they have had some experience as workers. All observers must realize the limitations of human nature in order to judge and record the proper element times.

The selection of proper observers is essential, particularly if the selected element times are to be indexed and placed on file for future use. Improperly established element times may cause many errors in future combinations of elements when new task times are being formulated from records.

The position of the observer with respect to the worker while under observation is important. The observer should not be close to or in front of the worker, thus distracting the latter's attention. He may be at either side or a little to the rear, always having the motions of the employe in full view. It is best not to interrupt the worker with questions or suggestions of change in method while the study of several cycles of work is being made. Notes and symbols can be made by the observer on the data sheet, recording abnormal conditions or increments of time. These can be discussed with the worker and others at a later period. By following this practice the observer will find that the best time studies are made by having the stop watch run continuously from the start to the finish of the study, with complete notes covering all delays.

Under no consideration should studies be made without first explaining to the worker what is to be done. In most cases it is decidedly advantageous to have previously acquainted the foreman or overseer with the plan which is to be pursued. Having informed the department head and worker, the observer will find that a brief study of the methods and motions, as performed when the time study analysis is started, will be of considerable value later for comparative purposes.

Any change in the equipment, methods or motions should be carefully explained to the worker and an opportunity afforded for him to become proficient in the new method before final observations are made. Proper instruction and training in changed methods are of vital importance.

Special attention should be paid by the observer to recording the description of motions and elements which are being studied. Experience has shown that it is possible to use abbreviations to such an extent in describing an element that it is difficult for other observers to interpret, check or use the element times at some later date. It is well to record on the detail study or data sheets a complete description of the motion of the worker in performing each element of the task in question, giving the symbol, size, height, etc., of the machine, bench, table or truck. It is also advantageous to make sketches of the product, showing it before and after the operation with an outline of the position and use of tools. It is far better to record too much than not enough. The abbreviating can best be done when summarizing, indexing and filing finished element times.

There are many methods of observing, recording, and selecting element task times. However, almost all have a close relation to the probability or law-of-average curve. In the case of one method, a series of stop watch readings or elements in repetitive cycles gives a group of element times. From these an average is determined and the minimum selected. The ratio of this minimum to the average time for the element gives a measure of the human factor in the problem, or the variation from one hundred per cent perfection. This is perhaps best explained by saying that if a worker can constantly perform the motion, or group of motions constituting an element, in the minimum time, then the average time and minimum time will be equal. The ratio will be unity and the worker will be literally a machine—an impossible situation.

It is apparent that this ratio of the average to the minimum is the representation of the departure or deviation of the human worker from an imaginary machine performing the motion in the same manner. Such a ratio, or departure of the average from the minimum time, has been found to range between 1.20 and 1.30 for average workers, although this varies to some extent according to the nature of the work being performed. It is well to carefully consider time studies which show ratios of average to minimum times greater than 1.30 before making use of them for setting task times.

When the deviation for each element or part of the cycle of work has been determined, these are totalled and a cycle deviation obtained. The average times for each element are now divided by this cycle deviation and the selected minimum times result. It is these selected minimums for motions, or groups of motions comprising elements, that are now indexed or placed in tabular form for

future reference as standard times to be used in making up other groups of elements or task times.

As Mr. Merrick's paper brought out, Mr. Taylor found that it became necessary to apply a percentage allowance to the element times for "the quickest and best method," the latter corresponding to the previously mentioned selected minimum times. He stated that this percentage should vary according to the length of cycle, number of elements and the frequency of repetition.

Since the presentation of Mr. Taylor's paper of 1912 before the American Society of Mechanical Engineers, a number of methods of arriving at these allowance percentages have been devised. One illustration of the method of establishing such a variable allowance curve is described in Chapter 5 of the book "Time Studies as a Basis for Rate Setting" by Mr. Dwight V. Merrick.

When the elements comprising the cycle are summarized, a percentage from such a chart or curve is applied. The result, together with allowances for the unavoidable delays, determines the task time.

Another plan for computing studies is to separate the abnormally high and low element times from those which are the more predominant, and through a series of computations, to determine an allowance for high and low values. This allowance is then added to the average of the predominating element times.

Such a plan does not start with minimum times as a basis. It uses average times and is believed to permit an opportunity for greater error resulting from the influence of the human element of the worker in the problem.

It is a well known fact that almost all the countries of the world very carefully maintain and safeguard their standards of length and weight, and that the people use these as a basis from which all larger amounts are measured by comparison. In like manner, it seems proper that we should use the minimum times as a basis for selecting the best time for the one best method, especially if we have a means for determining the best time by comparison with one hundred per cent perfection.

Operations which consist of cycles of work that are periodically repeated may be studied by being broken down into individual motions or groups of motions, giving elementary times. On the other hand, it often becomes necessary to establish task times on automatic or semi-automatic machines. In this case, the time study takes the form of a production study where the delays are analyzed and, if possible, each delay broken down into its elementary times.

Another form of study is that required when a group of machines performing different operations are assigned to one workman. An example of this is a group of milling machines where each cycle consists partly of handling time—removing the finished piece from the fixture and placing the next one in position, followed by a period of automatic machine feeding. In this case, elementary observations of each machine or operation are made separately. The handling time cycles may then be summarized and plotted on a chart so that it is visually represented that the automatic feeding element of the first machine will end at nearly the same time that the workman has finished the handling time element on the other machines of the group. In most cases, an effort is made to have the first machine finish its feeding cycle and wait for the man rather than arrange the group of machines so that the man is waiting.

When studying machines which require the employment of a number of workers, as for example, large heating or annealing furnaces where groups of men are required to load and remove the material and where a varied heating time is required according to the size and shape of the product, it is advantageous, after making elementary studies of each workman, to arrange a system of units as a basis for assembling and tallying the amount of work done. These units may be minutes, tenths of an hour or some other increment of time. The result of such a plan will be that the individual workers in the group will receive increased payment the higher the total units per man measured over a definite period.

Time study has been regularly used for improving methods, equipment and shop layouts. It is also of value for many other subordinate purposes, such as a basis for estimating and budgeting.

When a complete set of time studied standard times is available for the operations on a product or a representative group of products in a department it is possible to formulate a basis for labor planning, covering both direct and indirect labor. For varied activities of a department or shop the man hours of direct labor for each class may be esti-