CHAPTER 10 - BASIC SOARING TECHNIQUES

THERMAL SOARING

Thermal sources

Thermals form when a patch of ground becomes locally heated to a higher temperature than the general terrain. A number of factors govern whether a thermal is likely to form or not. These include the colour of the terrain, its composition, vegetation, moisture content and the angle at which the sun's rays strike the surface.

Colour

It is well-known that darker colours absorb more heat than lighter colours. Try this on a glider - feel the temperature of a white fibreglass wing and then feel the temperature of the darker red at the wingtip. There is an appreciable difference.

The same applies to the earth's surface. Dark earth colours absorb more heat and, by a process of conduction, spread this downward through the soil. Lighter colours absorb less heat and reflect more of it back to the atmosphere.

Insolation (solar energy) conducted into the soil may do some useful work for the farmer, but does not help the soaring pilot very much, as the surface does not get heated enough to form a thermal. On the other hand, insolation reflected back into the atmosphere is lost for ever.

Very dark surfaces, such as newly-ploughed paddocks, could therefore be a disappointment if they are relied upon to produce a thermal. So can very light surfaces, such as salt-pans. What is needed is a surface which will get hot enough to heat the air above it, neither conducting it away into the soil nor reflecting it back into the atmosphere.

All things considered, there are so many factors involved in the production of thermals that it is difficult to be hard and fast about it. The main thing is to be aware that different surfaces heat up at different rates and to be conscious of large contrasts in the patchwork of colours which make up the landscape.

Composition

There are many different surfaces which may affect the amount of local heating. Rock outcrops will heat up at a different rate from loose sand. Add this to the effect of the different colours and you can see that the picture is becoming quite complex.

Lakes are generally useless as thermal sources. They reflect most of the solar energy that hits them and, even in summer, remain quite cold.

Vegetation

Cereal crops, very common in Australia, are generally quite good from the point of view of thermal production. They do not reflect too much insolation and they do not result in much conduction of heat away from the surface. If the crop is reasonably long, it can trap heated air for long enough to form a thermal bubble, which only needs a trigger (such as a light breeze) to cause a bubble to leave the ground.

Trees use up much of the solar energy given to them. In the case of a large group of trees, the sun's energy is largely absorbed by the trees themselves, much of this energy never reaching the ground. The solar energy entrapped by the trees is used mainly to evaporate from the leaves much of the moisture which the tree has absorbed from the ground. This process is known as evapo-transpiration.

However, although forested area are generally not good thermal sources in the early part of the day, they can often be relied upon later in the day to provide quite large areas of gentle lift.

Moisture content

If there is large moisture content in the soil, much of the sun's energy will be used in evaporating this. Little or none may be left over to heat the surface itself. This accounts for why irrigation areas are quite rightly regarded as "sink-holes" for glider pilots.

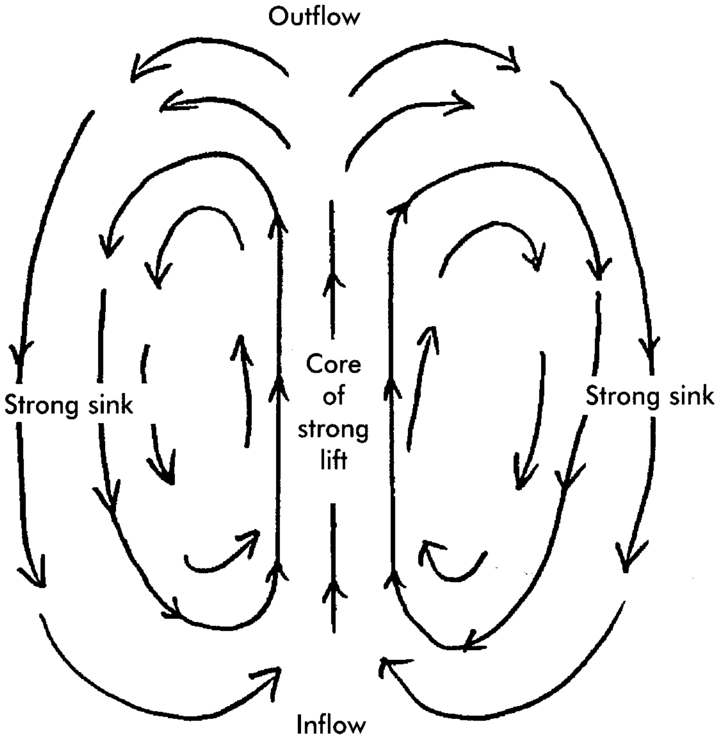
The angle at which the sun's rays strike the ground

