Synoptic Conditions of Wave Formation above Convection Streets

By H. Jaeckisch, Hamburg

Presented at the 13th OSTIV Congress, Vršac, Yugoslavia (1972)

Glider pilots often observed wave lift which could not be interpreted as the well known lift of lee waves because there was insufficient windspeed across orographic obstacles or there were no ridges or for both reasons. Studies of detailed flight reports and the meteorological conditions showed that there appeared to be internal atmospheric obstacles: thermals caused wavelike deformations of the surface of the convection layer when convection is organized in streets. All cases investigated until now show the upper flow to be directed nearly 90 degrees to the flow within the convection layer, and rising and descending across its wavelike surface a wave motion is induced in the middle troposphere.

It seems that gliding once again has resulted in a new discovery in meteorology: a special system of atmospheric motions with interaction between organized convection and wave flow. Glider pilots would of course like to be given correct forecasts of this phenomenon. But the accomplishment of this task is beset by the same difficulties as any weather forecasting. We know how weather phenomena depend on given physical values of the atmospheric situation. But the problem of forecasting is that of forecasting these atmospheric conditions. As long as numerical methods give only rough results which do not allow further computations of special, more detailed or small scale phenomena to be made directly we have to use the method of estimation by experience. For that purpose we must first find out what sort of synoptic situation favours the phenomenon concerned. To that end this paper is a contribution to the problem of forecasting waves above convection streets.

Several reports of thermal wave flights are available. But to be on the safe side, in the following only those which contained definite observations of the street shape of convection have been used. One of the three cases already published 1965 [1] and 1968 [2] had to be left out. It is the flight of E. Loh in 1954 near Cologne. The report [1] contains little beyond the information that the pilot went up to 4000 m in a nearly cloudless airmass, the lift intensifying with height. Kant discussed the lapse rates of the representative sounding of Wiesbaden, obviously having in mind that the lift was of the dry thermal type. Because it seems doubtful that thermals could have passed through the stable thick layer (2000 ft) around 700 mb wave lift was assumed in discussing the paper at South Cerney in 1965. The remaining two flights (Reinhardt/Flentje: 27. 9. 1960 near Munich; Lamparter: 5. 7. 1964 near Stuttgart) together with two recent flights (Eckart: 1. 8. 1971 near Cologne; Huth: 6. 8. 1971 near Nürnberg) will be used in the following discussion.

Figure 1 shows the surface chart with some upper air additions of the first case near Munich (M on the figure). The isobars can be regarded as evidence of the average airflow within the convection layer. They indicate a slack gradient over Central Europe. As we know [2] the sounding of Munich revealed 340° 4 kts at 900 mb. Obviously cool air from the Baltic has come nearly at rest over Southern Germany. For determining the upper conditions in comparison with those at the lower level, temperatures at 850 mb and winds at 700 mb are plotted at the sounding stations Munich (M), Stuttgart (S), Cologne (C), Hannover (H), and Berlin (B). The horizontal temperature distribution at 850 mb determines the pressure pattern at 700 mb for the most part. We therefore notice that in the area of slack pressure gradient at surface level near Munich the upper wind direction is parallel to the isotherms at 850 mb. Figure 2 concerning the second case shows also the connection between horizontal temperature distribution at 850 mb and the upper flow. We know from the sounding at Stuttgart [2] that there was a weak northerly flow within the convection layer and Lamparter observed cloudstreets oriented from N to S. The isotherms at 850 mb caused a westerly airstream at 700 mb. Figure 3 shows a flat cell of high pressure over northern Germany which had crossed the Cologne area from SW to NE in the early morning. During Eckart's flight in the afternoon high ground stations at a distance of 50 to 100 km from Cologne reported weak southeasterly winds whereas the soundings of Essen revealed at 700 mb 200° 20–30 kts (table I and fig. 4). Eckart reached 4100 m and had a beautiful view at a system of cloudstreets oriented from 120° to 300°. The spacing was 7 km. The cloud base was 1700 m and the tops of their smooth lens shaped surface were at 2500 m. The phenomenon lasted 90 minutes only. Very distinct again is the connection between the horizontal tem-

