RESTRICTED

PILOT'S NOTES

VALIANT

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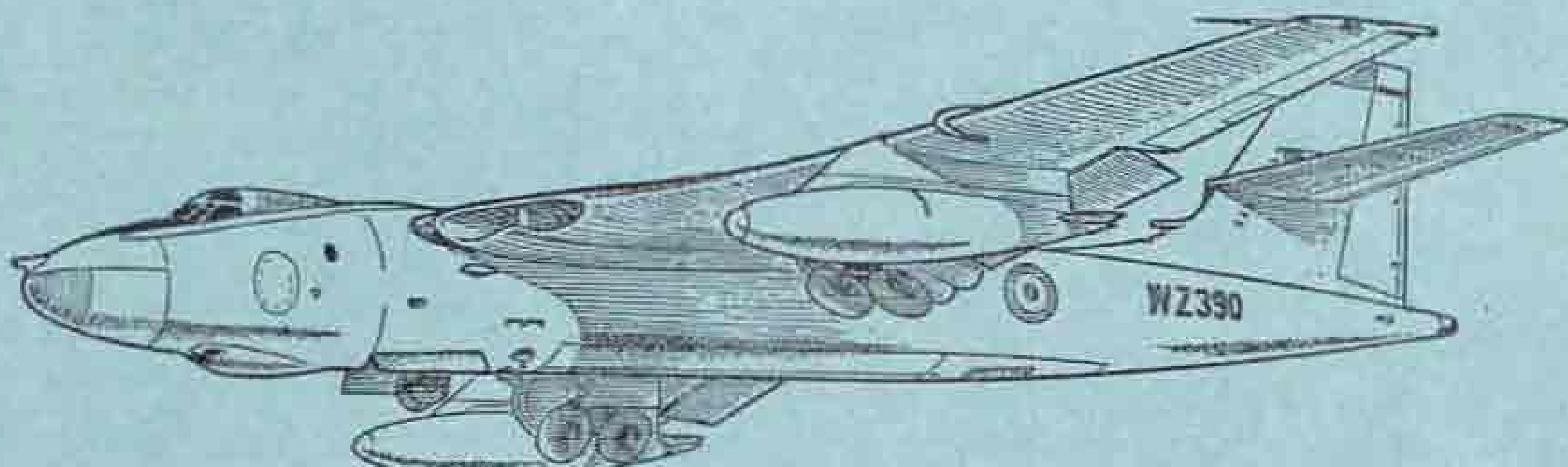
VALIANT MK. 1 AIRCRAFT



Prepared by Direction of the Minister of Supply

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Amendments

Amendment lists will be issued as necessary and should be inserted in the appropriate place in the Notes. New or amended paragraphs will be indicated by a vertical line on the left of the matter affected. This line merely denotes a change and is not a mark of emphasis. When a page is issued in a completely revised form the line will not appear. Incorporation of an amendment list must be certified by inserting the date of incorporation and initials below.

A.L. No.	*Initials*	*Date*	*A.L. No.*	*Initials*	*Date*	*A.L. No.*	*Initials*	*Date*
1	A. Taylor	31/3/58	11	P. Jones	3/9/63	21		
2	E. Stokes	26/6/58	12	J. Whibley	6.10.64	22		
3	E. Stokes	1/8/58	13			23		
4	E. Stokes	13/1/59	14			24		
5	E. Stokes	23/3/59	15			25		
6			16			26		
7	J. Whibley	9/3/60	17			27		
8	P. Jones	13/4/61	18			28		
9	P. Jones	25/5/61	19			29		
10	P. Jones	23/11/62	20			30		

Notes to Users

1. These Notes are complementary to AP 129 (6th Edition), Flying, and should be read in conjunction with the Flight Reference Cards which are issued separately. Reference should also be made to the Valiant Operating Data Manual.

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

3. Throughout this publication the following conventions apply:

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

(*b*) The numbers quoted in brackets after items in the text refer to the illustrations in Part VI. The letter refers to the illustration and the number to the item on that illustration, e.g. (F14) refers to Fig. F, item 14.

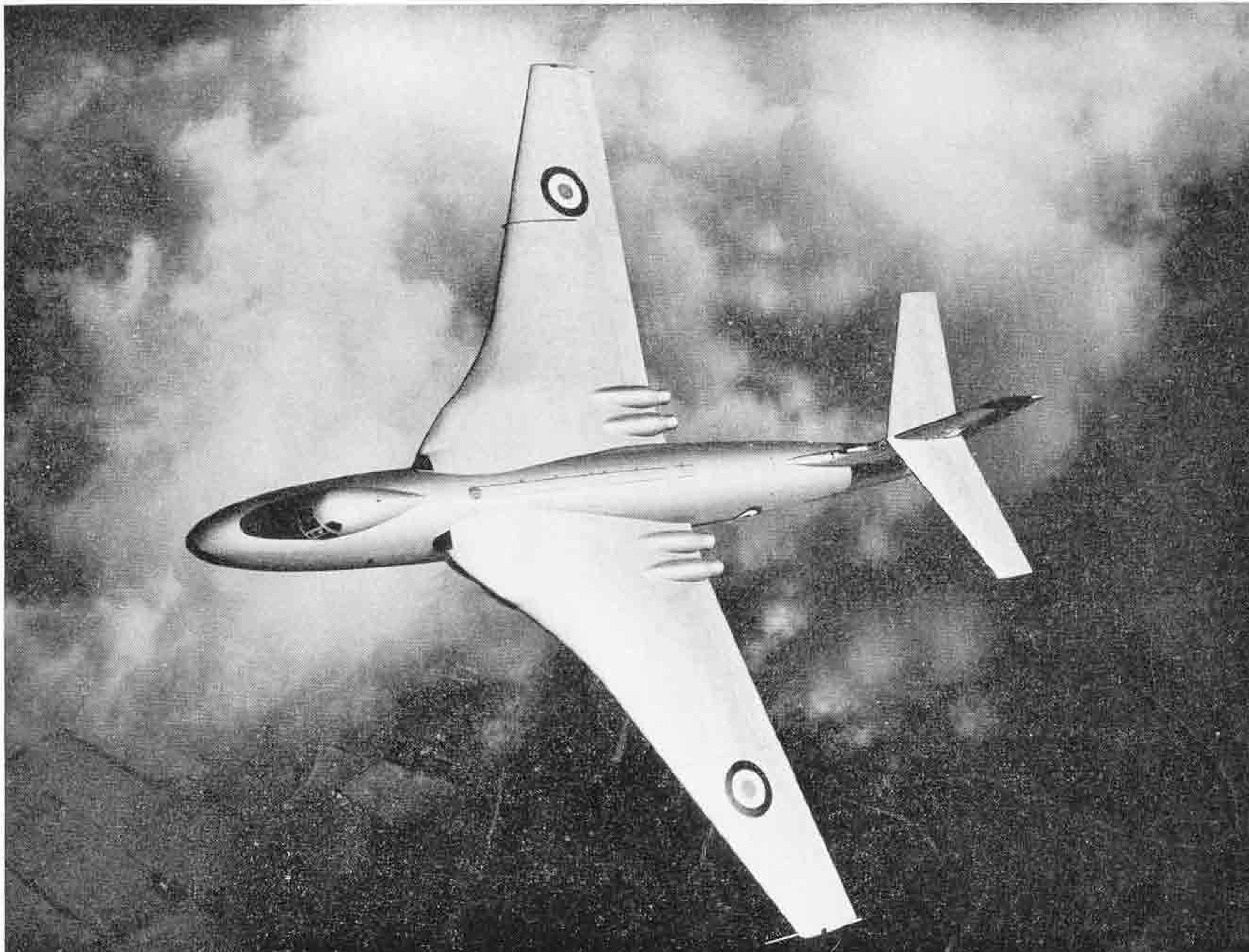
(*c*) Unless otherwise stated all airspeeds and Mach numbers quoted are " Indicated."

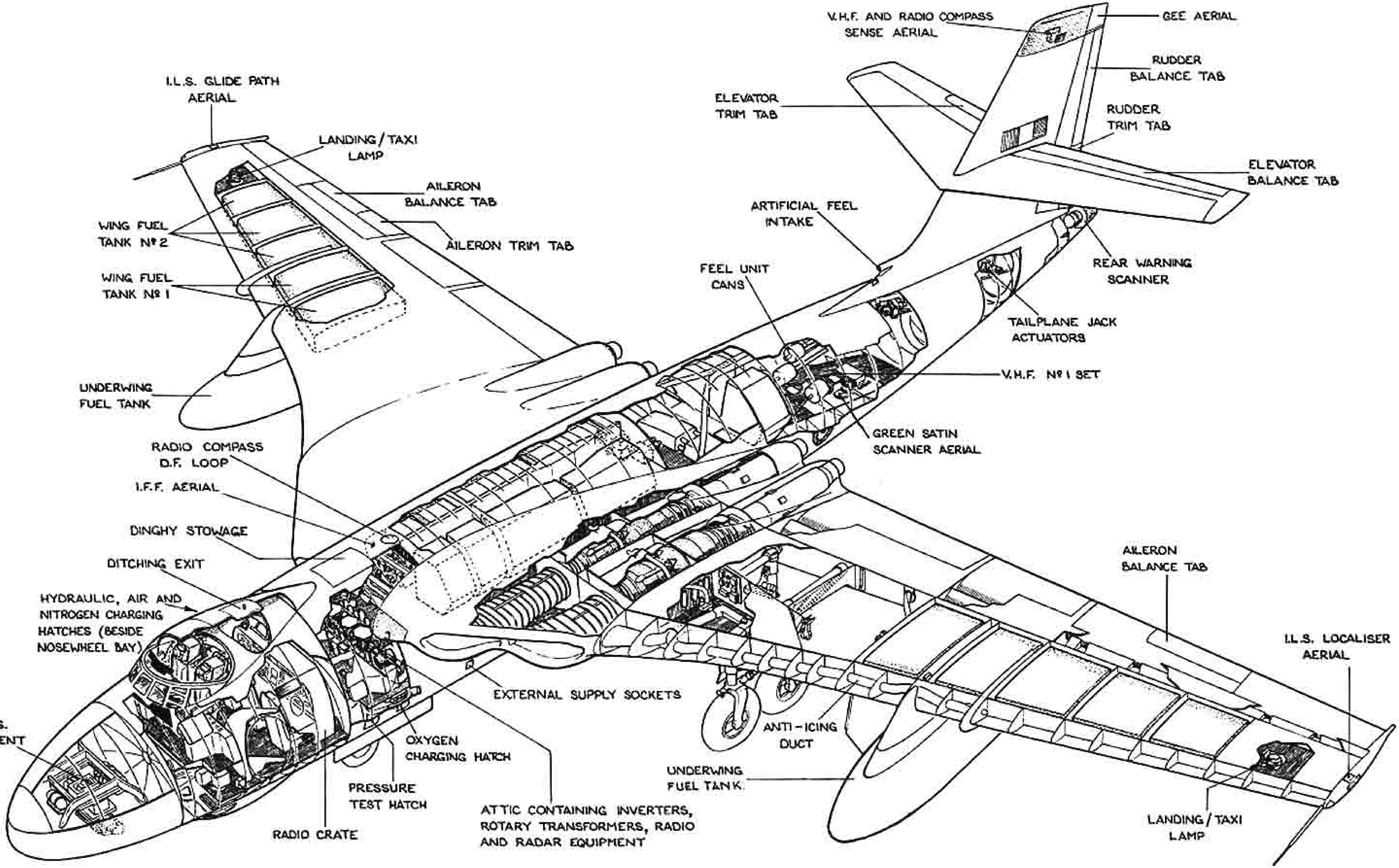
(*d*) In cases where a Mod. number is followed by an aircraft serial number the latter refers to the first aircraft in which that Mod. was incorporated in production. On aircraft prior to this number it will be necessary to check the aircraft log book and the Form 700 if it is desired to know whether that Mod. has been incorporated.

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

List of Associated Air Publications

	AP
Valiant B1, B(PR)1, BK1 and BK(PR)1 aircraft	4377A
Avon 201 and 204 engines	4481A and D
Aircraft fuelling equipment	4511
Aircraft refuelling in flight	4611
Aircraft wheels, tyres and brakes	2337
Electrical manuals	4343 series
Ejection seats, Mk. 3	4288C
Hydraulic equipment, Vickers	1803N
Instrument manuals	1275 series
Powered flying controls	4603
Pressurising and air conditioning equipment	4340
Safety and survival equipment and flying clothing	4380





Equipment Layout

Contents

Valiant Mk. I Aircraft. Introduction

(*a*) The Valiant aircraft is a high-wing, all-metal monoplane powered by four Avon 204 or 205 engines, each of 10,000 lb. static thrust. The only significant difference between the Avon 204 and 205 is that the latter is equipped for water-methanol injection.

(*b*) The B.1 is a bomber and the B(PR)1 is a B.1 converted to a photographic reconnaissance role. The BK.1 and BK(PR)1 are equipped for being refuelled in flight and provision is also made in them for the addition of tanker equipment. Thus a BK.1 or a BK(PR)1 can be either a "receiver" or a "tanker/receiver" aircraft. All types are basically identical and these Notes refer to all aircraft, but where differences exist the words "B.1 only", "BK(PR)1 only", or as appropriate, appear in the text or in the paragraph headings.

(*c*) *These Notes refer to WP.205 and subsequent aircraft, the earlier aircraft differing considerably in equipment and instrument layout. Basically, however, the Notes may be used for the earlier aircraft, but Pilots should make sure they know the differences.*

(*d*) The aircraft is operated by a crew of five accommodated in a pressure cabin. The two pilots are seated side-by-side in ejection seats on a raised portion at the front of the cabin. This portion is referred to in these Notes as the cockpit. Behind the pilots, facing aft, are the air electronics officer, the navigator, and the radar navigator/bomber, seated in front of a large crate containing their equipment. This portion of the pressure cabin is referred to in these Notes as the cabin. The bomb aiming station is below the floor, entry to it being gained through a hatch.

(*e*) The flying controls are power operated through duplicated supplies, and if complete failure occurs, reversion to manual control is automatic. A Mk. 10 automatic pilot is fitted. Double-slotted trailing-edge flaps are fitted and there are air brakes on the under-surface of the wings. The tailplane incidence is variable. The engines, the leading edges of the air intakes, wings, tailplane and fin are equipped for thermal anti-icing. The nose-wheel is steerable for manoeuvring on the ground.

(*f*) The four engines each drive a 22½kW., 112-volt generator, from which all auxiliary power in the aircraft is taken. Air for cabin heating and pressurising, for anti-icing and for fuel tank pressurising is taken from bleeds on the compressor casings of the four engines. Provision is made for assisted take-off, using water-methanol injection or R.A.T.O.G.

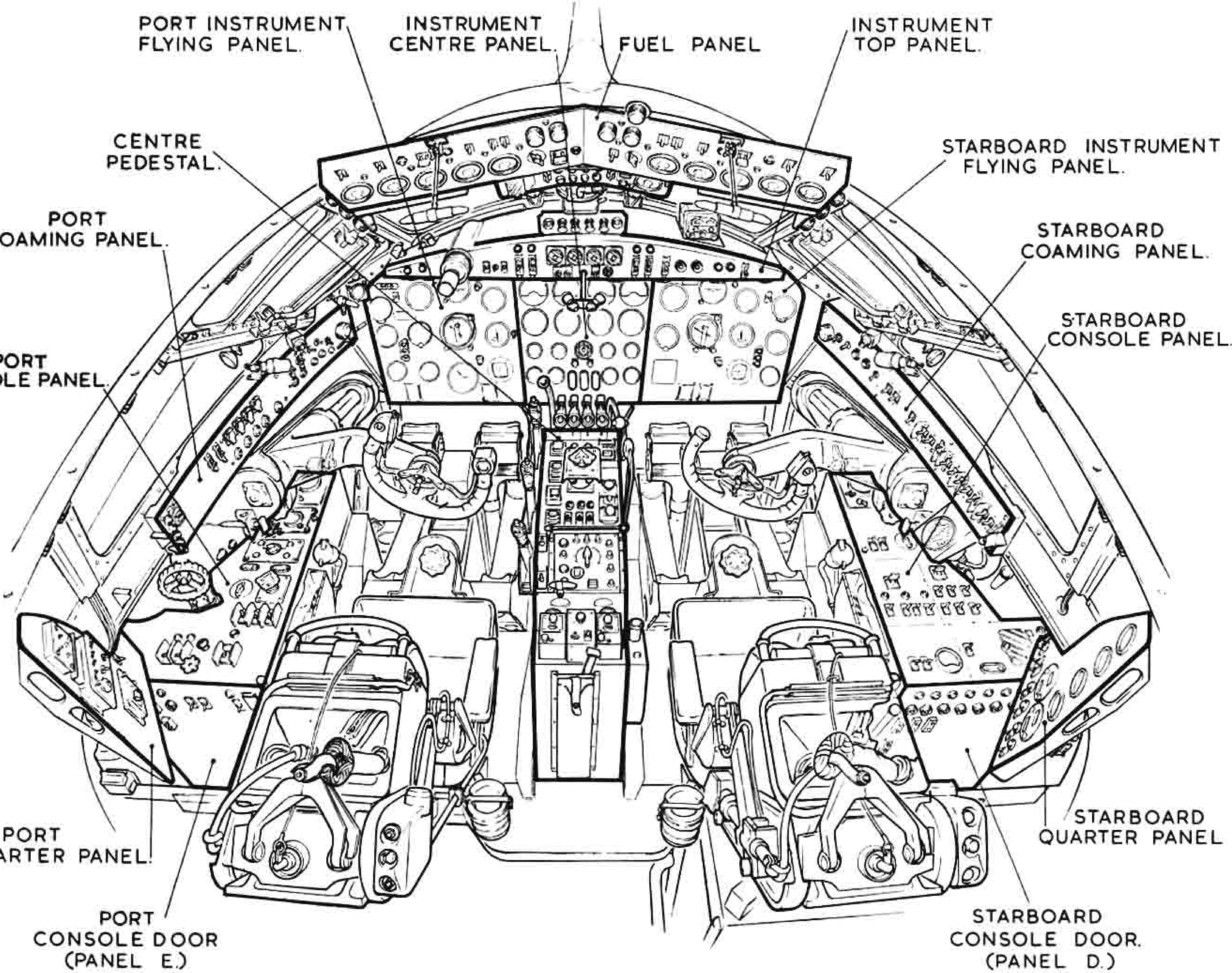
(*g*) The principal dimensions of the aircraft are as follows:

	ft.	in.
Overall length	108	3
Wing span	114	4
Height to top of fin	32	2
Tailplane span	40	9
Wheel track	28	0
Wheel-base	24	8
Minimum turning circle (but see Part IV, para. 6(e))	100	0

(*h*) *Load Classification Number*

The following L.C.N's assume a tyre pressure of 112 lb./sq. in. up to a weight of 138,000 lb. and 142 lb./sq. in. above this weight.

Weight (lb.)	L.C.N.
167,000	65
138,000	47
130,000	45
120,000	42
110,000	39
100,000	36
90,000	33
80,000	31



Location of Instrument Panels

Part I

DESCRIPTIVE

Part I

Descriptive

List of Contents

List of Illustrations

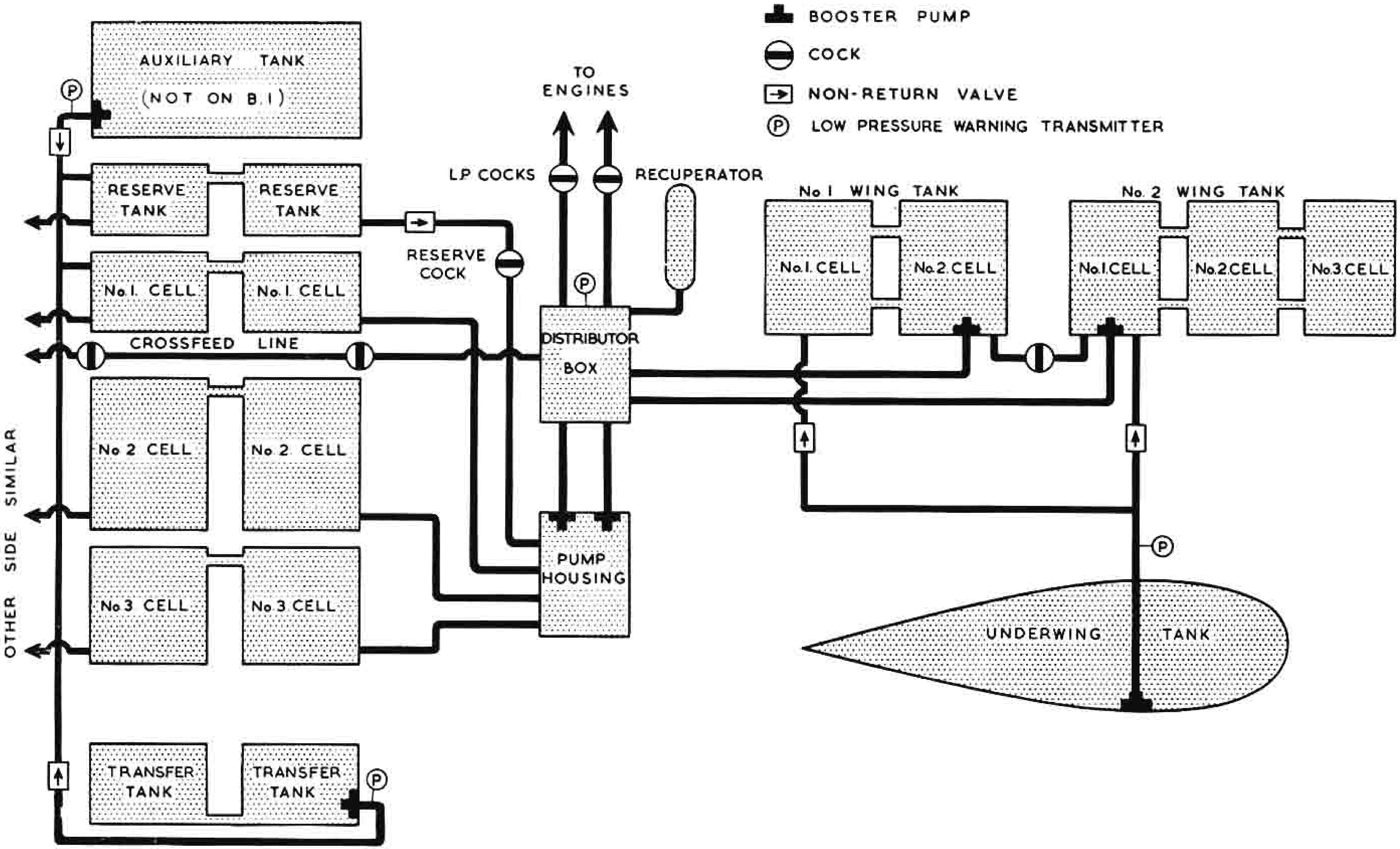


Fig. 1 Fuel system (simplified)

PART I

Descriptive

Fuel System

1 General

Fuel is carried in a number of flexible-bag type tanks in the fuselage and wings. Each tank comprises one or more cells. Extra fuel may be carried in fixed under-wing tanks, one mounted on a pylon under each wing.

2 Fuselage tanks

(*a*) The forward pair of cells, one on each side of the aircraft centre-line, comprise the reserve tank, each pair of engines being fed from one cell. It is not, strictly, a reserve tank, but, if the transfer tank fails to transfer, fuel is retained in the reserve tank.

(*b*) The six cells in the centre of the fuselage above the bomb bay comprise the main fuselage tanks, each pair of engines being fed from the three cells on the relevant side. There is no inter-connection between any of the three cells on one side.

(*c*) The rear pair of cells comprise the transfer tank, fuel from this being fed into the port cell of the reserve tank and into the port front fuselage cell.

(*d*) Each pair of cells is connected across the fuselage at the top of the cells, thus ensuring that when they are full the level in each pair of cells is the same. The transfer tank cells are also inter-connected at the bottom.

3 Wing tanks

The five cells in each wing are grouped to form two wing tanks. The two inboard cells are inter-connected to form the No. 1 wing tank; the three outboard cells are inter-connected to form the No. 2 wing tank.

4 Underwing tanks

Provision is made for carrying tanks on streamlined pylons under the wings. These tanks are completely self-contained, incorporating their own independent nitrogen systems and electric pumps, as well as a compressed air system for jettisoning fuel. Fuel from each tank is fed by an electric pump into the wing tanks. The tanks are not jettisonable. The nitrogen system may also be used to transfer fuel to the wing tanks if the electric pump fails. (See Part III, para 9.)

5 Auxiliary tank—BK1, B(PR)1 and BK(PR)1 only

Provision is made for fitting an auxiliary tank in the forward end of the bomb bay (camera bay) on BK1, B(PR)1 and BK(PR)1 aircraft. This tank incorporates its own electric pump which transfers the fuel into the port cell of the reserve tank and into the port No. 1 fuselage cell.

6 Tank capacities

(*a*) The following table shows the approximate effective fuel capacities of the tanks in gallons and pounds at 0·76 SG. The actual capacities may vary to a certain extent depending on the operation of the refuelling float valves and also on the attitude of the aircraft, but the figures given here are an average of the capacities actually obtained on a number of aircraft.

(*b*) There is a certain amount of unusable fuel in the tanks amount ing to a total of between 240 and 400 lb. This is not included in the capacity, nor is it shown on the gauges.

	Gallons	Lb at 0·76 SG	CG ft, Aft of datum
Fuselage:—			
Cell 1	735	5,586	36·85
Cell 2	1,370	10,412	42·32
Cell 3	1,286	9,773	49·23
Reserve	590	4,484	33·54
Transfer	710	5,396	64·25
Auxiliary (Not B.1)	575	4,370	37·95
Wing:—			
Tank 1	1,106	8,406	52·59
Tank 2	946	7,190	56·53
Total external fuel (B1)	6,763	51,247	48·261
Total internal fuel (others)	7,318	55,617	47·450
Underwing tank (2 x 1,615 gall)	3,230	24,548	47·32
Total fuel, all tanks (B1)	9,993	75,795	47·958
Total fuel all tanks (others)	10,548	80,165	47·411

NOTE 1: 15 gallons of fuel are unusable in each underwing tank.
NOTE 2: All tanks and cells are subject to a tolerance of ± 10 gallons.

7 Normal operation

(*a*) Two pumps in each wing, one in each wing tank, deliver fuel to the respective distribution box in the fuselage. The fuselage tanks on each side feed by gravity through non-return valves, one to each cell, into the respective fuselage pump housing whence fuel is delivered by two electric pumps to the distributor box. Fuel is fed from each distributor box to the two engines on the respective side, each line incorporating an engine master cock, a fuel filter de-icing heater and a flowmeter transmitter.

(*b*) Fuel from the reserve tanks feeds by gravity, through a pair of cocks and non-return valves, into the pump housings. Fuel from the transfer tanks is delivered to the port cell of the reserve tank and the port front fuselage cell by a single electric pump. Mod 2443 will introduce an additional pump. Float valves in the reserve and fuselage tanks prevent flooding. Fuel from the underwing tanks is delivered to the wing tanks by an electric pump in each underwing tank. Float valves in the wing tanks prevent flooding.

NOTE: Until Mod 1012 (WP208) is fitted, there are no non-return valves in the lines from the reserve tank. The reserve cocks should therefore be closed whenever the aircraft is in a nose-down attitude, otherwise fuel will flow from the main fuselage tanks into the reserve tank.

(*c*) Fuel from the auxiliary tank (when fitted) is fed into the port cell of the reserve tank and the port front fuselage cell by a single electric pump.

(*d*) *Recuperators*

A recuperator is fitted on each side in parallel with the distributor box. One side of the recuperator is supplied with air from the engines at a constant pressure, and the other side is supplied with fuel from the distributor box at the fuel pump pressure which is higher than the air pressure. Under conditions of negative G when the fuel pumps might be uncovered and there is no pressure in the fuel lines, the recuperators will discharge their fuel into the distributor boxes and maintain the supply to the engines. When normal conditions are resumed the fuel pumps will again supply the engines and recharge the recuperators. (See Part III, para 10.)

8 Fuel pumps and indicators

(*a*) Eight electric fuel pumps, two each side of the fuselage and two in each wing, are controlled by eight ON/OFF switches (A/5, 6, 11, 12, 24, 25, 30 and 31) on the fuel panel. Two low pressure warning lights (B/32) on the right of the instrument top panel come on when the pressure in the distributor boxes falls appreciably below normal, which may be due to lack of fuel or failure of the pump(s) in use.

(*b*) Pre-Mod 2443 a single electric pump in the transfer tank is controlled by an ON/off switch (A/41) on the fuel panel. Post-Mod 2443 two pumps are fitted and the switch is changed to a three-position MAIN/OFF/AUX switch. The MAIN position controls one pump, and the AUX position controls the other. A warning lamp (A/42) below the switch comes on when pressure drops due to the failure of the pump or due to the tank being empty, but will go out when the pump is switched off.

NOTE: Until Mod. 1501 (WZ361) is embodied the warning lamp remains on when the pump is switched off.

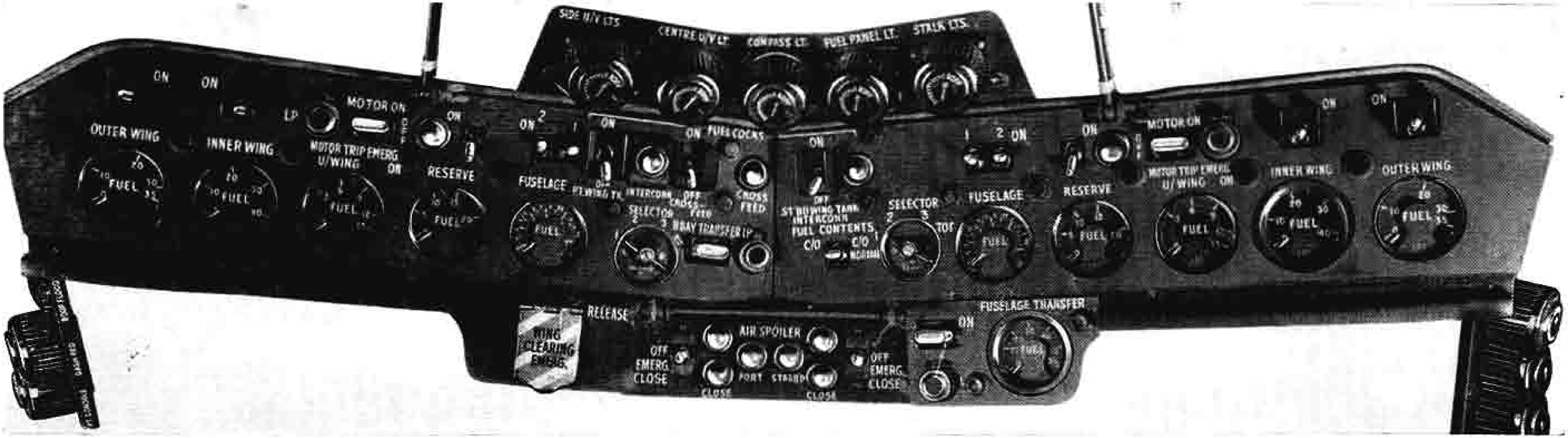


Fig. 2 Fuel Panel (Post-Mod. 2330 or 2331)

Fig. 2 Fuel Panel (Pre-Mod. 2330 or 2331)

(*c*) (i) The pump in each underwing tank is controlled by a switch for each tank (A8 and 28) on the fuel panel. When these pumps are switched on, the underwing fuel is pumped into the respective wing tanks through a refuelling valve which is controlled by a float switch in the wing tank. A low pressure warning light (A7 and 29) beside each switch comes on when the underwing tank is empty or if the pump fails. Pre-Mod. 2732 (B1 and B(PR)1), the LP warning light stays on all the time except when the pump is delivering fuel. Post-Mod. 2732, and on all BK1 and BK(PR)1 aircraft, the light is only energised when the pump is switched ON or EMERG. Each switch has three positions, MOTOR ON, OFF, and MOTOR TRIP. EMERG. ON. When the latter position is selected the pump is stopped and the nitrogen in the nitrogen bottles is released into the tank to transfer fuel to the respective wing tank.

(ii) Post-Mod. 2784 or Command Mod. 45 two indicators (A45 and 48) on the fuel panel are operated by the underwing tank pump contactors. Each indicator shows black when the contactor is tripped and the pump is not running; it shows white when the contactor is energised. In the latter condition it does *not* indicate that the pump is running (i.e. the pump may have failed) but only that the pump circuit has been made.

(*d*) Although there is no harm in letting a booster pump run dry for a short time, the relevant booster pumps should be switched off when the " tank empty " warning appears.

(*e*) Pre-Mods. 2444 and 2473, a single pump in the auxiliary tank is controlled by an on/off switch (A49) on the fuel panel. Post-Mods. 2444 and 2473, two pumps are fitted and the switch is changed to a three-position MAIN/OFF/AUX switch. The MAIN position controls one pump, and the AUX position controls the other. When operating in the tanker role, the AUX position *must not* be used. A light (A47) beside the switch comes on when the tank is empty or if the pump fails. Until Mod. 1747 (WZ376) is embodied, the light stays on when the pump is switched off.

9 Fuel cocks and indicators

(*a*) The four HP cocks are controlled by the throttle levers (C12). When the levers are brought back beyond the ground idle gate, the HP cocks are closed. When opening the HP cocks, to ensure that they are fully open the throttles should be opened beyond the gate and then brought back to the gate. There are no HP cock indicators.

(*b*) The four engine LP master cocks are controlled by four ON/OFF switches (B15, 16, 26 and 27) on the instrument top panel. Indicators above the switches show black when the cocks are open and white when OFF is selected. *The black indication shows that the cock is actually open, but the white indication only shows that OFF is selected and does not necessarily mean that the cock is closed; e.g. if the actuator has failed and the cock does not close, the indicator will still show white when the switch is at OFF.*

(*c*) The two reserve tank cocks are controlled by two switches (A10 and 26) on the fuel panel. When these cocks are open fuel drains by gravity from the reserve tank into the pump housing. Indicators (A9 and 27) beside the switches operate in the same way as those for the engine LP master cocks, except that they show white when the cocks are open and black when off is selected.

(*d*) The wing tank interconnection cocks, one between the two wing tanks on each side, are controlled by two switches (C20 and 22) on the central pedestal pre-Mod. 2330 or 2331, or (A13 and 20) on the fuel panel post-Mod. 2330 or 2331. When the cocks are open the No. 1 and No. 2 wing tanks are inter-connected. Indicators above the switches operate in the same way as those for the engine master cocks, except that they show white when the cocks are open and black when off is selected. There are two crossfeed cocks, one each side, in the crossfeed line connecting the two fuel distributor boxes. They are both controlled by a single switch (C21) on the central pedestal pre-Mod. 2330 or 2331, or (A16) on the fuel panel post-Mod. 2330 or 2331. An indicator near the switch shows white when both cocks are open and black when closed is selected, in a similar manner to those for the engine LP master cocks.

10 Fuel contents gauges and flowmeters

(*a*) The fuel contents gauges are of the pacitor type, reading in pounds. All gauges are on the fuel panel; two for the fuselage tanks (A39 and 52) and two for each pair of wing tanks (A4, 32, 36 and 55), one gauge for each of the two underwing tanks (A37 and 54), two gauges for the reserve tank (A38 and 53) and one for the transfer tank (A40). Post-Mod. 2296 (not on B1 aircraft) the transfer tank gauge can also be used to show the contents of the bomb bay auxiliary tank by selecting the switch (at A51) on the fuel panel.

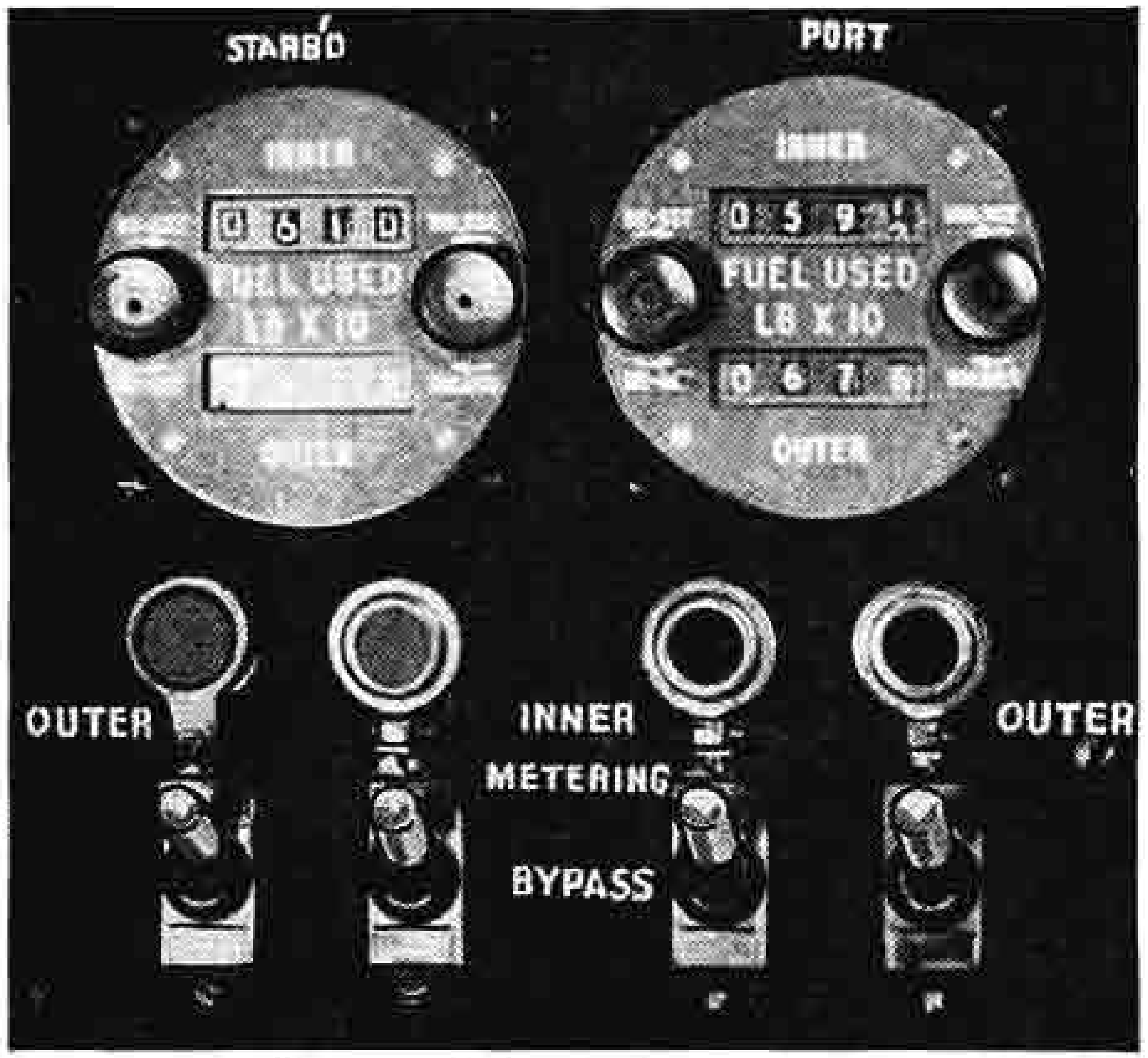


Fig. 3 Fuel flowmeters

(*b*) All gauges normally show the total contents of their respective tanks, excluding any unusable fuel. A selector switch (A43 and 50) beside each fuselage tank gauge enables the contents of each individual cell of the fuselage tanks to be checked, by moving the selector switch to No. 1 CELL, No. 2 CELL or No. 3 CELL. The switches should normally be left at TOTAL.

(*c*) If either the port or starboard wing tanks contents gauge power unit fails, the other may be used to operate the gauges by operating the changeover switch (A44) on the fuel panel. The port power unit then provides the power for the starboard gauges and vice-versa.

(*d*) Two dual flowmeter indicators (J8 and 9) on the starboard quarter panel indicate the "pounds gone" to each engine. Four METER/BY-PASS switches (J10, 11, 12 and 13) and four blue lights are below the indicators ; the lights come on when the flowmeters are switched to METER.

(*e*) Mod. 1039 introduces flowmeters, reading in pounds, at the navigator's station.

11 Tank venting and pressurising

(*a*) All internal tanks are pressurised with air from the engines, or nitrogen. Nitrogen will not normally be used except under operational conditions. The nitrogen and air systems are complementary to each other, using the same reducing valve. When nitrogen is used it will feed the tanks until the supply is exhausted, at which point the air supply automatically takes over. Air will automatically be used the whole time when nitrogen is not used. There are no controls or indicators in the cockpit.

(*b*) Seven, eight or nine nitrogen bottles may be fitted according to the role, and these are fitted in the nose behind the radome, in the "attic," and in the starboard servicing bay.

The servicing bay contains pressure gauges, shut-off cocks, a charging valve and test points. When the system is to be used the shut-off cocks must be opened before flight. There are no other controls. Damage to any one bottle will not affect the supply from the others.

(*c*) The underwing tanks each have two nitrogen bottles mounted inside the tank. A pressure gauge, charging valve and shut-off cock are in the nose fairing of each tank. The shut-off cock must be opened before take-off, after which the system is automatic.

(*d*) The air supply is tapped from all four engines, and starts as soon as the engines are running. The air (or nitrogen, if used) passes through reducing valves to supply all tanks except the underwing tanks which, if not using nitrogen, are atmospherically vented through inward relief valves. All fuselage tanks are inter-vented, the vents discharging to the underside of the rear fuselage. The wing tanks are inter-vented on each side, discharging to the wing tips. Reducing valves control the air or nitrogen pressure in the tanks at 0·9 to 1·2 PSI differential pressure, and vent valves maintain a pressure of 2 PSI when climbing. Inward relief valves are incorporated to prevent the tanks collapsing during a descent in the event of failure of the pressure reducing valves. Mod. 2107 (XD

857) introduces a thermostatically controlled heater muff round the reducing valves. The heaters are on whenever electrical power is available, and there are no controls or indicators in the cockpit.

12 Fuel filter de-icing

The fuel pipe to each engine passes through a heat exchanger which is used to heat the fuel if ice should form in the fuel filters. If ice forms in a fuel filter the filter will tend to clog, thus increasing the pressure differential across it. When this happens a pressure switch closes and lights a blue warning light (B25) (Command Mod. 64) on the instrument top panel. The spring-loaded switch (B24) beside the light should then be held up to feed hot air from the airframe de-icing system through the fuel heat exchangers, the air being exhausted through two vents in each side of the fuselage. The system should be checked for functioning before each flight. The switch has a TEST position which enables the functioning of the warning light to be checked. (See Part III, para. 13.)

13 Fuel jettisoning

The underwing tanks each contain a bottle of compressed air which enables the fuel in these tanks to be jettisoned in emergency. Two switches (E5 and 6) on the port coaming panel, when set to ON, open an electro-magnetic valve in the tank stub pylon, which releases high-pressure air to open the jettison valves in the bottom of the tanks. For fuel jettisoning drill see Part III, para. 9(*j*).

Refuelling Systems

14 Ground refuelling and defuelling

(*a*) On B1 and B(PR)1 aircraft, four pressure refuelling connections are fitted, one on each side of the fuselage under the centre of the wing root for the fuselage tanks, and one beneath each wing, aft and outboard of the main wheel bay, for the wing tanks. On BK1 and B(PR)K1 aircraft the wing refuelling connections are not fitted and all tanks are refuelled from the two fuselage connections. Switches at each refuelling point control the circuits to the float switches and shut-off valves in the tanks, and these control the supply of fuel to the tanks and automatically shut off the fuel when the tanks are full.

Filler caps are not provided for any tanks.

(*b*) Defuelling of all tanks may be carried out by the refuelling connections, and hand-operated cocks are fitted which enable any individual tank or cell to be defuelled.

15 Flight refuelling—Tanker See Appendix A.

16 Flight refuelling—Receiver See Appendix A.

Oil System

17 Each engine has its own independent integral oil system; the sump of each holds 9·6 pints and the system holds 2·4 pints. This gives a total capacity of 12 pints, of which only 7 pints are consumable. Four oil pressure gauges (B50 and 59) are on the instrument centre panel.

Electrical System

NOTE: The DC electrical systems were originally 112 and 28 volts, and these figures are quoted in these Notes. The voltage controllers have been reset to give 110 and 27·5 volts respectively. However, throughout these Notes, and on labels in the aircraft, the systems are referred to as 112-volt and 28-volt systems.

18 Introduction

(*a*) All auxiliary power used in the aircraft is taken from the electrical system. Undercarriage, flaps, bomb-doors, etc., are directly operated by electric motors, and electro-hydraulic systems are installed for the brakes, for the nosewheel steering and for the power controls.

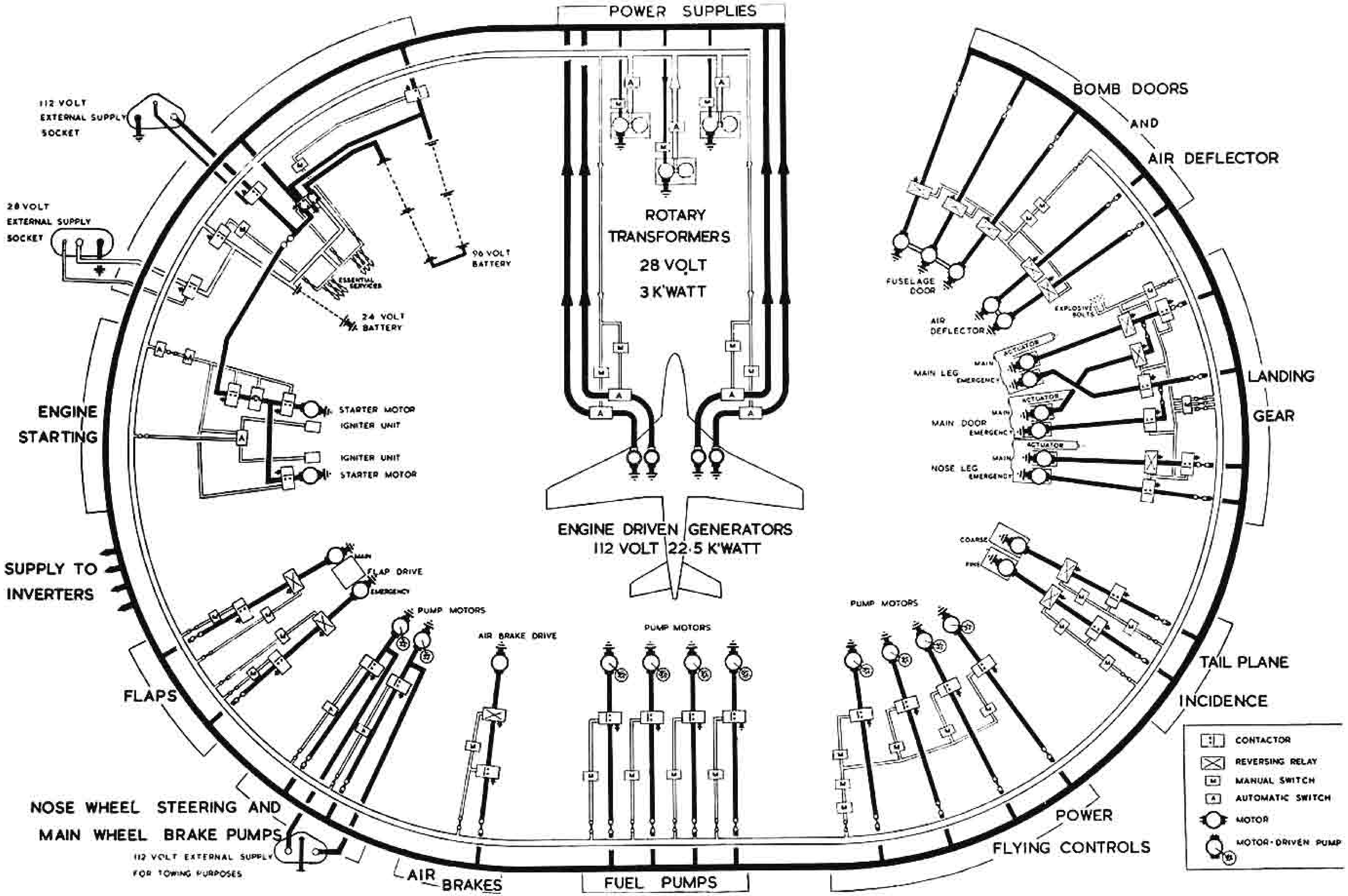


Fig. 4 Electrical system (simplified)

(*b*) Two DC systems are used in the aircraft, a 112-volt system for the heavy duty services, and a 28-volt system for the instruments and other services, as well as for the control lines of all services. The 28-volt system is fed by three rotary transformers driven from the 112-volt system.

(*c*) All services are remotely controlled through relays or contactors ; i.e. when a service is switched on, a 28-volt supply is connected to a relay or contactor which closes and makes the circuit between the system and the service selected.

(*d*) AC for operating the flight instruments and radar equipment is supplied by inverters. One of these, the instrument inverter, is driven from the 28-volt system, the others from the 112-volt system.

(*e*) Two main power distribution panels are in the "attic" aft of the pressure cabin, which also houses most of the electrical equipment. One power panel carries the 112-volt busbar which is fed with the combined output of the four generators, and the other panel carries the 28-volt busbar which is similarly fed by the three rotary transformers. The various services obtain their supply from the busbars through local fuses and, for the heavy duty services, through high-rupturing-capacity (HRC) fuses.

(*f*) An " essential services " busbar, which is permanently connected to the 24-volt battery, is on the 24-volt battery control panel at the forward end of the bomb bay. It supplies the following circuits:

Battery master control
Crash switch
Fire-extinguishers through crash switch
Internal start control (not used)
Intercomm when nosewheel towing plug is in
Canopy jettison
Fatigue meter

19 112-volt system

(*a*) There are four 22½kW generators, one driven by each engine. Full voltage is obtained at all engine speeds from idling to take-off RPM. These generators charge a 96-volt battery and supply power for the following services:

Fuel pumps
Undercarriage main and emergency motors
Flap main and emergency motors
Air brake motor
Tail plane incidence coarse and fine motors
Power controls hydraulic pump motors
Brakes and nosewheel steering hydraulic pump motors
Bomb door and deflector motors
28-volt rotary transformers
Radar inverters
H2S scanner
Hose drum unit (on Tanker aircraft only)

Fig. 5 (Deleted)

(*b*) Each generator has an ON—RESET—TRIM OR OFF switch, a failure warning light and an ENGAGE pushbutton. After a generator has been switched ON and has reached its correct output (see Part III, para. 19) it is brought on to line by pressing the ENGAGE pushbutton.

(*c*) On the right of the four switches is a rotary four-position selector switch and a voltmeter. Setting the switch to the appropriate generator number and selecting TRIM OR OFF on the generator control enables its voltage to be read when the generator is off line.

20 28-volt system

(*a*) Three 3kW rotary transformers are driven by the 112-volt supply ; they charge the 24-volt battery and provide power for operating all services not powered by the high-voltage system. The 28-volt system is also used to operate the control relays in all electrical circuits.

(*b*) All rotary transformers start up together as soon as the 112-volt busbar is energised, provided that the control switches on the generator panel are ON.

(*c*) Each rotary transformer has a failure warning light and an ON—OFF OR RESET—TRIM control switch (Q5, 6 and 7) on the generator panel on the radio crate. If a warning light comes on it indicates failure of the rotary transformer. The TRIM position is only used when adjusting rotary transformer output.

(*d*) On the left of the switches is a three-position rotary switch and a voltmeter. Setting the switch to the appropriate rotary transformer number and selecting TRIM or OFF enables its voltage to be read when the transformer is off line.

21 Batteries

(*a*) The batteries are nominal 96 volts and 24 volts respectively, but are charged from the 112-volt and 28-volt systems when the generators and rotary transformers are charging. The batteries are in the battery compartment at the forward end of the bomb bay. The batteries are also charged from the ground trolley when it is connected.

(*b*) *96-volt battery control*

The 96-volt battery is controlled by an ON/OFF switch (F5) on the port console panel. When the switch is set to ON the battery is connected to the 112-volt busbar and a magnetic indicator (F7) above the switch shows black. The battery is disconnected from the busbar by setting the switch OFF and will also be automatically disconnected by operation of the crash switch (see para. 24). When the battery is disconnected the indicator will show white.

(*c*) *24-volt battery control*

The 24-volt battery is controlled by an ON/OFF switch (F4) on the port console panel. When the switch is set to ON the battery is connected to the 28-volt busbar and a magnetic indicator (F6) above the switch shows black. The battery is disconnected from the busbar by setting the switch OFF and will also be automatically disconnected by operation of the crash switch (see para. 24). When the battery is disconnected the indicator will show white.

NOTE: The 24-volt battery is always connected to the "essential services" busbar.

(*d*) *Emergency batteries*

(i) A 24-volt emergency battery, above the radio crate, supplies the canopy jettison circuit. This battery is completely independent of the aircraft systems and is not chargeable. There is no separate switch for it other than the hood jettison levers.

(ii) A separate battery at the rear of the port console panel, independent of the aircraft supplies, may be used to operate the main instrument panel emergency lamps. These are operated by a switch (E15 and G24) on each coaming panel.

(iii) Post-Mods. 2828 and 2876 two 12-volt batteries, in series, are fitted below the pilots' platform, port side, for the operation of the abandon aircraft warning signs and crew escape emergency lamps.

22 External supply sockets

(*a*) There are two external supply sockets on the port side of the aircraft forward of the bomb bay, one for the 112-volt system and one for the 28-volt system. An additional supply socket for use when towing, is in the nosewheel bay (see Part I, para. 36).

(*b*) When the 112-volt external supply is plugged in, all 112-volt services may be operated provided the 24-volt battery switch is ON. The rotary transformers can then be started. Pre-Mod. 2260 (XD816) the 96-volt aircraft battery will be charged from the external supply irrespective of the position of the 96-volt battery switch. Post-Mod. 2260 the battery will only be charged if its switch is ON. If the rotary transformers are running the 24-volt battery will also be charged.

(*c*) When the 28-volt external supply is plugged in, the 24-volt battery will be charged, and if the 24-volt battery switch is ON all 28-volt services may be operated from the external supply. If the No. 3 rotary transformer is ON, it will not run as long as a 28-volt external supply is plugged in.

23 Voltmeters and ammeters

(*a*) The voltage trimmer panel, on the cabin port wall forward of the radio crate, carries two voltmeters (L7 and 13) which continually indicate the voltage of the busbars. Voltmeter (L6 and 15) and ammeter (L8 and 11) test sockets are also fitted on the panel, together with selector switches (L5 and 14), which enable the output voltage and current of each generator and each rotary transformer to be checked on the ground.

(*b*) Post-Mod. 2454 ammeters in the generator and rotary transformer circuits are fitted on the radio crate. These indicate continuously the current supplied by each generator and each rotary transformer.

Fig. 6 Voltage trimmer panel

(*c*) Post-Mod. 2650 two charge/discharge ammeters are fitted on the extreme right of the radio crate, one for the 24-volt and one for the 96-volt battery. These show at all times the battery charge or discharge current and consequently, in the event of generator or rotary transformer failure, can be used to check the load which may have to be shed to protect the batteries. They will also give an immediate indication of a battery short to earth. (See Part V, para. 13 to 17.)

(*d*) Post-Mod. 2982 an accurate 0-160v AC voltmeter and a 0-40v DC voltmeter are fitted to the AC Manual changeover switch-box (see para. 61(*a*)(iii)) at the AEO's station. The meters are connected in parallel with the voltmeter test sockets and can thus be switched to read accurately the off-line voltage of any generator and the rotary transformer voltages.

24 Inertia switches

(*a*) In the event of a crash, inertia switches isolate the batteries from all aircraft services except the "essential services" busbar, and automatically discharge all the fire-extinguisher bottles in the engine and fuel tank fire-extinguisher systems. The generators are also isolated from the system by the inertia switches.

(*b*) Post-Mod. 2259 and 2680 additional inertia switches and associated latched contactors are fitted, one in each generator field circuit. When these switches trip in the event of a crash, the generator field circuits are broken, thus reducing the voltage generated if the engines are still rotating.

25 AC supplies

AC for the instruments, radar, radio and special equipment is provided by inverters. The instrument inverter is operated from the 28-volt system, the others from the 112-volt system.

	Inverter	Supply	Stand-by
	Instrument inverter Type 100A	Artificial horizon (1st pilot's only Post-Mod. 2218) Tanker controls (K only) PR Recce sight (PR only) Oil pressure gauges (Pre-Mod. 1350) Mk. 4B compass (Pre-Mod. 2040)	No. 2 and 3 radar inverters
Radio and radar inverters	No. 1 Type 350	H2S NBC	No. 3 radar inverter
Radio and radar inverters	No. 2 Type 350	Mk. 4B compass (Post-Mod. 2040) Oil pressure gauges (Post-Mod. 1350) Auto-pilot Auto-stabiliser (Post-Mod. 2252) Tail warning Radio altimeter Gee H, Mk. II IFF T4 Bombsight (Post-Mod. 1648) Alternative store control Stand-by for instrument inverter Zero reader 2nd pilot's artificial horizon (Post-Mod. 2218)	No. 3 radar inverter
Radio and radar inverters	No. 3 Type 350	ARI 5910 (PR only) Stand-by for instrument and No. 1 and 2 radar inverters	No stand-by
	Type 153	Green Satin	No stand-by
	Type 153A (Post-Mod. 2756)	Rebecca Mk. 10 (Post-Mod. 2742) Eureka Mk. 10 (Post-Mod. 2741)	No. 3 radar inverter

26 Deleted

27 Instrument master switch

(*a*) The instrument master switch (B28) on the instrument top panel is a guarded three-position switch marked ON (up) and OFF (down) with a central position into which it is spring-loaded. When an external 24-volt supply is plugged in and/or when the 24-volt battery switch is ON, the instrument master switch, when selected to ON, connects a supply to the instrument circuit-breaker and, if the internal control locks are disengaged, to the power controls contactor. When the switch is released it returns to the central position, but the circuit-breaker and contactor remain "made". The instrument circuit-breaker can only be tripped by selecting the instrument master switch to OFF. When the internal control locks are engaged the power controls contactor will trip, but this will not affect the instrument circuit-breaker. When the locks are disengaged the contactor may be re-made by selecting the instrument master switch to ON; the instrument circuit-breaker, if previously energised, will again not be affected. Until Mod. 2089 (WZ403) is fitted, the power controls contactor is tripped when the instrument master switch is selected to OFF.

(*b*) The following circuits are controlled by instrument master switch:

Instrument inverter
Bomb bay heating control and temperature gauge
Cabin temperature control indicator
Pilot's outside air temperature gauge
Undercarriage position indicator
Flap position indicator
Tailplane incidence indicator   Feel trim indicators
Elevator trim warning lights
Manual trim tab indicators
Fuel contents gauges   Fuel flowmeters
Fuel low pressure warning lights
Fuel filter de-icing control and warning light
Engine starting controls
Airframe anti-icing overheat warning lights
Turn-and-slip indicators
Hydraulic pressure magnetic indicators   Hydraulic pumps

28 Instrument inverter control

The Type 100A inverter is operated from the 28-volt system. The instrument master switch (B28) on the instrument top panel, when selected to ON, connects the instrument DC supplies and starts the instrument inverter. At the same time the inverter failure warning light (M21) on the radio crate will come on; it will go out as soon as the inverter has run up to full speed. The inverter can be shut down by selecting the instrument master switch to OFF, but this is not recommended in flight. If it is necessary to shut down the inverter in flight, this should be done by removing fuse D90.

29 Instrument inverter failure

If the instrument inverter fails, a torque switch will operate to connect the supply from the radar inverter No. 2 to the instruments provided No. 2 inverter is switched on. The supply to the failed inverter will automatically be cut and the inverter failure warning light (M21) will come on.

NOTE: On aircraft prior to WZ 366, until Mod. 1051 is embodied the warning light (M21) is marked "No. 1 inverter," though it does in fact indicate failure of the *instrument* inverter.

30 Radio and radar supplies

The three inverters supplying AC to the radio and radar equipment are operated from the 112-volt system. They supply 3-phase 400 CPS at 115 volts, and single-phase 1,600 CPS at 115 volts.

Radar Inverter No.	400 CPS	1,600 CPS
1	H2S NBC	H2S NBC
2	Tail warning Auto-pilot Auto-stabiliser (Mod. 2252) Instrument inverter stand-by Mk. 4B compass (Post-Mod. 2040) T4 Bombsight (Mod. 1648) Alt store control Oil press (Post-Mod. 1350)	Tail warning Radio altimeter T4 Bombsight Gee H, Mk. II IFF
3	ARI 5910 (PR only)	ARI 5910 (PR only)

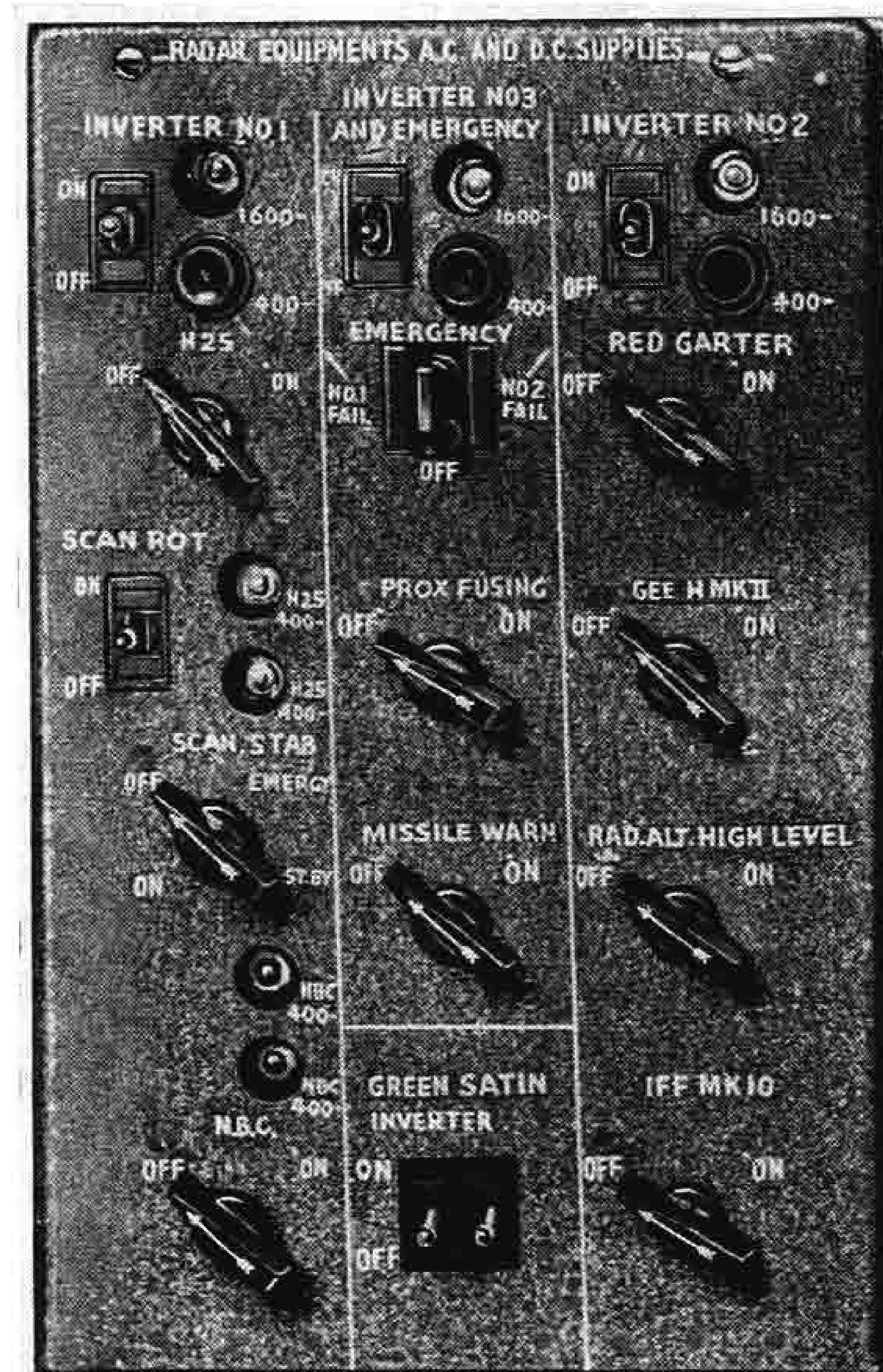


Fig. 7 Radar panel

31 Radio and radar inverter controls and indicators

(*a*) All radar control switches, including the inverter switches and warning lights are on the radar panel (M26) on the radio crate. Each inverter has its own ON/OFF control switch, a green warning light and a neon phase failure indicator (O6, 8 and 9) on the radar panel. The green light is on the 400 CPS side, the neon light is on the 1,600 CPS side. In addition four neon lights (O2 and 4) indicate correct functioning of the A and C phases (phase B is earthed) in the 400 CPS supplies to the H2S and NBC equipment.

(*b*) *Inverter test sockets*

Three test sockets (L9) are provided, one for each of the radio and radar inverters, on the voltage trimmer panel on the cabin port wall.

(*c*) *Green Satin supply*

The 400 CPS supplies to the Green Satin equipment are obtained from a separate Type 153 inverter operated by the 112-volt system. Post-Mod. 2399 the inverter is controlled by an ON/OFF switch (O17) on the radar panel, and the equipment is controlled by an adjacent switch (O16). Pre-Mod. 2399 a single switch controls the inverter and the equipment. There is no indication of failure and there is no stand-by.

(*d*) *Rebecca/Eureka supplies*

The supplies for the Rebecca/Eureka equipment (Mod. 2741 and 2742) are obtained from a separate Type 153A inverter (Mod. 2756) operated by the 112-volt system. The supply is controlled by a NORMAL ON/OFF/EMERGENCY ON switch on the right of the radio crate. In the NORMAL ON position, the 153A inverter is switched on and supplies the Rebecca/Eureka equipment. In the EMERGENCY ON position, the equipment is supplied from the No. 3 radar inverter provided this is running and not being used for something else. A green warning light beside the switch comes on, in the NORMAL ON position only, to show that the 153A inverter is supplying power.

32 Radio and radar DC supplies

The DC supplies to those items of equipment using AC also, are controlled by the same switches on the radar panel. Circuit-breakers for the DC supplies are on the right of the generator panel.

Hydraulic Systems

33 General

(*a*) Hydraulic power, supplied by two electrically-driven hydraulic pumps, is used to operate the mainwheel brakes and the nosewheel steering. Fluid is stored in a double tank in the " attic " behind the pressure cabin.

(*b*) There are two separate and independent services. Service No. 1 supplies the mainwheel brakes through anti-skid (maxaret) units, and the nosewheel steering; service No. 2 supplies the nosewheel steering, and also the brakes direct through a change-over cock (C27). Three hydraulic accumulators are fitted in each service, one for the nosewheel steering and two for the brakes. The steering accumulators are initially charged with air to 1,800 PSI, and the brake accumulators to 1,500 PSI. Air charging valves and pressure gauges are fitted on a panel in the starboard servicing bay. This panel also contains the hydraulic pressure release levers which enable all hydraulic pressure to be released from the accumulators and systems.

34 Normal operation

(*a*) The pumps operate when the 112-volt busbar is live, the instrument master switch is ON, and the nosewheel is down. They are then controlled independently by two pressure switches which switch them on when hydraulic pressure drops to 1,900 PSI, and switch them off when it rises to 2,300 PSI. If a pressure-switch fails, the pump runs continuously, the pressure then being controlled by an automatic cut-out valve which cuts in at 2,000 PSI and cuts out at 2,500 PSI, diverting fluid back to the reservoir. Retraction of the nosewheel cuts the supply to the pumps.

