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3 The Use of Cost Measures: The Dow Chemical Company, 1890–1914

Margaret Levenstein

3.1 Introduction

This paper examines the evolution of the measure and use of cost data in a medium-size chemical company in the American Midwest from 1890 to 1914. This was a period during which there was significant innovation in the techniques of cost measurement.[1] It was also a period of experimentation on the part of manufacturing firms in the design of their information systems.[2] These changes reflected new demands arising from the growing size and complexity of firms. In the small, vertically disintegrated manufacturing firm common in the early part of the nineteenth century, the demand for the generation of formal measures of internal firm activity was limited, first, by the availability, through direct observation, of virtually costless "informal" information, and, second, by the relatively restricted set of choices available to managers given the level of technological development. With the growth in the size of the firm and the increasing separation of ownership from management, direct observation of employees and production processes was more costly, if not physically impossible. With the introduction of new, mobile, and inanimate sources of power, firms had much more flexibility in their choice of location and pro-

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1. See Chatfield (1977) and Garner (1976) for surveys of the introduction of new techniques in cost measurement and accounting.

2. See, for example, Johnson (1975); Kistler, Carter, and Hinchey (1984); Loveday (1980); Lubar (1984); McGaw (1985); Tyson (1988); and Yates (1989).

duction method.[3] Vertical integration gave firms greater control over the marketing of their products, and greater responsibility for setting their own prices.[4] These changes led to an increase in the demand for formal data collection for use in firm management and decision making.[5]

Managers, of course, did not simply haphazardly increase the quantity of data collected. These various decisions required different kinds of information. Historically, there is a typical order to the introduction of new uses of formal information systems in manufacturing firms.[6] This order reflects in part the preexistence (i.e., the existing supply, as discussed in Yates, chap. 4 in this volume) of certain information-gathering and aggregation techniques, in particular those developed over the previous several centuries by merchant firms, which I will refer to as "mercantile" accounting techniques. These techniques were appropriate to certain needs, particularly preventing and detecting fraud, that manufacturing firms had in common with their mercantile predecessors. This common order also reflects a similarity in the evolution of demands placed upon formal information systems during this period.

In this paper I focus on the shift in demand for information associated with changes in firm strategy. The strategic shifts observed in this case study are fairly characteristic of nineteenth-century "Chandlerian" firms. In the early years of our story the firm is small and single-product and markets its entire output through exclusive wholesale agents. Later it pursues a technologically innovative, multiproduct strategy that catapults the Dow Chemical Company into a large, modern, vertically integrated firm. By following the evolution of the firm's information system over this period, we can observe the changes in the types and uses of information demanded as a result of this strategic shift.[7]

3. While technological change in the production of power is perhaps the most dramatic change observed during this period, many other innovations also presented firms with new choices. See, for example, McGaw's (1985) article describing the use of costing data in choosing between rags and wood in the production of paper.

4. For example, Chandler's (1977) description of the information system at the Lyman textile mills suggests that it was used to control waste of labor and materials. But, "these statistical data were not used in pricing or in making investment decisions. . . . Such decisions remained almost entirely with the firm's selling agent" (247). Until the firm integrated forward and controlled its own sales, there was no managerial demand for cost data to inform pricing decisions.

5. This presumes, of course, that there was an elastic supply of information-gathering techniques. See Yates (chap. 4 in this volume) for a discussion of the innovations in mechanical and managerial techniques of data collection and processing that gave rise to this elastic supply.

6. For a more detailed chronology of the changes in information systems during the nineteenth century, see Levenstein (1991, chap. 2).

7. This assumes that the supply of information is perfectly elastic and itself stable, so that all observed changes trace out shifts in demand. Of course, neither of these assumptions is correct. As the Yates paper (chap. 4 in this volume) makes clear, there were exogenous shifts downward in the supply of information as a result of technological innovation. And despite these declines in costs, the collection and processing of information undoubtedly continued to display increasing marginal costs. This affected not only the quantity of data collected, but the type as well. In order to economize, firms would force data to do "double duty," choosing to produce a measure that could be used for more than one purpose, even if it was not the optimal measure. I examine both how firms made these compromises and what the implications were for decisions taken.

3.2 The Functions and Forms of Information

In the discussion that follows it will be useful to make distinctions as to both form and function in describing the data produced by a firm's information system. Included in the "form" of data are features such as units of denomination (e.g., dollars, kilowatts, etc.), frequency of production, degree of aggregation, and whether estimated measures (e.g., standard costs, allocated overhead) are included.

The functions of these data in a manufacturing firm can be divided into two categories: monitoring and planning (see fig. 3.1). The primary distinction between information used to monitor and that used in planning is the timeliness with which it must be produced. Information available only at the end of the period, that is, after a decision has been taken, is still helpful in monitoring. For information to be used in planning, the system that generates it must do so prior to the time when the decision is made.

We may further distinguish between two types of monitoring: monitoring people and monitoring processes (fig. 3.1).[8] Monitoring a process, say to determine whether it is "in-control" or not, is, at least theoretically, a relatively straightforward statistical control problem. Monitoring people is a more complicated problem. In a typical principal-agent problem, the outcome reported by the information system does not perfectly distinguish information about the state of the world from information about the effort and ability of the person monitored. However, the knowledge that one is being monitored influences the behavior of the agent. Thus the form and content of the data gathered must be selected to both inform the principal and provide the appropriate incentives to the agent.

Two different kinds of accounting techniques are used to monitor people. Mercantile accounting procedures were developed, in part, to monitor the honesty of those entrusted with the principals' investment.[9] These techniques provide information on transactions between the firm and outsiders to the firm. During the late nineteenth century new techniques were developed to inform the principal as to the effort and ability of an agent. Like those used to monitor processes, these techniques focused on activity internal to the firm. These techniques were sometimes, though not always, a part of a firm's cost accounting system.[10] These techniques included such measures as time cards

8. See Demski and Kreps (1982) and Baiman (1982) for further discussion of the different uses of information.

9. See Littleton (1933) and ten Have (1976) for survey histories of accountancy. Greif (1989) gives an example of another method developed by merchants to ensure the honesty of their agents when they could not easily be monitored.

10. In chapter 2 in this volume, H. Thomas Johnson distinguishes between "cost accounting" systems, which produced measures of average total cost to be used as input into the firm's financial accounts, and "managerial accounting," which produced various measures, possibly including cost of product, in response to managerial demands for information. During the period under discussion, there was no general agreement as to whether cost and financial accounts should be integrated (see, e.g., Arnold 1899). Thus the line of demarkation is quite fuzzy.

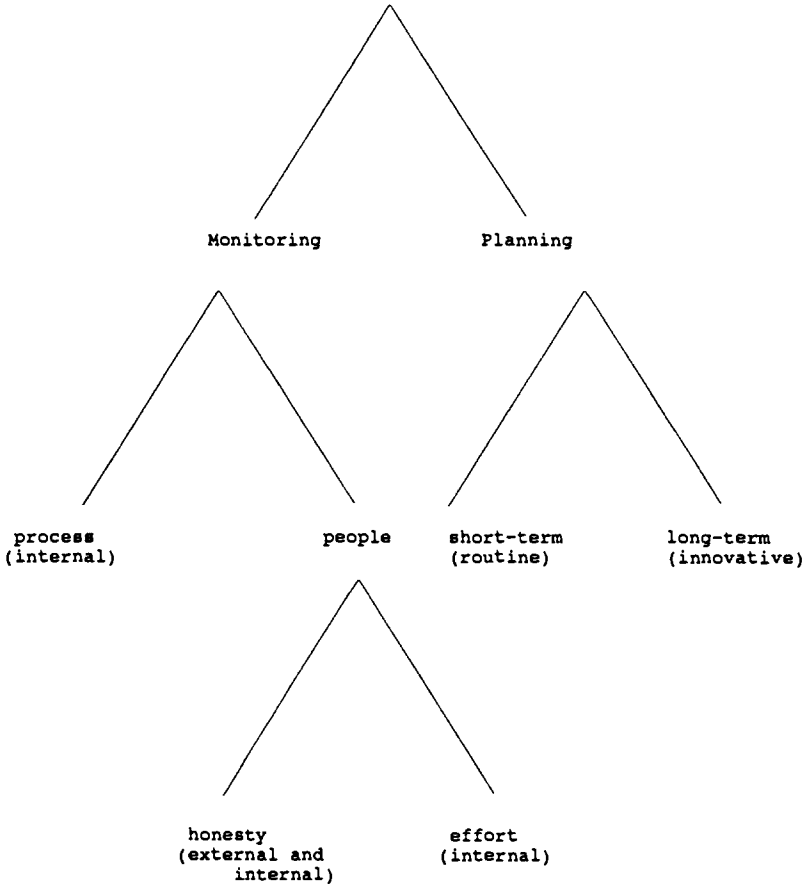


Fig. 3.1 Functions of information in a manufacturing firm

and time clocks, which were introduced widely during this period.[11] Frequent reporting of cost, profitability, and other aggregate measures of firm success was used to inform investors of managerial quality.[12]

The planning function can be broken down further into long- and short-term decision making. Short-term decisions include choosing output levels of goods already in the firm's product line, choosing inputs to production, including make or buy decisions that do not involve a large fixed capital investment, making minor modifications to an existing production process, and so

11. An early example is Metcalfe (1885). See Jacoby (1985) for a discussion of the introduction of labor-monitoring techniques in this period.

12. While the calculation of profits was not an invention of the late nineteenth century, periodic reporting was (see Previts and Merino 1979).

forth. Many short-term decisions are made repeatedly (e.g., deciding how much to produce each month). Thus the data necessary to inform these decisions are produced regularly, and the decision rule (the decision as a function of the reported data) can be made routine.

The most important aspect of long-term planning is the making of capital allocation decisions. In a multiproduct firm, comparative measures of profitability may be used to allocate capital among different product lines. However, because the investment decision is inherently prospective, and data produced by a firm's ongoing information system are inherently retrospective, a firm that is innovative in its investment decisions (e.g., considers new product lines) will also rely on ad hoc data to inform its investment decisions.

In general, the purpose of the first formal, systematic use of accounting data in firm management was the use of mercantile accounts to monitor managers' (as well as customers' and suppliers') honesty (monitoring people for honesty, in fig. 3.1). During the nineteenth century, firms began to use accounting and cost data to monitor activities internal to the firm (monitoring processes and monitoring people for effort). Once these data were being produced to monitor internal firm activity, managers began to use them to inform *short-term planning* decisions. As managers faced new strategic and technological choices, they adapted these measures and produced new ones. It was only in firms with already well-developed internal information systems that we observe the use of such data for *long-term planning* (see Levenstein 1991, chap. 2).

3.3 Very Brief Organizational History of the Dow Chemical Company

The Midland Chemical Company was incorporated in 1892 on the basis of an invention by Herbert Dow for the electrolytic production of bromine from brine. Its financial backers were a group of Cleveland businessmen, none of whom had a background in chemistry. It was located in Midland, Michigan, where there were underground springs with a relatively high bromine content.

Despite the advantages of Herbert Dow's new technology, there were both technological and marketing bugs to be worked out. The bromine market was at that time controlled by a cartel. This cartel was essentially run by two large fine chemical manufacturers, Powers and Weightman of Philadelphia and Mallinckrodt Chemical Works of St. Louis, who were the only wholesale distributors of pharmaceutical bromides in the United States.[13] Dow, as general manager of the new firm, advocated that the Midland Company operate independently of the cartel. He believed it could supply the entire American mar-

13. For a more detailed description of the structure of the bromine cartel in this period, see Levenstein (1989).

ket at a lower cost than the current producers.[14] This proved impossible because of the established reputations of the older firms.[15]

With a variety of technical problems and nowhere to sell the output Midland was producing, finances became extremely tight. They were a continual source of friction between the Cleveland investors and Dow. In late 1893, B. E. Helman, the company treasurer and largest stockholder, fired Dow from his position as general manager. He was replaced by Henry S. Cooper, a less innovative but also less obstinate man, with a background in manufacturing but not in chemistry. In 1894 the Midland Chemical Company contracted with Powers and Weightman and Mallinckrodt Chemical Works to sell all of its output to them at a fixed, and very profitable, price. In return it agreed to limit its output to a predetermined amount, about 50 percent of its capacity.

Dow remained in the employ of Midland, nominally as its secretary. Most of his time was devoted to developing processes for extracting the chlorine and magnesium that remained in the waste brine after the bromine was extracted. After an explosion in the experimental chlorine bleach plant, Helman vetoed further development of a bleach process, and Dow left the employ of the company he had founded three years before.

The Midland Chemical Company continued to produce bromides, selling them through the cartel, but engaged in little or no further research and development and reinvested little of its profits. It had no incentive to invest in increased capacity or improved quality, given its relationship with Mallinckrodt and Powers and Weightman. In summary, Midland adopted a very successful "adaptive" strategy of living off the profits of Dow's initial innovations, but without engaging in the more risky technological or marketing strategies associated with continued innovation.[16]

In 1895 Herbert Dow, again with the backing of Cleveland investors, formed a new company, the Dow Process Company, in Navarre, Ohio, to develop an electrolytic process to extract chlorine from brine. This company never produced chlorine on a commercial scale and was taken over in 1897 by the newly formed Dow Chemical Company. The Dow Chemical Company's plant was adjacent to the Midland Chemical Company. It received the Midland's waste debrominated brine, and from this extracted chlorine for bleach manufacture.

Unlike the Midland Company, Herbert Dow's new company pursued a policy of investing in the development of new products and processes to take

14. See letter from H. H. Dow to B. E. Helman, 9 December 1892, file 920021-Ax, Herbert H. Dow Papers, Post Street Archives, Midland, MI.

15. See letter from H. H. Dow to F. G. Trimble, Asst Sec'y Manistee Development Co., Manistee, MI, 20 September 1905; "Some 12 or 15 years ago we attempted to dispose of some Bromide on the open market, and we went all over the country offering it at about 60% of the recognized market value and could not dispose of it although our Bromide was better than the competing article. The wholesale Drug houses told us they had no demand for KBr [potassium bromide] of an unknown make" (file 050039x, Dow Papers).

16. See Lazonick (1988 and 1990) for further discussion of innovative and adaptive strategies.

advantage of both its natural resource and human capital bases. The ultimate decisions regarding the company's investment policy were still made by a Cleveland board of directors, but Dow's intention from the beginning was to pursue an innovative strategy. He wrote to M. B. Johnson on 5 June 1897, offering him the position of superintendent of the new plant: "We expect with your assistance to beat the world on bleaching powder in the next year or two and on numerous other substances in years to follow" (file 970073c, Dow Papers). By 1914 the Dow Chemical Company was producing at least a dozen other chlorine-consuming products and a dozen different kinds of bromine compounds, and was embarking on research into organic synthesis that made it the first U.S. company to synthesize indigo dyes.

