SLINGSBY T67M

STUDENT TRAINING MANUAL

SPECIALIST FLYING TRAINING

SLINGSBY T67M

STUDENT TRAINING MANUAL

C O N T E N T S

INTRODUCTION

General Information

1 This Publication has been prepared to supplement the flying and ground instruction you will receive during flying training. The information contained is complementary to your formal ground instruction and, in particular, is designed to help you, the student pilot, to understand more fully your flying instructor's in-flight instruction and pre-flight briefings. All the exercises taught during training are discussed in turn. In each case the principles of flight involved are considered, and this is followed by important points of airmanship and by a resume of the main points of the air exercise. The exercises are listed under main titles numbered from 1 to 22 (see 'contents' page). Initially, sorties will be confined to a particular exercise but, as you progress, your instructor will revise previous exercises as well as introducing you to more advanced ones. Eventually, you will be covering a number of exercises in one sortie. The exercise numbers should be used for recording the sortie details in your log book.

Principles of Flight

2 The principles of flight for each exercise have been deliberately limited to the basic principles involved. Deeper knowledge and understanding will come from studying ground school lectures, and from discussion with your flying and ground instructors. The information given in this Publication, together with ground school instruction, is the foundation on which your instructor will base your flying training.

Air Exercise

3 Each air exercise will be fully covered in your mass and pre-flight briefings (see below). You will then be taught it in the air by your instructor. This book will serve as a reminder of the main points arising from the briefings and from the air trip and, perhaps, clarify some points not immediately clear to you.

Mass Briefings

4 Ideally, a mass briefing is given before each new exercise is taught in the air. As the name suggests, this briefing is given to a number of students together and it covers the subject in detail. It may take up to an hour to deliver and, during this briefing, the lessons learnt in the ground school are linked to the practical aspects of flying. If a mass briefing is not possible, your instructor will extend your pre-flight briefing to cover all the essential points.

Pre-flight Briefings

5 Your instructor will give you a pre-flight briefing just before each flight. This will be a resume of the main points of the air exercise and will also cover details which may affect the flight - such as weather, airfield state, and air traffic control.

Post-flight Discussion

6 After every dual sortie, your instructor will discuss the flight with you. He will encourage you to analyse your own flying and to ask questions about any problems that have cropped up, or about special points of interest. Do not be content with just copying your instructor's methods blindly - make sure you understand the reasons for what he does. A good pilot always seeks to improve his knowledge and technique by asking questions. Don't be afraid that you will lose face by failing to understand some simple point. In aviation, a mistake can be very expensive, so only the irresponsible conceal their ignorance.

Your Instructor

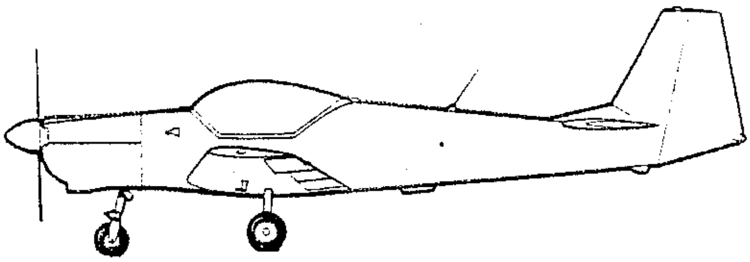
7 Your instructor is well qualified to achieve his aim of helping you to become a competent pilot. You can learn from him by his example as well as from his formal instruction; so watch carefully when he is flying. If a particular course of action is not self-explanatory, ask the reasons for it. It is again stressed - never be afraid to ask questions.

Private Study

8 When your instructor is flying with his other students, use the time to revise your previous lessons: re-familiarize yourself with the Flight Manual, and with the aircraft. Your crewroom will contain plenty of literature covering all aspects of flying, and you can learn much from reading such literature. You will also be encouraged to talk 'shop'. By helping yourself in this way you will get the maximum value from your flying instruction. As you gain knowledge so your confidence will increase and you will derive increasing enjoyment from your flying.

EXERCISE 1

A I R C R A F T   F A M I L I A R I Z A T I O N



Introduction

1 In this exercise you will be introduced to the aircraft, and to its controls and systems. Your instructor will show you how to do the checks that are carried out before and during flight, and he will instruct you on the emergency procedures.

2 You will have already been issued with the Pilots Notes. This contains all the information you need to know about the T67M. You should carry your FRCs with you whenever you fly.

3 Aircraft checks are required on every sortie, and you will be expected to know them thoroughly - and also the emergency procedures - before being sent solo. This Exercise, therefore, will feature in all your flights during flying training and in all your subsequent flying.

The Aircraft

4 It is important that a pilot should know something about the many components that go to make his aircraft. Your instructor will, at first, point out only the main features. But, as you progress, you should be able to discuss your aircraft and its components in detail. This is particularly important when you have to report aircraft unserviceability to the servicing personnel.

5 The cockpit layout will be shown to you in the order in which each item is checked before flight. The checks given in the FRCs may seem lengthy and complex but, as you work round the cockpit, you will notice that they are done in a logical order. You will be shown:

* How to get in and out of the cockpit.

* How the canopy operates.

* How to strap yourself in and adjust your harness.

* How to adjust the rudder pedals according to your leg length.

You will be given plenty of opportunity to practise these before flying. But remember - never enter any aircraft without permission and, when permission is granted, always check that the ignition is switched 'off'.

Aircraft Systems

6 Instruction on the aircraft systems is carried out in the ground school and at the flights; this instruction continues throughout your training. Before going solo you will be required to have a working knowledge of the following:

a Fuel and oil systems.

b Starting system.

c Engine and propeller controls.

d Brake system.

e Electrical system.

f Radio installation.

g Canopy operation.

Checks

7 Initially, you will have to rely a good deal on your Flight Reference Cards (FRC) to carry out your checks. As you gain experience, they should become instinctive, and the time taken to do them will reduce. After a time, you should be able to locate items in the cockpit without looking. Use your spare time to practise checks - but beware of learning them 'parrot fashion'. Make every check mean something, and when in doubt, use the Flight Check Card.

Emergency Drills and Equipment

8 Just as your checks must become well-practised, so must your initial reaction to emergencies. In modern aircraft, emergencies are fortunately rare, but pilots must be able to deal promptly with any situation that may arise. You will practise the emergency drills frequently in the air and you should always make these practices as realistic as possible. Before being sent solo you must know the following drills thoroughly:

a Action in the event of fire - in the air, and on the ground.

b Engine failure in flight, and re-starting procedure.

c Engine failure after take-off.

d Abandoning the aircraft.

e Forced landing actions.

Summary

9 Your task, as set out in this exercise may, at first, seem a formidable one. However, you will have plenty of time to get to know your aircraft and, as the course progresses, you will find your interest in technical matters stimulated, and enlightenment will quickly follow. The technical knowledge you acquire will not make you an aeronautical engineer, but it will qualify you to meet the engineer on common ground and enable you to perform your flying duties with greatly improved insight and effect.

EXERCISE 2

PREPARATION FOR FLIGHT AND AFTER-FLIGHT ACTION

Introduction

1 Thorough and efficient preparation is essential for the safety and overall success of every flight. In this exercise you will be taught how to prepare for flight, and also the action required after landing.

Briefing

2 As explained in the 'Introduction' to this book, your instructor will brief you on all dual and solo sorties. He will cover everything about the nature of the flight and the factors affecting it. As you gain experience you will take a more active part in the preparation and will eventually carry out a supervised form of self-briefing for certain exercises.

Preparation for Flight

3 There are a number of things to be checked before every flight. These include:

* A check on your flying clothing.
* Having suitable maps available.
* Obtaining authorization for the flight.
* Accepting the aircraft for flight.
* External and internal checks of aircraft.
* A check for loose articles in the aircraft.
* Awareness of starting and taxying precautions.

Each of these items is considered in turn in the paragraphs that follow.

Flying Clothing

4 It is your responsibility to maintain your flying clothing up to the required standard. The importance of having this equipment checked at regular intervals of time cannot be overstressed. Many student pilots find difficulty in deciding what to wear underneath their flying clothing. Until you gain experience, ask your instructor's advice on this.

Maps

5 You will carry a map on all your training sorties (Fig 2.1). Mark it clearly with the local flying area, low-flying areas, prohibited areas, airways, and any other pertinent navigational or air traffic information. You may find that an abbreviated map of your local area, fitted in your knee pad, will be useful for plotting radio bearings and fixes. But do not rely on this alone; always relate your fix to your larger map. Remember, also, that radio aids, although normally reliable, may not always be available or serviceable. It is important, therefore, that you get to know your local area. But guard against becoming over-confident; varying conditions of weather and season can alter the aspect of ground features. When in doubt, always refer to your map.

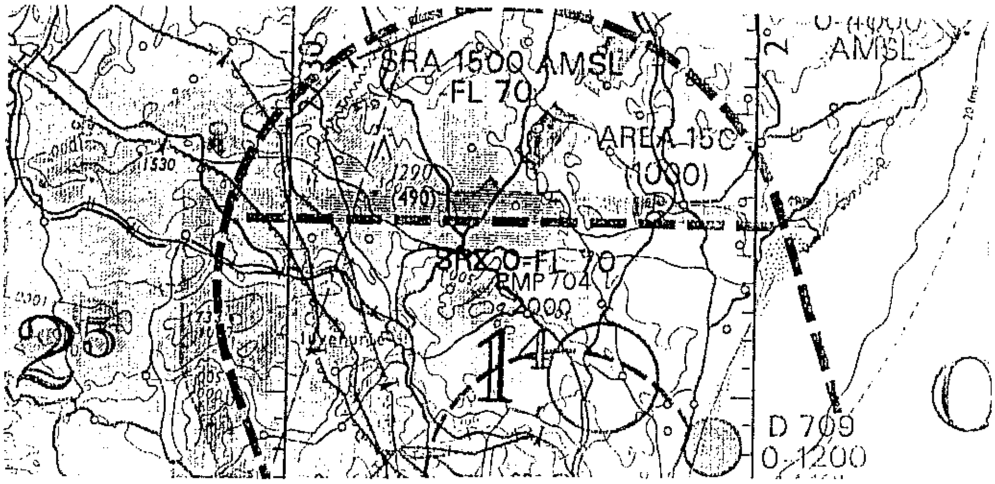


Fig 2.1 Importance of maps

Flight Authorization

6 All flights must be properly authorized. This authority is delegated to certain members of the instructional staff. For the majority of your sorties, the authorizing officer will be your instructor. However, certain flights - first solo, for example, may require a higher authority.

7 Before flying solo on any exercise, (except first solo), you will be required to initial the authorization sheet, thereby signifying that you fully understand the nature and requirements of the sortie.

Aircraft Acceptance

8 An aircraft is not allowed to leave the ground on an authorized flight unless the aircraft captain and groundcrew are both satisfied that it is in a fit condition to fly and accomplish its task. This assurance is given in the aircraft log - the basic record of aircraft servicing. In this document, the servicing tradesmen indicate by their signatures that all the necessary servicing has been done and, on this evidence, the aircraft captain can accept the aircraft.

9 From your early flights, and throughout your training, your instructor will show you how to use the aircraft log. When you reach the solo stages of flying training, a working knowledge of the log is essential, because you are then the captain of the aircraft. If, when you check the log you are in any doubt about the serviceability of your aircraft, seek advice from your instructor. The log is in constant use, and is a permanent record of servicing on an aircraft; so handle it carefully and make all entries neat and legible.

Aircraft Checks

10 Although the groundcrew will have thoroughly checked the aircraft, it is up to the pilot to ensure that it is safe for flight. To this end, a series of checks and vital actions are carried out prior to flight (and also during, and after, flight). The checks are lengthy, but you will be introduced to them gradually. Guard against paying lip service to these checks; realize their importance and make each one mean something. Every so often, check them fully against your Flight Reference Card; you will then probably find that you don't know the checks quite as well as you thought you did. Doing these checks will bring you close to the aircraft's propeller. Propellers should always be treated as 'live'. You must never allow any part of yourself or your equipment to come within the arc that would be covered by the revolving propeller blades.

Loose Articles

11 The danger of loose articles in aircraft cockpits will have been covered by your instructor - but it cannot be overstressed. Numerous incidents have been attributed to 'foreign objects' being left in the aircraft by untidy aircrew. Personal items - such as pens, pencils and keys - can be the cause of an accident if allowed to foul flying controls (Fig 2.2). If you do drop anything in the cockpit, you must always report it to the servicing personnel who will make a thorough search until it is found. Only then will the aircraft be allowed to fly again.

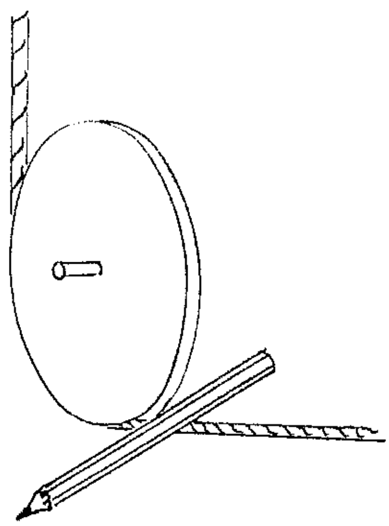


Fig 2.2 Danger of loose articles

Aircraft Operation on the Flight Line

12 On the flight line, there are always items of ground equipment and other aircraft, and also personnel working on them. Consequently, all pilots must be conscious of the safety precautions required when starting aircraft engines and when taxying. Your instructor will show you the hand signals used between the groundcrew and the pilots to ensure the safety of personnel, aircraft and other equipment. When taxying into, or out of, the flight line, the groundcrew may give you directions by means of authorized marshalling signals. Remember, however, that the pilot is always responsible for the safety of the aircraft.

After-flight Action

13 Just as there were a number of things to be checked before any flight, so there are actions that have to be taken after every flight. These include:

- Awareness of taxying precautions (as in para 12).
- Internal and external checks of aircraft (as in para 10).
- Completion of the aircraft log.
- After-flight action on authorization sheet.

Completion of Aircraft Documents

14 At the end of every flight, the captain of the aircraft (normally your instructor, but yourself if flying solo) enters the aircraft's flight time and serviceability state in the log.

POST-FLIGHT ACTION

S							
	PROGRESSIVE TOTAL						
	BROUGHT FORWARD						
TOTAL AIRBORNE TIME		CHOCK TO CHOCK TOTAL	LDGS	I/F	X/C	DEFECTS OR COMMENTS	CAPTAIN'S SIGNATURE
12	13	14	15	16	17	18	19

Fig 2.3 Captain's after-flight certificate

If you place the aircraft unserviceable, make sure that the entry clearly describes the fault. Before placing an aircraft unserviceable, discuss the fault with the groundcrew and with your instructor. This is particularly important in the early days of your training, until you gain sufficient experience to determine what is normal and what is abnormal.

EXERCISE 3

A I R E X P E R I E N C E

Introduction

1 The purpose of this exercise is to introduce you to your new environment, and to give you your first flight in a T67M. No formal instruction is normally given. However, the flight will provide you with an opportunity to talk to your instructor over the intercom and - more particularly - to get used to your instructor's voice.

Form of the Flight

2 Your instructor will have had an opportunity to discuss your previous background with you, and he will plan the sortie taking this into account. Whenever possible, the first flight is given in weather conditions which enable you to maintain visual contact with the ground. This will give you the chance to look at some of the main ground features in the local area, and will allow you to get to know the different appearance of things from the air.

3 If you would like to see some particular feature, ask your instructor. If you would like to do some aerobatics, again ask your instructor. But if you subsequently find that you have 'bitten off more than you can chew' and feel queasy, don't hesitate to let your instructor know, and he will stop. Air sickness on first flights is not uncommon, but it rarely persists on subsequent sorties.

4 This flight will also give you the opportunity to check your flying clothing for serviceability and comfort. Discuss any doubts about these points with your instructor, because discomfort in the air will reduce your ability to absorb instruction. Above all, don't be afraid to ask your instructor questions about this trip, or any later one. He can only help you if he knows your problems.

Conclusion

5 This is your one 'free' ride before getting down to work. Enjoy it by all means, but remember:

* Get used to the sound of your instructor's voice over the intercom.

* Have a good look round the local flying area.

* Assess the comfort of your flying clothing.

EXERCISE 4

E F F E C T S   O F   C O N T R O L S

Introduction

1 This exercise is your first airborne instructional sortie. Obviously we have to start at the beginning and, as you are going to learn how to control the aircraft, you must learn how the controls work and their effect on the aircraft in flight. This is the foundation upon which all other exercises are based and, unless you master this exercise and learn properly from it, you will have difficulty in later ones. So, if at any stage you have problems, get the answer from your instructor.

2 The exercise is such that it will not be completed in one flight. Indeed, some parts may not be taught until they are relevant to a specific exercise.

PRINCIPLES OF FLIGHT

Aircraft Axes

3 To control an aircraft in flight you must be able to manoeuvre it in any desired direction. To achieve this, the aircraft must have the ability to move in three planes - namely, the pitching, rolling, and yawing planes. The aircraft pitches about its lateral axis, rolls about its longitudinal axis, and yaws about its normal axis (Fig 4.1).

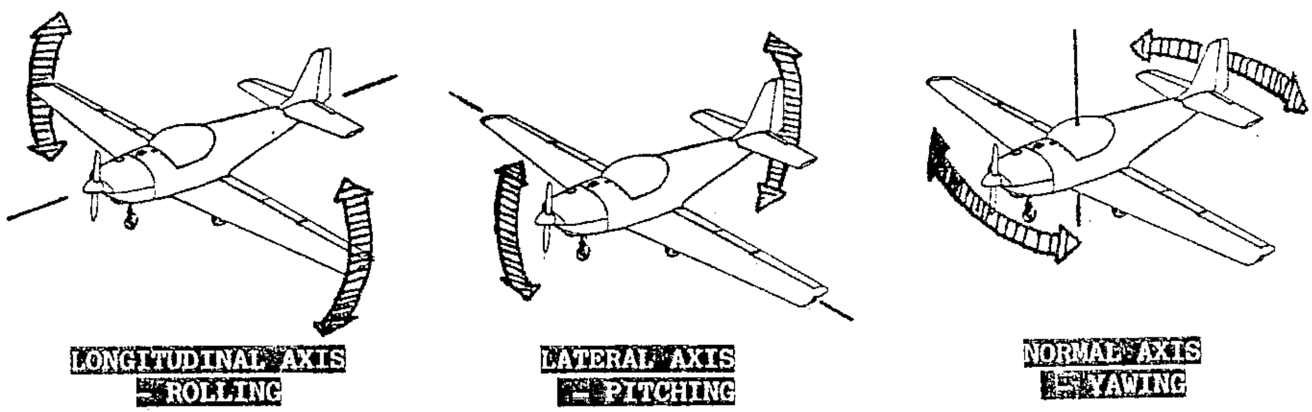


Fig 4.1 The axes of an aircraft

Flying Controls

4 Control of movement about the three axes of the aircraft is achieved by the flying control surfaces listed in Table 4.1.

Axis	Movement	Control Surface
Lateral	Pitching	Elevators
Longitudinal	Rolling	Ailerons
Normal	Yawing	Rudder

Table 4.1 Flying control surfaces

In addition, as we shall see later, the aircraft has another control surface - flap.

5 The three planes of movement are fixed relative to the aircraft and the pilot. Therefore, whatever the attitude of the aircraft, the control movements will always produce the same pitching, rolling or yawing movement relative to the pilot.

6 When the flying controls are moved in the cockpit they deflect hinged controls mounted externally on the airframe. These controls modify the aerodynamic forces on the surface to which they are hinged in such a way as to produce a moment about one of the three axes. Let us see simply how this is achieved.

7 Elevators. The elevators are control surfaces hinged to the rear end of the tailplane (Fig 4.2). They are connected such that they operate as a single control - i.e., both up or both down together. A forward deflection of the control column in the cockpit causes the elevators to deflect downwards, and this modifies the aerodynamic forces at this surface, causing the nose to drop. A backwards deflection of the control column causes the elevators to go up, and the nose rises. Movement is, therefore, being controlled in the pitching plane.

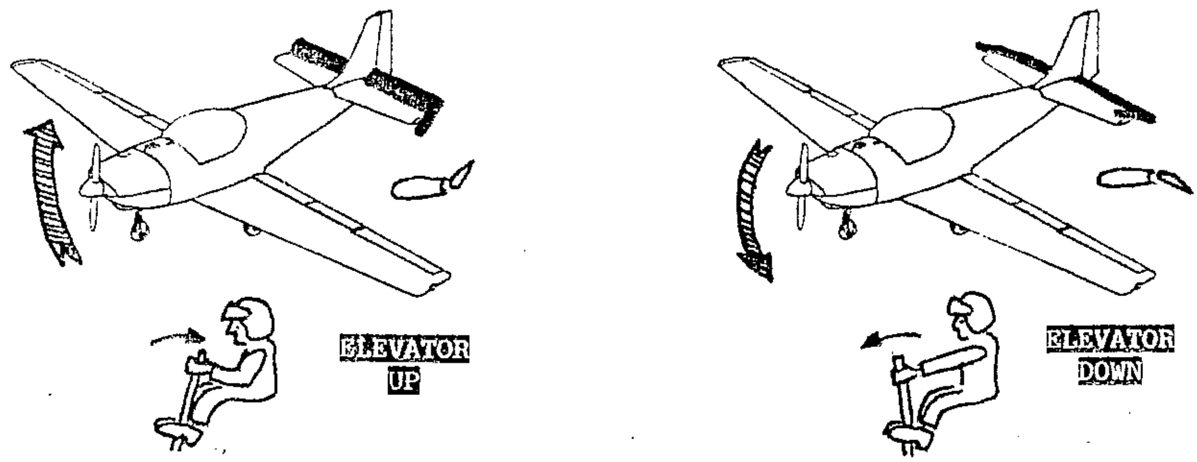


Fig 4.2 Elevators - operation and effect

8 Ailerons. The ailerons form part of the outer ends of the trailing edges of the mainplane (Fig 4.3). They are operated from the cockpit by a side-to-side movement of the control column and are inter-connected so that, when the control column is moved to the left, the port aileron moves upwards and the starboard aileron goes down. This movement in flight causes the aircraft to roll to port; reverse movement would cause a roll to starboard.

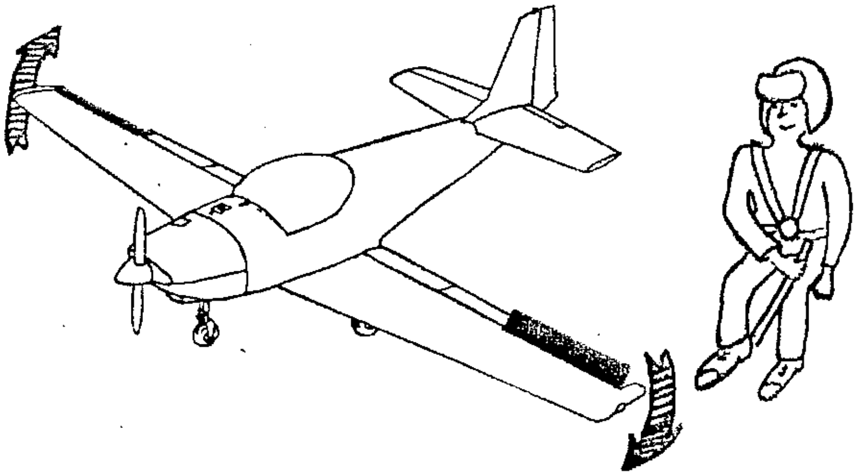


Fig 4.3 Ailerons - operation and effect

9 Rudder. The rudder is a movable control surface hinged to the rear edge of the fin (Fig 4.4). It is connected to, and operated by, foot pedals in the cockpit. Pushing the left foot forward on the rudder bar pedal causes the aircraft to yaw to port. Right foot forward on the pedal would cause a yaw to starboard.

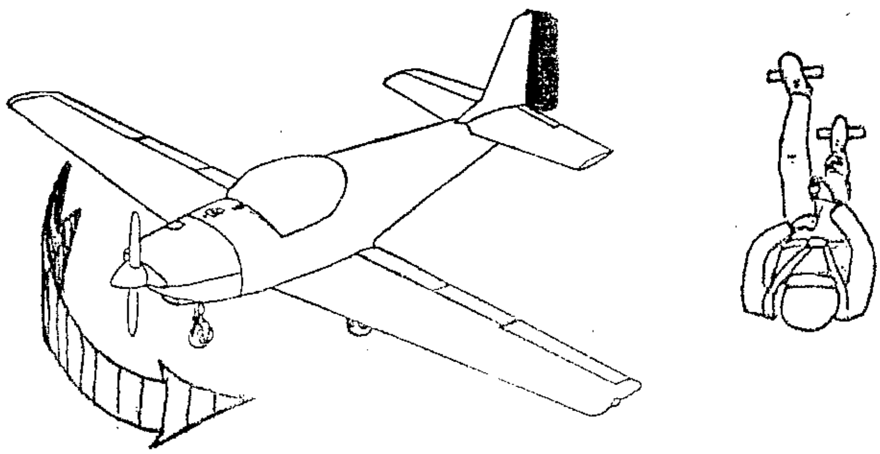


Fig 4.4 Rudder - operation and effect

Aircraft Response to Control Movement

10 The above paragraphs have considered the primary effects of the basic flying control surfaces. We now have to consider how the aircraft actually responds to control movements (i.e. control effectiveness). The aircraft response to control movement depends primarily on three things:

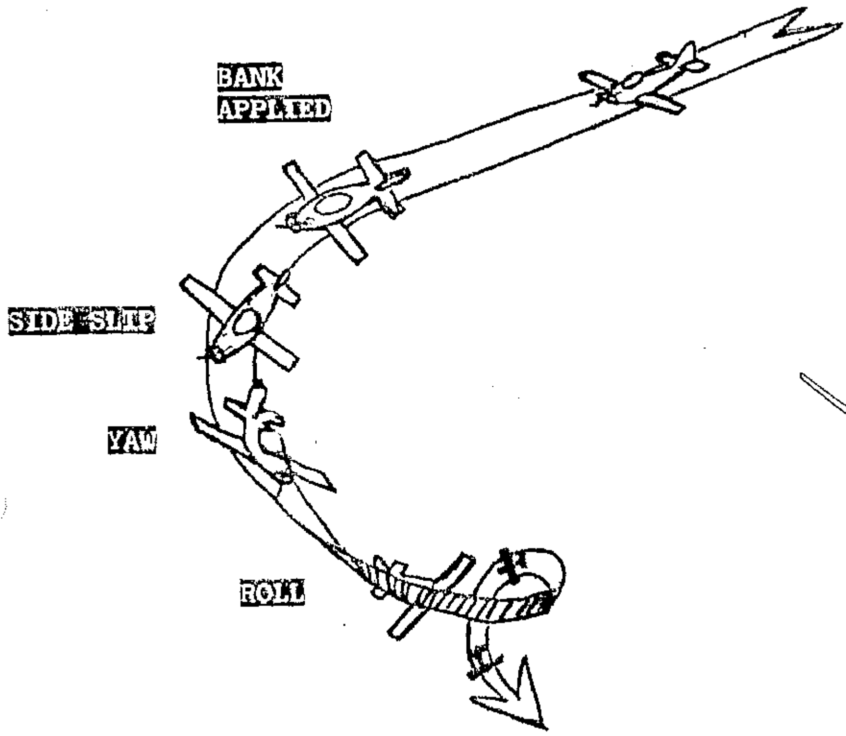
a The amount by which the control surface is deflected; more deflection means more response from the aircraft.

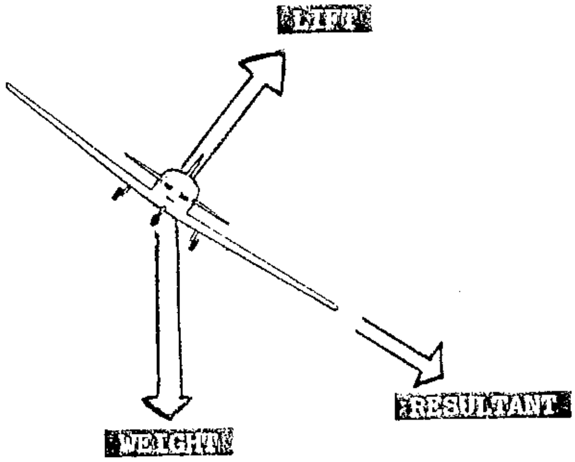
b The speed at which the aircraft is flying; the higher the airspeed, the greater is the aircraft response to a given control movement. For example, a given aileron deflection at higher speeds will give a faster rate of roll than the same deflection at a lower speed.

c The airflow from the propeller (slipstream); more slipstream means a greater response for a given control movement. Slipstream affects only the elevator and the rudder, and is most noticeable at low airspeeds and high engine power settings.

Further Effect of Ailerons

11 We saw earlier that movement of the ailerons causes the aircraft to roll; this is the primary effect of aileron. Aileron also has a further effect: if an aircraft is flying along a straight path and bank is applied by rolling the aircraft with the ailerons, then - if no further action is taken - the aircraft will sideslip towards the lower wing (Fig 4.5). As a result of this sideslip the pressure of air on the keel surface of the aircraft will cause yaw in the direction of the slip. If unchecked, this will cause further roll, because the outside wing is moving faster and producing more lift than the inside wing. This, in turn, produces more slip, then more yaw and more roll and, if allowed to continue, the aircraft will enter a spiral dive (Fig 4.5). The T67M will react in this way when bank is applied, although the effect is reduced by the lateral stability given by the wing dihedral.





Vectors in a side slip

Fig 4.5 Bank, causing sideslip, leading to a spiral dive

Further Effect of Rudder

12 Movement of the rudder causes the aircraft to yaw; this is the primary effect of rudder. However, just as aileron has a further effect, so has rudder. This can be described as follows:

* If an aircraft is yawed by using the rudder alone, the aircraft will continue for a time in its original direction of flight and so will 'skid' in that direction. The effect of this is that, during the yaw, the outer wing travels faster than the inner wing. Thus, the outer wing develops more lift and the aircraft will roll in the same direction as the yaw. If the rudder is held on, this will lead to further yaw and more roll and, once again, the aircraft will enter a spiral dive.

Trimming Controls

13 Once an aircraft attitude has been selected it may be necessary to keep the control surface deflected to maintain the attitude; thus, the pilot would be required to maintain some pressure on the control. This pressure can be excessive and, if held for a long period, would cause fatigue. Consequently, to enable a pilot to maintain an attitude with zero pressure on the controls, a trimming control is fitted to elevator. By operating trimming control in the cockpit, the pilot can move a small tab attached to the elevator. If the trimming control is moved in the same direction as the pressure being applied to the control, the tab moves in such a way as to create aerodynamic forces which relieve the control forces.

14 Trimming controls are very sensitive and have considerable effect on the aircraft; for this reason, they must be used with care. They are used only to relieve sustained control forces and not to manoeuvre the aircraft. When the trimming controls (trimmers) have been adjusted so that no pressure is required on the controls, the aircraft is said to be 'in trim'. In trim, the forces acting on an aircraft are in equilibrium; movement of any control that affects these forces (thrust, drag, lift, or weight) will, therefore, upset the trim of the aircraft and it will have to be re-trimmed.

Engine Controls

15 The Slingsby T67M is fitted with a variable pitch propeller and constant speed unit whose function is to maintain the RPM selected by the pilot. In addition to this the engine is a fuel injection aerobatic engine. The result is that the engine controls and indicators differ considerably from that of a carburettors engine with a fixed pitch propeller. With a fixed pitch propeller, the pilot can only directly control engine power output with the throttle - with a variable pitch propeller the throttle and the RPM levers both vary power output; the throttle controls the fuel and air pressure being fed to the cylinders whilst the RPM lever controls the number of cylinders that fire per minute. More fuel and air - more power; but also - more cylinders per minute - more power. Maximum power is thus available only when at maximum throttle (Max MAP) AND Maximum RPM. The engine controls are the throttle, the RPM control and the mixture/cutoff control.

a Throttle. The throttle moves in the natural sense ie forward for more power, back for less. Opening the throttle when the engine is running allows more air to the engine and results in an increase in Manifold Air Pressure (MAP) as shown on the MAP gauges. The resultant increased airflow through the manifold allows the addition of more fuel to the air; this is achieved by increasing the fuel pressure so that more fuel is sprayed out of the fuel injector at the cylinder inlet ports. The increased fuel pressure is shown on the fuel pressure needle on the same instrument face as the MAP. Thus opening the throttle with the engine running results in an increase in both MAP and fuel pressure.

b RPM Control. The RPM control moves in the natural sense ie forward for more RPM, back for less. It should never be moved sharply as this may temporarily exceed the engine limitations. A low RPM should not be used with a high manifold pressure (throttle) setting.

c Mixture/Cutoff control. This control is fully forward for full rich mixture; as the control is moved back, the fuel flow to the engine is completely cut off. Your instructor will show you the use of this control.

16 Your flying instructor will show you the correct use of these controls.

Effects of Varying Power

17 Increasing or decreasing the power from the engine has two effects:

a It alters the thrust and this, in turn, alters the airspeed.

b It alters the strength of the slipstream over the inboard wing area and tail surfaces.

Both of these effects alter the longitudinal trim of the aircraft, the nose tending to rise as power is increased and fall as it is decreased. Alterations in the strength of the slipstream over the fin and the rudder will also make the aircraft yaw. Alterations in the slipstream over the inboard wing area result in more lift over them at a given airspeed and may lead to the wingtips stalling before the inboard wing at high power settings.

Effects of Flap

18 Lowering flap will alter both the lift and the drag of the aircraft (Fig 4.6). Flap is normally lowered in two stages:

* The first stage (½ flap) produces an increase in lift and also a trim change.

* The second stage (full flap) increases both lift and drag; drag has much the greater effect, producing a trim change which tends to mask the effect of any increase in lift.

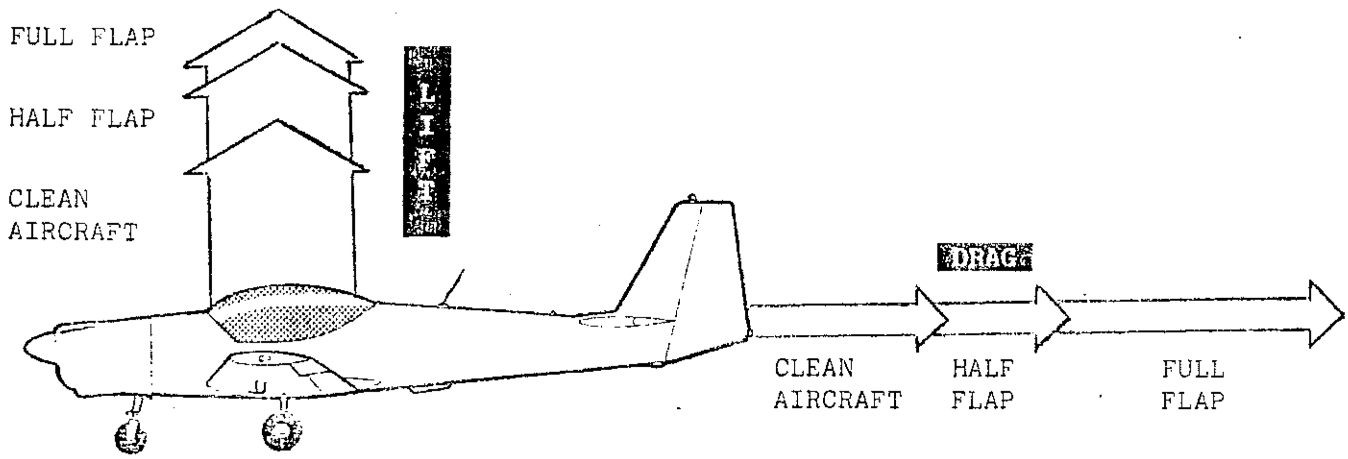


Fig 4.6 The use of flap and its effect

19 If the altitude is maintained after the selection of '½ flap' or 'full flap', the pilot may need to relieve the stick forces by operating the elevator trimming control; in both cases, the airspeed will reduce. Selecting 'flap up' will produce the opposite trim changes, and a progressive increase in airspeed.

AIRMANSHIP

Handing Over and Taking Over Control

20 In any dual-controlled aircraft it is important that the method used for handing over and taking over control of the aircraft is clearly defined and understood. The drill to be used at all times is illustrated in Table 4.2.

Action	Instructor	Student
Handing over control	Says 'You have control'	Places feet lightly on the rudder pedals, with right hand on the control column and left hand on the throttle, and then replies 'I have control'.
Taking over control	Says 'I have control	Removes hands and feet from the controls and then replies, 'You have control'.

Table 4.2 Handing over and taking over control

Following Through

21 To enable you to appreciate the amount of control movement needed for any manoeuvre, your instructor may wish you to 'follow through'. To follow through, place your hands and feet lightly on the controls and 'feel' his control movements. Make sure you apply no pressure yourself on the controls. By following through in this way you will be able to feel the amount of control movement needed and the rate at which it is applied.

Lookout

22 This air exercise will require from you a high degree of concentration, but don't become oblivious to what is happening around the aircraft. If you do see other aircraft, point them out to your instructor.

AIR EXERCISE

Sequence of Instruction

23 Because of the time required to cover the whole of this exercise, it is normally taught in parts - namely:

a Effect of main flying controls; effect of airspeed, slipstream and trimming controls.

b Effect of engine controls.

c Effect of power.

d Effect of flap.

We shall now consider each of these in turn.

Effects of Main Flying Controls, Airspeed, Slipstream and Trimming Controls

24 Main flying controls. As noted earlier, movement of the main flying controls gives rise to primary effects and also - for aileron and rudder - further effects. These are considered below:

a Primary effects. Your instructor will demonstrate the primary effect of the elevator, aileron, and rudder as they affect the aircraft movement in relation to the pilot. Each control effect will be demonstrated separately, after which you will be allowed to operate the control yourself. The control movements required are normally small, and you may find it easier to associate the necessary movement with the pressure you feel when using the controls rather than attempt to judge the amount of movement. Pressure on the controls should be applied smoothly and evenly. Notice that:

* The aircraft will continue to respond for as long as the pressure is applied.

* The rate of response is directly related to the amount of control deflection.

When the aircraft is banked, as always, movement is in relation to you and not to the horizon.

b Further effects. When your instructor is satisfied that you fully understand the primary effects of the flying controls, he will demonstrate the further effects, which are summarized in Table 4.3.

Control	Primary Effects	Further Effects
Elevators	Pitch Airspeed changes	Nil
Aileron	Roll	Slip; Yaw; more roll; nose down; spiral descent
Rudder	Yaw	Skid; Roll; nose down; spiral descent

Table 4.3 Controls and their effects

25 Effect of airspeed. You will be given the opportunity to operate the flying controls both at high and low speeds at a constant power setting. At high speed, the aircraft will feel very lively and responsive. At low speeds, the response to the controls is very much reduced and the controls - although, of course still functioning - will now feel 'sloppy'.

26 Effect of slipstream. At low airspeed and at a low power setting, the control effectiveness will be as described in para 25. At the same low airspeed, but at a high power setting, the ailerons will remain 'sloppy', but the elevators and rudder - which are now affected by the slipstream - will be relatively responsive.

27 Effect of trimming control (trimmer). To show the effect of the trimmer your instructor will hand over control of the aircraft to you in the 'trimmed' condition. You will remember that when the aircraft is in trim and in steady flight, no pressure is required on the controls. To demonstrate how the trimmer works, and how powerful it is, your instructor will ask you to prevent the aircraft from changing its altitude while he deliberately operates the trimming controls to put the aircraft out of trim. You will find that the pressures required to hold the datum position can be very high, and this should convince you that careful trimming is essential for sustained flight. Your instructor will then ask you to operate the trimmer to reduce the control pressures to zero once again. Note how the trimmer operates in the 'natural' sense - i.e. it has to be moved in the same direction as the pressure being applied to the control.

Effects of Engine Controls

28 Effect of Throttle/RPM variations. Your instructor will show you the correct handling and use of these controls and will ask you to observe the effects on the aircraft of varying the settings of these controls.

29 Effect of Mixture Control. The correct technique for setting the mixture for efficient engine operations will be shown to you by your instructor.

30 Engine Handling Technique. The engine should never be run with high MAP and low RPM. As a guide, the MAP in inches must never be more than 4 greater than the RPM in hundreds, eg for 2200 RPM, the maximum allowable MAP is 26 inches. To avoid momentary engine overloading, always increase the RPM before throttle, and when decreasing power, throttle back before decreasing the RPM. Finally, make all control movements smooth to avoid temporary overspeed or overload.

Effect of Power

31 First of all, you will be shown the effects of power variation with the aircraft trimmed, hands and feet off (zero control forces). You will be asked to note the effects of power variations, but the main purpose of the demonstration is to make you aware of what the effects are so that you can anticipate them and prevent them from occurring.

Effect of Flap

32 The effect of flap has already been discussed in paras 18-19. During the air exercise you will be shown how to lower and raise flap with the aircraft trimmed, hands off. You will then practise this yourself. As in the 'effect of power' discussed in para 31, your main concern here is to note the effects of flap so that you can anticipate them and prevent the aircraft from 'wandering' when changing the flap setting. Because flap is used when the aircraft is near the ground, anticipation of the effects of flap is most important. The limiting speed for lowering flap, and flying with the flaps down is 92 kts for both flap settings.

Conclusion

33 The ground covered in this exercise forms the basis of all your later exercises. Even when you have moved on as far as aerobatics, instrument flying, and formation flying, you will find that points from this exercise are still cropping up. Remember that your instructor is there to help; he can only do so, however, if he is aware of your problems. So, if anything at all worries you, or if there is something you do not fully understand, ask for his help.

EXERCISE 5

T A X Y I N G

Introduction

1 In this exercise you will be taught to manoeuvre the aircraft on the ground under its own power (i.e. to carry out aircraft taxying procedures). The factors affecting an aircraft when taxying are many and variable. Therefore, your instructor will show you how to deal with each situation as it arises rather than follow any set sequence. You will be taught, and allowed to practise, taxying procedures on each sortie until you become proficient.

GENERAL CONSIDERATIONS

Inertia and Momentum

2 As with any mass, an aircraft has the properties of inertia and momentum and will resist any attempt to change its state of rest or of uniform motion. Therefore, more power is required to start an aircraft moving from rest than is required to keep it moving. Once moving, an aircraft tends to travel in a straight line (depending on the wind) and at the same speed (depending on the surface); it will resist any changes either in speed or in direction of travel. Because of this, any changes in speed or direction will take time and intended changes must, therefore, be anticipated.

3 There are three other important points to be considered:

a The centre of gravity (CG) of a T67 is forward of the main wheels. This makes the aircraft stable directionally and, hence, loath to turn. Unless the turning force is maintained during a turn, the aircraft will stop turning.

b Harsh use of power and/or brake will cause a nose-down pitching moment.

c Excessive braking will eventually lead to brake overheating; the brakes may either bind on or may become completely ineffective.

Speed of Taxying

4 Ideally, the speed at which an aircraft is taxied should remain constant. The factors affecting taxying speed are:

a Surface gradient.

b Nature of surface.

c Wind velocity.

d Power used.

To keep the speed constant, the pilot must consider the nature and gradient of the surface and the wind velocity and, anticipating their effects, adjust power accordingly.

Direction of Taxying - Effect of Wind

5 The effect of wind on an aircraft's taxying speed has been mentioned in para 4. A strong crosswind will also affect the control of direction when taxying, because the aircraft tends to behave like a weathercock and turn into wind (Fig 5.1). Because of this it is slightly more difficult to turn an aircraft downwind than it is to turn it into wind.

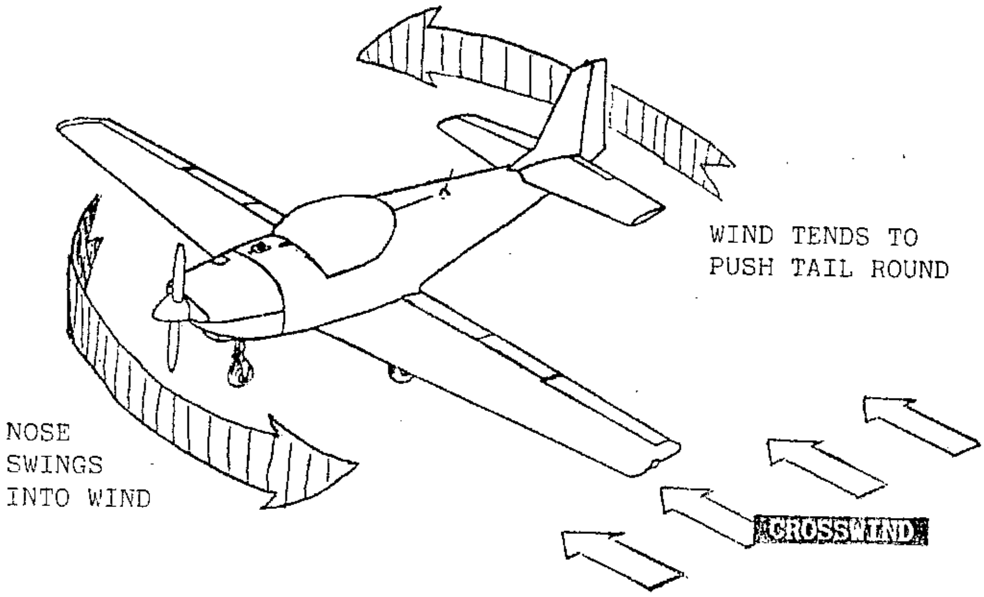


Fig 5.1 Weathercock tendency of an aircraft

Use of Controls

6 The controls used during taxying are the throttle, the rudder pedals, and the brakes. These are used as follows:

a Throttle. To vary power, it is essential that throttle movement be made smoothly. The aim is to use the minimum power necessary to obtain the correct speed. Because of the time lag between throttle movement and aircraft response, the power requirements must be anticipated.

b Rudder pedals. The rudder pedals are directly linked to the nose wheel leg, and the aircraft is steered on the ground by moving the rudder to left or right. The rudder pedals and rudder are not to be moved when the aircraft is stationary.

c Brakes. The disc brakes on each main wheel are independantly hydraulically operated by a pedal on each rudder. The brakes are independent of the nose wheel steering. To turn the aircraft, the nosewheel steering should always be used before any differential braking is applied, the brakes really being used only to slow down or stop. If a very small radius turn is required full nosewheel steering should be applied and then light braking applied to the inside wheel, heavy braking may lock the wheel and damage the tyre. The parking brake simply holds the brake pressure on and the brakes must be applied after setting or before releasing the parking catch.

Note. Excessive braking can cause overheating of the brakes and this, in turn, can lead to 'brake fade' or the brakes sticking on. Brake effectiveness can also be reduced by taxying through pools of water.

AIRMANSHIP

RT Clearance

7 Before any aircraft is allowed to taxy from dispersal, the pilot must obtain clearance from Air Traffic Control (ATC).

Lookout

8 When approaching the aircraft before flight, check that the ground immediately in front of the aircraft is clear of obstructions and that it is suitable to take the weight of the aircraft. When taxying, remember that the wing tips have a limited clearance above the ground and that the bulk of the fuselage is behind the cockpit. It is particularly important to remember these points when manoeuvring in the dispersal area where other aircraft, servicing personnel and ground equipment are in close proximity. The captain of an aircraft is always responsible for the safety of his aircraft. Even when manoeuvring with the assistance of a marshaller, it remains the pilot's responsibility to ensure that there is adequate clearance for his aircraft and that the propeller slipstream does not cause damage to other aircraft or equipment, or danger to personnel. If you are in any doubt:

* Stop.
* Summon the marshaller through ATC.
* Satisfy yourself that he understands the problem.
* Make sure that you are, in fact, clear to proceed.

Right-of-Way

9 Taxying aircraft have right of way over vehicles and pedestrians but not over aircraft being towed. With converging aircraft there are no hard and fast rules. In general, aircraft returning to dispersal after landing give way to aircraft taxying to the take-off point. It is not normal to overtake an aircraft taxying in front of you; if in any doubt, seek ATC assistance. For obvious reasons, a good lookout is required when taxying across a runway; if the runway is in use, you must first obtain clearance on RT from ATC.

Instrument Checks

10 Certain instruments can be checked only when the aircraft is moving. Ideally, these instrument checks are carried out, once you are clear of dispersal, on the natural bends of the taxyway whilst taxying out for take-off. They are never done in the dispersal area. Whilst turning, check that:

a The turn needle shows the correct direction of turn and that the ball moves in the opposite direction.

b The direction indicator and magnetic compass indicate the correct heading changes.

c The artificial horizon shows no pitch or bank.

Rudder Check

11 Full and free movement of the rudder can be checked only when the aircraft is moving (because the rudder pedals are directly linked to the nose wheel leg). You may well need a 90° turn either way to get full rudder on. Thus, before making the check, ensure that:

* you are well clear of obstacles and other aircraft - in front and behind you.

* you have plenty of room.

* you are travelling at a low speed.

Change of Surface

12 It is often necessary on an airfield to cross from one type of surface to another. There is always the possibility of meeting soft ground or a ridge unexpectedly. Therefore, the change from one type of surface to another should always be done at a low speed. You will always need more power to taxy on grass than on a metalled surface. When crossing a ridge or crossing from one surface to another, do so at an angle so that no two aircraft wheels cross over the edge together; this minimises any tendency for the aircraft to rock nose up and down which could cause the propeller to stroke the ground.

Starting

13 Close the throttle, apply the toe brakes and put the parking brake lever to off. Release the brakes, open the throttle smoothly until the aircraft moves, close the throttle and apply the brakes evenly to check them. Then apply power as necessary to maintain the required taxying speed. The power required to taxy depends upon the wind velocity and direction, and the surface and gradient of the taxyway.

Stopping

14 When about to stop, make sure that the nose wheel is pointing straight ahead and that the rudder bar is central. To stop the aircraft, close the throttle and gently apply the brakes together, smoothly, until the aircraft stops. When the aircraft is stationary, put the parking brake on, apply the toe brakes firmly and set 1200 r.p.m. Check that the brakes are holding.

Turning

15 As noted earlier, the rudder pedals are connected, not only to the rudder, but also to the nose wheel leg. Thus, the aircraft is turned on the ground by operating the rudder pedal: right foot forward to turn right, and left foot forward to turn left (Fig 5.2). The greater the movement of the rudder pedals, the smaller is the radius of the turn.

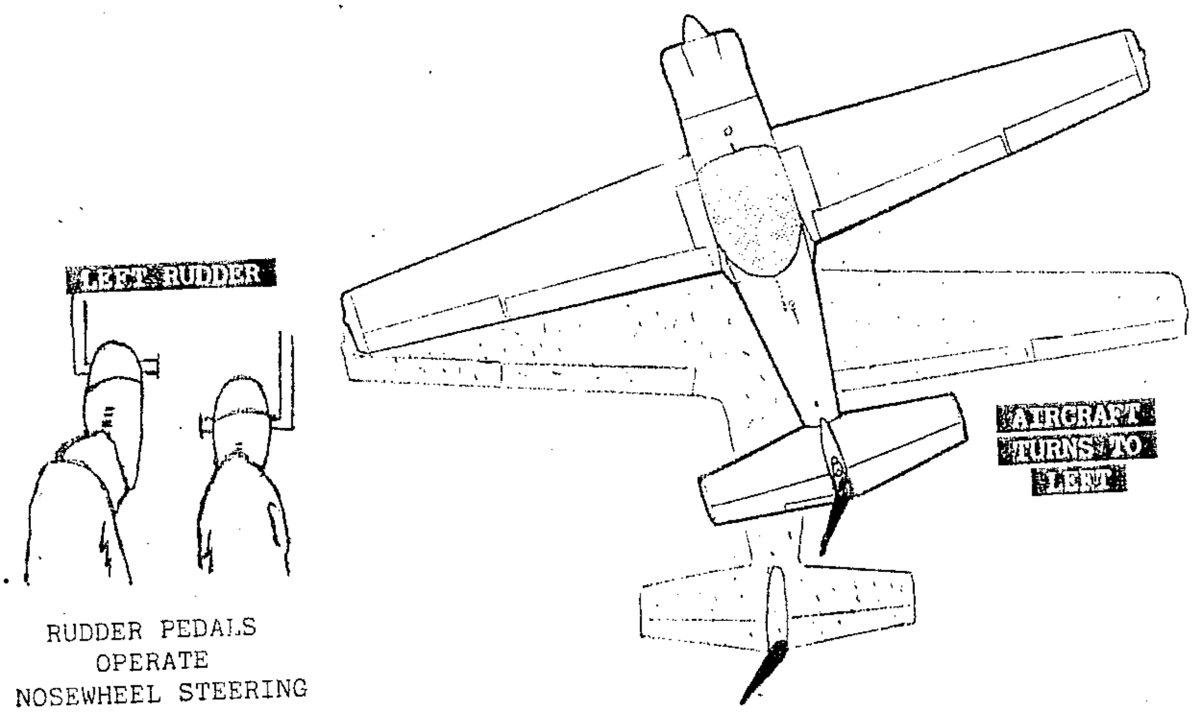


Fig 5.2 How to turn a T67 during taxying

16 The aircraft's weathercock tendency will cause turns into wind to tighten up. Turns downwind are more sluggish. However, by being constantly aware of the wind direction, the efforts that will be required for turning into wind or downwind can be anticipated.

Control of Speed

17 Your instructor will give you guidance on what the speed should be for safe taxying. He will also show you how to use power and brake to control the taxying speed. Very few taxyways have continuously flat, even surfaces; you will, therefore, have to anticipate well ahead to keep the speed constant.

Turning in Confined Spaces

18 The technique for turning the aircraft in confined spaces is the same as that used for turning on the taxyway (paras 15-16 above). Speed, however, will need to be low. Note further that even small changes of direction produce large angular movements of the wingtips and tail (Fig 5.3); so make absolutely sure that the area around you is clear before turning. A little 'inside' brake may help achieve a very small turning radius (see para 6c).

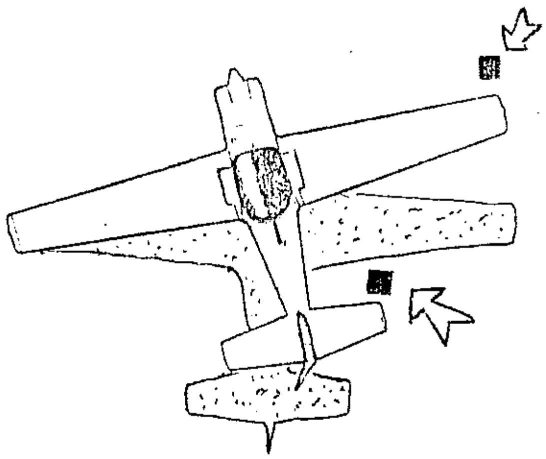


Fig 5.3 Take care when turning in confined spaces

Leaving Dispersal

19 To leave dispersal, you must first obtain 'taxy clearance' from Air Traffic Control. After making sure that the way ahead is clear, close the throttle, and wave away the chocks using a clear signal (Fig 5.4). When the marshaller is in position and giving you the signal to move ahead, roll forward slowly. Once the aircraft has moved forward clear of obstructions, test the effectiveness of the brakes. The aircraft should only be allowed

to move slowly before the brakes are checked in case they are unserviceable. If the check is satisfactory, the brakes are then released and the throttle reopened to move the aircraft forward slowly under the marshaller's guidance. Dismiss the marshaller as soon as you are able to proceed safely on your own. When clear of the dispersal area, check that you are taxying at the correct speed and adjust as necessary. On the natural bends of the taxyway, carry out the instrument checks described in para 10.

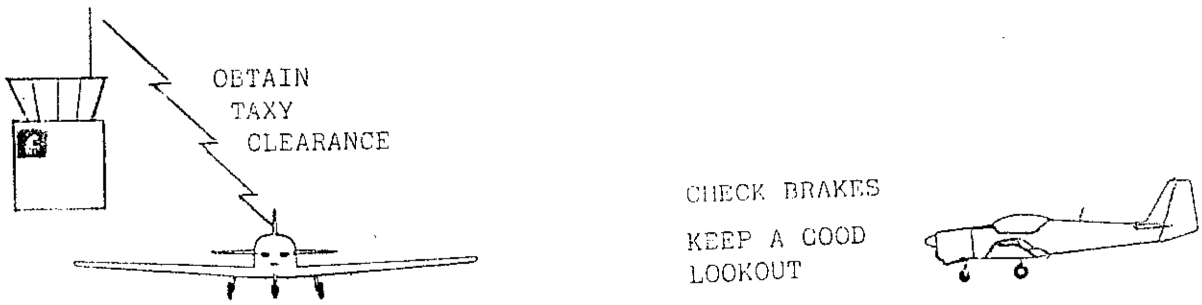


Fig 5.4 Checks on leaving dispersal

Nosewheel Steering Failure

20 This is an extremely unlikely event but, if it does happen, the situation can be handled very easily. In the event of nosewheel steering failure, the aircraft can be brought to rest quickly using the brakes. When stopped, shut the aircraft down and wait to be towed back to dispersal.

Brake Failure

21 If one brake should fail, the aircraft can be stopped safely by using the serviceable brake, the resulting change of direction being corrected by nosewheel steering. If both brakes fail, steer the aircraft clear of obstacles using the nosewheel steering and, when clear, switch the engine off. With the engine off, the aircraft will stop fairly quickly of its own accord so long as it is not pointing down on a slope.

Conclusion

22 The aim of good taxying is to move the aircraft smoothly and safely from one point to another on the airfield. Excessive variation of power and harsh use of the brakes cause unnecessary strain on the undercarriage and tyres, and should, therefore, be avoided. There is always the temptation to taxy too fast; resist this temptation - particularly when solo. Finally, always bear in mind the need for extreme caution when:

* It is raining.

* Snow or ice are present.

* Manoeuvring in a confined area or in close proximity to other aircraft or obstacles.

EXERCISE 6

S T R A I G H T   A N D   L E V E L   F L I G H T

Introduction

1 In this exercise you will learn to fly the aircraft at a constant height, in a constant direction, and 'in balance' - i.e. in straight and level flight. No matter which types of aircraft you subsequently fly during your career, you will find that your productive flying will include more 'straight and level' than any other form of flying. Thus, your proficiency in this exercise will be a good indication of your ability as a pilot; so always strive for a high standard of accuracy.

PRINCIPLES OF FLIGHT

Level Flight

2 In Exercise 4 it was noted that the forces acting on an aircraft in steady flight were in equilibrium or balance. Therefore; to maintain level flight, there must be no residual force tending to move the aircraft from its path. The forces acting on a T67 in steady level flight are illustrated in (Fig 6.1). They are:

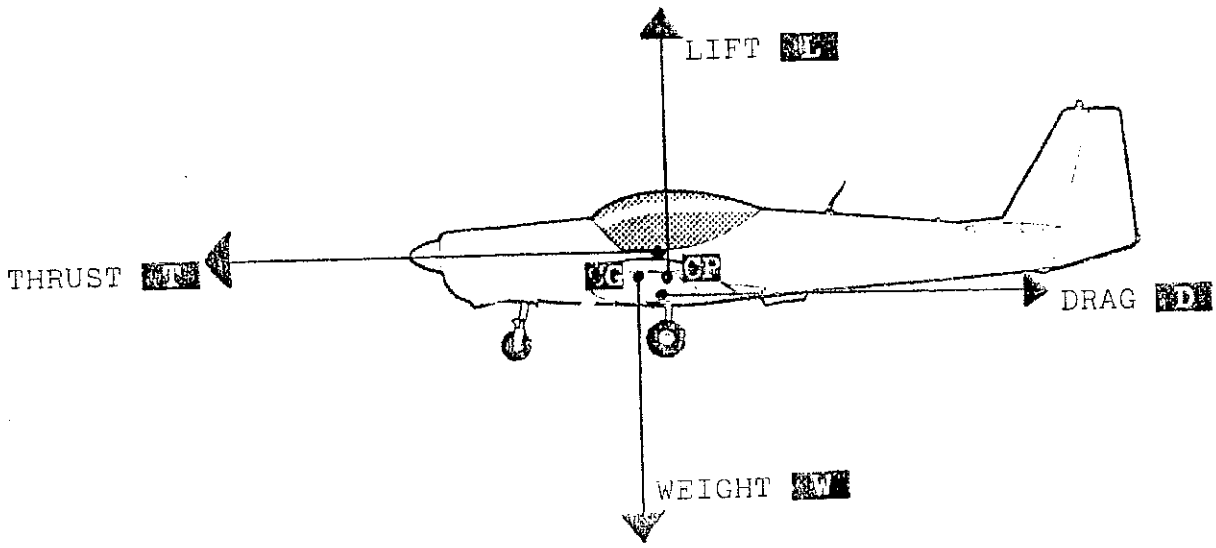


Fig 6.1 Forces acting on aircraft in steady level flight

a The resultant of the lifting force of the wing (lift), which acts at right angles to the path of flight, through the centre of pressure (CP).

b The weight of the aircraft, which acts vertically downwards through the centre of gravity (CG).

c The thrust of the engine, which may be taken to act approximately parallel to the direction of flight.

d The drag of the aircraft, which acts horizontally backwards from a point which varies with the flight attitude and configuration of the aircraft.

