Thermalling

1 Thermal recognition and thermal detection

A basic skill in gliding is to recognise a thermal as you approach it. A thermal cannot rise through the lower atmosphere without leaving some sort of disturbance in its wake. Therefore the first sign of nearby lift is some slight turbulence and the second is an increased rate of sink. Although no two thermals are the same, this sink usually weakens gradually and is soon replaced by a second patch of rough air. This is another indicator of a nearby thermal. When sink gradually turns into weak lift cruising speed should be slowly reduced in anticipation of the thermal. The airspeed should be kept high enough to ensure a quick and positive aileron response. For a modern unballasted single seater, a speed of around 55 – 65kt would be fine.

On entering the thermal you will notice a surge, a sensation sometimes combined with being slightly tilted to one side. This is an indication of a strong updraught which is often embedded in a larger area of buoyant air with less powerful but still quite useful lift. It is not displayed by your instruments as quickly as you would like because instruments can only indicate lift after the aircraft has undergone a change of altitude. Pilots possess faster reacting and very sensitive body sensors which reduce their reliance on the instruments and on the variometer in particular. Some of these sensors are located in the inner ear and form part of the body's balance system. In addition, your body's nerve endings also act as sensors. Those in your backside are especially useful. They instantly detect even minute changes in seat pressure. Your brain quickly converts this information into an indication of lift or sink and makes it superior to even the best variometer. An almost instantaneous "seat of the pants" feedback provides a response time of almost zero. If you disregard the seat of the pants information you will initiate a turn only to find yourself in sink near the thermal's outer fringes.

When the presence of a thermal is confirmed by the fastest variometer, usually the electric one, you become interested in an indication of its strength. Your body is good at detecting changes in vertical airspeed but it cannot interpret the rate of climb. Your variometer does come in handy now; in fact it is crucial for an indication of thermal strength.

A word of warning though, keeping the eyes glued to the variometer during thermal entry is a bad habit, depriving you of other valuable clues including hints from outside the cockpit. It is dangerous and masks the ability to feel the thermal because the human brain automatically assigns top priority to sight. Scientific evidence suggests that only in the absence of visual clues are other stimuli taken into account. As glider pilots, our preference for visual clues has a significant drawback. It means that by looking at the instruments our brain automatically disregards the more instantaneous "seat of the pants" information.

2 Centering a thermal

Having found a thermal and being satisfied with its strength, decisions need to be made. You need to initiate a turn, but the problem is one of timing. Sometimes you need to roll into the turn very soon after you feel the vertical acceleration but on other occasions you should wait for a few seconds. Apart from your entry speed, the size or horizontal extent of the thermal plays an important role. Usually a swift turn is the right course of action at low altitude, but when high it is almost always best to delay the turn for a while. The turn should be initiated when the vertical speed has peaked. This is best determined by your sense of feel – not by the variometer. Varios have a lag time of about 3 seconds and are frequently providing incorrect readings due to horizontal air movement. Remember that the peak of the acceleration is not the peak of the thermals strength.

Just as important as the correct timing of your turn is the decision whether to turn right or left. The instruments are of little help here. With a very light touch on the controls, and by looking outside, you will often notice a lifting wing while closing in on the core. This is never as dramatic as illustrated below, but it can be a useful indicator. Obviously the rising wing is travelling through more buoyant air providing a good indication in regards to direction of turn. (Refer to Figure 1)

