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PRECIPITATION OF ICE NEEDLES AS A FACTOR CAUSING DISAPPEARANCE OF FOG

by

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1. *Introduction*

Ice needles occur in stable winter conditions, usually in the intense cold of the polar winter. Experimental work has been brought out on the dependence of ice needles on temperature. The laboratory studies of NAKAYA [1] show that they are formed between —2°C and —8°C. GOLD and POWER [2] obtained the temperature interval 0°C — -11°C. They state that the occurrence of needles indicates supersaturation at relatively high temperatures and thus high icing hazard.

The precipitation of ice needles is a local phenomenon and difficult to foresee, but of great importance to the aviator. There is a relationship between ice needles and fog. According to experience of aviation weather service in Southern Finland fog sometimes disappears when ice needles begin to fall.

2. *Weather conditions under which fog may disappear during the precipitation of ice needles*

At Helsinki airports (60°19'N, 24°58'E and 60°15'N, 25°03'E) fog is dispersed in connection with the precipitation of ice needles a few times in the course of the winter, and in the main under the following circumstances. In a stationary anticyclone a convergence line, besides

the typical divergence line, occurs as a left-over from an occlusion front, or is formed in the pressure field due to some other reasons. When the anticyclone begins to move so that the observation station shifts from the area of convergence to the area of divergence, ice needles begin to precipitate at the point of transition, which leads to dispersal of the prevailing fog.

3. *A detailed analysis of a typical case*

The weather on *January 8, 1954* is studied as an example of the problem (Fig. 1). According to the morning chart at 0600 GCT[1]) a ridge

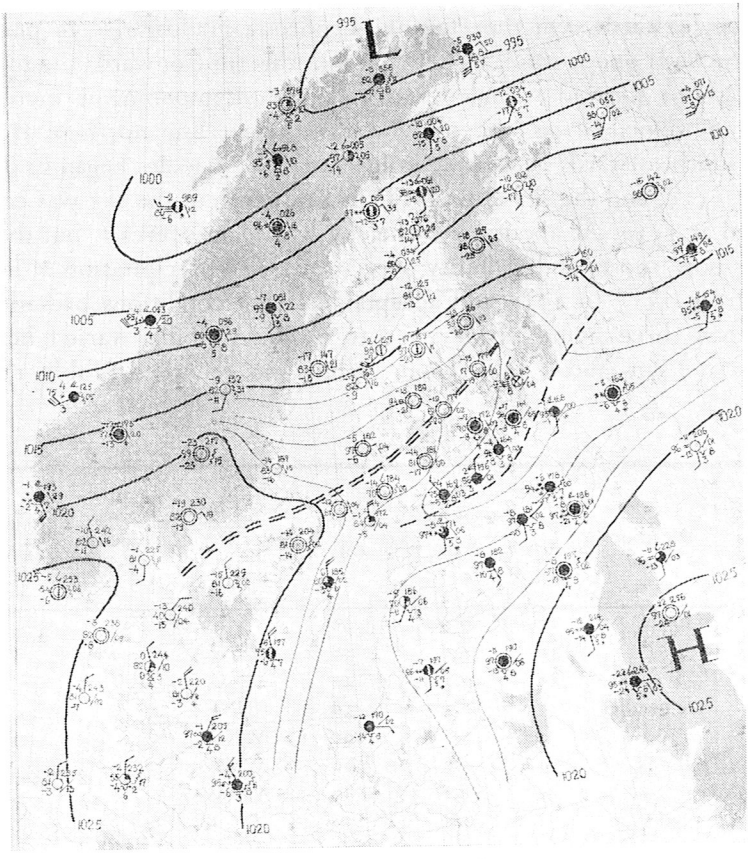

Fig. 1. Surface chart 8.1.1954 0600 GCT.

[1]) The time here is given in GCT.

of high pressure extends from the southwest over Western and Central Finland to the northeast. When the isobars are drawn at intervals of one mb a narrow trough of low pressure appears south of the divergence line, extending from the coast of the White Sea along the northern shore of Lake Ladoga southwestwards to the Gulf of Finland and the Baltic Sea. The convergence line in the trough runs approximately parallel with the divergence line. Over the Arctic Sea there is a depression.

In the Helsinki district the winds were light and turned clockwise from W to NNW in the forenoon, and after sunrise mist and fog developed.

The depression in the north began to move southeastwards pushing the ridge forwards. On the Helsinki airports a gradual rise in pressure, persisting until 0900, was first noted. From this time onwards the pressure was steady or showed a tendency to fall. A contemporaneous increase of the wind velocity was noted. The divergence line north of Helsinki moved southeastwards decreasing in intensity. Ice needles began to precipitate at 1515, and the sky cleared. Only one tenth of the sky was covered by cloud at 1530. At about 1630 the sky was again overcast, but the ceiling was now 100 m and visibility over 1 km. The precipitation of needles lasted from 1515 to 1710 and acceptable flying conditions prevailed for more than three hours, from 1515 to 1830. Visibility varied between 0.8 and 1.5 km, and a 70—100 m ceiling was recorded (Table 1).