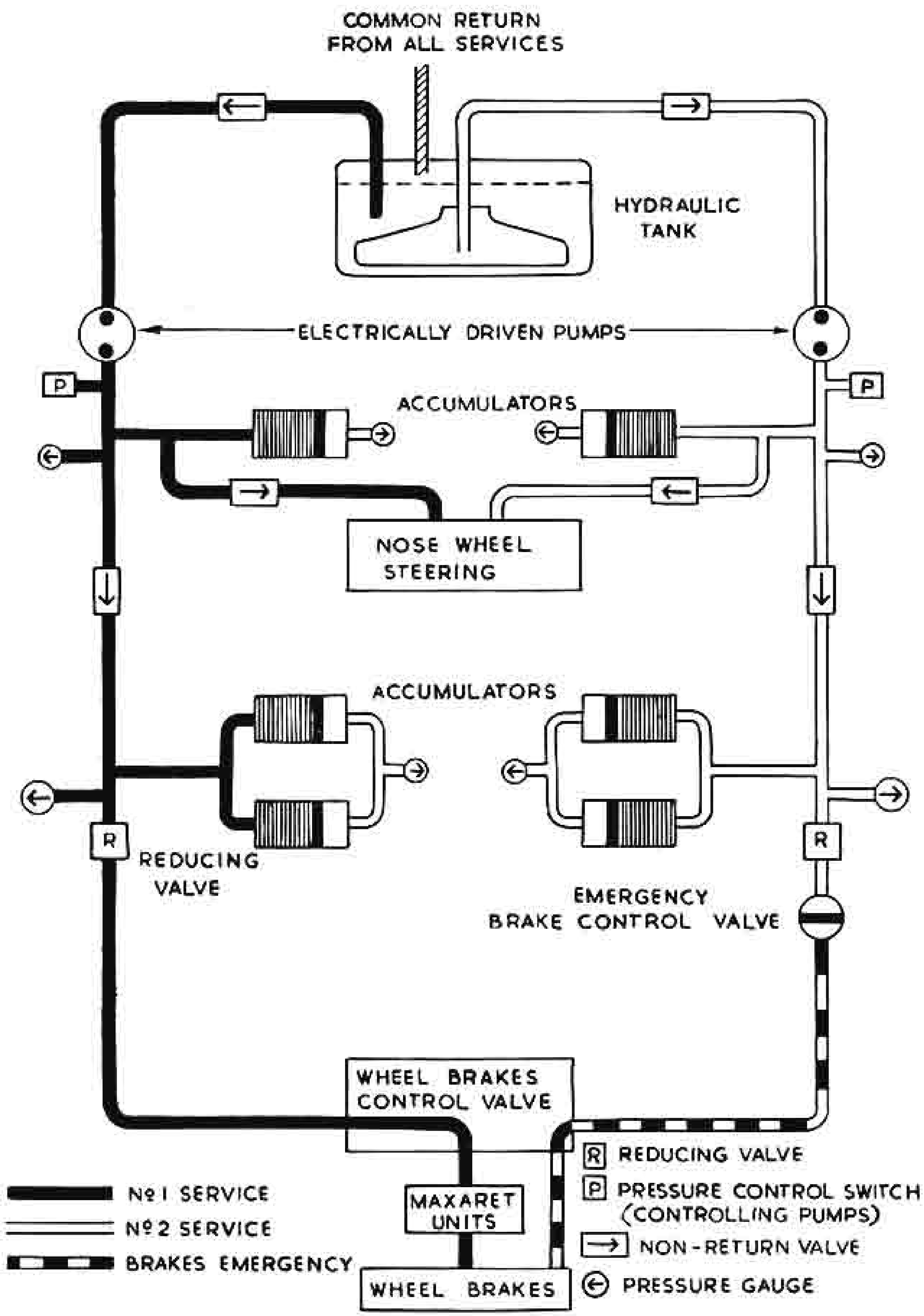


Fig. 8 Hydraulic system (simplified)

(*b*) *Magnetic indicators*

Two magnetic indicators (E21 and 22) on the port coaming panel operate as follows:

(i) *Nosewheel locked down*. When the hydraulic pressure falls below 1,900 PSI the pumps will start to run and the indicators will show white. When the pressure reaches 2,300 PSI the pumps will stop and the indicators will show black.

(ii) *Nosewheel up*. Pre-Mod. 2084 (XD816) the indicators will show white at all times when the nosewheel is up, but Post-Mod. 2084 they will show black.

(iii) *Pump failure*. In the event of pump failure, the relevant indicator will remain white.

(iv) *Electric failure*. In the event of electric failure the indicators will show white.

NOTE: Post-Mod. 1613 (WZ376) but pre-Mod. 2084 (XD816) the indicators show OFF instead of white and ON instead of black.

(*c*) *Pressure gauges*

Four gauges (J4, 5, 6 and 7) on the starboard quarter panel show the pressure supplied by each pump to the brakes and to the nose-wheel steering. Normally both gauges in each service will show the same pressure, but if the pump fails they will show the hydraulic pressure available in their respective accumulators.

35 Pump failure

(*a*) Failure of a pump will be indicated by its indicator remaining white or showing OFF when the pressure in the service falls below 1,900 PSI. If No. 1 pump fails, the nosewheel steering will be supplied by No. 2 pump and the brakes will be supplied by the two brake accumulators and the steering accumulator in No. 1 service. No. 2 pump will not recharge any of these accumulators.

(*b*) If No. 2 pump fails, No. 1 pump will supply the brakes in the normal way and will also supply the nosewheel steering. If both

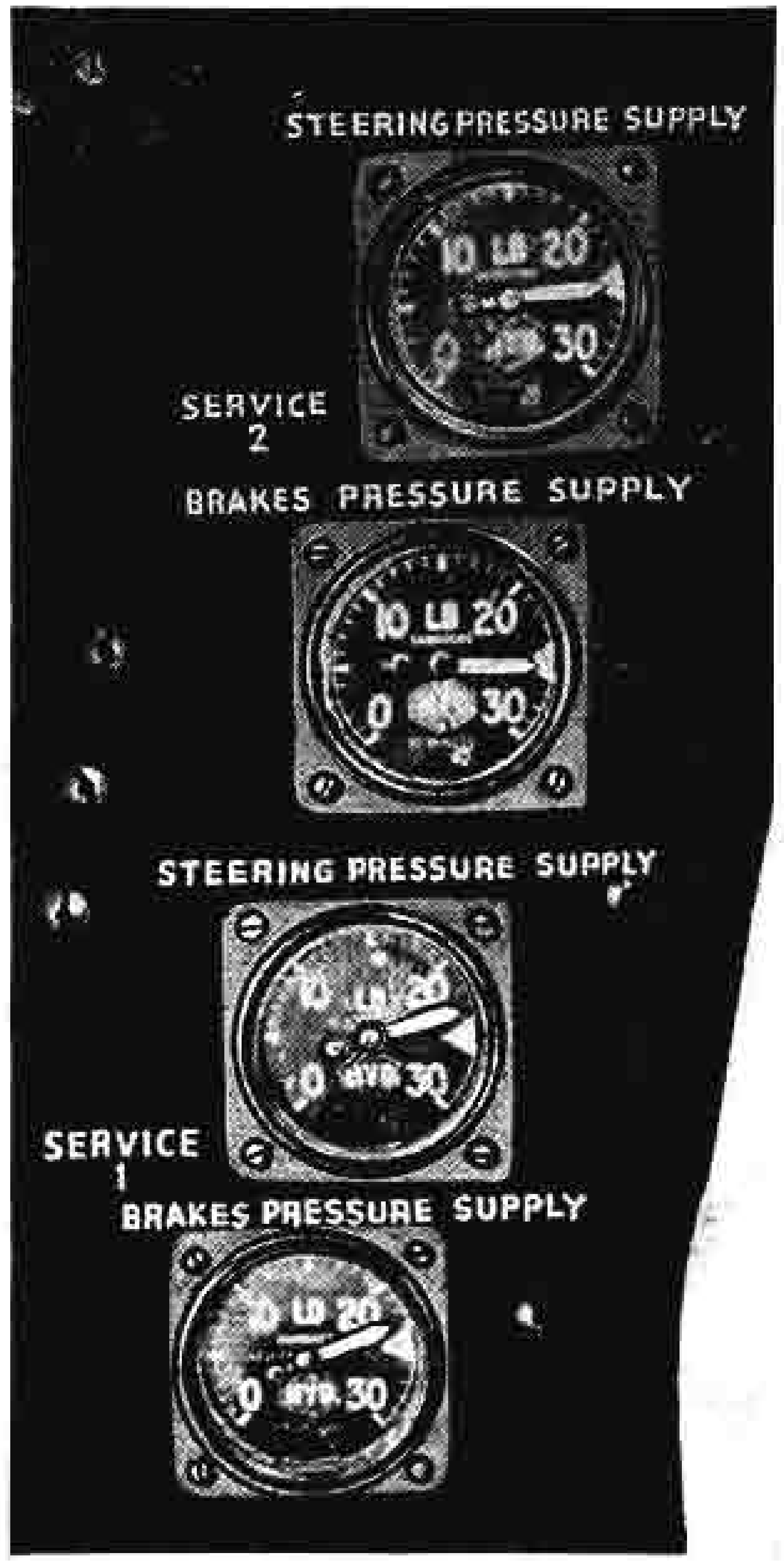


Fig. 9 Hydraulic pressure gauges

pumps fail, the nosewheel steering will be supplied by both steering accumulators and the brakes will be supplied by the two brake accumulators and the steering accumulator in No. 1 service. A changeover lever (C27) on the rear of the central pedestal enables the No. 2 service to be used for the brakes if necessary (see Part I, para. 74(*b*)).

36 External supply

A 112-volt external supply socket is in the nosewheel bay for use when towing. When an electric supply is plugged in to this socket both hydraulic pumps will run continuously, the pressure being controlled by the automatic cut-out valves. At the same time the aircraft intercomm system is connected to the 28-volt "essential services" busbar.

Pneumatic Systems

37 General

Two completely independent pneumatic systems are provided, one for operating the canopy and door seals and one for pressurising the H2S installation. The systems are separately supplied by two air bottles in the starboard servicing bay, where there are also pressure gauges and charging valves.

38 Canopy and door seals

The air for the canopy and door seals is reduced from 450 PSI to 4 PSI by reducing valves and then fed direct to the company seal which is always inflated, and to the door seal valve. This valve admits air to the door seal when the door is closed and exhausts the seal when the door bolts are withdrawn. A cock (M31) on the top of the radio crate may be used to shut off the supply for ground servicing. It is normally wired open.

39 H2S pressurising

The air for pressurising the H2S is reduced from 1,800 PSI and fed to the equipment in the nose. A pressure gauge and shut-off valve, as well as a charging connection, are in the starboard servicing bay, and the system is controlled by a shut-off valve below the starboard console door. A pressure gauge (M3) is on the right of the radio crate.

Engine Controls

40 Throttle controls

The four throttle levers (C12) are on the central pedestal. The throttles also control the HP fuel cocks ; there is a gate at the idling position and the throttles may be brought back through the gate to close the HP cocks after pulling the catches on the top of the levers

Post-Mod. 3225 (204 engines) there is a further gate at the forward end of the throttle quadrant. When the throttles are opened to this gate 8,000 RPM are obtained. After pulling the catches on top of the levers the throttles can be opened fully through the gate to obtain 8,200 RPM. When opening the throttles they can only be moved and pushed forward through the gates after releasing the catches. Each throttle lever also incorporates a relight button. The throttle friction may be adjusted by either of two levers (C10 and 14) one on each side at the front of the central pedestal.

41 Variable pitch guide vanes and air bleed valves

The first row of stator blades in the engine compressor consists of variable pitch inlet guide vanes which assist in imparting swirl to the incoming air. At low RPM the first stages of the compressor deliver more air than is acceptable to the later stages. To prevent instability of flow, i.e. surge, the surplus air is bled off through an air bleed valve, and the guide vanes are held closed to give an angle of flow acceptable to the first stage blades at low RPM. As the normal flight range of RPM is reached, the air bleed valve closes and the guide vanes move progressively to the minimum swirl position.

42 Engine starting controls

(*a*) Each engine is started by its own electric starter motor. Power is normally obtained from a ground supply plugged into the external socket on the port side. The engine starting switches are on the port console panel; a master switch (F1) marked ISOL—SAFE—START, a selector switch (F3) marked 1, 2, 3 and 4, and a starter pushbutton (F2). The master switch must be set to START before any of the engines can be started; when set to ISOL the engines can be turned over on the starters but the igniters will not operate. The master switch must be returned to SAFE after starting the engines. The selector switch is used to select the engine to be started. When the starter button is pressed for a couple of seconds and released, starting is controlled by a time switch through which the igniters and starter motor are operated for 22 seconds or until the engine has run up to speed, whichever is less. When the starter motor stops operating, the starter button will reset, but the full cycle of 36 seconds must elapse before it can be operated again. The green warning light (F24) on the port console panel will be on until the engine runs up to speed, or until switched off by the time switch (in 22 seconds), in the case of motoring over or failure to light up.

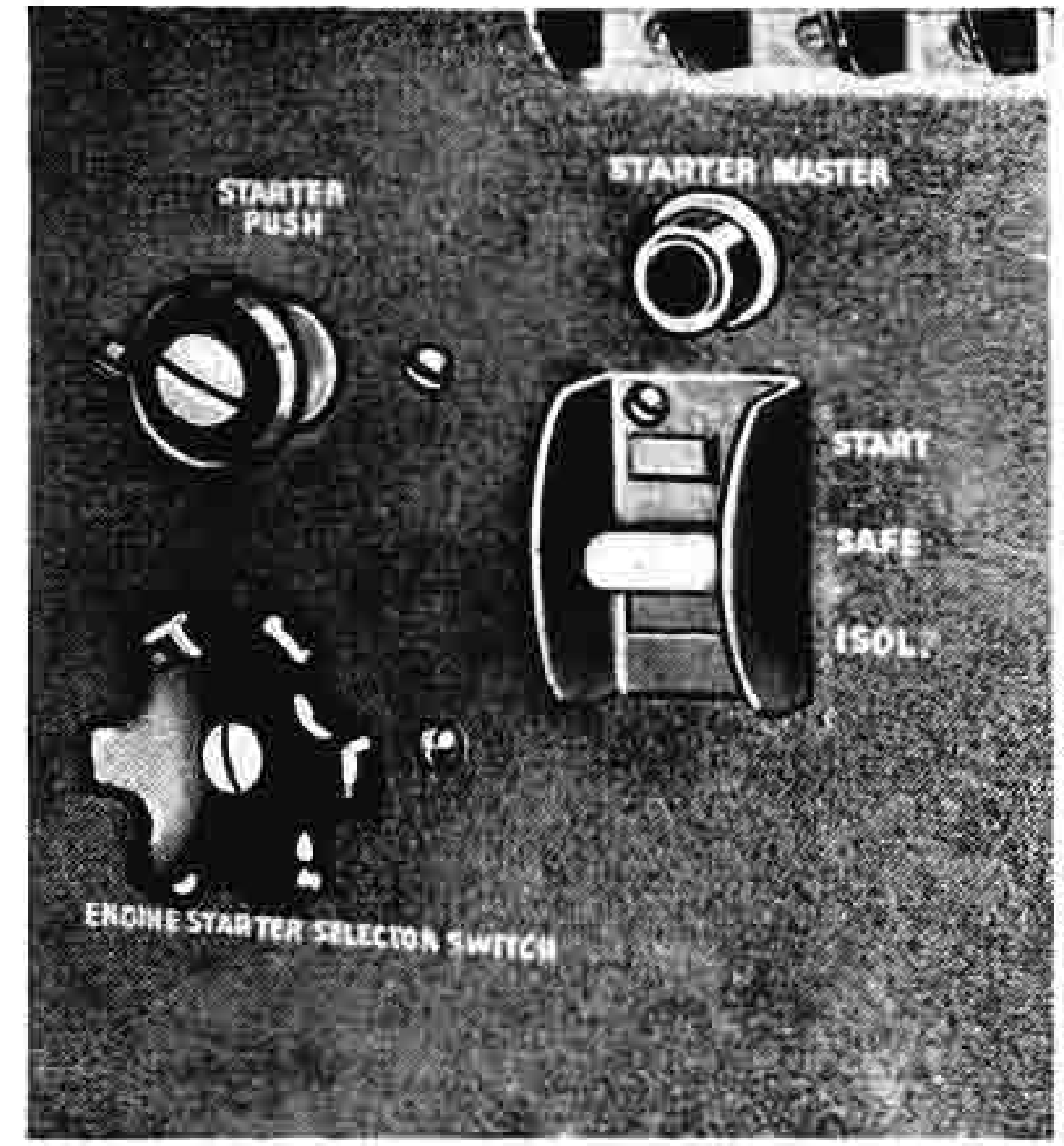


Fig. 10 Engine starting controls

(*b*) To reduce the time interval between starting and take-off the following items are connected via quick release couplings to tethered ground installations, and are automatically released as soon as the aircraft commences to move:

Engine start connections	(Mod. 3087)
Electrical supply . . .	(Mod. 3088)
Telescramble . . .	(Mod. 3089)
True earth	(Mod. 3090)
Feel unit static vent plugs and pitot static vent cover .	(Mod. 3091)
Ground air-conditioning equipment . . .	(Mod. 3107)

43 Engine relighting system

The high energy igniters may be used to relight an engine in flight by pressing the relight pushbutton in the head of the appropriate throttle lever.

44 Engine instruments

Oil pressure gauges (B50 and 59), RPM indicators (B17) and JPT gauges (B20) are on the instrument centre panel. Fuel contents gauges are on the fuel panel and fuel low pressure warning lights are on the instrument top panel.

45 JPT fuel control

(*a*) If the jet pipe temperature rises above the maximum at full throttle, an automatic control reduces the fuel flow to the engines, so reducing the jet pipe temperature. Each engine is separately controlled by identical systems which are operated electrically. A single switch (B34) on the right of the instrument top panel, when set to ISOLATE, cuts out the automatic operation of all control units. It should usually be set at NORMAL, the ISOLATE position only being used for take-off in case one of the units fails and prevents full take-off power being obtained. When the switch is at ISOLATE the jet pipe temperatures are controlled only by the throttles.

NOTE: If Mod. 1106 is not embodied, the system is not operative. Jet pipe temperatures are then controlled only by the throttles.

(*b*) Considerable loss of power may occur if the engines are at high RPM with the JPT controller at NORMAL, and No. 3 inverter is switched ON following a failure of No. 2 inverter. To prevent this loss of power the following drill should be adhered to should the No. 2 inverter fail.

(i) Switch the JPT controller to ISOLATE.

(ii) Switch No. 3 inverter ON, and No. 2 inverter OFF.

(iii) Allow 30 seconds to elapse and switch the JPT controller to NORMAL.

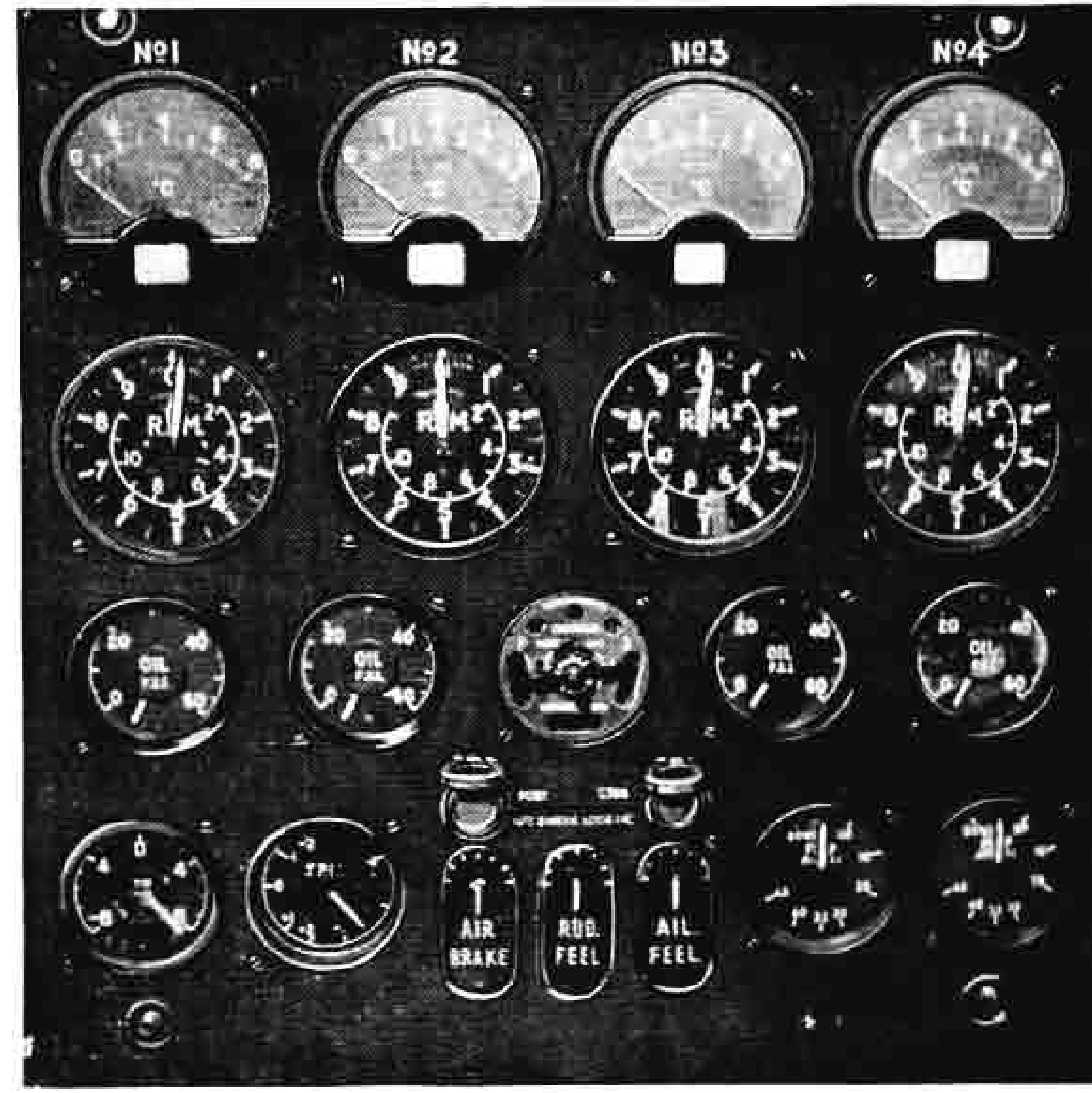


Fig. 11 Engine instruments

46 Engine overheat warning

(*a*) When Mod. 3094 is embodied heat detectors are fitted in the LP cooling discharge air duct of each engine to give warning of rear bearing failure, thereby minimising a possible fire hazard.

(*b*) Four red warning lights, one for each engine, are mounted on a panel above the engine fire extinguisher pushbuttons, to warn the pilots of dangerously high temperatures at the engine rear bearings.

(*c*) Each lamp is controlled, via a relay on fuse panel E, by two heat detectors wired in parallel.

(*d*) Two filament test switches, one at each end of the bank of four lights, when depressed connect a supply to the warning lamp filaments. Each switch serves two lights.

Thrust Augmenting Systems

47 Water-methanol system

(a) General

(i) Water-methanol is carried in a light-alloy tank, of 145 gallons usable capacity, in the fuselage forward of the transfer tank. The tank consists of two interconnected cells. A refuelling connection is on the starboard side of the fuselage aft of the wing trailing edge, and a vent system has its outlet in the fuselage belly just aft of the rear access hatch.

(ii) Water-methanol is pumped to the engines by four air-turbine-driven pumps, one for each engine; the air for operating the pump is taken through two shut-off cocks from the tail port and starboard anti-icing ducts on the engine side of the anti-icing shut-off valves. The engine gate valves (see para. 76) must be open (switches J1, 14, 15, 16) at NORMAL for the air to be available. A water-methanol shut-off cock is in the line from each pump to the engine.

(iii) At the maximum rate of flow, the water-methanol will last for about 45 seconds. The increase in thrust is about 1,000 lb per engine.

(b) Controls and indicators

(i) *A master switch* on a small bracket at the forward end of the starboard coaming panel. This is a ganged double-toggle on/off switch which controls the supply to the two air shut-off cocks ; it also connects a supply to the engine minimum speed switches, the four water-methanol shut-off cocks and a tank low-level switch, when these function as described in sub-para. (*c*). When Mod. 3004 is embodied the master switch is repositioned at the starboard side of the top instrument panel to avoid fouling the anti-flash screens.

(ii) *Two indicator lights* on the extreme right-hand side of the instrument top panel. These come on to indicate that the air shut-off cocks are open and that air pressure is sufficient to drive the pumps. The lights are not of the press-to-test type.

(c) Functioning of the system

When the master switch is selected on, the air shut-off cocks are opened and the indicator lights should come on to show that there is adequate air pressure. The pumps should now be running. Provided that the engines are running at over 6,700 to 7,500 RPM, depending on ambient temperature and altitude, and provided that the tank is full, the minimum speed switches and the tank low level switch will close, thus connecting an electrical supply to the water-methanol shut-off cocks which will then open. Water-methanol will now be injected into the engine combustion chambers. At the same time the engine speed governors will be re-set by the water-methanol pressure to allow the engine speed to rise to 8,300 RPM maximum. When the level in the tank has fallen to the unusable quantity of about 6¼ gallons, the low level switch will cause the water-methanol shut-off cocks to close. At the same time the engine speed governor is re-set to the normal 8,000 RPM maximum. When engine RPM drop to this figure the master switch must be set off, thus closing the air shut-off cocks and isolating the complete system.

48 Deleted

Aircraft Controls

49 General

Dual controls are fitted for the side-by-side seated pilots. Electro-hydraulically operated power controls with automatic and selective manual reversion are fitted for all surfaces, and an artificial feel system is incorporated. Provision is made for an electric Mk. 10 auto-pilot and an auto-stabiliser. Internal control locks are provided which, when engaged, also restrict the throttle opening, though allowing sufficient power for taxying.

50 Control handwheels

(*a*) Each control handwheel is on a curved arm which slides backwards and forwards on a bar at each side of the cockpit. The handwheels are adjustable for reach by a starwheel (F13 and H2) below the outboard end of each arm. Each handwheel may be disconnected from the elevator controls by pulling out and turning the knob (F9 and H9) at the rear of each slide-bar; the handwheel may then be pushed forward out of the way. The elevators may be re-engaged by turning and releasing the knob and then pulling the handwheel slowly back until the controls re-engage.

(*b*) Both handwheels incorporate twin brake levers, tailplane incidence and master switches, a press-to-transmit pushbutton and an auto-pilot instinctive cut-out switch. The left handwheel carries, in addition, a brake parking catch and a RATOG firing pushbutton. On a few early aircraft a bomb release pushbutton is on the arm carrying the left handwheel; the switch is not operative, and is deleted by Mod. 1197 (WP216).

(*c*) For abandoning the aircraft, both control handwheels are disconnected from the elevator controls, and moved fully forward to clear the pilots' knees during ejection. This is done by operating the canopy jettison levers (F22 and H15) but, although either lever will jettison the hood, the two levers disconnect their respective handwheels only, i.e. the port lever only disconnects the port handwheel.

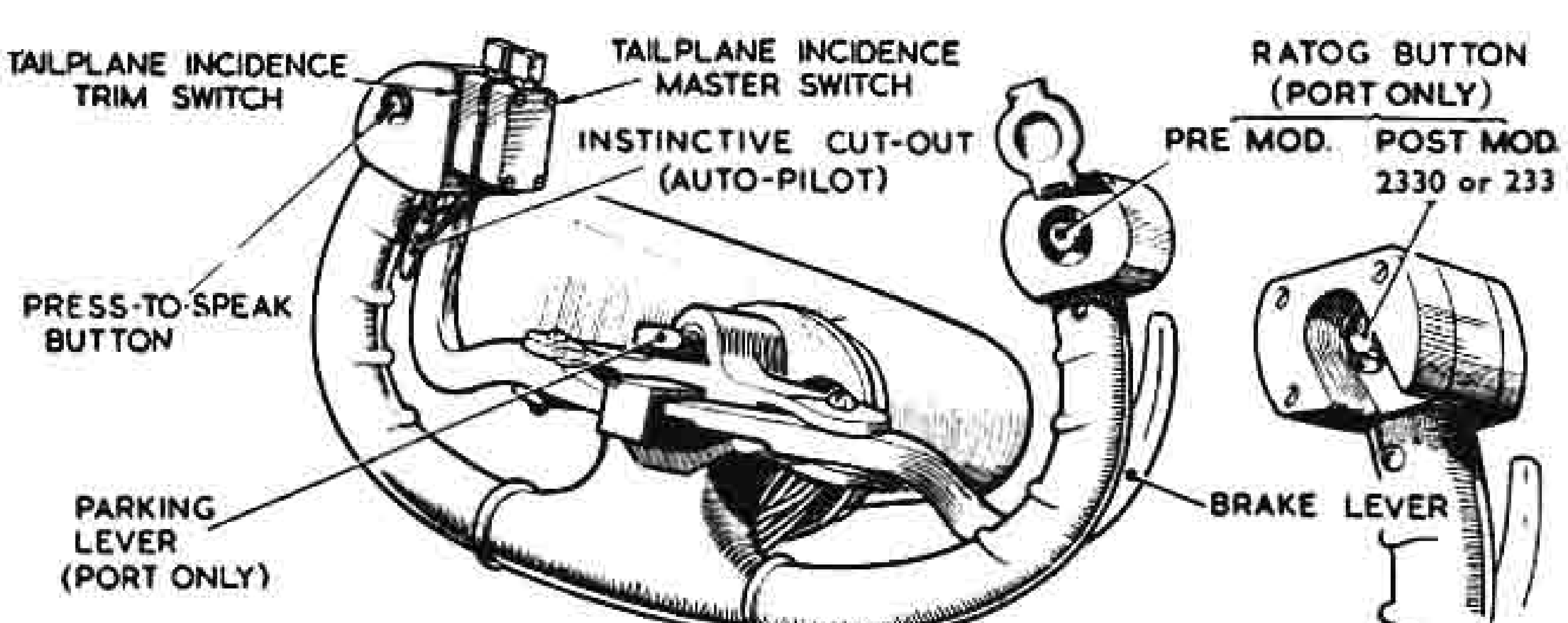


Fig. 12 Control handwheel

51 Rudder pedals

Each pair of rudder pedals incorporates a pair of brake toe pedals and is adjustable for reach by a starwheel immediately forward of the pilot's feet.

52 Flying control locks

The flying controls are locked by a built-in locking system operated by a lever (C23) on the central pedestal. The locking lever also operates a micro-switch which stops the power control motors when the controls are locked. Mod. 1976 (WZ400) introduces a lock in the form of a spring clip to hold the locking lever in the unlocked position.

53 Power controls

(*a*) The power controls are operated by four electrically-driven hydraulic pumps, two for the ailerons, and two for the rudder and elevators. The systems are so arranged that if one aileron pump motor fails the ailerons will still operate, but only at half rate ; rudder and elevators are not affected. If one of the rudder and elevator pump motors fails, the rudder and elevators will operate at half rate ; ailerons are not affected. Any further motor failure will cause the affected controls to revert automatically to manual.

NOTE: The maximum rate at which control deflection can be applied is considerably greater than would normally be required, even at half rate.

Consequently failure to half rate of any control surfaces will not have any noticeable effect on handling unless an abnormally high rate of control deflection is required.

(*b*) The four pumps are controlled by the instrument master switch (B28) on the instrument top panel. The pumps will not operate if the internal control lock lever is engaged. If the power control motors are running, they will automatically be stopped as soon as the internal control lock lever is engaged (but see Part III, para. 45) ; the pumps will not start running again when the lever is disengaged, until the instrument master switch is re-selected ON. When the power control motors have been tripped it takes about 12 seconds for the hydraulic pressure to dissipate and to cause reversion to manual control. This period will be reduced if the controls are moved after tripping the motors. The motors can only be tripped by operating the control locking lever or the individual trip pushbutton (see (*c*) below).

Fig. 13 Power controls

(*c*) Four warning lights (E26, 27, 28 and 29) on the port coaming panel give individual warning of low pressure delivery by any pump. If any of these lights come on, the appropriate pump motor must be tripped without delay by pressing the pushbutton (E7, 8, 9 and 10) above the light. The light will remain on when the motor is tripped.

(*d*) A master warning light (B11) on the port instrument flying panel gives warning of low pressure delivery by any one or more of the pumps. If this light comes on, the immediate action should be to check the four warning lights on the port coaming panel and then trip the relevant pump motor ; the master warning light will then go out. If one of the four lights comes on and the master light stays out, check the operation of the filament by pressing the master light. If this is all right, contactor failure is indicated (as opposed to pump failure) and an attempt may be made to re-set it by selecting the instrument master switch on. If it fails to re-set and the light stays on the motor must be tripped. If one of the other motors has previously been tripped due to failure this should again be tripped after releasing the instrument master switch.

54 Feel units

(*a*) As the power controls are irreversible and therefore have no feedback it is necessary to provide some form of feel. This is provided through three units which get a ram air supply from an inlet at the root of the fin leading edge. They also get a static supply from vents in the top of the rear fuselage. The feel is a function of indicated air speed and control deflection and thus, although it is artificial, is similar to that obtained on a manually controlled aircraft.

(b) Feel unit heaters

The feel units are heated electrically by thermostatically controlled muffs. The switches are on Panel E (Mod. 3058; Command Mod. 61).

(c) Feel unit release

If any of the feel units should jam or be damaged, they must be disconnected from the controls system by pulling back the relevant one of the three cut-off levers (C3, 7 and 9) on the left of the central pedestal. If a feel unit has been disconnected accidentally, it can be reconnected in flight by putting the lever forward and making small movements of the controls until the unit re-engages ; the elevator feel can, however, only be reconnected if the release lever is moved forward under the same speed and flight conditions as when it was released. A locking button is in the top of each cut-off lever; Pre-Mod. 2814 this button must be pressed before the lever can be moved forward, Post-Mod. 2814 the button must be pressed before the lever can be moved either way.

55 Trimming

(a) General

There are two separate methods of trimming, one for use when flying with the power controls operating, and one for use if the power controls have failed. Under normal conditions the variable incidence tailplane is used for longitudinal trimming and the aileron and rudder feel unit trimmers are used for lateral and directional trim. When the power controls have failed and control has reverted to manual, conventional trimming tabs are used for lateral and directional trim, and the variable incidence tailplane is used for longitudinal trimming, in conjunction with the conventional elevator trimming tab. When flying in power, it is important that the aileron and rudder manual trimmers are left at neutral, and when flying in manual the feel trimmers must not be moved.

(b) Variable incidence tailplane

(i) The incidence of the tailplane is varied by two electric motors controlled by one or other of two incidence switches one on each control wheel. Two " master " switches, one on each control wheel, are mounted inboard of, and side-by-side with, the incidence switches. They control a master relay in the power supply to the tailplane actuator. All four switches are three-position and spring-loaded to the central (off) position.

(ii) Only one incidence switch is operative at a time, according to the setting of a guarded selector switch (C6), on the central pedestal, marked 1st PILOT and 2nd PILOT. When the selector switch is set to 1st PILOT, only the incidence switch on the left hand wheel will operate the tailplane. This selector switch does not control the two " master " switches. Only one motor is used at a time, this being selected by a guarded switch (C4), marked COARSE and FINE, on the central pedestal. When this is set to COARSE the fast motor will operate the tailplane incidence at about three seconds per degree, full travel being obtained in 24 seconds. When the switch is set to FINE, the slower motor will operate the tailplane incidence at about six seconds per degree, full travel being obtained in 45 seconds.

(iii) When either master switch is moved either forward or back the master relay is energised and the tailplane circuit is made live. Operation of the selected incidence switch while the master switch is being held on will energise the tailplane actuator motor and change the tailplane incidence. When the master switch is released and returns to the central position the master relay is tripped, causing the tailplane circuit to become dead and the actuator motor to stop, even if the incidence switch is still held on. When the selected incidence switch is held back, the trailing edge of the tailplane is raised, giving a nose-up change of trim. The motor will run until the incidence switch or the master switch or both are released or until the tailplane actuator reaches the end of its travel.

(iv) If the limit switches at either end of the travel of either motor fail, an overtravel micro-switch will operate to trip the contactor and stop the motor. The tailplane can be moved on the other motor, and when it is brought back within limits the tripped contactor will automatically reset.

(v) When trimming, the selected incidence switch an adjacent master switch must be operated and released simultaneously. The master switch must not be held on in anticipation of trimming.

(vi) An indicator (B58) on the instrument centre panel shows the position of the tailplane at all times when electrical power is available. On aircraft prior to WP214, until Mod. 1200 is embodied the indicator is at (B60).

(c) Feel unit trimming

The feel units for the rudder and ailerons may be trimmed to relieve the foot and hand loads by operating the trimming switch (C15) on the central pedestal. Sideways movement of the switch trims the aileron feel unit, and rotary movement trims the rudder feel unit. Indicators (B53 and 55) are on the instrument centre panel. The elevator feel unit cannot be trimmed. The trim indicators do not show applied trim, but show neutral when the controls are in trim. When the controls are moved, without being re-trimmed, the indicators will be displaced.

(d) Trimming tabs

Trimming tabs are fitted on the rudder and starboard ailerons, for use when flying in manual, and on the starboard elevator to enable the elevators to be kept in trim with the tailplane when flying in power or in manual (see sub-para. *(e)*). They are operated by electric actuators controlled by three master switches (F20, 21 and 23) and a single trimming switch (F19), all on the port console panel. The rudder tab is operated by turning the trimming switch in the required direction ; the aileron tab by moving the switch to either side ; and the elevator tab by moving the switch forwards or backwards. In all cases the actuators operate until the switch is released or until they reach the limit of their travel. Position indicators (F11 and 18) for all three tabs are on the port console panel.

NOTE: Until Mod. 1958 (WZ390) is embodied the Rudder and Elevator trim master switches are transposed. Thus they are not in line with the indicators, and care must be taken to avoid confusion.

(e) Elevator trimming

Owing to the power controls having no feed-back, it is possible, due to variations in speed, CG and weight, for the elevators to be

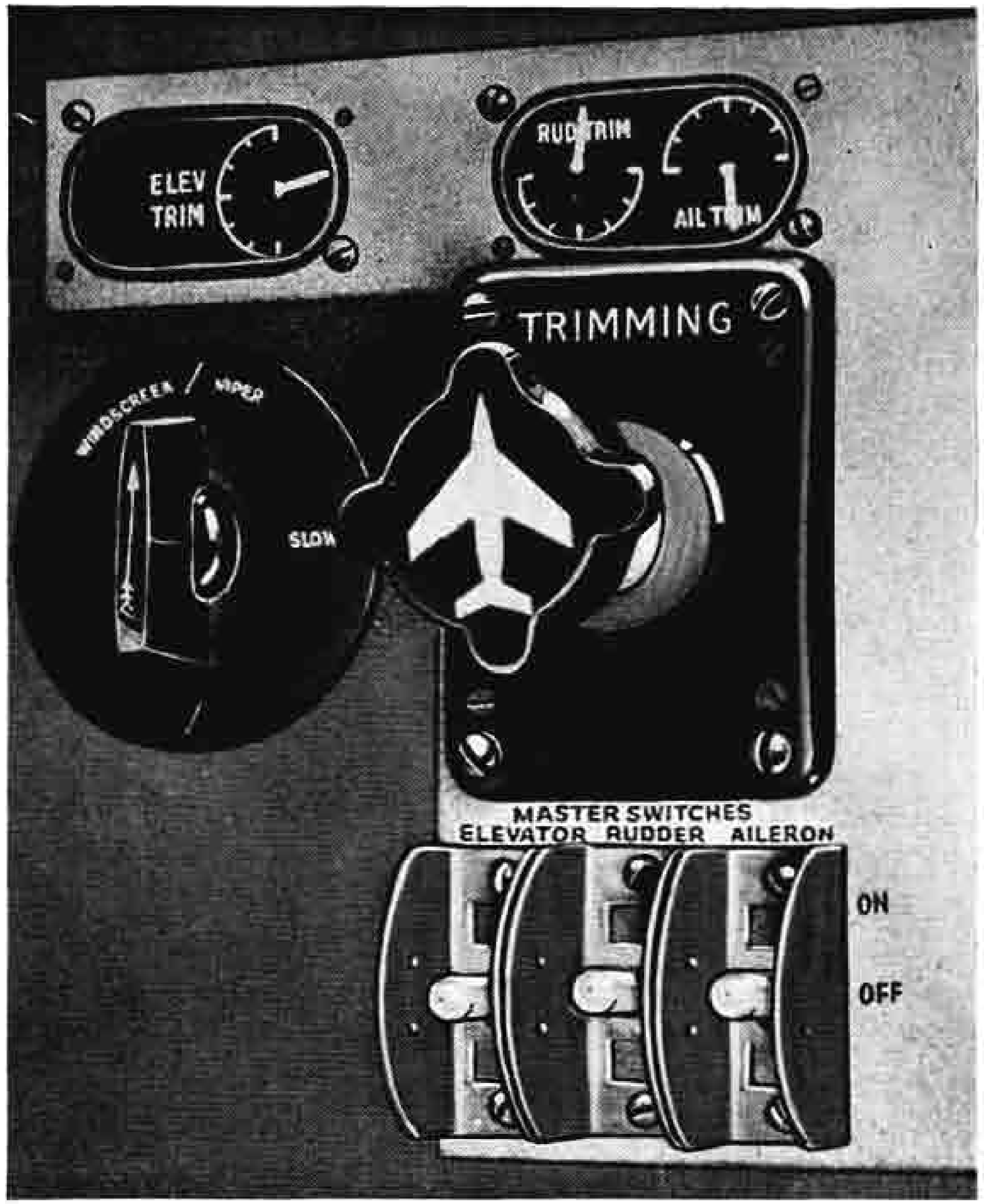


Fig. 14 Trimming controls

considerably out of trim without there being any corresponding force felt on the controls. If the elevators were greatly out of trim at the time of failure of the power controls, with consequent automatic reversion to manual control, the forces on the control handwheel could be higher than the pilot could hold. To avoid this risk, it is necessary during normal flight to keep the elevators trimmed within the limits of acceptable stick force. It is also necessary to keep the elevator in trim when flying in manual, to avoid unnecessary loads in the control run and to avoid the consequent trim change when re-engaging power. An elevator trimming indicator (B9), in the form of two lights on the left of the instrument top panel, shows when the elevator is out of trim by a certain amount. The DOWN light comes on when a nose-down trim change is required, and goes out when the force has been trimmed out. Similarly the UP light comes on when a nose-up trim change is required. If the lights are out, the stick force on reversion to manual control will be light.

56 Trim tab settings

(a) *Elevator trim tab*

The elevator trim tab movement is nine degrees up and two degrees down. The trim tab position indicator has not been recalibrated.

(b) *Aileron trim tab*

The aileron trim tab movement is reduced from 4·45 inches each way to 1·39 inches each way by STI/Valiant/5 (August, 1955) or by Mod. 1808 (WZ400). The STI did not call for recalibration of the trim tab position indicator but when Mod. 1808 is embodied the indicator is recalibrated.

(c) *Rudder trim tab*

The rudder trim tab movement is reduced from 2·1 inches each way to 0·48 inches each way by STI/Valiant/6 (August, 1955) or by Mod. 1809 (WZ400). The STI did not call for recalibration of the trim tab position indicator, but when Mod. 1809 is embodied the indicator is recalibrated.

57 Flap control and indicators

(*a*) The flaps are operated by an electric motor controlled by a lever (C13) on the central pedestal. The lever has three positions, UP, OFF and DOWN and is spring-loaded to the central (OFF) position. The normal range of movement of the flaps is down to 58 degrees on the main motor and 45 degrees on the emergency motor.

(*b*) To lower the flaps the lever should be held in the DOWN position. The motor will then run to lower the flaps until either the lever is released or the flaps reach the fully down position when the motor will automatically be stopped. To raise the flaps the lever should be held in the UP position, the motor again being stopped by releasing the lever or when the flaps reach fully up. If the normal motor fails, the flaps can be operated by an independent emergency motor. This is controlled by the three-position switch (C5), labelled UP—OFF—DOWN, on the central pedestal.

(*c*) Should the limit switches at either end of the flap travel fail, an overtravel micro-switch will operate to trip the main contactor and stop the motor ; at the same time a contactor reset warning light (P7) on the starboard console door will come on. The contactor may be reset by pressing the push-button below the warning light, but before this is done the direction of flap travel should be reversed by setting the emergency selector switch (C5) on the central pedestal to UP or DOWN according to whether the flaps have overrun the down or up limit switches. It is not necessary to let the flaps complete their travel; as soon as the flaps are back within the normal range, the emergency motor can be stopped by returning the emergency switch to OFF. The main contactor may then be reset.

(*d*) If, while the flaps are moving up or down on the normal motor, it is decided to reverse their movement, it is not necessary to wait until they reach the end of their travel. The lever may be moved from one selection to the other and the flaps will change their direction of movement after only a slight delay while the motor slows down and reverses.

(*e*) If, while the flaps are moving up or down on the emergency motor, it is decided to reverse their movement, the switch must be moved to OFF and left there for two seconds before making the new selection.

(*f*) The emergency motor incorporates overrun micro-switches which operate in the same way as those for the normal motor, the emergency contactor reset warning light (N4) and pushbutton (N3) being on the port console door. If the flaps overrun on the emergency motor and flap movement cannot be reversed by the normal motor they will remain immovable. The normal motor cannot be operated while the emergency motor is running because when the emergency motor is operated the normal contactor is tripped.

(*g*) In the event of a run-away motor, the main or emergency contactors may be tripped by operating the relevant one of two pushbuttons (B29 and 30) on the instrument top panel, and reset by pressing the relevant one of the two reset pushbuttons, the normal one (P7) on the starboard console door, and the emergency one (N3) on the port console door.

(*h*) Two indicators (B49 and 51) on the instrument centre panel show the position of the flaps at all times.

(*j*) The times of full movement of the flaps, from one extreme to the other, are as follows:

NORMAL		*EMERGENCY*
34 to 42 secs	UP	$7\frac{1}{2}$ to $9\frac{1}{2}$ mins
34 to 42 secs	DOWN	$6\frac{3}{4}$ to $8\frac{3}{4}$ mins

58 Airbrakes

(*a*) The airbrakes are operated by an electric motor controlled by a lever (C/11) on the central pedestal ; they have two positions, IN and OUT. No emergency control is provided. Mod 1608 (WZ 390) introduces a position indicator (B/56) at the foot of the centre instrument panel.

(*b*) Should the limit switches at either end of the air-brake travel fail, an overtravel micro-switch will operate to trip the main contactor and stop the motor ; at the same time a contactor reset warning light (P/6) on the starboard console door will come on. To reset the contactor the airbrake selector lever must first be placed in the opposite position to the airbrakes, and then the reset button below the warning light should be pressed. When the reset button is pressed the light will go out ; if it stays out when the button is released, the contactor will have been reset. The button should only be held in momentarily.

59 Automatic pilot

(*a*) A Mk 10 automatic pilot is installed and is operated by the control unit (C/24) on the central pedestal. A heading selector (F/15) is on the port console, thus the main control is accessible to both pilots while the heading selector can only be operated by the first pilot. An auto-pilot cut-out trigger switch is fitted to each pilot's control handwheel. AC for the auto-pilot is supplied by No. 2 radar inverter and DC is supplied from the 28-volt system.

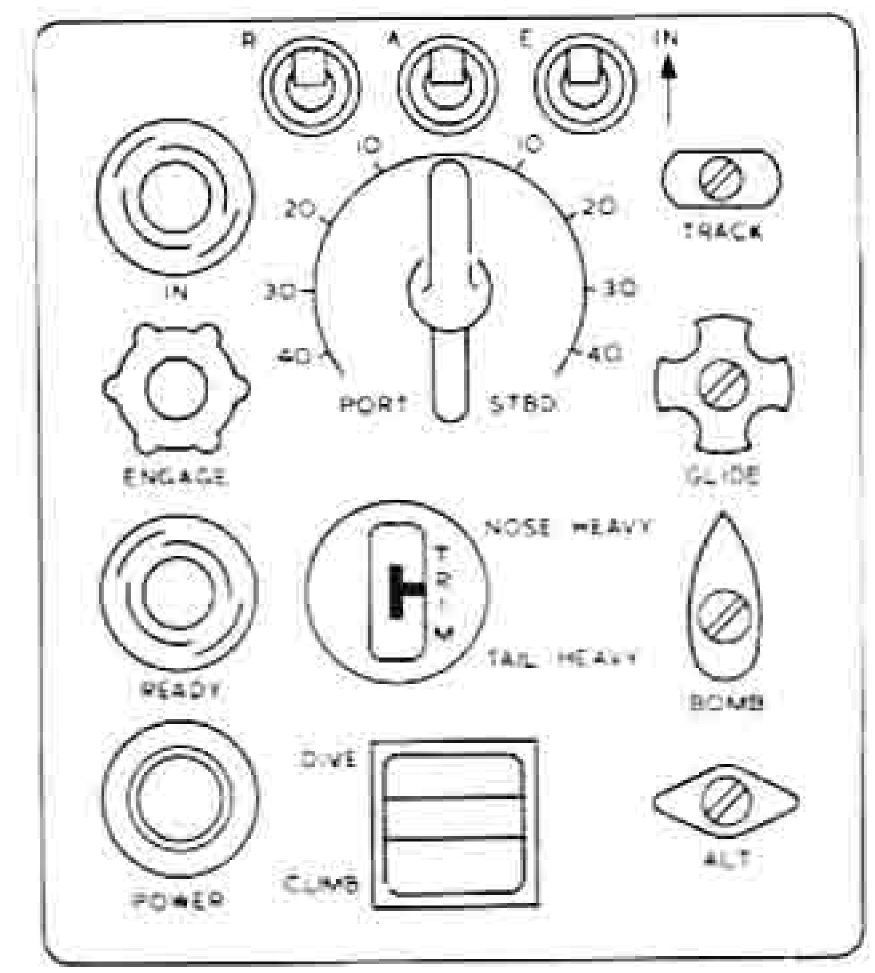


FIG 15 *Auto-Pilot Controller*

(*b*) *Control unit*

(i) The control unit has the following controls and indicators located on it:

POWER switch and associated READY magnetic indicator

ENGAGE switch and associated IN magnetic indicator

Rudder, Aileron, and Elevator channel switches

Trim indicator

NBS link switch, marked BOMB

ILS link switch, marked TRACK (localiser beam)

ILS link switch, marked GLIDE (glide path beam)

Height lock switch, marked ALT

Bank control knob and scale

Pitch switch, marked CLIMB and DIVE

(ii) The bank control knob is not spring-loaded, but has a zero bank location (central position). The pitch control switch is a five-position switch spring-loaded to the middle (off) position. The rudder, aileron and elevator channel switches are conventional two-position (IN forward) toggle switches. The remainder of the switches are of the pull (on)—push (off) type.

(*c*) The controls on the control unit function as follows:

(i) *POWER switch.* When the POWER switch is pulled, electric power is connected to the auto-pilot. After approximately 60 seconds the READY magnetic indicator (in front of the power switch) will change from black to black and white stripes, indicating that the auto-pilot is ready to be coupled to the aircraft controls.

(ii) *ENGAGE switch.* Providing the rudder, aileron and elevator channel switches are IN, pulling the ENGAGE switch will couple the auto-pilot to all three control surfaces, whereupon the IN magnetic indicator will show white and the READY magnetic indicator will go black. The controls can be disengaged from the auto-pilot by pushing the ENGAGE switch in, although this will normally be done by depressing the instinctive cut-out on the hand-wheel.

(iii) *Channel switches.* If a control channel switch is selected off, its particular control surface will be disengaged from the auto-pilot. The IN magnetic indicator will remain white and the READY indicator will show black and white stripes. Re-engagement can be achieved by putting the channel switch IN again, when the READY indicator will show black. If all three channel switches are off at the same time their control surfaces cannot be reconnected to the auto-pilot simply by putting them on again, and the normal engage procedure (by pulling out the ENGAGE switch when any one of the three channel switches is IN) will have to be used.

NOTE: Until Auto-pilot Mod E30 is embodied, the READY indicator shows amber in place of black and white stripes, and the IN indicator shows green in place of white. The black (off) conditions are unchanged.

(iv) *Trim indicator.* The indicator shows any out-of-trim load being carried by the auto-pilot elevator servo-motor. The pointer must be within the centre $\frac{3}{4}$ of the white sector before the auto-pilot is engaged. It must be kept within the centre $\frac{3}{4}$ of the white sector during flight by adjusting the aircraft trim as necessary, on the tail-plane trimmer. Post-Mod 2062, a remote trim indicator is on the bottom left corner of the instrument centre panel, in place of the OAT gauge (B/60).

(v) *Height lock switch.* When this switch is pulled the auto-pilot will lock on to the barometic height prevailing.

(vi) *Bomb, Track and Glide path switches.* The bomb switch, when pulled out, links the NBS equipment to the auto-pilot, which then controls the aircraft heading according to the signals produced by the NBS. The other two switches, when pulled on, link their respective ILS signals to the automatic pilot which then controls the aircraft according to the ILS localiser and glide path beams.

(vii) *Bank control*. The aircraft can be turned at a pre-set angle of bank by selecting the control knob to the bank required. The knob will remain on the selected angle and the aircraft will maintain the turn at that angle of bank until a different angle is selected, or the knob returned to the central position, when the aircraft will resume straight flight.

(viii) *Pitch control*. The pitch control switch is operated in the natural sense, i.e. moving the switch forward produces nose-down pitch, and vice-versa. The switch is spring-loaded to the centre (off) position. Movement of the switch is opposed by two spring rates so that initial movement against a weak spring produces a slow rate of change of aircraft attitude whilst further movement against a stronger spring will cause a fast rate of attitude change.

(*d*) *Heading selector*

The heading selector (F15) comprises a compass repeater, course setting knob and pre-select turn engagement button. With the TRACK switch on the control unit off, courses can be pre-selected on the heading selector and the aircraft will turn on to the selected heading when the pre-select turn button is depressed. The angle of bank when using the heading selector for turns is restricted to 30 degrees. With the ILS on, the runway heading (or the ILS localiser QDM if the beam is offset) should be pre-selected on the heading selector before pulling the TRACK switch on.

(*e*) *Torque limiting devices*

Torque-switches are fitted in the circuits of the auto-pilot to guard against auto-pilot runaway; they will operate in the event of a runaway occurring and thus prevent any danger from the sudden or over-application of the control. Pre-Mod. 2424 the aileron circuit is not fitted with a safety device; should a roll runaway occur, the auto-pilot will have to be cut out by the operation of the control column cut-out switch, the engage switch or the power switch.

60 Auto-stabiliser (Mod. 2252)

The auto-stabiliser suppresses any tendency of the aircraft to oscillate in yaw, or to dutch roll, by increasing the directional damping. It functions in all conditions of flight and is controlled by an ON/STANDBY/OFF switch on the central pedestal. Prior to switching ON or OFF, the auto-stabiliser *must* be switched to STAND-BY for *at least* five seconds.

Flight Instruments

61 Compasses

(*a*) *Mk. 4B Compass*

(i) The Mk. 4B compass master indicator (M19) is on the radio crate and a repeater (B46 and 66) is on each instrument flying panel. Each repeater embodies caging and setting knobs. The control panel (F17) is on the port console panel. It incorporates a switch marked PORT—OFF—STARBOARD which is used to select either the port or starboard repeater to compass, the repeater not selected being automatically set to DG. Mod. 1818 provides a repeater at the prone station on PR aircraft.

(ii) Mod. 2190 or 2533 introduces a switch, marked DG/G4B, at the navigator's station. This enables the compass to be selected to directional gyro in lieu of magnetic monitoring so as to reduce compass errors in turns when using H2S. When the switch is set to DG the compass is automatically switched to directional gyro by the H2S when the angle of bank exceeds six degrees. With the switch at G4B the compass is always monitored, whatever the angle of bank. This switch is only operative post-Mod. 2190 when H2S and NBC are switched on, or post-Mod. 2533 when H2S is switched on.

(iii) Mod. 2982 introduces a switch box on the cabin port wall above the voltage trimmer panel. This box contains two power failure indicators (AC voltmeters), one each in the power supply circuits to the Mk. 4B compass and the artificial horizon, and also a NORMAL/EMERGENCY change-over switch. (See Part III, para. 21(*e*).)

(*b*) *Magnetic standby compass*

Pre-Mod. 2791, a P12 magnetic standby compass is mounted below the front centre of the canopy, below the fuel panel. Post-Mod. 2791 the P12 compass is replaced by two E2B compasses, one on each side, suspended below the fuel panel.

62 Turn-and-slip indicators

Each turn-and-slip indicator has two independent and separately fused DC supplies controlled by the instrument master switch. If one supply fails for any reason the feed to the indicator is automatically changed over to the other supply by a relay.

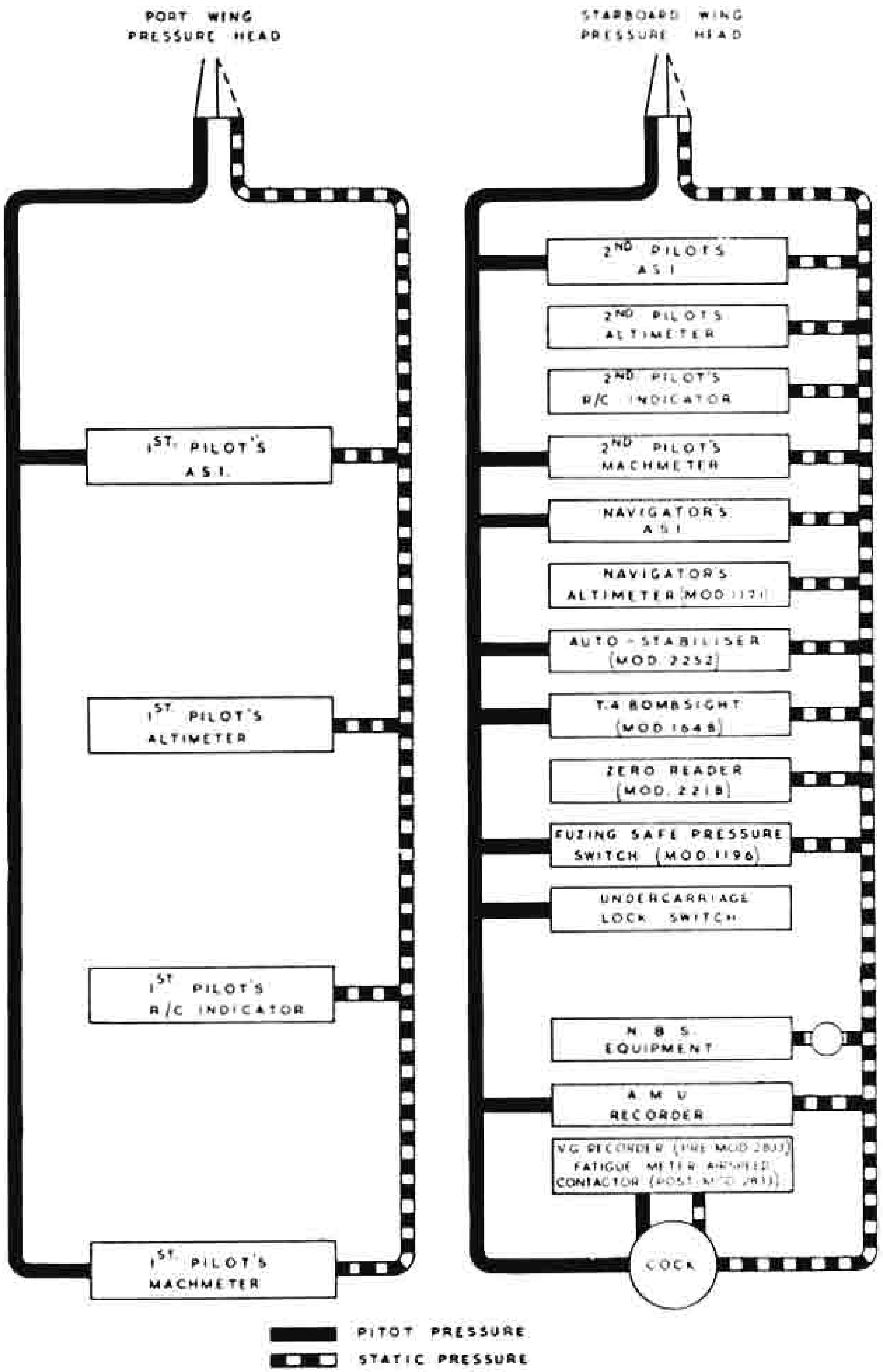


Fig. 16 Pitot-static systems

63 ASI systems

(*a*) Two pitot/static heads are fitted, one at each wing tip. The port head supplies the first pilot's airspeed indicator, machmeter, altimeter and rate of climb indicator. The starboard head supplies similar instruments on the second pilot's instrument flying panel and also supplies the navigator's airspeed indicator and altimeter, as well as the instruments and equipment shown in Fig. 16. There is no connection whatever between the two systems.

(*b*) A shut-off cock (M2) on the radio crate enables the VG recorder to be turned off as desired.

(*c*) A heater is incorporated in each pitot/static head; each has a switch (B5 and 36) on the relevant instrument flying panel.

64 Machmeter

The machmeter is subject to error and should be checked periodically against IAS and altitude, using the graph in Fig. 17.

65 Accelerometer

A Mk. 2 accelerometer (B6) is introduced by Mod. 1656 (WZ380). It is in front of the pilot to the left of the instrument flying panel.

66 Artificial horizons

Each artificial horizon has a fast erection pushbutton (B3 and 33) below and to the left of it. The instrument is not self-erecting when first switched on, unless the horizon bar is within 10 degrees of horizontal in the roll sense. After the engines have been started the fast erection button must, therefore, be pushed in and held until the horizon bar falls within these limits. This may take some 10 seconds. Self-erection within the 10 degrees limits is slow; about 5 degrees per minute. If the gyro is toppled in flight, the aircraft must be flown level by reference to the other instruments before the fast erection button is pressed. The gyro has full freedom of movement in the rolling plane, but will topple if more than 80° of climb or dive is exceeded. (See also para. 61(*a*)(iii).)

Undercarriage Controls and Indicators

67 General

The mainwheel units and outer doors, and the nosewheel unit, are retracted and extended by electric actuators each incorporating independent main and emergency motors.

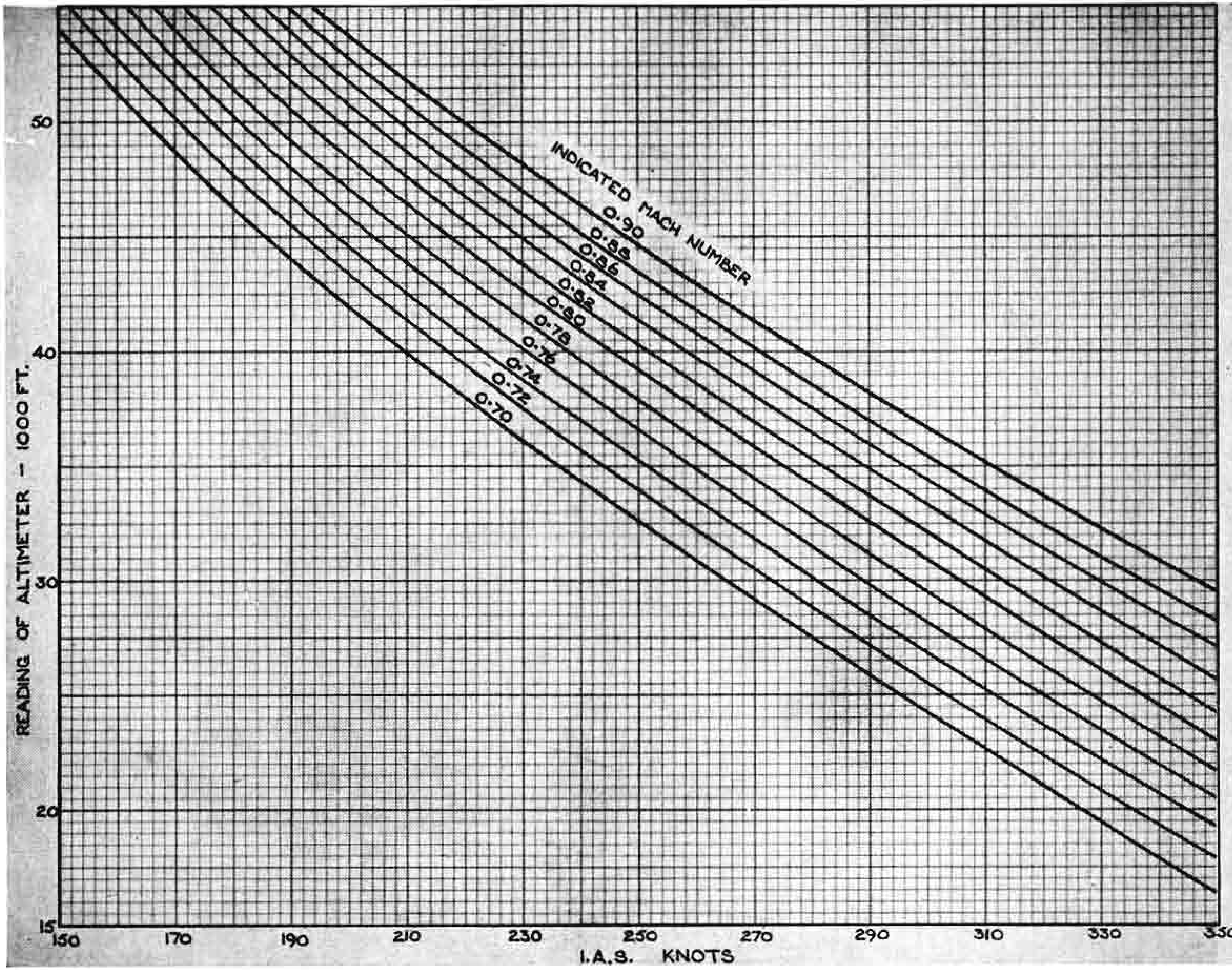


FIG. 17. *I.A.S./I.M.N. Conversion Chart*

68. Normal operation

Two pushbuttons (C/17 and 18) marked UP and DOWN, on the central pedestal, are used to raise and lower the undercarriage. The UP button is locked against inadvertent operation by an airspeed-operated switch set to release at 80 to 85 knots. In emergency the lock can be overriden by turning the ring round the UP button and then pressing the button.

NOTE: Selection *must not* be reversed until travel is complete. (See also Part V.)

69. Emergency operation

An EMERGENCY pushbutton (C/19), aft of the normal buttons, enables the undercarriage to be lowered if the normal circuit has failed. It will not retract the undercarriage (see Part V, para. 7 and 8).

70. Extreme emergency operation

Two two-position switches, shielded by a flap (H/11), on the starboard console panel may be used if mechanical damage prevents operation, or in the event of failure of the normal and emergency circuits. Operation of these switches fires explosive bolts to release the main-wheel units and doors, which will then lower until the down locks engage. These switches operate the main-wheel units only. If only one main-wheel unit fails to lower, it is of course necessary to operate only the one EXTREME EMERGENCY switch. Two circuit-breakers (P/3 and 4) are on the starboard console door. It is essential that these are made before the extreme emergency switches are operated, also, the main contactors for the main-wheel units must be reset before the main wheels can be lowered by the EXTREME EMERGENCY switches. (See Part V, para. 7 and 8.)

71. Contactor trip and reset

Three lights (P/9, 10 and 11) on the starboard console door come on if the main contactors for the three undercarriage units trip due to a fault. This may also happen due to operation of a clutch slip device which trips the contactor after 10 revolutions of clutch slip, thus protecting the motors from overload. If any light comes on, the contactor may be reset by pressing the reset button below the light, but it is important to do this in the manner laid down in Part V, para. 7 and 8.

72. Undercarriage position indicators

(*a*) A standard undercarriage position indicator (B/54) is on the centre instrument panel. The lights are duplicated and a night screen is fitted. The indicator will operate when the instrument master switch has been selected ON.

(*b*) Two amber lights (B/52 and 57) are on the centre instrument panel. These come on when the main undercarriage secondary locks are made, and give, in conjunction with the standard position indicator, visual indication that all down locks are home. If these two lights are on, but the main-wheel green lights are not on, it is quite safe to land the aircraft.

(*c*) The position of the main-wheel doors is indicated by two red lights (G/2 and 3) on the starboard coaming panel. These come on when the doors are not fully closed.

73. Undercarriage warning horn

A warning horn in the cabin sounds if all four throttles are closed below about 5,000 to 5,500 engine r.p.m. if all undercarriage units are not locked down. A warning horn test push-button (H/10) is on the starboard console panel.

74. Wheel brakes

(*a*) Equal braking on all main wheels is obtained by operating either of the twin levers on each control handwheel. A parking catch is on the left handwheel. If fully serviceable, the brakes are capable of holding full power on all engines. Differential braking is obtained by using the rudder bar toe pedals independently. Anti-skid (Maxaret) units are fitted which allow the maximum braking power to be used without the risk of locking the wheels.

(*b*) *Supply change-over*

The brakes are normally supplied from No. 1 hydraulic service through the anti-skid units. If No. 1 service or the anti-skid units fail, the lever (C/27) on the rear of the central pedestal should be set over to port. When this is done the brakes will be operated direct from No. 2 hydraulic service, the anti-skid units being by-passed.

