# DUST DEVIL SYSTEMS

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On Tuesday, 1 September 1970, a fire burned from valley to valley over a 250-metre high ridge, Granite Peak, situated some 6 km north-west of the Atmospheric Physics Laboratory in Reno, leaving the surface devoid of vegetation and largely covered by a layer of powdery ash. On the following three days, numerous dust devils were observed between about 1200 and 1600 Pacific daylight time on the lee side of the hill. The flow aloft was prevailing west-south-westerly, with a speed of 13 m $s^{-1}$ on Slide Mountain, a peak 800 m higher than the valley, and 35 km to the south. Rain on the fifth day wetted the ash and ended the high frequency of dust devils. On Friday, 4 September, starting at 1300 PDT, a series of photographs of the dust devils was taken using a 35-mm still camera and a 16-mm movie camera operated at 12 frames per second. The photographic site lay approximately 2 km to the east of the dust devils. At the time of observation the air temperature at a height of 2 m was close to 30°C, the temperature of the soil surrounding the burned area was 39°C, while the temperature of the ash was greater than 51°C.

Typically, the dust devils had a diameter of approximately 5 m and rose to a height of almost 75 m where the rapidly circulating columns broke up (Fig. 1). Some of them appeared on top of the ridge and moved downward through the burned area, descending the side of the mountain at velocities between 5 and 10 m $s^{-1}$. These dust devils occurred every two minutes or so, and persisted for about a similar time. They had characteristics comparable with those reported previously, for example, by Ryan and Carroll (1970).

The most striking observation was that on many occasions a widespread circulation with a diameter about 100 m developed over the lower slopes. The central area was quite clear, as can be seen in the series of photographs from the 16-mm film, printed at 1·2-second intervals and shown in Fig. 2. Small dust devils formed at the periphery of this circulation and could be easily distinguished. They moved with a speed sometimes greater and sometimes less than that of the general rotation. From the dust cloud to the left of the first photograph a small circulation developed (arrow in frame (a)), advancing ahead of the more diffuse cloud with a speed of about 6 m $s^{-1}$. A second one formed, (b), and advanced along with the first, (c), and apparently split into two, (d). These two died out, (e), the original one slowing down and strengthening, (f). These smaller dust devils formed at intervals of a few seconds for irregular periods of 2 to 3 minutes. Their linear velocity decreased as their local rotation rate increased. In contrast to this somewhat irregular circulation at lower levels, the circulation above about 10 m, which most smaller dust devils failed to reach, was quite steady.

The rotation rate of two such circulating systems, averaged over about 100 seconds, was $9° s^{-1}$ and $6° s^{-1}$, giving a linear velocity of 7 and 4 m $s^{-1}$. A few small dust devils originated at a considerable distance – 100 to 200 m – from the periphery of the larger circulation. These joined the main circulation by moving in along a tangent. Some were fully developed, extending upwards some 20 m, while others, originating closer in, were confined to a shallow layer some 5 m deep and they appeared to be associated with a wave-like motion on a shallow layer of air moving into the main circulation.

These large circulations moved irregularly, in a direction parallel to the hill, that is, at right angles to the upper wind. They persisted whilst in the burned area for more than 5 minutes. The dust in the upper periphery of the circulation was moving upwards with a velocity of about 10 m $sec^{-1}$. Since the flow aloft was strong westerly, it appears likely that these circulations were associated with some form of lee eddy, as has been observed on an even larger scale for a well-developed lee-wave situation (Hallett 1969). This observation stresses how important meso-scale circulations may be in providing regions of horizontal shear for generation of the initial rotation for dust devil formation.

