French Philosophy of Technology

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1 A Short History

Is there, actually, a French philosophy of technology? If the answer may be "yes", we can point out that such a philosophy does not have a clear beginning. Of course we must go back to René Descartes (1596–1650) to find the first formulation of such a thought and the earliest idea that technology and applied sciences are essentially tools to understand and master the world. This matrix of all the later optimistic visions of science appears in the most famous work of the father of rationalism, *Le discours de la méthode* (part VI), when Descartes explains that, thanks to technology, man may become like master and owner of all of nature.[1] In the same way, we read in *Les principes de la philosophie*, another anthology piece saying that science is a tree, the roots of which are metaphysics, the trunk is physics, and the different branches are the three applied sciences known at the time (mechanics, medicine and morals).[2] These ideas are very significant in the context of the period, when the increase of population, the expansion of cities and towns, and a confident faith in the new Galilean physics made things looked rather hopeful. Friend of Villebressieu,[3] a prolific engineer who made numerous inventions, spent his fortune building them and finally ruined himself, Descartes was an expert in technology, especially lifting devices, about which he wrote a notice enclosed with a letter to Huyghens:[4] "The explanation of machines with the help of which a small force can move heavy weights".[5] But his knowledge of basic machines (pulley, screw, whee or wheel, lever, inclined plane) does not make of Descartes a real philosopher of technology. As Blaise Pascal (1623–1662), who had one of the first calculators made by some craftsman and wrote a few things about it,[6] Descartes was, above all, an actor of the technical revolution. But probably too close to it, he could not think a lot about the break it caused in culture. As a matter of fact, we only find, in

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Les principes de la philosophie (IV, 204), the famous metaphors comparing nature with an immense engine, which produces trees and fruits as a clock gives the time. Which does not mean that the "factory of earth and sky" may be reduced to a human trick. As Descartes wrote in the same passage "all rules of mechanics belong to physics, so everything which is artificial is also natural". Here we must be careful and not misinterpret these words. In spite of the well-known Animal-machine thesis, we cannot read this sentence in the reverse order. The philosopher never said that nature is entirely mechanical, because the natural factory is not a human fact. The boss is God. His technology is subtler than ours, His intentions and goals are beyond our belief. So, some kind of deep-rooted finality remains a vivid ground of cartesianism, which prevents it turning into a flat materialism.

We cannot say exactly the same for Diderot and d'Alembert, happy project managers of the great *Encyclopédie*, one of the lighthouses of the 18th century, which contributed spreading the new technology in society at large. By adding to the numerous volumes of their beautiful book a supplement especially intended for craftsmen, they put within the reach of everyone the possibility of finding tools' designs, technical instruments' patterns and industrial drawings of new machines. So it is no exaggeration to say that Diderot, long before Mac Luhan and communication theory, may be viewed as a true theorist of the new media.[7]

Throughout the Enlightenment, a philosophy of technology began to develop as scientists progressed with their research. Vaucanson's automata, for instance, leads Condorcet (1799) to some cursory reflections about what he called the "genius of mechanics" that is, for him, "an abstract art of composition", the theory of which lies in Leibnizian *Analysis situs*, a science that made only little progress during the century. But the distance between technology and science was so obvious that, some years later, Poncelet still could see for himself that a big gap separated the teaching of mechanics everywhere in the schools from the various manners of applying it, even the more simple and usual ones.[8]

That it is quite difficult to find an actual existence of a philosophy of technology in the Classical Age in France may be easily understood: there could be, actually, nothing like it at the time. Strictly speaking, the term "philosophy of technology" is believed to find its origin in the work of Ernst Kapp, a 19th century German philosopher (1808–1896) who authored a book entitled *Philosophie der Technik*. Influenced by Georg W. F. Hegel and Karl Ritter, Kapp, in the late 1840s, fell out of favor with the German authorities and was forced to leave his homeland. He then emigrated to the German pioneer settlement of central Texas where he lived for two decades.[9] Perhaps his life on the American frontier motivated his writing about technology, which was essentially for him – as for Descartes, indeed – a means to overcome dependence on undomesticated nature.

But that book could not play any role in the early decades of the 19th century, when Auguste Comte was attending the École polytechnique. Comte, not only as an engineer, but also as secretary to Saint-Simon, was very aware of recent developments in science and new technology. He knew as well the needs of modern societies, based on big industrial sectors, dense urban fabrics and powerful networks of communication. At that time, the Saint-Simonian school was so active that Enfantin, Lesseps, and some others, began to build a lot of roads, railways, canals (Suez), which were going to change the face of the world. So, Comte was well placed to note the birth of a new social class in western societies, the class of engineers, "whose special destiny was to organize the relations between theory and practice".[10] Yet, though he might recognize that philosophical observations on such an organization would have been of great interest and importance, he said he could not go into that. For a work which would embrace scientific knowledge and the corpus of the new class doctrine would be at present (the middle of 19th century) totally premature: because these intermediate doctrines between pure theory and direct practice still did not get off the ground.

For lack of such doctrines, French philosophy of technology began by some observations closely related to sciences of power, machines and principles of mechanisms, which appeared in the works of Carnot (1824) or Coriolis (1829), following those of Joule, in England, or Franz Reuleaux, in Germany. Those scientists, at that time, tried to compute the effects of mechanization, they measured the productive action of industry on matter and laid the foundations for a general theory of machines. In this context, the old idea of Bacon – to command obedience to Nature by beginning to obey it (*De dignitate et augmentis* II, 2) –, was defended again by Taine in the "introduction" to the *Essais de critique et d'histoire*, when he wrote that the most fruitful research is the one that enables the hand of man to interfere in the great mechanism of Nature, and so, clearly using it to his benefit, may introduce a big change in its working.

Some time later, Henry Le Chatelier, a disciple of Taine, brought that thesis to a successful conclusion by showing that the history of industrial development in the late 19th century never did anything else. Mining engineer by trade, and Professor of industrial Chemistry and Metallurgy, Le Chatelier wrote, at the end of his life, a book about science and industry,[11] in which, for the first time, was studied the development of applied sciences and the beginning of Taylorism. This modest and competent man, famous for the discovery of the principle bearing his name (the equilibrium principle of Le Chatelier[12]), consistently tried to integrate theory with practice and directed his most successful research toward the problems of industry. By his reflection on the development of industrial chemistry, he is perhaps one of the foremost philosophers of technology in France.

As opposed to this ambient widespread positivist thought, a philosopher like Bergson was to react and supported another thesis. While thinking that technology fulfills basic human needs and that man, a tool-making animal, is less an *Homo sapiens* than an *Homo faber* (so that technology must be considered as belonging to the very nature of mankind), Bergson did not support the purely materialistic understanding of technological artifacts.[13] On the contrary, his philosophy pointed out the continuous nature of the world, this being for him the result of a spiritual energy expansion which explodes like a bomb and then falls again like a flare or a rocket in a big fireworks display. The successive drops in temperature make energy crystallize in life, matter and finally understanding, which has a lot of affinity with matter, but less with spirit and time (which is, for Bergson, "duration"). So, for this philosopher, technology plays only a minor role among the numerous and sometimes unknown possibilities of human mind.

