PART III
HANDLING

54. **Cockpit checks**

Item	Check
Oxygen selection cocks (16)	At P.B. with type "J" masks or At ECON. with type "H" masks
Fire-extinguisher and crash axe	Stowed
Electrical control panel	
Battery isolating switch (8)	On
Generator switches	ON
Voltmeter	Reading
Generator failure warning lights (6, 9)	On
Pilot's services and generator field circuit-breakers (5)	Set
Radar master switches (20, 21, 22)	All off
Circuit-breakers at rear base of pedestal	All set
Circuit-breakers for L.P. cocks and pumps (front face of pedestal) (11, 18, 19)	All set
Ejection seats safety pins	Remove and stow

When seated and strapped in, start on left-hand side and work clockwise round the cockpit.

Rudder lock	Removed

Item	Check
Bomb door emergency control lever (30)	Wired SHUT
Windscreen D.V. panel heater, pressure head heater and vent valve switches (24, 25 and 23)	Off
Canopy "sandwich" de-mister (50)	Off
Oxygen (31)	On Check contents and flow
Bomb door switch (27)	SHUT
Aileron and rudder trimmers (46, 47)	Function Operation of indicators
External lighting switches (at 44)	All off or as required
Canopy jettison master switch (at 36)	ON
H.P. pump isolating switches (43)	NORMAL (down)
H.P. cocks (32)	Off
Throttles (34)	Closed
Intercomm. amplifier (33)	On
I.F.F. switches (35)	Off
D.V. panel	Closed
Flap indicator (40)	Indication
Undercarriage indicator (52)	Three green lights Check changeover and day/night screen
Undercarriage selector (54)	DOWN. Check position of UP button override.
Flaps selector (38)	Locking pin out
Undercarriage emergency handle (37)	In
Canopy internal de-mister	OFF
Ventilator (39)	As required
Ignition switches (93, 97)	On

Item	Check
Mk. 4B compass selector (91)	COMP.
Fuel pressure warning lights (82, 90)	On
L.P. fuel cock and booster pump switches (67, 71, 83, 85, 87, 88)	All OFF
Cabin pressure and heat control (80)	Function, leave indicator at COLD
Cabin pressure warning horn override switch (73)	On (up)
Brake pressure (79)	2,500 lb./sq. in. or pump to this figure
Internal lighting switches	As required
Magnetic stand-by compass (65)	Heading
Entrance hatch	Locked (emergency handle strapped in position)
Hydraulic handpump handle (15)	Fitted in its operating position
Brakes	On
Tailplane actuator (64)	Full up, full down, then neutral *Then 1 div. nose up, 1 div. nose down, finally return to neutral.*

55. Management of the fuel system

(i) Start the engines with all booster pumps on, then use the fuel as follows:—

Take-off. Take-off with all pumps on. At 30,000 feet, or after 10 minutes, switch off No. 1 and 2, and fly on No. 3.

Cruise. Fly with No. 3 tank on until 300 gallons remain in it, then turn on No. 1 and fly on 1 and 3 until 200 gallons remain in No. 1.

Then (a) If, due to uneven feeding, No. 3 tank contains more than 100 gallons when No. 1 is down to 200 gallons, No. 1 should be switched off until the level in No. 3 falls to 100 gallons.

(b) If it is essential to obtain maximum range, as much fuel as possible should be used from No. 3 tank at this stage.

When No. 1 is down to 200 gallons and No. 3 to 100 gallons (or less), switch on all pumps and leave them on for the rest of the flight.

Land Land with all booster pumps on.

NOTE.—When any tank is empty the booster pumps should normally be switched off, though there is no harm in leaving them running for a short time.

(ii) *General*

(a) When using No. 3 tank, while the fuel from the wing tip tanks is transferring to No. 3 tank the fuel gauge for this tank will normally read full, but under certain conditions of flight the level may fall to 450 gallons before transfer has been completed. When the level in No. 3 tank falls steadily below 450 gallons, it indicates that the transfer of fuel from the wing tip tanks has ceased. Normally the rate of transfer from each wing tip tank will vary, giving rise to emporary lateral trim changes. If one tank will not feed at all, and the other one is empty, a safe landing is possible provided that the speed is kept about 5 knots above the minimum for adequate lateral control and that weather and runway conditions are suitable. Otherwise, both tanks should be jettisoned before landing.