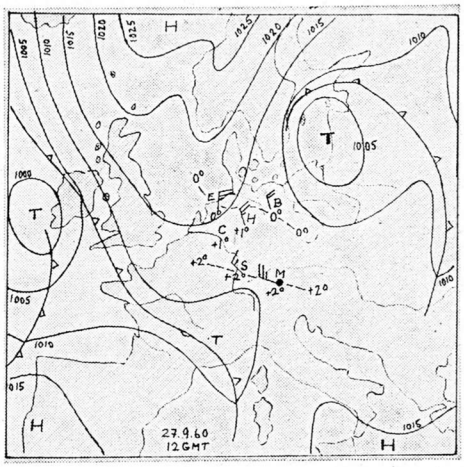

Fig. 1

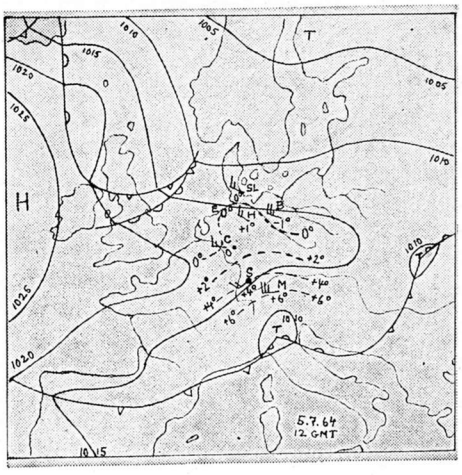

Fig. 2

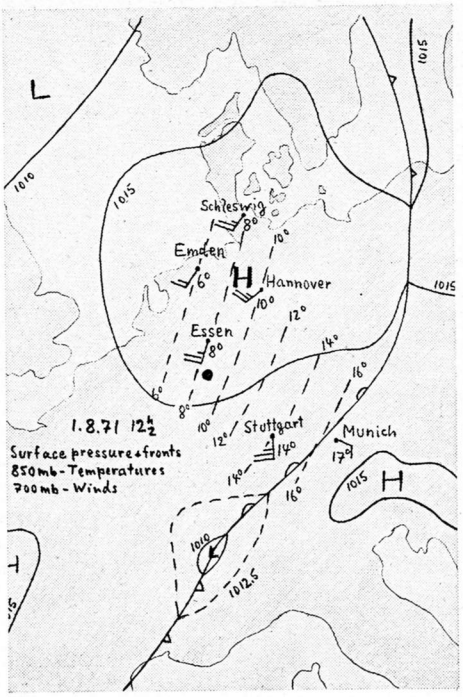

Fig. 3

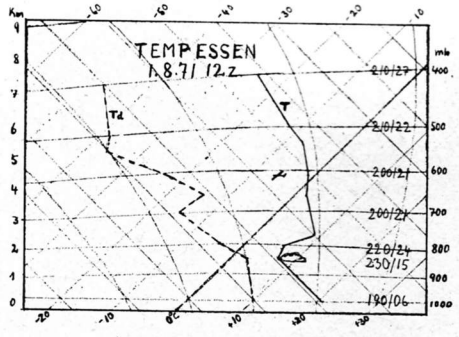

Fig. 4

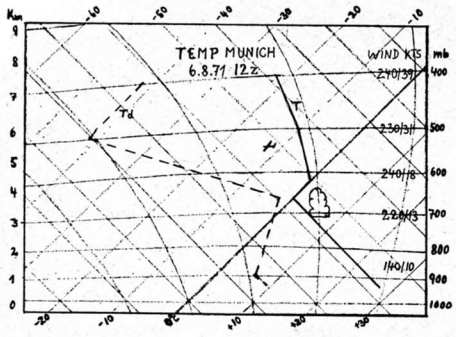

Fig. 6

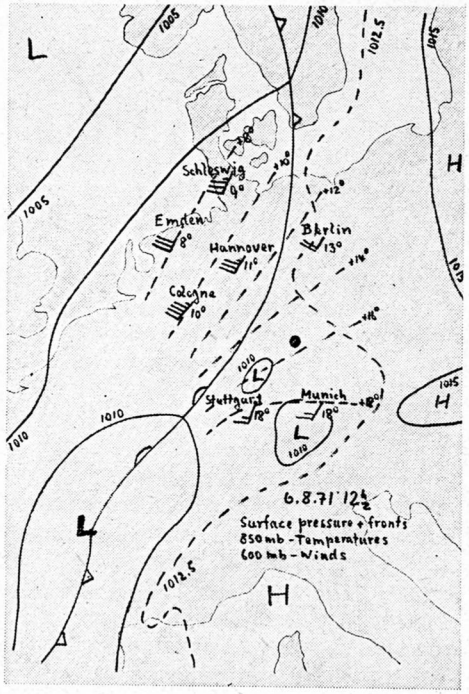

Fig. 5

perature distribution at 850 mb and the flow at 700 mb in conjunction with a slack pressure gradient at the surface. Figure 5 shows the situation on the 6. 8. 1971 when Heinz Huth reached 5000 m 50 km north of Nürnberg and had to give up because of lack of oxygen though still having 1 m/sec lift. According to his verbal report there was a slight southerly flow below the clouds and a strong westerly wind above S-N-oriented cloudstreets. The Cloudbase was at 2000 m rising gradually up to nearly 3000 m during the flight (12–15 h). The tops at 3000 m went up to 3500 m. The cloudstreets were not of the type of solid stripes with a smooth surface like those observed by Eckart near Cologne. They consisted of long rows of cumulus. The ragged western borders indicated a vortexlike upward motion. Sometimes caps were to be seen. Because the convection layer was deeper than in the previous cases (750 mb, fig. 6) the upper flow is shown in figure 5 by winds at 600 mb. They are directed at nearly 90° to the lower flow which is indicated by the 1012.5 mb line in that area and is confirmed by the observations of mountain stations (table II). Again the isotherms at 850 mb determine the upper airstream.

Conclusion

