Developing and Utilizing Technological Leadership: Industrial Research, Vertical Integration, and Business Strategy at the Draper Company 1816-1930

William Mass
University of Connecticut at Hartford

> The Draper firm was *sui generis* and followed none of the set patterns in the textile machinery industry's development. During its formative years it possessed what was unquestionably the most dynamic developmental organization in the industry, an organization quite unmatched in any other textile-machinery firm in any other period in American history [16, p. 117].

Beginning in the 1870s and continuing for over three-quarters of a century, the Draper Company was the dominant force and worldwide leader in shaping mechanical innovations in the cotton textile industry. The Draper Company was the central and directing agency in the development and continued improvement of high-speed ring spinning (the most important spinning innovations of the late 19th century textile industry) in the 1870s and 1880s. The Draper automatic loom, introduced in 1895, was a breakthrough in weaving technology; its fundamental design remained the industry standard and was not rivaled in significance by any 20th century textile innovation, until the post-World War II development of shuttleless looms.

The exceptional technical and industrial leadership of the Draper Company and its top owner-managers has been recognized by industry historians [16; 7, pp. 212, 214]. Yet its path-breaking "dynamic developmental organization" has remained largely unexplored and unexplained. What follows is a brief account that in part fills this gap, along with some broader speculations.

Origins of a "Dynamic Developmental Organization"

The Draper Company began formally when Ira Draper was issued his first loom temple patent in 1816. A pair of loom temples holds the cloth at the proper width during the process of weaving. Draper's invention doubled a weaver's productivity by enabling one operative to run two looms at a time [3, 1903, p. 261; 5, July 1901].

Over the next fifty years active management passed to a second and third generation of Draper family members, who were based in Hopedale, Massachusetts after 1837. Several structural and strategic characteristics in production and marketing set the Draper organization apart from the rest of the textile machine industry even before it assumed a dominant role. First,

BUSINESS AND ECONOMIC HISTORY, Second Series, Volume Eighteen, 1989.
Copyright (c) 1989 by the Business History Conference. ISSN 0849-6825.

with minimal manufacturing capacity they continued to specialize in the development of widely marketed loom temples along with other textile machine parts and attachments. Second, their product development proceeded from in-house personnel but was complemented by the aggressive acquisition of patents with commercial potential. Third, the most promising inventors were brought into the company as employees, or in the case of their main rival, Warren W. Dutcher, as a manager and minor partner.

The Drapers marketed both parts and licensing rights to the manufacturers of new machines and sold replacement parts directly to the mills in all regions and for nearly all loom models. The latter sales were particularly unusual in an era when mill repair shops made almost all their own spare parts.

From the start the core strategy of gaining control of key patent rights was complemented by pioneering efforts in the use of "personal" or self-promotional advertising. The established machine manufacturers with more or less local, "captive" markets could self-servingly respond to such marketing practices with disdain, but they could not afford to ignore them when mill customers demanded Draper attachments [16, pp. 91-93; 7, pp. 203, 230].

The Draper Spindle Patent Pool 1870-1890

Textile industry interest in the potential of a lighter and faster spindle was sparked in April 1871, when Jacob H. Sawyer, the mill agent of the Appleton Mills in Lowell, presented the successful results of his spindle experiments to the New England Cotton Manufacturers' Association. George Draper had gotten the jump on the rest of the industry, for he already had bought a large interest in Sawyer's patent at least a month prior to Sawyer's public presentation. Just as Draper had done with Warren Dutcher, he brought J.H. Sawyer to Hopedale to manage the Sawyer Spindle Company, which specialized in spindle design and development. George Draper & Son soon established one of the earliest patent pools in the U.S. in order to control the development and marketing of "high speed" ring spindles [16, pp. 181, 184, 591, 186; 8, p. 71].

The Draper-owned Hopedale Machine Company produced Sawyer spindles as replacements in spinning frames already in place. Too small to supply the primary market for spindles in new frames, the Drapers tried contracting with several small specialty manufacturers, but the spindle deliveries periodically were late and inferior in quality. In 1874 the Drapers reluctantly licensed seven sizeable textile machine shops for the manufacture of spindles applied to their new frames.

