Fog, Dust and Rising Air: Understanding Cloud Formation, Cloud Chambers, and the role of Meteorology in Cambridge Physics in the late 19th Century

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Abstract

C.T.R Wilson's cloud chamber has become something of an icon in our understanding of the historical relations between meteorology and physics in the development of scientific theories of cloud formation and matter. In particular Peter Galison and Alexi Assmus have described the cloud chamber as resulting from the interplay of mimetic and analytic traditions of experimental physics, but stressed the distances between these traditions [1]. Their account of the genesis of Wilson's instrument shifts decisively from the Ben Nevis meteorological observatory and John Aitken's dust-counting cloud chambers on the one hand, to the Cavendish Laboratory and J.J. Thomson on the other. In this paper I argue that there was an intermediary tradition of meteorological physics already present in the Cavendish Laboratory that is likely to have played an important role in the timing of Wilson's work, and in setting the goals that Wilson addressed. William Napier Shaw lectured and researched on meteorology in Cambridge from the late 1870s, before becoming Secretary and then Director of the Meteorological Office from 1900. Shaw's work on cloud formation in 1895 shows that along with Ben Nevis haloes and Cambridge matter physics, Cambridge fogs played their part in inspiring a new use of the cloud chamber. Further, an analysis of Wilson's notebooks and publications will demonstrate that the important step of eliminating dust from the air within the chamber did not remove Wilson's experiments from the mimetic tradition. Rather than the fundamental opposition that has been implied by Galison and Assmus's argument on this point, I will show that Wilson's early experiments themselves represented a sustained and fruitful interplay between mimesis and analysis (but one that also proved controversial). While in Wilson's hands the cloud chamber remained both mimetic and analytic, I will argue that the episode does reveal a longer-term institutional development, in which meteorological research (and other facets of cosmic physics) increasingly moved from physics laboratories to other institutional homes.

Shaw's Pedagogy and Research: Practical Physics and the Guts of Meteorology

An undated fragment headed "The Cambridge Attitude Towards Meteorology," in Shaw's papers offers a graphic image of the standing of meteorology in Cambridge:

"My son's had a good eddication he's passed the locals he says you don't want to go to no lectures [on Meteorology] if there is anything you wants to know I'll learn you myself." Meteorology is geography or physics or mathematics according to the problem under investigation. We have a school of geography, a famous school of physics, and a whole faculty of mathematics. So of meteorology as a science we have the legs and the lungs and the head and anybody who has got the legs and the lungs and the head has got the

whole bird, except the guts, which are too disgusting for scientific gentility. [2] Nevertheless, as a researcher, demonstrator and finally university lecturer under three different directors of the Cavendish Laboratory, Shaw often lectured and conducted research on meteorological topics, conducting a thorough study of dew-point instruments, for example. An examination of Shaw's activities will indicate his importance for the laboratory Wilson entered as a student, while I will argue that Shaw's teaching methods provide a potential explanation for his relative lack of visibility in accounts of the Cavendish and of Wilson's experimental research. As a demonstrator Shaw promoted engagement with original experiments and encouraged his students' individual responsibility.

Wilson's Research on Dust Free Air

In a lecture to the Royal Meteorological Society on March 20, 1895, Shaw outlined a view of cloud formation that provides a natural context for the research Wilson took up a week later. In particular, Shaw argued that as a result of condensation on dust nuclei and the weight of the resulting droplets, air rising through cloud would be free of dust [3]. The suggestion indicates that Wilson's use of cotton wool (or continual expansions) to filter his air sample of dust was understood mimetically, as simulating the behavior of dust free air rising above a cloud. A study of Wilson's notebooks and publications confirms his adherence to Shaw's view [4].

While Wilson and Shaw understood the new cloud chamber mimetically, Aitken argued against the mimetic purchase of the experiment, acting as a referee for Wilson's papers in the *Philosophical Transactions*. In Aitken's view the dust free state and supersaturated condition of Wilson's experimental arrangement were never met in nature; a suggestion Wilson combated in *Nature*.

The episode illustrates the importance of mimetic and analytic modes of experimentation in meteorological research, but also shows that Wilson understood his experiment both mimetically and analytically. Nevertheless, both the practical, standards-based research that Shaw represented, and meteorology as a field of study, were to be increasingly separated from academic physics at the Cavendish Laboratory in the period following Shaw's departure in 1900.

References

[1] Peter Galison and Alexi Assmus, "Artificial Clouds, Real Particles," in *The Uses of Experiment*, ed. David Gooding, Trevor Pinch, and Simon Schaffer (Cambridge: Cambridge Univ. Press, 1989), 225-274. A revised version, differing little in regard to the description of the formation of the experiment itself, is included in Peter Galison, *Image and Logic: The Material Culture of Microphysics* (Chicago: Univ. of Chicago Press, 1997), chap. 2.

[2] W.N. Shaw, "The Cambridge Attitude Towards Meteorology," CUL ADD 8434 Box 3.

[3] W.N. Shaw, "The Motion of Clouds Considered with Reference to their Mode of

Formation," *Quarterly Journal of the Royal Meteorological Society* 21 (1895), 166-180.

[4] Wilson's key paper on the early cloud chamber is: C.T.R. Wilson, "Condensation of Water Vapour in the Presence of Dust-Free Air and Other Gases," *Philosophical Transactions of the Royal Society of London A* 189 (1897), 265-307. His notebooks are available at the Royal Society, London.

Note: An extended version of this paper is forthcoming in Liba Taub and Frances Willmoth, eds. *The Whipple Museum of the History of Science: Instruments and Interpretations* (Cambridge: Whipple Museum with University of Cambridge Press, forthcoming 2004)

Biographical Sketch

After undergraduate studies at the University of Melbourne, I completed my PhD on the early work of Max Born at the University of Cambridge in 1992. The present paper stems from research initiated for two exhibitions at the Whipple Museum in Cambridge (1992-95), but was completed while at the Max Planck Institute. Since 2000 I have taught at the University of Wisconsin-Madison. My research has been on relativity, the relations between instruments, experiments and theory, and the role of participant histories in the development of new theory. I am at present completing a book on "Physics circa 1900."