On Self-Centering In Thermals

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- an advance in its understanding

As in generally known, a full-size glizer pilot must rely on his instruments in thermal flight, not only for finding lift but also for adjusting the turn radius for the best rate of climb. The rate of climb is highest in the center of a thermal. Without complex equipment the pilot would never succeed in centralizing the glider, which has a tendency to drop out of thermals. An RC-glider pilot also has to work hard to center the model in the thermal, usually by observation, trial, and error. On the other hand, it is always puzzling to observe the thermaling of a free flight glider. If properly trimmed, it seems to remain on a thermal for hours on end, always centering in the thermal core by itself. A dethermalizer is indispensable: the World Records for distance and duration by free-flight gliders prove that they are capable of flying almost indefinitely in suitable thermal conditions.

Where do these self-centering properties of a free-flight-glider come from? It is true that constructional outline, rigging and trimming have a considerablle influence on theor rhermaliong properties. In this contex I assume that the major distinguising feature of a free-flight model - the dihedral wing - has the greatest impact on the centering properties of a glider in a thermal, and we shall deal with this phenomenon later on. First we have to explain that this only comes into play when the model meets with the thermal shell itself. So the questions asked are:

1. What is the nature and structure of a thermal shell?

2. Why do only free flight models (with dihedral wing) use thermals to best advantage, especially in respect of working their way towards the center?

As is well known, a thermal is not just a column of rising air. Thinking of a thermal shell resembling a huge balloon filled with warm air comes somewhat closer to the mark, but is not the whole story. There must be something unique regarding the structure of a thermal. If it were only a motionless mass of buoyant air, a model or a bird would glide down from the top to the bottom and leave the thermal. This view is quite common, and as a proof we may show a misrepresentation published in a recent issue of an RC magazine.

On the contrary, it can be observed that birds or models often enter a thermal at very low altitudes, e.g. buzzards 20 to 30 m above ground level, and leave it at great height. From this it may be concluded that they rise in the thermal bubble itself. Therefore a thermal must have an entire circulation mechanism, in which the air rises in the center and drops outside.

When a buoyant mass of warm air separates from the ground, the friction of the rising warm air at the outside of a thermal causes the cooler air around the bubble to circulate. The warm air itself takes up the shape of a giant smoke ring and looks like a doughnut around which cooler air revolves descending at the periphery, returning at the bottom to the center and there rising again. In this way a continuous flow of cooler air is pumped upwards in the center, and its upward speed is highest in the plane of the vortex ring. Hence any flying objects such as dust, pollen, spores, seeds or model gliders can be taken aloft and will rise if their sinking speed is less than the rate of updraft with respect to the vortex ring. This rotary system is shown in Fig. 2. It may be considered as the universal key to the understanding of thermaling!

This rotary system can attract flying objects towards the center of the lift and keep them within the shell. How this system works in real flight can best be shown by the strange behaviour of F1E-models entering a thermal. Such models have to fly straight ahead through a thermal shell: when approaching the thermal, then always lift their tails, simultaneously speeding up tremendously as if attracted by a giant magnet. They then rise like an elevator, after a while slowing down, sometimes even being pushed back Seemingly, they always enter a thermal at the bottom, for first they have to fly through a downdraft on the outside of a thermal, where they sink.

The acceleration and the subsequent slowing down are caused by the so-called "entrainment" (the inflowing cool air into the center of a thermal). When approaching a thermal. they encounter a tailwind, caused by the synchronous rotation, as it were a co-rotation, but when having passed the center they have to overcome headwind caused by the counter-rotating bubble.

Some well known West-German F1A fliers (Nordic A-2) who also compete in F1E-events profit from these observations when tow launching, especially in stronger winds when tow circling is impossible. A straight flying model on tow shows the same thermal behaviour as a straight flying magnet model.

Now let us come to the question of why a circling model tightens its turn according to the strength of lift. The rotary system also causes the "entrainment" at the base of a thermal shell, and this entrainment drifts a model to the center of lift. The stronger the lift the stronger is the inflow of cooler air - the "entrainment" - and the greater is the central drift resulting in a tightening of the turn.

But why does a full-size glider obviously drop out of a thermal and not drift into the center by itself? It always encounters more lift at the inner panel of the wing which is nearer to the center of a thermal. As a result the glider is banked away from the core, unless the pilot counteracts.

