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Indice / Summary

Antoine Picon. Short biography

Antoine Picon is the G. Ware Travelstead Professor of the History of Architecture and Technology and Co-Director of Doctoral Programs (PhD & DDes) at the GSD. He teaches courses in the history and theory of architecture and technology. Trained as an engineer, architect, and historian, Picon works on the history of architectural and urban technologies from the eighteenth century to the present.

His *French Architects and Engineers in the Age of Enlightenment* (1988; English translation, 1992) is a synthetic study of the disciplinary «deep structures» of architecture, garden design, and engineering in the eighteenth century, and their transformations as new issues of territorial management and infrastructure-systems planning were confronted. Whereas *Claude Perrault (1613-1688) ou la Curiosité d'un classique* (1988) traces the origin of these changes at the end of the seventeenth century, *L'invention de l'ingénieur moderne. L'École des Ponts et Chaussées 1747–1851* (1992) envisages their full development from the mid-eighteenth century to the 1850s. Picon has also worked on the relations between society, technology and utopia. This is in particular the theme of *Les Saint-Simoniens. Raison, imaginaire et utopie* (2002), a detailed study of the Saint-Simonian movement that played a seminal role in the emergence of industrial modernity. Picon's most recent book, *Digital Culture in Architecture: An Introduction for the Design Profession* (2010) offers a comprehensive overview and discussion of the changes brought by the computer to the theory and practice of architecture.

Picon has received a number of awards for his writings, including the Médaille de la Ville de Paris and twice the Prix du Livre d'Architecture de la Ville de Briey, a well as the Georges Sarton Medal of the University of Gand. In 2010, he was elected a member of the French Académie des Technologies.

Picon received engineering degrees from the École Polytechnique and from the École Nationale des Ponts et Chaussees, an architecture degree from the École d'Architecture de Paris-Villemin, and a doctorate in history from the École des Hautes Etudes en Sciences Sociales.

Antoine Picon. Profilo biografico

Antoine Picon è professore di Storia dell'Architettura e della Tecnologia presso la cattedra G. Ware Travelstead e co-direttore dei programmi di Dottorato alla Harvard Graduate School of Design (GSD). Attivo come ingegnere, architetto e storico, Picon studia la storia delle tecnologie architettoniche e urbane dal XVIII secolo a oggi.

Il suo *Architectes et ingénieurs au siècle des lumières* (1988) è uno studio sintetico delle «strutture profonde» della disciplina dell'architettura, del progetto del paesaggio e dell'ingegneria nel XVIII secolo, oltre che uno studio comparativo delle loro trasformazioni nelle nuove istanze di controllo del territorio e di pianificazione delle infrastrutture. Se il volume *Claude Perrault (1613-1688) ou la Curiosité d'un classique* (1988) traccia l'origine di questi cambiamenti, alla fine del XVII secolo, *L'invention de l'ingénieur moderne. L'École des Ponts et Chaussées 1747–1851* (1992) analizza il loro pieno sviluppo a partire dalla metà del XVIII secolo sino al 1850. Picon ha inoltre indagato le relazioni tra la società, la tecnologia e l'utopia. Si tratta, in particolare dell'argomento centrale in *Les Saint-Simoniens. Raison, imaginaire et utopie* (2002), uno studio dettagliato del Sansimonismo, movimento che ha svolto un ruolo fondamentale nella nascita della modernità industriale. Il libro più recente di Picon, *Digital Culture in Architecture: An Introduction for the Design Profession* (2010) offre una panoramica completa e una discussione approfondita sui cambiamenti introdotti dal computer nella teoria e nella pratica dell'architettura.

Picon ha ricevuto numerosi premi per i suoi scritti, tra cui la *Médaille de la Ville de Paris* e due volte il *Prix du Livre d'Architecture de la Ville de Briey*, oltre alla Medaglia George Sarton dell'Università di Gand, mentre nel 2010 è stato eletto membro della Académie des Technologies.

Picon si è laureato in Francia, in ingegneria presso *l'École Polytechnique* e *l'École Nationale des Ponts et Chaussées*, in architettura presso l'*École d'Architecture de Paris-Villemin*, e ha conseguito il dottorato in storia presso l'*École des Hautes Études en Sciences Sociales*.

Towards a History of Technological Thought[1]

by Antoine Picon

Technological Systems and Technological Thought.

To study the broad canvas of technological change, it is necessary to understand what exactly is changing, and to characterise the general equilibria that massive innovations upset. Technological change cannot be described only as a succession of controversies and minute adaptations, of the kind that the sociology of knowledge takes most of the time into account. Technological change is also the result of global displacements that one can best interpret with the help of the notion of technological system. Historians have proposed various definitions of this notion. But two definitions seem to me especially significant. They are at once complementary in their approach to technological regulations and to technological change seen as system shift.

The French historian Bertrand Gille gave the first of my two definitions in a general survey of the history of technology. Struck by the fact «that within some limits, as a very general rule, all techniques are, to various degrees, depending on one another, so that there should be some coherence between them»[2], Gille tried to define and describe this coherence. He began by considering elementary structures corresponding to what he called «a single technical act», such as the use a tool with the gestures attached to it, or the utilisation an individual machine designed for a specific aim. At a different level, he introduced technological sets as combinations of structures meant to achieve larger goals, such as the production of iron in a blast furnace. Those sets were in their turn part of broader entities, called by Gille technological ways – in French «*filières techniques*» –, such as the process leading from the mine to the blast furnace. On this analysis, a technological system could then be defined as «the coherence, at different levels, of all the technical structures, of all the technological sets and ways»[3] that coexist at a time. Looking back at the historical development of technology and using his definition of technological

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[1] Article published in *Technological change. Methods and themes in the history of Technology*, edited by Robert Fox, Harwood Academic Publishers, London 1996, pp. 37-49.

[2] BERTRAND GILLE, *Prolégomènes à une histoire des techniques*, in *Histoire des techniques,* edited by B. Gille, Gallimard, Paris 1978, pp. 1-118, on p. 19.

[3] B. GILLE, *Prolégomènes*…, cit., p. 19.

system, Gille made for example a crucial distinction between the age of «classical systems», centred on the use of water and wood, and the first industrial system based on steam, coal and iron. In this perspective, major technological changes, such as the first industrial revolution of the late eighteenth and the first half of the nineteenth century, appeared as transitions leading from one system to another.

French historians drawn heavily on Gille's approach. But though it is stimulating, his conceptual frame is difficult to relate to more socially oriented studies of technology and technological change. In filling the gap between Gille's systemic conception and the precise analyses of individual institutions and professions, Thomas P. Hughes's definition of technological systems provides with useful tools[4]. His definition is meant to establish a strong link between a technical basis and the institutional and professional organisations that create and run it. It has enabled him to describe the development of electrical power in the Western world in a very convincing way[5]. Since Hughes's work is well known among Anglo-Saxon historians of technology, it does not require lengthy presentation. Less global than Gille's systems, Hughes' technological systems are perhaps less closely constructed since they include heterogeneous realities such as human organisations and technical artefacts. What they lack in the field of conceptual closeness is nevertheless amply counterbalanced by their empirical fecundity.

The approaches of Gille and Hughes represent major contributions to the history of technology. In my paper, I should like to propose an addition to these two approaches by taking into account technological thought and its evolution, especially the collective mental frames to which actors of production, such as managers, engineers or workers, are referring to when they think and act. As I shall try to show, those mental frames characterise types of knowledge and reasoning as well as types of behaviour. They give birth to representations and patterns of thought, which apply, at various levels, to very different kinds of realities. There are, for example, very general representations of efficiency, based on associated interpretations of nature and society, and there are more specific representations of the organisation and the techniques of production. Mixing energy with social reflections, the modern concept

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[4] THOMAS P. HUGHES, *The Evolution of large technological systems,* in *The Social construction of technological systems,* edited by Wiebe E. Bijker, T.P. Hughes, 1987, re-issue MIT Press, Cambridge, Massachusetts 1990, p. 51-83.

[5] T.P. HUGHES, *Networks of power. Electrification in western society 1880-1930,* John Hopkins University Press, Baltimore 1983.

of work is a typical product of the first kind of representation[6]. There are at the same time patterns that apply to supervision of workers whereas others influence problems of design.

The main purpose of my work on technological thought is to suggest a close relationship between such collective mental frames and the notions of coherence on which Gille's technological systems are founded. At the same time, those mental frames have to relate technical bases to the forms of institutional and professional organisation in which they are realised. They play a role in the construction of Hughes' systems. It follows that their evolution is part of the major technological changes. In some recent research, I have tried to show how the transformation of the engineers' mental references influenced the process that led France from the end of the classical age into the industrial era[7]. The main part of this article will deal with that specific example and with the lessons that can be drawn from it. By way of preliminary, to precise my type of approach, I begin, however, with some general views on technology and technological thought as a way of clarifying my general approach[8].

Technology, Nature, and Society

Many contemporary historians, from David Landes to François Caron, define technology as a form of social production. At the same time, one must not forget that technology deals with nature. More accurately, it provides an interpretation of nature in connection to the social division of labour. Technology is meant to adapt this division of labour to the principles of efficiency that can be drawn from the observation of the physical world. Those principles are partly the result of mental constructions and representations. There is no universal nature, no enduring principles of efficiency, rather there are historically determined representations of nature and of the principles of efficiency that derive from them[9]. Until the eighteenth

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[6] See ANSON RABINBACH, *The Human motor. Energy, fatigue and the origins of modernity*, University of California Press, Berkeley, Los Angeles 1992, as well as below.

[7] A. PICON, *L'Invention de l'ingénieur moderne. L'École des Ponts et Chaussées 1747-1851,* Presses de l'École nationale des Ponts et Chaussées, Paris 1992. Some of the themes studied in this book are also dealt with in A. PICON, *French architects and engineers in the age of the enlightenment,* English translation, Cambridge University Press, Cambridge 1991.

[8] I have recently developed the theoretical bases of my approach of the history of technological thought and engineering in A. PICON, *Pour une Histoire de la pensée technique. Rapport pour l'habilitation à diriger des recherches*, EHESS, Paris 1993.

[9] In this respect, I suscribe entirely to the approach of nature developed by contemporary sociology of

century and the start of the first industrial revolution, the principle of automatic working was synonymous, for example, with transmission of movement. Engineers such as the famous Renaissance designer Francesco di Giorgio conceived chiefly cinematic devices. With the development of steam engine, automatic working became synonymous with production and transmission of energy during the nineteenth century[10]. It has changed again recently to correspond to the circulation of information. Through this kind of evolution, it seems that technology is continually trying to humanise nature by appropriating it to human needs and concerns. It attempts at the same time to naturalise society by adapting the alleged natural principles of efficiency to the organisation of production.

The history of technological thought must take into account the simultaneous representations of nature and of society. The major transformations of technological thought correspond to changes in those representations. For instance, the evolution of French eighteenth-century engineering was linked to a global change in the interpretation of the physical world and the construction of nature it led to. The eighteenth century vision of nature no longer focused on architectonic regularities. It became more and more centred on the natural dynamism of things and beings. Such a change was also linked to a new approach to society and to the role technology was supposed to play in human destiny. In the Enlightenment period, the idea of a collective progress was taking shape. Technological development and social progress seemed more and more closely related.

Technological Thought and Rationality.

Technological thought is a complex system functioning at different levels. For each actor of production, it comprises a set of know-how and interiorised rules of decision and action. Know-how plays a role in the worker's manual skill as well as in the engineer's design or in the manager's decision process. Technological thought also includes formalised knowledge such as mechanics, physics or chemistry for the engineer; lastly it embraces themes and representations which belong to an imaginary sphere. The common obsession of engineers with fluidity has clearly something to do with the imaginary. These various levels overlap. The ideal of automatic working appears for example at the intersection of the known and the imaginary.

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knowledge, by Michel Callon and Bruno Latour in the French context for instance. See *La Science telle qu'elle se fait. Anthologie de la sociologie des sciences de langue anglaise,* edited by Michel Callon and Bruno Latour, La Découverte, Paris 1991, pp. 29-35.

[10] JEAN-PIERRE SÉRIS, *Machine et communication,* Vrin, Paris 1987.

