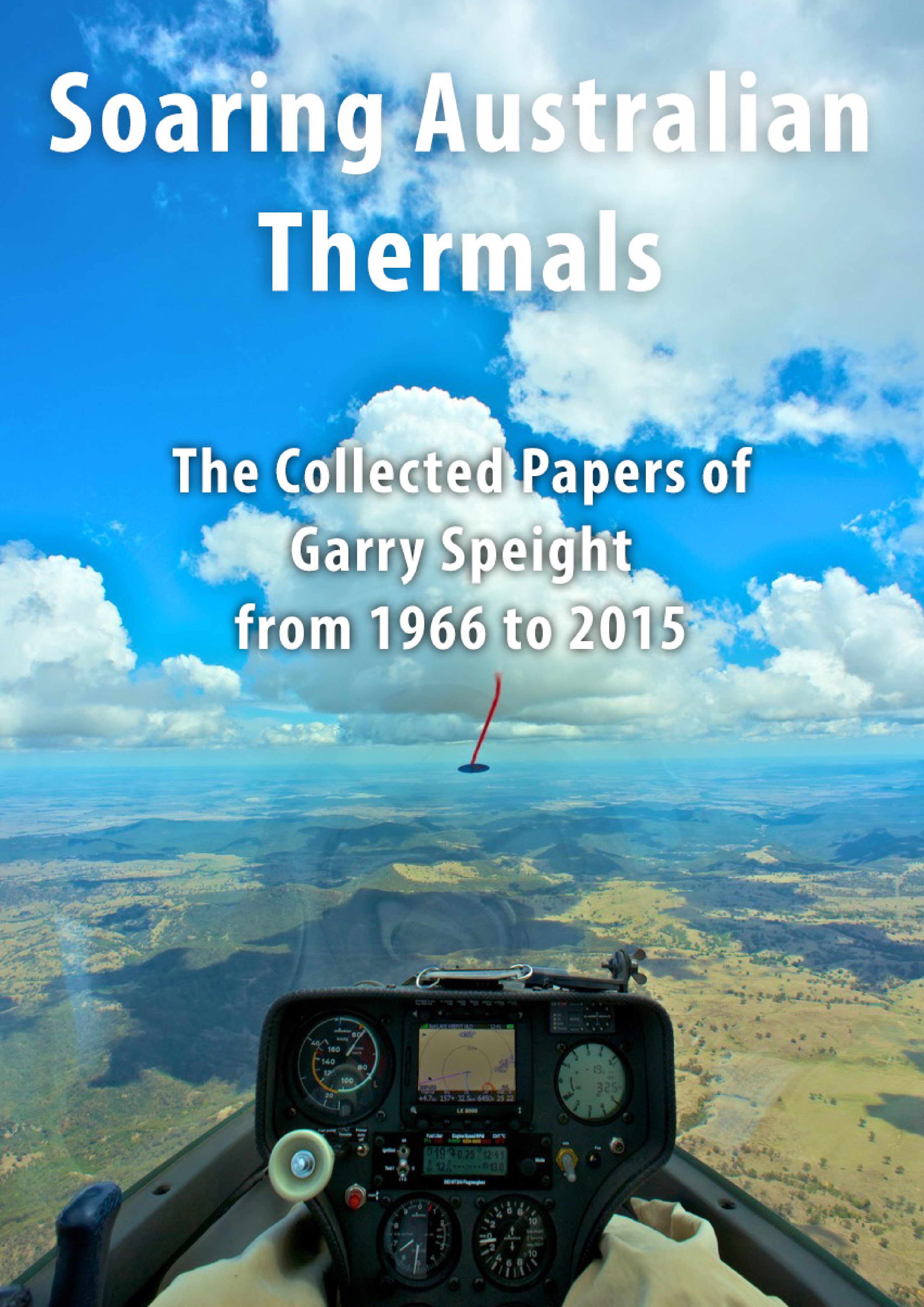
Soaring Australian Thermals

The Collected Papers of Garry Speight from 1966 to 2015



Rotating Thermals

By E Sherwin

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I found the articles by Garry Speight, 'thermals that rotate', most interesting, especially after reading that of Kingsley Just* (letters to the editor). Herewith, a slightly different view in support of Garry, sparked off by Kingsley's letter.

