# PART 3

# HANDLING

## List of Chapters

# PART 3

# CHAPTER 1 — STARTING, TAXYING AND TAKE-OFF

Contents



## 1 Preparation for Flight

(*a*) Carry out the **Safe for Parking, External** and **Internal Checks.**

(*b*) Carry out **Engine Starting** procedure.

(*c*) Carry out **Checks After Starting.**

## 2 Handling on the Ground

(*a*) With one engine at maximum RPM, 80% or above must be maintained on the other engine to prevent overheating of the slower running engine.

(*b*) (i) If the OAT is below +5°C and the runways are wet or visible moisture reduces visibility to 1000 yards or less, anti-icing must be switched on (DE-ICE) immediately after starting and left on for taxying.

(ii) With duct lip anti-icing embodied, before selecting anti-icing increase No 2 engine RPM to 70% to ensure that AC remains on-line during the selection. Once anti-icing is operating, RPM may then be reduced, but AC is likely to come off-line at engine speeds below 65% RPM.

(*c*) Have the chocks removed and release the wheel brakes parking catch. Idle/fast idle is usually sufficient power to get the aircraft moving. Whenever an engine is accelerated from idle, care must be taken to observe the JPT limitation: this action is particularly important under adverse conditions of hot day and/or tailwind. Move forward and check the brakes. Once taxying speed is reached, set the throttles to idle/fast idle; the aircraft tends to accelerate at this power setting and frequent braking is necessary to prevent excessive speed. Avoid harsh braking and sharp turns because vented fuel may enter the auxiliary air intakes.

(*d*) Keep No 2 engine RPM at 58% (65% if duct lip anti-icing is in use) to ensure continuous AC supply. Do not slam the No 2 throttle to the fast idle stop otherwise RPM may reduce to below 58%.

◀(*e*) In conditions of high ambient temperature and/or tailwind, maintain the slower running engine at a minimum of 40% RPM in order to avoid excessive JPTs. Such symptoms can be produced by a wide range of temperature and/or wind conditions and can occur in the UK. ▶

(*f*) The canopy may be left open, but off the top stop, provided the airstream against the canopy does not exceed 65 knots (ie taxying speed plus wind component). If canopy vibration occurs, either close the canopy or reduce speed until the vibration stops.

(*g*) Fuel consumption at idle/fast idle is approximately 55 lb/minute.

3 *Not used.*

**4 Take-off Performance Considerations**

(*a*) V STOP and V GO speeds are given in Part 2 of the ODM. If speed is at or below V STOP, the take-off may be abandoned and the aircraft brought to rest by the use of maximum braking techniques in the remaining length of runway. If speed is at or above V GO, the take-off may be continued after the failure of an engine; the aircraft will become airborne in the remaining distance.

(*b*) Provided V STOP is greater than V GO, only V STOP need be considered. If V GO is greater than V STOP, however, a speed band would occur between the two speeds in which engine failure would result in the aircraft running into the overshoot area irrespective of whether the take-off was continued or not; in these circumstances, reheat should be used from the start of the take-off run and, if either reheat fails to light, the take-off should be abandoned.

(*c*) If the engine failure occurs at or below V STOP, the take-off should be abandoned.

(*d*) If an emergency occurs which would make it unsafe to become airborne, the take-off should be abandoned even if V STOP has been exceeded. If there is no arrester barrier, the decision whether or not to eject from the aircraft will depend on the circumstances.

(*e*) If a failure which is not included in para 4 (*c*) or (*d*) occurs, the pilot's actions depend on the circumstances. If the speed is above V STOP, the take-off should be continued and a precautionary landing made subsequently.

(*f*) If a cold power take-off is continued after an engine failure, reheat should not be selected because a successful engagement of reheat is of little benefit in shortening the take-off run. Furthermore, if the nozzle opens but the reheat fails to light, the resultant thrust reduction aggravates the emergency. Both throttles should be left at the position selected for take-off because there is no yaw to assist the pilot in determining which engine has failed. When the aircraft is safely airborne, the undercarriage should be raised and then the failed engine identified and the HP cock closed.

(*g*) It has been shown that the use of flap during take-off improves the unstick characteristics of the aircraft. However, for normal operations this technique is not recommended for the following reasons. It has been established that should No 1 engine fail during a reheated take-off, the combined nose-down pitching forces of flap and No 2 engine in reheat may be sufficient to prejudice a safe take-off. Similarly the flaps must be selected up when reheat is not used for take-off because the climb-out performance in cold power with flaps down is marginal if one engine fails. Details of climb-out performance with one engine windmilling are given in Part 2 of the ODM.

(*h*) If a 'rotation' is to be performed after a reheat take-off, it must be started at a minimum of 250 knots and acceleration is not to exceed plus 3g.

## 5 Take-off in Icing Conditions

(*a*) Anti-icing should always be used for take-off in icing conditions but if runway length is limiting, switch on anti-icing and run the engines at not less than 85% RPM for 1 minute, then switch off and take-off immediately. This procedure removes any ice already formed but affords no further protection; therefore, anti-icing should be switched on again as soon as practicable after take-off.

(*b*) The use of anti-icing adversely affects take-off performance by up to 4·5% with engine anti-icing only and 5·5% when duct lip anti-icing is operative.

(*c*) If an engine fails on take-off and anti-icing is in operation, the net thrust from the remaining engine is reduced by 8·5%. This results in a reduction of 5 knots on V STOP speeds and an increase of 25 knots on V GO speeds. The maximum weight for climb-out is reduced by 3000 lb.

**6 Take-off**

(*a*) Carry out the **Checks Before Take-off**.

(*b*) (i) Align the aircraft on the runway with the nose wheel straight and apply the brakes. Parallel No 1 throttle with No 2 and then open both throttles to 85% RPM. Check that the brakes hold at this setting. If required, switch on rain dispersal unless committed to a take-off in icing conditions. Release the wheel brakes, increase both throttles to maximum cold thrust and check that:

The nozzles have moved to the closed position.

The JPT increase to at least 650°C.

If these conditions are not satisfied, abandon the take-off.

(ii) If reheat is required, rock the throttles through the gate and move them smoothly and quickly to maximum reheat; the TTC lights come on momentarily. Check that the nozzles open fully and monitor the JPT. When the reheats have lit, the TTC lights go out and the JPT indicates between 700°C and maximum.

Note: Take-off RPM may vary between 97% and 102·5%, depending on the ambient temperature, use of reheat, use of anti-icing, JPT controller operation and intake effects.

(iii) Speed increases quickly during the take-off run and there is no difficulty in keeping straight even in strong crosswinds. Check that the strip speed display and standby ASI indicate approximately the same IAS at 80 to 90 knots. Differential braking may be necessary until the rudder becomes effective at 100 knots. Commencing at 145 knots (135 knots when missiles are not fitted), progressively move the control column rearwards to raise the nosewheel, avoiding an excessive attitude; at 150 knots, move the control column smoothly rearwards aiming to unstick the aircraft at about ~~170~~ 175 knots. Coarse backward movement of the control column at the unstick speed must be avoided otherwise the tail bumper area may strike the runway.

Note: During take-off using full reheat with flaps down, when carrying Red Top missiles without wings, the nosewheel raising speeds and unstick speeds are increased by up to 10 knots with an associated increase in ground roll of up to 200 yards. Pilots must be prepared to use more aft stick than usual to lift the nosewheel. This advice is not applicable to a flaps-up, cold power take-off.

(iv) In a strong crosswind the up-wind wing may rise slightly and, when the aircraft unsticks, the downwind wing may drop. The wing-drop can be corrected easily by use of aileron.

(v) As soon as the aircraft is safely airborne, apply the brakes and retract the undercarriage, keeping the speed below 250 knots and the brakes applied until the wheels are locked up. The nosewheel locks up with a distinct thud. Raise the flaps (if used) at not less than 180 knots.

(*c*) Carry out the **Checks After Take-off**.

## 7 Abandoning the Take-off

(*a*) *Actions*

Move the throttles to idle/idle.
Stream the brake parachute (may not deploy if speed is below 100 knots).
Employ maximum wheel braking technique (Part 3, Chapter 3, para 3).

(*b*) Considerations

Failure of the services pumps will not be indicated to the pilot since AC is off-line. If a double failure occurs, the wheelbrakes accumulator will usually meet the braking requirements of the aircraft. However, if frequent 'maxaretting' and/or differential braking occur, the accumulator may be exhausted.

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# PART 3

# CHAPTER 2 — HANDLING IN FLIGHT

## Contents



### 1 Climbing

(*a*) The aircraft accelerates rapidly after take-off if the climbing angle is shallow. Allow the speed to increase to 420 knots and then increase the climbing angle to about 16° to establish the recommended speed of 450 knots.

