return valve in the outlet from each cell is normally open but, if proportioner failure occurs or if the engine is stopped, the valves close. However, additional valves in by-pass ducts open and allow unmetered fuel to pass into the supply line, providing a feed to the engine, but not at sufficient pressure to stop the recuperator from discharging.

(*b*) If a master tank becomes empty and the FNA valves fail to close, two cells in the affected proportioner will be receiving air only; the proportioner will not pass this to the engine*, but the other two cells will continue to pass fuel. If the inter-tank transfer valves are opened and a master tank becomes empty, both fuel and air will be supplied to two cells and these cells will pass a fuel and air mixture which may cause a flame-out of one or both engines.

*Except at very high fuel flows (above 320 lb./min. for 2-engine operation or 160 lb./min. for single-engine operation).

(*c*) If, with two associated master tanks empty, the cross-feed cock is opened, the dry proportioner will overspeed and can then pump sufficient air to affect both engines.

11 Fuel recuperators

(*a*) Two recuperators in No. 1 fuselage tank each supply one engine when its supply pressure falls below 20 PSI e.g. under negative-G conditions when the proportioner stops. Each recuperator contains approximately 5 gallons of fuel which is sufficient to allow for 10 seconds operation at full power. The recuperators are pressurised at 20 PSI by air from the engine air-bleed system. Air pressure acting on a diaphragm at the head of the recuperator also holds open the fuel inlet valve, allowing the bag to become charged with fuel by the proportioner. If the shell of the recuperator fractures, the air is released, thus closing the valve and preventing fuel entering the bag. If the bag punctures, a non-return valve in the air supply line prevents fuel entering that line and a restrictor in a pressure relief valve prevents excessive loss of fuel.

(*b*) When the recuperator check pushbutton on the starboard console is pressed, it has the same effect as negative-G stopping the proportioners; this allows recuperator discharge to be checked.

12 Flight under negative-G conditions

When negative-G is experienced, the proportioners are stopped and fuel transfer from the fuselage tanks ceases; the engines are then fed from their respective recuperators. These have a capacity sufficient for 10 seconds operation at maximum power. Application of negative-G operates the float switches of the fuel/no-air valves in the master tanks; these cause a solenoid to be energised which allows air pressure to close the valves, effectively cutting off the fuel supply to the proportioners. At the same time inverted flight switches energise the proportioners hydraulic supply shut-off valves to stop the proportioners. As the pressure in the fuel supply lines to the engines decreases, the air pressure in the recuperators discharges the fuel.

13 Fuel jettison

(*a*) *Fuselage tanks*

Fuel from all fuselage tanks can be jettisoned through a single outlet on the underside of the rear fuselage. Operating the FUEL JETTISON PULL AND TURN rotary switch energises two jettison valves in each line from the proportioners. The proportioners' maximum speed is limited by a flow control valve. Fuel jettisoning continues until the rotary switch is returned to its normal position, or until two low-level float switches, one each in No. 3 and 6 tanks, open, thus de-energising, to close, the jettison valves. In the latter case the rotary switch should be returned to the normal position after jettisoning ceases. The low-level float switches are so located that approximately 500 gall. (4,000 lb.) fuel remains in the tanks. A nozzle restrictor, positioned at the outlet on the under-surface of the rear fuselage, prevents fuel starvation at the engines during fuel jettisoning. Air pressure from the tank pressurisation system automatically purges the fuel jettison lines when the fuel jettison valves close.

(*b*) *Overload tanks*

Fuel from the wing tanks and bomb bay tank can be simultaneously jettisoned through valve-controlled outlets, on the undersurface of the rear portion of each wing tank and on the under-surface of the bomb door, respectively. The pneumatically-operated valves are selected electrically by operating an OVERLOAD TANKS FUEL JETTISON-ON/OFF switch, on the starboard console. The principle of operation is the same for each tank. Selecting the jettison switch to ON fires a detonator, shattering a frangible pillar assembly which is screwed into the neck of the fuel jettison air bottle. High pressure air then operates the jettison valve; at the same time a valve is energised to close an exhaust line from the air bottle. The valve remains open until all the fuel has been jettisoned. The jettison switch should then be selected to OFF to de-energise the electromatic tap which exhausts the residual air pressure to atmosphere and allows the jettison valve to close under spring pressure.

NOTE: If the tanks are unpressurised, i.e. the transfer switches are off, the jettison rate is reduced.

14 Wing tanks jettisoning

The wing tanks can be jettisoned by moving the jettison ◄selector switch, on the pilot's port console, (pre-mod 1188) to WINGS INNER and pressing the STORES JETTISON pushbutton, (post-mod 1188) to WINGS 1 or WINGS 2, as required, and pressing the STORES JETTISON pushbutton after each selection. ►

NOTE: The wing tanks can also be jettisoned with the jettison selector in the ALL position, but it must be remembered that this ◄action jettisons all stores including bomb door stores if the bomb door is open. ►

15 Fuel-flow and fuel-remaining indicators

(*a*) A fuel-flow indicator is on the starboard side of the instrument panel, in the pilot's cockpit. The adjacent fuel-remaining indicator is reset automatically during refuelling. It does not record fuel jettisoned or fuel transferred to the flight-refuelling pod. The indicators are controlled by three fuel-flow transmitters, one in each engine fuel supply line and one in the refuelling line. To correct for changes in density due to temperature variation, four temperature transmitters are fitted, two in the port supply line, one in the starboard line and one in the refuelling line. A manual fuel-density corrector is on the refuelling panel.

(*b*) The fuel-remaining indicator can be re-set by operating the pushbuttons under a flap below the instrument.

16 Fuel contents indicators

(*a*) *Fuselage tanks*

The fuel contents indicators are in two banks, each controlled by its own system. The forward bank indicators show the fuel in the slave tanks (4, 8, 1 and 7) and the rear bank the fuel in the master tanks (2, 6, 3 and 5). The systems automatically compensate for changes in fuel density and are operative whenever a 115v AC supply is being received. A FUEL IND SUPPLY—NORMAL/CHANGEOVER switch is used if one bank fails.

(*b*) *Overload tanks*

Three fuel contents indicators, one for each wing tank and one for the bomb bay tank, are on the auxiliary panel above the observers' port console.

17 Cross-feed cock and inter-tank transfer valves

(*a*) *Cross-feed cock*

The cross-feed cock, when open, interconnects the two engine supply lines downstream of the proportioners, allowing one proportioner to supply both engines. When the cock is open, the magnetic indicator adjacent to the controlling switch shows a horizontal white line; with the cock closed, a vertical line is shown. When DC is disconnected the indicator shows cock closed, therefore, if a DC failure occurs after the valve has been opened, the indication is false, as the valve remains open.

(*b*) *Inter-tank transfer valves*

The inter-tank transfer valves are controlled by a FUSELAGE INTER-TANK TRANSFER—ON/OFF switch. There are no indicators for these valves. If the valves are open when a DC failure occurs they stay open.

NOTE: Opening the inter-tank transfer valves does not restore any previous out-of-balance condition.

18 Engine inlet pressure indicators

Two PUMP INLET FUEL PRESS magnetic indicators, labelled PORT ENG and STBD ENG respectively, are controlled by pressure switches at their respective HP pump fuel inlets. An indicator normally shows black when its engine is running but shows cross-hatched when the pump inlet pressure is low, or when the DC supply is disconnected.

19 Fuel/no-air valve manual override switches

Four FUEL/NO-AIR VALVE switches, labelled NORMAL/CLOSED TANK 2 and TANK 6 (PORT ENGINE), and TANK 3 and TANK 5 (STBD ENGINE) enable the pilot to override the FNA valve automatic float switches; there are no indicators for the valves. Closing the FNA valves associated with an empty tank prevents fuel aeration in the engine feed line and the consequent engine flame-out risk.

Normal Operation

20 Before starting the engines

With 115V AC and 28 volt DC supplies available, check that the contents gauges changeover switch is at NORMAL and then read off the indicators. Check that the cross-feed cock magnetic indicator shows a vertical white line and that the magnetic indicators for the fuel proportioners, the HP pump inlets and the tanks pressurisation all show cross-hatched. Check that the fuel/no-air valve switches are selected to NORMAL.

21 After starting the engines

(*a*) *First engine*

Check that the magnetic indicator for tank pressurisation and the HP pump inlet and fuel proportioner magnetic indicators associated with this engine now show black. Check flowmeter indicating.

(*b*) *Second engine*

Check that the HP pump inlet and fuel proportioner magnetic indicators for the second engine have turned to black. Check flowmeter indicating.

22 In flight

(*a*) *Fuel balancing*

The FNA valves can be used to re-balance fuel between two ◀associated master tanks or between two "sides" but no more than two valves should be closed at any one time.▶ See para. 29.

WARNING: Both FNA valves of the same tank group must not be closed at the same time unless the inter-tank transfer valves are open, otherwise a flame-out of the associated engine will result.

(*b*) *FNA valve failure*

Failure of an FNA valve to close does not represent a hazard if the inter-tank transfer valves are kept shut. (See para. 10(*b*)). However, the appropriate FNA valve switch should be set to CLOSE if a master tank indicates 75 lb.

(*c*) *In-flight refuelling*

If all internal tanks are not completely full on completion of in-flight refuelling, out-of-balance will exist. Rebalancing should be carried out.

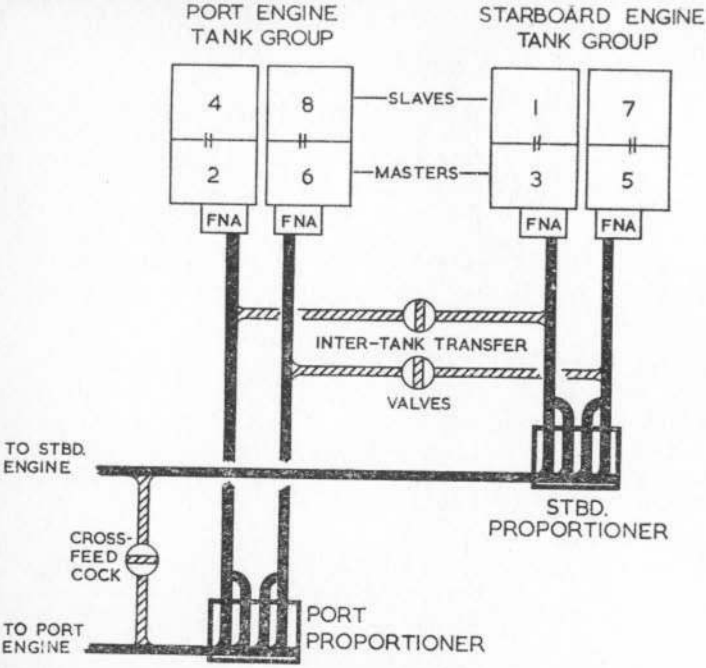

Fig. C—Fuel system (simplified)

23 Overload fuel transfer (two-engine flight)

(*a*) Immediately after take-off, switch on the overload tanks switches. This ensures that all fuselage tanks are kept topped up and that proportioning starts from a sound basis when the overload tanks are empty. When the overload tank(s) become empty their respective switches should ◀be set off, or slave to master tank transfer may not take place. ▶

NOTE: If desired, the transfer switch may be set on before take-off.

(*b*) If in-flight refuelling takes place the fuselage tanks (at least) should normally be fully topped-up for the reason given in sub-para. (*a*).

(*c*) If the overload tanks have also been refuelled, transfer to the fuselage tanks cannot start until the FLIGHT REFUEL switch has been set OFF.

24 Intentional single-engine flight

Shut down and restart each engine, in turn, leaving equal fuel available for two-engine recovery.

25 Unintentional single-engine flight

If engine failure occurs, first use fuel from the failed engine's tank group by opening the inter-tank transfer valves and then closing the FNA valves of the live engine's master tanks. The FNA valves must be re-opened just before either master tank belonging to the failed engine indicates 75 lb, then the inter-tank transfer valves must be closed. Any fuel remaining on the failed engine side will be unusable.

◀**WARNING:** Operation of the fuel system switches should be made with a pause between each switch selection so that the effect of the first selection can be checked before the second selection is made. ▶

26 Fuel jettisoning

(*a*) Normally fuel jettisoning should take place immediately before landing and with the aircraft in a clean configuration. All non-essential services in the radio bay should be switched off. If one tank group fails to jettison fuel, open the inter-tank transfer valves; all tanks may then jettison fuel but the rate may be reduced. Extra care should be taken to monitor the fuel gauges in this case. After landing, the radio bay should be inspected for ingress of fuel.

(*b*) Fuel jettisoning may be used throughout the flight envelope. The approximate rate of discharge is 1,240 lb./min. (155 gal./min.).

(*c*) If an unbalanced fuel state results, balance the contents as described in para. 29.

WARNING: Fuel contents gauges should be monitored during jettisoning and the jettison facility switched off when 4,000 lb. of fuel remain. The auto cut-off facility should not be relied upon.

27 Rapid defuelling

If, when embarked, rapid defuelling is required after the engines have been started, the starboard engine should be stopped and the procedure for rapid defuelling laid down in the Flight Reference Cards followed.

28 Fuel contents indicator failure

The most likely cause of one bank failing to indicate is oscillator failure. Setting the FUEL IND SUPPLY switch from NORMAL to CHANGEOVER, switches in the oscillator from the other system, allowing a contents check to be made.

29 Re-balancing

(*a*) Re-balancing should not be attempted when jettisoning or transferring fuel to the air-to-air refuelling pod, as the FNA valves may be sucked open and the switching, there-◀fore, ineffective. For landing all valves should be open except those in a tank which has less than 75 lb. fuel.▶

(*b*) *Between two associated master tanks*

If malproportioning occurs between two associated master tanks and it becomes necessary to re-balance, this can be done by closing the FNA valve of the master tank with the least fuel, allowing the proportioner to draw fuel only ◀from the other tank. While the valve is closed, a careful watch should be kept on engine performance and master tank fuel gauges for an early indication of an interruption of the fuel flow. The valve should be opened when balance has been re-established. ▶

NOTE 1: Closing the No. 6 tank FNA valves may cause the port proportioner magnetic indicator to fluctuate. Closing No. 3 tank FNA valves may have the same effect on the starboard proportioner magnetic indicator.

NOTE 2: The most likely cause of malproportioning is malfunctioning of a proportioner non-return valve. Attempt to purge the valve as follows:—Set maximum RPM on engine with affected proportioner. Press recuperator test button until inlet fuel pressure MI shows cross-hatched. Continue operating in this condition for 30 seconds.

(*c*) *Between port and starboard engine tank groups*

If it is required to re-balance fuel between engine tank groups, the inter-tank transfer valves must first be opened. Closing the FNA valves of both master tanks of the group having least fuel will then cause both engines to be fed from the group having most fuel. When balance has been re-established, open the FNA valves and close the inter-tank transfer valves.

30 Single proportioner failure

(*a*) If a proportioner fails, fuel will continue to be supplied to its associated engine by tank pressurisation, but contents in the associated master tanks may become unbalanced. The recuperator will discharge. The engine will continue to ◀run satisfactorily up to 35,000 ft. except with AVTAG.▶

(*b*) Fuel can be re-balanced by closing the FNA valve of the associated master tank showing least fuel, re-opening when balance has been restored. If an FNA valve, on the failed proportioner side, fails to close when its master tank becomes empty, the engine will flame-out irrespective of the amount of fuel in the other master tank.

NOTE: The inter-tank valves and the cross-feed cock should remain closed.

31 Double proportioner failure

(*a*) *Both proportioners*

(i) If both proportioners fail, each engine will continue to be fed with fuel by tank pressurisation. The engines ◀will continue to run satisfactorily up to 35,000 ft. except with AVTAG.▶

(ii) Balance fuel between associated master tanks as in para. 29 (*b*). The inter-tank transfer valves and the cross-feed cock should remain closed.

(iii) Close each FNA valve before its associated master tank becomes empty.

(*b*) *Engine and one proportioner*

(i) If one proportioner and the opposite engine fails, open the inter-tank transfer valves. The remaining engine will then be fed from all tanks. The engine will ◀continue to run satisfactorily up to 35,000 ft. except with AVTAG.▶

(ii) If unbalance occurs, close the FNA valves of the tanks with least fuel. Not more than two should be closed at one time. Re-open the FNA valves when balance is restored.

(iii) Close the inter-tank transfer valves before any master tank becomes empty. Any fuel remaining in the tank group not associated with the serviceable engine will be unusable after the inter-tank transfer valves are shut.

(iv) Close each FNA valve before its associated master tank becomes empty.

WARNING: If it seems likely that all the fuel will be required, the fuel in the failed engine side should be used first. To do this, open the inter-tank transfer valves and close the FNA valves of the live engine tank group. Open these FNA valves when either master tank on the failed side shows 75 lb.

◀32 Proportioner failure when using AVTAG

When using AVTAG and flying above 20,000 ft. with a failed proportioner there is a probability of HP pump cavitation due to fuel boiling and this could lead to flame-out. Recent high speed, low level flight will increase the risk of flame-out. If flight above 20,000 ft. is made when using AVTAG, the HP fuel pump must be examined on completion of the flight.▶

PART I—DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 4A—IN-FLIGHT REFUELLING

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1 In-flight refuelling (Receiver role)

Whenever in-flight refuelling is to take place a fixed probe is mounted in the starboard side of the nose, before flight. Flight refuelling is controlled by a FLIGHT REFUEL—ON/OFF switch on the pilot's starboard console. Selecting this switch to ON prepares the refuel/defuel valves to the master tanks and the overload tanks for refuelling. While refuelling is in progress the fuel-remaining indicator is automatically reset by a fuel-flow transmitter in the refuelling gallery.

2 In-flight refuelling (Tanker role), general

A streamlined pod, carried on a special pylon at the starboard inner station is used to refuel other aircraft in flight. The pod receives its fuel from the aircraft fuel system and when not required for refuelling it acts as a normal drop tank. Operation of the flight refuelling pod is automatic once certain settings and switch selections have been made. The controls for operation of the pod are contained on a role control panel, on the observer's port console. The role is selected by a MASTER—ON/OFF switch on the control panel. When the master switch is OFF, the pod functions as a normal drop tank and an adjacent TRANSFER SYSTEM magnetic indicator shows an arrow pointing to NORMAL. When the pod is used as a tanker, i.e., the master switch is ON and certain internal circuits are complete, the arrow points to REFUELLING. The remaining controls and indicators on the panel are as follows:—

WIND/TRAIL switch	For controlling the hose drum motor and brake.
POD FUEL LEVEL magnetic indicator	Shows MAX when pod is full, MIN when pod is empty and black at other times.
FUEL SELECTION LB × 100 dials	Two controls for setting the amount of fuel to be taken by the receiving aircraft. The left hand control is marked in tens, from 0-80 (× 100) and also has a MANUAL ON position. In this position the quantity of fuel is not pre-selected and flow continues until the dial is returned to zero, or the jettison low-level float switches operate. The right hand control is marked in digits, 0-9 (× 100).
FUEL GONE LB × 100 veeder counters	Indicate the quantity of fuel delivered to the receiving aircraft. An adjacent RESET control is used to zero the counters.
FUEL JETTISON-ON/OFF switch	A guarded switch which opens the fuel jettison valve and at the same time closes the pod refuelling valve.
TURBINE OVER-SPEED warning light	Shows a red light if the ram-air turbine overspeeds.
REFUEL LTS-DAY/NIGHT switch	In the DAY position it provides a by-pass for a resistance in the light circuits, thus increasing the brilliance of the lights.
EMERGENCY TRAIL/off/HOSE RELEASE switch	For use in case of hydraulic failure. In the latter position the hose is jettisoned, providing the switch has first been set to EMERGENCY TRAIL and that the hose is fully trailed.

Circuit breakers ...	Two press-to-reset circuit breakers; CB1 supplies the normal circuits, CB2 supplies the emergency circuits.
HIGH FUEL PRESSURE light	An amber light which comes on when the fuel delivery pressure is above 50 PSI causing the pressure control valve to close. The circuit may be reset by pressing the lamp cap.
HYDR POWER FAIL warning light ◀	A red light which comes on when the hydraulic pressure supply has failed. Pre-mod 1178 the failure warning is only operative providing the MASTER switch is ON. Post-mod 1178 the warning circuit is independent of the MASTER switch. ▶
BRAKE ON light ...	A blue light which comes on when the emergency brake is applied because of over-speeding of the drum, or when the hose is fully wound in.
HOSE IN light ...	A white light which comes on when the hose is fully wound in.
Red, amber and green signal light monitors	These lights monitor the three signalling lights at the rear of the pod. The lights come on automatically, as required, during the refuelling operation.
EMERGENCY SIGNAL—ON/OFF switch	Used to switch on the red light irrespective of the automatic operation.

3 Air to Air refuelling (tanker role) operation

(*a*) The pod has a self-contained hydraulic system for operating the hose drum and applying the brake, and a pneumatic system for emergency release of the emergency brake. A fuel pump is provided for pumping out the fuel and both it and the hydraulic pump are driven by a ram-air turbine at the nose of the pod. The various electrical circuits are designed to make the refuelling operation as automatic as possible, except for trailing and winding-in the hose.

(*b*) Switching on the MASTER switch prepares the system for refuelling, ensuring that the pod is full of fuel (POD FUEL LEVEL magnetic indicator showing MAX), that the two jettison valves from the pod to the proportioners (aircraft fuel system) are open, that the pod refuelling valve (aircraft system) is under the control of high, mid and low-level float switches in the pod, and, providing the wing tanks transfer switch is on, that the pod is pressurised. The TRANSFER SYSTEM magnetic indicator arrow points to REFUELLING and the red signal light monitor, the brake light and the hose-in light all come on. The quantity of fuel to be transferred to the receiving aircraft must be set on the fuel selection controls by rotating the selector knobs in an anti-clockwise direction to the required settings. This pre-selection may be made before the master switch is set to ON. Selecting TRAIL on the WIND/TRAIL switch releases the hose drum brake; the brake light goes out, and the drogue then pulls out the hose, causing the hose-in light to go out. If the speed of the drum becomes excessive, the governor applies the brake and the brake light comes on again. When the hose reaches the full trail position the brake is applied mechanically and microswitches are operated which extinguish the red signal light and illuminate the amber light. The brake light remains out.

NOTE: If, after selecting TRAIL, it is required to wind in the hose the drogue must be allowed to go to the fully-trailed position before selecting WIND, or damage may result.

(*c*) When the receiver aircraft makes contact the hose winds in a length of 5 to 7 ft. due to the forward thrust of the probe, and a microswitch operates to open the fuel supply valve, allowing fuel to be pumped to the receiving aircraft. This valve is also under the control of the float switches and, as fuel flow from the pod may be greater than the flow into it, the pod empties and the low-level float switch operates, closing the fuel supply valve. As the pod is refuelling the valve opens again when the mid-level float switch operates. It follows that fuel flow to the receiver may be intermittent and vary in quantity. In the first instance a full tank is transferred, but subsequently only a half tank will be transferred each time the valve opens. The position of the valve also controls the amber and green signal lights. When the valve opens after the initial contact the green light comes on and the amber light is extinguished. As the valve closes for refuelling of the pod, the green light is extinguished and the amber light comes on again. Passage of fuel to the receiver is monitored by a flowmeter which sends a pulse signal for every 100 lb. of fuel passed. This signal is used to operate the FUEL GONE counters and the FUEL SELECTION dials which gradually return to zero. When zero is reached the pressure control valve closes, the green light is extinguished and the amber light comes on. As the tanker aircraft normally carries additional fuel in the port overload tank, the OVERLOAD TANKS FUEL TRANSFER, WING switch should be selected ON during refuelling.

(*d*) When the receiver aircraft breaks contact, setting the TRAIL/WIND switch to WIND selects power to the hose-drum motor and brings on the red light. As soon as the hose starts to wind in, the amber light goes out. When the hose is fully wound in, the hose-in light and the brake light come on.

PART I—DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 5—SPEY Mk.101 ENGINE SYSTEMS

Contents

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1 Engines, general description

(*a*) Two Spey Mk. 101 by-pass turbo-jet engines are mounted one on each side of the fuselage at the wing root. Air from the intake flows through a four-stage ◀LP compressor. Part of the air is then directed into the HP compressor and the remainder enters the by-pass duct.▶ Each compressor has its own two-stage turbine, the LP shaft rotating inside the HP shaft. HP air from the HP compressor exit flows through the 10 combustion chambers, then through the two-stage HP and LP turbines to be mixed with the by-pass air in the jet-pipe.

(*b*) Variable-incidence guide vanes at the HP compressor inlet and an associated air-bleed at the 7th stage are fitted to ensure compressor stability during acceleration and deceleration. A permanent 7th stage air-bleed provides

General Service air for fuel tank pressurisation etc. (see Ch. 6) and an additional large volume bleed provides air for boundary layer control on demand. The supply valves are pneumatically-operated by air from the 12th stage and this stage also supplies air, on demand, for engine anti-icing purposes.

(*c*) Fuel for combustion is provided by an HP pump whose outlet to the spray nozzles is controlled by an HP cock and, automatically, by the engine fuel control system. The datum for the latter, i.e. the HP compressor speed, is set by the pilot's combined HP cock and throttle lever.

(*d*) Two gearboxes, one driven from the HP shaft and the other from the LP shaft, provide drives for various accessories. The HP gearbox also receives the drive from an LP air starter which, for starting purposes, is supplied with air from a Palouste engine, the latter being automatically controlled by the starting circuits.

2 Engine controls

(*a*) *On port console*

Description	*Function*
PORT and STBD ENGINE START MASTER switches (two)	Provide a DC supply for their starting circuits
PORT and STBD ENGINE START pushbuttons (two)	Initiate their engine's starting cycle
PORT and STBD HP COCK and THROTTLE levers (two)	Control the HP cock and throttle for their engine. Each lever has an ENGINE RELIGHTING button on its forward side.

(*b*) *On starboard wall*

ENGINE ANTI-ICING switches (two) (No. 1 VALVES & No. 2 VALVES)	Selects the engine intake anti-icing systems.
ANTI-ICING ENGINE SELECTION PORT/STBD switch	Permits ground testing of the anti-icing valves.
PORT and STBD TGT AUTO/OFF switches	For switching off top temperature control.

3 Engine indicators

On the instrument panel

PORT and STBD HP RPM indicators (two)	Indicates HP shaft RPM%
PORT AND STBD LP RPM indicators (two)	Indicates LP shaft RPM%
◀PORT and STBD LP COMP O/SPEED lights (two)	Light comes on when its associated LP compressor exceeds 98·5% RPM. ▶
PORT and STBD TGT indicators (two)	Indicates turbine gas temperatures from zero to 800°C
LP ROTAT green light ◀	Light flashes and then remains on when the LP shaft is rotating, while the starter circuit is energised. When Mod. 1121 is embodied, the light indicates only when rotation is in the normal direction. ▶
ENGINE THRUST meter	Indicates engine thrust as a pressure ratio. A PORT/STBD selector switch provides for engine selection.
PORT and STBD OIL PRESSURE magnetic indicators (two)	Indicates oil pressure in terms of HIGH, cross-hatched and LOW.
ENG ANTI-ICE magnetic indicator	Indicates systems switched off (cross-hatched) System switched on (ON) System pressure too high (OP)
PORT and STBD FUEL FILTER ICING magnetic inicators (two)	Indicates no icing (black) or icing present (cross-hatched)
PORT and STBD DUCT OVERHEAT lights (two)	Indicates when engine internal cooling air reaches too high a temperature.

4 Engine fuel system, general description

The main fuel flow from the HP pump is to a combined acceleration and speed control (CASC) unit and thence via an LP shaft governor and the HP cock, to the spray nozzles in the combustion chambers. Once the pilot has moved the throttle lever to give a selected engine speed, the fuel flow is controlled automatically by the CASC unit and the LP shaft governor.

5 HP fuel pump

The multi-plunger type HP pump receives fuel from the aircraft system via an oil cooler and a filter and delivers it at varying pressures, according to demand, to the CASC unit, to the HP cock during starting, to the LP shaft governor for control purposes and to the airflow control actuator. If fuel delivery pressure reaches a pre-determined value, a proportion of the output is returned to the inlet side of the pump via a pressure relief valve.

6 Combined acceleration and speed control unit

(*a*) The CASC unit provides a constant selected HP shaft speed at all altitudes and airspeeds. Further it provides protection from exceeding the permitted maximum HP shaft speed, the maximum TGT or the maximum HP compressor exit pressure. It also increases fuel flow when BLC is in operation, thus restoring the acceleration rate.

(*b*) The CASC unit controls the main fuel flow to the spray nozzles via the LP governor and the HP cock and a primary flow to the nozzles via the HP cock only. The unit is, essentially, a slide valve which varies the fuel inlet and outlet orifices. The position of the valve is determined by servo fuel pressure influenced by the following:

HP compressor speed
HP compressor inlet and exit pressures
Selection of boundary layer control

Position of the valve is also determined by acceleration and deceleration stops and the CASC throttle lever position which, in itself, can be modified by the top temperature control actuator.

7 Turbine gas temperature control system

(*a*) The TGT control system provides turbine gas temperature indication in the cockpit and control of that temperature by reducing fuel flow if the temperature reaches a predetermined figure. When BLC is selected the maximum temperature datum is automatically reset to a higher figure.

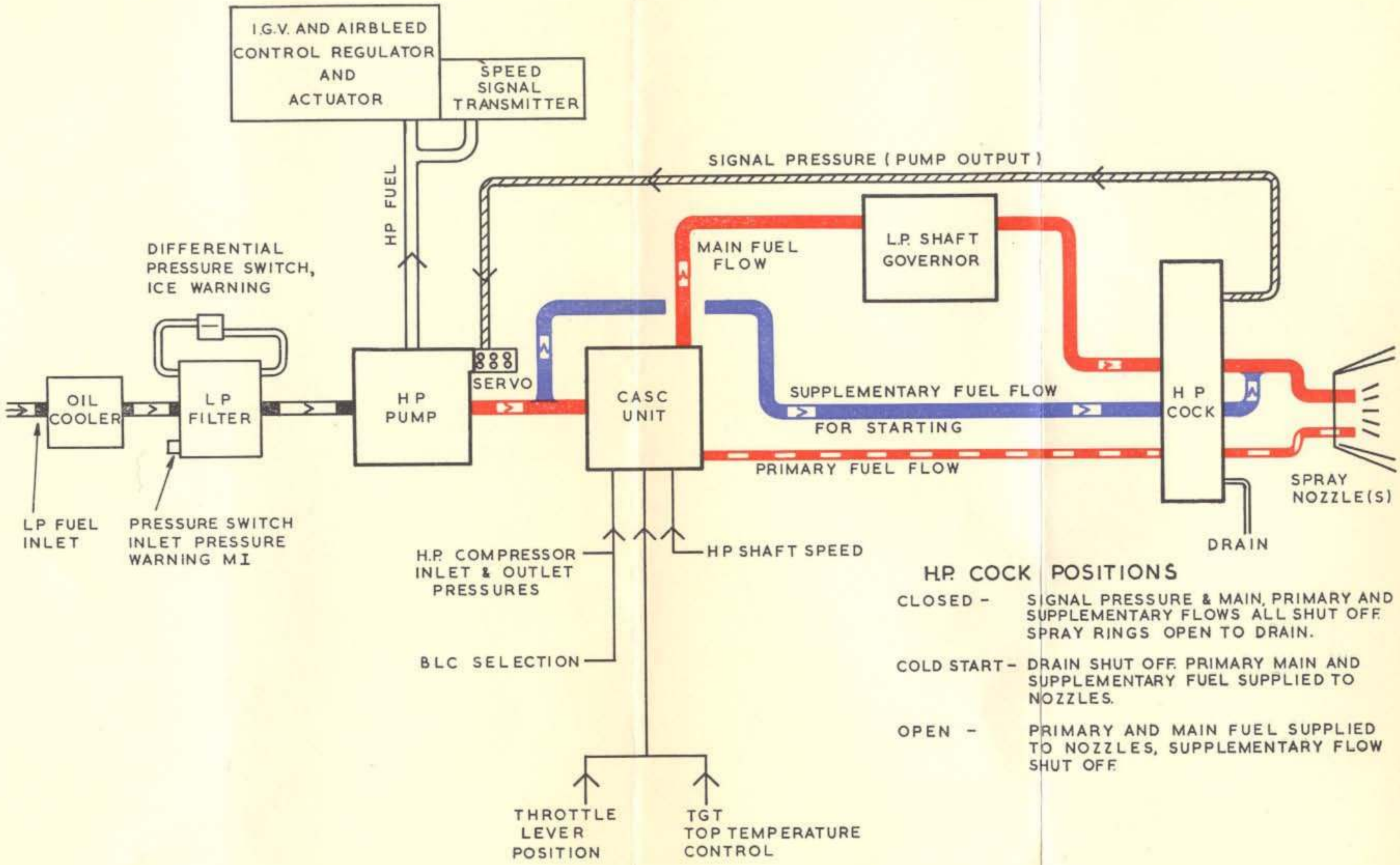

Fig. A—Engine fuel system (simplified)

(*b*) The system consists, basically, of a temperature control signal amplifier which is electrically connected to two thermocouples subjected to engine-intake air, and ten thermocouples behind the LP turbine. The amplifier output controls an actuator which resets the throttle linkage and thus the CASC datum.

(*c*) The control amplifier can be disconnected from the actuator by switching to OFF, a TGT CONTROL switch in the cockpit. If this switch is OFF, it is essential that the pilot monitors the TGT to ensure that the limiting TGT is not exceeded.

◀(*d*) The design characteristics of the Spey engine result in the specified maximum thrust being developed at an individual TGT. Mod Spey 3119 enables the engine's top temperature control to be adjusted to allow a specified thrust plus one per cent, blow on and blow off. In conjunction, Buccaneer mod 1224 enables the TGT gauge to be adjusted so that at the top temperature limits the indication is 595°C blow on and 585°C blow off.

NOTE: With these modifications embodied a variation of up to 2½% HP RPM may be observed between engines operating at the maximum permissible TGT. ▶

8 LP shaft governor

The LP shaft governor receives the main fuel flow from the CASC unit and normally passes all of it to the HP cock. If, however, the limiting LP shaft speed is reached, flyweights, driven from the LP shaft, move a port which restricts the fuel flow, thus increasing the HP pump delivery pressure and therefore the differential across the pump servo piston. This reduces the pump stroke and therefore fuel flow to the engine.

9 HP cock

The three-position HP cock is operated by the combined HP cock and throttle lever in the cockpit. When the cock is shut the primary fuel flow from the CASC unit and the main fuel flow from the LP shaft governor is shut off. In addition fuel from the main and primary nozzle galleries drains through the cock to a collector tank fitted with an ejection pump.

(*b*) When the cock is in the ground start position, the drain is shut off but the main and primary flows from the

CASC unit and a supplementary flow direct from the HP pump, are fed to tbe spray nozzles. These flows give an HP shaft speed slightly above the ground-idling figure.

(*c*) When the cock is open, i.e. HP cock and throttle lever is at the throttle closed position, primary fuel from the CASC unit is supplied to the primary nozzles gallery and the main fuel from the LP governor is supplied to the main nozzles gallery. In addition fuel is also supplied to one side of the piston in the HP pump stroke servo unit which controls the pump stroke. With the cock open, the fuel flow gives ground-idling HP shaft speed. It follows that, wben the HP cock and throttle lever is moved forward from the ground-start position to the throttle-closed position HP RPM fall slightly.

10 HP compressor airflow control system

(*a*) To ensure freedom from surge and facilitate rapid acceleration/deceleration above approx. 77% HP RPM, variable-incidence inlet guide vanes at the inlet and a 7tb stage air bleed are provided for the HP compressor; both are controlled and operated by an airflow control regulator and actuator supplied with fuel at high pressure from the HP pump.

(*b*) An airflow control rev./min signal transmitter driven from the HP shaft, provides a signal fuel pressure related to HP shaft speed. This pressure is used to control the position of a servo piston within the airflow control regulator. The piston is moved by high-pressure fuel supplied from the HP pump.

