Recreational Aircraft Assn.
of New Zealand (Inc.)

MICROLIGHT PILOT TRAINING MANUAL

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FOREWORD

This Training Manual has been put together by the Recreational Aircraft Association of NZ to assist those who wish to fly these remarkable aircraft and to enjoy the sport safely and with confidence.

Flying any type of aircraft, including the microlight, carries with it critical responsibilities. The pilot is responsible for not only his or her own safety but for the safety of his or her passengers and the public at large. There are also other matters to consider such as avoiding causing nuisance, respect for property and the rights of others. As a potential operator it is necessary to understand and subscribe to these responsibilities so that the reputation of the Association and its many members continues to enjoy the respect of the NZ public and of the international microlight fraternity.

The material contained in this manual was not prepared for the casual reader. It should be read with the intention of learning it and putting it into practice. Knowing what is contained in this document may well save lives.

Microlighting has come a long way in the past fifteen years or so and the publication of this manual is another step towards the goal of safe, relatively cheap flying for those enthusiasts wishing to enjoy what has been described as the most enjoyable way to experience the freedom of flight. I commend it to all microlight pilots and I congratulate the RAANZ on producing it.

Stuart McIntyre
CBE, DFC, FRAeS
Patron

MICROLIGHT AIRCRAFT OWNERSHIP

Unlike conventional aircraft with their established maintenance schedules and regular inspections by aircraft engineers, microlights in New Zealand rely largely on the owner/operator to take responsibility for maintaining the aircraft's airworthiness, detecting faults and organising correct repair. It is a responsibility not to be taken lightly, but one which the owner/operator can easily manage by ensuring a regular and thorough inspection of the aircraft is made. This is in addition to the normal preflight inspection which the pilot in command is responsible for.

It should be assumed at every inspection that deterioration has taken place. Only by constant vigilance can structural failures be checked. Remember that by nature of their very design, virtually every component of the microlight is vital to the overall airworthiness.

Every two seat microlight must have a valid "Permit to Fly" before it can be flown. Microlight Inspection Authority people are available for this – contact your local club.

Once the owner/pilot has completed his or her training and gradually leaves the watchful eye of the instructor, there may be a tendency for flying standards to lower. Here again it is the pilot's responsibility to ensure flying skills are maintained. Remember that instructors are available to help.

Indeed skills should continue to grow with experience, and pilots are encouraged to seek qualified advice if ever they feel they need it, in the interests of safety and increased enjoyment of the sport.

PREFLIGHT INSPECTION

Before any flight the pilot is responsible for ensuring the aircraft's airworthiness for that flight. This entails an inspection of the microlight known as the **preflight**. The pilot should develop a routine for carrying out this visual inspection (including in it the items following) and use the same method each time. Some prefer to check specific items in sequence, i.e. – engine and prop, then fuel, undercarriage, controls and so on. Others may like to start at a certain point, say the nosewheel, and work their way around the whole aircraft thoroughly until they have gone right round and back to the nosewheel again.

Whatever method is used, the aim is to satisfy yourself that everything is up to standard and free from defects. An established routine helps ensure nothing is missed. Discovery of a defect means the aircraft must be grounded until repaired and inspected by the appropriate person.

A procedure for completing a preflight inspection is detailed in the RAANZ pilot logbook.

If your preflight inspection is interrupted you must start the inspection again.

Preflight should include:

Pilot documentation:	Appropriate pilots certificate, warm clothing, eye protection and helmet.
Microlight Documentation:	Registration, Flight permit, and radio licence if required.
Propeller:	Propeller integrity, security of gearbox or belts and external bearings and shafts.
Engine:	Security of spark plugs and all electrical leads, throttle movement and cable integrity, choke and ignition switch operation, check all mountings, carburettor and exhaust for cracks and security.
Fuel:	Correct mix, sufficient for flight plus reserve, filters for contamination, fuel lines for hardness and integrity fuel cock operation, check fuel drain for contamination.

Controls:	Correct and full movement, cables, pulleys, rods and hinges for excessive wear.
Airframe:	Integrity of structure, i.e. no cracks and dents in tubing, or sloppy bolt holes, or loose nuts/bolts, security of internal bracing wires, fabric not ultra violet damaged or ripped, no kinks or broken strands on wires/cables. Check locknuts, pins and locking wire security.
Undercarriage:	Security of, integrity, tyre condition and inflation.
Instruments:	Operation. Setting. Security.
Miscellaneous:	Seating and harness integrity, baggage security.
Airstrip:	Length sufficient, surface suitable, no obstacles.
Weather:	No rain, wind less than 75% stall speed, crosswind within capability of microlight pilot. Cloud amount and type base height. Weather forecast for period and route of flight.
Map/s:	Airspace, flight route, terrain, height of obstacles.

Note:

- If the machine requires fuelling, do this before the preflight check.
- Sight down tubes – this makes bends or kinks more apparent.
- Using a rag to protect your fingers, run your fingers along cables checking for any kinks or broken strands. Ensure windscreen and propeller are clean.
- Watch for missing locking pins and sufficient bolt thread showing through nuts, elongation of boltholes, cracks and wear.
- Secure baggage before preflight so controls operation and freedom can be checked.
- Physically move controls and control surfaces to check for proper operation and attachment.
- Do not allow scarves to trail loose and check for loose clothing, particularly if the prop is behind. Detachable helmet peaks and visors can easily come adrift in flight.
- Do not adopt a casual approach to defects! Ensure they are reported and attended to.

GROUND HANDLING

Proper control of the microlight on the ground is important, as a large proportion of the damage to aircraft is suffered whilst taxiing or during the take–off or landing roll. Perhaps the most important thing to remember is that the microlight is a lightweight aircraft with a relatively large wing area, meaning that any surface wind can have a powerful effect on it.

Proper handling of the microlight on the ground involves:

- Positioning your aircraft before start–up to minimise the effects of propblast on other aircraft and open hanger doors behind your aircraft.
- Making sure all bystanders, pets etc are a safe distance from the aircraft before start–up, then call "Clear Prop".
- Correct use of power.
- Keeping to a safe speed for the conditions.
- Correct positioning of the controls.
- Consideration for obstacle clearance and braking.
- Keeping a good lookout.

Correct use of power. To get the aircraft moving, a fairly large amount of power may be needed. Once moving however, only a reduced amount will be required. Microlights without nose wheel steering rely on the slipstream acting on the rudder to assist directional control. Care must be taken to use sufficient power when needed to carry out the turn, but not for long enough to increase taxiing speed dangerously.

Keeping a safe speed for conditions. Special care must be taken when taxiing (in even moderate wind conditions). A brisk walking pace is acceptable in calm conditions, however a fast taxi into a head wind could bring the microlight close to lift–off airspeed, whilst control response may be insufficient to counter the effects of gusts etc. Beware of taxiing too fast downwind as braking distance increases and control response may be nil with reduced slipstream over the control surfaces (nosewheel steering microlights are generally easier to manage).

Of course fast taxiing over rough ground can do considerable damage not only to the undercarriage, but the entire airframe, as the shocks and vibrations are absorbed. Take particular care over rough ground, and if necessary shut off the engine and manhandle the microlight through the rough areas. Allow for gentle radius turns and avoid sharp turns at speed. Turning out of wind (i.e. turning left from a position with a right crosswind or turning from upwind to downwind), may require a greater turning radius as the wind on the rudder surface counters the turn. More power will probably be needed out of wind.

Correct positioning of controls. Always bear in mind the relative airflow of the wind over the whole microlight while taxiing. Depending on the type of microlight and the control system, position the controls as required to avoid the wind picking up a wing, turning the microlight or nosing over. Check with your instructor as to what is required for your aircraft. For a conventional aircraft, Fig. 1 shows the use of controls while taxiing in wind.

Approach all obstacles gently. Allow plenty of room to slow down and stop. Taxiing downwind requires more braking distance. Remember to ensure the wingtips are well clear of obstacles. Avoid taxiing close to people, buildings, vehicles, fences, trees, etc.

Keep a good lookout. Although you are still on the ground, you must maintain a **SHARP LOOKOUT** for other aircraft which may be taxiing, taking off or landing. If operating without a radio from a controlled airfield don't forget to watch for light signals from the tower.

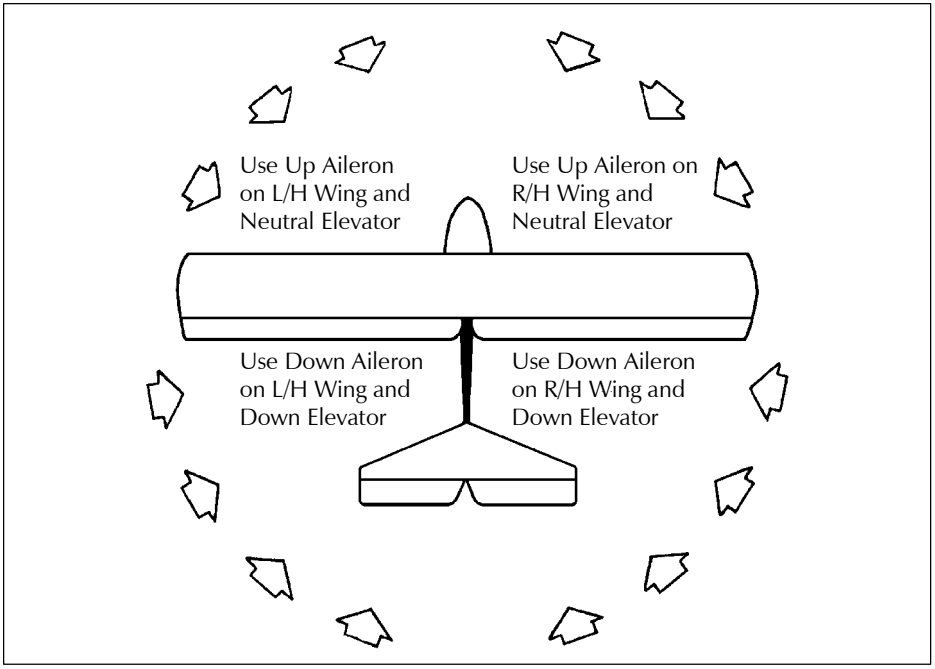


Fig. 1 *Correct positioning of the controls for taxiing in wind.*

FORCES ACTING ON THE MICROLIGHT

A microlight in flight has four forces acting upon it.
WEIGHT, – LIFT, – THRUST, – DRAG

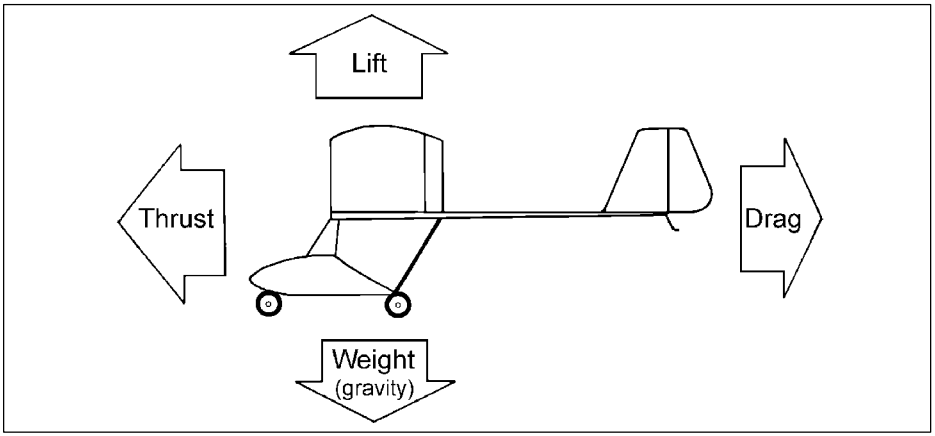


Fig. 2 *The four forces acting on an aircraft in flight.*

Weight: Acts vertically down (gravity) and has to be overcome by a force acting vertically upwards so that flight may be sustained. It is basically constant in flight except for a decrease taking place with the usage of fuel.

Lift: Acts upward to overcome weight. It will vary according to airspeed and/or angle of attack. It acts at right angles to the airflow but not necessarily in exact opposition to weight when out of level flight.

Thrust: Produces the forward movement to provide an airflow over the wing. It will vary according to the power applied and/or the angle of attack.

Drag: The force which tends to hold back or resist forward movement. It will vary with airspeed and angle of attack and acts in opposition to thrust.

During straight and level flight at a constant speed –

LIFT equals **WEIGHT**

THRUST equals **DRAG**

and the aircraft is said to be in equilibrium.

Any inequality between lift and weight will result in the microlight entering a climb or descent. Any inequality between thrust and drag will result in acceleration or deceleration.

Before discussing these four forces further, let us examine some of the terms used extensively in this section.

Airfoils

An airfoil is a device which gets a useful reaction from air moving over its surface. When moved through the air it is capable of producing lift. Wings and propellers, horizontal and vertical tail surfaces are all examples of airfoils.

For convenience we will use a cross–sectional view of a wing in our discussion. Microlights can have either a single surface or a double surface wing as drawn in cross–section following. However, for our purposes we will use a double surface airfoil.

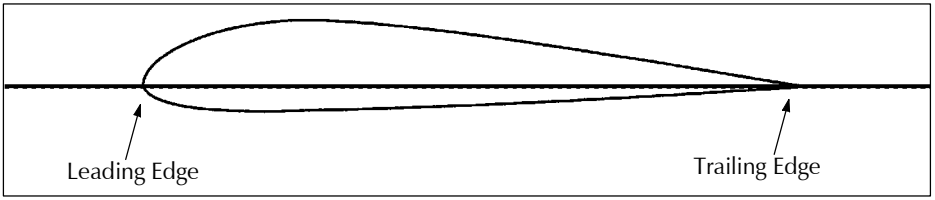


Fig. 3 A typical airfoil.

The forward part of an airfoil is rounded and is called the leading edge.

The aft part is narrow and tapered and is called the trailing edge. A reference line often used when discussing airfoils is the chord line. The chord line is an imaginary straight line joining the tips of the leading edge and the trailing edge.

Angle of Incidence

The angle of incidence is the angle formed by the chord line and the longitudinal axis of the microlight. The longitudinal axis being an imaginary line running lengthways through the machine from nose to tail. The angle of incidence is not usually able to be changed by the pilot.

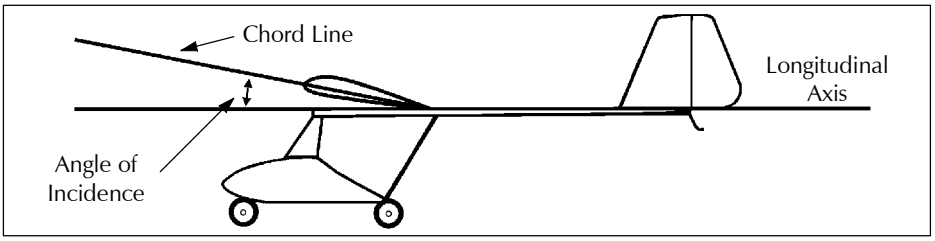


Fig. 4 Angle of Incidence.

Relative Wind

The relative wind is the direction of airflow in relation to the wind. If, for example, a wing is moving forward horizontally, the relative wind moves backwards horizontally. If a wing is moving forward and upward, the relative wind moves rearward and downward. Thus the flight path and relative wind are always parallel, but travel in opposite directions. See Fig. 5.

A microlight moving through the air has relative wind, just as does a microlight stationary on the ground with the wind blowing over it.

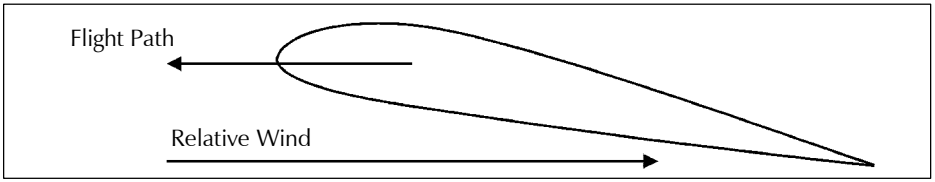


Fig. 5

Angle of Attack

The angle of attack is the angle between the direction of the relative wind and the chord line of the wing, (or between the flight path and the chord line). See Fig. 6.

Do not confuse angle of attack with the angle of incidence.

The angle of incidence is normally fixed, but the angle of attack may be varied by the pilot and is relative to the flight path.

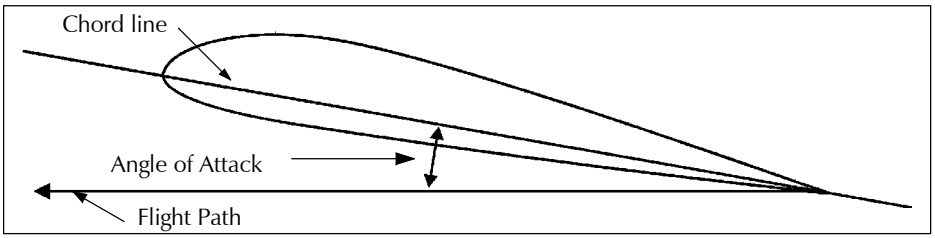


Fig. 6

Bernoulli's Principle

Many years ago the scientist Bernoulli discovered that the pressure of a fluid (liquid or gas) decreases at points where the speed of the fluid increases. This simply means that high–speed flow is associated with low pressure and low speed flow is associated with high pressure.

This principle has particular application to airfoils, which are designed to increase the velocity of the airflow above their surfaces. This decreases the pressure above the airfoil. At the same time, the impact of air on the lower surface of the airfoil increases the pressure below. It is this combination of decreased pressure above and increased pressure below which produce lift. Approximately 80% of lift is produced by the TOP surface. See Figs. 7 & 7a.

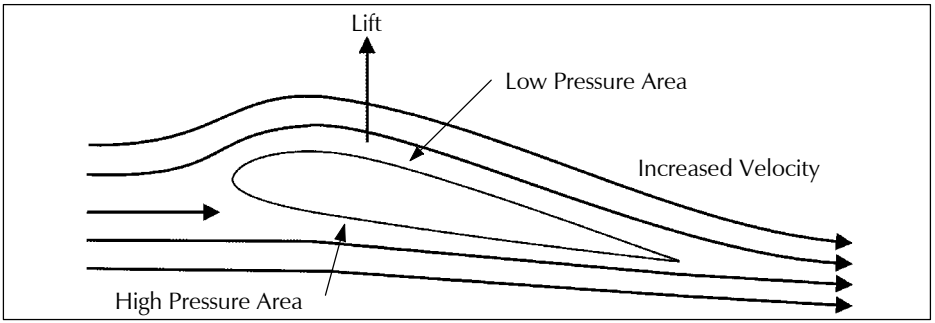


Fig. 7

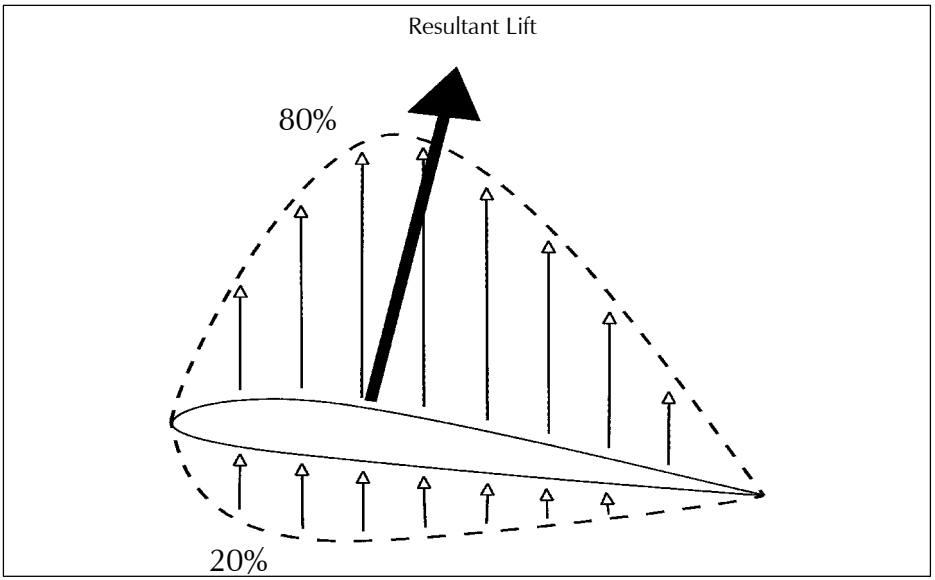


Fig. 7a Lift distribution – Upper and Lower surfaces.

Lift

We have already mentioned that it is the airflow over the airfoil which produces the lift. The upward component of this force is lift, but during its production there is a backward component and this is drag. See Fig. 8.

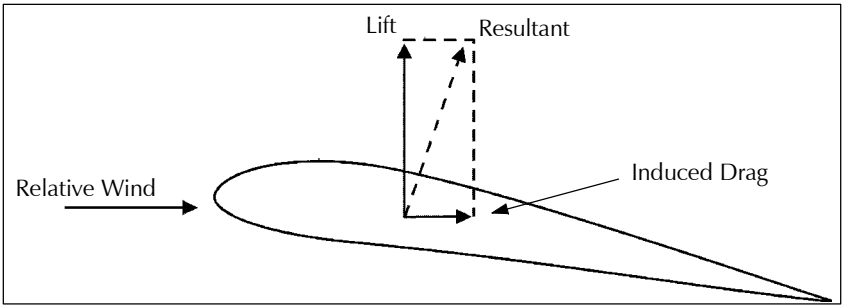


Fig. 8

Drag

The total drag of a microlight, as shown on the four forces, is actually made up of two types of drag: **Profile or Parasite Drag** and **Induced Drag**.

Profile Drag is simply the drag created by the form itself of the microlight airframe, undercarriage, rigging, etc. As the speed increases, profile drag increases sharply. In fact, if the speed is doubled the drag is four times as much as the previous speed.

Induced Drag is a result of the production of lift by the wings/airfoils. At high angles of attack the induced drag is high. At low angles of attack the induced drag is low. The use of streamlining of the airframe results in significant reductions in parasite drag, but reduction of induced drag is more difficult.

Briefly, long slender wings (high aspect ratio) such as found on sailplanes minimise induced drag. Wide chord wings of short span (low aspect ratio) produce more induced drag.

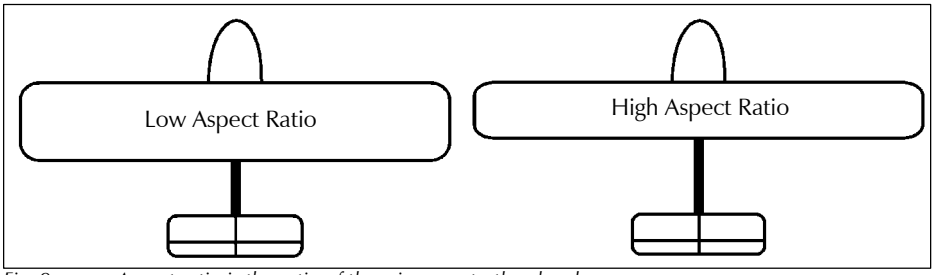


Fig. 9 Aspect ratio is the ratio of the wingspan to the chord.

Relationship between Lift and Angle of Attack

As mentioned before, the angle of attack is the acute angle made by the chord line of the wing and relative wind or flight path.

At small angles of attack there is a small differential between the increased pressure beneath the wing and the decreased pressure above the wing.

By increasing the angle of attack, the effective camber (curvature) of the wing is increased. Thus the air is required to travel a greater distance in the same time. In order to travel this greater distance, Bernoulli's Principle tells us it must accelerate, producing a greater decrease in pressure. So, increasing the angle of attack results in an increased pressure differential, meaning greater lift. It also results in increased drag. See Figs. 10a &10b.

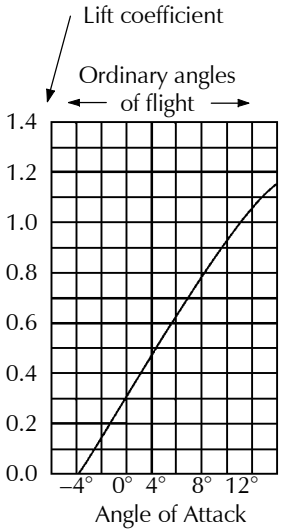


Fig. 10a Lift Curve.

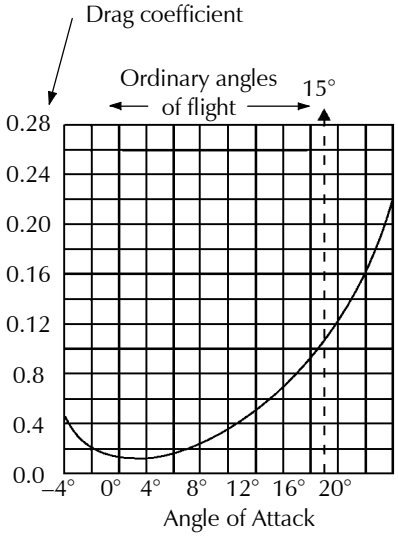


Fig. 10b Total Drag Curve.

With the angle of attack increased to around 15 to 16 degrees or so on most airfoils, the air can no longer flow smoothly over the upper surface of the wing because a large change of direction is needed.

With the increasing angle of attack, break up of the airflow begins at the trailing edge and moves forward. See Fig. 11.

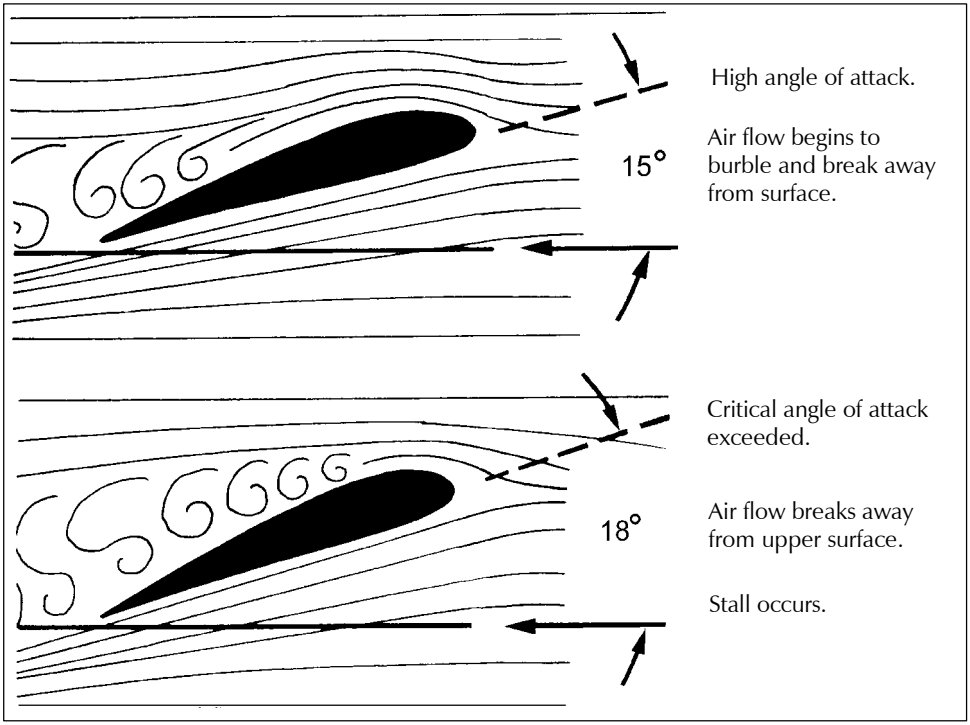


Fig. 11

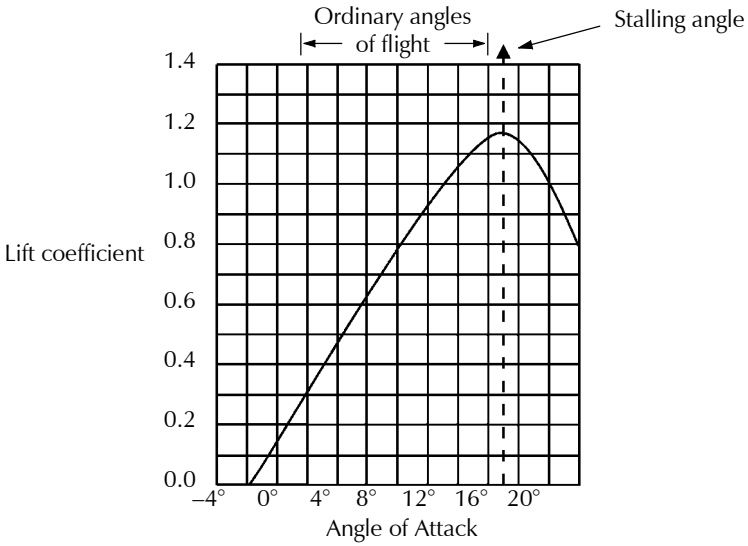


Fig. 12 Lift Curve.

At the critical angel of attack, the turbulent flow, which has appeared at the trailing edge at lower angles of attack, suddenly spreads forward over the whole surface of the wing. This action of the airflow increases the pressure on the top surface of the wing, along with an equally sudden increase in drag. Lift is greatly reduced and the wing is said to have stalled. See Fig. 12. (Refer to Stalling section.)

Centre of Pressure

If the pressure forces over the wing were combined to give a single resultant force, then the point where this resultant intersected the chord line would be called the centre of pressure.

Since the distribution of the lift forces varies, then it follows that the centre of pressure moves back and forth along the chord with changes in angle of attack.

For normal flight conditions the centre of pressure moves forward with increase in angle of attack and rearward with decrease in angle of attack. As the stall takes place the centre of pressure moves rapidly backwards, resulting in the nose of the aircraft pitching down.

Relationship of Thrust and Drag in Straight and Level Flight

In straight and level flight at a constant airspeed, thrust and drag are equal. If the thrust output of the propeller is increased, thrust will momentarily exceed drag and airspeed will begin to increase (assuming that straight and level is maintained). The increase in speed will cause an increase in drag and at some new higher speed drag and thrust will again equalise. The speed will again be constant.

At full power, the speed will increase until drag equals thrust and the constant speed this gives will be the top speed for the aircraft in that configuration and density altitude.

If thrust is reduced to less than the drag, the microlight will decelerate to a slower airspeed (assuming straight and level maintained) where the thrust and drag become equal.

Of course, reducing the airspeed too much would result in a stall. As already mentioned, an increase in speed will increase the drag rapidly.

Relationship of Lift and Weight in Straight and Level Flight

The upward force of lift on the wing always acts perpendicular to the direction of the relative wind. In straight and level flight, lift opposes the microlight's total weight. With lift equal to weight, the aircraft will neither climb nor descend. Should lift become more than weight, the aircraft will enter a climb; and if lift become less than weight, the aircraft will enter a descent.

Factors Affecting Lift and Drag

Many factors alter lift and drag, such as airfoil shape, airspeed over the wing, angle of attack, wing area and air density.

Effect of Airfoil Shape on Lift and Drag

By increasing the upper curvature of the airfoil (up to a point) the lift produced will be increased. Thus, a wing designed for high lift will have a deep wing section and possibly a concave lower surface. High lift wings, by the way, are not suited to high–speed flight because of increased profile drag.

Lowering an aileron has the effect of increasing the curvature of the wing, thus increasing the lift on that portion of the wing. Unfortunately, this also results in an increase in drag creating adverse yaw.

Raising an aileron effectively reduces the camber of that part of the wing, reducing the lift there.

Moving the tail surfaces also changes their curvature, causing the direction of their lift to change.

Any damage to the contour of the wing will have a serious effect on the lift production of that part of the wing. Stall characteristics may also change for the worse. So don't, for example, fly with sail battens damaged or missing! The shape of the airfoil is critical.

Effect of Wing Area on Lift and Drag

If wing area is doubled, other things being equal, the lift and drag created by the wing will also be doubled. Wing area cannot normally be changed by the pilot.

Effect of Airspeed on Lift and Drag

Increasing the speed of the air passing over the wing increases the lift and drag. This is because of the increased relative wind on the lower surface producing greater positive pressure, as well as the increased speed of the relative wind over the upper surface giving a lower pressure there.

If we double the speed, the lift and drag quadruple (assuming the angle of attack remains the same).

Effect of Angle of Attack on Lift and Drag

As already mentioned, increasing the angle of attack increases both the lift and drag, up to a point called the "stall".

Atmospheric Effects on Lift and Drag

The **density** of the air affects lift and drag. As air density increases, both lift and drag increase; and as air density decreases, lift and drag also decrease. The density of the air is governed by: **Temperature, Humidity** and **Pressure.**

Pressure

An increase in altitude brings a decrease in pressure, which translates to less dense air. Therefore, in order to produce the same lift at altitude, the airspeed over the wings or the angle of attack must be increased. Taking off from airfields at higher altitudes requires longer takeoff distances.

Warm air is less dense than cool air, therefore performance suffers in warmer air.

Moist air is less dense than dry air, therefore performance will suffer in moist air.

From above it is clear that on hot, humid days, operating from high altitude fields will see the microlight's performance at its worst!

EFFECT OF CONTROLS

Conventional aircraft are considered to have three axis of movement. Whenever the aircraft changes altitude in flight, it will rotate around one or more of these axis. The three axis intersect at the centre of gravity and each one is at right angles to the other two. See Fig. 13.

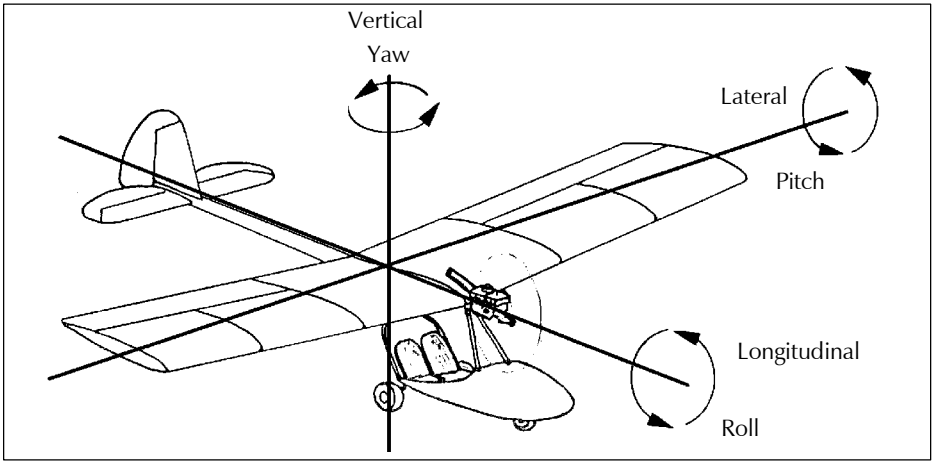


Fig. 13 Three Axis of Motion.

The Lateral or Pitch Axis

This is a straight line through the centre of gravity and running spanwise toward the wingtips, at right angles to the longitudinal and normal axes. Movement around this axis is called pitching and is achieved with the elevators.

The Longitudinal Axis

This is a straight line running lengthways through the aircraft's centre of gravity from nose to tail. Movement around this axis is called rolling and is achieved with the ailerons.

The Normal or Vertical Axis

This is a straight line through the centre of gravity and is vertical when the aircraft is in the rigging position, it is at right angles to the longitudinal axis. Movement around this axis is called yawing and is achieved with the rudder.

Control Surfaces

For the purposes of this section we will be dealing with a microlight of conventional layout and control configuration. In a later section we will look at some other configurations.

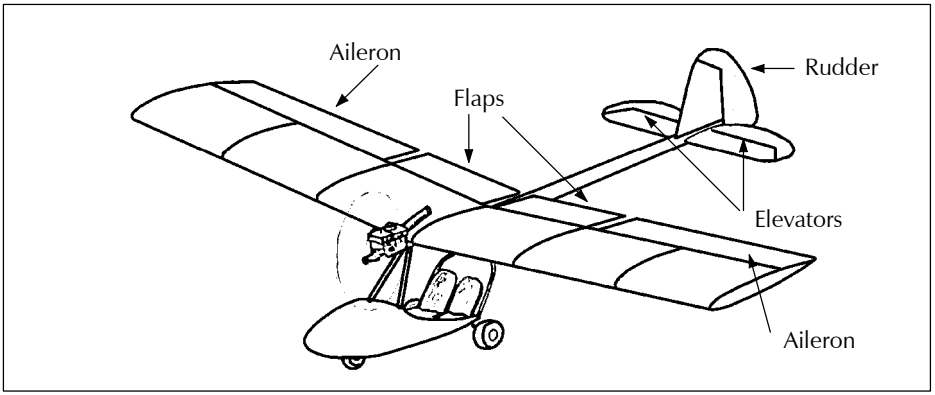


Fig. 14 Controls on a conventional three–axis microlight.

Elevators

The elevators control movement about the lateral axis, which is called pitch. The elevators are hinged to allow the surface to swing up and down. On some aircraft, the entire horizontal tail surface may move, but usually it is only the aft portion that moves.

The horizontal tail surface along with the elevators make up a single airfoil. Changing the position of the elevators therefore alters the camber of the airfoil and thus increases or decreases the lift it produces. The elevators are also connected to the control stick and fore and aft movement of the stick moves the elevator surface.

Moving the stick forward moves the elevator down, while aft stick moves the elevator up. Forward stick therefore increases the lift of the tail surface and causes the nose to pitch down. The elevators control the angle of attack of the wings. When the nose is lowered, the angle of attack is reduced. When the nose is raised, the angle of attack is increased. See Fig. 15.

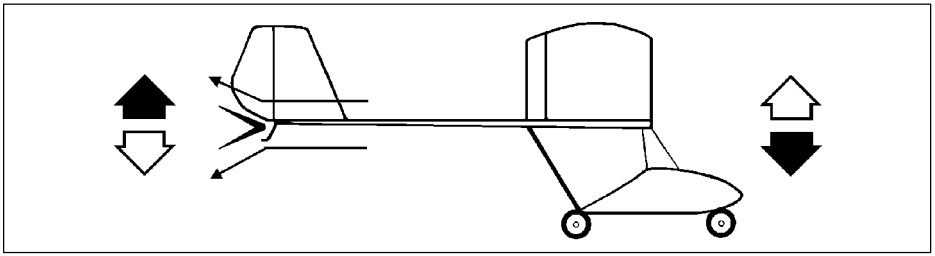


Fig. 15 Effect of Elevator.

Ailerons

The two ailerons, located at the trailing edge of the wing, are moveable surfaces that control movement about the longitudinal axis. On some types these surfaces span the entire trailing edge of both wings.

As one aileron surface is lowered, the other is coupled so that it is raised. The wing with the raised aileron goes down because of decreased lift. Moving the control stick to the right moves the left aileron down and the right aileron up, rolling the microlight to the right. This happens because the down going left aileron increases the wing curvature (camber) and thus increases the angle of attack. The right aileron moves upward and decreases the camber, resulting in a reduced angle of attack. Thus the decreased lift on the right wing and the increased lift on the left wing causes a roll and bank to the right. See Fig. 16.

