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Frederick Winslow Taylor's contributions to cost accounting

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Abstract: This article is to introduce the cost accounting system that Frederick Winslow Taylor installed at the Tabor Manufacturing Company sometime in the 1890s. A comparative analysis between this system and Captain Henry Metcalfe’s *Cost of Manufactures* is also made in order to investigate their sources and influences. It is concluded that Taylor was a pioneer in many aspects of cost accounting, but his most important contribution was the development of the managerial approach that paved the way for modern managerial accounting.

In the later stages of the Industrial Revolution, businessmen were under increasing competitive pressure and were, therefore, striving to improve their managerial efficiency. It was largely in response to this drive for efficiency that Frederick W. Taylor (1856-1915) pursued the study of scientific management. Realizing that efficient managers require timely, complete, and accurate accounting information, he devoted a great part of his time to studying accounting in the 1880s. Following the widespread acceptance of scientific management, his methods of cost accounting became popular. This popularity lasted at least up until the 1920s. Accounting history has not done justice to Taylor’s contributions. This is probably because he had little interest in publicizing or claiming credit for the originality of his bookkeeping and costing systems. Nevertheless, an introduction to his work in cost accounting serves a valuable purpose. For one thing, it provides better understanding of his system of scientific management in general. It also helps identify Taylor’s role in the development of industrial accounting and thereby bridges a historical gap in an important period of modern industrialization.

Acknowledgement is made to Dean V. K. Zimmerman and Professor R. I. Dickey of the University of Illinois, Dean Emeritus Paul Garner of the University of Alabama, and the anonymous reviewers of this paper for their comments and encouragement. Great appreciation is extended to the Stevens Institute of Technology for the use of the Taylor Collection, without which this paper would have been impossible.
Using sources from the Taylor Collection of the Stevens Institute of Technology, this study describes Taylor's cost system that he installed for the Tabor Manufacturing Company in the 1890s, including his innovative procedure of expense distribution. According to one authority, Taylor “was the pioneer in the method of distributing shop expenses . . . through the medium of machine hour rates.”1 Our study will proceed from (1) a discussion of the features of Taylor’s cost accounting system, (2) an introduction to his cost reports, (3) an examination of his costing process, and finally to (4) an investigation of the originality of his cost system in comparison with that proposed by Captain Henry Metcalfe, the author of the first modern cost accounting book published in 1885.

Features of Taylor’s Cost Accounting System

It was during his first period of employment, at the Midvale Steel Company from 1878 to 1890, that Taylor already demonstrated his great interest in accounting, especially cost accounting. In a short paper found in his Midvale file, Taylor traced several distinctive features of his accounting system including: (1) monthly closing of the books; (2) monthly determination of unit costs; and (3) monthly accounting reports consisting of a balance sheet, an expense analysis sheet, a detailed cost sheet, and a detailed income account. Taylor maintained that these “are the features in which my system of accounting differs from ordinary commercial and manufacturing accounting, and, so far as I know no other system has as yet attempted to accomplish the above.”2

It is unlikely that Taylor installed any accounting system, as such, while he was still working with the Midvale Steel Company. However, a study of the accounting systems that he later installed in various manufacturing companies reveals little change in these distinctive features, apart from a clear separation of costing from bookkeeping functions. As a result of functional separation, the following features attributable to cost accounting can be identified:

1. Cost Accounting as a By-Product of Scientific Management. In his paper on his cost keeping system, Taylor started with the statement that cost department is a by-product of his system, under which “the same sets of forms used in recording Labor and the amount of Material needed in planning the work are now used for making the Cost.”3 Copley, Taylor’s biographer, also pointed out that “placing the cost accounting in the planning room, he [Taylor] made it a by-product of operations . . . the papers and slips he designed to plan and control operations became the documents on
which was based both the cost and production records." As a by-product, cost accounting is articulated with managerial planning and control on one hand, and serves as a link between the shop and the bookkeeping department on the other.

2. **Accuracy as the First Principle of Cost Accounting.** Taylor stated that an objective of costing is to establish a legal base for setting the price of an article and to determine the amount and source of profit for the different products manufactured. For this purpose, accuracy is considered the first principle of cost accounting. Even in his later years when he reconsidered the usefulness of cost information, Taylor maintained that "my experience has been, however, in industrial establishments, that keeping of costs with a reasonable degree of accuracy can be made a matter of very great profit to the company." Implicit in his system, cost accuracy indicates two things, namely, actual (historical) costing and proper distribution of overhead.