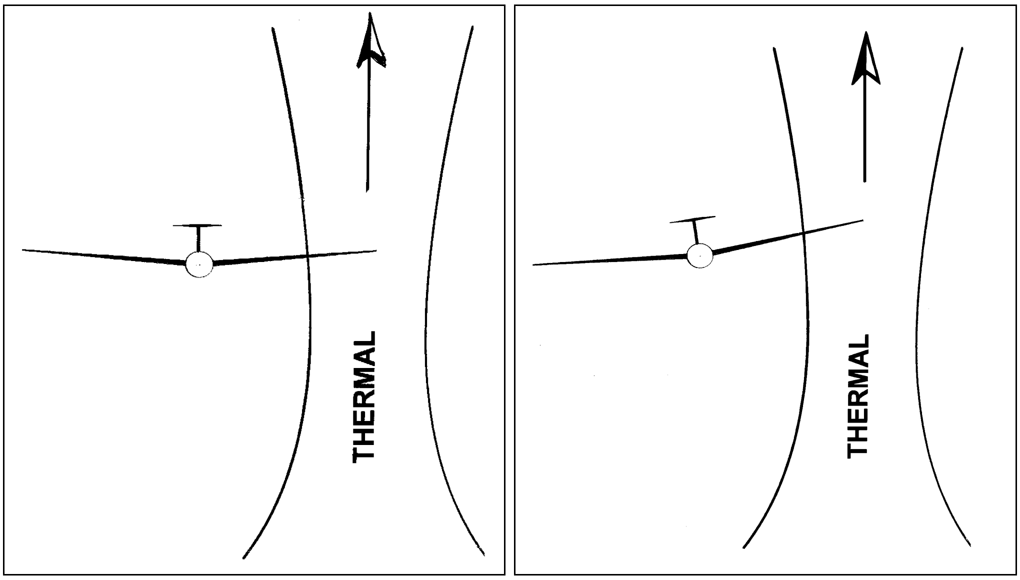

Figure 1 Lifting of wing by thermal (not to scale)

By simply banking towards the lifting wing and doing the exact opposite of what the glider is forced to do, chances of striking the best part of the lift are increased and the risk of going through the heavy sink normally found nearby are much reduced. If your eyes are glued to the variometer, your chances of turning towards the core are 50 percent at best and your chances of turning into sink are the same.

This decision making sequence is best described as:

Decide: whether to turn, when to turn and then which way to turn.

Now it is only a matter of closing in on the core. This is usually achieved when the air becomes smooth or the amount of turbulence decreases markedly. Often this coincides with improved control responsiveness and a reduced noise level within the cockpit.

Doing the exact opposite of what your glider seemingly wants to do means that you must be able to thermal to the right and to the left.

Even the best glider pilots do not get exactly into the core on the first turn and need to perform some thermal centering. Two basic rules help greatly when it comes to moving the glider closer to the centre of the lift.

Rule 1: Never fly through the same patch of bad air twice.

Rule 2: Always shift your circle towards the stronger part of the thermal.

Thermal centering by varying angle of bank

Obeying Rule 2 is easier said than done. However, it becomes much easier if you increase the angle of bank as the lift decreases (to get away from the sink) and decrease the angle of bank as the lift increases (to move towards the lift).

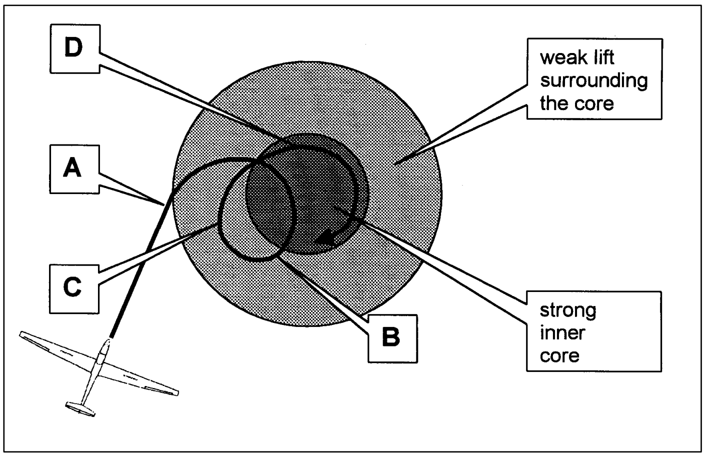

Figure 2 Thermal centering by varying angle of bank

A — B turning into lift

B — C steep angle of bank due to weakening lift

C — D shallow angle of bank due to increasing lift

D maintain normal 45° angle of bank while in steady lift

Centering a thermal by varying the angle of bank is only advisable when the glider is slightly displaced from the core. However, if your turn is partly in sink or with considerable variances on either side of the turn, you have to take more drastic measures. A major position change is called for which involves a short term levelling of your glider's wings.