(*c*) The range of IGV movement (post Spey mod 2187 or 2214) is + 38° to − 2°. As HP shaft speed is increased above approximately 77% the inlet guide vanes start to open and the air bleed starts to close. When the IGV angle is zero, the HP shaft RPM is between 88 and 96%.

11 HP compressor air-bleed

Tbe air-bleed system provides a continuous supply of air for operation of various services (Chapter 6) and, on demand, air for the boundary layer control system. When a demand is made, air from the seventh stage of the engine HP compressor is delivered to the BLC system ducting, via a manifold and sbut-off valve. The off-take of air for the blowing system disturbs the relationship between the exhaust gas temperature and the turbine entry temperature.

To compensate for this factor, the top temperature control datum is automatically reset electrically. At the same time the CASC unit is reset by BLC air pressure, to increase the fuel flow during an engine acceleration.

12 Thrust indication

A thrustmeter on the instrument panel indicates thrust in terms of the ratio of pressures, derived from the mean of nine pitot heads in the jet-pipe and a static vent in the engine bay. The meter is marked from 1 to 3·5 and a switch is provided to select the particular engine required.

13 Engine overheat warning

Two engine LP cooling air overheat lights, one for each engine, are on the instrument panel. If the internal temperature of the engine rises above a pre-determined level. a thermal switch in the engine LP cooling air duct closes to illuminate the warning light. Operation of the fire extinguishers is ineffective, and remedial action is to throttle back, or to shut down the engine.

~~NOTE: The system is inoperative until mods 1012 and Spey 1883 are embodied~~.

AL9

14 Oil system

(*a*) Each engine has a self-contained oil system which supplies oil in a continuous flow cycle from an oil tank, having a capacity of 8 pints, through a pump, an oil cooler and a filter to lubricate and cool the bearings, gears and shaft splines throughout the engine at pressures and temperatures that are within specified limits. Scavenge pumps then return the oil to the tank. A relief valve ensures that the pressure in the system is maintained within safe limits, and by-pass valves in the cooler and filter ensure an adequate flow of oil at low oil temperatures or with a partially blocked filter.

(*b*) A vertical sight-glass, indicating pints to fill, is fitted to the oil tank to provide visual indication of the oil level. The tank is replenished through a pressure connection which incorporates a non-return valve; provision is also made for gravity filling of the tank but this should not normally be used.

(*c*) Two pressure switches, on the pressure filter, control the 3-position magnetic indicator in the cockpit to give

◀indications of LOW, cross-hatched or HIGH, depending on the pressure, as shown below:

Indication	*Pre-mod Spey 2725*	*Post-mod Spey 2725*
LOW	Below 25 PSI	Below 15 PSI
Cross-hatched	25 to 30 PSI	15 to 30 PSI
HIGH	Above 30 PSI	Above 30 PSI

NOTE: The indicator also shows cross-hatched if the DC supply fails. ▶

15 Engine fire protection systems

For details of the engine fire protection systems, refer to Chapter 2.

16 Engine anti-icing systems

For details of the engine anti-icing systems refer to Chapter 8.

17 Engine starting, general

Each engine is started by a low-pressure air starter on the front of the high-speed wheel case, supplied with air from a Palouste turbine starting trolley. The air delivery hose connections and the electrical sockets are accessible through the engine lower cowling. Once the Palouste is started and connected to the engine it is controlled by the starting cycle. The engine to be started is selected by setting ON the appropriate engine master start switch and the starting sequence is initiated by pressing the required ENGINE START, PORT or STBD guarded pushbutton at the rear of the port console. To prevent hot starts where conditions of strong surface winds persist, starting with the aircraft tail-into-wind should be avoided. If this is not possible the LP compressor may be rotating in the wrong direction and it is essential that, pre-mod. 1121, the LP compressor rotating light be seen to stop flashing and then start again before the HP cock is opened to the ground start position. Depending on wind strength this may be up to 15 seconds after the starting cycle is initiated.

18 Engine starting, operation

(*a*) With the battery master switch on and the appropriate ENGINE MASTER START switch ON, pressing an ENGINE START pushbutton completes an electrical supply to:

(i) Wind up the time switch

(ii) Operate the high-energy ignition units

(iii) Energise an acceleration valve and open an air supply valve on the Palouste.

(*b*) The supply of air then rotates the LP starter which turns the engine; light-up occurs 2 to 3 seconds (usually immediately) after moving the throttle lever to the GROUND START position. At 33-35% RPM the overspeed switch breaks the supply to the Palouste, closing the acceleration valve—which causes it to reduce to idling speed —and the air supply valve. At the same time, the supply to the HE ignition units is disconnected. If the engine fails to light-up within 15 seconds from pressing the starter button, the throttle lever should be moved to the HP COCK CLOSED position and the engine allowed to motor over for the remainder of the start cycle (30 seconds total), after which the ENGINE MASTER START switch should be set to OFF. The engine must be allowed to drain for 2 minutes before making a further attempt to start.

WARNING: If the Palouste does not cut out, terminate the cycle immediately by switching off the start master switch.

(*c*) Initial rotation (either way pre-mod 1121) of each engine LP compressor shaft during the starting cycle is indicated by the flashing of an LP ROTAT green light on the instrument panel. Immediately this light comes on, the throttle lever should be moved to the GROUND START position, but must remain at HP COCK CLOSED if the light does not appear. The light goes out at 33-35% RPM. If during a starting cycle no indication appears, the sequence should be terminated by selecting the appropriate ENGINE MASTER START switch to OFF.

19 Engine relighting

(*a*) An ENGINE RELIGHTING pushbutton is on the forward face of each throttle lever. Pressing a button

PART I—DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 6—ENGINE AIR-BLEED SYSTEM

Contents

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1 Air-bleed system, general description

(*a*) Both engines supply air for a common system which provides air for boundary layer control and the following general services:

Windscreen rain clearance
Pressurisation of the main hydraulic reservoir
Pressurisation of the fuel tanks
Pressurisation of the recuperators
Operation of the fuel/no-air valves
Pressurising and conditioning of the cabin
Conditioning of the radio bay
Pressurisation of the oil tanks and oil cooling (CSD units)
Engine jet-pipe cooling
Radome pressurising

(*b*) The air-bleed system is supplied through three tappings off the engine casing opposite the 7th stage of the HP compressor. These bleeds merge within a common manifold, at the rear of each engine, from which air is distributed through two large-bore ducts to the boundary layer control and general services systems. When the engine(s) are running, the general services system primary duct circuit receives a continuous supply of air through regulating valves, one in each supply duct close to the manifold. From the primary duct circuit, branches extend to the services listed in para 1(*a*). For convenience, the supply to the tailplane blowing slits is taken from the general services system; this supply and the supply for mainplane BLC is only supplied on demand.

2 Boundary layer control valves

(*a*) Air for boundary layer control over the mainplanes, flaps and ailerons is taken from the engine bleed manifolds, the supply duct from each manifold incorporating an electro-pneumatic shut-off valve. The two ducts are united by a cross-feed duct.

Tailplane boundary layer control is supplied from the General Services air system. An electro-pneumatic shut-off valve is incorporated in the duct to control the supply to the tailplane in conjunction with main planes blowing.

(*b*) The three electro-pneumatic valves are each controlled by a main and a standby solenoid. For normal use both solenoids are energised by the normal DC supply, but for emergency use the standby solenoid only is energised, from the emergency battery.

3 Function of valves

With AUTO selected, drooping the ailerons causes the shut-off valves in the engine supply outlets and the tailplane supply duct to be energised to open. The system is then fully operative.

4 Windscreen rain clearance

Rain can be cleared from the windscreen by an air jet if the windscreen wiper proves ineffective. The jet is supplied from the engine air-bleed system through a shut-off valve controlled by an ON/OFF switch on the starboard wall. An altitude switch closes the shut-off valve during ascent at 15,000 ft. and opens the valve on descent at 8,000 ft. if the ON/OFF switch is left ON.

5 Controls and indicators

(*a*) The boundary layer control switch is at the rear of the standby control panel and marked BLOWING SYSTEM—OFF/AUTO. With AUTO selected, control of the electro-pneumatic valves is effected by the aileron droop mechanism, whereby two microswitches are actuated to render the system operative by the time the ailerons are drooped 5°. This automatic operation can be overriden by selecting the switch OFF. A BLOWING SYSTEM

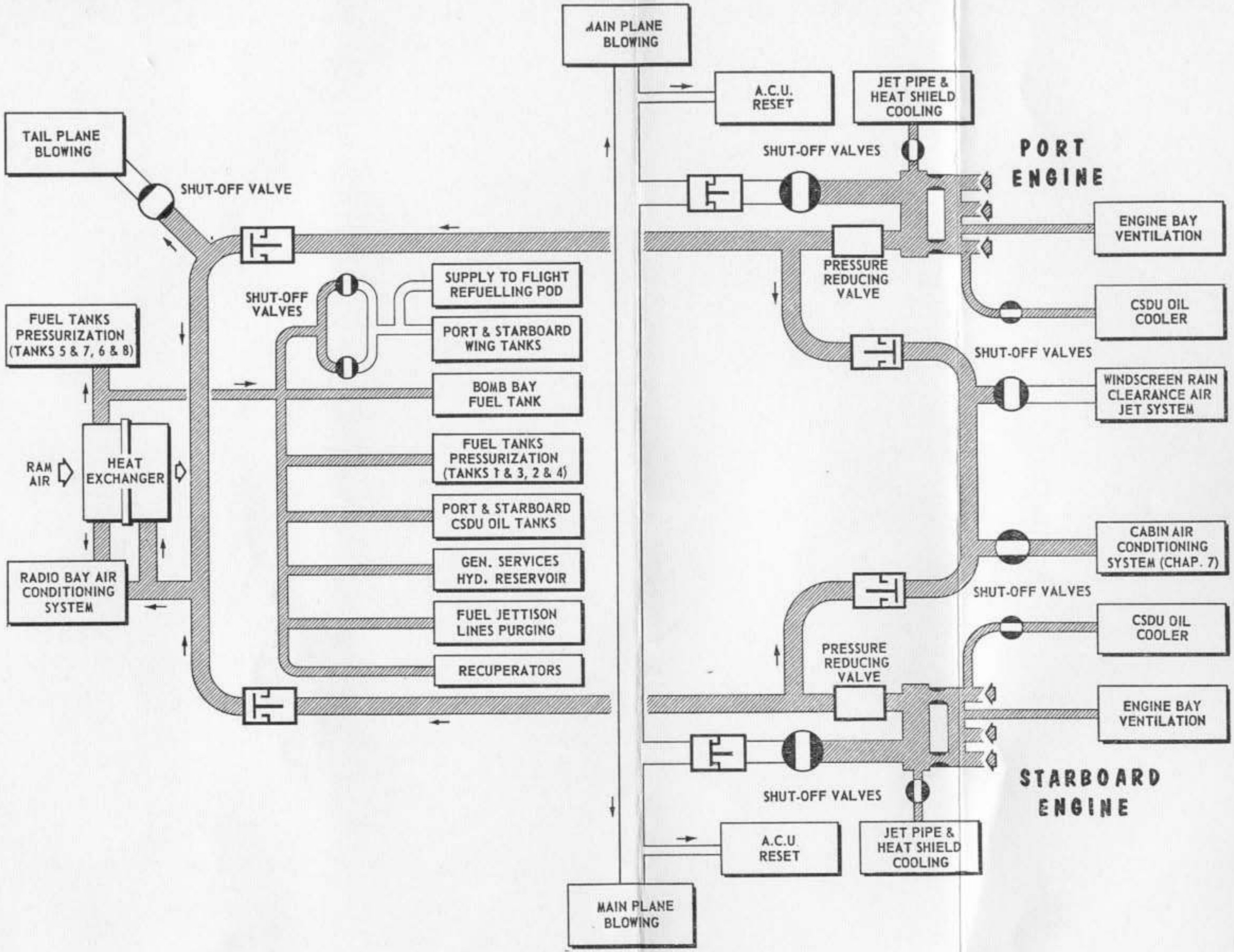

Fig. A—Engine air-bleed system

SUPPLY—NORMAL/EMERGY guarded switch, on the port control panel, controls the DC supply to the BLOWING switch. When at NORMAL the supply is taken from the normal DC busbar, but when at EMERGY the supply is from the emergency battery.

(*b*) *Blowing system indicators*

(i) *Magnetic indicators*

Two BLOWING SYSTEM—ENGINES—PORT and STBD magnetic indicators are under the port side of the instrument panel shrouds. The indicators show ON when their respective valves are at least 92% open, OFF when they are closed more than 17% and cross-hatched when in an intermediate position or when DC is disconnected.

(ii) *Pressure gauges*

Two WING BLOWING—PORT and STBD pressure gauges are on the starboard side of the instrument panel shroud and a BLOWING TAILPLANE pressure gauge is on the port wall. The gauges indicate the pressure in the ducts leading to the aileron and tailplane blowing slits, respectively.

▶◀

(*c*) Two BLOWING SYSTEM CIRCUIT TEST switches, marked MAIN—ON/OFF and STANDBY—ON/OFF, are aft of the port console. Spring-loaded to the ON position, these switches permit the testing of the control valve circuits. The emergency DC supply can also be tested if, with the MAIN circuit test switch held to OFF, the SUPPLY switch is set to EMERGY.

(*d*) The windscreen rain clearance system is controlled by a W/SCR CLEAR AIR JET—ON/OFF switch, on the starboard wall. An ON selection operates the valve controlling the flow of air to the windscreen air jet. An associated RAIN CLEAR light, with a PRESS-TO-TEST facility, on the instrument panel starboard shroud, comes on whenever the system is switched ON.

6 Normal management of the air-bleed system

(*a*) The General Services, with the exception of the cabin air conditioning and the windscreen rain clearance system, are supplied with air whenever an engine is running.

(*b*) The BLC switch should normally be left in the AUTO position.

PART I—DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 7—AIR CONDITIONING SYSTEM

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1 General description

The cockpit and radio bay air conditioning systems are supplied with compressor air from the engine air-bleed system (Chapter 6); they are entirely separate in operation. In addition to conditioning the two cockpits, a number of subsidiary services are fed from the cockpit supply; these are windscreen de-misting and washing, anti-G and ventilated suits, canopy seal, radome pressurisation and cooling and accessories bay cooling. These services are dependent upon the cockpit system being switched on.

2 Cockpit air supplies

(*a*) The controls and indicators for the cockpit air supplies are:

Description	*Location*	*Function*
CABIN & RADOME PRESS—NORMAL/OFF/EMERGY switch	On starboard console	Controls the supply of air for all cockpit services except rain clearance
HOT .... COLD selector	On starboard console	Selects required cockpit temperature
AUTOMATIC/MANUAL switch	On starboard console	Selects temperature control mode
RAM AIR VALVE—ON/OFF lever	On starboard console	Provides emergency ventilation
CPR warning ..	On SWP	Warns of pressurisation system failure
Cockpit altimeter ..	On observer's port console	—

(*b*) *Air supply*

Air from the engine air-bleed system is supplied through a twin solenoid-operated shut-off valve, beyond which the flow divides, one line passing through the temperature control valve, the other passing through the first stage of a two-stage heat exchanger; this flow again divides, one line supplying the anti-G suit system, the other passing through the second stage of the heat exchanger and separating to supply various services. The cockpit air passes through a cold-air unit and joins the warmer air from the temperature control valve, at tfie water extractor. The conditioned air then passes through a second heat exchanger, where it conditions the ventilated-suit supply, and thence to the cockpit, through a non-return valve. An intake on tbe starboard side of the fuselage is the source of supply of ram air to the first heat exchanger and the cold-air unit.

(*c*) One solenoid of the shut-off valve is energised when the control switch is at NORMAL and the supply is from the DC normal busbar. When the switch is at EMERGY, only the second solenoid is energised and the supply is then from the emergency busbar.

3 Temperature control

The required cockpit temperature is obtained by mixing uncooled air with air from the cold air unit and this can

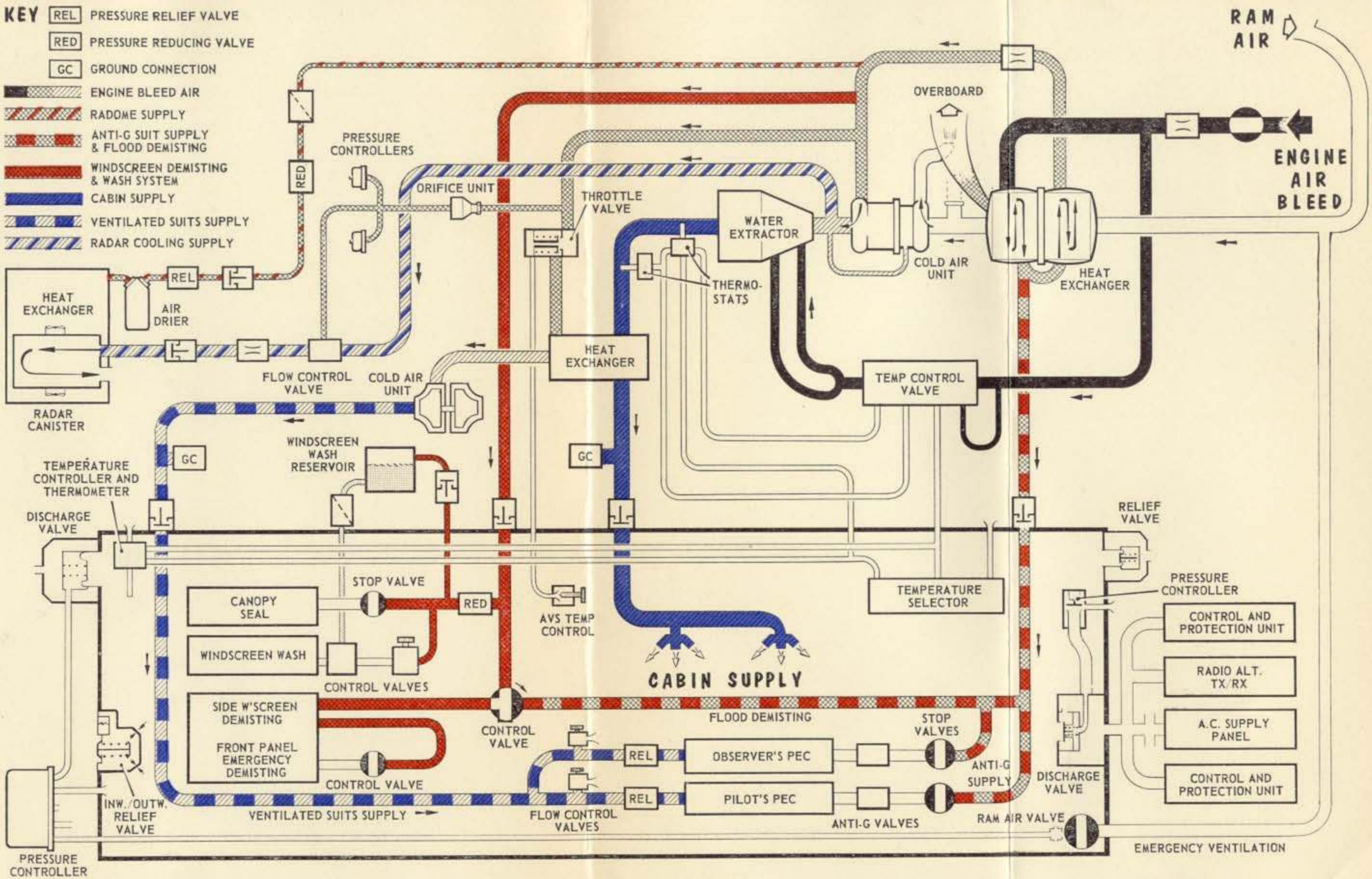

Fig. A—Air conditioning system

be varied either automatically or by manual control. The temperature control valve, which supplies the uncooled air, has an infinite number of positions between open and closed and is controlled by a rotary selector in the cockpit. For automatic operation, the desired temperature is set on the selector and a temperature controller then controls the position of the temperature control valve, to maintain the set temperature. For manual operation the temperature controller is switched out and the rotary selector in the cockpit controls the position of the temperature control valve.

4 Pressure regulation

(*a*) Cockpit pressure is regulated by a pressure controller and two discharge valves. Below 8,000 ft. the controller is inoperative and the discharge valves are fully open. At 8,000 ft. the controller becomes effective and progressively closes the discharge valves as altitude is increased, until at 25,000 ft. the pressure differential is 4 PSI. This value is then maintained irrespective of any further increase in height but, if a failure occurs, a CPR warning is given when the cockpit altitude exceeds 32,000 ft. The table below shows pressure altitude and the approximate equivalent cockpit altitude.

Pressure altitude (ft.)	*Cockpit altitude (ft.)*
0	0
8,000	8,000
10,000	8,500
15,000	10,000
20,000	11,000
25,000	12,000
30,000	14,750
35,000	17,500

(*b*) If the discharge valves fail shut, two safety valves start to relieve pressure at a differential pressure of $4\frac{1}{2}$ PSI and ensure that a differential pressure of $4\frac{3}{4}$ PSI is not exceeded. Below 7200 ft. approx. the CPR warning is given if excess cockpit pressure causes a differential exceeding approx. $1\frac{1}{4}$ PSI.

(*c*) One of the safety valves also incorporates an inward relief valve. If, in a rapid descent at low power, the ambient pressure exceeds cockpit pressure, the valve opens and equalises the pressures.

5 Emergency ventilation

If malfunctioning of the system occurs, the normal operation of the pressure controller and the discharge valve can be overriden by opening an emergency ram-air valve. When the lever operating this valve is set ON, air at ram pressure is admitted to the cockpit and the front discharge valve is fully opened. The lever is retained in the OFF position by a spring clip.

6 Canopy seal and windscreen demisting

(*a*) The controls and indicators are:

Description	*Location*	*Function*
OFF/DEMIST/ FLOOD control	On starboard console	Controls the source of the air supply and the supply to the side windscreens.
EMERGENCY DEMIST—PULL AND TURN control	On starboard coaming	Provides additional demisting/de-icing of the front windscreen.

NOTE: The cock for the canopy seal is controlled by the canopy lock lever.

(*b*) A tapping from the cockpit supply, between the two-stage heat exchanger and the cold-air unit, provides for inflation of the canopy seal when the canopy is locked, and normal de-misting of the side windscreen and forward sides of the canopy. The air for the canopy seal is reduced to 8 PSI above cockpit pressure and is under the control of a stop valve incorporated in the canopy control (Chapter 12). The de-misting air is under the control of a three-way cock which stops the supply, admits the normal supply, or admits the normal supply and an additional supply, according to selection. The additional air supply is from the anti-G suit supply line and is at a relatively higher temperature.

(*c*) If the windscreen anti-icing system fails, operating the emergency demist control provides front windscreen de-icing/demisting by ducting air from the side windscreen de-misting system.

◀(*d*) To prevent ingress of water into the cockpits when the engines are stopped, a handpump and non-return valve in the nosewheel bay provide for inflating the canopy seal.▶

7 Windscreen washer

A spray tube in front of the windscreen is supplied with liquid solvent from a reservoir, by air pressure tapped from the canopy seal supply. The system is controlled by a SCREENWASH—PRESS AND RELEASE plunger valve which supplies air to a liquid control valve; the reservoir is pressurised whenever the cockpit pressurisation system is operative. The plunger valve control protrudes through the starboard console and should be pressed and released immediately, as this gives a 15 second application of liquid to the windscreen; during this time the windscreen wiper should be in operation. The capacity of the reservoir is sufficient for approximately 15 such applications.

8 Anti-G and ventilated suit supplies

(*a*) The controls for the anti-G and ventilated suits are:

Description	*Location*	*Function*
	Front cockpit	
ANTI-G—ON/OFF cock	On starboard console	Controls air supply to pilot's anti-G valve.
ANTI-G VALVE ..	On starboard console	Controls air supply to pilot's anti-G suit.
AIR VENT SUIT TEMP control	On starboard console	Controls temperature of air to both ventilated suits.
AIR VENT SUIT—OPEN/SHUT control	On starboard console	Controls the supply of air to the pilot's ventilated suit
	Rear cockpit	
ANTI-G—ON/OFF cock	On starboard console	As above
ANTI-G VALVE ..	On starboard console	As above
AIR VENT SUIT—OPEN/SHUT control	On starboard console	As above

(*b*) *Anti-G suits*

The supply for anti-G purposes is taken from the cockpit supply after the first stage of the two-stage heat exchanger. After passing through a non-return valve the flow divides, one line going to the pilot's PEC and the other to the observer's PEC. An anti-G valve and a stop valve are in each line.

(*c*) *Ventilated suits*

The supply for the ventilated suits system is tapped from the cockpit supply line between the first heat exchanger and the cold-air unit. The air is passed through a throttle valve, a heat exchanger and a cold-air unit, and then passes through a non-return valve. At this point the flow divides, each line passing through a flow control valve and a relief valve and thence to the respective PEC. The temperature for both suits is controlled by the throttle valve, which varies the mass flow through the heat exchanger and the cold-air unit, by means of an air bleed in the throttle valve, which is controlled from the front cockpit.

9 Radome pressurising

(*a*) Air for radome pressurisation is tapped from the cockpit supply between the first heat exchanger and the cold-air unit. The air passes through a filter, pressure reducing valve, non-return valve, pressure relief valve and an air drier. Air supply is automatic whenever the cabin pressurisation system is operative.

(*b*) Air within the radome is circulated through a heat exchanger, its passage being assisted by two electric fans. Operation of the fans is automatic when the radar is switched on.

(*c*) Cooling air for the radome heat exchanger is obtained from the cockpit air supply line, downstream of the cold air unit. The cooling air passes through a pneumatically-operated flow control valve, a restrictor and a non-return valve. A tapping off the ventilated suits supply line provides the air for operation of the pneumatic flow control valve. The operating air passes through a filter and a duplicated pressure controller which controls the air pressure. This pressure acts upon one side of a spring-loaded piston, in the flow control valve, the other side of which is exposed to atmospheric pressure. With increasing altitude, the constant pressure of the operating air overcomes the spring and decreasing atmospheric pressure, and the piston moves to progressively close the flow control valve, until at 40,000 ft. the valve is fully closed. When this occurs, the ambient temperature is sufficiently low to maintain an acceptable temperature level within the radome.

(*d*) A blue light, on the azimuth range indicator, comes on if radome pressurisation falls to 15 PSI when the system is on.

10 Accessories bay cooling

The discharge valve on the cockpit rear bulkhead operates in conjunction with a pressure controller to cool electrical equipment in the accessories bay up to an altitude of 8,000 ft., above which height the bay temperature is naturally low enough to prevent overheating.

Radio Bay

11 Radio bay cooling

(*a*) The controls and indicators for the radio bay cooling system are as follows:—

Description	*Location*	*Function*
MISC TEMPS indicator	Observer's cockpit, port side	Indicates temperature in radio bay, bomb bay or under-carriage bay, as selected.
1. TYRE/ 2. RAD BAY/ 3. BOMB BAY selector	Adjacent to MISC TEMPS indicator	For selecting required temperature indication.
OVERRIDE RADIO BAY COOLING NORM/OVERHEAT switch	Observer's port console	For closing shut-off valve in air supply to temperature control valve.
NORM/cross-hatched/O-HT magnetic indicator	Adjacent to switch	Indicates position of shut-off valve, above.
CAU RADIO BAY—NORMAL/ISOLATE switch	Pilot's starboard console	For closing air supply to cold air unit.
R BAY warning	On SWP	Indicates when shut-off valve in supply to temperature control valve, is shut.

(*b*) Air for conditioning the radio bay is supplied by the engine air-bleed system (Chapter 6). A heat exchanger and a cold-air unit both fed from an air intake in the fin, reduce the temperature of the supply air to keep the temperature of the bay between 0° and 55°C. A thermostat pneumatically governs a temperature controller to restrict the minimum temperature to 0°C.

(*c*) An electrically-operated shut-off valve is incorporated in the temperature control by-pass duct to prevent overheating of the bay through failure of the temperature controller or thermostat. Normally open, the shut-off valve is closed by a flamestat if the temperature of the supply air rises to approximately 45°C and does not re-open until the temperature has fallen to 30°C; this shut-off valve can also be closed by the observer. Operation of the valve, whether automatic or by switch selection, also initiates the R BAY warning on the standard warning panel.

(*d*) A second electrically-operated shut-off valve is embodied in the main air conditioning duct to the cold-air unit. Should an overheat condition persist after operation of the temperature control shut-off valve (sub-para. (*b*)), failure of the cold-air unit is indicated. In this event the flow of hot air through the cold-air unit can be shut off by the pilot.

◀(*e*) A temperature indicator in the observer's cockpit indicates bay temperature. A selector switch is provided and the indicator shows radio bay, bomb bay or undercarriage bay temperature as selected by the switch. ▶

Malfunctions

12 Malfunctioning of the cockpit pressurising system

(*a*) If the CPR warning is given on the SWP when above 8,000 ft. the cockpit is under-pressurised.

(*b*) If the CPR warning is given when below approx. 7,200 ft. the cockpit is over-pressurised, indicating failure of the discharge and outward relief valves. Depending on circumstances the situation can be relieved by any, or a combination, of the following:

Switch off pressurisation
Reduce engine speed
Increase height
Open ram-air valve (this may open the front discharge valve)

13 Malfunction of the radio-bay cooling system

(*a*) If an R BAY warning is given on the SWP it indicates that the shut-off valve to the temperature control unit has closed: the magnetic indicator in the observer's cockpit will show O/HT.

◀(*b*) If the magnetic indicator fluctuates between NORM and O/HT, it also indicates failure of the temperature control unit. The observer should set the OVERRIDE SWITCH to OVERHEAT.

AL9 (*c*) If the MI remains at O/HT and the bay temperature rises, it indicates a probable failure of the cold air unit. The pilot should set the CAU RADIO BAY switch to ISOLATE, monitor the bay temperature and climb to a lower ambient temperature, say 25,000 ft, and switch off unnecessary radios.

(*d*) If the radio bay temperature exceeds 65°C without an SWP or magnetic indicator warning, the observer should set the OVERRIDE switch to OVERHEAT. This closes the shut-off valve to the temperature control unit; the R. BAY warning then operates and the magnetic indicator shows O/HT. Monitor the radio bay temperature, which should reduce. If it does not, switch off all unnecessary equipment and climb to a lower ambient temperature. ▶

PART I—DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 8—ICE PROTECTION SYSTEMS

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1 General description

The ice-protection systems prevent the formation of ice round the engine air-intakes and intake cowlings, the cabin and radio bay air-intakes, the windscreen and the pressure heads. Anti-icing of all the air-intakes is under the control of two ganged switches, but the windscreen and the pressure heads each have their own switch. All three switches are on the starboard switch panel in the pilot's cockpit. Ice protection for the engine air-intakes and cowlings is provided by hot air tapped from the engines HP compressors. The cabin and radio bay air-intakes, the windscreen and pressure heads are provided with electric heating elements. Indication of icing conditions is provided by a magnetic indicator.

2 Ice detector

(*a*) Pre-mod. 630 the ice detector comprises a resistance bulb, in the nosewheel door, which measures temperature, and a detector head (two bulbs) under the nose forward of the door, which measures humidity. A control unit receives these signals and, in icing conditions, energises a relay to supply DC to an ICE magnetic indicator, on the instrument panel starboard shroud. The indicator shows ICE when energised and is black at other times. The DC supply, from the normal busbar, is through an ICE DETECTOR ON/OFF switch on the starboard switch panel and also through an airspeed switch which closes at 145 knots and opens at 115 knots. A TEST ON/AUTO/TEST OFF switch, also on the starboard switch panel, is spring-returned to the AUTO position. To test the system, selecting TEST ON simulates icing conditions and the warning should be given. TEST OFF should be selected before allowing the switch to return to AUTO.

(*b*) Post-mod. 630 the ice detector is an electrically-driven rotor and a knife edge, on the port side of the folding nose door. Onset of icing increases the power required to turn the rotor and the increased torque moves the motor in its housing and makes two contacts. These complete the supply to the magnetic indicator which then shows ICE. The installation is controlled by the ICE DETECTOR—ON/OFF switch on the starboard switch panel. DC for the indicator is supplied from the normal busbar; AC is supplied from the port 200v busbar.

3 Air-intakes (engine)

(*a*) The system for each engine is similar. Twelfth-stage air is supplied via two solenoid-operated control/pressure reducing valves, in parallel, to the inlet guide vanes, the engine nose fairing and the intake cowling before being discharged overboard. A small proportion from the intake cowling is vented through the engine.

(*b*) The system is controlled by two ENGINE ANTI-ICE, No. 1 VALVES and No. 2 VALVES—ON/OFF ganged switches, on the starboard switch panel; each switch controls two valves, one on each engine. With DC available and the switches selected ON, the pressure regulating valves are energised (open). Located in the duct downstream of the regulating valves are a low-pressure switch and a high-pressure switch. When the pressure in the duct rises above 5 PSI, the low-pressure switch contacts close and an associated ENG ANTI-ICE magnetic indicator, on the instrument panel starboard shroud, changes from cross-hatched to ON. If any regulating valve fails and the duct pressure exceeds 65 PSI, the high pressure switch contacts open and the magnetic indicator shows O/P (over pressure). ◀Should this occur one valve, normally No. 2, must be▶ switched off to prevent over-stressing of the duct.

(*c*) To permit testing port and starboard engine regulating valves after starting the engines, an ENGINE ANTI-ICE TEST, PORT/STBD switch is provided on the starboard wall, aft of the switch panel. Selection of the switch indicates, on the ENG ANTI-ICE magnetic indicator, the position of the port or starboard pressure regulating valves respectively and these may be operated via the No. 1 VALVES and No. 2 VALVES switches, with at least 90% HP RPM (temperate conditions). After take-off, the operation of the circuit protection relays (Chapter 1) bypass the test switch; in flight, therefore, failure of any regulating valve to close is shown on the magnetic indicator, irrespective of the position of the test switch.

4 Cabin and radio bay air-intakes

The cabin air-intake, located below the starboard engine nacelle and adjacent to the bodyside, and the radio bay air-intake, in the dorsal fin, are provided with spraymat heating elements. These elements are each controlled by an integral thermostatic switch. The 115V single-phase AC and 28V DC supplies are routed through a relay, operated by contacts of an airspeed contactor, which close at 145 knots and open again at 115 knots. The DC supply is also routed through the engine anti-icing No. 1 valves switch and, providing this switch is selected on, the spraymats are automatically controlled.

5 Windscreen

The windscreen is provided with gold film AC heating elements between the laminations, for anti-icing and demisting purposes. The temperature of the windscreen is controlled by two integral sensing elements which operate in conjunction with a temperature control unit. One element signals temperature variations to the control unit which controls the temperature at 50°C at the windscreen, providing a WINDSCREEN HEATING—ON/OFF switch is ON. If a short circuit fault causes a failure of this element, an overheat sensing element operates at 65°C ± 5°C. The power requirements are 200V AC and DC from the normal busbar. When there is no DC to the system, a W/S DE-ICING magnetic indicator, on the instrument panel starboard shroud, shows cross-hatched. The indicator shows NORM when the system is operating normally, but if the overheat sensing element operates, the magnetic indicator changes to O/H.

NOTE: Full voltage cannot be applied to the heating elements until the circuit protection relays are operated when the aircraft becomes airborne.

6 Pressure heads and ADD probe

Two pressure heads, one for the air-data system and the other for the standby capsule-type instruments, the flying controls artificial-feel simulator and the deck landing ASI each have electric heating elements. The elements are controlled by a PRESSURE HEADS—ON/OFF switch on the pilot's starboard switch panel. This switch also controls the heating element in the ADD probe, on the starboard side of the folding nose.

Normal Operation

7 Management of the engine anti-icing systems

(*a*) *After starting the engines*

Anti-icing should be switched on if the dry bulb temp-ature is below +8°C and the wet bulb temperature is below +4°C. If the wet bulb temperature is not known it should be switched on if the ambient temperature is below +10°C and if visible moisture in the form of rain, sleet, snow etc. reduces horizontal visibility to less than 1,000 yds.

(*b*) *Climb*

Climb as rapidly as possible and leave anti-icing switched on for one minute after reaching clear air.