(b) When No. 1 and 3 booster pumps are on together, the rate of feeding will vary. No. 1 will normally feed faster than No. 3.

(c) In an emergency it may be necessary to vary the fuel drill. For instance, if a bomb hangs up on the forward beam the C.G. will be well forward of the limit. This necessitates a higher approach speed, there will be reduced elevator control and very careful judgment of the landing will be required. The pilot may counteract this to a large extent by having as much fuel as possible in No. 3 tank. Similarly, if a bomb hangs up on the aft beam, No. 1 tank should be kept as full as possible.

(d) In a steep climb, or when rapid accelerations or manoeuvres are being made, there is a risk of fuel surge uncovering the pumps in No. 1 and 3 tanks if they contain less than 60 and 80 gallons respectively. Normally this surge will not be dangerous, as with the levels in 1 and 3 so low, No. 2 will be on as well, but the fact should be remembered if it is necessary to vary the fuel drill.

(iii) *Reserve fuel*

The last 150 gallons in No. 2 tank is the minimum safe allowance for a circuit, an overshoot and a landing. The surge in No. 2 does not become dangerous until the level has fallen to 50 gallons, but even below this level all fuel can be used provided all manoeuvres or attitudes which might lead to fuel surge are avoided.

(iv) *Fuel booster pump failure*

(a) If two or three booster pumps on one side are on, no immediate indication will be given if one pump fails; but if all pumps fail, or if only one pump is on and it fails, the warning light on that side will come on.

(b) The effect of booster pump failure depends on altitude and engine r.p.m. and may also vary between aircraft. It may also be influenced by the head of fuel in the tanks.

(c) The engine-driven H.P. pump is designed to operate with a positive inlet pressure and as booster pump failure causes the pump to have to suck fuel from the tank, the delivery to the engine will be affected. At medium altitudes a drop of 50 to 100 r.p.m. may be expected; above 35,000 feet a drop of 400 r.p.m. may occur at full power, but this drop becomes progressively less at lower powers and is about 50 to 80 r.p.m. at 6,500 r.p.m. Power can be restored by opening the throttle. If the distribution of fuel permits, another booster pump should be switched on. Fuel from the tank with the failed pump may be used for the other engine.

56. **Engine handling**

(i) *Fuel pump isolating switches*

(a) When taking off at weights above 37,000 lb. it is recommended that both fuel pump isolating switches are set to ISOL. With the switches set to NORMAL the failure of an H.P. pump or part of the servo mechanism will be shown by a rapid and unaccountable loss in r.p.m. Should this occur the throttle must be fully closed immediately, and the appropriate fuel pump isolating switch set to ISOL. (up). If the engine then idles normally an attempt may be made to accelerate it. If it fails to idle normally, the H.P. cock should be closed and the engine re-lit as recommended in para. 77 leaving the isolating switch set to ISOL. Having re-lit, it may not be possible, at low altitudes, to obtain maximum r.p.m.

(b) With a fuel pump isolating switch set to ISOL., considerable care must be exercised when the engine is opened up from idling r.p.m. If the throttle is handled coarsely at engine speeds below 5,000 r.p.m., the engine is prone to over-fuelling, excessively high jet pipe temperatures and a possibility of fire. While opening the throttle a check should be kept on the r.p.m. and j.p.t. If the j.p.t. rises rapidly and reaches the maximum, the r.p.m. meanwhile remaining constant, the throttle should be closed immediately and a slower acceleration attempted.

(c) At all times during flight, engine speeds lower than 4,500 r.p.m. should be avoided. If the r.p.m. fall below this figure, care must be used when opening up again otherwise it is possible to stall the compressor. This applies especially when the speed is low and the aircraft is sinking.

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(ii) *General*

(a) Above about 3,000 feet the effect of the A.C.U. is reduced and rapid acceleration of the engine up to 5,000 r.p.m. will cause over-fuelling and surging. Engine acceleration deteriorates progressively with altitude and care is required when increasing power at the higher altitudes.

(b) At altitudes above 35,000 feet, the engine should not be throttled to below 6,500 r.p.m. otherwise the bleed valves will open. If the bleed valves open the throttle must be fully closed and not opened up again above 28,000 feet. During a descent with the throttles closed there may be an audible rumbling from the engines accompanied by a slight increase in j.p.t. This is not harmful but the j.p.t. will become excessive if an attempt is made to open the throttle above 28,000 feet.