(*b*) The optimum climb in the troposphere is obtained at 450 knots/0·87M. If a climb to greater heights is required, the recommended technique is to accelerate the aircraft near the tropopause and then employ the energy climb. For specific details of climb profiles and the best altitude for accelerating to supersonic flight refer to the Lightning ODM.

### 2 Engine Handling in Flight

(*a*) (i) The JPT control switches should be set to AUTO and, providing the control is serviceable, the JPT will be prevented from exceeding the maximum limitation. Maximum RPM will vary according to the ambient air temperature, altitude and airspeed. Throttle back if necessary to keep within RPM limitations.

(ii) If the JPT control for an engine becomes unserviceable or is switched to OFF, manual throttling of the engine will be necessary to prevent the JPT exceeding the limitation; the excessive temperature component of the reheat trip system will be inoperative.

(*b*) Operate the throttles smoothly at all times.

▶◀

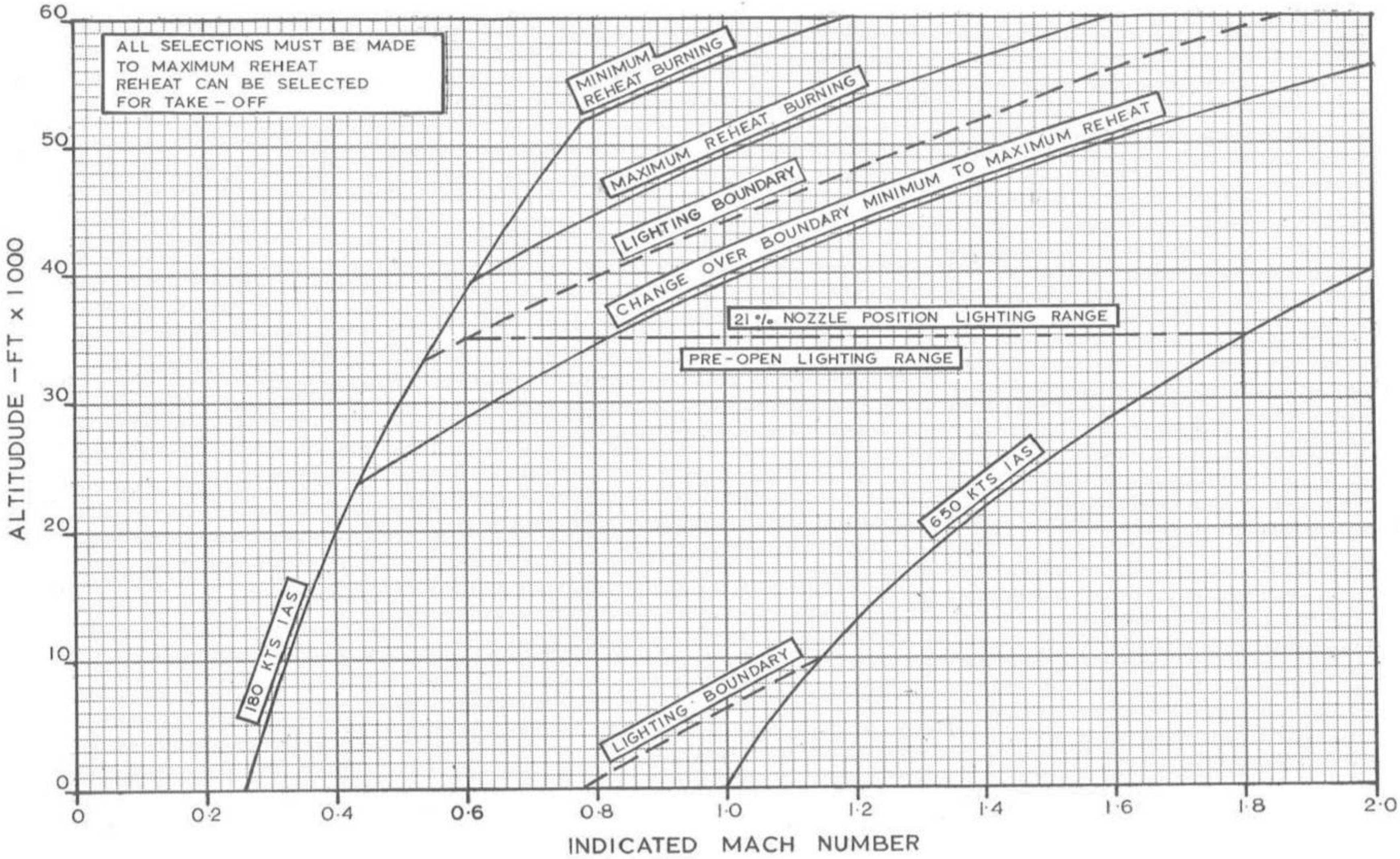
(*c*) At about 60,000 feet, 1·1M to 1·2M, with maximum cold thrust selected, RPM fluctuations with or without audible rumbling may occur; loud bangs may also be experienced. The engines should be throttled back until the fluctuations cease. Engine characteristics at high mach numbers are described in para 11 of this chapter.

(*d*) In circuit conditions, accelerations from 60% RPM to maximum cold thrust can be achieved within 5 seconds.

(*e*) Maintain at least one engine above 58% RPM to ensure continuous AC electrical supplies. Engine RPM will fall below 58% if both throttles are left at idling below approximately 15,000 feet and 250 knots.

(*f*) To conserve fuel, operate the engines in the cruise nozzle position whenever practicable.

◀ **WARNING:** At airspeeds in excess of 500 knots, particularly at altitudes below 5000 feet, there is a risk of engine surge and consequent damage if the engine is rapidly throttled back. At speeds above 500 knots, therefore, RPM reductions must be made slowly and progressively; slam or rapid throttle movements must not be used. Care must also be exercised when handling in reheat and particularly when cancelling reheat since engine deceleration is again involved. If it is intended to reduce airspeed, this should be achieved where possible by the use of airbrakes and/or climbing before reducing engine RPM. ▶




◀ **Fig 1 Reheat Lighting and Burning Range** ▶

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**3 Reheat Handling in Flight**

(*a*) All selections of reheat must be to maximum and should be made within the flight envelope shown in Fig 1. ▶◀ When selection is made during a shallow climb or dive through 35,000 feet, it is possible for operation of the altitude switch to cause transient nozzle staging which could be misinterpreted by the pilot as a system malfunction. In such cases, provided a successful light-up results, the system may be regarded as serviceable.

(*b*) After light-up, unrestricted throttle movements in the reheat range may be made anywhere within the reheat burning envelope (Fig 1): the limit of successful changeover from minimum to maximum reheat is not a handling restriction. However, when minimum reheat has been selected for more than 20 seconds, if the throttles are then opened to maximum reheat, successful changeover is unlikely outside the limit shown. If reheat extinction occurs in these circumstances, an immediate re-selection within the maximum reheat burning envelope will often be successful.

(*c*) If, within the recommended lighting range, reheat fails to light in 5 seconds, cancel the selection and wait 2 seconds; ensure that the TTC lights are out and then re-select. If reheat again fails to light, further attempts are unlikely to be successful and the system should be regarded as unserviceable.

(*d*) (i) If automatic cancellation occurs through any cause, one re-selection of reheat may be made; if auto-cancellation occurs again, no further attempt to light reheat should be made.

(ii) The possibility of reheat cancellation through flame extinction increases at higher altitudes. Successful re-selection of reheat under these circumstances is affected by altitude and mach number.

(*e*) If, after manual cancellation of reheat, the nozzle remains fully open, there will be a thrust loss of approximately 40% at maximum cold power. A subsequent selection of reheat is permissible.

**4 Engine Handling with Anti-Icing in Operation**

(*a*) When anti-icing is switched on, there is usually a rise in JPT of approximately 20°C and, at full throttle, RPM will fall if the JPT controller comes into operation.

(*b*) If climbing, employ the maximum practicable rate of climb. When an adjustment of RPM is necessary, move the throttles slowly.

(*c*) If icing conditions are met in level flight, select DE-ICE and climb or descend out of the icing as continued flight in these conditions may result in flame extinction. Should an engine flame-out, attempt an immediate relight. If this is unsuccessful, the second attempt should be made within three minutes of the flame-out; any attempt after this interval may damage the engine.

(*d*) (i) During descent in icing conditions, select DE-ICE and maintain engine speed for periods up to 5 minutes at not less than 70% RPM and for periods exceeding 5 minutes at not less than 75% RPM. The maximum anti-icing protection is obtained with the highest practicable RPM. Descend at the maximum practicable rate.

(ii) If icing persists down to airfield level, check the engine response before approaching to land and keep the engine speed above 70% RPM, if possible, until finally committed to a landing. If it is necessary to overshoot, open the throttles smoothly.

(*e*) After leaving icing conditions, wait at least one minute before switching the anti-icing OFF.

