From the paper Taylor contributed to the discussion of this A. S. M. E. report we shall quote at length, not only because of its interest in connection with the question of the origin of time study, but also because Taylor here made his most careful attempt to define the nature of this thing which had been so generally misunderstood.

The historical portion of the report [wrote Taylor] shows careful study, and is evidently the result of much research. In certain particulars, however, it is somewhat misleading; that portion of it, at least, which includes the quotations from Adam Smith, etc., and particularly tables 1 and 2, given in the Appendix.

Although the fact is not specifically stated, still the general impression from reading this part of the report is that "time study," which is the foundation for "the transference of skill from the management to the men," was practically carried on in 1760 and in 1830, as it is now under scientific management. This is, however, far from the truth, and in the interest of historical accuracy it may be desirable to make a statement as to the beginning of "time study," although I realize that questions as to who started time study, and when it was started, are of very little consequence, the important questions being, what is time study? and, how shall we make it more useful?

Time study was begun in the machine shop of the Midvale Steel Company in 1881, and was used during the next two years sufficiently to prove its success. In 1883, Mr. Emlen Hare Miller was employed to devote his whole time to "time study," and he worked steadily at this job for two years, using blanks similar to that shown in Par. 367 of "Shop Management." He was the first man to make "time study" his profession.

It is true that the form of Tables 1 and 2, given in the Appendix to the Committee's report, is similar to that of the blanks recording time study, but here the resemblance ceases. Each line in Table 2, for instance, gives statistics regarding the average of the entire work of an operative who works day in and day out, in running a machine engaged in the manufacture of pins. This table involves no study whatever of the movements of a man, nor of the time in which his movements *should* have been made. Mere statistics as to the time which a man takes to do a given piece of work do not constitute "time study." "Time study," as its name implies, involves a careful study of the time in which work *ought* to be done. In but very few cases is it the time in which the work actually was done.

Previous to the development of "time study" in the Midvale Steel works, there had in all probability been many instances in which men have carefully studied and analyzed the movements of other men, and have timed them with watches. (No such instances have, however, come to my personal attention.) Any such former work was without doubt confined to isolated cases, and was of short duration; and (most important from the historical point of view) it did not lead to the development of a new trade, or, more properly, to a new scientific occupation, "the profession of time study."

Any former efforts of this kind would bear the same general relation to the time study done in the Midvale Steel Works that the many early attempts at flying bear to the work of the Wright brothers. The Wright brothers started "man flying." The Midvale Steel Works started the "profession of time study." (I do not of course intimate that the two developments are of equal importance.)

Time study is the one element in scientific management beyond all others making possible the "transfer of skill from management to men." The nature of time study, however, is but imperfectly understood, and it is therefore important to define it clearly. "Time study" consists of two broad divisions, first, analytical work, and, second, constructive work.

The analytical work of time study is as follows:

a. Divide the work of a man performing any job into simple elementary movements.

b. Pick out all useless movements and discard them.

c. Study, one after another, just how each of several skilled workmen makes each elementary movement, and with the aid of a stop watch select the quickest and best method of making each elementary movement known in the trade.

d. Describe, record and index each elementary movement, with its proper time, so that it can be quickly found.

e. Study and record the percentage which must be added to the actual working time of a good workman to cover unavoidable delays, interruptions, and minor accidents, etc.

f. Study and record the percentage which must be added to cover the newness of a good workman to a job, the first few times that he does it. (This percentage is quite large on jobs made up of a large number of different elements composing a long sequence infrequently repeated. This factor grows smaller, however, as the work consists of a smaller number of different elements in a sequence that is more frequently repeated.)

g. Study and record the percentage of time that must be allowed for rest, and the intervals at which the rest must be taken, in order to offset physical fatigue.

The constructive work of time study is as follows:

h. Add together into various groups such combinations of elementary movements as are frequently used in the same sequence in the trade, and record and index these groups so that they can be readily found.

i. From these several records, it is comparatively easy to select the proper series of motions which should be used by a workman in making any particular article, and by summing the times of these movements, and adding proper percentage allowances, to find the proper time for doing almost any class of work.

k. The analysis of a piece of work into its elements almost always reveals the fact that many of the conditions surrounding and accompanying the work are defective; for instance, that improper tools are used, that the machines used in connection with it need perfecting, that the sanitary conditions are bad, etc. And knowledge so obtained leads frequently to constructive work of a high order, to the standardization of tools and conditions, to the invention of superior methods and machines.

