a resultant saving in the time required to complete the job.

Wherever the quantity warrants, special jigs and fixtures should be used, as they effect a great saving in time and assure more accurate and uniform work. Multiple jigs and fixtures, that is, those made to hold several pieces, should be applied whenever it would be an advantage to do so. Indexing and rotary fixtures should be used in machining operations wherever possible, as they very often make it possible to reduce the time for performing an operation to the time required to remove and place the part to be machined. Self-centering devices on lathe operations should be used where practicable. Often it will be found advantageous to secure two fixtures where it is necessary to remove the fixture to reload it. The operator can then load one while the cut is being made on the other.

The time study engineer should continually try to reduce time and labor by the elimination of elements of the operation through the application of specially designed fixtures. To give an example of what can be accomplished by the application of special fixtures, a job that was formerly ground on a plane surface grinder was held in a vise during the operation. It was suggested that a multiple fixture be made and that the job be done on a Blanchard grinder. Accordingly a fixture to hold twenty pieces was designed and made. The work was transferred to the Blanchard grinder and a saving of eighty per cent in time was made.

Bench operations should not be neglected even though they appear to be of a simple nature. Analysis may show that the location, design, and arrangement of the bench are not what they should be. The height must be right to avoid fatigue. In special cases the bench may be made to suit conditions.

Handling devices which may aid the performance of the operation should be utilized when, by so doing, the time will be reduced. Jib cranes are often essential near machines handling large, heavy parts. Gravity fed chutes, from which supplies may be quickly extracted, a given number at a time, may be utilized to speed up bench operations. Chutes fed by overhead conveyors save a molder much time in filling his flask with sand. The properly trained time study engineer will constantly seek to use devices which will either improve the quality of the product without increasing the cost or which will decrease the cost without detracting from the quality.

The manner in which the material is supplied and the finished product removed after the operation has been completed is an important consideration. Where the workman is obliged to go for the material himself he should be allowed time for it. Perhaps it will be found that so much time is required in this handling that it would pay to have a lower priced material handler attend to these duties and thus release the high grade operator for more appropriate work.

Material and part handling should be reduced to a minimum. The sequence of operations should be studied for the purpose of determining the best possible layout of equipment, selecting that arrangement which provides for the installation of conveyors between machines or work stations, if the nature of the work prevents efficient moving of material by hand. Gravity conveyors should be employed wherever possible due to the cheapness of installation and low upkeep common to this type of conveyor. Special trucks, racks and ingenious devices may be made to handle delicate parts with the least possible amount of damage.

Many jobs require the use of nuts, bolts, lock washers, rivets, and other miscellaneous parts that are commonly called indirect materials or supplies. The amount of time which the operator must spend in getting such materials from the storeroom and in placing them in convenient receptacles around his work station, must be considered with the view to later determination of a supply allowance.

A special allowance should be made for indirect operations such as oiling and cleaning machines, general maintenance of equipment and the supplying of so-called expense materials such as sand paper, solder paste, cutting compound, and the like.

The human element must be taken into account. It was formerly thought that the workman was not concerned about the conditions under which he labored to earn a livelihood for himself and his dependents as long as he received his wages. The fallacy of this is now generally recognized, and most employers know that money spent to provide good healthful conditions is an investment which pays dividends.

One of the most important requirements of a time study engineer is that, in his analysis of a job, he be able to determine the proper fatigue

allowance for each element of an operation. Standard allowances, based on an extensive study of the strenuousness of the work, should be determined for the different classes of operations. It is quite evident that heavy filing is more fatiguing than the laying out of a part, and that forging requires the expenditure of more energy than most classes of assembly work.

An operator cannot be expected to work steadily all day without delays from some cause. Human requirements, minor breakdowns and other irregularities which cannot be foreseen will interfere, thus necessitating the determination of an allowance to add to all time values to care for such unavoidable delays. It would be unjust to penalize the workman for something over which he has no control.

Temperature is an important consideration. In many places, such as around furnaces or near solder pots, it is nearly impossible to maintain the ideal temperature. Fans or some other kind of forced draft may be used to advantage to keep the air circulating, but in most cases the temperature will be variable. An allowance for such conditions must be made when considering the effort an operator will be able to give throughout the day.

Ventilation should be adequate to provide sufficient fresh air at all times. In ordinary work places, such as machine shops or assembly rooms, it is usually easy to insure this through proper arrangement of windows, fans and ventilators. In many places, however, the matter of proper ventilation offers a serious problem. Acid fumes, dust, and the like must be removed by specially constructed suction devices. Paint shops and dip rooms often abound in unpleasant odors which, while not actually injurious, are irritating and may cause headaches. An operator cannot be expected to do his best work under such conditions, and if the conditions cannot be corrected extra allowances must be made.

Daylight is preferable to artificial light and should be utilized wherever possible. Eye strain due to poor light should always be guarded against. A man cannot turn out accurate work if he cannot read his scales and verniers with ease, nor can he work at his greatest speed if he is not able to see exactly what he is doing.

It is not possible to overestimate the importance of giving due consideration to all these factors.

Standardizing the Job

Analysis, as has been said, always precedes standardization. The former involves the determination of the best way to perform a job; standardization deals with associating like characteristics of operations and jobs and is much broader in application. During analysis, one particular operation is considered while, in standardization, operations as a class are considered and attempts made to standardize those which are similar.

The advantages of standardizing and specializing have been recognized in almost every industry. Few will try to belittle what has been accomplished by standardization in industrial plants where a single product is manufactured. Many, however, believe that this is the only type of plant to which the principles of standardization may be applied. It is true that a single product plant lends itself more readily to standardization than does the plant manufacturing a variety of products in small quantities. But standardization should not be thus restricted, for there is proportionately as much to be accomplished in the latter case as there is in the former.

Standardization first comes into play in the engineering department where the designs are made. Design engineers, like everyone else, wish to be original and want to create something. This tendency, while laudable in the field of research, must be somewhat suppressed in the field of minor design after the fundamental features to be incorporated in the product have been fully developed. This minor design involves the designing of various sizes, capacities, and the like, for a standard type of product. In designing several of these, the engineer is likely to make minor changes in each size part for no other reason than that he does not want anyone to believe him incapable of working out things for himself. He does not wish to appear to be copying some other engineer's work.

In manufacturing, by cutting down the number of designs emanating from the engineering department, standardization permits longer runs with fewer set-ups. Less study on the part of the workman and less clerical work are required since the number of drawings and the amount of manufacturing information is reduced. Familiarity with the drawings and specifications ultimately brings to any shop advantages of specialization.