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Two examples of concretization

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This paper provides two examples of concretization, an important concept in philosophy of technology that can also be applied to the study of media more broadly construed. It begins with a short summary of the preexisting literature on concretization, followed by a survey of the uses of concretization in the work of its primary theorist, the French philosopher Gilbert Simondon. The paper proceeds with a brief analysis of a famous example of concretization offered by Simondon (the Guimbal turbine) before engaging a new analysis of concretization in the context of contemporary information and communication technologies (planar transistors). The argument is made that Simondon provided an early (and simple) philosophical explanation of concretization, one that is useful for tracking (analog and digital) technological evolution over time.

"Mechanology" was the preferred term for a field started by a group of thinkers in France who, inspired by early cybernetics, wanted to create a universal philosophy of technology. Their spiritual godfather was a man named Jacques Lafitte. Lafitte wrote a philosophical treatise on machines that included reflections on the great British polymath Charles Babbage and his landmark paper, "On a Method of Expressing by Signs the Actions of Machinery" (1826). On the topic of Babbage's difference engine – the famous calculating machine that Babbage (1826, p. 250) described as "for the purpose of calculating tables and impressing the results on plates of copper", a machine that would never be built in Babbage's own lifetime – Lafitte (1932, p. 26) wrote: "What is important to determine is less the very form of the organs than the sequence of the functions". In the same book, Lafitte included passages on the work of Robert Willis, Auguste Choisy, Eugène Viollet-le-Duc, and Franz Reuleaux, among others. This obscure little book on the "philosophy of the machine" as "an organized extension of ourselves" (Lafitte, 1932, p. xv) was published in 1932. Lafitte called it *Reflections on the Science of Machines*.

The French philosopher Gilbert Simondon was influenced by Lafitte's mechanology of functions, and the bulk of Simondon's work on Lafitte can be found in the posthumous publication *Invention in Technics* (2005), in two chapters titled "Passive Individualized Technical Objects (Or the Passive "Machines" of Lafitte)" (p. 170) and "Information Devices (Lafitte's "Reflexive Machines") (p. 221), as well as in a few other sporadic places. Simondon (1958), it can be said, attempted to further the "philosophy of the machine" proposed by Lafitte, arguing for a theory of "general technology". He would eventually introduce the concept of *concretization* into this philosophy, and it would become one of his most important and lasting philosophical contributions. In the present paper, I will start by offering a definition of concretization before glossing over a short summary of the preexisting literature. Then, I will conduct a brief analysis of one of Simondon's own examples of concretization (the Guimbal turbine) before offering one of my own (planar transistors).

The word "concretization" is generally used in regard to the evolution of technological artefacts. It is not concerned with concretization in terms of its common sense usage or etymological history, such as "to make" something "real", "tangible", or "specific". Nor is concretization meant to represent something like that which is implied by the sentence "the concretization of an abstraction". Rather, concretization is a useful concept for thinking technological artefacts and their evolution over time. It is offered as a concept that can be put to work in thinking about technological things. Concretization deals with the ontological engineering of technical artefacts and, as such, it is closely tied to reality and all of the minute technical details that researchers and philosophers use to confront it. In this sense, one could call concretization a type of "philosophical engineering". Gilles Deleuze and Félix Guattari (1994, p. 8) once said that philosophy is "the creation of concepts". Luciano Floridi (2011) has likewise stated that philosophy is a type of "conceptual engineering". It is with a similar idea in mind that that one should approach concretization. Concretization deals precisely with "the things themselves", that is, with what happens to the specific elements that make up technological artefacts over the course of their evolution.

