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GLIDING IN CONVECTION CURRENTS

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GLIDING IN CONVECTION CURRENTS*

By W. Georgii

SUMMARY

A survey of the possibilities of gliding in convection currents reveals that heretofore only the most simple kind of ascending convection currents, that is, the "thermic" of insolation, has been utilized to any extent. With increasing experience in gliding, the utilization of the peculiar nature of the "wind thermic" and increased glider speed promises further advances. Evening, ocean, and height "thermic" are still in the exploration stage, and therefore not amenable to survey in their effects.

INTRODUCTION

The three conditions governing the development of gliding flight - exploration of atmospheric gliding possibilities, suitable gliders, and skill and experience of glider pilots - may be distinctly traced in their effects on the performance increase of gliders. The first representative gliders, Klemperer's "Blaue Maus" and particularly, Madelung's "Vampyr", formed the basis of the successful advance in gliding. Gliding skill opened up all the possibilities of slope gliding and raised the performance to distance flights of 100 km (62 miles). Meteorological research pointed the way to "thermic" gliding and thus, from the hills to the plains also, bringing in its wake the development of the necessary auxiliaries, airplane towing, and winch towing. With the opening up of "thermic" gliding, which at present includes cloud, front, and pure "thermic" gliding - flight without clouds - we became familiar with all gliding possibilities apt to be en-

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*"Thermischer Segelflug." Luftfahrtforschung, October 25, 1934, pp. 117-121.

countered in human gliding flight. However, this does not mean the end of the stage of development ushered in a few years ago by thermic gliding. On the contrary, the performances of the 1934 Rhön Contest have proved just the opposite. They have shown the way in which further progress is still possible - progress which is not altogether dependent upon improved glider design and gliding skill. This is equally proved by the diversity of the gliders and the number of glider pilots who obtained approximately identical performance increases in the 1934 contest. According to this, thermic gliding undoubtedly still offers many possibilities unknown heretofore and awaiting exploration.

Some information regarding this problem may be found in the physical principles of the thermic vertical motions of the atmosphere. Excepting local superheating, thermic vertical movements stipulate a labile atmosphere, i.e., a vertical temperature gradient greater than the dry or damp adiabatic gradient. This instability may be due to the daily solar insolation, that is, the heating of the lower air strata, but it may also be caused by cooling at greater heights. This cooling in higher layers may equally induce radiation processes. But more important for our particular problem, are the processes in which the cooling in the higher layers is caused by the advection of cold air. Just as the advection of cold air masses may be contingent upon a labile atmosphere, so warm air masses carried from southern latitudes may be followed by a labile atmosphere and bring the thermal energy stored up in southern latitudes to dissolution in our climes as thermic vertical currents.

From these physical principles a system of thermic gliding possibilities may be deduced which shows the ways which still await exploration. The characterization of the thus ensuing thermic gliding condition is chosen to conform to the language and the power of conception of the glider pilot.

THERMIC GLIDING POSSIBILITIES

a) Solar or Insolation Thermic

The insolation thermic is formed by the normal thermal upcurrents on summer days familiar to every glider.

pilot. It is the result of overheating of the lower air strata and therefore markedly affected by local ground conditions, such as open fields, woods, damp meadows, etc. The distribution of the upcurrent and downcurrent zones is irregular, conforming to the nature of the terrain. The best time for gliding is between 9 a.m. and 6 p.m. The majority of thermic flights has been made under these conditions.

Figure 1 contains the equilibrium curve of the atmosphere with insolation thermic, plotted as "emagram"*; the left-hand curve giving the temperature of the quiescent air, the right-hand curve, the temperature of an air particle ascending from the ground. The shaded portion illustrates the lability of the atmosphere, which is decisive for the rate of the vertical movement and for the attainable height of the ascending air.

b) Evening Thermic

This has been repeatedly observed by glider pilots without ever having been explained up to now. The corresponding equilibrium curves of figure 1 (July 2, July 21, August 17, and August 19, 1914) give the explanation for these thermal upcurrents occurring after sundown. It pertains to a still-remaining thermal residue left from the day heating at altitude. While the lower air layers near the ground have already cooled off from the effect of the incipient nocturnal radiation and are consequently very stable (July 2, August 18 - ground inversion), that is, free from vertical motions, the lability of the atmosphere at heights above 1,000 m (3,280 ft.) is on the increase, so that under these conditions, free vertical motions may still occur late in the evening at heights above 1,000 m. But the lability of the atmosphere and likewise the free vertical motions of the air are in need of dissolution; that is, air particles within the labile layer must be lifted by some process from their position of rest wherein they are in thermal equilibrium.