The early Sawyer spindle designs were deficient in sustaining the promised high speeds, although they did permit significant cost savings in power. The Drapers faced competition from independent inventors pursuing the goal of high-speed spinning in a variety of design alternatives. More importantly, the very manufacturers the Drapers had licensed also financed efforts at developing commercially viable alternatives, either to escape from the Drapers' patent coverage or to increase their share of the returns to the patent pool.

The Drapers' strategic response to the competition was three-pronged. First, they committed company resources to further invention and patent activity. Second, they sought to purchase the rights to competitors' inventions and consolidate them into their pool, even if on occasion the purchase price included sharing some degree of control over the patent pool. Third, if patent competition could not be prevented by the first two strategies, then patent litigation was the inevitable third step. The three prongs of the strategy complemented one another; a strong position in one, enhanced the potential effectiveness of the other two.

The best known tactic in the strategy was the skillful deployment of legal resources [7, p. 218, 642-648; 16, ch. 10]. By raising the costs of patent competition through unrelenting and effective litigation, they were more likely to create wide berth for internally developed patents and enhance their bargaining leverage when acquiring patent rights.

The strategic use of litigation was effective because of the complementary efforts at external patent acquisition and intra-firm spindle development. Between 1870 and 1903 the spindle pool included 463 patents of which the Drapers claimed control of "over 400 patents" at a single point in time. Draper in-house inventor-patentees were responsible for one-quarter of the patent pool [14, pp. 15-17].

Innovations in Automatic Weaving

In the late 1880s George Draper and Sons faced both the impending expiration of several key Sawyer spindle patents and renewed patent competition from the Whitin Machine Company. Their patent royalties had provided a singularly large and liquid capital fund among textile machinery manufacturers. In 1889 the company decided on a radical departure in new product development and committed resources to experimentation in redesigning the common power loom [17, p. 18; 1, p. 13].

During these experiments, James H. Northrop, a Draper employee, thought up the idea of changing the bobbin in the shuttle while the loom continued weaving. Since the early 19th century, the most time-consuming manual task performed by the common power loom weaver was replenishing the filling. By the mid-1890s the norm in New England was for each weaver to tend eight looms and repeat this task once or twice every minute.

Within two years Northrop had designed the essential features for automatically changing bobbin filling without stopping the loom. With the key patented inventions in hand, the Drapers organized the Northrop Loom Company in 1892 in the same manner they had established companies based upon the patents and active participation of Dutcher and Sawyer. To successfully develop an automatic loom, at least doubling the number of looms tended per weaver, many other mechanisms had to be improved.

In the case of Northrop, however, the endeavor was internally directed from the start. The Drapers listed 250 patentees responsible for 227 Northrop loom-related inventions by 1900. Twenty-four intra-firm inventors accounted for two-thirds of all listed patentees, over 50% came from the top five in-house inventors (William F. Draper, his son George Otis Draper, and three

employees) [14, pp. 24-25]. Clearly, in the early stages of patent development a small number of in-house inventors were notably prolific. While refining and extending the applications for the new mechanisms, the Draper Company coordinated a growing number of inventors both inside and outside the company.

In the first four and one-half years of the century, the number of in-house inventors issued patents for loom-related inventions grew to 34, and the top five accounted for a still significant 48% of in-house patentees. During this period the Draper company acquired roughly equal numbers of patent rights from intra-firm (178 patentees) and extra-firm inventors (195 patentees). Market relations of the latter were far from arms length transactions, as the Draper Company coordinated both the invention and patent process *before* acquiring patent rights. In fact, when the Drapers identified an invention with commercial promise, their affiliated attorneys directed the patent application and charged no fee unless a patent was obtained.

Although the Drapers' major commitment in product development was the automatic loom, they realized some economies of scope by committing resources to improving other products through internal research and patent acquisition. The peak year for total patents assigned to and acquired by the Draper Company was 1904, when they secured control of 128 patents.

The firm's internal patent activity relative to the rest of American industry was also at its zenith at this time. The 1904 Annual Report of the Commissioner of Patents listed 55 inventors having assigned newly issued patents to the company. The number of inventors assigning patents was greater only at General Electric (134), with Westinghouse and affiliates a close third (46), and the rest of American businesses relatively far behind [14, pp. 26-28].