After Bergson, we may observe that French philosophy of technology came to fork into different trends:

First, a descriptive philosophy of technology, connected with history, and made by former engineers or technicians, go on with Couffignal (1952), Laffitte (1932), Daumas (1953), de Latil (1953), Russo (1969 et 1986), Moles (1970) and then comes to Jacomy, Guillerme, Maitte or Ramunni.

Secondly, a more sociological and anthropological approach develops with Friedmann (1946), Leroi-Gourhan (1943), Schuhl (1948), and Lévi-Strauss (1962, 1985) who takes interest, as an ethnologist, in manual labor and "do it yourself" activities, Salomon (1984, 1986, 1992), Sfez, Musso, Gras, or even Breton.

Thirdly, an epistemological current makes its appearance with the Bachelardian school : Canguilhem (1967), Dagognet (1973, 1989, 1995), Simondon (1969), and Beaune (1980a, b), Séris, Debray, Chazal and Parrochia.

Fourthly, a properly philosophical sometimes ethical, and most often metaphysical mode of thinking arrives with French disciples of Heidegger (Dominique Janicaud, Bernard Stiegler) and of Michel Serres (Pierre Lévy) or a philosopher like Jean-Yves Goffi. We may also attach to this fourth current the works of Dominique Bourg, a student of Frank Tinland, or of the Belgian philosopher Gilbert Hottois, even if the writings of the latter offer a stubborn resistance to Heidegger's treatment of the question of technology.

2 Technique and Technology: A Problem of Words

Until now, I used the expression "philosophy of technology" as if I did not know French language has two words – "technique" and "technologie" – for translating "technology". In fact, they do not have the same meaning.

"Technique", from Greek *technikos*, "which concern some art", comes from *technè*, art, experience, skill or even ability to do something. In the former sense, it denotes a set of manufacturing processes properly applied to manual labor, especially to the use of tools as material objects, adding to the properties of human body those of natural ones (club, axe, hammer, saw, bow, sling, javelin, string, pot, net, etc.). In the modern sense, "technique" is a synonym of applied sciences, viewed as a consequence of the progress of physical sciences and of the systematic use of natural or processed forces (coal and steam, hydrocarbons, electricity, nuclear power, etc.).

"Technologie", from Greek *technologia*, denotes at first a treatise or a description of the rules of some art. In its technical sense, the term, which is not completely fixed, is close to the second sense of "technique" and means at first technical trades (study of tools, equipment, materials, processes with a view to industrial outputs). But more and more, "technologie" is well and truly applied mathematics or physics (electronics and robotics, computer science, astronautics, satellites technology, etc.), and the complex objects produced with the help of those sciences. There is also a second sense of the word, with which "technologie" means a philosophical reflection on techniques, a study of their relations with theoretical or fundamental sciences, the political, economical, social or moral consequences of their development, especially from the point of view of social sciences. Very often in France, philosophy of technology amounts to that. This explains that Jean-Pierre Séris[14] may have said that “la technologie”, that is, a more or less general discourse on the consequences of technology, should not mask “les techniques”, that is, the art itself.

3 Technology and Science

In France, a long tradition of “history of technology” precedes (or, at least, accompanies) what is properly called “philosophy of technology”. Now, taking a certain historical view reveals many things and especially teaches us that in most cases – until the beginning of the 19th century – inventors never based their discoveries on an antecedent intellectual knowledge.

In the General Foreword of his masterly *Histoire des techniques*, Maurice Daumas clearly asserts that, for more than 20 centuries, the relationships between Science and Technology remain very fragmentary ones.[15] They began certainly with the elementary contributions of astronomy and arithmetic in Antiquity, but the major scientific activity of Pericles’ century did not bring any substantial gain in the field of technology. Later, in the Middle Ages, cathedrals builders apparently borrowed nothing from mathematicians, in a time when navigation and medicine scarcely began to use scientific discoveries. It was only in the middle of the 17th century that Huyghens was able to apply isochronism pendulum oscillations found by Galileo, to the control of clocks. But this was still an exception. We can observe that men were building compasses long before the *De Magnete* of Gilbert was published. And we must note also that this book, which is the first modern study on magnetism, did not influence the art of navigation. There was no change until the middle of the 19th century. Still at that time, steam engines were working for 70 years before someone tried to draw up their theory. And the building of machine-tools antedates by a good deal theoretical works of 19th century engineers.

Some French anthropologists or philosophers of life and technology have drawn drastic consequences from these observations. The most demonstrative argument in this way is the example of the locomotive. As Canguilhem[16] says, the building of the steam engine remains unintelligible if one does not know that it is not by applying previous theoretical knowledge that it could be done but by finding a solution to a millenary problem, that of mining drainage. In the same order of ideas, Leroi-Gourhan goes further when he maintains that it is, in fact, the spinning wheel which stands at the origin of steam engines and today’s machines.[17] So Canguilhem concludes that science and technology are two kinds of activities which cannot be grafted nor transplanted on one another, each one contenting itself with borrowing from the other, sometimes particular solutions, and sometimes particular problems. For Canguilhem, the origin of such a technology is an irrational one, and it is only because we are used to rationalize our techniques that we should forget this irrational origin of machines. So we must make room for the irrational in the evolution of technology, even and especially if we want to support rationalism.[18]

The relationship of this thesis with that of Bergson one is obvious. In *Les deux sources de la morale et de la religion*, Bergson explicitly wrote that the spirit of mechanical inventions, though science keeps going on, remains rather distinct, and if need be, could part with it.[19] For Bergson is one of the few French philosophers to consider mechanical invention as a biological function, an aspect of the organization of matter by life. But Leroi-Gourhan is very close to him when he tries to understand the phenomenon of tool-making by comparing it with the movement of an amoeba, pushing outside of its mass an excrescence which takes and captures the external object of its covetousness. On the contrary, for the Bachelardian school, evolution of life or evolution of technology will look much more like a broken line than a smooth slope.

