Rationalizing maintenance activities within French industry during the *Trente Glorieuses*[*] (1945-75)

By Konstantinos Chatzis [**]

Introduction

Although historians have already expressed a lot of interest in the rationalization process within the French industry, it is clear that up to the present the subject has been dealt with selectively. While historical analyses concerning rationalization during the inter-war period constitute a considerable body of literature,[1] the same cannot be said of

---

[*] This article develops a lecture given at the conference: Le travail d'organiser et de s'organiser. Recherches sur l'entreprise en histoire, sociologie et gestion, held at the Cité des Sciences et de l'Industrie de la Villete, in Paris from January 27-28, 2000. The lecture was published in French under the title: "Une Rationalisation par sous-projets specialisés: la fonction Entretien durant les Trente Glorieuses (1945-1975)", Cahiers du Centre de Recherches Historiques, 2000, 25: 115-127. The author would like to thank the participants at the Paris conference (especially Yves Cohen) for their comments (Yves Cohen's comments were published in the aforementioned issue of the Cahiers du Centre de Recherches Historiques, pp. 128-133).

[**] Université Paris-Est - Laboratoire Techniques, Territoires et Sociétés (LATTS) - UMR CNRS 8134 – FRANCE – E-mail: chatzis@mail.enpc.fr

[1] See especially: Aimée Moutet, Les logiques de l'entreprise. La rationalisation dans l'industrie française de l'entre-deux-guerres (Paris: Editions de l'EHESS, 1997); Yves Cohen, Organiser à l'aube du taylorisme. La pratique d'Ernest Mattern chez Pegeaut, 1906-1919

the period known in French as the *Trente Glorieuses*[2] (1945-75).

We do not mean to suggest that no research concerning rationalization exists for the period 1945-75. The renewal of French sociology after the Second World War was (largely) down to the work of a new generation of industrial sociologists grouped around Georges Friedmann (1902-1977) who began to visit workplaces in order to measure the actual effects of rationalization on the very people who were subject to it.[3] However the rationalization techniques implemented by engineers during this period as well changes in these techniques over time also represent questions of historical interest which do not yet appear to have been (sufficiently) dealt with by the historians of industrial rationalization. Nevertheless, the *Trente Glorieuses* that began with a pilgrimage organized by the French state to the promised land of rationalization (i.e., the US),[4] was to witness the

(Besançon: Presses Universitaires de Franche-Comté, 2001); Eric Geerkens and Aimée Moutet, "La rationalisation en France et en Belgique dans les années 1930", Travail et Emploi, 2007, 112: 75-86.

2 Literally, 'Thirty Glorious Years' – French expression for the Post World War II boom period (1945-1975).

3 See, for example, the contributions compiled in the *Revue Française de Sociologie*, 1991, 32(3).

4 We should bear in mind that between July 1949 and November 1953, some 2,500 'missionaries' from all sorts of backgrounds – engineers, technicians, business leaders, civil servants and union representatives – traveled to the United States. They were entrusted with the task of studying the American industrial model and bringing back the 'magic recipe' this was thought to represent to France, both at the technical-organizational and industrial relations level. Concerning these productivity missions, see, for example: Richard F. Kuisel, *Seducing the French: the Dilemma of Americanization*, (Berkley: University of California Press, 1993); Dominique Barjot ed., *Catching up with America. Productivity Missions and the Diffusion of American Economic and Technological Influence after the Second World War* (Paris: Presses de l'Université de Paris-Sorbonne, 2002); Régis Boulat, *Jean Fourastié, un expert en productivité. La modernisation de la*

creation of numerous "rationally" designed turnkey factories by the Engineering departments of major French firms[5] as well as record rates of growth for French industry before ending in a crisis of efficiency and a search for new methods of producing and rationalizing[6] was thus a period of intense rationalization which is at least as deserving of historians' attention as previous periods.

France (années trente-années cinuqante) (Besançon: Presses universitaires de Franche-Comté, 2008); Marie-Laure Djelic, "L'arrivée du management en France. Un retour historique sur les liens entre managérialisme et Etat", *Revue Politiques et Management Public*, 2004, 22(2): 1-17; For an European perspective, see: Dominique Barjot and Christophe Reveillard eds, *L'américanisation de l'Europe occidentale au XXe siècle: mythe et réalité* (Paris: Presses de l'Université de Paris-Sorbonne, 2002); Jonathan Zeitlin and Gary Herrigel eds, *Americanization and its Limits. Reworking US Technology and Management in Post-War Europe and Japan* (Oxford: Oxford University Press, 2000).

5 P. Pélata, "L'industrie fordienne et l'espace français", unpublished PhD diss., EHESS, 1982; Aimée Mouter, "Etudes de temps et intensification du travail dans l'industrie française de 1945 à la décennie 1960", in *Le travail nous est compté. La construction des normes temporelles du travail*, eds Danièle Linhart and Aimée Moutet (Paris: La Découverte, 2005), pp. 28-62; Nicolas Hatzfeld, "Du règne du chronomètre au sacre du temps virtuel. Une histoire de succession aux usines Peugeot (1946-1996)", in *Le travail nous est compté. La construction des normes temporelles du travail*, eds Danièle Linhart and Aimée Moutet (Paris: La Découverte, 2005), pp. 63-73; Nicolas Hatzfeld, "L'intensification du travail en débat. Ethnographie et histoire aux chaînes de Peugeot-Sochaux", *Sociologie du Travail*, 2004, 46(3): 291-307; Konstantinos Chatzis, "Searching for Standards: French Engineers and Time and Motion Studies of Industrial Operations in the 1950s", *History and Technology*, 1999, 15(3): 233-261.

6 The literature relating to the crisis of Taylorim and the new (Post-Taylorist) patterns of industrial organization is quite extensive. See, for example, the works by: Pierre Veltz, *Le nouveau monde industriel* (Paris: Gallimard, 2000); Robert Boyer and Michel Freyssenet, *The Productive Models: The Conditions of Profitability* (New York: Palgrave Macmillan, 2002); Luc Boltanski and Eve Chiapello, *The New Spirit of Capitalism* (London: Verso, 2007, first ed. in French 1999), especially for the post-taylorist managerial discourses; Stephen Wood ed., *The Transformation of Work? Skill, Flexibility and the Labour Process* (London: Unwin Hyman Ltd, 1989); Cédric Lomba, "Beyond the Debate over 'Post'-vs. 'Neo'-Taylorism. The Contrasting Evolution of Industrial Work Practices", *International Sociology*, 2005, 20(1): 71-91.

This article is part of a broader project to study the rationalization processes that swept through major French industries during the *Trente Glorieuses*.[7] It proposes a first analysis of rationalization techniques developed in a specific domain of industrial activity, i.e., *maintenance*. The first section of the article outlines the general analytical framework we propose to use to tackle the rationalization movement implemented in France after the World War II. In the second section, this general analytical framework will be applied to the study of the rationalization of maintenance activities during the *Trente Glorieuses*. After outlining the different types of maintenance activities successively tackled by engineers' rationalizing zeal, we will focus on a limited number of rationalization techniques in order to provide an overview of the whole project to rationalize maintenance activities.

Finally, in offering a historical perspective of the rationalization of maintenance activities in France during the *Trente Glorieuse*, we wish analyze a facet of the rationalization process that has received scant attention up to now. But we also wish to draw historians' attention to the issue of *maintenance in general* which unfortunately occupies a relatively minor place in the history of technology, still dominated by an "innovation-centric picture of technology".[8]

---

7 For a presentation and a first "implementation" of this project in English, see: Chatzis, "Searching for Standards".

8 This expression is borrowed from David Edgerton, "Creole Technologies and Global Histories: Rethinking how Things Travel in Space and Time", *HoST. Journal of History of Science and Technology*, 2007, 1, 2007: 75-112, on p. 79. The same historian develops a convincing argument calling on historians of technology to focus on topics like maintenance. See, for example, David Edgerton, *The Shock of the Old. Technology and Global History since 1900* (New York: Oxford University Press, 2007).

SECTION I: Rationalizing during the *Trente Glorieuses*: an analytical framework

Although it does have a number of points in common with Pre-War rationalization projects – such as separating the conception from the execution of work, disassociating innovation and routine tasks, "objectifying" and measuring work carried out by machines and laborers, breaking down the work into simple operations, and standardizing and optimizing tasks and processes, etc. – in our opinion, Post-War II rationalization is also characterized by original features that distinguish it from its Pre-War counterpart. Let us say that it represents a "second level" in the rationalization edifice built by the father of scientific management, Frederick W. Taylor (1856-1915).

The first difference is one that we will refer to only in passing. While several French "rationalizers" during the Inter-War period wished to deal both with "technical" and "social" issues (just like Taylor, himself) such as effective cooperation (ensuring mutual benefits) between workers and employers or improving the living standards of the entire population based on increased productivity,[9] Post-War engi-

9 I first developed this interpretation of Taylorism in Konstantinos Chatzis, "La Régulation des systèmes socio-techniques sur la longue durée", unuplished PhD diss., ENPC, 1993; see also Chatzis, "Searching for Standards", pp. 235-237. We may glean information in support of such an interpretation in the following publications (naturally, the authors mentioned are not responsible for the use which I make of their work): Regarding the US: Judith A. Merkle, *Management and Ideology. The Legacy of the International Scientific Management Movement* (Berkeley: University of California Press, 1980); for the situation in France: Gerard Brun, *Technocrates et technocratie en France, 1914-1945* (Paris: Albatros, 1985); Michel Margairaz, "Jean Coutrot, 1936-1937. L'Etat et l'organisation scientifique du travail", *Genèses*, 1991, 4: 95-114;

neers appear to have focused their efforts purely on technical issues.

But World War II marked another significant watershed in rationalization. Whereas Pre-War "rationalizers" were frequently "generalists", i.e., advocates of an approach and a doctrine that dealt indiscriminately with a number of different activities and functions within the firm – with priority being given to questions of production –, rationalization during the *Trente Glorieuses* was characterized both by an extension of the range of issues addressed and by the *development of specialized, autonomous rationalization subprojects*. One of the most striking features of the postwar rationalization process in France is the fragmentation of the modern firm into a series of key "functions" – i.e., organizational units established to operate in, and be responsible for, a specific activity or physical or functional area, for example the Production Department, Maintenance Department, Engineering Department, Product-Design Department, Purchasing Department, Personnel Department... Each of these "functions" produced its own management tools and its own body of rationalization techniques. Thus, engineers from the Engineering Department were concerned with rationalizing production activities, maintenance engineers rationalized the activities relating to this function and so on and so forth

Patrick Fridenson, "Un tournant taylorien de la société française (1904-1918)", *Annales ESC*, 1987, 42(5): 1031-1060. We should also note that it was not only engineers advocating rationalization who subscribed to the idea of social and economic improvement based on scientific management. Numerous French Inter-War union leaders also succumbed to the attraction of such a promise. See, for example, Georges Ribeill, "Les organisations du mouvement ouvrier en France face à la rationalisation (1926-1932), in *Le Taylorisme*, eds Maurice de Montmollin and Olivier Pastré (Paris: La Découverte, 1984), pp. 127-140.

for those concerned by the other major functions of a modern firm (Quality Control, Purchasing, Personnel Management, etc.). The creation of specialized professional journals as well as the foundation of professional associations based on the corporate function of their members are a clear sign of this specific form of rationalization during the *Trente Glorieuses,* characterized by the existence of specialized, autonomous sub-projects designed and executed by distinct "collective actors" within large French corporations.[10]

