But what is, perhaps, of more importance still, the rate-fixing department has shown the necessity of carefully systematizing all of the small details in the running of each shop; such as the care of belting, the proper shape for cutting tools, and the dressing, grinding, and issuing same, oiling machines, issuing orders for work, obtaining accurate labor and material returns and a host of other minor methods and processes. These details, which are usually regarded as of comparatively small importance, and many of which are left to the individual judgment of the foreman and workmen, are shown by the rate-fixing department to be of paramount importance in obtaining the maximum output, and to require the most careful and systematic study and attention in order to insure uniformity and a fair and equal chance for each workman. Without this preliminary study and systematizing of details, it is impossible to apply successfully the differential rate in most establishments.

. . . really successful application not only involves a thorough organization but requires the machinery and tools throughout the place to be kept in such good repair that it will be possible for the workmen each day to produce their maximum output.

. . . what is of equal importance is, that it spurs the firm to keep their shop in the best of order. Everything must be kept up in the finest state of repair, or the men cannot earn their differential rate, and I think, if possible, that this indirect result of the system is a greater benefit to the firm than the rate is itself.

From my own observation while a workman and foreman at Midvale a few years after Taylor had left, it was evident that improvement in method, growing out of studies undertaken for purposes of rate fixing, was an important factor in the increase of production. "Laying out" of work on a surface plate previous to machine tool operations was carried far beyond the practice prevailing even in the best shops of that day. For the benefit of those not familiar with machine shop practice I should explain that "laying out" consists of accurately marking on castings or forgings lines that will facilitate the setting of work on machine tools, save time in accomplishing it, insure accuracy of results, indicate the location and size of cuts to be taken on various surfaces, the holes to be drilled, etc. This is not only done more accurately and conveniently on a surface plate by a man specializing in such work, with certain direct advantages, but—and this is of greater importance—the machine is actually permitted to run a greater part of the time, which means an increase in output without an increase in investment or overhead. Another practice embodying the same principle was illustrated by the use of a chuck or device for holding forgings, such as hoops for naval guns, while being machined. These chucks consisted of a base fastened to the machine table, into which fitted a detachable upper portion holding the work. For each machine there were two of the upper or work-holding sections so designed that forgings set in them on a surface plate apart from the machine would be properly centered when the upper part containing the forging was dropped into place on the base section on the machine. While one forging was being machined another to follow it was being prepared on a surface plate. These are but two of many cases indicating that *methods study* was practiced to a greater extent in Taylor's Midvale days than would appear to the average reader of his "A Piece-Rate System," or even his "Shop Management." However, one example of methods study described in "Shop Management"[2] is remarkable for its thoroughness as well as for the fact that it covered a maintenance operation rather than a production operation. I remember seeing these or similar instruction cards, in Taylor's own handwriting, which compare favorably with the best present-day practice.

After the writer had become convinced of the economy of standard methods and appliances, and the desirability of relieving the men as far as possible from the necessity of doing the planning, while master mechanic at Midvale, he tried to get his assistant to write a complete instruction card for overhauling and cleaning the boilers at regular periods, to be sure that the inspection was complete, and that while the work was thoroughly done, the boilers should be out of use as short a time as possible, and also to have the various elements of this work done on piece work instead of by the day. His assistant, not having undertaken work of this kind before, failed at it, and the writer was forced to do it himself. He did all of the work of chipping, cleaning and overhauling a set of boilers and at the same time made a careful time study of each of the elements of the work. This time study showed that a great part of the time was lost owing to the constrained position of the workman. Thick pads were made to fasten to the elbows, knees and hips; special tools and appliances were made for the various details of the work; a complete list of the tools and implements was entered on the instruction card, each tool being stamped with its own number for identification, and all were issued from the tool room in a tool box so as to keep them together and save time. A separate piece-work price was fixed for each of the elements of the job and a thorough inspection of each part of the work secured as it was completed.

The instruction card for this work filled several typewritten pages, and described in detail the order in which the operations should be done and the exact details of each man's work, with the number of each tool required, piece-work prices, etc.

The whole scheme was much laughed at when it first went into use, but the trouble taken was fully justified, for the work was better done than ever before, and it cost only eleven dollars to completely overhaul a set of 300 H. P. boilers by this method, while the average cost of doing the same work

[2]Taylor, F. W., *Shop Management*, Harper & Brothers, New York, 1911, pp. 181-182.

on day work without an instruction card was sixty-two dollars.