(*c*) *Level flight or descent*

Switch on both switches. Maintain not less than 0·8M and engine speeds above 80% RPM if icing persists for more than 5 minutes.

PART I—DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 9—FLYING CONTROLS AND AUTOPILOT SYSTEMS

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1 General description

(*a*) The flying controls can be divided into two groups, the main control surfaces and trimmers, i.e. ailerons, tailplane and rudder, and the auxiliary control surfaces comprising mainplane flaps, aileron droop and tailplane flap, and the airbrakes. The main surfaces are operated by powered flying control units, supplied from both flying controls hydraulic systems, and are controlled by either a mechanical input from the pilot or an electrical input from the autopilot system. In the latter case, safeguards are incorporated which isolate the system if malfunctioning occurs.

(*b*) Short period autostabilisation is provided in pitch, roll and yaw. The pitch channel has a single gearing, and the yaw and roll channels have two gearings, approach and high speed. The autostabiliser is normally in permanent use. A standby yaw damper system is also provided, but this should not be used when the normal autostabilisation yaw channel is in use.

(*c*) The autopilot has height, Mach, and heading locks, but the heading facility is only available if the height or Mach channels are engaged.

(*d*) A boundary layer control system is incorporated to give increased lift and control at low speed. Air from the engine bleed system is directed over the inner and outer planes, mainplane flaps, ailerons and under the tailplane. To give feel to the controls, spring boxes are incorporated in the control linkages. Additional feel, relative to airspeed, is provided for the rudder and tailplane controls by hydraulic feel simulator units controlled by pitot pressure. Trimming is by electric actuators which act on the linkages between the controls (control column and rudder pedals) and the control units. Both ailerons can be drooped, for use as additional flaps, while still maintaining normal differential control; the change in trim is approximately balanced by a tailplane flap which moves upwards. Aileron droop and tailplane flap are selected by the same lever. The tailplane flap is electrically selected and actuated; the aileron droop is selected electrically but hydraulic operation of the PFCU's droop the ailerons. With the blowing system switch set to AUTO, the boundary layer control comes on before the aileron droop reaches 5°. Mainplane flaps and airbrakes are provided and both are powered by the General Services hydraulic system. The control lever for the mainplane flap is angled towards, and has the same angular movement as, the aileron droop lever so that both levers may be used as one, when required.

Main Control Surfaces

2 Powered flying control units (PFCU)

Each PFCU consists of a tandem jack, two rotary control valves and an electric actuator. Each half of the jack is fed from the port or starboard flying controls hydraulic system, as appropriate, through its respective control valve. The control valves can be manually operated by the pilot's conventional controls or, electrically by the actuator, on signals from the autopilot system.

3 PFCU operation

(*a*) *Manual demand*
A control demand made by the pilot is taken, mechanically, to the control valves which open to admit fluid to the appropriate side of the jacks; movement of the jack then drives the associated control surface. A mechanical follow-up movement closes the valve when the correct control surface position is reached.

(*b*) *Autostabiliser system demand*
A signal from the autostabiliser system is taken electrically to the actuator, which then moves the control valves. Although the mechanical follow-up movement is still operative, an electrical feed-back is also provided to control the position of the actuator.

(*c*) *Autopilot system demand*
A control demand made by the autopilot system is taken electrically to the actuator which, in turn, moves the control valves. In the autopilot mode, the mechanical follow-up is inoperative and an additional electrical feed-back is provided to control the position at which the actuator returns to neutral and closes the control valves.

4 Artificial feel

(*a*) To provide feel during application of aileron, tailplane, or rudder, double-acting spring units are incorporated in the control linkages to the control valves of the PFCU. As the pilot's controls are displaced from the neutral position an increased force is required to overcome the springs.

(*b*) To give additional feel relative to airspeed, for the rudder and tailplane only, a hydraulically-operated feel unit is incorporated in each of their control runs. This unit comprises a feel simulator control and hydraulic jack. The feel simulator control meters fluid to the jack under the control of pitot pressure, so that movement of the jack resists the pilot's control movements. The resistant force increases in proportion to the square of the speed. To give additional resistance to control movement from neutral, on the ground, the feel simulator control passes a datum pressure even where there is no pitot pressure.

5 Rudder and aileron trim

(*a*) Trimming of the rudder and ailerons is effected by two actuators, one connected to each control system by a lever and a double-acting spring link (para. 4 (*a*)). By altering the position of the spring link lever, the neutral position of each control can be moved, to give the necessary trim. Pre-mod 1045 the available rudder trim is $\pm$ 5°; post-mod 1045 the available trim is $\pm$ 8°.

(*b*) The actuators are controlled by a RUDDER/AILERON TRIM control on the port console. Rotary movement of the control operates two micro-switches controlling the rudder trim actuator and lateral movement operates the two switches controlling aileron trim. The control is spring-loaded to the central position. Simultaneous operation of both trimmers is not possible.

(*c*) The rudder and aileron trim indicators are on the port console, forward of the throttles. The rudder indicator shows a plan representation of the aircraft relative to the fore-and-aft axis, and the aileron indicator shows a pictorial representation of the aircraft (in roll) relative to the horizon. When mod 1177 is embodied, a bridge piece on the indicator is engraved from 0° to 5° on either side of centre (pre-mod 1045) or from 0° to 8° on either side of centre (post-mod 1045).

6 Tailplane and tailplane trim

(*a*) (i) The incidence of the all-moving tailplane is varied through a maximum range of 28° by combined movement of the control column and a datum-shift trimmer. Its position is shown on a TAILPLANE indicator on the port ◀console which has markings every two degrees (one degree post-mod 1208) from 8° NOSE DOWN to 20° NOSE UP. Note that the NOSE UP and NOSE DOWN markings refer to aircraft attitude and not tailplane incidence. A yellow sector (pre-mod 1208) between 2° and 4° nose up indicates the nominal take-off limits. When mod 1199 is embodied, a pointer is attached to the inboard edges of the tailplane and the fin is marked from 0 to 8½ so that an accurate check of the tailplane trim setting can▶ be made externally.

The authority of the control column is dependent upon the trim applied; the relationship is shown below:

Total movement of tailplane — 8° nose down to 20° nose up.

Total movement by control column (with 4° nose up) — 12° nose down to 10° nose up.

Total movement of trimmer — 4° nose down to 13° nose up (pre-mod. 1123).

It follows that if the tailplane is trimmed to 13° nose up and the control surface can only move to 20° nose up, then the available nose up control column authority is $20° - 13° = 7°$. Similarly, if the tailplane is trimmed to 4° nose down, then the available nose down control-column authority is $8° - 4° = 4°$.

NOTE: With the control column in the neutral (no force) position, the applied trim is shown on the indicator.

(ii) When mod. 1123 is embodied, although tailplane movement remains the same the maximum nose up tailplane trim is reduced from 13° to 9°. Hence, if the tailplane is trimmed to 9° nose up, then the available nose-up control-column authority is $20° - 9° = 11°$.

(*b*) The tailplane is trimmed by the datum-shift method in which a twin-motor actuator, connected to the control run, varies the tailplane angle without moving the control column, i.e., the neutral (no force) position of the control column, indicated by a pointer on the control column slide, is constant irrespective of the trim applied. The normal motor in the trim actuator is controlled by fore-and-aft movement of four single-pole linked switches on the control column. The integrity of circuits can be tested by pulling out the outer actuating lever and then operating each lever independently; the actuator should not run.

(*c*) The auxiliary motor in the trim actuator is controlled by a STANDBY TAILPLANE TRIM—NOSE UP/NOSE DOWN double-pole switch on the port console. The DC supply to this switch is from the emergency busbar.

7 Aileron gear-change unit

An aileron gear-change unit, incorporated in the aileron control run to the PFCU, is controlled by an AILERON GEAR CHANGE—PULL FOR LOW SPEED control on the starboard console. When in the normal (down) position, aileron movement is restricted by control stops and the maximum permissible aileron travel of ± 12½° is obtained by approximately ± 25° of stick movement. When pulled up for low speed flight, full aileron travel of ± 17½° is obtained with the same stick movement.

Autopilot System

8 Autopilot system, general

(*a*) (i) The autopilot system is fully integrated with the flying control system. It provides short period autostabilisation of the aircraft in the pitch, roll and yaw axes (autostabilisation—manual mode) and this facility is normally in operation at all times, thus augmenting the aircraft's natural stability. To provide stability if the yaw channel fails, a yaw damper, not normally in operation, is provided (see para. 12).

(ii) The system also provides, in the autopilot mode, Mach and heading locks, a barometric height lock and radio monitoring of the height lock. Radio monitoring is at present inoperative.

(*b*) *Safety devices*

Four safety devices, one manual and three automatic, are provided to prevent autopilot run-away causing aircraft structural failure; operation of any safety device gives an AP warning on the SWP. The manual device is an instinctive cut-out button on the control column; automatic protection is provided by limit switches on the tailplane and aileron. Tailplane runaway is limited to + ¾° to minus 1½° and aileron runaway is limited to ± 2°; in addition single aileron runaway is prevented by two differential limit switches. If any of the safety devices operate, both autopilot and autostabiliser modes will be disengaged.

9 Autopilot computer

(*a*) The autopilot computer is the heart of the autopilot system and its function is to effect all data storage and, after computation, to make the necessary switching required for the autostabilisation and autopilot modes, thus controlling the PFCU actuators. The power requirements are 28V DC from the normal busbar and 3-phase AC from the 200V busbars.

(*b*) The computer receives data from the following sources:—

Air-data system
MRG
Compass
Radio altimeter

10 Autostabilisation

(*a*) In this mode, three rate gyros, one each for the pitch, roll and yaw channels are employed. Signals produced by angular rate of movement are fed to a computer, where they are amplified and then fed to the actuators of the PFCU, as appropriate, to move the control surfaces. As the control surface movement required is dependent on airspeed, provision is made for pilot selection of either high or low-speed gearings in the yaw and roll channels. The normal flying controls remain operative when the autostabiliser channels are engaged.

(*b*) Channel selection is made from a panel under the instrument panel shroud, starboard side, containing three switches, one each for the YAW, ROLL and PITCH channels; the switches have three positions, APPROACH/OFF/HIGH SPEED. Providing the adjacent ICO RESET pushbutton has been pressed, operation of the autostabiliser channel selectors engage their respective channels, except in the case of the pitch channel where switching to either HIGH SPEED or APPROACH engages the one pitch gearing available. The channels are disengaged automatically if the ICO pushbutton on the control column is pressed.

11 Autopilot

(*a*) The autopilot mode provides three facilities additional to autostabilisation, namely height lock (barometric) or Mach lock and heading lock. Switching from Mach lock to height lock mode or vice versa with the autopilot engaged is not effective; if such changes of mode are desired, the autopilot must be disengaged and the required mode selected before the autopilot is re-engaged. The selection of heading lock can only be made after engagement of the autopilot in either height lock or Mach lock modes. Upon engagement of the heading lock mode, the roll and yaw autostabiliser HIGH SPEED channels automatically become operative irrespective of the autostabiliser channel selector position; as does the autostabiliser pitch channel when either height lock or Mach lock modes are engaged.

(*b*) The autopilot mode selector switch, ICO reset push-button and a magnetic indicator are on the instrument panel starboard shroud. In addition, two toggle switches and a pushbutton switch are on the engine control box, and two further pushbutton switches are on the control column. The function of the switches is as follows:

Starboard shroud

ICO RESET pushbutton ...	Used as a power switch for the whole system and is also used to clear autopilot warnings on the SWP. In addition, it is used to re-energise the circuits after operation of the instinctive cut-out or after operation of any of the automatic safety cut-outs.
AUTOPILOT mode switch Selecting: OFF MACH BARO } HEIGHT RADIO } HEIGHT	Used as an ON/OFF switch for the autopilot mode. Also used for selecting the Mach lock, barometric height lock or barometric height lock plus radio altimeter monitoring of the height lock. NOTE: The RADIO position is inoperative.
AUTOPILOT magnetic indicator	Shows OFF when the autopilot mode switch is at OFF, RDY when a channel is selected, and ENG when the autopilot engage switch is operated.

Port console

AUTOPILOT ENGAGE pushbutton	To engage the autopilot mode after appropriate selection of the autopilot mode switch.
AUTOPILOT HEADING ON/OFF switch	To engage the heading lock.
HEIGHT TRIM DOWN/UP switch	Used to make small adjustments to height when flying ◀with the barometric height lock engaged (post-mod 1287). At high altitude its accuracy is poor. ▶

NOTE: Slowly turning the heading knob on the navigation display changes the heading hold datum and therefore the aircraft heading.

Control column	
I/CUT OUT pushbutton ...	Instinctive cut-out for disengaging the whole autopilot system, including the autostabilisers.
◀DISENGAGE trigger switch (the lower trigger on the front of the control column)	To disengage the autopilot mode, but not the autostabilisers. ▶

12 Yaw damper

A yaw damper is provided to improve damping of the lateral and directional oscillations of the aircraft when the autostabiliser yaw channel is inoperative*. An electro-hydraulic actuator, attached to the rudder control run, is controlled by a rate gyro which detects any change in rate of yaw and transmits a signal to the actuator via an amplifier. The actuator moves the rudder controls, applying a force in opposition to the oscillation. The yaw damper is controlled by a YAW DAMPER—ON/OFF switch on the starboard shroud panel, adjacent to the autostabiliser switches. The power requirements are DC from the normal busbar and AC from the 200V busbar.

*There is no yaw channel failure warning, and it is extremely difficult to detect a failure on the ground.

Auxiliary Control Surfaces

13 Mainplane flaps, normal control and operation

The mainplane flaps are each operated by a single jack, powered from the normal side of the general services hydraulic system. The flaps are synchronised by mechanically linking the port jack selector slide valve to the starboard jack. Pressure is applied continuously to the down side of the jacks and upward movement is made possible by the use of differential piston areas in the jacks. Flap selection is by a FLAPS—UP/TAKE-OFF/DOWN switch, on the port control panel, which is additionally marked 0°, 15°, 30° and 45°. Each switch contact is connected to a corresponding contact on a drum switch which is linked to the starboard flap to ensure a follow-up movement. When a down selection is made, the drum switch makes the circuit to the down solenoid and the selector valve opens to connect the up side of the starboard jack to return. The continuous pressure on the down side of the jack piston moves the jack and the jack linkage rotates the drum switch to the correct position. When the selected movement has taken place, the contact is broken and the selector valve closes, stopping further movement of the jack. At the same time, the mechanical connection to the port jack selector slide valve completes a similar operation. When an up selection is made the up solenoid is energised and this directs fluid to the up side of the jack pistons. Due to the larger piston area on this side, the pressure overcomes the continuous pressure on the down side and upward movement takes place.

14 Mainplane flaps, standby control and operation

(*a*) If the normal side of the general services hydraulic system fails, or the normal selector is inoperative due to a DC power failure, the flaps can be lowered once only by using a FLAPS—OFF/DOWN switch on the standby control panel. A DOWN selection on this switch energises the emergency selector valve, which directs fluid from the emergency side of the general services hydraulic system, to the down side of the starboard jack and to a release valve. The release valve, in moving, opens the up side of the starboard jack to return, allowing the continuous pressure on the down side of the piston to move it down. As the jack moves, the mechanical linkage to the port selector valve selects down for that jack and the emergency pressure moves the jack down.

(*b*) If, with the flaps down or at an intermediate position, the General Services control valves go to the neutral position, flap creep could occur. To prevent this, any movement of the port flap slide valve closes a micro-switch which automatically switches the system to emergency, thus providing hydraulic power to lock the flaps.

15 Airbrakes, normal control and operation

(*a*) The airbrakes consist of two petals which are hinged at their forward end and extend byond the rear fuselage, forming a tail cone when closed. The brakes are hydraulically-operated by power from the normal side of the General Services hydraulic system, and solenoids of a selector which control a single jack are energised by selection of an AIRBRAKES—IN/OUT switch on the starboard throttle lever handle. Intermediate positions between in and out are obtained by releasing the switch which is spring-loaded to the centre (off) position. If it is desired to retract the airbrakes fully, the switch can be moved past the IN position, in which case the spring return is overridden. The position of the airbrakes is shown on an AIR-BRAKES indicator on the instrument panel. When the airbrakes are in, a black disc is displayed, but as the air-brakes are extended, an orange coloured sector of an equivalent angle to the airbrakes is displayed.

(*b*) When OUT is selected, the out solenoid in the selector valve is energised and fluid is fed to the jack which, in moving, extends the airbrakes to a maximum of 144°. An IN selection energises the in solenoid of the selector valve which directs fluid to the in side of the jack, retracting the airbrakes.

(*c*) Two microswitches in the control circuits are normally closed. Inserting a safety pin in a hole in the starboard side of the rear fuselage, just forward of the airbrakes, opens these microswitches and prevents airbrake operation. This safety pin is a ground equipment item.

16 Airbrakes, standby control and operation

If the normal side of the General Services hydraulic system, or the normal selector fails, the airbrakes can be operated in both directions by an AIRBRAKES STAND-BY — IN/OFF/OUT pull-to-unlock switch on the port control panel. The switch is spring-returned to OFF from the OUT position. Selecting IN or OUT on this switch has the same effect as the normal selector, but in this case power from the emergency side of the general services hydraulic system is directed through an emergency selector valve and shuttle valves. In addition to operating the jack, the emergency fluid is fed to a release valve to open the normal lines to return. The valve must be reset on the ground before the normal selector is again operative, but the General Services system reverts to normal once the airbrakes are in.

17 Aileron droop, normal control and operation

(*a*) Drooping of the ailerons and the compensating upward movement of the tailplane flap is controlled by a single AILERON DROOP — UP/TAKE-OFF/DOWN selector switch, on the port control panel. The switch quadrant has four additional markings, 0°, 10°, 20°

(TAKE-OFF) and 25° (DOWN). The switch controls the main motor in each of two actuators, one for the ailerons and the other for the tailplane flap. The ailerons actuator moves the control valves in the aileron PFCU and the ailerons themselves are therefore moved hydraulically; the tailplane flap actuator, however, directly moves the flap. Angular movement of each surface is synchronised and this movement is indicated by AIL DROOP and TAILPLANE FLAP indicators, on the instrument panel shroud, port side.

(*b*) When aileron droop is selected it is possible for an electrical fault to prevent initial starting of either actuator. If malfunctioning occurs it is recommended that the normal selector be left in its selected position and the appropriate standby switch used immediately. Once either standby switch has been used, the normal selector is inoperative until the reset button is pushed.

WARNING: The aileron droop and tailplane flap indicators must be carefully monitored during all selections to ensure that both surfaces are operating simultaneously.

NOTE: When the ailerons are being returned to 0° (NORMAL) from any drooped position, the aileron droop and tailplane flap indicators may show a difference of up to 6° whilst travelling.

18 Aileron droop, standby control

If, due to failure of the selector or an actuator main motor, a normal selection of aileron droop and tailplane flap cannot be made, the second motor in each actuator can be controlled separately by a TAILPLANE FLAP—IN/OFF/OUT switch and an AILERON DROOP—UP/OFF/DOWN switch, as appropriate. Operation of either of these switches, which are mounted in adjacent positions on the standby control panel, isolates the DC supply from the normal control circuit, ensuring that conflicting selections cannot be made. To restore the supply to the main motors after testing the standby motors, an AILERON DROOP AND T/P FLAP RESET pushbutton, at the aft end of the port console, must be pressed.

Normal Operation

19 Management of the autopilot system

(*a*) *Before flight*

With the engines running and with hydraulic, AC and DC power available operate the ICO reset button and confirm the SWP warning clears. Engage the autostabilisation mode in the gearing required. Carry out the functional checks listed in the Flight Reference Cards.

(*b*) *General*

(i) In all modes the rate of application of bank must not exceed 10°/sec.

(ii) Tailplane trim must not be used in turns.

(iii) Longitudinal trim must be maintained within $\pm\frac{1}{4}°$ using markings on the control column slide.

(iv) The autopilot may be cut out by:
Switching off the autopilot mode selector
Using the AP trigger on the control column
Using the ICO button (autostability also cuts out)

(*c*) *Climb and descent* (*MACH*)

Select 'MACH'— MI shows RDY
Trim the aircraft in the climb between 0·7M and 0·85M (above 260 knots, 275 knots with underwing tanks). Note that regular trimming will be required to maintain the longitudinal trim within $\pm\frac{1}{4}°$ otherwise the autopilot will cut out.
Max. altitude 35,000 ft.
Max. bank angle 30°.

(*d*) *Height hold* (*BARO*)

Select BARO — MI shows RDY
Trim the aircraft in level flight between 0·7M and 0·85M (above 260 knots, 275 knots with underwing tanks). Engage the autopilot above 4,000 ft. (400 ft. VMC by day over sea) — MI shows ENG.
Max. altitude 35,000 ft.
Max. bank angle 30° (above 25,000 ft. gentle turns only).
Speed variation should not exceed ± 30 knots.
Autopilot should be disengaged for turns below 1,000 ft. except for minor turns up to 10° bank.

(*e*) *Heading hold*

Align the heading pointer with the aircraft heading.
Confirm MACH or BARO selected.
Engage heading hold using engaging switch on throttle box.

Turns. In the heading hold turns are made by rotating the compass heading pointer. To avoid exceeding 10° bank/sec. initial selection of tbe pointer should be slow until the max. bank angle of 22½° is achieved.

(*f*) *Checks before landing*

(i) Disengage the autopilot.

(ii) Select the autostabiliser switches to APPROACH.

(*g*) *After landing*

Switch off all switches if applicable.

Malfunctioning

20 Autopilot malfnnctions

(*a*) If a mild restriction to tailplane or aileron control movement is experienced after disengaging the autopilot, apply one or two sharp movements of the appropriate control in each direction over about one third of the control travel. If this is impracticable, switch the appropriate autostabiliser OFF; if the restriction is then removed, return the autostabiliser switch to its original position. The autopilot must not be re-engaged.

(*b*) If the control restriction cannot be removed or if locking of the tailplane or aileron control occurs after disengaging the autopilot, press the ICO button. Do not re-engage the autostabilisers or the autopilot.

PART I—DESCRIPTION AND MANAGEMENT OF SYSTEMS

CHAPTER 10—FLIGHT INSTRUMENTS
(Completely revised by AL9)

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Integrated Flight Instrument System

IFIS—General

1. The IFIS consists of an air data system, a master reference gyro system and attitude indicator, and a navigation display system. The IFIS provides the crew members with flight and navigational information, it also forms the main source of information for other user equipments in the inte-

grated weapons system. The system operates on 115v AC and 28v DC.

Air Data System

2. The air data system provides information regarding the speed of the aircraft and the atmosphere through which it is flying. It involves centralised measurement, computation, correction and electrical transmission to the servo-operated presentation units and to other equipment. The system comprises the following main units:

Pitot/static transducer

Static transducer

Height-lock transducer

Air data computer

ADC power supply unit

Height and vertical speed display

IAS and Mach number indicator (speed display)

Height and TAS display

Transducers

3. (*a*) A pressure head under the port mainplane supplies pitot and/or static pressure to transducers, each consisting of a capsule unit and a servo-operated gearbox. The transducers convert the pressure signals into electrical signals which are routed as required.

(*b*) *Pitot/Static Transducer*. Pitot and static pressures are fed to the pitot/static transducer which converts them into two electrical outputs. One signal is fed straight through the computer and drives the IAS indicator, and the other is a factor of the Mach number output. The transducer does not start transmitting until 65–70 knots is reached.

(*c*) *Static Transducer*. Static pressure is fed to the static transducer which converts it into three electrical outputs. Two of these outputs are representative of height, but one is more sensitive than the other and is fed straight through the computer, to drive the height sections of the height and vertical speed display and the height and TAS display in the pilot's and observer's cockpits, respectively. In the computer the less sensitive output is differentiated with respect to time and the resultant fed to the vertical speed indicator. The third output, after suitable processing, is used to operate the Mach number indicator and, after further processing by signal from an air temperature sensor, to drive the TAS section of the height and TAS display.

(*d*) *Height Lock Transducer*. The height lock transducer receives static pressure and, although receiving its power supplies from the air data system, its electrical output is fed solely to the autopilot.

Air Data Computer (ADC)

4. The air data computer comprises a number of servo units, each of which instantly resolves a mathematical equation when the initial value of any variable is changed. In addition to providing the data for presentation on the flight instruments, the computer also provides basic data for the strike sight, autopilot and Doppler navigation system. The computer provides a DC supply to an undercarriage warning light on the instrument panel when the Mach number is below 0·25M with the nosewheel locked up.

ADC Power Unit

5. AC and DC for operating the computer, the air thermometer and the transducers, is supplied by the ADC power unit. The unit is itself supplied with AC from the 115V busbar.

Integrated Instrument Display

6. The information provided by the ADC and the transducers is displayed on three instruments, each instrument presenting two readings. The indicators (sub paras (*a*) and (*b*)) are on the pilot's panel; the indicator (sub para (*c*)) is on the observer's panel.

(*a*) IAS *and Mach Number*. The speed display of IAS and Mach number is read horizontally. A single moving pointer is used for both scales; the IAS scale is fixed and the Mach number scale moveable in order to relate IAS to Mach number.

(b) *Height and Vertical Speed.* The height and vertical speed display comprises two units, one above the other. The lower unit indicates rate of climb and descent between 0 and 6,000 ft/min on a conventional indicator. The unit will accept uncalibrated rates of change up to 60,000 ft/min. The upper unit displays height on a three-digit counter, plus dial and single pointer presentation. One revolution of the pointer indicates 1,000 ft. The counters are visible through apertures in the dial and indicate every 100 ft, with a cross-hatched display on the left-hand counter below 10,000 ft. A millibar counter setting knob is below the dial. An amber disc in an aperture at the top of the height dial is illuminated to indicate power failure to both units. The disc is normally covered by a black shutter.

(c) *Height and* TAS *Display.* The height and TAS display in the observer's cockpit presents the information on two vertical moving tapes, each of which is read against a fixed index.

MRG and Navigation Display Systems

7. The MRG and navigation display systems together provide information of heading and attitude of the aircraft. The following are the main units:

Master reference gyro system
Detector Unit
Navigation display amplifier
Attitude indicator
Navigation display
Navigation display repeater

Master Reference Gyro Mk 1 System—General

8. The MRG Mk 1 feeds electrical signals which are representative of flight attitude and heading to the attitude indicator, compass system and other user equipment. It consists basically of a servo-operated gyro stabilised platform carrying a vertical and an azimuth gyro. To maintain the vertical gyro spin axis to the earth's vertical, gravity-seeking mercury switches are used to control torque motors which precess the gyro back to the vertical. To limit the effects of acceleration, the erection signals are cut off when a predetermined acceleration is reached. The azimuth gyro spin

axis is maintained relative to the magnetic North by monitoring signals from the detector unit. Monitoring is cut off if DG is selected on the navigation display or when flight accelerations and attitudes would cause erroneous signals from the detector unit.

9. The starting cycle operates as soon as DC is available and the 115v AC busbar is live. For the first 3 seconds the platforms are set rapidly to their datum positions and for the next 17 seconds fast erection of the earth gyro takes place. At the end of this period the MRG is erected to within 1° of its datum.

WARNING: If it is necessary to disconnect the AC or DC supply within 4 minutes of it being switched on, a period of 4 minutes must elapse before it is again switched on or damage to the MRG will result.

10. To allow the MRG to be switched off, while other servicing which requires an AC supply is carried out, an MRG—ON/OFF switch is fitted in the radio bay. If, during cockpit checks, the power failure disc in the attitude indicator is still showing, the position of this switch should be checked.

Master Reference Gyro Mk 2 System—General

11. The MRG Mk 2 system incorporates the following units:

(*a*) Master reference gyro, comprising:

(1) Gyro reference unit (GRU).

(2) Electronic unit (EU).

(*b*) Heading servo-repeater unit (HSRU).

(c) Latitude resolver unit (LRU).

12. The MRG provides pitch, roll and heading information. Signals are fed from the GRU to the EU, the attitude signals being relayed to the attitude indicator and other user equipment, via a junction box, and the heading signals to the navigation display and other user equipment via the HSRU. 115v AC and 28v DC operate the system. To allow the MRG to be switched off, while other servicing which requires an AC supply is performed, an IFIS isolation switch is in the

radio bay. If during cockpit checks the power failure disc in the attitude indicator is still showing, the position of this switch should be checked.

13. *Gyro Reference Unit*. The GRU contains two low-drift directional gyro units mounted in servoed pitch and roll gimbals. The gyro erection cycle lasts a maximum of 3 minutes at the end of which the gyros are inertially stable and the platform is within 0·25° of vertical. During periods of power failure of up to two minutes the coasting gyros remain inertially stable thus when the system is re-energised the roll, pitch and heading servos resume their correct positions and the system does not need re-orientation. During aircraft manoeuvres platform re-erection to a false datum is prevented by cutting back the erection rate.

14. *Electronic Unit*. The EU provides the switching and controlling devices for starting and energising the GRU, gimbal control, gyro precession signals and the transmission of heading information.

15. *Heading Servo—Repeater Unit*. The HSRU receives heading information from the EU and provides a number of heading outputs for transmission to other user equipment. Provision is made for the heading outputs to be slewed to some external reference for alignment, e.g. ship's heading.

16. *Latitude Resolver Unit*. The LRU converts manually set latitude information into electrical signals that represent the local vertical and horizontal components of the earth's rate for any set latitude angle. These signals are fed into the EU to provide correction to both azimuth and vertical outputs. The LRU must be updated for any change of latitude. The unit is on the port wall in the observer's cockpit and has the following controls:

(a) *Hemisphere Switch*. Marked PRESS TO RELEASE —NORTH/SOUTH, it is used to select the appropriate hemisphere.

(b) *Latitude Selector*. A rotary selector marked in minutes of latitude, MIN from 0 to 60. One revolution of the control changes the DEGREES indication in two adjacent windows.

Detector Unit

17. The detector unit is in the starboard wing tip. It measures the horizontal component of the earth's magnetic field and its outputs are fed to the navigation display on the instrument panel. The output signals are compared with the compass card position and are resolved as one signal which represents the card misalignment. This signal is amplified by the navigation display amplifier and fed:

(*a*) MRG *Mk* 1. To precess the azimuth signal which then returns a signal to move the compass card until the misalignment signal is nulled.

(*b*) MRG *Mk* 2. To the EU. Here it corrects the heading output to the HSRU and hence the HSRU heading output to the navigation display, thus nulling the misalignment signal. This facility only operates when COMP is selected on the navigation display.

Attitude Indicator

18. The attitude indicator is operated by signals from the MRG. Bank and elevation angles are indicated throughout 360° of roll and pitch. The display consists of a roller blind on a rotatable carriage, the latter being parallel to the face of the instrument. The blind is half white and half black, the dividing line representing the natural horizon. A black star (zenith) and a white star (nadir) on the blind each has a long tail which normally indicates the direction of the horizon. On the blind there are marks to show elevation at 10° intervals. The marks for 10, 30, 50 and 70° are of equal length. The marks for 20, 40, 60 and 80° are of progressively increasing length. With changes in pitch the blind is driven up or down relative to the glass of the instrument. The carriage is rotated to maintain the bank pointer, which is attached to the carriage, vertical; movement of the case thus representing bank angles. A zero bank reference and 10, 20, 30, 60 and 90° in both senses are indicated at the bottom of the bezel. A zero datum mark and an aircraft symbol are on the centre of the glass. A ball-type slip indicator is at the top of the instrument.

19. A translucent orange disc bearing two white arrows is covered by a black flag when the normal power supplies are connected. If either an AC or DC failure occurs, the

black flag moves, revealing the arrows, one of which points to the navigation display as there is no separate power failure warning for that instrument. A fault in the elevation circuit causes full nose-down attitude to be indicated. A fault in the bank circuit causes the roller blind to rotate clockwise at about 40 RPM.

20. The flight director system assists the pilot to maintain a predetermined flight plan. The index bead indicates deviation from the desired flying conditions and gives direct indications of the control action required to correct such deviation. The bead is mounted on two wires, one stretched horizontally and the other vertically across the display, in front of the roller blind. In this installation it is used to display UHF homer information and only the horizontal director is used.

21. An ATTITUDE FAST ERECTION — ON/OFF switch for the MRG is to port of the flight instruments display. The switch must not be operated when the aircraft is in an attitude other than level flight or is accelerating or decelerating, otherwise errors will be introduced by the gyros tending to erect to false verticals. Fast erection rates are:

MRG Mk 1	10° in 11 to 14 seconds
MRG Mk 2	10° in 30 to 60 seconds

NOTE: The fast erection switch must not be operated during the normal erection cycle, which is completed only when the orange power failure warning disc on the attitude indicator is covered by the flag.

WARNING: With the MRG Mk 2, errors of up to 10° in pitch and bank can be displayed on the attitude indicator after extended periods of high-G manoeuvres (e.g. during sessions of dive attacks on the range). The errors will be reduced slowly by the normal erection process when straight and level flight is resumed; the ATTITUDE FAST ERECTION switch should be used when large errors need correction (see para 21). Sperry Mod MRG 250 is introduced to eliminate or reduce the errors. Nevertheless, the attitude indicator should be monitored by reference to the standby artificial horizon and, if possible, the true horizon. Any discrepancy between them should be removed in straight and level flight as soon as it is discovered.

Navigation Display

22. The navigation display on the pilot's instrument panel operates in any one of four modes: COMP/ILS/TAC/DL selected by a rotary switch on the instrument. The compass functions as either a directional gyro or a gyro magnetic compass; the compass card is visible and operating in all modes. In all modes other than compass, information is presented on a roller blind behind the compass card. The blind is driven from the blank compass mode section to the section bearing the ILS or Tacan displays, and is mounted on a carriage which has complete rotational freedom. A COMPASS CARD LOCK—LOCK/FREE switch is to port of the flight instruments display; selecting LOCK prevents the compass card from indicating any heading changes.

23. *Compass Mode (COMP)*

(*a*) With COMP selected on the mode switch, the display shows only the compass card, the roller blind is blank and stationary. A COMP/DG pushbutton is to the left of the

(*continued on* FS56)

display. When DG is selected the MRG is used as a DG, a flag marked DG appears in a window below the button. When COMP is selected the DG flag is cleared and the MRG is slaved to the magnetic detector unit.

(*b*) A compass monitoring annunciator window is on the face of the instrument. With COMP selected and the compass synchronised using the COMPASS SYNC switch (MRG Mk 2) or the SYN knob on the instrument (MRG Mk 1), a dot/cross annunciator slowly oscillates in the window. If DG is selected the annunciator is rigid in the de-energised central position.

(*c*) In the event of MRG failure the COMPASS CARD LOCK switch should be selected to LOCK, the compass card will not then indicate heading changes. To allow for magnetic heading checks and correct ILS and Tacan display orientation, however, it is possible to synchronise the compass manually by use of the SYN knob (with the MRG Mk 2 the SYN knob operates *only* in the compass card locked position). The COMP/DG button must be selected to COMP for synchronisation.

(*d*) At the bottom left of the instrument is an HDG knob which, when depressed and turned, moves the heading selection pointer on the dial. With autopilot heading lock engaged, turning the knob slowly changes the heading of the aircraft. Turning the knob rapidly, breaks the heading lock.

24. *ILS Mode*. ILS is not fitted. The indicators on the instrument used with ILS, when fitted, are the BEAM and GLIDE windows, and ILS MARKERS light.

25. *Tacan*. The Tacan display shows a series of concentric arcs with a straight line passing through the origin. The origin represents the beacon or offset point (pilot's display only in TAC mode). Along the line the arcs are marked at 20 NM intervals from the origin and indicate range by the appropriate arc intersecting a fixed index at the centre of the display. Range is also repeated by veeder counters in a RANGE NM window at the top left of the display. Bearing is shown by the position of the line relative to the compass card. The end of the line nearest to the origin giving the bearing of the beacon or offset point from the aircraft. The

Tacan modes are TAC and DL. The display states for alternative mode and Tacan control selections are listed in Part I Chapter 14 FS76.

