Exploration by Sailplanes of the Structure of Thermals

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Attempts have been made to measure the temperature excess of thermals by means of a sailplane and to correlate this with the size and the rate of rise of the thermal. A Slingsby Skylark 2 was used, the only instrument carried in addition to the standard ones was a sensitive temperature indicator which was capable of measuring the wet and dry bulb temperatures to 0.1° C. A miniature wire recorder was carried on which was transcribed readings of altitude, temperature, time, rate of climb and visual observations.

Ideally several sailplanes should fly in and around a given thermal at the same time. There is, however, a considerable amount of information that can be obtained from only one glider. It was found that temperatures must be measured over a limited area and time. A reading in a thermal may be lower than that outside the thermal at the same altitude if the second measurement is taken several thousand metres away and a few minutes later.

The method used was to spiral up 500 to 1000 feet inside the thermal, leave it and then spiral down in the area immediately adjacent to the thermal. Figure 1 shows a typical measurement. Diagram (a) shows the sounding which was made on tow and immediately afterwards. Notice the temperature difference at 5000 feet. The measurement on the right was made when ascending in cloud, those on the left when spiraling down adjacent to the cloud. Diagram (b) partially overlaps the sounding and is a continuation. The release was made 200 feet below cloud base and while looking for the maximum area of lift measurements were taken and cloud base was reached. Diagram (c) is continued from (b). When the termal was encountered there was no cloud above. The average rate of climb was 3 ft/sec from 3850 to 4100 feet. Three minutes, from 1457:50 to 1500:45, were then spent in marginal lift between 4100 and 4200 feet. The horizontal position was not altered. During the end of this three minute period a small cloud started to form above; the lift increased until it averaged 4 ft/sec below cloud base. Climb was continued in cloud for 100 feet, then left and measurements were taken while descending in the adjacent area.

This sequence of events was observed in virtually all thermals (above 1500 feet) that have been investigated to date. When there was a cloud above the lift tended to increase as cloud base was approached. (In a limited number of cases, however, a "sub-cloud layer" was found several hundred feet below the base where there was a decrease in the rate of climb.) When a thermal was entered and there was no cloud above the lift decreased. In some cases, such as above, it again increased as cloud base was reached. A cloud would form when the sailplane was 300—600 feet below the base. When doing research of this kind it is necessary to have some sort of model in one's mind. The model used was the "vortex ring" described in the above summary by Scorer. Observations tend to bear this theory out. A cloud which has already formed above the thermal would tend to indicate that part of the bubble has already reached condensation level. A glider which enters the lower part of the thermal would find an increasing rate of climb as he spiraled in the centre and rose in relation to it. (There is of course the possibility that the cloud was formed by a bubble which had ascended previously.) If there is no cloud above, when encountering a thermal 500—1000

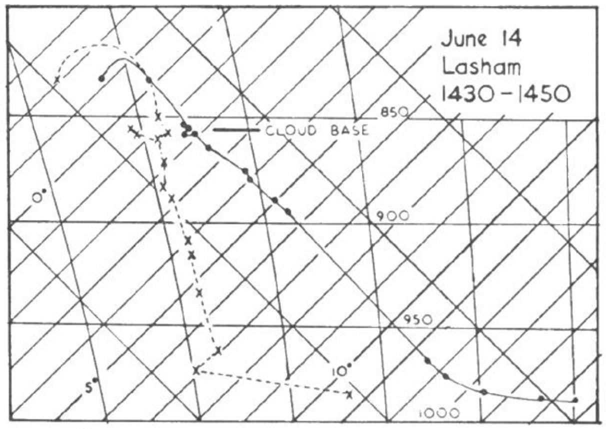

Figure 1a. Vertical sounding taken by the sailplane at 1440 GMT

feet below the base, it appears that one enters the bubble at a higher point. He rises until he is near the top and then proceeds upwards at the rate of rise of the bubble. If the thermal is small or if he is not in the centre he may find himself in marginal lift and remaining at the same altitude for a short time. If this is the case he will descend in relation to the bubble. If the centre of the thermal is found his rate of climb will increase and he will again rise to the top. A small cloud will form when he is a few hundred feet below the base.

Though present observations bear out the "vortex ring" theory, when flying in insolated thermal bubbles above 1000—1500 feet and below cloud base, it should be stressed

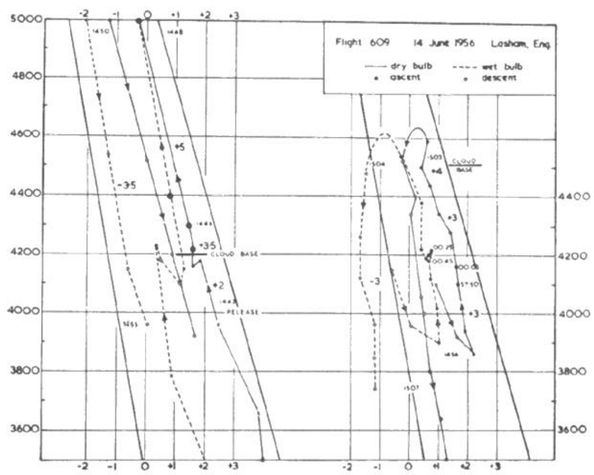

Fig. 1b Fig. 1c

Figure 1b and 1c. Temperatures measured during ascent in thermal and descent in still air adjacent to the thermal. The line to the right of each figure represents the dry adiabatic lapse rate; that to the left the wet adiabat. The numbers to the right of the ascending and descending lines are vertical velocities of the sailplane obtained from time vs. altitude that many of the observations can also fit other models. Many more observations must be taken, preferably with two or more sailplanes. It should also be remembered that in the atmosphere there is seldom an idealized thermal. Two or more bubbles may amalgamate. Wind sheer must be taken into account.

In Figure 1 b it can be seen that the dry bulb temperature excess is approximately 0.8° C and the wet bulb approximately 1.3° C. In terms of buoyancy an excess of 1.3° C on the wet bulb is equal to 0.2° C on the dry bulb (when cloud base is 850 mb and the thermal is at 860 mb). These measurements are those made when the time interval was small, i. e. 2 or 3 minutes. It can be seen that in the centre of the diagram the maximum dry bulb excess is 1.2° C and the wet bulb 2.2° C. This pattern is approximately the same on all observations. There is a possibility that a greater temperature excess may exist because one is in a different part of the thermal. It is more probable however that this difference occurs because the time interval between the measurements is too great, i. e. 8—15 minutes.

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