Nevertheless, a group of people that simply share the same corporate function (handling maintenance issues or rationalizing production, for example) do not constitute a "collective actor", i.e., a stable "entity" (agency), capable of designing and carrying out shared projects over the long term. The identity of a collective actor is based on language, representations and narratives involving its members. The

[10] Jean Fombonne, a former practitioner-turned-historian, recently retraced the history of the « Personnel Management » function in France. See Jean Fombonne, *Personnel et DRH: l'affirmation de la fonction Personnel dans les entreprises (France, 1830-1990)* (Paris: Vuibert, 2001). Data compiled in this publication highlights the existence of similar phenomena to those described in this article (see below). For example, the years after the Liberation of France, which, according to the author, represent the mature phase of the "function", were marked by the creation, in 1947, of the *Association Nationale des Directeurs et Chefs de Personnel* (National Association of Personnel Department Directors and Chief Executives) (ANDCP); by the organization of day-long workshops focusing on the rationalization of personnel management procedures; by the launch of a specialized professional journal: *La Direction du Personnel* (which changed its title to *Personnel* in 1968) etc. Similar developments may be noted in the "Quality Control" function. After 1945, quality-related issues were systematically dealt with in large French corporations by a distinct "collective actor". In 1956, the French automobile corporation Renault set up a Quality Control Department and a national association grouping together the specialists in this area was founded a year later (see Patrick Fridenson, "Fordism and Quality: The French Case, 1919-93", in *Fordism Transformed*, eds Haruhito Shiomi and Kazuo Wada (Oxford: Oxford University Press, 1995), pp. 160-183.

collective actor needs spaces of interaction in which professional practices and experiences can be shared and discussed and common representations and meanings can develop and be accessible to all members, thus becoming a commonly-available resource for shared projects.[11] Forums, such as study days, as well as long-distance methods of communication (and communion), such as professional journals provide both the infrastructure required to develop rationalization techniques and a collective self-image for the actors involved in rationalization.

However, in order for the specialized rationalization sub-projects sponsored by the various collective actors (engineering department engineers, maintenance engineers, etc.) to become reality within a large firm, it was not enough the actors themselves to be convinced of the merits of their own projects. They also had to be able to make their project attractive for others. First of all, they had to convince the power holders at the head of the corporation to accommodate the rationalizing practices they wished to promote within the firm. They also had to negotiate with and win over other collective actors in the firm who were also sponsoring their own specialized rationalization sub-projects with possibly

[11] The literature relating to the formation of collective actors is more extensive. See, for example: Edward P. Thompson, *The Making of the English Working Class* (London: Penguin Books, 1991; first ed. 1963); Luc Boltanski, *The Making of a Class: Cadres in French Society* (Cambridge: Cambridge University Press; Paris: Editions de la Maison des Sciences de l'Homme, 1987; first ed. in French 1982); Yves Cohen, "Industrie, despotisme et rationalisation. L'URSS et la France de l'entre-deux-guerres", *Annales HSS*, 1998, 53(4-5): 915-936; Jesper Strandgaard Pedersen and Frank Dobbin, "The Social Invention of Collective Actors. On the Rise of the Organization", *American Behavioral Scientist*, 1997, 40(4): 431-443.

conflicting requirements. Let us develop this last point a little further. Functional differentiation (specialization) within the large firm has traditionally been viewed as a kind of division of labor, the institutionalization of an intellectual project based on the inherent advantages of specialization. Our conception of functional differentiation is different. Following the system theory developed by Niklas Luhmann,[12] our approach allocates to each function, in addition to its being a part of the whole (the firm), a relation to the whole, which becomes its environment. Under this approach, a system such as a large corporation, which is internally differentiated, is more than a set of different parts segmented on the basis of maximum efficiency. Rather, it is an entity which is entirely reconstructed by many irreducible, and nearly always partial and contradictory, perspectives (one for each function). Put another way, functional differentiation necessarily introduces tensions and conflicts which originate both from the necessity of delineating "authority and responsibility decision areas" within the whole organization and, above all, from the fact that each function considers the whole firm in its own way. Indeed, as we shall see, in some respects the Post-War rationalization process in France was not only a battle between management and labor, as historians and sociologists have extensively (and often rightly) claimed, but also a kind of "civil war" between many rationalization sub-projects sponsored

[12] See Niklas Luhmann, *Social Systems* (Stanford: Stanford University Press, 1995; first ed. in German 1984).

by the different collective actors comprising large corporations.

SECTION II: Rationalizing maintenance activities during the *Trente Glorieuses*

Maintenance as an activity has always been an integral part of the world of production and is usually associated with its flaws (machine breakdowns, production stoppages, etc.). But it was really only harnessed to scientific management practices, at least in France, in the wake of the Second World War. This is not because engineers during the Inter-War period had totally ignored it and excluded it from the scope of the scientific management, but because their priorities lay elsewhere. When the rationalization process was in its infancy, it gave priority to tapping into the rich unexploited areas of the production activities. Compared to production, maintenance was relegated to the background in terms of the priorities of the engineers of the period who also considered it to be much more resistant to a policy of rationalization. Indeed, unlike leviathan and largely repetitive manufacturing operations, maintenance is characterized by its specific, discontinuous nature, and the need to respond to sudden breakdowns in the production process.

Therefore, it is hardly surprising that the technical literature of the inter-war period in France makes little mention of maintenance. The small body of publications devoted to the activity can be divided into two distinct categories.

The first category consists of texts of a directly operational nature intended for workers involved in mainte-

nance activities. They contain descriptions of different machines which workers encountered in the course of their work as well as a series of helpful hints to enable them to confront the many possible problems and to carry out the necessary *repairs* effectively.[13] Therefore, this category is made up of manuals that do not address issues of rationalization in the strict sense (e.g., planning and organizing the work related to maintenance activities, etc.).[14] It is in the publications authored by engineers interested in the rationalization of labor that we encounter the first reflections on the rational organization of the maintenance activity.[15]

---

[13] See, for example, Corentine-Emile Dème, *Cours d'entretien. Avaries et réparations* (Paris: Edition et propriété de l'Ecole du Génie Civil, 1927).

[14] These manuals contain random reflections related to plans for rationalization however they never get beyond mere recommendations. Thus, in Dème's opinion, "maintenance work should include preventative measures and there is no reason to wait until a piece of equipment is in a defective state of repair before inspecting it; rather, we should inspect it when we consider that it is approaching the limit whereby it falls into disrepair" (Dème, *Cours d'entretien*, pp. 1-2). However, Dème does not go any further than this.

[15] See, in particular, MM. Michelin, "Comment nous avons taylorisé notre atelier de mécanique d'entretien ?", August 1928, special edition of *Prospérité*, a quarterly review of scientific management and economic studies edited by MM. Michelin; J. Breuil, *Méthodes modernes. L'organisation du service d'entretien dans les usines* (Vannes: Imprimerie J. Lafolye et J. de Lamarzelle, 1932); Lt-Colonel Rimailho, *Organisation à la Française* (Paris: Delmas Editeur, 1936), especially the second part, chapter IX, pp. 115-124 (the book is 430 pages long); Jean Coutrot, *Le système nerveux des entreprises* (Paris: Delmas Editeur, 1935), especially the chapter entitled "Entretien du matériel"); François Caron, "A propos de la rationalisation du travail dans les ateliers des compagnies de chemin de fer en France, 1880-1936", *Revue d'histoire des chemins de fer*, 2003, 28-29: 190-206. See also the references contained in works by Aimée Moutet: "Une rationalisation du travail dans l'industrie française des années trente", *Annales. ESC*, 1987, 42(5): 1061-1078, and Id., *Les logiques de l'entreprise.* Rationalization of maintenance activities during this period essentially concerned locomotive repair yards (the organization of major periodic equipment servicing typically involving repetitive operations such as the dismantling and reassembling of machine parts) and the central workshops of major steel factories which were actually manufacturing

Maintenance rationalization projects during the Inter-War period focused on three main themes.

The first involved transposing one of the key ideas of the scientific management movement into maintenance activities, i.e., *preparing* work prior to *executing* it. Thence, the idea of setting up a *Works Planning Unit* which should be regularly informed of the work to be done by the head of the maintenance working teams. Some members of this planning department were in charge of preparing the work slips that specified the work which the maintenance operatives had to carry out, while others had to process the "order slips" for the corresponding supplies (materials and articles required). A "tooling slip" should be attached to the "work slip" in order to cover specific tooling requirements while drawings considered useful for carrying out repairs were also to be prepared by the members of the Planning Unit and made available to those executing the work. Planning personnel also had to estimate the time deemed necessary for carrying out the repairs. We should note that even though the time specified by the members of this new department was used to calculate the bonuses paid based on the time gained by the maintenance operatives, the evaluation of such time appeared to correspond more to planning requirements than to controlling the intensity of the work effort provided by these operatives. Indeed, the times specified should serve to establish "an estimated price to be accepted by the interested party [for example, the manufacturing department], and

workshops that produced the spare parts required by the maintenance activity.

subsequently [to] correctly slot the maintenance work to be executed into the series of tasks carried out in the workshop, providing the estimating amount of time for the corresponding work stations".[16]

Those interested in the rationalization of maintenance activities during the inter-war period were not content merely to deal with the breakdown "rationally" *once it occurred*, by preparing the repair work to be carried out by operatives, for example. They also began to reflect on *preventative measures*. They stressed that "equipment to be maintained must be inspected periodically in order to make it possible to detect the symptoms of a problem before an actual breakdown occurs".[17] Special documents were to be drawn up in such a manner that "the inspection is carried out by adhering to a strict order, based on that outlined in the documents, so that attention is drawn to each aspect whose correct functioning needs to be ensured".[18] Drawing up a log of breakdowns and interventions on machines was strongly recommended. For each machine, the ultimate goal was to draw up "a logbook containing the damage incurred and the repairs carried out (dismantling, reassembling, etc.) together with estimated time and the time actually spent".[19] These logbooks should make it possible to map the past and the present states of each machine and they were supposed to be helpful in taking decisions concerning the future. Thus, if the logbook showed that repairs had to be carried out too

[16] Rimhailo, Organisation à la Française, p. 122.
[17] Ibid., p. 123.
[18] Ibid.
[19] Ibid., p. 122.

often, according to J. Breuil,[20] the author of a book dealing with maintenance methods, the machine should be modified or replaced.

However, in the opinion of the inter-war "rationalizers", rationalization of maintenance activities should not be reduced to operations on machinery only. Rationalization was considered a kind of *spiritual revolution* to shape actors' mentalities and imbue them with a sense of economic optimization which, according to the "rationalizers", was totally lacking in the workshops of this period. Thus, foremen had to realize that "a spare part was only worth keeping if it has a well-defined purpose and can actually be used". There was a need to combat the tendency of elderly foremen, and sometimes engineers, who wished to "'hold onto everything' under the pretext that 'they could always come in handy'. This may be true, however, it could actually cost money to make use of such material as buying the new nuts and bolts that you could have used would cost much less than paying somebody five francs an hour to rummage through a pile of old scrap iron".[21]

The principal themes of the maintenance rationalization project during the Inter-War period consisted of preparing repair work, preventative actions, putting together technical documentation on machine behavior and educating workshop personnel who were locked into old habits that conflicted with "best" management practices. All of these themes, which were dealt with in a rather incidental

[20] Breuil, Méthodes modernes.
[21] Ibid., p. 6.

and sporadic manner by the engineers most preoccupied by manufacturing-related issues, were to be dealt with in a more systematic and collective fashion by the engineering community specialized in maintenance issues.