The Drapers initially hoped to create a marketing arrangement for their loom inventions similar to the spindle patent pool. In 1892 the Drapers secured licensing agreements with the six major loom manufacturers to receive royalties for the use of their patents on automatic loom attachments. The Drapers expected to produce all the filling-changers and warp stop motions used on the new looms manufactured by the other companies [14, pp. 20-21; 12; 16, p. 274]. However, they encountered unanticipated difficulties marketing their inventions.

The Drapers had incurred large fixed costs during the stages of invention and development, and they found that it was necessary to assume even greater capital risks in order to market the loom. The total cost of bringing the automatic loom to market in 1895 was advertised as a million dollars, probably the largest such expenditure for a single machine in the 19th century. An important part of the marketing effort began with the organization of the first mill fully equipped with Draper looms, the Queen City Cotton Mill in Burlington, Vermont. The central importance of Queen City Cotton was its history as the Draper flagship print cloth mill [14, pp. 33-38]. By establishing a mill under direct control, they simultaneously presented a demonstration of the loom's success to the rest of the industry and gained

a closely-controlled proving ground for further development of the machine and labor practices.

While the Queen City Cotton mill demonstrated the commercial viability of the invention, most of the sales still were directed to the Draper Company for looms manufactured at their own facility. The sale of components to other loom manufacturers under the licensing arrangement was never considerable.

It is unclear why the market coordination of licensed loom manufacturers and Draper attachments failed before 1900. Certainly the greater novelty of an innovation suggests concomitantly greater uncertainties and higher costs of both informing and persuading owners of complementary specialized assets to undertake the risk of an irreversible investment [19, pp. 11-18; 9]. After the demonstration of the Queen City Cotton mill, the market success of the automatic loom may not have been certain, but information costs surely must have been significantly lower.

A more likely explanation of the resistance from rival loom manufacturers lies with their recognition that the Drapers had the basis to appropriate the present and future bulk of the rents from innovation. Unlike the case of the high-speed spindle ring where frame manufacturers made their own spindles for new frames, loom manufacturers were never going to get the opportunity to produce the Northrop mechanisms. The latter firms were unlikely to develop the resources necessary for independent patent development and the leverage to assure their returns on any substantial investment in modifying their loom to take the Draper motion.

By 1897 the Drapers recognized the need to further concentrate resources toward coordinated efforts in developing and marketing the new loom. In that year they absorbed five Hopedale enterprises (all except the Sawyer Spindle Company) into the newly incorporated Draper Company and established a centralized experimental staff. By 1899 the Draper Company accepted the fact that other manufacturers would not push the automatic loom and decided to build a plant capable of meeting the entire national market for single-shuttle looms.

The expansion program made the Draper Company the industry's largest manufacturer of textile machinery at the turn of the century. They simultaneously consolidated their organization as an integrated producer of all parts required for loom manufacturing and improved the quality of the loom by incorporating the best manufacturing practices in the U.S. and abroad. The cost of new molding machines alone required an investment the Draper Company was confident no other loom manufacturer could afford. With the use of modern machine tools as well, the Draper Company reorganized as a mass producer, instead of a sample-order, job shop like all the other loom builders [14, pp. 41-43].

In 1896 fifteen large machinery shops dominated the textile machinery industry. The next year saw an acceleration in the consolidation movement, similar to what was occurring in many sectors across the economy. The merger activity began as the two largest multi-shuttle, fancy loom producers combined into Crompton-Knowles in 1897, largely in response to the creation of the Draper Company.

Mergers began in the same year among manufacturers of equipment preparatory to weaving. By 1913 two firms emerged in control of that market segment, the Whitin Machine Works and the Saco-Lowell Shop. These four firms dominated the textile machine market in the United States for forty years. Only the Draper Company grew to its dominant position purely through increased integration and internal expansion without recourse to merger and consolidation [16, pp. 254-259, 485-486, 531-534; 7, pp. 267-460].

Utilizing Technological Leadership: The Choice at the Pinnacle

Within the century's first decade the technical development of the automatic loom had progressed in its application to almost all single-shuttle weaves.[1] The unmatched superiority of the Draper Company in technology, production, and marketing, left little scope for rivals. Having successfully vanquished competitors and erected effective barriers to potential entrants, monopoly returns were at hand. A split soon developed among the owner-managers over the future direction of corporate strategy and the use of assets accumulated in an era of innovation.