◀ **WARNING:** There is a risk that prolonged and unnecessary use of engine anti-icing may cause an explosion in the IPN fuel system; therefore it is essential that anti-icing is switched off when clear of icing conditions. ▶

### 5 General Flying

(*a*) *Ailerons*

The ailerons are effective and the control forces light throughout the speed range. Aircraft response to aileron increases with speed and, at high subsonic and at supersonic speeds, high rates of roll can be achieved. Care must be taken to observe the rolling limitations (see Part 2, Chapter 1, para 11) in order to avoid inertia coupling. Large, rapid aileron movements will cause adverse yaw which is more pronounced at low indicated airspeeds and in high speed flight (see Part 3, Chapter 2, para 11). When the undercarriage is down, the aileron stops are removed and available travel is increased from 8° to 16°. This improves lateral response during flight with the undercarriage down.

(*b*) *Tailplane*

(i) Below about 200 knots, longitudinal response is slow and large control movements are necessary during the round-out to land.

(ii) At higher airspeeds, the tailplane is more effective and response is good.

(iii) At supersonic speeds, aircraft response to tailplane movement decreases and relatively large control movements are necessary to manoeuvre.

(*c*) *Rudder*

(i) At subsonic speeds, aircraft response to rudder movement is satisfactory. Foot loads are heavy at all speeds with the undercarriage up. With the undercarriage down, however, the hydraulic component of feel is automatically removed and the rudder forces are moderate. At circuit speed, relatively small applications of rudder will induce a marked roll.

(ii) At supersonic speeds the response to rudder deteriorates and this, combined with a reduction in aerodynamic damping necessitates larger deflections to co-ordinate manoeuvres or to trim out any asymmetry.

(*d*) *Harmonisation of controls*

The aileron and tailplane controls are well harmonised at subsonic speeds. Manoeuvres at supersonic speed require large tailplane movements in comparison with aileron movements. Rudder deflections to co-ordinate manoeuvres are necessary only at low indicated airspeeds and at supersonic speeds, particularly in the region 1·2M to 1·4M.

(*e*) *Trimmers*

(i) The tailplane and aileron trimmers are effective throughout the speed range.

(ii) On some aircraft, at supersonic speeds, an increasing directional trim change may occur with increasing speed.

(iii) The rates of operation, especially of the tailplane trimmer, are slow.

◀(iv) With the air-to-air refuelling probe fitted, more marked directional trim changes with speed can be expected above 500 knots, therefore careful attention should be paid to rudder trim. At Mach numbers between 1·7 and 1·8 the probe may oscillate, imparting a slight vibration to the airframe. ▶

(*f*) *Airbrakes*

The deceleration obtained with airbrakes extended is moderate over the speed range. Extension causes slight buffet at all speeds. At high speed, a slight nose-down trim change occurs and is accompanied by slight directional oscillation.

(*g*) *Changes of trim*

| | |
|---|---|
| Increase in power ... | Slight nose-up |
| Undercarriage down ... | Slight nose-down |
| Flaps down ... ... | Slight nose-up on selection, then slight nose-down |
| Flaps up... ... ... | Slight nose-up |
| Airbrakes out ... ... | Slight nose-down at high speed; slight directional oscillation. |

## 6 Flight conditions involving high structural loads

(*a*) *General information*

High structural loads are incurred in certain maneouvres and flight conditions. The aircraft has been designed to withstand these but excessive repetition of high loads will reduce its useful life through fatigue damage. Therefore, the aircraft should not be subjected unnecessarily to the following flight conditions:—

(i) Repeated application of high G.

(ii) Low level/high speed flight, particularly in turbulence.

(iii) Certain rolling manoeuvres (see sub-para. (*b*) to (*e*)).

NOTE: At high G, the slip-ball is less sensitive to sideslip than at 1G and even small displacements of the ball should be corrected.

(*b*) *Aircraft with two or no missiles*

(i) During rapid rolls at high G, roll-yaw inertia coupling tends to produce higher than normal loads. This is particularly true at the speed/height combination of 0·8M to 0·95M and 20,000 to 35,000 feet where the high angle of attack, signified by buffet, produces sideslip and hence fin load; the amount of sideslip increases with higher rates of roll and higher G.

(ii) In the region of 1·2M to 1·4M, adverse yaw, due to aileron application, becomes pronounced, particularly at high IAS (500–650 knots) and under applied G. This produces sideslip and, therefore, high fin loads and appreciably reduces the normal rolling capability of the aircraft. Extension of the airbrakes aggravates the situation: their use (within the limitations) should be kept to a minimum in these circumstances. Rudder should be used to decrease the sideslip and fin loads. If G also is reduced, rolling response will be improved and the fin loads further reduced.

(*c*) *Aircraft with single missile*

(i) High load regions are similar to those in sub-para. (*b*), with an additional fin load due to the yawing moment of the single missile: this is particularly marked at high G. If the sideslip loads due to the single missile and full aileron rolling are additive, i.e. rolling away from the missile, particularly high fin loads can be produced in the region defined in (*b*). The situation will be aggravated if the airbrakes are extended: their use in these circumstances (within the limitations) should be kept to a minimum.

(ii) Indications that asymmetry is becoming excessive are given by:—

The inability to correct the yaw, despite a large rudder pedal force.

A marked change of lateral trim.

(iii) The loads should be reduced by minimising sideslip and reducing G.

(*d*) *Firing and breakaway*

(i) If only one of two missiles is fired and then a rapid breakaway performed, high fin loads will be produced. The aircraft will yaw and, due to the sweep-back, will have a strong rolling tendency. If aileron is applied to oppose this roll, even higher fin loads may result.

(ii) The loads should be minimised (and rolling response improved) by correcting sideslip with rudder and reducing normal acceleration to between 1G and 3G.

(*e*) *Autorotation due to inertia coupling*

Unless low roll rates are use, rolls involving less than 1G can produce auto-rotation. Therefore, it is essential that only aileron control be used when rolling rapidly through 360°. Should auto-rotation occur, only the minimum amount of aileron should be used to stop the rotation with the rudder kept central and the control column in the position for 1G flight.

(*f*) *Transonic yaw divergence*

Supersonic manoeuvrability is restricted by the G limitations but, at high altitudes the use of full tailplane may not achieve these limits. If full, or nearly full, tailplane is applied, or maintained, at supersonic speeds below 1·3M above 30,000 feet, there is a danger of achieving a large angle of attack with little or no pre-stall buffet warning. In this situation a reduction of lateral/directional stability may cause the aircraft to roll and/or yaw; if this occurs, G should be relaxed immediately. These conditions must be avoided because the yaw may be severe and can induce high fin loads. Furthermore, the high angle of attack causes a rapid loss of speed which, combined with the yaw, may induce a spin as the aircraft becomes subsonic. Accordingly, when decelerating transonically above 30,000 feet, applications of large tailplane angles should be avoided until the aircraft is subsonic, when buffet will provide pre-stall warning. However, because of the large stick travel and heavy force required, a determined effort is needed to sustain these large tailplane angles.

NOTE 1: For the same tailplane angle, the G will increase markedly when decelerating through Mach 1.

NOTE 2: Airbrakes will aggravate the reduced stability.

NOTE 3: With a single missile the additional yawing and rolling effects may conceal the onset of the symptoms.

## ◀7 Stalling in 1G flight

**WARNING:** Intentional stalling is prohibited and speed should not be reduced below the minimum speed limitations (Part 2, Chap. 1, para 3). During any manoeuvres below 200 kt., engine RPM should be maintained above 60% to ensure rapid acceleration to full power.

(*a*) 1*G stall sequence*

The 1G stall sequence outlined below applies to an aircraft carrying two missiles with undercarriage and flaps up. The minor differences to this sequence if missiles are removed are given in sub para. *b*:

| | |
|---|---|
| 220 kt. (approx) ... | Slight buffet begins |
| 180 kt. ... ... | Gentle wing rock may occur. |
| 170 kt. ... ... | Buffet increases in intensity. ▶ |

◀140 kt. decreasing to 115 kt. ... ... Aircraft begins to wander in roll, yaw and pitch. The wander becomes more pronounced as speed is reduced. The rate of descent can increase to over 6,000 ft./min. as the stall is approached. The IAS at which sink commences varies according to the rate at which the control column is moved aft. Up to this point, recovery is immediate on centralising the control column but coarse use of aileron or rudder could easily result in a spin.

115 kt. (approx) ... Aircraft yaws rapidly followed by wing drop and entry to a spin. At this stage, centralising the control column may not prevent a spin developing.

(*b*) 1*G stall sequence—missiles not carried*

With missiles off, the buffet level is higher and there is some stick force lightening as speed is reduced below 125 kt. which gives a "knife edge" feeling.