The emergence and consolidation of a collective actor

> "(...) when the importance of great personalities is sidelined by the contribution and cooperation of all; when the forces contained in numbers and measures tend to prevail over much more accidental and much less durable exaltation of feelings and passions (...)"[22]

"During this period we wished to define the function of the head of maintenance operations and we concluded as follows: it was originally a general 'dogs-body', a 'go-for'; however, the 'go-for' evolved over time: he was no longer 'a drudge' as he now had mechanical, electrical and other types of devices at his disposal. We also pinpointed the antagonism that existed at this time between the manufacturing department, which had priority over everything, and the head of maintenance operations, who was at their beck and call".[23] These remarks were made by a certain Rousset at an

[22] Antoine-Augustin Cournot, *Considérations sur la marche des idées et des événements dans les temps modernes* (1872), quoted by Jacques Bouveresse, *L'homme probable* (Combas: Editions de l'Eclat, 1993), p. 19.

[23] Rousset in Bureau des Temps Élémentaires (henceforth referred to as BTE), "L'Entretien, entretenir, c'est prévoir" (information seminars held from May 5-6, 1961 on maintenance issues by BTE), *Les cahiers du BTE (n° 401-02). Quatrième série. Préparation du Travail*, p. 15 (henceforth referred to as *BTE. Journées d'information 1961*). Bureau des Temps Elémentaires (Bureau of Elementary Times) was an inter-professional association for research into work measurement. It was created in 1937

information seminar bringing together several engineers concerned with maintenance issues held some thirty years after the creation in 1933 of the *Association des chefs d'Entretien* (Association of heads of maintenance operations) by three heads of maintenance (Bertrand, Rambaud and Rousset himself).

There is a striking contrast between the maintenance function discourses put forward by "rationalizers" during the inter-war period –, reflecting a "dispassionate" and impersonal view produced by people interested in industrial rationalization in general – and the resentful assessment of Rousset, whose reflections on maintenance issues were based on personal experience and reflected his own specific position in the factory. Undoubtedly, there was a decisive shift regarding the rationalization of the maintenance function between the inter-war period of Rimailho and Breuil and the 1960s.

Indeed, after the Liberation of France at the end of the Second World War, rationalization of the maintenance function became the preserve of a clearly-defined group of actors within the firm. Based on their daily experiences, engineers specialized in maintenance now began to rationalize the various maintenance activities. They no longer merely applied the precepts of a general rationalization doctrine to a specific activity (in this case maintenance), but tailored projects based on the peculiar characteristics of this

by a group of major French firms (Alsthom, Compagnie Electomécanique, Rateau, Société Générale de Constructions Mécaniques, Société Nationale des Chemins de fer Français, etc.) and began to operate in 1941 (see Chatzis, "Searching for Standards", p. 258).

activity of which they had first-hand knowledge. Furthermore, these maintenance actors also had to carve out their own "sphere of action" within the factory and deal with the firm's other actors who were sponsoring rationalization projects of their own (see above). Thus, rationalization of maintenance activities did not take place merely at a "cognitive" level (designing and implementing efficient practices within a function); it assumed a "social", or even a "power-relationship" dimension, as it also involved regulating the relationships established between the "Maintenance" collective actor and the other actors of the firm. How did this come about?

We have already referred to the *Association des chefs d'Entretien*, set up in 1932. This provided the Maintenance function with its first representative body and provided maintenance engineers with their first forum for forging a collective identity. Once the Second World War was over, special sections set up within engineering associations and engineering consulting firms, such as CEGOS (*Commission Générale d'Organisation Scientifique*),[24] and devoted solely to maintenance-related issues also participated in the creation of the Maintenance collective actor. The gradual creation of a communication network (specialized journals

[24] *Commission Générale de l'Organisation Scientifique du Travail* (CGOST: General Commission for the Scientific Organization of Work): set up in 1926 jointly by the State and the French employer's federation; it was set up as CGOS in 1934 and became CEGOS in 1936, before becoming one of the most important French consulting firms after 1945. See Odile Henry, "Le Conseil, un espace professionnel autonome?", *Entreprises et Histoire*, 1994, 7: 37-58; Moutet, *Les logiques de l'entreprise*; Antoine Weexsteen, "Le Conseil aux entreprises et à l'Etat en France. Le rôle de Jean Milhaud (1898-1991) dans la CEGOS et l'ITAP", unpublished PhD diss., EHESS, 1999.

and special series of publications,[25] forums, seminars and courses for industry professionals[26]) provided the actors involved in the maintenance function with a constant, visible presence within the "rationalization" landscape.

The Study Days of 1949-1950

The Maintenance collective actor first came to prominence via a series of "Study Days" organized by CEGOS on May 30-June 3, 1949, January16-18, 1950, and May 15-17, 1950[27]. Maintenance engineers in various leading firms such as Etablissements Merlin et Gérin, Saint-Gobin, Société des Constructions Electriques Patay, Compagnie des Meules Norton, Etablissements Bessonneau, Socony Vacuum française (which became Mobil Oil France in 1967), Société Fran-

[25] In particular: *Les Techniques de l'Entretien* (n° 1: January 1950); *Achats et Entretien* (n° 1: January 1952). On the history of French engineering journals, see Konstantinos Chatzis and Georges Ribeill, "Des périodiques techniques *par et pour* les ingénieurs. Un panorama suggestif, 1800-1914", in *La presse et les périodiques techniques en Europe, 1750-1950*, eds Patrice Bret, Konstantinos Chatzis and Liliane Pérez (Paris: L'Harmattan, 2008), pp. 115-157.

[26] See, for example, R. Ducellier, *Organisation du travail dans les ateliers de réparation et d'entretien, leçons n° 062-062 bis*, 1956 (Courses of the Ecole de l'Organisation scientifique du travail (EOST)) (Library of the Conservatoire national des arts et métiers-Paris). The EOST was set up by the Comité National de l'Organisation Française (CNOF) in the mid-thirties (the CNOF was set up in the mid-twenties following the merger of Henri Fayol's Centre d'Etudes Administratives and the Conférence de l'Organisation Française, dominated by taylorist engineers).

[27] We should also mention the pioneering article by M. Téper (a graduate of the engineering school Ecole centrale des Arts et Manufactures (Paris) and Chief Engineer of the Paul Planus engineering consulting firm): "Organisation rationnelle d'un service d'entretien", *Chimie et Industrie*, 1947, 57(6). In this article, the author focuses on themes which were subsequently addressed in the course of the CEGOS Study Days (preventative maintenance, introduction of bonuses for maintenance operatives, etc.).

çaise de Constructions Bebcock-Wilcox, Electricité de France, Societé Française Duco, and Société Dunlop,[28] came together for several days in order to both exchange their experiences of maintenance-related activities and to develop a rational doctrine to replace the empirical approach which, in their opinion, had previously predominated. These Study Days were devoted to two issues in particular: preventative maintenance and the remuneration of staff involved in maintenance activities.

Preventative maintenance

Most participants in the Study Days felt that France had fallen way behind: "in the area of preventative maintenance, we would not exactly say that nothing had been accomplished in France, as this would be a gross oversimplification, however, much remained to be accomplished and any initiatives taken were only in their infancy",[29] declared a certain Vallée, Chief Engineer of CEGOS. A comparison with the US provided an indication of the efforts which French industrialists still needed to make in this domain. Whereas, in America, in well-organized firms, 8/10th of maintenance staff appeared to be allocated to preventative maintenance and only 2/10th to repair activities, according to the author, even in the most progressive French firms the proportions

[28] See: L'Entretien. Journées d'Etudes des 30 mai-3 juin 1949 (Paris: CEGOS, 194) (thenceforth referred to as Journées de 1949); CEGOS, L'Entretien. Journées d'Etudes des 15, 16 et 17 mai 1950 (Paris: CEGOS, 1950), pp. 25-28 (thenceforth Journées des 15-16-17 mai 1950).

[29] S. Vallée, "L'entretien préventif", in *Journées de 1949*, part 1, p. 11.

were inversed. Why did preventative maintenance in France lag so far behind?

According to the organizers of the Study Days, two factors account for this state of affairs. Firstly, maintenance departments were overworked and inundated by breakdowns in manufacturing departments which monopolized all their staff's time. This led to a self-perpetuating "viscous circle": the lack of preventative maintenance was responsible for the large number of breakdowns observed in French factories; these breakdowns in turn occupied maintenance operatives who were left with no time to devote to preventative maintenance, thence the large number of breakdowns... Add to this "viscous circle" the absence of a body of doctrine devoted to preventative maintenance and we have largely explained, according to the organizers of the Study Days, why preventative maintenance was virtually unknown in France at the end of the 1940s.

There were two obstacles to carrying out preventative maintenance in Post-War II France, i.e., two fronts along which the engineers of the period could attack. In order to break out of the viscous circle which we have just described, a major organizational overhaul of the traditional maintenance department appeared necessary: "there is only one way out and that is to *take a firm decision to set up a Preventative Maintenance Service within the Maintenance Department* [the italics are ours]. Once such a decision has been taken this service must have complete autonomy and under no circumstances should the people working in this section be transferred to day-to-day maintenance tasks (...).

The staff transferred to such a service must stay there even if the factory roof is caving in!".[30]

Whereas maintenance departments were traditionally organized on *an activity basis* (mechanics, boiler works, electricity, buildings, etc.),[31] engineers who were advocates of preventative maintenance wished to experiment with a new organizational approach: *a functional approach* that organizes the maintenance department according to its two major types of activities, i.e., *repair* and *preventative maintenance*.

This led to a debate between the participants in the Study Days as to the structure of the Maintenance Department that needed to be created. While no definitive doctrine was finalized in this regard, a consensus appeared to have been reached by the participants at the Study Days regarding the criteria for choosing between the two types of organization. Thus, for small firms requiring reduced maintenance services which did not have the resources to set up two autonomous maintenance structures (i.e., dealing with breakdowns and preventative maintenance) given the risks of such a strategy in terms of under-utilization of labor, organization by activity remained the best option. However, "for large firms where 150 to 200 people are involved in

[30] Ibid., pp. 14-15.

[31] A survey of 21 firms carried out by CEGOS in 1949 showed that 14 of them had Maintenance Departments organized by activity, 2 used a functional organization and 5 had a mixed organization (CEGOS, *L'Entretien. Journées d'Etudes des 16-17-18 janvier 1950* (Paris: CEGOS, 1950) (thenceforth, *Journées des 16-18 janvier 1950*). See also the description of a "typical" Maintenance Department organized by activity provided in Breuil, *Méthodes modernes*.

maintenance activities, a functional organization is preferable".[32]

However, although the creation of a functional organization made it possible to break out of the spiral of endless breakdowns by according preventative maintenance an autonomous role within the Maintenance Department, it only constituted a first step in the development of preventative maintenance. It would have remained an empty shell in the absence of a body of doctrine devoted to new tasks of preventative maintenance. At the CEGOS Study Days, a significant amount of time was devoted to developing such a doctrine. A report dealing with maintenance-related issues drawn up following productivity assignments to the USA led by English industrialists and engineers provided participants with the first elements just such a sought-after doctrine.[33]

In this report, we encounter the *principle of regularity*: once the different operations involved in preventative maintenance have been identified (e.g., lubrication, verification, settings, standard replacement), they must be performed by workers in accordance with a set plan whose implementation will be closely monitored by first-level management (the maintenance foremen) on the basis of work reports. The operations must be performed regularly and be

---

32 Aimé Périer, "Conclusion et programme de travail" in *Journées des 16-18 janvier 1950*, p. 33.

33 The United States, which welcomed a number of productivity missions during the 1950s, also participated in the creation of a "Preventative maintenance" doctrine via the *Commissariat du Plan* (Commission for the National Plan). Thus, the mid-1950s witnessed the setting up of several maintenance groups within the Regional Productivity Committees created under the impetus of the *Commissariat du Plan* (see the accounts of Marcel Aupetit, published in *BTE. Journées d'information 1961*, pp. 87-94).

based on knowledge of the equipment to be serviced. In the absence of manufacturers' documentation, maintenance engineers must carry out "an in-depth study at the time of installation that takes account of all the mechanical parts subject to wear and tear and the most fragile parts that may break under abnormal operating conditions". Lastly, they must note the "different setting mechanisms and the frequency with which these are used".[34] Naturally, the process of getting to know the equipment does not end once the equipment has been installed. The life of such equipment must be closely monitored by providing a true machine "semiology": monitoring and statistical processing of a certain number of indicators (consumption of lubricants, electricity, steam, etc.) established for each machine, informing those in charge of preventative maintenance of any problems or abnormal machine behavior (premature wear and tear, etc.) and enabling them to develop prevention programs.