In this brief analysis, I am referring to collective actors, professional types or professions principally. In other words, the history of technological thought which I should like to promote is more concerned with the shared know-how, knowledge and representations, than with the content of the individual mind. Applied to the question of invention, it means that the history of technological thought is more concerned with the mental context which allows invention to take place, than with the actual process of invention.

Given one actor of production, let us say an engineer, the main problem is how to describe the complex system of his technological thought with appropriate interpretative structures or concepts. The historian must also fashion other structures or concepts should to characterise the common references that different actors share within large firms or institutions. In order to remain concise, I shall concentrate on the first sort of these problems.

One can use the concept of rationality to clarify the specific organisation of know-how, knowledge, and representations that characterises the technological thought of the actors of production. The definition of rationality I am referring to is very different indeed from the classic definition, used especially in economics. First, it does not separate the objectives from the means employed, in the way that Max Weber did when he distinguished between rationality depending on the objectives and rationality depending to the means[11]. In my definition of rationality, objectives and means are in constant interaction in technological reflection and action. Secondly, my definition does not limit rationality to rational calculation. It characterises the global attitude of an actor towards the world of production, rather than the specific techniques of decision he uses to cope with it. Thus, rationality is guided by values and representations. Some of these values and representations are ordinarily considered as irrational. In this sense, rationality is a general disposition linking all levels of technological thought and providing a frame for rationalisation schemes. Technical thought and rationality are linked to the devising of schemes or plans. This planning dimension gives them a dynamic quality.

Looking at the history of a number of forms of engineering rationality from the Renaissance to the present, we can distinguish successive ages. For example, there seemed to be an age of classical – i.e. geometrical or Vitruvian, rationality. At the turn of the eighteenth and nineteenth century, this age was supplanted by another that could be described as the age of analytical rationality. Taking the case of French engineers, I shall deal now with this transition from geometrical or Vitruvian

[11] MAX WEBER, *Economie et société* (1921), French translation, Plon, Paris 1971.

rationality to analytical rationality.

From Geometrical to Analytical Rationalities.

Since I have emphasised the importance of the representations of nature, I shall begin by evoking the change in the perception of the physical world that took place in eighteenth-century France. In that period, there was a general trend towards a more dynamic perception of nature. Whereas the Classic philosophers, scientists and engineers, used to consider nature as something organised according to the laws of order and proportion, as something essentially architectonic, eighteenth-century elites were increasingly impressed by the mobility of natural elements. While Bossuet wrote that God had created the world with order and proportion, Diderot and D'Holbach declared that change and movement were the main characteristics of nature[12]. Mobility was seen as synonym of a vital activity, while immobility became synonymous with decay and death. Efficiency was no longer linked to an ideal arrangement of means ruled by proportions; it was seen as the expression of natural dynamism. Eighteenth-century urbanism and territorial planning were clearly inspired by this conception. Nothing was to prevent water and air to circulate freely in cities. «It is well known that the healthiest water would corrupt without the movement which maintains its purità», wrote for example Parmentier in his *Dissertation sur la nature des eaux de la Seine* of 1787[13]. The suppression of urban ditches with their stagnant water was a consequence of that sort of conviction. The destruction of the houses built on bridges was another since those houses were supposed to prevent the renewal of atmosphere[14]. Understanding the natural

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[12] See for instance JACQUES BÉNIGNE BOSSUET, *Introduction à la philosophie, ou de la connaissance de Dieu et de soimesme,* D. Horthemels, Paris 1722; DENIS DIDEROT, *Pensées sur l'interprétation de la nature* (1754); PAUL HENRI THIRY D'HOLBACH, *Système de la nature, ou des lois du monde physique et du monde moral* (1770), E. Ledoux, Paris 1821.

[13] ANTOINE AUGUSTIN PARMENTIER, *Dissertation sur la nature des eaux de la Seine, avec quelques observations relatives aux propriétés physiques et économiques de l'eau en général*, Buisson, Paris 1787, p. 21.

[14] On these major preoccupations of eighteenth-century urbanism, see, for example:
- BLANDINE BARRET-KRIEGEL, BRUNO FORTIER and other, *La Politique de l'espace parisien à la fin de l'Ancien Régime,* Comité pour la recherche et le développement en architecture, Paris 1975;
- JEAN-CLAUDE PERROT, *Genèse d'une ville moderne. Caen au XVIIIe siècle,* Mouton, La Haye & Paris 1975;
- ANDRÉ GUILLERME, *Les Temps de l'eau. La cité, l'eau et les techniques*, Champ Vallon, Seyssel 1983;
- BERNARD LEPETIT, *Les Villes dans la France moderne (1740-1840)*, Albin Michel, Paris 1988;
- A. PICON, *French Architects and Engineers in the Age of Enlightenment,* cit.

dynamism was becoming a very general concern of philosophers and scientists as well as a practical issue for architects and engineers.

If natural efficiency was linked to mobility, social happiness and progress had to lie in a similar mobility, embracing the mobility of people, ideas, and merchandises. The fight against the prejudices that prevented free exchanges between men, and the promotion of trade and free enterprise by suppressing custom barriers as well as the corporate organisation of labour, became the priorities of political and economic elites. The Physiocrats and their famous formula: «let do, let pass» illustrate that concern well.

French engineers clearly subscribed to this ideal of natural and social fluidity, especially the Ponts et Chaussées engineer's whose mission consisted in building bridges and highways to promote trade. In relation to this concern, social evolution in two aeras at least must be taken into account.

First, engineers who had previously been relatively marginal came to be recognised as important agents of economic and social progress. In France, this recognition took place under the patronage of the State, through the creation and development of specialised institutions, administrative corps, and professional schools. While the corps of fortification engineers was created at the end of the seventeenth century, the Ponts et Chaussées and the Mining corps were founded during the eighteenth century[15]. A whole range of schools was created as well. The École des Ponts et Chaussées was founded in 1747, the École du Génie at Mézières (a school for fortifications engineers) in 1748, the École des Mines in 1783, the École Polytechnique in 1794. Gaining rapidly prestige, these schools were going to play a deciding role in the recognition of engineers and their rise in status[16].

Simultaneously, the attitude of engineers towards society began to change. Engineers defined themselves less and less as artists serving a prince, on the model of the engineer-architects of the Renaissance and classical age. They considered themselves as responsible for a more collective form of progress; and they saw it as

[15] About those different corps, see for instance:
- ANNE BLANCHARD, *Les Ingénieurs du «Roy» de Louis XVI à Louis XVI. Etude du corps des fortifications,* Université Paul Valéry, Montpellier 1979;
- JEAN PETOT, *Histoire de l'administration des Ponts et Chaussées 1599-1815,* M. Rivière, Paris 1958;
- ANDRÉ THÉPOT, *Les Ingénieurs du corps des Mines au XIXe siècle. Recherches sur la naissance et le développement d'une technocratie industrielle*, thesis, Editions Eska, Paris 1991.

[16] *Enseignement et diffusion des sciences en France au XVIIIe siècle,* edited by René Taton, Hermann, Paris, 1964; C.C. Gillispie, *Science and polity in France at the end of the Old Regime* (Princeton, Princeton University Press, 1980); A. PICON, *L'Invention de l'ingénieur modern…,* cit.

their duty to defend new values, such as public utility and prosperity. «It is the engineer who is in charge of the designs meant to provide happiness»[17], wrote for example one Ponts et Chaussées engineer convinced of the extreme importance of transport infrastructures.

At the intersection of the ideal of fluidity and the evolution of the engineering profession, a radical change in the engineers' field of competence took place gradually. Their knowledge and the way they conceived and designed their projects were going to evolve. Engineers no longer defined themselves through the mastering of purely geometrical knowledge, as designers or as «artist engineers» closely related to architects. They created for that purpose a new science, involving the use of calculus. They adopted new spatial and constructive patterns and, in turn, new methods of design.

Until the end of the eighteenth century, this change in the profile of engineering competence was impeded by a very traditional technological context, by a «classical technological system» as Bertrand Gille would say. It was also prevented by a system of knowledge still based on Vitruvian principles and the intensive use of geometric patterns. What the mots advanced engineers tried to achieve, however, was to understand and to master natural and human process ranging from the floods to the organisation of labour on construction sites or in factories. As they lacked the scientific and technical tools which would enable them to control those realities, they used a provisional method consisting in a systematic decomposition of things and phenomena, a decomposition which should lead in due course to a more rational recomposition. It must be noted that, in accordance with eighteenth-century political philosophy, they also interpreted society as something which could be decomposed into individuals before being recomposed in terms of institutions and nations. This conception inspired for instance to the Ponts et Chaussées engineer, Achille- Nicolas Isnard, a *Traité des richesses* published in 1781. In this treatise, Isnard defined the «science of man» as a kind of mechanics based on the rational decomposition and recomposition of individual interests[18]. Territory as well could be decomposed and recomposed. The creation of the departments at the beginning of the Revolution was nothing else than the result of a decomposition of the old system of regions and its

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[17] P. PLANIER, *French essay of 1779*, manuscript of the École nationale des Ponts et Chaussées, Carton «Concours de style et concours littéraires 1778-1812».

[18] About Isnard, see J.C. PERROT, *Premiers aspects de l'équilibre dans la pensée économique française*, «Annales Economies Sociétés Civilisations», 1983, 5, p. 1058-1074.

replacement in a process of rationalised recomposition[19]. Engineers, however, applied this method mainly to technical devices, as well as to the process of production which they perceived as a combination of workers' moves giving birth to tecnical operations. This attitude is well illustrated by their approach of engineering and architectural design in terms of basic functions and movements. Once identified, these functions and movements provided with a general frame for the actual design of the equipment, whether a bridge or a building. This approach is also detectable in their studies of human labour, such as Charles-Augustin Coulomb's famous memoir on «the quantity of action men can develop by their daily work, according to the different ways they exert their strength»[20].

This method was very similar indeed to the one used in the descriptions of the arts and crafts given in the *Encyclopédie*. Such a convergence is not surprising since many encyclopedists shared the same concern for rationalisation. In his article on the knitting machine, Diderot unfolded the principles of a satisfactory description. It was based on «a kind of analysis, which consists in distributing the machine in various parts […], before assembling those parts to rebuild the entire machine»[21]. The manufacturing processes could be decomposed and recomposed in the same way. The engineer Jean-Rodolphe Perronet, who was later to become the first director of the École des Ponts et Chaussées, gave a remarkable demonstration of that possibility when he studied a pin factory in 1739-1740[22].

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[19] See MARIE-VIC OZOUF MARIGNIER, *La Formation des départements. La Représentation du territoire français à la fin du 18e siècle,* EHESS, Paris 1989.

[20] CHARLES-AUGUSTIN COULOMB, *Résultats de plusieurs expériences destinées à déterminer la quantité d'action que les hommes peuvent fournir par leur travail journalier, suivant les différentes manières dont ils emploient leurs forces,* Paris 1799, re-issue in C.-A. COULOMB, *Théorie des machines simples*, Bachelier, Paris 1821, p. 255-297. On Coulomb's memoir, see:
- CHARLES STEWART GILLMOR, *Coulomb and the evolution of physics and engineering in eighteenth century France,* Princeton University Press, Princeton 1971;
- MICHEL VALENTIN, *Charles-Augustin Coulomb (1736-1806)*, *«Sécurité et médecine du travail»,* 1974-1975, 33, p. 19-26;
- FRANÇOIS VATIN, *Le Travail. Economie et physique 1780-1830,* PUF, Paris 1993.

[21] D. DIDEROT, *Bas*, in *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers,* Briasson, Paris 1751-1772, 1, 98-113, on p. 98. About this article, see JACQUES PROUST, *L'article Bas de Diderot*, in *Langue et langages de Leibniz à l'Encyclopédie,* edited by M. Duchet and M. Jalley, Paris, 10/18, 1977, pp. 245-271. About the analytic method used by the encyclopedists, see also A. PICON, *Gestes ouvriers, opérations et processus techniques. La vision du travail des encyclopédistes*, «Recherches sur Diderot et sur l'Encyclopédie», 13, 1992, pp. 131-147.

[22] J.R. PERRONET, *Explication de la façon dont on réduit le fil de laiton à différentes grosseurs dans la ville de Laigle*, 1739, manuscript of the École nationale des Ponts et Chaussées, Ms 2383; J.-R.