Literature on concretization

Simondon's closest philosophical contemporaries included Raymond Ruyer (1954) – who, along with Simondon, also published on philosophy of information – and Gaston Bachelard, who worked predominantly on the philosophy of science (Simondon remained friends with both throughout his life, debating Ruyer in papers and conversing with Bachelard in letters). It is becoming well-known that Marshall McLuhan read French philosophy, particularly the work of Lafitte, Simondon, and Jacques Ellul; an English translation of Lafitte's text was carried out and published at the University of Western Ontario under the auspices of John Hart (founder of Computer Science at the University of Western Ontario in 1964) and Jean Le Moyne (a Canadian journalist and eventual senator), both of whom attempted to popularize mechanology in Canada via French philosophers (Hayward and Thibault, 2014; Thibault and Hayward, 2014). They began a translation of Simondon's *On the Mode of Existence of Technical Objects*, but the project stalled and was never finished. Back in France, Simondon would go on to influence a wide variety of philosophers and researchers, including, most famously, Gilles Deleuze, Bruno Latour, and Bernard Stiegler.

The secondary literature on Simondon and the concept of concretization is growing, mostly in France, with works by Muriel Combes (2013), Pascal Chabot (2012), Stiegler (1998), and Barthélemy (2005a; 2005b), the last of whom is regarded as the world's leading expert on Simondon, having founded *Cahiers Simondon* (2009, 2010, 2011, 2012, 2013, 2015), currently in its sixth volume and the Centre international des études simondoniennes. Barthélemy (2005a; 2005b; 2008; 2014) has written four books about Simondon's philosophy that provide very clear exegeses of his work and offer new, unique perspectives from which to read Simondon (quantum information and mechanics). While Combes' and Chabot's texts have been translated and published in English, the works of Barthélemy are yet to be so, which is unfortunate. Lastly, as for original English books on Simondon, Edinburgh University Press' edited collection *Gilbert Simondon: Being and Technology* (2012) is an excellent anthology and concretization is covered there in some detail. David Scott's *Gilbert Simondon's Psychic and Collective Individuation: A Critical Introduction and Guide* (2014), also published by Edinburgh, is a good introduction to that text.

Gilbert Simondon's concept of concretization

The concept of concretization is one of the most important notions in the philosophical system laid out by Simondon. His most thorough explication of it is found in chapter one ("The Genesis of the Technical Object: The Process of Concretization") of the first part ("The Genesis and Evolution of Technical Objects") of *On the Mode of Existence of Technical Objects* (1958a), the shorter of his two published doctoral dissertations.[1] There are areas where Simondon references "concrete" reality and "concreteness" in *Individuation in the Light of the Notions of Form and Information* (1958b), the larger of the two books, however Simondon offers a much deeper account of concretization proper in the shorter (though certainly no less complex) book. Along with Simondon's concepts of individuation, allagmatics, disparation, transduction, and the preindividual, concretization stands among his most technical and powerful. Like the others, it is a mediatory concept, meant to be applied to technological objects that are themselves, Simondon (1958a, p. 10) will tell us, "mediators between nature and man".

The first task should be to find a definition of concretization. Putting aside *On the Mode of Existence of Technical Objects* (hereafter METO) for a moment, Simondon discusses variations on the theme of concretization in other texts, including the posthumously published works that emerged as books containing papers from his courses and conferences. The benefit of beginning with these texts is that they generally do not contain substantive remarks on concretization and therefore, where concretization is mentioned, it is explained simply and clearly. Many of these titles have been released in France; however as of this writing none of them have appeared in English. These are *L'invention dans les techniques* (2005), *Cours sur la Perception* (2006), *Imagination et invention* (2008), *Communication et Information* (2010), *Sur la Technique* (2014), and *Sur la Psychologie* (2015).

[1] Hereafter, all references to Simondon's work are my own translations from the original French.

