History and Technology
An International Journal
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713643058

Beck Back in the 19th Century: Towards a Genealogy of Risk Society

Jean-Baptiste Fressoz

Online Publication Date: 01 December 2007
To cite this Article: Fressoz, Jean-Baptiste (2007) 'Beck Back in the 19th Century: Towards a Genealogy of Risk Society', History and Technology, 23:4, 333 - 350
To link to this article: DOI: 10.1080/07341510701527419
URL: http://dx.doi.org/10.1080/07341510701527419

History and Technology
Vol. 23, No. 4, December 2007, pp. 333–350

Beck Back in the 19th Century: Towards a Genealogy of Risk Society

Jean-Baptiste Fressoz

This article aims at historicizing the 'risk society' thesis (Ulrich Beck). I first present an important book by Eugène Huzar, La Fin du monde par la science *(Paris: Dentu, 1855). The author reflects upon the global catastrophes produced by new technologies and tries to imagine a safer way of governing science and nature. I contextualize this work by providing a series of case studies on various 19th-century technological controversies (ranging from deforestation to vaccination and the chemical industry). I argue that, in every case, what is usually put under the label 'resistance' to progress was in fact crucial for the shaping of safer technologies.*

Keywords: Ulrich Beck; Eugène Huzar; Risk Society; History

There is today an assumption, shared by most thinkers of post modernity that for about two generations we have been experiencing a complete transformation of our relationship with science, progress and risk. The story goes like this: as modern technologies have radically changed the scale of human action, risks have changed in nature; they are global, concern future generations and pose threats to human existence. Consequently, two pillars of industrial society have been undermined. First, the consensus on progress that linked technological achievements and the hope of a better future has been breached and technological choices now depend on the outcome of social conflicts. Second, the capitalist after-the-event management of risk by insurance companies, which socialized the consequences of technological accidents, is rendered inadequate by major global risks that necessitate a new political prudence, summarized by what is known as 'the precautionary principle.'

Landmark writers of social theory have coined labels to name our epoch and express its novelty: 'risk society' as opposed to 'industrial society,' 'reflexive modernization,'[1] 'second modernization,'[2] 'high modernity,'[3] or 'mode II society;'[4] while philosophers have reflected on the recent transformation of the 'nature of human action.'[5] Of

Jean-Baptiste Fressoz is at EUI, Florence, Italy and EHESS, Paris, France. E-mail: jbfressoz@gmail.com

ISSN 0734–1512 (print)/ISSN 1477–2620 (online)
DOI: 10.1080/07341510701527419

course, sociologies and philosophies of risk differ widely in many aspects,[6] but there is a general agreement that technoscience has transformed the question of risk only quite recently.

In this article I would like to challenge the supposed radical novelty of our situation. I believe that the historical narrative underlying contemporary literature on technological risk is (in part at least) a construction which, for the sake of sociological argument, has reduced past risks to somewhat reassuring categories. Contrasting our nuclear and biotechnological times with the old days of coal and steam, when technologies were supposed to be simple enough and the risks local, legitimizes at a theoretical level new forms of political engagement and risk assessment, and the call for democratic participation in technological choices; however, this opposition between a previous society of 'progress' and a new 'risk society' has two main defects. First, it overlooks the polymorphous nature of risk in the 19th century and the perplexities that contemporaries expressed in the face of their new technological powers. Second, it prevents us from understanding that these perplexities, and the social mobilization they fostered, had an essential role for the construction of safer technologies.

The alternative narrative proposed here is an attempt to historicize the 'risk society' thesis and use its hindsight to better understand the relationship between technoscience and society in the 19th century. This is not only a retrospective construction: thinkers of the mid-1850s already discussed modernization in terms of the transformation of risks, and insisted on such concepts as uncertainty, the fallibility of science or man's global responsibility for nature. I will present in some detail the works of a completely though unjustly forgotten philosopher, Eugène Huzar, who wrote two books of great interest, *La Fin du monde par la science* (1855) and *L'Arbre de la science* (1857).[7] Reflecting on the technological shocks of his time (vaccination, steam technologies, railroads, chemical manufacturing, deforestation, transoceanic canals, and so forth) and imagining the future, Huzar prophesized the global disaster that progress entailed. His complete disappearance from our historical knowledge is even more surprising given that, in his time, his arguments aroused great interest and much controversy.

Eugène Huzar's Technological Apocalypse

Huzar's originality lies in his critique of progress founded on technological catastrophism. He is not a romantic writer railing against the ugliness of industrialization. On the contrary, he defends himself from the charge of being in any way reactionary: 'I wage war on neither science nor progress, but I am the implacable enemy of an ignorant science, of a blind progress that walks with no guide and no compass.'[8] According to Huzar, being 'anti-progress' would in any event be useless because it is the driving force of the world. His theory fully integrated the usual discourse of progress: technological advances would accelerate 'as the square law' as society itself became increasingly organized to produce innovations. Knowledge democratization and the increasing interaction between science and industry ('Science makes the industrialist, and in turn, the industrialist makes the savant because every day industry creates new phenomena to observe') would establish the conditions for unlimited technoscientific progress as each worker would be at the same time an experimenter, a scientist and an inventor.[9] National rivalries would cease, races would fuse and one language (French of course) would integrate all other tongues. In short, humanity would be unified in its quest for technological progress.

Nevertheless, after singing the praises of the future, Huzar warned his readers that however powerful science may become, it will always remain *experimental*, that is, it can, by definition, learn only *a posteriori* and therefore cannot anticipate the far-reaching consequences of increasingly powerful technologies. He called this the principle of '*science imprésciente*'; that is, science cannot predict all the results of its own actions. Meditating on railroad disasters caused by unforeseen events that killed many he argued that 'it is impossible for our limited reason to anticipate everything so as to prevent everything … . With the discoveries of science, death is becoming collective. Fatalities used to be sporadic and were of individuals only; now, with science, they are epidemic.'[10]