In 1898 Herbert Dow regained control of the Midland Chemical Company and was named its president. Helman's stock was purchased by other Cleveland investors and a new treasurer, H. E. Hackenberg, was elected. Hackenberg was the treasurer of the National Carbon Company, a much larger chemical company based in Cleveland.[17] The general manager of the Midland was replaced by a Dow Chemical Company employee, James Graves. In 1900 the two companies were merged. Herbert Dow was named general manager and James Graves superintendent of the new firm. Hackenberg became its secretary.

Continued innovation in its production processes gave the Dow Company access to technologies with large economies of scale. Continued innovation in product development led it into new markets and encouraged it to develop closer ties to the final consumers of its products. In each case, Dow's strategy of technological innovation led it into conflict with the existing distribution organizations in the pharmaceutical and chemical markets. In most cases, these organizations divided up market share, restricted output, and kept the manufacturer at arm's length from its customers. Thus in 1902, the Dow Company withdrew from its long-standing arrangement with Mallinckrodt and Powers and Weightman. In 1904, it canceled its exclusive agency agreement for the distribution of its bleach. In 1905, it established its own sales organization.

Despite periods of very slim profits, largely the result of a series of severe price wars in the various markets in which the Dow Chemical Company sold its products, the company pursued an aggressive strategy of both absolute growth and product diversification in the period up to World War I. There were other trace elements left in the brine after the bromine and chlorine were removed. The company was continually engaged in research to identify new, inexpensive ways to extract these elements, and to find or create new sources

17. Hackenberg was secretary of the National Carbon Company (of Ohio) until 1899. In that year he became treasurer of the National Carbon Company (of New Jersey). That firm was created in 1899 as the result of a nationwide merger of carbon companies. In 1917 it merged with Union Carbide to found Union Carbide and Carbon. See letter from H. E. Hackenberg to H. S. Cooper, 26 January 1899, file 990047x, Dow Papers, and Chandler (1977, 355).

of demand for their consumption. The company was also engaged in research to find new uses for the bromine and chlorine that it could produce in much greater supply than could be consumed in existing markets.

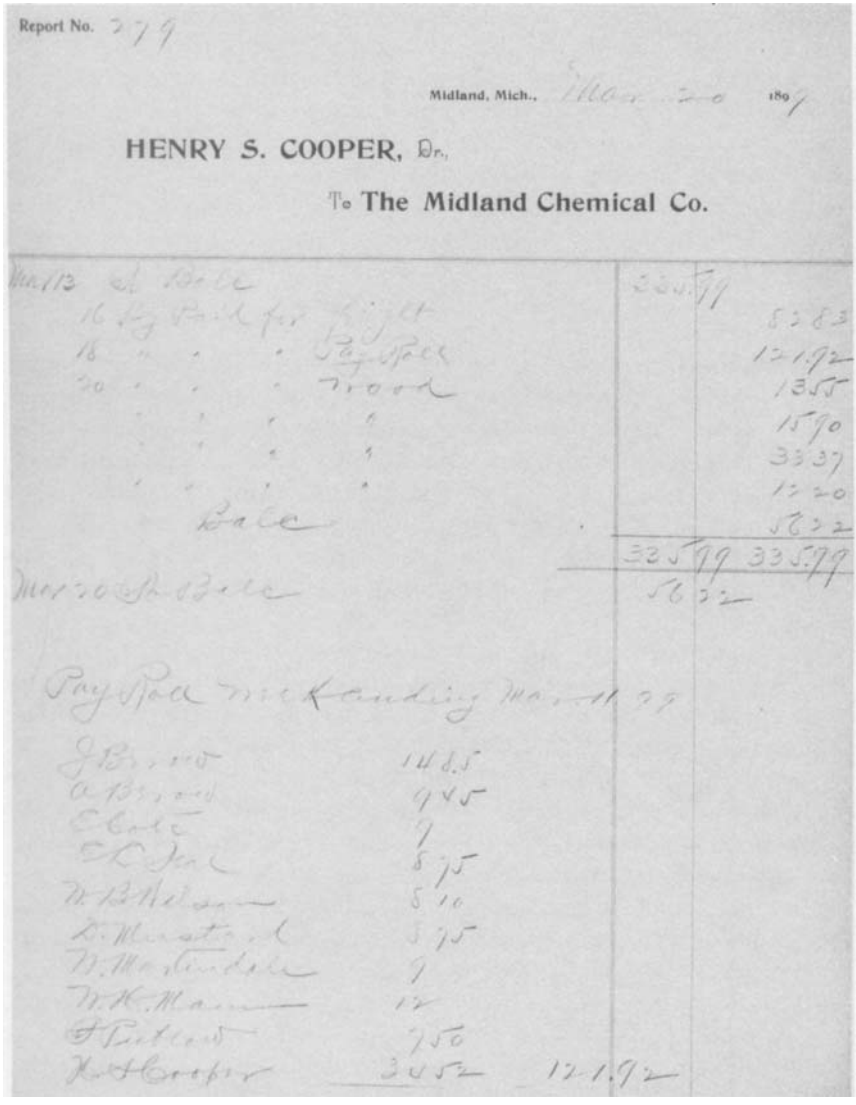
3.4 Accounting and Strategy at Dow

The design of the accounting system, and the kinds of information that it produced, reflect both the changes in the organizational structure and the strategic posture of the company over this period. The order of the introduction of these changes was similar to that of other manufacturing firms described above. More specifically, I find that, from 1892 to 1898, the design of the accounting system of the Midland Chemical Company (1892–1900) was essentially mercantile. By that I mean that it was designed to keep track of transactions with outsiders to the firm (in fig. 3.1, monitoring people for honesty). The only regularly produced internal report, the general manager's weekly report to the treasurer, mimicked the account statement of an outside supplier to the firm (fig. 3.2). While this system provided necessary information for the provision of funds to the manufacturing plant, it was not used on a regular basis to inform decision making at the plant level or for the monitoring of plant management by the board of directors (i.e., neither for monitoring people for effort nor for monitoring processes nor for planning). The small size of the firm (itself the result of the strategy pursued) did not require it to develop formal systems for monitoring employees. The noncompetitive market in which the firm sold its products permitted, if it did not actually encourage, a relatively lax attitude toward cost saving.[18]

When the Dow Chemical Company began operations in 1897, it adopted a more aggressive, innovative attitude both toward the improvement of production technology and the development of new output markets. This was accompanied by the systematic calculation and use of several measures of production efficiency. This included weekly estimation of the average (variable) cost of bleach, as well as several nonmonetary measures of technical efficiency and quality. During the first four years of the company's existence, this measure (of average variable cost) was used primarily by the company's board of directors as a device to monitor plant management (i.e., monitoring people for effort). The nonmonetary measures were more important in plant-level decision making (i.e., short-term planning).

After the merger of Midland and Dow Chemical in 1900, a new set of reports gave not only average product costs but also average profit on the firm's two primary products, bleach and potassium bromide. In 1905, at the urging of a public accounting firm, the Dow Company modified its costing system to permit a calculation of net income for each of its ten products. At the same

18. For a similar case of high profits diminishing the demand for information, see Yates's discussion of Illinois Central (section 4.1 in this volume).


Report No. 279

Midland, Mich., Mar. 20 1899

HENRY S. COOPER, Dr.

To The Midland Chemical Co.

Fig. 3.2 General manager H. S. Cooper's weekly report, Midland Chemical Company, 1894–99

time, it resisted the suggestion of its auditors to calculate measures of average total cost by allocating its fixed costs among its products.[19] While the account-

19. The practice of allocating fixed costs to determine average total cost of product is perhaps the defining characteristic of those information systems that Johnson refers to (chap. 2 in this volume) as "cost accounting" systems. These measures of average total costs are used to value

ing and information system went through several modifications between 1901 and 1914, each facilitated the calculation and comparison of net income on an increasing number of products. This measure was used both as a monitor of managerial performance at Midland (i.e., monitoring people for effort) and, more informally, to aid the board of directors in making decisions regarding which product lines to pursue (i.e., long-term planning).

Unlike the procedure adopted at Du Pont during this period, the Dow Company did not regularly or systematically calculate or compare rates of return on each of these products.[20] Rather it treated the largest costs of the firm, the fixed, joint costs of the wells, power plant, and so forth, as essentially sunk costs. These costs were not allocated to any products. Separate accounts were established to keep track of the development expenses of new products; informal comparisons between expected net income and the cost of development were frequently made. These measures were included in discussions by the board of directors of product development policy, capital allocation decisions, and so forth, though no rule was formulated specifying minimum expected returns on the incremental investment in a particular product (as was the case at Du Pont). That is to say, these data were used to inform long-term planning decisions, but there was no attempt to make these decisions a *routine* function of these data.

In summary, like other manufacturing firms of the period, Herbert Dow's chemical companies initially relied on mercantile accounting techniques, which focused on transactions with outsiders to the firm. The only internal information produced was designed to perform a similar function, that is, monitoring people for honesty. Later, as the companies began to pursue a more innovative strategy, more information was required. In the first phase of this new strategy, the focus was on developing new products and new production techniques. Information on product costs and technical efficiency was collected to satisfy this new demand. This information was used first to monitor people for effort and to monitor processes, and soon after to aid in short-term planning decisions. The company soon realized, in typical Chandlerian fashion, that in order to successfully pursue the product diversification strategy adopted in the first phase, it must revise its marketing and distribution strategy. This required a new kind of information, and we soon observe the production of data on price-cost differentials and net income for individual products. These new measures allowed the board of directors to better monitor plant management's performance of this more complex strategy (i.e., moni-

inventories in the financial accounts, thus providing the link between the costing system and the financial accounting system. See Levenstein (1991, chap. 5) for a more detailed description of Dow's capital accounting procedures and the influence of accountancy thereon.

20. For a more detailed description of Du Pont's use of rate of return measures in capital allocation decisions, see Chandler (1977) and Johnson (1975).

toring people for effort) as well as make better-informed long-term planning decisions.

3.5 The Evolution of the Information System at Midland

3.5.1 Stage I: Accounting for Cash

In the early years of the Midland Chemical Company, before bromides were being produced and sold at a profit, the company's record keeping focused on estimating and reporting cash flows over short lengths of time (i.e., days and weeks). These measures were used for two purposes. The first was to inform Treasurer Helman, in Cleveland, of the cash needs of the production unit in Midland. The second was to inform both the management in Midland and the stockholders in Cleveland of the achievement or proximity to profitability, that is to say, whether the firm was producing bromides regularly and cheaply enough that the business was profitable. Each of these purposes required somewhat different information.

The only systematic reporting of information to Cleveland was a weekly report that Herbert Dow sent to B. E. Helman. This report was first produced in April 1892 (see file 920021-Ax, Dow Papers). No copies of this report have been found, but correspondence indicates that it included all of the cash expenditures made during the week at Midland. These expenditures included payroll and any other small, inexpensive items purchased. Invoices for more expensive items were sent to Helman for payment.

These reports gave the Cleveland office information about the cash expenditures at the plant, but in and of themselves gave little information about whether or not Herbert Dow's process was going to be profitable (about which there was some question) or what the future demands for cash would be. In the period before the contract with Powers and Weightman and Mallinckrodt Chemical Works was signed, demands for cash frequently meant demands on the pocketbooks of the Cleveland investors, since receipts for sales were few and far between. Ad hoc reports were prepared to fill this gap.

At the end of 1892, Helman visited Midland, and Dow and Helman estimated the daily expenses of the company. Helman included in this estimate an amount for depreciation and 7 percent interest on capital invested. Dow wrote to another investor, J. H. Osborn, that "profits would not be counted at all unless they exceeded 7%."[21] This suggests that the reason for the determination of daily expenditures was to give an estimate of the required daily income for the firm to be earning positive economic profits, that is, covering both its actual and its opportunity costs. On the other hand, in this letter to Osborn, Dow gives an estimate of the daily expenses, without interest, suggesting that

21. H. H. Dow to J. H. Osborn, 16 December 1892, file 920021-Ax, Dow Papers.

this is how much they needed to "see us through." Dow's estimates do include a daily charge for depreciation, which did not reflect a cash expenditure. Thus the estimate of daily expenses was intended both to give an idea of future cash needs and the proximity to profitability; it did both only with some mismeasurement.

In the terms of figure 3.1, these systematically produced data were not amenable to use in short-term planning. This is not to say that there was no cost consciousness at Midland during its early years. Quite to the contrary, the lack of funds led to a preoccupation, on the part of both plant and Cleveland management, with minute expenditures.[22] Rather, the weekly reports were not designed or used to aid in cost cutting. They were used to some extent to monitor the activities, as reflected in the list of expenditures, of plant management, but did not provide sufficient information to the Cleveland stockholders to evaluate the wisdom of those expenditures. For example, Helman wrote on 6 November 1893, "I must ask you to cut down on every expense and keep it as low as possible. Can you figure out for me the following. 1. What can you make the average weekly output? Give me a safe figure. 2. To make this what would be your expense? Itemize it. If we can save on the fuel item we must do it. I only wish I had the $200 for you" (file 930007c, Dow Papers). Despite weekly reports and frequent letters, this information was not readily available.

3.5.2 Stage 2: Information in an Adaptive Firm

After the contracts with Powers and Weightman and Mallinckrodt Chemical Works were signed and the profitability of the company was assured, Midland had to decide whether it would continue to pursue an innovative strategy in other product areas, as the gains to innovation in bromine were limited by the output restrictions in the new contract, or whether it would "consume" the high profits generated by the new contract. There was a brief period during which the company supported Herbert Dow's further research into chlorine and magnesium production, but the stockholders (and particularly Helman) were not willing to accept either the risk or the reinvestment of the firm's surplus that such a strategy required. Dow's research support was cut off, and he left the full-time employ of the company.

This set of decisions, to refrain from significant investment in improving the bromine process, to allow other firms to market its product, and to restrict its product line to crude potassium bromide, had several significant implications for the development of the information system over the following years.

First, the high profitability itself (the company paid monthly dividends of 2–3 percent) seems to have lessened concern for cost cutting. There is certainly less discussion of such matters in the correspondence between Midland and Cleveland during the following years.

22. See, for example, letters from H. H. Dow to B. E. Helman, 13 June 1892, 31 June [*sic*] 1892, 5 July 1892, 13 July 1892, and 9 December 1892, file 920021-Ax, in which he responds to Helman's criticism of his purchase of a lock and expenditures for ashes for potash.

Second, the nature of the sales contract, which inhibited competition among bromide producers and prevented any contact between Midland and its customers (and therefore the establishment of any reputation associated with its brand), provided no incentive for the firm to produce a higher-quality product. Hence, information regarding product quality was not produced as regularly as would be the case later on, and such information as was produced was usually not forwarded to Cleveland.