4 The Technical Phenomenon

With Jean-Pierre Séris, we must now come into the technical sphere and the world of technology. Here we have to raise some questions about the technical phenomenon, which needs not only a phenomenological description (or description of its appearance) but actually an *objective* description, which will not necessarily coincide with the immediate point of view of the users or agents.[20]

From the user's point of view, a technique is first a means or set of means to achieve one's ends. Though integrated to our habits as the short way, even the "best one way" to do something, a technique, which is an arrangement of means and mediations, is in fact constituted by chains, networks and systems. As Séris says, the technical chain is a path in a pre-existing network of available means. The technical apparatus that Bachelard tried to describe in physical science[21] with the concepts of "apparatus consciousness" and "special determinism" may appear in technology as different kinds of systems. So, we may ask three questions about that systemic representation :

First, is there one system or many? Bertrand Gille thought there was only one, because many technological systems tend to make one: for him, technology is a set of consistent means at the different levels of every structure of all the sets and all the fields.[22] It was also the opinion of Jacques Ellul, whose concept of a "technical system", one of the dominant factors of the occidental world, was in fact self-contained. But one may consider such views simplifications: generally speaking, historical reality is more complex and technology is rarely close to the state of equilibrium and other requirements of a "system". For instance, in the first part of the 19th century, we cannot say that there is a technological system based on the steam engine because steam power overtook hydroelectric only around 1864. Also the case of the compass and printing in ancient China are very well known: for different reasons, these major inventions did not lead, at the time, to a technological system. In the same way, control techniques were mastered by the engineers of Alexandria, but none of them was able to invent the steam engine. So we must be very careful if we want the concept of system to be useful in the domain of technology.

The second point is the question of the nature of the system itself. Bertrand Gille was thinking that its main feature was coherency, self-organization and self-regulation. On the contrary, Jacques Ellul supported the idea that a technological system is accurately lacking of them. It is a fact that optimization, organization and management tasks are less and less abandoned to some “invisible hand”, automatic regulation or chance. They are claimed to be technical tasks dependent on the responsibility or competence of technology itself. In this context, Gabor’s law (everything which is possible will be necessarily realized) is not a pessimist’s report but just an act by which we take into account the fact that the graph of techniques is a quasi-complete one, i.e. a graph where (almost) everything is in communication with (almost) everything. In fact, it is not quite true. In the domain of technology, exclusions and correlations may be so that every arrangement is not necessarily practicable.

In the end, technological systems are historical ones. What about their evolution? For some authors like M. Bloch, M. Mauss, A. Leroi-Gourhan, A. G. Haudricourt, B. Gille or M. Daumas, the idea of system specifies a domain of research (the “technical history of technology” from Lucien Febvre, for instance, or technology as a part of ethnography). And so, human reason, as in Hegel’s philosophy of History, may understand what happens. But for others (Jacques Ellul, Gilbert Hottois, Michel Serres or Michel Henry), the concept of a technological system essentially allows us to speak about the present time, especially for making a diagnosis of it, and a prognosis on its future. For the former, the technological system is an object which surely can be known; for the latter, it is an object which slips from our hands. These accusers of today’s technology denounce a breaking with the past. The autonomy of it is thought of as an infernal machinery left to a catastrophic and giddy progress, at any rate when things are following their usual train. And nobody can actually direct it. So a technological system is a dynamical one which appears, more and more, to be “out of control”. In fact, since the paleolithic Age, History shows many kinds of technological systems with a lot of periods of stagnation and revolution. There are many structural or extrinsic reasons which can explain why a technological system advances or halts. As Jean-Pierre Séris showed it, jamming may have social or political reasons (China), ideological ones (Alexandria), religious ones (Muslim world after the year one thousand), or material ones (the lack of some raw materials, for instance). These are extrinsic reasons. But there are also structural ones. Haudricourt, for instance, explains that the lack of the wheel in pre-Columbian America is not due to the fact that the natives could not invent it. In fact, the invention of wheel can only take place in an agricultural civilization with a flat land, when men succeed to domesticate big herbivores. Without draught animals, one cannot get a continuous movement. Quick elimination of horses and elephants would have deprive Paleolithic hunters recently arrived on the continent of technical reasons to bring the wheel in. This kind of structural reason is not due to the system as a system. There are many other aspects of technology that French philosophy has well studied (normativity, historicity, relationship with machines, arts or responsibility) that we cannot develop here. For more information, the reader may be referred to Séris (1994).

5 Machines, Engines, Automata, Networks

A history of the philosophical attitudes towards technology, and particularly towards machines, was written by Pierre Maxime Schuhl, who published, in the mid-20th century, a remarkable little book on the subject.[23] This history may be summed up the following way: it begins with a resignation without hope (Antiquity), and after an enthusiastic and very promising period (roughly, from 17th to 19th century), comes back to some hopeless feelings (contemporary thought). But the difference between the beginning and the end is obvious: it was due to the *absence* of the machine that the philosopher of Ancient times was sorrowing, whereas it is due to its *presence* that today's philosopher must resign himself.

These observations prove in fact that, very often, philosophers – especially French ones – are not interested in machine itself or in its technical reality, but in the machine as a human or social fact. In other words, the philosophical problem of mechanism does not depend on the place of the machine in production, but rather on its influence on human life.

Commenting on the book of Schuhl in some papers published in the journal *Critique* in the late 40s, Alexandre Koyré explained the failure of the Cartesian dream by saying that, in the succession of centuries, man realized that instead of becoming free and happy, he was going to be more and more a slave of the machine. Instead of being the Golden Age of humanity, the age of the machine was in fact her Iron Age. Needles and shuttles were now moving by themselves, as Aristotle, at the beginning of his *Politics*, wished it could be; but unfortunately, the weaver remained, today more than ever, chained to his work. French philosophy is full of lamentations of this sort. Proudhon, Fourier, Villermé and even Michelet, a supporter of mechanism, describing the 17 hours a day labor of the 19th-century workmen, all deplore the hard conditions and the extreme poverty following from it.

However, like Schuhl himself, and unlike Samuel Butler in *Erewhon*, Koyré does not proscribe machines, nor condemn them. He does not scrap anymore new manufactures or industries, and even disculpates the machine of the charge of necessitating continuous adjustments between man and his technical and cultural environment, leading in the end to a kind of Huxley's "brave new world" where, whatever the events may be, nobody protests against what happens. In fact, Koyré, in spite of all the negative aspects of the accumulative stage of capitalistic or even socialist systems, maintained that the technical intelligence of man has fulfilled its promise. Nothing is more characteristic of modern technology than the more and more widespread use of more and more artificial materials which are not to be found in nature as they are: alloy, glass, plastic materials,[24] now aramid fibers, Kevlar and kevlar reinforced composites materials, phenolic resins and glass-reinforced phenol, polyurethane engineering plastics, new thermoplastics, carbon and graphite fibers, polyester molding compounds, hybrid polyesters in general, new epoxy resin systems, etc.[25]

So, trying to throw light on the reasons of the birth of technology, and of its stages of development, Koyré never gives up any right to naturalism nor to simplistic explanations. At that time, two theories, in fact, were facing one another: the Marx-Engels theory of history supporting that, at a certain stage of their development, the material forces of production come into conflict with the existing relations of production, inducing a lot of change in social organization as a whole; the other one was the psychosociological explanation supported – among others (for instance, Emile Meyerson) – by Pierre–Maxime Schuhl. According to this philosopher, the technical stagnation of Antiquity, may be explained by the structure of ancient society and its economy. If machines were of no use, it was because Greeks or Romans had at their disposal living machines, cheap and numerous, as far removed from the free man as from the beast: slaves. This contrast between liberal and servile, prolonged by the difference between science and technology, would explain that one must wait until the end of Middle Ages and the growth of towns, trade, industry, to see the scientific method applied in the realm of practical experience. In other words, Schuhl was showing that, if the Ancient Greeks or Romans never developed machines (excepted clepsydra and some rudimentary mechanisms in Alexandria[26]), it was because machines were something unimportant for them.

