PART 2: SECTION 3

CHAPTER 1

GENERAL FLYING

Introduction

1. Because of the diversity of aircraft types in service it is impracticable to discuss every aspect of all the exercises that a pilot is likely to attempt. The following paragraphs therefore contain the general considerations applicable to most types of aircraft when performing the basic flying manœuvres. It should be appreciated that many factors affect these considerations, and allowance should be made for exigencies which are not included in this section.

2. A pilot must be thoroughly familiar with his aircraft before flying it. His knowledge of the location and function of all controls, instruments, and equipment in the aircraft should be such that he feels at home in the cockpit. He must also know all the flying limitations, emergency systems, and drills. To this end, full use should be made of all available training aids such as flight simulators, instructional fuselages, and mock-ups of fuel, hydraulic, and electrical services. The chief sources of information are the Pilot's Notes, this manual, and the Volume 1 series for the aircraft.

3. Pilot's Notes contain detailed information on the actual operating of a particular type of aircraft.

Preparation for Flight

4. **Flight Planning.** Before every flight the procedure described in Section 1, Chapter 4, which includes flight authorization, and briefing by the appropriate specialists should be carried out. The success of any sortie or operation may depend on the thoroughness of this pre-flight preparation.

5. **Equipment Checks.** The serviceability of all equipment that is taken into the air should be carefully checked. The pilot should ensure that he and his crew have the appropriate safety and survival, oxygen, and R/T equipment.

6. **Form 700.** Form 700, the aircraft servicing form, must be scrutinized by the pilot who, when he is satisfied that its entries show the aircraft to be serviceable, is to sign the form in the appropriate columns. A full description of the Form 700 is in Chapter 5 of Section 1.

7. **Aircraft Checks.** The pilot must make a preliminary check of the aircraft before each flight. The check is normally divided into the following phases :—

(*a*) Before entering the aircraft.

(*b*) Before starting the engine.

(*c*) Starting the engine.

(*d*) Warming up and running up, if applicable.

Detailed information on these checks may be obtained from Pilot's Notes and in Chapter 6 of Section 1.

General Flying

8. A pilot will derive greater enjoyment from his flying and achieve a higher degree of professional skill if he makes an effort to broaden his knowledge of aviation subjects ; the paragraphs that follow aim to do this by describing and discussing factors concerned with handling and the airmanship associated with particular manœuvres. It is presumed that the reader has sufficient knowledge of the principles of flight, which are explained in Vol. 1.

Flying Controls

9. An aircraft's attitude in flight is usually controlled by elevators, ailerons, and rudder. Movements of these controls cause a change of attitude in the pitching, rolling, and yawing planes respectively. These planes are fixed relative to the aircraft about the lateral, longitudinal, and vertical axes respectively.

Effectiveness of Controls

10. **Airspeed.** At a given height the effectiveness of a control surface varies with the airspeed over it. With propeller-driven aircraft the slipstream appreciably increases the effectiveness of the rudder and elevator when these lie within the slipstream. In general, however, if the speed of the airflow over a control surface is reduced a larger control movement is required for a given change and rate of change of aircraft attitude.

11. **Altitude.** Air density decreases with altitude, so, for a given T.A.S., the mass flow over the controls is reduced and they become less effective. Also, for an increase in altitude with a constant I.A.S., there is a reduction in the rate of change

of the flight path for a given control movement because the directional inertia of the aircraft is a function of the T.A.S., which is increasing with altitude, and it is this inertia which must be overcome by the flying controls which are inherently becoming less effective with altitude.

Taxying

12. Taxying is the movement of an aircraft along the ground under its own power, excluding the take-off and landing runs.

13. **Control on the Ground.** Any special points to be watched while taxying are described in the Pilot's Notes for the type. The pilot should, in particular, observe the limitations of engine temperature, and brake-system operating pressures ; whenever braking effectiveness seems low, the pressure must be checked. Each brake should be tested briefly and then both together as soon as possible after starting to taxy, while the speed is still low. In general, the amount of power used in taxying should be kept constant and as low as possible since aircraft brakes can quickly overheat if abused or if a long period of taxying is necessary involving much stopping and starting. During taxying, check that a slight amount of brake is not being applied inadvertently, especially when toe-operated brakes are fitted. The effects of propeller slipstream and jet efflux on buildings, other aircraft, and personnel, should be remembered.