## 8 G-Stalling

Speed can be lost rapidly as G is applied. With a gradual application of G, the onset of moderate buffet occurs well before the stall (see Fig 2). Further evidence may be provided in the form of gentle wing rocking and directional wandering. If the aircraft fails to respond normally to control movements or starts to deviate from its flight path without pilot action, the controls must be immediately centralised or the aircraft is likely to flick roll. Instinctive use of aileron to oppose any roll will aggravate the situation and probably cause the aircraft to roll and yaw in the opposite direction to the applied aileron. (With airbrakes OUT, the flick manoeuvre is less predictable and usually more severe). If G is applied suddenly by a harsh control movement, the aircraft may pass rapidly through the buffet zone into the flick manoeuvre. Coarse use of the controls should be avoided when manoeuvring in the buffet zone. ▶

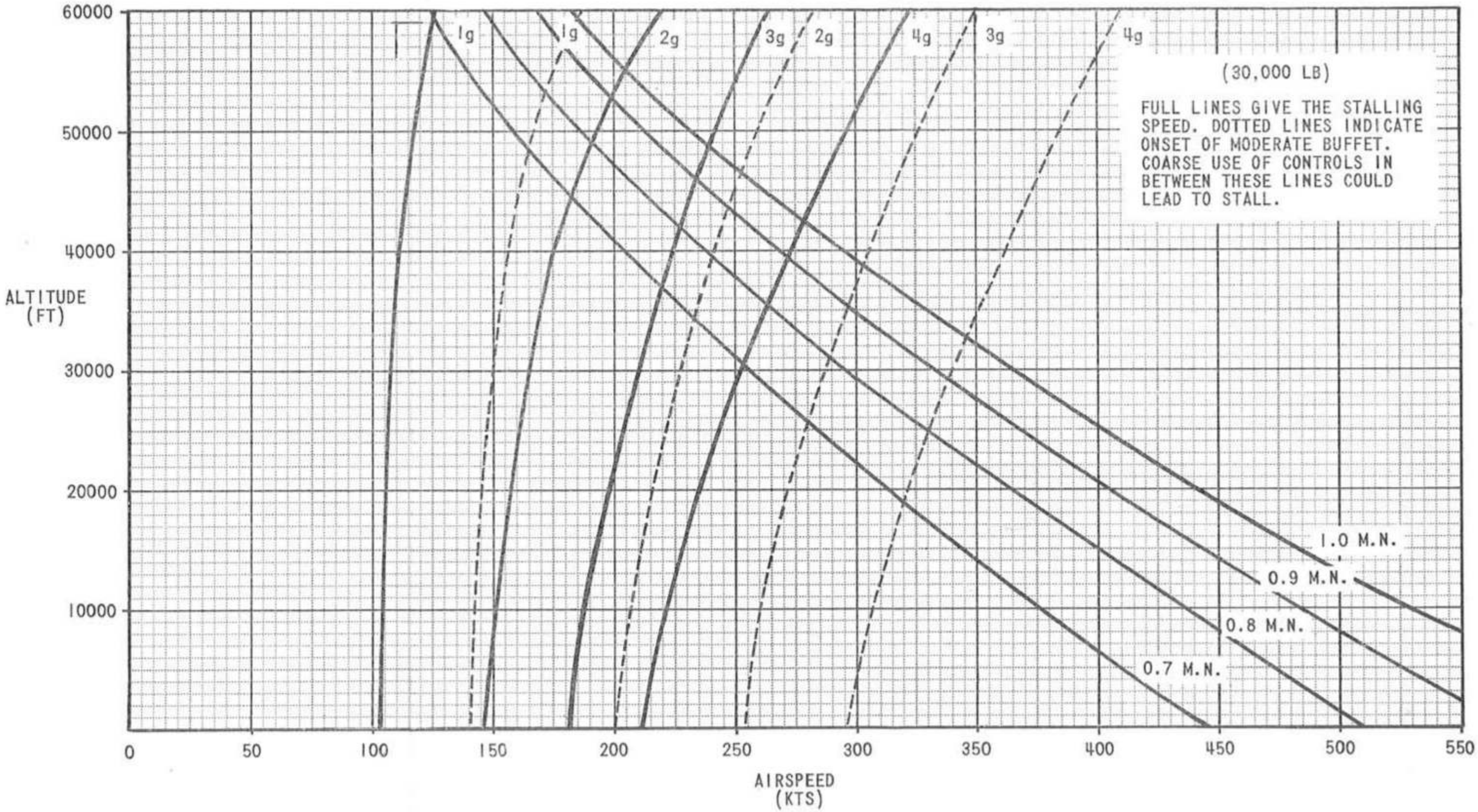


**Fig. 2 Stalling speeds and buffet boundaries**

## 9 Spinning

**WARNING:** Intentional spinning is prohibited. The following information is to acquaint pilots with spin characteristics and recovery from inadvertent spins.

(*a*) *Incipient Spin and Spin Characteristics*

The characteristics of the incipient spin vary considerably and depend on the type of manoeuvre and control positions at the moment the aircraft departs from controlled flight. If control is lost during manoeuvre, the fully developed spin may be preceded by one or more rapid rolls; if the control column and rudder are centralised at this stage the aircraft may recover. Generally at stalling incidence the aircraft yaws rapidly and then begins to roll, the higher the g on departure, the greater the rate of roll. In the spin the nose tends to drop after the first half turn and then rise towards the end of the first turn. The second and subsequent turns are steeper and the spin remains oscillatory in roll, yaw and pitch. The fully developed erect spin is fairly steep. The horizon will be found to be located between 40° and 60° above the aircraft nose. Rate of rotation is quite slow, being about one turn every 6 to 8 seconds. The rate of descent in a spin is approx 20,000 ft/min (2000 to 2500 feet/turn). The ASI will fluctuate between off-scale and up to 140 knots, once per turn. It must be emphasised that after the application of anti-spin control the aircraft may take up to 15 secs or two full turns to recover. Spin characteristics differ with the various missile configurations but the recovery behaviour is not affected.

(*b*) *Spin Recovery*

**WARNING:** If the aircraft is not under control by 10,000 feet AGL (under control means that the aircraft is responding normally to control inputs and is accelerating through 200 knots) — *Eject*.

| Actions | Considerations |
|---|---|
| **1. Centralise the control column and rudder** | 1. This action may result in recovery at this stage; if not, hold these control positions until actions 2 and 3 are completed. |
| **2. Positively confirm that aircraft is spinning** | 2. Confirmed by sustained rotation in yaw with ASI fluctuating between off-scale and 140 kt. |

| Actions | Considerations |
| --- | --- |
| **3. Postively assess direction of rotation** | 3. The aircraft has no turn needle and external references must therefore be used. If the direction of spin is in doubt (eg at night, IMC, or pilot confused) there is a high probability that the aircraft will recover within three to four turns (approx 8000 ft) if both the rudder and control column are kept central; rudder should therefore *not* be applied unless the direction of spin is definitely established. |
| **4. Apply full rudder against the direction of rotation. Keep control column centralised** | 4. A force of 200 lb is needed to apply full rudder. |
| **5 Monitor height and airspeed** | 5. The aircraft may be slow to respond initially but will recover within two turns (4000 to 5000 ft: 15 secs) after applying full rudder. *The best sign of the aircraft recovering is the airspeed increasing through* 150 *knots.* |
| **6. Centralise the rudder when airspeed rises through 150 kt** | 6. — |
| **7. Allow the airspeed to increase to 200 kt before opposing any residual roll with aileron** | 7. Residual roll will probably be present after the spin has been broken. If the pilot attempts to counter this before 200 kt is reached, there is a chance that the aircraft will re-enter a spin. |
| **8. Recover from the unusual position and then pull out from the dive at 270 to 300 kt using 2½ to 3 g** | 8. Total altitude loss from entry to recovery to level flight from a fully developed spin is likely to be 10,000 to 15,000 ft. Altitude loss in pulling out of a 90° dive at 270 to 300 kt using 2½ to 3g reduces from 7000ft at the tropopause to 5000 ft at 10,000 ft. The MRG may topple during a spin and therefore the attitude indicator and compass should be regarded as unreliable until they can be checked after recovery. |

▶◀

◀ Note: Use of the brake parachute to assist recovery from a spin is not recommended since the parachute is likely to collapse onto the airplane and hinder use of the flying controls. ▶

(*c*) *General Spinning Information*

(i) *Disorientation.* During an unintentional spin, for example from a combat manoeuvre, there is a high probability that pilot disorientation or confusion will occur. It cannot be overemphasised that the control column and rudder must be held central, from the moment of departure from controlled flight until recovery is affected, or until a fully developed spin with a known direction is recognised and full recovery action taken, or ejection height is reached. In circumstances where it is extremely difficult to count the number of turns (8/8 cloud, sea, etc), the recovery period of approx 15 seconds or two full turns of the spin may seem interminably long. Bearing this fact in mind recovery action once decided on must be given time to work and any temptation to experiment with other actions must be resisted.

(ii) *Engine Effects.* The engines should not flame out or surge in a spin although reheat (if in use) may extinguish. Varying the power setting in a spin has negligible effect on recovery and therefore the throttles should be left in the pre-spin setting until recovery is accomplished.

