Business and Economic History
On-Line

Vol. 2 2004

Technical Networks at Schneider

Gabriel Galvez-Behar

Although knowledge may be considered a public good, it is not a free one. Technical information is often seen as an immaterial good, but it is supported by material objects such as professional papers, exhibitions, and patents. My hypothesis is that all the objects and actors supporting technical knowledge comprise a technical information network. I look at the Schneider Company, a large French firm, to understand how it fit into such a network at the beginning of the twentieth century. Schneider employed engineers who paid attention to technological developments, had patent agents charged with providing information, and created an organization of innovation through new laboratories. The firm controlled this technical information network because all these agents interacted within a social network. Schneider's innovation system reflects, in some ways, the evolution of French innovation generally.

The theme of "networks" has engaged the attention of business historians in recent years, but the meanings of this concept are as different as they are numerous. Three main usages can be distinguished. Industrial networks are composed of technical elements that must be linked to be efficient. Industrial networks can be compared to technical systems in Thomas Hughes's sense.[1] Social networks describe groups by insisting on the centrality of relationships. The form of the links between social entities is as important as the nature of the entities themselves. Analysis of this kind of network is often used to bring to the fore structures in corporate governance[2] or to get into a firm's "black box."[3] The concept of actor network, proposed by Bruno Latour and Michel Callon, focuses on

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[1] Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore, Md., 1983).
[2] For example, David Bunting and Jeffery Barbour, "Interlocking Directorates in Large American Corporations, 1896-1964," *Business History Review* 45 (Autumn 1971): 317-35; Frans N. Stokman, Rolf Ziegler, and John Scott, eds., *Networks of Corporate Power: A Comparative Analysis of Ten Countries* (New York, 1985).
[3] For example, Emmanuel Lazega, "Teaming Up and Out? Cooperation and Solidarity in a Collegial Organization," *European Sociological Review* 16 (Summer 2000): 245-66.

Gabriel Galvez-Behar <galvez@univ-lille3.fr> is a doctoral candidate at the University of Lille III-Cersates.

URL: http://www.thebhc.org/publications/BEHonline/2004/GalvezBehar.pdf

the role of intermediaries in defining actors and denies analytical difference between humans and non-humans.[4] An "actor" is defined by the ability to put intermediaries such as texts, patents, machines, and workers into circulation.

Because of its multiple meanings, the concept of network is not easily used by historians. For example, network analysis based on the theory of graphs and statistical methods requires determining the whole set of relationships among elements. Historical sources are rarely so obliging, however, and historians are usually not able to show all the relations among members of the same group. Defining the network concept precisely is all the more necessary when the meanings are not evident.

In this paper, I bring technical networks into the account. Historians of innovation have viewed research and development as being produced by institutions. In the usual explanations of technical progress and economic growth, the focus has been on laboratories and the emergence of research inside the firm.[5] Obviously, Schumpeterian analysis was a determining influence here. Other approaches, however, consider technology as knowledge, the circulation of which allows the production of new technology. Analysis of such circulating technical knowledge minimizes the opposition between individual innovation and innovation within firms, because permanent knowledge exchanges tend to make invention collective.[6] On the other hand, economists and historians tend to insist on the role of intermediaries in the circulation of

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[4] Michel Callon, "Some Elements for a Sociology of Translation: Domestication of the Scallops and Fishermen of St. Brieux Bay," in *Power, Action and Belief: A New Sociology of Knowledge?* ed. John Law (London, 1986), 196-229; Michel Callon, "Techno-economic Networks and Irreversibility," in *Essays on Power, Technology and Domination*, ed. John Law (London, 1991), 132-63; Andrew Barry and Don Slater, "The Technological Economy," *Economy and Society* 31 (May 2002): 175-93.

[5] For the U.S. case see Leonard Reich, *The Making of American Industrial Research: Science and Business at GE and Bell, 1876-1926* (New York, 1985); David Hounshell and John Kenly Smith, Jr., *Science and Corporate Strategy: Du Pont R&D, 1902-1980* (New York, 1988); David Hounshell, "The Evolution of Industrial Research in the United States," in *Engines of Innovation: U.S. Industrial Research at the End of an Era*, ed. Richard Rosenbloom and William Spencer (Boston, 1996), 13-85; David Mowery and Nathan Rosenberg, *Technology and the Pursuit of Economic Growth* (New York, 1989), chap. 4. For the British and the German cases, see Ulrich Marsch, *Zwischen Wissenschaft und Wirtschaft: Industrieforschung in Deutschland und Grossbritannien, 1880-1936* (London, 2000). For the French case see Muriel Le Roux, *L'entreprise et la recherche: un siècle de recherche industrielle à Pechiney* (Paris, 1998).