3 As implied from (Fig 6.1), the lift and weight forces act in opposition, as do the thrust and drag forces. For steady level flight, these opposing forces must be equal and opposite, i.e.:

* Lift (L) = Weight (W)

* Thrust (T) = Drag (D)

Note. Although the forces in opposition are equal in steady flight, there is a considerable difference between each pair of forces. In practice, the lift/weight (L/W) forces are considerably larger than the thrust/drag (T/D) forces.

Pitching Moments

4 The positions of the centre of pressure (CP) and the centre of gravity (CG) in an aircraft are variable; under most conditions of level flight they do not coincide. The result is that the opposing forces of lift and weight set up a 'couple' which produces a pitching moment. Whether the pitching moment causes a 'nose-up' or 'nose-down' movement depends upon the position of CP in relation to that of CG. If CP (the point through which weight acts), a nose-up pitching moment results, as shown in (Fig 6.2a). If lift is behind CG, as shown in (.ig 6.2b), a nose-down pitching moment is produced.

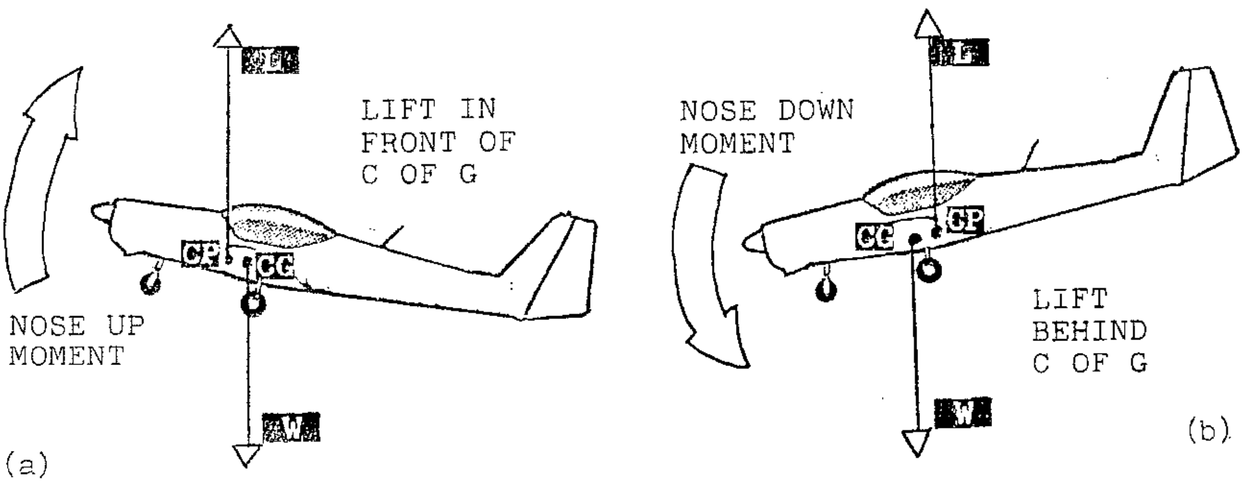


Fig 6.2 Pitching moments due to L/W couple

5 The same consideration applies to the lines of action of thrust and drag (see Fig 6.1). Again, the couple formed by the thrust and drag forces causes either a nose-up or nose-down pitching moment, depending upon the relationship between the points through which these forces act.

6 Although it is sometimes possible to arrange for the L/W and T/D couples to oppose each other (as in Fig 6.3a), there will always be a residual unbalanced force, because of the difference in the magnitude of the two couples. This residual force results in either a nose-up or nose-down pitching moment. Sometimes, as in the T67 the two couples complement each other and produce a large moment in one direction (Fig 6.3b).

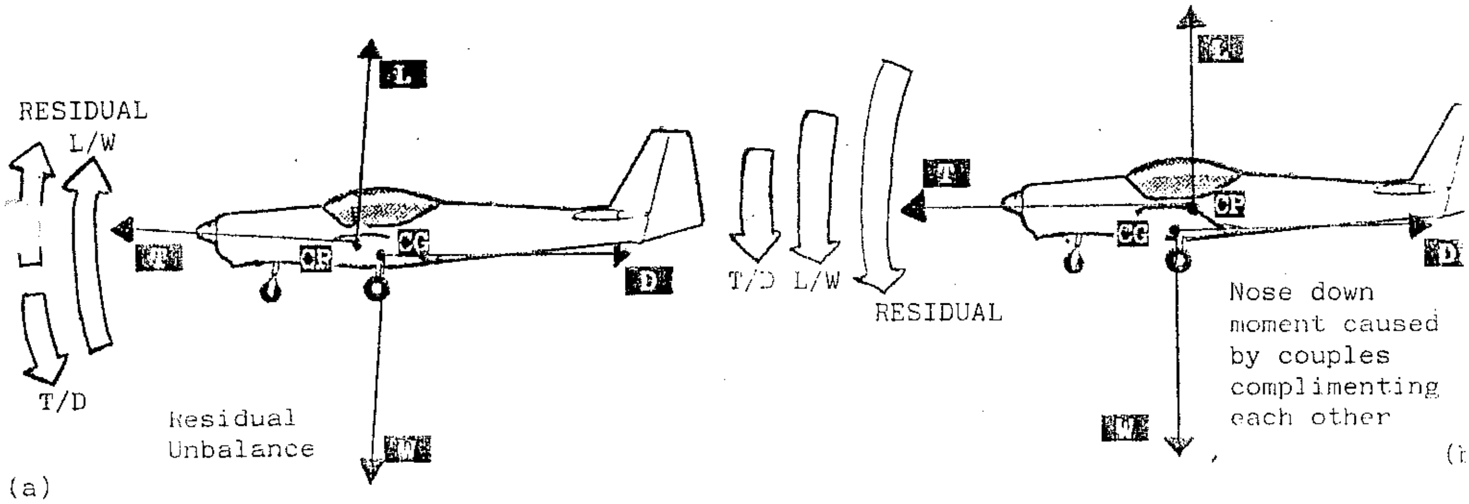


Fig 6.3 Resultant pitching moments with both couples

Tailplane and Elevator

7 The basic function of the tailplane is to stabilize the aircraft in pitch; it does this by supplying the force necessary to counter pitching moments arising from the L/W and T/D couples. The required force on the tailplane need only be a small one, because the tailplane is positioned a considerable distance from the CG and, thus, can apply a large moment to the aircraft (Fig 6.4). The fixed tailplane will counter the residual pitching moment for only one condition of level flight. However, by using the elevators, the pilot can modify the lift produced by the tailplane and so adjust the tailplane moment to counter residual pitching moments for all conditions of level flight. Once adjusted, the elevators should be trimmed.

Attitude for Level Flight

8 You may remember that, when you were shown the effect of the elevators on the aircraft in Exercise 4, your instructor used approximately

2400 r.p.m. and 20 in manifold pressure for the demonstration. During this demonstration, you were shown that moving the control column forward moved the nose down away from you, causing the airspeed to increase and the aircraft to descend. Conversely, when the control column was moved back, the nose of the aircraft moved up towards you, the airspeed reduced, and the aircraft gained height. From these demonstrations, therefore, it should be clear that an attitude can be selected where both speed and height will remain constant.

* The attitude selected to give constant height and speed is the attitude for level flight at that power setting.

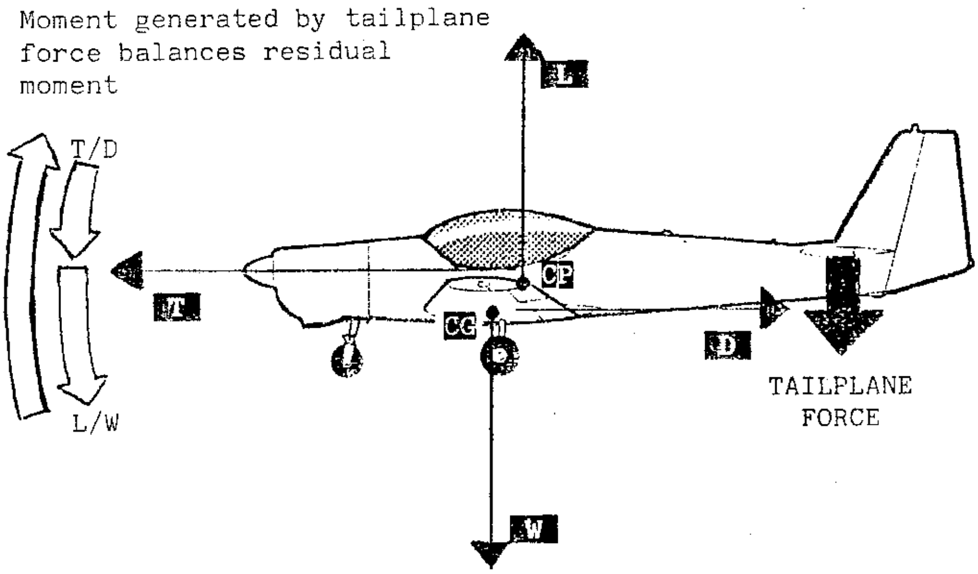


Fig 6.4 Effect of tailplane

You will be taught straight and level flight, initially, at a constant power setting. The aircraft's pitch attitude can be determined by noting the relative positions of the airacraft's nose and the horizon. This 'picture' changes as the attitude is changed (Fig 6.5).

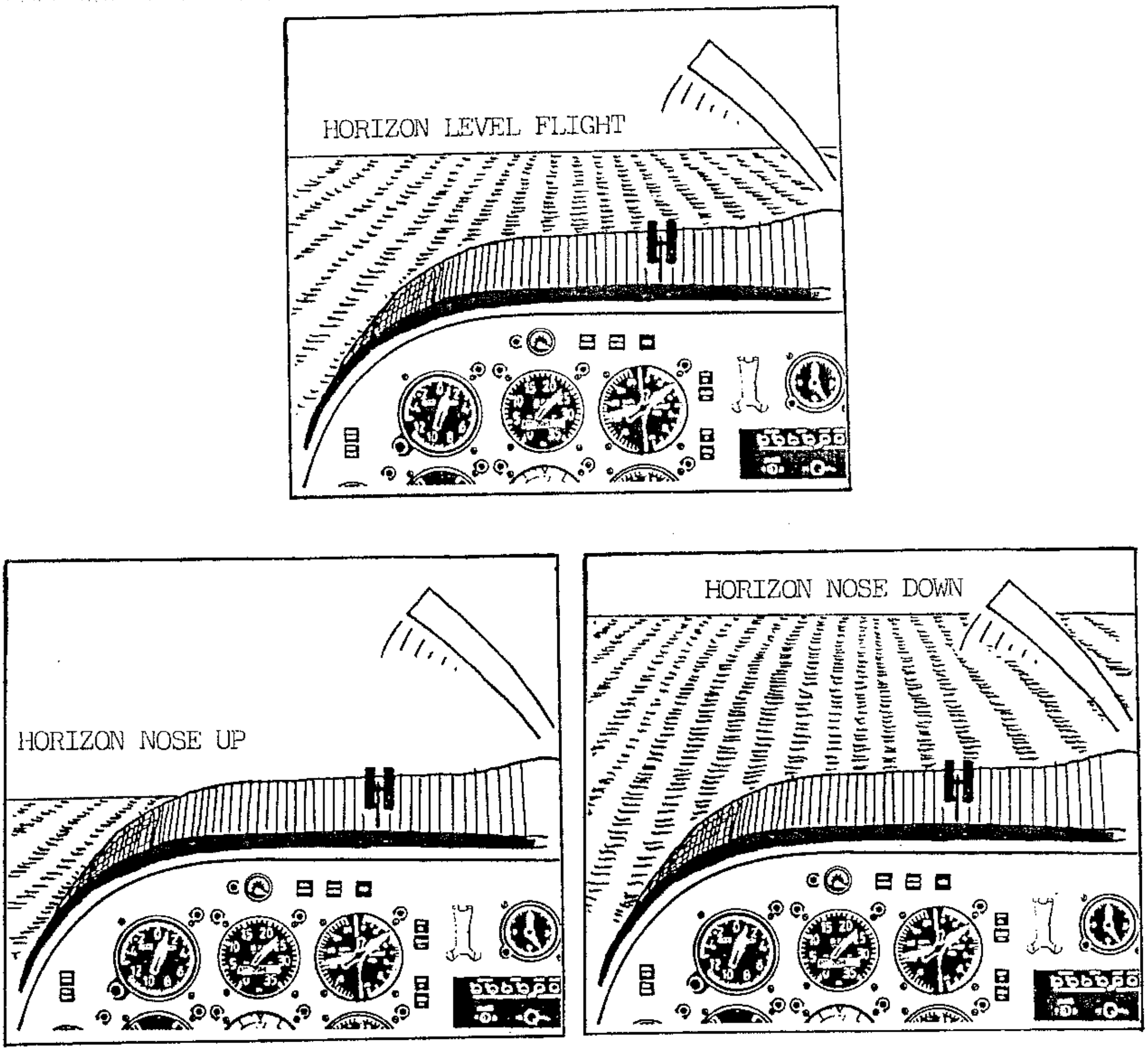


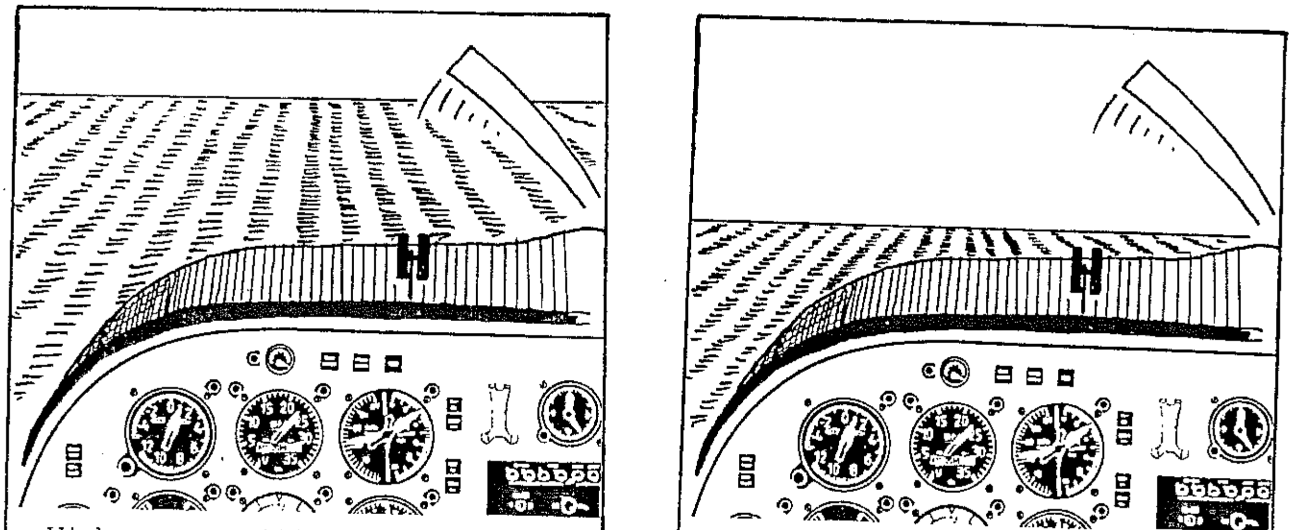
Fig 6.5 Changes of attitude - viewed through the windscreen

Level Flight at Various Power Settings

9 Having established the attitude required for level flight at one power setting, we must now consider how level flight is maintained at other power settings. If power is increased when the aircraft is trimmed for level flight, the increase in power (thrust) will cause the airspeed to increase. The increased airspeed will increase the lift and, if the original attitude is maintained, the aircraft will start to climb. However, the aim in this exercise is to maintain level flight; this is achieved by selecting a lower nose attitude, which reduces the angle of attack and keeps the lift constant despite the increased airspeed. The process of lowering the nose must be continued progressively whilst the airspeed is increasing, until the forces acting on the aircraft are again in equilibrium. Thus:

* To maintain level flight at high power settings, a lower nose position (and, therefore, a change of trim) is required, and the aircraft will fly at a higher speed (Fig 6.6a).

If full power is used, the speed achieved will be the maximum speed of the aircraft at that particular height.



High power setting - high speed
Lower nose position - trim change

Low power setting - low speed
Higher nose position - trim change

Fig 6.6 Level flight at various power settings

10 If power is reduced when the aircraft is trimmed for level flight, the reduced thrust will cause the speed to reduce if the original attitude is maintained. The effects are now the reverse of that described in para 9: the reduced speed will reduce the lift and the aircraft will descend - unless the angle of attack is increased by selecting a higher nose attitude. Thus:

* To maintain level flight at low power settings, a higher nose position and a change of trim are required, and the aircraft will fly at a lower speed (Fig 6.6b).

All aircraft have a minimum power for sustained level flight. In the T67, if the power is reduced below this minimum value, the aircraft will no longer be able to maintain height because it stalls.

Level Flight at Selected Airspeeds

11 Rather than fly at selected power settings (as described above), it is more usual to fly modern aircraft at selected indicated airspeeds (IAS). We have already seen that the speed for level flight varies with the power used. It follows from this that, to fly at a given speed, it is necessary to select the power that will give this speed.

12 Mention has also been made of the minimum power required for level flight. Flight at this power setting is at the 'minimum power speed'. Level flight is not possible at speeds below the minimum power speed, (Fig 6.7 shows 'power available' and 'power required' curves plotted against 'power' and 'speed') because, in the Firefly, the minimum power speed is below the stalling speed (see para 10).

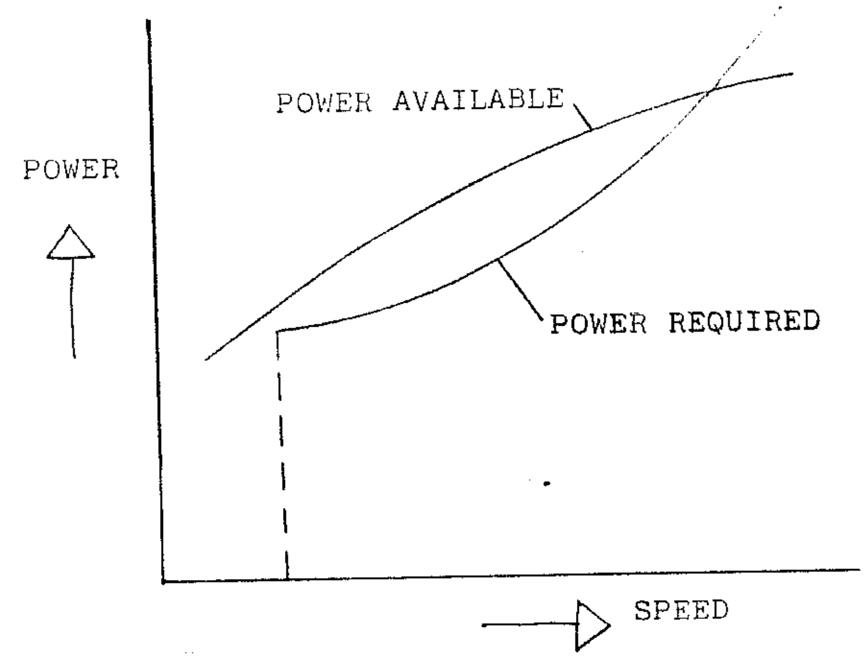


Fig 6.7 Power required for level flight

13 With a constant speed propeller, the r.p.m. achieved by the engine at a fixed throttle setting stays the same as the airspeed increases. Thus, if it is known that a particular r.p.m. and MAP will give a certain speed, these settings can be set at a higher or lower airspeed without the need for re-adjustment as the speed changes.

Straight Flight

14 The considerations affecting level flight are valid only when the aircraft's wings are level. The wings should also be level for straight flight because, as we have seen, when an aircraft is banked it will also yaw, and this will cause the aircraft's nose to move around the horizon. However, if the nose moves round the horizon when the wings are level, it means that the keel surfaces must be producing an unbalanced force which is causing the aircraft to yaw. To stop the yaw under these conditions, an equal balancing force must be applied. The required force is produced by applying rudder in the opposite direction to the yaw.

Balanced Flight

15 We said at the start of this exercise that we would learn to fly the aircraft straight and level and 'in balance'. It is possible to fly an aircraft straight and level but in a 'skidding' configuration, in just the same way as a car on an icy road skids sideways in one direction although it is pointing in another direction (Fig 6.8). Such skidding in an aircraft is called 'slip' or 'unbalance'. It increases the drag on an aircraft and causes a reduction in airspeed. It is, therefore, uneconomical to allow an aircraft to fly in this way. To avoid such excess drag, we fly 'in balance'.

16 Marked unbalance is easily detected, because it can be felt. But slight unbalance is not so easy to detect; we now need the assistance of an instrument (the slip indicator) - the displacement of the ball in this instrument being the indication of unbalance, which can now be corrected.

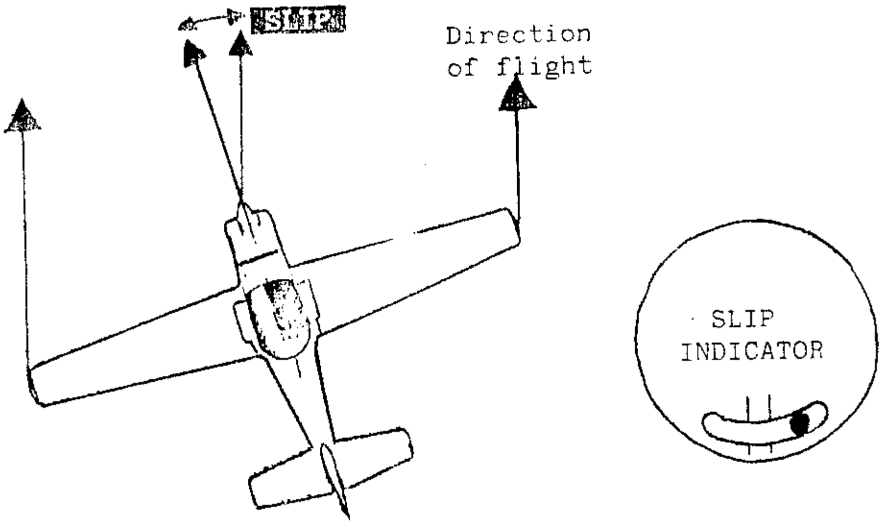


Fig 6.8 Unbalance in an aircraft

AIRMANSHIP

Lookout

17. When flying (either dual or solo) you must keep a good lookout for other aircraft. An aircraft approaching from 'head on' has a very high closing speed and there is little time available for the necessary avoiding action. Thus, you must stay alert to prevent any situation developing which could lead to a collision, or necessitate violent evasive action. Bear in mind that the airspace in the vicinity of an airfield contains the highest level of air traffic density.

18 Your instructor will show you how to develop a lookout technique and will demonstrate the clock code system of reporting aircraft. This system envisages your aircraft superimposed on an outsize clock face, as in (Fig 6.9). Other aircraft are then reported according to where they lie on the clock face, and whether they are high, low, or level relative to you.

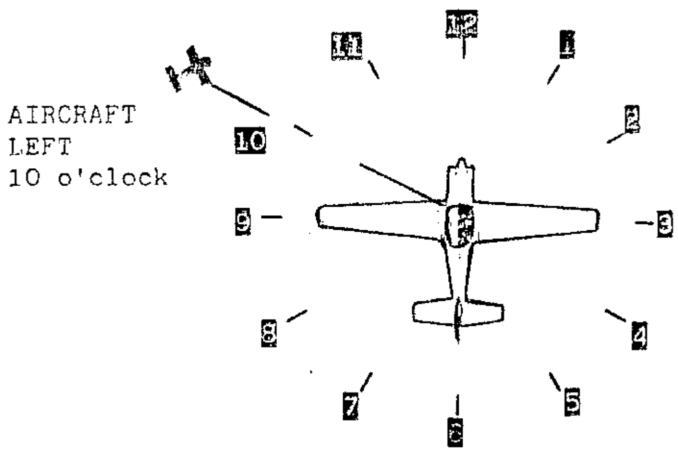


Fig 6.9 The clock code

Orientation

19 Besides watching for other aircraft, it is important that you keep a picture in your mind of where you are in relation to your base airfield. Your actual position can be established visually by using your knowledge of the local area when below cloud or, when above cloud, by using the radio. When you are flying try to develop the habit of keeping a mental plot of your position in relation to the airfield, using the radio, as necessary, to help you remain in a selected area.

Fuel and Engine Checks

20 It would obviously be stupid and inexcusable to run out of fuel on any sortie. Therefore, in this exercise - and in all later ones - your instructor will ask you to check the fuel contents at regular intervals.

21 Checks of the engine instruments, suction and the electrical voltage must also be made at frequent intervals.

AIR EXERCISE

Sequence of Instruction

22 Because of the time required to cover the whole of this exercise, it is normally taught in two parts, as follows:

a Straight and level flight at cruising power.

b Straight and level flight at various power settings and at selected airspeeds.

Straight and Level Flight at Cruising Power

23 Indications of straight and level. Your instructor will demonstrate straight and level flight at cruising power. Whilst this is being done, note the following points:

* Notice where the horizon cuts the windscreen, because this shows you the required pitch attitude for level flight.

* Notice that the wings tips are equi-distant below the horizon and that the cockpit coaming is parallel to the horizon; this is the 'wings level' position.

* Notice that the nose is not yawing left or right; pick a feature ahead (either a cloud or a ground feature) and you will see that you are flying straight towards it.

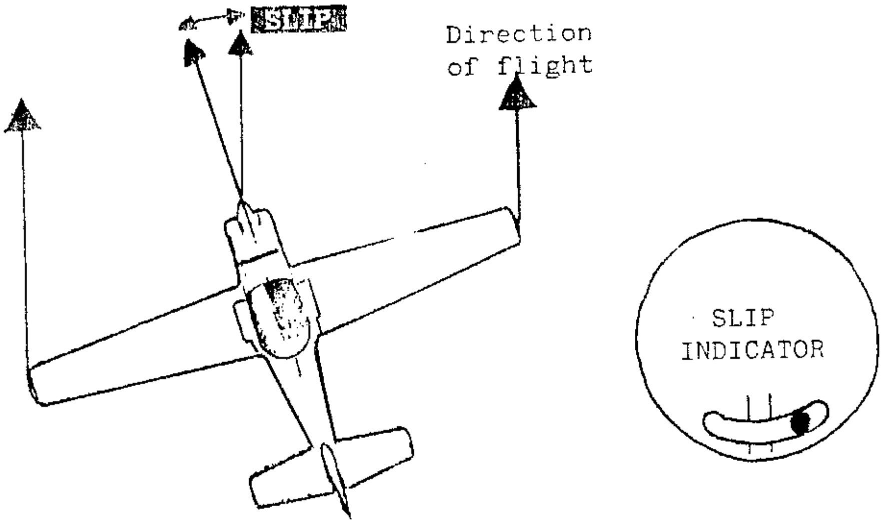


Fig 6.8 Unbalance in an aircraft

AIRMANSHIP

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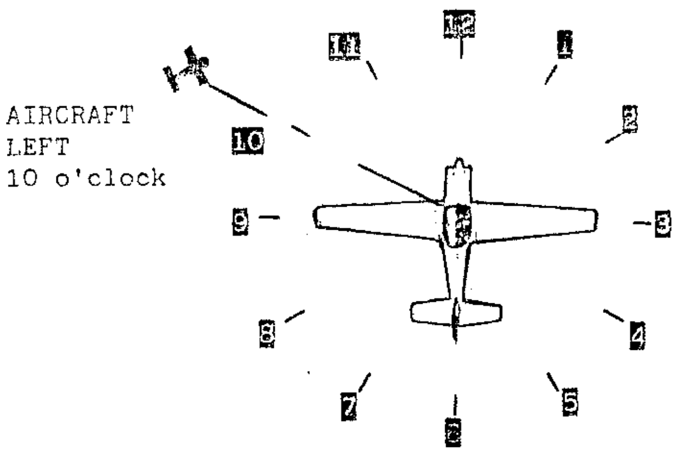


Fig 6.9 The clock code

Orientation

19 Besides watching for other aircraft, it is important that you keep a picture in your mind of where you are in relation to your base airfield. Your actual position can be established visually by using your knowledge of the local area when below cloud or, when above cloud, by using the radio. When you are flying try to develop the habit of keeping a mental plot of your position in relation to the airfield, using the radio, as necessary, to help you remain in a selected area.

Fuel and Engine Checks

20 It would obviously be stupid and inexcusable to run out of fuel on any sortie. Therefore, in this exercise - and in all later ones - your instructor will ask you to check the fuel contents at regular intervals.

21 Checks of the engine instruments, suction and the electrical voltage must also be made at frequent intervals.

AIR EXERCISE

Sequence of Instruction

22 Because of the time required to cover the whole of this exercise, it is normally taught in two parts, as follows:

a Straight and level flight at cruising power.

b Straight and level flight at various power settings and at selected airspeeds.

Straight and Level Flight at Cruising Power

23 Indications of straight and level. Your instructor will demonstrate straight and level flight at cruising power. Whilst this is being done, note the following points:

* Notice where the horizon cuts the windscreen, because this shows you the required pitch attitude for level flight.

* Notice that the wings tips are equi-distant below the horizon and that the cockpit coaming is parallel to the horizon; this is the 'wings level' position.

* Notice that the nose is not yawing left or right; pick a feature ahead (either a cloud or a ground feature) and you will see that you are flying straight towards it.

For ease, the exercise is now broken into two phases, as follows:

a Level flight.

b Straight flight.

24 Level flight. Your instructor will show you how to achieve level flight from a climb or a descent, and will then allow you to practise. Select the pitch attitude which you think will give you level flight, and then trim. Allow the aircraft to settle and check the altimeter for constant height. If necessary, adjust the attitude, retrim, and allow the aircraft to settle again. Repeat this process until the altimeter gives a steady reading, and then retrim accurately. Keep the picture you see through the windscreen constant, and you will maintain level flight.

25 Straight flight. Your instructor will show you how to roll the wings level with the horizon, using the wing tips and cockpit coaming as references. He will indicate a reference point ahead and will show you how to stop any yaw with rudder in order to fly straight (the rudder then being retrimmed). You will then be able to practise achieving straight flight from various banked attitudes.

26 Straight and level flight. Your instructor will now show you how to put the previous parts of the lesson together, in order to select straight and level flight from various pitched and banked attitudes. Initially, you will be encouraged to use one control at a time - e.g., select wings level, then select the pitch attitude, and then check any yaw. However, after practise, you will be encouraged to use all the controls simultaneously.

27 Balance. Your instructor will demonstrate the condition of extreme unbalance to convince you that this form of flight is inefficient and uneconomic. By following the 'wings level and stop the yaw' technique, you will easily correct for this marked unbalance. Your instructor will point out, however, that slight unbalance is very difficult to recognize - particularly if the horizon is poorly defined - and requires the use of the slip indicator. If the ball in the turn and slip indicator is to the right, you will need right rudder to centralize it and to put the aircraft in balance. Trim out any foot loads remaining.

28 Straight and level flight in a given direction. You will now be shown straight and level balanced flight in a given direction, and then allowed to practise it for yourself. Your instructor will indicate the reference point towards which he wishes you to fly. Apply a small amount of bank and allow the nose to move slowly around the horizon until you are pointing in the required direction; then level the wings. Check that you are in straight and level flight, and in balance, as follows:

a Level flight. Check altimeter: adjust attitude as necessary.

b Straight flight. Check that the wings are level with the horizon; check yaw; adjust both as necessary.

c Balanced flight. Check the ball in the slip indicator; correct as necessary.

29 Stability. If you have trimmed the aircraft correctly, you should be able to take your hands and feet off the controls and the aircraft will continue to fly straight and level.

Straight and Level Flight at Various Power Settings

30 Sequence of instruction. This part of the exercise is split into two phases, as follows:

a Straight and level flight at various power settings.

b Straight and level flight at selected airspeeds.

31 Straight and level flight at various power settings. You may remember that when you increase power the nose of the aircraft will try to rise, and the aircraft will also tend to yaw to port; similarly, when you decrease power, the nose of the aircraft will try to pitch down and yaw to starboard. Thus, every time you change power you have to anticipate, and correct, these tendencies. The actions to maintain straight and level flight when decreasing and increasing power may be summarized as follows:

a Decreasing power. Decrease power to the required setting and, as the speed decreases, progressively raise the nose. When the speed has stabilized, and the height is constant, trim the aircraft. Note the higher nose attitude and the lower speed. Check that the aircraft is straight and level and in balance. Remember that there is a minimum power for level flight below which it is not possible to maintain height.

b Increasing power. Increase power to the required setting and, as the speed increases, progressively lower the nose. When the speed has stabilized, and the height is constant, trim the aircraft. Note the lower nose attitude and the higher speed. Check that the aircraft is straight and level and in balance.

32 Straight and level flight at selected airspeeds. This is an extension of the previous part of the exercise; the required actions may be summarized as follows:

a Flying at a reduced airspeed. Select the power which you think will give you the required airspeed, and maintain level flight. Trim the aircraft and, as the airspeed approaches the required figure, adjust the power if necessary and retrim. Check that the aircraft is straight and level and in balance.

b Flying at an increased airspeed. Select the power which you think will give you the required airspeed, and maintain level flight. Trim the aircraft and, as the airspeed approaches the required figure, adjust the power if necessary and retrim. Check that the aircraft is straight and level and in balance. For a large increase in airspeed, select full power, maintain straight and level flight, and adjust the power as the required airspeed is approached.

Conclusion

33 Accurate straight and level flight is mainly a matter of good trimming and making full use of the natural stability of the aircraft. If you follow the correct technique, you will find that the T67 largely 'flies itself', leaving you free to concentrate on lookout and orientation. However:

* Remember to make a regular check of your fuel state, the engine instruments, and the voltage reading; these are most important - but easily forgotten.

EXERCISE 7

C L I M B I N G

Introduction

1 In Exercise 6, we learned how to cruise in straight and level (S & L) flight. The next stage is to discover how to get our aircraft up to the height at which we wish to cruise - i.e., how to climb the aircraft. As we shall see in this exercise, there is only one way to do this efficiently.

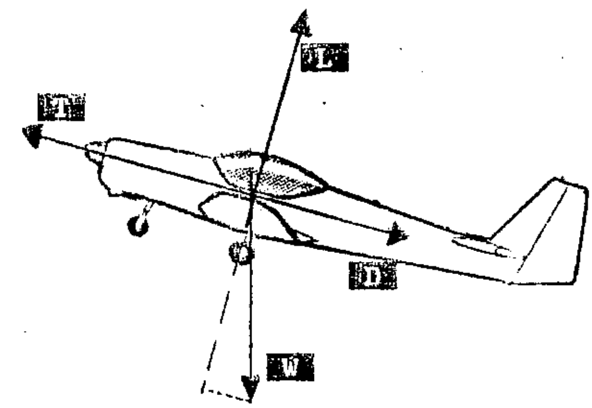
PRINCIPLES OF FLIGHT

Forces Acting on an Aircraft in a Climb

2 In straight and level flight, we saw that the forces acting on the aircraft are balanced - i.e., thrust T equals drag D (and lift L equals weight W). As an aircraft is made to climb, the requirement for thrust increases and the forces are then balanced differently. In a climb, as shown in (Fig 7.1a), thrust must now equal drag plus a portion of the weight. This is necessary because lift is now less than weight.

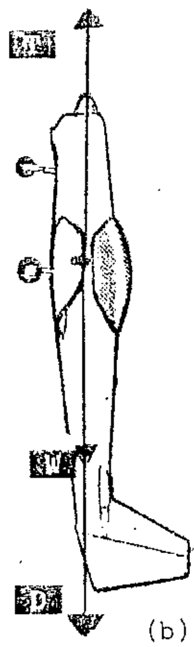
3 As the climbing angle is increased, the proportion of weight that has to be balanced by thrust increases until, in the vertical climb, thrust must equal drag plus the total aircraft weight (Fig 7.1b).

4 From (Fig 7.1), it may be seen that, at a given speed, the amount of thrust available, over and above that required for S & L flight, will determine the angle of climb. Together, the angle and the speed (IAS) determine the rate of climb.



Thrust = drag + proportion of weight
Left = proportion of weight

(a)



(b)

Fig 7.1 Forces acting on an aircraft in a climb

Best Rate of Climb

5 The speed to achieve the best rate of climb can be obtained from the power curve, an example of which is shown at (Fig 7.2). The 'THP required' curve illustrated is computed using the aircraft drag curves, and shows the amount of power required to maintain S & L flight at the various airspeeds. The other curve (THP available) shows the amount of power that the engine can produce at each airspeed, after allowing for propeller inefficiency. The maximum rate of climb (best angle of climb/TAS ratio) is at that speed where there is most power available in excess of that required for S & L flight - i.e., at that speed where the difference between THP available and THP required is greatest.

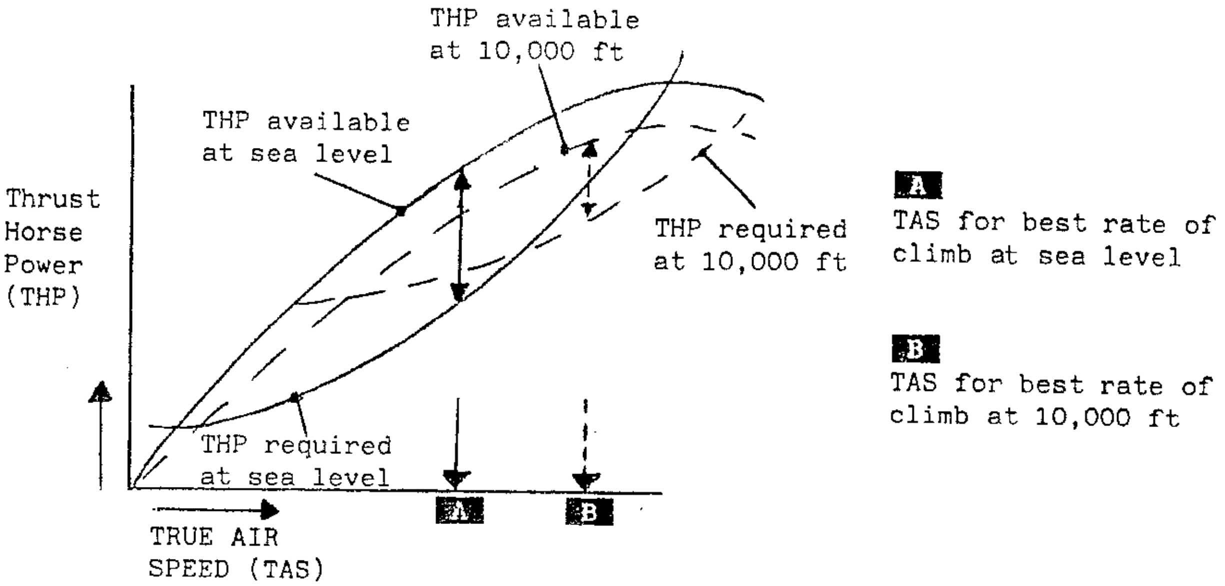


Fig 7.2 Best rate of climb (THP curves)

6 You can also see from (Fig 7.2) how the power curves change with an increase in altitude. The curves 'scissor' together as the altitude increases and have the effect, in this case, of increasing the TAS required for the maximum rate of climb. Note that the IAS, in fact, reduces because the effect of density on the IAS is greater than this 'scissor' effect. Thus, it is seen that the speed at which the maximum excess of power occurs changes with altitude. It would appear, therefore, that as the aircraft climbed, the pilot would be required to fly at an ever-increasing airspeed. However, in practice, a compromise speed is computed for specific 'height bands'. This speed is the 'recommended climbing speed' and is the one normally used.

Best Angle of Climb

7 To obtain the best angle of climb from the power curves, a separate graph must be compiled that shows the rates of climb obtainable at the various airspeeds. (Fig 7.3) shows a typical example. Note that the rate is zero at the slowest and fastest S & L speeds and that the best angle of climb speed is lower than the speed which gave us the best rate of climb.

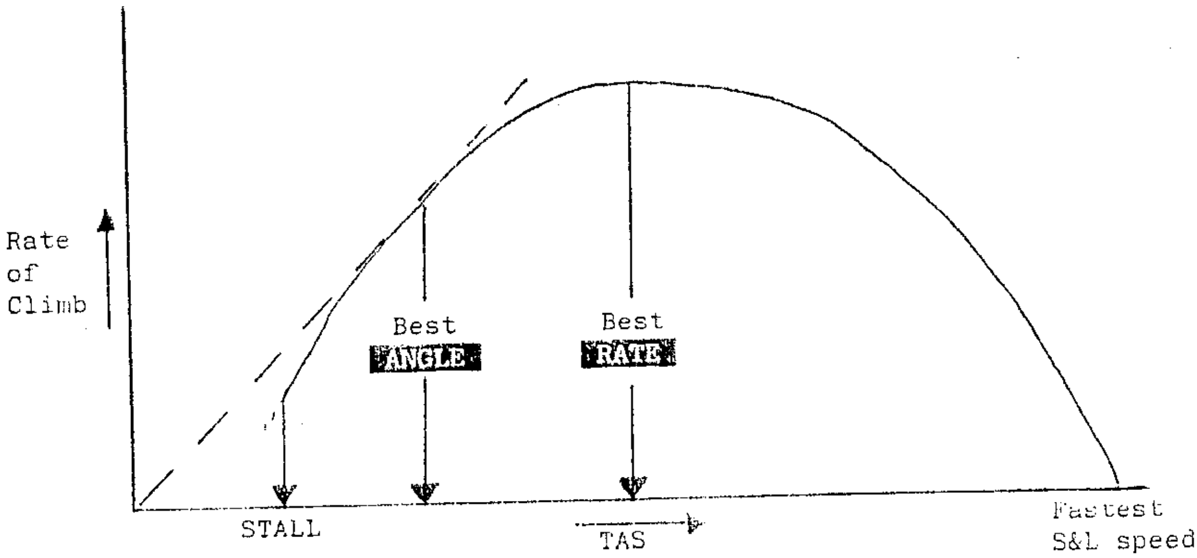


Fig 7.3 Best angle of climb

AIRMANSHIP

Lookout

8 The lookout scan is carried out in the normal manner but, as the aircraft is climbing, you must also 'clear' the airspace above and behind the aircraft. Moreover, since the T67 has a high nose attitude which obscures the forward view, you will need to weave the nose occasionally to ensure that the way ahead is clear.

Engine Handling

9 When you are established in the climb, carefully check the engine instruments. At a convenient height - normally 2000 ft - weaken the mixture to the best power setting. It is necessary to make adjustments every 1000 ft.

Altimeter Setting

10 The altimeter is to be set as follows:

* After leaving the circuit, change the altimeter sub-scale to the Regional Pressure Setting (Reg QNH), or as local rules dictate.

* If you climb above the transition altitude (normally 3000 ft), then you must set the Standard Pressure Setting of 1013.2mb on the No 1 altimeter, leaving the No 2 on QNH to give a true height reference.

AIR EXERCISE

Sequence

11 The air exercise is usually divided into three parts:

* The entry into the climb.
* Levelling-off from the climb.
* Maintaining the climb.

The Entry

12 Your instructor will first demonstrate how to enter a climb and then allow you to practise. The sequence is as follows (Fig 7.4):

a Carry out the lookout procedures to make sure that the airspace around you is clear.

b If clear, select max RPM, then open up to full throttle.

c Select the climbing attitude and approximately trim the aircraft to relieve most of the back pressure on the control column.

d Keep the ball of the turn and slip indicator in the centre by adjusting the rudder as necessary.

e Allow time for the aircraft to lose momentum and settle at a speed before making any adjustments to the attitude and before making the final accurate trim.

f Check the airspeed; if it has settled too high, raise the nose slightly and retrim; if it is too low, lower the nose slightly and retrim.

g Finally, remember that the final trim can only be done when the airspeed has settled at 80 kts.

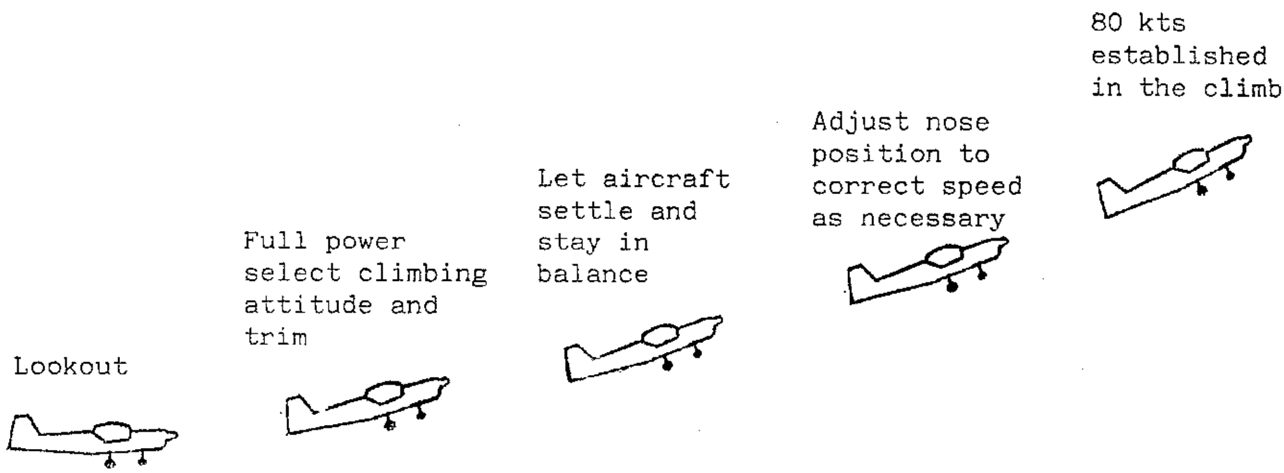


Fig 7.4 The entry to a climb

Levelling-off

13 This part of the exercise is really further training in straight and level flight. The sequence is as follows (Fig 7.5):

a From the climbing attitude, with the engine still at full power, lower the nose to a position which gives level flight at the low airspeed.

b Because of the power setting, the airspeed will quickly increase; as it does so, you must lower the nose to maintain level flight and correct any tendency to yaw by using the rudder.

c As the speed approaches 100 knots, trim to relieve some of the heavy forward pressure necessary to maintain the attitude, and select cruising MAP and RPM.

d Make small adjustments to the power to maintain exactly 100 knots and trim accurately.

e Finally, check that the wings are level, that the ball of the turn and slip indicator is in the centre, and that you have carried out the lookout procedure.

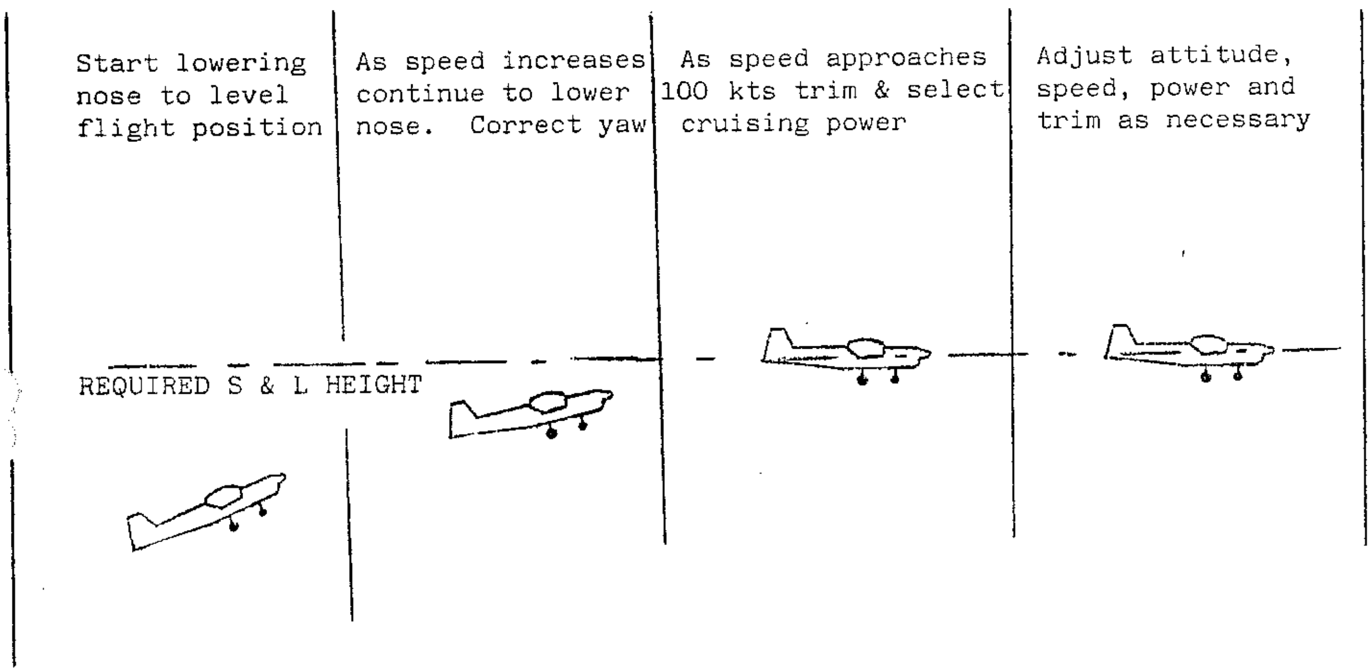


Fig 7.5 Levelling-off from a climb

14 When you have practised the technique of para 13 to the satisfaction of your instructor, he will then show you how to level off at a given height. The technique is the same as that described above but, to allow for aircraft momentum, begin the levelling-off process about 100 ft before the desired height. Later, as you gain experience, this figure can be reduced.

Maintaining the Climb

15 Since airspeed in the climb is critical, it is important that the aircraft be flown accurately at the correct airspeed for each height band. Any deviation from the recommended climbing speed will reduce the rate of climb. The following points are also important:

- With the aircraft flying at 80 knots, and with the engine at full power, the slipstream tends to yaw the aircraft to the left; counteract this with right rudder to keep the ball in the turn and slip indicator in the centre and trim out the foot load.

- Check the engine temperatures and pressures at regular intervals during the climb.

- Maintain a good lookout during the climb and, in addition, remember to clear the airspace ahead by weaving the nose of the aircraft from time to time.

Conclusion

16 Climbing is not a difficult exercise. The basic technique is similar to that for straight and level flight, except that the attitude is adjusted to maintain a given speed instead of a given height. As in S & L flight, make sure that you trim accurately to make full use of the aircraft's natural stability. Avoid chasing the airspeed; give it time to settle after making minor adjustments to the nose position.

EXERCISE 8

D E S C E N D I N G

Introduction

1 In Exercise 7 we considered the factors involved in climbing the T67. There is a saying, 'What goes up must come down'. Thus, having arrived at height, we must now consider how to descend. Early sorties will be devoted to the simple glide. You will then be shown how the descent characteristics change when flap and power are used. Later, you will be taught how to descend at other airspeeds and in other configurations.

2 The basic principles learnt in this exercise are of prime importance because of their application to more advanced exercises - in particular, to the exercise on approach and landing (Exercise 13).

PRINCIPLES OF FLIGHT

Gliding

3 In Exercise 7 we saw that any power in excess of that required for straight and level flight at a given speed enabled the aircraft to climb. Conversely, if power is less than that required for straight and level flight at a given speed, the aircraft will descend. Furthermore, the rate of descent will increase if the power is further reduced.

4 If power is reduced to a minimum (i.e. if the throttle is closed), and the aircraft is trimmed to maintain a given speed, the aircraft is said to be gliding. This simple form of descent is frequently used in all forms of flying, and will play an important part in your flying training.

5 The forces acting on an aircraft in a glide are shown in Fig 8.1. For a steady glide - with the engine throttled right back - the lift L, drag D and weight W forces must be in equilibrium. Fig 8.1 shows that the weight is balanced by the resultant of lift and drag. The lift vector, acting as it does at right angles to the relative airflow, will now be tilted forward, while the drag vector still acts parallel to the relative airflow.

6 Examination of the geometry of the vectors in Fig 8.1 shows that the angle included between the lift vector and the resultant vector is the same as that between the glide path and the horizontal (i.e. 1 = 2). It follows from this that if we can make the angle 1 smaller, 2 will become smaller also - in other words, the gliding angle will be smaller. How then can we make the angle 1 (and, hence the gliding angle) smaller?

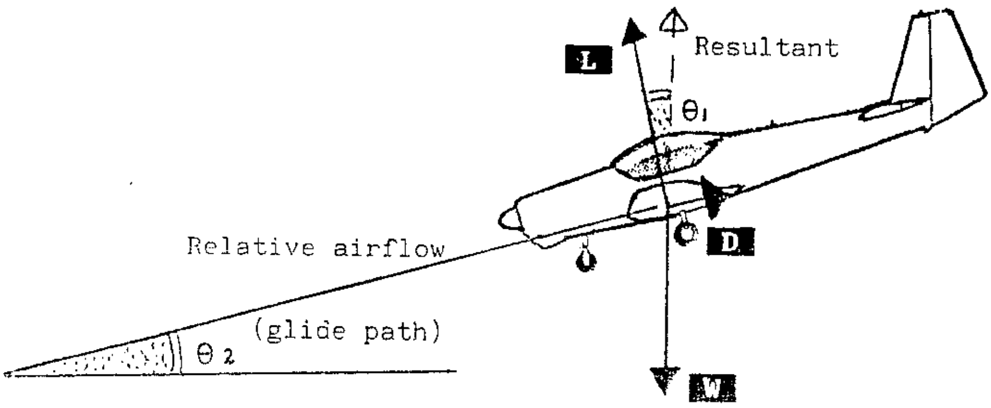


Fig 8.1 Forces acting on an aircraft in a glide

7 The gliding angle becomes smaller as the ratio of lift to drag (L/D ratio) is increased. Therefore, the higher the L/D ratio, the flatter is the glide (Fig 8.2). An aircraft gliding at its best L/D ratio will obviously cover the maximum distance possible when descending in a glide from any given height.

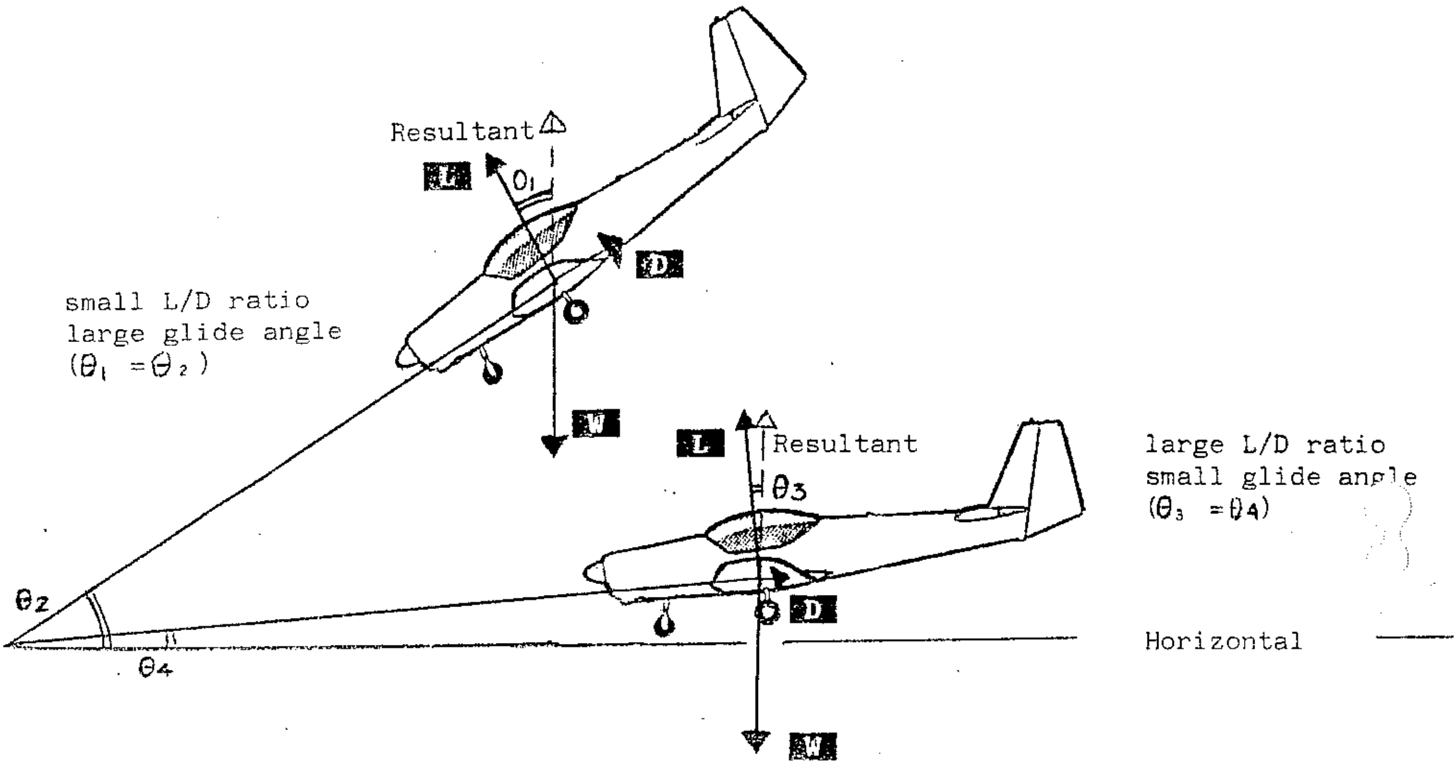


Fig 8.2 Effect of L/D ratio on gliding angle

8 A pilot has no direct indication of the L/D ratio. However, the best L/D ratio is achieved by gliding at the recommended gliding speed for the aircraft. For the T67, this is 80 knots. The gliding angle obtained at the recommended gliding speed is very small (Fig 8.3). It is important to appreciate this because, to make the drawing clearer, most diagrams that illustrate the forces acting on an aircraft in a glide tend to show much steeper angles of glide than those actually encountered in flight (e.g. compare Fig 8.2 and Fig 8.3).

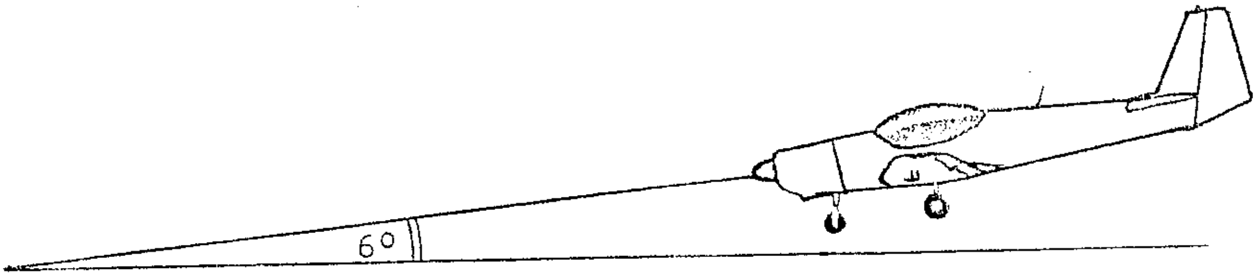


Fig 8.3 Best L/D ratio - very small gliding angle

Factors Affecting the Lift/Drag Ratio

9 The previous paragraphs show that the L/D ratio is a measure of the gliding efficiency of an aircraft. It follows that any factor affecting this ratio will affect the gliding performance. The factors affecting the L/D ratio are:

* Speed * Drag * Power

Let us consider each of these factors in turn.

a Speed. An aircraft gliding at a speed other than the recommended gliding, speed will glide more steeply. This applies to speeds either higher or lower than the recommended gliding speed (80 knots for the T67). This can be readily appreciated in the T67 at speeds in excess of 80 knots, because both the rate of descent and the angle of glide increase considerably (Fig 8.4). However, at speeds below 80 knots, the difference in the glide angle is not so apparent, for the rate of descent can be less than that achieved at the recommended speed. A glide at a speed below 80 knots requires a relatively high nose attitude and this, coupled with the reduced rate of descent, can easily be misinterpreted as a better gliding performance. It is important that you fully appreciate the implications of gliding at speeds below the recommended speed, in that it can only result in a steeper glide path (Fig 8.4). You must, therefore, resist the temptation to try and 'stretch a glide' by raising the nose.

