as well as analytical features, is easy to see. As he listed the motions made by his men, he could not well have failed, his mentality being what it was, to observe them *critically*—to question whether they could not be made more deftly and whether they were all necessary. Take any particular motion. If he had not been there with his watch, he would not have been likely to give it a thought; but as he watched the second hand of his watch go around while the worker went through that motion, that motion *loomed up*. All of which is to say that the very process of recording *in detail* the time taken to do work inevitably brings up the question as to whether it is done *efficiently;* that is, whether the same result should not be obtained with less effort, or more result obtained with the same effort.

Obviously such a question can be determined only by experiment; and as Taylor began the experiments which had for their prime object the discovery of false or unnecessary motions, he naturally had to select men for the experiments and fully inform them as to the part they would be called upon to play—certainly in the case of all time *study*, as distinguished from mere time recording, secrecy is impossible.[1] It seems, indeed, that Taylor, when asking permission from his "Uncle William" Sellers to do some experimenting, discreetly mentioned only those of the machine or metal-cutting type, and that for a considerabe period Sellers was unaware of the time study. In this event, however, Sellers probably was the only one connected with Midvale who did not know of the time study when first it really began, and this "blissful ignorance" in his case was made possible by the fact that he came to Midvale but rarely.

It is certain that in inaugurating his time study Taylor did not have the sympathy of a single soul inside or outside of those works. His most intimate friends just sat back and wondered. Says one of those friends, Theophilus B. Stork:

> I can well remember when, at the Midvale Steel Works, he began what seemed to us all at the time a hopeless and useless undertaking, the ascertaining exactly how long it took a workman to do a given piece of work. Imagine a young cadet of industry, a student just out of the technical school, with a stop watch and a huge diagram before him, stationed by Taylor opposite a workman to note minute by minute, aye, almost second by second, each and every movement. Now he takes up a tool; click goes the stop watch, and down on the prepared diagram goes the number of seconds that are required for the movement; and so on, day after day, month after month, until stacks of these diagrams of the time required for the workman to do the simplest act were collected. No wonder many thought the whole work fanciful and its cost of thousands of dollars thrown away.

It was not that there were lacking at Midvale men who appreciated the general idea that if you could find out how long it should take to do a job, you would save endless disputes; but it was thought that in making his minute studies and developing his elaborate records, Taylor again was carrying things to a "crazy" extreme.

To us now there clearly appears in his time study his genius for recognizing that trifles make perfection, or his genius for detail. Such we call it; but in his own philosophy, it was a manifestation, not of genius, but of will. He was likely to be impatient with men who said they had no head for details; he could not help but feel that they simply were too lazy to bother with them.

It would seem that throughout his lifetime it was hard for people both in and out of industry to understand that, regardless of the variety of work done in a shop, the great majority of movements there made are made over and over again, and that when once these movements are standardized, they require no further analysis or timing. Moreover, the whole nature and technic of time study was deliberately and maliciously misrepresented by Taylor's foes. We again quote from the testimony taken by the Special House Committee:

> Mr. Redfield. The statement has been made that it is un-American and an indignity for a workman to submit to time study with a stop watch; that it is annoying and makes a man nervous and irritable. To what extent have you any knowledge as to what extent that is true or not?
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> Mr. Taylor. Mr. Redfield, I think that the average workman, if any man came to him with a stop watch without any previous explanation or understanding and began timing every motion and writing down what he was doing, would become nervous and would be irritated by it. . . . I am very sure that I should be nervous to a greater or less extent if anyone were timing every one of my motions. I would feel that it was a darn mean job while the thing was going on. But, Mr. Redfield, I wish to call your attention to one fact, which is not at all appreciated: Somehow there has come to be an impression in the minds of people who speak and think of scientific management in its relation to time study, that for every workman who is working in the shop there are probably four or five men standing over him year in and year out with stop watches. Let me tell you that in some of our shops there are many workmen who, in the whole course of their lives, never have a stop watch held on them. And that probably the average man would not be timed for more than one day in his lifetime. So that probably one day of the workman's life would sum up the total of this terrible nerve-racking strain which several of the men who have testified before our committee have complained of. Therefore, if any man objects to time study, the real objection is not that it makes him nervous. His real objection is that he does not want his employer to know how long it takes him to do his job.