For Koyré, however, psychosociological theory does not provide a satisfactory answer. But it is not because another theory gives a better explanation. According to Koyré, we must realize that, in the history of technology, there is no general answer for everything. Perhaps we can indeed go on a bit beyond this prudent advice by making two points: first, the machines the engineers of Alexandria would have been able to build were steam engines. But steam engines need wood for working and there was not much wood left in Ancient Greece because of the excess of shipbuilding (triremes were big consumers of wood). Second, engines and factories lead to the development of what we can call mass production. But mass production must be sold off. And to this end, one needs not only some network (road, railways, and so on) but vehicles to run on it. In the Ancient Times, the only vehicle one can dispose of was the team (pulled by horses or oxes) and the rough nature of packsaddle forbids, in fact, too heavy loads. So machines were of no use at that time and this, probably suffices to explain why there were no engines in the Ancient Greece.

6 Technology and Ideology

Since the middle of the 1960s, a large part of the French tradition in philosophy became very critic towards technology, and sometimes said surprising things about it. Many people, who had never opened a science book nor gone into a factory or a laboratory, allowed themselves to pass judgments on things of which they had no knowledge of. Inspiration coming from Heidegger or Habermas took the place of thinking by themselves, and so, technology, from that time, tended to disappear behind a purely idealistic mode of thought.

Roland Barthes, in his *Mythologies*, showed that the objects of consumer society are surrounded by a halo of connotations in which they are captured as in a net. These connotations which do not refer to Benjamin's aura nor to anything real, were supposed to make a system of signs which can be studied for itself. That is what Jean Baudrillard[27] did in *Le système des objets*, which developed a purely semiotic point of view about things becoming kinds of gadgets and being totally out of touch with the real world. Commenting on a striking image of the book (an iron, the bottom of which was covered with nails), Raymond Ruyer[28] made the common sense observation that such a thing, if it ever exists, could not be produced in a large quantity. A society rarely uses up its power and raw materials in vain.

Sfez position on the problem of health,[29] as Pierre Musso's on communication and networks, do not seem to me more tenable. After being very critical with decision theory, Sfez developed a critical approach of communication and has led to a denunciation of the ideology of perfect health. But who believes in that? Apart from a few American researchers who dreamed of a global ecological system equilibrium regulated, nobody thinks seriously that it is the main problem of the time. In the domain of medicine, crucial questions of the century are rather emerging diseases and the return, under another form, more virulent, of former infectious ones. The great challenge of our modernity is there, and nowhere else.

In the field of network philosophy, Musso[30] claimed that the notion of network, initiated by the Saint-Simonian school, deteriorated so to speak and rapidly transmuted into an ideology. For him, we find there a kind of networks' cult, at the origin of a theology of transparency which, for Philippe Breton,[31] rather took place in the cybernetic project and the early writings of Norbert Wiener. Musso established a connection between this ancient cult of networks and more recent propaganda about information superhighways such as Bill Gates' view of the world.

But it does not seem to me that such considerations belong to philosophy of technology. The sociological and political approach of Sfez and Musso do not take into account the actual history of technological concepts nor theories. The authors only speak about what Hegel did not consider as concepts but as representations of concepts, which is not the same thing. And more than one philosopher today knows very well that the present time is more fertile in representations of concepts than in concepts.

7 Ethics and Technology

In a very paradoxical way, thinking about technology in France has often means to make some ethical observations on man and the relations between technology and morals. As it is said in a very typical book on the subject,[32] technology is often viewed as a "social science". At least some scientists try to persuade themselves that it would have to be so. Why do, very often, thoughts about technology imperceptibly change into ethical observations? A possible answer is that, in the domain of technology, we are dealing with values. What is a technical value? For Séris,[33] it is a value of usefulness, which has to be distinguishable from market values (not necessarily connected to the previous one), and from biological or aesthetic values. For instance, innovation is certainly a properly technical value, which has many consequences for society. Now we cannot say that this kind of value has absolutely nothing to do with aesthetics or biology, because a successful innovation may be a neat solution for a technical problem (which can lead, for instance, to some elegant object), and also because, in the end, this innovation, if it is useful, will be selected and will remain for a long time, possibly for ever, in the collective memory. So we are led to the following question: what is important for human societies, and not only at one point of their history but for the future? And this is an ethical question. Values of usefulness are inserted, in fact, in complex chains of operations which imply controversial debates, collective decisions and social commitments. For instance, ensuing public transport or developing solar power rather than nuclear power are technical choices linked to scales of values on which everyone does not necessarily agree. French philosophers often prefer such debates to serious and well-informed study of what technology, in concrete terms, is. So we have lost count of the malcontents and of their numerous bemoaning speeches: the imprecations of Janicaud[34] against the blind combinations of an autonomous technology for which everything is possible, the indignations of Virilio[35] against the collusion of technology and war, militarization of language or virtualization of the whole reality, the temptation of sinking into deep ecology, support of the so-called "rights of nature" in the papers of the disciples of Hans Jonas, the belief in the ideology of a "sustainable development", popularized by the World Commission on Environment and Development (WCED) in its 1987 report entitled "Our common future", as if classical technology aimed only at short-lived or ephemeral productions, and so on. But all this talking is not getting us anywhere and the progress of technology is sometimes a better contribution to peace than the dreams of UNESCO.[36] It is far from obvious that a dynamic balance between cultural differences and a supposed emerging global ethic is a key concept in educating for a sustainable future. Thinking that actions of people and businesses in their own communities, at local levels, may extend outwards in spirals of shared understandings and revised or renewed vision of things is an optimistic and probably completely idealistic point of view. This ideology, unfortunately, gains ground, while the critics of big technological systems,[37] forgetting the benefits they have brought to us, go on with their undermining. Another recent sign of the times is the importance devoted to technological risks in the context of nuclear sciences, genetic engineering or nanotechnologies. In a very dark and anxious book, Jean-Pierre Dupuy[38] shows that the frightening future of technology, which, according to him, is waiting for us, should be, in fact, a matter of public concern. Following H. Arendt, he recalls that technology, today, has the capacity of activating no return processes, and so, is more a matter of *action* than a matter of *production*. But whatever the importance of the danger (that we must not underestimate), the existence of possible technological disasters cannot forbid on their own the scientific and technological progress, especially since the former sources of power are coming to an end.