NOTE.—On engines fitted with Mod. 175 (progressively variable swirl vanes) the throttles may be opened up at any altitude. Great care is still necessary, particularly at high altitudes.

(iii) *High altitude surge*

When flying at 7,800 r.p.m., with low forward speed, in an indicated air temperature of $-55°$C. or less, there is a risk of engine surge resulting in flame extinction. This risk may be avoided by throttling back by 100 r.p.m. per 5°C. drop in temperature below $-55°$C.

57. Starting the engines

NOTE 1: Whenever the external battery is plugged in or removed, the battery switch and the aircraft battery isolating switch must both be off. On aircraft pre-Mod. 258, where the GROUND/

FLIGHT switch is still fitted, the switch is to be at FLIGHT while the external battery is plugged in or out. When there is no GROUND/ FLIGHT switch the battery is always to be plugged in or removed by moving the 3-pin adaptor and lead complete.

NOTE 2: If no external battery is used, from the time that the battery isolating switch is switched ON until the generators cut in at about 3,800 r.p.m. all electrical power is taken from the aircraft battery. Provided that checks are carried out without undue delay and the period spent on the ground before take-off is normal the aircraft battery can cope with these demands. An external battery is only required when it is anticipated that the time spent doing checks will be longer than normal. If an external battery is used it is recommended that it should be removed before starting the engines.

NOTE 3: During the starting procedure numbers 2 and 3 inverters should be checked as follows:—

(a) While starting the port engine, when the master starting switch is put on, the stand-by inverter for the flight instruments (No. 3) will be heard to cut in and the emergency instrument supply indicator will show white. Check that the G4B compass starts up.

(b) While starting the starboard engine, when the master starting switch is put on, the normal inverter for the flight instruments (No. 2) will cut in; the indicator will then show normal (black).

(i) *Checks before starting*

Immediately before starting, have the external battery, if used, unplugged and the access door closed.

H.P. fuel pump isolating switches	NORMAL (down)
Throttles	Closed
H.P. cocks	Closed

Ignition switches	On
L.P. cocks and booster pump switches	All ON (one at a time) aural check Fuel pressure warning lights out
Canopy "sandwich" de-mister	ON

(ii) For each engine in turn switch ON the master starting switch, open the H.P. cock and press the starter button for about 2 seconds.

(iii) When the cartridge fires, the engine speed builds up rapidly to 1,500 to 1,800 r.p.m. and may then drop back slightly. When the engine lights up the r.p.m. increase steadily to the idling figure of 2,750 ± 100 r.p.m.

(iv) Check that the oil pressure builds up to not less than 3 lb./sq. in.

(v) *Failure of an engine to start*

(a) If an engine fails to accelerate to idling r.p.m. the H.P. cock should be closed immediately and the master starting switch set to off. When the engine has come to rest, the starter may be re-loaded. The master starting switch should be set to ON and the H.P. cock opened immediately before the new cartridge is fired.

(b) If a cartridge fails to fire, the H.P. cock should be closed immediately. Wait for one minute before removing the breech cap. If a second cartridge fails to fire the electrical circuit should be checked.

(c) Two cartridges may be fired in succession but a period of 10 minutes must elapse between each subsequent re-loading, otherwise the starter will overheat.

(d) After a failure to start, if the H.P. cock is closed without delay there should be no necessity to "blow through" the engine. If in doubt, excess fuel may be removed by firing another cartridge as follows:—

Master starting switch	ON
Ignition switch	OFF
H.P. cock	Closed

If an engine fire is suspected the L.P. cocks and pumps for the engine must also be put OFF.

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58. **Checks after starting**

Instruments	Set Mk. 4B compass Check heading by E2A compass
Hydraulic system	Test by partially lowering and raising flaps
Wheelbrakes	Pressure 2,500 lb./sq. in.
Airbrakes	Check operation

NOTE.—If it is desired to test the isolating valves, increase r.p.m. to 6,000 and move the isolating switch to ISOL. Immediately an increase in r.p.m. occurs, return the switch to NORMAL.

59. **Taxying**

(i) *Checks before taxying*

Instruments	Serviceability
D.V. panel de-mister	ON
Pressure head heater	As required
Wheel brakes	Operation as soon as possible

(ii) The hydraulic brakes are powerful. Rudder and control column loads can be high when taxying in strong winds.

