# Airborne Electrical Measurements in Dust Whirls[1]

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During the spring and summer of 1962, while conducting airborne electrical measurements in East Central Illinois for a cloud electrification study, the writers made measurements of the vertical potential gradient and space charge concentration in the tops of three large dust whirls. The whirls formed over dry, dusty fields and attained a height of about 150 m before they dissipated or disappeared. In each case the limited duration of the whirl, after it had first been observed, allowed only enough time to fly several kilometers to reach the whirl and to make one pass through the top of it.

The aircraft used was a light weight, single-engine plane instrumented to measure and record potential gradient (Vonnegut *et al.*, 1961), and space charge (Moore *et al.*, 1961). A meteorograph recorded the temperature, pressure, and humidity. However, because the transits through the whirls were rapid compared with the response time of the meteorograph, the meteorological parameters associated with the whirls could not be measured, and only electrical measurements were obtained. The whirls were observed within 30 km of a field station where weather observations were taken three times daily. The meteorological conditions at this station are given for periods preceding the whirls.

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At 0820 CST 16 May 1962, the sky was clear, the humidity 55 per cent, the temperature 28C, and the winds were SSW at 5 m $sec^{-1}$. By 1310 CST there was 0.6 cloud cover, 39 per cent humidity, the temperature had risen to 31C, and the winds were S at 7 m $sec^{-1}$. At 1310 CST a dust whirl was sighted and the aircraft proceeded toward and descended to the visible top of the whirl. As the whirl was approached, it drifted over a grassy field, and once removed from its dust source it began to disappear. Immediately after its disappearance, measurements were taken in the clear air approximately where the top of the whirl had been, at an altitude of 150 m above terrain. A small amount of negative space charge and an increase in the potential gradient were encountered along with one or two seconds of light turbulence in excess of that normally found in the exchange layer (Fig. 1a). Because the measurements were taken at essentially the top of the whirl, the increase in potential gradient indicated an excess of negative charge below.

Several minutes later a second whirl was observed and similar measurements were taken at the top of the whirl at 150 m. The second whirl exhibited considerably more negative space charge and a larger enhancement in the potential gradient (Fig. 1b), indicating more negative space charge below than that encountered in the first whirl. Another dust whirl was observed several minutes later but it completely dissipated before it could be penetrated.

On 18 May 1962, measurements were taken in a third whirl. Throughout the morning the winds at the field laboratory were from the SE at 4 m sec$^{-1}$. At 0830 CST, the temperature was 24C, the humidity 56 per cent, and the sky was 0.7 altocumulus. At 1245 CST, the temperature was 30C, humidity 52 per cent, and the sky 0.7 cumulus with several thunderstorms in the area. The aircraft was flying several kilometers south of a thunderstorm when the dust whirl was observed. The plane immediately proceeded toward the area, but by the time it reached the whirl, the whirl had passed from the dusty field onto a grassy area and had become invisible. The location of its base, however, was easily tracked by the swirling pattern it was producing in the grass. When the aircraft passed over the swirling pattern at an altitude of 150 m, moderate to heavy turbulence was encountered for one or two seconds. The space charge recorder saturated negatively and jammed. The potential gradient reversed in the general vicinity of the whirl but the reversal was similar to ones that had been occurring regularly at that time (Fig. 1c). They were characterized by a slow reversal followed by a relatively rapid recovery and were undoubtedly caused by lightning discharges in the nearby thunderstorm. There does not appear to be a gradient perturbation that can be accredited directly to the dust whirl. Either the perturbation was small in comparison with the background potential gradient or the gradients resulting from space charge both above and beneath the aircraft cancelled each other.

The response times of the potential gradient probes and the space charge filter were not rapid enough to clearly define the horizontal extent of the space charge concentrations or potential gradient perturbations. Consequently, the measurements appear on the figures to extend well beyond the visual boundaries of the dust whirls and are probably conservative estimates of space charge and potential gradient.

Surface electric field measurements near a dust devil reported by Freier (1960) indicated a dipole charge distribution with negative charge on top. The writer's space charge measurement at the top corroborate the suggested negative charge, although the potential gradient measurements do not indicate a dipole charge distribution.

The data are also in agreement with other electrical measurements of airborne dust made in this area. On 22 and 23 May 1962, and on 8 May 1963, clouds of dust were being carried from dry fields by high winds. A flight through one of these clouds revealed negative space charge. Surface potential gradient measurements taken at least 2 km from the nearest possible dusty field showed a reversed potential gradient throughout the day with many reversals as large as $-1000$ v m$^{-1}$, indicating large concentrations of negative space charge overhead. Similar reversals have been noted on other dusty days. A Faraday cage located on the ground during the blowing dust of 8 May 1963 indicated negative space charge concentrations in excess of 1000 elementary charges per cm$^3$. These were associated with potential gradient variations of several hundred v m$^{-1}$. Both instruments saturated, so measurements of the extremes were impossible.

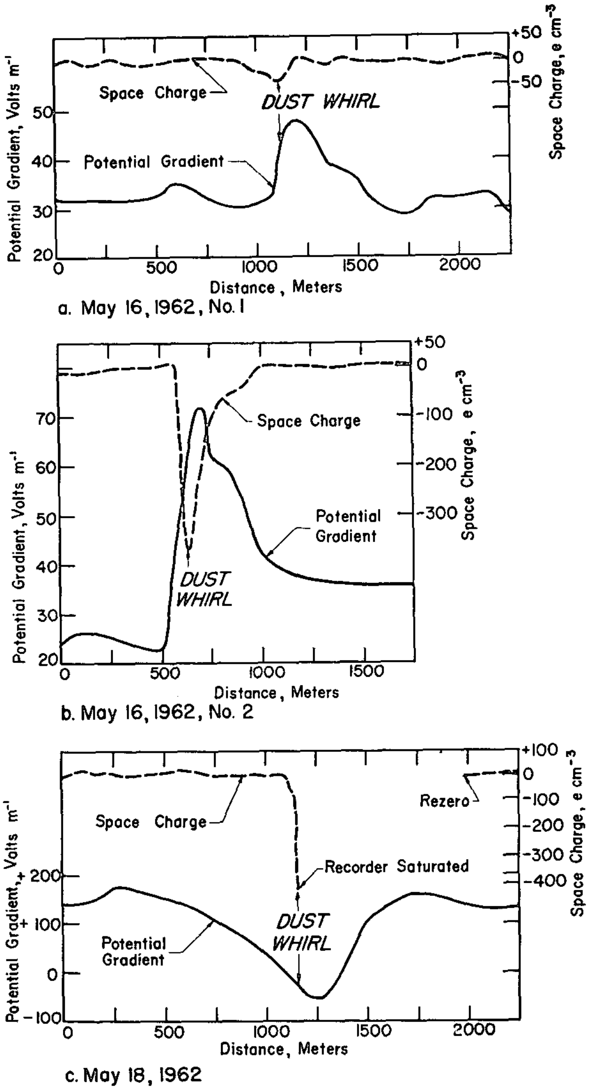


Fig. 1. Space charge and potential gradient observed at a height of 150 m in three dust whirls.

It appears that most dust clouds in central Illinois carry a negative charge. Further investigations are in progress at the present.

## REFERENCES

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