In 1907 the growing conflict over basic business strategy came to a head. Alternative strategies were advocated by two management groups. The first included William Draper, who initiated the company's commitment to the development of the Northrop loom, and his two sons. George Otis Draper supervised most of the early development of the loom and his younger brother, Clare Draper, was most active in furthering technical development of the loom. The heart of their organizational priorities were centered in the Draper Experiment Committee, which pursued new product development. The opposition was led by the other senior Drapers, William's two brothers, Eben S. Draper, the top marketing executive, and George A. Draper, the treasurer and corporate officer with full responsibility for financial matters. The early steps taken to redirect business strategy included disbanding the Experiment Committee and forcing William Draper to step down as President of the company in July 1907 [5, April 1914, February 1923, July 1907].

A general exodus of company officials and inventors responsible for the development of the Draper looms soon followed. George Otis and Clare Draper left the company and took with them four employee-inventors including Jonas Northrop, who had assumed the position of chief loom inventor after his brother James left the company in 1898. The seven officials and employees that left the Draper company had been issued nearly one-third of all intra-firm patentees ever assigning patent rights to the company. Clearly, a great deal of talent for innovation was deemed expendable relative

---

[1]The company had successfully opened the market for replacing common looms with Northrops except in the southern New England mills. In the case of the one-fifth of the industry located in Fall River and New Bedford, Massachusetts, there was little prospect for significant inroads through further technical innovation. These mills secured cost advantages primarily on shorter run, custom order cloth production and, without economies of speed, the potential labor cost savings on Draper looms could not compensate for their increased unit capital costs [13, chapters 3 and 4].

to the importance of pursuing an alternative course of business [5, March & April 1908; 4, p. 8].

The top executives asserting control over corporate strategy had witnessed at least seventeen years of new product development, marketing, and the rapid expansion in production capacity. At the same time the Draper Company had taken steps to develop sales to the secondary market. In 1902 they purchased 30,000 acres of New Hampshire timberland and built facilities for seasoning wood and manufacturing bobbin blanks. In 1906 the Draper Company opened a southern office and supply warehouse in Atlanta, Georgia as "more or less of an experiment." The southern office's immediate success led to its enlargement within the year to establish a full line of loom parts locally [5, October 1909, August 1924, May 1930, December 1939, July 1914, May 1907].

With the ability to define an industry standard without a challenger on the horizon, the Draper Company could maximize profits by increasing the combined sales of the new loom and replacement parts. In fact, standardization assured greater manufacturing economies of speed by increasing the utilization of already existing, specialized assets. The firm could turn from a strategy dominated by innovation to a more adaptive strategy of farming the assets accumulated in the era of rapid innovation. The human as well as physical resources remaining within the firm still could aim at new product development, but within the constraints of continued complementarity with the standard loom designs. The patent strategy was likely to be even more defensive to guard against encroachment by inventors focusing on the secondary markets for supplies and replacement parts.

The severest test of the Draper Company's organizational performance came from the departing officers and inventors. In 1912, the year the original Northrop loom patents expired, Clare Draper and Jonas Northrop established and directed the Hopedale Manufacturing Company. They made their presence felt immediately. Their success in gaining warp stop motion orders prompted sharp price competition and the prevailing prices on comparable "motions" dropped fifty percent. Their initial strategy was to sell automatic filling changers to attach to looms "with twenty years' life left." The company explained that many cast iron looms could operate for fifty years. The Hopedale Manufacturing Company initially sold a set of attachments to make common looms automatic at one-third the price of new Draper looms. By 1919 the Hopedale Manufacturing Company was selling its own complete automatic "Nordray" looms [4, p. 15; 21, August, September, December 1920, February and April 1921].

During this time the Draper Company continued to make good its threats of aggressive legal action against patent infringement by its former managers and newest competitor. By 1920, however, at least 260 of the Draper Company's Northrop loom patents had expired and the Hopedale Manufacturing Company was increasingly free to copy and improve the Northrop loom design. By 1920, its first full year of deliveries, they had sufficient capacity to produce 5000 Nordray looms, one-fifth the capacity of the Draper plant. The Hopedale Manufacturing Company was more like a job order shop than a mass producer. It continued to specialize in

manufacturing custom fit attachments for other manufacturer's looms, which they referred to as their "own peculiar field" [4, p. 28; 21].