Such a procedure bears also some analogy with the very general analytical method used by philosophers at the time. «Analysis is the entire decomposition of an object and the arranging of its components so that generation becomes at the same time easy and understandable»[23], wrote for example Condillac in his *Cours d'études* of 1775. In that broad sense, we can speak of the emergence of a new kind of rationality which can be called analytical. It was linked to a new way of studying efficiency in natural and social processes. It was founded on new relations between the parts and the whole, and between the local or the instantaneous and the global. Whether characterising a natural phenomenon or an artefact as a machine, parts were supposed to combine in a dynamic way, instead of being composed according to rules of order and proportion analogous to the principles of architecture. What was actually at stake was the transition from a static knowledge of structures to a more dynamic knowledge of operations and functions. Nature and society were taken to be organised through operations and functions that were synonymous with mobility. Eighteenth-century scientists were also examining operations and functions. Lavoisier's chemistry was clearly analytic, just as Diderot's descriptions or Condillac's theory of ideas and language. In their field, engineers tryed to put this promising analytic orientation into practice, although the results it led to were quite modest at first.

Rather than describing in more detail this turning point in the history of engineering rationalities, I should like now to evoke some of its main consequences. The first consists in the emergence of a new engineering science based on calculus. From the first half of the nineteenth century, mathematical analysis progressively replaced many of the geometrical tools which engineers used during the classical age. As early as the 1820's, Claude Navier's or Jean-Victor Poncelet's lectures at the École des Ponts et Chaussées and the École du Génie et de l'Artillerie at Metz were based on calculus, on derivations and integrations that linked local or instantaneous laws to

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PERRONET, *Description de la façon dont on fait les épingles à Laigle en Normandie*, 1740, manuscript of the École nationale des Ponts et Chaussées, Ms 2385. Some of the drawings made by Perronet on this occasion were later used in the Encyclopédie.

[23] ÉTIENNE BONNOT DE CONDILLAC, *Cours d'études pour le prince de Parme*, and *V. De l'art de penser*, in *Oeuvres philosophiques de Condillac*, P.U.F., Paris 1947-1951, 1, p. 769. About Condillac's definition of analysis an the later interpretations given to this key term of eighteenth century philosophy, see GILLES-GASTON GRANGER, *La Mathématique sociale du marquis de Condorcet*, 1956, re-issue. O. Jacob, Paris 1989; ERIC BRIAN, *La foi du géomètre. Métier et vocation de savant pour Condorcet vers 1770*, «Revue de synthèse», 1988, 1, p. 39-68.

global phenomena[24]. Some spectacular progress were made in that way concerning strength of materials or applied hydrodynamics. In his famous *Résumé des leçons données à l'École des Ponts et Chaussées sur l'application de la mécanique* published in 1826, Navier analysed for example beams on supports as well as beams with ends built-in. With proper integration, the expression of the local bending moment enabled him to give the formula of the global deflection curve[25]. The frame of mind created during the eighteenth century, the new type of relation between the parts and the whole it induced, laid the foundation for this massive introduction of calculus in the technological field.

The new engineering science encapsulated in the work of Navier or Poncelet will be in continuity with the pure sciences that use calculus as well. Whereas most of the Vitruvian engineers subscribed to the idea that there was a gap between science and engineering that could only be filled with a long immersion in technical reality, their nineteenth century, technological education, focused on an apprenticeship of engineering science, developed in this perspective[26].

This new engineering science defined itself as a science of the natural processes. At the same time it established strong links with another new kind of knowledge concerning human processes, that is to say economic calculation. Engineers like Claude Navier or Jules Dupuit rank moreover among the pioneers of this economic knowledge[27]. Through these links between engineering science and economic calculation, one can apprehend another important aspect of the age of analytical form of rationality. The preoccupation of the engineers rested no longer in the mastering of space alone, as it was the case during the classical period; it rested now on the simultaneous mastering of space and time, these two dimensions being submitted to economic knowledge. In a way, classical engineers knew only about book-keeping. Their thinking was bounded by the present on one side, by eternity on

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[24] A. PICON, *L'Invention de l'ingénieur moderne*, cit., p. 469-505.

[25] CLAUDE NAVIER, *Résumé des leçons données à l'École des Ponts et Chaussées sur l'application de la mécanique à l'établissement des constructions et des machines,* F. Didot, Carilian-Gury, Paris 1826.

[26] On the development of technological education in France and in Europe, see for instance:
- JOHN H. WEISS, *The Making of technological man. The socials origins of French engineering education,* MIT Press, Cambridge Massachussetts 1982;
- A. PICON, *L'Invention de l'ingénieur moderne …*, cit.
- *Education, technology and industrial performance in Europe, 1850-1939,* edited by R. Fox and A. Guagnini, Cambridge University Press / Editions de la Maison des Sciences de l'Homme, Cambridge / Paris 1993.

[27] FRANÇOIS ETNER, *Histoire du calcul économique en France,* Economica, Paris 1987.

the other. They either had the means to act immediately, or they had to wait an undefined time. The minuteness of their tasks was counterbalanced by the ideal of eternal monuments of technology comparable with the great works of the Romans. What is emerging is in fact the middle-term of modern economics.

Last but not least, a new approach to the processes of production also appeared. Production was now seen, as we have said, as a combination of elementary moves organised into a succession of technical operations. Introduced by engineers like Coulomb, this new grid of interpretation enabled the engineer to rationalise production by exposing its components, workers' moves and elementary operations, and submitting them to the principles of science. In connection with this conviction, a kind of «proto-taylorism» can be traced among French engineers of the second half of the eighteenth century[28]. This «proto-taylorism» reached its climax with the «revolutionary productions» of powder, weapons and guns organised during the Terror[29]. Its practical results were a failure on short-term, but it gave birth to the modern notion of work. Used to find a common measure between the various gestures and operations engineers deal with, between human effort and mechanical power above all, this notion received its mathematical translation during the first half of the nineteenth century, while economists stressed its fundamental importance in the task of understanding social and economical process[30].

From the coupling of science and technology to the stress put on the notion of work, the emergence of analytical rationalities corresponded to the construction of a new collective mental frame. Some features of this new collective mental frame, such as the engineers' ideal of fluidity, are still influential in the industrial world that surrounds us. At the same time, the reflections on the transition from Vitruvian to analytical rationalities that I have been summarising are inseparable from a broader program of research. This program is linked to the changes we are experiencing in our own day in the field of technology and industrial organisation. Are we on the brink of a new transition between the analytical ideals we have inherited from the industrial revolution and new conceptions of efficiency? When we consider the

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[28] A. PICON, *L'Invention de l'ingénieur modern*, cit.; A. PICON, *Gestes ouvriers, opérations et processus techniques*, cit.

[29] CAMILLE RICHARD, *Le Comité de Salut Public et les fabrications de guerre sous la Terreur,* F. Rieder et Cie, Paris 1922; P. BRET, *La Pratique révolutionnaire du progrès technique. De l'Institution de la recherche militaire en France* (1775-1825), thesis, Paris 1994.

[30] I. GRATTAN-GUINNESS, *Work for the workers: advances in engineering mechanics and instruction in France, 1800-1830*, «Annals of science», 1984, 41, p. 1-33; F. VATIN, *Le Travail …*, cit.

recent evolution of our interpretation of nature, or when we take into account some of the changes induced by the use of computers, some signs can make us believe in such a transition. Until now, efficiency was synonymous with the rational regulation and management of the dynamism created by mass production and consumption. But now, the complexities of our contemporary world and its uncertainty, seem to call for a more systemic efficiency based on the identification of levels of technological and managerial relevance. How are we to articulate those different levels? In some advanced fields, engineers and managers are looking for new design and decision procedures taking into account the effects of complexity and uncertainty. Computer-assisted in most cases, these procedures try to order logically the possible events that can affect production and marketing. Whereas analysis of operations and functions was clearly the basis of former dynamic regulations, the use of logical structures is perhaps conveying a new approach of technological efficiency[31].

Technological Thought and Culture.

As a conclusion, I should like to offer two comments on the history of technical thought as I have tried to present it. The first concerns the definition of the engineer. In a recent article, the American sociologist Peter Whalley rejected what he called «essentialist definitions» because of the extreme diversity of engineers' aeras of competence and employments[32]. To cope with this diversity, he suggested that we should define engineers by their status, a status of privileged employees trusted by the owners of capital and by the managerial power. The interest of such an approach is undeniable. At the same time, I think it is necessary to counterbalance it by taking into account the history of engineers' rationalities. After all, engineers can also be characterised by the constant pursuit of a systematic knowledge that provides the organisation of production with efficiency. The historical forms taken by this pursuit can perhaps throw some light on the possible definition of the profession.

A second remark concerns the relationship between the history of engineers' rationalities and social history. It must be clear that this relationship is mainly achieved through the mediation of culture. The history of rationalities provides with a means of connecting technological change and cultural evolution. Such a connection is in no way determinist, that is to say that the transformation of

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[31] A. PICON, *Pour une histoire de la pensée technique*, cit.

[32] PETER WHALLEY, Negociating the boundaries of engineering: Professional managers and manual work, «Research in the sociology of organizations», 8, 1991, pp.191-215.

technological thought is not always a necessary condition for tecnical innovation. The steam engine, for instance did not develop because a new frame of mind emerged during the eighteenth century, leading to an analytical engineering science. Engineering science was stimulated rather by the development of the steam engine. However, one can easily demonstrate that without a new analytical frame of mind and the scientific results it led to, machine development would have stagnated at the end. Instead of a direct link of causality between technological thought and innovation, one is often faced with indirect or deferred causality. Lewis Mumford pointed out the interest of that kind of causality when he saw the remote origin of the possibility of mechanisation in the precise measurement of time introduced in medieval monastic life[33]. On a smaller scale, the history of engineering rationality contributes to explanations of the same type. It helps us to understand the meaning of technological change before trying to assign definite causes to it.

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[33] L. MUMFORD, *Technique et civilisation* (1934), French translation, Seuil, Paris 1950, p. 22-26.

De l'utilité des travaux publics en France aux XVIII^e et XIX^e siècle[1].

by Antoine Picon

Introduction

Des politiques aux ingénieurs, des idéologues en tous genres aux entrepreneurs, les XVIII^e et XIX^e siècles français ont beaucoup réfléchi et beaucoup écrit sur les travaux publics, qu'ils soient militaires ou civils. Au carrefour de cet ensemble de réflexions et de ces écrits très divers figure la notion d'utilité. Plus encore que l'industrie ou le commerce dont ils conditionnent le développement, les travaux publics sont utiles. L'étude de cette notion clef permet du même coup de saisir la genèse et le développement d'un certain nombre d'idéaux et de préoccupations des ingénieurs d'État chargés de mener à bien des projets d'infrastructure pour le compte de la collectivité. Une telle étude n'est sans doute pas inutile moment où la redéfinition des missions de ces ingénieurs, celles des ingénieurs des Ponts et Chaussées en particulier, semble mettre à mal quelques uns des présupposés sur lesquels se fondait leur action.

Une notion d'origine philosophique

Au XVIII^e siècle, la notion d'utilité apparaît tout d'abord dans le cadre du discours philosophique dominant. «L'utile circonscrit tout. Ce sera l'utile qui dans quelques siècles donnera des bornes à la physique expérimentale, comme il est sur le point d'en donner à la géométrie»[2], écrit par exemple Diderot dans ses *Pensées sur l'interprétation de la nature* de 1754. Sous la plume du philosophe, l'utilité met en relation les résultats scientifiques touchant à la connaissance de la nature et leurs effets sur le bien-être collectif. C'est cette relation qui est appelée selon lui à s'approfondir, jusqu'à dicter à la science ses directions de développement.

Employée à l'appui d'un nouveau type de jugement porté sur les productions naturelles et humaines, jugement non plus fondé sur les principes d'autorité et de

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[1] Article paru dans *Acteurs privés et acteurs publics: une histoire du partage des rôles*, Ministère de l'Equipement, des Transports et du Tourisme, Direction de la Recherche et des Affaires Scientifiques et Techniques, Paris 1994, pp. 129-136.

