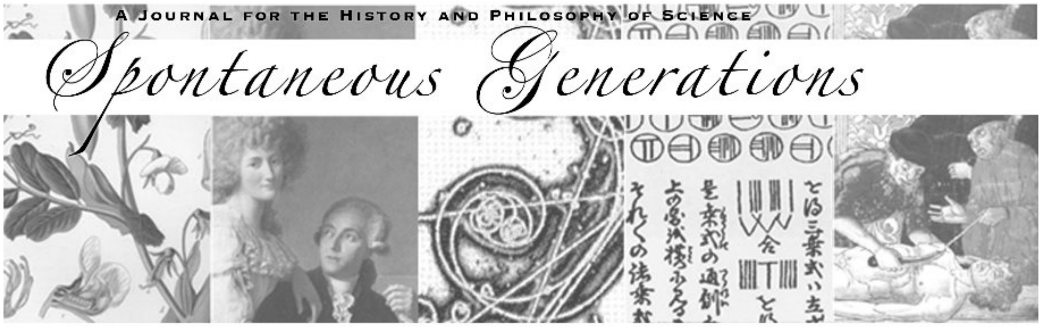

Let Freeness Ring: The Canadian Standard Freeness Tester as Hegemonic Engine

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Source: *Spontaneous Generations: A Journal for the History and Philosophy of Science*, Vol. 4, No. 1 (2010) 61-70.

Published by: The University of Toronto
DOI: 10.4245/sponge.v4i1.11331

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ISSN 1913 0465

FOCUSED DISCUSSION INVITED PAPER

Let Freeness Ring

The Canadian Standard Freeness Tester as Hegemonic Engine[*]

James Hull[†]

In important respects measurement practices underlay both the Second Scientific Revolution and the Second Industrial Revolution. Such practices, using increasingly accurate and precise instruments, both turned laboratories into factories for the production of exact measurement and also made factories the sites of laboratory-type and laboratory-quality measurement. Those who had learnt the protocols of precise, instrumentational measurement in university science and engineering classrooms, used those instruments and their skills to monitor and control industrial production, exchange technical data within and among firms and formulate and implement technical standardization in industry. That these instruments measured not natural phenomena but technological ones made them no different in kind from what are more conventionally regarded as scientific instruments. Some indeed were simply instruments developed for scientific investigation and adapted for industrial use while others were created specifically for particular industrial applications. But more than the purely technical was going on in the use of those instruments. In addition to their function of producing knowledge they were also, in industrial production, instruments of hegemony–hegemony which, as Gramsci reminds us, begins in the factory. Among the lesser known of these devices is the freeness tester, used in production to control the manufacture of pulp and also in industrial research laboratories for the investigation of the pulping process. The Canadian Standard Freeness Tester (CSFT), developed at a Canadian government research facility on the campus of McGill University in the 1920s, quickly became a standard instrument in the pulp mills of North America and gained wide acceptance in other countries; it remains in use to this day. An understanding of its creation and function can provide a useful case study of the general observations discussed above.

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[*] Received 15 January 2010.

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Spontaneous Generations **4**:**1** (2010) ISSN 1913-0465. University of Toronto.