Consequently, Huzar believed that the gulf between technological ability and limited foresight, as exemplified by the railroad system, would cause the apocalypse. He was actually a very good prophet of doom: he imagined an impressive list of man-made global disasters, some of which seem quite prophetic indeed. For example: 'As man becomes more involved with industry and uses more coal you can predict that in one or two centuries, the world being criss-crossed by railroads and steamboats and being covered by factories and industrial plants, billions of tons of carbon dioxide will be emitted, and as the forests will have been eliminated, these billions of tons of carbon could well trouble a little the world's harmony.'[11] Who knows whether, by extracting ton after ton of coal, man will not change the center of gravity of the Earth and tilt its axis of rotation? Who knows whether, by digging transoceanic canals, man will not cause a perturbation of maritime currents and terrible flooding? But according to Huzar, the best candidate for the apocalypse is a future substance that man would invent, which could set fire to water, burn the oceans, melt the soil and destroy organic life on Earth. Of course, scientists argued that such fears were unfounded, but Huzar proposed that on such important matters the burden of proof should be shifted. Scientists must show that canals, mines, deforestation or any other proposed innovations are perfectly harmless. 'If we are so demanding toward science it is because nowadays science tends to substitute its blind action for nature's; but before doing so, it is necessary to prove that science will do better than nature.'[12]

Modernity, according to Huzar, is characterized by man's feeling of responsibility toward his planet. He systematically compared the Earth to a living body (deforestation as Earth's baldness, mines as aneurisms and so forth). Man's actions were like wounds inflicted on the Earth-as-body:

> I will be told that what man does to nature is like a scratch on the skin of a healthy man. I agree, but who does not know that sometimes a simple scratch can cause death? So it is right to say that the smallest causes can produce the greatest effects. … I would understand that a primitive man … says that the earth is infinite and therefore man cannot disturb its harmony. … But today, with science, this proposition is inverted: it is man who has infinite

> capacities and the planet that is very finite. For us, our planet is limited, very limited. … When one sees something as limited as the earth, and a power as unlimited as man using science, one can only wonder what impact this power will have, one day, on our poor small earth.[13]

The prophylactic measure proposed by Huzar was the global governance of nature and innovation by science. First, a new science 'will have to be created so as to determine and study the laws that govern the globe's equilibrium.'[14] Second, a world council (*édilité planétaire*) should be instituted as the first authority on Earth for 'regulating humanity's work' and 'watching over the globe's harmony.' It will grant authorizations to scientists to perform important experiments, or to nations to deforest, extract coal or cut an isthmus. This breach of national sovereignty was necessary to prevent 'abuses of freedom that would compromise the general harmony.'[15] Huzar's utopia is a 'demo-technocracy': the world governors are to be nominated by their fellow citizens among the elites of science. The world council would work as a global panopticon: based in a major city, its telegraphic network would ensure that 'nothing important in the world could be done without it being informed … . You have to know it: science will be one day the queen of the world, everything will be ruled by her. Her responsibility will become very great; she will have to take care of the world's souls.'[16]

However, Huzar thought that the world council, being guided by experimental science, could only delay rather than prevent the apocalypse. Something different from science had to emerge: a kind of 'prescience' or 'intuition.' He remained rather elliptic on this point because it was supposed to be the subject of a third book (*L'Arbre de vie*), which was never published, but he hinted at a new utopia—the construction of a desirable future that would allow mankind to shape the present and resist the destructive logic of progress, with its tendency to replace nature by artifacts. 'Today the oracles are mute and the world is drifting, without compass, without guide, driven by an irresistible force: progress. … Man needs a conception of the future, which would allow him to shape the present according to such an ideal type.'[17]

Huzar liked to depict himself as a misunderstood prophet: 'This is the defect of all prophecies; the milieu in which they are pronounced is not ready to receive them. … I resign myself to not being understood; [I am] pretty sure that one day this book will reflect everyone's opinion.'[18] 'This book is not for this century.'[19]

In fact Huzar had an excellent sense of timing. 'Progress' was of course the buzzword of the 1850s, but, more specifically, he elaborated his ideas during, and in opposition to, the technophilic craze which anticipated the Universal Exhibition of 1855 in Paris. The publication of *La Fin du monde par la science* in April of that year was timely, for the Exhibition opened on 15 May. As five million visitors went to the *Palais de l'Industrie* to admire all sorts of machines and the press was saturated with eulogies of Progress and Industry, the book was obviously intended to be provocative. It succeeded: every major periodical reviewed it[20] and most of them spoke of it very highly: 'This is the book I have always dreamt of.' 'Mr. Huzar's system does not lack grandeur or truth.' 'This is a completely new system which, although strange, is based on facts.' This first book by an obscure lawyer with some dubious scientific background was unquestionably a great success, and by 1865 it had been through three editions. Celebrated literary and religious figures took some inspiration from it; indeed Lamartine, in his very popular *Cours de littérature,* was accused of having plagiarized Huzar in proposing that Eden was in fact an advanced civilization. Huzar also inspired Père Joseph Félix to deliver in Notre-Dame a series of sermons, attended by the great and good of Paris, concerning the dangers of technological progress without its ethical and Christian counterpart.[21] Huzar tried to repeat his success, and offered a sequel with *L'Arbre de la science* which, although much longer than *La Fin du monde* and somewhat lacking its zeal, nevertheless got excellent reviews. To the renowned numismatist and historian Felix de Saulcy, it was 'one of the most enticing books [he] had ever read,'[22] and the poet Auguste de Vaucelle went so far as to praise 'one of the most remarkable books of this century … a book of capital interest for humanity.'[23] Huzar was not an obscure Cassandra: the French public of the 1850s and 1860s enjoyed his books and his technological catastrophism circulated widely in the middle of a century said to be intoxicated by progress.

From Eugène Huzar to Ulrich Beck

On one point at least, Huzar's prophecy proved to be right: his anxieties concerning technological progress are nowadays our common currency and he could be praised as a precursor of 20th-century technological catastrophism. My reading here, however, will be quite different: even if Huzar's tone and intent are prophetic, he derived many of his arguments from actual technological and environmental disputes he witnessed himself. Rather than being a prophet, Huzar was in fact a critic of mid-1850s technological risk, and the fruitful question that his works invite us to ask is whether the society that Huzar lived in can be analyzed as an early form of risk society.

Ulrich Beck's Risk Society thesis will be my point of reference because he is one of the rare sociologists who has clarified his historical construction and pointed out what he considers to be the fundamental transformations defining post-modern and risk society as opposed to modern and industrial society.[24]

Beck says risks have changed in nature. They used to be natural or sanitary; they are now produced by modernization. They used to be limited in space and time; they are now global and potentially of unlimited duration. They used to be insurable; they now defy any risk calculus. Indeed, their probabilities are minuscule or undeterminable but their potential consequences are limitless. Although scientific expertise is increasingly needed, it is often powerless to foresee the consequences of technological systems, some of which have reached a degree of complexity that renders their behavior undeterminable. Technologies are tested in the real world: technoscience has turned society into a laboratory.