[2] D. DIDEROT, *Pensées sur l'interprétation de la nature*, 1754, p. 23. Sur la notion d'utilité dans la philosophie des Lumières, on pourra consulter par ailleurs G. GUSDORF, *Les principes de la pensée au siècle des Lumières*, Payot, Paris 1971, pp. 428-443.

dignité propres à la société d'Ordres, mais sur l'évaluation de la contribution de ces productions au bien-être collectif, la référence à l'utilité devient très vite inséparable d'une redéfinition très générale des catégories de l'efficacité. Pour les élites des Lumières, l'efficacité ne réside plus dans des dispositifs statiques mais bien dans le libre jeu des dynamiques tant naturelles que sociales. A une nature en mouvement perpétuel doit correspondre une société d'individus libres et égaux en droits aussi fluide que possible. Le célèbre «laissez faire-laissez passer» des physiocrates n'est jamais que la traduction dans le domaine économique de cette conviction largement répandue selon laquelle toute entrave au mouvement, à la circulation et aux échanges, se révélait nuisible. Le savant qui étudie les dynamismes naturels, le philosophe qui lutte contre les préjugés, ces barrières qui divisent les hommes, l'ingénieur enfin qui entreprend de surmonter les obstacles du relief, s'inspirent de cette même conviction.

Rien d'étonnant dans ces conditions à ce que l'utilité fasse son apparition sous la plume des ingénieurs. On la retrouve à toutes les lignes des écrits des élèves et des ingénieurs des Ponts et Chaussées chargés pour le compte de l'État de la conception et de l'exécution des routes, des ponts et des canaux. «Quelle est l'utilité des Ponts et Chaussées, relativement au commerce et à l'agriculture», demande-t-on aux futurs ingénieurs des Ponts en 1778 en guise d'épreuve de français, tandis qu'il leur faut disserter en 1789 sur «l'utilité que l'on peut retirer pour l'État et pour la société de l'établissement fait depuis 1747 de l'École des Ponts et Chaussées»[3]. Assez systématiquement, leurs réponses conjuguent préoccupations morales et économiques. Les routes, les ponts et les canaux s'inscrivent dans une perspective de régénération de la société, en même temps qu'ils contribuent aux progrès matériels de celle-ci.

Pour les ingénieurs du XVIII^e siècle, l'utilité possède ainsi une signification à la fois éthique et pratique. Elle inspire la politique routière de l'administration des Ponts et Chaussées, la principale entreprise du siècle en matière de travaux publics[4], en la reliant à des impératifs beaucoup plus ambitieux d'intensification des échanges. Les

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[3] Ces épreuves de français ou «concours de style» sont destinés à évaluer les qualités d'expression écrite des élèves des Ponts et Chaussées. Leur contenu est révélateur des grandes orientations du discours tenu par les ingénieurs. Nous avons déjà eu l'occasion d'en faire usage dans A. PICON, *Architectes et ingénieurs au siècle des Lumières*, Parenthèses, Marseille 1988, pp. 103-113; A. PICON, *L'invention de l'ingénieur modern. L'École des Ponts et Chaussées 1747-1851*, thèse de doctorat, EHESS, Paris 1991, pp. 164-175 notamment.

[4] Sur la politique routière des Lumières, voir J.M. GOGER, *La politique routière en France de 1716 à 1815,* thèse de l' EHESS, Paris 1988 ; A. PICON, *L'invention de l'ingénieur modern…*, cit., pp. 39-47.

quelques 3 135 lieues (13 932 kilomètres) de chaussées construits par les ingénieurs des Ponts dans les seuls pays d'élections du royaume participent de ces impératifs d'intensification des circulations de tous ordres. L'importance de l'enjeu justifie l'emploi d'une main d'úuvre forcée. C'est au nom de l'utilité que les ingénieurs forcent les paysans à travailler à la belle saison sur leurs chantiers. L'utilité à laquelle se réfèrent les ingénieur d'État se pare ainsi d'une ambiguïté fondamentale, puisque l'intérêt collectif fait peser un ensemble de contraintes pénibles sur une partie de la société. Plus généralement, l'émergence de cette notion s'accompagne de tensions nouvelles entre bien-être général et violence nécessaire à son accomplissement, entre l'État garant de ce bien-être et les individus et les groupes qui composent la société. Constitutives des relations entre l'administration et le corps social, de telles tensions impriment encore leur marque sur l'action des ingénieurs d'État contemporains.

Par delà ses effets immédiats, l'accent mis sur l'utilité semble préluder à la constitution d'une science de l'homme mathématisée susceptible servir de guide à l'ingénieur. Telle est par exemple la conviction qui anime un Achille-Nicolas Isnard, l'un des pionniers de l'économie mathématique, dans son *Traité des richesses* de 1781.

«Connaître la nature, apercevoir les choses et leur coordination, observer leurs qualités, leurs actions et leurs forces, calculer ou mesurer leurs quantités ou leurs grandeurs, et les quantités de forces, de mouvement et d'action pour découvrir leurs rapports, voilà la marche du philosophe; c'est avec elle que l'on arrivera à la science, et ce sera la science de l'homme, lorsque l'observation, les découvertes et les rapports aperçus et trouvés seront utiles aux hommes»[5].

Pour Isnard, il ne fait guère de doute que cette science de l'homme emprunte ses outils à l'analyse mathématique, comme la mécanique rationnelle dont Lagrange réordonne vers la même époque les fondements. Maîtrisant mal les subtilités du calcul différentiel et intégral, la plupart des ingénieurs des Ponts sont incapables de le suivre sur ce terrain. A leurs yeux, la simple arithmétique doit largement suffire à la quantification de l'utilité individuelle et collective. Au cours du siècle suivant, les tentatives de mathématisation de la notion d'utilité vont en revanche prendre une importance croissante. Plus généralement, le registre de l'utile va devenir beaucoup plus complexe. En s'affranchissant progressivement de la tutelle philosophique, il va prendre un contenu politique, économique et social encore plus concret. De nouvelles tensions vont se faire jour ce faisant entre les différentes dimensions de l'utilité. Ce sont quelques unes de ces tensions que nous voudrions à présent passer

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[5] A.N. ISNARD, *Traité des richesses*, F. Grasset / Cie, Londres – Lausanne 1781, p. VII.

en revue. Leur analyse permet de mieux cerner le statut privilégié dont jouissent les travaux publics dans la société française post-révolutionnaire ainsi que les ambiguïtés qui s'attachent à l'action des ingénieurs d'État chargés de leur conception d'ensemble.

La conquête de l'espace national et la question du lien social

Certes, le XVIII^e siècle était parvenu à la définition d'une politique routière cohérente, mais ce n'est qu'au cours du siècle suivant que s'opère véritablement la conquête de l'espace français au moyen des routes, des travaux de navigation et du chemin de fer. En matière de routes, le Premier Empire, la Restauration et la Monarchie de Juillet achèvent le réseau national, développent considérablement celui des départements et se lancent enfin dans la réalisation d'une voirie vicinale digne de ce nom[6]. Dans le domaine de la navigation intérieure et maritime, les progrès sont tout aussi remarquables, du plan Becquey d'achèvement des canaux lancé au début des années 1820 aux travaux de régularisation des rivières et d'aménagement portuaire entrepris par la Monarchie de Juillet et le Second Empire[7]. A partir de 1830, le développement rapide des chemins de fer vient révolutionner enfin les transports en abaissant considérablement leurs délais et leur coût[8]. Le chemin de fer permet de désenclaver durablement l'ensemble des départements et des communes françaises en même temps que se constitue un marché national des biens et des services produits par l'industrialisation. Si l'utilité de la route et de la voie d'eau fait l'objet d'un large consensus, celle de la voie ferrée est encore plus éclatante aux yeux des contemporains de la première Révolution industrielle.

Cependant, la portée des grands travaux n'est pas qu'industrielle et commerciale aux yeux des élites du XIX^e siècle qui tentent d'assigner un sens aux bouleversements politiques et sociaux consécutifs à la Révolution française. La Révolution a vu la fin d'un âge de l'humanité et d'un type de société, la fin de réseaux de solidarité

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[6] Sur les progrès routiers réalisés par le XIX^e siècle, lire H. CAVAILLÈS, *La route française son histoire sa fonction*, A. Colin, Paris 1946, G. REVERDY, *Atlas historique des routes de France*, Presses de l'École Nationale des Ponts et Chaussées, Paris 1987; A. GUILLERME, *Corps à corps sur la route Les routes, les chemins et l'organisation des services au XIXème siècle*, Presses de l'École Nationale des Ponts et Chaussées, Paris 1984.

[7] Voir par exemple *Un canal… des canaux…*, catalogue d'exposition, Caisse Nationale des Monuments Historiques et des Sites, Picard, Paris 1986.

[8] Cf. A. PICARD, *Les chemins de fer français Etude historique sur la constitution et le régime du réseau,* J. Rothschild, Paris 1884-1885; F. CARON, *Histoire de l'exploitation d'un grand réseau. La compagnie du chemin de fer du Nord 1846-1937*, Mouton, Paris 1973; G. RIBEILL, *Management et organisation du travail dans les compagnies de chemins de fer des origines à 1860*, CERTES, ENPC, Paris 1985.

séculaires qui ont été balayés en quelques décennies à peine. Quel ordre reconstruire sur les ruines de l'Ancien Régime, en d'autres termes, comment terminer la Révolution?[9] La question préoccupe de nombreux esprits, des monarchistes aux républicains, des partisans du protectionnisme économique aux pionniers du libéralisme. Elle rejoint les interrogations du siècle sur la marche générale des sociétés et de la civilisation. Les principes permettant de rendre compte de cette marche et la périodisation qu'on lui applique font bien sûr l'objet de controverses. Chacun s'accorde néanmoins à voir dans l'histoire des travaux publics l'un de ses indicateurs les plus sûrs. Les pyramides du Caire incarnent l'esprit de la civilisation égyptienne, les voies et les aqueducs celui de la romanité, tandis que les canaux du Grand Siècle ou les aménagements hydrauliques du parc de Versailles témoignent du degré de civilisation atteint sous le règne de Louis XIV. De façon similaire, l'évolution des techniques constructives reflète les âges successifs de l'humanité comme le souligne l'ingénieur-architecte Léonce Reynaud ou encore Eugène-Emmanuel Viollet-le-Duc.

Si les travaux publics et l'architecture évoluent au rythme des sociétés, si le XIX[e] siècle s'annonce comme le siècle des routes, des ponts et des canaux de plus en plus nombreux, comme le siècle des chemins de fer, des gares et de l'architecture métallique, le rôle de l'aménagement et de la construction va bien au-delà de leur utilité économique immédiate et du témoignage qu'ils rendent des progrès successifs de l'humanité. Ils contribuent en effet à structurer les échanges et à organiser par conséquent la société. Dans la France post-révolutionnaire en proie à un individualisme destructeur, comme s'accordent à le souligner de nombreux penseurs, de Saint-Simon à Louis de Bonald, une ambitieuse politique de travaux publics constitue peut-être le seul contrepoint efficace à l'atomisation des relations sociales, la seule voie permettant de sortir des troubles engendrés par les rivalités entre factions. Tel est bien l'arrière-plan idéologique d'une opération comme le plan Becquey d'achèvement des canaux dans lequel se lance la Restauration. «Dans les gouvernements modernes, comme dans les anciens, on a senti qu'une des premières conditions de la civilisation, et qu'ensuite l'un de ses premiers avantages, consistaient dans l'étendue et la facilité des communications», déclare d'emblée le directeur général des Ponts et Chaussées Louis Becquey dans son *Rapport au roi sur la navigation intérieure de la France*de 1820, avant d'évoquer l'heureuse «influence des communications sur les múurs», influence qui leur permet de «lier entre elles et d'assembler les différentes parties d'un grand tout, ce qui contribue à les maintenir

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[9] Voir sur ce thème P. ROSANVALLON, *Le moment Guizot*, Gallimard, Paris 1985; F. FURET, *La Révolution de Turgot à Jules Ferry 1770-1880*, Hachette, Paris 1988.

sous une même loi politique et sous un même gouvernement»[10]. A la France pacifiée par les canaux et les routes succédera bientôt la France pacifiée par le chemin de fer plus sûrement que par une bonne constitution. «Les classes laborieuses sont plus malheureuses en France que dans les autres états, par suite des obstacles administratifs apportés à l'exécution des travaux publics. Quinze millions de français n'ont pas, terme moyen, plus de 29 centimes par tête et par jour pour se procurer la nourriture et toutes les nécessités de la vie»[11], constate au début des années 1830 l'inspecteur général des Ponts et Chaussées Louis Cordier pour qui les chemins de fer et les emplois qu'induisent leur construction et leur exploitation constituent la seule réponse adaptée à la question sociale qui commence à devenir préoccupante. Jusqu'au plan Freyssinet d'achèvement du réseau ferré voté en 1878, grands travaux et préoccupations politiques et sociales seront ainsi indissociables. C'est dans ce contexte qu'il convient bien sûr de replacer les ateliers nationaux organisés pendant quelques mois à la suite de la révolution de 1848.