(iii) Fuel consumption while taxying is of the order of 2 galls. per minute for each engine.

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60. Take-off

(i) *Checks before take-off*

Trimmers	All neutral
Airbrakes	IN
Fuel	Contents
	All L.P. cock and pump switches ON and circuit-breakers made
	Fuel pressure warning lights out
	H.P. cocks full on and tightened
	Fuel pump isolating switches NORMAL
Flaps	UP
Instruments	Jet pipe temperatures and oil pressures within limits
	Check Mk. 4B compass
	Flight instruments supply indicator—black
Oxygen	On (check with crew)
	Cabin pressurisation and heating as required
Hatches and canopy	Entrance door closed, handle locked
	D.V. panel closed
	Canopy jettison master switch ON
Bomb doors	Closed

(ii) Align the aircraft on the runway and apply the brakes. Under crosswind conditions it may be necessary to head the aircraft into wind to prevent surging and ensure satisfactory engine acceleration. In this case the aircraft should not be re-aligned with the runway until just after the bleed valves close at about 6,600 r.p.m.

(iii) At weights above 37,000 lb. open up the engines against the brakes to 7,000 r.p.m. and set the fuel pump isolating switches to ISOL.

(iv) Increase to 7,000 r.p.m. On engines not fitted with Mod. 175 check that the swirl vanes and bleed valves operate correctly.

(v) Release the brakes and open the throttles fully.

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(vi) There is a tendency for the nosewheel to rise early in the take-off run. It should be held just clear of the ground by a slight push force on the control column. At high weights the take-off run is increased if the nosewheel is held too high.

(vii) Ease the aircraft off the ground at 95 to 110 knots, depending upon the weight.

(viii) The safety speed is 140 knots.

(ix) When comfortably airborne apply the wheel brakes and retract the undercarriage. There is little change of trim but care should be taken not to exceed 190 knots before the wheels are locked up.

(x) If the take-off has been made with the H.P. pump isolating switches set to ISOL., return them to NORMAL.

(xi) The aircraft accelerates rapidly and above 120 knots an increasing nose up change of trim should be trimmed out.

(xii) If a climb to altitude is intended the engines should be throttled to give 7,600 r.p.m. and the speed held at 330 knots. For circuit practice it is recommended that the speed be kept below 200 knots. For the climb to circuit height 7,000 r.p.m. is sufficient.

61. **Climbing**

(i) The aircraft is easy to trim on the climb and holds the trimmed speed well.

(ii) The recommended climbing speed is 330 knots until .72M is reached at about 20,000 feet. Thereafter maintain .72M until the desired altitude is reached.

(iii) R.p.m. tend to increase with altitude and must be restrained by careful throttling. At high altitudes the precise setting of a desired r.p.m. is not easy. Jet pipe temperatures remain roughly constant up to about 30,000 feet, after which they may increase slightly at constant r.p.m.

(iv) If the cabin pressurisation control has not been set before take-off, pressurise at 10,000 feet by holding the control switch to HOT until the indicator needle is vertical.

62. **General flying**

(i) The aircraft is easy to trim and pleasant to fly at all altitudes. Lateral trim is sensitive to asymmetric thrust and rudder trim; a deliberate yawing of the aircraft produces a pronounced rolling motion in the direction of the yaw.

(ii) *Controls*

These are well harmonised and smooth in operation at all altitudes. The rudder is light and sensitive for small deflections but becomes quickly heavier with increase of movement. It should be used with care at high I.A.S. The ailerons are light at low speeds but become heavy at high speeds. They are effective at all speeds down to the stall but their effectiveness decreases suddenly at the highest mach numbers. The elevator is light and powerful, but becomes heavier at high speeds and loses effectiveness at the highest mach numbers. Because of the increased heaviness of the controls at high I.A.S. the aircraft is tiring to manoeuvre for any length of time.

(iii) *Trimmers*

The tailplane incidence control is powerful at all speeds and becomes very sensitive at high I.A.S. when it is best used in a series of short "blips". The rudder trimmer is powerful and quick in operation; it requires care in its use. The aileron trimmer is the least powerful of the trimmers and slowest in operation.