[6] Robert Allen, "Collective Invention," *Journal of Economic Behavior and Organization* 4 (1983): 1-24.

technology.[7] Indeed, technology exchanges are based on institutions, which make them possible.

In taking intermediaries of technical knowledge into account, I do not refer to the intermediaries between sellers and buyers of technology, but rather the intermediaries between the various producers of technical knowledge. That knowledge, the actors who make its circulation possible, and the institutions within which they act constitute a technical network.

We can use this concept to reconsider the innovation strategy of a large French firm, Schneider and C^ie^, headquartered in Le Creusot. At the end of the nineteenth century, Schneider represented one of the most important iron and steel firms in the world. It employed more than 10,000 workers, and the firm's capital reached 70 million francs in the 1890s. In addition, Schneider managed technological innovation well. As a result of the research of Floris Osmond and Jean Werth, the Schneider Company was considered a leader in the development of nickel-steel armament. Its particular skills also enabled the firm to acquire technical knowledge through license agreements; in 1893, Schneider bought the Harvey process, developed by American engineer Hayward Harvey for hardening steel plate, which improved the construction of steel armor. Two years later, Schneider adopted the Krupp process, which deepened the hardening on one side of a coated steel plate.[8] The company was also very effective in constructing new machines, and in the mid-1890s it was involved in electrochemical activities. By the end of the nineteenth century, Schneider could be considered a major actor in iron and steel innovation.

However, some observers were doubtful of Schneider's ability to innovate. In 1898 Crédit Lyonnais engineers, who studied French firms for the purpose of making financial recommendations, concluded that Schneider was unable to manage innovation.[9] They highlighted the company's failure to retain Osmond, who had decided to concentrate on research at the Sorbonne. According to the engineers, the Le Creusot laboratory was not a real research laboratory like those in the United States or Germany. They argued more generally that Schneider managers did not show initiative (in contrast to managers at Krupp, for example).

How can we explain this apparent contradiction between technical progress at Schneider and the diagnosis of the Crédit Lyonnais engineers?

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[7] Naomi Lamoreaux and Kenneth Sokoloff, "Intermediaries in the US Market for Technology, 1870-1920," in *Finance, Intermediaries, and Economic Development*, ed. Stanley R. Engerman et al. (New York, 2003), 209-46.

[8] Claude Beaud, "L'innovation dans les établissements Schneider, 1837-1960," *Histoire, Économie et Société* 3 (Summer 1995): 501-18; Agnès d'Angio, "Comment concilier recherche interne et brevets extérieurs? L'exemple de Schneider et Cie." in *La Technologie au risque de l'histoire*, ed. Robert Belot, Michel Cotte, and Pierre Lamard (Paris, 2000), 297-305.

[9] Crédit Lyonnais Archives, box DEEF 24595.

How did Schneider manage innovation without having special institutions devoted to research and development? The reality is that Schneider made significant efforts to control technical networks and built a new organization to manage innovation.

Silent Research at Schneider

Internal research at Schneider was a problem of the utmost importance. Although there is no doubt that Schneider's engineers initiated some technical progress, there is no evidence of a real strategy of innovation. A brief study of Schneider's patent portfolio shows that the firm was not involved in intensive innovation. Between 1865 and 1885, the Schneider Company obtained 11 patents, while between 1870 and 1885 the German metallurgic firm Siemens obtained 26 French patents. In addition, between 1872 and the beginning of the 1880s, Schneider paid taxes on only 20 French patents. Among those, 9 patents were not awarded to the company but were probably bought by it.[10] If Schneider had developed an intensive innovation strategy, more patents would have been granted, and they would have been taken in the name of the firm.

The mere existence of a laboratory does not in itself represent a coherent industrial research strategy. Schneider's laboratory, founded in the 1850s, was devoted to chemical product trials. At the end of the nineteenth century, twenty workers were affiliated with the laboratory, which was managed by Jean Cohade, a former assistant in the laboratory of Urbain Le Verrier in the École des mines de Saint-Étienne where he had studied.[11] In 1887, Cohade was hired as chief of the laboratory for Usines Jacob Holtzer in Unieux, near Saint-Étienne. Although he had worked in several laboratories, Cohade was not an academic scientist and his career was not totally devoted to scientific investigations. Before Schneider hired him, Cohade was director of a metallurgic firm in Spain. Thus, the manager of the Le Creusot laboratory was not an industrial research specialist, reflecting the fact that industrial research at Schneider was not the object of a specialized division of labor.