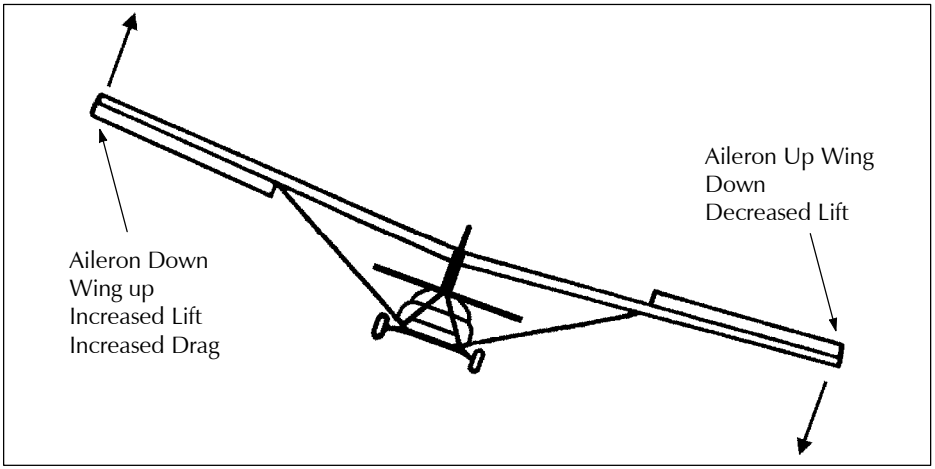


Fig. 16 Effect of right control stick (rear view).

Rudder

The rudder surface controls movement of the microlight about its vertical or normal axis, which is called **yaw**.

Much like the elevator, the rudder is a hinged surface which may swing from left to right and is attached to what is called the vertical stabiliser or fin. Its action is similar to the elevator except that it produces movement in yaw axis, swinging the nose from side to side. It is controlled by the rudder pedals. Application of the left pedal starts a yaw to the left and the right pedal to the right. See Fig. 17.

The rudder is normally not used to initiate turning of the microlight, but rather to balance the turn, as we shall see shortly.

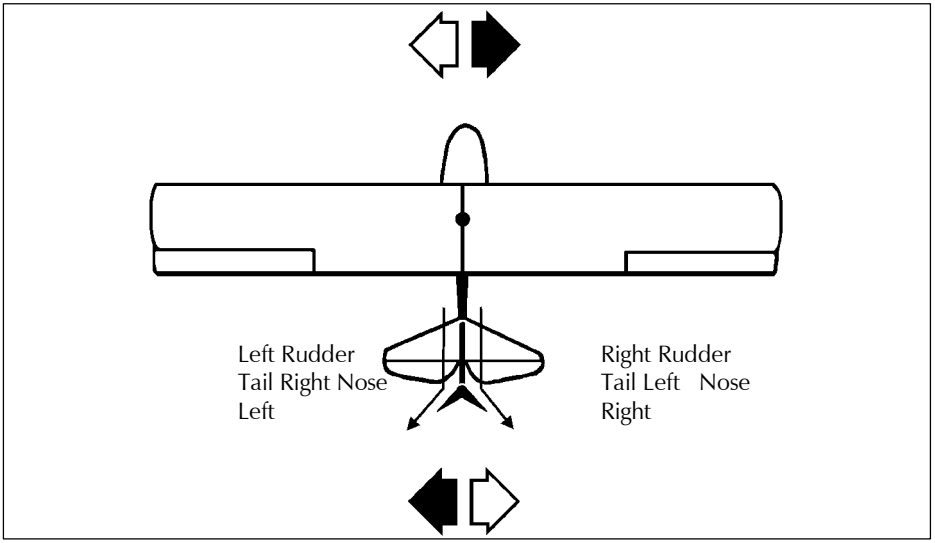


Fig. 17 Effect of Rudder.

Flaps

Flaps are another aerodynamic control surface found on an increasing number of microlights. Flaps work in the same way as ailerons and vary the wing camber, they provide a decrease in landing speed when deployed whilst retaining maximum speed when up. The flaps on each wing are connected so that they can be raised and lowered together (as opposed to ailerons where one goes up while the other goes down).

By increasing the effective lift, flaps reduce the stalling speed and enable the microlight to fly at lower airspeeds. Also, by increasing drag and acting as airbrakes, flaps enable the aircraft to glide at a steeper angle with no increase in forward speed. See Fig. 18.

Microlights utilise flaps either inboard of the ailerons or in combination with the ailerons called **Flaperons**. Flap use sometimes causes a pitching moment by shifting the wing's centre of pressure.

Flaps are normally partially down to shorten the Take–Off roll, and fully down to shorten the approach and landing. There is a maximum speed limit for flap lowering to avoid overstressing the mechanism, refer to your aircraft's handling notes for optimum settings and recommended speeds.

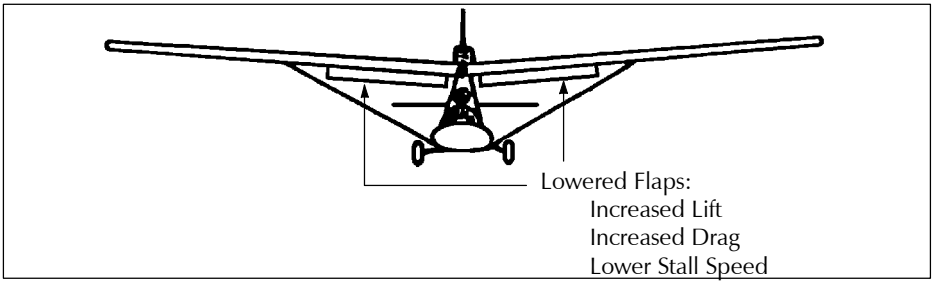


Fig. 18 Effect of Flaps.

Trim devices

Some microlights have the means to reduce the manual loads in the controls in some modes of flight. For example, an elevator trim can be used to ease the backpressure required to maintain a climb, or could be altered to provide hands–off level flight.

On some aircraft this may be achieved by physically moving the entire control surface to get the desired effect. Sometimes a spring tension is applied to the surface or control linkages/cables.

Another is the trim tab which is a small moveable surface attached to the control surface. Moving this tab surface alters the lift characteristics of the control surface it is on, thus changing the stick loads felt by the pilot.

Further Effects of controls

In addition to the primary effects of controls already mentioned, each control application will produce a secondary effect which must be considered.

Aileron: Use of ailerons will produce yaw. This is due to the uneven drag of the up and down ailerons and is called **adverse yaw or aileron drag**.

Elevators: Use of the elevators alters the angle of attack of the wing, and this effects the **speed** of the microlight.

Rudder: Use of the rudder produces **yaw**. This yaw increases the speed of the wing opposite the direction of the yaw which produces greater lift on that wing thus inducing roll towards the yaw.

Power: Increased power normally causes a “pitch up” moment with yaw, while decreased power causes a “pitch down” moment with yaw. The greater the power variation, the greater the effect.

Effect of Airspeed:

High airspeed – all controls firm and effective.

Low airspeed – all controls sloppy and ineffective.

Effect of slipstream:

High power – rudder and elevator firm and effective.

Low power – rudder and elevator sloppy and ineffective.

Ailerons are unaffected by slipstream and give a good indication of airspeed.

STRAIGHT AND LEVEL FLIGHT

We have already seen that in straight and level flight, the four forces acting on the microlight are balanced with their opposite, (assuming a constant airspeed). Level flight is possible at any speed above the stall speed, right up to the maximum attainable in level flight. Let us look at a microlight in level flight at full power.

The four forces are balanced, with thrust equalling drag, and lift equalling weight. If we were to reduce power to, say 75%, what happens? As the thrust is reduced, drag slows the aircraft down until thrust equals drag again.

If we had kept the angle of attack the same, the aircraft would now begin to descend because at the same angle of attack the lower speed will produce less lift. So, in order to maintain level flight at this lower speed, we have to increase the angle of attack to produce the lift needed.

This process continues as we slow down further. The slower the airspeed, the greater the angle of attack needed to produce the lift needed for level flight.

However by increasing the angle of attack remember we are also increasing the drag created by the wing. We can counter this by applying more power, but if the aircraft is in slow flight with a nose high attitude then there comes a point where there will be insufficient extra power available.

This situation is called “flying on the backside of the power curve” or “Deadmans Curve!” and occurs when the power available is insufficient to overcome the drag when flying at a high angle of attack. The situation is most likely to develop if the pilot throttles back while climbing and then at a slower airspeed, and in a nose high attitude, opens the throttle again and the aircraft does not respond as expected. The recovery is simply to lower the nose allowing the airspeed to return to a higher figure.

The danger of the above situation is much greater if near the ground as there may be insufficient height for recovery. Recovery will mean a loss of height.

The purpose of this section is to point out that a high power setting does not necessarily mean flight at high speed. It is the elevators and thus angle of attack which is primarily responsible for speed control. Remember, flight is possible at low speed and high angle of attack, high speed and low angle of attack, and an infinite number of combinations of angle of attack to obtain the same value of lift.

CLIMBING

We have already seen that a climb will result if lift exceeds weight. As long as there is more thrust available than that required for level flight, then the microlight can be made to climb. The more excess thrust available the greater the rate of climb possible. When we raise the nose increasing the angle of attack to produce the extra lift for climbing, we know of course that the airspeed will drop as we do so. For this reason, the extra power needed to sustain the climb should be applied just **before** raising the nose.

When making changes in altitude or re–establishing level flight from a climb, use the following:

When entering a climb from level flight

1. **P**ower. Apply climb power.
2. **A**ttitude. Change the attitude to the climb position.
3. **T**rim. Trim if applicable.

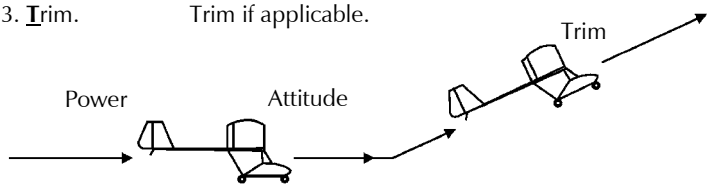


Fig. 19

When entering level flight from a climb

1. **A**ttitude. Lower the nose to the level flight attitude allowing speed to increase to cruise speed.

2. **P**ower. Reduce power to cruise power.

3. **T**rim. Trim if applicable.

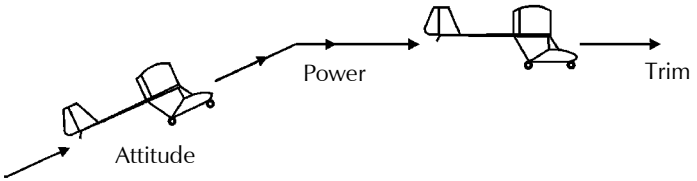


Fig. 20

Best Rate of Climb

At climb power, every aircraft has a climb speed which will give an optimum rate of climb. This speed corresponds to an angle of attack which provides the most lift for the least drag (best L/D). In this configuration the aircraft will climb the highest in the least time. If a rapid climb is desired, to climb at above the optimum speed will reduce the rate of climb, since there is thrust being wasted on speed rather than lift production. Likewise, attempting to climb at below the optimum speed will reduce the rate of climb as the extra drag of the higher angle of attack requires more thrust (which is not available) to counter it.

Best Angle of Climb

The best (steepest) angle of climb will be achieved with climb power at an airspeed a little less than that for the best rate of climb. This speed corresponds to an angle of attack which produces the most lift but higher drag. Here again, maintaining the right speed is important if the best angle of climb is desired.

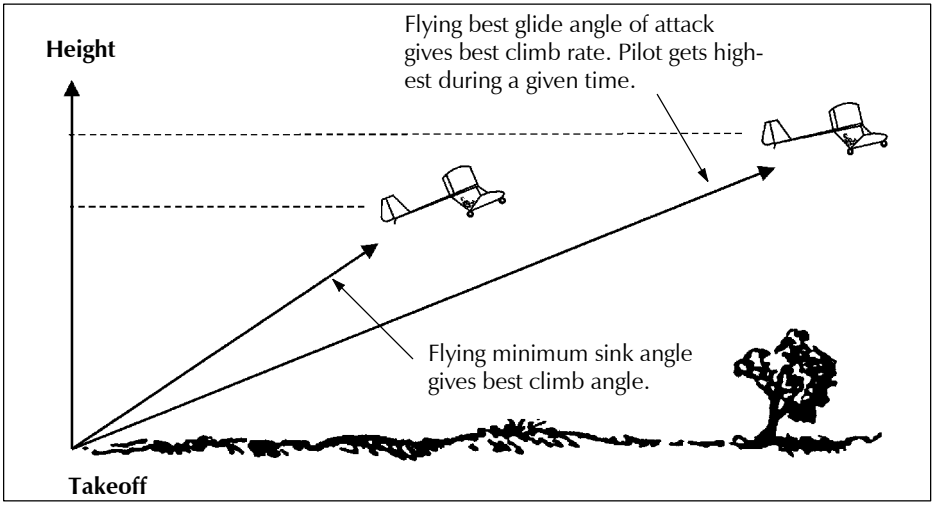


Fig. 21 Best angle of climb versus best rate of climb.

Factors Affecting Climb Performance

An increase in **weight** will reduce rate and angle of climb. Rate and angle of climb will reduce with increasing **altitude** as engine, propeller and airfoil performance suffers from reduced air density. Climb performance will be reduced in **warm and humid air**.

The use of flaps can allow for an increase in the angle of climb and a reduction in the climb airspeed.

Best angle of climb would only be used after takeoff from a short field where obstacle clearance is important and once clear, best rate of climb airspeed would be resumed.

Check your owner's manual for any best climb speed given. The usefulness of such information is dependent on the accuracy of your air speed indicator as a few knots variation either way could greatly detract from the desired performance. Care should be taken in some aircraft to avoid overheating the engine in a climb. If necessary, level off occasionally or increase airspeed to aid cooling.

It must be stressed that the correct airspeeds be maintained in order to climb efficiently. Holding the nose as high as possible with full power does not mean the microlight is climbing well! Indeed it may be descending! Maintain a healthy margin above the stall speed during the initial climb, until well clear of the ground.

DESCENDING

A microlight will descend from level flight any time there is insufficient thrust to maintain level flight and/or the weight of the aircraft is more than the lift being produced. From level flight we can descend either by lowering the nose, reducing power, or both. It can be seen that descent is possible at any power setting and this is because gravity is the force naturally trying to make the aircraft descend at all times. From level flight at cruise speed, for example, if we lower the nose the angle of attack is reduced and the reduced lift initiates the descent. If we have not reduced the power, the speed will increase considerably as we now have both thrust and gravity assisting us in our downward path. When the forces of thrust and gravity equalise with the drag of our new speed, the rate of descent will stabilise.

Descents are usually made with reduced power because in this way there is less increase in speed. During a descent with power on, the aircraft may reach its maximum permissible speed fairly easily and at a shallower angle than with power off. When entering a descent from level flight, first reduce power, maintain height until airspeed reaches descent speed, then lower the nose for the descent and trim (if applicable). Periodically warm the engine during long descents at low power to avoid overcooling and/or spark plug fouling.

The use of flaps can allow for an increase in the angle of descent and a reduction in the approach airspeed.

When making changes in altitude or re–establishing level flight from a descent, use the following:

When entering a descent from level flight

1. **P**ower. Reduce power.
2. **A**ttitude. Lower the nose to the descent attitude.
3. **T**rim. Trim if applicable.

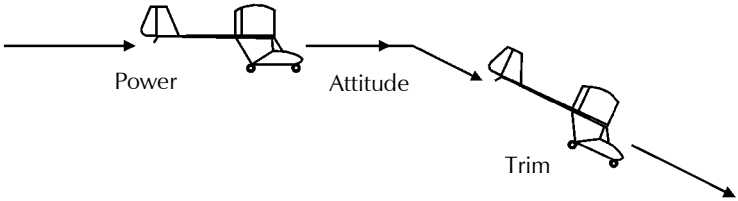


Fig. 22

When entering level flight from descent

1. **P**ower. Increase to cruise power.
2. **A**ttitude. Raise the nose to level flight attitude.
3. **T**rim. Trim if applicable.

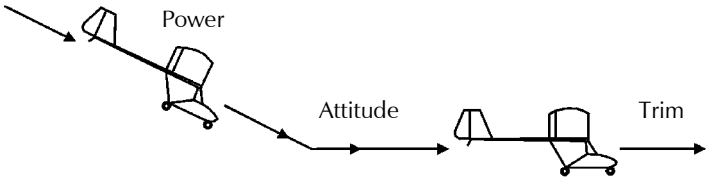


Fig. 23

GLIDING

If we look at our four forces of flight we see that with the power off, gravity takes over the job of thrust in providing our forward momentum and the flight path is downward.

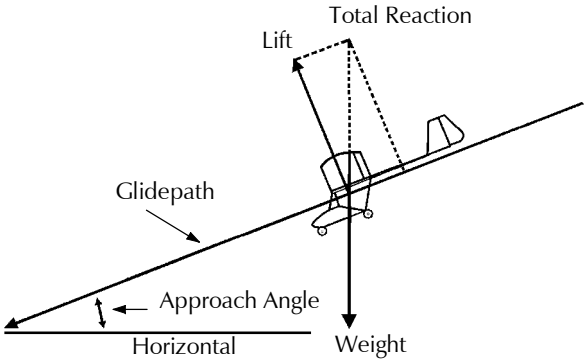


Fig. 24

The pilot still has complete control with the exception of being able to climb or maintain height. At a given airspeed, the most lift for the least drag will be produced by the wing and at this speed the microlight will glide the greatest forward distance for the least height lost (best L/D speed).

At another slightly slower speed, more lift will be produced, but at the cost of more drag, resulting in the least rate of descent possible with power off. This speed gives the best duration in the air but **NOT** distance.

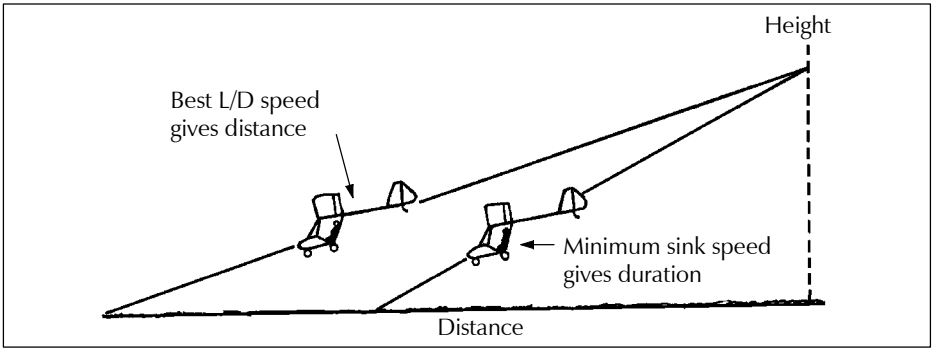


Fig. 25

The correct use of flaps will reduce the best L/D speed and sink rate.

Consult your owner's manual for the best L/D and best sink rate speeds. Care must be taken to maintain sufficient airspeed in the glide, especially near the ground as stall recovery without power requires considerably more altitude.

TURNING

Two fundamental laws of mechanics must be borne in mind when considering medium turns.

Firstly, a microlight will continue in a straight line at a constant velocity unless acted upon by an external force.

Secondly, the acceleration applied by an external force is inversely proportional to the mass. In other words, the heavier the microlight the larger the force required to change direction and the more resistance to that change in direction (i.e. inertia).

At this point it is appropriate to mention that a pilot must not enter a turn unless a **proper lookout** has been done.

"Proper lookout means that the pilot has checked to the right, centre, left, above and below, before changing direction."

When flying a high wing microlight, it makes good sense to "clear the turn" first. This is simply done by first momentarily raising the wing on the inside of the intended turn and checking for traffic in that direction. If it's all clear, proceed with the turn. Low wing microlights don't need too "clear the turn", since the inside wing clears the view as it drops.

A turn is produced by lift pulling the microlight from its straight course while overcoming gravity. Thus, if altitude is to be maintained in a turn the wings must produce lift equal to the weight of the microlight plus the centrifugal force caused by the turn.

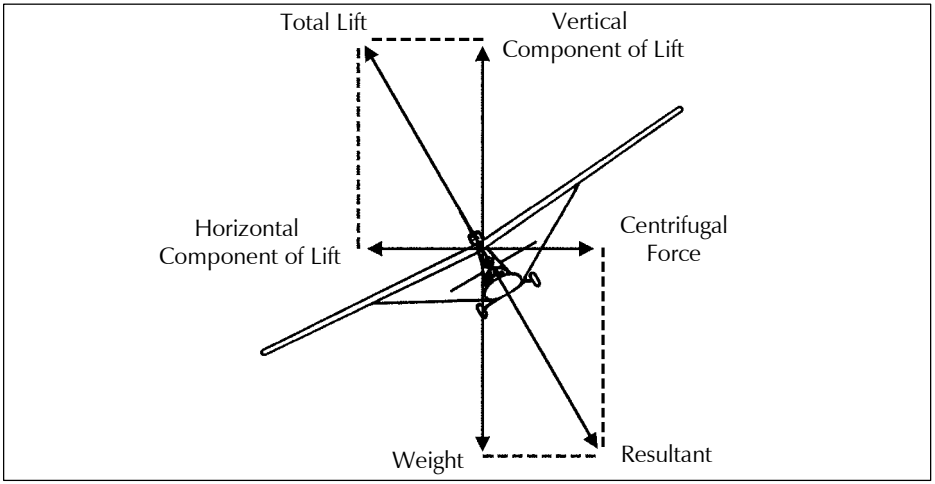


Fig. 26

The increase in lift is normally obtained by increasing the angle of attack, the airspeed or the power (or all three). So it is inclining the lift that produces the turn. If a turn is made during a climb, the rate of climb will decrease as some of the available lift is being used to effect the turn, rather than help the climb. Therefore, whilst climbing, only shallow angles of bank should be used so that a positive rate of climb can be sustained.

To initiate a medium turn from level flight the aircraft must be rolled in the desired direction with the ailerons. It is here that adverse yaw may appear.

Adverse or Aileron Yaw as it is often called, is a yaw produced by the ailerons. Remember in the effect of controls section, it was stated that the down going aileron increases the curvature (camber) and thus the lift. Unfortunately, a further effect of this is increased drag. Therefore, the wing with the lowered aileron (which produces more drag than the raised one), causes a yaw to that side, which is the opposite side to the direction of the desired turn.

For this reason, it is important to prevent this yaw and maintain balance with the rudder in the direction of the turn (with reference to the slip indicator, or yaw string), i.e. no slipping or skidding. See Fig. 27.

So, here we are with the microlight rolled to about 30° angle of bank and the slip indicator indicating balanced flight. As we rolled, the nose will have wanted to drop a little and this is prevented with aft stick which increased the lift (angle of attack). Now the microlight will be turning.

The **speed** is controlled with the **elevator, angle of bank** with the **ailerons**, and **balance** with the **rudder**, while **rate of climb or descent** is controlled with **power**.

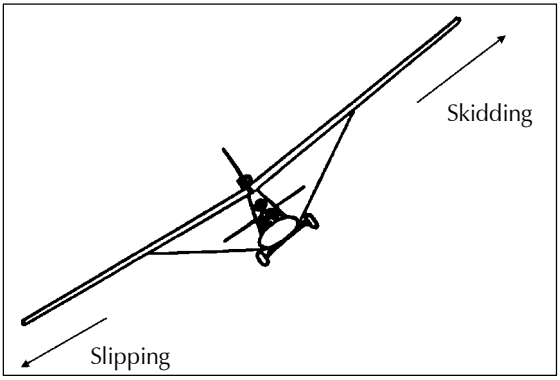


Fig. 27

To stop the turn, roll the aircraft level with the ailerons while maintaining balance with the rudder and keeping the nose from rising or falling with the elevator. In the turn the outside wing travels through the air faster than the inside wing so it will develop more lift and tend to roll the microlight into the turn even more. This has to be countered with opposite aileron once in the turn.

LOAD FACTOR

Effect of Turn on Load Factor

Since a turn is produced by inclined lift pulling the microlight from its straight course while overcoming gravity, if altitude is to be maintained the wings must produce lift equal to the weight of the microlight plus the centrifugal force caused by the turn.

As the bank gets steeper the centrifugal force builds up. Therefore, any time the microlight flies in a curved path at a constant altitude, the load supported by the wings is greater than the weight of the microlight, thus the **load factor** increases. See Fig. 28.

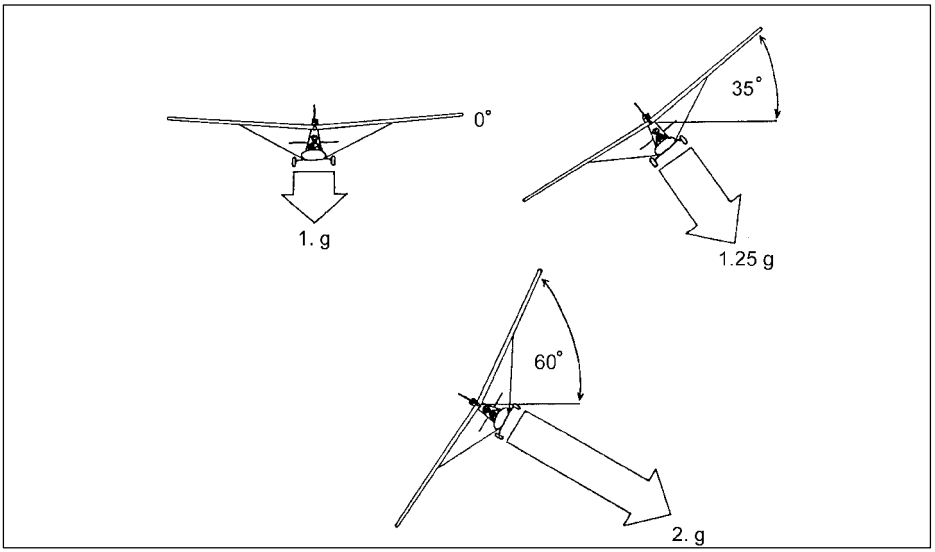


Fig. 28

Effect of Load Factor on Stall Speed

With an increase in load factor there is an increase in stall speed. The load factor increases when a microlight follows a curved flight path (turns), pullouts from dives, or sudden application of backpressure on the control stick. Consequently, the stalling speed also increases in these same manoeuvres.

Effect of Turbulence on Load Factor

Severe vertical gusts impose loads on the wings which can be excessive. These gusts cause a sudden change in angle of attack, resulting in large wing loads which are resisted by the microlights inertia.

When encountering strong turbulence, reduce airspeed. This enables the airframe to withstand the forces more easily.

Assuming a constant airspeed, the load factors at various angles of bank will be:

Angle of Bank	Load Factor
0	1g
35	1.25g
50	1.5g
60	2g
75	4g
83	9g

The increase in load factor causes an increase in stalling speed:

Angle of Bank	Stalling Speed Increases by
60	40%
75	100%
83	200%

As the loading is increased, the stalling speed increases and the microlight becomes less manoeuvrable. The pilot will feel the force pushing him/her down into the seat.

At high loadings, the pilot's vision may be impaired and at about 5g or 6g the pilot may "black out".

During recovery from steep dives, allow for the extra height loss due to inertia and also the higher stalling speed.

STEEP TURNS

The principles of flight relating to steep turns are the same as those for medium turns. With a steeper angle of bank, the rate of turn is greater. With medium turns it was mentioned that extra lift had to be produced to maintain height and it is the same for steep turns, although considerably more lift is needed. To achieve this, as the bank is applied, the power is increased to help counter the increased drag of the high angle of attack.

Available power is usually the limiting factor in steep turns and few microlights can sustain angles of bank greater than 50 – 60 degrees without losing height.

Just as in any other turn, **speed** is still controlled with the **elevator, angle of bank** with the **ailerons** and **balance** with the **rudder**.
The increased lift required during turns increases the load factor and, as previously discussed, this increases the stall speed:

Angle of Bank	Loading	Increase in Stall Speed
30	1.16 times	10%
60	2 times	40%
75	4 times	100%

The increase in loading stresses the microlight airframe and there is a design limit each type can safely handle. Find out the extent of your aircraft's ability to withstand this g loading from the owner's manual.
The pilot, of course, is also subjected to this loading in turns and it is felt as a pressure pushing one into the seat. The amount of this g force the body can handle varies from person to person, but most people feel decidedly uncomfortable at 3g.
It should be pointed out that for brief periods one can cope with quite high loadings on the body and it is extremely difficult to judge this accurately. Therefore, a careless pilot could easily overstress his microlight momentarily with improper use of the controls, and not realise it.
The increase in stall speed dictates a higher entry speed into the steep turn. Failure to maintain sufficient airspeed in the turn could result in a stall. To stall in a steep turn invariably results in a rapid change in direction and loss of height (and may possibly develop into a spin). More height may be needed to recover from such a stall and naturally all steep turns should be avoided near the ground.
To summarise, an increase in rate of turn requires:

- Increased angle of bank.
- Increased angle of attack.
- Increased power.

which results in:

- Increased wing loading.
- Increased stall speed.
- Decrease in air speed (due to extra drag of high angle of attack).

Before entering any turn – **LOOKOUT** – !!!

Effect of speed on Load Factor

The degree of excess load the microlight is exposed to depends on how fast it is flying.
At **slow airspeed**, the available lifting force of the wing is only a little greater than what is needed to support the weight of the microlight. As a result, the load factor cannot become excessive, even if the controls are moved abruptly.
At **high airspeed**, the lifting force of the wing is so high that a sudden gust or sharp movement of the controls could increase the load factor beyond safe limits.
"At high speed avoid rough air and abrupt coarse control movements."

SPIRAL DIVE

As mentioned in the section on turning, the nose must be raised to provide the extra lift needed to maintain level flight in the turn. However, if the correct nose attitude is not held, and the nose is allowed to drop, the microlight will begin to descend (and rate of turn will be less).

A descending turn like this can develop into a spiral dive.

There is nothing wrong with a spiral dive as long as the airspeed is kept within limits, the loading is not excessive and the correct method is used to recover from it.

Unfortunately, the spiral dive can be a problem for new pilots as they make turns. If they allow the nose to drop too much in the turn, there comes a point where trying to raise the nose with elevator merely tightens the descending turn. This is not a big problem at shallow angles of bank, but if ever in a descending turn, the development of a spiral dive is possible.

Symptoms of a Spiral Dive

- Nose below the horizon.
- Airspeed increasing.
- Moderate to steep angle of bank and turning.

Confirmation that you are in a spiral dive will occur if you try to raise the nose to recover from the dive. There will be a tightening of the turn and increased G loading felt without any recovery from the dive. Your instructor will demonstrate this condition and the correct recovery which is:

"Roll the wings level with the ailerons and ease out of the dive."

By rolling level first, the turn is eliminated leaving the microlight in a dive, which is recovered by raising the nose (being careful not to do so too abruptly, thus overstressing the airframe).

STALLING

We have already seen that by forcing the angle of attack of the wing too high the smooth airflow over the top surface of the wing is destroyed and lift is lost. In this condition the wing is said to have stalled.

Symptoms of the Stall

- Low airspeed (generally, unless the angle of attack is forced too high at a high speed).
- High angle of attack (note this is wing angle of attack and not the machines attitude).
- Sluggish controls.
- Buffeting caused by turbulence over the wing and the tail surfaces.
- Nose and sometimes wingdrop. (Some microlights have an indistinctive and mushy stall without appreciable nose or wing drop.)

Typical stall from Level Flight

With the increase of angle of attack, the airspeed will reduce, providing the first clue to the pilot through both the airspeed indicator and the sound and feel of the airstream diminishing.

As the airspeed reduces further the controls become sluggish. Normal movements of the controls provide only poor response. Depending on the aircraft, it may feel nose heavy, requiring effort to hold the nose up.

With the angle of attack getting very near to stalling point, the smooth airflow over the top of the wing may begin to break up from the trailing edge, causing a turbulent flow over the tail surfaces which may be felt as buffeting in the airframe and controls. On some aircraft it is possible to see the wing–covering wrinkle as the flow becomes turbulent.

The microlight is now very near the full stall and any further increase in angle of attack will stall the wing. Instantly this occurs, the controls will seem to have little or no effect, as airspeed is very low. The nose will want to drop and a wing may drop also. See Fig. 29.

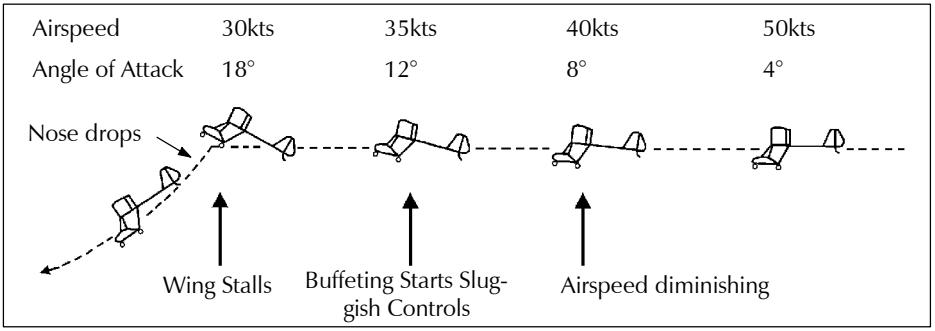


Fig. 29

The Wing Drop

At the point of stall, if one wing produces more lift than the other, one wing may drop. The nose will yaw towards the lower wing and the nose will drop sharply as the angle of bank increases.

The angle of attack on the upper wing is less than that of the lower wing and this may actually unstall the upper wing. The upper wing is moving faster at a lower angle of attack, the lower wing is moving slower at a higher angle of attack, and this begins a brisk rotation, called auto–rotation. From this point some microlights may enter a spin, continue auto–rotation or enter a spiral dive.

Recovery from the Stall

All that is required to unstall the wing is to **reduce the angle of attack to restore smooth airflow** over the wing.

To minimise the height loss of the stall recovery, power should be used to assist. Control will be regained faster with less loss of height. The slipstream over the wing (with tractor mounted engines) may smooth the airflow and help reduce the relative angle of the airflow.

Therefore, recovery is a matter of lowering the nose and applying full power together, regaining airspeed and control and recovering from the dive. Rudder must be used to keep the aircraft straight. If a wing drops at the point of stall, the ailerons must **NOT** be used to raise the lowered wing as the downward positioned aileron further increases the angle of attack of that part of the wing, resulting in further loss of lift which can result in greater roll and subsequent auto–rotation. The correct recovery for a wing drop stall is to prevent further yaw with the rudder, then lower the nose and apply full power. As control is regained, level the wing and recover from the dive.

SPINNING

From a stalled condition, some microlights may be capable of entering a spin which is a stalled auto–rotation. The spin may develop from a stall where there is **Associated Yaw**.
See Figs. 30 & 31.

In most microlights, a spin is a fairly unlikely event, usually requiring gross mis–handling of the controls.

During the spin, the microlight is in a fairly steep nose down attitude, auto–rotation continues and the airspeed is low.

The dangers connected with spins are:

- Considerable height is needed for recovery.
- Not all microlights are designed for spinning, therefore, check the manufacturer's literature for spin details, including any recommended recovery technique.
- Pilots who have not received comprehensive spin training may instinctively hamper or prevent recovery by incorrect recovery technique.

While the spin is not the most pleasant manoeuvre for some, pilots should be encouraged to get spin training in an aircraft cleared for spinning.

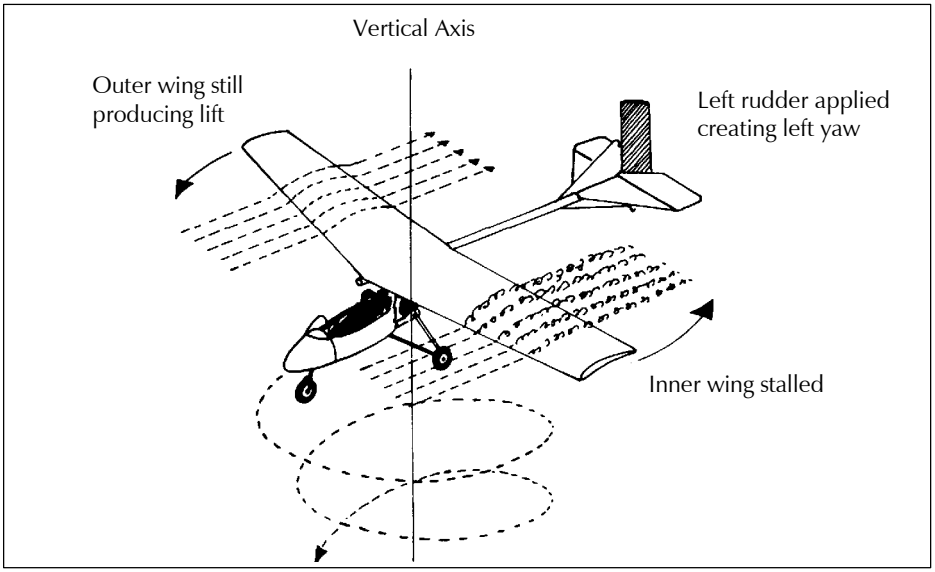


Fig. 30

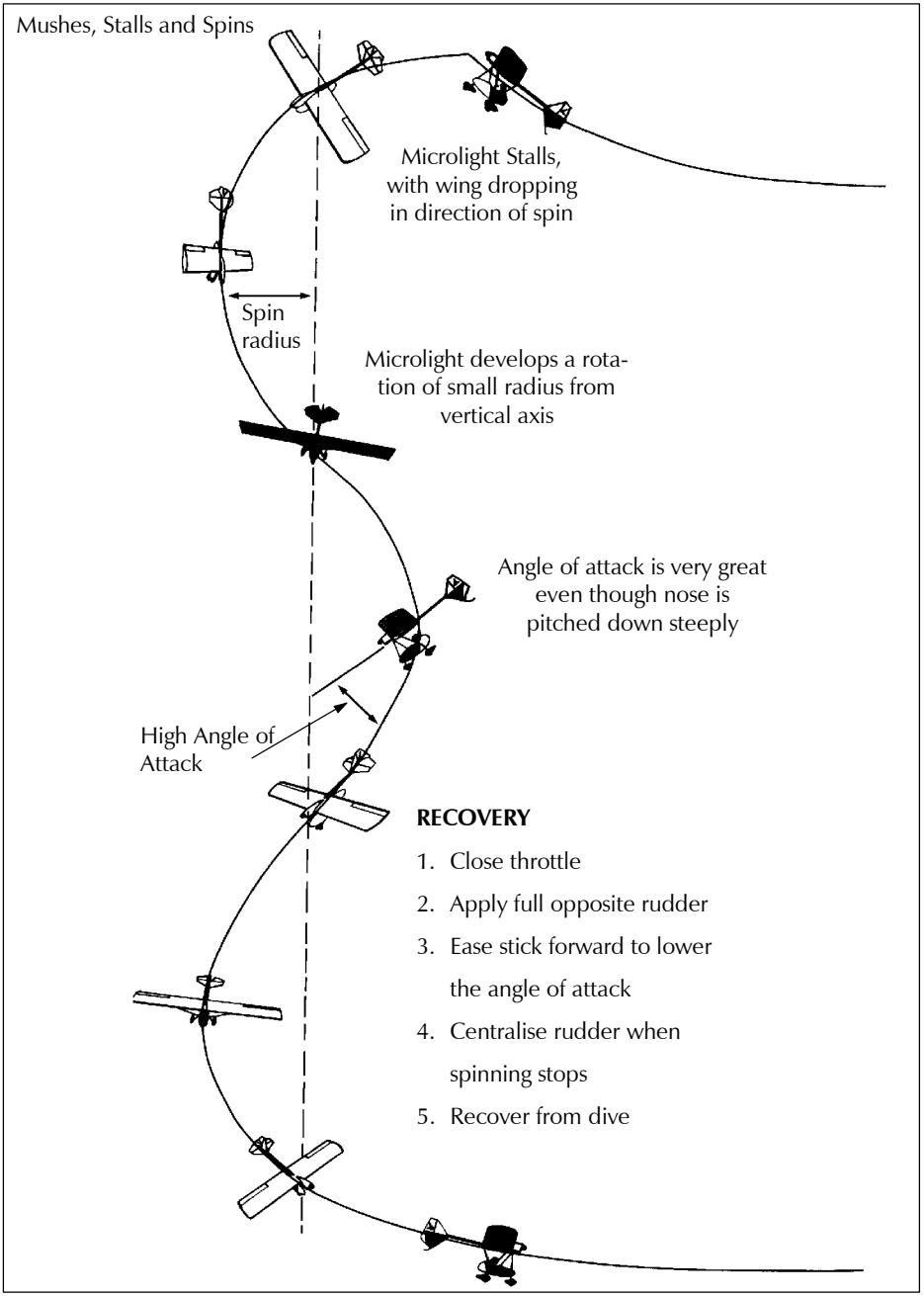


Fig. 31 *The sequence of a spin. The microlight is stalled and rotating around a small radius from the vertical.*

Recovery:

- Ensure throttle closed.
- Apply full opposite rudder.
- Ease the stick forward.
- When spinning stops, centralise the rudder.
- Level the wings and ease out of the dive.
- Reapply power as the nose approaches the climb altitude.