As passing time depleted the Draper Company arsenal of key patents, they increasingly relied on the advantages of scale economies. This was even more important for maintaining their share of the secondary market where a small firm could grab a toehold in the marketplace, as the Hopedale Manufacturing Company had shown. Given the decrease in textile industry growth and its increased volatility over the next two decades, the Draper Corporation move to standardization at the possible expense of the pace and depth of their pursuit of innovations was a strategic success.

The top management at the Hopedale Manufacturing Company were "by nature" innovators. The Hopedale Manufacturing Company continued operation until 1927, when the family division was bridged by its absorption into the Draper Corporation and Clare Draper was made a director [6].[2]

The inventor-managers who had remained at the Draper Company were also highly talented inventors. At the same time, their inventive functions were contained within and limited by their broader managerial responsibilities and the priorities of the other top executives. Whether these managers were more conservative due to experience, socialization, inclination, or just more accurate in anticipating the future, their strategy was the right one in a slowly expanding primary market.

Implications of the Draper Case History

Recent research has emphasized the importance of concentrating resources in research and development as an explanation of the rise of vertically integrated, dominant firms within American industry [2, 18; 15]. Other studies, based on transaction cost analyses, have identified advantages in integrating various activities within the firm. These activities range from industrial research through production and marketing or, wherever there are cost savings available, through internalized use of specialized assets as compared to the higher transactions costs involved in relying on contractual relations for their coordinated use [22, 20].

As an early 20th century national leader in its scale of industrial research, the Draper Company provides an important case study for evaluating the transactions cost framework. The achievements of the Draper Company cannot be sufficiently explained by the degree to which they internalized activities that other firms relied on the market to obtain. As successful innovators they did not adapt to existing circumstance and prevailing market uncertainties; to the contrary, they confronted and overcame uncertainties, often of their own making.

The Draper Company's superior performance resulted from their *organizational success in the coordinated creation of specialized assets* and the

---

[2]The company had changed its name in 1916 to the Draper Corporation. In 1967 Draper Corporation and its subsidiaries merged with North American Rockwell Corporation, now Rockwell International.

continued exploration and development of the capabilities of these assets through internal coordination. Their *coordination* was the essential factor, whether or not the relevant specialized assets were generated inside or outside the firm. At the same time, and especially in their initial efforts, the Drapers brought into existence new conditions that *increased* uncertainties.

The process of achieving a breakthrough innovation is fundamentally an uncertain endeavor. Efforts toward critical revision to develop the invention's commercial potential are fraught with technical uncertainties and are resource intensive. Both types of technical uncertainty can be considered together as the sum "production uncertainty" inherent in invention [10]. Initiating and confronting such uncertainties, the Drapers responded in part by investing in an increasing scale of internalized inventive activity.

At the same time, the process of innovation (defined as marketing the invention) is further hampered by uncertainties regarding the manner of competition that could erode the returns to innovation. In the case of a process innovation there are three types of "competition uncertainties." First, imitators and followers may succeed in selling substitute innovations inspired by the "first mover's" success. Second, given the technical capabilities of the new machine, the rate of diffusion depends largely on the relative cost savings achieved by the firms adopting the new technology, which depends in turn on the production conditions these firms can establish. Third, the manufacturers of established technologies and the mills operating with the older machines may find ways to adapt and achieve sufficient cost reductions to maintain their continued viability [10].

An innovating firm confronts both production and competition uncertainties simultaneously, since the willingness and ability to confront one side will be enhanced by the relative conquest of the other. In the case of the Drapers' key innovations the links between technical development and the first two aspects of competition uncertainty were developed through strategic decisions and organizational developments.[3]

---

[3]For example, the Drapers' succeeded in limiting "second movers" to minor shares of the high speed spindle market and thoroughly dominated the market for automatic looms. They thus captured the profits generated by their innovations, the degree of success in confronting the other types of competition uncertainty influencing the size of these profits. The Draper Company achievement in this regard can be summarized as the creation of a "tight appropriability regime," as an end result of the integration of in-house inventive activities, control of competing and complementary patents, and the aggressive use of legal resources for patent protection.

