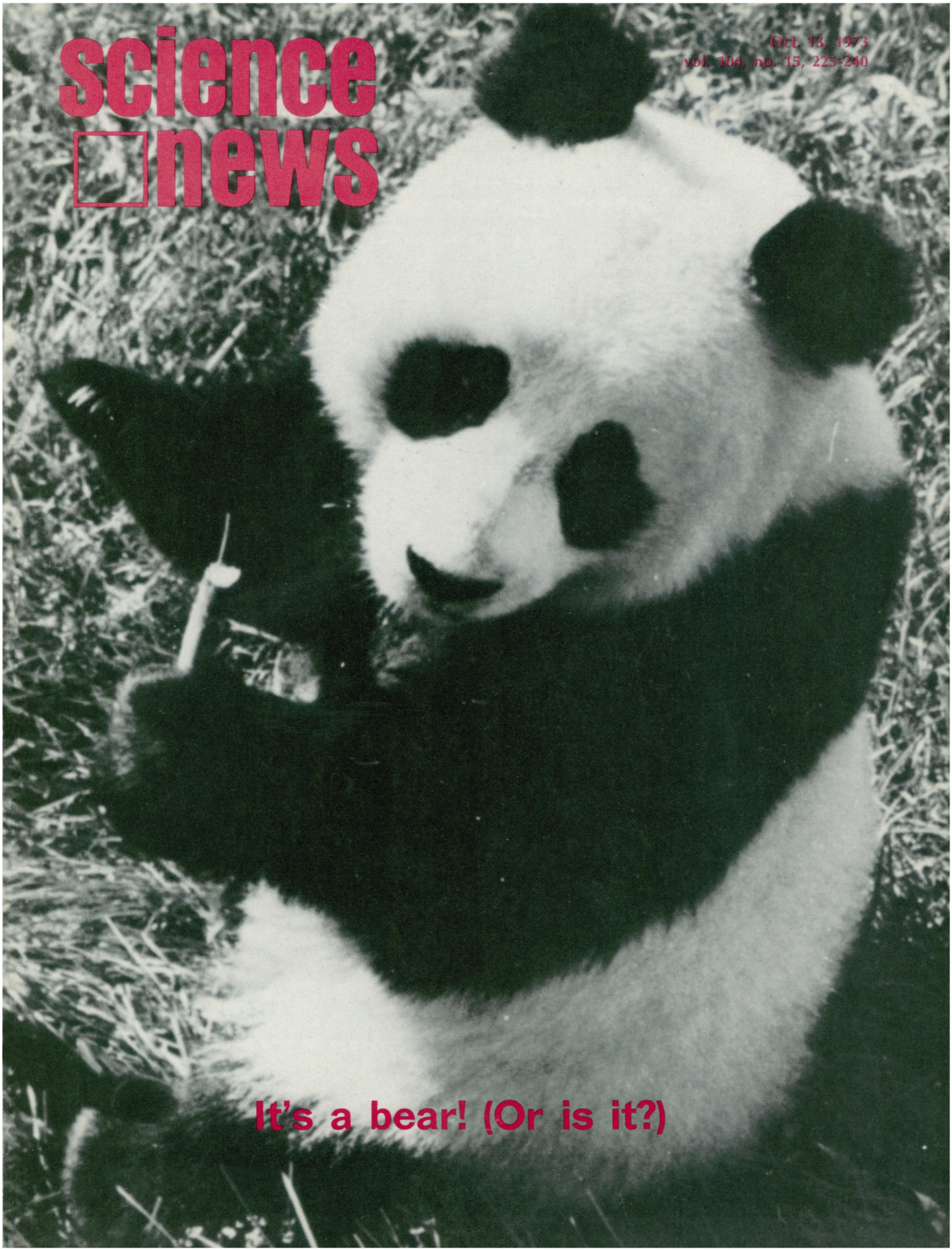
science news
Oct. 13, 1973
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It's a bear! (Or is it?)

Conversation Pieces

Technically intriguing items from TRW, guaranteed to add luster to your conversation and amaze your friends.

Tornadoes, Rockets and Sonja Heine

So far, 1973 has been a banner year for tornadoes. By mid-year, more than 750 of these violent storms had swept down on the United States, killing 59 people and causing millions of dollars in property damage. Scientists expect the existing tornado record of 928 (set in 1967) to be easily shattered before the year is over.

Recently, tornado research has received help from an unexpected source — namely, studies made by TRW scientists of flow patterns in the propellant tanks in ICBM missiles. When you pump fuel out of a liquid rocket tank, much the same thing happens as when you pull the stopper out of your bathtub — a radial flow pattern develops (the particles move in spiral paths toward the center) and a vortex appears. To find out how swirling fluids behaved in propellant tanks, TRW scientists made some fundamental studies of the formation and behavior of vortexes. Further research has extended their analyses to the behavior of the large vortical patterns in the atmosphere we know as tornadoes, waterspouts, dust devils, and fire whirls.