The shallower the angle at which insolation strikes the ground, the less heating effect it will have. Hills and slopes facing the sun will usually produce local hot-spots, creating useful thermal sources. It is even better if the sun-facing slope is sheltered from any cooling wind which might be blowing - the so-called "wind-shadow" effect.

Thermal shapes and lift distribution

Thermals come in all shapes and sizes and it is impossible to generalise. The late "Wally" Wallington, probably the finest of all soaring meteorologists, said that thermals are as varied as trees around the world, no two are exactly alike and no particular specimen can be described as typical of all the others (Meteorology for Glider Pilots).

However, thanks to research, we know enough about them to have a general idea of their shape and characteristics. It is generally agreed that a thermal, once it has broken free of the ground and more or less organised itself, forms itself into a "vortex ring". This resembles a smoke-ring, which can occasionally be seen from a cigarette, or in a more extreme form, a nuclear explosion. From the soaring point of view, the important feature of a vortex ring is that the central core of the rising ring ascends at a greater rate than the ring as a whole. The diagram below gives a rough idea.



This vertical circulation of a doughnut-shaped vortex ring accounts for why thermals have "cores" which give much better climb rates at the centre than they do at the edges.

Because of the vortex ring nature of thermals, a glider may experience a good rate of climb when it is well-established in the core, about half-way up the "doughnut", but another glider joining the thermal a few hundred feet underneath may only find weak and scrappy lift, or may find nothing at all. This is a common experience for all glider pilots.

The fact that the best climb-rate will be found in the core, weakening outside the core and eventually turning into strong sink just outside the thermal, means that a pilot must learn the skill of turning quite steeply in order to get the best out of each thermal. Thermal turns typically use 40 degrees of bank or more and it is fair to say that most pilots in the early stages of learning to soar are reluctant to use more than about 20 degrees of bank. Make sure you get plenty of instruction in steeper turns, stressing accuracy of flying and keeping everything under close control, including of course the airspeed and control coordination. It is in nobody's interest to have you losing control and spinning down on top of another glider a couple of hundred feet below.

Locating a thermal

If cumulus clouds are present, locating thermals is not difficult. Each cumulus is fed by its own thermal and you just have to head off underneath the cloud to find it. However, you could still get caught. The life cycle of a typical fair-weather cumulus cloud is quite short, probably less than twenty minutes, so it is quite possible that by the time you get there, the thermal that originally formed the cloud has long gone. This can leave you with a feeling of considerable disappointment.

The trick is to decide which of the clouds you can see in the sky are growing, which have stagnated and which are dying. It is difficult to put this into words, but probably the closest one can get is to say that growing clouds have a well-defined base and hard, well-formed edges. Dying clouds are much more ragged in appearance, both at their bases and around the edges.

If you think picking the right cloud is a bit of a lottery, try finding a thermal in "blue" conditions; that is without any cloud. Australia being for the most part an arid country, most of our thermals do not contain enough moisture to condense out into cumulus clouds. Australian glider pilots must become adept at finding and using thermals without any beacons in the sky to guide them.

The simplest method is the so-called "forest theory". This says that, if you blindfold a man and let him wander in a forest, sooner or later he is bound to bump into a tree. A remarkable amount of thermal searching in blue conditions follows this random procedure. It is surprisingly successful.