(*c*) *Pressure gauges*

The pressure in both hydraulic systems is shown on four pressure gauges (J/4, 5, 6 and 7) on the starboard quarter panel, two for the brakes and two for the nose-wheel steering. The bottom gauge (J/7) and the second gauge from the top (J/5) show the pressure available for the brakes in No. 1 service and No. 2 service, respectively.

75. Nose-wheel steering

(*a*) Hydraulic power from both hydraulic systems is used to operate the nose-wheel steering jacks. Steering is controlled by a handwheel (F/8) on the port side above the port console panel. The maximum steering angle is 50 degrees each side of neutral and the wheel will travel from neutral to full lock in a maximum of two seconds.

(*b*) When the weight is taken off the nose-wheel it automatically centres, thus operating a micro-switch to allow it to retract. While the nose-wheel is retracted the steering hand-wheel will be locked in the central position. If the automatic centring fails to operate the micro-switch, the hand-wheel may be used to overcome any slight sticking (but see Part V, para. 6).

(*c*) *Pressure gauges*

The pressure in the hydraulic systems is shown on four gauges (J/4, 5, 6 and 7) on the starboard quarter panel, two for the brakes and two for the nose-wheel steering. The top (J/4) and third (J/6) gauges show the hydraulic pressure available for steering in No. 2 service and No. 1 service respectively.

Cabin Air Conditioning and Pressurising

76. General

(*a*) Hot air for pressurising and air conditioning the cabin is taken from a bleed on the starboard side of the compressor casing of each engine. Each bleed is controlled by a gate valve. Each gate valve is operated by a switch (J/1, 14, 15 and 16) on the starboard quarter panel, marked NORMAL and EMERGENCY CLOSE. This operation is overridden by a throttle-operated micro-switch. When the switches are at NORMAL, the gate valves will open as soon as the H.P. cocks are open.

(*b*) From the gate valves the cabin air is divided into two systems, normal and flood flow (emergency increased air supply).

NOTE: Until Mod. 984 (WP.209) is embodied, the gate valve switches are transposed from the normal system of numbering engines; i.e. they are numbered No. 4, No. 3, No. 2, No. 1 from port to starboard. Post-Mod. 984 they are in the logical order.

77. Air conditioning

(*a*) Air from both engines on each side passes through a constant flow valve to a shut-off valve. The shut-off valves are controlled by two CABIN AIR SUPPLY switches (H/5) on the starboard console panel, labelled ON and OFF; when the switches are ON, the valves are open. The air then combines from both sides of the aircraft and is admitted to the cabin either hot (direct from the engines) or cooled by passing it through an inter-cooler, or cooler still by passing it through the inter-cooler and a cold air unit. An inter-cooler valve is used to direct the hot air from the engines either direct to the cabin or through the inter-cooler. Intermediate positions of the valve determine the degree of cooling by varying the proportion of air passed through the inter-cooler, the rest passing direct to the cabin. From the inter-cooler the air is passed by a refrigerator valve either direct to the cabin or through the cold air unit, intermediate positions of the valve again being obtainable.

(*b*) Both valves are controlled by a single switch (H/12) on the starboard console panel. It is marked RAISE – LOWER and is spring-loaded to the central (off) position. Assuming that all the hot air is passing direct to the cabin, when the switch is held at LOWER the inter-cooler valve is progressively opened, passing more and more air through the inter-cooler. When the inter-cooler valve is fully open, if the switch is still held at LOWER, the refrigerator valve is progressively opened, passing more and more air through the cold air unit. When the switch is held to RAISE, the reverse happens; first the refrigerator valve closes progressively, then the inter-cooler valve closes progressively, both gradually increasing the temperature of the air supplied to the cabin. A dual indicator (H/12) on the starboard console panel shows the position of the two valves.

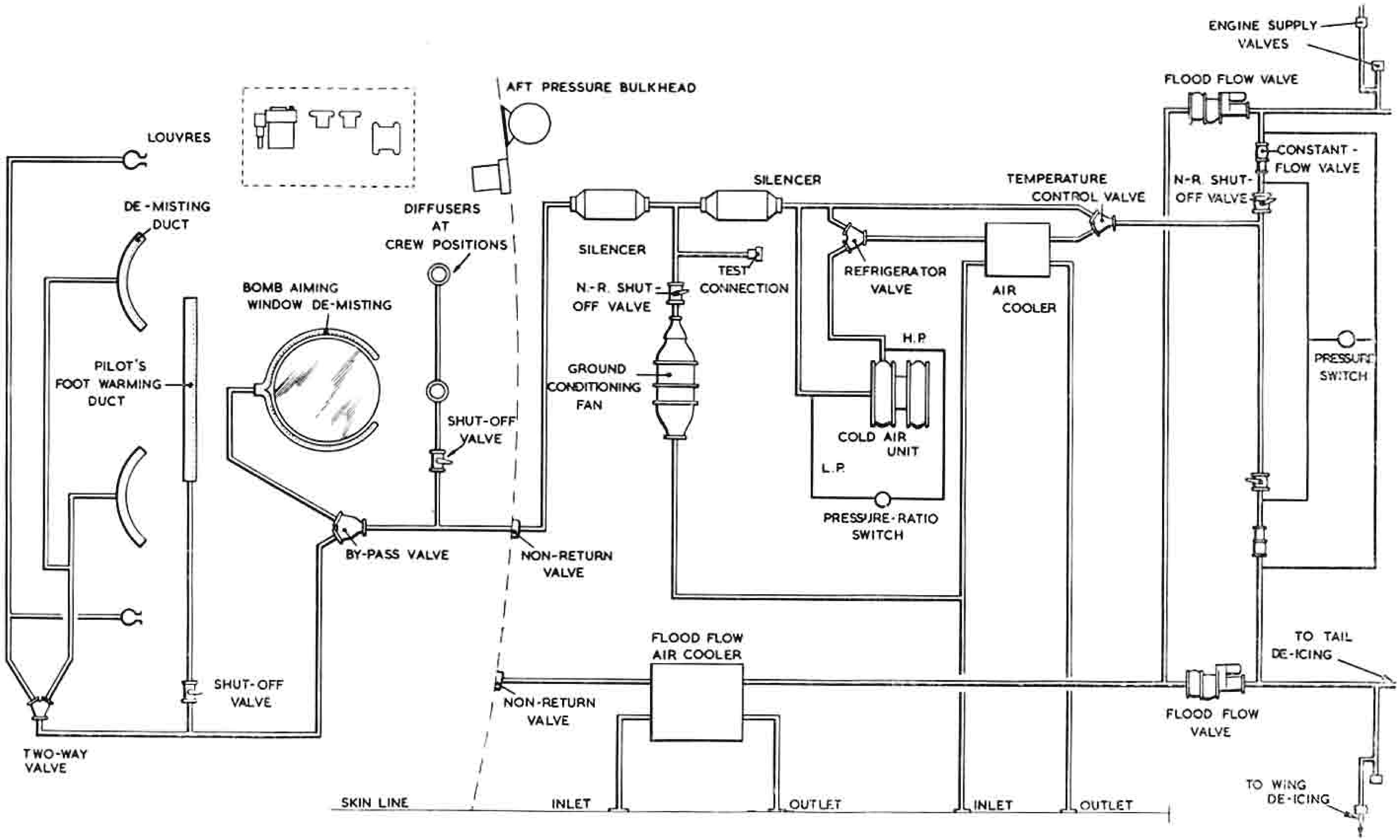


FIG. 18. *Air Conditioning System (Simplified)*

(*c*) Either valve may be stopped in any intermediate position by letting the switch return to OFF: the refrigerator valve will not open until the inter-cooler valve is fully open, nor will the inter-cooler valve close until the refrigerator valve is fully closed.

(*d*) The air in the cabin is distributed through two diffusers in the floor at the rear of the cabin, de-misting ducts for the windscreen, louvres (E/13) and (G/4) and foot-warmers for the pilots and a de-misting duct over the bomb-aimer's window. The latter is normally shut off, but may be turned on by a lever at the bomb-aimer's station ; when this lever is operated the air to the diffusers and foot-warmers is shut off, and the supply to the windscreens is restricted, thus giving the bomb-aimer's window the maximum supply. A control (E/19) at the front of the port coaming panel enables the restricted air supply to be passed to the windscreens or to the louvres, or to both. Mod 2023, on B(PR)1 and BK(PR)1 only, provides an additional heating supply in the prone bombing position. This is controlled by an ON/OFF lever on the port side of the prone bombing station.

(*e*) *Low pressure switches*
At very high altitude the air pressure from the engines may be insufficient to drive the cold air unit and to pass an adequate supply to the cabin. If this should happen, a pressure switch, operated by the pressure drop across the contant flow valves, closes the refrigerator valve sufficiently to ensure adequate ventilation. Full control of the inter-cooler valve is still possible when this happens. A similar pressure switch across the cold air unit operates in the same way to protect the system.

(*f*) *Ground ventilation and unpressurised flight*
On the ground, or when flying unpressurised, cold air may be admitted to the cabin from an intake in the leading edge of the port wing. A shut-off valve in the duct is controlled by an ON—OFF switch (H/6) on the starboard console panel. When the switch is placed to ON the valve will open and cold air at ram pressure will be admitted to the cabin. An electric fan in the duct is controlled by a GROUND VENT FAN switch (H/8) on the starboard console panel, marked ON and OFF. Before the fan is switched ON, the

FIG 19 *Cabin Temperature Control*

ram air shut-off valve must be opened. The fan must not be used in flight. Until Mod 2362 (B1 and B(K)1) or 2446 (B(PR) 1 and B(PR)K1) is fitted, a circuit-breaker (P/5) is on the starboard console door.

78 Pressurising

(*a*) Cabin pressure is regulated by a pressure controller on the starboard wall at the rear of the cabin. A pressure selector switch (H/4) on the starboard console panel is marked CRUISE, COMBAT and NO PRESSURE. When Mod 1202 is fitted the switch is gated and incorporates a safety catch. When the switch is set to CRUISE, pressurisation starts at an altitude of 8,000 feet. The pressure controller maintains the cabin at 8,000 feet until the maximum differential pressure of 9 lb/sq in. is reached, when the controller maintains this differential. Similarly, when the switch is set to COMBAT pressurisation starts at 25,000 feet, this being maintained up to the maximum altitude.

(*b*) When the pressure selector switch is moved from CRUISE to COMBAT, the pressure will drop from 9 lb/sq in. differential to 25,000 feet in about 35 to 40 seconds. It will rise from COMBAT to CRUISE in about six minutes.

FIG 20 *Cabin Pressure Control*

(*c*) There is an emergency de-pressurising switch (F/12) on the port console panel, and a cock handle (M/24) above the radio crate, which enable the cabin to be de-pressurised quickly in emergency. When either of these controls is operated, two deflation valves open to de-pressurise the cabin. The differential pressure will drop from 9 lb/sq in. to 3½ lb/sq in. in about six seconds. This differential pressure of 3½ lb/sq in. is the maximum *safe* pressure for jettisoning the cockpit canopy. It should be noted that if the gate valve switches are at EMERGENCY CLOSE there will be no pressurising and no ventilation in the cabin.

(*d*) *Cabin altimeters and pressure warning light*

(i) *Cabin altimeters.* An altimeter (B/1 and 43) showing the cabin altitude, is on each instrument flying panel.

(ii) *Pressure warning light.* Post-Mod 2490 a cabin pressure warning light, which gives warning of cabin over-pressurisation, is on the starboard instrument flying panel above the pressure head heater switch (B/36). The pressure switch controlling the light is connected to cabin pressure and to the starboard static line. The light comes on if the cabin differential pressure rises to 9·5 lb/ sq in.; after appropriate action has been taken (see Part V, para 4) and the cabin pressure falls, the light will go out when a differential pressure of 9·1 lb sq in. has been reached.

79 Flood flow system

(*a*) Air is taken from the engine side of the constant flow valves, via two flood flow (or emergency increased air supply) valves to a common duct which passes it straight to the cabin through a separate cooler. The system provides a very high flow of air from the engines to cater for a high rate of leakage due to damage to the pressure cabin.

(*b*) The flood flow valves are operated automatically by pressure switches which operate if the cabin altitude rises to 29,000 feet. The valves will remain open, irrespective of the cabin pressure, until the flood flow switches (H/7) are set to DECREASE, but even then the valves will only close if the pressure switches have opened again due to the cabin altitude having fallen below 29,000 feet. When the valves open, a scoop in the port side of the aircraft aft of the cabin is opened, and an oval plate further aft is jettisoned to provide an adequate flow of air through the separate cooler. The flood flow system will not operate, whatever the cabin altitude, if either emergency de-pressurising control (see para 78 (*c*)) is operated or if the cabin pressure selector switch (H/4) is set to NO PRESSURE.

(*c*) The flood flow valves can also be operated by the two double-pole EMERGENCY INCREASED AIR SUPPLY switches (H/7) on the starboard console panel, labelled INCREASE, OFF, DECREASE. They are spring-loaded to the OFF position. Pre mod 2386 they are single-pole switches and are *not* spring-loaded to the OFF position. The valves are opened when the switches are set to INCREASE, and closed when set to DECREASE.

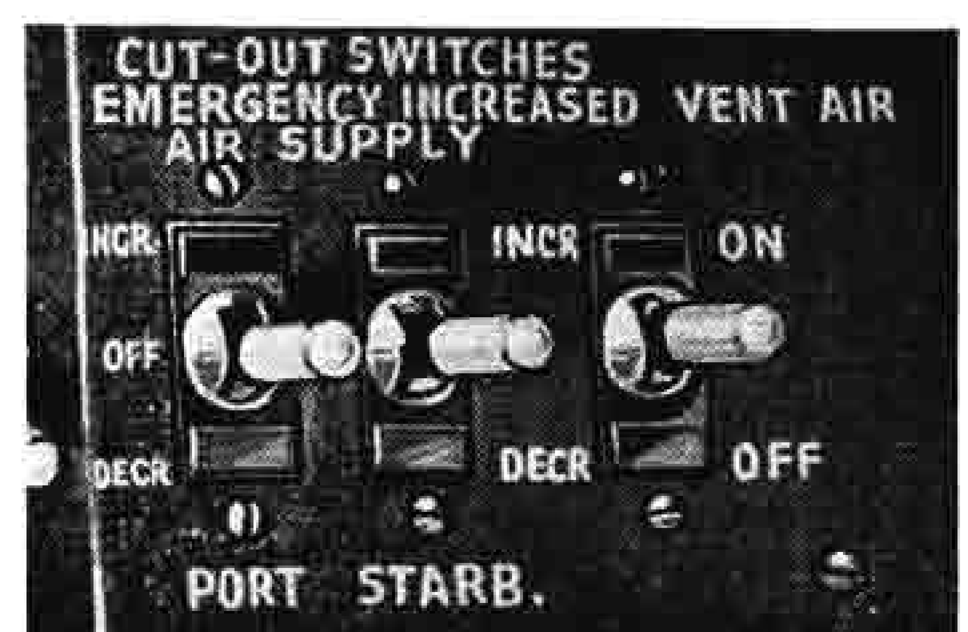


FIG 21 *Flood Flow Switches* (*Pre-Mod* 2386)

80 Inward vent valves

An inward vent valve is incorporated in the discharge valve to prevent a negative cabin pressure during a rapid descent.

81 Pressure failure warning

A pressure switch in the controller closes to operate a warning bell if the cabin pressure falls excessively below the selected pressure.

Oxygen Systems

NOTE: Pressure demand masks Type A.13A/1 or Type A.13A/2 *must* be worn.

82 Normal supply

(*a*) Oxygen is supplied by seven, eight or nine cylinders, four forward of the front pressure bulkhead and three, four or five in the roof of the "attic". The number depends on the aircraft type and Mod state (see Fig 22). Two HP valves, normally wire-locked open, are fitted, one under each console panel. Two contents gauges (M/34 and 35) are on the port side of the radio crate. The starboard HP valve controls the supply from two of the forward bottles and two of the attic bottles, the contents being shown on the upper gauge (M/34). The port HP valve controls the remaining bottles, their contents being shown on the lower gauge (M/35). Either HP valve supplies all regulators. An external charging valve is at the rear of the port servicing bay.

(*b*) Oxygen regulators are fitted as follows, according to the Mod state:

(i) *Original fit*. Six Mk 17 regulators, one for each pilot (F/14 and H/1) at the front of their respective console panels ; three (M/1, 33 and 50) for the crew members on the radio crate ; and one on the starboard side of the bomb aimer's prone station.

(ii) *Mod* 1604. The two Mk 17 regulators for the pilots are replaced by Mk 17C regulators, and a separate magnetic blinker indicator (B/8 and 35), one for each regulator, is on each instrument flying panel above and outboard of the artificial horizons.

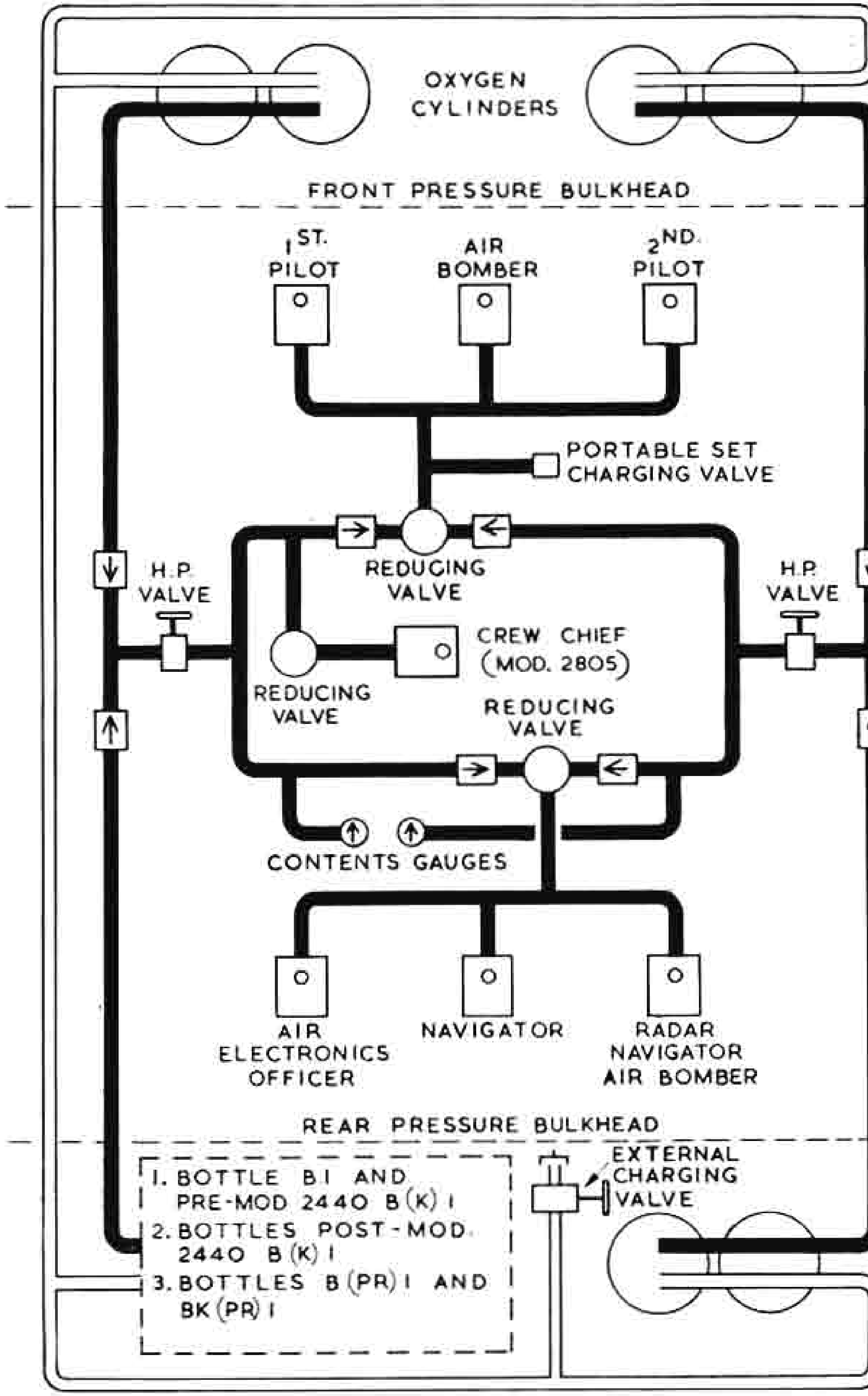


FIG 22 *Oxygen System (Simplified)*

(iii) *Mod*. 2398. All six regulators are changed to the Mk 17D type, the pilot's remote indicators being retained.

(iv) *Mod* 2805 *or Command Mod* 40. An additional Mk 17D regulator is provided for the occupant of the occasional seat.

(v) *Mod* 2967. All regulators are changed to the Mk 17E type, remote indicators being retained.

(vi) *Mod* 3003 (*Command Mod* 74). A remote indicator for the regulator at the bomb aimer's prone station is fitted on the radio crate at the Navigation Plotter's station.

(*c*) Each regulator comprises:

A regulator pressure gauge.
A visual flow indicator.
An ON/OFF valve.
An air inlet switch, marked NORMAL and 100% OXYGEN.
An emergency three-position switch which can also be pressed in when in the central position. Normally set central.

On the Mk 17 and 17C regulators, the visual indicator is combined with the pressure gauge; on the 17D and 17E it is a separate magnetic indicator on the regulator panel. When oxygen flow ceases, the relevant indicator, and also the remote indicator (if fitted) will remain black.

(*d*) The ON/OFF valve is normally wire-locked ON, and must remain ON at all times. On Mk 17, 17C and 17D regulators, the air inlet switch must always be at 100% OXYGEN, and pure oxygen is then supplied at all altitudes. On the Mk 17E regulators the air inlet switch may be at NORMAL: the regulator then functions automatically, providing a mixture of oxygen and air at low altitudes, the amount of oxygen being increased as height is gained until, at about 30,000 feet cabin altitude, pure oxygen is being supplied. Above about 12,000 feet cabin altitude the supply is at a slight positive pressure, thus aiding breathing and preventing inward leakage at the mask. Pure oxygen may be obtained at any altitude by moving the air inlet switch from NORMAL to 100% OXYGEN: this should be done in the event of smoke or fuel fumes entering the cabin, or if symptoms of anoxia are apparent. In the event of cabin pressurisation failure, the pressure of the supply may be increased by setting the emergency switch to the right or left. In the event of oxygen flow ceasing, for whatever reason, the air inlet switch should be set to NORMAL (this applies to Mk 17, 17C and 17D regulators) or the mask tube disconnected, and an immediate descent made if necessary.

(*e*) Before flight the mask should be checked for fit by pushing the emergency switch in fully in the central position. This will supply oxygen under pressure and the mask can be adjusted until no leaks are apparent. The firmer the switch is pressed the greater the oxygen pressure; when fully in, the pressure is five times as great as with the switch in either of the side positions.

NOTE: When an oxygen point is not being used it is essential that the blanking plug is fitted in the tube to prevent waste of oxygen, unless modified sockets are fitted.

83 "Walk-round" and stand-by facilities

(*a*) *Extension tube and dual feed coupling*

Mod 2735 introduces a 3-foot extension oxygen tube, complete with extension intercomm. cable, and a dual feed coupling. They are stowed in a bag on the port side of the cabin above the entrance door. The extension tube and cable can be plugged in to any crew position, the mask tube and intercomm. lead being connected to the other end, enabling that crew member to move about the cabin. The equipment can also be used to provide an alternative oxygen supply to any one of the crew in the event of regulator failure, as follows:

(i) If one of the pilots' regulators fails, the extension tube can be used to enable that pilot to couple up to the prone bomb-aimer's regulator.

(ii) If one of the crew members' regulators fails, the dual feed coupling should be connected to one of the other serviceable regulators, the affected crew member and the one whose regulator is being used both connecting up to the dual feed coupling.

(b) Portable oxygen set
When Mod. 2735 (see *(a)* above) is not fitted, a single portable oxygen set Mk. 4 is stowed on the rear of the centre crew seat. It may be recharged from the aircraft system by a charging connection and cock at the rear of the pilot's platform. When fully charged, the set lasts for about 10 minutes. It is not fitted on aircraft prior to WP209 unless Mod. 848 is incorporated.

84 Emergency supply

(a) Each pilot has an emergency oxygen cylinder in his seat cushion. The supply can be made available manually by pulling up the yellow ball at the outboard side of each seat, or will be made available automatically as soon as the seat is ejected.
(b) When ejection seat Mods. 385/386 are embodied, each pilot's emergency bottle is removed to the inboard rear side of his seat. Additionally Mod. 1306 moves each pilot's emergency oxygen control to the inboard side of the respective seat. The seat-mounted emergency bottles remain with the seats after separation occurs following ejection.
(c) Each of the crew members also has an emergency oxygen cylinder in his parachute pack. The supply is made available by pulling the manual release.
(d) Whenever the emergency oxygen cylinder is brought into use, the mask tube must be disconnected from the main supply.
(e) When Mod. 2799 is embodied a stowage for the emergency oxygen bottle pins is attached by a bracket to the aft end of the signal cartridge centre rack.

Anti-Icing Systems

85 Engine anti-icing

Hot air for anti-icing the engines is taken from a gate valve on the left of each engine and directed into the front of each engine. The gate valves are controlled directly by the ENGINE AND AIRFRAME DE-ICING MASTER switch (H/19) on the starboard console panel and will open as soon as the switch is put ON. There are no other controls and no indicators for the engine anti-icing system.

FIG 23 *Anti-Icing Controls*

86 Airframe anti-icing

(a) The leading edges of the wings, engine intakes, tailplane and fin are anti-iced by hot air taken from a gate valve on the right of each engine. These gate valves also supply air for cabin heating and pressurising and are controlled by four NORMAL and EMERGENCY CLOSE switches (J/1, 14, 15 and 16) on the starboard quarter panel, and also by throttle-operated micro-switches. With the switches at NORMAL the gate valves will open when the HP cocks are opened and will close when the HP cocks are shut. When the switches are set to EMERGENCY CLOSE the gate valves will close even if the HP cocks are open.

(b) Hot air is then led through four shut-off valves, one for each wing and two for the tail, controlled by four switches (H/14) on

the starboard console panel. The shut-off valves can only be opened when the ENGINE AND AIRFRAME DE-ICING MASTER switch is ON. They will automatically shut when the master switch is put OFF (unless Mod. 701 is not fitted (see Part III, para. 37)).

(*c*) From the shut-off valves hot air is taken to the leading edges through mixing valves which are thermostatically controlled. If a fault occurs in the mixing valve or thermostat, warning of overheating will be given by one of the three overheat warning lights (H/16, 17 and 18) on the starboard console panel, one for each wing and one for the tail. When one of these lights comes on the appropriate shut-off valve should be closed.

86A Modified anti-icing system

(*a*) On aircraft embodying Mods. 605, 925, 2599, 2637, 2708, 2807, 2808, 2889, 2890, 2939, 2940, 3034, 3035, 3037, 3070, 3073, and 3132 a revised airframe anti-icing system is fitted, giving greater protection for the engine air intake lips ; spraymats are introduced for the intake splitter vanes. The mainplane de-icing system is deleted.

(*b*) The system is manually selected ON by a master switch and four individual switches at the second pilot's station. The master switch controls both engine and airframe supplies while the individual switches control as follows:—

No. 1—Port engine intakes

No. 4—Stbd. engine intakes

Nos. 2 and 3—Tail unit and feel intakes

(*c*) *Engine de-icing spraymat heaters*

(i) Spraymat de-icing heaters forming an integral part of the outer engine air intake splitter vanes are introduced by Mod. 2939. The heaters, operated from the aircraft 112 volt dc supply, are individually controlled by thermistors embedded in the heaters and a twin channel thermal controller. The heaters are brought into operation when the ENGINE AND AIRFRAME DE-ICING MASTER switch is selected ON.

(ii) With the DE-ICING MASTER switch selected ON a 112 volt dc supply is routed to the spraymat heaters and operation of the system is automatic. Temperatures in excess of the operating point are sensed by the thermistors in the individual heaters and the overheated spraymat is switched off. To prevent hunting a wide differential temperature is covered before the cooling spraymat is switched on again.

(*d*) *De-icing temperature indicator*

(i) Indication that the airframe thermal de-icing system is operating is provided post-Mod. 2708 by an electrical thermometer which, by means of a selector switch, gives a continuous indication of the temperature in any one of the three air diffusers in the de-icing system on a temperature indicator adjacent to the system controls on the starboard console.

(ii) Temperature sensitive resistance bulbs fitted to the port mainplane, the starboard mainplane and the tail unit de-icing system diffusers are connected through the selector switch to the temperature indicator.

(iii) The selector switch, a six position rotary switch, three positions of which are not used, adjacent to the indicator enables selection of any one of the three temperature bulbs, and the temperature in that part of the system is shown on the indicator.

(*e*) *Ice detector*

(i) Warning of icing conditions is provided post-Mod. 2599 by an ice detector, mounted in the lower fuselage forward of the bomb-aimer's fairing, with the sensing elements protruding through the aircraft skin operating a red ICING warning indicator lamp on the starboard console. A three position test switch TEST OFF/AUTO/TEST ON is mounted adjacent to the indicator and should normally be selected to AUTO.

(ii) With the test switch selected to AUTO, system operation is controlled by selecting the starboard pressure head heater switch

ON. A pitot operated switch prevents operation of the system below 80 kts.

(iii) The TEST ON/TEST OFF positions of the switch can be used to test the serviceability of the system in flight or on the ground. TEST ON brings on the red indicator lamp indicating that the system is serviceable and TEST OFF extinguishes it.

87 Windscreen and bomb-aimer's window de-icing

(*a*) Fluid for de-icing the pilots' windscreens and the bomb-aimer's window is carried in two tanks on the starboard side of the cabin, both having a common filler cap in the fuselage skin. The tank supplying the pilots' windscreens has a capacity of 4½ gallons, and that supplying the bomb-aimer's window, 2½ gallons.

(*b*) *Pilots' windscreens*

Two electrically driven pumps supply fluid to spray nozzles forward of the windscreens. They are controlled by two switches (H20 and 22) on the starboard console panel and may be used separately or together. Mod. 3071 introduces a guard for the switches. The slow pump (No. 2) delivers 7·2 pints per hour, the fast one (No. 1) delivers 15 pints per hour. This gives an endurance, running continuously, of 5 hours and 2½ hours respectively or just over 1½ hours if both pumps are used together continuously.

(*c*) *Bomb-aimer's window.* A single twin-delivery electrically driven pump supplies fluid to spray nozzles forward of the bomb-aimer's window. It is controlled by a master switch and a rheostat on the bomb-aimer's panel, the rheostat being used to control the flow. The maximum rate of flow is 26 pints per hour, giving a minimum endurance, running continuously, of about 35 minutes. Until Mod. 2188 is fitted, there is no master switch ; the rheostat has ON and OFF positions.

88 Windscreen wipers

A windscreen wiper on each windscreen is operated by its own closed-circuit electro-hydraulic pump. The pumps are controlled by two four-position switches (F10) and (H3), marked FAST, MEDIUM, SLOW, OFF, one on each console panel. Until Mod. 1393 (WP219) is incorporated, the FAST setting is inoperative. Pre-Mod. 2361 there are also two circuit-breakers (N2) and (P2), one on each console door. A lever on each windscreen pillar is used to PARK or START the wipers. To start them, move the levers to START, and then set the rotary switches to SLOW. To stop the wipers, first turn OFF the switches then move the levers to PARK. The two wipers may be operated quite independently of each other.

89 Bomb bay heating

(*a*) Hot air for heating the bomb bay is taken from the tail anti-icing supply, on the engine side of the shut-off valves, and fed to the bomb bay through diffusers on each side. Hot air is obtained whether anti-icing is on or not.

(*b*) Two shut-off valves, one on each side, are controlled by two switches (H13) on the starboard console panel, and continuous indication of the bomb bay temperature is given by a temperature gauge beside the switches. The temperature should be kept at +5 to +30 degrees indicated.

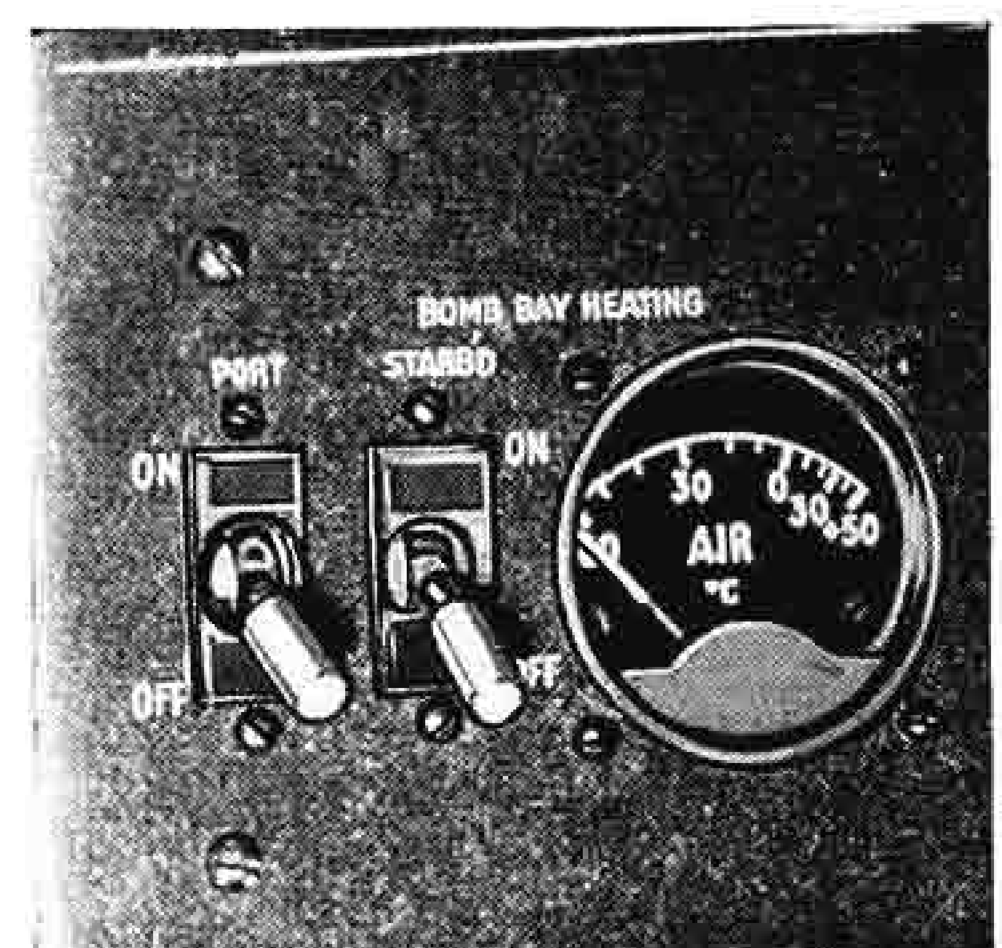


Fig. 24 Bomb bay heating controls

Cockpit Equipment

90 Access

Entrance to the cabin is through the door on the port side, which is hinged at the top. The door is opened from outside by a flush-fitting handle below the door, and from inside by a handle (L17) above and aft of the door. A magnetic indicator (E25) on the port console panel shows white when the door is open or unlocked, and black when the door is locked securely.

91 Emergency operation of the entrance door

(*a*) The normal handle (L17) must not be used to open the door in flight. The entrance door can be jettisoned in flight, after de-pressurising, for use as a parachute exit by the three crew members. The black-and-yellow striped handle (L16) above and aft of the door should be turned anti-clockwise; this withdraws the hinge-pins and locking bolts and allows the door to fall away. At the same time a windshield at the forward edge of the door aperture is projected out into the airstream, where it forms a wind break to facilitate the crew's escape. The door should be jettisoned by the signaller who should remain strapped in his seat while operating the jettison handle.

(*b*) Operation, or even partial rotation, of the normal handle will prevent the windshield from extending. Consequently, should the normal handle be partially rotated inadvertently, it must be returned to the fully closed position before the door is jettisoned.

92 Ejection seats—Mk. 3A

WARNING: Both ejection seats must be rendered safe for parking whenever the aircraft is on the ground by inserting safety pins in the:

Seat pan handle (Post-Mod. ES2157)
Ejection gun-firing unit sear

(*a*) Fully automatic Mk. 3A ejection seats are provided for the pilot and co-pilot. Each seat incorporates a ZF harness, a headrest, two folding armrests, a container for the Mk. 9 parachute, a seat pan which contains an SS dinghy in a Q-type survival pack and 10-minute emergency oxygen bottle, and leg restraining cords (see (*l*) overleaf). The seats may be adjusted for height by a lever, incorporating a thumb-operated spring-loaded catch, on the outboard side of each seat.

(*b*) The harness lock may be released by a spring-loaded lever on the inboard side, to allow the wearer to lean forward. Four alterative positions are provided, the lever having to be operated to move forward from each position. When moving back it is only necessary to operate the lever to release from the second forward position. It is safe to eject with the harness in the second forward position, but normally the fully back position should be used for ejection.

(*c*) The main oxygen tube is connected to the outboard lap strap of the safety harness, and the intercomm plug is connected to the inboard shoulder strap. These incorporate quick release connections which break on ejection.

(*d*) Leg restraining cords pass through D-rings on a pair of leg-straps and are then fastened to the safety harness. This ensures that the legs are drawn together close to the seat pan during ejection, thus providing leg clearance and preventing the legs being blown apart after ejection.

(*e*) The leg restraining cords are fastened to the floor with rivets which shear at 400 lb load. The cords pass through snubbing units at the front of the seat pan. These allow the cords to pass freely *down* through them, but prevent the cords passing *upwards*. Thus on ejection when the cords are pulled downwards the legs are pulled in close to the seat pan. The legs are held there until the harness is released, when the cords are pulled through the leg-strap D-rings and free the legs.

(*f*) Martin Baker Mod. 225 provides for a vertical safety pin fitted through the face blind strap. This pin is attached to the canopy by a lanyard, thus ensuring that the face blind cannot be operated until the canopy has been jettisoned.

(*g*) The ejection seat is fired by pulling the handle above the head-rest, or by pulling the alternative handle, if fitted (see (*l*) below). After ½ second a drogue gun fires, releasing a pair of drogues which stabilise and slow down the seat. When the seat and occupant have fallen to 10,000 feet a barometric capsule starts a time delay. (This starts on ejection if the ejection height is less than 10,000 feet.) After three seconds the safety harness is unlocked and the drogue main rope is unshackled from the seat top. The drogue then pulls on a lifting line which disconnects the face blind and headrest pad from the seat. The apron attached to the headrest pad straightens and pushes the occupant forward in the seat. He is prevented momentarily, from leaving the seat (by two parachute harness restraining straps clipped on to the seat pan) until an extension of the drogue lifting line draws his parachute canopy from its pack and its subsequent development lifts him clear of the seat to descend in the normal way. By this arrangement the possibility of a collision between the seat and the occupant after separation is eliminated.

NOTE 1: The time of free fall from 40,000 feet to 10,000 feet is about three minutes.

NOTE 2: A 5,000 metre barometric capsule can be fitted for flights over mountainous terrain.

(*h*) *Manual override*

If necessary, due to damage, or if the seat does not eject when the ejection control is operated, or if the automatic gear does not operate, the parachute pack can be disconnected from the seat, enabling the occupant to operate the parachute manually.

(*j*) To do this the occupant must first pull the outer D-ring. This action disconnects the parachute from the seat and uncovers the inner D-ring by which the parachute rip-cord is pulled. This arrangement ensures that the controls are operated in the correct sequence and there is no danger of the parachute rip-cord being pulled manually while the parachute is still connected to the seat.

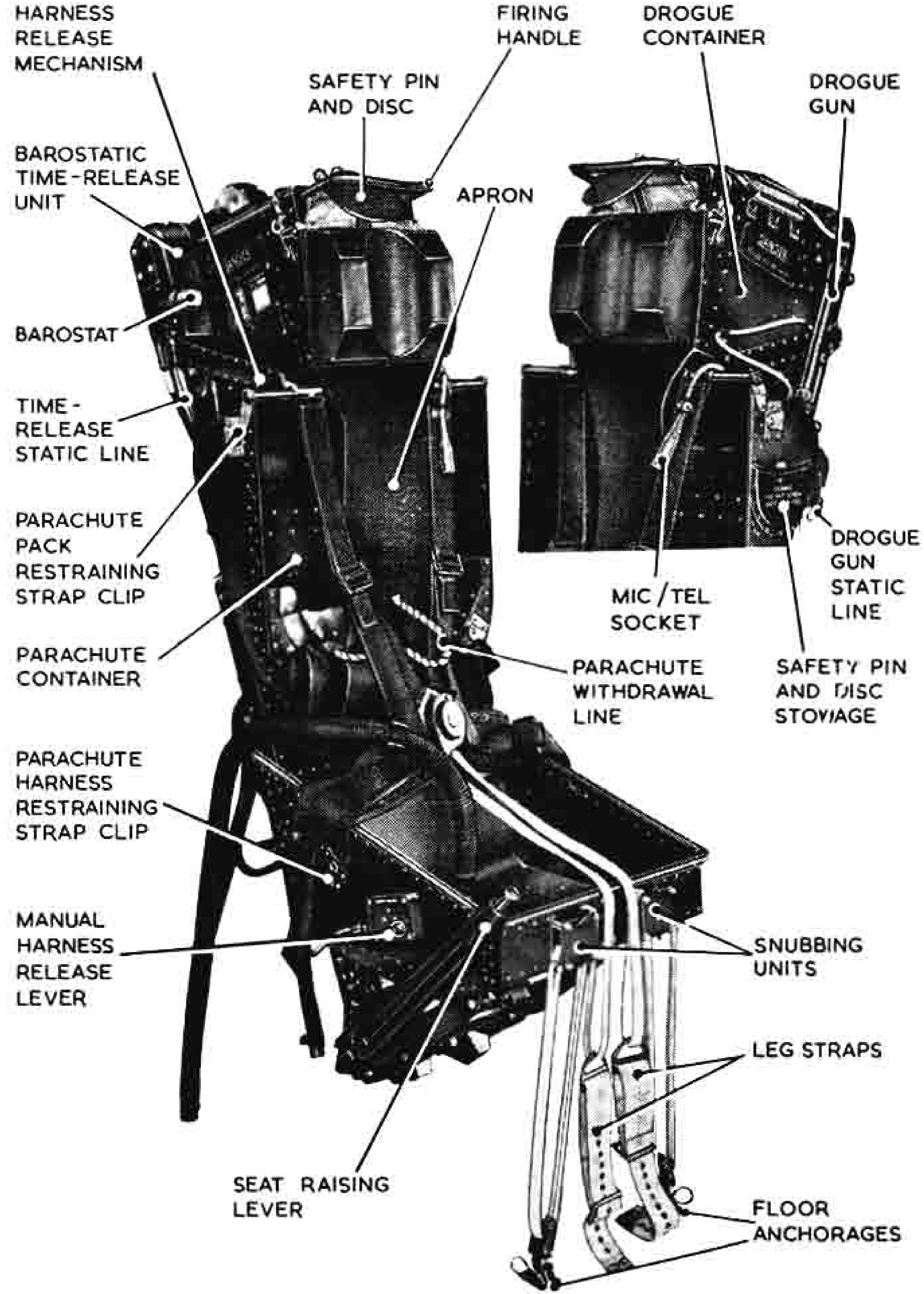


Fig. 25 Ejection seat Mk. 3A

(*k*) The occupant then manually unfastens the seat safety harness and leaves the seat, later opening his parachute by pulling the rip-cord D-ring.

(*l*) *Seat modifications*

The following ES modifications alter the basic ejection seat and affect its operation as shown below:

ES Mod	*Title*	*Effect on seat*
276	" B " shaped firing handle and new headrest	Enables use of protective helmets
293 387 491	22" pilot drogue Solid drogue gun piston 1¼ second time delay and G stop	All three together give the seat a ground-level ejection capability in flight parallel to ground and above 90 knots. The G stop prevents main parachute opening if speed at ejection is too high for safe deployment
385 386	1st pilot's emy oxygen repositioned 2nd pilot's emy oxygen repositioned	Bottles repositioned on seat inboard beams. Type R PSP must be used instead of Q. (Mod. 1306 is embodied concurrently —see para. 84)
2157	Introduction of alternative firing handle	Handle fitted to front of seat pan. There is no safety device to prevent its use before the canopy has jettisoned

93 Crew seats, parachutes and survival packs

(*a*) Three straight-backed light alloy seats facing aft are mounted side-by-side on sets of twin rails immediately inside the main entrance door.

(*b*) The seats can be locked in any one of five positions fore and aft by pushing down a handle on the rear right leg of each seat. Post-Mod. 2879 the centre seat has a duplicate handle on the rear left leg ; either handle may be used to lock or unlock the seat. Post-Mod. 2878 the AEO's seat (nearest the door) incorporates a spring-loaded catch which engages and locks the seat automatically when

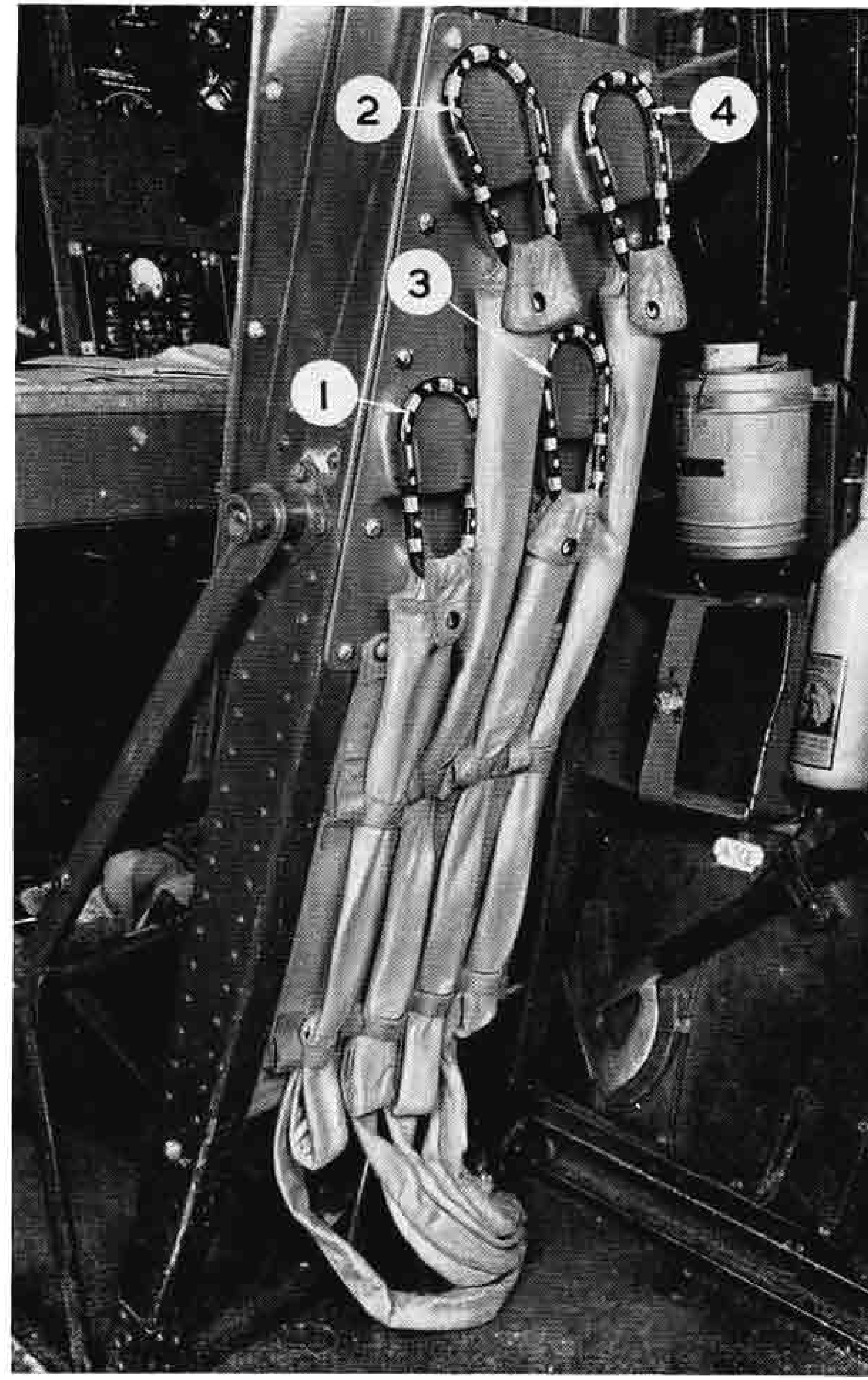


Fig. 26 Static lines on signaller's seat

the seat is pushed fully aft. The headrest of each seat is adjustable for height. The seat pan accommodates a survival pack containing an SS dinghy. A "Z"-type lap strap safety harness is fitted. Either a Mk. 17 or 20 automatic back-type parachute may be worn by all rear crew members.

(*c*) The Mk. 17 parachute pack contains a 24-foot canopy and is fitted with a quick-adjustment harness. An emergency oxygen bottle is fitted in the pack and is operated by a red knob on the harness. There is a quick-release connection for the dinghy pack on each side of the lower harness. A barometric release, fitted inside the pack, is set to operate instantaneously below 10,000 feet. This release is actuated by a D-ring on the parachute harness. There is a black and yellow override knob also fitted to the parachute harness; this knob requires a 40 lb pull and will open the parachute immediately irrespective of height.

(*d*) The Mk. 20 is an automatic parachute designed to be operated by static line. As with the Mk. 17 parachute the release is set at 10,000 feet and a manual override knob is fitted. Mod. 2539 introduces four static lines to be used with the Mk. 20 parachute. These lines are mounted on a panel attached to the back of the signaller's seat, i.e. the seat nearest the door. When abandoning the aircraft the static lines must be used in the correct order as shown in Fig. 26.

(*e*) *Occasional seat*

Mod. 2341 (XD862) introduces an occasional seat in the cabin. This is a rearward-facing folding seat situated behind and between the navigator and the radar navigator/bomber's seats.

93A Swivel seats (Post-Mod. 3193)

(*a*) Each rear crew member is provided with a swivel seat incorporating an assister cushion and a Mk. 40 parachute with a demand emergency oxygen set. The two navigators' seats swivel clockwise and the AEO's seat swivels anti-clockwise.

(*b*) The seats are mounted on rails which allow them to be slid fore and aft and locked in any one of five positions. The seat rails are reinforced to take crash landing loads. Fore and aft movement of the seats is controlled by either a lever at the base of the rear of each seat (move to the right to unlock) or by the rearward movement (in relation to occupant) of the yellow and black lever on the left of the seat.

(*c*) (i) Swivelling of the seats is controlled by either a lever at the top of the rear of each seat (move right to swivel) or by forward movement of the yellow and black lever on the left of the seat. When the seat is in its normal position, i.e. occupant facing the table, the crew member may adjust the rake of the seat back by pushing the yellow and black lever forward and then pressing against the back of the seat (against spring pressure). Once the seat has been swivelled it cannot be moved on the rails, except by the lever at the base of the seat.

(ii) When it is required to swivel the seat, the first movement of the lever forward causes the seat back to spring to an upright position forcing the occupant forward and then the seat is free to swivel. When the seat is rotated by the occupant to the limit of its travel (up to 180°) the seat locks in that position and the lever returns to its neutral position. When abandoning the aircraft it is vital that the seat is locked in this position, as failure to do so may result in the seat turning round if another crew member attempts to pull himself up by gripping the back rest.

(iii) Before swivelling the seat it must be fully back on the rails to ensure that the back rest does not jam against the table.

(*d*) The yellow and black swivelling lever incorporates a handle into which the individual parachute static line is clipped when leaving the seat prior to abandoning aircraft.

(*e*) (i) The assister cushion is inflated by CO_2 stored in a bottle at the back of the seat, at a pressure of 1,200 PSI. A pressure gauge is incorporated in the bottle.

(ii) The CO_2 is released to the cushion by pulling up a yellow and black knob, at the right of the seat, to the full extent of its travel. Additionally this action also releases the harness lap strap anchorages thereby freeing the occupant from the seat.

(*f*) The seat thigh supports can be adjusted for individual comfort by means of a star wheel mounted under the supports centrally.

(*g*) Two lugs are fitted to the top of the seat back rest and pockets on the parachute shoulder harness straps enable them to be locked onto the lugs during flight.

(*h*) The back type Mk. 40 parachute is fitted in the swivel seat and is normally operated by the crew member attaching its static line to the hook on the swivelling lever before leaving the aircraft. This arms the barostat unit, which delays deployment until either the escaper has fallen freely to 13,000 feet or, if already below that height, for two seconds so as to be clear of the aircraft. This unit can be overridden by the yellow and black knob on the left shoulder strap. Static line operation should always be chosen as it automatically ensures deployment, even if the escaper is injured during the escape; the override is a safeguard in case of failure of the automatics, or of inability to hook on the static line for any reason.

(*j*) (i) This parachute embodies a demand EO set, normally initiated automatically by the static line. A red loop on the harness provides direct manual initiation if required.

(ii) The set consists of a small storage cylinder fitted with an operating head which turns on the supply when the release is operated and reduces the output to a steady medium pressure. This is stowed at the top of the parachute pack. A tube delivers the medium pressure oxygen to the demand regulator stowed in the pocket at the back of the right half-belt. From the regulator, a breathing pressure hose is connected to the Hose Assembly while " strapping in."

(iii) The endurance of the set is approximately 10 minutes. It should be noted that although this is a demand set, the cylinder will rapidly exhaust itself if it is accidentally initiated and the outlet is not connected to a mask. The set will discharge itself in an attempt to produce safety-pressure. The set must therefore be replaced if accidentally initiated while strapping-in.

(iv) In the case of failure of a main oxygen regulator, rear crew should normally transfer, if possible, to the sixth crew member's regulator rather than use the EO set. This will enable the flight to be continued without reducing altitude.

94 Adjustable stool

Mod. 1308 introduces an adjustable stool for use at the sextant station. When in use, the stool stands on the navigators' table and it is adjustable for height. Its stowed position is under the NBC crates aft of the second pilot's seat.

95 Canopy, DV panels, and de-misting

(*a*) The jettisonable canopy cannot be opened on the ground or in flight. It is a light-alloy structure extending from the top of the windscreens to behind the pilots' seats, and across the cockpit from the top of the side windows. It is secured all round by explosive bolts.

(*b*) Two direct vision panels are fitted in the windscreen corner panels. When the cabin is not pressurised the windows can be opened by pulling and lifting the locking bar and then hingeing the window downwards. They must always be closed and tightly secured before the cabin is pressurised. When flying de-pressurised the DV panels may be open up to the limiting speed of the aircraft, but at and approaching this speed the noise level is extremely high.

(*c*) The windscreens are de-misted from the air-conditioning system through two ducts. When Mod. 2400 is embodied, the centre windscreen is also de-misted. When the bomb-aimer's window de-misting control is operated the supply to the windscreen and pilots' louvres is restricted; a control (E19) on the port coaming panel enables all or part of this restricted supply to be passed to the windscreens. Unless the cabin air-conditioning is shut off there will always be some air directed on to the windscreens.

96 Canopy jettisoning and control parking

(*a*) The shielded levers (F22) and (H15) between the pilots' seats and the console panels are for jettisoning the canopy and for disconnecting the control handwheels from the elevator circuit and throwing them forward to clear the pilots' knees on ejection. Both levers jettison the canopy but each lever disconnects and throws forward only the handwheel on the same side.

(*b*) Before operating either jettison lever the cabin must be de-pressurised (see Part I, para. 78 (*c*)). Then, when either lever is operated, after the first $\frac{3}{4}$ inch of lever travel the canopy explosive bolts are fired from the main electrical system. At the full travel position a supply from the canopy jettison emergency battery, in the roof at the rear of the cabin, will be connected to the explosive bolts to fire them if they have not already fired. At full travel of the lever, also, the control column on the same side will be disconnected and thrown forward. Operation of the other lever will then only disconnect and throw forward the other control handwheel. If the levers are not pulled all the way, the canopy will be jettisoned but the control handwheels will not be disconnected ; it is important, therefore, that the levers are pulled to full travel before ejection.

(*c*) Once a control handwheel has been disconnected by this method, it is not possible to re-connect it in flight. When both control handwheels are disconnected, control of the elevators will be lost except through the auto-pilot. The variable incidence tailplane and the elevator trimmers will still be operative.

(*d*) Post-Mod. 3182 a canopy detonator master switch is fitted in the cabin roof. When this switch is in the OFF position the canopy explosive bolts cannot be fired either by the main electrical system or the emergency battery. When the aircraft is on the ground the switch must be OFF and the safety pin fitted.

97 Anti-flash screens

NOTE: It is important that the methods of fitting the screens are strictly followed.

(*a*) When Mod. 2744 is embodied, anti-flash blinds and screens are provided for all windows in the cockpit, cabin and prone bombing station.

(*b*) *Pilots' windscreens*

(i) Five roll-up blinds are provided for the pilots' windscreens and side windows. The blinds are secured in the rolled-up position by two straps each, which are fastened with quick-release clips. To fit them, the straps should be released, the blinds rolled down and fastened along their bottom edges with the press clips, and then the zips between adjacent blinds and at the rear ends of the end blinds should be fastened. The zips must not be fastened until the blinds have been clipped in position. When removing the blinds they must first be unzipped, then unclipped, and then rolled up with the black side showing and fastened with the straps.

(ii) For the two windows in the canopy, metal screens are provided which are stowed in a canvas bag on the cabin starboard wall. To fit the screens, each one should be slid into position and locked with the handle.

(*c*) *Cabin windows*

The two windows in the cabin are provided with blinds similar to those for the pilots' windscreens. When fitting them they must be clipped in position before the zips are fastened. When removing them they must be unzipped, then unclipped, and then rolled up with the black side showing and fastened with the straps.

(d) Prone bombing station

The two side windows are provided with metal screens which are slid into position and then locked with the handles. The port screen must be slid under the T4 bombsight bracket. The centre window is provided with a blind at the rear edge of the window which is fitted and removed as described for the other blinds.

98 Cockpit lighting

(*a*) All panels in the cockpit are illuminated by red floodlights. In addition, the main instrument panels and the accelerometer are provided with ultra-violet lights. All red and ultra-violet lights are controlled by dimmer switches as detailed in the following table:

Panel	*Illuminated by*	*Controlled by*
Top panel and instrument panels (Fig. B)	Four UV lights, one on each coaming panel (E11) and (G6), one for the accelerometer, above the port side of the top panel, and one for the RATOG lights panel	One dimmer switch (A14) on the fuel panel
	Twin UV lights plugged in on the top panel (B23) and stowed on the starboard side (J3)	One dimmer switch (A17) on the fuel panel
	Six red lights below the top panel and one red light, for the accelerometer, on the port side	Two dimmer switches (A2 and 34), one on each side of the fuel panel. The port switch also controls the accelerometer light
	Two red lights in the canopy	One dimmer switch (A3) on the left of the fuel panel
Fuel panel (Fig. A)	Buried lights for the fuel panel and a strip light for the small panel below the fuel panel	One dimmer switch (A21) on the fuel panel
	Two twin lights on adjustable mountings	One dimmer switch (A23) on the fuel panel
Port coaming and quarter panels (Fig. D and E)	Three red lights, mounted behind the coaming panel and showing through the transparent lettering. One light (D3) on the rear of the coaming panel, for the quarter panel	One dimmer switch (E18) on the forward end of the port coaming panel
Port console panel. (Fig. F)	Three red lights above the panel	One dimmer switch (A1) on the left of the fuel panel
Starboard coaming and quarter panels. (Fig. G and J)	Three red lights, mounted behind the coaming panel and showing through the transparent lettering. One light (J2), on the rear of the coaming panel, for the quarter panel	One dimmer switch (G1) on the forward end of the starboard coaming panel
Starboard console panel. (Fig. H)	Three red lights above the panel	One dimmer switch (A35) on the right of the fuel panel
Central pedestal (Fig. C)	Four red lights, one at the rear of the pedestal and three under a shield round the trimming switch. Also a tubular red light above and forward of the autopilot control panel	One dimmer switch (A33) on the right of the fuel panel
Magnetic standby compass(es)	One red light (each) One red light for PDI	One dimmer switch (A19) on the fuel panel

(*b*) *Wander light*

A retractable wander light (C25) on a long lead is in a mounting on the right side of the rear of the central pedestal. The light can be withdrawn from its mounting and used as required. To retract the light a button on the mounting should be depressed, when the cable will be wound in by a spring. The light automatically comes on when it is withdrawn from its mounting, and goes out when the button is pressed to retract the lamp.

(*c*) *Instrument panel emergency lights*

Three emergency white lights, one for each instrument flying panel and one for the machmeter, are controlled by two ON/OFF switches (E15) and (G24), one on each coaming panel. Each switch controls the light for the instrument flying panel on its own side, and the port switch also controls the machmeter light. Each switch has a luminous spot on it.

(*d*) *High-intensity cockpit lights*

Post-Mod. 1965, two high-intensity lights are mounted on each side, on the rear pillar of each side window. Each pair of lights is focussed directly on the artificial horizon on the same side. All four lights are controlled by a single DIM—OFF—BRIGHT switch (C1) on the central pedestal. An ON (bright) OFF switch is on the radio crate ; this switch overrides the one on the central pedestal.

(*e*) *General lighting*

(i) A single white light in the centre of the canopy is controlled by an ON/OFF switch (E16) on the port coaming panel.

(ii) A single white light in the cabin roof is controlled by an on/off switch (N6) on the port console door.

(*f*) *Navigators' crate lighting*

The navigators' crate is illuminated by tubular red lights above the crate, and four anglepoise red lights, one at each end and two near the centre of the crate. All lights are controlled by dimmer switches on the navigators' crate near the bases of the anglepoise lights.

(*g*) *Starboard console door lighting*

Lighting for the starboard console door, the ration heater switches and nearby equipment is provided by an anglepoise red light, with associated dimmer switch (P15), mounted on the starboard console door.

(*h*) *Emergency lamps for crew escape*

When Mod. 2876 is embodied, four lamps are fitted in the cabin roof and are controlled by two EMERGENCY LIGHTING switches on the forward edge of the radio crate table or by the ABANDON AIRCRAFT switch (Mod. 2828). Power supply is from two 12v batteries in series.

99 External lights

(*a*) An EXTERNAL LIGHTS MASTER switch (G5) on the starboard coaming panel controls the supplies to the external lights. It does not control the supplies to the landing/taxying lamps actuators, and these may be extended and retracted when the master switch is OFF, though their filaments will not light unless the master switch is ON.

(*b*) The navigation lights are controlled by a BRIGHT—DIM—OFF switch (G8) on the starboard coaming panel, and, Post-Mod. 2593, by a FLASH—STEADY switch on the same panel. Pre-Mod. 2232 the navigation lights are steady when on, but Post-Mod. 2232 they are flashing; when the FLASH—STEADY switch is fitted either can be selected for both the BRIGHT and DIM positions. Mod. 2638 on B(K)1 and B(K)PR1 aircraft only, introduces a tail lights ON-OFF switch (G23) on the starboard coaming panel (see Appendix A, para. 17(*e*)).

(*c*) An amber downward identification light is in the bomb aimer's fairing. It is controlled by a STEADY—OFF—MORSE switch (G7) on the starboard coaming panel. With the switch at MORSE, the light may be used for signalling by using either of the two morse keys (F16) and (H21), one on each console panel.

(*d*) A combined landing and taxying lamp is fitted under each wing, near the wing tip. Both are controlled by a single spring-loaded four-position IN—LAND—TAXI and OFF switch (B13) on the left of the instrument top panel, and two filament switches (B12 and 14) on either side of the four-position switch. When the switch is held to TAXI, the lamps are fully extended, and when held to LAND the lamps are partially extended. Intermediate positions can also be obtained by releasing the switch as soon as the required position is reached. The filaments can be switched on with the lamps in any position.

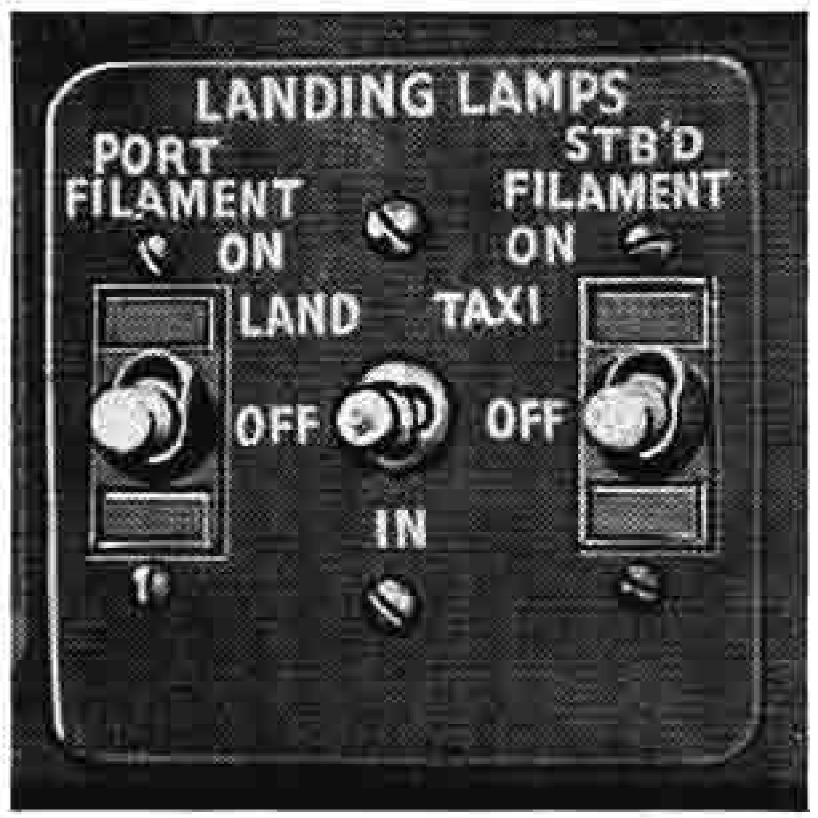


Fig. 27 Landing lamp controls

(*e*) On aircraft prior to WP209 until Mod. 392 is embodied there are no filament switches for the landing/taxying lamps. Each is controlled by a spring-loaded four-position IN—LAND—TAXI and OFF switch on the left of the instrument top panel. When TAXI is selected the lamp is fully extended, and when LAND is selected the lamp is partly extended. The lamp will light as soon as it has left the fully " in " position, and will go out as soon as it returns to fully " in ".

100 Periscope and rear view mirrors

Mod. 664 introduces a periscope to enable condensation trails to be detected. Mod. 1521 (WZ395) provides two rear viewing mirrors, one on each side aft of the DV panels.

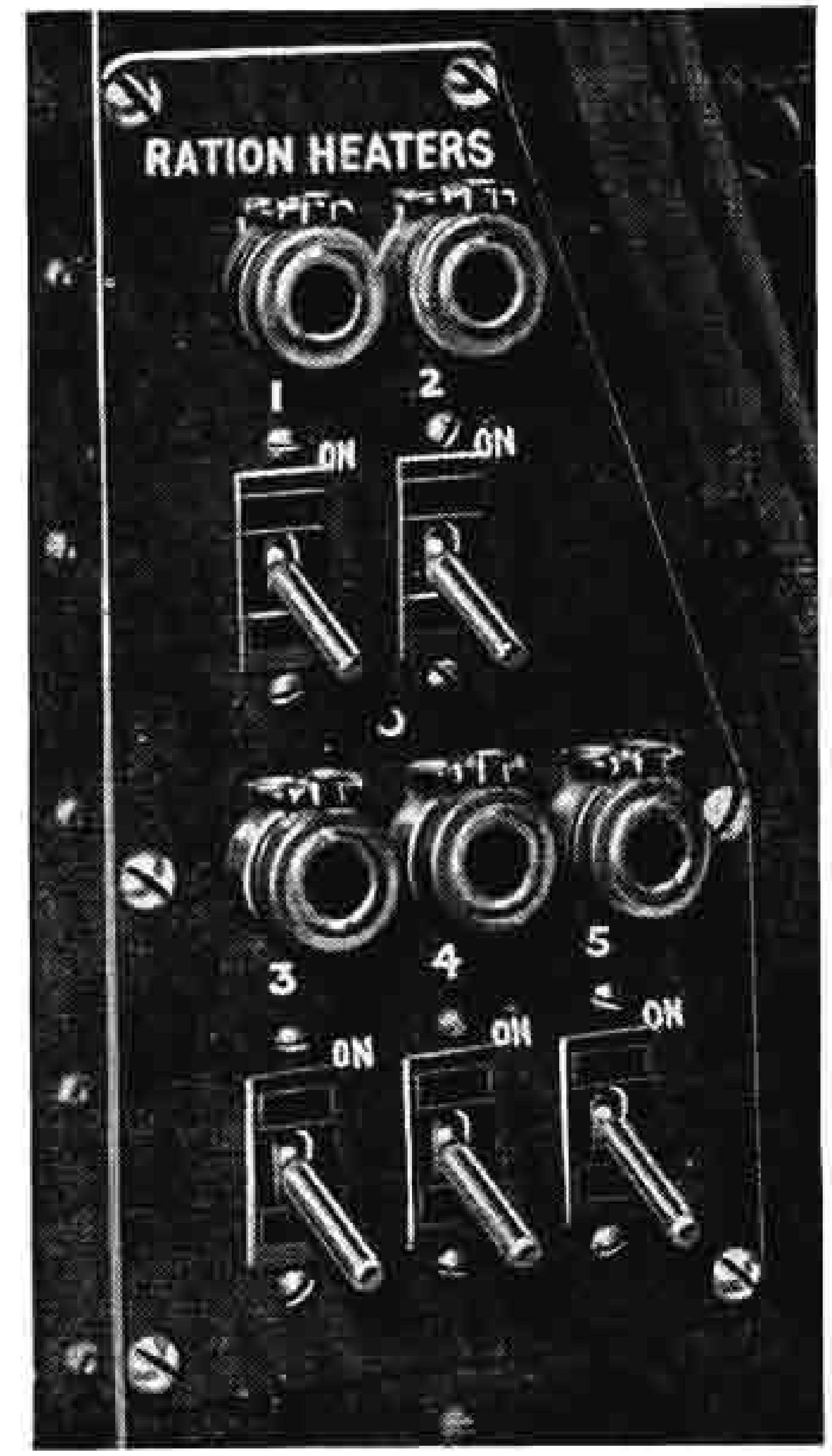


Fig. 28 Ration heater controls

101 Loose equipment stowage

Mod. 1334 introduces a pannier in the cabin for the stowage of loose equipment.