(iii) *Aileron Effects.* Full out-spin aileron will prevent recovery. More than ½ in-spin aileron results in an extremely rapid recovery which can easily reverse into a spin in the opposite direction; neutral aileron is therefore recommended for spin recovery. The 'feel' in the aircraft's control system helps to achieve the neutral position.

(iv) *Tailplane Effects.* Fore and aft control column position has no effect on recovery time but with the column fully forward, an uncomfortable bunt results after rotation ceases; a too far aft control column position could result in a further stall following recovery.

(v) *Air-to-Air Refuelling Probe and Airbrakes.* The affects of the probe and airbrakes are so small they can be ignored.

(vi) *General.* Particularly prior to air combat flights, pilots should ensure on the ground that they can achieve full rudder travel even though this might result in a slightly knee-high sitting position.

**10 High Speed Flying**

(*a*) The aircraft is capable of exceeding its airspeed and mach number limitations of 650 knots/2·0M (1·8M with only one missile) and care must be taken to avoid flying beyond these limits. The mach number must not exceed 1·3M when the airbrakes are in operation.

(*b*) (i) The aircraft is subject to intake vibration and intake buzz. Vibration occurs with the engines at full power at speeds above 1·88M and may also occur within the range 1·35M to 1·60M; it is due to turbulence of the airflow behind the intake bullet. It is felt as a low amplitude vibration similar to aerodynamic buffet and is structurally acceptable to the aircraft.

(ii) Intake buzz is caused by a more violent disruption of the airflow in the intake and will occur if the engines are throttled rapidly at speeds above 1·85M. With increased g, buzz will occur at a lower mach number and at higher RPM. It is indicated by a series of loud and rapidly recurrent bangs. The condition will not persist because, with application of g or on throttling back, the aircraft will decelerate rapidly beyond the buzz boundary. Intake buzz causes no damage but should be avoided if possible.

(*c*) Transition from subsonic to supersonic flight can be achieved from sea level to 45,000 feet. As speed is increased beyond 0·9M there is a slight nose-up trim change; beyond 0·96M the trim change is slight nose-down and the aircraft is back in trim at 1·0M. These trim changes are accompanied by slight buffet which is barely noticeable in 1g flight but becomes more pronounced under increased g and/or with a ventral tank fitted. The slight nose-down trim change continues progressively up to 1·3M. There is no significant change of trim between 1·3M and 1·6M. Above 1·6M, the nose-down trim change increases slightly.

(*d*) In the transonic range, a reduction in damping causes a slight deterioration in stability. Above 1·0M control improves and application of g, within the limitations, is restricted only by a gradual decrease in tailplane effectiveness with increase in mach number.

(*e*) The handling characteristics change appreciably in the region of 1·2M to 1·4M above 550 knots, particularly when missiles are fitted and when g is applied. In this region application of aileron induces pronounced adverse yaw, causing reduced roll response and a feeling of control heaviness. Difficulty may be experienced in accurate lateral trimming. Therefore, close rudder co-ordination is important during all manoeuvres.

(*f*) On some aircraft, at supersonic speed, an increasing directional trim change may occur with increasing speed. This will require repeated applications of rudder trim as mach number is increased.

(*g*) Airbrake operation at high speed causes a slight nose-down trim change and mild buffet. Directional stability is reduced with the arbrakes extended, hence the more severe limitations in this configuration.

(*h*) As speed is reduced, a progressive nose-up trim change occurs down to the transonic region.

## 11 Formation Flying

(*a*) There is a possibility of the structural limitations of the aircraft being exceeded during formation flying due to airflow interference between aircraft. The following speed and manoeuvre limitations are to be observed.

(*b*) *Operational Close Formation Flying (Excluding Aerobatics)*

(i) Speeds should normally be restricted to 450 knots or 0·92M whichever is the less. Normal acceleration should not exceed 2g. Lateral clear separation should not normally be less than half wing-span and must never be reduced to less than a quarter span. The wing man's overtaking speed should be low enough to allow correction for any lateral disturbances due to the other aircraft's airflow pattern.

(ii) If it is required to fly at higher subsonic speeds or higher normal accelerations, a minimum clear lateral separation of two wing-spans (70 feet) must be maintained.

*Intentionally Blank*

(iii) Aircraft must not fly directly behind another aircraft at speeds greater than 0·70M. Below this mach number, every endeavour must be made to keep the fin tip clear of the other aircraft's jet stream.

(*c*) *Formation aerobatics and formation display flying*

(i) In close formation no aircraft is to exceed 0·87M.

(ii) At speeds less than 0·7M, or 450 knots indicated, maintenance of lateral separation consistent with avoidance of collision is satisfactory.

(iii) Between 0·7M and 0·87M no aircraft should exceed 3G and clear lateral separation should be one half span (18 feet). At no time must this separation be reduced to less than one quarter span (9 feet).

(iv) Aircraft must not fly directly behind another aircraft at speeds greater than 0·7M. Below this mach number, every endeavour must be made to keep the fin tip clear of the other aircraft's jet stream.

(v) If it is required to make high subsonic speed low level runs in formation, aircraft must be flown in echelon only and are to have a minimum lateral separation of twenty-five yards between aircraft.

(*d*) *Supersonic manoeuvres*

Special care is necessary to avoid the pressure field of an aircraft flying at supersonic speed. In any passing manoeuvre between aircraft, one or both of which are travelling supersonically, a clear separation of at least two spans (of the larger aircraft if different) must be allowed in any direction normal to the line of flight.

**12 Air-to-air refuelling**

(*a*) *Considerations*

(i) The following information is based on refuelling from a Victor tanker but applies equally to air-to-air refuelling operations with a KC135 or Buccaneer tanker, except that in the latter case, minor differences exist which are covered in (*c*) (i) and (ii) below.

(ii) Reheat should not be used unless absolutely necessary. If refuelling in conditions where cold power is inadequate, reheat must not be engaged whilst in contact with the drogue. The recommended technique is to establish lateral separation from the tanker and engage one reheat only. When speeds are synchronised, refuelling can be effected as described in (*c*).

(*b*) *Actions before refuelling*

(i) Check autostabilisation on and functioning correctly.

(ii) Check fuel contents.

(iii) Select the air-to-air refuelling switch to FL. REFUEL and check 'tanks full' indicator lights.

(iv) Move into line astern formation on the appropriate drogue, maintaining 10–15 yards probe/drogue longitudinal clearance.

(v) Note the natural trail angle of the hose.

(*c*) *Refuelling*

(i) *Making contact*

Move into position 4–6 feet astern of the drogue, with speeds synchronised. Once this position is established, the drogue should be steady and the aircraft control forces may now be trimmed to zero. When using a wing drogue with Victor and KC135 tankers, it is necessary to apply about 2/3 available aileron trim away from the tanker fuselage: some rudder trim away from the tanker may also be required. With a Buccaneer tanker, ¾ aileron and ¾ rudder trim away from the tanker are required; as the tip of the probe is about to enter the drogue, a small amount of right rudder is required to prevent a minor yaw displacement: rudder is not required once contact is made. Increase power to accelerate and, as soon as contact is made, reduce power to maintain an overtaking speed of 2–4 knots.

(ii) *In contact*

Continue to overtake the tanker at 2–4 knots until the amber section of the hose reaches the Hose Drum Unit (HDU): reduce power slightly so that speeds are synchronised when the amber section is wound on the HDU. Maintain position during refuelling by keeping the hose at its natural trail angle and the amber section steady on the HDU. Slight variations in aircraft position result in noticeable changes of trim, particularly when refuelling from a wing drogue, but control effectiveness is adequate to cope with these changes. Monitor the fuel contents gauges and the refuelling panel indicator lights; the ◀latter go out when their respective tanks are full. With a Buccaneer tanker, a small amount of fuel may vent from the tanker pylon during refuelling and may spray onto the receiver's windscreen, but this does not present any difficulty. ▶

(iii) *Breaking contact*

Reduce power slightly and withdraw the hose at a low rate—less than 5 feet per second—keeping the hose at its natural trail angle. If the hose is withdrawn at an excessive rate, the HDU safety brake will operate and cause immediate disconnection of probe and drogue; this may delay the refuelling of accompanying receiver aircraft.

(iv) *Emergency break*

Move the throttles to idle/fast idle and extend the airbrakes. When the rate of hose withdrawal exceeds 7 feet per second, disconnection of the probe and drogue will occur.

(v) *Hose/drogue malfunction*

Structural failure of the hose or drogue may result in excessive fuel spillage; the fuel may enter the air intake and cause engine flame-out. If this occurs, an immediate relight should not be attempted. Close the appropriate HP cock and wait for as long as practicable but for at ◀least 1½ minutes before carrying out the relight drill. ▶

(*d*) *Actions after refuelling*

(i) Select the air-to-air refuelling switch to NORMAL.

(ii) Check that the ventral tank is feeding.