14. **Speed.** Taxying speed depends entirely on circumstances, but it is wiser and safer to taxy at a speed which gives time to cope with any emergency and limits the stresses on the undercarriage. When manœuvring sharply, or amongst obstructions, the speed should be no more than a fast walking pace. When the surface is poor or uneven the speed should be slower than normal to minimize inertia effects and unnecessary stresses on the aircraft. The heavier the aircraft the slower should be the speed, and special care should be taken not to overstress the nose wheel or, on tail-wheel aircraft, to brake violently enough to tip the aircraft on its nose. With jet-engined aircraft of short endurance and high fuel consumption, full use should be made of the improved view and powerful brakes to taxy at a higher speed when circumstances permit. Some piston-engined nose-wheel aircraft have little clearance between propellers and the ground, therefore care should be taken when crossing gullies or similar obstructions as the propeller tips may touch the ground.

15. **Centre of Gravity.** In tail-wheel aircraft, which have the centre of gravity behind the main wheels, there is a tendency for a turn, once started, to tighten up. In nose-wheel aircraft, in which the centre of gravity is ahead of the main wheels, a natural directional stability results, and the turning force has to be maintained to sustain the turn. The simple mechanics of these characteristics are shown in Vol. 1, Part 1, Sect. 5, Chap. 3, Figs. 4 and 5.

16. **Effect of Wind.** The wind velocity can be an important consideration when taxying. The effect of the wind on the keel surfaces normally tends to weather-cock an aircraft into the wind. This is most noticeable on light aircraft with a large keel surface and a tail-wheel undercarriage ; in a strong wind the effectiveness of the brakes in countering weather-cocking may be the limiting factor in the use of these aircraft. In strong or gusty winds the controls must be held firmly to prevent them being blown forcibly against their stops. Pilot's Notes indicate when control locks may be used while taxying. With aircraft fitted with irreversible power-operated controls the wind has no effect on the controls.

17. **General Points.** Whenever possible the correct operation of gyro and other instruments should be checked while taxying to the take-off position. Other general points are :—

(*a*) It is usual to taxy with the flaps retracted to reduce the chance of damage, especially on propeller-driven aircraft when stones may be lifted by the slipstream and thrown against the flaps.

(*b*) To prevent damage to tyres and undercarriage legs the brakes should not be misused by locking the inner wheel when turning. This distorts and throws undesirable stresses on the tyre.

(*c*) If the forward view is restricted by the nose of the aircraft, as in some single-piston-engined aircraft, taxy slowly along a zigzag path ; *i.e.* yaw the nose from side to side to ensure that the way ahead is clear. In large aircraft where the view of the wing tips is restricted, it is normal to post crew members in suitable vantage points in the aircraft to act as additional look-outs. If doubt exists about clearances or the positions of obstacles, the aircraft should be stopped.

Straight and Level Flight

18. A high standard of straight and level flight is the basis of all accurate flying and is essential to good navigation. It involves flying the aircraft on a constant heading, at a constant height and airspeed. Engine handling will depend on the requirements of the flight (*e.g.* maximum range) and should accord with the recommendations in Pilot's Notes. As in all flying exercises, a good look-out is essential ; and this should be systematically combined with frequent scanning of the instruments.

19. **Stability and Trimming.** Aircraft are generally stable, and so tend to return to straight and level flight if they have been disturbed from it. Full use should be made of all trimming devices to relieve the pilot of any loads on the controls and thus reduce fatigue. At greater heights, stability is normally reduced ; accurate trimming then becomes increasingly more difficult but correspondingly more important.

20. **Flaps.** When flying straight and level at low speed some advantage may be gained by lowering the flaps to the position recommended in Pilot's Notes ; the stalling speed is thereby reduced, more power is required to overcome the additional drag of the flaps at a given speed and, with propeller-driven aircraft, the additional slipstream increases the effectiveness of rudder and elevator controls. If the forward view is initially restricted by the nose-high attitude, the lower position of the nose with the flaps lowered will improve the view.

Climbing

21. An aircraft will climb if more power is used than that required for straight and level flight at a set I.A.S. The rate of climb varies with the amount of surplus power and the airspeed. The maximum rate of climb is achieved at full power and at a recommended climbing speed which varies with height and weight. Pilot's Notes give the engine settings and airspeeds, or mach numbers, to be used on the climb. During the climb the speed, power settings, engine temperatures, oxygen flow, and cabin pressurization should be checked periodically. If the forward view is poor in the climbing attitude, turn the aircraft occasionally to check the sky ahead unless operational considerations require a climb on a constant heading.