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Simondon mentions concretization by name in some of the posthumous publications and not in others. For example, in *Course on Perception* (2006), a book based on a seminar on phenomenology that Simondon gave during the school year 1964-1965, he spends some time talking about concrete reality and concreteness, as in the larger dissertation book, but he does not engage concretization proper. On the other hand, in *Imagination and Invention* (2008), another collection of papers that have been published in France from a seminar on innovation that Simondon gave in 1965-1966, Simondon does reflect on concretization in a fashion that is similar to that found in METO (for more on Simondon and innovation, see Bontems 2014). Under the section "Invention as Production of a Created Object or Work", Simondon (2008, p. 163) references concretization in a chapter titled "The Creation of Technical Objects". Here he offers a simple definition, writing that concretization concerns the iterations that technological objects go through as they evolve. Iterations, Simondon (2008, p. 171) says, often contain an invention that "provides a wave of condensation, of concretizations that simplify the object by loading each structure with a plurality of functions". Concretization, then, is when an element in a new iteration of a technological object has been endowed with a greater "plurality of functions". It simplifies the object by assigning a plurality of roles to the elements. Following this, the total amount of elements tends to decrease. As a particular element fills another element's role, that element may fall to the wayside.

Simondon (2008, p. 171) writes that concretization can not only preserve the "old" functions of technological objects, but that concretization brings, "in addition new properties of additional functions" which he calls, importantly, "overabundant functions". A technological object is charged with overabundant functions when it concretizes; each individual element fulfils additional functions that increase while the total amount of elements decrease, leading to a deceivingly complex yet "simple" object. These overabundant functions constitute "the class of a true advent of possibilities in addition to the expected properties of the object" (Simondon, 2008, p. 171). A new iteration of the technological object offers a concretization of overabundant functions that can be the source for new technological possibilities. The technological object becomes (oddly) less complex, particularly in regard to its quantity of physical elements, as it develops. In offering a general definition of concretization, Simondon (1958a, p. 31) says that "each structural element" may fulfil "several functions instead of only one".

It is important to understand that not all iterations of a technological object qualify as examples of concretization. For concretization to occur there must be some way by which the object has reduced the number of component elements while at the same time assigning one or more of the existing elements an overabundant functionality. The technological object must become more self-sufficient, relying less and less on "extra" parts: what Simondon (1958a, p. 25) will refer to as "analytic" components. A genuinely new iteration will seek external support in its "milieu" (Simondon, 1958a, p. 21), effectively "offloading" the burden of functions to its environment so that the object does not need to maintain a high amount of functions. The milieu stands for the surrounding environment and can mean something as simple as water or air. As it concretizes, the technological object may use its milieu. At the same time, a "minor" improvement (to use Simondon's term) is not an instance of concretization. He mentions the invention of the rotating anode for the Coolidge tube as an instance where concretization does not occur (Simondon, 1958a, p. 37). Rather, it lessens a disadvantage instead of converting it into a "positive" function for the whole object. Minor improvements are only "detours" that, while sometimes practical and helpful, do not "promote the evolution of the technical object" (Simondon, 1958a, pp. 39-40). In ignoring the schematics of technics by installing what Simondon (1958a, p. 40) calls "palliative measures", minor improvements provide a "false understanding" of the evolution of technical objects. What Simondon is describing here are basically "quick fix" solutions. They may work in the short run, but in the long term they do not provide an overabundant functionality.

Simondon (1958a, pp. 45-46) offers the evolution of the tetrode and pentode as an example of proper concretization, contending that they result from the evolution of the original diode system through "saturation and synergetic concretization". With the tetrode and the pentode, concretization concerns schemes of technology and organization of invention so that iterations of the technological object lead to unity and the discovery of what Simondon (1958a, p. 40) calls "the distinction of a technical lineage" that is almost natural. What is more, this lineage is provided to us in a mediatory and intermediary way in that the natural world and the world of technics are already engaged in an interrelated concretization that is defined by a relational function (Simondon, 1958a, p. 52). Simondon (1958a, p. 55) invents the word "techno-geography" to describe this relation. Concretization operates in a type of middle-zone between nature and technics.