Table 1.

Time (GCT)	Weather	Cloudiness (in tenths)	Visibility (km)	Ceiling (m)	Wind direction	Wind velocity (kt)	Temperature (°C)
1400	fog	10	0.6	60	C	0	— 9.1
1430	»	10	0.5	50	NNE	2	
1500	»	10	0.5	40	C	0	— 9.5
1530	ice needles	1	1.5	50	NNE	2	
1600	» »	9	1.1	100	WNW	2	—11.0
1630	» »	10	1.2	100	WNW	2	
1700	» »	10	1.1	80	WNW	2	—11.1
1730	rime	10	0.8	70	C	0	
1800		10	1.5	80	C	0	—11.6
1830		8	1.3	70	C	0	
1900	fog	10	0.6	40	S	2	—12.2
1930		10	0.2	0	S	2	—11.2

The Helsinki radiosonde ascent at 1500 shows an isothermal layer from the ground up to 250 m and then an inversion up to 400 m (Fig. 2). The surface humidity with fog is high, 97 per cent, the relative humidity

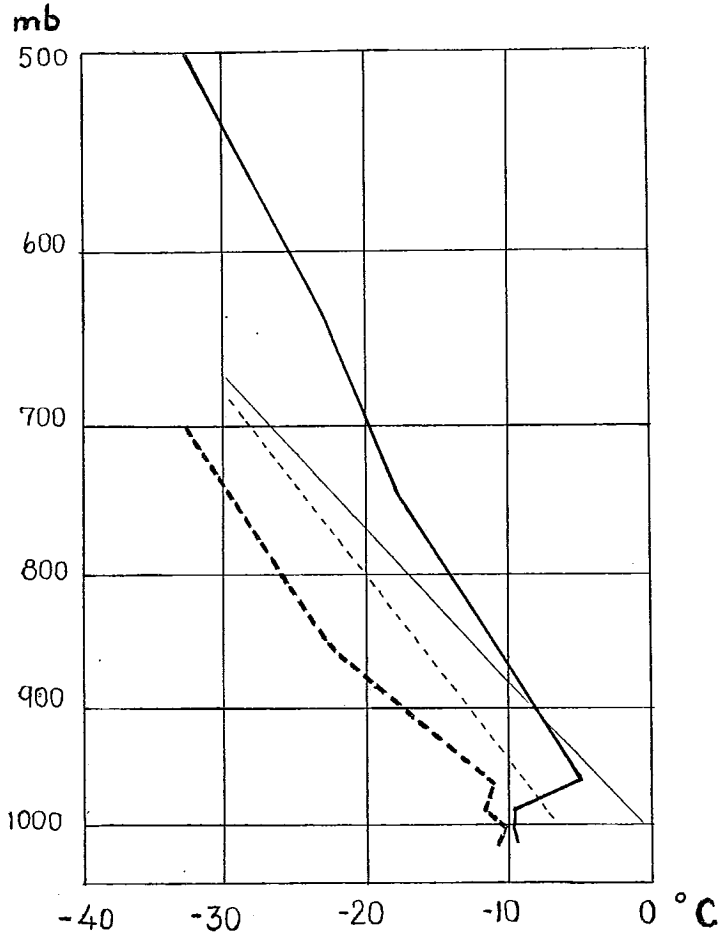

Fig. 2. The Helsinki radiosonde ascent (heavy, solide line) 8.1.1954 1500 GCT. Heavy, dashed line indicates the dew-point, thin, solid and dashed lines indicate the dry- and moist-adiabatics, respectively.

being at 130 m 90 per cent and on the top of the inversion 63 per cent. But higher up the air is very dry, at 1200 m 38 per cent, at 3500 m 25 per cent.

As was mentioned, the occurrence of ice needles is a characteristic of high supersaturation at a relatively high temperature, and thus of severe icing. In the present case, however, low supersaturation was sufficient for formation of ice needles, as appears from the pilots' reports. Before the fall of the needles between 1220 and 1418 three planes were in the air above the Helsinki district, one of them on a test flight. They all reported cloud layer at the height of 400—500 m above the fog. Higher up there were no clouds at all. No ice needles fell from aloft, as sometimes happens in clear air, nor was any icing noted in the cloud and fog layers. The height of the needles formation must be that of the apparently non-precipitating cloud or fog layers.

4. Conclusion

Since there was no increase either in temperature or in wind velocity before the ice needles precipitated, these factors could not have dispersed the fog (Table 1). The direction of the wind did not change until the phenomenon started, and then it backed from NNE to WNW (in the rear of the above-mentioned convergence line). As both these directions were downslope [3] the possible drying effect was approximately equal (the wind velocity was only 1 m/sec.). After 1500 the pressure was falling more rapidly, ½ mb in one hour, and the cloud layers began to lift. This, together with radiation from the clouds (the sun set at 1532), may have resulted in the formation of the needles. An amount of condensation nuclei and moisture now departed from the air with the needles precipitation. Consequently, it seems justifiable to suggest that it was the fall of the ice needles which made the fog disappear.

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