8 Technology and Metaphysics: The Ontological Approach

As I already said, a not inconsiderable part of French philosophy deals with the Heideggerian idea that science (and likewise technology) does not think anything. How is it possible to attach the least importance to such a vacuous statement is very mysterious. But a lot of French philosophers surely share with Heidegger the convoluted thought that "the question concerning technology is the question concerning the constellation in which revealing and concealing, in which the coming to presence of truth, comes to pass".[39] What do they mean by that? It is hard to say and it is no more sure those bombastic words can hardly mean something, it would certainly be better not to waste one's time to look for an answer.

However, as this kind of thought is now very widespread, we cannot avoid saying some words about it. The main purpose of Heidegger's thesis is, in fact, to show that the sense of technology has changed with the development of science in the 17th century. From the earliest times until Plato, technology was no mere means. It was a kind of bringing-forth (*Her-vor-bringen* in German), a mode of revealing, linked to what we call truth, translating the Roman *veritas* and the Greek *aletheia*: "Technology is a mode of *aletheuein*. It reveals whatever does not bring itself forth and does not yet lie here before us, whatever can look and turn out now one way and now another".[40] So, for the Greeks, in fact, technology and handcraft manufacture belonged to *poiesis*, as arts, poetics, but so does physics. Now when we say that modern technology is something incomparably different from all earlier technologies, it is not only because it is based on modern physics as an exact science. For Heidegger:

> the revealing that holds sway throughout modern technology does not unfold into a bringing-forth in the sense of *poiesis*. The revealing that rules in modern technology is a challenging [*Herausfordern*], which puts to nature the unreasonable demand that it supply energy that can be extracted and stored as such.[41]

And while the work of the peasant does not challenge the soil of the field, mechanized industry is now challenging all the energies of nature. "Air is now set upon to yield nitrogen, the earth to yield ore, ore to yield uranium, for example; uranium is set upon to yield atomic energy",[42] and so on. A famous example is supposed to make us feel the difference between former and recent technology: the hydroelectric plant, set into the current of the Rhine, is not built into the Rhine River as was the old wooden bridge joining bank with bank for hundreds of years. This factory "sets the Rhine to supplying its hydraulic pressure, which then sets the turbine tuning. This turning sets those machines in motion whose thrust sets going the electric current for which the long-distance power station and its network of cables are set up to dispatch electricity".[43] As Heidegger said, the river is now dammed up into the power plant, and what it is now, namely, a water power supplier, derives from the essence of the power station. For Heidegger, such a state of affairs is monstrous:

> In order that we may even remotely consider the monstrousness that reigns here, let us ponder for a moment the contrast that speaks out of the two titles, "The Rhine" as dammed up into the power works, and "The Rhine" as uttered out of the art work, in Hölderlin's hymn by that name.[44]

The conclusion is that the Rhine is now reduced to "an object on call for inspection by a tour group ordered there by the vacation industry".[45]

Commenting on the different papers of Heidegger about the question of technology, Jean-Pierre Séris showed that Heidegger's ideas were not very new nor original ones. Jacques Ellul, in "La technique ou l'enjeu du siècle" (1954) and 20 years after in "Le système technicien" was already opposed to the current conception of modern technology which is criticized by Heidegger and may be called an "instrumentalistic anthropologism". Gabor, Mumford, Illich, in the 1970s, were denouncing the supposed unlimited and so totalitarian modern system of technology. This leitmotiv of the 60s and 70s is still fashionable today. Bruno Latour took up the story around the 1980s, showing that scientific knowledge is, by role and necessity, totally unlimited, as capitalism which gave its birth to it.[46]

Séris himself was not convinced by Heidegger's arguments though he understood very well its stake, which is to set out the Nietzschean "will for power" as a manner of fulfilling occidental metaphysics. But after the moment of criticism comes the question of knowing what we can do. And we cannot content ourselves with gazing at the marvelous old bridge of Heidelberg when extreme poverty, destitution, famine and diseases still exist in the world. Heideggerian condemnation of technology reveals in fact the casualness of a privileged being living in an opulent society, and who comes to forget what he is owing to it. I would also point out that an old bridge is again a technological object, which belongs to a network organization of the society certainly different from ours but historically specific and well defined. Perhaps it links together the church and the castle, or two trade fair towns on both sides of a river. But if we want to understand what technology is, we should not give priority to a particular state of its development.

9 Back to Technology Itself

Far from these critical and panoramic views, the Bachelardian school stressed the necessity to return to technology itself, and to begin to describe it.

Bachelard himself, who was first and foremost a philosopher of science, did not have a lot to say about technology. There are only a few passages devoted specifically to it in his works and most of them are dedicated to scientific apparatus. But there remain some in which we can disclose an actual interest in the technology of machines. For instance, we may read in *Le matérialisme rationnel*, that a machine is an inflatable apparatus which can be arranged in many ways according to its use.[47] And this observation has been very well verified afterwards when applied to machines like computers, which are governed by a program.

François Dagognet, a disciple of Bachelard born in 1924 and who wrote more than 50 books, is not only a philosopher of the life sciences. Throughout his work we find several reflections devoted to philosophy of technology. In *L'invention de notre monde, l'industrie: pourquoi et comment?* for instance Dagognet, after Marx, takes the factory as a philosophical object. For him, industry works wonders: from some cheap, ordinary and generally very abundant ingredients (the inputs) – that are modified, joined or transformed by some machines –, it makes valuable goods (the outputs). This process from less to more is something of a miracle. Though it is not a creation *ex nihilo*, the fact remains that it is a remarkable improvement.[48] Against all those philosophers who merely point out the negative effects of industrialization and content themselves with investigations based on too obvious charges, Dagognet, after Hume, Saint-Simon and Auguste Comte, says in manufacturers' defense that industry is actually a true demiurge. Against Marx and Marcuse, he shows that modern societies progressively create a set of laws which try to protect workmen as purchasers. Little by little, machines yield increasing outputs and more and more independence. The engines of Savery, Newcomen or Watt, lead to growing and growing productions. The perfecting of engines and the rules they must obey to give new forms of machinery and gears (Woolf, compounds, Ebinger machines). The progress of chemistry puts on the market new objects based on wood cellulose $(C_6H_{10}O_5)_n$ or polythene $(CH_2\text{-}CH_2)_n$ times, for instance, which gives polyvinyl chloride, PVC, when an atom of chlorine takes the place of an atom of hydrogen), and again polyamides like nylon and other polymers. By these inventions, industry does not only create a new universe, it changes the natural world into a human one, and establishes new kinds of relations between men or between men and objects. In fact, for Dagognet, industrial environment leads to a true religion and a burning art (*art brûlant*). In another book on the same subject, *L'essor technologique et l'idée de progrès*, Dagognet tries to save the idea of progress, even if, as he said, this idea may succomb under the blow of progress itself.

