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First and Last Things: The Signatures of Visualization-Artists

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Abstract

Nanotechnology began for real when Don Eigler and Erhard Schweizer used 35 xenon-atoms to spell the name of their sponsor "IBM." The resulting image has since been called "The Beginning" and, indeed, physical processes at the molecular level have since been used countless times to write the names of laboratories and sponsors and sometimes logos (including, of course, the White House and the American Flag). Indeed, when we conquer new territory, we tend to mark our presence and produce a souvenir of it by carving our name. But the first things we do may express our final purposes and thus already anticipate the last things we do. By signing their names as artists do, nanoscale researchers have claimed not only specific accomplishments but also their proximity to the arts – they are embarking on an explicitly creative project, namely to shape the world atom by atom in their own image.

Keywords: Molecular writing, Signatures, Names, Theoretical understanding and technical control, Willfulness

Аннотация

Нанотехнологии начались по-настоящему, когда Дон Эйглер и Эрхард Швейцер использовали 35 атомов ксенона, чтобы написать имя своего спонсора "IBM". Полученное изображение с тех пор было названо "Начало", и, действительно, физические процессы на молекулярном уровне с тех пор использовались бесчисленное количество раз для написания названий лабораторий и спонсоров, а иногда и логотипов (включая, конечно, Белый дом и американский Флаг). В самом деле, когда мы завоевываем новые территории, мы стремимся отметить свое присутствие и изготовить на память о нем свое имя. Но первое, что мы делаем, может выражать наши конечные цели и, таким образом, уже предвосхищать наши последующие поступки. Подписывая свои имена, как это делают художники, нано-исследователи заявляют не только о конкретных достижениях, но и о своей близости к искусству – они приступают к явно творческому проекту, а именно к формированию мира атом за атомом по своему собственному образу.

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I.

On February 23, 1778 Göttingen physicist Georg Christoph Lichtenberg reports in a letter a curious experiment he had conducted. Basis for the experiment was a recently discovered phenomenon, the so-called Lichtenberg Figures (Hamanaka, 2015). The figures result when dust is sprinkled on the site of an electric discharge into a resin cake. The dust does not distribute evenly but displays a fascinating branching pattern. Moreover, the patterns are significantly different for discharges of positive and negative electricity. Initially, therefore, Lichtenberg esteemed them for their theoretical significance, excepting that his discovery might turn out to be decisive for the ongoing dispute about the nature of electric charge and the number of electric fluids (the question of the dispute was whether positive and negative electric charge represent excess and lack of a single fluid, or whether it is the manifestation of two counteracting fluids).

Lichtenberg's expectation remained unfulfilled and his figures unexplained until well into the 20th century. This is not to say, however, that his figures remained inconsequential. Numerous trajectories lead into the present. Only one of these proved to be theoretically significant. Lichtenberg's discovery did not decide the dispute and yet made it go away: In order to recommend his discovery to the warring parties, Lichtenberg introduced the formal notation of "+E" and "-E" either to indicate excess and lack of charge or as names for the two electric fluids. The availability of this neutral terminology allowed theorists and experiments to keep working without settling the issue (Nordmann, 1999, 2003).

With the theoretical potential of his discovery quickly exhausted, what remained was the fascination with the phenomenon and the question of its technical possibilities. This fascination owes on the one hand to the aesthetic appearance of the figures and that is often how they are discussed – as a boundary object, even trading zone between physics and aesthetics (for example, Kliche, 2003). Ultimately, the source of the fascination lies deeper. Martin Kemp identified it as follows:

> There is something compelling about a phenomenon that can inscribe itself, drawing its own diagram through the direct visual recording of traces of its activity. We are familiar with these kinds of traces in the cloud and bubble chambers of atomic science, but the idea that the unseen forces of nature might reveal their actions through visible traces has a much longer history. Acoustics was probably the first field to visualize

[1] This paper dates back to (Nordmann 2006a) and its companion piece (Nordmann 2006b). It thus originated under the impression of the overblown claims and expectations that were made in its early years on behalf of nanotechnology. This is not to say, however, that the paper lost its significance. Not only did the overblown claims of nanotechnology prepare the ground for a transformation of research culture which calls for a philosophy of technoscience - to which this paper makes a contribution. Furthermore, the practice described here can also be found among designers of computer chips. It is currently rampant in genetic engineering and synthetic biology with researchers encoding texts in genes. Most famously, perhaps, when Craig Venter created the „first synthetic life form“ he encoded in it a quote by Richard Feynman which is a credo of technoscience: „What I cannot create, I do not understand“ (Ewalt, 2011).