Third, the need for secrecy to protect its negotiating position vis-à-vis the cartel came to outweigh any benefits to the systematic production of cost data. Years later, Herbert Dow wrote, "If a pound of pure Bromide cost the same in the old Midland Chemical Co. plant a pound of its commercial Bromide would have cost [$].0846. This is about what the actual cost was but I think Mr. Hackenberg will be able to give the exact figure. We were so particular about our costs not being made public that I have not been able to find any document in which it is given" (about May 1904, file 030044x, Dow Papers).

Thus the quantity of information produced for managerial use during this period was limited. In terms of the *functions* of information, the data were used primarily to monitor people for honesty, in both internal and external relationships.

Three different reports were produced during this period, each of which will be discussed in more detail below. Cooper continued the practice, begun by Dow, of submitting a weekly statement of his "personal" account with the company (fig. 3.2). Helman produced annual (and then semiannual) financial statements (fig. 3.3). And for approximately one year, Cooper prepared and submitted to another important Cleveland stockholder, J. H. Osborn, a weekly report on plant activity.

The limited number and content of these reports reflected the strategic attitude of the firm. None of these reports included measures of the monetary cost or technical quality of product. While the weekly reports sent to Osborn did include physical measures of output and input consumption (per week), these data do not appear to have been used by plant management (i.e., for short-term planning), and their production was shortly discontinued. Helman's financial reports were not produced frequently enough, or even with enough continuity of content, to be very useful in evaluating managerial success or failure (i.e., monitoring people for effort). The lack of such data both reinforced the existing managerial attitude toward the importance of cost cutting, particularly relative to the enormous concern displayed regarding renegotiation of the exclusive sales contracts, and denied managers information that would have aided in more aggressive cost cutting.

3.5.2.1 Henry Cooper's Weekly Report

After Henry S. Cooper replaced Herbert Dow as manager of the Midland plant in November 1893, he submitted a weekly report to Helman that showed

cash received (from Helman) and dispensed (fig. 3.2).[23] The report was designed to mimic the statements of account prepared for outsiders to the firm (i.e., the firm's suppliers). The form itself is identical to that used for suppliers' accounts. The amounts spent in Midland appear exactly as if they were items supplied by Cooper to the firm (e.g., "By Paid for freight," "By Paid for Pay Roll," and "By Paid for Wood"); the amounts received by Cooper[24] appear as if they were payments made to him.[25] Thus while it was the only systematic communication to Cleveland on the internal activity of the firm, the form of the report constrained it to reporting "mercantile" information (i.e., monitoring Cooper for honesty). Occasionally the report would disaggregate the weekly payroll, as in the bottom half of the form shown in fig. 3.2. There were no folio numbers or any indication that these costs were aggregated into subsidiary accounts. There was no information about production or sales activity, though Helman was notified of shipments to Mallinckrodt and Powers and Weightman by the submission of a copy of the invoice. Cooper also occasionally wrote notes to Helman at the bottom of the form indicating his expected cash needs, for example, "Will need about $250. per week for wood for a while."[26]

The continued use of a general manager's personal account, to which all of the Midland expenditures of the firm were credited on the company's ledger, made it impossible to calculate input costs or fluctuations therein. Expenditures included in this account do not appear to have ever been disaggregated into accounts breaking down the cost of product. Thus when Cooper, after Helman's departure from the company, asked the new treasurer for information about the cost of potash, Hackenberg could not easily extract this information from Helman's accounts. Cooper had not, in his own capacity as general manager, kept records that would allow him to measure these input costs.[27]

Thus while this report was produced with frequency and regularity, its content and method of aggregation did not lend themselves to use in the "planning" functions discussed above. This report did permit Helman to monitor Cooper's dispensation of the cash sent to him, and thus detect gross fraud (i.e., monitoring him for honesty), as suggested by the mercantile form, but it did not facilitate an evaluation of his performance as general manager (i.e., monitoring him for effort). However, since Cooper (and his brother) had a

23. See files 980053x and c, 990039c, 990038c, and 000050c, Dow Papers.

24. By chance, no such receipts appear on the report shown in fig. 3.2, as Cooper had received no check from Cleveland during the week covered.

25. It should be clear that Cooper's account is fictitious. Cooper was an employee, not an inside contractor. He was not the residual claimant to this account (i.e., to the amount of $56.22 listed "By Balc"). The local bank accounts to which these amounts were deposited and charges drawn were in the name of the Midland Chemical Company, not Cooper.

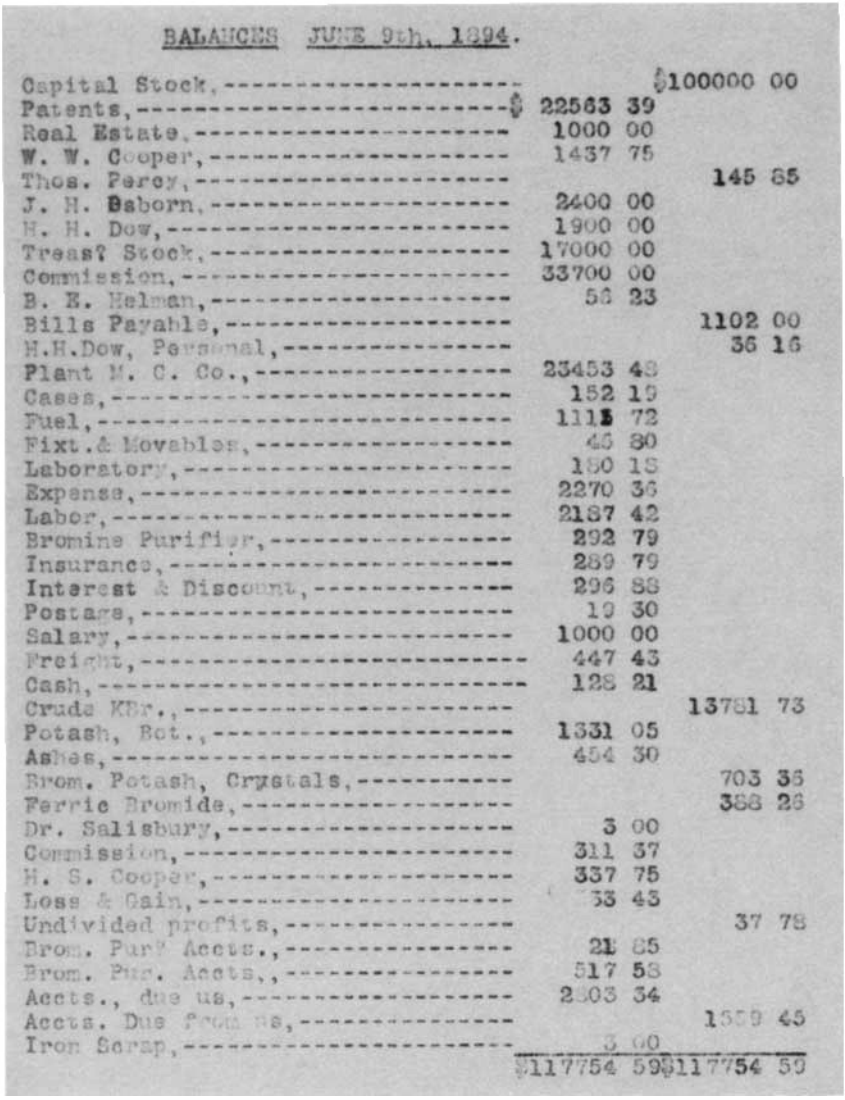
26. See report no. 265, 5 December 1898, file 980053x, Dow Papers.

27. See letter from H. E. Hackenberg to H. S. Cooper, 26 January 1899, file 990047x, Dow Papers.

sizable stockholding in the company, the use of a direct performance measure was probably considered unnecessary.

3.5.2.2 B. E. Helman's Financial Statements

Helman produced financial statements, from a set of ledgers kept in Cleveland, on an annual and sometimes semiannual basis (fig. 3.3). The first such



BALANCES JUNE 9th, 1894.

Capital Stock,		$100000 00
Patents,	$ 22563 39	
Real Estate,	1000 00	
W. W. Cooper,	1437 75	
Thos. Percy,		145 85
J. H. Osborn,	2400 00	
H. H. Dow,	1900 00	
Treas? Stock,	17000 00	
Commission,	33700 00	
B. E. Helman,	56 33	
Bills Payable,		1102 00
H.H.Dow, Personal,		35 16
Plant M. C. Co.,	23453 48	
Cases,	152 19	
Fuel,	1115 72	
Fixt.& Movables,	45 80	
Laboratory,	180 18	
Expense,	2270 36	
Labor,	2187 42	
Bromine Purifier,	292 79	
Insurance,	289 79	
Interest & Discount,	296 88	
Postage,	19 30	
Salary,	1000 00	
Freight,	447 43	
Cash,	128 21	
Crude KBr.,		13781 73
Potash, Bot.,	1331 05	
Ashes,	454 30	
Brom. Potash, Crystals,		703 35
Ferric Bromide,		388 26
Dr. Salisbury,	3 00	
Commission,	311 37	
H. S. Cooper,	337 75	
Loss & Gain,	33 45	
Undivided profits,		37 78
Brom. Pur? Accts.,	21 85	
Brom. Pur. Accts.,	517 58	
Accts., due us,	2303 34	
Accts. Due from us,		1509 45
Iron Scrap,	3 00	
	$117754 59	$117754 59

Fig. 3.3 Midland Chemical Company annual report 1894

statement known to have been produced, though no copy still exists, was dated January 1894.[28] The June 1898 report was the last produced by Helman.[29] Copies of these statements were distributed to the board of directors of the company.[30]

The statement displayed in figure 3.3, the earliest one produced, consists of a one-page balance sheet. The assets and expenditures of the firm are listed in the left-hand column. The liabilities, equity, and income are listed in the right-hand column. Most of the accounts listed (e.g., cases, fuel, ashes, "Potash, Bot.") represent the cost of goods and materials that the firm had purchased during the period. The accounts listed by individual name (except for Dr. Salisbury, who was an independent pharmaceutical sales agent) represent loans to and from the firm to its principal stockholders. Note that Dow has two accounts listed, one of which is his personal account and the other of which represents his account as manager of the company, as described above. The account listed for H. S. Cooper represents his account as general manager following Dow's dismissal. While the statement is at variance with modern standard accounting procedures in many ways, some of the accounts listed are quite familiar to modern readers. The asset side of the balance sheet includes patents, real estate, plant and equipment, and accounts "due us." The liability side of the balance sheet includes the capital stock (though the amount of $100,000 is incorrect) and accounts "due from us."

These statements always included a balance sheet, and sometimes included sales, inventory, and "loss and gain" statements. No separate income statement was ever produced during Helman's reign as treasurer. Instead, sales are listed as liabilities on the balance sheet (e.g., "Crude KBr., [$]13781[.]73"). The cost of product already sold is included with the cost of materials inventories, labor, and so forth, still in stock as an asset of the firm (e.g., the account "Potash, Bot." might include the cost of potash currently in stock as potash, the cost of potash now stored as potassium bromide inventories, and the cost of potash in potassium bromides already sold). Thus, the value of the potash account on the balance sheet did not report the (historical) value of the potash stock of the firm.[31] Rather it aggregated the cost of potash consumed during the previous year and the value of the existing stock. The cost of potash consumed in producing the previous year's output was never disaggregated. Thus, even on an annual basis, it was nearly impossible to estimate fluctuations in the cost of inputs. This was true as well for estimates of the total cost of production and, therefore, for the profitability of the firm.

28. See letters between B. E. Helman and H. S. Cooper, January 1894, file 940001c, Dow Papers. There are still in existence annual and semiannual financial statements produced by Helman from June 1894, January 1895, June 1896, December 1896, January 1898, and June 1898. See files 940017x, 950080x, and 960111x.

29. File 960111x, Dow Papers. See letter from J. H. Osborn to H. H. Dow, 10 June 1898, indicating that this was the last report produced by Helman (file 980013c).

30. See letter from H. H. Dow to H. S. Cooper, 24 January 1896, file 960027c, Dow Papers.

31. Because of Helman's peculiar method of keeping the accounts, it did not report the entire cost of potash during the previous year, which might also have been useful.

These statements, distributed only to the board of directors of the company, provided very general information about how funds had been spent, the indebtedness of the company, and so forth. The information was not available to most plant managers, except for Dow and Cooper, and therefore would have been of limited use in short-term planning even had the report been produced frequently enough for such a purpose. Because of the unusual aggregation of the accounts, inhibiting the measure of costs over time, the data were not amenable for use in evaluating the performance of plant management (i.e., monitoring people for effort). Thus, the frequency, the type of aggregation, and the degree of dissemination of these reports, like Cooper's weekly report, reflect a focus on monitoring people for honesty, rather any use in monitoring people for effort or providing information for short- or long-term planning.

3.5.2.3 J. H. Osborn's Report

The only indication of any systematic reporting of plant operations to Cleveland during this period is found in correspondence between Cooper and J. H. Osborn, the first vice-president of the company, during 1895 and 1896. After making a series of requests for information about plant activities and costs in letters, Osborn asked that Cooper send him a regular report.

> Some time ago Mr. Dow gave me some figgures [*sic*] refering [*sic*] to amount of product per amount of current . . . Have you or can you verify these figgures. Do you keep account of the [ ] current used daily I presume you keep a record of shipments made if so I wish you would send me a complete list of shipments since Jan first of this year; and also amount of labor and salary up there and if you have the record the one amount of current used. I have not heretofore had any regular reports nor indeed know very much about how things were running up there as I never could get any reports from Herbert [Dow]. I should like to have monthly report if you can find time to make it out and in order to make as little work for you as possible I think perhaps I will make out a form and have some printed and sent you so that you will simply need to fill in the figgure and mail it to me. I am often at a disadvantage when talking with Mr. Helman and I know very little about what is going on unless he chooses to tell me. I am of the opinion which I think I expressed when there that you should keep a careful record there of all that is done day by day because it might be useful sometime—another thing I would like to know if possible that is exactly how much potash there is in a pound of KBr as you make it. (10 September 1895, file 950019c, Dow Papers)

Osborn had the form printed in Cleveland and sent to Cooper.[32] There is no indication that Cooper ever sent copies of this report to Helman. No copies of this report still exist, but correspondence indicates that it included potassium

32. See letter from J. H. Osborn to H. S. Cooper, 14 November 1895: "I sent you by mail a few days since a package of blank reports. I expect you have received them ere this. I was a long time getting them they were in the printers hands for some time" (file 950019c, Dow Papers).

bromide produced, inventoried, and "in works" per week, and daily power consumption.[33] It did not include any measure of technical efficiency akin to the "bleach output per ampere day," which would later be calculated at the Dow Chemical Company. Osborn did, himself, use the data to calculate output (pounds of potassium bromide) per kilowatt.[34] The report did not include any measure of average cost. The reports were produced for about a year, until November 1896. While Osborn occasionally made comments suggesting his pleasure or displeasure at the results achieved by Cooper (i.e., used the data to monitor effort), his primary use of these data was in formulating the company's position in contract negotiations with the bromine cartel. That winter Osborn went into semiretirement, and there is no indication that the reports were continued in his absence from Cleveland.

