OHNO'S BOOK

THE "BIBLE" OF THE

TOYOTA PRODUCTION SYSTEM

Preface

It was the oil shock in the fall of 1973 that drew attention to our Toyota production system. This was because in the slow-growth economy which followed, Toyota Motor Company showed a relatively stronger resistance to recession than other companies.

The Toyota production system was a response to the state of the automobile industry in Japan after the war, namely: [redacted]

The Toyota approach was the result of many years of trial and error as searched for a way to survive in competition with the mass production systems already well established in Europe and America.

Basically, [redacted] It is a product of the Toyota history which started with Mr. Sakichi Toyota and has continued through Mr. Kiichiro Toyota to the present.

From the beginning, we felt we had some original ideas particularly suited to the economic environment of Japan. So, we did not want other companies, especially those of the advanced countries, to understand it easily. Consequently, we practiced the [redacted], and other techniques without publicizing them. Thus, it is only natural that our system was not understood easily.

Recently, I heard often from the outside that there seems to be some sort of secret in the Toyota production system and in "Kanban", which is the method of operating the system. We have received many direct and indirect inquiries from many people on the Toyota method of making things. They were not only from people in business, but from professors who are teaching production management in the universities and management consultants.

We are grateful for this interest on the Toyota production system. However, as the attention grows and as more people in the business in this country study the subject, there seems to be misunderstanding in some cases or, sometimes, certain convenient portions are abused.

One specific example is to make a shortcut conclusion that Toyota production system is a "Kanban system".

"Kanban" is one of the operational means of the Toyota production system and just the adoption of "Kanban" alone does not mean that the productivity will rise accordingly. And the intent of improving the record of a parent firm by "harassing the subcontractors" is entirely out of character with the idea of the Toyota production system.

So, in order for others to understand and apply the Toyota production system correctly, I have written this book.

In order to ensure correct understanding, emphasis was placed on the ideas and principles involved rather than giving many specific examples. I would like to tell this to the readers in advance.

To the distorted interpretation and criticism on the system by some people, I have not given any explanation or clarification. This is because I firmly believe that [redacted]

March, 1978

Taiichi Oono

A Comment on This Book

Rintario Muramatsu

Faculty of Science and Engineering

Waseda University

In all the countries around the world, various studies are being made on the production methods. In Japan, a marvelous production method was born, the Toyota production system. It was developed about 30 years ago by Mr. Taiichi Ono, presently the vice president of Toyota Motor Company, and it is showing tremendous results today. It is a revolutionary production system which it is believed [redacted]

In the multi-step production system which characterizes many production processes, there is the "pushing method" and the "pulling method". In the former, planned production quantity is determined from the demand prediction for a certain period and the inventory at hand; each succeeding production period is determined from the standard information at a certain time for each step, and the product is made in sequence from the earlier process. This method is used widely. In the [redacted] Each of the two methods has merits and shortcomings and which one to choose and how to apply it in an effective manner depends on the philosophy and creative innovation in practice of the managers and supervisors.

The Toyota production system is a "pulling method". In order to understand why it is giving such tremendous results today, it is important to understand the overall philosophy and concept which constitutes its basis without being side tracked by individual phenomenon such as "Kanban".* If the "Kanban" is introduced merely as a form without being part of the total philosophy, I believe there will be many troubles. It is important to recognize that the system did not happen overnight. Creative innovations have been worked on for 30 years aimed at not only improving overall efficiency but also the enhancement of the work environment.

In this sense, I think it important for the industrial world that Mr. Oono, the man most responsible for the Toyota production system, has written this book to describe his philosophy and ideas for reforms.

Mr. Oono is a man with some very special skills and determination. He has always challenged existing concepts and this has enabled him to conceive and apply improvements which are both accurate and swift. He is one of those rare people who can do this, and I have learned much from observing him and listening to his theories.

If one wishes to improve the character of one's business or increase productivity, just reading this book may not bring it about.

*"Kanban" - Instructions enclosed in a clear plastic envelope which communicates what is needed to be known at the point where the knowledge is needed. (i.e., a work station)

For this reason, I recommend this book not only to those associated with production and manufacturing, but to anyone who is a manager or supervisor.

But if one reads this book and uses one's own creativity and imagination in applying the theories herein, improvement should come about even in a business very different from Toyota.

LIST THE THEORIES, AXIOMS, TRUTHS..

Chapter 1. A Start from the Needs

o The Oil Shock Opened our Eyes

Starting at the time of the oil shock in the fall of 1973, people began to show a strong interest in the Toyota Production System.

The effect of the oil shock was great on government, business and on the lives of individuals. During the next year, the economy of Japan collapsed to a state of zero growth.

Because of the recession, many companies were suffering a great deal. Toyota, although its profits also suffered a decrease, kept earning more profit than other companies and this got attention. People wondered what it was about the Toyota production system which made this possible.

Beginning a time long before the oil shock, I had been trying to discuss the Toyota manufacturing technology and Toyota production system with anyone I came across but I could not arouse much interest.

After the oil shock through 1975, 1976 and 1977, Toyota's profit kept rising and the gap between Toyota and other companies kept growing; and with this, the Toyota production system started drawing attention.

During the era of rapid economic growth which Japan had maintained until 1973, the American system of mass production worked well. When the rapid growth stopped and the growth rate dropped, however, it became very obvious that a business could not be profitable with the conventional mass production system.

After the war, in 1950 and 1951, we never imagined that the number of cars would increase to today's level. A long time before that, in America, the method of cutting costs by mass production of fewer types of cars had been developed: that settled into the American way of life. In Japan, however, this was not the case.

Our problem had been how to develop a method of cutting the cost while producing small numbers of many types of cars.

During the 15 year period starting from 1959 to 1960, Japan achieved unusually rapid growth in economy. As a result, mass production, American style, was effective in fairly many areas. But we kept reminding ourselves that careless imitation of the American mass production system could be dangerous. Making small numbers of many types cheaply - wasn't this something we Japanese could develop? And we kept thinking that such a production system developed by Japanese might be able to surpass even the so called mass production system.

In summary, the Toyota production system is a method which can produce small quantities of many types.

o "Slow Growth" is Scary

During the previous eras of high growth rate — before the oil shock, the business cycle usually consisted of two to three years of prosperity and, at the most, half a year of recession. At times, prosperity lasted even more than three years.

"Slow growth" is the reverse of such a cycle. Annual economic growth rate of 6 to 10 percent lasts at the most half a year to one year and the next 2 to 3 years see a small growth or none at all or even below zero growth.

Industry in Japan, in general, has been accustomed to an era of "if you make, you can sell" and the automobile industry was no exception. I am afraid that, because of this, many business managers' thinking is geared toward quantity.

In the automobile industry, the term "Maxi Silverstone Curve" has been used frequently. This principle of the effect of mass production says that, although there is a limitation in the extent of cost reduction, the cost of an automobile decreases drastically in proportion to the increase in the quantities produced. This was proven thoroughly during the era of high growth rate and the principle is buried in the mind of people in the automobile industry.

But, today, having entered the slow growth era, we must get rid of the idea of the merit of the mass production effect as soon as possible.

We have entered an era in which the production system of aiming at the mass production effect by enlarging the lot size (for example, taking the case of operating a press, punching out as many as possible with a die given units of time) is not applicable any more. We must realize that such a production system also generates all sorts of waste on top of having become inapplicable.

o "Catch Up With America"

I am not saying that all imitation of American ways is bad. We have learned many things from the automobile empire of America. America generated wonderful production management techniques and business management techniques such as QC (quality control) and TQC (total quality control). Japan imported these techniques and used them fruitfully. The same has been true also with IE (industrial engineering).

These techniques were born in the American environment and they were generated by the efforts of American people. I think Japanese people should realize these facts and never forget them.

August 15, 1945 was the day on which Japan lost the war and it was also a day of a new start. Mr. Kiichiro Toyota (1894 - 1952), president of Toyota Motor Company at the time, said, "Catch up with America in three years. Otherwise, the automobile industry of Japan will not survive." For this goal, we had to know America and thus we had to learn American ways.

In 1937, I was working in the weaving plant of Toyota Textiles. Once I heard a man say that a German was producing three times as much as a Japanese was. When he went to America from Germany, the ratio between Germany and America was 1 to 3. Thus, the ratio between Japan and America turned out to be 1 to 9. I still remember my surprise at hearing that it took nine Japanese to do a job which one American could do.

I wondered if productivity had changed from one ninth of America to one eighth during the war. Anyhow, President Kiichiro Toyota was saying that we should catch up in 3 years. Would it not be very difficult to raise productivity by 8 times or 9 times in 3 years? Would it not mean that a job which was being done by 100 men had to be done by 10 men?

Furthermore, the figure of one eighth or one ninth was an average value. If we compared with the automobile industry which was one of the most advanced industries in America, the ratio would have been much different. But, of course, it could not be that an American was putting out 10 times more physical work. It must be that Japanese people were wasting something. So, if we could eliminate the waste, productivity should rise by a factor of 10. This way of thinking was the starting point of the present Toyota Production System.

o Two Pillars of the Toyota Production System

The basic idea of the Toyota Production System is "absolute elmination of waste." There are the following two pillars which are needed in supporting the work to achieve this idea.

(1) Just-in-time ✓

(2) Auto-activiation ✓

"Just-in-time" means that in a process of assemblying a car in a flow process, a part needed in assembly reaches the assembly line every time it is needed and only as many as needed. If such a situation can be realized throughout a company, it would approach zero "inventory".

From the standpoint of production management, this is an ideal state. However, with a product like a car which is made of thousands of parts, the number of all of the processes involved is a huge one. Obviously, it is an extremely difficult job to bring the production plan of all of these processes to the state of "Just-in-time" in a very orderly manner. An upset in the prediction, a mistake in the paper work, defective product and necessary corrections, trouble with the facilities, change in the employees' attendance record ... the problems are countless.

If a problem arises at an earlier part of the process, there is always a defective product in a later part of the process. This would cause a line stop or change a plan whether you like it or not.

If we disregard such situations and consider only the production plan for each process, the parts would be produced without any regard to the later processes. waste would result. defective parts on one hand, huge inventories of other parts which are not needed immediately on the other. This would create a worsening of the production efficiency and lowering of business efficiency.

Even worse, there would be no distinction between normal and abnormal states on each line of the production field. When the rectification of an abnormal state is delayed, too many workers are making too many parts. Such situations can not be corrected quickly.

Therefore, in order to satisfy the condition of "Just-in-time" in which each process receives an item which is needed, at the time it is needed and as many as needed, the conventional method of management in which the production plan is directed to each process and an earlier process carries the items to a later process. is not believed to work well.

o Utilize the Out-of-Common-Sense Idea "Rule of Thumb"

I kept thinking about how to realize the "Just-in-time" system in which the parts needed are supplied when needed, with as many as needed. I am fond of thinking about a problem over and over. Flow of production is the transfer of materials. So, I tried to think of the transfer of materials in the reverse direction.

Process Flow EARLIER ----------> LATER

The conventional way of thinking was "to supply materials from an earlier process to a later process." In the production of automobiles, a material is machined into a part; the part is assembled with others into a unit part, and this flows toward the final assembly line. As the material progresses from the earlier processes toward the later processes, they form the body of the car.

EARLIER <---------- LATER

Now look at this flow of production in reverse: "a latter process going to an earlier process to pick up the parts needed when needed and as many as needed?" In that case, would it not be "all right if the earlier process makes only the portion which is picked up?" As far as the means of interconnecting many processes is concerned, would it not suffice if clear indications are made of "what and how many" are needed?

· WHAT.
· How many.

Let us call this means of indication a "kanban" (indication board) and circulate this between each of the processes to control the amount of production, i.e. the amount needed. This was the beginning of the idea.

We tried the idea in various ways and finally decided to pursue the following system: Taking the "final assembly line" as the starting point, the production plan is given only to the assembly line: as for the method of transferring the parts which were used at the assembly line, we switched from the conventional system of forwarding the parts from an earlier process to a later process to the system of "a latter process going to an earlier process to pick up the parts needed at the time they are needed, as many as needed and the earlier process making only the portion which is picked up."

On this basis, the production plan can be given to the final assembly line. indicating the desired types of cars. The time they are wanted and the quantity wanted: then the method of managing the transfer of materials is reversed to one in which a later process goes to an earlier process to pick up the various parts which are used in the assembly line: in this way, the manufacturing process is followed reversely up toward the earlier processes as far as to the department where the roughly shaped materials are prepared: then the chain is connected and synchronized and the condition of "Just-in-time" system is satisfied. By this, the management work force is also reduced drastically. Here, the means which is used for conveying the information of picking up or production order is the "Kanban" which we touched on previously.

About this "Kanban", we shall describe it in further detail in a later section. Here, I want the reader to understand the basic posture of the Toyota production system. The basic idea of the Toyota production system is supported by the "Just-in-time" system which we have discussed so far and the "auto-activation" which we shall touch upon in the next section. The "Kanban" method is the means which moves the Toyota production system smoothly.

o Give the Machine Human Intelligence

Another pillar of the Toyota Production System is "auto-activation". It is not "automation". It is "auto-activation".

There are many machines which operate by themselves once the switch is turned on. Recently, the machines are becoming faster with high performance capability. As a result, any small abnormal situation such as a piece of scrap falling into the machine can damage it in some way. The dies break, for instance, or the taps. When this happens, defective parts start to be produced and tens, hundreds of them quickly pile up.

With this kind of automated machine, we cannot prevent the mass production of defective products and there is no built-in automatic checking system against troubles occurring in the machines.

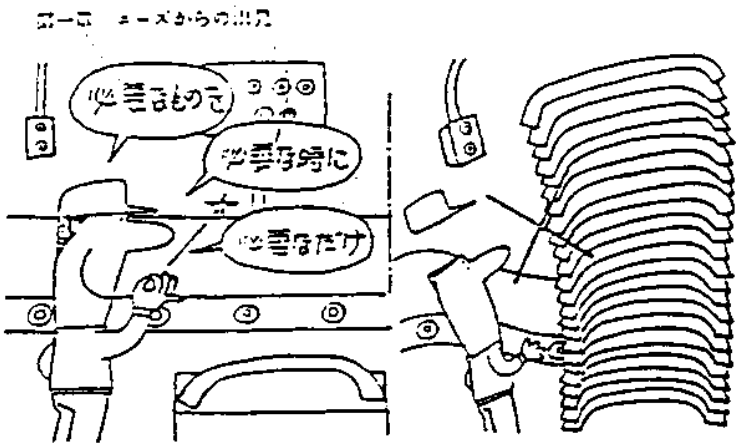
$\neq$ AUTOMATION

This is why Toyota has been placing emphasis not on simple automation but on the "auto-activation."

The spirit of "auto-activation" orginated with the invention of an auto-activated weaving machine by Mr. Sakichi Toyota (1867 - 1930), the founder of Toyota Company.

at the time when needed

as many as needed.

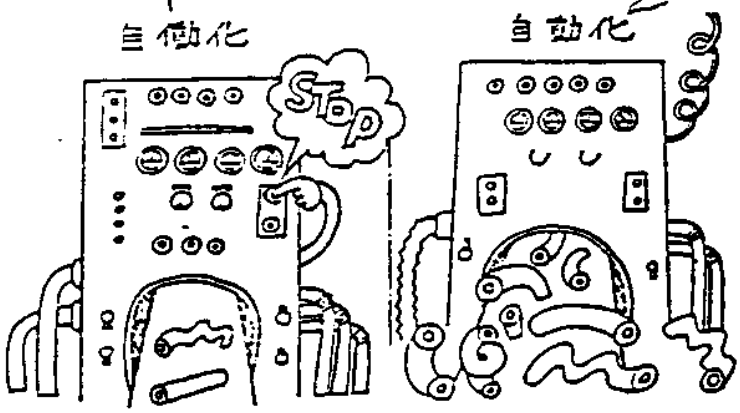


ジャスト・イン・タイム

Just-in-time

Auto-activation

Automation



自働化と自動化

Autoactivation and automation

This machine would stop instantly if any one piece of the vertical or lateral threads broke. In other words, "a device which makes the judgement of good or bad" was built in the machine. As a consequence, defective products were not made.

At Toyota, the "auto-activated machine" means "a machine which is attached to an automatic stopping device." In all of Toyota plants, most of the machines, whether they are new machines or old machines, are equipped with an automatic stopping device. For example, "fixed position stopping system", "full work system" or "prevention of defective products (BAKAYOKE) and various safety devices are additionally installed. Thus, human intelligence is given to the machines.

Such auto-activated machines change the meaning of management greatly as well. Thus, an operator is not needed while the machine is working normally. Only when the machine stops because of an abnormal situation does it get attention. As a result, one man can attend to several machines, making it possible to decrease the number of operators and increase production efficiency drastically.

Another way of looking at this is that if a man must always attend to a machine and replace the machine when something abnormal happens, this means that the abnormal situation would never disappear. An old Japanese proverb says, "If something stinks, put a cover on it." If the material or machine gets repaired without the managing supervisor being made aware of the fact, improvement is never achieved and the cost never goes down. Stopping the machine when there is trouble forces awareness on everyone. If the problem is clearly understood, improvement is now possible.

Expanding this way of thinking, we set a rule that even in a production line which is operated manually, the workers themselves should push the stop button and halt the production line if there is any abnormality.

The automobile is a product for which the safety aspect must be always regarded as important. Therefore, with any machine on any line in any plant, it is indispensable that the distinction between normal and abnormal operations is clear and the countermeasure against the recurrence of any trouble is ready for application. This is why I took this as one more pillar for supporting the Toyota Production System.

o Synergism Effect of Individual Skill and Team Play

How to implement the "auto-activation" is up to the wisdom of the managers and supervisors of each production area. The key point is to attach human intelligence to the machine and , at the same time, the point is "how to adapt the simple movement of the operator, the man, to the auto-activation."

How should one describe the relation between "Just-in-time" and "auto-activation" which can be called the two pillars of the Toyota Production System?

Comparing this to a baseball team, "auto-activation" corresponds to the skills and talents of each player. "Just-in-time" might be seen as the teamwork involved in reaching an agreed upon objective.

For example, a man in the outfield has nothing to do as long as the pitcher has no problems. But a problem -- the opposing batter getting a hit -- activates the outfielder who catches the ball and throws it to the baseman "just in time" to put the runner out.

Managers and supervisors in a manufacturing plant are like the manager, batting coach, base coach and field coach in the baseball team so to speak. A strong baseball team is the one which has mastered the team play, i.e. the coordinated play with which they can meet any situation. The production team which has mastered the "just-in-time" system is precisely like a baseball team which plays well together.

On the other hand, "auto-activation" performs the role of eliminating over-production which is an important waste in manufacturing and of preventing the production of defective products. For this, the "standard operation" which corresponds to the ability of each player must be recognized at all times and, when an abnormal situation arises, i.e. when the ability of a player cannot be brought out, the player must be given special instruction so that he can be restored to his usual posture. This is an important duty of the coach.

TRAINING

MGR. ✓✓

In the "auto-activation" system, "management by seeing with eyes" can be achieved and the weaknesses which exist in the production field, (i.e. in each of the players) brought out to the surface. As a result, it is possible to apply a measure for strengthening the player involved.

ERRORS COME TO LIGHT.

A team which wins the championship in the World Series or in the Japan Series has good team play and good individual plays without exception. The original source of this power comes from the synergism effect of the two factors.

In the same way, a production line where the "Just-in-time" and "auto-activation" work together is stronger than any other system.

o Cost Reduction is the Goal

Frequently we use the word "efficiency" as in "production efficiency", "management efficiency", and "business efficiency." The reason for pursuing "efficiency" in modern business is to realize the "reduction of cost" which can be called the root of the business goal.

Not only in Toyota but in all industries, profit in a manufacturing business can be obtained only by reducing costs. The way of thinking along the "cost doctrine" (in which the price is determined by adding profit to the actual cost) is something like sending the final check to the consumer. In today's automobile industry, such thinking has no place.

Our products are scrutinized by cool-headed consumers in free, competitive markets.

How much a product costs to make is not a consumer's concern. The question is whether or not the product is of any worth to the buyer. If a high price is set because of high cost to manufacture, the consumers will simply turn away.

For a manufacturing business of consumer products to survive in free, competitive markets, the supreme order which it has to obey is the reduction of costs.

During a period of high economic growth rate, anyone can achieve lower costs through high production. But today, in an era of slow growth, any form of lowered costs is not easy to achieve. There is no magic method simple and absolute.

What is needed is a total management system in which human ability is drawn out fully to enhance the fruitfullness and utilize the facilities and machines well, performing the work with absolute elimination of wastes.

We have discussed the two pillars which support the basic idea of the Toyota production system that advocates "absolute elimination of waste". This production system was born in the Japanese environment because it had to be born. Today, entering the era of slow economic growth worldwide, it is believed that this production system is a management system which is effective for any type of business.

o An Illusion of Japanese Industry

Shortly after the war, Mr. Kiichiro Toyota, father of domestic car production, advocated, "Catch up with America in three years", and this became the specific business goal of Toyota.

When there is a clear goal, man's activity becomes vigorous. The same is true also with business activities.

During the war, in 1943, I changed my job from textiles to automobiles, and the experience with textiles was a big plus. The idea of "auto-activation" which was discussed previously was obtained from the auto-activating weaving machine of Mr. Sakichi Toyota. When I moved to the automobile production plant, I could spot the merits and shortcomings of the automobile production plant in comparison to the textile plant although I was a layman in the field of the automobile.

During the time of rehabilitation after the War, the road for Japan's automobile industry was very rough. Domestic car production in 1949 was 25,622 trucks and only 1,008 passenger cars. Domestic production was really insignificant. Despite all this, the Toyota production plant seemed to be filled with the eagerness of people trying to do something. President Kiichiro Toyota's words "Catch up with America" generated such a spirit.

In 1947, I was in charge of the No. 2 manufacturing machine shop at the present Main Office Plant (Kyobo Plant at the time) in Toyota City. As a method of catching up with America, I started thinking about having one operator take care of many machines and also machines of many processes rather than having one man operating one machine. Therefore, the first thing to do was to establish a flow system in the machine shop.

In American machine shops as well as in the machine shops of most Japanese companies, a lathe operator, for example, operates only lathes.

In many of the plant layouts, 50 or 100 lathes are located in one place. When the machining is completed, the items are collected and taken to the subsequent drilling process. When that is finished, the items are taken to the milling process.

In the case of America, there is a union for each job function and many unions are present in a company. So, the lathe operators operate only the lathes. A drilling job has to be taken to a drilling machine. Because the operators are single-skilled, a welding job required at the lathe work cannot be done right there. The only way to have the welding done is to take the item to the welding section. As a consequence, the number of machines is large and number of people is also large. For American business which must achieve cost reduction under such conditions, it is obvious it can be achieved only through mass production.

By producing large quantities, the labor cost per car is reduced. Allocation of depreciation is reduced. This requires large, high performance, high speed expensive machines.

This type of production system is a planned mass production system. Each of the processes makes many parts and forwards them to the next process. This method naturally generates lots of waste. From the time Japan acquired this American system until the time of the oil shock in the fall of 1973, Japanese businesses had the illusion of regarding this system as fitting the Japanese environment.

o Establish the Flow of Production

It is never easy to break the conservative system of the machine shop in which operators are fixed to jobs, e.g. lathe operators to lathe work, welders to welding work. Although this might be impossible in America, it was possible in Japan only because we had the willingness to do it. The beginning of the Toyota production system began with my challenge to this old system.

With the outbreak of Korean War in June, 1950, Japanese industry recovered its vigor. It is obvious that the automobile industry also expanded riding on this wave. This year was busy and hectic for the Toyota Motor Company. From April to June, there was the labor dispute caused by the reduction of manpower. President Kiichiro Toyota resigned, taking the responsibility. After this, the Korean War broke out.

Although there was the special demand situation, production was far from mass production. The types were many. There was no change in the production of small quantities of many types.

At the time, I was the manager of machine shop of Kyobo Plant. I started an experiment in which the different machines were arranged in the sequence of machining processes.

This was a radical change from the conventional system in which many pieces of an item were machined in one process and then were forwarded to the next process.

In 1947, machines were arranged in the "shape of the character " = " and "the shape of the character L" and we took the challenge of trying the system of one operator using three machines or four machines along the sequence of processing.

Resistance from the production field was naturally strong. Although there was no increase in the amount of work or working time, the skilled workers at the time were fellows with the strong temperament of craftsmen and they strongly resisted change.

They did not like changing the arrangment of machines; changing from the old system of one man, one machine, to the system of one man many machines in a sequence of different processes being required to work as a multi-skilled operator.

Such resistance was understandable. Also, by actually trying, various problems became known. For example, a machine must be set up to stop when a machining is finished: sometimes there were so many adjustments that an unskilled operator found the job difficult to handle. As such problems gradually became clear, they taught me the direction of the next move.

I was young and eager to push. But I decided that pressing drastic changes in a short time was not a good idea. I approached the problem with patience.

o We Were Beaten by "Dekansho" Production

When the fierce labor dispute ended and the Korean War boom with its special demands arrived, tension filled the production plant and things turned lively.

For a business, there is nothing which is more pleasing than orders from customers. How should we handle the special demand of trucks? People in the production plant were frantic.

At any rate, it was a time of shortage of everything from the crude materials to the parts and we could not get things in the quantity we needed or at the time we needed them. Of course, the cooperating firms which supplied the parts were also short of facilities and manpower.

Because Toyota was a maker of chassis when many parts did not arrive at the time they were needed and by as many as were needed, we could not start the assembly work. Because of this, we could not do the assembly during the first half of the month. The only thing we could do was to gather the parts which arrived intermittently and irregularly and do the assembly work around the end of the month. Like the "Dekansho season" of sleeping away half of a year, this was "Dekansho production" and we were almost completely beaten by this situation.

If a part is needed at a rate of 1,000 pieces per month, it would be good to make 40 pieces a day for 25 days; 40 pieces today and 40 pieces tomorrow. It is desirable to make at a constant rate. Furthermore, it is important to make 40 pieces taking one day. If the time of work per day is 480 minutes, it would be good to make one piece in 12 minutes. This idea developed into "averaged production" later on.

Establishment of the flow of production and setting up the system of supplying the raw materials of parts to be machined at constant rates from outside -- would this not be the way the Toyota production system, (or the Japanese production system) should be operated? Our minds were rampant with imagination.

Because it was a time of shortges of everything, we must have believed it would be all right if we somehow increased manpower and machines to make things and store them.

At the time we were making at the most 1,000 to 2,000 cars a month and having every process hold an inventory of one month's supply, might not have been too much of a burden. However, for this purpose, we needed a large warehouse. What would happen if the quantity of production increased? We thought it would be a big problem.

Therefore, we studied how the "all production around the end of a month" could be averaged to a flat rate of production. We started by looking at the inside of the Toyota Motor Company itself. Then, wherever an outside supplier was needed, we would approach the other company and, after listening to their wishes, would ask for their cooperation in helping us achieve averaged production.

Depending on the time and place, we discussed the cooperating in various aspects of manpower, materials and money. All of this effort was made to get out of the "Dekansho production", i.e. the "all production around the end of a month."

o In the Beginning, There Was the Need

So far, I have described, in sequence, the fundamental idea of the Toyota Production System and the skeleton which makes up the basis of Toyota Production System. I would like to emphasize that all of this has been realized because there were clear purposes and needs at all times.

Even today, improvements at the plants of Toyota are made on the basis of needs. I believe very earnestly that "necessity is the mother of invention." Thus, it is not an error to say that the key to great progress in production improvement is to let the plant people feel the needs.

The fact that I, myself, have been building the Toyota Production System described above block by block has also been based on the strong need to discover a new production method, eliminating wastes, to "catch up with America in 3 years."

For example, the idea of "a later process going to an earlier process to pick up" came about under the following circumstance. When the conventional system was used, an earlier process continuously forwarded products to a later process regardless of the situation of production in the later process. So, there was formed heaps of parts at the later process. Men at the later process had to spend time

looking for storage space and finding parts. Because of this, the important part of their job, their production, did not make progress. This waste had to be eliminated somehow and it meant that the forwarding of parts from the earlier process had to be suppressed. The strong feeling of these needs made us think about the idea which was the reverse of the past method.

Establishment of the flow of production with the changing of machine arrangment in the machine shop eliminated the waste caused by storing parts and brought the realization of the "one operator many machines" system (more accurately the "one operator many processes" system) and raised production efficiency two and three times what it had been before.

I already mentioned the fact that, in America, this sytem of one operator many different types of machines could not be implemented easily. As to why it was possible in Japan, one reason was that Japan does not have the job function oriented unions like those in Europe and America. Consequently, transition from the one-skill operator to the multi-skill operator went relatively smoothly in Japan, although there was some resistance caused by the temperament of craftsmen.

This fact does not reflect a weakness of unions in Japanese industry relative to the unions in Europe and America. Much of the difference lies in the history and culture.

It is generally said that the trade unions in Japan are good examples of the vertically divided society which does not have mobility while the job function oriented unions in Europe and America are examples of laterally divided society which has great mobility. Is this actually so? I don't think so.