Though Dagognet wrote about many things, and also about technology, he is known, above all, as a philosopher of Chemistry and the life sciences. It was in fact another disciple of Bachelard, Gilbert Simondon (1924–1989), who developed the first great philosophy of technology of the second part of the 20th century. In a very dense book, entitled *Du mode d'existence des objets techniques*, Simondon, whose main problem was in fact the question of psychological and biological individuation,[49] tried to show how technology developed. In this book, he criticized Norbert Wiener's theory of cybernetics which, according to him, had accepted what any theory of technology must refuse namely a classification of technological objects conducted by means of established criteria and following genera and species. Simondon preferred to overcome the shortcomings of cybernetics and to develop a general phenomenology of machines, which shows especially, the numerous influences on the production of technical objects[50] and how, at every step of their development, these objects are synthetically reorganized – the engine, for instance, becoming more and more compact and its parts more and more interrelated.

After Simondon, Jean-Claude Beaune is surely, among the Bachelardians, one of the philosophers who has done the most to stimulate studies and reflections on philosophy of technology. Probably influenced by Mumford (1963, 1971), Beaune essentially took into account ambiguous and mythic entities. For instance, he wrote a beautiful book on the ambiguous concept of automaton,[51] which is not only a scientific notion but a philosophical one. The term of automaton, indeed, comes from Greek *automaton* which, in the beginning, meant nothing but chance. But the historical evolution of the word revealed another meaning, which is, on the contrary, completely deterministic: the *automaton*, as it is supposed to do always the same thing, is quite repetitious. Consequently, reason and unreason are involved in that concept, in an indissociable manner. We can even say more: with the great figure of repetition, which is linked to the Freudian principle of repetition, death is not very far of. Thus Beaune's observations on technology are also a meditation on death, and the relations between technology and death. One of the major themes of Beaune's philosophy is that man, when he tried to substitute technological systems for life – and that is one of the main and more useful aims of technology – never entirely succeeds because life is not comparable with a mechanical apparatus. When this confusion is made, then, the mechanization of life induces curious effects, like those we can see when medicine unduly prolongs human life, making of men some kinds of dead-living beings.[52] Beaune also wrote about other ambiguous entities like remedies and drugs, and perhaps has been one of the first French philosopher to show that illness (or the scientific definition of the feeling of sickness) is, most of the time, a social disease: that is how former vagrants became, for 19th century's medicine, "itinerant automata", a short-lived and completely unfounded category.[53]

In the last two decades, with the publication of four or five books, a new philosopher suddenly appeared in France, Gérard Chazal. This disciple of Dagognet, Beaune and Gayon, formulated first a philosophy of computer science,[54] before he developed it into a full-fledged philosophy of technology, a philosophy of forms[55] and even a theory of culture in general.[56] Influenced by the French mathematician René Thom (Fields Medal 1958), whose "catastrophe theory" belongs now to true science, Chazal, like Beaune, took an early interest in the concept of *automaton*. But he understood it essentially in the sense of computer science. For him, computer science allows us to go beyond logic and to get around the famous limits that Gödel's theorem (1931) impose on formal sciences. Also concerned with the concept of neuronal network, Chazal tried to use it to propose a new interpretation of the Aristotelician hylemorphic schema, which, according to him, may contribute to solve the mind-body problem by way of an updated materialism. In his latest books, Chazal attaches the utmost importance to the concept of "interface", which is, for him, not only the well-known computer science notion, but a true mediation which can explain many cultural facts or contemporary behaviors: from tattooing (because the body is an interface) to theory-making (when theories are some kind of abstract tools with which we can capture the world). In his latest book, *L'ordre humain ou le déni de nature* (2006), he has returned to the technology of building, information science as well as mind and body techniques, which are, for him, manners of making our (incomplete) world more human.

I have now a few words to say about my own involvement in the realm of technology. After working for more than 2 years with a space engineer at the CNES (Centre National d'Etudes Spatiales) in Toulouse, I wrote two books on modern technology : *La conception technologique* (1998) and *L'homme volant* (2001). In these works, I tried to explain what modern design is, especially in the field of aeronautics and spacecraft engineering, and undertook to combat rampant "technophobia", widespread in everyday life of all western societies. From the shipwreck of the Titanic to the nuclear accident of Tchernobyl, the comprehensible mistrust that could be generated by technological failures transmuted into an incomprehensible hatred based on ignorance and neglect of the great victories of humankind. I was naive enough to believe in a project of setting things straight, which was probably to bite off more than I could chew. But I maintain with Dagognet that French philosophers must leave their favorite meditations about consciousness and subjectivity, open their eyes if they are still prepared to look, and describe, if they are still capable of understanding what actually happened in the real world in the last century. The period 1900–2000 is not only the century of two bloody world wars. During those 100 years, man learned more about nature and its laws than during the whole stretch of earlier history. One of the main examples is the resolution of the problem of flying. From the dawn of aerodynamic thought to George Cayley, throughout the infancy of aerodynamics and its first applications by the Wright brothers, the scope of hydrodynamic phenomena subjected to exact analysis increased more and more, until a true science developed. Finally, the question of flying (or how to pose correctly the three problems of propulsion, lift and control) was to be solved by a meticulous study of gliding, even if the truth of the matter is that a powerful engine is enough to produce a propulsion and bring about a take off.

I want to conclude by saying that, like most of French philosophers, I am filled with admiration for the works of Jean-Pierre Séris, whose premature death deprives French philosophy of technology of one of its best representatives. As former student of the École normale supérieure (rue d'Ulm), Jean-Pierre Séris was evidently well versed in classical and modern philosophy. But he became also an expert in game theory and machine making, and probably wrote one of the best book published in France on the subject. Another of his books, on technology, entitled *La technique*, that I quoted often in this paper, is far more than a manual. It is one of the best guides I ever read on the topic, and should in my opinion remain for a long time a major book. I wanted to pay tribute to this modest, competent and clever man, Professor at the Sorbonne, Director of the Institut d'histoire des sciences et des techniques in Paris, a master and an example for all of us.

Endnotes

1 Descartes, 1953, p. 168.
2 Ibid., p. 566.
3 Descartes wrote a letter to Villebressieu in the summer of 1631, telling his friend that he carried out himself many experiments in mechanics. Cf. ibid., pp. 943–945.
4 "A Huygens, 5 octobre 1637", in ibid., p. 971.
5 Ibid., pp. 973–981.