The Midland's accounting system in this period (1892–98) was quite typical of nineteenth-century manufacturing firms.[35] The techniques (i.e., the reports and account books) did not innovate on those used by mercantile firms. Thus the information available was useful in monitoring people for honesty but in none of the other potential functions of information discussed above. Given the strategic posture of the firm and the market in which it was operating, this information was sufficient to sustain a very profitable enterprise.

3.5.3 Stage 3: Information in an Innovative Firm

While the Midland Chemical Company was pursuing a strictly adaptive strategy, in terms of production technology, product line expansion, and marketing, Herbert Dow was taking the Dow Process and then the Dow Chemical Company on a different path. This meant being more innovative in terms of product and process but, for the first five years, did not mean deviating from the historical norms in the distribution of product.[36]

The changes in the information system were similarly gradual. Thus, during the Dow Process Company period (1895–97), the "mercantile" form of the general manager's weekly report was adopted from Midland Company practice (see fig. 3.4). However, daily time cards, which gave both plant and Cleveland management more detailed information about internal plant activity, were also introduced. When the Dow Chemical Company was founded,

33. See letters from J. H. Osborn to H. S. Cooper, 5 December 1895, file 950019c, 4 March 1896, and 20 March 1896, file 960001x, Dow Papers.

34. See letter from J. H. Osborn to H. S. Cooper, 5 December 1895, file 950019c, Dow Papers.

35. See, for example, Chandler's (1977) description of the Lyman textile mills or McGaw's (1985) description of the Berkshire paper manufacturers.

36. The question of the optimal degree of vertical integration was already an item of discussion at both Midland and Dow. Herbert Dow continued to argue that the Midland should sell its product independently of the bromine cartel. When Hackenberg became a stockholder of the Dow Chemical Company in 1900, he also began to urge that it consider forward integration. He wrote, "I do not wish to be considered presumptuous, especially at this early stage, in again suggesting to you the advisability of making all sales direct instead of through Sales Agents, and hope this matter will be considered in the near future" (June 1900, file 000055x, Dow Papers).

May 22",1897.

REPORT NO. 47. FOR WEEKS ENDING AS BELOW.

H. H. DOW, IN ACCOUNT WITH THE DOW PROCESS CO.

DR.

To check from THE DOW PROCESS CO.		$500.00

CR.

By balance from last report		1354.87	
Labor vouchers for week ending Mar.20"	61.85		
" " " " " 27"	55.73		
" " Apr. 3"	54.85		
" " " 10"	62.88		
" " " 17"	59.65		
" " " 24"	57.03		
" " May 1"	74.48		
" " " 8"	47.85		
" " " 15"	92.25		
" " To May 22" not"inclusive	51.89	618.46	
Postage		2.00	
Expense, trip to Alpena & return		17.09	
4 Barrels Alpena lime		2.45	
Freight on lime (receipts enclosed)		.94	
Expense 4 trips to Cleveland & return		58.15	
Apparatus used in Cleveland		3.40	
Receipts for options		15.00	
Express amounting to		1.80	
Receipts for telegrams		1.65	
Attorney (preparing report for tariff committee)		5.00	
Stenographer		4.50	
Draying lime,etc.		.75	
Expense (trip to Saginaw & return		1.55	
Livery(Co. work)		2.00	2089.61
Overdrawn Acct.			1589.61
			500.00

Fig. 3.4 General manager's weekly report, Dow Process Company, 1895–97

while the firm certainly continued to keep financial accounts, the general manager's "personal" account report was dropped. It was replaced by a report that included measures of technical efficiency and product cost (fig. 3.5). For the first time, the firm's formal information system was being used by the board of directors to monitor and evaluate plant management (i.e., monitoring for effort), and by plant management to make short-term planning decisions.

Similar changes were enacted at Midland after Dow regained control of the firm. The general manager's weekly "personal" account report was replaced by one modeled on the Dow Chemical Company report (fig. 3.6). Hackenberg also introduced the production of uniform monthly financial statements (fig.

3.7).[37] These changes reflect the influence of Hackenberg's greater background in accountancy than that of earlier management as well as the more aggressive strategy of the firm in both minimizing costs and improving quality.

3.5.3.1 Information at the Dow Process Company

While the Dow Process Company had a very short life and never produced bleach on a commercial scale, its record keeping procedures represent an important transition period, in which Herbert Dow demonstrated, for the first time, an interest in using formal costing procedures in company management. The primary systematic communication between the plant (in Navarre, Ohio) and the investors (in Cleveland) remained, as at Midland, a weekly statement of the "personal account" of the general manager (fig. 3.4). However, a new information-gathering device, the daily time card, was introduced at the plant. These cards were introduced primarily to improve "accountability" (i.e., monitoring employees for effort, providing an incentive for greater effort) on the part of the employees but, once produced, were also used to calculate and compare costs over time. Thus, they were amenable for use by Herbert Dow in making short-term planning decisions about changes in the developing bleach process.

The weekly report Herbert Dow sent to Cleveland was similar to those he and H. S. Cooper sent to Helman for the Midland.[38] It focused on cash transactions at the plant. The first report is dated September 1895, the last May 1897; thus it covered the entire period of the company's existence. The form is a one-page, double-entry list of the receipts and expenditures made at the plant in Navarre. The receipts, reported as "To check from THE DOW PROCESS CO.," are debited to Herbert Dow's "general manager's account" on the books of the Dow Process Company. That account is credited with the expenditures made at Navarre (e.g., labor costs, postage, freight, etc.), which are listed individually below.

These reports were sent to James Pardee, the secretary and treasurer and Herbert Dow's former classmate at the Case School.[39] They were entered by him into the financial books of the company, which, like the Midland's, were kept in Cleveland. If any financial statements were prepared from these books, they have not been located.

After receiving Dow's first report, Pardee suggested that he modify his record keeping for payroll. He wrote, "Your report is all right only that you had better make out a payroll for your labor and have the men sign it. This might

37. As described by Yates (chap. 4 in this volume), the attempt to achieve greater uniformity in reports was accomplished by the replacement of a typed report with a printed blank form into which the month's entries were made.

38. See files 970086 and 950034, Dow Papers.

39. Pardee became vice-president of the Dow Chemical Company in 1901 and chairman of the board in 1935.

be done in a book which you can keep and make copy and send to me. What are the items for your labor account of $59.61 to September 17."[40]

Dow went further than simply having his employees sign the payroll book. He instituted a system of daily time cards for all employees.[41] The use of these time cards is the first instance of any interest displayed, on Dow's part, in the use of accounting or cost data in management. A similar system was used in the Dow Chemical Company throughout the entire period of this study. His reasons for introducing these cards were discussed in a letter to H. S. Cooper, in which he urges Cooper to do the same. "We have every man fill out a labor time card. I think men are more liable to make a showing if they have to account for all their time in detail and it enables us to know what each thing costs by referring back to cards even if a separate account is not kept" (13 November 1895, file 950023c, Dow Papers). That is, by monitoring effort the cards provided workers with an incentive to increase their effort. The information, once produced for its monitoring and incentive functions, was used to calculate costs for short-term planning. Unfortunately, none of these cards appear to have survived.

3.5.3.2 Information at the Dow Chemical Company

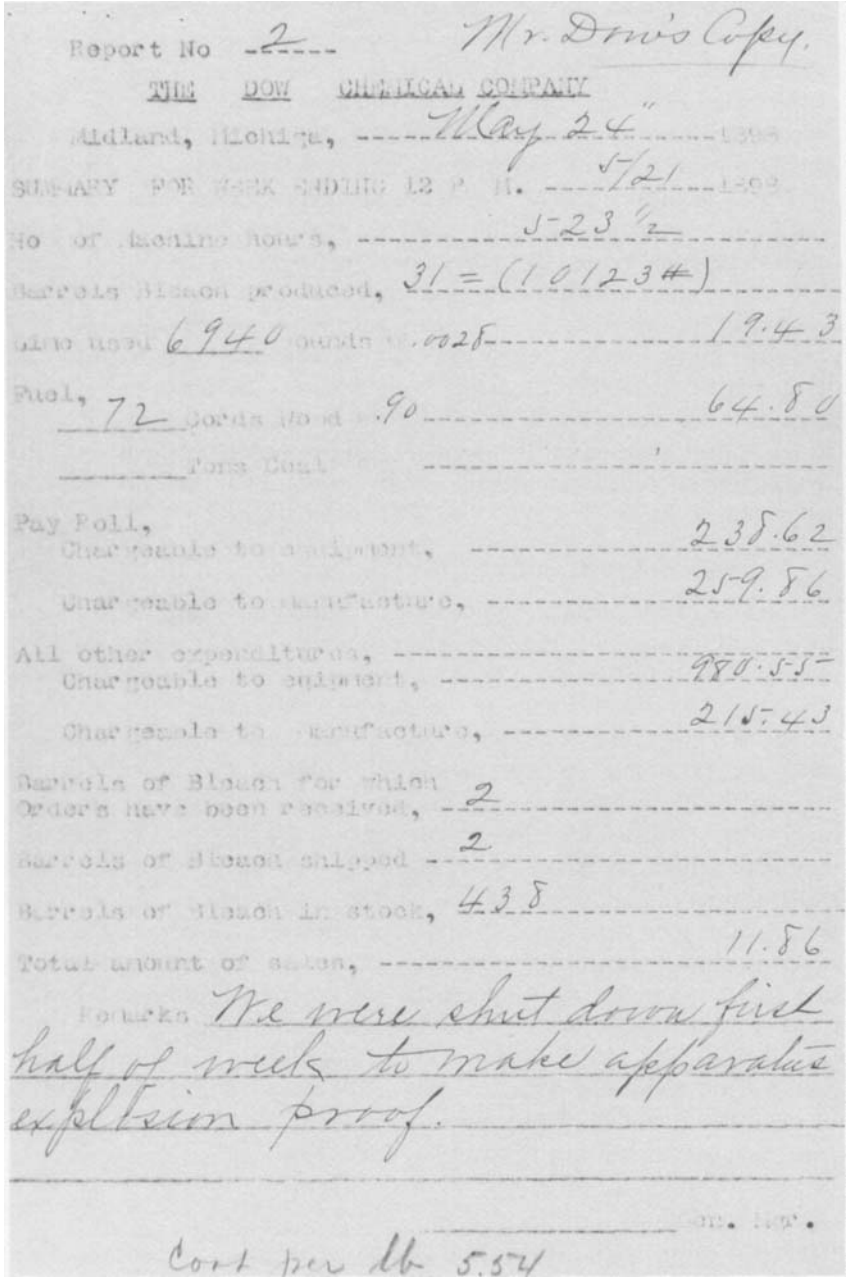
When the Dow Chemical Company was formed, the "personal" account of the general manager was dropped. The new account books were designed to allow periodic calculations of the cost of plant activities. The weekly report form (fig. 3.5) included data on the cost of these activities (e.g., cost per pound, fuel cost, lime cost) and on various measures of technical efficiency and the quality of product (e.g., barrels of bleach produced, pounds of bleach per ampere day, and percentage of chlorine in escaping gas). The latter measures were calculated with the greatest frequency and appear to have been most important in the day-to-day management of the plant. The report usually included brief discursive remarks on plant events (shutdowns, etc.). The report included total value of sales but did not report an average price received.

The average dollar cost of product was, however, more easily comprehensible to the nonchemist stockholders and was added to this form shortly after it was introduced. Cost per pound is equal to the sum of lime cost, fuel cost, payroll chargeable to manufacture, and all other expenditures chargeable to manufacture, divided by pounds of bleach manufactured. Thus there were no "depreciation" or allocated machinery charges included in this measure of costs. This was a measure of average *variable* costs.[42]

40. 22 September 1895, file 950043c, Dow Papers. See file 950034x, report no. 1.

41. Card-based cost systems were becoming increasingly popular during this period (see Arnold 1899).

42. Herbert Dow confirms this understanding of the measure of cost in a letter to James Pardee, in which he says, "Enclosed please find a statement of average cost per pound making bleach for a number of weeks past. As more bills for current expenses are paid some weeks than others, a



Report No 2 Mr. Dow's Copy.

THE DOW CHEMICAL COMPANY

Midland, Michigan, May 24"

SUMMARY FOR WEEK ENDING 12 P. M. 5/21

No of working hours, 5-23 1/2

Barrels Bleach produced, 31 = (10123#)

Lbs used 6940 Cords Wood .028 19.43

Fuel, 72 Cords Wood .90 64.80

Tons Coal

Pay Roll,

Chargeable to equipment, 238.62

Chargeable to manufacture, 259.86

All other expenditures,

Chargeable to equipment, 980.5-5-

Chargeable to manufacture, 215.43

Barrels of Bleach for which Orders have been received, 2

Barrels of Bleach shipped 2

Barrels of Bleach in stock, 435

Total amount of sales, 11.86

Remarks We were shut down first half of week to make apparatus explosion proof.

Cost per lb 5.54

Fig. 3.5 General manager Herbert Dow's weekly report, Dow Chemical Company, 1898–1900

This report included a summary report on the previous week's expenditures. These expenditures were divided between those chargeable to manufacture and chargeable to "equipment."[43] The inclusion of the latter item reflected the expectation that the company would continuously invest in its plant and equipment. This was a decidedly different strategic position than that of the Midland Chemical Company; the latter distributed its surplus (and probably some of its capital, given its nonexistent depreciation procedures) to its stockholders, rather than reinvesting in the firm.

This format, with various modifications, usually new measures of production efficiency (e.g., pounds of bleach per ampere day, apparent cost per ampere day, percentage of chlorin in escaping gas, etc.), continued in use until the merger with the Midland Company.

During the first two years of its operation the Dow Chemical Company struggled to achieve profitability. While within the plant this meant monitoring chlorine losses and the efficiency of traps and tanks (monitoring processes), discussions between Herbert Dow and Cleveland stockholders focused on the proximity of average costs, included in the weekly reports, to selling price (a proxy measure of Dow's effort and ability, as well as indicator of when the firm would cease to be a drain on the pocketbooks of its stockholders and instead fill them). For example, A. W. Smith, a large stockholder and Case Technical School chemistry professor writes,

> I was quite disappointed in the showing made, as I had hoped very much to hear by this time that the cost was below the selling price. It seems that this much desired state of affairs has never yet been reached. It is very essential, it seems to me, that every effort be made to bring this about at once, or we shall have a fine row on our hands with Mr. Convers [the Dow Chemical Company's president and largest stockholder] and Co. Just what is the cause of the large difference between your estimated output and that obtained? (30 April 1899, file 990003c, Dow Papers)

However, perhaps because of the lack of profitability, Dow does not include average selling price or average profits in the weekly report during this period. He prefers to emphasize their production of electric power at low costs or the

comparison is not strictly reliable, and as Mr. Post has a few minor items of expense, insurance for example, that are not included in the above, the exact cost would be a trifle greater than here shown. Depreciation would only be apparent to a small extent in the above figures" (24 October 1898, file 980014c, Dow Papers).

