The Role of Engineers in Japanese Industry and Education
— An Industrial Sociologist's View —

By Kenji Okuda

The number of Japanese companies with manufacturing facilities in the United States and West European nations has increased markedly in recent years. But this only serves to remind us of the many cultural and social differences that continue to exist between Japan and industrialized Western countries. One striking example is the difference in the roles of engineers and frontline operations in the factory. In Japan's case, the social distance between graduate engineers and operators is, by and large, remarkably small. Engineers wear the same uniforms as operators. And they have their desks at the shop site, in most cases right alongside the foreman's desk.

The narrowness of this social distance between graduate engineers and frontline operators is even more conspicuous in comparison with examples from many developing countries. Engineers in those nations demand from the start that they be allowed to work in a private office away from the production site. They seek a high post from the very outset, such as assistant to the president.

The role of engineers in many Japanese companies differs considerably from that in either the industrialized Western nations or the developing countries. This article focuses on the unique relationship between engineers and operators in Japanese industry.

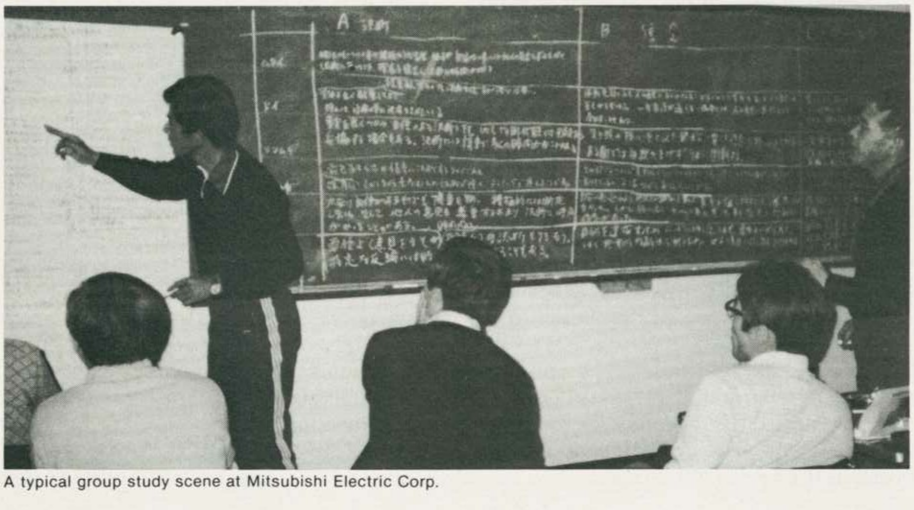
Engineers as sociologists

It is widely acknowledged that the high productivity of Japanese manufacturing enterprises results from extensive factory automation or robotization. One must not overlook the fact, however, that success in automation is itself a result of close cooperation between engineers and operators at the factory level.

Consider the automation of rolling work in the steel industry. The success or failure of automation depends on the availability of accurate data on the differences in rolling methods resulting from material quality, the subtle bending of rolls caused by rolling, roll expansion due to high temperature, roll wear from repeated rolling, the effects of cooling water, and so on. Engineers receive this data from operators and sort it out, analyzing causal relationships and establishing correlations in the form of numerical formulas. Only when this is done, it becomes possible to automatically control the job. In other words, successful automatic control can be achieved by combining the practical experience of frontline operators at the production site and the scientific analysis of engineers.

Another case in point is the robotization of automobile assembly lines. Most assembly-line robots have been designed and manufactured by engineers on the basis of the suggestions or desires of assembly workers. For example, one painting robot was designed in response to the operators' desire to avoid inhaling thinner gas, which is injurious to the human body. By the same token, the work of filling the gap between window frames and glass was automated when mechanical engineers designed a robot for that purpose on the basis of suggestions from operators. Few automobile producers purchase assembly-line robots that have been developed by other companies specializing in the manufacture of robots.

Thus most of the robots on the as-



A typical group study scene at Mitsubishi Electric Corp.

sembly lines have been designed on the basis of suggestions made by operators themselves. It is frequently said that modern mass production deprives workers of opportunities to express themselves, and that low worker morale is but a reflection of this. On the assembly lines of the Japanese auto industry, however, robots have become a means of self-expression for operators.

