Let us consider some of the more specific reasons why the science of engineering has not been applied more rapidly. This should aid us in ascertaining the reasons underlying the conditions of mechanized industry all along the line from variable to continuous processing, and should indicate also the management problems involved. We as engineers are concerned with the possibilities of improvement, for we must live by future accomplishments, not past glories. The social-economic aspects especially demand attention, because engineering is interwoven with our ways of life.

Managers should readily accept the idea that changes so extensive as those brought about by research and engineering make desirable, in addition to the direct improvements, a whole chain of related improvements. They should expect to obtain indirect as well as direct values of engineering. They should be willing to accept the fact that if engineering changes operation it also changes organization. They should prepare the facilities for such changes. Operating and social changes, as well as the physical products of engineering, should be prepared for and integrated.

However, management accepts the immediate direct results of engineeering without perceiving, accepting and preparing for the resultant conflict with established habits. Instead of the way being opened for a complete utilization of engineering, operating and social conflicts are set up, and the full results of engineering are not realized. The difficulties are chiefly problems of administrative leadership.

Managers have been accustomed to watch most intently at the fabricating ends of the factory, for here are represented processes and methods, things which are easily observable. However, in the past processes and methods were almost entirely created and the results realized in the factory, whereas today they are in large part created and realized outside the factory. Often their training and experience will not permit managers carefully to look behind the scenes and observe the full organizational, economic, and sociological significance of engineering.

Engineering has of necessity been accepted as a technical influence, but not sufficiently as a controlling force within organization. Engineers have very materially aided in the building of our scientific age and in forming our social structure; but there is still a lack of primary recognition of this fact.

The responsibility for greater recognition and progress rests to a considerable extent with the engineer himself. He has not properly formulated the phenomena of his work into principles of plant and social organization. He has been wrapped up in the technical, justifiably in this new art, to the exclusion of administrative and economic purposes. Because of this he has been accused at times of being interested in engineering for engineering's sake. The engineer has upon occasion wanted his department segregated and has been willing that his product should be accepted purely as an objective device. We should not confuse the influence of a science and the practice of individuals, however.

The engineer, because he has been engrossed in the technique of his profession, has not taken time for the wider aspects of his work. He must see himself and the results of engineering as a part of the organization function before engineering will receive the recognition due it and make the progress that it should make.

It is true that many of the organizers of the country have come from the engineering profession and the mechanical trades. These are individuals who, as leaders in enterprise rather than technicians, have seen the importance of the philosophy as well as the technique of engineering, and have made universal application of the economic purposes of engineering, whereas pure technicians often made only spotted improvements. Therefore some engineers are becoming, partly in spite of the profession, solvers of social problems; not only creators of technical devices, but designers and creators of processes involving both machinery and men.

It might be argued that industry is satisfactorily working out its economic course. It is important, however, that we should understand the phenomena resulting from the application of engineering principles, so that we may check our philosophy and enlarge its application.

The Function of Engineering

Engineering discovers, creates and standardizes product; it creates and standardizes processes; and it provides machinery and methods. It deals with products, processes, and methods of industry.

Let us consider some of the evolutions of the machine that led to mechanization. Looking backward, the machine is first seen as a mechanical device for changing the form of some material which had previously been worked on by hand. The product or purpose of the machine already existed.

The newer machinery differs by comparison, although there is much in the present evolution of machinery that is similar to the old. But under the newer conditions of industry the work of research laboratories—metallurgical, chemical, electrical and mechanical, singly or conjointly—often creates the product and formulates the principles underlying processes, and these accomplishments in turn suggest mechanical features or methods. The development and application of lacquer is an illustration. Methods, in the engineering sense, are closely allied with scientific, as well as physical and mental processes in the formation of products. This should also be so in the factory sense, but often they are considered largely as physical ways of proceeding only.

Under the older conditions the mechanics, managers, or inventors who built machinery provided primarily a device for doing a kind of operation. Power was often considered a matter of attaching the new machine to some central power source, or left to solution by trial and error. It was expected that man power would provide the means of set-up and manipulation and that it would deliver materials to and remove them from the machine. The creating of machinery was primarily a question of creating a machine to perform some particular cutting, forming or mixing operation. Other work was naturally left to factory operation, as was often the devising of machinery, and some very splendid work was so accomplished.

Modern mechanical engineering is interested in the broadest sense in scientific processes, production methods, and the complete processes of production. It is interested in time in the technical and cost sense, and in quantity and quality of product from start to finish. It is interested in man's relation to process. It is further interested in the time and cost of its own service as a part of industrial production and cost.

It is not surprising that so thorough an investigator as the man this Society honors in name and purposes should find, when he carefully considered factory processes and methods from the economic side, that he had also to do the following:

1. He had to develop an art for the forming, or cutting, operation of machinery. His studies made him dissatisfied with existing formulated laws and led to scientific research to improve existing standards.

2. He had to consider power, machinery, design, and speeds and feeds, in order to control time in relation to the unit of production. Engineering became more than a device for performing an operation. It was a problem of ascertaining the time in which work could be done. The art had been considered before the method and time were provided for.

3. He had to consider and provide means for material handling and manipulation.

4. He had to deal with man manipulation of machinery and tools.

These four points indicate that consideration was given to scientific research and the complete factory process. Engineering was seen to involve the whole situation and not mechanical operations only.

A careful study of Taylor's work clearly shows that these subjects received engineering treatment, and that techniques were developed where they had not been developed before. Hathaway and Merrick especially stressed the necessity of recognizing all classes of engineering that went into process and method; the fact that gain came from all of them and that often engineering construction offered more opportunity for gain in manipulation than in forming. It is of interest to mention this pioneer work, which advanced the philosophy of engineering. Present types of continuous process, automatic machinery, as well as much of the machinery used in variable industry, show that the true function of mechanical engineering is to consider the whole line of methods, including the primary operation of the machine and the manipulation of the supporting tools and devices. Various engineering sciences may have developed the arts and processes themselves and mechanical engineering, in its mechanization of industry, has to take them all into consideration. The complete economic process of industry involves everything from purely mechanical to physical and mental processes.

As we look back it seems natural that Taylor should have written into his principles of industrial organization, "A science must be developed for each