Thermal centering by the worst heading method

This leads us to the so called “worst heading” method. It is best employed if you find yourself a fair distance away from the centre of the thermal. (Figure 3)

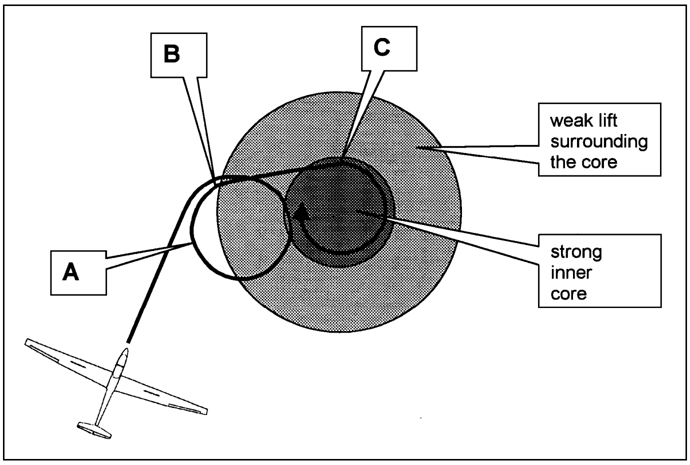

Figure 3 Worst heading thermal centering method

The worst heading centering method requires that you make a mental note of your worst position in the thermal, Point A, and wait for almost a quarter of a turn before you level your glider completely Point B. After a short while, roll the glider back in the same direction, Point C and you should now be positioned substantially closer to the core. Whatever levelling time you decide upon depends on the diameter of the thermal, your speed, and your distance from the core. This manoeuvre needs to be repeated as long as subsequent turns are still partly in sink. A good indication of being in the core is an even and relatively smooth climb relatively free of turbulence. The best way to know when to turn back into the thermal is to wait till the acceleration eases. At this moment you are going up at maximum speed.

Most experienced pilots use a reference point and form a mental picture of the thermal. The reference point may be the position of the sun or some feature on the ground. The position of the sun is a good option simply because it is useful even while flying over featureless terrain. It does not matter which reference point you use but it is of utmost importance to establish a mental picture of the lift distribution in the thermal. By paying careful attention to the “feel” of the air you get useful clues about the location of the core. A short moment of smooth air should make you shift your position towards this smoother patch of air. Equally, sudden turbulence indicates a position close to the edge of the thermal and a need to move towards the opposite side of the circle. In other words, you must update your estimate of the position of the core all the time using firm and precise control inputs.

3 Angle of bank

The single most important issue in terms of extracting the maximum rate of climb from a given thermal is to fly at the appropriate and optimum angle of bank. Thermals are strongest at their centres and the optimum bank angle is the one which maximises the glider's climb rate.

Circling at too shallow an angle of bank means that you will fly around the core and work very weak lift. On the other hand, an angle of bank too steep for your thermal is also detrimental to your rate of climb due to a significantly higher sink rate of your glider.

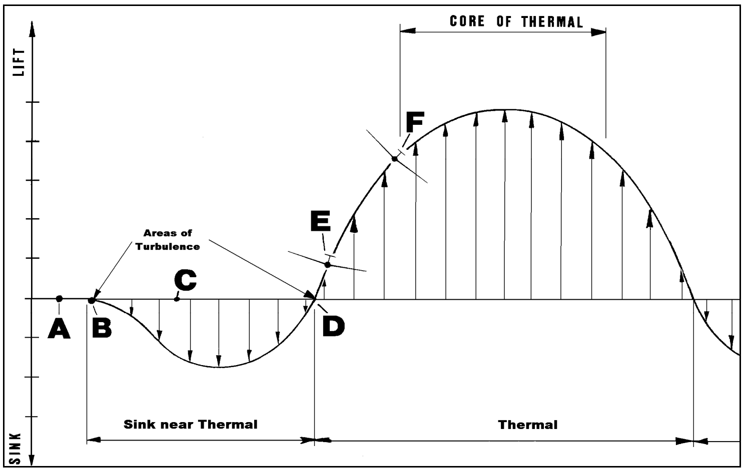

Figure 4 Vertical air movements (simplified)

The above Figure 4 indicates the cross section of a thermal, where the lift in the centre is strongest, and drops off to the outside.

A small and comfortable angle of bank will result in a radius of turn which is too large to stay in lift. At best you will be flying near Point E. It means that you will only climb in weak lift and be close to heavy sink.

It would be better to increase your angle of bank and achieve a smaller radius of turn and fly near the core, Point F, taking advantage of lift at least twice as strong as near Point E. Furthermore, you would still be in weak lift after momentarily losing the core and can re–centre the thermal just by variations in the angle of bank. Despite the fact that the glider is banked and has a higher sink rate, the rate of climb will be higher. It has been found that for the majority of Australian thermals a bank angle of 45° is close to optimum.

