Tornadoes: Puzzling Phenomena and Photographs

The letters under the above title in the 6 January 1967 issue of *Science* raise a question which probably has a relatively simple solution. It is very probable that on occasion the tornado funnels show luminosity. This has been reported by observers who have survived passage through one, as well as shown in the photographs discussed in that issue. The explanation doubtlessly comes in terms of a laboratory investigation of swirling flows in ducts, from the Aerospace Research Laboratories of the Illinois Institute of Technology by Z. Lavan and A. A. Fejer, published in *J. Fluid. Mech.* **23**, 173 (1965). In this it was observed that swirling jets of saturated moist air, or of water, enclosed in transparent insulating walls produced rather extensive glow discharges. These were very competently investigated by Lavan and Fejer and were shown to be caused by Lenard spray electrification. As a result of centrifugal forces the larger positive drops of water were thrown to the insulating walls with the fine mist of negative droplets in the interior of the tube. The potential gradients were sufficient to set up a glow discharge in the moisture-laden air. The potentials measured in excess of 20 kv, and currents of 90 μa were recorded. Radio frequency radiations of from 10^4 to 10^7 cy/sec were detected from the positive corona streamers. The luminosity, as expected of such discharge, was due to the second positive group in the N_2 spectrum. This comes from the positive streamers coming from spray disintegrated drops in a high electrical field. This luminosity corresponds to the type visually reported in tornadoes.

That such phenomena may *occasionally* appear in the tornado funnel is not surprising and depends on the amount of moisture present and entrained. The centrifugal forces in any case will hurl the larger solid masses, including positive water drops, toward the outside of the funnel, and the finer materials, including the negative water spray, will be interior. If, in addition, solid elastic impacts of water are needed, these would result from impact with larger debris particles. Whether a particular funnel is luminous or not depends on the water entrained—that is, on the character of the ground traversed. Did the funnel touch down on rain-saturated earth?

That the analogs of tornado funnels are highly electrically charged, even without water, has been proven by W. D. Crozier [*J. Geophys. Res.* **69**, 5427 (1964)] in his study of the static electrification of dust devils. Here asymmetrical contact-charging of dust with heavier particles is responsible.

It would thus appear that the controversial photographs are, in the first place, probably the correct recording of a meteorological event and, secondly, that such phenomena have a perfectly simple and sound physical basis which can be duplicated on a small scale in the laboratory.

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Partial Pressure of Anesthetic Gases and Their Mode of Administration

In a recent article by Folkman *et al.* (*1*), it was stated correctly that modern anesthetic techniques require that the concentration of anesthetic be limited to allow space for oxygen, as both must be administered together through the lungs. It was also stated that there would be an advantage in using a coil of silicone-rubber tubing to administer the anesthetic for "it is conceivable that with two separate ports, one may in the future administer 100 percent anesthetic gas through the blood stream and up to 100 percent oxygen through the lungs." It should not be inferred, however, that 100 percent oxygen will be present in the alveoli, since the sum of the partial pressures of the gases dissolved in the bloodstream cannot exceed the ambient pressure, in this case 1 atm (*2*). Therefore, as the steady state is approached, within a period of 10 minutes, the gas in the alveoli will contain a partial pressure of anesthetic gas that will be as high as if the anesthetic had been given by inhalation, for the differences in partial pressures between arteries and alveoli are, in general, insignificant (*3*). Thus, for a procedure lasting more than 10 minutes there will be no benefit in improving oxygenation or in achieving higher partial pressures of anesthetic in the blood if the proposed procedure is used over the usual inhalation procedure.

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2. F. W. Sears and M. W. Zemansky, *University Physics* (Addison-Wesley, Reading, Mass., 1963).
3. J. H. Comroe, *Physiology of Respiration* (Year Book, Chicago, 1965).

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Glauser *et al.* make a very good point. We did not wish to imply that the advantage of a separate intravenous port for anesthetic gas would allow 100 percent oxygen to remain in the alveoli. This statement was meant to emphasize the fact that the intravenous route would overcome the delay during induction that relates to the blood-gas coefficient of the anesthetic.

This advantage would extend beyond the stage of induction for patients with pulmonary insufficiency. The intravenous administration of anesthetic gas should become more efficient in proportion to the severity of pulmonary disease because of the increased ease of getting the anesthetic into the blood and because of the decreased ability of the patient to exhale it.

An additional advantage implied in our statement was that the problem of gas-mixing valves and vaporizers would be simplified or eliminated. For example, we have found that methoxyflurane (Penthrane) applied directly to a short (20 cm) silicone-rubber arteriovenous shunt will produce deep anesthesia in dogs without any rebreathing device and without any hemolysis. No vaporizer is necessary. The anesthetic depth is regulated simply by the number of milliliters of Penthrane applied or by the number of centimeters of tubing exposed.

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