(iv) *Air brakes*

At high I.A.S. these are effective but below about 300 knots their effectiveness decreases until at approach speeds their effect is negligible. At high mach numbers their use causes increased buffeting with little deceleration and, at .81M, a slight nose down change of trim. Their use above .82M is not recommended normally (but see para. 65 (iv)(f)).

(v) *Changes of trim*

Undercarriage down	Slight nose up
Undercarriage up	Little change
Flaps down	Strong nose up
Flaps up	Strong nose down
Air brakes out	Little change except for slight nose down at high mach numbers
Air brakes in	Little change
Bomb doors open or closed	No change

(vi) (a) When lowering flaps, slight buffeting occurs which decreases as the speed is reduced.

(b) Buffeting and vibration is most marked when the bomb doors are opened at high airspeeds and mach numbers. At lower combinations of mach number and airspeed, buffeting is less marked.

(vii) *Flying at reduced airspeed*

Reduce speed to approximately 150 knots and keep the flaps up.

(viii) *Flying in conditions of severe turbulence*

The recommended speed is 240 knots up to 35,000 feet.

63. **Stalling**

The approximate stalling speeds in knots are :—

Power off	32,000 lb. *No wing tip tanks*	42,000 lb. *Wing tip tanks*
Undercarriage and flaps up	85 to 90	105 to 110
Undercarriage and flaps down	75	
Power on		
Typical approach conditions		
Undercarriage and flaps down	75	

NOTE.—The power off stalling speeds quoted above apply with the engines throttled back. When practising stalling, an engine speed of not less than 4,500 r.p.m. should be maintained to avoid the possibility of stalling the compressor.

(ii) Warning of the approach of the stall is given by a slight buffeting some 10 knots above the stall which increases as the stall is approached; at the stall the buffeting may be severe enough to make accurate reading of the A.S.I. difficult. At about the speeds quoted above the nose and either wing may drop gently. Aileron control is effective in raising the dropped wing and the recovery from the stall is straightforward on release of the backward pressure on the control column. The height lost in recovery is small. The stalling speed is not noticeably affected by opening the air brakes or bomb doors, but a slight increase in buffeting may be noticed.

(iii) At any time when "g" is applied ample warning of the approach of the stall is given by buffeting which increases steadily down to the stall proper at which there is a tendency for either wing to drop. Recovery is immediate upon releasing the pull force on the control column.

(iv) With wing tip tanks the pre-stall buffet is more marked and at the stall slight aileron snatch occurs together with a mild wing drop. If ailerons are used to hold up the dropped wing the snatching becomes more marked and the wing drops sharply. The speeds at which these characteristics occur are 5 to 10 knots higher than the stalling speeds without using tip tanks.

64. **High speed flying—Limitations**

(i) The aircraft is easily capable of exceeding its airspeed and mach number limitations even in level flight. Care is therefore needed to avoid exceeding the limiting I.A.S.

(ii) Up to 15,000 feet the limitation of .75M must not be exceeded. Above this speed severe buffeting and longitudinal oscillation commence suddenly and may overstress the airframe.

(iii) Between 15,000 and 25,000 feet a limitation of .79M is imposed for the same reasons as given in (ii) above. In this height band, however, exceeding the limit inadvertently is less likely to result in overstressing of the airframe unless buffeting is severe.

(iv) Above 25,000 feet no mach number limitation is imposed for a clean aircraft, but it is recommended that .82M, or any lower mach number at which compressibility effects become marked, should not be exceeded. (See para. 65 (iv)).

NOTE.—When wing tip tanks are carried, a limitation of .80M is imposed which must not be exceeded, as the behaviour of the aircraft at higher speeds becomes unpredictable.

65. **High speed flying—Characteristics**

(i) *Sea level to 15,000 feet*

As speed increases there may be a slight change of longitudinal trim, and, at the maximum speed or mach number, slight intermittent buffeting may occur. If a rapid longitudinal oscillation develops at or near the I.A.S. or mach number limitation, speed should be reduced as quickly as possible until the oscillation ceases.

(ii) The air brakes are effective at high I.A.S. but their use is accompanied by noticeable buffeting.

(iii) *15,000 to 25,000 feet*

As speed is increased buffeting commences at about .77M and increases in strength as the speed rises. If the limitation of .79M is exceeded there is a tendency for lateral unsteadiness to develop.