(*a*) *TAC Mode*. With TAC selected, the display indicates the aircraft's range and bearing from a point offset from the Tacan beacon. The range and bearing of the offset point from the beacon are set on the offset computer above the observer's display repeater. Direct Tacan can be received when the offset computer is set to zero. The range signal passes through the offset computer and slight errors in range may occur; these errors are eliminated by using the DL mode for direct Tacan.

(*b*) *DL Mode*. With DL selected direct range and bearing from the Tacan beacon is presented.

Navigation Display Repeater

26. The navigation display repeater, on the port console, is similar to the navigation display. The compass card follows the navigation display compass card at all times. A fixed lubber mark indicates heading against the compass card. True or grid heading is indicated by a variable arrow-head lubber and the reciprocal is indicated by a short straight pointer. The variable lubber is rotated by a variation setting control (VSC) on the front of the instrument. The applied variation or grivation is also indicated by a counter system behind two windows, one either side of the control, marked VAR/GRIV–W and VAR/GRIV–E respectively. When the VSC is set at zero the fixed and variable lubber marks are in line. The Tacan display is the same as that of the navigation display but offset Tacan cannot be received. Irrespective of the mode selected on the pilot's navigation display direct Tacan can be received on the repeater.

27. A power failure indicator is provided in the form of an illuminated yellow and white disc. The disc is normally covered by a black flag. Should the AC or DC supplies fail the flag is released and the disc exposed.

Compass Alignment (MRG Mk 1)

28. With the MRG Mk 1 system the azimuth gyro and the compass card are continuously monitored by the magnetic detector unit. Set the grivation on the repeater using the VSC knob and select COMP on the COMP/DG button.

Align the compass using the SYN knob and the annunciator, both on the pilot's display. Both compass cards now indicate magnetic heading; grid heading, as indicated by the VSC variable lubber is transmitted to other user equipment.

Compass Alignment (MRG Mk 2)

29. The compass can be aligned by several methods; four are described below:

(*a*) *Carrier-Borne* (*Ship's Heading System*). The aircraft is electrically connected to the ship's heading system through a socket in the starboard wheelbay, and a MRG ALIGN light on the observer's port console flashes when the connection is made. DG must be selected on the pilot's navigation display and the grivation set at zero on the repeater. During alignment the light is out, but comes on steady when alignment is complete and remains on until the plug in the wheelbay is removed. An automatic reset ensures that the light again flashes if the plug is re-connected.

NOTE: The compass is aligned to a grid heading.

(*b*) *Airfield Alignment* (*Known Runway Heading*)

(1) The grid heading of the runway must have been accurately surveyed before this method is used.

(2) Select DG on the navigation display and ensure that zero grivation is set on the repeater. Taxy onto the runway and align the aircraft with the runway heading using the strike sight for accuracy. Align the compasses with the runway heading using the COMPASS SYNC switch, at the rear of the pilot's port console, to slew the HSRU as appropriate.

(*c*) *Airfield Alignment* (*MRG Mk 2 Synchroniser*)

(1) The grid heading of the aircraft is accurately determined by reference to a line of known grid heading painted on the aircraft hardstanding; the heading is recorded by the ground crew for the information of the aircrew.

(2) The MRG Mk 2 synchroniser is electrically connected to the aircraft through a socket in the starboard wheelbay, and a MRG ALIGN light on the observer's port console flashes when the connection

is made. The heading of the aircraft is set on the synchroniser before alignment starts.

(3) After starting the engines and functional checks are complete, the observer checks that DG is selected on the pilot's navigation display and that zero grivation is set on the repeater; he then signals for the ground crew to switch on the synchroniser for alignment. During alignment the ALIGN light is out, but comes on steady when alignment is complete and remains on until the plug in the wheelbay is removed. An automatic reset ensures that the light again flashes if the plug is re-connected.

(*d*) *Airfield Alignment* (*Detector Unit*). To align the compass with the detector unit, the observer first sets the grivation using the VSC. The pilot selects COMP on the COMP/DG button and aligns the compass using the COMPASS SYNC switch, and the dot/cross annunciator to slew the HSRU as appropriate. When aligned the compass is continuously monitored by the detector unit while COMP is selected. For greater accuracy select DG for flight, this still gives magnetic heading on the compass cards. When the compass cards are indicating magnetic heading, grid heading is transmitted to other user equipment. If after selecting DG, grid heading is required on the compass cards the VSC must be set at zero.

NOTE 1: Adjusting the VAR/GRIV setting moves the compass cards by the amount of the adjustment. When COMP is selected re-synchronisation is achieved slowly by the gyro magnetic loop. The pilot must re-align the compass if large changes in grivation are applied.

NOTE 2: The airfield alignment described in sub para (*d*) should be considered as a standby method. The methods described in sub paras (*b*) and (*c*) are more accurate and should be used whenever possible.

Pressure Operated Instruments

Pitot/Static Systems

30. (*a*) *Nose system.* A pressure head under the port side of the fuselage nose and two external static vents, one on each side of the folding nose, supply the following:

Standby ASI Mk 18 and standby altimeter Mk 27
Tailplane and rudder artificial feel simulators
Cabin pressure controller and altitude switch

An ASI correction card is on the pilot's cockpit starboard wall.

(*b*) *Port Wing System*. A pressure head under the port wind provides pitot and static pressures to the following:

Deck landing ASI
Height-lock transducer
Static transducer
Pitot/static transducer
Airspeed switch

(Height-lock transducer, Static transducer, Pitot/static transducer, Airspeed switch: } IFIS)

(*c*) *Pressure Head Heaters*. Both pressure head heaters and the ADD system probe heater are controlled by a PRESSURE HEADS—ON/OFF switch on the starboard switch panel.

Standby Gyro Instruments

Artificial Horizon and Direction Indicator

31. A Mk 6D artificial horizon and a Type A direction indicator are on the instrument panel and are for use if the IFIS fails. The artificial horizon has a fast-erection button but this must not be used until power has been applied to the gyro for at least 30 seconds. The direction indicator has a combined fast-erection and card-setting knob. To set the card the knob is turned, but for fast erection the knob is pushed in. A blue light at the top right of the instrument comes on when the knob is pushed in, but goes out when the knob is released unless the gyro is more than 15° from datum. Both instruments are fed from a single control unit, supplied with AC from the 115v, 3-phase AC busbar, and with DC from the normal busbar. The AC supply is for operation of the gyros but, if this supply fails, changeover to an alternative supply from a transformer within the control unit is automatic. The DC supply is routed through a STANDBY SUPPLY—NORM/EMGY switch above the artificial horizon. When the switch is at NORM, the supply is from the normal DC busbar and when the switch is at EMGY, the supply is from the emergency battery. If the normal DC supply fails, the gyros continue to operate satisfactorily providing the switch is selected to EMGY within 30 seconds of the failure. To reduce running time when on the ground, the DC supply is wired so that the changeover to DC operation does not take place unless the battery master switch is on.

Standby Compass

32. A type E2B standby compass is on the centre of the windscreen frame. A light in the base of the compass provides direct lighting of the bowl. A deviation card holder is on the inboard face of the pilot's starboard console.

Airsteam Direction Detector System (ADD)

33. (*a*) The airstream direction detector system provides visual and audible indication of the aircraft's angle of attack. The system comprises a horizontal probe unit on the starboard side of the nose, a single-pointer angle of attack indicator, with OFF sector, on the port side of the instrument panel, and index lights to port of the strike sight. An audio signal is injected into the intercomm. The system is controlled by an APPROACH AID—ON/OFF switch, on the ADD controller on the cockpit port wall, and adjacent to it is a volume control. The probe has a heater element which is controlled by a thermostat and the pressure-heads heater switch.

(*b*) The system is operated by DC, supplied from the normal busbar when an ADD SUPPLY switch, adjacent to the angle of attack indicator, is at NORM. Setting the switch to EMGY. provides a supply from the emergency battery; this supply provides the audio signal approach-aid facility only.

34. The detector unit is divided, horizontally, into upper and lower halves, each half having a row of slots which face into the airstream; these slots transmit air pressure through separate passages into the opposite sides of a paddle chamber. The paddle is attached to the probe immediately adjacent to two potentiometers, which transmit the rotational movement by varying the DC supplies passing through them.

35. The angle of attack indicator has a moving pointer and a circular scale marked 0, 10, 20 and 30 units. When the aircraft is at its optimum angle of attack (in the two engine 45-25-25, blow configuration) the pointer indicates 20 units, any variation of the angle being either an increase or decrease from this position. The indicator has a yellow warning segment covering angles of attack in excess of 24

units. The pointer rests in an OFF sector when no electrical supply is available.

36. The three vertically-mounted index lights are behind a screen which has a central broken circle, above which is an open vee. Below the circle is an inverted open vee. The circle represents the optimum approach angle of attack and the vees point to the direction in which the aircraft should be rotated to reach the optimum. A day/night screen is operated by a control on the top of the index.

37. When switched on for the approach, the audio signal is first heard as a high-pitched note, interrupted at a rate of 10 interruptions per second. As the optimum angle of attack is approached the rate of interruption decreases to 1 per second and is superimposed on a continuous medium-pitched note. As the optimum angle is reached only the steady medium note is heard. With further increase in the angle of attack, a low-pitched note, interrupted at 1 per second is superimposed on the steady medium note, which eventually eeases, leaving the low-pitched note. Interruptions of this note increase to 10 per second as the stalling angle is approached.

38. When mod 1253 is embodied, three forward facing lights, red, amber and green, are athwartships under the nose. The lights indicate as shown in the table below which also shows the index lights indications and the operating ranges:

Index lights	Approach speed	Approach light	Operating range about datum Kts
V	Too slow	Green	$-1\frac{1}{2}$ or more
V ○	Slow		
○	Normal	Amber	$-1\frac{1}{2}$ to $+4\frac{1}{2}$
○ Λ	Fast		
Λ	Too fast	Red	$+4\frac{1}{2}$ or more

A NORM/TEST, ADD EXTERNAL LIGHTS switch in the nose is used when ground testing the external lights. Setting the switch to TEST provides a circuit in parallel with the circuit protection relays and the lights can then be tested by gently rotating the ADD probe.

Accelerometer

39. (*a*) *Pre-mod* 1162. A direct-reading accelerometer is fitted to the top of the instrument panel starboard shroud. The instrument is visible through an aperture in the panel, to starboard of the strike sight.

(*b*) *Post-mod* 1162. Post-mod 1162 the accelerometer is moved to a position above the starboard coaming.

Fatigue Meter

40. A fatigue meter fitted at the starboard side of the bomb bay is installed to record positive and negative accelerations in excess of 0·4G only in flight. An airspeed contactor is employed to switch on the instrument when a speed of 145 knots is reached and to switch it off again when the speed is reduced to below 115 knots. The DC supply is from the normal busbar.

Air Thermometer

41. An electrically-operated indicator on the observer's port console is controlled by a resistance bulb on the fuselage undersurface, forward of the nosewheel door. The indicator covers the range minus 80°C to plus 80°C. The electrical supply is from the normal DC busbar.

PART I—DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 11—LANDING GEAR AND ASSOCIATED CONTROLS

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1 Undercarriage, general description

The undercarriage comprises the port, starboard and nose wheel units and the tail skid, all operated by hydraulic power from the normal side of the general services hydraulic system. The undercarriage is controlled by three selector valves, one for the leg jacks, one for the doors and up-locks and one for the tail-skid jack. The wheelbrakes are operated automatically when the undercarriage is selected up and care should be taken to avoid using the brake pedals after the undercarriage has been selected up.

2 Undercarriage, normal controls and indicator

(*a*) Normal selection of the undercarriage is by two of three pushbuttons on the port control panel. The buttons are interconnected to ensure that only one button can be pressed in at a time. A locking solenoid, controlled by the circuit protection relays (Chapter 1), prevents the UP button being pressed in when the aircraft weight is on the legs. This lock can be overridden by rotating a ring round the button, to the stop. Normally the undercarriage cannot be retracted unless the nosewheel is centred, but this does not apply if an emergency up selection is made.

(*b*) *Catapult launch*

Provision is made for the *selection* of undercarriage up before the oleos have extended. Pressing a DECK TAKE-

OFF hutton on the cockpit port wall releases the locking solenoid and allows the UP hutton to be pressed in, but does not make the bydraulic selection. The latter is made automatically when the weight is removed from the undercarriage legs. A magnetic indicator, adjacent to the pushbutton, shows ON when tbe button has been pressed and resets to black when the undercarriage legs have extended on take-off.

WARNING 1: This facility should not be used for take-offs asbore, as pressing the button renders inoperative the emergency retraction facility (weight on undercarriage).

WARNING 2: If the button is inadvertently operated, the system can only he reset by switching off the battery master switcb and the AC generator switcbes, if both engines are running.

(*c*) The undercarriage position indicator is adjacent to the pushbuttons. Each position has two bulbs in parallel and a day/night screen is fitted. A red warning light on the instrument panel illuminates when the indicated Mach No. is less than 0·25 (approx. 165 knots at sea level) and the nosewbeel is locked-up; it is signalled from the air-data ◀computer. When mod 1279 is embodied, the warning light is automatically dimmed when tbe cockpit lights master switcb is on. A microswitch in the engine control▶ box is operated by the port throttle lever to cut out the warning light during take-off.

3 Undercarriage, emergency down selection

(*a*) If the normal selector fails, or if there is a shut-down of the normal side of the general services hydraulic system, tbe port, starboard and nosewheel units (but not the tail skid) can be lowered by operating the third (EM DOWN) pushbutton on the port control panel. Pressing in this pushbutton energises a door locks emergency selector valve and, through sequencing microswitches, an undercarriage emergency selector valve. Selection of these valves provides power from the emergency side of the general services bydraulic system to operate the jacks, through shuttle valves. Normal sequencing takes place.

(*b*) (i) If any one of the door-unlocked microswitches fails to sequence on a down selection, the undercarriage cannot be lowered hy eitber a normal or emergency down selection. For this case, a U/C EMERGY OVERRIDE—OFF/DOWN switch is provided on the standby control panel. Selecting this switch to DOWN, *after first pressing the emergency down pushbutton*, by-passes all the sequencing microswitches and energises the undercarriage emergency selector valve, the door locks emergency selector valve having already been energised by the EM DOWN selection.

(ii) The override switch is spring-loaded to OFF and is held off by a plastic covering. The covering must be broken and the switch held DOWN until the undercarriage is locked down.

4 Nosewheel steering

(*a*) The nosewheel can be turned through an arc of approximately 100°, i.e. from 50° on either side of centre, by a hydraulic jack, powered by the normal side of the general services hydraulic system. Control of the jack is by a drum switch, whose position is selected by the position of the rudder pedals. A follow-up movement ensures step-by-step operation of the valve. The service is selected by pressing a red NOSE WHEEL STEERING pushbutton on the starboard throttle lever; holding down this button energises a by-pass valve selector and the by-pass valve is then closed to prevent free circulation of the fluid on either side of the steering jack, thus locking the jack, until a steering selection is made by moving the rudder pedals.

NOTE: At high AUW's, jack stalling may occur, resulting in the full ± 50° not being available. In addition, operation of services which have a large hydraulic demand, e.g. airbrakes or wingfold, may also cause jack stalling.

(*b*) The following features are built into the system:—

(i) On take-off, the circuit protection relays energise the by-pass selector valve and a centre contact on the drum switch. This centres the nosewheel, providing it is within the self-centring range, i.e. within 60° of the central trailing position.

(ii) When the nosewheel is retracted, the by-pass valve selector remains energised, thus locking the nosewheel in the centre position.

(iii) On landing, the by-pass valve is de-energised, thus allowing free castering of the nosewheel until the steering pushbutton is depressed.

(iv) If, with the steering pushhutton pressed, the aircraft touches down with drift, a relief valve operates and allows the nosewheel to trail relative to the forward direction.

(v) The relief valve also operates on take-off when the stage is reached where rudder control overcomes the nosewheel steering selection.

5 Wheelbrakes

(*a*) The hydraulically-operated wheelbrakes on the main wheels are supplied with power from the normal side of the general services hydraulic system. An accumulator, charged with air to 1,100 to 1,300 PSI provides a reserve of power if the normal side of the general services system becomes inoperative. A standard triple pressure gauge on the front cockpit port wall shows the pressure at each hrake unit and the accumulator fluid supply pressure. The hrakes may become inoperative as the accumulator pressure drops to 1,300 PSI.

(*b*) The brakes are controlled hy master cylinders, one on each rudder pedal, which operate a relay valve giving progressive and differential hraking. The valve restricts the pressure at the hrake units to a maximum of 1685 $\pm$ 75 PSI. This valve is also hydraulically-operated hy pressure from the undercarriage up-line when the undercarriage is selected up and it follows that the hrakes are on during flight, although at a reduced pressure. The minimum number of hrake applications that can be made with a full accumulator and the hydraulic system failed is sixteen, providing anti-skid is not in use.

WARNING: The wheelhrakes must not be applied during the undercarriage retraction cycle.

(*c*) Mod. 892 introduces an emergency hand braking facility, by which the aircraft can be hrought to rest. It is entirely independent of the normal system and is controlled by a hrake lever on the pilot's starboard console. The emergency system is connected into the main hydraulic supply line in the nosewheel hay and includes an independent hrake accumulator. Neither differential hraking nor anti-skid protection (see para. 6) are availahle. A WHEEL BRAKES—HAND pressure gauge on the pilot's cockpit port wall shows the pressure at the hrake units during operation. The hand control is annotated PULL FOR EMGCY BRAKING. TO PARK—EXTEND FULLY

& TURN (clockwise). The recommended technique for normal parking is to bring the aircraft to a standstill using the normal wheelbrakes and then lock them on by means of the emergency braking hand control.

6 Anti-skid protection

Protection against skid is effected electrically. The system is selected by a guarded ANTI-SKID—ON/OFF switch, on the front cockpit port console. Two solenoid-operated shut-off valves are located, one in each line, from the foot-operated relay valves to the brake units. Each valve is controlled by a signal from its respective wheel-unit generator, and as a skid condition is approached, the valve is shut, thus releasing the pressure from the brake unit irrespective of the position of the foot pedal. As the skid condition recedes, the brakes are automatically re-applied. **WARNING:** If a brake failure occurs, the anti-skid switch should be set OFF; this may restore the normal braking facility. If it does not, the emergency hand brake will have to be used.

7 Arrester hook, normal operation and control

The arrester hook is operated by power from the general services hydraulic system and is controlled by an ARRESTER HOOK—UP/DOWN switch, on the port control panel in the front cockpit. When a down selection is made, the down solenoid in a selector valve is energised and fluid is passed, via a release valve and the selector valve, to the up-lock release jack. At the same time, fluid on the up side of the hook jack returns, via the selector valve, and allows pressure stored in an air-charged accumulator connected to the downside of the hook jack, to move the jack and lower the hook. A damping valve is provided in the system to prevent hook bounce on landing. When an up selection is made, fluid is directed, via the release valve and selector valve, to a recuperator, where it passes through the piston and the damping valve to the up side of the hook jack. As it retracts, this jack re-charges the accumulator ready for lowering the hook when the next selection is made.

8 Arrester hook, standby operation and control

If the normal side of the general services hydraulic system is shut down (Chapter 3), or a hook selector failure occurs, the hook can be lowered, but not raised, by using the emergency side of the general services hydraulic system. If the ARRESTER HOOK—OFF/DOWN switch on the standby control panel is set to DOWN, the release valve is energised. This cuts off the normal hydraulic supply to the selector valve and supplies fluid from the emergency side of the general services hydraulic system to the up-lock release jack, via a shuttle valve. This withdraws the up-lock and allows accumulator pressure to lower the hook.

9 Hook light and deck approach light

(*a*) *Pre-mod* 1253

◀An amber light under the nose is used as an external indication of the position of the undercarriage and hook. A green light on the port control panel in the pilot's cockpit comes on when the arrestor hook is fully down. When the undercarriage is locked down the approach light shows a steady light; if the hook is then fully lowered a flashing unit is brought into the approach light circuit and the arrester hook light comes on.

(*b*) *Post-mod* 1253

When mod 1253 is embodied the approach light is disconnected from the arrester hook/undercarriage circuits, but the light is then used, in conjunction with a red and a green light, as an ADD external indication. ▶

PART I—DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 12—GENERAL EQUIPMENT AND CONTROI S

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1 Canopy, general description

(*a*) A single sliding canopy, mounted on two jettison rails, encloses the tandem cockpits. The canopy is normally opened and closed by an electric actuator controlled by a CANOPY MOTOR—TO CLOSE/OFF/TO OPEN lever on the front cockpit starboard wall. The DC supply to the actuator is direct from the main battery and is therefore independent of the battery master switch or the crash relays (Chapter 2). Provision is also made for declutching the actuator to allow manual operation of the canopy, and if this proves to be impracticable an external hand-winding mechanism is also provided. Mechanical locks, one on each side of the canopy, lock it in the closed or open position. An indicator light, adjacent to the canopy controls, comes on when the canopy is incorrectly locked. The filament of this light can be tested by pressing the light.

Three canopy control levers are provided. One on the front cockpit starboard wall, forward of the canopy motor lever, is labelled CANOPY — LOCKED / UNLOCKED / DECLUTCH and is connected by Teleflex cables to a PULL TO DECLUTCH CANOPY MOTOR lever on the observer's cockpit starboard wall. The third lever, labelled CANOPY—RELEASE, is on the outside of the aircraft and is integral with the internal control. Normally flush-fitting in the surface skin, the handle is released by pressing an adjacent button. The lever positions are indicated by the words UNLOCK and DECLUTCH painted on the fuselage; the locked position is the stowed position. When the lever is moved to UNLOCK, it exposes a canopy motor control lever.

(*b*) A canopy seal is inflated by air pressure (Chapter 7). To prevent seal inflation when the canopy is unlocked, or in the open locked position, a stop valve is operated by the canopy control lever.

2 Canopy operating control lever

(*a*) When the main canopy control lever is moved from LOCKED to UNLOCKED the Teleflex cables withdraw the canopy locks. The canopy indicator light comes on. At the same time, the canopy seal stop valve is operated, shutting off the air supply, and a microswitch is operated which completes the circuit to the canopy motor open and close microswitches.

(*b*) When the control lever is moved from UNLOCKED to DECLUTCH it disengages the actuator motor and breaks the circuit to the motor open and close microswitches.

(*c*) *Observer's lever*

If the observer's PULL TO DECLUTCH CANOPY MOTOR lever is operated it completes the operation at (*a*) and (*b*) in one movement.

WARNING: This lever is for emergency use only and after use can only be reset on the ground.

3 Canopy, normal operation

With the canopy control lever at UNLOCKED, selecting TO CLOSE on the motor control lever operates a close microswitch. This supplies DC via a close relay and a reversing relay to the actuator and to an actuator brake release. When the canopy reaches the fully-closed position, a limit switch breaks the circuit to the actuator and to the brake release. Selecting TO OPEN energises, through a bi-metal strip, an open relay and the reversing relay. The bi-metal strip causes a 2–3 sec. delay, to allow time for the canopy seal to deflate before the canopy starts to move. To avoid overheating, a 6 minute period should be allowed to elapse after one complete cycle of canopy operation.

4 Canopy hand-winding

The hand-winding gear is under a panel at the aft end of the canopy winding mechanism. It consists, simply, of a folding handle which, when attached to a sprocket, engages the winding mechanism. The actuator must be declutched by the external control lever before the handle can be turned. When not in use the handle is folded and strapped in a stowage just forward of the winding mechanism.

5 Canopy jettison, control and operation

The canopy can be jettisoned from three control positions, one above the instrument panel coaming, port side, one adjacent to the port console at the observer's station and a third, external, handle on the port side of the nose. Pulling any one of these handles fires a cartridge in its associated primary breech. The resulting gas pressure is fed to a port main breech where it fires the main cartridge. Gas pressure from this cartridge acts on the pistons of two rail guns which unlock the canopy rails. As the pistons move forward, exhaust ports are uncovered and the escaping gas fires the cartridge in the starboard main breech. The gas from this cartridge passes to two jettison guns which force the canopy upwards, allowing the airflow to carry the canopy clear of the aircraft. During the initial movement, the canopy is disengaged from the winding mechanism.

6 Wing and nose folding

(*a*) *Wing fold*

The outer main planes are folded or spread by power from the normal side of the general services hydraulic system, under the control of a WING SPREAD/INTERRUPT/WING FOLD lever on the starboard console. This lever is mechanically linked to the selector valve. A solenoid-operated lock is fitted to prevent movement of the lever when the weight is off the undercarriage legs, or if jury struts are fitted. When WING FOLD is selected, fluid is passed to two latch jacks, one to each mainplane, which withdraw the latches. Final movement of each latch opens a sequence valve which allows fluid to pass into the fold side of the two wing-fold jacks, one to each main plane. Movement of the latch pins also operates microswitches in the warning circuit (sub-para. (*c*)). Selecting INTERRUPT during the folding or spreading operation centralizes the selector valve, thus closing both the supply and return lines of the jacks. The resulting hydraulic lock ensures that the wings come to rest before a reverse selection is made, but does not prevent one wing folding and the other spreading. Selecting WING SPREAD reverses the sequence of operation and spreads and locks the main planes.

(*b*) *Nose fold*

The nose-section, forward of the cockpit, folds to port and is secured in that position by a built-in jury strut which enters an anchorage on the port side of the fuselage. The nose, when closed, is secured by three latches and these are locked by a handle on the starboard side of the nose. A spring catch retains the handle flush with the skin when the nose is locked. When the latches are fully home, a mechanical lock indicator, incorporated in the handle, lies flush with the fuselage skin. The locking mechanism operates a microswitch which is part of the standard warning system.

(*c*) *Indicators*

A WING AND NOSE FOLD LOCK magnetic indicator on the starboard console shows black when both main planes are locked spread and the nose is locked. If any of these are unlocked the indicator changes to cross-hatched, and a WF warning is also given on the standard warning panel.

7 Windscreen wiper

A hydraulically-operated windscreen wiper is powered by a self-contained hydraulic system. A twin electrically-driven hydraulic pump unit, each half having two horizontally-opposed pistons, provides suction and pressure alternately to drive a rack and pinion assembly to which the wiper arm is attached. The motors are controlled by a

WINDSCREEN WIPER—OFF/SLOW/FAST rotary switch on the starboard wall. When FAST is selected, both motors are running and the wiper operates at 200 cycles/minute. When selected to SLOW only one motor runs and the wiper operates at 100 cycle/min. An OFF selection results in the wiper moving slowly, under the influence of the airflow, to a parked position on the starboard side of the windscreen. One motor is fed from the port 200v AC busbar and the other from the starboard busbar. Failure of the electrical supply to either motor causes the wiper to operate at 100 cycles/min if FAST is selected.

8 Emergency arrester barrier cutters

Emergency arrester barrier cutters are fitted to the folding nose in a central position, one each on the top and bottom surfaces of the nose. The cutters are designed to sever the horizontal nylon tension rope, allowing the vertical members to be deflected away from the engines.

9 Navigation equipment stowage

◀A stowage on the observer's windscreen is provided for a navigation computer and a protractor. A stop watches mounting bracket is on the beam below the windscreen. When mod. 1252 is embodied a quick-release mounting is provided for the stop watches. ▶

Lighting

10 Navigation lights

The usual navigation lights are controlled by a NAVIGATION LIGHTS—STEADY/OFF/FLASH switch on the starboard switch panel. When the switch is at FLASH, a flashing unit is brought into circuit. The brilliance of the lights is controlled by a NAVIGATION LIGHTS—BRIGHT/DIM switch, also on the switch panel.

11 Formation lights

Two lights, one in the outboard trailing edge of each aileron, and a third light, which is the second filament in the tail light, are used as formation-keeping lights. They are controlled by a FORMATION LIGHTS—BRIGHT/OFF/DIM switch on the starboard switch panel.

12 Rendezvous lights

Two rendezvous lights are mounted one on the dorsal fin and the other below the fuselage on the accessories bay rear door. The lights each have separate DC supplies but are controlled by a single RENDEZVOUS LIGHTS—ON/OFF switch on the starboard switch panel. A twin-filament oscillator unit in each light causes it to flash at 80-90 flashes per minute.

13 Downward identification light

An amber downward identification light on the rear accessories bay door is controlled by a DOWNWARD IDENT LIGHT–STEADY/OFF/MORSE switch on the pilot's starboard switch panel. The switch is spring-biased to OFF, from MORSE.

14 IFIS lighting

The integrated flight instrument display is grouped on two panels; one is on the pilot's instrument panel and the other is on the observer's port console. The instruments are illuminated by integral low-voltage lamps, supplied from the 200v AC busbar, and each group is controlled by a separate DC-operated control system. The pilot's lamps are controlled by an IFIS LIGHTING—ON/OFF switch and an adjacent dimmer on the port console. The observer's ◀lamps are controlled by an IFIS LIGHTING—ON/OFF switch and an adjacent DIMMER on the instrument lighting panel. ▶

◀15 Instrument lighting

(*a*) *Pilot's instrument lighting*

The instruments and switches on the port and starboard shroud panels and the instrument panel are illuminated by pillar lamps with red filters. Each instrument and switch has two lamps, each one in a separately fused sub-circuit.▶ The lamps are supplied from the DC busbar and are controlled by an INSTRUMENT PANEL—ON/OFF switch and an adjacent dimmer on the port console. A second switch labelled NORMAL/EMERGENCY is left at NORMAL except on failure of the DC supply. If this occurs, selecting the switch to EMERGENCY provides DC from ◀the emergency battery to provide essential lighting. ▶

(*b*) The E2B compass lamp is supplied through the INSTRUMENT PANEL lamp switch, and the emergency position of the NORMAL/EMERGENCY switch. In addition a STANDBY COMPASS—ON/OFF switch, to port of the E2B, is provided to switch off the lamp when it is not required.

◀(*c*) *Observer's instrument lighting*

Each instrument and switch on the port auxiliary panel, the miscellaneous temperature indicator and the flare control is illuminated by a pair of single pillar lamps with red filters. The radio bay cooling override switch and indicator have a single pillar lamp. The doppler indicator, Blue Parrot, fuzing control unit (pre-mod 1188), bomb distributor, and the control units for HF, IFF, SIF, UHF and tape recorder (post mod 1258) are illuminated by integral lamps. All the lamps are selected by a RADIO, RADAR CONTROL & INSTRUMENT LIGHTING—ON/OFF switch on the lighting control panel. A DIMMER control is just forward of the switch. Illumination is by two separately fused sub-circuits; if either fails the serviceable sub-circuit continues to illuminate the essential units.

16 General interior lighting

(*a*) *Pilot's cockpit floodlighting*

Illumination of the cockpit is provided by red flood lamps and pillar lamps with red filters. Illumination of the control units for the radio altimeter, Tacan and UHF is by integral lamps. The lamps are controlled by a COCKPIT FLOOD—ON/OFF switch and two dimmer controls marked PORT DIMMER and STBD DIMMER; the controls are on the lighting control panel on the port console.

(*b*) *Observer's cockpit floodlighting*

Illumination of the cockpit is provided by red flood lamps, they are controlled by a COCKPIT FLOODLIGHTING—ON/OFF switch and a DIMMER control on the lighting control panel. A white flood lamp is provided for chart table illumination, its operation and brilliance is controlled by an adjacent dimmer. A wander lamp is on the starboard wall, it is fully adjustable and can be detached from its mounting for use as a hand torch. An OFF/BRIGHT▶

◀dimmer switch is on the rear of the lamp and a rotating bezel at the front selects a white or red wide angle or spot beam. ▶

(*c*) *Accessories bay*

One lamp is fitted in the roof of each of the two compartments in the accessories bay and a further lamp is fitted adjacent to the main hydraulic reservoir to facilitate fluid level checks. All the lamps are controlled by a single ACCESSORIES BAY LIGHTS switch on the forward hulkhead.

(*d*) *Bomb bay*

Three lamps in the bomb bay are controlled by a special pin inserted through an aperture in the fuselage undersurface. When inserted and turned through 90° it actuates a microswitch to transfer the DC supply from the bomb door operating circuit, rendering it inoperative, to the lamps.

(*e*) *Radio bay*

Three lamps in the radio bay are controlled by a RADIO BAY LIGHTS—ON/OFF switch on the mic/tel panel in the bay.

PART I—DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 13—AIRCREW EQUIPMENT ASSEMBLY AND OXYGEN

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Ejection seats

1 Ejection seats, general

(*a*) An ejection seat Type 4MSA, Mk. 3 or Type 6MSA, Mk. 1 is fitted in each cockpit; the latter seat is rocket-▶

◀assisted. The Type 4MSA seat has a ground-level ejection capability provided the aircraft's flight path is parallel to the ground and speed is not less than 90 knots; if the aircraft is descending or is nose down, more than the minimum altitude will be required. The addition of the rocket pack to the Type 6MSA seat gives it a higher trajectory which provides safe ejection down to zero speed and altitude, when there is a high sink rate or when the aircraft is at low level in a nose-down attitude.

(*b*) Each seat has a combined seat and parachute harness which is released by a quick-release box. A back-type parachute assembly of the horse-shoe type is fitted. The▶ pack is secured by two restraining straps at the upper end and fitted with a headrest. The seat pan accommodates a personal survival pack. Two leg restraining cords are fitted at the front of the seat pan. An emergency oxygen bottle is stowed at the back of the seat.

(*c*) The seat height may be adjusted electrically by operating the switch on the starboard side of the seat. The harness lean-forward release lever is the forward lever on the starboard side of the seat pan.

(*d*) *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 frees the occupant from both seat and parachute.

2 Ejection gun and firing handles

(*a*) An 80 ft./second ejection gun is fitted. The ejection gun is fired by pulling the face-screen firing handle or the seat-pan firing handle. To permit ejection through the canopy, when necessary, the seat is fitted with canopy breakers on the drogue container and the seat pan. If conditions necessitate the use of the seat-pan firing handle, the occupant must first press his head firmly against the headrest.

◀(*b*) The Type 6MSA seat-pan firing handle has a safety pin which must be removed before flight. The Type 4MSA seat-pan firing handle has a safety pin when Mod. ES3209 is embodied but previous to that it has a safety lock.

2A Rocket pack (Type 6MSA seat only)

The rocket pack is fitted beneath the seat pan. The sear in a firing unit between the rocket tubes is attached to a▶

◀static line which is itself attached to a disconnect unit on the cockpit floor. When the seat has travelled approx. 6ft. by operation of the ejection gun (para. 2(*a*)) the static line withdraws the sear from the rocket firing unit to initiate rocket firing. The disconnect unit is operated by the underwater escape system to prevent rocket firing when underwater ejection takes place. ▶

3 Barostat/G-stop time delay

(*a*) After ejection, at heights of 10,000 ft. and below, a barostat causes an automatic cycle to commence. After ◀1¼ sec. (1½ secs. Type 6MSA seat) if the G-stop has not▶ operated (sub-para. (*b*)), the safety harness is released from the seat, as are the face-screen firing handle and headrest pad. At the same time the seat-man separation bladders are inflated.

(*b*) A G-stop is incorporated to prevent the opening of the main parachute if the speed of the seat after ejection is too high for safe deployment. The stop prevents the operation of the barostatic time-delay until the speed of the seat has fallen to a safe figure.

4 Lean-forward harness release

A lean-forward type of harness release is controlled by a lever on the starboard side of the seat pan. The harness is released only while the lever is held forward and a spring-loaded drum takes up the slack when the seat occupant leans back.

5 Manual separation handle

The handle on the port side of the seat has a thumb press safety lock. When the catch is depressed and the handle is pulled up, linkages release the parachute harness locks, the man component of the PEC, and the leg restraint cords. In addition the seat/man separation bladders are inflated, thus assisting the occupant to leave the seat. As the parachute is pulled away from the seat a static line withdraws the sear in the guillotine which fires and severs the drogue link line, separating the parachute from the seat. A safety pin is provided for the guillotine sear.