Locating a thermal is partly a matter of seeking out likely sources, partly a matter of feel for the subtle changes which occur in the air as a thermal is approached. For instance, as the glider gets close to a thermal, there will be an increase in sink as it traverses the air immediately surrounding the vortex ring. This will then be followed by a noticeable "surge" under the glider, probably accompanied by an increase in airspeed as the glider encounters the horizontal gusts associated with the vertical gusts in the thermal. Some pilots also claim that they can see the horizon fall away in the canopy as the thermal is entered. If this works for you, use it. Finally, the variometer will confirm what the seat of your pants has been trying to tell you.

Centring a thermal

Once a thermal has been found, the next thing is to decide which way to turn. There are two ways to approach this decision. You can either take pot luck and turn in any direction at random, on the basis that you can re-adjust when you know a bit more about the thermal. Or you can try to feel whether the main surge occurred under one wing rather than the other. If you can feel that the surge occurred under, say, the left wing, the thermal lies to the left side and you should turn in that direction.

Before going any further, this is a good opportunity to reinforce the need for good airmanship at all times, but especially when turning. When faced with the difficulties of thermal location and centring in the early stages, it is easy to forget that a good lookout is essential if you are not to become a menace to other airspace users. Never, never turn without "clearing your turn" first by means of keeping a good lookout.

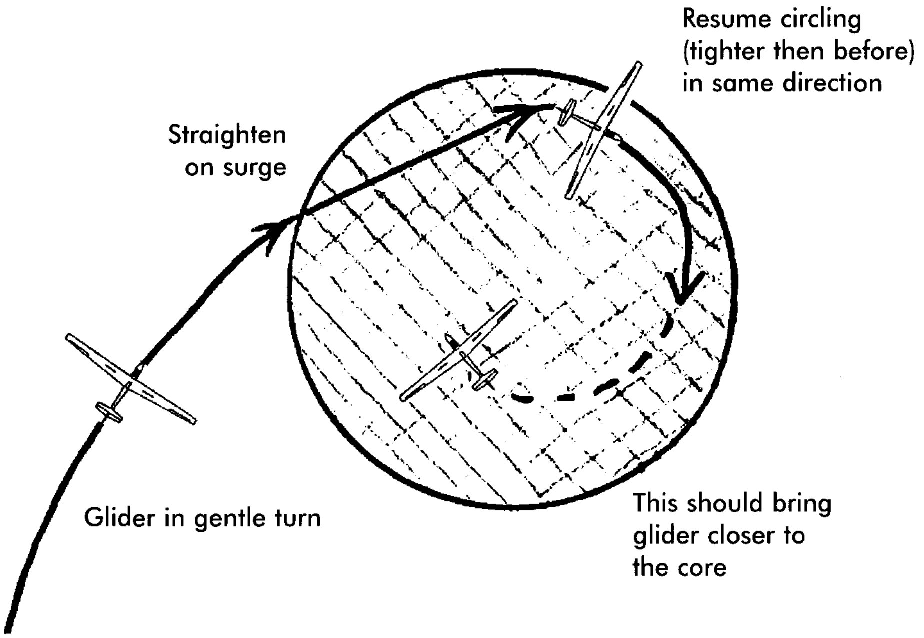
An audio device connected to or built into the variometer is a useful aid to keeping the head out of the cockpit during thermalling. Some may say it is essential and it is difficult to argue with this.

Now to locate the strongest part of the thermal, the so-called core. This is a process known as "centring" and is an important skill to acquire. A pilot who can locate a core quickly and circle the glider entirely within this core is destined to become a very efficient soaring pilot.