102 Leak stoppers

When Mod. 911 (WZ366) is fitted, five leak stoppers are stowed on the cabin port wall above the voltage trimmer panel.

103 Ration heaters

There are five ration heaters in the cabin, one on the inboard side of each pilot's seat, one on the starboard wall (K8), one on the

Fig. 29 Engine fire-extinguisher controls

port wall (L19) and one on the rear of the pilots' floor. They are electrically heated from five switches (P13 and 14) on the starboard console door. Each switch has a warning light above it which comes on when the heater is on.

Fire-Extinguishers

104 Engine fire-extinguishers

(*a*) There are four fire-extinguisher bottles in each wing, one for each engine and one for each jet pipe. Four fire-extinguisher pushbuttons (B22) each incorporating a warning light, are on the instrument top panel. When any of the fire detector switches in the engine or jet pipe bays closes due to fire, the appropriate warning light will come on. Both fire extinguisher bottles for that engine are discharged, one into the engine bay and one into the jet pipe bay, by pressing the pushbutton. The warning light should go out when the fire is extinguished. Once the bottles for any engine have been discharged, there is no means of extinguishing a further outbreak in the same engine, and therefore no attempt should be made to re-start an engine once its fire-extinguisher bottles have been discharged.

(*b*) The warning lights may be tested by gently pulling out the fire-extinguisher pushbuttons, when the lights should come on. These pushbuttons must be treated with care as they are very sensitive. When Mod. 1919 (WZ395) is fitted, two test pushbuttons (B18 and 19) are below the fire-extinguisher pushbuttons. These should be pressed to test the lights, each one operating two lights.

(*c*) All fire-extinguisher bottles will be automatically discharged when the crash switches operate in the event of a crash landing.

105 Fuel bay fire-extinguishers

Two fire-extinguisher bottles in each wing and twelve bottles in the "attic" supply the fuel tank bays in the wings and fuselage respectively. All bottles will be automatically discharged when the crash switches operate in the event of a crash landing. There is no indication in the cabin of fire breaking out in any fuel tank bay: the bottles will *not* discharge automatically in this event nor is there any means of discharging them.

105A Firewire detection system

(*a*) When Mods. 1669 (B1) and 3019 (B(PR)1, B(PR)K1 and B(K)1) are embodied additional fire protection for the bomb bay and forward servicing bay is provided by a Firewire detection system. Power supplies are of 115 volts, 400 CPS AC and 28 volts DC and provided from the AC relay box and panel Z respectively. The system uses the fire extinguisher bottles in the forward servicing bay ; the operation of the existing systems remains the same but the bottle extinguishant distribution is revised.

(*b*) Remote test push-switches and Test/Fire warning lamps are provided below the fuel panels.

(*c*) Bottles 3, 4, 7 and 12 are controlled by the detector element encircling the forward servicing bay and the port and starboard bays immediately below. Crash relays operate bottles 3, 4, 9, 10, 11 and 12.

(*d*) Firewire loops are provided in the forward and rear ends of the bomb bay.

(*e*) *Fuel tank fire extinguisher system*

The fuel tank fire extinguisher system, which operates when the crash switches are operated, controls fire bottles No. 1, 2, 5, 6, 7 and 8 plus the two fire bottles in each main undercarriage bay.

(*f*) *Fire extinguishers and spray pipes*

The spray pipes are arranged to direct the fire extinguishant to cover the areas where fires may occur. Spray pipes are fitted and use fire bottles as follows:—

(a) Top of Bomb Bay Wall (port) Bottle No. 7
(b) Bottom of Bomb Bay Wall (port) Bottle No. 8
(c) Bomb bay roof (port) Bottles No. 6, 9 and 10
(d) Fuselage tanks (port) Bottle No. 1
(e) Fuselage tanks (stbd.) Bottle No. 2
(f) Bomb bay roof (stbd.) Bottles No. 8, 10 and 11
(g) Bottom of bomb bay wall (stbd.) Bottle No. 5
(h) Top of bomb bay wall (stbd.) Bottle No. 6
(j) Forward servicing bays (port and stbd.) Bottles No. 7 and 12
(k) Forward servicing bay (forward and aft) Bottles No. 3 and 4

NOTE: Bottles No. 6, 7, 8 and 10 are fitted with dual heads and serve either one of two functions according to the location of a fire.

106 Hand fire-extinguishers

There are five hand fire-extinguishers in the cabin, one on the back of each pilot's seat, two (K5) on the cabin starboard wall and one (L18) on the port wall immediately aft of the entrance door.

Miscellaneous Emergency Equipment

107 Abandon aircraft signs and emergency exits

(*a*) Mod. 2828 provides two flashing ABANDON AIRCRAFT signs, one at the 1st navigator's station and one at the bomb aimer's prone position. The flasher units and emergency lamps are controlled by an ABANDON AIRCRAFT ON/OFF switch on the 1st pilot's fuel panel. Power supply is from two 12v batteries in series, mounted below the pilot's platform, port side.

(*b*) The pilots' canopy and the entrance door are used for abandoning the aircraft in flight (see Part I, para. 91 and 96). In addition there are two other exits for use after a crash landing, when the entrance door might have jammed, or after ditching.

(*c*) *Crash landing exit.* The window on the starboard side of the rear of the cabin may be used as an emergency exit after a crash landing by turning the yellow and black striped handle (K6) clockwise and pulling in the window. The window can also be pushed in from outside after depressing the heel of the flush handle, pulling out the handle and turning it clockwise.

(*d*) *Ditching exit.* The sextant dome may be used as a ditching exit by squeezing the two yellow and black striped handles at each side of the dome and then pulling the dome inwards. The dome is heavy and cumbersome.

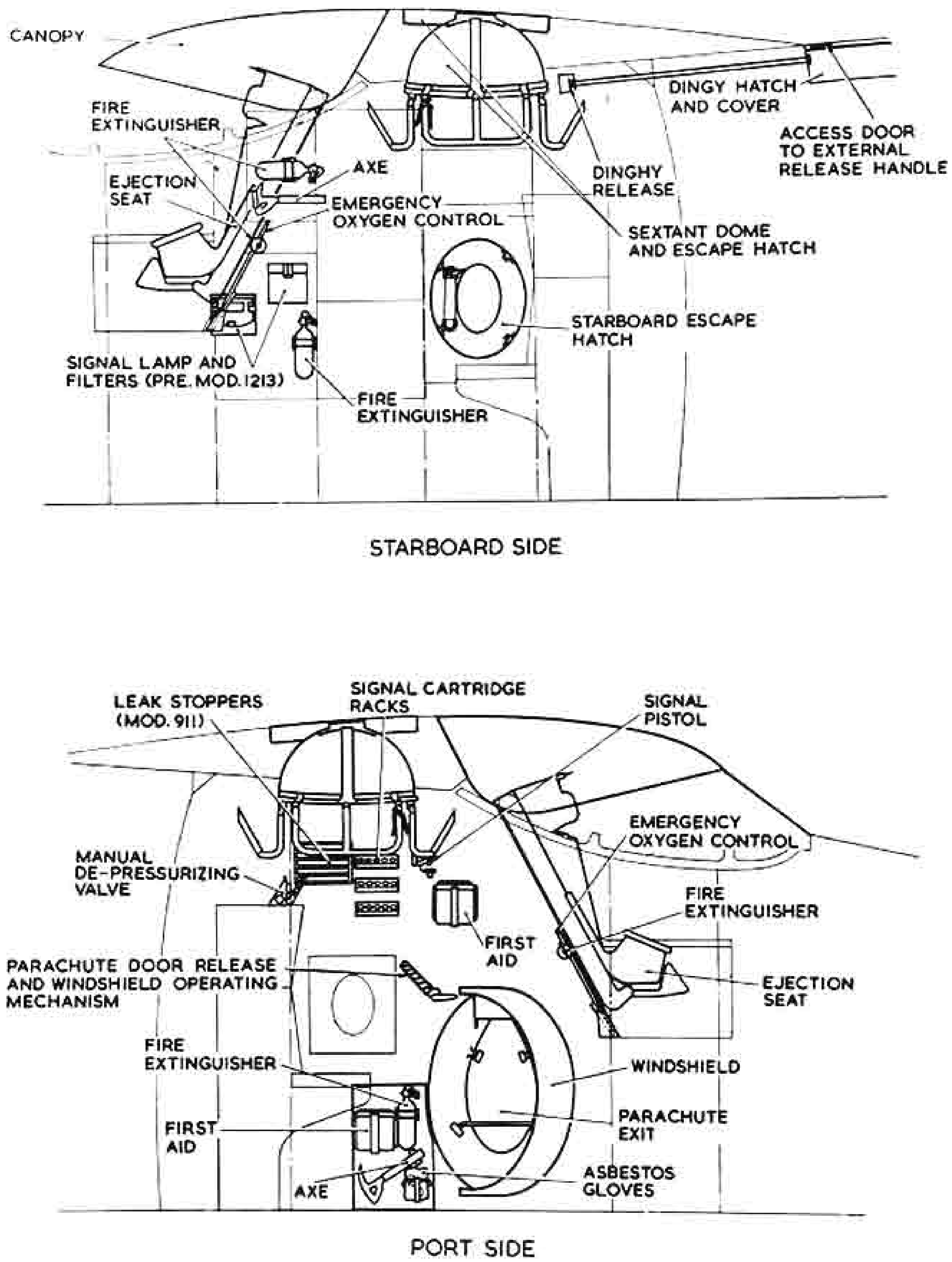


Fig. 30 Emergency equipment

108 Dinghy

An MS 5 inflatable dinghy, complete with auxiliary equipment, is stowed in a compartment in the roof of the " attic ", immediately aft of the cabin. The dinghy release is immediately aft of the sextant dome in the roof of the cabin, and consists of a shielded toggle. When this toggle is pulled to its full extent the dinghy is automatically inflated and released from its container. It remains moored by a painter to an anchor ring in the container. The dinghy may also be released from outside the aircraft by lifting a hinged cover in the lid of the dinghy container and then pulling the red handle.

109 Aircraft survival pack

(To be issued later.)

110 Crash axes

Two crash axes are stowed in the cabin, one (K4) on the starboard wall, and one on the port wall aft of the entrance door.

111 Asbestos gloves

A pair of asbestos gloves is stowed on the cabin port wall aft of the entrance door.

112 First-aid kit

A first-aid kit (L12) is on the cabin port wall above the entrance door, and another (K2) on the cabin starboard wall.

113 Signal pistol

A signal pistol (L10) is in a pressure-tight mounting in the cabin port wall above the entrance door. Cartridges are stowed in three racks on the wall near the pistol.

114 Signal lamp

A signal lamp (K1) is on the cabin starboard wall, the filters being in a stowage beside the lamp. A supply socket (L21) for the signal lamp is at the extreme port side of the radio crate desk. There is no separate switch. The signal lamp and stowage are deleted by Mod. 1213 (WP223) but the supply socket will remain.

Navigational and Radio Equipment

115 Radio compass

The radio compass control unit (M40) and indicator (M51) are on the radio crate. A bearing indicator (B48) is on the starboard instrument flying panel, and Post-Mod. 2218 there is a second indicator (B2) on the port instrument flying panel.

116 Radio altimeters

(*a*) *High level.* A high level radio altimeter (M10) will be fitted later on the radio crate. The twin aerials are in the fuselage immediately forward of the bomb bay.

(*b*) *Low level.* Post-Mod. 1005 a low level radio altimeter (B2 and 41) with limit lights (B42 and 68) is on each instrument flying panel. Mod. 2218 removes the altimeter on the port panel, but the limit lights are retained. The aerials are in the bottom of the fuselage below the fin. An ON/OFF switch (C30) is on the central pedestal. When Mod. 2437 is embodied the switch is moved to the 1st pilot's coaming panel.

117 VHF/UHF installation

(*a*) The VHF installation incorporates two transmitter-receivers TR 1985—TR 1986, both 10-channel sets. On the rear of the central pedestal are two control units (C26 and 31), a volume control (C29) and a change-over switch (C28). A press-to-transmit pushbutton is on each control handwheel. Until Mod. 1636 is fitted the VHF sets are TR 1934—TR 1935.

(*b*) (i) Mod. 2437 introduces a UHF installation, and retains the present VHF facilities. No. 2 VHF set controller is moved to the AEO's station adjacent to the morse key.

(ii) On the rear of the centre pedestal are the following:

No. 1 VHF controller
VHF volume control
UHF control unit
VHF/UHF selector switch
No. 1 VHF/No. 2 VHF selector switch
UHF aerial change-over switch
UHF tone switch

(iii) It should be noted that in modified aircraft, the pilot selects the channels on No. 1 VHF set and the AEO selects those on No. 2 VHF set (see also para. 118(*b*)).

118 Intercommunication

(*a*) Intercommunication is by amplifier A1961 (L4) which, with the control unit, is on the port side of the radio crate. On the control unit on the radio crate is an ON/OFF switch (L2) and a NORMAL/EMERGENCY change-over switch (L3). The latter, when set to EMERGENCY, provides intercomm through the VHF circuit. Mic/Tel sockets are provided at each crew station, in the nosewheel bay, under the port wing root leading edge and in the port servicing bay. Mod. 1496 (WZ381) introduces a socket beside the sextant mounting in the sextant dome.

(*b*) *Mod.* 2874

(i) This modification provides additional intercommunication facilities, in lieu of ARI 18089, as follows:

VHF/UHF transmit, receive and volume control facilities for the AEO in isolation.

Radio compass audio output to the 1st and 2nd pilot's positions.

Intercomm conference facilities for the navigators.

1st pilot's emergency override.

1st pilot's call facilities to the navigators and AEO, by call lamp.

AEO's call pilot facility.

(ii) On the 1st pilot's coaming panel between items (E4) and (E5) are three switches:

RC/IC, to connect 1st pilot's telephones to radio compass or intercomm output.

CALL CREW, energises two lights, one at the AEO's station and one at the nav/plotter's station.

NORMAL/EMERGENCY. In the NORMAL position any crew member may select any available facility. In the EMERGENCY position all crew members are returned to normal intercomm.

The 2nd pilot is also provided with an RC/IC switch below item (G3).

(iii) At the AEO's station are the following:

VHF ISOLATION OFF/ON switch which when set to ON gives VHF facilities to the AEO only.

PRESS TO TRANSMIT switch, in parallel with the pilots' switches when the AEO is in ISOLATION.

CALL LIGHT energised by the 1st pilot's CALL CREW switch.

CALL PILOT SWITCH enables the AEO to call the 1st pilot at all times.

VHF VOLUME CONTROL

(iv) At the nav/plotter's station are the following:

CALL CREW light energised by the 1st pilot's "call crew" switch.

OFF/ON CONFERENCE switch. When set to ON an additional A1961 amplifier is switched on.

NORM/CONF AMP switch. When set to CONF the navigators are in isolation from the other crew members.

119 Gee H, Mk. 2

The Gee H control units (M44 and 45) and indicator (M47) are all on the radio crate. The pilot's indicator lights (B7) are on the top of the port instrument flying panel. The H function of the Gee H, and the pilot's indicator lights, are rendered inoperative by Mod. 1957 and are removed by Mod. 2537. When Mod. 3165 or 3166 is embodied the installation is deleted.

120 ILS

The ILS controller (D1) and master switch (D4) are on the port quarter panel. Mod. 1945 (WZ400) introduces a volume control (E20) on the port coaming panel. An ILS indicator (B45 and 61), with a marker warning light (B47 and 63) beside it, is on each instrument flying panel. Mod. 2218 replaces the port indicator with a zero reader flight director; Mod. 3032 re-introduces the port ILS indicator at the position previously occupied by the 1st pilot's clock.

121 Zero reader (Mod. 2218)

A zero reader indicator is on each instrument flying panel. The control panel and course selector are below the centre of the fuel panel. When the zero reader is fitted the 1st pilot's ILS indicator is removed until Mod. 3032 is embodied.

122 Green Satin

This equipment is used to measure the ground speed and drift angle of the aircraft in flight. The power supply is obtained from a separate Type 153 inverter which is controlled by a switch (O17) on the radar panel. Pre-Mod. 2399 this switch also controls the equipment. Post-Mod. 2399, an additional switch (O16), which controls the equipment, is fitted. The Green Satin control box (M46) is on the radio crate and incorporates an indicator showing ground speed, drift angle and distance flown. The GPI (M49), which is used in conjunction with the Green Satin, is beside the Green Satin set. The aerial system is in the bomb bay deflector.

123 Tone release

(*a*) Mod. 2456 introduces tone release facilities for simulated bombing practice which may be obtained from either VHF or UHF. The NBS operator has an ON/OFF and an OFF/BIASED switch together with an indicator light. When the ON/OFF switch is ON and the OFF/BIASED switch is set to BIASED the indicator light comes on and an audio tone is produced and transmitted over the VHF or UHF set. This continues until bomb release.

(*b*) If the practice run is abandoned after the OFF/BIASED switch has been set to BIASED, the tone may be stopped by setting the ON/OFF switch to OFF.

(*c*) At the AEO's station are two SIMBOMB TONE OVERRIDE NORMAL/EMERGENCY switches, one for VHF and one for UHF. Setting the system to EMERGENCY stops the tones and reverts the system to either normal VHF or UHF.

123A HF STR 18B

HF communication is by STR 18B, and the control unit which carries a function switch, a channel selector, volume and fine tuning controls is at the AEO's station. R/T transmissions can be made, if required. The power supply is 28 volt DC.

123B Tacan and Collins UHF/DF

(*a*) *Post-Mod.* 3165. Tacan is fitted. The control unit and indicator are fitted at the navigator's station. The pilot's repeater indicator is above his instrument flying panel. The equipment takes about 1½ minutes to warm up.

(*b*) *Post-Mod.* 3166. Collins UHF/DF is fitted in tanker aircraft and, in conjunction with a modified Tacan installation, provides the range and relative bearing of the receiver aircraft from the tanker. The indicator is fitted adjacent to the Tacan indicator.

(*c*) A Type 153A inverter provides power (115-volt, 3-phase, 400 CPS) for both Tacan and Collins UHF/DF.

123C NBC and H2S

(*a*) The navigational bombing system is installed. The controls and indicators are all at the nav. radar's position.

(*b*) Signals from the NBS are fed into the auto-pilot when the BOMB switch is pulled out.

(*c*) Power is supplied by No. 1 Type 350 inverter.

123D IFF Mk. 10

IFF Mk. 10, with SIF and I/P facilities, is fitted and the controls are at the AEO's station. Power is supplied by the No. 2 Type 350 inverter.

Bombing Controls (B1 and BK1)

124 General

(*a*) Bombs are carried in the bomb bay in the fuselage. The bomb doors are operated electrically and there is a deflector at the rear of the bomb bay which, when raised, reduces the buffeting with the bomb doors open. The system is so arranged that the bomb doors will not open until the deflector is raised, nor will the deflector lower until the bomb doors are closed.

(*b*) All bombs may be dropped manually by the air bomber from either of his stations, or automatically by the NBC. All bombs may be jettisoned in emergency.

125 Bomb door control

The bomb doors are controlled by a switch (C8) on the central pedestal, marked OPEN, CLOSE and AUTO. When the switch is set to OPEN the deflector will rise and, as soon as it reaches the fully up position, the bomb doors will open. The bomb release circuits are not operative until the bomb doors are fully open. When the switch is set to AUTO the deflector will rise and, when it reaches the fully up position, will make a connection between the bomb door opening circuit and the NBC. The bomb doors will not open until the circuit is completed by the controller, this being fully automatic. To close the bomb doors, whether they have been opened by using the OPEN or the AUTO position, the switch must be set to CLOSE. The bomb doors will then close, and as soon as they have reached the fully closed position the deflector will lower. Bomber Command Mod 20 provides a pin fitting in the switch guard to prevent the switch being inadvertently selected to AUTO (see also Part II, para 4 (*k*)).

126 Indicators

There are two magnetic indicators on the central pedestal forward of the trimmer switch which show the position of the deflector and bomb doors. The front one shows black when the deflector is fully down (closed) and white when it is in any other position ; the rear one shows white when both doors are fully open and black when they are in any other position.

127 Jettisoning bombs

A switch (C/16) on the central pedestal, marked NORMAL and JETTISON, may be used to jettison all bombs in an emergency. When this switch is set to JETTISON the deflector will first rise, then the fuselage doors will open. As soon as the doors are fully open (in about seven seconds) the bombs will drop. The doors will start to close again in the normal manner about 30 seconds after JETTISON has been selected. The cycle is complete in about 40 seconds. There is also a " live jettison " push-button at the bomb-aimer's prone station, at the starboard side of his window. This can be used to jettison all bombs " live " provided the bomb doors are open.

NOTE: The doors will close at the end of the jettison cycle, whatever the selection of the normal bomb door switch, but when the jettison switch is returned to NORMAL the doors will go to the selected position.

128 Ground safety switches

(*a*) On the port side of the battery compartment are two isolating switches, one for each fuselage bomb door. These switches are for use during ground servicing and, when they are set to ISOLATE, the doors can be opened from the cockpit but cannot be closed. The doors *will* close at the completion of the time cycle if the jettison switch is set to JETTISON. It is essential that the isolating switches are returned to NORMAL before flight.

(*b*) Between the isolating switches is a single NORMAL/TRIP switch and a green light. When this switch is set to TRIP, the green light will come on and the doors cannot be operated by the normal circuit. The bomb jettison switch will operate the bomb doors, and the bombs can be dropped by either the normal or jettison circuits.

129 Weapon in-flight safety locks

Mod 2996 introduces two in-flight safety lock switches on the left of the port coaming panel. They are marked LOCKED and UNLOCKED and are sealed in the LOCKED position. Beneath each switch are two lights, a green and an amber. The green light is on with the switch at LOCKED and the amber comes on when the switch is set to UNLOCKED.

130 Air spoiler control

An air spoiler in the form of four vertical slats at the front of the bomb bay, has to be extended to break up the airflow over the bomb bay prior to releasing the 10,000 lb bombs. It has only two positions, fully extended and retracted, and is controlled by an IN/OUT switch on the bombing panel on the radio crate. Two magnetic indicators (A/46) below the fuel panel show white when the air spoilers are extended and black when they are in or selected in.

Camera and Photoflash Controls (B(PR)1 and BK(PR)1)

131 General

The PR aircraft are standard B1 aircraft modified to enable them to be converted for photographic duties in either a day role or a night role.

132 Day role

(*a*) For the day role the aircraft carries up to eight main fan cameras, three cameras for the tri-installation for wide angle cover, and one survey camera. The main cameras and the centre tri-installation camera are mounted in the camera crate in the bomb bay ; after of these, in a rear fairing, is the survey camera and above this are mounted the two oblique cameras of the tri-installation.

(*b*) The special PR bomb doors contain camera windows each with a door, and cannot be opened from the cockpit (see also para 134). An auxiliary fuel tank may be carried in the forward part of the bomb bay.

(*c*) There are two camera control panels in the cabin, one on the starboard wall and one at the air bomber's prone station. A reconnaissance sight may be fitted at the air bomber's prone station.

(*d*) All cameras are controlled by either one of two controllers, one on the cabin starboard wall and one at the prone station. Ratio selector switches on the day role panel on the cabin starboard wall enable the survey and tri-installation cameras to be pulsed in a ratio of 1 to 1, 1 to 4 or 1 to 8 exposures of the main cameras. The camera window doors are all controlled by a single OPEN—CLOSE switch on each control panel. Until one of these switches is set to OPEN, none of the main cameras can operate. Each camera can be individually selected by switches on the cabin control panel. Indicator lamps above the switches pulse as the selected cameras operate. These lamps (but not the switches) are duplicated at the prone station.

(*e*) Mod 2099 and 2122 introduce a survey camera pulse indicator (B/21) at the top centre of the centre instrument panel. This is a green light which comes on three seconds before the survey camera is pulsed and remains on until the camera has pulsed. This is a warning to the pilot to level the wings, as the camera can be corrected for drift and pitch but not for bank.

133 Night role

(*a*) In the night role the aircraft carries five or six cameras in the camera crate in the bomb bay, and five or six photo-cell units. Photo-flashes are carried in a flash crate at the rear of the bomb bay.

(*b*) The special PR bomb doors contain camera windows, each with a door, and cannot be opened from the cockpit (see also para 134). An auxiliary fuel tank may be carried in the forward part of the bomb bay.

(*c*) There are two camera control panels in the cabin, one on the starboard wall and one at the air bomber's prone station. A reconnaissance sight may be fitted at the prone station.

(*d*) All cameras and photo-cells are controlled from either of the two control panels. The camera window doors are all controlled by a single OPEN—CLOSE switch on each control panel. The flash crate doors are controlled by the bomb doors selector switch (C/8) on the central pedestal ; door OPEN and CLOSED indicators (A/46) are below the fuel panel and on each control panel. Pre-Mod 2800 all indicators show the position of the doors ; Post-Mod 2800 the pilot's indicators remain the same, but the other indicators only show OPEN when the doors are open and the flash fusing strips are energised. The cameras cannot operate until the camera window doors and flash crate doors are open. Each camera can be individually selected by switches on the starboard wall control panel only. Camera pulse indicators, an exposure counter and a flashes released counter are on each control panel.

(*e*) Two of the cameras are known as master cameras and supply pulses for releasing the photo flashes. A selector switch on the control panel enables the selection of either master camera according to the group of cameras being used. Provided that the camera window doors and flash crate doors are open, operation of the CAMERA START AND FLASH RELEASE switch (one on each control panel) will energise the selected cameras and start the predetermined flash release cycle. Each time a flash bursts, the photo-cells are energised and the cameras are operated. A CAMERA STOP and a FLASH STOP switch are on each control panel. Normally when photography is to be stopped the FLASH STOP switch should be operated first ; when all the flashes which had been released at this time have burst, the cameras should be stopped by operating the CAMERA STOP switch. The flash crate doors must not be closed while the cameras are operating.

(*f*) All photo-flashes may be jettisoned, live only, by the pilot's NORMAL/JETTISON switch (C/16) on the central pedestal. When JETTISON is selected, the flash crate doors operate and the flashes drop in exactly the same way as described for jettisoning bombs (see para 127).

134 PR bomb doors

The special bomb doors fitted in the PR role cannot be operated from the cockpit. There is an OPEN/CLOSE switch on the external electrical panel and a LOCK IN/LOCK OUT switch, with a mechanical indicator, at the front of the starboard door near the hinge line. To open the doors the lock switch must be set to LOCK OUT until the indicator shows that the lock is withdrawn, then the OPEN/CLOSE switch should be set to OPEN. To close the doors the switch should be set to CLOSE ; when the doors are shut, the lock switch should be set to LOCK IN until the indicator shows that the lock is fully engaged.

Aircraft Destructors

135 General

Two aircraft destructors are stowed in containers on the outside of the pressure cabin under the canopy fairing and just aft of the sextant dome. Access to them is obtained by removing the sextant dome.

136 Position of application

The most effective position of application of the destructors is on the top of the fuselage over the fuselage fuel tanks, choosing tanks which are still fairly full of fuel. The destructors should not both be positioned above the same cell, and each should be about 2 to 3 feet from the aircraft centre line. The positions of the cells can be judged from the relative position of the bomb hoists ; No. 1 hoist (forward) is towards the rear of No. 1 cells, No. 2 hoist midway along the rear half of No. 2 cells, No. 3 and 4 hoists midway along No. 3 cells, No. 5 hoist at the rear of No. 3 cells, and No. 6 hoist about a foot forward of the transfer tank. The reserve tank is about 2 feet aft of the DF loop. The method of application is covered in Part V, para 21.

Part II

LIMITATIONS

PART II

Limitations

List of Contents

Illustration

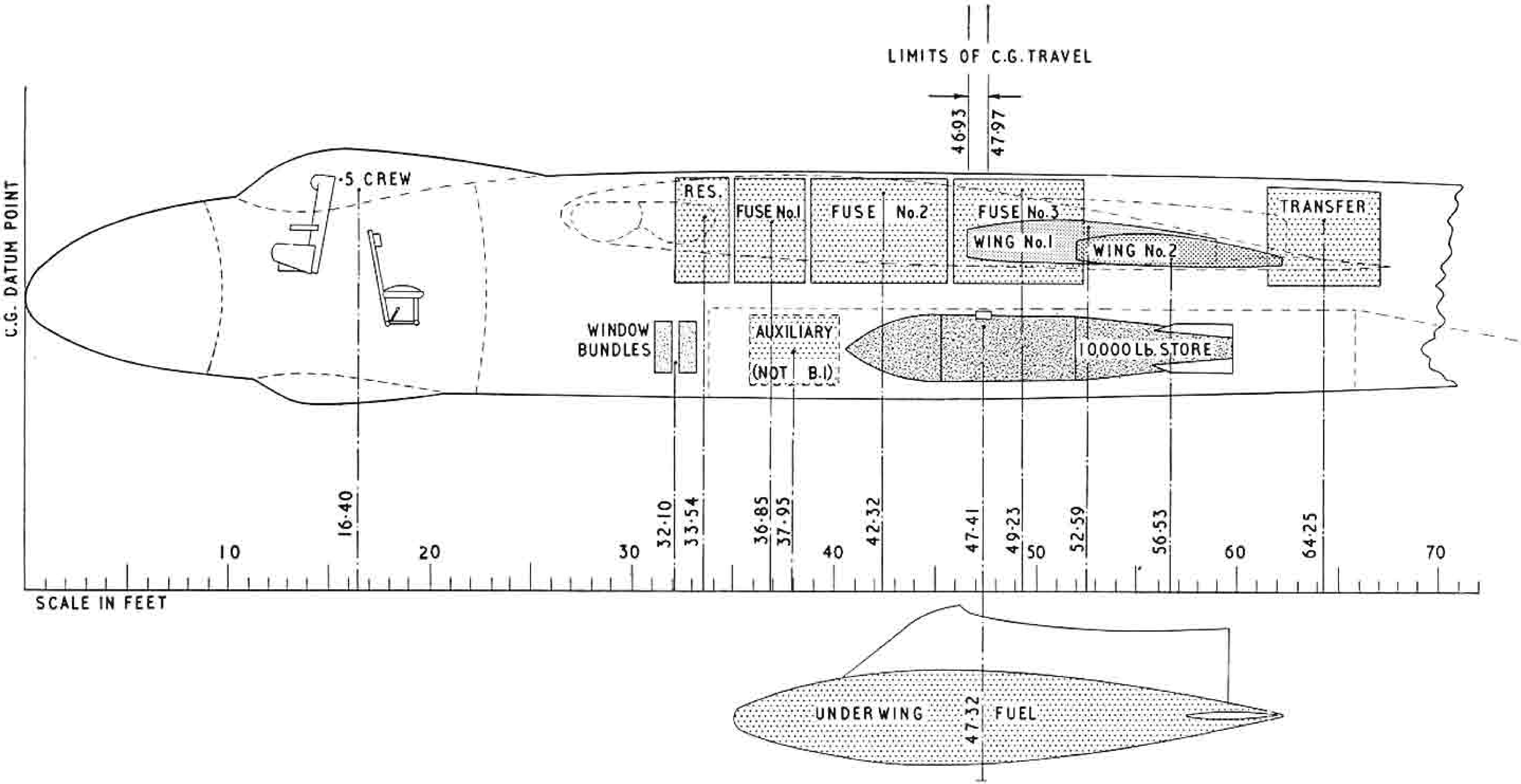


FIG. 1—*Loading Diagram*

Part II

Limitations

1 Engine limitations—Avon 204 and 205

(*a*) RPM *and* JPT

Condition	*Time limit (mins.)*	RPM	JPT °C
Take-off using water-methanol (Avon 205 only)	Governed by capacity of WM system	8300^{+50}_{-75}	660
Take-off and operational necessity . . . . (Without water-methanol)	10	8000±50	660
Intermediate	30	7800	635
Max. continuous . . .	Unrestricted	7600	610
Ground idling . . .	—	3000±200	500

NOTE 1: A reduction of up to 150 RPM in the governed speed may occur up to an altitude of about 40,000 feet.

NOTE 2: The governed RPM will vary with a change in the specific gravity of the fuel from that at which the engine settings were made. A higher specific gravity will cause a drop in RPM and vice-versa. Every 0·01 change in SG will cause a corresponding difference of 50 in the governed RPM.

NOTE 3: Unless Avon Mod. 1222 is embodied on Avon 204 engines, RPM must be restricted when flying in low air temperatures (see Part III, para. 28 (*c*)).

NOTE 4: On initial starting the limiting jet pipe temperature is 660°C.

NOTE 5: On initial starting, whilst the engines are cold, the idling RPM may be as high as 3,400.

(*b*) *Oil pressures*

Normal at max. continuous	34 PSI
Minimum at max. continuous and over . . .	25 PSI
Minimum at ground idling	20 PSI

(*c*) *Emergency take-off rating*

An emergency take-off rating of 8,200 RPM and 690°C jet pipe temperature may be used with Avon 204 engines only, subject to a time limit of two minutes at this rating. The RPM controllers and JPT controllers (if operative) will have to be adjusted before this rating can be obtained, and should be re-adjusted to the normal settings after flight. This emergency take-off rating is only to be used in cases of operational necessity when the normal take-off thrust is inadequate owing to high ambient air temperature and/or insufficient runway length for the aircraft weight. The decrease in take-off run using this rating (as against the normal take-off rating) is about 6-7% in ISA conditions and about 10-11% in tropical conditions, both at sea level. Reference should be made to the Operating Data Manual.

(*d*) Post-Mod. 3225 the engines may be run at full throttle (8,200 RPM) for three hours, in the war case only, providing the jet pipe temperature does not exceed 685°C and that the current reconditioning life of 500 hours has not been exceeded.

2 Flying limitations

(*a*) *General*

Spinning and aerobatics are prohibited. With undercarriage up and flaps up or less than 20 degrees, the aircraft must not be flown at speeds below that for the onset of the pre-stall buffet (see Part IV, para. 11(*c*)).

(*b*) *Speed and mach number limitations*

(i) The following limitations, which can easily be exceeded in level flight at the lower altitudes, must be observed. Limitations vary linearly between altitudes quoted.

(ii) The Modifications quoted in the following table are:

Mod. 1680 (XD818)—Strengthened pitot heads (Mk. 9B)

Mod. 2332 (XD822)—Pitot heads (Mk. 9C)

Mod. 2086 (WZ397)—Vortex generators on wings

(iii) *Aircraft incorporating Mod.* 1680 (*or* 2332), 2086 *and* 1850.

Altitude	*With Underwing Tanks*		*Without Underwing Tanks*	
	Bomb Doors Closed	*Bomb Doors Open*	*Bomb Doors Closed*	*Bomb Doors Open*
SL to 10,000 ft. .	320	320	360	360
At 20,000 ft. .	320	320	320	320
At 30,000 ft. .	295 or 0·82M	290 or 0·80M	295 or 0·82M	290 or 0·80M
Above 35,000 ft. .	0·85M	0·82M	0·85M	0·82M

(iv) Aircraft without Mod. 1680 or 2332 are restricted above 30,000 feet to 290 knots IAS or 0·80M.

(v) Aircraft without Mod. 2086 are restricted at 30,000 feet to 290 knots IAS or 0·80M and above 40,000 feet to 0·82M.

(vi) Aircraft without Mod. 1850 (WZ405) are restricted to 320 knots IAS for operation of bomb doors.

(*c*) *Application of G loads*

The maximum permissible normal accelerometer readings are as follows (see Part IV, para. 12).

Speed up to 0·82M (Bomb doors closed) . . . . 2·5G

Above 0·82M (Bomb doors closed) . . . . 2·0G

At weights above 135,000 lb with underwing tanks . 2·0G

At all speeds when operating bomb doors or flying with them open . . . . 2·0G

NOTE 1: If heavy buffet is encountered in manoeuvres, G must be reduced immediately.

NOTE 2: When an accelerometer is not fitted, gentle manoeuvres only are permitted and the aircraft must not be flown beyond the threshold of the buffet.

(*d*) *Maximum speeds*

For lowering the undercarriage . . . . . . 170 knots

For flying with undercarriage down . . . . . 195 knots

For raising the undercarriage . . . . . . 195 knots

Flaps down to 20 degrees . . . . . . 190 knots

Flaps down 20 to 58 degrees . . . . . . 150 knots

Air brakes out . . . . No Limitation

(*e*) *Maximum weights*

	Without tip tanks	*With tip tanks*
For take-off	138,000 lb	175,000 lb
For normal landing .	110,000 lb	110,000 lb
For overload landing .	138,000 lb	138,000 lb

NOTE 1: At weights above 98,000 lb, the limiting factors on landing are the rate of descent on touchdown and the capacity of the brakes. The allowable rate of descent is further influenced by the loading condition. Reference must be made to Part IV, para. 18.

NOTE 2: At weights in excess of 170,000 lb turning radius on the ground must not be less than that given by full nosewheel steering lock. The turn must not be assisted by the use of wheel brakes or differential engine thrust.

(*f*) CG *limits*

In flight and for take-off and landing	563·2 to 575·7 in. aft of datum (·30 to ·35 SMC) (46·93 to 47·97 ft.)

3 Use of different fuels

(*a*) The fuel normally used is AVTAG. When obliged to land away from base AVTUR may be used to return to base provided that the operation of bleed valves and swirl vanes is satisfactory. The use of AVTUR for other purposes is only permitted if the engines are re-adjusted (see NOTE 3 to Part II, para. 1 (a)).

(*b*) When necessary, JP4 fuel may be used instead of AVTAG. No re-adjustment or special precautions are necessary if the SG range of the fuel is within the range of AVTAG normally used.

4 Other limitations

(*a*) *Powered flying controls*

(i) *Deliberate reversion to manual.* Deliberate reversion to manual control in flight, for practice flying in manual, is permitted subject to the correct drill being followed (see Part IV, para. 25). If the outside temperature is below −26°C the aircraft should not be flown in manual for longer than one hour as it may be difficult or impossible to re-engage power if the power units cool down to this temperature. The power units are self-heating only while in operation. When in manual control the following limitations must be observed:

Maximum speed . .	Normal limitation or 0·76M, whichever is lower
Maximum angle of bank .	20 degrees
Maximum flap for landing	40 degrees

(ii) *Failure of power controls.* All the above limitations apply in the event of total reversion to manual, i.e. complete failure of all power control motors. In the event of partial failure the above limitations apply as follows:

0·76M . .	Failure of any one motor or more
20 degrees bank .	Failure of one or both aileron motors
40 degrees flap .	Failure of *both* elevator/rudder motors

NOTE: The flaps may be lowered fully if one elevator/rudder motor has failed. Owing to the strong nose-down trim change it is important that the flaps are not selected beyond 40 degrees when *both* elevator/rudder motors have failed, but if the second elevator/rudder motor fails while the flaps are fully down they may be left down.

(*b*) *Stalling*

High speed stalling, stalling with flaps up or less than 20 degrees and stalling with underwing tanks fitted when the weight is in excess of 135,000 lb, is prohibited. Stalling is permitted in the circuit and approach configuration, but special note should be taken of Part IV, para. 11.

(*c*) *Bomb doors*

The bomb doors may only be opened and closed in straight flight. See also para. 2(*c*).

(*d*) *Pressure cabin flood flow system*

The flood flow system is operative when certain modifications are embodied. (See Part III, para. 42.)

(*e*) *Anti-icing systems*

(i) The unmodified airframe anti-icing system may only be used as detailed in Part III, para. 36 and 37.

(ii) Engine anti-icing may be used subject to the precautions detailed in Part III, para. 32 to 35 being observed.

(iii) The modified anti-icing system may be used as detailed in Part III, para. 37A, provided all essential modifications are embodied.

(*f*) *Nitrogen system*

The nitrogen system may be used provided that Mod. 2107 (XD857) is embodied.

(*g*) *Auto-pilot*

The auto-pilot may be used as a pilot aid and, provided that Mod. 785 and 1489 are embodied, it may also be coupled to the NBS for direct and off-set bombing. It is subject to the limitations detailed in Part III, para. 49.

(*h*) *Water-methanol*

The following limitations apply to the use of water-methanol:

(i) The engine RPM and JPT limitations quoted in para. 1(*a*) must be observed.

(ii) The pumps must not be allowed to run dry. To avoid this, the master switch must be switched off as soon as water-methanol flow ceases, indicated by the engine RPM dropping to 8,000.

(iii) Water-methanol must not be switched on more than 15 seconds after the engines have reached 8,000 RPM. If the system has been switched on, but has not cut in by this time, it must be switched off.

(*j*) *Radio and radar equipment*

(i) ILS may only be used for approaches down to 300 feet above the ground as indicated by the altimeter (but see Part III, para. 54(*a*)).

(ii) If Mod. 2040 (WZ395) is embodied, NBS may be used for direct manual bombing, using any stores which have been cleared (see Part II, para. 5). If Mod. 2040 is not embodied, NBS may be switched on and used for familiarisation and for dropping 100 lb practice bombs only. Navigation exercises may also be undertaken. If Mod. 2190 (XD858) is embodied, the NBS may be used for off-set manual bombing.

(*k*) *Window launcher*

The installation may be used for type D10, D21 and D22 chaff provided that:

(i) The port launcher is not used unless Mod. 2779 is embodied.

(ii) Altitude is not less than 35,000 feet unless Mods. 5574 and 5575 are embodied.

(iii) Mods. 89, 576, 698, 1302, 2385, 2407, 2619, 2694, 2801, 2813 are all embodied.

With Mod. 2385 fitted, the release of window will automatically stop as soon as the bomb doors are selected open. Release will start again as soon as the bomb doors are fully closed, if the window launcher is still switched on.

5 Aircraft approach limitations (AAL)

The AAL's are:

Precision radar	200 feet	Above airfield level
Search radar	400 feet	
Manual ILS	300 feet	
Auto ILS	200 feet	
ILS/Zero reader	200 feet	

6 PR role limitations

(a) Day role

There are no special limitations in the day role, and the normal aircraft limitations apply.

(b) Night role

The normal aircraft limitations apply in the night role, with the addition of the following limitations on the photo-flashes.

(i) *Carriage of photo-flashes*

28 × 8″ photo-flashes No. 1 mark 3 or No. 2 mark 1 may be carried with flash crate doors open or closed within the normal aircraft limitations. When a full load of photo-flashes is carried, the transfer fuel tank must be empty; when a full load of flashes is not carried the combined weight of flashes and fuel in the transfer tank must not exceed the maximum permissible weight of flashes.

(ii) *Release of photo-flashes*

No. 1 mark 3 flashes may be released at speeds up to 320 knots in straight and level flight.

No. 2 mark 1 flashes may be released in straight and level flight throughout the height range of the aircraft and up to 320 knots or the aircraft speed limitation, whichever is the lower.

Release of photo-flashes results in forward CG movement. Before commencing the release of photo-flashes therefore, use of fuel should be so arranged to allow for this CG movement.

(iii) *Jettison of photo-flashes*

Photo-flashes can only be jettisoned live. Jettison is permitted at speeds up to 320 knots in straight and level flight

Release of photo-flashes results in forward CG movement. Before commencing the release of photo-flashes therefore, use of fuel should be so arranged to allow for this CG movement.

(iv) *Landing with photo-flashes*

Landings with photo-flashes on board should be regarded as overload landings, and gentle touchdown made (see Part IV, para. 18).

(c) Camera heating

To ensure efficient camera operation and freedom from misting of the camera windows, the bomb bay temperature should be controlled as in Part III, para. 38.

7 Armament limitations

(a) The following restrictions apply to the carriage of stores in the bomb bay.

(i) When bomb loads in excess of 10,000 lb are carried, the excess bomb load over 10,000 lb and the weight of the bomb gear, must be considered for loading purposes as though it were fuselage fuel. The overriding condition of 30/70% wing/fuselage fuel distribution still applies.

(ii) The fuselage transfer fuel tank must be empty when 5 × 1,000 lb stores are carried on the rear (No. 6) station. If fewer than five are carried on this station the combined weight of stores on this station and fuel in the transfer tank must not exceed 5,000 lb.

(iii) Landings with more than 18 × 1,000 lb stores on board or with more than two stores on the rear (No. 6) station should be regarded as abnormal. Every endeavour must be made to make a smooth, gentle landing.

(b) The air spoilers must not be extended during the release of any stores other than the 10,000 lb MC Mk. 1 bomb.

STORES	LOADING POINTS	CARRIAGE LIMITATIONS	RELEASE LIMITATIONS	JETTISON		REMARKS
				NAVIGATOR'S	PILOT'S EMERGENCY	
10 × 2,000 lb. Mines "A" Mk. 12	On 5-store carriers at L.P. 2 and 5	Within normal aircraft limitations	Between 25,000 and 35,000 ft., in straight and level flight ±5°. Up to 240 knots at 25,000 ft. reducing to 200 knots at 35,000 ft. T.A.S. not to exceed 350 knots.	As for release.	If lower stores have been released only; otherwise only if risk of damage to aircraft is acceptable. As release limitations but up to 49° climb, 48° dive and 9° roll.	Stores must be released first from No. 2 loading point then from No. 5.
21 × 1,000 lb. M.C. Mk. 6, 11 and 12 bombs	5 each on L.P. 1, 4 and 6 3 each on L.P. 2 and 5	Within normal aircraft limitations	Straight and level flight ±5° at the following speeds: S.L. to 10,000 ft. 360 knots 20,000 ft. 320 knots. 25,000 ft. 310 knots. 30,000–40,000 ft. 290k/0·80 M. Above 40,000 ft. 0·82 M. For release of stores from stations 18 and 20, speed is restricted to 310 knots below 25,000 ft.	As for release of stores from stations 18 and 20.	Only if risk of damage to aircraft is acceptable. S.L. to 25,000 ft. 310 k. 30,000–40,000 ft. 290k/0·80 M. Above 40,000 ft. 0·80 M. Max. 25° climb 24° dive 15° roll	During stick bombing the release limitations on stores from stations 18 and 20 must be applied to *all* stores if stores from stations 18 and 20 are included in the stick to be released.
16 × 1,000 lb. M.C. Mk. 6 bombs *and* 5 × 1,000 lb. T.I. bombs HA/HS	5 each on L.P. 1 and 6 3 each on L.P. 2 and 5 On L.P. 4	Within normal aircraft limitations	Straight and level flight ±5° To normal limitations for flying with bomb doors open. For release of stores from stations 18 and 20, speed is restricted to 310 knots below 20,000 ft.	As for release of stores from stations 18 and 20.	Only if risk of damage to aircraft is acceptable. S.L. to 20,000 ft. 310 k. 30,000 ft. 290k/0·80 M. Above 35,000 ft. 0·82 M. Max. 25° climb 24° dive. 15° roll.	During stick bombing the release limitations on stores from stations 18 and 20 must be applied to *all* stores if stores from stations 18 and 20 are included in the stick to be released.
15 × 1,000 lb. T.I. bombs HA/HS *and* 6 × 1,000 lb. M.C. Mk. 6 bombs	5 each on L.P. 1, 4 and 6 3 each on L.P. 2 and 5					
Up to 15 × 1,000 lb. T.I. bombs HA/HS *and* Remainder (to total 21) of 1,000 lb. M.C. Mk. 6 bombs	T.I. bombs *not* to be on L.P. 2 or 5 T.I. bombs and M.C. Mk. 6 bombs *not* to be mixed on same carrier.					

STORES	LOADING POINTS	CARRIAGE LIMITATIONS	RELEASE LIMITATIONS	JETTISON		REMARKS
				NAVIGATOR'S	PILOT'S EMERGENCY	
12 × 1,000 lb. M.C. Mk. 7* bombs	3 each on L.P. 1, 2, 4 and 6	Within normal aircraft limitations	Within normal aircraft limitations	As for release.	Not recommended except in dire emergency.	
21 × No. 38 Clusters	5 each on L.P. 1, 4 and 6 3 each on L.P. 2 and 5	Within normal aircraft limitations	Straight and level flight ±5° Within normal aircraft limitations	As for release.	Only if risk of damage to aircraft is acceptable. As for release, but up to 30° climb or dive and 21° roll.	
18 × 100 lb. Practice bombs	On upper stations of lower carriers	Within normal aircraft limitations with bomb doors closed, and up to 300 knots or 0·76 M. with bomb doors open.	Straight and level flight, up to 300 knots or 0·76 M.			
18 × 25 lb. Practice Smoke and Flash No. 1 Mk. 1 Smoke Mk. 1*** and 4 Flash Mk. 3** and 5	On practice bomb carriers carried on upper stations of 1,000 lb. carriers on L.P. 1, 4 and 6	Within normal aircraft limitations.	Between 12,000 and 45,000 ft. in straight and level flight ±5°. 12,000–20,000 ft. 320 knots. 30,000–40,000 ft. 290k/0·80 M. Above 40,000 ft. 0·82 M.	As for release.	Not recommended except in dire emergency.	

Part III

MANAGEMENT OF SYSTEMS AND EQUIPMENT

Part III

Management of Systems and Equipment

List of Contents

Part III

Management of Systems and Equipment

Management of the Fuel System

1 General

(*a*) The fuel from the wing and fuselage tanks is fed to the distributor box on each side of the aircraft, and from there to the two engines on the same side through the engine LP master cocks and the HP cocks.

(*b*) If the wing-tank pumps are switched on and the fuselage pumps switched off, only wing tank fuel will be used ; conversely if the fuselage pumps are switched on, and the wing tank pumps switched off, only fuselage tank fuel will be used. To keep the CG within the limits during flight it is necessary to use the wing tanks and fuselage tanks alternately for short periods (see Part III, para. 4).

(*c*) The decision when to transfer the fuel from the transfer tank or the auxiliary tank (when fitted) (to both the port reserve tank cell and the port No. 1 fuselage cell, or to the No. 1 fuselage cell only if the reserve tank is still full) and when to use the reserve tank fuel by opening the reserve tank cocks will depend on the CG position. In PR aircraft, to keep the CG within limits, it may be necessary to keep up to 2,000 lb of fuel in the transfer tank. Landings with fuel in the transfer tank should be regarded as overload landings and care taken to make gentle touchdown (see Part IV, para. 18).

(*d*) When fuel is transferred from the transfer tank and/or the auxiliary tank (if fitted), there may be an unbalance of fuel in the fuselage. If the reserve tanks and the No. 1 fuselage cell levels are low there will not be enough fuel transferred to fill both the port and starboard cells. The port cells will overspill into the starboard cells, but not enough to balance the levels. In this event lateral balance should be restored by using the cross-feed cock (see Part III, para. 8).

(*e*) Fuel in the two tanks in each wing should be levelled out periodically in flight if necessary, by opening the wing tanks interconnection cocks until the levels in both tanks become stabilised. The cocks should not be left open except in the event of failure of one wing tank pump (see Part III, para. 11(*b*)).The contents gauges for the two tanks in each wing form a good guide to the level ; if the gauge needles are parallel the fuel levels will be about equal Wing tanks interconnection cocks should only be used in level flight. If climbing, fuel will feed from inboard to outboard tanks and vice-versa if descending.

2 Starting up and taxying

Keep at least two fuel pumps per side running. Fuel consumption when idling is about 25 lb per minute per engine.

3 Taking off

Have both fuselage pumps and both wing pumps on each side running. Keep the reserve tank cocks, the cross-feed cocks and the wing tank interconnection cocks off. The transfer tank pump and the under-wing tank pump should also be off. About 800 lb of fuel are used for take-off.

4 Climbing and cruising

After take-off switch off either the two fuselage pumps or the two wing tank pumps on each side, and then " cycle " the wing and fuselage tanks to keep the CG within limits. The time period for use of each tank is laid down on each particular load sheet and reference must be made to this before each flight. Departure from this set procedure may be necessitated by fuel pump failures, bomb hang-ups, etc., in which cases CG position and fuel drill can be determined by using the computor stowed on the rear of the central pedestal. To aid in calculation, the CG position for each tank is given in Part I, para. 6.

5 Landing

Land with both fuselage pumps on each side running, and all other pumps on in tanks containing fuel.

6 Distribution of fuel during flight

The distribution of fuel must be arranged so that for every 100 lb in the tanks at any stage of a flight, not more than 70 lb are in the fuselage tanks and not less than 30 lb in the wing tanks. The exception to this rule is when returning to base with low fuel when it is necessary to ensure that the minimum of unusable fuel remains in the wing tanks. In this case wing fuel must all be used in level flight before starting a descent to base, and the aircraft should not be flown in a nose-down attitude on wing tanks alone (see para. 7 below).

NOTE: Underwing tank fuel is not countable as wing fuel when calculating the 70/30 ratio.

7 Use of fuel to ensure minimum quantity of unusable fuel

(*a*) The minimum safe quantity of fuel, prior to joining the circuit, is 5,040 lb. This is sufficient for one low level instrument approach pattern, an overshoot and a visual circuit and normal landing. This fuel, plus sufficient fuel for the descent, will have to be concentrated in the fuselage reserve and No. 1, 2 and 3 cells to ensure that the whole amount will be available in all attitudes of flight.

(*b*) The maximum permitted quantity of fuel in the fuselage, with no stores on board and with wing tanks empty, is 10,000 lb. Aircraft not fitted with NBS can carry this amount of fuel in the fuselage reserve and No. 1, 2 and 3 cells and remain within the CG limits. Aircraft fitted with NBS can also carry 10,000 lb of fuel in the fuselage with wing tanks empty, but so as to remain within the CG limits 4,100 lb of this fuel must be in the transfer tank.

(*c*) To allow for the above, the transfer tank contents should not be allowed to fall below 4,100 lb unless it is certain that by so doing the CG will not move outside the limits when down to low fuel states with the wing tanks empty. A situation may arise, when, due to unserviceability of fuel pumps or a seized reserve tank cock, the CG will move forward beyond the limits at low fuel states. In this event speed is not to exceed 240 knots or 0·75M.

(*d*) The wing fuel must be used completely in level flight, otherwise the quantity of unusable fuel (in other than level flight) will be increased. In a 10 degree dive the unusable fuel in the wings is about 1,200 lb per tank. When the fuselage tank contents reach a total of 13,000 lb, fly on wing tanks alone until 1,600 lb remain in the wings. Then switch on all pumps, and by the time the wing tanks are empty, 10,000 lb of fuel should remain in the fuselage. The wing tanks should not be emptied on aircraft fitted with NBS unless at least 4,100 lb of the permissible 10,000 lb of fuselage fuel remain in the transfer tank. If the transfer tank is empty, sufficient fuel will have to be left in the wing tanks to prevent the CG moving forward of the limit. To provide the minimum safe usable quantity of 5,040 lb in the fuselage reserve and No. 1, 2 and 3 cells, 3,600 lb of fuel will be required in the wing tanks to keep the CG within limits if the transfer tank is empty. Any further fuel in the fuselage reserve and No. 1, 2 and 3 cells, which is required for the descent, must be compensated by additional fuel in the wings in the ratio of one in the wings to two in the fuselage.

(*e*) With the 10,000 lb store on board, 5,040 lb of fuel only is permitted in the fuselage, with wing tanks empty, as an emergency. The additional amount of fuel required in the fuselage will have to be balanced by fuel in the wing tanks in the ratio of 30 in the wings to 70 in the fuselage. Therefore to provide the minimum safe quantity of 5,040 lb of fuel in the fuselage reserve and No. 1, 2 and 3 cells, 2,560 lb. of fuel will be required in the wings to relieve wing root stresses. This condition is also subject to the need to keep the C.G. within limits as specified in (*d*) above.

8. Use of cross-feed cocks

If an engine fails, and particularly if both engines on one side fail, fuel (both wing and fuselage) in the failed engine side should be used for the live engines to preserve lateral level. This is done by opening the cross-feed cocks and switching off the fuel pumps on the live engine side, thus allowing the fuel to be fed across the fuselage.

9. Use of underwing tanks

(*a*) The pumps must *not* be operated whilst the aircraft is on the ground unless adequate ram air cooling is available. If cooling facilities are not available it is permissible to run the pumps for testing only, but it is essential that the running time is limited to not more than one minute.

(*b*) Underwing fuel must not be used during take-off because of the absence of adequate ram air cooling. After take-off fuel from the underwing tanks should be used as follows:

(i) *B.1 and B(PR)1 aircraft*

As soon as practical after take-off, start a wing cycle and select the underwing tank pumps to MOTOR ON. The pumps should be left on until the underwing tanks are empty. (See sub-para. (*c*).)

(ii) *BK.1 and BK(PR)1 aircraft*

As soon as practical after take-off start a fuselage cycle and continue this until about 23,000 lb. of fuel have been used. The reserve and transfer tanks will have to be used in such a way as to maintain the C.G. within limits. When 23,000 lb. fuel have been used out of the fuselage tanks, change to a wing cycle, select all refuelling valves OPEN and select the underwing tank pumps to MOTOR ON. When the underwing tanks are empty switch off the pumps (see sub-para. (*c*) and (*d*)), close the refuelling valves and start the normal fuselage and wing cycling.

NOTE: On BK.1 and BK(PR)1 aircraft, the method given in (i) above may also be used if desired, but the method given in (ii) is preferable in that it reduces the running time of the underwing tank pumps, eliminates venting of fuel from the wing tanks and ensures more rapid and complete transfer of fuel from the underwing tanks if the emergency system has to be used.

(*c*) The L.P. warning light will start to flicker before the tank is empty; the pump should be left on, but switched off as soon as the light becomes steady. The pump must not be allowed to run dry.

(*d*) To switch a pump off, the switch *must* be selected to MOTOR TRIP – EMERG. ON for two seconds and then to OFF otherwise the pump will not be stopped. The switch must not be left at MOTOR TRIP – EMERG. ON for longer than two seconds otherwise the high pressure nitrogen system will operate unnecessarily. Post-Mod. 2784 or Command Mod. 45, the switch need only be left at MOTOR TRIP–EMERG. ON until the relevant pump indicator goes black; as soon as this happens the switch should be set to OFF.

(*e*) In case of pump failure, the switch should be selected to MOTOR TRIP – EMERG. ON and then to OFF. When cruising altitude is attained (35,000 feet approx.) the switch should be selected to MOTOR TRIP – EMERG. ON, enabling the remaining fuel to be transferred by the emergency nitrogen system.

NOTE 1. The emergency system should not be used during the climb as the limited supply of nitrogen may not be sufficient to complete fuel transfer at lower altitudes.

NOTE 2. The L.P. warning light remains on continuously when using the emergency system.

(*f*) Tests show that it is not possible to achieve complete fuel transfer when using the emergency system and up to about 1,500 lb. of unusable fuel will remain in each tank. The switch will have to be selected OFF when the contents gauge reading becomes steady.

(*g*) In the event of pump failure after transfer has commenced, it may be possible to complete transfer of the remaining fuel by the emergency system and in this case the switch will have to be selected OFF when the contents gauge reads nearly zero to avoid passing high pressure nitrogen into the main fuel system.

(*h*) In the event of a fault in the main wing tank refuelling circuit, indicated by a failure to transfer from the underwing tanks without the L.P. warning light coming on, it is possible on BK.1 and BK(PR)1 aircraft to restore a transfer condition by switching ON the appropriate No. 1 and 2 wing tank in-flight refuelling switches on the starboard coaming panel. On B.1 and B(PR)1 aircraft it is not possible to remedy this condition and any fuel remaining in the tank at the time of failure will be unusable.

(*j*) *Fuel jettisoning*

(i) The fuel in the underwing tanks may be jettisoned by selecting the appropriate tank jettison switch to JETTISON. The fuel level will drop to 1,000 lb. per tank in about 3 minutes, complete jettisoning being obtained in about 4 minutes. If a faster rate of jettison is required the underwing tank pump switches may be set to MOTOR TRIP – EMERG. ON, thus pressurising the tanks with nitrogen. In this case the fuel level will fall to 1,000 lb. per tank in 1·1 minutes, complete jettison being obtained in about 2½ minutes.

(ii) When jettisoning fuel the flaps must not be down more than 20°, but the undercarriage may be up or down. It is recommended that speed should not exceed 300 knots or 0.76M, though higher speeds may be used if necessary. When practical, altitude should not be less than 2,000 feet A.G.L. as this is the minimum for complete vaporization.

10. Application of negative G

The maximum period of time for which the recuperators will supply the engines in conditions of negative G, and the time required for the recuperators to recharge, varies with the engine fuel demands, i.e. with power and altitude. For example, using maximum power, at 40,000 feet the recuperators will suffice for about ½ a minute and will recharge completely in one minute whereas at sea level they will only suffice for 10 seconds and will take four minutes to recharge.

11. Fuel pump failure

(*a*) Despite fuel pump failure fuel will feed through gravity and tank pressurisation from wing or fuselage tanks (excepting transfer, underwing and auxiliary tanks) to the distributor box, and the supply should be sufficient for normal engine operation up to cruising power and medium altitudes. Gravity feed will be insufficient to provide the fuel required for the higher power settings or for satisfactory engine performance at high altitude, in which cases cross-feeding from the side without pump failure should be used. In this event the tanks on the failed pumps side will not feed at all, therefore to maintain lateral level and make full use of the available fuel, cross-feeding should be kept to the minimum required.

(*b*) If one of the wing fuel pumps fails, the other pump will feed fuel from both tanks if the wing tank interconnection cock is opened. If both pumps fail the wing fuel will feed by gravity into the distributor box, provided that the fuselage pumps on that side are off.

(*c*) If both fuselage fuel pumps on one side fail, fuel will feed by gravity to the distributor box, but engine performance may suffer due to the lack of fuel pressure. The cross-feed cocks may be opened to interconnect the two distributor boxes but in this event the fuselage tanks on the side on which the pumps have failed will not feed at all. To preserve lateral level and to make full use of the available fuel, the cross-feed cocks should not normally be opened unless full engine power is required.

(*d*) If the pump in the transfer tank fails, the warning light will come on. Pre-Mod. 2443 any fuel left in the tank will be unusable; Post-Mod. 2443 the pump switch should be selected to AUX. to start the stand-by pump.

(*e*) If the pump in the auxiliary tank fails, the warning light will come on. Pre-Mods. 2444 and 2473 any fuel left in the tank will be unusable; Post-Mods. 2444 and 2473 the pump switch should be selected to AUX. to start the stand-by pump.

(*f*) If the pump in either underwing tank fails, the nitrogen system may be used to transfer the fuel by setting the appropriate underwing tank fuel pump switch to MOTOR TRIP – EMERG. ON (see para. 9).

(*g*) No indication is given of the failure of one wing or fuselage pump provided that a second pump on the same side is on and working. If both wing or fuselage pumps in use on one side fail, the fuel pressure warning light should come on. The warning lights may not come on if the fuel level in the tanks is high and the engine fuel demand is low. This means that with more than about half fuel, at power settings less than about 7,600 r.p.m., there may be no indication of total fuel pump failure.

12 Use of fuel flowmeters

(*a*) The fuel flowmeters should always be selected to BY-PASS for take-off. The flowmeters should be switched to METERING on the climb, and must be switched to BY-PASS for landing.

(*b*) If a flowmeter transmitter jams, the fuel flow to the relevant engine may be seriously reduced. This will not be shown by the LP fuel warning light, but if this is suspected, the flowmeter should be switched to BY-PASS.

13 Use of fuel filter de-icing

(*a*) Warning of icing of one or more of the LP fuel filters is given by illumination of the blue light (B25) on the instrument top panel. Icing may also occur at the flowmeter filter and in the HP fuel system; this will not cause illumination of the warning light but may cause fluctuation of RPM. Operation of the LP fuel filter de-icing heaters for the recommended period should clear both filters and the HP system of ice.

(*b*) If during a take-off the FUEL FILTER DE-ICE warning light illuminates before the stop speed is reached the take-off should be abandoned. If the light illuminates after the stop speed is reached no action should be taken until the aircraft reaches a safe height when the filter de-icing drill should be carried out.

(*c*) If the blue FUEL FILTER DE-ICING warning light illuminates, the FUEL FILTER DE-ICE switch (B24) should be selected ON and held for three minutes. The heater will normally clear the filter in 20 seconds causing the light to go out but, because ice crystals cleared from the filter may re-form in the fuel control unit, the switch must be held ON for the full three minutes. If engine malfunctioning is experienced without throttle movement, and especially if fuel filter icing is probable, even if the blue warning light does not illuminate, the FUEL FILTER DE-ICE switch should be selected ON and all booster pumps switched on. The fuel heater should be kept ON for three minutes which should clear either flowmeter or HP fuel system icing. If it does not, flowmeter BY-PASS should be selected.

(*d*) If the foregoing action fails to cure the engine malfunction, engine RPM should be reduced and descent made to a lower altitude. Should an engine flame out before any remedial action can be taken, descend to a lower altitude before attempting to relight the engine. If relighting is unsuccessful, the aircraft should be landed as soon as possible.

(*e*) If the fuel filter de-icing system has been used in flight the FUEL FILTER DE-ICE switch should be selected ON for a period of two minutes at the bottom of the descent. An increase in engine speed of approximately 200 RPM will be incurred, but this will decrease again approximately five minutes after the fuel heaters are switched off.

(*f*) If any engine is shut down when the fuel filter de-icing heater is switched on, pressure will build up in the fuel lines of the shut down engine. Therefore the LP cocks of all engines should be open whenever the fuel filter de-icing heater is switched on.

Management of Flight Refuelling Systems

14 Flight refuelling—Tanker See Appendix A

15 Flight refuelling—Receiver See Appendix A

Management of the Electrical Systems

16 Battery control

(*a*) *96-volt battery*

(i) When starting from an external power supply or from an external bank of batteries the 96-volt battery should be switched OFF until the engines have started and the external power supply is removed. It must be switched ON for an internal battery start. It must be switched OFF after flight, but only when all four generator warning lights have come on. The magnetic indicator will be black when the switch is ON and white when the switch is OFF.

NOTE: It has been found that if, on shutting down, the 96-volt battery is switched OFF before the warning lights come on it is possible for one of the differential relays to remain closed. This can result in the generator attempting to drive the engine, consequently breaking the quill drive shaft the next time external power is connected with the generator switched ON.

(ii) The battery will be in-situ charged when a generator is on line or the 112-volt external power supply is connected and the battery is switched ON.

(iii) Operation of the crash switch will disconnect the battery from the busbar.

(*b*) *24-volt battery*

(i) The battery is permanently connected to the " essential services " busbar unless the battery connections are removed.

(ii) To connect the 24-volt battery to the 28-volt busbar, set the 24-volt battery switch to ON. Check that the magnetic indicator goes black.

(iii) When the 28-volt external supply is plugged in, the 24-volt battery is charged irrespective of the battery switch being ON or OFF, however, the switch must be at ON to allow the external supply to reach the 28-volt busbar. The battery will only be charged from the rotary transformers when the battery switch is ON. The battery will be disconnected from the busbar either by the crash switch or by setting the battery switch to OFF when the magnetic indicator will go white.

