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THERMALLING TECHNIQUES

Preface

The following thermalling techniques document is provided to assist Instructors, Coaches and Students as a training aid in the development of good soaring skills.

Instructors and Coaches should be familiar with the concepts and be competent with the techniques prior to teaching in practical flight training. Also, students should be provided with copies and understand the concepts prior to in-flight demonstration/training

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Introduction

When teaching thermalling, it is essential that both the instructor and student are aware of the geometry of the centring technique. While some may not actually need to be aware of this geometry in the air, every pilot should at least understand the reasoning behind the correction technique being employed. However, many will need an explicit understanding of this geometry to obtain the essential mental picture of the glider and the thermal required for efficient centring.

Frequently, when the thermals are large and regular, adequate climb rates can be achieved using less than ideal techniques but as soon as the thermals become small or broken (and hence must be correctly centred the first time) inadequate techniques result in the impression that the thermal is irregular and never in the same place twice. Much of the troubles we have with "difficult" thermals we create ourselves. These self-induced problems can be eliminated if the pilot has a clear understanding of the geometry of the correction technique being used and, in particular, of the traps in that technique.

Thermal Structure

Some understanding of thermal structure is required to relate what you see to the geometry you expect. For those not interested in anything more than the bottom line, the next two paragraphs can be skipped. Those with an interest in the fluid dynamics of what is occurring may be interested in the following simple model.

The detailed fluid dynamics of thermal structure is complicated, however the following simple model will do for our purposes.

A thermal can be considered to be a large Reynolds number jet. Because the jet has a large Reynolds Number it will be turbulent. Turbulent flows consist of eddies or bursts of fluid motion which, when averaged over time, add up to the overall flow pattern. A thermal has a large Reynolds Number because the jet diameter is large and the viscosity is low. This means that the turbulent eddies (surges of fluid motion) are large and relatively slow. These eddies therefore have a large time scale and if we examine the flow field at any instant we will find irregularities which are caused by this turbulence and which persist for a considerable time. The time scale of these eddies is such that we can detect these turbulent irregularities both by "feel" and the vario. We refer to these as surges. A further consequence of the large diameter and low viscosity is that the core of the thermal is not subject to significant shear and becomes lamina in character — despite the overall large Reynolds number of the jet formed.

The bottom line is that the thermal has an instantaneous and a time averaged structure. The instantaneous structure contains significant irregularities, while the overall average thermal structure is regular. We need to centre on this average structure. If we concentrate on this average structure then, despite our impressions, thermals are basically regular and can be assumed to be symmetrical. That is, as is shown in Fig. 1, the average vertical speed of the air can be assumed to decrease in a symmetrical fashion with distance from the centre.

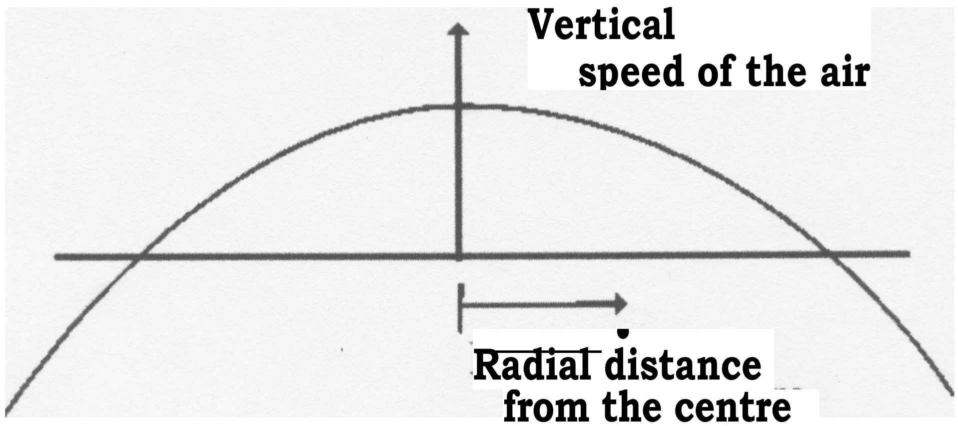

Fig. I Symmetrical thermal

On most days, this regular structure is dominant and easily detected. However on other days the turbulent nature of the thermal appears to dominate and we say the thermal is "broken". If the thermal is broken, moving or very small we need a technique which keeps the glider in contact with the thermal and makes regular small corrections, allowing us to use the surges as they come along. Such techniques are more difficult and can only make small corrections. For all other cases this is unnecessary. We therefore need two different correction techniques — one for general use and the other for small and/or broken cores

It is strongly recommended that, when learning thermalling, the first of these techniques be thoroughly learnt before the second is attempted.