REFERENCES

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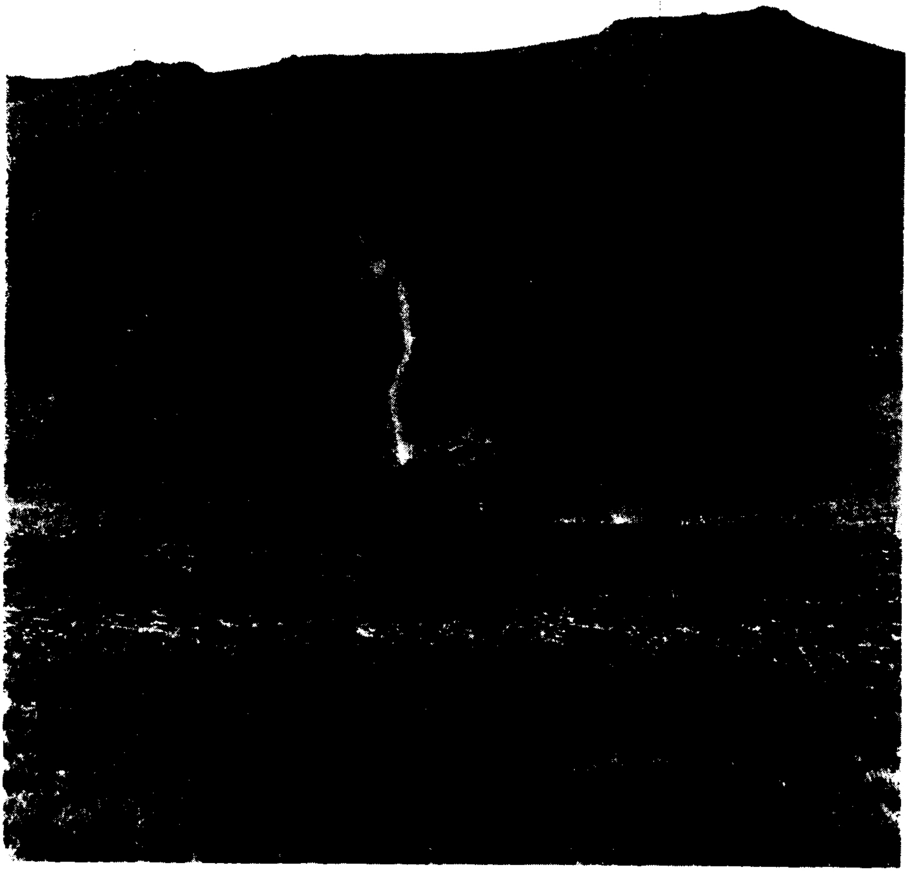

Fig. 1. Dust devil rising to a height of about 75 m; 2–4 m diameter. Identifiable dust patches were moving upward with a velocity of 20 m $s^{-1}$

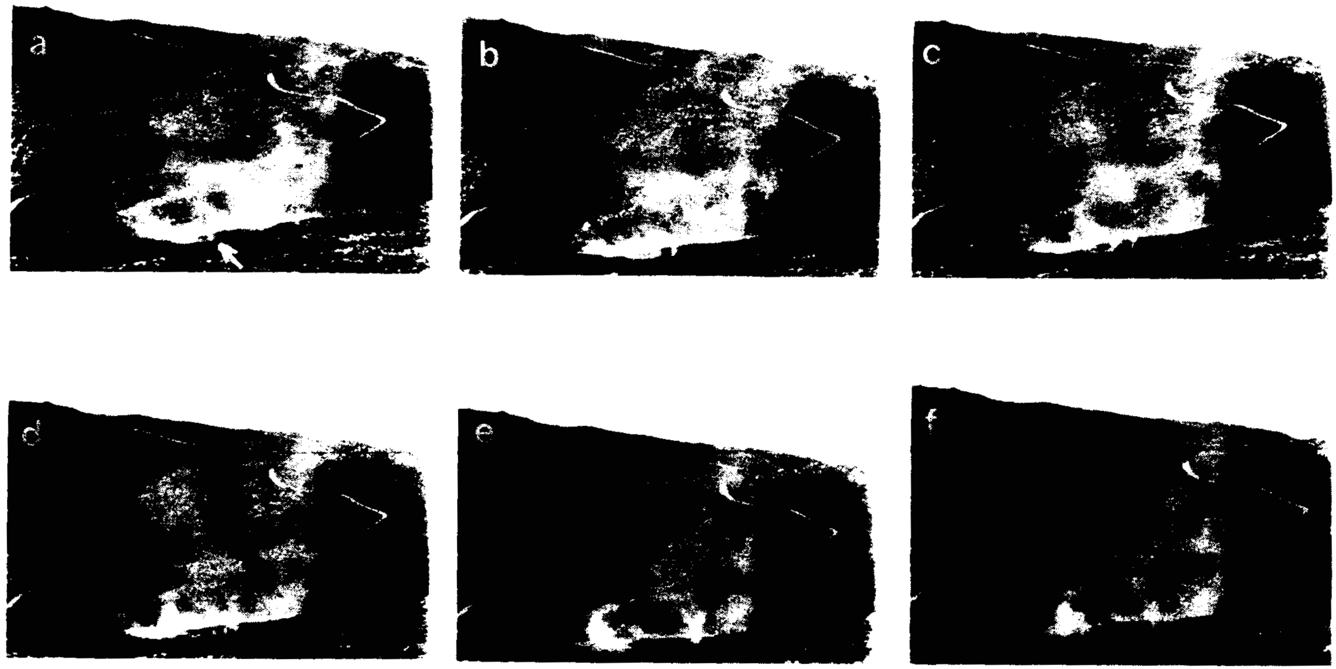


Fig. 2. Sequence taken from cine-film at intervals of 1·2 seconds, showing small dust devils forming and disappearing whilst rotating around a larger clear core, of diameter about 85 m