

# HENRY METCALFE

Henry C. Metcalfe was a captain in the U.S. Army Ordnance Department, having been graduated from West Point in 1868. As superintendent of several arsenals he developed and applied the methods which he describes in his book, *The Cost of Manufacturers and the Administration of Workshops, Public and Private*.

It seems highly unusual that a career army officer at that time would be so interested and concerned with costs and administration, and that he would be able to write so prophetically about them. He was convinced that there were many variables of administration which could be applied in a great number of cases and which could be found by recording and comparing observations. He was interested in the control of costs and of materials and suggested ways of accomplishing these controls through the flow of information and assignment of responsibility.

Metcalfe presented a paper entitled, "The Shop Order System of Accounts" at the same A.S.M.E. meeting in 1886 at which Henry Towne presented his paper on "The Engineer as an Economist" (see following excerpts). Metcalfe's paper suggested a plan of organization which divided the work between the "workshop" and the "office"—an idea which seems to be equivalent to Taylor's separation between planning and performance. Taylor was present at the meeting and participated in the discussion that followed the presentation of both papers during which he indicated that he had been working on a plan similar to Metcalfe's during the previous ten years at the Midvale Steel Company. Reprinted below is the introduction to Metcalfe's book which outlines his basic approach.

## Introduction to the Cost of Manufactures

It may be stated as a general principle that while Art seeks to produce certain effects, Science is principally concerned with investigating the causes of these effects.

Thus, independently of the intrinsic importance of the art selected for illustration, there always seems room for a corresponding science, collecting and classifying the records of the past so that the future operations of the

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Reprinted with permission from Captain Henry Metcalfe, The Cost of Manufacturers and the Administration of Workshops, Public and Private, Chapter II, pp. 15-24, Published by John Wiley & Sons, New York, 1885.

art may be more effective.

The administration of arsenals and other workshops is in great measure an art, and depends upon the application to a great variety of cases of certain principles, which, taken together, make up what may be called the science of administration.

These principles need not be formulated, nor even recognized as such, and they vary with the conditions which call them forth; so that while their essence may be the same, the special rules of conduct derived from them may, in various circumstances, be widely different. Yet, for each set of conditions their character is the same, and in all they constitute what is known as our experience.

Some men have the gift of so arranging their experience that it is always ready with an answer to whatever question new conditions may propose. But such men are rare and are seldom found in subordinate positions. In any case their knowledge goes with them when they depart, instead of remaining, as it should, and in great measure might do, as one of the most valuable earnings of the business in which it was acquired.

For this purpose it should be formulated, if a way were found, so that its record might be plain to whoever had the right to read it.

Now, since the operations of good administration are in their nature gradual, and for their successful issue depend rather upon uniform attention to their progress than upon occasional violent efforts to adjust them to the current of affairs, it will be seen that the most useful teachings are those gained from a continuous record of events; for these may be expected to recur with time, while great catastrophes can seldom be provided for, or, in fact, prevented, better than by the daily discharge of the duties pertaining to direction.

If there be a science correlative to the art of administration, it must, like every other physical science, be founded on the comparison of accumulated observations.

Since the accuracy of the knowledge sought can be no greater than the exactness of the data from which it is derived, in order to make a proper comparison it is important that the observations be as free from error as possible, and that they be measured by a common standard.

Errors of observation may be divided into two general classes; the instrumental, and those due to the personal bias

of the observer; the former referring to the standard itself, and the latter to the application of the standard and the record of the measurement.

Whatever be the standard of measurement, it suffices for comparison if it be generally accepted, if it be impartially applied and if the results be fairly recorded.

In regard to personal errors of observation it is generally admitted that truth is most nearly approached when, having observers of equal goodness they are most numerous, and when they individually know least of the immediate consequences of what they report.

Hence the most truthful records will be had when each observer's share of the work is reduced to a minimum; for the number of observers being the greatest possible, each one will have so much the less to do, and being, therefore, better able to do his share, each will feel more responsible for the accuracy of the aggregate result and will besides be most likely to have his bias neutralized by the opposing tendencies of the other observers.

Now, efficiency being admitted, the excellence of an administration is universally measured by its cost.

This cost is composed of the sum of the costs of each of its actions; so that to properly value an administration we require to know both what it has done and the cost of doing it.

The greater the detail of this knowledge the greater its value; for the more exactly then can causes of past expenditure be traced back from their effects, and the more certainly may estimates of future cost be based on what is already known and established.

Success in manufacturing depends almost entirely upon accuracy of estimate.

The extent to which the analysis of cost and product may be carried need only be limited by the expense of making it or by the power of comprehending and comparing the results which it affords.

