PART 3

CHAPTER 3—HANDLING IN FLIGHT

Contents

CLIMBING

General

1. The aircraft accelerates rapidly after take-off if the climb angle is shallow. Allow the speed to increase to 430 knots and then increase the climb angle to about 14° (F Mk 3, 16°) to establish the recommended speed of 450 knots.

2. The optimum climb in the troposphere is obtained at 450 knots/0·87M. If a climb to a greater height is required, the recommended technique is to accelerate the aircraft near the tropopause and then carry out an energy climb. For specific details of climb profiles and the best altitudes for accelerating to supersonic flight, refer to the ODM.

ENGINE HANDLING IN FLIGHT

General Operation

3. The JPT CONTROL switches are wire-locked to AUTO, thereby providing maximum JPT limiting and automatic reheat cancellation if the maximum allowable JPT is exceeded by 60°C. Maximum RPM varies according to the ambient air temperature, altitude and airspeed. Throttle back if necessary to keep within the RPM limitations. If the JPT control malfunctions, switch off the JPT CONTROL switch and control the JPT manually.

4. Make smooth throttle movements. At low altitude, acceleration from 60% RPM to maximum cold power can be achieved in five seconds.

5. To conserve fuel, operate the engines in the cruise nozzle position whenever practicable.

6. Maintain at least one engine above 58% RPM to ensure continuous AC electrical supplies. Below 15,000 feet and 250 knots IAS, the RPM with the throttle at idle is less than 58%.

7. At about 60,000 feet and 1·1M to 1·2M with maximum cold power selected, RPM fluctuations with or without audible rumbling may occur; bangs may also be experienced. Throttle back the engines until the fluctuations cease. Engine characteristics at high Mach numbers are described in para 41.

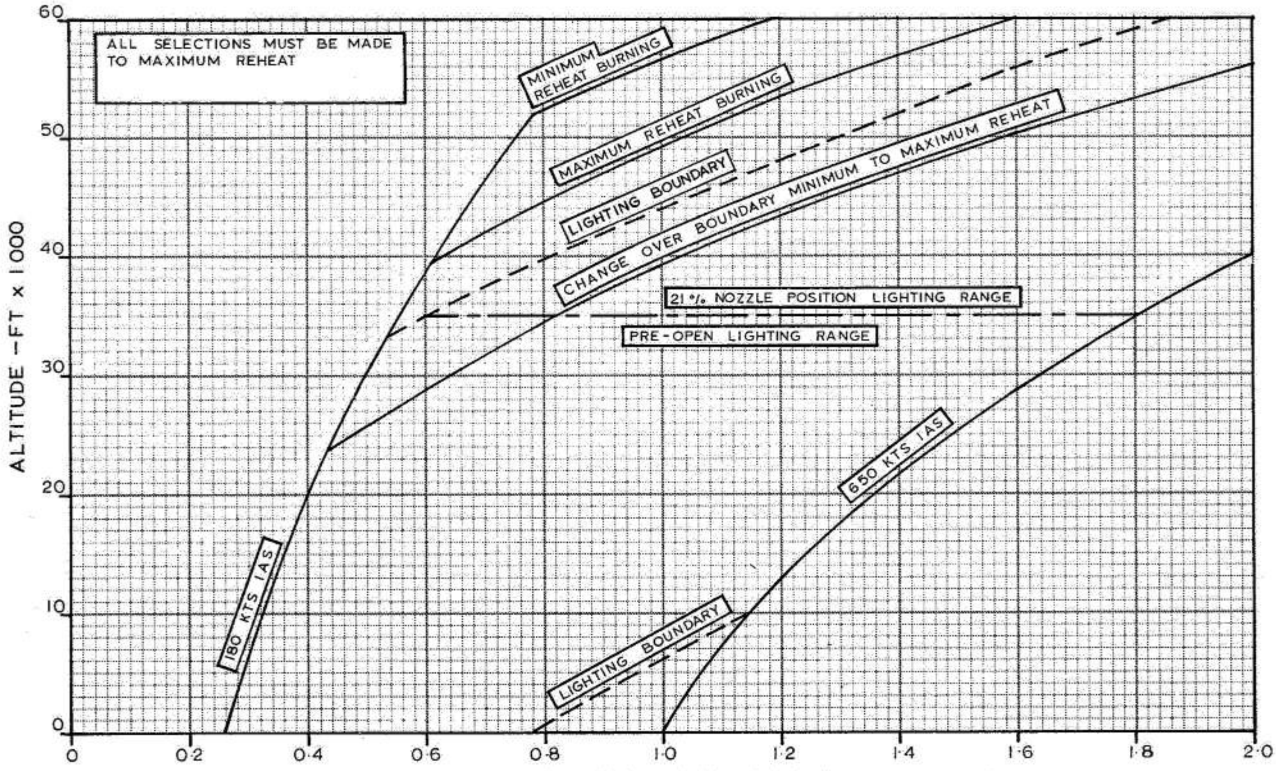
WARNING: At airspeeds in excess of 500 knots there is a risk of engine surge if the engine is throttled back rapidly, especially at altitudes below 5000 feet. Therefore, avoid slam or rapid throttle movements above this speed. Similarly, care is to be exercised when using reheat, and especially in cancelling reheat, when at a high IAS. It is preferable before cancelling reheat at high IAS to reduce airspeed to below 500 knots by the use of airbrakes or by climbing.