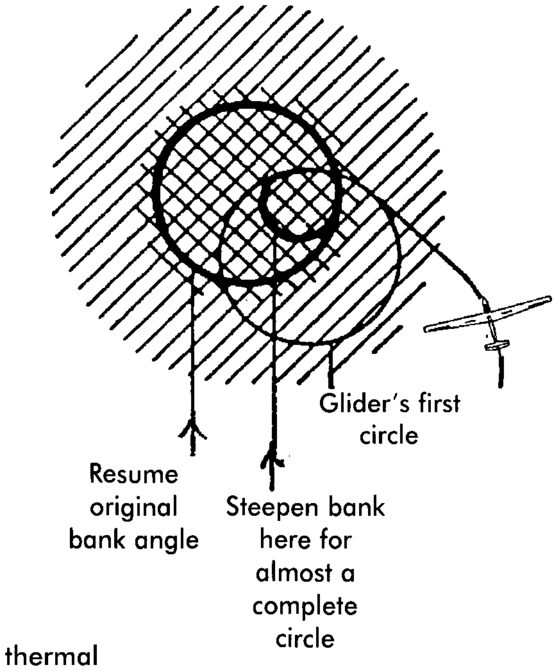
The first clue occurs at the moment you first encounter the thermal. If you feel that a wing is being lifted, but there is little or no corresponding lift indication on the variometer, you are well to the side of the core and you need to turn immediately toward the wing that was pushed up. Make a heading change of about 45 degrees, and then straighten out. If the variometer shows an increase in lift, maintain your new heading for about two seconds, then turn once again in the direction you were turning before. This should take you closer to the core and you should monitor the vario indication (but don't forget a careful lookout too - this is where the audio vario really comes into its own).

You may be lucky and find that this does in fact result in a good strong lift indication all round the circle. If it does, all well and good. If it doesn't, you have a choice.

One choice is to use the "straighten on the surge" method, where you simply straighten the glider when you feel the maximum surge, then resume the turn in the same direction after two or three seconds. This has the effect of shifting the glider towards the core. See below.



Another choice is the so-called "Huth" method, perfected by the famous German soaring pilot Heinz Huth in the 1950s. In this method, when the glider flies out of the thermal, keep circling until it comes back into the lift. At this point, after a pause of about a second, the bank is steepened and the rate of turn thus increased. Maintain this increased bank angle for not quite a complete circle, say about 300 degrees, then go back to the bank angle you had before. The diagram below illustrates the principle.



Maximising rate of climb in a thermal

One of the most common questions asked by new soaring pilots is "how much bank should I use in a thermal"? Unfortunately there is no single answer to this riddle. It depends on a number of factors. About the only thing which can be said with certainty is that almost all pilots learning to soar use far too little bank and their climb rate suffers as a consequence.

Advocates of very steep bank angles claim that this is the only way to get into the real core of the thermal. Advocates of lesser bank angles reply that the greater sink rate of the glider at steep bank-angles negates any advantage that might be gained by banking steeply, and that a lesser bank angle is more efficient. Both are right.

The answer to the bank-angle question is that it depends on the thermal. If the core is strong and the thermal not very wide, the steeper bank angles undoubtedly work better. This is the situation which might exist in the lower levels of a thermal. Higher up, the thermal widens out and it may be better to ease off the bank angle a little and reduce the glider's sink rate.

The important thing is that there is no "standard" thermal, any more than there is a standard thermalling method. You must be prepared to use any or all techniques in search of the most efficient use of each thermal.

Finally, what speed to use? Theoretically the glider will lose the minimum amount of height at the speed for minimum sink rate. In level flight, this is about 7 knots above the stall speed. However, if the glider is banked, it will need an extra margin of speed because of the increased stalling speed in a turn, especially if you have chosen to use 40 degrees of bank or more. Furthermore, aileron control is often not very good at minimum sink speed and it is prudent to add a little to improve this. All things considered, unless the thermal is silky smooth (most are not), a reasonable speed to thermal a glider would be its maximum L/D speed, which is a little higher and a little less efficient than min sink speed in terms of sink rate, but gives a better margin of control and greater peace of mind.