Levin, et. al., [11] recently have studied the varying empirical significance of a range of appropriability devices across industries and among technologies. David Teece [20] developed the notion of an "appropriability regime" to refer to *factors outside the control of the firm* that govern the innovator's ability to capture the profits generated by an innovation. Teece describes the environment as a "tight" appropriability regime if the nature of technology and the efficacy of legal protection, as given to the firm, make it relatively easy to protect new technology. Teece's purpose is to use the concept of appropriability regime as a set of factors explaining the links between technological innovations and firm integration. I prefer using this notion to summarize organizational changes and strategic choices that simultaneously changed the outcome of and incentive to innovation.

Once having attained a dominant position, the innovative firm must address the issue of how to sustain its competitive advantage. The background provided in this paper provides a basis to extend the examination of the Draper Corporation's strategic policies and its organizational development and performance into subsequent decades. Much remains to be uncovered regarding the full scope of the intra-Draper family and inter-corporate rivalry. A hypothesis that has evolved out of the research presented in this paper is the possible relationships between the Draper Corporation's emphasis on the replacement market, the likely increased defensive orientation in its inventive and patent activity, and its loss in technological leadership in the post World War II era when the developments in shuttleless weaving passed them by. Many firms today have turned from innovative to adaptive strategies. The Draper Company history was a harbinger and extensions of this case study will contribute toward understanding the broader phenomenon.

References

1. William Chase, *Five Generations of Loom Builders* (Hopedale, 1950).
2. Alfred Chandler, *The Visible Hand* (Cambridge, MA, 1977).
3. G.O. Draper, *Textile Texts*, 1st, 2nd, 3rd and 4th editions, (Hopedale, 1901, 1903, 1907, 1917).
4. _____, "Nordray Loom Catalogue," (Hopedale Manufacturing Company: Milford, circa 1921) in the possession of William F. Northrop, (grandson of Jonas Northrop,) Vice-President, DREX associates, (photocopy in author's possession).
5. Draper Company, "Cotton Chats," (Hopedale, MA).
6. *Draper, Preston and Allied Familes*, Ruth Lawrence, sup., (New York, 1954).
7. George Gibb, *The Saco-Lowell Shops* (Cambridge, MA, 1950).
8. David Hounshell, *From the American System to Mass Production, 1800-1932* (Baltimore, 1984).
9. Richard Langlois, "Economic Change and the Boundaries of the Firm," *Journal of Institutional and Theoretical Economics*, 144 (September 1988).
10. William Lazonick, "The Causes and Consequences of the Modern Corporation: Innovation and Adaptation in the Theory of the Firm," paper presented to the University of California Intercampus Group in Economic History Conference, University of California, Santa Cruz, April 29-May 1, 1988.
11. Richard Levin, et. al., *Survey Research on R & D Appropriability and Technological Opportunity. Part I. Appropriability* (New Haven, 1984).
12. Jonathan T. Lincoln, "Cotton Textile Machinery - American Loom Builders", *Harvard Business Review*, XII (October 1933).
13. William Mass, *Technological Change and Industrial Relations: The Diffusion of Automatic Weaving in the United States and Britain* (unpublished PhD dissertation, Boston College, 1984).
14. _____, "Mechanical and Organizational Innovation: The Case of the Draper Loom," paper presented to the University of California Intercampus Group in Economic History Conference, University of California, Santa Cruz, April 29-May 1, 1988.
15. David Mowrey, *The Emergence and Growth of Industrial Research in American Manufacturing, 1899-1945* (unpublished PhD dissertation, Stanford University, 1981).

16. Thomas Navin, *The Whitin Machine Works Since 1831* (Cambridge, MA, 1950).
17. _____, "Innovation and Management Policies," *Business History Review*, 25 (March 1951).
18. Leonard Reich, *The Making of American Industrial Research* (Cambridge, MA, 1985).
19. Morris Silver, *Enterprise and the Scope of the Firm* (London, 1984).
20. David Teece, "Profiting from Technological innovation: Implications for integration, collaboration, licensing and public policy," *Research Policy*, 15 (1986), 285-305.
21. "Textrin Themes," (Milford, MA).
22. Oliver Williamson, *The Economic Institutions of Capitalism* (New York, 1985).