La portée politique et sociale des travaux publics, l'utilité qu'ils présentent de ce point de vue, prennent un relief particulier sous la plume des saint-simoniens. De tous les courants de pensée du XIX^e^ siècle français, le Saint- Simonisme est certainement celui qui a consacré le plus de réflexions au rôle civilisateur des travaux publics[12].

Rien d'étonnant à cela si l'on se rappelle l'importance des ingénieurs des Mines et des Ponts et Chaussées au sein du mouvement. Les travaux publics participent d'une vision globale de l'histoire humaine placée sous le signe de la perfectibilité des individus et du progrès collectif des sociétés. L'individualisme du temps, les querelles fratricides et les guerres entre les peuples sont appelées à céder la place à l'«association universelle» des producteurs organisés comme une seule et même armée pacifique. Les grands travaux représentent l'un des moyens privilégiés de

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[10] L. BECQUEY, *Rapport au roi sur la navigation intérieure de la France*, Imprimerie royale, Paris, 1820, pp. 5-6, 18. On trouvera une bonne analyse du plan Becquey dans A. FORTIER, P. PINON, *L'achèvement des canaux sous la Restauration et la Monarchie de Juillet*, «Annales des Ponts et Chaussées», 19, 1981, pp. 72-83.

[11] J. CORDIER, *Considérations sur les chemins de fer* (1830), citation en couverture.

[12] Sur le mouvement Saint-Simonien et la question des grands travaux, lire notamment H.R. D'ALLEMAGNE, *Prosper Enfantin et les grandes entreprises du XIXe siècle*, Gründ, Paris 1935; R.B. CARLISLE, *Les chemins de fer, les Rothschild et les saint-simoniens*, in *Economies et sociétés, «Saint-Simonisme et pari pour l'industrie»*, V, 1971, pp. 1185-1214; J. WALCH, *Les saint-simoniens et les voies de communication,* «Culture technique», 19, 1989, pp. 285-294; P. RÉGNIER, *Les Saint-Simoniens en Egypte (1833-1851)*, Amin F. Abdelnour, Le Caire 1989.

réalisation de l'ordre nouveau dont ils rêvent. Le lendemain de l'émeute provoquée par l'enterrement du général Lamarque au début du mois de juin 1832, ils proposent par exemple de lutter contre le malaise politique et social ambiant en lançant toute une série de grandes entreprises. Il faut selon eux commencer immédiatement la ligne de chemin de fer de Paris à Marseille, exécuter les travaux d'adduction d'eau et d'assainissement qui manquent si cruellement à la Capitale, percer le grand axe du Louvre à la Bastille qui doit désengorger le cúur de la ville, envoyer dix-mille hommes en Bretagne pour mettre en valeur les landes incultes qui déparent cette province, amorcer enfin la transformation de l'armée en une organisation industrielle «en sorte que tout régiment serait une école d'arts et métiers et que tout soldat en sortirait bon ouvrier»[13]. On retrouve bien d'autres propositions du même type sous la plume de Michel Chevalier et de ses collaborateurs du *Globe*. Dans son fameux «Système de la Méditerranée», paru en 1832 dans *Le Globe*, Chevalier imagine un vaste réseau de communications sillonnant l'Europe et reliant les grandes capitales aux principaux ports maritimes. Ce réseau est pour l'essentiel ferroviaire, en effet: «dans l'ordre matériel le chemin de fer est le symbole le plus parfait de l'association universelle»[14]. En France, la ligne Le Havre-Marseille via Paris et Lyon semble la plus urgente à réaliser; il n'est pas étonnant de voir figurer des saint-simoniens éminents comme Enfantin et son ami le financier lyonnais Arlès-Dufour parmi les promoteurs du tronçon Paris-Lyon au début des années 1840[15]. Plus généralement, animé d'une vision véritablement géopolitique des travaux publics, les saint-simoniens vont être à l'origine de certaines des entreprises essentielles du XIX[e] siècle comme le canal de Suez destiné à relier l'Occident à l'Orient et à faire de la planète toute entière une demeure digne de la puissance grandissante de l'homme[16].

L'organisation des travaux publics, entre modèle autoritaire et libéralisme

En retrait des visions généreuses développées par les saint-simoniens, l'utilité des travaux publics est pour partie fonction de leur organisation. En France l'État jouit depuis le XVIII[e] siècle d'un quasi-monopole en matière de grandes infrastructures de

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[13] J. TERSON, *Mémoires*, Arsenal FE 7787.

[14] M. CHEVALIER, *Religion saint-simonienne Politique économique Système de la Méditerannée*, Bureaux du Globe, Paris 1832, p. 36. Sur les conceptions de Chevalier, voir J. WALCH, *Michel Chevalier Economiste saint-simonien 1806-1879*, Vrin, Paris 1975.

[15] R.-B. CARLISLE, *Les chemins de fer…*, cit.

[16] La métaphore est de Jean Reynaud, in J. REYNAUD, *Prédication sur la constitution de la propriété*, impr. Everat, Paris 1831, p. 23.

transport, par l'intermédiaire du corps des Ponts et Chaussées créé sur le modèle du corps du Génie militaire, avec des inspecteurs généraux à sa tête, des ingénieurs en chef, des ingénieurs ordinaires et des aspirants placés sous leurs ordres[17]. A cette hiérarchie correspond une pyramide des compétences. Tandis que les inspecteurs généraux contribuent à orienter la politique des travaux publics, les inspecteurs en chef supervisent l'ensemble des projets et des chantiers d'un département, les ingénieurs ordinaires et les aspirants ayant quant à eux la responsabilité directe d'une opération ou d'un site.

Cette organisation qui exclut pratiquement tout recours à l'initiative privée et dans laquelle le rôle des entreprises se borne à l'exécution possède des avantages certains. Au premier rang de ces avantages figurent l'uniformité des procédures de décision administrative et la cohérence qu'elle confère à la politique des travaux publics française. Recrutés à la sortie de Polytechnique, les ingénieurs des Ponts peuvent se targuer en outre d'une culture scientifique approfondie bien différente de celle de leurs homologues anglais formés pour la plupart sur le tas. Dernier avantage enfin aux yeux des ingénieurs des Ponts et Chaussées qui aiment à souligner leurs mérites: l'impartialité propre aux fonctionnaires qui leur permet selon eux de n'être mus que par l'amour du bien public.

Si l'utilité des travaux publics se confond avec celle du corps des Ponts pour ses membres convaincus du bien-fondé de leurs prérogatives, le corps n'en fait pas moins l'objet de critiques fort vives tout au long du XIX[e] siècle. Pour une partie de ses détracteurs, l'administration des Ponts et Chaussées et l'organisation qu'elle a donnée aux travaux publics présentent l'inconvénient de n'être que des demi-mesures sur la voie conduisant à un dispositif encore plus autoritaire et plus rationnel. Au lieu d'appointer chèrement des ingénieurs des Ponts, au lieu de faire travailler à des prix presque toujours surévalués des entrepreneurs privés, pourquoi ne pas avoir recours à l'armée pour commencer? L'armée ne dipose-t-elle pas de cadres qualifiés avec les ingénieurs du Génie, la troupe ne constitue-t-elle pas une source de main-d'úuvre abondante et bon marché? La tentation de ce recours à l'armée est particulièrement prononcée sous la Restauration et la Monarchie de Juillet. Un article paru dans le *Journal du génie civil* s'en fait par exemple l'écho en 1829. «Quoi de plus simple et de plus naturel que d'employer la force publique à l'accroissement de la prospérité publique, lorsque cette force n'est pas nécessaire à la défense du trône et de la

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[17] Sur le corps des Ponts et Chaussées aux XVIII[e] et XIX[e] siècles, voir J. PETOT, *Histoire de l'administration des Ponts et Chaussées 1599-1815*, M. Rivière, Paris 1958; A. BRUNOT, R. COQUAND, *Le corps des Ponts et Chaussées,* CNRS, Paris 1982; A. PICON, *L'invention de l'ingénieur modern…*, cit.

patrie!»[18], s'exclame son auteur dans le droit fil de certaines prises de position saint-simoniennes. Comme pour lui donner raison, les routes stratégiques de l'Ouest entreprises par la Monarchie de Juillet dans les années 1830-1840 feront largement appel à la troupe[19]. Celle-ci sera également mise à contribution pour réaliser les fortifications de Paris au début de la décennie suivante[20].

Dans le même ordre d'idées, la première moitié du dix-neuvième siècle s'intéresse aussi aux possibilités d'abaissement des coûts offertes par le travail forcé. Chargé des travaux de l'arsenal de Toulon, l'ingénieur des Ponts et Chaussées Raucourt emploie vers 1820 une main d'úuvre composée de forçats dont il souligne à plusieurs reprises le caractère économique[21]. Son collègue Poirel aura également recours à des forçats pour aménager le port d'Alger à partir de 1830[22]. Mais le nombre de prisonniers dont on peut disposer se révèle singulièrement limité au regard des besoins. Quant au recours à la troupe, est-il aussi rentable que le prétendent ses partisans? Tous calculs faits, l'ingénieur Collignon affirme par exemple que les soldats employés pour construire les routes stratégiques de l'Ouest reviennent plus cher que les ouvriers civils[23]. Ne sait-on pas d'ailleurs depuis Adam Smith que le travail des esclaves se révèle toujours moins rentable que celui des hommes libres? Ces différentes raisons constituent autant de freins au développement du travail embrigadé ou forcé. Reste alors l'alternative libérale qui verrait la fin du monopole de l'administration sur les travaux publics.

Les libéraux qui souhaitent déréglementer le secteur des travaux publics, allant

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[18] «Du mode d'exécution des travaux publics, et plus particulièrement des travaux des Ponts et Chaussées», par un ancien élèves de l'École Polytechnique, «Journal du génie civil», 2, 1829, pp. 219-227.

[19] Distinctes des voies ordinaires, qu'elles soient royales, départementales ou vicinales, les routes stratégiques de l'Ouest ont pour but de pacifier des pays où l'attachement à la branche aînée des Bourbons demeure très vif après la révolution de 1830. D'une longueur totale de 1 500 kilomètres environ, elles sont construites par les Ponts et Chaussées et l'armée en un peu moins d'une dizaine d'années. Cf. H. CAVAILLÈS, *La route française…*, cit., pp. 202-203.

[20] Archives du Génie Art. 8, Sect. 1, § Paris, travaux de défense, cartons 7-8.

[21] A. RAUCOURT, *lettre au directeur général des Ponts et Chaussées du 10 novembre 1830*, Archives Nationales F14 23082.

[22] L. POIREL, *Mémoire sur les travaux à la mer, comprenant l'historique des ouvrages exécutés au port d'Alger, et l'exposé complet et détaillé d'un système de fondation à la mer au moyen de blocs de béton*, Carilian-Gúury, Paris.

