Part III

MANAGEMENT OF SYSTEMS AND EQUIPMENT

Part III

Management of Systems and Equipment

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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 $\frac{3}{4}$ 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 auto-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.


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