In the American system, a lathe operator is always a lathe operator and a welder is a welder to the end. In the Japanese system, an operator has a broad spectrum of skills. He can operate a lathe, handle a drilling machine and also handle a milling machine. He can even perform welding. Comparing the two systems, which system should one say is better?

It is difficult to argue which is superior and which is inferior. Much of the difference must be coming from the difference in the history and culture of the two countries. Each has its merits and demerits. So we should seek the merits of each. In the Japanese system, each one of the operators acquires a broad spectrum of production skills and thus participates in building up a total system in the production plant which I call "manufacturing skill." In this way, one may feel the worth of working.

Needs and opportunities wait. They are not born. We must go and grab them. In order to grab the opportunities which are practical, it is necessary to drive oneself to the uppermost.

What would be the utmost needs of business under the slow growth conditions? Repeating the point, the question is what to do to raise productivity while the production quantity does not increase.

o Consciousness Revolution is Indispensable

There are numerous wastes in business but none is more terrible than the waste of over production. Why does it occur?

It appears we always feel insecure if we do not hold a considerable amount of inventory. Before, during and after the War, an era of continual material shortage. buying and hoarding were very natural behaviors. Even in this affluent modern time. people bought up tissue paper and detergent when the oil shock came and this behavior of the mass of people also originated from the hoarding psychology.

Is this not the response of a farming tribe? Our ancestors grew rice as main food, and they stored it to be prepared for natural disaster. From our experience during the oil shock, we learn that our basic nature has not changed much even in the present time of material affluence.

Modern business also seems to be stuck with the same way of thinking. A businessman may be overwhelmed with uneasiness at being unable to survive in this fiercely competitive society unless he has at hand some inventories of raw materials, materials in processing, and products.

What I assert is that modern industry must step out of this. We cannot stay in the state of a farming tribe. We have to become a hunting tribe and muster courage to procure only the needed items at the time they are needed and in the amount needed. We should not call it courage. I think it should be the common sense of modern industrial society.

This will require what I call a "consciousness revolution" on behalf of business people, a change of attitude and viewpoint.

For a large inventory to be held in an era of slow growth causes the waste of over-production. It also causes "defective inventory" which is a most serious business loss.

We must first comprehend these situations in depth. Only then, I think can we achieve a "consciousness revolution."

Chapter 2. Evolution of the Toyota Production System

o Can You Repeat "Why" Five Times?

Have you ever put the question of "why" five times to a single matter? This is easy to say but it is difficult to practice.

For example, suppose a machine stopped functioning.

(1) "Why did the machine stop functioning?"

"There was an overload and the fuse blew."

(2) "Why was there an overload?"

"It was because lubrication of the bearing was not sufficient."

(3) "Why was the lubrication not sufficient?"

"Because the lubrication pump was not pumping sufficiently?"

(4) "Why was it not pumping sufficiently?"

"The shaft of the pump was worn and it was rattling."

(5) "Why was the shaft worn out?"

"There was no strainer attached and this caused metal scrap to get in."

Thus, by repeating the question "why" five times as above, one can discover the real problem and correct it.

If the procedure of pursuing the "why" was not thorough, one might have ended with the replacement of the fuse or with the replacement of the pump shaft. If this was the case, the same trouble would have occurred again within a few months.

To tell the truth, it can be said that the Toyota production system has been built by the accumulation and evolution of this scientific approach.

By asking the question of "why" five times of oneself and then by answering the question each time, one can really get to the true cause of the problem which is hiding behind more obvious symptoms of the problem.

"Why, at Toyota Motor Company, can one person operate only one machine? (At Toyota Textile, one young woman would oversee 40 to 50 of the automatic weaving machines)."

By starting with this question, we obtained the answer: "Because the machines are not set up to stop when the machining is completed" and from this the idea of "auto-activation" was derived.

To the question of "Why can a thing not be made just-in-time?", one can obtain the answer: "The earlier process makes the thing too fast. It is not known how many is being made per minute." From this result, the idea of "averaging" could be derived.

To the question of: "Why are we generating the waste of making too many?", there evolved the first answer of "because there is no function of suppressing over-production." This led to the idea of "management by seeing with eyes" and then this led to the idea of "Kanban."

It was already stated in the previous chapter that the Toyota Production System is based on the fundamental idea of complete elimination of waste.

"Why is the waste generated to start with?" By asking this one question, one is actually asking the meaning of the profit, which is the condition for the continued existence of a business. At the same time, this question is asking the basic nature of the reason for man's working to the man himself.

About the production plant operation, I regard the "data" as important but I regard the "fact" as the most important. When a problem arises, if the procedure for pursuing the cause is not thorough, the action being taken can be out of focus. This is why the question of "why" needs to be asked five times repeatedly. This forms the basis of the scientific attitude of the Toyota system.

o Complete Analysis of Waste

As the basic ways of thinking for the complete elimination of waste, it is important to keep the following two points in mind.

(1) Improvement of efficiency makes sense only when it is tied to the reduction of cost. To achieve this, one has to advance in the direction of making only the things needed with minimum amount of manpower.

(2) Look at the efficiency for each of the operators, for each of the lines, then at the operators as a group and for the whole plant consisting of all the lines. The efficiency must be improved at each of the steps, and at the same time, it also has to be improved for the whole plant.

Let us expand the above statements in further detail. Throughout the labor dispute which started with the manpower cut in 1950 and throughout the boom of the special demand which came later with the breakout of the Korean War, the Toyota production plant struggled with the problem of how to increase production without having to increase manpower. As one of the persons in charge of the production plant, I put my ideas into work in the following ways.

Say one line has 10 men and makes 100 pieces of the products a day. Starting the thinking from this basis, the capability of this line is 100 pieces per day and the productivity per person is 10 pieces per day.

However, if we observe the movements of the line and workers in further detail, there are over-productions, workers waiting, and other scattered movements depending on the time of day.

Suppose we improved the situation and achieved reducton of manpower of two workers. In other words, the fact that production of 100 pieces could be done with 8 men would make it look as if it would be possible to make 125 pieces a day without the reduction of manpower, amounting to an increase of efficiency by 25 pieces a day.

In actuality, however, the capability of making 125 pieces a day existed even before. The only thing was that the capability for making 25 pieces was being wasted in the form of unnecessary work or making too many.

From the above considerations, for individual workers or for the whole line, the following equation holds if we regard the truly needed work as the work and the rest as the waste.

Present capability = work + waste

(Operation = working + waste)

The true improvement of efficiency is making the waste part zero and bringing the percentage of the work to 100 percent. Furthermore, in the Toyota production system, one must make only the amount needed. Therefore, the manpower must be reduced to trim the excess capability to match the quantity needed.

As the preliminary step toward the application of Toyota production system, all wastes must be identified completely.

(1) Waste of making too many

(2) Waste of waiting

(3) Waste in carrying

(4) Waste of machining itself

(5) Waste of inventory

(6) Waste of movement

(7) Waste of making defective products

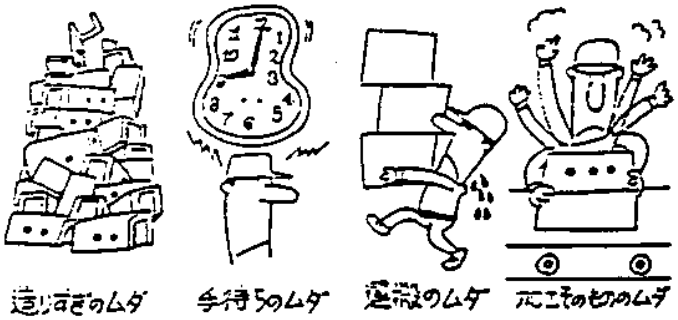
By eliminating these wastes completely, it becomes possible to improve the operating efficiency by a large margin. In this case, we must not make any more than needed and, therefore, extra manpower floats up. The Toyota production system is a system of floating up the excess manpower clearly. Because of this fact, some labor union people have been suspicious of the Toyota Production System as a means of cutting peoples' jobs. But the fundamental idea is not something cheap like that. The responsibility of the management is to identify the excess manpower and utilize it effectively. Employing people when production has to be increased because of good business and then laying off the people or recruiting early retirees when recession hits are not good practices and managers should use them with prudence. On the other hand, for the workers, eliminating the meaningless and wasteful work amounts to enhancing the worth of work done by the individual worker.

o My "Plant-First" Principle

I am fundamentally a man of the "plant-first" principle. This may be partly due to my up bringing in the production plant while I was young. Even after becoming a manager, I have been unble to separate myself from the production plant which makes up the major source of information for the manufacturing business. As one of top management at the present, I am even closer to the production plant.

The time which provides me with more direct and live information about management and which is most stimulating is not time spent in the office pondering things as a vice president but, rather the time spent in the plant close to the reality. Maybe the "plant-first" principle fits my character. Anyhow, this is the result of a long experience.

The figure on page 37 of the original book



Waste of making too many

Waste of waiting

Waste in carrying

Waste of machining, itself

Sometime in 1937 - 1938, while I was working with Toyota Textile, I was once told by my boss to "prepare a standard work procedure of textile work" and I had a hard time doing it.

I bought a book on the standard work procedure from Maruzen and managed to do the job. However, a proper standard work procedure cannot be written at a desk. It must be revised many times over at the production plant to make a perfect one. Furthermore, I realized that it must be a standard work procedure which anybody can "understand by seeing."

When I moved to the Toyota Motor Company during the war time, it was only natural that I first called upon my men to prepare the standard work procedure. Actually, there was a strong need for it. Skilled workers had to transfer from the production plant to the battle field and the machines were gradually being manned by inexperienced men and women. This situation naturally increased the need for the standard work procedure. I think the experience I gained at the time formed the basis of the Toyota production system which I have worked on for 35 years.

This was also the starting point of my "plant-first" principle.

In each plant of the Toyota Motor Company, as well as in the production plants of the cooperating firms which adopt the Toyota production system, "the management by seeing with eyes" is thoroughly established. At the work station the standard work sheets are shown clearly. When one looks up, the line stop indication board which is called "Andon" comes into everybody's sight. This will show at one glance the situation about the troubles.

On the boxes containing the parts which are brought to the side of the production line, there is attached the "Kanban" which is the very symbol of the Toyota production system. In order to insure the delivery of the items needed at the time they are needed, by the quantity they are needed, the "Kanban" is carried with the items at all times. Thus, while it indicates the movements of the products, it also provides information of operation directives.

As the means of the "management by seeing with eyes" which is the means of management of the Toyota production system, I want to discuss the standard work sheet first.

o Write the Standard Work Sheet Yourself

A man working in the production plant should have the experience of writing the standard work sheet himself. In order to write it so that somebody else will understand it, first it has to be something which is sufficiently convincing to himself.

The standard work sheet is an important basic element of the Toyota production system. What should be written into the standard work sheet and what kind of thoughts of the plant people should be filled into the sheet?

We have carried out (1) the elimination of waste through the examinations of the available facilities, (2) arrangement of machines, (3) improvement of the machining process, (4) innovation of auto-activation system, (5) improvement of the tools, examination of the (6) transportation method, and (7) optimization of the amount of materials at hand for machining.

7

Also we have maintained high efficiency in production by preventing recurrence of defective products, operational mistake, injury (and many other unfavorable points) and by adding the wisdom of the men in the plant. What really has supported these efforts without being conspicuously visible is the standard work sheet.

The important point of the standard work sheet is to combine most effectively the materials, men and machines considering all of the conditions to perform the procuction efficiently. At Toyota Motor Company, the procedure of this combination is called the "combination of works" and the result of this combination is regarded as the standard work procedure.

As for the basics in preparing the standard work sheet, the content is not much different from the one which I was asked to prepare 40 years ago at the textile plant. However, the present standard work sheet at Toyota Motor Company is thoroughly based on principles. Furthermore, this plays an important role in the "management by seeing with eyes" in the Toyota production system.

As a matter of logical consequence, the standard work sheet at Toyota Motor Company lists the following 3 elements of the standard work procedure clearly.

(1) Cycle time
(2) Sequence of work
(3) Standard inventory

"Cycle time" means the length of time in which one piece or one unit has to be made. This is determined by the production quantity, i.e. the quantity required and the operating time.

Quantity required per day can be computed by dividing the quantity required per month by the number of operating days per month.

"Cycle time" is computed by dividing the operating hours by the quantity required per day.

Even if the cycle time is determined in this way, individual difference shows up for the person who makes it.

It is said that "time is the shadow of action." In most cases, delay is generated because of the difference in the action and the sequence. It is the job of the field supervisors (section chief, group foreman) to train the workers. About unskilled workers who joined newly, I say, "train them so that they will be full-fledged workers in 3 days." This means that, by teaching them the sequence of work and the key tricks clearly and making the instruction clearly, the workers should be trained to get quickly out of the wasteful actions such as redcing a job or making faulty parts.

In order to achieve this, the trainer must take the hands of the workers and teach them. This generates their trust toward the supervisors. Simultaneously, on the other hand, the connecting process between a worker and another is arranged so that the workers can "help each other." Because the work is being done by people, there are small individual differences and difference of working time caused by the physical conditions. Such differences are absorbed by the worker who came to the process first. This is similar to the use of the baton touch zone in the track relay competition. Carrying out the standard work in the cycle time, the "harmony between men" is allowed to grow.

"Sequence of work" means as the words say. This is the sequence of work with the flow of time when a worker machines a part such as carrying things, mounting on the machine and taking it out of the machine. It should be noted that this does not mean the sequence of processes through which the product flows.

"Standard inventory" means the amount of material being worked in the process, the amount being what is needed to carry out the work. This includes the materials which are mounted on the machine.

When the work is being done in the sequence of machining, the standard inventory, in general, is sufficient if it could cover the items which are attached to the machines; no inventory is needed between the processes. However, if the work is being done in the reverse sequence relative to the direction of the progress of processes, it is necessary to have inventory of one between two processes (inventory of two if two are attached to a machine).

In the Toyota production system, the parts must arrive "just-in-time" and, therefore, the standard inventory must be established more strictly.

o Team Work is Everything

In the section where we discussed the "cycle time", we touched upon the harmony between people. Here, I would like to discuss breifly my belief about "team work."

Between the work and sports. there are very many points in common. Among the traditional Japanese competitions, there are many individual competitions like sumo, kendo, judo. In the Japanese tradition, we do not call them competitions but we "seek the way and study it" with devotion of mind. This coincides with the fact that, in the world of work, the individual art of the craftman is valued.

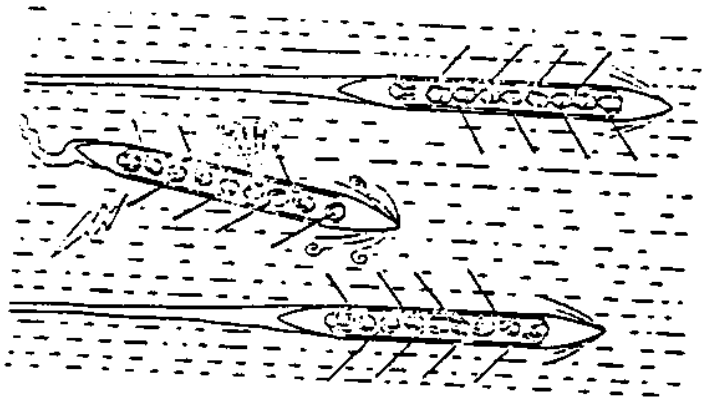
After the western culture was imported, group competition sports of western style were also imported. With this, the world of work has also seen the modern industrialization in which harmony between the people in a group, i.e. the team work. is demanded more than the individual art of a craftman.

For example, in the race of a boat which is rowed by 8 men. in the baseball game in which a team has 9 men, the volley ball game in which 6 people play on a team. and in the soccer game with 11 people on a team, the key which determines the winning or losing is the team work. It is interesting that a team cannot win necessaily even if it has one or two star players.

Our work is also done in team work, actually. In completing one job, 10 or 15 people play their roles: for example, in a flow process, a product is started from the material and completed into the product. In such a situation, the team work becomes more and more important. How many machinings one person finished here or how many drillings one man completed there is not so important as how many completed products a team made and this is the key point.

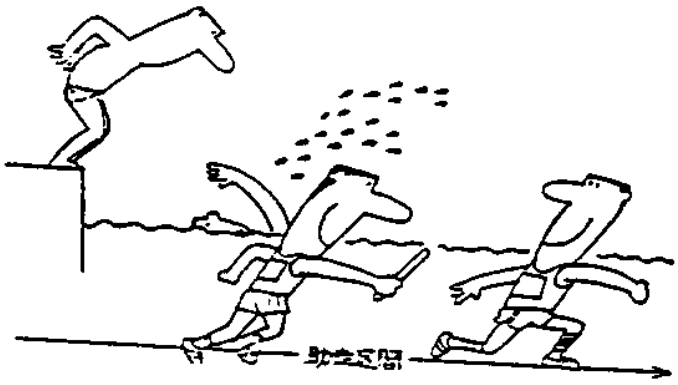
A long time ago, one favorite story which I used to tell the men in the production plant was the example of a boat. A boat is rowed by 8 men. Four men are on the left hand side and the other four men are on the right hand side. If they do not do the rowing right. the boat would go in ziezag ways.

See the picture of boats on p. 45 of the original book



See the picture of swimming relay on p. 47 of the original book.

The caption reads "Zone of Running Assistance"



If a man feels that he is strong and the other is weak so he should row twice as hard. But if he starts messing with his oar, the boat's progress is upset and it will not go straight. The best way to propell the boat fast is that every one distributes the force in a balanced way and put the oar to a uniform depth by a uniform act.

A volley ball team has 6 players today but it used to have 9 players. How would it be now if the players of a 6-member team try to play a game under a 9-member system? If a member tried a rotating receiving, the players might bump into each other and get injured. Also, suppose a game is played between a 9-member team and 6-member team. The team with more members would not necessarily win the game. Rather, the 6-member team may end up winning. This is similar to the case in the story of Ieyasu Tokugawa who was watching a rock-throw fight when he was a child and predicted victory for the team with the less number of members.

When team work is involved and other various reasons are involved, it seems to be possible that a team of fewer members ends up winning. I believe that the same is possible with work also. ✓

From the sports, one can get many hints. While watching the baseball game, if someone draws lines in the inner field defense zone and says that this area is the responsibility of the second base player and that area is the responsibility of the thrid base player, all the fun of baseball would be gone. This point passes into the work in the plant also. Just because the line of responsibility has been drawn, that does not mean that things will go fine.

o The Skill of Baton Touch

It happened just about the time when I was beginning to work with the Toyota production system. The Korean War was coming to an end and the newspapers were filled with the words of the so-called 38th parallel. After reading the news, I said that the 38 degree line should never be drawn because it is a tragedy of the nation. The same is true with our work. We cannot draw a 38th parallel in the area of each other's work.

At the time, I used to bring out the subject of sports and say that we should regard the area of work like the track relay competition without drawing the 38th parallel. In the relay competition, there is always the region of passing the baton. If the baton passing is done well, the resulting record can be better than the sum of the individual records of the four runners.

In the swimming relay, the next swimmer cannot jump in before the hand of the current swimmer touches the pool wall. In the track relay, the rule is different and a strong runner can cover a weak runner. This is a very interesting point.

The same goes with work. When a job is being done by 4 or 5 people, the parts should be handed over as if they were the batons. If the later process operator is delayed by some problem, others should help set up the machine which belongs to the later process man. When that man returns to his normal position, give the baton to him and then return to your position. I am persistent in telling my people that they must perform skillful baton passing.

In work as well as in sports, it is desirable that the members of a team, for example five of them, work with an equal level of strength. In actuality, however, this is not the way it goes. For example, there is a newly hired employee who is not familiar with the work at all. In our production plant, the work is done with the baton passing system like in relay, and in the Toyota Motor Company, this kind of team work is called the "Mutual Assistance Movement." This "mutual assistance movement" provides the power for generating more powerful team work.

Sports and work have many points in common. The one common point which I regard as the most important is that, both in the work and sports, practice has to be stacked on practice and training has to be stacked on training. Understanding theory in the head is not the problem. The problem is to remember it by the body, to make it instinctive. To have the spirit to endure this training is the road toward the winning in competition.

o A Hint From the Supermarket

It has been repeatedly stated that the two pillars of the Toyota Production System are "Just-in-time" and "Auto-activiation." The tool which is used in operating this sytem is called "Kanban." I would like to describe where the idea of this was originated from.

As a matter of fact, the "Kanban system" originated from a hint which I obtained from the supermarkets in America.

After the war, many things came into this country from America. These were chewing gum, coca cola and, among the cars, the jeep. The appearance of supermarkets in Japan started after we entered the mid 1950's. From the earlier time, with the increase in the number of Japanese people traveling to America, people heard how closely the supermarkets in America are related to daily living and, as a consequence, the supermarkets became the object of interest to the Japanese people who have a strong curiosity and fondness for imitation.

I went to America in 1956 and toured the production plants of GM, Ford and other machinery companies. The most strong impression I received in America at the time was the extent of the spread of the supermarkets.

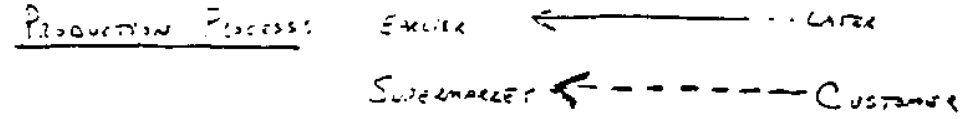
To me, there was a special reason for this also. Already from the later half of the 1940's in the machine shop where I was in charge in the Toyota Motor Company, we were studying the supermarkets of America and starting the application to our work.

The combination of automobile company and supermarket - this may look odd but, from an earlier time, hearing from others about the set up of supermarkets in America, we stretched our imagination on the connection between the supermarket and our "Just-in-time" system.

A supermarket is a place where a customer can get the things he needs at the time he needs in the amount he needs. A customer's desire sometimes exceeds what he needs and he ends up buying extra things. In principle, however, it is a place where one can buy the things he needs.

From the side of the supermarket, the operator must prepare and arrange things so that customers can come to buy at any time.

In comparison to the traditional merchandising methods in Japan such as "Drug Sale in Toyama", "Goyokiki", "Furiuri", this "supermarket system" which we learned from America is a more rational system because, from the viewpoint of the seller, he does not have to waste labor in carrying things which he is not sure of selling and, from the view point of the buyer, he does not have to worry about buying extra things.



The hint which we got from the supermarket was that it might be possible to look at the supermarket as the earlier process in a production line. The later process which corresponds to the customer goes to the earlier process which corresponds to the supermarket to purchase the required commodities (parts) at the time he needs them in the quantity he needs. The earlier process immediately makes up the portion which the later process picked up. We believed that, by working in this way, we would approach our big goal of "Just-in-time" and, in 1953, we actually applied the system within our machine shop of the main plant.

When I went to America in 1956, I had the opportunity of seeing the supermarket which I had been interested in for such a long time and finally fulfilled my desire to see them in person.

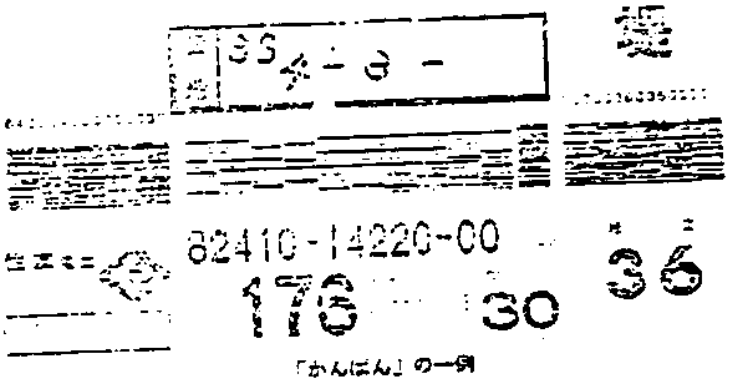
In the 1950's, supermarkets of American style appeared in Japan also, bringing the object of our study close to us and providing research materials conveniently.

The first biggest problem we faced in this system was that, when a later process picked up a large quantity of a same part at one time, the earlier process would run into a confusion. In order to achieve "just-in-time", this was a problem which we could not pass by avoiding and, therefore, we had to squeeze out our wisdom to solve this problem. Eventually, after many trials and errors, we arrived at the "averaged production." We shall describe this in a later section.

o What is "Kanban?"

The operating means of the Toyota production system is "Kanban." The most frequently used form of "Kanban" is a piece of paper which is contained in a rectangular, vinyl envelope.

The illustration on page 52 of the original book.



Caption: An example of "Kanban"

This piece of paper carries information which can be divided into three categories: "Pickup Information", "Transfer Directive Information", and "Production Directive Information." This runs vertically and laterally within the Toyota Motor Company and between Toyota and the cooperating firms carrying the information.

Earlier, it was mentioned that the hint was obtained from the supermarket. Suppose we take the "Kanban" into the supermarket; how would it work?

The commodities which were purchased by the customers are checked out through the register. After this, the cards which carry information of the types and quantities of commodities which the customers purchase are forwarded to the Purchasing Department (this card corresponds to the "Kanban"). Using this information, the commodities are swiftly made up by purchasing. This card corresponds to the "Pick up Kanban" in the Toyota Production System. In the case of the supermarket, the commodities which are displayed in the store corresponds to the inventory at the production plant.

If a supermarket has its own production department nearby, there would be the "Production Directive Kanban" in addition to the "Pick up Kanban" between the store and the production department. By the directive given in this Kanban, the production department makes up the quantity of the commodities which were picked up.

Of course, the supermarkets have not gone that far. In our production plant, however, we have been trying this from the beginning.

It was mentioned that the supermarket system was adopted in the machine shop around 1953. As the actual means of operation, we used pieces of paper on which the part number of a part and other information related to machining work were listed and we called this "Kanban."

Subsequently, this was called the "Kanban system" and it was felt directly that, if this system were used skillfully, all the movements in the plant could be unified, i.e. systematized. After all, one piece of paper was providing the information of production quantity, time, method, sequence, or transfer quantity, transfer time, destination, storage point, transfer equipment, container, etc. clearly for grasping at one glance. At the time, I believed that this means of conveying information would certainly work.

Generally, in business, information of the type of "what, when, how many" is generated by the work planning section in the form of work start plan, transfer plan, production order, delivery order and these are passed through the plant. When this system is used, "when" is interpreted arbitrarily and people think it will be all right if it is in time. Finishing early is taken to be all right, but the parts which were made too early take a lot of labor for warehousing. The word "just" of "Just-in-time" has a meaning. If it is simply "in-time" (meet the deadline), then the waste can not be eliminated.

In the Toyota production system, "over-production" is completely prevented by "Kanban." As a result, there is no need for extra inventory and, consequently, there is no need for the warehouse and its manager. The generation of countless numbers of paper slips is also not needed.

o Unsound Tactics Become the Cause of Big Casualties

When one uses a better tool, he gets wonderful results. But, if one makes a mistake in using the tool, the tool brings a reverse effect.

"Kanban" can cause varieties of troubles if it is not used right. In order to use "Kanban" correctly and skillfully, we tried to have a clear understanding of the purpose and role of the "Kanban" and then set up the rules of using the "Kanban."

"Kanban" is a means for achieving "Just-in-time" and its purpose is "Just-in-time." "Kanban" becomes the self-regulating nerve of the production line. On the basis of this, workers in the production field start the work by themselves and make decisions on overtime work.

It delineates the roles of managers and supervisors and shows clearly what has to be done by the person in the upper position. It is certain that this will expedite the improvement of work and improvement of the facilities.

The objective of waste elimination is also delineated by "Kanban." Use of the "Kanban" system immediately shows what is waste, allowing creative study about it and proposals for improvement.

BENEFITS

In the production plant, "Kanban" provided a great force in the (1) reduction of manpower, (2) reduction of inventory, (3) elimination of defective products and (4) prevention of the recurrence of breakdown.

Now, the following shows the "role" and "rules for use" of "Kanban."

(1)	"Pick up information" or "Transfer Directive Information"	The later process goes to the earlier process to pick up as many as indicated by the "Kanban."
(2)	"Production Order Information"	The earlier process makes items requested by the "Kanban" in the quantity indicated by the "Kanban" and in the sequence indicated.
(3)	Prevention of "Over-production and "Over Transfer."	When there is no "Kanban" do not transfer and do not make.
(4)	As the "Ticket of goods", it is the certificate of needed work.	A "Kanban" is always attached to the goods.
(5)	For the "prevention of defective products", this is a system which makes the process which made the defective products.	100% must be good products without defects.
(6)	This is a tool for "revealing the existing problems" and is a tool for "inventory control."	The number of sheets of the "Kanban" is reduced with progress.

It is not an overstatement to say that "Kanban", which is the means of operating in the Toyota Production System, controls the flow of goods in Toyota Motor Company. Thus, it is controlling the production of a company which exceeds 2 trillion yen a year.