3. **Equitable Expense Distribution as the First Step in Obtaining Cost Accuracy.** Taylor noted that the first step in obtaining accuracy of cost is to determine an equitable method for distributing expenses. For an equitable expense distribution, expenses are divided into direct expense, construction, and overhead. The latter is divided into shop, general business, and selling expenses (to be described later). Like direct costs, overhead is considered legitimate and necessary to promote the progress of work in process towards being salable products. Thus each of the classes of the product bears a certain proportion of overhead, and the cost keeper must make out a distribution showing the proper proportion of overhead that each class of the product will have to bear.

**Cost Reports**

Being a by-product of the general system of scientific management, the cost department is responsible for preparing three monthly comparative reports that are to be sent to the administrative department so that steps can be taken to control the expenditures of the business. The comparative presentation of cost and profit figures exemplifies Taylor's management by exception principle, according to which the manager should receive only condensed, summarized, and comparative reports. These summaries are to be scrutinized by an assistant in order to highlight all exceptions to past averages before the report reaches the manager.

1. **Expense Analysis Sheet.** The expense analysis sheet gives a general outline of all the expenses, direct and indirect, incurred during the month. The direct expenses for all worked materials manu-
factured are divided into classes of products, such as grinding machines, molding machines, etc. For each of the expense accounts shown on the sheet, four figures are given on a comparative basis: this month, last month, average this year to date, and average last year.

It is important to note that a comparative presentation of various overhead distribution rates (i.e., the rates for distributing shop expense, general business expense, and selling expense, respectively) is also given on the expense analysis sheet as a means of performance evaluation. For example, a higher shop expense distribution rate could indicate an increase in shop expense and/or idle machine time. The procedures of determining and applying these rates will be analyzed in detail later.

2. *Worked Materials Finished Sheet.* The worked materials finished sheet shows mainly the unit cost of one lot in comparison with other lots. For each class, various expenses are presented in their separate columns including the total cost of the worked materials finished during the month, the unit costs of this lot and the last lot, the best cost in the past twelve months, and the best previous cost. To compare current unit cost with the best historical unit cost could reflect a rigid standard of performance evaluation. In addition, this sheet allows the bookkeeping department to record costs of goods manufactured and thus to update inventory accounts.

3. *Income Account.* The income account is separated into two parts. The summarized figures such as total sales, total manufacturing cost of merchandise shipped, total selling expense, total profit or loss on merchandise sold, total profit or loss from other sources, and net profit or loss are presented in the upper part. In addition, the totals of expenses, orders received, credits allowed against accounts receivable, and the manufacturing cost of orders for merchandise finished (minus transfer-in costs) are presented in the memorandum record section.

In the lower part, the income account shows the profitability of both worked materials and stores sold. The total worked materials sold are further itemized according to the classes of products. For each class, selling price and total costs (including manufacturing and selling expenses) are shown and the resulting profit is determined. Finally, the ratio of profit to sales is computed as an indicator of relative profitability. All the above figures of this month are to be compared with those of last month, the total for this year to date, and the total for last year, so that the performance of individual products can be comparatively evaluated against their respective historical records.
Costing Process

The above described cost reports are outputs of a comprehensive costing process designed to assure accurate cost determination and equitable expense distribution. As indicated in Figure 1, costs recorded in the shop, such as wages, stores, and worked materials, are first entered on cost collecting cards. At the end of the month, these cards are sorted and totaled, and other cost data kept in the bookkeeping department are obtained. The total amounts of various cost categories are then computed and entered in (1) the detail cost sheet, (2) the detail analysis of expense sheet, and (3) the sheet of expense distribution. Each phase of this costing process is described in the sections to follow.

1. The Cost Collecting Cards. A separate cost collecting card is made out for each cost factor recorded in the shop such as wages, stores, or worked materials used. On each card is a symbol designating the account to which the cost will be charged. These symbols are derived from Taylor's well-known mnemonic classification system in which a combination of letters and numbers is used to specify a worked material account. For example, the symbol GD20 indicates a charge against the class of worked material G, division D of this class, and the twentieth lot (or batch) of this class that is being manufactured. Likewise, three letters are used to represent an indirect expense account. The first letter shows the class of the department, the middle letter the name of the department, and the final letter the nature of the expense. An example of such symbolic presentations of shop expense accounts is shown below:

D.—MANUFACTURING DEPARTMENTS: When any letters follow the letter D, they indicate a charge AGAINST some one of the various MANUFACTURING DEPARTMENTS, and should be classified as SHOP EXPENSE (DIRECT).

DM.—MOTOR DEPARTMENT: The main body of the Machine Shop in which motors are made.