Andrew Barry has declared that “the sociology of measurement and calculation ... remains central to understanding some of the key political and economic processes of the modern world” (1993, 459). At least by Victorian times scientific laboratories were factories producing precise measurements (Wise and Smith 1986; Schaffer 1992). But so too in the Second Industrial Revolution had the factory become itself a site for the making and using of precise measurements. These measurements, used in the precise control of productive processes, the exchange of technical data and the implementation of standardization, were made by scientifically trained personnel using precision instruments. That these instruments measured not natural phenomena but technological ones–a difficult distinction to make–made them not different in kind from what are more conventionally regarded as scientific instruments (Buchwald 1996). While Gooday (2004) has identified difficulties in transferring ideas about precision measurement from scientific to engineering realms as a cultural and not narrowly technical problem, it is exactly such a transfer which the Second Industrial Revolution was all about. In a penetrating discussion, Carroll-Burke (2001) uses the term “epistemic engine” for four categories of tools and instruments: meters, scopes, graphs and chambers. But in addition to their function of producing knowledge, they are also, in industrial production, instruments of hegemony (Hull 2003); hegemony which, as Gramsci (1997, 285) reminds us, begins in the factory. The Second Industrial Revolution involved new productive processes and transformed existing productive processes, not least in the manner in which they were controlled. In the nineteenth century, skilled craftsmen, using empirical methods, deeply knowledgeable about traditional materials and their properties, exercised almost complete control over most productive processes. While Taylorism would represent one line of assault on the positions of those workers, more fundamental was the new process control technology developed and implemented by university-trained engineers and chemists (Donnelly 1994). The pursuit of regularity–the use of testing, inspection, and standards to control the quality of output–in industry after 1900 was an economic goal pursued by management. But, in addition, “epistemological trends–such as increasing precision, quantification, or standardization–embody the social visions to which scientists and engineers...subscribe” (Slaton 2001a, 10). Continuous flow processes placed a premium on the tight control of production. They allowed not just greater throughput but a more uniform output of a given quality to be produced. This, however, required a much deeper understanding of raw materials and of what changes took place during production. The results were impressive. Petroleum refiners could increase and predict their yields, reduce corrosion in machinery and cut in half losses of volatile material in storage tanks. In the pulp and paper industry, sulphur consumption dropped by a third, stock losses by an order of magnitude and production speed increased threefold. Smelters could, when necessary, treble the prices they paid for ores as other costs declined so sharply. The ore processed daily in a furnace doubled. Textile production, long plagued by temperature and humidity variability, became climate controlled. Canners cooked under greater temperatures and pressures, thus reducing production times. Conversely, nitric acid could be manufactured more safely as certain operations came to be conducted efficiently at lower pressures.

How was the new process control implemented? Prior to control came testing; testing of raw materials, intermediate products during production, and final output. To begin with, tests were ad hoc, individual, qualitative, and sensory. Over time they became standardized, routinized, codified, quantified, and instrumentational. The quantification of tests obviously permitted greater precision (Bennett 1991). Less obviously, they required a new vocabulary to describe tested properties and new types of skills in the interpretation of quantified measurements. The use of instruments rather than sensory observations was essential to quantification (Sibum 1998). As well, such instruments, over time, came to be standardized themselves and to function automatically. Recording instruments also allowed for ready comparison across space and time. They helped to create what O'Connell refers to as "material collectives, communities of persons and institutions mutually exchanging the same representations and material representatives for abstract scientific entities" (1993, 130).

Testing became more and more directly integrated into process control. This could involve the control of, say, pressure vessels within a very narrow range of conditions, or the control of furnace gases with the objective of greater fuel economy of differential heating within the furnace. Precision testing instruments were the rams and catapults which the hosts of BScs, MEs, and their cohorts used to smash their way onto the shop floor where the master craftsman once held sway. The replacement of skilled workers judgments by testing procedures was, perhaps more than any one other thing, the technological heart of the Second Industrial Revolution (Locke 1984). An institutional structure supported these scientific weapons logistically. This included manuals and textbooks to describe the instruments and how they should be used, engineering and standards bodies to calibrate instruments and promulgate standard methods for their use, and research laboratories to underpin them all.

The first instruments were thermometers and microscopes. But the arsenal soon expanded to include pyrometers, polariscopes, and spectroscopes, as well as more specialized turbimeters, flarimeters, and colorimeters. Among the lesser known of these devices, outside of the industry of its employment, is the freeness tester. Roughly speaking, such an instrument measures the rate at which water drains away from a sample of pulp on a screen or perforated plate; that is, under conditions analogous to the formation of paper from pulp stock. It is used in production to control the manufacture of pulp and also for laboratory investigation of the pulping process. The Canadian Standard Freeness Tester (CSFT), developed in Montreal during the 1920s, quickly became a standard instrument in the pulp mills of North America and gained wide acceptance in other countries. Both in its development and use, the CSFT formed part of a new approach to technology in industry. An understanding of its creation and function can provide a useful case study of the general observations discussed above.