It is unusual to make a study such as this of the elementary movements of the workmen in a trade. The instances in which this has been done are still rare. Most of the men who have made what they call "time study" have been contented with getting the gross time of a whole cycle of operations necessary to do a particular piece of work, and at best they have thrown out the time when the workman was idle, or evidently purposely going slow.

Taylor's correspondence reveals that when he stated in the foregoing paper that time study was begun at Midvale in 1881 and that Emlen Hare Miller was employed in 1883 to devote his whole time to it, these dates were fixed from his memory, which we know was usually poor. However, as he went to Midvale in 1878, became a boss in the machine shop late in that year or early in 1879, and quarreled with his men "two or three years" before he resolved to acquire exact knowledge of what was a full day's work for them, the probabilities are that his dates are approximately correct; and to this confirmation is lent by the fact that he stated that his time-study and metal-cutting investigation were started at or about the same time, and in his paper *On the Art of Cutting Metals* we find it printed (page 37) that the first of his metal-cutting discoveries were made in 1881.

At the same time, it is to be considered that, on the basis that "mere statistics as to the time which a man takes to do a given piece of work do not constitute time study," it hardly would be possible for anyone to fix an exact date for the beginning of *true* time study. This because the thing did not spring full panoplied from Taylor's brain, but, as was typical of his revolutionary work in general, was a gradual development from a humble beginning, the manner of it being as follows:

The work of his shop principally was that of machining locomotive tires and car axles, and was repetitive. There was, however, some miscellaneous work; and when the drawing was ready for a new job and an attempt was made to figure its cost, the question arose as to what material would be needed and how long the work would take. Always a fairly accurate estimate could be made as to the material, but when the foreman was called in to settle the time question, all he had to guide him at the best were such records as he might have of the total time it had taken to do former jobs of a more or less similar nature; and it is plain that estimates based on such statistics represented guess work almost pure and simple. Incidentally it was by such guessing also that the foreman right along had set for the workmen a piece-rate in connection with the new job.

Now, few things could have been more abhorrent to Taylor than this guessing; moreover, it eventually "occurred" to him that "it was *simpler* to time with a stop-watch each of the elements of the various kinds of work done in the place, and then find the quickest time in which each job could be done by summing up the total times of its component parts, than it was to search through the time records of former jobs and guess at the proper time and price."[1]

From this it is clear that at the start he had for his object only the improvement of the statistics which long had been used in his shop, and there can be no doubt that for a period he attempted only to record such times as actually were taken. Even here, however, his timing was greatly different from that mentioned by Babbage as having been done in France in 1760. The French observer, one Perronet, simply listed the various processes entering into pin manufacturing (such as straightening and cutting the wire, pointing the pins, and heading the pins), and his timing was confined to recording the gross time it took the workmen to complete each of these divisions of the work, on the basis of lots of 12,000 pins. And when Babbage, seventy years later, got up a new table for English manufacturers, he also contented himself with recording these gross times. On the other hand, it will be seen that from the very beginning Taylor was concerned with timing the *elementary motions* of which individual labor operations consist; which is to say that his work from the beginning lay along the lines of what these days is called job analysis, or the splitting up of jobs into their component parts.

Back of it all was his observation that, no matter how much the jobs coming into his shop might vary, they represented but different combinations of the same elemental motions. If this fact ever had been observed before, it does not appear that it was *deliberated upon* and its significance thus grasped, and in such case the observation was not a real one. What can be affirmed with positiveness is that Taylor was the first to *act* on this fact; that is, really act on it in the sense of pushing the thing through to its logical conclusion.

It will be recalled that when he was at Phillips Exeter, he was profoundly impressed by his observation of the way his professor of mathematics, "Bull" Wentworth, had timed the work of the students in solving various problems, and so was able to give out standard lessons in the sense that he knew how much time the average boy would take to do them. All the indications are that to the extent Taylor was indebted to anyone else for the general idea of timing work, his indebtedness was not to anyone in industry, but, curiously enough, to his old professor of mathematics solely.

At first he did his listing and timing of motions in person, and in connection with the regular work of the shop while the workmen did not know they were being observed. It is probable, in fact, that he began to use a stop-watch in secret while yet he was struggling to force his men to increase their production. It is safe to say also that his first observations were not very elemental, but became more and more so.

Before long he established what one of his associates calls the "unalterable rule that all time study for rate setting must be done not merely with the knowledge but with the cooperation of the worker." As a matter of fact, Taylor's secret use of his watch was fairly feasible only as long as his object remained simply that of improving the statistics long used in the shop in connection with setting piece-rates for and figuring the labor costs of new jobs.

Now he was led from the mere betterment of these statistics into true time study with all its constructive

[1] *Shop Management*, p. 148.