[23] C.A. COLLIGNON, *Emploi des troupes aux travaux des routes stratégiques,* «Annales des Ponts et Chaussées», 1[er] semestre 1840, pp. 1-35.

même jusqu'à réclamer la suppression du corps des Ponts, ont pour eux un argument de poids, l'exemple de l'Angleterre qui ne possède ni administration ni ingénieurs des Ponts et Chaussées, ce qui ne l'a pas empêchée de se doter d'un système de voies de communication sans rival en Europe. Les lenteurs apportées par l'administration à la réalisation du plan Becquey d'achèvement des canaux ainsi que les erreurs commises dans l'évaluation de l'enveloppe financière nécessaire vont leur donner une magnifique occasion de s'exprimer publiquement. L'action des Ponts et Chaussées fait en effet l'objet d'un débat à la Chambre en 1828 après que Becquey ait demandé le vote de crédits supplémentaires. «Beaucoup au faste, au luxe, à l'ostentation, et rarement à l'utilité réelle, voilà les principes qui sembleraient avoir souvent guidé l'administration»[24], déclare un député au cours de la séance du 9 juillet 1828, tandis qu'un autre fustige le lendemain les «faiseurs de projets»[25] qui n'ont pas su mener à bien la construction des canaux en respectant l'enveloppe financière initiale. Pourquoi ne pas confier leur conception et leur exécution au privé, se demandent certains de leurs collègues ? «C'est aujourd'hui un des préceptes les plus accrédités du formulaire constitutionnel, que l'État est le pire des constructeurs»[26], peuvent écrire peu après Lamé, Clapeyron et les frères Flachat dans leurs *Vues politiques et pratiques sur les travaux publics de France*. Ce précepte va être repris par les premiers ingénieurs civils français qui se réclament de l'exemple anglais.

La profession d'ingénieur civil naît en France dans les années 1820-1830. La création de l'École Centrale des Arts et Manufactures en 1829 constitue à cet égard un événement clef[27]. Pour la première fois une formation d'ingénieur se destinant au secteur privé voit le jour à côté des établissements réservés aux futurs ingénieurs de l'État comme l'École polytechnique, l'École des Mines ou l'École des Ponts et Chaussées. La suppression du monopole exercé par l'administration sur les travaux publics fait figure de cheval de bataille pour de nombreux ingénieurs civils, qu'ils soient ou non passés par l'École Centrale. «Les développements de l'art de l'ingénieur ont été profondément retardés en France par l'absence de stimulant résultant de

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[24] *Archives parlementaires*, 2e série, éd. J. Mavidal, E. Laurent, P. Dupont, Paris 1862-1895, t. LV, p. 718.

[25] *Ibid.*, p. 744.

[26] B.P.E. CLAPEYRON, E. FLACHAT, S. FLACHAT, G. LAMÉ, *Vues politiques et pratiques sur les travaux publics de France,* impr. d'Everat, Paris 1832, p. 14.

[27] Cfr. J.-H. WEISS, *The making of technological man. The socials origins of french engineering education*, MIT Press, Cambridge Massachussetts, 1982.

l'organisation même du corps des Ponts et Chaussées[28]», peut-on lire par exemple dans les *Observations présentées au Comité des travaux publics de l'Assemblée Nationale par la Société Centrale des Ingénieurs Civils* en octobre 1848 qui plaident en faveur de l'ouverture des marchés de conception et d'exécution des infrastructures de transport à la nouvelle profession.

L'organisation des travaux publics qui finit par prévaloir avec le chemin de fer ne répond qu'en partie aux attentes des ingénieurs civils. L'État conserve en effet la maîtrise des études et dans bien des cas celle de l'exécution des infrastructures. Mais il concède tout de même les lignes à des compagnies privées chargées d'en assurer l'exploitation. C'est un régime mixte qui s'impose ainsi, excluant aussi bien les solutions autoritaires dont avaient rêvé certains polémistes de la première moitié du XIX^{e} siècle que le libéralisme intégral prôné par leurs adversaires. Au nom de l'utilité des travaux publics s'élaborent du même coup de nouvelles relations de coopération entre l'action de la puissance publique et l'initiative privée, entre les ingénieurs d'État et les ingénieurs civils, relations qui vont orienter durablement le développement économique «à la française», même si leur critique est devenue aujourd'hui l'un des poncifs de la réflexion politique et économique.

Du monument à l'équipement, la quantification de l'utilité

La question de l'organisation des travaux publics recouvre en réalité toute une série d'interrogations concernant l'économie qui doit régner dans ce secteur clef. Qu'est-ce que l'économie, comment se mesure-t-elle, comment mettre en relation le coût d'une infrastructure et les bénéfices que l'on peut en escompter? Le XIX^{e} siècle marque de ce point de vue la fin des conceptions rudimentaires de l'économie dont s'étaient longtemps contentés décideurs et techniciens.

Pour les ingénieurs de l'âge classique, l'économie apportée à la réalisation d'un projet et sa rentabilité ultérieure ne se mesuraient pas vraiment. Sa conception demeurait tributaire d'un idéal de magnificence qui conduisait à voir dans un ouvrage d'art ou un canal un monument annonçant la grandeur du pouvoir qui l'avait ordonné de même que Versailles constituait une sorte de vitrine de la monarchie française. Cet état d'esprit avait commencé à évoluer au cours de la seconde moitié du XVIII^{e} siècle, en même temps que s'étaient fait jour les premières

[28] *Observations présentées au Comité des travaux publics de l'Assemblée Nationale par la Société Centrale des Ingénieurs Civils*, impr. centrale des chemins de fer de Napoléon Chaix, Paris 1848, p. 9. Sur la Société Centrale des Ingénieurs Civils de France, lire par ailleurs B. JACOMY, *A la recherche de sa mission La société des ingénieurs civils*, «Culture technique», 12, 1984, pp. 209-219.

tentatives d'évaluation de la rentabilité des infrastructures. Une telle évolution demeurait toutefois limitée, comme en témoignent de manière presque caricaturale les *Réflexions sur les grands ouvrages en général* publiées par l'ingénieur en chef du Havre Lapeyre autour de 1810. Défendant une conception encore très monumentale de l'aménagement et de la construction, Lapeyre distingue la véritable économie d'un ouvrage, qui est «en raison inverse du prix divisé par le temps de sa durée»[29], de la moindre dépense dont l'évaluation est toujours sujette à caution. «Si Rome et Athènes n'eussent considéré que la moindre dépense dans leurs ouvrages, il ne nous resterait pas aujourd'hui des preuves de leur puissance», déclare-t-il avant d'ajouter: «tâchons de faire un pont, une écluse, etc., d'un seul bloc de granit, qui durerait autant que le monde: et d'après le principe que nous avons établi, telle que fût la dépense, étant divisée par l'éternité, la fraction serait infiniment petite; par conséquent l'économie la plus grande possible». A l'appui de son opinion, l'ingénieur invoque enfin le désir d'éternité des Ponts et Chaussées, «un des corps les plus instruits de France», qui ne saurait fonder «sa juste réputation sur le mot toujours équivoque d'économie»[30].

Cette conception de l'économie va se trouver progressivement remise en cause sous la pression de plusieurs facteurs. L'avance technologique anglaise dont les français prennent conscience à partir de 1815 démontre tout d'abord que monumentalité n'est pas forcément synonyme d'efficacité. A partir de la Restauration, les dépenses de l'administration des Ponts et Chaussées sont inscrites d'autre part au budget, un budget voté chaque année au terme d'un débat parlementaire[31]; elles doivent du même coup faire l'objet de justifications plus poussées qu'autrefois. La nécessité de se justifier est enfin d'autant plus nécessaire que certains libéraux soupçonnent assez systématiquement les ingénieurs d'État de gabegie et ne se privent pas de le faire savoir.

Dans ce contexte, on assiste à un développement rapide du calcul économique avec les contributions d'ingénieurs comme Barnabé Brisson ou Claude Navier[32]. Il s'agit de démontrer l'utilité des projets en cernant leur coût de manière plus fine qu'autrefois et en la rapportant aux bienfaits que le commerce peut en attendre. Sous

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[29] J. LAPEYRE, *Réflexions sur les grands ouvrages en général, et particulièrement sur les travaux maritimes qui sont confiés aux ingénieurs des Ponts et Chaussées,* Le Havre, p. 11.

[30] *Ibid.*, pp. 12-13.

[31] Cf. M. BRUGUIÈRE, *La première Restauration et son budget*, Droz, Genève – Paris, 1969.

[32] Sur le développement du calcul économique, lire F. ETNER, *Histoire du calcul économique en France*, Economica, Paris 1987.

la plume des ingénieurs pionniers du calcul économique, l'utilité se détermine ainsi en comparant deux grandeurs qu'on suppose *a priori* quantifiables. Jusqu'à Jules Dupuit, la démarche adoptée afin d'évaluer les gains du commerce consiste généralement à évaluer l'abaissement des coûts de transport unitaire résultant de la réalisation d'une nouvelle infrastructure et à multiplier le résultat obtenu par le volume de marchandises qui transitent d'ores et déjà entre les deux points dont la liaison va se trouver améliorée. Dans son célèbre article publié en 1844 dans les *Annales des Ponts et Chaussées*, «De la mesure de l'utilité des travaux publics», Dupuit reformule le problème en faisant observer que l'ouverture d'une nouvelle voie communication s'accompagne généralement d'une modification de la demande de transport. Il redécouvre du même coup la fonction de demande déjà mise en évidence par Cournot dans ses *Recherches sur la théorie des richesses* de 1838[33]. Modélisables au moyen du calcul différentiel et intégral, ses analyses constituent un jalon essentiel sur le chemin qui mène à l'approche marginaliste. Celle-ci ne verra néanmoins le jour que dans les dernières décennies du XIXe siècle.

Plus que leurs détails, c'est par le changement de mentalité qu'ils annoncent que les écrits des premiers adeptes du calcul économique parmi les ingénieurs nous retiendront en définitive. Ils participent d'un nouveau rapport au temps. Le temps des grands travaux n'est plus pris en étau entre l'immédiateté de l'instant et l'éternité du monument. Ce qui s'invente, c'est le moyen terme, le temps de l'investissement, de l'amortissement du capital, du cycle de vie des infrastructures, le temps de la spéculation et de l'usage économique. Les grands travaux d'infrastructure changent du même coup de registre. Ils ne font plus figure de monuments destinés à glorifier un pouvoir d'essence intemporelle; on ne saurait plus exiger d'eux une durée éternelle. L'utilité se confond de plus en plus avec ce caractère fonctionnel qui rapproche l'équipement de la machine. Mais elle prend du même coup une dimension quelque peu paradoxale puisqu'elle continue à renvoyer au registre du monument sous couvert d'exprimer les progrès successifs de la civilisation. Un autre paradoxe tient à la coexistence sous une même rubrique d'idéaux sociaux extrêmement généraux et de considérations plus directement instrumentales. Ce qui s'esquisse peut-être derrière les multiples acceptions du terme utilité, c'est le statut moderne dont jouissent les grands travaux dans un pays comme la France, des

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[33] J. DUPUIT, *De la mesure de l'utilité des travaux publics*, «Annales des Ponts et Chaussées», 2e semestre 1844, pp. 332-375. Sur Dupuit, lire F. ETNER, *Histoire du calcul…*, cit., pp. 150-156; sur les conceptions de Cournot on pourra consulter C. MÉNARD, *La formation d'une rationalité économique: A.A. Cournot,* Flammarion, Paris 1978.

travaux soumis à des règles de programmation et de gestion de plus en plus rigoureuses, en même temps qu'ils demeurent empreints d'une part de rêve et d'exaltation.

Ce statut moderne des grands travaux permet de mieux comprendre à présent l'héritage au travers duquel se définissent les ingénieurs d'État français contemporains. Cet héritage réside tout d'abord dans l'interaction étroite entre préoccupations politiques et déterminations techniques. La notion de «politique technique», chère à des ministères comme l'Equipement ou l'Industrie, n'est jamais qu'une des conséquences de cette imbrication. L'idéal de complémentarité harmonieuse entre une administration centrale qui définirait les grandes lignes de développement de la nation et un secteur privé souvent chargé de sa mise en úuvre concrète participe de ce même héritage que la dérégulation économique et la régionalisation semblent remettre en cause. Plus généralement, les justifications traditionnelles auxquelles recouraient les ingénieurs d'État semblent avoir perdu aujourd'hui une partie de leur efficacité. Etudier la genèse des représentations de l'utilité collective véhiculées par ces acteurs longtemps privilégiés devrait du même coup préluder à un travail de redéfinition des valeurs sur lesquelles se fonde leur action. Les raisonnements économiques sophistiqués qui ont succédé aux premières tentatives de quantification des Brisson, Navier ou Dupuit, ne permettent plus d'éluder un certain nombre de questions fondamentales. Qu'est-ce que l'utile aujourd'hui? De quelle façon l'État doit-il contribuer à son développement? Renouant avec la richesse de la réflexion des Lumières, c'est à la reconstitution d'une philosophie de l'utilité qu'il importe peut-être d'úuvrer.