Large Corrections — Worst Heading Technique

This is a simple, very effective technique and should be used except where the thermal is small or broken.

The principle is illustrated in Figs. 2 and 3, over.

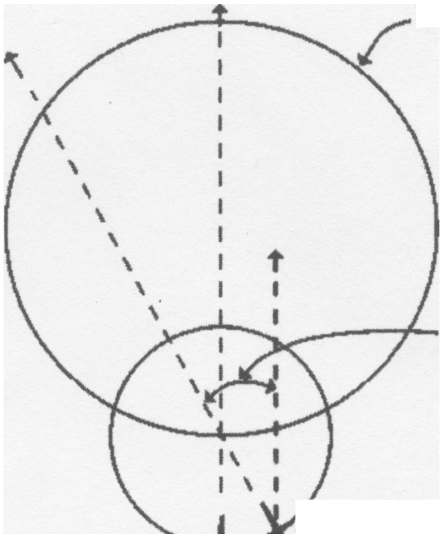

Fig. 2 Worst Heading Principle

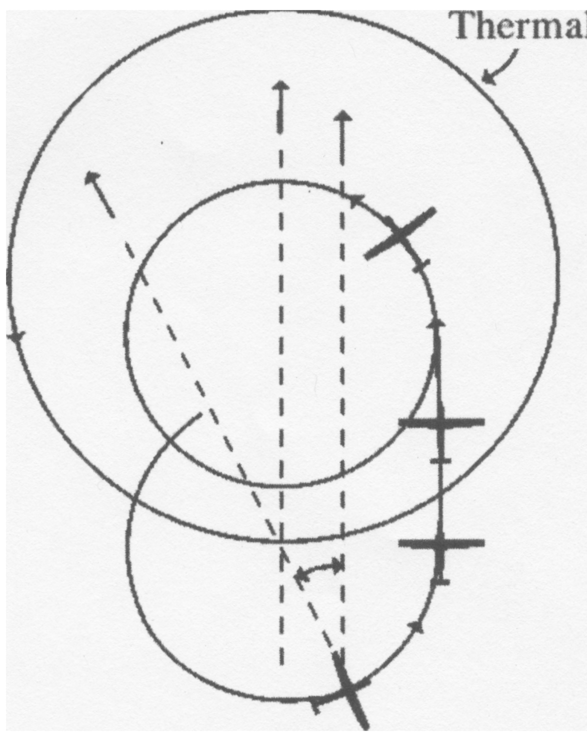

Fig. 3 Worst heading correction

Referring to Fig. 2 and assuming that the lift/sink is regular (Fig. 1, above) when the glider is in the worst heading position, (the point where the actual sink rate is maximum or the climb rate minimum), it is furthest from the thermal centre and at this point (as shown) the wing is pointing at the centre of the thermal. If, at this position, one looks along the wing to the horizon then the direction of the centre of the thermal can be fixed by noting the point on the horizon towards which the wing is pointing. Looking now at Fig. 3, if the glider is rolled out on that heading and a correction made in this direction, it is clear that the desired correction will be made.

Referring back to Fig. 2. It is important to remember that the vario lag will mean that the position of the glider at the point of indicated worst heading is further around, as shown (Fig. 2). Consequently, it is necessary to look forward of the wing at an angle sufficient to allow for this lag. The correction is made using this heading as shown in Fig. 3.

The instantaneous irregularities in the thermal will occasionally interfere with the determination of the worst heading position. This is not often a problem but if it is then either make a judgement as to where the worst heading was and make it correction, (being ready to have a second go) or leave the correction to the next turn. Less experienced pilots are recommended to leave the correction to the next turn.