Losing a thermal

Thermals are lost for a number of reasons. The two most common reasons are (i) failure to fly the glider accurately enough, and (ii) the thermal distorting or bending during its climb.

(i) Failure to fly accurately enough

After a thermal has been found, accurate flying is needed to keep it. Variations in speed or bank-angle change the radius of turn of the glider and are a major cause of pilots losing thermals. Accurate control of attitude and maintaining a constant bank angle are the biggest contributions a pilot can make to keeping a thermal which has taken so much effort to find.

(ii) Thermal changing its shape or bending as it climbs

As a general rule, thermals expand as they climb. This may demand that the pilot changes the bank angle to stay in the best lift as height is gained. If you don't do this, the thermal may appear to peter out and, to all intents and purposes, has disappeared. In fact it is probably still there, but the pilot has lost it through failure to adapt to change as the thermal ascends.

Thermals may change their shape in other ways too. If the wind changes with height, which it usually does, it can cause thermals to "shear", that is to suddenly move off to one side. This occurs without warning and the pilot has to be alert for any sign of rapidly deteriorating lift, so that a decision can be made whether to carry out a search for the thermal or whether in fact you have reached the top.

There is another variation to consider. Thermals may have more than one core. In this case, if you manage to identify that such is the case, you will have to decide whether it is more profitable to try to centre on one strong core (which may be very narrow) or go from one core to another at a reduced bank angle, but still at an acceptable overall rate of climb.

Re-locating a lost thermal

Many pilots give up the ghost when they lose a thermal. It may be of course that the thermal has stopped climbing or has petered out to virtually nothing. This can often be checked, either by noting the base of any clouds which may be present, or by observing the performance of other gliders in the vicinity. If there are others well above you, the chances are that the thermal is still there and you have lost it.

At the risk of stating the obvious, the first thing to do is to search for the lost thermal. On the assumption that it is a blue day and you have no clouds for guidance, this is best accomplished by firstly reducing your angle of bank, thereby increasing the radius of turn. It may be that the increased turn radius will take you back into lift at some part of the circle, whereupon you can re-centre on the core as per the "centring a thermal" section.

If this does not work, you have an awkward decision to make. Do you search upwind, downwind, crosswind or completely at random? Going downwind may work quite well, as the thermal may "bend" in a downwind direction due to an increase in wind-strength with height. Going downwind also has the advantage of higher groundspeed and thus greater chance of coverage of thermal-producing terrain.

On the other hand, there are some days when the wind decreases in strength with height. In this case, the thermals will appear to "bend" into wind and you will probably profit by searching in an into-wind direction.

Selection of a "working height band".

This is a basic cross-country skill. Thermals seldom ascend at a constant rate over their entire height-span. Typically (if we can assume for a moment that there is such a thing as a "typical" thermal) the climb-rate might be a bit weak near the ground, strengthen to achieve a much better climb-rate as it gets higher, but then taper off to a lesser rate as it approaches temperature equilibrium with the surrounding air.

In their early days of using thermals, pilots naturally want to see how high they can get. They stay with the thermal until they reach the very top, even though the climb-rate tapers off to a pretty feeble rate in the last few hundred feet. They do this in every thermal they come across. This is not an economical way to use thermals for cross-country flying, and the pilot needs to acquire the knack of leaving the thermal when the rate of climb falls off to an uneconomical level, in order to maximise cross-country speed (and therefore distance covered).

In the same way, the pilot will notice that it may be a bit of a struggle to get started in the thermal, as thermals can often be weak and narrow low down. The pilot will apply this knowledge on any given day, by remembering that below, say 3,000 feet, thermals were broken and narrow, excellent between 3,000 and 6,000 feet and began weakening noticeably above 6,000 feet. This establishes a "working height band" for that sector of the cross-country flight of 3,000 to 6,000 feet.