The remuneration of staff involved in maintenance activities

"In Maintenance Departments, it is always extremely difficult to measure staff performance; it appears that there is no real basis of measurement. In the absence of such information, it is quite difficult to develop a formula for awarding performance-related bonuses".[35] Why did the issue

34 *Journées de 1949* (part 2), p. 16.
35 S. Vallée, in *Journées de 1949* (fascicule 2), p. 9.

of performance-related bonuses appear so important to French maintenance engineers in the early 1950s? The answer provided by the engineers who actually participated in the Study Days constitutes a genuine example of professional sociological analysis.[36]

"In manufacturing workshops, workers receive either an individual or group performance-related bonus while maintenance staff are simply paid by the hour. What effect does this have? We sometimes note that the skilled worker in the Maintenance Department does not earn any more than unskilled manufacturing workers who, thanks to their 33% bonus, make as much over a two week period as the skilled maintenance operative (...). Each time we encounter a situation like this, we cannot fail to note a certain uneasiness, or at the very least a lack of job satisfaction, and it is common to hear remarks (I have heard them in all types of different firms) such as: 'What's the point in learning a trade if you're only paid the same as an unskilled laborer'".[37] For the engineer *cum* sociologist quoted here, the "democratic spirit" dissected by Tocqueville in his classic analysis, *Democracy in America*, was spread in the factory. The constant comparison made by skilled maintenance operatives between their own position and that of their unskilled manufacturing colleagues, are themes which continually preoccupied main-

[36] Regarding the figure of the engineer-sociologist, see Michel Callon, "Society in the Making: The Study of Technology as a Tool for Sociological Analysis", in *The Social Construction of Technological Systems*, eds W.E. Bijker, Th.P. Hughes and T.J. Pinch (Cambridge (Mass.): The MIT Press, 1987), pp. 83-103.

[37] S. Vallée, in *Journées de 1949* (part 2), p. 9.

tenance engineers.[38] They considered that cross-comparisons, which are a potential source of conflict and demotivation, must be neutralized at all costs. But how?

Manufacturing workers received bonuses. Maintenance workers "envied" them. In order for the envy and resulting demotivation to cease, maintenance personnel would also have to receive bonuses. But how could such bonuses be calculated given that the activities of the maintenance operatives, unlike those of their manufacturing worker colleagues, appeared to be "unmeasurable" in terms of a scientific analysis of tasks?[39] Two possible ways of proceeding were examined by the participants at the CEGOS Study Days.

The first was a line of action *that remained internal* to the Maintenance function. If it proved impossible to "measure" the maintenance activity, then why not try to control its results? Thus, certain engineers proposed to pay maintenance operatives a bonus based on compliance with budgeted maintenance costs. This was a possible solution, however other engineers countered that maintenance foremen would be very likely to cheat, given that the temptation to set forecasts that were sure to be met would probably prove too strong. What about a bonus based on machine availability? Possibly, however such availability was the result of a number of factors which were not controlled by the Maintenance Department, such as the way in which the

[38] As regards the issue of comparisons between people and the feelings (such resentment) this may generate**,** see also Jean-Pierre Dupuy, *Le sacrifice et l'envie* (Paris: Calmann-Lévy, 1992).

[39] See Vallée, in *Journées de 1949* (part 2), pp. 13-14.

machines were handled by the manufacturing workers, the age of the machines in the workplace, etc.

As the first "internal" (to Maintenance Department) line of action proved to be full of pitfalls, the participants proposed another solution: why not reward the *de facto* solidarity shown in terms of the availability of the machines for the various actors in the firm by paying *an identical group bonus to the manufacturing workers and the maintenance staff*: "the manufacturing workers are paid an unskilled labor rate while the maintenance operatives receive a skilled labor rate. If they all receive the same type of performance-related group bonus (say 25%, 35% or 40% of their base wages) there would be an incentive for everyone. Thus, the maintenance operatives have the impression that justice has been done and indeed, they are much more productive and set about their work with much more urgency. For their part, the manufacturing workers constantly harass the maintenance operatives to ensure that their machines do not break down as this would lead to production stoppages, a dip in individual productivity and a sharp fall in their bonuses".[40]

Let us analyze this view a little further. It illustrates a general "management technology" which we could term *the*

[40] Ibid., p. 10. An (anonymous) factory manager having experienced this idea of a common bonus provides this informative comment: "In my factory, the manufacturing workers provide me with precious aid in controlling the performance of maintenance operatives (...). I frequently have to listen to the complaints of Manufacturing Department foremen who consider that maintenance operatives take far too long to carry out relatively simple tasks. Therefore, the new bonus for both categories has the fortuitous effect of making it possible to increase the output of workers whose output is difficult to monitor." (Ibid., p. 11). We encounter the same line of reasoning in *Journées de 15-16-17 mai 1950*, pp. 24-28.

ideal of automaticity which allows the engineer to channel the workers' (supposed) interests and feelings in the direction wished for. The engineer builds a self-regulated system capable of accomplishing the plans designed by the engineer without any external intervention. The reason we attach so much importance to the ideal of automaticity is that we will see it in action on several different occasions when the engineer comes to implement his rationalization project.[41]

As we have seen, issues concerning preventative maintenance and systems of remuneration were ever-present during the three Study Days organized by the CEGOS. These two issues continued to mobilize a considerable portion of maintenance engineers' energy during the 1950s. Another issue soon emerged that was to broaden the themes covered by their rationalization project: the planning of repair work.

[41] Concerning the origin of the ideal of automaticity, see Otto Mayr, *Authority, Liberty and Automatic Machinery in Early Modern Europe* (Baltimore: The Johns Hopkins University Press, 1986). H.L. Gantt, a disciple of F.W Taylor, offers to use this idea to regulate the relationship between workers and foremen in *Travail, Salaires et Bénéfices* (Paris: Payot, 1921, first ed. in English 1910), ch. 8. For a series of examples of the implementation of the ideal of automaticity by engineers, see Konstantinos Chatzis, *La pluie, le métro et l'ingénieur. Contribution à l'histoire de l'assainissement et des transports urbains (XIXe-XXe siècles*) (Paris: L'Harmattan, 2000); Chatzis, "Searching for Standards".

1950-1960: The experimental years

From systematic preventative maintenance to systematic (scheduled) inspections

Once the CEGOS Study Days devoted to maintenance issues were over, the development of preventative maintenance, "this serum that provides equipment with a long life" in the words of Aimé Périer – an engineer from the Ecole Centrale des Arts et Manufactures[42] and, as we shall see, one of the leading "rationalizers" of maintenance activities –, undoubtedly figured as an essential task to be carried out by the heads of maintenance departments. In the 1950s, the reflections developed during the Study Days of 1949-50 were further developed and some of them were transformed into a system of operational techniques.

The euphoria created by the notion of preventative maintenance, which was supposed to turn most production breakdowns into a thing of the past, quickly subsided once a simple fact sunk in: extensive preventative maintenance applied on a large scale (for all machines in the Production Department) is very expensive. Thence, the modification of the original doctrine and the transition, for most equipment, from *systematic preventative maintenance* to *systematic (scheduled) inspections*. Instead of applying systematic maintenance to the equipment (changing worn out parts,

[42] Concerning the history of French Engineering schools, see Konstantinos Chatzis, "Theory and Practice in the Education of French Engineers from the Middle of the 18th Century to the Present", *Archives internationales d'histoire des sciences* (forthcoming).

etc.) according to a fixed timetable, maintenance "rationalizers" now proposed to inspect the machines at regular intervals and take action based on an assessment of the machine status by *the inspector*, an original professional figure created to carry out the new task of inspection. Obviously, the new doctrine was a lot less costly in terms of money (no systematic replacement of spare parts) and time (according to the engineers, an inspection lasts a quarter, or even one-tenth of the time required for systematic maintenance).

Once the notion of systematic (scheduled) inspections had been introduced, it had to be made operational. Thus, standard inspection sheets were prepared that indicated for each machine the points to be monitored, the inspections to be carried out and the operations to be performed on-site. As regards the design of these sheets, the idea was to "include too much rather than too little detail so that the work could be done by other people in the event of the regular operative's absence".[43] In order to be sure that the inspector (whose "subjectivity" is supposed to be neutralized by the detailed nature of the instructions) complies with the recommendations contained in the inspection sheets, the maintenance "rationalizers" invented clever little control tricks: "Inspectors must also complete an on-site report of their inspection in which they are responsible for each key point on the inspection sheet. This report must be completed in the columns on the right hand side of the machine

[43] Aimé Périer, *Entretien et constructions en usine. L'organisation du service* (Paris: Editions de l'Entreprise moderne, 1959), pp. 92-93.

inspection sheet and the inspector simply puts a cross in one of the columns marked N, F or R: N stands for nothing to report; F for minor repairs identified and carried out by the inspector; R stands for repairs to be carried out for which a works request form has to be submitted. In this latter case, the inspector simultaneously fills out the works request form as he also has a book of work request vouchers for this purpose. The idea of combining the inspection sheet and the book of vouchers *forces the inspector to actually bring the inspection sheet and thus to monitor the list of key points during the inspection instead of working from memory*" [the italics are ours].[44]

Even though inspection largely replaced systematic preventative maintenance, the latter did not disappear altogether. Systematic preventative maintenance was now reserved for key equipment parts and security facilities where a breakdown could pose a serious threat to personnel. The machines in the workshop were firstly listed and then categorized in terms of their importance in ensuring an uninterrupted production process.

The last remaining task for maintenance engineers was to define the frequency of inspections and systematic replacement of spare parts for facilities subject to systematic preventative maintenance. 1950s engineers proceeded by successive approximations. Thence, they started off at a "rate that was obviously too low" and extended the time between

44 R. Jabot, *Entretien et Travaux neufs* (Puteaux: Editions Hommes et Techniques, 1969), pp. 85-86.

two inspections until the incidence of breakdowns became unacceptable.[45]

What organization for the Maintenance Department?

Another issue debated at length during the 1950s was the organization of the Maintenance Department. As we have already seen, the emergence of preventative maintenance had a major impact on the traditional approach to organizing the department. Engineers captivated by notions of preventative maintenance wished to replace organization by activity (mechanical, electrical, etc.), *known as organization by trade*, with a functional approach that divided maintenance operatives into two groups: the first group handled breakdowns (repair function) while the second looked after preventative maintenance.