Note: With a forward centre of gravity, the spin will be steeper and less stable, with easier recovery.

With an aft centre of gravity, the spin will be flatter and more stable, with a slower (or even impossible) recovery.

Never attempt to spin any aircraft not cleared to do so by the manufacturer, or without proper spin training. Don't be a test pilot!!!

Factors Affecting the Stall

Weight

Increased weight(such as passenger and baggage) requires more speed to produce the greater lift needed at all angles of attack. The stalling speed will be higher.

Power

At high angles of attack, the angle of the thrust line may contribute to the lift. Tractor mounted engines with the slipstream over the wings may help prevent the airflow breaking up and provide more lift.

Flaps

With use of flap, more lift is produced at a lower airspeed, thus reducing the stall speed.

g Loading

The stalling speed will increase with loading such as in a turn or during sudden pitching up in a dive recovery.

We have looked at the stall from level flying but, in fact, a stall is possible **in any attitude** of flight relative to the horizon. No matter where the nose is pointing the aircraft will stall if the wings are presented at too great an angle to the relative airflow.

TAKEOFF CIRCUIT AND LANDING

General

Most microlights takeoff and climb so readily that it is easy to forget that this phase of flight includes hazards associated with flying near the ground (albeit briefly) at low airspeed.

Good pilot technique includes careful consideration of the following factors which affect the performance of any microlight:

Air Density: A lower air density will extend the takeoff roll because it decreases the performance of the engine and prop and the lift developed by the airfoil. Air is less dense when it is hot, or moist, or at higher elevation, or at lower pressure.

Weight: The heavier the microlight the more lift is required to offset it. Therefore, the lift–off speed and distance will be greater, and with a slower acceleration.

Runway Surface: The ideal surface would be smooth and hard, such as concrete or asphalt, which allows a faster acceleration and thus a shorter takeoff roll. Tall grass, especially when wet, severely hampers acceleration. Surface water (puddles) cause a lot of drag, with the added prospect of water being thrown up, damaging the prop and causing the belts to slip.

Runway Slope: A downhill slope allows a much faster acceleration, while an uphill slope will extend the takeoff roll alarmingly! It is generally better to takeoff downhill where possible.

Wind: Taking off into a headwind means lift–off airspeed will be reached after a shorter ground run, and lift–off occurs at a lower groundspeed. Windspeed should not legally be greater than 75% of the microlight's stall speed.

Obstacle Clearance: With all factors in mind, there must be no doubt that all obstacles can be easily cleared. If there is any doubt, stay on the ground until conditions improve sufficiently, or disassemble and trailer the microlight to another field.

Remember, obstacle clearance includes things on the climbout path – it is no use blasting out of a paddock with room to spare if you can't clear safely something else further on.

Having considered the factors of performance, there are a couple of other points which must be dealt with:

- For the wind conditions, what objects, if any, are going to be possible causes of wind shear or turbulence both during and after takeoff? (See Turbulence section page 68.)
- Is the terrain on the climbout path suitable for a forced landing in the event of an engine failure? Where are the best areas?
- Is your initial climbout going to upset people or stock? Remember the laws about flying near people.

Takeoff

Assuming all is well with the microlight and conditions, we can taxi out toward the runway. Before taxiing onto the runway the following checks should be carried out:

C – Controls are checked for full, free and correct movement. Choke off.

H – Harness and Helmet on and secure, no unsecured objects. (Hatches closed.)

I – Ignition switches on and instruments functioning and set. For dual ignition motors check rev. drop between ignitions.

F – Fuel sufficient for flight plus reserve, turned on and checked for correct mix and contamination. Flaps (if used) set.

T – Throttle functioning correctly through full power range. Trim (if used) set.

A – Airfield Lookout prior to moving on to the runway. Approaches clear of traffic.

The lookout on the ground is probably best achieved, where possible, by making a 360° turn to allow a more complete view of the whole area.

Never move onto the active runway until all checks are completed.

Always use the full length of the runway available.

The object of the takeoff roll is to accelerate on the ground until lift–off airspeed is attained. Lift–off airspeed is a speed that enables the microlight to become airborne with good control response. It can be possible to achieve lift–off below the ideal speed, (with the aircraft flying in "Ground Effect") but this can put the aircraft in a vulnerable position for a few moments, as control response may be limited to counter gusts, etc. It is better to lift off at a comfortable airspeed that ensures a positive rate of climb can be established immediately. Of course, holding the microlight on the ground for too long is no good either.

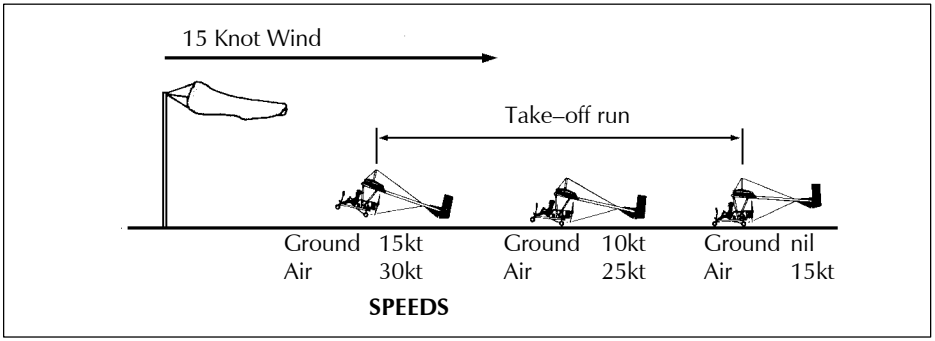


Fig. 32 The effect of a 15 knot headwind on the take–off run.

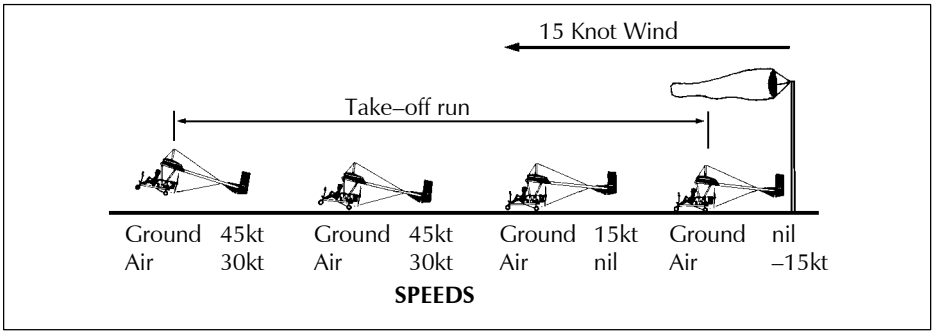


Fig. 33 A downwind take–off in a 15 knot wind. The run is greatly increased.

Line up on the runway and smoothly apply full power, keeping the aircraft straight. As the airspeed increases, the controls will begin to have effect. At the appropriate airspeed we can become airborne, carefully lowering the nose if necessary, to build up to the climb speed, while in ground effect (within one wingspan height). Then the climb should begin.

It is vital that careful attention is paid to maintaining the correct climb speed. Using **FULL POWER** and correct recommended climb speed, ensures a safe climbout can be made to 500ft altitude.

Never haul the microlight off the ground and point it skyward at some incredible angle and expect it to get a spectacular climb. The result would be an initial zoom after lift–off, followed by a very rapid loss of airspeed and stall and, not surprisingly, there is **unlikely to be sufficient height for recovery!!**

Remember, use the **recommended climb speeds** to give **the best attainable** climb performance.

Something else to consider is the consequence of an engine failure shortly after takeoff.

With the high nose attitude and low airspeed of the climb, should the engine fail, a rather positive nosing down of the microlight will be needed to maintain safe airspeed.

If the engine failure occurred in a steep climb at low altitude, there may actually be insufficient height available to lower the nose, restore airspeed and arrest the considerable rate of descent at the flare of landing. The result could be a very heavy landing or crash.

The cure is simple – refrain from an initial steep climb until a safer height is reached, at least 300ft AGL. **This is especially so for two–place microlights**, with their higher wing loadings and inertia.

During the takeoff roll make sure you are getting the full power selected, and that acceleration is normal for the conditions. Keeping a straight roll is vital.

The Circuit

The circuit is a rectangular path flown by aircraft around an airfield or runway. Generally, all turns in the circuit are made to the left for powered aircraft, unless specified right.

With all traffic adopting the circuit pattern it is very much easier to sequence aircraft for takeoff and landing because one can observe another aircraft in the circuit and predict it's subsequent likely actions.

The actual physical dimensions of the circuit may vary between pilots, machines and airfield, but there is a uniformity of traffic flow. Thus, a number of aircraft can operate, even without radio, in an orderly and safe manner. It is important, therefore, that the circuit you fly is tidy and you consider other airspace users.

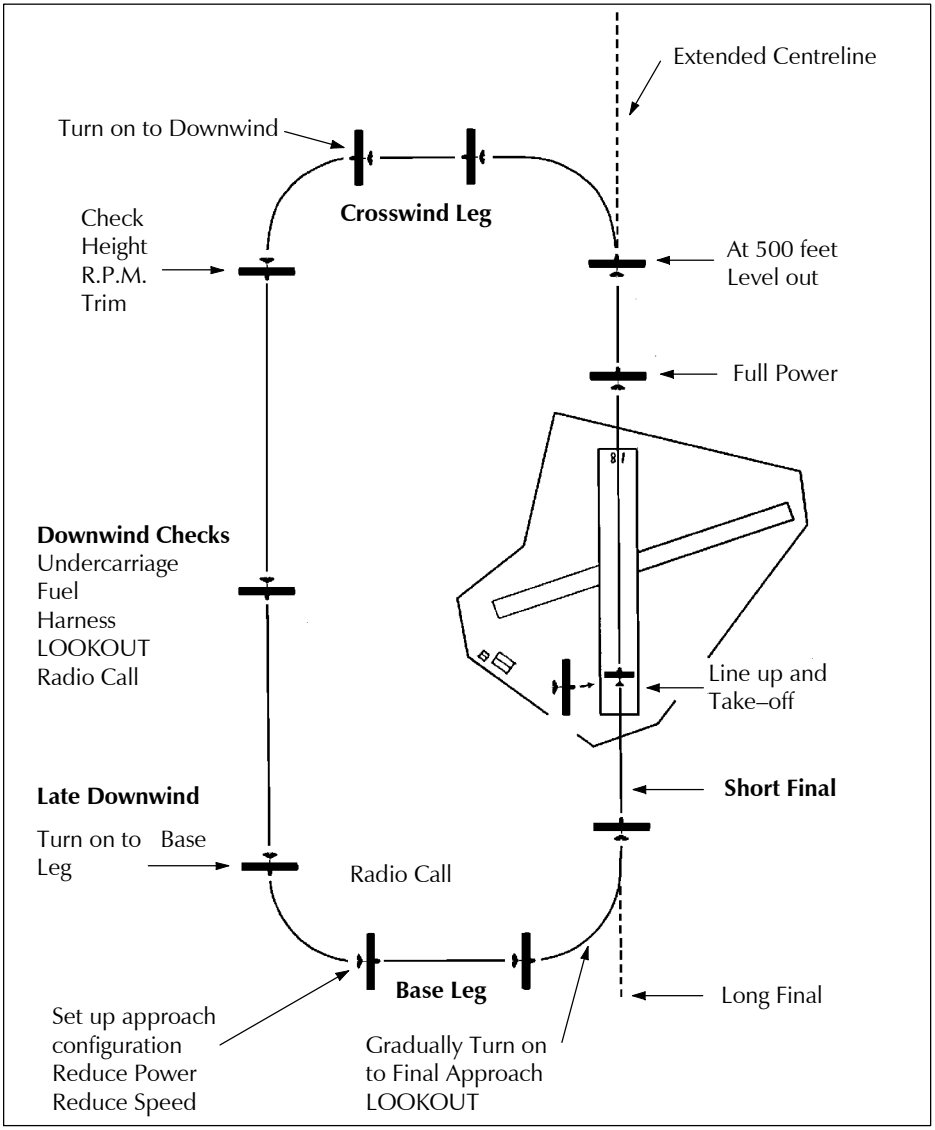


Fig. 34 The Normal Left Hand Circuit.

After takeoff, we climb under full power to the normal microlight circuit height of 500ft above ground level (AGL), taking care to maintain ground track on the extended centreline of the runway. (General Aviation aircraft circuit height is normally 1000ft AGL.)

Upon reaching 500ft we level out, looking for other traffic and turn left to a ground track 90° to the runway heading. This is the “crosswind leg” or in this case called “left crosswind” for our left–hand circuit.

From the crosswind leg we have to position ourselves on the "downwind leg" (left downwind here). Another left turn brings us parallel with the runway, downwind. Where possible, the downwind leg should be flown within gliding distance of the runway in case of engine failure. However, not too close so as to cramp the circuit.

On the downwind leg, check height, speed and engine RPM. Also check the windsock for wind direction and strength and the airfield for obstructions.

Carry out the pre–landing checks, which should include:

Undercarriage – down and locked, brakes off (if applicable).

Fuel – check quantity, sufficient for another circuit plus 20 mins reserve, selected to the appropriate tank (if applicable).

Harness – secure.

Lookout – for other traffic.

Normally a radio–equipped microlight would make a radio call mid downwind and prior to turning final.

Care must be taken not to cut in front of other traffic in the circuit, so although it would be desirable to make the next turn onto base leg, (left base), while still within gliding distance of the runway, it may be necessary to extend downwind to allow for other traffic ahead.

One more left hand turn onto "final" brings us back onto the extended centre line of the runway, into wind and ready to land.

Before discussing the final approach to landing, a few points on the circuit:

- Keep a good lookout.
- Fly a rectangular circuit, allowing for wind drift as required.
- Don't skip pre–landing checks.
- Check the windsock and airfield on downwind.
- **LOOKOUT**.

Final Approach

A well executed approach places the microlight in the ideal position, at the ideal speed, from which to make a landing.

The approach involves controlling the rate of descent and airspeed to allow landing at a chosen position on the airfield.

Remember when setting up an approach:

- **Pitch** control governs the **airspeed**.
- **Power** controls rate of **climb** and **descent**.

Speed Control

The landing itself, whenever possible, involves touching down with the least possible groundspeed and at an airspeed low enough to ensure that the microlight has really quit flying once it is on the ground.

Therefore, arriving at the right height over our aiming point on the runway without excessive speed means less runway will be used in landing. By the same token, too slow an approach speed could place the microlight near the stall with poor control response and maybe insufficient pitch control left to arrest the descent.

So, obviously, each type of microlight has an ideal approach speed for normal conditions. This speed is probably something like the best climb speed.

As mentioned above, control the airspeed with elevators (pitch control). We will discuss varying the approach speed for the conditions later in the section. Speed control is important, particularly in the latter stages, where a stall near the ground could be disastrous, or too much speed could greatly increase the runway length needed.

Approach Angle

The angle of the final approach is important and is a product of the rate of descent and the airspeed, as well as the wind factor. If the approach is made from too low (shallow angle), the dangers are that of undershooting, being near the ground for longer than necessary and therefore being subjected to mechanical turbulence for longer. An engine failure on this approach would mean little or no chance of reaching the runway and an extremely limited choice of alternatives.

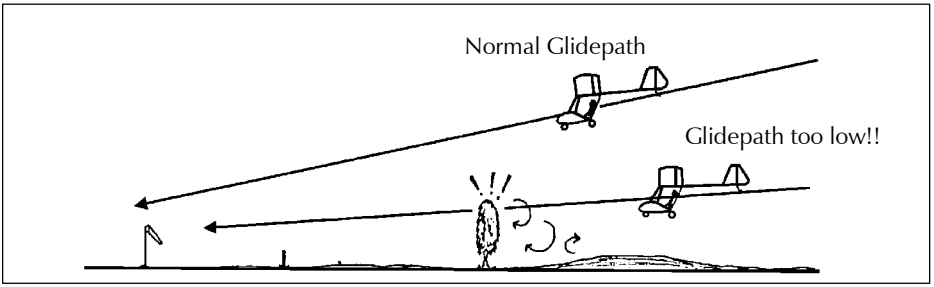


Fig. 35

Too steep an approach means a very high likelihood of overshooting the aiming point (or even the whole runway!!).

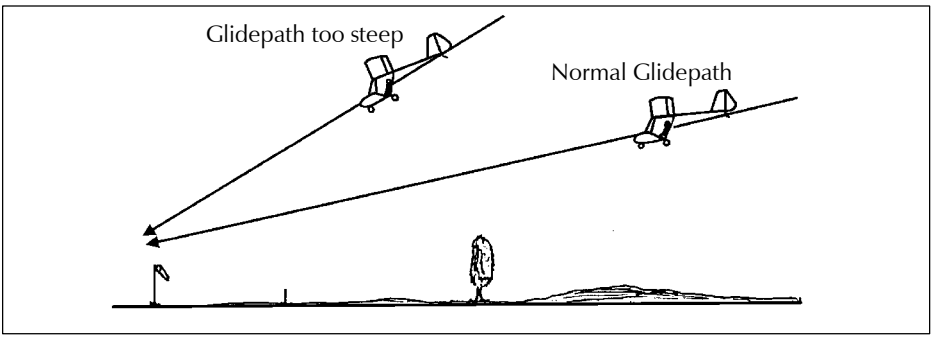


Fig. 36

This final approach angle, known as the glide path, is an imaginary line down which the final approach is flown to touchdown. It is on the extended centreline of the runway. With your instructors help you will learn the normal glidepath.

Flying down this glidepath involves:

- Maintaining the proper speed.
- Keeping to the extended centreline.
- Exercising height control to keep to the glidepath.

To help with judging progress down the glidepath are two visual clues commonly in use:

1. When operating from a runway, if you are too high the runway will look tall and long:

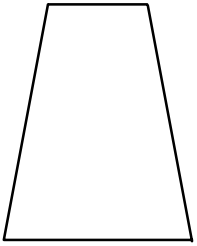


Fig. 37a

If you are too low it will seem to flatten out:

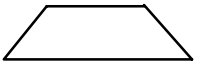


Fig. 37b

The normal approach glidepath will look something between the others, thus:

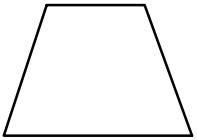
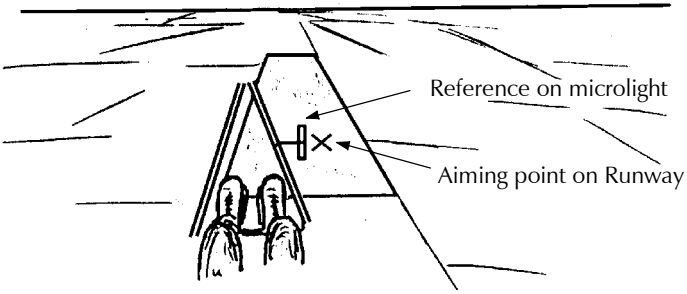


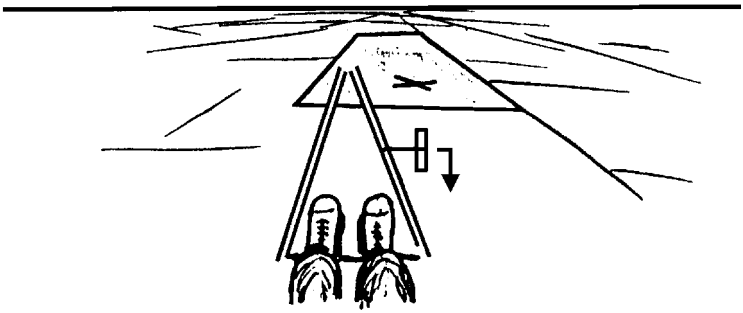
Fig. 37c

2. The second uses a point on the microlight to assess progress down the glidepath. Once positioned on the glidepath, line up a point on the airframe ahead with your aiming point on the ground. If this point on the airframe starts moving up the runway during approach then you are getting too high. Conversely, if it moves back off the runway, you are becoming too low.



Point on airframe stays with aiming point on runway.

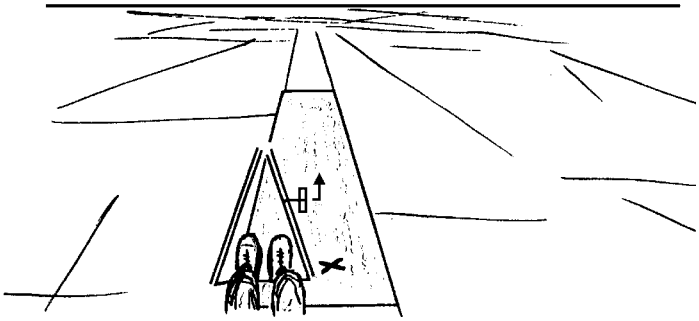
Fig. 38 On Glidepath.



Point on airframe moving down and back off runway.

Fig. 39 Becoming too low.

If you notice you are sinking below the glidepath, power is required to retrieve the situation; apply power and raise the nose maintaining the approach speed. When back on the glidepath, lower the nose and reduce power again as required to maintain the glidepath and correct speed.



Point on airframe moving up runway.

Fig. 40 Becoming too high.

In the event of becoming too high, reduce power and lower the nose to increase the descent maintaining the approach speed. Once back on the glidepath, resume the power and speed to hold it. Small corrections made early make things very much easier. If the approach goes badly wrong, do not hesitate to abandon the landing, apply power and overshoot for another circuit.

Factors Affecting the Glidepath

Wind As already mentioned, wind strength and direction. (See Flying in Wind section.)

Areas of Lift and Sink Lift and Sink produced by convection current activity and wind flow over terrain.

Wind Shear Discussed with lift and sink in the turbulence section.

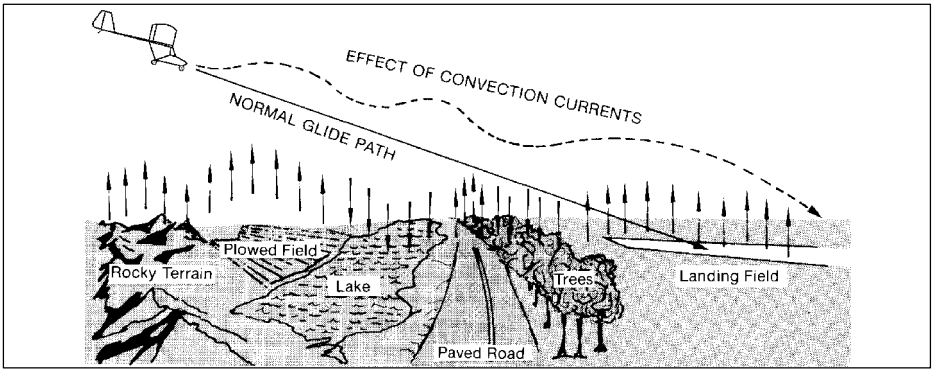


Fig. 41 Effect of Convective or Thermal turbulence.

Assuming we have flown a good approach, we are ready to land the microlight. As mentioned before, this is a matter of touching down with the least forward speed, in a gentle fashion we hope!!

Landing

During our approach we hold the right airspeed and descend at a moderate rate. During the landing sequence the following should occur. As we near the ground (often at around wingspan height) the nose is raised slightly to slow the rate of descent. This is called **roundout**.

When correctly timed, the roundout places the microlight a foot or two above the ground, ready for the flare. Generally, the power is off in the flare.

The aim is to achieve level flight just above the ground, progressively raising the nose to do so. As the airspeed drops, the microlight will be unable to remain airborne, and will settle on to the runway.

Of course, during this phase of flight the microlight must be kept straight. Every landing requires special attention, especially in strong or variable winds. Be ready on the controls to counter any effects of fickle winds, remembering that at reduced speed control response will be less.

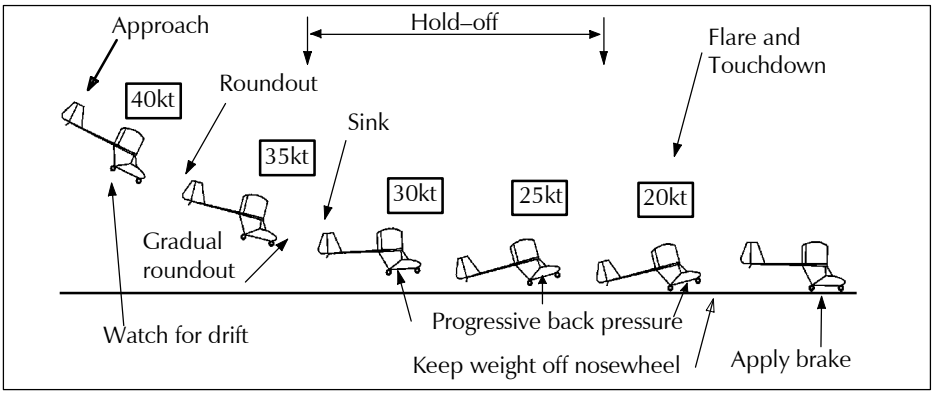


Fig. 42 Typical landing sequence for nosewheel aircraft.

After landing, wherever practical, turn off to the left. If operating from a field land to the left if possible, leaving room for allowing traffic to land on your right, anticipating your left turn after the landing roll.

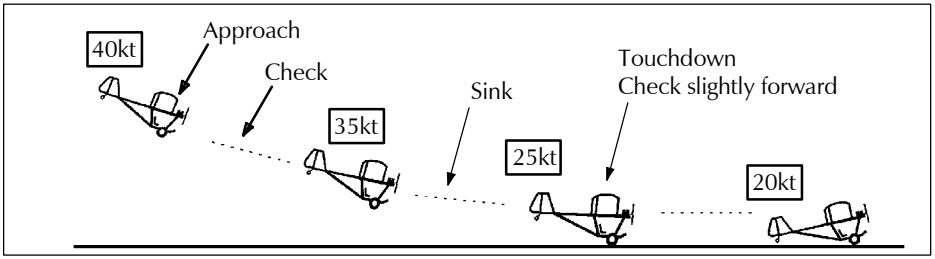


Fig. 43 Typical wheel landing (Tailwheel microlight).

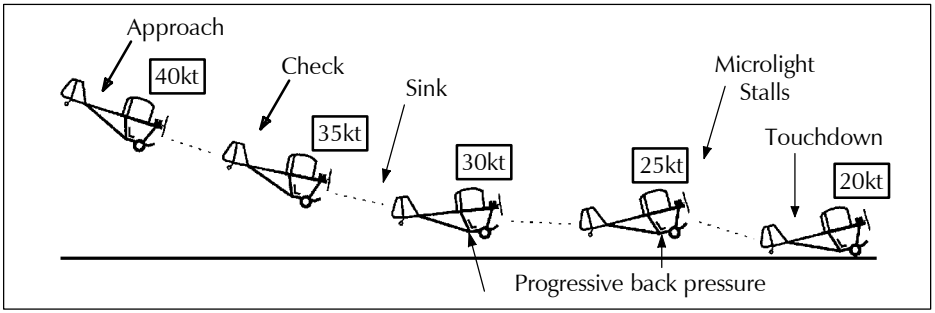


Fig. 44 Typical three point landing (Tailwheel microlight).

Notice the lower touchdown speed for the three–point landing compared to the wheel landing.

EMERGENCY PROCEDURES

As engine failures in microlights are a constant possibility for which every pilot must be prepared, especially as the occurrence of failures to date is quite high, an immediate and correct response to engine failure is essential.

Very much in the microlights favour is the fact that most microlights glide fairly well and are capable of a safe landing in a small field. This, in addition to a skilled pilot, should give every chance of a happy outcome to what can be a traumatic experience for the ill prepared.

A simple rule which should be adhered to, is to **always keep within gliding distance of a suitable emergency area** and to have one in mind at all times.

Complete Power Loss

In the event of an engine failure at circuit height (500ft AGL) or below, there is unlikely to be sufficient time to remedy the engine problem without seriously distracting from the task of performing a forced landing. For this reason, an engine failure at low altitude should be considered permanent, the throttle closed and all concentration given to the landing. After all, the engine may be beyond starting again, and to attempt a restart at the expense of planning a landing is foolish. At higher altitudes, once the forced landing is planned and set up there may be time to attempt a restart.

Therefore, in the event of engine failure at low altitude or in the circuit:

- lower the nose, maintain gliding airspeed.
- check the wind direction and strength.
- choose your emergency landing field (at this height it will be practically right below or very near.
- plan your descent.

If time permits, then check:

- Fuel supply to engine.
- Choke off.
- Ignition.

"Do not mess up an approach because of an engine restart attempt!!"

Engine failure during take off roll

Unless the field you are using is very short, an engine failure before lift–off should allow room to roll to a stop before the end fence. If there looks to be insufficient distance ahead it may be best to initiate a ground loop.

Engine failure during climbout

There may be enough runway left to land ahead, otherwise make a landing further ahead. Should the failure occur further in the climb there is little or no prospect of returning to the airfield because:

- Considerable height is needed to complete the 180° turn back. In haste the pilot could easily stall the microlight. Also the groundspeed at touchdown will be higher with any tailwind component.
- Having taken off into a headwind **you are better off to land ahead into wind**, even on a rough surface, because the touchdown groundspeed will be lower.

Engine failure in the circuit

Where possible a circuit should be flown close enough to allow a safe glide back to the airfield from the mid downwind position, should the engine fail.

Prior to the mid downwind position, landing back on the runway into wind is unlikely, therefore the pilot must choose the best area easily reached, preferably into wind.

In a future section, we shall look at engine failures at altitude.

OVERHEAD REJOINS

When arriving at an airfield the standard circuit rejoin procedure is used to join the circuit safely. It is used for all unattended aerodromes and may be required by Air Traffic Control at attended aerodromes, even if the microlight is equipped with radio or if you have a radio failure at a controlled airfield.

Being thoroughly familiar with the circuit procedure is important to avoid dangerous confusion in the circuit. You can ascertain from a Visual Flight Guide (VFG) the circuit procedure for registered airfields. Although left–hand circuits are normal, most airfields have a combination of left and right hand circuits operating for a variety of different reasons. Check with your instructor if you are not sure.

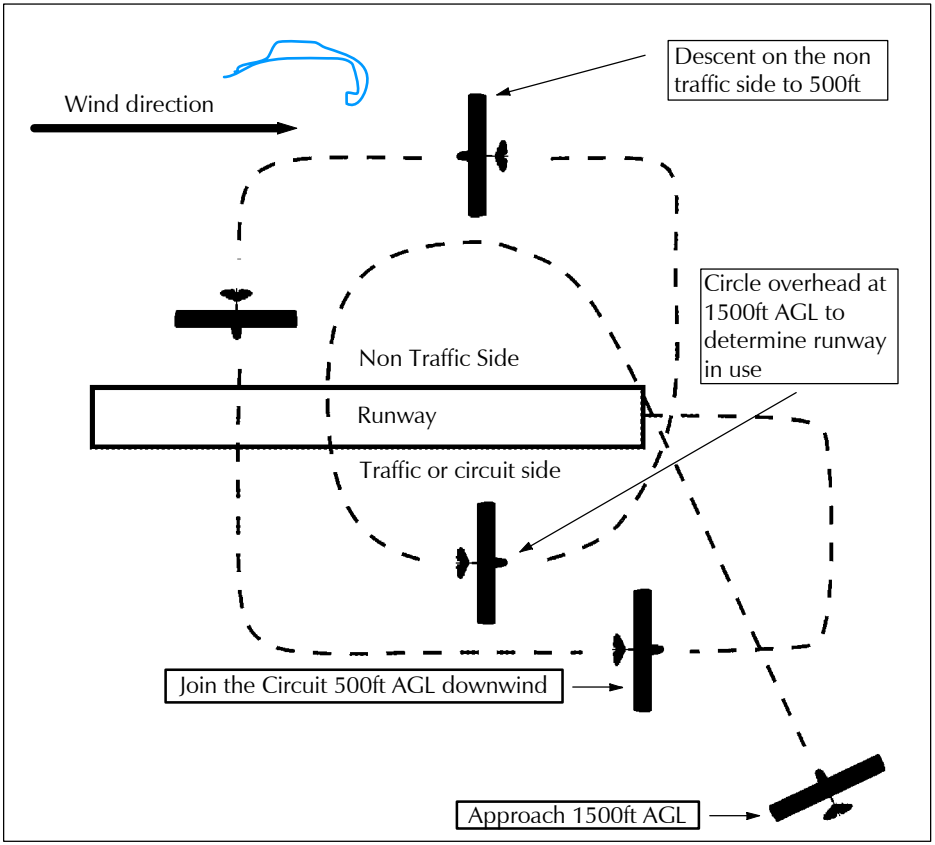


Fig. 45 Standard Overhead Rejoin.

The aerodrome should be approached **1500ft** above ground level (or 500ft above circuit height). When arriving overhead check for other traffic, then determine the wind direction and runway in use. This is done while circling overhead in a left turn, unless ground signals indicate a right hand circuit in use.

This circling turn can continue until the pilot is sure of the wind, runway to be used and other traffic. A turn or two extra to get things properly sorted out in your mind is no disgrace at all.

When sure of things, it is time to descend to the circuit height of 500ft above ground level. This descent must take place on the non–traffic side of the circuit. The side of the runway over which the circuit is flown is known as the traffic side of the runway.

Once down at circuit height, cross the runway at a position that will allow any high performance aircraft to clear you (this may well be 2/3 or 3/4 way down the runway) and then join the circuit downwind and continue in the normal manner.

NOTE:

- A good lookout is vital when rejoining the circuit.
- Windsocks are generally located on the left–hand side of the runway threshold. Remember General Aviation aircraft will be flying at 1000ft AGL.

- When contacting an Air Traffic Control Unit to fly into a controlled airfield, ensure that the circuit height to be used is established, as some may prefer a 1000ft circuit be flown.
- Take into consideration the very much higher speeds flown in the circuit by larger aircraft as well as their wider circuit.

Glide Approaches

Glide approaches are taught to give the judgement needed to make an approach without power, touching down at a desired point. Usually a normal circuit is flown but at the late downwind position the power is brought back to an idle.

In order to judge the approach so as to touch down at 1/3 of the way into the airfield, we must consider the effects of:

- The microlight's airspeed on its glide angle.
- Wind.
- Wind gradient.
- Lift and sink on the glidepath.

The Speed adopted in the glide is very important. The best lift to drag ratio speed ensures the most distance is covered horizontally for the least height lost, so naturally this is the ideal speed. Gliding above or below this airspeed will reduce the glide range.

Wind As discussed in the Effect of Wind section, the stronger the headwind, the steeper the glidepath. See Figs. 46 & 47.

Wind Gradient Descending into reducing windspeed will reduce the gliding range as the nose is lowered to maintain the airspeed and as a result, the glidepath will steepen. See Fig. 48.

Lift and Sink encountered on the glidepath will alter the approach. See Fig. 41.

Aiming to land at least 1/3 into the runway helps allow for the effects of unexpected sink or deterioration of the glidepath. The judgement required for the glide approach into a small field is considerable, but a very worthy skill to strive for. See Fig. 49.

Steep angles of bank greatly increases the stall speed and also increases the sink rate, causing a large loss of height. Avoid **all** steep turns near the ground. Warm the engine periodically or as recommended. When there is medium to strong wind, do not get too far downwind of the field as glide cannot be stretched!

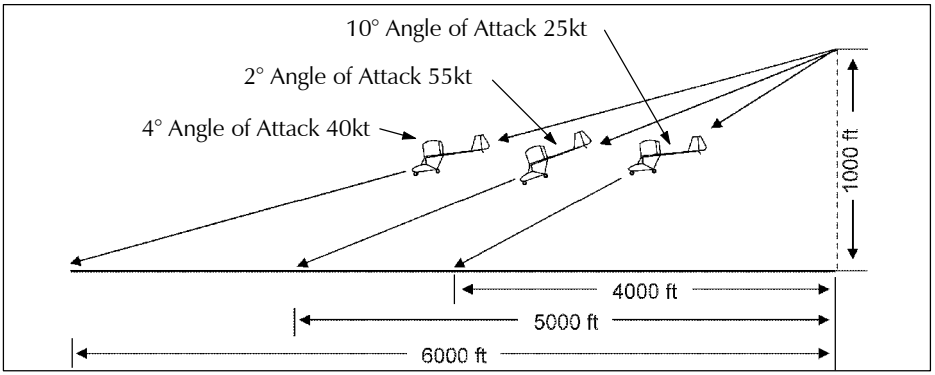


Fig. 46 *The effect of airspeed on the angle of glide. At 25 kt the microlight sinks rapidly. At 55 kt height is lost in a gentle dive. 40 kt is the best L/D speed for this particular microlight.*

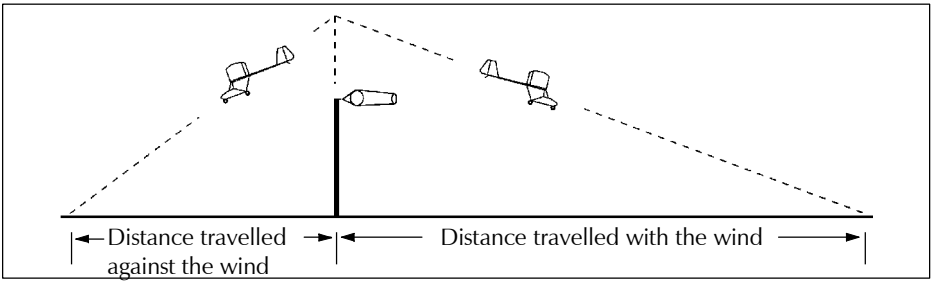


Fig. 47 Effect of wind on angle of glide relative to the ground.

