Keio Business School

Suzuka Fuji Xerox Co., Ltd. (A)

—— The Dream and the Reality of Automation ——

In the summer of 1993, Mr. Tsutsumi reflected on the first decade of the company's history. Mr. Tsutsumi was the manager of the administration department of Suzuka Fuji Xerox Co., Ltd. and served as the No. 2 production department control manager and IS (information systems) section manager. He states:

> It was an age of great turbulence. When our company was established ten years ago, everybody had a big dream—that of achieving full FA (factory automation) based on the most advanced computer technology. Being part of the IS department, I made a tremendous effort to realize our dream. Our plant today differs greatly from a true FA factory. Yet, we do not think that our dream was wrong. Manufacturing is not so simple to allow FA or CIM (Computer Integrated Manufacturing) to be applied quickly. Even capable staff can not provide an excellent system unless they know manufacturing thoroughly. The manufacturing line uses sophisticated systems and tools. Since those who use them know best, they must develop the tools and systems by themselves. "Make your own by yourself" is the key. Therefore, the people in manufacturing must constantly develop their skills. This is our new dream, quite different from our dream ten years ago.

The Birth and History of the Company at Suzuka

Suzuka Fuji Xerox was established in June 1982 as a wholly owned subsidiary of Fuji Xerox Co., Ltd. The purpose of the factory was to manufacture OA equipment parts. The company occupied about 270,000 square meters in Suzuka City, Mie Prefecture. It is located 40 minutes by car from Yokkaichi, which is a 30-minute ride by Kintetsu Express Railway from Nagoya. Hence, the plant is convenient for product transportation. It takes only 40 minutes by car from the plant to Nagoya via an expressway. A specific goal set at the establishment was to contribute to the sales of Fuji Xerox, its parent company, of one trillion-yen. The company also aimed to reduce parts cost by 30%. The company employed 200 people, including part-time workers. It aimed at achieving the sales turnover of 10 billion yen in the first year, to increase its workforce and sales turnover to 700 or 800 people including part-time workers, and 80 billion yen, respectively, by fiscal year 1986. It was established as an independent subsidiary. The company also wanted to serve the local area, establish a supply system for companies other than Fuji Xerox and to build production expertise. The plant formed two basic policies. One was to automate areas that could be automated. This could allow people to pursue more sophisticated work. Second, the company wanted to achieve stock-less and timely parts and products shipment with small lot multi-item production. With these policies, the Fuji Xerox production engineering staff and a dedicated group of a leading computer producer organized a project team. The team planned to construct what was to be the most sophisticated FA plant. It made use of an automated warehouse, automated guided vehicles, NC (numerically controlled) machine tools, and a host computer controlling the whole production system.

The main business of Suzuka Fuji Xerox was to process and assemble parts for OA equipment. These included such products as copy machines and printers. Parts can be divided into four groups: 1) mechanical parts (metal shafts for feeding paper inside copiers, rubber rollers used in copiers, plastic parts such as front covers) 2) electronic parts (printed circuit boards, switching power sources) 3) electronic devices (unit products such as image sensors for optical input and output processing of character information and thermal heads) 4) assembled finished products such as copy machines and printers. Since Fuji Xerox was stronger at manufacturing large models of its mainline copy machines versus small and medium sized models, small lot multi-item production of parts was inevitable. For instance, more than 100 types of parts required press machining. Frames and shafts were machined using presses and lathes. The plant also accompanied production of magrolls (magnetic rolls), PWBAs (printed circuit boards), metal dies and plastic moldings. Production started in three blocks in the eastern half of buildings A, B, and C, totaling 21,000 square meters of floor space. The assembly work of printers, facsimile machines, electronic devices, copier units and optical units (ROS assays) started in 1983, '84, '85, '87 and '89, respectively. The floor space was increased, adding one block each year. By 1993, the total floor space reached 68,000 meters (refer to Exhibit 1). Over the years, the firm raised its capital from an initial 300 million yen to 4 billion yen today. In addition, sales turnover was 51 billion and 300 million yen (as of 1992; 80% was occupied by sales to Fuji Xerox). The company also employed 1,250 people (as of January 1993, 700 were regular employees). Exhibit 2 is a summary of the firm's main financial data. The present organization is slim and simple with few staff sections (Exhibit 3).