In this way, the "Kanban" of Toyota Motor Company clearly reflects our wishes and, in practice, it is used under strict rules and its effectiveness is also shown in the records of the business. However, the Toyota production system is advancing every minute. Close examination of the rules of Kanban is an eternal problem.

o Talent and Courage for Making Reverse-Common Sense into Common Sense

As mentioned already, the first rule of using Kanban is that "the later process goes to the earlier process to pick up products" and this rule was derived from the need and by looking at things upside down or by looking in a way which is out of common sense or reverse of common sense.

In practicing this first rule, understanding with simple knowledge is not enough. The top management of business must reform their consciousness and make up their mind to reverse the flow of the conventional production, transfer and delivery. This faces lots of resistance and it takes courage. But, in order to complete the Toyota production system, the decision must be made.

In 1943, during the war, I moved from the world of textiles to the world of automobiles and, for more than 30 years since then, I've been working on the idea of the Toyota production system and have been in the vanguard of pushing this system all the time.

Now, finally, the Toyota production system is drawing the attention of people but, at the beginning, there was no such thing as a Toyota production system. For a long time, I had kept on searching in the dark for a self-styled Oono system. During this time, sometimes I lost self-confidence myself. But, supported by the cooperation of people with deep understanding, I overcame the obstacles and could reach a new stage of evolution.

This may sound presumptuous but, if one traces the path of growth of the Toyota production system, one finds a lot of coincidence with the growth of the scope of my own responsibility in Toyota Motor Company.

In 1949 - 50, when I was Manager of the Machine Shop of what is the Main Plant of today, I made the first step toward the "Just-in-time" idea. Then, in order to establish the flow of production, the arrangement of machines was changed and we took the approach of the so-called multi-process system in which one operator handles 3 to 4 machines. From then to the present, with the growth of my authority, I utilized my authority to the fullest extent to broaden these ideas.

During this period, all of the ideas which I boldly put to practice were intended for the improvement of the old system (the old, conservative production system), but they might have looked highhanded. Top management of the Toyota Motor Company quietly kept watching the situation, and I admire the attitude which they have taken.

In the middle of the discussion of the first rule of "Kanban," we turned abruptly to the topic of the top management of business. The reason for having done so is that if the rule of "the later process goes to the earlier process to pick up the items needed when needed by the amount needed" is put into practice in a poor manner, the whole business could be shaken from the foundation. "The later process going to the earlier process to pick up the items" means, in the situation of a production plant, the items needed reaches the side of the production line at the time needed by the amount needed.

To the earlier process, however, this is linked to the denial of the "schedule plan sheet" with which they have been familiar for a long time. The psychological resistance of the production plant men to the idea that what they are supposed to make cannot be indicated a priority cannot be removed easily. Trying to make up the items which were picked up runs into the problem of changing the setup unless the production line is a monopolized one. Usually, people think that it is advantageous for the earlier process to make a lot of an item. But while making item A in quantity, the process may not meet the need for item B. Consequently, there arises a new need for shortening the time for changing the setup and making the lot as small as possible.

Among the problems which arise, the most difficult ones come when the later process picks a large quantity of one type of item. When this happens, the earlier process immediately runs out of the item. If one tries to counter this by holding some inventory, he does not know which item will be picked up next and so he has to have an inventory of item A, item B and so on. If all of the earlier processes start doing this, heaps of inventory will be formed in every corner of the plant.

Therefore, a realization of the system in which the later process picks up requires the reformation of the method of making in the earlier process and, at the same time, the reformation of the method of making in the later process. With patience, I solved the problems related to the system of the later process picking up, step by step. All of this was by trial at first for there was no manual. What would happen could be found out only by trying and every day was a continuity of tension. We tried and corrected and then we tried again. We corrected again. Repeating this, I expanded the system within the company of the later process picking up. Experiments were always carried out at a plant within the company. During this period, we did not deal with the parts which are ordered from outside. The idea was to exhaust the problems of the new system within the company.

It was in 1963 that we started handling the delivery of the parts which were ordered from outside. It really took almost 20 years of time. Recently we hear frequently a chassis-maker asking the cooperating firm to bring parts just-in-time as if "just-in-time" was the most convenient system. If "Kanban" is used for picking up the parts ordered from outside without changing the method of making within the company, "Kanban" immediately turns into a murderous weapon and it becomes an entirely different thing which is far from playing its real role.

"Just-in-time" is an ideal system in which the items needed arrive at the side of production line at the time needed and in the quantity needed. But a chassis maker cannot ask the cooperating firm to work in this system. Adoption of the Toyota production system is nothing but complete overhaul of the existing production system. Therefore, once you want to adopt it, you should start it with your mind set firmly.

c "Establishing the Flow" is the Basic Condition

After the war, we were concerned mainly with the question of how to make good products and we assisted the cooperating firms outside our company along this line. After 1955, the question became how to make the quantity needed. It was after the oil shock that we started giving guidance to the outside firms on the method of making goods under the "Kanban" system.

Prior to that, the Toyota Group gave guidance to the cooperating firms on the way of doing work in Toyota system, i.e. on the "method of making."

Outsiders seem to think that the Toyota system and "Kanban system" are the same thing. But the Toyota production system is the "method of making" and the "Kanban" system is the "method of management."

So, until the time of the oil shock, we were giving guidance on the method of making under the Toyota system and this was focused on how to make goods so that there would be as much flow as possible. Because this ground work had been done already, it was very easy to give guidance to the cooperating firms of the Toyota Group on "Kanban."

Unless one completely grasps this method of doing work so that things will flow, it is not possible to go right into the "Kanban system" when the time comes. The fact that the Toyota Group adopted and somehow managed to digest it was possible because the production plant already had the idea of "establishing flow" and they were actually practicing it. When people have no idea of this, it is very difficult to introduce the "Kanban" system.

When we started to try the "Kanban" system for the final assembly line and went to a machine shop of an earlier process to pick up the items needed at the time they are needed by the quantity needed, it never worked. This was only natural. It was not the fault of the machine shop. We have to realize that the system would not work unless we set up the system of production flow which goes back step by step sequentially and which can handle the "Kanban" system.

"Kanban" is a tool for realizing "Just-in-time." As the preliminary condition for the tool to work fairly well, it is indispensable that the production processes be managed to flow as much as possible. One can say that this is really the basic condition. Other important conditions are "averaging" the production as much as possible and doing work always in accordance with the "standard work procedure."

Now, in the Main Plant of the Toyota Motor Company, the flow between the final assembly line and the machining line was established in 1950 and the so-called "synchronization" had started although the scale was small. From then, we kept going in reverse toward the earlier processes and gradually laid the groundwork for the company-wide adoption of the "Kanban" so that the work and the transferring of parts could be done under the "Kanban" system. This was done by gradually gaining the understanding of all people involved.

It was only in 1962 that we could manage the "Kanban" system on a company-wide scale. After achieving this much, we called the cooperating firms and asked them to study it by watching how it actually worked.

We were teaching people who had no idea about "Kanban" and making them understand it witnout any textbooks was difficult.

We asked the cooperating firms nearby to come, a few of them in a group, and then had them study the system. For example, the press firm people were asked to see our press operation and the machine shop people were asked to see our machine shop. Teaching in this way had the advantage of showing the economical production of goods in the actual production plant.

As a matter of actual fact, it would have been difficult to get them to understand the system by having them explore it in the dark.

This effort started with the cooperating firms nearby and it spread to the Nagoya district. In the Kanto district, however, the progress was somehow delayed. Part of this reason was the distance. But the fact was that the part makers in Kanto district were supplying their products not only to the Toyota Motor Company. Because they were supplying their products to other companies also, their attitude was that they could not work under the "Kanban" system only with the Toyota Motor Company.

We decided that this would take time to have them understand, and we set out to follow up with a lot of patience.

In the beginning, the cooperating firms looked at the "Kanban" as something troublesome. Of course, none of the top management members came. Even the directors in charge of production or the Manager of the Production Department did not show up in the beginning. Usually people in charge of the operation would come, but no important people came.

I believe that at first many firms came perhaps without knowing what was involved. Anyhow, we wanted them to understand "Kanban." If they didn't understand, men from the Toyota Motor Company would go and help. People of the nearby firms understood the system early although they faced resistance in the companies. It is a pleasure to see that all of this effort is bearing fruit.

o Urge Them to do Using Your Authority

After all, in the beginning no one knew what "Kanban" was. First, it was against common sense and, as a result, there was strong resistance. Therefore, I had to experiment with "Kanban" within the sphere of my authority. Of course, we tried to avoid causing any interference with the regular work.

In the 1940's, I was in charge of the machine shop and the assembly line. At the time, the Main Plant was the only plant. After the end of the labor dispute in 1950. there was the No. 1 Producton Department and No. 2 Production Department in the Main Plant, and I was the Manager of the No. 2 Production Department. The No. 1 Production Department was doing the forging and casting of crude materials and "Kanban" could not be tried in it because this plant was related to the whole main plant. Therefore, "Kanban" could be applied only at the No. 2 Production Department machining and assembly.

In 1959, the Motomachi Plant was completed and soon I became the manager of that plant, and so I immediately experimented with "Kanban" at the Motomachi Plant. However, the crude materials had to come from the Main Plant and so "Kanban" could not be tried there. Eventually "Kanban" could be tried only at the machine shop, press shop and assembly line.

In 1962, I became the manager of the Main Plant and, only then, "Kanban" was started with forging and casting. At this point, finally, "Kanban" became company-wide. Until then, "Kanban" could be applied only locally.

Establishing "Kanban" within the Toyota Motor Company took more than 10 years. This seems to have been a long time, but I think this was natural because we were breaking in basic concepts which had not existed until then. Anyhow, it was a valuable experience.

To have "Kanban" understood around the company, we have to involve everybody. Suppose the manager of the production department did understand it; if the men under him did not understand, "Kanban" would not work. The foremen class of people seemed to have been quite lost because they were told of something which was entirely different from the conventional practice.

If a foreman was under my jurisdiction, I could "yell" at him. But I could not yell at a foreman from the neighboring department. So, having "Kanban" understood by the people in every corner in the plant naturally took a long time.

During this period, the top manager was a man of great vision and he left the whole thing to me completely without saying anything. When I was urging the foremen of the production plant to understand the "Kanban" with some pressure, a considerble number of complaints seemed to have been submitted to my boss. They were voicing their feeling that the fellow by the name of Oono was doing something which was utterly ridiculous and it should be stopped. But I was not told to stop. Sometimes, the top manager must have been in a difficult position, but even then he must have been trusting me. I am grateful for this.

In 1962, "Kanban" was adopted on the company-wide scale and this meant that "Kanban" had earned its recognition. After that, we entered the high growth rate period, and I think the timing was very good.

I think that the gradual spreading of "Kanban" made possible the strong production yield.

When I was in charge of the assembly line, I applied the "Just-in-time" system around this assembly work. In this, the first most important processes were the earlier processes of machining and body painting. The bodies were coming from the press section and, as for the machining, it was difficult to connect it to the crude material section by "Kanban"; but we made the effort to make the connection by the machining itself and kept stacking up the preparations. During this period, we could check the inadequacies of "Kanban" and this was a valuable experience.

o Mountain Should be Low and Valley Should be Shallow

In order to make the second rule of using "Kanban" work, i.e. "the earlier process produces the amount which was picked up by the later process," the manpower and facilities must be prepared in all aspects so that all of the production processes can produce the quantities needed at the time they are needed.

In this case, if the later process picks up the items at fluctuating time intervals and by fluctuating quantities, the earlier process cannot avoid having extra manpower and facilities. These become very heavy burdens.

The larger the fluctuations in the quantities which the later process picks up, the more extra manpower and facilities must be held by the earlier process.

To make the things worse, the Toyota production system is tied through so-called "synchronization" not only to each production process within the Toyota Motor Company but also to the production processes of the group of cooperating firms outside Toyota by use of "Kanban"; because of this, the fluctuations of production and fluctuations of orders at the final process transmits a bad effect which impacts on the earlier processes.

In order to avoid the occurrence of such bad cycles, what has to be done at the large chassis maker, (specifically at the final car assembly line of the Toyota Motor Company which corresponds to the first process), is to cut down the mountain peak of production as much as possible to lower peaks and, at the same time, make the valleys shallow so that the flow surface is mild. This is called "averaging of production" in the Toyota production system.

It would be ideal to carry out the averaging so that, at the final assembly line which corresponds to the last process, the fluctuation is zero. But this is very difficult.

The reason for this difficulty is that more than 200,000 cars are coming off the several assembly plants of Toyota per month. And there are an almost infinite number of varieties of cars.

The number of varieties reaches thousands just by consideration of the combinations of car size, body type, engine size, car style, and speed shifting methods. If the colors of the cars and combinations of various options are put into consideration, it is very rare in reality to have the opportunity of making completely identical cars.

Diversification of the people's standard of values which symbolizes the modern times appears directly in the "diversification" of cars and, in fact, this "diversification" has certainly been the cause of thinning the effectiveness of mass production in the automobile business.

With respect to the adaptation to this "diversification," the Toyota production system has shown a much higher efficiency in comparison to the mass production system under the Ford style production plan which was developed in America.

Originally, the Toyota production system was conceived in the Japanese environment for the production of small quantities of many types; then it has evolved on this foundation and has been built into a production system. As a consequence, it is a system which basically is "strong against diversification."

Being "strong against diversification" means that, while the mass production system under the historical production plan is relatively inflexible against change, the Toyota production system is very elastic and it can take the difficult conditions of "diversification" and digest them. This is because the Toyota system has the depth and room to do this.

After the oil shock, people started paying attention to the Toyota production system. As to the reason for this, I would like to make it clear here that the reason lies in the system's unsurpassed flexibility in adapting to changing conditions. This capability is the source of the power of resistance which is strong even in the era when the quantity does not increase.

o Challenge to "Averaging"

Let me tell a story about a specific case of "averaging" of production. In the Tsuji Plant (Toyota-shi, Aichi-ken) of the Toyota Motor Company, the averaged production is carried out as follows. In this plant, there are 2 production lines and they make passenger cars: Corona, Kareener, Celica.

In one line, the Corona and Kareener flow alternately. They don't lump the Corona into the morning and the Kareener into the afternoon. This is to maintain the "averaging."

The number of the same item to be made at the same time is kept as small as possible; great care is taken to avoid generating the undesirable effect of fluctuation to the earlier process.

Even in the production of large numbers of Corona in a line, a fine averaging scheme is used. For example, suppose we make 10,000 units of the Corona working 20 days in a month. Assume that this breaks down to 5,000 sedans, 2,500 hard tops and 2,500 wagons. This means that, every day, 250 sedans, and 125 of hardtops and 125 of wagons are made. The way these are arranged on the production line is as follows: One sedan, one hard top; then a sedan, then a wagon and so on.

By this way, the lot can be minimized and the fluctuation in production can be minimized.

Such finely controlled production is being carried out in the assembly line of completed cars which is the mass production process in the Toyota Motor Company. The fact that such production can be carried out shows that the earlier process, for example the press section, has settled down with the familiarity of the entire new Toyota Production System after breaking away from the mass production system under the past production plan.

The idea of "averaging" to make a lot small and to minimize the flow of a same item continuously was too brutal a demand of the press section in the beginning.

This was because it has been a long established common sense of production field that continuous punching with one mold in the pressing brings the cost down. It was common sense to make a lot as large as possible and punch continuously without stopping the press.

In adopting the Toyota production system, one has to do the "averaging" of production and make a lot as small as possible. Thus one has to go completely contrary to the common sense.

To cope with this problem, how has the press section been trying?

Making a lot small means that one cannot punch with one mold for a long time. Consequently, in response to the changes in the product types which are dizzying, the press mold has to be changed. Thus, the so-called "Change of Preparation" has to be done frequently.

The same is true for other machine sections. This propagates back to the earlier processes. Even the cooperating firms which produce the parts ordered from outside are using the passwords "make a lot small, change the preparation fast" which is an idea completely contrary to the past.

In the Toyota Motor Company, change of press preparation took 2 to 3 hours in the 1940's. As the averaged production was spreading in the company in the 50's, this time went under one hour down to 15 minutes and, in the later half of the 60's it has shortened to a mere 3 minutes.

In summary, the need for change of preparation was generated and steps were taken to perform the change of preparation; eliminate the adjustments; these were the things which were never in the manual in the past. To do this, everybody chipped in with ideas and, at the same time, workers were trained to shorten the time. At the time, within the Toyota Motor Company and in the cooperating firms, the desire of people to achieve the new system was beyond description. Thus, the system is a product of lots of effort.

o "Averaging" and "Diversification"

It was mentioned before that the "averaging of production" which is an important condition in the Toyota production system is much more advantageous than the mass production system in the conventional planned production in coping with the phenomena of "diversification" which is seen in the automobile market.

We can say this with confidence. Generally speaking, however, there is no reason that "diversification" of market and the "averaging" of production might be in harmony from the beginning. Rather, they have aspects which do not accommodate each other.

It is an undeniable fact that "averaging" becomes more difficult as "diversification" develops more. However, I want to emphasize again that the Toyota production system can cope with it well enough with more effort.

In keeping the "diversification" of the market and "averaging" of the production in harmony, an important measure in the area of the facilities is to avoid the exclusive use of facilities which could have more general utility.

For example, taking the production plan of the Corolla which is the car of largest mass production in the world today, a definite production plan can be set up on a monthly basis. So this can be divided with the number of working days (number of days on which actual production can be carried out) to "average" the number of cars to be made per day.

On the production line, even finer "averaging" has to be done. On one production line, to let the sedans flow in the morning and to let coupes flow during a fixed interval of time is contrary to the "averaging" because the same item is let to flow in a lump. If two production lines are used, one each for sedans and coupes exclusively, averaging is easier to do but this is not possible because of the restrictions in space and facilities. What can be done?

If one production line is set up such that sedans and coupes can both be assembled in any sequence, then the "averaging" would be possible.

Thinking in this way, mass production using exclusive facilities which is the strongest weapon for cost take out is not to be simply pushed forward. More important efforts are needed to add to the minimum limit of facilities and fixtures for general utility as mentioned in the previous example. To do this, one has to mobilize all the wisdom to avoid adversely affecting the benefits of mass production.

By giving such considerations to all of the processes, we can maintain the "diversification" and "averaging" in harmony and can respond to the orders of customers in timely manners. In view of the further development of "diversification" in the future market, we must put in more effort than ever on this point.

Rules

o "Kanban" Accelerates Improvements

It was already mentioned that, through the application of the first and second rules of using "Kanban," the "Kanban" performs the role of picking up information, transferring directives and production orders.

The third rule of using "Kanban" is "when there is no 'Kanban', do not transfer and do not make." The fourth rule is a "'Kanban' is always attached to the goods." The fifth rule is "100% must be good products." The sixth rule is "keep reducing the number of 'Kanban.'" When these rules are faithfully practiced, the role of "Kanban" expands to a broader extent.

A "Kanban" always moves with the goods which are needed and so it becomes the certificate of the work needed. Thus, a "Kanban" can prevent "over-production" which is the largest loss in the production field.

In order to ensure that "100% must be good products", we must set up a system which informs automatically if any process generates defective products, i.e. a "system in which the process which generated defective products feels the pain". This is indeed the one-man-show stage of the "Kanban" system.

If each process produces in a "Just-in-time" system, it does not need any extra inventory at hand. If it generates defective parts, the later process faces a line-stop. Furthermore, this is clearly visible to everybody's eyes. It is an embarrassing situation. The defective part is returned to the earlier process. This is for prevention of the recurrence of such situations.

If we extend the meaning of "defective" beyond "defective parts" to "defective work", then the meaning of "100% must be good products" becomes more clear.

In other words, because of insufficient standardization and rationalization of defective work, there arises "waste," "inconsistency," and "strain" in the working procedure and working hours, and this eventually relates to the production of defective products.

Unless such defective work is reduced, it is difficult to assure the supply to the later process (picked up by the later process) and also to achieve the objective of producing as cheaply as possible.

Through the efforts of stabilization and rationalization of the processes, realization of "auto-activation" needs to be pushed. Only with this background, can the 'averaging' of production demonstrate its worth satisfactorily.

It takes a great effort to practice the 6 rules of "Kanban" which have been discussed above. Practicing these rules means nothing other than the adoption of the Toyota production system as the management system of the whole Company.

Introduction of "Kanban" without actually practicing these rules will not result in the expected result of "Kanban" and will not bring cost reduction. Thus, a halfway introduction of "Kanban" brings one hundred harms and not one gain.

If one recognizes the effectiveness of "Kanban" as a tool of production management for advancing the cost reduction, he has to be determined to observe the rules overcoming all difficulties.

They say, "Improvement if forever and endless". It should be the duty of those working with "Kanban" to keep bettering it with creativity and innovation without locking in at any stage.

o "Kanban" Combined with the Carrying Carts

The so called "Kanban" designates the piece of paper contained in a rectangular vinyl envelope which has been described so far. One of the important roles of "Kanban" is to provide the information which interconnects the earlier process and the later process at every level.

A "Kanban" is always with the goods and thus is the essential communications tool for "Just-in-time" production. Here, we shall describe a case in which the role of "Kanban" is made even more effective by combining it with the carrying carts.

In the Main Plant of the Toyota Motor Company, they use a carrying cart of limited load capacity in picking up the assembled units of engines and transmissions in the final assembly line.

A "Kanban" is attached to the engine, for example, which is carried on this carrying cart. But the carrying cart itself also performs the role of a "Kanban" at the same time. Thus, if the standard number of engines at the side of final assembly line (3 to 5 units) is reached, the worker in the section which attaches the engine to the vehicle goes with the vacant carrying cart to the assembly point (which is the earlier process) and picks up a carrying cart loaded with the necessary engines leaving the vacant carrying cart.

In principle, a "Kanban" should be attached. In this case, however, even if the "Kanban" itself is not attached to the carrying cart, the earlier process and the later process can talk to each other and decide the number of carrying carts to be used and agree on the rules of picking up so that the same effectiveness can be achieved by use of simple number plates.

Thus, for example, in the unit assembly line, if there is no vacant carrying cart, there is no place to put the completed units and so over-production is automatically checked even if someone wants to make more than needed. The final assembly line also cannot have any extra inventory other than that which are on the carrying carts.

As the basic idea of the "Kanban system" penetrates into manufacturing, many tools can be devised. However, I wish to repeat that one should not forget to use the "Kanban" in principle.

Let me raise another example. In the production plant of an automobile factory, many chain conveyers are used as a means of rationalization of transportation. A part can be suspended to this while painting or the parts for assembly work are supplied to the side of the line by this. In this case, also, it goes without saying that there is no part on the hanger if there is no "Kanban".

When many types of parts are carried by use of this chain conveyer, indicators designating the parts needed can be attached to the hangers of the chain conveyer at an averaged interval to make no mistake on "how many of which parts should be suspended when." Thus, by installing the "designated seat" for which the indicated part should be made and no more, smooth supply and pick up of the needed parts can be achieved while the averaging is maintained with the circulation of the designated seats with the conveyer.

o Elastic Nature of "Kanban"

For the purpose of letting the readers understand the true meaning of "Kanban," I would like to raise various examples.

The propeller shaft is an important functioning part of an automobile but this part causes unexpected problems in assembling work.

In order to eliminate imbalance of the shaft, small pieces of iron pieces are attached as a balance weight by workers during the finishing stage.

There are 5 types of these small iron pieces. A piece which is suitable for a particular degree of imbalance of the propeller shaft is selected from the 5 types and is attached. If there is no imbalance, then no balance weight is needed. In some cases, many pieces have to be attached. The number of these 5 types of balance weight which are used is rather irregular and it is different from the ordinary parts in that the amount needed cannot be told when the production plan is written. Thus, with these kinds of parts, sometimes, an urgent need for some parts arises while, in other cases, unnecessary inventory piles up unless the production is managed very well.

One cannot say it should not be a serious problem because, after all, it is only a small piece of iron. This is a big problem. Because of this problem, extra indirect manpower may be kept idle.

This is a new challenge to the "Kanban" of Toyota production system.

"Kanban" must work effectively as the means of operating the plant in the "Just-in-time" manner. Also, in order for "Kanban" to deliver its effectiveness, "stabilization and averaging of production" are the indispensable conditions. Some people think that "Kanban" can be used only in the management of the parts which are used in stabilized quantities every day but this is a mistaken notion. Also, some people think "Kanban" cannot be used unless pick up of the parts is steady. This is also wrong thinking.

So, "Kanban" was introduced to the balance weight which is one of the most difficult processes to manage in the production of automobiles.

In order to manage well the production, transfer and use of the balance weight for which the amount of use is not stable, the first necessary step is an accurate grasp at all times of the inventories of the 5 types of parts in each process. Also, in thinking of this inventory situation at all times, it is necessary to start the production or transfer so that there will be no urgent need and no excessive inventory. The "Kanban" system was adopted to achieve this goal.

What was the result? By attaching a "Kanban" to the actual balance weights, types and quantities of the goods available could be identified accurately. With the "Kanban" being circulated between the processes around and around, the start of production and transfer of the parts could be done in the necessary sequence at all times, as a result, the amounts of inventory of the 5 types could be kept constant and, eventually, the inventory could be reduced drastically.

I want to emphasize that the "Kanban system" is not an inflexible, stiff system. I want the readers to know that, as seen in the example of the balance weight, it has been proven in the Toyota Motor Company that "Kanban" is an effective tool even in the management of specialty parts for which the amount of use is unstable and application of "Kanban" seemed to be unmanageable at first.

o An Autonomic Nerve System to the Business Organization

The business organization as a whole can be considered often in comparison with the human body.

In the human body, there are various nerves such as the autonomic nerves which work without any relation to the human wish, and the motor nerves which control the muscles which do. The human body has a structure and functioning which is really amazing; the fine balance and the precise way in which the parts of body are accommodated in the overall design are ever more marvelous.

The autonomic nerve in the human body causes the increase of secretion of saliva when a person sees tasty, gourmet food. It accelerates the beating of the heart when he exercises so that circulation is enhanced and performs other similar functions to respond to the change in the body automatically. These functions are performed unconsciously without any directive from the brain. This caused us to think about how to institute an autonomic nerve system in a business organization which was getting larger and larger.

In our production plant, the autonomic nerve means the autonomous function of making judgement at the lowest possible level. For example, there are judgements to make such as: no more production is needed today; the parts should be made in such and such sequence. Today, it is necessary to make a certain number of parts even if it means doing overtime work. This kind of judgement can be made by the workers in the factory themselves without having to consult the production control department or engineering department which correspond to the brain in the human body. The plant should be a place where such judgements can be made by the workers in an autonomous manner.

In the case of the Toyota Motor Company, I believe such an autonomic nerve system was set up by injecting the idea of "Just-in-time" broadly and deeply into the production field and by ensuring the observance of the rules by using "Kanban".

Now, I began thinking about the business organization, and about the autonomic nerve in the human body; I interconnect them, and overlap them and stir up my own imagination. In business, in actual practice, the production control department put out various directives, acting as the center of operation. Then there occurs continuously the situations in which the plans have to be altered. These plans which affect the present and future of the business may be what correspond to the backbone in the human body.

Plans change very easily. The worldly affairs do not always go according to the plans and the contents of plans have to be changed rapidly with the changes in the situations. If one sticks to the idea that, once you set up a plan, it should not be changed, the business cannot continue to exist.

About the backbone in human body, there is a saying that "a sturdier backbone bends more easily". Such elastic nature is important. If something goes wrong and the backbone is put into a cast, the vitally needed backbone gets stiff and stops functioning. The idea of sticking to a plan once it is set up is similar to the human body wearing casts. It is not healthy.

One may think that the bones of acrobats must be soft but this is not true at all. An acrobat is not a mollusk. He has a well-forged backbone and only then can he perform the tricky actions.

The backbone of an aged person like myself does not bend easily. And, once it bends, it cannot be unbent quickly. This is definitely a phenomenon of aging, one should realize. The same thing can be said about the aging phenomenon of a business.

I also think a business should have reflex nerves which can respond smoothly to small changes in the plan by providing instant response without having to go to the brain. It is similar to the reflex action of the eyes in fluttering when a small piece of stone is about to get into it or the reflex action of the hand which pulls away fast when it touches something hot.

The larger a business becomes, the better reflex nerves it needs to institute. If a small change in a plan must be accompanied by the command of the brain to make it work, i.e. the production control department issuing order slips, putting out plan change sheets, the business will be unable to fend off burns or injuries and will lose big opportunities: Institute a fine adjustment function inside the business so that change will not be felt as change. This amounts to the installation of the reflex nerve inside the body. In the beginning of this book, I said that "the management by seeing with eyes" works through "Just-in-time" and "auto-activation." I firmly believe that this reflex nerve can be trained by use of the two pillars which support the Toyota production system.

o Provide the Necessary Information When Needed

I have emphasized that an "agricultural mind" does not work in the industrial age, causing problems. Should we then go to the "computer mind" in one jump? That is not so again. There should be an "industrial mind" between the "agricultural mind" and the "computer mind."

The computer is indeed a great invention. Since computers became available, it is a waste to perform calculations by hand. Human intelligence would dictate that such computational work should be given to the computers.

