Accounting Historians Journal

Volume 34
Issue 1 *June 2007*

Article 7

2007

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Accounting Historians Journal
Vol. 34, No. 1
June 2007
pp. 91-124

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THE EMERGENCE OF MECHANICAL ACCOUNTING IN THE U.S., 1880-1930

Abstract: For centuries, accounting was a manual process. Starting in the late 1800s, a series of technological innovations emerged that not only changed the way the accounting process was conducted but dramatically changed the workplace, the workforce, the information provided, and the accounting profession itself. By 1930, most major US companies had adopted mechanical accounting as a more efficient way of processing accounting information. This paper examines the historical development and influence of mechanical accounting in the U.S. from 1880 to 1930.

INTRODUCTION

For centuries, accounting was a manual process. Whether by quill or steel pens, entries were recorded by hand in the journal and posted by hand to the ledger. Although there were devices (abacus, Napier's rods) that helped with basic computations, most accounting tasks (e.g., totaling, closing entries, trial balances) were dependent upon the mental and manual dexterity of the accountant for their completion. In large organizations, prompt access to financial information was basically impossible due to a need to conduct extensive and time-consuming manual searches through bound ledgers, resulting in "trial balances [that] appeared at historic intervals, and departmental digests and comparison reports were almost unheard of" [Leffingwell, 1926, p. 18].[1] "Typically, only external transactions were re-

[1]In a vivid description of the information process before mechanization, Leffingwell [1926, p. 18] writes: "The average executive preferred to keep most of his facts in his head rather than burrow through the hand-made office encyclopedias

Acknowledgments: We would like to thank former editor, Stephen Walker, and the current editor, Richard Fleischman, for their excellent suggestions for improving this paper. We also would like to thank the anonymous reviewers for the comments and suggestions which improved the paper significantly.

corded," for even in the late 19th century, there was no efficient way to process management accounting information, and the demand for such information was only emerging [Yates, 2000, pp.108-109].

Starting in the late 19th century, a series of information processing innovations emerged that changed not only the way accounting tasks were accomplished but dramatically changed the workplace, the workforce, the information provided, and the accounting profession itself. Although there was an early reluctance to accept such innovations, by the third decade of the 20th century, the adoption of mechanical accounting by major companies was nearly universal in the U.S. The "mechanical" period would last for two more decades until there emerged a second major innovation in information processing, the computer. In contrast to the computer's electronic era (vacuum tubes, transistors, chips), the mechanical era was dominated by devices that were dependent upon the mechanical actions of levers, gears, and wheels to process data. Although hand operated at first, later mechanical devices were often electric or motor driven; however, they still relied upon levers or gears to process data. Thus, although referred to as electric calculators or billing machines, they remained mechanical in nature.

An examination of mechanical accounting is important for the evolution of mechanical accounting encompasses far more than the simple adoption of information processing innovations such as typewriters or bookkeeping machines. In actuality, mechanization changed nearly every facet of the business world and accounting. Mechanization would be a major contributing factor to the expansion of the availability of information that became necessary for the emergence, expansion, and managerial control of large corporations. As Chandler [1977, p. 19] points out, "a constant flow of information was essential to the efficient operation of these new large business domains." Prior to mechanization, however, such information often was unavailable, or, if available, its cost was "almost prohibitive because of the expense and time involved" [Galloway, 1919, p. 83].

Johnson and Kaplan [1987, p. 8] note that often the information required was cost or managerial in nature, and "without a corresponding increase in the quantity and quality of manage-

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to dig out his information. If the proprietor of a large enterprise wanted to get a line on a given department, he usually went into that department in person and stayed there until he had made a check-up. Personal contact was his chief means of intercourse both with his employees and his customers."

ment accounting information, these organizations would not have been able to capture the full potential gains from increased scale of operations." With mechanization, managerial and financial data became easier and quicker to obtain at a much reduced cost. In fact, these methods became "so rapid and inexpensive… they encouraged new uses of data not thought of by the original systematizers" [Yates, 1994, p. 41]. As a result, in Abbott's [1988, p. 228] view, "the machines created, virtually overnight, the field of cost accounting."

There has been considerable controversy as to when cost accounting actually emerged. As Tyson [1992, p. 2] points out, by the early 1820s and 1830s in the Lowell cotton textile mills, "cost information was fully utilized by mill owners and managers and, in conjunction with other disciplinary and social factors, provided critical information needed to the business profitably." Chandler [1977, pp. 109-120] writes extensively about the development and use of cost systems by the railroads in the mid-1800s in the U.S. However, as Marquette and Fleischman [1992, p. 130] write, during these early periods, "accountants, on the other hand, were unimpressed by cost accounting and generally considered 'cost-keeping' and 'cost-finding' the work of others." This indifference was to change with mechanization, for companies could now obtain the data needed to implement cost systems and establish sales analysis programs [Strom, 1992, pp. 181-182]. With the increased importance of and demand for such information, the accountant was forced to become involved with cost finding and cost analysis or risk the loss of influence in this area.

Mechanization was also an important contributing factor to the separation of bookkeeping from accounting. With the onset of mechanical accounting, the recording of accounting information became routine and repetitive. A bookkeeper or clerk could process, at a lower cost, the information that the accountant once had recorded. At the same time, the type of information that companies needed was changing. Corporations now required information for capital management, standard costing, financial statement preparation, and cost and ratio analysis – information that bookkeepers could not provide, but accountants could. While accounting became responsible for providing and analyzing financial/managerial data and the way the information was to be used [Abbott, 1988, p. 228], bookkeeping became routinized, concerned primarily with clerical tasks. Accounting became a profession while deskilled, repetitive, task-based bookkeeping became a trade.

The mechanization of bookkeeping was a major factor in the genderization change of the bookkeeping workforce. With a perception as a menial task with few opportunities for advancement, bookkeeping became an occupation for women. In addition to the demand created by a shortage of male bookkeepers, women were perceived to have greater manual dexterity and greater patience with routine tasks [Oppenheimer, 1968, p. 227]. Moreover, women could be hired at much lower wages. Thus, while accounting remained largely male, women began to dominate the bookkeeping workforce. Unlike previously, when bookkeepers were paid a "skill" premium in comparison to other jobs, the "deskilled" female bookkeepers were paid considerably less [Cooper and Taylor, 2000, p. 556].

With an increased demand for accounting information and accountants, the accounting area became more complex with additional layers of management. Within accounting, major changes had to occur to accommodate mechanization because the mechanical devices could process the information only if it was uniformly presented. Thus, standardization of accounts and reporting, within a company and an industry, became necessary for the efficient processing and analysis of information. With mechanization came centralization as the bookkeeping function; machines often were located in a single office. Macve [2002, p. 465] adds that it was this business expansion that led to "the modern explosion in accounting, and the growth of the modern accounting and auditing profession in the nineteenth century." In only 60 years (1870-1930), the number of accountants/bookkeepers in the U.S. increased from circa 54,000 workers [U.S. Census Office, 1872, p. 706] to more than 900,000 [U.S. Bureau of the Census, 1933, Tables 3, 49].

PREVIOUS STUDIES

Though the mechanization of information processing affected many facets of the business world, studies have often concentrated on the effect of mechanization upon labor and the composition of the office workforce, of which bookkeepers were increasingly considered a part. These studies [e.g., Coyle, 1929; Baker, 1964; Rotella, 1981; Davies, 1982; Lowe, 1987; DeVault, 1990; Fine, 1990; Strom, 1992; Kwolek-Folland, 1994; Wootton and Kemmerer, 1996] have traced the transformation of the office workforce (typists, secretaries, stenographers, bookkeepers) from predominately a male occupation to one primarily staffed by women, who were paid substantially lower wages than the men they replaced.