17 Ground supply management

(*a*) It is normal to connect both the 112-volt and 28-volt external supplies. All the aircraft services can be used when both external supplies are connected. The 112-volt external supply will be connected direct to the 112-volt busbar. The 24-volt battery switch must be placed to ON to connect the 28-volt external supply to the 28-volt busbar. When the external supplies are connected, No. 1, 2 and 3 generator and No. 1 and 2 rotary transformer control switches must be OFF. No. 4 generator and No. 3 rotary transformer control switches may be ON (the generator and rotary transformer are held off line by hold-off relays). When the external power is disconnected, providing No. 4 engine is running, the generator and rotary transformer will come on line.

(*b*) When only the 112-volt external supply is connected, all 112-volt services may be operated, but the 24-volt battery switch and one rotary transformer must be ON. No. 1, 2 and 3 generator switches must be OFF.

(*c*) When only the 28-volt external supply is connected, any 28-volt service may be operated if the 24-volt battery switch is ON. No. 1 and 2 rotary transformer switches must be OFF.

18 Starting the engines

(*a*) *Normal start using external power supplies*

(1) No. 1, 2 and 3 generators OFF, No. 4 ON
(2) No. 1 and 2 rotary transformers OFF, No. 3 ON
(3) 112-volts and 24-volts external supplies connected and ON
(4) 24-volt battery switch ON, indicator black, check busbar voltmeters
(5) No. 2 inverter ON
(6) Instrument master switch ON
(7) Engine master cocks ON. Indicators black
(8) Select fuel tanks for starting
(9) Engine selector switch to required engine (No. 3 first)
(10) Generator voltmeter rotary switch to required generator (No. 3 first)

(11) Engine start master switch to START

(12) Press starter button and check green light on

(13) HP cock open

(14) JPT and oil pressure normal, generator voltage 110-volt (approx.) fire warning light out

(15) Repeat (9), (10), (12), (13) and (14) for remaining engines

(16) Start master switch SAFE

(17) No. 4 generator ENGAGE button pressed and held in whilst external power is disconnected, warning light out. No. 3 rotary transformer on line, warning light out

(18) 96-volt battery switch ON, indicator black

(19) Generators No. 1, 2 and 3 ON and ENGAGE, warning lights out

(20) Rotary transformers 1 and 2 ON, warning lights out

(*b*) *Using internal batteries*

(1) All services selected OFF

(2) If ambient air temperature is below 5°C, pre Command Mod. 61, fuses Z10, Z11 and Z12 removed ; post Command Mod. 61, artificial feel unit heater switches OFF. (Port console panel door.)

(3) Helmets off

(4) All generator and rotary transformer switches OFF

(5) 24-volt battery switch ON, indicator black

(6) 96-volt battery switch ON, indicator black

(7) No. 3 engine master cock ON, indicator black

(8) Fire warning lights, test

(9) Instrument master switch ON

(10) Select one booster pump for starting, check fuel low pressure warning light out

(11) Starter master switch to START

(12) Engine start selector switch to No. 3

(13) Generator voltmeter rotary switch to No. 3 generator

(14) Press starter button and check green light on

(15) HP cock open

(16) Check JPT normal, generator voltage 110-volts (approx.), fire warning light out

(17) No. 3 generator ON and ENGAGE, No. 3 rotary transformer ON, warning lights out

(18) No. 2 inverter ON

(19) Oil pressure normal

(20) I/C ON, helmets on

(21) Select remaining engines master cocks ON, indicators black

(22) Select additional booster pumps as required, check fuel low pressure warning lights out

(23) Open up No. 3 engine to 6,500 RPM

(24) Select No. 2 engine, No. 2 generator voltmeter and start normally

(25) JPT and oil pressure normal, generator voltage 110-volts (approx.), fire warning light out

(26) No. 3 engine to 3,000 RPM

(27) No. 2 generator ON and ENGAGE, warning light out

(28) No. 2 rotary transformer ON, warning light out. Complete functional checks

(29) No. 2 and 3 engines to 5,000 RPM

(30) Select No. 1 engine, No. 1 generator voltmeter and start normally

(31) JPT, oil pressure normal, generator voltage 110-volts (approx.), fire warning lights out

(32) No. 1 generator ON and ENGAGE, warning light out

(33) Select No. 4 engine and No. 4 generator voltmeter, and start normally

(34) JPT, oil pressure normal, generator voltage 110-volts (approx.), fire warning light out

(35) No. 2 and 3 engines select 3,000 RPM

(36) No. 4 generator ON and ENGAGE, No. 1 rotary transformer ON, warning light out

(37) Pre Command Mod. 61, fuses Z10, Z11, Z12 replaced. Post Command Mod. 61, artificial feel unit heaters ON

19 Generator control

(*a*) Before starting the engines, switch ON No. 4 generator and ensure that the remaining ones are set to TRIM or OFF. As each engine is started select the voltmeter to the associated engine and monitor the generator output which should stabilise at approximately 110-volts. When all engines are started press the No. 4 generator ENGAGE button and hold it in while the external power supply is disconnected. Check the warning light out. Select and engage the remaining generators in turn at approximately 110-volts.

(*b*) (i) In order to avoid damage to contacts of generator interlock relays and circuit breakers, switching on and off of generators in flight, particularly at high altitudes, should be avoided. Switching should only be carried out in case of emergency or during essential flameout and relighting procedures. The AEO must be informed of any intentional or unintentional flameouts, and the appropriate generator should be switched OFF as soon as possible. If the engine is relit the generator should be brought back onto line when the output registers 110-115 volts and before the throttle is opened beyond idling.

(ii) The generators automatically come off-line if they fail or are overloaded. If a generator fails, the circumstances of the failure should be noted and the appropriate action, as shown in Part V, paragraphs 13, 14 and 16, taken.

(*c*) In the event of generator failure, refer to the load shedding drills set out in Part V, para. 13, 14 and 16 and in the Flight Reference Cards.

NOTE: If all four generator fuses rupture through an overload condition, the warning lights will not come on. This wil be indicated by the busbar voltage falling to the battery potential and, Post-Mod. 2454, by the ammeters reading zero. In this case the overload will be applied to the battery which will rapidly discharge.

20 Rotary transformer control

(*a*) The rotary transformers are manually controlled by operation of the ON—OFF OR RESET—TRIM control switches on the generator control panel. The 112-volt busbar must be energised by an external supply or the aircraft generators before the transformers can be run (the 96-volt battery must not be used to run the transformers). When the 112-volt busbar is energised and the 24-volt battery switch is ON, each rotary transformer will start up as its switch is put ON.

(*b*) When a 28-volt external supply is connected, No. 1 and 2 rotary transformers must be switched OFF ; No. 3 can be ON and it will come on line when the external power is removed.

(*c*) If a rotary transformer failure warning light comes on, it indicates that the transformer has gone off line due to failure or temporary overload. An attempt may be made to bring the transformer back on line by moving the control switch to OFF OR RESET and after *ten seconds* to ON again. A second attempt may be made if necessary but this time an interval of *one minute* must be allowed. No further attempt to reset may be made. If the failure warning light goes out the transformer is back on line. If the light stays on the switch should be put to OFF OR RESET and left.

(*d*) If two rotary transformers come off line simultaneously, the cause is probably the over-volting of the remaining transformer. Check the voltage of the remaining transformer ; if it exceeds 29 volts it must be switched OFF. The two remaining rotary transformers should then come back on line. Great care must be taken if this fault occurs. Any serious over-volting of a transformer may "boil" the 24-volt battery ; if this battery fails there will be no supply to re-connect the remaining transformers to the busbar.

(*e*) In the event of rotary transformer failure refer to the load shedding drills in Part V, para. 15 and 17.

21 Inverter control

(*a*) Before the engines are started the instrument master switch must be put ON. The instrument inverter (Type 100A) should then start.

(*b*) When the engines have been started and the generators and rotary transformers are on line, the Types 350 and 153 inverters can be started by means of their respective switches on the radar control panel. The 1,600 CPS loads must all be OFF while the inverters are started but the 400 CPS loads can be on. The 1,600 CPS must not be switched ON until voltage and frequency control are established, i.e. about 10 seconds after starting the inverters. When the inverters are functioning correctly their associated green and neon lights, adjacent to their control switches, will be on.

(*c*) If the Type 350 or 153 inverters are run for more than a few minutes on the ground, without ground cooling equipment, if the ambient air temperature is above 85°F, inadequate cooling may cause frequency fluctuation with consequent tripping of the equipment fed by these inverters.

(*d*) If the instrument inverter (100A) fails, its red warning light on the navigator's panel will come on. The No. 2 Type 350 inverter will already be running and will automatically take over the 100 A's load (the artificial horizons). If required, an attempt may be made to restart the 100A by removing and replacing fuse D91. The instrument master switch should not be switched off in the air. If the inverter starts up it will automatically retrieve the load of the artificial horizons from the No. 2 Type 350 inverter. If the inverter does not start up again, the fuse must be removed and left out.

(*e*) Mod. 2982 introduces POWER FAILURE indicators (AC voltmeters) in the Mk. 4B compass and artificial horizon circuits and an associated change-over switch (see Part I, para. 61(*a*)(iii)). If the artificial horizon indicator verges on or enters the red sector, it indicates that the output of the instrument inverter (100A) is too low for satisfactory operation of the artificial horizon. The automatic change-over switch may have operated, transferring the load to No. 2 radar inverter. If the automatic change-over switch has failed to function, setting the switch by the power failure indicator to EMERGENCY should cause the No. 2 radar inverter to take over the supply to the artificial horizons. If the Mk. 4B compass indicator verges on or enters the red sector, it indicates failure of the No. 2 inverter; in this event No. 3 inverter should be started up and set to No. 2 FAIL, when the supply to the compass should be restored.

(*f*) If any of the Type 350 inverters fail completely, their associated green lights will go out ; if only the 1,600 CPS side fails, the neon lights, and normally the green lights as well, will go out. To distinguish between these failures all equipment fed by the inverter should be switched off ; if the green light stays out it indicates failure of the inverter. If the green light comes on again it indicates failure of part of the equipment ; the various parts should then be switched on in turn until the failed part is identified by the green light going out again. The failed part should be switched off and left off.

(*g*) In addition to the inverter and 1,600 CPS failure lights, four neon lights on the radar panel indicate correct functioning of the A and C phases (phase B is earthed in the 400 CPS supplies to the H2S and NBC equipment). These go out if the relative phase or associated inverter fails.

22 Type 350 inverter change-over (standby supply)

(a) If either No. 1 or No. 2 Type 350 inverter fails, No. 3 Type 350 inverter can be made to take over the failed inverter's load by:

(i) Switching the failed inverter's loads OFF

(ii) Switching the failed inverter OFF

(iii) Switching No. 3 Type 350 inverter ON

(iv) Switching the EMERGENCY switch on the radar control panel to the No. 1 FAIL or No. 2 FAIL position (No. 3 will automatically discard its own load).

(v) Switching the failed inverter's loads ON

(*b*) If, when it fails, No. 2 inverter is supplying the artificial horizons due to failure of the instrument inverter, No. 3 inverter when switched to No. 2 FAIL will supply the artificial horizons as well as the No. 2 inverter load.

(*c*) If No. 2 inverter fails whilst the JET PIPE TEMPERATURE control switch is selected to NORMAL and the engines are operating at high RPM, a temporary loss of power on all engines may be experienced due to over-action of the JPT controller when the load is transferred to No. 3 inverter. To obviate this loss of engine power, the JET PIPE TEMPERATURE control switch should be selected to ISOLATE if No. 2 inverter fails. Switch ON No. 3 inverter, switch the EMERGENCY switch to the No. 2 FAIL position, and wait approximately 30 seconds before returning the JET PIPE TEMPERATURE control switch to NORMAL.

(*d*) If the Type 153 inverter fails, there is no warning light indication of inverter failure. The inverter failure would be indicated by failure of the Green Satin/GPI Mk. IV.

(*e*) If the Type 153A inverter (Mod. 2756) fails, the green light by its control switch will go out. The No. 3 Type 350 inverter may be used to supply the 153A inverter's load.

23 Action in the event of power failure

For action to be taken in the event of generator or rotary transformer failure, also bus-bar shorts to earth, see Part V, para. 13 to 17.

24 Electrical equipment restrictions

(*a*) *Undercarriage*

(i) *Normal operation*: The normal undercarriage motors may be operated five complete cycles consecutively, but this must be followed by a minimum cooling time of 30 minutes before further operation. Alternatively they may be operated one complete cycle every 10 minutes continuously.

(ii) *Emergency operation*: If the emergency motors have been used to lower the undercarriage, no attempt must be made to retract it owing to the possibility of damage to the undercarriage and motors.

(*b*) *Flaps*

(i) *Normal operation*: The normal flap motor may be operated three complete cycles consecutively, but this must be followed by a minimum cooling time of 30 minutes before further operation. Alternatively it may be operated one complete cycle every 15 minutes continuously.

(ii) *Emergency operation*: A minimum of 60 minutes must be allowed between each cycle of the emergency motor.

(*c*) *Bomb doors*

The bomb doors may be operated five complete cycles consecutively, but this must be followed by a minimum cooling time of 30 minutes before further operation. Alternatively, they may be operated one cycle every 10 minutes continuously.

(d) Air brakes

The air brakes must not be used more than three complete cycles in 15 minutes, except in emergency.

Management of the Hydraulic System

25 Normal operation

(*a*) Check that the brake change-over lever is selected to starboard—anti-skid on.

(*b*) When the engines are running check that the pressure gauges on the starboard quarter panel all read between 1,900 $^{+0}_{-200}$ and 2,300 ±50 PSI.

(*c*) While taxying, when the brakes and steering are being used, check the indications of the magnetic indicators on the port coaming panel ; they should show alternately white then black as the pumps are switched on and off by the pressure switches.

26 Standby operation

If No. 1 pump has failed, indicated by its indicator remaining white when the pressure in the service falls below 1,900 $^{+0}_{-200}$ PSI, and the brake accumulators are discharged, or if the anti-skid units fail, the brakes may be operated from No. 2 service by putting the change-over cock on the rear face of the central pedestal over to port. The brakes will then be operated from No. 2 service in the same way as from No. 1 service, but the supply is taken direct to the brakes from the control valve, by-passing the anti-skid units.

NOTE: While taxying, prior to take-off, the change-over cock should be put over to port and the brakes applied gently to check that the No. 2 service is functioning correctly. Apart from this check the change-over cock must not be put over to port while No. 1 pump is functioning or while there is pressure in the No. 1 service accumulators, otherwise harsh braking may ensue. For this reason, the brakes must be applied with care when checking the functioning of the No. 2 service.

27 Towing

Before the aircraft is towed check that an external 112-volt supply is plugged in the socket in the nose-wheel bay and that the 96-volt and 24-volt aircraft battery switches are at OFF.

Engine Handling

28 General

(*a*) Unless Avon Mods. 1900 and 1924 are embodied, when running engines on the ground, either singly or in pairs, RPM of between 6,300 and 6,700, and also between 7,300 and 7,700 must be avoided.

(*b*) The engines incorporate automatically variable intake guide vanes which, with an accelerator control and fuel flow control, help to give satisfactory operation of the engines throughout their speed range. The throttles should, however, be handled smoothly. Slam accelerations are likely to result in compressor stalling and flame extinction, and must be avoided. In the event of a baulked landing, the engines will accelerate satisfactorily from idling RPM provided that the throttles are opened smoothly, but maximum acceleration will not be obtained if RPM are below 4,500.

(*c*) If Avon Mod. 1222 is not fitted to Avon 204 engines, RPM are to be regulated in relation to the outside air temperature. They are to be reduced below maximum RPM by 100 for each 5°C below −45°C. For instance the maximum RPM to be used at a temperature of −75°C would be 7,400. The temperatures quoted above are true temperatures.

NOTE: The object is to restrict the rpm to a maximum $\frac{N}{\sqrt{T}}$ value of 510, where T is the engine intake temperature.

29 Climbing

The RPM tend to creep slightly on the climb and should be adjusted with the throttles. At intermediate power above about 40,000 feet it will be necessary to adjust the throttles to keep within the JPT limit: this is not necessary when the fully automatic JPT control units are fitted. Under asymmetric conditions at low power, and particularly at higher airspeeds, there is a slight tendency to engine air intake buffeting, but this may be disregarded.

Management of Thrust-Augmenting Systems

30 Deleted

31 Water-methanol system

(a) Checking before flight

The correct functioning of the air shut-off cocks should be checked as follows:

(i) Open Nos. 1 and 4 engines to 5,500 RPM, select the water-methanol master switch ON and check that the red indicator lights come on.

(ii) Switch the master switch OFF and check that the lights go out.

(iii) Throttle back to idling RPM.

(b) Operating the system

(i) The time, during the take-off, at which the water-methanol system must be switched on, is determined by the aircraft weight and the runway and weather conditions (see Part IV, para. 5). To start the system, switch on the master switch and check that both indicator lights come on, then check that RPM on all engines rise to about 8,300 within 3 seconds. (In tropical conditions RPM may not rise above 8,250.) After about 45 seconds the water-methanol will be shut off and RPM will rapidly drop to 8,000. As soon as this occurs the master switch must be switched off and the indicator lights checked out.

(ii) If an indicator light does not come on when the master switch is set on, failure of an air shut-off cock to open is indicated and water-methanol injection will not be available on either engine on that side. If, nevertheless, the RPM rise normally, failure of the light may be assumed. If the lights come on but RPM fail to rise on any engine, failure of a pump, an engine minimum speed switch or a water-methanol shut-off cock is indicated. If the system fails to function correctly the take-off may have to be abandoned (see Part V, para. 1 *(a)*.

(iii) If an indicator light fails to go out when the system is switched off, failure of an air shut-off cock to close is indicated. If this happens both engine gate valve switches on that side must be set to EMERGENCY CLOSE and left there for the remainder of the flight. In this event the air supply to the cabin may be affected and there will be no anti-icing supply to the wing on that side ; the air supply for bomb bay heating and tail unit anti-icing will also be affected.

(iv) Water-methanol injection may be stopped completely at any time by switching off the master switch. It may also be stopped to any individual engine by closing the throttle to below the minimum speed switch operating RPM of 6,700 to 7,500. In the event of engine failure, injection to that engine will automatically stop; in this case the time of injection to the other engines will be increased by a third of the time of injection remaining at the time of engine failure.

(v) Some idea of the RPM at which the engine minimum speed switch operates may be gained from the following figures which are approximate:

6,700 RPM at 0°C Sea level
6,900 RPM at +15°C Sea level
7,250 RPM at +45°C Sea level
7,500 RPM at +45°C 5,000 feet

Management of the Engine Anti-Icing System

32 General

Should icing conditions be met in flight, climb or descend out of the icing. The anti-icing system is a means of protection during climb and descent. It should not be used above 30,000 feet and is not to be used for long periods in level flight.

33 Taxying and take-off

(*a*) The engines are susceptible to icing at low power when taxying and at high power on take-off, when the temperature is less than +4°C and the relative humidity is 95% or more. As a guide, when the visibility is less than 1,000 yards in fog or mist it can be assumed that the humidity is at least 95%.

(*b*) The engine anti-icing system should be used as follows for taxying and take-off.

(i) When the temperature is +4°C or less and the visibility is 600 to 1,000 yards, the engine anti-icing should be switched on for taxying, and also for take-off if the available runway length is sufficient. If the runway length is insufficient, the engines should be run with the engine anti-icing on for one minute at 6,000 to 6,500 RPM. The engine anti-icing should then be switched off and the take-off commenced as soon as possible after allowing 15 seconds for the anti-icing gate valves to close. As soon as practicable after take-off the anti-icing should be switched on again and used until clear of the icing range.

(ii) When the temperature is +4 to −5°C and the visibility is less than 600 yards, the engine anti-icing must always be used for taxying and take-off. If in these circumstances the runway length is insufficient, the take-off may be made as in (i) above only if the circumstances warrant a calculated risk of this nature.

(*c*) If engine anti-icing is used on take-off, reference is to be made to the Operating Data Manual for take-off performance corrections.

(*d*) The use of engine anti-icing causes an increase of JPT's of up to 30°C under ISA conditions. However, since JPT's are sensitive to intake temperature, i.e. if the intake temperature is low the JPT will be proportionately lower, it is unlikely that the use of anti-icing will critically affect JPT's in the conditions where use of anti-icing is necessary. The possibility of high JPT should nevertheless be borne in mind when assessing the adequacy of available runway length.

34 Climbing

Climb in the normal manner, but it will be necessary to throttle back sooner than with the system not in use, to maintain the JPT within limits. When clear of icing conditions switch the anti-icing system off and wait about 10 seconds before making any large throttle adjustments.

35 Descending

(*a*) During descents with anti-icing on, RPM must not be allowed to fall below 6,000, and in very severe icing a minimum of 6,600 RPM must be maintained otherwise surging or flame-out may result due to insufficient heat to the anti-icing system. When clear of icing conditions switch the anti-icing system off and wait about 10 seconds before making any large throttle adjustments. Check the engine response before approaching to land.

(*b*) Should conditions demand the use of anti-icing down to aerodrome level, engine RPM must not be allowed to fall below 6,000 until the pilot is finally committed to a landing. In the event of an overshoot, the throttles must be opened smoothly. Full power may be used but, whenever possible, RPM should be restricted to 7,600.

Management of the Airframe Anti-Icing and Bomb Bay Heating Systems

36 Limitations

(*a*) If Mod. 1522, 2183 and 2392, as well as Mod. 1548 *or* 1549 *or* 1550 are embodied, the airframe anti-icing system may be used in emergency only. If these Mods. are not fitted the system must not be used.

(*b*) If, in addition to the above, Mod. 925 *or* 2108 is embodied, the airframe anti-icing system may be used for short periods (up to 20 minutes) during crew training. Only one such period is allowed per sortie, and it should be towards the end of the sortie. Practice overshoots with the system operating should normally be limited to 7,600 RPM, though higher RPM may be used if necessary.

(*c*) It should be noted that when the airframe anti-icing system is on, the engine anti-icing system will also be on. The limitations and precautions detailed in para. 32 to 35 must be observed.

37 Use of the airframe anti-icing system

(*a*) For the system to be operative the gate valve switches on the starboard quarter panel must be at NORMAL, the engine and airframe de-icing master switch on the starboard console panel must be ON, and the airframe supply isolating switches on the starboard console panel must be at NORMAL. The system then functions automatically by thermostatic control. Warning of overheating will be given by one of the three overheat warning lights on the starboard console panel. When one of these lights comes on, the appropriate isolating valve must be closed. In addition, if overheating occurs in the wing anti-icing system, the appropriate isolating valve will close automatically until the temperature drops sufficiently. If an overheat warning light stays on after the appropriate isolating valve has been closed, the appropriate engine gate valves must be set to EMERGENCY CLOSE. It must be remembered that when this is done the air supply to the cabin and to the bomb bay heating system will be affected.

(*b*) If the MASTER switch is put OFF while the isolating valve switches are at NORMAL, the isolating valves will automatically shut. They will open again, however, when the MASTER switch is put ON, unless the switches have in the meantime been set to OFF. If Mod. 701 (WP214) is not fitted, the isolating valves must be shut *before* the MASTER switch is set OFF.

(*c*) Whenever the system is used the fact must be recorded in the appropriate after-flight certificates and the necessary inspections of the system carried out.

37A Management of the modified anti-icing system

(*a*) The system may be switched ON for an unlimited time with the aircraft stationary provided that the following RPM/OAT limits are not exceeded:

4,600 RPM/15°C
4,000 RPM/30°C

For ground test purposes it is permissible to carry out a short duration run, not exceeding 10 seconds, up to a maximum of 6,800 RPM.

(*b*) If icing conditions prevail at the start of a sortie the engine system may be selected ON prior to take-off but the airframe system should not be selected ON until after take-off, about the time when undercarriage is raised.

(*c*) In the air the system should, ideally, be selected ON several minutes before entering icing conditions. This can be done before entering cloud, if icing conditions are forecast or anticipated. The system should, in any event, be selected ON if local icing conditions or the formation of ice on the windscreen pillars are noticed by the pilot.

(*d*) The system may be left ON until after landing provided that it is switched OFF before *taxying* or using high engine RPM on the ground.

(*e*) The loss of thrust due to selection of the system is as follows:

Engine system . . .	1,050 lb per engine
Airframe system . . .	310 lb per engine

The loss of take-off performance with the engine system ON is an increase of ground run of about 8%.

(*f*) If Mod. 3132 is not embodied the anti-icing system may only be used in emergency. Above 20,000 feet four gate valves may be opened; below 20,000 feet only two gate valves may be opened. There is no restriction on RPM.

38 Use of the bomb bay heating system

(*a*) *General*

The bomb bay heating system should be used whenever the aircraft is flying in ambient temperatures below +5°C. When the indicated bomb bay temperature on the ground is less than +15°C, the bomb bay heating system shut-off valve switches should be switched on after starting the engines. Subsequently, these switches should be operated *together* to maintain the bomb bay temperature between +5°C and a maximum of +30°C to provide optimum conditions for the aircraft batteries.

(*b*) *PR role*

When operating in the PR role, the bomb bay temperature should be kept as near as possible to +17°C, and it is essential that both switches are used together so as to avoid uneven heating. In practice it has been found that the system should be switched on during the climb as soon as the temperature has dropped to +17°C and should be switched off on the descent as soon as the temperature rises to +17°C. If the temperature on the ground is less than +17°C, the system should be switched on after starting the engines.

(*c*) When carrying the 10,000 lb MC Mk. 1 bomb, the bomb bay heating system must be used to keep the temperature within the limits of 0°C and +30°C.

Management of the Pressurising and Cabin Heating System

39 General

Unless one or both of the cabin air supply switches (H/5) is on, there will be no air coming into the cabin. The engine gate valve switches on the starboard quarter panel must also be on ; they are normally left on at all times except in the event of operational damage, or if it is necessary to cut off all the air supply to the cabin.

40 Take-off and climbing

Before take-off select ram air OFF and set the cabin pressurisation switch (H/4) to CRUISE or COMBAT. After take-off switch ON one or both of the cabin air supply switches, and use the cabin temperature control switch (H/12) to obtain the desired temperature. It is recommended that only one valve should normally be used, a change-over being made for a short time during the climb to check the functioning of the other half of the system. A warning bell rings if the cabin is not being pressurised as the aircraft climbs to about 10,000 feet with the pressurisation switch set to CRUISE, or 26,000 feet with the switch set to COMBAT.

41 Cruising and descent

For cruising, one or both of the cabin air switches may be used, according to requirements. One is adequate for pressurising and heating, but two may be needed at high altitude to prevent windscreen icing, and both should be on for at least 15 minutes before starting a descent, to prevent misting during the descent. To de-pressurise, set the pressurisation switch to NO PRESSURE and set the cabin air switches to OFF.

42 Flood flow system

(*a*) If Mod. 2057 and 2386 are not embodied, the fuse in the flood flow system is not normally fitted and the system will not operate. For certain flights, if it is considered that flood flow protection may be required and the fuse is therefore fitted in spite of the above Mods. not being embodied, the aircraft must not be flown unpressurised above 20,000 feet. When Mod. 2057 and 2386 are embodied, the system will not operate, whatever the cabin altitude, if either emergency depressurising control is operated or if the cabin pressure selector switch is selected to NO PRESSURE. Flood flow *will* operate, however, if the selected control (or controls, if more than one has been selected) is subsequently returned to normal when the cabin altitude is at or above 29,000 feet unless fuse D60 has been removed. It is usual to descend to 26,000 feet before re-selecting CRUISE or COMBAT after a practice de-pressurisation.

(*b*) After the flood flow system has operated, to ensure the minimum loss of performance the following drill should be carried out:

(i) Instruct the crew to use the leak stoppers as necessary

(ii) Select the cabin pressurisation switch to COMBAT

(iii) Hold one INCREASE/DECREASE switch to DECREASE endeavouring to stabilise the cabin altitude at 25,000 feet, as shown on the cabin pressure altimeter.

(iv) During the descent the procedure detailed in (iii) above should be repeated frequently. It may become necessary to use both INCREASE/DECREASE switches to achieve the required conditions as altitude is reduced.

(v) At 25,000 feet the flood flow system should be shut off by use of both INCREASE/DECREASE switches.

NOTE: If the damage to the pressure cabin is such that the flood flow system will not maintain sufficient pressure, it will not be possible to stop the bell ringing.

Management of the Powered Flying Controls

43 Starting and testing the controls

(*a*) Check controls locked.

(*b*) Ensure 112-volt external supply is connected or that the generators are on line.

(*c*) Select the instrument master switch to ON and release.

(*d*) Engage control hand-wheels and adjust for reach.

(*e*) Exert a backwards and forwards force on the control column and check that the out of trim warning lights flash on and off.

(*f*) Manual trimmer master switches ON.

(*g*) Check manual trimmers for full travel and leave at neutral.

(*h*) Check artificial feel cut-off levers forward, operate artificial feel trimmer over one division each way, leave at neutral.

(*j*) Unlock the flying controls by moving the controls locking lever on the centre pedestal fully forward until it is engaged in the catch.

(*k*) Check all four control failure warning lights on.

(*l*) Check manual control operation over full travel, all main control surfaces.

(*m*) Select instrument master switch ON and check that all four failure warning lights go out.

(*n*) Post-Mod. 2006 or 1617, press to test the master warning light.

(*o*) Test the controls for full and free movement, at the same time check that the desynn indicators function correctly. Correct sense movement may be confirmed with the ground crew.

(*p*) Trip all four power control motors with the trip buttons on the port coaming panel and check that all four individual lights come on. If the controls are not exercised it will take approximately 12 seconds for the hydraulic pressure to dissipate and the lights to come on.

44 Deleted

45. Locking the controls

The controls must never be locked while there is pressure in the power controls system otherwise damage may result. To lock the controls first trip all four power control motors. Centralise the controls and when all power control failure warning lights come on pull back the locking lever fully. Check that the controls are locked by lightly trying to move them. The controls may be locked during the landing run if desired, once the aircraft is firmly on the ground.

Management of the Variable Incidence Tailplane

46. General

When trimming, the selected incidence switch and the adjacent master switch must be operated and released simultaneously. The master switch must not be held on in anticipation of trimming.

47. Testing before flight

Before take-off the system is to be tested for a live circuit by operating each switch separately, on each handwheel in turn, with the 1st PILOT – 2nd PILOT changeover switch set as appropriate. The actuator should not operate when any one switch is operated under any conditions. The actuator should then be checked for correct functioning by operating both switches together in both directions, first on one handwheel and then on the other, and using both the COARSE and the FINE motors. While these checks are being made, all switches should spring back freely to the central position. The aircraft must not be flown if a live circuit is proved when any one switch is operated alone, or if the tailplane operation is faulty.

48. Testing in flight

The circuits should be checked for a live circuit periodically in flight as described above. If a live circuit is proved, no further attempt must be made to trim in either direction, on either motor, or from either handwheel, and a landing should be made as soon as possible.

Management of the Auto-Pilot

49. Limitations

The limitations to be observed when the automatic pilot is being used are:

(*a*) Maximum airspeed 340 knots I.A.S.
Maximum Mach No. ·82 I.M.N.
Minimum altitude 1,000 feet A.G.L. (except on auto-approach (see Part III, para. 54) (*c*).)

(*b*) The auto-pilot *must not* be engaged if feel trim has been disengaged.

(*c*) When flying in manual control, the control forces are such as to cause the torque limiting switches to cut out the auto-pilot. No attempt should therefore be made to use the auto-pilot when flying in manual.

(*d*) The auto-pilot must not be used at night until the "on" segments of the power and engage magnetic indicators are modified to black and white stripes, and white respectively so that they can be seen under red light.

(*e*) When the bombing coupling unit (N.B.S. link) is used, the following limitations must be observed:

(i) For turns through more than 20 degrees in heading, the coupling unit must be disengaged.

(ii) The height lock must be disengaged if a pitch oscillation develops.

(*f*) Longitudinal trim must be maintained within ¾ of the fixed white sector on the auto-pilot trim indicator.

(*g*) The change of trim on operation of the airbrakes may be sufficient to trip the auto-pilot elevator cut-out, and should be anticipated on the tailplane trimmer.

50. Pre-flight checks

(*a*) Ensure No. 2 radar inverter is running.

(*b*) Pull out the POWER switch, wait approximately 60 seconds for the READY magnetic indicator in front of the switch to show black/white stripes.

(*c*) Switch IN the rudder, aileron and elevator channel switches.

(*d*) Check trim indicator within the centre $\frac{3}{4}$ of the white sector.

(*e*) Check aircraft controls unlocked and in "power".

(*f*) Auto-pilot heading selector synchronised.

(*g*) With the aircraft controls central, pull the engage switch and check that the IN indicator goes white and the READY indicator goes black; check on engagement if there is any apparent aileron movement. If there is, the aileron channel drift should be removed by re-alignment of the compass monitor as follows:

(i) Check Mk. 4B compass controller set to PORT.

(ii) Cage 1st pilot's Mk. 4B and adjust until stick movement ceases. (Increase compass reading if the movement is to starboard and vice-versa.)

(iii) Disengage the auto-pilot and re-synchronise the 1st pilot's Mark 4B compass.

(iv) Re-engage the auto-pilot.

(*h*) Press lightly on all three controls to check that the auto-pilot is properly engaged.

(*j*) Press the cut-out switch on the 1st pilot's control wheel, check the controls become free, the IN indicator shows black and the READY indicator shows black/white stripes. Re-engage the auto-pilot. Repeat the check for the second pilot's cut-out switch.

(*k*) Check the operation of the excess torque cut-outs by applying a steady force to the relevant controls in both directions until the auto-pilot cuts out. Re-engage the autc-pilot.

(*l*) Test the rudder, aileron and elevator channel switches in turn by checking that selecting off disengages the associated control and causes the READY indicator to show black/white stripes and that re-selecting IN restores the previous condition.

(*m*) Check that movement of the pitch control switch forward and backwards produces corresponding movements of the control column.

NOTE: The control column will continue to move very slowly after releasing the pitch control.

(*n*) Check that displacement of the bank control knob produces movement of the control hand-wheel and rudder pedals in the correct direction. At the same time, check the operation of the roll error cut-out by operating the bank control in both directions to its full travel. The ailerons should start to move and then the aileron channel should cut-out in each case. Re-engage the auto-pilot.

(*o*) Check that forward and backward pressure on the control column produces corresponding nose-heavy and tail-heavy deflection of the trim indicators (both, if two are fitted).

(*p*) Push the POWER switch off.

51. Operation in flight

(*a*) *To engage the auto-pilot*

(i) Pull out the POWER switch and wait approximately 60 seconds for the READY magnetic indicator to show black and white stripes. Check that the three channel switches R, A and E are switched IN. Check that the trim indicator is within the centre $\frac{3}{4}$ of the white sector. Trim the aircraft to fly hands and feet off in the desired flight attitude and then pull the ENGAGE switch.

NOTE: If the trim indicator pointer is outside the centre $\frac{3}{4}$ of the white sector the auto-pilot must not be engaged.

(ii) Check that the IN magnetic indicator shows white, and the READY indicator shows black.

(iii) Check elevator trim.

(*b*) *To turn the aircraft*

Rotate the bank knob to the bank figure required; return the knob towards the central position as the new heading is reached. During prolonged turns there will probably be some loss of datum, with the result that when the turn knob is returned to the central position, the aircraft may over or under bank before finally assuming level flight. It is not necessary to re-set the heading selector except where specified in (*e*) below.

NOTE: If the auto-pilot is engaged while the bank control knob is in any position other than central, this control will be inoperative until it has first been returned to the central position.

(c) Climb or descent

Move the pitch control switch fore or aft as required to achieve a change of pitch attitude, release the control to maintain the new pitch attitude, then retrim the aircraft. Two rates of change of attitude are available. Initial movement of the pitch control against a weak spring will bring a slow rate into operation, while further movement against a stronger spring will bring a fast rate into operation.

NOTE: No attempt should be made to change the pitch attitude of the aircraft, when under auto-pilot control, by use of the tailplane trimmer.

(d) Manual operation of one or more control surfaces

Although any channel may be temporarily disengaged in straight and level flght, in no circumstances should a turn be initiated with the aileron channel disengaged. Also, should any one channel become inoperative because of some unknown defect, the auto-pilot is unserviceable and should immediately be disengaged. Disengage the channel or channels required by selecting off the appropriate switch or switches. To resume automatic control of the disengaged channels (if not more than two) select the appropriate channel or channels IN by the channel switch or switches. If all three channel switches have been selected off it will be necessary to re-engage by pulling out the ENGAGE switch when any one or more channel switches are IN.

(e) Use of the heading selector

The heading selector can be used for:

(i) Executing pre-selected turns. A desired heading can be pre-selected by the course-setting pointer and the aircraft can be turned on to that heading by pressing the pre-select turn button for at least one second.

(ii) Monitoring the aircraft heading in the TRACK phase of an automatic approach. The heading (QDM) of the runway should be pre-selected and the TRACK switch on the control unit then pulled.

(f) Barometric height control

(i) To engage the barometric height lock pull the ALT switch at the desired altitude. It is recommended that the height lock is engaged only after the aircraft has been trimmed in level flight: the auto-pilot should then hold the barometric height quite accurately, whereas if the height lock is engaged when the aircraft is climbing or descending the aircraft may hunt about the height selected, possibly to such an extent that the elevator cut-out is operated. Following rapid changes of height, time must be allowed (approximately one minute in level flight) for the follow-up mechanism to stabilise. If insufficient time is allowed it may be indicated by a " kick " on the controls as the follow-up mechanism attempts to return the aircraft to an incorrect datum.

NOTE: The rate of travel of the follow-up mechanism in the barometric height control is 5,000ft. per minute.

(ii) With the height lock selected the pitch control will be rendered inoperative at the slow rate position in either direction. To remove the barometric height lock, push in the ALT switch. The height lock will automatically release to the off position if the pitch control is moved to the fast rate position in either direction, or if the elevator channel is disengaged for any reason.

(g) Disengaging the Auto-pilot

To disengage, press either cut-out on the control wheels. Do not push off the POWER switch if the auto-pilot is to be used again, otherwise it will be necessary to carry out the full procedure as in *(a)* above instead of merely reselecting the ENGAGE switch on. Alternative means of disengaging the auto-pilot is to push off the ENGAGE switch on the control unit, or to switch off the three channel switches.

52 Checks before landing

Before landing, the auto-pilot power switch should be pushed off.

53 Emergencies

In the event of malfunctioning of the auto-pilot, it must be disengaged and corrective recovery action taken immediately. It is advisable not to snatch the controls. Do not re-engage the auto-pilot.

54 Automatic approach

(a) General

The ILS can be linked to the auto-pilot to provide an automatic approach down to an AAL of 200 feet. On some occasions, it may be found that full scale deflection of the ILS glide path needle occurs before 200 feet. If this occurs the approach cannot be continued with safety. The following range of approach speeds versus aircraft weight have to be used when approaches are continued down to 200 feet in order that the aircraft can be landed on the ILS touch down point.

110,000 lb and below	135 knots
100,000 lb and below	130 knots

(b) Initial approach

The aircraft should be manœuvred around the initial pattern by the normal auto-pilot controls at 15 knots above the recommended approach speed. Prior to turning on to the final approach, the runway heading, corrected for drift, must be set on the heading selector. When at an angle of less than 180 degrees to the final approach heading the TRACK switch on the auto-pilot controller may be pulled, and the aircraft will be turned automatically on to the centre of the ILS beam.

(c) Final approach

When settled on the centre of the beam, make any corrections necessary to the drift setting on the heading selector. When the glide path needle reaches the top of the circle, select 40 degrees of flap and trim. Speed will reduce to the final approach speed and when the glide path needle reaches the centre of the circle, pull the GLIDE switch on. It will be necessary to follow up the flap selection immediately on the tailplane incidence control, in order to keep the auto-pilot trim indicator in the centre. If the flap selection is not trimmed out, the out of trim loads on the auto-pilot will be sufficient to trip it. Lowering the flap should establish the required rate of descent without the necessity to make large adjustments to the power settings. The speed has to be held constant by use of the throttles throughout the approach and the trim indicator monitored frequently. The flight instruments and the ILS meter should be scanned as for normal instrument approaches to detect any malfunction of the auto-pilot. Should any malfunction be suspected, the auto-pilot should be tripped immediately and the approach continued manually, or broken off as required. The approach may be continued automatically down to an absolute minimum of 200 feet above runway level, or to the altitude when full-scale deflection of the glide path needle occurs if this happens higher than 200 feet.

(d) When the recommended break-off height is reached, the auto-pilot must be tripped. Below 200 feet the beam is likely to become unstable which will cause the aircraft to pitch nose up or nose down.

(e) If the recommended approach speeds have been used, no difficulty will be experienced in landing normally on the ILS touch-down point.

Management of the Auto-stabiliser

55 General

(a) The auto-stabiliser is necessary only above 30,000 feet. However, it is not necessary above this height when the auto-pilot is being used. It must not be used at the same time as the auto-pilot unless the rudder channel of the auto-pilot is switched off. However, it is preferable for accurate balanced flight to use the rudder channel of the auto-pilot rather than a combination of auto-stabiliser and auto-pilot. If the auto-stabiliser and auto-pilot combination is used co-ordinated turns will not be possible since the benefit of the auto-coupling will be lost.

(b) There is no indication that the auto-stabiliser is functioning other than the damping of oscillations (see para 56 *(d)* below). The auto-stabiliser will not function if the rudder power control system is not functioning, ie if the rudder has reverted to manual. No harm will be done if the auto-stabiliser is switched on with the flying control locks engaged.

56 Method of operation

The following procedure for using the auto-stabiliser is to apply:

(*a*) *Switching on and off*. Prior to switching on or off, the auto-stabiliser must be switched to "standby" for at least five seconds.

(*b*) *When to switch on*. During the checks after take-off the auto-stabiliser is to be switched to "standby." Subsequently, provided that the auto-pilot rudder channel is not in use, the auto-stabiliser can be switched on when required.

(*c*) *When to switch off*. Auto-stabiliser is to be switched to "standby" and then "off" during the descent prior to landing.

(*d*) *Testing*. To check the correct functioning of the auto-stabiliser after switching on, the oscillation following a kick on the rudder should damp out in one and a half cycles.

(*e*) *Emergency*. If it is necessary in an emergency to switch off the auto-stabiliser, switching to "standby" will de-clutch and disconnect the auto-stabiliser immediately.

Use of Ejection Seat Equipment

WARNING: The ejection seats must be rendered safe whenever the aircraft is on the ground by inserting the safety pins in the ejection seat sears and in the delay mechanisms. It is normally the signaller's responsibility to ensure that the pins are removed and stowed before take-off and replaced after landing.

57 Preparation for flight

The safety of the pilots on ejection depends primarily on their correct use of the equipment. The following drill should therefore be carefully followed when preparing for flight.

(*a*) On arrival at the aircraft, and before starting the internal checks, ensure that both ejection seats are safe.

(*b*) Before sitting in the ejection seats, check that the pin has been removed from both emergency oxygen bottles.

(*c*) Sit in the seat and adjust it for height.

(*d*) Connect the survival pack lanyard to the life-jacket left-hand webbing strap, ensuring that the lanyard passes *over* the parachute harness lower suspension strap.

(*e*) Secure the leg restraining straps below the knees, metal D-rings to the rear. Cross the leg pull-in cords above the snubbing units and pass one through each D-ring then lay the ends across the knees until secured as in (*g*) below.

(*f*) Fasten the parachute harness, ensuring that the waist belt passes *over* the survival pack lanyard and the shoulder straps pass *under* the life-jacket stole.

(*g*) Secure and adjust the safety harness, passing the metal ends of the shoulder straps through the loops of the leg pull-in cords. Take up the slack in the cords by pulling down through the snubbing units, but allow sufficient slack for full movement of the rudder bar.

(*h*) Connect the main and emergency oxygen tubes to the oxygen mask tube, ensuring that the emergency tube passes *under* the safety harness right shoulder strap. Connect the mask tube chain to the D-ring on the life-jacket.

(*j*) Connect the inter-comm lead.

(*k*) Carry out the pre-flight oxygen checks.

(*l*) Check that the seat is adjusted so that the top of the head is just touching the firing handle. Check that the firing handle can be reached with both hands together.

(*m*) Have the safety pins removed and stowed.

Use of swivel seats

58 Preparation for flight

(*a*) Check the contents of the assister cushion bottle.

(*b*) Remove the demand safety pin.

(*c*) Slacken all parachute straps fully and stow the straps in their stowages before entering the seat.

(*d*) Insert the leg straps into the QRB and have them slack.

(*e*) Connect the PSP lowering line.

(*f*) Fasten the seat lap strap.

(*g*) Check the operation of the seat swivelling and sliding action and check that the PSP lowering line does not foul the control handle.

(*h*) Connect the static line to the strong point on the seat.

(*j*) Put on the helmet, connect mask tube to the aircraft oxygen tube and plug in the mic./tel. lead.

(*k*) Connect the demand emergency oxygen tube.

(*l*) Check the intercomm and oxygen systems.

Part IV
HANDLING

Part IV

Handling

List of Contents

Part IV

Handling

Preliminary Checks

1 Preparation for flight

Carry out the Safety Checks, Internal Checks and Cockpit Checks in the Flight Reference Cards.

Starting, Taxying and Take-off

2 Starting the engines

NOTE: The normal starting order is 3, 2, 1, 4.

(*a*) Before starting confirm:

External supply, battery, generator and rotary transformer controls set as required by the method of starting (see Part III, para. 18).

Instrument master switch .	ON
Throttle/HP cocks . . .	Fully closed
LP master cocks . . .	ON
Fuel pumps	Two ON each side Fuel pressure warning lights out
Engine starter selector switch	To engine to be started
Engine starter master switch	START
No. 2 radar inverter . .	ON

(*b*) *Starting*

Press the starter button. Check that it remains in and that the green starting cycle indicator light illuminates. Without delay move the throttle/HP cock lever to the idling position (just through the gate). The engine should light up within four to eight seconds of pressing the starter button. Check that the fire warning light remains out and that the indications of oil pressure and JPT are normal. During the starting cycle the JPT may rise momentarily up to 660°C, but should not exceed 500°C when RPM have stabilised at the idling figure.

(*c*) When the engine reaches self-sustaining speed, or after 22 seconds (whichever is the less), the starter button should reset and the green indicator light should go out. However, the starter motor may not be operated again to start the remaining engines until starting cycle time of 36 seconds has elapsed.

(*d*) When all engines are idling normally return the starter master switch to SAFE.

(*e*) *Failure to start*

(i) After a failure to start, if the HP cock is closed without delay there should be no need to "blow through" the engine. If in doubt excess fuel may be removed by motoring over the engine in the same way as for starting, but with the HP cock closed and the starter master switch at ISOL.

(ii) When the engine start button is depressed, if the hold-in relay does not operate, no further attempt to start must be made and existing engines must be shut down immediately. External or internal power must be switched off and the engine start relays examined for overheating or fire.

(*f*) Carry out the Checks After Starting in the Flight Reference Cards.

3 Taxying

(*a*) The aircraft should always be taxied with the flying controls locked and with four engines running. If it is necessary to taxy with less than four engines running, all radar equipment load shedding should be carried out appropriately.

(*b*) On level concrete, 5,000 to 6,000 RPM on all engines will be required to start the aircraft moving. Once moving sufficient thrust for taxying on level surfaces may be obtained with all engines idling. Total fuel consumption while taxying with all engines idling is approximately 80 lb per minute.

(*c*) It is generally better to use the handbrake in conjunction with the nosewheel steering, since the toe brakes are quite sensitive, and uneven application will tend to interfere with the nosewheel angle selected, thus preventing continuous smooth taxying and putting unnecessary strain on the nosewheel unit. If the steering system becomes unserviceable, direction can be controlled without difficulty by using the toe-brakes independently, so achieving differential braking. Whenever toe-brakes are not being used, or not being applied, care must be taken that the weight of the feet is not on the toe-pedals, otherwise a small amount of brake will be inadvertently and continuously applied with consequent overheating of the brake units.

(*d*) As soon as possible check the operation of the 1st pilot's hand-brake. Whilst taxying check the brake systems as follows:—

(i) Co-pilot test hand-brake and toe-brakes on No. 1 system.

(ii) Check No. 2 system pressure and change to No. 2 system.

(iii) 1st pilot check toe-brakes.

(iv) Check No. 1 system pressure and change to No. 1 system.

Frequent checks of hydraulic pressures must be made whenever the aircraft is being taxied.

(*e*) When taxying in strong cross-winds, any tendency to weather-cock may be corrected by use of the nosewheel steering. Should it be necessary to taxy on icy surfaces, a marked reduction in nosewheel steering effectiveness must be anticipated, and directional control should be maintained by careful use of the toe-brakes.

(*f*) Owing to the tandem main wheel units, severe damage can be caused if the aircraft is allowed to pivot round one unit and great care must be taken to avoid this. The minimum turning circle that can safely be achieved is about 100 feet. These facts reinforce the recommendation to avoid use of toe-brakes with steering since if differential brake is applied in support of full nosewheel steering, the turning circle will be extremely small. When the aircraft is parked, deformation of the main wheel tyres produces " flats " in the tyre periphery. The extent of the flats will depend on the weight and the length of time the aircraft is parked. At high weights the flats can be of considerable size and in such cases, to avoid stresses due to shaking of the airframe, taxying should be cautious.

4 Take-off

NOTE: 1. The second pilot should operate the engine, undercarriage and flap controls and check for engine unserviceability; this will allow the first pilot to concentrate fully on the steering and subsequent take-off. Normally all changes in power, undercarriage and flap selection should be called by the first pilot and actioned by the second pilot.

NOTE: 2. Engine running on the ground at full power should be kept to a minimum.

(*a*) Carry out the Pre-Take-off Checks in the Flight Reference Cards.

(*b*) Align the aircraft on the runway and hold the hand-brake fully on ; leave the parking catch off. The brakes should be held by the right hand and the steering wheel grasped in readiness by the left hand.

(*c*) Open the throttles to 7,000 RPM, but avoid holding this power for longer that 5 seconds whilst the aircraft is at rest. Check that the JPT and oil pressure indications are normal, and that the throttles are synchronised. Poor throttle synchronisation may be an indication of swirl-vane malfunction. If an engine is suspect open it, together with the adjacent engine, to full power where de-synchronisation will be more evident. For a given RPM the throttle lever of a defective engine will tend to trail behind that of a serviceable engine. If throttle de-synchronisation is accompanied by a lower JPT than normal, or if there is any overspeeding, the take-off must be abandoned and the suspect engine stopped. In temperate climates, any JPT below 580°C at full throttle opening should be considered abnormal.

(*d*) Release the brakes and open the throttles. Check that the required RPM are obtained on all engines and that there is no over-speeding when full power is selected. Maintain directional control by use of the nosewheel steering until rudder control becomes sufficiently effective, normally 70 knots. Check acceleration during the take-off in accordance with previous calculations (see Operating Data Manual).

NOTE: As soon as possible during the take-off run a comparison check should be made of the air speed indicators.

(*e*) The following unstick speeds are recommended:

Take-off weight (lb)	Unstick speed (kts)
90,000	103
100,000	108
110,000	113
120,000	118
130,000	123
140,000	128
150,000	132
160,000	137
170,000	141
175,000	144

(*f*) The aircraft accelerates quite rapidly, particularly at medium and low weights. Care should be taken to avoid harsh backward movement of the control column which may result in the aircraft being pulled off the ground too quickly or in an exaggerated nose-up attitude. At about 25 knots before the unstick speed the control column should be eased back steadily in order to raise the nose-wheel at 10-15 knots before unstick speed and to fly the aircraft off the ground at the correct unstick speed. If the maximum safe angle of climb is required after take-off, speed should be allowed to increase to 20 knots above the unstick speed and this speed maintained until clear of any obstacles. For distance to unstick and to 50 feet see the Operating Data Manual.

(*g*) There is no difficutly in taking off cross-wind but pilots should be ready to counteract, on the steering, the tendency for the aircraft to turn into wind when the brakes are released ; also, the nosewheel steering should be used to control direction up to 90 knots before change is made to rudder control.

(*h*) *Safety speed*

There is very little tendency to swing after an engine failure and the safety speed will always be below the unstick speed. Action after an engine failure will depend on the speed attained and the available length of runway in which to stop. For refusal speeds, reference should be made to Part 2 of the Operating Data Manual.

5 Assisted take-off

(*a*) After aligning the aircraft on the runway open the throttles to 8,000 RPM against the brakes. To ensure that the extra thrust is not lost until after the aircraft has reached 50 ft., and depending upon the aircraft weight, runway slope and weather conditions, the water methanol master switch should be switched ON eight to ten seconds after releasing the brakes. After switching on, check that the indicator lights come on and that the RPM rise on all engines. The normal take-off technique should be used.

(*b*) The cutting in of the water-methanol is not very marked, and is unlikely to be felt, but the cut-out at the end of the time of injection is sudden and quite marked. As soon as water-methanol injection has ceased, the master switch must be switched off.

6 After take-off

When comfortably airborne apply the brakes for four seconds, release them and raise the undercarriage. When the undercarriage is locked up, select the required climbing power and raise the flaps as required. Speed must not exceed 190 knots before the flaps are fully raised. When it is necessary to turn after take-off before the flaps can be fully raised, the turn should be made at 180 knots with the flaps at 20°. In order to avoid an excessively steep climbing attitude being required to maintain speed below 190 knots until the flaps are raised, engine speeds may be temporarily reduced according to the AUW. Normal climbing power of 7,800 RPM should be set at weights above 130,000 lb, 7,600 RPM is recommended for weights below 130,000 lb and 7,400 RPM for weights below 110,000 lb. The change trim is the undercarriage retracts is negligible, but as the flaps are raised a fairly strong nose-up trim change should be anticipated and trimmed out by use of the TPI control. The final stage of flap travel is very slow and a particular check must be made to ensure that they are fully raised before increasing speed for the climb. Carry out the After Take-off Checks in the Flight Reference Cards.

7 Circuit practice

To prevent overheating of the electrical equipment involved and to allow cooling of brake components, the undercarriage and flaps should be left down when practising circuits. To avoid exceeding limiting speeds the engines should be throttled to about 7,200 RPM after take-off and the aircraft climbed at 160 to 170 knots.

Handling in Flight

8 Climbing

(*a*) On starting the climb, one or both of the cabin air supply switches should be switched on. Once the undercarriage and flaps are up, acceleration is fairly rapid and there is a progressive nose-up change of trim which should be countered with the TPI control. The aircraft is easy to trim on the climb and holds the trimmed speed well.

(*b*) For normal training purposes, climb at 250 knots until this speed is co-incident with 0·73M and thereafter continue to climb at 0·73M. The intermediate power setting of 7,800 RPM or 635·C JPT should be used but a limitation of 30 minutes continuous use must be observed. After 30 minutes engine speed must be reduced to 7,600 RPM or less. If, for operational purposes, maximum rate of climb is required, the following speeds and RPM should be used.

RPM	*Height (ft.)*	IAS	
		Below 130,000 *lb*	*Above* 130,000 *lb*
7800	SL	275	315
”	10,000	275	300
”	20,000	275	275
”	30,000	250	250
”	40,000	220	220
”	45,000	0·75M	0·75M

(*c*) The RPM tend to creep slightly on the climb and should be adjusted with the throttles. At intermediate power above about 40,000 feet it will be necessary to adjust the throttles to keep within the JPT limit.

9 General flying

(*a*) Unless otherwise determined by operational or training requirements, a normal cruising speed of 0·75M is recommended at heights where this does not exceed the maximum IAS limitations. At all times at least one pilot and one rear crew member must have their oxygen masks on and correctly fastened. Throughout the flight periodic checks must be made of each crew member's oxygen supply equipment, and the functioning and indications of all aircraft systems in use.

(*b*) The aircraft has no vices and is generally easy and pleasant to fly. Due to the artificial feel system the controls, despite being power-operated, have the inertia and response characteristics of heavy aircraft fitted with conventional controls.

(*c*) The artificial feel must always be engaged when flying with the power controls in operation, otherwise, due to the ability of the pilot to apply unrestrained power control the aircraft can very easily be overstressed even to the extent of a complete structural failure. The power control failure warning lights must be checked frequently in flight and if any of them come on the appropriate motor must be tripped without delay.

(*d*) At speeds up to about 200 knots all controls are reasonably light. As speed is increased they become progressively heavier until, near the limiting speed, only small aileron movements are possible and even gentle manœuvres require considerable pilot effort.

(*e*) The nose does not form a good reference point during turns, and initial movement of it is difficult to detect. Cross-reference with the flight instruments should be made to ensure that the required attitude is maintained during a turn. This is most important when turning at high Mach numbers (see Part IV, para. 13(*e*)).

(*f*) *Trimming*

(i) *Tailplane and elevator.* Longitudinal trimming, whether the power controls are *in or out*, is done with the variable incidence tailplane. Accurate longitudinal trimming takes some care, but when properly trimmed the aircraft holds its speed well. It will probably be found best to use the coarse motor for climbing, descents and circuits, and the fine motor for cruising. The elevator out-of-trim warning lights must be kept out at all times in flight, using the manual trim tab. The only exceptions to this are during turns and in flight in bumpy conditions when, provided the TPI is not being used to supplement stick movements, flickering of the lights can be ignored.

NOTE: To avoid strain on the actuator, tailplane trimming should not be achieved by a series of flicks on the control switches. Out-of-trim conditions should first be fully corrected with the stick and then the resultant load felt by the pilot trimmed out by a sustained application of the TPI control switches.

(ii) *Rudder and ailerons.* When flying with the power controls engaged, trimming of the rudder and ailerons is done by using the artificial feel trimmers. The manual trim tabs must not be used and should be left at neutral.

When flying in manual control trimming of the rudder and ailerons is done by using the manual trim tabs. The feel unit trimmers must not be moved.

(*g*) *Airbrakes.* The airbrakes are either in or out and have no alternative system. They may be operated at any speed. They are effective at high speed but at low speed little effect can be noticed. Extension of the airbrakes produces moderate buffeting at high speeds, the buffeting decreasing with lowering speed until below 150 knots it becomes insignificant. Airbrakes out produce a nose-up change of trim up to 0·8 M, decreasing to neutral at 0·84 M, thereafter becoming progressively nose-down. If during the operation of the airbrakes the circuit-breaker trips it may be reset after making an opposite selection with the airbrakes selector lever. If on the next operation the circuit-breaker is again tripped, further use of the airbrakes must be abandoned.

(*h*) *Changes of trim*

Lowering undercarriage . .	Negligible (but moderately heavy nose-up when in manual control)
Raising undercarriage . .	Negligible
Lowering flaps	Nose-down, strong between 15 and 25 degrees
Raising flaps	Strong nose-up
Extending airbrakes . . .	Strong nose-up (up to 0·8 M)
Retracting airbrakes . . .	Strong nose-down
Opening bomb doors . .	Slight nose-down
Closing bomb doors . . .	Slight nose-up
Throttling back . . .	Moderately light nose-down
Air spoilers out or in . .	Negligible

10 Flying in turbulence

(*a*) *Speed in turbulence*

In conditions of severe turbulence, speed should be maintained at about 220 knots up to 38,000 feet, reducing by four knots per 1,000 feet above this height. These figures apply at all weights.

(*b*) *Low altitude turbulence*

The aircraft is designed as a high altitude bomber and is not intended for prolonged low altitude operation. Flight at low altitudes, particularly in turbulent conditions or at high speed, must be kept to the minimum.

(*c*) *High altitude turbulence*

In cases of severe turbulence at high altitude (cobblestone effect), directional and lateral control becomes very difficult and use of aileron or rudder can readily result in the attempted corrections becoming out of phase with the oscillations, with consequent increase in amplitude of the aircraft motion. Flight in these conditions must not be continued and a gentle climb or descent should immediately be made to clear the turbulence, the vertical extent of which is normally very limited. Elevator control in these conditions remains satisfactory.

11 Stalling

(*a*) *Approximate stalling speeds* (knots)
Undercarriage up or down.

Weight (lb)	*Flaps up*	*Flaps 20°*	*Flaps 40°*	*Flaps 55°*
80,000	94	83	80	74
100,000	105	95	91	90
120,000	116	105	100	99
130,000	120	108	104	103
140,000	124	113	108	108
150,000	130	118	112	111
160,000	134	120	116	115
167,000	138	124	118	117

(*b*) Behaviour near and at the stall can vary slightly between individual aircraft and will also depend on weight, the configuration and the method by which the stall is executed. Nose and wing dropping and degree of buffet may be gentle or severe but in all cases the standard method of recovery will allow complete recovery in 800 feet or less. Airbrakes do not affect the stall, nor is the behaviour altered by the CG being forward or aft. The general characteristics of stalling are given below.

(*c*) *Undercarriage and flaps up*. Slight buffet begins some 12 knots before the stall. As the stick is pulled back and speed reduced there may be a tendency to lateral rocking which can be held with aileron; meanwhile the buffet will increase in intensity and can eventually become extremely marked with pronounced vertical shaking of the aircraft as the stall becomes imminent. As the aircraft stalls, the nose and probably a wing, normally the port, will drop; sometimes the wing-drop occurs just before the stall. Recovery is effected by relaxing the backward pressure on the stick, and levelling the wings ; the latter will probably require the use of rudder since the ailerons are not very effective near the stall. Buffeting will persist for a considerable period during the recovery.

(*d*) *Undercarriage and flaps down*. The undercarriage has no effect on the stall, but flaps, apart from reducing the stalling speed, also reduce the pre-stall buffet. With 30 degrees or more of flap, there is virtually no stall warning, and the first indication of the imminence of the stall will be a high rate of sink.

(*e*) *Stalling in turns*. If the aircraft is stalled during turns it will almost invariably roll out of the turn, and recover when the back pressure on the stick is released. Occasionally an aircraft will roll into the turn when stalled, but this is most likely to happen when the turn is being done at a very low speed. Recovery action as in (*c*) above is effective. The stall warning buffet occurs only a few knots above the stall and, again, flaps have the effect of reducing the stall warning.

(*f*) *Inadvertent stalling.* Inadvertent stalling is very unlikely to occur, since from straight and level flight the stalling attitude will be pronounced nose-up, which should be readily detected by one or other of the pilots on either the natural or the artificial horizon. In turning flight, considerable G will be required to stall the aeroplane unless the pilot is lax enough to have a very large angle of bank with little forward speed.

(*g*) *Practice stalling.* It is recommended that stalling practice is generally confined to the stage where the onset of buffeting or obvious lessening of lateral control is established. Relaxation of the backward pressure on the stick at this stage will allow recovery with small loss of height. Full stalling should be kept to the absolute minimum, so that severe buffet is avoided. Repeated buffet can cause damage to the airframe itself, as well as to the delicate radar and electronic equipment.

12 Application of G

At high altitudes the application of G induces buffeting which increases in intensity with G until a severe harsh shaking of the aircraft occurs. This harsh shaking can be encountered within the G limitations (Part II, para. 2 (*c*)) depending on aircraft weight, height and Mach number. If this severe shaking is encountered, G must be reduced immediately because of the risk of structural damage. Reference should be made to the Operating Data manual, Section 10, Fig. 1.

13 High speed flight

NOTE: The machmeter is subject to error and should periodically be checked against IAS and altitude (see Part I, fig. 17).

(*a*) The behaviour of the aircraft is quite normal when flying at high speed, within the limitations, at low altitudes. With increase in speed there is a progressive nose-up change of trim accompanied by increasing heaviness of the controls, especially the ailerons. Manœuvring becomes difficult at high speed and there is not much danger of the G limitations being exceeded through physical operation of the controls. The tailplane incidence control, however, will have a powerful effect especially if the coarse control is selected, and care must be taken in its use. If turbulence is encountered at high speed, shaking of the airframe is likely to be considerable and speed must be reduced to that quoted in Part IV, para. 10.

(*b*) It is possible to exceed the IAS limitations in level flight and if this is done inadvertently recovery should be made by first throttling back and then extending the airbrakes. When the airbrakes are extended near the limiting speed it will probably prove impossible to prevent the aircraft gaining 400 to 500 feet in height before sufficient control can be applied to regain level flight.

(*c*) *Trim change with Mach number.* As Mach number is increased to 0·8 there is a slight nose-up change of trim ; this trim change persists with increase in Mach number, being moderate above 0·8 M, until 0·84 M is reached when it suddenly becomes quite marked. Unless this sudden change is anticipated it may cause sufficient G to bring on severe buffet. Extension of airbrakes causes a nose-up change of trim which reduces to negligible effect at about 0·84 M. At 0·86 M the effect of airbrake extension is reversed, i.e. there is a nose-down change of trim. The rolling effect with rudder reverses above 0·82 M, i.e. left rudder causes the aircraft to roll to the right.

(*d*) *Buffet.* At 0·8 M compressibility buffet is just noticeable ; it becomes moderate with increase of speed, and will become severe with application of G. Flying in conditions of moderate or severe buffet should not be persisted in. The aircraft gains speed rapidly during a dive and it is easy to exceed the limit.

(*e*) *Turning at high Mach number*

Application of G when turning at Mach numbers over 0·78 M will produce buffet which, depending on weight and amount of G applied, may be severe enough to cause vertical shaking of the whole aircraft. If this severe buffet is encountered recovery must be made at once and repetition avoided otherwise structural damage may result. At speeds up to 0·72 M the aircraft can be stalled in a turn within the limitation of 2·5 G. Approach to the stall will be marked by buffet and at the stall the aircraft will pitch nose-up and roll out of the turn. If the nose is allowed to drop during a turn acceleration into buffeting conditions is fairly rapid. Should this happen recovery should be effected gently to avoid aggravating the buffet with application of positive G.

14 Bombing and astro-navigation

It is recommended that the auto-pilot be used to control the aircraft during bombing runs and whilst taking lights for astro-navigation.

15 Descending

NOTE: Descents must not be made using the wing fuel tanks alone if fuel is low.

The maximum rate of descent will be achieved by closing the throttles, extending the airbrakes and maintaining the maximum permissible Mach number and IAS. The maximum rate of descent should only be used in case of emergency or for training purposes. Under normal flying conditions, a normal rate of descent, which is more acceptable for Air Traffic Control procedures, may be obtained by closing the throttles, extending the airbrakes and descending at 0·75 M until this is co-incident with 240 knots, and thereafter maintaining 240 knots. This configuration will give an average rate of descent of 3,500-4,000 feet per minute. If the engine anti-icing system is used, minimum engine speeds of 6,000 RPM or 6,600 RPM as appropriate (see Part III, para. 35) must be maintained, and speed should be increased to 250 knots to maintain an acceptable rate of descent under these conditions. In order to avoid misting or icing of the windscreen and side panels when low altitudes are reached, both cabin air switches should be selected ON prior to descending. The TPI may be selected to COARSE or FINE motor for the descent but should be selected to COARSE motor before reaching 2,000 feet.

Circuit Procedure and Landing

16 Approach and landing

(*a*) Carry out the Pre-Descent or Joining Checks in the Flight Reference Cards.

NOTE: If the fuel filter de-icing system has been used in flight, or the aircraft has descended through icing conditions, the fuel filter de-icing switch should be selected ON for a period of two minutes at the bottom of the descent.