It was Schneider's attention to gathering information that accounted for the firm's success in technical innovations and in the marketing of technology. The firms' engineers made many study trips within France and around the world to gather technical knowledge. Between 1882 and 1906, 82 Schneider engineers produced 197 reports on their observations.[12] Many of the trips, of course, concerned specific technical problems in company plants. Schneider and its director Maurice

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[10] Institut National de la Propriété Industrielle (French Patent and Trade Marks Office); Académie François Bourdon, Le Creusot, France [hereafter, AFB], box 187 AQ 134 to 154.

[11] AFB, box SS0716 and box 0117Z0001.

[12] AFB, box FX0058.

Gény were aware, however, that such trips were necessary for the general technical development of the firm.

The 1902 Düsseldorf exhibition is a relevant example. In March 1902, Gény suggested to the Board of Directors that the exhibition could be of value, and it was decided to send an engineer to the exhibition on a reconnaissance. He reported that the machines displayed were of special interest because of the innovative ideas they evoked.[13] In the end, twelve Schneider engineers visited the Düsseldorf exhibition. Visits to competitors were also the source of suggestions for improvement. In a visit to Vickers plants at Barrow-in-Furness, Gény observed a carbonic-gas recording machine that would be useful in the Le Creusot laboratory, and he decided to employ this device at Schneider.

Thus, the Schneider Company was deeply interested in technological innovation. They tried to be well informed about inventions and did not hesitate to take information where they found it: from other firms, exhibitions, and technical reviews.

In the late 1890s, such interest was not a given, but rather was dependent on managers' decisions. The hiring of Édouard Saladin in 1898 underlines Schneider's focus on managing technical information. Born in 1856, Saladin was a former scholar at the École Polytechnique and, in contrast to Cohade, he was a trained scientist with a degree in physics. He began his career in the copper mining industry, and between 1894 and 1898 Saladin managed a mining firm in Junction City, California.[14] Saladin was probably a good friend of Maurice Gény; they studied in the same schools (the École Polytechnique and the École des Mines in Paris), and Saladin addressed the general director with the familiar form, "tu."[15] We can assume that Gény asked Saladin to leave his job and rejoin him at Schneider. When he came to the company, Saladin took the title of principal engineer ("*Ingénieur principal attaché à la direction*").

Although Saladin was concerned with production, he also had to coordinate technical information research. This coordination had two major facets: to participate in a technical and scientific network and to resolve patent problems.

Several activities illustrate Saladin's participation in a scientific and technical network. In April 1899, Saladin visited Aldolphe Carnot at the École des Mines in order to collect information about the use of uranium and vanadium in the steel industry. Carnot was not a uranium specialist, but he had learned about this issue through conversations and was able to provide some information. In a sense, he can be considered an agent in Saladin's technical intelligence network.[16] The same month, Osmond, the former engineer at Le Creusot, received Saladin at the Sorbonne. Osmond

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[13] AFB, box 01G0482-A.
[14] AFB, box 0117Z0001.
[15] AFB, box 01G0549.
[16] Saladin to Gény, 23 April 1899, AFB, box 01G0549.

had no bitterness toward the Schneider Company. He gave Saladin some advice and recommended that he contact another scientist. By visiting these scientists, Saladin not only received information, but also succeeded in building a useful social network.

Participation in scientific meetings was not symbolic but rather essential for gathering information for industrial research. At the beginning of May 1899, Saladin took part in an international meeting devoted to steel technology. Saladin sent the papers from that meeting to Le Creusot to be used by the engineers, indicating specifically that the Schneider engineer who worked with nickel should read one concerning the diffusion of elements in steel.

Another goal of participating in these events was to show off the Schneider Company's own technical skills. For the same reason, Schneider's engineers published their works in technical and scientific journals. Saladin encouraged Cohade to publish his work about phosphoric iron before others outstripped him. In 1905, Cohade took part in an international meeting of chemists. One year later, at an international meeting on applied chemistry in Rome, Saladin presented a paper by a Schneider engineer that received the congratulations of Adolphe Carnot, who chaired the meeting.[17]

By encouraging its engineers to publish (on the condition that it did not prevent the company from later filing for a patent) and to present papers at professional meetings, the company showed how competitive it was and demonstrated its technical and scientific skills. Positive reactions to such papers affirmed the company's technical choices.[18] In addition, publishing could be useful in proving precedence in the case of patent lawsuits.