In several studies, Yates [1982, 1985, 1989, 1991, 1993, 1994, 2000] examined the changing needs for communications within businesses and the development of innovative communication, storage, and analyzing devices (e.g., file systems, press books, tabulators, telegraphs, typewriters) to serve these needs. Yates [1994, pp. 28-29] has also set forth the concept that while, for many years, there was little need for extensive financial/managerial information due to the owner/manager structure, the availability and cost of such information became increasingly important as companies grew larger and more geographically diverse, resulting in management becoming separated from ownership.

Studies also have examined individual business machines and/or the effects of innovation upon specific industries. Norberg [1990] examined the introduction and the effects of punch-card machines on business and government in the early 20th century. Campbell-Kelly [1992] reviewed the introduction of data-processing innovations at the Prudential Assurance Company to handle the vast amount of information generated within the insurance company. Wootton and Wolk [2000] traced the development of the loose-leaf system, its influence upon accounting, legal challenges to the concept, and its final acceptance by businesses. In November 2004, a special *Accounting, Business & Financial History* issue appeared whose purpose was "to provide a forum for the expression and hopefully the further development, of ideas relating to the historical impact of technological change on banking and the financial services" [Batiz-Lazo and Boyns, 2004, p. 226]. Included here was Bonin's [2004] discussion of the introduction of accounting machines in French banks from the 1920s to the 1960s. Commenting on the articles, Cortada [2004, pp. 235-236] wrote that the "topic of how information technologies were used by individual industries and organisations is a vast untapped area of exploration."

One important area for exploration is the influence of mechanization upon the cost/managerial side of accounting practice. Accounting innovations were largely responsible for the dramatic change in the availability and timeliness of accounting information and the noticeable decrease in the cost of processing such information. Moreover, mechanization had a major influence upon the "development and use of standard accounting systems" by corporations and trade groups (e.g., Retail Dry Goods Merchants Association), for as Geier and Mautner [1932, pp. 336, 338] wrote: "machines can only be economically applied when the operations are such that there is an endless

duplication of transactions." Mechanical accounting also had a significant influence upon the evolution of financial/managerial accounting and the resulting expansion of accountants' responsibilities. Finally, the entry and role of women into accounting/bookkeeping for nearly one hundred years were defined and influenced by mechanization.

PURPOSE AND SOURCES

The purpose of this paper is to examine the historical development and influence of mechanical accounting from its beginnings in the late 19th century to its widespread use by most large companies in 1930. In doing so, we examine the informational, economical, and social forces that influenced and ultimately led to its use in the business world. Especially useful to our study were the contemporary discussions of the merits, weaknesses, and implementation of mechanical accounting contained in such journals as *System*, *World's Work*, *The Magazine of Business*, and *Commerce, Accounts & Finance*. Equally important in the journals were the advertisements which first reflected the creation then, subsequently, the evolution and improvement of the mechanical devices. As the practical use of such machines was largely unknown, advertisements served an important role in the adoption of mechanical accounting by businesses. Moreover, the journals and advertisements of the period reflect the changing role of bookkeeping and women. Rarely seen in early advertisements, as comptometers and bookkeeping machines evolved, advertisements increasingly featured women as the machines' operators and, by the end of the period, the only operators of such machines.

OUTLINE OF PAPER

The paper consists of five sections. The first section discusses the manual process of accounting before the emergence of technical innovations. The inflexibility of such a system is reviewed, and its hindrance on the collecting and reporting of financial/managerial information is noted. The section also examines the first emergence of basic informational processing devices (e.g., typewriters, adding machines). The second section examines the development of machines/systems (e.g., loose-leaf systems, bookkeeping machines) specifically designed for the processing of accounting information, and their influence upon the availability, cost, and analysis of such information. It notes that a new innovation often increased the efficiency of a previ-

ous innovation – a movement toward an accounting system. The third section reviews the mechanization of the accounting process. As the availability and flexibility of mechanical devices increased and the costs of such machines dramatically decreased, the use of mechanical accounting greatly expanded. With this expansion, bookkeeping became a trade, staffed by women, while accounting assumed a more managerial role, staffed by men. The fourth section recognizes the emergence of a true accounting system and contrasts the processing of accounting information in the 1880s with that in the 1930s. The final section presents the summary and conclusions of the study.

NEW MACHINES EMERGE, 1880-1895

In 1880, accounting was still a manual process. As both the journal and ledger were bound books, only one person at a time could work with a volume. Moreover, entries could not be recorded in a journal while it was being posted. Thus, larger companies often maintained two sets of journals in order that entries could be recorded in one journal while the other was posted. On the following day, the journals were reversed [Betz, 1944, p. 515].[2] Of course, with a bound ledger, only one person at a time could perform the closing process. The bookkeeper performing these tasks was a white male who considered bookkeeping a respected career with an excellent chance of advancement, maybe even the possibility that it might lead to one's own business [Wootton and Kemmerer, 1996, p. 548].

De Wit et al. [2002, pp. 69-70] write that office machines were usually introduced with one "specific functional domain" in mind, but due to the dynamic interaction between the producers and users of the machines, the functions of a machine normally expanded. The introduction of one technology often leads to "the development and use of other types." This was the case with the typewriter. Introduced with one activity (writing) in mind, the typewriter was the antecedent for the mechanization of accounting that followed. Its introduction and adaptation

[2]The number of books involved and the labor intensity can be seen in a description of the accounting process in a factory before the introduction of mechanical devices: "Factory accounting can be performed, long hand, by the use of the ordinary commercial books, which are a blotter in which is recorded a plain statement of every transaction made, a day-book, in which the blotter entries are translated into commercial language, a journal in which the day-book entries are once more translated into debit and credit items, and a ledger in which these debit and credit journal items are collected in individual accounts" [Arnold, 1901, p. 9].

would not only change accounting but the office place itself and the very composition of the labor force within the office.

For more than a hundred years, various writing (typing) machines had been patented; however, none had proved practical or commercially successful. Then, in 1873, E. Remington & Sons, a well-known manufacturer of firearms, agreed to manufacture a "type-writer" that Christopher Latham Sholes, aided by Carlos Glidden and James Densmore, had spent five years perfecting [Bliven, 1954, pp. 42-56]. Although the original market for type-writers was thought to be reporters, lawyers, and authors [Cortada, 1993, p. 16], by the early 1880s, the typewriter or caligraph had begun to gain acceptance in businesses.

The introduction of the typewriter also coincided with the U.S. becoming the world's leading industrial nation [Chandler, 1990, p. 47], and the emergence of large corporations that were dependent upon the prompt completion of reports to keep track of their vast operations. Although first used to type letters and office memos, the typewriter was soon seen as a way to prepare invoices and reports.[3] In contrast to reports that "had to be laboriously written out by hand," reports now could be prepared at the rate of several words per minute. Purchase or sale invoices could be completed in a few minutes, especially if a business used prepared forms that had "spaces for entering specific information" [Yates, 1991, p. 122]. Companies, such as Sears, Roebuck & Co. and Montgomery Ward, found typewriters and their adaptations essential to their operations. Sears often filled 100,000 orders a day from a single Chicago plant [Chandler, 1990, p. 61]. With increased sales and invoices, managers in "credit and collection" departments found it essential to work closely with those in the accounting department [Chandler, 1977, p. 222].

