them into goods suitable for consumption also becomes available day by day only in a limited quantity. With even the most effective application of the daily available energy to the daily available materials, only limited quantities of the various kinds of goods can be made available for the satisfaction of the several varieties of wants. Every spoilation or other waste of material, every misapplication of energy, makes less the quantity of some variety of goods that becomes available.

Now material can be wasted by faulty planning of the use of it, as every garment cutter knows. Energy can be wasted in various ways. It can be wasted by doing work that need not be done, by doing needed work with the assistance of implements that are not best adapted to the purpose, or, even with the assistance of the best implements, by applying the energy in a manner that consumes more of it to accomplish the given purpose than would be the case if it were applied in a different manner.

Time is involved even where a unit of a commodity is produced with the minimum consumption of material, by the application of only the minimum amount of energy in the most effective manner with the assistance of the best adapted appliances. More time per unit is usually involved where more energy is applied in the less effective manner or with the inferior appliances. Certainly more time as well as energy, and sometimes more material, are consumed where unnecessary work is done, i. e., work that does not contribute to the desired effect. And time is important as well as are materials and energy; for our wants not only require time in their satisfaction, but they recur in time.

Now time study is a method of investigation whereby are discovered removable or avoidable conditions that make the work content of operations greater, more energy-consuming, more time-consuming than is necessary; a method of investigation whereby the various modes of performing an operation are studied so as to determine which is the least time-consuming. These uses of time study are quite as important as is the third use; namely, that of furnishing data on the basis of which to form intelligent and reasonably accurate judgment as to the rate at which the given operation should be performed under specified conditions, with specified appliances and by a specified method.

To illustrate, I found by means of an over-all time study on a certain operation, that forty-four per cent of the available time was wasted for the operatives because they were kept waiting for work to be assigned to them. They were putting wrappers on spools of copper wire; and I found that much of their time was consumed in stripping off wire that had loosed up and formed a tangle. Valuable material also became useless because of these tangles, for the wire was worth seventy-eight cents per pound. The entire waste of material and all but four-one-hundredths of a minute of time per spool were avoided by lengthening the preceding operation to the extent of securing the end of the wire. An assistant of mine found in a certain coat shop a variety of methods of performing the same operation, the most time-consuming method requiring nearly twice as much time per coat as the least time-consuming method.

The discovery of these makes possible the removal or avoidance of the conditions that consume the operative's time and energy unproductively, makes possible the choice of, and instruction in, methods that enable him to turn out more units of product with the same effort in the same time.

Increasing output thus does not involve "speeding up" the worker, except where the result of the time study is to speed up an automatic machine, or combination of automatic machines, and then only to the extent that the previous mal-adjustment of the machines wasted the worker's time. Indeed the only speeding up of workers, other than the elimination of enforced idleness and of loafing, that is possible is that speeding up that comes through the worker's gain in skill.

As an operative repeats a given sequence of motions time after time under like conditions and with like appliances he gains facility and precision in the performance. In the course of time he attains to a maximum facility and precision. When this maximum is reached, he performs the sequence. I believe, with the minimum personal expenditure of effort. The period of practice required for this maximum skill probably varies with the nature of the work and with the operative. In winding fine wire electro-magnet coils on specified power-driven machines, the period was six to eight weeks. (But we could determine by the end of the third week whether a given operative would be able to attain that skill necessary for attaining



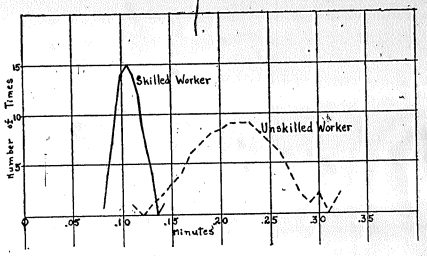
the production standard.) As the operative gains in skill he automatically "speeds up."

This is the only kind of "speeding up" that should be aimed at, except the elimination of loafing and inattention. The speeding up that comes with increased skill does not increase the strain upon the worker or the drain of his energies.

If the leaders of the great body of workers could gain a thorough appreciation of the above stated production problem and the above stated functions of time study, so that explanations could come to the workers from sources in which they have confidence, the attitude of the workers could be brought around to an enthusiastic support of time study properly safeguarded.

An elementary time study made upon an operation performed by a fully skilled operative presents features that are markedly different from those of a time study made upon the same operation performed by a relatively unskilled operative. This is particularly true if the conditions are so nearly uniform that there are no variations in conditions from unit to unit of product to cause a marked variation in the time of certain constituent elements. If each operative be timed for each elementary operation on each of, say, one hundred units of product and the recorded times for an element be charted, the graphs for the element as performed by the two operatives will present appearances similar to those in the accompanying chart. In this chart distances along the base line represent time in minutes and vertical distances represent the frequencies with which the particular elementary operation is supposed to have been observed to have been performed in the designated amounts of time. The straight line graph represents the performance of the highly skilled operative; the broken line graph represents the performance of a relatively unskilled operative. Both graphs exaggerate somewhat the degree of concentration that has been observed in practice; but they picture the differences very well.

The tabulated values for the skilled operative will exhibit the following features for each elementary operation: (1) there will be an observed time for the element whose frequency is pronouncedly greater than the frequency of any other element time, except, perhaps, the frequencies of the two readings nearest it (one greater, one less); (2) there will be a number of other readings, but the graph will slope steeply away from the reading of maximum frequency—more rapidly on the side of smaller than on the side of larger readings, so as to form a "skew" curve of variation; (3) the minimum reading will usually be close to the reading of greatest frequency; (4) the whole range of variations will be comparatively narrow.




The readings for the same element as performed by the relatively unskilled operative will present the following features: (1) the range of variation will be from three to five times as great as in the case of the skilled operative; (2) there will be no one reading, or group of three adjacent readings, of frequency markedly greater than the frequencies of a number of other readings; (3) the reading of maximum frequency, if there is a maximum, will be much greater than the maximum for the skilled operative, and the frequency much less pronounced; (4) the minimum reading is likely to be near or somewhat above the reading of maximum frequency for the skilled operative; (5) the graph is much flatter than for the skilled operative.

As the unskilled operative becomes more skilled, his performance will exhibit more and more the characteristics portrayed by the graph for the skilled operative. If, however he is not so adaptable to the particular kind of work, he will not be able to develop a performance whose graph will coincide with that of the adaptable operative who has attained to full skill, but his most frequent reading for the given element will remain appreciably higher.

Time studies for the purpose of obtaining element time data for production standards should be made only with the co-operation of skilled operatives. As far as practicable, the operative should be so absorbed in the work as to forget that he is being observed; for otherwise his conscious mind