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OPPORTUNITIES IN MANUFACTURING

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American manufacturing is in trouble.

Important challenges must be addressed. Consider the primary factors of production. Usually these are taken to be labor, material and capital. When we compare the United States with Japan we find that the cost of equivalent labor per hour is substantially less in Japan than in the United States. In most manufacturing that labor is not so productive in Japan but in some manufacturing, notably consumer electronics and automobiles, the labor not only costs less per hour but it accomplishes more. One reason for that difference is the fact that the cost of capital in Japanese manufacturing is substantially less than in the United States. The lower cost of investment makes it easier to invest in labor saving equipment and work force training -- both leading to greater productivity. Also it is easier to invest in programs leading to higher quality, also leading to higher productivity.

At one time, roughly up until the sixties, the United States enjoyed a substantial advantage over its foreign competitors in the cost of material, especially steel, aluminum and other energy intensive materials. This advantage is now gone.

Engineering labor is a factor of production which has become more important as production processes become more difficult, more demanding technically. The fabrication process required in a front wheel drive,

automatic transmission car requires much more production or process engineering than did the rear drive manual transmission. The production machinery is much more complex and the production work force requires much more engineering support to get its job done. Here again the Far Eastern and European manufacturing firms can obtain the engineering talent they need at a significantly lower cost than their American competitors. The cost advantages enjoyed by foreign competitors in all the major factors of production present a formidable challenge.

There is a cultural difference between the United States and its foreign competitors which also presents a challenge to American manufacturers. Our society places great value on steady growth, especially in earnings. Those who buy and sell common stocks increase the prices of the stocks of companies which exhibit steady earnings growth. These are usually valued more than stocks of similar companies which have irregular earnings growth, even though their total earnings may be greater.

Corporate managers are aware of this behavior on the part of the buyers and sellers of common stocks and they behave accordingly. They tend to avoid courses of action which introduce irregularity in the earnings growth pattern and seek those which result in stable growth. This means that manufacturing managers tend to avoid the higher risk, higher pay off investments such as quality improvement or productivity improvement programs. Also these take a long time to pay off.

Existing measurement and evaluation systems present still another challenge to those who would capitalize on the opportunities available in manufacturing. The means to change to a better system are all available to senior corporate managers but the cultural barriers to using those means are considerable.

Finally, the strong, or overvalued, dollar presents a challenge. Even if U.S. manufacturers were manufacturing as well as their European and Far Eastern competitors they would lose market share and manufacturing volume to them because of the currency differential. That volume provides the means to pay for the investments required to capitalize on the opportunities. As long as the dollar stays as strong as it is today American manufacturers have little expectation of significant foreign markets and can expect to lose volume domestically to foreign imports.

Formidable as these challenges are, today substantial opportunities exist in American manufacturing. This is demonstrated by the fact that some firms do a much better job than others in manufacturing. In subcompact automobiles and consumer electronics American manufacturing as a whole is not competitive with Japanese manufacturing, taken altogether. Looking at individual firms, we can see some of the reasons for this state of affairs and find some guides to the ways to improve manufacturing in the United States. Instead of looking at particular firms and their characteristics, or at the factors of production and their costs, I will describe the opportunities as I see them in several different manufacturing functions or aspects of manufacturing.

In most manufacturing/marketing firms the manufacturing task is divided up among several relatively autonomous sub-functions. Usually these are: shop supervision, process or manufacturing engineering, quality management or quality control, production planning and control, materials management (including purchasing), industrial engineering, and shop accounting. In some firms two or more of these functions may be merged. Materials management is sometimes included with production planning; sometimes manufacturing engineering will do all the industrial engineering needed.

Sometimes a personnel function or an industrial relations function supplements those shown.

To a certain extent these separate functions exist because a problem area has been identified and a group of specialists created to deal with it. This is illustrated by the growth of the materials management function during the 1960s. Companies found they had problems with parts shortages and excessive inventories and set up materials management groups to deal with that.

To a certain extent this bureaucracy is the source of some of the current problems/opportunities. I will look at some of the perceived problems under these headings in order to describe how they may become opportunities.

Quality is often cited as a problem in American manufacturing that must be solved if we are to compete successfully with the Japanese. Our traditional approach of creating a quality management group to deal with the problem is not appropriate--we already have a quality management group and we still have the problem.