In addition to increasing the efficiency of the typewriter, the use of preprinted forms also encouraged greater consistency and uniformity in the reporting of financial information. Consistency in reporting was essential as companies expanded their manufacturing capabilities and branch offices throughout the U.S. and the world. Moreover, standardized forms "made it easier to extract the data for compilation and analysis at higher levels." Using carbon paper, typists could even prepare several

[3]In a 1890 advertisement ["Caligraph," 1890, p. 12] in *The Atlantic Monthly* emphasizing the "caligraph" as "best for manifolding (making multiple copies)," the American Writing Machine Co. "caligraph" was listed with a price of $85.

copies of an invoice at once [Yates, 1994, pp. 32-33].[4] With such innovations, the cost of processing information noticeably dropped [Page, 1906, p. 7682], and with lower costs, the demand for information increased. In addition to the demand for information created by expanded operations, the need for financial information was further increased as large corporations began to provide some, but often crude, financial reports to their shareholders [Norberg, 1990, p. 757].

Although the typewriter increased the efficiency of processing information such as invoices, it could not directly enter accounting transactions in bound records. It would be nearly two decades (1896) before the loose-leaf accounting system emerged, permitting individual journal/ledger sheets to be placed around a typewriter's platen for processing. As a result, the typewriter had to be modified to work with bound volumes, and the modification became known as the book-typewriter. The premise behind the book-typewriter was that it would type on a flat surface, but instead of requiring ledger sheets to be brought to the typewriter, the typewriter would go to the ledger. The first flat-surface typewriters emerged around 1891, when two competing companies, the Elliott Book Typewriter Company and the Fisher Book Typewriter Company, introduced typewriters, both with flat platens that could record accounting transactions directly in bound volumes [Moore, 1932, pp. 56-57].

The book-typewriter, which had a flat keyboard, was placed above a bound volume, and the carriage, the writing mechanism, moved on rails along the surface of the book with the "type bars strike[ing] downward." An important feature of the Elliott book-typewriter was "the tabulating attachment which permits the operator to jump from the last character…on a column to the exact place…on the next column" ["Elliott Book-Typewriter," 1902, p. 436]. Although developed for recording transactions in bound volumes, the book-typewriter because of its ability to make multiple copies quickly became used for "all sorts of billing and inter-office reports as well as general commercial billing and

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[4]In 1906, Page [pp. 7682-7683] related the prior practice of recording sales at his Dry Goods Commission: "Our old office practice in charging goods was to have the bill, the duplicate bill, the salesbook and the sheet for our Boston house written by four different men to whom a fifth called off the terms, yardage, etc." and "there were three sets of men…for the three sales departments." Continuing, Page stated that the men were replaced by one billing clerk, who through the use of carbons recorded the same information, and a woman, who "extends the yards on the comptometer and extends the bills on the arithmometer, and does the work of six men with great ease."

statistical recording" [Moore, 1932, p. 57]. The book-typewriter's ability to type upon various surfaces and to make multiple copies (manifolder) made it especially attractive to banks and railroads. *Commerce, Accounts & Finance* ["Book Typewriter," 1902, p. 28] reported that one railroad employed more than 700 book-typewriters "for way-billing freight, twelve or fifteen copies of these way-bills being required."

At approximately the same time as the book-typewriter was introduced, the first widely available, commercially successful, adding machines (adders) and calculators (arithmometers) became available in the U.S. Like the typewriter, adders or calculators had been patented for over a century in various countries. Some calculators like the Thomas arithmometer, developed by Charles Xavier Thomas de Colmar in France around 1820, became successful in Europe and continued to be used there for nearly a century [Cortada, 1993, pp. 27-28]. However, in the U.S., the Thomas arithmometer achieved little popularity, and most accounting computations continued to be performed manually.

In the late 1880s, however, this changed with the introduction of the "comptometer," "a multiple-order key-driven calculating machine," developed by Dorr Eugene Felt [Turck, 1921, p. 75]. Martin [1925, p. 93] wrote in an early history of calculating machines, "the comptometer belongs to the class of true calculating machines because not only addition and subtraction but also multiplication and division may conveniently be carried out." Moreover, comptometer items "could be footed directly from the book or papers, while to be added the old way they would have to be listed" ["Mechanical Accountant," 1902, p. 27]. By 1888, major production of the comptometer had begun [Turck, 1921, p. 75], and, in the following year, Felt received a patent for his comptograph, a device similar to the comptometer except that it printed results [Martin, 1925, p. 104]. During the same period, William S. Burroughs received a patent for his recording-adder machine [Turck, 1921, p. 95]. Although Burroughs did not live to see the success of his machine, the company he founded, the Burroughs Adding Machine Company, became a leader in the development of billing and bookkeeping machines.

In only a few years, dozens of adders/calculators entered the marketplace with the principal market being businesses [Cortada, 1993, p. 26]. These machines had an immediate impact upon accountants and auditors, greatly increasing their efficiency, since computation was a major component of accounting. In

fact, Seward [1904, p. 607] in *Engineering Magazine* stated: "addition, indeed, makes up about 95% of all the accounting work required in a factory." Previously, in order to prepare a trial balance from a ledger, to determine totals from invoices, or to determine the cost of manufacturing an item, each number had to be first listed on paper and then the column totaled manually. Once calculated, the total had to be verified by re-adding the column. Companies even employed "lightning calculators," "people who could add long, wide columns of numbers rapidly" [Cortada, 1993, p. 27]. With the adding machine, account balances could be entered directly into the machine without first listing the balance with the total automatically determined. *Commerce, Accounts & Finance* [1902, p. 27] commented on the increased efficiency: "There is no class of arithmetical work connected with accounting…on which it cannot be used, when skilfully operated, at a saving of from one-half to three-quarters of the time required by an expert mental computer."

Although it would be the early 1900s before it would be widely utilized for this function, the calculator/comptometer also made possible the "rapid and accurate analysis" of data [Abbott, 1988, p. 228]. Previously, data had to be manually processed. Many companies did not collect or analyze financial/managerial data because of the cost and time involved [Galloway, 1919, p. 83]. With the calculator, costs could be quickly obtained, and the determination of unit costs became a simple process. As accounting tasks (e.g., trial balances, closings) could be completed in a timelier manner and at a lower cost, more businesses began to prepare quarterly or monthly reports instead of simply an annual report.

Another important impact of the adding machine was that it often allowed an accountant to be replaced by a clerk. As Cortada [1993, p. 30] writes, "a less well-paid clerk could do more work with an adding machine than a better-paid accountant working by hand." There was a consequence of replacing an accountant with a less well-paid clerk, namely, the loss of status for the task being performed. Actually, at this time, the status for clerical work was diminishing in all facets of the business office. There was a movement toward functionalization; that is, workers specialized in one function or on one machine, greatly increasing their efficiency and output. With the introduction of mechanical processors (e.g., typewriters, comptometers), the need for an office in which these functions could be centralized also increased [Yates, 1989, p. 10]. Thus, at many firms, the operators of typewriters and comptometers were assigned to

a "central" office. As specialization and the number of clerical workers increased, those performing the tasks suffered a loss of status, a deskilling of the positions. Prior to mechanization, clerical jobs often were considered as "transitional" positions, a job which would lead to upward progression in the firm or a position in which one could secure the knowledge necessary to start one's own business [Fine, 1990, p. 10]. At most firms, the clerical workforce was small and consisted of white, middle-class men. Thus, as Cooper and Taylor observe [2000, p. 561]: "Clerks of the mid 19th century were the predecessors of modern middle management rather than the army of clerks found in the modern workplace." However, with the vast increase in the clerical workforce, a thousand-fold in 60 years, coupled with functionalization [Hooks, 1947, p. 75], a clerical job was no longer considered a transitional position. It was perceived as a deskilled, dead-end job, often occupied by women. DeVault [1990, p. 17] writes that, at this time, there was the widely accepted belief that women were well-suited for "routinized, dead-end employment."