> such forces. As early as 1680, Robert Hooke studied wave formations in flour on glass plates agitated by a violin bow. This began a tradition of materializing sound that passed via Ernst Chladni in 1787 and Hermann von Helmholtz to modern oscilloscopes. But nowhere were the results of direct transcription more spectacular than in the new science of electricity in the late eighteenth century. Working at the University of Göttingen, Germany, as professor of physics, Georg Christoph Lichtenberg stumbled across the explosively beautiful dendritic structures of electrical discharge that still bear his name. (Kemp, 2005)

The "direct transcription" of the Lichtenberg figures differs from bubble chambers on the one hand, from Chladni's acoustic figures on the other hand in that the observer does not witness how a physical process produces a trace but, instead, how the already inscribed, now static trace of the process is made visible by the dust which yields a permanently fixed image. Indeed, one can make a print of the Lichtenberg figures by lifting them off with an appropriately treated sheet of paper. And even after it has been removed, new dust can be sprinkled on the resin again and the same pattern will emerge. Especially Adolf Traugott von Gersdorf saw in this a new technique for printing and Chester Carlson, the inventor of xerography cited the Lichtenberg figures as a precursor (see Baird and Nordmann, 1994; Carlson, 1965; Herrmann, 2016).

Lichtenberg himself had nothing to do with and apparently no interest in such technical applications. And yet, though he insisted that these phenomena do not belong to the class of electrical amusements but allow the study of the nature and motion of electrical fluids (Lichtenberg, 1779), instead of studying the motion of electrical fluids he ended up with a focus on expanding his capacity to control that motion. He reported a particular achievement of control in that letter of February 1778. He tells of a fairly large lecture and how he became emboldened by his own capacity to spite the humidity in the room and succeed with the majority of experiments.

> When I said that I would now write in a single motion a GR that even Franklin would respect, you should have seen how everyone was rooting for me, and when I succeeded without a glitch, some applauded in amazement. (Lichtenberg, 1983, no. 450, compare the letter of March 15)

During a time when the great electrician and American revolutionary Benjamin Franklin was disrespectful of Georgius Rex or George III of England, the Göttingen professor, British subject, and teacher of GR's sons wrote the initials of his king and employer in a manner that even Franklin would respect.[2] He wrote this by spraying electrical charge from a modified Leyden Jar directly onto the resin cake (alternatively, the discharge could be guided along a metal chain or into a cookie-cutter form that was sitting on the cake). To be sure, this was by no means the only name that Lichtenberg wrote, but it is the one that was included on the plate "Lichtenberg Figures" of the *Encyclopedia Britannica* (Beuermann, 1992, p. 352).

II.

[2] Göttingen belonged to Hannover and George III was one of the British kings from the "House of Hannover."

If there were a general motto that would at once account for and justify Lichtenberg's approach that saw him writing the name of his king, it would be one of Lichtenberg's own aphorisms: "One has to make something new in order to see something new (*Man muss etwas Neues machen, um etwas Neues zu sehen*)" (Lichtenberg, 1973/1975, SB 2, J 1770). Arguing for Lichtenberg's continued relevance for modern science, the physicist Peter Brix noted in 1992:

> Also the nobel-laureates for physics in 1986, Gerd Binnig and Heinrich Rohrer, have "made something new to see something new": With their scanning-tunneling microscope (as small as a matchbox) one can see single atoms on the surface of solid bodies and now one can even re-position them. (Brix, 1992, p. 404)

Brix is here referring to an accomplishment that, once again, consisted in writing the name of one's employer instead of announcing a hypothesis or testing a theory. In 1990, Don Eigler and Erhard Schweizer had reported that they had used "the STM at low temperatures (4K) to position individual xenon atoms on a single-crystal nickel surface with atomic precision" (1990). To demonstrate their achievement of control, they famously used the individual xenon atoms to spell the letters "IBM." An explanation for this choice was offered on the website of Eigler and Schweizer's laboratory:

> Artists have almost always needed the support of patrons (scientists too!). Here, the artist, shortly after discovering how to move atoms with the STM, found a way to give something back to the corporation which gave him a job when he needed one and provided him with the tools he needed in order to be successful.[3]

Whether or not this is really why Eigler and Schweizer (1990) chose to spell "IBM," it includes a telling rhetorical move: Scientists are like artists in that they need the support of patrons, but the accomplishment of writing with atoms is that of an artist. At this point, an even more telling twist came in: In IBM's web-gallery of STM-images, the writing of „IBM" appeared as an artwork on the virtual wall, and the title of that artwork was "The Beginning." However, artisans and artists sign their names to a work (or write a dedication to their patrons) only when that work is done. So perhaps this signature to IBM's accomplishment marks a beginning that is already a kind of end, for example, a proof of concept that heralds the fulfillment of the technoscientific promise of nanotechnology.