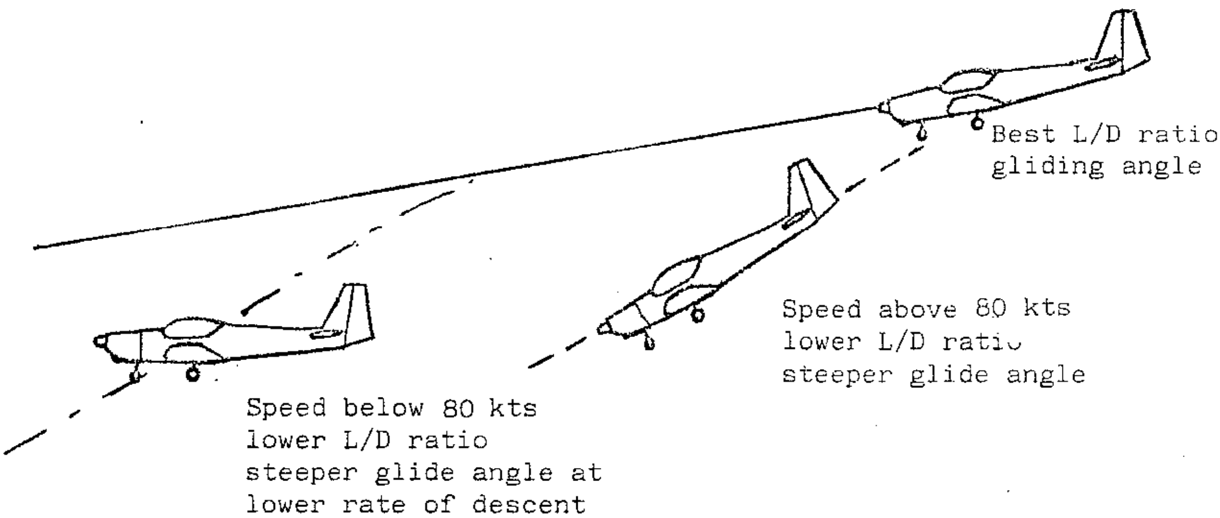


Fig 8.4 Effect of speed on gliding angle

b Drag. Any factor that increases the drag of an aircraft gliding at a given speed will alter the L/D ratio and, therefore, adversely affect the gliding performance. A T67 gliding at 80 knots with the flap selected will have a steeper angle of glide and a higher rate of descent than a 'clean' aircraft descending at the same speed.

c Power. If power is applied during a glide descent, the increase in thrust partially offsets the drag and causes the aircraft to accelerate if a constant attitude is maintained. However, it is normal to descend at a selected airspeed. Thus, if power is applied, the nose must then be raised to keep the speed constant. The subsequent descent will be at a lower rate of descent and at a flatter angle (Fig 8.5). Therefore, power is used to obtain the required rate of descent for descents at various speeds and aircraft configurations.

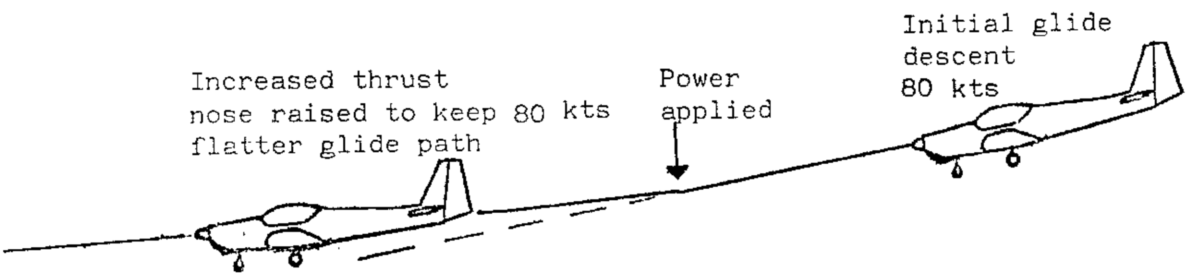


Fig 8.5 Effect of power on gliding angle

Note. If an aircraft in a steady glide is made to side-slip, the increase in drag will reduce the L/D ratio and, thereby, steepen the descent angle.

Effect of Wind

10 When the glide path and glide angle of an aircraft are plotted by an observer on the ground, they are found to vary according to the strength and direction of the wind. Starting from a given height, a glide into wind at the optimum airspeed covers less distance over the ground than a glide downwind. Since, in both cases, the rate of descent (measured as the height lost per minute) is the same, the angle - as seen by the observer - is governed only by the ground speed; the angle is steeper, at the lower ground speed, when gliding into wind. Therefore, as shown in (Fig 8.6), the effect of wind is:

* to decrease the range when gliding into a headwind component;

* to increase the range when gliding downwind.

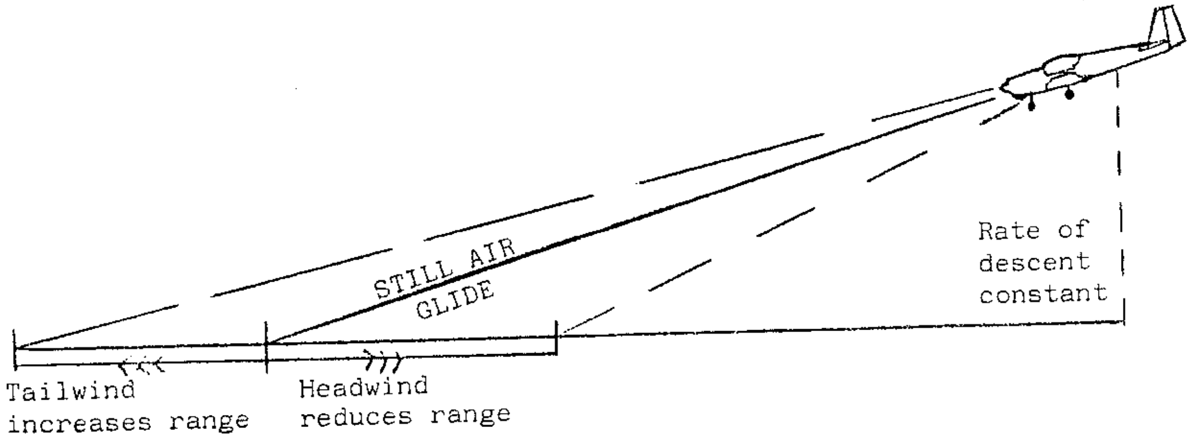


Fig 8.6 Effect of wind on gliding angle

AIRMANSHIP

Lookout

11 As always, lookout is important. Before descending, make sure that the area ahead, behind, and below the aircraft is clear. In particular, remember the blind spot under the aircraft's nose; in a long visual descent, make frequent heading changes to make sure that this area is clear.

Descent Through Cloud

12 Descents through cloud should not be made unless some form of controlled descent is being used, or unless you are sure that there is adequate clearance between the cloud base and the highest ground in the vicinity. Never descend below your safety height in cloud unless under some form of control from the ground.

Avoidance of Controlled Airspace

13 Certain areas in the vicinity of an airfield are used for controlled climb and descent procedures. These areas are to be avoided when descending towards an airfield.

Altimeter

14 Before descending, always check that you have the correct pressure setting selected on the altimeter sub-scale and that you are reading the altimeter correctly.

Physiological Effects

15 When you are climbing in an aircraft, the pressure in your ears equalizes with the pressure outside with no real effort on your part. However, this does not happen as easily in a descent. It is then necessary for you to 'clear' your ears at regular intervals during the descent - by swallowing or by holding your nose and puffing your checks out. Failure to do this can be extremely painful and, at worst, could cause permanent damage to your ear drums (especially if you have a cold). This is one of the reasons for the rule:

> * Never fly with a cold, or the after-effects of a cold, without first obtaining medical advice.

Engine Handling

16 In a long descent, with the engine throttled right back, there is a possibility of the engine sparking plugs becoming oiled and failing to provide the spark. It is necessary, therefore, to clear the plugs at intervals during the descent. This is done by opening up to full power and maintaining full power for three seconds, repeating this every 1000 ft during the glide.

AIR EXERCISE

Sequence

17 This exercise is taught in two parts, as follows:

a Glide descent.

b Effect of flap and power when descending.

Glide Descent

18 This part of the exercise is taught in three stages, as follows:

a The entry to the glide.

b Levelling-off from a glide.

c Maintaining the glide.

19 The entry. Your instructor will show you the gliding attitude and will then teach you how to enter a glide, after which you will be allowed to practise. The sequence during this stage of the exercise is as follows (see also Fig 8.7):

(1) Look out all round the aircraft, with particular attention to the area into which you are going to descend, and also below and behind the aircraft to make sure that you are not going to descend on an aircraft cruising at a lower altitude.

(2) Close the throttle (preventing yaw as you do so) and hold the attitude while the speed reduces.

(3) Just before the speed reaches 80 knots, select the gliding attitude and trim.

(4) Allow the aircraft to settle and, if the speed is incorrect, adjust the attitude and re-trim.

(5) Pick a reference point and check that you are not turning; check also that you are in balance.

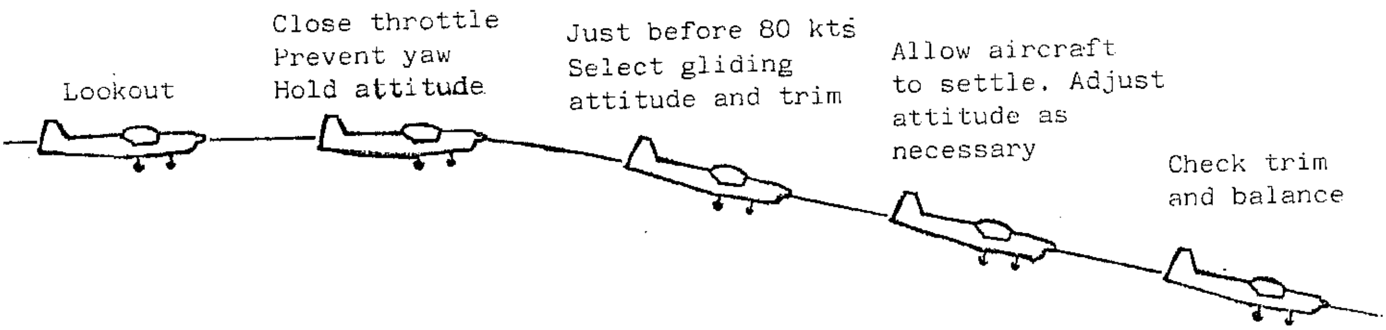


Fig 8.7 Entering the glide

20 Levelling-off. Your instructor will show you how to level off and will then allow you to practise. The sequence is as follows:

(1) Make sure that you are not going to level off in the path of another aircraft.

(2) Select cruising RPM/MAP (checking yaw as you do so) and hold the gliding attitude while the speed increases.

(3) Just before the speed reaches 100 knots, select the straight and level cruising attitude and trim the aircraft.

(4) Allow the aircraft to settle, adjust the attitude and MAP as necessary, and re-trim.

(5) Check that you are straight and level and in balanced flight.

When you have practised levelling-off as described above, your instructor will show you how to level off at a pre-determined height. The technique is the same as described earlier, but anticipation is now required, the levelling-off process starting some 200 ft before the chosen height.

21 Glide descent into climb. You may often wish to enter a climb after a glide descent rather than to level-off. Your instructor will demonstrate the method of entering the climb using the following sequence:

(1) Make sure you are not going to climb into the path of another aircraft.

(2) Simultaneously apply full throttle (preventing yaw) and select the climbing attitude.

(3) Allow the aircraft to settle; retrim the elevators and rudders.

(4) Now use the climb technique you have already learnt.

22 Maintaining the glide. To maintain the glide, keep the 'picture' you see after entering the glide, and check the airspeed to make sure that you are holding the correct attitude. During the descent, look out to make sure that you are not descending across the path of another aircraft, and weave the nose to make sure that the area ahead and below is clear. Every 1000 ft during the descent, clear the engine and, as you do so, keep the speed constant and keep straight. This means that as you open the throttle, you will have to make co-ordinated movements with the rudder and elevator. You have already seen that the attitude for 80 knots and full power is the climbing attitude so, as you reach full power, you will be close to the climbing attitude. Maintain this attitude while at full power and, as you close the throttle again, re-select the gliding attitude. To prevent yaw, you will have to increase pressure on the right rudder as you open the throttle, and relax the pressure as you close it. Check that the wings are level and that the aircraft is in balance after clearing the engine. Make certain that you set the Regional Pressure Setting (RPS) or the QFE before descending through the transition level.

Effect of Flap and Power When Descending

23 Flap and power are considered separately at the beginning of this part of the exercise and are then put together to allow you to practise clean and flapped descents at a constant speed. A thorough understanding of this exercise is important because the principles involved are all used in the final approach before landing.

24 Effect of flap. Your instructor will revise the previous part of the exercise and, in particular, draw your attention to the clean gliding attitude and the rate of descent. He will then lower flap and show you that you need a lower nose attitude to maintain the airspeed and that this results in a higher rate of descent. You will practise lowering flap during the glide, and you will be expected to anticipate the aircraft's reaction so that you maintain the speed both during, and after, selecting flap. Re-trim when you have selected the new attitude.

25 Effect of power. Your instructor will put the aircraft into a normal glide and will then show you the effect of applying power during the descent, after which you will be allowed to practise. As power is applied,

the aircraft will accelerate unless the attitude is changed. To keep the speed constant the nose has to be raised and, as a result of this, the rate of descent will decrease. Once again, you must anticipate the effect of increasing the power, and use the elevators to keep the speed constant both during, and after, the power change. When in the new attitude, you must retrim. The greater the power increase, the lower is the rate of descent. Thus, if the power is increased progressively, a stage will be reached where the aircraft will be flying level at 80 knots, and any further increase in power will cause the aircraft to climb.

26 Effect of flap and power. You will now appreciate that flap increases the rate of descent and that power can be used to control the rate of descent (see Fig 8.8). You will be asked to carry out descents both with and without flap at given rates of descent. When you return to the circuit, note how your instructor, when on the final approach, controls his rate of descent with power and his airspeed with the elevators, just as you have been doing during this exercise.

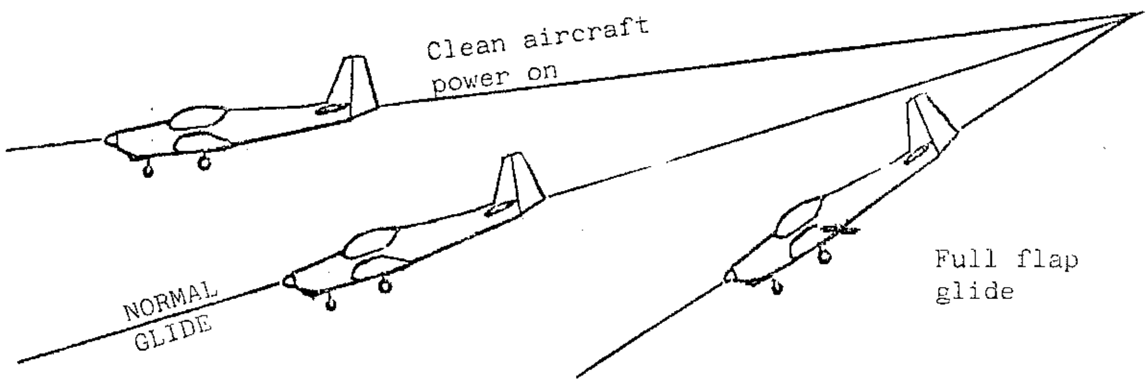


Fig 8.8 Effect of flap and power on 80 knots glide

Conclusion

27 The techniques for controlling the airspeed and the rate of descent of an aircraft that you have learnt in this exercise are fundamental to successful circuit flying (discussed later). Smooth co-ordination of power and elevator is the key to success. Remember to clear the engine during a glide and to re-set your altimeter sub-scale correctly before descending below the transition level. Most important of all - keep a good lookout.

EXERCISE 9

B A S I C   T U R N I N G

Introduction

1 From previous exercises we have learnt how to climb, cruise, and descend - but only on constant headings. We must next learn how to turn the aircraft. In this exercise you will be taught to turn the aircraft at medium angles of bank (up to 35°) on to specified headings.

2 The exercises which you have learnt up to now have been mainly concerned with pitch attitudes (which you have selected with the elevators), and with performance (which you have controlled by the power). This exercise introduces movement in the third plane and, for this, you will be required to co-ordinate elevators, ailerons, and rudder. You will be required to practise level, climbing, and descending turns.

PRINCIPLES OF FLIGHT

Forces Acting on an Aircraft in a Turn

3 A body in a state of uniform motion in a straight line will remain in that state, unless compelled to change by an applied force. Therefore, if we want to turn an aircraft which is flying straight and level, we must apply a force to it. We supply this force by inclining the lift towards the centre of the turn - i.e. by applying bank. (Fig 9.1) shows the forces acting upon an aircraft in a turn.

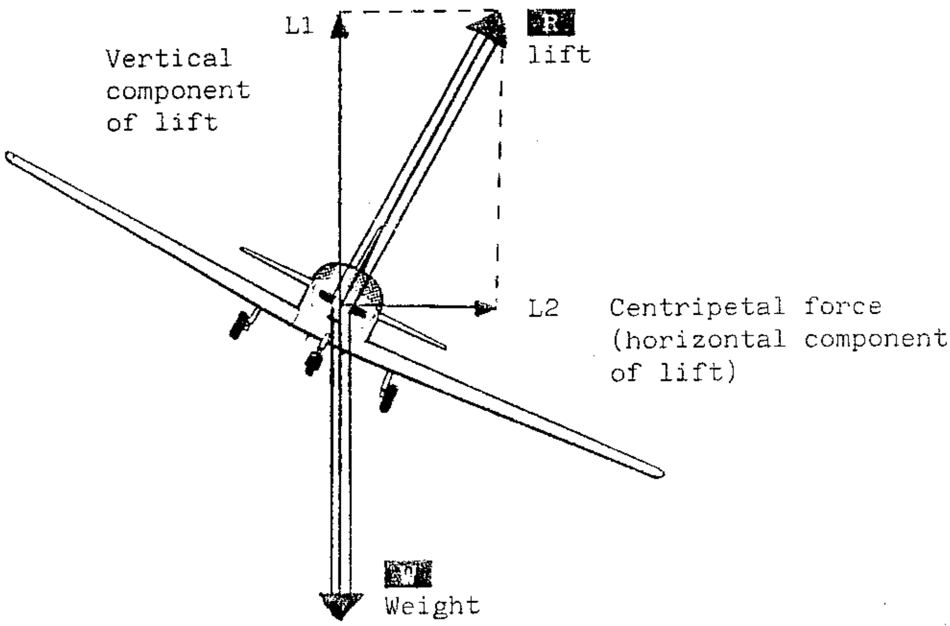


Fig 9.1 Forces acting on an aircraft in a turn

4 Centripetal force. If an aircraft is banked and the angle of attack is kept constant, the vertical component of the lift force L1 will be too small to balance the weight, and the aircraft will start to descend. If we are to maintain horizontal flight whilst turning, then as the angle of bank is increased, the angle of attack must be increased progressively by a backward movement of the control column. This increases the total lift, and the vertical component L1 in (Fig 9.1) becomes large enough to balance the weight, while the horizontal component L2 provides the force required for the turn. This force is called 'centripetal force (CPF)'.

Apparent Weight and 'g'

5 The pilot of an aircraft can be compared with the water in a bucket suspended on the end of a rope - the bucket representing the aircraft and the tension in the rope the lift. When the bucket is still, the rope is vertical and the tension in the rope equals the combined weight of the water and the bucket. If the bucket is swung round in a circle, like an aircraft in a turn, the bucket swings out and the rope is no longer vertical - it can now be likened to an aircraft banking and tilting the lift vector. The tension in the rope (analogous to lift) increases, but the water remains firmly in the bucket even though the bucket may swing up to the horizontal (vertical bank) position. While the bucket is being swung round, its apparent weight, which is equal to the tension in the rope, has increased. Thus, in a turn, the pilot of an aircraft remains firmly pressed into his seat and his apparent weight is increased in proportion to the increase in lift, referred to as the 'load factor' and given by the ratio lift/weight of the aircraft. This ratio multiplied by 'g' (the acceleration due to gravity) gives the acceleration that a force equal to the lift would produce. Thus, a lift force equal to the weight would equal 1g, and if the lift were doubled it would produce an acceleration of 2g. However, although not strictly accurate, it is common practice amongst pilots to refer to the ratio of lift to weight directly in terms of 'g'. For example, when the lift in a turn is equal to twice the weight, the aircraft is said to be doing a 2g turn. (The error in this statement becomes apparent when the 'g' forces in a loop are analysed). However, as stated, we speak of a 2g turn when the force we feel pulling us into the seat is twice that experienced in level flight.

Drag

6 In para 4 it was stated that, in a level turn, the control column would have to be moved back to increase the total lift. To you, the pilot, this will be more apparent as an increase in back pressure on the control column, sufficient to maintain the attitude necessary for a level turn. As the back pressure increases, so the angle of attack increases and this causes an increase in drag which results in a reduction of airspeed in a sustained turn. This reduction is accepted during medium level turns, but not when climbing or descending. Later you will learn that at angles of bank greater than 35° it is important to maintain the entry speed.

Balance

7 Because of the excellent aerodynamic balancing of the ailerons in the Firefly, there is no need to apply rudder to stay in balance whilst the ailerons are deflected (i.e. when rolling in to or out of a turn). Once the aircraft is established in a turn, very small rudder pressures may be necessary to maintain balanced flight.

Level Turns

8 It is convenient to split the level turn into three parts and consider the use of the controls during each part, as illustrated in (Fig 9.2) and described below:

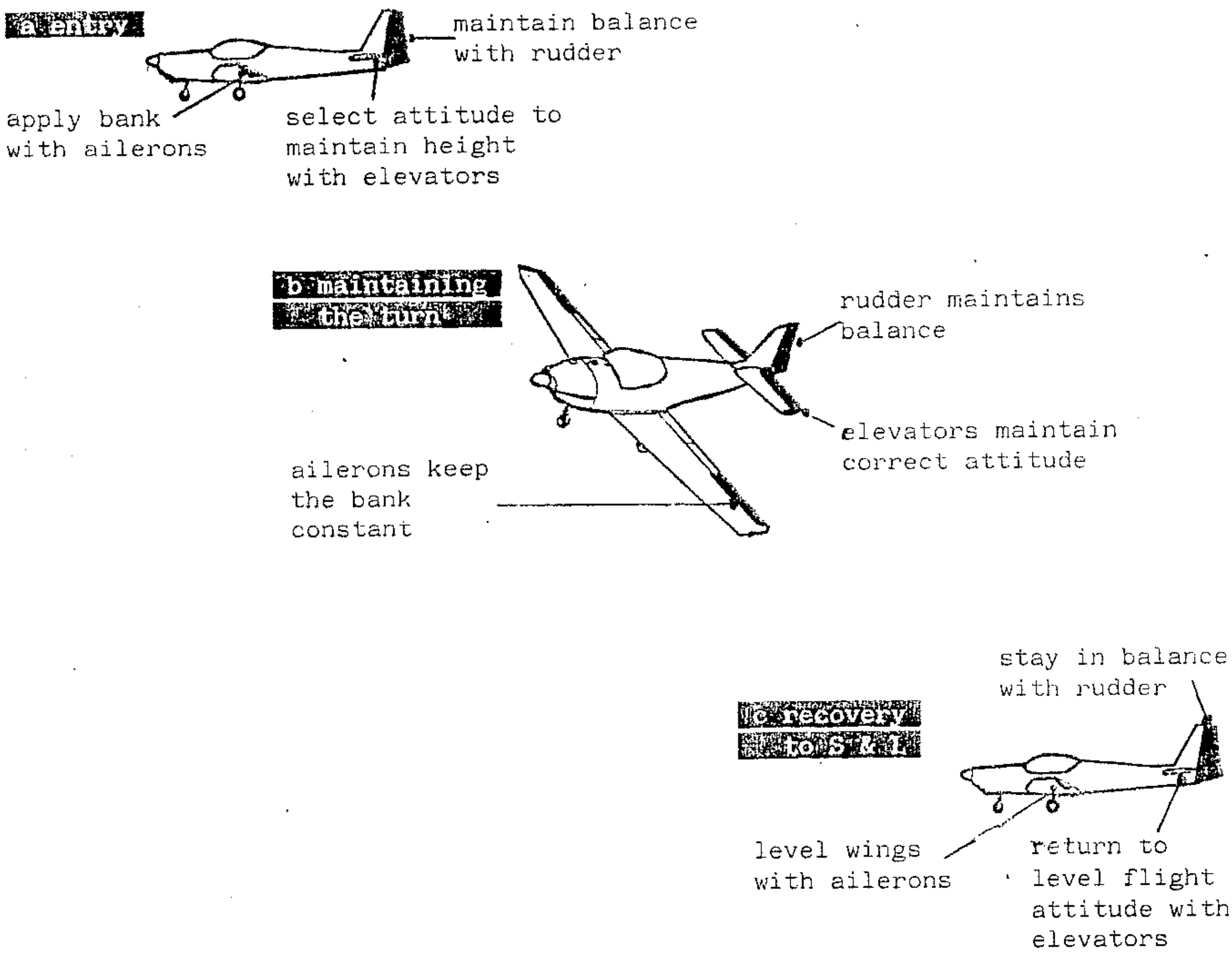


Fig 9.2 Level turns

a   Entry. To start the turn:

* Apply bank using ailerons and, at the same time, maintain balanced flight using a small amount of rudder.

* As the bank increases, use the elevators to select the attitude necessary to maintain height.

* At the required angle of bank, centralize the ailerons and rudder.

b   Maintaining the turn. During the turn:

* The ailerons must be used to keep the bank constant.

* The rudder is used to maintain the aircraft in balance.

* The elevator is used to maintain the attitude for a level turn.

c   Recovery to straight and level (S & L). To recover to straight and level flight:

* Level the wings by using the ailerons. At the same time, use the rudder to maintain balanced flight and the elevators to change the attitude to the level flight attitude used in S & L.

* When the wings are level with the horizon, stop the roll and remove the small amount of rudder used.

Climbing Turns

9   During climbing turns, the controls are used in the same way as for a level turn but the considerations for their use are different. As we saw when we discussed climbing in Exercise 7, it is important to fly at the recommended speed. This applies whether we are in a straight climb or in a climbing turn. Therefore, during a climbing turn, the amount of back pressure required is that necessary to maintain the climbing airspeed. Since we are already at full power in a climb, some of the excess power previously available for the straight climb must now be used to offset the turning drag. This results in a lower nose attitude and a lower rate of climb - which become noticeable at the higher angles of bank. The ailerons are used to keep the bank constant as before.

Descending Turns

10   In a descending turn, the controls are used in the same way as for a level turn. However, the considerations governing the use of the elevator are again different. The pitch attitude is still controlled by the elevator but it is determined by the need to maintain a speed and, because of the increased turning drag, you must lower the nose slightly to maintain your entry speed. This results in an increased rate of descent. If you wanted to maintain the entry rate of descent, power would have to be increased accordingly. The ailerons still control the angle of bank.

AIRMANSHIP

Lookout

11 A good lookout is very important both before and during a change of direction, particularly on the side into which you intend to turn or are turning. Before turning, begin by looking as far back as you can in the direction of the intended turn. Then rotate your head, scanning all the time the area level with the aircraft, until you are looking as far back as possible in the direction opposite to the intended turn. From this point, move your head to look above the aircraft and end with a final look into the area of the intended turn. Once you have completed the lookout procedure, do not delay the entry to the turn. Remember that, once banked, you will have a blind spot caused by the upper wing and the side of the aircraft and so, after you have recovered to straight and level again, make a point of looking towards what was the outside of your turn to make sure that it is still clear.

Orientation

12 If you practise a series of turns, the aircraft will drift downwind. Therefore, you must make a conscious effort to remain in a selected area by completing a turn as nearly into wind as possible. Before you begin to practise your turns, look for an easily recognizable ground feature nearby and check your position relavive to it after each turn.

AIR EXERCISE

Effects of the Controls

13 Remember that the effects of the controls remain the same, whether in a turn or in straight and level flight - i.e.:

a Ailerons control angle of bank.

b Elevators control pitch attitude.

c Rudder controls yaw.

Medium Banked Level Turns Entered from Cruising Speed (100K)

14 Your instructor will teach you medium turns in the three separate phases discussed earlier - the entry to a turn, maintaining the turn, and recovery from the turn. Your instructor will determine the order in which these phases are taught. When you have practised the separate phases, he will then show you how to put them together so that you will be able to do a complete turn for yourself. After this, you will be shown how to use the turn to change direction either towards a reference point or a specified compass heading. The three separate phases for the medium level turn are considered below:

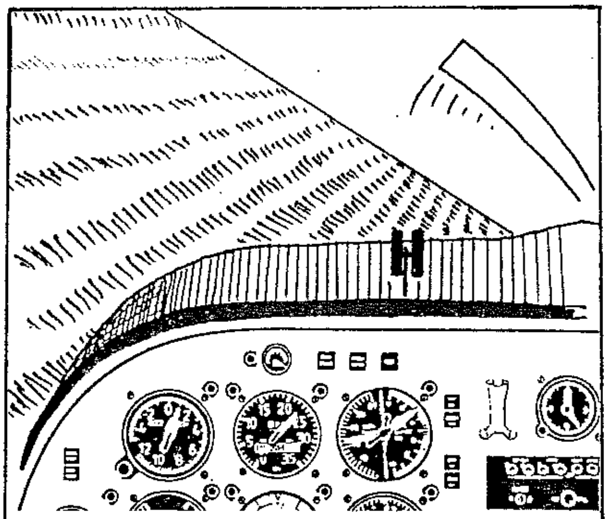
15 The entry to a turn. Before entering the turn, make sure that the area is clear (see para 11). The entry requires a co-ordinated movement of the main flying controls. The sequence is as follows:

* Using the ailerons, roll the aircraft slowly into the direction of the turn and, at the same time, apply a small amount of rudder in the same direction.

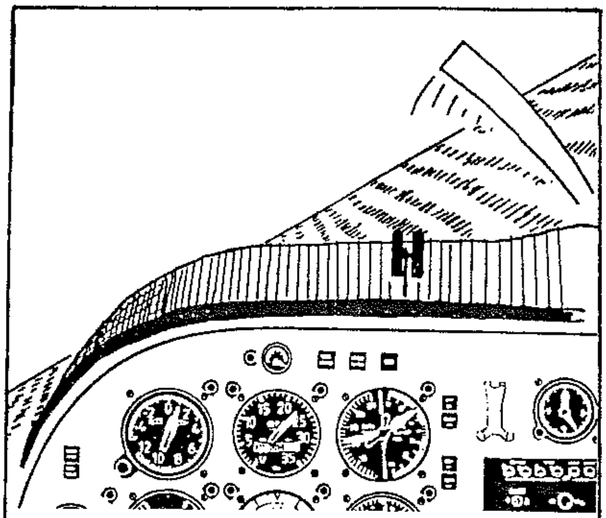
* As the bank increases, apply a gentle back pressure on the control column to select the pitch attitude already shown to you by your instructor.

* Use the horizon as a guide to the angle of bank (Fig 9.3).

* Stop rolling the aircraft at 30° bank.



9.3. 30° bank left



9.3. 30° bank right

16 Maintaining the turn. The points to note are as follows:

* Maintain the correct angle of bank with the aileron, adjust the nose attitude with the elevator to maintain height, and keep the aircraft in balance with the rudder. There is no need to trim whilst in the turn.

* Throughout the turn, the sequence should be: lookout, then check bank and attitude using the 'picture' you see through the windscreen (Fig 9.3).

* Confirm that you are maintaining height by reference to the altimeter and that you are in balance by reference to the ball of the turn and slip indicator. Adjust as necessary. Be careful, though, that you do not spend too much time looking down at the instruments at the expense of lookout and checking the 'picture'.

* Continue the sequence of lookout, check bank, attitude and instruments throughout the duration of the turn.

* Remember that there will be a small decrease of airspeed during the turn.

17 Recovery to straight and level flight. To recover to straight and level flight:

* Slowly level the wings with aileron and, simultaneously, begin to relax the back pressure on the control column and select the straight and level pitch attitude as the wings come level with the horizon.

* Stop rolling when the wings are level and remove the small amount of rudder used at the beginning of the recovery.

* Check that you are straight and level and in balanced flight.

* Lookout - make sure that the area previously on the outside of your turn is still clear.

18 Turning on to selected headings. As you approach the required heading, start to roll out of the turn in plenty of time. You will be shown, and will then practise for yourself, rolling out on to selected reference points, such as cloud or ground features. The lessons learnt here will then be applied to rolling out on to specified compass headings.

Medium Banked Level Turns Entered from 120K

19 Your instructor will teach you to maintain 120K during the turn by increasing power. Otherwise the technique remains the same as for turns entered from cruising speed.

Climbing Turns

20 The entry into the climbing turn is exactly the same as that for a level turn, except that the elevators are used to maintain the airspeed rather than the attitude; you will have to select a slightly lower nose attitude than that used for a straight climb. As noted earlier, the rate of climb will be slightly lower in the turn.

Descending Turns

21 Once again the entry is as for a level turn, except that the elevators are used to maintain the speed by selecting a lower nose attitude than used in a straight descent. There is an increased rate of descent, and power must be used should you wish to reduce it.

Conclusion

22 An accurate turn results from the co-ordinated use of the ailerons, rudder and elevator. Movements and pressures on the flying controls are small and, as this is only a temporary condition of flight, the aircraft is not trimmed. Initially, accuracy will be improved if turns are entered slowly and deliberately. Remember to keep a good lookout throughout the exercise, and do not become disorientated by a series of turns.

EXERCISE 10

STALLING

Introduction

1 Although so far not mentioned specifically, you were shown a stall on your last exercise and, until then, the aircraft had always been under positive control throughout the exercise. During the demonstration of the stall for the short period from the time your aircraft stalled until your instructor took recovery action the aircraft was out of control. It is, therefore, important for you to realize that, having stalled, you cannot manoeuvre your aircraft until you have recovered from the stall. Recovery from the stall is, thus, the prime consideration.

2 Your aim should always be to handle your aircraft with a skill that will avoid stalling inadvertently. But should a stall occur, you must know how to recover control. During this exercise you will learn how to recover from the stall. However, to know when you need to take stall recovery action you must first learn to recognize the symptoms of the stall. Furthermore, because prevention is better than cure, you must also learn the symptoms of the approaching stall so that you can take the necessary action to prevent the stall developing. These factors are discussed in the paragraphs that follow.

PRINCIPLES OF FLIGHT

The Stall

3 The stall occurs when the wing exceeds the stalling angle of attack. Let us see what this means. You have seen during straight and level flight that if we reduce power the airspeed decreases and, because the lift has decreased, the aircraft wants to descend. We can stop this descent by selecting a higher nose attitude because this restores the lift by increasing the angle of attack of the main-planes (Fig 10.1). If we throttle right back, then we can continue to fly level by further increasing the angle of attack - but only up to a certain point. Beyond this point we can get no more lift by increasing the angle of attack. In fact, beyond this critical point, increasing the angle of attack will produce markedly less lift. We have now reached the angle of attack known as the stalling angle of attack and, with flaps up, the speed has reduced to the basic stalling speed.

4 The reduction in lift after we exceed the stalling angle of attack is caused by the breakdown of the airflow over the wings (Fig 10.2). This breakdown is a gradual process at first, the amount of air separating from the normal flow pattern over the wing increasing as the angle of attack increases. At the higher angles of attack the effect becomes more noticeable. Beyond the stalling angle the final breakdown of the airflow is abrupt, the lift reduces quickly and the centre of pressure moves aft. All these factors contribute to a nose-down pitching movement.

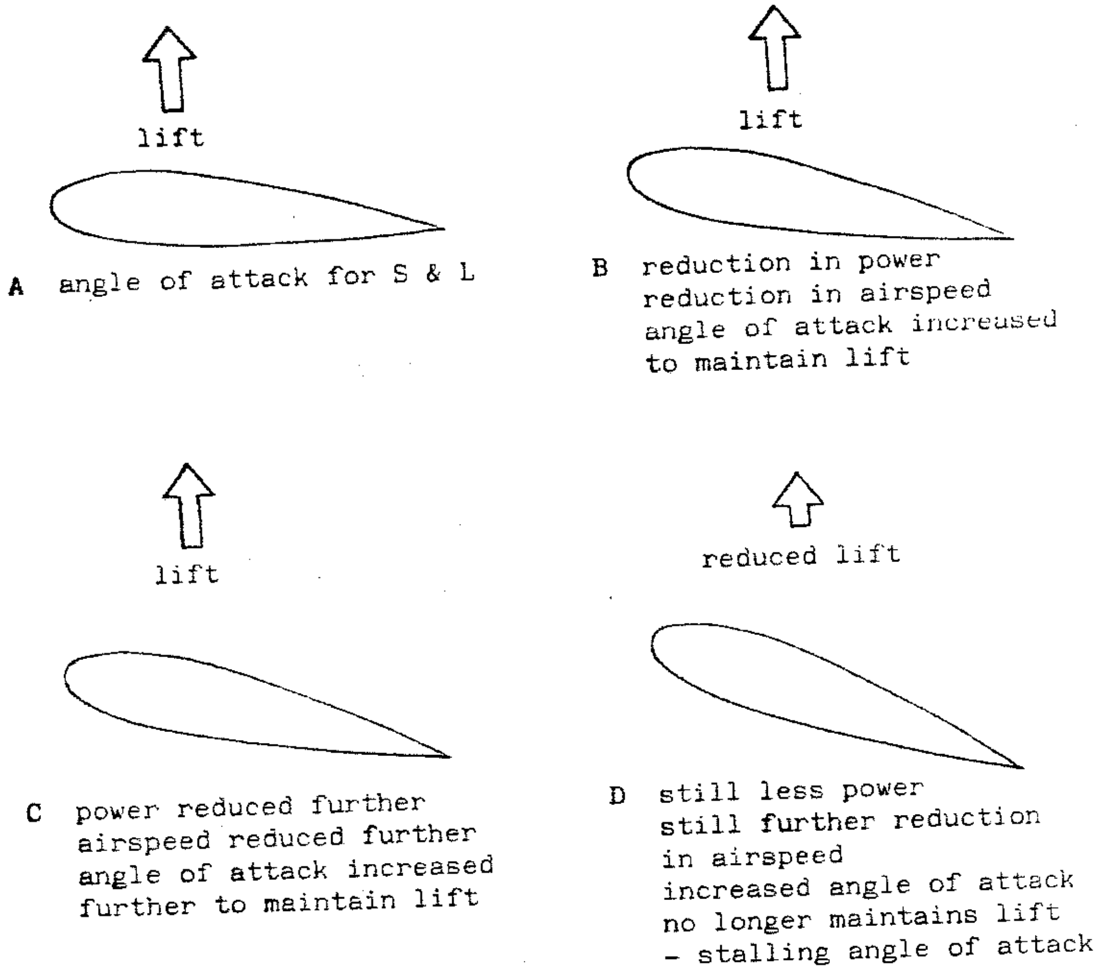


Fig 10.1 Effects of increasing angle of attack of wings while maintaining level flight

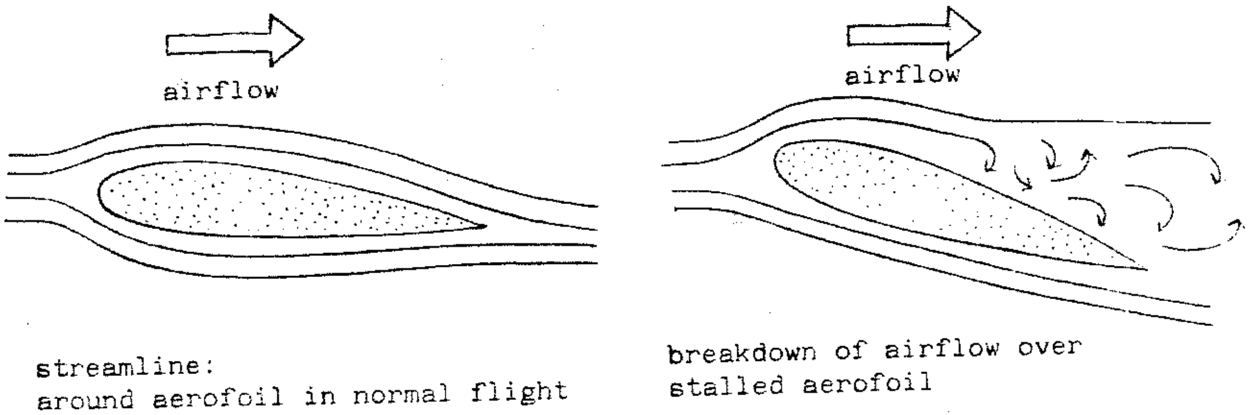


Fig 10.2 Airflow over the wings

5 Minor inequalities in the manufacture of the wings may cause one wing to stall before the other. If this happens in practice, you have reduced the lift sufficiently for the aircraft to pitch nose down and descend as before; but, in addition, with more lift on the unstalled wing than on the other the aircraft rolls and then yaws towards the down-going wing. This phenomenon is known as wing drop at the stall; it may occur in any aircraft and the wing drop can be in either direction.

Symptoms of the Approaching Stall

6 Let us consider what happens if we close the throttle and maintain straight and level flight. The speed will decrease and this, in itself, is a warning that we are tending towards the stalling angle of attack. As the speed decreases, the controls become sloppy and less effective and, to fly level, we now require a noticeably higher nose position. At high angles of attack the stall warning vane will operate, sounding a horn and illuminating the stall warning light in the cockpit. To summarize, the symptoms of an approaching stall are as follows:

a Decreasing airspeed.

b Sloppy, less effective controls.

c High nose attitude when approach to stall made from level flight.

d Stall warning operates.

Symptoms of the Stall

7 If you continue the attempt to maintain level flight by further increasing the angle of attack the lift will decrease as you pass the stalling angle and the aircraft will descend. Despite having the control column fully back, the nose will pitch down and, if one wing stalls before the other, the wing will drop. The symptoms of the stall are summarized as follows:

a Nose-down pitch.

b Possible wing drop.

c Aircraft descends.

Recovery from the Stall

8 Unstalling the wings Logically you can argue that if you induce the stall by selecting a high angle of attack and allowing the airspeed to decrease then you can recover from the stall by selecting a low angle of attack and allowing the airspeed to increase. This is quite true and your initial stall recoveries will be made by moving the control column forward, allowing the speed to increase, and then selecting the straight and level attitude. The only unusual aspect of this is that, for the first time you will be correcting a downward movement of the aircraft with, initially, a forward movement of the control column. However, this will not present any problem if you are quite clear in your mind as to what you are trying to achieve.

9 Wing drop If you have a wing drop at the stall, it must be dealt with immediately. At first sight, the wing drop indicates a roll and your instinctive reaction will be to correct with aileron. However, consider the matter further. The reason that one wing has dropped is because it has stalled and lost lift. In going down, it further increases its angle of attack and remains stalled, while the up-going wing has a decreased angle of attack and retains more lift. The drag of the stalled downgoing wing causes the aircraft to yaw towards it, and this tends to speed up the up-going wing and add to its lift. The roll thus continues.

10 If you try to use aileron to pick up the down-going wing you will be trying to increase the angle of attack of that wing. But the wing is already beyond its stalling angle of attack and we know that increasing the angle of attack in this situation causes a decrease in lift so that the roll will become worse. It is true that if you correct with aileron when you have moved the control column far enough forward to unstall the wings the roll correction will be effective. However, if you have not moved the control column far enough forward you will merely aggravate the situation as already described. Therefore, the use of aileron is not the answer. We know that the drag of the down-going wing causes yaw which, because it increases the speed of the up-going wing, assists the roll. If we correct this yaw we will minimize the rolling tendency. Rudder is the answer to the wing drop at the stall and we use it to stop the yaw and minimize the roll. Note that there is no question of restoring wings level with rudder; it is centralized as soon as the elevators have unstalled the wings.

11 Use of power We have unstalled our aircraft by using elevator and we have prevented further yaw with rudder. Therefore, we can now regain level flight. These are the basic principles of the stall recovery, but to unstall using elevator and rudder alone takes time and time spent with the nose below the horizon means extra height lost. In fact, recovery in this manner means a height loss of about 400 ft. This is not acceptable and we must try to improve our performance. When we move the control column forward we are seeking to increase our airspeed as well as reduce the angle of attack. To increase the airspeed more quickly (i.e. better acceleration) we can use power and to get the best acceleration we use full power which gives quicker recovery. The increased slipstream also helps to unstall the wing more quickly. The use of full power will reduce our height loss during recovery by about 200 ft.

12 Standard stall recovery We have now evolved the method whereby, having stalled, we can regain control with minimum loss of height. These actions are known as the 'Standard Stall Recovery', and are summarized as follows:

a Take the following actions simultaneously:

* Move the control column centrally forward to unstall the wings.
* Select full power.
* Use rudder to prevent further yaw.

b When the wings are unstalled, immediately:

* Level the wings using ailerons.
* Centralize the rudder.
* Gently ease the aircraft into a climb.

13 Recovery from the incipient stall The standard stall recovery can also be used should we inadvertently approach the stall and get the pre-stall symptoms. Obviously, if we were close to the ground and, through mishandling, felt the symptoms of the approaching stall, we would not allow the stall to develop before taking recovery action since we know it would involve a height loss of at least 200 ft. If you get any pre-stall symptoms you must forget any thought of continuing to manoeuvre your aircraft until you have taken the standard stall recovery actions.

Factors Affecting the Stall

14 The factors which affect the stall are considered below:

a Weight If extra weight is carried, greater lift will be needed to keep the aircraft in flight. Therefore, at all angles of attack including the stalling angle, more airspeed will be needed to provide the extra lift. In other words, the stalling speed will be higher. The converse is true if less weight is carried.

b Flaps Amongst other things, flap increases the lift generated by the wings. The speed required to maintain sufficient lift for level flight is less with flaps down - so the stalling speed is lower. Stalling speeds with intermediate (take off) flap and full flap are quoted in the Pilots Notes.

c Power If an aircraft stalls with power on, the thrust line is inclined upwards as the angle of attack is increased, and a component of the thrust will contibute to the lift (Fig 10.3). In addition, slipstream over the inboard section of the wings contributes to the lift. Because of the additional lift, the aircraft stalls at a lower speed and, because of the slipstream effect, the stalling angle of attack is higher. This will be seen as a higher nose attitude at the stall. The higher the power setting, the lower will be the stalling speed.

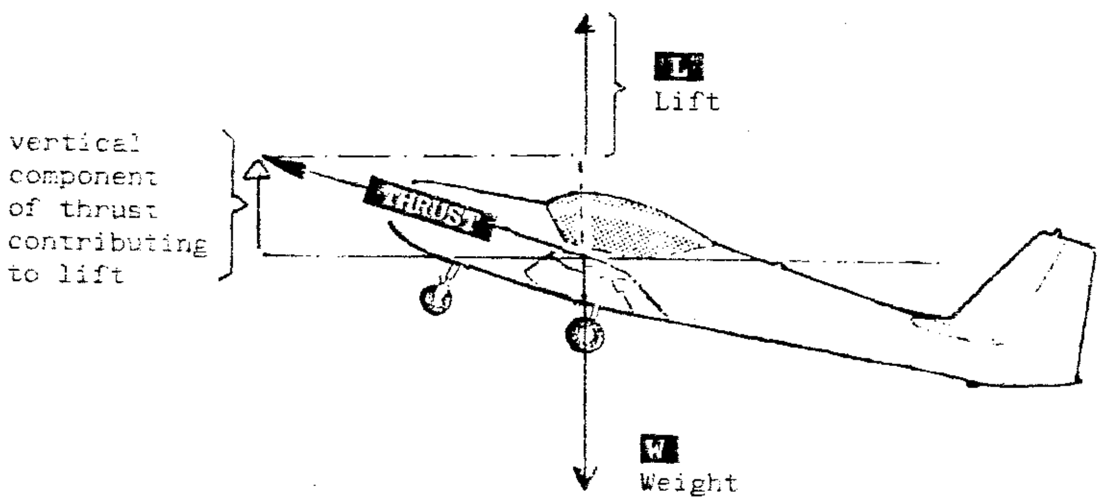


Fig 10.3 Effect of power on the stall

d Icing and airframe damage As already explained, any factor which contributes to the lift of an aerofoil results in a lower stalling speed. Conversely, any factor which reduces the lift characteristics of an aerofoil results in an increase in stalling speed. An aerofoil which has its shape altered by ice accretion has reduced lift characteristics; damage to the aerofoil may have the same effect and the stalling speed will be increased.

e Loading To support the aircraft during certain manoeuvres, extra lift is required from the wings for reasons already discussed in Exercise 9. This extra lift is measured as 'Load Factor' which is the ratio of wing lift to aircraft weight. The increase in lift required for a manoeuvre has the same effect on the stalling speed as an increase in weight; thus the stalling speed increases in a manoeuvre. For example, in a 60° banked turn the stalling speed is nearly half as much again as the basic stalling speed. (As lift is proportional to V^2 - i.e. (aircraft speed)^2 - it can be shown that the stalling speed in manoeuvre is increased in proportion to the square root of the load factor).

f Attitude Attitude and stalling speed can only be related when the stall is entered from straight and level flight where, at the stalling speed, the nose is high in relation to the horizon. Otherwise, it can be said that the stall can be induced in any attitude and at any speed whenever the stalling angle of attack is exceeded.

AIRMANSHIP

Essential Checks

15 There are certain essential checks to be carried out before entering any manoeuvre involving large movements in all three planes, or where manoeuvrability is restricted by operating the aircraft beyond the limits of control. These are the HASELL checks and this mnemonic is explained below:

a H - Height. We have seen that during the stall the aircraft is temporarily out of control and descending. When practising stall recoveries it is, therefore, very important that we complete the recovery at a safe height above the ground. This safe height is laid down in the Pilots Notes. You will not want to add problems to stall recoveries by having to complete them in cloud; so make sure that you have adequate vertical separation from cloud before you enter a stall.

b A - Airframe. Check that the flaps are locked in the position required for the stall that is to follow. Remember the flap limiting speeds, particularly during the recovery.

c S - Security. Loose articles. If they are big enough they can cause you personal injury; if small enough, they can come to rest in the most inaccessible places and could jam the controls. Before entering a stall, a check must be carried out to ensure that all personal equipment and aircraft equipment are securely stowed. You, yourself, will not wish to become a 'loose article' - so check that your straps are tight. Check the hood also; if it comes open it could cause a distraction at the wrong time.

d E - Engine. You should be checking engine instruments at regular intervals during the sortie. You will need to do so before and after each stall, because large power changes are made during this manoeuvre. The mixture and RPM controls are set to ensure quick and reliable response from the engine.

e L - Location. For obvious reasons, avoid stalling over built-up areas. Avoid active airfields; other aircraft are likely to be flying there. Never stall in controlled airspace. During a series of stalls the aircraft will tend to drift downwind; so pick some ground feature to help check your position between stalls. Beware of using a gap in the clouds as a reference point when stalling; you can inadvertently travel a long way downwind using this procedure.

f L - Lookout. Before every stall have a good lookout to check that you are clear of cloud and that your flight path will not conflict with that of other aircraft. To ensure that the airspace is clear for stalling it is necessary to turn the aircraft to have a good lookout. Try to make your turns accurate - although this is secondary to the lookout requirement.

AIR EXERCISE

Sequence

16 Your instructor will show you how to do the HASELL checks and then you will learn how to enter a stall. When you can do this, you will be able to appreciate the symptoms of the approaching stall and the full stall. After this, you will learn stall recoveries using elevator and rudder and, finally, the standard stall recovery. You will practise this technique following full stalls and then practise recovery at the incipient stage when you notice the symptoms of the approaching stall. Your second sortie on stalling will deal with the effect of flap and power on the stall. You will also practice recovery from the full and incipient stall with the aircraft under simulated approach conditions.

Entry to the Stall

17 To enter the stall, first carry out your clearing turns referred to in para 15f and then close the throttle and maintain level flight by raising the nose progressively to keep the aircraft in level flight. Check the tendency to yaw by using the rudder.

a As you approach the stall, note:

* Decreasing airspeed.
* Decreasing effectiveness of controls.
* High nose attitude.
* Stall warning horn and light.

b Continue moving the control column rearwards until it is right back and the aircraft stalls fully. The symptoms of the full stall are:

* Nose-down pitch.
* Possible wing drop.
* Aircraft descends.

Recovery Without Power

18 Your instructor will show you how far forward to move the control column and also the resulting nose-down pitch attitude necessary for the aircraft to accelerate. Make sure you move the control column centrally forward despite any wing drop and pay attention to the way in which your instructor uses the rudder to counteract any yaw. When the wings are unstalled and the airspeed starts to increase, level the wings with aileron, centralize the rudder and ease gently out of the dive. Apply cruising power when the nose reaches the level flight attitude. This part of the exercise is useful for learning the necessary control movements and enables you to get the feel of the aircraft during stall recovery. Remember, however, that we wish to recover with the minimum of delay - which means with a minimum height loss - and, for this, it is normally necessary to apply power.

Recovery With Power

19 As the aircraft stalls apply full power, use the rudder as before to prevent further yaw and move the control column centrally forward. The forward movement of the control column and the nose-down attitude are less than those experienced during recovery without power (para 18) because the power largely takes the place of gravity as the accelerating force. When the wings are unstalled and the airspeed is increasing, level the wings as before, centralize the rudder, ease gently out of the dive and establish a climb. With the aircraft climbing, allow the speed to increase to the correct climbing speed. Check that you are in balance. Because of the better acceleration and the higher nose attitude you will find that, by correctly using the Standard Stall Recovery, your height loss in a stall is at a minimum.

Incipient Stall Recovery

20 Recovery at the incipient stage of a stall means applying the standard stall recovery as soon as the stall warning horn operates. In this case the control column movement is very small. Check any yaw with rudder. To cater for the case of an unserviceable stall warning system you will also be taught an incipient recovery from the first symptom of the stall. In either case recovery is instantaneous and little or no height is lost.

Effect of Power on the Stall

21 In 'Principles of Flight' we have discussed the effects of power on the stall (para 14c). Your instructor will demonstrate a stall and recovery with approach power set. Because of the thrust from the engine reduction in airspeed will be slow. Notice that the elevator and rudder controls retain their effectiveness in the slipstream; note also that there is a higher nose attitude at the stall and a lower stalling speed. Because the slipstream delays the stall over the inboard section of the wings the tips will tend to stall first; this gives an increased tendency to drop a wing and the stall is more marked. After the stall carry out the standard stall recovery.

Effect of Flap on the Stall

22 In 'Principles of Flight' we also discussed the effect of flap on the stall (para 14b). Your instructor will show you how to enter a stall with full flap down and you will notice the rapid reduction in airspeed (because of the increased drag). This leads to a shorter period of stall warning. You will notice that, compared with a 'clean' stall, the stalling speed is lower and so also is the nose attitude. Recovery is made by using the standard stall recovery and, although the extra drag reduces the acceleration, a safe flying speed is gained earlier because of the lower stalling speed.

Stall Under Approach Conditions

23 If we combine the previous two parts of the exercise (paras 21 and 22), we will be stalling with flap down and power on. This, as you will have noticed, is the configuration of the aircraft when on the final approach. Do not ignore the approaching stall symptoms simply because you feel in control by virtue of the effective elevators. The stall is masked and you will see from the height loss the importance of recognizing the approaching stall when on final approach to land. Following this, you will practise entering the stall in the approach configuration and recovering at the incipient stage. The most realistic method of entering the stall in the approach configuration is to fly a simulated circuit at height using the base leg and finals turn to make sure that the airspace is clear. Your instructor will also show you how neglect of airspeed can cause you to stall the aircraft in the final turn. For this practise, Takeoff flap and approach power are set and recovery is made at the incipient stage. After recovery the aircraft is climbed away and flap raised at a safe height and speed.

High Speed Stalls

24 A harsh rearward movement of the control column at speeds above the basic stalling speed can cause the aircraft to stall. You will probably find this out if you try to be over-ambitious during your stall recoveries and ease out of the dive too early or too quickly. Recovery is instantaneous once the back pressure is relaxed but remember that further rearward movement of the control column may cause a wing drop and a full stall.

Conclusion

25 Practice stalls are the premiums you pay on an insurance policy which guarantees your safety when you fly at, or near, the aircraft limits. If you correctly apply the lessons you have learnt, you will never stall inadvertently; but, should the occasion arise, the knowledge and skill you acquire from the practice in this exercise will enable you to recover from the situation promptly and safely.

EXERCISE 11

S P I N N I N G

Introduction

1 Ever since the early days of flying, both pilots and students under training have approached the subject of spinning with reservations and, perhaps, some apprehension. The reason for these feelings are many but, whatever they are, the net result is that a general air of mystique surrounds spinning.

2 Spinning is a condition of flight which can develop if an aircraft is not recovered promptly or correctly from a stall. Thus, an accidental spin can only stem from mishandling of the controls. The extent of mishandling required to spin accidentally will vary with different types of aircraft as will the characteristics of the spin itself. You will find that it is difficult to spin the T67 accidentally and you may well ask why, in that case, do we include spinning in the flying training syllabus.

3 Briefly, the answer is that any professional pilot should always pride himself on his ability to fly his aircraft to its limits; the general rule is that if the aircraft is cleared to spin by the manufacturer, then we will spin it. Apart from this, the ability to enter a deliberate spin and effect a safe recovery will enable you to guard against disorientation and will build up your confidence. The confidence bred by the knowledge that you can, safely and speedily, recover from a spin, will enable you to safely handle operational aircraft close to their limits - vital to a successful combat pilot. Also, as your confidence increases, any apprehension you may have felt about spinning will disappear.

PRINCIPLES OF FLIGHT

Wing Tip Stalling

4 In Exercise 10 (Stalling), it was stated that one of the characteristics of a fully developed stall was that a wing may drop. This was because the stall does not usually occur simultaneously over the entire wing; one section may stall earlier than another. This unequal stalling causes a local reduction in lift over the affected section. The remainder of the wing is unaffected, and the result is a tendency to roll towards the stalled section. The extent and suddeness of the stall determines the rate at which rolling takes place.

Autorotation

5 The fact that one wing may drop at the stall - whether the stall is intentional or accidental - is the basic cause of spinning. This may be seen by reference to the graphs showing variations of CL and CD with the angle of attack (Fig 11.1). Suppose that a wing is just at the stalling angle and, therefore, at peak of the CL curve. If the aircraft now rolls for some reason, the angle of attack of the down-going wing, particularly at the tip, is increased to some figure greater than the stalling angle (B in Fig 11.1), while that on the up-going wing is reduced (A in Fig 11.1). Both wings will suffer a loss of lift. Because of the difference in gradient of the CL curve before and after the stalling angle, the loss of lift on the downgoing wing is greater than that on the upgoing wing which only serves to further increase the rolling motion. The CD curve shows that, after the stall, there is a marked increase in drag, and the drag on the down-going wing is, therefore, higher than that on the other wing. This results in a movement which yaws the nose towards the down-going wing. This increase in drag tends to hold back the wing which is dropping, so causing it to lose still more speed and lift.

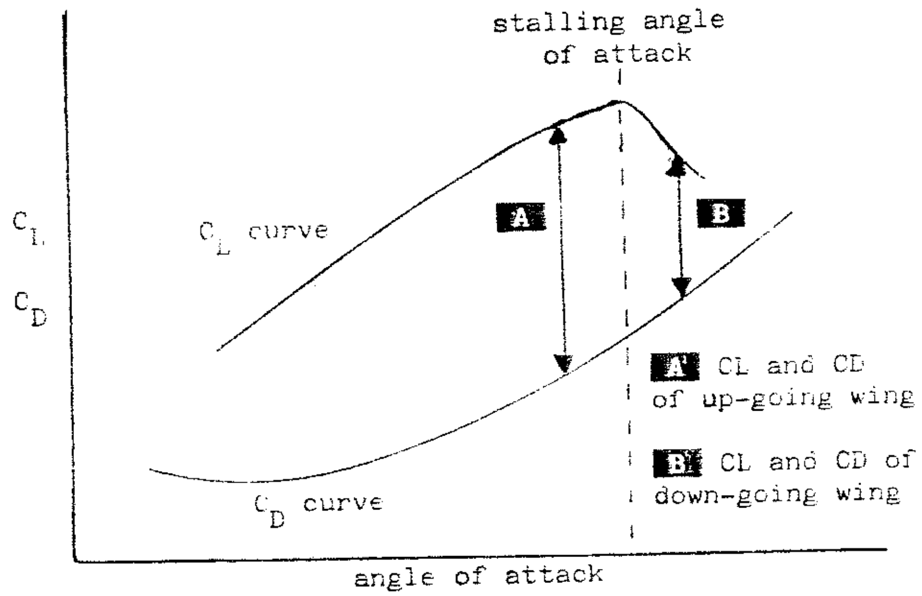


Fig 11.1 Variation of CL and CD curves with angle of attack

6 If this cycle continues, the result is a stalled wing with the nose of the aircraft rotating automatically towards the lower wing. This is known as autorotation. The process of autorotation, if not checked, can lead to a number of complicated and unsteady manoeuvres involving motions about all three aircraft axes and these motions may, in turn, lead into a spin.