Simondon warns us that a concretized technological object sits in an "intermediate place" between natural objects and scientific representation: given the technical object cannot be fully concretized, it can never become fully natural. The "artificialization" of a natural object is not an example of concretization, since such a process would need additional analytical functions to thrive. In the concretization of the technological object, however, the originally artificial object becomes more and more natural. Yet, one must always be careful to remember that there is a division between the milieu (nature) and technics (concretization). Although Simondon (2008, p. 175) goes so far as to say that nature is recreated in technics – that he sees nature as necessitating formalization and concretization in the world of technology – he is careful to observe that nature is already completely concretized while technological objects can never be so. All technological objects can do is continue to concretize as their components give way to overabundant functions. He notes that in English the word "versatility" is used to describe something like the process of concretization (Simondon, 2008, p. 177), and that concretization deals with "raising the level of internal compatibility to produce external adaptability". This is one of Simondon's most beautiful and helpful phrases: in its quest to concretize, the technological object *increases internal compatibility to produce external adaptability*.

Elsewhere, Simondon will refer to the process of concretization as "internal resonance". In *Invention in Technics* (2005, p. 85), he states that technological evolution is "made possible by internal resonance, the concretization, the multi-functional overdetermination that is the auto-correlation of various components". He often uses other terms; Simondon also describes concretization as "synthesis" or "*tetrium quid*" (a term associated with alchemy), this *tetrium quid* meaning a type of third additional "thing" that is unclear but which is connected to two others that are clear or known. The synthesis of these known elements produces the third and "raises the level of organization" (Simondon, 2005, p. 164), offering yet another formulation for describing concretization. In a paper on Lafitte, Simondon (2005, p. 169) describes concretization as "functional condensations for synergies".

"Synergy" is repeated often in METO; in concretization the technical object progresses by an "interior redistribution of functions" that is not done "function by function" but "synergy by synergy" (Simondon, 1958a, p. 34). Simondon believes that it is the synthesis of functions and not the functions themselves that matter. It is through this synergy that concretization can "result in an aspect of simplification" where a single "function can be performed by a number of synergistically related structures" (Simondon, 1958a, p. 34). Concretization concerns the organization of what Simondon refers to as the "subassemblies" of the technical object into synergistic units that contribute to the total functioning of the object, rather than contributing a single unique function. In concretization, "marginal aspects" become incorporated into the "functioning scheme" (Simondon, 1958a, p. 35): the elements that at first might have seemed unusable are turned into "functional links". Although each of the definitions that Simondon provides is slightly different, they maintain enough commonality such that the essence of concretization should remain clear. There is a list of helpful concepts to think through the concept of concretization in Simondon: overabundant functions, internal compatibility, external adaptability, internal resonance, *tetrium quid*, synergy, overdetermination, and so on. However, in order to understand concretization, there is another important concept that must be explained, and that is Simondon's concept of "technical essence".

Technical essence

Ostensibly a book about technology, Simondon (1958a, p. 26) states quite explicitly in METO that he is rather unconcerned with the material technical object *qua* object, and that he is instead interested in the *essence* of the technical object, its evolution. "Essence" is a curious word to use in a book about the philosophy of technology, but it is fitting when one understands precisely what Simondon means by it. For Simondon (1958a, p. 48), essence in technology is a certain type of mode or operation and not a type of unchanging universal quality, writing that what "alone count are exchanges of energy and information in the technical object or between the technical object and its milieu". Indeed, "the essence of the concretization of the technical object" is described as the "organization of functional subsets within the

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total operation" (Simondon, 1958a, p. 34). For Simondon, the technical object exists as a type of shell, something that "envelops" (Floridi, 2014) the informational essence or interacts with the essence of another informational milieu. There is a whole line of philosophy in Simondon on the invention and creation of such essences (Simondon, 2005; 2008), and one of his first examples is given at the beginning of METO. In the section titled "Absolute Origins of a Technical Lineage" (1958a, pp. 41-42), he describes the invention of the diode as one such beginning:

> [t]he diode is made from the association of this reversible phenomenon of the transport of electric currents through a field and the irreversibility created by the fact that the production of transportable electric currents is the production of a single kind of electric charge (negative only) and by one of two electrodes, the hot electrode; the diode is a vacuum tube in which there are hot and cold electrodes, between which an electric field is created. Here surely we have an *absolute beginning*, residing in the association of this condition of electrode irreversibility and in the phenomenon of the transport of electric currents across a vacuum: *technical essence* has been created.