6 Leg restraint cords

The leg restraint cords ensure that the occupant's legs are drawn back automatically and restrained close to the seat pan during ejection, thus providing leg clearance and preventing the legs being blown apart after ejection. The cords pass through snubbing units on the front of the seat pan, through the rings on the garters and are then inserted into the thigh guard sockets. The snubbing units allow the cords to pass freely down through the unit, but prevent them passing upwards. A push-up plunger is provided under each snubbing unit, to allow the occupant to adjust the cords to give comfortable leg movement in the aircraft. An interconnection between the restraining cord sockets and the PEC makes connection of the cords impossible until the man component of the PEC is mated with and locked to the seat component.

7 Personal equipment connectors

(*a*) To enable the aircrew's main oxygen, emergency oxygen, ventilated suit, anti-G suit, LSW inflation hose connections and the mic/tel lead to be connected or disconnected from the aircraft in one action, a PEC is fitted to the starboard side of the seat pan. The connector comprises three components, the aircraft component connected to the cockpit floor, the seat component bolted to the seat pan and the man component attached to the flying clothing.

(*b*) The man and seat components are mated by sliding the nose of the former into hooks at the front of the seat component and then pressing downwards the handle at the rear. To release the man component, press the thumb button in the handle and lift the handle.

(*c*) An excess pressure valve at the rear of the PEC prevents build-up of excessive pressure at the mask when the emergency oxygen supply is in use.

(*d*) When the man component of the PEC is removed, a dust cover must be fitted in its place. The cover is stowed on the starboard side of the seat.

◀8 Safety pin stowages (Type 4MSA seat) ▶

The safety pins for the face-screen firing handle, the guillotine sear, the canopy jettison handle, the manual underwater firing handle and, post-mod 1198, the seat pan firing handle, are stowed on the starboard wall of their respective cockpits.

◀**8A Safety pin stowages (Type 6MSA seats)**

The safety pins for the face-screen firing handle, seat-pan firing handle, canopy jettison handle, manual underwater firing handle and the rocket pack firing unit sear are all stowed on the starboard wall of their respective cockpits. The guillotine sear safety pin for each seat is stowed on top of the starboard side of the main spar dividing the two cockpits. ▶

Anti-G and air ventilated suit systems

9 Anti-G system

(*a*) The purpose of the system is to provide air at low pressure for the aircrew's anti-G suits, a connection for which is on each PEC.

(*b*) Air for inflation of the suits is provided by the cockpit pressurising system (Chapter 7). A set of controls is in each cockpit. With air pressure available and an ANTI-G—ON/OFF cock on the starboard wall ON, when G in excess of approximately 1½ is applied, an anti-G valve on the starboard console operates and allows air to pass to inflate the anti-G suit. The degree of inflation depends upon the degree of G applied. The valve has an H and L setting, and when H is selected the suit is inflated at 1 PSI/G. With L selected, inflation is at 0·8 PSI/G.

(*c*) The suit may be tested, with the cock ON, by pressing the ANTI-G TEST button, on top of the valve, as gently as possible to avoid severe discomfort due to too rapid inflation.

10 Air ventilated suit system

The air ventilated suit system provides low pressure air for aircrew cooling; a connection is on each PEC. The pilot's control is aft of the anti-G valve and the observer's control is on the side of the starboard console.

Oxygen system

11 Oxygen system, general description

Liquid oxygen, for both crew members, is supplied from a single, ten-litre packaged LOX container in the radio bay.

Each crew station has a Mk. 17F regulator and two remote blinkers, one for each crew supply. A contents gauge, on the starboard console at the pilot's station, indicates the contents of the container in ⅛ fractions of capacity. A contents gauge and cursor and a filling/vent valve are provided in the radio bay. Normally, the container is charged before installation, but provision is made for in situ charging.

NOTE: Transmitting on HF or Tacan may cause the contents gauge to fluctuate.

12 Mk. 17F regulators

(*a*) The regulator has an ON/OFF valve which controls the flow of oxygen, an air inlet NORMAL/100% OXYGEN switch, a pressure gauge, an emergency three-position switch and a magnetic indicator which shows black when oxygen is not being used, or when electrical power is not available, and a vertical white line when oxygen is being demanded.

(*b*) When the ON/OFF valve is on and the inlet switch is at NORMAL, an air/oxygen mixture is fed to the crew member's mask, up to a height of 32,000 ft. at which height 100% oxygen is automatically delivered. When the inlet switch is at 100% OXYGEN no air is added irrespective of the height. The emergency switch, when moved to right or left, admits oxygen under greater pressure.

(*c*) If the cabin altitude exceeds 40,000 ft., the regulator automatically delivers oxygen under pressure.

(*d*) The mask may be tested before flight by deflecting the emergency switch sideways and holding the breath. If the magnetic indicator on the regulator remains black there are no leaks around the mask. If the indicator changes to white the mask requires to be tightened.

13 Emergency bottles

(*a*) The emergency oxygen supply for each seat is contained in a Mk. 8C bottle mounted on the rear of the seat. The bottle remains *with the seat* after separation has occurred following ejection.

(*b*) A manual control on the right of each seat pan is pulled up to turn on the emergency oxygen bottle.

(*c*) A safety pin for the bottle is normally removed and stowed in a bag on the port wall of the front cockpit (starboard wall, rear cockpit).

Underwater escape system

14 Underwater escape system, general description

(*a*) Provision is made for a fully automatic underwater escape system. This is capable of ejecting an unconscious occupant from the aircraft, separating him from his seat and supporting him on the surface by his fully inflated LSW, without any action being necessary on his part. The main components and their functions are shown in the following sub-paras.

(*b*) *Water pressure sensing unit*

Stainless steel pipes lead from a static pressure hole, in the port cockpit skin, to the pressure sensing diaphragm assembly of a compressed air bottle firing unit at the base of each ejection gun. When the sinking aircraft reaches a depth of approximately 13 ft. the pressure on the valve diaphragm moves the restraint on the firing pin, allowing it to descend under spring pressure and fire the cartridge in the head of each main air bottle.

(*c*) *Main air bottle*

A main air bottle charged to a nominal 3,000 PSI is behind each seat, integral with the pressure sensing diaphragm assembly. Pipes from the assembly lead to the base of the ejection gun via a two-way cock and the drogue gun trip rod release unit. Bottle pressure is indicated on a gauge.

(*d*) *Ejection gun*

Each ejection gun had a plug fitted to the lower end of the inner piston tube and held in position by two shear rivets. This reduces the volume of air required and also prevents the compressed air from bursting the diaphragm of the primary cartridge and possibly causing it to fire. A non-return valve is fitted into the base of each ejection gun to prevent any loss of cartridge gas into the underwater escape system during normal ejection. In addition, a modified type of sear is fitted to the firing unit in the ejection gun breech, which allows the firing cable to disconnect when the ejection gun extends, thus preventing the firing of the primary cartridge.

◀(*e*) *Rocket pack static line disconnect unit* (*Type* 6*MSA seat only*.)

Air from the main air bottle is also piped to the rocket pack static line disconnect unit, via the base of the ejection gun. On underwater ejection, the static line is disconnected, thus preventing firing of the rocket pack. ▶

(*f*) *Auxiliary CO_2 bottle and bladders*

The auxiliary CO_2 bottle is on the starboard side of the seat, above the harness release lever. When fired by rotation of the harness release lever, gas is piped to two inflation bladders, one behind the parachute pack, and the other underneath the dinghy pack. The action of these bladders, on inflation, is to force the occupant forward and upwards.

(*g*) *Modified LSW*

The LSW inflation bottle in the starboard side of the LSW is modified so that it is actuated by air from the main air bottle, via the drogue gun trip rod release unit and PEC. In addition it is increased in capacity from 34 to 86 grammes of CO_2 to ensure correct LSW inflation when subjected to water pressure. To prevent a build-up of excessive internal pressure, a pressure relief valve, set to 3 PSI, releases excess gas when on or near the surface. Manual operation of the LSW and the oral inflation facility are still available.

(*h*) *Modified PEC*

The personal equipment connectors are modified to include the air line to the LSW inflation bottle and incorporates a spring-loaded ball valve in the aircraft portion, held open when the seat and aircraft portions are connected and automatically closed to conserve the air when they separate during ejection.

(*j*) *Underwater escape selector handle*

The underwater escape selector handle, to port of the seat, has two positions: SAFE and UNDERWATER. When SAFE is selected, the handle is in the up position and a slide valve is moved so that it blanks off the delivery ports to the base of the ejection gun and the drogue trip rod release unit. The same movement opens a port so that compressed air would exhaust to atmosphere outside the cockpit should the main air bottle inadvertently discharge. Upon selection of UNDERWATER, by depressing the locking knob in the end of the handle and pushing the handle down, where it relocks, the slide valve is moved so that the vent to atmosphere is closed and the bottle contents, upon release, initiate the ejection sequence.

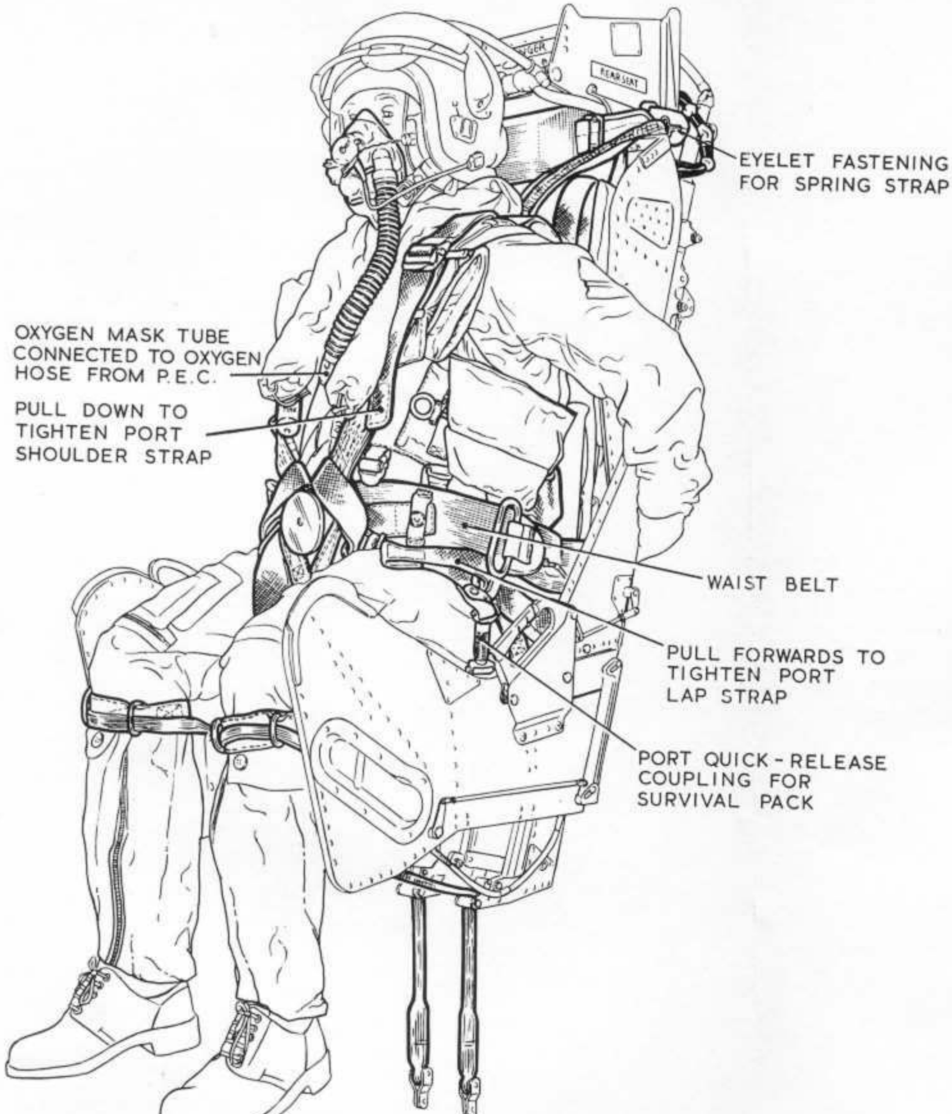

Fig A—Ejection seat (1)

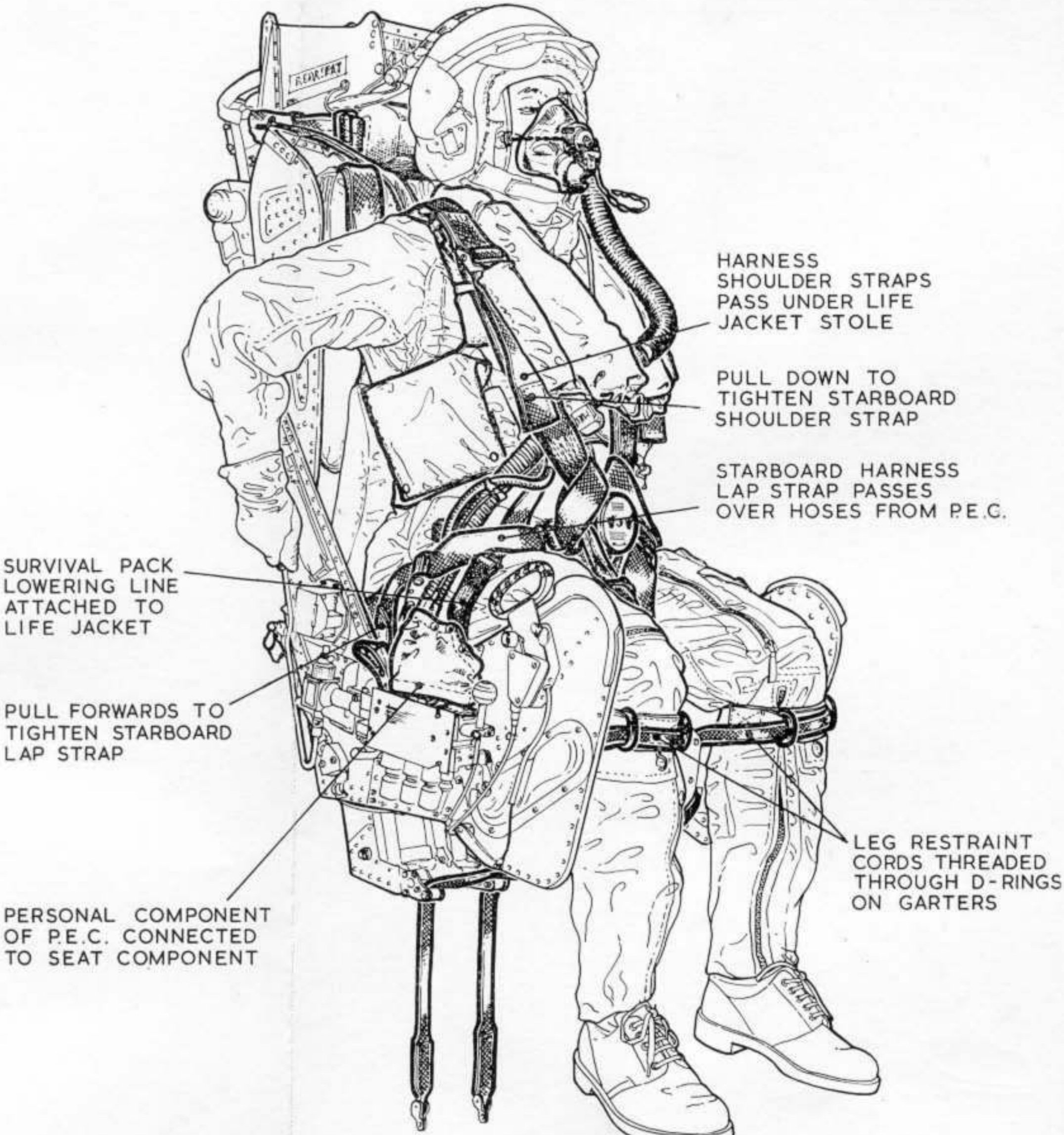

Fig. B—Ejection seat (2)

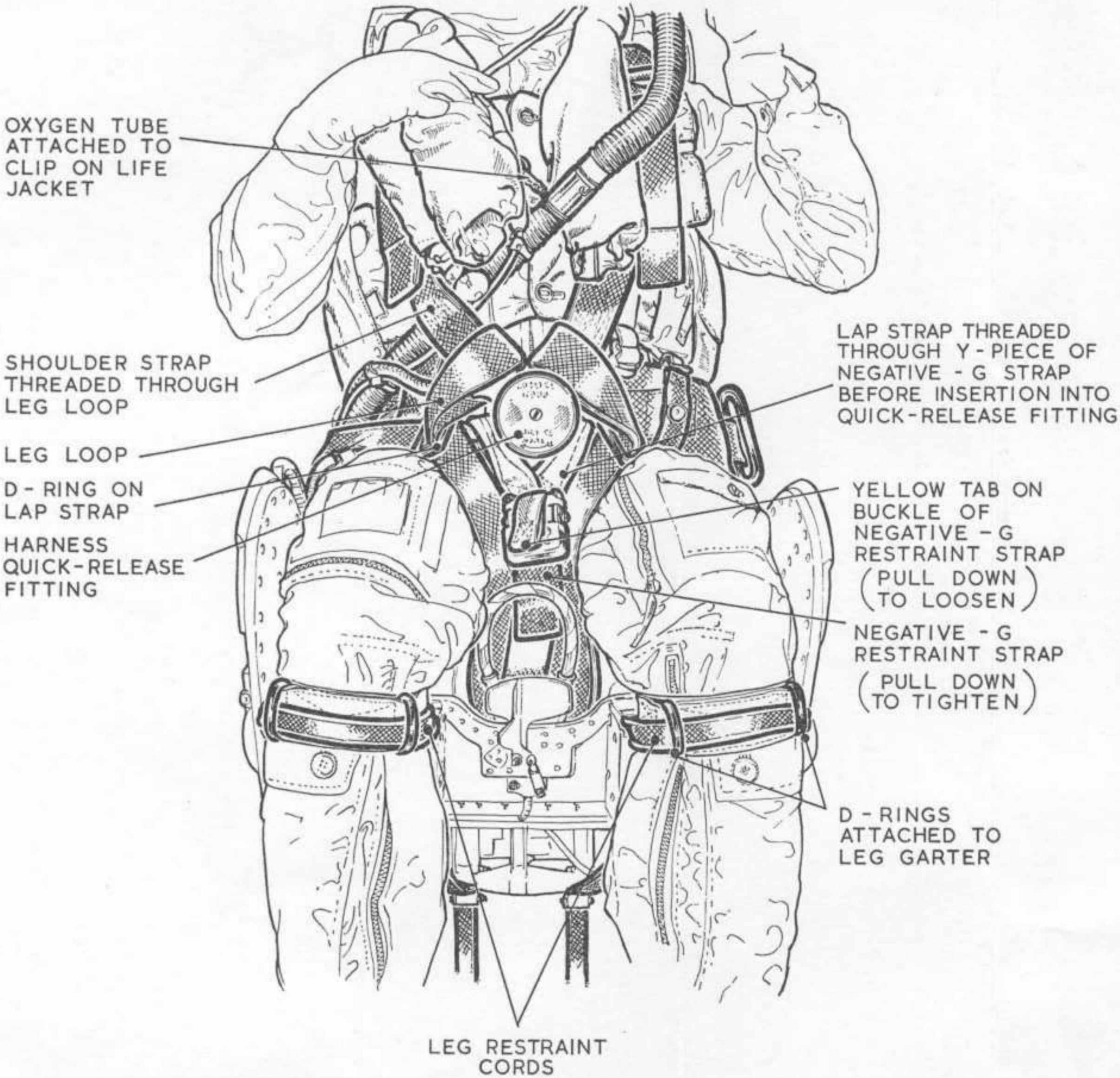

Fig. C—Ejection seat (3)

◄ Seat-pan firing handle safety lock replaced by pin, post-mod ES 3209 ►

(*k*) *Manual firing handle*

A manual firing handle is fitted to the starboard thigh guard. The action of pulling the handle up withdraws a sear from a breech unit mounted on the compressed air bottle diaphragm assembly. When the striker fires the cartridge, the gas pressure impinges on the valve diaphragm which removes the restraint on the main air bottle firing pin, thus initiating the escape sequence.

15 Automatic underwater escape

When the sinking aircraft reaches a depth of approximately 13 feet the pressure on the valve diaphragm removes the restraint on the firing pin, allows it to descend under spring pressure and fires the cartridge in the head of the bottle. ◀The compressed air is thus released and, on entering the bottom of the ejection gun, forces the piston tubes upwards, unlocking the seat and ejecting it from the aircraft without firing the ejection gun cartridges. At the same time air to the Type 6MSA seat rocket pack static line disconnect unit operates the unit to disconnect the static line and prevent the rocket pack firing. The air to the drogue gun▶ trip rod release unit forces a plunger out of its housing, and this releases the drogue gun trip rod, preventing the gun from being fired. At the same time the plunger strikes a linkage which withdraws the guillotine sear, thus severing the link line between the drogues and parachute. The movement of the plunger uncovers a port in the unit, allowing the air to proceed to the modified LSW inflation bottle, via the PEC. The bottle is thus actuated and the LSW inflated. As the seat rises on ejection, the time-release unit is tripped and ◀runs for its normal period of 1¼ seconds (1½ seconds Type 6MSA seat), when the plunger descends and strikes the▶ harness release lever. As the harness release lever rotates, it releases the harness locks and at the same time operates the auxiliary CO_2 bottle which inflates the seat-man separation bladders. The occupant is thus forced from the seat, and is free to rise to the surface where he floats, supported by his LSW.

Use of the aircrew equipment assembly

16 Strapping-in procedure

Having carried out the ejection seat checks (listed in the Flight Reference Cards) strap in as follows:

(*a*) Connect life raft lanyard to LSW, passing it outside the left thigh. Connect life raft side attachments to LSW. Connect LSW hose to man component of PEC.

(*b*) Remove and stow PEC dust cover.

(*c*) Connect man component of PEC and check correct locking.

(*d*) Pass right leg restraint cord through rings on front of right garter and engage taper plug in right thigh-guard socket. Pull sharply on the cord to check locking. Connect left leg restraint cord in a similar manner.

(*e*) Adjust lumbar cushion to correct position.

(*f*) Check QRB locked.

(*g*) Slip leg strap lugs through negative-G strap loops and then connect harness lap straps, ensuring that the negative-G straps are clear of the seat-pan firing handle, (QRB has to be held rotated past locked position before harness lugs can be inserted):

(i) To be as tight as comfort permits, then tighten negative-G strap.

(ii) With QRB as low as possible

(iii) Right strap to pass *outside* PEC hoses

(iv) Allow small bight in hoses, between lap strap and PEC, to avoid strain under negative-G.

(*h*) (i) Pass each leg loop through its respective lap-strap ring, and engage the loop over the shoulder harness lug.

(ii) Engage the shoulder harness lugs in the QRB (push the leg loops well down on the lugs).

(iii) Ensure shoulder harness passes under LSW stole.

(*j*) (i) Tighten the parachute (blue inner) harness shoulder straps.

(ii) Tighten the seat safety (khaki outer) harness shoulder straps.

(*k*) (i) Operate the lean-forward lever, lean forward and then release lever.

(ii) Ground crew fold rucks in harness behind back.

(iii) Lean back and check snubbing unit. Check finally locked.

(iv) Check-tighten the shoulder straps but do not over-tighten.

(*l*) Put on the flying and protective helmets and fasten the chin straps.

(*m*) (i) Connect oxygen mask tube to supply hose.

(ii) Connect clip ring on LSW.

(*n*) Connect mic/tel lead.

17 Checks after strapping-in

(*a*) Raise and lower seat through its complete range once only. Reposition to correct height so that face-screen firing handle can be reached by both hands together.

(*b*) Move the body to the left and right through the maximum range, ensuring that no strain is imposed on PEC.

(*c*) Set the oxygen mask toggle to the low-pressure position and adjust it until there is no leakage when the regulator is set to EMERGENCY. Select 100% OXYGEN.

◀(*d*) *Type 4MSA seat*

Remove seat-pan firing handle safety pin (post-mod. ES3209) or place the safety lock in the flight position (pre-mod. ES3209). In addition remove the pin from the canopy jettison handle and the underwater manual firing handle. The ground crew removes the pin from the face-screen firing handle and hands to seat occupant who stows all pins.

(*e*) *Type 6MSA seat*

Remove pin from seat-pan firing handle, rocket pack firing unit sear, canopy jettison handle and underwater manual firing handle. The groundcrew remove pin from the face-screen firing handle and hands to seat occupant who stows all five pins. ▶

(*f*) Select underwater escape handle to UNDERWATER for carrier borne take-off and landing only; SAFE at all other times.

18 Normal exit procedure

When leaving the aircraft after landing, the following procedure should be used:

◀(*a*) *Type 4MSA seat*

Engage the seat-pan firing handle safety lock pre-mod ES 3209. Remove the safety pins (except the guillotine pin) from their stowage, fit the appropriate pin through the seat-pan firing handle (post-mod. ES 3209) and the canopy jettison handle. Hand one pin to the ground crew who fits it through the face-screen firing handle lock. Fit the remaining pin in the underwater manual firing handle.

(*b*) *Type 6MSA seat*

Remove the pins from the starboard wall stowage. Insert appropriate pin in seat-pan firing handle, the sear of the rocket pack firing unit and the canopy jettison handle. Hand one pin to ground crew, who fits it in face-screen firing handle, and then fit remaining pin in underwater manual firing handle. ▶

(*c*) Return the underwater escape handle to SAFE.

NOTE: If no ground crew is available, the aircrew members must fit all safety pins before leaving the aircraft.

(*d*) Operate the harness QRB, free the straps and return the fitting to the locked position.

(*e*) Disconnect the oxygen mask tube from the oxygen supply hose.

(*f*) Disconnect the mic/tel lead.

(*g*) Disconnect and remove the man component of the PEC from the seat component and refit the dust cover. Free the leg restraint cords from the garters. Pass the helmet and PEC component to the ground crew.

(*h*) Disconnect the life-raft lanyard and the two side connections from the life jacket.

▶◀

(*j*) Climb out of the aircraft.

19 Sequence of events during ejection

(*a*) As the seat ascends the guide rail, the following sequence occurs:—

(i) The leg restraint cords tighten until the rivets shear in the dead-eyes securing the cords to the cockpit floor.

(ii) The auto-tone UHF transmission is automatically switched on.

◀(iii) After approx. 6 ft. of travel the rocket pack is fired (Type 6MSA seat only).

(iv) The time-delay mechanism for the drogue gun is actuated, the gun being fired after a delay of ½ sec. (¾ sec. Type 6MSA seat) ▶

(v) The time-delay mechanism for the barostatic time-release unit is actuated. The actual delay before parachute withdrawal commences is variable and depends upon airspeed and height at the time of ejection. If ejection takes place above approx. 10,000 ft. the barostat delays parachute withdrawal and separation from the seat until that height is reached. A G-stop is fitted to the time-release unit to prevent parachute withdrawal taking place until the seat has slowed to a speed suitable for development; when the seat has slowed to this speed and is below ◀10,000 ft. there is a further delay of 1¼ sec. (1½ sec. Type 6MSA seat) before parachute withdrawal occurs. ▶

(vi) The seat component of the PEC is separated from the aircraft component, disconnecting the main oxygen hose, anti-G suit, and air ventilated suit air supply hoses, the LSW inflation hose and the mic/tel lead.

(vii) The seat raising/lowering actuator lead is disconnected.

(viii) The emergency oxygen is turned on, whether required or not.

◀(*b*) As separation and parachute withdrawal occurs, the occupant is pushed from the seat by the inflation of the seat-man separation bladders. If, following ejection, it is▶ suspected that the automatic separation mechanism is not functioning, separation must be initiated manually; but it should be noted that separation from the seat may not occur immediately due to the delays imposed by the G-stop and the barostat.

Use of the oxygen system

20 Use of the emergency oxygen bottle

(*a*) If it is necessary to use the emergency oxygen bottle through failure of the regulator or because of exhaustion of the main supply, pull up the emergency control on the right of the seat.

(*b*) The duration of supply from the emergency bottle cannot be accurately guaranteed and may vary from 6 to 10 minutes, therefore the descent to 10,000 ft. cabin altitude should be made within 5 minutes. Upon exhaustion of the hottle, breathing becomes difficult hecause the inward relief valve is hlanked off. Check that NORMAL is selected and, if desired, unplug the mask tube.

(*c*) On ejection, the main supply tube to the PEC seat component is automatically released and the emergency set hrought into use. In all high altitude ejections the duration of the set will last until the seat has reached 10,000 ft. and separation occurs. The emergency oxygen set then remains with the seat and the PEC man component is automatically disconnected from the seat component. If descending into water the oxygen mask should be removed.

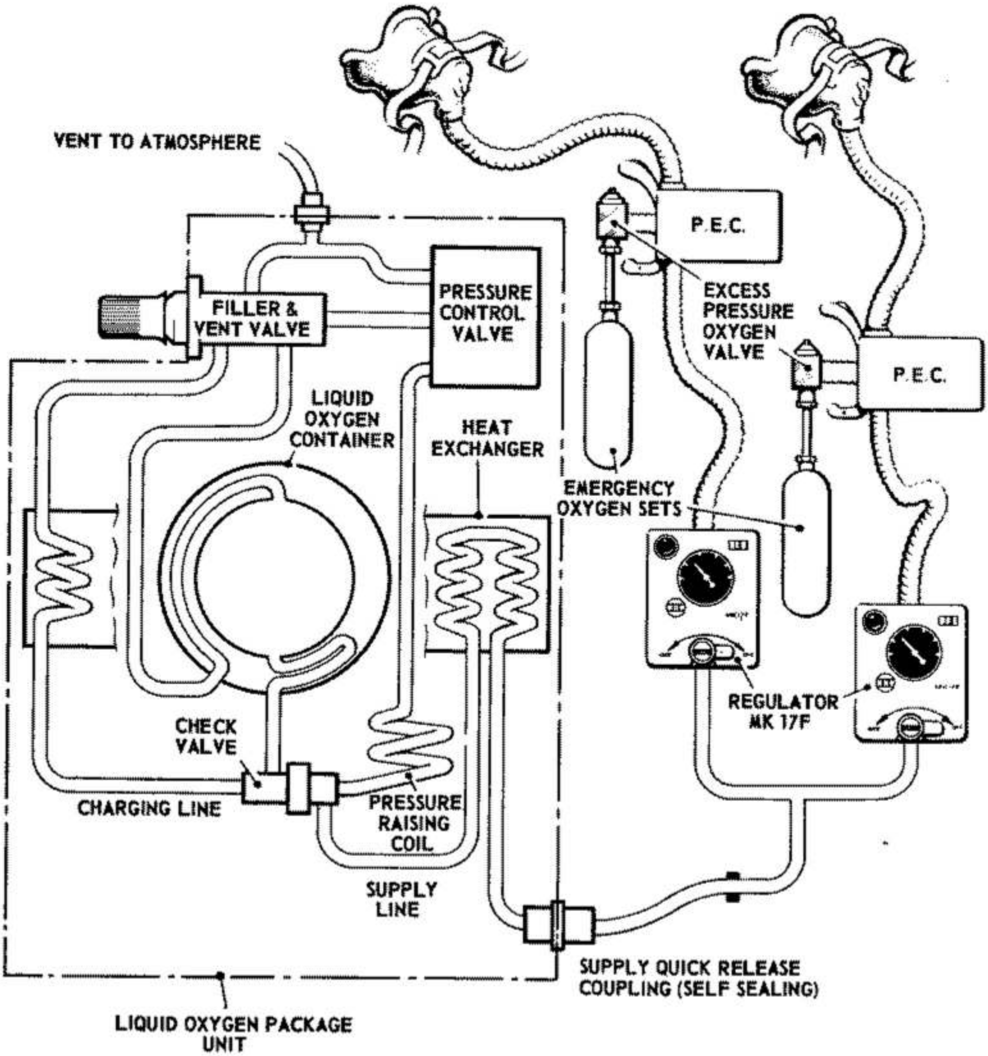

Fig. A—Liquid Oxygen system

Malfunctioning of the oxygen system

21 Regulator indicator failure

(*a*) If the magnetic indicator ceases to operate, check that the main tube is correctly connected, that the pressure on the regulator gauge is normal and that the main oxygen contents gauge is indicating that oxygen is still available. Select 100% OXYGEN.

(*b*) If the above indications are satisfactory, depress the regulator EMERGENCY switch, when in the central position. A supply of oxygen under increased pressure indicates that the regulator is serviceable but that the indicator is defective.

22 Regulator failure

(*a*) The immediate effect of serious failure of the regulator is either:

Excessive delivery of oxygen with difficulty in exhaling and oxygen streaming into the eyes.

No delivery of oxygen with the inability to inhale, the mask being sucked on to the face.

(*b*) In either event, the emergency procedure is as follows:

Turn on the emergency oxygen supply.

Turn off the regulator.

Commence an immediate rapid descent to a cabin altitude of below 10,000 *ft*.

NOTE: Where the regulator failure results in excessive delivery of oxygen, making exhalation difficult, the pressure may be relieved by lifting the lip of the mask with a finger.

PART I—DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 14—RADIO AND RADAR

Cootents

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Radio

1 Radio, general description

The radio installation provides multi-channel voice communication on UHF (main and standby) and HF. In addition

UHF homing facilities using the main set, and bearing and distance information using Tacan, are available. Provision is made for connecting telebriefing circuits, and a telebriefing light and P to T switch are provided in each cockpit. The main UHF set is supplied with 28v DC and AC from the 200v busbar, whilst the standby set receives 24v DC from the normal DC busbar or the emergency battery. The HF is supplied with AC at 200 volts and 28v DC, and the Tacan receives 115v AC from 200v busbar. A centralised audio selector system (CASS) provides a number of aircraft transmitter and receiver services and an intercomm. service. It is controlled from a station box in each cockpit.

WARNING: If the HF is used on the ground all ground personnel and equipment must be well clear of the aircraft, owing to the high radiated voltage during transmission.

2 Radio, controls and indicators

(*a*) *Pilot's cockpit*

(i) The UHF controller is on the starboard console. A switch panel on the port console, contains the following selector switches reading from outboard to inboard:—

Emergency P to T switch
UHF HOMER—MAX/MIN switch
UHF AERIALS—UPPER/LOWER switch
STANDBY UHF CHAN—GUARD/ALT'VE switch
STANDBY UHF POWER—NORM/OFF/EMERGY switch

(ii) The pilot's P to T pushbutton is on the starboard throttle lever handle above the airbrakes switch.

(iii) A T/B light is located on the port console.

(iv) A mute switch is on the cockpit port wall.

(v) An AUTO-TONE/CANCEL switch is on the pilot's port console.

(*b*) *Observer's cockpit*

(i) A TELEBRIEF indicator light is on the starboard console, outboard of the CASS unit.

(ii) The observer's P to T is located on the port console.

(iii) The HF control unit is on the starboard console.

(iv) A foot-operated mute switch is on the starboard side of the cockpit.

(*c*) The ground crew have a mic/tel socket and a spring-loaded call switch in both port and starboard wheel bays and a mic/tel socket in the radio bay.

3 Centralised audio selector system

(*a*) The Centralised Audio Selector System (CASS) provides grouping of all radio and intercomm. facilities and controls into two identical station boxes. The aircraft transmitters are fed from their separate control units through a main junction box. Each station box has one rotary selector switch, nine pushbuttons and EMERGY/NORMAL switch. The functions of these controls are as follows:

(i) The rotary selector switch in the centre of the panel controls the selection of transmit facilities.

(ii) The nine pushbuttons are sub-divided into eight normal receiver channels and an override button. To select a service the button should be depressed gently and turned to the required volume setting. If the rotary selector switch is set to transmit on one facility, the corresponding pushbutton need not be depressed but may still be used as a volume control. The override selector on each station box permits the reception of intercomm. at a high audio level irrespective of services selected on individual boxes.

(iii) The EMERGY/NORMAL switch is for use should a fault develop in the station box amplifier or on DC failure (see para. 13). By selecting EMERGY, the amplifier is by-passed and the receiver channels are routed through the amplifier of the service selected on the ◀rotary selector switch. This should be at UHF, UHF SBY or HF, but if the switch is set to HF it will be necessary to operate a P to T to talk. Both boxes must be switched to EMERGY for emergency intercomm. ▶

NOTE: Whenever the switch is set to EMERGY, ensure that the ADD volume control is set to maximum, otherwise the mic/tel lines will be overloaded, resulting in a reduction or loss of intercomm. and of reception on UHF or standby UHF.