In reality, however, the situation seems to be a little different. The human being is intended to control the computers freely. But the computer became so speedy that now it looks as if the human being is pushed around by the computer.

Is it indeed economical to provide too much information too speedily? It is just like buying a high performance, large type machine that produces too much. The extra items are not needed and have to be stored in a warehouse. This raises the cost.

Among the excessive information which the computer generates, a considerably large amount is not needed for the production field at all. Too speedy information causes delivery of raw materials faster than necessary and this causes waste. Too much information pushes the production field into confusion.

The "industrial mind" which is neither the "agricultural mind" nor the "computer mind" extracts the wisdom of the people in manufacturing, gives the wisdom to the machines which work as the hands and feet of men, and devises the organization of production for the whole plant including the cooperating firms outside.

The mass production system of America has used the computers extensively and effectively. In our Toyota Motor Company, we do not reject the computer itself. Rather, the computer is essential in the planning of averaged procedures and calculation of the required number of parts per day at the planning stage. We use the computer freely as a tool but we try not to be pushed around by the computer. We reject dehumanization caused by the computers and reject the way of using the computers which results in higher costs.

The "Just-in-time" production in the Toyota production system is a method of delivering the required number of goods to the side of the production line when needed and the method does not require any extra inventory. Similarly, with regard to the information, the needed amount of information when needed is sufficient and the needed information can be sent to the production field with exact timing.

Anyhow, a computer performs in an instant the calculation which up to now has taken an hour and its tempo is incompatible with that of human. Unless one recognizes this clearly, one can run into completely unexpected situations.

Using a computer to sort out the orders from the customers, i.e. the information of the needs of the market is a very good thing. To make this use more effective, men's wisdom must be extracted and gathered. However, the information which is needed at the production field gradually becomes obvious and settled and the information which is needed today is not needed 10 days or 20 days earlier.

"An industrial mind" must be very realistic. In this sense, the Toyota production system is a method of producing on the basis of the "industrial mind".

5 Toyota-Style Information System

Like any other organizaton, the Toyota Motor Company naturally has many plans. The fact that we produce "Just-in-time" in response to the orders coming in from the Toyota Automobile Sales Company (i.e. in response to the needs of market) does not mean that we can operate without any plans.

In order to operate the Toyota production system smoothly, the Toyota-style production plan and the Toyota-style information system must be tightly inter-combined.

First, the Toyota Motor Company has its annual plan. This means the rough number of cars to be produced (also to be sold) during the current year. For instance, we say that we shall make 2 million cars this year.

Next, there is the monthly production plan. For example, as to the cars to be produced in March, the types and quantities to be made are "announced internally" and, in February, the car types, models and other details of the items to be produced are "decided." The information "announced internally" and "decided" is sent to the cooperating firms outside at about the same time the actions are taken. Based on these plans, the daily plan is set up in detail.

In the Toyota production system, the method of setting up this daily plan is important. At this stage, "averaging" of production is woven into the daily plan.

During the later half of the previous month, each production line is informed of the daily production quantity for each type of products. In the Toyota Motor Company, this is called the level per day. On the other hand, "the sequence plan" which arranges the daily plan in a further averaged manner is sent to only one place i.e. the head of the final assembly line.

This is one special characteristic of the Toyota-style information system. In other firms, various information must be sent to all of the production processes.

Now, let me explain how the Toyota-style information system works in the production field.

At an earlier process, if the production line uses the parts which are at the side of the line to assemble the car, the "Kanban" comes off the parts which are picked up. The earlier process makes as many parts as were picked up. Therefore, the earlier process does not need any special production plan. In other words, the "Kanban" acts as the production information and it goes backward to the earlier processes. Now, what sort of information does the assembly process itself (or body assembly process) work with?

Let me use an illustration to explain this point. The illustration depicts the assembly line (or the body assembly line) which is the final process in an automobile plant. Each sub-assembly process combines with the main line which goes through the middle to form the production line. The numbers in the illustration are the car pass numbers. Thus, the No. 1 car is about to get off the line and the No. 2 car has just entered the process No. 1.

Illustration on p. 68 of the original book

Bumper preparation (Process 3)

Window glass preparation

Console box preparation

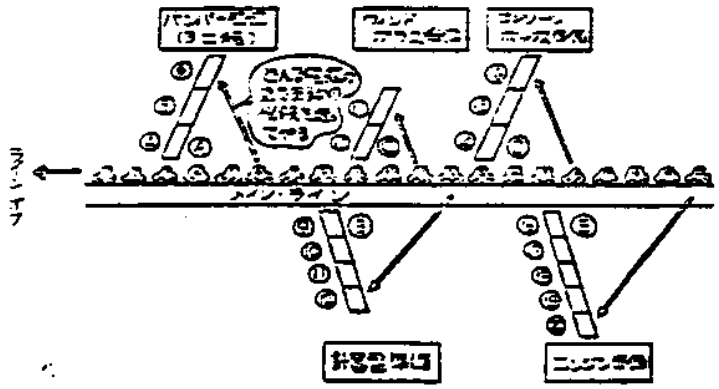
Car type information

Line off

Main Line

Instrument panel preparation

Engin preparation



The production information (the sequence plan) is issued to the process No. 1 for each car (at the moment, the specification of car No. 20 was issued). The worker at the process No. 1 attaches a sheet of paper (production order sheet) on this car, the sheet showing all the information needed for the production, i.e. in the information indicating what kind of car this is. The workers in the processess below the No. 2 process can tell which parts to assemble with by looking at the car.

The workers in the sub-processes also can tell what to do when they can see the car. When the car is not visible because of the blocking by facilities or pillars, the following type of information is issued. Suppose, now, that the bumper was being assembled in process A. Let us say that the process where the bumpers are prepared is process No. 3. What the process A needs now is what type of bumper goes to the car No. 6. Therefore, the process in the main assembly line which is assembling the car No. 6 gives the information to the head worker of the bumper process. Now, no other information is needed.

If one uses a computer, it is possible to tell each process the information which it needs now. For this purpose, however, huge peripheral equipment and wiring are needed. This is not realistic from the viewpoint of expense and problems rise also in terms of the reliability. In the use of the general types of computers which are being used today, the information on car No. 20 is issued to the head of process A at the same time when it is issued to the head of the main line. Process A needs only the information of car No. 6 now, but it is getting the information on car No. 20.

Information is supplied Just-in-Time
just like anything else.

Too much information induces going too much ahead and can cause a mix up of sequence. Items needed cannot be made when needed or too many items are made and, at the same time, with defects. Eventually, this generates a situation in which a change of plan cannot be done for the production line in a simple manner.

In the business field, excessive information must be suppressed. At the Toyota Motor Company, the information is suppressed by letting the products being made carry the information.

o The Working of Fine Adjustments

If the information system is organized as described above, an important effect shows up in the actual production line, automatic fine adjustments.

Not only with the automobiles but with the market in general, there is always the repetition of gradual increase and gradual decrease even when there is no big economic shock.

Even if the production plan is set up on the basis of the market demand prediction, the quantity and types of products actually required vary all the time.

In coping with a market which never ceases to fluctuate like this, it is most desirable for the production line to respond with the changes of plan. In actual situations, however, the information system is difficult to change or the constraints in the production field make the change difficult.

The important characteristics of "Kanban" is that it performs fine adjustments automatically within a certain limitation. Each line does not have detailed plans beforehand and so it does not know what type of car it is to assemble until the "Kanban" is taken off. For example, it anticipated 4 of A's and 6 of B's for a total of 10 cars. But in the end, it may turn out to be in the reverse sequence. The reversal of ratio, however, does not cause someone to run around to tell of the change. It occurred simply through the production which followed the information carried by "Kanban." The big merit of "Kanban" is that this degree of change can be handled automatically. If one ignores the movements in the market and does not make adjustments accordingly, sooner or later he would be forced to make a big change of plan. For example, if one sticks to a production plan for 3 months despite a 5-10% sales slump. he would be forced to cut the production by 30-40% in one step 4 or 5 months later under the guise of inventory adjustment. This would cause problems not only within his own firm but also for the cooperating firms. The larger the business, the larger the social impact as well, and this could be a serious probiem.

The idea of sticking to a plan once it is set up, regardless of the situation, is the way of doing things under the systems of controlled economy or planned economy.

Under the system of controlled economy where it is believed that everything will go well by following the plan, I believe that the fine adjustment of production by use of "Kanban" carrying the human wish would not work.

o Coping With the Charges

The term "fine adjustments" has a hidden significance which should be understood, especially by the top management of a firm. Everyone knows that things do not go always as planned. But there are people in the world who recklessly attempt to push as planned although they know they cannot. They will say, "it is good to follow the plan" or "it is a shame to change the plan" and will try to do things through all sorts of means. As long as one cannot foresee the events ahead perfectly, it is natural to change the way of doing things when the situation changes. Also, it is important to build up the character of production people so they can cope with change and keep their thinking flexible.

I, myself, have struggled a long time with the job of the Toyota production system which is not easily understood by other people. Looking back at the route on which I have continued to work persistently with the problem, I believe I can say the same thing. A mistake should be corrected immediately -- rushing causes loss of work. Wait until the opportunity is ripe. These signals were derieved from the operational tool which is called the "Kanban" and this prevented us from failure and misjudgement.

As to the role of "fine adjustements," I believe it is not only to indicate whether the change of plan is for a "go" for a temporary "stop" but also, in case of "stop." enabling one to find why the stop occurred and how to do the fine adjustments to make it go again.

The Toyota production system is not yet perfect. More development needs to be done for more roles of "fine adjustments."

I naturally prefer the ways of free economy based on the individual responsibilities of private businesses over the controlled economy and planned economy. However, in today's environment where the sociality of private enterprise is questioned more frequently, it is felt imperative that the function of "fine adjustments" must be performed by everyone more naturally.

o What is "True Economy?"

"Economy" is a word which is used daily. It is not easy to understand the true meaning of "economy" in the real situations of living and business activities.

Particularly in the business activities, how the "true economy" is pursued is directly tied to the survival of the business. Therefore, one must consider this point with all seriousness.

Let us discuss the way of thinking about "economy" in the Toyota production system in terms of the "manpower reduction" and "cost reduction."

In order to elucidate the relation between these two elements, I would like to consider a "manpower reduction" policy as a means of realizing "cost reduction," which is the most critical condition for the survival and growth of a business.

The manpower reduction activity in Toyota is a company-wide activity manufacturing and its purpose is, stating again, "cost reduction." Therefore, all considerations and improvement ideas, when they are boiled down, must be tied to the cost reduction.

Saying this in reverse manner, criteria of all decisions is whether the decision can achieve cost reduciton.

In what we refer to as the cost reduction problem, there are two other problems: the "problem of judging" (which of A and B is more advantageous) and the "problem of selecting" (which is most economical and advantageous among the several alternatives of A, B, C . . .). We must consider these two problems separately.

Let us first consider the "problem of judging." Frequently, problems arise on judging which is better. For example, should a certain product be made internally or should it be ordered from an outside firm. In making a certain product, should we purchase an exclusive machine for the purpose or should we use a geneal purpose machine presently in use.

In making the judgements in such cases, one should not be biased and one should take another cool look at the situations under his jurisdiction. One should not base his judgement on a simple cost calculation and conclude that it would be cheaper to order outside than to make internally.

With regard to the "problem of selecting," one can consider many methods for example, on achieving the goal of "reducing the number of workers."

There is a method of reducing the number of workers by buying automated machines or there is the method of reducing by changing the combination of work. One can also consider buying robots and having them do the work.

In purusing such ideas of improvements. "there are very many ways or means for one objective" at the stage of studying the ideas. Therefore, one should list numerous conceivable ideas for improvements and each one of them should be examined in depth and, finally, the best idea should be selected.

If the improvement is pushed before thorough study is completed, one can easily end up with an improvement with small cost reduction for which too much money was spent.

For example, let us suppose that there is an idea of installing a 100,000 yen electrical control device for reducing one worker.

If by applying this idea, one worker could be reduced with 100,000 yen, it would be a big gain for the Toyota Motor Company.

If, however, a closer study revealed that one worker could be reduced by changing the sequence of work without spending any money, then the idea of spending 100,000 yen can be regarded as a failure.

Such examples were frequent at Toyota in earlier times. This was an especially easy trap when automatic machines were purchased.

This is a problem which exists not only in the big businesses, but is a problem common to medium size businesses and small businesses.

The Main Plant, which is the oldest plant in Toyota Motor Company, is an example of having established smooth flow by rearranging the conventional machines which resulted after studying the sequence of work from all angles.

The manager of a certain small business came to see the Main Plant with the idea that Toyota would have nothing relevant to his firm because Toyota is a big company. When he looked around the production plant, he realized that the old machines which he discarded long ago were working well in Toyota. He was amazed and suspected that some kind of remodeling work must have been done to the old machines.

What is crucial in the production plant is to design the layout in which the men's work would be reflected upon the flow. This can be achieved by changing the sequence of work in various ways.

If the most advanced high performance machine is purchased suddenly, it will only generate the waste of over-production.

o Re-examination of the Wrong of Waste

The Toyota production system is a method of eliminating the waste thoroughly. By eliminating the waste, the productivity is enhanced.

The waste in the production field refers to all elements of production which "only raises the cost."

For example, it refers to too many people, excessive inventory, and excessive facilities. If there are more men, facilities, and products than necessary, they only increase the cost. Furthermore, this waste causes secondary waste.

For example, because there are too many people, some work is invented and this causes new additional power consumption and consumption of supplies. This is the secondary waste.

Interesting Scenario

The largest waste among these is the one caused by the excessive inventory. Suppose there is excessive inventory. If the inventory cannot be held within the plant, a warehouse must be erected. And the company must hire the workers who will carry the goods to this warehouse.

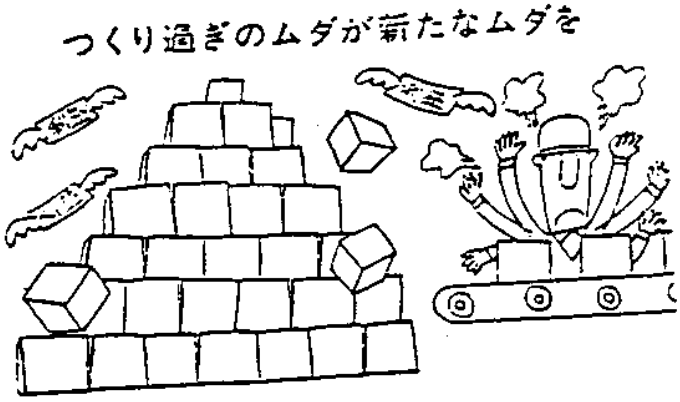
Then, let us assume that one lifting cart was purchased for each worker. Then, in the warehouse, they would need some people to do the work of rust prevention and inventory management. Even then, the stored goods will rust and will suffer damages. Because of this, they will need workers who will fix the goods before the goods can be taken out of the warehouse for use.

Once certain goods are stored in the warehouse, it is necessary to know the quantity stored at all times. For this purpose, more men are needed in the inventory management department. When this situation reaches a certain level, then some people start thinking about buying computers for inventory control.

If the quantities in the inventory are not controlled completely, there can arise shortages. So some people will think, despite the daily production at the planned rate, that there is the shortage so this is the reflection of the shortage of production capability.

So a plan for increasing production capability is put into the next year's facility investment plan. When this facility is purchased, the inventory increases even further.

Illustration on page 98 of the original book.



The waste of over-production causes new waste.

profit

profit

profit

The vicious cycle of waste generating waste is hiding everywhere in the production field. Unless the managers and supervisors of the production plant have a full understanding of what the waste is and what causes the waste, there is always the danger of the vicious cycle of waste causing more waste.

The above example was described on the basis of the worst situation. I believe this would never occur in the production field of the Toyota Motor Company. But the similar phenomena can occur easily although the degree of extent would be different.

All of the primary waste and secondary waste which was described above eventually enter the direct labor cost, indirect labor cost, depreciation cost and general management expenses and they would contribute to the increase of cost.

When one considers these facts, one can never ignore the elements which raise the cost. If one mistake is made, the resulting waste will eat up the profit which ordinarily amounts to only a few percent of the sales, endangering the business itself. At the bottom of the idea that the Toyota production system aims at the cost reduction, there lies the above mentioned understanding of the cost facts.

Elimination of waste is specifically aimed at the reduction of cost by reducing the manpower and inventory, clarifying the extra availability of facilities, and naturally diminishing the secondary waste. Regardless of how much is said, adoption of the Toyota production system will have no meaning at all if this understanding of the elimination of waste is not complete. That is why I explained this once again.

o Generate "Extra Capability"

It was mentioned that there are very many means and methods for achieving one goal. Here, let us consider the way of thinking under the Toyota production system about what is advantageous economically from the standpoint of production capability.

On the subject of having or not having the extra production capability, the judgement on economic advantage differs. In brief, there is extra capability, we are using the men and machines which are idle and, therefore, no new expense is incurred. In other words, they are free.

Let us consider the extra capability in the internal production versus outside production. Often, cost comparison is made on making a product internally or ordering from outside. If there is extra capability for internal production, the only cost which is actually incurred is the variable expense which increases in proportion to the amount of production, e.g. the material cost and oil cost. Consequently, without having to look at the cost comparison, internal production would be advantageous.

Let us consider the problem of waiting. If a transfer worker has to wait until a pallet is full, then having him do the work in line or work of preparation would not cause any increase of the cost. This point should not require any study. It would be an error to calculate this manpower and increase the cost by this.

Next, let us consider another problem of making a smaller lot. When the general purpose machine, such as a press, has extra capability, it is advantageous to make a lot as small as possible, apart from the separate problem of shortening the time for change of preparation. If the machine still has extra capability, it is better to practice the change of preparation than to do nothing.

As in the above mentioned examples, if there is extra capability, loss or gain is clear without even requiring the study of cost. The important point is to clearly grasp the extra capability at all times. If one does not know whether there is extra capability, he is bound to make a mistake in making the selection and cause the increase of cost.

In the Toyota production system, we go one step further and try to extract extra capability as an improvement. This is because, if there is extra capability, one does not have to worry about new cost being incurred.

o Significance of "Understanding"

In this section, I would like to discuss how important it is to understand the details of the work in the production area through the consideration of the method of proceeding with manpower reduction.

With the way of doing work now, the rate of operation in the line is fairly high and the defect ratio is not too bad. Therefore, as a whole, things are going in a passable way . . . If one feels this way, any hope of progress comes to a halt. One is cutting away the bud of improvement by himself.

If you look carefully at any production area, there is waste and there is room for improvement. "Understanding" the manufacturing function does not mean merely walking through the work area, seeing and knowing. It means grasping the whole picture and grasping the role and function of each section.

"Understanding" is my favorite word. I believe it means something very strict, approaching an objective positively and grasping its nature.

Observing the field work in fine detail, one can divide the movement of workers into waste and work.

(1) Waste . . . The worker repeating something several times but for no need. Consequently, this must be eliminated immediately. For example, waiting or stacking of intermediate products.

(2) Work . . . There are two types in this. The first is the "work for no additional value" and the second is "net work for raising the additional value."

The "work for no additional value" may be regarded as a waste in the conventional sense. However, it may be something which has to be done under the present working condition. For example, walking to pick up parts, opening the package of goods ordered from outside, operation of the push buttons, etc. belong to this category. In order to eliminate this, conditions of the working place must be changed partially. The "net work for raising the additional value" means some kind of "processing" for changing the shape, changing the property, or assembling. "Processing" means adding values. In other words, in making the parts or products, the cruce materials or semi-products are worked on as the object of processing to generate the added values. The higher the ratio of this, the better the working efficiency.

Examples of the processing are: assembling parts, forging the crude materials, pressing iron plates, welding, tempering the gears, painting the bodies.

In addition, in the production area, there are activities which are outside the standard work. For example, these are small repairs of the facilities or tools and corrections of defective products. As one considers these items, one comes to realize that the ratio of the net work, which raises the added value, is lower than what most people think.

This is why I frequently emphasize that the "movement" of the workers at the production area must be made to be "working." Regardless of how much moving one does, it may not be working. "Working" means making the process go ahead and getting the job done. Workers must understand this clearly.

Manpower reduction means raising the ratio of the net work. One hundred percent net work is the ideal goal and approaching this ideal goal has been the point of my greatest concern in the process of building up the Toyota production system.

o Utilizing the "Full Work System"

In order to raise the ratio of the net work, one has to be concerned with the movements outside net work, i.e., with the complete elimination of waste. In connection with this problem, let us consider the redistribution of work.

In a job which is being done by a certain number of workers, if someone does some "waiting" or does some meaningless moving, it is not so difficult to eliminate the waste, redistribute the work and reduce the manpower.

In reality, however, such waste does not show up on the surface and frequently it is hidden somewhere and it is difficult to eliminate. Let us look at some examples.

In any manufacturing situation, one frequently observes the "over-progress of the work." While someone should be waiting, he would do the next work. So the waiting is hidden.

If this situation is repeated, what would happen?

After a line or between the lines, inventory accumulates. This inventory has to be moved or stacked up neatly. If these actions are regarded as "work," then one cannot tell the waste from work.

In the Toyota production system, this phenomenon is called "waste of over-production" and is regarded as the worst enemy. I have stated this over and over but here I would like to add one more point. The "waste of over-production" helps hide other waste and, in this sense, it is the most fundamental waste.

In advancing the actions of reducing the manpower, the most important thing to do is to eliminate this "waste of over-production" and to set up the measure of doing it.

In trying to make the Toyota production system as one's own system, a rough grasp of what the waste is will not do.

Unless one detects all sources of waste and sets out to crush them, success is a hopeless dream.

Let us consider one of the measures. With an automatic machine, suppose that the "standard inventory" of a process is 5 pieces. If at a time, the inventory is only 3 pieces, the earlier process automatically starts processing the item until the inventory becomes 5 pieces.

When the inventory reaches the required number of 5 pieces, the earlier processes stop sequentially and the processing of any more items than those needed is suppressed.

Also, looking at the later process, if the inventory of the later process decreases by one from the standard inventory of 4, the earlier process starts processing the item and sends it to the later process. When the inventory of the later process reaches the required number, the earlier process stops the processing.

Thus, in such a system, the "standard inventory" of each process is always maintained and the machines of each process work in an interconnected situation and so the "waste of over-production" is prevented. Such a system is called the "full work system."

o Do Not Make a False Show

So we want to prevent generating the "waste of over-production" and make the items needed when they are needed, one by one. Here, one has to know when is the "time they are needed." Thus, the idea of "takt" becomes important.

"Takt" (time) means the length of time, minutes and seconds, it takes to make one piece of the product. This has to be calculated reversely from the "required number" of the product.

"Takt" (time) is obtained by dividing the "operable time per day" by the "required number per day" (pieces). The operable time means the length of time in which the production work can be carried out per day.

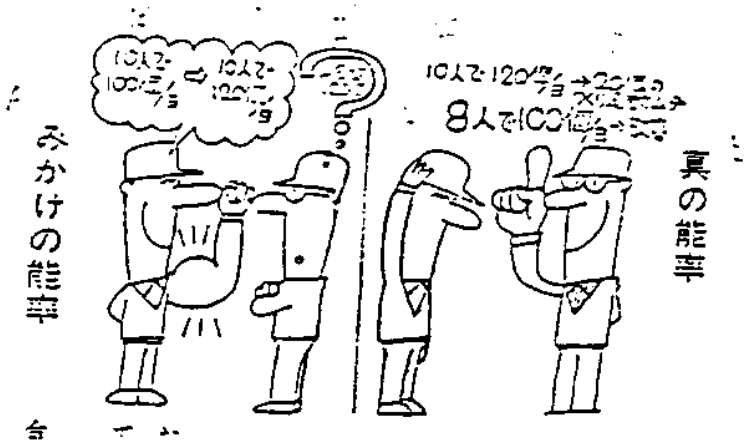
In the Toyota production system, we make strict distinction between the "operating rate" and "operable rate." The "operating rate" means the production record, at the present, of a machine based on the full time operation capability of the machine. On the other hand, "operable rate" refers to the state of operable condition when it is desired to operate. The ideal operable rate is 100%. For this, maintenance of the machine has to be kept up at all times and it must be possible to shorten the time for change of preparation.

Let us illustrate the difference between the "operating rate" and the "operable rate" by examples.

With regard to a person's car, the operable rate means the percentage of the state in which the car would run smoothly when the person wants to drive the car and the ideal rate is 100%.

On the other hand, the operating rate refers to how much time out of a day one rides in his car. Everybody would ride on the car only when he needs to and, therefore, 100% is not necessarily the ideal rate. If one rides in his car from morning till night even if there is no need for that, he would burn gasoline and oil and increase the probability of mechanical troubles. All of this would cause losses.

Illustration on page 108 of the book



A. Apparent efficiency

B. 100 pieces/day with 10 men

C. 120 pieces/day with 10 men

D. Is the required number 120 ?

E. True efficiency

F. 120 pieces/day with 10 men

G. Waste of over-producing 20 pieces.

H. 100 pieces/day with 8 men → Improvement

In considering the "takt" (time) here, we have to ascertain clearly how the "required number" is originated.

Before going into that, we would like to touch upon the relation between "the production quantity and number of men" as a point which is worth thinking about in tracing the "required number."

If we express the relation between the production quantity and number of workers in terms of the efficiency, we should remember that "improvement of the efficiency and cost reduction are not necessarily equal to each other."

Eli will love this.

Let us consider an example. In a production line, 10 men produce 100 pieces of products per day. Improvement was made on this line and, as a result, the efficiency rose and 10 men now can produce 120 pieces. This amounts to a 20% increase in efficiency.

The time of this improvement somehow coincided with the period of increased production. So, the production plan was set up to make 120 pieces per day and this was achieved without having to increase the manpower. By this, the cost was reduced and this tied to the profit, obviously.

Now, after this, suppose that the demand of market i.e. the "required number" dropped to 100 pieces or 90 pieces per day. What do we do? If we keep making 120 pieces a day because of the improved efficiency in this case, 20 to 30 pieces of products would be left over per day. This would eat up the material expense and the labor expense and at the same time bring the bad problem of inventory.

In this kind of case, how should we realize the improvement of efficiency which also ties to the cost reduction?

The problem is solved by making the daily requirement of 100 pieces by 8 men. If 90 pieces are needed, let 7 men make them. To be able to do this, the process has to be improved.

In the Toyota production system, increasing the efficiency by increasing the production quantity while the required number is not changing or when the production is to be reduced is called "apparent increase, or increase in calculation, of efficiency."

o "Required Number" is All Important

During the era of high rate growth when anything made was sold, people tended to forget the concept of "required number" because they were busy thinking about buying large high performance machines to catch up with the rising demand. While the business was preparing for increased production, however, it had also to grasp the "required number" strictly and be prepared with a system which could shift to reduced production. I believe that the Toyota production system has been built always on the "required number."

So, I would like to describe my thinking on the "required number." In increasing efficiency, there are two methods. One is to increase the production quantity and the other is to reduce the number of workers.

If, in the actual production line, one is asked to take any one of these methods for the increase of efficiency, most of the production lines would perhaps choose the increase of the production quantity. This is probably because the later method would involve the reorganization of the whole worker and it is a difficult one as a means of improvement.

However, if the situation is one in which demand is going down, it is unrealistic not to reduce the number of workers.

As I have repeated several times, the goal is cost reduction and, therefore, increase of efficiency must be achieved by a method which is consistent with this goal. In order to eliminate the waste of over-production and tie this to cost reduction, it is absolutely necessary that "production quantity" and the "required number" are equal.

"Required number" means the "sales." This is determined from the trend of the market. Consequently, the "required number" is something which is given to the production field and it is obviously a quantity which cannot be increased or decreased arbitrarily.

Each plant of the Toyota Motor Company carries out production in accordance with the "required number." From the dealers all around the country, daily orders come into the main office of the Toyota Automobile Sales Company in Nagoya.

These orders are classified by computer with respect to the type of car, model of the body, gas discharge rate of the engine, car style, method of speed changing, color, etc. and the resulting data comes to the Toyota Motor Company. These quantities are the basic "required numbers" for the production plants of the Toyota Motor Company.

The production departments prepare the production system according to these "required numbers." An increase of efficiency by reducing the manpower can be realized only by eliminating waste from the production "takt" calculated from the "required number" so that more work is done by a person or by "auto-activating" a portion of the human work so that the resulting extra manpower can be utilized for other work to carry out the production activities with less men.

At this time, for the machines, facilities, tools or transportation equipment, which has already been paid for, there is no room for reducing the cost. Therefore, they can be used according to the production "takt" as calculated from the "required number." The "operating rate" of the machines is also determined by this.

o The Rabbit and the Tortoise

When we deliberate the waste of over-production, I often tell the story of "the rabbit and the tortoise."

In a plant where the production is carried out on the major premise of "required number," I would like to say that the tortoise who advances ahead ceaselessly and persistently causes less waste and is much more desirable than the fast rabbit who takes naps.

The Toyota production system can be realized only when all the workers become tortoises.