In this process, Beck concludes, industrial and capitalist societies have been deeply transformed. The traditional class divides are remodeled by the environmental conflict: in prosperous post-industrial societies, arguments about the repartition of risks have overshadowed the class struggle over the repartition of wealth. This leads to a 'scientification' of society: as risks become the center of social conflict, expertise plays an increasing political role for it produces the social realization of otherwise insensible threats. Thus the functioning of expertise is becoming a key political issue.

My aim is twofold: I discuss this historical narrative of risk and modernization, and at the same time I use it as a guide to explore the complex territory of technological risk in 19th-century France.

The 'New Risks of the Past': Uncertainty and Catastrophe

To start with, the clear-cut opposition between old natural and sanitary risks and new technological ones is difficult to sustain. Risks often mixed the natural or sanitary with the technological: for instance, the management of miasmas. In 1833, the entrepreneur of the fecal dump of Paris located in the town of Bondy could not get rid of the water and urine that was mixed with the precious fecal matter that he intended to sell to farmers. He decided to use the new technique of 'absorbing wells' to empty the 80,000 square meter basins. The idea was to drill deeper than the water table of the Paris wells so that the fetid liquids (but not the fecal matter) flowed into a permeable layer seventy meters underground. On the first day of its use 200 cubic meters of liquid were absorbed. However, on hearing about this the Prefect of Police ordered the immediate closure of the new well and a sanitary evaluation. At that time, right after the 1832 cholera epidemic, the potential risk of this technology seemed gigantic: no less than a general contamination of the Paris water table and the return of the epidemic. The *conseil de salubrité* of Paris used rather doubtful geologic evidence to show that fears were unjustified because the waters in the deep layers were like torrents which would carry the noxious liquid far away. The 40,000 cubic meters of dilute urine that annually poured into the well could not, they said, do any harm.[25]

Just as epidemics could be man-made, climatic catastrophes were not exogenous, 'natural' events. In the 19th century, trees were conceptualized as the great climatic moderators, 'intermediate siphons between clouds and soil,'[26] regulating humidity, rain and rivers. Thus, both droughts and floods were ascribed to deforestation. During the hot summer of 1800, the *Moniteur Universel* published lengthy articles by the agronomist Cadet de Vaux who blamed the Revolution and the anarchy in forestry that followed: 'we are devoured by drought and science says we must not blame nature but man. By altering Earth's surface we have changed atmosphere and seasons … [our existence] is linked to the fate of forests and therefore to political associations.'[27] Climate was and remains a political issue. In the 1820s, after several bad winters the ultra royalist party blamed the preceding liberal government of mismanaging forests. The Minister of the Interior ordered a nationwide inquiry: elders, farmers and agronomists were asked by mayors about forests, seasons, precipitation and temperatures.[28] When in 1836, at the National Assembly, a law granting the freedom to clear land was proposed, François Arago, the famous deputy and scientist improvised an answer: 'If you authorize land clearance it might be, I don't say it will be, please notice the difference, it might be that one day you may regret it.'[29] After this cautious preliminary, he gave an apocalyptic portrayal of deforestation, which could transform temperate climates into extreme ones, increase the number of hailstorms, transform peaceful rivers into torrents, etc. Given this uncertainty, climatologic research was badly needed and the assembly voted to form a parliamentary committee, chaired by himself.

After the terrible floods of 1855 and 1856, the evils of mountains' deforestation were on every lip. For the popular science magazine *Cosmos*: 'Altitude forests should become, as they used to be, the object of a religious cult.'[30] Subsequently a political consensus was built, which paved the way for the reforestation law of 1860.[31]

If we focus on the new technologies as such we can discern the same concerns about the potential, long term, catastrophic consequences of human actions. Let us take, for instance, the debates that occurred when vaccination began in France in 1800. Opponents of Jennerian vaccine claimed that governments, by advocating general vaccination, played Russian roulette with their population. They argued that vaccinators knew nothing about the long-term effects of their practice because it was analogous to no other existing remedy. Eighteenth-century smallpox inoculation only involved a known disease, whereas the effect of cowpox on the human constitution was completely unknown. The opponents therefore asked for longer and more rigorous clinical experiments before vaccinating hundreds of thousands of children across Europe. For Dr Marcus Herz, two years' experience was completely insufficient. The number of cases was not the point: '50,000 trials or 100,000 trials could not decide the question.' The problem was the long-term consequences. Thus the first thing to do was to stop vaccinating and observe the fate of the vaccinated population. Then, after 8 or 10 years of observation, the results should be published and discussed by the medical world. After that, it might be decided to vaccinate another 100,000 people. Finally, only if vaccination was still considered safe and effective after a generation, with no side-effect on the progeny, should the practice be universalized. Herz could not understand that 'vaccinators without a qualm … expose an entire generation to a procedure that is still experimental … . Great happiness or great sorrow can come out of it.'[32]

The potential disaster linked with vaccination was thought to be not only about body-counts but also about the human constitution itself. Dr Vaumes argued that impure vaccines could transmit hereditary diseases such as syphilis or scrophulas, and so 'propagate its malignant influence over future generations.'[33] Chambon de Montaux, a renowned antivaccinist doctor and mayor of Paris during the Revolution, warned that the matter 'concerned the safety both of our contemporaries and of our descendents.'[34]

The debate on vaccine and degeneration flourished in 1850s France. Hector Carnot, using statistical data, argued that vaccination had changed the laws of mortality, but not for the better. True, life expectancy had increased since the beginning of the 19th century, but for children only. A 20-year-old Parisian man had a life expectancy of 37 at the end of the 18th century, but of only 26 in 1844.[35] Vaccine, Carnot said, was responsible for the change: smallpox killed mainly during infancy, but vaccination allowed the survival of delicate children, thus transferring the burden of death onto the adults. The consequences of such an interference with natural laws were disastrous: the balance between the generations had been disrupted, thus forcing able-bodied workers to support the needs of a proportionately larger population, which in turn had resulted in pauperism and—as Carnot hinted—in the 1848 revolution.[36] Medical explanations of Carnot's statistics drew on the hygienists' observations that typhoid fever and tuberculosis were on the rise: vaccination had simply replaced smallpox by these major new killers. Antivaccinationism was not considered as a medical eccentricity and was voiced by mainstream medical reviews such as *la Gazette des hôpitaux* and *la France médicale*.[37] Indeed, the general public was shocked to find that matters of such crucial importance were still controversial. For Eugène Huzar this 'medical logomachy about vaccine'[38] was symptomatic of the problem posed by a 'science *impresciente*.'