Figure 5 illustrates the magnitude of the reduction in circle diameter.

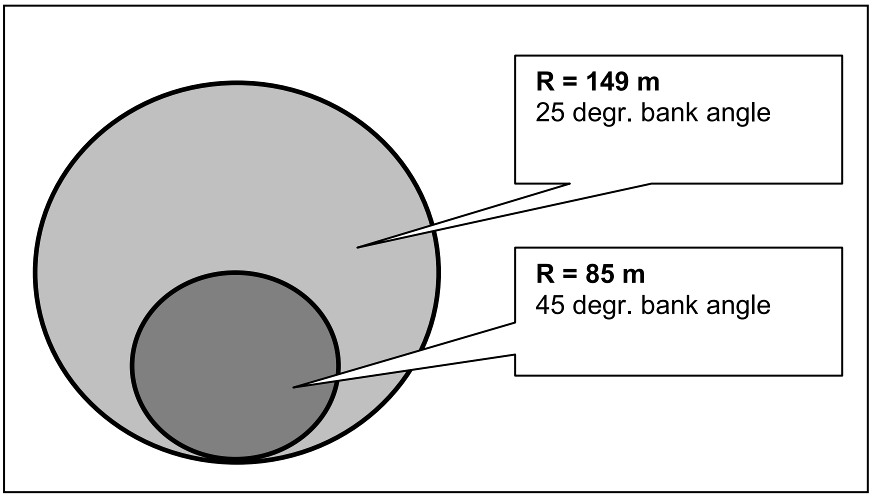

Figure 5 Comparison of circle diameters

Flying at higher or lower angles of bank has a detrimental effect on the achieved rate of climb. Figure 6 shows that circling at 45º achieves a climb rate of less than 2 m/s (or 4 kt). Banking the glider 30º makes for a climb rate of 1 m/s (or 2 kt) and a mere bank angle of 25º will at best result in zero sink. Excessive banking of 60º is also far from ideal. It can only be justified when extremely narrow lift is encountered (e.g. at low altitudes) and a circling diameter of less than 70 m is necessary to climb at all.

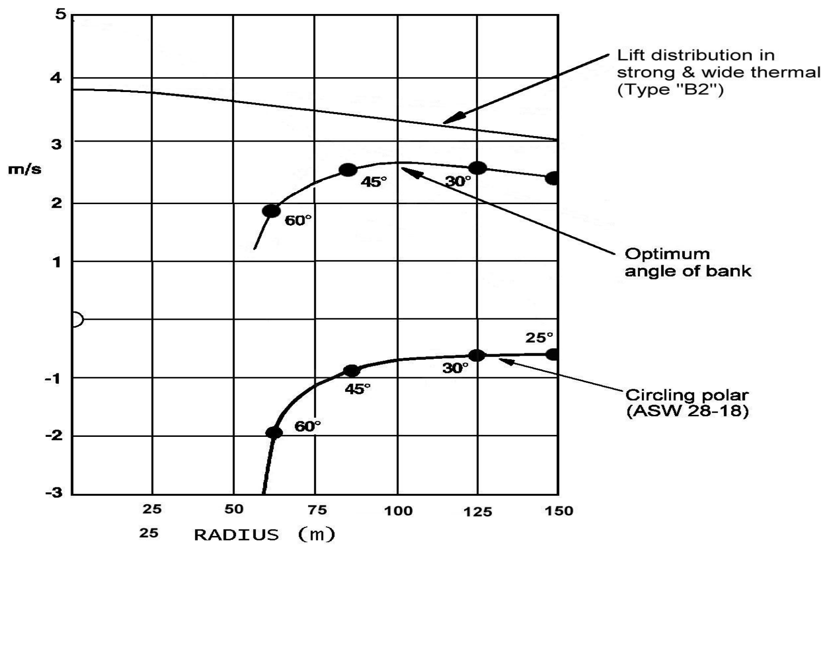

Figure 6 Optimum angle of bank for strong and wide thermal

4 Thermalling speeds

Minimum sink speed, Point B in Figure 7, is the best speed for thermalling. This is not "just above the stall speed", as a significant penalty is paid for flying too slowly. Consider the polar curve of a typical two-seat trainer.