(iv) *Above 25,000 feet*

(a) Up to about 35,000 feet warning of the approach of severe compressibility effects is given by a nose-up change of trim which occurs at about .84M to .85M. Below this speed the first symptoms are given by slight buffeting which commences at about .78M to .8M. At about .81M, the buffeting increases in intensity and at .83M, a slight nose-down change of trim occurs, followed by a nose-up change at about .85M. The lateral trim becomes sensitive at these speeds and lateral unsteadiness may be encountered.

(b) Above 35,000 feet warning of the approach of severe compressibility effects is given by a tendency for one wing, generally the starboard, to become heavy at about .84M. At about 45,000 feet the wing starts to get heavy at slightly lower speeds, between .82M and .83M. Below these speeds the symptoms are much the same as in (a) above.

(c) Above 35,000 feet if the aircraft is accelerated past the speed at which a wing becomes heavy, any wing drop that occurs is usually accompanied by aileron snatching, and complete loss of aileron effectiveness may occur. At the same time the elevator loses most of its effectiveness and very severe buffeting sets in. Should control be lost, great care must be taken to avoid overstressing the aircraft during the subsequent recovery at the lower altitudes when the I.A.S. may be high. Use of the tail trimmer during recovery should be avoided but extreme oare must be taken if it has to be used.

(d) The behaviour under compressibility will vary between aircraft and is also likely to vary on individual aircraft depending on the C.G. position and the external condition of the aircraft. Although the wing heaviness case is given as being the most critical from the point of view of possible temporary loss of control, other effects such as strong nose-up or nose-down changes of trim, lateral rocking and directional instability may be noticed. As soon as compressibility effects become marked, irrespective of the altitude but particularly at the highest altitudes, speed must be reduced as the consequences of still further increasing the speed are unpredictable and may be serious. The remarks in this paragraph apply both to the clean aircraft and when wing tip tanks are fitted.

(e) Recovery from mild compressibility conditions best made by throttling back to not less than 6,500 r.p.m. and reducing speed, care being taken to avoid high "g" which will aggravate matters. After throttling back to 6,500 r.p.m. a constant check should be kept on the r.p.m. indicator to prevent the engine speed falling to the bleed valve/swirl vane changeover point, as the airspeed decreases.

(f) If control is lost the engines must be throttled right back, the air brakes extended and the control column held hard back. About 10,000 feet may be lost before the mach number has fallen to a figure at which control can be regained. During the recovery "g" loads must be kept low. Use of the tail trimmer during recovery should be avoided, but extreme care must be taken if it has to be used.

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NOTE.—With tip tanks fitted the compressibility effects described above will occur at slightly lower mach numbers, and will occur even lower if they are badly fitted. If complete loss of control occurs recovery may be more difficult.

66. **Maximum range and endurance**

(i) *Flying for range*

(a) Climb as recommended in para. 61 or, if it is necessary to reach cruising altitude in the shortest practical distance, climb at any speed down to 280 knots and .7M above the coincident height. The charts in the centre of the book are based on a climb at this speed but the overall range is unlikely to vary to any significant extent if climbing speeds between the two extremes (280/.7M to 330/.72M) are used. Climb to an altitude at which the rate of climb has fallen to about 300 feet per minute. Speed should then be increased to .72M and r.p.m. reduced to 7,400. If height is not maintained at this speed or r.p.m. the aircraft should be allowed to find its own cruising ceiling by permitting it to gain or lose height without changing speed or r.p.m.

(b) For extreme range the speed and r.p.m. quoted above should be maintained and, as the weight of the aircraft decreases with the use of fuel, it should be allowed to climb. Under these conditions the aircraft should gain height at approximately 1,500 feet per hour.

(c) If extreme range is not essential, the loss of range resulting from restricting the height to 48,000 feet, for pressure-breathing considerations, is not large. When the aircraft reaches this altitude any further tendency to gain height should be countered by reducing r.p.m., level flight being maintained at .72M.

(d) The loss in range due to cruising at altitudes below 40,000 feet is considerable as can be seen from the range charts. If, however, operational considerations necessitate flying at lower altitudes, maximum range will be achieved by flying at the highest practicable altitude at the air speeds shown on the charts. At any height the aim should be to maintain the optimum speed, but if this involves the use of r.p.m. less than 6,700, care is necessary to ensure that the swirl vanes and bleed valves have not moved to their low power position, as this seriously increases the specific fuel consumption. Should this occur, the r.p.m. must be increased until the vanes and valves take up the high power position and then carefully decreased to 6,700 r.p.m. or as much below as practicable, the resulting speed being accepted. Below 30,000 feet this speed will generally be in excess of the optimum, as are the speeds given on the range charts for these conditions.