One distinctive characteristic of the 'new risks,' according to Ulrich Beck, is that they cannot be subjected to risk calculus and insurance because they have minute probabilities but potentially unlimited consequences. Therefore the possibility of an accident cannot be admitted, and the politician has to invoke a dogma of technical infallibility so as to legalize these new risks. The management of such a risk was precisely at the center of a controversy that occurred in 1820s Paris concerning the dangers of a gasometer of an unprecedented size: at 200,000 cubic feet it was 10 times bigger than the biggest in London at that time.[39] Its opponents thought that it was simply unconscionable to establish this structure in the French capital. They imagined Paris razed to the ground: 'Six hundred thousand citizens are at the mercy of a single malfunction,' warned one, while another claimed that a million lives could be destroyed through an act of negligence or malice.[40] Even without the inevitable exaggeration, this was obviously a major risk. Opponents of the scheme recalled that in 1794 the explosion of the Grenelle gunpowder manufactory in Paris had caused more than 1000 casualties. The academicians, very much in favor of a technology that they had helped to develop and in which some were financially interested, also acknowledged that an explosion 'would be a disastrous event for the whole neighborhood,' but they immediately added that it was practically impossible. Such a statement failed to reassure the opponents, who subtly employed this small but frightening uncertainty. They pointed out that the actual risk was unknown, and that, in consequence, the insurance companies would insure neither their houses nor the gasholder. They also challenged the government to take moral responsibility for the scientific uncertainty, small as it might be: '[The academicians] told you that the explosion is possible but very improbable, thanks to the measures suggested by science, but we ask you, *Messieurs*, if one or the other might not fail, and if you will have on your conscience such a responsibility?'[41] The answer, as it turned out, was affirmative, but the government imposed very strict technical requirements in order to make the infallibility dogma credible.

Complexity and Unpredictability: Testing Innovations in Society

Entrepreneurial discourse in the 1820s on technological infallibility, even when backed with the government's support and the enforcement of safety norms, soon became outdated as accidents and catastrophes continued. These were increasingly ascribed to the complexity of modern technological systems. For instance, accounts of the early railroad accidents in the 1840s often mobilized the notions of unpredictability and instability to explain the regular and statistical occurrence of accidents, despite safety procedures and strict regulations. In a book paradoxically called *Les Merveilles de l'industrie*, Arthur Mangin explains that railroad disasters are complete mysteries with no ascertainable cause. They are the results of 'minuscule accidents … which should not be attributed to error or incompetence … . They occur in consequence of the inhering causes of the system, which nobody can predict or prevent given its complexity.'[42] Félix Tourneux, a prominent railroad engineer, thought that trains were 'analogous with what the scientists call unstable equilibrium, which the smallest force can disrupt.'[43]

These arguments echoed the scientific and juridical debates which occurred after France's first railway disaster on the 8 May 1842 on the Paris–Versailles line. The Academy of Science debated at length possible explanations for the sudden rupture of the locomotive's axle, which was new and made of good quality iron. Various hypotheses were proposed: metal oxidation, the effect of a magnetic force, a change in the molecular structure of the metal, or vibrations causing micro-cracks.[44] Subsequently the railway company and its officers were charged with manslaughter. During the trial, experts' testimonies were so contradictory that no explanation could be settled upon; therefore no guilt could be demonstrated and no compensation paid, which greatly shocked public opinion. The company's defense, that progress necessitates heroic sacrifice, and that the passengers on the Paris–Versailles line were the worthy sons of the brave of Valmy and Austerlitz, convinced neither the public, who demanded a culprit, nor the public prosecutor, who insisted that engineers and scientists could indulge in heroics, good for them, but not at the expense of passengers.[45]

This ambiguity between the experimental and the commercial phases was also deeply resented by the public in the case of gas lighting. In 1823 one of the rare academicians to oppose the new system insisted that unless one wanted to turn 'every house into a delicate physical instrument,' and every consumer into a careful experimenter, accidents were bound to recur. Even worse, experimental laws could not be easily applied to gasometers. During the 1823 House of Commons enquiry on gas lighting, Humphrey Davy pointed to the gulf between the laboratory and the industrial scales: 'From experiments made on a small scale, it is not possible to reason with perfect confidence when the scale is 100,000 times larger.' In the same way, the circulation of gas under pressure through many miles of pipes was a new and little-understood process. The problem derived from the elasticity of gas, which rendered its flow and pressure irregular. This could cause massive leakage, as in 1840s Paris when approximately 25% of the gas was lost to the atmosphere! Moreover, in the customer's house the flame could become a foot tall or be suddenly extinguished which, of course, posed considerable safety problems. Scientists elaborated complex equations to describe the flow of gas using the gas network as an experimental apparatus, and gave some rules about pipe-laying in order to limit the consequences of the elasticity of gas,[46] but the problem was not solved until the late 1840s when the introduction of '*gazocompensateurs*,' complex technical devices placed along the pipes, enabled a proper regulation of pressure. In the early history of gas lighting, the experimental phase thus largely overlapped the commercial.

The same overlapping occurred in the case of steam technologies, with disastrous consequences for those enginemen who became the victims of explosions. Boilers may seem exemplars of a deterministic system obeying simple natural laws relating pressure to temperature, but in fact, during the first half of the 19th century, the explosion of steam boilers was a baffling mystery for scientists and engineers. If many such explosions could be blamed on worn-out components, or on an engineman who screwed down the safety valve or overheated the boiler, many others remained unaccounted for. The technical literature of the time abounded in theories purporting to explain 'sudden explosions.' For example, boilers sometimes exploded when the pressure and temperature were *decreasing*, and a supposed spheroid state of water was invoked to explain this. According to the somewhat confused theory, in certain conditions the water was 'flying' upon a bubble of overheated steam, and so not in contact with the metal plates of the boiler. If at some point the metal then cooled slightly, the water, no longer supported by a bubble, was brought into contact with the plates and thereupon flashed into steam causing a dramatic explosion.[47] Other theories could involve water foaming in overheated steam, electrical phenomena, the variation of material strength with temperature, the chemical decomposition of water, and much else.

In France, between 1820 and the late 1860s, steam boilers were the subject of both scientific and administrative concern. Arago, Dulong and Regnault tried to establish with greater accuracy the law of pressure at high temperatures in order to devise better regulations. At the same time, a rigorous administrative surveillance of steam boilers was established with a twofold aim: first, to impose throughout France the compulsory regulations that the Academy had devised; and second, to collect data pertaining to explosions. The *ingénieurs des mines* kept a register of steam boilers with all their characteristics, inspected them every year, and above all made very detailed inquiries concerning the circumstances of any explosion. The police were also told to maintain vigilance over steam boilers, their proprietors and their enginemen. At the center of this network an expert body, the *commission des machines à vapeur*, collated all this information. For the French technical administration, the whole industry, every steam boiler and every engineman, constituted a vast laboratory in which types of boilers, different safety devices, and the regulations concerning them could be tested in the real world.