The problem of productivity is even more confusing. American productivity (measured as output per man hour) in the economy as a whole is still higher than that of any other major industrialized country. Even our manufacturing productivity is the highest in the world although in some industries and industry sectors this is not the case. The current concern about productivity is with the rate of increase in labor productivity which is substantially higher in both Europe and the Far East than it is in the United States, leading to an expectation of catch-up in the near future. Given our higher cost per hour, with parity in output per labor hour we will be at a disadvantage.

Not only do we have problems with quality and productivity, we continue to have problems with the planning and control methods used. Material Requirements Planning (MRP) or Manufacturing Resource Planning was supposed to reduce inventory equirements and improve customer delivery reliability. Often it did neither of these. At the same time, Toyota installed a just-in-time production control system that seemed to do both.

I will examine these problems separately in an attempt to show that their solutions are closely related. In fact, an attempt to solve any one of them without dealing with the entire manufacturing process will very likely fail. Only by taking an entirely new approach to the manufacturing process can we expect to realize the opportunities in manufacturing.

QUALITY

The nature of the opportunities available in many American manufacturing firms is illustrated by the steps needed to make major improvements in quality. The need to dramatically improve quality became clear in the 1970s when American consumers began to show a distinct preference for foreign-built television sets and automobiles. American manufacturers asked, "How can foreign manufacturers produce such high quality products at such low prices?"

American managers tend to seek what is called an "Aha!" solution to a problem -- a simple, innovative, insightful answer or procedure which, as soon as it is understood, can be adopted by anyone with a similar operational situation. Unfortunately, there didn't seem to be any simple answer or single procedure which was providing the high product quality. Some Japanese firms were using quality circles and this seemed to help improve quality. (A quality circle is a group of workers in related jobs who meet periodically to discuss their operation and ways of improving it. Management participates in these meetings and follows up on the suggestions.)

Some firms were using the statistical process control methods long advocated by the Americans Deming and Juran. Sometimes these firms were also using quality circles, sometimes not. It quickly became clear that process control was an essential ingredient in any manufacturing system that was going to produce consistently high quality products. This notion is sufficiently important to deserve illustration. In Figure 1a we see a chart of the performance of a lathe which is supposed to produce a shaft with a diameter of 1.000 ± 0.001 inches. In other words, the shaft will perform adequately if the diameter is between 0.999 and 1.001 inches. As shown by the chart, the diameters measured on a sequence of parts are comfortably within that range. In fact, it is rare to find that the diameter of the shaft is more than five ten-thousandths away from the desired dimension. The lathe, its tooling, and the operator make up a system which can operate "in control" and produce the parts according to specification.

Contrast this with Figure 1b, which charts the performance of a poorer lathe system. The overwhelming majority of the parts produced still lie within the specification limits but the fact that an occasional shaft is produced off-spec means that all the output must be inspected and any off-spec parts reworked or scrapped. In this case the lathe, tooling, and operator system is unable to produce reliably the desired part. In that sense, the process is out of control.

Suppose you manufacture snow blowers in the United States, you use a shaft specified this way, and you have a system like that shown in Figure 1b. To change the system to the performance shown in Figure 1a will require investment--perhaps a new lathe or a rebuild of the current lathe, maybe new tooling or better operator or toolmaker training, possibly a different approach by the supervisor, placing more emphasis on meeting the specification and less on output volume.