The situation in which high performance machines were desired lasted for a long time, and because of this, the term "high performance" has been used for a vague meaning without a thorough examination.

When one says a high performance machine, it means a high precision finishing in some cases, low energy consumption in some cases, and trouble-free machine at other times.

Each of these must be a correct judgement. However, one of the mistaken notions which are misjudged with unexpected frequency is to regard "high productivity facilities" as being equal to "high speed facilities."

If the speed can be raised without dropping of "operable rate." without shortening the life of the facilities, without changing the required manpower and selling all products which were made, then one can say that a high speed means a high productivity.

An increase of speed naturally must be accomplished by durability.

How meaningless such speed without durability is can be seen easily by the story of "the rabbit and the tortoise" which all of us know very well since the days of our childhood.

Also, if the machine is not designed to endure the speed, increase of speed would certainly shorten the life of the machine.

Increasing the speed under the name of productivity improvement without expecting any benefit or resisting the reduction of speed to avoid a drop in productivity, even though the machine can not endure the speed, looks like cooperating with production.

In actuality, however, this type of action hinders the production in reverse. The managers and supervisors of the production field as well as the managers in the world should understand this in depth.

o Take Good Care of the Facilities Which Gave Long Service

Does the value of facilities really go down? In the case of a man, years of experience adds a depth to the person and his value goes up. In the case of a machine, however, it does not have a personality like a man and, in general, a machine which gave long service is discarded under the present situation.

I want to advocate that, like a man, a machine which gave long service also should be used with great, great care.

In the language of business economy, there are terms such as the "depreciation cost," "residual value" or "book value." These are, however, terms which were set artificially for accounting, for tax purposes and for convenience. It is very regretable that people behave as if they forgot the fact that such terms do not have any relevance to the inherent and actual value of a machine for use.

For example, we often hear the saying such as "this facility has already been depreciated completely; its price has been paid off and, therefore, we can discard it any time without loss" or "the book value of this facility is zero. It is a loss to spend any money for remodeling such an item. Rather, it should be replaced with a new, advanced machine."

Such thinking is truly unwise and it is a big mistake.

If an old facility which was purchased in the 1920's has been kept up well so that at the present time an operable rate close to 100% can be guaranteed and it is bearing the burden of production in an area, the value of the facility certainly has not gone down a bit. On the other hand, if a new advanced machine which was purchased a year ago has not been kept up well so that it can put out only 50% operable rate, then its value should be regarded as having gone down by 50%.

The value of a facility is not determined by the number of years of its service or oldness of the model. It is determined by the earning power which it still retains.

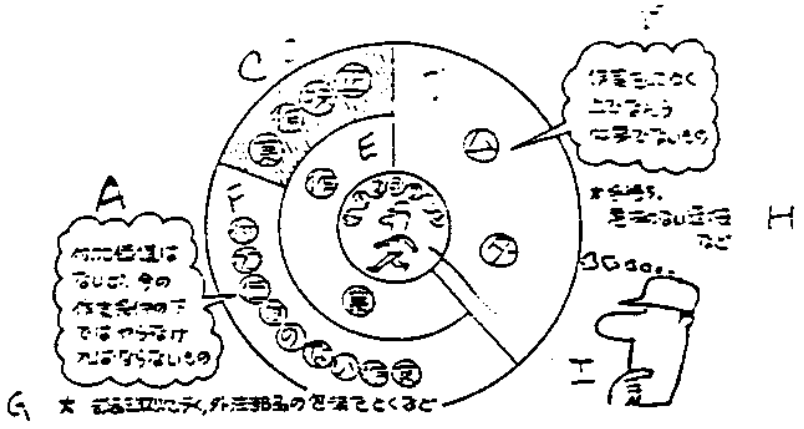
In renewing the aged facilities, there are various ways of economic examinations. There are the methods of cost comparison and the investment interest method. Can such methods be really used in the plant?

Certainly, these methods look as if they were set up with tight logic. However, what we must not miss here is that every one of these methods stands only on some premise.

For example, some people think that the conventional method of maintenance is the only available method: then they decide that the amount of loss which can be calculated only under several premises is an absolute amount of loss. In actual problems, such methods cannot be used even as some kind of standards.

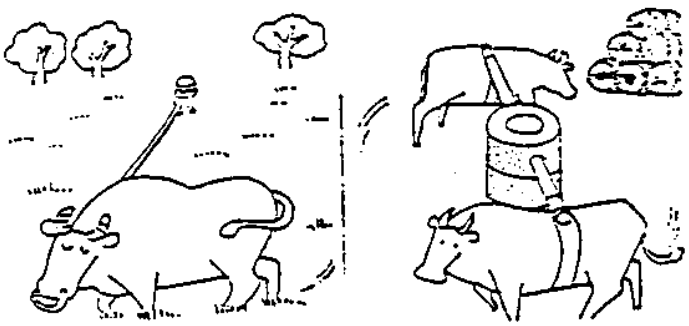
Despite this, facing a facility which was not maintained well and put into the state of dying, one applies such methods and concludes that "it is advantageous to renew the facility." This is totally irrational.

Illustration on page 102 of the book.



A. There is no added value but, under the present working condition, it has to be done
B. This is not needed at all in doing the work.
C. Net work.
D. Waste
E. Work
F. The work which has no added value.
G. *Walking to pick up parts or opening the package of parts ordered to outside.
H. Waiting, meaningless transfer, etc.
I. Movements of the workers.

Illustration on page 103 of thebook



Moving and Working

Then, what should be the basis of judging whether an aged facility should be renewed? Stating the conclusion first, if sufficient maintenance has been applied, one should think that replacing with a newly purchased item can never be cheaper even if maintenance of the old item takes some expense.

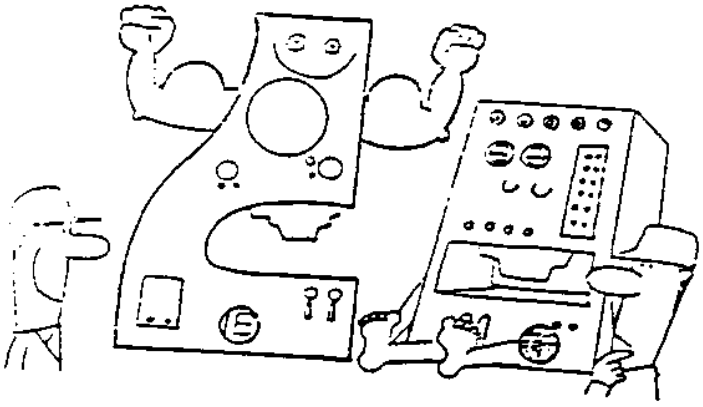
Suppose one reached the conclusion that renewing would be advantageous: then it must have been caused by a deceptive calculation or wrong method of maintenance.

When the basis of argument through the comparison of economy is lost, next comes the argument of the validity of renewal by skillful combination of the reasons such as "it is technically difficult to restore the required precision" or "we want to do an overahaul but there is no machine to substitute."

Such reasons cannot be the basis of arguing the validity of renewal. All of these merely amount to saying that they want to have extra facilities because they have no better idea. Whether the reasons should be accepted or rejected should be decided on the basis of separate judgement of the situaton which has no relevance to the renewal of the aged facilities.

Whether it be the overhaul of a machine or renewal of an aged facility, if sufficient maintenance is not given and the units are driven close to death and then renewal of the facilities is approved with ambiguous judgement, the cost which is incurred by such actions would become enormous. If this is computed as the "maintenance cost," for example, it would not have any significance if one does not achieve actual effect in proportion to the increase of the "maintenance cost."

§ Illustration on page 115 of the original book.



o Look Straight at the Reality

Business management must be very realistic. Drawing up the vision of the future is important but the vision must be down to earth.

In this age, if one misreads the ceaseless changes in reality, the business can fall behind instantly. We are surrounded by such a harsh environment.

It is frequently said that the character of the business must be altered. Some people speak out loud that, because the base of economy changed from the high growth rate to the low growth rate, one should repay the loan and work tightly with his own capital. This point, however, should have been the concern of us exen during the era of high growth rate.

During the era of high growth rate, such alteration of the character of business should have been rather easy. If someone else increased production, this made one uneasy and he also increased the facilities and expanded sales. Machines were increased and manpower was increased without questioning the true efficiency. As a result, the profit rate did not increase at all although the sales increased. If one was satisfied with this, it was indeed a story of the age before management came into being.

If one was prepared to carry out true rationalization of the business during the era of high growth rate, one could have held his own growth to 5 percent without increasing machines and men while other companies expanded their sales by 10 percent. By doing so, one would have been able to raise the profit, which is the most crucial element, and he would have been able to increase the facilities with his own funds and repay all the debt. This sort of action would have put the business in a position which is desirable from the management viewpoint.

Now that we have entered the era of low growth rate, the market competition is becoming more and more fierce; it is becoming a cut-throat fight for life and death.

In such an environment, strengthening the character of business is an absolute requirement for survival.

In the effort to make the Toyota production system truly effective, there is a limitation in what the Toyota Motor Company, which is a chasis maker, can do alone. Only by working together with the cooperating firms as their partner sharing the common fate, is it possible to advance toward the perfection of this system. The same is true with the improvement of the characteristics of management. Strengthening the Toyota Motor Company alone cannot achieve the goal if the cooperating firms do not work together.

So, we have been asking our cooperating firms to implement the Toyota production system policies in their own businesses.

About 10 years ago, I went to see a tempering shop of a company. At the time, monthly production was approximately 70,000 cars. But the manager said, "We are prepared with men and facilities to cope with your order even if you would be making 100,000 cars."

So, I asked him, "Then, is your plant closed for 10 days out of one month?" He answered, "We would never do that sort of silly thing."

I went to the earlier process which was the machine processing section. Women workers were working like dogs. They were working at a maximum limit because they did not want to keep the furnace idle.

Certainly, on the calculation, the unit price was fairly low. In the tempering plant, also, the furnace was filled with the items to treat so that the fuel cost per unit would be less. Because they had the capability for 100,000 cars' parts, extra parts for 30,000 cars were accumulating each month. However, we were going to pick up only as many as we needed. So, that firm had to build a warehouse probably.

It was from the time of the oil shock that people began to understand that over-production is a waste. And only then people began to recognize the true value of the Toyota production system. I wish the readers could ascertain with their own eyes that the warehouses are disappearing from the sites of our cooperating firms one by one.

o 0.1 Man is Also 1 Man

In a business, we are always concerned about how to make more with less people.

In our company, we use the term "man saving" in contrast to "manpower saving." The term "manpower saving" is somehow easily misused in a manufacturing company. The manpower saving facilities such as the lift and bulldozer, which are used mainly in the construction work, are certainly connected directly to "manpower saving." However, the problems which are seen in the automobile plants are the partial automation and localized automation. In work which involves several actions, an automatic device is put in only at the portion where the final commodity is placed. In other portions, work is done manually as before. I think this kind of manpower saving is absolutely wrong. If the "auto-activation" system is working, it is fine. But, if the automation is used to allow someone to take it easy, this would cost more money.

How can we get a large quantity of production with a small number of men? If we consider this question in terms of the number of man-days, it is a mistake. We should consider it in terms of number of men. The reason is that, even if we reduced 0.9 man-days, this still is not a "man saving." First, improvement of work and improvement of facilities should be considered. Improvement of work alone should contribute half or one third. Next, auto-activiation or improvement of facilities should be considered. I repeat that one should be careful not to mix the improvement of work and improvement of facility. If the improvement of facilities is done first, the cost does not go down but goes up only.

In the company newspaper, a report was made on a talk I gave on "man saving." In the story, the term "man saving" was printed as "less men working." Obviously, this was an accidental error. But, when I saw this, I thought, this is true. "Less men working" seems to represent the essence of the problem much better than "man saving."

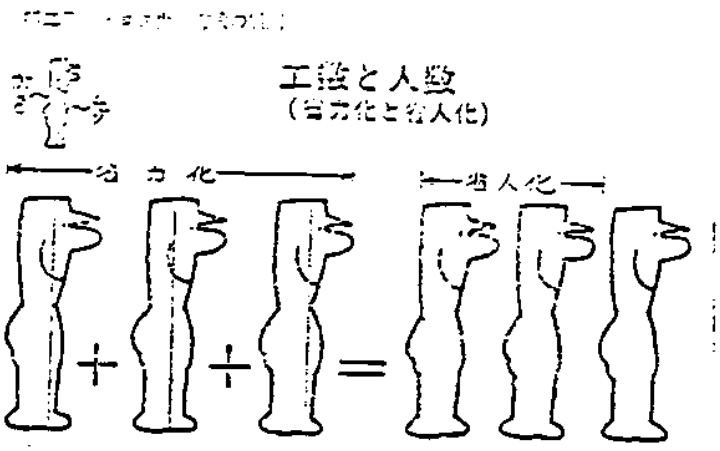
"Man saving" does not sound good because it means a man is eliminated. "Man saving" means, for example, that a job which took 10 men in the past is being done by 8 men and 2 men are eliminated. On the other hand, less men working allows 5 men or 3 men depending on the production quantity and there is no fixed number of men. "Man saving" can be taken as meaning that the manager hires many men to start with and he reduces the number of men when he does not need all. On the other hand, "less men working" is an idea of working with less men from the start. In our actual experience, we had a labor dispute caused by the manpower cut in 1950 and, immediately after the settlement of the dispute, the Korean War broke out and the special demand came. We met this demand with just enough people yet increased production. We utilized the valuable experience.

Since then, we have kept producing the same production quantity as other companies with 20 to 30% less people. What made this possible? In a few words, it was the creative mind, effort and power to put into practice by Toyota people that which has been crystalized in the Toyota production system. This statement is not merely an expression of self-admiration.

In the Toyota production system, we frequently say, "Do not make an isolated small island." If the workers are sparsely positioned one here and one there among the group of machines, it looks as if there are not many men. However, if a man is put by himself, team work between men cannot be done. Even if the work is for only one man, we say that 5 or 6 of them should be gathered so that they can do team work. By providing such an environment which contains the human aspects, it becomes possible to implement the idea of "less men working" realistically.

TEAM WORK

Illustration on page 121 of the book



A. Number of man-days and number of men
(Manpower reduction and man saving)

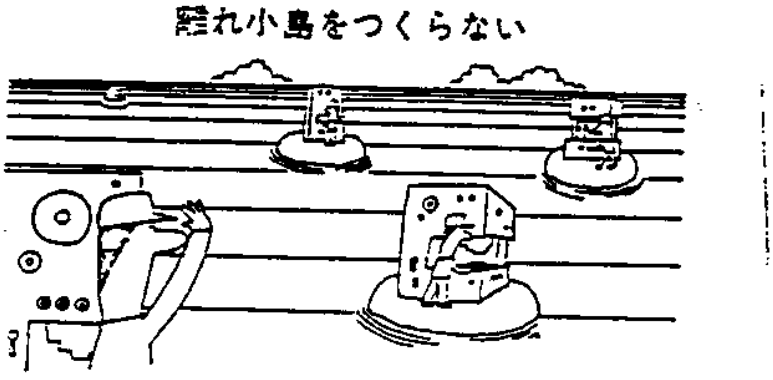
B. Working

C. Waste

D. Manpower saving

E. Man saving

Illustration on page 122 of the book



Do not make isolated small islands.

o Management by "Ninjutsu" (Art of Invisibility)

It is understandable that one would feel the unit price per piece is certainly reduced by mass production. However, such understanding is wrong. There is a confusion in the calculation.

In the balance sheet of a business, the goods in process are regarded as having some added value. In other words, they are treated as inventory or property. This is where the error in thinking starts.

Most of this inventory is frequently unneeded inventory rather than having the added value. Increased production is a prosperous business. Materials are purchased, workers do overtime work. Although they are generating unneeded inventory, it is natural that the workers would demand payment for the overtime work and an increase of the bonus.

We have been accustomed to the environment in which expanding sales, increasing capital, increasing manpower and increasing machines were believed to be good. Now, naturally, the business managers should check out how the key factor, profit, is doing.

Somehow, the management of "seeing the trees but not seeing the forest" was practiced everywhere.

People these days do calculations too fast and this sometimes causes problems. The following incident happened about the end of 1966 when we were starting to put out the Corolla.

The Corolla was fairly popular and it sold well. We started with a plan of making 5,000 cars. I directed the chief of the engine section to "make 5,000 units with less than 100 men." After 2 to 3 months, he reported, "We can make 5,000 units with 80 men." After that, Corolla kept selling well. So I asked him, "How many men can make 10,000 units?" He instantly answered, "160 men." So I yelled at him. "I was taught in grade school that 2 times 8 is equal to 16. After all these years, do you think I should learn that from you? Do you regard me as a fool?"

Before long, 100 men were making more than 10,000 units. One might say that this is possible because of the mass production. But, mostly, this was made possible by the Toyota production system in which waste, inconsistency and excesses are eliminated thoroughly.

I frequently say, "Management should not be done by arithmetics. It should be done by ninjutsu (art of invisibility)." The meaning of this is as follows.

In foreign countries, the word "magic" is frequently used in place of the Japanese work "ninjutsu." Expressions like "Magic of management" or "Magician of management" are used these days. In Japan, perhaps "ninjutsu" is more suitable for management.

The ninjutsu which we watched in motion pictures when we were children were tricks. The hero would disappear suddenly. Ninjutsu, as a management technique, however, is something very rational.

The "Management by ninjutsu," which I am talking about, means acquiring the skills of management by training. In this age, I am painfully aware of the fact that people tend to forget the need of training. Of course, the skills learned should be creative and stimulating and require the best of people: otherwise, the training may not seem worthwhile. But, here, let us take a cool look at the world. There is no goal, regardless of how small the goal is, which can be achieved without sufficient training.

If there is magic in American management, I think the Toyota production system may be called the "management by ninjutsu" which was originated in Japan and reflects the Japanese character and culture.

"Man of Action"

o In an "Art," Action is Needed

If you find the word "engineer" in an English dictionary, there is, as you know, the translation of "technologist." In the Japanese translation there is the character "art." If you analyze this character, you find that it is constructed by inserting the character "require" between the character "action." So, "art" seems to be something which requires action.

Even in mathematics, use of the abacus requires practice. The principle which is involved with the beads of an abacus can be understood easily by anybody, and anyone can move the beads. But fast and accurate operation takes constant practice.

The marshal art of using Shinai (bamboo sword) was first called "Gekken" (attaching with sword) but it soon became "Kenjutsu" (art of using the sword). When actual fighting with the sword ceased in the beginning of Meiji era, this became "Kendo" (the way of sword). Then, recently, it is being called "Kengi" (technique of using sword).

During the era when the one with stronger power won, it was "Kekken" fighting with swords. Then the "art" was born and even the one with weaker power could win and so it became "Kenjutsu." When the practical use of the sword was not needed any more, it became "Kendo." I believe that, during the era of Kenjutsu, the skill advanced most. It was only natural because the action was required.

In "Gijutsu" (technology), similarly, action is required. Actual action is what counts. The character "talk" is also pronounced "jutsu." Recently there seems to be more of those who "talk about technology" than those who "act with technology." It is a matter which concerns us very much.

I feel I am still a "technologist" (who acts with technology). So, even though I am not so good in talking to people, I do not feel ashamed. With the art of talking about the technique, there is not much one can do.

Mathematics is being done by the computers and Kenjutsu changed from Kendo to Kengi in this era. I still think "art" has its own merit and am attracted to it greatly.

o Advocating "Profit-Making IE"

After the war, Japan has been influenced greatly by America in many aspects. There was the cultural influence and the American attitudes became fairly common in politics and the country, generally.

In the world of industry, America is undisputedly the leader. "Catching up with American and surpassing her" was not a job which could be done in a day. In catching up, the shortest route was to buy the advanced American technology. So, everyone imported technology from America.

So, the high level production technology and manufacturing technology of America were imported in succession and these were adopted by the aggressive businesses of Japan. A great deal of business management techniques of America were studied and discussed in the academia, business and everywhere.

For example, Japanese businesses studied hard the IE (industrial engineering) which is the "company-wide manufacturing technology which is directly tied to the management" developed, applied and evolved in America.

Now, the definition of this IE seems to be fairly difficult. When the IE was introduced, it was pointed out that the Toyota production system was an ME (method engineering) and not an IE. It is not wise to be confused with such definitions. I myself have accepted, as mentioned already, the definition that "IE is the company-wide manufacturing technology which is directly tied to the management."

In brief, I believe that IE is not a partial production technology but rather a total manufacturing technology which reaches the whole business organization, i.e. it is a system. The Toyota production system may be regarded as the Toyota style IE. What is the difference between the traditional IE and Toyota system? In short, Toyota-style IE is "Mikeru (profit-making) IE" (MIE). Unless the IE brings cost reduction and profit increase, I believe it is meaningless.

There are various definitions of IE. The leader of the American Steel Workers' Union defined it as: "The function of IE is to enter the plant and make improvements of methods and procedures to cut down the cost." This is exactly what it is.

"IE is the use of techniques and systems to improve the method of manufacturing and its scope includes items ranging from the simplification of work to the large scale capital investment plan." ("Factory Journal").

"IE has two meanings. One aims at the improvement of the methods of acting in the plants or in the work. The other one means the specialized work of studying the action and time. However, this is the work of a technician. Essentially, an IE studies systematic approaches to improvements" (Professor Clark of the Massachusetts Institute of Technology).

I would like to raise one more definition by SAM (The Society for Advanced Management), an organization which succeeded the Taylor Association.

"IE applies the engineering knowledge and techniques for the study, improvement, planning and implementation of the following various items: (1) Method and system, (2) Qualitative and quantitative planning and various standards including the various procedures in the organization and work, (3) Measurement of actual records under the standards and management of taking suitable actions. All of this is done for exercising better management with a special consideration for the welfare of the employees, and it does not restrict the business to the objective of lowering the cost of improved products and services."

I have listed above various definitions of the IE. Each of them says good things. They are useful references. However, in a private business, making this really effective is not an easy matter.

The reason I named Toyota IE "the mokeru (profit-making) IE" was my wish that the Toyota producton system which was already born and raised within the Toyota Motor Company be comparable or superior to the IE which is an American-born business management technique and manufacturing system.

We are very happy that the Toyota production system has penetrated into the Toyota Motor Company as the "company-wide manufacturing technology which is directly tied to the management" which I intended; and, fortunately, it is expanding the ring of understanding among the outside cooperating firms as well.

o Surviving the Slow Growth Economy

I have already mentioned that I calmly accept the words "slow growth."

More than 5% growth of macro economy would be regarded as prosperity rather than recession. Three to five percent growth would be the normal situation. In the future, zero growth or negative growth could be coming in certain periodic cycles. We must be prepared for this.

The automobile industry was visited by the negative growth immediately after the oil shock and, at one time, it fell into a deep slump. After that, however, the exporting situation improved and, in comparison to the sluggish state of other industries, the automobile industry alone seems to be enjoying good luck. However, the actual situation is not necessarily optimistic.

The domestic demand has entered the period of maturity after a cycle and a large demand cannot be hoped for in the present situation.

Expansion of export will also come under a braking action as a matter of course. Political and emotional restriction against Japanese cars is gradually rising in Europe and America. With the rise of the yen, a lowering of the competitiveness of Japanese cars in the international market is also an obvious fact to expect. American firms are now really getting into the manufacturing of small cars. This will also act negatively against the export of Japan.

The automobile industry may have been endowed with too much good fortune. Already there is the hidden danger. If the domestic demand continues to suffer the low growth and if the export bumps into even a slight slump, we shall have to face a really serious situation.

The fiber industry and electric furnace industry are regarded as economically depressed and it has been said that there is no formula for recovery unless some basic shift of the industry is carried out. The automobile industry is presently booming. But once the situation changes, there is no guarantee that it will not also fall on hard times.

As to how the business should be managed in a severe recession or slow growth economy the private businesses must persevere through this by whatever means they can muster.

The Toyota production system has thoroughly gotten rid of the waste, inconsistency and excesses from the production field. It is by no means a passive or defensive management.

The Toyota production system is a revolution of the consciousness, so to speak. Because there is the need for the fundamental changes in the way of thinking, I hear strong voices of support as well as the voice of criticism.

When I seek the cause of such criticism, all of it is because of insufficient understanding on what the Toyota production system is.

Of course, we have not made enough efforts to make people understand the nature of the Toyota production system.

However, it would not be an exaggeration to say that the Toyota production system already left Toyota and it is putting down its root as the production system which is uniquely Japanese.

Since the oil shock of the fall of 1973, the Toyota production system attracted attention from the people outside the Toyota Group and it has been studied by many people.

Chapter 3. Genealogy of Toyota Production System

o A Universal World Was Right Near Us!

Soon after the war, Mr. Kiichiro Toyota who was the president of the Toyota Motor Company, at the time commanded us to "Catch up with America." This was already mentioned in this book.

It is said that Mr. Kiichiro Toyota once told Mr. Eiji Toyota (president of the Toyota Motor Company at present), "In a synthetic industry such as the automobile industry, the best system of working would be to gather the parts for the car assembly to the side of the line just in time."

As the readers already know, "Just-in-time" is a system in which "the goods needed arrive at the side of the assembly line when needed and in the quantity needed" and this makes up the basic idea of the Toyota production system.

The words "Just-in-time" which Mr. Kiichiro Toyota pronounced gave a kind of revelation to some people among Toyota management.

I

It was one of those who became attached to these words. Actually, I have been attached from the very beginning to the present. The words "Just-in-time" themselves were new at the time but what we found exhilarating was the content of those words. The scene of needed parts arriving at the side of each process on the production line when needed and in the quantity needed was wonderful and stimulating to the imagination.

It seemed to contain some aspects of fantasy but there was something which made one feel that it would be possible to realize. It looked very difficult but not impossible to do. In any case, it was stimulating.

I was a layman to the automobiles. But, at the time, I was awestruck by the pronouncement of Mr. Kiichiro which gave me a suggestion.

In the spring of 1932, I had graduated from the Department of Mechanical Technology of Nagoya Technical High School and joined Toyota Textiles. The company was founded by Mr. Sakichi Toyota who might be called the father of Toyota.

At the time, the world saw the big crash of the New York stock market 2 years earlier and the worldwide economic depression which followed the crash still remained deep in the Japanese economy. Business was down and unemployment was on the increase. The social atmosphere was rather violent and it was the year in which the assassination of Prime Minister Inukai occurred.

My motive for joining Toyota Textiles was to make use of the learning of technology which I had. It was a time when jobs were scarce. My father was an acquaintance of Mr. Kiichiro Toyota and this contact helped me land a job with Toyota Textiles.

I never anticipated that I would encounter Mr. Kiichiro Toyota in the world of automobiles. In 1942, during the War, Toyota Textiles was dissolved and so I was tranferred to Toyota Motor Company the next year, 1943. Thus, I went into the camp of Mr. Kiichiro Toyota who was busy with production of automobiles while the War was going on fiercely.

To me, the experience with the textiles was valuable. Whether it is automobiles or textile, the relation between men and machines in the production field is basically the same. For a private business which belonged to a secondary industry which mainly "made things", cost reduction was the largest problem of management and it has been so in the east and west and in the olden days as well as today.

The textile world of Japan had been struggling in the rough wave of world economy for a much longer time than the world of the automobile, i.e. since the time before the War. In order to catch up with Lancashire of England and surpasss Yorkshire, we had been implementing the cost reduction measures to strengthen our position in the international competition.

Under these circumstances, the Japanese textile industry already had a worldly view before the War and had been working on the rationalization of production operation.

In comparison to this, the automobile industry of Japan was an industry with a short history. Before the War and during the War, the teams of automobile engineers and automobile business managers headed by Mr. Kiichiro Toyota made attempts to mass produce automobiles domestically. Truck production reached a fair level of quantities. But the mass production of passenger cars which he desired was still far away.

It was from the later half of the 1940's that this desire finally started seeing the possibility of realization. In October, 1949, the restriction on the production of small passenger cars was lifted and also the price control on the automobiles was abolished. Overall the lifting of the distribution control and the transition to free sales came in April, 1950. Unfortunately, at about this time, Mr. Kiichiro Toyota taking the responsibility for the labor dispute, resigned from the position of president.

What I want to say here is that both Toyota Textiles, which I worked for first and the Toyota Motor Company to which I moved later, were small in scale but I found the atmosphere inside these companies to be at the world level.

I had joined Toyota Textiles in 1932 and Mr. Sakichi Toyota had died two years before that. In this company, however, the legacy of a great inventor remained and, unconsciously, we seemed to know what the world level was. That was something to be thankful for.

After this, I moved into the world of automobiles and there I met Mr. Kiichiro Toyota whose foresight could be matched by no one else's.

Thus, right near us, there was this "universal world" which passed to the whole world. We were certainly fortunate.

o Two Extraordinary Characters

Earlier, we touched upon the two pillars which support the basic ideas of the Toyota production system.

"Auto-activation" was taken from the idea and practice of Mr. Sakichi Toyota. The Toyota type auto-activated weaving machine, which was invented by Mr. Sakichi, was not only fast but also was equipped with a device which stops the machine automatically if any one of the many vertical threads was broken or lateral thread ran out.