Indeed, that is how this "Beginning" has been read from the beginning – as proof that atoms can be moved at will. Some, including Eric Drexler himself, took this to mean that the realization of the outlandish Drexlerian vision of „molecular assemblers" was from now on only a matter of time (Baird and Shew, 2004, p. 153). All you could hope for from nanotechnology appeared to be manifested by the achievement of control that consisted in doing something as arbitrary as writing in atomic or molecular fashion one's name or the name of one's lab. On the one hand, this supposition was confirmed by nanotechnological practice and rhetoric which produced countless ways of writing a name

[3] This website no longer exists: www.almaden.ibm.com/vis/stm/gallery. Some of it - though not the STM gallery or this quote - was archived at www.ibm.com/ibm/history/exhibits/vintage/vintage_technology.html, compare (Nordmann and Bylieva, 2021).

or drawing a picture.[4] On the other hand, this supposition is denied by most researchers, including Don Eigler himself, especially when it was said to include Drexler‘s incredible vision (Hennig, 2004). For obviously, "nudging along an atom that skates on the surface without any propensity to engage with the substrate is comparatively easy; picking up a chemically active atom and placing it somewhere in a huge chemically active three-dimensional molecule is completely different" (Hessenbruch, 2004, p. 141). The impasse between simultaneous confirmation and denial shows that Eigler's "Beginning" became burdened by an excess of meaning when it was declared to herald the fulfillment of nanotechnology's promise.

III.

While this reading and the associated impasse is familiar enough, there is a more interesting, perhaps deeper sense in which the auspicious beginning of writing one‘s name gestures at the purpose or end of controlling the world at the nanoscale. It emerges from a consideration of instrument makers and experimentalists as a craft elite that has a long tradition of demonstrating precision by writing in ever smaller print (Ditzen, 2005). In this tradition, the willful virtuosity of the artist is the ultimate proof of the achievement of technical control. Indeed, as Cyrus Mody (2004) has pointed out,

> [a]s artisans, some positioned themselves as a craft elite within the probe microscopy community. Through spectacular images (such as Eigler’s atomic corrals), they generate much of the publicity [and] take on leadership roles. (p. 128)

A more detailed reconstruction would consider the signature as a "boundary practice" between art and science. The painter and the nanotechnological visualization artist share with artists like Albrecht Dürer, Marcel Duchamp, and Ben Vautier the ambition to write their name as no one has ever written their name before. When Duchamp signs a found object, he does not thereby claim that he is the author or creator of that object, but he does claim authorship of his putting his name just there, of claiming that object for art (Dörstel, 2001, p. 311). His signature seals an act of appropriation – and this holds clearly for the territorial ambitions of those who claim the nanocosm (Nordmann, 2004).

Further dimensions of meaning can only be suggested here (compare Nordmann, 2006a):

1) as in art, so in the visualization practice of nanotechnology, the signature represents the unmistakable originality of a way of doing things;

2) it signifies a proprietary claim to intellectual ownership as does the signature on a deed that certifies ownership of land or privilege of trade;

3) it marks a moment of closure within the fluidity of the creative process;

4) it serves as a trace of personal presence; not unlike a photograph of herself that a tourist brings home from an exotic destination, the signature is testimony of an achievement on a canvas, at the nanoscale or some other exploration;

5) to the extent that names are purely conventional and that writing them is an arbitrary expression of a willful personality, the signature asserts human freedom as

[4] For another example of this - using atoms to produce the Japanese sign for „atom“ - see Nordmann and Bylieva (2021).

against the determination inherent in the mere expression of nature and the unfolding of natural processes;

6) like scratching one's name in the bark of a tree, the signature represents an original or archaic act that precedes and, as it were, announces the achievement of further, perhaps more differentiated competencies, and finally of cultivating what has been claimed in the original act of appropriation - the signature is a promise to oneself and to others of what is to come;

7) the signature shares with all writing a combinatorial capacity, it is composed of elements that constitute a significant whole; the person who produces a sentence knows how to combine signs just as the person who produces a machine knows how to combine gears and levers (Hamilton, 2001, Nordmann, 2020); this combinatorial capacity is imposed on the material as it is in supramolecular "designs" of chains, baskets, rotors: compositional elements are physically and chemically inscribed into nature (Schummer, 2005);

8) finally, the signature is a sign of the artist; by signing their names or the names of their laboratories, nanoscale researchers explicitly claim for themselves that they are creatively shaping the world.