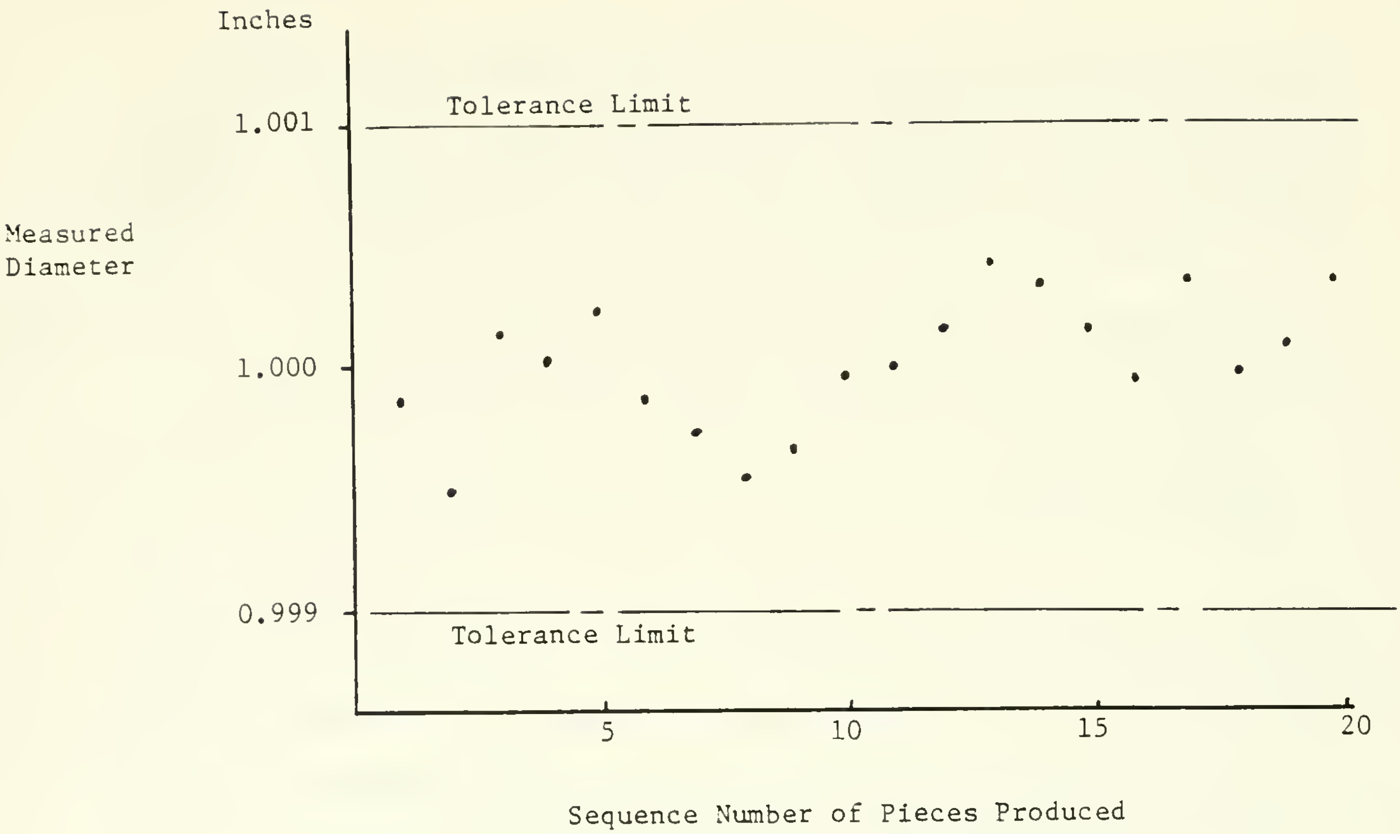

Figure 1a. Control Chart for a Process in Control

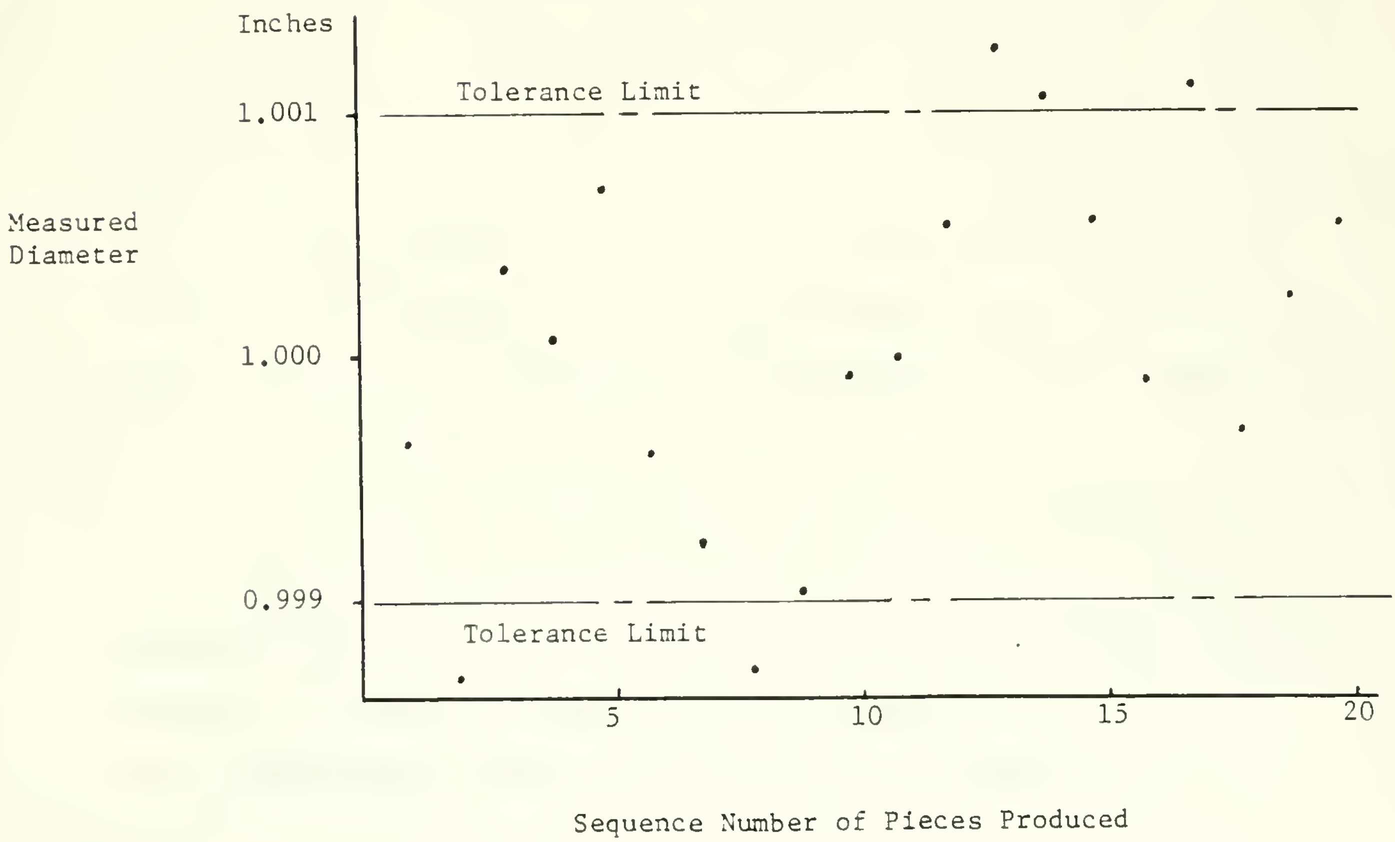

Figure 1b. Control Chart for Process Not in Control

It is not easy to justify this investment. If one looks at the cost of the pieces produced, using conventional cost accounting data, the cost will probably be greater using the high-quality system than with the low-quality system. Even if the cost of scrap and rework is included, the cost reduction will not be enough to justify the investment. It appears that those who have developed quality production systems of this type have done so without benefit of economic justification. They believe that it is better to operate that way and do so as a matter of company strategy or policy.

It has been argued that it is, in the long term, economical to operate a process in control and produce no defective products or a minimum number of defects. This may very well be true if one takes into account the customer loyalty engendered by a high quality, reliable product. Even if only short-run costs are included, there are cases in which the costs resulting from defective parts are sufficient to justify the investment required. The cost of a defective part increases rapidly as stages of electronic assembly proceed. It costs roughly ten times as much as the part is worth to deal with a circuit board containing a defective part. Perhaps another factor of ten is involved if the defective part is not detected until the circuit board has been installed in a computer and another factor of ten of cost increase may result if the defect is not discovered until the computer is in the hands of a customer.

Many U.S. firms do not have data of the type shown in Figure 1. They will inspect a sample of the output of the lathe and, if it meets the acceptance limits, they will accept the entire output of the lathe for some set period. The defective parts in any such lot will not show up until there is an assembly problem or perhaps a final inspection failure, or, worst of all, a customer report of a field failure.

Even if a company had data of the type shown in Figure 1, it also needs to have people to look at the control charts and point out the need for remedial action (system improvement) when the system starts to go out of control.

Here the operator plays a crucial role. If the operator is responsible for the quality of the output and the maintenance and adjustment of the lathe which produces the output, he can be counted on to take appropriate corective action to the limits of his ability to do so. Before that limit is reached, it is important to bring the matter to the attention of management, whose broader span of authority can make the needed system modifications before the system gets out of control.