7 To summarize, the circumstances that must prevail before an aircraft will spin are:

* The aircraft must be stalled.

* There must be yaw.

During the course of your flying training, you will find that your aircraft may assume some unusual attitudes. However, whatever attitude your aircraft is in it will not spin without yaw. We can now define a spin:

* A spin is a condition of STALLED flight in which the aircraft describes a SPIRAL DESCENT. During a spin, the aircraft is simultaneously auto-rotating, pitching, and yawing - these movements continuing automatically until recovery is initiated by the pilot.

Characteristics of the Spin

8 It should be clearly understood that not only will the spin characteristics differ greatly between aircraft types, but also that the spin characteristics of a particular aircraft will vary according to several factors, as follows:

* The geometry of the aircraft.

* The distribution of mass throughout the aircraft.

* The setting of the controls.

* The aircraft attitude during the entry to the spin.

For these reasons, it is not possible to generalize about all types of spins and only the T67 spin characteristics are discussed here. Aircraft such as the T67 which are cleared for spinning are said to have a 'normal spin'. The normal spin is a smooth, settled motion in which the aircraft describes a steady, descending, corkscrew path about a vertical axis with the mean angle of the wings greater than the stalling angle (Fig 11.2). In the T67M, the first two turns may be oscillatory in nature with changing rates of pitch and yaw. Thereafter, the rates of pitch, yaw and roll stabilise and the spin becomes steady.

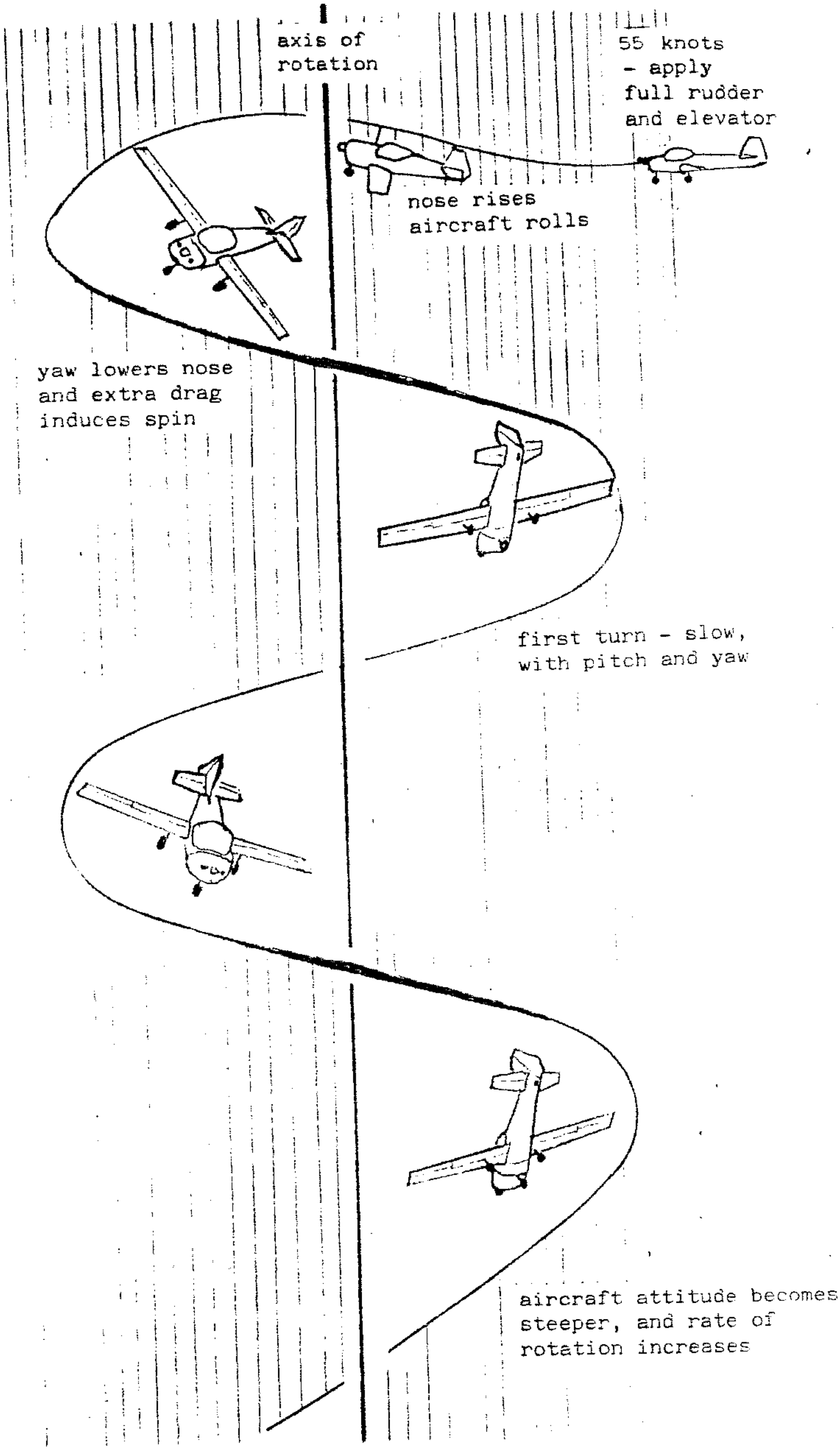


Fig 11.2 Normal Spin

AIRMANSHIP

Safety Checks

9 Before you commence practice spinning, carry out the HASELL checks which were introduced in Exercise 10. Your height loss in a spin and subsequent recovery will be greater than when carrying out a stall and recovery; so make sure you start with sufficient height above your minimum recovery height. To prevent disorientation, never spin when there is a poorly defined horizon.

Recovery Instructions

10 During a spin, the aircraft can lose height quite quickly. It is important, therefore, that you take immediate recovery action when told to do so by your instructor. To prevent any misunderstanding, your instructor will say 'Recover now', and you must acknowledge by saying 'Recovering now, Sir'. If you do not acknowledge your instructor's order in this way he will assume that you have not heard him and he will take control of the aircraft and carry out the recovery.

Aircraft Limitations

11 The aircraft is cleared for a maximum of eight (8) turns of a spin.

AIR EXERCISE

Sequence

12 The aim of the exercise is to accustom you to spinning and to teach you how to enter, maintain and recover from a spin. The exercise is taught in two parts: the first part deals with entering and recovering from spins started from level flight; the second part deals with recovery from spins entered during manoeuvres.

Demonstration Spin

13 If you have not been shown a spin before, your instructor will begin the exercise by demonstrating a fully-developed spin. Note that having induced the spin, there is no problem in recovering.

Spin Entry From Level Flight

14 Your instructor will show you how to enter the spin and then you will practice. Before each spin, make sure that the area around and, particularly, below you is clear. Begin as if you were going to enter a stall from straight and level flight:

* Close the throttle and maintain level flight as the airspeed decreases.

* To achieve a positive entry to a spin, we induce the aircraft to yaw at a speed slightly above the stall. At stall warning, firmly apply full rudder in the direction you wish to spin and, at the same time, move the control column fully back keeping the ailerons neutral. Ensure you obtain full control deflection to ensure the aircraft enters a normal erect spin.

* Hold the controls firmly in this "pro-spin" position.

* As the controls are applied, the nose rises and the aircraft rolls sharply in the direction of spin.

* For the first turn or two, the spin is in the oscillatory stage, which is identified by erratic movements about the aircraft axis. It then settles into a steady state of rotation in quite a steep attitude.

Maintaining the Spin

15 The spin is maintained by keeping the controls in the full pro-spin position (as described above). Make sure that you maintain full rudder and full up elevator and that you keep the ailerons neutral. During the exercise your instructor will point our several features. When he does so, try to look by moving your eyes rather than your head; in this way you will reduce any feeling of disorientation. For the same reason, when looking out, avoid looking at the ground immediately over the nose of the aircraft and look up instead towards the horizon. In a spin, the main instrument indications are as follows:

* The altimeter and VSI will show a high rate of descent.

* The turn co-ordinator will show full deflection in the direction of the spin.

* The airspeed will remain at a constant low value. This is not necessarily below the stalling speed and will vary with the direction of rotation.

Recovery Actions

16 Just as the entry to the spin requires firm, positive movement of the controls so also does the recovery from the spin. We entered the spin by applying yaw and stalling the aircraft. The recovery is made by correcting the yaw and unstalling the aircraft:

* Apply full rudder opposite to the direction of the spin; immediately the rudder has been applied move the control column smoothly and firmly forward until the spin stops ensuring that the ailerons are neutral throughout.

* Immediately the spin stops - but not before - centralize the rudder, level the wings with aileron and ease out of the dive.

* Apply power when the nose reaches the horizon and climb.

You will notice that the initial forward movement of the control column requires little effort but, after a short travel, slightly more pressure will be required to sustain the movement. Make sure you keep the ailerons neutral. Any attempt to slow the roll with ailerons will have the same effect as using ailerons to correct wing drop at the stall: it will merely make the spin more stable and slow the recovery. Depending on the spin conditions, it may be necessary to move the control column fully forward to stop the spin.

Spin Steepening

17 Having settled in the spin, do not expect instantaneous recovery when you move the controls. As your spin recovery actions take effect the nose-down attitude steepens and the rate of roll appears to increase. Your first reaction to this may be to think that you have done the wrong thing and made the spin worse. Your second reaction could then be to change the recovery control movements you have made. But don't do it; do not be led astray. The steepening of the spin is, in fact, a sign that your recovery action is taking effect.

'g' Effects

18 As you pull out of the dive, brace yourself against any 'g' effects. During a spin, your 'g' threshold may be lowered, so that even the small amount of 'g' present in a normal pull-out is noticeable. Do not be surprised if you have a little difficulty in accurately levelling the wings after the spin has stopped. This is due to slight disorientation following the change from rotating flight to straight flight and this symptom will tend to disappear as you become accustomed to spinning.

Throttle Position

19 If you spin from a manoeuvre and have power applied, this power will increase your rate of descent in the spin and increase the height lost before recovery. Therefore, to our recovery actions, we add a check that the throttle is closed.

Aileron Position

20 Should you spin from a manoeuvre it is unlikely that the ailerons will be in the desired neutral position, so we add a further check of 'ailerons neutral' to our recovery actions.

Flap Position

21 The aircraft recovers from a spin with less height loss if the flaps are up; also there is the possibility of overstressing the flaps during the recovery, so we add a further check that the flaps are up.

Use of the Turn Co-ordinator

22 As you will be shown later, it is quite possible to manoeuvre your aircraft in one direction and, through mishandling, spin in another. The tendency will be to think that you are spinning in the direction of the original manoeuvre. Obviously, we must be certain that we know the direction of spin in order to use the correct rudder movement for recovery. This brings us back to the turn co-ordinator which, as we know, indicates the direction of spin. A glance at the instrument will indicate which rudder movement must be used to recover from the spin - e.g. turn left, use right rudder; turn right, use left rudder.

T67 Spin Recovery

23 By adding to our recovery actions at para 16, the checks on throttle position, turn co-ordinator and ailerons, we have evolved the T67 Spin Recovery. This can be summarized as follows:

- a Check that the throttle is closed and flaps are up.
- b Check direction of rotation - turn co-ordinator.
- c Apply and maintain full rudder to oppose yaw.
- d Immediately full rudder is applied move the control column smoothly and firmly forward until the spin stops ensuring that the ailerons are neutral throughout.
- e Centralize the rudder when spin stops.
- f Level the wings with aileron and ease out of the dive, bracing yourself against any 'g' effects.
- g Apply full power as the nose reaches the horizon and climb away.

Due to the high rates of descent involved, it is also important that you monitor height during any spin. If you are unfortunate enough to enter a spin accidentally you will not have conveniently calculated your entry height beforehand.

Recovery at the Incipient Stage

24 If we spin accidentally, we normally recover as soon as possible. This will usually be before the spin has developed - i.e. at the incipient stage. The recovery is:

- Centralize the controls.
- Apply full power unless the nose is below the horizon.
- Level the wings and climb away.

If the spin has fully developed and the incipient recovery does not work, use the spin recovery drill as in para 22.

Abandoning the Controls

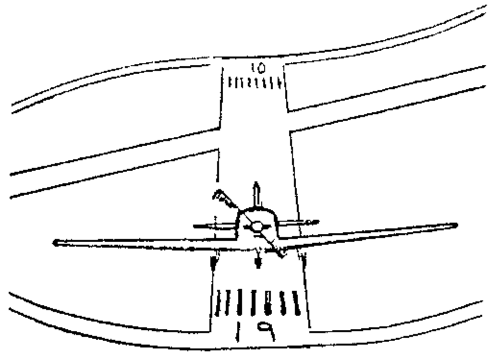
25 If the controls are abandoned during a spin they will remain in the pro-spin condition; the aircraft will not recover from the spin by itself but will remain in a stable spin.

Conclusion

26 You should rarely, if ever, find yourself spinning accidentally during your flying career because an accidental spin only results from mishandling of the controls. However, there is always the risk of an accidental spin and, for that reason, we spin deliberately to accustom ourselves to the sensations of spinning and to practise the recovery drill until it becomes automatic.

EXERCISE 12

TAKE-OFF AND CLIMB



Introduction

1 Before being given detailed instruction on this exercise, you will have had ample opportunity to watch your instructor do several take-offs. You will also have been given the opportunity to assist on some of these take-offs by operating some of the controls.

2 A take-off involves accelerating the aircraft on the ground until it attains flying speed, flying the aircraft off the ground, and establishing a climb at normal climbing speed. The subsequent climb-away procedure will depend on whether the aircraft is leaving the circuit for upper-air work or is remaining in the circuit to practise circuits and landings.

PRINCIPLES OF FLIGHT

Unstick Speed

3 In order to take off safely, the aircraft must be accelerated to its 'unstick speed' (which is approximately 15% above the stalling speed). At this point, there is sufficient speed to enable the angle of attack to be increased and so provide the lift necessary for the aircraft to leave the ground.

Yaw on Take-off

4 As you accelerate to unstick speed, the aircraft will show a tendency to yaw. The factors which cause this tendency are as follows:

a **Slipstream** The column of air forced rearwards by the propeller has a rotary motion and, therefore, meets the fin and rudder at an angle. The fin is an aerofoil section and, if an airflow is at an angle, it will provide 'lift'. This 'lift' acts to the right or to the left depending upon the rotation of the airflow, and causes the nose of the aircraft to yaw. The slipstream produced by a right hand propeller meets the fin and rudder from the left. Lift is, therefore, generated to the right, causing the aircraft to tend to yaw to the left. As the speed of the aircraft increases towards the unstick speed, the airflow passing the fuselage starts to straighten and meet the fin and rudder at a lower angle of attack. Therefore, the tendency to yaw due to slipstream effect decreases as the aircraft approaches its unstick speed.

b **Torque reaction** The engine produces the torque force which causes the propeller to rotate. The reaction to this torque force, known as torque reaction, causes the aircraft to try to rotate around the propeller shaft in the opposite direction to the propeller rotation. As seen by the pilot, the T67 tends to rotate to the left. Clearly, the aircraft does not actually rotate but the effect of torque reaction in the T67 is to put more weight on the port wheel than on the starboard wheel. The increased friction of the port wheel causes the nose of the aircraft to tend to yaw to the left during take-off - although the effect is only slight because of the relatively low-powered engine.

Factors Affecting the Length of the Take-off Run

5 Never treat a take-off as routine, because there are many factors which affect the length of the take-off run. These factors are as follows:

a **All-up weight** We have already seen in Exercise 10 (Stalling) that as the weight is increased the stalling speed increases. We also noted in para 3 that we need to accelerate to some 15% above stalling speed before take-off. It follows that if the stalling speed is increased because of increased weight, the take-off speed will also be increased. In addition, because of the heavier weight, the inertia is greater and this reduces the rate of acceleration. The lower rate of acceleration and the need to accelerate to a higher take-off speed both lead to a longer take-off run.

b **Wind velocity** Wherever possible, take off into wind. This will lead to a shorter take-off run because the aircraft, pointing into wind, already has an IAS equivalent to the wind speed (Fig 12.1). If you take off downwind, you start with a minus quantity in airspeed and need a very long take-off to overcome this deficiency. If you take off with a crosswind, then you will lose some, or all, of your headwind component and the take-off run will again need to be long.

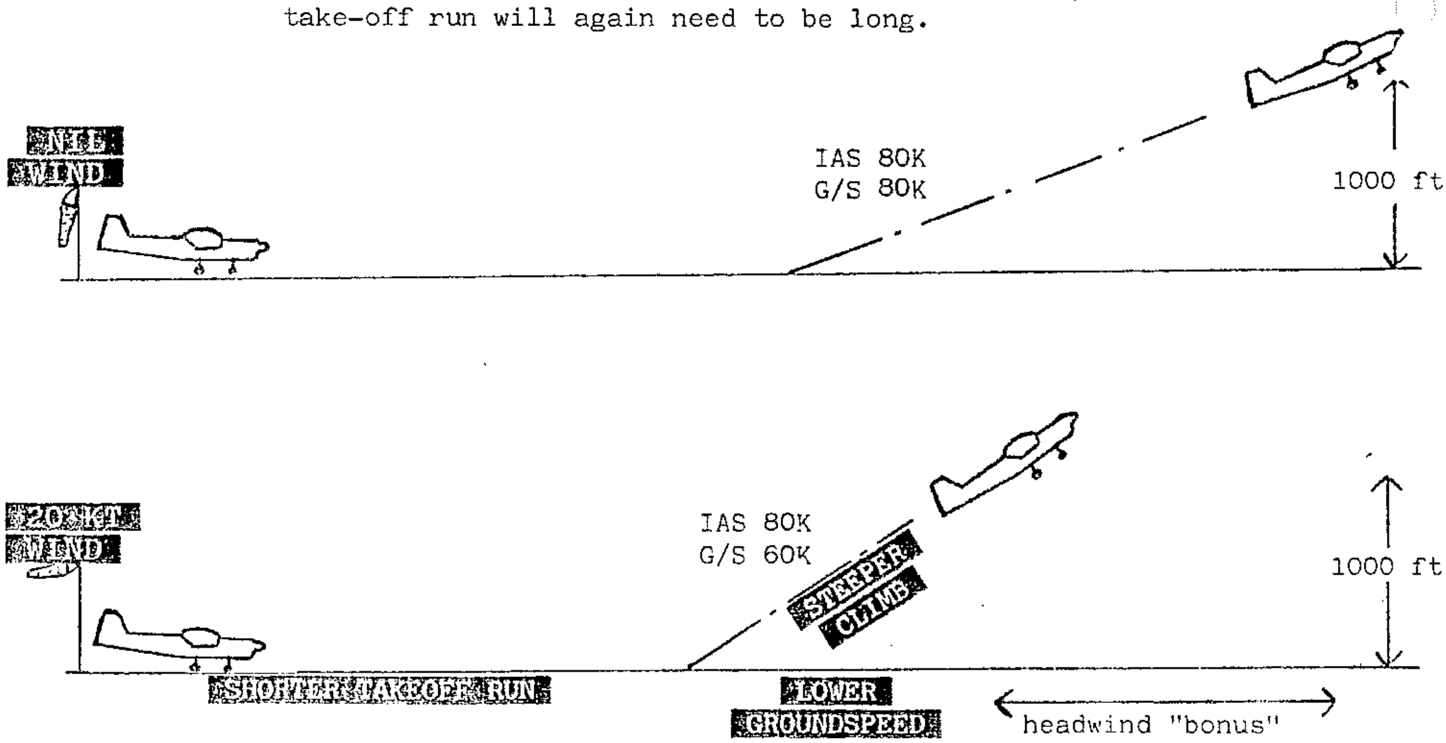


Fig 12.1 Effects of headwind on the take-off run

The additional advantages of taking off into wind are:

1 The ground speed at the time of unstick is lower.

2 A lower ground speed reduces the stresses on the under-carriage and tyres.

3 The rate of climb is unaffected by the take-off direction, but climbing into wind gives a lower ground speed and, therefore, a steeper angle of climb (Fig 12.1).

4 If the engine malfunctions during the take-off run, the lower ground speed will make it easier to stop the aircraft, and the shorter take-off run means that more runway remains available to bring the aircraft to a halt.

c **Flap** Half flap increases the lift obtainable from the wings, reduces the stalling speed, and enables you to take off at a lower indicated airspeed. This means that you will have a shorter take-off run.

d **Engine power** The more power you have available for a given aircraft all-up weight, the better will be your rate of acceleration and the shorter will be your take-off run. Altitude and air temperature, both of which affect engine power, will be discussed later.

e **Gradient of the take-off path** If you take off on an up-hill slope, you will have less acceleration and the take-off run will be longer. An adverse slope of 1° will give approximately a 10% increase in take-off distance.

f **Surface of the take-off path** Any surface that retards the wheels will lengthen the take-off run. Thus, your shortest take-off run (all other factors being constant) will be made on the dry surface of a runway.

* If there are puddles on the runway they can produce a marked retardation - you may have felt this effect when driving a car.

* Compared with a runway take-off, a take-off on grass will mean a longer take-off run. The height of the grass will give you a guide as to the extra distance you will require.

* Wet ground will hinder your acceleration because the wheels will tend to sink into the surface.

* Snow and slush have a similar, but more dramatic, effect and you should not attempt to take off if the depth of slush exceeds ½ inch or the depth of dry snow exceeds 2½ inches. Remember that even less than ½ inch of slush can increase the length of your take-off run by 50%.

g **Air temperature** An increase in air temperature leads to a decrease in air density. This means that your IAS for take-off is reached at a higher TAS and, therefore, at a higher ground speed. Thus, as you have to reach a higher ground speed before unstick, your take-off run will be longer. Low air density also means less engine power available and this, too, will increase your take-off run.

h **Airfield elevation** High airfield elevation means reduced air densities so that the length of your take-off run will again be increased (for the reasons given in sub-para g above).

Use of Controls

6 Remember that the flying controls gradually become more effective as the speed increases during the take-off run. This increased effectiveness is less marked with the rudder while the nose-wheel is on the ground because nose-wheel steering is unaffected by speed.

AIRMANSHIP

General Points

7 A high standard of airmanship is essential to assist you safely and speedily to position yourself for take-off, and then take off, and clear from, or join, the circuit. We can discuss airmanship under four headings as follows:

a Use of RT.

b Engine testing.

c Vital Actions before take-off.

d Lookout.

Use of RT

8 All aircraft movements on the airfield and in the circuit area are controlled by the Tower Air Traffic Controller - usually referred to as 'Tower Control' or just 'Tower'. On your base airfield, this frequency is used for taxying instructions, take-off clearance, and control of aircraft flying in the circuit. The Tower frequency is, thus, usually very busy and it is most important that you adhere rigidly to the standard RT procedures.

* Maintain a vigilant listening watch for specific air traffic instructions directed at you.

* Listen-out before you press the transmit button and, thus, avoid blocking another transmission.

* Before you press the transmit button, think about your message and clarify in your mind what you are going to say. Remember 'Engage brain before operating mouth'.

* Equally important, try to anticipate the form of reply. This will enable you to absorb more easily the information passed, so that you do not just acknowledge a transmission without realizing its significance.

* If you do not understand a transmission made to you from the tower, do not hesitate to ask the Controller to 'Say again'.

Engine Testing

9 Before every flight we check that the spark plugs and magnetos are all working correctly: on the first flight of each day the correct operation of the propeller constant speed unit is also checked. These checks are done at a fairly high power setting and are normally carried out away from the dispersal area because high power means lots of slipstream, and we do not want to cause any damage to other aircraft or injury to personnel. Also, it is desirable to have a clear area ahead of the aircraft in case of brake failure. The engine test procedure is given in the Flight Check Cards (FRCs).

Vital Actions Before Take-off

10 The vital actions before take-of. are the minimum number of checks you must do in order to take off safely. Avoid rushing these checks because you think that you are hindering other aircraft behind you or because you are going to be late in taking off. Remember that they are VITAL actions; all checks are equally important and must be carried out conscientiously. You will have ample opportunity to learn the checks but, if you are uncertain that you have done them all correctly, you can always check against your Card (which you must always carry in your flying overalls).

Lookout

11 In the busy area around an airfield, lookout is absolutely vital. Not only is it important for you to see other aircraft, but you must also be able to anticipate their movements and plan your own movements accordingly. Your instructor will give you more detailed instruction on this important aspect of circuit flying. As far as this exercise is concerned, the following points are not readily appreciated by a student and you are advised to note them carefully:

a At the marshalling point, you will park your aircraft so that the slipstream does not interfere with aircraft behind. You must also point towards the runway so that you can see any aircraft on base leg and finals. When you have completed your Vital Actions, look out to make sure that the runway is clear and that no aircraft are on base leg or finals before you request take-off clearance. This lookout becomes even more important on an airfield with no RT control.

b Having established the climb after take-off, look out all round you - but pay particular attention to the areas above and behind you to note if there are any aircraft overshooting from finals or joining the circuit.

AIR EXERCISE

Sequence

12 By now, you should be proficient at taxying the aircraft and doing the engine test. The air exercise is concerned with the following points which are discussed in the paragraphs that follow:

- a Actions at the marshalling point.
- b Lining up on the runway.
- c Taking off into wind.
- d Common faults.
- e Crosswind take-off.
- f Short take-off.
- g Clearing the circuit.
- h Joining the circuit.
- j Engine failure during the take-off run.
- k Engine failure immediately after take-off.
- l Engine failure during the climb after take-off.
- m Engine failure in the circuit.

Actions at the Marshalling Point

13 When you are given taxi clearance you will be told the 'Runway in Use'. Each runway has a 'holding point' known as the marshalling point. If the marshalling point is on a taxiway, it will be marked with a solid and broken yellow line on the taxiway and adjacent to this, but off the taxiway, may be a yellow board with the runway heading indicated in black figures (Fig 12.2).

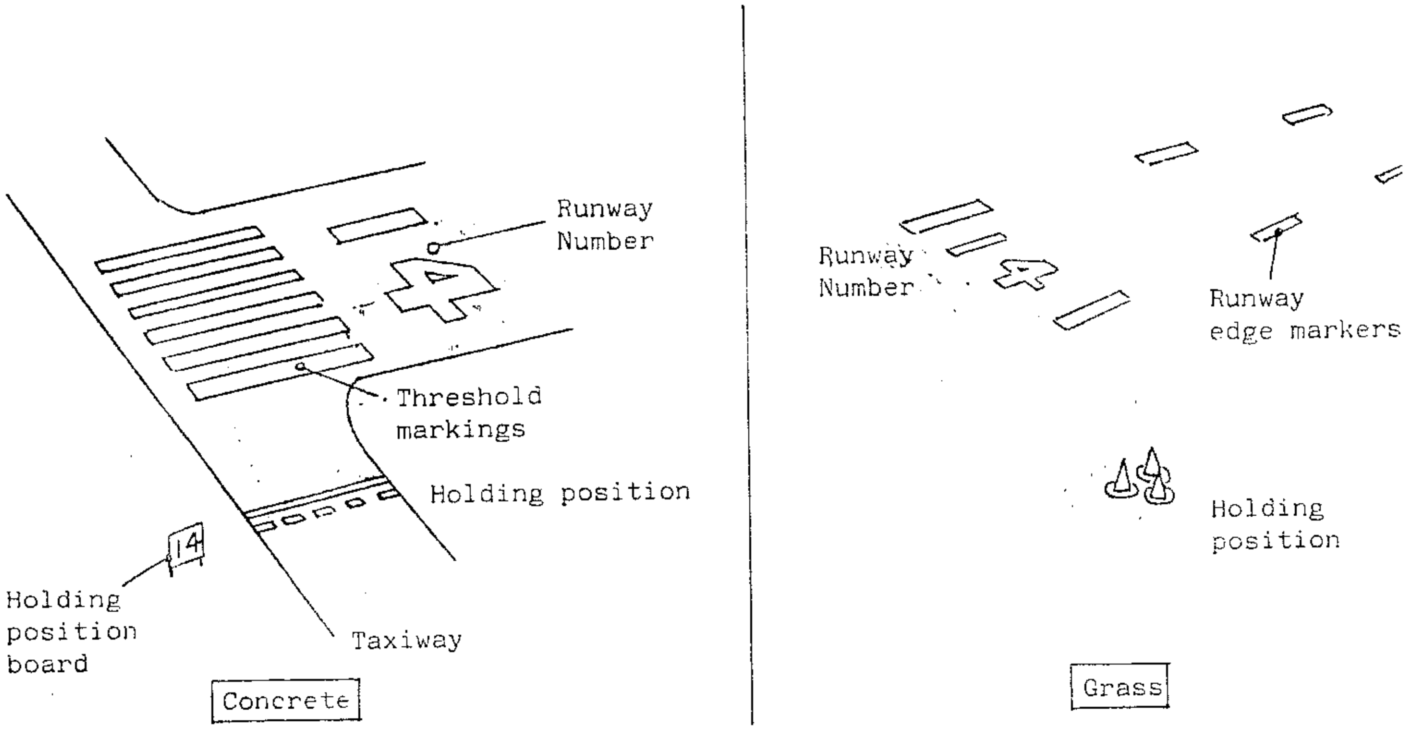


Fig 12.2 Marshalling point

14 When you reach the marshalling point, proceed as follows:

a Stop the aircraft in such a position that you can see:

* The base leg and the final approach.
* The runway caravan (if provided).
* The control tower (if possible).

b With 1200 rpm set, carry out your Vital Actions before take-off.

c Check that the approach and runway are clear and obtain take-off clearance.

d If there is a runway caravan, look to see if there are any lastminute signals.

Lining Up on the Runway

15 As soon as you have been given take-off clearance, taxi forward on to the runway. Taxi at your normal speed and, as you approach your runway or take-off path, have a look at the final approach to make sure that you are clear to proceed. Remember the phrase 'there is nothing so useless as the runway length behind you' and position yourself at the end of the runway so that you have the maximum length of runway available for your take-off. Always line up in the centre of the runway and, after completing your turn to line up, roll forward to make sure that the aircraft is straight. Brake gently to a halt.

Taking Off into Wind

16 In your first attempts, you will not find the take-off easy. It requires a lot of concentration, but try to avoid becoming tense. Tenseness may cause you to take a vice-like grip on the controls and this will probably lead to over-controlling.

* Before starting your take-off, check the wind direction and, if there is a caravan, have a look for any last-minute signals (Fig 12.3).

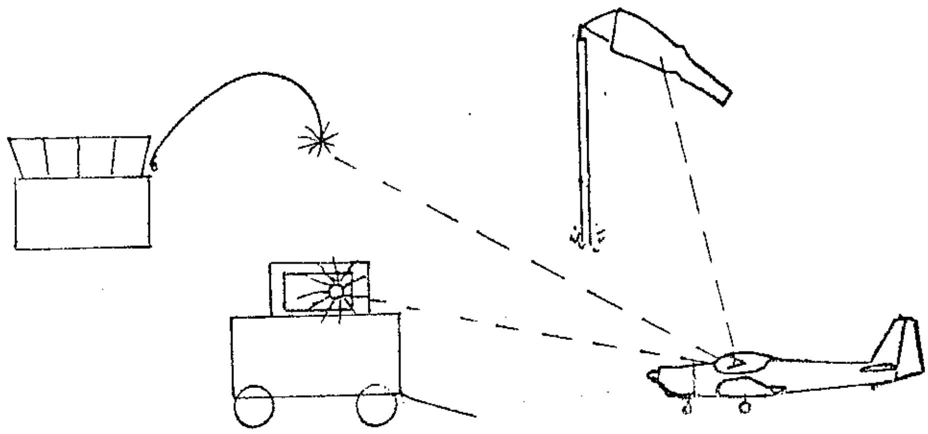


Fig 12.3 Taking off into wind

* Release the brakes and, 'olding the control column central, firmly but smoothly advance the throttle to full power. While you are doing this, correct any yawing movements of the nose with rudder (nosewheel steering).

* At 45K move the control smoothly rearward until the nosewheel leaves the ground. You will now feel the aircraft 'coming to life'. The controls feel firm and the aircraft feels light on the wheels as if they are barely touching the ground.

* Hold the take-off attitude previously demonstrated to you and keep straight using the rudder; the aircraft will fly itself off the ground at 50-55K.

* Once airborne, hold the pitch attitude you had at lift-off, keep the wings level, check that you have a positive rate of climb and check that the speed is increasing towards climbing speed. Check also that you are in balance.

* At 70K select the normal climbing attitude, pick a reference point on which to keep straight, check that you are in balance and trim the aircraft.

* Look out all round you - but particularly above and behind. If all is clear, carry out the after-take-off checks.

Common Faults

17 The faults discussed in this paragraph do not apply to every student, so do not imagine you are going to make all the errors mentioned - or even any of them! However, the pitfalls are there; so be warned. We shall consider the possible faults at the different phases of take-off as follows:

a **Raising the nosewheel** Until you are familiar with the amount of control movement required, take things very easily when raising the nosewheel. Too harsh a backward movement may cause the tail to touch the ground.

b **Leaving the ground** If you hold the take-off attitude, the aircraft will fly itself off at 50-55K. Should you attempt to leave the ground too soon (or if your original attitude was too nose-high) you may start to bounce. With the wings at a high angle of attack and supporting much of the aircraft's weight, it needs only a small irregularity in the ground to bounce the aircraft into the air. Since there is insufficient lift to keep the aircraft airborne, it will sink back on to the main wheels. If you instinctively move the control column back at this stage (which is the tendency), you may 'drag' the aircraft back into the air in a near-stalled condition. Alternatively, you may slightly miss-time your rearward movement of the control column so that you accentuate the bounce caused by the undercarriage oleos rebounding. The correct technique is to select the right attitude when you initially raise the nose and, thereafter, to fly the aircraft off at 50-55K. If you do start to bounce, hold the control column neutral until you have flying speed and then lift the aircraft clear of the ground. Beware of trying to correct the bounces with control movements that get out of phase, leading to a kangaroo-style departure (Fig 12.4).

c **Climbing after take-off** Do not be too anxious to select the climbing attitude, otherwise you will climb away from the ground at a low airspeed. Treat this period of flight as a transitional period where you are completing the take-off by climbing - albeit gently - away from the ground, at the same time accelerating to your correct climbing speed.

Fig 12.4 Beware of kangaroo-style departure

Crosswind Take-off

18 In Exercise 5, we discussed the effect of a crosswind on taxying. The effect discussed there also applies to the take-off run when the aircraft will try to weathercock into any crosswind. This tendency is easily overcome with nosewheel steering. A crosswind component of about 8 kts or more can be considered significant for T67 operations.

19 Consider also the effect of drift caused by a crosswind. We take off along the given direction of our take-off path and, as soon as we become airborne, the aircraft will drift sideways because of the wind. If we then allow the aircraft to sink back on to the runway, we will impose undesirable side loads on the undercarriage. Our crosswind take-off technique is designed to prevent over-stressing the undercarriage and we do this by preventing the aircraft sinking back on to the runway with drift on. The technique is to make sure that the aircraft does not become airborne at too low a speed - achieved by keeping the nosewheel on the runway until we reach 55K. At this point, move the control column rearwards so that the aircraft leaves the ground cleanly. Climb away normally at first but, when safely off the ground, use 10° of bank to turn the aircraft towards the wind. Straighten up so that you can continue the climbing track along the extended centre line of the runway.

Clearing the Circuit

20 Unless your airfield has a specified departure procedure, clear from the circuit using either of the following two methods:

a **Climb out followed by climbing turn** Proceed as shown in (Fig 12.5) and described below:

* Climb out on the extended centre line of the runway to 500 ft.

* Look out, and then make a climbing turn in the same direction as the circuit pattern.

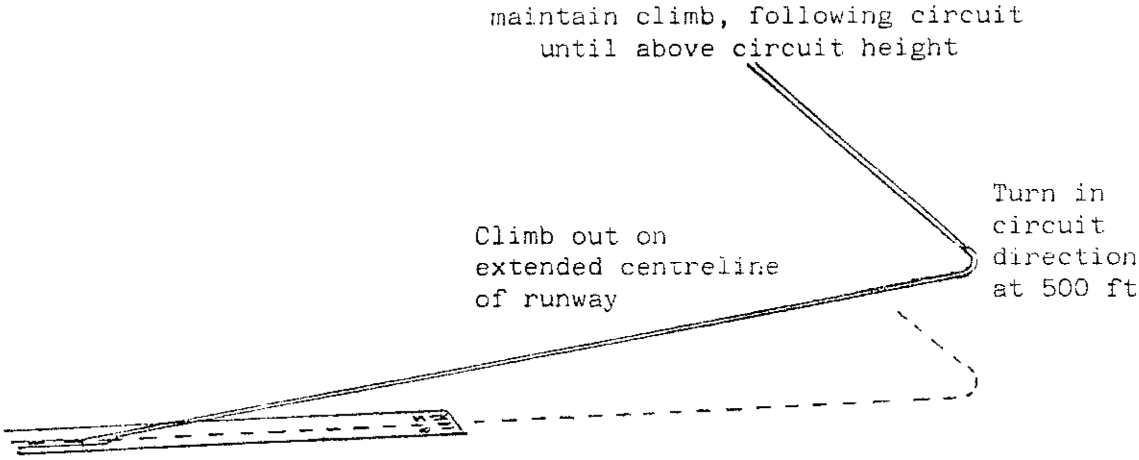


Fig 12.5 Climb out followed by a climbing turn

* Roll out of the turn to track at right angles to the runway and continue to climb.

* Once above circuit height, keep a good lookout for aircraft rejoining the circuit and then head direct for your operating area, or make a further turn in the same direction as the circuit pattern and roll out on the required heading.

* The advantage of this method is that, in turning to clear the circuit, you are able to keep a better lookout for other aircraft.

b **Straight climb out** You may also climb straight out on the extended centre line of the runway. Make sure that you keep a good lookout both above and behind you. When you are above circuit height, you may turn in either direction to make for your operating area. This procedure is normally used where the heading required to reach the operating area is close the heading of the runway in use.

Joining the Circuit from Take-off

21 To join the circuit pattern, proceed as follows:

* Climb out on the extended centre line of the runway.

* Look out and, at 500 ft, make a climbing turn in the direction of the circuit pattern.

* Climb to circuit height, level off, accelerate to circuit speed, adjust your power to maintain this speed, and trim.

* Lookout.

* You are now ready to continue the circuit (as discussed in Exercise 13).

Engine Failure During the Take-off Run

22 Engine failure during the take-off run normally presents little problem. If the nose wheel is still on the ground when the engine fails, close the throttle, hold the control column central, and use the brakes to stop the aircraft. When you have stopped, turn off the fuel, the ignition and the battery switch and leave the aircraft immediately taking the cockpit fire extinguisher with you if possible. Retire at full speed to a safe distance and observe the aircraft for signs of fire. Do not risk yourself in an attempt to prevent or put out any fire.

23 If the aircraft is in the flying attitude during the take-off run and the engine fails, proceed as you would when completing a normal landing. Close the throttle and allow the nose wheel to settle on the ground. Then brake to a halt and complete the drill as described in para 22 above.

Engine Failure Immediately After Take-off

24 Except on the shortest of runways, engine failure just after take-off should still leave enough runway length to land the aircraft and stop it as before. If the aircraft seems likely to over-run the airfield boundary, consider lengthening the ground run available by turning the aircraft away from the take-off path.

Engine Failure During the Climb After Take-off

25 We are now considering engine failure on the climb between the period when it is no longer possible to land straight ahead on the airfield and straightening up on the downwind leg after the climbing turn. Because of the height loss in turning through 180°, and the danger of stalling in the turn, you should not attempt to turn back to the airfield until you have had the necessary instruction and practice in the exercise.

26 Let us consider an engine failure at 300 ft after crossing the airfield boundary on the climb. You are in the climbing attitude and the engine fails:

* The first thing you must do is to lower the nose of the aircraft to the gliding attitude before you stall. At the same time, close the throttle and carry out the fire drill if necessary.

* You now have time to think and the important subject for thought is where you are going to land. Pick a field, preferably within 30° either side of the nose as this will mean that you can land virtually into wind without losing extra height in making large turns.

* Having picked a field, you must now plan your approach. Think about the wind strength and decide when you are going to use flap. Do not lower full flap until you are sure of reaching your selected field.

* Having planned what you are going to do, there is now time to take further action to ensure your safety. Do the forced landing checks and make a Mayday call to tell Air Traffic Control of your engine failure.

* Now concentrate on your final approach and land in your chosen field.

You may find that an engine failure near the ground, when you least expect it, causes such a shock that it is difficult to take the necessary positive action. For this reason, you will practise the exercise frequently. You will find it a great help if you learn the actions off by heart. These are summarized below:

a Select the gliding attitude (and carry out the fire drill if necessary).

b Pick a field.

c Plan the approach (use of flap).

d Make Mayday call.

e Carry out forced landing checks.

f Carry out final approach and landing.

Turnbacks

27 Turning back to the airfield following an engine failure after takeoff is a manoeuvre which requires considerable skill and judgement. Fortunately, the T67 has a high aspect ratio wing and loses comparatively little height in a gliding turn if flown properly; thus, dependent on the skill and speed with which the aircraft is handled, it may be practicable to turn back following an engine failure after takeoff. The minimum height from which one should be attempted is 500 ft and unless the airfield is small and the surface wind light, it should be practicable to land back from this height. The decision on whether to turn back or not requires a lot of thought and could not be safely made in a hurry in the air; thus the airfield conditions should be carefully considered before takeoff and decisions made on the plans to be followed if the engine should fail. The following actions are a general guide but may need varying to suit the circumstances:

a Select the gliding attitude and achieve 80 kts.

b Turn (into wind if there is any crosswind) using 45° bank.

c Plan the approach.

d Make an emergency call.

e Carry out forced landing checks.

f Carry out final approach and landing.

28 Experience has shown that the height losses during a turnback manoeuvre are approximately as follows:

Ht lost in establishing a 80 kt glide	50'
Ht lost in 180° turn @ 80 kts @ 45° bank	225'
Allowance for further manoeuvering to line up with runway	125'
Min ht for wings level final approach	100'
	500'

It can be seen that, for a large open grass airfield, it could be possible safely to start a turnback from as low as 350'; this is one of the possibilities that should be covered when carrying out the pre-takeoff emergency brief.

29 If half or full flap is still down at the point of engine failure, a considerable increase in the height loss allowances will be incurred - particularly with full flap. It is not recommended that a turn back be attempted if any flap is down unless conditions are outstandingly favourable.

Engine Failure in the Circuit

30 After completing the turn on to the downwind leg you should have no trouble in landing on the airfield should the engine fail in the circuit. Do not feel that you are obliged to land on a runway. Any unobstructed path is satisfactory - but obviously it will be better if you can get into, or nearly into, wind for your landing. How you would land on your particular airfield after engine failure at different points in the circuit is a matter for discussion between you and your instructor. However, your actions will be as follows:

a Glide at 80K (and carry out the fire drill if necessary).

b Choose your landing path.

c Plan the approach (use of flap).

d Make Mayday call.

e Carry out forced landing checks.

f Carry out final approach and landing.

Conclusions

31 Both ground handling and in-flight handling are involved in performing a take-off, and you must learn to make the transition from one to the other with smoothness and co-ordination. After becoming airborne, the aircraft must be climbed away safely. Never treat any take-off as routine; always be aware of the many factors which affect your take-off distance and the subsequent climb. Carefully learn your actions in the event of engine failure, and practise them frequently. Never be lulled into a false sense of security no matter how many take-offs you have accomplished successfully.

Exercise 13

A P P R O A C H   A N D   L A N D I N G

Introduction

1 When you first saw an aircraft land, you probably thought that the procedure looked difficult - even dangerous. A student, struggling to come to terms with his aircraft, once remarked that any fool could fly an aircraft; the trouble was that hardly anyone could land it properly! However, although the knack of successful landing takes time to master, the problem is nothing like as daunting as it may appear at first. Already you will have found, for example, that the closing speed between the aircraft and the ground is not as high as perhaps you first thought.

2 Nevertheless, you will find, at first, that flying during an approach and landing seems much more demanding than upper air work. You will tend to feel rushed initially, and you may have the impression that you are 'lagging behind' the aircraft. In this respect, you can help yourself and your instructor by learning your checks thoroughly. You can then complete them quickly and accurately so that you are ready for the next phase of the 'circuit'. Also, as you progress to different types of circuit, you must learn the different circuit procedures (which are attached as Annexes to this Exercise) so that your actions become almost automatic. Finally, it is important that you familiarize yourself with the standard rejoining procedure.

Sequence

3 The aim of this exercise is to learn the various techniques of approaching and landing. These techniques will be taught in a certain sequence:

* To start, you will be concerned with the standard circuit and the normal powered approach.

* Later, you will learn how to land from a glide approach and from a flapless approach.

* In subsequent exercises, you will learn:

  How to cope with different weather and wind conditions.

  How to rejoin the circuit.

  The procedure for going round again from a misjudged approach or landing.

  How to land in a restricted space using the short landing technique.

DEFINITIONS

New Terms and Phrases

4 In this exercise we shall be using several terms and phrases which are new to you. We have for example, already used the term 'circuit' in para 2. So let us start with a series of definitions.

The Circuit

5 To position and prepare for a landing, the pilot has to take account of the wind, the runway, and other aircraft. Experience has shown that this can be done more easily and more safely by flying an organized pattern around the landing path at a given height. This organized pattern is known as the circuit and is illustrated at Fig 13.1. The circuit direction is normally left-hand (as shown in all the illustrations in this exercise) but it may be right-hand occasionally for some particular reason. The circuit has several distinct parts which are described below.

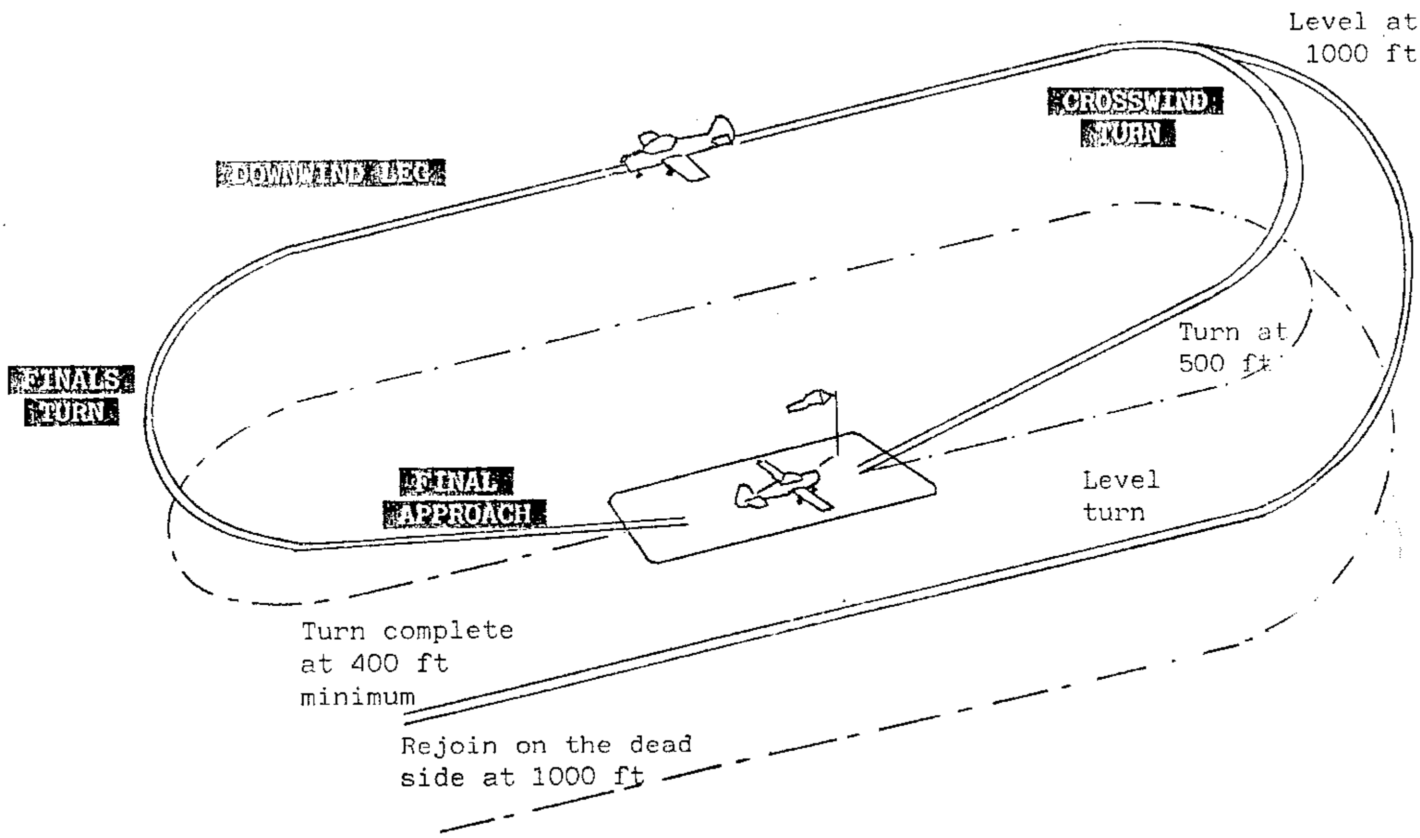


Fig 13.1 The circuit

a **Crosswind turn** This part of the circuit is flown turning away from the runway. If you are rejoining the circuit after an upper air exercise, the crosswind turn is flown at circuit height starting over the upwind end of the runway. If you are starting a normal circuit after take-off, the crosswind turn starts after your climbing turn at 500 ft. Until you reach circuit height, the turn is flown as a climb, and after reaching circuit height it is flown in level flight.

b **Downwind leg** The downwind leg follows the crosswind leg and is flown parallel to the landing path - but in the opposite direction to the landing path. While flying this leg, the pilot prepares the aircraft for landing by doing the landing checks.

c **Finals turn** The finals turn takes the aircraft back towards the runway landing path. During this turn you make further preparations for the landing by reducing height (to between 500 and 600 ft) whilst making a descending turn on to the final approach.

d **Final approach** You should complete your descending turn by 400 ft and, at that stage, be lined up on the extended centre line of the runway in use. After the descending turn from the base leg you begin the final approach.

e **Round-out** The round-out is the stage at the end of the final approach where the pilot puts the aircraft into the landing attitude.

f **Touch-down point** The touch-down point is the point where the aircraft touches its wheels on the ground.

g **Landing run** The landing run refers to the distance covered on the ground after touch-down before the aircraft stops.

h **Dead side** The dead side of the circuit is the airspace extending out from the landing path on the side opposite to that of the downwind leg. Sometimes left and right-handed circuits may be in use simultaneously: under this circumstance there is no 'dead side' as both sides of the circuit are 'live'.

Types of Circuit and Approach

6 After learning the techniques for flying a circuit ending with a normal powered approach, you will go on to learn all the different types of approach and the adjustments you have to make in planning the circuit. The different types of circuit and approach are discussed below.

a **Normal powered approach** For a normal powered approach, the finals turn is so planned that after you have straightened up on the final approach and selected full flap, you need power to enable you to reach the runway. The powered circuit and approach are shown at Annex A.

b **Glide approach** The practice of glide approaches is a lead in to forced landing practice. The circuit for the glide approach is planned so that, when you are on the base leg, you can close the throttle when you estimate that you are within gliding range of your selected initial aiming point. Full flap is lowered in order to achieve a landing at your touchdown point. However you must ensure that the lowering of full flap will not cause you to undershoot. While the application of this technique to landing after an engine failure is obvious, it is also practised as a precision exercise to improve your flying ability and judgement. The glide approach and circuit are shown at Annex B.

c **Flapless approach** The flapless approach is practised so that, should the flap mechanism fail, or wind conditions make a flapless landing advisable, you will be quite familiar with the sort of approach you will have to make. To enable you to use power on the final approach, fly your base leg further from the field than for a normal powered approach. The flapless approach and circuit are shown at Annex C.

d **Crosswind approach** Flying a circuit in a crosswind needs careful planning. The final approach is flown so as to track down the extended centre line of the runway and there is a special technique for the actual landing. The circuit and approach in crosswind conditions are shown at Annex D.

e **Approach for a short landing** The short landing is practised to familiarize you with the techniques of landing your aircraft in a confined space. It is a powered approach in which the airspeed is reduced to little more than stalling speed to minimize the float and hold-off period. Firm braking is used after touch-down to shorten the landing run. The circuit and approach for a short landing are shown at Annex E.

f **Low-level circuit** The low-level circuit is used when the cloud base is lower than the normal circuit height but the visibility below cloud is good. The low-level circuit is shown at Annex F.

g **Bad visibility circuit** The bad visibility circuit is used when the visibility is poor but is, nevertheless, sufficient for the pilot to be able to see the runway or for suitable landmarks to be kept in sight. This circuit is shown at Annex G.

Other Terms Used in Approach and Landing

7 Other terms, frequently used in circuit work, are explained below:

a **Going round again** For many reasons you may find it necessary to discontinue your circuit or approach and 'go round again' for another circuit and landing. If you are still at circuit height, the procedure is to continue a square circuit on to the dead side. On the other hand, if you have started your descent on the base leg or final approach, you employ the overshoot procedure.

b **Touch and go landing** To practice as many landings as possible in a given time, we use the touch and go landing. Instead of stopping the aircraft on the runway after landing, we open up to full power and carry out another take-off.

c **Threshold speed** The threshold speed is that indicated airspeed you should have as you cross the threshold of the landing strip.

Effect of Flap

8 In Exercise 8 you practised using flap for descending, and in Exercise 10 you saw the effect of flap on the stalling speed. When approaching to land, we use flap for the following reasons:

a To give a steeper descent path for a given airspeed (and, hence, better obstacle clearance).

b To give a better view over the nose of the aircraft.

c To give a lower stalling speed which, in turn, enables us to use a lower approach speed and a lower threshold speed. The subsequent touch-down speed will also be lower, giving a shorter landing run.

Effect of Wind on the Circuit

9 Wind direction and strength have a marked effect on circuit flying. In the Annexes, which show the different types of circuit, the wind direction is indicated by the windsock and the aircraft are flying headings to make good the tracks necessary for an oval circuit. Obviously, the headings will vary as the wind varies, so your must be conscious of the wind speed and direction on every circuit you fly. If you do not check the wind when rejoining, you will have a poor chance of making a good circuit and approach. Remember, however, that the windsock will give you a guide to the wind direction at surface level only, and sometimes you will find an unexpected difference between this and the wind at circuit height. If you fly a circuit taking the speed and direction of the surface wind into account, and the circuit fails to conform to the correct shape, think first about the wind and adjust your next effort accordingly. Just as the wind speed affects the descent path on the final approach (see para 10), so it will also affect where you turn from the downwind leg onto the base leg; in very light wind conditions you will need to travel well past the threshold before turning on to the base leg. Setting the DI heading bug to the runway heading will assist in choosing headings to fly on each leg of the circuit.

Effect of Wind on the Final Approach

10 There are three main reasons why, whenever possible, the final approach and landing is made into wind:

a As illustrated in (Fig 13.2), an approach into wind gives a steeper descent path and, hence, better obstacle clearance.

b For a given airspeed, the ground speed is at a minimum. Thus, the ground speed at touch-down is lower when landing into wind and this gives a shorter landing run.

c As there is no drift, the undercarriage will not be subjected to undesirable side loads.

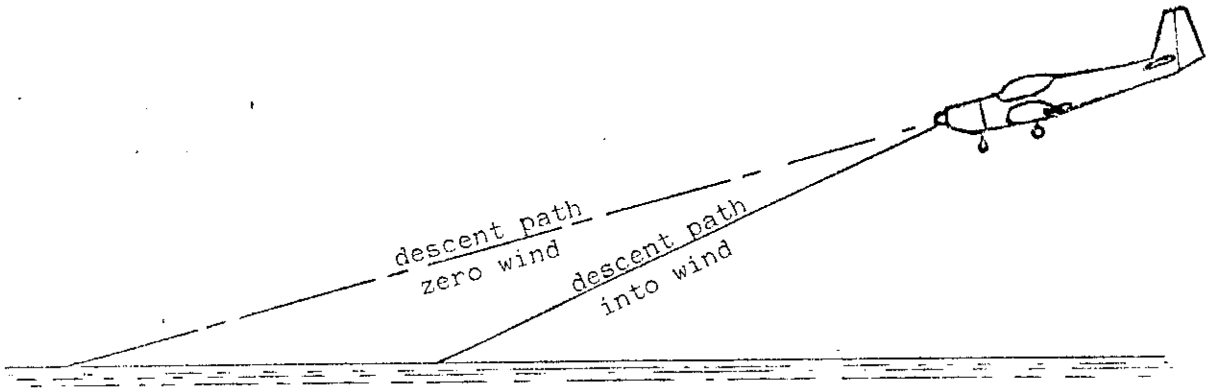


Fig 13.2 Steeper descent path when landing into wind

Wind Gradient

11 In the circuit, the term 'wind gradient' refers to the progressive decrease in wind speed in the lower layers of air near the ground. It is most pronounced when a strong wind is blowing over uneven ground surfaces. A pronounced wind gradient causes a sudden reduction in IAS and this will cause an aircraft, approaching to land, to sink suddenly. Sometimes the wind gradient effect is accentuated by a downdraught which, combined with the loss of lift, can cause the aircraft to sink very rapidly. The dangers of this effect near the ground are obvious. Therefore, if you encounter a wind gradient, use power to arrest the extra rate of descent as the aircraft starts to sink.

Wind Gusts

12 Gusts are caused by eddies and thermal currents, which can cause the wind to change in speed and direction. Gusts are most vigorous when the wind is strong on hot days, because this is when the effect of thermal currents, caused by the uneven heating of the earth's surface, is most pronounced. Gusts can also occur when thunderstorms are nearby. The effect of gusts is similar to that of a wind gradient, except that a sudden increase in airspeed and lift, as well as a decrease, may occur. In very gusty conditions, it may be prudent to use no flap at all.

Manoeuvrability

13 From the end of the downwind leg, and particularly in the later stages of the final approach, you are flying at a reduced airspeed. Because your stalling speed increases in a turn, you must not use more than 30° of bank during the final turn. This is no problem provided that you correctly judge the point at which to start to turn. The most common fault is delaying the start of the turn until the aircraft has almost reached the extended centre line of the runway, and then starting a normal turn which has to be increased to higher angles of bank in order to line up with the runway; this temptation must be resisted. If you find yourself in this situation, discipline yourself to maintain bank. If you have only slightly flown through the centreline, a gentle 'S' turn is permissible to regain it; otherwise you must overshoot and resolve to anticipate more on your next attempt.

Factors Affecting the Landing Run

14 The detailed discussion in Exercise 12 (para 5) of the factors affecting the length of the take-off run will enable you to work out for yourself the factors affecting the length of the landing run. If in doubt, discuss these points with your instructor. The factors are as follows:

- a Aircraft all-up weight.
- b Surface wind (speed and direction).
- c Approach configuration and technique (use of flap and power).
- d Gradient of the landing path.
- e Surface of the landing path.
- f Air temperature.
- g Airfield elevation.
- h Braking technique.

AIRMANSHIP

Need for a High Standard

15 The circuit area may be very busy, with several aircraft practising circuits and landings, taking off, or rejoining. A high standard of airmanship is essential. In particular it is important to remember the points discussed in the following paragraphs.

Rejoining Checks

16 Complete your joining checks when you have the airfield in sight (and, therefore, no longer need assistance on the approach frequency) but before you arrive overhead the airfield. You will then be able to give all your attention to lookout, assessing the wind, and planning your descent to circuit height.

Rejoining Procedure (Annex A)

17 The standard rejoin procedure is only applicable when there is a dead side of the circuit (see para 5h). When no dead side exists Air Traffic Control will instruct you how to join the circuit and will usually require you to join at circuit height direct into the crosswind, downwind or base leg. Familiarise yourself with the standard rejoining procedure, which is shown at Annex H. You will find it difficult, at first, to orientate yourself over the airfield and to identify the runway in use. You will find that it helps if you approach the airfield, keeping the airfield on the same side as you would for a circuit - i.e. for a left-hand circuit approach with the airfield on your left. Then proceed as follows:

* Fly above Air Traffic Zone (usually 2000ft AGL) - or, if this is not possible, then at a safe height below cloud - and turn in the same direction as the circuit direction while you identify the runway in use.

* Look out for other aircraft, check the wind, and establish which side of the airfield is the dead side.

* Position yourself over the live side of the airfield, above the downwind leg, and then turn so that you cross the threshold, tracking at right angles to the runway but pointing towards the dead side.

* Once past the runway, and on the dead side, you are clear to descend. Look out to make sure that the area below you is clear and that no-one is descending from above.

* Throttle back to 1500 rpm and descend at 85K. Never descend in a straight line. If you do, you can easily descend on to another aircraft and if you have not kept a good lookout above you, someone can descend on you. Use just 10° of bank initially in your descending turn; you can always increase the bank later if necessary. But if you start with more bank, then you may find you have to stop the turn and we are back with the undesirable straight descent.