Experts' Definition of Risk, and its Critics

Technological risk also played an important role in the empowerment of institutionalized expertise in early 19th-century France. I will take as an example the Parisian hygienists who organized themselves around the *Conseil de salubrité*, a body of a dozen experts founded in 1802 to advise the Prefect of Police on public health matters.[48] These doctors, pharmacists and chemists argued that industrialization had created many new imperceptible threats (from industrial fumes to food adulteration), which made their expertise vital. Factories' neighbors' perception of risk was generally brushed aside as biased, subjective and self-interested. Contrary to medical doctors—who tended to confirm the fears of their clients—hygienists' knowledge about risk came from a new interdisciplinary approach. The *Annales d'hygiène* (the conseil's review) insisted on the knowledge gap between private doctors and the hygienists: 'An excellent practitioner is useless in the Conseil because important questions can be solved only by mobilizing a wide array of disciplines' ranging from medical topographies, geology, professional medicine, toxicological studies and chemistry.[49] Statistics, in particular, which is a striking feature of the *Annales d'hygiène*, set a boundary between the 'numerically objective' experts of the imperceptible risks and the pre-statistical doctors. It is noteworthy that risk calculus in the first decade of the hygienist movement was more frequently used to undermine danger claims than for the opposite.

Defining imperceptible threats could wield great power. The hygienists considered themselves as new moral authorities: they would draft laws for the industrial age, help people to choose occupations, provide actuaries with the risk data necessary to calculate annuities, and even contribute to social justice by fixing fair salaries by reference to the occupational risks. On the question of industrial pollution they were, as Darcet and Parent-Duchatelêt put it, 'the arbiters, the real judges whose advice can determine the fortune of an industrialist or the well-being of a whole neighborhood.'[50]

However, criticisms founded on alternative models for risk definition flourished. The Enlightenment's discourse of the public sphere—that is the public space of critical discussion—was often mobilized in technological controversies to criticize expertise. It was argued that the public was the only impartial and disinterested body. For example, when the official *Comité de vaccine* was accused of concealing the existence of vaccine contaminations, Vaumes proposed the setting-up of an 'independent jury' composed of '*honnêtes hommes*' who could 'impartially assess the facts.'[51] Doctors were to be excluded as they were already too implicated in the case.

During the Parisian gas lighting controversy, public debate was praised for producing *better* knowledge than specialized expertise, because it involved a greater variety of competencies and personnel. Clement-Désormes, a prominent chemist, advocated a kind of 'democratic technology assessment.' He compared the progress of civilization to a series of immensely risky bets and 'only public debate, which attracts the attention and participation of many people, can produce a sound decision. Most of the time … inventions [are] considered only from the technical point of view; their worth to society is ignored … Public discussions would have the immense advantage of uniting in the same spirit all the ideas indispensable for good judgment.'[52]

In the second half of the century, imperceptible risks fostered a general distrust of experts and administrators, who were accused of concealing vital information from the public. Popular medical reviews such as Raspail's heterodox *Manuel annuaire de santé* were keen to publish stories about industrial poisoning and hygienists' carelessness. In 1862, a virulent book against 'industrial poisons' warned the public 'about the misdeeds of industry,' which threatened the health of both present and future generations by allowing dangerous chemicals such as arsenic, white lead, mercury, and phosphorus to proliferate.[53] This *fin de siècle* climate of suspicion was linked to the development of organic chemistry. The only remedy was public self-organization. Raspail wanted to 'teach suspicion' to the reader, who should become knowledgeable about his own body, testing on himself the effects of different dietary regimes and by elimination discovering which food was contaminated. Raspail's denunciation was not isolated: popular manuals on food adulteration teaching simple chemical analysis proliferated. In 1889 a private *Société générale de contrôle et de garantie alimentaires* was founded, which performed chemical analysis and delivered labels of quality.[54] In Paris, neighbors agreed upon small commercial networks of trustworthy producers and retailers.

The most dangerous rivals for administrative expertise were probably the civil courts. In the case of industrial pollution, the way civil courts handled expertise was particularly appreciated by complainants because they could choose their own experts, attend experiments and propose different ways of measuring and tracing the pollution, making the expertise more reflective of their own experience of living in a polluted environment. The result was that many civil courts' judgments contradicted administrative decisions by imposing high fines on factories that government hygienists had authorized.

Risk and Social Conflict

Historians have recently started to study environmental conflicts, the records of which abound in administrative and judicial archives. As Beck argues, they seem to cut across the capitalist social order. For the *conseil de salubrité* of Paris this was a 'war between property and industry' and thus an 'absurd antagonism between capital and capital.' Indeed, until the 1860s at least, the workers' movement did not address questions of health hazards. My analysis of three working-class newspapers of the 1840s (*L'Atelier*, *l'Echo de la fabrique*, and *l'Artisan*) returned very few articles about these issues and the few that do exist (about lead poisoning mainly) echo the external debates of the hygienists. Various strategies were used to prevent workers mobilization against health hazards. White lead manufacturers in the early 19th century generally employed ex-convicts, single, syphilitic men whose diseases were more difficult to impute to their occupation and of little social consequence.[55] The chemical manufactures could also import foreign workers to perform the most dangerous tasks. By 1820, of the 72 workers in Chaptal's factory at Istres, near Marseilles, 34 were Genovese. At the end of the century in Istres, out of a population of 7000, 1078 were foreigners, mainly Armenians and Kabyles employed in the chemical industry.

To show how pollution segmented local communities, I will take as an example the alkali industry around Marseilles.[56] In the early 19th century, the hydrochloric fumes caused by soda manufacturing damaged vineyards and olive trees for miles around. Cultivators were enraged. Popular unrest loomed. In 1816 the Prefect put the leaders in jail and sent the gendarmes to guard the factories. As the administration sided with the industrialists, the countryside organized an impressive judicial battle. In the 1820s approximately 10% of all civil cases in the Marseilles and Aix tribunals were actions against chemical manufacturers. Some lawyers created a business *ab initio* out of these trials by persuading small farmers to sue the chemical companies and advancing the money for the court fees in exchange for a share of the damages that the companies would be required to pay. Chemical factories successfully divided the rural population. In Istres there were two clans: the *plouvino* ('white frost' in *Provençal*), composed of landlords and small farmers, and the *fumado* ('smoke'), composed of factory workers. Each group had its own church, its own shops and its own local festivals. Political life revolved around this conflict, the mayor being either the director of the factory or a big landlord.