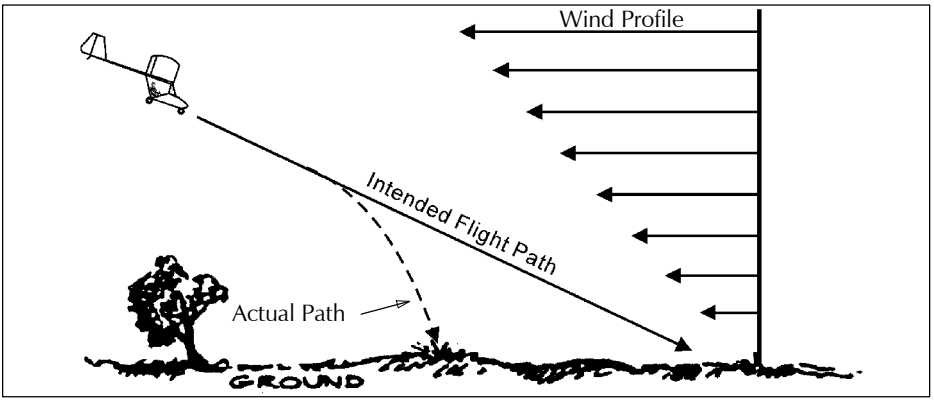


Fig. 48 Stalls due to wind gradient.

FORCED LANDING WITHOUT POWER

The pilot must bear in mind the fact that an engine failure could occur at any time, and this demands preparedness.

One of the basic safety rules already mentioned is to ensure that there is a good landing area always within easy gliding distance, even if this seems a detour must be made. Another rule is that, having plenty of height when the engine fails gives the pilot a better choice of landing field within gliding distance, and more time to plan a descent and possibly rectify the engine failure.

Flying over rugged terrain is asking for trouble!

If the engine should fail, adopt the following course of action immediately which should be memorised thoroughly:

1. Assume the gliding attitude and airspeed and close the throttle.
2. Check the wind direction and strength.
3. Choose a suitable field for landing.
4. Plan descent.
5. Check fuel, choke and ignition.
6. Brief passenger.
7. Mayday call if applicable.

1. **Assume the gliding attitude and airspeed:** Once the engine has failed you are now flying a glider so lower the nose to the best glide angle airspeed.

2. **Check wind direction and strength:** The pilot should always have an idea of the wind direction and strength, but double check it with observation of:
   - smoke or dust drift.
   - wind lanes in crops or on water.
   - tree movements.
   - movement of cloud shadows on the ground (reflects wind strength and direction at cloudbase).
   - flags or windsocks (you should be so lucky!).
3. **Choose suitable field:** Pick a field that is within easy gliding distance, preferably enabling you to arrive overhead with enough height for a glide approach. The field should be as long as possible, into wind to reduce touchdown speed and with good obstruction free approaches. It should also have a reasonable surface and be free from obstacles and be flat or slightly uphill.
4. **Plan Descent:** With the field selected, an approach has to be planned to carry out a successful landing. If there is sufficient height, plan to arrive abeam the threshold at 500ft AGL (as in glide approaches).
5. **Check fuel, choke and ignition:** If there is sufficient height and time, check fuel sufficient, cock turned on, choke off (mixture correct), ignition on. Check for partial power – the engine may lose power but not necessarily stop, in which case any partial power may assist the landing, but should not be relied upon.
6. **Brief passenger:** If you are flying a two place with a passenger, he or she will be greatly reassured by your brief explanation of your intentions. Point out your intended landing field and calmly show them the location of any emergency equipment (first aid kit etc) on board. Make sure helmets and straps are secure. A little reassurance goes a long way in a situation like this.
7. **Mayday Call:** If radio equipped and time still permits, make the standard Mayday call. Continue with approach. Don't forget the downwind checks and select fuel and ignition off, throttle closed on final.

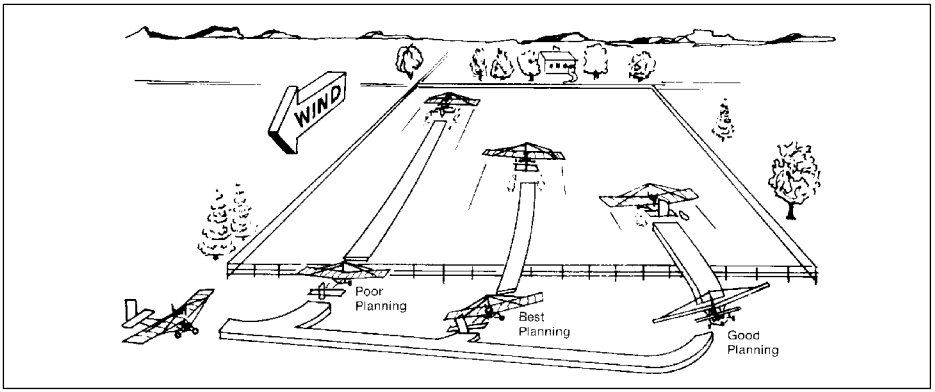


Fig. 49 Forced landing into wind to touchdown in first half of field.

Remember:

- Avoid steep turns.
- If you are too high execute gentle "S" turns to lose height while approaching the field. Do not try a quick 360° turn as you will lose more height than you think.
- Stay near your chosen field and keep it in view at all times.
- Keep the landing field at an angle of 45° to you at all times, this will assist you not becoming too low.
- Try to note the distance and direction to the nearest dwellings.
- Don't let a restart attempt or Mayday call distract from approach judgement.

"Do not get airborne again until the engine problem has been correctly and carefully rectified."

Once safely down, secure the aircraft and if possible, notify the appropriate people of your whereabouts and situation.

PRECAUTIONARY LANDINGS

This is simply an unplanned landing carried out for safety reasons. There are many situations where a precautionary landing is called for. A problem with the microlight, deteriorating weather, or becoming lost are some examples. The aim of a precautionary landing is to terminate a flight safely before a dangerous situation arises or gets out of hand.

No pilot should feel compelled under any circumstances to continue with a flight if safety is going to be compromised and a safe landing can be made. For whatever reason it is decided to terminate the flight, the next course of action is to select a suitable landing field. Depending on the situation the choice of field may vary, but look for the largest, flattest, smoothest field around with good approaches into wind.

Before approaching to land at your selected field, it should be closely inspected from the air first. Descend to 500ft and circle the field looking closely for suitable surface, slope, wind orientation, length and obstacle free approaches. Note any features upwind which might cause mechanical turbulence and look particularly carefully for **wires** across the field and on the approaches. Assuming all looks well from 500ft, plan your approach and carry out an approach with an overshoot, so as to check the field and approach more closely. This should be done by flying to the right of the centreline of the landing field to inspect the left–hand side (where you intend to land). If this shows everything to be satisfactory then commence the circuit from the overshoot and land.

It takes an experienced eye to pick a good field from the air. Slope is very difficult to ascertain, particularly if the field lies in a valley where the surrounding hills give a false horizon. Also, when the sun is high in the sky, undulating paddocks can sometimes appear flat, and with a low sun they can sometimes look more rough than they really are. Don't forget to note the distance and direction to the nearest dwelling before landing.

After landing, secure the microlight against wind and stock damage, then notify the landowner and other appropriate persons of your situation and your intentions. As mentioned above, picking good fields from the air is not always easy, but by making a habit of **observing** and **evaluating** potential fields at **every opportunity**, when the day comes for a real precautionary landing, the event will be that much easier.

CROSSWIND OPERATIONS

Microlights are very prone to being affected by a crosswind because they are very light. When taking off or landing with a wind from the side, there is a tendency to weathercock (turn into wind)

as the wind acts on the rudder surface. The extent of this tendency depends on the undercarriage position relative to the centre of gravity and the centre of pressure, and the strength of the side wind component.

Also to be considered is the effect of the dihedral angle of the wings in a crosswind. Microlights with a pronounced dihedral may tend to have the upwind wing lifted as the wind gets beneath it. It is these factors which makes keeping the microlight moving in a straight line on the ground in a crosswind difficult, and requires care by the pilot. To some extent the turning moment can be counteracted by use of roll control (aileron), in applying an opposing downward force on the upwind wing by holding the controls into wind. The ability to control the microlight in a straight line is to a large extent dependent on the effectiveness of the rudder in counteracting the weathercocking tendency.

Crosswind Takeoff

Hold full roll control into wind and use the rudder to keep the microlight straight as the take off begins. As flying speed is near ease off the into wind control as effectiveness increases. A slightly higher than normal lift–off speed is desirable. The slightly higher lift–off speed assures a positive rate of climb initially to preclude any chance of touching down again; since to touch down while crabbing to offset the drift would almost certainly damage the microlight. So once airborne, offset the drift to track straight down the runway.

Crosswind Landing

On the approach crab so as to track down the extended centre line of the runway, a slightly higher than normal approach speed may help with control of the microlight in windy conditions. When rounding out the microlight must be straightened with the rudder so as to face directly down the runway.

There are two methods of counteracting drift:

- The nose of the aircraft can be turned in the opposite direction to the drift, so that its fore–aft axis is at an angle to the flight path.
- A sideslip can be made towards the wind which will cancel or balance the drift.

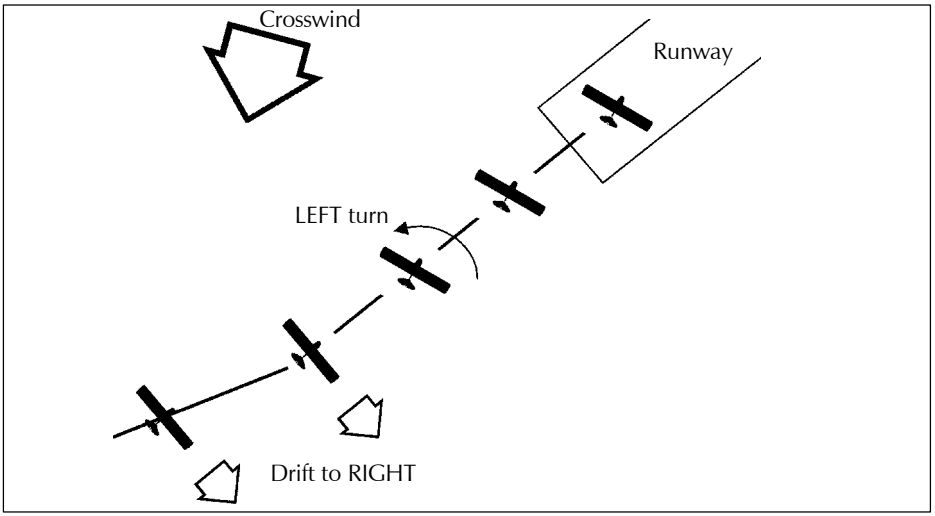


Fig. 50 Drift is counteracted by turning the nose of the aircraft towards the wind.

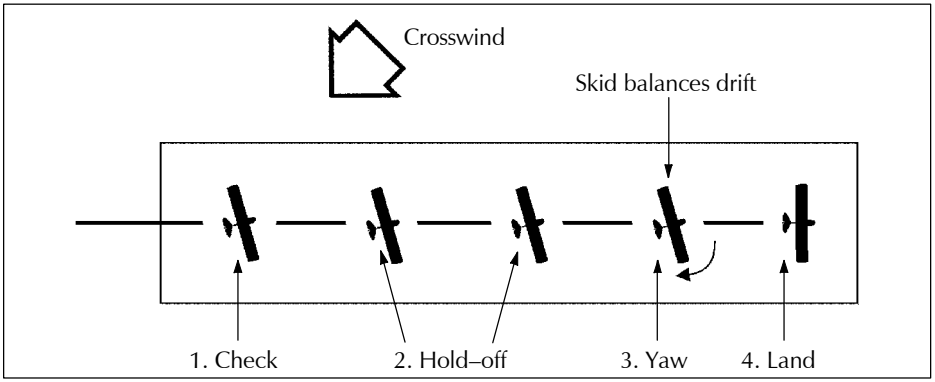


Fig. 51 The final stages of a crosswind landing (method 1). Lining up with the runway causes a skid which balances drift.

"The microlight must not be landed while travelling sideways across the ground."
If the aircraft does begin to drift sideways the upwind wing should be lowered, preventing the yaw with the rudder. The microlight is flared and lands on the upwind wheel first, and after touchdown holds full roll control into wind. It is once on the ground that the fun can really begin. As the aircraft slows and control effectiveness reduces, the crosswind will try to weathercock it into wind, lift the upwind wing, or both. The pilot must be ready to use full controls to counter these tendencies. Each type of microlight behaves differently and can cope with varying degrees of crosswind, so consult your owner's manual and get expert advice.

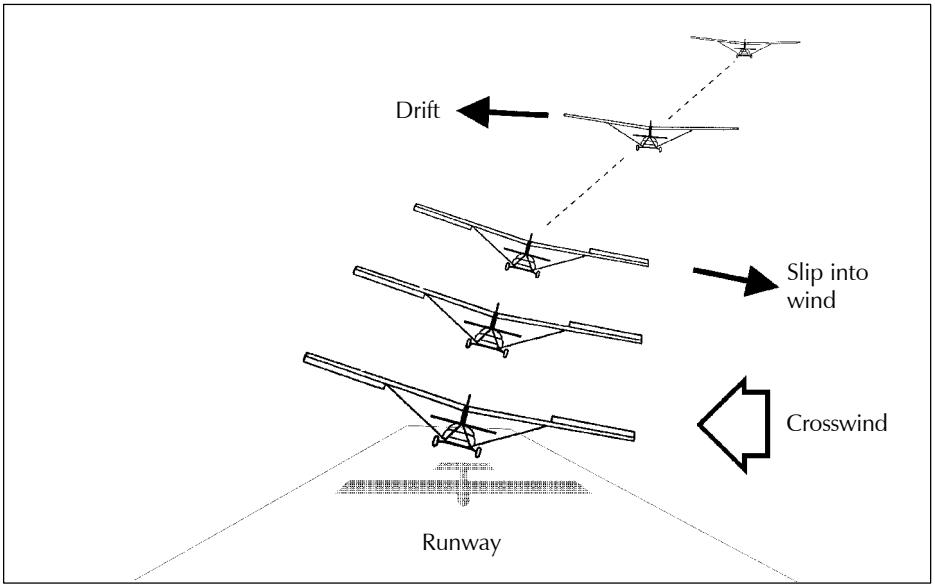


Fig. 52 Crosswind landing (method 2). A sideslip is used to counter drift.

SIDESLIPPING

This is a method of increasing drag which is normally used on final approach as a way to reduce height. This can be achieved by **cross–controlling** the **aileron** and **rudder**, (i.e. left aileron and

right rudder) and adjusted as required to maintain the centre line of the runway. The maximum effect being achieved when either, or both controls are fully deflected. Care must be taken to resume normal (balanced) flight prior to landing. In some aircraft the effect of this manoeuvre can be quite dramatic as there can be a very large increase in the rate of descent.

LOW FLYING

New Zealand Aviation Rule Part 91 states that flight should be at least 500ft AGL except when on the extended centre line of the runway taking off or landing. Therefore low flying should only occur during training or in marginal weather as an operational requirement. When at low altitude, the sensation of speed is greatly increased. Care will have to be taken to anticipate the time and distance required for turns. This is especially so when there is any wind present. The ground track of a turn made out of wind will be much wider than a turn into wind and a climb with a tail wind will reduce the climb angle. Also a turn downwind will need an increased airspeed.

Aspects like these are mentioned in the flying in wind section, but we point them out because at low altitude their importance is magnified. Collision with an obstacle or the ground is only a miscalculation away. Grim as it may sound, it is essentially true. Flying near the ground requires considerably more accurate flying skills than at altitude. A low altitude stall for example could be disastrous as there may be insufficient height to recover. It is possible to fly in to an area which is too restricted to turn out of or climb out of. Naturally, mechanical turbulence at low altitude will be violent and make control difficult.

When low flying, keep in mind the following:

- Maintain proper airspeed and make balanced turns at all times.
- Anticipate! Keep your thinking well ahead of the aircraft, anticipate all manoeuvres with regard to effect of wind, turbulence, room needed etc.
- Do not forget to monitor engine and fuel supply. Bear in mind that map reading will be difficult due to the smaller field of view.
- Choices of emergency landing fields will be extremely restricted should the engine stop.

Lookout! When low flying, one's attention should be largely outside the cockpit, looking ahead carefully, anticipating what is required. Below 500ft AGL there is a real possibility of flying into a wire of some sort. The possibility of encountering other aircraft at that height is also there – after all, if you have been forced to fly low by weather, then so will any other pilot in the vicinity. Operating at low altitude requires total concentration for safety. Low flying in bad weather in unfamiliar country with turbulence while trying to map read is best avoided if at all possible!

Landing & Taking–off on Hill strips

New Zealand, because of its terrain has many sloping airfields, many of them agricultural strips. The golden rule is to **land up hill** and **take–off down hill** regardless of a possible downwind component (providing flying conditions are suitable). **Beware of turbulence.**

Landing: When making an approach to a sloping (rising) airstrip, extra speed is required on the approach to effect a roundout, and then **"fly up"** the strip before the wheels touchdown. If you are landing into wind, uphill, beware of rotor turbulence.

Taking–off: Take–off downhill as most aircraft will be unable to outclimb the rising ground, irrespective of wind direction. Generally, the steeper the slope the greater the downwind component can be, for a downhill take–off.

WEIGHT AND BALANCE

All aircraft are designed to operate within certain load and balance conditions. It is the pilot's responsibility to make sure that the microlight is not overloaded and is within its centre of gravity limits.

When loading an aircraft there are three kinds of weight we must consider:

- **Empty Weight** – this is the weight of the basic microlight, the airframe, engine, all fixed instruments and equipment, unusable fuel supply, undrainable oil (if any).
- **Useful Load or Payload** – This is the weight of pilot, passengers, useable fuel supply, baggage and drainable engine oil (if any).
- **Gross Weight** – **(M.A.U.W.)** This is the empty weight plus the useful load, giving us the gross weight at takeoff. When the machine is loaded to the maximum weight stated in the manufacturers manual, the machine is at Maximum All Up Weight (M.A.U.W.). This is also referred to as Maximum Takeoff Weight (M.T.O.W.).

The manufacturer will normally state in the owner's manual (it's a good idea to placard it in the microlight) the maximum and minimum weight of pilot and passengers. Remember a person's weight includes the weight of clothing and items carried.

What happens if we exceed the weight limits advised?

OVERLOADING

Overloading a microlight will severely reduce the aircraft's performance! It will result in:

- A higher takeoff speed.
- Longer ground run.
- Reduced rate of climb.
- Reduced angle of climb.
- Shorter range.
- Reduced cruise speed.
- Increased stall speed.
- Increased sink rate.
- Higher landing speed.
- Longer landing roll.
- Lower maximum ceiling.
- Decreased g loading capability.

Take another look at this list. If you overload your aircraft you will not suffer from just one of the above, but **ALL** of the above!

An aircraft with a designed load factor of 3.8g at MAUW,flown with a 25% overload, has its capability reduced to about 3.0g.

Balance

Further to the issue of loading your microlight there is the equally vital question of whether or not the aircraft is balanced correctly.

Centre of Gravity

This is the term used to describe the point about which an aircraft would balance if suspended. If the aircraft is loaded so that the centre of gravity is within the fore and aft limits prescribed by the manufacturer, then the aircraft will handle and function normally (assuming it is not overloaded!).

Few microlight manufacturers provide aircraft type–loading graphs to help determine the centre of gravity for whatever load it is intended to carry. However, they will normally indicate minimum and maximum pilot/passenger/baggage weights and keeping within these limits assures a correctly balanced aircraft. Consult your owner's manual and study any information therein related to the weight and balance of your aircraft.

Loads forward of the centre of gravity "C of G" (which is usually about 1/3 mean chord) impose a nose down force, and loads aft of the centre of gravity impose a tail down force. Loads at the centre of gravity do not alter the C of G.

The further the distance from the C of G a load is placed, the greater the effect on the balance will be. When the loads ahead and aft of the C of G are proportioned correctly, the aircraft will be balanced for flight.

Effect of Aft C of G

With an aft C of G (too much weight behind the desired C of G) generally an aircraft becomes more pitch unstable and often stall characteristics become more violent. Extra nose down control input will be needed to prevent the aircraft pitching up into a stall. On takeoff the aircraft might develop a high nose attitude which may be difficult or impossible to correct. Only very light control forces will be needed to pitch the nose up, and in this condition the aircraft may easily be overstressed.

Effect of Forward C of G

With the aircraft loaded with a forward C of G (too much weight ahead of the desired C of G) extra nose up control input will be needed to prevent the aircraft pitching down. There may be insufficient nose up control available to rotate for lift–off and for flaring for landing. Dive recovery will be impaired.

Both the previous conditions cause pilot fatigue as the unusual loads required on the controls may be more than the aircraft's trim systems can relieve (assuming it has one). Weight and balance must be taken seriously.

"A Microlights behaviour in the air is dependent on weight and balance"

THE PROPELLER

The job of the propeller is to convert engine power into forward thrust. The propeller is made to rotate by the engine, and in doing so develops lift at approximately right angles to the plane of rotation. This produces a backward stream of air called the slipstream, which is the thrust.

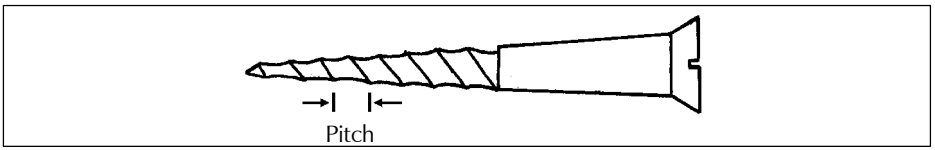


Fig. 53 The action of the propeller through the air is similar to that of a wood screw through wood.

The airfoil section of each propeller blade is set at an angle to the plane of rotation, this is called the **Pitch**.

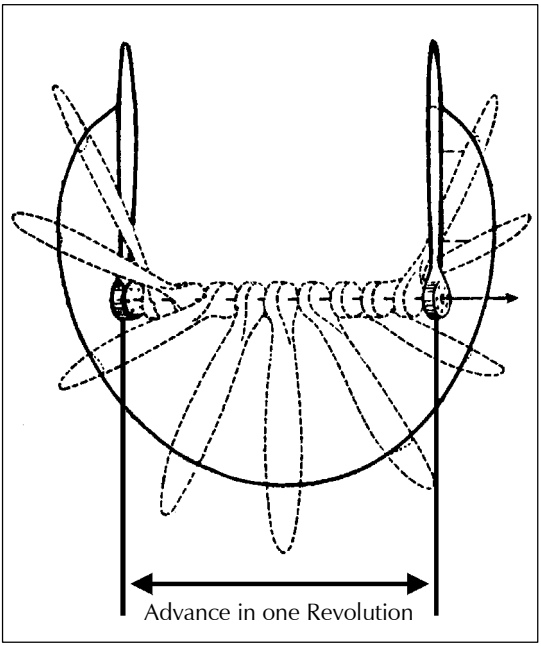


Fig. 54

Because the tips of the propeller travel very much faster than near the hub, the pitch is at its maximum at the hub and progressively reduces towards the tips.

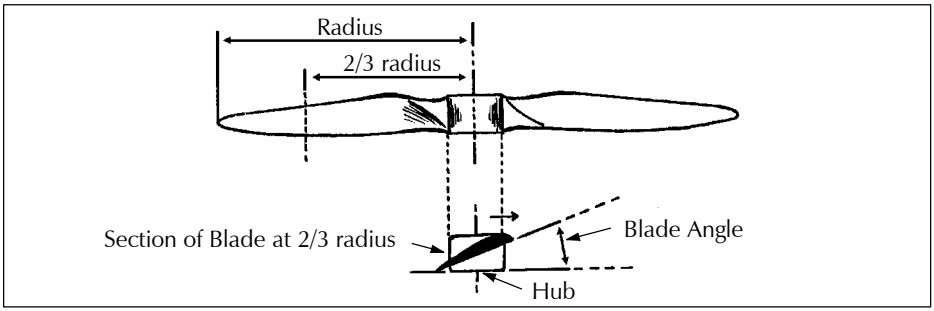


Fig. 55

Propeller theory is complicated by the fact that the propeller blade angle relative to the airflow changes with forward speed and R.P.M., being at its maximum while the aircraft is at rest at high R.P.M., reduces to a minimum during flight at maximum speed, and assumes a negative angle in a steep dive at low R.P.M. In this respect the fixed pitch prop will only be at its most efficient at the revolutions and forward speed intended by its designer.

This last point highlights the dilemma of the fixed pitch propeller. A fixed pitch propeller can be designed to be most efficient at only one task, e.g. a fast cruise speed. While it may excel at one task, it may be fairly unsuited to another. For this reason most fixed pitch propellers are designed as somewhat of a compromise to provide adequate performance for each task, although probably favouring one goal.

Two such propellers are the Cruise and Climb propellers. A propeller designer wishing to produce a propeller that will afford a fast cruise speed will create a coarse pitch design. The coarse pitch refers to a larger blade angle which will produce good thrust at lower R.P.M. and at a greater forward speed. However, this propeller will result in an extended takeoff run and reduced climb performance.

Cruise propeller	Advantages	Disadvantages
Coarse pitch	Good cruise speed	Long takeoff roll
		Poor climb performance

Climb propeller	Advantages	Disadvantages
Fine pitch	Good takeoff run	Low cruise speed
	Good climb performance	

A propeller designed to give a short takeoff and good climb capability will be of a fine pitch design. The fine pitch refers to a lesser blade angle, which will produce good thrust at high R.P.M. (takeoff power) and low forward speed. Thus an aircraft with a fine pitch prop will accelerate quickly, takeoff with a shorter ground run and climb well. Unfortunately the cruise speed will not be as good as with a cruise prop.

Propellers are described in terms of their diameter and pitch. For example a 54x27 inch prop is a propeller 54 inches in diameter, and with a theoretical pitch giving 27 inches of forward movement per prop revolution.

The long distance flyer will probably choose a cruise prop for his/her aircraft, while the pilot who does not fly far, but sometimes operates from smaller fields, would require a climb propeller.

Of course, a variable pitch prop, adjustable in the air, would provide the best possible solution, enabling the use of fine pitch for takeoff and climb and then coarse pitch for cruise. Unfortunately such propellers are not commonly in use on microlights and are sure to be expensive and significantly heavier.

There are available however, ground adjustable units. The idea here is that the pilot can select and set up the desired pitch before takeoff according to the task at hand.

Propeller Care

When you start the engine and the propeller becomes a blur, it is easy to overlook the incredible forces it is coping with during the course of its work. As it spins centrifugal force tries to rip each blade out of the hub. At the same time there are various twisting and bending forces associated with the production of thrust. At high R.P.M. in particular the propeller is under enormous strain.

When we consider that the propeller is also acting as a flywheel, it is plain that it must be perfectly balanced in order to spin smoothly without vibration. With the high tip speeds any imbalance will cause serious vibration. Furthermore like any lifting surface it must be aerodynamically balanced to operate smoothly.

Microlight propellers seem to suffer from more than their fair share of woes. They are mainly constructed from carbon fibre or from laminated wood and although this material is well suited to the task, the prop needs a fair amount of care during its life.

A propeller's (especially wooden) biggest enemies are the likes of water, stones, sticks, thistle stalks, cow pats, sheep manure and mother earth.

The outer third leading edge of each blade is the most subject to damage from these things, and normally this section is given some sort of protection in the form of a plastic tape, fibreglass coating, metal cap or other. These devices are intended to help reduce impact damage (small

objects only) and abrasion to the leading edge. Flying in rain, a wooden prop without leading edge protection can be badly damaged as the raindrops blast through the varnish and begin tearing at the wood fibres, thus in a short time the leading edge may be ruined.

Obviously, a stone or other hard object striking the prop will really do some damage. Stones and gravel usually find their way into the prop disk by being sucked up off the ground by the propeller if it is near enough, or by being thrown up by the wheels. It pays to assess an airfield's surface carefully, even pace it out, to check for anything likely to cause propeller damage. That discarded piece of fencing wire lurking in the grass could spoil your day.

The propeller itself deserves special attention during the preflight. Inspect both faces of each blade and each edge, looking for nicks, worn spots, cracks. Wipe the prop clean if needed. Check the security of any leading edge protector. A piece of propeller tape for example, missing or peeling off, could produce vibration bad enough in flight to necessitate the immediate shut down of the engine! Watch for play around the propeller hub mounting. Any damage should be considered serious and replaced or repaired by someone qualified.

If vibration occurs in flight suspect propeller trouble, reduce power if possible and land. In the event of severe vibration – **shut the engine off immediately**. Treat all propellers as live and never allow people near your aircraft while the engine is running.

Reduction Drives

The use of small two–stroke engines in microlights has necessitated the use of reduction drives because these engines develop their power at R.P.M. far in excess of suitable propeller R.P.M.

To give an example, a small propeller of say 48 inches diameter would have a tip speed of 785 M.P.H. (685 kts) when driven at 5500 R.P.M. assuming the engine could develop sufficient power. Much of this power would be wasted shock waves as the propeller exceeded the speed of sound across the outer areas of the blade. Therefore, some sort of reduction is needed to match ideal propeller speeds with the best engine efficiency R.P.M.

These can take the form of:

- Chain drive.
- Toothed belt drive.
- Multiple V belt drive.
- Gearbox.

The most commonly used reduction method utilises a gearbox with a reduction of approximately 2.5 to I, i.e. the engine runs at two and a half times the propeller R.P.M. Gearboxes require the oil to be checked regularly.

If a belt reduction is used the belts must be checked during preflight for correct tension and wear. The correct tension is maintained with an adjusting device. Slipping belts result in a loss of power to the propeller, and rapid and destructive wear to the belts. A good feature of belt drives is their ability to absorb engine and prop vibrations.

Accurate alignment of pulleys is important.

PISTON ENGINES

The microlight engine produces power by converting petrol into heat and energy. The energy is collected by mechanical means and the resultant power is transmitted by a rotating shaft which is linked to a propeller in the aeroplane. It is self evident that when ignited a liquid fuel will burn and produce heat but how the heat is able to provide mechanical energy will be less obvious until it is realised that heat can be applied to air. When heated, air will expand considerably, exerting great pressures if contained in any way.

Method

To provide perfect combustion in the engine, petrol and air must be mixed in a ratio of approximately fifteen parts of air to one part of petrol by weight. Too much petrol causes a "rich" mixture (which may be recognised by black exhaust smoke). This is both wasteful of fuel and damaging to the engine because heavy carbon deposits build up in the combustion areas. Conversely, too little petrol in relation to air causes a "weak" mixture. This too, is damaging to the engine, for instead of the mixture burning at an even rate on ignition, an explosion occurs causing severe strain on the engine accompanied by overheating and loss of power. In most piston engines fuel is mixed with air in the "carburettor".

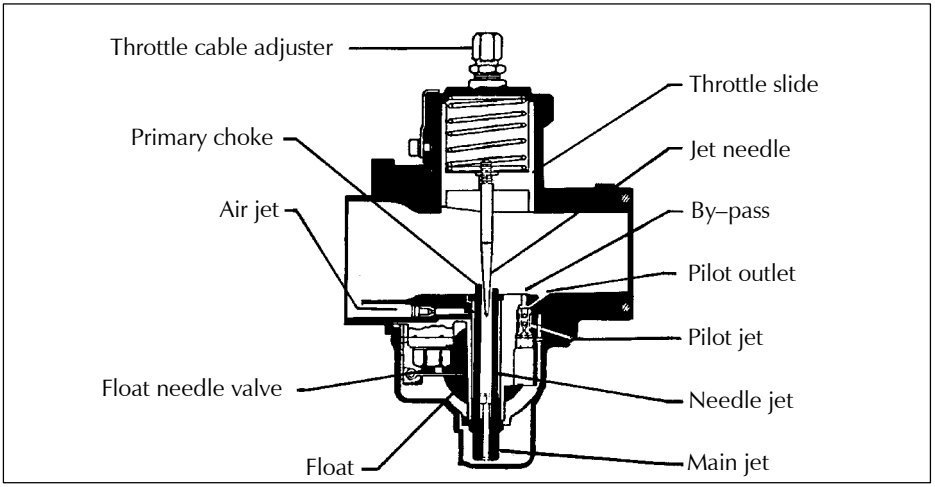


Fig. 56 Cross–Section of a float carburettor.

Fuel from the aircraft tanks is pumped to the carburettor and enters a device similar in design to a domestic toilet cistern called a "float chamber", its function being to maintain the fuel at the correct level in the "jets". These jets create an atomising action rather similar to that of the nozzle of a scent spray. It is usual to provide a "slow running jet" for the purpose of engine idling and a "main jet" for normal operation. On some carburettors when the throttle is opened for maximum power an additional "power jet" is brought into operation.

A reduction in air density will occur as the aircraft gains altitude and since this would result in an over rich fuel/air mixture, the carburettor may be provided with a "mixture control". A throttle slide is positioned between the jets and the engine and linked to the pilot's throttle control so that the amount of mixture entering the engine may be regulated, this in turn determines the power output to the propeller.

The carburettor just described is typical of the type used in many microlights powered by simple two–stroke engines. Some microlight motors are fitted with a diaphragm carburettor (instead of a float chamber type). The advantage of these carburettors is that they are not affected by operating in any attitude.

The tuning of any carburettor is important and should be done in accordance with your particular engine manual. For two strokes, because they can generate large amounts of heat quickly, correct tuning is critical. A useful check for correct tuning is to examine the spark plugs after a full power run, they should look a **light tan** in colour. If they are **blackish** then your engine is too **rich**. If they are **whitish** then your engine is too **lean**.

For engines with dual carburettors it is important that the throttle slides are set the same throughout the throttle range. The jetting and float levels must also be the same.

Provision of Rotary Motion

In a bicycle the reciprocating motion of the rider's legs is transmitted to the crank via a pair of pedals so converting an up and down motion into a rotation which is transmitted by a chain to the rear wheel.

In a piston engine the crank and pedals are replaced by a "crankshaft" and the "legs" of the engine are provided by a "connecting rod" which links the crankshaft to the piston (the muscles of the leg). To allow for the sweeping motion of the crankshaft as it rotates within its "crankcase" provision is made for the connecting rod to pivot on a "gudgeon pin" inserted across the axis of the piston. The pin passes through the "small end" of the connecting rod and the "crank pin" (equivalent to the pedals on a bicycle) is free to rotate in the connecting rod "big end bearing".

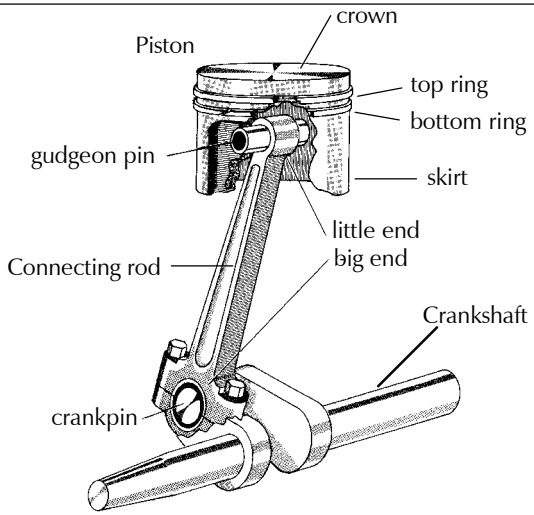


Fig. 57

When the engine is running at 3000 R.P.M. the piston and connecting rod must go up the cylinder, stop, descend down the cylinder and stop again (ready for the next ascent), fifty times every second, and it is usual practice to counterbalance the crankshaft so that vibration is kept to a minimum.

Cooling

Quite apart from the heat generated by fast moving parts is the very considerable heat resulting from combustion in the mixture. When running at 3000 R.P.M. an engine such as the single–cylinder unit under discussion would ignite every revolution or at 3000 R.P.M., 50 times per second. When there is a need to burn more fuel to provide extra power (e.g. during a climb) the engine temperature increases. Unless the surplus heat generated were dissipated in some way it would only be a matter of minutes before the cylinder head became excessively hot and the engine seized. In a car the problem is solved by surrounding the cylinder and cylinder head with a series of passages cast in the cylinder block. Water is pumped through these passages (water jacket) and returned through a radiator to disperse the heat by the air flowing through it.

While liquid cooling has in the past been adopted for some very successful high performance aero engines (notably the Rolls–Royce Merlin) large engines are now practically confined to the gas turbine family. Lower power aero engines have almost without exception always relied upon a cooling system which dispenses with the radiator and its tank, the water jacket around the cylinder and the coolant itself. This simpler and lighter method, in fact the one used on motor

cycles and small petrol mowers, is called “air cooling”. Fins are machined around the outside of the cylinder barrel and cylinder head and a system of sheet metal baffles guides the airflow through the engine cowling and around the fins, carrying away the excess heat through the rear of the engine bay.

Liquid cooling is now more common in microlights, due to technological advances.

Unfortunately some two–thirds of the fuel energy in an internal combustion engine is wasted, only the remaining third being converted to power.

The Two–Stroke Engine

Although four–stroke power units are available, the two–stroke engine is still the most commonly used for microlight aircraft, primarily due to their relatively lower cost and higher power to weight ratio. The two–stroke engine is less fuel efficient than the four stroke per horsepower, although it generates more heat, it also has less tolerance to running lean etc. The two–stroke engine has fewer moving parts than a four stroke because it does not have complex valve train components.

Feeding the Mixture to the Engine

The need to draw in and compress the mixture, burn it then clear the cylinder (making it ready to accept another charge) is essential to all piston engines, but in a two–stroke design two functions are enacted simultaneously.

It will be seen (in Fig. 58) that no mechanical valve gear is provided. Instead the piston is arranged to cover and uncover ports cut into the cylinder walls thus providing the dual function of compressor/power collector and inlet/exhaust valves.

Imagine the engine is running. As the piston rises to compress a fresh charge, pressure decreases within the crankcase, the inlet port is uncovered by the piston skirt and mixture from the carburettor flows in. The engine fires and during the power stroke the inlet port is closed, and the mixture trapped within the crankcase is compressed by the descending piston. Towards the bottom of the power stroke the piston crown uncovers an exhaust port and at the same time opens a transfer port which communicates between the crankcase and the top of the cylinder (i.e. combustion chamber).

Mixture under pressure within the crankcase now escapes through the transfer port to the combustion chamber. The incoming mixture assists exit of the burned gas through the exhaust port.

Note the design of the piston crown which is contoured to encourage the gas flow just described. During the next compression stroke a fresh charge of mixture will be drawn into the crankcase ready for transfer to the combustion chamber as the following stroke occurs.

Having regard to the fact that a two–stroke engine produces a power stroke every revolution, one might expect it to develop twice the power of a four–stroke engine of similar capacity.

