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Turbulent convection at high Rayleigh numbers[1]

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Russ Donnelly had a vision of building a ten-meter tall Rayleigh-Bénard convection cell for use at helium temperatures at one of the high-energy physics facilities with very large helium liquefaction capacity. It would have reached Rayleigh numbers in the 10^{20} range and had the promise of yielding detailed information about the so-called ultimate state of turbulent convection which is highly relevant to many geophysical and astrophysical problems as well as to oceanography and climate physics. Although this was not to happen for reasons beyond his control, a laboratory-sized precursor of this venture yielded data for Ra up to 10^{17}. [3] The results were interpreted to yield no definitive indication of a transition to the ultimate state. This talk will review some of these data and compare them with more recent measurements using SF_6 at ambient temperatures and high pressure. [4] This comparison suggests that the Donnelly group actually entered a transition range to the ultimate state near $Ra_1^* \simeq 6 \times 10^{12}$, but re-entered the classical state at larger Ra because with increasing Ra the Prandtl number (which affects Ra_1^*) also increased in those experiments. In view of the above, one can estimate that, for the same parameter values, the originally envisioned ten-meter cell could have yielded a range of a couple of decades of Ra in the ultimate state.

3.) J. J. Niemela, L. Skrbek, K. R. Sreenivasan, and R. J. Donnelly, Nature **404**, 837 (2000).
4.) G. Ahlers, X. He, D. Funfschilling, and E. Bodenschatz, New J. Phys. **14**, 103012 (2012).

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