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The Toyota production system regards it as an absolute condition to eliminate thoroughly the waste, inconsistency and excess from the production field. Therefore, if the machine has any slight abnormality and there is the possibility of generating defective products, it is essential that the machine stops immediately.

We learned from the work of Mr. Sakichi that putting human intelligence into the machine was the only way of making machines work for man.

What we had to learn was the earnest attitude of Mr. Sakichi toward things. The following is an excerpt from the writing of Mr. Haraguchi entitled "Conversation with Mr. Sakichi."

At the time, the textile industry was not in such a large scale as today. Mostly, grandmothers were weaving by hand in individuals homes. In my village, every family was farming and each house had a hand weaving machine. Probably under the influence of the environment, my thinking gradually went toward this hand weaving machine. Sometimes, I watched a neighbor grandmother weaving all day. I gradually came to understand the way the weaving machine worked. The woven cotton was being wound up to a thicker and thicker roll. The more I watched, the more I got interested.

Mr. Sakichi was talking about the spring of the year when he was 20 years old, looking back at the time of about Meiji 20. Reading this, I was impressed by his attitude of watching the grandmother weaving all day, gradually understanding the way the machine was working, and getting more and more interested as he watched.

I always repeat saying that "why" should be repeated five times on an object. This principle of thinking in the Toyota production system actually ties to this attitude of Mr. Sakichi.

We talk about the improvement of work, but without knowing the production field thoroughly, one cannot do anything. Stand in the production field and watch all day. Then you will naturally come to know what has to be done. I have been repeatedly saying this.

If you keep your eyes open and stand in the Manufacturing Plant, then you really understand what waste is. You should also be able to discover a specific method of making the "moving" to "working" on which we ceaselessly keep cautioning.

The words "Just-in-time" was pronounced directly by Mr. Kiichiro Toyota. This pillar did not have the object like the Toyota type auto-activated weaving machine which prompted the idea of "auto-activation" and, so in a sense, this was a difficult subject.

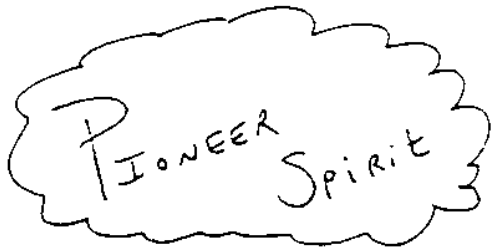
It was the year of 1910 that Mr. Sakichi went to America for the first time. It was the time when the automobile industry was beginning. The popularity of automobiles was rising and every firm was embarking on the production of automobiles. Ford started selling the Model T just 2 years before (1908) and Mr. Sakichi saw himself the appearance of the cars into the market.

Looking back now, it must have been a terrible stimulus. Furthermore, the person was the great inventor Mr. Sakichi. During the four months stay in America, he must have grasped what an automobile was. Perhaps, he understood that the automobiles could become the feet of the public. This he must have done with his unique sense. One proof of this is that, after his return, he repeatedly said, "From now on, it is the era of the automobiles."

It must have been with the understanding of the wish of Mr. Sakichi that Mr. Kiichiro Toyota went into the automobile business and the understanding of the automobile industry which he had and his observations of the American automobile industry seem to have been very perceptive. In other words, he understood how large the potential of the automobile industry was and he registered deep in his mind the difficulty of the automobile industry involving countless numbers of peripheral firms and the business system to fit the situation.

I received a strong revelation by Mr. Kiichiro Toyota's words "Just-in-time." But after this, I thought about the origin of this idea with a lot of imagination. Of course, I do not know because I could not ask him directly. But it is clear that he did a lot of thinking about how to surpass the automobile production system which had been developed greatly in America.

"Just-in-time" is really a unique idea. Considering the fact that it cannot be understood easily even now, I cannot help paying respect to the rich imagination of Mr. Kiichiro.



o Learning From The Unyielding Spirit

I think both Mr. Sakichi and Mr. Kiichiro Toyota had a strong unyielding spirit.

Mr. Sakichi had an exposed unyielding spirit. Mr. Kiichiro seems to have had it hidden inside.

In the statements made by Mr. Sakichi, he speaks in a strong tone that Japanese people should challenge the world with intelligence. The statement was made around 1922 - 1924.

"Presently, white people question what contributions Japanese people made to the modern civilization. Chinese people invented the magnetic compass. But what invention did Japanese people make? Japanese people are merely imitating people. This is what they are saying ..."

"Therefore, Japanese people must face this situation with very serious determination. I am not saying let us have a fight. I am not saying that we must fight with armed forces. I am saying that let us prove the excellence of our intelligence and clear ourselves from this shame ..."

"Rather than stirring up hostility in the international competition, we should take one step and two steps of progress and demonstrate excellent intelligence of individuals and clear ourselves from the shame on the humans with spirits."

"We had Takadiastaze and we had Dr. Hideyo Noguchi. But they achieved what they achieved under the guidance of white people, with their assistance and using their facilities. I am saying that, now, let us achieve a great invention absolutely by the capacity of Japanese people without having anything to do with the white people..."

We can feel in these statements the tremendous enthusiasm of vision combined with intelligence.

When Mr. Kiichiro Toyota told us to "catch up with America in three years," this feeling did not show the exposed fighting spirit like that shown in the saying of Mr. Sakichi. However, his determination clearly reveals a challenging posture which is remarkable.

When we consider the uniqueness of the idea of "Just-in-time", we see an "unyielding spirit" which connects to the "absolutely by the capacity of Japanese people" of Mr. Sakichi.

In the history of Toyota, Mr. Sakichi and Mr. Kiichiro are the two great leaders.

In November 1935, at the Tokyo exhibition of Toyota Motor's model cars which was held in Tokyo Shibaura, Mr. Kiichiro stated that Mr. Sakichi once told him, "I served our country with the weaving machines. I want you to serve the country with automobiles." This became his dying wish. This story became a favorite topic among the people.

Just a short time before this automobile enterprise was going into full scale operation. Mr. Kiichiro passed away on March 26, 1952. It was indeed a great loss.

As far as I am concerned, I believe that "Just-in-time" was the dying wish of Mr. Kiichiro Toyota.

o Toyotaism with Scientific Nature and Rational Nature

I think Toyotaism was established by Mr. Kiichiro Toyota. The way the automobile business should exist as Mr. Kiichiro envisioned had to satisfy the following conditions:

(1) The goal is to provide cars for mass of people.

(2) We have to perfect the passenger car industry.

(3) Make cars with prices which are salable.

(4) What keeps the maker's plan alive is the sales power.

(5) Establishment of the basic material industry.

Mr. Kiichiro wrote an article entitled "The Way Which Led Toyota Motors to Today" (September 1936, published). It provides a very specific description of the Toyotaism. The article contains many suggestive points. In the following, some portions which include these points are quoted.

"Finally, Toyota's cars are being put out in the market. What brought these cars here today was not a simple hobby of an engineer. The cars were born as the result of hard research work of numerous people, gathering of knowledge from various fields, and the effort over a long time with countless failures."

Would it indeed be possible to make cars for the mass of people in Japan? Three years ago, many people thought it was almost impossible. Especially those who had experiences in the field of automobiles thought so more seriously. We started early on the design of engines and on research. In 1933, most preparation was finished and on September 1, the tenth anniversary of the great earthquake, we formally embarked on the automobile production as a company.

Many people said the venture was rather reckless. Some people gave us direct warnings. We were told how difficult it was to operate an automobile industry. However, we had known this very well for several years and we had been working hard in preparation. Therefore, we firmly believed that, with the current capability of Toyota's automatic weaving machine manufacturing business, it would not necessarily be impossible. However, there were numerous problems which were different from those of the weaving machine and we thought it would be difficult to make it a business; so, under the name of a hobby, we have managed the business during the past three years. But here we came to have the unexpected "Law of the Automobile Manufacturing Business" and now we cannot make the automobiles with the attitude of a hobby. Now, the business involves an obligation to the country. Whether we like it or not, we have to work hard to make it into a business as soon as possible.

After we had formally decided to go into the manufacturing of automobiles three years ago, what have we done? (some portion omitted). I would like to describe what sort of preparations we have made during the past three years.

What is most important in the manufacturing of automobiles? Without having to say anything, it is the problem of materials. Embarking on the manufacture of automobiles without solving the problems of materials is like building a house without preparing the foundation.

In Japan, the steel industry is in a fairly advanced stage and they can provide materials which are exclusively suitable for the automobiles. But, bringing this into a business would require a considerable sacrifice. Also, a considerable effort of research would be needed. No material maker would be patient enough to provide that assistance until that stage. Even if there was one, it would be impossible for him to continue the research which we think is needed indefinitely.

With the progress in the materials, the engine can be improved. And, with the progress in the engines, the materials must be improved. As to the manufacture of the materials which are indispensable in the research of the engine, we in Japan today are in a situation where the manufacture of materials must be done by ourselves. Regardless of how well an engine is made, its life would be short, its price will be high and its performance will be poor if proper materials are not used at the proper place. Without being able to make the materials, we cannot do the research on automobiles. This would cost more than two million yen, but in Japan today, this is the lifeline for the automobiles. But would it be possible to make the materials just by Japanese people? I thought that the fastest way of getting the answer was to ask Professor Kotaro Honda. So, I went to Sendai and asked him. He said, "It can be done by the capability of Japan at present, there is no need to hire foreigners." I was greatly relieved and immediately set out to the erection of a steel mill.

From some of the people who come to visit our company, we are asked how many percent of the cast products pass the test. Normally, 95% of the cast products must pass; otherwise, the business cannot be sustained.

I felt that, if we are in a miserable situation of having to worry about the passing percentage of cast products while we want to manufacture automobiles, we might as well give up making automobiles. So, I encouraged the men at the plant and said that it would be a shame for Toyota if we cannot make the cast products. Before we succeeded in blowing the cylinders in the mold using the molding machines with the pass ratio of over 90%, we failed many times. But we succeeded using the molding machines for many years and because we had been casting thin parts for the weaving machines using electric furnaces. Even so, we failed for 500 - 600 cylinders. When one thousand pieces of an item are made, most workmen become familiar and skillful and they make without mistakes. Among the first several hundred pieces, there are some good items but one has to be prepared to discard them until the skills are established. In this manner, the problems of materials were solved to an acceptable level.

o Provide Good Machines Even If The Factory Is A Barracks

In the following, I quote an excerpt which shows how Mr. Kiichiro Toyota sought good machines to keep up the quality and how he worked to let these machines be used effectively.

"There is no doubt that machine manufacturing can be done by use of the required machine tools. But the problem is how to make them cheaply."

"Machining of the cast portion is not much different from the manufacturing of the textile machines. Manufacturing the textile machines must proceed by the method of mass production to a considerable extent. The same is true for the automobiles. In the case of the textile machines, there is a fairly large number of varieties. In the case of the automobile, this is less. However, higher accuracy is required and more specialized machines must be used. Some fine boring may also be needed. Some honing machines may be needed. For these, we can get correct ideas if we observe the present situations in the foreign countries and study the new type machines for automobile manufacturing which are being developed by various machine makers. In this area, it is obvious that by using the very much advanced facilities, one can make cheap products which are not inferior to those made in the foreign countries. I felt that the buildings could be barracks but I tried to buy one whole set of machines which can perform perfect manufacturing work even though this might cost some money. We need many of the machines which cost fifty thousand to sixty thousand yen per machine but we do not have any other way. If one would hesitate in buying these machines, one would be better off by not going into the automobile business. So, one must be prepared to spend a lot of money on machines. In this situation, I tried to save money by using barracks as the plants and tried to save in research spending and was laughed at. Regardless of how much I was being laughed at, I would have been short of funds if I kept spending money on things which were not needed. We have to buy good machines by saving all small wastes. And, about these machines, we have to choose them very carefully: otherwise, we would end up buying the wrong machines. It was not odd at all that we went to America to examine so that we would not end up buying wrong the machines. If one buys a wrong machine, thirty thousand to fifty thousand yen are lost. Once we buy such good and expensive machines, the next

problem is to use the machines skillfully and satisfactorily. So, we need to study the use of tools and get more skilled. Regardless of how good a machine is, one cannot make large quantities of products accurately without good tools. Thus, we need the design of tools which is geared up for mass production. Design and production of these tools can easily take three to four years and now you would understand what we have been doing since Toyota bought the machines three years ago."

"For three years after buying millions of yen worth of machines, hundreds of people worked hard without putting out one single car in the market and most of the stockholders started to worry and wonder when the cars would start rolling out. The people in charge of the operation also felt that somehow we should put out one or two cars to show we are working. However, a car made in this way would not be a satisfactory one. This is a point which is hard to be agreed upon between the managers and capital investors. If there is no manager who has enough courage to make a bold commitment into the car manufacturing, there would also be no investor who would trust the engineers and leave everything to them. It would be easy if one is to make money certainly once the cars are made. But it is clear that one has to lose money during the first few years. This is what makes it difficult to establish this business. Even in such a business, if a person does things without considering the future, I myself would regard him foolish. Up to the first one to two years, many managers were thinking in this way. It was natural that I was considered as a too confident man or as a man who is flattered by people and does business without considering the future. Fortunately, the Law of Automobile Manufacturing Business has been enacted and this helped the business a lot."

"Rather than doing a business which would clearly make money by use of a known method, doing difficult business which no one else would do is a challenge to a human being. If it fails, it would be because of his own shortcomings. Then one could commit harakiri with a clear conscience. I will go as far as I can. If I would do something, I would do the making of cars for use by the mass of people which others say is the most difficult business. This is the position where I started from."

o Pursuit of the Japanese Style Production Method

The work of Mr. Kiichiro who was laying the rails of the automobile business was to seek the Japanese style production methods on Japanese soil. For this, human intelligence is utilized at many points.

"One reason that it was difficult to develop an automobile industry in our country was that production of the body cannot be done in mass production as in America. On the other hand, it is difficult to set up the automobile industry by making the body by hand. How to solve this problem was always the most agonizing question. Someone suggested that we hire a foreigner. Then it would amount to importing the mass production system of America and it would not fit the situation in our country. On the other hand, the present situation in our country was that there was almost nothing in this industry and actually things were being made by hand. Japanese people are relatively crafty and were making many things by hand. In mass production, however, one must use the presses. But we are not going to make tens of millions of cars like in America, and so we cannot put in too much money in making the mold. Somehow, we had to improvise a method which is uniquely Japanese. The main thing is the press and the subsequent portion may be done by hand. We cannot adopt the American method as it is."

"I thought it was necessary for me to take a thorough look at this industry to learn how far it has advanced, and so I toured the plants in Tokyo area with the guidance of Mr. Kazuo Kawakita. On this occasion, I happened to be touring Sugiyama Tekkosho where they were making fenders with pressing machine. There could have been other plants where they were doing similar work but, anyhow, I asked Mr. Sugiyama if he would be interested in making the mold for the body. He said he would, and I obtained unexpected help in this area. In the making of this mold, this was the first time and there was the need for studying the method of making it in various ways. However, as we had no machine for this, we had to finish the mold by hand. In foreign countries, of course, they have the machines for making the mold. In foreign countries, some firms are specializing in making the molds for various companies and they can afford to install thousands of such machines. In Japan, we cannot copy this. Hand finishing would be faster and it would cost less also. So, we decided to make it by hand this time and we could make a rough mold in about one and a half years. In this area, we need to do a lot of studies in the future."

Next, the quality of the thin plate for making the press affects the making of the mold very much. If one uses the top grade of thin plate, it is much easier to make the mold. We asked Dr. T. Mishima of the University to study the thin plate. During his foreign tour, study in this area seems to have advanced considerably, and I believe we shall be making better products in our country. In the area of coating and lining, there are many experienced men in our country and there is no need to worry."

"Finally, in the area of assembly work, we need facilities and setups in a similar manner and we need skills. So, we have to train the workers but this is not a difficult problem. Japanese people are very skillful with their hands. and I believe it will be in the near future that we can make cars cheaper and better than the foreign cars."

o Making Products Which Have The Values

With the enactment of the Law of Automobile Manufacturing Business in 1936, domestic automobile firms came under protection and assistance. However, the need in the market is that a business can provide the goods with salable prices. Mr. Kiichiro's real spirit as a business man can be seen clearly in the following excerpts:

"With the gathering of the present knowledge of Japan, we finally can make the automobile at least in its shape. Further development and improvement of this will progress with academic research. This, however, is a future problem and the big problem we have to face now is that, regardless of how good a car we can make, it would mean nothing unless we can make it economically. Eventually, the problem is connected to the price. What is the quantity that has to be produced in Japan so that the domestic cars can be sold with reasonable prices? This is a figure which everyone wants to know but no one can provide with certainty."

The cars have to be sold at the current salable prices. What is the salable price? At least we know that the cars would not sell unless the prices are cheaper than the foreign made cars. By appealing to the patriotic minds, one might manage to sell 50 to 100 cars a month. But selling 200 or 500 cars would be difficult. In the end, we must compete with the price. People's habit is such that they feel pleasure in buying a new thing with a cheaper price.

We know from our experience in buying machines that sometimes the prices are beaten down more than necessary. The cars needed by the government agencies may bring the desired prices but in other cases the prices are bound to be beaten down. Appealing to patriotism in this regard would be in fact, impossible. Therefore, the prices must be kept low, otherwise, we cannot sell hundreds of cars a month. With good sales technique and skillful advertising, one might be able to deceive the buyers for a while but it would not last. As the people understand the values of domestic cars, they will buy with reasonable prices. Until then, many people will take the attitude using the domestic cars if the cars were offered free. There will be very few people who would go ahead of others to use the domestic cars for the sake of the country. As we are making something new, we must put in a lot of money and make it good but we must also make the price cheap. If one wants to make cars domestically and sell them, he has to think this much. However, whether the business can make the ends meet with such prices is the point which the manufacturers must consider most carefully.

"Fortunately, the Law of Automobile Manufacturing Business has been enacted to a certain extent. However, if this law would help raise the prices of both the foreign cars and domestic cars higher than before, we shall have no excuses. On the contrary, this law should help improve the domestic cars so that the users can buy cheap cars. On this point, we have a great responsibility. But, naturally, we cannot make the price cheap from the beginning. Would it be possible to make domestic cars economically at salable prices? Making the prices cheap is all right but if this means poor materials and poor quality and eventually unusable products, then nothing is achieved. This is a very difficult point in the outset with the domestic cars. There is no change in the principle that cheap and good products would sell, but we cannot expect to make cheap and good products from the beginning."

" How do we break through this difficult check point? The Law of Automobile Manufacturing Business would be useful in preventing the excessive competition, especially the dumping practice by the well established foreign companies. But, in a fair competition, the only way is to rely on one's own capability."

Before the above article by Mr. Kiichiro Toyota was published, in May of the same year, the "Law of Automobile Manufacturing Business" was enacted as part of the government policy of establishing the domestic car industry. In this law, the automobile industry was made a business which requires a permit from the government and the domestic automobile industry was to be protected for growth by suppressing the foreign car assembly business. This was a powerful protection policy of the government.

About this, Mr. Kiichiro said that it would prevent wild competition but, if the industry relies on it too much, it will eventually be abandoned by the customers who are the most important people using the cars. Thus, he was warning himself. In his thinking, we see the concern of self-responsibility of the private business.

o Overall View of the Chess Board and Checkmating

Both Mr. Sakichi and Mr. Kiichiro had the international sense and I believe they were better than others in seeing the world. They had excellent foresight. They were similar to each other in that they spent their lives mostly in the production fields. They kept on looking at things always realistically, cooly and objectively. They got to the essence of the object.

When a person stands in a production field, he tends to clean the corner of a heavy box with a toothpick. But, both Mr. Sakichi and Kiichiro were different in that.

They were always drawing the whole picture and had the overall view of the chessboard. They were drawing in their heads rich designs constantly.

Even then, their checkmating was accurate.

The inventive life of Mr. Sakichi can be learned in "Conversation with Mr. Sakichi" written by Mr. Haraguchi. One finds that he was a man of effort and a genius.

"He would not read the catalogues or books. He would not borrow help from newspapers or magazines. He would not beg teaching from others or borrow knowledge from others to help invention. He never studied mathematics or learned physics. He thought completely by himself, devised by himself to achieve the invention which people look up to. Furthermore, his logic fit all of the scientific principles and no mathematics teachers, no mechanical scholars could find faults with his invention. As his invention came directly from the actual work, there was some discrepancy with the scientific principles. However, when it came to the actual applications, his invention would demonstrate better results than the scientific principles would. Thus, he was a man of practice."

"He did not have any consultant or assistant. He was incependent and alone. He did not have any special research lab. He did not have any reference materials at his side. The living room in his home was his lab and office. There was no visitor and he would not call on anyone. From morning till night, he would sit in the room, looking up at the ceiling and looking down at the surface of the mattress, and pondering over things quietly. In this way, he generated over one hundred patents from his head."

Find out some material to think about, stare at the object almost until a hole is bored on the object, and find out the essential nature of the material. Stand and watch the neighbor grandmother's hand-weaving machine for a whole day. This was the source of imagination for Mr. Sakichi and this was his posture of tracking things down to the specifics.

He observed the circumstances in the foreign countries with his own eyes and learned a great deal. This shows his progressive nature. We are also impressed by the width of his scope of view. It is not only diffusing outward endlessly like expanding gas. For, at the next moment, he would be condensing the imagination emanating from the object material to a specific form. In terms of the game playing, he had both the overall view of the chessboard and checkmating capability.

Mr. Sakichi toured in Europe and America in 1911. Prior to that, he had some complicated situations and he quit the Toyota System Weaving Machine Company and was in an adverse circumstance. But, in America, he saw the "Northrop System" and "Ideal System" automatic weaving machines which were regarded as the epoch-making inventions at the time. He realized that the auto-activated weaving machine which he invented is much more superior and he got a boost on his vigor. Thus, touring in a foreign country, he found a jumping board. This again demonstrates his unyielding spirit.

At that time, in America, he also saw the automobiles. Thus, he felt that he would go into the automobile business after the auto-activated weaving machine. In the imagination of Mr. Sakichi, the auto-activated weaving machine and automobiles were tied to each other very strongly.

The Toyota System auto-activated weaving machine and the Ring Type weaving machine, which were the creations of Mr. Sakichi, had some common aspects with automobiles in principle. Both the automatic weaving machine and automobiles are the machines which work automatically by the machine power. Also, the Ring Type weaving machine which overcame the limitation of length in making textiles and the infinite nature of an automobile which runs freely on a road without tracks were machines of the same dimensions in terms of the idea and applications.

The imagination of Mr. Sakichi which did not know an end always developed into specific forms in the real world and then soon converged to the final form.

After returning from America, Mr. Sakichi is said to have repeatedly said aloud "It is the automobile from now on." Thus, in his head, next to the checkmating with the auto-activated weaving machines, the overall chessboard view of the automobile industry in Japan was forming.

o Seeking Something of Japanese Origin

The path from Mr. Sakichi Toyota to Mr. Kiichiro Toyota and then to the present Toyota Motor Company was the path of developing and maturing of modern industry in Japan and there is a straight line which passes through all this.

The thick line which passes through this is the seeking of technology of Japanese origin.

It was in 1901 that Mr. Sakichi first thought about the invention of the auto-activated weaving machine. It was completed in 1926. Thus 25 years of time was spent during this period.

The greatest achievement of this was "a great invention entirely by the capability of Japanese people" which was the earnest wish of Mr. Sakichi. Thus, his wish was fulfilled.

Going through the records of Mr. Sakichi's words and actions, one finds a fierce, challenging posture of rivaling the Europeans. He himself stated that this was a "challenge with intelligence" and this attitude was something fresh and new, going way ahead of his time.

Training and cultivating the "intellect" inherent to the Japanese people and then selling the Japanese original products produced by the intellect to increase the national wealth — this was Mr. Sakichi's outlook on life, outlook on business and outlook on the world.

Thus, Mr. Sakichi sold the "intellect" itself which he cultivated, i.e. his patents. In today's way of saying, the development and production of Mr. Sakichi's auto-activated weaving machines was no other than a high density "know how industry."

An agreement of selling the patent application right was entered with Platt Brothers of England in 1930. It is a well know story that the one million yen which resulted from this deal was spent for research on automobiles.

I am overwhelmed by Mr. Sakichi's tenacity of purpose in making use of the intellect of Japanese people which he regarded as most important. He also believed that, unless we discover the creativity of Japanese people and original technology of Japanese people, not only a business but the whole nation of Japan will always remain behind the European - American world. He took this national consciousness as his own admonition.

In the trade of buying and selling commodities in today's world economy, the role which Japan is playing is very large. Actually, the role is sometimes too large and this is causing some friction. In order to overcome this problem, we shall need agreements through political dialogues and this will facilitate the adjustment of quantities. When I think about what to do in pure economical terms, I conclude that we must export the commodities which are desirable both to them and to us and which have high added values, i.e. the commodities on which much of the intellectual work was done as Mr. Sakichi used to say. Eventually, we may have to export the intellect itself.

Mr. Sakichi pursued and achieved Japan's original technology, and I do not know any other example like Mr. Sakichi who discovered the things to study in the real life, without confirming himself to an ivory tower, and invented the auto-activated weaving machine which reached the highest level of mechanical structure and performance in the world and then commercialized it. Although there are great inventions in the academic world, we see few examples in which the invention is born in industry and it becomes the nucleus of the industry itself. Especially, in Japan, such examples are rare.

Takadiastaze of Dr. Jokichi Takamine which Mr. Sakichi also pointed out was obviously a creation by a Japanese but the work was done in a laboratory of a foreign country. This does not mean that the invention had a low value: its difference from the invention of Mr. Sakichi was that it was achieved under different conditions and in a different place. Scientific achievements by Japanese people are not many, and furthermore, the soil on which such achievements are raised was not yet fertile. For this reason, Mr. Sakichi's achievement was more unique.

Here, we also want to touch upon the keen insight of Mr. Kiichiro. In the article "The Way Which Led Toyota Motors to Today" which was published in 1936 and was cited earlier, Mr. Kiichiro stated, "The quality of the thin plate for making the press affects the making of mold very much. If one uses the top grade of thin plate, it is much easier to make the mold. We asked Dr. T. Mishima of the University to study the thin plate ..."

The MK steel, which was invented by this Dr. Mishima, was one of the few originals of Japan along with the ferrite or NKS magnet (invented by Dr. Kotaro Honta) and Mr. Kiichiro's expectation on this was exceptionally great. Regretably, Bosch Company of Germany and General Electric Company of America put more work to the application of these inventions. But, among the Japanese businessmen, Mr. Kiichiro watched them most earnestly.

Whenever there was an opportunity, Mr. Kiichiro emphasized that, in order to establish the basic industry such as the automobile industry, it is necessary to consolidate the academic world which becomes the base of this industry. For this purpose, he had a strong desire for increasing what we call today the cooperation between industry and academia. He was a man who thought that, for everything, the base was important.

o Witnessing a Dialectic Evolution

Mr. Kiichiro Toyota was a man of automobiles but, before that, he was a man of weaving machines.

There are many of our elders who worked with Mr. Sakichi, assisting him with his great invention and helping him in putting the invention to work in the business but without being visible to the outside world.

Even during the era of the weaving machines, Mr. Kiichiro worked busily at the hands and feet of Mr. Sakichi. All the work of Mr. Kiichiro was about the weaving machines, development and commercialization of the auto-activated weaving machine, selling it to the foreign businesses, and negotiation of the technical contracts, etc.

Naturally, he had been interested in automobiles from the earlier time, but it was perhaps during his tour of Europe and America in 1930 when he went to England for the case with Platt Brothers that he received the most strong influence. In particular, in New York, he must have seen the flooding of automobiles. I believe it was quite a shock to him.

When he returned home, Mr. Sakichi, who was ill and in bed, asked him to report in detail about the automobile situations in America and Europe. Then, Mr. Sakichi instructed him to spend the one million yen from Platt Brothers on the research of automobiles. This courage and foresight of Mr. Sakichi was really amazing. On the other hand, Mr. Kiichiro who received the instruction must have been full of the sense of responsibility and excitement.

I look at the change of time from Mr. Sakichi to Mr. Kiichiro as a new evolution of things. In this sense, I look at the change of time from Mr. Kiichiro to ours also as a similar and continuing evolution. In this evolution, there are the mountains and the valleys. There are the successes and the failures. Thus, there are favorable situations and adverse situations. There are movements and stagnations. The flow of a stream is sometimes rapid and sometimes slow. At times, the flow of a stream seems to have paused and sometimes it looks as if it would dry up.

In this evolution, there is something in the stream of Toyota that has been continuous all the way. I firmly believe that there is something very solid. As mentioned before, pursuit of the Japanese originality has certainly been continuous in the stream of Toyota.

Mr. Kiichiro, to whom Mr. Sakichi left all work with the saying "Next is the automobile industry," realized better than anybody else that things cannot be achieved in a day. This is clear from his article "The Way Which Led Toyota to Today."