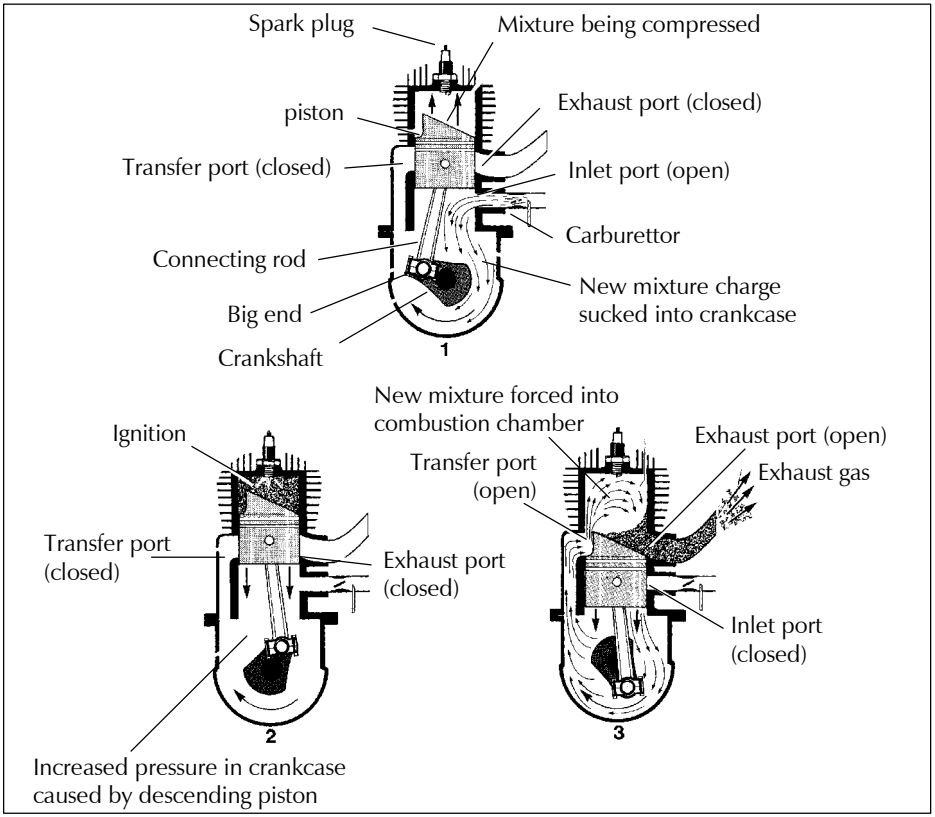


Fig. 58 Typical two stroke engine.

Unfortunately scavenging of the exhaust gas and imperfect induction reduce its efficiency and, on average, a two–stroke will develop only 50 per cent more power than a four–stroke engine of the same capacity. Furthermore, both oil and fuel consumption per horsepower hour is higher for a two–stroke. Against this must beset the advantages of simplicity and low weight per horsepower.

Air Filters

There are only two inputs that are mixed to cause the engine to develop power – Petrol and Air. The Air Filter is an important component that requires regular attention. Regular cleaning of the Air Filter will ensure that the engine does not start to run "rich". If the two–stroke engine is caused to run "rich" then a consequence can be that it will "bogg down" as the power is applied. This event can be disastrous on final approach. Typically the Air cleaner and the spark plugs are attended to at the same time.

Lubrication

Unlike the four–stroke engine with its wet sump or separate oil tank, oilways, and, in many engines, oil pump(s), two strokes are lubricated by the simple method of mixing suitable oil with the petrol. When one of the modern oils developed for two–strokes is used the normal mixture is one part to 50 parts of petrol. However this may vary in engine brands, so always consult the manufacturers handbook or aircraft flight manual for the type of oil recommended and amount to be used. Excessive use of oil will lead to heavy carbon deposits around the exhaust ports and

fouled sparking plugs. The petrol and oil mixture (often called petroil) must be thoroughly shaken to ensure even distribution of the oil before refuelling.

Cooling

In addition to the cooling fins already described in the earlier section, some two–strokes have a small cooling fan attached to the drive shaft. Some water–cooled engines are appearing on the scene and could become more popular with the passing of time. These utilise a "water jacket" built into the engine block and head, through which coolant (usually a 50/50 mix of water and antifreeze) is pumped. Having absorbed heat from the engine, the coolant is then piped to the radiator (usually mounted in the airflow but where it will cause the least amount of drag) which disperses the heat into the surrounding air, thence back to the engine to reabsorb more heat.

Care of water cooling components is relatively simple:

- Check the coolant level before each flight.
- Check hoses and the radiator for leaks or damage.
- Check all mounting hardware for security.

Ignition

Purpose–built four–stroke aero engines and some newer two–stroke engines are provided with two independent ignition systems (dual ignition) to:

- ensure safety, *and*
- provide better ignition of the mixture in what is by automobile standards a large volume combustion chamber.

Microlight engines now have both single plug and dual plug ignition systems, with either solid state, electronic or magneto type ignition.

The spark plugs on either type of engine require regular maintenance. Cleaning or replacing and regapping at 25 hours is a fairly typical recommendation.

Engine Handling

Be sure to follow any engine operating procedures recommended by the engine manufacturer. Proper handling will improve the reliability of an engine greatly. Some points to remember:

- use of continuous high R.P.M. settings will cause increased strain and wear of components; this may lead to high cylinder head temperatures which in turn can cause detonation and poor cylinder wall lubrication.
- do not use high power settings until the engine has warmed. High R.P.M. causes very rapid wear to a cold engine. Therefore, takeoff must be delayed until cylinder head temperatures are above the minimum.
- the throttle should be advanced smoothly to prevent strain on the engine.
- the fuel mixture and carburettor mixture must be kept at the recommended settings.
- avoid long power–off descents which can lead to a spark plug fouling – warm the engine periodically.
- remember that at high power and low airspeed (climb), engine cooling will be diminished.
- constantly monitor engine temperatures in flight.

"If you want a reliable engine, look after it!!"

Fuel Storage

Not surprisingly, petrol engines perform well on petrol and not at all on water and other contamination. Ensuring your engine always has a good supply of clean fuel goes a long way toward preventing engine failures. Containers used for fuel storage should be completely clean and without residue of anything else they may have contained. There should be no sediment or deterioration of the inside surfaces. Likewise the associated hoses, funnels and pumps used must also be clean.

Water can mysteriously find its way into seemingly leakproof containers and microlight fuel tanks by means of the condensation process. To minimise this, keep fuel containers as full as possible. Fuel drums should be stored on their sides if in the open, so that the expansion and subsequent contraction of the fuel and drum cannot draw in water which has collected in the rim.

On the first preflight of the day and after every refuelling, include a check for water which will collect in the low points of the system, this can best be removed by a drain tap at that point. Drain a little fuel into a glass and water will appear as bubbles on the bottom.

Mixing the correct ratio of the right oil to petrol for two–stroke engines is vital! It may be helpful to draw up a chart showing the appropriate amount of oil for various amounts of petrol. Be particularly careful when mixing fuel in the microlight's fuel tank on an outlanding or cross–country stop. Know what you are doing! Your engine manual will specify what octane rating your engine requires.

Only use fresh fuel as it deteriorates with time. Old fuel has a reduced octane rating which may cause engine problems.

Fuel Management

Fuel related accidents usually fall into three categories – Fuel contamination, Fuel starvation and Fuel exhaustion. Fuel contamination is covered above. Fuel starvation and exhaustion are the result of poor pilot practice.

Fuel Exhaustion

Is simply running out of fuel. That's it, you've burned every last drop, meaning an engine failure and forced landing. Knowing what sort of endurance you have, plan your flight to have at least 20 minutes of fuel remaining, once the flight is completed. Do not be tempted to reduce this safety margin. There are many reasons for keeping this reserve of fuel such as the situations below, which all eat into your fuel supply:

- unexpected headwinds.
- use of high power settings longer than usual as in multiple takeoffs or climbs to altitude.
- becoming lost.
- the need to divert to another destination due to weather, wind or unserviceability of proposed landing field etc.
- higher than normal fuel flow.

Whenever possible take off with a full fuel load. Be thoroughly familiar with your aircraft's fuel capacity and know what sort of endurance you can safely expect at the power settings you use, for the amount of fuel you are carrying.

If you find yourself in a situation where there is doubt that the fuel remaining is going to be sufficient to reach a destination safely, then don't press on, land at the next safe field. It is far safer to make a precautionary landing with power than an emergency landing without power where landing options are severely limited.

"I think I can make it" is right at the top of the list of famous last words in aviation history.

Remember – the useable capacity is not necessarily the total capacity of fuel carried due to the location of the fuel pick up point.

Fuel Starvation

This can occur in microlights with fuel on/off taps and/or more than one fuel tank, where the fuel supply is interrupted by wrongly positioning the fuel tap. It may sound unlikely that anyone would select the fuel off or change to an empty or near empty tank, but it certainly happens.

The obvious cure for fuel starvation problems is to stay aware of your fuel system. The fuel selector would normally be positioned "on" to the appropriate tank before start up and checked again before takeoff during the pre–takeoff checks.

The fuel filter/drain should be checked for contaminants/water, prior to flight.

In flight the pilot should constantly monitor the fuel situation and know beforehand when the change to another tank should be made. Needless to say, don't wait until the "Big Silence" before changing to the new tank either!

Ensure fuel selectors are clearly marked as to their positions and when moving the selector think about your action. Don't rush your preflight checks.

Summary –

- Know your fuel system – selectors, on/off valves etc.
- Know the useable capacity of fuel on board.
- Know the consumption rates at various power settings for the particular microlight being flown.
- Check for fuel contamination after every refuel.
- Don't change tanks just before takeoff – allow time to verify the fuel flow before takeoff.
- Always check fuel quantity yourself before flight.
- Plan to have easily enough fuel plus reserve for each flight.
- Keep refuelling equipment clean.
- Constantly monitor fuel state in flight.

FLYING IN WIND

Wind is simply a mass of air moving over the earth's surface. An airborne microlight is flying in that moving mass of air. The wind has no effect on the microlight itself (turbulence excepted – see turbulence section) but does have an effect on its path over the ground and its speed relative to the ground (ground speed).

It is vital to understand the difference between airspeed and groundspeed.

AIRSPEED – the speed of the microlight through the air.

GROUNDSPEED – the speed of the microlight over the ground.

The two are completely separate and different values!

Airspeed is an important factor in controlling the microlight in the air and groundspeed is only a measure of progress over the ground, having no relevance to the flying characteristics of the microlight whatsoever.

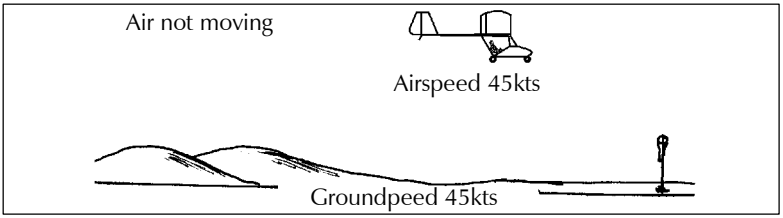


Fig. 59

Effect of a direct headwind

Flying into a direct headwind reduces the groundspeed by a factor equal to the wind speed.

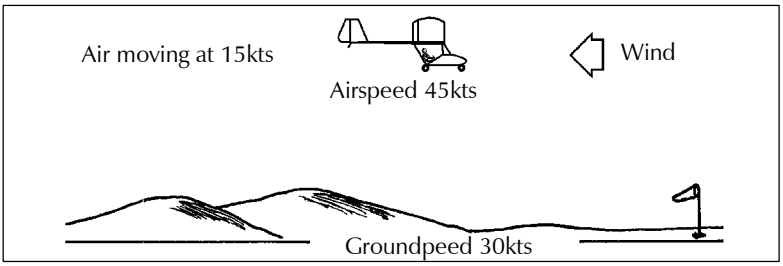


Fig. 60 The reduced groundspeed means more flight time needed to reach a destination (i.e. more fuel required) and there will be an illusion of slow airspeed.

Effect of a direct tailwind

A direct tailwind increases the groundspeed by a factor equal to the wind speed.

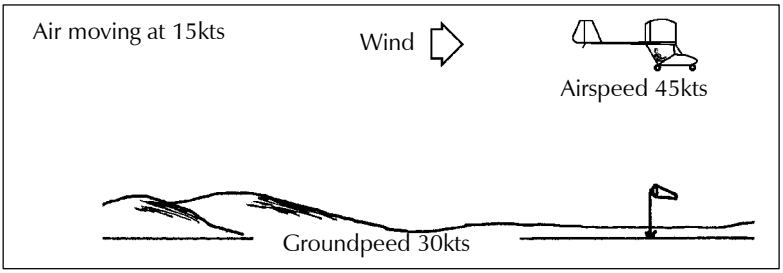


Fig. 61

The increased groundspeed gives a faster time to reach a destination and gives an illusion of faster airspeed. This illusion of extra airspeed will be more pronounced when near the ground and can be dangerous if the pilot slows down to what his normal speed "looks like" in nil wind, thus possibly resulting in a stall.

During a cross–country, every pilot loves a tailwind.

CROSS WIND

A wind blowing across the desired flight path (crosswind) will carry the microlight off the desired path in the direction the wind is blowing.

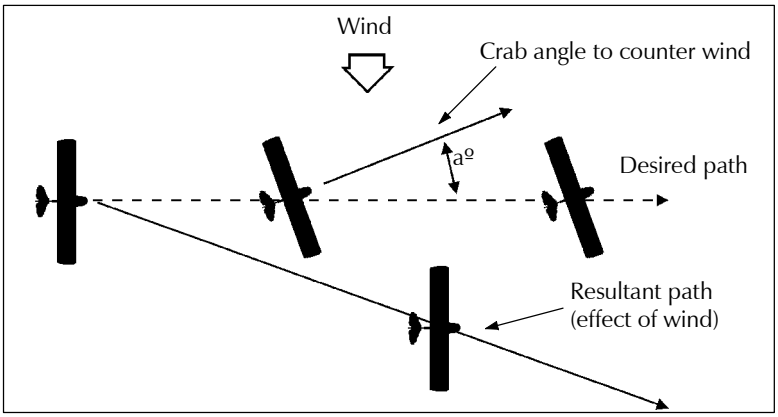


Fig. 62

To counter the effect of a crosswind a balanced turn should be made into wind until the effect of the crosswind is halted and the track made good is along the intended flight path. This is called **crabbing**. See Fig. 62.

Initially it may seem strange to have the nose pointed away from your destination, but correcting for drift in this way ensures the quickest time between points.

Of course, there are variations of headwind, tailwind, and crosswind components.

Effect of Wind on Climb

Firstly it must be stated that wind from any direction will not have any effect on **rate of climb.** However, wind will effect the **angle of climb.**

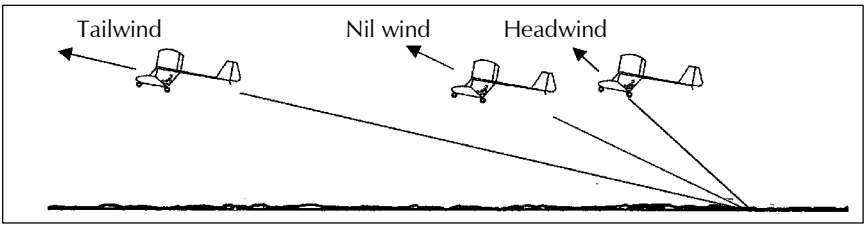


Fig. 63 Effect of wind on climb angle.

Climbing with a tailwind means the groundspeed is increased while the rate of climb remains the same as normal. This translates to a flatter climb angle relative to the ground.

A pilot climbing with a tailwind has to remember there is going to be an illusion of speed and the aircraft may feel as though it is not climbing properly. Therefore the pilot must be sure to maintain normal climb airspeed, and beware that the flatter climb angle could affect obstacle clearance. Rate of climb is unaffected.

Climbing with a headwind means the groundspeed is reduced while the rate of climb remains the same as normal. This translates to a steeper climb angle relative to the ground. Rate of climb is unaffected.

Effect of Wind on Descending

The same principles apply to a descending microlight. Angle of descent relative to the ground will change, while rate of descent will not.

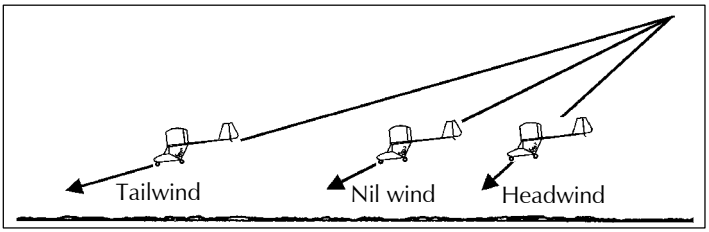


Fig. 64 Effect of wind on descent and glide angle.

Effect of Wind on Gliding

The same principles apply to a gliding microlight. The important thing to remember is that a headwind will greatly reduce the distance a microlight is capable of gliding, while a tailwind will extend the glide distance. **These are vital considerations during a forced landing.**

Effect of Wind on Turning

If you were to observe from the ground, a microlight with a smoke generator making a 360° turn of constant angle of bank and rate of turn, the smoke would describe a perfect circle even if there was a ten knot wind blowing. However, the microlight's ground track would look very different!

During the turn in the wind, the microlights ground track was affected by the wind. Let's use an example of a microlight flying with a direct crosswind from the path over the ground. If the pilot commences a constant rate turn to the left, the microlight will be helped along its groundpath to the left by the wind from the right.

Visually, it will seem that the microlight is accelerating rapidly and turning too fast for the angle of bank (slipping). The pilot may even feel that the aircraft is losing height.

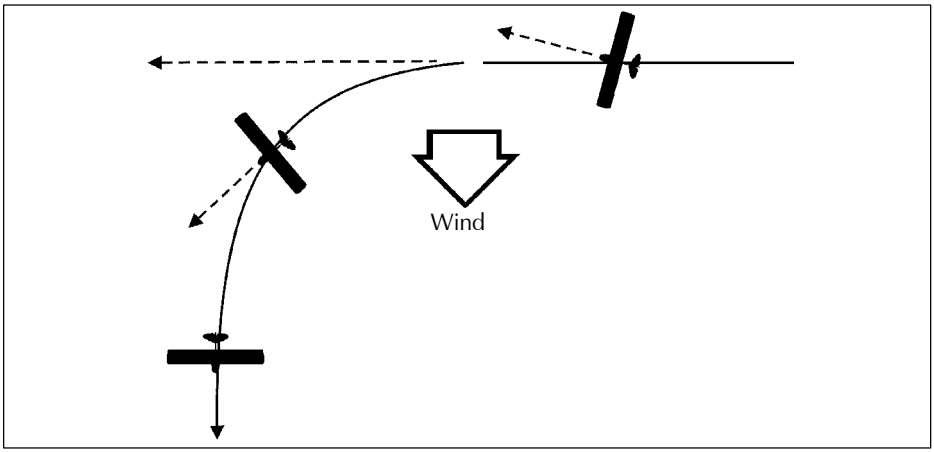


Fig. 65

Now the microlight is in the downwind portion of the turn and it seems to be going very fast because the ground is flowing by quickly. As the turn continues it will appear as though the aircraft is sliding out of the turn and that it is not turning very well. The pilot may tend to steepen the bank.

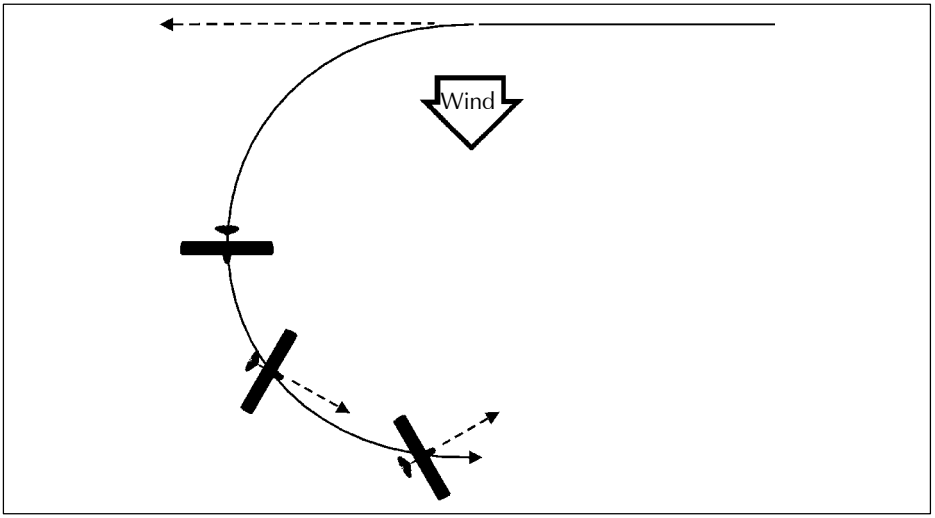


Fig. 66 *The microlight is now in the crosswind position again and it will seem to be flying sideways (skidding). As the turn continues into the upwind position it will appear to be slowing as the groundspeed reduces.*

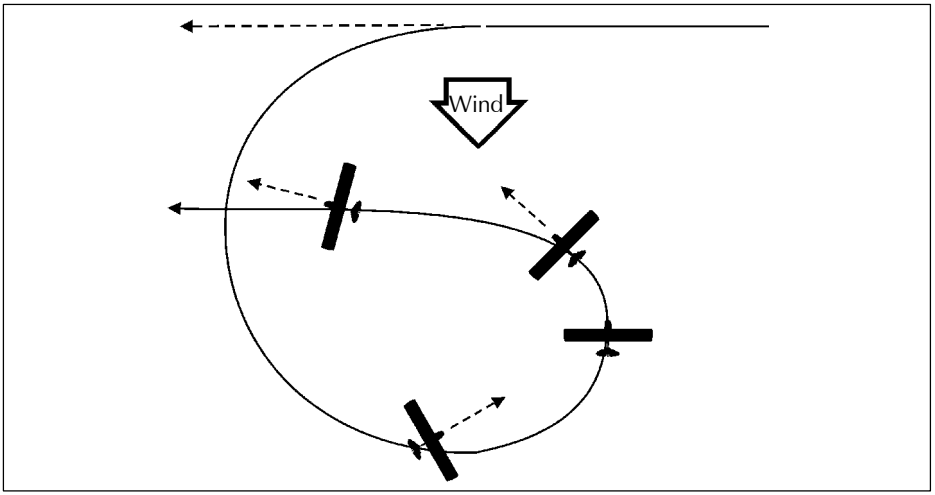


Fig. 67 *The turn is completed with another apparent slip to the left as it resumes its crosswind course.*

We can now see that reference to the ground gives a false impression of what the aircraft is experiencing while making turns in the wind. It is vital to fly balanced, correctly banked turns at the proper airspeed, disregarding any illusions gained from looking too closely at the ground.

"An aircraft is flown in relation to the air it is flying in, and not by reference to the ground."

However, there are times when we wish to fly a course in relation to the ground and it is here that we use our knowledge of how the wind affects our groundspeed and ground track, to adjust our path through the air to achieve the desired result.

The constant radius turn is an example. This is a turn where the desired result is a turn around a point on the ground which gives a ground track of constant radius around that point.
See Fig. 68.

In still air this is relatively easy as a constant rate turn will give the constant radius ground track around the point. If there is a wind blowing however, the turn will have to be modified, to compensate for the effect of the wind.

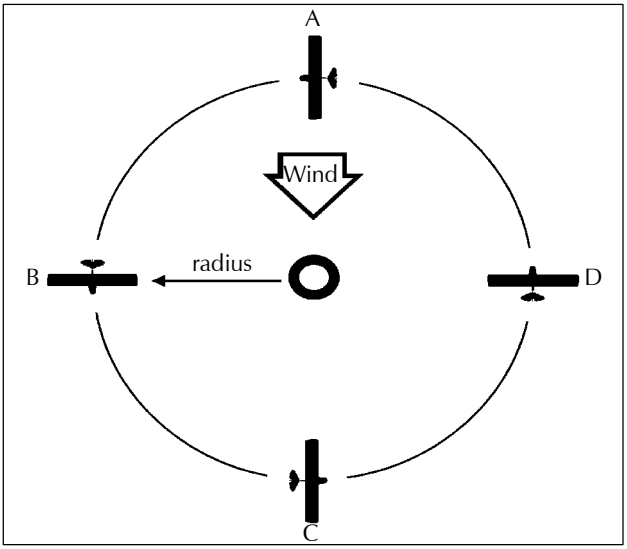


Fig. 68 Constant radius turn.

In our figure the turn is commenced at point A being careful not to use too much bank as the wind aids our path to point B. At point B the angle of bank will have to be increased until at point C the bank is at its steepest and starts to reduce again approaching point D and to point A again.

Remember:

- maintain correct airspeed and balance at all times.
- don't be fooled by illusions caused by groundspeed or ground track.
- use your knowledge of the effects of wind to your advantage.
- **the closer one is to the ground, the more dramatic the effects of wind appear.**

TURBULENCE

If the atmosphere in which we flew were always still, no pilot would have his microlight bounced around the sky. As it happens, our sky is almost always in motion. Some of this motion is smooth and some is quite abrupt or violent.

There are two types of turbulence – **Mechanical** and **Thermal** (or convection).

Mechanical Turbulence

If you have ever watched the water in a shallow stream, swirl and bubble over rocks submerged or partly submerged in it, then you have seen a close approximation of the action of air flowing over similar objects on the earth's surface.

Unfortunately we cannot see the air, but we can make a fairly accurate guess of the degree and type of turbulence to be expected for a given situation. As the microlight flies into disturbed air, its flight path is affected accordingly.

Whenever possible, try to observe the effects of mechanical turbulence by watching smoke or the movement of thistle "fairy" seeds as the breeze passes over the landscape. Even in light winds you will be surprised at what movements in the air these indicators show.

In an open paddock with some obstacles in it (barn or row of trees etc) one can stand in the lee and feel the turbulent flow, or wind shadow.

An awareness of mechanical turbulence is important, especially as many microlight operations involve airstrips closely surrounded by turbulence – producing objects and terrain, as opposed to the wide open space of big airports.

Let's look at some typical examples of mechanical turbulence.

Remember, any time the air is made to flow over or around an object, the airflow will be affected. Where the airflow is required to change direction abruptly, the flow will break up and become turbulent.

The extent and severity of the lift and sink in mechanical turbulence, increases sharply with increasing wind strength.

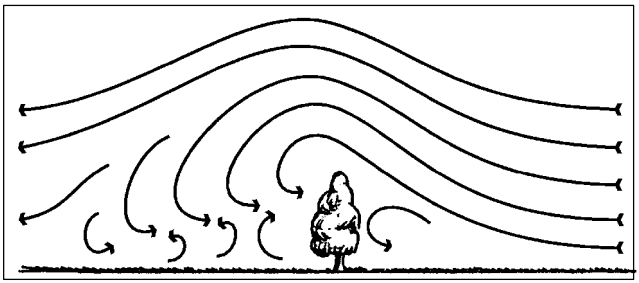


Fig. 69 Wind flow over a row of close thickly leafed trees.

Wind flowing over these trees (Fig. 69) will be forced to go over the top as not much air will be able to flow easily through. This will cause an abrupt change as the air rises over the row, and then behind will be an area of turbulent air as the flow breaks up. As a general rule allow at least 6 or 7 times the height of the trees downwind to be free of the turbulence in moderate winds.

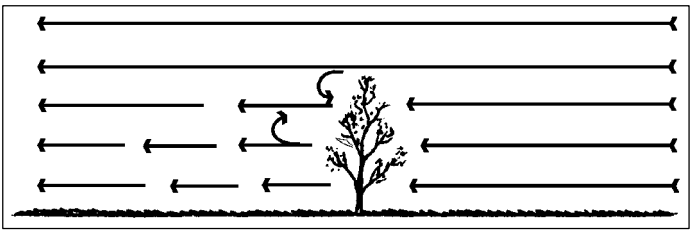


Fig. 70 Wind flow over a row of thinly leafed or less densely spaced trees.

If the trees are spaced apart or thinly leafed, then the turbulence may be reduced as a significant flow of air will be able to pass through the trees.

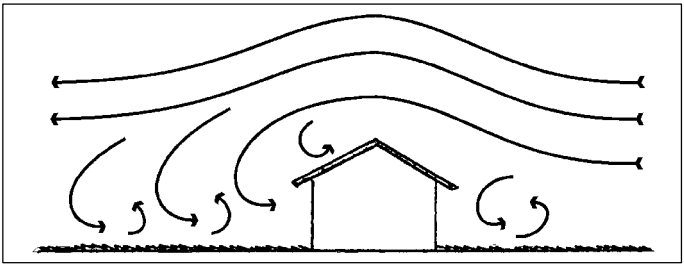


Fig. 71 *Wind flow over building. This is much the same as over trees.*

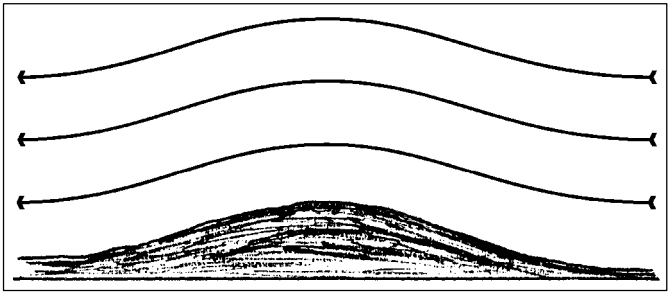


Fig. 72 *Wind flow over terrain. Wind flow over smooth gentle hills may produce little or no turbulence, only lift up–wind and sink down–wind.*

Effect of Wind Speed on Extent of Turbulence

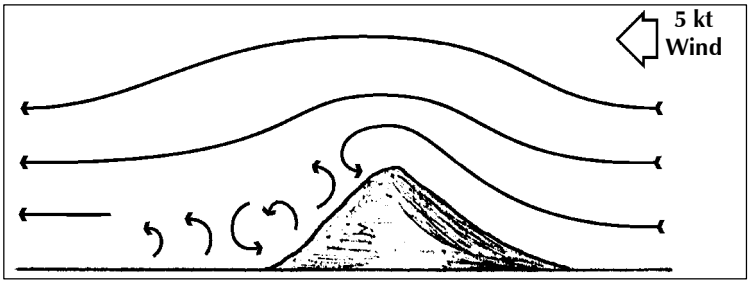


Fig. 73 *Effect of 5 kt Wind.*

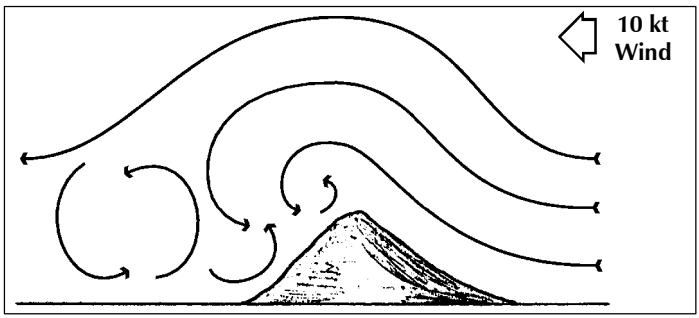


Fig. 74 *Effect of 10 kt Wind.*

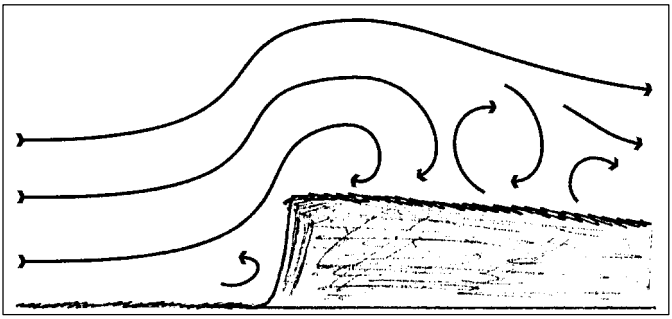


Fig. 75 *At the base of a cliff there may be a turbulent area and almost certainly behind the lip of the cliff it will be very dangerous.*

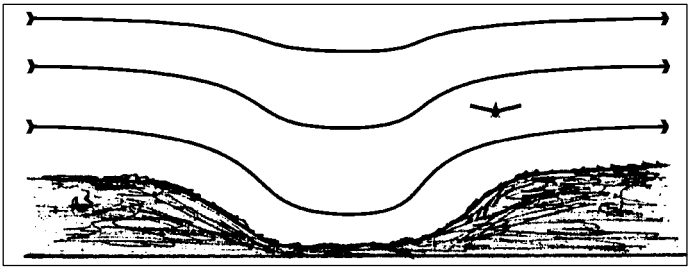


Fig. 76 *When flying along a valley with the wind blowing across it, stay on the down–wind side where the air will be smoother and rising.*

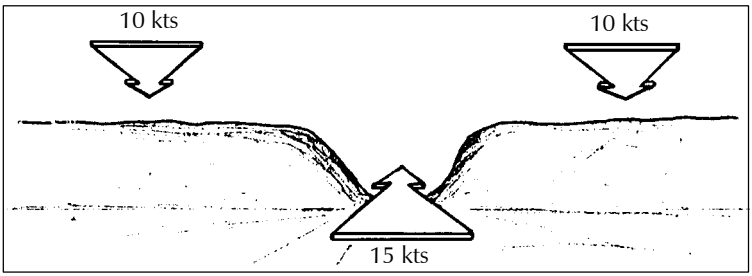


Fig. 77 *Wind speed increases when flowing through gaps in ranges.*

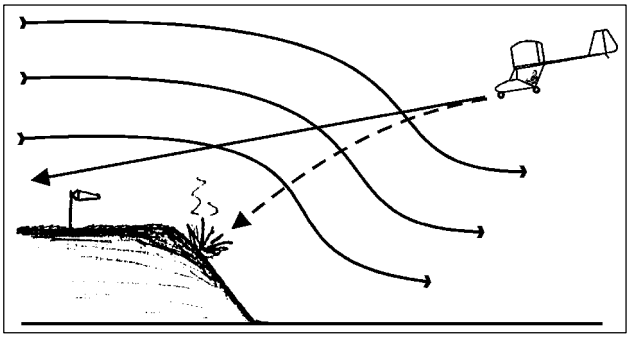


Fig. 78 *With a drop off the landing end of a runway, there is likely to be sink which will affect the glidepath.*

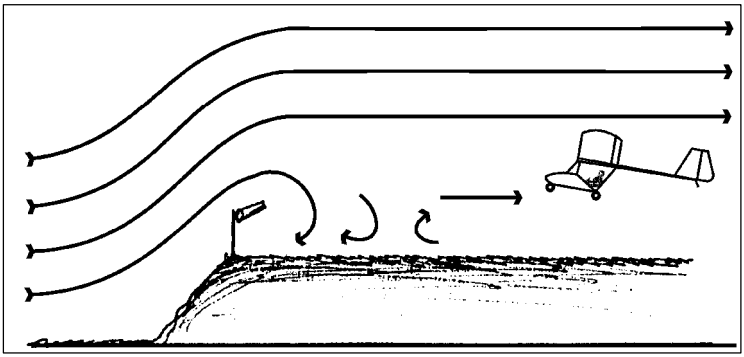


Fig. 79 *Likewise, with a drop off the takeoff end of the runway there will be sudden lift and even turbulence back from the edge.*

Flying into Lift and Sink

Flying into lift (rising air) momentarily increases the angle of attack of the wing as the relative airflow is changed. This will cause a drop in airspeed due to the increased drag of the higher angle of attack. If the lift is sufficient the microlight will rise.

Flying into sink (descending air) momentarily reduces the angle of attack of the wing as the relative flow is changed. This will cause an increase in airspeed due to the less drag of the smaller angle of attack. The microlight may descend.

When encountering lift or sink and the airspeed is altered, the microlight will try to return to its previously trimmed value.

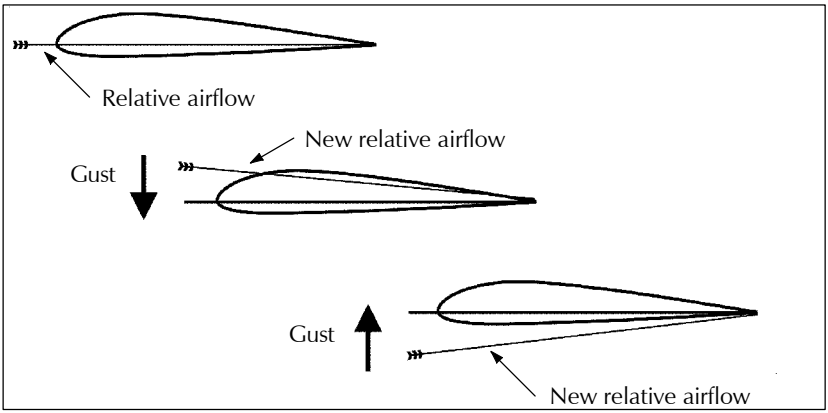


Fig. 80 *These vertical gusts causing rapid changes in angle of attack, impose stress on the microlight airframe. The load factor alters.*

Wind Shear/Gradient

Due to the friction the air experiences flowing over the surface of the earth, the wind speed near the ground is usually less than that at altitude. These effects are usually (but not always) small when the winds are light, but become greater when the winds are strong. Added to this is the effect of mechanical down draughts. Down draughts can cause a sudden decrease in the microlights rate of climb immediately after takeoff, or a sudden increase in the rate of the descent during the approach to landing.

The possibility of meeting such conditions creates a need for all pilots to be aware of the hazards associated with these variations in wind velocity during the takeoff and landing stages in particular.

Any variation of airflow velocity, whether it be horizontal or vertical, produces a shearing action between layers of air, hence the term "wind shear". The effects of wind gusts and associated turbulence can be appreciated fairly easily, but changes in the horizontal wind speed and/or direction will require more explanation. Lift is the force which overcomes weight and an aircraft obtains this lift from the angle of attack at which the wings are presented to the airflow and the speed at which it is flown. The higher the airspeed, the greater is the lift. Therefore, any sudden change in the wind speed or its direction relative to the aircraft will affect the lift being produced.

A microlight descending through layers of air where the wind speed is decreasing rapidly, will be penetrating a region of wind shear/gradient, the effect of which will temporarily lower the airspeed. Less lift will be produced and the microlight will descend more quickly.

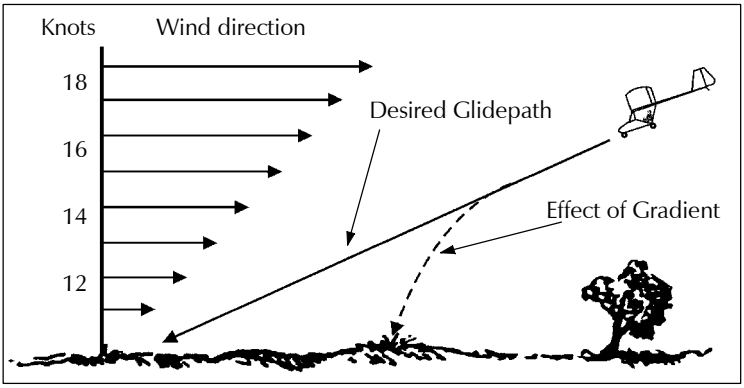


Fig. 81

When the gradient is gentle the pilot will have no trouble in lowering the nose of the microlight to regain its original airspeed, but if the wind gradient is rapid and pronounced he will need to act very quickly to re–adjust the microlights' airspeed, and also increase engine power to help arrest the descent.

Sometimes the effects of mechanical turbulence, thunderstorm activity, or an inversion, can create the effect shown in the illustration below.

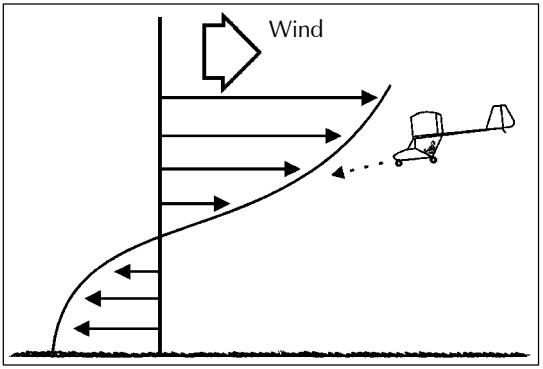


Fig. 82 In this case the wind direction has become temporarily reversed near the ground requiring very quick reactions from the pilot during the takeoff or landing phase.

Wind shear is a particularly common occurrence during thunderstorm activity, and can be met on any side of such an area. The wind shift line (or gust front) can precede a storm by 15–20 miles, consequently, when thunderstorms are within this distance wind shear hazards must be anticipated at any time.