* Aim to complete your descent so that your crosswind leg tracks across the upwind end of the runway at circuit height. This will keep you clear of other aircraft climbing after take-off.

Lookout

18 We have already mentioned the need for a good lookout when rejoining. Lookout when flying the circuit is equally important, because the circuit area is the most congested airspace in which you fly. Thus, keep a good lookout at all times. In particular, remember the following points:

a When turning downwind, watch for aircraft joining on to the downwind leg at circuit heightor for aircraft already in the circuit.

b When doing the pre-landing checks, do not concentrate your gaze in the cockpit for the duration of the checks. Look out before you start the checks and continue to look out for other aircraft, except when it is necessary to look in the cockpit at a particular item listed in the checks.

c On the base leg, look out away from the circuit for other aircraft on finals from different types of circuit or radar approaches. Never start your final descent until you can see all the aircraft that Air Traffic Control have told you are ahead of you.

Vital Actions

19 Be conscientious when doing your landing checks and do each one deliberately. One of the most common faults in carrying out the Vital Actions (VAs) is to recite 'Fuel - contents sufficient' without actually checking that they are.

Circuit Congestion

20 If you find yourself too close to an aircraft ahead of you in the circuit, do not extend your downwind leg to gain more separation. Aircraft behind you will then have to do the same, and the result is that circuits become bigger and bigger so that no-one is able to practise a proper approach. If your separation is inadequate, go around again at circuit height, adjusting your spacing as you do so, so that the next time you are downwind you can continue to make a normal approach from the correct position. Never orbit on the downwind or base legs to gain separation: such action completely baffles those behind you and results in you flying in the wrong direction up the "live" side at one stage - hardly safe!

RT Procedure

21 Always make your RT calls at the correct position in the circuit. This enables Air Traffic Control, and other aircraft to pinpoint where you are in the circuit. Pay close attention to the replies from Air Traffic Control to your Downwind and 'Finals' calls as you will be told whether there any aircraft in front of you who have priority over you.

Misjudged Approach

22 Your chances of making a good landing from a misjudged approach are poor. In such cases you should always go round again and, as you do so, analyse where you made a mistake on your first effort. Never be too proud to admit your mistakes.

Threshold Speed

23 The threshold speeds for each different type of approach are given in the Manual. You must learn these speeds. If there is gustiness or turbulence on the approach, consider increasing the threshold speed by an appropriate amount. In some conditions it may be prudent to use no flap: your instructor will discuss this with you.

Signals Square

24 Nearly every airfield has a signals square. In this square, symbols are used to indicate:

* The direction of take-off and landing.

* The circuit direction.

* Any restrictions or warnings about the use of the airfield.

You must learn the meanings of the symbols used. When rejoining a circuit, never assume that the runway in use and the circuit direction are the same as they were for your original take-off.

AIR EXERCISE

General Points

25 Discussion of the air exercise is devoted mainly to the normal circuit and landing. Some common faults will be mentioned in the text but, in the main, discussion of these will be left to your instructor. He will demonstrate each type of circuit and will then help you to improve your own judgement so that you can, eventually, prevent or correct your own errors. Throughout the exercise, note that the emphasis is on planning ahead to prevent errors. As you progress, you must rely less and less on your instructor, and learn to exercise your own judgement and take action accordingly. Your instructor cannot consider sending you solo until you consistently fly an accurate circuit, make safe landings, and correct mistakes - all without his intervention.

Standard Rejoin

26 We have already discussed the standard rejoin in para 17; the procedure is outlined at Annex H. Your instructor will demonstrate this before you attempt it on your own. When he demonstrates, listen and watch carefully. If there is anything you do not understand, ask for an explanation. Never be afraid to ask questions. If you find that you have problems in orientating yourself, then do some homework with the aid of a sketch-map of the airfield and a map of the area:

* Picture yourself approaching the airfield from your normal operating area and then 'join' for different runways and circuit directions on your sketch-map, mark the dead side and the circuit pattern, and then trace your path round the airfield, inserting heights, airspeeds and power settings until you start your crosswind leg at circuit height. Having done this in still wind conditions, repeat the process for conditions where there is wind. Draw an arrow to indicate the wind down the runway in use and re-trace the circuit pattern, making sure that you adjust your 'heading' to offset the wind effect.

Procedural Rejoin

27 At some airfields, you may not be able to carry out a standard rejoin. Instead, you may be required to join the circuit from a specified ground feature at a given height. This type of rejoin is called a procedural rejoin. Carry out your rejoining checks before reaching your descent point. Descend as for a standard rejoin, ensuring a good lookout before descending and, also, during the descending turn.

The Normal Circuit, Powered Approach, and Landing

28 This is the first type of circuit, approach and landing that you will be shown. You will then be required to practise it. The circuit pattern is drawn at Annex A. This pattern is regarded as the 'standard' circuit, all

other types of circuit being related to, and explained by means of, this standard circuit. We shall break this circuit down into its component parts and discuss each in turn. This is done in the following paragraphs (refer also to Annex A).

29 **Crosswind turn** You normally start this turn at 500 ft but, starting the turn, the speed and direction of the wind must be considered, as it will affect the amount of bank you need to use during the turn. Your aim is to fly downwind at the same distance from the runway on each circuit (Fig 13.3). If the wind is tending to blow you towards the runway during your crosswind turn, you must apply less bank during the turn if you want to end up the correct distance from the runway. If the wind is blowing you away from the runway you will need extra bank. With no crosswind you will need about 15° of bank. In very strong wind conditions you may have to climb above 500 ft before starting your turn to make sure that you can finish your turn before reaching the downwind call position. Now you want to roll out of your turn on a heading that will track you parallel to the runway; assess your probable downwind leg drift and make an allowance for it when rolling out of the crosswind turn. You are now starting your downwind leg.

30 **Downwind leg** When you have completed your turn on to the downwind leg, proceed as follows:

* Check that you are straight and level and in balance at 85K.

* Check that you are the correct distance out from the runway. At the correct distance out, the landing path should appear under the join between the flap and the aileron (see Fig 13.3)

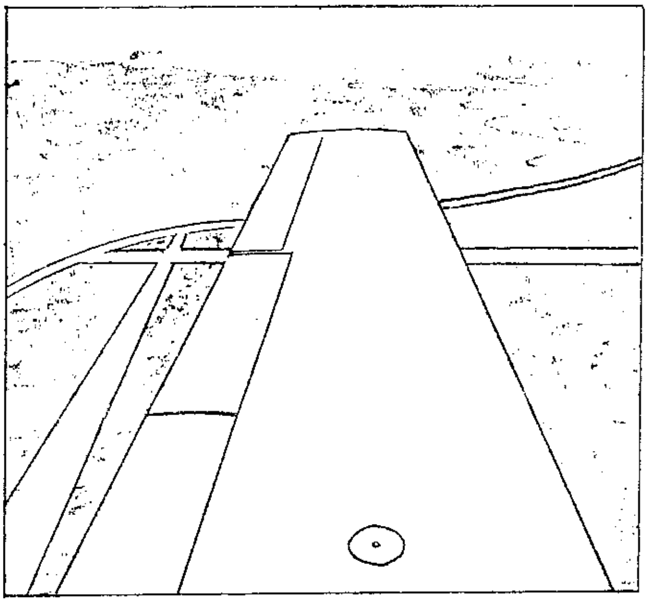


Fig 13.3 Judging distance out from runway

* At the same time, assess any tendency to converge or diverge with the runway and adjust your heading accordingly. Pick a reference point ahead; this will help you to maintain your heading while you do the landing checks (VAs).

* When you are level with the upwind end of the runway, call 'Downwind' on the RT and state your intention - to land, overshoot, or touch-and-go.

* Complete your Downwind Checks and, when you have done so, check that you are still paralleling the runway. Monitor the airspeed and adjust power to hold 85K on the downwind leg.

* We must now judge when to turn onto finals. As explained in para 9, the distance you go downwind depends on the wind strength. Your instructor will show you how the turn-in points varies in different wind conditions.

31 **Finals turn**

* Before starting the finals turn, look to the outside of your circuit, for other aircraft in the turn or on finals. Do not start your descent until you can see ALL the aircraft that Air Traffic Control have told you are ahead of you.

* Throttle back to 1500 rpm.

* Lower take-off flap, holding the aircraft level until the speed falls to 70K.

* Lower the nose to hold 70K, and trim.

* Start your finals turn using about 15° of bank.

* Adjust the power as necessary for the wind conditions.

* Your aim now is to have your wings level, lined up with the runway, at a height of 300ft. Halfway round the turn, however, call 'Finals'. During the turn, do not exceed 30° bank; in fact, if you have planned correctly, 15° of bank will be adequate.

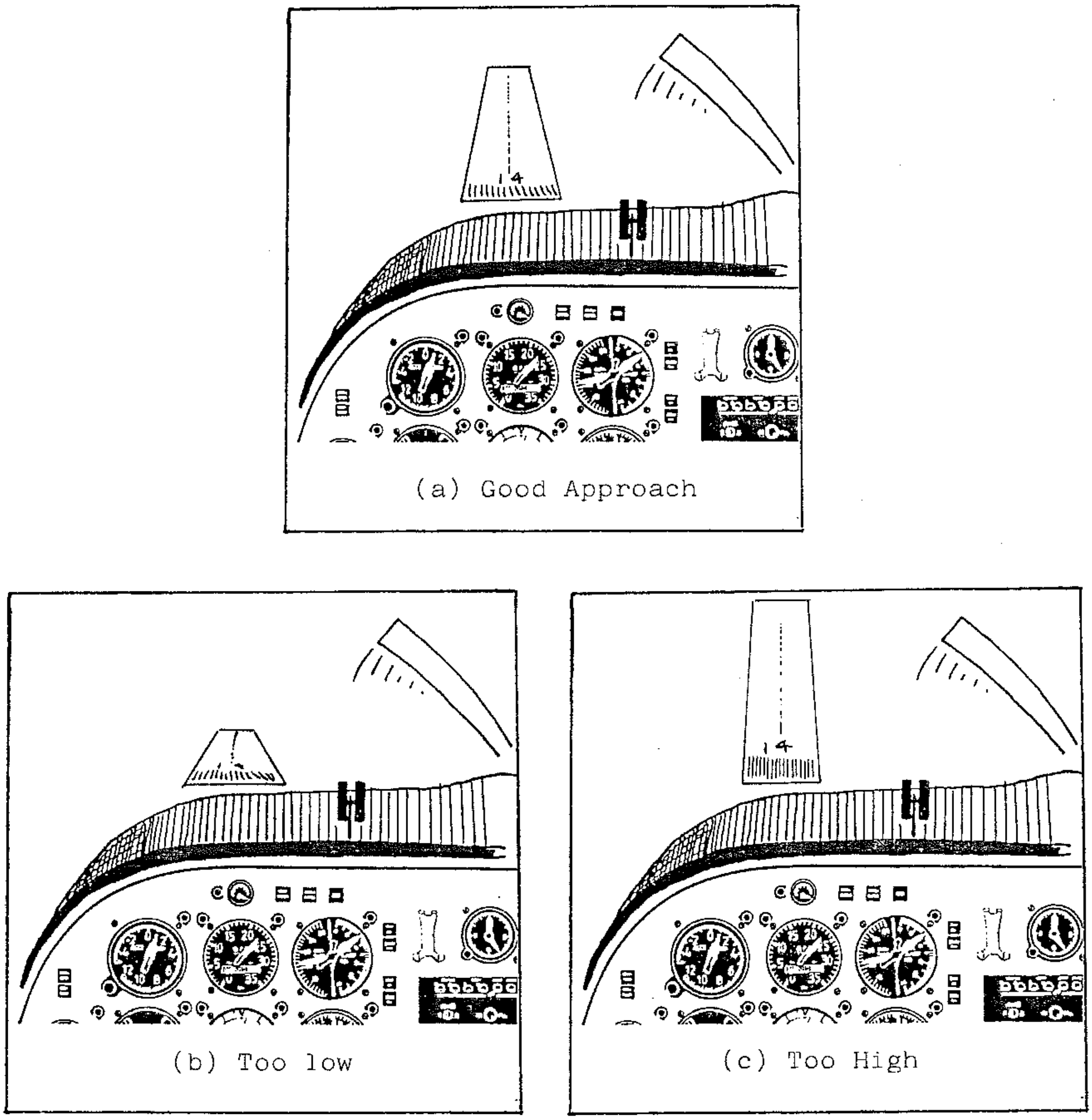
* During the turn, maintain the same nose attitude to hold 70K.

* Complete your Final Checks.

32 **Final approach** On the final approach hold the same attitude and select full flap, allow the speed to reduce to 65K, and trim. Your instructor will show you how to recognize the correct approach path using the aspect of the airfield. The low, normal and high approach paths are illustrated in (Fig 13.4). Your instructor will also show you how to adjust your approach with power should it be necessary.

* Once settled on the correct approach, with full flap selected and the aircraft trimmed, maintain the airspeed at 65K.

* The airspeed is controlled by the attitude and, should the airspeed increase, you will need to raise the nose slightly to reduce it. To enable you to do this without the aircraft climbing above the correct approach path, you will have to throttle back slightly as you raise the nose. Remember, however, that only very small movements of the stick and throttle are required.



(a) Good Approach

(b) Too low

(c) Too High

Fig 13.4 Approach paths using airfield aspect as a guide

* If your speed falls, lower the nose slightly and increase power to prevent the aircraft dropping below the correct approach path.

* When you are close to the ground, do not make large corrections to the attitude; they are not necessary. An increase in power will not only reduce the rate of descent for a given IAS but will also initially help to accelerate the aircraft back to the correct speed.

* Elevator and throttle movements must be gentle and co-ordinated if the aircraft is to stay on the correct approach path at the correct speed.

* Two common faults are:

(1) Bad trimming, leading to poor speed control.
(2) Over-correcting on the throttle through not allowing for the inertia of the aircraft. Make small corrections and allow time for them to take effect.

33 **Landing** In the final stages of the approach we are getting very near the ground. So we must now consider the actual landing. The landing can be discussed in four stages, as follows:

a **The round out** Our rate of descent on the final approach is much too high for landing. We must, therefore, reduce the rate of descent by 'rounding out'. Your instructor will show you the correct height at which to start the round out. At this height, move the control column gently back so that the aircraft is flying parallel with the ground and, at the same time, close the throttle. The speed will, of course, immediately start reducing.

b **Touch-down** If done at the correct speed, the round out will leave the aircraft in an attitude in which it will start to descend gently onto the runway as the speed falls, touching down main wheels first. Maintain the control column position until the nosewheel touches down - do not force it onto the runway. Conversely, do not try to hold the nosewheel off as there is then a danger of the tail skid hitting the runway.

c **The landing run** Do not relax after touch-down; the landing is not completed until the aircraft has stopped. Hold the control column aft of the neutral position and keep straight using nosewheel steering. Test the brakes and, if necessary, use them to ensure that you are at taxying speed before reaching the end of the landing path.

d **Clearing the landing path** Once the aircraft is safely under control and at taxying speed, clear the runway as soon as possible so that you do not hold up other aircraft waiting to take off or land. If you are landing on a grass airfield where several aircraft are permitted to land simultaneously, then:

* Bring your aircraft to a halt in a straight line.

* Turn.

* Stop to look for other aircraft landing.

* If another aircraft is landing and will cross your taxi path, hold your position. It is up to him to take avoiding action.

* When it is safe to do so, taxi well clear of the landing path and complete the after-landing checks in the normal way.

The Touch-and-go Landing

34 For a touch-and-go landing, make a normal approach and landing but, instead of stopping after touch-down, hold the nosewheel off the ground and complete another take-off immediately. Keep straight with rudder, and open up to full power. Continue as normal and, when safely airborne and with a speed of 65K, raise the flap to take-off and increase speed to 70K. At 300 ft, raise the flaps fully and increase speed to 80K.

Going Round Again

35 The procedure for going round again is known as the 'overshoot procedure'. The actions are as follows:

a Level the wings and apply full power.

b Look out, and climb at 65K with landing flap or at 70K with take-off flap; trim.

c Turn towards the 'dead side' if there is one; otherwise climb straight ahead.

d Raise flap as you would after a touch-and-go landing.

e Complete the climb to circuit height.

f Space yourself clear of other aircraft and join the crosswind leg - preferably at the upwind end of the runway as if from a standard rejoin.

The Glide Approach and Landing

36 The glide approach is outlined in para 6b and the circuit diagram is at Annex B. If you compare Annex B with Annex A, you will see that the glide circuit is the same as that for a normal powered approach until the end of the downwind leg (see also paras 28 to 30). However, we have already agreed that the secret of good circuit work is planning ahead. So, at the start of the downwind leg, select the following points:

* **Selected touchdown point** This is the point where it is intended that the aircraft should be landed, and it should be selected a little distance up the runway to allow room for slight undershoots. It is used after landing as an indication of the accuracy achieved, and should be nominated to your instructor or to yourself when solo.

* **Initial aiming point** This is a point about ⅓ up the runway and is the point where the aircraft would land if full flap were not used.

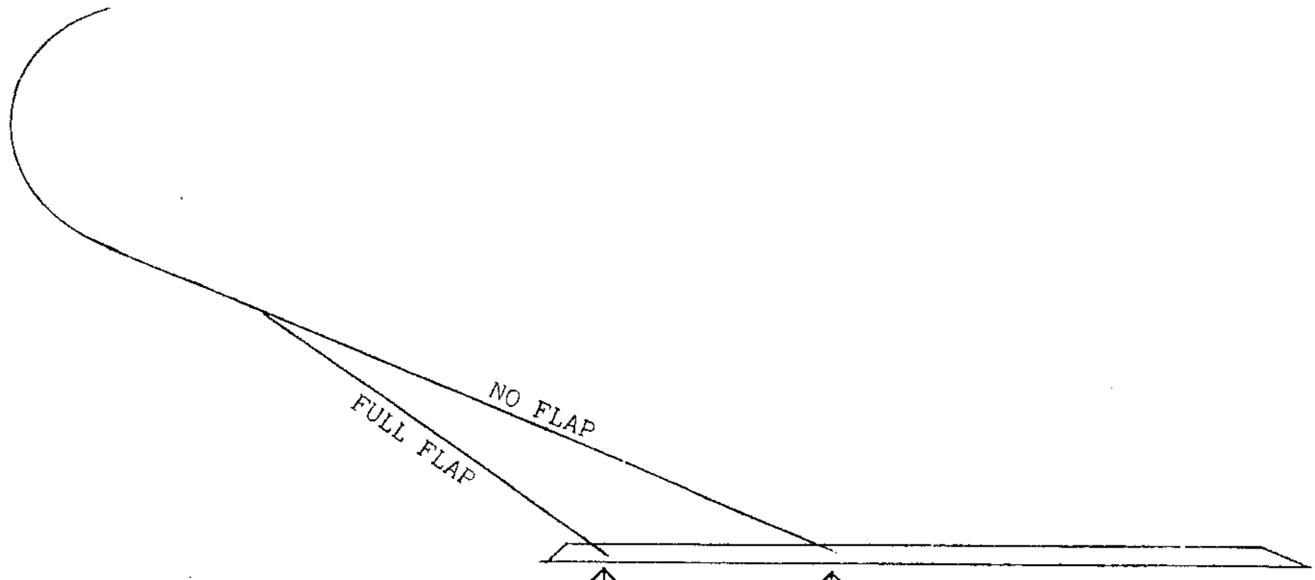


Fig 13.5 Aiming points on a glide approach

37 Action is as follows: fly downwind at 1000 ft and 85 kts and decide when to close the throttle. To do this, visualise a curved approach path on to the required landing direction, with a short straight final leg to the initial aiming point. The throttle is closed when you judge that a gliding aircraft flown along this path will, if full flap is not used, land at the initial aiming point. You have already considered the wind velocity when deciding where to turn base leg; you must now consider it again when making the decision when to close the throttle.

Trim for a 80K glide and start flying the proposed approach path to the initial aiming point. It is now most important that you maintain 80K. Firstly, if you do not, you will receive false impressions of the aircraft's gliding performance. Secondly, this should give safety and manoeuvrability in the finals turn. Now continually compare the aircraft's actual flightpath with the one required, using visual cues. Early in the turn you may find it helpful to assess the sightline angle subtended by the Initial Aiming Point, or the change in aspect of the area around this point. These principles are explained in Exercise 17, paras 1-5. However, you will soon be close enough to the airfield to visualise the actual flightpath of the aircraft, and compare it with the one you require. Whichever combination of visual cues you use, the action you take is the same. If you are undershooting, cut the corner by increasing bank up to 45°; if you are overshooting, allow the aircraft to fly wider by reducing bank, maintaining 80K throughout.

If you have flown this part of the circuit correctly, you will enter the final approach stage with some 30° still to turn, and at approximately 300-400 feet. Your present flightpath (i.e. without full flap) should take you overhead your selected touchdown point, with an actual landing somewhere near the Initial Aiming Point. Indeed, on some practices your instructor may well allow you to continue without full flap, so that your appreciation of the aircraft's gliding performance is improved.

38 **The final approach** The following are the main considerations:

* As you close towards the extended runway centre line, and you are certain of reaching the Initial Aiming Point, transfer your attention to the selected touchdown point.

  ° Assess your approach relative to the selected touchdown point. When certain that there is no risk of undershooting the runway, lower full flap so that the aircraft lands at the selected touchdown point.

  ° Before selecting full flap bear in mind the possibility of a wind gradient. Do not select full flap if your height is less than 200 ft AGL, or if your speed is low.

* When lowering full flap care must be taken to adjust the nose attitude to maintain 65K.

* During a glide approach you will have a much higher rate of descent and a more nose-down attitude than for a powered approach. Also, the stalling speed without power is higher. Therefore, during this final part of the approach, the speed should be maintained at 65K and the round out started earlier than for a powered approach.

39 **The landing** The landing from the glide approach is performed in the same way as that for a powered approach (see para 33).

WARNING Heed the following words of warning:

(1) Never 'stretch' a glide. You will misjudge some of your earlier attempts at a glide approach and will probably find that some fall short of your touch-down point. The tendency is to try to increase your range by pointing the nose hopefully at your selected touch-down point. The speed reduces and, with your attention concentrated on your touch-down point, you may not notice the reduction. The gliding range decreases if you fly either below or above your ideal speed - so you will merely worsen the situation by trying to stretch the glide. If you are tending to undershoot, cling to your ideal speed until it becomes obvious that you will undershoot and then go round again for another attempt. There is little point in continuing with a high approach so, once again, go round again.

(2) Do not delay your decision to overshoot to the point where it becomes necessary to move the throttle rapidly from idle to full power. Although the engine will usually respond, this is poor technique and airmanship. Furthermore, there are occasions when rapid throttle movement can lead to momentary rough running, and a consequent loss of power, causing you to stall and touch short of the runway before the engine regains sufficient power to enable you to climb away.

(3) If the speed is not maintained initially at 80K and then at 70K when full flap is selected below 200 ft agl there will be sufficient height to regain the correct speed and effect a correct roundout.

Flapless Approach and Landing

40 The flapless approach and landing was outlined in para 6c and is illustrated at Annex C. As with all circuits, the planning for the final approach begins as you start the downwind leg. On the flapless approach you lose the benefits of flap described in para 8, so you will have a shallow approach path. You want to use power, and this will give an even shallower approach. Consequently, your downwind leg should be longer than that for a normal powered approach. Your instructor will show you the exact point at which to turn - it will certainly be well past the turn-in point for a normal powered approach. Let us consider the finals turn, final approach and landing for a flapless approach and landing.

41 **The finals turn** On the finals turn you have no flap selected, so you will need a lower power setting to be half way round at 500 ft and 600 ft, flying at 75K. Make small throttle movements and observe their effects before re-adjusting power as necessary. Trim accurately. During your turn on to final approach observe the rules carefully. Without flap you are nearer the stall, so do not exceed 30° of bank.

42 **The final approach** On the longer, shallower, final approach, adjust power carefully to achieve 70 kts. With a clean aircraft, power changes must be small and, if you do not immediately adjust your attitude and trim, your speed will be erratic. You will notice a higher nose attitude which tends to mask your view of the runway. This effect becomes more pronounced as you reach your threshold speed of 65K.

43 **The landing** Landing from a flapless approach presents no unusual problems. Because of the shallow descent angle, only a very small pitch change is necessary to round out. The nose attitude will be higher than normal and only a small round out should be used to avoid touching the tail on the ground. The touch-down speed will be higher than that for a normal powered approach and the ground run will be correspondingly longer than normal. Because of the extra ground run, there may be a danger of running out of airfield, so:

* The flapless approach must always be flown very accurately.

* Aim to touch down at the beginning of the landing path.

Crosswind Approach and Landing

44 As we saw in para 10, whenever possible we land into wind. However, there are occasions when the most suitable runway is not directly into wind and we have to make a crosswind approach and landing. The circuit for this is illustrated at Annex D. There are two recognized methods of completing the final approach and landing in a crosswind. These are the 'crab' technique and the 'wing down' technique. The crab technique is the technique most widely used, and you will be taught this method; later in the course your instructor may show you the wingdown technique. Both methods employ the same circuit pattern up to and including the final turn. So, before we consider the different techniques for the final approach and landing, let us consider the common part of the circuit:

a **The crosswind turn.** During this turn there will be either a head wind or a tail wind component. Consequently, you will have to either decrease of increase the bank used in the turn so that the aircraft travels over the correct ground path.

b The **downwind leg** To track parallel to the runway on this leg, it will be necessary to head the aircraft either slightly towards the airfield or slightly away from it - depending upon the direction of the crosswind component. Use the DI to assist in making the drift allowance. When judging the position at which to turn onto base leg, note two things:

(1) Not all the wind on the windsock is going to be head wind on the final approach, so you may have to extend downwind.

(2) In judging how far you have travelled past the end of the runway, remember that the aircraft is not heading parallel to the runway.

c **The finals turn** In addition to the normal wind effect blowing you away from the **airfield,** you now have another component which is either increasing or decreasing your ground speed on the finals turn. You must take action accordingly:

* If the wind is behind you, you will need to use less power as you must still be on finals at 500ft to 600ft. Beware of bank, or you will be forced into using excessive bank angles to line up.

* With a headwind on the finals turn you will need extra power and can use less bank during approach.

45 **Crab technique approach and landing** The previous para considered the parts of the circuit that were common to the two recognized techniques for the crosswind approach and landing. We must now consider each of the techniques used during the final approach and landing. The crab technique is as follows:

* Roll out of the final turn so that you track down the extended centre line of the runway. To do this, you will have the nose pointing off the runway direction towards the wind, and you maintain this situation throughout the final approach and round out.

* After the round out, and just before the aircraft touches down, use the rudder to yaw the nose onto the runway heading. Be ready to correct any roll with aileron.

* Because of the crosswind, there will be a tendency to yaw after touch-down; this is corrected with rudder and/or nosewheel steering.

46 **Wing down technique approach and landing** The wing down technique on the final approach and landing is not recommended in the T67 as the large wingspan and low dihedral make the ground wingtip clearance too small. Your instructor may demonstrate one at some stage but this is only done so that you experience it.

Approach for a Short Landing

47 The aim of the exercise, which is taught at a later stage in the syllabus, is to learn how to land in confined spaces. In order to achieve this, we want to touch down at a selected point and reach this point at the lowest safe speed. We plan our circuit accordingly. On the downwind leg, select your touch-down point and plan your finals turn according to the wind. The circuit is illustrated at Annex E. Make certain that you can use power on the final approach by turning onto the base leg just past the point where you would turn for a normal powered approach. The base leg is flown as for a normal powered approach and you arrive on the final approach lined up at 400ft. Let us now consider the final approach and landing.

48 **The final approach** The actions during the final approach for a short landing are as follows:

* As soon as you start the final approach, lower full flap and reduce your speed to 65K.

* Adjust your power so that you will reach your touch-down point, and trim carefully.

* The remainder of the approach is flown with small adjustments of power to control the rate of descent, and small changes of attitude to reach your touch-down point at a threshold speed of 55K. Trim carefully throughout.

* You will notice the higher nose attitude.

* Should you begin to overshoot your touch-down point at this late stage, make only a small power reduction. A large reduction at this low speed will cause the aircraft to sink rapidly to the ground.

49 **The landing** Provided the approach has been well judged, the landing presents no problems. However, note the following points:

* Beware, as you near the ground, of trying to arrest any sink with a rearward movement of the control column. Should you sink in a down draught or wind gradient, arrest the sink with an increase of power.

* Due to the fact that the nose is high during the final approach, only a small round out is required.

* As the aircraft touches down, close the throttle.

* Commence braking as soon as the nosewheel is on the ground.

Low Level Circuit

50 The low level circuit is illustrated at Annex F. We use this type of circuit when the cloud base is lower than circuit height, aiming to keep 200ft below the cloudbase for safety. Thus the circuit height depends upon the cloud base but, for your initial practices, you can assume a cloud base of 700ft and use a circuit height of 500ft agl. Although we fly the circuit at this lower height, we keep the same distance from the airfield as for a normal circuit, so that on the downwind leg the airfield appears to be further away than usual. Your instructor will show you how to judge your circuit in relation to the field. On the finals turn, you maintain height initially and, as you intercept your normal approach path, adjust power and complete a normal powered approach.

Bad Visibility Circuit

51 The bad visibility circuit, illustrated at Annex F/G, is used in conditions of low cloud and bad visibility. Circuit height depends upon conditions but, as for the low level circuit, you can practise at 500ft. Because of the poor conditions, we use the bad weather, low flying configuration and fly the circuit at 70K with ½ flap selected. (See page 16.5)

* Start by flying along the intended landing path.

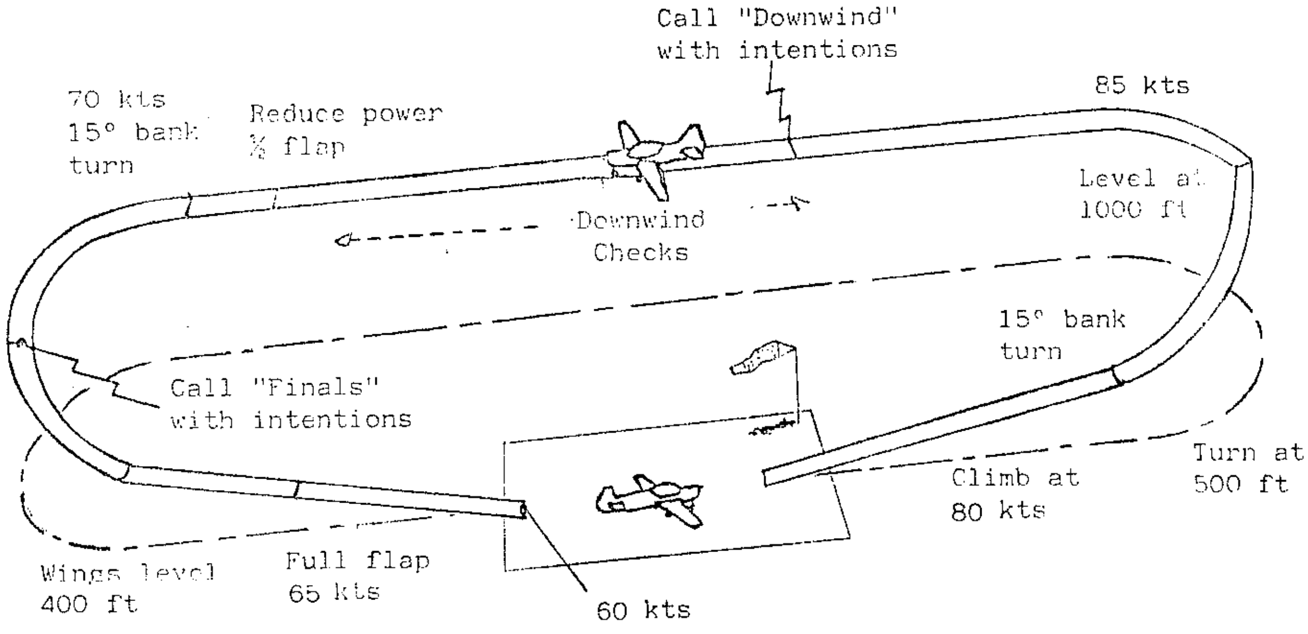
* Note any useful landmarks on the circuit side of the airfield; these will help you to fly a straight downwind leg and also give a guide as to where to turn at the end of this leg.

* Note the DI heading.

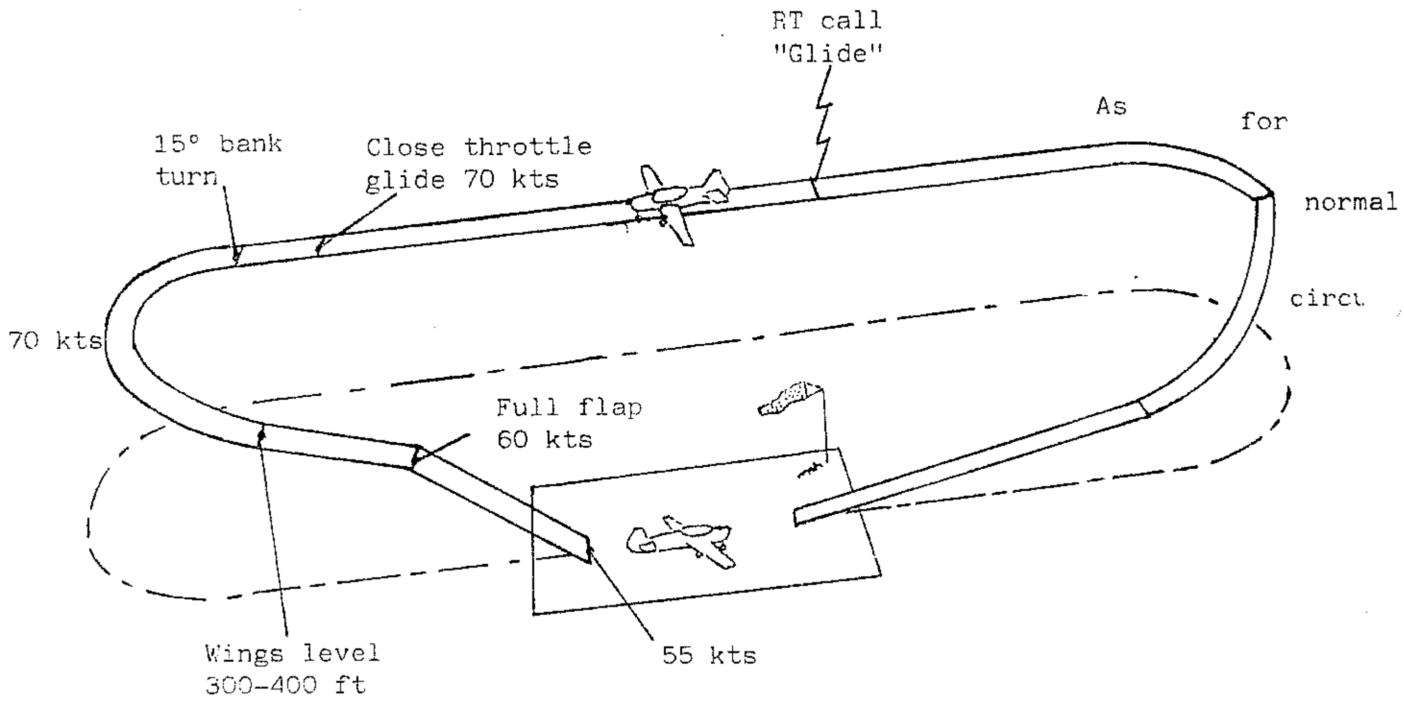
* Once past the upwind end of the runway, make a continuous turn through 180° on to the downwind leg. Use the DI to help you and aim to keep either the landing path or the landmarks in sight while you do your vital actions.

* At your end-of-the-leg landmark, make a continuous turn on to the final approach heading.

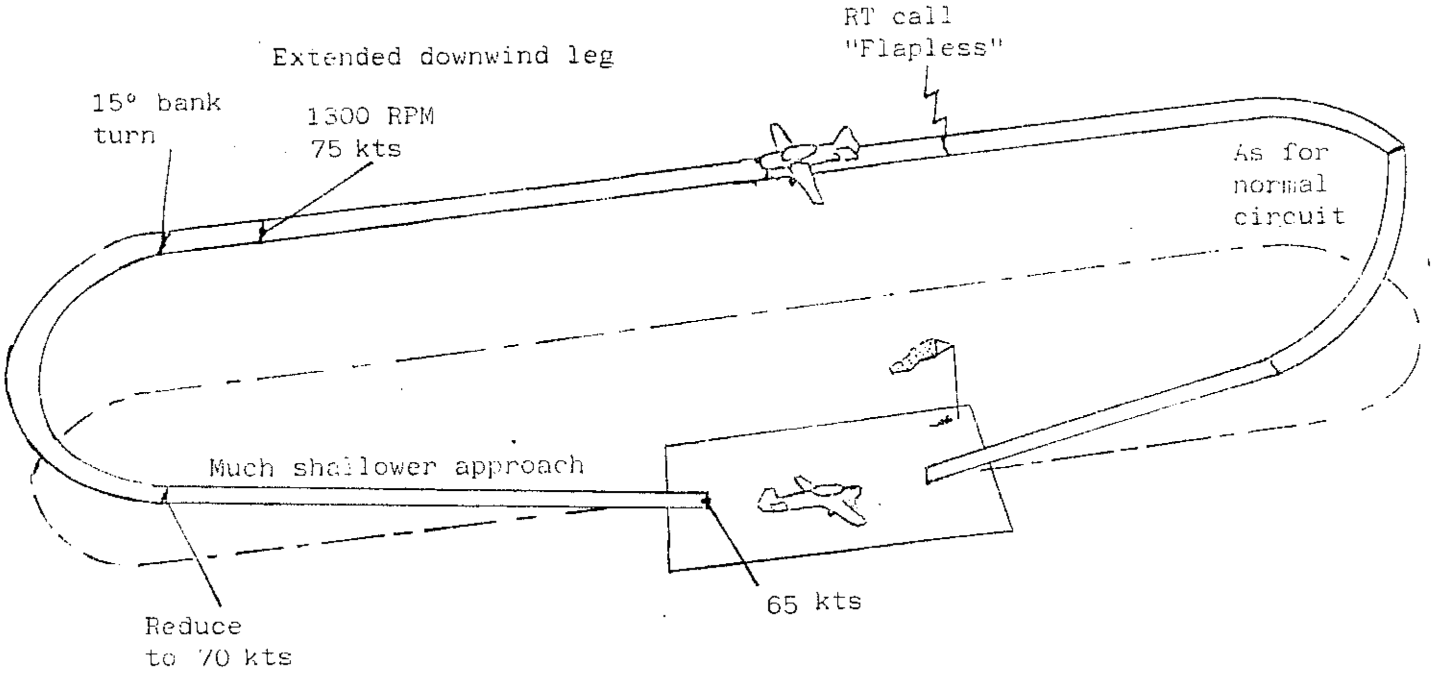
* Descend when you are in contact with the approach lights or the runway threshold, and make a normal powered approach.



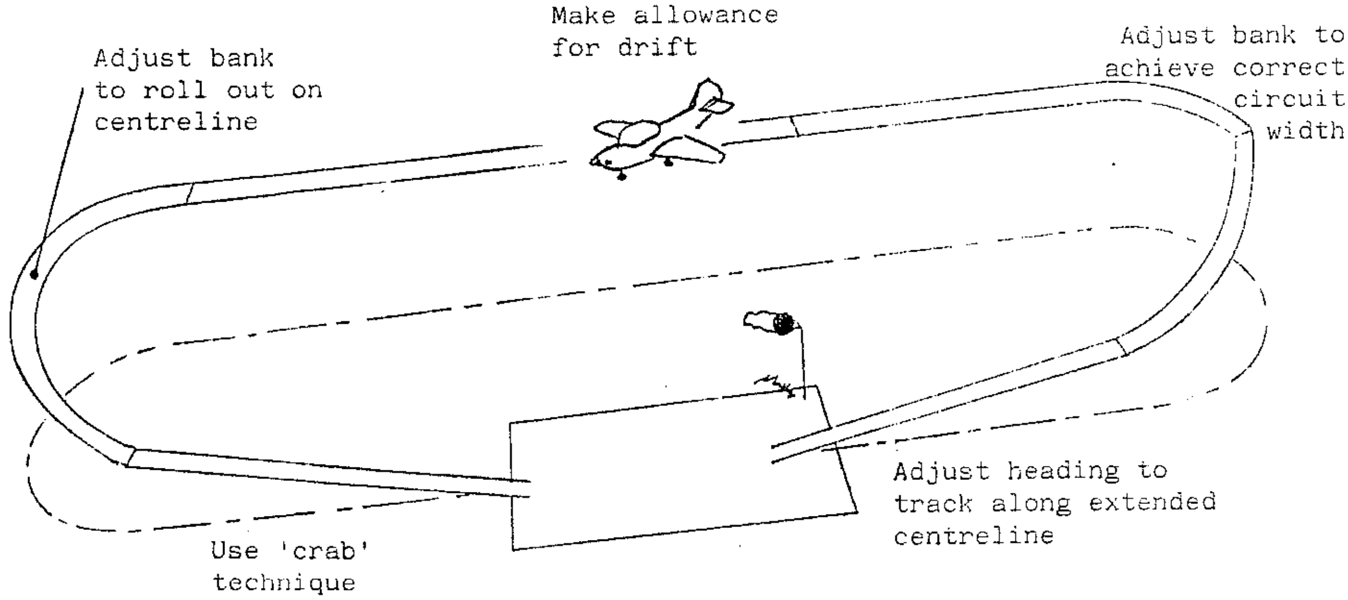
ANNEX A Normal Circuit, powered approach, and landing



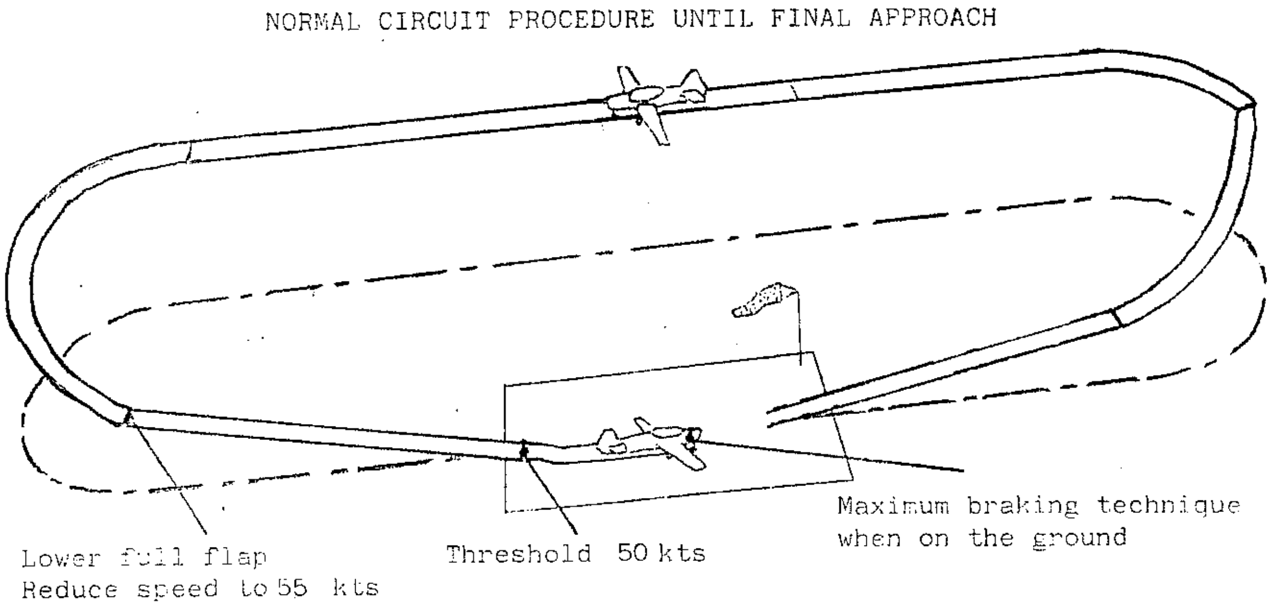
ANNEX B Circuit for glide approach and landing



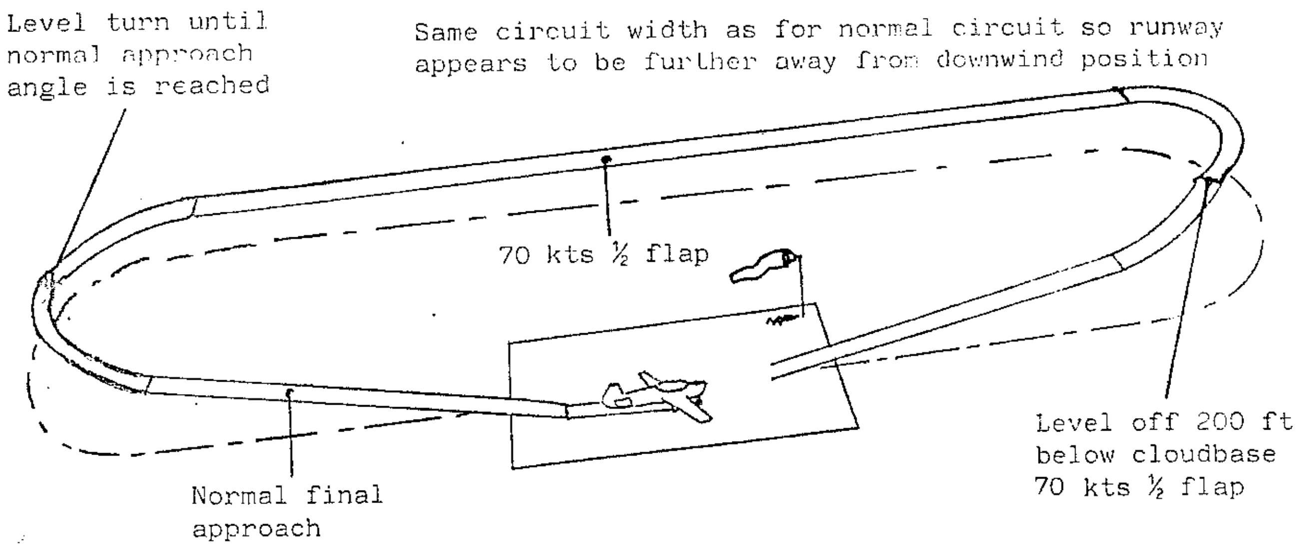
ANNEX C Circuit for flapless approach and landing



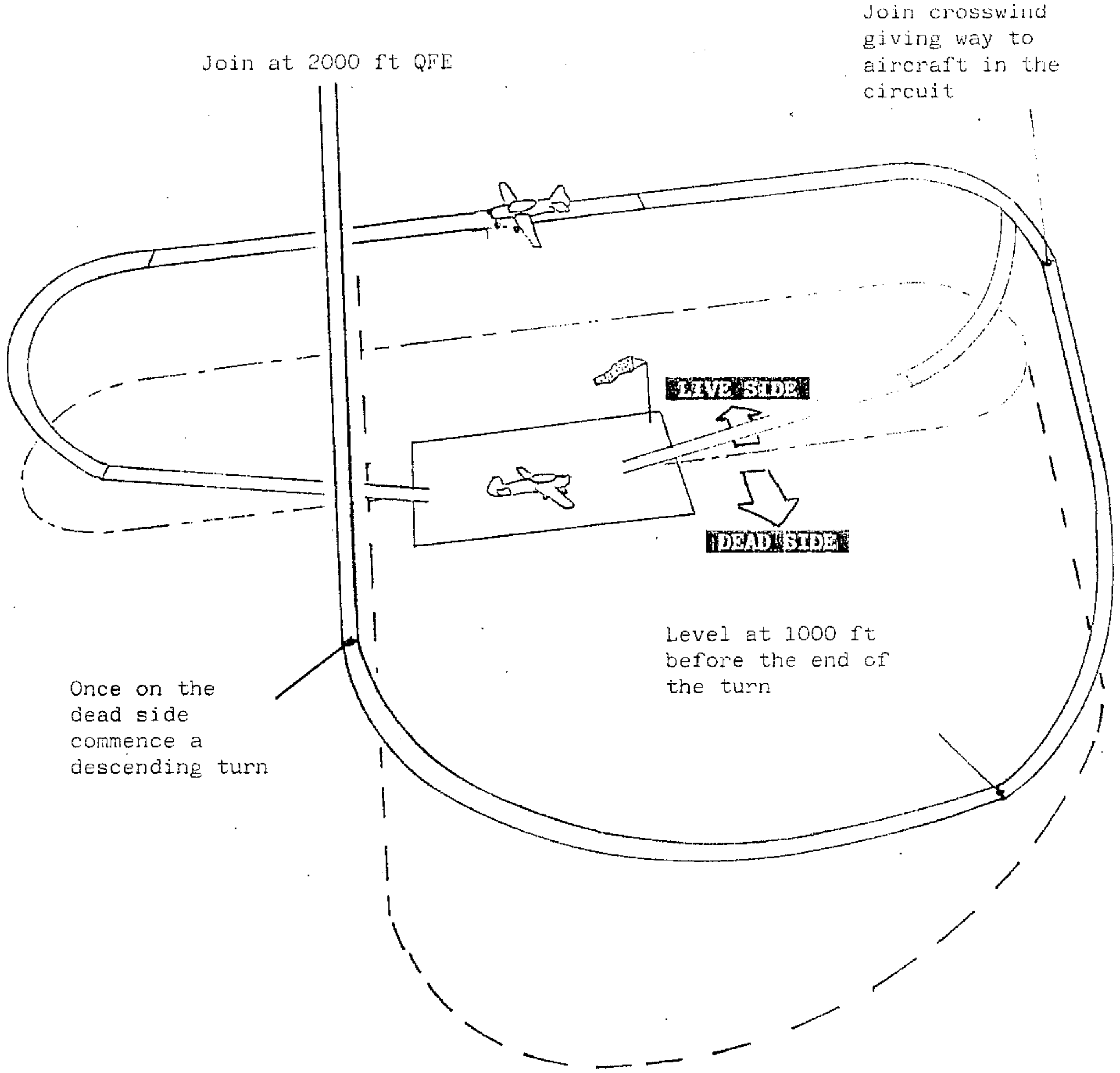
ANNEX D Circuit for crosswind approach and landing



ANNEX E Circuit for short landing



ANNEX F/G Low level circuit (Low cloudbase/Poor visibility)



ANNEX H Standard rejoin procedure

Over controlling on Landing

53 If you bounce the aircraft on landing, or pull back too harshly or too much on the control column, you may find that the aircraft assumes a very nose-high attitude. In these circumstances it would be natural to move the control column forward to lower the nose and maintain flying speed. Unfortunately there is a high probability that you will lower the nose too far and either bounce again or, in an attempt to avoid this, again pull back too harshly on the control column. This cycle can obviously continue until the aircraft either stalls or suffers a heavy landing and/or damage to the nosewheel assembly. Consequently, the correct recovery action is to overshoot by holding the control column slightly aft of central (in about the take-off position) whilst opening the throttle fully and keeping the wings level. In this attitude, even should the aircraft strike the ground during the overshoot, it will do so on the main wheels, which are designed to absorb the impact, and is therefore less likely to sustain damage.

Conclusion

54 Good landings begin with good approaches; good approaches start with good planning; and good planning requires you to think ahead and make due allowance for the wind.

55 Do not think you are a failure, nor become nervous, because your first attempts at landing seem to bring you near to disaster. You will learn from your mistakes, and your instructor will never let you go too far. Listen carefully to his advice, watch his demonstrations and, particularly on the final approach and landing, try to see the overall picture rather than concentrate too much on one aspect at one time. As you progress, you must rely less on your instructor. If you do a bad approach or landing and think you ought to go round again, then do so without waiting for him to make the decision. Do not be despondent if, after several circuit sorties, you cannot make consistently good approaches or safe landings. Do all you can to help by learning your checks and the relevant procedure illustrated in the Annexes. Remember that the ability to land safely can be acquired suddenly in one sortie even when the previous one was, you thought, hopeless. Dual time before solo is not so important as a thoroughly safe and confident first solo flight.

Finally:

* Never treat a landing as routine.

* Remember that the landing is not finished until you have stopped safely and cleared the runway.

EXERCISE 14

F I R S T   S O L O

1 Every summer a host of fledglings are booted out of the nest, and they must learn to fly before they reach the ground or not at all. The parents cannot claim a 100% success rate, for the fledglings do not have the advantages of the previous Exercises 1 to 13, or of a conscientious instructor.

2 You are more fortunate and, having been cleared to fly solo, need have no doubts about your ability. Listen carefully to your briefing and do exactly as you are told. You will find the flight most enjoyable and, in making your first solo, acquire increased confidence in your own ability.

EXERCISE 15

A D V A N C E D   T U R N I N G

Introduction

1 Up to and including your first solo and circuit consolidation the medium turn had been sufficient for you to manoeuvre your aircraft adequately. However, if you are to exploit the performance of your aircraft fully, you need to be able to turn at high rates of turn and this involves using higher angles of bank.

2 In this exercise you will learn the following:

* How to turn at high rates of turn.

* How to recover should you inadvertently stall in the turn.

* How to obtain the maximum turning performance.

* How to execute steep descending turns.

PRINCIPLES OF FLIGHT

Points to be Discussed

3 In 'Principles of Flight' we shall examine the following:

* The forces acting on the aircraft.

* The use of power.

* Stalling in the turn.

* The situation required to obtain a maximum rate, minimum radius turn.

* The effect of altitude.

* Physiological effects on the pilot.

Forces Acting on the Aircraft

4 In Exercise 9 (Medium Turns) we considered the forces acting on the aircraft in a turn and we saw there that to maintain level flight and to provide an accelerating force the wings had to produce extra lift.

These forces are shown again in Fig 15.1 but this time with the aircraft turning at a higher angle of bank. Notice that greater lift is required to maintain level flight. This extra lift is generated by increasing the angle of attack of the wings during the turn. This in turn increases the drag.

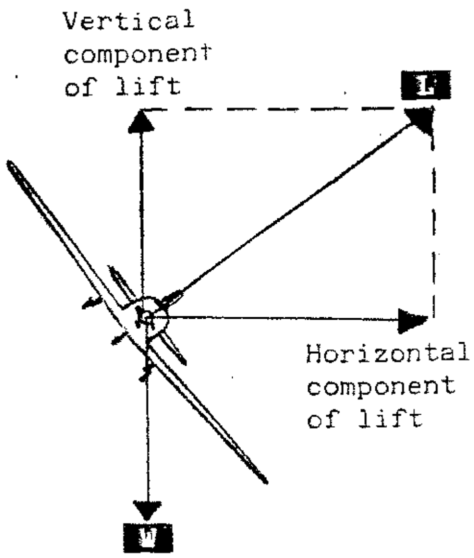


Fig 15.1 Forces acting on an aircraft in a steep turn

Use of Power

5 The increase in drag in a medium turn caused an acceptable loss of 5K in airspeed. However, as we increase bank the need to increase the angle of attack causes a drag rise which results in an unacceptable decrease in airspeed; the greater the angle of bank, the lower the airspeed falls - until we eventually stall. Therefore, to maintain an airspeed in a steep turn we increase power (thrust to offset drag). However, there is a limit to the power available. Thus, any further increase in the angle of bank after the throttle has been fully opened will cause a reduction in airspeed.

Stalling in the Turn

6 In Exercise 10 (Stalling) you learnt that manoeuvres such as turns have an effect on the stalling speed. This effect is in proportion to the square root of the load factor which is the ratio of wing lift to aircraft weight. The higher the angle of bank, the greater is the load factor. For example, in a level 60° banked turn the wings have to produce twice as much lift as would be required to balance the aircraft weight in level flight. The load factor in this case is 2. If we consider an aircraft in level flight at an angle of attack just below the stalling angle then to be able to turn at 60° of bank the amount of lift must be doubled. Since the angle of bank cannot be increased without loss to the vertical component of lift the extra lift can only be produced by flying faster; that is, in a turn, the stalling speed is increased. As a guide, in a 60° bank level turn, your stalling speed is approximately half as much again as the basic stalling speed.

Maximum Rate and Minimum Radius Turns

7 Taking the exercise to its logical conclusion, let us examine the factors involved in turning at maximum rate and minimum radius. Considering again the forces acting during a turn you can see that the greater the accelerating force available the better is the rate of turn. This accelerating force is provided by the lift; when more lift is produced, greater accelerating force is available to make the aircraft turn. Lift is a product of speed and angle of attack and will be a maximum when the aircraft is flying at just below the stalling angle at the highest possible airspeed. To make use of the lift we adjust the angle of bank so that we have sufficient lift to support the weight of the aircraft and use the remainder of the lift as the accelerating force. For a maximum rate, minimum radius level turn, we fly as follows:

a Maximum angle of attack (just below the stalling angle).

b Maximum power (to achieve maximum speed).

We are now in a situation whereby the aircraft is generating the maximum sustainable amount of lift. In order to maintain a level turn we must ensure that the vertical component of this lift is just equal to the weight of the aircraft. As, to sustain the maximum rate of turn, the lift cannot be reduced nor the weight varied, only the angle of bank is variable to maintain height. Therefore, the technique of maintaining height in a maximum rate turn is that the back pressure on the control column remains constant and the angle of bank adjusted to maintain height.

Thus, when the aircraft is in level flight we will have:

c Maximum angle of bank.

Effect of Altitude on Turning Performance

8 We have shown in para 7 that for maximum rate, minimum radius turns we require maximum power in order to sustain the maximum possible speed. However, as our altitude increases the engine power available reduces and our turning performance becomes progressively worse. Also, as we go higher certain other factors further reduce the rate of turn available; we shall not consider these 'other factors' at this stage of your training.

Physiological Effects

9 The physiological effects of 'g' are not pronounced in Firefly operations. Nevertheless, they are present and an understanding of the factors involved will help you to reduce the effects.

10 We have already discussed the accelerating force which acts on an aircraft in a turn. (Note that a change of direction is a change of velocity, hence the term 'accelerating'). As the aircraft accelerates round a turn the apparent weight of both pilot and aircraft increases. Under these conditions the excess 'g' forces, acting in a head-to-foot direction, have the following effects upon the pilot:

a The blood tends to drain from the head and 'pools' in the abdomen and legs.

b Greater muscular effort is required to move the limbs and the head.

11 As a result of para 10a the eyes and the brain can be starved of oxygen. Partial loss of vision (grey-out) begins and, if the 'g' is sustained, total loss of vision (black-out) can follow. If the acceleration is high enough a black-out may be followed by a complete loss of consciousness. These effects disappear as soon as 'g' is reduced to normal although, for a few seconds, you may be confused and have some difficulty in focusing your eyes.

12 However, take heart. In the Firefly high values of 'g' cannot be sustained. But in some manoeuvres if you do not take the precautions outlined in the next paragraph you can experience some grey-out symptoms. Otherwise, apart from the symptoms of para 10b, 'g' effects present no problems.

13 Tolerance to 'g' may vary in the same individual from day to day, and is considerably reduced by: illness, hunger, fatigue, lack of physical fitness, lack of oxygen, or a 'hangover'. At any time. the pilot can increase his tolerance to 'g' by:

* Taking a deep breath.

* Bracing his stomach muscles as for a blow in the stomach.

* Crouching in his seat.

For these measures to be most effective you must anticipate the 'g' and not wait for the onset of the symptoms.

AIRMANSHIP

14 The matters on airmanship mentioned below are familiar points but are included as a reminder.

a **Lookout** We have already learned that a good lookout is to be maintained at all times. In particular, when changing direction make sure - both before and during the turn - that the area is clear.

b **Orientation** Remember that you will be blown downwind if you practise a series of steep turns without taking steps to maintain you original ground position. Re-checking your position against a prominent ground feature after each turn helps orientation considerably.

c **Pre-stalling checks** Before practising stalling in the turn you must always carry out the pre-stalling, spinning and aerobatic checks.

AIR EXERCISE

Steep Level Turns

15 **Sequence** Your instructor will first demonstrate a steep turn and show you the attitude relative to the horizon and the improved turning performance of the aircraft. He will then show you the three phases of the turn - the entry to the turn, maintaining the turn and the exit from the turn - and you will practice at each stage. For your initial practices you will start with 45° banked turns and then progress to using 55° of bank. The main differences from medium turns emerge when we consider each phase of a steep turn. These are outlined in the following paragraphs and illustrated in (Fig 15.2).