Technological traditions and national identities. A comparison between France and Great Britain during the XIXth Century[1]

by Antoine Picon

A context of growing competition.

During the nineteenth century there was a strong link between technology, between engineering in particular, and the construction of national identities. This link was somewhat paradoxical since the nineteenth century saw the internationalization of technology. Technological knowledge and know how had been generally local. Now they were circulating all over the world. Throughout the century, the evolution of manufacturing processes and technological artifacts was to a large extent the result of this circulation. However, such a circulation was accompanied by a growing political and economical competition between nations. In this context, technology and its engineering component became both dimensions of the various national identities and measures of the degree of excellence of the nations present on the international stage. By the end of the century, this double role was epitomized by great civil engineering works such as the Eiffel tower, the Firth of Forth bridge or the Brooklyn bridge. These achievements were meant to be objects of national pride as well as arguments on the international market of civil engineering expertise[2].

Such a role implied that technology and engineering were to be all at once specific, intimately linked to National cultures, and comparable from one country to another. How were these rather contradictory requirements met with? This question will be the starting point of this article. In order to answer it, I will take French and British engineering as two case studies. Throughout the nineteenth century, French and British engineers were constantly looking at each other, trying to distinguish themselves while being often inspired by their mutual achievements. In other words, French and Great Britain engineering traditions were constructed in close relation one with another.

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[1] Article published in *Science, Technology and the 19th century state*, edited by Efthimyos Nicoladis and Konstantinos Chatzis, Institut de Recherches Néohelleniques, Athens 2000, pp. 13-21.

[2] Cf. D. BILLINGTON, *The Tower and the bridge. The New art of structural engineering*, Princeton University Press, Princeton, 1985; A. PICON, *L'Art de l'ingénieur. Constructeur, entrepreneur, inventeur*, Centre Georges Pompidou, Le Moniteur, Paris 1997.

Technology and national prejudices.

Do something like national identities exist? Given the diversity of countries like France or Great Britain the answer is not evident[3]. My purpose here is not to discuss this difficult issue. My starting point will be rather the following observation: whereas the existence of national identities is problematical, the attempts made to create or characterize them cannot be dismissed as mere illusions. Throughout the nineteenth century, a whole range of authors tried to define the French and the British national identities, often in contrast one to the other. Mutual prejudices arose from these attempts. When attempting to understand the relations between France and Great Britain, it is almost impossible to get rid of these prejudices.

In his *Notes sur l'Angleterre*, Hippolyte Taine gave a good account of the most common prejudices regarding the French and the British during the nineteenth century. Taine began by comparing, I quote, «the interior of an English head with a Murray guide. It holds a many facts and few ideas, a lot of useful and precise information, little statistical surveys, numerous figures, accurate maps, short and dry historical accounts, moral and useful advises as a foreword, no general view, no literary ambition». «The French like the ideas for their own sake, added Taine, whereas the English tend to use them as mnemonic or predictive tools»[4].

Revealingly, Taine gave an example of these allegedly contrasting dispositions taken from the scientific and technological field. Stephenson and Foucault were the two figures involved in the comparison.

«The great engineer Stephenson was once asked how he had invented his machines, the locomotive in particular. He answered that it was by dint of conceiving with an extreme precision the different part, their shape, their dimensions, their articulations, their possible movements and the complete set of consequences brought by the replacement of one part, or by the change of a dimension or an articulation. Thus his mind looked like a workshop; all the components were numbered and labeled; he took them one after the other, made them fit, and by trial and error found the right combination. On the contrary, Lon Foucault told me once that having found a theoretical proposition in mechanics that had been overlooked by Huygens and Lagrange, he had followed its consequences and these consequences had led him to the principle of his regulator».

[3] A stimulating discussion of this question can be found in E. KRANAKIS, *Constructing a bridge. An Exploration of engineering culture, design and research in nineteenth-century France and America*, MIT Press, Cambridge, Massachusetts, 1997.

[4] H. TAINE, *Notes sur l'Angleterre*, Paris 1871, rd. Hachette, Paris 1890, pp. 325-326.

«Generally, added Taine, the French understands through the use of deductive classifications, whereas the English thinks in inductive terms, by dint of application and memory, through the realistic representation of a large amount of individual facts, through a mass of distinct and juxtaposed documents»[5].

Taine gave a fairly representative account of the differences between the French and the British attitudes towards science and technology as they were figured out by the nineteenth century. Whereas the French were supposed to be primarily driven by theoretical speculations, the English were allegedly more practical. Whereas the former were deductive, the latter were mostly inductive.

This kind of assessment was rooted in more general beliefs regarding the differences between the Latin and the Anglo-Saxon cultures. In his *Lettres sur l'Amérique du Nord* published in 1836, the Saint-Simonian engineer Michel Chevalier drew a parallel between the passionate character of the French and the more reasonable nature of the English, between the enthusiasm and imagination of the former, and the common sense of the latter[6]. In the Saint-Simonian doctrine, England was made by the way responsible for the material advances of humanity, while France was supposed exert leadership on spiritual matters[7]. Although the English side generally agreed on the importance of its contribution to the material welfare of mankind, the second part of the proposition was met more reluctantly.

The opposition between theoretical and practical orientations, between deduction and induction, was as for it well summarized by the precedence given by the French to mathematics, whereas the English were supposed to refer themselves more often to mechanics, practical mechanics of course. Such a contrast can still be found in Duhem's *LaThorie physique*. Duhem was the inheritor of a typical nineteenth century prejudice, when he found fault with the use of mechanical representations by the British physicists. «The English mind can be clearly characterized by the extent of its faculty to conceive concrete ensembles and by the weakness of its faculty of abstraction and generalization»[8], declared Duhem for whom abstraction and

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[5] *Ibid.*, p. 326.

[6] M. CHEVALIER, *Lettres sur l'Amrique du nord*, Charles Gosselin, Paris, 1836. On Michel Chevalier, see in addition J. WALCH, *Michel Chevalier conomiste saint-simonien 1806-1879*, Vrin, Paris, 1975.

[7] *Doctrine de Saint-Simon. Exposition*, Première et deuxième annes, Paris, Bureau de l'Organisateur, 1830. On the Saint-Simonian doctrine, see for instance S. CHARLTY, *Histoire du Saint-simonisme (1825-1864)*, Paris, 1896, rd. P. Hartmann, 1931; *G. Iggers, The Cult of authority. The Political philosophy of the saint-simonians*, La Haye, 1958, rd. M. Nijhoff, La Haye 1970.

[8] P. DUHEM, *La Thorie physique, son objet, sa structure*, Paris, 1906, rd. Vrin, Paris 1981, p. 126.

generalization were undoubtedly French.

This kind of prejudice was for sure grounded into some kind of reality, a reality even more evident on a technological ground than on a purely scientific one. The French engineering profession emerged in domains such as fortification and engineering that bore almost no relation with mechanical construction[9]. On the contrary, throughout the eighteenth and nineteenth centuries, the construction of machines represented an essential field of activity for British engineers. The founding father of British engineering, John Smeaton, was involved both in civil and mechanical engineering[10]. Trained initially in the making of scientific instruments, he designed steam engines as well as bridges. In this context, the mechanical turn taken by an engineer such as Stephenson was by no mean exceptional. As the French engineer Joseph Dutens remarked in his *Mémoires sur les travaux publics de l'Angleterre* published in 1819, even the canals were designed as machines in England, whereas the French saw them as liquid roads or monuments[11].

But once more, my aim is not to indicate what is true and untrue in the representations of technological traditions constructed in the nineteenth century. My objective is to understand rather how they were constructed in order to allow both for international comparison and exchange and for the alleged existence of national identities.

Differences and complicity

To understand this construction, it can be useful to pay attention at the situation that was prevailing before, in other words to the relations between French and British engineers in the eighteenth century. French and British engineers were for sure quite different at the time. The French engineers were State engineers, organized in hierarchical corps such as the *Ponts et Chaussés* or the Genie corps. They were trained in specialized schools. They saw themselves as agents of a collective progress, of a fight against nature placed under the aegis of values such as public utility. In France, engineering could already be considered as a profession[12].

The British situation was quite different insofar that engineers were still relatively

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[9] Cf. A. PICON, *L'Invention de l'ingénieur moderne. L'École des Ponts et Chaussées 1747-1851*, Presses de l'École nationale des Ponts et Chaussées, Paris 1992.

[10] On Smeaton, see *John Smeaton FRS*, edited by A.W. Skempton, Thomas Telford, London 1981.

[11] J. DUTENS, *Mémoires sur les travaux publics de l'Angleterre, suivis d'un mémoire sur l'esprit d'association et sur les différents modes de concession,* imprimerie Royale, Paris, 1819, p. v.

[12] Cf. A. PICON, *L'Invention de l'ingénieur modern…*, cit.

isolated individuals trained through traditional apprenticeship, often as instruments makers or surveyors. John Smeaton began for instance his career as an instrument maker. In Great Britain, engineering was not yet a fully organized profession[13].

What British engineering lacked in formal organization was counterbalanced by its creativity. From the steam engines to the first iron bridges, British engineers were already paving the way for the industrial revolution, contrary to their French colleagues who remained rather traditional in their approach of technological problems.

Despite these major differences, the French and the British saw themselves as colleagues rather than representatives of contrasting national differences. Their differences had by the way nothing to do with those that historians usually mention when they try to compare French and British engineering. Contrary to a rather common assumption, French engineers were not that versed in theory, in mathematics in particular, compared to their British counterparts. John Smeaton for instance a better scientist than his French equivalent, Jean-Rodolphe Perronet, the founder of the École des Ponts et Chaussées.

They were differences indeed in the way French and British designed roads, bridges or harbors. French roads were for instance rather straight, whereas their British counterparts were much more curved in order to avoid trimming the private properties which they ran alongside. During the second half of the eighteenth century, French engineers seldom built great humpbacked bridges, contrary to the British[14]. Although the United Kingdom already dominated the seas, rational harbors and arsenals such as those designed by the French for Cherbourg and other places could be seen nowhere along its coast[15].

However, those differences were not considered as essential. Revealingly, when he visited England in 1785, the assistant director of the École des Ponts et Chaussées , Pierre-Charles Lesage, remarked almost none of them[16].

The discrepant political, social and economical contexts were seen as more

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[13] On the history of British engineering, see R. A. BUCHANAN, *The Engineers. A History of the Engineering profession in Britain 1750-1914*, Jessica Kingsley, Londres 1989.

[14] Cf. T. RUDDOCK, *Arch bridges and their builders 1735-1835*, Cambridge University Press, Cambridge 1979.

[15] On the French designs for rational harbors and arsenals, see A. DEMANGEON, B. FORTIER, *Les Vaisseaux et les villes*, Mardaga, Bruxelles / Lige 1978.

[16] P. CH. LESAGE, *Journal et observations sur les chemins d'Angleterre et principalement sur les grandes routes*, 1784-1785, E.N.P.C. Ms 48.

significant than technology itself. The United Kingdom considered itself as more advanced in these matters than absolutist France. A French engineer like Lesage agreed and he wrote in his diary that «no Englishman is excluded from the quality of citizen. Hence the self assurance, the patriotism and the pride of the English people». «Few countries pay their taxes with such a tranquillity, with so little complaint than England; in no other country are so many charities established for the suffering people»[17], added Lesage. It is no hazard if the construction of a clearly identified technological tradition was to rely strongly on this type of differences.

Constructing Engineering as a Profession

By the very end of the eighteenth century, the creation of the *École Polytec*hnique and the subsequent evolution of the French higher education system began to drive French and British engineering apart[18]. French engineers became learned in sophisticated mathematics and mechanics, whereas their English colleagues were still using more down-to-earth knowledge. Moreover, the French profession was more and more school based, whereas the English one remained faithful to the system of apprenticeship[19].