The technique is easy to execute in the air. The position of indicated worst heading is noted. Look to the horizon forward of the wing tip an amount to allow for vario lag and note the heading. The size of this angle actually depends on the vario lag but for most circumstances 20° forward of the wing works well (see below). Continue the turn until you can roll out on that heading. Do so and hold the correction for a period suitable to the thermal size on the day and then roll back in as shown.

(A brief note about correction size. This is judged to be a proportion of the turning circle diameter by time. It is not possible to judge the distance travelled. The diameter of a "normal" thermalling turn is equivalent to about 7 sec. flying time — a 3.5 sec. correction is half a diameter — often a suitable correction). The actual correction required depends on the day — the size of the thermals — but a common error by the inexperienced is to make too many, corrections which are too small.)

The Importance of a 'Correct' Centring Technique

As noted in the introduction, use of a centring technique which is systematically wrong will create the impression that the thermal is moving and is never in the same place twice. While thermals are sometimes broken and moving, this is not as common as often assumed and mostly this impression is created by the use of an wrong centring technique.

This is illustrated below assuming a wrong allowance for vario lag.

The allowance for vario lag is critical. A consistently wrong allowance makes the correction consistently wrong. This is only obvious if the thermals are small and this is the most common reason for those days when the thermal never seems to be in the same place twice. The real problem is a faulty technique made obvious by the small size of the thermals — not an irregular thermal.

This systematically wrong correction resulting from a wrong allowance for vario lag is illustrated in the two diagrams below. These diagrams are exaggerated to make the demonstration clear. Fig. 4 shows the effect of underestimating the vario lag. A large vario lag is assumed in this case so that the point of detected worst lift, (the position shown on the diagram) is well past the point of actual worst life (Fig. 4). The correction is drawn for no allowance for vario lag. As can be seen underestimation of the lag causes the correction to be consistently late and hence in the wrong direction. This makes the turning circle of the glider process backwards (as shown). The result in the air is that the apparent position of the thermal moves against the direction of turn. (That is appears earlier each time.)

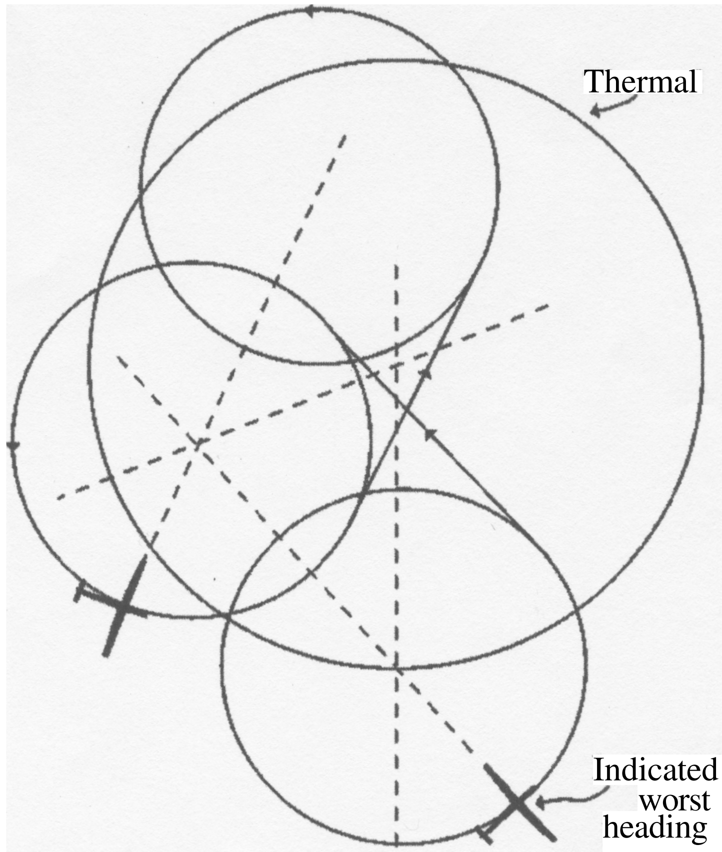

Fig. 4 Successive corrections with inadequate allowance for vario lag - zero allowance in this case

Fig. 5 assumes a small vario lag (the position of detected worst lift is close to the actual worst lift) combined with a large allowance for vario lag (the correction is made in a direction well ahead of the point to which the wing is pointed. Overestimation of the vario lag makes the turning circle process forwards, that is, the thermal appears to move in the direction of the turn (is later each time) (Fig. 5).