Of course, installing robots on the line is only one of the many steps that must be taken. The robot must also be taught the correct work procedure. On Japanese assembly lines, teaching robots is one of the more important jobs for frontline operators. Each operator is encouraged to acquire the ability to break down his traditional manual work into computer programs and input these into the robot. This ability differs fundamentally from the ability to do conventional manual work. Dividing manual work and reassembling it into a more efficient procedure requires a capacity for logical thinking. Put the other way round, operators must be able to process information. Engineers have an important role to play in helping operators acquire this skill.

In addition, operators are required to learn how to keep the robots in good-working order. This ability to do maintenance work is essential, since product quality cannot be maintained unless the robots are kept working accurately. The same is true of all automated facilities. Today, operators make it possible to turn out high-quality products by preserving the accuracy of mechanical equipment. To do so they must correctly understand the structures and operating principles of the equipment they handle and the control systems. In addition to the traditional skills required for their jobs, they need the ability to think logically and process information (see Note 1).

Operators cannot express themselves in modern automated factories dominated by a network of complex control systems unless they equip themselves with these sophisticated skills. Engineers play a vital role in supporting the operators' efforts to acquire such new abilities. If an operator fails to achieve this he may be relegated to a position where he would be little more than another of the numerous parts of the automated system. He would find himself in the degrading position of in effect being used by the robot.

The current trend toward robotization is here to stay. But operators will still be able to express themselves, even in the age of automation, if they succeed in improving their skills. Conversely, operators will be placed in the position of serving the robot and will find themselves increasingly frustrated if they fail to improve themselves, or if their employers do not invest in their self-improvement.

Thus we stand at a crossroads. Many Japanese enterprises have chosen the first road and continue to make positive efforts in that direction. I have the greatest respect for the tremendous contribution Japanese engineers have made to these efforts. In this sense, they are no longer technological engineers but sociological engineers.

Operators often amuse themselves by giving pet names to robots. In some cases robots are taught to do simple calisthenics, and "join" operators in these workshop exercises, which usually form an introductory part of the work day with the emphasis on safety. Clearly, Japanese workers regard the robot as a visible product of their own self-expression and therefore do not consider it a threat to their jobs. This may be taken as an expression of the tendency of the Japanese people at large to combine work and play.

Developing the abilities of engineers

The above discussion has left out one important question about the engineer —namely, his role as economist. In order to ensure efficiency in production activities, the engineer must acquire various management techniques including skills in process management, inventory management and cost management. Space limitations prevent a detailed discussion of this subject here, but it is an essential ingredient in the making of a good engineer.

To sum up, then, the engineer must possess the following three sets of attributes: (1) technological engineering; (2) managerial economics engineering; and (3) sociological engineering.

Abilities (1) and (2) require logical thinking and can be acquired through systematic education at academic institutions. However, sociological engineering requires abilities that are difficult, if not impossible, to acquire through formal school education. Under practical circumstances, an engineer needs "social skills" to be able to provide operators with the technical information they need and help them understand it in ways appropriate to their individual abilities. This kind of skill must be acquired by individual engineers through on-the-job experience. In Japanese industry, activities aimed at developing engineers' abilities thus naturally emphasize the acquisition of social skills, and it is accordingly important to create an educational environment conducive to such acquisition through experience.

Of course, this does not diminish the importance of acquiring practical abilities in the course of an engineer's education in technological and managerial economics engineering.

Technical education and introductory education on management techniques are critical for newly hired engineers. The standard practice in Japan is for company managers and specialists to offer a series of lectures on the present state of any technology unique to the company, the firm's pressing themes in technological research, and the direction it intends to move. In addition, new engineers are taken on tours of production sites and research laboratories to further their understanding of the total company effort. There is nothing peculiar about this education. In fact, it or its equivalent is provided by practically every Japanese corporation.