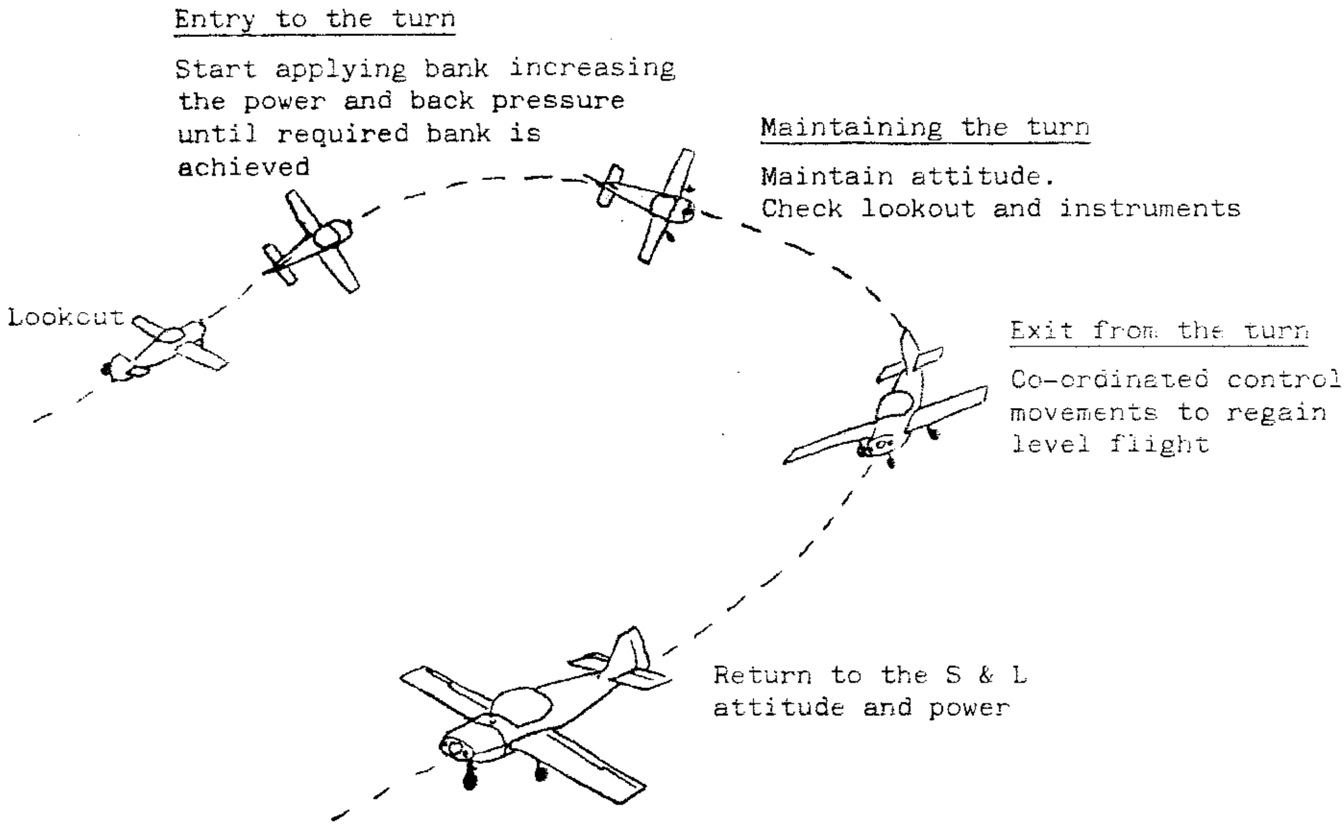


Fig 15.2 Steep level turns

16 **The entry to the turn** Look out and then start to enter as for a medium turn (see pages 9-3/9-4). Continue as follows:

* We want to maintain our speed in the turn so as we increase the angle of bank we have to increase power.

* To obtain the attitude demonstrated by your instructor you will find that you will need increased back pressure on the control column.

* Use the ailerons to select and hold the required angle of bank.

* Do not become engrossed in the engine instruments in trying to select an accurate power setting. Your instructor will show you the approximate throttle movement required.

17 **Maintaining the turn** When maintaining the turn divide your attention between the following three aspects:

a Lookout.

b Maintaining attitude.

c Checking instruments; these are:

(1) Airspeed indicator (speed as for entry - adjust power as necessary).

(2) Altimeter (constant height - adjust attitude as necessary).

(3) Artificial horizon (required angle of bank).

Note You may find a tendency to over-bank and descend while looking out. This is a common fault which disappears with practice. It will help if you go from looking out in the direction of turn to a check of the attitude before glancing at the instruments.

18 **The exit from the turn** To straighten out from the turn use the same co-ordinated control movement which you used in leaving a medium turn. In addition, when straightening out - particularly after a sustained turn - do not rely on merely relaxing the back pressure on the control column. If you do no more than that the tendency is, subconsciously, to hold some pressure on. Instead you must make a positive selection of the straight and level attitude. As you have been turning at a higher rate than normal you need more anticipation in order to roll out in a specified direction.

Recovery from Poorly Executed Turns

19 Let us consider the recovery from a poorly executed turn in both the climbing and descending situations. The following paragraphs discuss this.

20 **Climbing situation** A climb will result from the application of back pressure on the control column without regard to the attitude. Having seen that the aircraft is climbing (from attitude, altimeter, airspeed), check that you have the correct angle of bank and then release some of the back pressure. Anticipate the aircraft response and as the nose approaches the normal attitude re-apply sufficient back pressure to maintain the correct attitude.

21 **Descending situation** We must consider this situation in relation to a 45° bank turn and then to turns with more than 45° of bank:

a **45° bank turn** If when executing a 45° banked turn you pay insufficient regard to attitude and fail to apply sufficient back pressure the aircraft will descend. In this case make sure that you do have 45° of bank and then increase the back pressure to raise the nose to the required attitude. Once there, adjust the back pressure to hold the correct attitude.

b **Turns with more than 45° of bank** Descending while attempting a level turn with more than 45° of bank is again due to disregard of attitude and failure to match the angle of bank with enough back pressure. Whereas the recovery with up to 45° of bank was a simple matter of increasing the back pressure, this is no longer the case. Increasing the back pressure will give only a very slow recovery or, at very high angles of bank, no recovery at all and lead to a tight spiral or stall in the turn. In such cases the recovery action you must employ is as follows:

(1) Decrease the bank.

(2) Select the correct nose attitude.

Once you have regained the correct attitude re-apply the correct bank and back pressure and continue the turn.

Solo Practice

22 The preceding paragraphs cover as much of the air exercise as you will complete in one dual sortie. As your instructor will tell you, you are not cleared to practise the exercise when solo until you have had a satisfactory dual sortie on 'stalling in the turn'.

Stalling in the Turn

23 **Aim of exercise** In para 21b we have already seen one situation where we could stall in the turn. There are others - the most obvious being the situation where you fail to apply sufficient power for the turn which you intend to perform. The aim of this exercise is to show you how the stalling speed increases in the turn, to impress on you the need to increase power to maintain speed in the turn and, should you ask too much of your aircraft, to show you how to recognize and recover from the stall.

24 **Pre-stall symptoms** After doing the pre-stalling checks, your instructor will start a turn at 85K and, without increasing power, will increase the angle of bank in a level turn. (These actions simulate starting a steep turn at cruising speed without increasing power and enable us to reach the stall more quickly). Note the decrease in airspeed and also the speed at which the stall warning occurs. For the reasons already discussed this speed is higher than the normal stall warning speed in straight and level flight. Your instructor will show you that you can recover by relaxing the back pressure. Any attempt to continue the turn with the same angle of bank again causes the warning but the turn can be continued at a lower angle of bank.

25 **Symptoms of the stall** Like the pre-stall warning, the stall itself occurs at a higher speed than for a stall in straight and level flight. Your instructor will tighten the turn (ignoring the horn warning) until the aircraft stalls. As the aircraft is brought to the stall by rearward movement of the control column some buffet may be felt and wing drop may then occur. The wing drop, or roll, is quick and the aircraft may roll out of the turn or steepen the angle of bank used in the original turn. Any attempt to stop this roll with aileron, while the column is held back, will only increase the rate and extent of the roll. The symptoms of the stall are summarized below:

a Stall warning

b Wing drop

This is an interesting demonstration. From it you will see that it requires gross mishandling of the controls to induce the stall. However, the exercise is not unrealistic. When you begin aerobatics you may experience situations where, despite a low airspeed and sometimes a little buffet or stall warning, you will try to complete an aerobatic manoeuvre producing similar results.

26 **Recovery from the stall** To recover from a stall in the turn it is necessary to modify the standard stall recovery slightly because, as we have seen, the stalling speed is increased with 'g' loading. The action of moving the stick forward need now only be sufficient to reduce the 'g' loading. This sometimes amounts to no more than relaxing the back pressure. The application of full power used in the standard stall recovery is not always desirable when recovering in the turn:

* If the nose of the aircraft is on or above the horizon at the moment of stall, full power should be applied.

* If the nose is below the horizon, the throttle can be left where it is or completely closed depending on how far the nose is down.

Rudder should be used to prevent yaw in the usual way. The summarized action becomes:

a Simultaneously:

(1) Move stick forward to unstall the wings.

(2) Check any yaw with rudder.

(3) Adjust power as required.

b Adopt the straight and level attitude (Fig 15.3).

27 **Recovery at the stall warning** By now you will have had plenty of practice at recognizing the stall warning and will have seen that, if it is ignored, there is no question of continuing the turn. What we are seeking is a way to continue the turn safely at the original rate after experiencing stall warning.

28 To get the answer to this we enter the turn as before and tighten it to stall warning. At the warning, we slightly relax the back pressure and, simultaneously, apply full power. With little or no height loss we can continue our turn at the original rate.

29 The limitations of this recovery are obvious. If we have selected a higher angle of bank than can be sustained with full power we must revert to the recovery which we saw during the demonstration of the pre-stall symptoms (para 24): release the back pressure, check that full power is selected and continue the turn at a lower angle of bank.

30 If, by mishandling, you make the aircraft stall in the turn with full power selected then the stalling speed is higher and there is a greater tendency to roll.

Maximum Rate Turns

31 **Aim** The aim of this part of the exercise is to show you how to achieve a maximum rate level turn and, after practice, to get you to learn the application of the technique to avoid other aircraft and obstacles. (After a sustained maximum rate turn, your airspeed will settle below your normal cruising speed. So do not automatically throttle back on leaving the turn; wait until you have reached cruising speed).

32 **Low power setting** Your instructor will demonstrate a turn using a low power setting and ask you to note the following:

a Maximum angle of bank with this power setting.

b Maximum rate of turn with this power setting.

c Airspeed when stall warning occurs.

d Rate of turn carries on increasing when further back pressure is applied with stall warning already on.

e Stage is reached when aircraft then stalls - maybe with some buffet first.

f There is no way of judging how far past the stall warning you can pull before the aircraft stalls. Therefore do not pull any harder once the stall warning is on.

33 **High power setting** Your instructor will demonstrate a further turn using a higher power setting and ask you to note the following:

a Increased angle of bank.

b Increased speed at onset of stall warning.

c Increased rate of turn.

34 **The effect of power** From paras 32 and 33 you will see that the amount of power determines our rate of turn. Your instructor will show you that at full power you can obtain the following:

a Maximum angle of bank.

b Maximum airspeed before stall warning.

c Maximum rate of turn.

35 **Use of maximum rate turn** The maximum rate turn is a combat manoeuvre of which you will learn more later. At this stage in training we apply the technique to avoid other aircraft or obstacles which, should they appear suddenly, present us with the need to change heading very rapidly. We call this procedure the 'emergency break'.

The Emergency Break

36 Consider the sort of situation in which you would need to make an emergency break. Let us assume that you spend a long time setting your Direction Indicator to the compass heading. You look up and see an aircraft approaching head-on. You need to initiate an emergency break (to the right) immediately. Let us consider the entry, the turn and the exit of the emergency break.

37 **The entry** Your instructor will demonstrate the attitude which you need. Although you want to make an accurate level turn, speed of entry is the essential factor. When entering make the following simultaneous movements:

a Bank, using full aileron deflection, to approximately 80° of bank.

b Apply full power.

c Apply back pressure sufficient to give intermittent stall warning.

38 **The turn** When dealing with maximum rate turns you saw that you could not sustain a turn using 80° of bank. We can only start the turn with this degree of bank because the airspeed on entry was higher than that which we could sustain in a maximum rate level turn. As the turn starts the

airspeed decreases (drag) so we have to decrease our angle of bank and also the back pressure to avoid stall warning. We settle at the continuous maximum rate turn which you have already seen. Continue the turn until you are between 90° and 180° off your original heading.

39 **The exit** Roll out of the turn in the normal way and look out immediately to see if further avoiding action is necessary.

40 When practising this exercise solo do not forget to look out first. After you have learned this exercise, your instructor will give you frequent practice. He will call 'Emergency break - right (or left)' and expect you to take immediate action. He will have already looked out, so that you can break immediately in the required direction.

Steep Descending Turns

41 In this part of the exercise you will learn to do steep descending turns safely. Your instructor will begin by showing you the absolute limit of the descending turn at the normal gliding speed of 80K. You will see from this that you reach the stall warning approximately 50° of bank. To keep an adequate margin above the stall we must increase our airspeed if we wish to do turns of greater than 30° of bank. Your instructor will then show you another turn at an increased airspeed and you will see that you can safely obtain a higher angle of bank and an increased rate of turn. This, however, involves the penalty of a high rate of descent.

42 Let us consider two situations where we could need a steep descending turn:

a **Steep descending turn to avoid cloud** We can imagine the situation where you are on a solo sortie climbing between cumulous cloud and then you find that, with the cloud increasing, you are 'boxed in' but can see the ground through a gap in the cloud below you. You are unrated so you must not go into cloud - but this would be the result if you attempted a straight glide descent. To keep clear of cloud you must do a steep descending turn to spiral down below the cloud base. As you have been shown already, you can do a steep descending turn but this involves a high rate of descent. Clearly, you do not want to pop out of your gap in the clouds at a high rate of descent - a procedure which may bring you close to the ground before you can recover or which may land you on top of another aircraft which should not be, but it, cruising close to the cloud base. To decrease your rate of descent, use power. Your instructor will show you how you can control your rate of descent with power, while maintaining the speed, angle of bank and rate of turn.

b **Steep descending turn to final approach** The steep descending turn on to final approach would not be made in normal circuit work. Having made an error on the base leg you would go round again (See Exercise 13). The situation where we are more likely to need a steep descending turn is during a poorly planned forced landing - perhaps when picking an alternative field. Be quite clear about the rules. If you are going to do a steep descending turn you must increase your airspeed and accept the increased rate of descent. Obviously, you cannot continue the turn too near the ground and, if you have successfully made the turn, you must accept the embarrassment of the additional airspeed as you start the final approach. Your instructor will ask you to practise steep gliding turns and then to roll out, raising the nose to reduce speed, and selecting flap as soon as possible in a straight glide.

Conclusion

43 This exercise will show you how to get an advanced turning performance from your aircraft. The separate parts of the exercise are spread over several dual sorties. As well as their practical value the advanced turns provide an excellent means of improving your flying ability in terms of co-ordination and precision. Also, as you will see later, the lessons learned in this exercise have an application to aerobatics.

44 Be conscientious in your solo practice. Do not just heave the aircraft round the horizon at various angles of bank and various power settings. The essence of the exercise is good attitude flying. As a reminder, the steep turn and maximum rate level turn are re-defined as follows:

a **Steep turn** When practising steep turns, nominate the angle of bank you are going to use and perform a turn using power to retain your cruising speed. Normally, you use at least 45° of bank, but this will depend on the power available (altitude effects this). If you attempt a steep turn at a specified angle of bank and find, despite the use of full power, that your airspeed is decreasing, then you will have to reduce the angle of bank accordingly.

b **Maximum rate level turn** When practising maximum rate level turns, select full power and the maximum angle of bank which you can sustain while just reaching the stall warning.

EXERCISE 16

L O W   F L Y I N G

Introduction

1 With the introduction of more powerful and more effective radar detection systems, low flying may provide one of the means left open to aircraft to penetrate defences and reach a target area undetected. To do this requires skilled, accurate flying - very low and very fast below the 'radar horizon'.

2 The operational uses of low flying are outside the scope of the flying training syllabus. Nevertheless, this exercise is included to introduce you to flying near the ground and to give you some indication of the problems involved. You will also be taught bad-weather low flying.

3 Safe low flying requires a high standard of both flying ability and self-discipline. You will get a true impression of speed during this exercise and may become so fascinated with low flying that you may be tempted to indulge in it beyond your capabilities. BE ADVISED - DON'T!

Regulations Governing Low Flying

4 The following regulations are important and are to be noted:

a Low flying in a light propeller-driven aircraft is defined as any flight below 500ft above ground or water level. It is prohibited except:

(1) When specifically authorized.

(2) When taking off, landing or making a forced landing.

(3) When necessitated by weather.

(4) When so directed by any Air Traffic Control Authority.

b Para 4a above is an extract from Air Legistation. The extract is not comprehensive, Local Flying Orders may lay down more stringent limits. The exact regulations are laid down in Section 2 Rule 5 of the A.N.O. at Annex A to this chapter.

c If, during a flight, a pilot is forced to fly at an altitude less than 500ft above ground or water level (because of bad visibility or weather, or for any other reason not stated in para 4a), the occurrence is to be reported in the flight authorization book by the captain of the aircraft immediately after landing. You, as a student, should report such an occurence to your instructor.

5 **Flying over populated areas** There will be a number of towns and built-up areas in your local flying area, which you should avoid flying over - except at heights which would enable you to reach open country in the event of engine failure. This is covered in the A.N.O. at Annex A to this chapter.

6 **Dangerous of negligent flying** As a student, you will not be authorized to practise solo low flying, except for solo low-level navigation sorties if they are included in your syllabus. All low flying practices are carried out in approved areas or along selected routes and, even though properly authorized, it remains the pilot's responsibility to ensure that he complies with the A.N.O. in that his aircraft is not manoeuvred in the air in a manner likely to cause injury or annoyance to persons, damage to livestock or property, or to the aircraft itself.

Effect of Wind

7 The effect of wind is more noticeable near the ground than at altitude, and is much more noticeable at low airspeed than at high airspeed. At a low IAS, the difference in ground speed becomes apparent when you are flying upwind as compared to downwind. Furthermore, turns are deceptive because of the effect of drift. When turning downwind the aircraft appears to slip into the turn, even though the turn is correctly balanced. Conversely, when turning into wind, the aircraft appears to skid. Do not attempt to use the rudder to correct these illusions. You will find that, as the IAS increases, each of these items becomes less noticeable.

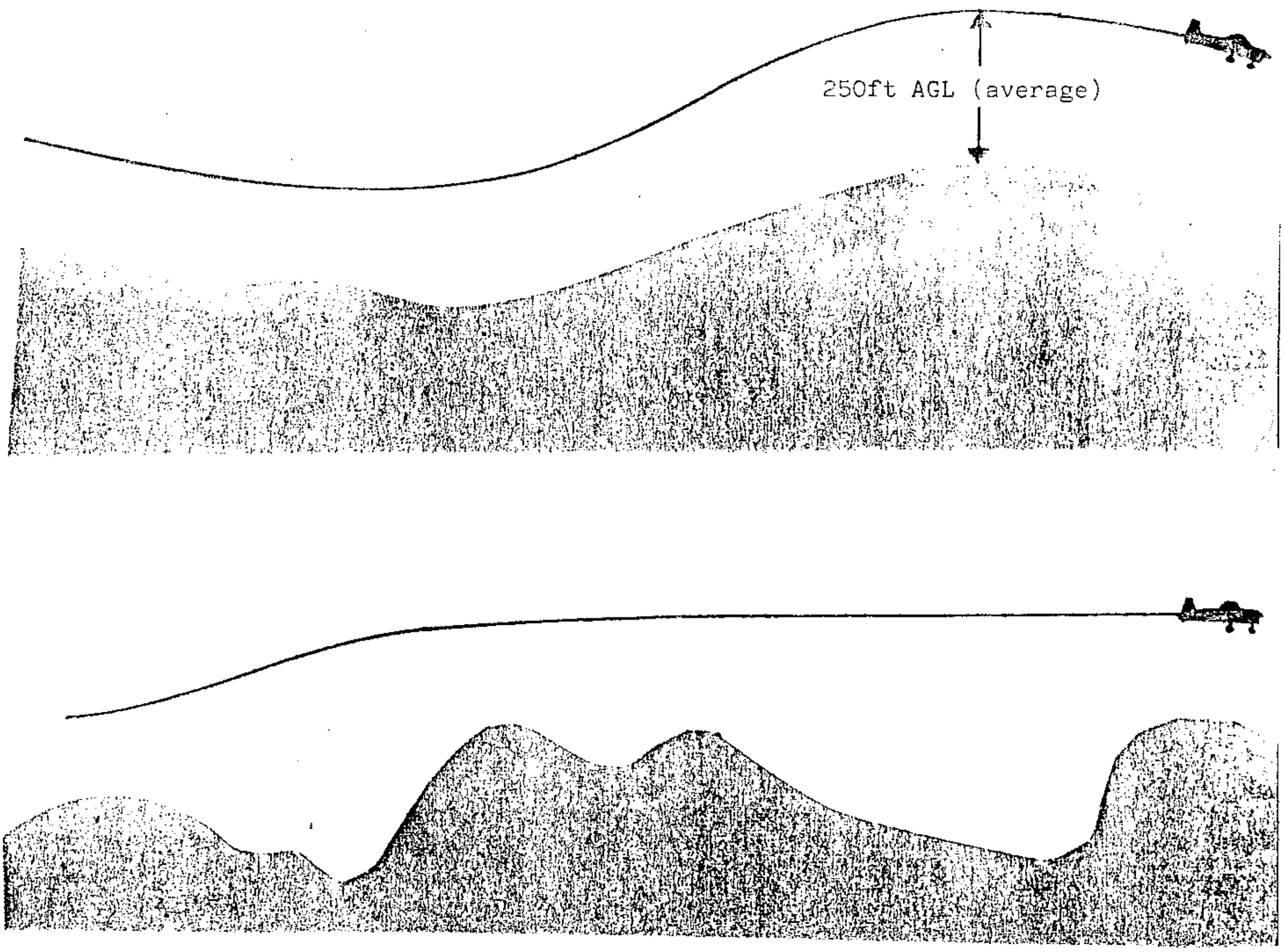


Fig 16.1 Terrain clearance

8 **Turbulence** Turbulence may become severe near the ground, and its affect on the aircraft increases with airspeed - a fact you will probably have noticed already during your circuit flying.

Terrain Clearance

9 The fundamental consideration in low flying is terrain clearance. For the purpose of practising low flying, your instructor will expect you to maintain 250 ft agl. You will appreciate that, at 250 ft agl you will be flying well below the Transition Altitude, and your altimeter will approximatley indicate your height above sea level. From this, you will gather that you must rely on visual judgement to maintain 250 ft agl. Once you have been shown what 250 ft agl looks like from the air, it is relatively easy to maintain it over flat terrain; but if the countryside is hilly, you will have to maintain 250 ft agl by following the contours. Obviously, under some circumstances, this is neither practicable or possible. For example, if you are flying across a narrow valley where the contours change rapidly, it would be dangerous if you were to try to maintain a constant 250 ft above ground level (Fig 16.1).

Navigation

10 The problem of navigating from point to point will be covered more fully during the low level navigation sorties. However, it is absolutely essential that, whilst practising low flying, the aircraft is kept on the authorized low flying route. This calls for careful preparation and an advance study of your map, bearing in mind the following points:

a At 250 ft agl, the range of vision is reduced and the horizon appears much nearer.

b Accurate identification of ground features is complicated by the low perspective and their limited time in sight.

c The range and accuracy of radio aids is seriously reduced.

d More concentration is required to fly the aircraft accurately.

Bad Visibility Low Flying

11 Your instructor will show you how to set the aircraft up for bad visibility low flying. Although the demonstration will be given in clear conditions, you should remember the practical application of the demonstration and resort to the technique shown whenever you are faced with a flight in poor visibility. For example, if you are returning to base in heavy precipitation, you will find it much more comfortable flying at the bad visibility speed and configuration than at range speed.

AIRMANSHIP

Low Flying Area

12 You should have the low flying area and obstacles, such as high tension cables, marked on your map. All low level sorties must be properly authorized, and the minimum height agl for the exercise clearly stated.

Entering the Low Flying Area

13 Before descending to low fly, carry out the following checks:

a Check that your fuel contents are sufficient.

b Synchronize DI with the compass.

c Inform the operating authority and then listen out on the appropriate frequency.

d Set the regional pressure setting (RPS) on the altimeter.

e Note the wind direction and speed.

f Check that your harness is tight (because of increase in turbulence near the ground.

g Positively check that you are on a low flying route.

Descent into the Low Flying Area

14 The descent to low fly should be made at a moderate rate of descent. Whilst descending, keep a good lookout, carrying out gentle turns to clear blind spots ahead of, and below, the nose.

In the Low Flying Area

15 Remember that you may not be the only aircraft using the low flying area, so maintain a good lookout for other aircraft. A point to bear in mind in this connection, is that aircraft using the low flying area maybe at the same height and, with no vertical separation, the risk of collision is greatly increased. You should also make frequent checks of your position if in doubt, climb to establish it before carrying on with the exercise. Wherever possible, avoid flying over livestock or built up areas.

AIR EXERCISE

Descent into the Low Flying Area

16 The descent is made at cruising speed and, as you descend, you should note:

a The increasing impression of speed as you get nearer to the ground.

b The changing aspect of ground feature; you will notice, for example that hills, houses, and trees now have a three dimensional appearance.

Familiarization at Low Level

17 Your instructor will carry out a demonstration, after which you will practise.

a **Demonstration** With the aircraft trimmed for 100k, your instructor will show you what 250 ft agl looks like and will point out that this is purely a visual assessment, the altimeter being of little use. If practicable, you will also be shown the boundaries of the low flying area and any prominent ground features, and obstructions.

b **Dual Practice** When you are given control of the aircraft, try to maintain height and airspeed. To do this, you must be prepared to vary the power when flying up and down over large contours. To do this well, you must try to anticipate the power variations needed well in advance of the changing slopes.

Effects of Wind

18 In para 7 we stated that the effect of wind was more apparent in low level flying. Your instructor will demonstrate the following effects of wind at low level:

a **Crosswind** To track along a line feature that is at right angles to the wind, you must allow for drift. This is to be borne in mind when trying to avoid obstacles; in other words, remember that the aircraft does not always go in the direction in which it is pointing.

b **Turns** The effect of wind on a turn is to cause an apparent slip when turning down wind, and a skid when turning into wind. Because these are false impressions and, provided the aircraft is in balance, they can be ignored. They must, however, be allowed for when turning to avoid obstacles.

c **Groundspeed** At a constant airspeed, there is a marked increase in groundspeed when flying down wind. Because of this, you may be tempted to throttle back; but DON'T DO IT. Conversely, flying into wind gives a marked decrease in groundspeed. Clearly, these effects are present at all heights; they only become apparent when you are flying near to the ground.

Low Level Steep Turns

19 The procedure for practising steep turns near the ground is exactly the same as at height - except that there is, of course, a need for greater precision and accuracy, and the lookout (both before, and during, the manoeuvre) must be 100% complete. Once again, allowance must be made for wind effect during a turn to avoid obstacles.

20 Your instructor will ask you to fly a pattern over the ground, using steep turns to position the aircraft in relation to specified ground feature. This will probably be a figure of eight pattern centred over a crossroads the aim of pattern flying is to demonstrate the need to allow for the wind when turning, by varying the angle of bank, then maintaining a fixed path over the ground.

Bad Visibility Low Flying

21 The main points are considered below:

a You will need only a short time near the ground at normal cruising speed to appreciate how dangerous this would be in conditions of poor visibility. The answer, of course, is to fly much slower. The speed used is 70K. You already know that, at low airspeeds, the nose altitude is quite high, and this in itself is a disadvantage in terms of maintaining a good lookout. Use of ½ flap, however, provides the following advantages:

(1) A lower nose position, giving better forward view.

(2) A greater margin over the stall because of the lower stalling speed.

(3) A smaller turning radius for a given angle of bank; your instructor will show you this.

b Against these advantages, remember that the higher power setting required with flap increases the fuel consumption, so that both range and endurance are reduced.

c In conditions of low cloud and poor visibility, it is vital that you remain in visual contact with the ground. The aim should be to fly at least 200ft below cloud, provided it is safe to do so.

Engine Failure at Low Level

22 Very limited time is available to do any drills - very similar to an engine failure after takeoff.

Simulated Turn-back

23 Your instructor will show you how the minimum height for a turnback is made up.

CONCLUSION

24 Low flying exercises are carried out to give you some indication of the problems involved, to increase your confidence when flying near the ground, and to teach you to judge distances and perspectives at low level. Low flying training exercises are normally carried out at 250 ft agl and are to take place only on approved routes.

ANNEX A TO EXERCISE 16

L O W F L Y I N G

Air Navigation Order
Section 2
Rule 5

5 (1) Subject to the provisions of paragraphs (2) and (3) of this rule;

(a) An aircraft other than a helicopter shall not fly over any congested area of a city, town or settlement below:

(i) such height as would enable the aircraft to alight clear of the area and without danger to persons or property on the surface, in the event of failure of a power unit; or

(ii) a height of 1500 feet above the highest fixed object within 2000 feet of the aircraft, which ever is the higher.

(b) A helicopter shall not fly below such height as would enable it to alight without danger to persons or property on the surface, in the event of failure of power unit.

(c) Except with the permission in writing of the Authority and in accordance with any conditions there in specified a helicopter shall not fly:

(i) over a congested area of a city, town or settlement below a height of 1500 feet above the highest fixed object within 2000 feet of the helicopter; or

(ii) over the area specified, below such height as would enable it to alight clear of the area in the event of failure of a power unit, that is to say the area bounded by straight lines joining successively the following points:

Kew Bridge (51°29'11"N 00°08'58"W).

The Eastern extremity of Brent Reservoir (51°34'18"N 00°14'01"W).

Gospel Oak Station (51°33'16"N 00°08'58"W).

The South East corner of Springfield Park (51°34'07"N 00°03'12"W).

Bromley-by-Bow Station (51°31'28"N 00°00'39"W).

The South West corner of Hither Green (51°26'43"N 00°00'38"W).

Herne Hill Station (51°27'11"N 00°06'04"W).

Wimbledon Station (51°25'14"N 00°12'16"W).

The North West corner of Castelnau Reservoir (51°28'-52"N 00°14'02"W).

Kew Bridge (51°29'11"N 00°17'10"W).

excluding so much of the bed of the River Thames as lies within that area between the ordinary high water marks on each of its banks.

(a) An aircraft shall not fly:

(i) Over, or within 3000 feet of, any assembly in the open air of more than 1000 persons assembled for the purpose of witnessing or participating in any organised event, except with the permission in writing of the Authority and in accordance with any conditions therein specified and with the consent in writing of the organisers of the event; or

(ii) below such height as would enable it to alight clear of the assembly in the event of the failure of a power unit.

Provided that where a person is charged with an offence under the Order by reason of a contravention of this sub-paragraph, it shall be a good defence to prove that the flight of the aircraft over, or within 3000 feet of, the assembly was made at a reasonable height and for a reason not connected with the assembly or with the event which was the occasion for the assembly.

(e) An aircraft shall not fly closer than 500 feet to any person, vessel, vehicle or structure.

(2) (a) The provision of paragraphs (1)(a)(ii) and (1)(c)(i) of this Rule shall not apply to an aircraft flying:

(i) on a route noted for the purposes of this Rule; or

(ii) on a special VFR flight as defined in Rule 23 of these Rules in accordance with instructions given for the purposes of that rule by the appropriate air traffic control unit; or

(iii) on a flight in respect of which a special VFR clearance has been given pursuant to Rule 36 of these rules in accordance with instructions given by the appropriate air traffic control unit.

(b) Paragraphs (1)(d) and (1)(e) of this Rule shall not apply to an aircraft in the service of the police authority for any area of the United Kingdom.

(c) Paragraphs (1)(d) and (1)(e) of this Rule shall not apply to the flight of an aircraft over or within 3000 feet of an assembly of persons gathered for the purpose of witnessing an event which consists wholly or principally of an aircraft race or contest or an exhibition of flying, if the aircraft is taking part in such race, contest or exhibition or is engaged on a flight arranged by, or made with the consent in writing of, the organisers of the event.

(d) Paragraph (1)(e) of this Rule shall not apply to:

(i) any aircraft while it is landing or taking off in accordance with normal aviation practice;

(ii) any glider while it is hill soaring;

(iii) any aircraft while it is flying in accordance with provisio (1) of Article 39 (2) of the order;

(iv) any aircraft while it is flying under and in accordance with the terms of an aerial application certificate granted to the operater thereof under Article 40 of the Order.

(3) Nothing in this Rule shall prohibit an aircraft from flying in such a manner as is necessary for the purpose of saving life.

(4) Nothing in the Rule shall prohibit any aircraft from flying in accordance with normal aviation practice, for the purpose of taking off from, landing at or practising approaches to landing at, or checking navigational aids or procedures at, a Government aerodrome, an aeroplane owned or managed by the Authority or a licensed aerodrome in the United Kingdom or at any aerodrome in any other country:

Provided that the practising of approaches to landing shall be confined to the airspace customarily used by aircraft when landing or taking off in accordance with normal aviation practice at the aerodrome concerned.

(5) Nothing in this Rule shall apply to any captive balloon or kite.

EXERCISE 17

F O R C E D   L A N D I N G   W I T H O U T   P O W E R

Introduction

1 In the event of a partial, or complete, engine failure, the actions you must take will vary considerably depending upon the aircraft height, the weather, and the type of terrain over which you are flying. As the Firefly is designed so that it can be operated from relatively small grass areas, the most likely course of action is for you to execute a forced landing without power (FLWOP). The procedures outlined in this exercise are to be used as a guide only; ultimate success will depend to a large extent on your ability to modify the procedures to suit the conditions (aircraft height, weather etc). Sound common sense and good airmanship play a very important role.

2 It is easy to get over-engrossed in the various checks to be carried out prior to a forced landing to the detriment of your flying. Thus, it is important to learn, and remain aware of, the priorities. The aim of a forced landing is to save life. If this can be done with minimum damage to property, and without wrecking the aircraft, so much the better. BUT DO NOT FORGET THE AIM.

PRINCIPLES INVOLVED

Basic Principles

3 If you refer back to Exercise 8 (Descending), you will recall that a glide descent at a constant speed will give a constant angle of glide. From the cockpit, if you look along the descent line of the aircraft to where it would touch the ground, the angle subtended to the horizontal (the sightline angle) will remain constant. Apparent shapes of features will retain the same perspective although the size of the objects will increase as descent continues.

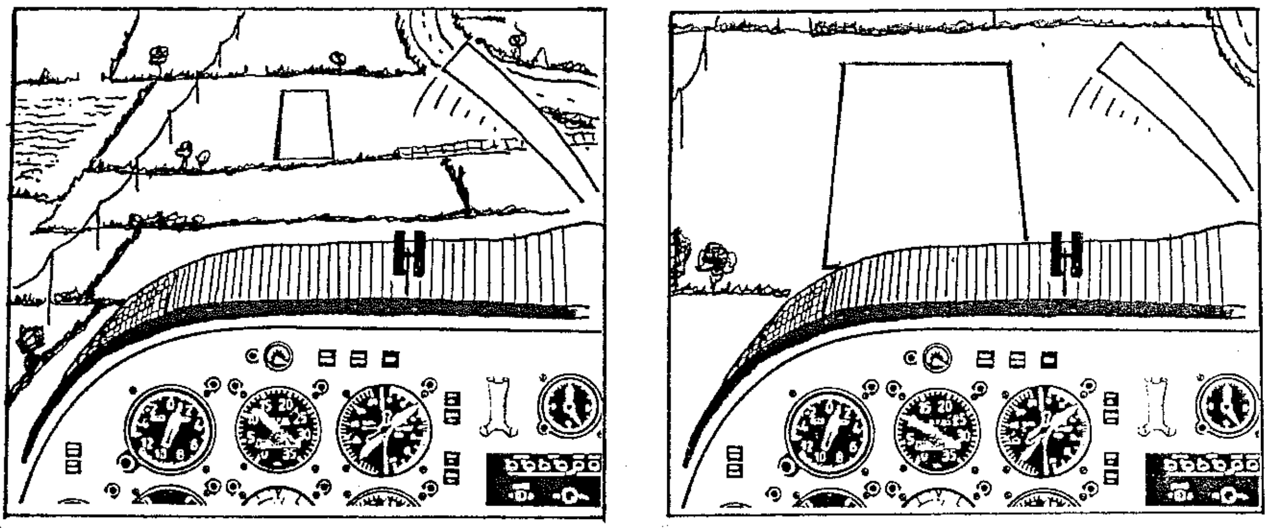


Fig 17.1 Constant sightline angle

4 If you can imagine the same descent, but flown around the surface of an inverted cone, it can be seen that a square field at the point of the cone will also maintain a constant perspective ie the sightline angle remains constant. We will use this principle to position the aircraft at a point in space on the cone from where a glide approach, similar to that already practised on the airfield, can be made into a field.

Control of Sightline Angle

5 You will already have seen how to vary the approach path by using bank during glide approaches to the airfield. The same technique is used when maintaining a constant sightline angle in a descending turn during the forced landing, as in (Fig 17.2). You can steepen the sightline angle by increasing bank and flatten it by reducing bank. Therefore, any tendency for the sightline angle to change can be counteracted by adjusting bank.

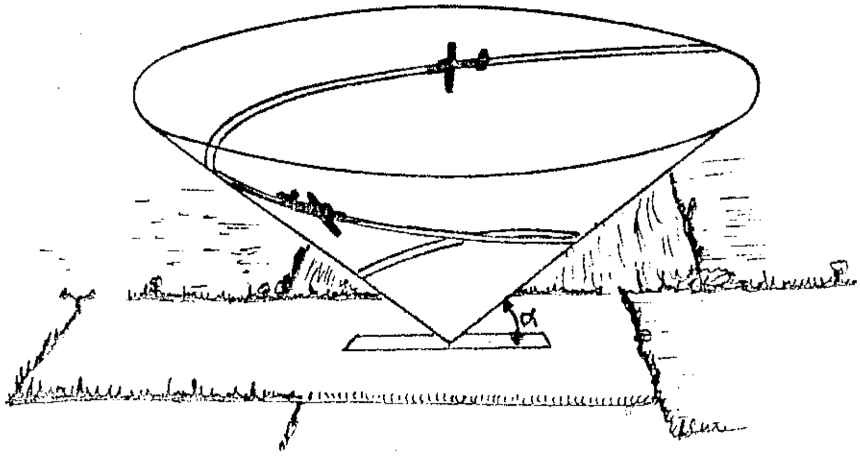


Fig 17.2 Constant sightline angle in descending turn

The Forced Landing Pattern

6 The required pattern is illustrated in (Fig 17.3) and described below:

* The pattern itself is started from the 'High Key' position. This position is defined as that where, with the aircraft heading in the same direction as it will land (normally into wind), the initial aiming point, one-third of the way into the field, is just in view on the left side of the cowling, in front of the leading edge of the wing, with the aircraft at, or above, 2000ft (Point 1 in Fig 17.3). The height is not absolutely critical, and will be discussed further in paragraph 9.

* From the 'High Key' point, the aircraft is flown straight, until the initial aiming point appears behind the trailing edge of the wing. (Point 2 in Fig 17.3).

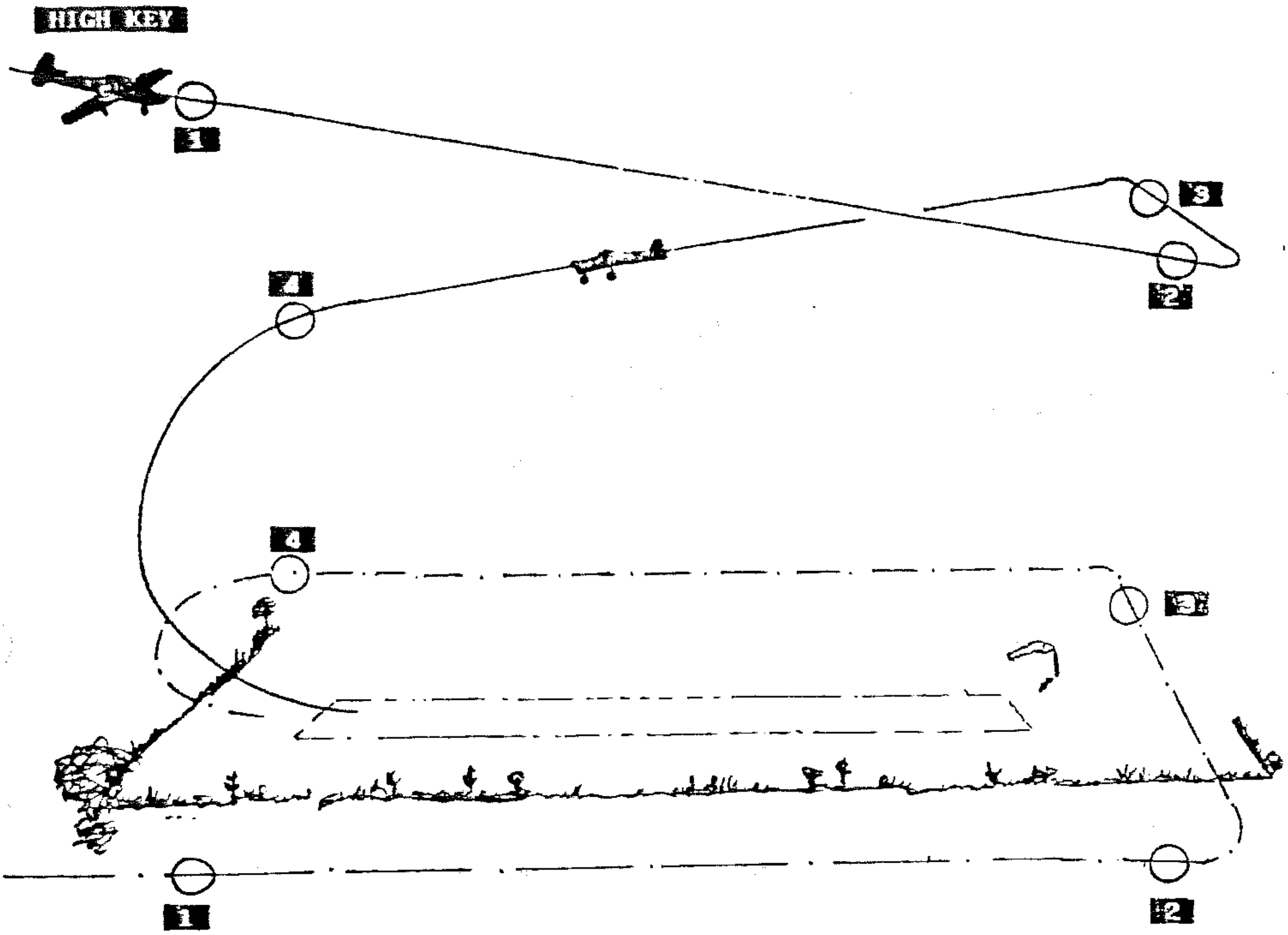


Fig 17.3 Forced landing patterns

* The aircraft is then turned until it tracks at 90° to the landing direction and this heading is maintained until the selected touchdown point appears behind the wing in the 7 or 5 o'clock position relative to the aircraft (Point 3 in Fig 17.3).

* At this point turn and fly a "downwind" leg until, at the latest, the selected touchdown point is abeay the wing tip. Bank is then applied and adjusted to maintain the sightline angle until the aircraft reaches a positon coincident with that seen on a glide approach at about point 4 in Fig 17.3.

* As in the glide approach, flap should be selcted only when you are quite sure by doing so you will not undershoot the field. This is particulary critical if the chosen field is small where full flap is selected at a lower height to achieve a landing in the field. When practising, the selection of full flap may be precluded by the need to overshoot by your briefed height.

* Do not make the error of deliberately overshooting your initial aiming point and then correct by an early selection of full flap. Remember your judgement of the approach improves as range decreases and therefore early selection of full flap makes the achievement of an accurate touchdown point very difficult.

Effect of Wind

7 If we always flew when there was no wind forced landings (either practice or real) would be very simple because we could then learn the correct sightline angle for a glide approach and maintain it all the way down. However, you will already have seen that the stronger the wind the steeper will be the approach angle (Fig 17.4)

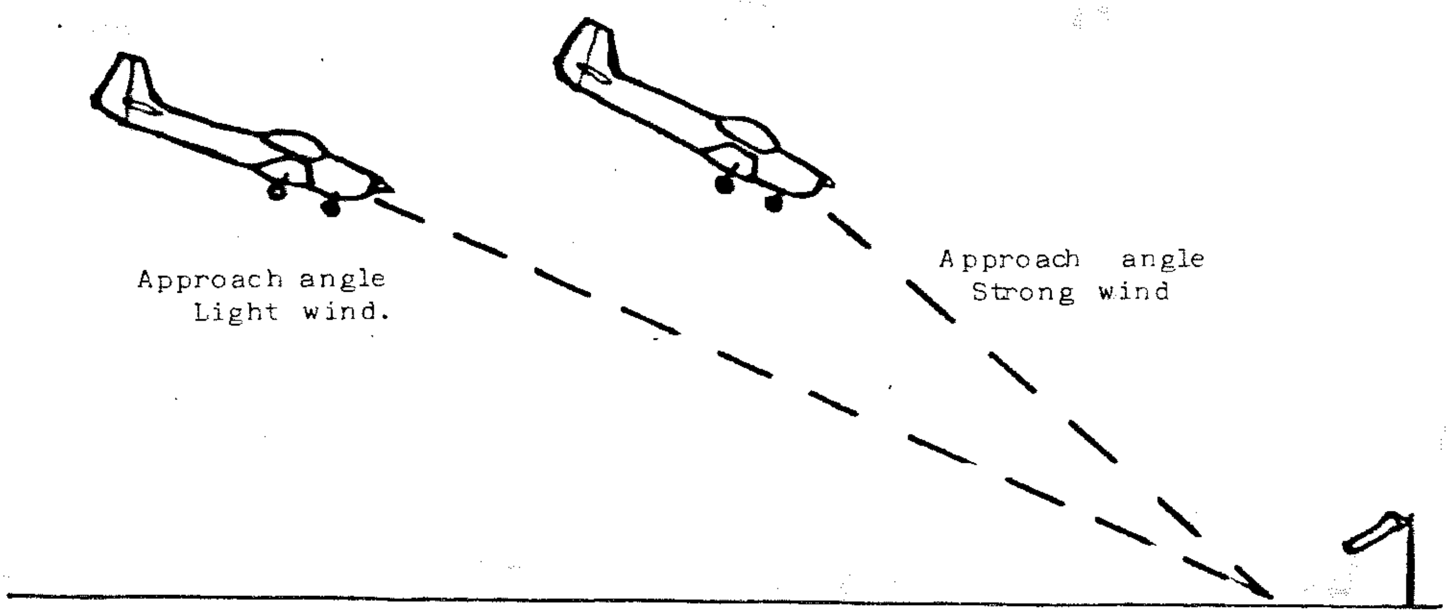


Fig 17.4 Effect of wind on approach angle

8 If you refer back to paragraph 6 and Fig 17.3, you will see that we TRACK at right angles to the landing direction when flying crosswind. It follows that the stronger the wind, the more we must head into it and the closer we will be to the field when it appears at point 3 in Fig 17.a. The modified pattern is illustrated at Fig 17.5. As we are closer to the field the aspect will be steeper which is exactly what we want.

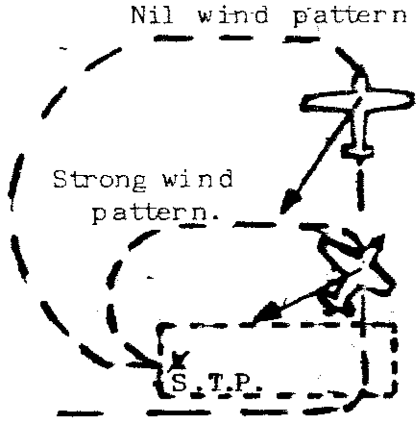


Fig 17.5 Effect of wind on pattern

Height at High Key

9 The height of 2000ft agl should be taken as the minimum height at high key. The same pattern could be used for any height above 2000ft although, above 3000ft, it is simpler to orbit at the high key position until down to between 2000ft and 3000ft. It is easy to see that increasing the height at high key merely enlarges the pattern throughout, the various positions remaining the same (Fig 17.6).

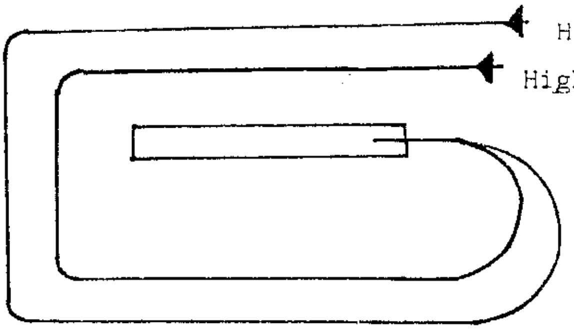


Fig 17.6 Effect of increasing height at high key

Engine Failure Below 2000ft agl

10 Up to now we have assumed that the engine failure has occured far enough above 2000ft agl to enable you to manoeuvre into an acceptable high key position. However, although most of your practices will allow you sufficient time to do everything correctly, real engine failures can often occur when they are least easy to deal with. If the engine fails below 2000ft agl, the best course of action may well be different for even small differences in aircraft height, aircraft heading, or wind conditions. In these circumstances, there can be no substitute for common sense. However, based on other pilot's experiences there are some considerations that can be borne in mind, and these are set out below as a guide.

a In a 70k gliding orbit through 360° the Firefly looses 600ft at 30° bank and 400ft at 45° bank. In the event of actual engine failure the height losses involved will be greater.

b With the aircraft heading downwind, wings level, a field which appears just under the blue wing stripes will be in approximately the correct position for normal wind conditions (Fig 17.7). If you are above 600ft agl, you could start an immediate turn towards the field to intercept a normal pattern.

c It follows from sub-paras 10a and 10b that if you are above 900ft agl, you have enough height to turn downwind and accept the best field which appears closer than the wingtip.

d Between 600ft and 900ft agl, you have sufficient height to turn the aircraft into wind before carrying out an EFATO (engine failure after take-off - see Exercise 12) if the procedure of sub-para 10b is not parcticable.

e Below 600ft agl you will be unable to perform a 180° turn safely, and will probably be better to treat the emergency as an EFATO, turning the aircraft as much into wind as possible with the height available. Remember that the above information is intended only as a guide. However, if it makes you think about what you would do in various situations BEFORE you get airborne, it will have achieved its object.

f Having learnt the ideal pattern your instructor will show you ways of intercepting a forced landing patterns from various start positions and heights. Unlike the ideal situation it may not be prudent to select ½ flap immediately. Although ½ flap has little effect on the aircraft's gliding performance, always wait until you have achieved a satisfactory sightline angle on your selected field before selecting ½ flap.

g Remember there is no substitute for experience; experience can only be gained by practising and thinking about these various situations. Good principles to follow are to always keep monitoring the sightline angle of your selected field; if necessary, change your field to one that will improve your chances of success should you have errorred in your initial selection or judgement - Remember this decision is best made earlier than later in the pattern.

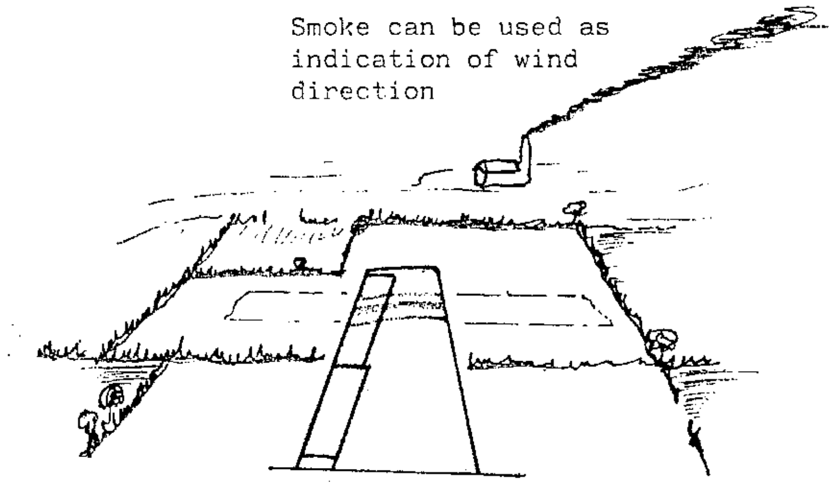


Fig 17.7 Showing approximate aspect of a suitable landing field from below 2000ft in the downwind position

Choice of landing area

11 The gliding angle of the Firefly is quite shallow but this proscribes the choice of landing area. As a rough guide (regardless of altitude), it is possible to reach any field within a circle drawn through the wing tips (Fig 17.8). If there is an airfield within this area, then that would probably be your first choice. Failing this, you must choose a suitable field. There are five factors to bear in mind in making a choice of field. You should remember them as the 'Five Ss': Surface, Size, Shape, Surrounds, Slope. These factors are considered further below:

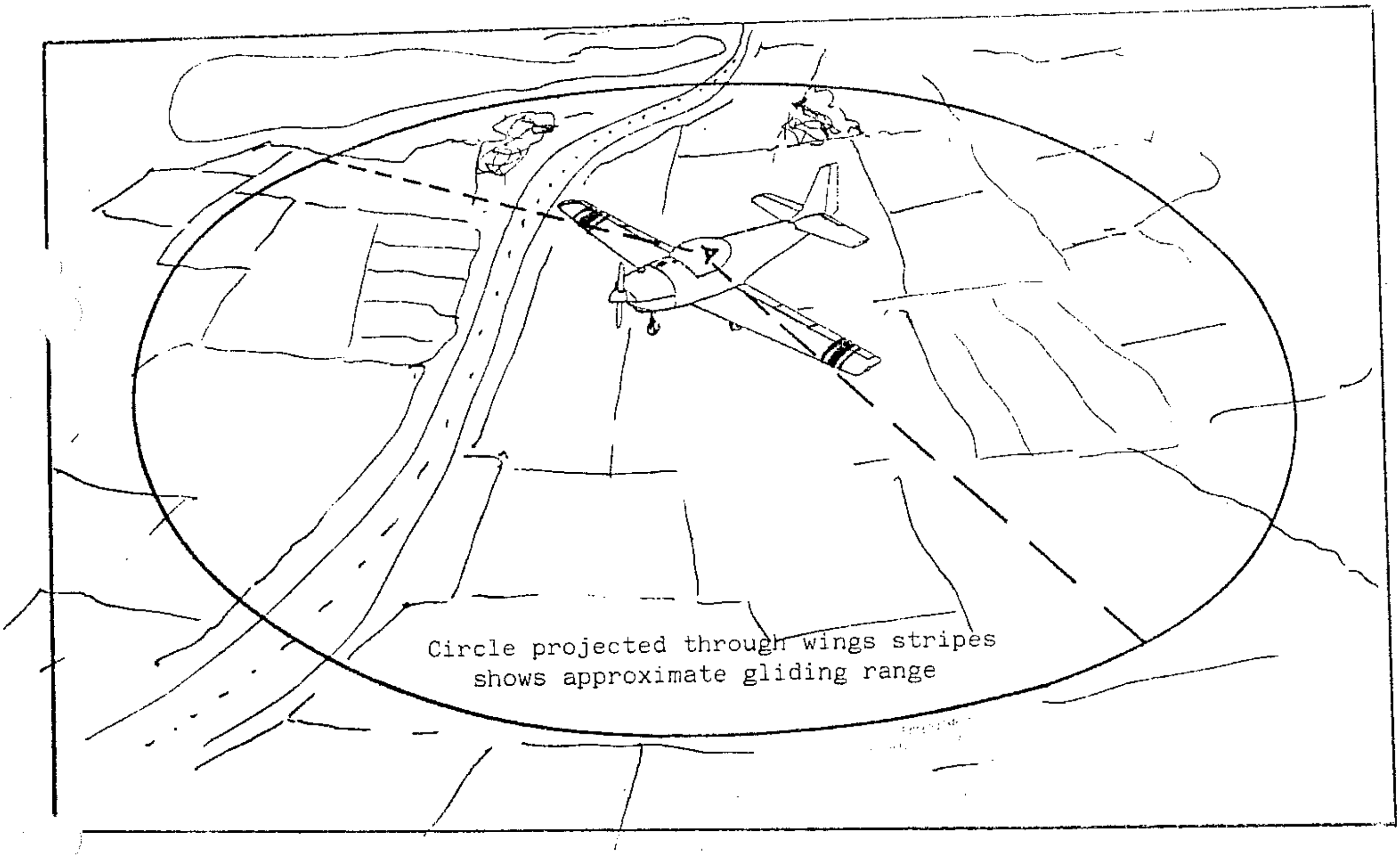


Fig 17.8 Approximate guide to possible landing fields

a **Surface** If possible, the ideal choice is a grass field. Other surfaces are likely to be more hazardous. For example, a freshly ploughed field will almost certainly cause the undercarriage to break with unpredictable results. Yet once the same field has settled and produced a young growth it may be almost as suitable as a grass field. Moreover, after the crop has been gathered in, the stubble usually forms a very good surface. The variations on this are almost infinite and will be discussed by your instructor.

b **Size** The field selected should be large enough for the 'round out' and the landing run. Do not forget to allow for the longer landing run in light wind conditions, or if you are not landing exactly into wind.

c **Shape** A square field is normally a better choice than a longer, narrower field. A square field offers two main advantages: firstly, it offers a landing run into wind; secondly, it does not restrict you to one landing path - if you find you are undershooting or overshooting on the later part of the pattern, it is possible to steepen or slacken the turn to take up a new landing line.

d **Surrounds** When choosing a field, try to choose one with a clear approach into wind and with alternate fields near it. High trees, overhead cables, and buildings could cause you to modify your flight path and waste valuable height. When practising a forced landing without power, you must also ensure that the overshoot area is clear for you to climb away safely.

e **Slope** At height, it is difficult to tell whether a field is sloping or not. If you are committed to land on sloping ground, remember that the landing run will be shorter uphill and longer downhill. (Remember too, that slope will also change the aspect of the field as you fly the pattern from high key).

Planning the Descent

12 Your instructor will concentrate initially on showing you how to choose a suitable field and teaching you the pattern from high key. Once you have become proficient at flying the pattern, you will progress to more realistic situations. With an engine failure at height, your probable sequence of actions will be:

a Set up a 80K glide descent and trim the aircraft.

b Pick a suitable field (of a suitable area, leaving the choice of an individual field till later) and, having noted the wind conditions and height available, plan the decent so as to arrive at high key, heading into the wind. You will have to monitor how the descent is going down to high key, adjusting as necessary.

c Try to find out why the engine has failed and, if there is no obvious reason, attempt to restart it.

d Put out 'Mayday' call on RT.

e For practice forced landings without power (FLWOP), clear the engine every 1000ft in the descent.

Additional Considerations

13 So far we have discussed the fundamentals of a (FLWOP). The factors now about to be discussed could, for want of better words, be described as the 'administrative details'. This is not to say that they can be ignored or treated lightly; but the omission of any one of them would not always affect the final outcome.

14 **Abandoning the aircraft** The decision whether or not to abandon the aircraft should be made early. Usually, the decision is taken as you select the field. If there is suitable landing area available; then there is little point in leaving the aircraft. On the other hand, if you are over extensive forestry or mountainous terrain, there is little point in staying with the aircraft. Having decided to attempt a FLWOP, you may later wish to change your mind - either through obtaining a better view of the ground and deciding it is not suitable after all, or by badly misjudging the descent and deciding that you would prefer to use the parachute. The lowest height at which to initiate abandoment of the aircraft is 2000ft agl.

15 **Checking cause of failure** It would be foolish to land from 3000ft simply because the magneto switch had been accidentally put off. The possible causes of failure are, therefore, to be checked if there is time available using the drills laid out in the flight reference cards.

16 **Distress Call** If the rescue services know your position before you land you can expect speedy assistance soon after landing. Thus, it will clearly pay you to let them have this information. To do this, transmit a distress call on the frequency you are using or, if the frequency you are using is the 'quiet' frequency, select your base approach frequency and transmit your distress call. Finally, if you have time, and require more comprehensive assistance from the ground, make a call on the Emergency Distress frequency as well. You should be familiar with the full contents of a distress call, but remember it is only necessary to transmit that information that you have time to impart, and that you consider vital. An example of such a call is as follows:

MAYDAY, MAYDAY, MAYDAY

BRAVO ONE THREE, BRAVO ONE THREE, BRAVO ONE THREE

8 MILES NORTH OF TADCASTER

ENGINE FAILED

MAKING FORCED LANDING

Do not get involved in a long discussion with the controller to the detriment of your judgement.