Saladin was also in charge of patents and patentees. At the end of the nineteenth century, the Schneider Company had no patents department, but it worked with an important patent agent in Paris, Émile Bert. Bert was a former scholar at the École centrale and a lawyer who taught industrial law in the École commerciale de Paris. Bert filed patents for Schneider and conducted some precedence investigations. Saladin did not put himself entirely in Bert's hands, however: he often visited him and corrected the patent drafts that Bert submitted.[19] From time to time, Saladin went to Paris to do his own research in the Office national de la propriété industrielle (the French Patent Office).[20]

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[17] AFB, box 01G0060.

[18] Saladin said: "These two last papers have a great interest for us by showing to you that the path into which we turned . . . is right or, at least, the one that everyone has adopted." Report on 6th Meeting of Applied Chemists by Saladin, May 1906, AFB, box 01G0060.

[19] Saladin to Gény, 23 Aug. 1903, AFB, box 01G0549.

[20] Saladin to Gény, 27 Oct. 1903, ibid.

Thus, Saladin occupied a central position in Schneider's technical network. He was a vital intermediary who collected technical information for the firm and controlled the diffusion of Schneider's knowledge outside the company through publishing or patents. His rank, *Ingénieur principal attaché à la direction*, underlines the importance of this centralization of technical knowledge. Saladin was aware of the necessity of adopting new tools. In 1904, he proposed cataloguing all the metallurgic information available at Le Creusot.[21]

Thus, we can see that by the end of nineteenth century, the Schneider Company understood the need to organize innovation inside the firm. But internal research was not the only basis for such organization; above all, it depended on controlling those networks where technical knowledge was available. Saladin's appointment represented a major step in the process of knowledge management. As a result of his relationships, Saladin was at the hub of a technical network and thus was able to centralize information useful to the firm.

From Individuals to Structures

Nevertheless, the actions of one person were insufficient to manage the technical knowledge of a growing company. New structures became all the more necessary for the Schneider Company after the beginning of the twentieth century, when the death of important managers forced the firm to reorganize frequently: in 1906, after Gény's death; in 1909, after the death of Maurice Lichtenberger, Schneider's commercial manager; in 1911, and again in 1913. Each time, the question of innovation management had to be resolved.

At the beginning of 1905, Eugène Schneider II had already requested the creation of a central laboratory at Le Creusot. Schneider and Gény entrusted Saladin with the task of giving this idea concrete expression. Saladin met the principal engineers at Le Creusot to discuss the premise for the new laboratory. It was to be reserved for general questions that could not be disseminated outside the firm. Department managers could propose technical problems, some of which would be selected for study after consideration by a special committee.[22] In addition, the central laboratory would catalogue information from all the Le Creusot plant studies and archive other French and foreign technical publications.

Because historical sources are lacking, we do not know more about the plans for the central laboratory, but the death of Maurice Gény in January 1906 probably prevented implementation of the project. However, Schneider's managers clearly expressed their will to build new structures to manage innovation. In October 1906, Eugène Schneider II again urged the laboratory project. He argued that it was necessary "to

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[21] Saladin to Gény, 24 Sept. 1904, AFB, box 01G0549.
[22] AFB, box 01MD0125-03.

create a central laboratory outside the plant to be used as an industrial research department."[23] In October 1913, Maurice de Courville, the new operating director, proposed a reorganization of the Le Creusot laboratory, though the document in which he gave his precise instructions has been lost.[24] Although it is difficult to know exactly what happened inside the Le Creusot laboratory, it is clear from these glimpses that Schneider was committed to the creation of innovative structures.

After the death of Maurice Gény in January 1906, the General Director's function disappeared and four divisions were created. Saladin needed a new role. In May 1906, Lichtenberger suggested that the company create a new appointment of Principal Engineer attached to the Commercial Division. This new Principal Engineer should examine inventions for consideration by the firm and keep well-informed about both French and foreign improvements concerning Schneider's activities. "He [could] perform or initiate investigations, study trips, visits of plants or of experimental laboratories, investigations in Patent offices, in libraries. He [would] control the archives of scientific documents, patents, etc."[25] This engineer would represent the Schneider Company in scientific meetings and in intellectual societies. Having to be in touch with notables of the industrial world, he could collect ("thanks to his relations") information of interest to Schneider. He also was to stay informed about manufacturing technology inside the firm. Finally, the new Principal Engineer would be consulted about grant requests from laboratories, industrial schools, or scientific reviews. Obviously, Saladin was nominated for this position.[26]