DMA.—FOREMEN, GANG BOSSES, CLERKS, AND INSPECTORS, whose work cannot be charged to a particular manufacturing order.

DMB.—ALL MISCELLANEOUS LABOR that cannot be charged directly to a particular manufacturing order.

DMC.—STATIONARY FIXTURES, such as benches, cupboards, shelving and partitions that are fixed or immovable.
Figure 1
Costing Process Under the Taylor System

Cost Collecting Cards
(Shop Records)

Labor
Stores
Worked Materials

Direct Manufacturing Expenses

Detail Cost Sheet

Worked Materials
Construction

Indirect Manufacturing Expenses

Detail Analysis of Expenses

A. Auxiliary Depts.
B. Business Depts.

allocated Overheads

General Journal and Register of Accounts Payable

(Bookkeeping Records)

Rents
Insurance

etc.

Indirect Manufacturing, Business and Selling Expenses

Expense Distribution

B Rate

C Rate

DM Rate

Other Cost Information
With such a comprehensive mnemonic symbol system, the recorded cost figures are easily processed, and the chance for classification error is greatly reduced.

At the end of the month, the cost collecting cards are gathered and sorted, and the costs are classified, totaled, and entered on the respective cost sheets. For cost classifications, the following cost concepts are specified:

a) Direct Expense—that which is directly chargeable to salable product.

b) Construction—that which is chargeable for work that will increase the value of the plant. (It is, in a way, direct expense, as this is a sale of product to the firm for its own use.)

c) Indirect or Overhead Expense—that which is not directly chargeable to a salable product or construction. In every manufacturing plant, indirect or overhead expenses can be further separated into:
   (1) Shop Expense—that which attaches itself to the use or running of the machine in the plant.
   (2) General Business Expense—that which is incurred by the business or administrative end and which has no connection with the manufacturing end.
   (3) Selling Expense—that which is necessary for carrying out sales in addition to manufacturing costs.

Taylor developed an innovative flow chart to facilitate cost classification. A modified version of this flow chart is shown in Figure 2, for which cost data are either derived from cost collecting cards of the shop, or obtained from the records of the bookkeeping department. The third column of the chart shows the accounts to be charged with their respective symbolic presentations.

2. *The Detail Cost Sheet.* The detail cost sheet is essentially a job order cost sheet. A separate sheet is prepared for each class of worked material or construction. This sheet is divided into columns in which the costs incurred monthly are recorded. Total costs are separated by rows into wages, general business expense, shop expense, drawing and pattern expense, stores, worked material from stores, and miscellaneous. Both the shop and the general business expenses are apportioned to the specific job order on the basis of their relative apportionment rates.

Taylor regarded actual cost apportionment as a special feature of his bookkeeping system. As this feature is found in the books of Tabor Manufacturing Company, the last month's rates are used to
Figure 2
Flow Chart of Cost Classification

Cost Data

Is the cost for work done on a product to be sold? yes

Worked Materials

G. Grinding Machines
L. Taylor System
M. Molding Machines
N. Miscellaneous
P. Repair Work
R. Milling Cutters
T. Saws
V. Parts and Accessories

X. Part Construction:
   Fixtures, Apparatus,
   Tools, etc.
Y. Machinery and Motive
   Power such as shafting,
   piping, and all
   machinery for operation
   by hand and power

Does the work done increase the permanent value of the plant? yes

Construction

A. Auxiliary Departments—
   Shop Expenses (Auxiliary)*
B. Business Department—
   General Business Expenses
C. Selling Department—
   Selling Expenses
D. Manufacturing Departments—
   Shop Expenses (Direct)*
E. Drawing and Pattern
   Department—Drawing
   and Pattern Expenses

no

Expenses

* Direct shop expenses are those indirect manufacturing costs charged directly to manufacturing departments, in contrast with auxiliary shop expenses which are charged first to auxiliary departments and then transferred to manufacturing departments.
apportion both the shop and the general business expenses. This use of historical rates can be justified on the grounds of needing timely information. According to Taylor, bookkeeping and costing systems should be so arranged that a daily statement could be readily copied from the books showing the summary of all the transactions of the previous day. By using historical rates, one could provide updated cost information right after the completion of a specific job order at any time during the month.

On the detail cost sheet, the apportionment rates of general business and shop expenses for the month are presented along with their respective application bases: namely, "wages" and "machine hour x cost number." The sheet also shows the date that the order is finished, total quantity produced, and the unit cost of the order.