**WARNING:** If the air-to-air refuelling switch is left at FL. REFUEL, the ventral and flap tanks fuel will not transfer.

◀(*e*) *Broken probe.* If the end of the probe is damaged or lost, restrict speed to below 350 knots. ▶

**14 Range and endurance**

(*a*) Maximum range and endurance are obtained at approximately the following heights:—

| | | | |
|---|---|---|---|
| (i) On two engines | ... | Range: | 36,000 feet |
| | | Endurance: | 30,000 feet |
| (ii) On one engine | ... | Range: | 30,000 feet |
| | | Endurance: | 20,000 feet |

(*b*) For details of cruise performance, refer to the ODM.

**15 Flight in turbulence**

The recommended speed for flight in severe turbulence is the lesser of 350 knots/0·9M.

**16 Breakaway after guided missile attack**

◀Refer to AP.101B–1003, 5 & 6–15B. ▶

**17 Aerobatics**

(*a*) *General*

The IAS, G and rolling limitations given in Part II must be strictly observed. Within these limitations, aerobatics are easy and pleasant to perform.

(*b*) *Rolling manoeuvres*

The recommended speed is 350 knots which, below 15,000 feet, affords the greatest scope within the rolling limitations.

(*c*) *Looping manoeuvres*

(i) Considerable height is covered in looping manoeuvres and small variations in technique will significantly affect recovery.

(ii) Reheat or maximum cold power should be used for loops. If it is intended to use reheat, it should be operating before the loop is started. Similarly, reheat should not be selected during an intended cold power loop because the initial opening of the nozzles causes a marked reduction in thrust.

(iii) The recommended minimum entry speed for loops is 400 knots. Until experience is gained, it is recommended that loops are started in the 7,000—12,000 feet height band at a speed of 450 knots. An initial acceleration of about 4G should be applied and it should be expected that slight buffet will occur during part of the manoeuvre.

(iv) For a half-roll off the top of a loop, an initial speed of 500 knots is recommended.

(*d*) *Inverted flying*

(i) The recommended speed is 350 knots.

(ii) Negative G must not be sustained longer than 15 seconds. Fuel starvation will not occur but the oil pressure will reduce, causing the OIL lights to illuminate. If it is required to perform successive prolonged negative G manoeuvres, a minimum period of 10 seconds positive G must be established between each manoeuvre to prevent oil starvation of the air turbine gear box.

## 17 Descent procedures

(*a*) *Fast descent*

◀Speed ... ... 0·95M/550 kt. ▶
Airbrakes ... ... Out
Throttles ... ... Idle/Idle

(*b*) *Normal descent*

Speed ... ... ... 0·9M/375 knots
Airbrakes ... ... Out
Throttles ... ... Idle/Fast Idle

(*c*) *Slow descent*

Speed ... ... ... 0·9M/250 knots
Airbrakes ... ... In
Throttles ... ... Idle/Idle (No. 2 engine to fast idle before RPM fall to 58%).

(*d*) *Single-engine descent*

Move the live engine throttle to fast idle and descend as for ◀a two-engine descent. Increase attitude to 7° nose-up for at least 15 secs. half-way down the descent. ▶

PART 3

# Chapter 3—CIRCUIT AND LANDING PROCEDURES

**Contents**



## 1 Approach and landing

(*a*) An overshoot followed by a circuit and landing uses up to 200 lb./side. An overshoot followed by a normal GCA/ILS to landing uses up to 500 lb./side. When calculating the fuel required for landing, it is important to remember that up to ~~350~~ 400 lb./side gauged fuel may be unusable. AL 10

(*b*) After joining the circuit, carry out the 'checks before landing'.

(*c*) (i) At circuit speeds slight buffet is present and during the final turn, aileron must be held on to maintain bank. These characteristics are noticeable for only a few flights.

(ii) It is recommended that a shallow approach is used, maintaining at least 60% RPM to ensure rapid engine acceleration if this becomes necessary. Steep approaches should be avoided due to the danger of striking the tail bumper area at the round-out.

(iii) Make the initial turn on to finals at 190 knots. As the runway heading is approached, reduce the bank angle and the airspeed progressively to line-up at 175 knots. Reduce speed slowly to cross the threshold at 165 knots, aiming to touch down at 155 knots. When landing in turbulent conditions, add 5–10 knots to the threshold and touchdown speeds. Nearly full backward movement of the control column is necessary for the round-out which should be performed smoothly, with power on, to prevent the tail striking the ground. When the main wheels are on the ground, close the throttles to idle/fast idle, lower the nose-wheel to the ground and pull the brake parachute handle to its full extent. To prevent damage to the parachute during streaming, hold the control column fully forward; when the parachute has deployed, move the No. 2 throttle to idle. If the brake parachute is streamed at speeds below 100 knots, the airflow may be insufficient to assist the pilot chute to deploy the main canopy.

(iv) The braking effect of the parachute is high and it should always be used. The parachute will normally reduce the aircraft speed to 20 knots in approximately 2,000 yards without use of wheel brakes and irrespective of runway surface conditions. Use the wheel brakes as necessary to supplement the braking effect of the parachute and to keep straight. If wheel brakes only are used, the landing ground roll is increased by approximately 50% on a dry runway and approximately 65% on a wet runway.

NOTE: The approach speeds quoted above apply to AUW of 30,000 lb. and below. At weights above 30,000 lb., the speeds should be increased by 5 knots for every 2,000 lb. increase in weight. The AUW with a full armament load, empty ventral tank and 1,250 lb./side internal fuel remaining is approximately 30,000 lb.

**2 Failure of the brake parachute**

(*a*) Failure of the brake parachute to stream will considerably increase the landing run and/or place a heavy demand upon the wheel brakes. In the most adverse conditions it may not be possible to stop the aircraft in the runway length available. The action to be taken in the event of a brake parachute failure will be governed by prevailing conditions and must be decided upon before commencing the final approach.

(*b*) If the fuel state, weather, etc. permit:—

(i) Overshoot action should be taken and the aircraft landed on a runway long enough to meet the ground roll requirements. If landing at the same airfield, leave the undercarriage down to cool the main tyres. It is very important that the correct threshold speed should be used on the subsequent landing.

(ii) Carry out normal approach and touchdown. Move both throttles to idle/idle. After lowering the nosewheel to the ground, use the maximum wheel braking technique.



(but see para 3(a)(ii) for braking on wet surfaces)

(iii) If both services hydraulic pumps have failed, wheel-braking will be provided only by the accumulator. This will usually meet the braking requirements of the aircraft but, particularly if frequent 'maxaretting' occurs, its capability may be marignal. Failure of a services pump is not indicated to the pilot.

(*c*) If circumstances make an overshoot inadvisable, the possibility of brake parachute failure should be anticipated and the following precautionary landing technique adopted:

(i) Carry out a normal approach and touchdown. Move the throttles to idle/idle. After lowering the nosewheel to the ground use the maximum wheel braking technique and simultaneously pull the brake parachute handle to its full extent.

(ii) If the brake parachute deploys, the wheelbrakes should be released and a normal landing run completed. If the brake parachute fails to deploy, continue the maximum wheel braking technique.

(*d*) Should the parachute stream and then collapse, overshoot action should be considered. The decision will depend upon the initial deceleration obtained, the length of runway available and the prevailing runway surface conditions. If overshoot action is taken, the parachute jettison button must always be operated; once the parachute has collapsed the pilot will be unaware whether or not the parachute is still attached. If landing at the same airfield, leave the undercarriage down for tyre cooling.

(*e*) After landing without a brake parachute, the aircraft should not be taxied because damage to the brakes and tyres may have occurred.

(*f*) Landing ground roll distances and airborne distance to clear 50 feet are contained in the ODM.

**3 Use of the Wheel Brakes**

(*a*) After the nose-wheel has been lowered on to the runway the brakes can be used, dependent upon runway conditions, as follows:

(i) *Dry Surfaces*

On dry surfaces the maxaret units will normally prevent the wheels from locking when excessive brake pressure is applied but, unless the shortest possible run is required, more gentle use of the brakes is recommended. The aircraft must be firmly on the ground before the brakes are applied as the maxaret units do not operate unless the wheels are rotating. As a safeguard against locking the wheels during a bounce, the maxaret units remain operative for several seconds. If a slip or skid is felt or if difficulty is experienced in keeping straight, release the brakes momentarily.

(ii) *Wet Surfaces*

Braking effect may be greatly reduced and will depend directly upon the amount of water and on the type of runway surface. Generally, under wet conditions it is recommended that light continuous braking action be commenced after the aircraft is firmly on the ground and the wheels have had time to spin up. The brake application may then be progressively increased as the speed falls off. If a slip or skid is suspected the pressure should be released, to allow time for the wheels to spin up, and then re-applied gradually.