Reheat

8. All selections of reheat are to be maximum and should be made within the reheat lighting boundary shown in Fig 1. When selection is made in 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 as a system malfunction. In such cases, provided a successful light-up results, the system may be regarded as serviceable.

9. In addition to the reheat lighting range, Fig 1 also shows the boundaries for minimum and maximum reheat burning and the limit for successful change from minimum to maximum reheat. After light-up, unrestricted throttle movements may be made throughout the reheat range anywhere within the reheat burning boundaries. The limit for successful change from minimum to maximum reheat shown on the graph is not a handling restriction; however, when minimum reheat has been maintained for more than 20 seconds above the change-over boundary line and maximum reheat is selected, successful change to maximum reheat power is unlikely. If reheat extinction occurs in these circumstances, an immediate cancellation of reheat followed by a re-selection to maximum reheat is often successful, provided the aircraft is within the reheat lighting boundaries.

10. If, when within the recommended lighting range, reheat fails to light in five seconds, cancel the selection and wait two 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.



3—3 Fig 1 Reheat Lighting and Burning Envelope

11. If automatic cancellation occurs through any cause, one re-selection or reheat may be made. If automatic cancellation occurs again, make no further attempt to light the reheat.

12. 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.

13. If, after manual cancellation of reheat, the nozzle remains fully open, there is a thrust loss of approximately 40% at maximum cold power. However, a subsequent selection of reheat is permissible.

Icing Conditions

14. If icing conditions are met in level flight, select DE-ICE and climb or descend out of the icing because continued flight in these conditions may result in flame extinction. If climbing, employ the maximum practicable rate of climb.

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

16. When a power adjustment is necessary, move the throttles slowly. If an engine flames out, attempt an immediate hot relight. If this is unsuccessful, make a cold relight attempt within three minutes of the flame-out; any attempt after this interval may damage the engine.

17. The maximum anti-icing protection is obtained with the highest practicable RPM. Therefore, prior to descending through icing conditions, ensure that DE-ICE has been selected, descend at the maximum practicable rate, and maintain at least 70% RPM (75% if the descent in icing conditions is expected to take more than five minutes).

18. If icing persists down to airfield level, check the engine response before approaching to land and maintain at least 70% RPM, if possible, until finally committed to a landing. If it is necessary to overshoot, open the throttles smoothly.

19. After leaving icing conditions, wait at least one minute before switching the anti-icing OFF.

WARNING: There is a risk that unnecessary and prolonged use of the engine anti-icing may cause an explosion in the AVPIN fuel system; therefore, it is essential that the anti-icing is switched OFF when sufficiently clear of icing conditions.

IN-FLIGHT HANDLING

General Handling

20. *Harmonisation.* The aileron and tailplane controls are well harmonised at subsonic speed. 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.

21. *Ailerons.* The ailerons are effective and the control forces are light throughout the speed range. Aircraft response to aileron increases with speed and, at high subsonic speeds, high rates of roll can be achieved. Care is to be taken to observe the rolling limitations (see Part 2, Chapter 1) in order to avoid inertia coupling. Large, rapid aileron movements cause adverse yaw, which is more pronounced at low indicated airspeeds and in high speed flight (see para 30 to 34). When the undercarriage is down, the aileron stops are removed and available travel is doubled, thus improving lateral control.

22. *Tailplane.* Below 200 knots, longitudinal response is slow and relatively large control movements are necessary during the round-out to land. At higher airspeeds, the tailplane is more effective and response is good. At supersonic speeds, the response to tailplane movement again decreases and relatively large control movements are required for manoeuvre.

23. *Rudder.* Rudder foot loads are heavy at all speeds with the undercarriage up, but, when the undercarriage is down, the hydraulic component of feel is automatically removed and the rudder forces are moderate. At circuit speed, relatively small applications of rudder induce a marked roll. At supersonic speeds, rudder response reduces and this, combined with a reduction in aerodynamic damping, necessitates larger deflections to co-ordinate manoeuvres or to trim out any asymmetry.