With the increased demand for office workers and a shortage of potential male workers, the composition of the clerical workforce changed, including the bookkeeping area. Prior to mechanization, bookkeepers held a well-respected position within the firm, often assuming responsibilities that would now be considered managerial [Rotella, 1981, p. 52]. However, with specialization, the duties of the bookkeeper changed from managerial to task-based. With a shortage of men available for bookkeeping positions and the lower wages women commanded, companies began to hire women as bookkeepers [Wootton and Kemmerer, 1996, pp. 578-579]. In 1870, less than 1% [U.S. Census Office, 1872, p. 706] of the bookkeepers in the U.S. was women; however, by 1890, the number had risen to more than 17% [U.S. Census Office, 1897, Table 116]. Although they were paid substantially less than male bookkeepers, women in bookkeeping positions normally earned considerably more than women in nearly every other area [DeVault, 1990, p. 56]. Thus, bookkeeping became an attractive employment area for women. Yet, at the same time, the field of accounting offered few employment opportunities for women [Wootton and Kemmerer, 1996, pp. 556, 581].

NEW METHODS OF INFORMATION PROCESSING, 1896-1915

With many companies recognizing typewriters and adding machines as essential to their businesses, manufacturers began

to design machines more directly related to specific industries or accounting needs. In adopting accounting innovations, banks often preceded other types of organizations. For example, in the mid-1890s, Leicester Allen developed what was called "Allen's double entry accounting machine." The Allen machine recorded a deposit/withdrawal of cash on the depositor's bank book while at the same time generating "a paper tape, giving the number of the depositor's book, and the amount" which became the permanent record of the event [Arnold, 1901, p. 383].[5] In 1896, an Allen machine was accepted for trial by Union Dime Savings Institution in New York. After a three-year trial, two more machines were purchased. The noted accountant and president of Union Dime, Charles E. Sprague, wrote: "I consider the Allen Double Entry…a valuable invention…It insures desirable results which – with less certainty…could be attained only by the employment of two special clerks" [Arnold, 1901, p. 381]. Given the adaptability of mechanical accounting devices to the banking industry, manufacturers often sought and advertised such financial institutions as customers. For example, in a 1900 advertisement ["Burroughs Registering…," 1900, p. 93] Burroughs Bookkeeping Company emphasized the adoption of its registering accountant machine by over 3,000 banks, small as well as large" (emphasis in the original).

Near the end of the 19th century, another innovation occurred that greatly increased the efficiency of accounting, the loose-leaf system. Like the typewriter, it was an innovation easily integrated with others, a process that greatly hastened its further development. Up to this time, accounting transactions were recorded in bound journals and posted to bound ledgers. For larger businesses, the process was quite complex and labor intensive [Wootton and Wolk, 2000, p. 83]. Bound ledgers also prevented more than one person at a time working on an account, thus greatly slowing the closing process. Moreover, a bound system prevented further modification of the typewriter to process accounting information more efficiently. Although the book-typewriter could enter transactions in bound volumes, it was a large, slow, sometimes difficult to operate machine [Oden, 1917, pp. 54-55].

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[5]Before accepting the Allen double entry accounting machine for trial, the Union Dime Savings machine set 19 specific requirements that the machine had to meet. Most of the requirements dealt with the prevention of fraud by the machine user and the maximum time required to complete an operation, "the average time of the entire operation is about twenty seconds" [Arnold, 1901, p. 383].

Garner [1954] points out that, in addition to being conducive to the modification of the typewriter and the creation of the bookkeeping machine, the loose-leaf system (often represented as the "card system") played an important role in the development of cost accounting and the introduction of perpetual inventory. Henry Metcalfe in 1885 articulated the card system as an essential element in the control and determination of raw material costs, advocating that "a card should be made out for almost every possible type of transaction or transfer of material" [Garner, 1954, p. 92]. As Metcalfe [1885, p. 20] pointed out, the card system was much more flexible and efficient in a large factory "where books required to transact the morning's business numbered 18 and weighed about 60 lbs."

The card system was widely used for inventory control. In 1899, H.L. Arnold, in *Complete Cost-Keeper*, described a "stores ledger card system" in which the balance in the materials account "was known at the end of each day," and which would be physically verified "at least every sixty days" [Arnold, cited by Garner, 1954, p. 95]. By 1904, "cost authorities were referring to the perpetual inventory plan [stores ledger card] by its present title [Garner, 1954, p. 96]." Even in banks, which Sprague [1913, p. 100] noted had previously "posted the depositors' accounts from these clumsy books and not from the easily handled (deposit) tickets," now "universally" posted from the tickets.

Two leading companies in the vanguard of the loose-leaf system were Baker-Vawter, which began national sales of a loose-leaf ledger in 1896 [Vawter, 1917, p. 17], and the Krag Manufacturing Company, which began sales of the Tengwall file system in 1897 [Stoeckel, 1940, p. 26]. Both systems were similar to today's three-ring notebooks in that leaves could be added to or removed from the binder [Wootton and Wolk, 2000, p. 88]. The loose-leaf system allowed the greater use of adding machines as several accounts could be totaled at the same time, significantly reducing the time required to close accounts. Another advantage was that loose-leaf forms could be inserted directly into typewriters or bookkeeping machines for processing. As a result, the "total" accounting system, combining the loose-leaf system with a bookkeeping machine, became the emphasis of advertisements by manufacturers of both. As Moore [1932, pp. 67-68] notes, without the "equal development" and acceptance of loose-leaf and standardized forms, "the business machine industry could not successfully exist."

Another major innovation for processing accounting information was the tabulating machine. Leffingwell [1926, p. 164]

commented on why the tabulating machine emerged: "It [was] almost imperative that the age-old, slow, inaccurate, and costly methods of gathering data be supplanted by some mechanical substitute." However, the gathering of such information was dependent upon the "recording, storing and retrieving, analyzing, and presentation of large amounts of numerical information within companies" [Yates, 2000, p. 112]. Although some companies may have kept such records, the manual cost to actually process the information made it virtually unusable except for the largest companies where the tabulating machine found its initial and greatest use.

It was the need to process large amounts of data that led to the development of the tabulating machine. Employed at the U.S. Census Office, Herman Hollerith knew that census information was still being tabulated five years after the 1880 census was conducted [Harmon, 1975, p. 102]. With this in mind, Hollerith began work on a machine that could process great amounts of data. In 1889, the Census Office considered three methods of tabulation for the 1890 census, including Hollerith's card tabulating system, which was eventually selected. In contrast to the seven and one-half years needed to compile the 1880 census, Hollerith's machine permitted the 1890 census to be tabulated in less than two months [Harmon, 1975, pp. 102-103]. Recognizing the commercial possibilities of the machine, Hollerith started the Tabulating Machine Company, ultimately IBM, in 1896. For over a decade, Hollerith faced little competition. However, in 1911, James Powers formed the Powers Accounting Machine Company, later acquired by Remington Rand, which used a different method of tabulation [Harmon, 1975, pp. 106-107].