Technology begins with a single act of invention that belongs to the order of information or energy and not technical objects as such (this is why Simondon has little patience for those who are concerned with what he calls the "minor" improvements of technical objects). METO concerns itself with the evolution of technical objects that begin each of their series with "a defined act of invention […] what was necessary was a new phenomenon" (Simondon, 1958a, p. 43). He writes that the "beginning of a lineage of technical objects is marked by a synthetic act of invention that is basic to a *technical essence*". This essence stays with the technological object throughout its evolution; "Technical essence can be recognized by the fact that it remains stable throughout the evolutionary lineage, and not only stable, but also producing structures and functions through internal development and progressive saturation" (Simondon, 1958a, p. 43). Simondon (1958a, p. 44) uses the example of the internal combustion engine and claims that its technical essence allowed for it to become, eventually, a diesel engine; it did so by "a supplementary concretization of functioning". This, again, is what Simondon (1958a, p. 20) means by "internal resonance" of the technical object; the technical object "evolves by convergence and by adaptation to itself; it is unified from within according to a principle of internal resonance". A connecting of milieus begins the moment of technological evolution, and this original convergence lasts as newer ones develop. Now, let us move on to some examples of concretization. The first is a famous example that Simondon references throughout his work (the Guimbal Turbine), while the second is a new example to explain how concretization can be applied to the study of digital technologies.

Jean-Claude Guimbal's turbine

Simondon often uses the example of the Guimbal turbine to describe concretization. The engineer and inventor Jean-Claude Guimbal was born in Simondon's hometown of Saint-Étienne. Saint-Étienne has historically been an industrial centre that once produced arms, coal, and bicycles. These industrious surroundings may have influenced Simonton's thinking, and his choice of the Guimbal turbine was almost certainly a reflection of his upbringing in Saint-Étienne (a city once named the "city of design" by UNESCO). Simondon (1958a, p. 72) even mentions his hometown in METO, referring to "the quality of Saint-Étienne steels".

Guimbal issued a patent for his turbine in 1953. In it, he outlined the distinctive characterizes of his design, which included up to then unprecedented techniques for turbine manufacture. In his original patent for the turbine, Guimbal (1953, p. 4) includes four main objectives:

> [i]n a unit constructed in accordance with the present invention the turbine and generator are built together as a single unit for installation under water. The unit is preferably constructed for installation at the throat of a convergent-divergent conduit which conveys water to and conducts it from the turbine unit. An object of the invention is to provide a turbine and generator unit of the type described in which the space required is reduced to a minimum. Another object is to provide, in a turbine unit of the type described, improved means for preventing leakage of water into the unit. A further object

> of the invention is to provide, in a unit of the type described, improved apparatus for cooling and for lubricating the unit. A further object is to construct a unit of the type described which may be installed with its principal shaft either horizontal, vertical or at any oblique angle.

As noted by commentators such as Brian Massumi (De Boever et al. 2012, p. 23-24), Simondon references such a Guimbal turbine in an essay titled "Technical Mentality" (the original can be found in the collection *Sur la Technique*, 2014, p. 301, while a translation can be found in De Boever et al. 2012, p. 1), but once again his most insightful observations are made in METO. In METO, Simondon (1958a, pp. 54-55, 57) writes that the Guimbal turbine can be seen as a paradigmatic example of concretization, and the amount of technical knowledge that Simondon displays here is impressive. He states that the genius of Guimbal's concretization is in placing the turbine into the penstock (a sort of intake tunnel or pipe that controls the flow of water), thus submerging it in water, as well as in connecting the turbine to a generator contained in a crankcase (housing for a crankshaft) filled with pressurized oil. Given this, Simondon (1958a, p. 54) notes that the dam contains everything in the penstock and that both the water and the oil become "multifunctional". First, the water becomes multifunctional by supplying the energy that activates the turbine and the generator. Second, it serves another function by evacuating the heat that is produced by the generator. Next, Simondon notes that the oil becomes multifunctional in four ways. First, it lubricates the generator. Second, it insulates the coil. Third, it conducts heat from the coil to the crank case. Fourth, it prevents the seepage of water into the crankcase, since the pressure of the oil is greater than that of the water. Simondon also notes that the pressure itself is multifunctional, since it causes permanent greasing under pressure and thus prevents seepage. All paradigmatic examples, Simondon says, of multifunctionality in concretization.