Why would anyone wish to measure freeness with an instrument? Papermakers desired pulps of uniform freeness, so as to run the Fourdrinier machines faster and with less downtime. Thus throughput, that key measurement of industrial efficiency in continuous process production, would be increased. As well, with greater control over the freeness of groundwood pulp, a greater proportion of that cheaper product could be used relative to the more expensive sulphate pulp in newsprint. Practical papermakers controlled the freeness of the pulp by feel and rule-of-thumb during pulping and had a vocabulary to discuss it. “Freeness,” “slowness,” and “wetness” formed a cluster of terms used to describe a certain property of the pulp stock; that is, the mixture of fibers and water sent to the Fourdrinier machine. The rate at which water drains from the stock (fibers) on the paper machine wire is highly variable. Quick-draining pulp was termed free, and the quicker the freer. Wetness was an infelicitous term as it is inherently misleading, the terms “wet” and “dry” being used for another aspect of pulp and paper production. Slowness (or “greasiness”) proved redundant as papermakers could simply discuss the degrees of freeness, though only qualitatively (Stephenson 1922). In the early twentieth century, engineers began to raise the question of whether this quality could be quantified, measured exactly by a testing instrument, and applied to mill control to produce pulp with uniform and closely-specified freeness. In Vincenti’s (1990) terms, such a tester would be an objective means to a subjective end. It would also involve replacing a qualitative discourse rooted in the senses with a quantitative one rooted in precision measurement.

In Germany in 1907–08, Dr. Paul Klemm developed the earliest known device to measure freeness, Klemm’s Sedimentation Tester, manufactured and co-patented by Louis Schopper (Clark 1931). When, in 1921, the Canadian government’s Forest Products Laboratory (FPL) began the investigations which would lead to the CSFT, its researchers could draw upon more than a decade of previous work. Testers had begun to find their way into mills, in particular for use in control of groundwood pulping. However, these testers lacked the combination of accuracy, ease of use, and ruggedness needed for everyday operation by mill hands. As well, the absence of any standard tester and standard test method severely hindered the interpretation of results and the dissemination of information gained from freeness testing. The initiative for the FPL Pulp and Paper Division's involvement in testing came from the Committee on Chemical and Physical Standards of the Canadian Pulp and Paper Association's (CPPA) Technical Section. The Pulp and Paper Division agreed to cooperate with that committee in developing standard methods for strength testing of pulp. The firm of John Date, a Montreal brass machinist, built a test instrument for the FPL to use in this work.

The approach which the researchers took right from the start of this project is of crucial importance to an understanding of the FPL's contribution to freeness testing. The following account of the tester's development is recreated from the monthly Reports of the Forest Products Laboratories Superintendent (FPL Supervision Report, 1921–26). Division staff identified a series of challenges in the application of freeness testing to mill control. Testers would have to be constructed to exact and standard specifications, machined to close tolerances, and be properly maintained and checked to ensure that usage had not degraded their performance. This required the setting of standards of performance for the device itself but also a testing protocol which, while it included careful instructions, aimed at being as operator-independent as possible. Although the testing ought to be done under standard conditions of consistency and temperature of stock, it had to be fast and accurate enough for use in mill control, not just laboratory investigation. In short, FPL researchers envisaged their task not as a design problem, though work would have to be done at the drafting table, but as a search for a testing methodology into which instrument design would be integrated. The complete process from producing the instruments to conducting the test would have to be brought under strict control.

The FPL investigators fully understood the limitations to the conduct of laboratory metrology in an industrial environment (Gooday 2004). Their next step was an attempt to apply the tester to actual mill conditions so as to establish the suitability of the apparatus for control of production. Achieving standard conditions of consistency and temperature for each freeness test was simply out of the question. The amount of time required would be prohibitive for process control purposes. Instead, experimental work would have to derive a set of so-called correction curves to convert actual conditions of temperature and consistency to standard results. Thus, the operator would need only to know the actual conditions of the sample, which could be done relatively easily, and not spend time altering them to standard conditions. Rather, he would perform the test and read off the equivalent freeness under standard conditions from graphs or tables. The researchers did not in fact attempt to establish such curves, as any correction curves which they derived from a given experimental instrument would be applicable only to that instrument and any others calibrated from it. Instead, they restricted themselves to studying the effect of variation of temperature and consistency on freeness test results. The design objectives met, as stated in the final report of the Canadian Pulp and Paper Association's Sub-Committee on Standardization of Freeness Test, included "ease and accuracy of manipulation," "rigidity during testing," "ease of calibration," "sturdiness," and "ease and accuracy in quantity production."

By the autumn of 1924, a three-part device achieved these objectives. A frame supported shelves for the other two components. This helped to ensure rigidity during use, clearly of importance in an instrument allowing the controlled drainage of a fiber suspension. The second component, mounted on the upper part of the frame, was the drainage cylinder; this was a brass cylinder with a perforated plate through which the stock drained. The hinged bottom of the cylinder could be quickly released. Stock was introduced at the top of the drainage cylinder which featured a hinged lid carried on the frame and a stop (or pet) cock used when opening and closing the cylinder to prevent a build-up of pressure from affecting the flow of the stock. Mounted below the drainage cylinder was the third component, a drainage funnel into which the water which passed through the screen plate would fall and be caught. Within the funnel were an upward pointing cone, a large discharge tube from the side, and a small discharge tube at the bottom. (Image available at www.testingmachines.com/images/33-23-canadian-standard-freeness-testers.jpg).