In his paper, "A Bonus System for Rewarding Labor," Gantt indicated more specifically the importance of methods study, or seeking to develop what Gilbreth aptly designated "the one best way," by the following statement:

. . . instruction cards may be made out to show the best method of doing the work which we can devise with our present knowledge and appliances. Such cards will seldom represent the very best method of performing the work but will usually represent a method far superior to that which the ordinary workman would employ, and if we can get the men to do the work as directed on these cards we can very largely increase the efficiency of their work. . . It is hard to over-estimate the value of a *complete set of instructions showing the best method* of performing a piece of work.[4]

Again, in a paper presented in 1908, Gantt directs attention to the part played by "scientific investigation" in effecting improvement in methods, saying:

The fact, so repeatedly emphasized by Mr. Taylor, that *tasks should be set only as the result of a scientific investigation*, has proved of an educational value hardly to be overestimated, for the scientific investigation of a process that has been developed without the assistance of science almost always reveals inconsistencies which it is possible to eliminate, thus perfecting the process and at the same time reducing its cost.

It is the duty of the investigator to develop methods and set tasks, and unless the methods developed by him are pretty generally a great deal better than those suggested by the workmen, he is not retained in the position. Working at tasks is pretty good training for task setting, and the writer has gotten more than one task setter from the ranks of task doers.

. . . the best expert available investigates the work, standardizes the appliances and methods and sets a task that involves utilizing them to their very best efficiency. While the stop watch is often used to establish a method, it is used to determine the time needed to do the work only when the standard methods and appliances are used efficiently. Stop-watch observations on work done inefficiently or with ill-adapted appliances, or by poor methods, are absurd and serve only to bring into disrepute all work in which the stop watch is used. Moreover, such use of the stop watch justly excites the contempt and opposition of the workman.

To make real and permanent progress, the expert must be able to standardize appliances and methods and write up such instructions as will enable an intelligent workman to follow them.[5]

[4]Gantt, H. L., "A Bonus System of Rewarding Labor," *Transactions of the American Society of Mechanical Engineers*, Vol. XXIII, 1902, pp. 346 and 347.

[5]Gantt, H. L., "Training Workmen in Habits of Industry and Co-operation," *Transactions of the American Society of Mechanical Engineers*, Vol. XXX, 1908, pp. 1038 and 1043.

That such studies as Gantt refers to included what is now frequently spoken of as "motion study" was brought out in the discussion of Gantt's paper, "Training Workmen in Habits of Industry and Co-operation."

One of the operations on this job was the setting of the piece in a jig, the man who was put on it taking regularly 1 min. 40 sec. After a study of the exact motions required to pick the piece up and set it accurately we showed the same man how to do it in 20 sec. . . . distinction should be sharply drawn between work done at high speed and work done in a hurry; the first will give perfect goods because the speed is attained by elimination of all the unnecessary motions, the latter bad work because it is a speeding up of all the operations, necessary and unnecessary.[6]

My principal object up to this point has been to show that what Taylor and his associates referred to as "the study of unit times," "elementary rate fixing," "the study of elementary operations," "time study" or "scientific time study" embodied in fact and in principle, if not in terminology, all that today is considered under the headings "time study," "motion study," or "standardization." As Colonel Babcock says in his chapter, "Research for Production," in the recently published book of the Taylor Society, "Scientific Management in American Industry"[7]: "In Taylor's day time study and motion study were not considered separately; although he sometimes used the term 'motion study,' Taylor usually used the term 'time study' to cover both." Carl G. Barth in his foreword to the book, "Time Studies for Rate Setting"[8] by Dwight V. Merrick, said of time study work undertaken by men not properly qualified for it: ". . . time studies cannot be separated from motion studies, and motion studies cannot be made by a person who does not fully appreciate the purpose of the motions made by the operator he observes."

The importance of the study of motions becomes increasingly obvious in efforts to improve and establish standard methods and performance standards for simple repetitive operations where all or most of the work is done by hand. It is also of sufficient importance to justify its being given more consideration than it usually receives in varied product and varied operation industries, such as the general machine shop or foundry. In the latter class of work the study of isolated groups of elements, composing frequently

[6]*Ibid*, p. 1055.

[7]Harper & Brothers, New York, 1929, p. 91.

[8]Engineering Magazine Company, New York, 1919, p. viii.