The height band will not remain constant throughout the day, but will vary as the daily temperatures vary, probably reaching a peak of thermal strength in the mid-to late afternoon. The pilot must constantly assess the behaviour of each thermal in order to update the information to make the most efficient use of the thermals.

HILL SOARING

The mechanics of hill soaring

Hill soaring, otherwise known as ridge or slope soaring, is the simplest of all soaring techniques to understand and apply. However, like all skills, there are precautions to observe and specific techniques to understand.

Hill lift occurs when the wind blows toward a suitable hill. Some requirements are:-

1. A sensible minimum height for a suitable hill is at least 300 feet higher than the surrounding terrain. Even so, a pilot must be rated for outlandings before soaring on this kind of hill, because even a slight reduction in wind-strength may dump a glider very quickly and a landing quickly becomes necessary if this occurs. For operations on hills of this rather low height, the assumption is made that the glider takes off from a strip at the bottom of the hill on the windward side, or is approaching the hill from the windward side on a cross-country flight.

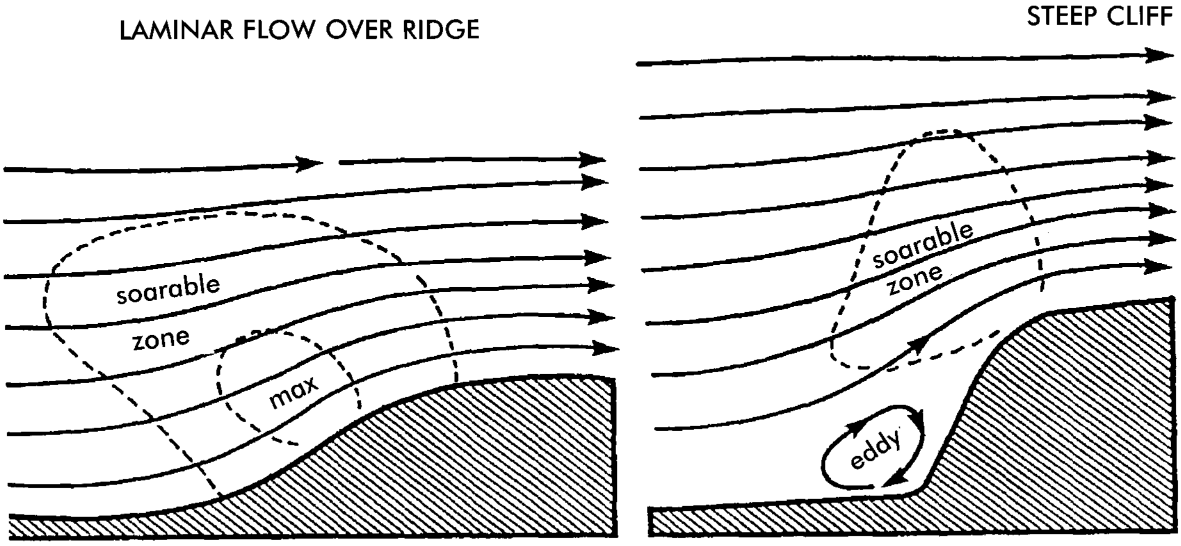
   If the glider is to be launched, and intends to land, on top of the hill, the hill should be at least double that height. Otherwise, the hill lift may not work to sufficient height to enable a circuit to be carried out for a safe landing on top.

2. Ideally the hill should slope at somewhere between 20 and 45 degrees. Shallower hills do work, but they are not as reliable and need more wind to produce a useable strength of lift. Steeper hills produce narrower updrafts and in some cases a vortex may form toward the bottom of the hill, effectively reversing the flow and causing trouble for a glider which gets low.

3. The wind should be blowing as close as possible to 90 degrees to the hill. Anything less than 90 degrees detracts from the strength of the hill lift.

4. The hill should not be too short. Anything less than about 2 kms in length may persuade the wind to blow around the ends rather than climb over the top. Even 2 kms may not be enough; some pilots discovered a few years ago that even Ayers Rock did not work in quite a brisk wind, probably because of this phenomenon.