3. **Detail Analysis of Expenses.** While the detail cost sheet of worked materials is in part a subsidiary statement of the worked materials finished sheet, the detail analysis of expense sheet is a supplementary statement of the expense analysis sheet. For every department in which overhead expenses occur, a sheet is prepared to record costs according to Taylor's mnemonic coding system. A part of the sheet presenting the costs incurred during one month is shown in Table 1. On another part of the sheet the total amount of the month is compared, account by account, with (1) the total amount of last month, (2) average per month this year to date, (3) average per month for corresponding period last year, and (4) average last year. It is interesting to note that, even though Taylor has been generally regarded as a pioneer of standard costs, standard cost per se has not been found in any of his cost reports.

<table>
<thead>
<tr>
<th>Name or Symbol of Account</th>
<th>Wages</th>
<th>Salaries</th>
<th>Total Wages &amp; Salaries</th>
<th>Stores</th>
<th>Misc.</th>
<th>Materials</th>
<th>Total This Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM</td>
<td>$1,000</td>
<td>$500</td>
<td>$1,500</td>
<td>$300</td>
<td>$50</td>
<td>$240</td>
<td>$2,090</td>
</tr>
<tr>
<td>DMA</td>
<td>300</td>
<td>120</td>
<td>420</td>
<td>80</td>
<td>30</td>
<td>100</td>
<td>630</td>
</tr>
<tr>
<td>DMB</td>
<td>400</td>
<td>200</td>
<td>600</td>
<td>120</td>
<td>10</td>
<td>80</td>
<td>810</td>
</tr>
<tr>
<td>DMC</td>
<td>300</td>
<td>180</td>
<td>480</td>
<td>100</td>
<td>10</td>
<td>60</td>
<td>650</td>
</tr>
</tbody>
</table>

4. **Expense Distribution.** The whole process of overhead expense apportionment is shown on the expense distribution sheet. Also shown is the computation of the three basic rates, namely: B (general business expense), C (selling expense), and DM (shop expense) rates. To prepare this sheet, the costs in the accounts shown in
Figure 2 and the costs of stores issued for sales are copied from the detail cost sheets and some other original records, such as the register of accounts payable and the general journal.

Each of the cost accounts is presented in a separate column on the sheet. The following cost factors are then shown in rows:

- Wages and Salaries
- Stores Used
- Worked Materials Used
- Chargable to Expenses other than Production
- Miscellaneous Expenses
- Accounts that are Pro-Rated or Charged through a Journal Entry
- Amount to be Added to or Subtracted from General Business and Direct Shop Expenses

The above "accounts that are pro-rated or charged through a journal entry" include advertising and interest expenses. The above "amount to be added to or subtracted from general business and direct shop expenses" is considered an adjustment for last month's under- or over-applied overhead, i.e., the difference between actual overhead and the overhead applied to products based on the previous month's rates.

An illustration of the whole process of expense distribution is presented in Table 2 using hypothetical figures. In this table, the distributable expense accounts are rearranged in the order of distribution, and no difference between the distributed and the actual costs for either the general business or shop expense is assumed.

Table 2 shows that after the costs have been summarized and totaled, the following seven-step distribution process begins:

**Step 1.** Apportion drawing and pattern expense (E). One half of this expense is to be apportioned to the general business expense (B), and the other half to worked materials (G, L, M, N, P, R, T, and V) according to the related work done on job orders.

**Step 2.** Partially apportion selling expense (C), general business expense (B), and direct shop expense (D). Each of these expense accounts is to be apportioned to stores sold (S) at a rate of 5% of the cost of stores issued for sale.

**Step 3.** Apportion general business expense (B). This expense is to be apportioned to construction (X and Y) and worked materials (G, L, M, N, P, R, T, and V) by multiplying the wages and salaries charged against each of these accounts by last month's B rate.
Table 2

Stepwise Expense Distribution Schedule Under the Taylor System

<table>
<thead>
<tr>
<th>Expense Accumulation</th>
<th>E (Drawing &amp; Pattern Expense)</th>
<th>B (General Business Expense)</th>
<th>X (Part Construction)</th>
<th>A (Auxiliary Shop Expense)</th>
<th>D (Direct Shop Expense)</th>
<th>C (Selling Expense)</th>
<th>Y (Construction)</th>
<th>W* (Worked Materials)</th>
<th>S (Stores Issued For Sale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wages &amp; Salaries</td>
<td>$500</td>
<td>$500</td>
<td>$200</td>
<td>$500</td>
<td>$500</td>
<td>$400</td>
<td>$400</td>
<td>$400</td>
<td>$500</td>
</tr>
<tr>
<td>Stores Used</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Worked Materials Used</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>200</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>50</td>
<td>30</td>
<td>350</td>
<td>50</td>
<td>20</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>200</td>
</tr>
<tr>
<td>Pro-Rated Charges</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Adjustments</td>
<td>—</td>
<td>20</td>
<td>—</td>
<td>—</td>
<td>30</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Total Before Distribution</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$1,000</td>
</tr>
</tbody>
</table>