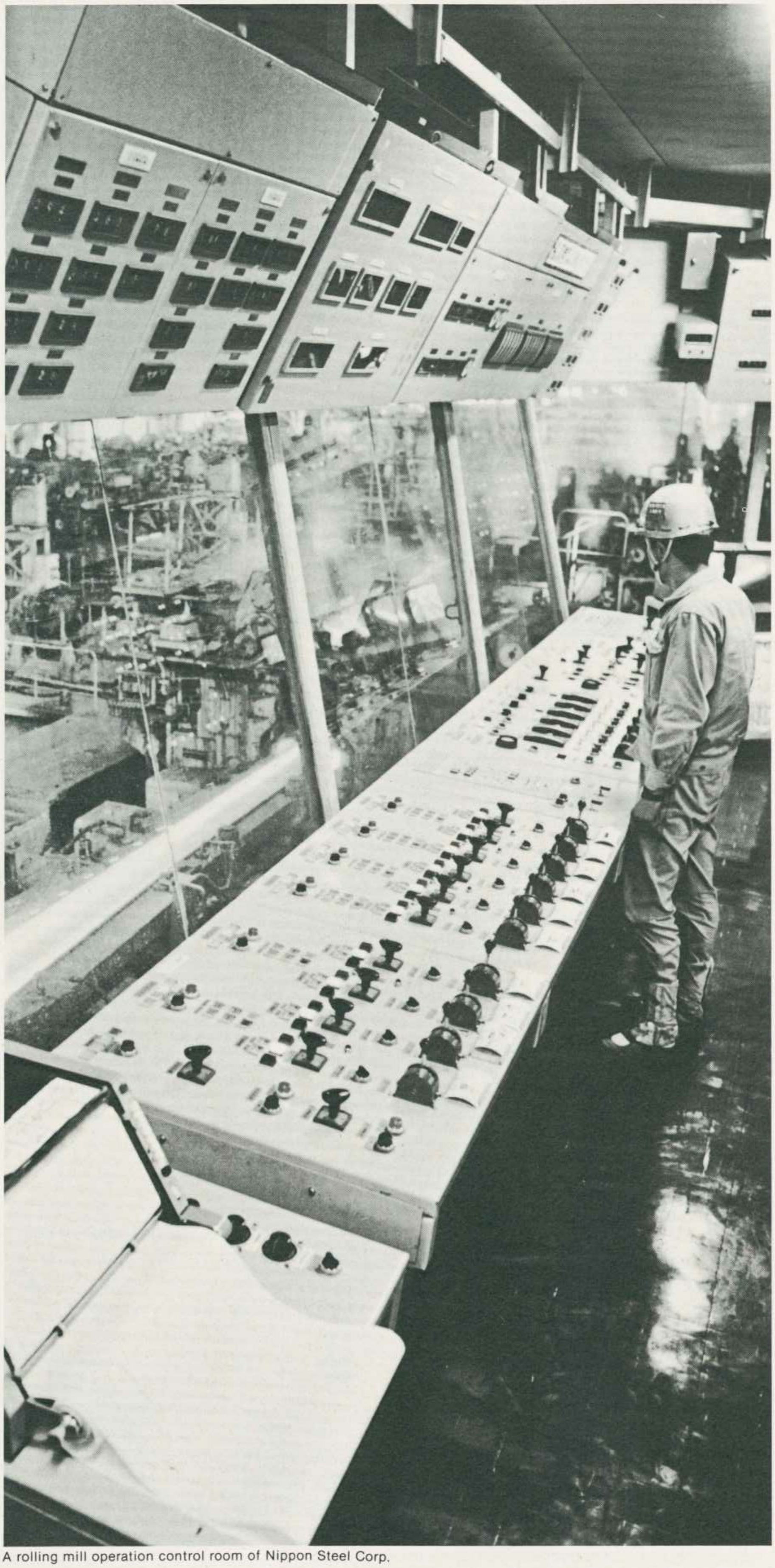
Japanese companies believe, however, that the practical technological engineering abilities required of the engineer can be developed only through hands-on experience after his assignment to a particular section to perform a particular job. For example, the design engineer develops his skills in the process of trying to incorporate various ideas into his designs without losing track of the cost requirements in order to satisfy the needs of particular customers to the greatest degree possible. His practical abilities are improved through constructive criticism of his drawings by his superiors or through their encouragement and assistance in making the designs more functional and workable at the manufacturing site. In short, practical engineering abilities, as opposed to formalistic knowledge, can best be developed on the job.

For this reason, it is widely held in Japanese industry that those in supervisory positions in the shop must be good teachers for their subordinates. It takes a long time, however, before such "on-the-job" education bears fruit. Moreover, the supervisor must give each of his subordinates a job that demands of him greater technological expertise than he already possesses if he is to improve his abilities.

This means, of course, that the subordinate always faces the possibility of failing at his new task. Yet even if he fails, he can still learn useful lessons from the experience, and thus improve his abilities over the longer haul. It is therefore essential that supervisors have the courage to give their subordinates demanding jobs that will help them improve themselves; they should not fear failure.