Fortunately, estimation of the required allowance for vario lag need not be accurate and if this guess is anywhere near correct the technique works well and is very easy to use, provided the thermal is not small or moving. For most circumstances an allowance of 20°, as shown, is successful.

It is worth noting that this consistent error is less serious if the correction is made smaller, so while the correction must be significant if it is to work (remember the turn diameter is equivalent to around 7 — 9 sec.), if in doubt make somewhat smaller corrections.

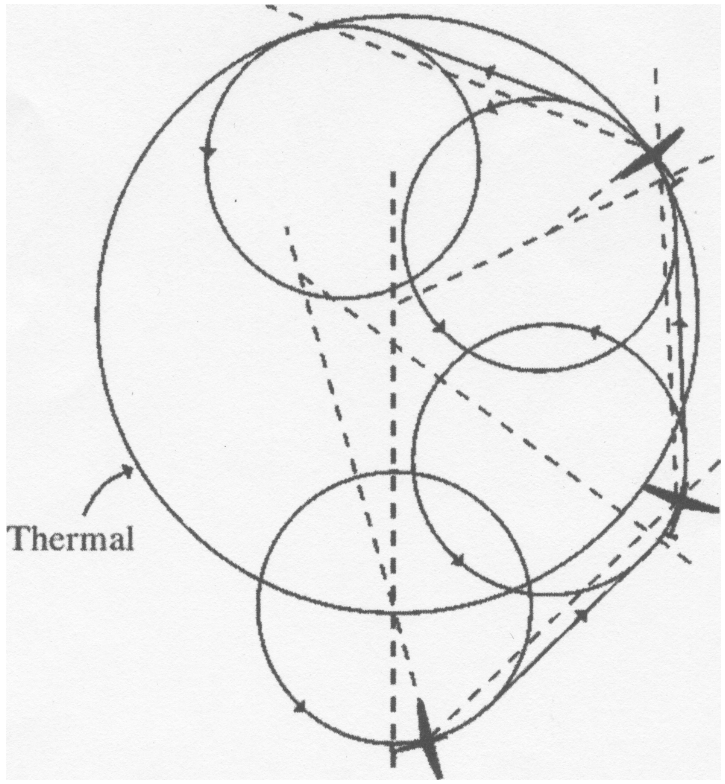

Fig. 5 Successive corrections with too much allowance for vario lag

Small Corrections — Broken Thermals — "Cutting Out the Sink"

When either the thermal is not much larger than the turning circle of the glider or the thermal is broken (the instantaneous irregularities dominate our sensing of the thermal) and it is necessary to stay in contact with the thermal using the gusts as they come along, the worst heading technique will not always do. Under these circumstances a technique which depends on tightening up to avoid the sink — "cutting out the sink" is preferable.

a) Glider encounters a surge of lift

Fig. 6 shows the case where the glider is entering the best lift. Some vario lag must be allowed for but if this is too large then thermalling by feel is required. No technique will work under these circumstances if there is a large lag. The technique here is commenced by tightening up as hard as the glider will allow without increasing speed (Fig. 6). It is essential that the glider be flown clean as any slip or skid will destroy the correction. The turn is held tight for 300° — that is, 60° less than a full 360° (as shown). Then return to the normal thermalling turn.