In each community where factories were located there was a kind of contest between social and technological forces: who was to adapt to whom? In Septêmes, social mobilization took on an exceptional intensity and went far beyond the question of lost harvests. Health was invoked at first, with little success because parish records did not show a clear increase of the mortality rate. Ultimately it was arguments invoking air quality, water purity and the beauty of the landscape, arguments analogous in many ways to our contemporary notion of the environment, which served as the judicial weapon against the chemical manufactures. For the opponents of acid fumes, landscape was laden with sentiment. Pollution equated family properties desecration and humiliation. In 1819 a group of erudite writers created a literary review named *La Ruche provençale* in which they sang the beauties of Provence. However, these very same authors wrote pamphlets and court depositions against the factories, and thus provided opponents of industry with a powerful rhetoric: they described the country around Septêmes as a waste land where 'spring would not return,' acid fumes having performed a 'general castration.' Desertification was looming: the region would little by little be transformed into a 'desert of charred rocks … one monument only with the inscription "HERE WAS SEPTÊMES" would recall the name of the region.'[57]

In any case, Septêmes landlords argued that even if they received compensation for the damage to their crops, they still suffered *moral damage*. The environment received a juridical consecration when in 1826, after virulent debates, the Cour Royale d'Aix, contradicting the Conseil d'Etat's jurisprudence, acknowledged the existence of *moral* damage. In consequence, compensation skyrocketed, as major landlords could receive up to 80,000 francs for moral damage plus annual fees amounting to several thousand francs. At a lower level, expertise was astutely instrumentalized by opponents of the factories (under the benevolent eyes of the judges): they asked the expert to perform a great number of chemical experiments in order to make the expertise very expensive for the industrialists who were condemned to pay the court fees. In some cases, damages of a few francs were awarded on the basis of an expert report of a hundred pages costing over a thousand francs!

All in all, given the price of polluting, it appeared that a technique of condensing the hydrochloric fumes might be financially attractive. Famous Parisian engineers and chemists (Péclet and Clément-Désormes) were commissioned to devise such a means of condensation, but with no success. It was a Septêmes manufacturer named Rougier who designed a somewhat awkward but nevertheless efficient apparatus which required half-mile-long tunnels to be dug in the chalk hills surrounding the factories: the hydrochloric acid fumes were trapped by the chalk. However, the process eroded the tunnels which therefore had to be rebuilt every two years.[58] In fact, being expensive, the condensation scheme lasted only as long as the local community was vigilant and prepared to sue the industrialists for damages. Elsewhere alkali manufactories continued to pollute just as before and the community dissolved under acid rain.

Conclusion: Historicizing the Risk Society and Politicizing the History of Technology

As the heteroclite ensemble of technologies, controversies and catastrophes that we have touched upon testifies, risk society is probably not a radically new phenomenon in the history of mankind. From this starting point, research can go in several directions. First, acknowledging that risk society has a past obviously calls for a rethinking of what is really changing in the relationship that our contemporary societies have with technoscience. Second, in contemporary debates about technological risk, historians could bring an essential input: hindsight. Since they can objectify risk they could propose a kind of 'retrospective technological assessment'. Which organization of expertise produced better risk assessment? Which regulation (through technical norms, the judiciary or insurance companies, etc.) was most efficient? Historians can also study the degree of 'malleability' of technologies in risky and controversial environments. Taken in the long run, innovations do not appear as external essences that society has to accept or refuse, they can assume quite different shapes according to the nature of the regulations that surround them. Hence what in history of technology is traditionally put in the footnotes, under the label of 'opposition' or 'resistance' to progress turns out to be essential for the 'shaping' of safer technological systems.[59] Finally, from a broader perspective, history of technological risk would become political history. Not in the traditional sense of government and party politics, or not even in the sense of the political disputes about technologies and environment, but in the sense of the progressive composition of the political 'collectives' that comprehend both humans and non humans.[60] Indeed, by focusing on dangers we can trace the (unpredicted) networks which link the many entities that are affected and mobilized by innovations. In this perspective, history of technology would neither be a history of progress (nor a history of its 'dark side') but a history of the growing interlacing of the technical, the natural and the social, that is a genealogy of our present experience as technologized humans living on a technologized planet.

Notes

[1] Beck, *Risk Society*.
[2] Giddens, *Modernity and Self Identity*.
[3] Luhmann, *Risk: A Sociological Theory*.
[4] Nowotny *et al.*, *Re-Thinking Science*.
[5] Jonas, *The Imperative of Responsibility*.
[6] Proposals vary from a democratization of technoscience and expertise (Rip, *Managing Technology in Society*), the heuristics of fear (Jonas, *The Imperative of Responsibility*; Dupuy, *Pour un catastrophisme éclairé*) to a complete renewal of our cosmopolitics (Serres, *The Natural Contract*; Latour, *Politics of Nature*).

[7] Huzar, *La fin du monde*; Huzar, *L'arbre de la science*. Eugène Huzar seems to have cultivated eclectic interests. His books are full of references to science, medicine, politics, philosophy and religion. He mentions going to courses at the Conservatoire des arts et métiers and attending chemical experiments. Well versed in the symbolism of religions, he takes pleasure in showing the similarities between different mythologies. For example, since many religions across the globe share the idea of a fall of man because of his hubris, they must refer to the same actual event, that is according to his system, a global disaster caused by science. Furthermore, Huzar argued that history is cyclical and that in the nineteenth century mankind was once again approaching Eden and its calamitous conclusion. Politically he was a fervent republican: against Louis Napoléon Bonaparte, he published in 1850 a bill proposing that the National Assembly move to Bourges so as to resist a possible usurpation. He also read many socialist authors, in particular Charles Fourrier and his important essay 'Détérioration matérielle de la planète.'

[8] Huzar, *L'arbre de la science*, 40.

[9] Huzar, *La fin du monde*, 32.

[10] Huzar, *L'arbre de la science*, 129–31.

[11] Ibid., 106.

[12] Ibid., 110.

[13] Ibid., 112–3.

[14] Ibid., 275.

[15] Ibid., 277.

[16] Ibid., 278.

[17] Ibid., 70.

[18] Huzar, *La fin du monde*, 24.

[19] Ibid., 162.