◀(*b*) ADD and SWS signals are fed directly to the crew's▶ headset. The volume of the ADD signal is adjusted by the volume control panel, whilst that of the SWS is pre-set.

(*c*) The station boxes are provided with edge illumination which is derived from two miniature lamps fitted with red filters. The lettered engraving on the top panel is illuminated from below, having a white appearance by day and a red appearance by night. The perspex pushbuttons are not illuminated in their off positions, but when depressed to the on position light enters the spindles, illuminating the buttons and giving indication of services selected.

4 Intercomm.

An intercomm. system for use between aircrew, and aircrew and groundcrew, is incorporated in the centralised audio selector system. Intercomm. is normally available between all five mic/tel locations when the IC pushbutton on each aircrew station box is depressed. The use of intercomm. does not mute incoming selected receiver signals, but the individual pushbutton volume controls permit these signals to be toned down when required. The override system, selected by an O/RIDE pushbutton on each station box, permits the reception of intercomm. at the opposite crew station at a high audio level irrespective of the service which may have been selected at the station boxes.

5 Telebriefing and groundcrew call

A telebriefing plug is in the starboard wheel well. When telebriefing is connected the white TB ON lights are illuminated. If a groundcrew call switch is made, the lights are occulted. When telebriefing is disconnected the white lights go out but will come on (steady) if a groundcrew call switch is made.

6 Main UHF set

(*a*) The ARC 52/TR4 is a V/UHF set, but VHF is not available in this installation. It is controlled from a control unit on the pilot's starboard console and provides multi-channel (225-399·9 MHz) voice communication on a total of 1,750 frequencies of which 19 may be pre-set. One of the pre-set frequencies is always "guard". A separate receiver within this set operates on the guard frequency only, when the main control switch is set to T/R & G, and signals received on this frequency will be superimposed on whatever other frequency is selected. Either of two aerials, one aft on the central dorsal fin and the other, a pair of aerials in parallel, on the fuselage undersurface below the pilot's cockpit, may be used and they are selected by a UHF AERIALS—UPPER/LOWER switch.

(*b*) The controls of the set are as follows:—

Switch		*Function*
Function switch		A four-position switch selecting:
	OFF	No power supplied
	T/R	Permits reception and transmission on a selected frequency.
	T/R & G	Permits reception and transmission on a selected frequency and reception on the guard channel.
	ADF	Switches in homer for presentation on attitude indicator. Normal communication facility is retained.
Channel selector switch		A twenty-position switch selecting
	M	Manual tuning.
	G	Selects guard channel.
	1-18	Selects the pre-set channels as required.
Manual tuning controls		Four controls with associated indicator windows which show the selected frequency. They are read from left to right.
Volume control		Controls audio output to the station boxes. Should be set to maximum volume and the required audio level obtained by adjustment of the UHF selector button on the station box.

(*c*) When mod 1135 is embodied an additional frequency selector is provided, on the observer's port console. For the observer to be able to select a frequency a UHF CONTROL—PILOT/OBSERVER switch inboard of the UHF controller on the pilot's starboard console, must be at OBSERVER. A green light on the observer's frequency selector is then illuminated.

(*d*) The mic/tel and the P to T are connected to tbe main set through tbe centralised audio selector system.

7 Standby UHF set

(*a*) The standby UHF set provides two-channel voice communication. One channel is pre-set to 243 MHz, the guard channel; the other is pre-set to 243·8 MHz, and is normally used for test purposes. A single aerial is on the dorsal fin, forward of the main UHF aerial. The set is controlled by the UHF/SBY selector switches on the station box in each cockpit which, when operated, connects the mic/tel and the normal P to T to this set. The emergency P to T is always connected to the standby set and can only be used with this set, but if it is used, the CASS NORMAL/EMERGY switch must be set to EMERGY. The channel is selected by a STANDBY UHF CHAN—GUARD/ALT'VE switch, and the power supply is controlled by a STANDBY UHF POWER—NORM/OFF/EMERGY switch which at EMERGY is supplied from the emergency battery.

WARNING: The power output of the standby set is lower than the main set, therefore a reduced range should be expected.

(*b*) ~~Post-mod 1117, the standby set is transistorised and has a lower current consumption (see Ch. 1, para. 21).~~ A19

8 Auto-tone UHF transmission on ejection

If either crew member ejects, provision is made for automatic transmission of an interrupted tone signal on the frequency in use. Operated by the respective ejection seat, a transmission tone of 1,000 Hz is injected into the UHF. If UHF standby has been selected the transmission tone will lie within the range 800-1,200 Hz. An AUTOTONE/CANCEL switch, on the pilot's port console, enables the pilot to cancel the transmission if, after the observer has ejected, he decides to land the aircraft.

9 UHF homer

The UHF homer uses the main UHF receiver and the lower aerials, and displays the bearing of any transmission on the frequency in use. The display, in azimuth only, is shown as a bead on the attitude indicator. The main UHF set controller switch must be at ADF and the sensitivity of the display is controlled by a UHF HOMER—MAX/MIN switch.

10 HF set

(*a*) The HF set provides multi-channel (2·5 to 27·0 MHz) voice communication up to 1,500 miles. The set is tuned in one KHz steps, providing a total of 24,500 frequencies.

Power requirements are 200V AC and 28V DC. A notch-type aerial is located in the dorsal fin. Control of the set is from a control unit on the starboard console in the observer's cockpit; the mic/tel and P to T are connected to the set through the centralised audio selector system (para. 3).

The functions of the control unit selectors are as follows:

Control		*Function*
Service selector		A six-position switch selecting:
	OFF	No power supplied, Power is automatically applied to the set when the selector is moved from the OFF position.
	USB	Upper sideband mode for voice communication.
	LSB	Lower sideband mode for voice communication.
	AM	Amplitude modulation mode for voice communication.
	DATA	For use when it is desired to operate auxiliary data equipment with the set. *Not in use.*
	CW	Continuous wave communication *Not in use.*
Tuning controls		Four selector knobs, with associated windows, which should be rotated until the desired frequency appears, reading from left to right.
RF SENS control		A volume control. Should be used in conjunction with the HF pushbutton selector on the station box to adjust the audio level to the headphones.

(*b*) An HF RADIO SILENCE—NORMAL/SILENCE switch is located on the observer's starboard console. In flight conditions requiring HF radio silence, this switch must be selected to SILENCE before changing the listening-out frequency, to avoid spurious transmissions.

◀10A Tape recorder

(*a*) A tape recorder, on the starboard side of the observer's cockpit when mod 5209 is embodied, is used to record communications. Fixed fittings are introduced by mod 1258 and a playback facility is provided when mod 1314 is embodied. The recorder has a RECORD/REPLAY switch, an ON/OFF/REWIND/FAST WIND control, a digital footage counter which indicates tape used. A separate switch, forward of the recorder selects CONT RUNNING or VOICE CONTROL. In addition, a VOICE-REPLAY button on the CASS station box is used to improve amplification on REPLAY.

(*b*) Lifting a handle at the front of the recorder allows the chassis to be withdrawn for loading a cassette; the footage counter is automatically reset to zero. When voice control is selected, recording is activated only when speech or other sounds are detected. When all sounds cease, the tape stops after a pre-set period of silence.

11 Tacan

(*a*) The Tacan installation provides a continuous indication of bearing and distance from a ground radio beacon on the pilot's and observer's display of the IFIS. A separate offset computer enables the position of an offset point relative to the beacon to be set up. The pilot's display then shows the range and bearing of the offset point from the aircraft. This facility is not available on the Observer's display. When mod 1513 is embodied, an air to air ranging facility enables a number of aircraft to obtain simultaneous distance information from a single transponder aircraft whose Tacan operating frequency differs by 63 MHz from the interrogating aircraft. The set is controlled from the pilot's port console where a controller has the following switches:

Power supply switch ...	An on/off switch.
BRG/DIST.BRG switch	When BRG is selected no aircraft transmission is made, and only bearings are indicated. For use under radio silence conditions. Pilot must select DL on navigation display to avoid 'hunting' of range scale. When DIST. BRG is selected both range and bearing are indicated. ▶

Channel selectors	Four pushbuttons and a single selected channel window, for selecting any one of the 126 available channels. Pusbing the top buttons increases the channel number and pushing the bottom buttons decreases the number. In each case the left button moves the tens.

WARNING: Care must be taken not to turn the channel numbers below 01 or above 126, as damage to the selector mechanism may result.

Volume control ...	Controls tbe audio to the centralised audio selector system.

Two aerials under the fuselage, one by tbe nosewheel bay and the otber aft, under the radio bay, are selected by a TACAN AERIALS—FWD/AFT switch adjacent to the controller.

(*b*) The offset computer is fitted on the observer's port console. A controller forward of the observer's repeater has the following controls:

Range control and window	For setting the target distance from the beacon.
Bearing control and window	For setting tbe target bearing from the beacon.

DISPLAY STATES FOR ALTERNATIVE MODE AND CONTROL SELECTIONS (TACAN)

Switch positions

POWER	BRG
	TAC selected on navigation display
ON	Compass display on both instruments Beacon identity tone
OFF	Compass display on both instruments
	DL selected on navigation display
ON	Valid direct Tacan display (bearing only) on both instruments Beacon identity tone
OFF	Meaningless Tacan display (with zero range) on both instruments.
	COMPASS or ILS selected on navigation display
ON	Compass or ILS (inoperative) display on pilot's instrument Compass display on repeater Beacon identity tone
OFF	Compass or ILS (inoperative) display on pilot's instrument Compass display on repeater

Switch positions	
POWER	DIST/BRG
	TAC selected on navigation display
ON	Valid offset Tacan display on pilot's instruments Valid direct Tacan display on observer's instrument Beacon identity tone
OFF	Meaningless Tacan display on both instruments
	DL selected on navigation display
ON	Valid direct Tacan display on both instruments Beacon identity tone
OFF	Meaningless Tacan display (with zero range) on both instruments
	COMPASS or ILS selected on navigation display
ON	Valid Tacan display on repeater only Compass or ILS (inoperative) display on pilot's instrument Beacon identity tone
OFF	Meaningless Tacan display on repeater Compass or ILS (inoperative) display on pilot's instrument

12 Operating the radios

(a) Main UHF

To operate the main UHF:

Set UHF CONTROL—PILOT/OBSERVER switch (post-mod 1135) as required.

Set the function switch as required

Set the volume control as required

Select the required aerial(s)

Select the channel or frequency required

Set the CASS station box rotary switch to UHF

Depress the UHF pushbutton on the CASS station box and rotate tbe button to obtain the required volume

If reception is weak, change to other aerial

(b) CASS

Select transmit facility on rotary switch

Depress required pusbbutton and adjust for volume

(c) Homer

Operate the main set as in (*a*) but set the function switch to ADF

Select min. or max. sensitivity as required

(d) Standby UHF

To operate the standby UHF:

Set the STANDBY UHF POWER switch as required

Select the CASS rotary selector switch to UHF SBY; depress the UHF SBY pushbutton and adjust the volume.

(e) HF

To operate the HF:

Press HF button on CASS and rotate to about ⅔ volume.

Set RF SENS to about ⅔.

Set SILENCE switcb to NORMAL.

Select *at least* 10KHz off required frequency and tben set mode switch to USB, LSB or AM, as required. After 1 minute warm-up a 1 KHz tuning cycle is heard; select operating frequency. On completion of further tuning cycle the set is ready for use, except that HF must be selected on CASS rotary switcb before transmitting. Adjust RF SENS to provide a comfortable listening level with minimum background noise. Small adjustments to the CASS HF volume may be required.

NOTE 1: If tuning cycle is not heard, or if there is no transmission or reception, including loss of side tone, reselect at least 10 KHz off frequency and then back to operating frequency, to retune. If OFF is selected, or there is a break in AC or DC supplies it will also be necessary to retune.

NOTE 2: After operation in SILENCE, the tuning note is heard indicating that the aerial unit is retuning, when NORMAL is selected.

NOTE 3: If a continuous tuning note is heard, retune; if this is unsuccessful, switch OFF, wait 2 minutes and then start switching on sequence again.

WARNING 1: Operation with the SILENCE switch at NORMAL provides a RADHAZ to armament and personnel. Avoid ground transmissions whenever possible and do not transmit during Air-to-Air refuelling.

WARNING 2: Damage to tbe antenna coupler may result from frequent changes in frequency which should be avoided.

◀12A Operating the tape recorder

(*a*) *To record*

Select RECORD

Set CONT RUNNING or VOICE CONTROL as required

Select four-position switch to ON

Check movement of footage counter

(*b*) *To play back*

Select REPLAY on two-position switch

Depress VOICE-REPLAY button on CASS box and rotate to desired volume.

Set four-position switch to REWIND until tape is wound back sufficiently.

Switcb ON ▶

13 Radio failures

NOTE: Whenever the CASS switch is set to EMERGY, the ADD volume must be fully up.

(*a*) *Failure of the main UHF*

If the main set fails, switch on the standby set by selecting the STANDBY UHF POWER switch as required, the CASS rotary selector switch to UHF SBY and depressing the UHF SBY pushbutton.

(*b*) *Failure of intercomm.*

If the intercomm. fails depress the CASS O/RIDE push-button. If the intercomm. is not restored, select the NORMAL/EMERGY switch to EMERGY, set the rotary selector switch to UHF or UHF SBY. In the event of continued failure, use the normal P to T. It should be noted that in the latter case all intercomm. will also be transmitted.

(*c*) *Failure of the P to T's*

◀If both the normal P to T's fail, switch on the standby set as in (*a*), select EMERGY on tbe CASS normal/emergency switch and use the emergency P to T. If a P to T jams on,▶ select the CASS rotary switch to TEL BRF to avoid spurious transmissions.

(*d*) *Failure of the DC supply*

If the DC warning is given on the SWP, switch on the standby UHF set, select the STANDBY UHF POWER switch to EMERGY and select the CASS EMERGY/NORMAL switch to EMERGY. The normal P to T can be used.

Radar

14 Blue Jacket Doppler radar, general description

Blue Jacket is a twin-beam pulsed Doppler radar equipment operating in the X band, which is used to indicate position, wind, track and ground speed and to drive a roller map. It consists of four units, the aerial, transmitter/receiver, navigational computer and the indicator. The power supplies are DC from the normal busbar and AC from the 200V busbar.

15 Aerial and transmitter/receiver

(*a*) The aerial is located below the radio bay. To prevent false inputs to the computer it is stabilised in pitch by the MRG, between the aircraft angles of 7° dive and 13° climb; a roll cut-out operates when 6° of roll is reached.

(*b*) The transmitter/receiver is in the radio bay. A signal cannot be received below 150 ft AGL.

16 Navigational computer

The computer is in the radio bay and has two units, the tracker unit and the computer unit. The tracker unit locks on to Doppler information and computes aircraft ground speeds along and across the heading. A TAS and heading input allows computations of wind speed and direction. The along and across heading speeds are passed to the roller map and the computer unit. The computer unit computes drift angle and ground speed for Blue Parrot radar (target marker computer) and for presentation of track and ground speed on the indicator. Northings and Eastings or changes in latitude or longitude are also computed.

17 Indicator

(*a*) The indicator is in the observer's cockpit, starboard side forward, below the roller map. It displays either track and ground speed or wind speed and direction, as selected, by means of two pointers. Veeder counters display present position in either grid or lat/long co-ordinates, as selected. Jumping of these counters up to 1 mile or 6 minutes of longitude may occur when first switched on. The indicator also houses the controls and secondary indicators.

(*b*) The system has a memory mode which operates when the transmitter is off, the aircraft is below 150 ft., the signals received are too weak for use or the roll cut-out operates. In this case the computer continues to compute present position using TAS and the last calculated wind; the wind may be corrected by using the inching controls. When in the memory mode a memory light will come on and will remain on until normal operation is resumed. If a signal is received but is too weak for the tracker to lock on, the memory light will be intermittent.

18 Doppler controls and secondary indicators

The Doppler controls and secondary indicators are:—

Main ON/OFF switch	Controls the power supply
HT ON/OFF switch	Controls the power to the transmitter

GRD LAT/LONG switch	Selects mode of veeder counters
Counters ON/OFF switch	Starts the veeder counters
Manual control	Allows manual setting of veeder counters. Counters switch must be off for this operation
LAND/SEA	When at the sea position adds 1% correction factor for signal losses over the sea
Memory light	See para. 17(b)
AGC indicator	Indicates strength of received signals (short=strong)
WIND SPEED/TR GR	Selects pointer display
Wind direction } Wind speed }	Inching controls for wind settings when on 'memory'

19 Operating Doppler

To operate Doppler, set the controls as follows:—

Main ON/OFF switch	ON, a 5 min. warm-up period is required before the equipment is functional
GRID LAT/LONG switch	As required
Veeder counters	Set to position
LAND/SEA switch	As required
WIND SPEED/TR GR switch	WIND SPEED. Inch wind speed to zero and then to display local wind
AGC indicator	Check that full bar is showing
Memory light	ON

At unstick speed switch on counters, noting counter jump. When airborne switch HT to ON.

WARNING: Do not switch on counters before take-off as the minimum TAS output (about 60 knots) may be applied, giving spurious ground speed and counter movements.

20 Doppler malfunctioning

Unexpected wind display

Cause—failure of TAS input

With HT—ON

Computation of present position, track and ground speed will continue correctly. Wind displayed will be of sufficient strength and direction to combine with the false TAS and balance the computed ground speed and drift angle. If the equipment goes to memory when the TAS input has failed, present position indication will no longer remain correct.

21 Roller map, geaeral description

The roller map is Doppler driven and consists of a coupling unit in the radio bay and display head in the observer's cockpit, above the Blue Jacket indicator. The power supplies are 28V DC from the normal busbar and AC from the 200V busbar.

22 Coupling unit

The coupling unit is fed with along and across heading ground speeds direct from the Blue Jacket navigation computer, and with compass bearings. A correction for chart angle is applied manually at the display head and from these inputs the along and across chart movements are computed. This information is passed to the display head.

23 Display head

The display head is held in position by a quick-release bracket. The map is held between two rollers and gives a 5 in. x 5 in. display. Approximately 12 ft. of map can be held on the rollers and the speed of movement of the map, up or down the display, is kept proportional to the ground speed by the along chart input. A monitoring system corrects any tendency to vary the speed due to build-up of map on one roller. Movement of the aircraft across the chart is displayed on a tape. The chart angle (i.e. the true centre-line track of the cut chart) is set in by a knurled knob marked TRACK. Two scales (½m. and ¼m) are provided. Movement of the aircraft off the map coverage, up to 10 in., is possible (e.g. up to 75 miles on ½m scale) and on returning to the map no accuracy should be lost. To allow maps to be changed the top roller is removable.

24 Roller map, controls and indicators

The roller map has the following controls and indicators:—

Scale selector OFF switch	A three-position switch for selecting ½m or ¼m with a central OFF position. Also supplies power to the display head when set to either of the side positions.
Chart angle veeder counters (TRACK)	Display selected chart angle.
Chart angle selector	For setting chart angle on veeder counters.
Aircraft position indicator tape	A vertical black arrow on the transparent tape shows the aircraft position. The tape is marked at 1 mile intervals on either side. Horizontal arrows show the direction of the aircraft when off the map.
Tape control	Allows manual control across the chart.
Rapid movement pull wires	Two wires allow rapid manual movement of the chart, up or down the display. The fine control should be used to maintain accurate monitoring.
Fine chart control	Allows fine electro-manual chart control, when the scale is selected.
Back track marker	A small marker on the upper perspex guard which may be placed on the track when back-tracking, to allow more of the chart to be viewed.
Lamp dimmer control	For controlling the illumination of the chart.

25 Operating the roller map

To operate the roller map, first check that Blue Jacket is switched on. The Blue Jacket main on/off switch also controls power to the roller map coupling unit. Then:

Set chart angle.

Set up chart and tape display starting position

When over the starting position:
Select chart scale
Reset chart by fine control, as required.

26 Roller map malfunctioning

Most Blue Jacket failures affect the roller map.

27 Radio altimeter general description

The Mk. 7B radio altimeter provides direct height indication in two ranges, 0 to 500 ft. and 0 to 5,000 ft., The equipment primarily consists of transmitter/receiver, amplifier, two aerials, indicators, limit lights and a control unit. A test (confidence) circuit is provided. The accuracy in the 0-500 ft. range is $\pm$ 3 ft. or 3%, whichever is greater, and in the 0 to 5,000 ft. range is $\pm$ 30 ft. or 3%. This accuracy is dependent upon the aircraft not exceeding 20° in roll or 17° in pitch.

28 Radio altimeter, controls and indicators

(*a*) The controller is on the pilot's port console and has three toggle switches and a rotary switch as follows:

ON/OFF switch	Selecting ON supplies DC to the equipment. After switching on there is a 40 to 60 sec. delay for warming-up, before the equipment starts operating.
LIMIT SELR switch	A twelve-position rotary switch with adjacent windows which shows OFF, 50, 100, 200, 300, 400, 500, 1,000, 2,000, 3,000, 4,000 and 5,000 (ft.) as selected for the operation of limit lights.
TEST switch	A spring-loaded confidence switch. Selecting TEST inserts a known delay into the circuits. Providing the equipment is serviceable, the indicator will read 65 ft. irrespective of aircraft height.

RANGE 500/5,000 switch	Selects either the 0 to 500 ft. or 0 to 5,000 ft. range.

(*b*) *Indicator*

The indicator on the instrument panel is a single-pointer instrument with an OFF-flag and a scale having figure markings at 0, 1,000, 2,000, 3,000, 4,000 and 5,000 ft. When the 0 to 500 ft. range is selected on the controller, a base plate is rotated and this deletes one nought from each of the figure markings except zero, thus making the indicator direct reading on both ranges.

(*c*) *Limit lights*

Three limit lights operate as follows:

Red light	Indieates that aircraft is 5% or more helow the selected limit.
Green light	Indicates that the height set on the limit selector has been obtained.
Amber light	Indicates that the aircraft is 5% or more above the selected limit. The light filaments can be tested by pressing the fitting.

Dimming facilities are provided by rotating the fitting.

(*d*) *Management*

(i) *Switching on*

On/off switch	ON.
Limit switch	As required.
Range switch	500 ft.

Allow equipment to warm-up (up to 1 min) then operate ◀test switch, check indicator shows approx 65 ft. ▶

(ii) *Climbing*

Check hold-off height is more than 1,500 ft.

NOTE: The hold-off height is the barometric height at which the radio altimeter indicator pointer starts to fall back from the hard-over position when climbing. It should not be less than 1500 ft. when set to the low range over the sea.

(iii) *High speed, low level*

Before starting high speed, low level flight check the hold-off height.

29 IFF with SIF, general description

(*a*) The IFF installation is a secondary radar system which provides automatic identification of aircraft when interrogated hy radar. The system also provides for identification of specific friendly aircraft and has a distress signal. The installation has three operational modes and also incorporates an identification of position (IP) facility, as follows:

Mode 1 — For general identification; selected on the SIF controller.

Mode 2 — For individual identification; code is pre-set before flight.

Mode 3 — For aircraft classification; selected on the SIF controller.

IP — For identifying position; normally provides for rapid identification on Mode 1 irrespective of mode in use. Can be set up for use with Mode 3.

Continued on next sheet

◀EMERGENCY For emergency use; provides a▶ readily identifiable distress signal on interrogation irrespective of mode selected.

◀NOTE 1: Neither IP or EMERGENCY are available on Mode 2.

NOTE 2: IP and EMERGENCY are only available on Mode 3 by pre-flight adjustment of links within the coder unit. They will only be seen on the display when the interrogator is operating on the aircraft's correct Mode 3 code. ▶

(*b*) Two shark-fin aerials are fitted one below the fuselage forward of the accessories bay door and the other on the tailplane upper fairing. The electrical supplies are DC from the normal busbar and 115V single-phase AC from the 200V AC busbars.

30 IFF with SIF, controls

(*a*) The whole installation is under the control of an IFF MASTER switch and two control units, both on the observer's starboard console.

(*b*) The IFF master switch controls the DC to the installation.

(*c*) The IFF control unit has one rotary switch and three toggle switches as follows:

Rotary switch positions:

OFF	No power supplied
STDBY	In standby position; only the heaters are warmed-up and about one minute is then required before the equipment will function.
LOW	Low sensitivity. The equipment will only respond to strong interrogation signals.
NORM	The normal operating position. The equipment will respond to any signal received.
EMERGENCY	The emergency position which can only be selected after pressing a red button.

Toggle switches (*two*)

Select modes 2 or 3 respectively. Mode 1 is naturally selected when both switches are OFF.

◀*IP/OUT/MIC switch*

The MIC position is unused and the switch is spring-biased to OUT. Selecting IP operates Mode 1 (or Mode 3 if set up) for 15 seconds after the switch is released. ▶

(*d*) *SIF*

The SIF control unit has two double rotary switches one pair selecting the codes for mode 1 and the other pair selecting the codes for mode 3. The outer ring of the pair selects the first digit of the code, and the inner ring selects the second digit.

NOTE: Mode 2 codings are pre-set and cannot be changed in the air.

31 Wide Band homer, general description

(*a*) The Wide Band homer is a detection device of pulsed radar transmissions. These transmissions may originate from any source whose frequency is within the receiver band-width and lies within about 100° of the aircraft heading. It is capable of operating at any altitude and provides the observer with a visual indication in the form of a bright orange line on a CRT. This display gives either port, starboard or dead ahead bearing information; the dead ahead information is correct within about 5°. An audio signal, the pitch of which is determined by the PRF of the transmitter, is also provided. This signal should be heard by botb crew members, providing the WBH pushbutton on the CASS station box in each cockpit has been depressed.

(*b*) Two aerial pods are carried, one under each wing, and an indicator is situated on the port side of the observer's cockpit. The indicator displays ahead, left or right indications in relation to aircraft heading and an approximate indication of signal strength. All the controls are mounted on the face of the indicator.

(*c*) When Tacan is operating, a suppression pulse is used to switch off the homer receiver during transmission.

(*d*) Power supplies required are 200V single-phase AC and 28V DC from the normal busbar.

32 Wide Band homer, controls and indicator

(*a*) ON/OFF attenuator switch

This switch has seven positions, as follows.

OFF

In this position power supplies are not provided. To prevent inadvertent switching off in flight a stud must be pressed on a guard pillar to allow the switch to be placed in the OFF position. A few seconds are required after switching on before the equipment is fully operational.

Position 1

In this position noise flickers on the display and audio clicks are provided at the rate of about one per second. This position is used to check that the homer is operating and to set up the trigger bright-up controls. It is the most sensitive position which is normally used when searching.

Positions 2-7

Attenuation of the received signal is provided by a step control. This effectively increases or reduces the trace length of the displayed signals. This control does not affect the audio volume but gives some indication of signal strength. The channel gain control is set up with this position selected. The signal should only be attenuated when a full scale deflection is observed.

(*b*) *Trigger bright-up control*

This controls the overall sensitivity of the equipment. It is set up with the ON/OFF attenuator switch on position 1. It may occasionally be necessary to readjust the trigger rate while airborne to approximately one click per second.

(*c*) *Brilliance control*

This controls the brilliance of the display and should normally be kept at a practical minimum to avoid burning the CRT face. It is set up on position 1.

(*d*) *Audio volume control*

This controls the volume of noise being passed to the CASS station box in each cockpit. It is set up on position 1.

(*e*) *CRT display*

This displays bearing only in the horizontal plane.

(*f*) *Pre-set control*

These are covered by small plastic covers and must not be touched in flight. Two are used to balance aerial channels.

33 Management of the Wide Band homer

(*a*) Confirm that both AC generators are on-line (the bus-tie indicator should show a vertical white bar).

(*b*) Depress the WBH pushbutton on the CASS station box.

(*c*) Switch ON/OFF to position 1.

PART I—DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 15—WEAPONS SYSTEM

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Fire Control System

1 General description

(*a*) The fire control system consists of two main parts; the radar and the sighting systems. The radar provides the observer with a means of locating the target and subsequently provides the sighting system with target range and bearing, together with other information set in by the observer. The sighting system computes and displays to the pilot the information that is required for aiming, and completing the necessary manoeuvre for correct release of the selected store. The release is automatic in all modes except depressed sight line attacks.

(*b*) The complete system is made up of nine different units. To function, it receives constant information on roll, pitch, compass bearing, true airspeed and rate of climb from the IFIS. The Blue Jacket Doppler radar provides drift angle and ground speed.

(*c*) One of the units, the weapon system recorder, may be fitted optionally for attack recording purposes only. It then becomes part of the sighting system.

(*d*) The power supplies required are 28V DC and 200V, 3-phase, 400 CPS AC.

(*e*) The power supply to the whole system is DC controlled through an ON/OFF switch and timing relays ensure a 5-minute warm-up period.

Radar

2 Blue Parrot

(*a*) The radar is primarily designed for long range detection of surface vessels, using X-band. An integrated target marker enables blind 2000 lb. HEMC attacks to be made on either radar-visible or non-discrete targets.

(*b*) A monopulse system is employed which gives the radar additional facilities for visual dive attacks and low flying. These facilities provide three modes of use:

Normal
Radar ranging
Terrain warning

(*c*) The radar system consists of four units:—

(i) *Radar main set*. This is the largest unit and is housed in a canister in the folding nose, pressurised to an absolute pressure of 20 PSI. It consists of the scanner, Tx and Rx, a dead reckoning navigational computer called the target marker computer (TMC), display and range servo, and lock-on circuitry.

(ii) *Azimuth range indicator*. This is a CRT in the port forward corner of the observer's cockpit, displaying the information derived from the radar set. Either sector PPI 'B' scan or 'Z' scope displays, with ranges out to 240 nm. are used. The video information is provided by a logarithmic receiver which allows a wide-range of echo signal strength to be simultaneously displayed. A target marker is also displayed. There are controls beneath the CRT, selecting range scales and controlling the display quality.

(iii) *Radar set control*. This has a joystick for marker control and a number of other switches and controls affecting the radar set. It is situated outboard of the observer's right knee.

(iv) *Indicator control*. This has controls and switches affecting the use of both the radar and sighting systems, such as the radar and the target marker mode switches, wind and target data controls. It is situated directly in front of the observer, below the chartboard.

(*d*) The scanner movement is physically limited by its construction in two directions:—

(i) In azimuth up to 50° either side of heading.

(ii) In elevation from 10° elevation to 30° depression.

(*e*) The scanner may be stabilised by the MRG in two planes:

(i) Roll, in all radar modes, up to 90° stbd and 180° port aircraft roll.

(ii) Elevation, in the normal mode only, at the required angle to the MRG horizontal between the scanner limits.

NOTE: In the event of MRG failure, aircraft axes data may be substituted.

3 Radar normal mode

(*a*) The normal mode is further sub-divided into three phases. The first two, Search and Acquisition, are available on all range scales and displays. The third, Track, is available only on the ½m (short range) scale.

(i) *Search*. An azimuth scan on a wide sector, 50° either side of the aircraft heading.

(ii) *Acquisition*. An azimuth scan on a narrow sector, 10° either side of the target marker bearing. This provides a higher data rate than Search.

(iii) *Track*. This phase provides automatic lock follow of a discrete radar target. The target marker must be carefully placed about the target using the Acquisition phase. The scanner is, on selection of Track, at first automatically directed at the target marker position. The radar then searches the area within the marker boundaries and locks-on to the strongest signal in this range and azimuth bracket. Provided lock is held the scanner is then controlled in azimuth and elevation by servo-systems driven by error signals derived from the monopulse scanner through a linear 3-channel receiver. These three channels receive signals of range, elevation and azimuth, respectively, and then produce the error signals required. This receiver is totally unaffected by the display controls. While lock is held the radar thus automatically derives target range and bearing in azimuth and elevation. This target information is the most accurate available. When locked-on to a target a lock-light illuminates above the display. It is possible to obtain a false lock-on to heavy clutter, nearby land or shipping. In most cases the radar bearing will be seen to drift away from the target marker bearings and the range gate may be seen to wander in its search for a discrete signal; the lock-light remains on. Noise-jamming may also provide a false lock, the radar bearing and elevation may be correct but the range will almost certainly be false. An anti-counter measure switch allows target marker range information to be passed to the sighting system while retaining the use of radar bearing and elevation.

(*b*) The display scales provided on Search and Acquisition are as follows:

Sector PPI displays of	½m	0— 30 miles
	1m	0— 60 miles
	3m	0—180 miles

A 'B' scan from 60 to 240 miles

Expanded 'B' scans from	80—140 miles
	130—190 miles
	180—240 miles

A 'Z' scan display on the ½m scale.

The expanded 'B' scans are designed to improve ship detection capabilities, while the 'Z' scan provides improved azimuth discrimination at short ranges. All the displays are heading stabilised only.

(*c*) In the normal mode, the scanner elevation is tied, unless lock is achieved, to the MRG horizontal datum. There are two main methods of control and one additional facility, either:—

1 Manually (by the calibrated scanner depression wheel)

or

2 By use of fixed depression angles. These are 2½° depression at long range scales, normally used at high altitude: 1° depression at short range scales (½m or 1m) at low altitude.

and

3 A two-bar nod scan sweeping ½° above and below the desired scanner elevation angle which may be selected and super-imposed on either of the above. This is to improve the vertical coverage for intermediate altitudes and small errors in MRG pitch datum. (Note: MRG fast erection. A switch allows fast erection, when in steady level flight, to restore the datum.)

4 Radar ranging mode

(*a*) Radar ranging is available for visual dive attack, but accuracy may not be achieved with dive angles below about 15°. The scanner, after rotation through 90° to improve elevation discrimination, is slaved to the pilot's aiming mark: it remains roll stabilised. The correct target slant range is presented on the pilot's display unit when his aiming mark is about the target. The lock circuitry for radar ranging is started by the pilot 'accepting' at the top of the dive, causing the range gates to hunt from 5 miles to ½ mile and lock-on to the ground returns.

(*b*) An additional facility, DTM, is selected by depressing the red button, on the right of the indicator control, after initial radar ranging has been achieved in the dive. This gives more accurate range information by locking to the radar discrete target.

5 Terrain warning mode

Terrain warning is for low-level use over land. The scanner is again rotated 90° and depressed 2° to the aircraft datum, pointing directly ahead; it remains roll stabilised. A red terrain warning lamp, above the pilot's port coaming, illuminates when any obstruction is detected within 4000 yards range, in the aircraft's flight path.

6 Target marker system

(*a*) The target marker system employs a DR navigational computer providing a variety of tactical facilities. The resulting marker range and bearing are displayed on the azimuth range indicator and are tied in accurately with the radar time bases and scanner control circuits, so that a radar discrete object can be accurately marked.

(*b*) The movement of the marker is controlled in three ways:

(i) Along or across heading (i.e., up and down or across the CRT when using PPI displays) by manual rate control of the radar set control handle.

(ii) The true bearing and range, by manually-controlled position offsets on the indicator control. The range and bearing are displayed on veeder counters.

(iii) By automatic ground stabilisation.

NOTE: No allowance is made for target movement.

(*c*) The marker range and bearing are produced in the target marker computer. This computer receives the inputs manually fed in as in sub-para. (*b*) (i) and (ii). These control movements are resolved into marker distances north and east of the aircraft. The ground stabilisation (sub-para. (*b*) (iii)) is provided by resolving and integrating the inputs of drift angle and ground speed from Blue Jacket and true heading from the variation setting control. The resulting miles flown north and east may be constantly subtracted from the initial marker distance to provide present marker distances. These present distances are resolved and displayed as range and relative bearing from the aircraft.

(*d*) The marker range and relative bearing are displayed on the IAR and can be passed to the sighting system where it may be displayed to the pilot by a target spot denoting bearing and, when inside 12 miles, by a range circle. True bearing information is also available to the scanner control circuits for acquisition and track phase, to direct the scanner towards the target. When in Track phase, the range is used by the 3-channel receiver to denote the target area in which to search for lock-on.