The opposition between the advocates of these two organizational approaches blurred over time. Maintenance engineers realized that a functional approach and an approach by trade (organization by activity) were not mutually exclusive and may coexist within the Maintenance Department. In fact, several combinations are possible. Thus, a given department could be organized by trade with sub-divisions organized on a functional basis. Moreover, engineers began to appreciate the positive aspects of the traditional organization of maintenance activities. Indeed, organization by activity came to be considered more effective than functional organization when a certain number of

[45] Périer, Entretien et constructions, pp. 49-54.

circumstances are present.[46] Thus, in a firm where few breakdowns occur, organization by activity was recommended. The reason provided by engineers was the following. In a situation where there is not a large volume of breakdowns (stable environment), problems of coordination between the different specialized maintenance operatives are of secondary importance. It is rather the variable "chain of command" that is most important in deciding on the choice of organization. Organization by activity appeared to produce the best results from a "chain-of-command" perspective as the maintenance teams are managed by specialists in a particular area,[47] who, thanks to their expertise have a sort of moral authority over their subordinates (as we can see, division of labor also has a political dimension[48]).For maintenance engineers, functional organization would be chosen as a basis for organizing the Maintenance Department only when the volume of preventative maintenance work is significant.[49]

Along with debates and arguments over alternative Maintenance Department organization patterns (organization by activity versus functional organization), this period

[46] Ibid., p. 142 *sq*.

[47] In the case of organization by trade, experienced mechanics are in charge of teams of mechanics, experienced electricians are placed in charge of electricians, etc., whereas in the functional model, the head of a "repair" team or a "preventative maintenance" team is in charge of both mechanics and electricians.

[48] We refer to the seminal work by Stephen A. Marglin, "What do Bosses do? The Origins and Functions of Hierarchy in Capitalist Production", *The Review of Radical Political Economics*, Part I, 1974, 6(2): 60-112; Part II, 1975, 7(1): 20-37.

[49] For a more detailed discussion of this point see, Périer, *Entretien et constructions,* pp. 141-144, and Périer, in *Journées de 1949*, part 1, p. 29.

also witnessed the emergence of other heated issues, this time concerning centralization vs. decentralization. As in the case of the aforementioned debate, single best-way solutions were avoided. Instead of proposing a unique formula, maintenance engineers identified different work contexts and established several selection criteria. As such, given that centralization has several advantages (more effective coordination of teams, ability to control and monitor staff, reduction in the number of managers and employees), it should be chosen as a solution whenever possible. However, decentralization is recommended when the factory is spread over a wide area and the average time taken for maintenance operatives to get from one place to another exceeds ten minutes.[50]

A new topic: the planning of breakdown repair work

Maintenance "rationalizers" penchant for calculation, their obsession with order and their desire to forecast and plan for everything were not restricted to the domain of preventative maintenance. Breakdown repair work, a topic that had previously been seen as an irregular, hazard-related activity, and thus clearly excluded from the scope of scientific management, would gradually come to interest the engineers preoccupied with the rationalization of the maintenance function.

In order to "rationalize" repair work, maintenance engineers tried to imitate the example set by those who had

[50] Ibid., pp. 116-117.

rationalized manufacturing activities. The idea was to slot in a third activity between the occurrence of the breakdown and the repair work, i.e., *planning*, and to provide the operative with "a clearly-defined job, as well as the most suitable techniques and means for carrying out the job, the list of materials required and available and the time needed [for the operations]. This in turn provided an idea of the deadline and the wages of the staff involved".[51] However, unlike preventative maintenance whose benefits were immediately recognized by engineers specialized in the maintenance function, the notion of preparing breakdown repair work was much more difficult to put into practice. Before trying to develop a doctrine, it was first necessary to convince the "skeptics" who challenged the very purpose of such a project. How is it possible to prepare for the unforeseeable? And, even if we actually manage to do this, would the operation be worth the cost, given the once-off, non-repetitive nature of breakdowns and the related repair work?

In the face of such objections, advocates of planning replied that the first thing to do was to disprove the standard idea of repetition that people spontaneously associate with manufacturing: "when we think of repetition, we immediately think in terms of major production volumes and even of assembly lines. But repetition takes place here over a very short time (...). For us maintenance engineers, (...) [the] similar-type work does not recur very frequently. However, over ten, fifteen, twenty or even fifty years, i.e., the duration of a building or a piece of equipment, the same work

[51] Périer, Entretien et constructions, p. 81

frequently recurs several times, particularly if we have taken the trouble to break it down into basic units which recur more often, but in different maintenance work contexts".[52] For those who advocated preparing breakdown repair work, the solution was to harness the *analytical ideal*[53] to maintenance issues (that is, break down the problem to be dealt into its basic parts) and choose an appropriate time horizon that would highlight the repetitive (common) elements of different repair activities that can be subjected to planning work (e.g., dismantling and reassembling parts which have broken down for a variety of reasons).

Once it had been decreed that planning for breakdown repair activity[54] was indeed possible, such planning had to be endowed with a rational doctrine. Who would carry out such planning? What relationship would this person have with the on-site maintenance foremen and their repair works team? What rules should guide their action?

---

52 Ibid., p. 82. We should point out that Périer also published two other works which were intended not for the engineer in charge of the Maintenance Department but for maintenance foremen: Aimé Périer, *L'Agent de maîtrise et l'entretien du matériel* (Paris: Les Editions de l'Entreprise moderne, 1955); Id., *Guide du chef d'entretien* (Paris: Editions Hommes et Techniques, 1953; 2nd ed.).

53 Concerning the analytical ideal and its various applications in the field of engineering, see Chatzis, *La pluie, le métro et l'ingénieur* ; Chatzis, "Search for Standards".

54 Planning comprises the following: the list of operations to be carried out and their scheduled execution over time, the duration of each operation, technical guidelines, preparation of materials (materials issue sheets), daily progress and workload, cost evaluation of the work requested on the work slip based on the labour and materials required to carry out such work, flow chart of the global workload for the different works section.

The maintenance planner and the on-site repair team

Guided by the idea that a special structure had to be set up for each specific function,[55] some maintenance engineers decided to introduce a new figure into the work environment: the maintenance planner in charge of carrying out the new planning tasks. However, slotting this new actor into the existing structures also introduced a risk of conflicting lines of command (maintenance planner and on-site maintenance foreman).[56] In response to such a risk, rules setting out the precise functions of each actor, as well as techniques for controlling whether the division of tasks between planner and on-site foremen was complied with, were gradually introduced by maintenance engineers. Thus, the maintenance foreman was forbidden from starting a new job without first consulting with the maintenance planner, while the latter was to restrict his role to planning and was forbidden from interfering in the subsequent execution of the work. Engineers gradually introduced clever ways of keeping the maintenance planner and the works foreman in check and ensuring that each complied with their respective roles. In order to prevent maintenance planners from being

55 Maintenance engineers explicitly echoed Henri Fayol (1841-1925), the French Scientific Management theoretician who advocated this approach. See Konstantinos Chatzis, "L'analytique des tâches et l'entreprise comme corps", *Cahiers d'histoire et de philosophie des sciences*, 2006, special issue: 261-265.

56 Thus, Périer recounts the experience of introducing a process planner into the firm (Etablissements Merlin et Gérin) where he was working at the end of the 1940s: "the first [difficulty] was the overlapping chain of command which became a serious obstacle. When urgent breakdown work had to be carried out, the process planner, who had previously been an on-site maintenance foreman, tended to bypass the head of the maintenance works team, i.e., the person actually responsible for carrying out the work" (*Journées d'Entretien de 1949* (part1), p. 25).

bypassed, maintenance "rationalizers" provided planners with counterfoil books. They were the only ones in possession of such books and they used them to assign a numbered work slip to each job to be carried out. Workers' wages came to be based on such work slips. As payment was contingent on the existence of a work slip issued by the maintenance planner, workers were well-advised to refuse any orders issued by a works foreman that were not substantiated by a work slip. Thus, works foremen who were tempted to bypass the planner would be reined in by their own workers. This is another example of the ideal of automaticity transformed by maintenance "rationalizers" into a "disciplinary technology"[57] intended to make it possible to self-regulate the collective work environment without the constant intervention of the engineer.

As the centerpiece of the new rationalized maintenance function, maintenance planners risked being the cause of numerous problems if their estimates (especially those in respect of the time allocated to carry out specific maintenance tasks) turned out to be inaccurate. Thus, engineers proposed methods designed to assist the planners in their judgments as well to control them. "The recommendations in this respect are both to exercise care when choosing the technician who will subsequently estimate the time required, and to train this technician in Descartes' 'advice' of breaking down a problem into its simpler constitutive elements so that all estimated times concern short (elementary) mainte-

57 To use Foucault's terminology. See Hubert L. Dreyfus and Paul Rabinow, *Michel Foucault: Beyond Structuralism and Hermeneutics* (Chicago: The University of Chicago Press, 1982).

nance operations. Thus, there will be less errors in absolute terms and in keeping with the statistical law of "large numbers", the total number of errors in relative terms will be very low. It should be pointed out that this is the most widely used method in the area of maintenance".[58] As we can see, statistics are used by maintenance engineers of the period not only as quantitative operators but also as a basis of reasoning and justification: application of the analytical ideal, combined with the law of large numbers, leads, via a sort of automatic elimination of errors affecting each elementary operation, to global estimates deemed sufficiently accurate with regard to practical needs.

We should note that the emergence of maintenance planners was to profoundly alter the question of the remuneration of maintenance staff. Their estimates of the time to be allocated to various maintenance tasks rendered common bonuses, shared by both maintenance and manufacturing operatives, obsolete; as we have seen, these were offered by maintenance engineers at a time when it was difficult to control the activities of workers involved in maintenance activities and the time required to carry out the different operations (see previous section). In fact, from the 1960s on, remuneration ceased to be a preoccupation for engineers focused on rationalizing the maintenance function.

[58] Périer, Entretien et constructions, p. 86.

Dealing with the other actors of the firm

Although the rationalization project developed by maintenance engineers was mainly applied to the internal activities of their corporate function, they also put a lot of energy into reshaping the relationships between the maintenance function and the other actors of the firm, such as the Production or the Purchasing Departments, or the leading corporate decision-makers.

1) Getting to grips with the Production Department

Thanks to inspection sheets, machine files and other documents for preventive maintenance and planning repair work, Maintenance Departments began to develop a "literacy" or "writing culture" ("scriptural economy", in the words of de Certeau). Maintenance engineers were not merely content to develop this new culture within their departments, they also wished to expand it in their dealings with other departments throughout the firm, in particular, with the Production Department. Thence, all requests emanating from this department now had to be made in writing and reach the Maintenance Department in accordance with carefully defined procedures and communication channels.[59] Setting all communications down in writing had several advantages. Apart from the fact that it avoided sub-

[59] Périer, *Entretien et constructions,* pp. 55-63. On the (formal internal) written communication within modern manufacturing firms, see the classic JoAnne Yates, *Control through Communication: The Rise of System in American Management* (Baltimore: The John Hopkins University Press, 1989).

sequent complaints by manufacturing agents (requests not complied with, disputes concerning the nature of the work requested, etc.), a document-based approach reinforced the "recall capacity" of the various actors within the firm: "[the work slip] is a document that follows each job regardless of whether it is actually carried out or not. In any case, this job will not be forgotten".[60] Moreover, written documents did not serve merely to passively record oral conversations, they also function as instruments capable of making information more precise and extracting more information – things which an oral exchange can never hope to do: "[the work slip] is also a way of forcing the person making the request to provide the necessary information as accurately as possible. This is frequently a major problem when carrying out our work: i.e., unclear requests".[61] Lastly, we should note that forms are a way of saving time while they also guarantee a certain degree of correctness (that requests will be properly expressed and correctly received): "Forms ensure that all information is provided in a well-ordered manner; firstly, the person making the request does not forget anything (...), while the Maintenance Department always looks for a given item of information in the same place on the document and thus avoids loosing time and sometimes even omitting certain details, which can happen when the request is written on a simple sheet of paper (...)".[62]

---

[60] Périer, Entretien et constructions, p. 55.