The foregoing discussion illustrates three components of a manufacturing system to produce high quality products: a measurement system that provides data on production system performance, an operator to observe and interpret that performance data, and a response system that modifies the production system when the performance begins to approach control limits. Note that all three of these are essential. If management does not respond to problems reported by the operator, the operator loses interest and stops reporting. If the operator does not know how the performance of his operation is related to the overall product quality and how to interpret the performance information he gets, he cannot respond effectively or send relevant signals to higher management.

Enter the quality circle, one process which assists in two important aspects of the quality production system. It is a discussion session which serves to inform operators of how the process works and helps them learn their role in the process. It also gleans from the operators their knowledge of the shortcomings and difficulties with the system, system

characteristics that present them with problems they cannot solve. A third point, which tends to follow from these two, and may be more important than either of them, should also be mentioned. The quality circle shows the participants that they are important elements in the system. The consequences of this, in operator dedication and performance, are hard to overestimate.

Let us look briefly now at the contrast between a traditional or conventional production system with associated quality management system and a production system dedicated to quality production. In the conventional system, parts are produced by machines tended by operators who take little interest in either the machine or the characteristics of the output. The inspection or quality control group tells the operator or a set-up or maintenance person when adjustment is needed. An "acceptable" level of defects is estalished, often on the basis of a rough economic analysis of the tradeoff between the costs of improved quality and the costs of defects. The operators are used primarily as transducers, to load and unload machines and to respond to a limited range of signals from the machine. Usually, any thinking about the process is done by manufacturing engineers who initially set up the process and then review it when complaints arise. Indeed, in some companies, large efforts have been made to "de-skill" the operator's job in order to reduce training costs and labor costs.

Changing from the conventional process to the quality dedicated process presents a substantial challenge. Process information systems and process control systems have to be developed and installed. Operators have to be trained in the use of process performance information to tell when the process is in control and how to respond when it is not. Operators and supervisors must learn new roles and learn to value these roles.

These are not tasks that can be done quickly. Manufacturing or process engineers must design the process so it will produce the specified product while operating within its own control limits. Product designers must design the product so that it will perform reliably when produced according to specification and, at the same time, use specifications that can be met at reasonable costs by a system in control. The entire organization must operate in a coordinated and unified way, with each individual understanding his or her role and valuing the contribution they can make.

PRODUCTIVITY

Even though a great deal has been said about productivity in the past few years, little has been done to increase the rate of productivity growth. Before examining how we might increase productivity further in manufacturing, we should first review some definition and measurement problems.

Productivity is defined in a number of different ways. In general, it is the ratio of an output to an input and defined only by the way in which it is measured. A common way to measure labor productivity is the dollar value of output per labor hour of input. One can use this ratio for the entire economy or for any part or sector of the economy for which data are collected. Clearly, there are problems in defining how much of the "labor" expended in the economy should be included in the input. Should we use only direct labor, and if so, how much labor is direct? Looking at the economy as a whole combines some very different kinds of productive activity ranging from manufacturing to mining to agriculture. Further, the services sector of the economy is now larger than the goods production sector.

Not only is labor productivity difficult to measure in a way which improves understanding but labor is not the only factor of production that

concerns us. If we limit ourselves to manufacturing, the primary inputs are labor, capital, and material. As we have already seen, labor productivity can often be improved by increasing the capital input. In highly automated facilities for the production of parts and components enough capital has been invested to reduce the labor content of the output almost to a negligible amount. Clearly, there is not much opportunity for further increases in labor productivity in such a facility.

In relatively labor-intensive manufacturing, such as assembly activities, the labor productivity challenge is greatest. A comparison of some Japanese and U.S. automobile assemblies showed that, for the same value of output (in subcompact cars), the Japanese were using fewer labor hours at a lower cost per hour and, at the same time, employing a smaller amount of capital in the process. Even this is not necessarily an unambiguous comparison since the material used might well be more valuable by virtue of being at a higher level of subassembly when it arrived at the asembly plant. For example, in one case, a fully wired instrument panel could be purchased while in the other the panel wiring might be a part of the final assembly process.

In spite of this ambiguity, there do seem to be substantial opportunities in productivity improvement, considering all three primary factors of production--labor, capital, and material.

The first opportunity, described above, is in quality. Clearly, once the quality production system is in place, it produces more output for the same input of material and labor, by reducing or eliminating scrap and rework. Further, the same capital equipment may be used, the only "investment" being in training and development of participative management systems.