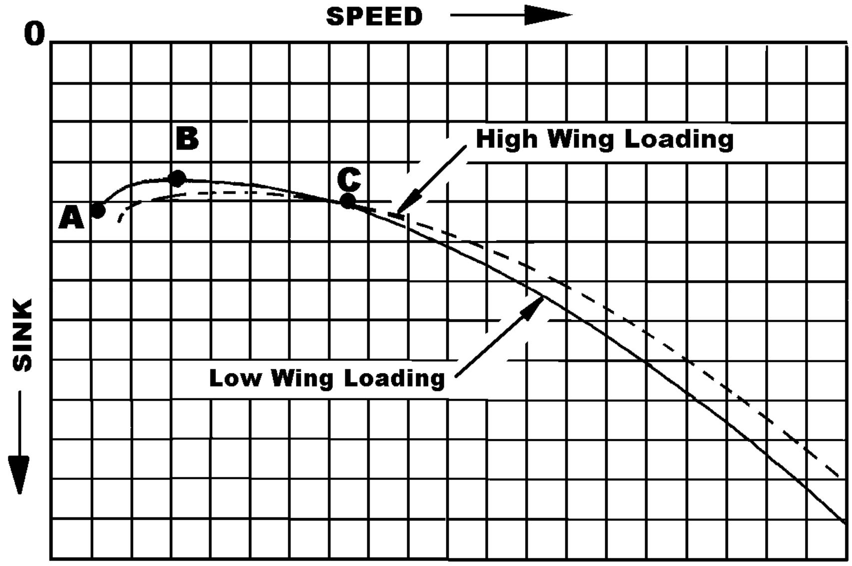

Figure 7 The polar curve (Speed polar)

Point A represents the minimum speed at which the glider will still fly. Any slower and the aircraft stalls.

Point B is the rate of minimum sink, the optimum if the aim is to sink as slowly as possible.

Point C is the speed for best glide ratio.

Flying at speeds between points A and B results in a higher than necessary sink rate. Also, circling just above the stall can be dangerous, uncomfortable and inefficient and far from ideal from a performance point of view. Poor aileron control makes thermal finding and centering difficult, unpleasant and tiring and you can not feel the air.

The benefits of thermalling at higher than minimum speeds are:

- *Control response is much better, enabling you to manoeuvre your glider quickly, effortlessly and easily into the best part of the thermal.*
- *The nice feel and the feedback a glider gives if you fly at the right speed makes it so much easier to feel where the best part of the thermal is, thus decreasing your reliance on the instruments.*
- *Higher speeds increase safety margins. If you hit a severe gust or have inadvertently washed off some airspeed, you are less likely to drop a wing or even enter a spin — a very important issue in a crowded thermal.*

For a given bank angle, the radius of turn varies with the square of airspeed and therefore it is important not to fly faster than necessary. If you need to keep an eye on the airspeed indicator while thermalling then you are not yet ready to fly in close proximity to other gliders.

Experienced pilots only glance at their airspeed indicator from time to time, but take far more notice of these secondary indicators, sound and attitude. By doing so they can observe the airspace around them, watch other gliders, soaring birds, dust devils etc.

5 Flying accurately

Pilots often work very hard to find thermals only to drop out of them soon afterwards. Getting into the core is one thing; but staying there is quite another.

The answer is surprisingly simple. ***Fly accurately – very accurately —, or better still, – very very accurately indeed.***

Flying accurately means maintaining airspeed, yaw string and angle of bank appropriate for the current thermal. Even minor inaccuracies cannot be tolerated if you want to hang on to the core and extract the maximum rate of climb. If you tolerate fluctuations of only 5 kt in airspeed and 5º in the angle of bank, you will probably loose the core, and struggle in the thermal's outer fringes.

For example, if you are circling at 45º angle of bank for half a turn and flying at 45 kt, and for the other half of the turn you allow the airspeed to increase to 50 kt while simultaneously reducing the angle of bank to only 40º, the glider will move approximately 50% from its original centre. Details are shown in Figure 8.