Mr. Kiichiro was more eager than anyone else to learn at GM and Ford of America, and this was because he wanted to learn the basics of the automobile industry as soon as possible. Thus, very clearly, he studied the basics from the automobile industry of America and, from this, he acquired the materials to compare with that of Japan and then he sought the Japanese method of producing automobiles.

In 1933, Mr. Kiichiro announced the policy of the development of domestically produced cars for the mass of people. In one of the clauses, he said, "As for the method of production, we shall learn from the American method of mass production. But, we are not going to copy it as it is. We shall utilize the idea of research and creation and devise a method of production which suits the situation of our country." I believe this indeed was the origin of Mr. Kiichiro's idea of "Just-in-time."

The so-called true innovation, i.e. the true technological innovation, brings social reform in some manner. The typical example is the Ford revolution. Mr. Sakichi's auto-activated weaving machine also brought an industrial revolution.

The world of the automobile into which Mr. Kiichiro entered was a composite industry of a broad field. In order to narrow the gap between the automobile industry of America, he had to explore the way of learning the basic technology, master the individual production technology, organize the production system, and seek the Japanese production technology, i.e. the production system.

Thus, Mr. Kiichiro must have been envisioning in his head the "Just-in-time" system as the next production system resulting from the learning of the basic technology and acquiring the production technology.

"Just-in-time" is really the starting point of the Toyota production system and it constitutes the skeleton of the system. Therefore, from this, one should be able to read the flow of Toyota ideas of seeking the Japanese originality.

From Mr. Sakichi to Mr. Kiichiro, and then to our times, Toyota itself has achieved the self-evolution in the midst of the big changes in the business and outside the business. I believe this procedure may be something which might be called a dialectic evolution.

Chapter 4. True Intention of the Ford System

o Ford System and Toyota System

It was Henry Ford I (1863 - 1947), without dispute, who established the production system for automobiles.

Strictly speaking, there may be as many methods of making automobiles as the number of automobile companies or automobile plants. This is because the method of production reflects the philosophy of business management and the individuality of the person in charge of the plant.

However, the foundation of the automobile production in the modern industry is the mass production system which Ford himself demonstrated through practice.

The "Ford system" is the term which will symbolizes mass production and mass sales of America even today. "Ford system" is the mass production system based on work flow. This is sometimes called the automation system.

This is the real mass production system in which the materials are machined in the work flow using the belt conveyors, the materials becoming the assembled parts, and then the assembled parts of various types being supplied to each of the processes of the final assembly line which moves at a fixed speed, the parts being assembled, and finally the assembled cars going off the line one-by-one.

In order to clarify the difference between the Ford production system and the Toyota production system, let us first take a close look at the Ford production system to find what it is.

Charles E. Sorenson, who was the first president of Ford Company, described the history of development. This man was originally the head of production. Thus, he was an important man in the history of Ford.

His book is full of suggestions. In the following, we quote the portion which describes vividly the scene of developing and starting the Ford system.

"Assembling a car is simpler than bringing the parts to the place where the car is assembled. We decided to carry the parts which were easy to move and we solved this problem gradually. The engines and axles and similar large parts required large spaces. In order to reserve this space, we decided to leave the small, easy-to-handle items in the warehouse which was located at the northwest corner in the compound. Next, with the cooperation of the warehouse section, one set of the parts which were crated and marked was brought up to the third floor (assembly line) at a certain time interval."

"Handling of the parts was simplified in this manner and the situation became clear and neat. However, I somehow did not like this method at all. At this time, the following idea popped up. If we move the chassis — first, start moving the chassis frame from one end of the plant, attach axles to this next, rather than bringing the parts warehouse to the chassis, pass the chassis attached with the axles through the parts warehouse — the assembly work can be simplified easily and the speed of work should increase. I asked Lewis to place at one end of the building the parts which are needed in the beginning of the assembly work and then line up the parts on the floor in such a manner that the parts are located in sequence along the line through which the chassis was moving."

Until the axles and wheels were attached, the chassis frame was placed on a sleigh; then a rope was attached to the front portion of the chassis and the chassis was pulled by this through the assembly work. Next, the chassis was moved by use of the wheels which were attached; it was moved through the middle of the parts and the assembly work was tried out.

While experimenting with this moving assemblying line, we carried out, on the other hand, the sub-assembly work (e.g., attaching hoses to the radiator) with the parts in such a manner that the parts can be attached to the chassis fast. So, these were attached to the chassis fast and then the steering gear and spark coil were attached." - (from "The Glory and Tragedy" by Ford, translated by Tatsuo Takahashi.)

This was the description of the scene of first experiment for setting up the work flow of the Ford system.

The basic form of this "work flow" is common to all automobile businesses around the world. Recently, in the system like the Volvo system, one person does the assembly of the whole engine. However, the main stream is still the flowing work of the Ford system.

The scene which was described by Sorenson was at the time of about 1910, but the basic pattern has not changed since then to now.

Like the Ford system, the Toyota production system is based on the work flow system. The difference is that, while Mr. Sorenson was worried about the warehouse for storing the parts, the Toyota system does not need any warehouse. The reader will recall the "Just-in-time" system in which the parts needed arrive at the side of each process of the final assembly processes at the time when they are needed and in the quantity which is needed.

o Small Size of Lots and Fast Changeover of Preparations

Making the same parts using the same mold in a lump, i.e., making a lot large and punch out many parts without exchanging the press mold, is a common sense rule in the production field even at present. The key of the mass production system under the Ford system is really this point. American automobile business has continuously shown that the planned mass production has the greatest effect on the reduction of cost.

Toyota system takes the reverse course. Our slogan in the production field is "keep the size of a lot small and do the changeover of the press mold fast".

Why are the Ford system and the Toyota system so different? Why are they so opposite to each other?

For example, the Ford system makes a lot size large and handles quantities, requiring inventories everywhere. In contrast, Toyota system works on the idea of eliminating to zero the waste of over-production which is generated from the inventories and the cost related to the men, land, building, etc., which are needed for managing the inventory.

For this purpose, we are practicing the "Kanban" system in which a later process goes to an earlier process to pick up the parts needed "just in time".

In order to stick to the idea of "the earlier process producing as many as was picked up by the later process", all of the production process must be prepared with men and facilities to produce the products at the time they are needed by the quantity which is needed. In this case, if the later process picks up in a fluctuating manner in terms of the time and amount, the earlier process must be prepared with the maximum need in the fluctuating situation. This is a clear waste which boosts up the cost.

Complete elimination of waste is the main idea of the Toyota production system. Therefore, "averaging" of the production is strictly practiced and fluctuation is crushed. The size of a lot is made smaller and the flow of a large quantity of a same item is avoided. For example, in the production line where Corona and Kareener are made, the flow of one item in a lump is avoided: so, we do not lump the production of the Corona into the morning and lump the production of the Kareener into the afternoon. Corona and Kareener are always produced in an alternating sequence. We discussed such "averaging" of production in Chapter 2. In short, Ford system sticks to the idea of making a same item in one lump: in contrast, Toyota system takes the approach of "synchronized production of each unit". In this approach, the underlying thinking is that "In the final market, each customer buys a different car: therefore, in manufacturing also, the car is made one by one: in the stage of making the parts, also, production is carried out for one piece by one piece".

For "averaging" the production and "making the size of a lot small", naturally there arises the need for "making the changeover of preparation fast".

In the 1940's, in the production department of the Toyota Motor Company, changeover of a mold in a large type press took 2 to 3 hours. From the consideration of efficiency and economy, changeover of preparation was avoided as much as possible and, in the beginning, the new approach met strong resistance in the production field.

Changeover was regarded as an element which reduces the efficiency and increases the cost and, therefore, there was no reason for the workers to do the changeover with pleasure. However, on this point, we had to ask the workers to change their attitudes.

Fast changeover is an absolute requirement in the application of the Toyota production system. Making the size of a lot small and generating the need for changeovers. the workers had to be given repeated on-the-job training.

In the 1950's, when the averaged production within Toyota Motor Company was being pushed, the changeover time was cut down to below 1 hour and it even reached down to 15 minutes. This is an example of defeating the common sense with the practical training of workers to meet the needs.

GM, Ford and the European automobile makers have been carrying out the rationalization of the production process in their individual manner. But they do not seem to have embarked on the "averaging" of production which Toyota production system has been working to achieve.

Taking the changeover of a large type of press as an example, the European and American makers still take a long time for the job as in the past. This is perhaps because there is no need. To attempt to make parts more commonly usable was a very new approach. But, still the size of a lot is large and the effect of mass production under planned production system is being pursued.

Which is in the superior position, the Ford system or the Toyota system? Each system is undergoing daily improvement and innovation and, therefore, one cannot draw a quick conclusion. However, I myself believe firmly that, naturally, Toyota system is a method of production which is better suitable in the era of low growth rate.

o The foresight of Henry Ford I

In Sorenson's writing, it is said that Henry Ford I was not the father of the mass production system but he was a sponsor and one can find some disagreement about this point. Nevertheless, I am awed at the greatness of Henry Ford I.

I believe that, if the King of Automobiles in America, Henry Ford I, were still living, he would surely be doing the same thing as the Toyota production system which we have been struggling with.

The reason for my thinking in this way is that (and I feel more so every time I read his writing) he was a born rationalist; he had a very cool and scientific way of thinking about the way of existence of industry in the American society.

For example, about the question of "stancardization" and about the nature of "waste" in a business, Henry Ford's way of seeing things was orthodox and universal.

In the following, I quote from Ford's writing the portion which shows his way of thinking, i.e., philosophy on the industry. The theme is "learning from waste."

"If men did not use anything, there would be no waste. This reasoning seems to be too obvious. Or should we look at this from other angles? If we do not use anything, is not everything being wasted? Would it be conservation or waste to stop completely the utilization of natural resources? If a person lives through the prime time of his life with nothing but the idea of being thrifty and tries to be prepared for the time of old age, would this be protecting his properties or would this be wasting his properties? Is he a constructive economizer or destructive economizer.

Preserving natural resources without utilizing them is not doing service to society. Such an attitude would be nothing but sticking to that old idea that material is more important than man. At the present time, the natural resources in our country are sufficient to meet all our needs. We do not have to be concerned about the resources. What we should be concerned with is the waste of the human labor. Let us take an example of the vein of ore in a coal mine. As long as the coal is sleeping in the mine, it is not important. But, as soon as the bulk is brought out of the mine and carried to Detroit, then it becomes important. This is because the coal represents the amount of human labor which was spent for digging and transporting. So, if we waste any amount of the coal, i.e., if we do not utilize the coal to the fullest extent, we would be wasting the time and effort of human beings. If we produce something which is to be wasted, we cannot receive a large amount of wages.

"My theory on waste goes from the material itself back to the labor which produces the material. Our desire is to utilize all of the value of the labor so that all of the value of the labor can be paid for. What we are concerned with is utilization and not preservation. In order not to waste the time of human beings, we want to use the materials to its utmost limit. Originally, the material itself is free. It has no value until it goes into the hand of a manager."

Saving the material as a material, and saving the material for the reason that it represents the labor may seem to mean the same thing. However, the difference in these two ways of thinking generates an important difference. If one regards the material as something which represents the labor, he would use it more carefully. For example, just because a material can be reused through regeneration, one would not waste it lightly. For, it takes labor to utilize the used materials. The ideal thing to do is to generate no waste material to be used.

In our place, we have a large scale department for using the waste materials. This department is bringing more than 20 million dollars of profit annually in the known figures. As this department gradually grew, increasing its importance and becoming a very valuable operation, we began to have the following doubts. "Why is so much waste material being generated? Are we not paying more attention to the regeneration of waste materials than to the prevention of generating the waste"?

So, keeping this idea in mind, we began to examine all the processes in our plants. Our studies and examinations up to the present have brought savings of eight hundred thousand pounds of steel per year. This steel had previously been made into scraps which had to be regenerated at the expense of new labor. This corresponded to about three million dollars per year. Using a better suitable expression, this corresponds to the employment of more than 2,000 laborers when converted by use of our wages. This savings was achieved so very simply and we are wondering why we did not do this much earlier.

o "Standard" is Something you set up Yourself

In 1937-38 when I was still working with Toyota Textiles, once I was told by my boss to prepare the "Standard Work Sheet of Weaving". As I mentioned earlier, I found it very difficult. Since then, I have kept thinking about what is meant by "Standard" of the standard work.

The elements which are considered in the standard work are men, machine and materials. They have to be always combined effectively. Otherwise, it is impossible to carry out efficient production, because the working men are alienated.

The "standard" is something which the men at the production field should prepare. It should not be pressed down from up above. In the design of the whole business, however, the system of the plant as a whole should be established. Only then, the "standard" for each production department would become flawless and elastic.

In this sense, the "standard" should be conceived not only as the "standard work" of the production department but also as the top concept of a business. So, let us hear the opinion of Henry Ford I on this point and learn from it:

"In establishing a standard, it is necessary that one takes a prudent attitude. For, as a standard, one can more often establish something wrong than something correct. In standardization, there are elements which represent the "inertia" and the elements which represent the "progress". Therefore, it is dangerous to argue about standardization in a vague manner. There are also two view points, that of the producer and that of the consumer. For example, let us suppose that a committee or a department of the government surveyed a product to find out how many styles and varieties are available in the field and established a so-called standard after eliminating those which they regarded as wasteful duplicates. How would the public benefit from this? Except for the case of war time when the whole country must be regarded as one production unit, the answer is totally none. First, no organization has the knowledge which is needed in establishing such a standard. This is because such knowledge is obtained from within each section of the production departments; it is never obtained from outside. Secondly, even if they had such knowledge, the standard will eventually hinder the progress although it might bring some economical effect temporarily. The reason for this is that the producers would be satisfying themselves to make the products for the standard rather than for the public. Human ability would become dull rather than become sharp."

We see in Henry Ford I's thinking his strong belief that a standard is something which is not given down from up above. Whether it is with the national government, top management of a business or a manager of a plant, the person who establishes the "standard" should be the person who works in the production field. Otherwise, he emphasizes, it would not be a standard for the "progress". I agree with him. Let us read a little more of Ford.

Pursuing the question "What is a standard"?, Ford's thinking reaches the future of private businesses and the future of industry.

"The end point of industry is not the world in which everything is standardized and automated and there is no need for the human brain. The end point is the world in which there is abundance of machines which are operated by men as their brains. In such a world, a man would no longer have to work from morn till night to earn a living. The true objective of industry is not to fit the human beings into one mold. Neither is it to elevate the working man to an apparently highest position. The industry exists to provide services to the public including the working man. The true objective of the industry is to fill the world with good and cheap products and free the soul and body of a man from the hard labor for survival. How far the products should be standardized is not a problem for the government, but it is a problem for each of the producers."

Here, the foresight of Henry Ford I is revealed clearly. We see that the automation system which Ford and his collaborators invented and developed and the work flow were never intended for having machines drive the people to harder work and to cause the alienation of men.

Like in everything else, regardless of what the good intention of a creator was, the intention does not always evolve as it should.

Tracing the conception and evolution of "work flow" by Henry Ford I and his associates, I do not think their true intention was to put a flow of work from the flow work of final assembly line to all other processes, i.e., from the machine processing to the press which corresponds to the earlier processes.

Setting up a flow which connects not only the final assembly line but also the whole processes, one reduces the lead time of production. Perhaps envisioning such situations, Ford used the work "synchronization".

Successors of Henry Ford I, however, did not make the flow of production as Ford intended. They ended up with the idea of "the larger the lot, the better" which makes a dam and stops the flow at machining and stamping.

As I touched upon previously, the lateral split system of the union which is a social custom of America also may have hindered the flexibility of the work in the production field. But I think that was not all. Much of the cause is that the successors of Henry Ford I who inherited the "work flow" made a wrong interpretation. The final process is indeed a "flowing work". But in other production lines, I do think they are "pushing the work to flow".

In the course of realizing the Toyota production system, changing the old way of "pushing the work to flow" in the production field to "flowing work" took countless repetition of the work of transplanting human brains to the machines. We recall again that "Just-in-time" and "auto-activation" are the two pillars which are the means of realizing the system and also they were the objectives.

o Prevention is Better than Curing

In preparation against the future natural disasters, people have long been accustomed to store up, as in the long history of the farming tribes. One cannot say that this custom is not good at all.

What I would like to deny is a stage in industry, i.e., storing the raw materials and the finished products in preparation of unexpected situations in the modern business management.

Business is always connected to the outside world. Then, why should it store things for the safety of only itself? This feeling for storing is the starting point of the waste in business. I have repeated this point over and over.

If one buys a machine, why does one have to keep it operating full time? While the machine runs smoothly, let us make a lot. In preparation of the trouble with the machine, let us make while we can. This is a way of thinking which is still deeply rooted among people.

With the arrival of the era of low growth rate, such a way of thinking does not apply anymore. However, the tendency of making and storing is still strong.

If "goods needed can be acquired when needed by the quantity which is needed" by the principle of "Just-in-time" in Toyota production system, certainly there is no need for holding extra raw material and extra products.

But what should one do if the machine stops and production can not be done? Under the "Kanban" system, if the later process went to the earlier process to pick up the goods needed and found that the machine stopped and the goods cannot be made, what should one do? Certainly, it would be a difficult situation.

For this reason, Toyota production system has impregnated all processes in the production field with the need of "prevention". If one would keep inventory in anticipation of the machine troubles, why not think about preventing the machine troubles before they occur?

As the Toyota production system spread and penetrated gradually within and without Toyota Motor Company, I asked all people concerned to study how the machine trouble and process difficulties could be prevented. Thus, "preventive medicine" is tightly organized into the Toyota production system.

As a fulfillment of the social mission of business, Henry Ford I established the famous Ford Foundation, hospitals and schools. When a hospital was built, Ford's opinion on the health, disease, curing and prevention was published.

In the previously quoted writing of Henry Ford I, there is an article entitled "Curing and Prevention". Ford argues that if we can prepare perfect food, then we can keep health. In other words, the disease can be prevented Ford argued earnestly.

Prominent physicians seem to be in agreement that the method of curing most of the light diseases lies with the food rather than the drugs. Then, as a problem prior to the curing, why do we not try to prevent the diseases? When we keep studying this problem, we come to the following conclusion. If bad food is the cause of the diseases, perfect food is the basis of the health. And if this is a fact, we should seek more perfect food and find it. When this perfect food is found, the world will make the greatest progress.

Ford pointed out that the possibility of realization of this great goal would be much greater if this scientific study is organized as a need of business management than if it is done in a research institution.

He did not say that this idea of prevention itself is indispensable in the "work flow" which is the foundation of the Ford system. But it is interesting that the man who invented "work flow" would also think about such problems. This made the reading of "Curing and Prevention" even more interesting.

In describing the mutual relationship between the "Just-in-time" and "auto-activation" which are the two pillars of Toyota production system, I stated that they complement each other and help make up a production line which has a strong character. A production line with a strong character means a business with a strong character. The strong character of Toyota has been built not by curing but, rather, by the "preventive medicine".

Is there no Ford after the Ford?

I have been identifying the origin of the mass production system represented by the Ford system which presently dominates America.

With respect to the point of work flow, the Toyota system also has learned a lot from the Ford system. However, in consideration of the fact that the Ford system was born in the American environment and that the Ford system brought forth the age of cars for the mass of people with the introduction of Model T Ford which was mass-produced, I have been seeking a Japanese style production system which suits the environment of Japan.

As to how the "flowing work" of the Ford system has evolved in American automobile businesses including Ford Company, I think that the true intention of Henry Ford has not been understood accurately. As I have repeated a few times, the reason for my thinking in this way is that, in comparison to the smooth flow in the final assembly line in an automobile plant, the flow of other processes has not been established and the system of having a large lot which seems to stop the flow has been consolidated.

What was the reason for this? Before the ultimate aim of Ford was understood clearly, competition in the American automobile market intensified and the Ford Company itself came under pressure because of its rival, GM. I think this situation did not allow the company to think about the correct evolution of the Ford system.

The fact that the American automobile market faced a big turning point in the 1920's is well described in the book "With GM" written by A. P. Sloan, Jr., the former Chairman of the Board of GM (translated by Y. Tanaka, S. Karino and H. Ishikawa).

According to this book, during the period of 1924 to 1926, there occurred an incident which caused a big change in the automobile market of America. This was a change from the age of high class market of limited size which had continued since 1908 to the age of the market of better class cars for the mass of people.

In other words, the era in which Henry Ford I's thinking that the "automobile is a cheap means of transportation" dominated the market changed to "the era of the market of constantly improving cars for mass of people".

Starting with the development of the automobile industry in the 1920's, American economy entered a new rising period. With this, new elements appeared and the market changed again. Thus, there was formed a dividing point which differentiated the past from the present.

The new elements can be divided into the following four categories: installment sale, trade-in of used cars, sedan type body, and annual modeling (new model car for every year. (If we also take the environment of cars into consideration, I would like to add the improved roads.) These elements have deep roots in today's automobile industry and it is impossible almost to think about the industry with exclusion of them. Before 1920 and for a little while after that, car buyers were limited to those who were going to own the cars for the first time and the prices were paid in cash or by a special loan. Many cars were of the Touring or Roadster type and the style did not change from the previous year.

This situation continued for a while. Even if the model changed, the change was not conspicuously visible until it reached the climax. This was because each of the new elements started to change separately and developed at different rates and, finally, they mutually interacted to achieve a complete change.

Sloan of GM grabbed this big change in the market and applied the full line policy which was the unique strategy of GM to answer the needs of the market. How did the automobile business respond to this "diversification"?

When the era of mass production of Model T Ford changed to the era of the full line policy of GM, each of the production processes naturally also got complicated. In order to reduce the cost while making many types of cars, common use of the parts was clearly advanced. But the Ford system was not modified to any great extent.

It was about this time that the skills with pricing policy were actively demonstrated with the wide variation in response to the "diversification of the market". In the production field, however, I think the unfinished Ford system was still deeply rooted and consolidated.

In the process of building up the Toyota production system, I always kept in my mind the characteristics of Japanese market which meant many types and small quantities and was different from the American market characteristics of few types and large quantities and I have kept thinking that we must invent the Japanese production system.

Now, the Toyota production system helps the production according to the needs of the market and we fully realize that, to the Toyota production system which was built on the premise of many types and small quantities in the Japanese environment, the condition of many types and large quantities is rather desirable. Thus, it is proving its effectiveness in the grown up Japanese market. At the same time, I think Toyota production system can be applied in America also which has become the market for many types and large quantities of automobiles since the time of Sloan.

o Inverse Conception and the Spirit of a Businessman

Henry Ford I's book "Today and Tomorrow" was published in America in 1926 which was the highest point of his career. In fact, however, this was also a time of the turning point for the automobile market in America. We shall discuss the details of the change which occurred later but, in short, this time was the highest point of Henry Ford I's career and, at the same time, ironically, Ford was going to be driven down by GM and enter the downhill period.

This year of 1926 corresponds to Taisho 15 in Japan and, coincidently, this was the time when Mr. Sakichi Toyota's auto-activated weaving machine was perfected.

Henry Ford I was the man who perfected the automobile industry which is called the combined industry and he knew in detail of all the materials which were used in the automobiles. About steel, various metals, nonferrous metals and fibers, he made them into businesses by his own hand: as a result, his knowledge was not superficial.

Henry Ford I thought elastically about matters without being caught by the existing concepts. Among the stories of his experiences, there is one about the textiles.

"Technology of textiles and cloth has been taught from generation to generation over a long time and it is surrounded by many customs to such an extent that it may be said that it is almost sanctified. The textile industry is one of those industries which started using power at the earliest times. But it is also one of the first industries which exploited child labor. Many textile industrialists believe that low cost production is impossible without low wages. This industry has achieved up to the present fairly impressive technological advancements. However, it is another question whether anyone could enter this industry from a free position without being caught by the customs."

To the textile industry which was "sanctified" by the old customs, the auto-activated weaving machine of Mr. Sakichi gave a change. But the time of this writing must have been much earlier. Anyhow, the conception and specific business development of Henry Ford I forces us to open our eyes.

"In our daily production, we use over one-hundred thousand yards of cotton and twenty-five thousand yards of wool cloth per day. In the beginning, we thought it was natural to use cotton cloth. Prior to that, we never used materials other than cotton as the base material for the top of the automobile and for artificial leather. So, in the beginning, we purchased a weaving machine and started the experiments. However, because we were not caught by the customs, we started to have the doubts of whether the cotton is the best material which can be used here soon after the starting of the experiment."

"In the meantime, we found that the reason for having used the cotton up to that time was not because cotton was the best cloth but because cotton could be obtained most easily. Linen should be stronger than the cotton because strength of cloth is determined by the length of fiber and fiber of linen was the longest ever known and the strongest. Cotton had to be raised in places which were several thousands of miles away from Detroit. Linen could be raised in Michigan and Wisconsin and, therefore, it was possible to get it in the immediately usable state. However, in the production of linen, there are more customs than with the cotton and it was believed that a lot of manual work was indispensable. In this country, up to then, there was no one who was producing the linen in a large scale. We started the experiment in Dearborn and, as a result, we proved that linen could be treated by machine. This project is already over the experimental stage and the economic feasibility is being verified."

I was attracted to the question "Is cotton the best material which can be used here?" which Ford asked.

As Ford pointed out, man moves by the old customs. This may be allowable in a private life. In the industrial business, however, bad customs must be eliminated. In the process of asking "why", we vividly see one facet of the spirit of Henry Ford I as a business man.

If one is satisfied with the present situation, no progress can be generated. The same is true with the improvement and betterment of production. If we just walk aimlessly, we cannot put up even a question mark.

I always tried to see things upside down. In reading Ford's writing, I received a great stimulus by the fact that he repeatedly did the brilliant inverse conception.

o Getting off from the Quantity and Speed

I want the reader not to forget the fact that the book "Today and Tomorrow" by Henry Ford I which I am now quoting was written in the 1920's, more than half a century ago.

When this book was written, Henry Ford's career was at its peak. Shortly, he would face failure for the first time and discouragement although, of course, the Ford Motor Company survived.

For a long time, I have had doubts that the mass production system of America today and the American style mass production system around the world including Japan were not the true intention of Henry Ford I. For this reason, I have been constantly seeking the origin of the idea of Henry Ford I.

Let us take a look at the social situation in America in the 1920's when Ford was prospering.

"Not only in the production of automobiles but also in our lives, in general, is our movement too fast? It is frequently said that the laborers are completely being consumed by the harsh labor, that the so-called progress is being achieved at the sacrifice of something else and that, in the name of efficiency, the elegant aspect of the life is gradually being destroyed.

"Today, it is undeniable that life lacks balance and that it has been that way for a long time. Until very recently, most of the people did not have leisure time and, even if they did, they did not know how to utilize it. One important problem of ours is to achieve the balance between work and entertainment and the balance between sleeping and eating and, in the end, to find the cause of diseases and death of human beings."

"Definitely, the society is moving faster than in the olden times. More accurately speaking, it is being moved faster. But which is more comfortable and fortunate: to walk patiently for four hours on an unpaved road or to go through it by a car in twenty minutes? When the traveler reached the destination, in which case would he be healthier? In which case, is he saving time and energy? In the near future, the travel which takes several days by a car will take only an hour by an airplane. When this happens, are we going to suffer nervous breakdowns?"

"It is said that at present all of us are heading toward nervous breakdowns. Is such a situation occurring presently? Or is it something which is written in the books only? In various books, it is stated that the nerves of laborers are being fatigued to the end: did anyone hear this directly from a laborer himself?"

"The reason that the word efficiency is hated is that things which are not efficient are being disguised as efficiency. Efficiency is to carry a trunk up a hill in a truck rather than carrying it on one's back. It is to train the laborers and give them the power so that they will earn more, possess more and live more comfortably. In comparison to the Chinese coolies who do long hours of work for a few cents a day, American laborers who possess their houses and cars are better off. One is a slave and the other is a free man."

Between the time half a century ago and the present, big changes have occurred. Circumstances in China have undergone big changes.

Recently (September 1977 to September 1978), I went to see the Chinese industry. They were trying hard to push modern industrialization.

I think, from the time of Henry Ford I through the time after the war when we started on the Toyota production system to the present, and under the industry which China is trying to achieve, there is one universal element which Ford pointed out as the true "efficiency".

Henry Ford I said that: "Efficiency is a simple matter of doing work by the best method we know, quitting the poor methods". // DEFN.

The Toyota production system also has worked with the same idea.

"Efficiency" is never a function of the quantity and speed. Ford raised the question "Is our movement too fast?" Considering this question in connection with the automobile industry, it is undeniable that we have been pursuing the efficiency regarding the quantity and speed as the two large factors. Toyota production system, however, always suppressed the over-production and produced in response to the needs of the market.

During the era of a high growth rate, the need of market was very large and the loss caused by over-production did not show up on the surface. In the era of a low growth rate, however, it shows up whether one likes it or not. This waste is indeed the result of pursuing quantity and speed.

As the characteristics of Toyota production system, we explained the idea of "small size of a lot and fast changeover of preparation". Actually, at the base of this idea, there is the intention of reforming the existing concept of "faster and more", which is deeply rooted, by generating the flow of work.