This counteraction is equally made by the outer wingtip of a dihedralled model: the airstream flowing to the center causes a greater angle of attact at the outer pannel, thus counter-balancing a possible excess of lift at the inner pannel which is nearer to the center. In addition, the inflow of air to the center affects the upturned wingtips the lateral area of which (not visible, only projected) render the drift possible.

Experiments were made with different dihedral angles in order to test the thermal-seeking qualities. It became very clear that models with little dihetral (only sufficient for a stable flight in calm air) usually dropped out of a thermal, whereas those with greater dihedral stayed in. We also know from observation of thermal-soaring birds, that from time to time they fold up their wings to a positive dihedral. In conjuction with upturned pinions this may give a better central drift. Buzzards are real "models" for studying thermal flight.

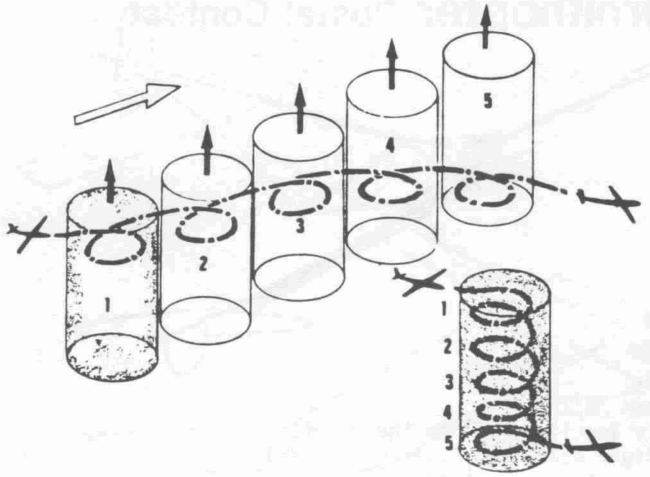

Figure 1 - A false representation of the flight path of a soarer in a thermal shell drawn as a cylinder (implying a volumn of rising warm air) in which the gliders sink from the top to the botton - according to a French RC-magazine 1980.

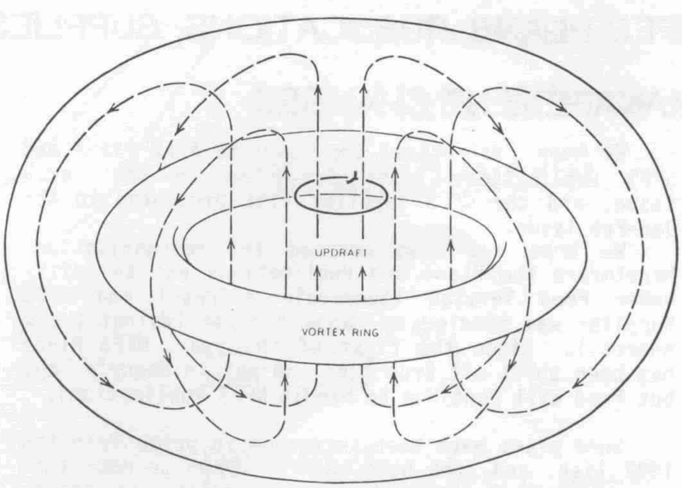

Figure 2 - A correct representation of the rotary system within a thermal shell, as published in "The Scientific American" April 1962. The original explanation of the drawing says: "THERMAL SHELL is composed of a vortex ring (torus, or doughnut) around which a current of cooler air circulates in closed streamlines (broken lines). The soaring bird flies in a circle the radius of which gives the bird an aerodynamic sinking velocity equal to the velocity of the updraft. In this equilibrium position within the shell it is carried aloft as the shell rises.

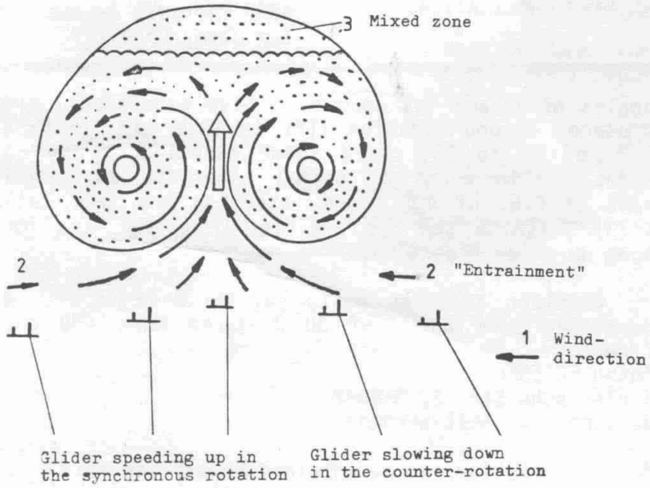

Figure 3 - No caption.