Seeing the success of the tabulating machine in processing census data and recognizing its potential for analyzing such data, companies that generated large amounts of data soon were renting their own tabulating machines. Among the major users of tabulators were the railroads where "one of the most widespread uses of tabulating machines was in railroad freight accounting and rate statistics" [Norberg, 1990, p. 766]. For example, shortly before the turn of the century, the New York Central Railroad installed several tabulating machines, each with four attached adding machines. Scott [1905, p. 5976], referring to the tabulators' benefit to the New York Central, wrote: "(it) will compute shop costs, analyze and take account of sales, make distribution of expenditures, and make almost any analysis of a great volume of facts…(and) where the amount of business justifies its installation it is much cheaper." In the case of the New York

Central, the amount of data was phenomenal. It was estimated that tabulators processed approximately four million waybills in 1897 [Norberg, 1990, p. 762]. The use of a tabulator also had an effect on the duties of the railway accountant. With a lower-paid bookkeeper or clerk responsible for data entry, the accountant now assumed responsibility for the determination of what data (costs) should be gathered.

Another area in which there was a vast amount of information to process was the insurance industry. At the turn of the 20th century, it was estimated that the largest insurance companies each had approximately one million small insurance policies (collected weekly) and one hundred thousand larger policies (collected monthly) which had to be recorded, billed, and collected. The companies also faced multiple-states regulations of their policies and were under some pressure to provide "a quasi-public service at the lowest cost possible" [Yates, 2000, pp. 130-131]. Thus faced with a vast amount of data and a need for detailed cost information, insurance companies, such as Continental Casualty, began to make extensive use of tabulating machines, especially in the area of financial analysis. On one "claim settlement card," Continental stated that it could record the policyholder's account number, address, age, type of claim (one of 9,999 different possibilities), settlement date, and amount of settlement. The cards could then be sorted (e.g., by type of claim) at the rate of 300 cards per minute and totaled at the rate of 150 cards per minute. With this information, the general auditor of Continental Casualty stated that the company could "determine with absolute precision not only the claim cost of the many different forms of accident and health policies that we issue, but…determine very easily what each of those conditions contributes toward the total cost of any form of policy" [Luse, 1911, pp. 60-62]. In contrast to the slow, expensive, manual collection of information, companies could now obtain cost data quickly and inexpensively, encouraging them to request even more information.

With the capability now of determining the actual costs of a policy or process, the next logical step was to develop a "standard" cost for the product. However, the determination of a standard cost required an expansion of costing theory, or, as Abbott [1988, p. 232] writes, "[the] estimation of standards required solving the 'burden problem' [of allocating overhead costs], smoothing out random fluctuations in shop work, and calculating the effects of fluctuating factors of production." Thus, the accountant's responsibility expanded beyond the mere reporting

of numerical data. The accountant had to become involved in the day-to-day operations of a plant, to analyze complex production processes, and now to make the assumptions required to set a standard that could be used to evaluate the efficiency of future output. In Abbott's view [1988, p. 232], it was "these conventions [that] created the crucial judgments that made cost accountants real professionals."

By 1910, the "complete" billing machine had emerged. Three popular billing machines were the Elliott-Fisher, the Moon-Hopkins, and the Underwood [Schulze, 1913, p. 42]. A billing machine combined the features of the typewriter with the adding machine. This allowed a simultaneous "billing and ledger statement posting," which led *The American Business Manual* [Montgomery, 1911, p. 279] to declare: "The compound [billing] machine is probably the most efficient and accurate mechanical device ever designed." These "compound" features were often the focus of advertisements. For example, Elliott-Fisher ["Billing and Adding…," 1906] claimed that its billing machine would do "all the typewriting capable of being done by any typewriter" plus "all the printing and adding of figures hitherto done by Adding and Listing Machines." In fact, the advertisement stated: "It will print the figures in columns and automatically total the figures wherever the column or columns may be located." The price of the Elliott-Fisher billing machine, including one adding register, was $325. A separate register (price $60) was required for each column to be totaled. Thus, the total price of a billing machine that could record and total two columns was $385.

Although accounting machines were comparatively expensive, companies could recover their initial costs through greater efficiency. In 1914, the Gulf Pipe Line Company reported that its use of seven Burroughs listing machines allowed it to reduce the size of its accounting department from 39 to 35 employees, saving "at least $500 per month" [Lewis, 1914, p. 164]. In another illustration of cost efficiency, the Warner Sugar Refining Company reported that its bookkeeping department now consisted of "three girls and three bookkeeping machines." These "girls" could post 1,000 accounts a day, prepare the brokerage statements, and write all checks. Using a bookkeeping machine, Warner Sugar reported that one operator "takes the place of three men" [Galloway, 1919, p. 84]. The "girl" was typically paid a lower wage than a male employee [Wootton and Kemmerer, 1996, p. 569].

As the complete billing machine emerged, there were continued improvements in the operations of adding machines

and calculators. Major brands (e.g., Dalton,[6] Wales, Barrett, Mechanical Accountant) extensively advertised their machines' advantages. However, for basic computations, the comptometer remained the machine of choice as it was recognized as very fast and very reliable. Moreover, many comptometer operators were trained by the machine's manufacturer, greatly increasing their efficiency.[7]

Despite the proliferation of accounting machines, there was a demand for a machine that could total multiple columns or calculate sales by departments as it determined the total sales of a business. In response, the "duplex" adder, a machine that could do multiple computations at once, was introduced in the early 1910s. The duplex had two separate adding wheels, upper and lower rows, and the ability to transfer amounts between wheels. Therefore, it could conduct two operations at once. Among the most successful duplexes were the Burroughs duplex and the Burroughs cost keeping machine, which had greater computation capacity and flexibility than the duplex. A 15-column duplex would allow a company to "add six columns of five figures each at the same time" [Lewis, 1914, p. 181]. With the "unlimited split" option, the number of figures in a column could be increased or decreased to meet a company's needs. Thus, businesses could record and total both the costs and selling prices of merchandise at the same time.

While the duplex machine was useful for cost and price information, it was particularly useful for payrolls. With a duplex, a company could calculate and record the payroll for each department at the same time the total payroll was determined. Burroughs even offered a "payroll" version that printed the employee's payroll number and earnings for the period on individual payroll envelopes at the same time as it recorded the payroll sheet [Lewis, 1914, pp. 179, 188].

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[6]Although most adding/calculating machines (e.g., the Burroughs, comptometer) were full-keyboard machines at this time, the Dalton adding machine was a ten-key adding machine. In contrast to the full-keyboard models where operators had to look at the keyboard, the Dalton could be operated by touch [Martin, 1925, p. 133].

[7]Felt & Tarrant Mfg. Co., the manufacturer of the comptometer, sponsored a training program on the use of its machines. The length of the training program was from two months to ten weeks with six hours of training each day. In 1915, the usual tuition to attend a training program was $40 with five to seven students in a class [Eaton and Stevens, 1915, p. 214]. In their comments on the placement of its graduates, Eaton and Stevens wrote, "great effort made. Good operators not idle. Girls trained according to demand."

Another use for the duplex machine was cost determination and control. Webner [1917, pp. 173-180] examined how the "mental calculations" of a card cost system could be reduced through the use of a duplex machine. The duplex's great commercial success was emphasized in a 1913 Burroughs' advertisement. "This 'two-in-one' machine in a little more than a year has made a big 'hit' 2,600 out of the 20,000 Burroughs machines sold last year were Burroughs Duplexes" ["Burroughs Duplex…," 1913].