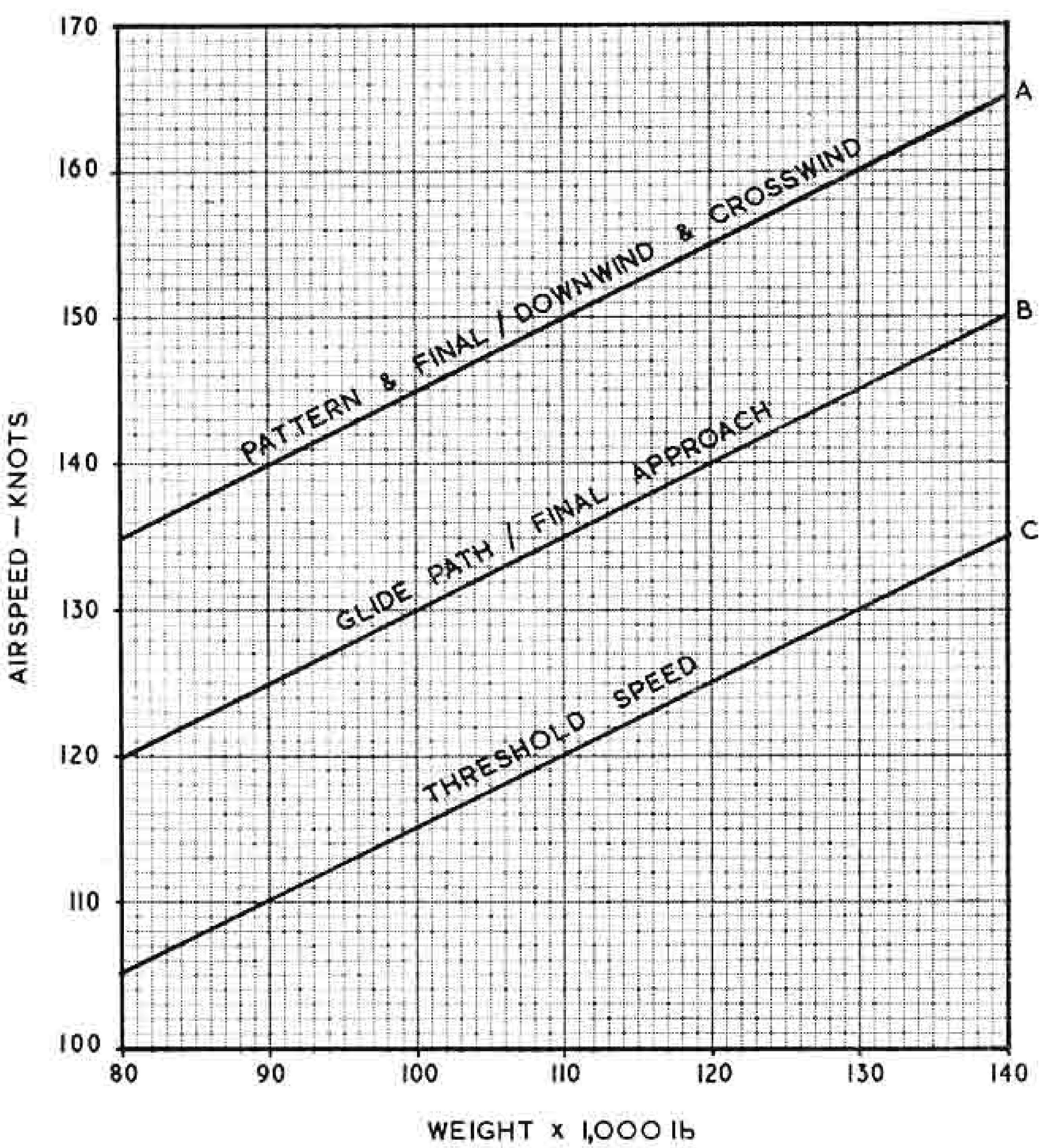
(*b*) *Checks before landing*

Join the circuit at 190 knots and lower flaps to 20 degrees. Maintain the speed at 170 knots until on the downwind leg then reduce to speed A on the graph opposite and carry out the Pre-Landing Checks in the Flight Reference Cards.

(*c*) *Approach and landing*

Approach speeds are shown on the graph opposite. During the initial stage of an instrument approach, or on the downwind leg of a visual circuit, reduce to appropriate speed for the AUW shown at A. Maintain this speed until ½ mile before interception of the glide path, or until opposite the downwind end of the runway during a visual circuit, and then lower flap to 40°. At AUW's in excess of 110,000 lb speed must be reduced to 150 knots before selecting 40° flap. Commence descent to maintain the correct glidepath, or turn onto the final approach, and reduce to the correct glide path/final approach speed shown at B. This speed should be maintained until full flap is selected. Full flap should not be lowered until 200 to 300 feet above the ground. The effect of full flap on speed is marked ; if lowered early the resultant drag effect will necessitate an increase in power ; if lowered too late there will be little time for trimming out the nose-down trim change before touch-down. After selection of full flap, speed should be adjusted so that the runway threshold is reached at 105 knots for weights up to 80,000 lb; for every increase of 10,000 lb add five knots to this speed. If a landing is to be made using 40 degrees of flap, speed should be reduced progressively during the approach until the runway threshold is reached at the correct speed for weight as quoted above. At approximately 50 feet the engines should be throttled back in order to lose residual thrust before the aircraft is checked in the normal manner and touch-down made on the main wheels. When landing on a wet runway a firm touch down should be made. The nosewheel should be lowered gently on to the runway and, when all wheels are firmly on the ground, the nosewheel steering should be used for directional control.

APPROACH SPEEDS



(d) Crosswind landing

It is recommended that the crab technique is used, the aircraft can then be comfortably controlled in crosswinds up to a 20 knot component. When landing in higher crosswinds extra care must be taken in correcting the drift immediately prior to touch-down. Lower the nose-wheel on to the runway immediately after touch-down, so that steering is available at once. If the side-slipping technique is used in high crosswinds there is a risk of insufficient aileron control being available for gust correction.

(e) Downwind landing

In conditions of poor visibility and/or low cloud base, it may be necessary to land on the instrument runway even though a downwind component exists. In this event the landing run will necessarily be increased. Tests indicate that a large safety margin exists at weights up to 110,000 lb in a downwind component of 10 knots on a 9,000 foot runway. In emergency the following downwind components would be acceptable at weights up to 110,000 lb:

6,000 foot runway — 10 knots
9,000 foot runway — 15 knots

For safety margins to be adequate it is assumed that touch-down is made in the first 1,200 feet of runway, that the nosewheel is lowered as soon as practicable and that firm braking is then applied immediately.

(f) Flapless landing

Because of the increased risk of scraping the rear fuselage on the ground, the practice of flapless landings is not recommended. If, because of any malfunction, a flapless landing becomes necessary, weight should be reduced to 98,000 lb or less and the landing made on a runway of 9,000 feet or more length. A straight-in (instrument) approach is recommended, using a 2° glide-path if available. If a visual circuit is necessary, a slightly longer approach than normal should be made, and bank angles should be limited to 30°. Carry out the pre-landing checks and lower the undercarriage in the normal manner. The normal pattern speed should be used and maintained for the initial approach. During the approach attitude will be considerably more nose-up than when flap is lowered, and forward visibility may be improved if the seat is raised. Aim to cross the threshold with power reducing, at 10 knots above the recommended normal threshold speed, for weights up to 98,000 lb, and 15 knots above the recommended speed for higher weights. A prolonged hold-off should be avoided. The nosewheel will be very high after touchdown, and should be lowered so that normal braking action may be used as soon as possible.

17 Braking

(*a*) When the nosewheel has lowered on to the runway the brakes can be used continuously and the maxaret units will prevent wheel locking. The landing run can be cut to less than half normal by using continuous full brake, but this procedure causes rapid brake wear and should not normally be used.

(*b*) The aircraft must be firmly on the ground before applying the brakes. *There is a delay of three or four seconds between applying the brakes and the brakes coming on.* If the aircraft is allowed to touch down with the brakes on, the maxaret units will not operate and the wheels will lock. However, if once having started turning the wheels should stop because of a skid or a bounce, they will not lock unless the skid or bounce continues for more than four seconds.

(*c*) Every effort should be made to avoid overheating the brakes, and braking should, therefore, be judicious according to the length of the runway. Landings involving heavy braking should not be made at intervals of less than 10 minutes and if, while taxying after such landings, heavy differential use of the brakes is made, the time interval should be doubled.

(*d*) When landing on short runways, or under circumstances where it is necessary to apply brakes shortly after touchdown and at high speeds, extra care must be used when braking. If the control column is forcibly pushed forward to lower the nosewheel and held there while braking action is started, weight may be taken from the rear main wheels causing them to lift from the runway. This may lead to locking of the rear main wheels and consequent damage to tyres. To avoid this occurrence, after the nosewheel has been lowered onto the runway, apply steady and progressive brake pressure. At the same time ease the control column steadily back so as to place increasing weight on the rear main wheels, and so that the control column is pulled fully back if full brake pressure is applied. This technique may cause slight reduction of nosewheel steering effectiveness, and pilots should anticipate this.

18 Overload and emergency landings

(*a*) (i) The normal maximum weight for landing is 110,000 lb. The maximum permissible weight for overload landing is 138,000 lb.

(ii) The pattern, approach and threshold speeds appropriate to the AUW should be used. If the AUW is greater than 110,000 lb, necessitating a reduction of pattern speed before 40° of flap may be extended, the reduction of speed and lowering of flap may be delayed, at the captain's discretion, until the turn onto final approach is completed. The stalling speed is reduced by five or six knots when flap is lowered from 20° to 40°. At AUW's greater than 120,000 lb the recommended pattern speed is higher than 155 knots, and therefore flying at the recommended pattern speed with 20° flap allows a greater margin above the stalling speed than flying at 150 knots with 40° flap. At high AUW's and particularly if one or more engines are inoperative, angles of bank should be restricted, if possible to 20°, when flying at circuit and approach speeds.

(*b*) *Rate of descent on touchdown*

(i) The design velocity of descent on touchdown, for which the aircraft and loading points have been stressed, is 11 feet per second at 95,000 lb, which is 660 feet per minute. It will be appreciated that a landing at this rate of descent would be a very heavy landing indeed and is in fact equivalent to continuing the ILS glide path right onto the runway.

(ii) If the weight is increased, and particularly if any load is carried on LP6 or 7, or there is fuel in the transfer tank, the rate of descent on touchdown must be reduced. For instance, at weights up to 138,000 lb with a full load on LP6 or 7, or if the transfer tank is full, the rate of descent must not exceed 8·8 feet per second (528 feet per minute). Again, this would be a very heavy landing.

(iii) From observation and experience it appears that almost all landings with Valiants are made at a rate of descent on touchdown of between 2 and 4 feet per second, the lower figure being a good smooth landing. The pilot has no means of checking these figures other than judgement, and consequently, although the figures are given for information and comparison, whenever an overload landing is to be made, and particularly with stores or fuel in the rear fuselage, every endeavour should be made to make a normal smooth landing.

(*c*) *Emergency landing*

Landings at weights above 138,000 lb will only be made in extreme emergency, when lack of time, mechanical failure or other circumstances make it impossible or impractical to jettison underwing fuel or stores. In this event a smooth gentle touchdown must be made, keeping the rate of descent on touchdown as low as possible.

(*d*) *Use of brakes*

The effectiveness of the wheel brakes is limited by their heat absorption capacity, and this is a function of aircraft weight and the speed at which the brakes are applied. If the brakes are applied at too high a speed for a given weight, overheating will occur, leading to brake fade and possibly complete loss of all braking force. This may be accompanied by fire. The table below shows the maximum speeds at which brakes should be applied at two weights on wet or dry runways. The " normal " speed is that at which brake damage should not occur. The " emergency " speed is that at which brakes may be applied if brake damage is acceptable. If higher speeds are used the brakes will fade and fail before the aircraft has been brought to rest. It must be emphasised that a " preliminary prod " at the brakes serves no useful purpose ; best results are achieved by using aerodynamic braking until the speed falls to the required figure and then putting the brakes full on and leaving them on. The landing run will be reduced if the HP cocks are closed immediately after touchdown.

	138,000 *lb*		175,000 *lb*	
	Normal	*Emergency*	*Normal*	*Emergency*
Wet Runway .	111	—	92	114
Dry Runway .	99	—	88	110

NOTE: The above figures are for ICAN sea level conditions. Further information, including correction factors for wind, temperature, etc., are given in the Operating Data Manual. Where no figure is quoted above, the maximum braking speed is above the touchdown speed.

19 Instrument approach

(*a*) On reaching the initial approach altitude reduce speed to a maximum of 190 knots and lower 20 degrees of flap. At 170 knots lower the undercarriage. The range of approach speeds versus aircraft weight given in the graph of para. 16(*c*) are recommended and will have to be used on those approaches down to 200 feet AGL, so that the aircraft can be landed on the correct touchdown point. The initial pattern should be flown at the speeds shown by line A which are never more than 15 knots above the approach speed line B, so that lowering flaps from 20 degrees to 40 degrees on intercepting the glide path will be sufficient to establish the required rate of descent and the correct approach speed without the need to alter the power settings substantially.

(*b*) The procedure for auto-ILS approaches is detailed in Part III, para. 54. The procedure for ILS approaches is in AP 129, Vol. I, Part 2, Section 4, Chap. 2, and for Zero-Reader—ILS in Chap. 3. The procedure for GCA is in AP 129, Vol. I, Part 3, Section 1, Chapter 2.

20 Going round again

This presents no problems. At normal weights with all engines operating it is not necessary to use full power. The flaps should be raised as soon as possible, at least to the 20 degrees position. The undercarriage may be left down or, if desired, raised at the same time as the flaps.

21 Roller landings

(*a*) When carrying out roller landings it is not normally necessary to lower the nosewheel on to the runway. However, if it is intended to reduce speed during the roll to below 90 knots, or in strong cross-wind conditions, the nosewheel may be lowered to assist in maintaining directional control.

(*b*) When opening the throttles particular care must be taken up to 5,000 RPM and pilots should be prepared for a difference in response from each engine. Check at 7,000 RPM that symmetrical thrust is being obtained before opening the throttles further.

(*c*) Care must be taken to avoid adopting an exaggerated nose-up attitude as the aircraft accelerates. It is recommended that the aircraft is held on the ground until 10 knots below the calculated threshold speed for the weight.

22 After landing

In conditions of strong or gusty winds head the aircraft into wind. Carry out the After Landing Checks in the Flight Reference Cards.

23 Closing down

Carry out the appropriate Shut-down Checks in the Flight Reference Cards.

Flying in Manual

24 General

If failure of the powered flying controls occurs or is induced for practice purposes the aircraft can be flown under manual control without difficulty providing care is taken not to exceed the limitations in these circumstances (see Part II, para. 4(*a*)).

25 Full manual reversion

Any power control motor which fails must be tripped without delay by operating the appropriate trip button.

(*a*) On reversion to manual, the change-over on the elevators and rudder is smooth, and there should be practically no trim change if the elevator out-of-trim lights have been kept out. It is most important that the out-of-trim lights are kept out in flight. On the ailerons a wing-down trim change may develop rapidly but only a small movement of the tab is needed to restore lateral trim. When flying in manual, the manual trimmer tabs must be used for trimming the ailerons and rudder, the tailplane being used for longitudinal trim, and the elevator manual trim tab used to keep the out-of-trim lights out.

(*b*) On reversion to manual the appropriate artificial feel units should not be disconnected. On no account may the feel unit trimmers be moved as an out-of-trim condition may result when re-engaging power. Also, if the feel trimmers are moved, they will move the controls which will have to be trimmed by the manual tabs. All controls are heavy, particularly at speeds approaching and above 200 knots. It is recommended that, when flying in manual, a speed of 240 knots should not be exceeded. When manœuvring, the necessary control movements should be anticipated since the considerable physical effort required causes aircraft response to movement of the controls to seem sluggish, thus making the precise selection of bank a little difficult. The trim tabs are very effective, and should not be used as servo controls except in emergency.

(*c*) *Trim changes*

Extending airbrakes	Strong nose-up
Lowering flaps	Strong nose-down
Lowering undercarriage	Moderate nose-up

(*d*) *Landing*

Not more than 40 degrees flap should be used. All controls are heavy and it is essential to use the tailplane to trim out the trim changes. A strong pull is required to flare-out just before landing, and care is necessary to avoid a heavy landing. Trim changes should be trimmed out as quickly as possible ; some attempt should even be made to anticipate them.

26 Practice flying in manual

(*a*) Reversion to manual control for practice flying may be made at any speed between the recommended final approach speed and 240 knots. However, it should be borne in mind that the manual aileron and rudder trim neutral positions correspond to a speed of 170 knots, and these controls may be slightly out of trim at any other speed. To revert to manual control the following drill should be carried out:

Ensure speed is below 240 knots, and trim the aircraft to fly hands off.

Check elevator trim lights out. Check elevator trim tab not more than one division forward.

Check aileron and rudder manual trim tabs neutral.

Trip out aileron 1 and elevator/rudder 1 motors.

Trip out aileron 2 motor and correct for any trim change by using the aileron manual trimmer.

Trip out elevator/rudder 2 motor.

(*b*) If there is any indication of malfunctioning of the controls after reverting to manual, *immediately* re-engage power by re-selecting the instrument master switch ON. Such a case will occur if there is a defect in the manual reversion valve. This will be indicated by a slack movement of about four inches at the controls without any corresponding movement of the control surfaces. Re-engaging power will immediately free the controls, enabling the aircraft to be returned to base.

(*c*) Before re-engaging power trim the aircraft at a speed of 240 knots or less, then select the instrument master switch ON. In cases of necessity power may be re-engaged at any speed, but the likelihood of being out of trim should be anticipated. Provided that the aileron and rudder feel trimmers have not been moved and the elevator trim lights are out, the out-of-trim when re-engaging power will be small at all speeds.

Asymmetric Flying

27 Asymmetric flying

Since the engines are so close inboard, asymmetric flying presents little handling problem even when two engines on the same side are out. The loss of one generator will not make any material difference to the electrical system but with the loss of two generators, load shedding will be necessary. The loss of any engine will affect the airframe de-icing, and may affect the cabin pressure depending upon altitude.

28 Re-lighting an engine in flight

Re-lighting must not be attempted above 35,000 feet or at more than 200 knots IAS.

Master cock on.
HP cock off.

Press the re-light button for four seconds, open the HP cock, bringing the throttle back to the gate, and keep the re-light button pressed until the RPM or JPT start to rise. If the engine has not re-lit after 30 seconds maximum, release the re-light button and close the HP cock. In emergency a second attempt may be made to re-light, but the flaps must first be lowered to 20 degrees for five minutes to ensure that any excess fuel is drained away. A descent of at least 10,000 feet is recommended before the second attempt and the appropriate re-light fuse should be examined for serviceability.

29 Asymmetric landing

An asymmetric landing should be treated in the same way as an ordinary landing except that the RPM of the good engines will be higher.

30 Asymmetric going round again

This presents no difficulty, even with two engines on one side failed at the maximum normal landing weight; however, the decision to overshoot should be made as early as possible, and in any event before a height of 200 feet above runway level is reached. Until the decision to land has been made the airspeed must be maintained above the critical speed, and flap extension restricted to 40°. When going round again full power should be applied and the flaps raised to 20°.

Part V

EMERGENCY HANDLING

PART V

Emergency Handling

List of Contents

Illustration

Part V

Emergency Handling

1 Engine failure on take-off

(*a*) If an engine fails on take-off there is little tendency to swing and the safety speed will always be below the unstick speed. The decision whether to continue or abandon the take-off will depend on the aircraft configuration and airfield conditions as determined by the Operating Data manual. Exactly the same applies if water-methanol fails to provide increased thrust on one engine, or even two engines on the same side. In the event of a water-methanol assisted take-off being continued after an *engine* failure, it should be noted that the duration of increased thrust on the remaining engines will be increased (see Part III, para. 31(*b*)(iv)), thus helping the initial climb.

(*b*) If it is necessary to abandon an assisted take-off, close the throttles and use the brakes in the normal way. The water-methanol will stop as soon as the throttles are closed, but as soon as convenient the master switch must be put off.

2 Engine failure in flight

(*a*) *Flame extinction*

If an engine flames-out in flight with no indications of mechanical failure or engine fire, close the HP cock, switch OFF the ENGINE MASTER COCK (LP fuel cock) and switch OFF the generator. At the captain's discretion one attempt may be made to relight the engine at a height below 35,000 feet and speed below 200 knots.

(*b*) *Mechanical failure*

If an engine fails in flight with indications of mechanical failure, close the HP cock, switch OFF the ENGINE MASTER COCK (LP fuel cock) and switch OFF the generator. Keep close observation for warning of engine fire. Do not attempt to re-start the engine.

(*c*) *Engine Overheat Warning or Low Oil Pressure*

If a progressive decrease of oil pressure is noted, or if pressure falls below 25 PSI in normal flight, or, post-Mod. 3094, if the engine overheat light comes on, it is an indication of possible failure of the engine rear bearing. If any of these indications are noticed check oil pressure, close the HP cock, switch OFF the ENGINE MASTER COCK and switch OFF the generator. The fire extinguisher must not be used unless the EFWL comes on; a close watch should be kept on this light. The affected engine must not be restarted and the ENGINE MASTER COCK should not be re-opened.

NOTE: Once the engine overheat warning light has come on it will remain on even though the temperature decreases.

(*d*) Following any engine failure select the CABIN AIR SUPPLY switch for the affected side to OFF, and that for the other side to ON.

3 Action in the event of fire

(*a*) *Engine fire*

Engine fire will be indicated by the red warning lights in the head of the FIRE EXTINGUISHERS push-buttons. The following action must be taken without delay:

(i) Close the HP cock.

(ii) Warn crew.

(iii) Switch OFF the ENGINE MASTER COCK.

(iv) Press the fire extinguisher button.

(v) Fuselage pumps ON, Wing pumps OFF.

(vi) Select the engine GATE VALVES for the affected side to EMERGENCY CLOSE. Select CABIN AIR SUPPLY switch for the affected side to OFF and for the other side to ON.

(vii) Switch OFF the generator.

(viii) Use the sextant to inspect the affected wing for signs of fire or smoke. DO NOT ATTEMPT TO RELIGHT THE ENGINE.

(*b*) If consistent with safe operation of the aircraft, the adjacent engine should be stopped by closing the HP cock and the ENGINE MASTER COCK, and its generator switched OFF. Switch OFF the CROSS-FEED cock and switch OFF all booster pumps on the affected side. Provided that the fire is extinguished, and that the fire was not accompanied by indications of mechanical failure, the unaffected engine may be re-lit at the captain's discretion. If essential for the safe completion of the flight the affected wing fuel may be used following a minimum period of 30 minutes after the fire has been extinguished, but after any fire the aircraft should be landed as soon as possible.

(*c*) *Fuel tank fire*

The fuel tank fire-extinguishing systems only operate through the crash switches in the event of a crash landing. There is no indication in the cabin of fire having broken out in a fuel tank bay, nor is there any means of extinguishing it.

4 Cabin over-pressurisation

(*a*) Cabin over-pressurisation may be detected by its physical effects but is more likely to be noted by reference to the cabin altimeter which should be checked at frequent intervals during flight at altitude. Post-Mod. 2490, a cabin pressure warning light, which comes on if the differential pressure rises to 9·5 PSI, it fitted (see Part I, para. 78(*d*)). If cabin over-pressurisation should occur the following drill should be put into operation at once:

(i) If flying with CRUISE selected, re-select to COMBAT. If the malfunction is due to the pressure controller this action may clear the fault. If this does not cure the fault, proceed as follows:

(ii) The 1st pilot should reduce the cabin differential at once by holding the normal/depressurise switch to DEPRESSURISE, aiming to bring the cabin altitude to 15,000 feet.

(iii) The cabin air supplies should be selected port ON, starboard OFF. The starboard bomb bay heating should be selected ON and attention should be given to the bomb bay temperature when stores are carried.

(iv) Select one of the port engine gate valves CLOSED (to reduce the mass flow of air into the cabin).

(v) Once the cabin altitude has been stabilised at approx. 15,000 feet, and all of the above actions have been completed, a steady leak rate should be set up by careful adjustment of the manual depressurising control in the rear cabin (this control will give a variable leak rate from fully open to fully closed position). The objective is to hold the cabin altitude at 15,000 feet.

(*b*) In the event of the above actions failing to bring about the desired results the aircraft altitude should be reduced to 30,000 feet and the cabin depressurised by means of the manual depressurising control in the rear cabin.

(*c*) The wire-locked knurled knob on the top of the pressure controller can be used to re-set the capsule stack to control at $3\frac{1}{2}$ PSI. Adjustment of this knob should not normally be necessary, but if the combat selection on the pressure selector switch does not bring the capsule stack to the "combat" position, then manual setting of the capsule stack should be attempted by rotation of the knurled knob.

5 Tailplane malfunction

(*a*) Modification action has considerably reduced the possibility of a runaway TPI motor, but the following drill should be applied in the unlikely event of a runaway, partial runaway or reversal of the trim motor.

(*b*) A malfunction of this nature is most likely to occur whilst attempting to retrim the aircraft, and should become apparent by a changing or worsening out-of-trim condition. In all cases the first action must be to release the trim switches immediately.

(*c*) TPI *malfunction, nose-down*

(i) The pilot at the controls should resist the nose-down pitch by use of the elevator and at the same time warn the crew.

(ii) At the earliest possible moment the 1st Pilot should make opposite selection on the 1st Pilot/2nd Pilot and the coarse/fine switches.

(iii) The other pilot will be alerted by the warning and should assist at once in resisting the nose-down pitch, on the control column.

(iv) The pilot who now has control of the TPI should attempt to retrim the aircraft.

(v) If unable to trim the aircraft the airbrakes should be extended, further acceleration avoided and the IAS reduced, if the flight conditions permit, by reduction of power.

(vi) Once the aircraft is under control, the 1st pilot should trim out the elevator load lights. If the TPI has run to the fully nose-down position, reduction of speed to 170 knots and reversion to manual control will enable the aircraft to be flown comfortably at that speed with all stick forces relieved. If speed is further reduced, elevator control effectiveness will be reduced, but control may still be maintained down to 120-130 knots. However, the change of trim associated with lowering of flap may introduce control difficulties. It is therefore recommended that before landing the AUW is reduced to 98,000 lb or below, and that only 20° of flap is lowered during the approach. After touch-down full flap may be lowered to provide increased drag during the landing run.

(*d*) TPI *malfunction, nose-up*

(i) The pilot at the controls should resist the nose-up pitch by use of the elevator and warn the crew. A turn may be commenced to assist in absorbing the out-of-trim loads, but bank angles in excess of 50° should not be used.

(ii) The other pilot will be alerted by the warning and should assist at once in resisting the nose-up pitch, on the control column.

(iii) At the earliest possible moment the 1st Pilot should make opposite selection on the 1st Pilot/2nd Pilot and the coarse/fine switches.

(iv) The pilot who now has control of the TPI should attempt to retrim the aircraft.

(v) If unable to retrim the aircraft, flap should be lowered to at least 40°. Further acceleration should be avoided, and the IAS reduced, if flight conditions permit, by reduction of power.

(vi) Once the aircraft is under control the 1st Pilot should trim out the elevator load lights.

NOTE: In either case, if the runaway cannot be rectified and prolonged flight is essential with heavy out of trim loads, revert to manual control of rudder and elevators and use the manual trimmers to restore the in trim condition.

6 Artificial feel failure

(*a*) Pilots are warned that when flying in power with the artificial feel units disengaged there are no control forces except the friction in the circuits and care must be taken to avoid overstressing the aircraft by applying excessive control deflections. With feel disengaged on any surface, speed must not exceed 220 knots.

(*b*) The artificial feel must never be disengaged in flight except in the unlikely event of a feel unit (or units) jamming. Should this occur, speed should first be reduced to 200 knots, or lower if possible, and then the appropriate power control motors must be tripped out. The affected feel unit should be disengaged by operating the lever on the control pedestal. Only the control affected should be reverted to manual, but if either the rudder or the elevator feel unit has failed it will not be possible to revert to manual on only one of these controls.

(*c*) Should it become necessary subsequently to revert to power control the following should be borne in mind:

(i) With rudder feel disengaged, the rudder should not be used if at all possible and the feet should be removed from the pedals.

(ii) With elevator feel disengaged, manoeuvres should be kept to a minimum and only initiated very gently. Constant reference should be made to the accelerometer to avoid applying excessive G. It will be necessary to restrain the control wheel from moving forward under its own weight during steady flight.

(iii) With aileron feel disengaged it will be necessary to restrain the control wheel from moving to port.

7 Failure to raise the undercarriage

(*a*) There is only one system for raising the undercarriage, and failure of this system will necessitate abandonment of the sortie. If excessive pressure is required to operate the undercarriage selector UP button, the attempt to raise the undercarriage must be abandoned. If selector fuse failure is suspected, the up control fuse (No. 16 at panel D, 10 amp) may be changed once in order to effect retraction. If the nosewheel fails to retract, and misalignment is suspected, the nosewheel steering system must not be operated in an attempt to complete retraction ; operation of the nosewheel steering system in flight may cause damage to the nosewheel strut and may result in the nose-wheel jamming in the wheel bay.

(*b*) If an attempt is made to retract the undercarriage at speeds above 195 knots, or under conditions of excess G, the clutch slip device may operate to trip the contactors, protecting the motors against overload. If it is considered that failure to retract was due to these conditions it is permissible to reset the contactors after reducing speed below 195 knots and releasing any excess G. If the contactors again trip, the undercarriage should be lowered as in (*c*) below.

(*c*) If the undercarriage fails to retract, the sortie must be abandoned and the aircraft flown at a speed below 195 knots if the undercarriage is fully down and locked, or below 170 knots if the undercarriage is not fully locked down. At the captain's discretion, 20° flap may be lowered to improve controllability. A *normal* DOWN selection should be made as soon as possible. If the undercarriage is fully locked down, weight should be reduced and a normal landing made. If the undercarriage is not fully locked down, weight should be reduced to 110,000 lb before any further action is taken, except in cases of extreme emergency. Because of the attendant fire risk if an emergency undercarriage actuator motor continues to run after the undercarriage has locked down, an EMergency DOWN selection should not be made until the aircraft is down to landing weight. If an EMergency DOWN selection is made, a normal DOWN selection must be made as soon as the undercarriage is fully locked down, and the aircraft should be landed as soon as possible.

8 Failure to lower the undercarriage

(*a*) Failure of the undercarriage to lower normally may be due to electrical failure or to a mechanical jam of the door or up-lock. The following procedure should be followed according to the circumstances.

(b) Suspected electrical failure or door jammed

Indicated by red door light remaining out and the red travel light remaining out.

(i) Select emergency down.

If the undercarriage still does not lower :

(ii) Re-select normal down.

(iii) Check that the extreme emergency circuit-breaker(s) made as required.

(iv) Operate the extreme emergency switch(es).

(v) Reset the undercarriage main contactors.

(vi) DO NOT RETRACT UNDERCARRIAGE.

(c) Suspected up-lock jammed

Indicated by red door light coming on, but red travel light staying out. In this case the contactor will automatically be tripped.

(i) Select emergency down for 10 seconds maximum.

If the undercarriage still does not lower :

(ii) After 10 seconds re-select normal down.

(iii) Check that the extreme emergency circuit-breakers are made.

(iv) Operate the extreme emergency switch(es).

(v) Reset the undercarriage main contactors.

(vi) DO NOT RETRACT UNDERCARRIAGE.

NOTE: When the extreme emergency system is used there is possibility of the undercarriage door becoming completely detached. When this system is used, therefore, it is important that the flaps are up and the aircraft in straight and level flight.

(d) Contactor tripped during travel down

Indicated by red door and travel lights remaining on, and contactor light coming on.

(i) Reset contactor, but do not hold in if it again trips.

(ii) If the undercarriage does not lower select emergency down and proceed as in sub-para. *(b)*.

9 Landing with the undercarriage up

(a) When a " wheels up " landing is necessary it should, if possible be made on grass. If the grass surface is very bad, and likely to result in the break-up of the aircraft, the landing may be made on a runway; in this event, however, the fire risk is increased, particularly when carrying underwing tanks.

(b) Before joining the circuit ensure that the cabin is depressurised and that all loose articles, maps, charts, etc., are securely stowed, the ejection seats safe and the crew securely strapped in with their parachute harness locks at UNLOCK.

(c) The entrance door should not be jettisoned as there is some risk of debris coming into the cabin. The ditching exit and the crash landing exit on the starboard side should, however, be removed. The noise level will be somewhat higher than normal and it is therefore advisable that the captain's orders and intentions are given beforehand.

(d) The circuit should be made at the normal speeds and flap settings. For the final approach, the normal speed should be used, but the flaps should be restricted to 40 degrees. The engines should be fully throttled back as the runway threshold is reached and the aircraft then held off the ground for as long as possible in order to touch down at the lowest practicable speed. After touch-down the 2nd pilot should shut all high pressure and low pressure cocks and

then operate all the engine fire extinguishers. Greater deceleration will be obtained by pushing the stick fully forward after touch-down.

(*e*) As soon as the aircraft has come to rest all crew members should leave by the ditching and crash landing exits. An attempt may be made to jettison the entrance door, but it may jam due to distortion; if it does not jettison immediately no further time should be wasted. There is no object in firing the canopy explosive bolts unless the other exits are obstructed or fire makes a quick exit essential. If the bolts are fired the canopy will not leave the aircraft but will have to be lifted off by the pilots. Provided all bolts have fired this is quite straightforward, but the canopy is heavy.

10 Landing with the nosewheel up

If the undercarriage failure is such that the nose-wheel is not extended (note that the extreme emergency switches only lower the main wheels) then, time and fuel permitting, the remaining fuel should be used in an attempt to move the CG to the extreme aft limit (575·7 in. aod) and to reduce the weight as much as practical. There is little likelihood of the entrance door becoming jammed so there is no point in jettisoning it, especially as the noise level is very high with it off. However, if desired the astro-dome may be pulled in after depressurising ; no undue noise or discomfort results. The ejection seats should be made safe and all crew members should disconnect parachutes and oxygen leads, and tighten their harnesses. A normal landing should be made, on grass, if possible, and if the surface is good. After touchdown the nose should be held off for as long as possible. When the elevators start to become ineffective (at about 50 knots) the nose should be lowered gently on to the ground, and gentle braking used to stop the aircraft.

11 Failure to raise or lower flaps

(*a*) If the flaps fail to operate on the normal motor they should be operated by the emergency motor. Being a much smaller motor, this takes a considerable time to raise or lower the flaps (see Part 1, para. 57 (*j*)) and care should be taken not to exceed the limiting speed with the flaps down. If both motors fail, the flaps will remain immovable.

NOTE: The flaps will only go down 45 degrees on the emergency motor.

(*b*) It is possible that a section of the flaps might stick at any position during their travel. In the event of any flap malfunction or any abnormal change of trim during flap operation, the selection must be stopped immediately. An attempt may be made to equalise the flap setting by making an opposite selection. After this attempt no further flap selections should be made and the aircraft should be landed as soon as possible, if necessary with partial flap only.

12 Landing with no wheel brakes

If hydraulic failure makes it necessary to land with no wheel brakes, the following procedure should be adopted. It should be remembered that the nosewheel steering will also be inoperative.

1 Use the longest available runway into wind.

2 Reduce weight to a minimum.

3 Prepare the aircraft for a crash landing.

4 Cross the threshold 10 knots above the stalling speed.

5 Flame out all engines on touch-down.

6 Switch off generators, rotary transformers and inverters.

7 Keep the nosewheel off as long as possible.

8 Towards the end of the landing run directional control will be nil.

9 If the aircraft leaves the runway and major obstructions are in the way, rotate the undercarriage override and select wheels up.

13 Action in the event of partial generator failure

(*a*) *Generator resetting procedures*

(i) *Single-generator failure*

Check voltmeter

If voltmeter reads zero .	Leave ON
If voltmeter reads approx. 106 volts (undervolting) .	Leave ON
If voltmeter reads 110 volts	Switch OFF, change control fuse, Switch ON and ENGAGE

NOTE: In the first two cases the generator must be left ON until a technical investigation is made.

(ii) *Three-generator failure*

If this is caused by overvolting of the fourth generator, the three ammeters will read zero and the remaining ammeter will indicate an excessive load; the busbar voltage will be high.

Switch OFF the remaining generator.
ENGAGE the failed generators.

(iii) *Four-generator failure*

Shed loads (see para. 14).
Leave all generators ON.
Check voltages, ENGAGE any generator giving 110 volts.

(*b*) The maximum permitted rating of the generators depends on whether or not generator Mod. A.175 (PEG 11 brushes) is incorporated.

(i) *Pre-Mod. A.175*

The generators are cleared to operate at a continuous load of not more than 100 amps each at all altitudes. They are also cleared to operate up to 135 amps each for 5 hours provided that they are inspected after flight.

(ii) *Post-Mod. A.175*

The generators are cleared to operate at a continuous load of not more than 150 amps each at all altitudes.

(*c*) The *average continuous* load to be met by the generators during day or night cruising conditions is approximately:

B 1 aircraft . . .	150 to 180 amps (Excluding underwing tank pumps)
B/PR 1 aircraft in PR role	170 to 200 amps (Excluding underwing tank pumps)
B/K/PR 1 aircraft in tanker role during fuel transfer	315 to 345 amps

(*d*) In the event of generator failure, load must be reduced to within the clearance of the generators:

(i) Pre generator Mod. A.175, if one generator fails, the remaining generators may be run above the 100 amp clearance but within the 135 amp clearance. If two or three generators fail. the remaining ones should not be run above the 100 amp clearance.

(ii) Post generator Mod. A.175, generators should always be kept within the 150 amp clearance.

(*e*) The following table gives a guide to the action to be taken following generator failure (resetting action having been taken unsuccessfully), but it is emphasised that it is only a guide. The total continuous loads vary so much between aircraft and in various conditions that it is not possible to lay down a rigid drill.

Condition	*B1*	*B/PR 1 in PR Role*	*Tanker during transfer*	*RCM Aircraft (not WF214)*
One generator failed	No action	No action	No action	Selected, limited RCM equipments only
Two generators failed	No action	No action	Discontinue transfer. Reel in hose. Close bomb doors	Emergency RCM ON/OFF switch OFF. (No. 1 & 4 type 350 inverters and all RCM equipments OFF with this switch.) Royal Inverter OFF. No. 4 rotary transformer OFF
Three generators failed	No. 1 & 2 rotary transformers OFF. Underwing tank fuel pumps OFF. Shed NBC & H2S No. 1 type 350 inverter OFF. Power controls to ½ rate	No. 1 & 2 rotary transformers OFF. Underwing tank fuel pumps OFF. Shed NBC & H2S No. 1 type 350 inverter OFF. Power controls to ½ rate. Cameras OFF	No. 1 & 2 rotary transformers OFF. Discontinue transfer. HDU OFF. Jettison hose. Close bomb doors. Underwing tank fuel pumps OFF. Shed NBC & H2S No. 1 type 350 inverter OFF. Power controls to ½ rate.	Emergency RCM ON/OFF switch OFF. Royal Inverter OFF. No. 1, 2 & 4 rotary transformers OFF. Underwing tank fuel pumps OFF. Power controls to ½ rate.

NOTE: In the two or three generator failure condition it is recommended that the undercarriage be lowered on the emergency system to keep the temporary overload on the remaining generator as low as possible. (Attention is drawn to Part III, para. 24(*a*)(ii).

(*f*) The following tables gives an indication of the average load taken by various electrical services.

Service	*Amps*
Underwing tank pumps . .	40 each
Power controls	50
Night role cameras . . .	22 (PR only)
Day role cameras . . .	19 (PR only)
No. 1 radar inverter . . .	45
No. 2 radar inverter . . .	35
No. 3 radar inverter . . .	10
Green Satin	14
H2S	10
Windscreen wipers . . .	11
HF Trans./Rec.	15
Ration heaters	5
Fuel booster pumps . . .	3 each

NOTE: All the above loads show the effect on the generators, not on the rotary transformers.

(*g*) Mod. 2454 introduces ammeters for the generators and rotary transformers on the radio crate. Prior to this Mod. the generator load shedding will have to be estimated.

14 Action in the event of total generator failure

(*a*) *Indication of failure*

The indications of total generator failure will be:

(i) Illumination of all four generator warning lights.

(ii) Post-Mod. 2454, all four generator ammeters reading zero.

(iii) Post-Mod. 2650, the 96-volt battery ammeters showing a discharge equivalent to the 112-volt loads.

(*b*) (i) The 96-volt battery reading *must* be carefully monitored at the moment of failure. If the battery voltage falls very rapidly, and Post-Mod. 2650 the battery ammeter shows a maximum discharge, the fault is not a four generator failure but an earth on the 96-volt busbar. This fault is much more serious than a four generator failure. The drills set out in para. 16 will apply.

(ii) The battery ammeters fitted by Mod. 2650, although having a small scale can be used to cross check on the calculated battery loads to within ±5 amps after load shedding has been completed.

(*c*) *Immediate actions*

Reset action must be taken without delay as in Part V, para. 13. If this is unsuccessful, the following actions should be taken.

(*d*) The essential object is to conserve battery power, especially the 24-volt battery, as this battery will limit the duration of flight. The following actions should be taken as quickly as possible.

1 Immediate reversion to manual control and power control motors switched OFF.

2 Underwing tank fuel pumps and fuselage fuel pumps OFF. Use one wing fuel pump (preferably No. 2) on each side only. If fuel will gravity feed then all pumps OFF.

3 Simultaneously with 1 and 2 the AEO will switch all type 350 inverters OFF, type 153 inverter OFF, all rotary transformers OFF. (NBC OFF, H2S OFF.) (Note that oil pressure gauges and Mk. 4B compass will be inoperative.)

4 If at night use emergency lighting and switch OFF all navigation lights. (Emergency battery should last at least 3 hours.)

5 Starboard pitot head heater OFF ; port pitot head heater ON when in cloud and air temperature is below 0°C, otherwise OFF.

6 Artificial feel disengaged. Post Command Mod. Valiant 61 artificial feel unit heater switches OFF.

7 Bomb bay heating must be ON.

8 *Tanker aircraft during transfer*, additionally:

Discontinue transfer
Switch OFF HDU
Jettison hose
Close bomb doors

9 *RCM aircraft* (not WP214) additionally:

Switch emergency RCM ON/OFF switch OFF (Ensure No. 1 & 4 type 350 inverters OFF with switch)
Switch Royal inverter OFF
Ensure all RCM loads are OFF with emergency switch

(*e*) *Subsequent actions*

Subsequent actions and use of the remaining battery power will depend on the circumstances prevailing. It is not possible to provide hard and fast drills for all conditions, but the following cases are given to help pilots to make their decisions according to circumstances.

(i) *Failure within easy reach of airfields* (100 miles).

The aircraft should be landed at the nearest airfield. The following drill is given for guidance:

1 Lower the undercarriage on the emergency motor.

2 Commence descent without using airbrakes.

3 Jettison underwing fuel if carried.

4 TPI to be used only when absolutely necessary.

5 STR18 to be used for distress message then switched OFF (circuit breaker tripped).

6 If artificial horizons not required 100A inverter switched OFF by removing fuse D90. (To reselect the 100A inverter it is necessary to replace fuse D90 then remove and replace fuse D91).

7 VHF to be used for distress message and vital transmissions only; only the required set to be switched ON, otherwise OFF.

8 Manual trimmers to be used only when absolutely necessary.

9 Flowmeters to bypass.

10 In the circuit, one fuselage fuel pump ON each side (if all have been switched OFF). Flaps may be used at the captain's discretion, bearing in mind runway length and the state of the batteries. If used they should not be lowered to more than 40° and the main motor should be used. Flaps must not be lowered until landing is certain owing to the hazard to rear crew escape (see Part V, para. 19).

NOTE 1: *The battery readings must be monitored continually.* The 24-v battery will be the limiting factor and under certain circumstances it may be possible to relieve the load of the 24-volt battery by switching ON one rotary transformer. This action will rapidly exhaust the 96-volt battery and should only be adopted when absolutely essential.

NOTE 2: If in good condition the batteries should last approximately 1 hour if the above drills are complied with. This time, however, cannot be relied on; battery voltage should constantly be checked and when 24-volt battery and 96-volt battery voltages fall to 20 and 80 respectively, operation of any service should be not relied on. The 24-volt battery life will be considerably prolonged by adopting the methods suggested in para 14 (f). Under certain flight conditions, the batteries may be switched OFF, to extend their life. If a landing can be made within the hour, depending on the state of the batteries, the ILS may be used to assist the approach.

(ii) *Failure in adverse weather conditions*

The considerations in (i) above apply also to this case, but with the added problem of the availability of the ILS and/or other navigation and landing aids. The most economical method of using the remaining electrical supplies for navigational aids is to use the VHF for "Steers." In adverse weather conditions the 100A inverter will have to be ON for the artificial horizons, this load can however be reduced by removing fuses 8 and 15 Post-Mod. 988, or fuses 41 and 44 Pre-Mod. 988, from the radar AC/DC distribution box (the removal of these fuses will switch OFF the starboard artificial horizon). Depending on the 24-volt battery state the ILS may be used for the approach. Pilots should consider abandoning the aircraft rather than risk the failure of instruments and aids at a critical phase in an instrument landing. When the battery voltage has fallen to 20v the operation of any service cannot be relied upon.

(iii) *Failure far from an airfield*

If total generator failure occurs a considerable flying time from an airfield, the problem becomes one of the CG control. Assuming that distress calls have been made, the undercarriage has *not* been lowered, and that the minimum current is being used, all available battery power will have to be used for the fuel pumps to keep the CG from moving so far as to make the aircraft uncontrollable. When battery power fails, there will be no means of controlling the CG or of trimming against it. The aircraft can be flown with the CG a considerable way outside the limits, but control for landing is marginal with the CG even a short way outside the limits. Fuel flow from the various tanks, without any pumps running, is unpredictable, but it is expected usually to result in an aft CG travel. The best thing to do in these circumstances is to keep one fuel pump only on each side running to maintain fuel supply and to control the C of G. The reserve tank cocks must be left closed and wing No. 2 pumps and transfer tank pumps selected on as necessary. This will keep the C of G well forward and allow a good period of flight after battery power fails.

(*f*) *Conserving the batteries*

(i) After all switched loads and all radio and radar loads have been shed during the initial load shedding action, certain loads remain on the 24-volt battery. These are unswitched loads and are on whenever the 24-volt battery switch and the instrument master switch are ON. The following table gives these loads and the methods of shedding them. By shedding these loads the 24-volt battery life can be appreciably extended.

Service	*Load in Amps*	*Method of removing loads from the 24-v battery*
Sextant	0·65	Remove plug
Mk 4B compass (DC supply)	0·35	Remove fuse 38 on AC/DC distribution box
Outside air temp . .	0·05	Remove fuse G51
Power control failure warning lights	0·4	Remove fuses E40 to E43
Generator and rotary transformer warning lights .	0·8	Remove bulbs
Differential pressure switch (cabin pressurising) .	0·35	Remove fuse D24
TPI changeover relay .	0·15	Select TPI to 'coarse'
Instrument circuit-breaker without 100A . . .	4·5	It is not recommended that this is switched OFF
100A inverter	11·5	Remove fuse D90 (to switch on when required, replace fuse D90 then remove and replace fuse D91)
Intercomm	1·5	Switch OFF
Artificial feel unit heaters .	6·0	See para 14 (d) 6
Unswitched and uncontrolled loads . .	0·8	Not possible to remove power
Total . .	27·05	

(ii) Various intermittent loads will be applied to the battery during the operation of manual trim actuators, fuel cocks and 96-volt service selections. These loads should not affect the battery to any great extent.

(iii) If it is possible to dispense with the 100A inverter, the battery life will be extended as this is the biggest continual load on the battery. It may be practicable to switch OFF the intercomm; the crew can then communicate by voice after helmet removal. It will normally be possible to shed most of the other loads by the methods suggested in the table, e.g. it is pointless wasting power to illuminate failure indicators in generator, rotary transformers and power control motors after they are known to have failed or have been switched OFF.

(iv) When flight conditions permit, the 24-volt battery can be switched OFF. In this condition there will be no instruments or indicators except the pressure instruments, the rpm gauges, jet pipe temperature gauges and the magnetic compass.

15 Action in the event of rotary transformer failure

(*a*) It is assumed that in the event of 1, 2 or 3 rotary transformers failing, RESET action is immediately taken without result.

(*b*) One rotary transformer failed—no action except RCM aircraft; shed selected RCM loads where necessary.

(*c*) Two rotary transformers failed:

(i) *B1 aircraft*—no action.

(ii) *B/PR1 aircraft in PR role*—cameras OFF otherwise no action.

(iii) *Tanker aircraft during transfer*—discontinue transfer, reel in hose, close bomb doors.

(iv) *RCM aircraft* (not WP214)—RCM emergency ON/OFF switch OFF, ensure all RCM equipments OFF. Royal inverter OFF.

(*d*) Three rotary transformers failed, indicated by:

(i) Three warning lights on.

(ii) Post-Mod. 2454, rotary transformer ammeters reading zero.

(iii) Post-Mod. 2650, 24-volt battery ammeter showing a discharge equivalent to the 28-volt loads.

The 24-volt battery reading *must* be carefully monitored immediately the failure occurs. If the battery voltage falls very rapidly, and post-Mod. 2650 the battery ammeter shows a maximum discharge, the fault is not rotary transformer failure but the very much more serious 24-volt bus-bar short to earth. As soon as the rotary transformer failure is established, apply the drills as recommended in para. 14, except that one generator should be left ON and the power control motors are only reduced to half rate. As in the case of a total generator failure, the 24-volt battery will limit the flight and the same remarks apply in regard to duration.

16 96-volt bus-bar short to earth

(*a*) The indications of a 96-volt bus-bar short to earth are:

(i) 96-volt bus-bar voltmeter showing sudden fall, post-Mod. 2454 generator ammeters showing excess current, and post-Mod. 2650 battery ammeter showing maximum discharge. Note that the generator warning lights *may not* come on.

(ii) Type 350 inverter serviceability lights out.

(iii) Power control motors and all other 112-volt services failing.

(*b*) The 24-volt battery will have to be immediately relieved of all possible loads as detailed in para 14. The aircraft will be controllable only as long as the 24-volt battery will support the manual trimmer load, the fuel will gravity feed and the C of G remains in limits. If an airfield is immediately available the aircraft is committed to a manual, wheels up, flapless landing, otherwise the aircraft must be abandoned.

17 24-volt bus-bar short to earth

(*a*) The indications of 24-volt bus-bar short to earth are:

(i) All services will fail except those switched by latched contactors, e.g. power control motors and inverters.

(ii) No rotary transformer or generator warning lights (generators will be OFF line because there will be no power to maintain main circuit-breakers closed).

(iii) 24-volt bus-bar voltmeter showing sudden fall, post-Mod. 2454 rotary transformer ammeter showing excess current, and post-Mod. 2650 battery ammeter showing maximum discharge.

(iv) No intercomm or W/T or VHF for distress calls.

(v) At night, all lights out.

(vi) Pressure instruments, JPT gauges, RPM gauges and magnetic compass only.

(*b*) The aircraft will be controllable only as long as:

(i) The 96-volt battery will support the power control motors (it is not possible to conserve power by tripping out power controls, no 24-volt power available).

(ii) The fuel will gravity feed (the fuel pumps will stop as the 24-volt power fails).

(iii) The C of G remains in limits after the power control motors have failed (the power control motors will fail in approx 15 minutes).

(*c*) No landing should be attempted, the crew should bale out as soon as the speed has been reduced.

18 Flight with the canopy and/or door removed

(*a*) Test flights have shown that flight with the canopy and/or the entrance door off with the eye-lid extended is quite practicable at speeds up to 300 knots ; further tests to higher speeds will be carried out later. The handling characteristics of the aircraft are unaltered except that the stalling speed may be increased by up to 10 knots.

(*b*) The noise level in the aircraft is extremely high, making VHF communication very difficult above 170 knots and normal inter-communication very difficult above 200 knots. These conditions are alleviated slightly if crash helmets are worn.

(*c*) Airflow conditions in the cabin do not become uncomfortable, but when the canopy is off there is considerable forward flow of air between the pilots' seats, particularly when the door is off also, and this becomes turbulent with increase in speed. At 300 knots considerable buffeting behind the pilots' heads is felt which may be severe enough to cause loss of vision.

(*d*) At all speeds the ejection seat blind handles can easily be reached by the pilots and conditions in the cabin allow any movement by crew members to be made without difficulty.

(*e*) *Cabin altitude*

Tests indicate that a negative differential pressure exists within the cabin when flying with the door off. Relative altitudes are as follows:

Aircraft altitude	*Speed*	*Cabin altitude*
45,000 feet	0·85 M	50,000 feet
47,000 feet	160 knots	50,000 feet
35,000 feet	0·85 M	40,000 feet
38,000 feet	160 knots	40,000 feet

In view of the limitations on oxygen equipment it is recommended that, when circumstances permit, the cabin door should not be jettisoned at altitudes greater than those which give a cabin altitude of 50,000 feet. The oxygen limitations permit one minute at 50,000 feet, and a descent should be made at once. 40,000 feet (cabin altitude) should be reached within 2 minutes of the cabin pressure loss. To allow for the scatter of test results, a reduction of 2,000 feet should be made to the aircraft altitude figures quoted above.

19 Abandoning the aircraft

(*a*) *General*

(i) Before an attempt is made to abandon the aircraft, the cabin pressure must be reduced by operating the emergency depressurising cock above the radio crate. In addition, circumstances permitting, the 1st pilot should operate the emergency depressurising switch on the port console panel and the 2nd pilot should select the cabin pressure control to NO PRESSURE.

NOTE: As the emergency depressurising cock is above the radio crate, it is unlikely that the crew will be able to operate it above $2\frac{1}{2}$ G.

(ii) The entrance door should be jettisoned by the AEO (i.e. nearest the door) who must remain strapped in until jettisoning is complete (see Part I, para. 91). Tests indicate that the door will jettison satisfactorily at speeds up to 300 knots ; the flaps should be up.

Fig. 1 Rear crew abandoning posture

(*b*) *Abandoning—Rear crew members*

(i) The rear crew members should bale out in the following order:

1 AEO (nearest door)

2 Navigator plotter (centre seat)

3 Navigator radar (farthest from door)

NOTE 1: If the occasional seat is occupied, the occupant should bale out third, i.e. between the Nav. plotter and the Nav. radar.

NOTE 2: In aircraft fitted with ARI 5910, the occasional seat is near the door. The occupant should remain strapped in until the door has been jettisoned, and should then bale out after the AEO.

(ii) After the door has been jettisoned, each man, in the above order, should leave his seat, the first two moving their seats *fully aft* against the radio crate table and locking them there. The emergency oxygen bottle manual release must be pulled immediately before disconnecting the mask tube.

(iii) If static lines are fitted (see Part I, para. 93 (*c*)), each man, as he comes to the door to escape, should grasp one static line ring and attach it to the parachute barostat release hook. The static lines should be taken by the crew members in the order shown in Part I, Fig. 26. The behaviour of a static line after use is unpredictable, and as it might flail and present a hazard to the second and subsequent crew member it is recommended that if time permits, each line, after use, should be pulled into the cabin and stowed aft between the port seat and the side of the aircraft by the following crew member before making his escape.

(iv) Each man, in turn, should then step on to the eyelid platform, facing outward and parallel to the eyelid, and crouch down adopting as compact (" balled up ") a position as possible (see Fig. 1). The head must be down, the arms around the shins, and hands grasping the surplus material of the overall legs (see (vi) 3 below), or the hands interlocked, so as to ensure maintenance of this posture when exposed to the airflow. Exit should then be made by rolling forward, and every endeavour must be made to remain " balled up " for two or three seconds until well clear of the aircraft. The last man out should tap the pilot immediately before making his escape.

(v) Tests have shown that underwing clearance is good provided that the flaps are up, and that there is little danger of striking the undercarriage if this is down. Fuselage clearance, however, is marginal, but should be adequate if the recommended compact posture is maintained. Tests were made at speeds up to 360 knots straight and level, and with maximum permissible starboard side-slip. In the latter condition there was an improvement in fuselage clearance.

(vi) The chances of avoiding injury in escape are considerably increased if the following points are observed.

1 The protective helmet must be a good fit and the chin-strap secure and *tight*.

2 The oxygen mask must be securely and tightly fastened, or, if fitted with toggle harness this must be in the emergency position.

3 The flying overalls should be worn outside the flying boots (see (iv) above).

4 The dinghy pack should be removed unless required ; if retained it must be correctly and securely fitted. The type C is almost certain to be lost, but the type S, which is replacing the type C, should remain attached if correctly and securely fitted.

(vii) *Limitations*

Tests have shown that successful escape from the aircraft is possible in straight and level flight at speeds up to 360 knots, and with small amounts of starboard sideslip. However, at speeds above 270 knots there is increased possibility of injury, and of loss of the protective helmet, type S survival pack and life-jacket equipment. Every endeavour should be made to reduce speed to below 270 knots and if possible, to the optimum speed range of 180-220 knots. The bomb-doors should be closed and the flaps should be up. If possible the undercarriage should be retracted although escape is possible with the undercarriage locked down. Whenever possible there should be no yaw, bank or applied G. The prone position cannot normally be vacated at more than $1\frac{3}{4}$G, and the rear crew seats cannot normally be vacated at more than $2\frac{1}{2}$G.

(*c*) *Abandoning aircraft at low altitude*

Should it be necessary to abandon the aircraft at low altitude (below 1,000 ft.), reduction of the time interval between the moment at which the order to abandon aircraft is given and the moment at which the parachute is deployed can be of overriding importance, and the following points should be borne in mind.

(i) Whilst it is highly desirable to connect a static line, time should not be wasted if this proves troublesome.

(ii) The static line arms the parachute barostat, which then withdraws the pack pins after a delay of 2 seconds. Therefore, irrespective of whether the static line is connected or not, the manual override should always be pulled as soon as possible after abandoning the aircraft below 1,000 feet.

(*d*) *Abandoning—Pilots*

NOTE: When seat-mounted emergency oxygen bottles are fitted, they remain with the seat after separation occurs at or below 10,000 feet.

(i) When time permits, the canopy should not be jettisoned until the rear crew members have baled out, otherwise their difficulties may be considerably increased. When the pilots are ready to eject:

1 The second pilot must operate his canopy jettison lever (this will also disconnect and throw forward the 2nd pilot's handwheel) and then fire his ejection seat, using the main firing handle if possible, or the alternative firing handle.

2 The first pilot must then operate his canopy jettison lever (to disconnect and throw forward the 1st pilot's handwheel) and then fire his ejection seat, using the main firing handle if possible, or the alternative firing handle.

WARNING: Operation of the alternative firing handle without first jettisoning the canopy will have fatal results.

(ii) *Limitations*

1 The limitations for minimum safe height for ejection are indicated on a small plate attached to each ejection seat. Without a G-stop fitted the minimum height for ejection is 100 feet. With a G-stop fitted the seats have a ground level ejection capability provided that the speed is 90 knots or above, and the flight path is parallel to the ground. If the aircraft is descending the minimum height for safe ejection must be increased.

2 The optimum speed for ejection is 200 knots, but there is no IAS limitation for ejection other than that mentioned at 1 above. However, successful canopy jettison trials have only been carried out at speeds between 150 and 300 knots.

Unless unavoidable the ejection seat should not be used when the aircraft is inverted. The canopy must always be jettisoned before ejection, as the chances of surviving an attempt to eject through it are nil. (When Mod 1018 is embodied it is not possible to eject until the canopy is off). There is also a risk of severe injury if the control hand-wheels are not disconnected and thrown forward before ejection (see Part I, para 96). If it is necessary to use the parachute manual override, the parachute should not be opened above 20,000 feet.

20 Ditching

(*a*) Although the ditching characteristics are rather poor, model tests indicate that the aircraft can be ditched safely under certain conditions.

(*b*) The behaviour of the aircraft on ditching is dependent on the position of the bomb doors, air spoilers and flaps. It is also dependent on the touch-down attitude and rate of sink. The following table shows the probable behaviour under various conditions:

Configuration	*Flaps*	*Landing attitude*
Bomb doors closed Air spoilers in	Up	Safe below 9°
	55°	Safe below 6°
Bomb doors closed Air spoilers out	0° to 55°	Safe below 10°
Bomb doors open Air spoilers in	0° to 55°	Catastrophic dive at any attitude
Bomb doors open Air spoilers out	0° to 55°	Safe below 9°

From this it will be seen that while it is advisable to have the bomb doors closed, it is really the air spoilers which have the greatest effect on the behaviour. Except in the clean condition (bomb doors closed and air spoilers in) the flaps have little or no effect. The best chance appears to be with bomb doors closed and air spoilers out. The undercarriage, of course, must be left retracted. The approach should be made at not more than nine degrees nose-up, every endeavour being made to keep the landing shock as light as possible by keeping the rate of sink low.

(*c*) An angle of yaw of up to five degrees has no effect, but the angle of roll must not exceed three degrees otherwise the lower wing-tip may bury, causing the aircraft to ground loop.

(*d*) Landing in waves, especially in a well-defined swell, should be made along the wave crests. If the landing is made across the waves there appears to be a strong likelihood of the nose burying, with consequent violent deceleration.

(*e*) Whatever the conditions, only the upper ditching hatch should be removed and stowed prior to ditching. When the aircraft has come to rest, a crew member should be ready to pull the dinghy release handle. The crew members and pilots should make their escape through the ditching exit. The entrance door and the crash landing exit on the starboard side must not be jettisoned or opened. The canopy may be jettisoned if desired, but not until the aircraft has almost come to rest. When the canopy explosive bolts have fired the canopy will not leave the aircraft owing to the absence of air flow, and it will have to be lifted off by the pilots. Provided all bolts have fired this is quite straightforward, but the canopy is heavy.

(*f*) No information is available about the flotation qualities of the aircraft, but if the ditching has been clean and no major break-up has occurred, there should be adequate time for successful escape.

21 Use of aircraft destructors

The following drill should be used for applying and firing the aircraft destructors.

(*a*) All except two of the crew members should evacuate the aircraft and take cover.

(*b*) The two remaining crew members remove the sextant dome, and one member climbs out on to top of fuselage.

(*c*) Second crew member stands on chart table, unseals and opens destructor containers, passes destructors out to other crew members and then climbs out on to top of fuselage.

(*d*) Each crew member moistens the destructor suction cup and applies the destructor in the selected position (see Part I, para. 134). Retaining a grip on the flyoff levers, the crew members remove the transit and primary safety pins and then, at a pre-arranged signal, release the fly-over levers.

(*e*) Both crew members leave the aircraft as quickly as possible and take cover. If a wing-tip is on the ground the wing can be used as a walkway ; otherwise, the pitot head can be used to help the crew swing down to the ground.

(*f*) A built-in time delay allows about 60 seconds between releasing the fly-off levers and the firing of the destructors.

Part VI

ILLUSTRATIONS

PART VI

Illustrations

List of Illustrations

Key to Fig A

1 Port console floodlamp dimmer switch
2 Top panel, instrument panel and accelerometer floodlamps dimmer switch
3 Roof floodlamps dimmer switch
4 Port outer wing tank fuel contents gauge
5 Port outer wing tank fuel pump switch
6 Port inner wing tank fuel pump switch
7 Port under-wing tank low pressure warning light
8 Port under-wing tank fuel pump switch
9 Port reserve tank fuel cock indicator
10 Port reserve tank fuel cock switch
11 Fueslage tanks pump switch—port, No. 2
12 Fuselage tanks pump switch—port, No. 1
13 Port wing tanks interconnection cock switch (Post-Mod 2330 or 2331) (see C/22)
14 Instrument panel u/v lights dimmer switch
15 Port wing tanks interconnection cock indicator (Post-Mod 2330 or 2331) (see C/22)
16 Crossfeed fuel cock switch (Post-Mod 2330 or 2331) (see C/21)
17 Centre u/v lights dimmer switch
18 Crossfeed fuel cock indicators (Post-Mod 2330 or 2331) (see C/21)
19 Stand-by compass lamp dimmer switch
20 Starboard wing tanks interconnection cock switch (Post-Mod 2330 or 2331) (see C/20)
21 Fuel panel floodlamps dimmer switch
22 Starboard wing tanks interconnection cock indicator (Post-Mod 2330 or 2331) (see C/20)
23 Fuel panel general lighting dimmer switch
24 Fuselage tanks pump switch—starboard, No. 1
25 Fuselage tanks pump switch—starboard, No. 2
26 Starboard reserve tank fuel cock switch
27 Starboard reserve tank fuel cock indicator
28 Starboard under-wing tank fuel pump switch
29 Starboard under-wing tank low pressure warning light
30 Starboard inner wing tank fuel pump switch
31 Starboard outer wing tank fuel pump switch
32 Starboard outer wing tank fuel contents gauge
33 Central pedestal floodlamps dimmer switch
34 Top panel and instrument panel floodlamps dimmer switch
35 Starboard console flood lampsi dimmer switch
36 Starboard inner wing tank fuel contents gauge
37 Starboard under-wing tank fuel contents gauge
38 Starboard reserve tank fuel contents gauge
39 Starboard fuselage tanks fuel contents gauge
40 Transfer tank fuel contents gauge
41 Transfer tank fuel pump switch
42 Transfer tank low pressure warning light
43 Fuselage tanks (starboard) contents gauge selector switch
44 Wing tanks contents gauges emergency change-over switch
45 Under-wing tank port, pump contactor indicator
46 Air spoiler indicators
47 Auxiliary tank low pressure warning light (not on B 1)
48 Underwing tank stbd, pump contactor indicator
49 Auxiliary tank fuel pump switch (not on B 1)
50 Fuselage tanks (port) contents gauge selector switch
51 Abandon aircraft switch
52 Port fuselage tanks fuel contents gauge
53 Port reserve tank fuel contents gauge
54 Port under-wing tank fuel contents gauge
55 Port inner wing tank fuel contents gauge

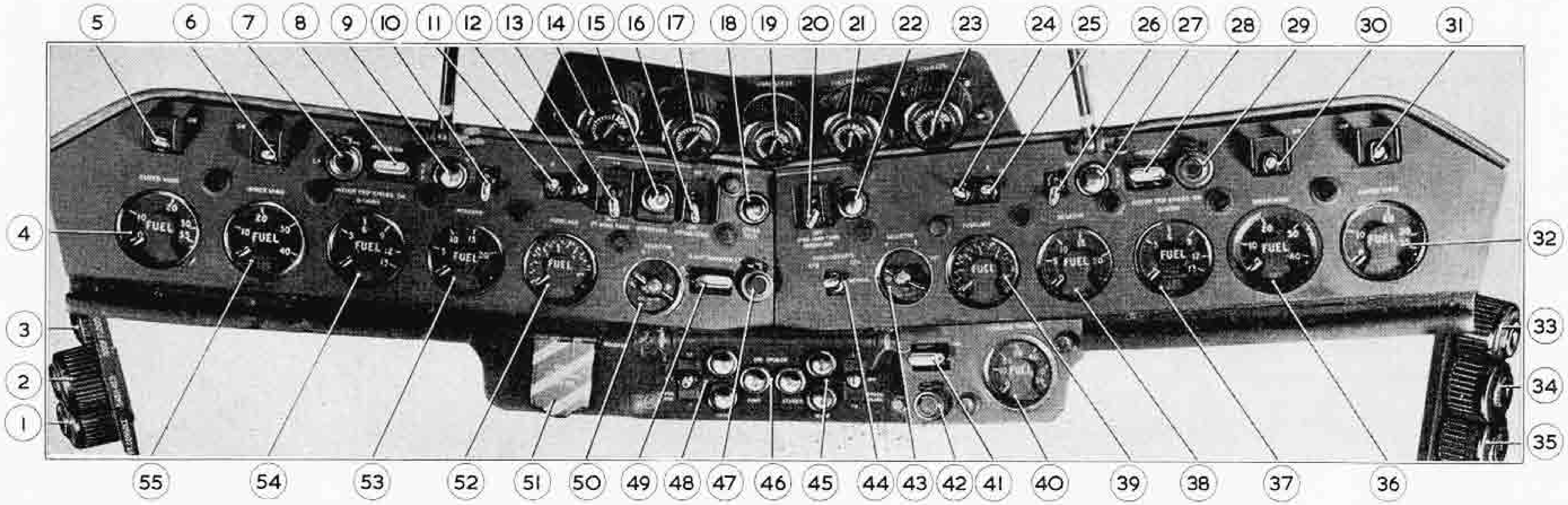


FIG. A. FUEL PANEL (Post-Mod. 2330 or 2331)

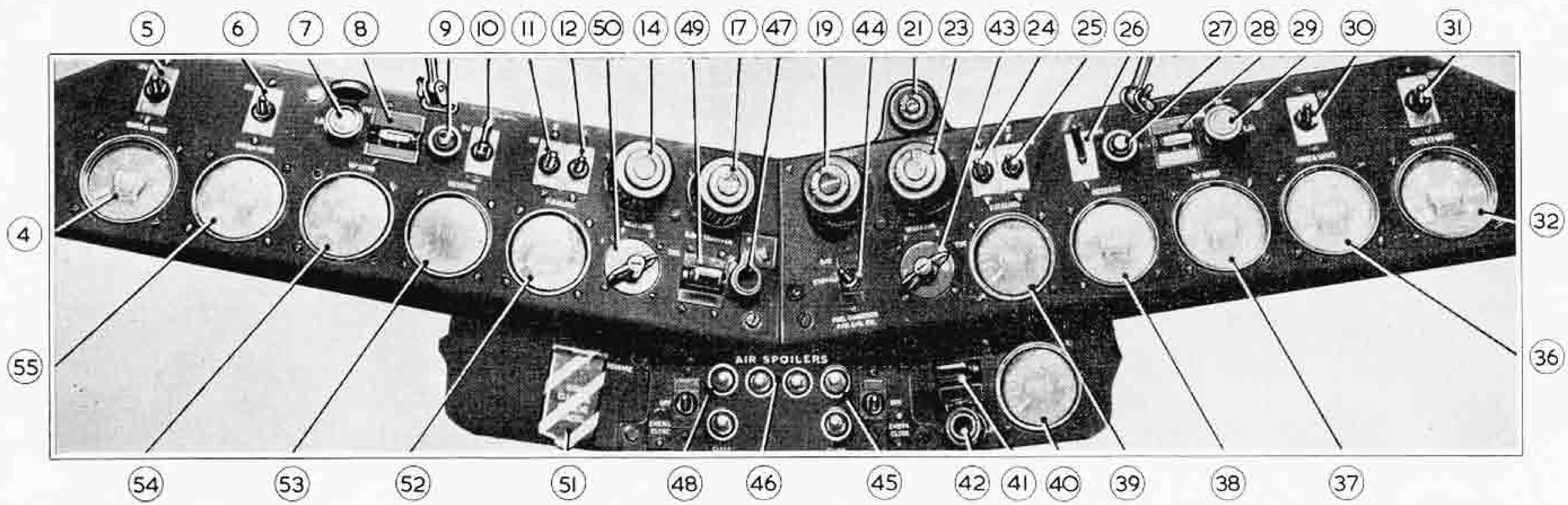


FIG. A. FUEL PANEL (Pre-Mod. 2330 or 2331)

Key to Fig. B

1. Cabin altimeter.
2. Radio altimeter (low level).
3. Artificial horizon fast erection pushbutton.
4. Machmeter.
5. Port pressure head heater switch.
6. Accelerometer (Mod. 1656).
7. Gee-H indicator lights.
8. Oxygen remote blinker indicator (Mod. 1604).
9. Elevator trim indicator lights.
10. Rear warning indicator.
11. Power controls master failure indicator (Mod. 1617 or 2006).
12. Port landing lamp filament switch.
13. Landing lamps control switch.
14. Starboard landing lamp filament switch.
15. No. 1 engine L.P. master cock switch and indicator.
16. No. 2 engine L.P. master cock switch and indicator.
17. R.P.M. indicators (4).
18. Fire-extinguisher warning lights test pushbutton (Mod. 1919) – port lights.
19. Fire-extinguisher warning lights test pushbutton (Mod. 1919) – starboard lights.
20. J.P.T. gauges (4).
21. Survey camera pre-pulse indicator (Post-Mod. 2099 and 2122).
22. Fire-extinguisher pushbuttons (4).
23. U/v lamp socket (lamp stowed at J/3).
24. Fuel filter de-icing switch.
25. Fuel filter de-icing warning lamp.
26. No. 3 engine L.P. master cock switch and indicator.
27. No. 4 engine L.P. master cock switch and indicator.
28. Instrument master switch.
29. Main flap motor trip button.
30. Emergency flap motor trip button.
31. Time-of-fall remote control unit (Pre-Mod. 2397).
32. Low pressure fuel warning lights.
33. Artificial horizon fast erection pushbutton.
34. J.P.T. fuel control switch.
35. Oxygen remote blinker indicator (Mod. 1604).
36. Starboard pressure head heater switch.
37. R.A.T.O. high thrust indicator lights (Mod. 2330 or 2331).
38. R.A.T.O. low thrust indicator lights (Mod. 2330 or 2331).
39. Machmeter.
40. Rate of climb indicator.
41. Radio altimeter (low level).
42. Low level radio altimeter limit lights.
43. Cabin altimeter.
44. Turn and slip indicator.
45. I.L.S. indicator.
46. G.4B compass indicator.
47. I.L.S. marker indicator.
48. Radio compass bearing indicator.
49. Starboard flap position indicator.
50. Oil pressure gauges – starboard engines.
51. Port flap position indicator.
52. Starboard wheel secondary lock light.
53. Aileron feel trim indicator.
54. Undercarriage position indicator.
55. Rudder feel trim indicator.
56. Air brakes position indicator (Mod. 1608).
57. Port wheel secondary lock light.
58. Tailplane incidence indicator.
59. Oil pressure gauges – port engines.
60. O.A.T. gauge.
61. I.L.S. indicator.
62. Turn and slip indicator.
63. I.L.S. marker indicator.
64. Bombing direction indicator.
65. Rate of climb indicator.
66. G.4B compass indicator.
67. Clock.
68. Low level radio altimeter limit lights.