(iii) *Flooded or Icy Runways*

Whenever possible these conditions should be avoided due to the certainty of a reduction in braking effectiveness. If a landing has to be made, employ the technique described in (ii) above, using extreme caution.

(*b*) Every effort should be made to use the brakes judiciously according to the length of the runway, thus avoiding overheating.

(*c*) If maximum braking is necessary the following technique should be used: the nosewheel should be lowered on to the ruway as soon as possible after touchdown. With the stick held fully forward firm brake pressure should be applied, simultaneously streaming the brake parachute. Progressively move the stick rearward and increase the brake pressure as the aircraft slows, aiming to avoid 'maxaretting'. In inclement conditions observe the caution as described in (*a*) (ii) above.

**4 Overshoot Procedure**

Normally 90% RPM will be sufficient for an overshoot before touchdown. Open the throttles smoothly, retract the airbrakes and raise the undercarriage. The undercarriage may be left down if required; it *should* be left down for a short time to assist cooling if the wheels have touched the runway. Delay selection of flaps to UP until 180 knots has been attained. On an emergency roller from the runway, after the brake parachute has been streamed, full cold power must be used and the brake parachute jettisoned.

**5 Instrument Approach**

(*a*) It is recommended that ILS approaches be monitored by GCA.

(*b*) *Speeds and power settings*

The following speeds and power settings are recommended for use during instrument approaches. The figures apply to aircraft fitted with ventral tank and two missiles:—

*TWO ENGINES*

| | *U/C* | *Flap* | *A/brake* | *Approx.* % RPM | *Speed* (Kts.) |
|---|---|---|---|---|---|
| Level | Up | Up | In | 79 | ◀230▶ |
| Level | Down | Down | In | 84 | 190 |
| Glide path | Down | Down | Out | 84 | 175 |

*SINGLE ENGINE*

| | *U/C* | *Flap* | *A/brake* | *Approx.* % RPM | *Speed* (*Kts.*) |
|---|---|---|---|---|---|
| Level | Up | Up | In | 90 | ◀230▶ |
| Level | Down | Down | In | 92 | 190 |
| Glide path | Down | Down | Out | 92 | 175 |

(*c*) *Missed approach procedure*

(i) It is recommended that the undercarriage flaps and airbrakes should be retracted during the overshoot. The subsequent approach pattern should be flown at the same speeds and settings as shown in (*b*) above, lowering the undercarriage at the end of the downwind leg.

(ii) If the fuel state is marginal for dealing with a subsequent undercarriage malfunction, leave the wheels down during and after the overshoot.

**6 Auto-ILS approach**

(*a*) The let-down should be planned so that on reaching check-height the aircraft is suitably positioned within the engagement area (see Fig. 1). Do not descend to less than 1,000 feet AGL until the glidepath is intercepted.

(*b*) During or after the let-down, set or confirm:—

(i) Auto-stabilisers selected and functioning satisfactorily.

(ii) ILS master switch ON (below 30,000 feet); select appropriate channel and check beacon identification signal. Select ILS on Navigation Display.

(iii) VP/ILS switch to ILS.

(iv) Heading selector set to QDM(D). (See Note 1.) Localiser index set to beam QDM.

(v) BEAM and GLIDE amber lights not showing.

(vi) Control column auto-pilot switch OFF.

(vii) Select TRACK on the auto-pilot control unit.

(*c*) With airbrakes out and throttles set to idle/fast idle, reduce speed at circuit height for checks before landing.

(*d*) As the speed falls through 250 knots, set both engine RPM at 75% and select the throttle servo to ENGAGED.

(*e*) Lower the flaps and the undercarriage and then select airbrakes IN.

(*f*) Continue flying the aircraft manually at constant height and allow the speed to stabilise at 175 to 180 knots under throttle servo control. It may be necessary to make small adjustments to the power setting to achieve this speed; the servo clutch may be over-ridden, without having to disengage it, by manually moving the throttles.

(*g*) Trim the aircraft. The autopilot trim indicator should fluctuate about the central position.

(*h*) When suitably positioned within the engagement area and on a correct heading (less than 170° from the QDM(D)), check that the ILS indication is logical and that the autopilot trim indicator is central. Select control column switch to AP; the flight director bead will move from its parked position.

(*j*) The autopilot will immediately apply up to 30° of bank to turn the aircraft towards the localiser beam and fly an interception heading of up to 45° to the QDM(D). During this turn, the aircraft may descend as much as 400 feet. This height loss may either be accepted or it may be corrected by the pilot; if it is to be corrected it is preferable to do so by over-riding the autopilot rather than by using the trimmer, otherwise the aircraft will need re-trimming when the turn is completed.

(*k*) The autopilot will align the aircraft with the localiser beam after one overshoot. At short interception ranges, this overshoot may cause full-scale deflection on the ILS indicator.

(*l*) When the glide bar begins to move down, select airbrakes OUT and press the GLIDE key. The aircraft will pitch down and follow the glide-path (see NOTE 2).

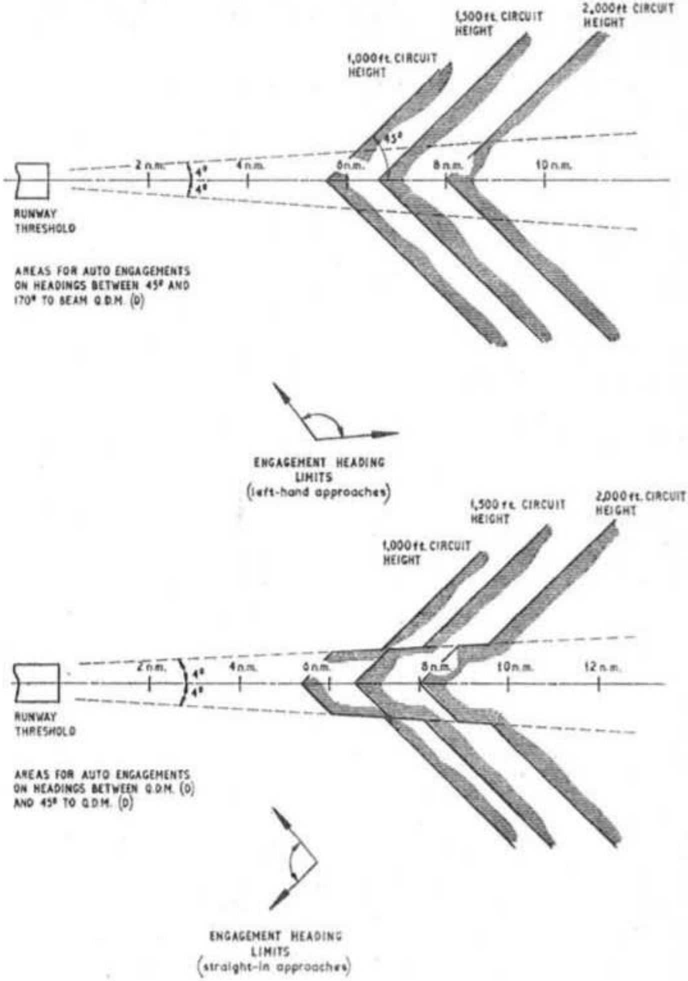


**FIG. 1. PERMISSIBLE ENGAGEMENT AREAS FOR AUTO-ILS APPROACHES—3° GLIDE PATH**

(*m*) Throughout the approach, carefully monitor autopilot trim and approach speed and keep them correct by trimming and over-riding the throttle servo clutch as appropriate. The small corrections that may be necessary should be followed by a delay of about 30 seconds, where practicable, to allow the system to stabilise.

(*n*) Continue the approach until visual contact is gained or until break-off height is reached.

(*o*) Disengage the throttle servo, select the control column switch OFF and then land or overshoot as appropriate.

NOTE 1: QDM(D) is the heading required at ground level to track the beam centre-line and is the beam QDM corrected for drift due to the surface wind. In cases of strong crosswinds or large wind shear, the aircraft will tend to 'sit-off' the beam at the start of the approach and progressively converge with the centre-line as height decreases during the glide-path phase. It is important that an accurate value of QDM(D) is obtained since the final approach accuracy depends on it.

◀NOTE 2: The autopilot trim indicator registers error signals in the pitch channel. The direction of displacement on the indicator shows the direction in which the aircraft would pitch if the autopilot were to be disengaged. Prior to engagement it should indicate zero and, if this is not the case after 10 seconds of steady flight, the autopilot should not be engaged lest there be a latent malfunction. ▶

NOTE 3: Selection of GLIDE reduces the auto-pilot authority in bank angle. Therefore, GLIDE should not be selected with a heading error of greater than 10° from QDM(D) or with a localiser error in the order of full scale deflection. If necessary, transition to glide may be delayed until a half-scale 'fly-down' glide signal is indicated.

### 7 Flapless landing

(*a*) Maintain 200 knots downwind and on the final turn. The absence of flap results in a marked nose-up attitude throughout the circuit and, unless the seat position is raised, difficulty may be experienced in retaining an unobstructed view of the runway when lined up on the final approach.