A further note in relation to wind shear is that it is not necessarily associated with strong winds. For example, when a temperature inversion exists, a common situation is for very light or zero wind to be present at the surface although winds just above the inversion layer may be moderate to strong.

Thermal or Convection Turbulence

This is caused by the heating of the earth's surface which in turn heats the air in contact with it, and causes convection currents which over land reach their maximum intensity about mid–afternoon. If the rising air is moist, convection cloud will form – cumulus (Cu), strato cumulus (Sc), or possibly in very unstable conditions, cumulonimbus (Cb).

On days when these clouds are present expect to encounter both lift and sink associated with the convection process. In general, this lift and sink is fairly mild and the lift can even be used by a skilled pilot to enhance climb performance or even to sustain lift. However, when such thermal activity is vigorous the conditions can become very violent. The lift associated with the above–mentioned clouds can be stronger than the microlight's ability to descend through it. Thus, there can be a very real danger of being "sucked into" cloud, (discussed in meteorology) so as a general rule keep well clear of fast–growing towering cumulus–type clouds.

With the exception of thunderstorms or line squalls, the effects of turbulence are usually greatest near the surface or just below large cumulus clouds. These regions can normally be avoided during en–route flight. However, the altitude band in which microlights operate is somewhat restricted, and additional care will be needed when mountains or high hills have to be traversed. In these regions, very strong up and down currents are often present and they can produce considerable hazards. Undertake such flights only in the most ideal conditions.

Summary

Knowledge of turbulence is vital to any pilot. Being able to distinguish safe conditions from dangerous conditions improves the safety of operations immensely. Even the experienced pilot will on occasion be surprised by unexpected turbulence, but the important thing is to be ready to take action and to try and ascertain the cause so as to learn from the event.

Don't just regard the sky as something you make holes in with your microlight. Respect it for the living moving thing it is, and strive to understand its ways and habits.

Wave

Under certain conditions the airflow over a range of hills or mountains can set up an unusual "wave" in the lee.

It is a similar action to water ripples in a stream immediately after flowing over a boulder or rock, except, of course, on a grand scale.

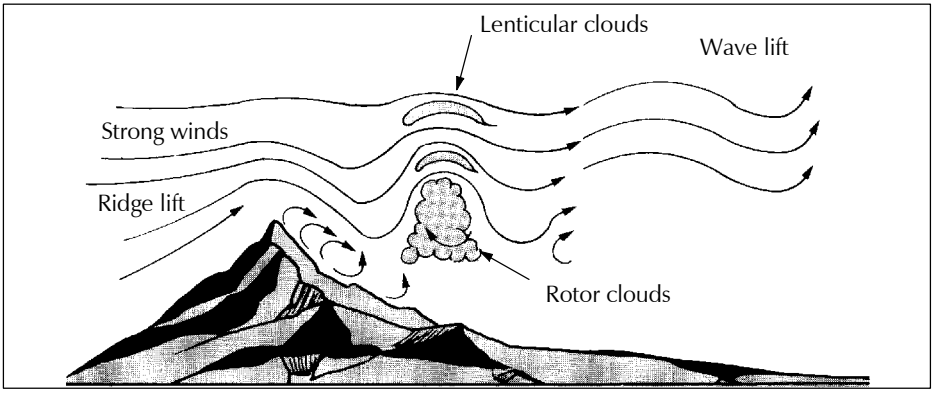


Fig. 83 *Long lines of lenticular clouds perpendicular to the wind flow, which remain stationary, are the prime indication of the wave conditions.*

Associated with wave are very strong lift and sink, and severe turbulence in the rotor areas which occur between each row of lenticulars. The rotor turbulence can be encountered at the altitudes microlights normally operate in, and has been responsible for in–flight destruction of aircraft.

Generally speaking, the wind required for the wave system to form would normally preclude microlight operations. However, if the surface winds are not excessive but a wave system is present, expect higher upper winds and violent turbulence in the lee of the ranges.

In some parts of the country, wave formations are often enormous, with the wave systems extending many miles downwind and with lift and sink in regions sometimes reaching the 30,000ft mark! Microlights are not suited to tackling wave conditions. Sometimes, smaller localised wave systems can develop.

Wake Turbulence

The following has been reproduced from the February/March 1984 Flight Safety Magazine. Although the discussion deals mainly with wake turbulence produced by aircraft of jet transport size, from a microlight pilot's point of view the wake from any other aircraft needs to be avoided. Light wing loading, low speeds and often less than sharp control response (especially roll) make microlights more susceptible to wake turbulence.

Vortex Generation

Lift is generated by the creation of a pressure differential over the wing surface of an aircraft, the lower pressures being above the airfoil. This pressure difference induces a rolling motion in the airflow behind the aircraft, producing swirling air masses which trail downstream from the wing tips. As the rolling motion is completed, the wake develops into two counter–rotating, cylindrical vortices, the characteristics of which vary according to conditions, aircraft configuration and changes of airspeed. They may be described as a pair of horizontal tornadoes trailing behind the wingtips.

Wake vortex strength is directly related to lift generated, size of the airfoil and angle of attack of the airfoil, and is generally inversely proportional to the airspeed of the generating aircraft. The greater the weight of the aircraft (fixed or rotor wing) the more intense will be the wake. The longer and broader the airfoil the greater the area affected. Tangential velocities of up to 85 metres per second (166 kts) within the vortex core have been recorded in trials conducted with Boeing 747 and 727 aircraft.

The danger to light aircraft from wake turbulence stems from the fact that this rate of roll easily exceeds their control capabilities, particularly when the affected aircraft has a shorter wingspan than that of the generating aircraft. As an indication of how powerful wake vortices can be, the

pilot of a Beech Bonanza approaching an airport in the US planned to pass above the altitude of an airliner that was on base leg for landing. At 1170ft AGL and indicating 160 MPH, the pilot heard a loud bang and felt a jolt. The control wheel jerked aft and the aircraft abruptly entered what the pilot described as a wings–level loop of some 3–5 seconds duration. After coming out of the upset manoeuvre he could not read his instruments because of severe vibration. After reducing power and airspeed, the vibration ceased and he completed a safe landing. Structural deformation was discovered on the right hand stabiliser.

The degree of danger associated with wake turbulence diminishes in direct proportion to the distance and time interval between the aircraft involved, and the height above ground at which it occurs. These factors directly affect the chances of recovery from an upset. Wake turbulence strength is likely to be at its peak when the generating aircraft is large, clean (flaps and landing gear retracted), and flying slowly, which suggests that a large aircraft in the holding configuration presents the greatest threat of wake turbulence.

Vortices generated near ground level typically last between one and two minutes, while those generated at higher altitudes can last as long as five minutes, leaving a trail of turbulent air several miles long.

Vortex Behaviour

The movement of these areas of violently disturbed air conforms to certain predictable patterns in most instances, enabling pilots to visualise the wake location and thus avoid the vortex core.

Vortices generated at altitude sink at a rate of 400–500 feet per minute initially, then gradually stabilise 900–1,000ft below the flight path of the generating aircraft. Eventually the vortices break up, the process being hastened by any atmospheric turbulence.

The cardinal rule for avoiding a wake turbulence encounter is to **keep clear of the area behind and below a generating aircraft ahead**, whether taking off, landing or flying en route. All precautionary techniques are based on that principle.

Pilots should be particularly alert to the possibility of wake turbulence in calm conditions and in situations where the vortices could:

- Remain in the touch down area.
- Drift across from an aircraft operating on a nearby runway.
- Sink into the flight path of an aircraft flying at a lower altitude.

Other rules of thumb are:

- Be particularly cautious when a light quartering tail wind exists on approach and a larger aircraft has already landed.
- Use the full length of runway available to help to keep the climbout path above that of preceding aircraft.
- Be alert for wake turbulence when a preceding large aircraft has executed go–round, or when your rotation point will be further along the runway than that of a preceding large aircraft.
- If you are in doubt about the possible existence of wake turbulence, delay the takeoff or execute a go–round.

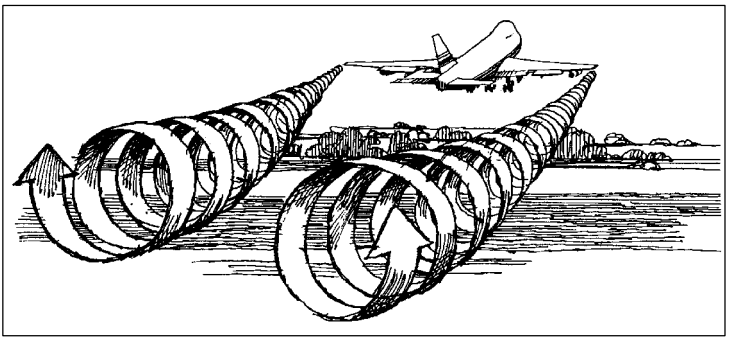


Fig. 84 *Wake generated behind a Boeing 747 on takeoff.*

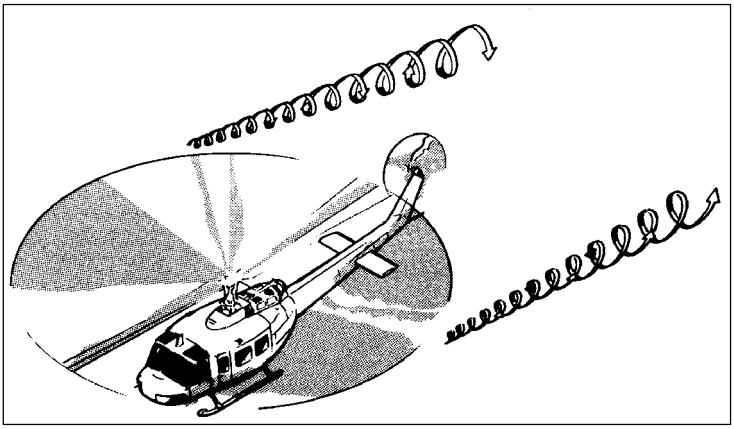


Fig. 85 *Wake generated by a helicopter in flight is similar to that of a fixed wing aircraft.*

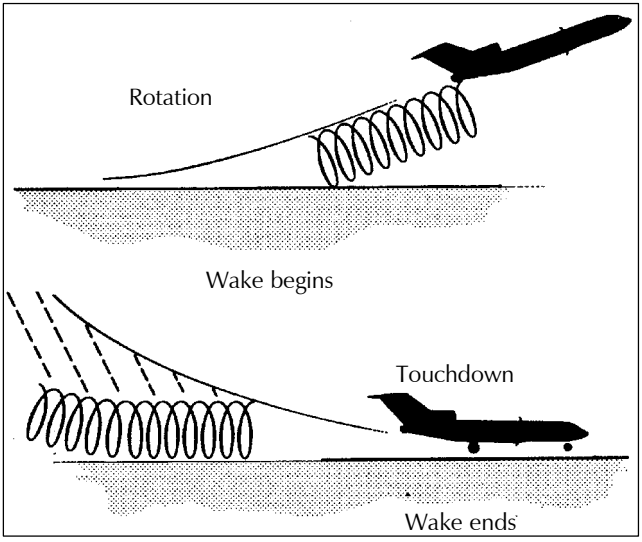


Fig. 86 *On nosewheel aircraft wake vortices are generated at the point of rotation for takeoff.*

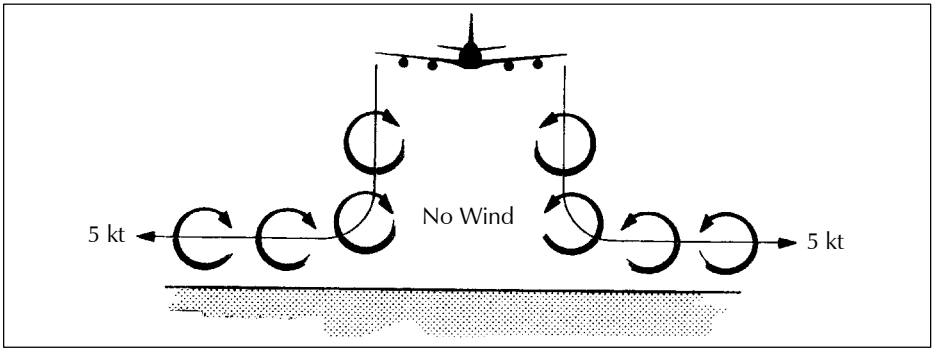


Fig. 87 *In nil wind conditions these vortices settle to the ground and then move outwards at a speed of about 5 knots.*

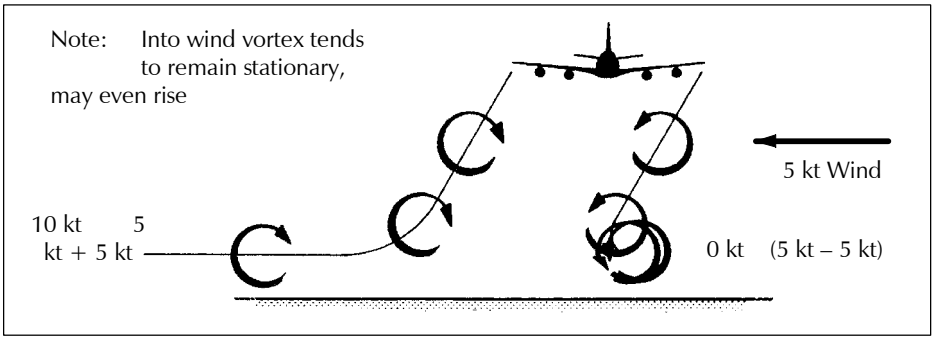


Fig. 88 *If a light crosswind is present, it will arrest or impede the outward movement of the upwind vortex while assisting the movement of the downwind vortex.*

METEOROLOGY

Introduction

This Chapter on Meteorology is designed to be read in conjunction with the book **"Weather to Fly for Recreational Pilots"** by W. J. Wagtendonk. Copies are available from the author at 155 Waipapa Road, Omokoroa, Tauranga.

The weather and its changing patterns has always been of interest to man. However, the degree of importance attached to it varies considerably between individuals. For example, a traveller by road or rail is only ever hampered by the severest of weather, whereas the pilot in his aircraft can have his flight affected by even slight changes in weather conditions. One could say that the ground traveller travels underneath the weather, while the pilot travels through the weather itself.

Weather conditions play a vital role in the operation of microlight aircraft. If microlight operations are safely planned, a knowledge of the anticipated weather conditions is a basic requirement and because weather forecasts cannot be guaranteed, either in their accuracy or availability, the pilot must develop a basic understanding of the elements involved in weather prediction, so that he/she can make sensible decisions prior to and during flight.

"The competent aviator has a sound knowledge of and respect for the weather and its relation to flight operations."

A microlight is an aeroplane and it operates in the environment of the air just like any other aircraft. It is therefore essential that a microlight pilot is aware of the problems which result from

deteriorating weather and has a basic understanding of how changes in the weather conditions can affect his operations. This does not mean that pilots have to be meteorologists, but rather they must have a basic knowledge of the weather elements and how they interact to produce good or bad flying conditions. They will also need to know the limitation of the weather forecasting services and be familiar with the methods of obtaining weather reports and forecasts.

Although it is the responsibility of the Meteorological Service to provide weather information to pilots in the form of forecasts and reports, it will always remain the pilots' individual responsibility to make wise decisions in respect of whether a planned flight can safely be made.

To the pilot, Aviation Meteorology could be summed up as consisting of four basic elements:

- Visibility.
- Cloud Base.
- Precipitation.
- Wind Velocity.

However, a pilot's role in relation to safe flight operations cannot be achieved unless he is conscious of how these elements may affect his own limitations and those of his aircraft. Therefore, although the information in the following pages is part academic, and part practical, it must be understood by any pilot if he is to become capable of assessing the hazards associated with various weather phenomena. Ignorance of this will lead him to taking chances, which in turn can easily result in the occurrence of dangerous "In–flight" situations.

The Organisation of the Meteorology Service

The organisation of the Meteorology Service is designed to fulfil three main functions:

1. To record information on past weather.
2. To report present weather.
3. To forecast future developments and to describe them in a weather forecast.

NOTE – The distinction between the last two functions should be clearly understood as it indicates the difference between a weather **Report** and a weather **Forecast**.

Ordering of Weather Forecasts

Weather forecasts should always be ordered through the National Meteorological Briefing Office in Christchurch. FreePhone 0800 654 957. They will read it out to you, or fax it to you at no charge. Avoid going through Air Traffic Control facilities if possible.

Metar (hourly) reports from most airfields throughout N.Z. are available to pilots on request, both prior to takeoff and while in the air. If in doubt, ask for a Metar Report. They are usually available around 10 to 15 minutes after the hour for manned airfields.

If your destination does not issue Metars then obtaining one from the nearest manned aerodrome could be of some use.

No pilot should take off on a cross–country flight without a complete understanding of his route and Terminal Forecast (at destination) or without the latest Metar reports of his destination, alternate and en–route airfields.

Special Weathers (specis) are significant changes in weather at aerodromes which could be a danger to aircraft, for example strong winds or very low visibility and/or cloud ceiling. Once a flight plan has been lodged or a pilot signifies to A.T.C. his intention to proceed enroute, past or to an aerodrome at which a Speci is in force, A.T.C. will inform the pilot.

The Weather Map

The weather map is the foundation of forecasting. It is simply a map showing weather conditions over any area with which one is concerned. Maps are normally drawn up by the Meteorological

forecaster every few hours. The weather information used in the preparation of a weather map consists of simultaneous observations of such elements as wind direction and speed, cloud form, amount and height, temperature, pressure, visibility etc, taken at a number of stations distributed over a wide area. When this information has been plotted on the chart and the forecaster has drawn in the isobars, fronts etc, the completed chart presents a view of the general weather situation as it is expected at the time when the observations were taken.

The weather map below gives a general picture of the weather situation over NZ at a given period.

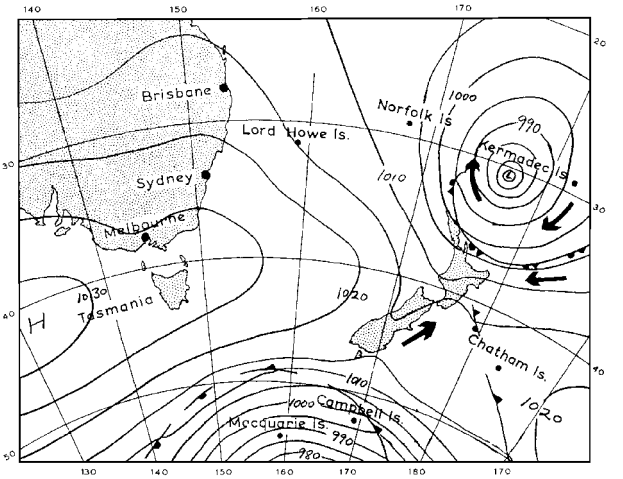


Fig. 89

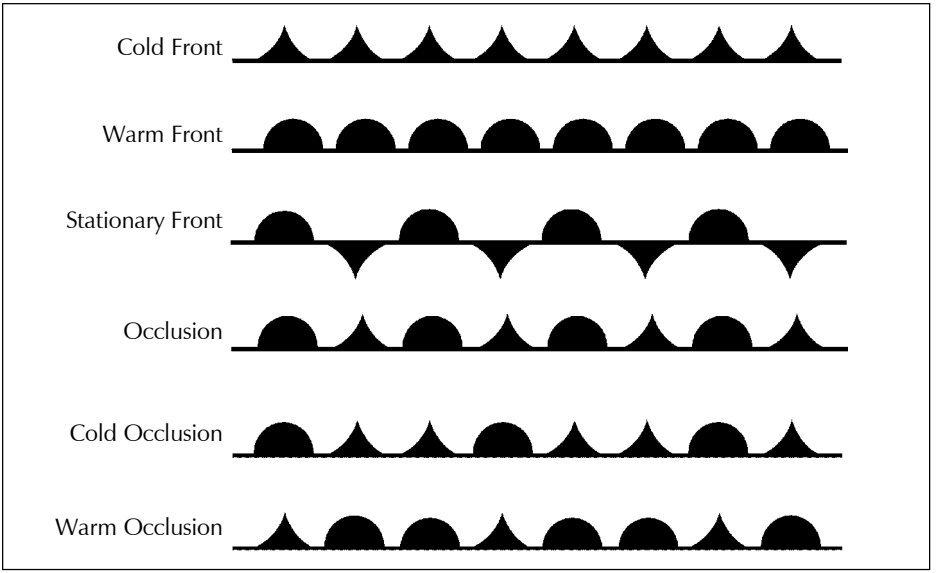


Fig. 90 Frontal Symbols.

The Atmosphere

The atmosphere of the Earth is comprised of approximately 4/5 volume Nitrogen and 1/5 Oxygen. It contains a small, but very variable amount of water vapour which by changing into water droplets or crystals, can form fog, rain, hail, snow, etc.

Atmospheric Pressure

The weight of the atmosphere results in what is known as atmospheric pressure and at sea level, this pressure is approximately fourteen and a half pounds to the square inch. To facilitate the calibration of instruments this pressure is commonly expressed in millibars or inches of mercury. Barometric pressure decreases with height, it varies from day to day and place to place, but is assumed to be 1013.2 millibars in the Standard Atmosphere at sea level.

The Standard Atmosphere is one of the assumed conditions for the calibration of instruments. It is sometimes referred to as the I.C.A.N. atmosphere and it assumes a sea level pressure of 1013.2 millibars and a temperature of 15 degrees centigrade, with a decrease in temperature of two degrees per 1,000ft.

Atmospheric pressure is the force per unit exerted by the weight of the atmosphere. Since air is not solid it cannot be weighed with conventional scales. Instead it is measured by means of either a mercury barometer or an aneroid barometer.

The mercury barometer is very accurate but too bulky for use in aircraft, so aircraft altimeters are the aneroid type. The aneroid barometer consists of a flexible bellows which is sealed after most of the air has been extracted from it. The bellows contracts or expands in response to the air pressure exerted on it. The unit of pressure now in general use is the millibar and a pressure of one millibar is equivalent to a force of 1,000 dynes acting upon a square centimetre.

Air Density

The rarified air at greater heights in the atmosphere is lighter than air near the ground. Its air density is less.

The less the pressure the less the air density.

The greater the air temperature the less the air density.

Aircraft and engine performance suffer in reduced air density.

As air density and pressure at around 10,000ft is only about 3/4 of normal M.S.L. (Mean Sea Level) value, above this altitude lack of oxygen can cause the pilot and passengers adverse physiological effects. We therefore do not fly without oxygen above 10,000ft.

The Pressure Altimeter

The dial of an aneroid barometer can be graduated in feet instead of units of pressure and the instrument can then become an altimeter. As the change of pressure with gain in altitude is not constant, the altimeter is constructed to read correctly under certain conditions known as the **International Standard Atmosphere (I.C.A.N.).**

This assumes:

- A sea level pressure of 1013.2 mbs at 15 degrees C.
- A temperature drop with height of 2 degrees C per 1,000ft.
- Up to approximately 36,000ft above which the temperature is assumed to remain constant at – 56.5 degrees C.

As the above conditions do not always prevail, for instance at times the air temperatures may remain constant or even increase with height, altimeters are not always completely accurate.

Altimeter Subscale Settings

Altimeters can be expected to give the correct reading when they have been correctly set. That is, the position of the needle adjusted to read zero when the altimeter is at the airfield level when

carrying out circuit practice, or to read the airfield height above sea level when on the airfield if doing cross country or local flying. These settings depend on the air pressure which varies, so the correct zero setting also varies. Different pressure settings can be adjusted by use of the knurled knob to set the correct pressure setting in the altimeter subscale box.

QFE

When an altimeter is set to read zero on a particular airfield it will only indicate when airborne the height of the instrument in relation to the airfield. This setting is known as QFE and in N.Z. is sometimes used for circuit flying ONLY.

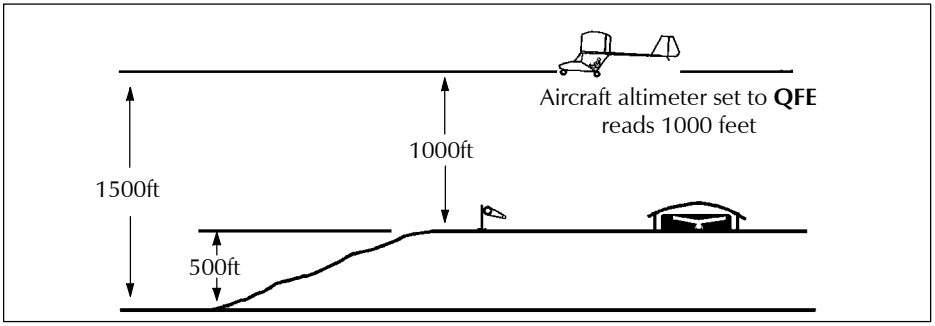


Fig. 91 *QFE is therefore the altimeter set to read the airfield level pressure, when set the altimeter will read zero on the airfield.*

QNH

When the altimeter is set to read the height of the airfield above M.S.L.(mean sea level) when airborne, the altimeter will indicate the height of the aircraft above M.S.L. This setting is used at all times in N.Z. except occasionally during circuit practice.

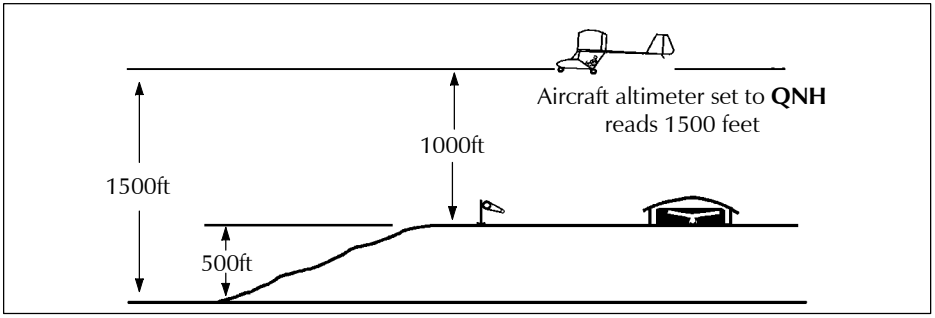


Fig. 92 *QNH is therefore the altimeter set to airfield level pressure converted to M.S.L. pressure using the I.C.A.N. atmosphere.*

The altimeter when set will read the height of the airfield above M.S.L.

Values of QNH are always available from Air Traffic Control as required and are the pressure settings always given unless otherwise requested by the pilot. The area QNH is normally given by A.T.C. upon every radio contact and acknowledged by the pilot by reading back.

As an aircraft climbs the pressure decreases and the altimeter indicates an increase in height. Therefore, when flying from an area of high pressure to an area of low pressure the altimeter will read high and vice–versa.

Remember: **High – Low – High** = When flying from high to low pressure the altimeter will read high.

Low – High – Low = When flying from low to high pressure the altimeter will read low.

Isobars

We have learnt that the atmosphere has weight, and due to the uneven heating of the earth's surface the atmosphere tends to "pile up" and "thin down" in various places causing a direct effect on the weather. These horizontal pressure differences provide the force which moves the air over the earth's surface and so produces wind.

Due to the rotation of the Earth, these large pressure differences tend to move in certain general directions in various parts of the world. In NZ they tend to move from the West to the East, causing our changes in weather.

Observations of barometric pressure made simultaneously at many locations and corrected to M.S.L. pressure, are plotted on weather maps, but the pressure distribution is not apparent until the isobars are drawn in.

An Isobar is a line on a weather (synoptic chart) map joining places of equal pressure at the same height. On your newspaper and TV weather map the isobars are drawn in at M.S.L. Isobars make up certain well–defined patterns to which special names are given.

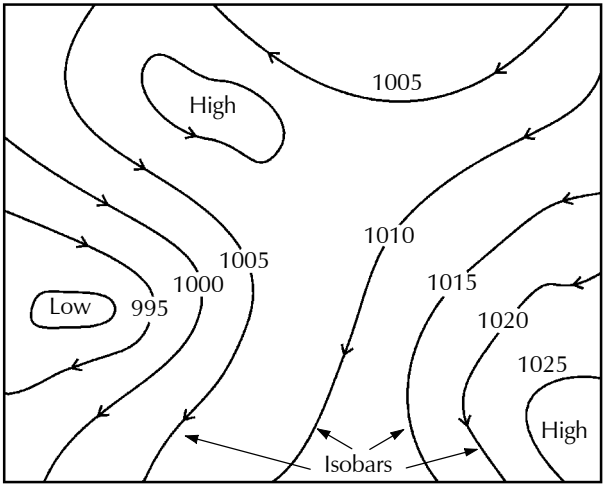


Fig. 93

A Depression or Low is a region of low pressure shown by one or more less concentric isobars enclosing an area where the pressure is lowest. The isobars are generally fairly close together.

An Anticyclone or High is a region of high pressure shown by more or less concentric isobars enclosing an area where the pressure is highest. The isobars are generally further apart.

A trough of Low Pressure is indicated by isobars extending outwards from a low with a higher pressure each side.

A Ridge of High Pressure is indicated by isobars extending outwards from a high with areas of low pressure each side.

These defined patterns, or more correctly, pressure systems, move across from West to East and on proceeding weather maps the pattern of isobars tend to retain their shape, but will be seen to change as depressions deepen or highs intensify. The various types of isobaric configurations are in general associated with certain types of weather and are therefore of particular importance

to forecasting. Knowledge of the weather to be expected from the various isobaric configurations can be gained from a regular study of your local newspaper and TV weather map and associated forecast.

Air in Horizontal Motion and Wind

Winds are of major importance to microlight pilots. For every takeoff and landing a pilot must consider wind direction, strength and gustiness. On cross–country flights wind must be considered because of its effect on the track and groundspeed.

In a weather report or forecast, wind speed is always described in knots and the direction in **degrees true**, or in points of the compass.

The direction is always given from which the wind is blowing, i.e. 090/25, the wind is from the East blowing at 25 knots.

Generally the wind will back with gain in altitude and increase in strength. A wind is said to **back** when it changes anti–clockwise and to **veer** when it changes clockwise.

Gusts are short sudden increases in wind strength and often change in direction. Their cause is due to mechanical effects such as trees, hangars, etc.

Squall is a blast of wind which sets in suddenly, lasts some minutes, then dies away. They are caused by some weather feature such as moving thunderstorms. Squalls often cause a complete change in wind direction for their duration.

Gales are said to occur when the surface wind has reached an average speed of 34 knots or more.

Fohn Wind

A warm dry wind blowing down a mountain range. As a prevailing wind blows up a mountain range, it loses its moisture due to adiabatic cooling then goes down the other side gaining heat due to adiabatic heating of dry air. This is a Fohn wind such as our westerlies and Canterbury's nor–wester.

Land and Sea Breezes

These are a feature of coastal districts in settled weather with sunny days and cloudless nights. The microlight pilot should be aware that the effects of a sea breeze can be noted 10 or more miles inland from the coast on occasion, and may or may not be anticipated in a forecast.

Sea Breeze

During the day the land heats up more rapidly than the sea. The air in contact with the land heats up by conduction, becomes less dense, and so rises in the form of convection currents or thermals. The colder more dense sea air then begins to flow toward the land to replace the air that has risen. This can set up the on–shore wind we know as the sea breeze, and it occurs during the day, getting stronger as the day progresses, having its maximum strength around mid–afternoon, and dies away towards evening.

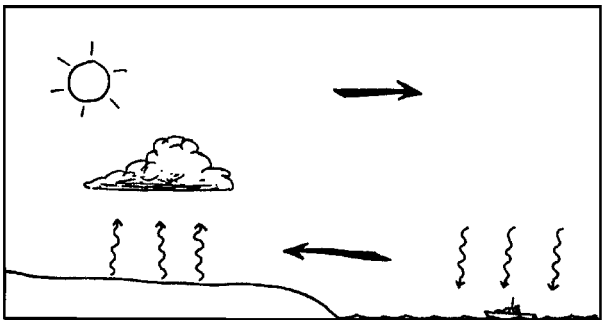


Fig. 94 Sea Breeze.

Land Breeze

A Land Breeze is the reverse of a sea breeze. It tends to occur at night when the land cools more rapidly than the sea and the air over the land becomes colder and more dense than the air over the sea, resulting in a land breeze which sets in only after dark reaching its greatest strength before sunrise.

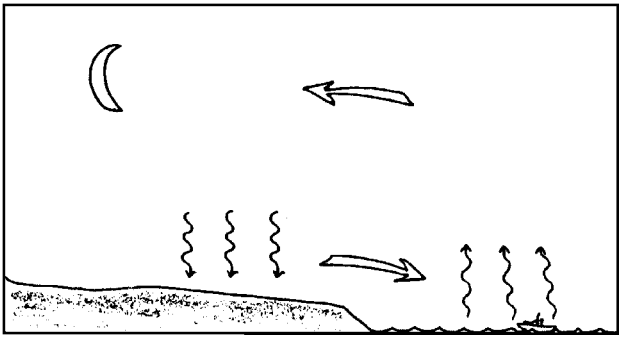


Fig. 95 Land Breeze.

The most common small–scale effect experienced in hilly terrain is the daytime upslope winds and the evening downslope breeze.

In the morning when the sun begins heating the valleys, the different pressures created in the air causes a light breeze to begin drifting up the slopes of the hills. The upslope wind is known as a valley or anabatic wind. Valley winds are the strongest in summer when the sun's heating is the greatest.

Downslope winds are termed catabatic or mountain winds. They occur in the evening when the valleys begin to cool. The air lying over the surfaces of the slope cools and slips downward, filling the valley. As the valley fills, the air in the centre is lifted so that a pilot flying in the evening usually finds a better climb rate in the middle of the valley than above the slope (in the absence of ridge lift).

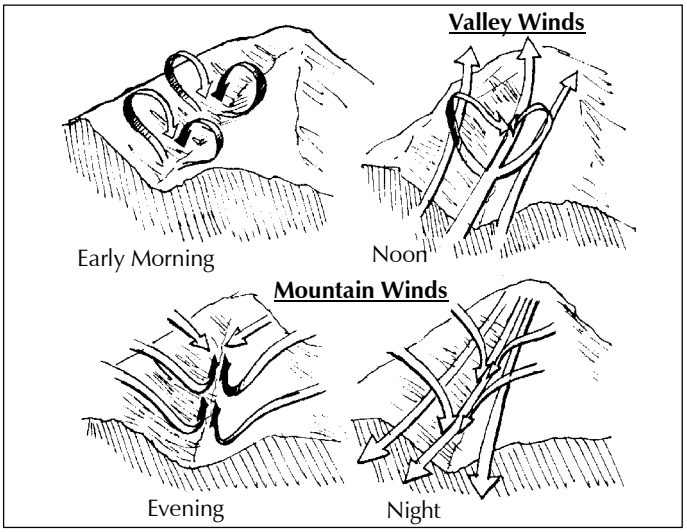


Fig. 96 Circulation due to Solar Heating.

Temperature and Humidity

Air temperature and the way it changes horizontally, vertically, and with time, largely governs the development of the weather. The sun warms the earth by radiation of its heat without heating the atmosphere through which it passes, and the earth in turn warms the atmosphere by conduction. This observed lapse rate can vary considerably in the lower 10,000ft depending whether a cold or warm front has passed through. The earth heats the air in contact with it by the process of conduction; this warm layer of air expands and rises, and thus a thermal is formed.

Inversion

Generally air temperature decreases as we ascend. If at any time there is an increase of temperature with gain in height, this condition is known as a temperature inversion. An example of this condition is when, during a cold clear night, the air in contact with the ground cools more rapidly than the air at a higher level. This will cause an inversion. If the temperature remains constant as we ascend through an applicable layer, then this is called an **isothermal layer**.

We can often see an inversion when flying in haze. After a long period of fine anti–cyclonic weather, the upper air has also become warmed and all atmospheric impurities or smoke and dust are trapped beneath the stable layer of inversion.

Water Vapour

The atmosphere contains water vapour which under certain conditions can condense into millions of tiny droplets of water or ice crystals, which construct clouds and fog. Water droplets and ice crystals tend to fall from clouds under the influence of gravity. Some are supported by rising air currents but others reach the ground in the form of rain, hail or snow.

Air is said to be saturated when at a given temperature it contains the maximum possible amount of water vapour. The temperature at which any given parcel of air becomes saturated is known as its **dew point**. Once air has cooled to its dew point, any further cooling will cause condensation to take place. That is, the water vapour will turn into water droplets, thus forming clouds, fog or ice crystals if the temperature is low enough. Condensation can be seen on a glass of cold drink, when the air comes in contact with the cold glass, it cools to its dew point and condensation occurs.

Relative Humidity

Is the term used to express the amount of water vapour present in a sample of air, in comparison to the amount that the air could contain at the same temperature before it becomes saturated, that is, reaches its dew point.

Latent Heat of Condensation

When a solid melts or liquid boils to form vapour, heat is absorbed without any rise in temperature. When a liquid solidifies or vapour condenses, heat is given off without any change in temperature. The latent heat of condensation is the amount of heat given off to change a unit mass of vapour into liquid. Therefore, we can expect a cloud that is forming to be giving off heat and thus increasing the convection currents within that cloud.

The opposite applies to a decaying cloud, hence the greater rate of sink experienced under such clouds.

Air in Vertical Motion

The vertical currents of air, or up and down draughts, are all that a glider relies on to climb in and fly through, and they affect a microlight by causing the flight to be turbulent or bumpy. Actually, the knowledgeable microlight pilot can use this lift in the same way as glider pilots do, enabling fast climbs to altitude using little fuel for example.

These vertical currents vary in strength, reaching violently destructive forces in thunderstorms (towering cumulus and cumulonimbus clouds). These clouds must be given a wide berth by microlights as the turbulence generated (especially by cumulonimbus Cb) can extend 15 to 20 miles away!

"The danger from these developments cannot be overstressed."

The interior is a freezing hell of incredibly strong vertical currents, hail and lightning. To enter a Cb would probably result in one being turned into a twisted flesh and aluminium hailstone, and that is no exaggeration. Even large aircraft go around Cb's.

Other air in vertical motion exists in the lee of hills and mountains, and is discussed in the turbulence section.

Stability of the Atmosphere

The intensity of vertical air currents depends on the stability of the atmosphere. In a stable atmosphere a parcel of air tends to resist being displaced vertically and if displaced will return to its original height. On the other hand, in an unstable atmosphere, the air so displaced will continue to rise or fall until its temperature reaches that of surrounding air.

If a parcel of air is raised for any reason, due to the lowering of pressure through increased height, it will cool down, (like air escaping from a cylinder). If it is lowered (downdraught) due to an increase in pressure it will heat up, (like air does when you pump up a tyre). This is known as adiabatic temperature change, and dry air will lose 3 degrees for every 1,000ft or approximately 1 degree for each millibar change of pressure. Moist or saturated air on the other hand, will only lose 1.5 degrees C for every 1,000ft. This is because latent heat is given off.

Flying Conditions – Unstable Air

A pilot flying in unstable conditions is likely to encounter clouds of the heap or cumuliform type, possibly containing quite violent down draughts, the flight will be bumpy and there is likely to be showers and possibly thunderstorms.

Flying Conditions – Stable Air

A pilot flying in stable conditions will have a smooth flight and any cloud encountered will be of the layer type. The weather will usually be fine although drizzle cloud may occur. Surface visibility will be moderate to poor owing to the concentration of atmospheric impurities beneath the stable layer.