6 Pascal 1954, p. 357.
7 See the conclusion of Dagognet, 1973. A recent disciple is Debray, 1991.
8 Poncelet, 1829.
9 Mitcham, 1994, p. 23.
10 Comte,1830, pp. 66–69.
11 See Le Chatelier, 1925.
12 “Every change of one of the factors of an equilibrium occasions a rearrangement of the system in such a direction that the factor in question experiences a change in a sense opposite to the original change”, H. L. Le Chatelier, 1888, *Annales des Mines*, 13 (2), p. 157.
13 Bergson, 1970, p. 613.
14 Séris, 1994, p. 1.
15 Daumas, 1962, p. XI.
16 Canguilhem, 1967, p. 124.
17 Leroi-Gourhan, 1945, p. 100.
18 Canguilhem, 1967, p. 125.
19 Bergson, 1970, p. 1235 sq.
20 Séris, 1994, p. 46.
21 See Bachelard, 1951.
22 Gille, 1978, p. 19.
23 See Schuhl, 1947.
24 Koyré, 1981, p. 316.
25 See Parrochia, 1993.
26 See B. Gille, 1980.
27 Baudrillard, 1968.
28 See Ruyer, 1971.
29 See Sfez, 2002.
30 See Musso, 1997.
31 See Breton, 1987.
32 Bayle, Bourg et al., 1994, p. 51.
33 Séris 1994, p. 32 sq.
34 See Janicaud, 1985.
35 See Virilio, 1990, 1995.
36 I except the very good report of Ladrière (1977).
37 See Gras, 1993.
38 Dupuy, 2006, p. 135.
39 Heidegger, 1954 in Lovitt, 1977, p. 32.
40 Ibid., p. 12.
41 Ibid., p. 13.
42 Ibid., p. 14.
43 Ibid., p. 15.
44 Ibid.
45 Ibid.
46 Latour, 1988.
47 See Bachelard 1951, p. 13.
48 Dagognet, 1995, p. 24.
49 See Simondon, 1964.
50 Simondon, 1969, p. 72.
51 See Beaune, 1980a, b.
52 See Beaune, 1988.
53 See Beaune, 1983.
54 See Chazal, 1995.
55 See Chazal, 1997.
56 See the late developments of the philosophy of the author in Chazal, 2000, 2002, 2004 and 2006.

Bibliography

Bachelard Gaston (1951), *L'activité rationaliste de la physique contemporaine*, Paris, PUF.
Bachelard Gaston (1953), *Le matérialisme rationnel*, Paris, PUF, 3rd ed., 1972.
Barthes Roland (1970), *Mythologies*, Paris, Point-Seuil.
Baudrillard Jean (1968), *Le système des objets*, Paris, Gonthier-Médiations, 1975.
Bayle F., D. Bourg, R. Debray, D. Ettigoffer, A. Finkielkraut, M.-A. Hermitte, B. Jacomy, D. Janicaud, B. Latour, R. Laufer, P. Lévy, A. Moles, J. Perrin, A. Picon, Ph. Quéau, M. Sicard, F.Sigaud, B. Stiegler, P. Virilio, J. Weissenbach (2000), interrogés par R. Scheps, Paris, Point-Seuil.
Beaune Jean-Claude (1980a), *L'automate et ses mobiles*, Paris, Flammarion.
Beaune Jean-Claude (1980b), *La technologie introuvable*, Paris, Vrin.
Beaune Jean-Claude (1983), *Le vagabond et la machine*, Seyssel, Champ Vallon.
Beaune Jean-Claude (1988), *Les spectres mécaniques*, Seyssel, Champ Vallon.
Beaune Jean-Claude (1998), *Philosophie des milieux techniques*, Seyssel, Champ Vallon.
Beaune Jean-Claude (2002), *Le balancier du monde*, Seyssel, Champ Vallon.
Bergson Henri (1970), *Œuvres*, Paris, PUF.
Blamont Jacques(1993), *Le chiffre et le songe, histoire politique de la découverte*, Paris, Odile Jacob.
Breton Philippe (1987), *Histoire de l'informatique*, Paris, La Découverte.
Breton Philippe, Rieu Alain-Marc, Tinland Frank (1990), *La techno-science en question*, Seyssel, Champ Vallon.
Canguilhem Georges (1967), *La connaissance de la vie*, Paris, PUF.
Carnot Sadi (1824), *Réflexions sur la puissance motrice du feu*, Paris, Blanchard, 1953, reed. Gabay, 1995.
Chazal Gérard (1995), *Le miroir automate, Introduction à une philosophie de l'informatique*, Seyssel, Champ Vallon.
Chazal Gérard (1997), *Formes, figures et réalité*, Seyssel, Champ Vallon.
Chazal Gérard (2000), *Les réseaux du sens: de l'informatique aux neurosciences*, Seyssel, Champ Vallon, 2000.
Chazal Gérard (2002), *Interfaces: enquêtes sur les mondes intermédiaires*, Seyssel, Champ Vallon.
Chazal Gérard (2004), *Les médiations théoriques*, Seyssel, Champ Vallon.
Chazal Gérard (2006), *L'ordre humain ou le déni de nature*, Seyssel, Champ Vallon.
Comte Auguste (1830), *Cours de philosophie positive*, vol. 1, 1st lesson, Paris, Rouen frères (Bachelier); *The Positive Philosophy of August Comte*, transl. & condensation, H. Martineau, 1853.
Condorcet Marquis de (1799), "Éloge de M. de Vaucanson", in *Éloges des académiciens de l'Académie royale des sciences*, vol. 3, Paris.
Coriolis Gaspard Gustave de (1819), *Du calcul de l'effet des machines*, Paris, Carilian-Goeury, 1829.
Couffignal Louis (1952), *Les machines à penser*, Paris, Minuit.
Dagognet François (1973), *Écriture et iconographie*, Paris, Vrin.
Dagognet François (1989), *Éloge de l'objet*, Paris, Vrin.
Dagognet François (1995), *L'invention de notre monde, l'industrie : pourquoi et comment?*, Fougères, Encre Marine.
Daumas Maurice (1962), *Histoire des techniques*, 5 vol., Paris, PUF, "Quadrige", 1996.
Daumas Maurice (1953), *Les instruments scientifiques au XVIIe et au XVIIIe siècle*, Reed., Gabay, 2004.
Debray Régis (1991), *Cours de Médiologie générale*, Paris, Gallimard.
Descartes (1953), *Œuvres*, Paris, Gallimard.
Dupuy Jean-Pierre (2006), *Retour de Tchernobyl, journal d'un homme en colère*, Paris, Seuil. Trans. J. Wilkinson, *The Technological Society*, New York, Alfred A. Knopf, 1964.
Ellul Jacques (1954), *La technique ou l'enjeu du siècle*, Paris, Armand Colin, 1954.