24. *Airbrakes.* The deceleration obtained with airbrakes extended is moderate over the speed range. Extension causes slight buffet at all speeds, and at high speed, directional stability is reduced. This reduction is more marked in the T Mk 5 and results in a lower Mach limitation for airbrake use.

25. *Trims and Changes of Trim.* The rates of trim operation, especially of the tailplane trimmer, are slow. Increase in power or raising the flaps both cause a slight nose-up trim change, whilst lowering the undercarriage or extension of airbrakes at high speed, cause

a slight nose-down change. Lowering flap results initially in a slight nose-up change followed by a slight nose-down change.

26. *Armament.* Stick forces per g at all speeds are higher for an aircraft without missiles than for an aircraft with missiles. The carriage of a ventral gun pack (with or without ammunition) in place of the ventral tank has no appreciable stick force effect.

27. *Refuelling Probe.* The AAR probe causes a marked directional trim change at speeds above 500 knots. At Mach numbers between 1·7 and 1·8 the probe may oscillate, imparting a slight variation to the airframe.

28. *Overwing Tanks.* The handling of the aircraft is not noticeably affected by the carriage of overwing tanks. It is easy to exceed the overwing tank carriage limitations, imposed mainly for structural reasons, especially at low fuel states and when flying below 10,000 feet and above 400 knots.

Manoeuvrability

29. *General.* In order to avoid excessive airframe fatigue caused by manoeuvres involving high structural loads, particular care is required in the configurations and flight conditions as specified in the following paragraphs.

30. *Aircraft with Two or No Missiles.* 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. In the region of 1·2M to 1·4M, adverse yaw due to aileron application becomes pronounced, particularly at high IAS (500 to 600 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) is to be kept to a minimum in these circumstances. Use rudder to decrease the sideslip and fin loads. If g is also reduced, rolling response is improved and fin loads further reduced.

31. *Aircraft with Single Missile.* The regions of high loading, and the corrective actions, are similar to those in para 30; however, the problem is exacerbated by further fin loading owing to the yawing moment caused by the single missile, which is additive when rolling away from the missile. Indications that asymmetry effect is becoming excessive are:

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

b. A marked change in lateral trim.

32. *Firing and Breakaway.* If only one of two missiles is fired and then a rapid breakaway is performed, high fin loads are produced. The aircraft yaws and, owing to the sweep-back, has a strong rolling tendency. If aileron is applied to oppose this roll even higher fin loads result. Minimise loads by reducing normal acceleration to between +1 and +3g and correcting sideslip with rudder; this also improves rolling response.

33. *Autorotation.* Unless low roll rates are used, rolls at less than +1g can produce autorotation. Therefore, it is essential that only aileron control be used when rolling rapidly through 360°. Should autorotation occur, only the minimum amount of aileron is to be used to stop the rotation with the rudder kept central and the control column in the position for 1g flight.

34. *Transonic Yaw Divergence.* Supersonic manoeuvrability is restricted by the g limitations but, at high altitudes, the use of full tailplane may be insufficient to 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 the reduced lateral and/or 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, avoid the application of large tailplane angles until the aircraft is subsonic, when buffet will provide stall warning. However, because of the large stick travel and the heavy force required, a determined effort is required to sustain these large tailplane angles, and the g increases markedly when decelerating through 1·0M.

Note 1: Airbrakes aggravate the reduced stability.

Note 2: With a single missile, the additional yawing and rolling effects may conceal the onset of the symptoms.

Flight in Turbulence

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

Aerobatics

36. The IAS, g and rolling limitations given in Part 2 are to be strictly observed. Within these limitations, aerobatics are easy and pleasant to perform.

37. *Rolling Manoeuvres*. The recommended speed for rolling manoeuvres is 350 knots which, below 15,000 feet, affords the greatest scope within the rolling limitations.

38. *Looping Manoeuvres*. Considerable height is covered in looping manoeuvres and small variations in technique significantly affect recovery. Use reheat or maximum cold power for loops. If reheat is to be used, select it before entry, thereby avoiding the thrust loss associated with nozzle opening prior to light up during the manoeuvre. The recommended minimum entry speed for loops is 400 knots though, until experience is gained, 450 knots should be used, starting at 7000 to 12,000 feet. Apply 4g initially, anticipating slight buffet during part of the loop. For a half-roll off the top of a loop, an initial speed of 500 knots is recommended.