(*b*) A flatter approach than normal should be made at 185 knots and the threshold crossed at 175 knots, aiming to touchdown at 165 knots. The high angle of attack reduces tail bumper clearance when rounding-out and extra care is necessary at this stage of landing. The higher touchdown speed may cause the aircraft to bounce; this should be prevented by moving the control column forward as the main wheels touch the ground. The minimum landing run will be about 200 yards longer than that for a normal landing.

Note: When carrying out a flapless landing, ensure the flap selector is in the UP position to prevent inadvertent lowering of flap during the final approach and landing.

## 8 Crosswind Landing

(*a*) The crab technique is recommended for approaches in crosswind conditions. When rudder is used to eliminate drift, a rolling moment due to yaw results and should be anticipated:

(i) Lower the nosewheel immediately after touchdown and stream the brake parachute, anticipating the weathercock effect by use of rudder as necessary to keep the aircraft on or parallel to the centreline. Apply into wind aileron to keep the wings level and equalise the weight distribution on the wheels as far as possible. Maximum use of rudder is recommended for directional control until asymmetric wheel braking becomes necessary as the rudder loses its effectiveness. Total available tyre/runway adhesion is divided between braking and opposition to sideways motion (drift) and therefore, delaying the use of wheel brake reduces the tendency to drift.

(ii) The most critical part of the landing run is between 125 and 100 knots and in strong crosswinds the aircraft assumes a noticeable nose-into-wind angle and downwind wing low attitude. Below 100 knots normal wheel braking up to the maximum may be used as required without significant adverse effect on directional control. Landing distances are longer than normal.

(iii) These recommendations and those in para 8 (*b*) remain valid in the event of brake parachute failure. The degree of wheel braking practicable depends on the conditions and there is an increased risk of engaging the airfield barrier.

(*b*) If an uncontrollable drift to the downwind side of the runway occurs in extreme circumstances such as an unavoidable landing outside normal crosswind limits, the following actions are recommended:

(i) Release brakes, allowing maximum use of the force provided by tyre/runway friction to oppose drift.

(ii) Allow weathercock effect to yaw the aircraft nose into wind and to restore tracking towards or parallel to the upwind side of the runway.

(iii) Delay use of brakes until rudder control becomes insufficient or until directional control ceases to be critical.

(iv) Do not jettison the brake parachute unless retaining it is likely to cause the aircraft to leave the runway.

## 9 Roller Landings

Roller landings are not normally permitted due to the possibility of overheating the tyres.

## 10 Landing at Weights Above 34,500 lb

(*a*) *Considerations*

(i) A landing at high AUW requires a higher touchdown speed and a longer ground run than normal. To minimise the chance of brake parachute failure, it is advisable to delay streaming until the normal selection speed is reached and this delay further increases the ground run. Whenever possible, therefore, reduce AUW before landing.

(ii) If the brake parachute fails, the decision whether to accept the increased landing run or to abandon the aircraft by ejection must depend upon the circumstances.

(iii) Details of landing ground run are in the ODM.

(*b*) *Actions if High AUW Landing is Inevitable*

(i) Employ the circuit and landing speeds appropriate to the weight.

(ii) Make a flatter approach than normal and, for undercarriage strength reasons, aim to touch down as gently as possible.

(iii) As soon as the nosewheel is on the ground employ maximum wheel braking technique.

(iv) It is recommended that the brake parachute is streamed at 150 knots; after a successful stream, wheel braking should be moderated as required. The landing run may be reduced by closing one HP cock.

## 11 Checks After Flight

(*a*) Carry out the **Checks After Landing**.

(*b*) Carry out the **Shut-down Checks**

# PART 3

## CHAPTER 4 — SINGLE-ENGINE FLYING AND RELIGHTING

### Contents



### 1 Stopping an Engine

(*a*) Shutting down an engine in flight is to be restricted to the following occasions:

(i) Appropriate emergency procedures.

(ii) When specifically required on an air test.

(iii) When there is an operational necessity to conserve fuel (but see relighting restrictions para 4 (*b*) (*x*)).

(*b*) Practice single-engine flying should be carried out by throttling back No 2 engine whenever possible, to alleviate high compressor blade stresses in No 1 engine. As No 1 engine has no fast idling stop, manual control must be used to prevent inadvertent selection of RPM below 58%.

(*c*) If an engine is to be shut down, consideration should be given to stopping No 2 engine in preference to No 1 for the reason at para 1 (*b*) and so that the undercarriage and brake parachute are available if the shut down engine fails to relight. Carry out the following procedure:

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

(ii) Transfer fuel to the tanks in use.

◀ Note: If an engine is shut down on an air test or to conserve fuel, the appropriate FUEL COCK switch should be left on to provide fuel lubrication for the engine HP fuel pump. ▶

### 2 Single-engine Flying

(*a*) There are no asymmetric handling problems associated with single-engine flying.

(*b*) Flight through icing conditions should be avoided owing to lack of protection on the shut-down engine.

(*c*) Fuel asymmetry occurs and should be corrected by using the fuel transfer switch. Both DC pumps switches must be on.

Note: With the aircraft in straight and level flight both DC pumps are uncovered when the fuel level in the tanks associated with the stopped engine has fallen to approximately 400 lb gauged fuel. This fuel is transferred at approximately 33 lb/minute if the windmilling RPM of the shut-down engine are maintained at a minimum of 30% RPM.

### 3 Single-engine Landing and Overshoot

(*a*) A single-engine landing presents no difficulty and the approach and landing should be carried out at the normal speeds.

(*b*) At normal landing weight and at a speed above 145 knots, an overshoot with the undercarriage and flaps down can be achieved in maximum cold thrust. Details of climb-out performance are given in the ODM. Raise the undercarriage when safely airborne and the flaps at not less than 180 knots.

### 4 Relighting an Engine in Flight

(*a*) (i) If a flame-out occurs, an immediate relight may be attempted at any altitude and airspeed/mach number by pressing the appropriate relight button for 2 seconds, leaving the throttle at its set position (but see para 4 (*a*) (ii)). A successful relight will be indicated by the RPM stabilising and then commencing to rise. Ensure, by throttling back if necessary, that the maximum JPT is not exceeded. If no relight occurs within 20 seconds, select HP cock OFF and wait 1·5 minutes before attempting a cold relight as in para 4 (*b*).

(ii) If flame-out occurs whilst in reheat, cancel the reheat selection before proceeding as in para 4 (*a*) (i).

(*b*) Relights are practicable up to 40,000 feet and 0·9M. Relighting becomes progressively more certain at lower altitudes. For the *first* attempt to achieve a cold relight on either engine proceed as follows:

(i) Maximum speed, 0·9M.
(ii) Maximum altitude, 40,000 feet.
(iii) Check HP cock closed on the dead engine.
(iv) Check engine master switch on.
(v) Appropriate fuel cock and DC pumps switches on.
(vi) Press the appropriate relight button for 2 seconds.

(vii) Without delay, advance the throttle to the idle position.

(viii) When the RPM and JPT have stabilised, the RPM may be increased as required.

(ix) If the RPM and JPT fail to rise within 20 seconds of pressing the relight button, close the HP cock and wait for at least 1·5 minutes before making a further attempt.

(x) Following an unsuccessful attempt to achieve a cold relight, the aircraft must be positioned, whenever possible, for any further attempts between 250 to 300 knots and below 25,000 feet. Second and subsequent attempts to achieve a cold relight must only be made in the following circumstances:

*Relighting No 1 Engine.* If there are overriding flight safety reasons for *not* making a single-engine recovery.

*Relighting No 2 Engine.* If *ejection* is the alternative course of action.

Note 1: The minimum recommended windmilling RPM for a relight is 15 to 20%. However, in an emergency situation, relights may be attempted at any RPM. Where possible, power on the operating engine should be reduced to around 95 to 96% before commencing the relight drill (apart from the immediate relight). The 1·5 minute delay between successive relight attempts is intended to provide a drying out period and so prevent a 'wet' relight and associated 'flaming' through the turbine and jet pipe. This could cause overheating of the hot end units. It is therefore important to observe this delay.

Note 2: Each time an unsuccessful attempt is made to relight an engine in flight, a quantity of fuel is discharged into the engine and jet pipe. Repeated attempts may result in the accumulation of a sufficient quantity of free fuel to constitute a fire risk. The greater risk occurs when attempting to relight No 2 engine.

## 5 Relighting in Icing Conditions

If an engine flames-out when flying in icing conditions an immediate attempt to relight, as described in para 4 (*a*), may be made. If this is unsuccessful, the second attempt should be made after a delay of 1·5 minutes from the flame-out but within 3 minutes of the flame-out; an attempt after this interval may damage the engine. Where possible, descend out of icing conditions before making a second attempt to relight (see para 4 (*b*)).

*Intentionally Blank*