[61] Ibid.

[62] Ibid., p. 56. Maintenance engineers "agree" here with Jack Goody, *The Domestication of the Savage Mind* (Cambridge: Cambridge University Press, 1977) and Michel de Certeau, *The Practices of Everyday Life*

Thus, maintenance engineers no longer wished to respond to non-formal, oral requests formulated by the Manufacturing Department, and they also wished to control the exact timing of the execution of maintenance. Thence, a struggle began between the Maintenance Department and the Production department regarding the priorities to be assigned in respect of maintenance work requested. "If everyone in the firm acted in a reasonable manner, it should definitely be the Manufacturing Department (...) that sets these [the order of priorities]". However, according to maintenance engineers, the lack of trust and the fear of "being had" led manufacturing managers to act in an "uncooperative and selfish" manner, to use the vocabulary of game theory: "the typical reaction is (...) to think that if we don't request the work immediately it will be forgotten about and never get carried out". Thence, it was up to those in charge of maintenance to restore the missing trust: "this is a major problem that must be overcome (...): the Maintenance Department must meet the deadlines it has promised at all costs in order to gain its customers' trust".[63]

2) Getting to grips with the Purchasing Department

The desire of the maintenance engineers to redefine their relationship with the other actors in the firm did not merely concern the Production Department. Dealings with the Purchasing Department were also the subject of

(Berkeley and Los Angeles: University of California Press, 1984; first ed. in French 1980), on the powers of "literacy" and of "writing".

[63] Périer, Entretien et constructions, p. 96.

discussions among maintenance engineers. Although most engineers did not subscribe to radical solutions that advocated creating an internal purchasing service within the Maintenance Department, everyone agreed that the relationship between these two departments, which had always been characterized by conflict and tension, needed to be reconsidered. Firstly, the two departments, whose actions were guided by different (and often conflicting[64]) approaches, needed to be brought closer together. Therefore, in the view of maintenance engineers, the Purchasing Department should stop assessing equipment solely in terms of price, while the Maintenance Department for its part, should pay more attention than in the past to the cost of the equipment which it uses.[65] As such, maintenance engineers proposed a compromise to their colleagues in the Purchasing Department: "we in maintenance must clearly specify the deadlines for receiving the equipment and material we need as well as their technical features. The Purchasing Department must then obtain this equipment and material at the most competitive price".[66]

64 "(...) it is not unheard of in certain firms for this department [Purchasing] to claim the right to cancel certain orders on the grounds that it does not consider them to be justified" (Ibid., p. 182).

65 "Let us just say a few words on this matter which, unfortunately, is a sore point in many firms. To be perfectly frank, we must admit that for us, all too frequently, price is not a real consideration and only technical aspects are important. On the other hand, for the Purchasing Department, price is everything and technical considerations are of no importance" (Ibid., p. 187).

66 Ibid.

3) Getting to grips with Top Management

As we have just seen, management engineers wanted to redefine relationships with the firm's other actors. But wanting something is one thing, actually being able to do so it another matter. Simply being convinced of the well-founded nature and purpose of a project to which one subscribes is obviously not sufficient to have such a project implemented. In order to develop their rationalization project, maintenance engineers had to "enroll" the decision-makers at the top of the corporation and get them "interested" in their cause.[67] This accounts for the development by maintenance engineers of several "persuasion programs" targeting top management. Such programs usually relied on the power of concrete (quantified) results to convince. In order to plead the cause of preventative maintenance, engineers presented sets of figures (cumulative maintenance costs, cumulative costs related to non-operational equipment, rate of breakdowns, etc.) in respect of two groups of identical machines, only one of which had been subject to preventative maintenance, thus illustrating the benefits of such an approach.[68]

But before presenting convincing results, one must be able to produce these. Sometimes, dominant beliefs preassign a project a judgment so unfavorable that they do not even allow it the opportunity to defend its potential benefits "in action". In order to be able to produce diagrams illus-

---

[67] On the "interest" and "enrollment" issues, see Bruno Latour, *Science in Action. How to Follow Scientists and Engineers through Society* (Milton Keynes: Open University Press, 1987).

[68] Jabot, Entretien et Travaux neufs, pp. 87-88.

trating the economic benefits of preventative maintenance and, more generally, the planning of maintenance work, the Maintenance Department had to recruit some new figures such as planners and inspectors into its ranks. Obviously, an increase in the number of maintenance staff equals an increase in the so-called indirect labor costs (ILC) (costs related to people who do not perform production tasks directly). Given French top managers' obsession with the "Indirect Labor Cost / Direct Labor Cost (ILC/DLC)", ratio, which it wished to keep as low as possible,[69] there was a good chance that it would be opposed *in principle* to any project that leads to an increase in indirect labor costs. Thence, the efforts by maintenance engineers to replace the ILC/DLC ratio by a ratio that would cast their project in a more favorable light: "top management had to be persuaded to replace the ILC/DLC ratio by the:

(ILC+DLC)/Volume of production

ratio under which maintenance engineers can demonstrate the benefit of planning maintenance work (if the denominator increase faster than the numerator).[70]

---

[69] For example, in the early 1900s, the famous French industrialist Louis Renault was not favorable to Taylorism because of the increase in indirect labor costs which it generates. See, for example, P. Fridenson, "Un tournant taylorien".

[70] *Le Service Entretien. Méthodes actuelles de gestion* (Paris: Entreprise Moderne d'édition, 1968), p. 78. This book consists of a collection of major articles first published in the journal *Revue Technique de l'Entretien et des Travaux Neufs*, and representing the state-of-the-art maintenance procedures. The collection is edited by Aimé Périer who also contributed introductions inserted at the beginning of each chapter. In tackling the role of management tools, maintenance engineers apply here a sociological approach which was subsequently developed by

Building a collective "self image"

At the end of the 1950s, maintenance engineers displayed all the features of a collective actor. Their rationalization project was based on collective self-awareness, clearly illustrated via a series of narratives. We have already referred to the bitterness apparent in the accounts of maintenance engineers at the beginning of the 1960s when recollecting their "function's" past. This recollection of a "bleak" common past, a first expression of a collective "we", was to be enriched in the 1950s by other narratives, enabling maintenance engineers to create "a feeling of togetherness".

1) Highlighting the specific nature of maintenance activities (differences with manufacturing operations)

"Firstly, maintenance work is of a unitary nature; no two jobs are ever the same; there is a mixture of difficulties that constitute a cocktail (...) which is always different and always contains something new. Finally, this unitary, urgent work prevents an in-depth, detailed review being carried out from an economic perspective".[71] Infinitely more varied than manufacturing, maintenance work is, according to maintenance engineers, also much more satisfying for the person carrying it out. Here, it is not the machine that dominates

researchers in the field of organizational studies. See, for instance, Michel Berry, *L'impact des outils de gestion sur l'évolution des systèmes techniques* (Paris: Centre de Recherche en Gestion – Ecole Polytechnique, 1983).

[71] Périer, *Journées de 1949* (part 2), p. 3.

man, but the opposite: "In maintenance operations, it is typical to encounter the 'man-machine system' that we find in production and in which the machine plays the dominant role. Here, this is played by man; you have to train him, not only tell him, but explain to him the goal being sought after (...)".[72]

2) Manufacturing and maintenance: father and doctor

The metaphor of the medical profession is omnipresent in the speeches of maintenance engineers during this period, who use this metaphor to represent their position and function in the factory and their relations with the Production Department. "You have to picture the manufacturer as the "father" of the equipment. Just like any good father whose child is sick, he calls on competent people, i.e., the medical corps consisting of doctors, nurses and even specialist equipment. Thus, the medical corps is the Maintenance Department. It includes 'doctors', i.e., technicians who carry out the diagnosis and the serious operations, as well as the 'nurses' in charge of administering day-to-day care: lubricating operatives, preventative maintenance workers and operatives in charge of replacing a unit whose condition has deteriorated. Furthermore, as in the case of clinics, hospitals and the health services, there is even equipment that corresponds to that found in these establishments. The operating tables, surgical and medical instruments corres-

[72] Marcel Gilly, in BTE. Journées d'information 1961, p. 14.

pond to the dismantling, repair and test equipment present in our department".[73]

3) Looking for illustrious predecessors

Little by little, maintenance engineers came to produce a collection of illustrious men whose reflections were to be enlisted to support their own rationalization project. Thus, a certain Pierre Salmon kicked off the Study Days organized by the Bureau des Temps Elémentaires in 1961 by recalling Dautry's aphorism: "a firm may be judged (and these are not my words, but those of one of our illustrious predecessors, Mr. Dautry) in relation to its maintenance function".[74] And another maintenance engineer named Marcel Gilly had no hesitation in evoking Rousseau to explain why the maintenance function suffered so badly in the past (in France): "The French take care of nothing and do not respect any monument; they are all action, full of passion to embark upon projects; but all too frequently, they finish and take care of nothing".[75]

4) A brighter future

The identity of collective actors is forged over time. They draw experience both from the past and the present; in

---

73 Périer, Entretien et constructions, p. 28.

74 *BTE. Journées d'information 1961*, p. 6. On Raoul Dautry, an engineer who graduated from the Ecole polytechnique, see Rémi Baudouï, *Raoul Dautry (1880-1951). Le Technocrate de la République* (Paris: Balland, 1992).