IV.

By arriving thus at the proximity not of science and art but of the nanoscale researcher or genetic engineer and the artist, it becomes possible to diagnose the technoscientific conceit of nanotechnology or synthetic biology, namely the conceit to recreate the world in our own image. In particular, it allows us to better understand the historical transformations that led from the Lichtenberg Figures to the IBM-logo. Of course, one conceptual bridge between 18th century electrophore and 1980s STM was already mentioned above. It consisted in Lichtenberg's motto that "we must make something new before we can see something new."

The program, if not the practice of nanotechnology is often traced to Richard Feynman's visionary call that we must make new microscopes in order to see and explore that there is "plenty of room at the bottom":

> [T]here is a device on the market, they tell me, by which you can write the Lord's Prayer on the head of a pin. But that's nothing; that's the most primitive, halting step in the direction I intend to discuss. [...] *Why cannot we write the entire 24 volumes of the Encyclopedia Brittanica on the head of a pin?* (Feynman, 1960, p. 22; compare Ditzen, 2005)

In the same year as Feynman articulated the physicist's vision of miniaturization down to the nanoscale by mechanical means, the chemist Arthur von Hippel published *Molecular Science and Molecular Engineering* (Hippel, 1959) which was followed, in 1965, by *The Molecular Designing of Materials and Devices* (Hippel, 1965). Von Hippel is only one among several scientists who are not normally recognized as "founding fathers" of nanotechnology even though his program and influence clearly entitles him to the claim. In his autobiography, he accounts for the creation at MIT in 1956 of a "Summer Session Course on Molecular Engineering":

> When I first started my investigations of cathodic sputtering and electrical breakdown in gases, liquids and solids, the formation and properties of materials were generally

described by thermodynamic-statistical approaches and by the phase diagrams of physical chemistry. The data were tabulated and accepted as prescribed by nature. Now, we asked more and more insistently how and why these phenomena happen and how they could be influenced by molecular changes. (Hippel, 2000, p. 10)

While this insistent questioning " ranged from the formation and structure of atoms and molecules through the designing of liquids and solids, including their electric and magnetic properties, explosions and breakdown to the air vehicles of the future," it had begun with "investigations of cathodic sputtering and electrical breakdown in gases, liquids and solids" and thus with Lichtenberg Figures (Merrill and Hippel, 1939):

Lightning recorded as Lichtenberg figures transforms terror into enchantment. The genesis of complex phenomena unfolds in beautiful designs studied by scientists in puzzled contemplation.[5] In these images, electronic excitation and ionization, the release of charge carriers from surfaces and gases, their cumulative action and re-absorption, the effects of space charges and of field distortion all can be studied in detail. And, in principle, the way is open to extend these studies from gases to liquids and solids. (Hippel, 1982, p. 6)

According to von Hippel, the war interrupted his work on Lichtenberg figures "with its urgent demands" and thus left him "with many beautiful pictures still on hand that might be enjoyed by the lay person as 'art in science'" (Hippel, 1982, p. 2). But after the war, von Hippel‘s work would take on a new purpose. He would no longer tabulate, record, or simply accept what is „prescribed by nature.“ He would now explore how he could influence the organization of matter by molecular changes and the design of electric properties. Hippel thus continued the work of transforming "terror into enchantment."[6]
The figure of the nanotechnologist as artist can be completed by researchers who self-consciously produce and market art-works. One of them is Harvard physicist Eric Heller who continues where Lichtenberg and von Hippel leave off.[7] A some-time collaborator of Don Eigler, Heller produced a branching pattern not at all unlike Lichtenberg figures when he launched 100,000 electrons in a computer simulation and followed their tracks across a sheet of charged atoms. The resulting image Electron IV graced the title page of scientific journals, numerous funding applications and promotional brochures for nanotechnology, they were for sale as archival and museum quality prints, and are still exhibited as artworks.[8] And the physical scientist and artist Eric Heller has gone on to study the history of phenomena that inscribe themselves, a study that has taken him back to Chladni and his acoustic waves.

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[5] Here, von Hippel refers to a woodcut by M.C. Escher which the artist contributed to (Hippel, 1965).
[6] The story goes on from here. In 2005, von Hippel’s son Eric published a book that expresses the technoscientific mindset, and one of his father's striking Lichtenberg Figures dramatically appears on the cover of *Democratizing Innovation* (von Hippel, 2005).
[7] For other examples see (Nordmann, 2006a) and (Nordmann, 2006b).
[8] https://ejheller.jalbum.net/

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