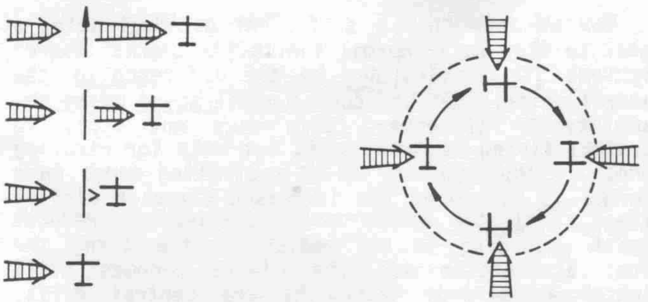

Figure 4 - Left: Side drift of a straight flying model in a crosswind.
Right: Central drift of a circling glider in a thermal.

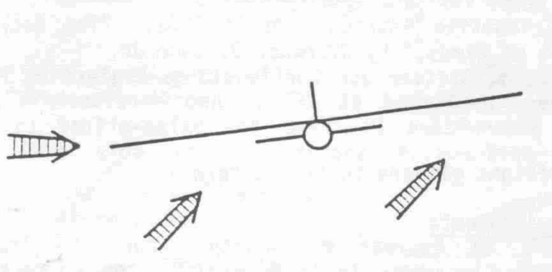

Figure 5 - Full size glider banked away from the core of the thermal caused by excess of lift at the inside wing.

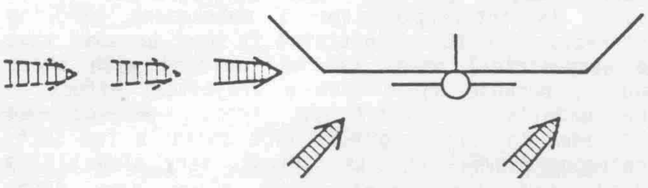

Fig. 6 Free-flight glider with its outer panel counterbalancing possible excessive lift at the inner panel, simultaneously offering a side area for central drift.

Now we know that a sufficient dihedral helps a model to stay in a thermal and that a thermal soarer tightens its circles due to the influence of the central drift. But why does a model speed up at the same time? (Remember, this does not apply to straight flying magnet-models, but only for circling models). The speeding up of a circling model in a thermal is caused by the increased circular airflow effect of tighter turns. Since the decalage reduces itself according to the radius of the turn, the model accelerates and the circle becomes still tighter as already caused by the central drift, which often ends in a lethal sprial dive. Hence the modern wing-adjustment of wash-in at the inner pannel, which is said "to hold the inside wing up." Some interesting articles hve been published in the subject of trimming for thermaling, e.g. by Willaim Baker in the NFFS Sympo 1980 "How to trim free flight models for thermaling."

We also explored the thermal properties for rear-steered magnet-gliders, when the straight flight course is interrupted for a subsequent circling interval. For the uninitiated it must be said that no assymetrical warps can be employed with these models, because warps have a prejudical effect on the model's straight-flight trim. However, we succeeded in rendering this type suitable for self-centering thermal flights. First, very slow flying speeds and very light wings allow very tight circles, hence the model picks up the slightest bit of a thermal activity. Moreover, we applied trim-change systems like V.T.I., which can prevent spiralling. But the real breakthrough came with the application of new stabilizers with an aeroelastic covering, which inverts the curvature at negative angles of attack (as occurs in dive conditions) and produces strong negative lift in this way. With a C.G. of 90 to 95% chord these stabilizers are as effective in terms of spiral stability as normal ones at C.G. of 60% chord, assuming the same tail volume. (Also see the article "Magnet-gliders for long duration flughts").

Complete steering units can be ordered with a certified bank check of 30 Deutsche Mark (30 DM) from:
Anton FRIESER
Schlesische Str. 2, D-8832
Weissenberg, West-Germany

More information can be obtained by writing to:
Hans Gremmer
Oberbretenauer Str. 11, D 8300
Landshut, West Germany

References

NFFS-Sympo 1977 and 1980
The Scientific American, April 1962: "The Soaring Flight of Birds," by Clarence D. Cone Jr.
"Vom Balsa-Gleiter zum Hochleistungs-Segler" by Hans Gremmer, published at "Flug- und Modeltechnik", D 7570 Baden-Baden (= "From the balsa-glider to the high performance soarer" - the only book on free-flight gliders in the Western World)

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