Before Guimbal's invention, argues Simondon, no one would have dreamt of placing the generator under water since, regardless of seepage problems, generators were unusually large at that time. However, it is due to Guimbal's genius in realizing that the turbine could be cooled in water that this concretization could occur, since it is by virtue of the automatic water cooling that the turbine could be built much smaller (becoming a technological object interacting with its milieu to achieve the next iteration in its evolution). Simondon (1958a, p. 55) goes on to suggest a weird sort of technological reverse-causality given that the turbine could not even be submerged if it were not for the fact that water produced cooling. This same invention would be perfectly impossible if it were set in the air, he notes. It is the milieu of the water that is necessary for the concretization to occur.

Building on this, Simondon ends METO's section on the Guimbal turbine with a highly insightful passage. He stresses that concretization is determined in the case of the turbine according to "an invention *which assumes that the problem is solved*" (Simondon, 1958a, p. 55). The concretization of the turbine was only possible due to the conditions that were established by the concretization itself. He says that the "act of adaptation" is not only established with predetermined milieus but that "adaptation-concretization" is a process that itself can *cause* the birth of a milieu (Simondon, 1958a, p. 55). Adaptation-concretization is caused by a milieu, according to Simondon (1958a, p. 55, my emphasis), that "had merely *virtual* existence" before the invention. The invention occurs due to a "jump" that the invention makes possible due to the appearance of a new "techno-geographic" milieu that is its condition. Simondon (1958a, p. 55) writes: "*Therefore, the technical object is the condition of itself as a condition for the existence of this mixed milieu,* which is at once technical and geographical". The invention of the technological object in a sense retroactively "invents" its new milieu.

Jean Hoerni's "dirty" planar transistors

The idea that a technological object can retroactively necessitate its own milieu, one that is capable of finalizing the technological object's "jump" to the next stage of its evolutionary iteration, can be explained by looking at the evolution of transistors. While Simondon provided examples of concretization from his own time (largely analog technologies such as the lever or the engine), little work has applied Simondon's theory of concretization to specific, contemporary information and communication technologies (ICTs) – Mills (2011), Hui (2015), and Bontems (2009) being three exceptions. Concretization is valuable for

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describing the evolution of ICTs in the same way that it is useful in analysing the development of analog technologies.

In the past, transistors had to be kept absolutely clean and scrubbed of dirt or excess particles that may have appeared during construction, but this would soon change. Jean Hoerni was one of the "traitorous eight" who left the Shockley Semiconductor Laboratory to form Fairchild Semiconductor in 1957. Hoerni was responsible for elaborating "a radically new kind of transistor: a more compact, flatter device whose sensitive parts were protected beneath a thin layer of silicon dioxide" (Riorden, 2007, p. 1). This was in part due to the fact that Hoerni utilized the multiple layers of silicon oxide growth leftover from the construction of the transistor that often formed on the silicon itself, usually a nuisance. The oxide growth, Hoerni discovered, was not simply a dirty, natural excess to be wiped off. It could be used for insulation. After Hoerni's discovery, engineers could "begin printing transistors on silicon. Planar transistors would prove to be much more reliable and perform far better than other designs" (Riorden 2007, p. 1). The dioxide that was naturally produced during the construction process could actually be used and harnessed as a type of insulator, contrary to widespread belief. As such, the "dirty" planar transistor is an even more interesting case of concretization than the one found in the Guimbal turbine. Where the turbine removed an element and used the milieu of the water to concretize, the transistor here does not even add a milieu in that it simply utilizes an excess element contained in itself to cause the next iteration of its evolution, something that is closer to Simondon's technological essence. The planar transistor's "dirty" excess was put to use.