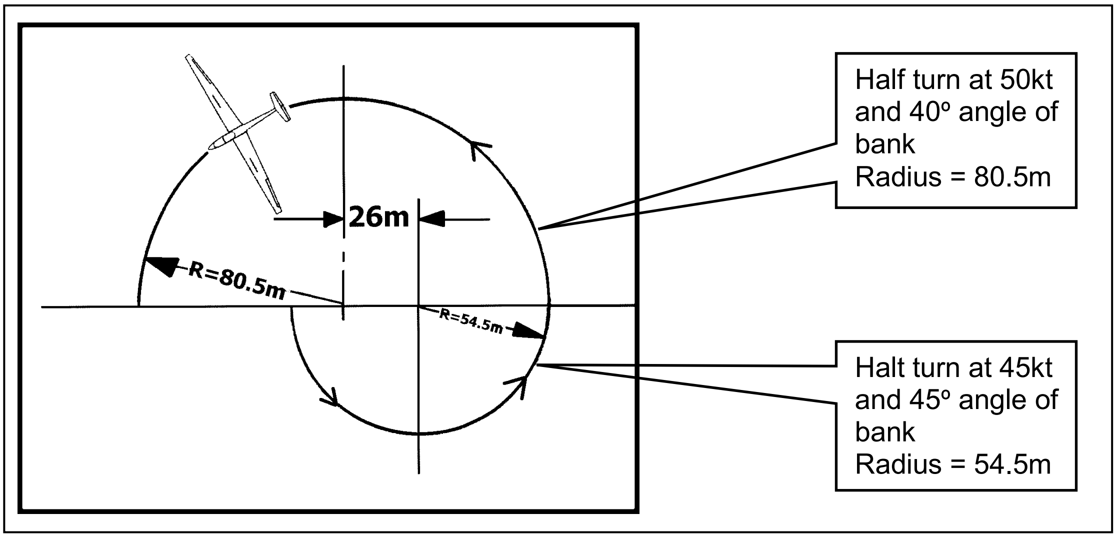

Figure 8 Re–positioning of a glider as a result of inaccurate flying

A glider's yaw-string is mounted ahead of the aircraft's centre of gravity, particularly in a two seater, and the air striking the yaw-string arrives slightly from one side of the aircraft's nose as shown in Figure 9. Therefore the yaw string misreads. You should keep the yaw-string a few degrees to the outside of the turn with a small amount of top rudder. This technique makes it easier to maintain an accurate airspeed at a steeper angle of bank.

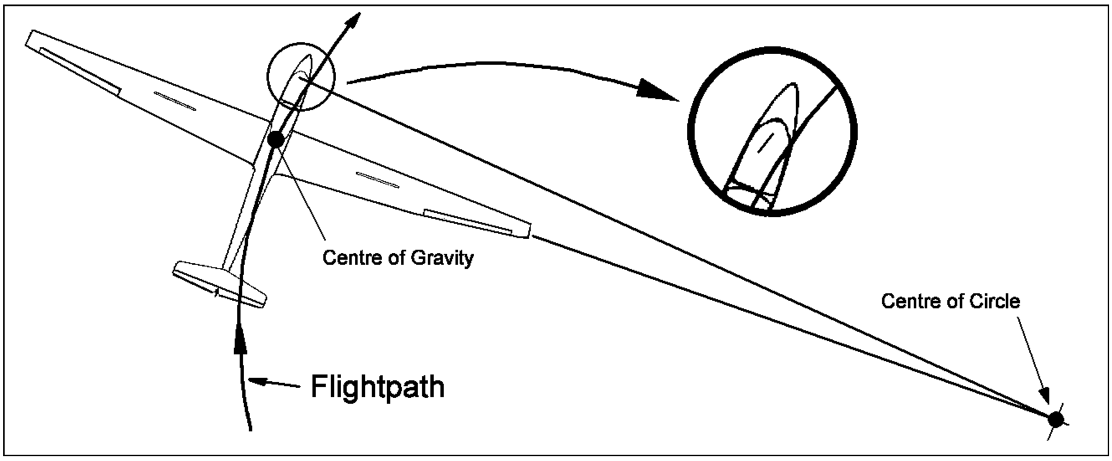

Figure 9 Use of "top rudder" for optimum thermalling performance

6 Thermalling etiquette and thermal approach procedures

If you are joining a circling glider, fly towards the outside of the circle made by the other glider, from a safe distance out. The first glider in the thermal determines the direction of turn. On approach, you continue to keep a good lookout because there is every chance that several gliders are attracted to the same thermal. This is not the time for looking at instruments. A thorough visual search above and below the horizon is of prime importance as the sun could obscure another glider until it moves into a position of better visibility. Remember it is the glider you have not seen that you could collide with.