To tell the truth, even within Toyota Motor Company, it is very difficult to put the press section, resin moiding section, casting section, forging section into the flow of total production in a consolidated manner as in the flow of the assembly line or machine processing.

For example, the "changeover" work of a large type press can be done in 3 minutes or 5 minutes as a result of training and this time is shorter than that of other companies by a surprisingly large margin. In future, as the flow is perfected, this speed can be made "more slow" and even then it could be done in 10 minutes.

Thus, Toyota production system is an antithesis, so to speak, against the mass production and mass sales which generates unnecessary loss because of pursuing quantity and speed.

Chapter 5. Surviving the Era of Low Growth Rate

o The System Which Was Raised in the High Growth Rate Era

From the later half of 1955, Japan entered the era of high economic growth which was rare around the world. In 1962, when Japan was well into its growth. "Kanban" which is the tool for the application of the Toyota production system, was adopted company-wide.

It has a deep significance that the time when the "Kanban" system, which is the tool for operation of the Toyota production system put down its roots, coincided with this period of time.

As soon as Japan entered the era of high economic growth rate with the courageous call for income doubling, it seems that the businessmen of Japan lost sight of traditional Japanese ways, lost sight of an economy unique to Japanese business and lost sight of the society itself. The force which caused this loss of sight was the American mass production idea and the public trend of believing that consumption is a virtue.

In the automobile industry, there came a flood of high performance large-type machines for increasing the efficiency such as the Transfer Machine or Robot. During the high growth rate era, whatever was made was sold and, therefore, the mass production machines demonstrated their effectiveness.

However, the problem was the attitude of receiving and understanding this economy of quantity and speed.

In our eyes, at Toyota, although we were excited about the automation and robot, it was very doubtful whether the purpose of these, i.e. the increase of "true efficiency," was being achieved.

It is easy to understand the intention to realize the "manpower saving" by using less men with the help of the high performance, large type machines, i.e. by automation. After all, riding on the trend toward the income doubling, the level of national income rose sharply and the advantageous production cost based on the low wages could not be counted on any more. That is why the businesses jumped into the automation.

However, the machines and facilities for automation had the shortcoming of being unable to make judgements, or to stop by themselves. Therefore, in order to prevent the loss caused by the production of large quantities of defective products and the loss caused by the damages of facilities, tools and molds, an operator's supervision was necessary. As a consequence, the number of men did not decrease even if the automation was done. The machines just substituted the manual work in most cases and thus, while the machines indeed "saved the manpower," they did not increase efficiency.

To me it was questionable whether it was manpower saving when there were two times the number of men needed. It would be all right if one was prepared to reduce the number of men into half by employing the high performance machines. But that did not happen. Then I decided the work could be done well with the presently existing machines without having to buy the high performance machines.

In reality, it is a very dangerous situation when the industrialists do not realize this. If one is blindly concerned with riding the trend of the times, what would he do when the economy of quantity breaks down? It was not difficult to envision the confusion and helter-skelter which they would run into.

As we entered 1965, the volume of Japan's economy expanded through the first round and second round and the desire for the high performance large type machines at the production plant became stronger. The desire was not only at the production field. Top management took a leading role in acquiring them.

At the time, I felt very seriously that it would be dangerous to keep buying the high performance large type machines in this manner.

Within the Toyota Motor Company, we all had a good understanding about the danger involved in running toward the high performance large type machines. The problem was with the cooperating firms.

Thereupon, we asked the cooperating firms to understand and adopt the Toyota system of production. We gathered the top managers of the firms and asked them to cooperate.

(3) At the time, we discussed "reduction of manpower for the reduction of cost." We tried to have them understand from the actual record of the Toyota Motor Company that if we carry out true rationalization, production can be done more cheaply without using the robots.

At the time, or even now, many people still think so. Many thought that the cost reduction can be achieved if only the number of men can be reduced by acquiring the facilities for automation or by manpower saving with things such as robots. Looking at the result, however, we find that the cost was not reduced at all.

It was obvious that the root of the problem was the idea of "manpower saving" through automation.

o Raising Productivity in the Era of Low Growth Rate

In order for the automation to be effective, we must implement a system in which the machines make judgements of any abnormalities of themselves and stop themselves. In other words, we must give the automated machines some intelligence to make them "auto-activated" and thus realize "men saving" rather than "manpower saving."

The oil shock which came in the fall of 1973 brought a new turn to the economy of Japan which had been growing smoothly until then. In the Toyota Motor Company where the production increase was made every year since the 1930's, we also had to reduce the production in the next year of 1974.

Throughout the industrial sector in Japan, profits plummeted because of zero growth and the shock of production cutbacks and the result was horrible. At this time, people started paying attention to the Toyota production system which suffered less effect of the shock.

With the reduction of production after the oil shock, the Toyota Motor Company also faced new problems which were hidden and not visible during the time of increasing production.

The problem had to do with the auto-activated machine to which a fixed number of oprators were assigned. A perfect auto-activated machine (a machine without an operator) is an exception. The auto-activated machine which needed two men to operate a full production was the problem. When the production was reduced by 50%, the operation could not be done by one man. The same two workers were needed, one at the inlet and one at the outlet of a large type auto-activated machine, for example.

Thus, an auto-activated machine discovers any abnormality and does the useful role of preventing the production of defective products. But, when seen from another angle, it has the shortcoming of having to be operated by a fixed number of workers.

This is a big handicap in any factory which has to respond to the change. Therefore, in the next step, the Toyota production system embarked on demolishing the system of a fixed number of workers. This was the idea of "reducing the number of workers."

This idea is applied not only to the machine but also to the production line where people are working. In a five-men line, for example, it is organized in such a way that the work can also be done by four men in case one man takes off. But the quantity of production becomes 80%. In order to do this, improvements of the layout, worker training (to make multi-skilled), and improvement of facilities must be instituted during normal times.

"Reducing the number of workers" means that a production line or a machine can be operated by one, two or any number of workers and the idea was started with the denial of the idea of fixed number of workers for a machine.

Is this not an idea which is needed by all businesses in the era of low growth rate? Raising the productivity in the era of high growth rate could be done by anyone. How many would be able to do it in the era of low growth rate? This is the deciding point for a business to win or lose.

Even during the era of high growth rate, we avoided buying the mass production machine arbitrarily in order to prevent the generation of unnecessary inventory caused by over-production. We knew how large a strain could be brought to manufacturing by the approach of big battle ships and big guns and so we solely concentrated on the advancement of the Toyota production system without being pushed into the tide of the time.

The Toyota production system first established the base of rationalization with the method of making under the Toyota system and then challenged with "Just-in-time" by adopting "Kanban" and embarked on the elimination of waste.

In anything, one needs a specific measure. If we just say that waste should be eliminated or you have too many men, people will not believe it.

But when the Toyota production system is introduced, the waste can be identified immediately. (I always say it can be done by half as many workers.)

Presently, in the Toyota Motor Company, various changes are occurring in each production area. Everyone knows the large fluctuations of various factors with different types of cars. When one type of car drops in sales, its costs rises. But you cannot ask the customers to pay more for the car.

For the type of car whose quantity decreases, we have to make it cheap somehow and sell it at the same price and still make money. Facing this reality, we have kept studying the method of raising the productivity even when the quantity decreased.

Presently, the Corona sells well. But, at an earlier time, it did not sell and we had a hard time. Each car type has its history. When it does not sell well, we must raise the efficiency even with a small quantity and achieve cost reduction. I always tell the people in manufacturing:

"There must be tens or hundreds of people around the world who can improve the productivity and efficiency by increasing the quantity. In Toyota, also, we have many such foremen. But, there are not many people in the world who can raise the productivity even when the quantity decreases. If there is even one more such person, the character of the firm will be that much stronger."

But people like to work with large quantities and they do not like to work hard and extract wisdom for small quantities.

It has been over 30 years since I embarked on the Toyota production system. During this period, I have been taught many ideas from many people and from society. All of these have been conceived and evolved in response to the needs.

I think, in a company, it is more worthwhile to work in the area where they have problems because of dwindling sales than working in an area where sales are going well for there is more urgent need for the improvement. However, the reality does not seem that way.

It is a shame that such a hardened way of thinking is ingrained in today's business and industrial society.

Work and man, machine and man, confrontation between them, . . . this sounds somewhat harsh. But these two are sharing a common fate in this world. Therefore, we should be more generous, resourceful and creative to keep improving.

In the conception and evolution of the Toyota production system, I frequently applied the reverse common sense, off common sense, or inverse conception. The managers, the intermediate supervisors and the foremen in the production field as well as every one of the workers should also use their brains more flexibly in going about their work. This is what I want to say forcefully.

o Learning From the Flexible Brains of Ancient People

Changing the topic to an unexpected direction, it is said that the "fermented soybean" and "bean curd" are reverse to each other in their original meanings.

(Translator's Note: There follows an example of the Japanese system of naming which does not translate which was intended to demonstrate the unique way of thinking of the Japanese people.)

Among the Chinese characters of Japan also, we can find this method of conception of Japanese people which is different from that of Chinese who were actually our seniors. Such method of conception is something which is born in the Japanese environment.

I want to value the native idea unique to Japan. The Toyota Motor Company has become a two trillion yen firm but even now we do not think about moving away from the main office in Mikawa. Sometimes we hear advice saying that in such a place we miss the information of the world. I do not think this is the kind of factor which would keep us in the dark from the information of the world or information of Japan.

The Toyota style information system which is organized into the Toyota production system as mentioned earlier is working very effectively in this sense.

Of course, what is important is not the system but the creativity of human beings who select and interpret the information. Fortunately, the Toyota production system is still on its way toward perfection and it is making daily advancement with the vast amount of proposals for improvements originating from all of the employees.

I myself renew my determination everyday (give the whipping of creation to my brain which tends to harden, and want to walk in the production field today again).

Appendix: Glossary for Major Terminology

As a guide in understanding and applying the Toyota production system, 24 major terms were selected and explanations are given to these terms.

Toyota Production System

If the Toyota production system is analyzed, first there is the "Toyota style method of making." This is putting a "flow" into the manufacturing. In the past, lathes were placed together in the lathe section, and milling machines were placed together in the milling machine section. Now, we place one lathe, one milling machine and one drilling machine in the sequence of the process.

In this way, instead of one worker operating one machine, we have one worker overseeing many machines or, more accurately speaking, the change is toward "one worker operating many processes." This helps improve productivity.

Next is the "Kanban" system as an operational tool for carrying out the "just-in-time" production method. In order to acquire the correct components at the time they are needed by the quantity which is needed, "Kanban" functions effectively as the "Pick up information" or "Transfer directive information" of the goods and also as the "work order information" within the production processes.

"Just-in-Time"

If it is possible to acquire the goods needed at the time they are needed by the quantity which is needed, then waste, inconsistency and strain can be eliminated and the production efficiency can be improved. The person who originally conceived this idea is Mr. Kiichiro Toyota, founder of the Toyota Motor Company. This idea was developed into a production system by his successors. The important point is that it is not only in-time but just-in-time. Together with the idea of "auto-activation" which is explained under the next heading, "Just-in-time" constitutes the two basics of the Toyota production system.

Auto-activation

In the Toyota production system, we have "auto-activation" rather than "automation". "Auto-activation" means transplanting human intelligence to a machine. The concept of "auto-activation" was originated from the auto-activated weaving machine of Sakichi Toyota who was the founder of Toyota Company. It was equipped with a device which immediately stopped the machine if the vertical thread or lateral thread broke or ran out. In other words, a device which makes the judgement of good or bad is built into the machine. At Toyota, this idea is applied not only to the machine but also it is extended to the line where the workers are. In other words, if any abnormal situation arises, the worker is required to stop the line. By "auto-activation," generation of defective products is prevented, over-production can be suppressed and also the abnormality on the production line can be checked automatically.

Management by Seeing With Eyes

"Auto-activation" means stopping the line or the machine whenever there is an abnormal situation. The basis of this idea is to make clear what is normal and what is abnormal. In terms of quality, any defective product is forced to surface; in terms of quantity, progress of the work with respect to the plan is clearly visible at all times. This idea applies not only to machines or the line but also to the method of placing things, inventory, circulation of "Kanban", method of working by the workers, etc. In the production line where the Toyota production system is used, "management by seeing with eyes" is thoroughly utilized.

"Andon"

"Andon" represents the "management by seeing with eyes." This is the "Line stop indication board" which is hung up at the production line. This trouble indicator light works as follows: During normal operation, the green light is on. When a worker wants to adjust something in the line and calls for help, he turns on a yellow lamp. If a line stop is needed to rectify a problem, the red lamp is turned on. In order to eliminate any abnormality thoroughly, no worker should be afraid of stopping the line.

"Kanban"

"Kanban" is a tool of management for realization of "Just-in-time" which is the first pillar of the Toyota production system. In most cases, we use a small piece of paper which is inserted in a rectangular vinyl envelope. On this piece of paper is written "how many of what" is to be picked up or "how to make what." In the "Just-in-time" method, a later process goes to an earlier process to pick up goods needed, at the time they are needed, by the quantity which is needed and the earlier process then makes up the portion which was picked up. In this case, when the later process goes to the earlier process to pick up, they are interconnected by the "pick up information" or "transfer directive information" and these are called "pick up Kanban" and "transfer Kanban" respectively. This is an important role of "Kanban." Another one is the "in-process Kanban" which tells the operator to make up the portion which was taken away from the earlier process. These two "Kanbans" work as one and circulate between the processes within the Toyota Motor Company as well as between the Company and the cooperating firms and also between the processes in each cooperating firm. In addition, there is the "Signal Kanban" which is used in the production of stampings, for example, where the production of a specific quantity (perhaps more than required of "just-in-time") cannot be avoided. Basically, "Kanban" is a simple and direct form of communication which is always at the point where needed.

Ask Yourself "5W1H"

In finding a problem, repeat "why" 5 times. This is the basic attitude in the Toyota's scientific approach. Thus, in the Toyota production system, 5W is 5 whys. When one repeats "why" 5 times, the essence of the problem comes to be known and how to solve it (HOW) also comes to be known. Thus "5 Whys equals 1 How" (5W1H).

"True Cause" Rather than "Cause"

On the other side of the "cause," the "true cause" is hidden. In all cases, it is necessary to dig up the true cause by asking "why", "why", "why", "why", "why" to find the true cause. Otherwise, effective actions cannot be taken.

"Manpower Saving" — "Man Saving" — "Reducing Number of Men"

If high performance, large type machines are bought, the power of men is saved. In other words, "manpower saving" is realized. However, the more important thing is to reduce the number of workers by use of this machine and reassign these workers to other departments where they are needed. If, as a result of "manpower saving", 0.9 of a man is saved, it does not mean anything. At least one person must be saved and only then does it bring a cost reduction. Therefore, "man saving" must be achieved. In the Toyota Motor Company, we set up a new goal. It is "reducing number of men." Aiming at "man saving," we have pushed "auto-activation." When the production decreased, however, we could not reduce the number of men in proportion to the decrease in production. This was because "auto-activation" was operating on a system of fixed number of workers. In the era of low growth rate, we have to demolish this system of a fixed number of workers, and we need to find new ways to set up the lines where production can be carried by any number of men in response to the required quantity of production. This is the aim of "reducing the number of men."

Make "Moving" into "Working"

Regardless of how much moving workers do, it does not mean that work was done. "Working" means that a process has progressed, that a job was done and that there was little waste and efficiency was high. The supervisor must make efforts to make his men's "moving" into "working."

Recognize Waste and Eliminate It

In order to recognize waste, one must classify the nature of the waste specifically. The waste in the production field can be divided into the following categories: (1) the waste of over-production; (2) the waste of waiting; (3) the waste of transporting; (4) the waste of too much machining; (5) the waste of inventories: (6) the waste of moving; (7) the waste of making defective parts and products. Consider the "waste of over-production," for example: it is not an exaggeration to say that such waste is a crime to society more than it is a loss to the business in an era of low growth rate. Elimination of waste is the first objective for a business.

Bakayoke

In order to make 100% good products in a production process, various innovations must be made to the tools and fixtures to install devices which will prevent the generation of defective products. This is called "bakayoke". In "bakayoke", for example, there are the following devices. (1) When there is a working mistake, the material will not fit the tool. (2) If there is irregularity in the material, the machine will not start. (3) If there is a working mistake, the machine will not start machining. (4) When there is a working mistake or action mistake, the mistakes are corrected automatically and machining is continued. (5) Irregularities in the earlier process are checked in the later process to stop the defective products. (6) When some work is forgotten, the next process will not start.

Strict Adherence to the Standard Work Procedures

In the Toyota production system, "just-in-time" production is carried out and, therefore, the standard work sheet of each process has to be prepared in a clear and concise manner. Three elements of a standard work sheet are: (1) "Cycle time," which indicates the length of time (minutes and seconds) in which one unit or one piece is to be made; (2) "Work sequence" which shows the sequence of work with the flow of time; (3) "Standard inventory" which is the minimum amount of goods in the process which is needed to keep the process going.

"Flowing Work" and "Work Pushed to Flow"

"Flowing work" means that values are added in each process by processing while the product is flowing. If a conveyor is used to carry the goods, it is not "flowing work" but is "work pushed to flow." As the basic condition of the Toyota production system, we can list "setting up flow" in manufacturing. Naturally, this means establishing "flowing work."

Multi-Process Operating

In the process of machining, for example, suppose now that 5 units each of lathe, milling machine, and drilling machine were lined up along the flow of production in vertical parallel. Here, if an operator operates 5 units of the lathe, we call this "multi-unit operating." The same is true for handling 5 units of the milling machine or 5 units of the drilling machine. Now, separately, if an operator uses one unit of the lathe, one unit of the milling machine, one unit of the drilling machine — (i.e., many processes), we call this multi-process operating. In the Toyota production system, setting up the flow of production is regarded as most important. Therefore, we try to realize the "multi-process operating" system. This ties directly with "reducing number of men." On the part of the worker in the production line this means shifting from a "single skill worker" to a "multi-skill worker."

Establish the "Baton Passing Zone"!

In the swimming relay, the faster person or slower person has to swim the same fixed distance. In the track relay, however, a faster runner can cover a slower runner in the baton passing zone. In work on a line, the method of track relay is desirable. In order to improve the efficiency of the line, it is important that the supervisor establish a "baton passing zone."

Do not make an "Isolated Small Island"

If the workers are positioned one here and one there, they can not help each other. If the combination of the work is studied and the work distribution or work positioning is done so the workers can help each other, this can be tied to "reducing the number of men." When the living flow (work flow) is properly laid out, an "isolated small island" does not form.

Averaging of Production

In the production line, if there is a fluctuation in the flow of products, waste increases. This is because the facilities, workers, inventory and other various elements required for production must be prepared for the peak production rate. If a later process picks up the parts in a fluctuating manner in terms of timing and quantity, the size of the fluctuation widens as the fluctuation goes up the processes toward the earlier processes. In order to prevent fluctuation in the production line, including those of outside cooperating firms, we have to make an effort to keep the fluctuation in the final assembly line at zero. In the final assembly line in the Toyota Motor Company, the same style of automobile is not repeated again and again. Averaged production is carried out by making first one style of car, then a different one, then still a different one.

Make the Size of a Lot Smaller and Do the Changeover Faster

For the "averaging of production," a batch is made as small as possible, whereas in "mass production" in the past, it was felt that "larger is better." This is not true at the Toyota Motor Company where we try to avoid as much as possible assembling the same type of cars. When the final assembly process produces this result, the earlier process (such as a press operation) naturally has to go along with it. Thus, the changeover has to be done often. All other processes must follow suit. The common sense rule up to now has been that, in pressing, one mold is used to punch as many as possible. In the Toyota production system, however, this common sense does not apply. Therefore, one has to make the changeover swiftly. The speed of changing over improves with training. In the 1940's it was 2 to 3 hours. In the 50's it dropped from 1 hour to 15 minutes. Presently, it has been shortened to 3 minutes.

Do Not be Afraid of "Line Stop"

A production line which does not stop is either a marvelously perfected line or a line with large problems. When many people are assigned to a line and the flow does not stop it means that the problems do not show up on the surface. This is quite a bad line. The important thing is to set up the line such that it can be stopped any time when it is necessary, to prevent the generation of defective goods, to accummulate improvements with a few people, and finally, to establish a characteristically strong line which does not need to be stopped. There is no need to be afraid of line stop.

Required Number = Quantity of Production

In the Toyota production system, the quantity of production is equal to the number needed in the market. The number needed is the number sold. Therefore, as the need of the market is directly connected to production, manufacturing cannot arbitrarily change the quantity of production. Improvement of efficiency also has to be achieved on the basis of the required number. By doing so, waste of over-production can be prevented.

Operating Rate and Operable Rate

The "operating rate" is current production relative to the full operation capacity of the machine for a fixed length of time. If sales goes down, the operating rate naturally drops. On the other hand, if orders increase, the operating rate can reach 120% or more through the overtime work or shift work. Whether this operating rate is good or bad is related to the problem of selecting the facilities relative to the number needed. The "operable rate" in the Toyota Motor Company means the state of operable condition whenever operation is desired. Ideally, 100% is good. For this, maintenance has to be up to date and also shortening of the changeover time must be achieved.

From Work Improvement to Facility Improvement

Plans for the improvement of production can be roughly divided into: (A) "work improvement" such as setting up work rules, redistributing work and clearly indicating the places where the things are to be placed and (B) "facility improvement" such as buying equipment and making machines auto-activating. The "facility improvement" takes money and it cannot be redone. In the Toyota production system, sequencing and standardization of work is done first and thoroughly. In this way, most of the problem areas can be eliminated or improved. If "facility improvement" comes first, manufacturing will not do the improvement. Therefore, first "work improvement" should be done, then the "facility improvement."

Profit-Earning IE

IE, industrial engineering, is the production management technique which came in from America. It is a business management technique. Putting aside its definition in the Toyota production system, it is regarded as the "production technology" which attempts cost reduction by harmonizing quality, quantity and timing all across the production field. It is not the IE method which is discussed in the academia. The most important characteristics of "Toyota system IE" is that it is the "profit-earning IE" which ties directly with the cost reduction.

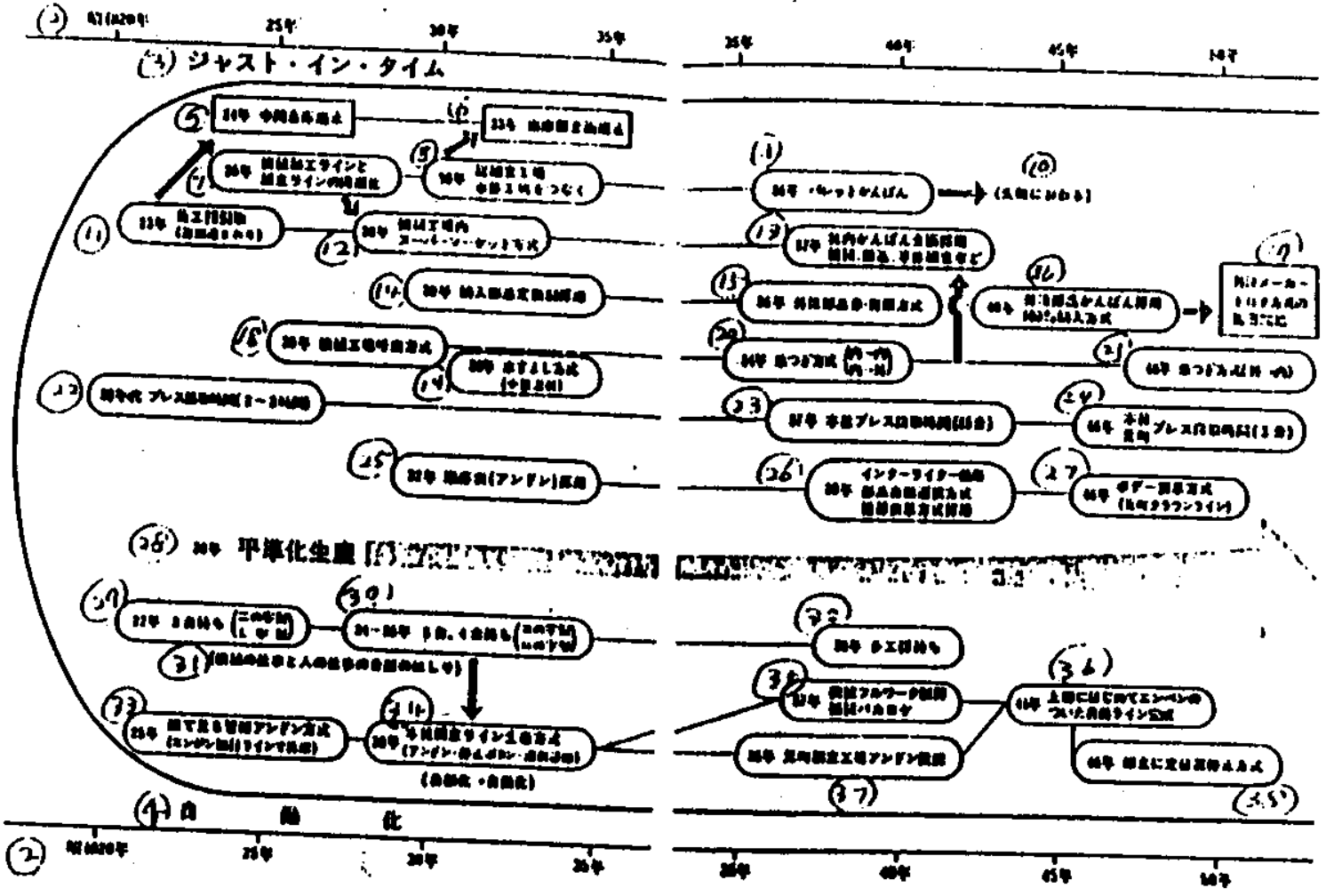
Figure on p. 228 and p. 229 of the original book

(The boxes were numbered for reference. See the original for numbers.)

1. Footsteps of Toyota production system
2. Time Frame
3. Just in Time
4. Auto-activation
5. 1949. abolition of the intermediate warehouses
6. 1958, complete abolition of the warehouse takeout tickets
7. 1950, synchronization of machining line and assembly line
8. 1955, The whole assembly plant and body plant are connected
9. 1961, pallet Kanban
10. (Ended in failure)
11. 1948, pick up by the later process (reverse rotation of transportation
12. 1953, supermarket system in the machine shop
13. 1962, company-wide adoption of Kanban in machining, forging, car body assembly, etc.
14. 1955, adoption of the fixed number system for parts supplied
15. 1961, red and blue card system for the parts ordered to outside
16. 1965, adoption of Kanban for the parts ordered to outside, 100% supply system
17. Initiation of teaching the outside makers the Toyota system
18. 1953, call system for the machine shop
19. 1955, water finishing system (a little amount was mixed)
20. 1959, ride continuation system (out to in)
22. Showa 20's, press change over time (2 to 3 hours)
23. 1962. Main plant press change over time (15 minutes)

24. 1971, Main Office, Motomachi, press change over time (3 minutes)
25. 1957, adoption of sequence sheet (andon)
26. 1963, use of inter-lighter, adoption of the system of auto-activated selection of parts: adoption of the information indication system
27. 1971, body indication system (Motomachi crown line)
28. 1953, averaged production
29. 1947, 2 units operating (in the shape of the character = and in the shape of the character L)
30. 1949 - 50, 3 units and 4 units oprating (in the shape of the character and in the shape of the character)
31. Separation of machine work and men's work
32. 1963, multi-process operating
33. 1950, management by seeing with eyes, Andon system (adopted in the engine attaching line)
34. 1955, main office assembly line production system (andon, stopping button, mixed load transportation) (automation → auto-activation)
35. 1962, machine full work control, machine bakayoke
36. 1966, the first auto-activated line completed in Uekuni
37. 1961, andon installed in Motomachi assembly plant
38. 1971, fixed position stopping system in the assembly

① トヨタ生産方式の歩み



Postscript

My wish has been to have the readers somehow understand the basic ideas of the Toyota production system. I wanted to illustrate that the Toyota production system is a way of achieving cost reduction not by the improvement of productivity through the increase of quantities but by human effort and innovations even in the era of severely low growth rate.

While I was writing the book with this in mind, I witnessed that the current Japanese economy is running into more and more serious situations surrounding the international problems of the yen. This makes me very concerned. The automobile industry has grown in the last two to three years mainly through exporting. This growth, however, seems to have reached the limit already. We must get away from a belief in mass production and quickly.

Thus, the whole industry of Japan needs a transition based on bold ideas. It would be very fortunate if the Toyota production system can serve as a material useful in generating the ideas for transition.

In finishing this book, I received a lot of help from Mr. Setsuo Mido of Keizai Journalist. Without his enthusiastic cooperation, this book would never have been born. I wish to record the fact here and express my gratitude to him.

Reading the writings and records, I have been touched freshly by the greatness of Mr. Sakichi Toyota and Mr. Kiichiro Toyota.

Finally, I wish to thank the staff members of the Publication Bureau of Diamond Company for their labor which they provided without receiving visible recognition.

Taiichi Oono