With the geographic expansion of American businesses and the wave of mergers between companies, the information required to manage these widespread operations grew dramatically. With the increased demand for information, there occurred an explosive growth in the office workforce needed to provide it. For example, from 1890 to 1910, the number of typists and stenographers increased from 33,418 to 316,693 [U.S. Bureau of the Census, 1914, Table 15]. As the clerical workforce expanded, there was a corresponding increase in the number of bookkeepers/accountants needed to process the financial information required by these companies.

With the greater acceptance of mechanical innovations, the separation of accounting from bookkeeping accelerated. Previously, many bookkeepers had worked directly with their employers [Fine, 1990, pp. 166-167]. Moreover, the accountant/bookkeeper had "assumed responsibilities that [were] managerial" [Rotella, 1981, p. 52]. However, with mechanization and specialization, the collection and recording of information were often moved to a central office where the financial information was processed by a bookkeeper or clerk. In regard to this change, Sweetland [1906, p. 196] wrote: "It might appear that the various mechanical aids.…make a mechanical accountant. But they really make the accountant less mechanical by giving him only mental work." Thus, it was the accountant who now assumed the "managerial and planning aspects of the bookkeeper's job" [Strom, 1992, p. 185].

Although the separation of bookkeeping from accounting had begun, the bookkeeper and the accountant were still considered to perform the same tasks for census purposes and were thus classified in the same category. In only 20 years (1890–1910), the number of bookkeepers/accountants increased from 159,374 to 482,814. However, the increase of women in the bookkeeping/accounting workforce, largely as bookkeepers, was even more dramatic, increasing from 27,772 to 184,999 [U.S. Bureau of Census, 1914, Table 15]. By 1910, women comprised

more than 38% of the bookkeeping/accounting workforce contrasted to only 1% in 1870.

THE MECHANIZATION OF ACCOUNTING, 1916-1930

By 1920, the market for tabulating machines had expanded beyond traditional users, such as railroads and insurance companies, to large manufacturers.[8] Companies in the rubber, textiles, and automobile industries, for example, found that tabulators could reduce the menial side of information gathering, allowing them to concentrate on identifying and analyzing data [Norberg, 1990, pp. 767, 772].

Tabulators also began to have an impact upon the accounting area. Kent [1918, p. 137] related the effect of the introduction of the Hollerith tabulating system upon the accounting and costing process of the Pennsylvania Steel Co. With its adoption of tabulators, the company substantially reduced its accounting workforce and basically eliminated the need for accountants to work at night. Before the adoption of the tabulator, it was not normally until the 15th of the next month before a cost statement could be prepared. With the new technology, cost reports could be completed in five to seven days. Furthermore, whereas 27 products had previously been costed and analyzed, now 130 products were individually tracked.

Other companies, such as Marshall Field and Eastman Kodak, made use of tabulating machines to implement new costing and sales analysis programs [Strom, 1992, pp. 181-182]. The Larkin Company, a food distributor, used the punch-card system to manage its inventory. Scovill, which already used a Hollerith machine to process large quantities of data, added to its operation a Powers tabulator, justifying its need: "The Powers Machine will open up a large field of statistical investigation and presentation" [Davis, 1919, quoted in Yates, 1991, p. 147].

In addition to aiding the analysis of information, tabulators increased the timeliness of cost/financial reports. One reason for this efficiency was that the tabulating system allowed manufacturing costs to be entered on cards as incurred; then "at the end of the month [these data could be] quickly sorted and tabulated to obtain the information required to close the books and for

[8]Unlike other business machines that could be purchased, sorting and tabulating machines normally had to be rented. In 1924, the costs to rent a Hollerith's sorting machine and a five-counter printing tabulator were $25 and $150 respectively per month. The keypunch machine could be purchased for $100 [McCarthy, 1924, p. 358].

posting to the detail cost records" [Eggleston and Robinson, 1921, p. 417].[9] Tabulators also allowed "bookkeeping" departments to prepare daily balance sheets, which, in turn, allowed management and "accountants" to analyze changes in balance sheet items [de Wit and van den Ende, 2000, p. 99].

While the tabulating machine gained acceptance by larger manufacturers, the development of the accounting machine continued. As a result, while some companies still advertised billing machines (e.g., the Moon-Hopkins[10] billing machine), many advertisers (e.g., Burroughs, Underwood) hawked bookkeeping or figuring machines, which emphasized the machines' more expansive nature. Other companies (e.g., Elliott-Fisher, Remington) even labeled some of their products "accounting machines."

Regardless of their names, these machines performed many of the tasks that previously had been done manually. No longer did a transaction have to be recorded in a bound journal, posted to a bound ledger, and the balance manually determined. Machines could now record a transaction in the journal and ledger at the same time and strike the balance automatically [Geier and Mautner, 1932, pp. 250-251]. However, the person recording the transaction was probably no longer an accountant but a clerk or bookkeeper. The accountant was the person supervising the bookkeeping department. This concept of the accountant as a director, not a recorder, was emphasized in advertisements of the period. In an advertisement for its bookkeeping machine, Elliott-Fisher stated that the machine lifts the accountant "out of the *machine-class*…and gives you the opportunity to use your

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[9]Other uses for tabulating machines included inventory control and billings. One company used three punching machines, one sorter, and three tabulators to keep track of the merchandise it distributed to 400 grocery and meat stores in New York. Upon receipt of merchandise, the company classified the goods and entered the data upon cards. As goods were distributed, the respective cards were removed, tabulated, and "a regular invoice [is provided] in duplicate, showing the number of units, description, weight, retail price, and retail extension of each classification of merchandise delivered" [Leffingwell, 1926, p. 178]. Moreover, the company could determine its inventory at any time by simply running the remaining cards through the sorting and tabulating machines.

[10]Although still referred to as the Moon-Hopkins billing machine and often recognized as the leading billing machine by this time, its original manufacturer, the Moon-Hopkins Company, had been acquired by the Burroughs Adding Machine Company. The major advantage of the Moon-Hopkins was its rapid processing of invoices. The price of the basic Moon-Hopkins, without a multiplier-subtractor, was $650 while the advanced electric model was $950 [McCarthy, 1924, p. 432].

time, your hands and brains in *directing* work ["Turn That Bookkeeping…," 1915] (emphasis in the original).

The idea that a bookkeeping machine could take over the manual aspects of accounting was delineated in a two-page advertisement in *System* ["*New York Times*," 1923, pp. 704-705]. In the ad, Underwood Typewriter Company claimed that the *New York Times* had installed 12 Underwood bookkeeping machines in its accounting department. With the machines, the department was assured that "all the business of that day has been recorded – all the charges made – all the credits entered – all the balances struck."

The concept that a bookkeeping machine was to work with the accounting department as well as to improve its efficiency was emphasized in advertisements of the period. In introducing its new "automatic-electric," flat-surface accounting machine, Elliott-Fisher stated that the only way to see how "this machine can be used in *your* accounting department…[is to] see it in operation." As did similar machines, the Elliott-Fisher "automatic-electric" eliminated several manual steps. It automatically returned the carriage, spaced lines, tabbed columns, totaled columns, decimal spaced, aligned forms, fed carbons, and provided a written proof of balance ["Announcing the New…," 1926, pp. 844-845]. Martin [1925, p. 116], in his early history of the calculating machine, described how an electric upright Burroughs machine worked in an office:

> The account sheet is fed into the automatic jump carriage…the old balance is typed…the electric key is pressed…the date is automatically typed…the debit is automatically subtracted…the credit is automatically added…the new balance is automatically calculated and typed…the account sheet is ejected…at the end of the workday, the machine supplies a check of the entries…except for the fact that the amounts that are to be entered must be typed, and the electric key must be pressed, the machine operates automatically throughout.