[20] Among others: *l'Illustration*, *le Courrier*, *l'Athénaum*, *l'Artiste*, *la Revue française*, *la Revue de Paris*, *l'Organe de l'industrie*, *l'Univers*, *le Moniteur*, *la Gazette de France*, *La Revue Britannique*, *le Siècle*. The book was also reviewed in Britain: 'All up with every thing', *Household Words*, 318, 25 April 1856, 336–9.

[21] *Courrier de Paris*, 21 October 1857. See: Lamartine, *Cours familier de littérature*; Félix, *Le Progrès par le christianisme*. Other Huzar's legacies could well be Jules Verne's novels: *Sans dessus dessous* and *l'Eternel Adam*, which describe catastrophes similar to Huzar's.

[22] *Courrier de Paris*, 21 October 1857.

[23] *L'Artiste*, 9 August 1857.

[24] Beck, 'From Industrial Society.'

[25] Girard and Parent-Duchatelet, 'Des puits forés ou artésiens;' Barles, *La Ville délétère*.

[26] Rauch, *Harmonie hydrovégétale et météorologie*, 1, 12. On Rauch's natural networks see: Larrère, 'Les utopies de François Antoine Rauch.' The history of the forest–climate relationship (which can be traced back to Theophrastus of Erasia) is yet to be written. Since the 17th century at least, one can find such anxieties regularly voiced by the French provincial Parliaments. For a good treatment of this problem in the 18th century tropical and colonial setting see: Grove, *Green Imperialism*.

[27] Cadet de Vaux, 'Observations sur la sécheresse actuelle.'

[28] *Procès-Verbaux de l'Académie des sciences*, 16 February 1824.

[29] Arago, *Œuvres complètes*, 12, 432.

[30] *Le Cosmos*, 11 July 1856.

[31] For a social history of forest management see: Corvol, *L'Homme au bois*; Kalaora and Savoye, *Forêt et sociologie*.

[32] Herz, 'L'inoculation brutale.'

[33] Vaumes, *Les dangers de la vaccine*.

[34] Chambon de Montaux, *Comparaison des effets de la vaccine*, 128

[35] Bertillon refuted Carnot's use of mortality tables. See: Bertillon, *Conclusions statistiques*.

[36] Carnot, *Essai de mortalité comparée*.

[37] Modern histories of vaccination often describe it as such. See: Darmon, *La longue traque*. Antivaccinationism in France never gained the impetus it had in England. For England see Durbach, *Bodily Matters*.
[38] Huzar, *L'arbre de la science*, 124.
[39] Fressoz, 'The Gas Lighting Controversy.'
[40] Nodier and Pichot, *Essai critique sur le gaz hydrogène*, 4.
[41] *Des dangers de l'existence des gazomètres en ville*, 7.
[42] Mangin, *Les merveilles de l'industrie*, 216.
[43] Tourneux, *Encyclopédie des chemins de fer*, 3.
[44] *Comptes rendus de l'Académie des sciences*, 15, 1842.
[45] Lan, *Les chemins de fer français*, 99; Stemmelen, 'Une catastrophe technologique,' 309.
[46] Girard, *Mémoire sur l'écoulement uniforme*; Navier, 'Sur l'écoulement des fluides élastiques'.
[47] Arago, *Œuvres complètes*, 5, 117–77; Boutigny, *Etudes sur les corps à l'état sphéroïdal*.
[48] On the conseil de salubrité, see: Corbin, *The Foul and the Fragrant*; LaBerge, *Mission and Method*; Guillerme, *Dangereux, insalubres et incommodes*.
[49] Parent-Duchatelêt, 'Quelques considerations,' 1833, 249.
[50] Parent-Duchatelêt and Darcet, 'Sur les véritables influences,' 1829, 170.
[51] Vaumes, 'Mémoire confidentiel sur la vaccine.'
[52] Clément-Desormes, *Appréciation du procédé d'éclairage*.
[53] Raspail, *Appel urgent*.
[54] Bravais, *De l'alimentation hygiénique*. On the birth of the 1905 Food Regulation, see: Stanziani, *Histoire de la qualité alimentaire*.
[55] Bréchot, 'Mémoire sur les accidents.'
[56] Smith, *The Origins and Early Development*; Daumalin, *Du sel au pétrole*.
[57] Mémoire et consultation contre les sieurs Mallez, 1818.
[58] De Villeneuve, 'Des condensateurs des fabriques de soude,' 129.
[59] MacKenzie and Wajcman, *The Social Shaping of Technology*.
[60] Latour, *Politics of Nature*.

References

Arago, François. *Œuvres complètes.* Paris: Gide, 1859.

Barles, Sabine. *La ville délétère.* Paris: Champs Vallon, 1999.

Beck, Ulrich. 'From Industrial Society to Risk Society.' *Theory, Culture & Society*no. 9 (1992): 97–123.

——. *Risk Society: Towards a New Modernity.* London: Sage, 1992 (first published 1984).

Bertillon, Louis-Adolphe. *Conclusions statistiques contre les détracteurs de la vaccine.* Paris: Masson, 1857.

Boutigny, Pierre-Hyppolite. *Etudes sur les corps à l'état sphéroïdal, nouvelle branche de physique.* Paris: Masson, 1857.

Bravais, Raoul. *De l'alimentation hygiénique. Société générale de contrôle et de garantie alimentaires.* Paris: imprimerie des chemins de fer, 1889.

Bréchot, Fils. 'Mémoire sur les accidents résultant de la fabrication de la céruse', *Annales d'hygiène publique,* 12 (1834): 73–80.

Cadet de Vaux, Antoine-Alexis. 'Observation sur la sécheresse actuelle, ses causes et les moyens de prévenir la progression de ce fléaux.' *Moniteur Universel,* 26 August 1800.

Carnot, Hector. *Essai de mortalité comparée avant et depuis l'introduction de la vaccine en France.* Autun: Dejussieu, 1849.

Chambon de Montaux, Nicolas. *Comparaison des effets de la vaccine avec ceux de la petite vérole inoculée par la méthode des incisions.* Paris: Pillet, 1821.

Clément-Desormes, Nicolas. *Appréciation du procédé d'éclairage par le gaz hydrogène du charbon de terre.* Paris: Delaunay, 1819.

Corbin, Alain. *The Foul and the Fragrant. Odor and the French Social Imagination.* Cambridge, MA: Harvard University Press, 1986.

Corvol, Andrée. *L'homme au bois: histoire des relations de l'homme et de la forêt, XVIIe–XXe siècle.* Paris: Fayard, 1987.