To fully grasp what it was like to keep a traditionally clean piece of electronic equipment *dirty*, one must understand just how counterintuitive it was. Christophe Lécuyer and David C. Brock (2010, p. 29) write, in their masterful book on the history of the Fairchild semiconductor, that Hoerni

> would leave the oxide on top of the silicon wafer and open small windows in it to create transistor contacts. […] the idea of leaving the oxide layer on top of the wafer after multiple diffusion processes went, like gold doping, against all accepted knowledge in the semiconductor community. Semiconductor engineers and scientists considered the oxide layer that had served as a mask for diffusions to be "dirty"—that is, full of contaminants that would impair the electrical characteristics of the transistor. This idea of the "dirty" oxide seems to have originated at Bell Labs in 1955 and then spread rapidly to the entire community of semiconductor scientists and engineers. By the time Hoerni jotted down his ideas on the planar process in his patent notebook, it was widely accepted that the oxide layer that had been exposed to diffusions had to be stripped off and replaced by a "clean" re-grown oxide.

The dirty oxide allowed for better transistor insulation and a leap forward in transistor innovation by virtue of the introduction of an "internal" element to the transistor. In this way, one might say that the technological essence found in the invention of the transistor is located in this process, since it follows an internal path of resolution over additive or palliative measures. The dirty planar transistor, as a paradigmatic example of concretization, shows that such moments in the history of technology may be instructive for thinking about technological evolution today, and may offer a glimpse into the types of internal, multifunctional iterations and innovations that should be sought in technological research and development over external additives.

The concretization of artefacts

Contrary to much of the current literature on concretization that focuses on its metaphysical underpinnings, concretization is much more than metaphysics of technology; it has the potential to think the technological object from speculative and analytic perspectives. Marc de Vries (2007, p. 1) suggests that it would be valuable to revisit some of the early philosophers of technology such as Simondon, who "published ideas that were not yet followed up because they were too analytically-oriented to be recognized as interesting in an era in which the overall approach in the philosophy of technology was still Continentally-dominated".

It is true that Simondon's philosophy can be re-examined in light of the current growth of analytic philosophy of technology, particularly as practiced by the Dutch School and their strikingly similar "dual nature" approach (which views technological artefacts as at once physical and intentional). Vries (2007, p. 12) ends by stating that "the dual nature account of technical artefacts should be preferred over Simondon's more speculative account", before admitting that his work "does bear resemblance" to the dual nature account and seems to "fulfil the criteria for an ontology of technical artefacts". Now, while Vries contributes some insightful observations in his text, Simondon's philosophy still offers a very fruitful philosophical foundation for thinking about technology that attempts to go beyond such easy distinctions. Simondon (1958a, pp. 12, 87) states that "there is a human reality in technical reality" and that "human action" is "fixed and crystallized" in the "functioning structures" of technology. He attempts to go beyond the dualisms of "culture and technology" and "man and machine", searching instead for an "alien reality" (Simondon, 1958a, p. 9). He starts from the observation of our failure to understand the machine, yet he is not concerned with science fiction, nor is he concerned with inert matter only. Simondon's (1958a, p. 13) work attempts to start a new philosophy of technology and calls for a new figure: a philosophy on the "open plurality of technics", done by a technologist, or better yet, a *mechanologist*.