NOTE 1: Until Mod. 1200 (W.P.214) is embodied, items 58 and 60 are transposed.

NOTE 2: When Bomber Command Mod. 30 is embodied, the rate of climb (40 and 65), turn and slip (44 and 62) and I.L.S. (45 and 61) indicators are re-arranged. The I.L.S. indicator is then at the top, the rate of climb indicator below it and the turn and slip indicator below that.

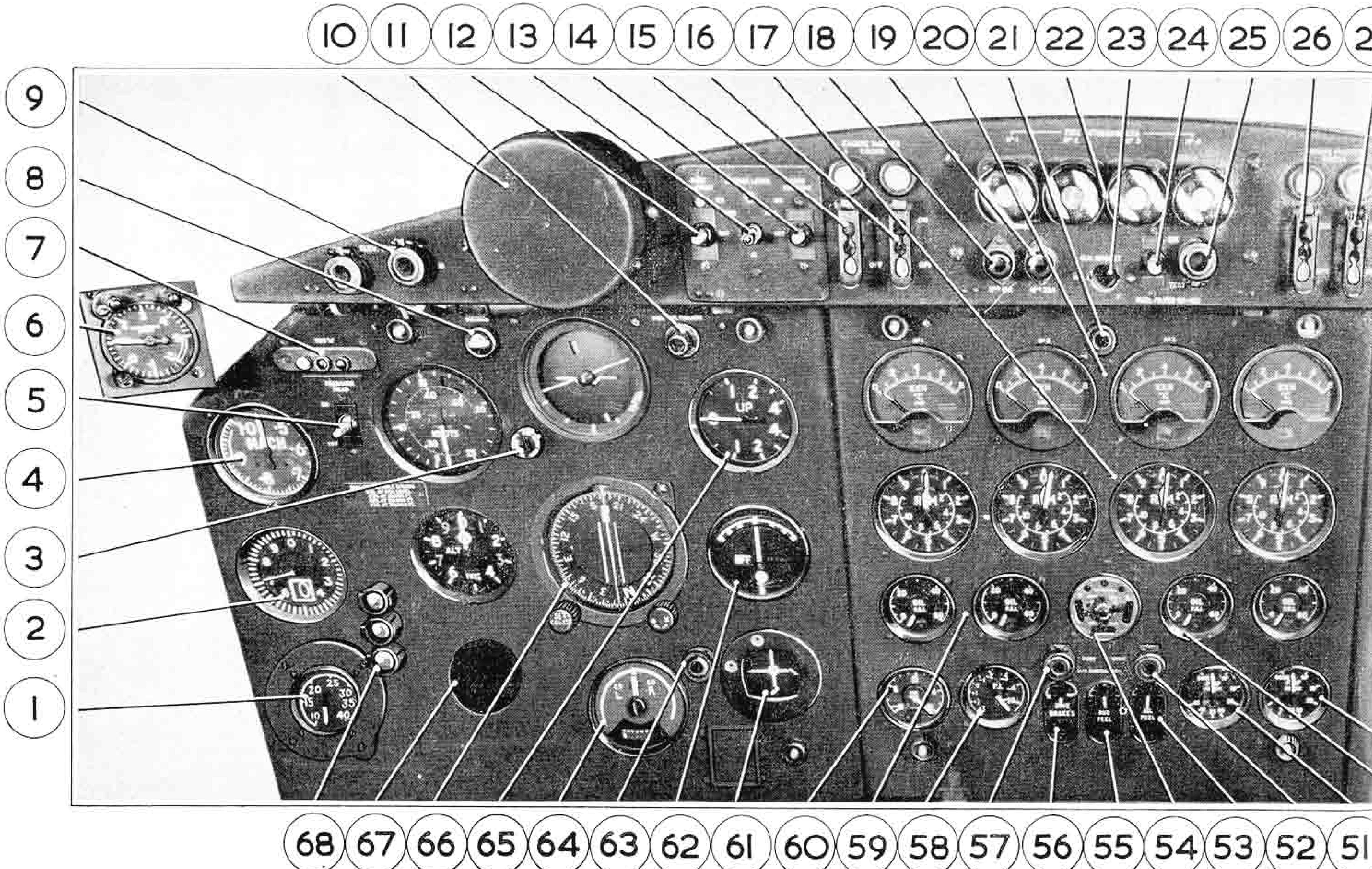
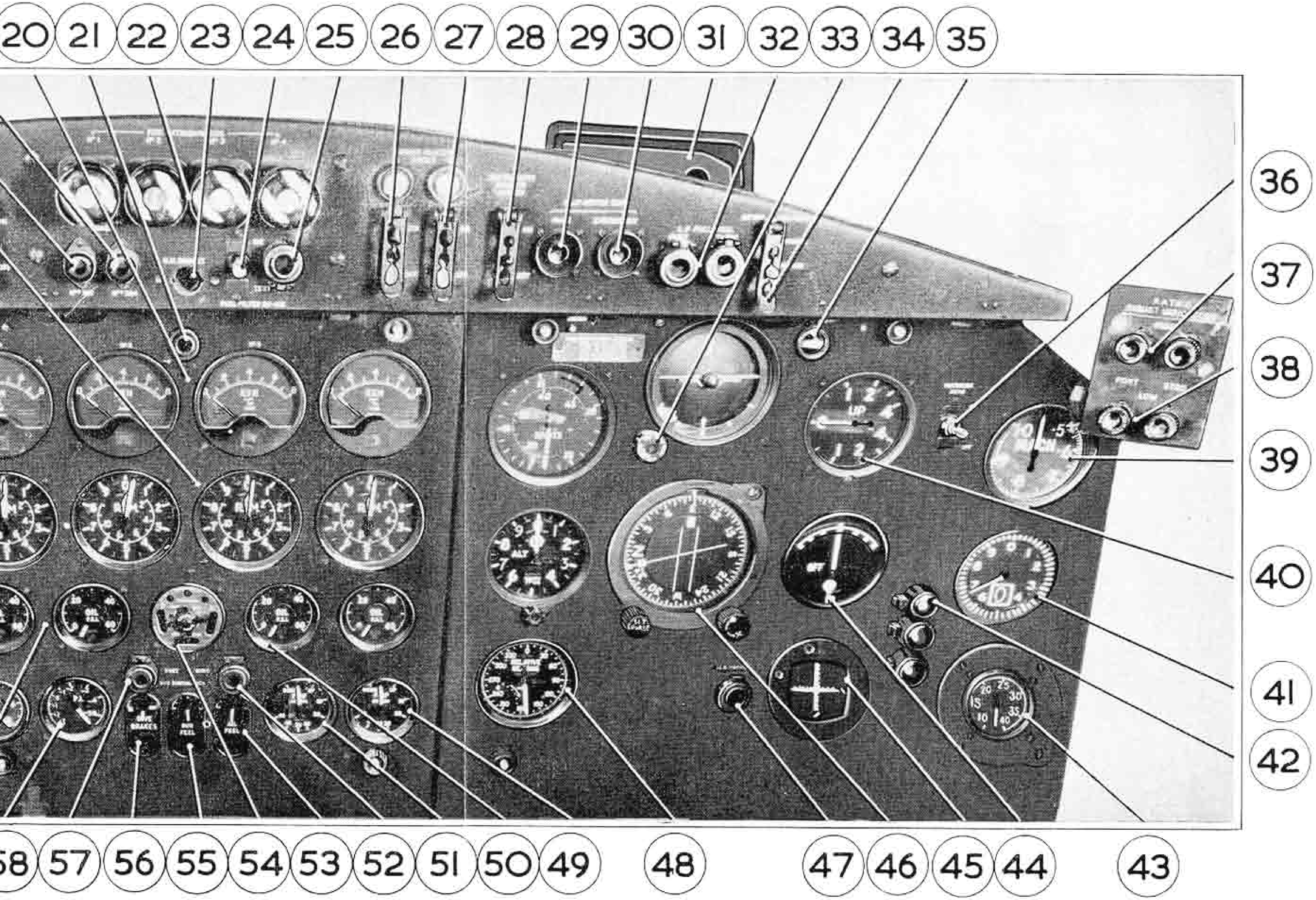


FIG. B. TOP PANEL AND INSTRUMENT PANELS



G. B. Top panel and instrument panels

Key to Fig. C

1. High-intensity cockpit lamps switch (Mod. 1965).
2. R.A.T.O.G. master switch (Mod. 2330 or 2331).
3. Elevator feel unit cut-off lever.
4. Tailplane incidence COARSE/FINE switch.
5. Flap emergency selector switch.
6. Tailplane incidence 1st Pilot/2nd Pilot switch.
7. Aileron feel unit cut-off lever.
8. Bomb door control switch.
9. Rudder feel unit cut-off lever.
10. Throttle friction lever.
11. Air brakes selector lever.
12. Throttle/H.P. cock levers – incorporating re-light buttons.
13. Flap lever.
14. Throttle friction lever.
15. Feel units trimming switch.
16. Bomb jettison switch.
17. Undercarriage down selector button.
18. Undercarriage up selector button.
19. Undercarriage emergency down selector button.
20. R.A.T.O.G. jettison indicator lights (Post-Mod. 2330 or 2331).
20. Starboard wing tanks interconnection cock switch and indicator (Pre-Mod. 2330 or 2331) (see A/20 and 22).
21. R.A.T.O.G. emergency release switch (Post-Mod. 2330 or 2331).
21. Crossfeed fuel cock switch and indicator (Pre-Mod. 2330 or 2331) (see A/16 and 18).
22. R.A.T.O.G. normal release switch (Post-Mod. 2330 or 2331).
22. Port wing tanks interconnection cock switch and indicator (Pre-Mod. 2330 or 2331) (see A/13 and 15).
23. Internal control locks lever.
24. Auto-pilot controller.
25. Wander lamp.
26. No. 2 V.H.F. controller.
27. Wheel brake hydraulic system emergency change-over cock.
28. V.H.F. change-over switch.
29. V.H.F. volume control.
30. Low level radio altimeter switch.
31. No. 1 V.H.F. controller.

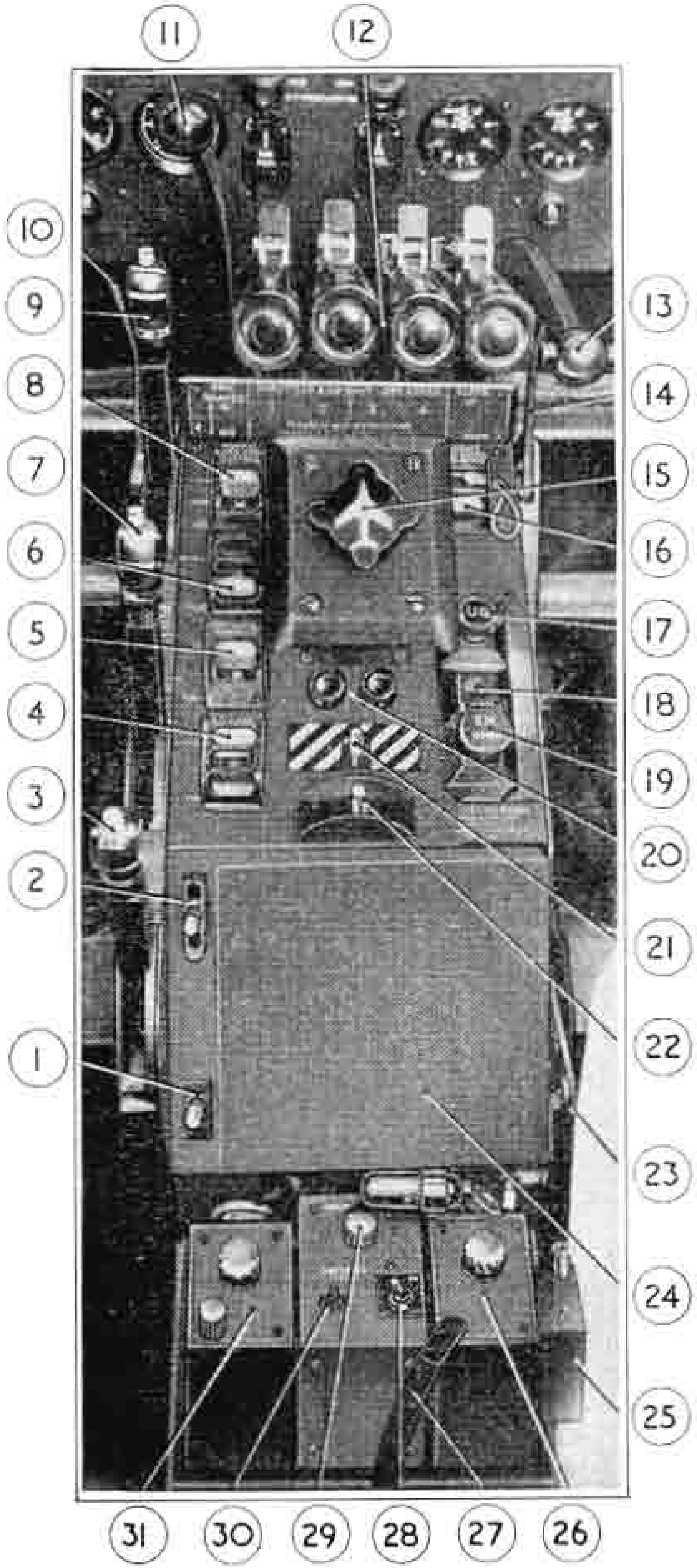


FIG. C. CENTRAL PEDESTAL
(Post-Mod. 2330 or 2331)

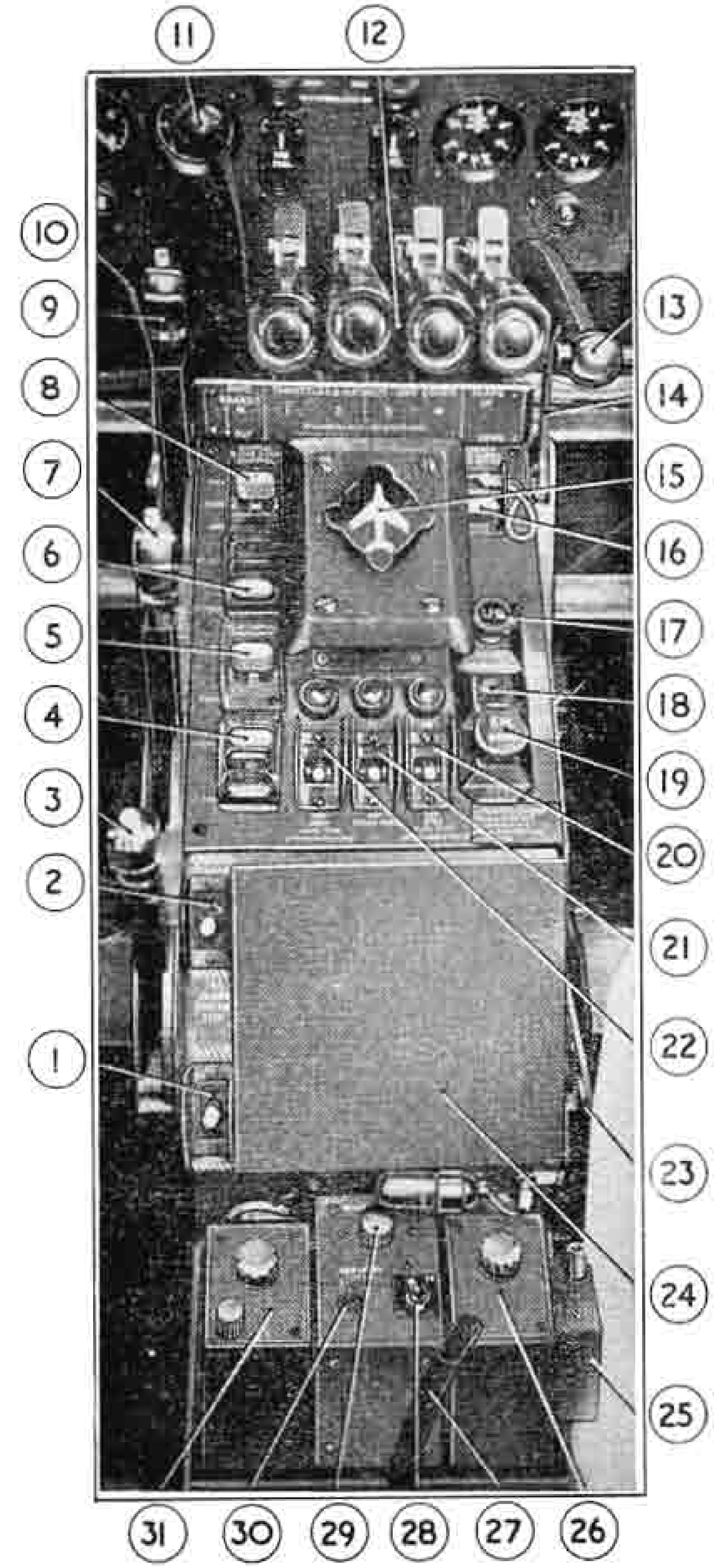


FIG. C. CENTRAL PEDESTAL
(Pre-Mod. 2330 or 2331)

Key to Fig. D

1. I.L.S. controller.
2. Rear warning auxiliary control unit.
3. Quarter panel lamp.
4. I.L.S. master switch.
5. Rear warning control unit.

Key to Fig. E

1. Water-methanol low pressure warning light – No. 3 engine.
2. Water-methanol low pressure warning light – No. 2 engine.
3. Water-methanol low pressure warning light – No. 1 engine.
4. Water-methanol master switch.
5. Port under-wing fuel jettison switch.
6. Starboard under-wing fuel jettison switch.
7. Power controls trip push-button – Aileron No. 1 motor.
8. Power controls trip push-button – Aileron No. 2 motor.
9. Power controls trip push-button – Rudder and elevator No. 1 motor.
10. Power controls trip push-button – Rudder and elevator No. 2 motor.
11. Port instrument panel u/v lamp.
12. Not used.
13. Ventilation louvre.
14. Not used.
15. Port instrument panel and machmeter emergency lamps switch.
16. Cockpit roof lamp switch.
17. I/C—H/F switch.
18. Port coaming and quarter panel lamps dimmer switch.
19. De-mister selector.
20. I.L.S. volume control (Mod. 1945).
21. No. 2 hydraulic pump indicator.
22. No. 1 hydraulic pump indicator.
23. Not used.
24. Not used.
25. Entrance door indicator.
26. Power controls failure warning light – Rudder and elevator No. 2 motor.
27. Power controls failure warning light – Rudder and elevator No. 1 motor.
28. Power controls failure warning light – Aileron No. 2 motor.
29. Power controls failure warning light – Aileron No. 1 motor.
30. Water-methanol low pressure warning light – No. 4 engine.

Key to Fig. F

1. Engine starter master switch.
2. Engine starter pushbutton.
3. Engine starter selector switch.
4. 24-volt battery switch.
5. 96-volt battery switch.
6. 24-volt battery indicator.
7. 96-volt battery indicator.
8. Nose-wheel steering control.
9. Port control hand-wheel release.
10. Port windscreen wiper control.
11. Elevator trim tab position indicator.
12. Emergency de-pressurising switch.
13. Port control hand-wheel adjustment.
14. Oxygen regulator.
15. Auto-pilot heading selector.
16. Identification light morsing push-button.
17. G.4B compass controller.
18. Rudder and aileron trim tabs position indicator.
19. Trim tabs switch.
20. Elevator trim tab master switch.
21. Rudder trim tab master switch.
22. Canopy jettison lever (under cover).
23. Aileron trim tab master switch.
24. Engine starting cycle light.

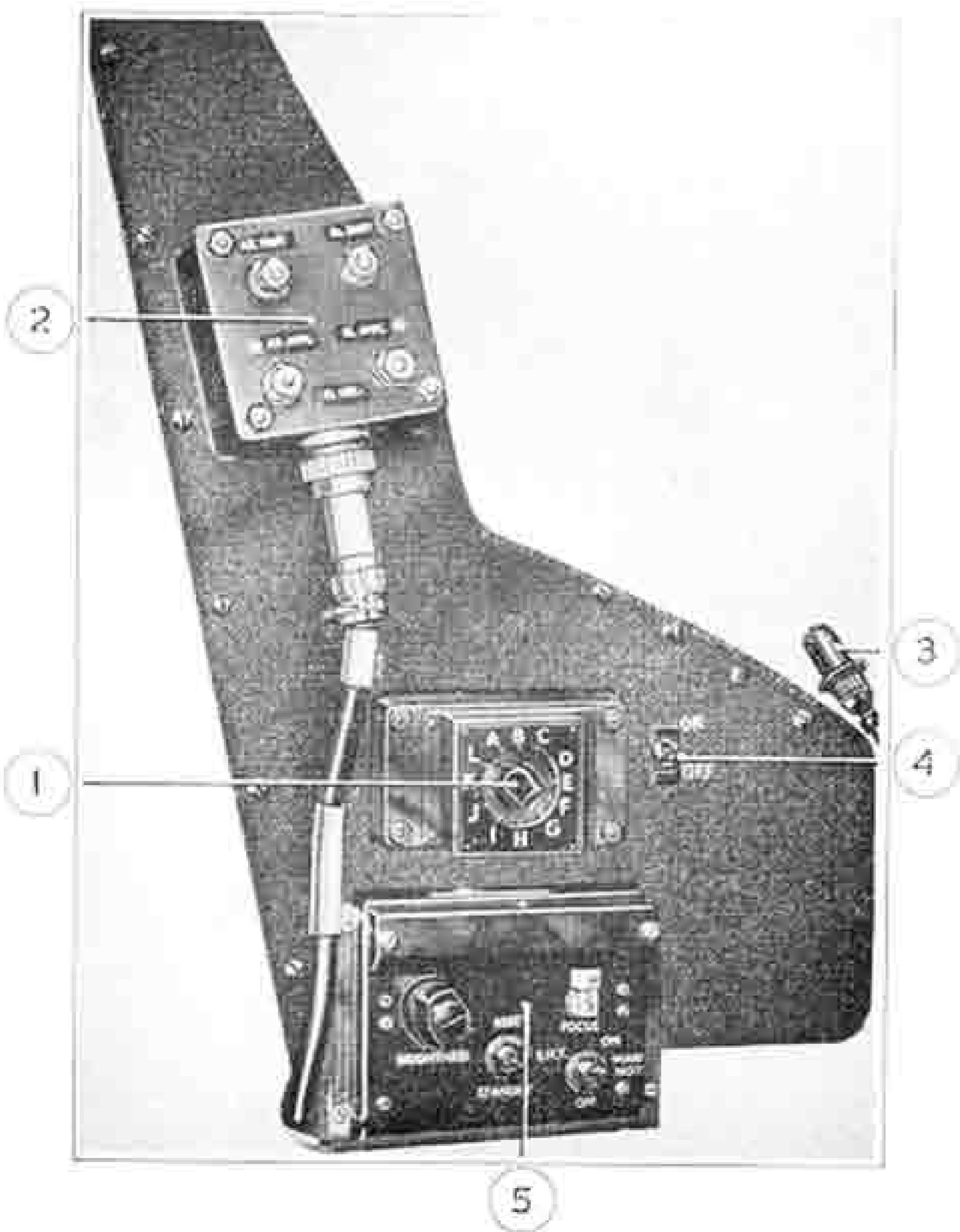


FIG. D. PORT QUARTER PANEL

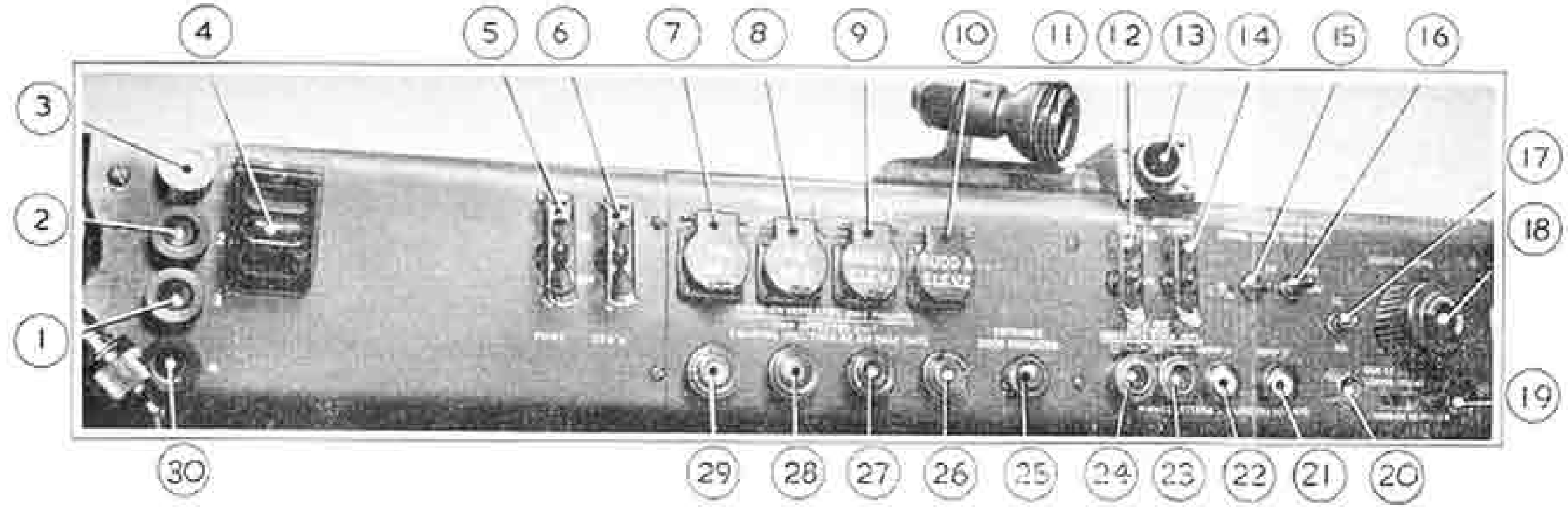


FIG. E. PORT COAMING PANEL

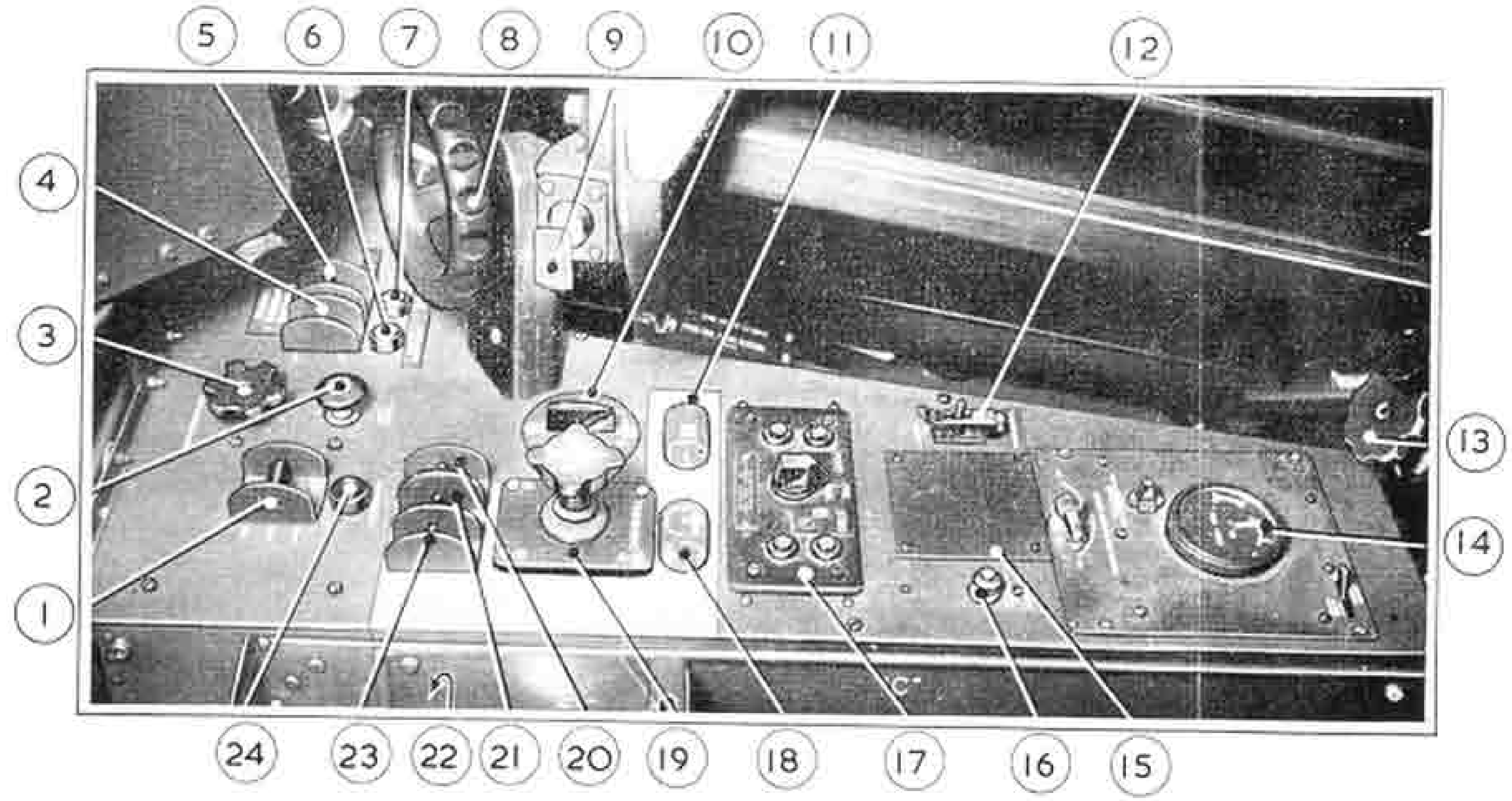


FIG. F. PORT CONSOLE PANEL

Key to Fig. G

1. Starboard coaming and quarter panel lamps dimmer switch.
2. Port main-wheel door indicator light.
3. Starboard main-wheel door indicator light.
4. Ventilation louvre.
5. External lights master switch.
6. Starboard instrument panel u/v lamp.
7. Identification lights switch.
8. Navigation lights switch.
9. Probe lights dimmer switch – port light.
10. Probe lights dimmer switch – starboard light.
11. Starboard under-wing tank refuelling valve switch.
12. Starboard No. 2 wing tank refuelling valve switch.
13. Starboard No. 1 wing tank refuelling valve switch.
14. Transfer and auxiliary tanks refuelling valve switch.
15. Fuselage No. 3 cell refuelling valve switch.
16. Fuselage No. 2 cell refuelling valve switch.
17. Fuselage No. 1 cell refuelling valve switch.
18. Reserve tank refuelling valve switch.
19. Port No. 1 wing tank refuelling valve switch.
20. Port No. 2 wing tank refuelling valve switch.
21. Port under-wing tank refuelling valve switch.
22. Probe de-icing switch.
23. Tail lights switch.
24. Starboard instrument panel emergency lamp switch.
25. I/C – H/F switch.

NOTE: Items 9 to 23 inclusive are on B(K)1 and BK(PR)1 aircraft only.

Key to Fig. H

1. Oxygen regulator.
2. Starboard control hand-wheel adjustment.
3. Starboard windscreen wiper control.
4. Cabin pressure selector switch.
5. Cabin air supply switches.
6. Ram air switch.
7. Flood flow cut-out switches.
8. Ground ventilation fan switch.
9. Starboard control hand-wheel release.
10. Undercarriage warning horn test push-button.
11. Undercarriage extreme emergency lowering switches (under cover).
12. Cabin temperature control and indicator.
13. Bomb bay heating switches and temperature gauge.
14. Airframe anti-icing shut-off valve switches.
15. Canopy jettison lever (under cover).
16. Anti-icing overheat warning lamp – tail.
17. Anti-icing overheat warning lamp – port wing.
18. Anti-icing overheat warning lamp – starboard wing.
19. Airframe and engine anti-icing master switch.
20. Windscreen de-icing pump switch – No. 1.
21. Identification light morsing push-button.
22. Windscreen de-icing pump switch – No. 2.

Key to Fig. J

1. No. 1 engine gate valve emergency close switch (cabin air).
2. Quarter panel lamp.
3. Main panel u/v lamp stowed (see B/23).
4. Hydraulic pressure gauge – No. 2 service – Nose-wheel steering.
5. Hydraulic pressure gauge – No. 2 service – Brakes.
6. Hydraulic pressure gauge – No. 1 service – Nose-wheel steering.
7. Hydraulic pressure gauge – No. 1 service – Brakes.
8. Flowmeter indicator – starboard engines.
9. Flowmeter indicator – port engines.
10. Flowmeter switch and indicator light – port outer.
11. Flowmeter switch and indicator light – port inner.
12. Flowmeter switch and indicator light – starboard inner.
13. Flowmeter switch and indicator light – starboard outer.
14. No. 4 engine gate valve emergency close switch (cabin air).
15. No. 3 engine gate valve emergency close switch (cabin air).
16. No. 2 engine gate valve emergency close switch (cabin air).

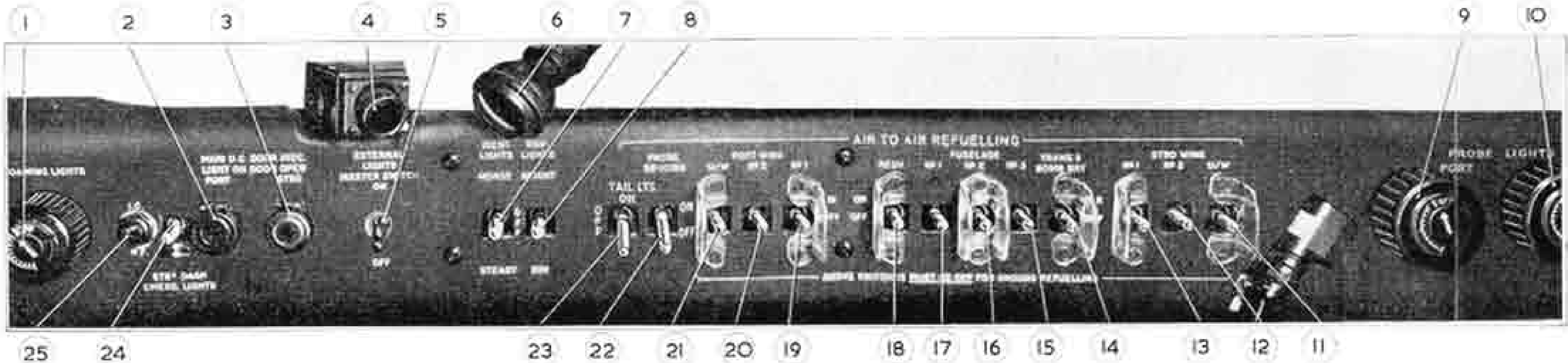


FIG. G. STARBOARD COAMING PANEL

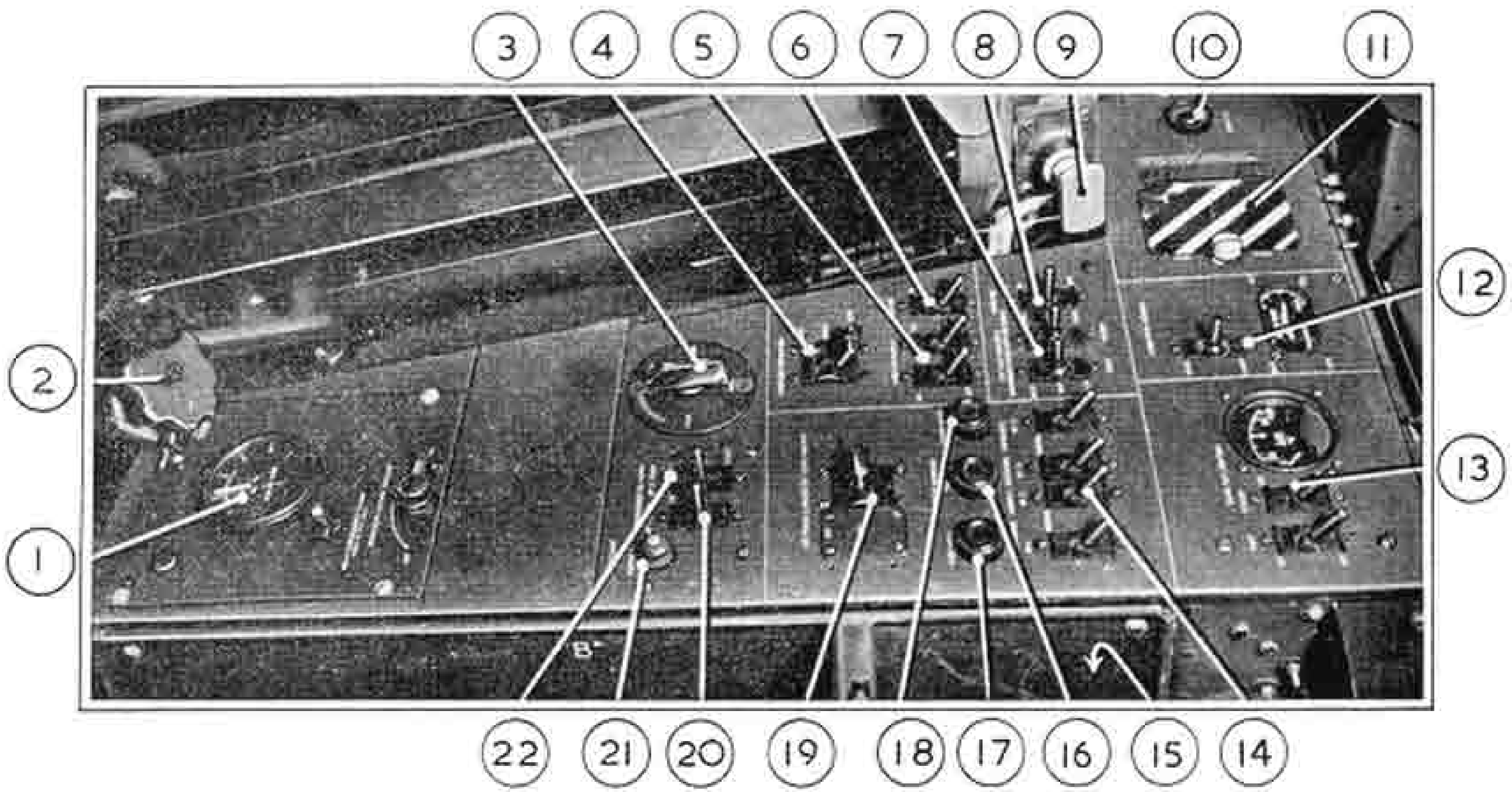


FIG. H. STARBOARD CONSOLE PANEL

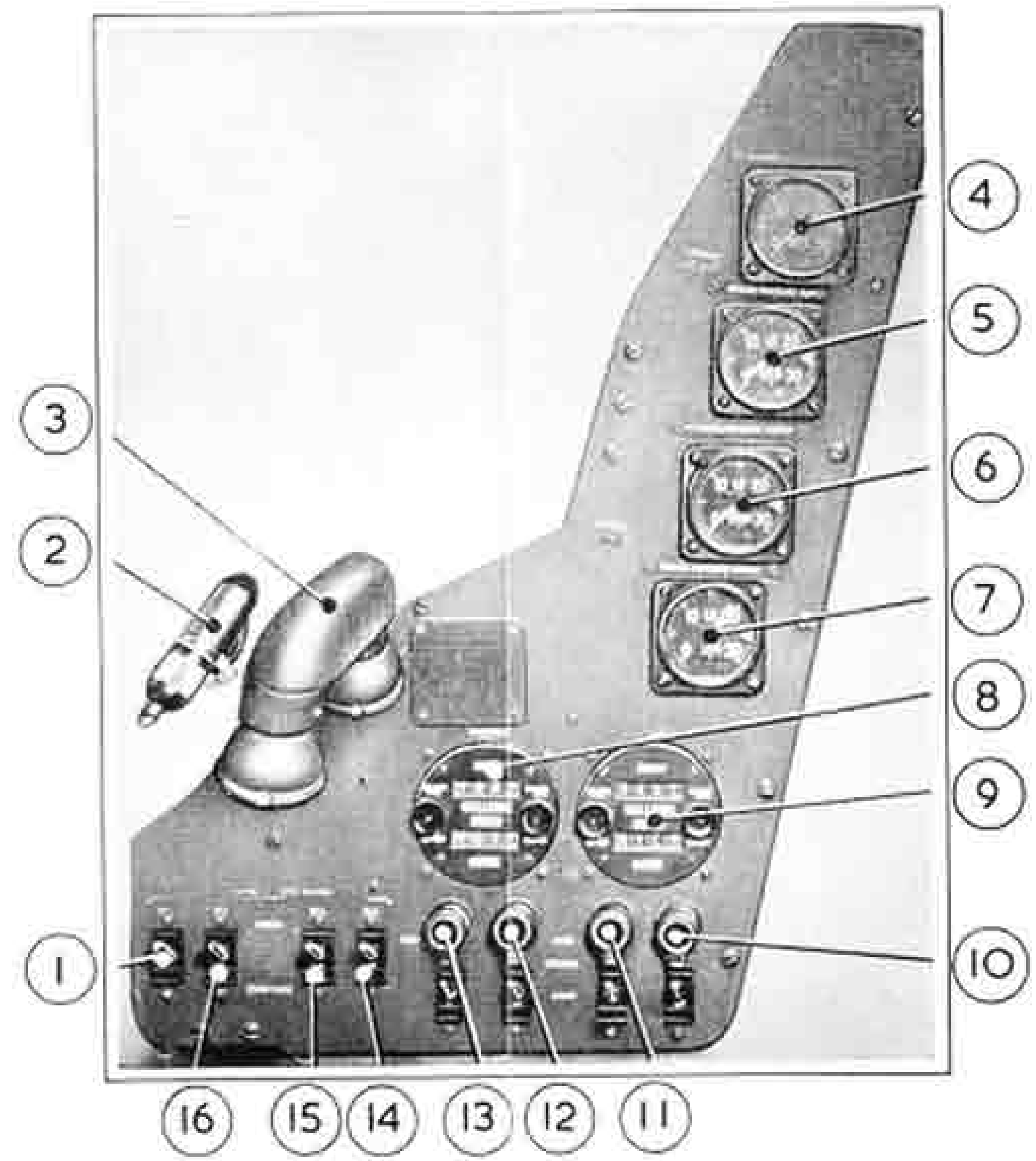


FIG. J. STARBOARD QUARTER PANEL

Key to Fig. K

1. Signal lamp (Pre-Mod. 1213).
2. First aid kit.
3. Fuse panel "F".
4. Crash axe.
5. Fire extinguisher.
6. Crash landing exit release lever.
7. Cabin emergency de-pressurising control.
8. Ration heater.
9. Deviation corrector (G.4B compass).
10. Removable panel, varying according to role.

Key to Fig. L

1. H.F./I.C. change-over switch.
2. Intercomm. ON/OFF switch.
3. Intercomm. NORMAL/EMERGENCY switch.
4. Intercomm. amplifier.
5. 112-volt test socket selector switch.
6. 112-volt test socket.
7. Voltmeter (112-volt).
8. Generator test sockets (ammeter).
9. Inverter test sockets.
10. Signal pistol.
11. Rotary transformer test sockets (ammeter).
12. First aid kit.
13. Voltmeter (28-volt).
14. 28-volt test socket selector switch.
15. 28-volt test socket.
16. Door emergency jettison handle.
17. Door handle.
18. Fire extinguisher.
19. Ration heater.
20. Morse key.
21. Signal lamp supply socket.
22. Adjustable lamp and dimmer switch.

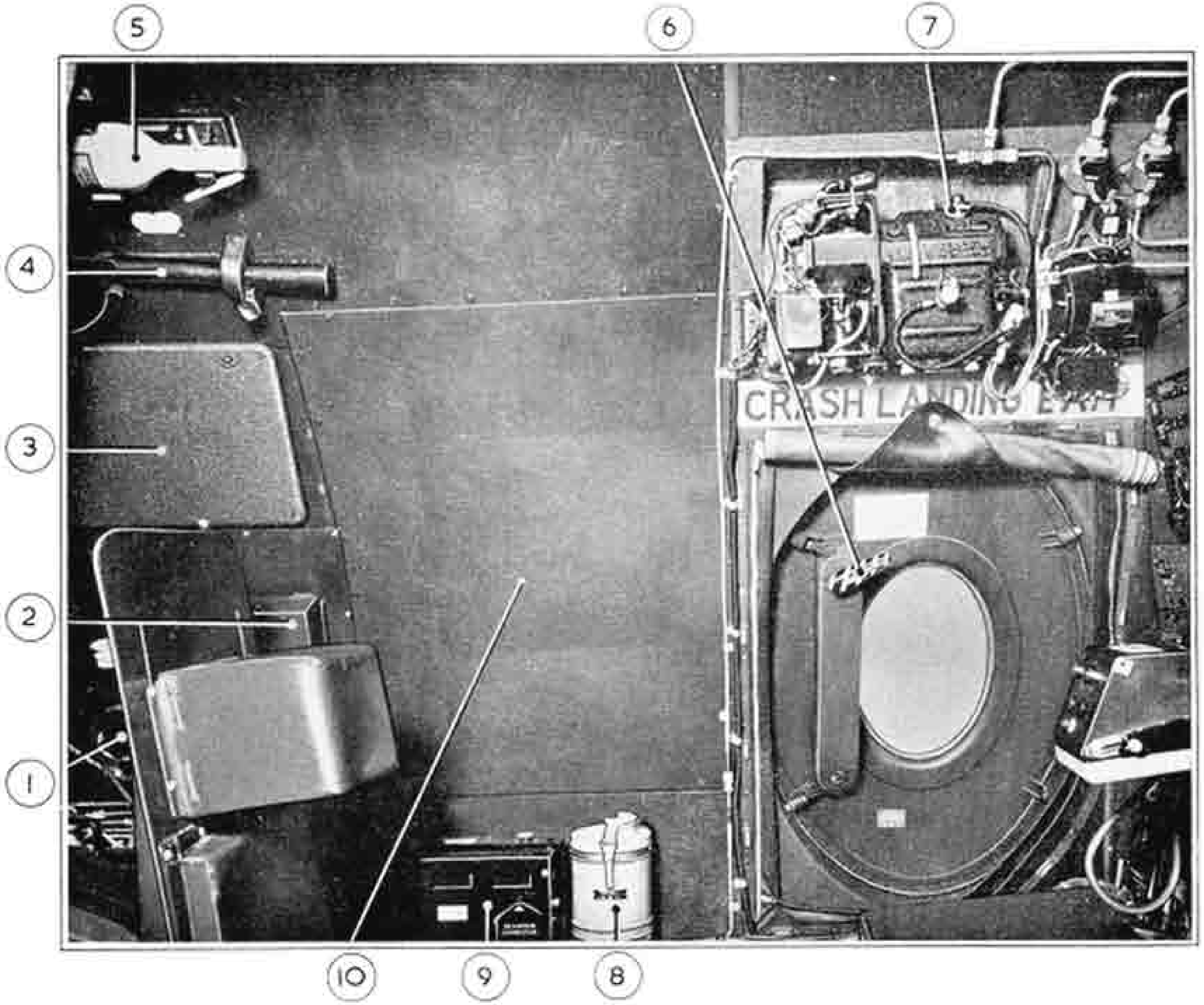


FIG. K. CABIN STARBOARD SIDE

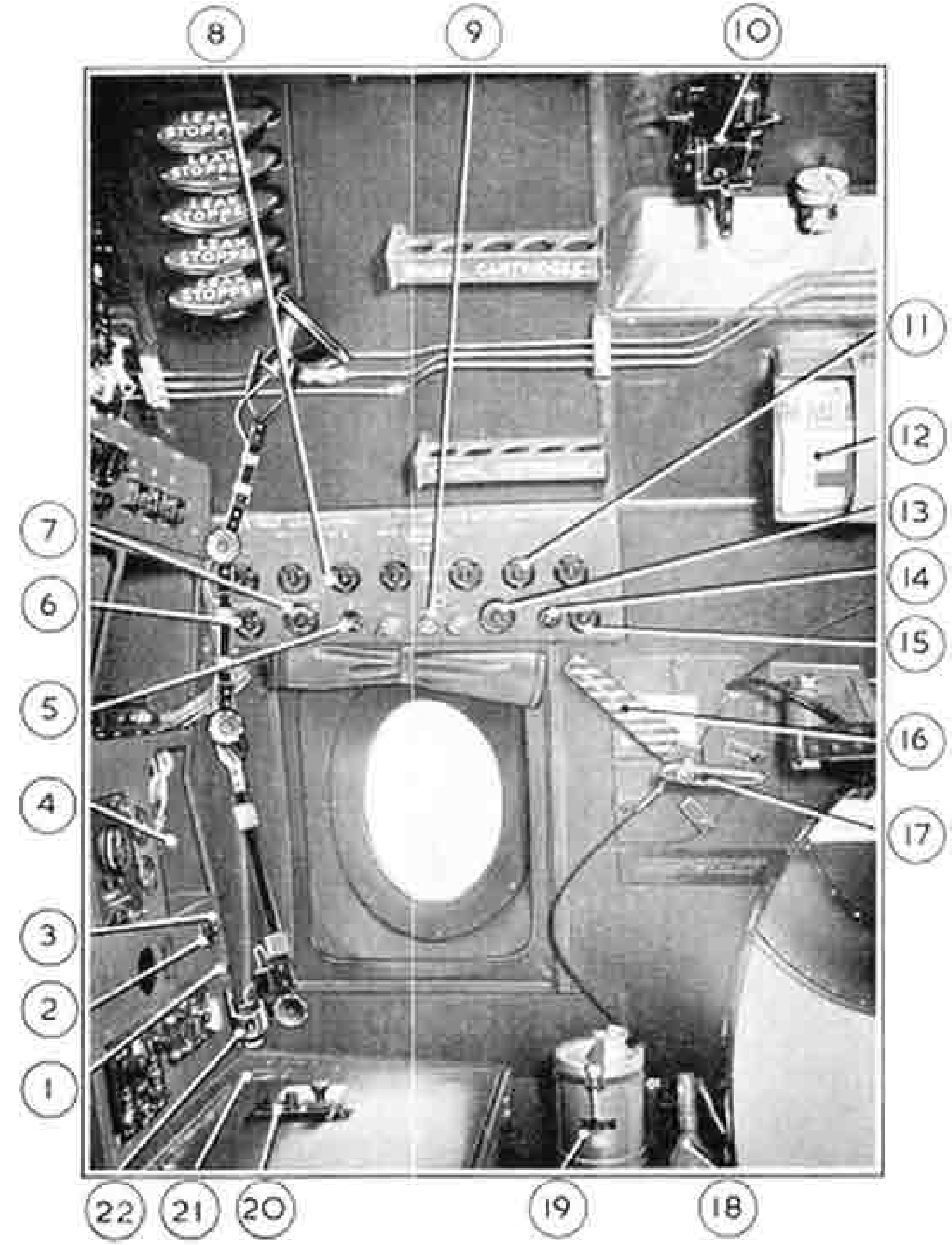


FIG. L. CABIN PORT SIDE

Key to Fig. M (WARNING – See Note under Fig. M.)

1. Oxygen regulator.
2. V.G. recorder cock.
3. H2S air pressure gauge.
4. Fuse timing selector.
5. Bombing panel.
6. Fore-and-aft level light dimmer switch.
7. Fore-and-aft level.
8. Bomb aimer's control panel.
9. Air burst delay unit.
10. High level radio altimeter indicator.
11. 12/24 way bomb distributor.
12. Mk. 2 bomb distributor.
13. N.B.S. navigation panel.
14. Gee receiver.
15. Periscope sextant supply socket.
16. Starboard anglepoise lamp.
17. Air speed indicator.
18. O.A.T. gauge.
19. G.4B compass master indicator.
20. I.L.S. receivers.
21. Instrument inverter failure warning light.
22. Clock (Pre-Mod. 1485).
23. Altimeter.
24. Emergency depressurising cock.
25. Port anglepoise lamp.
26. Radar panel (see Fig. O).
27. Radio compass receiver (not fitted on WP.209 and subsequent).
28. "Window" control units.
29. H.F. selector unit.
30. Generator panel (see Fig. Q).
31. Door seal air pressure cock.
32. H.F. voltage regulator.
33. Oxygen regulator.
34. Oxygen contents gauge.
35. Oxygen contents gauge.
36. Clock.
37. I.F.F. control unit.
38. H.F. aerial control unit.
39. Rear warning indicator.
40. Radio compass control unit.
41. Port anglepoise lamp dimmer switch.
42. H.F. control unit.
43. Starboard anglepoise lamp dimmer switch.
44. Gee H control unit 522.
45. Gee H control unit 426A.
46. Green Satin control box and indicators.
47. Gee H indicator.
48. A.M.U. control panel.
49. G.P.I.
50. Oxygen regulator.
51. Radio compass master indicator.
52. H2S bombing panel.
53. H2S control 626.
54. H2S indicator.
55. H2S control panel.

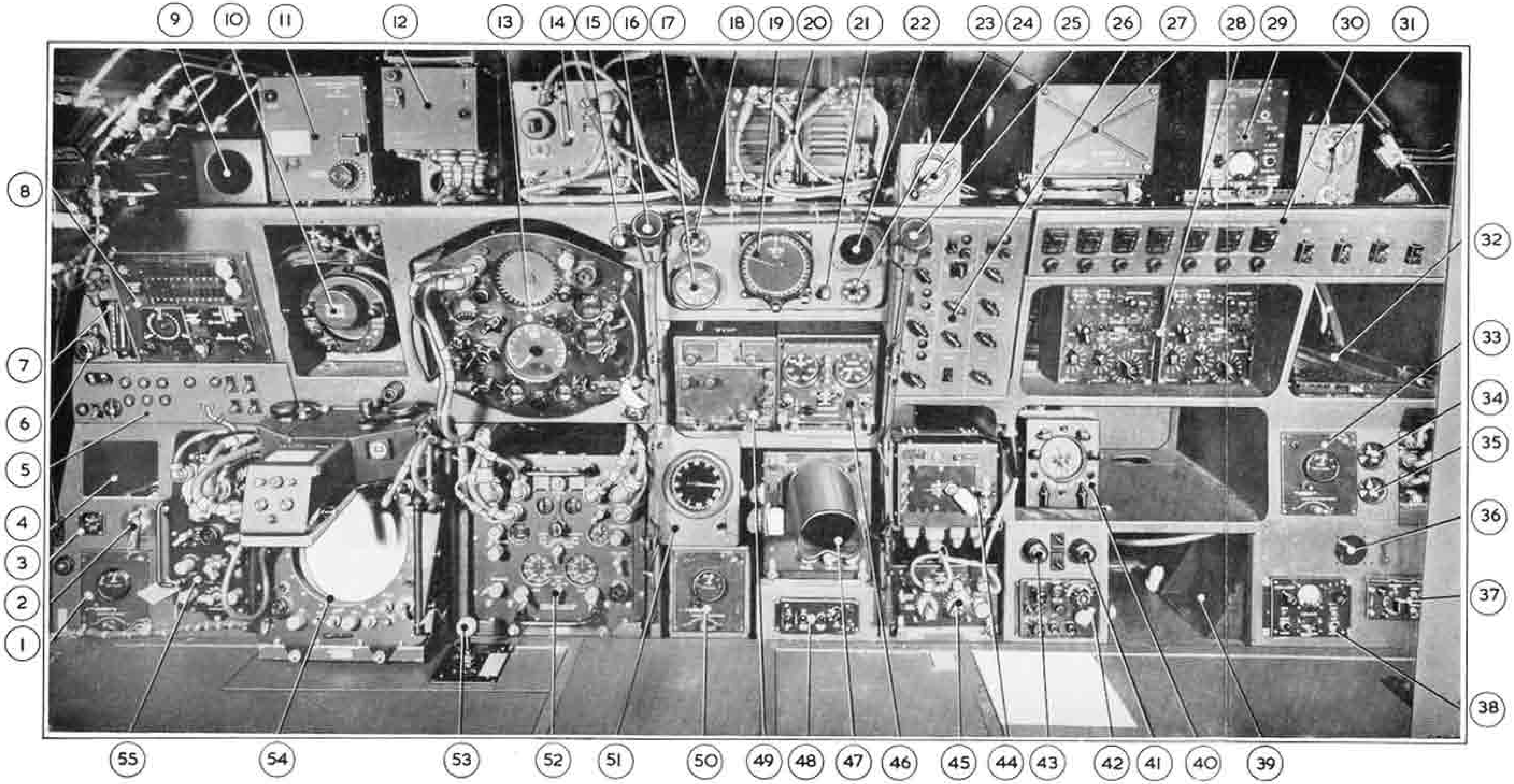


Fig. M Radio crate

NOTE: *This illustration is not up to date and does not take account of considerable variations between individual aircraft. It is given for reference only*

Key to Fig. N

1 Not used
2 Port windscreen wiper circuit-breaker (Pre-Mod. 2361)
3 Flap emergency contactor re-set pushbutton
4 Flap emergency contactor tripped warning light
5 Not used—deleted on later aircraft
6 Cabin lamp switch
7 Servicing lamps indicator
8 Servicing lamps switch
9 Internal start selector switch
10 Port console door-panel "E"

Key to Fig. O

1 NBC master switch
2 NBC supply phase indicators
3 Scanner switch
4 Scanner master switch and supply phase indicators
5 H2S master switch
6 Inverter No. 1 control switch and lights
7 Inverter No. 3 emergency change-over switch
8 Inverter No. 3 control switch and lights
9 Inverter No. 2 control switch and lights
10 Rear warning master switch
11 Yellow Aster switch (PR only)
12 Gee H master switch
13 Radio altimeter (high-level) master switch
14 IFF master switch
15 Not used
16 Green Satin equipment switch (Post-Mod. 2399)
17 Green Satin inverter switch (Post-Mod. 2399)

NOTE: Pre-Mod. 2399 items 16 and 17 are combined in a single switch.

Key to Fig. P

1 Starboard console door—panel "D"
2 Starboard windscreen wiper circuit-breaker (Pre-Mod. 2361)
3 Starboard wheel extreme emergency circuit-breaker
4 Port wheel extreme emergency circuit-breaker
5 Ground ventilation fan circuit-breaker (Pre-Mod. 2361)
6 Air brakes contactor reset pushbutton and indicator
7 Flaps normal contactor reset pushbutton and indicator
8 Not used
9 Port wheel main contactor reset pushbutton and indicator
10 Starboard wheel main contactor reset pushbutton and indicator
11 Nosewheel main contactor reset pushbutton and indicator
12 Not used
13 Ration heaters switches and indicators—No. 1 and 2
14 Ration heaters switches and indicators—No. 3, 4 and 5
15 Dimmer switch for adjustable lamp

Key to Fig. Q

1 112-volt generator switch—No. 1 engine
2 112-volt generator switch—No. 2 engine
3 112-volt generator switch—No. 3 engine
4 112-volt generator switch—No. 4 engine
5 28-volt rotary transformer switch—No. 1
6 28-volt rotary transformer switch—No. 2
7 28-volt rotary transformer switch—No. 3

NOTE: Below each of the above switches is a power failure warning light.

8 HF supply circuit-breaker (Pre-Mod. 2362 or 2446)
9 ILS supply circuit-breaker (Pre-Mod. 2362 or 2446)
10 NBC supply circuit-breaker (Pre-Mod. 2362 or 2446)
11 Low level radio altimeter supply circuit-breaker (Pre-Mod. 2362 or 2446)

NOTE: Post-Mod. 2362 or 2446 item 8 is repositioned to the bottom port corner of the radio crate. Items 9, 10 and 11 are deleted altogether.