Steps of Expense Distribution

1. (E) to (B) & (W) (1,000) 500 — — — — — 500 —
2. (B), (D) & (C) to (S) (50) — — (50) (50) — — 150 —
3. (B) to (X) (Y) & (W) (1,450) 290 — — — 560 580 — —
4. (X) to (A) & (Y) (1,290) 645 — — — 645 — — — —
5. (A) to (D) (1,645) 1,645 — — — — — — — —
6. (D) to (Y) & (W) (2,595) — 595 2,000 — — — — —

Total After Distribution
$0 $0 $0 $0 $0 $0 $950 $2,820 $4,080 $1,150

Cost of (W) Shipped $3,000

Total of (W) Sold
$0 $3,950

*For simplicity W is used to indicate all of the worked materials including G, L, M, N, P, R, T, and V. (See Figure 2 for specifications.)
Step 4. Apportion part construction (X). One half of this account is apportioned to auxiliary shop expense (A), and the other half to construction (Y).

Step 5. Apportion auxiliary shop expense (A). The total amount of this account is to be transferred to direct shop expense (D).

Step 6. Apportion direct shop expense (D). This expense is apportioned to construction (Y) and worked materials (G, L, M, N, P, R, T, and V) by multiplying relative cost of machine time for each account by last month’s DM rate.

Step 7. Apportion selling expense (C). This expense is apportioned to worked materials sold by multiplying the cost of each worked material shipped by current C rate.

When the first six steps of expense distribution are completed, the sheet will show the total costs of: (1) construction, (2) various worked materials, (3) stores sold, and (4) selling expense. The last step is to apportion selling expense by adding the distributed selling expenses to the cost of worked materials shipped in order to obtain the total cost of merchandise sold.

The general business, selling, and direct shop expenses are applied by the use of B, C, and DM rates, respectively. The applications of these three rates are introduced as follows:

a) **General Business Expense:**
   General Business Expense Apportioned = Relative Wages and Salaries x B Rate
   Where: $B\ Rate = \frac{\text{General Business Expense}}{\text{Sum of Wages and Salaries for all of the Construction and Worked Materials}}$

b) **Selling Expense:**
   Selling Expense Apportioned = Relative Cost of Worked Materials Shipped x C Rate
   Where: $C\ Rate = \frac{\text{Selling Expense}}{\text{Sum of Costs of the Worked Materials Shipped}}$

c) **Direct Shop Expense:**
   Direct Shop Expense Apportioned = Relative Cost of Machine Time x DM Rate
   Where: $DM\ Rate = \frac{\text{Direct Shop Expense}}{\text{Sum of Relative Costs of Machine Time}}$
Relative Cost of Machine Time = Machine Time \times \text{Relative Cost Number}

Machine Time = \text{Total Time of a Machine Worked on Jobs}

\text{Estimated Operating Expenses}

Relative Cost Number = \frac{\text{Allocated to the Machine}}{\text{Expected Machine Time of the Machine}}

S. Paul Garner concisely summarized Taylor's cost number system in his study of the evolution of cost accounting. This system was developed by Taylor as a means of distributing shop expense. To illustrate the whole process of determining and applying relative cost numbers and the DM rate, an example is presented in Appendix A.

Originality of the System and its Influence

Taylor's cost accounting system is characterized by the use of: (1) a cards system of cost collection, (2) a mnemonic system of cost classification, (3) the machine-dollar-hour method of overhead distribution, and (4) the comparative approach to cost reporting. To some extent, this system is close to Metcalfe's *Cost of Manufactures* (1885), which has been generally recognized as the first modern book on cost accounting. In view of the similarities of the two systems proposed by these two pioneers living in the same period, it seems appropriate to present a comparative analysis in terms of the four characteristics stated above.