22. **Jet-Engine Handling.** Engine limitations must be watched, remembering that different temperature limitations may apply to similar engines in different aircraft, owing to different jet pipes and cooling facilities. The amount of engine adjustment required for an increase in altitude is usually small, but attention must be paid to the j.p.t., particularly at high altitudes where it becomes more critical. If the temperature exceeds the maximum it should be decreased by reducing the r.p.m. ; increasing the airspeed is not recommended as it may well have the opposite effect. During the climb, small throttle adjustments may be required to maintain constant r.p.m., depending on the engine characteristics. Detailed information on engine handling is contained in Vol. 1, Part 1, Sect. 3, Chap. 12.

23. **Piston-Engine Handling.** The correct handling for a climb is :—

(*a*) *R.P.M. and Boost.* During a sustained climb the r.p.m. and boost should be as near as possible to those recommended in Pilot's Notes. If a constant-speed unit is fitted, the r.p.m. need little more than periodic checking. At a constant throttle setting, the manifold pressure and hence power output of an unsupercharged engine decreases as height is gained. The throttle must therefore be opened progressively to maintain the required figure. An automatic boost control in a supercharged engine keeps the boost constant up to the full-throttle height for the boost and r.p.m. in use, but above this height the boost pressure falls off unless the r.p.m. are increased beyond those permitted for the climb.

(*b*) *Mixture.* To maintain the correct air/fuel ratio on aircraft fitted with a manual mixture control, the pilot must adjust the mixture control as altitude increases. Most British aircraft, however, have some form of automatic mixture control which requires little or no attention from the pilot.

(*c*) *Temperatures.* The engine tends to overheat while climbing, owing to the combination of high power and low I.A.S. : this is shown by a tendency for the coolant, cylinder head, and oil temperatures to rise. Temperatures must be watched and the radiator, oil cooler shutters, or other controls, set to keep the temperatures within the permissible limits. It may sometimes be necessary to sacrifice rate of climb for efficient cooling by increasing airspeed or reducing power.

(*d*) *Hot/Cold Air-Intake Shutters.* Carburettor air-intake shutters should normally be in the COLD position while climbing, as in this position slightly more power is obtained than if warm air is used at the same throttle setting. Warm air should be used when necessary to counter carburettor ice. Detailed information on engine handling will be found in Vol. 1, Part 1, Sect. 2, Chap. 7.

Descending

24. A descent can be made at different rates and airspeeds, with or without the use of engine, flaps, or airbrakes. Pilot's Notes indicate how maximum rate, cruising, or maximum range descents are best made.

25. **General Handling.** It is a relatively simple matter to obtain a slow rate of descent, whether following a particular method described in Pilot's Notes or by simply reducing the power. When descending slowly from considerable heights a large distance is always covered, and the flight plan should allow for this.

26. **Maximum Rate Descents.** Operational necessity or an emergency may require the maximum possible rate of descent through a large height band from a high altitude. Airbrakes should be opened, power adjusted, and speed allowed to build up to the recommended mach number or I.A.S. Under instrument flying conditions the steepness of a dive is limited to some extent by the difficulty of interpreting the attitude from the artificial horizon, as the distance between the image and the horizon bar becomes too great for accurate visual assessment. The mach number used may depend on the degree of control available and compressibility effects. At a lower altitude the I.A.S. is usually the limiting factor. The amount of power used varies with the type of aircraft and the requirements of the operation or emergency. On turbo-jet engines the minimum r.p.m. at high altitude may be governed by the need to maintain cabin pressure, and the maximum r.p.m. may be limited by the need to achieve the steepest descent path at a desired speed. When no cockpit pressure is available the rate of descent may have to be limited for physiological reasons. Frequently, in rapid descents from high altitude, the large and comparatively rapid change of air temperature and the high humidity at lower levels will cause frosting or misting of the cockpit windows and even of the faces of the instruments. Full use should be made of the defrosting and demisting devices to counteract these effects. It may be necessary to allow time for the aircraft to warm up at low altitude to disperse this misting, before attempting to land. Allowance must be made for the height needed to level out from rapid descents so that the manœuvre is completed at a safe height above ground level ; at high I.A.S. and angles of descent, this allowance can be of the order of several thousand feet.