43. Maintenance charges were included in expenses "chargeable to manufacture." Amounts charged to "equipment" were strictly betterment and addition charges and were not included in the cost of product. The record gives no indication of how these distinctions were made during this period. However, at least after H. E. Hackenberg became secretary (in 1900), the company followed a "conservative" policy of charging to current manufacture everything but new plant and equipment. For further discussion of this, and the related question of depreciation policy, see Levenstein (1991, chap. 5).

high quality of the bleach, rather than the continued high cost of bleach or the declining selling price.[44]

In April 1900, after the departure of Cooper and Helman from the Midland and the installation of a former Dow employee as general manager, Midland began producing a weekly report similar to that at the Dow Company (fig. 3.6). It provided information on both physical consumption of inputs (e.g., "potash used," "fuel used"), output (e.g., "pounds potassium bromide made"), inventories ("pounds potassium bromide in stock"), shipments ("pounds potassium bromide shipped"), and the division of the week's expenditures between operations ("chargeable to manufacture") and betterments and additions. It also included data on the operation and efficiency of the brine wells. Two measures of efficiency, one technical and one financial, were included. They were "pounds bromide per 1000 lbs. brine" and "apparent cost per pound."[45]

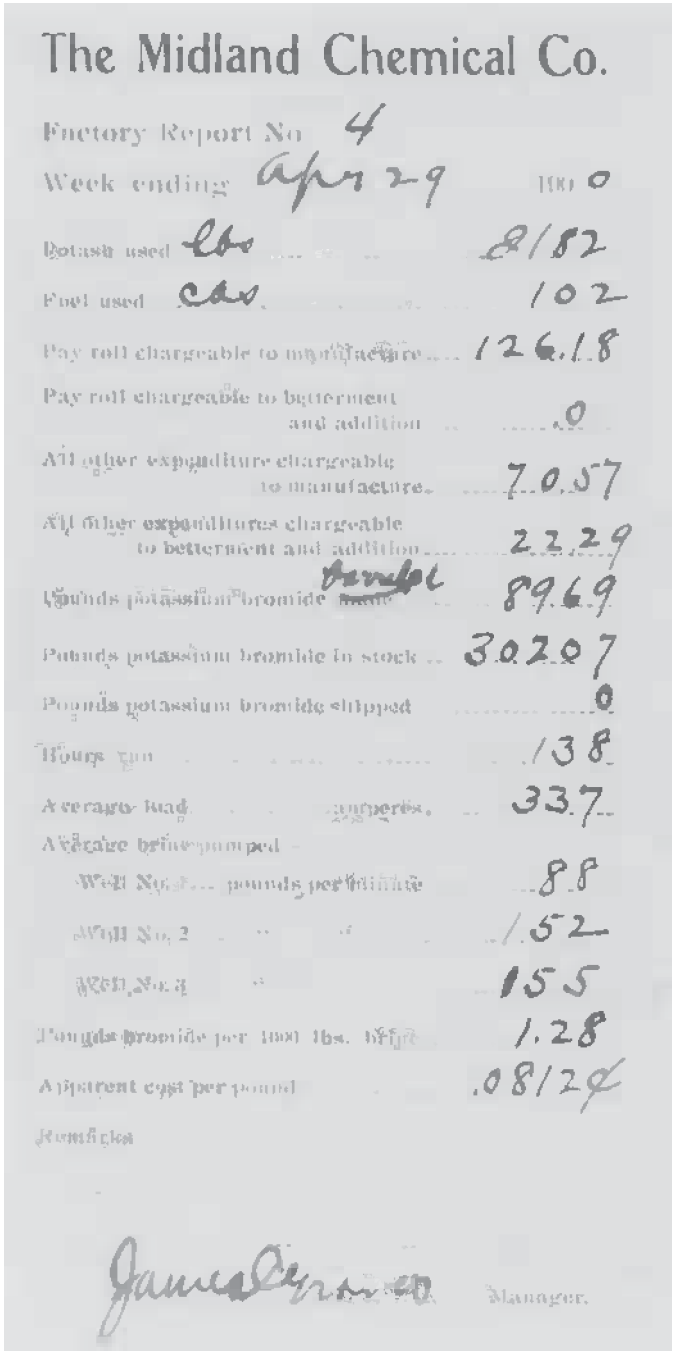
This was the first time that Midland's report systematically distinguished between expenditures on contemporaneous production and expenditures on plant and equipment. This reflected a change in the investment posture of the company. While during Helman's tenure all profits were distributed to stockholders, after Dow became president, the company accepted, at least in principle (it did not remain independent long enough to establish any practice), the notion that a portion of income would be retained and reinvested. In fact, the lack of any depreciation charges during Helman's tenure suggests the possibility that, in addition to consuming the profits of the company, the shareholders were also consuming its capital.

It was also at this juncture that monthly financial reports, including an income statement, were produced for the first time (fig. 3.7). Helman had produced his balance sheet statements only on an annual, and occasionally semiannual, basis. Hackenberg, the new treasurer, had prepared a printed form for the new report, insuring greater regularity in the items included and in its general organization. These changes probably reflect Hackenberg's greater familiarity with professional accounting procedures. That is to say, the demand for this change appears not to have been managerial, but rather to have arisen from a desire to have the account books follow convention.[46] However, particularly after the merger of the Midland and Dow companies, monthly income figures were used for both monitoring for effort and long-term planning.

44. See letters from H. H. Dow to J. H. Osborn, 29 November 1898, file 980013c, and 1 February 1899, file 990009c, Dow Papers.

45. An amount was entered for the latter item only three times during the twenty-five weeks that the form was produced. Problems measuring gaseous bromine apparently created difficulties in measuring output accurately on a weekly basis. Because estimates of the amount of gaseous bromine contained in the "bromine towers" were necessary to calculate average cost, the form refers to that measure as "*apparent* cost per pound."

46. The firm increased its capitalization from $100,000 to $300,000 following these changes in the accounting system. Correspondence indicates that management felt that having more standardized accounting procedures would facilitate its access to capital markets.



The Midland Chemical Co.

Factory Report No 4

Week ending Apr 29 1900

Potash used lbs	8182
Fuel used cds	102
Pay roll chargeable to manufacture	126.18
Pay roll chargeable to betterment and addition	0
All other expenditure chargeable to manufacture	70.57
All other expenditures chargeable to betterment and addition	22.29
Pounds potassium bromide made (bromide)	8969
Pounds potassium bromide in stock	30207
Pounds potassium bromide shipped	0
Hours run	138
Average load amperes	337
Average brine pumped	
Well No 1 pounds per minute	88
Well No 2	152
Well No 3	155
Pounds bromide per 1000 lbs. brine	1.28
Apparent cost per pound	.0812¢

Remarks

James Graves Manager.

Fig. 3.6 General manager James Graves's weekly report, Midland Chemical Company, 1900

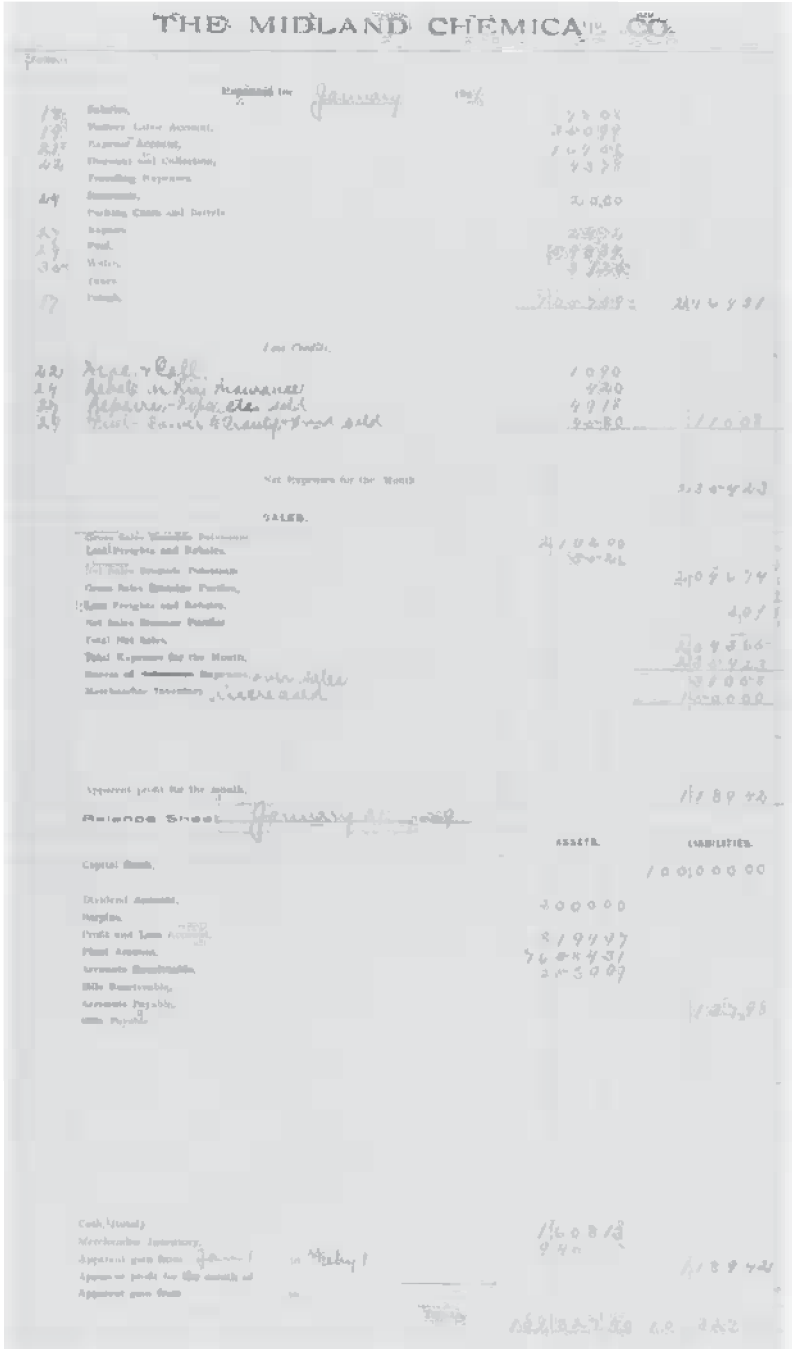


Fig. 3.7 Monthly financial statement, Midland Chemical Company, 1898–1900

Thus we observe that, with the adoption of a more innovative strategic posture by the Midland and Dow companies, demands for new forms of information, designed to fill new functions, were created. The first systematic production of data on the internal operations of the firm focused on monitoring processes and monitoring production workers for effort. Those data were then used, sometimes in a modified form (i.e., input costs were aggregated to produce a measure of average cost), for monitoring plant management for effort and ability and, by plant management, for short-term planning.

3.5.4 Stage 4: Information in the Multiproduct Firm

The systematic production and use of data in management accelerated after the merger of the Midland and Dow companies. The new firm was substantially larger (capitalized at over a million dollars). Immediately following the merger it increased its capacity considerably by constructing a second bleach plant, a much improved new bromide plant, and a new electric power plant. It also began experimenting with the addition of a third product, sulphur chloride. While Dow was somewhat notorious for his "hands on" approach to management of the growing firm, the increasing number of reports and growing references to the data included in both minutes of daily meetings of plant management and correspondence with Cleveland indicate the new uses made of such information.

After the merger in 1900, the company faced, for the first time, the difficulties in measuring cost in a multiproduct firm. Its initial response was to change little in how bromides and bleach costs were calculated. Where joint costs had to be divided, it relied on the firm's own history as its guide. As the number of products of the firm increased, this response became inadequate, and new methods were adopted. The firm also began to produce more disaggregated measures of cost that reported average input costs for particular inputs (e.g., lime cost per pound of bleach, packaging cost per pound of bleach, etc.) that were product-specific.

The information system continued and increased the production of physical measures of quality and efficiency. These measures were produced primarily for use by plant management to monitor processes and make short-term planning decisions, but summary data (i.e., more aggregated data) were also provided to the firm's board of directors on a regular basis, allowing them to monitor effort and ability on the part of plant management.

The Midland Chemical Company's practice of monthly financial statements was adopted. More detailed monthly income statements for each chemical were also produced. The system of monthly reports was adapted, in steps, to provide management, particularly at the level of the board of directors, with data that would allow it to allocate capital resources among the various products on which research was conducted at Midland (i.e., to aid in long-term planning).

3.5.4.1 The Weekly Report: Timeliness Trade-offs

A new weekly report, introduced immediately following the merger, simply combined the two reports of the original firms (figs. 3.5 and 3.6). This continued to include both financial and technical data and was distributed to members of the board of directors as well as Dow and Graves at the Midland plant. However, partly because the production of financial data occurred with a lengthier delay, and partly because financial and technical data were made accessible to different members of plant management, several modifications were shortly made in the regular report forms.

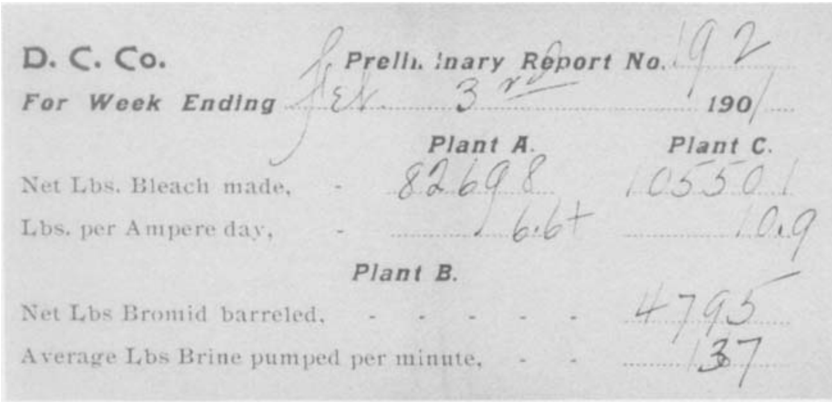
In October 1900, a new "preliminary" report form was introduced, in response to complaints, mostly from the treasurer Charles Post, that the lengthier weekly report was not being produced promptly (fig. 3.8).[47] The new report was printed on one-inch-by-three-inch card stock.[48] It reported only net pounds of bleach made and "Lbs. [bleach] per Ampere day" (a measure of technical efficiency) for both plants A and C (the bleach plants) and net pounds bromide barreled and "averaged Lbs Brine pumped per minute" (also a measure of technical efficiency) for plant B (the bromide plant). Several copies were made each week and sent to members of the board of directors. These physical measures of output and efficiency, regularly used by plant management in monitoring the production process, were available essentially instantaneously. Monetary data were available only with a delay.