Such processes are found in the orographic dissolution or forced ascent of air particles on obstacles of the earth's surface, dissolution through differences in roughness (transition of air currents from water to land, or from open field to forest), or turbulent dissolution in

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*Energy - mass diagram.

the boundary layer of two air masses moving at different speeds. During the day the dissolution of the thermic vertical motions occurs ordinarily at the ground where the varied character of the ground offers numerous possibilities of dissolution. With evening thermic the dissolution can no longer take place from level ground when superposed by a lower, cooled-off, extremely stable air layer.

The dissolution of the upper lability is contingent upon highlands or mountain ranges, which still extend into the upper labile air layer and which forcibly lift the oncoming air. In consequence, the evening thermic, with the exception of the case of turbulent dissolution, is unsuitable for gliding except in mountainous regions. Many flights during the Rhön Contest, especially the smooth flights in the evening hours at great heights, are readily explained by this evening thermic.

c) Wind Thermic

The so-called "wind thermic" explains the long-distance flights made during this year's Rhön Contest. Figure 2 shows the long-distance flights of over 300 km (186.4 miles) made on July 26 and 27, 1934. The majority of these flights, effected by different pilots and different gliders, and the sequence on two consecutive days proves that special atmospheric conditions made these flights possible. The combination of suitable thermic with high-wind velocity together with the ensuing high glider speed made such distances possible. The term "wind thermic" characterizes the existing special conditions. The surprising fact is, that the same conditions had not been utilized in past years for flights of this kind. However, the possibilities during a contest are not all favorable; neither is every contest favored with the presence of storm fronts. Added to that, there is the general belief (justified to a certain extent) that propitious thermic is bound up with low-wind velocities. The combination of good thermic and high-wind velocities is indicative of the fact that the propitious thermic conditions of the air are not local, that is, the result of local insolation, but rather due to the advection of homogeneous, damp-warm air masses.

A study of these particular flights has shown these masses to be damp-warm, tropical air which, on these particular days - July 26 and 27 - had reached Europe probably from the Atlantic Ocean south of the Azores. The air

masses stored up the thermal energy from these tropical latitudes, to be dissipated in the observed impressive thermic. The process of dissolution of such labile air masses also is typical and portentous for gliding. Whereas with locally produced insolation thermic, the upcurrents and downcurrents are unevenly distributed, uniformly unstable air masses manifest a certain regularity in their upcurrent distribution. The existing thermal lability of the atmosphere, combined with higher wind velocity, is broken up in large and, to a certain extent, evenly arranged air rollers. These rollers, with axes in wind direction, form extensive cloud trains which denote upwind paths for the glider pilot, along which he may glide without losing altitude and consequently, without losing time. This also explains the high speed of the gliders on July 26 and 27.

Heini Dittmar's barogram of his flight in the "Sao Paulo" on July 27, also illustrates these conditions very fittingly (fig. 3).

Entirely different from the normal barograms of thermic gliding flights with wide altitude variations, Dittmar's flight on that date was made in almost one and the same height layer. The frequently proffered cloud tracks could be utilized without the time-consuming circling in arbitrarily distributed upwind zones. Peter Riedel's barograms with the "Fafnir I", recorded during the German Gliding Expedition in South America, are of the same type. This is comprehensible because these flights were made in the identical, labile, damp-warm, tropical air masses as those on July 26 and 27 at the Wasserkuppe. In the localities selected by the South American expedition in Brazil and Argentina, the gliding conditions are much like those encountered in our own country. The existence of insolation thermic caused by local overheating, is also a normal occurrence in these countries. Dittmar's altitude record of 4,300 m (14,108 ft.), on February 17, 1934, at Campos dos Alfonso near Rio de Janeiro, was made under disturbed weather conditions.