Forced Landings in Hazardous Areas

17 Although you would normally expect to carry out a forced landing after an engine failure, the situation can arise where it would be hazardous to land on the terrain within the gliding range of the aircraft. Ideally, the aircraft should be flown above 2000ft agl, over hazardous terrain, such as steep hills, moorland and flooded fields etc, so that you can safely abandon the aircraft. There are, however, occasions when flight below 2000ft agl is operationally necessary - eg essential low level navigational sorties, or if you are forced to fly low to avoid cloud. In these circumstances, if you suffer an engine failure below committal height, no one can tell you the precise series of actions to take, since the situation presented to you (nature of the surface, length of landing run, wind conditions and your individual skill) is almost infinitely variable. The following guidelines, in addition to the airmanship you have already been taught, may help you to arrive at the solution to a complex problem:

a Convert speed to height - but be careful. In bad visibilty configuration, your potential height gain is zero, and even from a 100 knots you are not going to gain much more than 100ft.

b If possible, make the final approach into wind since the effect on ground speed is considerable in low performance aircraft; but do consider the effects of this on the landing run available, particularly if it will lead to landing on a steep downslope.

c Glide, as you have already been taught, at 80 knots. Reducing the glide speed may give a slightly lower rate of descent, but it will also increase the likelihood of approaching a stall. To recover from this situation will require an increased rate of descent, thereby nullifying any previous gain. Additionally, a reduced speed may restrict your ability to reduce the rate of descent to an acceptable figure for touchdown, and will also make it hard for you to manoeurve to alter your landing direction slightly should you so wish. Gliding at 80 knots, on the other hand, not only gives you the best gliding range, but will also ensure that you retain sufficient speed to control your touch down successfully. This is particularly important since the Firefly gives the pilot little protection from vertical decelerations.

d Your available methods of losing excess height are S turns, side slipping or even changing your chosen landing direction or field.

e After the roundout, you have the choice of putting the aircraft down at around 55 knots or holding the aircraft a little above the surface until it runs out of flying speed. The former technique would be suited to the situation where there is a hazard ahead, whereas the latter would be appropiate if the landing run was adequate but the surface was hazardous. In either case, touchdown on the mainwheels and try to keep the weight off the nose wheel; but be careful not to pull back sufficiently far on the control column to cause the aircraft to lift off again.

Engine Failure at Night

18 If you have engine failure at night, do not attempt to force land unless you are below Committal Height. Should the engine fail in the circuit after you have made the cross wind climbing turn, then turn and land in the best direction available to you on the airfield. Above Committal Height, make every effort to restart the engine. If there is no response:

* Turn the aircraft towards a dark, unpopulated area.
* Make a distress, call if there is time.
* Abandon the aircraft.

Engine Failure Above Cloud

19 If the engine fails when you are above cloud and you do not know your exact position, or the height of the cloud base, you must abandon the aircraft. If you know your position, and the cloud base is above committal height, you may descend and, when in visual contact with the ground decide whether or not to force land. If you elect to descend through cloud do not go below your safety altitude. Under these conditions, safety altitude is your committal height.

Crash Actions

20 The crash actions during a FLWOP should be done immediately you are sure that there is no chance of restarting the engine. (For practice FLWOP's, the crash action checks should be simulated, and the before-landing-checks should be done to ensure that the engine is correctly set for overshooting). The crash actions are made to ensure that the engine does not restart momentarily during the approach to a forced landing and that you are properly prepared for a crash landing and a quick evacuation in the event of fire.

Actions After Landing

21 Your first concern is for your safety and that of other people. Ensure that the aircraft is rendered safe by checking that the mag switches and the battery master switch are OFF. You must then do what you can to notify base of your success and to guard the aircraft.

AIRMANSHIP

General Points

22 Practice FLWOPs may only be made on active airfields or in the authorized low flying areas. Touchdowns may be made only on the airfield; all practice FLWOPs in open country must be terminated at minimum heights laid down in Legislation. This height is normally 500ft agl single piston aircraft.

23 Prolonged descents with the throttle closed allow the engine to cool appreciably. On some aircraft, this action also causes the sparking plugs to oil up. Therefore (as in Exercise 8 - Descending), clear engine at least every 1000ft during the descent and, for the last time, before commencing the finals turn.

24 Most areas in which FLWOPs are practised are busy flying areas. Thus, make sure you keep a good look-out all around you, with special emphasis on the area below because it is from this area that another aircraft may be climbing up and away from a practice forced landing.

AIR EXERCISE

Standard Procedure for Forced Landing

25 All methods of completing a forced landing use a standard procedure which you must learn. The complete procedure when the engine fails is as follows:

a Close the throttle and gain height if possible, whilst reducing speed to 80k for the glide.

b Trim and check that the aircraft is in balance.

c Set RPS on the altimeter. You must remember to do this at this stage, because your circuit planning depends upon the distance you can glide; this, in turn, will depend upon your height above ground. With RPS set, your altimeter tells you your approximate height AMSL. By subtracting the height of the ground beneath you from reading on the altimeter, you will know how much height you have in hand and will be able to start planning the descent.

d Assess the wind velocity; look around for any smoke (eg from a factory chimney), or remember the wind velocity at take-off and use the DI.

e Select a landing area and fly towards the high key position.

f Make a distress call on RT.

g Check for cause of failure.

h Assess your progress towards high key and, if you are not going to be there by at least 2000ft agl; select a closer landing area.

j Decide whether or not to abandon the aircraft. Minimum height for abandoning is 2000ft agl; this is the lowest height to start leaving the aircraft - not for thinking about it.

k If you arrive at high ..ey between 2000ft and 3000ft agl, then complete the forced landing pattern. If you are above 3000ft agl at high key, make 30° banked orbits until you are at high key between 2000ft and 3000ft agl. Never loose sight of the field.

DO NOT FORGET THE AIM: TO SAVE LIFE

EXERCISE 18

A E R O B A T I C S

Introduction

1 Aerobatics are an essential part of a pilot's flying training. Although their practical value is limited, aerobatics will improve your confidence, judgement and co-ordination in handling your aircraft at extremes of attitude and airspeed. These personal attributes are the foundation of an operational pilot.

2 For aerobatics to be smooth and co-ordinated, you must understand the effects of the primary flying controls. No doubt, at this stage, you think you do; but go back to Exercise 4 and see how much you have forgotten! The secondary effects, and the effect of airspeed on control response, becomes particularly important in aerobatics.

3 Your instructor will help you to become proficient at aerobatics - but practice is a major factor. Use every opportunity on your solo general handling sorties to practice your aerobatics; when doing so, avoid practising rolling manoeuvres only in the direction of roll that you prefer.

PRINCIPLES OF FLIGHT

Stalling Speed

4 As we saw in Exercise 15 (Advanced Turning), stalling speed is a function of wing loading which, in turn, is a function of acceleration (change of velocity). Acceleration (and, therefore, wing loading) can change in value throughout a manoeuvre so that our actual stalling speed is constantly changing. The airspeed indicator is no longer a direct indication of our margin above the stall, and we must rely on the 'feel' of the aircraft for stall warning. You will remember that we encounter the same problem in maximum rate turns where we cannot fly a turn using the airspeed indicator but must obtain the maximum performance by using the various indications of high angle of attack.

Effects of Changing Airspeed

5 During aerobatics, we experience marked changes in airspeed. As the airspeed changes, the response to a control deflection also changes; thus, if we wish to maintain a constant rate of aircraft movement, we must meet every airspeed change with a change of control deflection. Remember also that your 'g' loading and control forces are a function of airspeed. Airspeed changes also necessitate rudder movements in order to stay in balance; this is an important factor in Firefly aerobatics.

Effect of Altitude

6 Power decreases with increase in altitude. At altitude, with less power available, manoeuvres which cause an increase in drag will cause a greater reduction in IAS than those at sea level. The aircraft will have to be dived more steeply to gain the required entry speed and the height loss in the manoeuvre at altitude will be marked.

Effect of 'g'

7 We discussed the effects of positive 'g' in Exercise 15 (Advanced Turning). During the current exercise you will, at some stage, experience negative 'g'. The effect of negative 'g' is to force blood into the head and, if the value of negative 'g' is high enough, it can cause the pilot to 'red out'; the effect of this is a decrease in vision - with a red film in front of the eyes.

AIRMANSHIP

Engine Handling

8 Aerobatics require frequent power changes - but remember your basic handling techniques and avoid 'slamming' the throttle open or closed. The engine has inverted flight capability; and will not stop, but lack of oil circulation when inverted will cause engine damage if the inverted flight limitations quoted in Pilot's Notes are exceeded.

Airframe Limitations

9 There should be no problem in keeping inside the speed limits because this speed can be reached only in a very steep power dive.

* Never apply more than normal pull forces to the controls.
* If, because of low airspeed, you lose control in a vertical or near-vertical climb, centralize the controls and wait for the nose to drop below the horizon. Keep a firm grip on the controls and hold them central against snatch loads which the airflow may exert on the control surface.
* Intentional tail slides are forbidden; should you perform one inadvertently when solo, return to base and report to your instructor.

Regulations Concerning Aerobatics

10 The rules to be observed when performing aerobatics are contained in Rule 18 of The Air Navigation Order. Before attempting aerobatics, carefully read Rule 18.

Checks

11 As with stalling and spinning (Exercises 10 and 11), complete the HASELL checks before starting aerobatics.

* Pay particular attention to your harness: make sure that your lap strap is fully tight, and then tighten your shoulder strap.
* The lookout you do in these checks will help you to make sure that the area is clear of other aircraft and that you are clear of cloud. The situation can change rapidly; so have a good lookout before each manoeuvre and try also to keep a good lookout during each one.
* Wherever possible, keep the sun on the beam. By doing this, there is less chance of you becoming dazzled, to the detriment of your lookout and flying accuracy.

Entry Speeds

12 Learn the entry speeds recommended in the Pilot's Notes. With experience, you may be able to reduce these slightly, but it is not necessary to increase them. Once you have mastered entries from a straight dive, you will find it easier to go from one aerobatic to another via a wing over. This gives you a chance to look out properly, without interrupting the flow of aerobatics.

Orientation

13 Aerobatics - particularly a sequence of aerobatics - can rarely be performed in such a way that you travel in a given direction. You will tend to drift downwind unless you check your position frequently and take steps to stay in a selected area.

AIR EXERCISE

Sequence of the Exercise

14 The sequence of the exercise is so arranged that you begin with the easiest manoeuvres and work through the basic aerobatics to the more advanced ones. Aerobatics form a part of each general handling exercise and your instructor will rarely, if ever, devote a whole sortie to aerobatics, even in the advanced stages.

Basic Aerobatics

15 The basic aerobatic manoeuvres are listed below with their entry speeds:

a Loop 115K

b Barrel roll 115K

c Slow roll 110K

d Stall turn 110K (rotate 50K)

e Roll off the top of a loop 125K

f Half roll and pull through 80K

16 All the basic aerobatics are within the capability of the aircraft. We shall consider each one in subsequent paragraphs and, while doing so, show how to deal with any situation that may arise through mishandling the controls during practice. Although, in a book of this type, the control movements for any aerobatic must be tabulated, you must make a smooth transition from one stage to the next; do not picture the manoeuvre as a series of automatic actions. Except where stated, the accompanying illustration for each manoeuvre shows how it would appear to an observer.

The Loop

17 **Basic considerations** In performing a loop, aim to maintain a constant rate of pitch, and keep a positive 'g' loading throughout. Your instructor will demonstrate the rate of pitch required.

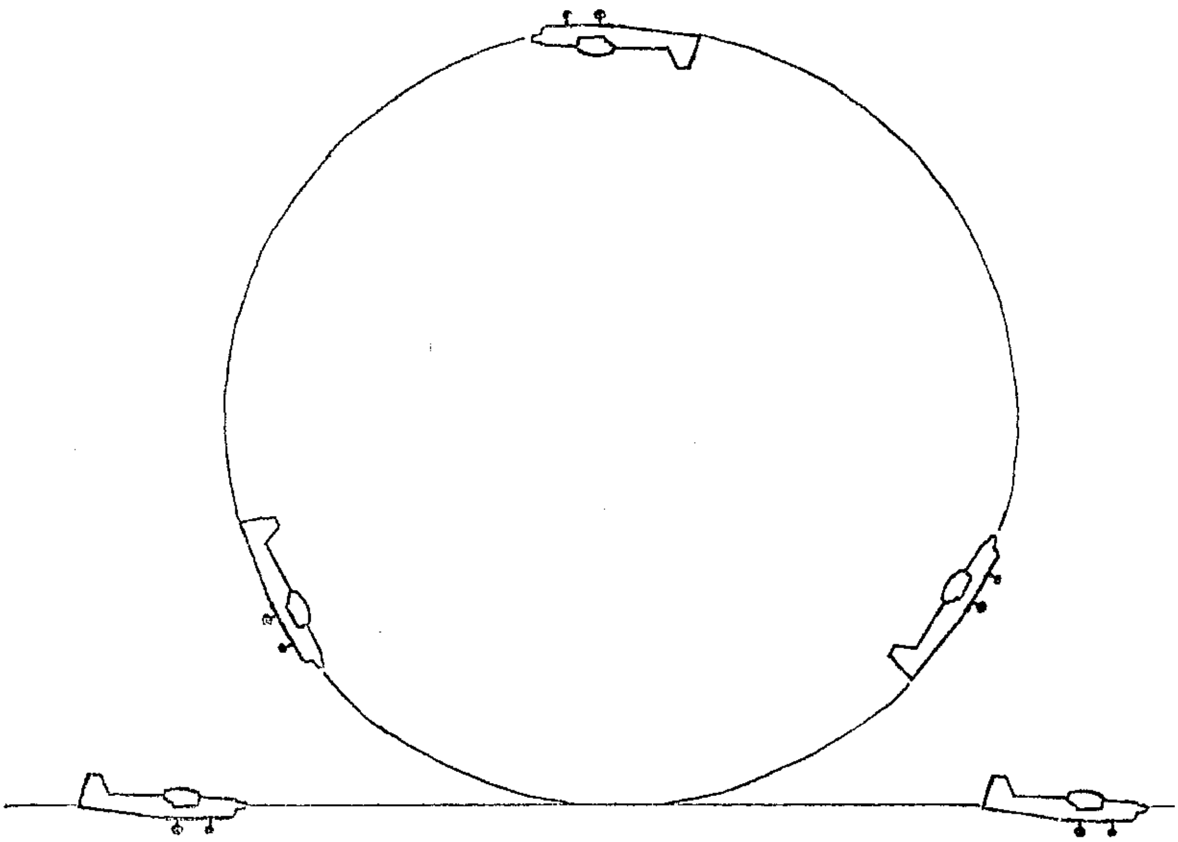


Fig 18.1 The loop

* At the beginning of the loop, the airspeed is high. The pull force is relatively high but the necessary control movement is small because the pitch response is good.

* As you start the climb, the speed decreases. The stick force also decreases but response to the control deflection is less; so, to maintain the rate of pitch, you must make a progressive rearward movement of the control column.

* As you start the descent, you must take account of the increasing airspeed. To keep the rate of pitch constant, and to avoid a high-speed stall, you will have to move the control column slightly forward. As the speed increases further, the stick force will again increase and you will notice the full force necessary to recover from the dive.

* Throughout, prevent yaw with rudder.

* The 'g' loading changes with change of speed and attitude. You will experience the highest 'g' loadings at the entry and exit of the manoeuvre.

18 **Sequence of Actions** The loop is shown at (Fig 18.1). The sequence of actions is as follows:

a Choose a line feature to help you keep straight on the entry and exit.

b Look out.

c Apply full power and dive along the line of your line feature to your entry speed. Prevent a yaw with a progressive application of left rudder.

d Start the pull-up at just below entry speed at the rate of pitch shown by your instructor.

e Check that the wings are level as the nose cuts the horizon and when climbing vertically.

f As speed decreases, maintain a constant rate of pitch by a progressive backward movement of the control column. Prevent yaw by progressively changing the left rudder, which you had on entry, to the right rudder application which you use in the climb.

g As the speed decreases further, keep the rate of pitch constant by a further rearward movement of the control column. You will notice the decrease in stick force. Make gentle control movements at the low speed.

h As you approach the top of the loop, look back for the 'far' horizon. Check that the wings are level.

i As the speed starts to increase, relax the back pressure to keep a constant rate of pitch. Smoothly decrease the amount of right rudder and apply left rudder to prevent yaw. What you do with the throttle depends on your next manoeuvre. Your instructor will discuss this.

j Ease out of the dive, checking your line feature and keeping the wings level.

k Climb away, allowing the speed to decrease to 80K and applying full power; prevent yaw and level off.

19 **Loop errors** Common errors are described below:

a **Too tight a loop** If you attempt to pull too tight in the loop with too high a rate of pitch, your increased angle of attack may lead you to stall. Recovery is immediate on relaxing the back pressure, but you will probably arrive inverted with little or no airspeed because of the extra drag when you stalled. Any attempt to keep the loop going with further rearward movement of the control column will result in another stall. So centralize the controls and wait for the nose to fall below the horizon; when the airspeed increases, pull out of the dive.

b **Too slack a loop** If you attempt to loop at a low rate of pitch, your speed will decrease rapidly as you slowly pass through the vertical. You will probably arrive inverted with little or no airspeed, and will then have to take the recovery action outlined in para 19a above.

c **Crooked Loop** A crooked loop is one which does not finish along the line feature used on entry. The reason is usually a failure to maintain the wings level - though the root cause is often the failure to correct yaw. The secondary effect of yaw is roll and, despite the fact that you have kept the control column laterally central, yaw may cause bank errors which become evident as you go over the top of your loop. After you have practised a few loops, you will find that it is quite easy to glance at the ball in the turn and slip indicator, and then to make any necessary correction somewhere between the vertical and inverted attitudes. Yaw is immediately apparent as you increase speed in the dive, so this presents no problems.

Barrel Roll

20 **Considerations** Of all the basic aerobatic manoeuvres, the barrel roll is probably the most graceful and gentle to perform. However, since it requires constantly changing pressures on all the controls throughout the manoeuvre, it is probably the most difficult to perform accurately.

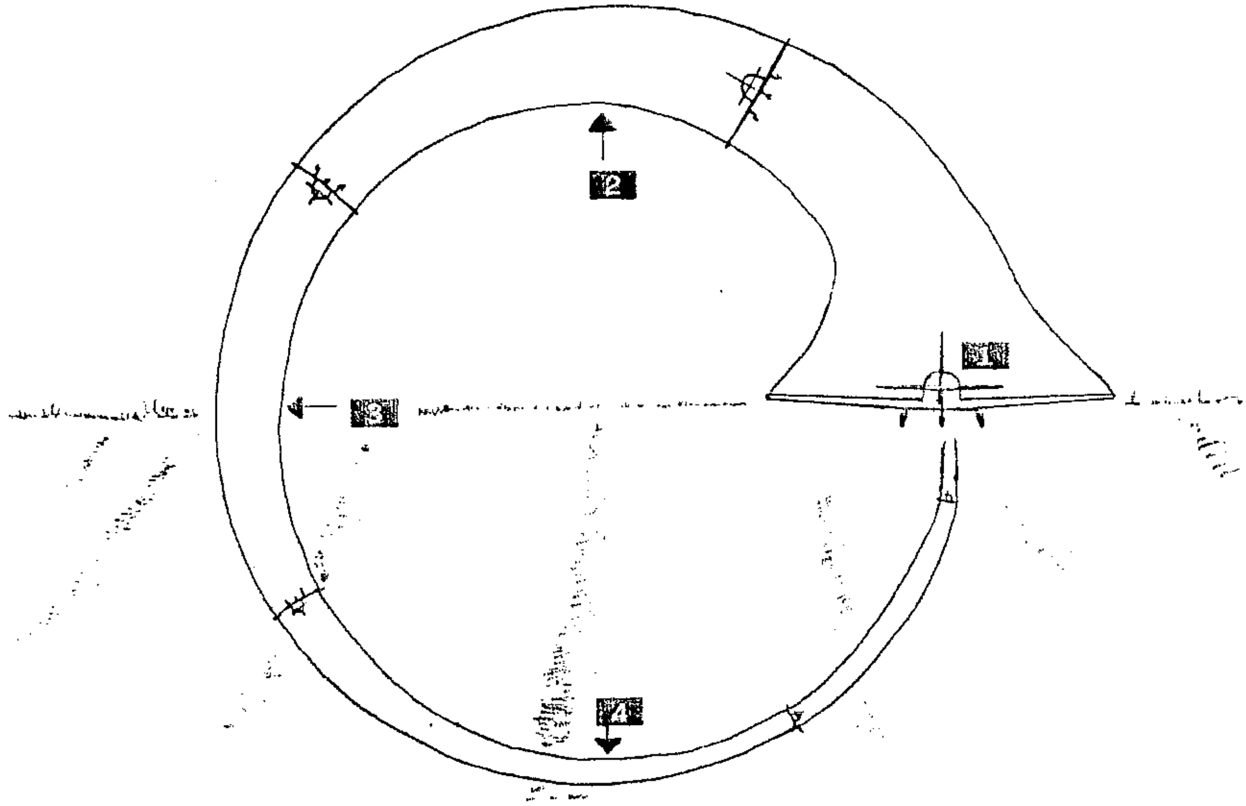


Fig 18.2 Barrel roll viewed from behind

21 Before describing in detail how to fly the roll, it will be easier for you to understand if you know what the barrel roll looks like to an observer and what it should look like to you in the cockpit. (Fig 18.2) and (Fig 18.3) show the barrel roll as viewed from outside and from inside the cockpit respectively.

22 **Lookout** Before barrel rolling the aircraft, scan the airspace that you are going to use for the roll and make sure that it is completely clear; then keep a good lookout during the manoeuvre. During your scan, select a point above the horizon (eg a cloud or a ground feature) and imagine a circle around it, noting any feature that will help you to remain orientated around the roll.

23 **First half of the roll** We shall consider the barrel roll in stages - although, as pointed out earlier, you must make a smooth transition from one stage to the next. The first 90° of the roll is illustrated in (Fig 18.4) and described below. Note that a roll to the right is assumed (a clockwise roll).

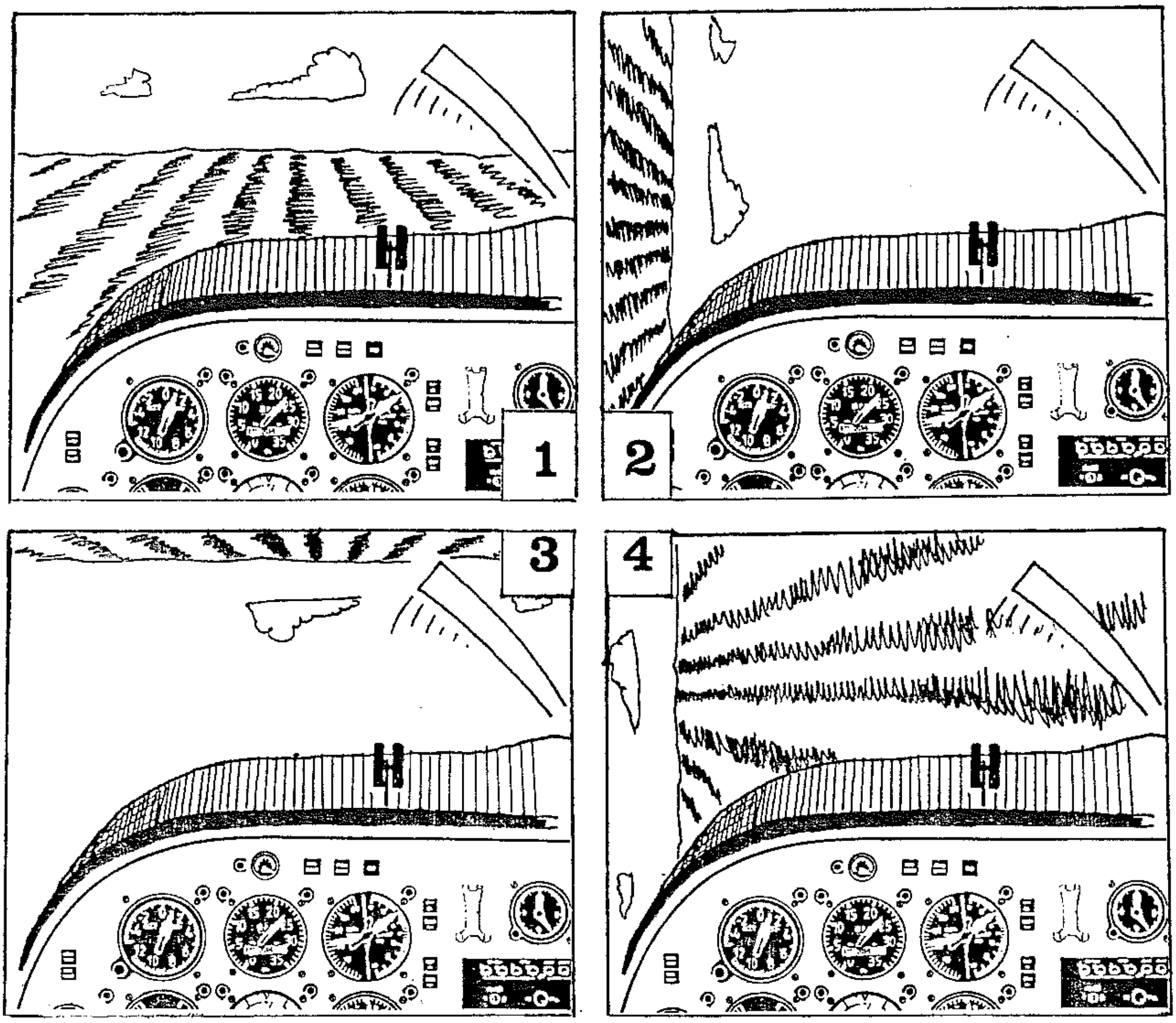


Fig 18.3 Barrel roll - pilot's view

* Dive the aircraft towards the 6 o'clock position on your imaginary circle until you have your entry speed, and then start a turn in the direction opposite to that of your intended roll.

* This turn should bring you towards the 8 o'clock position on your imaginary circle; anticipate this point and, just before you reach it, start reversing your bank to begin the roll, introducing a firm back pressure as you do so. The amount of aileron you use should be sufficient to bring your wings level as the nose is brought up through the horizon (see Fig 18.4).

* Since the airspeed will now be approximately back to your entry speed, and the aircraft is being made to climb out of a dive, apply quite a hard back pressure to bring the nose up to the 12 o'clock position on your circle and gently co-ordinate with aileron to roll the aircraft through the first 90°. Because the speed is high, the ailerons will be very effective and will require only a small deflection.

* As you will see from (Fig 18.2) and (Fig 18.4) we arrive at position 2 with the nose in its highest attitude and the wings perpendicular to the horizon.

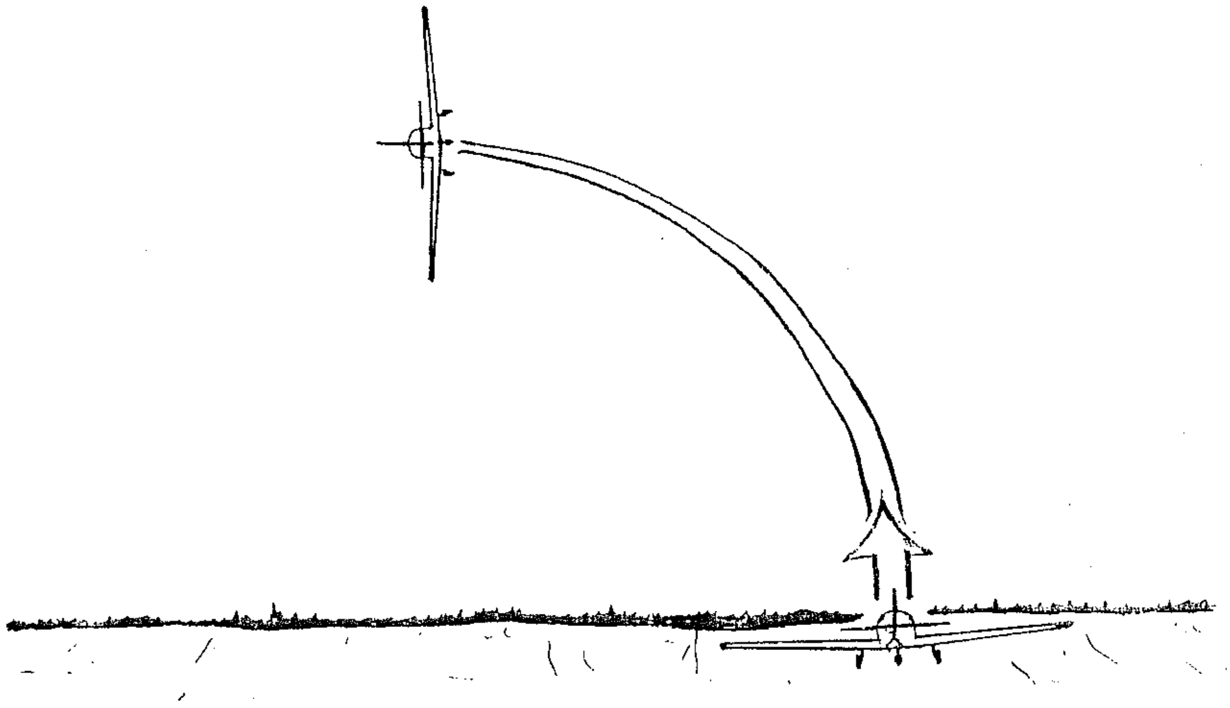


Fig 18.4 First half of barrel roll

24 **Check-point** The most important check-point during the roll is position 3 where the wings are again parallel with the horizon but, as (Fig 18.5) shows, this time with the aircraft inverted. Remember that this is the point of the roll when the speed is lowest; consequently, the control response is least:

* To get the wings round to become level slightly above the horizon by this stage, progressively more aileron must be applied.

* Furthermore, the amount of back pressure must be reduced as gravity begins to assist the nose through in the looping plane. However, do not relax the back pressure too much; the 'g' loading should always be positive.

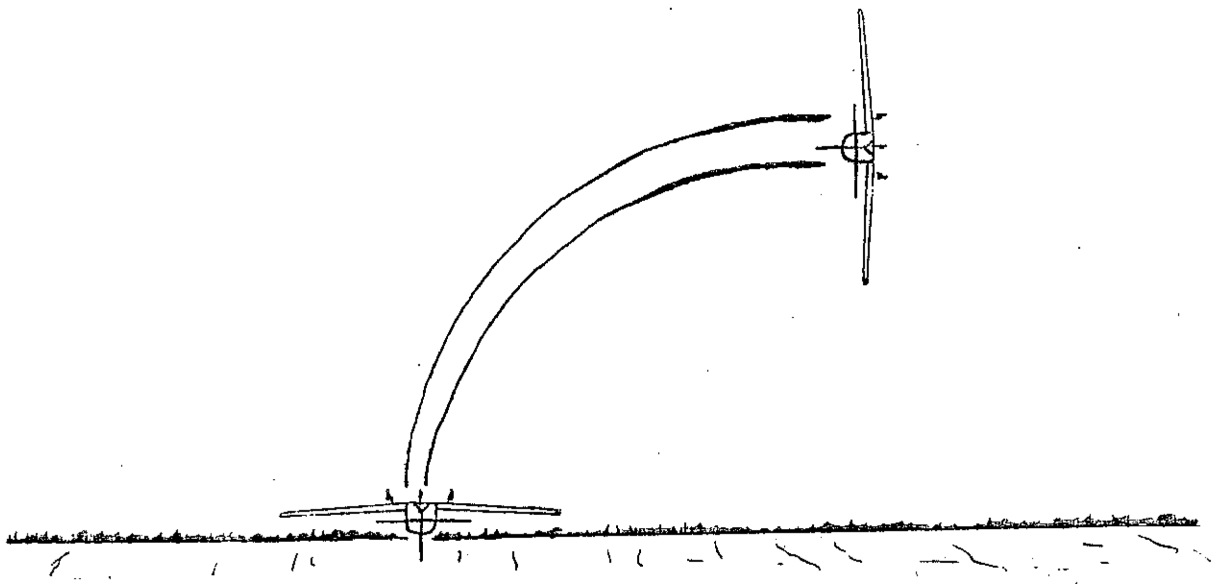


Fig 18.5 Main check-point position

25 **Summary of first half of roll** To sum up this point: whilst the nose of the aircraft is above the horizon, the airspeed is decreasing; therefore, to maintain a constant rate of roll, aileron must be progressively increased. Also, to maintain a constant pitch change (as in a loop), the back pressure must be quite heavy to begin with but then progressively reduced until the aircraft is fully inverted. From this point on, during the second half of the roll, these trends will be reversed; but before you read on, study the illustrations and make sure you understand the situation so far.

26 **The second half of the roll** The second half of the barrel roll is spent with the nose below the horizon in a descending attitude (see Fig 18.2). It follows, therefore, that the airspeed will increase until the aircraft is level again - ie with the nose somewhere near the horizon as at position 1. The increase in speed will be noticeable by the feel of the controls, particularly the elevator. The important actions during the second half of the roll are illustrated in (Fig 18.6) and described below:

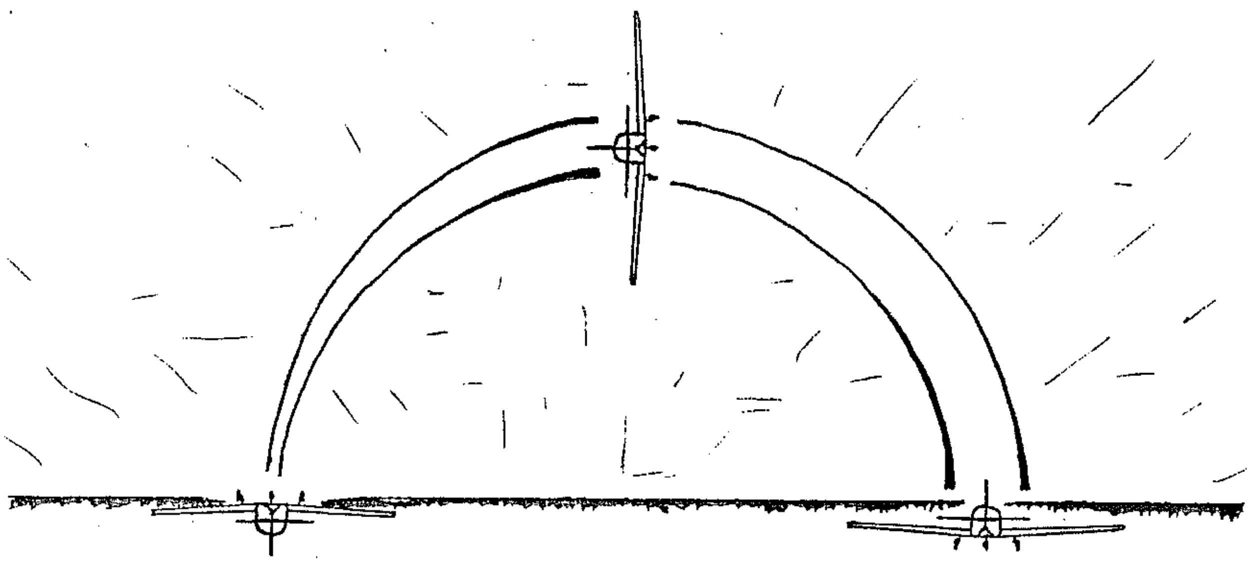


Fig 18.6 The second half of the roll

* You will remember that the elevator pressure had been reduced progressively until the aircraft was inverted at position 3.

* Now, as the nose comes down, the back pressure must simply be re-introduced until it is as heavy as your initial pull at the beginning of the roll. This usually occurs by about the 8 o'clock position on your circle but is already noticeable as you pass position 4.

* The ailerons also undergo a marked change, becoming more effective again, so that the extra aileron applied to get the wings level at the inverted position must now be slowly reduced.

* From the above, it is seen that, during the second half of the roll, it is necessary to re-apply the back pressure and decrease the amount of aileron to regain your original pull-up point at a constant rate or roll.

27 **Balance during the roll** If you are naturally co-ordinated throughout the roll, the aircraft will feel balanced. You might, after a few practices find time to check the ball in the turn and slip indicator when inverted. But, generally, if you apply the normal principle of rudder with aileron according to the amount of aileron being used, you will not be far out and the ride will be quite comfortable.

28 **Summary of barrel roll** The main points discussed in the previous paragraphs are summarized below:

* Look out in the direction in which you intend to roll.

* Prescribe an imaginary circle around a reference point.

* Dive the aircraft towards the 6 o'clock position on this circle.

* Turn in the direction opposite to that in which you intend to roll to join your circle at the 4 o'clock or 8 o'clock position as appropriate. Then proceed as follows:

a Pull up the elevator and start the roll with a small aileron deflection.

b Wings level slightly above the horizon.

c Co-ordinate elevator and aileron to fly round your imaginary circle, bearing in mind the points that follow.

d Wings perpendicular at position 2.

e Wings level just before the horizon, inverted.

f Wings perpendicular again by position 4.

g Wings level as you re-gain position 1.

h Aim to keep the rate of roll constant by varying aileron deflection.

j Elevator pressures are similar to those experienced in the loop.

k Remain balanced.

Slow Roll

29 To carry out a slow roll, you must slowly roll the aircraft through 360° and maintain height and direction as you do so (Fig 18.7). Let us consider the technique required to roll the aircraft to the right:

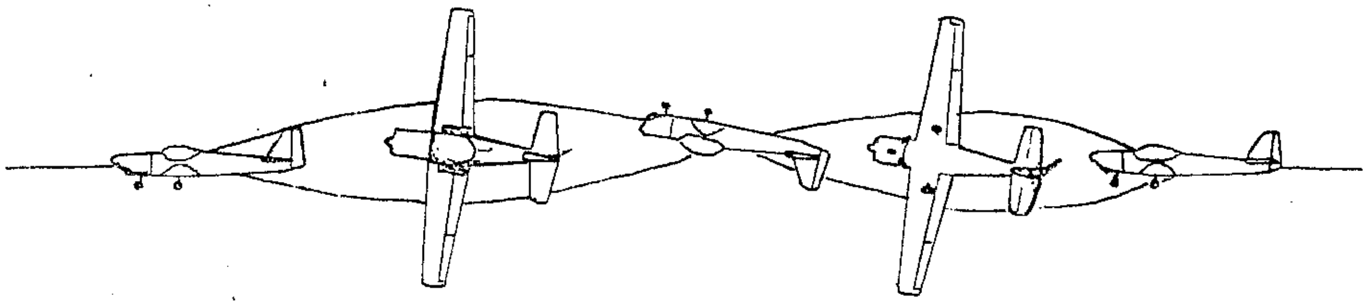


Fig 18.7 Slow roll

* First, dive the aircraft to get your entry speed and raise the nose to a slight climbing attitude. (Later, you will be taught to do the roll from straight and level).

* Roll the aircraft (in this case with right aileron) and prevent any turn with left rudder.

* As the first quarter roll is completed and the wings are perpendicular to the horizon, the nose should be kept up with top (left) rudder. Since the speed is still high, only small amounts of control are necessary at this stage.

* Continue to roll the aircraft with aileron but, as soon as the wings pass through the perpendicular, the rudder pressure must be steadily exchanged for a forward elevator pressure to adopt the inverted flight attitude.

* As the wings rotate through the level position, the rudder should be centralized and quite a heavy forward pressure applied to the control column to hold the nose above the horizon.

* As soon as the wings are past the inverted level position, the forward pressure on the control column can be reduced because, once again, we are approaching the situation where the aircraft is on its side and the nose can only be held up by top (right) rudder. However, because the speed is lower, more rudder will be necessary than on the previous occasion.

* Because of the need for more rudder, and for one other reason which will not be gone into now, there will be a progressive increase in the tendency to roll caused buy the further effect of rudder (remember?). In fact, if allowed to develop, the rate of roll will increase rapidly. This tendency must be controlled and kept in check by opposite aileron.

* Thus, you will pass through the perpendicular stage with a lot of top rudder (right, in this case) and a small amount of left aileron to keep the rate of roll constant.

* Complete the roll, using increasing bank pressure to hold the nose up as you return to level flight. The straight and level position is reached in quite a cross-controlled condition.

30 **Summary** The slow roll may be summarized as follows:

a Apply lookout procedures.

b Apply full power and dive to achieve entry speed.

c Pull up to a slight climbing attitude.

d Roll with aileron and prevent turn with rudder.

e By 90° of roll, increase top rudder to maintain nose attitude for level flight, maintaining roll with aileron.

f Past the 90° point, introduce forward elevator to maintain level flight, slowly reducing the rudder already applied. By the inverted flight position, the rudders are neutral and the forward elevator pressure pronounced.

g As you leave level inverted flight, progressively introduce top rudder to maintain level flight, and reduce the elevator pressure. These movements must be so co-ordinated that level flight and direction are maintained.

h By the 270° point, the elevator pressure is released and top rudder maintains height and rolls the aircraft.

j Control rate of roll by slight opposite aileron.

k Level wings and bring aircraft back to balanced flight. During the final 90° of roll, because of the decreased airspeed, a slight back pressure will be necessary to maintain height.

Stall Turn

31 The stall turn, illustrated in (Fig 18.8), is a method of changing direction through 180°. It was originally used as a combat manoeuvre; although not used as such today, it is nevertheless a good confidence builder and provides a useful education in aircraft behaviour at very low airspeeds.

32 In the T67, a stall turn to the right is more difficult than a stall turn to the left - the difference being caused by the additional effects of propeller slipstream during a turn to the right (see later). Consequently, we shall describe a stall turn to the left first.

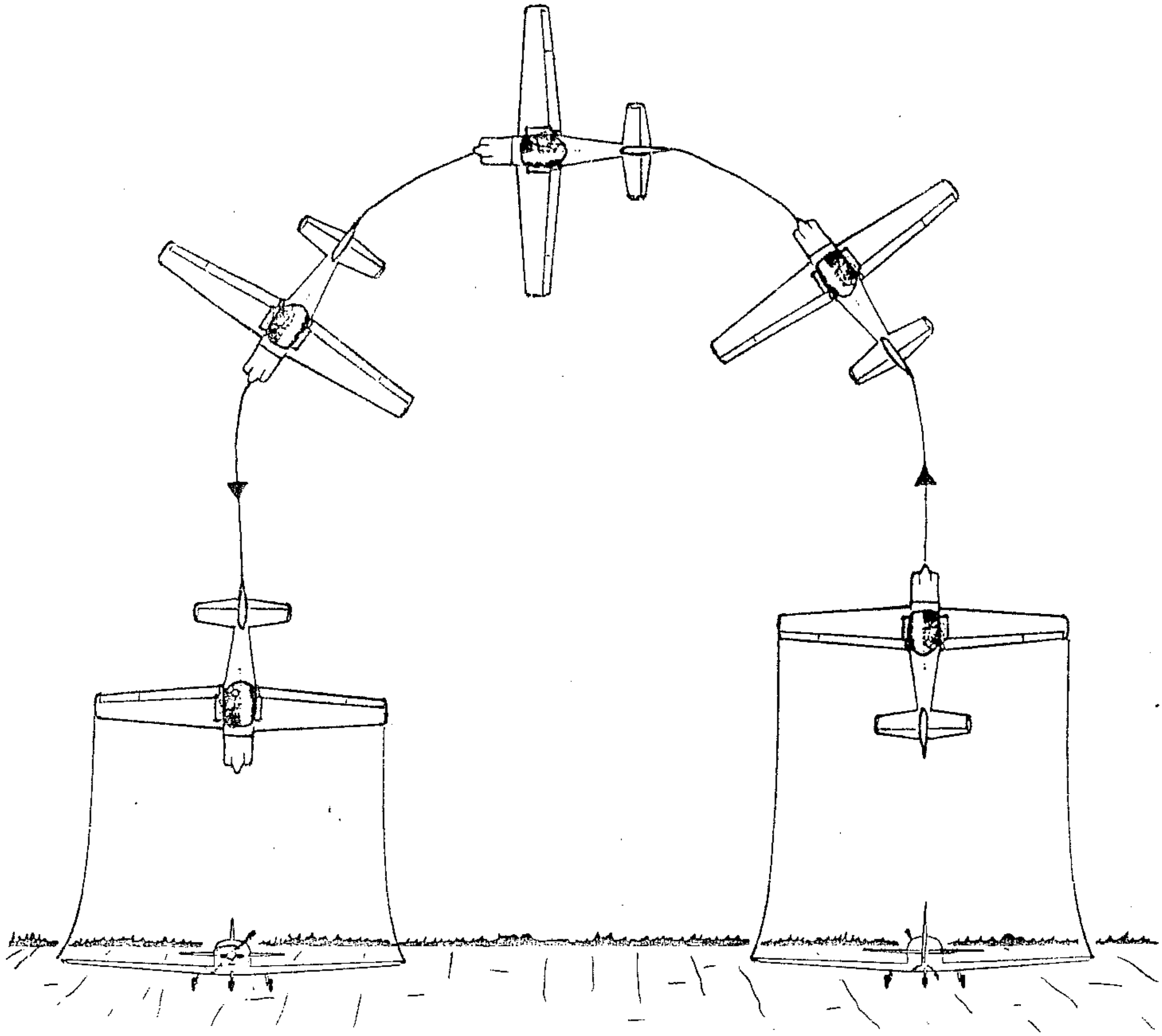


Fig 18.8 Stall turn to the left

33 **Stall turn to the left** To perform a stall turn to the left, ensure that the airspace is clear; then:

* Accelerate to entry speed by diving slightly.

* Look up, and then pull up to the vertical climb attitude, checking that your wings are level and that the ball is in the centre as you do so. Check the vertical attitude by noting the position of the left wing trip relative to the horizon; the cord line should be approximately perpendicular. To hold the attitude, a slight forward pressure will be necessary. Further, because the airspeed will be decreasing (rapidly), the left rudder introduced during the initial entry must now be reduced. All these checks can be carried out whilst looking out to the left - which is convenient, because it is also necessary to note a reference point on the horizon through which we can cartwheel the aircraft.

* Once the reference point is selected, apply left rudder to yaw the nose round to it. Don't be over-anxious; remain focused on your reference point and yaw the nose down. The aircraft still has flying speed at this stage, and so it will be quite manageable in all three planes. You may, therefore, use elevator or aileron as necessary to achieve your reference point. In fact, at this stage, because of the further effect of rudder (ie roll), the top wing tries to fall over into the turn and must be held up with top aileron. Thus, all three controls are used to fly the nose from the vertical down to the horizon: the rudder to supply the yaw, the elevator to guide the nose in pitch on to your point, and the aileron to prevent roll.

* The aircraft is now at the highest point of the stall turn and, to ensure that it drops through cleanly, the throttle is closed. The nose will then continue to fall through the horizon down to the vertical dive.

* Although the speed is low, the ailerons are still effective. This enables the aircraft to be controlled in roll. So turn your head to the right and control the right wing on to your reference point using aileron. Once there, re-direct your attention straight ahead towards the ground.

* As the aircraft reaches the vertical dive attitude, a small check movement with opposite rudder will be necessary. Also, if the speed is very low, a slight back pressure at this stage tends to dampen any oscillations that might develop.

* It only remains now to recover from the dive. Although the throttle is closed the airspeed will increase rapidly, allowing the nose to be raised almost immediately. Feel the aircraft through the pitch change as in a loop - except that you do not open the throttle until the nose comes up through the horizon.

34 **Stall turn to the right** As stated earlier, a stall turn to the right is more difficult than one to the left because of the effect of propeller slipstream. You will remember that the propeller imparts a circular motion to the air that is pushed back over the fuselage. The air then impinges on the fin at an angle, causing the aircraft to yaw to the left, this effect being at maximum when the aircraft is flying with full power applied at low speed. These are the conditions experienced during the stall turn and are the reasons why the stall turn to the right is more difficult. Let us now consider the actions:

* The entry to the turn is the same as for a stall turn to the left.

* The pull-up and checks in the vertical are also the same, except that this time you must check on the position of the right wing tip relative to the horizon. Immediately the aircraft is checked going up vertically, feed in right rudder progressively.

* Now it is particularly important that you focus on the external reference point at this stage because the rate of movement of the nose is critical:

° At first, the aircraft will respond quite nicely to the rudder and will yaw as required. However, as the speed decreases, the slipstream effect becomes stronger and tries to yaw the aircraft to the left and, if the engine is left at full power, the slipstream effect becomes stronger and stronger until it completely overcomes the full right rudder applied.

° It would appear from the above that the answer is to close the throttle. But if you do this, the airflow and, therefore, the effectiveness of the rudder, is reduced. What then is to be done?

° By carefully watching the nose movement to the right then, soon after the initial application of rudder, you should notice the nose being slowed down by the slipstream effect. As soon as you see this, continue feeding in rudder, and slowly reduce the throttle setting. This reduces the slipstream yawing effect but keeps the rudder effective. Once the rudder is fully applied, keep it so until you have stalled right through.

° The throttle movement is not so easily explained. This is a very slow movement; if you can imagine the throttle lever being connected to the nose, it 'pulls' the nose around to the horizon and reaches the closed position a little earlier than on a stall turn to the left.

° One important point that should be remembered is that the nose, once it has begun to yaw, should not be permitted to stop, because momentum plays a part in overcoming the slipstream effect. Therefore, it is important that the nose movement is observed closely and, once full rudder is applied, any slowing down must be counteracted by delicately closing the throttle.

* When the nose has been brought down to the horizon, the actions required to complete the manoeuvre are the same as for a stall turn to the left.

35 **Summary** The actions necessary to perform a stall turn are summarized as follows:

a Apply full power.

b Dive to gain entry speed, in balance.

c Look up, and then pull up.

d Check wings level.

e Check in vertical position using left or right wing tip as appropriate.

f Feed in rudder progressively and yaw the nose.

g Maintain the aircraft vertical in pitch and prevent roll.

h As the nose movement begins to slow down, slowly close the throttle to keep the nose moving. Bring the nose down to the position on the horizon vacated by the wing tip, using elevator.

j Allow the nose to drop through to the vertical.

k Check with rudder and a slight backward pressure to prevent osciliations.

l Recover from ensuing dive, applying power at horizon.

Roll off the top

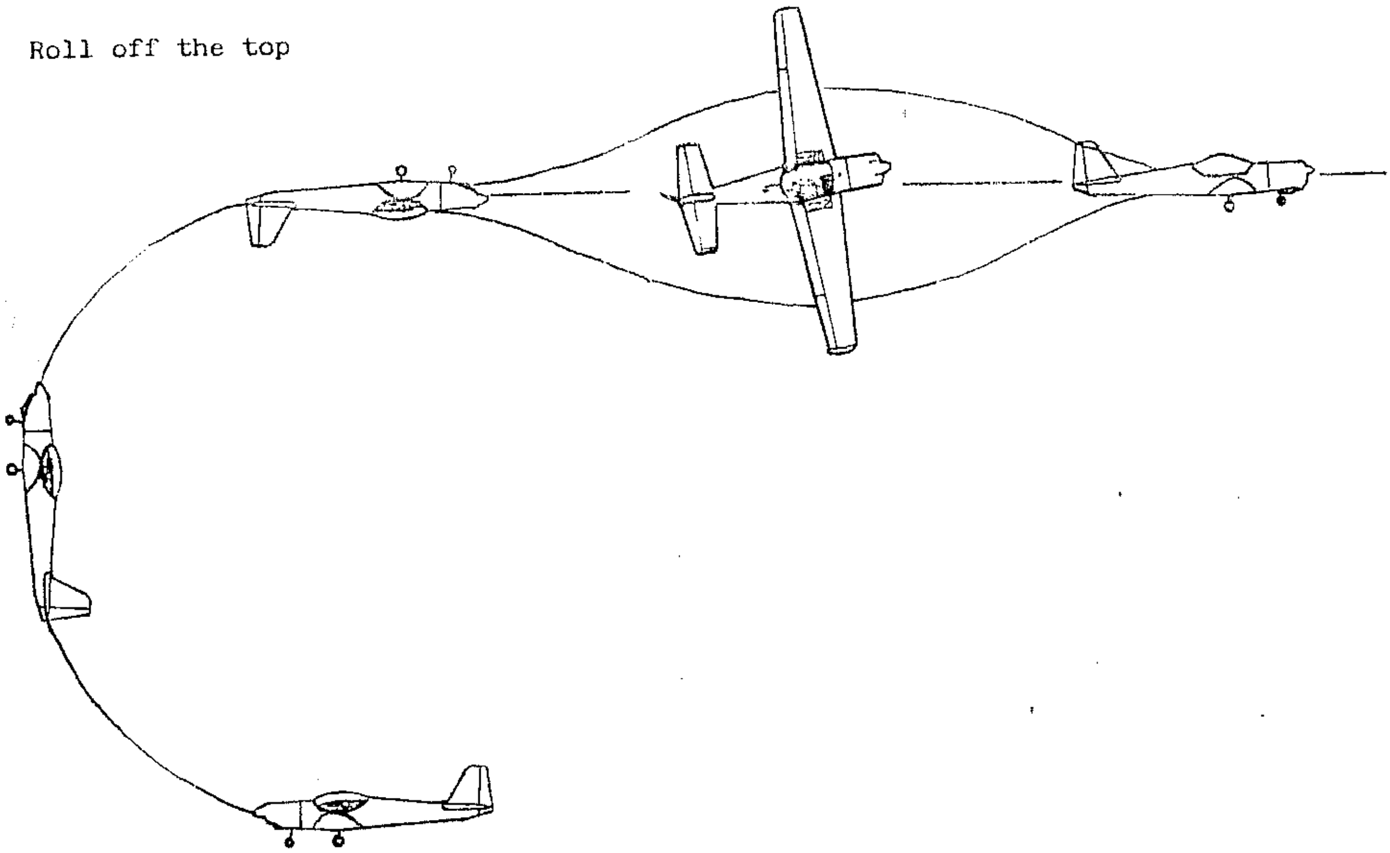


Fig 18.9 Roll off the top

36 The roll off the top of a loop is another method of changing direction rapidly through 180°. It was originally used during the 1914-18 war by the German fighter ace Immelman and, quite naturally, became known as the 'Immelman Turn'. It still retains the name in some air forces.

37 The roll off the top is illustrated in (Fig 18.9) and discussed below:

* You require a lot of speed for this manoeuvre - more than for a loop.

* The entry is the same as for the loop, except that the pull-up should be more pronounced. Check that your wings are level and that the ball is in the centre.

* In the vertical, confirm that both wing tips are on the horizon and, as you leave the vertical, drop your head backwards to view the horizon as soon as possible.

* Once the horizon is in view, prepare to stop the aircraft looping before the inverted flight attitude is reached. Since the speed will be quite low, the nose attitude should be clearly above the horizon and achieved by a positive, but not violent, check movement.

* From this inverted flight attitude the aircraft is rolled out to the straight and level attitude in a manner similar to that used in the second half of the slow roll:

  ° Initiate the roll either way with aileron; almost immediately, the nose must be prevented from lowering by quite a heavy pressure on the top rudder.

  ° At the same time, the forward elevator pressure that was holding the nose up in the inverted position must be released.

  ° The amount of top rudder required to hold the nose up at this stage will, as in the slow roll, try to speed up the rate of roll; this must be counteracted by slight opposite aileron.

  ° The aircraft actually "barrels" out from the inverted position.

38 **Summary** To roll off the top:

a Dive to achieve entry speed in balanced flight.

b Look up, and then pull up firmly.

c Check wings level and ball in the centre as you pitch through the horizon.

d Check wing tips relative to horizon when vertical.

e Continue to loop round to about 20° above the horizon.

f Check in this position by use of forward elevator.

g Roll with aileron.

h Introduce top rudder to maintain level flight, reducing elevator pressure as you do so.

j Control rate of roll with slight opposite aileron.

k Introduce back pressure to maintain level flight.

Half Roll

39 **Basic considerations** The half roll, illustrated in (Fig 18.10) is the second half of a loop and provides useful experience in adopting the inverted flight attitude and in recoveries from high-speed dives.

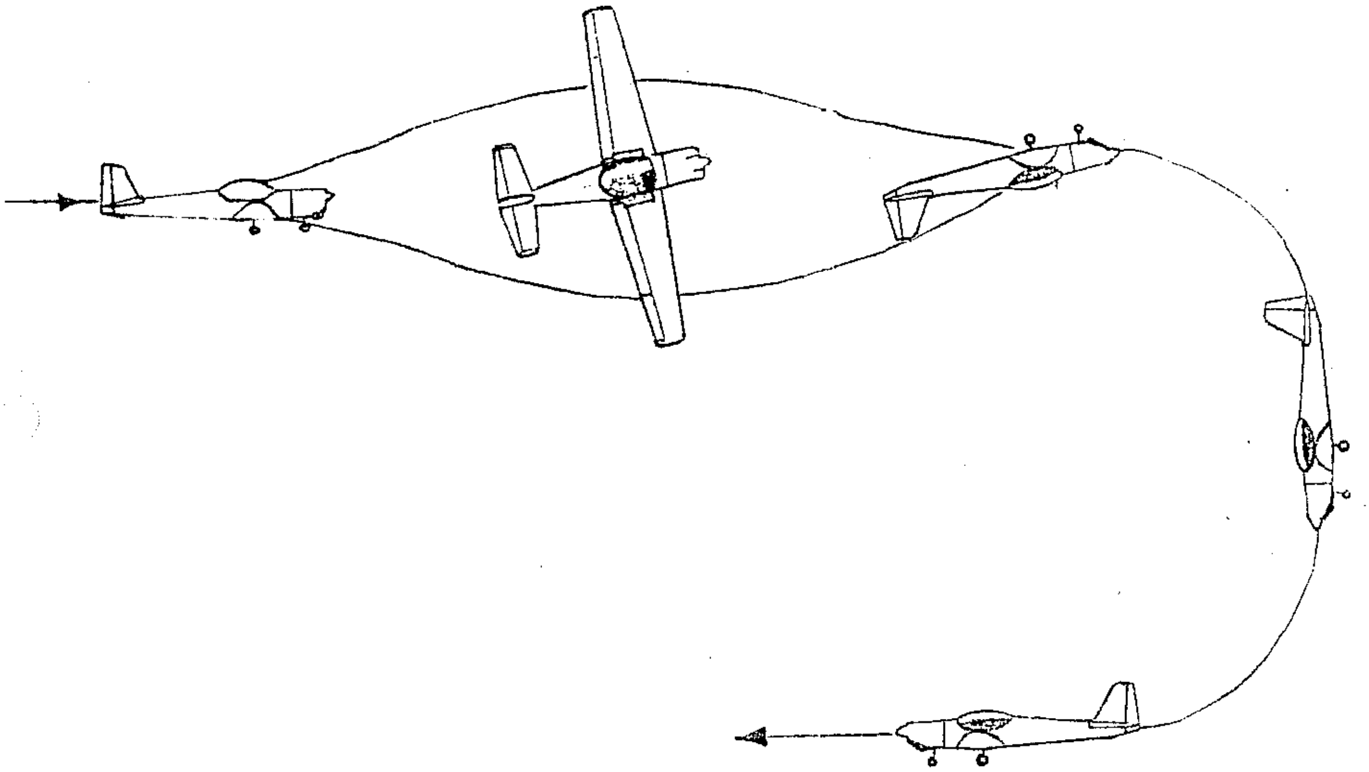


Fig 18.10 Half roll

40 There is no laid-down entry speed for the half roll, but theoretical considerations show that the higher the entry speed the less is the height loss during the subsequent dive and pull out. However, since this demands very accurate flying just off the buffet, and involves high 'g' loadings which could lead to over-stressing, the practice is to enter at a low airspeed to avoid any risk. Your instructor will introduce you to the manoeuvre with a low entry speed. This speed gives good control into the inverted attitude and a tolerable height loss.

41 **Actions** To perform a half roll, proceed as follows:

* Roll the aircraft into the inverted attitude using aileron. The rate of roll can be slow, as in the slow roll, or faster, as you wish. If a slow roll is used, it will be necessary to use rudder to prevent yaw and to keep the nose up when the aircraft is on its side. If a faster rate of roll is used, the nose does not have time to drop before the forward elevator pressure is introduced to hold the nose up in the inverted attitude.

* As the aircraft rolls into the inverted attitude, close the throttle. The wings should be level and the rudder should hold the nose steady on a point on the horizon. This requires a moderate forward pressure on the controls.

* From this inverted attitude, look beneath the aircraft to clear the area. When sure that it is clear, gently release the forward pressure on the elevators and allow the nose to move down.

* As the nose comes down through the horizon, the airspeed will begin to increase. As the airspeed increases, the controls will become more effective and, where it was necessary to make a control movement to start the nose moving, the movement is quickly transformed into pressure. The point in time at which to make this change can only be judged by remaining focused on the background and controlling a constant pitch change.

* Once the aircraft starts moving in the looping plane, the aim is to keep it coming right through at a constant rate, similar to the loop.

* As the vertical attitude is approached and the airspeed increases further, the elevator load becomes heavy. Keep the nose coming through and, as it passes the vertical dive position, look up for the horizon.