As has been well documented elsewhere, Simondon (1958a, p. 20) refers to his approach as a "genetic method" in that he is less interested with objects themselves (the "final product") then in the structures and functions of which they are comprised (Barthélémy 2008; Bontems 2009). He leaves aside "closed" automata (he says they are low degrees of technical perfection) and looks for the "margin of indeterminacy" (Simondon, 1958a, p. 30) in "open" technological objects that have the ability to interact with their environments. To begin thinking about this, he divides technical objects into his three famous types; elements, individuals, and ensembles. Roughly, elements are simple technical objects like hammers and cups, built by artisans. Individuals are machines, run mostly by thermodynamics (the industrial revolution). Lastly, ensembles are a product of the twentieth century and information theory, which replaces thermodynamics. It is with the latter that Simondon became primarily interested. But this is not to say that he was only interested in the abstract or the speculative. On the contrary, Simondon sought out and developed a highly analytical way to parse the distinctions between "abstract" and "concrete" technological objects.

One simple way to imagine what Simondon means by "abstract" and "concrete" is the following. Take an engine. In an abstract (older) engine, each element comes into play at a certain moment and does not contribute to the overall functioning of the machine and its other elements. Conversely, in a concrete (more modern) engine, the technical problem has to do more with the convergence of functions as a total structure. One of Simondon's favourite examples is the water-cooled engine and the air-cooled engine. In the former, the water acts as an additive element meant to solve the problem of cooling. It is "abstract" because it does not affect any of the other elements of the engine. An air-cooled engine, on the other hand, has the engine interacting with its environment. There is a convergence there that is not present in the water-cooled engine. The reason an older engine is "abstract" is that parts are literally added to increase functionality. Simondon describes this type of procedure as analytic. In this analytic technics, the object is additive, but it also becomes weaker, and this is the important point. It uses more material and work. It is simpler logically while complicated technically (Simondon, 1958a, p. 25). This is why Simondon (1958a, p. 33) emphasizes the stronger synergetic functions of a concretized technological object: those that are "performed by a number of synergistically associated structures". In the analytical object, each element is designed for a certain function and so the "chain" becomes weaker (Simondon, 1958a, p. 24). The analytical technical object adopts palliative measures to solve a problem, while in the concrete technological object the scheme incorporates everything. But this strength, at the same time, relies on and exploits a constitutive weakness in terms of knowledge of the universal structures of science.

There is always, Simondon tells us, a leftover margin of indeterminacy between the schema of the technical object and the universal schemas of science, and it is the "narrowing of the gap" between these two that motivates the process of concretization. The difference "resides only in the imperfection of science", and to this end, "the technical object is never completely known" (Simodnon, 1958a, p. 35). For this reason, the object is never completely concrete. The question of bridging the gap between science and technics then assumes two kinds of improvement. Those that "modify the division of functions", increasing the "synergy of functioning", and those that, without modifying the division in question,

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"diminish the harmful consequences of residual antagonisms" (Simondon, 1958a, p. 38). These Simondon calls "major" and "minor" improvements, and one quickly understands that major improvements are to be preferred, since minor improvements are potentially harmful to the technological object in the long run. They hide the true imperfection of a technological artefact by using "non-essential devices, incompletely integrated into the functioning of the whole, to compensate for real antagonisms; the dangers attendant on abstraction are evident anew in the case of minor improvements" (Simondon, 1958a, p. 37). Technological evolution, in this sense, does not appear in minor improvements of functioning at all. Only "discontinuous improvements" bring about "modifications in the internal scheme of the technical object" (Simondon, 1958a, p. 13) which can then constitute an instance of technological evolution.

If one considers technological artefacts from the point of concretization, then, one may better see each artefact in light of a technical object's virtual schemes. These leave open a space for contemplation of technical evolution as well as space for other considerations, such as safety. In following concretization – that is, in tracing the schematic evolution of technological objects via their iterations – one becomes attuned to the technological object's objectively defined and schematic necessity rather than to a wilfully imposed human abstraction. In this way, Simondon calls for a new *technological humanism*, one that saw the human in the machine. In an interview from 1983 titled "Save the Technical Object" (2014, p. 454), he invokes the myth of Prometheus: "I think, to me, the technical object has multiple values. It is primarily something that comes from a very old activity of man, and which has probably pulled us away from barbarity". For Simondon, technology is the pathway to civilization. Concretization, then, is one way of following that path.

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