On that day there was an influx of damp, equatorial air masses from the northern part of the continent, which reveals the close connection between Dittmar's two record flights - that for altitude in Brazil and that for distance at the Wasserkuppe. In both cases it was the propitious thermic conditions peculiar to damp, tropical air

masses carried from lower latitudes. On August 20, 1934, glider pilot Ziegler also made a flight of 330 km (205 miles) with the "Milan" from the Hesselberg near Ansbach. Here also the conditions were exactly the same as in the other flights, so that we are fully justified in considering the wind thermic as the most propitious factor for long-distance gliding, and in defining wind thermic as representing the transformation of potential energy of labile air masses, originating in tropical latitudes, into kinetic flow energy.

d) Ocean Thermic

According to the observations of the South American expedition, the conditions for gliding over the tropical parts of the ocean are very favorable. Here, however, the thermal lag of the water causes the conditions to be more dependent upon the temperature of the water relative to the air than on the daily insolation. Thermal upcurrents can occur anywhere on the ocean where the water temperature is higher than the air temperature. Even comparatively small temperature differences suffice for producing suitable ocean thermic. (See fig. 1.) Over the warmer water surface the lowest air layer develops a labile temperature gradient which may, under the added effect of liberated condensation heat, induce high atmospheric instability. Owing to the uniform and homogeneous surface of the ocean the processes of dissolution on the ocean also are much more regular than over the unevenly heated continent. In the same manner, but with greater regularity than with wind thermic over the continent, do we find the thermic upcurrents on the ocean accompanied by extensive transformation rollers which form remarkably regular and vast cloud paths over the ocean.

The members of the South American expedition photographed such cloud paths, which covered the whole sky from horizon to horizon, in sharply defined form. The ocean thermic is most pronounced in the early morning because the temperature difference between water and air is greatest at night and early in the morning. Based upon its observations, the South American expedition came to the conclusion that gliding in the tropical part of the ocean, is feasible. As the seaway in this zone is normally low, starting and landing should not be very dangerous. Starting could be effected by airplane towing, the airplane serving at the same time as tender to pick up the glider

after landing. Distance flights of 100 km (62 miles) or more are entirely feasible. And there really is an excellent opportunity to make such ocean flights in connection with the airplane tender "Schwabenland" stationed in those parts of the ocean.

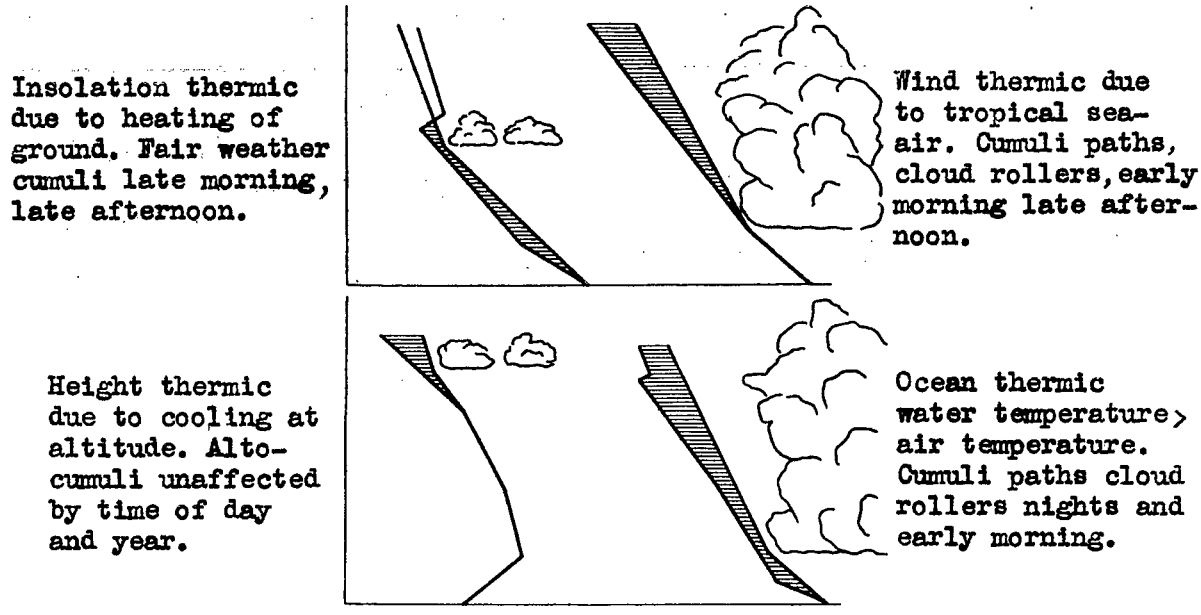
Heretofore gliding has been chiefly confined to daytime and the warm months of the year because of the necessity of utilizing the thermic due to insolation. Now, however, the previously cited physical principles of thermic upcurrents have revealed that thermic atmospheric instability and consequently thermic upcurrents, can also occur independently of insolation when with unchanged temperature conditions in the lower air layers, the cooling process of colder air masses - normally, of such as come from higher latitudes - begins at greater heights due to advection. This brings us to