1. Cards System. Garner pointed out that Metcalfe made several recommendations for a looseleaf recording arrangement, which was one of the first suggestions along those lines. The use of cost cards was a part of this arrangement, in which cards were used to record workshop expenses, such as service (labor) and material. Each card was limited to a single entry so that the cards could be sorted according to the amount and type of service or material used on each order. In 1886, at a meeting where Metcalfe presented his paper on this subject, Taylor commented that "we have tried it [the cards system], particularly in our works [the Midvale Steel Company], for nearly ten years." Furthermore, in his book, *Shop Management*, Taylor stated that "the writer [Taylor] appreciates the difficulty of this [Metcalfe's invention of the complete cards system] undertaking, as he was, at the same time, engaged in the slow
evolution of a similar system in the Midvale Steel Works.\textsuperscript{14} These statements left no doubt that Taylor's system had been developed without any direct influence from Metcalfe.

Metcalf admitted that "the use of cards in workshops as well as in libraries is no new thing."\textsuperscript{15} Evidently, neither Taylor, nor Metcalfe, was the first to introduce the cards system to the shop. Nevertheless, Metcalfe appears to have been the first to use cards as an integral part of his costing system, in which both the service and the material cards were designed for multiple uses. For example, the same material card could be used to record any kind of material transactions; such as, procurement, insurance, return, transfer, etc. As a result, the card was necessarily complex as it had to provide spaces for all foreseeable entries. In contrast, Taylor employed different cards for different purposes. The cost collecting card was designed solely for the recording and summarizing labor, stores, and worked materials used in shop operation. It was an innovative device to increase the efficiency of manual data processing and to reduce clerical error.

2. Mnemonic System. Metcalfe used symbols for both service and material costs and noted:

\textit{The idea is to keep a strict account with each job by such a simple and invariable method that the same work will always be called by the same name, and the resulting cost may be readily analyzed.}\textsuperscript{16}

For any service or material cost incurred, Metcalfe used a set of symbols to identify the account (or the output) to be charged. He defined these symbols as follows:

\begin{itemize}
  \item S-O. — stands for Shop-Order.
  \item C. — stands for Characters of expenditure such as P (plant), W (work), A (attendance) and T (tools).
  \item O. — stands for Object worked on represented by a combination of letters and figures.
  \item N. — stands for the Number of the operation.\textsuperscript{17}
\end{itemize}

For example, the cost incurred could be charged to:

\begin{itemize}
  \item S-O. — 617
  \item C. — P
  \item O. — A.31
  \item N. — 313
\end{itemize}
The most special feature of this system is the so-called "character of expenditure," (C). To explain this classification scheme, Metcalfe presented a tree diagram specifying the following three steps:

a) To classify service and material costs into plant (P) and work (W).
b) To separate work (W) into attendance (A) and productive work (W).
c) To separate productive work (W) into tools (T) and operative work (W).¹⁸

"The main difficulty" of this scheme, noted Metcalfe, "lies in expressing the idea that work, though capable of subdivision, retains its character unaltered in the undivided remainder."¹⁹ This difficulty seems to be a result of his unsuccessful attempts to separate direct and indirect expenses on one hand, and to allocate indirect expenses to products on the other. No such difficulty is indicated in Taylor's flow chart (see Figure 1), in which the expenses are clearly distinguishable and the classification of cost objects is comprehensive and operational. However, it is hard to tell whether or not Taylor's flow chart was influenced by Metcalfe.

While the origin of Metcalfe's tree diagram and Taylor's flow chart is in question, the bases of their symbolic systems is apparent. In 1881, Oberlin Smith, a close friend of Taylor, presented a paper entitled "Nomenclature of Machine Details" at the American Society of Mechanical Engineers. Metcalfe utilized it and even reprinted it in his book; because, in his own words, "I cannot do any better than transcribe his article entire."²⁰

In the meantime, as Taylor began to split up labor operations according to their elements, he was confronted by the need for a systematic classification scheme. After several unfruitful attempts, he worked out a system to meet his need. Like Metcalfe, however, he acknowledged his appreciation of "the mnemonic system of order numbers invented by Mr. Oberlin Smith and amplified by Mr. Henry R. Towne."²¹

Although evolved from the same source, Taylor's system is more sophisticated than Metcalfe's. More importantly, under Taylor's system, the classification scheme of costs was integrated into the general system of management. The symbols were used not only for costing, but also for planning and control. In this regard, Taylor's contribution and influence have been recognized elsewhere.²²

3. Overhead Distribution. Metcalfe gave relatively little attention to the distribution of overhead expenses. Nevertheless, he demon-
strated several distribution methods, emphasizing the one that follows:\textsuperscript{23}

Given: \( F \) = Fixed charges
\( V \) = Variable charges
\( D \) = Numbers of ‘direct days’ worked in the period

Then: \( C \) = Cost factor (i.e., apportionment rate)
\[ C = \frac{F + V}{D} \]