As accounting machines advanced, the basic adding machine/calculator also improved. With a noticeable increase in the number of manufacturers, the prices of machines dropped sharply. Emphasizing price and reliability in introducing its adding machine, the Victor adding machine Co. stated that it produced only one model. While it was comparable to other mass-produced adding machines, the company could offer an

eight-column listing machine for "a startling price" of $100 ["One and Only One…," 1923, p. 803]. Victor's price contrasted with other "five-column machines selling at about $250, and nine-column machines in the $300 to $400 range" [Darby, 1968, p. 29]. With this price advantage, the Victor Company's machine was a success. In two years, nearly 100,000 adding machines were sold [Darby, 1968, p. 58]. With lower prices, more businesses were able to afford the machines. It was not long before the adding machine became a required item in most offices [Cortada, 1993, p. 268].[11]

Some manufacturers combined the adding machine with other business machines. In its advertisements, the Sundstrand Adding Machine Company emphasized that businesses need to make decisions based upon daily information, and that its "Combined cash register-adding machine" allowed a company to "keep a perpetual inventory, keep a record of sales by departments, keep a record of each clerk's sales, and classify expenses for rent, salaries, etc." ["Merchants…," 1922, p. 731]. Although Felt & Tarrant's comptometer continued to be recognized as a fast, reliable calculating machine and its advertisements emphasized the comptometer's "99.4% first time accuracy," other manufacturers now offered competitive machines ["For Speed With Accuracy…," 1925, p. 805]. Indirectly criticizing the training required for the efficient use of the comptometer, Monroe Calculating Machine Co.'s advertisement emphasized that the Monroe "can be used by an inexperienced clerk" and one "you can operate yourself when you wish to get out confidential figures" ["Ten Reasons…," 1925, p. 794]. At this time, the price of a Monroe calculator ranged from $200 (6 x 6 keyboard, 12 places answer) to $400 (10 x 10 keyboard, 20 places answer) [Martin, 1925, p. 251].

With the gathering and processing of data largely mechanized in larger firms, the final separation of bookkeeping from accounting could occur. This growing separation was reflected by the U.S. Bureau of Census which, for the first time in the 1920 Census, separated bookkeeping from accounting in its reporting categories. Bookkeeping was now a trade, a clerical task [Kirkham and Loft, 1993, p. 513]. In contrast to the apprentice-

[11]Two years after the introduction of Victor's $100 model adding machine, the Portable Adding Machine Sales Company advertised a seven-column adding machine, built by the Corona Typewriter Company: "Truly portable [listing] adding machine" for $65. In contrast to other machines weighing up to 100 pounds, the portable machine's weight (16 lbs.) was an attractive feature ["At Last…," 1925, p. 784].

ship concept previously used to train most bookkeepers [Sampson, 1960, p. 460], they were now expected to bring with them knowledge of and an ability to use office machines. Bookkeepers, normally women, received such training in business courses in high schools or in special business schools, thus needing little additional training on the job [Blau and Ferber, 1992, p. 30]. In contrast to bookkeeping, the technical knowledge that accountants were expected to bring to the job increasingly required a college education or college courses. Yet, at several colleges, women could not take accounting courses, while at others, women could take accounting courses only in night programs. At nearly every college, women were discouraged from seeking careers in accounting [Wootton and Spruill, 1994, p. 242].

While bookkeeping was becoming a trade, accounting had evolved into a profession with management responsibilities [DeVault, 1990, p. 22]. With the separation of responsibilities and perceptions, dramatic changes took place in the workforce. Although the accountant was most likely male, the person operating the bookkeeping machine probably was a female who was paid substantially less than the male bookkeeper she succeeded in the job. By 1920, while 56.1% of bookkeepers were women, only 11.3% of accountants were [U.S. Bureau of Census, 1923, Table 4].

The change in the composition of the bookkeeping workforce and the corresponding change in responsibilities were also reflected in the advertisements of the period. Whereas in the early years of mechanization, advertisements normally presented the machine operator as a man, they now pictured the operator as a woman. In a typical advertisement, comptometer ["The Bookkeeper," 1916] emphasized how a "girl" with a comptometer could increase the efficiency of an "accounting" department. Instead of accountants having to prove the postings and balance the accounts in a ledger, the ledger now could be turned over to "the girl and the machine in the above picture" and she "will prove the postings...and balance the accounts" for them ["Bookkeeper," 1916]. There was now a separation of the accountant from the bookkeeper with the latter responsible for the menial tasks and the former for supervision.

MECHANICAL ACCOUNTING

By 1930, for most companies, the processing of accounting information had changed from being a manual process to a largely mechanical one. In his study of the use of accounting

machines in French banks, Bonin [2004, p. 267] points out two major reasons for this transformation: "They [accounting machines] helped reduce the number of employees and cut operating costs while, on the other hand, they improved the quality, reliability and speed of services." At this time, whether the firm was French or American, it was most likely that machines were designed or manufactured in the U.S. The U.S. had become the leading provider of accounting and tabulating machines throughout the world [Cortada, 1993, pp. 41-43]. These machines were also cost effective. For example, in 1923, one French bank estimated that the cost of its Burroughs accounting machines could be recovered in 14 months [Bonin, 2004, p. 260].

While accounting machines could be credited with the coincident reduction of the workforce and operating costs, the accounting transformation was greater, for it had reached what de Wit et al. [2002, p. 65] refer to as an "innovation junction" where "the successful integration of system machines into an administrative organization called for much closer cooperation between suppliers and users, who also frequently called on consulting firms for advice about office technology." This was the case in the U.S. Now there were companies that offered complete accounting systems that could handle nearly every phase in the processing of accounting information. If a business could not install its own accounting system, a company could be hired to do so. If a business was unsure of the system it needed, IBM advertised: "International Business Machines for forty years have been solving problems of this kind" ["It's Profit that Counts…," 1929, p. 100]. If IBM could not provide an answer, perhaps Baker-Vawter ["Accounting a Problem…," 1927, p. 859] could. Its advertisement recommended that all businesses should use an accounting machine; the question was: "Which accounting machine can I use to best advantage? And that is just where the Baker-Vawter man can help."

The changes in the availability and processing of accounting information in only fifty years were dynamic. Whereas in 1880, accounting computations were basically manual operations, by 1930, a business could purchase a printing Victor adding machine for $75 ["These are the Days…," 1929] or a Marchant portable calculator for $125 ["Add-Multiply-Subtract-Divide," 1929, p. 455] to handle the computations. The loose-leaf system, which offered greater flexibility and efficiency, had replaced the bound volumes of the manual system. Moreover, loose-leaf sheets could be used in electric accounting machines. The

development and use of uniform accounting systems within industries and companies accompanied the innovations. For example, by 1930, the Retail Dry Goods Merchants Association had developed a uniform accounting system "for use in department stores and other retail stores." It recommended to its members the "machines that have been found to be most capable of performing the operations embraced by that system" [Geier and Mautner, 1932, p. 338].

In addition to the development of standardized systems, accounting machines and systems were devised for specific needs. For a business with installment sales, Remington Rand ["Do You Sell…," 1928, p. 776] offered the Kardex visible systems ("which signal due dates and warn against bad credit risks"), the Baker Vawter-Kalamazoo loose-leaf system ("available for installment accounting"), and the Remington accounting machine ("particularly suited to posting installment accounts"). For banks, there was the Dalton dual bank bookkeeping machine, designed for "the posting of commercial checking accounts, savings accounts, stock records, etc." [Geier and Mautner, 1932, p. 278].

