the sum of the unit times to the total time required to perform an operation varies, as Taylor pointed out, with the number of different elementary operations and the frequency of their repetition. Consequently, if the time for elementary operations is determined by timing them as they occur in the performance of complete productive operations, the unit times so arrived at will exceed what I have spoken of as "net" times, in varying degree according to the length and complexity of the job and the number of times it is repeated. I shall discuss this further under the heading of "allowances."

From the beginning, Taylor had in mind analysis of jobs into their elements. He ascertained the time required to perform each element and classified and tabulated elementary time units so that the time for other and quite different jobs might be synthetically computed in advance of their performance. Up to 1906 the method followed was to make studies of complete jobs or portions thereof and to record the time for each elementary operation or group of elements as it occurred. For the purpose of making studies in this manner, the large time-study observation sheet was devised. Taylor was never satisfied with this method on account of its slowness, uncertainty and inaccuracy. Under it, years might be consumed in accumulating, in a general machine shop, foundry or similar plant, the complete data that would make possible the setting of tasks in advance for any and all jobs that might come along. It was time study of simple repetitive operations that pointed the way to a better practice which, however, is too little known and followed today.

To avoid inadvertent inclusion of anything in the nature of "allowance" in a base or standard unit time, time studies should be made of small groups or cycles of elements which, with relatively little practice, a worker will perform almost automatically with uniformity of motions and speed. Many simple, short repetitive operations, such as one finds in the manufacture of handkerchiefs, paper boxes or in a book-binding plant, may quite properly be studied as a whole.

It was not realized or appreciated until about 1906 when Dwight V. Merrick hit upon a satisfactory solution to the problem at the Link Belt Company's plant in Philadelphia, that in more complicated work groups of elements could be isolated and studied independently. For example, in a machine shop we could isolate and study independently the various suboperations incidental to the handling of each machine, the use of small tools and the handling of materials to be worked. As a result of this plan, time studies made in one shop may be used in any other shop having the same machine and tool equipment, although the nature of its product and operations may be quite different. In this way the same advantageous condition that exists in simple repetitive work is set up.

In a large, well-managed foundry in Japan I found the management keenly interested in improving methods and setting accurate piece rates. They had started making time studies after carefully studying various books on the subject, and had a pretty good understanding of how observations should be made. They were, nevertheless, laboring under the misapprehension that they could only set rates based on time study for the simpler castings ordered in large lots, and that they must in those cases make time studies on a part of such an order in order to arrive at a rate for the balance of the lot and for any repeat orders that might be received. It was like opening up a whole new world to them when I explained that they should study not the making of complete molds from a given pattern but the independent elementary operations for each class of molding, such as placing pattern boards, placing and locating pattern, placing flasks, filling riddle, riddling facing, shoveling sand, ramming sand, placing bottom boards, putting on clamps, rolling mold over, drawing patterns, etc., etc.

In another large plant I found that quite creditable studies had been made, improved methods established and rates set for many simple repetitive operations composed of relatively few elements which were, in a great measure, peculiar to the specific jobs. Almost nothing had been done, however, in the way of time and methods study in their large general machine shop, mainly because of the mistaken belief that time studies must be made of performance of the specific job to which a rate was to apply. It was a revelation to them when I explained the practice followed in a comparable shop in America.

One does not have to look far in America to find the same mistaken belief that I encountered in the two Japanese plants mentioned, and it is because

of the persistence of the idea that time studies must be made of *jobs* that American industry falls far short of realizing the full value of elementary time study.

This is a result of their failure to grasp the principal purpose of elementary time study as far as setting rates or tasks is concerned. As Gantt stated in his paper, "A Bonus System for Rewarding Labor": "When we realize . . . that any operation, no matter how complicated, can be resolved into a series of simple operations, we have grasped the key to the solution of many problems." Gantt might have added that any job done, for example, in an engine lathe is made up of a comparatively small number of such "simple" operations or groups of elements and that, from this comparatively small number of "simple operations," we may build up, by combining them in various ways, an infinite number of jobs or operations, of various lengths and complexity. The same elements and groups of elements occur over and over again in a great variety of jobs done in the same machine, and many of them may apply to work done in a number of quite different machines. This is comparable to the combination of the twenty-six letters of the alphabet into thousands of words and the combination of words to express an infinite number of thoughts, or to the combination of a limited variety of chemical elements in various molecular formations into an unlimited number of materials.

In the case of machine tools, analysis will show that, with the exception of actual cutting, these groups of elements or suboperations naturally fall into the following major classes: (1) manipulation of the machine, or machine handling; (2) manipulation of implements or small tools, or tool handling; (3) handling of materials.

To accumulate the data necessary to set a standard time for any and all jobs, regardless of whether they have ever been done before or may ever be done again, each machine in turn, after being put in standard condition, is taken out of production and turned over to the methods man and a first-class operator. A list of all of the small operations that might occur in performing various jobs on this machine is made up and classified. These small isolated operations are then resolved into their elements and a standard method for performing each settled upon, after which the "first-class" operator performs each in turn as many times as is necessary to the establishment of satisfactory unit times for the cycle and its elements. It is needless to say that for different machines a different operator might be assigned as the methods man's team mate.

The following examples of suboperations or machine-handling cycles, drawn from Merrick's book, "Time Studies for Rate Setting,"[36] will illustrate the foregoing. They relate to a 42-inch Gisholt Boring Mill.

	Time in Minutes
Start Motor	
Walk to controller	.05
Start motor by controller	.06
	.11
Stop Motor	
Walk to controller	.05
Stop motor by controller	.03
	.08
Change Feed Gears	
Walk to feed gear box	.05
Change position of lever	.07
Return to operating position	.03
	.15
Manipulate Turret Head	
Loosen clamping lever	.03
Revolve and set turret	.94
Tighten clamping lever	.03
	1.00
Manipulate Ram Head by Hand for 30" Machine	
Procure crank from tool stand	.04
Place crank on screw	.02
Move head in or out (see table for various distances)	
Remove crank and replace on tool stand	.05
	.11

From the above examples it will be understood that a complicated job of machine work, or the operation of a complicated machine tool, consists of quite simple suboperations. Similarly, the handling of the small tools or implements used may be studied independently. The same tools not only may be used on a variety of jobs done in a given machine but may also be used in connection with work in several different machines. After all small tools have been standardized and classified, the procedure is to take one kind after another and make studies of the entire list. From Merrick's book[37] I draw the following illustration:

[36] P. 122.
[37] P. 113.