The FPL staff knew that their task had by no means ended with the achievement of a successful design for an improved tester. Pulp and Paper Division engineers next worked out, in 1925, a calibration protocol to be applied to each production model. This calibration ensured that each tester was as near as practically identical in its performance to every other when shipped out. Crucially, the design of the tester also facilitated the recalibration of each device after a period of use. After every ten calibrations, the standard testing instrument used in calibration at the FPL would itself be checked against the Master standard, which was used only for this purpose and maintained with the highest possible degree of rigor. The FPL and its successor, the Pulp and Paper Research Institute of Canada (PAPRICAN), zealously maintained control over, and exacting standards in, the performance of this function.

In April of 1926, the FPL began discussions with the Committee on Groundwood Pulp of the U.S. based Technical Association of the Pulp and Paper Industry (TAPPI) with the aim of making the CSFT an American as well as a Canadian standard. The Committee recommended the CSFT, citing the "excellent piece of work" done by the FPL (Abrams 1927, 110). By the Second World War, 265 CSFTs had been calibrated and shipped to mills and laboratories in thirteen countries. The device had gained official recognition in the United Kingdom and Scandinavia in addition to North America (Cameron 1931). Over sixty years after its introduction the CSFT remains in use, with little modification, though it is finally being superseded by continuous freeness monitoring instruments.

Perhaps the most conclusive evidence of the importance of the tester comes from the standard CPPA/TAPPI textbook, *The Manufacture of Pulp and Paper*, edited by J. Newell Stephenson. The first, 1922, edition defined freeness and slowness qualitatively and used such adjectives as "greasy" or "slimy" to characterize slow stock. The third, 1937, edition simply stated, "freeness and its opposite slowness denotes the characteristic of pulps and stuffs that is measured with a freeness tester" (Volume 5, Section 5, 26-27). Truly had the World been transduced into Number (Carroll-Burke 2001).

The tester is an unprepossessing, unglamorous and arcane device. In general appearance it bears an unfortunate, if understandable, resemblance to an Edwardian bathroom fixture. The freeness tester is a hybrid type of Carroll-Burke's (2001, 602) epistemic engine, having something of the character of a meter, a boundary object drawing "phenomena over into the domain of mathematics"; a scope, framing a phenomenon and presenting it to our senses in a more understandable fashion; and a chamber, which captures and restrains physical phenomena that can be manipulated. But it is also firmly hegemonic, a means for one social group to gain consent for authoritative action from another social group. In this case, while partly used to allow engineers to have a dialogue amongst themselves (Hull 2005), it also acted as a means to assist those engineers to win control over workplaces in contention with skilled papermakers. As Shapiro (1997) points out, these standards were ways of controlling complexity and constraining choice. Slaton (2001a, 3) has discussed how technical standards acted to redistribute power away from skilled workers to laboratory engineers by bringing "a new understanding of what knowledge counted as authoritative on the building site, and what as retrograde and unreliable." Standards at the work site were part of engineers' exercise of ”intellectual authority” there, hand in hand with managerial authority. Standards ”precluded conflict altogether by bringing certain social groups into positions of unassailable intellectual authority” (Slaton 2001b, 79).

There is also an important spatial dimension to this activity. “Calibration and metrology networks serve to make facts and merchandise lose their local flavour” (Hessenbruch 2000, 416). Standardization of measurements was a means for an institution to reach out and exert control beyond its walls (Mallard 1998). Technical standards, resting fundamentally on precise instrumentational measurement, “not only ensured efficient technical operations but also instantiated a hierarchy of technical expertise in production contexts ... convey[ing] a particular distribution of labor from a centralized source ... to the dispersed sites of industrial production” (Slaton and Abbate 2001, 97). They were part of creating aspects of the world of the laboratory outside of the laboratory and “a means of mapping the universal onto the local” (Shapiro 1997, 293). Today, the Freeness Tester is part of an ISO standard which, ultimately, allows a single laboratory in suburban Montreal to measure locally and control globally.

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