Ellul Jacques (1980), *The technological system*, New York, Continuum.
Ellul Jacques (1990), *The technological bluff*, trans. Geoffrey W. Bromiley, Grand Rapids, Eerdemans.
Friedmann Georges(1946), *Problèmes humains du machinisme industriels*, Reed, Paris, Gallimard, 1955.
Gille Bertrand (1978a), *Histoire des techniques*, Paris, Gallimard, Encyclopédie de la Pléiade.
Gille Bertrand (1978b), *Les ingénieurs de la Renaissance*, Paris, Seuil, "Point-Sciences".
Gille Bertrand (1980), *Les mécaniciens grecs, la naissance de la technologie*, Paris, Seuil.
Gras Alain (1993), *Grandeur et dépendance, sociologie des macro-systèmes techniques*, Paris, PUF.
Guillerme André (1983), *Le temps de l'eau : la cité, l'eau et les techniques*, Seyssel, Champ Vallon.
Habermas Jürgen (1968), *Technick und Wissenschaft als Ideologie*, Frankfurt am Main, Suhrkamp Verlag, 1968.
Heidegger Martin (1954), "The Question Concerning Technology" in William Lovitt, *The Question Concerning Technology and Other Essays*, Harper & Row, 1977, pp. 3–35.
Henry Michel, (1976), *Marx*, Paris, Gallimard, 1976.
Henry Michel (1987), *La Barbarie*, Paris, Grasset.
Hottois Gilbert (1984), *Le signe et la technique, la philosophie à l'épreuve de la technique*, Paris, Aubier.
Hottois Gilbert (1996), *Entre symboles & technosciences, un itinéraire philosophique*, Seyssel, Champ Vallon.
Jacomy Bruno (1990), *Une histoire des techniques*, Paris, Seuil.
Janicaud Dominique (1985), *La puissance du rationnel*, Paris, Gallimard.
Koyré Alexandre (1981), "Les philosophes et la machines", in *Études d'histoire de la pensée philosophique*, Paris, Gallimard, "Tel".
Ladrière Jean (1977), *Les enjeux de la rationalité, le défi de la science et de la technologie aux cultures*, Unesco, Aubier-Montaigne.
Laffitte Jacques (1932), *Réflexion sur la science des machines*, Reed, Paris, Vrin, 1972.
Latil Pierre de (1953), *Introduction à la cybernétique, la pensée artificielle*, Paris, Gallimard.
Latour Bruno (1988), "Le grand partage", *Revue du MAUSS*, 1 (3); pp. 2764.
Latour Bruno (1992), *Aramis ou l'amour des techniques*, Paris, La Découverte.
Lebeau André (1986), *L'espace en héritage*, Paris, Odile Jacob, 1986.
Le Chatelier Henry Louis (1925), *L'industrie, la science et l'organisation au XXe siècle*, Paris, Dunod.
Le Chatelier Henry Louis (1988), "Recherches expérimentales et théoriques sur les équilibres chimiques", *Annales des Mines*, 13(2), p. 157.
Lecourt Dominique (1990), *Contre la peur*, Paris, PUF., "Quadrige", reed. 1999.
Leroi-Gourhan André (1945), *Milieux et techniques*, Paris, Albin Michel, reed. 1973.
Leroi-Gourhan André (1964), *Le geste et la parole*, vol. 1, *Technique et langage*, Paris, Albin Michel.
Leroi-Gourhan André (1965), vol. 2, *La mémoire et les rythmes*, Paris, Albin Michel.
Lévi-Strauss Claude (1962), *La pensée sauvage*, Paris, Plon.
Lévi-Strauss Claude (1985), *La potière jalouse*, Paris, Plon.
Lévy, Pierre (1987), *La machine univers*, Paris, La Découverte.
Lévy, Pierre (1991), *L'idéographie dynamique, vers une imagination artificielle?* Paris, La Découverte.
Mac Luhan, Marshall (1994), *Understanding Media*, Reed, MIT Press.
Maitte Bertrand (1981), *La lumière*, Paris, Seuil, "Point-Sciences".
Mauss Marcel (1948), *Sociologie et Anthropologie*, Paris, PUF.
Mitcham Carl (1994), *Thinking through Technology, the Path between Engineering and Philosophy*, Chicago, University of Chicago Press.
Moles Abraham (1970), *Créativité et méthodes d'innovation*, Paris, Fayard-Mame.
Mumford Lewis (1963), *Technics and Civilization*, Harvest/HBJ Books.

Mumford Lewis (1971), *Myth of the machine: Technics and Human development*, Harvest/HBJ books.
Musso Pierre (1997), *Télécommunication et philosophie des réseaux, la postérité paradoxale de Saint-Simon*, Paris, PUF.
Parrochia Daniel (1993), *Philosophie des réseaux*, Paris, PUF.
Parrochia Daniel (1994), "A Historical Note on Artificial Life", *Acta Biotheoretica*, 43, pp. 177-193.
Parrochia Daniel (1996) "Agorithmics and the Limits of Complexity", *Science in Context*, 9 (1), pp. 39-56.
Parrochia Daniel (1998), *La conception technologique*, Paris, Hermès.
Parrochia Daniel (2001), *L'homme volant, épistémologie de l'aéronautique et des systèmes de navigation*, Seyssel, Champ Vallon.
Poncelet, Jean Victor (1829), *Introduction à la mécanique industrielle*, Paris, Gauthier-Villars, 1870.
Ramunni Girolamo (1989), *La physique du calcul, histoire de l'ordinateur*, Paris, Hachette.
Russo François (1955), *Eléments de bibliographie d'histoire des sciences et des techniques*, Paris, Hermann, 2nd ed., 1969.
Russo François (1986), *Introduction à l'histoire des techniques*, Paris, Blanchard.
Ruyer Raymond (1968), *La cybernétique et l'origine de l'information*, Paris, Flammarion.
Ruyer Raymond (1971) *Les nuisances idéologiques*, Paris, Calmann-Lévy.
Salomon Jean-Jacques (1984), *Prométhée empêtré. La résistance au changement technique*, Paris, Anthropos.
Salomon Jean-Jacques (1986) *Les enjeux du changement technologique*, Paris, Economica.
Salomon Jean-Jacques (1992), *Le destin technologique*, Paris, Balland.
Schuhl Pierre-Maxime (1947), *Machinisme et philosophie*, Paris, PUF., 2nd ed.
Séris Jean-Pierre (1974), *La théorie des jeux*, Paris, PUF.
Séris Jean-Pierre (1987), *Machine et communication*, Paris, Vrin.
Séris Jean-Pierre (1994), *La technique*, Paris, PUF.
Serres Michel (1990), *Le contrat naturel*, Paris, Bourin.
Sfez Lucien (1998), *La Santé Parfaite*, Paris, Seuil.
Sfez Lucien (2002), *Technique et Idéologie*, Paris, PUF.
Sigaut François (1994), "La technologie, une science humaine", in F. Bayle, D. Bourg, R. Debray et al, *L'empire des techniques*, Paris, Seuil, "Point-Sciences".
Simondon Gilbert (1964), L'individu et sa genèse physico-biologique (l'individuation à la lumière des notions de forme et d'information), Paris PUF., 2nd ed. J. Millon, "Krisis", 1995.
Simondon Gilbert (1969), *Du mode d'existence des objets techniques*, Paris, Aubier-Montaigne.
Stiegler Bernard (1996), *La technique et le temps*, 2 vol., Paris, Galilée.
Tinland Frank (1991) (ed.), *Systèmes naturels, systèmes artificiels*, Seyssel, Champ Vallon.
Tinland Frank (1994) (ed.), *Ordre biologique, ordre technologique*, Seyssel, Champ Vallon.
Virilio Paul (1977), *Vitesse et politique*, Paris, Galilée.
Virilio Paul (1990), *L'inertie polaire*, Paris, Bourgois.
Virilio Paul (1995), *La vitesse de libération*, Paris, Galilée.