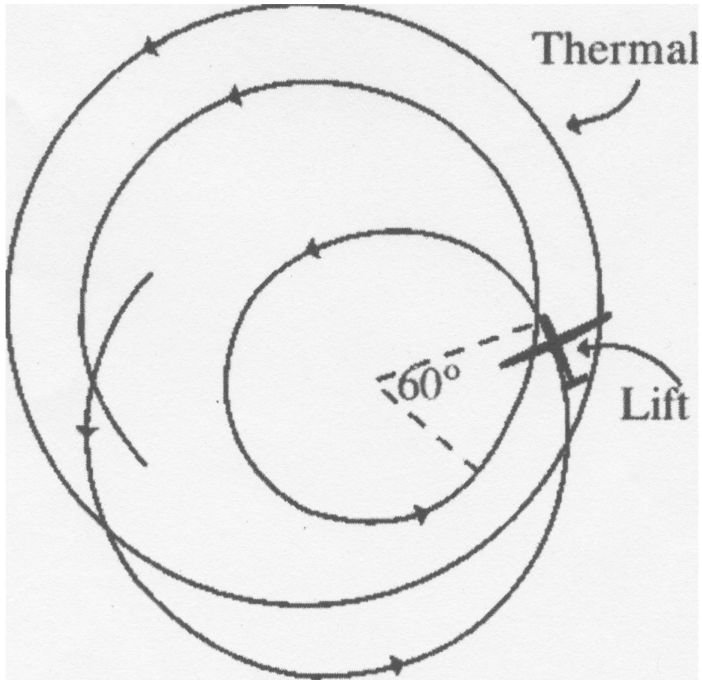

Fig. 6 Tightening up in the lift

Frequently, pilots flatten out under these circumstances — but this only works well if the thermal is large, (see Fig. 7 over). The actual and desired corrections are as shown. Because of vario lag and the time required to roll out, the actual correction is delayed and is hence in the wrong direction. This technique only works if the thermal is larger than shown.

To assure yourself of this fact refer back to Figs. 4 & 5 and consider the following. The correction technique depends on determination of the direction you wish to move the turning circle. If you flatten out on the heading you happen to have when you detect lift then you use this heading as the correction direction. This heading depends on how much the turning circle overlaps the thermal. As can be seen in Fig. 3 & 4, if the overlap is about half the turn diameter, then the heading is quite wrong. The heading at detection of lift and the desired correction direction only coincide at one amount of overlap between thermal and glider turn. Correction techniques actually depend on the ability to predict the correct heading for the correction, independent of the extent of overlap. The techniques recommended here achieve that aim.

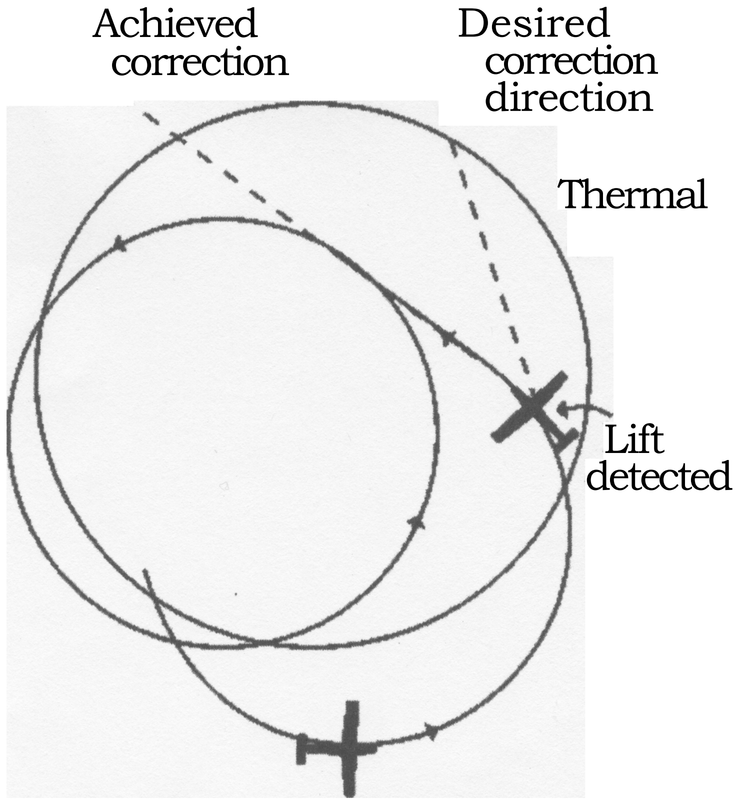

Fig. 7 Flattening out in the lift

Flattening out in the lift creates a systematically wrong correction and creates the impression the narrow thermal or core is moving all the time and requires re-centring all the time. As before, while this is sometimes the case, it is not common and this impression is mostly created by the application of a systematically wrong correction technique — in this case giving in to the temptation to flatten out in the lift.