NOTE.—If engine Mod. 175 is fitted, it is not possible to detect the swirl vane change, so r.p.m. below 6,700 should be avoided.

(e) In an emergency, at 20,000 feet or below, some increase in range can be obtained by flying on one engine. An indicated airspeed of 240 knots should be maintained and all non-essential electrical load must be switched off. Above 20,000 feet no worthwhile advantage is gained by flying on one engine. Below this height the advantage increases progressively provided the r.p.m. are maintained above the bleed valve and swirl vane changeover figure. At 10,000 feet the gain in range with a full fuel load is of the order of 50 miles.

(f) The descent should be made with the throttles fully closed, at .75M down to 20,000 feet and at 350 knots below this height. The r.p.m. will gradually decrease but should be prevented from falling below 4,500 by adjusting the throttles as necessary.

(g) The distance covered on the descent is appreciable due to the relatively low rate of descent in the initial stages.

(ii) *Maximum endurance*

(a) The speed for maximum endurance varies between 165 knots at sea level and 180 knots at 45,000 feet. At any required altitude the endurance speed may be found by flying at the speed which requires minimum r.p.m. to maintain level flight.

(b) Endurance increases progressively with increase of altitude up to 45,000 feet. Above this height little or no increase results.

(c) The climb to altitude should be carried out at the normal climbing speeds.

(d) At medium and low altitudes an increase in endurance will result from flying on one engine at the speeds recommended above. The saving in fuel varies with altitude, but at 3,000 feet is about 80 gallons per hour.

67. **Flight Planning Charts**

(i) The flight planning charts in the centre of the book show the fuel used for any range at any altitude when flying at either the best range speed or the maximum cruising speed. Conversely they can be used to find the maximum range at any altitude for a given fuel load. One chart shows the clean aircraft, the other shows the aircraft with wing tip tanks. The following paragraphs describe the use of the charts.

(ii) On the left of the chart is the altitude scale, the time to height, based on a climb as recommended in para. 61, being marked against it.

(iii) To the right of the altitude scale is the main part of the chart. This shows, on the left, the distance (in A.N.M.) covered on the climb. Altitude lines are drawn horizontally at 10,000 foot intervals, and above 40,000 feet the upward sloping line represents the climbing cruise to be used when extreme range is required (see para. 66). The body of the chart consists of curved distance lines, the distances being marked in air nautical miles. The unbroken curves represent the distance when flying at the best range speed, and the broken curves give the distance at the maximum cruising speed.

(iv) At the foot of the chart is the fuel scale, the specific gravity being shown at the side and the gallons used along the top. The last 150 gallons is the landing reserve. The top line, .80 S.G., represents 100 AVTUR which is normally used in the aircraft; the rest of the scale allows adjustment to be made to the range if a fuel of lower S.G. is used.

(v) At the right of the chart are the speed scales; the one marked HIGH WEIGHT is to be used at the beginning of the flight, and the other, marked LOW WEIGHT, at the end of the flight. Speeds should be interpolated for intermediate weights. It will be seen that at the lower altitudes the best range speed cannot always be used because it would be below the swirl vane change point (see para. 66 (i) (d)), and the maximum cruising speed can also not be used as it is above the I.A.S. or mach number limitation.

(vi) The descent data is tabulated at the bottom right hand corner of each chart.

(vii) *Example 1.*

To find the fuel required for a flight, with wing tip tanks, of 1,400 miles at best range speed, cruising at 40,000 feet, first subtract the distance covered in descent, 115 miles, leaving 1,285 miles. Interpolate between the points where the 1,200 and 1,400 mile unbroken curves cross the 40,000 foot line and then read downwards on to the fuel scale to find 1,310 gall. Add the fuel used on descent, 48 gall., and the landing reserve of 150 gall.; the total fuel required is 1,510 gall. approximately. To find the speed, read across from the 40,000 foot line on to the speed scales and then vertically down to read off a speed of 206 knots at the beginning of the cruise, and 180 knots at the end.