75 BTE. Journées d'information 1961, p. 10.

relation to the future, they form expectations while they also have hopes and fears. At the beginning of the 1960s, an analysis of the technical and economic development of industrial systems carried out by engineers involved in the maintenance activities reinforced their impression of serving a function with a bright future. Indeed, the impending increase in automation and competition discernable at the beginning of the 1960s was interpreted by these engineers as having a beneficial impact on the maintenance function. Here is a brief account of the history of industry as interpreted by maintenance engineers in the early 1960s. *Before* "was a time when a boiler, a steam engine, a tool/engine or a trade lasted two or three generations. Technical progress and the related developments with regard to competition were slow, it was easy to recoup costs and investments were infrequent. This department [maintenance] was so ill-considered that frequently, for 'admirably charitable reasons', it was allocated elderly or physically diminished workers who were no longer able to function properly in the production department (...)". *How times have changed!* The future looks very different. "In modern firms, machines are more and more complicated and costly. It is essential to recoup costs as quickly as possible, which means that they must have a very high usage rate".[76] Therefore, new automatic machines must be serviced by increasingly skilled workers. However, automation did not merely account for the increased level of skill required from maintenance operatives. It provided a new basis for allocating work between Production and Mainte-

[76] Ibid., p. 11.

nance Departments: increased automation in the future would result in less and less manufacturing staff. Thus, the maintenance function is set to monopolize jobs requiring high skills and increased responsibility and most positions within the industrial structures of tomorrow.[77]

Rationalizing maintenance operations in the 1960s: continuity and extensions

Continuity

Reflections concerning work planning, both in terms of preventative maintenance and breakdown repair work continued unabated. Whereas, in the 1950s, such analyses focused on the mechanical component of maintenance work, engineers now began to tackle repair breakdown work relating to the electrical and automated part of machinery. Unlike mechanical breakdowns, which were immediately visible (cracks, etc.), electrical faults and those relating to automation were harder to tackle. There was a considerable gulf between the symptoms observed (equipment malfunction) and locating the cause of the breakdown and this had to be bridged by the skill of the breakdown repair operative. As an engineer noted when referring to automation, "the worker will have to retrace the logic used to design the control system commands in order to detect the incident

[77] It is worth noting that professional sociologists also developed similar views: see, for example, Pierre Naville, *Vers l'automatisme social?* (Paris: Gallimard, 1963); Id., *L'automation et le travail humain (Rapport d'enquête, France, 1957-59)* (Paris: CNRS, 1961).

that is actually preventing the machine from functioning".[78] Different kinds of diagrams which provided the operative with an abstract representation of how the equipment functioned – synoptic diagrams, kinematic chains or flow charts in the case of automation, or the so-called Castello method in the case of electrical breakdowns – were ceaselessly developed during this period by maintenance engineers for the purpose of providing workers with the information necessary for identifying the cause of breakdowns and then fixing these.[79] Without examining such diagrams in detail or analyzing the principles underlying their design, we wish to stress the engineers' attempts to codify and standardize breakdown repair practices in the electrical and automation domains by making these independent of the operators' subjectivity. "Breakdown repair manuals" were also developed containing step-by-step instructions to be followed in order to deal with a breakdown[80].

---

[78] Pierre Henry (a maintenance engineer working for Kodak-Pathé), *in BTE. Journées d'information 1961*, p. 98.

[79] For an overview of these diagrams, see, Le Service Entretien. See also Pierre Castello, Clé des schémas électriques: étude logique des circuits et des automatismes (Paris: Dunod, 1965).

[80] Two examples of this eagerness to codify emanate from the iron and steel industry. "The purpose of the breakdown repair manuals is to enable *any electrician* [the italics are ours] to deal with a broken down machine rapidly and efficiently (...). If we exclude natural instinct or intuition, the only valid method for trying to resolve breakdowns is by process of elimination." (Chambre Syndicale de la Sidérurgie (henceforth, CSSF), *Organisation des services de l'entretien dans une usine sidérurgique*, (Paris, 1962), 2nd part, chapter 5, pp. 1 and 3. And, concerning automation: "Thus, breakdown repair operatives will successively place their devices on the test points indicated in the flow chart *without thinking* [the italics are ours], beginning at the end and following the correct order. When the abnormal situation recurs during the process, the breakdown will have been located (...)" (J.-P Schmit, "Les ordinogrammes", *Revue de Métallurgie,* 1972, LXIX: 541-552, on p. 552).

In the course of the 1960s, while work planning expanded by annexing new domains (electrical breakdowns, automation), it also had a more profound impact in the fields in which it was already present. A quantification movement took hold in maintenance workshops. During the 1960s, the qualitative approach of the preceding decade was actually grounded in quantitative terms; approximate solutions were transformed into quantified solutions. This is also the period in which more and more attention was paid to the "profitability" of work planning for maintenance operations (preventative maintenance, planning of breakdown repair work). Let us now examine the main features of this quantification movement.

We have already presented the reasons advanced by work planning advocates to counter the skepticism of those who insisted on the once-off, non-repetitive nature of their activities. During the 1960s, the proponents of work planning were able to enlist a plethora of statistics in support of their arguments. Thus, a "monthly analysis of four maintenance teams revealed that for each team (150 to 200 work slips), 40% of jobs were repetitive (2 to 13 times)". Another analysis of the work slips of a carpentry workshop revealed that "26 types of activity accounted for 4,943 hours of work out of a total of 18,200; the same analysis was conducted in a mechanical workshop, it revealed that only 25 types of jobs accounted for 8,026 out of a total of 19,200 hours".[81]

The same use of statistics that enabled engineers to highlight the repetitive nature of a significant portion of

[81] Le Service Entretien, p. 81; see also Jabot, Entretien et Travaux neufs.

maintenance activities also enabled them to defend the principle of work planning against those who challenged it on the basis of the urgency of the work in question: " if we use the work slips of any Maintenance Department to analyze response times, i.e., the % of work hours initiated in 1, 2, 3,...20 days, we get a curve (...) that proves that for the maintenance function, 60% to 80% of jobs are launched within a period that exceeds 48 hours. This makes it relatively easy to plan such jobs, if we so wish".[82]

However, these statistics do not merely demonstrate the possibility of planning maintenance activities. They also make it possible to "rationalize" such work by informing maintenance engineers if it is worthwhile from an economic point of view to carry out such planning work. Thanks to the use of the so-called Pareto diagrams or ABC analysis, engineers may choose the most "profitable" activities from among the various repair activities that it is possible to plan. The same concerns regarding rationalization led engineers to develop several instruments for use by maintenance work planners. The latter were provided with time lists corresponding to various maintenance operations.[83] Diagrams also made it possible to train the planners in adjusting the degree of planning in light of the expected results.[84] The work planner's judgment was also to be educated and controlled thanks to a series of practices: "Therefore, it is necessary to calibrate work planners' judgment over a period of at least

[82] Le Service Entretien, p. 79; see also Jabot, Entretien et Travaux neufs.

[83] R. Jabot, *Les temps de l'entretien CEGOS* (Paris: Editions Hommes et Techniques, 1968; first ed. 1961).

[84] Jabot, Entretien et Travaux neufs.

six months in order to correct their initial judgments. To do this, the work planner will have to mark the time allocated on a copy of the work slip, which is not transmitted to the worker, and to compare this to the time actually spent by the worker. All cases that show an excess of 10% of time allocated with respect to time actually spent must be investigated (...). Thus, work planner's 'degree of calibration' may be measured by counting the proportion of cases for which allocated time exceeds time actually spent by more than 10% (...)".[85]

The goal of economic optimization was also evident in research with the following aims: defining the optimal frequency for inspections and preventative maintenance operations with greater precision for different types of equipment; setting the optimal level for inventories of spare parts; optimization of work planning (introduction of scheduling techniques such as Program Evaluation Review Technique (PERT), from the US in the middle of the 1960s[86]). Although we do not have room here to provide a

[85] Ibid., p. 27. As the reflections of Jules Dupuit (1804-1866) of the *ponts et chaussées* engineering corps bear out, French engineers' wish to educate and control the judgment of implementers using various different mechanisms goes back a long way. See Konstantinos Chatzis, "Jules Dupuit, ingénieur des ponts et chaussées", in *Œuvres économiques complètes de Jules Dupuit*, 2 vols., Vol. I, eds Yves Breton and Gerard Klotz (Paris: Economica, forthcoming in 2009).

[86] PERT is a management tool first employed in the development of the US Navy's Polaris missile during the second half of the 1950s **(**see H.M. Sapolsky, *The Polaris System Development: Bureaucratic and Programmatic Success in Government* (Cambridge (MA.), Harvard University Press, 1972**)**. Concerning the introduction of PERT in French industrial engineering circles, see the journals: *L'Etude du Travail* (December 1963); *Revue Technique de l'Entretien et des Travaux neufs* (October 1966); *Achats et Entretien* (September 1966). Concerning the use of PERT in iron and steel factories in the 1960s, see: P. Bresso, "Méthodes de chemin critique: application pratique à un case", *Revue de*

detailed description of economic optimization techniques based on ideas such as the cost of breakdowns or the probability that a spare part will last, we should stress the transposition of results obtained based on mathematical analyses in the form of diagrams. Such transposition enabled factory personnel to automatically apply action programs defined by engineers.[87]

A new chapter in the maintenance rationalization project: sub-contracting

In the 1960s, a new dimension was added to the maintenance rationalization project: sub-contracting. The development of sub-contracting in Maintenance Departments was based on several arguments. Besides the traditional economic and technical reasons (increased efficiency due to the specialization of sub-contractors, possibility of

Métallurgie, 1972, LXIX: 561-577; R. Sadeler, "Méthodes de chemin critique: étude comparative", *Revue de Métallurgie*, 1972, LXIX: 553-558.

87 "Based on this method, low-level workers,(...) *automatically* apply [the italics are ours] the policy set by higher-level management if they follow the tables and do not feel they have to increase the level of inventories under the pretext that there is occasionally a shortage of spare parts" (*Le Service Entretien,* pp. 233-234). Concerning the application of operational research to the maintenance function, see Jabot, *Entretien et Travaux neufs,* pp. 97-98 and 367-421). One of the first books to appear in French dealing with operational research and maintenance is the translation of the work first published in English by P.M. Morse, *Files d'attente, stocks et Entretien. Analyse opérationnelle des systèmes à offre variable* (Paris: Dunod, 1960). See also, AFNOR, *La normalisation dans l'entreprise* (Paris: Editions AFNOR, 1967), pp. 169-175. Concerning the use of operational research in the maintenance function in iron and steel factories, see CSSF: *Gestion des stocks de pièces de rechange* (Paris, 1959) and *La standardisation du matériel et des articles de magasin dans une usine sidérurgique* (Paris, 1964). These methods were tested and subsequently applied in several factories (See Konstantinos Chatzis, "L'entretien dans la sidérurgie après 1950: de la fonction autonome aux groupes TPM", in *L'Autonomie dans les organisations. Quoi de neuf?,* eds K. Chatzis, C. Mounier, P. Veltz and Ph. Zarifian (Paris: L'Harmattan, 1999), pp. 188-206, on p. 192.

adjusting the number of maintenance operatives in line with the average workload, while charges were absorbed by the subcontractor at times of maximum load, etc.), there were also a number of other reasons worth mentioning here. Firstly, subcontracting offered an "excellent comparison with other corporations, which indirectly provides a means of subjecting the Maintenance Department of the firm in question to outside competition". The educational impact produced by the introduction of subcontracting is also far from negligible. In fact, one of the advantages of sub-contracting derives from the "awareness by foremen of the actual cost of various actions; when such actions were executed by the maintenance workshop, foremen frequently only had a vague idea of the cost. When they are provided with an estimate, they have a better idea and are frequently shocked at the price. They then try to find a less costly solution".[88]

Once the advantages of sub-contracting had been clearly spelt out, maintenance engineers examined the different forms of sub-contracting (daily rate, fixed rate, subcontracted labor, i.e., hired labor working under a factory foreman, etc.). Thus "a flat-rate formula is not advisable when operating in an unfamiliar domain".[89] The precautions to be taken when successfully hiring temporary staff and the advantages and drawbacks of hiring personnel from firms specialized in technical assistance were also formalized.

[88] Le Service Entretien, p. 264.
[89] Ibid., p. 268.

Tools to assist the head of the maintenance department in choosing between various options were also developed.[90]

The end of the 1960s up to 1975 : from "entretien" to "maintenance"

During the 1960s, French manufacturing facilities in several sectors constantly increased their production capacities while they were also subject to increased automation. This was particularly the case in the petrochemicals, steel and automobile sectors. Following a switch in the 1950s and 60s from coal to liquid hydrocarbon fuels, in 1968 petrol alone accounted for half of all consumption of primary energy sources in France. This period witnessed an enormous development of refining and petrochemical complexes and there were similar developments in the French steel industry where the State wished to create "national champions". The steel complex located at Usinor-Dunkerque, which was commissioned in 1963, had a capacity of 9 million tonnes by the end of the 1960s. In the automobile sector, the figures are just as impressive. French auto manufacturers built 500,000 vehicles in 1952; six years later they turned out 1,120,000 and the figure for 1970 was 2,700,000. In addition to these developments affecting French industry, we must also add the pressure to generate increased profits (financial logic) as French industry was subject to increased

[90] Jabot, Entretien et Travaux neufs, pp. 152-154.

competition from abroad.[91] Maintenance engineers sought to take account of such developments.