There can be little doubt that some thermals have a significant degree of horizontal rotation — a willy-willy, or dust devil, being the obvious example. Such a thermal may be described as a free vortex, the characteristic of which is:

The product of the tangential velocity v and the radius r is constant; ie, within limits, the tangential velocity increases as the radius of action decreases.

Succinctly: - r * v = constant (ref: Fluid Mechanics R.F. Pao)

If this were taken to a limit, then as radius tends to zero, the tangential velocity tends to infinity! Clearly this does not take place, since other factors come into play, not least being viscosity and inertial forces. These, inter alia, limit the tangential velocity. In the June issue of Soaring Australia (Ref. 1), under Technical Note 4, mention is made of the Rankine vortex, which covers the situation at the core. How closely this model relates to thermals sensed by glider pilots remains to be seen, but it is probably a truism to state that so far as atmospheric activity is concerned, anything that may take place, probably will take place.

Lately, I have taken every opportunity to investigate thermals for rotation and certainly many thermals are more benign when orbiting in one direction rather than the other. So, the more one learns of possibilities, the better is one equipped to gain from them.

The centering of narrow rotating thermals often comes with its own thrills. How often has one soared up into a thermal core, then wished for sufficient rudder authority to spin the glider around its wing tip to float up like a thistle? More often, there is a precipitous descent across the thermal through zones of more slowly rotating air until control is finally re-established. "Dear me", or words to that effect, emanate from the cockpit when it is found that the net gain in height has been zero, or worse.

With respect to Reference 2, Kingsley Just, wrote of the time associated with a Rate 1 Turn. Devices used to determine a rate of turn are calibrated gyroscopic instruments. These instruments take no account of headwind, tailwind, horizontally rotating air mass nor indeed the situation in deep space! Their output is derived solely from the inertia of the spinning gyroscope. An aircraft undertaking a given rate of turn does so with reference to the South Pole, Southern Cross, or any other suitable fixed point in space. Output from a Rate of Turn indicator is a function of angular velocity, which is true airspeed and radius of turn.

For our purposes, the true speed of the aircraft is the sum of the indicated air speed (assuming no positional error in the pitot/ static system) plus the rotational component of the air mass. An aircraft flying in nonrotating air will have, for a nominated rate of turn and airspeed, a fixed radius of turn (bank angle) relative to its air mass. However, in an air mass with horizontal rotation, the same aircraft, flown at the same rate of turn and airspeed, must be flown with an increased or decreased radius of turn depending upon whether the aircraft is flying with, or against, the rotation of the air mass.

NB. This will be further modulated by the inertia of the aircraft. For example, an increased, or higher, true speed will necessitate an increase in bank angle to counter the increase in angular momentum, which is itself a function of the angular velocity.

Our soaring pilot - operating on the fond assumption that the thermal has a bell shaped lift distribution, with negligible skew - will find the advantages of flying against thermal rotation

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compound. For a given indicated airspeed, and bank angle, the true tangential velocity, as indicated above, is the sum of the indicated air speed plus the rotational component of the air mass. In this case, the true airspeed will be less than the indicated air speed. This reduction in angular momentum leads to a smaller radius of turn, so enabling the glider to be flown in stronger lift near the thermal core. In addition, the greater tangential velocity of the air near the core, a function of a free vortex (see above) provides greater circulation (lift) over the inner wing, so reducing the extent of aileron input to hold off bank. If the aircraft is flying more efficiently, even greater use is made of the available lift. This latter point may be another useful clue about the nature of a thermal and therefore indicate an optimum direction of turn.

Whilst all the above seems very jolly, the point of the exercise is to offer another view on rotating thermals, but noting, in particular, the reasons Garry gives for flying contra rotation are well stated in his articles.

*Reference:

1. Soaring Australia May, June, July, September 2006, Garry Speight (Parts 1-4)

2. October 2006, Kingsley Just