The four cases discussed of wave flow above convection streets have shown mainly two criteria for a favourable synoptic situation. They can be deduced from observations and weathermaps normally available at meteorological offices; on the assumption that good insolation for thermal activity will be present:

1. Weak flow (5–10 kts) within the convection layer indicated by the isobars in the surface map.
2. Distinct horizontal temperature gradient within the convection layer, the isotherms being directed at approximately 90° to the isobars in the surface map.

This second point concerns a conservative quality. The temperature distribution and therefore the upper wind does not change very much in time because no distinct advection takes place if a slack pressure gradient prevails at the surface. We only have to watch whether the weak lower flow will be directed at nearly 90° to the upper airstream or not.

References

1 G. Kant: A remarkable high altitude flight over the Cologne-Bonn-aerea. Ostiv Publ. VIII (1965).

2 H. Jaeckisch: Wave flow above convection streets. Ostiv Publ. X (1968).

3 A. Eckart: Wellenaufwind im Kölner Raum. Aero-Kurier 9/71, p. 623.

Tab. I. Wind observations 1. 8. 1971 (Speeds in knots)

Essen 700 mb 70 Km in N	GMT	Nürburg 626m 55 Km in S	Kahler Asten 835 m 110 Km in ENE	Marienberg 547 m 80 Km in ESE
200/34	0			
	3			
220/32	6	110/02	330/07	360/05
	9	140/02	260/04	360/03
200/21	12	160/03	170/04	160/06
	15	140/05	100/04	120/05
200/31	18	140/07	110/06	090/02

Tab. II. Wind observations 6. 8. 1971 (Speeds in knots)

Munich 600 mb 180 km in S	GMT	Wasserkuppe 921 m 110 Km in NW	Gr. Falkenstein 1307 m 180 Km in SE	Stötten 734 m 150Km in SW
240/18	12	170/13	160/05	130/10
	15	150/11	140/08	120/07
230/20	18	130/11	140/10	130/02