e) Height Thermic

The equilibrium curve of the atmosphere for height thermic is shown in figure 1. The lower air layers, being very stable, may, especially at night and in wintertime, show ground inversion. Instability does not occur below 2,000 m (6,562 ft.) height, because of the increased temperature gradient resulting from the influx of cold air at greater heights. The shaded portion again shows the upwind zone at these altitudes. The first attempts of the D.F.S. to explore the height thermic were made this year. Figure 4 is the height time curve of Hanna Reitsch's flight in the "Präsident", made at 5:30 p.m., June 21, 1934. The glider was towed to 2,600 m (8,530 ft.). At 2,400 m (7,874 ft.) there is a sudden increase in rate of climb. After unhooking, the glider remains for some time at towing height. The height time curve reveals upwind velocities of around 1.4 m/s (4.6 ft./sec.) between 2,400 and 2,500 m (7,874 and 8,202 ft.), and of around 0.5 m/s (1.64 ft./sec.) at the ceiling.

These results are undoubtedly very promising for further attempts in this direction. As the height thermic is unaffected by insolation, it opens up possibilities for gliding at night and in wintertime. Of course the glider must be towed to an altitude of from 2,500 to 3,000 m (8,202 to 9,842 ft.). The characteristic weather conditions for altitude gliding is the appearance of altocumuli.

Translation by J. Vanier,
National Advisory Committee
for Aeronautics.



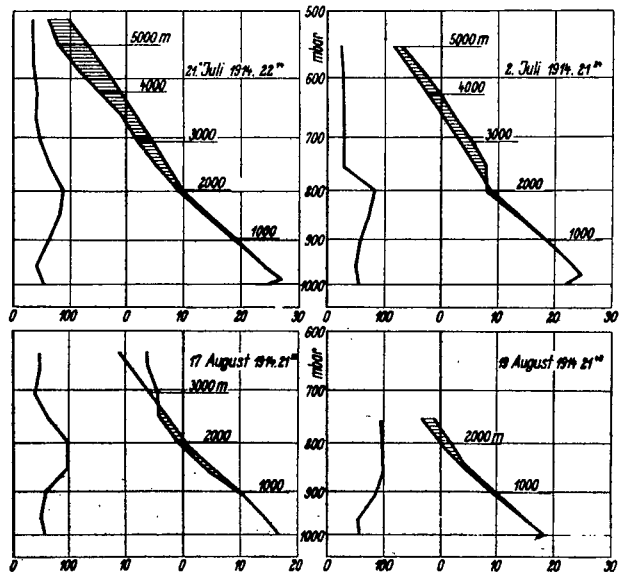


Figure 1.- Thermic of the atmosphere.