This is also why it is absolutely vital that managers' performance be evaluated from a long-range perspective. If only short-term performance is emphasized, the manager will be less positive about developing the abilities of his subordinates. He will not give them demanding jobs for fear he might be forced to take responsibility for their failures and, as a result, be given a low performance rating.

In Japanese industry the emphasis is on long-term performance evaluation. This lets managers foster the abilities of their subordinates under extended programs.



A rolling mill operation control room of Nippon Steel Corp.

Some Japanese academics criticize Japanese companies for making light of short-term quantitative performance evaluation, arguing instead that the long-term approach described above is not scientific. One must recognize, however, that success or failure in human development is too important a question to be decided solely on the basis of short-term quantitative evaluation.

The improvement of engineering abilities must be addressed from a long-term viewpoint. In the gradual process of skill development, engineers are, whenever necessary, sent to university as special researchers; they are also encouraged to publish their research at academic conferences or participate in projects involving not only academicians but engineers and researchers from other companies. Their abilities are improved in these and other ways. Human development must be undertaken consistently over a long period of time, without excessive preoccupation with the evaluation of quantitative achievements.

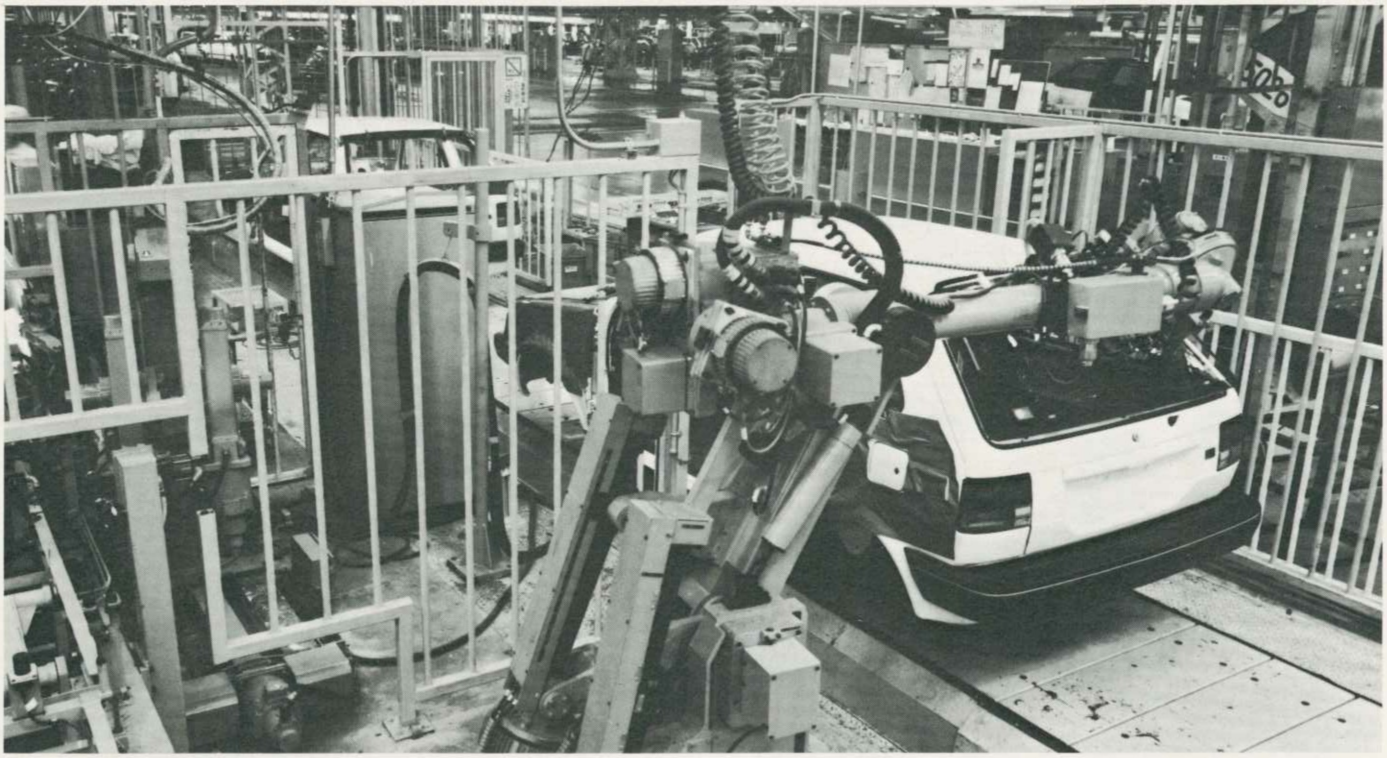
The principle of learning through work should be observed even more rigorously with sociological engineering skills, beginning with introductory in-house education.