3.5.4.2 Monthly Cost and Efficiency Reports

The firm continued to produce the data that had previously been included in the general manager's weekly report. It was now divided among several differ-

47. Post wrote to Dow, "Can you arrange to have the weekly reports sent in more regularly? I have frequent inquiries from the stockholders here, and it will be a great favor to me if the report for the previous week could be here as early as Wednesday. As you know, they are sometimes a week or more late, and if I could say to those inquiring that the report will be in on Wednesday, it would be a great convenience to us all" (27 April 1900, file 000012c, Dow Papers). Dow responded, "We can arrange to send you the output for each week on the following Monday morning, and by increasing our office force we could get a complete report out by Wednesday, but in that case there would not be enough work to keep them busy the balance of the week. As it is now our office force is of such size that we can get the reports of one week out of the way before the reports of the next one come in, but are not able to do much better than that. Under the present arrangement you see it would be impossible to promise the reports before Saturday afternoon, and they will not reach you until Monday morning" (30 April 1900, file 000012c). Post wrote back, "Your letter in regard to statement received yesterday. If [*sic*] course, it is not contemplated that you should increase the office force at present, but I was not aware that that would be necessary in order to get the statement in the following week, as you have sometimes sent them more promptly than you have been doing recently. However, if you could send me a short statement, giving the production for the week, amount sold, and price received, that would answer every purpose until your clerk would have time to make a complete statement" (2 May 1900, file 000012c). See file 010070 for samples of the new report. See file 000005 for the first nine weeks of the new report series.

48. The first nine weeks of the report were typed on half-size sheets of paper. See file 000005, Dow Papers.



D. C. Co. Preliminary Report No. [illegible]

For Week Ending [illegible] 190[illegible]

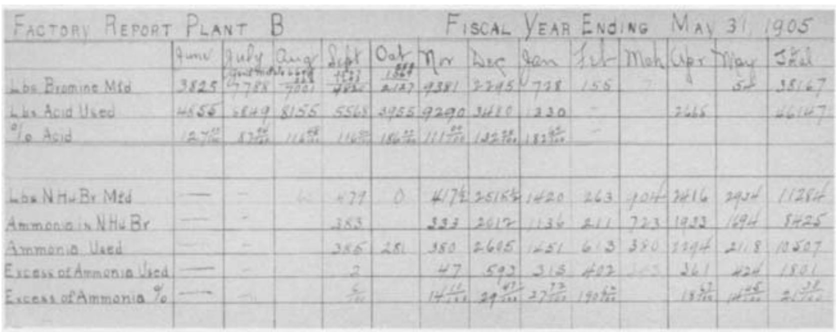
	Plant A.	Plant C.
Net Lbs. Bleach made,	82698	105501
Lbs. per Ampere day,	16.6+	10.9

Plant B.

Net Lbs Bromid barreled, - - - - - - 4795

Average Lbs Brine pumped per minute, - - 137

Fig. 3.8 Preliminary weekly report, Dow Chemical Company, 1900–?



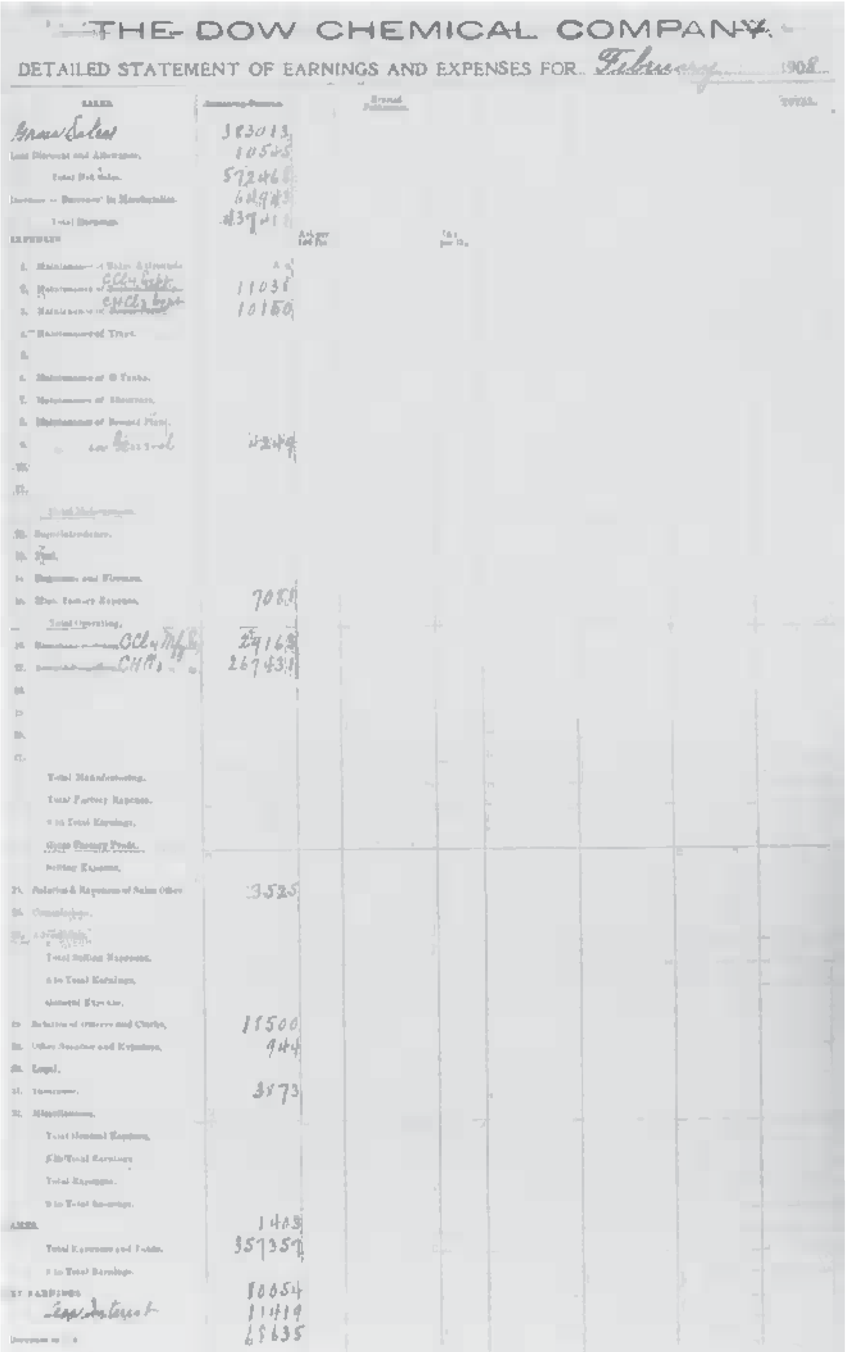
FACTORY REPORT PLANT B FISCAL YEAR ENDING MAY 31 1905

	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mch	Apr	May	Total
Lbs Bromine Mfd	3825	7788	7001	[illegible]	2187	4381	2245	728	155			52	35167
Lbs Acid Used	4656	5849	8155	5568	3955	9290	3410	230	–		2665		46147
% Acid	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	–				
Lbs NH4Br Mfd	—	–	[illegible]	477	0	417½	2516¾	1420	263	904	2816	2934	11284
Ammonia in NH4Br	—	–		383		333	2017	1136	211	723	1933	1694	8425
Ammonia Used	—	–		385	281	350	2605	1451	613	380	2294	2118	10507
Excess of Ammonia Used	—	–		2		47	592	315	402	[illegible]	361	424	1801
Excess of Ammonia %	—	–		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]

Fig. 3.9 Monthly factory report, Dow Chemical Company, 1902?–1914?

ent monthly reports, each of which had a somewhat different focus and audience. The monthly "factory report" (fig. 3.9) is one of several reports that were regularly produced, primarily for use by plant managers, that focused on technical and quality considerations. The report shown here gives technical data on the Midland bromide plant's production of liquid bromine and ammonium bromide, two of the newer products of the firm. Quality control became increasingly important as Dow Chemical integrated forward and was faced with a more competitive environment. The purity of Dow bromides increased from about 80 percent at the time of the merger to 99 percent in 1903. This gave it access to the European market, which had a very restrictive pharmacopoeia. It also allowed it to support an increase in the U.S. pharmacopoeia, which it could satisfy and its less diligent domestic competitors could not.

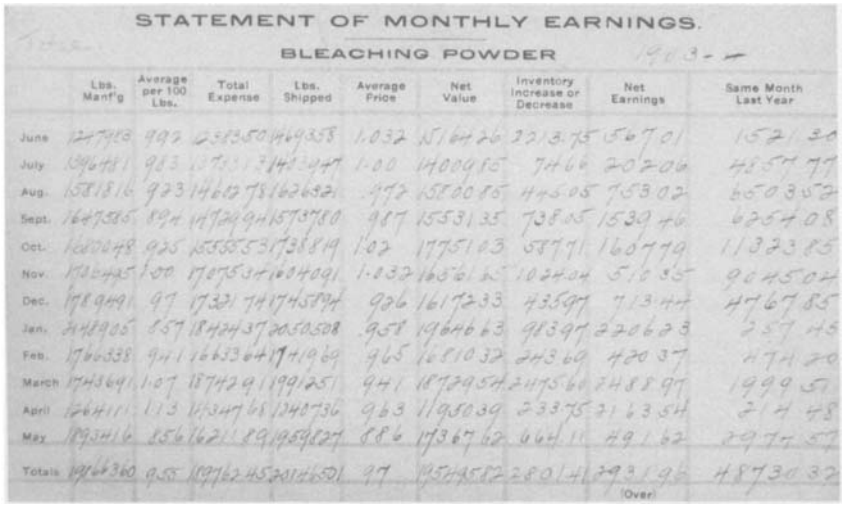
Average cost measures were included in several different reports, including the monthly financial statements (fig. 3.10), the "statement of monthly earn-



THE DOW CHEMICAL COMPANY

DETAILED STATEMENT OF EARNINGS AND EXPENSES FOR February 1908

Fig. 3.10 Detailed statement of earning sand expenses, Dow Chemical Company, 1900?–1907?



STATEMENT OF MONTHLY EARNINGS.

BLEACHING POWDER

	Lbs. Manf'g	Average per 100 Lbs.	Total Expense	Lbs. Shipped	Average Price	Net Value	Inventory Increase or Decrease	Net Earnings	Same Month Last Year
June									
July									
Aug.									
Sept.									
Oct.									
Nov.									
Dec.									
Jan.									
Feb.									
March									
April									
May									
Totals									

Over

Fig. 3.11 Statement of monthly earnings, Dow Chemical Company, 1902–10

ings" prepared for each product (fig. 3.11), and detailed (i.e., disaggregated) cost reports for each product.[49] The primary use of the average cost measure was still to give the stockholders in Cleveland a simple way of monitoring the effort and ability of management in Midland and comparing that performance over time. It was not used regularly by plant management to identify inefficiencies (i.e., to monitor processes), or in other ways that would directly inform short-term planning decisions about operations.

This is partly because cost data were not produced in as timely a fashion as other nonfinancial measures of production efficiency. Hence, pounds per ampere day could be reported on the preliminary report, as it was calculated regularly for in-plant use, while average costs took longer to compute. When average costs were computed on a weekly basis, the weekly reports frequently fell behind. Even after monthly reports were introduced, it was not uncommon for the reports to be late. For example, a report comparing the efficiency of the Mount Pleasant and Midland bromide plants stated, "Owing to extra work in Mr. Bennett's department the monthly production statements and balance sheets for bromine and carbonate are several months behind. . . . Mr. Bennett hopes to have his statements brought down to date within two or three weeks, and we should then be able to finally check the logic of the above reasoning" (Statement on Bromine Losses, 28 September 1905, file 050034x, Dow Papers).

49. The form reproduced in figure 3.10 was originally designed for use by the Dow Chemical Company but later modified for use by a second Midland Chemical Company, whose primary products were chloroform and carbon tetrachloride. Only forms that have been so modified are still in existence. Hence the handwritten changes in some of the items on the form.

For these and other reasons, monetary measures played a secondary role in both short-term planning and monitoring processes at the plant. In 1908 Herbert Dow compared the relative usefulness of bookkeeping and "factory efficiency methods" for informing plant-level planning and sided heavily with the latter.

> Successful manufacture, as I see it, consists in having all the operations run right practically all the while, and in order that this may be so it is necessary that when one step goes wrong it shall be detected and remedied immediately and to do so requires a means of control that is continually at work. For example, we analyze the brine in our bromide plant every half hour to make sure that the current and brine are proportionate to each other so that the maximum output is obtained. For example, there are probably a thousand places where the cost of Bleach might be increased. It would be absolutely impossible to devise a book-keeping system that would detect where the error was, and a system that would subdivide bleach charges so that in case the cost were too high it could be located a little closer than it can at present, would undoubtedly be some advantage but the advantage would be so slight that in actual commercial work it would not be worth while. (To H. E. Hackenberg, 31 August 1908, file 080015x, Dow Papers)

Another reason these measures of cost per pound were not used in short-term planning is that the data were not given to managers of individual plants. The only plant management that had access to these data were Dow; Graves, the general superintendent; and Bennett, the bookkeeper and assistant treasurer. Despite recognizing the benefits that might arise from giving these managers this information, it was decided that the risk of competitors obtaining this information was too great to permit its wider dissemination.[50]

This measure was used to monitor the effort (and therefore provide incentives to) of plant managers. Plant managers were aware of this and of the general method used to calculate costs. This appears to have been sufficient to influence their behavior without their observing the numbers produced by the information system. In at least one case a bromide plant manager specifically asked that he be given data on the costs of his plant, and that they be systematically compared with those of the other bromide plant.[51] In another case a plant superintendent asked that the charges for power consumption to his plant be reduced and charged to another plant, because he was not receiving power at the rate desired.[52]

50. See letters from H. E. Hackenberg to H. H. Dow, 25 May 1905, file 050014x; A. E. Convers to H. H. Dow, 22 May 1905, file 050011c; H. H. Dow to A. E. Convers, 24 May 1905, file 050011x; A. E. Convers to H. H. Dow, 31 May 1905, file 050011x; and H. H. Dow to A. E. Convers, 2 June 1905, file 050011x, Dow Papers.

51. See letter from Shepherd, superintendent of the Mount Pleasant bromide plant, to H. H. Dow, 21 March 1907, file 070052c, Dow Papers.