27. **Airmanship.** Although the view during the descent is usually good it may be necessary to turn frequently to check that the descent is being made into a clear space. Descents of any sort through cloud should not be made unless either :—

(*a*) The pilot is sure that within the circle of uncertainty of position there is adequate clearance between the ground and cloud base, or

(*b*) Some form of controlled descent is being used.

Turning

28. The force which turns an aircraft is the horizontal component of the lift obtained by banking. The total amount of lift required for any turn is therefore greater than that for the same speed in level flight ; and the drag will also be higher since the extra lift can only be obtained by increasing the angle of attack. This increase in drag, shown at a given power setting by a reduction in speed, is more quickly apparent in slow aircraft, though it also applies to faster aircraft at the higher angles of attack ; so much so that on occasions a tight turn could be usefully employed for reducing speed.

29. **Loading.** As the angle of bank is increased in a turn, the total lift must be gradually increased if the aircraft is to both maintain height and obtain the greater horizontal component needed to make the aircraft turn on a decreasing radius. A progressive increase in lift and loading, obtained by gradually increasing the angles of bank and attack, can be continued until one of the following limits is reached :—

(*a*) The aircraft stalls when the angle of attack reaches the critical angle.

(*b*) The pilot reaches his *g* threshold.

(*c*) The *g* limit of the aircraft is reached.

The angle of attack must not be sharply or suddenly increased since the applied load can become large enough to overstress the aircraft, although the pilot may not black-out because of the short duration of the load and/or the use of an anti-*g* suit. The loading imposed on the aircraft is evident to the pilot from the physiological effects of the increasing *g* and the indications of the accelerometer.

30. **Stalling Speed.** When the control column is moved back fairly rapidly at any speed greater than the stalling speed, the wings can be made to reach the stalling angle of attack before the speed has dropped much below the commencing speed, depending on how rapidly the backward movement has been made ; therefore when *g* is applied, the stall always occurs at a higher speed than that for the level flight stall. During a turn, the more the power used, the larger the angles of bank and attack that can be applied, the greater will be the horizontal component of the inclined lift vector and the smaller the turning radius ; at the same time the *g* will have been increasing steadily. If, while tightening the turn, the aircraft approaches the *g* stall, usually indicated by buffeting, recovery is made simply by reducing the backward pressure on the control column and, if not already at full power, increasing the power. If the aircraft actually stalls the same recovery action is used and any tendency for the aircraft to roll into or out of the turn countered by use of the rudder and/or ailerons as recommended in Chapter 3 of this section.

31. **Maximum Rate and Minimum Radius Turns.** Maximum rate or minimum radius turns are done at full power and at maximum lift, *i.e.* on the fringes of the *g* stall ; the higher the I.A.S. that can be maintained under these conditions, the faster the rate and the smaller the radius of turn. If less than full power is used the rate of turn is less and the radius is larger. Stalling speed is proportional to *g* and therefore increases as the angle of bank increases and the turn tightens. When gradually tightening a turn (increasing the *g*) at a constant I.A.S., the initial response from the aircraft is a slight increase in rate of turn and a considerable decrease in radius ; as the *g* stall limit is approached the rate of turn starts increasing rapidly but the rate of decrease of the radius falls off and eventually becomes negligible. These facts should be borne in mind when flying at high speed or in bad weather in poor visibility.

32. **Turning at Low Speed.** Low speed implies a high angle of attack giving a relatively small margin above the stalling angle. Any turn commenced at a low speed is limited in radius and rate of turn since the margin of speed between the level flight stalling speed and the *g* stall is small. Power should be used to prevent the speed from falling any lower. At the lowest speeds just above the stall only fractional amounts of *g* are required to bring on the stall.

33. **Compressibility in Turns.** Any increase in angle of attack and *g* further accelerates the flow of air over the upper surface of the wing. At high T.A.S., therefore, the increased angle of attack during a turn induces the onset of compressibility effects sooner, *i.e.* at a lower speed and mach number than when no loading is applied.

34. **Effect of Altitude on Turning.** Because of the reduced density of the air and the adverse effect of compressibility on the lift obtained at a given I.A.S. and angle of attack, the *g* to which the aircraft can be subjected without stalling is lower than at lower levels. Maximum rates of turn are much reduced and turning circles much increased ; fighter aircraft which could easily be damaged through excessive *g* at low altitudes are not able to exceed 1½ to 2*g* at their highest working altitudes, *i.e.* the manœuvrability is much reduced.