It would appear also that some people think that when you speak of the scientific, you necessarily are referring to something of hair-line accuracy. Thus when it was brought out in investigations of the workings of time study that, in recording such things as the "percentage which must be added to the actual working time of a good workman to cover unavoidable delays," one must depend largely on common sense, there were not lacking those who declared that that showed up the whole thing as unscientific. Taylor, of course, never dreamed of asserting that there was anything exact about time study in the sense that the sciences of mathematics and music are exact. "The whole subject of time study," he told the Special House Committee, "is only an approximation. There is nothing positively accurate about time study from end to end. All we hope to do through time study is to get a vastly closer approximation as to time than we ever had before."[1]

Somewhere along about 1881 it clearly was presented to him that his problem of getting metal cut in the quickest time involved studying both what his men could do and what the machines could do. Hence his two types of experiments; and it is highly probable, by the way, that his machine experiments, or those which constituted a "study of the art of cutting metals," were to a large extent inspired by what he observed while developing "accurate motion and time study of men." Say, for example, you are timing the motions made by a man in lifting a piece of steel to a planer table, in setting it level and true on the table, and in putting on the stops and bolts. Now he starts the planer, and as it works he, occasionally making adjustments, stands waiting for the machine to finih. Doesn't he wait too long? *Can't the machine run faster? Has the cutting tool been ground to just the right angle?* Such questions, at all events, must have occurred to one like Taylor.

As in the case of all men of great achievement, he accumulated his detractors; and one of their ways of attempting to belittle him was by saying that he was a man merely of the machine shop. If they had said *mainly*, their statement might have been true. This aside, Taylor's friends had justification for believing that if his first and great principle of reducing all work to a science could be applied in a machine shop doing any miscellaneous work, it could be applied to anything. "The development of a science," Taylor himself said, "sounds like a formidable undertaking, and, in fact, anything like a thorough study of a science such as that of cutting metals necessarily involves many years of work. The science of cutting metals, however, represents in its complication, and in the time required to develop it, almost an extreme case in the mechanic arts."[1]

Nowadays, thanks to Taylor's investigation, the quickest machine or actual cutting time can be readily calculated. In the early 1880's practically the whole art of cutting metals was left to the individual judgment of workmen and foremen, and thus it necessarily had no basis other than rule of thumb or empiricism. In raising it to an art resting on scientific principles Taylor had to work from the bottom up, and here indeed was an herculean task.

II. FROM EXPERIMENTATION TO STANDARDIZATION[2]

IN the notes he sketched for a paper on experimenting, we read further:

> Our experiments have been of two kinds: first, the reduction of the control and operation of machines from rule of humb to science, and, second, the examination and standardization of human actions and work with relation both to maximum efficiency and maximum speed.
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> In changing a machine from rule of thum both in design and in running to a science, first note carefully all the defects of the machine; that is, all things likely to get out of order and cause bad work or stoppage. Next chase down and analyze each defect and note the effect that it has upon the time problem; that is, upon the quantity and the quality of the output. Then centre upon the most important defect and correct it; then follow up in regular order of importance.
>
> Next study all the elements as they affect the speed and output, whether they are connected with the machine alone or with the man and the machine combined; then find the one or more elements which limit the speed of the output; centre on the most important, and correct them one after another. This generally involves a combination of study of the man with the machine and involves in many cases minute time observations with the stop watch.

His time study and his metal-cutting investigation were indeed closely connected and interwoven; having for their common purpose the cutting down of time to the minimum consistent with the doing of good work. In like manner his belting experiments, which were an offshoot of his metal-cutting investigation, had mainly

[1] As he reached this stage, Taylor of course studied each labor operation repeatedly before fixing a standard time for it. While doing this he must have found, as time-study men do today, that the worker frequently took different times to make the same motion or perform one of the units to which the operation had been reduced, and for this very reason had his critical attention drawn to that motion or unit. Since it always must impress the observer that there must be a reason why a man takes different times to do the same thing, the most skilful or deft way is indeed most likely to be discovered through the contrasting times of the same unit of an operation as these are presented in a number of studies of that operation.

[1] As in the case of other features of Taylor's work, the technic of time study has gone on developing, and this improvement, of course, has been in the general direction of getting results more nearly accurate.

[1] Testimony before Special House Committee.

[2] Chapter VI of Book III, the general title of Book III being "Developing His System at Midvale."