(*e*) The marker display consists of a bearing line, painting about 10 times a second, originating at zero range. Two arcuate range lines, painting with the display sweep, mark the inner and outer limits of a gap in this bearing line. This gap is either 1 or 4 miles wide, depending on the scale selected.

(*f*) There are five main modes of use controlled by a single switch, and one subsidiary controlled by a spring-loaded pushbutton:—

(i) *Search*. The marker remains at a fixed compass bearing and range from the aircraft. It is positioned by the radar set control only.

(ii) *Normal*. The marker is ground stabilised and is positioned by the radar set control only.

(iii) *Offsets*. By using the offset range and bearing controls the marker is placed about a displayed object. The range and true bearing from the aircraft of this object may be read off counters.

(iv) *Offsets plus Doppler*. The marker is ground stabilised about a point known with reference to a radar identified object. The true bearing and range of this point from the previously marked object is displayed on veeder counters. The radar identified object is marked, with the switch to Normal. On selecting O and D the marker jumps to the offset position and remains ground stabilised. The marker is then controlled by all three methods.

(v) *Identification points*. The marker may be ground stabilised about a point known with reference to a visual landmark. Before reaching the landmark the range and bearing of the point are set on the veeder counters. Selecting IP runs to ground stabilisation to zero, and displays the marker at the selected range and bearing. On passing overhead the landmark, the pilot presses the accept trigger. The marker, which at that moment is lying about the target's position, is ground stabilised. It is now controlled by all three methods as in O & D.

(vi) *Track marker*. A separate pushbutton displays aircraft track by deflecting the marker bearing line from the aircraft heading by drift angle. The arcuate lines remain about the target. This only affects the azimuth range indicator, the sighting system and scanner control circuits continuing to receive the target marker bearing.

(*g*) The operation of the marker is entirely independent of radar transmissions. A display is required only for sufficient time to mark discrete targets.

7 Radar system information available to the sighting system

(*a*) Information of target range, bearing and elevation is available in two forms; that manually set in by the observer by using the position control, and that which, on selection, automatically passes up-to-date information to the sighting system.

(*b*) *Manual position controls* (*on the indicator control*)

(i) *Wind speed and direction.* Two controls allow wind speeds up to 60 knots to be applied from any direction, for a closing speed of 560 knots. The across-heading component is used to offset the pilot's aiming mark so that a collision course is made to a stationary object.

(ii) *Target speed and direction.* Two controls allow target speeds up to 60 knots to be applied for any true course, for a closing speed of 560 knots. The across-heading component is used to offset the pilot's aiming mark of a collision course to a moving target. The along-heading component is applied to the Doppler ground speed to provide target closing speed to the sighting system.

(iii) *Height above burst.* A control allows height of TMB burst to be set in above, or below, approach altitude. This affects the release point of the weapon.

(*c*) *Information provided automatically*

(i) *Target marker.* The range and bearing of the marker is available to the sight in both Normal and Terrain warning modes. In elevation, the pilot's target spot is tied to the MRG, therefore it is not harmonised with the target in pitch. The accuracy of range and bearing is dependent on the TMC and its use. This information cannot be jammed.

(ii) *Radar.* Locked-on radar range, bearing and elevation are available when lock-on to a discrete target has been achieved, in the Track phase of the Normal mode only. It can be jammed.

(iii) *Target marker range and radar bearings.* This combination can be provided if jamming breaks the lock-on range lock. The scanner can still point at the jammer but target marker range is substituted for a false radar range.

(iv) *Radar range*. By use of radar ranging, range to a visual object, which is depicted by the pilot's aiming mark, is obtained. It can be jammed. No directional information is available.

Sighting System

8 General description

The sighting system is designed to provide the pilot with information to complete blind and visual 2000 lb. HEMC attacks using a Long Toss manoeuvre, and visual 2000 lb. HEMC attacks using an over-the-shoulder manoeuvre against ship, shore and inland targets, using either the target, an offset technique, or an IP. Blind conventional bomb attacks are possible against ships and some shore targets but only visual attacks are possible against inland targets, a Dive Toss or depressed sight line attack being used. In all these attacks the store is automatically released. When rocketing, or delivering Bullpup, only visual attacks with manual release are possible, using a depressed sight line technique. The sighting system consists of six units:

Control and release computer
Gyro unit
Display waveform generator
Pilot's display unit
Weapon system recorder
Recorder display supply and control unit

and four switches:

Armament selector switch (Attack selector - Mod. 1193) AL7
Accept trigger
Reject button
Manual/Auto switch.

It is used in addition to the control settings made by the observer (para. 7).

9 Sighting system units

(*a*) *Control and release computer* (*C & RC*). This is the main unit. It is situated on the vertical bulkhead, exposed when the folding nose is opened. The computer receives target range and bearing automatically from the radar system. Wind and target movement and aircraft height above bomb burst are set in by controls in the observer's cockpit. Aircraft flight information is received from the Blue Jacket Doppler, the integrated flight instrument system and the gyro unit. Store ballistics and method of delivery are selected by switching. The computer solves the necessary computations for three modes (Long Toss, OTS and Dive Toss) to:—

(i) Provide aiming mark deflection, to correct for cross-wind, and target movement and aircraft incidence, to facilitate tracking and collision course.

(ii) Initiate pull-up and provide appropriate warnings.

(iii) Provide a programmed pull-up at 7° per second rate of pitch (Long Toss, OTS and locked-on Dive Toss).

(iv) Provide control of the pull-up plane by aiming mark deflections. These correct for cross-wind, target movement and, during pull-up, changes in cross-wind but not changes in target movement.

(v) Initiate weapon release.

(*b*) *The gyro unit*. This is sited adjacent to the C & R computer. It contains two gyros; the target spot is tied to one and the aiming mark to the other. In addition there are two accelerometers for measuring aircraft movement through space, vertically and horizontally to the airframe. This unit provides essential information during approach and pull-out.

(*c*) *Display waveform generator*. This is sited in the port nose access bay. It provides the pilot's display and the weapons system recorder with the information produced in the C & RC.

(*d*) *Pilot's display unit* (*PDU*). This is situated in the pilot's forward view. A semi-transparent glass displays, by reflection, the information from a bright CRT. The display is collimated to infinity within a 16° cone of vision, this being the limits of the gyros before toppling. It presents the information required for approach, tracking and pull-up, the information is shown in the diagram opposite and comprises:—

The symbols tied to the target spot gyro, i.e.

Target spot
Roll bar

The symbols tied to the aiming mark gyro, i.e.:

Aiming mark (may be offset in azimuth to allow for wind and target movement. It is automatically compen-

sated in pitch for some measure of aircraft incidence, except in 2000 lb. HEMC attack).
True airspeed scale
Quadrantal marks
Range circle
Pull-up warning mark
3-sec event mark
Acceptance mark

NOTE: The roll bar is tied to the aiming mark gyro in a radar ranging attack.

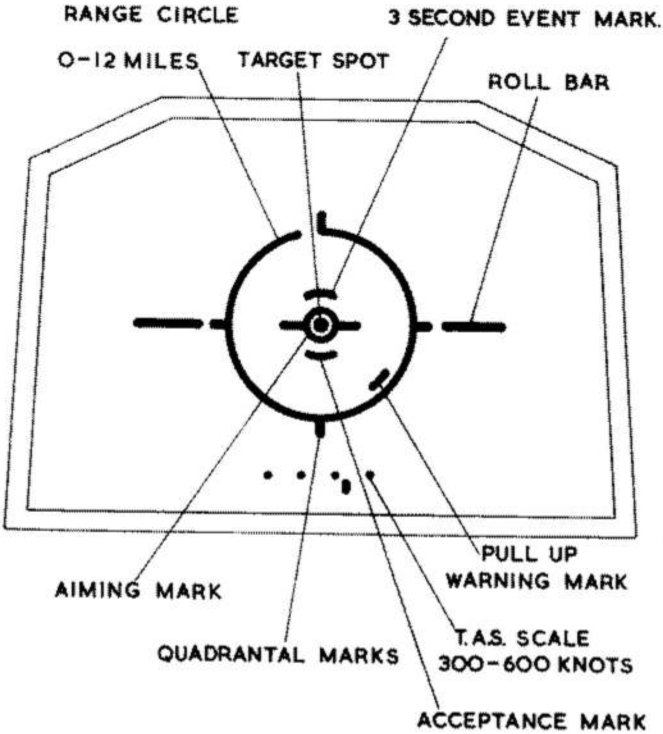

Fig. 1 Strike sight display symbols

Over-the-shoulder attack
Running in to target at low level
Target visual any moment
Set target course and speed
Radar locked-on
Wind set

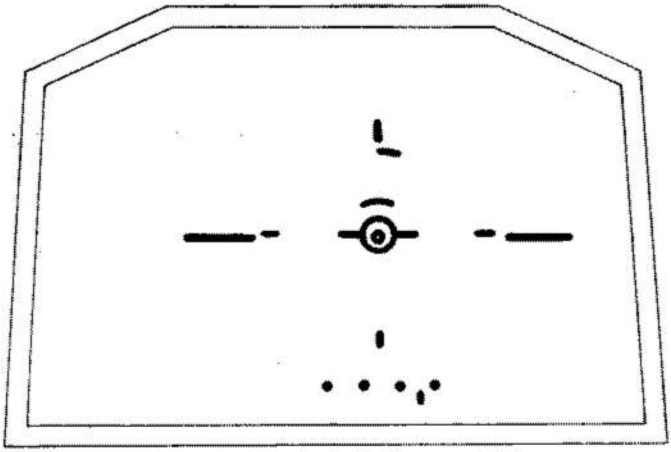

Fig. 2 Typical display on sight

(*e*) *Weapons system recorder*. This 16mm camera is situated under the nose in the folding portion. It automatically records on film a picture of the outside world with a superimposed sight display. The speed of filming is either 1 frame every 15 seconds or 15 frames per second. It is controlled by the C & R computer. The accept warning signal starts the fast speed which is continued until release, or until the reject button is pressed.

(*f*) *Recorder display supply and control unit*: This is sited adjacent to the weapon system recorder, in the nose. Its function is to supply power to the recorder.

10 Sighting system switches

(*a*) *Armament selector switch*. This is situated on the pilot's port console. It selects both the type of store to be released and its method of delivery. It consequently selects the type of calculations to be made by the C & R computer. The practice positions of the 2000 lb. HEMC modes allow the release signal to be passed to wing stations, for use with practice bombs.

(*b*) *Accept trigger.* This is sited on the forward side of the pilot's control column. Pressing the trigger allows:—

The C & R computer to provide a programmed manoeuvre at the pull-up point.
The release circuit to provide automatic release at the computed point.

And initiates:—

The ground stabilisation of the target marker computer when overhead the IP.
Tachometric tracking for conventional bomb attacks.
Radar ranging when selected.
Store release when Manual is selected.
The programmed pull-up when OTS is selected.
Speed-up of the weapons system recorder.

(*c*) *Reject button.* This is a red button on the starboard throttle lever handle. It cancels any computer manoeuvre initiated by the accept trigger and prevents release being signalled by the computer at any time up to release point. It also slows down the weapons system recorder.

NOTE: It may be necessary to press this button to obtain a display.

(*d*) *Manual/Auto switch.* Selects manual or automatic release. Normally this should be wire-locked to Auto as, when at Manual, no use of the computed manoeuvres, IP or radar ranging facilities is safe if the appropriate bomb station is selected. Manual is selected when rocketing or bombing with a depressed sight line.

Sighting System Functions

11 Sighting System functions, general

During various modes the whole system functions on two main phases (approach and tracking and then pull-up and release).

12 Long Toss (2000 lb. HEMC)

(*a*) *Approach and tracking*

(i) Target bearing and range information, from either the target marker computer or the radar set, when locked-on, is supplied by the radar. The pilot must take care not to track in elevation as level flight may not be maintained. Height lock would normally be used. The target itself should be tracked if possible.

NOTE: When IP is selected the pilot must press the accept trigger overhead the IP, before target information can be supplied.

(ii) The target closing speed is calculated by ground speed from Blue Jacket and along heading component of target speed (set in by the observer on the Indicator control). The pull-up point is based upon a fixed time to go, wbich is displayed by the pull-up warning mark close to the range circle on the pilot's display unit (PDU). At 12 miles the range circle appears and is wiped off as the range closes; the distance to target is read like a clock face. A 3-sec event mark is displayed on the PDU directly above the aiming mark.

(iii) The aiming mark is offset in azimuth by wind and target movement controls on tbe indicator control to ensure a collision course is flown towards the target.

(iv) The aircraft must approach as level as possible. Rate of climb from the air data system and the accelerometers in the gyro unit calculate the flight vector.

(*b*) ***Pull-up and release***

(i) At the appearance of the 3-sec event mark tbe pilot must accept, if be wisbes to continue tbe attack. On acceptance an event mark appears directly below the aiming mark.

(ii) At pull-up the target spot and aiming mark gyros are caged and centralise on tbe display. They remain stationary for ½ second. Range circle, pull-up warning, marker roll bar and quadrantal marks disappear.

(iii) One balf second after the gyros are caged the target spot starts to rise on tbe display. The pilot must enter the pull-up manoeuvre immediately and attempt to keep tbe target spot central within the aiming mark.

(iv) If a cross-wind is present a banked pull-up is ensured by deflection of the aiming mark. It is particularly important at the early stages of pull-up to track the target spot carefully in azimuth, using aileron control only.

(v) During pull-up the accelerometers calculate the aircraft's vector, the computing system becoming purely inertial. The C & R computer automatically compensates for an error of up to 1° per sec in the pull-up rate.

(vi) During this period there may be changes in cross-wind. Consequently an MRG monitoring system is incorporated in the C & R computer, which attempts to correct their effect by aiming mark deflections. No allowance is made for errors in azimuth tracking.

(vii) When the aircraft has reached the correct point in space the store is released. The complete display, except for TAS scale, is removed.

13 Over-the-shoulder (2000 lb. HEMC)

NOTE: Selection of OTS overrides the observer's computer IN/OUT switch.

(*a*) *Approach and tracking*

(i) Since OTS manoeuvres are initiated visually on top of the target (at zero range), no calculation of pull-up point is required. On selection of OTS the range servo therefore runs down to zero. This may be seen on the display; the pull-up warning mark is at zero range. The 3-second event mark appears when the computer is ready.

(ii) Steering signals may be used.

(*b*) *Pull-up and release*

On passing overhead the pilot accepts. The manoeuvre is identical in this phase to the Long Toss. However, release is not obtained until about 105° of the loop have been completed.

14 Dive Toss (conventional bombs)

(*a*) This mode can be sub-divided into two. One, when the radar is locked on to a discrete target, enabling blind attacks to be carried out; the other when visual attacks allow radar ranging to be used.

(*b*) *Radar locked-on* (*blind attacks*)

(i) *Approach and tracking*

The range circle appears at 12 miles but it is not wiped off until 4 miles from the target. The quadrantal marks represent miles to target. In other respects the display is identical to that of Long Toss. Autopilot is not used. At the start of the dive the pilot accepts. This:

1. Increases the sensitivity of the aiming mark gyro (5 secs.) to provide tachometric lead.

2. Displays the accept mark

NOTE: The aiming mark is automatically compensated in pitch for some measure of aircraft incidence, to facilitate tracking and can also be compensated, in azimuth, for wind and target movement. An approximate collision course dive is carried out, and 5 seconds tracking is required.

(ii) *Pull-up and release*

The appearance of the display at pull-up point is identical to that of Long Toss or OTS. However, the pull-up is very short before release is obtained. The pilot pulls up, maintaining his wings at the same bank angle to provide the extra lead required. Release is signalled when sufficient pitch-up has been obtained for the correct gravity drop. At release the TAS scale only is left.

(*c*) *Radar ranging* (*visual attack*)

(i) *Approach and tracking*

The range circle appears at 2½ miles (range scale as in blind attacks) and the target spot is removed. The roll-bar is tied to the aiming mark gyro. In other respects the display is normal. The autopilot is not used.

NOTE: Dive angles greater than about 15° are required for accurate radar ranging.

At the start of the dive the pilot accepts. This increases the sensitivity of the aiming mark gyro for tachometric tracking, displays the accept mark, and allows the range servo, hitherto held at 2½ miles, to search for the range cross-over (denoting the earth's surface). The range circle then displays the correct target slant range once the aiming mark is about the target. The range servo may run out to 5 miles in its search. About 2 seconds are required for the range servo to correctly lock-on to the cross-over. If, however, the target is radar discrete, this can introduce a ranging error equivalent to $\pm\frac{1}{2}$ of radar pulse length. To counteract this error the Discrete Target mode of radar ranging is available. A pushbutton on the Indicator Control is pressed after the pilot has accepted in the dive and is holding the aiming mark about the target. A narrow range gate is generated which sweeps the normal radar ranging gate and locks the target if it be of sufficient relative amplitude. The sweep lasts for two seconds, indicated by the lighting of a lamp by the pushbutton. If DTM lock is obtained, the lamp remains lit, and range is fed from the DTM gate. If lock is not achieved within this sweep time, the lamp goes out and the system reverts to normal radar ranging. The aiming mark is compensated in azimuth by wind and target movement, as in the locked-on dive attack. An approximate collision course dive is carried out.

(ii) *Pull-up and release*

A 3-sec event mark is displayed.

At the pull-up point only the aiming mark, event marks and TAS scale remain.

The pilot pulls up, maintaining his wings at the same bank angle.

Release is not signalled until sufficient pitch-up has been obtained for the correct gravity drop.

At release the TAS scale only is left.

15 Depressed sight line

(Rockets, and as a standby mode for conventional bombs)

(*a*) The observer selects the required aiming mark depression, by a control on the indicator control. This control is marked 0 to 7½°; it is depressed on the true vertical. This is in addition to the incidence correction made in the airframe vertical.

(*b*) The pilot must select manual release.

(*c*) No use of the C & R computer is made and there is no ranging. Therefore there is no target spot or range circle. The pull-up warning mark is at zero range.

(*d*) The aiming and release is manually judged by the pilot.

Controls and Indicators

16 Radar system

(*a*) *Radar set control Mk.* 2

Main ON-OFF	Switches power to the fire control system.
TX-SBY	Switches power to the radar transmitter.
Phase change switch	Selects search, acquisition or track in sequence as required. It is electrically connected to the radar mode switch and only functions when Normal mode is selected.

Clutch lever	Energises along/across marker controls.
Across heading marker control	Lateral movement of the handle moves the marker in an across heading direction, at a rate dependent on the amount of handle movement.
Along heading marker control	Fore-and-aft movement moves the marker in an along heading direction, at a rate dependent on the amount of control movement.
Elevation control switch	Selects fixed or manual depression of the scanner. When manual is selected, the depression scale is illuminated.
Manual elevation control	Manual elevation/depression can be set by using the calibrated scale.
1 or 2 bar scan	Up—selects single bar scan.
Track marker button	When depressed the bearing line displays track while arcuate lines remain about the target.
Main gain control	Controls the gain of the log receiver supplying the CRT display.
ACM switch	Selects radar locked-on bearing and target marker range. It functions only during Track phase.

(*b*) *Azimuth range indicator*

CRT display	Displays video, target and track marker as selected.
Range scale selector	A rotary switch selecting:—
½M	Either 30 miles sector PPI or 'Z' scope, depending on position of expanded scale switch.
1M	60 miles sector PPI.
3M	180 miles sector PPI.
'B'	60–240 'B' scan.
Exp. B	Allows use of expanded scale switch.
Expanded scale switch	When Exp. selected on rotary switch:— 1. gives 180–240 mile 'B' scan. 2. gives 130–190 mile 'B' scan.

	3. gives 80–140 mile 'B' scan. When ½m selected:— 1. gives 30 mile 'Z' scope. 2 & 3. give 30 mile sector PPI.
Brilliance control	Controls brilliance of CRT display.
Differentiation switch	OFF No differentiation Short A short time constant is introduced to reduce land clutter. Long A long time constant is introduced to reduce sea clutter.
Sensitivity control	Controls the threshold above which video signals are displayed.
Lock light	An amber light above the CRT illuminates:— 1. During warm-up until HT is present. 2. When the radar has locked-on during track phase, or has locked-on during a radar ranging dive-toss attack.
Pressurisation failure light	A blue lamp to the right of the lock light. Illuminates when radome pressurisation falls to 15 PSI.

(*c*) *Indicator control*

C/N button C—Caged N—Normal	A test facility to uncage scanner when the transmitter is switched off, to check scanner sweep (± 50°).
MRG out/in	Switches either MRG or, in the event of MRG failure, aircraft datums of roll, pitch and azimuth to the fire control system (in conventional attack 15° depression is applied to the C & R computer allowing dive attacks to be made at about 25° dive angles).

ROC out/in	Switches either rate of climb or zero input to the C & R computer in the event of an Air Data System failure.
ST sign out/in	IN position switches steering signals (target marker or radar) to the sighting system. OUT position provides a zero signal, centralising the target spot in azimuth but leaving the remainder of the display unaffected.
Comp out/in	When OUT inhibits C & R C switching signals and removes all pilot's display symbols except TAS.
Radar mode switch RR/N/TW	RR selects radar ranging. N selects normal mode. TW selects terrain warning.
Radar lock pushbutton DTM/RR	Ordinary discrete echo radar lock circuits can be selected for greater accuracy after radar ranging lock has been achieved, by pressing button. A red light on the side of the Indicator Control will illuminate.
Target speed / Target course	Provides sighting system with target information in true course and speed up to 60 knots.
Wind speed / Wind direction	Provides sighting system with wind information in true direction and speed up to 60 knots.
Height above burst	Sets aircraft approach height above required bomb burst height.
Offset range selector	0–50 allows fine short range settings (offset attacks) 0–250 allows long range settings (navigational fixing). The appropriate window is uncovered.
Offset range control	Controls position of counters uncovered by offset range selector. Push in for rapid movement.
Offset range counters	Display selected range.
Offset bearing control	Controls position of bearing counters.

Offset bearing counters	Display selected bearing.
Aiming mark depression control	Selects aiming mark depression for rocket attacks (0–3°) or bomb attacks ($3\frac{1}{2}$ to 7°).
Target marker computer mode switch	Selects:—IP (identification point), S (search), N (normal), O & D (offsets plus Doppler) or O (offsets) as required.
HT reset button	For use on HT failure.

17 Sighting system

◀(*a*) *Armament selector switch* (Pre-mod.1190) AL7.

Select as required:

OFF

CAMERAS (deleted by mod 1136)

DIVE PRAC

BOMBS

RP

BULLPUP (MISSILES, post-mod 1157)

NORM PRAC }
OTS PRAC } TMB
NORM }
OTS }

NOTE 1: OTS position overrides Comp OUT/IN switch on the Indicator control so that the pilot may attack without the aid of the observer.

NOTE 2: Practice positions select normal computer functions but allow release signal to be passed to different wing or bomb bay stations.

Accept trigger	Pilot's mode initiation or firing trigger.
Manual/Auto switch	Selects either manual by the pilot or automatic release by the C & R computer.
Reject button	Cancels the mode accepted and may be used to reset a display.

(*b*) *Pilot's display unit*

Brilliance control	Controls the display brilliance.

The reflector glass displays:—

TAS scale	Displayed at all times when the fire control system is switched on. Speed marks are 300, 400, 500 and 600 knots. From left to right.
Target spot	Displays target bearing. Controlled in pitch by MRG, except when radar inputs are switched in. Not displayed when radar ranging or rockets are selected.
Roll-bar	Displays bank angle through 360° (see Note 1).
Aiming mark	When placed about the target spot the system is aimed. It may be deflected left or right by wind or target movement controls, to provide a collision course to steer, and vertically by an incidence term.
Quadrantal mark	Provides four datums for the range circle.
Range circle	1. Represents 12 miles (clock form) in normal attacks. 2. Appears at 12 miles but does not begin to disappear until 4 miles (quadrantal form) in conventional locked-on attacks. 3. Appears at 2½ miles (quadrantal form) when radar ranging is selected.
Pull-up warning indicator	Provides an early indication of pull-up range.
3-sec. event mark	Appears 3 sec. before calculated pull-up, immediately above the aiming mark.
Accept mark	Appears when the pilot accepts the attack, immediately below the aiming mark.

NOTE 1: During normal 2000 lb. HEMC or locked-on conventional attack the roll-bar is tied to the target spot gyro.

NOTE 2: During radar ranging or rocket attacks the roll-bar is tied, as are the remaining symbols, to the aiming mark.

Management

18 Switching-on

Radar Set Control	*Observer*	*Pilot*
	Main ON/OFF switch to ON, lock light illuminates	Set armament selector to OFF
	TX/SBY switch to ON	Set manual/Auto as required
	Select fixed elevation control	
	1 or 2 bar scan, as required	
	ACM to OUT	
Indicator Control	MRG to IN	
	ROC to IN	
	ST sign to OUT	
	COMP to OUT	
	Radar mode to N	
	Target speed to zero	
	Wind speed to zero	
	TMC mode to search	
	Height above burst, as required	
	Aiming mark depression control, as required	
	B/DSL, as required	
Azimuth Range Indicator	Select display scale as required	
	Sensitivity max (clockwise)	
	Differentiation OUT (up)	
	Brilliance min (anti-clockwise)	

½ minute before the fire control system is fully warmed-up the lock light goes out. When fully warmed-up, the complete system is functional.

NOTE: Warm-up cycle (5 min). Timing relays prevent any damage to the fire control system after switch-on, whatever the switch positions may be (see note on HT reset button).

The sequence is as follows:—

Switch ON	Power supplied to the full system, warm-up begins, lock-light illuminates, TAS scale displayed.
4½ min later (+ 4½)	Warm-up complete, lock-light goes out.
½ min later (+ 5)	EHT signal, transmitter ready.

The HT reset button should not be pressed during the initial warm-up period.

19 Switching-off

Observer	*Pilot*
SBY/TX to SBY	Set armament selector to OFF
Brilliance to min. (anti-clockwise)	Brilliance to min. (anti-clockwise)
Main ON/OFF to OFF	

NOTE: No damage will result to the system but it is advisable to leave the other switches in the ON position.

Malfunctioning

20 Transmitter failure

This is indicated by loss of display video. The transmitter circuits will be automatically failed if the transmitter trips continuously over a short period. The TX/SBY switch should be temporarily switched to SBY. The transmitter should subsequently function correctly. Transmitter failure may, however, be caused by a failure of the main radar canister pressurisation which is part of the cabin pressurisation system. In this case the equipment should function correctly below 3,000 ft. Above 3,000 ft. the TX/SBY switch should be to SBY.

21 Failure of scanner stabilisation, roll-bar and target spot, or dynamic flight instruments

(*a*) Failure of the above may indicate a failure or partial failure of the MRG input. The MRG IN/OUT switch should be made to OUT.

(*b*) The OUT position provides fixed airframe datums of roll, pitch and azimuth.

Full use of the scanner is still available.

The target marker system is relative to aircraft heading and will only be ground stabilised over a steady track. Offset attacks are practically impossible.

Target and wind direction settings are relative.

The MRG monitoring system no longer functions.

Full use of the C & R computer is available (with the exception of the monitoring system).

Conventional Dive Toss attacks should be made at dive angles around 25°.

The roll-bar and aiming mark are locked to the airframe horizontal.

22 Failure of rate-of-climb indicator, or dubious air data information

(*a*) Failure of the above may indicate a failure or partial failure of the air data inputs of the airspeed and rate-of-climb. The rate-of-climb input switch should be made to OUT.

(*b*) When the switch is at OUT, a zero rate-of-climb is provided and the pilot must take care to approach as level as possible to a Long Toss or OTS attack.

PART I—DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 16—ARMAMENT EQUIPMENT

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Introduction

1. The weapons system and armament carriage and control equipment depends on the modification state of the aircraft. The latest states are mod 1190 (improved weapons system), mod 1157 (provision for Sidewinder) and mod 1188 (provision for Martel); previously mod 1143 made provision for tandem stores carriers and mod 1105 for 600 lb HEMC bombs. Originally provision was made for the 2000 lb HEMC bomb, Bullpup, and a variety of stores on the wing pylons and bomb door. Provision for the 2000 lb HEMC bomb and Bullpup is deleted by mod 1188.

2. In addition to provision for carriage, fuzing, release and jettison of the various stores, the system also includes built-in safety factors which prevent the stores being released on the ground or inadvertently in the air.

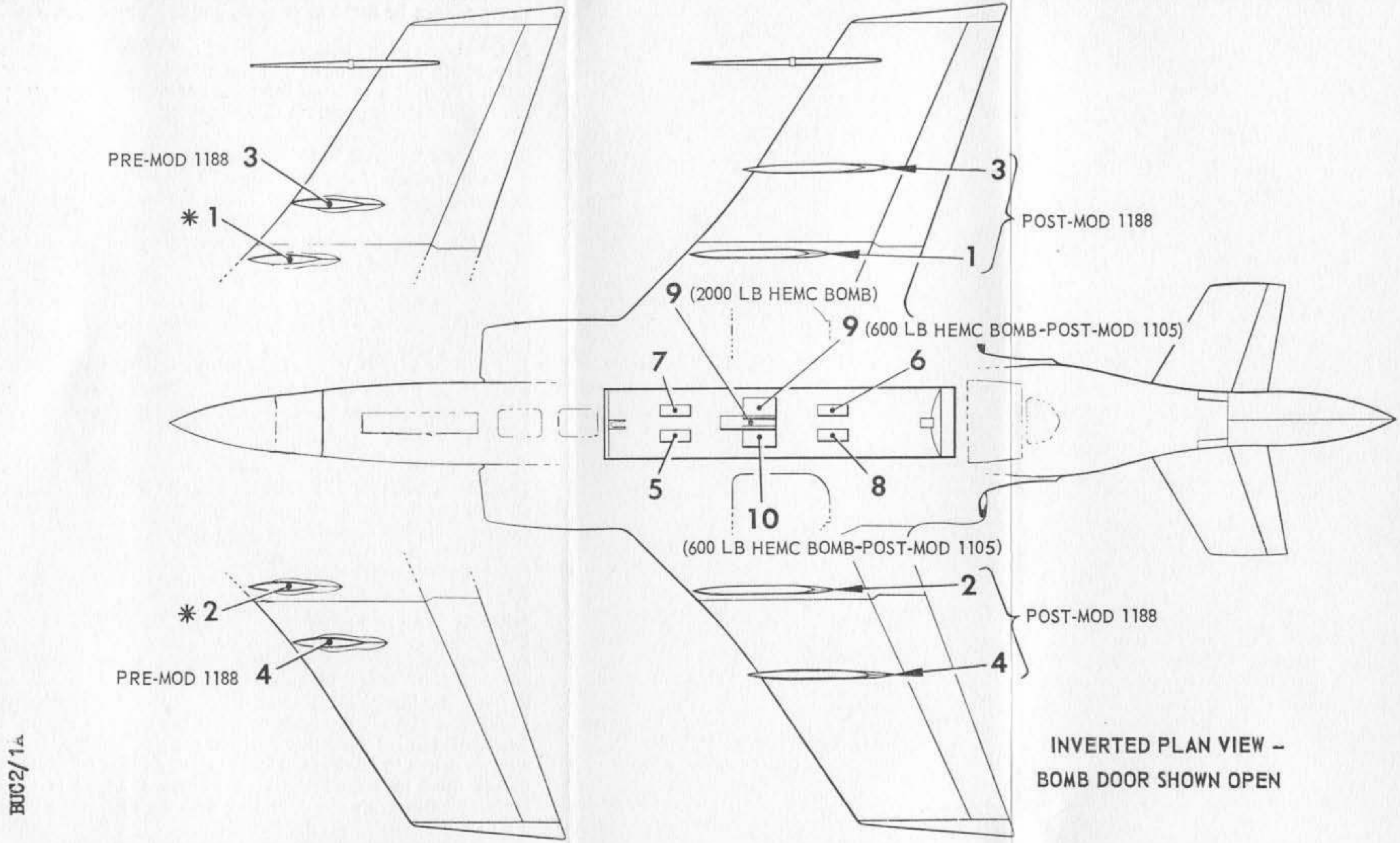
GENERAL INFORMATION

Pylon Stations

3. The detachable pylons are at stations 1 and 3 under the port wing and 2 and 4 under the starboard wing (fig 1). When mod 1188 is embodied all pylon stations are moved further outboard but the existing inboard stations (1 and 2) are retained for carriage of slipper tanks, pylons for LPAS pod or FR pod (stn 2) only.

Bomb Door

4. Internal stores are carried on the rotatable bomb door at stations 5 to 9 (pre-mod 1105) or 5 to 10 (post-mod 1105). Conventional stores are carried at stations 5 to 8, the 2000 lb



✱ USED ONLY FOR WING TANKS, LPAS POD PYLONS AND FR PYLONS (STN 2) POST-MOD 1188

Fig 1—Pylon and Bomb Door Stations

HEMC bomb (pre-mod 1188) at station 9 and 600 lb HEMC bombs at stations 9 and 10. When stations 5 to 8 are in use, stores cannot be fitted to stations 9 and 10, and vice versa.

5. Operation of the bomb door is by a hydraulic jack and it is locked in both the open and closed positions by four lock jacks. Provision is made for both normal and emergency selection of either position.

Bomb Door Controls and Indicator

6. *Normal Control and Indicator*. The normal control is a BOMB DOOR—CLOSED/OPEN pull-to-unlock switch on the throttle box. An associated BOMB DOOR POSITION indicator, adjacent to the throttle levers, shows white when the door is locked open, cross-hatched (de-energised) when the door is unlocked and black when the door is locked closed. Failure of the normal DC supply to the indicator causes the indicator to turn cross-hatched. In this event the indication can be restored by selecting the ARMAMENT JETTISON SUPPLY—NORMAL/EMERGY switch (pre-mod 1105) or the ARMAMENT SUPPLY—NORMAL/EMERGENCY No. 1 switch (post-mod 1105) to the emergency position.

7. *Standby Control.* The standby control is a BOMB DOOR—CLOSED/OFF/OPEN switch on the standby control panel. Operation of the bomb door position indicator remains as described in para. 6.

Bomb Door Normal Operation

8. Selecting the door to OPEN energises the 'normal' solenoid of a locks selector valve, allowing fluid to pass to the unlock side of the four lock jacks. As the locks disengage, final movement of each lock operates microswitches connected in series to complete an electrical circuit to energise the 'open' solenoid of the door jack selector valve. Fluid thus extends the jack, rotating the door to the open position. On reaching this position the door jack operates a microswitch to reselect the locks selector valve, which then passes fluid to extend the lock jacks. Pressure is then maintained in both the door jack and the lock jacks until a CLOSED selection is made.

9. Selecting the door to CLOSED initiates a reverse sequence to opening the door. Fluid pressure is also maintained on the jacks after completion of the operation.

10. Fluid for normal operation of the bomb door is supplied from the General Services system, tbrougb a release valve. A DC supply is provided from the normal busbar for operation of the control circuits; these circuits are so arranged thay they prevent tbe door responding to a reverse selection until it completes its travel in the selected direction; in this case the locks do not engage until the final movement is complete.

11. To ensure that the bomb door cannot be opened hy inadvertent operation of either the normal or standhy controls when a bomb bay fuel tank is fitted, two safety microswitches in the accessories bay are operated by the ground crew when fitting the tank. The normal circuit microswitch breaks the DC supply to the unlock solenoid and directs two DC supplies to energise the lock solenoid. The emergency circuit microswitch breaks the emergency circuits to the unlock solenoid and the door open solenoid.

12. To prevent operation of the bomb door during servicing, a pin can be inserted into a bole in the underside of the fuselage, forward of the bomb door, and turned through 90°. This, through a torque tube and cams, operates two safety microswitches which isolate the normal and emergency DC supplies to the control circuits and switch the normal supply to the homb bay lights. In addition, a second pin can be inserted inside tbe bomb bay and this prevents the torque tube from turning, ensuring that the external pin cannot be removed. The internal pin is stowed adjacent to the torque tube but the external pin is an item of ground equipment.