Often fog or mist or haze could be experienced in these conditions. Visibility above an inversion layer or above cloud will be good, but remember it is illegal to operate a microlight above cloud.

Clouds

Not only do clouds obscure ground features and other aircraft, but they often envelop high ground and may be associated with turbulence or ice formation.

Cloud cover is Sky clear, Few, Scattered, Broken, or Overcast.

- Sky clear (SKC) = 0/8.
- Few (FEW) = 1–2/8.
- Scattered (SCT) = 3–4/8.
- Broken (BKN) = 5–7/8.
- Overcast (OVC) = 8/8.
- Cloud base is given as the lowest point at which the base is likely to form.
- Cloud base in weather reports and terminals is given as the height above the airfield level. In route forecasts it is given as the height above mean sea level.

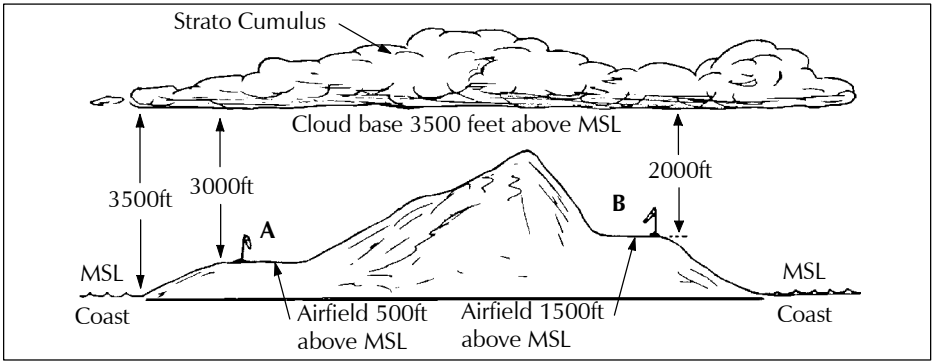


Fig. 97

In the above, if a flight route forecast was required for a coast to coast flight, the cloud base would be given as 3,500ft. A terminal for airfield **A** would give the cloud base as 3,000ft and for airfield **B**, 2,000ft.

Cloud Classification

Class	Family	Abbreviation	Likely range of cloud base and tops
High	Cirrus	Ci	20,000 to 40,000
	Cirro–stratus	Cs	20,000 to 40,000
	Cirro–cumulus	Cc	20,000 to 40,000
Medium	Alto–cumulus	Ac	7,000 to 20,000
	Alto–stratus	As	7,000 to 20,000
Low	Nimbo–stratus	Ns	1–2,000 to 2–7,000
	Stratus	St	500 to 2–4,000
	Strato–cumulus	Sc	1–2,000 to 2–4,000
Marked vertical development	Cumulus	Cu	1–3,000 to 7,000
Marked vertical development	Towering Cumulus	TCu	1,000 to 10,000
Marked vertical development	Cumulo–nimbus	Cb	500 to 20–40,000

Strato or stratus refers to a layer type cloud.

Nimbo or nimbus refers to a type of rain producing cloud.

Cloud consists of water droplets or ice crystals or a mixture of both. At temperatures above 0 degrees C (freezing point), clouds consist almost entirely of water droplets, whereas at lower temperatures and at cirrus cloud level, ice crystals predominate.

Water droplets do not necessarily freeze immediately the air falls below freezing point. Small droplets can persist to temperatures as low as –40 degrees C and are called supercooled. They are the most common cause of airframe icing.

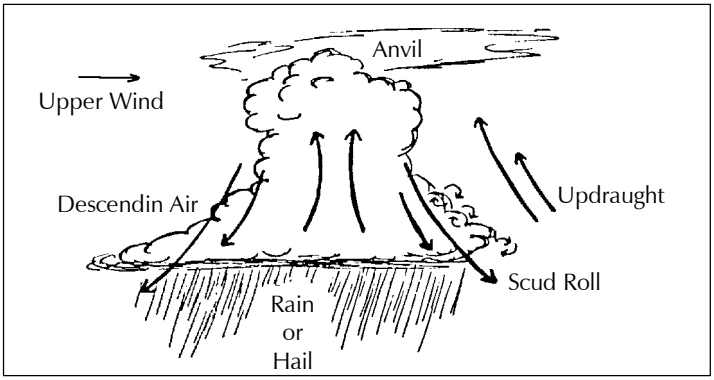


Fig. 98 *Cumulo Nimbus Cloud and associated turbulence.*

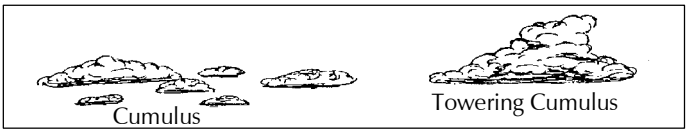


Fig. 99 *Cumulus types indicate instability in the atmosphere, thermal activity.*

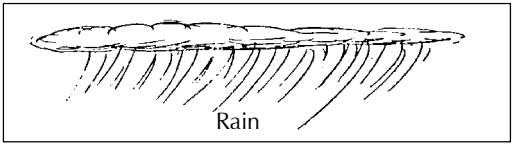


Fig. 100 *Nimbo – stratus. Fairly continuous layer, often dark looking with widespread rain.*

Fig. 101 *Stratus. Fairly continuous layer. Smooth conditions.*

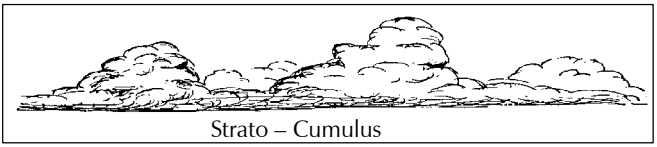


Fig. 102 *Fairly continuous layer with cumulus type development.*

Figs. 100–102 are stratus type clouds which are often in contact with the terrain.

Cold Front

When a cold air mass is displacing a warm air mass, then a cold front is said to exist at the intersection. Cold fronts usually travel at around 10–15 knots, and pass fairly quickly. It is preceded by cumulus and cumulonimbus clouds forming a “rain belt” usually some 50–60 miles through.

Flying conditions prior to the cold front are usually increasingly turbulent, with generally high cloud and good visibility. As the front passes there is likely to be heavy rain – perhaps hail and thunder. The wind may veer a little with squalls dying out as the front passes.

Behind the front the weather will be quite good with good visibility and ceilings.

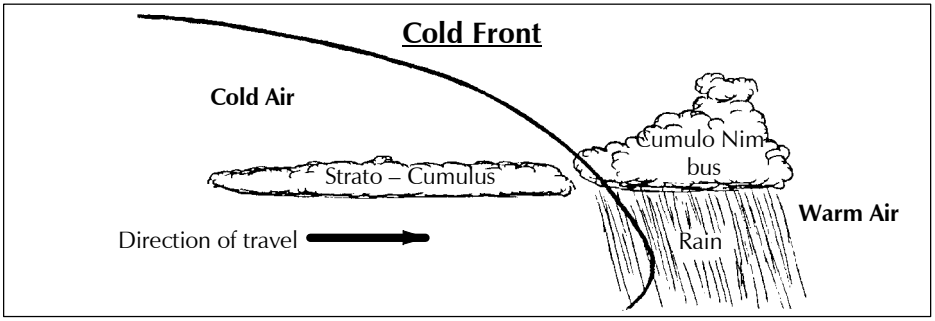


Fig. 103

Warm Front

When a warm air mass displaces a cold air mass, then a warm front is said to exist at the intersection. Warm fronts pass slowly and are preceded by some 500–600 miles by cirrus and cirro–stratus cloud. As the front approaches, the cloud will thicken and the base will lower. Rain will usually begin 250–300 miles ahead of the front.

Flying conditions prior to the front are not good, with poor visibility, rain and possible airframe icing. As the front passes the rain or snow may stop or reduce but visibility will remain poor, often with fog or mist.

Behind the front the weather will be fair or drizzly with continuous poor visibility. Fog or mist may remain.

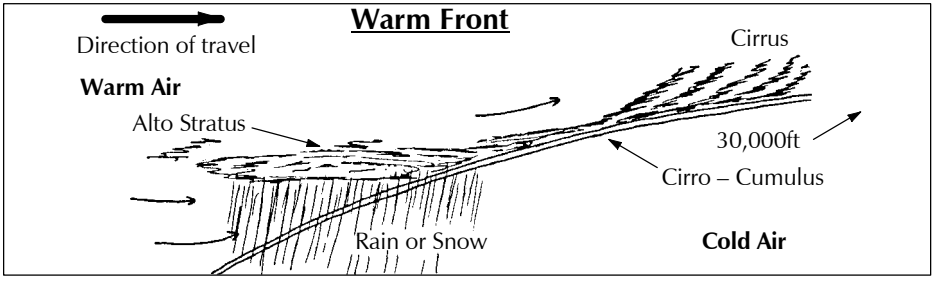


Fig. 104

At times a front may remain stationary, it is then known as a stationary front. It is represented on a synoptic chart by an alternate red and blue line or by:

Fig. 105 Stationary front

As a cold front moves at a higher speed than a warm front, it is common for the cold front to overtake the warm front. The front is then said to be occluded. It will then slowly disperse. It is represented on a synoptic chart by a double red and blue line or by:

Fig. 106 Occluded Front

Fog (Radiation Fog)

Fog is really only cloud formed close to the ground. Fog occurs on cold clear nights in settled weather with a wind of less than 10 knots.

During the night the Earth's surface cools rapidly and cools the air in contact with it.

- If the dew point of this air is reached, dew will form on the ground.
- If there is a wind of less than say 10 knots, fog will form.
- If there is more than 10 knots of wind, low stratus cloud will form.

If fog forms it will tend to thicken for a period around sunrise due to the mixing of air by convection currents. Once the temperature rises above the dew point of the air, the fog will disperse. If there is cloud cover above the layer of fog, the fog may persist for a long period – perhaps all day.

Any microlight pilot who considers taking off with the intention of climbing above the fog and expecting it to disperse by the time he lands is not only breaking regulations, but is asking for trouble. It is impossible to gauge the thickness of fog from the ground, and it could easily be several thousand feet thick, despite the tempting blue "holes" one can sometimes see. Furthermore, even if he managed to control the microlight long enough to get "on top" without reference to the ground he will soon be lost and the fog may last longer than the fuel supply!

The tendency is to not take fog seriously and this is sad because it holds the same dangers as any other cloud flying. (See Cloud Flying section.)

General Weather

Getting to grips with meteorology may seem a difficult task initially and it is in fact a very complex and diverse field, but the microlight pilot who has the basics along with good observation skills can soon become a good judge of weather. Don't just look at the sky on days you are about to go flying. Evaluate the weather every day by listening to radio–forecasts, looking at newspaper and TV predictions, and relating this to your own observations.

Become a habitual sky–watcher, noting wind direction and strength along with cloud development as the day progresses. On days with cumulus developments for example, you can watch the cycle of the cloud's birth, growth and decay. Some days you will observe the growth of many cumulus to form a continuous layer as they merge together. This is called over development. With the sun blocked out, the thermal source of this growth is cut off, and the cloud decays to begin the cycle again.

Such things go largely unnoticed by the public, but the microlight pilot should develop a weather eye that notes what is happening in the atmosphere every day. Those newspaper weather maps provide an interesting study. For an exercise, cut out and keep each days map for a couple of weeks and you can form a "cartoon strip" of the weather. Add your own observations each day and see how this fits with the prediction.

A useful point to remember is that the closer together the isobars are, the stronger the wind will be at that place.

WIRE STRIKE

Because of the nature of microlight operations, where paddock landings and farm airstrip operations are common, the possibility of flying into wires is relatively high. No pilot can afford to be complacent about wirestrikes.

Firstly it must be stated that as far as the Ministry of Transport is aware there are no wires anywhere above 500ft above ground level (AGL) in NZ.

The first defence against wirestrikes therefore is to **avoid unnecessarily flying below 500ft AGL.**

It is the takeoff and landing where a wirestrike is most likely.

Can't we see the wires? Yes, but only under ideal conditions. In fact, the odds of actually sighting the usual country power line or telephone wire from a safe distance (in flying terms) while airborne, are small. Against a plain contrasting background such as the sky, the wire is more likely to be seen.

The second defence against wirestrikes is to be aware of wires, to think wires. What is needed is an active awareness of the possibility of wires at low altitude. If the wire itself is difficult to see then the pole or pylon supporting it may be easier to spot. Electric fence wires strung across valleys and paddocks by farmers are probably the most difficult to see especially as the supporting pole may be small or even a tree or shed.

Ask the property owner and other pilots about any wires in the area and keep in mind that wires do literally appear overnight!

Inspect any prospective landing field very carefully for wires on the approach and overshoot either by visiting first on foot or with extreme care from a safe height when airborne. During the airborne reconnaissance, use circling manoeuvres as these will vary the light conditions and reflections and thus increase the chances of detecting wires or their supports. Finally make a lower level reconnaissance if possible, which may enable you to detect some wires that were not visible when viewed against the background of mother earth.

If in doubt, fly above the height of the supporting poles or pylons. Remember that there may be an earth wire running **above** the power wires.

Cross lines at an angle, and over, or at least near the pylons. The angled crossing gives an easy turn away if the height of the wires has been misjudged. If you can see high–tension transmission lines, beware of the earth wire that is often strung above them. Again, above pylon height will keep you above trouble.

Don't attempt to "just miss" wires, but give them a wide berth. Judgement of distance can be very difficult.

If you have to takeoff or land over wires, your main defence is a thorough understanding of the performance and capabilities of both your aircraft and yourself. Microlight pilots, in particular, need this skill for outlandings.

Electric fences used by farmers for grazing control can be extremely hard to spot. While some types of wire and standards used are brightly coloured they can still be virtually invisible to the pilot until very near.

Probably the easiest indication of the possible presence of an electric fence are variations in the colour of the surface of the paddock as it is grazed down. From the air this is readily apparent, but of course, only after stock have been grazing for some time.

Beware of support wires for aerials which can be anchored quite some distance from the structure itself.

CLOUD FLYING

Illegal? You Bet!!!

In flight we rely primarily on our sight to tell us which way in relation to the ground we are orientated. Take away our visual reference to the ground and even our balance sensing inner ear mechanism is of no use whatsoever.

In an aircraft with three–dimensional movement, without the help of visual contact with the ground, our brain gives us completely false sensations of "which way is up" (known as vertigo).

The microlight pilot who flies into cloud is suddenly enveloped in a damp, grey, featureless environment, and **visual contact with the ground is lost**. In a very short time (seconds) the pilot will be misinformed by his senses as to which way is up, and will move the controls according to this false impression, leading to erratic and uncontrolled flight. This could easily lead to overstressing of the airframe.

No matter how good you think your sense of balance may be, nor how experienced a pilot you are, the reality of vertigo is that you **WILL** suffer from it. Even pilots of suitably equipped larger aircraft in instrument conditions sometimes feel quite sure their instruments are wrong. Their senses tell them one thing, while the instruments, functioning perfectly, tell the undisputed truth.

Don't kid yourself that your microlights' inherent stability will keep things on an even keel until you emerge from the cloud. The interior of some clouds is violently turbulent with rain, hail, airframe icing and lightening.

Sometimes, when flying in reduced visibility, such as too close to cloud base or in light fog or rain, it is possible to see quite clearly downwards, while forward vision is badly obscured. The dangers here are obvious, and pilots should remember to judge their visibility with this in mind. See Aviation Law section for microlight visibility requirements.

NIGHT FLIGHT

Night flying in microlights is also illegal of course, with obvious vertigo and navigation problems. While no pilot hopefully would be fool enough to contemplate a night flight, there may be, on occasions, times when a flight has been badly misjudged and landing takes place near darkness. The hours of morning and evening civil twilight are in tables in the A.I.P. planning manual.

One of the problems of landing in partial darkness is that depth perception suffers, making it difficult to judge the last phase of the landing.

Remember that an overcast sky can effectively bring forward the onset of darkness quite considerably.

The hours of darkness are from after Evening Civil Twilight (ECT) to Morning Civil Twilight (MCT). These are published in the Visual Flight Guide (VFG).

RADIO

Flight in controlled airspace or operating from controlled and uncontrolled registered airfields can be made much simpler with the use of radio. Being in direct communication with Air Traffic Controllers, Information Units and other aircraft helps ensure efficient use of airspace.

With radio one can get cleared into or out of controlled airspace and airfields, obtain weather information en route, lodge or cancel flight plans etc.

Available from the Recreational Association at the current address is a booklet detailing radio procedures.

The requirements for use of radio are:

1. The pilot must be the holder of a current Flight Radio Telephone Operator rating.

This involves an operation of equipment test, which can be done by a flying Instructor or by an authorised Aviation Services Officer. Secondly, there is a written test on Practices and Procedures which can be organised at your nearest Club.

The study material and the application form to sit these tests are contained in C.A. pamphlet 13 Aeronautical Radio Telephone Service available from Civil Aviation, and/or "An Introduction to Radio for the VFR pilot" published by RAANZ and available through Microlight clubs and flight training establishments.

2. The radio equipment itself must be licensed. These can be hand held type radios with an external aerial fitted to the microlight.

Take every measure to ensure your radio equipment not only transmits clearly (your voice is not being drowned out by wind or engine noise) but is receiving clearly, so that instructions etc. can be easily acknowledged. A poor radio installation with unclear transmission and/or reception is probably more of a menace than a help.

Actual use of the radio can at first seem difficult as you strain to understand and respond to instructions. To help get used to the phraseology it can be worthwhile to arrange to spend some time up in a control tower just quietly listening and becoming familiar with radio procedures. A few hours of this can do wonders for your understanding of what is expected of you in practice. If permission is granted to let you up the tower, remember not to plague the controller with too many questions as he or she works.

Similarly, an air band receiver can be a useful aid for learning radio procedure, if there are busy frequencies nearby.

Remember to always keep a good listening watch on the radio, as this not only keeps you informed of other airspace users movements, but also helps to ensure that you immediately recognise being called by an A.T.S. Unit.

HEALTH

Pilots are supposed to be a pretty healthy lot, but even the finest human specimens have off days. On these days, the safe pilot stays on the ground. Even though you may be an experienced pilot, flying with any sort of impairment must be avoided. Piloting requires rapid and frequent decision making and this means one must be feeling fit and well rested.

It is up to the individual to assess ones fitness to fly on any given day.

Do **not** fly if–

- you are tired or feel weary.
- you have a hangover.
- you are drunk or drugged.
- you are on any medication (consult your doctor).
- you have a stomach upset or headache.
- you have been to a dentist and had a local anaesthetic.
- you have a lot on your mind.
- you have a cold, cough or flu etc.
- you are recovering from an illness.
- you have had a concussion or accident causing shock (consult your doctor).

If there is the slightest doubt about your fitness, forget flying until you are better.

When on any medication, see your doctor and ask how you might be affected, and when you might be fit to fly again.

THE COMPASS

The earth has a weak magnetic field, which culminates in two internal Magnetic Poles. These are situated near the North and South Geographic Poles (Geographic poles being on the earth's rotational axis).

The magnetic compass is a simple instrument which operates on the principal that a freely suspended magnetic needle will align itself with the earth's magnetic field, providing a datum for measuring direction on the earth's surface.

The Compass Rose

If a circle is divided into 360 equal parts and numbered clockwise from 0 to 360, then this will divide the circle into 360 degrees. Each division is one degree. Degrees are always expressed as a three–figure group, for example:

45	becomes	045
7	becomes	007
325	remains	325

Magnetic and True North

Although the earth's magnetic field lies roughly north and south, the earth's magnetic poles do not coincide with its geographic poles. Therefore, at most places on the earth's surface the compass needle will not point to true north pole, but to magnetic north pole.

Variation

The difference between magnetic north and true north (as represented by lines of longitude on charts) is expressed as an angle called Variation.

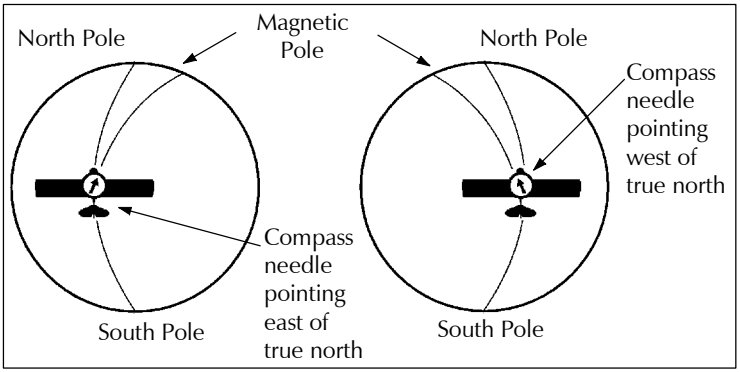


Fig. 107

Variation is called westerly if the compass needle lies to the west of true north, and easterly if the needle lies to the east of true north.

If variation is westerly, **Add** it to True to get Magnetic.

If variation is easterly, **Subtract** from True to get Magnetic.

Remember this:

Variation East, Magnetic Least – Variation West , Magnetic Best.

Variation is different for different places on the earth's surface. Furthermore, local magnetic fields from mineral deposits and other conditions can distort the magnetic field causing additional errors.

Variation is shown as broken lines joining points of equal variation on your charts; these lines are called Isogonals.

Deviation

Actually, the magnetic compass is rarely influenced solely by the earth's magnetic field. Metals, electrical equipment and even your microlight's airframe can influence the compass causing additional error.

The difference between direction indicated by an undisturbed magnetic compass and that indicated by a magnetic compass in an aircraft is called **deviation**. To eliminate this error a process known as "swinging the compass" determines the error for any heading and is shown on a card next to the compass. This tells the heading to steer to compensate for deviation.

Magnetic Headings	Steer by Compass
North	001
North East	045
East	091
South East	136
South	180
South West	223
West	266
North West	314

Fig. 108 A typical compass card.

Remember: any metal object placed near the compass may cause considerable error.

Longitude and Latitude

For the sake of convenient reference, the spherical surface of the earth is crossed with two sets of imaginary lines, called:

Meridians of Longitude

Parallels of Latitude

Every point on earth has a line of Longitude and Latitude running through it.

Longitude

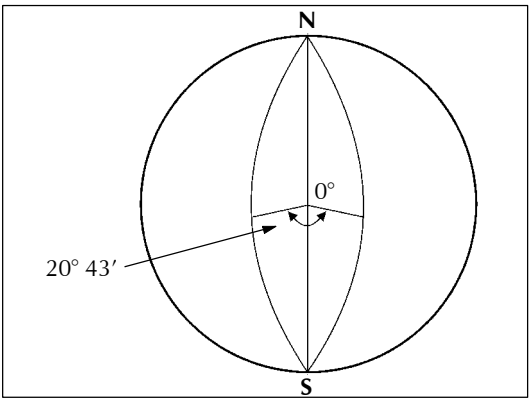


Fig. 109 Lines of longitude join the North and South Poles.

These lines are referenced through a line passing through Greenwich, London (0 – 360). At 180 from the Greenwich reference line the earth is halved and we have degrees longitude east and west. Thus 181 east becomes 179 west. The figure below shows this as it would be observed from above the north pole.

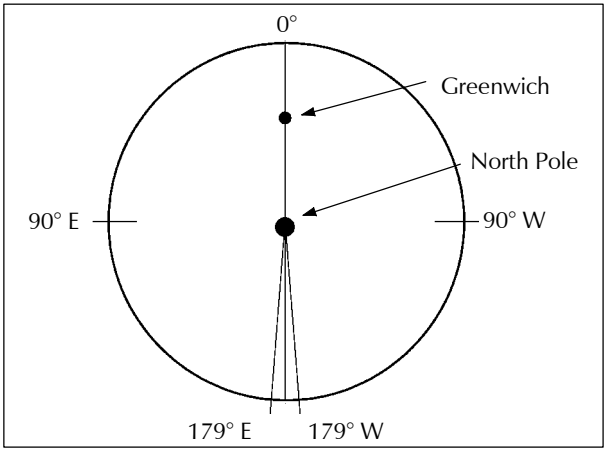


Fig. 110 Observing from above the North Pole.

The lines referenced throughout 0 (Greenwich) are usually expressed in degrees and minutes (a minute is 1/60th of a degree) and written as, say, 20° 43′ west, often abbreviated to 2043 W. The distance between lines of longitude one degree apart varies from 60 nautical miles at the equator to zero at the poles.

Latitude

Lines of latitude (or parallels as they are called) are lines which circle the earth parallel to the equator (which is equidistant to the poles). Thus all lines of latitude are parallel. The equator is the reference for latitude, being known as zero latitude.

Degrees of latitude in the northern hemisphere are expressed as degrees north and degrees of latitude in the southern hemisphere as degrees south.

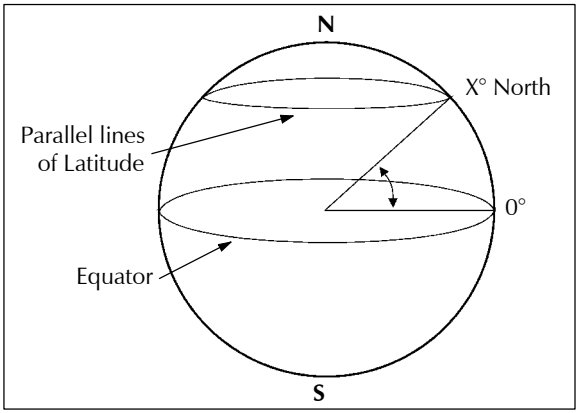


Fig. 111

It is now possible to specify any point on the earth's surface by using a line of latitude intersecting a line of longitude.

Your aeronautical chart has the lines of latitude and longitude printed on it marked in the appropriate degree. Thus for example we can find the point:

40° 28′ South
168° 28′ East

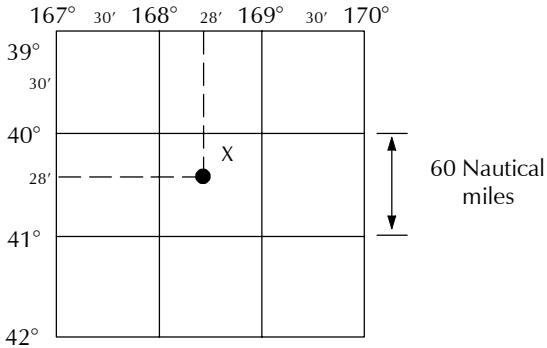


Fig. 112

When indicating a position of latitude and longitude, it is usual to give latitude first followed by longitude.

Of special note: **one degree of latitude equals 60 nautical miles**
one minute of latitude equals 1 nautical mile on the earth's surface.

Therefore, the graduations on the lines of **latitude** on your map may be used as a scale for measuring distance.

AERONAUTICAL CHARTS

An Aeronautical Chart differs from any road map you may use in your car in that it not only is a Topographical (showing heights and contours of the landscape) but is also overprinted with a wealth of information important to you as a pilot.

Obtain the chart covering the area you intend to fly in, from any flying establishment.

It is a:

- New Zealand Topographical Map, or
- 1:500,000 scale (one unit on the map equals 500,000 on the earth's surface), or
- Aeronautical Chart.

On all cross country flights, an appropriate aeronautical chart must be carried.

Check the date on the map and be sure to buy the most recently published one available as they are constantly updated.

Relief

Aside from the surface details such as roads, railways, rivers, towns etc. shown on the map, an important feature on these maps is their depiction of the type of terrain.

By means of spot heights (**above sea level**), hill shading and layer tints, a clear impression of the landscape is possible at a glance. There are also contour lines (joining points of equal height), but these are rather faint.

It is these features which allow the pilot to visualise the land as depicted on the map whilst planning a flight or when airborne map reading.

Airspace

Aeronautical maps show controlled airspace very clearly. It is **vital** that you know whether or not you are flying in controlled airspace of any kind, and road maps do **NOT** give this information of course!

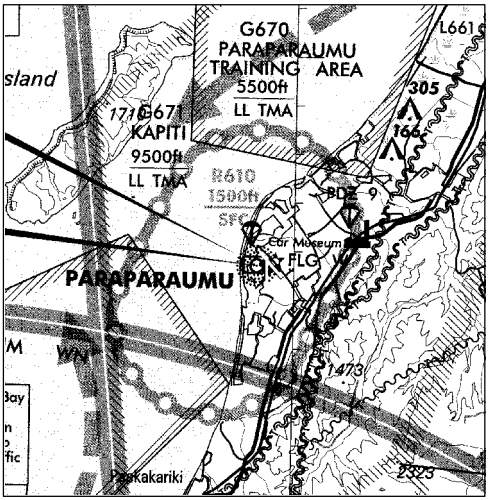


Fig. 112a

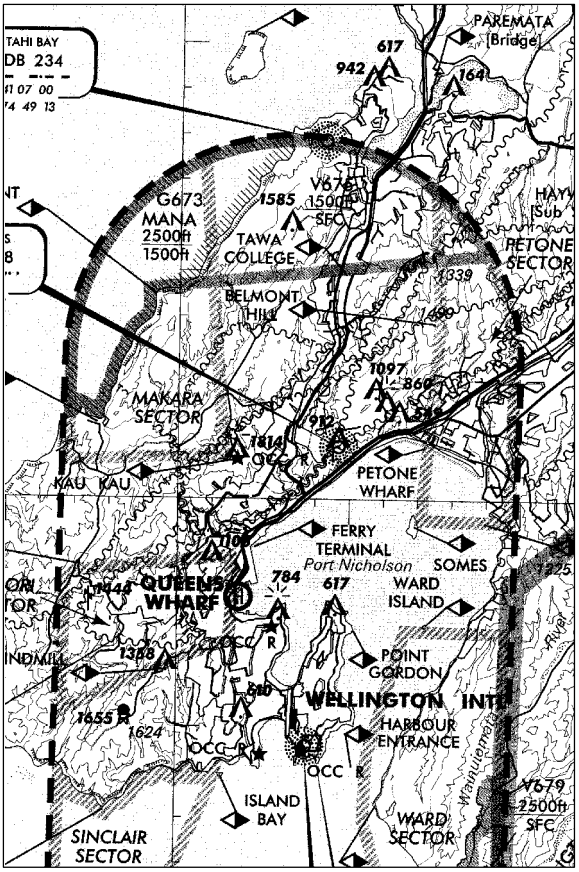


Fig. 112b

This is reason alone not to navigate with other maps.

Study your Aeronautical map very closely and become thoroughly familiar with the extent of Controlled Airspace in the area you will be flying in.

Accidental or unapproved flight into Controlled Airspace endangers yourself and others, not to mention the setting into motion of some very spectacular Airways Corporation wheels indeed!

Keep clear of Danger and Restricted Areas unless you have asked an ATC unit (Air Traffic Control Tower) about operating there.

PLANNING A CROSS COUNTRY FLIGHT

While it is acknowledged that few microlights are equipped with an aircraft type compass, there is a section following showing the proper use of the magnetic compass as an important aid to microlight navigation, however the recommended navigation method is detailed in "Map Reading" on page 106.

Even pilots of microlights without aircraft type compasses should understand the method as it has an application to any cross country flight in as much as the calculation of flight times, the drift to be expected etc is concerned.

The Route

Mark the takeoff and landing points on your map. Now study the map and visualise the route. What is there along the way which may influence the flight?

The direct route may be fine, or perhaps you may need to fly around some high ground or skirt around a populous area for example. Does the route you have chosen offer safe emergency landing areas? These are some of the things to consider.

Choose the proposed route and note the prominent features which will aid map reading.

Distance

On your Aeronautical map the lines of **latitude** are graduated in nautical miles (these graduations are minutes of latitude).

Measure the distance from takeoff along the route to your destination and note it in nautical miles.

Weather and Wind

With the help of the Meteorological service (see Meteorology section) determine the weather and wind conditions to be expected on your journey for the period of the flight.

A commonly held misconception is that during an out and return journey on a reciprocal heading any headwind component will be cancelled out by the tailwind on the reciprocal leg. **This is not true!!**

Lets use a simple example, (to make the calculations simple we will use mph instead of knots).

An aircraft is intending to fly out and return at 60mph:

- Each leg is 60 miles.
- Total time in nil wind conditions = 2 hours.

Now lets assume a 20mph tailwind on the out leg and a 20 mph headwind on the return leg:

- Groundspeed on the out leg is 60+20 = 80mph Flight time = 45 minutes.
- Groundspeed on the return leg is 60–20 = 40mph Flight time = 1 hour 30 minutes.
- Total time is now 2 hours 15 minutes.

Similar (although to a lesser extent) results can be experienced with the effects of crosswinds. A direct crosswind will still contain a headwind component adding time to your flight.

Assuming the weather is favourable, make a note of the wind speed and direction at the altitude you will be using.

- Wind speed will be given in **knots**.
- Wind direction will be given in degrees **true**.

For the exercise to follow we shall say that we have:

- Wind – 10 knots,
- Direction – 045 true.

Note: Always bear in mind that meteorological information may differ quite markedly from actual conditions, particularly at low level. This is no reflection on the service, but rather the fickle nature of the atmosphere. In flight the pilot must develop the ability to assess the conditions for himself.

True Track

If we are to use our compass as an aid to navigation, we must make allowances for wind and direction. Start by finding the true track to your destination by measuring the degrees clockwise from True North (longitudinal lines). This is called the True Track. For the exercise to follow we shall say that for example it is due east 090.

Consider the figure below. If the pilot of this machine simply follows a heading taken from the map to his destination, without compensating for the wind from his left he will never reach his goal. The wind will drift him to the right even though his compass heading remains constant.

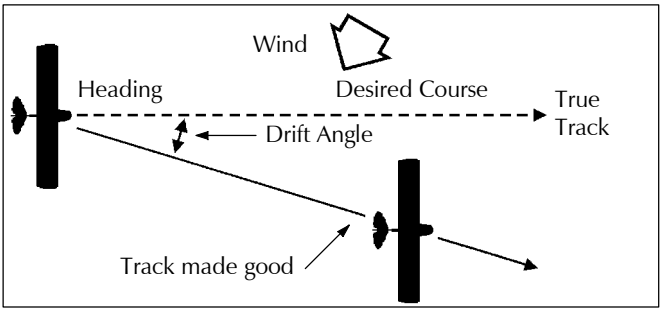


Fig. 113

The next figure shows a pilot who, with his destination in sight on the horizon, simply aims the nose of his aircraft straight at his goal. He will get to his destination, but only after a considerable detour caused by wind drifting him to the right of his desired path.

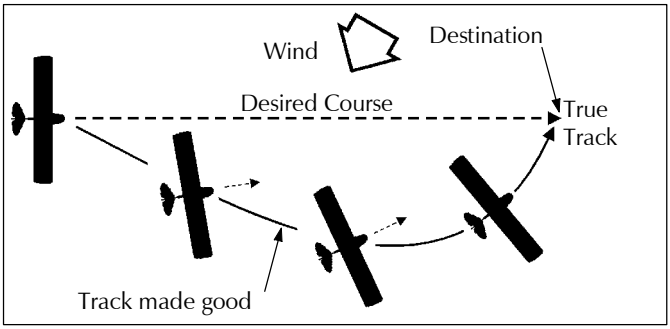


Fig. 114

The figure below shows a pilot who has visually, or by using a calculated compass heading, countered the effect of the wind drift and is making his way direct to his destination.

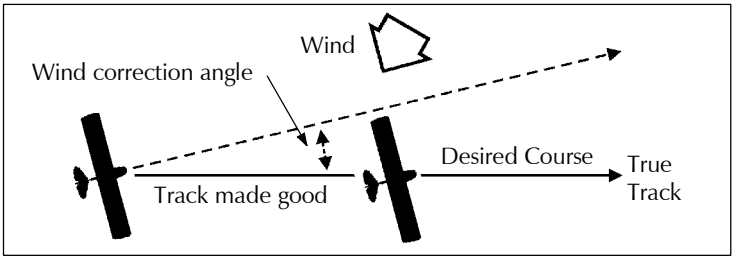


Fig. 115

How did the pilot calculate the drift and arrive at a compass heading to steer by? The method outlined below also told:

- Time the flight would take.
- Groundspeed.
- Fuel required.

The Wind Triangle

We need to know:

- Airspeed of machine.
- True Track.
- Distance.
- Wind Speed.
- Wind Direction.

We have assumed for this exercise that we have:

- True Track 090
- Distance 50 nm
- Wind Speed 10 kts
- Wind Direction 045
- Airspeed 40 kts

On a plain sheet of paper draw a vertical line representing north and south. (The various steps are shown on another page).

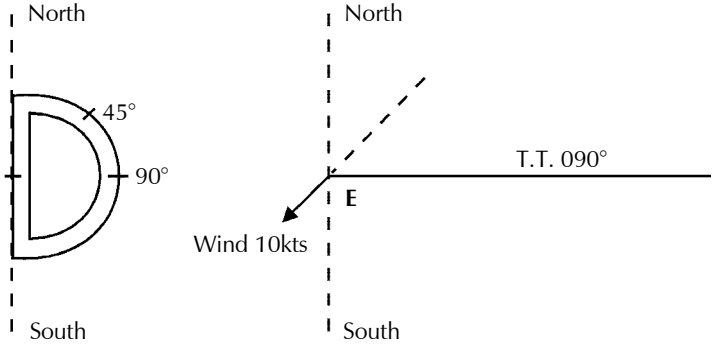


Fig. 116 Steps 1 & 2 & 3.

Place your protractor's centre dot on the line and with the protractor orientated north and south, mark a point labelled "E" (point of departure) and make a dot at 90° (indicating true track) and another at 45° indicating wind direction.

With a ruler draw the true track line from "E" extending it somewhat beyond the dot at 90° and labelling it "TT 090°".

Next align the ruler with "E" and the dot at 45° and draw the wind arrow from "E" not towards 045 but in the direction the wind is blowing, making it ten units long to correspond with the wind velocity of 10 kts.

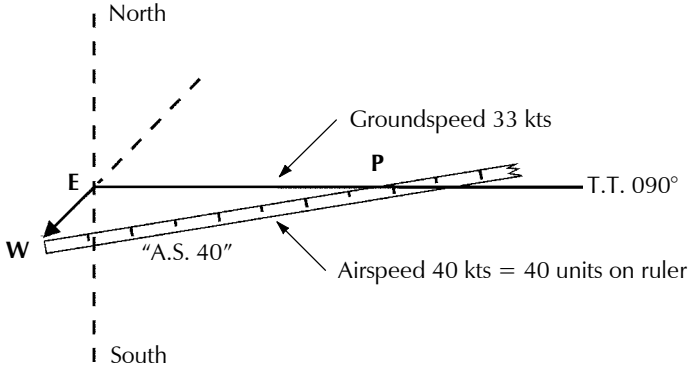


Fig. 117 Step 4.

Identify this line by placing the letter "W" at the end to show the wind direction.

Finally measure 40 units on the ruler to represent the airspeed, starting from the end point of the wind line to intercept the True Track line.

Draw the line and label it "A.S. 40" (airspeed 40 kts).

The point "P" placed at the intersection represents the position of the microlight at the end of one hour. The diagram is now complete.

The distance flown in one hour (**ground speed**) is measured as the number of units on the true track line. (33 kts in our example.)

