operators; (3) space for material to be processed or already processed; (4) space for tools, attachments, etc., needed in the processing. The apparent lack of observance of these space conditions in our high production plants leads frequently to the discovery, upon investigation, of a very clever concentration of some of these requirements. The worst offender in providing proper working conditions is the plant that is making a varied product. The manager is apt in consequence to tell you his business is different.

Standard conditions of a machine itself are best illustrated by a case illustration. Take, for instance, a vertical side head boring mill. What standard conditions are needed? First of all, all wrenches necessary for operating each tool and work-holding device must be provided. It is frequently assumed that these come with the machine, but surprisingly frequently some are left out. If the machine is not provided with scales showing the amount of movements of the various slides, these should be provided. Tee slots should be provided with wooden strips to close the slots against chips. Chuck jaw bolts should be provided with brass caps that close the counterbore against chips. This permits the ready removal of the chuck jaws for another set without losing time in digging the chips out from around the nut. Slings and hooks are provided for the proper lifting of material. All speed and feed levers are marked with a positive method of indicating the means of obtaining each speed or feed. Many of the present-day machine tools are provided with 20 per cent to 25 per cent speed increment steps. Where direct current, motor-driven machinery is used it is possible to split this increment to a 10 to 12½ per cent step by using a resistance in the field of the motor. When best results are desired from a machine tool the increment should not exceed 15 per cent.

Each machine is a problem in itself and should have intensive study to see that all the details are worked out correctly. Effective performance in the final analysis is a multiplicity of small things correctly done.

3. *Interlocking or Balanced Facilities.* To obtain their most effective use facilities should be balanced within reasonable bounds. While it is true that the presence of a new type of machine of higher productive value among a group of older machines has an influence toward speeding the older machine operations, it is truer that the presence of the older machines retards the possible development of the newer machine. This may sound like an argument against new and more improved equipment. It is not. On the contrary, it is an argument against letting your equipment get too old. In making improvements it is much easier to improve through evolutionary steps than through revolutionary.

A milling machine presents a good example of the balance of facilities referred to here. This machine is capable of removing a certain amount of metal in a given time provided the cutters are on a par with the machine, and are sharp. In a balanced condition, the cutters must be able to do what the machine will do, and means must be provided for regrinding the cutters to their original condition so economically that the operator of the milling machine has no fear of delay because the proper cutter is not ready. Most manufacturers of milling machines have been forced to manufacture cutter grinders in self-defense, and to educate users of milling machines in the correct way of grinding cutters.

4. *Knowledge of the Science of Processing.* To secure the most effective operation of a group of facilities it is evident that something must be known about the science of the particular type of processing at hand. This involves knowing not only how it is done, but how fast it can be done. How many processes today are the result of science and how many are the result of "rule of thumb"? It may be stated generally that the newer processes are more apt to have the scientific approach, while the older ones are more apt to be governed by rule of thumb.

When Taylor discovered high speed steel he proceeded through all phases of the discovery to determine how it could be used and what conditions were necessary for its most effective use. The steel as developed by Taylor has remained almost unchanged to the present day. But how about its use today? Unfortunately there are many people who have never heard of the fourteen variables encountered in cutting metal, and since they have never heard of them, it is safe to assume that they are not all considered in setting a cut. High speed steel is used in cutting much metal that could be cut at the same rate with carbon steel.

There is one curious feature about human nature that renders the adaption of the new tungsten carbide tools easier, and that is, that when we pay a lot of money for something we see to it that we get our money's worth. We rarely check up on our smaller expenditures. The writer is of the opinion that a considerable portion of the cutting gain attributed to tungsten carbide tools could be achieved by high speed steel tools if the science of processing by high speed tools were more broadly studied and known. The writer has tried to obtain information of this nature on tungsten carbide tools but finds it unavailable or unknown. Some day somebody will work it out in a manner similar to Taylor's classic "On the Art of Cutting Metals."

If you know the exact effect of varying the amount of any factor in your process then you can say that you are operating under a known science of processing.

5. *Methods Consciousness.* In developing scientific management in an organization, one of the intangible results sought is the acquisition of a technique of trained habit. Obtaining this trained habit is the result of repeated performance of good method procedure to the point where the good method procedure becomes a habit.

But at this point one also reaches one of the danger zones of scientific management. While I have not heard much comment of this sort lately, there was a time when you could hear on every side that the so-called Taylor System stifled the initiative of the individual. This would be true if the trained habit developed were to be held inflexible for time to come. Good methods, however, are in a constant state of flux, and it requires an alert individual to keep pace with the current development of methods in industry at large. Since this is true, we are in the position of being forced to constantly improve on our trained habit in order to stand still.

Methods consciousness, then, means that an entire organization is in a state of mind that puts it on its toes. It is checking on one hand to see that all its present practices are consistently the best practices, and seeking alertly, on the other hand, to improve these practices. What head of an organization would not like to be able to say, "My methods are the best obtainable, because every man in the organization is constantly trying to improve them." This is purely relative, but everyone can see the force that would be exerted for economical production. Possibly we have all been guilty of that statement at some time in the past, but it has been my experience that the more one finds out about good methods the more inclined one is to feel that the best possible methods are still some distance in advance. To make the problem more interesting, the research laboratories are turning out new products, processes and phenomena at a bewildering rate.

What do we mean when we say "good methods"? A good method is the best known procedure for doing a piece of work consistent with existing facilities. In this connection, we can say that methods consciousness and the best of modern facilities produce the best results. Of the two, I believe methods consciousness is more valuable than new and efficient equipment.

The advertisements of our equipment manufacturers in trade journals are emphasizing the importance of replacing old and obsolete equipment with the new and modern. What many of them do not tell is that into each piece of equipment is designed a method superior to the method of the previous cycle. With the increasing complications of equipment, it has become necessary for manufacturers to undertake the education of the personnel of the purchaser in the method of operation of the equipment. The manufacturer frequently finds this a discouraging task, particularly when the lack of methods consciousness in the plant of the purchaser permits the equipment to be used far below normal effectiveness. On the other hand, the manufacturer is frequently satisfied to impart only the rudiments of information on operation and to leave it to the ingenuity of the people in the organization to find its real possibilities. In the purchase of equipment it is advisable to check up and ask this question, "Have we received a real method of performance, or did we only get the physical mechanism of the method?" One is a live active force, the other only a cold lifeless machine.

To have effective utilization this same question must be asked and answered for every facility involved in the organization. It is in our endeavor to realize effective utilization that we are frequently forced to answer in the negative, and this should be the beginning of corrective measures.

The mechanisms of methods study form a very important step in the development of methods consciousness. As illustrative of the mechanisms, I