The second opportunity for productivity improvement is in worker motivation and involvement, without changing in any way the nature of the process used or the control of that process. Much of American labor-intensive manufacturing is characterized by an adversary relationship between workers and managers (or, if you prefer, between workers and owners). This need not be the case but it is not easy to change. Often attempts by management to change from an adversary relationship to a collaborative relationship are looked upon with suspicion by the work force. Nonetheless, changes do take place with enormous benefit for all concerned.

The third area of productivity improvement potential, often just as large an opportunity as the development of a collaborative relation between work force and management, is in the design of products for manufacturability. A product that is easy to make requires less labor and capital than a product that is hard to make. It may be possible to design two products that are equally attractive to the market but have very different manufacturing costs. Further, taking into account the manufacturing costs in various product features in the process of product design may lead to a very different product design and planned price.

What appears to be needed is a collaborative relationship between the product designers and the process engineers. Only when they begin to understand each other's problems and problem-solving practices can they begin to develop the products, and the production processes to make the products, that will appeal to the market.

PLANNING AND CONTROL

The last area of opportunity I want to discuss is planning and control systems. The opportunity is simple to describe but difficult to exploit.

Manufacturing processes would be much more economic, would make much better use of resources, if planning systems reflected the realities of the processes being planned. Many manufacturing operations are planned as though the processes were deterministic when, in fact, there is substantial uncertainty in the production output for a given resource input. In many instances schedules routinely overload the shop, i.e., treat capacity as unlimited when it is rigidly constrained. Many manufacturers prepare shop plans and schedules as though customer orders were not going to change when a brief examination of the order history will show that orders change more frequently than they stay the same during the manufacturing lead time.

Other operating managers, e.g., in transportation, seem to be able to develop more realistic plans and schedules which reflect not only the actual capability of the operating equipment and the uncertainties in the operating system and its environment (the commercial airlines seem to be a notable exception to this observation). This is why Federal Express and United Parcel provide reliable deliveries.

Material Requirements Planning (MRP) is widely used to assist in manufacturing planning. MRP develops proposed schedules for individual work centers based on the assumptions, first, that the requirement (master output schedule) will not change during the time required to accomplish all prior supporting activities (e.g. procurement, parts fabrication, and sub-assembly), and second, that sufficient capacity is available to accomplish all these tasks in the desired time period. Since MRP assumes determinism and unlimited capacity, it doesn't help much in attempting to deal with our two problems of uncertainty and capacity constraints. It is possible to address both of these within a general MRP framework but substantial modification of standard MRP systems is required.

A barrier to the implementation of planning systems that deal with uncertainty has been the reluctance of manufacturing managers to deal with the technology involved. In strong contrast, financial managers appear to be much more comfortable with rigorous definitions of risk and uncertainty and willing to make use of these concepts in making investment decisions. This is also surprising given the strong mathematical and technological background of many manufacturing managers.

Again, arriving at a sound planning and control system involves a recipe with multiple ingredients. First, the manufacturing management must want to have a planning system that deals with the real situation, even though that may include stringent capacity constraints and substantial uncertainty in process or in customer demand, or both. Second, the production planners and the MIS staff must be prepared to design and implement such a system. Such systems cannot today be purchased as completed packages from software houses, so a lot of in-house effort must go into the system development.

Finally, the production operation must develop a disciplined approach to executing the plan. Doing "better" than the plan may lead to congestion and confusion. Many production supervisors have become accomplished expediters, able to do the impossible on short notice. Often they are able to do this because there is excess slack in the system, more resources (usually in-process inventory and its close associate, lead time) are employed than are really needed to do the job efficiently. If the operation is planned with minimum resources, expediting is often impossible.

With management commitment to a lean and orderly operation and a willingness to manage rather than fight uncertainty, with production planners who have insight into the planning system needs of such an operation, and with production workers and supervision prepared to execute

the plans, much more efficient and effective production operations can be conducted.

The manufacturing scene today in the United States is not entirely one of unlimited opportunity. There are no quick fixes, no "Aha!" solutions. Only a patient pursuance of broad programs of major and comprehensive changes in manufacturing systems can be expected to keep our manufacturing industry vital. With such programs, we may look forward to great increases in manufacturing capability.