The great amount of time which the use of formulas will save is readily apparent. The time required to take and work up a time study on repetitive work will be from one to four hours where the length of the operation cycle is fairly small, and may be much longer on larger work where one operation cycle may run as high as one hundred hours. The time required to set a time value from a formula will, in the majority of cases, range from one to fifteen minutes, depending on the complexity of the formula and the amount of time required to determine the characteristics of the job. Where all necessary information is obtainable from the drawing of the part, the time value may generally be computed in less than five minutes.

With so much time saved in the work of the time study department, it is obvious that formulas will enable fewer men to cover a given amount of work or the same number of men to handle a much larger territory. The caliber of men required to apply formulas need not be so high as that of men who must take time studies. It is thus possible for a plant to have a few expert time study men who will make the time studies and compile all formulas. The rest of the work, that of setting time values from formulas, may be carried on by men better fitted for routine work and incidentally commanding less salary.

Formulas have made possible the application of time study methods and incentive plans to the job shop. Without them the cost of establishing time values would offset the savings which incentive plans produce, great as they are. With formulas, a large volume of time values may be set by a comparatively few time study men with a large net saving to the plant. Indeed, formulas are highly profitable on all but strictly standard work where operations are so few that it would take longer to compile formulas than to set values by actual time studies.

Where all time values are set by time study, some inconsistencies are almost certain to appear. Because of errors in judgment, unnecessary work that was allowed to pass unnoticed, and variations in the judgment of several time study men who handled the work over a period of time, some time values will be easier to meet than others. Simple jobs will, in some cases, have higher time values than much harder jobs upon which more work must be performed. Such inconsistencies tend to decrease the respect of the workers for time study and time study methods. It takes but one or two "wild" values to shake the confidence that hundreds of correct values have built up.

The only chance for inconsistency when time values are set by formula is in an error in determining the variables which will be substituted in the formula or in the mathematical solution of the formula. Usually such slips will give time values so far out of line that the time study man will see at once that he has made an error and will check his work. If a wrong value does get as far as the worker and he complains, it is a simple matter to recheck the job and determine whether or not the complaint is justified. Once the worker has been satisfied with the fairness and accuracy of a formula, he will very seldom ask for a recheck of a job unless he is reasonably sure that an error has been made.

It is thought by some who have but a superficial knowledge of formula work that formulas can be applied only to machine work where feeds, speeds, depth of cut, and the like are the only variables. The fields in which formulas have been successfully applied are, however, very much broader than that. Practically any line of work may be formulated accurately if sufficient data are first collected. This statement may appear rather broad to those who have not dealt intimately with formulas, but consider for a minute some of the operations upon which time values are being set daily by formulas, as represented by the following: all kinds of machine work; bench fitting and assembling; wiring; bench, machine, and floor molding; bench and machine core making; casting cleaning; foundry furnace work; arc welding; drop forging; chipping with air hammer; coil winding, taping, and insulating; copper forming (miscellaneous); motor assembly; structural steel assembling; painting; window washing; janitor work; maintenance work; wooden box making; storeroom work; tool making, and pipe fitting.

These examples should suffice to show the practically limitless scope of formulas.

The first step in compiling a formula is the making of a general analysis of the work to be covered. This analysis is similar to that made when taking an individual time study, but it is somewhat broader in that it covers the class of work as a whole and not merely the individual job that is being worked upon.

After a clear idea has been formed of what the formula will cover and what work its construction will entail, the next step is the actual collecting of data. This consists of taking detail time studies on a number of representative jobs.

There then comes the task of classifying each individual elemental operation as either a constant or a variable. Just which it is is not always readily apparent, and it requires a man of no little analytical ability to do this work. After the elemental operations have been classified, it is necessary to select a definite time value for each elemental constant and to make a further analysis of each elemental variable to determine just how and with what it varies.

When all constants and variables have been determined, there remains only the task of expressing the formula in its simplest terms and making a report which will explain clearly the construction and application of the formula.

Discussion

Eugene Bouton.[1] Very few people outside the time study profession realize how low the average efficiency of human endeavor is. There is always a limit or breakdown point in any process, either mechanical or manual. There has been more effort directed toward machine efficiency, however, than toward human efficiency.

The breakdown point of machines can nearly always be predetermined but there are more difficulties encountered in predetermining the limitations of an individual. Men are quick to originate and adopt the ideas of others in things mechanical, so that the same standard designs, methods and performances occur in widely scattered localities. Analysis of steel, coal, wood, etc., will give the best grade for any purpose desired. To apply this analogy to individuals is difficult as there are few keen observers who can analyze men and predetermine their capabilities. Individuals have different characteristics and different traits. The most common is ambition or desire for success.

In dealing with the fundamentals of individual operations we have all of the human characteristics to cope with. Men are hired for certain occupations because they claim to be fitted for them, but in reality very little is known of their capabilities and aptitudes.

When assigning work to machines, the fundamentals of operations are carefully studied and the right machine is selected to do the job. In those branches of industry where machine methods have been introduced, many agencies which are not to be classed as mechanical have been drawn into the process and have become integral factors in it. Chemical properties of minerals are counted in the carrying out of metallurgical processes, with much the same certainty and effect as are the motions of those mechanical appliances with which the minerals are handled. The sequence of the process involves both in a very intimate interaction. Wherever manual operations have been supplanted by a reasoned procedure, on the basis of systematic knowledge of the forces employed, there mechanical industry is to be found.

A comparison with individual effort might be made in the field of athletics. On a baseball team, all men cannot be pitchers or fielders. In things mechanical certain grades of steel will remove more cubic inches of metal than others. Many machines of some particular type, for example, milling machines, will vary in their productive output. The rigidity of the machine, its general design and its control features, as well as the power factors, govern its output. The fundamentals of men and machines, therefore, require considerable study.

Standardization of machines and processes has had a very real effect on cost reduction in manufacturing. Manual operations have been supplanted in many instances because of standardization, which was impossible with individual effort. Certain standards of units of measure and weight have been adopted legally. Engineering societies have standardized on materials and processes to some extent and these standards are accepted by industry. The legal adoption of weights and measures and the standardization of materials and designs have been effected after thorough research and, in my opinion, the progress of this engineering endeavor has been the means of eliminating a large percentage of individual effort. Because of the inefficiency of human effort, machinery, with its possibilities of standardization, has extensively supplanted manual operations in manufacturing.

Mr. Darrow, in a debate with Rabbi Brickner of Cleveland, claimed that a man was a machine possessed of a heart, lungs, mind, nervous system, etc.

[1] Chandler-Cleveland Motors Corporation, Cleveland, O.