OBSERVATIONAL STUDIES OF CONVECTION

By Joanne Starr Malkus, Andrew F. Bunker and Kenneth McCasland

The observations of cumulus clouds and thermals made at the Woods Hole Oceonograhic Institution during the summer of 1949 divide themselves into two sections. The first sections concerns the formation of cumulus cloud streets by the islands (such as Martha's Vineyard, Nantucket, and sometimes the smaller Elizabeth Islands) in the Woods Hole area, and the second section consists of a further verification of the asymmetries produced in cumulus clouds by the changing of the wind with height, already discussed in an article by Malkus in **Soaring,** September-October, 1949.

The study of the streets of clouds formed by the islands showed that such fine weather cumulus tend to occur only on days of relatively low stability. The immediate cause of their formation appears to be the heating of the air from below provided by the islands, rather than a barrier or frictional effect as has often been hpyothesized. The observations leading to these conclusions were (1) that the cloud streets formed on days when the winds were northerly and the air was undergoing heating by a warmer sea surface (so that the mean stability measured by airplane sounding was low), and that they did not form on days of southerly winds and greater measured stability, despite the equivalence of the other meteorological conditions; (2) the evidence demonstrating the importance of island heating consisted in part of pyrheliometer records which clearly showed in all cases the coincidence of the decline of the clouds and the decline of insolation. This coincidence, however, was even more strikingly revealed on one of the observation days when cumulus streets, vigorously growing in the morning, were suppressed shortly after noon by the arrival of a thickening altostratus overcast.

The observational procedure in this part of the study consisted of horizontal airplane traverses to locate areas of small-scale turbulence, vertical airplane temperature and wet-bulb temperature soundings to determine air stability and moisture content, airplane photography(pilot balloon measurements of the vertical wind distribution, plus pyrheliometer records, lapse-time motion pictures, visual observations, and data obtained by the local Weather Bureau .

The second part of the study verified the previously suggested asymmetries due to wind shear of both turbulence and vertical motion in cumulus clouds. The theories had suggested that since the wind at the level of origin of a cumulus or thermal is usually different from the wind at a higher level, the ascending column may have a horizontal velocity quite different from that of the air surrounding its upper portions. The fact that the ascending column is, then, actually moving **through** the air was hypothesized to cause part of the liquid cloud to be found outside the updraft, and hence dissipating, and part of the updraft outside the liquid cloud, and hence forming new cloud. Asymmetries in the vertical motions within clouds follow as a direct consequence.

In this latest cumulus study, it was found that the wind in the Woods Hole area frequently exhibited large changes in direction with height as well as changes in speed (as can also be expected in nearly every other North American locality). Hence the theory was extended to cover such cases. Observational verification was startling, showing that on days having a marked turning with height of the wind, the small cumulus were moving in directions which differed by as much as 45° from that of the wind at the altitude of their mid-sections (about 4500 ft.). A cloud direction and speed which is the vector mean of that at cloud base and that a few hundred feet below their tops seems in practice to verify well. When the cloud velocity so computed is vectorially subtracted from the external wind at the level of interest, the result-

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C. S. Logsdon, director of the contest division of NAA announces that the FAI has awarded the Lilienthal Medal for 1949 to John Robinson, 527 Norman Ave., Arcadia, Calif., for the most outstanding international glider record performance during 1949 (The single place altitude record).

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tail on the "Hummingbird" proved to be entirely satisfactory in all respects. The over-all tail effectiveness was increased both above and below the stall. No adverse or unusual effects were encountered in the stall either in straight or turning flight. Short period oscillations were heavily damped in all trim conditions both for power-on and power-off flight. Stick forces were found to be satisfactory and were proportional to changes in airspeed throughout the trim range. A stable stick force gradient was shown for all flight conditions.

The tail as used on the "Hummingbird" consists of a left and right surface each of which is attached to and driven by a common torque tube. The surfaces are removable for trailering and are held in place by two small taper pins. Each flap is actuated by a control horn on the flap and is connected by a push pull tube to a central screw jack in the fuselage. The screw jack is operated remotely from the cockpit for obtaining the desired trim speed.

The main surfaces are constructed of wood using a box spar of spruce cap strips and mahogany plywood shear web. The leading edge or "D" Section is plywood covered.

The aft section between the spar and flap employs truss type wood ribs and is fabric covered. The flap consists of a solid spruce spar and is plywood covered. Magnesium castings are used for attachment to the torque tube. The torque tube is actuated by a control horn which in turn is connected by cables to the control stick in the cokpit.

Designers contemplating new sailplane designs will find interesting possibilities in the use of this type of control curface.

Reference I—Theory and Preliminary Flight Tests of an All-Movable Vertical Tail Surface. By R. T. Jones and H. F. Kleckner (L-196). (Ed. Note: Is it Kleckner or Fleckner? Original copy is not clear.)

Reference II Flight Tests of an All-Movable Vertical Tail on the Fairchild NR2K-1 Airplane. By H. F. Kleckner (ACR 3F26).

Reference III—Flight Tests of an All-Movable Horizontal Tail with Geared Unbalancing Tabs on the Curtis XP-42 Airplane. By H. F. Kleckner. (TN-1139).

Reference IV Comparison of Fixed Stabilizer, Adjustable Stabilizer and All-Movable Tails. By S. M. Harmon. (ACR L51-104).