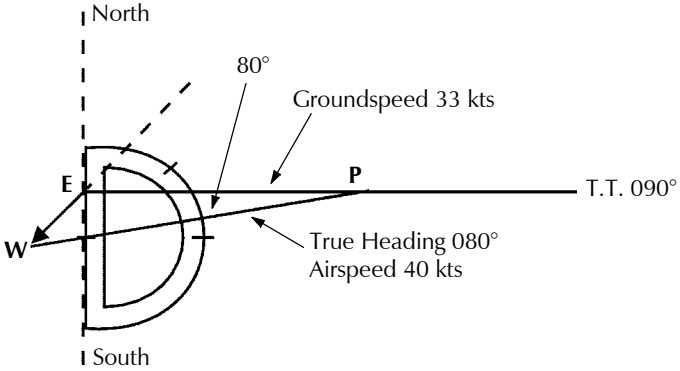


Fig. 118

The **True Heading** necessary to offset the drift is indicated by the direction of the airspeed line (A.S. 40) which can be determined in one of two ways.

- By placing the protractor along the north/south line, with the centre dot at the intersection of the airspeed line and north/south line, read the True Heading directly in degrees. (080 in our example.)

- Find the angle between the True Track line and the airspeed line at the intersection point "P". This is the **drift** angle which must be applied to the true track to obtain the True Heading.

In the example the wind correction angle is 10 degrees.

If the wind blows from the right of the true track, the angle will be **added**, if from the left it will be **subtracted**. Thus, in the example given the wind is from the left, therefore subtract 10 from the true track of 090 making the True Heading 080.

After finding the True Heading, apply the correction for magnetic variation to obtain the Magnetic Heading.

With our example we shall say the variation is 19E.

Therefore – 080 – 019 gives us 061.

The final correction is for **deviation**.

Your compass card will show what heading to steer for 061 magnetic.

Flight Time and Fuel

If the distance to your destination is divided by the groundspeed you will find the time required for the flight.

In our example: distance 50 nm
groundspeed 33 kts

50 divided by 33 gives you 1.5 hours (or 90 minutes).

If fuel consumption is 15 litres per hour you will use 15x1.5 or about 22.5 litres.

Briefly summarised, the steps in obtaining flight information are as follows:

True track: Direction of the line connecting two desired points, drawn on the chart and measured clockwise in degrees from true north.

Drift angle: Determined from wind triangle. (Added to true track if the wind is from the right; subtracted if the wind is from the left.)

True heading: The direction measured in degrees clockwise from true north, in which the nose of the aircraft should point to make good the desired path over the ground.

Variation: Obtained from the isogonal on the chart. (Added to true heading if west; subtracted if east.)

Magnetic heading: An intermediate step in the conversion. (Obtained by applying variation to true heading.)

Deviation: Obtained from the deviation card on the aircraft.

Compass heading: The reading on the compass which will be followed to make good the desired course.

Total Distance: Obtained by measuring the length of the true track.

Groundspeed: Obtained by measuring the length of the true track line on the wind triangle. (Using the same scale employed for drawing the diagram.)

Flight time: Total distance divided by ground speed.

Fuel Required: Predetermined litres per hour at cruise speed over the flight time. Allow a few extra litres for the climb to cruise.

Note: Additional fuel should be added for safety to allow for a diversion to another landing field, unexpected stronger head winds, getting lost etc.

Returning to Base

Because of changing weather, or other unforeseen events, it may sometimes be necessary to return to the point of departure. Clearly if we were to simply steer a reciprocal heading, any drift would now be acting in the opposite direction and track could be very different to what is required.

The rule to achieve a reciprocal course is:

- Bear in mind the drift being compensated for.
- Take the reciprocal heading and subtract twice this drift if it was previously from the port.
- Add twice the drift if it was previously from the starboard.

Remember after the turn the nose of the aircraft will not be pointing in the exact opposite direction to that before the turn.

Flying with a Compass

An aircraft such as a microlight does not always make a very steady platform on which to mount a compass. In turbulence the compass may swing about. Try to average this out, rather than chase the compass. Depending on the type of compass, most indicate incorrectly when being accelerated or decelerated, so read the compass during periods of stable airspeed.

Map Reading

The ability to plan a flight and set off with an accurate compass heading is very useful. However, it is important to bear in mind that without good map reading to back it up, navigating a microlight purely by following a compass heading is foolish. Should the wind change in strength or direction the compass heading is made useless, and unless you are carefully following your progress along the route marked on your map by map–reading, you would have no idea at all of any change.

The first thing you would know was that at the calculated time your destination would fail to appear! Therefore the ability to map–read is **vital**.

Assuming you have studied the map you will have no trouble recognising all the symbols on it. Also, by studying the route you will be flying and the surrounding area, you will have a good idea even before takeoff of what you should expect to see.

Read from the map to the ground and then from the ground to the map.

Remember the higher you are the further you can see, but keep in mind that at more height some features become less distinct. Below 3,000ft AGL this is seldom a problem.

Do not waste time looking for indistinct features if other more easily recognisable features are around.

Always positively identify a feature once you think you have sighted it, by checking others nearby and seeing that it fits.

Mark intervals of time along the track on your map, and note whether your groundspeed is as expected. Therefore make a note of the time you get airborne in the right direction along track. Keep reviewing your progress with regard to fuel consumption to ensure there is sufficient to complete the trip.

Navigating Without a Compass

Preparation for a cross–country flight without a compass is the same as for a flight with a compass. The pilot should still determine the route to be flown, airspace considerations and weather.

Drawing a wind triangle will give an idea of groundspeed, time, drift, and fuel required. All this information should be gathered **before** the flight.

The difference now is that we do not have a compass heading to steer by, therefore we must study the map and note the prominent features along the route. These need not be actually on the true track if they are sure to be easily seen – like a small lake or pond, racecourse, town, open cast mine etc.

Initially what is needed is a good prominent feature just a few miles from the takeoff point, preferably visible from the takeoff point. This is likely to be a small town, major intersection or similar, and should be on the true track.

Once airborne one can make for this feature, allowing for drift as required to keep on true track. This first stage, which may include the climb to cruise altitude, gets the flight started on track. From here, map reading from feature to feature along the route continues. Keep looking for the next feature to appear as you go.

However, it is **vital** that the first feature you make for is prominent and **positively identified.**

If you have mistaken this first feature and started off in the wrong direction, naturally the next features will not appear where they should. This will tell you immediately that your heading is wrong and you should still be very near your takeoff point and be able to return and look again for the correct feature while still having the option of landing.

It is a good idea as you head off from your takeoff field, to look back occasionally as you go to keep an idea of what the place would look like to return to if need be. Of course, if you have taken off from a controlled airfield then be sure you arranged for a possible return.

Use prominent features backed by smaller features. For example, if your track takes you three miles abeam a town, check that you are three miles abeam by checking a road intersection or something below.

Prominent features can easily be used to provide an approximate fix, accurate to within a couple of miles. From this position a more exact fix can be made from smaller details nearby.

An example of this method is outlined below, using the simplified map shown.

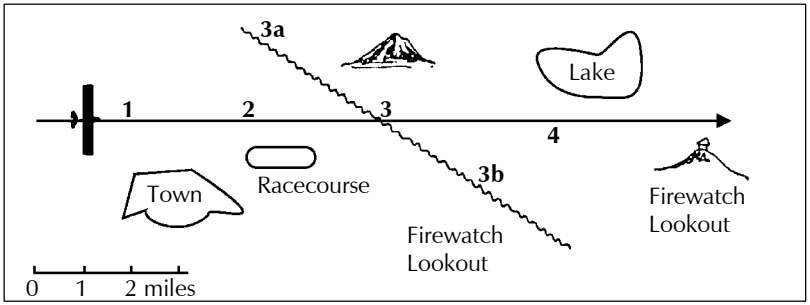


Fig. 119

Along this section of route we shall pick up from a position nearing the small town. We know our track will take us about a mile to the left of the town, so we continue in this way. As we reach position **1** abeam the town we should have the racecourse in sight just ahead and we should see that our track will take us about a half mile left of it.

Arriving at position **2** with the racecourse on our right, we should see the high ground peak about 40 degrees to the left of track at about three miles. We may see the power pylons and their wires converging to cross our track up ahead.

At position **3** we should have crossed the pylon line when the same high ground is almost exactly 90 degrees to the left of our track. If we have crossed it when the peak was still a little ahead (**3a**) we can deduce that we are to the left of track; if it was a little behind us as we crossed the wires (**3b**) we can tell that we are to the right of track, and so on to the next features.

In this fashion we can navigate with complete accuracy provided:

- We have studied the map before flight.
- We map read carefully recording progress along the track on the map as we go.
- We always have a positively identified feature in sight and another one ahead as the next reference.

This method is really quite simple and with practice becomes second nature.

GETTING LOST

Even though you may be the most meticulous of pilots, it is quite possible that on occasion you may find yourself unsure of your whereabouts. A missed or mistaken fix, or wind change during flight can easily cause confusion.

If you have been marking your progress frequently and if you have accepted your predicament immediately without hesitation, you should be able to have at least an educated guess as to your position by projecting on your map your expected progress since your last known position. This gives you at least a locality on your map to find recognisable features.

- If you can get back to your last known position, you can try navigating from there.
- If you are really lost, or confused, find a suitable area and land.

- Secure the machine and find out where you are, from someone.
- Do not continue blindly, wasting fuel and daylight. Land and get things sorted out.

If you think you may have entered controlled airspace accidentally, land as soon as possible. Likewise, if you become lost knowing you are in controlled airspace, land, find out where you are and advise the air traffic unit of your intentions. If you have been given a clearance, this may have to be revised.

Useful tips:

- Write down all relevant information tidily, to be easily referred to in flight.
- When following a road or railway (or any prominent feature) always keep it on the left.
- Do not continue if weather conditions or failing light gives trouble.
- Avoid causing a nuisance by flying low.
- Beware of the lee of terrain and ground obstacles.
- Beware of power wires or any other wire especially on landing.
- Always keep an emergency landing field in range.
- Keep a close check on fuel consumption.
- File a flight plan or advise someone of your intentions and route.
- **Lookout** for other aircraft.

Navigation in Bad Weather

It is not at all uncommon for weather conditions to deteriorate during the course of a flight. The pilot should constantly monitor the conditions and anticipate any problem with the weather before it becomes serious. If the trend is toward worsening weather, or you suddenly find conditions have gone bad, then you must decide the best course of action.

Depending on the situation, some of the possible options are return to point of departure, divert to another destination with better weather, or make a precautionary landing.

During any cross–country flight keep these options in mind at all times.

Some of the facets of bad weather which can be a hazard to safe flight and navigation are:

- Lowering cloudbase.
- Reduced visibility.
- Rain or hail etc.
- Increase in wind strength.
- Increase in turbulence.

It is usually true that deteriorating weather involves one or more (often all) of the above.

Lowering cloudbase – has the effect of forcing one to fly lower to maintain clearance form the ceiling.

Reduced visibility – makes map reading difficult by restricting or obscuring features on the ground.

Rain or hail etc – can be very damaging to airframes, particularly propellers.

An increase in wind strength – may drastically reduce the range of a microlight or render the landing field at the destination unsafe.

An increase in turbulence – may increase the pilot workload and possibly affect the controllability or overstress the microlight.

All of these conditions are serious in themselves and demand action, but when several are present the potential for danger is greatly increased. This is due to the cumulative effect, for example, a lowering cloudbase forces our pilot to fly lower and over unfamiliar rough terrain. Visibility becomes a problem with drizzle and wisps of low cloud, making map reading very difficult. Add to this strong wind and moderate to severe turbulence at the low level our pilot is flying, and the situation is rapidly getting out of hand.

Our pilot is now unsure of his whereabouts and the turbulence is both mentally and physically tiring. It is not long before he is completely lost. The ceiling drops further and whilst flying very low over unfamiliar ground in poor visibility, he flies into a set of high–tension wires strung across a valley.

The above scenario, grim as it may seem, is actually a fairly typical sequence of the events leading up to a weather related accident.

It is easy to say to ourselves, we would never get into that situation, which of course is the remedy to avert disaster, but it takes a certain discipline to take the appropriate action at the right time. The right time, of course, is to **take action at the first sign of trouble.**

In this way, a relatively simple decision is made before any danger arises. Navigating in poor weather is full of risks and best avoided.

Whilst on a cross country keep a constant check on:

- Your whereabouts, through careful map reading.
- Your progress with regards to fuel endurance remaining and time required to reach your destination.
- Weather conditions, not only ahead, but to each side and behind, in case of a possible diversion or return.
- Suitable landing fields in case of emergency.
- Other aircraft. Keep a constant **Lookout**.

AVIATION LAW FOR THE MICROLIGHT PILOT

Introduction

In this section we will cover the most common rules that affect microlight pilots. Microlight rules are embodied in the CAA rules. CAA rules Part 12, 91, 103, 149, all have in them rules which are applicable to microlight pilots. RAANZ is an Approved Organisation under Part 149 and the majority of microlight rules are in Part 103. Part 91 covers the General Operating rules which all aircraft operate under. Part 12 is the accident and defect reporting rule.

The CAA uses a number of other documents to convey further information and elaborate on the rules of flying.

NZAIP - New **Z**ealand **A**eronautical **I**nformation **P**ublication. This is used to cover orders, procedures and information. The AIP has the following supplementary publications being:

Planning Manual	Provides information for planning and reference on the ground.
Visual Flight Guide	Provides information and details of procedures required for operations under VFR for land aerodromes. This document can be useful to the microlight pilot flying in and out of licensed aerodromes.

VFG, Helicopter and Water Aerodrome	Provides information and details of procedures required for operations under VFR for heliports and water aerodromes.
Instrument Flight Guide	The Instrument flight guide is not applicable to microlight flying.
AIP Supplement	Contains information which is of a temporary nature not urgent enough to warrant promulgation by NOTAM, or that contains extensive text or graphics and cannot be clearly promulgated by NOTAM. AIP Supplements are distributed to holders of the Planning Manual, VFG, IFG.
NOTAM	NOTAM are used to promulgate temporary changes to operationally significant information that requires immediate dissemination. NOTAM are issued via the AFTN.
Aeronautical Charts	A number of Aeronautical Charts are published including Enroute Charts, Area Charts, Topographical Charts, Visual Terminal Charts and ICAO Type A Aerodrome Obstacle Charts. A description of all aeronautical charts is given in the NZAIP MAP Section.
Aeronautical Information	AIC–AIR contain information relating to the airworthiness of aircraft. AIC–AIR are only distributed to holders of the NZ Civil Airworthiness Requirements.

Responsibility of the Pilot in Command

The pilot in command is responsible to ensure that the microlight has valid documentation, is properly preflighted (i.e. not overloaded or badly loaded), has sufficient fuel and oil and the microlight is safe for the flight.

He shall make final decisions, is responsible for reporting defects (if the microlight is not his) and is ultimately responsible if any rules are broken.

In two seaters where two licensed pilots are flying, one must always be nominated pilot in command.

Drink and Drugs

A “no–no” – need any more be said? If a pilot is impaired in any way, he should not be flying. If on any medication, consult your doctor as to effects before flying.

Operation of Controls

Only licensed pilots (including students) are allowed to operate controls. This includes ground taxiing. The only exception to this is in two seaters where there is an instructor in the second seat.

Dropping of Articles

Any person dropping anything from a microlight is responsible for the article and where it may land. No article may be dropped that creates a hazardous situation.

Carriage of Persons on an Aircraft

No person shall be carried on a microlight unless they are located in an area specifically designed for that purpose, and the pilot in command has a passenger rating.

Classification of Operations

Private – not used for hire or reward. Microlight flying is a private operation. Instruction is considered a private operation as the student is considered “crew” not passenger. Where a passenger is paying for a joyride the operation must be carried out under CAA Part 115.

Documents

All flight crew shall keep a logbook. RAANZ have published a pilot logbook. These are available through affiliated clubs. Permanent entries shall be made within 48 hours of the flight and the logbook shall be kept at least six months after the last flight.

If a radio is used on the microlight then a radio license is required to be kept with the radio.

A flight permit shall be obtained for class II microlights. This flight permit is valid for 12 months and is renewable after a survey by an Inspection Authority Holder. A flight permit will only be given where the microlight has type acceptance and has been inspected by an approved person.

Registration marks must be affixed in accordance with CAA Part 47.

Test Flying

Approval must be held from RAANZ before a person may undertake a test flight in a microlight. All Senior Instructors are deemed to be Test Pilots.

Instruments

An altimeter, compass, and airspeed indicator are required for all flights.

Planning of Flights

The pilot in command must plan his flights to ensure safety and this must include:

- the checking of meteorological conditions.
- the checking of radio facilities if required.
- the checking of any licensed aerodrome to ensure microlight flight can be conducted safely and include gaining the necessary approvals. No flight is permitted within 3NM of a licensed aerodrome unless approval is gained from a Senior Microlight Instructor, or a Category “A”, or “B” Instructor.

Where flight in to or out of an attended aerodrome is contemplated permission must be obtained from the Air Traffic Services Unit at the aerodrome.

- The pilot shall satisfy himself as far as possible as to the safety of landing zones intended for use.
- He shall check air traffic rules and procedures applicable to the flight (i.e. entry into controlled airspace).

Prohibited, Restricted and Danger Areas

Prohibited Areas: No access at all is permitted. These relate to military or national security requirements.

Restricted Areas: Created in the interest of safety or the public interest. Entry is only permitted in accordance with specified conditions and times stated for that particular area. Instrument approach restricted areas are normally trapezoidal in shape and are between two flight levels.

Danger Areas: An area of danger or potential danger to aircraft. The nature of the danger is usually explained so that the pilot can enter the area if, after due consideration he does not believe it will affect the safety of his flight.

If a pilot accidentally enters a prohibited or restricted area he should get out by the most direct method possible and report the circumstances to the nearest ATC unit.

These areas are marked on aeronautical charts. See Fig. 112a.

Minimum Safe Heights

No flying over crowds is permitted. The rule states that you must not fly over a congested area. In addition, unless taking off or landing, no flight shall be conducted at less than 500 feet above

ground level. The only exemptions to this rule are if required due to stress of weather or in a designated low flying area with an instructor. If low flying is required as an operational requirement, approval must be gained from RAANZ.

Meteorological Conditions

Flight shall not be conducted unless the current and forecast meteorological conditions enable the VFR rules to be observed. For microlight pilots this includes the ground windspeed being less than 75% of stall speed and that the meteorological conditions in the table below can be observed.

If worse conditions are encountered in the flight, flight should only be continued to a point where a safe landing can be made.

All flights shall be conducted in conditions equal to or better than the tables below:

Airspace VFR meteorological minima

Class of Airspace	C, D, and E	G
Distance from cloud	1 nm horizontally 1000 feet vertically	Above 300 feet AMSL or 100 feet above terrain whichever is the higher 1 nm horizontally 1000 feet vertically At or below 3000 feet AMSL or 1000 feet above the terrain whichever is the higher clear of clouds and in sight of the surface
Flight visibility	8 km at and above 10 000 feet AMSL 5 km below 10 000 feet AMSL	5 km

For airspace classifications refer to page 118.

VFR minima at aerodromes with aerodrome control service in operation.

		Ceiling	**Visibility**
Flight outside the aerodrome traffic circuit	Day	1500 feet	8 km
	Night	3000 feet	16 km
Flight within the aerodrome traffic circuit	Day and Night	1500 feet	8 km

VFR minima at aerodromes without aerodrome control service in operation.

		Ceiling	**Visibility**
All aircraft	Day	600 feet	1500 m
All aircraft	Night	1500 feet	8 km

Special VFR Weather Minima

A pilot–in–command of an aircraft may perform a VFR operation in weather conditions below those in the above tables, within a contol zone, providing such operations are in compliance with an ATC clearance and ATC instructions.

VFR Flight Plan

Each pilot-in-command of an aircraft shall submit a flight plan to an appropriate ATS unit prior to the start of each flight under VFR:

- that proceeds more than 50nm from shore; or
- if the pilot–in–command rquires an alerting service.

Note: In controlled airspace ATC can authorise special VFR flights in a CTR with a cloud base down to 600ft and a visibility of 1500 metres.

Cross Country Flight

All microlight flight is VFR flight under Visual Flight Rules.

Prior to undertaking a cross country flight or any flight during which it is proposed to proceed beyond gliding distance of land in a microlight, the pilot shall advise a responsible person of their intentions and shall specify any action to be taken by that person if they does not receive notification of the safe termination of the flight.

When flight is conducted beyond gliding distance of land, a life jacket shall be worn and a responsible person notified of his intentions.

Appropriate charts shall be carried on all cross–country flights.

Fuel and Oil

Sufficient fuel and oil shall be carried for the safe conduct of the flight including allowances for any change in meteorological conditions and/or delays, plus a reserve for contingencies and landing at an alternative site.

General Operations

All flight shall be conducted clear of cloud and beneath the ceiling, i.e. beneath the base of the lowest cloud covering more than half the sky.

All circuits should be flown at 500ft AGL – after takeoff first turn shall be made at a safe height.

No flight at night is permitted. That means between Evening Civil Twilight (ECT) and Morning Civil Twilight (MCT).

All flight conducted by a novice pilot or student pilot shall be under the supervision of an Instructor.

Right of Way Rules

If you have right of way you are expected to maintain your current flight heading and speed to allow the conflicting traffic to avoid you. If you have to avoid traffic, ensure you pass well clear.

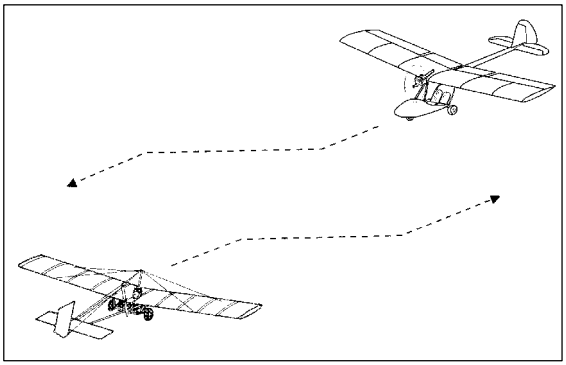


Fig. 120 Approaching head on – Each aircraft turns to the right.

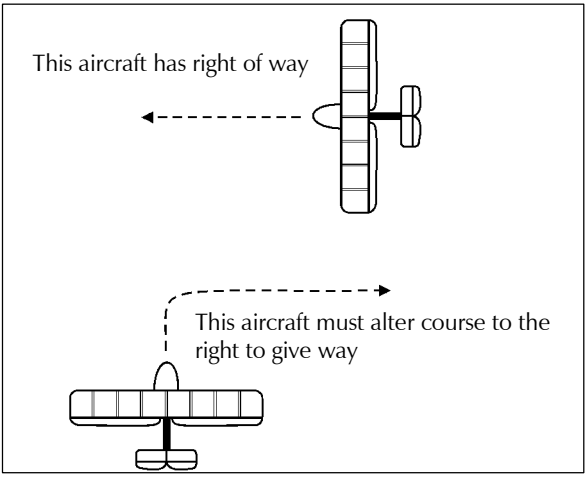


Fig. 121 *Converging – The right hand rule applies except that power driven aircraft give way to gliders or aircraft towing objects.*

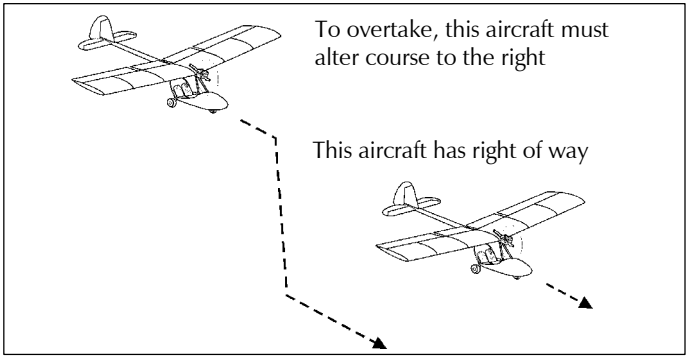


Fig. 122 *Overtaking – The slower aircraft has the right of way. If overtaking, alter course to the right.*

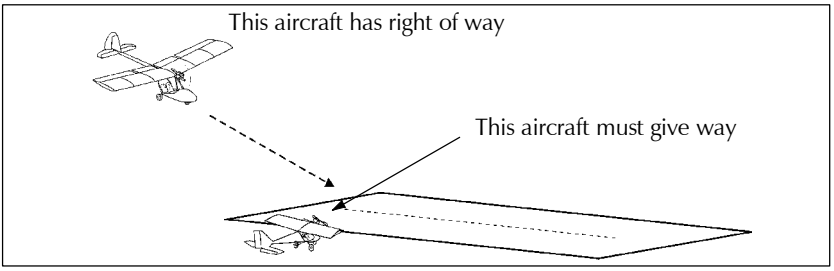


Fig. 123 *Landing – Any aircraft manoeuvring on the ground must give way to landing aircraft or aircraft on final approach.*

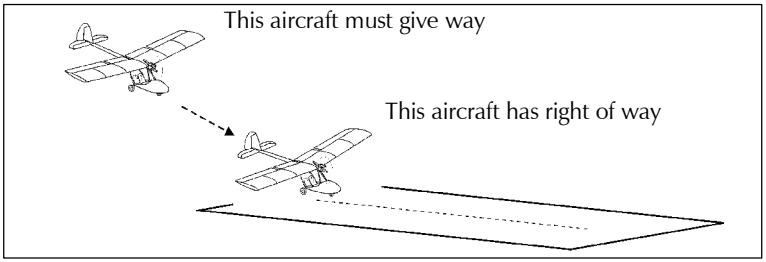


Fig. 124 If two aircraft are landing at the same time the lower aircraft has right of way.

Aircraft when landing must land to the right of any aircraft which has just landed or is about to land or which is taking off or about to take off.

An aircraft when landing must land on the left to leave reasonable room to the right for other aircraft.

Turn left after landing, unless instructed otherwise.

Everyone must give way to aircraft making an emergency landing.

Takeoff – no takeoffs are permitted when there is a danger of collision.

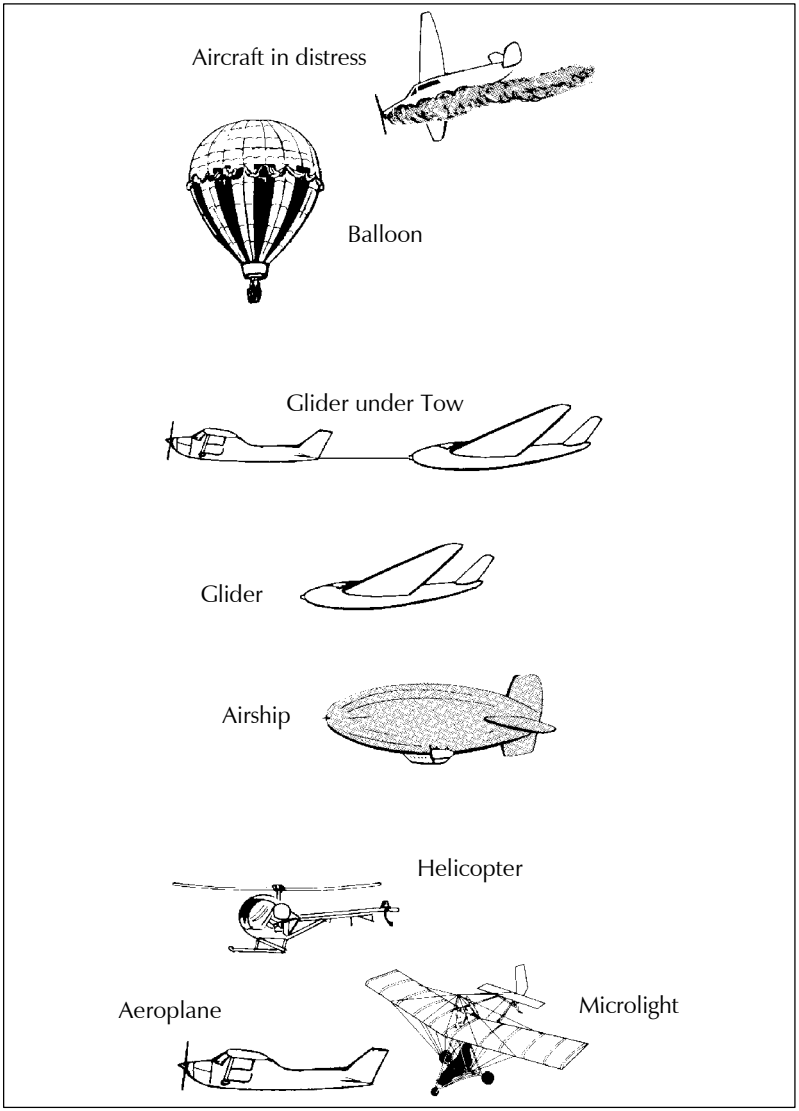


Fig. 125 Aircraft priority relative to manoeuvrability.

Signals

Where the pilot does not have radio communication and wishes to operate at an attended aerodrome he may receive light signals as follows:

Light Signal	Meaning in Flight	Meaning on Ground
Steady Green	Cleared to Land	Cleared to take off
Flashing Green	Return for Landing	Cleared to taxi

Steady Red	Give way to other aircraft and continue circling	Stop
Flashing Red	Aerodrome unsafe do not land	Move clear of landing area immediately
Alternate Red and Green Flashes	Danger, be on the alert	Danger, be on the alert
Flashing White	Land at this aerodrome and proceed to the apron	Return to the start point on the aerodrome
Red Flare	Do not land for the time being	

Dangerous Operation and Maintenance

No microlight shall be operated, maintained, serviced, flown or manoeuvred in such a manner where avoidable danger to life or property is likely to ensue.

This includes neglect to perform a duty, e.g. preflight or following good aviation practice which results in an exposure to danger.

Accidents

A notifiable accident is one where a person is killed or seriously injured or the microlight suffers serious damage or structural failure that adversely affects its structural strength, performance, or flight characteristics and requires major repair or component replacement. If a microlight is overdue on a flight an accident is deemed to have occurred.

The pilot in command, or, if he is incapacitated, the operator of the microlight shall notify the Civil Aviation Authority by the quickest means possible, and, if damage to a third party person or property occurs, the police must also be informed. Air Traffic Service Units are available to assist in the reporting of accidents.

Notification should include the following:

- Microlight Type and Registration.
- Name of owner, operator and pilot and any passenger.
- Date and time of accident.
- Point of departure, intended landing point and last known position.
- Any injuries or death and/or damage including third parties.
- Details of the accident.

From the time of accident the microlight is in the custody of the CAA. No person shall have access to the microlight or shall remove the microlight or any part from the accident site without the approval of the CAA except to:

- Remove persons or animals from the accident site.
- To remove the microlight to prevent obstruction to the public or to air traffic or other transport.
- The microlight can be brought to a place of safety if wrecked on water.

Anything that is removed from the aircraft should only be as far away from the aircraft as to ensure its safety. The Air Accident Inspectors have total control of the accident site.

After the investigation is concluded all held wreckage must be returned to the owner.

Controlled Airspace

Controlled airspace is divided into four categories:

- UTA Upper Control Areas – Most airspace above 9,500ft AMSL in which only authorised flights are permitted.
- TMA Terminal Control Areas – Controlled Airspace below 9,500ft AMSL in which only authorised flights are permitted. These are usually established at the confluence of air routes in the vicinity of a major aerodrome.
- CTR Control Zones – Controlled airspace about an aerodrome in which only authorised flights are permitted. See Fig. 112b.
- CTA/E – Control Area/Visually Exempted. Controlled airspace in which VFR flights are not subject to control, but most are radio (RTF) or Transponder mandatory.
- Approach conditional areas – situated at some unattended aerodromes protecting arrival of IFR traffic – VFR controlled airspace minima apply unless RTF equipped and can confirm no Instrument Traffic.

A control **area** is a defined area extending **upwards** from a specified lower limit.

A control **zone** is a defined area extending **up from the ground** to a specified limit.

In all controlled airspace, microlights shall only be operated in accordance with instructions issued by the appropriate ATC unit.

Control Zones may be sub–divided into VFR entry/exit lanes or VFR transit lanes.

The VFR entry/exit lanes permit VFR traffic to enter and leave a busy aerodrome without conflicting with IFR traffic. See Fig. 112b.

A transit lane (Victor Lane) is to enable VFR traffic to transit a zone without being subject to control and are set to avoid IFR traffic. See Fig. 112b.

Transponder Mandatory Airspace

CTR's and TMA's around major aerodromes and UTA airspace is Transponder mandatory. On charts Transponder mandatory airspace is shown as:

TMA/C

Airspace is also classified as to what service is being provided:

Class C	IFR separated from VFR
Class D	IFR not separated from VFR except in circuit areas
Class E	IFR not separated from VFR
Class G	Uncontrolled Airspace

Definitions

Cross–Country flight is any flight beyond 10NM from the takeoff point.

Microlights are classified into five classes.

Group A	***Weight Shift***	Controlled by lateral and longitudinal movement of the pilots body in relation to a control bar or A frame rigidly attached to the wing.
Group B	***Three Axis Control***	Control about the lateral axis is achieved by elevator or canard or sling, and about the longitudinal axis by ailerons, differential spoilers or wing warping and about the normal axis by rudder. Microlights in this category shall be stick and rudder control.
Group H	***Microlight Helicopters***	Conventional helicopter controls.
Group P	***Powered Parachutes***	Control is by pulling on the steering risers connected to the chute and throttle operation.
Group R	***Rotorcraft or Gyrocopters***	Control is through the cyclic to the rotor head. The rotor is free running with forward thrust provided by a separate propeller.

TYPE RATINGS

There are five type ratings for the microlight pilot:

- Tricycle undercarriage.
- Tail dragger undercarriage.
- Slow speed (applicable to aircraft with a VNE less than 100mph).
- High speed (applicable to aircraft with a VNE of 100mph or greater).
- Water (applicable to any aircraft operating on water).

After demonstrating competence to your instructor, he/she may endorse your logbook accordingly.

During the course of your microlight flying, you will probably have the opportunity to pilot microlights of various types and configurations.

When such an opportunity arises there are several points to consider. It is important to remember that the handling and performance of the various types can differ markedly. It is not acceptable to merely jump in and fly a new type without a type rating.

Wherever possible, observe the microlight flying – especially landing and taking off. In this way you can get an appreciation of what to expect in the way of ground run and performance.

Talk to your instructor about handling the aircraft, especially any noteworthy aspects such as what to expect at the stall onset etc.

Make sure you know thoroughly:

- Stall speed.
- Lift–off speed.
- Climb speed.
- Cruise speed.
- Approach speed.

- Takeoff, climb, cruise and descent R.P.M.
- VNE and manoeuvring speeds.
- Weight and balance figures.

Know the fuel quantity on board and consumption rate, as well as being familiar with the fuel cocks etc.

Ask to be shown a pre–flight of the microlight.

Ask about any unusual features you note. Get strapped in and familiarise yourself with the operation and location of **all** controls.

It does not hurt to spend time on the ground in the cockpit until you feel happy with the layout.

Note the attitude of the aircraft as it sits on the ground – and visualise the landing attitude.

If you are going to be flying a microlight employing a different control method, make sure you understand just how it works. Get it straight in your mind. Unless you are comfortable with the idea, you may not be ready.

Your first solo flight in a new microlight should be made in good weather conditions. You don't want to have to cope with a strong crosswind for example. Furthermore, the field used should be big enough to provide a comfortable margin for both take–off and landing.

The simple preparations above should help to make a type conversion easier and safer.

Strangely, it is often the experienced pilot of other types who leaps into a microlight for the first time who gets into trouble. No matter what your flying experience or background, respect the microlight and listen to the advice of those who know the aircraft.

Law and the Microlight Instructor

Requirements for Issue of the Instructor rating are:

- Be the holder of an advanced pilot certificate.
- Demonstrate to a RAANZ Testing Officer the ability to give ground instruction and ability to fly, within the group ratings for which he has ratings, all exercises being outlined in the RAANZ procedures manual.
- Be recommended by his club.
- Pass an oral exam on VFR Operations, Principles of Flight, Preparation and Operation of Microlights and Micro–meteorology as in the RAANZ procedures manual.
- Either have 100 hours microlight time including 10 hours cross–country time or 100 hours total flight time in aircraft of which 50 must be in a microlight with 10 hours cross–country. (Where the applicant has considerable aviation experience special conditions apply.)
- Where the applicant has considerable aviation experience these requirements may be reduced. If a current A, B, or C Instructor – Aeroplane, the pilot shall demonstrate competence to a Senior Microlight Instructor. If having previously held a Cat A, B, or C Instructor licence then 15 hours of microlight flight time is required before supervising microlight operations including cross–country No. 5 in the RAANZ procedures manual.
- Be a financial member of RAANZ.

Renewal	A check must be completed with a RAANZ Testing Officer in the last 12 months and a current medical is required.
Recent Experience	The privileges of an instructor shall not be exercised unless he has carried out three takeoffs and landings in the last 90 days.
Privileges	Give ground and flight instruction and authorise solo flight by the holder of a novice pilot certificate.

Only Senior Instructors may perform flight tests and send applicants on their first solo.

Instructors are considered trainee and must liaise with Senior Instructors.

Water Operations

A water rating is required to operate a microlight aircraft from the water. Contact an appropriately qualified **instructor**, as there are different piloting techniques to be learnt when operating from water because of:

1. The inherent dangers of water operations. These include:

- Extra Preflight Considerations e.g. water in the floats–hull, corrosion due to salt water and extra stress on the airframe.
- Take off and Landing techniques.
- Taxiing considerations (lack of low speed control).
- Weathercocking tendencies.
- Glassy water operations.
- Wind and water current assessment.
- Emergency procedures.

2. The variety of types and combinations of water aircraft – either Trikes or 3 Axis, with any of the following:

- Floats,
- Hulls,
- Amphibious,
- Air Dinghy.

A microlight operating from water is bound by the same regulations as a boat and therefore the pilot must be conversant with:

- General Harbour Regulations,
- Water Recreation Regulations,
- Rules for the Prevention of Collision at Sea.

It is possible to modify most microlights for water operations providing that the modification criteria have been followed. Most water aircraft are:

- heavier,
- have greater keel surfaces,

- greater frontal area (more drag),
- lower centre of drag.

This combination gives the aircraft a cumbersome feel when compared to its land counterpart. A training guide for water operations is available from RAANZ at the current address.

Flight Certificates

Requirements for issue

Novice	Medical Declaration.
Intermediate	Novice Pilot: Pass exam on Law, Nav., Met., and Technical Knowledge, (Rotorcraft and Helicopter where applicable). Demonstrate knowledge and ability and perform a flight test. If a PPL, demonstrate competence to a Senior Instructor.
Advanced	Cross–country requirements. Demonstrate knowledge and ability to conduct flight manoeuvres.
Passenger rating	An endorsement to carry a passenger is available to Intermediate and Advanced pilots when the applicant has 35 hours flight time and has demonstrated competence to a Senior Instructor.

Note: the difference between Intermediate and advanced certificates is the cross–country syllabus.

Recent Experience

Novice	No solo until basic exercises completed. Continue under Instruction.
Intermediate	Three takeoffs and landings every 180 days.
Advanced	Three takeoffs and landings every 180 days.

Privileges

Novice	PIC under instructor supervision for purposes of increasing skills or requalifying for expired licence.
Intermediate	Limited to 10NM of the takeoff point.
Advanced	May fly unlimited distance, although if flying within 5km of a licensed aerodrome, must be briefed by an Instructor.

Medical certificates are valid for up to four years if under 40, two years if over 40, or as specified on the certificate. If there is a medical condition, the Doctor may specify a shorter time and must indicate whether the applicant can carry passengers.

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