52. See letter from C. W. Jones, superintendent of the bromide plant, to H. H. Dow, 26 September 1912: "For the past few weeks the extraction of B plant [the Midland bromide plant] has not averaged quite 90%. At least another 5% might have been extracted had we gotten the desired

The use of this measure as a monitor for Herbert Dow was sufficient under ordinary circumstances. However, when the firm's finances reached crisis proportions in 1903, due to a fall in the price of bleach simultaneous with large expansion by the Dow Company, the board of directors demanded much more timely and more disaggregated information that would allow them to directly intervene in decisions that had previously been left to Dow.

Thus in August 1903 the executive committee of the board of directors requested the production of a weekly report on the firm's cash position.[53] The report, which continued to be produced for at least two years, included cash received and disbursed, cash on hand (or overdraft), sales of bleach and bromides, accounts receivable, and accounts payable.

The board was also given, from January 1902 to September 1903, a breakdown of cost per pound for bleach into all of the component accounts to which current expenses were charged. This allowed them to monitor Herbert Dow's decisions on a more detailed basis. These data were produced before and after this period, but only for the information of Dow and Graves.[54]

Thus, during this period the quantity and types of information systematically collected about internal operations continued to increase. In general, though there were exceptions, management relied on nonmonetary data for monitoring processes and making short-term planning decisions. Monetary measures were more frequently used for monitoring people for effort; the board of directors usually relied on highly aggregated measures to monitor Herbert Dow. More disaggregated monetary measures were used to monitor managers farther down in the firm hierarchy. Finally, as discussed below, as

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current, as we used to get. We have been getting a good supply of brine, but have not gotten sufficient current to handle it. The trouble seems to be due to favoring the caustic and chlorine plants. Since the maintenance of wells and cost of pumping brine is charged up to the Bromide plant, we are paying something that we are not permitted to use. We request that if it is not deemed expedient to give B plant the desired current, that a charge be made against the caustic and chlorine plants in favor of B plant, proportionate to the amount of loss we are forced to suffer; that is, a certain percent of the cost of maintenance of wells and pumping of brine be charged to caustic and chlorine plants" (file 120008x, Dow Papers). This is the first indication that I have seen of the costs measured by the accounting system being an issue of tension between the managers of the different areas.

53. See letter from H. E. Hackenberg to H. H. Dow, 5 August 1903, informing him that the executive committee would like to review all bills before payment and requesting that he send them "weekly all the information that you can give them of any kind relating to the business of the company. I have written Mr. Bennett to prepare a statement such as is contemplated" (file 030028c, Dow Papers). The only existing copy of this report is dated 11 March 1905, file 050045x.

54. See letter from Bennett, the bookkeeper, to Hackenberg, the secretary of the company, discussing the audit report by Haskins and Sells, 11 July 1905: "The information contained in Exhibit B. schedule No. 1 has practically been compiled in this same form in our office here for the past several years for the benefit of the General Manager and the Superintendent, who, of course, wish to know the cost of all raw materials etc. I believe that the President and Secretary both stated that such details should not be laid before them except as they cared to investigate the records from time to time in this office. I am forwarding these records as they may be some help if a new classification is desired" (file 050061x, Dow Papers).

the firm became more multiproduct, new informational forms were developed to aid in long-term planning.

3.5.4.3 Measuring Profits by Product

The most significant change in the accounting system following the merger was the production of data that allowed the board of directors to compare the profitability of its products. The computation of average profit for each product seems to have played an important role in shaping thinking about the relative profitability of different products and the allocation of capital to the production of various products (i.e., long-term planning). Changes were made in the method of calculating average profits for each product in 1905 and 1909. Each of the changes was designed to recognize the increasing multiproductness of the firm.

At no point during this period do we see the regular compilation of rates of profit on different lines of product that Chandler (1977) and Johnson (1975) have argued are the culmination of the development of accounting in the multiproduct firm.

The new monthly financial statement (balance sheet and income statements) also included a report entitled "Detailed Statement of Earnings and Expenses" (fig. 3.10). In this report, the firms expenditures were divided between bleach and bromides. Product expenditures were then reported as a percentage of gross earnings. Net earnings (i.e., profits) for each product are reported. Similar data were included, along with nonmonetary data, on the "Statement of Monthly Earnings" prepared for each product (fig. 3.11). The latter report shows manufacturing profit, while the former gives profits net of sales and general expense.

The production of these measures required that the firm divide the expenses of the firm between these two products. As might be expected, the division chosen reflected the historical evolution of the company. The maintenance of wells, for example, which had been the property of the Midland Chemical Company, was charged entirely to bromides. When the companies were separate, the Midland had provided debrominated brine to the bleach company at no cost, and even after the merger the capacity of the bromide plant did not constrain the capacity of the bleach plant (i.e., debrominated brine was not scarce), so bromides were charged with the entire cost of producing the raw brine. On the other hand, the maintenance of the electric power plant, built by the Dow Chemical Company, was charged primarily to the cost of bleach, though an estimated charge, based on the estimated output of the bromide plant, was charged to the cost of bromides, and credited to bleach. Note that both these charges were maintenance charges. The firm did not include any allocated fixed or depreciation costs in its cost of product, even when it was advised to do so by outside auditors.[55]

55. See Levenstein (1991, chap. 5) for a more detailed discussion of the Haskins and Sells report and the response of Dow management to it.

The use of these historically based divisions became problematic, however, as the number of products of the firm increased. These procedures were changed as a result of the recommendations of the 1905 audit by Haskins and Sells.[56] It had previously been the practice of the company to produce measures of product cost for bleach and bromides, as described above, on a regular basis. By 1905, however, these were not the only products of the company. The company sold electricity and water to the City of Midland and to other Midland firms. More importantly, an increasingly larger fraction of its output of chlorine was not consumed as bleach. Instead chlorine itself was sold to other firms that had built plants adjacent to the Dow Chemical Company for that purpose. These included the Midland (II) Chemical Company, which manufactured chloroform and carbon tetrachloride, and the Merck Company.[57] The Dow Company would itself use chlorine to produce a wide range of products over the next ten years. The accounting system at Dow treated the income from these various sales of power and chlorine as credits to the cost of producing bleach. No attempt was made to determine the cost incurred or profit earned on these transactions. While this allowed the firm to avoid the inherent arbitrariness involved in the allocation of joint costs, it also made it more difficult to evaluate the profitability of new products as they were introduced.

The Haskins and Sells 1905 report recommended creating separate accounts to credit receipts for sale of chlorine, electricity, water, and so forth, rather than simply crediting them to the cost of bleach.

> Certain accounts affecting the cost of product were found to be credited with the amount received for sale of electric current and other services. The materials and supplies inventory accounts were also found credited with the selling price of materials sold at a profit. These accounts were adjusted to eliminate the credit representing such element of profit, and the amounts for sale of electric current and water service from the operating plant are stated in Exhibit "B" as sales. (20 June 1905, p. 4, file 050061x, Dow Papers)

When this change was made, it led to problems in interpreting the cost of bleach figures that were produced later, as, absent these credits, bleach appeared more expensive.[58] The total profits earned by the company in the joint production of bleach and power were, of course, unchanged.

Haskins and Sells also recommended creating separate accounts to which

56. 20 June 1905, file 050061x, Dow Papers.

57. The Midland (II) Chemical Company was formed in 1902 by Herbert Dow, A. W. Smith, and W. O. Quayle. After several years of less than successful operation, its entire facilities were leased to the Dow Chemical Company in 1908. The Midland (II) Company was purchased by the Dow Company in 1914.

58. See letters from H. H. Dow to A. E. Convers, 31 October 1905, file 050012c; C. A. Post to H. H. Dow, 1 November 1905, file 050021x; H. H. Dow to C. A. Post, 3 November 1905, file 050021x; C. A. Post to H. H. Dow, 6 November 1905, file 050021x; and H. H. Dow to C. A. Post, 14 November 1905, file 050021x, Dow Papers.

to charge the cost of producing water and power sold to the city, and so forth, so that an estimate of the profit on these transactions could be made: "It is suggested that the maintenance of properties not employed in manufacturing be charged to separate maintenance accounts from those applicable to cost of production, so that the cost of maintaining such properties can be applied against the rental received therefrom" (20 June 1905, p. 5, file 050061x, Dow Papers). While this change led to confusion and difficulty in the short run, it highlighted the increasing profits that the firm was earning from chlorine consumed in other forms besides bleach.

Bennett's initial response to this proposal to set up separate accounts for each product varied depending on the importance of the product in the overall strategy of the Dow Chemical Company.

> I believe our method of handling the credit of sales with possibly the exception of the sales of Chlorin gas while probably not correct from a strict accounting standpoint has been correct inasmuch as the business is conducted only for the manufacture of Bleaching Powder and Bromides, and these credits have only been used to obtain the correct cost of Bleaching Powder and Bromides, and the profit contained in these credits is small in comparison to the total amount. (Letter from E. W. Bennett to H. E. Hackenberg, 11 July 1905, file 050061x, Dow Papers)

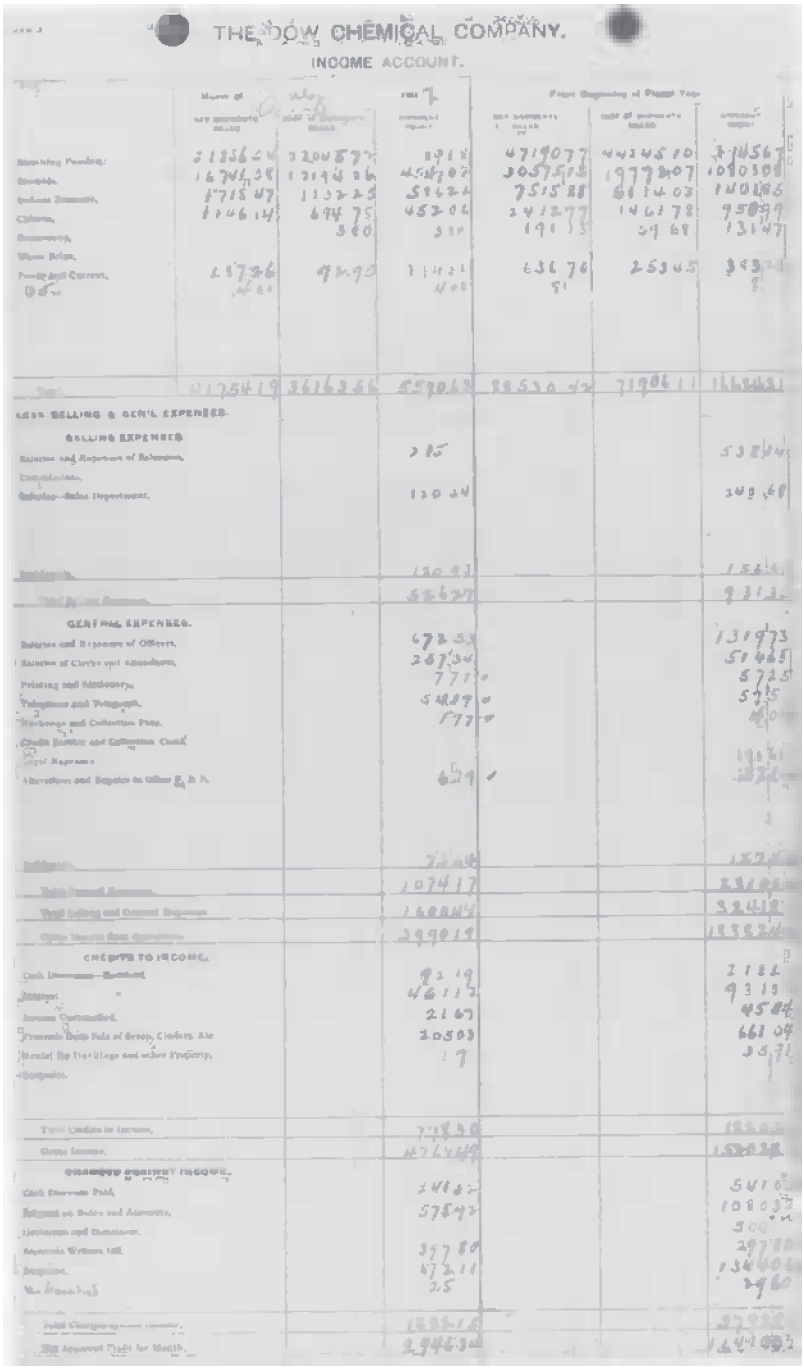
Despite Bennett's reservations, the existing records indicate that the company did decide to treat all items sold symmetrically, showing a separate profit for each item (fig. 3.12). The problem of allocating joint costs was not easily solved, however. Herbert Dow wrote to A. E. Convers, H. E. Hackenberg, and C. A. Post explaining the new method of computation of costs, and the difficulties arising therefrom.

> So far we have been unable to find a satisfactory system for separating the cost of chlorine sold Mr. Quayle and electric light sold the city. On this account, the cost was charged in with the Bleaching Powder, and the total receipts from Chlorine and electricity therefore stand, at the present time, entirely as profit. This system, of course, is just as bad as the old one, in which the profits stood as a credit to expense, but it is now in such shape that by another month we can probably show it as an independent item of profit. (31 October 1905, file 050012x, Dow Papers)

The problem was solved for the time being, but arose repeatedly as new products were added.[59] These difficulties were exacerbated when the company in-

59. Three years later Herbert Dow was still writing to Cleveland to explain the difficulties in dividing up joint costs among the increasing number of products.

> What has brought this matter up is a more or less exhaustive investigation of last month's run of the benzoate plant. In carrying this work out we find there is no one here who has a sufficient combination of chemical and book-keeping knowledge to be sure that the results obtained represent the actual conditions, (and if we wished to be extremely particular, we might say that strictly accurate accounting in this case is an absolute impossibility). In the benzoate plant there are a number of steps in the process and these steps are not so clear cut and well defined that


THE DOW CHEMICAL COMPANY.

INCOME ACCOUNT.

Fig. 3.12 Monthly financial statement, income account, Dow Chemical Company, 1907–13

troduced a new electrolytic cell in 1913 that jointly produced chlorine and caustic soda.[60] They were apparently outweighed by the information made available for an increasing number of products. The importance of this decision to calculate separately the cost of chlorine and other chlorine products is highlighted by the company's decision, in 1913, to withdraw from the bleach business and use all of its chlorine output to make higher-value products.[61]

Further changes in the costing system were made in 1909. The content of the changes in 1909 is not as clear from the record, but the purpose is. To a meeting of plant management on 30 July 1909, "Bennett stated briefly reasons for the change in system being necessary, principally because of the sale of a more extended line of products, which line is growing. The old system was not satisfactorily adaptable to even the present business, whereas present system has already shown our old idea as to cost of chlorine wrong. Present system is adaptable to increased line of manufacture" (Minutes Book of daily plant meetings).