The fact that new facilities were "analyzed with regard to their useful life calculated in advance, in accordance with economic laws that fell within the scope of financial expertise" meant that "maintenance became indissociable from *management issues*" [the italics are ours].[92] A *technical-financial* logic was now added to the *technical-economic* logic of the 1960s. This new logic required that the maintenance function take account of the economic obsolescence of equipment (obviously, costly maintenance practices applied to equipment that will soon have to be replaced for economic reasons should be avoided). The appearance of two new terms both attests to and reflects the incorporation of the concept of the (economic) useful life of equipment into maintenance practices. While, up to the end of the 1960s, engineers used terms such as breakdown repair work, systematic maintenance and preventative maintenance, at the end of the 1960s they also began to use terms like *corrective maintenance* ("maintenance corrective" in French) and *remedial maintenance* ("maintenance palliative" in French). What do these terms mean? Corrective maintenance takes

[91] See, for example: Denis Woronoff, *Histoire de l'industrie en France du XVIe siècle à nos jours* (Paris: Editions du Seuil, 1998); Maurice Lévy-Leboyer ed., *Histoire de la France industrielle* (Paris: Larousse Bordas, 1996).

[92] J. Soland, "Entretien des installations d'automatismes", *Revue de Métallurgie*, 1972, LXIX: 529-539, on pp. 530-531. See also: Ch. Guyot, *Initiation à la maintenabilité* (Paris: Dunod, 1969); Institut français du pétrole, *La fiabilité au service de l'entretien et de l'inspection du matériel* (Paris: Editions Technip, 1969); P. Chapouille, *La fiabilité* (Paris: PUF, 1972); Introductory article in no. 400 of the journal *Achats et Entretien.*

place at the beginning of an equipment's useful life. Its purpose is to detect the modifications or improvements that must be made when the equipment is put into operation in order to keep costs down (maintenance costs + production stoppages), whereas remedial maintenance comes at the end of the equipment's useful life and consists of using the least costly means possible of allowing the equipment to function until it is finally taken out of service. Therefore, at the end of the 1960s, preventative maintenance, the major innovation of the 1950s, ceased to be applied to old equipment.

The developments in automation in the 1960s also attracted the attention of maintenance engineers. Indeed, automatic machinery is characterized by random behavior (unlike mechanical equipment, electronic equipment is not subject to wear and tear and, thus, it is difficult – or impossible – to predict when it is going to break down). In order to deal with the characteristics of the new equipment, maintenance engineers drew on *conceptual innovations; reliability* (the probability that a unit carries out given functions over a given period under set external conditions) and *conduciveness to repair* ("aptitude à l'entretien" in French; nowadays referred to as maintainability), i.e., the probability that a system, when in need of corrective or preventative maintenance, can be restored to a given state of functioning, within set time limits, when the work is carried out according to prescribed procedures and under given conditions".[93]

[93] The concept of reliability was first mooted in relation to submarine cables for which even basic repairs were either enormously expensive, as a ship

The emergence of the concepts of reliability and maintainability represented a watershed in rationalization as it applied to maintenance activities. These breaks with the past led French engineers to abandon the French term for maintenance in use until then, i.e., "*entretien*" (upkeep), in favor of "*maintenance*".

In fact, reliability and maintainability are properties that are defined to a large extent when the equipment is designed. Thence a redefinition of the relationship between the Maintenance and Engineering Departments was required. "For a considerable amount of time, the heads of Maintenance Departments had claimed that 80% of problems were rooted in the equipment design phase, however, their system, based on preventative maintenance, prevented them from taking effective action at this stage as they would have liked. However, '*maintenance*', which was considered an extension of reliability, requires complete integration of equipment design and use. Maintainability can only be guaranteed via steps taken during the project-design phase and the specific application of such steps during maintenance. Thus, '*maintenance*' would appear to be a way of providing those in charge of the maintenance function with the means of fully carrying out the activities for which they

had to be sent out to carry out such work, or frequently impossible. Reliability got a second wind in the French aeronautics industry in the mid-1960s thanks to the action of actors connected to the Centre National de Fiabilité within the Centre National d'Etudes des Télécommunications (CNET).

are responsible, both during the useful lives of the machines and during their design phase".[94]

The advent of automated facilities required close cooperation between the Engineering Department which designed the equipment, the Maintenance Department in charge of its operation, and the Department responsible for replacing it at optimal cost. All these departments were now involved in the maintenance operation. As a result, maintenance operations were no longer the "preserve" of a single actor, i.e., the Maintenance Department, but were disseminated throughout several institutional areas within the firm (Engineering Department…). From about 1975 on, the relationship between the Production and Maintenance Departments also evolved significantly. In fact the development of larger, more integrated machines, based on economies of scale and uninterrupted flows, meant that even the smallest breakdown had a major impact on the entire production cycle. Despite the more important role it now had to play, the Maintenance Department had a struggle to deal with these new realities. Indeed, the strict demarcation between manufacturing and maintenance which had prevailed since the 1950s became a serious source of inefficiency. As they were not permanently present in the areas of production and they did not have ongoing contact with given facilities, maintenance operatives gradually saw their perfor-

94 B. Hamelin, *Entretien et Maintenance* (Paris: Ed. Eurolles, 1974), pp. 18-19. See also: *Le service d'entretien. Méthodes actuelles de gestion*, Paris, Entreprise modernes d'édition, 1976; the translation from English of a classic work dealing with maintenance: V. Priel, *La maintenance. Techniques modernes de gestion* (Paris: Entreprise moderne d'édition, 1976).

mances deteriorate due to a lack of anticipation, excessively long lead times and the difficulty of providing rapid diagnoses. In order to cope with these problems, several French firms tried to redraw the functional carve-up (and compartmentalization) used in former years by an "inter-penetration" of the manufacturing and maintenance functions. Beginning in the 1980s, we witness the creation of "major operating units" combining the maintenance and manufacturing functions, giving rise to multi-functional operators responsible for both production and maintenance tasks. Mixed working groups were set up consisting of manufacturing operators and maintenance technicians for the purpose of ensuring optimal availability of facilities (the co-called "Total Productive Maintenance" (TPM) groups).[95]

At the end of the 1970s, the autonomy of the maintenance function was being challenged. The more central maintenance activities became to the functioning of the firm, the more the Maintenance Department as a distinct, specialized and wholly-responsible actor for a defined activity and guardian of appropriate tools and representations and of its own scientific management organization and strategies, experienced difficulties in carrying out these new maintenance tasks on its own. Thus, as regards both the maintenance function and large industrial firms as a whole,[96] the end of the *Trente Glorieuses* marked the

95 The author participated in a study of the functioning of such (TPM) groups in the iron and steel industry. See K. Chatzis, F. de Coninck and Ph. Zarifian, "L'argumentation dans le travail", *L'Année sociologique,* 1994, 44: 145-173; Chatzis, "L'entretien dans la sidérurgie".

96 We should stress that the developments which affected maintenance also impacted other functions in the firm, such as Quality control, Research

beginning of a new era in industrial rationalization which is still in search of a defining project.[97]

Conclusion

The aim of this article was to formulate a research program regarding the rationalization movement in French industry during the *Trente Glorieuses* (1945-75) and to offer a first example of such research, based on the maintenance function. Given that it concerns a program, such research will naturally require developments and extensions. We consider that these should be of two complementary types.

The first involves a direct extension of the historical perspective presented here. Firstly, we would like to map the rationalization practices developed within each function of the firm as completely as possible – including those deve-

and development and Engineering Departments. According to sociologists of work and organizations, large firms currently seek efficiency not by entrusting specialized actors (the engineers in various functions) with responsibility for rationalizing a specific field of industrial practice – i.e., the rationalization project that characterized the *Trente Glorieuses* – but by mobilizing several actors from different backgrounds and different levels in the hierarchy around cross-disciplinary issues (even low-level operatives participate, frequently against their will, in the search for new types of efficiency). The example of the Quality function, which is now the responsibility of all, and the setting up of new structures for action, such as project-based management, are a good illustration of this trend towards rationalization via integration and not via the development of specialized sub-projects.

97 For an overall view, see Veltz, *Le nouveau monde industriel*. Do these changes signal the end of all specialization-based approaches to industrial rationalization? We do not believe so. If we just consider the Maintenance function, we note that maintenance engineers are still organized in France in an association, now called AFIM (Association française des ingénieurs et responsables de maintenance) that publishes the journal *Production Maintenance*. However, based on the available evidence, all specialist "rationalizers" will have to liaise with other specialist "rationalizers" to a far greater extent than in the past.

loped within the maintenance function – given that the review presented in this article merely seeks to outline the related issues rather than to present an exhaustive account of the subject. By shifting the perspective from one function to another, the intention is to reconstitute the "specialized" rationalization projects which have characterized French industry during the *Trente Glorieuses*. Once the work in respect of each function has been carried out, we may envisage an analysis that deals with the various procedures underpinning the rationalization projects internal to each function taking place within the overall operating structure of the modern firm which, based on the results in respect of maintenance, is characterized by numerous conflicts and rivalries.

The second approach concerns specific firms. It involves studying the dissemination and implementation over time and within different sectors of industrial activity of such rationalization projects developed in technical literature and professional meetings (professional journals, manuals, study days, etc.). In order to do this, it is essential to carry out archive research, supplemented by interviews with the actors (engineers, as well as operatives) involved in in-house rationalization projects during the *Trente Glorieuses*.[98]

Before terminating, we wish to briefly discuss what might be described as a by-product of our research. In the course of their reflections concerning rationalization pro-

[98] We have already begun to carry out research into maintenance rationalization practices in the iron and steel industry. For the initial results, see Chatzis, "L'entretien dans la sidérurgie".

jects, engineers constantly refer to other actors within the firm (in particular, foremen and workers) whose activity – frequently described in negative terms – has also been the subject of rationalization. Indeed, technical literature, as we have seen in the case of maintenance, contains numerous comments concerning the attitudes, "passions" and modes of behavior of men and women in the workplace. However, these people exist in an "oral culture" and leave no written trace of their activities. Would it not be possible to use technical literature to record the history of "man in the workplace"? Obviously, this type of source refers to working people only indirectly, given that it is both written, and written by engineers. As such, these sources frequently act as filters and intermediaries who deform "reality". Nevertheless, even though they are not completely objective (what source is!), in our opinion, the thoughts and observations of engineers, when interpreted in a critical manner, may still provide precious information in respect of all those who help to make the wheels of industry go round.[99]

Acknowledgement: this article was translated from the French by Neil O'Brien

99 Concerning such questions, see Carlo Ginzburg, *The Cheese and the Worms. The Cosmos of a Sixteenth Century Miller* (Baltimore: The Johns Hopkins University Press, 1980; First ed. in Italian 1976); Alain Cottereau, "Etude préalable. Vie quotidienne et résistance ouvrière à Paris en 1870", introductory article in D. Poulot, *Le sublime ou le travailleur comme il est en 1870, et ce qu'il peut être* (Paris: Maspero, 1980; first ed. 1870), pp. 7-102.