Judge your entry into the thermal so you position yourself roughly opposite the established glider. This is easier said than done, especially if your entry speed is relatively high. You would be well advised to slow your aircraft down well before you arrive at the thermal. Do not cut inside of another glider in front of you. Slotting in must be done without causing the pilot of the established glider the slightest bit of concern. If you arrive on the same side of the thermal as the established glider, you should simply fly a flat and slow turn until the established glider is roughly opposite.

When sharing a thermal with another glider, avoid following this aircraft in its blind spot. Apart from being very unnerving to the leading pilot, it is unsafe and far from ideal from a performance point of view.

Another method of enhancing safety is to use the radio in order to alert circling pilots about the imminent approach of another glider. If no acknowledgement is received, it would be prudent to adopt a cautious approach and attempt to establish contact via a friendly wave from the cockpit.

7 Thermalling training

When training new pilots it is recommended to take as many distractions away as possible. This will enhance their ability to feel the air and the glider. If the instruments are covered up for the first 10 – 15 flights the pilot will ultimately make a better and safer pilot. If airspeed is primarily determined by airflow noise, control resistance and attitude the need to focus on the instruments is largely eliminated.

Audio systems make finding and centering lift much easier. They free up time for scanning and feeling the air. Audio vario systems should be used during basic training. It means that a pilot does not have to look at the vario for indications of lift or sink and can instead scan the sky for other traffic. Pilots should not keep their eyes in the cockpit at the expense of a good lookout and safety.

Some pilots develop a habit of thermalling in the same direction all the time. This common problem can easily be corrected by teaching them to turn in the opposite direction and encouraging them to do so for half an hour or so every time they fly. Within a few weeks these pilots will lose their preference towards a particular direction of turn.

Early pilots will not be able to fly at 45° degrees angle of bank and simultaneously maintain a constant airspeed. Therefore instructors need to assist and gradually improve their ability with time and practice.

Most low hour pilots thermal at a shallower angle of bank than they think. Experience suggests that newcomers tend to circle at less than 30° when they think they are banking the glider at 40° or even more.

One simple suggestion, which can help pilots to fly near the optimum bank angle, is very easy to implement. It only requires a piece of wire, a bit of plywood and some masking tape.

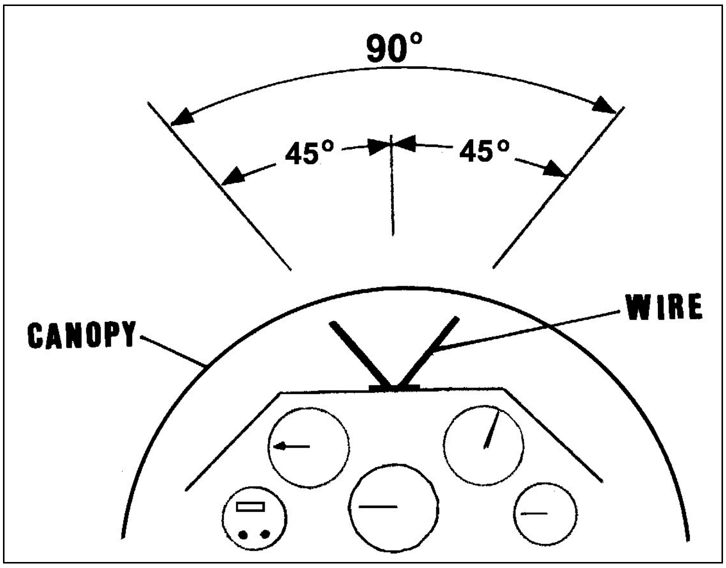

Figure 10 Angle of bank indicator

The wire is bent in accordance with Figure 10 above and is then permanently glued onto a piece of plywood of approximately 50 x 50 mm. This cheap gadget can easily be affixed to the top of the instrument panel with some masking tape.

While circling at 45° angle of bank one of the two ends of wire will stand perpendicular to, and the other horizontal with, the horizon. While checking the “nose/horizon attitude” it is easy to check whether the pilot is thermalling anywhere near your chosen 45° angle of bank. Straws or a 45 degree set square attached on the inside of the canopy have similar results.

Instructors should take every opportunity to thermal in close proximity to other gliders and teach students proper thermal joining procedures.