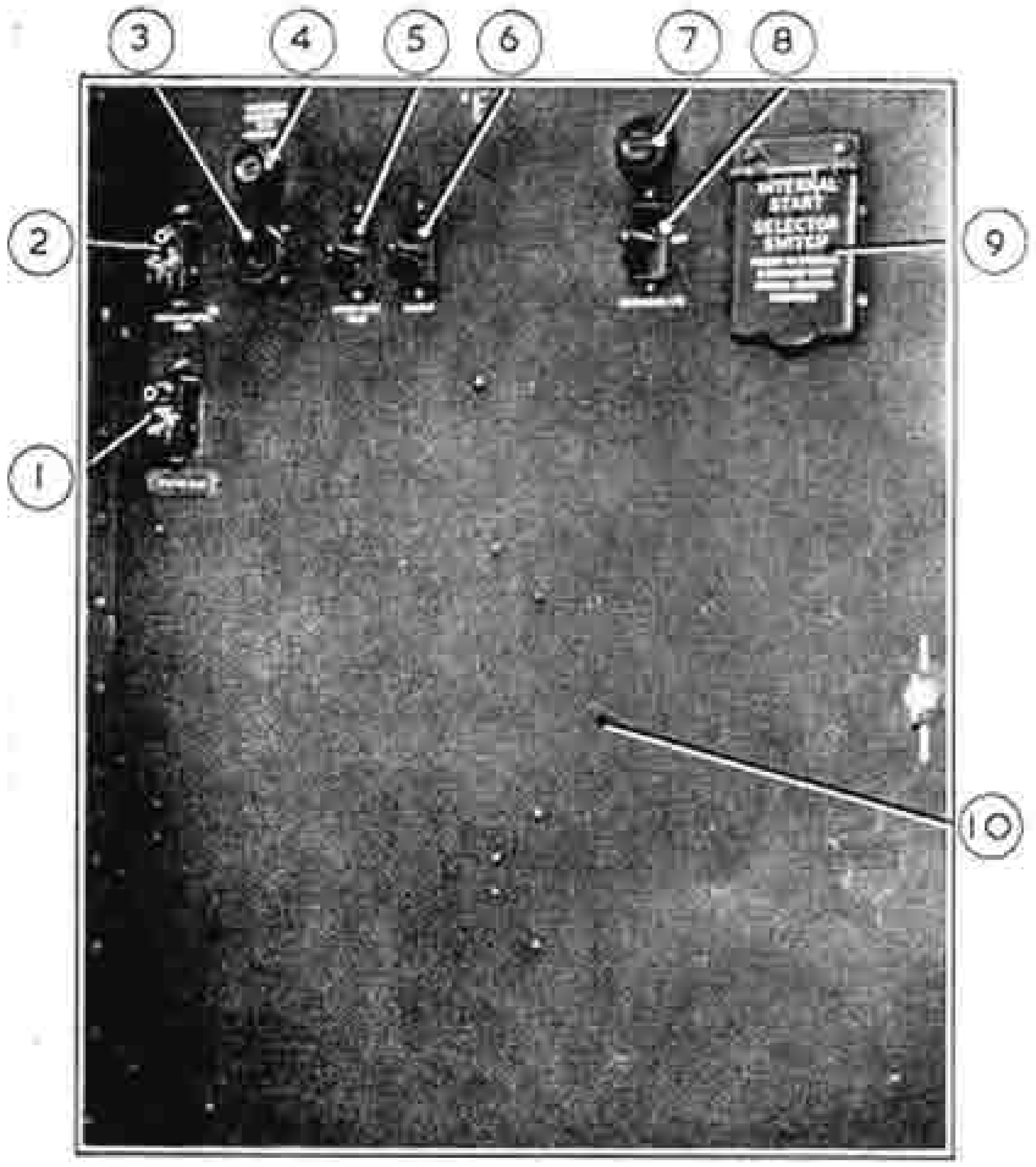


Fig. N. Port console door

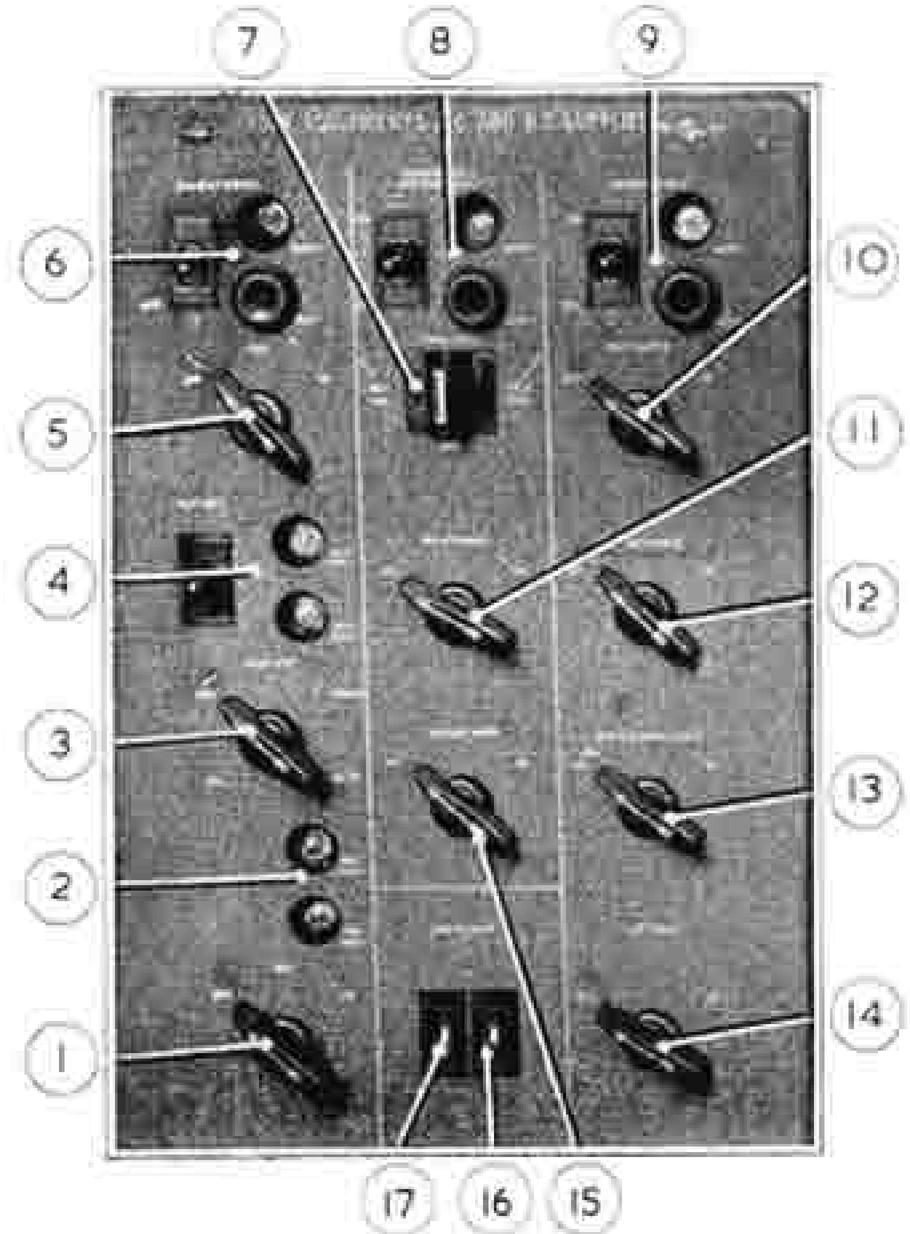


Fig. O. Radar panel

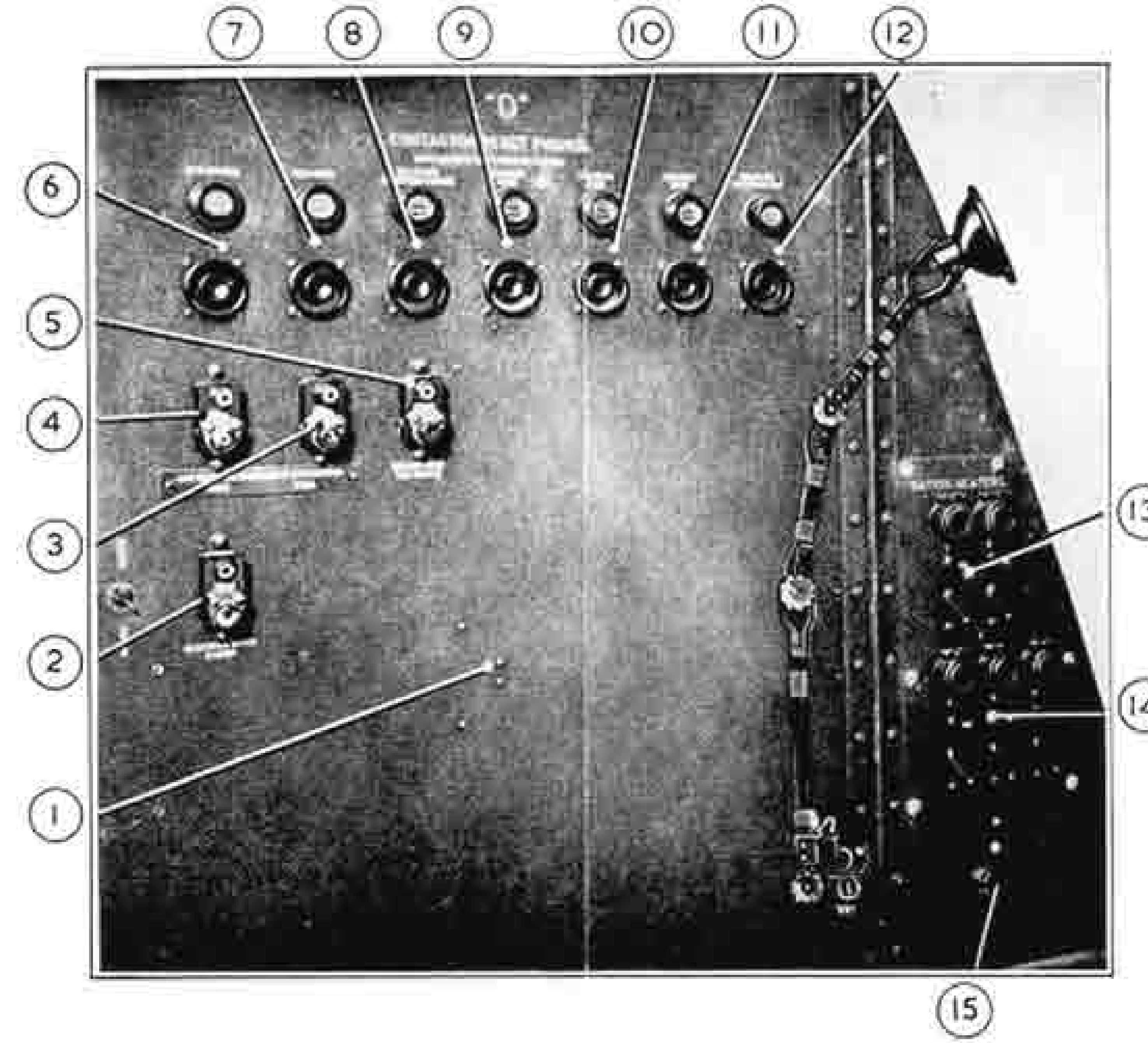


Fig. P. Starboard console door

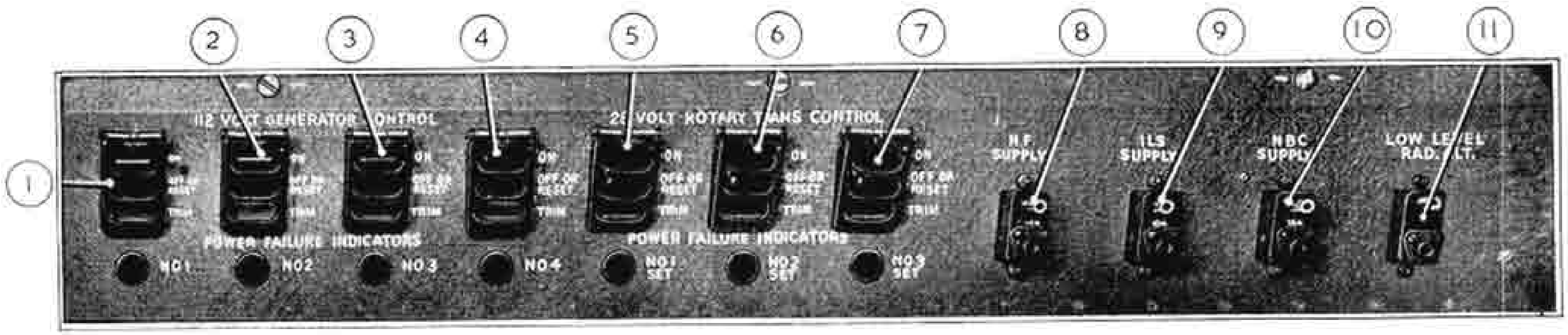


Fig. Q. Generator panel

Appendix A

FLIGHT REFUELLING

APPENDIX A

Flight Refuelling

List of Contents

APPENDIX A

Flight Refuelling

1 Introduction

(*a*) Either B(K)1 or BK(PR)1 aircraft may be equipped for refuelling in flight. The aircraft are of two types referred to in these Notes as Tanker or Receiver aircraft. Tanker aircraft are equipped for transferring fuel and also for receiving fuel, but Receiver aircraft are equipped only for receiving fuel.

(*b*) It is recommended that pilots and operators of either Tanker or Receiver aircraft should be familiar with the handling of, and operation of equipment in, the other aircraft.

2 General

(*a*) The probe and drogue system of flight refuelling is used, fuel being transferred from the Tanker to the Receiver through a flexible hose trailing from the bomb bay of the Tanker, and a probe in the nose of the Receiver. A full load of fuel can be transferred in about 15 minutes; if the main pump in the Tanker fails, successful transfer is still possible, but will take about twice as long. Radio silence can be maintained throughout the operation if desired, as all necessary signals to the Receiver are given by duplicated coloured lights.

(*b*) The tanks used for transferable fuel have a total capacity of 46,248 lb, but 1,160 lb of this is not transferable (see para. 15(*c*)). This gives a total of 45,088 lb of fuel which can be transferred from the Tanker to the Receiver.

3 Limitations

(*a*) The Tanker and Receiver aircraft are subject to the normal aircraft limitations (see Part II) except, for the Tanker aircraft, when streaming the hose.

(*b*) The following limitations apply specifically to the operation of refuelling in flight:

Maximum speed for streaming the hose and flying with it streamed. Gentle manoeuvres only; Maximum indicated G 1·5	300 knots or 0·8 M
Maximum speed for making contact . . .	250 knots or 0·76 M
Maximum altitude	No limit

(*c*) *Duration of trail.* The maximum period during which the hose may be trailed without fuel flow depends on the ambient air temperature. The limitations are shown in Fig. 1.

(*d*) *Auto-pilot and auto-stabiliser.* During the whole of a flight refuelling operation, both for Tanker and Receiver, the auto-pilot must be off. The auto-stabiliser (if fitted), however, will be a help to steady flying, and it is recommended that it should be in use.

(*e*) *Hose jettison.* The hose can be jettisoned at any speed, but it is recommended that where possible the speed should be 180 knots with 20° of flap selected.

4 Receiver equipment description

(*a*) The receiver aircraft is fitted with a refuelling probe in the nose which feeds into a " ring main " fuel system serving all fuel tanks. The probe incorporates a shut-off valve which is automatically opened when contact is established with the Tanker hose coupling, a vent valve, and a de-icing valve. All tanks can be filled in the air simultaneously.

(*b*) All controls for air-to-air fuel reception are on the starboard coaming panel. They consist of a refuelling valve selector switch (G11 to 21) for each tank or cell, a probe de-icing switch (G22), and a tank indicator below the rear of the panel. A fuel gallery pressure gauge is on the starboard quarter panel.

NOTE: BOMB BAY TEMPERATURE BEFORE HOSE TRAIL MUST BE ABOVE +10°C

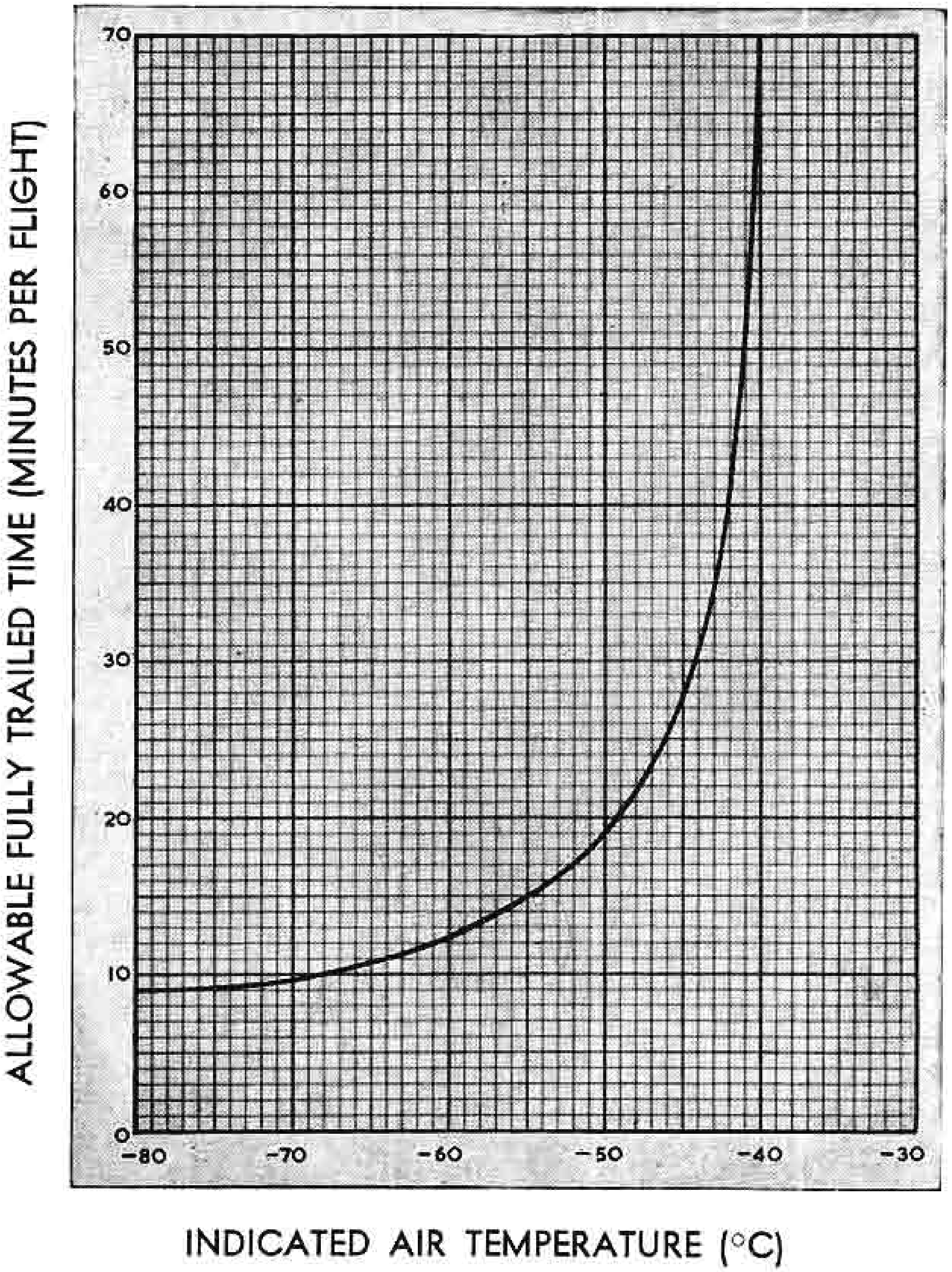


Fig. 1 Maximum hose trail time

(i) *Tank indicator.* The tank indicator comprises a circular dial on which is inscribed an outline of the aircraft. The approximate position of each tank is shown by a number and by a light, with the exception of the bomb bay and fuselage transfer tanks which have one common light. A visor is provided to shield the indicator from glare, and a ring round the indicator enables the brightness of the lights to be adjusted for day or night operation.

(ii) *Refuelling valve selector switches.* Each tank or cell contains a refuelling valve which is controlled by its relevant selector switch and also by a float switch in the tank or cell. When any refuelling valve selector switch is set ON, the refuelling valve in the selected tank is opened and the relevant light on the tank indicator comes on. When the tank is full, the float switch closes the refuelling valve and the light on the tank indicator will go out. When a tank is full, the selector switch will not open the refuelling valve, nor will the light come on. The refuelling valve can be shut at any time by setting the selector switch to OFF, when the lights will go out.

NOTE 1: The reserve and/or No. 1 fuselage cell lights will come on when the bomb bay and transfer tanks are selected at any time. The wing tank lights will come on when the underwing tanks are selected.

NOTE 2: The selector switches are only used for flight refuelling; it is essential that they are all OFF for ground refuelling.

(iii) *Fuel gallery pressure gauge.* The fuel gallery pressure gauge indicates the pressure of fuel delivery from the Tanker, and together with the fuel gauges, provides the only indication that fuel is being transferred. The pressures indicated on this gauge are:

Full flow rate, all tanks receiving—approx. 21 PSI.
Emergency transfer, all tanks receiving—approx. 10 PSI.

NOTE: As individual tanks reach their maximum capacity, the pressure may rise to a maximum of 60 PSI.

(iv) *Probe de-icing switch.* The PROBE DE-ICING switch, when set to ON, closes the vent valve and feeds fluid to de-ice the probe. The system is not yet operative, and must not be used.

(c) *Probe lighting.* The tip of the probe is illuminated by two lamps in the nose of the aircraft. The lamps have independent supplies, each being controlled by one of two dimmer switches (G9 and 10) at the rear of

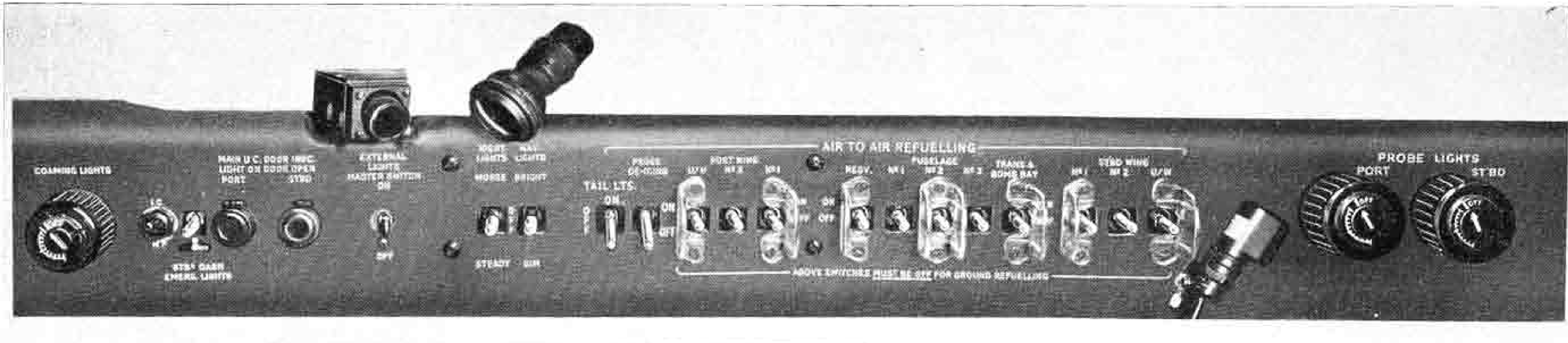


FIG. 2—*Starboard coaming panel*

the starboard coaming panel. The lamps may be used singly or together, according to the intensity of light required.

5. Signalling system

In order that radio silence may be maintained if necessary, all signals are made by the Tanker with coloured lights. Above the hose drum unit in the Tanker's bomb bay is a row of six coloured lights; two red, two amber and two green. The duplication is simply a safeguard against failure; a single signal light has exactly the same meaning as a pair. The lights have the following meanings:

(i) *Red lights*. Do not attempt contact *or* Break contact immediately.

(ii) *Amber lights*. Contact may be made, or if in contact, Tanker main fuel valve closed.

(iii) *Green lights*. Tanker main fuel valve open.

Refuelling in Flight—Receiver

6. Checks before making contact

Prior to making contact, make the following checks:

Auto-pilot OFF.
Auto-stabiliser ON (if fitted).
Probe lighting as required.
Refuelling valve selector switches, of tanks to be refuelled, ON.
Tank indicator lights, of tanks selected, ON.

NOTE: 1. If a tank light does not come on, the reason may be that the tank is full, the refuelling valve has failed, or the light has failed. In any event the tank should remain selected ON.

NOTE: 2. The above drill applies even if only dry contacts for practice purposes are made. For dry contacts at least one refuelling valve *must* be selected ON.

7. Initial approach

WARNING. If red or green lights are showing, or if no lights are showing, on the hose drum unit in the Tanker bomb bay, a contact *must not* be attempted. If, when in contact, a red light comes on or all signal lights go out, contact must be broken off *immediately*.

A contact may only be attempted when only amber lights are showing.
During the initial approach to the Tanker, the Receiver captain should check that the signal lights are amber before closing for

contact. The recommended Tanker speed for refuelling is 230 knots. An initial closing speed of not more than 5 knots T.A.S. relative to the Tanker speed should be established, approaching from dead astern, keeping the signal lights visible at all times.

8. Final approach to establish contact

(*a*) The last thirty to forty feet prior to contact must be made with the Receiver flying level, dead behind the drogue, when buffet will be felt, accompanied by a marked noise. From this point, accurate and steady flying is required. The ideal to be aimed at is a steady approach, keeping the probe in line with the centre of the drogue at a closing speed of not more than 5 knots T.A.S. When absolutely certain that a clean contact can be made with the centre of the drogue it will be necessary to apply power to counteract drag from the drogue and maintain the correct closing speed. Immediately a successful contact has been made, and the probe is observed to be positively coupled to the drogue, a definite reduction in closing speed should be made by slightly closing the throttles before moving up to the refuelling position.

(*b*) The Receiver pilot's attention should then be transferred to the signal lights and the hose markings. When the aircraft is steady, a small amount of power should be applied and the aircraft flown gradually up the line of the hose, keeping the signal lights just in view below the Tanker's bomb bay deflector, until the refuelling position is reached. This is indicated when the 10-foot long yellow band on the hose (30 to 40 feet from Tanker end of the hose) is just visible out of the hose drum unit. In addition to this yellow band there is a white band on the hose at 10 foot intervals. The first five feet are marked with red and white stripes. Seven feet of hose will have to be wound in before the fuel valve can be opened. The Tanker panel operator will open the fuel valve when approximately 25 feet of hose has been wound in. This is indicated by the lights changing from amber to green. The fuel gallery pressure gauge will then indicate the pressure of the fuel transfer (see Para. 4 (*b*) (iii)).

9. In contact

(*a*) Once in contact small control and throttle movements should be made to hold station; any tendency to over-correct must be guarded against. When fuel is being transferred at high altitudes (above 34,000 feet) and at high aircraft weights, it is important to anticipate as early as possible the changes of power necessary to hold station. Small movements of the Receiver relative to the Tanker can be detected by careful observation of the hose. It is essential for the Receiver to avoid flying too low relative to the Tanker. The ideal refuelling position is with the distinctive yellow mark on the hose just half way into the H.D.U., and with the signal lights just in view below the Tanker's bomb bay deflector.

(*b*) When fuel is flowing, cross reference should be made to the fuel contents gauges to ensure that the tanks are filling. If a tank is not filling, the C.G. may rapidly move outside the limits, and action must be taken quickly to counteract this condition (see para. 21). As tanks become full, the float switches will close the refuelling valves, and the relevant tank indicator lights will go out; as this happens the refuelling valve selector switch for the appropriate tanks should be put OFF. When all the fuel that is required has been transferred, the Tanker operator will close the fuel valve. This will be indicated by the lights changing from GREEN to AMBER. If it is only required partially to fill a tank, the appropriate selector switch should be put OFF when the fuel contents gauge shows the required level. All refuelling valves should be closed before contact is broken.

10. Breaking contact

(*a*) *Normal procedure*. To break contact, the throttles should be closed slightly and the Receiver allowed to fall back gently. The rate at which the hose is unwinding off the drum should be controlled by the throttles to keep it to a gradual movement. When the last 7 feet of hose is coming off the drum, the lights will change to amber, if the fuel valve in the Tanker has not already been closed. The aim should be to allow the drogue to part gently from the probe at its natural trailing position, when it will draw away in line with the probe where it can be watched all the time. If contact is broken higher or lower than the natural trailing position of the drogue, it will move rapidly to that position and will oscillate widely about it.

(*b*) *Emergency procedure*. If a red signal light comes on, or if all signal lights go out, or if due to any other emergency it is necessary to break contact as quickly as possible, the throttles should be closed fully. The Receiver will then decelerate rapidly, and when the hose reaches a speed of 5 ft./sec. the brake will be applied automatically and contact will be broken immediately. Such rapid disconnections should only be made in emergency conditions. The air brakes should never be used to make an emergency disconnect.

(*c*) *Clearing away*. When contact is broken, some fuel splash will occur. This splash, which is normally small, will be greater following an emergency disconnect. After breaking contact, the Receiver should clear downwards and to starboard, so that the Tanker can be held in view all the time.

11. Checks after breaking contact

The following checks should be made after breaking contact:

Refuelling valve switches all OFF.
Tank indicator lights all out.
Probe lighting off.

12. Flying techniques

It is important that the procedures detailed in para. 6 to 11 are adhered to in order to complete successful air-to-air refuelling. To achieve maximum success, the following common faults should be fully understood and avoided.

(*a*) Contacts in excess of a closing speed of 5 knots T.A.S. must be avoided, as the hose drum unit is only capable of taking up a closing speed of 7 knots before hose whip occurs. In this event it is unlikely that there will be sufficient time for the Receiver pilot to take corrective action to prevent the hose whip breaking off the probe nozzle. It is equally important that downward approaches on to the drogue are avoided, as this technique will result in hose whip. Similarly, after contact with the drogue the Receiver should be flown in line with the hose, and carrying the hose excessively downward or sideways must be avoided. In the event of the probe nozzle being broken off, all refuelling valves must be closed to prevent the tanks being pressurised by ram air. The Receiver should be moved clear of the Tanker immediately, as cockpit visibility is likely to be reduced by fuel spillage. The residual fuel in the probe tube will also spray back over the windscreen for some time afterwards. Aircraft handling with the probe nozzle broken off is not affected, but speeds in excess of normal cruising speeds should be avoided.

(*b*) The engagement of the probe with the drogue demands accurate flying, and any tendency to over-correct must be avoided. Pilots are strongly advised to guard against becoming impatient and making attempts at contact by chasing the drogue on the off chance of making a lucky connection. If it is thought at any time that the drogue is unsteady due to erratic Tanker flying, turbulence or bow wave effects, check by observing the drogue in relation to the Tanker. If the Tanker and the drogue appear to move together, then it is the Receiver which is unsteady. If, due to unsteadiness on the part of the drogue or the Receiver, smooth contact cannot be achieved, pause some thirty to forty feet behind the drogue, allow everything to become settled and then make a further attempt at contact. It is essential that hovering a few feet behind the drogue be avoided.

(*c*) If rough air is encountered the chances of making contact are reduced. If turbulence is making contact difficult, less time will be wasted if the altitude is changed.

(*d*) If a rim contact is made, or if the probe nozzle catches in the drogue spokes the hose will wind in. The correct action is for the Receiver to withdraw and allow the hose to be retrailed. When an amber light is displayed, a further attempt at contact can be made. If contact is made too slowly, i.e. below about 2 knots T.A.S. the probe will not positively lock in the drogue coupling. The Receiver must then withdraw and allow the hose to be retrailed.

13. Failure of a tank or tanks to fill

If one or more tanks fail to fill, the C.G. may rapidly move outside the limits and action must be taken quickly to counteract this condition and to maintain the aircraft in balance. The action to be taken depends on the tank position and the quantity of fuel in it. Information on this will be found in para. 21.

Tanker Equipment

14. General

The Tanker aircraft carries a hose drum unit (H.D.U.) in the aft end of the bomb bay, which consists of an electrically-driven drum carrying a 90-foot length of fuel hose, and also an air turbine-driven delivery pump. One end of the hose is connected to the transfer fuel system, the other end carries a conical drogue and refuelling coupling. A panel on the cabin starboard wall carries all the controls and indicators for the H.D.U. and the transferable fuel system.

15. Transferable fuel

(*a*) The fuel available for transfer is carried in the underwing tanks, the auxiliary (bomb bay) tank, the fuselage transfer tank and the fuselage tank No. 3 cells. Fuel from all except the underwing tanks is pumped by air turbine pumps to the H.D.U. delivery pump and then to the hose. Fuel from the fuselage No. 3 cells is isolated from the aircraft usable fuel by shut-off cocks between the cells and the fuselage pump housings (see para. 16 (*a*) (ii)). The electric booster pumps in the auxiliary tank and transfer tank are still connected to the pilot's normal controls, but on no account should these pumps be operated during flight refuelling. The transfer tank must contain not less than 800 lb. of fuel at any time that dry contact training is in progress, in order to keep the hose full of fuel.

(*b*) Fuel from the underwing tanks is transferred by the normal pump in each tank, in conjunction with the nitrogen pressure system and is fed to the H.D.U. delivery pump. When the underwing tanks are used by the pilot for his aircraft use, fuel is transferred in the normal way to the wing tanks by the pump alone, with the nitrogen system as an emergency stand-by in case of pump failure. The control circuits for the underwing tanks are so arranged that the pilot can take over control at any time from the Tanker operator by using the normal underwing tank switches.

(*c*) When using the air turbine pumps for transferring fuel to the Receiver, the amount of untransferable fuel is greater than the normally unusable fuel when using the electric booster pumps or gravity feed for feeding the Tanker's own engines. The approximate amount of untransferable fuel (extra to the normal unusable fuel) is as follows:

Auxiliary tank	40 lb.
Fuselage No. 3 cell	240 lb. per side
Transfer tank	240 lb. per side
Underwing tanks	80 lb. each

NOTE: Due to variations in transfer rate, the figures may be exceeded, particularly by the transfer tank, which may be as much as 2,000 lb.

After a flight refuelling transfer this untransferable fuel may be used for the Tanker's engines by setting the PILOT/OPERATOR switches to PILOT and using the normal electric booster pumps.

16. Tanker panel

(*a*) *Transferable fuel controls.* Apart from the H.D.U. controls, the panel carries a MASTER SWITCH and, for each transferable fuel tank, a PILOT/OPERATOR switch, pump START and STOP pushbuttons, a fuel L.P. warning lamp and a fuel contents gauge. The panel also carries two circuit-breakers, one for the normal supply and one for an emergency supply.

(i) *Master switch.* None of the turbine pumps can be operated, nor can the hose be paid out, until the bomb doors are open and the MASTER SWITCH is ON. The bomb doors are further interlocked so that they cannot be closed until the hose is fully stowed.

(ii) *Pilot/operator switches and fuel contents gauges.* The PILOT/OPERATOR switches, when set to PILOT, further isolate the turbine pumps and enable the contents of the transferable fuel tanks to be read on the pilot's contents gauges, with the exception of the bomb bay tank for which there is no gauge unless Mod. 2296 is fitted. In addition, the fuselage tank No. 3 cells are not shut off from the normal fuel system (see para. 15 (*a*)). With the PILOT/OPERATOR switches at OPERATOR, the turbine pumps can be operated, provided the bomb doors are open and the MASTER SWITCH is ON. The contents of the transferable fuel tanks will now read on the gauges on the Tanker panel; the pilot's gauges for these tanks will read zero and the fuselage tank gauges, when set to TOTAL, will show the contents of No. 1 and 2 cells only. Also, the fuselage tank No. 3 cell shut-off valves will be closed (see para 15 (*a*)).

NOTE: If Mod. 2296 (see above) is *not* fitted, it is important that the bomb bay tank PILOT/OPERATOR switches should not be set to PILOT, otherwise an accurate gauge reading cannot be obtained on the tanker panel gauges until up to 14 seconds after reselecting the switches to OPERATOR.

(iii) *Pump start and stop switches.* The pump START and STOP switches are only operative when the bomb doors are open, the MASTER SWITCH is ON, and the PILOT/OPERATOR switch is at OPERATOR.

(iv) *L.P. warning lights.* The L.P. warning light comes on to indicate pump failure or tank empty; it is live when the bomb doors are open, the MASTER SWITCH is ON and the relevant PILOT/OPERATOR switch is at OPERATOR.

(*b*) *H.D.U. controls.* The following H.D.U. controls and indicators are on the Tanker panel:

(i) *Motor warm switch.* Used to warm up the hose drum driving motor and its fluid drive.

(ii) *Hose wind/trail switch.* Selects the hose to be trailed or wound in.

(iii) *Hose tension control and hose tension indicator.* Enables the drive to the hose drum to be adjusted so as to give a tension on the hose appropriate to the airspeed. The hose tension indicator is calibrated in knots, so that the control can be adjusted until the indicator reads the aircraft's airspeed. The hose tension control setting must not be altered once the Receiver is committed to making contact.

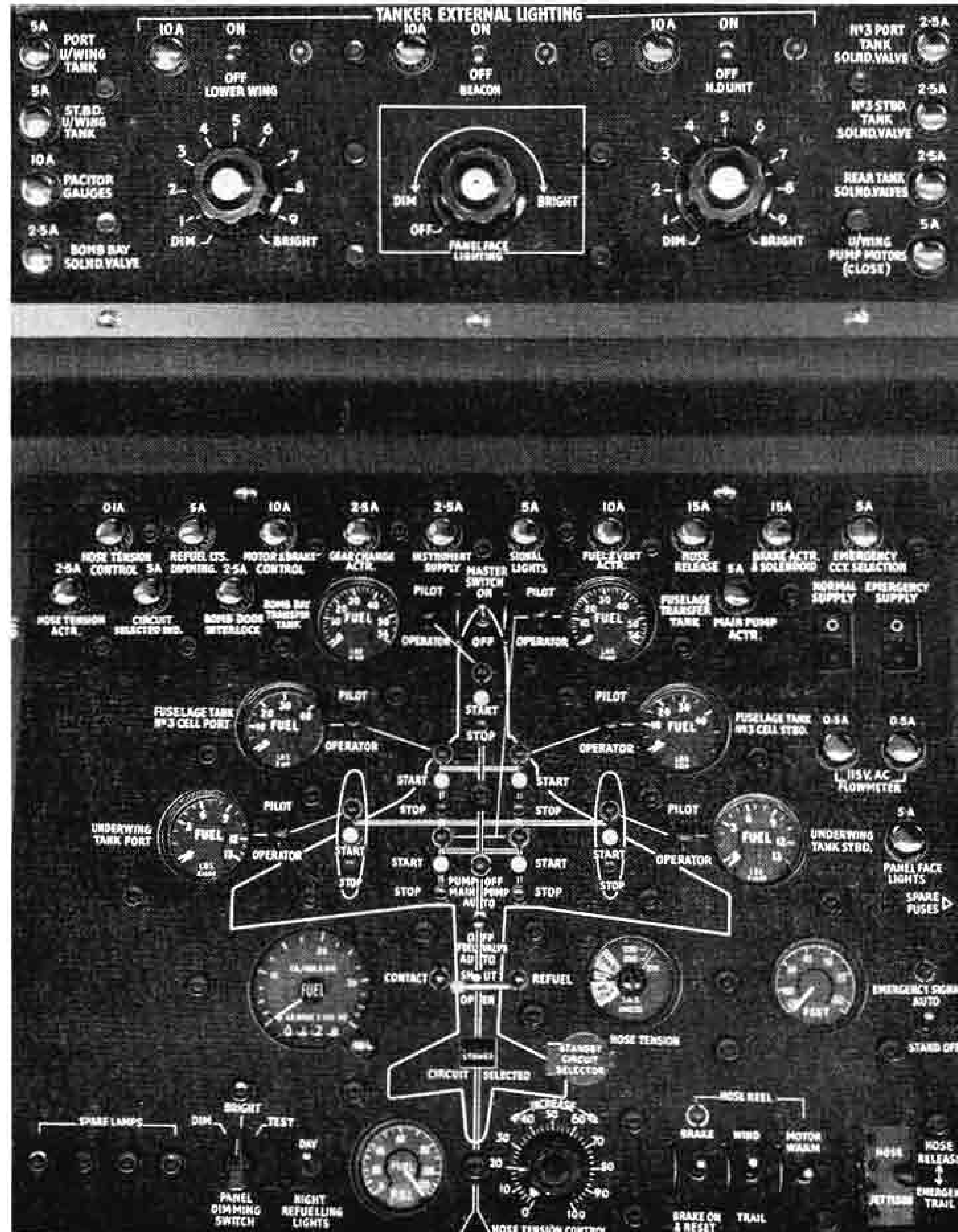


FIG. 3—*Tanker panel*

(iv) *Brake warning light and switch*. The brake warning light comes on to indicate when the hose drum motor brake is applied. The switch can be used to apply the brake if necessary or to reset the brake to off if the brake has been applied by the overspeed governor.

(v) *Footage indicator*. This indicates the number of feet of hose wound on the drum.

(vi) *Main pump switch and warning light*. This switch, marked AUTO and OFF, controls the air turbine-driven delivery pump. When the switch is set to AUTO, the pump will run when the Receiver aircraft has made contact and when the operator puts the fuel valve switch to AUTO when approximately 25 feet have been wound in. The OFF position enables the pump to be stopped at any time. The warning light comes on when the pump is not running.

(vii) *Fuel valve switch*. This switch, marked AUTO, SHUT and OPEN controls the fuel valve in the fuel delivery line. When the switch is set to AUTO, the fuel valve will open, thus allowing fuel to flow, when the Receiver aircraft has made contact and 7 feet of hose have been wound in. The OPEN and SHUT positions of the switch enable the fuel valve to be opened or shut as required. An interference bar prevents OPEN being selected inadvertently.

(viii) *Fuel flow indicator*. This shows the fuel flow in pounds per minute and also in pounds gone.

(ix) *Fuel pressure gauge*. This shows the fuel delivery pressure at the drogue reception coupling.

(x) *Circuit selected indicator*. Shows which circuit has been selected and gives an indication of correct sequencing of circuits.

(xi) *Stand-by circuit selector*. This is a push-button which enables the next circuit to be selected if this has not been done automatically.

(xii) *Contact and refuel lights*. These are repeaters of the amber and green signal lights on the H.D.U.

(xiii) *Emergency signal switch and warning light*. This switch controls the red signal light on the H.D.U., and the warning light is a repeater of the signal light. The switch has two positions, AUTO and STAND OFF. When the switch is set to STAND OFF, the red signal light will be on. When the switch is set to AUTO the red signal light will be off unless the hose is not fully trailed.

(xiv) *Hose jettison switch*. This is a guarded switch marked EMERGENCY TRAIL and HOSE JETTISON, and is spring-loaded to the central (off) position. When set, repeatedly if necessary, to EMERGENCY TRAIL, the hose will be fully trailed. Once the hose is fully trailed it is released from the drum and jettisoned by setting the switch to HOSE JETTISON.

17. Lighting

(*a*) *Panel lighting*. The warning and indicator lights on the face of the panel are controlled by a DIM – BRIGHT – TEST switch on the panel.

(*b*) *Signal lights*. A row of coloured lights, two red, two amber and two green, on the H.D.U. are used for signalling to the Receiver aircraft. The duplication is simply a safeguard against failure. The red lights warn the Receiver not to attempt contact, or to break away if in contact. They are controlled by an emergency signal switch (see para. 16 (*b*) (xiii)). The amber lights come on automatically when the hose is trailed and ready for contact to be made. When 7 feet of hose have been wound in, the fuel valve will open automatically when AUTO is selected, and it will be manually selected to AUTO at 25 feet when the MANUAL drill is being used. When the fuel valve is open, the lights will change from AMBER to GREEN. The GREEN lights will then remain on all the time that the fuel valve is open. The three pairs of signal lights each have a repeater on the Tanker panel, and their intensity is controlled by a DAY/NIGHT switch on the panel. This switch is marked REFUELLING LIGHTS.

(*c*) *Tanker aircraft floodlights*. The bomb bay and the underside of the wings, as well as the underwing tanks, are floodlit by four lamps. They are controlled by two dimmer switches on the top of the Tanker panel.

(*d*) *Tail beacon.* A flashing beacon is mounted on the tail of the Tanker. It is controlled by an on/off switch on the top of the Tanker panel.

(*e*) *Tail navigation light cut-out.* The tail navigation light causes some discomfort to the Receiver pilot when refuelling in the air at night, and a switch (G23) on the starboard coaming panel enables this light to be switched off while leaving the wing-tip navigation lights on.

Refuelling in Flight—Tanker

18 Aircraft handling

NOTE: Tanker pilots must refer to the Panel operators notes. In the air they should ensure that they are kept fully informed of the progress of the refuelling by the operator.

(*a*) The recommended contact speed for Valiant to Valiant refuelling is 230 knots, and in the refuelling configuration a light continuous airframe buffet will be felt. The Tanker should be trimmed out accurately before signalling "Ready for Contact." The auto-pilot must be disengaged, and the auto-stabiliser, if fitted, should be switched on. Use of the fine trimmer is recommended.

(*b*) When ready for contact, the Tanker speed of 230 knots should be accurately maintained so that the Receiver pilot can establish the correct closing speed of up to 5 knots TAS. Abrupt movements on the controls will cause the drogue to oscillate widely and will severely reduce the chances of making contact. Coarse use of the throttles must also be avoided. The aim must be to provide the steadiest platform possible to give the Receiver every chance of making a successful contact.

(*c*) When contact is made and the Receiver moves up into the refuelling position, a nose-down change of trim will be felt, and this must be countered by extremely careful use of the elevators. Also the speed will tend to increase unless power is reduced at this point sufficiently to maintain 230 knots. Likewise when the receiver moves out to break contact, a nose-up change of trim will be felt and the speed will tend to decrease. Equal care should be taken in correcting for it.

(*d*) Power will have to be reduced progressively as fuel is transferred to the Receiver in order to maintain 230 knots and level flight. Care must be taken to ensure that a rate of climb is not sustained. This is especially important towards the end of the transfer, when if a rate of climb in excess of 200 ft./min. is allowed to develop, the Receiver will probably not have sufficient power to maintain station or, in the worst case, to prevent an inadvertent disconnect.

(*e*) Rough air should be avoided when positioning for a contact as the chances of success under these circumstances are slight.

18A Cross refuelling

The aircraft can be operated in the tanker role in conjunction with the following, using Mk. 8 equipment:

Aircraft	*Day/Night*	*Recommended contact speed*
Javelin 9 . . .	Day	230K
Lightning 1A, 2 and 3	Day*	250K
Scimitar . . .	Day/Night	—
Sea Vixen 1 and 2 .	Day/Night	—
Victor 1A . . .	Day/Night	240K
Vulcan 1A, 2 . .	Day/Night	220-240K

* When Lightning Mods. 2162(1A) or 2101(2) are embodied night contacts are permitted.

NOTE: Limitations—See Part II and Appendix A, para. 3.

19 Equipment operation

The following tables give full details of the flight refuelling procedure:

(a) Pre-flight procedure

Operator's action	*Control panel indications*	*Circuit selected indicator*	HDU *response*
1 Ensure bomb doors closed, No. 3 inverter on, and instrument master switch selected on. Select PILOT/OPERATOR switches to OPERATOR for those tanks containing transferable fuel	Contents gauges read	Stowed	None
2 Ensure "Normal Supply" and "Emergency Supply" circuit-breakers are made	None	Stowed	None
3 Ensure main pump switch at AUTO and fuel valve switch at shut. Select signal lights day/night switch as appropriate	None	Stowed	None
4 Ensure wind/trail switch is at WIND	None	Stowed	None
5 Select master switch ON	None	Stowed	None
6 Select panel lights dimmer as required	As required	Stowed	None

(b) Normal procedure

Operator's action	Control panel indications	Circuit selected indicator	H.D.U. response
PREPARATION FOR REFUELLING			
Note: When refuelling is imminent, the pilot will open the bomb doors which will arm the H.D.U. and transfer pump circuits. If the underwing tanks are selected to OPERATOR the nitrogen bottles will charge them to 7 lb./sq. in. *Warning:* The fuel valve must not be selected to AUTO prior to contact.	With the MASTER SWITCH on and bomb doors open the following indications will be observed: Transferable fuel pump warning lights as selected on. Fuel pressure gauge will read 7 to 10 lb./sq. in. if underwing tanks are selected. Main pump and brake warning lights on.	Stowed.	
1. Select motor switch to WARM. Turn hose tension control to maximum. When hose tension needle is steady (1 to 3 min.) place motor switch to OFF (central).	Hose tension indicator will read a minimum of 270 knots.	Stowed.	Motor runs. Gear low. Brake on. Fuel valve closed.
2. Press the required pump start buttons and hold until the lights go out.	Fuel pressure gauge will read 50 lb./sq. in. if underwing tanks are selected, otherwise about 25 lb./sq. in.	Stowed.	None.
3. Reset fuel flow indicator.			
4. Select external lights as briefed; i.e. rotating beacon, underwing tank flood-lights and H.D.U. floodlights.	As required.		None.
TRAILING THE HOSE			
5. Select emergency signal switch to STAND OFF.	Red stand off light on.	Stowed.	Red stand off lights on.

Operator's action	Control panel indications	Circuit selected indicator	H.D.U. response
6. Select wind/trail switch to TRAIL and when, after 15 seconds, the hose tension gauge reads, turn hose tension control to the minimum setting. When hose starts to trail, increase hose tension until indicator reads trail setting.	(1) Brake warning light on. (2) Hose tension indicator reads. Brake warning light out.	Stowed. Trail.	(1) Brake on. Gear low. Then, after 15-second delay: (2) Motor on. Brake off. Gear low. Hose trails.
7. Observe hose movement on footage indicator.	Footage indicator shows hose movement to full trail. At full trail Brake warning light on, hose tension reads zero.	Gear high.	When hose is at full trail motor stops. Brake on. 15 seconds delay. Gear changes to high.
8. None.	Hose tension reads. Brake warning light out. Amber contact light on. Pump off warning light out.	Refuel.	Motor starts. Brake off. Amber contact lights on. Hot air gate valve open and air bleed valve closed.
9. Turn hose tension control to I.A.S. hose tension requirements.	Hose tension reading appropriate to I.A.S.	Refuel.	Fluid drive scoop tube moves as directed by hose tension control.
10. As directed by the Captain, select emergency signal switch to AUTO.	Red warning light out.	Refuel.	Red stand off lights out.
REFUELLING			
11. Before switching on the fuel the operator must first satisfy himself that a successful contact has been made. This can be done by: (i) Checking that approximately 25 ft. has been wound in on the drum. (ii) Checking that the brake light is OUT.			

Operator's action	Control panel indications	Circuit selected indicator	H.D.U. response
The main fuel valve should then be put to AUTO and the amber light will go out and the green light come on. If a positive contact has in fact been made, the flow gauge should show that fuel is being transferred. If the flow gauge does not register a flow of fuel, put the RED stand off lights on, and the fuel valve to SHUT, wait 10 secs. and retrail as detailed in para. 3 of the stand by procedure.			
12. During fuel transfer, observations must be made of the footage indicator, fuel pressure and flow gauges. If any tank containing transferable fuel should empty, the warning light relevant to that tank will come on. *Warning:* The hose tension indicator will be fluctuating considerably during this period, but under no circumstances should the hose tension control be touched.	Footage indicator will indicate the position of the receiver. When the fuel valve is put to AUTO the amber light will go out and the green light will come on. The fuel gauge will indicate rate and quantity of fuel flow.	Refuel.	Receiver establishes contact, the hose moves in and out as the distance from the Tanker is increased or decreased. When 25 ft. of hose has been wound on the drum the fuel valve will open, the green contact light comes on and the amber goes out. The air bleed valve will open and fuel will start to flow.

Operator's action	Control panel indications	Circuit selected indicator	H.D.U. response
13. (*a*) On completion of transfer of required amount of fuel, select the main fuel valve to OFF. (*b*) If no further refuelling operations are intended the pumps in those tanks still containing fuel will be stopped by pressing the stop buttons and holding them pressed until the warning lights come on. If further refuelling operations are intended, move interruptor bar on fuel valve switch and place switch to open for 30 seconds, to recharge hose with fuel.	Green light will go out and amber light come on. Flow rate will read ZERO.	Refuel.	Fuel valve closes green lights go out, amber lights come ON. The air bleed valve will open and the main pump will come off. The receiver will withdraw. Hose at Full Trail. Receiver clear.
WINDING IN THE HOSE			
14. Select wind/trail switch to WIND.	Brake warning light on. Hose tension reads zero. Red stand off and pump off lights on.	Gear low.	Motor off. Amber signal lights out. Red stand off lights on. Hot air gate valve closes. 15 seconds delay. Gear selected to low, and hose tension automatically adjusted.
15. Observe hose wind-in on footage indicator.	Hose tension reads. Brake light out, footage indicator shows hose winding in.	Wind.	Motor on. Brake off. Hose winds in.
16. Continue to observe footage indicator.	Hose tension reads. Brake light on when 80 ft. of hose wound on drum.	Pre-stow.	When approximately 80 ft. of hose has wound on the drum, the brake is applied.
17. None.	Brake light remains on when hose is fully stowed. Hose tension indicator then reads zero.	Stowed.	Motor off when hose fully stowed. Red stand off lights extinguished. Brake remains on.

	Operator's action	*Control panel indications*	*Circuit selected indicator*	HDU *response*
18	Select motor switch to WARM and hose tension control to maximum	Hose tension gauge indicates a minimum of 270 kts.	Stowed	Motor on. Hose is tightened on the drum
19	Ensure that stand off switch is at Auto and request Captain to close bomb doors	Transfer pump warning lights out. Instrument gauges read zero	Stowed	Motor off
20	Select PILOT/OPERATOR switches to PILOT	All fuel contents gauges read zero	Stowed	None
21	Place Motor Warm and master switch off, and trip normal and emergency supply circuit breakers. Report operation complete to Pilot, together with total weight of fuel transferred	Instruments read zero	Stowed	None

(*c*) *"Stand by" procedure*

Control panel indications	*Circuit selected indicator*	HDU *response*	*Operator's action*
EXCESSIVE TRAIL SPEED			
Symptom: Brake light on Footage indicator stationary	Trail	Speed control unit has applied the brake	Increase hose tension control slightly Press and release brake reset switch
Brake light out. Footage indicator shows hose trailing	Trail	Brake reset to Off. Hose moving to full trail	*Note*: If it is suspected that the Speed Control Unit is unserviceable the brake should be applied by pressing and holding the brake reset switch

Control panel indications	*Circuit selected indicator*	HDU *response*	*Operator's action*
FAILURE OF CIRCUIT SELECTOR TO PROCEED TO NEXT CIRCUIT AUTOMATICALLY			
Symptom: Failure of motor to restart following a gear change	As appropriate	Failure of an electrical item to signal Circuit Selector to next stage	Press and release standby circuit selector button *once only*
EXCESSIVE BREAKAWAY SPEED OR PREMATURE SEPARATION OF RECEIVER			
Symptom: Brake light on Footage indicator stationary Red stand off light on Flow indicator reads zero Reduction in pressure on fuel pressure gauge. Pump off warning light on	Refuel	Speed control unit has applied the brake. Fuel valve closed. Air bleed valve closed. Green lights off, amber lights on. Red stand off light on. Hot air gate valve closed	If the hose is not fully trailed select wind/trail switch to WIND and wind in the hose. Should further contacts be required by Receiver, retrail the hose
EXCESSIVE FUEL PRESSURE			
Symptom: Pressure gauge momentarily reads over 60 PSI Main pump warning light on	Refuel	Fuel and hot air valves closed. Air bleed valve closed	Set main pump switch to OFF then to AUTO. If main pump warning light comes on, place switch to OFF and allow a reduced fuel flow to Receiver
FAILURE OF MAIN FUEL VALVE TO OPEN WHEN AUTO SELECTED			
Symptom: (*a*) Brake light off (*b*) Footage indicator showing approx. 30-40 ft. on the drum and oscillating (*c*) Amber light on Green light OUT (*d*) No fuel flowing	Refuel	Receiver has successfully made contact, fuel valve closed, amber lights ON. Green light OUT No fuel flowing	Move interrupter bar on fuel valve switch and place to OPEN. Flow rate meter will indicate fuel flowing. Amber light will go out and green light come on

(d) Emergency procedure

Control panel indications	Circuit selected indicator	H.D.U. response	Operator's action
HOSE BREAKAGE It is assumed that hose breakage may only occur should the Receiver move the hose to a critical point outside the refuelling envelope. The electrical circuits are arranged to close the fuel valve and switch off the motor should the hose break and the remaining hose wind in to the "Pre-Stow" position while in the refuel condition. *Symptom:* Hose winding in rapidly. Hose tension reads lower than required I.A.S. setting. Fuel flow indicator reads maximum rate or Receiver pilot reports hose breakage.	Refuel to Pre-Stow.	Hose parted.	Place Master Switch OFF. Trip circuit-breakers. Leave bomb doors open to dissipate fuel vapour.
HOSE JETTISON Following an electrical or mechanical failure, applicable when hose has commenced to trail. 1. *Electrical failure* Hose Tension reads ZERO. No response on hose tension control. Brake warning light stays on. Red stand off light on.	Trail, Refuel or wind.	Motor off. Brake on. Air bleed valve and fuel valve close if in refuel condition. Red stand off signal light on.	Select hose jettison switch to EMERGENCY TRAIL and hold. Brake light will go out and will come on again; release switch and repeat his action until brake light stays out. Then select HOSE JETTISON with pilot's permission. Switch OFF master switch.

Control panel indications	Circuit selected indicator	H.D.U. response	Operator's action
2. *Mechanical failure* Hose Tension reads NO LOAD, no response on hose tension control. Brake light stays on, red stand off light on.		Mechanical failure of drive mechanism. Speed control unit has applied the brake.	As above.

(*e*) *Dry contact procedure*

1. Ensure pilot/operator switches are at PILOT.
2. Main pump selected OFF.
3. Fuel valve as for normal refuelling.
4. Proceed as normal refuel.

Note: The transfer tank must contain not less than 800 lb. of fuel at any time that dry contact training is in progress, in order to keep the hose full of fuel.

(*f*) *In the event of unsuccessful contacts the following conditions may occur*

1. RIM CONTACT ON DROGUE

   Symptom: Brake warning light on, hose not at full trail.

   Action: Reset brake switch until hose at full trail, with red stand off light on.

2. DROGUE TOPPLE

   Symptom: Brake warning light on, footage indicator stationary. Approximately 30 to 40 ft. wound on drum.

   Action: Proceed as excessive breakaway speed.

20. Failure of a tank or tanks to feed (Tanker)

Air turbine pump failure

In the event of failure of any of the air turbine pumps (i.e. in the fuselage No. 3 cells or the transfer or auxiliary tanks), the fuel in the affected tanks will not transfer. On completion of the flight refuelling operation, the equivalent weight of fuel which would have been transferred (if failure had not occurred) must be used from the fuselage tanks before using any further fuel from the wing tanks.

21. Failure of a tank or tanks to fill (Receiver)

(*a*) Figure 4 provides a ready indication of the action required to keep the C.G. within limits if a tank does not refuel correctly during flight refuelling. Provided that the C.G. position on completion of refuelling is known or computed, the chart enables the operator to decide at a glance if a C.G. problem exists, without the necessity of using the slide rule. The vectors represent the moment arms of the tanks for varying amounts of fuel. Two vectors are given for each tank, one at high weight and one at low weight. Interpolation is necessary for intermediate weights.

(*b*) Point o on the vectors represents the C.G. position which should be obtained when the predetermined flight refuelling is completed. Each vector shows the direction (away from point o) of the change of C.G. should any tank fail to refuel to the predetermined amount.

(*c*) Before commencing flight refuelling, calculate the C.G. and weight of the aircraft as it will be on completion of refuelling. The C.G. of the aircraft in relation to the C.G. limits of 46·93 and 47·97 feet aft of datum will then be known. For example, if the C.G. on completion of refuelling is calculated to be 47·7 feet aft of datum the aft limit is 0·27 feet aft of the C.G. and the forward limit is 0·77 feet forward of the C.G. Plot these two positions on the chart on each side of point o.

(*d*) By reference to the chart it can be seen that failure of any tank to refuel will not cause the C.G. to move outside the forward limit but if any of the reserve, fuselage No. 1, fuselage No. 2 or auxiliary tanks do not refuel beyond the point where the aft C.G. limit line crosses the vectors for the different tanks, the C.G. will be outside the aft limit.

(*e*) To compensate for the C.G. moving outside the limit it is necessary to reduce the contents of a tank whose moment arm is opposite to the faulty tank, by an amount which will move the C.G. to within the limits. As this involves a reduction in fuel capacity, further to that already lost by the failed tank, the C.G. should be compensated by a tank which provides the greatest change of moment for the least fuel capacity reduction. For aft C.G. compensation this is the transfer tank, and for forward C.G. compensation the reserve tank.

See overleaf for example

Example

Taking the calculated C.G. figures given in para. 21(c) plot the positions of the C.G. limits at 0·27 feet aft of point 0 and 0·77 feet forward of point 0. Let it be assumed that all tanks are to be completely filled and that the final all-up-weight will be 140,000 lb.

During refuelling it is noticed that the reserve tank does not refuel beyond 1,000 lb. The amount of C.G. compensation must now be determined.

From the reserve tank gauge reading scale for 1,000 lb. move horizontally to a point within the two reserve tank vectors, and interpolate for 140,000 lb. From this point move vertically upwards and obtain a reading of the distance aft from point 0, i.e. 0·37 feet. The amount by which the C.G. must be moved forward to come within the aft limit is therefore 0·37 – 0·27 = 0·1 feet.

From point 0 move horizontally to 0·1 feet forward and then move downwards to the transfer tank vectors. At a point within these vectors, again interpolate for 140,000 lb. and then move horizontally to the transfer tank gauge reading scale. A reading of 4,850 lb. is thus obtained. This figure represents the *maximum* capacity to which the transfer tank should be filled to bring the C.G. the requisite distance forward so as to be within the aft limit. Any further reduction in transfer tank capacity will result in further forward C.G. movement.

The total fuel capacity lost, therefore, due to the failure of the reserve tank to refuel beyond 1,000 lb. is:

Reserve tank, 4,720 – 1,000 =	3,720 lb.
Transfer tank, 5,680 – 4,850 =	830 lb.
	4,550 lb.

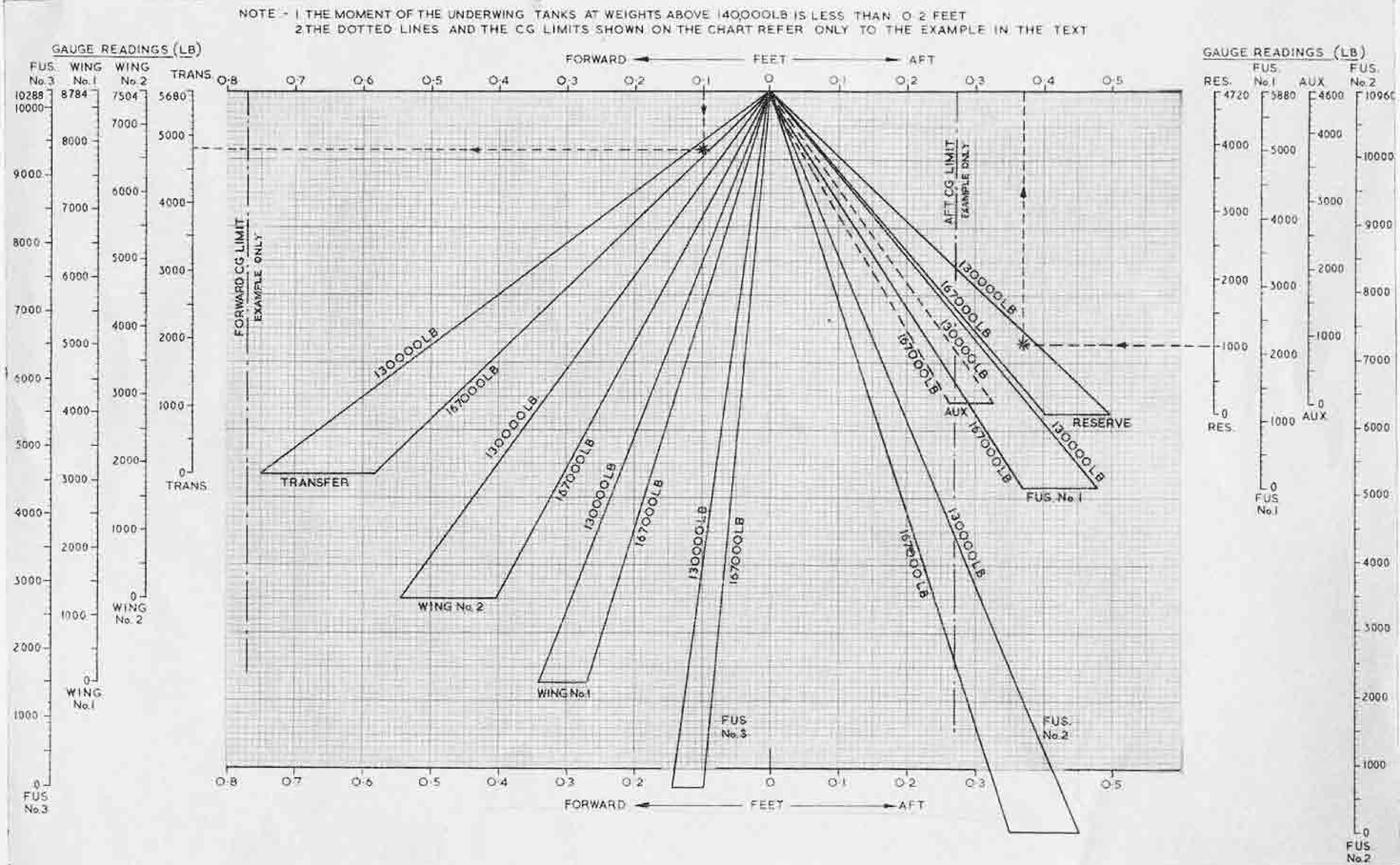


FIG. 4.—*C. G. correction chart*

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Appendix B

SPECIAL EQUIPMENT

VALIANT WP214

APPENDIX B

Special Equipment — Valiant WP214

1 General

This Appendix lists the special equipment fitted in Valiant WP214 and gives details of the power supplies to this equipment, as well as operating instructions for the special power supplies. In addition it details the alterations to the normal aircraft equipment, specific to this role. Special limitations, additional to the normal aircraft limitations, are also included.

Special Equipment

2 Special equipment

(*a*) The following special equipment, with special aerials as detailed, is fitted.

Equipment	*Aerials*
ARI x 18105	4 pairs, 1 pair each side of the upper nose cone, and 1 pair each side of the tail just forward of the tail cone.
ARI x 18076	3 flush-fitting disc aerials in the bomb bay deflector.
ARI x 18075	A slot aerial in each wing tip, each with a matching stub.
ARI x 18074	Uses the normal VHF aerial in the tail fin tip (see (*b*) below)
AN/APR9	One aerial in the [illegible] bay deflector.
ARI x 5919	Radar head in the [illegible] cone.
ARI x 18146 (alternate fit to No. 1 channel of ARI x 18076)	3 aerials just forward of the tail radar head.

(*b*) *VHF*

As the normal VHF aerial is used for the ARI x 18074, two rod aerials are [illegible]ted for the VHF sets. The No. 1 set uses an aerial on the starboard side of the upper fuselage ; the No. 2 set uses one on the port side of the lower fuselage. The normal VHF aerial change-over switch is deleted.

3 Controls for special equipment

(*a*) The special equipment control panel and individual control units are all mounted on the radio crate ; these include the controls and instruments for the power supplies and equipment cooling.

(*b*) Instrumentation controls to indicate temperature, voltage and frequency of services to the equipment are at the bomb aimer's position. The AN/APR 9 indicator and remote control unit are at the same position. In this position, an oxygen regulator, intercomm socket and special seat are provided for an observer.

4 Power supplies

(*a*) *AC supplies*

AC power supplies for the special equipment are obtained from a 200-volt, 30 kva, 3-phase, 400-cycle turbo-alternator. The turbo-alternator is driven by air supplied from the engine compressors, and the output is distributed to the equipment through a junction box in the rear fuselage which incorporates provision for connecting an external supply for ground testing. The junction box is fitted with a ground/flight switch ; this switch must be at flight at all times unless an external supply is connected.

(b) DC supplies

Supplies from the normal aircraft 28-volt DC electrical system are used for the turbo-alternator frequency controller, the turbo-alternator air control switches, the ARI x 5919 and for the equipment cooling pump relay. A supply from the normal aircraft 112-volt DC system is used for the equipment cooling pump.

5 Cooling systems

(*a*) The special equipment is cooled by a water-glycol cooling system operating through a heat exchanger. The heat exchanger is mounted in a fairing on the upper port side of the rear fuselage which incorporates a ram air intake and an air exhaust vent. The water-glycol system comprises a header tank in the upper port rear fuselage which connects with a fluid reservoir in which is an immersed pump driven from the aircraft 112-volt DC electrical system. Fluid is pumped through two filters, a temperature control valve and the heat exchanger, to the various units of the special equipment, whence fluid is returned to the header tank. The water-glycol pump is controlled by a switch on the turbo-alternator control panel.

(*b*) The ram air intake for the water-glycol heat exchanger (see (*a*) above) incorporates air intake ducts for cooling the turbo-alternator gearbox, the alternator, the turbine control unit and the ARI x 5919 tail radar unit.

(c) Ground running

When the equipment or the turbo-alternator are to be operated for ground testing, a cooling air supply must be passed through the ram air intake.

6 Turbo-alternator

(a) General

The air pressure used to drive the turbine is drawn from the engine compressors via the tail de-icing ducts on the engine side of the de-icing shut-off valves. The air supply is taken through two air supply valves whose limit switches operate OPEN and CLOSE indicator lights, one of each for each air supply switch. The turbo-alternator control switches and indicator lights, and the water-glycol pump switch, are on the turbo-alternator control panel on the radio crate. Beside this panel is another panel which carries an alternator voltmeter with phase selector switch, ammeter and frequency meter, as well as a gearbox oil pressure gauge.

(b) Operation

(i) *Starting the turbo-alternator*

Provided that at least one engine is running at not less than 5,500 rpm the turbo-alternator may be started as follows:

1 Switch ON the water-glycol pump motor.

2 Switch ON the turbo-alternator master switch.

3 *Wait one minute.* This is to allow the frequency control unit amplifier valves to warm up.

4 Select both air supply valve switches OPEN.

5 Check that both CLOSED indicator lights go out and that both OPEN lights come on.

The turbo-alternator will now be operating and the special equipment may be operated as required.

(ii) The following points should be noted:

1 If it is desired only to operate the turbo-alternator, without switching on any of the special equipment, the water-glycol pump need not be switched on.

2 At high altitude the full alternator output will not be available if one air supply fails or is switched off.

3 For ground running, only one air supply need be used, and one engine will provide this as long as its rpm are in excess of 5,500. Cooling air must be supplied to the ram air intake. It is recommended that an outboard engine be run so as to minimise tail buffeting.

(iii) *Stopping the turbo-alternator*

The turbo-alternators should be stopped as follows:

1 Select both air supply valve switches to CLOSE.

2 Check that both OPEN indicator lights go out and that both CLOSED indicator lights come on.

3 Switch OFF the turbo-alternator master switch

4 Switch OFF the water-glycol pump motor.

Additional Alterations

7 Fuel system

The port cell of the fuselage transfer tank has been removed. The fuel capacity quoted in Part I, para 6 is reduced by 355 gallons (2,840 lb) (see para 12). The fuel contents gauges have been compensated for this.

8 Intercomm system

On the port coaming panel are a " I/C—Radio compass " switch, a " P to T navigator " switch and a " Radio compass override " switch. On the starboard coaming panel is an " I/C—Radio compass " switch. These switches function as follows:

(*a*) *I/C—Radio compass switch.* This enables either pilot to listen to radio compass signals or to the intercomm as required.

(*b*) *P to T navigator switch.* The navigator can select either intercomm or audio-warning signals (from the ARI x 18105 equipment). Should he be selected to the latter, the pilot, by pressing the " P to T navigator " switch, can speak to the navigator on the intercomm system.

(*c*) *Radio compass override switch.* This enables the pilot to override the selection of all crew members who have radio compass facilities, by disconnecting them from the radio compass system and enabling him to talk to them on intercomm.

Limitations

9 General

All limitations quoted in Part II, other than those specifically quoted below, apply to this aircraft. Handling of the aircraft is not affected by the special installation. When landing, the rate of descent on touch-down must be kept low (see Part (IV), para 21).

10 Temperature limitations

The temperature gauge at the APR 9 observer's station can be selected, by the adjacent switch, to show the temperature at various points in the equipment. The temperatures shown on this gauge must always be kept within the following limits:

Switch position	Limits
1	+20°C to −20°C
2 and 3	+26°C to 0°C
4 to 11	+20°C to −20°C
12	OFF

NOTE: ARI x 18146 must not be switched beyond STANDBY unless the readings at switch positions 2 and 3 are 0°C or above.

11 Flight in icing conditions

Flight must not be continued in severe icing conditions, as there is no provision for avoiding ice formation in the water-glycol heat exchanger.

12 Fuel system

(*a*) To compensate for the aft CG of the aircraft, the reserve fuel tank contents must not be allowed to fall below 1,350 lb if window bundles are carried and retained, or 2,660 lb if window bundles are not carried or are discharged in flight.

(*b*) The port cell of the transfer fuel tank is not fitted (see para 7). The starboard cell may be filled if required.

13 Armament stores

No armament stores may be carried in this aircraft.

Performance

14 Climb/cruise

Measurements of climb/cruise performance at 0·73M and 0·75M show no difference from the performance figures given in the Operating Data Manual.

15 Range

The installation in this aircraft has no appreciable effect on range. Total range will, however, be reduced by virtue of the removal of one cell of the transfer fuel tank and by the restriction in the use of the reserve tank fuel.