By 1930, the Burroughs Adding Machine Company offered a machine for any size company and for nearly any accounting need. In collaboration with the National Standard Parts Association, Burroughs developed a manual [*N.S.P.A. Manual of Standard Bookkeeping,* 1929, pp. 3-24] for the Association's jobbers in which the functions of individual machines were described. For a small business, there was the Burroughs typewriter billing and bookkeeping machine so "the small Jobber will be able to obtain all the advantages of mechanical accounting." For larger jobbers with greater billings, there was the Burroughs typewriter billing machine that "writes and computes a complete invoice in one operation, including all typing, extending, figuring of discounts and totaling of the bill."

Machines were also designed for specific industries. For example, Burroughs manufactured a billing machine specifically for gas, electric, and water utilities. The operator had only to enter the customer's account number with the previous and present meter readings, and the billing machine computed the amount of consumption, determined the customer's charge, prepared the customer's bill, updated the customer's ledger account, and automatically injected and ejected the forms. The cost of the machine was $2,925 [McCarthy, 1924, p. 470].

SUMMARY AND CONCLUSIONS

As the mechanization of accounting progressed from the introduction of the typewriter to the more sophisticated calculating machines, coincident changes also occurred in the accounting workforce and the way managers viewed the information they needed to run their organizations. By 1930, "mechanical" accounting was in use at most major companies. Along with the general acceptance of mechanical accounting came the progression of accounting beyond bookkeeping and the perceived role that women would play in each.[12] The changing gender composition of the bookkeeping/accounting workforce is presented in Table 1. Prior to the 1920 Census, the U.S. Census Office classified accountants/bookkeepers "of all kinds" in a single category. In 1920, recognizing the separation of accounting from bookkeeping, the U.S. Census Office created two categories for classification purposes – accountants/auditors and bookkeepers/cashiers.

Bookkeepers using mechanical devices recorded and posted transactions, prepared invoices, received and made payments, and totaled the accounts and ledgers. Since these tasks were considered repetitive [Erickson, 1934, pp. 16-17] and more of "a mechanical process" [Parsons, 1917, p. 188], the "prevailing view at this time was that bookkeeping" was a proper area of employment for women [Wootton and Kemmerer, 2000, p. 182]. Thus, instead of hiring men as bookkeepers, companies began to hire white, middle-class women [Fine, 1990, p. xvii]. Whereas less than 1% of bookkeepers were women in 1870, by 1930, the number had risen to more than 60% (see Table 1). However, as

[12]There are several studies that have examined the entry and role of women in the fields of accounting and bookkeeping. Wescott and Seiler [1986], Reid et al. [1987], and Legge [1988] present broad studies of women's entry into the profession. Lehman [1992] examines the obstacles women faced entering the profession and the theories that explain women's "stratification" in the profession. Kirkham and Loft [1993] examine the separation of bookkeeping and accounting in England and Wales and, as a result, bookkeeping becoming "feminized." McKeen and Richardson [1998] look at the entry of women into the Canadian accounting profession. Shackleton [1999] traces the admission of women in Scotland as chartered accountants. Wootton and Kemmerer [1996, 2000] review the genderization of bookkeeping and accounting in the U.S. Walker [2003a] explores the entry of women to bookkeeping in late 19th century Britain, and finds retailing and distribution as areas in which initial employment was often found. Walker [2003b] examines the role and influence that household accounting had upon the entry of women into the outside job market, and found that it helped contain women in the private household sphere. Hammond [2003] summarizes "international research on race and gender."

TABLE 1

The Changing Gender Composition of the Accounting/Bookkeeping Workforce, Men and Women, in the U.S., 1870 to 1930

	Total	Men	%	Women	%
Year of 1870					
Book-keepers & Accountants	54,041	53,489	99.0	552	1.0
Year of 1890					
Bookkeepers & Accountants	159,374	131,602	82.6	27,772	17.4
Year of 1910					
Bookkeepers & Accountants	482,814	297,815	61.7	184,999	38.3
Year of 1930					
Bookkeepers & Cashiers	739,077	273,380	37.0	465,697	63.0
Accountants & Auditors	191,571	174,557	91.1	17,014	8.9

Sources: U.S. Census Office (Bureau of the Census) (1872), Vol. I, Table XXIX; (1897), Part II, Table 78; (1914), Vol. IV, Table 15; (1933), Vol. 5, Table 6

with other office workers, the wages paid to women bookkeepers were substantially lower than those of the men they replaced [Fine, 1990, p. 73].[13]

In contrast, accountants were often considered professionals. The separation of management from ownership required someone to represent the shareholders' and creditors' interests in the company. That person often was the public accountant [Porter, 1995, p. 91], bringing to the audit a sense of independence and professionalism. Within companies, accountants were responsible for the preparation of the financial statements, the analysis of cost and financial data, and the development and implementation of accounting systems. Accountants were typically viewed as managers [DeVault, 1990, p. 22]. "Women were usually perceived as not having the emotional makeup, the judgement, the analytical reasoning, or the long-term commitment to the job that was required for a manager" or for

[13]Although female bookkeepers were paid substantially less than male bookkeepers, women employed as bookkeepers, as were most office workers in the early 1900s, usually earned more than women in other occupations (e.g., teaching, retail clerks, production workers) at that time [Fine, 1990, pp. 42-43]. Moreover, as Strom [1992, p. 205] points out, working conditions for bookkeepers or office workers usually were better than for women in nonprofessional employment.

an accountant [Wootton and Kemmerer, 1996, pp. 583-584]. Thus, while women comprised over half of the bookkeeping workforce, women constituted less than 10% of the accounting workforce (see Table 1), a percentage that did not noticeably change until the 1960s. While the mechanization of accounting may not be viewed as creating the changing genderization, it did significantly alter the types of job responsibilities previously performed by both sexes.

The mechanization of accounting also coincided with a vast increase in the demand for information. As Chandler [1977, p. 109] points out, with the emergence of the large corporation, "a constant flow of information was essential to the efficient operation of these new large business domains." It was "bookkeeping, accounting, and statistical analysis...[that] allowed corporate managers to gain real control of their enormous organizations" [Strom, 1987, pp. 65-66]. The information they required was both financial and managerial, for "without a corresponding increase in the quantity and quality of management accounting information, these organizations would not have been able to capture the full potential gains from increased scale of operations" [Johnson and Kaplan, 1987, p. 8]. However, as Yates [1991, p. 120] observed: "This increased demand for internal information might have been curtailed by its high cost, except for some changes on the supply side of the equation." The change in the supply side was the adoption of new technological advances in the processing of information. It was the acceptance of typewriters, loose-leaf accounting systems, bookkeeping machines, tabulators, and other innovations to process information that allowed American businesses to greatly increase the availability and timeliness of financial and cost information. It also was the availability of these machines that allowed businesses to analyze the information in-depth.

By 1930, the initial phase of the mechanization of accounting was complete. The machines (e.g., calculators, accounting machines, tabulating machines) that would dominate the processing of accounting information for the next two decades had emerged [Cortada, 1993, p. 159]. There would be advances in accounting information processing devices; however, these changes would be primarily improvements, not major technological changes in the way information was processed. It would not be until after the World War II "that a comparably rapid period of change" would occur [Yates, 1994, p. 47]. Then, as had happened at the turn of the 20th century, a series of major technological innovations occurred (e.g., computers, copiers) and the

second phrase of the mechanization of accounting began. Thus, an important area for further research is to examine this second phase of mechanization and its effects upon the further development of accounting – its professionalization and the composition of its workforce.

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