In July 1909, after Lichtenberger's death, the Schneider Company was again restructured. The Commercial Division was dismembered into four commercial departments (for artillery, machinery, shipbuilding, and the construction industry). This restructuring did not prevent Schneider's staff from improving their control of technical information. It was felt that the Commercial Division made too many demands on the technical departments in the plants. Thus, a plan was developed to screen their requests. Each commercial department should have a technical department in charge of filtering and preparing requests for research to take place in the plants. The artillery research department was important in this system because it controlled the trial laboratory.[27] Another restructuring took place in April 1911.[28] Research was still to be conducted

[23] Executive Committee, 1 Oct. 1906, AFB, box 01G0484.
[24] Executive Committee, 24 Oct. 1913, AFB, box 01G0488.
[25] Executive Committee, 31 May 1906, AFB, box 01G0484.
[26] AFB, box 0117Z0001.
[27] Executive Committee , 2 Feb. 1911, AFB, box 01G0487.
[28] A decision of 7 April 1911 created a new company organization. This document has not been found, but it is mentioned in the Executive Committee minutes: Executive Committee, 11 May 1911, AFB, box 01G0487.

in the manufacturing department, without a clear distinction between production and innovation, but an operating committee was to make sure that "from a 'research' . . . point of view, each department contributed a part of its ideas and of its employees" and could initiate new research.[29] Although Schneider's laboratory had some difficulties, it was a central institution that managed innovation for the firm.

Another significant example of Schneider's innovation management was its establishment of a new organization for controlling patents. In 1907, Schneider's staff envisaged creating its own department of industrial property. The firm abandoned this idea because it feared being deprived of the technical information available through its patent agency, Bert's office. After 1908, however, events convinced Schneider's managers to re-examine the issue. The collaboration between Schneider and Bert's office provided expertise in dealing with patents taken out in foreign countries. In Germany, Bert's office collaborated with four German patent agents who translated Schneider's patents and defended them in the German *Patentamt*. But these German agents were unknown to Schneider, and the company had no guarantee that they were doing a good job as its representatives. One of Schneider's patents was rejected because of a German patent agent's mistake. Moreover, in January 1910, the engineer who was in charge of Schneider's affairs in Bert's office wanted to leave his job, which provided Schneider with an opportunity to hire him. Therefore, Schneider decided to take the problem in hand.[30]

A special commission was set up to examine whether it made sense to hire a patent agent inside the firm. An outside patent agent like Bert was costly: Bert's office was paid 20,000 francs annually for managing the artillery department's patents alone. Hiring an internal agent should produce savings. The person in charge of technical information in the artillery department proposed the creation of a new department for industrial property, which could develop a real strategy for defending Schneider's patents by taking infringers to court.[31]

However, Émile Bert belonged to the commercial court in Paris and was influential, making it tricky to break off collaboration with his office. The solution was for Schneider's agent to remain working in Bert's office but to be assigned only to Schneider's patents. In this way, Schneider would continue to take advantage of Bert's influence and the resources of his office while obtaining more satisfactory service. This agreement constituted the beginnings of a proper patent department within Schneider, though it was not fully implemented until after World War I.

Though in the end, this initial plan to create an internal patent department was unsuccessful, the issue underscores the importance Schneider gave to patents. The plans for a central laboratory and a patent

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[29] Executive Committee, ibid.
[30] Executive Committee, 14-16 Oct. 1909, AFB, box 01G0485.
[31] Executive Committee, 14-19 Feb. 1910, ibid.

department reflect a new attitude toward the organization of innovation in the firm. At the beginning of the twentieth century, centralization appeared as a method of making the control of technical information more efficient and secure.

Conclusion

The absence of traditional research and development institutions such as research laboratories within a firm does not mean the absence of an organization of technological innovation inside a firm. As the Schneider Company illustrates, it was possible to have a real interest in new technologies without having a central laboratory.

Innovation based on external production of technology needed its own organization to control the circulation of that technical knowledge. Saladin was in charge of identifying technology that could be useful to the company, and he used his connections to identify technical opportunities. In his case, controlling technical knowledge was based in part on social networking.

Gradually, interest in centralized structures appeared. There were two apparent reasons for this evolution. First, the growth of a firm tends to make the control of each sector within the company more difficult. An institution to control the circulation of technical knowledge was necessary to avoid waste. Such an institution could share technical and scientific resources among departments within the plants. Second, some distant actors in the technical network were unreliable; this was the case with the German patent agents, prompting Schneider to plan the creation of a patent department.

The examination of Schneider's activities in this period reveals that there was no one best way to use and to produce technical knowledge. Centralized R&D institutions were unnecessary even for big firms. What was essential, however, was to have some knowledge about, and some influence on, the technical network. This permitted several different patterns of organization, depending on the efficiency of networks. Big business did not automatically mean big science.