It is noted that this method, a forerunner of the direct labor hour method, was attributable to William Sellers and Company (as acknowledged by Metcalfe in both his book and his paper mentioned above).\textsuperscript{24}

Apparently, William Sellers and Company pioneered the idea of shop expense distribution in the 1880s. During most of the time that Taylor was with Midvale, Mr. William Sellers, a family friend of Taylor, was the president of both Midvale and Sellers. This connection enabled Taylor access to otherwise secret accounting methods including the one described by Taylor and summarized below:\textsuperscript{25}

Given: \( A \) = summation of value hours of all machines in the department where: value hours is the product of the machine’s value and its average working hours of the past five years
\( D \) = total expense of the period

Then: \( E \) = cost (or wage) per dollar hour of machine
\[ E = \frac{D}{A} \]

It seems apparent that the first Sellers method that Metcalfe utilized was a forerunner of the second Sellers method that Taylor described; and that the second Sellers method was, in turn, the forerunner of Taylor’s machine dollar hour method. Therefore, both Metcalfe and Taylor owed much to Sellers for their methods of shop expense distribution.

4. Cost Reporting. Unlike the above three characteristics, little similarity is found between Metcalfe’s and Taylor’s cost reporting systems. This is mainly because Metcalfe’s experience was limited to an Army arsenal where costing systems were designed for property accountability as required by laws and ordinance regulations. Although Metcalfe did attempt to apply his system to private shops, the proposed cost analysis sheets were merely a summary of direct and indirect costs and an allocation of these costs to departments. There was no information about unit costs, nor was there any indication of production efficiency.\textsuperscript{26} This kind of reporting system could not meet the needs of private industry as industry grew and became
highly competitive during the recession in the last quarter of the 19th century.

It was under these circumstances of recession and competition that Taylor developed his system of scientific management, of which the proposed timely, detailed, and comparative reports were a part. Copley pointed out that “more important still, his [Taylor’s] system called for monthly reports, and reports presented in such a way as, not only to be readily intelligible to the company’s officer, but also to lead them to realize the significance of the figures.” It appears that Taylor was a pioneer whose extensive comparative statements paved the way to modern variance analysis.

Concluding Remarks

The foregoing suggests that many aspects of Taylor’s costing system were his own creation. However, he never claimed the credit of their originality, nor did he ever claim to be an accountant. He was an industrial engineer interested in the organization of a shop. To a shop organizer, the most important function of costs is to aid in securing better management and greater efficiency. Indeed, Taylor was among the first shop organizers to realize that efficiency could and should be “checked” by means of accounting. Furthermore, Taylor’s concern with efficiency was not only mechanical (i.e., output/input ratio), but also commercial (i.e., benefit/cost ratio). In his first paper, read before the American Society of Mechanical Engineers, he compared the efficiency of two gases in the steel-making process and found that the one that yielded the greatest heat per unit did not yield the greatest heat per dollar. It was while in pursuit of the greatest commercial efficiency that cost accounting was conceived of being an indispensable part of management.

Apparently, Taylor’s approach to cost accounting was managerial. In 1909 he noted: “Fifteen to twenty years ago I looked upon a correct cost system as one of the most important among the various elements of management.” Evidence shows that by 1909, he shifted his emphasis from cost accounting to daily supervision as a means of cost reduction. Nevertheless, he still considered cost accounting as a necessary tool, given that an “active, practical, and money-saving use of the cost figured” could be assured. In other words, it was the effective managerial use of the output of cost accounting with which Taylor concerned himself. This concern reaffirmed his proposition that usefulness should be the primary criterion to justify a cost or any other accounting system.
FOOTNOTES

1Hathaway.
4Copley, Volume I, p. 369.
6Copley, Volume II, p. 376.
7Taylor, Unpublished Manuscript, C., p. 3.
9Taylor, 1911, p. 126.
10Garner, pp. 196-197.
11Chatfield, p. 159.
12Garner, p. 92.
16Metcalfe, p. 97.
17Metcalfe, pp. 97-105.
18Metcalfe, pp. 104-105.
19Metcalfe, p. 102.
20Metcalfe, p. 105.
21Taylor, 1911, p. 201.
22Copley, Volume I, p. 355.
23Metcalfe, p. 338.
24Metcalfe, p. 24, p. 349., See also Garner, p. 178.
25Taylor, Unpublished Manuscript, B.
26Metcalfe, pp. 336-337.
28Evans, p. 7.
29For a discussion of various efficiency concepts and Taylor's perception, see Haber, pp. 11-14. See also Taylor, 1886 B.