5. Even though there is always some variation of wind with height, the mistake is sometimes made of launching a glider if there are signs of wind at the top of a hill, even though it may be calm in the valley. The hill will not produce lift under these circumstances - the wind must blow all the way from bottom to top.



"OSTIV" diagrams

Where to find the best lift

If you get to the hill below hill-top height, you will need to go quite close to the hill in order to find lift, especially if the wind is not very strong. This sometimes means flying at only a wingspan away from the hill. This is a tricky business and should not be experimented with. Get some dual instruction from a competent hill-soaring instructor.

As height is gained, hill lift usually strengthens. If you are flying above the top of the hill, it will be advantageous to move away from the hill, into wind. When well clear of the hill, say as far above the hill as the hill is above the valley, the best lift will usually be found along a line approximately above the **bottom** of the hill.

The effect of atmospheric stability on hill soaring

If the air is unstable, thermals will probably form and these will mingle with the hill lift to cause some interesting effects. In the case of flying into a thermal which is mixed with hill lift, the climb rate can become very high and it is important to exercise good airmanship in using such thermals. When you recognize that you have hit a thermal embedded in hill lift, if you are below or close to the top of the hill, it is not prudent to circle in the lift. Given the vagaries of **any** kind of lift, the thermal may let you down at the very moment you are pointing straight at the hill. It is best to carry out "S" turns in this kind of mixed lift, all turns being away from the hill, until you are well clear of the hill and circling becomes safe.

The mixing of the climbing part of a thermal with hill lift has the obvious effect of greatly increasing the total lift. What may not be so obvious is that the sinking part of a thermal can sometimes negate the hill lift, leaving the glider going nowhere fast, or even worse starting to sink toward the hill. Don't panic, concentrate on keeping a safe distance from the hill and either resume using hill lift a bit later or use the rising part of the thermal if you meet it.

Neutral stability usually gives the best and most predictable hill-soaring conditions. If conditions are very stable, it is possible that the air may get blocked and in extreme cases may flow horizontally along the slope instead of upwards.

When hill soaring, remember that there may be other gliders around, and you must accommodate them as well as yourself. This brings us to the special rules for hill soaring.

Special rules for hill soaring

1. All turns must be outwards, i.e. away from the hill.

2. A glider overtaking another glider when hill soaring shall do so by passing between the overtaken glider and the hill.

3. If two gliders approach each other head-on while hill soaring, the glider which has the hill to its left shall give way by turning away from the hill.

4. When hill soaring, a glider shall not be flown lower than 100 feet above ground when within 100 metres horizontally of a person, dwelling or public road.

WAVE SOARING

The formation of lee standing waves

In the first chapter of this book, mention was made of a particularly smooth form of lift which was discovered, almost by accident, in the 1930s. This is the form of lift known to us as wave lift.

The waves form in the lee of a mountain range in certain wind conditions. The waves remain stationary with respect to the ground, the wind blowing through them. Hence the full title of "lee standing wave lift", usually abbreviated by glider pilots to just "wave lift".