Simultaneous with these changes a new set of monthly reports was introduced that highlighted the net earnings and price-cost margin (the difference between "Av. Price Received" and measures of "Average Cost") of each product (fig. 3.13). These reports were discussed at monthly meetings of the board of directors and were used to evaluate the success of both new and old product lines. The use of price-cost margins and net income, compared only informally to expected incremental investment, to inform long-term planning capital allocation decisions, continued throughout the period under study.

3.6 Conclusion

From 1892 to 1898 the Midland Chemical Company kept a very sparse set of records that did not much resemble standard accounting practice. The fi-

they can be isolated one from the other without introducing complications that would not seem advisable.

For example, Plant E is shut down. The benzoate plant derives steam from Plant E, as does one water works. During the time that Plant E is shut down nearly a full crew of firemen is employed and a big boiler and more or less big pipe kept hot with attendant losses. If it were not for the benzoate plant we would probably shut down plant E and get our water supply entirely from the other station. We are not sure of this fact, however, as the forcing of the pumps at the other station might not be satisfactory in every respect. During frosty weather it would be necessary to keep a boiler in Plant E running. Under these circumstances should the benzoate plant be charged an extra price for steam during the time that Plant E is not running?

If so, the rule would apply in a number of other cases and some of them are much more involved and complicated than this case. (H. H. Dow to H. E. Hackenberg, 31 August 1908, file 080015x, Dow Papers)

This suggests that, contrary to traditional accounting history, and similarly to Johnson and Kaplan's (1987) argument, firms in this period had a clearer notion of avoidable and incremental costs than did the accountants of the day.

60. Chlorine-caustic cells, though of a different design, had been in use at Niagara Falls since 1897 (Trescott 1981).

61. They continued to produce bleach for several years, however, selling to their established customers.

BLEACHING POWDER
MONTH OF APRIL 1912.

COMPARISON:

	April 1912	March 1912	April 1911
Net Earnings	1,329.56	1,507.10	2,563.49
Lbs. Shipped	1,995,446	1,909,181	1,537,630
Av.Price Received	1.246	1.25	1.25
Av. Total Cost	1.31	1.17	1.40
Lbs. Finished	2,050,554	1,842,505	1,460,493
Av. Factory Cost	1.19	1.08	1.35

Selling price normal.

Average factory cost abnormally high, partly due to high cost of lime. This was probably due to enormous stock of lime on hand in process, preventing securing of a correct inventory of the lime.

Package cost also high.

High total chlorine content in Bleaching Powder also increased the cost of chlorine per 100 lbs. of Bleach.

Auditor.

May 11th, 1912.

Fig. 3.13 Monthly product report, Dow Chemical Company, 1910–13?

nancial reports of the company were produced annually, or sometimes semiannually, but certainly not with enough frequency to be used as aids in management. That the irregular arrangement of these accounts prevented them from being used even as an aid to potential stockholders is indicated by Hackenberg's having them rewritten prior to an increase in capitalization and subsequent merger with the Dow Chemical Company.

I presume that I now have all the bills and books, etc. of the Company from its organization, and while I have not had time to more than casually look

> through the books, a system of accounts has evidently been employed at variance with anything in my experience of fifteen years, and I think it quite important to get the expert at work to write up a new set from the beginning, as soon as possible, especially in view of our intention to increase the Capital Stock to $300,000.00. (Letter from H. E. Hackenberg to H. S. Cooper, 18 January 1899, file 990047x, Dow Papers)

With Hackenberg's arrival in 1898, the accounts were kept with greater care and in a fashion comprehensible to others. Perhaps more importantly for our purposes, he instituted the production of monthly financial reports. This practice was adopted at the Dow Chemical Company when he became its secretary in 1900. These reports were used both by Herbert Dow and the board of directors to monitor effort by plant management.

Meanwhile, Herbert Dow, first at the Dow Process Company and then at the Dow Chemical Company, was experimenting with the use of reporting procedures such as daily job cards and weekly reports on factory efficiency, measured both in terms of physical consumption of inputs and their dollar cost. The former provided information that was used to monitor employee effort and make short-term planning decisions regarding plant operations.

After the merger of the Dow and Midland Chemical companies, the information system continued to be adapted to provide very frequent technical measures of quality and production efficiency, for use in monitoring processes and short-term planning, somewhat less frequent monetary measures, primarily used to monitor people for effort, and measures, even less frequent but still quite regular, of net profit on an increasing number of products, used somewhat informally to make long-term planning decisions.

While many factors influenced the firm's decisions regarding the collection and calculation of cost data, including the recommendations of professional auditors, the most important determinants were changes in firm strategy and the organization of the markets in which the firms' products were distributed. The firm's accounting records evolved during this period from a fairly haphazard affair, used rarely in the management of the firm, to a complex system that produced daily, weekly, and monthly reports used actively by both plant management and the board of directors to monitor plant managers and make long-term capital allocation decisions. As the firm evolved from one that produced only one product and sold it in cartelized market to one that produced many joint products sold in increasingly competitive markets, the demands on the information system changed. The modifications of the information system instituted by management seem to have responded well, if not always smoothly, to these new demands. Some of these modifications reflect movement toward modern standard accounting procedures, and some are quite distinct.

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Comment Barry Supple

Margaret Levenstein's paper raises a number of issues the importance of which is relevant to both company biography (in this case the early history of Dow Chemical) and more general themes (notably the symbiotic relation between accounting systems and management control on the one hand and markets and management strategies on the other).

The presentation of my comments on her paper may be helped if it is introduced by my own summary of what I take to be its highlights—which, at the least, will expose the degree to which I have grasped, or (it may well be) misunderstood, Levenstein's argument.

The core of the paper is the contrast between two types of information systems, although occasionally the phrase has a rather grandiose ring, dealing as we are with a fairly primitive institution, rather threadbare archives, and sketchy pieces of paper.

In any event, the "systems" under discussion are identified with two firms, whose histories were closely interwoven and ultimately identified by merger.

The original firm, the Midland Chemical Company, founded in 1892, is seen by Levenstein as a noninnovative enterprise, dominated by the aspirations of its nontechnical owners, who restricted the activities and ambitions of its striving and ambitious founder, Herbert Dow. The firm's investors were apparently content with a "mercantile" system of accounts, that is, broad reports by the general manager on his cash situation and the overall cash flow of the firm. By the same token, there was little systematized information available that would have been relevant to the monitoring of plant management and performance (product costs and quality, efficiency, and profitability).

In the paper these lackadaisical procedures are related to the participation of Midland in a cartel (where sales were assured but limited) and to the resulting absence of any very strong incentive to control costs. This seems persua-

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sive as far as it goes, although it seems to me that it would also have been helpful if the paper had provided some critical appraisal of the implications of the scale of operations involved; after all, a Mickey Mouse business may not need any very elaborate communication networks, and in these years Midland was hardly a giant among enterprises. But, whatever the relevance of grandiose concepts, the board's attitude and constraints ultimately led to the resignation of the founder, Dow.

Second, and by way of contrast, Levenstein discusses the case of the Dow Chemical Company (founded by Dow after he left Midland). Dow Chemical, she argues, provided a different context for information systems, since it first of all pursued a much more vigorous policy of product and process innovation and diversification, and subsequently exemplified a more aggressive attitude to market expansion and competition.

Although the direction of the functional relationship is not always clear, these strategies were associated with the gradual extension of Dow's system of information flows. This involved the use of daily time cards to keep track of labor (and then to analyze costs over time) and the compilation of weekly reports enumerating the cost of different plant activities and measuring technical efficiency and product quality.

Meanwhile, in 1898 Herbert Dow had gained control of Midland, which (not surprisingly) adopted the practice of weekly financial and technical reports. Further, Midland's treasurer, H. E. Hackenberg, introduced a system of monthly financial reports.

In 1900 the two firms merged, with Hackenberg as secretary. Now the monthly reports he had devised at Midland were adopted at the new corporation, and reporting systems were amalgamated and developed, being used primarily to monitor plant activity.

At this point we encounter the other stem of Levenstein's argument: the adducing of statistical information was extended from the sphere of financial reporting for the benefit of shareholders interested primarily in final performance. Now it was also adapted to the management and plant needs of a multiproduct firm—including the need to measure the profitability of different products, albeit not with the regularity and overriding investment implications to which Chandler has drawn our attention.

At the same time, however, Levenstein makes the point that much of the financial/cost reporting was still for the benefit of the board of directors, whereas more "technical" reporting (that is, reports on physical efficiency, throughput, and quality) evolved as a tool for (plant) management—a logical and perhaps necessary step at a time when quality control was becoming more important competitively. She quotes Dow himself on the superiority of "factory efficiency methods" over financial bookkeeping, and points to the secrecy surrounding unit cost data (with intermediate management being denied access to it)—both points that seem to bear out Thomas Johnson's thesis (in chap. 2 in this volume).

In practice, however (and again exemplifying some of Johnson's general themes), problems and pitfalls emerged because of the conceptual and practical difficulties of allocating joint costs between different products, and receipts between different accounts. Levenstein makes the point that until 1905 internal accounting was confused in its treatment of the firm's multiple products, and she illustrates this at two levels.

First, the division of costs between bleach and bromides was a function of the historical organization of the company (with the result that the cost of producing some products and the pattern of costs as a whole were unknown or neglected). Second, when the firm diversified into the production and sale of electricity, water, and chlorine, income was credited to the cost of producing bleach, and "no attempt was made to determine the cost incurred or profit earned on these transactions." Consequently, the firm found it difficult to evaluate the profitability of new products.

I have gone into this point at length, because it seems to me to need more explication in terms of the main themes of the paper. Given that these procedures seem to reflect inadequate information systems, how does that square with the paper's other implied argument, that Dow Chemical's systems exemplified a sensitive response to the pressures of a multiproduct firm operating in a more competitive market? What, in the end, determines the quality of the information system adopted? Is there scope for innovation in such a system, and would we expect competition to produce the best possible system at any one time?

These questions are the more pertinent in view of the fact that from 1905 on, as a result of the auditors' report, receipts from the sale of the new products (chlorine, electricity, water) were credited to separate accounts, rather than to the cost of the bleach with which their production had been associated. Curiously, however, Levenstein makes the point that "this change . . . led to problems in interpreting the cost of bleach figures that were produced later," since they made it seem more expensive. Yet, on the surface, the procedure seems more rational and managerially helpful than the preceding system: allocating incomes and (because of an associated recommendation) costs more nearly where they originated. For in this way the profitability of different operations was more easily measured, although the "jointness" of production means that conceptual precision could not be perfect.

In any event, it would have been helpful to have been told a little more about these innovations in information systems—or, since the records are obviously imperfect, to have been provided with a more extensive discussion of possibilities.

What might have been the respective role of accountants and managers? How much of a handicap was the confusing of accounts and products when it came to attributing costs and incomes? How far is the intervention of the auditors (which appears to have achieved an improvement in accounting and information) consistent with Johnson's theory that the objectives and direc-

tives of auditors did not always produce the best information basis for management?

In many respects Levenstein's conclusions (implicit and explicit) seem inescapable: subtle physical measures are obviously more useful devices than cash flow data for assessing the performance of different production processes; a firm that does not need (or does not think it needs) to worry about competition and has a generous profit margin will be that much less concerned with close monitoring of its technical efficiency and product costs; multiple products and/or competitive markets and/or an ambition to expand aggressively will (like hanging) concentrate a man's mind wonderfully; accurate cost accounting is better management practice than imperfect cost accounting; a knowledge of the structure of costs and the performance of productive agents is a better basis for business enterprise than a simple knowledge of a single financial outcome for a multiplicity of activities; and the needs and concepts of auditors and accounts concerned with final outcomes are not necessarily the same as those of managers, although on this last point I sense some confusion in that in this instance the professionals' intervention appears to have been a step toward better and more relevant information.

Leaving this last point aside, however, what is still not entirely clear from the material in Levenstein's paper is the extent to which accounting and information flows were "functional" in the sense of arising more or less directly and inescapably from the managerial needs of the business. Obviously, they were not purely so; first, because some of them appear to have been imposed by accountants whose perspective was different from that of managers; second, because innovation and diffusion depended on the outlook and abilities of individual managers; and third, because it is inconceivable that at any one point in time the content and flow of management information are as perfect as they might be—that is, it is obviously possible to envisage an as yet undevised or unapplied improvement, in which case business could perform at a level superior to the current one, and information (or any other) systems that might be generated by current "needs" are not being so produced.

And yet, this paper does on the whole give the impression that what happened was predetermined—the product of need—in the sense that there was a close fit between information and the market situation and strategy that it served.

I appreciate that this is a little unfair to Levenstein in that she does not claim that Midland performed optimally with the data it generated (i.e., it is possible to envisage a more efficient and profitable use of resources facilitated by better information, so that the spatchcock system used imposed its own obvious handicaps in terms of opportunities forgone).

Nevertheless, the tone of the argument is set by Levenstein's somewhat strained references to the relationship between changes in markets and firm strategy, shifts in the demand for information, and the evolution of information systems, and by her claim that, in modifying the information system,

management responded well to the new demands of the competitive sale of joint products.

The potential vulnerability of the general argument is exposed by the paper's conclusion, which does little more than highlight the principal narrative facts and associate them with some not particularly subtle concepts (distinctions between information used to monitor employee effort, to make short-term planning decisions, to monitor processes, etc.) and some analytical generalizations about the presumed role of strategy and markets in shaping information systems. The trouble, of course, is that we are here dealing with such a simple level of business organization and such a restrained degree of development that there seems to be a disconcerting contrast between the simplicity of the material and the apparent sophistication of the analysis.

Part of the problem is that so many of the potentially broader implications of the argument are left to be deduced by each reader from the paper itself. Indeed, it is precisely because there is so little apparent assessment of how far these events were representative, or of what might have been alternatives to them, that what happened at Midland and Dow Chemical have the air of functional inevitability.

And yet economists as well as historians should resist this conclusion. In saying this I do not mean to regress to the banalities of old-fashioned business history, seeking explanations and rationale in the unpredictability of individual effort and heroic enterprise. But the essence of the problem can be summarized in a number of questions that are only partially dealt with in Levenstein's paper: How far is organizational innovation a logical (and apparently inevitable) outcome of business needs? Why are information systems improved? In what sense are they "needed" at particular points in time? Why are they not "improved" even more at particular points in time?

Nor do I think that we should be too preoccupied with modernity. Reading about Dow's enthusiasm for "factory efficiency methods," I was reminded of the Boulton and Watt engine manufactory, one hundred years before, where processes were subdivided and measured, where machine speeds were studied and costed, where the average time and expense involved in making each part were calculated. In the evolution of information systems, as in so much of human activity, progress is not linear. More than this, when dealing with exiguous material, commonsense is often a better guide than excessively grand conceptualizations.