Des dangers de l'existence des gazomètres en ville. A messieurs les conseillers du roi pour les propriétaires-opposans à l'etablissement du gaz hydrogène, formé dans le faubourg Poissonnière, par M. Pauwels. Paris: Gueffier, 1823.

Darmon, Pierre. *La longue traque de la variole.* Paris: Perrin, 1985.

Daumalin, Xavier. *Du sel au pétrole.* Marseille: Tacussel, 2003.

De Villeneuve, H. 'Des condensateurs des fabriques de soude.' *Annales des sciences et de l'industrie du midi de la France* no. 6 (1832): 129–46

Dupuy, Jean-Pierre. *Pour un catastrophisme éclairé: quand l'impossible est certain.* Paris: Seuil, 2002.

Durbach, Nadja. *Bodily Matters: The Anti-Vaccination Movement in England, 1853–1907.* Durham, NC: Duke University Press, 2005.

Félix, Père Joseph. *Le progrès par le christianisme, conférences de notre dame de Paris.* Paris: A. Le Clère, 1858.

Fourrier, Charles. 'Détérioration matérielle de la planète.' *La Phalange, revue de la science sociale,* 6 (1847): 401–40.

Fressoz, Jean-Baptiste. 'The Gas Lighting Controversy. Technological Risk, Expertise and Regulation in Nineteenth-Century Paris and London.' *Journal of Urban History,* 33 (2007): 729–55.

Giddens, Anthony. *Modernity and Self Identity: Self and Society in the Late Modern Age.* Cambridge: Polity Press, 1991.

Girard, Pierre-Simon. *Mémoire sur l'écoulement uniforme de l'air atmosphérique et du gaz hydrogène carboné, dans des tuyaux de conduite lu à l'Académie des sciences le 12 juillet 1819.* Paris: Feugueray, 1819.

—— and Alexandre Parent-Duchatelet. 'Des puits forés ou artésiens pour l'évacuation des eaux sales et infectes.' *Annales d'hygiène publique et de médecine légale* 10 (1833): 317–56.

Grove, Richard H. *Green Imperialism, Colonial Expansion, Tropical Island Edens and the Origins of Environmentalism, 1600–1800.* Cambridge: Cambridge University Press, 1995.

Guillerme, André, Gérard Jigaudon and Anne-Cécile Lefort. *Dangereux, insalubres et incommodes: paysages industriels en banlieue parisienne, XIXe–XXe siècles.* Paris: Champs Vallon, 2005.

Herz, Marcus. 'L'inoculation brutale,' *Archives de l'Académie de Médecine,* Paris, Box V1.

Huzar, Eugène. *La fin du monde par la science.* Paris: Dentu, 1855.

——. *L'arbre de la science,* Paris: Dentu, 1857.

Jonas, Hans. *The Imperative of Responsibility, in Search of an Ethics for the Technological Age.* Chicago, IL: University of Chicago Press, 1979.

Kalaora, Bernard and Antoine Savoye. *Forêt et sociologie, les forestiers de l'école de Le Play, défenseurs des populations de montagne (1860–1913).* Paris: INRA, 1984.

LaBerge, Ann. *Mission and Method: The Early Nineteenth-Century French Public Health Movement.* Cambridge: Cambridge University Press, 2002.

Lamartine, Alphonse de. *Cours familier de littérature.* Paris: Didot, 1857: 2, Entretien 12.

Lan, Jules. *Les chemins de fer français devant leurs juges naturels.* Paris: Librairie internationale, 1867.

Larrère, Raphaël. 'Les utopies de François Antoine Rauch. Où comment sortir de la physiocratie tout en maintenant l'homme dans la nature.' In: *Nouvelles Sciences. Modèles techniques et pensée politique de Bacon à Condorcet,* edited by Frank Tinland. Paris: Champs Vallon, 1998.

Latour, Bruno. *Politics of Nature: How to Bring the Sciences into Democracy.* Harvard: Harvard University Press, 2004.

Luhmann, Nicklas. *Risk: A Sociological Theory.* New York: De Gruyter, 1991.

MacKenzie, Donald and Judy Wajcman. *The Social Shaping of Technology.* Buckingham: Open University Press, 1999 (first published 1985).

Mangin, Arthur. *Les merveilles de l'industrie, machines à vapeur, bateaux à vapeur, chemins de fer.* Tours: Mame & Cie, 1858.

Massard-Guilbaud, Geneviève. *Histoire de la pollution industrielle en France, 1789–1914.* University of Clermont-Ferrand Thesis, 2004.
Navier, Claude Louis-Marie. 'Sur l'écoulement des fluides élastiques dans les vases et les tuyaux de conduits.' *Annales des mines* 6 (1829): 371–442.
Nodier, Charles and Amédée Pichot. *Essai critique sur le gaz hydrogène.* Paris: Gosselin, 1823.
Nowotny, Helga, Peter Scott and Michael Gibbons. *Re-Thinking Science. Knowledge and the Public in an Age of Uncertainty*. London: Polity Press, 2001.
Parent-Duchatelêt, Alexandre, 'Sur les véritables influences que le tabac peut avoir sur la santé.' *Annales d'Hygiène publique,* 1829, 169–277.
Raspail, François-Vincent. *Appel urgent contre les empoisonnements industriels qui compromettent de plus en plus la santé publique et l'avenir des générations.* Paris: Rue du Temple, 1863.
Rauch, François. *Harmonie hydrovégétale et météorologie, ou Recherches sur les moyens de recréer avec nos forêts la force des températures et la régularité des saisons.* Paris: Levrault, 1801.
Rip, Arie. *Managing Technology in Society. The Approach of Constructive Technology Assessment.* London: Pinter, 1995.
Serres, Michel. *The Natural Contract.* Ann Arbor, MN: University of Michigan Press, 1995.
Smith, John Graham. *The Origins and Early Development of the Heavy Chemical Industry in France.* Oxford: Clarendon Press, 1979.
Stanziani, Alessandro. *Histoire de la qualité alimentaire, XIXe-XXe siècles.* Paris: Seuil, 2005.
Stemmelen, Hélène. 'Une catastrophe technologique au XIXe siècle à travers le journal le Temps.' *Culture technique* 11 (1983): 309–15.
Tourneux, Félix. *Encyclopédie des chemins de fer et des machines à vapeur à l'usage des praticiens et des gens du monde.* Paris: Renouard et cie, 1844.
Vaumes, Jean-Sébastien. *Les dangers de la vaccine.* Paris: Guiget, 1800.
——. 'Mémoire confidentiel sur la vaccine.' *Archives de l'Académie de médecine,* Box V1, 1806.