The Temperature Gradiometer for Soaring

by August Raspet

Editor's Note: This paper outlines the history and technique of temperature gradiometry. In the past, most new developments in motorless flight have been contributed by Europeans. The trend toward scientific prospecting for sources of atmospheric power is distinctly a development of the Soaring Society of America. Numerous experimenters have been inspired by the demonstration, in 1939, by Dr. A. Raspet, of the concept of temperature gradients as a parameter of convection prospecting. Among these experimenters are Barnhart-McReynolds (1940), Alvin Yates (1940) and Bob Symons (1941). In addition to developing the fundamental concept, the author built and developed numerous gradiometers along the lines laid down in this paper. The Raspet temperature gradiometers are aptly named "Thermal Sniffers."

This coming summer our active affiliate, SCSA, has undertaken a large program of research in which they plan to correlate temperature gradient measurements against the vertical velocity of the convection. This research will add immeasureably to our post war soaring accomplishments.

PART I

AT a technical session in 1935 held one evening at Hilltop in Elmira, N. Y., the author suggested a device for locating the diffuse interface of a thermal current. The mode of operation consisted of reflecting a short radio wave from the boundary of the thermal, somewhat similar to the Radar technique of today. While theoretically possible from the physical standpoint, the author realized that gliders in America, at that time, had not yet reached the dimensions of those of Russia and that being the case none of our ships would have been able to carry aloft the physics laboratory and the staff of instrument operators which would be necessary to make the measurements proposed above. It is entirely possible that the radio reflection technique may be useful to the sailplanist in the post-war era.

Following the author's proposal, Dr. W. B. Klemperer told of foreign pilots using sensitive thermometers to measure the temperature of the air as they flew through it. The lack of success of this technique may have been due to the difficulty of interpreting temperature readings to detect discontinuities, because the history of temperature readings had to be reviewed continuously.

Sometime, later in October, 1936, the author happened to be in the field and while casually observing the flight of buzzards, was lead to the naive suspicion that a buzzard probably detects thermals by measuring not the temperature but the gradient or the difference in temperature between its head and tail or its wing tips. This, in short, is the accidental cause of scientific prospecting for air mass discontinuities by means of the temperature gradiometer.

In 1938, the late Robert Platt of the NACA mathematically discussed the optimum conditions for securing lift. His treatment depended on deriving the lift obtainable as a function of the turning radius, of the vertical velocity of the thermal and of the sinking speed of the ship at the particular turning radius. He pointed out that, as yet, the exact structure of a thermal has not been determined. He made a neat derivation of maximum lift on the basis of a vertical velocity as an inverse function of the distance from the center of the thermal. In the discussion following, it was emphasized by various pilots that the practical application of the theory depended on locating the center of the thermal. One of the pilots suggested even as drastic a measure as putting the ship into a spin but at a later discussion, it was demonstrated that the force field of a thermal would tend to throw the sailplane out of the thermal.

It is the purpose of this study to show first, how a temperature gradiometer may be used to locate the center of a thermal, to give a measure of the strength of the thermal, to show, secondly, the instrumentation involved in these measurements and to show, thirdly, how the apparatus has been improved to make it a sensitive instrument capable of extending soaring beyond the flight-by-feel stage.

Theory of the Structure of a Thermal

For the simplest case of a thermal structure assume a thermal of the type shown in Fig. 1. It is generally known that a thermal consists of a rising column of air which may or may not be capped by a cumulus cloud. In this column (assumed for simplicity to be of circular cross-section) the core of the thermal is warmer than the outside. In the literature on this subject there appears to be no publication of measurements of these temperatures. E. N. Jacobs of NACA, in a conversation with the author, in July, 1938, was of the opinion