This initial orientation for new engineers is generally completed in one to three months, after which they are assigned to particular sections. Assignments are made based on their own requests as well as on the observations of personnel experts during the orientation period and aptitude assessments during interviews. Evaluations by the senior engineers who served as instructors during the orientation also carry great weight.

In all cases, the new engineers are, in principle, first assigned to production sites. Assignments to other places, such as technical and planning sections or quality control sections at the head office or technical staff sections at factories, are generally avoided. Thus, as a general rule, engineers spend the first few years of their career on the front line. This is considered the time to put primary emphasis on education.

This belief that engineers with a university education still need an additional one to two years of education may give the impression that Japanese companies do not accord much value to formal schooling. Far from it. What it really indicates is a belief that workshop experience is indispensable to the development of sociological engineering abilities.

Many Japanese, in fact, are of the opinion that a university education has clear limitations insofar as the sociological realm is concerned. They see such education as best suited to acquiring a logical system of knowledge; in other words, universities teach only what can be acquired through logical thinking. The life of the "common man" at the production



A robot is considered a friend of assembly-line workers and operators rather than an enemy in Japan. (Photo: Nissan Motor)

site, however, is not always logical. He is not accustomed to expressing his thoughts to the elite class in a logical form. By getting directly in touch with workers' lives and sharing their lives, engineers can learn about their mentality.

I have said here that the common man is not accustomed to expressing himself logically. This does not mean, however, that workers are the intellectual inferiors of engineers. Rather, they possess a profound wisdom about life and a deep pride in themselves. Once they are given an opportunity to show their pride and use their wisdom, they exhibit unsuspected energy. Mental activity, be it sustained concentration on maintaining and improving product quality or the creation of new ideas for improving work methods and raising production efficiency, cannot be carried out effectively without the strong energy of the common man. Engineers must be able to read correctly what individual workers have in mind and give them opportunities to fully demonstrate those basic desires which they find so difficult to express in logical form.

It is also an important task of engineers to give frontline operators technical information related to their jobs through day-to-day contact in the shop, and thereby give them confidence in their own work. Needless to say, classroom teaching methods do not serve the purpose. What is needed is a practical teaching method fitted to the concerns and abilities of individual workers.

In addition, engineers must try to encourage and help operators to develop their own ideas and present them in the form of specific suggestions. In this way, operators are offered an opportunity to experience the pleasures of self-expression. There is no denying that these and other "sociological engineering" techniques are a major source of the vitality of Japanese enterprises.

Before concluding, I might add that close cooperation between engineers and operators is not achieved through ordinary educational activities nor through so-called behavioral science measures. Certain economic and social preconditions must be met if a satisfactory relationship is to be established. As I stated at the outset, the social distance between engineers and operators in Japanese industry is traditionally very narrow. Moreover, both are members of the same union, which means that wages are calculated along the same principles. In addition, the wage gap is far smaller than in the industrialized Western nations. Engineers and operators both enjoy similar standards of living. Consequently, they share similar lifestyles, and find it easier to understand each other. This is another important fact that must not be overlooked.

Before World War II a wide differential existed between white-collar and blue-collar wages. The social distance was also wider than it is today. It is no exaggeration to say that the abolition of discrimination between white-collar and blue-collar workers through postwar trade union activities has had a sweeping effect on Japanese industry. This is probably not something that had been anticipated by the trade unions, but they have had tremendous influence nonetheless. I disagree with the view that Japanese unions have socially less power than their counterparts in the United States and other Western nations. But that is a topic for another article (see Note 2).

Note 1. Research and Development Institute of Vocational Training, Employment Promotion Projects Corporation, *Development of Human Resources in Projects of Technological Innovations*, the Printing Bureau, the Ministry of Finance, Japan, 1983. This research project, begun in 1981, has the financial backing of the Ministry of Labour. The writer is the project leader.

Note 2. This point is discussed in some detail in my *Japanese Pattern of Management and its Vitalization,* Japan Productivity Center, 1982. ●

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