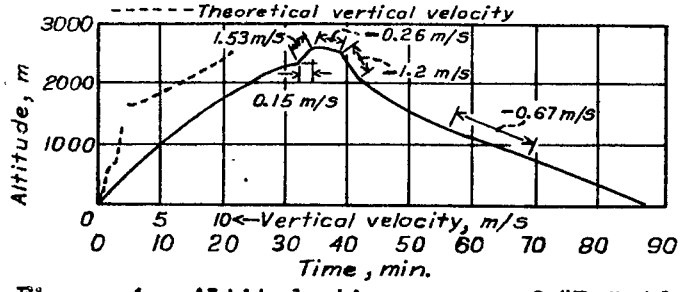
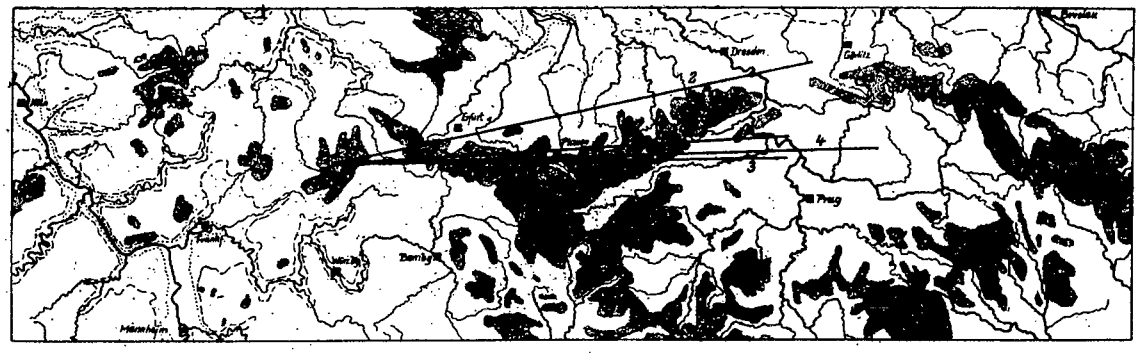


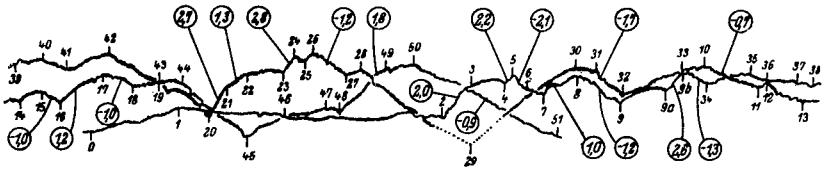
Figure 4.- Altitude-time curve of "Präsident", 5:30 PM, June 21, 1934.



Date	Pilot	Glider	Start	Landing	Time	Distance	Speed	Wind at 1000-2000m altitude	Flight No.
July 26	Hofmann . .	Ldgr. Baden	11^{18}	16^{45}	5 hr. 38 Min.	310 km	56 km/h	45 km/h	1
	Hirth	Moazagotl	11^{18}	17^{30}	6 » 11 »	351 »	56,5 »		2
July 26	Wiegmeyer .	Präsident	11^{33}	16^{45}	5 » 12 »	315 »	60,5 »	49,5 »	3
	Dittmar . . .	São Paulo	11^{53}	17^{30}	5 » 37 »	375 »	67 »		4

Figure 2.- 1934 Rhön contest: flights of more than 300 km.

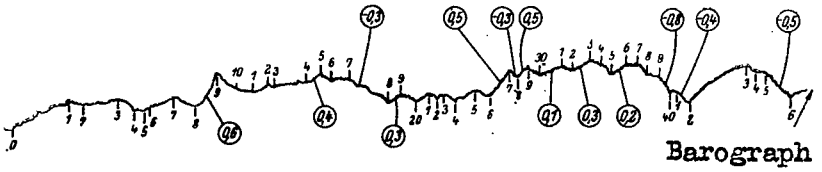
E. Wigmeyer in Präsident,
start: 11:33, land: 4:45 P.M.
distance: Wasserkuppe to Raudnitz (CSR) 310 km
barograph: Lufft 5410. 5000 m - 2 hrs.



Upper wind (km/h)

	1PM.	1PM.	4PM.	4PM.
	13h	13	16	16
3,0			•	
	1,8	1,3		14
2,0	23,43	23,65	-	25,54
			1.1	
1,0	24,40	24,61	24,28	25,61
			0,7	
0,5	25,36	-	25,22	-
0	26,22	-	-	-

H. Dittmar: Sao Paulo,
start: 11:53 A.M., land: 5:30 P.M.
distance: Wasserkuppe to Liban (CSR) 375 km
barograph: Lufft 5117. 5000 m - 6 hrs.



Barograph fails.

Figure 3.- Barogram of "Präsident" and "São Paulo", July 27, 1934

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