* Once the horizon is in view, the rate of pitch change is easily assessed and it becomes convenient to check your wings level and the ball in the centre.

* Continue looping the aircraft until the nose comes up through the horizon.

* Re-apply power.

42 **Effects of 'g'** Because the body is subjected to negative 'g' briefly during the first part of this manoeuvre, there is an increased possibility of a black-out when positive 'g' is applied during the pull-through. Be prepared for this, and brace your stomach and leg muscles as the positive 'g' develops.

43 Summary To half roll:

a Fly straight and level.

b Roll the aircraft on to its back, closing the throttle as you do so.

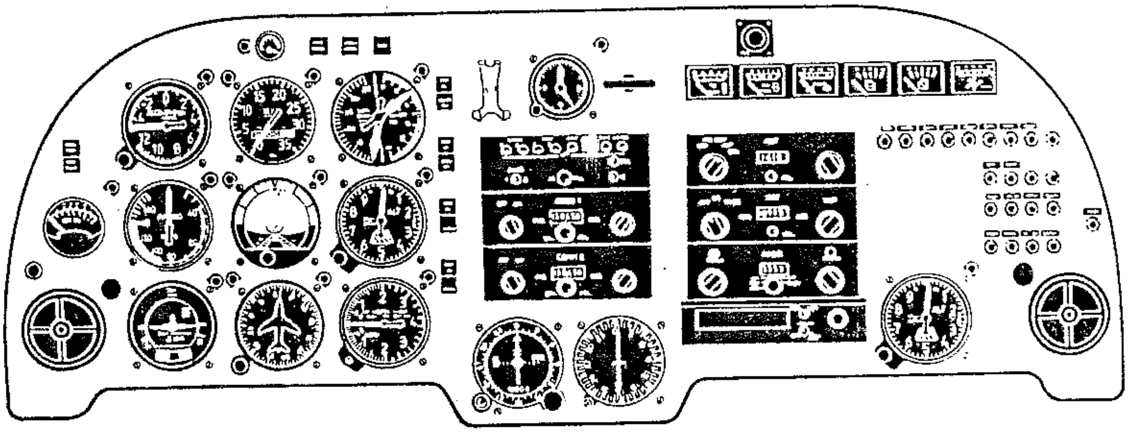
c Check in the inverted flying attitude.

d Look down and pull through the second half of a loop.

e Re-apply full power passing through the horizon to adopt the climbing attitude.

EXERCISE 19

AN INTRODUCTION TO INSTRUMENT FLYING



Introduction

1 The increase in the types and functions of instrument flying aids and procedures means that no pilot is properly qualified until he has a thorough knowledge of the instrument procedures and is competent to fly on instruments. During your primary flying phase you are only introduced to instrument flying. In later stages of training you will progressively go on to fly in cloud and carry out basic procedures, finally ending up qualified to use the aids and procedures to their limits. All you are trying to do at this stage is to find out the very basic principles of instrument flying to enable you to get out of cloud safely if, through your inexperience, you should enter it by mistake.

2 The mistake of entering cloud with little instrument flying experience has had serious, sometimes fatal, consequences for learner aviators. Usually it is a combination of poor flight preparation, poor weather appreciation and bad decisions to "press on" when it would have been safer to turn back - in other words, POOR AIRMANSHIP. The lesson must be clear - do not attempt instrument flying until you have had the proper training! The introduction to instrument flying that you receive in this part of your course should not be considered as a licence to put yourself in any situation where you are solely reliant on your instruments. This is not only a common sense "airmanship" restriction - it is also a requirement of UK Law - ANO Schedule 9.

PRINCIPLES INVOLVED

Artificial Horizon (AH)

3 So far in your training, emphasis has been placed on attitude flying. However, no matter how well you maintained an attitude, some instruments had to be consulted before you achieved accurate flight. If a correction was needed, the aircraft's attitude was adjusted by reference to the visual horizon. During instrument flying (IF), since the real horizon is no longer available, the artificial horizon (AH) is used instead. No basic change in technique is required; you simply use the AH in the same way that you use the real horizon in visual flight. Thus, the AH is the master instrument for selecting and determining the aircraft attitude.

Control and Performance Instruments

4 The combination of power and attitude is fundamental to aircraft performance. If the power can be set and the correct attitude selected, the performance of an aircraft can be controlled. Since the RPM and manifold pressure gauges are used for power control and, during IF, the AH is used for attitude control, these instruments are known as the CONTROL instruments (Fig 19.1). The remainder of the central panel instruments show what effect the selected power/attitude combination is having on the aircraft performance. Therefore, they are known as the PERFORMANCE instruments.

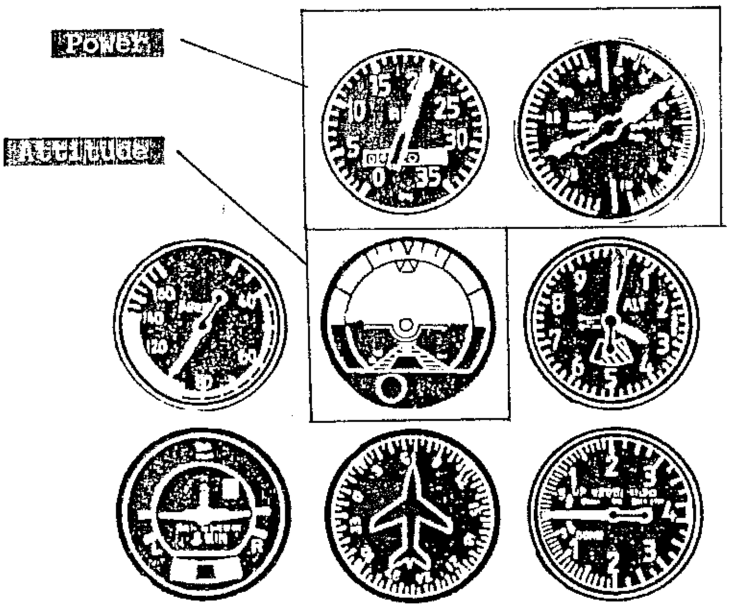


Fig 19.1 Control Instruments

Attitude Control

5 To control an aircraft accurately, it is necessary to be able to hold, or change to, an accurate attitude. Furthermore, it is necessary to know when to make a change and by how much to change. The AH meets the requirement of accurately indicating the attitude, but it cannot indicate when to make a change to an attitude or by how much the change should be; this information is obtained from the performance instruments. If the performance indications show that the desired flight path is not being achieved, then a change in the power/attitude combination is necessary. The amount of change needed is learned by practice. ALL CHANGES ARE MADE ON THE AH OR POWER. The result of the change will appear on the performance instruments. If the performance indications are still wrong, YOU MUST RE-ADJUST THE AH OR POWER.

Scanning

6 To obtain all the information shown on the instruments, they must be scanned methodically. An obvious method would be to look at each instrument in turn in, say, a clockwise or anti-clockwise direction. Although no instrument would be omitted from a scan such as this, it has the disadvantage that no priority would be given to the master instrument (AH) or to those performance instruments that were important for any particular manoeuvre (for example, the DI when rolling out of a turn). To overcome disadvantages such as these, the technique is to scan radially out from the AH to the performance instruments and back to the AH. Furthermore, since the performance information required differs for each manoeuvre, the scan is made selective. In this way, each performance instrument will be interrogated according to its importance at any given moment. This method, illustrated in (Fig 19.2), is known as selective radial scan. Note that two performance instruments are never scanned in succession; the route from one to another invariably goes through the master instrument (AH).

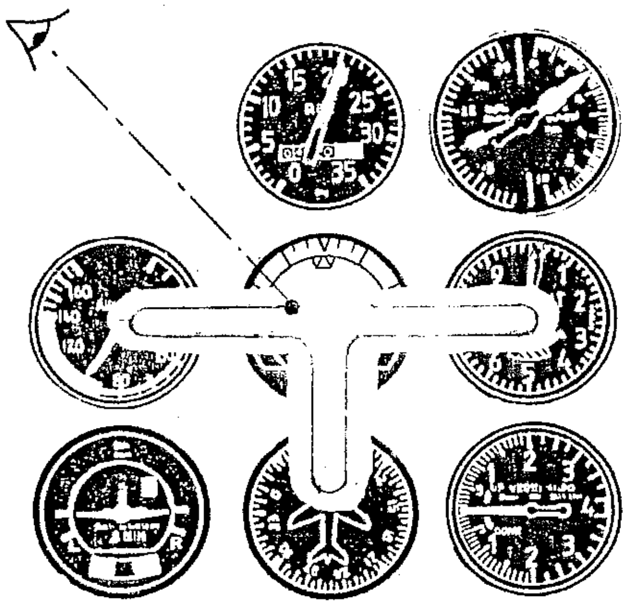


Fig 19.2 Principle of selective radial scan

Instrument Interpretation

7 The control instruments (the AH and the RPM and manifold pressure gauges) require no interpretation, since their indications are direct and respond immediately to control changes. On the other hand, the performance instruments give both direct and indirect indications, and are also subject to lag. An example of a direct indication is when the airspeed is read off the ASI. However, for a given power setting and aircraft configuration, if the speed is steady it means that the pitch angle is also steady. Thus, as well as giving a direct indication of airspeed, the ASI is giving an indirect indication of pitch. Table 1 lists the direct and indirect indications of each instrument.

TABLE 1 Direct and indirect instrument indications

Instrument	Direct	Indirect
ASI	Airspeed	Pitch
Altimeter	Altitude	Pitch
DI	Heading	Bank
VSI	Rate of climb/descent	Pitch
Turn needle	Rate of turn	Bank
Ball	Balance	Yaw or Bank

Power Control

8 Good power control stems mainly from memorizing the various settings used during each manoeuvre or part of a procedure. Changes in settings are made initially by feel and then completed by making small adjustments, assessed during quick single glances at the gauges, intermixed with your radial scan. However, when flying at a pre-determined airspeed, do not make a corrective power adjustment until you have compared the ASI reading with the altimeter reading. The speed may be incorrect because the aircraft has climbed or descended unnoticed, in which case the throttle setting could have been the correct one.

Trimming

9 We have seen that it is necessary to maintain a correct attitude when flying on instruments - accurate trimming will help you. Use the correct technique of relieving the control pressures, no matter how slight, and avoid hurried, coarse movements or any temptation to fly 'on the trim'. The aircraft is properly trimmed when a desired attitude is maintained on the AH 'hands off'.

Balance

10 The technique of keeping the aircraft in balance does not change when flying on instruments; the need to keep the ball in the centre is the same. Nevertheless, it is worth re-stating some of the more important occasions when it is necessary to do so:

* When making power changes, it will be necessary to keep straight using the DI; when opening the throttle, right rudder should be used and, when reducing power, left rudder. Provided the wings are level, this has the effect of keeping the aircraft in balance.

* Sometimes it is possible for a bank error to be present in the AH, possibly as a result of turning or acceleration errors. Under these conditions, although the wings have been correctly levelled on the instrument, the aircraft is still slightly banked. To apply rudder to maintain heading in this banked attitude would necessitate the rudder and bank to be working in opposition, thus moving the ball off centre. Therefore, when straightening from a turn, it is necessary to check the DI for a steady reading and that the ball is correctly centred.

AIR EXERCISE

Sequence

11 Instrument procedures are simply selected basic manoeuvres strung together. Think of them in this fashion and you will be able to plan ahead and decide what procedure to use and which selective scan should be used. The air exercise will include the following:

* A demonstration of instrument limitations and errors.

* An introduction to full-panel instrument flying.

* The basic manoeuvres (S & L, climbing, descending, and turning).

* DI failure.

* Recovery from unusual or extreme attitudes.

During the phase, you will be given airborne instruction on how to reduce the chances of disorientation.

Use of Artificial Horizon (AH)

12 Your instructor will introduce you to IF by comparing the true horizon and the AH. He will show you how to use the AH in the same fashion as you use the real horizon. The AH is a good substitute for the visual horizon but, for real accuracy, the support of the performance instruments is required.

Straight and Level Flight (S & L)

13 **To achieve S and L flight** The selective radial scan for this manoeuvre is illustrated in (Fig 19.3):

Fig 19.3 Achieving S and L on instruments

* To achieve S and L, select the S and L attitude on the AH and maintain.

* If the attitude you have selected is correct, the altimeter and DI will become stationary.

* Should the altimeter cont'nue to move, change the pitch attitude on the AH by 1° of pitch, up or down as appropriate.

* Whether or not you have the correct pitch attitude can be confirmed on the VSI; this instrument is very sensitive and, when the errors are very small, it will show a trend before the altimeter moves.

* Should the DI show a turn, ensure that the ball is in the centre, and then re-check the DI.

* If there is still movement of the DI, even though you have selected wings level on the AH, make an appropriate bank adjustment to stop the turn; some AH instruments develop temporary errors of this sort.

14 **To maintain S and L flight** To maintain S and L flight, hold the aircraft attitude on the AH and monitor the VSI, DI, and the altimeter (Fig 19.4). During turbulent flight, the VSI tends to oscillate around a mean position. Interpret this reading and compare with that of the altimeter before deciding if a correction is necessary. The greater the turbulence, the more should your attention (and therefore, reliance) be transferred to the AH.

Fig 19.4 Maintaining S and L on instruments

15 **To regain altitude** To regain a desired altitude, the correction applied will depend upon the magnitude of the error: for a 50ft error, an adjustment of 1° of pitch should suffice; for larger errors, 2° to 3° of pitch and also a small power adjustment, may be needed. Fractionally before the desired altitude is reached, adopt the S and L attitude on the AH and co-ordinate for S and L.

16 **To regain a heading** To regain a desired heading, simply apply bank in the direction you wish to turn. For small corrections, use an angle of bank equal to half the error - eg for an error of 10°, use 5° bank. As the heading is regained, level your wings on the AH and confirm by a steady DI reading. For large heading corrections, use enough bank to give you a Rate One turn.

17 **Increasing speed** To increase speed, apply full power and keep the DI steady by using right rudder. Maintain the AH attitude until the VSI moves upwards and then make a 1° pitch correction downwards. Thus, no change of scan is required initially but, as the aircraft accelerates, include the ASI. As the desired speed is reached, reduce the power by feel, maintaining the S and L scan, with a quick glance at the manifold pressure gauge to finally adjust the throttle, and retrim.

18 **Reducing speed** To reduce the speed, close the throttle to an estimated setting for the new airspeed. Maintain heading with left rudder, carrying out a normal S and L scan. This time, however, be prepared to make small pitch corrections as the VSI begins to show a descent. When settled with the speed steady, re-trim.

Climbing

19 Most instrument climbs are made when leaving the circuit at the beginning of a sortie. Thus, they will include the various airmanship checks normally carried out during a visual climb. These checks will be included into your responsibilities as your instrument training progresses. Instrument climbs may also be necessary when observing the quadrantal rules.

20 **Entry to climb** The scan used when climbing is illustrated at (Fig 19.5). At the entry to climb:

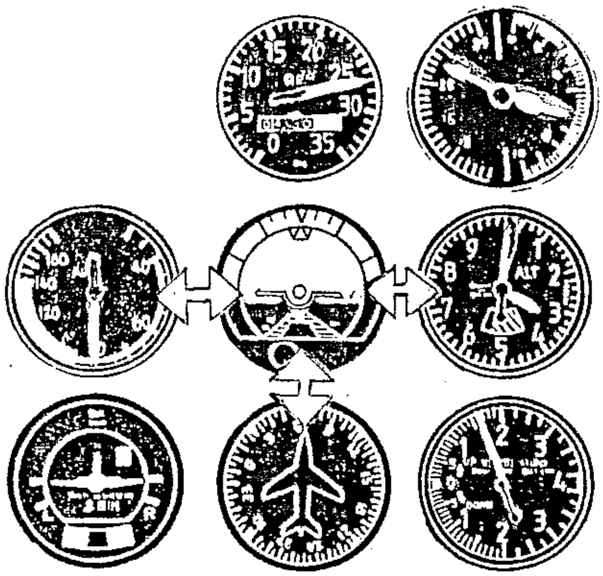


Fig 19.5 Climbing

* Apply full power, keeping straight on the DI; right rudder will be required.

* Select the climbing attitude and, if you wish, make a coarse trim.

* As the airspeed is settling, glance at the DI and adjust for any errors.

* When you are sure the airspeed has settled, decide whether an attitude correction is necessary; the amount of correction is approximately 1° per 5K (up or down as appropriate).

21 **Maintaining the climb** Proceed as follows (see also Fig 19.5):

* Maintain the attitude that gave the correct climbing speed.

* If the wings are level and the DI is steady, the aircraft will be in balance.

* As the flight level to which you are climbing draws nearer, progressively include the altimeter into your scan.

* Should a reduction in climbing speed be necessary, make the adjustments on the AH.

* When changing the altimeter setting during the climb, task is considerably easier with the aircraft accurately trimmed.

22 **Levelling-off from the climb** Proceed as follows:

* Anticipate the level-off **flight** level and adopt the S and L attitude for 100K, using the AH.

* As the S and L is reached, check the accuracy of the level-off on the altimeter and, if necessary, adjust on the AH just as you did when achieving level flight during S and L.

* Once in level flight, transfer to a 'maintaining' scan (para 31), but include the ASI.

* As the speed increases, the VSI will show a tendency to climb, which is your signal to lower the horizon bar.

* As 100K is reached, reduce RPM and MAP by feel (which rudder is required?), and maintain the S and L scan with single glances at the ASI and RPM and MAP guages as required.

Descending

23 You will be taught two types of descent on instruments:

* The normal descent at 100K for use when changing a quadrantal flight level or descending to pattern height.

* The descent used during a GCA final approach.

The first of these has a constant airspeed and power setting: the resulting rate of descent is accepted and not directly controlled. During a runway approach descent, the airspeed is kept constant but the power is varied to achieve a specific rate of descent.

Normal Descent

24 **To enter and maintain a normal descent.** To enter a normal descent:

* Set about 2000 RPM and 14' MAP and then adopt a gentle descending attitude on the AH.

* Once the attitude is selected and the RPM is correctly adjusted, scan ASI, AH and DI (Fig 19.6). The rate of descent will be about 500ft/min.

* As in climbing, airspeed corrections should be made by monitoring the AH. Do not hurry over these; there is a temptation to 'chase the airspeed'.

* Once the airspeed is correct, include the altimeter into the scan; once settled into the descent, the altimeter has the same importance as the ASI and DI.

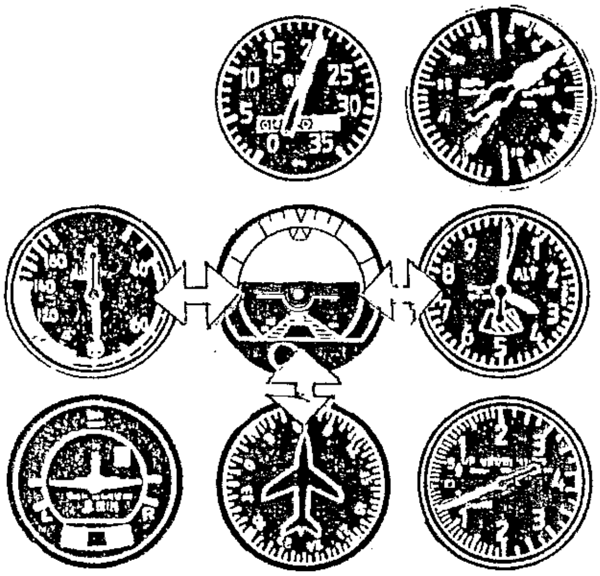


Fig 19.6 Descending

25 Level off at 100K The scan for this is illustrated at (Fig 19.7) the actions being as follows:

* Anticipate the height at which you intend to level off by 150ft, and re-apply cruise power, slowly changing the attitude to S and L on the AH.

* Once you have made the change, adjust the attitude, if necessary, to achieve level flight and check that you have the correct cruise power for 100K.

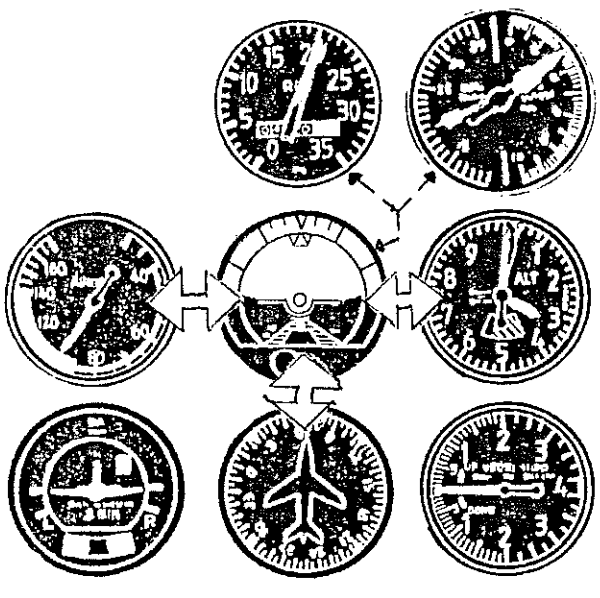


Fig 19.7 Levelling-off at 100K

Turning

26 **Rate One Turns** The rate one turn (3° per sec) forms the basis of the turning performance of the Firefly during instrument flying. Therefore at normal Firefly cruising speeds, the aircraft is flown using 15° of bank during an instrument procedures. If a small turn is required (eg through less than 15°), an angle of bank equal to half the degrees of turn is used (10° of turn - 5° of bank). When rolling out from a turn, anticipate the desired heading by a number of degrees equal to one half of the bank.

27 **Entering a turn** Before rolling into the turn, decide on the angle of bank to use. Then, using the scan illustrated at (Fig 19.8):

* Apply the bank, using the AH, and include sufficient back pressure to raise the orange dot 1° relative to the horizon.

* Check the bank at the required angle, and then include the VSI to ascertain that the pitch attitude you have adopted is correct. If necessary, raise or lower the nose proportionally by 1° of pitch per 100ft/min error. Avoid the temptation to make your corrections using the VSI because it leads to needle chasing.

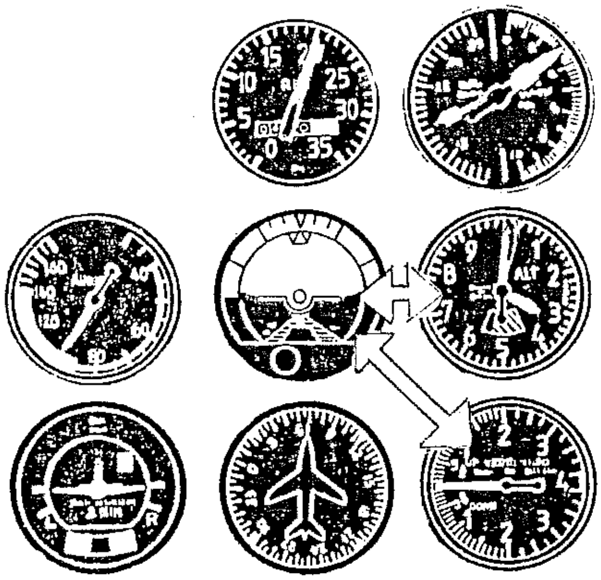


Fig 19.8 Entering a turn

28 **Maintaining a turn** The scan used is illustrated at (Fig 19.9):

* The AH is used to maintain pitch and bank during the turn.

* Bank can be kept constant using the bank scale, but the pitch indications will need to be supported by the VSI and the altimeter, as explained in S and L.

* As the turns proceeds, progressively include the DI into the scan to monitor the roll-out point.

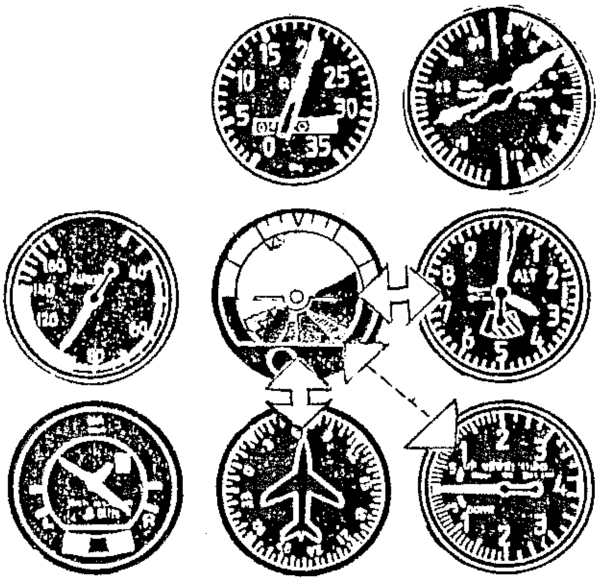


Fig 19.9 Maintaining a turn

29 **Roll-out** As the roll-out point is reached, concentrate on the AH. Level the wings and include a forward pressure to return the datum to the level position. As soon as the S and L attitude is reached, revert to the S and L scan - but, initially, include the ball for balance.

Climbing Turns

30 Climbing turns are normally made at rate one (about 15° of bank). The AH pitch indications need only be supported by the ASI.

* Apply bank using the AH and include, this time, sufficient back pressure to keep the pitch attitude constant.

* When 15° bank is reached, check the ASI reading and note any trend: if the airspeed is reducing, lower the nose by 1° of pitch; if increasing, raise the attitude by a similiar amount. Avoid any temptation to chase the airspeed; always adjust on the AH.

* To roll out on a heading, anticipate the desired heading by a number equal to one half of the bank, level the wings on the AH and continue as for a straight climb - after checking that you are still in balance.

Descending Turns

31 Descending turns follow exactly the same procedure as the climbing turn, except that greater emphasis should be placed on monitoring the altimeter, as in any descent. The scan used is illustrated at (Fig 19.10).

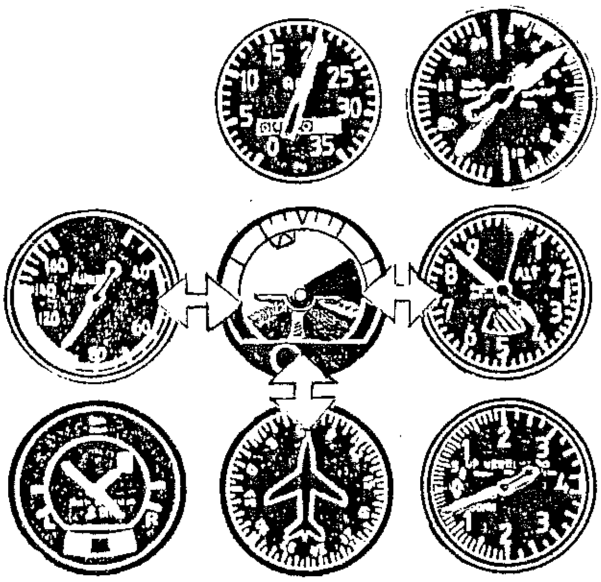


Fig 19.10 Descending turns

Directional Indicator Failure

32 If the DI is found to be unserviceable, the compass cannot be used as a direct substitute since it is subject to turning and acceleration errors, which your instructor will demonstrate. Therefore, it is included in the scan only when the aircraft is in straight, unaccelerated flight. Small heading errors (ie less than 20 degrees) are removed by turning the aircraft briefly and then re-checking the heading achieved once the aircraft has been straightened and the compass reading has stabilized. Larger heading changes are accomplished using the timed turn technique, which is based on the fact that heading is changed by 3 degrees every second in a rate one turn. Accordingly, the approximate heading change is calculated, and then divided by 3 to give the duration of the turn required. The turn is then timed from the commencement of roll-in to the commencement of roll-out. Once the aircraft and compass have stabilized, further corrections can then be applied as necessary.

Unusual or Extreme Attitudes

33 There are a number of occasions (eg entering cloud when manoeuvring) when your safest course of action is to achieve straight and level flight on instruments as quickly as possible. If you have no reason for suspecting the indication on the AH, then using the instrument for selecting the correct attitude is obviously the quickest and simplest method. However, the AH may not be indicating correctly (either due to instrument failure, or through being toppled during aerobatics), and there is a standard recovery technique that you will be taught for these circumstances. This is a simple, three-stage procedure which will ensure recovery to straight and level from any extreme attitude. The three stages break down into power, pitch, and bank - each of which is considered in the following paragraphs.

34 **Power** The following conditions apply:

* If the nose of the aircraft is below the horizon, the airspeed will be high or increasing. To keep the rate of descent to minimum, close the throttle.

* If the nose of the aircraft is above the horizon, the airspeed will be low or decreasing. Thus, there would be a possibility of stalling. Therefore, to reduce this possibility and delay the onset of a stall, apply full power.

* When opening or closing the throttle, apply some rudder to keep the ball near the centre.

35 **Pitch forces** The second action is to remove excessive pitch forces by selecting approximately + 1 'g' (indicated) on the accelerometer. This action will enable the turn needle to indicate more accurately.

36 **Bank** The third action is to level the wings using the AH or the indicatons of the turn needle. Aileron deflection will depend upon the angle of bank. However, if the bank is more than 50° or the turn needle is indicating a full deflection, use approximately 2/3 aileron deflection. Then, as the turn needle passes Rate ½, centralize the ailerons.

37 **Pitch** There are four instruments which could be used to level the aircraft in pitch: the AH, the VSI, the ASI, and the altimeter. However, in the interests of standardization throughout the various stages of training, you will be taught to use the altimeter if the AH is unreliable. Thus:

a **If the AH is reliable**

* Return to the level flight pitch position.

b **If the AH is unreliable**

* When the wings have been levelled on the turn needle, with ailerons neutral, apply elevator in the opposite sense to the altimeter movement.

* Maintain a constant pressure until the needle slows down and then stops, before reversing.

* As it stops, make a check movement to hold the needle stationary. The pressure necessary to achieve this will vary according to trim.

* The aircraft will then be in a roughly level attitude.

38 **Straight and Level** With a reliable AH, this is no problem. If the AH is unreliable, then immediately the pitch correction is made, cross-refer to the turn needle and re-centre if necessary. Adjust the power to resume cruising speed. The scan should now be extended to include the remainder of the instruments. Ensure each one is operating correctly and can be reliably included into your scan. Any instruments you are uncertain about should be excluded.

39 **Recovery procedure** The sequence for the recovery from an unusual or extreme attitude is summarized as follows:

a Airspeed high or increasing - throttle closed.
Airspeed low or decreasing - full power.

b Select approximately + 1 'g' on the accelerometer using elevator.

c Level wings on AH or centre the turn needle - anticipate zero according to aileron deflection.

d Ailerons central - ignore turn needle and apply elevator to achieve level pitch or to stop altimeter.

e Co-ordinate for S and L, adjusting power as necessary.

CONCLUSION

40 The selective radial scan embodies a logical mental discipline based on the fundamental power/attitude concept of aircraft performance. Thus, whenever the AH is usable, control movements are made only whilst looking at the AH. On limited panel, there is no one master instrument and groups of performance instruments are used to assess the attitude. Therefore full and limited panel flying require different scans and mental disciplines; the two should not be mixed.

EXERCISE 20

N I G H T   F L Y I N G

Introduction

1 The handling of an aircraft at night is no different from that during the day, and the transition to night flying - particularly for the pilot trained in instrument flying - is quite easy. Furthermore, flying at night is usually smoother than day flying because of the reduction at night of thermal or convection air currents.

AIRCRAFT LIGHTING

International Navigation Lights

2 The lights displayed by an aircraft at night not only indicate to you that there is another aircraft present, but they can also be used to determine its position relative to your own aircraft. (Fig 20.1) shows how each light shines through a specific arc. This is common to all aircraft and enforceable by law. Since all aircraft use this same international system then, if you see a white light ahead, you will know that you are astern of the other aircraft. If the white light changes into green, you will know that you are overtaking him on the starboard side or that he has turned to his right.

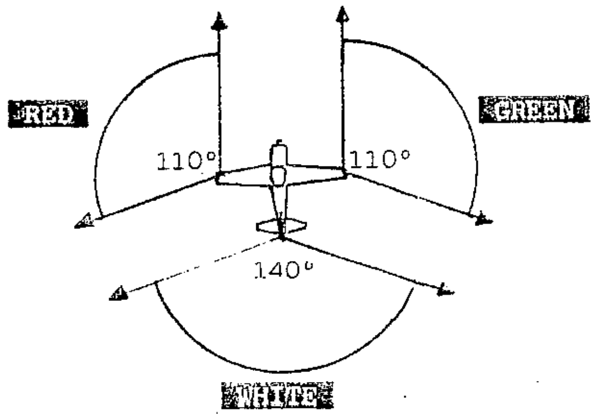


Fig 20.1 International navigation lights

Anti-Collision Light

3 In addition to the international navigation lights, the Firefly has an anti-collision strobe light (Fig 20.2). The navigation and anticollision lights are also used together to indicate the various states of aircraft readiness when on the ground: when the aircraft is manned, the navigation lights are on; and when the aircraft is ready for takeoff, the anticollision light is on as well.

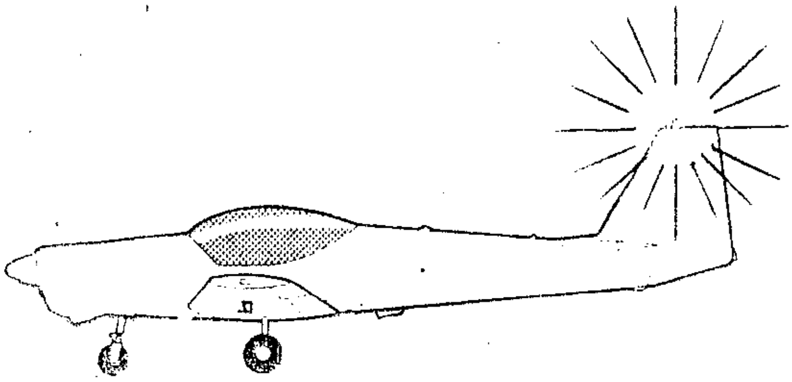


Fig 20.2 Anti-collision light

Location and Operation of Switches

4 During your training so far, you have been concerned with checking the lighting switches in the OFF position only. Now you must learn what each switch is for and how it is operated. Since you may need to operate them in the dark, it is good practice to spend some time in the cockpit before night flying giving yourself a blindfold check of all the controls and switches.

NIGHT VISION

Adjustment of Vision to Night Conditions

5 Much has been written about night vision - eg how it is necessary to sit in the crew room wearing red tinted glasses (to fool the rods in the eyeball into thinking that it is dark), or the need to eat two tons of carrots a year to maintain the correct chemical balance in the body! This may be necessary at the highest operational level but, for Firefly night flying operation, walk out to the aircraft a little early and your eyes will sufficiently adjust themselves for safe operation by the time you are ready to taxi.

6 It takes the rods in the eyeball approximately 30 minutes to adjust themselves fully to night conditions. The reverse process takes only a second or two. Therefore, do not undo 30 minutes effort by flashing a torch about the cockpit; rely on the cockpit lighting.

Lookout

7 Airborne lookout at night is the same as for day. However, if you wish to look at an object, shift your gaze slightly off centre and do not hold a steady gaze for more than a few seconds. It is another characteristic of rod vision that an image fades completely if the eyes are kept stationary for more than a few seconds.

AIR EXERCISE

8 The first night sortie will be mainly familiarization, and circuits and landings. Your instructor will highlight all the differences between day and night operation but, to prepare the way, some of the more obvious points are dealt with in the following paragraphs.

External Checks

9 The external checks will include a functional check of all external lights. Also, pay particular attention to the cleanliness of the canopy and windscreen. You will need a torch to carry out the external checks thoroughly, and you must carry one for the flight anyway. Tie the torch to your flying suit so that it cannot become a loose article in the cockpit but ensure that the string does not become a hazard in itself.

Cockpit

10 Once settled in the cockpit with the hood closed, you will see how the cockpit lights reflect from the canopy if the lights are turned up too high. Experiment with the dimmer switches until you can see out comfortably. As your eyes become more adapted to darkness, you will be able to reduce the brightness even further.

Taxying

11 It is extremely difficult to judge the taxying speed at night. The tendency is to taxi too fast. If in doubt, slow down and, if you think that you are approaching a hazard of any sort, **STOP**. Do not proceed at any time unless you are sure it is clear ahead; use your taxi lamp if necessary. When you stop the aircraft, make sure that the brake is fully on and look outside to check that you are not moving.

Instrument Checks

12 Since night flying is a combination of instrument and visual flying, it is important that the instruments are checked fully serviceable whilst taxying out.

Take-off

13 Before taking off, your instructor will pause for a few moments whilst you take note of the visual references of the touchdown position. This will help you with the landings later. Note that the runway lights converge ahead of the nose when you are correctly lined up. Your take-off technique is exactly the same as by day except that, to keep straight, you must aim to maintain the same picture of lights converging evenly from each side.

Climb after Take-off

14 Once safely airborne, transfer to instruments. Resist any temptation to look back at the airfield until you have turned and are completing the climb to circuit height.

General Handling

15 At night, the aircraft is controlled using both visual and instrument indications. Generally, you will use the instruments for changing the attitude of the aircraft and then, once settled in the new attitude, you will use both visual and instrument cues, the proportion depending upon the degree of darkness and the clarity of the visual horizon. If there is a moon, you will find that visibility into moon is better than that down moon; you will also find that the contrast between land and water is marked.

16 **Night disorientation** You will already have been given instruction on the physiological effects of flying on instruments, and no doubt may have experienced spatial disorientation during instrument flying and, to a lesser degree, during VMC flying. Night disorientation, however, is a supplementary problem and you should be aware of its implications.

During instrument flying, the eyes receive attitude information entirely from the aircraft instruments. Night flying, however, is a sensible combination of visual and instrument flying and, as such, the eyes receive a certain amount of outside visual reference as well as instrument indications. On a very dark night, any external small groups or pin-points of light can give false impressions of attitude that may be at variance with the instrument picture. During the look-out scan, and particularly during manoeuvre, the pilot can be easily confused by this unreliable orientation source. The problem may be compounded if the aircraft attitude changes without the pilot realising, and, when referring back to instruments he is confronted with a totally unexpected picture.

In all cases of night disorientation, you must rely solely on instruments to re-establish orientation. This will require you to totally ignore the outside visual indications and to concentrate entirely on instruments. In order to cut down the intensity of the outside distraction, it may help if the cockpit illumination is turned up, thereby allowing re-orientation in familiar surroundings.

Being a purely physiological phenomenon, night disorientation cannot be simulated. Your instructor, however, will give you practice at steep turns, and recovery from various manoeuvres, as part of your night familiarization, during which you will experience the supplementary disorientation problem of having outside distraction while recovering on instruments.

Remember, night disorientation can happen to anyone and usually it happens when it is least expected. Whatever your in-flight conditions, if you are in doubt, forget what is going on outside the cockpit and rely entirely on the instrument picture for orientation, while recovering back to straight and level flight using the UP recovery technique.

Radio Calls

17 At night, extra effort must be made to make all circuit RT calls from the correct positions so that ATC and other pilots have a reliable indication of your position. For the same purpose, it is also usual to make an additional RT call when crossing the upwind end of the runway during the rejoin procedure - but this additional call is not acknowledged by ATC.

Emergencies

18 In addition to the normal emergency procedures, there are three peculiar to night flying: failure of the navigation lights, radio failure, and total electrics failure. Since the procedures for dealing with such emergencies vary slightly from one airfield to another, they cannot be dealt with in this book; the procedures will be available locally and will be covered fully at each night flying briefing.

19 If you suffer an engine failure, your course of action will vary with the circumstances:

* In the circuit, because you are below 2000ft agl, you cannot abandon the aircraft and thus have no option but to land the aircraft. If you have completed about 90° of your turn after take-off, the airfield should be within your reach from then on in the circuit. A turn back may even be possible depending on circumstances, and you should cover this on your pre-take-off brief.

* If your engine fails during the initial climb after take-off, you will normally have to land straight ahead. The night may be bright enough to allow some judgement of an approach; the use of the landing and taxi lights will also help. Complete your crash actions if you have time, making sure that your harness is really tight. Then, when you hit the ground, you should come to little harm.

Landings

20 A good touchdown at night is probably the most difficult aspect of night flying. The secret is in having the correct threshold speed. Try to make a definite assessment of whether or not you are at the correct height, and avoid feeling hopefully for the ground. At the correct height, you will have the feeling of being down amongst the runway lights, the picture being similiar to that on take-off. When you have touched down, maintain the runway centre by keeping equidistant from each set of runway lights. Before turning off the runway, conscientiously check that you have slowed to normal taxying speed.

EXERCISE 21

P I L O T   N A V I G A T I O N

Introduction

1 The ability of a pilot to navigate an aircraft is an essential part of the general art of flying. This is true whether flying solo or as captain of a crew. The whereabouts of your aircraft is your responsibility. Since navigation is only part of your duties, the techniques employed must be simple and, whenever possible, be preceded by sound pre-flight planning to minimize the amount of work remaining to be done in the air.

GENERAL CONSIDERATIONS

Air Navigation

2 Your education in air navigation will start during the early flying lessons. During these, your instructor will point out prominent features in the local area and you will learn to identify them on your map. Your instructor may ask you to estimate a heading from a feature back to base, and then to fly that heading. Try to prepare for this whilst sitting in the crew room:

* Select a feature on the map and imagine a line between it and the airfield. Now estimate the true track and add variation. Check this with a protractor; with practice, you should manage an accuracy of +/- 10°.

The Effect of Wind

3 You may well ask at this stage 'What about the effect of wind?' Considering the short distances involved in flying around your local area, you can ignore it at the early stages. Later, as you gain experience, you will be taught to allow for drift. However, estimating and steering headings is all that is necessary for you to know before leaving the circuit on local solo sorties.

Drift

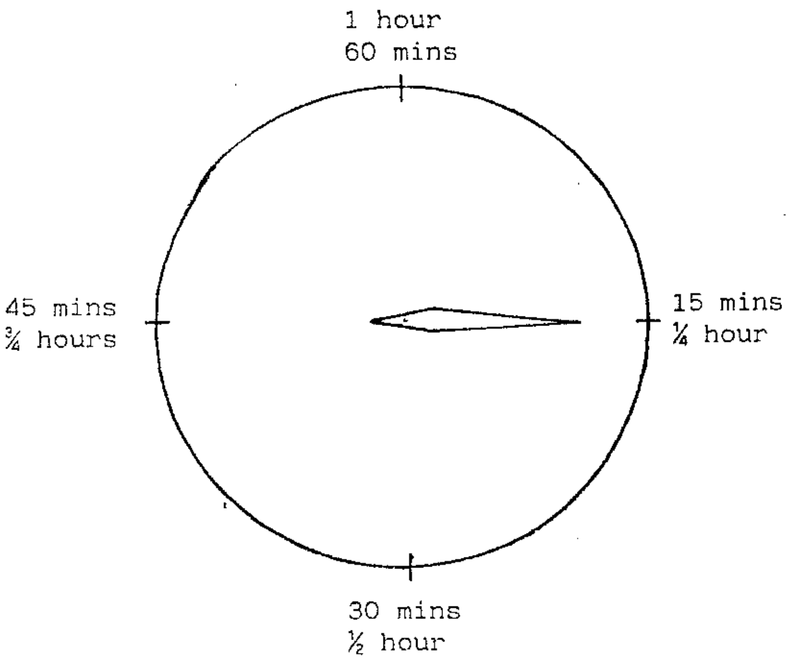
4 **Maximum drift** The maximum amount of drift can be easily calculated if the windspeed and the TAS of the aircraft are known. The equation is:

$$\text{Maximum Drift} = \frac{\text{Windspeed}}{\text{TAS}} \times 60$$

* Example. When flying at a TAS of 100K with a 25K wind on the beam, the drift will be:

$$\frac{25}{100} \times 60 = 15°$$

5 **Actual drift** To work out the actual drift, you need to know the angle between the wind and your track. Drift is taken as maximum if this angle is between 60° and 90°. An easy way of remembering the amount of drift in other cases is to use the minute hand on a watch face (Fig 21.1). If, for example, the wind is 15° off track, call this wind 15 mins - which is a quarter of an hour; the drift will be ¼ of maximum drift.



15 mins is ¼ hour
Wind 15° off track
gives ¼ maximum drift

30 mins is ½ hour
Wind 30° off track
gives ½ maximum drift

45 mins is ¾ hour
Wind 45° off track
gives ¾ maximum drift

60 mins is 1 hour
Wind 60° off track
gives 1 maximum drift

Fig 21.1 Amount of drift

A more accurate drift table is explained diagrammatically at (Fig 21.2).

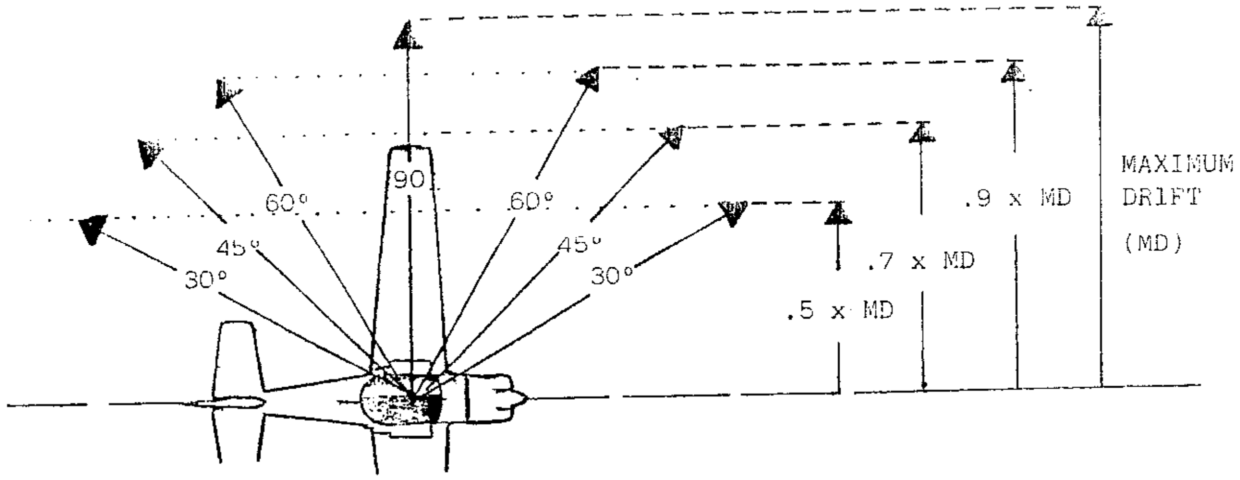


Fig 21.2 Drift table

Cross-country Navigation

6 The complexity of flying in the UK is likely to increase as the airspace becomes more congested. It is vitally important, therefore, that every cross-country flight is properly pre-planned. In the paragraphs that follow, we shall deal with the pre-flight preparations necessary for a successful cross-country journey; this will be followed by a discussion of the techniques to be used en-route and what to do if you are lost.

7 Initially, we are going to concentrate on navigating at medium level - at heights between 1,000ft and 10,000ft. At medium levels, you will use map and ground features to navigate accurately. Later, we shall consider low-level navigation (see para 22).

Pre-flight Planning

8 **Routes flown** Your instructor will show you the route to be flown and you should select the appropriate map and draw in the track. Study the route along the track and on either side, noting features which might affect planning - such as danger areas, large towns, or airways.

9 **Meteorological forecast** Next, study the meteorological forecast and note the wind and temperature and any warnings which may affect your route.

10 **Navigation warnings** Navigation warnings - such as Royal Flights and flypasts - can be over-riding. It is essential, therefore, that NOTAMS and other warnings are studied carefully.

11 **Preparation of maps** When you have checked the points mentioned above, and have decided that all is safe for flying your sortie, prepare your map and log. Map preparation will be taught in detail during ground instruction. Remember to keep the map uncluttered but, at the same time, do as much preparation as you can on the ground to reduce the work load in the air. Prepare thoroughly, and write clearly and neatly.

AIRMANSHIP

Preparation

12 Before going out to the aircraft, check that you have:

* Map.
* Log.
* Pencil (securely attached to your flying clothing).
* Watch (time checked).
* Flight Reference Cards.
* Communications supplement.

In the Air

13 Once airborne, it is most important to fly accurately the headings, heights, and speeds that you worked out on the ground. A high percentage of navigation sorties will be successful with no need for further calculations or adjustments, so long as the pilot flies the flight plan accurately. However, sometimes the forecast winds will be inaccurate, and it is important to make frequent checks that the route flown is according to plan.

Setting Heading

14 In the early exercises you will probably climb to the selected altitude close to the airfield and set heading from overhead. Later on, you will turn after take-off onto a pre-determined heading and climb on track. In any event, it is important to check three things:

* Heading - is it correct and is the DI synchronized?
* Altitude - to what altitude or flight level are you climbing?
* Time - have you noted the time?

Fixing Position

15 You will already have used your map extensively in the local area and will know how to orientate the map and how to pin-point your position. During the pre-flight planning you should have decided how often to fix your position: this will usually be every six (6) minutes, depending upon the availability of suitable features. Do not attempt to map-read continuously; you have selected certain features for their uniqueness, size and contrast in relation to the surrounding area, and map-reading using less suitable features in between times may only confuse. In any case, the idea of thorough planning is to reduce your work load in the air so that you can concentrate on accurate flying - and by map-reading continuously you would be overloading yourself. When in continuous contact with the ground the correct technique is to read from map to ground, using your watch and time marks to anticipate the selected features.

Revision of Heading

16 During cross-country work, resist all temptation to alter heading except from a reliable fix and after sensible calculation. The vital importance of flying according to the flight plan when pinpoints or other fixing aids are not available cannot be overstressed.

17 **The 1-in-60 rule** This rule provides you with a simple method of estimating angles or distances during a revision of heading. Although only useful for small angles, the formula is easy to remember:

* With a distance of 60 units, each unit at right angles will subtend an angle of 1° (Fig 21.3).

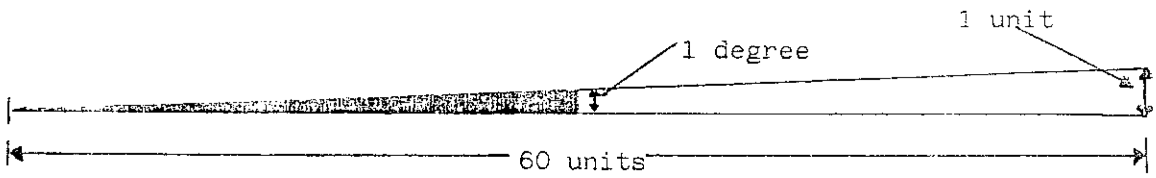


Fig 21.3 The 1-in-60 rule

Although, at first glance, this may not seem to be very useful, the rule is very adaptable. For example, if you are 1 mile off track after travelling 15 miles this is the same as saying 4 units off after travelling 60 units; the angle of error in this example is, therefore 4°. Conversely, if you know that your closing angle is 6°, and you still have 30 miles to go to the turning point, your distance off track is (6 x 30/60) = 3 miles.

18 **Closing angle technique** This is the method that your instructor will most likely use when he shows you how to calculate heading alteration. To do this we add Track Error (TE) to Closing Angle (CA). If the track is divided into proportions, it is easy to see that TE becomes a proportion of CA.

Example 1 If the fix is half-way along the track, as in (Fig 21.4a), then TE = CA and the alteration of heading is the sum of the two.

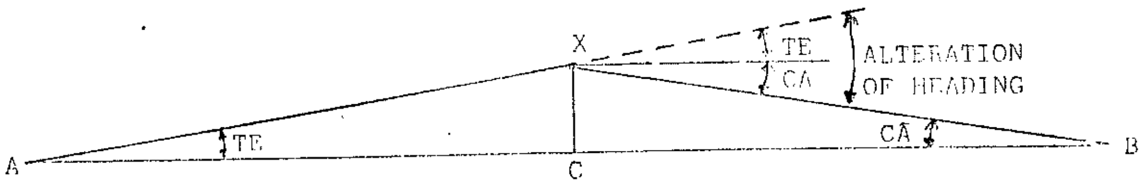


Fig 21.4a Closing angle technique

Example 2 If the fix is at C in (Fig 21.4b) (ie a third of the distance between A and B), then TE = 2CA; at D, TE = ½CA. This is easy to see if we apply the 1-in-60 rule and use some actual figures. Take the distance off track to be 1nm and AB to be 30nm, so that:

AC = CD = DB = 10nm

$$\text{If the fix is at C, TE} = \frac{\text{Distance off}}{\text{Distance gone}} \times 60 = \frac{1}{10} \times 60 = 6°$$

$$\text{CA} = \frac{\text{Distance off}}{\text{Distance to go}} \times 60 = \frac{1}{20} \times 60 = 3°$$

ie, TE = 2CA and the alteration of heading is 3CA = 9°.

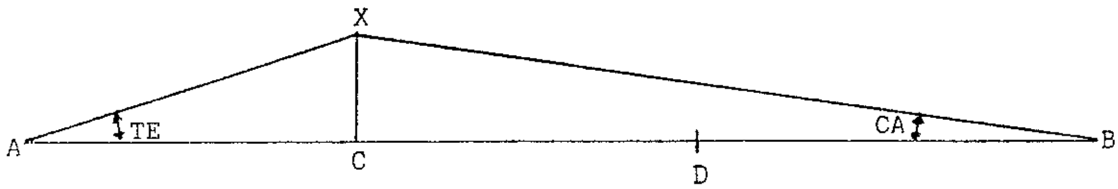


Fig 21.4b Closing angle technique

You can work out other examples for yourself, dividing the track into quarters, fifths, and sixths. The closing angle technique rule can be stated as:

$$\text{Heading alteration} = \text{Change in Closing Angle} \times \frac{1}{\text{Proportion of track flown}}$$

Once you have made your heading alteration, it is important to realize that your intended track is now from the fix to the turning point - you are no longer interested in your original track.

Revision of ETA

19 When it is necessary to revise the ETA at a check point or a destination, relate the error to a proportion mark. Time early or late must be proportionally increased and applied to the flight plan ETA.

Turning Point Procedure

20 You should arrange to make your last check on navigation at about two minutes before the end of a leg. Once a turning point has been positively identified, do the HAT checks:

* Heading - Resynchronize the DI and note the heading for the next leg.

* Altitude - Note the altitude of flight level for the next leg.

* Time - Note:

  ° the time of arrival, and compare it with the latest revised ETA

  ° the time of setting heading on the new leg

21 When you have settled down on the new heading, you can do the FHARTI checks to ensure that all is correct for the next leg:

* Fuel - Check the fuel remaining against the planned figure and ensure that you have sufficient to complete the sortie.

* Heading - Are you steering the planned heading and is the DI synchronized?

* Altitude - Correct quadrantal?

* Radio - Notify base at each turning point.

* Time - Did you remember to note the time of setting heading?

* Instruments - Are they correct?

Low Level Navigation

22 When navigating at low level, a pilot's view of the surrounding countryside is somewhat different to that seen from higher levels. The main differences are:

* The field of view is restricted so that you do not see features until they are quite close and they remain in sight only for a short time.

* The ground no longer looks like a map, as you can see the vertical aspect of features, but if you study the map carefully before flight you will be able to anticipate and make use of contours and other vertical features.

* The range and accuracy of radio aids are seriously reduced and will seldom be of much use.

* Becuase you are flying close to the ground, more concentration will be needed to fly the aircraft accurately.

23 **Planning** Careful flight planning and thorough map study are essential if you are to make a success of low level navigation. It is too easy to skimp map study, especially if time is short. So make sure you have enough time and allocate a period to map study; in fact, this should be about the same length of time that you take for the rest of the planning. Try to visualize the features on the map as they will appear to you when you fly the route; inagine that you are going to build a model using the map as your only reference. With practice, you should be able to distinguish steep and gentle slopes. Remember that, because you will be at low level, features on the ground that slope down away form your track may be particularly difficult to distinguish because you will not see a plan view.

AIR EXERCISE

24 The first and most important thing is to fly accurately. If you have studied the route you will be well prepared to anticipate check features and will only need to glance at the map to remind yourself what to look for. Hold the map at eye level so that you do not need to look down into the cockpit. When searching for a check feature, first look for the general relief features, because these will give an early indication of the exact position of the check feature. If there is no obvious relief associated with a check feature, common sense may indicate something that will stand out: for example, those parts of a meandering river which run straight towards you will easily be visible from some distance.

LOST PROCEDURE

25 Under normal operating conditions and when radio/radar aids are available, position fixing is relatively simple and these aids should be used to full advantage whenever possible. It is when they are not available that uncertainty of position becomes a problem and the pilot-navigator must then consider alternative methods of establishing his position. Nevertheless if uncertain of position, use these facilities before it is too late for effective assistance to be obtained, even if frequent attempts to make contact are unsuccessful.

26 It is not possible to lay down a firm procedure to be adopted by the pilot of a single-seat aircraft when he is uncertain of his position because his course of action will depend on the circumstances pertaining at the time. Bearing in mind the aim of the procedure, which should be the completion of the mission or successful diversion of the aircraft, certain guiding principles can, however, be formulated under the following headings:

a Immediate action for the safety of the aircraft.

b Assessment of DR position.

c Subsequent action.

Immediate Action for the Safety of the Aircraft

27 The two immediate actions are to check the safety altitude and the fuel.

a **Safety Altitude** The pilot must recheck the safety altitude with reference to his flight plan. If the ground is obscured the aircraft must be at, or above, this height; if in visual contact with the ground, an awareness of the safety height is all that is required in preparation for an immediate climb should contact be lost.

b **Fuel State** The total fuel remaining must be known because of subsequent actions will be affected by this. It can be quickly converted to either endurance or still-air range.

Assessment of DR Position

28 The DR position of the aircraft is calculated as accurately as possible, based on the most recent reliable fix; depending upon circumstances this may be done either by track plot or by air plot. If on a properly planned navigational flight, any turning point or destination is a ready-made DR position; it is logical to use one of these positions unless for some reason another is preferable. To be quite certain that the DR position is based on fact, make the following checks:

a **Heading**

1 Correct heading being flown.

2 Gyro compass checked against magnetic compass.

b **TAS**

1 Correct IAS being flown.

2 Correct height. (This affects TAS for a given RAS.)

3 Pilot heater ON.

c **Time**

1 Check watch against clock.

2 Times flown as per flight plan.

d **Previous Calculations** Any relevant calculations made during the flight must be checked for accuracy.

e **Wind Velocity** If in visual contact and at a relatively low altitude, wind lanes or smoke may assist the estimation of wind direction. The state of the sea will give a good indication of wind strength to the experienced pilot but is of little use to the beginner. Obvious changes from forecast conditions should be borne in mind.

It may well be that these checks will show the reason for the uncertainty of position, ie why the terrain is unfamiliar or why the aircraft is out of radio/radar range.

29 Once the DR position is established, encompass it by a circle of uncertainty of radius 10% of the air distance flown since the last reliable fix.

Subsequent Action

30 The action to be taken depends on the circumstances, which are broadly classified as:

a In visual contact with the ground or sea.

b Not in visual contact.

31 **In Visual Contact** If in visual contact - maintain contact. As the aircraft can be anywhere within the circle of uncertainty, an accurate track to a feature cannot be estimated. A line feature will absorb any track error and, therefore, select one conveniently placed outside the circle of uncertainty. Set heading towards the selected line feature and mapread from ground to map. Fly at the best endurance speed and when the feature is reached, if position has not been established, select the more favourable direction and track along the feature keeping to its right until further features enable a pinpoint to be obtained.

32 **Not in Visual Contact**

a In a controlled air space, the flight will be according to a flight plan and the procedure outlined in the emergency procedure section of the en-route document should be followed as closely as possible. Should the pilot decide to depart from this procedure, he must leave controlled airspace.

b If outside controlled air space, a descent may be made at any time provided that it is discontinued at the safety altitude if visual contact is not made. Descend in a spiral, followed, if necessary, by a spiral climb; by doing this, the DR position is simply moved by the wind effect during the descent and climb, and complicated calculations are eliminated. Alternatively, select a more suitable area such as over the sea. From the DR position a heading and ETA is estimated to a position such that its surrounding circle of uncertainty is wholly over a 'safe' area. Allowance must be made for the expansion of the circle of uncertainty. Fly at the recommended range speed and, at ETA, descend with the most accurate QNH available set on the altimeter.

33 The decision to descend below the safety altitude rests with the pilot. Altimeter errors may amount to ± 800ft and, therefore, the logical minimum altitude in an emergency is that of the highest point within the circle of uncertainty, plus 800ft.

NOTE Since only obstacles of a certain minimum vertical extent are plotted on maps, in the absence of any plotted obstacles in the descent area, this minimum height must be added to the maximum elevation data given when calculating any safety altitude. When visual contact is made, proceed as in para 31.

34 Should visual contact not be made, climb and fly to an area suitable for abandoning the aircraft, ie over land rather than sea. Fly the 'emergency radar triangle' pattern until fuel is exhausted; trim the aircraft pointing towards the sea or a sparsely-populated area and abandon if applicable.

35 In all cases of uncertainty of position early action is essential. Haphazard seeking of position is demoralizing, wastes valuable fuel and may well create a serious risk of collision.