To utilize such an examination two processes are necessary, one inductive and the other deductive; for the product and its cost having been analyzed as far as convenience will permit, the resulting items must be recombined into forms admitting of a comparison from which may be deduced certain general rules for the future conduct of affairs.

Then will Experience take definite form and become indeed a teacher; thus Science be the handmaid of the art.

It is the object of this book to show how the cost of administration may be determined, both in gross and the remotest details, by such impersonal, invariable means that their record may be looked upon as being as nearly absolutely true as that of any other similarly extended series of observations.

Together with this comes a method of administration which reduces its labors to a minimum and yet immensely increases its scope, by recording, in whatever minuteness of detail may ever be required, full information as to services performed and as to material in all stages of manufacture, received, expended and remaining on hand.

Furthermore, its records will be made continuously from day to day, it may be from hour to hour, so that, being disposed of in detail, the turmoil and anxiety of periodical accounting will be unknown.

Few will deny the advantages of such a scheme; many will consider it utopian....

Every transaction with material that could be imagined has been traced to its conclusion by certain uniform rules, every anomaly being considered due to some intrinsic defect in the rules, which being eliminated, they were re-applied until further exceptions seemed impossible.

These rules were:

1. To reduce all writing to a minimum by the use for all purposes of the same general kind of one comprehensive tabular form, completed by a simple symbolic notation and certified by characteristic punch marks.

2. To maké each card a representative unit, capable of combination with others, according to any one or more of their common features; thereby attaining by the mechanical operation of sorting, the results otherwise achieved only by the tardy and laborious processes of bookkeeping.

3. To avoid transcription by providing that the same card shall be dealt with by as many consecutive agents as require it, thereby saving time and preventing errors in copying.

4. For the preservation of the cards and their record to trust rather to their equivalency with the units they represent, and with which they are convertible, than to mere rules of conduct concerning their employment; and so, by depending upon the cards for all the temporary purposes for

which books are now employed, to make books unnecessary except for final records.

5. To disregard the number of cards consumed by using them singly as an immediate record of all transactions deemed worthy of note, in view of the ultimate saving in labor and the absolute avoidance of confusion due to their unrestricted employment for such purposes.

6. To render entirely unnecessary the removal to the workshops or storehouses of any records or correspondence pertaining to the external relations of the arsenal.

7. To make the cards so full of meaning that no one understanding the principles on which they were based could ever go amiss in using them; that no special rules should be required for special cases, but that the part of each user should be fixed by evident principles of general application; in a word, to make the cards suffice for all purposes to all who had to use them.

The departures from the letter of the Regulations are so slight that in view of the concluding portion of par. 48, Property Regulations, 1877, p. 14, it seems not unreasonable to hope that they may be condoned.

The principles on which the system is founded are so broad that though it may fully comply with every precaution required of trustees of public property, it seems none the less applicable to the smallest shop in the land. But it would not be necessary, nor even advisable, to follow their application in every case to the extent required by the uses of the Ordnance Department. However far this may be done, it seems plain to me that the results which those who have charge of workshops seem universally to desire can be attained in no other way so economically as by this Mechanical Book-keeping.

It seems as proper for a reformer to show that a change is needed as to explain the changes he proposes to make; so wholesome is conservatism, that a new thing should not only be shown to be good, but that which it proposes to replace should be proved to be relatively bad. I have been forced, therefore, not only to criticize much in our present methods that seemed bad; but I have also, for want of other sources of general information, been obliged to explain that which I criticized. I need hardly say that my only object has been to make evident the evils from which not only we of the Ordnance Department have been suffering, but which, in some form, few of the private workshops of my acquaintance have escaped.

Having been compelled to do the greater part of this work thousands of miles away from, and years after leaving the scenes and circumstances most in mind, it is to be expected that many inaccuracies will be found in my statements of details. Still I believe that it is all true in spirit, if not of all of the places considered, at least of some of them. It is hard to select examples which shall be typical and not appear invidious or exaggerated; but I have done my best to make sure that all the examples shall be at least possible and as true to the facts as my own memory and the concurrent testimony at my command would permit.

The use of cards in workshops as well as in libraries, is no new thing; others besides the men with whom I have worked have been driven to appreciate their advantages and have turned them to more or less account. But the administration of private workshops is in general limited by responsibilities so immediate and self-contained, that I doubt whether there are any where as strict an accounting has been made as is required by our trusteeship of public property. Indeed, had it not been for the rigorous exactions of the Ordnance Regulations, I doubt whether I would have been led to formulate a scheme as comprehensive as I hope this will be found. It is their spirit which has led me through this self-imposed task, and it is in extending its influence that I find my reward.