A tornado begins with a thermal instability in the atmosphere, e.g., large mass of warm moist air under a layer of cold dry air. Under such conditions, violent updrafts may begin, around which the surrounding air begins to flow radially inward, in a swirling, spiral pattern. As particles get closer to the center of the flow pattern, their velocity increases. Some readers will recall the startling rotational speeds Sonja Heine achieved as she drew her extended arms closer to her body. Particles of air experience this same increase in rotational velocity as they get closer to the center of the system.

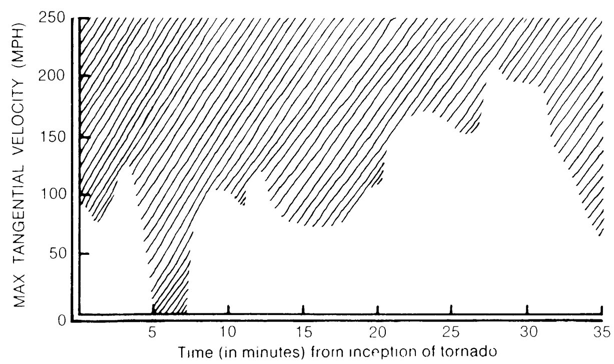
Ordinarily, turbulent diffusion opposes the swirling, and relaxes the disturbance — i.e., friction prevents Sonja from bringing her arms inward. However, in rare circumstances the radial inflow overwhelms turbulent diffusion, and a tornado develops. Actually, in a killer tornado much of the radial inflow is eventually confined to a layer near the ground, because at greater heights the increase of swirling ultimately creates a large centrifugal force that counteracts further radial inflow.

While dust and debris are being swept upward, the funnel of the tornado appears to descend. The latter occurs because the faster the air swirls, the more its temperature drops and the less moisture the air can contain. The resulting condensation of water vapor is seen as the funnel of the tornado, snaking down from the ominous cloud deck. Using these facts, TRW scientists have developed a formula which enables them to calculate the maximum velocity of winds in a tornado.*

TRW scientists have estimated the maximum wind speed in the funnel of a major tornado at around 225 m.p.h. Much of a tornado's destructiveness, however, stems not from the speed of the swirling wind, but from the radically low pressures inside the funnel. As a tornado engulfs a building, air trapped inside the building causes it to explode.

While much remains to be learned about large vortical storms, TRW's work with swirling liquid rocket propellants has lead to an important meteorological understanding of the behavior of destructive rotational storms.

**Maximum velocity, $V = (kgh)^{1/2}$, where h is the altitude of the cloud deck, k the fraction of the distance between cloud and ground the funnel cloud tip has descended, and g the acceleration of gravity.*



Using Weather Bureau data from the tornado of April 2, 1957, TRW scientists calculated the above time-history of estimated maximum wind speeds.

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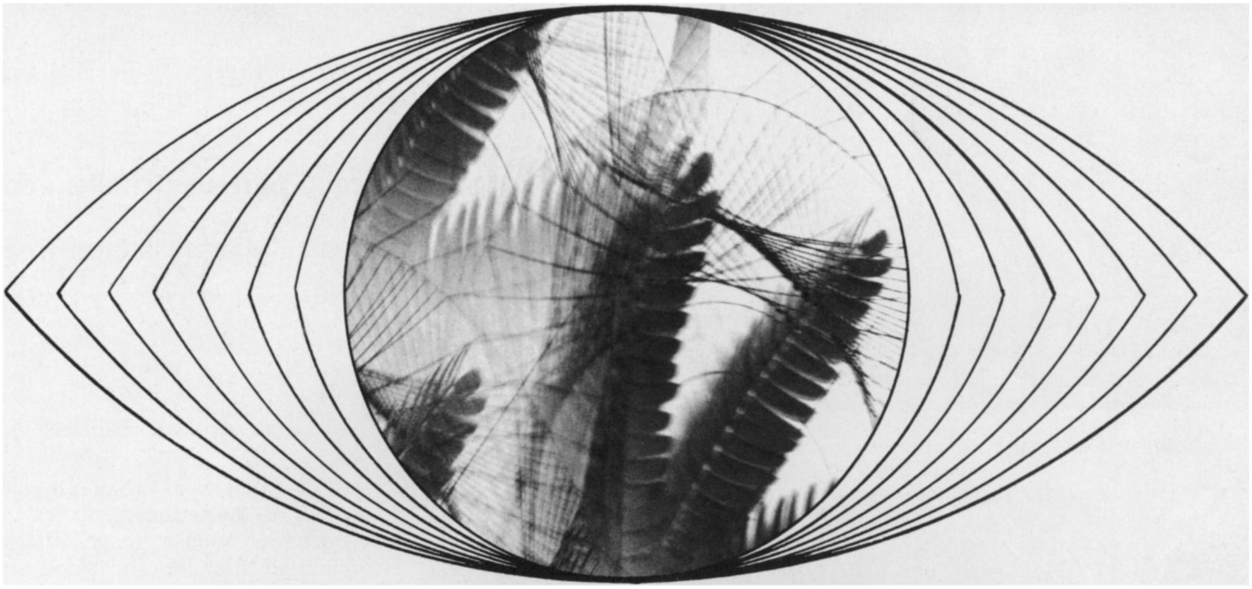

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