Bomb Door Emergency Operation

13. If, due to hydraulic or electrical failure, the bomb door fails to respond to a normal selection, the standby control must be used. An emergency selection operates the door as in a normal selection except that the solenoids of the emergency selector valves are sequenced instead of the normal selector valves. Shuttle valves are fitted to all jacks to permit emergency operation. In addition, emergency pressure is fed to a release valve which then opens all the normal lines to 'return', thus preventing a bydraulic lock. In the emergency case the GS system reverts to normal as soon as the door locks are fully engaged and pressure is not maintained at the jacks, providing the system is not on automatic emer-

gency or another system is not being operated on emergency. The standby selector should, therefore, remain in the OPEN or CLOSED position so that if application of G partially withdraws the locks, the GS system will immediately revert to emergency and supply the pressure to re-engage the locks fully.

NOTE: After the standby selector has been used the bomb door cannot revert to normal operation until the release valve has been reset on the ground.

14. A DC supply for emergency operation is provided from the emergency busbar. As in the case of normal operation, the circuits are arranged so that the door will not respond to a reverse selection until it completes its travel in the selected direction, but in this case the operation is completed, i.e., the door locks will engage, before the door responds to the second selection.

WARNING: Although it is possible to complete more than one cycle of bomb door operation using the emergency system, it should not be done if the system is on automatic emergency or if the flying controls integration valve(s) have been opened, as it will seriously affect the operation of other services (Chap. 3).

Circuit Protection Relays

15. Various armament circuits are routed through contacts of the circuit protection relays (Chap. 1). When the aircraft becomes airborne the relays are energised and the stores fuzing, release and jettison circuits are prepared for operation.

16. Inserting a key in a GROUND TEST microswitch in the starboard wheel bay, and turning it so as to operate the microswitch, energises the circuit protection relays to simulate flight conditions while the aircraft is on the ground.

Armament Master Safety Breaks

17. These consist of two shorting plug and socket connectors in the starboard wheel bay. With the shorting plugs disconnected and a blanking plate attached to the sockets, the armament system is rendered inoperative.

Servicing Safety Breaks

18. As a further protection against accidental release of conventional stores on the ground, each carrier and pylon

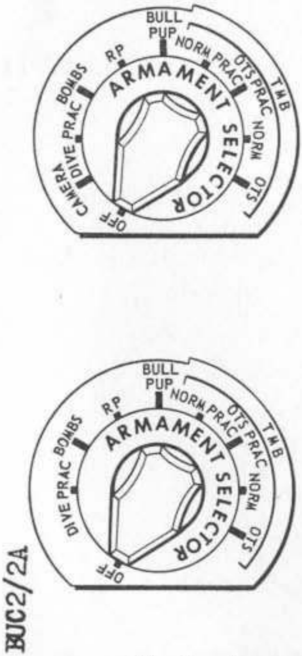
has a servicing safety break which, when disconnected, breaks the circuit to the explosive cartridge of the ejector release unit.

Stores Controls and Indicators, General

19. The following paragraphs describe the controls and indicators which are common to the release or jettison of two or more types of store. The controls and indicators peculiar to a particular store are described in the paragraphs relating to that store.

Armament Selector

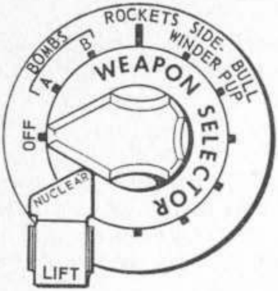
20. The ARMAMENT SELECTOR on the pilot's port console, pre-mod 1190, selects the store to be released. The selective positions vary with the modification state and are shown in fig 2. In addition to selecting the store, this selector



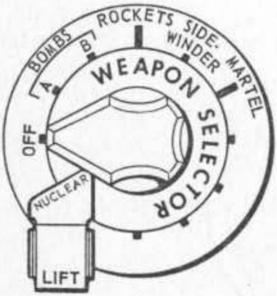
Basic

Post-mod 1136

Fig 2—Armanent selector (pre-mod 1190)



Pre-mod 1188



Post-mod 1188

BUC2/3A

Fig 3—Weapon and attack selectors (post-mod 1190)

also selects the computer mode and, consequently, switches the C & R computer (Chap. 15) to resolve the equation for the appropriate attack and store.

WARNING: To prevent release into the bomh bay if the safety circuits fail, a bomh door stores position should not be selected until the homh door has rotated open.

Weapon Selector

21. The WEAPON SELECTOR replaces the armament selector, post-mod 1190, and is used in conjunction with the attack selector (para 22), to enable a greater variety of attacks to be performed. The selective positions vary with the modification state and are shown in fig 3. The weapon selector selects only the store and the attack selector selects the mode of attack. Inadvertent selection of the NUCLEAR position on the weapon selector is prevented hy a spring-loaded stop which must be lifted to enable the knoh to be turned to this position.

Attack Selector

22. The ATTACK SELECTOR is next to the weapon selector and, post-mod 1190, is used to select the mode of attack. Manual, timed and computed attacks are provided for. The selective positions are shown in fig. 3.

WARNING: It is possihle to release stores in unsuitahle modes of attack hy making incorrect selections on the weapon and attack selectors. Some groupings such as BOMBS A or B and LONG TOSS are safe to perform hut large errors will he present in the delivery. Other groupings are safe hut irrelevant such as ROCKETS and LONG TOSS, and a few are hazardous such as BOMBS A or B and LAYDOWN when unretarded bombs are carried. It is essential, therefore, to critically examine the selections after setting up the attack to ensure that an inadvertent or hazardous release is not made.

Release Manual/Auto Switch

23. The RELEASE—MANUAL/AUTO switch is located aft of the throttle levers; it is only used in conjunction with the armament selector. In the MANUAL position it routes the output from the firing trigger to the stores release circuits or to the cameras. In the AUTO position the output from the firing trigger is routed to the C & R computer to initiate the release. The switch is wire-locked at

AUTO. With the introduction of the target accept hutton, post-mod 1190, the RELEASE—MANUAL/AUTO switch is deleted.

Bomb Release Safety Lock Controls and Indicators

24. Each 2000 lb and 600 lb HEMC bomh release unit has a BRSL which prevents inadvertent release of the store. The BRSL for the 2000 lh HEMC bomb is a twin-motor actuator which inserts a pin into the release unit and is on the bomh door. The BRSL for each 600 lh HEMC bomh is in the ejector release unit and locks the hook mechanism via a shaft. The controls and indicators are in Table 1.

Table 1—BRSL Controls and Indicators

Control/Indicator	*Marking and Function*
2000 *LB HEMC BOMB—PRE-MOD* 1105 (*PILOT'S PORT CONSOLE*):	
BRSL switches	LOCK/UNLOCK No. 1 & No. 2. Control BRSL motors
BRSL isolating switches	BRSL ISOLATORS—POWER ON/POWER OFF, No. 1 & No. 2 Control DC supply to each motor circuit
Locked and cocked lights (green)	LOCKED AND COCKED, PRESS FOR LOCKED INDICATION Indicate BRSL locked and release unit cocked. Each light indicates operation of one motor
Unlocked lights (amher)	UNLOCKED. Indicate BRSL unlocked. Each light indicates operation of one motor
2000 *LB HEMC BOMB—POST-MOD* 1105 (*OBSERVER'S ROLE PANEL*):	
BRSL switch	LOCK/UNLOCK. Controls BRSL motors. Wirelocked at LOCK
Locked light (green)	LOCK. Indieates BRSL locked
Unlocked light (amher)	UNLOCK. Indicates BRSL unlocked
Cocked light (amber)	COCKED. Indicates release unit cocked

Control/Indicator	*Marking and Function*
600 LB HEMC BOMBS (OBSERVER'S ROLE PANEL):	
BRSL switches	LOCK/UNLOCK (stn 9 & 10). Control BRSL motors. Wire-locked at LOCK
Locked lights (green)	LOCK (stn 9 & 10). Indicate BRSL's locked
Unlocked lights (amber)	UNLOCK (stn 9 and 10). Indicate BRSL's unlocked
Bomb-on-station lights (amber)	BOMB ON STN (stn 9 & 10). Indicate bombs correctly loaded

NOTE 1: The 2000 lb HEMC bomb locked and cocked lights and the unlocked lights, pre-mod 1105, have press-to-test and rotate-to-dim facilities. All other lights have press-to-test facilities only.

NOTE 2: Since the BRSL circuits are routed via the contacts of the circuit protection relays pre-mod 1283, indication of whether the BRSL's are locked or unlocked is not given when the aircraft is on the ground.

NOTE 3: If the 2000 lb HEMC bomb locked and cocked lights, pre-mod 1105, go out for no apparent reason the position of the BRSL pin can be ascertained by pressing the lights; if the lights come on the pin is in but the release unit is uncocked.

WARNING 1: If the 2000 lb or 600 lb HEMC BRSL is not unlocked before an attempt to release is made, release will not take place.

WARNING 2: If the 2000 lb HEMC BRSL is locked and the release unit is uncocked, release will take place immediately the BRSL is unlocked.

Multiple Stores Lights

25. When mod 1143 is embodied, four amber lights, marked MULTIPLE STORES, STN 1, STN 2, STN 3, STN 4, are on the starboard side of the observer's wind-screen lower frame. The lights come on when bombs or flares are carried on the tandem stores carriers providing the armament or weapon selector is set to BOMBS. Release of the last (forward) store from each carrier results in the associated light going out. Each light has a press-to-test and rotate-to-dim facility.

Bomb Distributor

26. (*a*) This unit on the port wall of the observer's cockpit works with the release and fuzing equipment to provide selection, spacing and release initiation of conventional stores. The controls and indicators are as shown in Table 2.

Table 2—Bomb Distributor Controls and Indicators

Control/Indicator	*Marking and Function*
Start switch	START—1/2/3/4/5/6/7/8. Selects first store to be released
Stop switch	STOP—1/2/3/4/5/6/7/8. Selects last store to be released
Spacing switch	SPACING—30/45/60/350 ms (pre-mod 1190)
	SPACING — 30/45/60/150/250/350/450/600/800 ms (post-mod 1190). Selects time interval between release of selected stores
Mode switch	MODE—OFF/SNGL/PAIR/ALL At SNGL stores released one at a time. At PAIR stores released two at a time. At ALL stores released in two sets of four with a 30 ms spacing between sets
Store release indicators	1/2/3/4/5/6/7/8. Indicate stores selected

WARNING: To jettison bombs 'safe' the mode switch must be OFF. The mode switch should also remain OFF until the bomb door has locked open and the bomb door should remain closed until in the range danger area.

◀(*b*) When NSM 3061 is embodied a modified bomb release sequence operates to allow alternate wing and bomb bay station releases. This modified sequence prevents interference between 1000 lb retarded bombs released from the bomb bay, and allows a stick of 5 or 8 bombs to be released at an interval of 150 milli-seconds between bombs. The modification is only fitted when retarded bombs are carried in the bomb bay and is removed for the carriage of all other stores. ▶

◀The following two loading configurations *only* can be used:

(1) *All stations loaded* (1–8).

When all stations are loaded the release sequence when START 1 STOP 8 is selected on the bomb distributor is station 1, 5, 2, 6, 3, 7, 4, 8.

(2) *Stations* 3, 4, 6, 7 *and* 8 *loaded* (*wing tanks fitted to stations* 1 *and* 2).

When START 4 STOP 8 is selected on the bomb distributor, the release sequence is station 6, 3, 7, 4, 8.

NOTE: For both configurations the MODE switch is to be selected to SNGL and the SPACING switch is to be selected to 150 MS. ▶

EL/EA Fuzing Control Unit

27. This unit is on the port wall of the observer's cockpit until deleted by mod 1188, and is used to select EA fuzing for Bullpup and other switching functions associated with the release of conventional bombs, Bullpup and Sidewinder. The EL fuzing facility for bombs is not used. The controls and indicator are in Table 3.

Table 3—EL/EA Fuzing Control Unit Controls and Indicator

Control/Indicator	*Marking and Function*
Store selector	WEAPON — B/M1/M2/M3/M4. Selects required store, bombs (B), Bullpup (M1, M2, M3 or M4) or Sidewinder (M3 or M4)
Fuzing selector	FUZING — A/B/C/D/E/F/G/H. Selects required fuzing channel (A, B, C or D) for Bullpup. Channels for EL fuzing not used
Arming switch	M ARMED/OFF/M UNARMED. At M ARMED missile launched fuzed. At M UNARMED missile launched unfuzed (Bullpup only)
Neon light	Lights when fuze charging unit is at full power.

NOTE: When mod 1188 is embodied there is no provision for Bullpup and the EL/EA fuzing control unit is deleted. The switching functions for conventional bombs and Sidewinder, previously performed by the store selector and arming switch, are effected by other means. In the case of conventional bombs, the function of the store selector is fulfilled by the WEAPON SELECTOR on the pilot's port console. In the case of Sidewinder, two new switches are provided on the port wall of the observer's cockpit (para. 88).

Pre-release Timer

28. When mod 1190 is embodied, a pre-release timer is on the observer's starboard console. The unit is used for the laydown and vari-toss modes of attack to enable a time delay period between the operation of the target accept button and the release of the stores to be selected. The delay is set by a rotary switch on top of the unit, the dial being graduated in 0·25 second intervals up to 4 seconds and 0·5 second intervals from 4 to 9 seconds. The setting of the switch for a particular attack is determined by reference to attack planning charts.

NOTE: If failure to release occurs during a timed attack, an immediate release can be achieved by selecting 0 SECONDS on the pre-release timer and pressing the accept button a second time. With the timer set to this position, a fully duplicated circuit is provided to the firing relays.

Firing trigger

29. The firing trigger is on the front of the control column and is protected by a mechanically-locked SAFE/FIRE (forward) safety catch. Pre-mod 1190 the switch initiates the release of the appropriate store or starts the cameras, as selected by the armament selector, when the release switch is at MANUAL. If the release switch is at AUTO the trigger is used to accept the target, thus initiating the release sequence.

30. When mod 1190 is embodied the firing trigger is used only in the manual release mode. The function of the trigger in the automatic mode is fulfilled by the accept button (para. 32).

31. When certain stores are carried, pressing the firing trigger or the accept button also operates the engine auto-relight circuit (see Chap. 5, para 19(b)).

Accept Button

32. The accept button on the port engine throttle lever, post-mod 1190, takes over the functions of the trigger switch regarding the C & R computer. In addition, the button is also used for timed releases and, with the pre-release timer set to 0 SECONDS, can also be used for the manual release of primary stores. All automatic release dive attacks using the 4 mile range servo (Chap. 15) require a 'double accept' technique; a first press uncages the range servo and the second press should be held until store release. This is a safety device to guard against premature releases, due to range scale over-run when the range servo commences to run down from the caged position to the true position. A SAFE/FIRE safety catch prevents inadvertent operation of the button.

Release Indicator Light

33. When mod 1190 is embodied an amber light, marked RELEASE—PRESS-TO-TEST & RESET (pre-mod 1291) or RELEASE—TO RESET PRESS REJECT SWITCH (post-mod 1291) is on the pilot's port console. The light comes on whenever a release signal energises the firing relays, and remains on until the target reject button (para 35) is pressed to reset the weapons system after the attack. The light has press-to-test and rotate-to-dim facilities.

NOTE: The press-to-test facility should not be used to make the light go out.

34. Besides indicating release of stores, tbe light also provides information in the event of failure to release. If the light comes on after an abortive release, it indicates that the firing relays bave operated; store selection should be checked. If the light does not come on, a fault is present in the 'accept' circuits. If the light comes on but cannot be reset, it probably indicates that the firing relays are energised and in this case all relevant armament switches sbould be set OFF or SAFE before returning tbe weapon selector to OFF.

Reject Bntton

35. The reject button is in the end of the starboard throttle lever handle, below the airbrakes switch. Its function is to enable the computer release programme, previously accepted by the firing trigger (pre-mod 1190) or accept button (post-mod 1190), to be cancelled and it is effective up to the actual time of release. The button is also used, post-mod 1190, to cancel the operation of the pre-release timer and reset the release indicator ligbt and, post-mod 1277, to cancel the operation of the cameras.

Jettison Selector

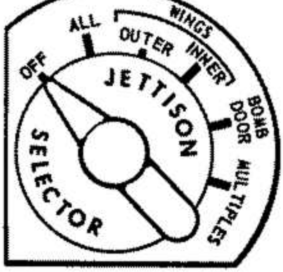
36. The JETTISON SELECTOR on the pilot's port console is used to select circuits to jettison stores from specific stations. The selective positions vary with the modification state and are shown in fig 4.

Jettison Pushbntton

37. The STORES JETTISON guarded pushbutton, to port of the pilot's instrument panel, initiates the appropriate ejector or electro-magnetic release unit, as determined by the jettison selector switch. In the case of Sidewinder, pre-mod 1188 only, it results in tbe missile being launched unarmed. If wing fuel tanks are carried, it initiates operation of the pneumatic ejector.

38. With tbe jettison selector at ALL, conventional stores can be jettisoned rapidly. If the bomb door is open, pressing the jettison button jettisons wing and bomb bay stores; if tbe bomb door is closed, pressing the button jettisons the wing stores only. If the bomb door is then opened, pressing tbe button a second time releases the bomb bay stores, with

Basic



Post-mod 1143

Post-mod 1188

BUC2/4A

Fig 4—Jettison selector

a 40 ms delay between release of stores on stations 5 and 6 and stations 7 and 8. To jettison the 2000 lb HEMC bomh at station 9, the selector must be at 7, 8 and 9 or BOMB DOOR, as appropriate to the mod state.

WARNING 1: The jettison pushbutton must not be operated a second time until the bomb door has rotated, or structural damage may result.

WARNING 2: Witb tandem stores carriers the jettison selector must be at MULTIPLES if it is required to jettison the stores only. If the selector is at ALL, INNER or OUTER the carriers will be jettisoned also.

NOTE: The 600 lb HEMC bombs at stations 9 and 10 cannot be jettisoned using the normal jettison facilities. A normal release sequence, without fuzing selections, must be performed instead.

Armament Supply Switch(es)

39. The ARMAMENT JETTISON SUPPLY—NORMAL/EMERGY switch on the throttle box is used to select alternative power supplies for the jettison circuits, 2000 lb HEMC BRSL, and homb door interlock relays. In the NORMAL position the supply is from the normal DC busbar hut wben EMERGY is selected, the supply is from the emergency battery. When mod 1105 is embodied an additional switcb is introduced next to the existing switcb. The two switches are together marked ARMAMENT SUPPLY—NORMAL/EMERGENCY, No. 1 and No. 2 and, in addition to selecting alternative power supplies for the above circuits, also select alternative supplies for the 600 lb HEMC BRSL's; botb switches sbould normally be operated together.

2000 LB HEMC BOMB

General

40. The 2000 lb HEMC bomb is carried at station 9 in the bomb bay, in pre-mod 1188 aircraft only. A BRSL whicb prevents inadvertent release is controlled from the pilot's port console (pre-mod 1105) or from a role panel in the observer's cockpit (post-mod 1105). An EP fuze cbarging unit supplies a 300V DC charging voltage, or the same voltage with one of five RF signals superimposed, as selected by a fuzing control unit on the port wall of tbe observer's cockpit. The fuzing controls and indicators are as shown in Table 4.

Table 4—EP Fuzing Controls and Indicators

Control/Indicator	*Marking and Function*
Channel selector	OFF/STANDBY/A/B/C/D/E/F. At STANDBY provides a 115V AC supply to bomb. At A provides a second 115V AC supply to bomb and the 300V DC voltage from fuze charging unit. B to F—As for A, but with superimposed RF signal.
Bomb-on-station light	BOMB ON STN. On while bomb is on station, providing armament selector is at NORM or OTS.
Standby light	STANDBY. On when STANDBY is selected.
Neon light	A. On when first AC supply is at bomb.
Neon light	B. On when both AC supplies are at bomb.
Neon light	POWER IND. On when 300V DC is at bomb.

NOTE: The bomb-on-station light and the standby light each have press-to-test and rotate-to-dim facilities.

600 LB HEMC BOMBS

General

41. When mod 1105 is embodied two 600 lb HEMC bombs can be carried at station 9 and 10 in the bomb bay. To prevent inadvertent release of the stores each ejector release unit houses a BRSL, the controls for which are on a role panel in the observer's cockpit. The role panel also houses the fuzing controls listed in Table 5.

Table 5—600 lb HEMC Controls and Indicators

Control/Indicator	*Marking and Function*
Station selector switch	SELECTOR–STN9/OFF/STN 10. Selects the station from which it is required to release a bomb.

Control/Indicator	*Marking and Function*
Fuzing channel switches (two)	CHANNEL A–ON/OFF, CHANNEL B—ON/OFF. Supply DC to fuzing control units.
ER fuzing control units (two):	
Channel selector	DH/OL/LW/LL/GP/GA/AP/AA/RP/RA/TEST
Live/safe/off switch	LIVE/SAFE/OFF
Option light	OPTION
Sub option light	SUB OPTION

CONVENTIONAL BOMBS

General

42. Conventional bombs are carried on the wing pylons at stations 1 to 4, and internally on the bomb door at stations 5 to 8. The types of bombs which can be carried are:

1000 lb MC Mk. 10 bombs (standard and retarded)
500 lb MC Mk. 21 bombs
540 lb MC Mk. N1 bombs
1000 lb MC Mk. N1 bombs } External carriage only
100 gal. No. 1 Mk. 1 fire bombs } External carriage only

When mod 1143 is embodied an increased number of bombs can be carried externally by fitting a special carrier to each pylon. Each carrier then mounts two 500 lb MC Mk. 21 bombs or two 540 lb MC Mk. N1 bombs in tandem.

43. To modify the C & R computer release equation to suit the types of bombs carried during medium and dive toss attacks post-mod 1190, a set of ballistic plugs is provided. There is a different plug for each type of bomb and they are fitted, two at a time, to a junction box in the aircraft nose. The sockets in the junction box are identified A and B, and they correspond to the BOMBS A and BOMBS B positions on the weapon selector. Thus if a 1000 lb bomb ballistic plug is fitted to socket A and a 500 lb bomb ballistic plug

fitted to socket B, the weapon selector should be set to BOMBS A before releasing 1000 lh bombs and to BOMBS B before releasing 500 lb bombs.

44. Selection, spacing and release initiation of tbe bombs is by the bomb distributor in tbe observer's cockpit, and either EM or VT fuzing is used. EL fuzing is also provided, pre-mod 1188, but this system is not used.

EM Fuzing Selector Switch

45. This switcb on the port wall of the observer's cockpit and marked FUZING SELECT—NOSE/NOSE & TAIL/TAIL completes a circuit from tbe bomb distributor to the appropriate EM fuzing unit(s).

RECONNAISSANCE FLARES

General

46. When mod 1143 is embodied up to eight 8 in. No. 1, Mk. 1 or Mk. 2 reconnaissance flares can be carried externally. The flares are carried two on eacb tandem stores carrier. A heigbt setting controller and a station selector switcb are provided by ~~mod 999~~. For the No. 1, Mk. 1 flares, the time delay before parachute deployment and flare illumination is set by adjusting a timing screw on the body of each flare prior to flight, and for the No. 1, Mk. 2 flares, by adjusting the height setting controller on the approach to the target. AL 9

Height Setting Controls

47. The beight setting controller is on a bracket below the Blue Jacket crate and is marked HEIGHT SETTER FOR 8" FLARE. The controller has a SECONDS DELAY indicator and a PRESS TO SET button. Pressing tbe button, as necessary, gives a repeating 12-settings sequence wbich is displayed on the indicator in the order SAFE–6–11–16–21–26–31–36–41–46–51–56. A station selector switch, STATION 1 & 2/STATION 3 & 4 is adjacent.

PRACTICE BOMBS

General

48. Up to eight 28 lh No. 1, Mk. 1 low-drag practice bombs, eight 28 lb, No. 1, Mk. 1 retarded practice bombs or eight

25 lb No. 2, Mk. 3 practice bombs may be carried in pairs at stations 1 to 4. Each carrier consists of an adapter which is attached to the station pylon ERU and mounts two small pylons, side-by-side. Each bomb is held on its carrier pylon by a release unit. 28 volt fuzing is used for 28 lb low-drag bombs but no fuzing connections are required for 28 lb retarded or 25 lb bombs. A four-position auto-selector is in each carrier, two positions only being wired, one for each bomb station. The wiring of each auto-selector is such that, on rotating after release of the starboard bomb, the firing circuit moves to the port bomb.

ATTACK PRACTICE FACILITY

General

49. When mod 1190 is embodied, with the weapon selector and bomb distributor mode switch set to OFF, the BRSLs locked, and no fuzing selections made, attacks with full sighting facilities, but without the release of the stores, can be performed in any mode. The required mode is selected on the attack selector and the whole procedure relevant to that mode is then performed, but the operation of the firing relays is the final stage in the release sequence. Indication that the firing relays have operated is given by the illumination of the release indicator light.

ROCKETS

General

50. Either four 36 tube 2 in. RP launchers, or four pairs of 3 in. (gloworm) rockets, or a combination of both, may be carried at the wing stations. Pre-mod 1136 the controls are on a role panel on the observer's port console. When mod 1136 is embodied the controls are permanently mounted on the starboard side of the observer's cockpit, thus enabling rockets and cameras to be operated together.

51. The controls provide for selection of individual wing stations and for fast, slow or single shot sequence for 2 in. RP's. Each station fires at 10 ms intervals (fast) or 40 ms intervals (slow) in the sequence: 3 (port outer), 4 (stbd outer), 1 (port inner) and 2 (stbd inner). 2 or 4 rockets are

discharged per firing pulse: or, if required for training purposes, 1 rocket by selective loading of the launcher matrix. RP firing ceases when the trigger is released. On re-pressing the trigger, the sequence always recommences at station No. 3.

52. 3 in. (gloworm) rockets are fired in pairs at the slow rate.

53. When mod 1190 is embodied provision is made for both automatic and manual firing. Manual firing is effected by operating the firing trigger. Automatic firing is initiated by operating the target accept button, actual release being effected at the selected range when an automatic signal is emitted from the C & R computer to energise the firing relays. The controls are as shown in Table 6.

Table 6—RP Controls

Control	*Marking and Function*
Mode switch	MODE—3 in. SLOW/OFF/2 in. FAST / SLOW / SINGLES. Selects type of RPs and mode of firing.
Station selectors	SELECT PYLONS, OUTER, INNER } PORT On/OFF OUTER, INNER } STBD On/OFF

NOTE: When mod 1136 is embodied the station selectors are under the general heading RP STATION SELECTORS.

BULLPUP

General

54. Provision is made, pre-mod 1188, for the carriage, launching and guidance (or jettisoning) of four Bullpup air-to-surface guided missiles. The missiles are carried on pylons, two on the underside of each mainplane. Selection and fuzing of the required missile is via the EL/EA fuzing control unit on the port wall of the observer's cockpit. Guidance is by a BULLPUP GUIDANCE control selector

on the pilot's port console. Eitber of two missile control systems can be installed, 'bang-bang' (pre-mod 951 or post-mod 951 and NSM 3039) or 'adaptive' (post-mod 951).

WARNING: If the UHF function switcb is at ADF tbe missile will be uncontrollable, because the UHF lower aerial is disconnected from the guidance system. Tberefore, before setting the armament selector (pre-mod 1190) or weapon selector (post-mod 1190) to BULLPUP, ensure that the UHF function switch is not at ADF.

'Bang-bang' Control Selector

55. The 'bang-bang' control selector consists of a band-grip in the top of which is a thumb switch which can be selected to any one of four positions, up, down, left or right. The missile is controlled and manoeuvred in the direction selected.

'Adaptive' Control Selector

56. Tbe 'adaptive' control selector consists of a knob-type handle, movement of which causes a DC signal to vary according to tbe handle displacement. The signal automatically decays to zero, thus minimising any tendency to over-control the flight of the missile by overlong displacement of tbe control handle.

SIDEWINDER

General

57. When mod 1157 is embodied provision is made for the carriage and launching (or jettisoning) of one Sidewinder air-to-air infra-red homing missile from either tbe port or starboard outer wing station.

58. Before release, the missile head searches for and acquires a target signal which is then converted into an audio acquisition tone and routed to the pilot's headset; a maximum tone assures the pilot that the missile is locked on target. A switch and volume control on the pilot's port console are used to control tbe audio signal, and the missile is selected and fuzed via the EL/EA fuzing control unit (pre-mod 1188) or the station selector and arming switch (post-mod 1188) on the port wall of the observer's cockpit. The controls are as shown in Table 7.

Table 7—Sidewinder Controls

Control	*Marking and Function*
Audio control switch	SIDEWINDER—ON/OFF. Controls transmission of audio tone.
Volume control	VOLUME. Adjusts volume in headset.
Station selector switch (post-mod 1188)	Selects missile station.
Arming switch (post-mod 1188)	SIDEWINDER—ARMED/OFF/UNARMED. Determines whether missile is launched armed or unarmed.

NOTE: Pre-mod 1188, the station is selected by the store selector on the EL/EA fuzing control unit, an armed launch by the arming switch on the EL/EA fuzing control unit, and an unarmed launch by the jettison selector.

PART 1—DESCRIPTION AND MANAGEMENT OF SYSTEMS

Chapter 17—PHOTOGRAPHIC EQUIPMENT

Contents

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General

1. The photographic equipment makes provision for both day and night photography, but only the daylighbt facility, using F95 cameras, is employed.

F95 Camera Installation

2. The cameras are carried in a crate on the bomb door, provided with automatically-controlled heating and window de-misting systems. DC and AC is supplied from the 28V and 200V busbars, respectively; the latter supply is for the two blower/beater units in the camera crate. Up to six F95 cameras can be installed, three vertical and three oblique, in the various combinations shown in fig 1. The side-facing oblique cameras can be mounted on one of three positions, depressed 10°, 15° or 20° from the horizontal. The forward oblique camera can be mounted at either 5° or 15° if fitted with a 12 in. lens, or at either 10° or 20° if fitted with a 4 in. lens.

Camera Controls and Indicators

3. Master control of the cameras is by the ARMAMENT SELECTOR on the pilot's port console (pre-mod 1136) or by a CAMERA CONTROL—PILOT/OFF/OBS switch adjacent to the port throttle lever (post-mod 1136). When NSM 3023 is embodied pre-mod 1136, the observer can operate the cameras irrespective of the setting of the armament selector. Mod 1136 permits simultaneous operation of photographic and armament equipment; the cameras are not dependent on the position of the armament selector

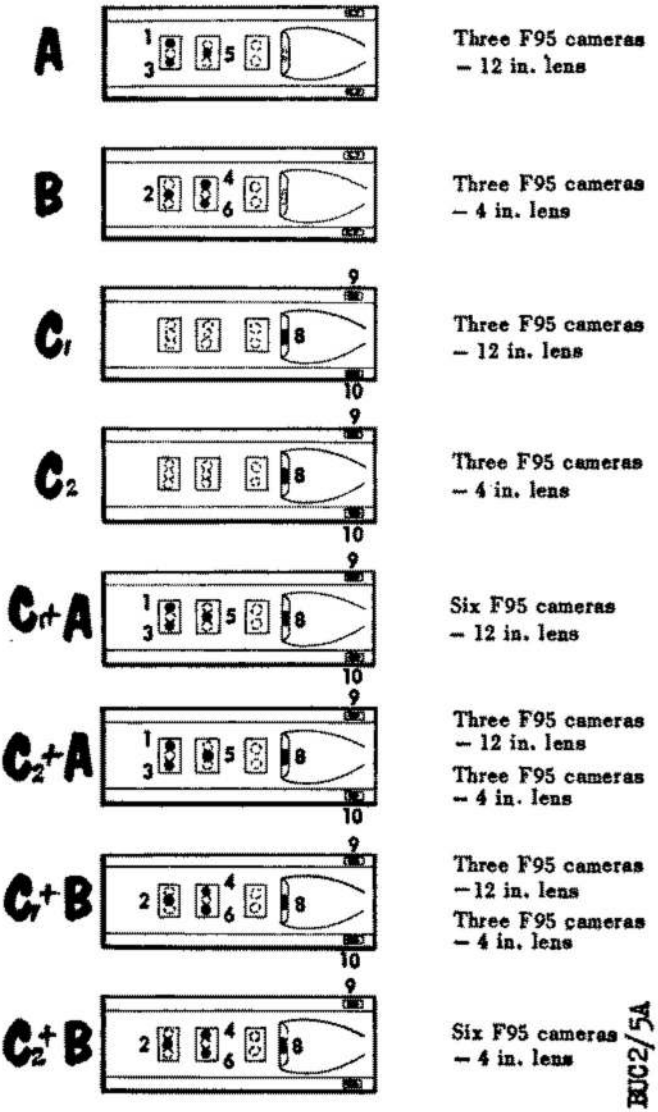

Fig 1—Camera arrangements

and the CAMERA position is deleted. With PILOT selected on the camera control switch, the cameras commence running when the firing trigger is pressed and continue running until either the camera control switch is selected to OFF or the reject button is pressed (post-mod 1277 only). With the camera control switch set to OBS, the cameras are under the normal control of the observer. Before pressing the firing trigger, the auto/manual switch aft of the throttle levers must be selected to MANUAL (pre-mod 1190) or the attack selector on the pilot's port console set to MANUAL RR or DSL (post-mod 1190). The remainder of the controls and indicators are on a role panel on the observer's port console and are as shown in Table 1.

Table 1—Camera Controls and Indicators

Control/Indicator	*Marking and Function*
Controls common to vertical and oblique cameras	
Camera selector switch	CAMERA SELECTOR—F95/F97. The F97 position is not used.
Control switch	CONTROL SWITCH—CONT/OFF/INTERRUPT. The observer's control switch. It is spring-loaded from INTERRUPT to OFF and the former position is for short-period operation. The CONT position is for continuous operation.
Camera heater switch	CAMERA HEATER F95—ON/OFF. Controls the DC heaters in the camera gearboxes.
Iris selector switch	IRIS SELECTOR—OPEN/2/3. Sets the irises of all the F95 cameras to any one of three preset apertures; the smallest aperture is obtained by selecting position 3.

Control/Indicator	*Marking and Function*
Intervalometer selector	INTERVALOMETER SELECTOR — 8FR/4FR/½SEC/¾SEC/1 SEC/2 SEC. Controls the camera speed to give 8 or 4 frames/sec or single frame at ½, ¾, 1 or 2 sec intervals as selected.

NOTE: There is no provision for single-shot operation of the port and starboard oblique cameras pre-mod 5208.

Vertical camera controls

Vertical cameras selector switch	VERTS—ON/OFF. A single switch for all vertical cameras, which operate together.
Vertical cameras film indicator	VERTICALS STN 1 or 2—F/¾/½/¼/0. A single indicator showing the quantity of unexposed film. Can be reset hy rotating the indicator pointer clockwise.
Film indicator lights (two) (green)	F95 VERTICALS—STN 3 or 6 and STN 4 or 5. The lights flash when their respective cameras are operating. Both lights have press-to-test and rotate-to-dim facilities.

Oblique camera controls

Ohlique cameras selector switches	OBLIQUE, PORT, FORD and STBD — ON/OFF. Three switches, allowing independent operation of each camera.
Ohlique cameras film indicators	PORT, FORD and STBD—F/¾/½/¼/0

Blower motors and heaters controls

Blower motors and heater switch	BLOWER MOTORS AND HEATERS — AUTO / OFF/ MANUAL. When selected to MANUAL the port and stbd hlower motors in the camera crate run continuously and each heater element is thermostati-

Control/Indicator	*Marking and Function*
	cally controlled. When AUTO is selected, both hlower motors run only during the period when one or both heater elements are switched on thermostatically. MANUAL should be selected if the OAT is below 30°C.
Blower heater indicators (two)	BLOWER HEATER, PORT and STBD. Magnetic indicators which show cross-hatched when the hlower motors and heaters switch is selected to OFF, and hlack when the switch is selected to AUTO or manual. If the element in one of the hlower heater units becomes overheated, it is isolated hy a thermostat which ruptures the fuse and the associated indicator will revert to cross-hatched. Should the heater element in both port and starboard hlower heater units be isolated, however, the hlower motors will run if the switch is selected to MANUAL.