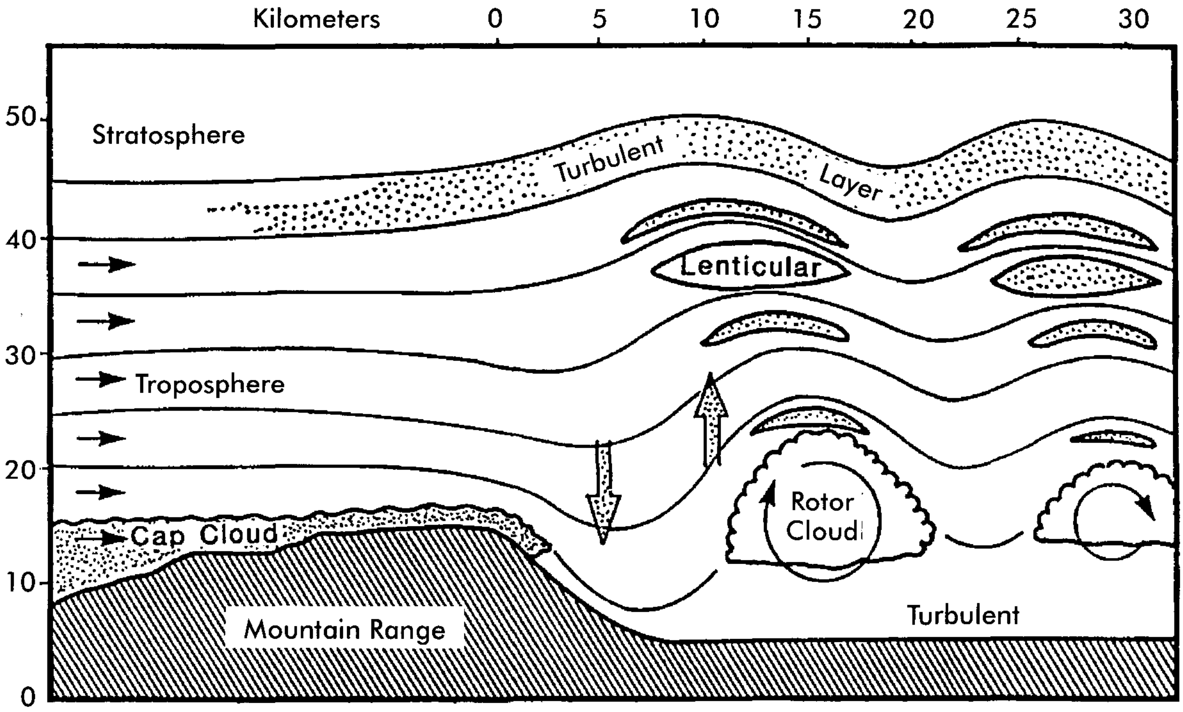
It is generally recognized that wave lift will form if the following conditions are met:-

1. The wind is blowing at close to 90 degrees to the mountain range.

2. The mountain range has a fairly steep windward slope and preferably a steeper leeward slope.

3. The wind increases in strength with height but maintains a fairly constant direction.

As might be appreciated, the complete set of conditions for the formation of lee standing waves is more complex than this rather simplified explanation, but it gives an idea of what is required.



"OSTIV" diagram

When waves form, they stream downwind of the mountains or hills which triggered them. The wavelength (distance between peaks) of the waves remains constant, whereas the amplitude decreases steadily until the wave system peters out some distance downwind of the hills.

Use of wave lift

Wave lift differs in one important way from thermal and hill lift. Because wave lift can go to great heights (the Australian height record is over 34.000 feet and the world record over 48,000 feet), oxygen needs to be carried on virtually every wave flight. It goes without saying that pilots using oxygen equipment must be properly trained in its use.

Wave lift is not only useful for height gains, but can be used for cross-country flights. Distances of over 2,000 kms are now being flown in New Zealand and such flights are bound to become popular.

Mountain waves often produce visible proof of their existence in the form of characteristic "eyebrow" clouds, known as lenticulars (lens-shaped). These clouds are very smooth in their outline and do not drift with the wind, but remain stationary over the ground.

In the immediate lee of the mountain range, underneath the first of the lee waves, is an area known as the "rotor". It is well-named, as the air rotates rapidly in this area and produces severe turbulence. Gliders sometimes have to use the lift on the upgoing part of the rotor in order to gain access to the smooth wave lift on the windward side. It is a very rough ride indeed and there have been cases in the USA (none in Australia) of gliders breaking up in the rotor. It is usually, but not always, marked with a cloud, which is invariably ragged in appearance and visibly rotating like a giant ferris wheel. If you look closely, you might even spot the "Keep Out" sign pinned to it!