(viii) *Example 2.*

To find the distance that can be covered on a given quantity of fuel, say 1,200 gall., at say 40,000 feet, first subtract the landing allowance of 150 gall. and the descent allowance of 48 gall., leaving 1,002 gall. Then read upwards on to the distance/altitude graph to find, at 40,000 feet, 925 miles (approx.) at the best range speed, or 850 miles at the max. cruising speed. Add the descent distance of 115 miles and find the relevant speeds as before from the speed scales.

68. **Pressure error corrections**

From To		150 200	200 350	350 knots 450 I.A.S.
At 26,000 lb.	Add	3	2	1
At 40,000 lb.	Add	5	4	3

Large errors in both airspeeds and altitude are induced on the instruments if the aircraft is yawed, the instruments tending to read low. Mod 262 moves the pressure head to the centre of the nose, but P.E.C.'s are not affected.

69. **Approach and landing**

(i) *Checks before landing*

Fuel — Contents
All L.P. cock and pump switches ON in tanks containing fuel
Circuit-breakers made
Fuel pump isolating switches NORMAL

Reduce speed to 170 knots and check

Undercarriage	Down Three green lights
Brakes	Pressure 2,500 lb./sq. in. Check operation
Flaps	Down on final
Air brakes	In

(ii) The flaps may be lowered on the cross wind leg and the turn on to the final approach made at 120 knots. Until the decision to land has been made, the r.p.m. must be kept above 4,500.

(iii) When lined up on the final approach the speed should be reduced to 105-110 knots early in the approach as the aircraft loses speed very slowly. At higher speeds the approach becomes unnecessarily flat. Speed should be reduced progressively until the airfield boundary is crossed at 90 to 95 knots. On throttling back, the thrust falls off slowly and the engines should be throttled fully back before reaching the airfield boundary so that the touchdown is made with the least amount of residual thrust. If landing at a forward C.G., and/or with tip tanks fitted, the final approach speed should be 100 to 105 knots.

(iv) After lowering the nosewheel on to the runway, the brakes may be applied continuously but should be used with care while the speed is high, to avoid locking the wheels. The pressure can be increased as the speed falls off but care will still be necessary to avoid locking the wheels, especially on a wet runway.

70. **Instrument approach**

The following speeds, flap and approximate power settings, are recommended for use during instrument approaches with the undercarriage down. The figures apply, specifically, to an aircraft without wing tip tanks. The effect of empty wing tip tanks on the r.p.m. required will be very small.

	R.P.M.*	Flaps	Airspeed knots
Pattern	6,300	UP	140
Final	6,100	UP	125
Glide Path	6,100	DOWN	105

*Bleed valves at low power setting.

NOTE.—When the glide path is intercepted and flap is lowered, the aircraft tends to maintain height unless the airspeed is kept at 125 knots until the flaps are fully down.

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71. **Going round again**

(i) A minimum of 150 gallons of fuel, which allows about 5 minutes of flying should be available for this possibility.

(ii) Open the throttle smoothly as required and raise the undercarriage. At 500 feet raise the flaps and trim as required. There is a strong nose-down change of trim during the last half of the flap travel

(iii) Throttle back as necessary to avoid exceeding the limiting speed of 160 knots for the flaps, while they are coming up.

NOTE.—If it is necessary to go round again after touching down, care is necessary when opening the throttles (see para. 56 (i) (c)).

72. **Checks after landing**

After landing carry out the following checks:—

Flaps	UP
Brakes	Pressure sufficient for taxying
L.P. cocks and pumps	One for each engine ON, all others OFF
Pressure head heater	Off
D.V. panel de-mister	Off
Canopy "sandwich" de-mister	OFF
Oxygen	OFF
Cabin pressurising	COLD (off)
Radar	Off
No. 4 and 5 inverters	Off
Master starting switches	Off

73. **Stopping the engines**

(i) Stop the engines by closing the H.P. cocks while the engines are at idling r.p.m Leave on one L.P. cock for each engine until the engines come to rest.

(ii) Carry out the following checks:—

Canopy and hatch master jettison switches	OFF
Chocks	In position
Brakes	Off
All electrical services	Off
L.P. cock and pump switches	OFF
Battery isolating switch	Off
Flap lever locking pin	In position
Ejection seat safety pins	In position