39. *Inverted Flying*. The recommended speed for inverted flying is 350 knots. Negative g is not to be sustained for longer than 15 seconds. Fuel starvation does not occur but the oil pressure reduces causing the oil lights to come on, and, in addition, the air turbine gearbox suffers oil starvation. During successive prolonged negative-g manoeuvres, a minimum period of 10 seconds positive-g flight is to be established between each manoeuvre to prevent oil starvation of the air turbine gearbox.

High Speed Flying

40. *General*. The aircraft is capable of exceeding its airspeed and Mach number limitations (Part 2, Chapter 1), especially in reheat power.

41. *Intake Vibration and Buzz*. 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 in the range 1·35M to 1·60M; this 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. Intake buzz is caused by a more violent disruption of the airflow in the intake and occurs if the engines are throttled back rapidly at speeds above 1·85M. With increased g, buzz occurs at a lower Mach number and a higher RPM. It is indicated by a series of loud and rapidly recurrent bangs. The condition does not persist because, with the application of g or on throttling back, the aircraft decelerates rapidly below the buzz boundary. Intake buzz causes no damage but should be avoided if possible.

42. *Trim Changes*

a. *F Mk* 3. In the F Mk 3, 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 becomes more pronounced under increased g and/or with a ventral tank fitted. A slight nose-down trim change continues progressively, up to 1·3M, then remains constant up to 1·6M and continues slightly nose-down above 1·6M.

b. *T Mk* 5. As speed is increased beyond 0·9M there is a slight nose-up trim change which becomes slight nose-down beyond 1·1M; at 1·25M the aircraft is back in trim. Buffet effects are as for the F Mk 3. The slight nose-down trim change continues progressively up to 1·6M; there is little trim change above this speed.

c. *F Mk* 6. As speed is increased beyond 0·9M there is a slight nose-down trim change; between 0·98M and 1·1M there is no trim change. Above 1·1M there is a slight nose-up trim change, continuing until 1·4M is reached; there is little trim change above this speed.

d. *All Marks*. 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 the gradual decrease in tailplane effectiveness with increase in Mach number.

43. *Directional Control*

a. *F Mk* 3 *and T Mk* 5. In the F Mk 3 and T Mk 5, the handling charcteristics change appreciably in the region 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. In the lateral plane, difficulty may be experienced in accurate trimming. Therefore, close rudder coordination is important during all manoeuvres. On some aircraft, and especially in the F Mk 3 at supersonic speed, repeated applications of rudder trim may be needed as Mach number is increased.

b. *F Mk* 6. With only one missile fitted, there is a pronounced directional change of trim with change of speed. At 10,000 feet the rudder trimmer authority is adequate but at 40,000 feet an increasing pedal force may be required above 1·7M.

Formation Flying

44. *General*. 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.

45. *Normal Close Formation Procedures*. During formation flying, speeds should normally be restricted to less than 450 knots or 0·92M, whichever is the lesser, and accelerations limited to +2g. Lateral clear separation should be not less than half wing-span and is never to be less than a quarter span. The wing man's overtake speed is to be slow enough to allow correction for any lateral disturbances due to the other aircraft's airflow pattern. When higher speeds or greater normal accelerations are required, a minimum lateral separation of two wing-spans is to be maintained. One aircraft is not to fly directly behind another at speeds greater than 0·7M. Below this Mach number, the fin tip is to be kept clear of the leading aircraft's jet stream.

46. *Formation Aerobatics and Display Flying*. During formation aerobatics, 0·87M is not to be exceeded. Between 0·7M and 0·87M, 3g is not to be exceeded and clear lateral separation should be at least one half wing-span, and is not to be less than a quarter span. The 'line astern' limitations are as given in para 45. High subsonic speed low level runs in formation are to be in echelon only with a minimum lateral separation of two wing-spans.

47. *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 is to be allowed in any direction normal to the line of flight.

Range and Endurance

48. Full details of the cruise performance are given in the ODM. In general, the maximum range and endurance are obtained at approximately the following heights:

a. *On Two Engines*: Range 36,000 feet
Endurance 30,000 feet

b. *On One Engine*: Range 30,000 feet
Endurance 20,000 feet

DESCENDING

Types of Descent

49. *Fast Descent*: Speed 0·95M/550 knots
Airbrakes Out
Throttles Idle/idle
(see Note)

50. *Normal Descent*: Speed 0·9M/375 knots
Airbrakes Out
Throttles Idle/fast idle

51. *Slow Descent*: Speed 0·9M/250 knots
Airbrakes In
Throttles Idle/idle
(see Note)

Note: Set No 2 engine at fast idle before RPM falls to 58% to keep AC power on line.

52. *Single-Engine Descent*. Set the live engine throttle to fast idle and use any 2-engine descent profile. Half-way down the descent, increase the attitude to 7° nose-up for at least 15 seconds to ensure that fuel pressure is maintained.