These emerging differences were not seen by the British engineers as absolutely fundamental. Many of them made an extensive use of the French textbooks, so that they didn't feel really behind their colleagues on a scientific ground. Telford was quite typical of this French influence. Among the books he donated to the Institution of Civil Engineers when he became its president, half were French[20].

Although proud of the technological superiority they had achieved by the end of the Napoleonic wars, the British engineers didn't look for a specificity to be found in their knowledge or even their productions. Their true superiority was moral. There

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[17] *Ibid.*

[18] On the content of the École Polytechnique curriculum as well as on the influence it exerted on the French higher education system, see B. BELHOSTE, A. DAHAN- DALMÉDICO, A. PICON, *La Formation polytechnicienne 1794-1994,* Dunod, Paris 1994.

[19] Apprenticeship remained dominant in Great Britain until the last decades of the nineteenth century. Cf. A. GUAGNINI, *worlds apart: academic instruction and professional qualifications in the training of mechanical engineers in England, 1850-1914*, in *Education, technology and industrial performance in Europe, 1850-1839*, edited by R. Fox and A. Guagnini, Cambridge University Press / Editions de la Maison des sciences de l'homme, Cambridge / Paris 1993, pp. 16-41.

[20] *Minutes of the proceedings of the Institution of Civil Engineers for facilitating the acquirement of knowledge necessary in their profession and for promoting mechanical philosophy. First session. 1818*, meeting of the 17th of March 1820, I.C.E., N 93.

lied the specificity of British engineering.

This specificity was epitomized by a new type of engineering institution: the professional society. The Society of Civil Engineers founded in 1771 and the Institution of Civil Engineers founded in 1818 were neither corps, neither engineering schools[21]. The models they referred to were typical institutions of the United Kingdom: the Parliament, the Royal Society, the political and socials clubs. «Thus our Institution resembles the British Parliament ; where from a variety of talents and acquirements, much useful practical knowledge is derived»[22], boasted the members of the Institution of Civil Engineers shortly after its official recognizance by a Royal Charter in 1826.

What was at stake in these creations was summarized by Telford in his first speech as president of the Institution of Civil Engineers in 1820. In the Institution, began Telford, «the good sense of the members will always prove that manners and moral feeling are superior to written laws». Then he added: «In foreign countries similar establishments are instituted by government, and their members and proceedings are under its control; but here a different course being adopted, it becomes incumbent on each individual member to feel that the very existence and prosperity of the Institution depends in no small degree on his personal conduct and exertion»[23].

Good sense, personal conduct and exertion, collective responsibility, those values derived from the British conception of what a profession was about. Through the creation of the Institution of Civil Engineers, this matrix of the British engineering profession, what was at stake was the transformation of a practice into a profession as honorable as law or medicine. Such a project was inseparable from political and social assumptions, from a liberal approach of engineering, an approach very different indeed from the French one.

This liberal approach was in its turn inseparable from a vision of the State as a moral authority in charge of general political, social and economical regulations. With the exception of domains such as the military, the State was not supposed to be directly in charge of technological progress. Professions and associations such as

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[21] On these two institutions, see G. WATSON, *The Smeatonians. The Society of Civil Engineers*, Thomas Telford, Londres 1989; G. WATSON, *The Civils. The story of the Institution of Civil Engineers*, Thomas Telford, Londres 1988.

[22] Institution of Civil Engineers, *Minute book 1826 to 1836*, v. 2, meeting of the 20th of January 1829, I.C.E.N. 93.

[23] *Minutes of the proceedings of the Institution of Civil Engineers. First session. 1818*, meeting of the 21st March 1820.

engineers and their institutions were the true actors of this movement towards progress.

It is in this perspective that the British claim for practicality must be probably understood. If it suited the British engineers to be seen as less theoretical and more practical than their French counterparts, it is probably because of their professional orientation, an orientation that they interpreted as their true specificity. Just as lawyers of physicians had to exercise their art, engineers had to be practical. They were not to be confused with scientists.

Constructing engineering as a vocation

Through the Polytechnic education, the relation between science and engineering was seen as a fundamental component of the French conception. After discovering their technological backwardness after the collapse of the Napoleonic Empire, French engineers often saw science as the only mean to catch up with their rivals. This vision was developed by engineers such as Charles Dupin or Claude Navier, in the memoirs they published after they had visited Great Britain[24].

But was science the true French specificity? Its universality forbade to see it as a permanent characteristic of the French engineering profession. Sooner or later, the British would catch up with the French scientific excellence. The political and social values promoted by the intensive use of scientific result were perhaps more fundamental.

These values, public utility, universality, impartiality, had been first appropriated by the State engineers. Impartiality was especially important when one had to expropriate people or to choose between projects that altered the value of land. By the end of the eighteenth century, two professional figures had been used by the State engineers as references impersonating utility, universality and impartiality: the army officer and the judge.

«If all men were reasonable, there would be no need for officers or judges, but given the men as they are, what is more useful, a great captain or a great judge?» such was the question asked to the students of the *École des Ponts et Chaussées* as a subject of French dissertation in the late eighteenth century[25].

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[24] On the visits paid by French engineers to Great Britain during the first half of the nineteenth century, see M. BRADLEY, *Engineers as military spies? French engineers come to Britain, 1780-1790*, «Annals of science», 49, 1992, pp. 137-161.

[25] On the French dissertation of the *École des Ponts et Chaussées*, see A. PICON, *L'invention de l'ingénieur modern…*, cit.

The perfect State engineer had to combine the discipline and the sense of duty of the officer with the impartiality of the judge. For both the officer and the judge, professional activity had the character of a call. After them, engineering was be a vocation rather than a profession.

This set of connotations were to survive the evolution of the French engineering profession towards a more liberal conception. Although highly critical towards the State corps of engineers, the Civils that appeared in France towards the end of the 1820s remained partially faithful to the fundamental values of their State predecessors[26]. Throughout the nineteenth century, French engineers saw themselves as relatively special. They were supposed to serve a great cause, the cause of public welfare and progress, with dedication and impartiality.

Such a conception had of course links with a conception of the State as a major partner in the process of innovation. Even as a civil, the engineer was still supposed to be a partner for the administration. Whereas competence and ethics were supposed to come first for British engineers, dedication and authority were perhaps the most fundamental characteristics of French engineers. By the end of the nineteenth century, the immediate transposition of general Lyautey's famous article on «the social role of the officer» into developments on «the social role of the engineer» confirmed the fact[27].

Technological tradition and politics

What I have tried to suggest in this article, is that throughout the nineteenth century, technological traditions had more to do with politics, with representations of what is legitimate, than with the actual content of the textbooks or what was realized by the engineers. Hence their association with the search for national identities. Technological traditions were supposed to be grounded in the fundamental ethics of the people. They had more to do with values than with achievements. Achievements made them however comparable. As a system of values, technology was rooted into the various national experiences. As a set of artifacts, it could be exchanged. This duality is perhaps still present today. After all, what we call

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[26] On the emergence of the French civil engineers, see J.H. WEISS, *The Making of technological man. The Socials origins of french engineering education*, The MIT Press, Cambridge Massachussetts 1982.

[27] L. LYAUTEY, *Du Rôle social de l'officier dans le service militaire universel*, Perrin et Cie, Paris 1891. Shortly after the publication of Lyautey's essay, a «Rôle social de l'ingénieur» is published by the journal *Etudes*. Its author is the Jesuit Henri-Rgis Pupey-Girard, the founder ot an Union sociale des ingénieurs catholiques.

globalization is based on the assumption that we can remain ourselves in a continuous process of exchange.

Bibliografia / Bibliography
Principali libri e saggi di Antoine Picon
Main Books and Texts by Antoine Picon

- RENZO PIANO, RICHARD ROGERS, *Du plateau Beaubourg au Centre Georges Pompidou*, interview with / intervista con A. Picon, Centre Georges Pompidou, Paris 1987.
- A. PICON, *Architectes et ingénieurs au siècle des Lumières*, Parenthèses, Marseille 1988.
- A. PICON, *Claude Perrault (1613-1688) ou la Curiosité d'un classique*, Picard, Paris 1988.
- A. PICON, MICHEL YVON, *L'ingénieur artiste. Dessins anciens de L'École des Ponts et Chaussées,* Presses de l'École nationale des Ponts et Chaussées, Paris 1989.
- A. PICON, *French Architects and Engineers in the Age of Enlightenment*, translated by / traduz. di Martin Thom, Cambridge University Press, Cambridge 1992.
- A. PICON, *Gestes ouvriers, opérations et processus techniques. La vision du travail des encyclopédistes*, «Recherches sur Diderot et sur l'Encyclopédie», 13, 1992, pp. 131-147.
- A. PICON, *L'invention de l'ingénieur moderne. L'École des Ponts et Chaussées 1747–1851,* Presses de l'École nationale des Ponts et chaussées, Paris 1992.
- A. PICON *and other / e altri, Marseille ville & port,* Parenthèses, Marseille 1992.
- ANNE COSTE, A. PICON, FRANCIS SIDOT, *L'ingénieur des Lumières. Émiland-Marie Gauthey,* Presses de l'École nationale des Ponts et Chaussées, Paris 1993.
- A. PICON, *Pour une Histoire de la pensée technique. Rapport pour l'habilitation à diriger des recherches,* EHESS, Paris 1993.
- A. PICON, *De l'utilité des travaux publics en France aux* XVIII*e et* XIX*e siècle,* in *Acteurs privés et acteurs publics: une histoire du partage des rôles*, Ministère de l'Equipement, des Transports et du Tourisme, Direction de la Recherche et des Affaires Scientifiques et Techniques, Paris 1994, pp. 129-136.
- BRUNO BELHOSTE, AMY DAHAN-DALMÉDICO, A. PICON, *La formation polytechnicienne, 1794-1994,* Dunod, Paris 1994.
- A. PICON, *Towards a History of Technological Thought, Technological change,* in *Methods and themes in the history of Technology*, edited by Robert Fox, Harwood Academic Publishers, London 1996, pp. 37-49.
- A. PICON, *L'art de l'ingenieur. Constructeur, entrepreneur, inventeur,* Centre George Pompidou, Le Moniteur, Paris 1997.

- MARC DESPORTES, ANTOINE PICON, *De l'espace au territoire. L'aménagement en France XVI-XX siecles*, Ponts et Chaussées, Paris 1997.
- A. PICON, *La ville territoire des cyborgs,* Éd. de l'imprimeur, Besancon 1998.
- *Le dessus des cartes: un atlas parisien*, edited by / a cura di A. Picon and / e Jean-Paul Robert, with / con Anna Hartmann, Éditions du Pavillon de l'Arsenal, Picard, Paris 1999.
- A. PICON, *Technological traditions and national identities. A comparison between France and Great Britain during the XIXth Century*, in *Science, Technology and the 19th century state*, edited by / a cura di Efthimyos Nicoladis and / e Konstantinos Chatzis, Institut de Recherches Néohelleniques, Athens 2000, pp. 13-21.
- A. PICON, *Les Saint-Simoniens. Raison, imaginaire et utopia*, Belin (coll. «Modernités»), Paris 2002.
- A. PICON, ALESSANDRA PONTE, *Architecture and the Sciences: Exchanging Metaphors,* Princeton Architectural Press, New York 2003.
- A. PICON, *Tra utopia e ruggine. Paesaggi dell'ingegneria dal Settecento a oggi,* edited by / a cura di Edoardo Piccoli, Allemandi, Torino 2006.
- *Inventare gli spostamenti. Storia e immagini dell'autostrada Torino-Savona,* edited by / a cura di Michele Bonino and / e Massimo Moraglio; introduction by / saggio introduttivo di A. Picon; preface to the photographic section by / prefaz. alla sezione fotografica Francesca Comisso and / e Nicoletta Leonardi, photographs / fotografie Giorgio Barrera and other / e altri, Allemandi, Torino 2006.
- *Marc Mimram: architettura ibrida,* with an essay by / con un saggio di A. Picon, Electa architettura, Milano 2009.
- A. PICON, *Culture numérique et architecture: une introduction*, Birkhäuser, Basel 2010.
- A. PICON, *Digital Culture in Architecture: an Introduction for the Design Professions*, Birkhäuser, Basel 2010.