Flattening out is used to extend the search area when the position of a small or broken thermal is in doubt.

b) Glider encounters a surge of sink

When the glider enters sink, (or reduced lift), tighten up to avoid the sink, as shown in Fig. 8. Then, proceed as follows. Hold the turn tight as possible without increasing speed for about 60°, then flatten somewhat, (normally) the wings will not reach level), and then return to the thermalling turn, as shown. (Note the initial action for both entering lift and sink is to tighten up.)

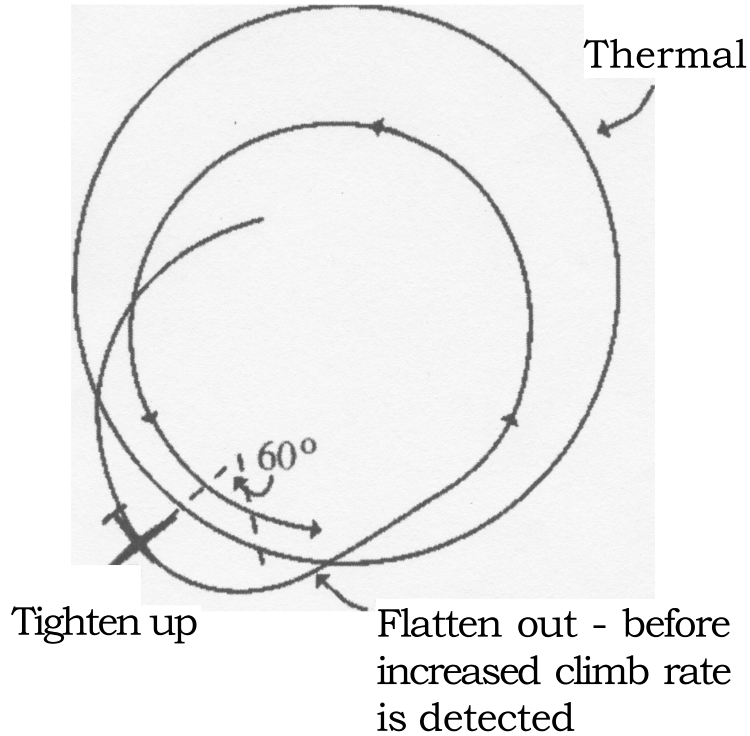

Fig. 8 Cutting out the sink

Summarising

If it is intended to use this second technique, firstly centre the region containing the core using the worst heading technique and then proceed as follows. When either sink (deceased lift) or lift (increased lift) is encountered, tighten up the turn as much as is possible without increasing speed. If it was increased lift then the tight turn is held for 300° — (360° minus 60°) and then return to the thermalling turn. If it was decreased sink, the tight turn is held for 60° and then the turn flattened momentarily before returning to the thermalling turn.

During these corrections it is essential that the radius of the turn actually be decreased when tightening. It is not successful to speed up to help the tight turn. Accurate flying at a constant speed is required.

This second technique, used for broken thermals, is not easy and requires accurate flying but it will keep the glider in contact with the thermal and it is the only technique which will get the glider into a tight and/or moving core.

Use of these Techniques

The worst heading technique is used for all routine corrections as cutting out the sink is difficult to use and only makes a correction which is a fraction of the full turning circle. Cutting out the sink is used only if accurate centring is required to either stay in a broken thermal or to centre the core of the "normal".

A final word. None of these techniques will work reliably unless the turns between corrections are circular. That means constant speed and angle of bank and a clean flight path. Also, the difficulty of both techniques increases with the vario lag. Feel is faster than any vario. **You should aim to thermal by feel and only confirm with the vario.**

Bob Hall