BIBLIOGRAPHY

Hathaway, H. K. Correspondence with Copley, Frank B. April 18, 1921. The Taylor Collection. Hoboken, New Jersey; The Stevens Institute of Technology.
Metcalfe, Captain Henry. The Cost of Manufacturers. 3rd ed. New York: John Wiley & Sons, 1907. The first edition was published in 1885. There is no substantial
change between these two editions. His paper, "The Shop-Order System of Accounts," (1886) was reprinted as the Appendix of this book (1907): pp. 311-353.


Appendix A
Determination and Application of DM Rate — An Illustration

Given the following information:

1. Estimated conditions for the year.
   a) Operating Expenses:

<table>
<thead>
<tr>
<th>Expense Account</th>
<th>Estimated Cost for the Year</th>
<th>Base of Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Expense</td>
<td>$30,000</td>
<td>Space Occupied</td>
</tr>
<tr>
<td>Machine Expense</td>
<td>40,000</td>
<td>Acquisition Cost</td>
</tr>
<tr>
<td>Power Expense</td>
<td>5,000</td>
<td>Horse Power of Machine</td>
</tr>
<tr>
<td>Total</td>
<td>$75,000</td>
<td></td>
</tr>
</tbody>
</table>

b) Machine in Operation:

<table>
<thead>
<tr>
<th>Machine</th>
<th>Cost of Acquisition</th>
<th>Space Occupied</th>
<th>Horse Power</th>
<th>Expected Machine Time for the Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$60,000</td>
<td>2,500 s.f.</td>
<td>8,000 h.p.</td>
<td>9,000 hrs.</td>
</tr>
<tr>
<td>B</td>
<td>100,000</td>
<td>5,000</td>
<td>12,000</td>
<td>12,000</td>
</tr>
</tbody>
</table>

2. Actual conditions for a month.
   a) Actual Machine Time:

<table>
<thead>
<tr>
<th>Worked Materials</th>
<th>Actual Machine Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>200 hrs.</td>
</tr>
<tr>
<td>M</td>
<td>300</td>
</tr>
<tr>
<td>N</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>600 hrs.</td>
</tr>
</tbody>
</table>

b) Actual Shop Expense: $11,600

Tables A and B show the process of determining and applying relative cost numbers and DM rates. Both the estimated operating expense and the expected machine time are based on ideal conditions and include a period of one year. The result shows that the rate per hour for the service of Machine A is $3 and of Machine B is $4. Thus Machines A and B are assigned the cost numbers 3 and 4, respectively, which represent their service charges. Based on these cost numbers, $2,800 of the total shop expense is apportioned to worked material L, $5,800 to M and $3,000 to N.
### Table A

#### Schedule of DM Rate Determination

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$10,000</td>
<td>$15,000</td>
<td>$2,000</td>
<td>$27,000</td>
<td>9,000 hrs.</td>
<td>$3</td>
<td>12,000</td>
<td>$1,800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>20,000</td>
<td>25,000</td>
<td>3,000</td>
<td>48,000</td>
<td>4,000 hrs.</td>
<td>4</td>
<td>4,000</td>
<td>4,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$30,000</td>
<td>$40,000</td>
<td>$5,000</td>
<td>$75,000</td>
<td></td>
<td></td>
<td></td>
<td>$5,800</td>
<td>$11,600</td>
<td>2</td>
</tr>
</tbody>
</table>

1. Estimated building, machine, and power expenses for the year are to be allocated on the bases of space occupied, acquisition cost of machine, and the machine horse power, respectively.

2. The determined cost numbers are to be applied for the year.

3. The determined DM rate is a monthly rate applied to the specific month.
# Table B

**Shop Expense Distribution**

**For the Month**

<table>
<thead>
<tr>
<th>Material</th>
<th>Machine Time Used</th>
<th>Machine Time Cost$^1$</th>
<th>Shop Expense Distributed$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Machine A (1)</td>
<td>Machine B (2)</td>
<td>Total (3)</td>
</tr>
<tr>
<td>L</td>
<td>200 hrs.</td>
<td>200 hrs.</td>
<td>400 hrs.</td>
</tr>
<tr>
<td>M</td>
<td>300</td>
<td>500</td>
<td>800</td>
</tr>
<tr>
<td>N</td>
<td>100</td>
<td>300</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>600 hrs.</td>
<td>1,000 hrs.</td>
<td>1,600 hrs.</td>
</tr>
</tbody>
</table>

Note:  
1. Machine time cost is the product of the cost number of a machine and the machine time used during the month.  
2. Shop expense distributed is the product of the machine time cost and the DM rate of the month.