Aiming for the Dream of FA
—Ideas at the Time of Establishment—

Nikkei Sangyo Shimbun of May 9, 1983, introduced the birth of Suzuka Fuji Xerox as follows:

> Rapidly rising waves of FA. The introduction of robotics and flexible production systems is becoming a supreme proposition for business managers. Suzuka Fuji Xerox has started FA and OA (office automation) simultaneously. The cost of the production facilities is 5 billion yen, 50% the total cost of the first phase of construction. Two computer systems, which will be the brains of process control and the administration, will be completed by he end of this year. The new and powerful plant will concentrate the entire expertise of Fuji Xerox. It is well worth calling this "a plant of the 21st century." The factory building is atypical, modern. It has abundant sunshine. The production and transportation facilities are colored in blue and yellow, respectively, for distinction. In the shaft machining section located in building B, nearly ten NC (numerically controlled) compound lathes stand in orderly lines, cutting and boring metal bars. Among these machines, automatic guided vehicles scurry about feeding parts and materials from the automated warehouse. Since all of the machines are very quiet, unless you strain your eyes to see them in motion, you may think that they are not in operation. Next to the shaft section, large-scale electric discharge machines are cutting metal dies quietly, based on data calculated by the system. NC machines are neatly arranged in the plant. People are few in number.

Suzuka Fuji Xerox started operation in 1983. It was the most modern FA factory of its time. It was equipped with the three sacred treasures of FA. NC machines, an automated warehouse and automatic guided vehicles (AGVs) were to be centrally controlled by a host computer. This would automate the entire spectrum of work from preparation of the work schedule to operating and controlling machines (refer to Exhibit 5). The shaft machining section was equipped with over ten NC lathes. Cutting tools were in accordance with machining operations. The cutting tool speed depended on the materials machined and the type of machining. The host computer gave instructions to operators about the timing of tool changes. It utilized information in its database on speed according to materials and machining types. Daily production plans (operation sequences) were prepared automatically by the computer. Retooling of over ten machines overlapped as little as possible. As a result, only three operations were involved in monitoring and retooling all the lathes.

Parts and products were transported entirely by automatic guided vehicles, the locations of which were controlled on-line by computer. When the machining was finished, the vehicle closest to the machine would receive machined parts. Another vehicle would arrive with another lot of materials. To optimize scheduling, complicated control logic was programmed in the host computer, controlling route selection and waiting position of AGVs.

Daily schedules (production plans) were worked out entirely by computer. Except for changing cutting tools, all the operators had to do was to press buttons to start machines. A "slipless" system, where no slips were attached to material parts, was realized. This was aided by computer instructions on what was to be machined in what quantities. When a cutting tool reached the end of its life, a lamp on the machine turned on. This let the operator know whether it needed to be replaced. In addition, complicated logic was incorporated into the computer system. Plastic parts, for example, require subtle control of molding conditions in terms of colors and temperatures. Therefore, it took time and man-hours to set up machines. In order to minimize this time, logic was programmed applying cluster analysis covering a year. Other logics for decreasing man-hours by learning and material requirement calculations corresponding to yields, were also systematized. For the development of the computer system, a total of 563 man months, dedicated people of leading computer manufacturer and 250 million-yen were invested over a year and a half. When it was established, newspapers were full of stories describing Suzuka Fuji Xerox as being the most advanced factory of its kind (see Exhibit 4). There was also an incessant group of visitors. In nine months after the start of its operation, Nikkei Shinbun selected it as one of the 100 most advanced plants in Japan. Together with major firms such as Nippon Steel, Nissan Motor, Fujitsu and Mitsubishi Electric, it was awarded the first Nikkei FA Prize. Regarding the factory concept at the time of establishment, Mr. Matsumoto, an auditor (when this case was developed), stated the following:

> The Establishment Preparation Office was composed of around twenty members, consisting mainly of engineers of research laboratories. Everyone had a big dream. Since Suzuka was not an industrial area, we knew that most of those who would become our operators lacked experience in manufacturing. The concepts of production facilities and the computer system were examined daily. We wanted to achieve a factory that would require operators to just press buttons, i.e., require no craftsman's skills. Our goal was to realize a fully automated system where a computer would centrally control machining and physical distribution. In addition, computers

would operate unmanned facilities as turret punches, perform material's handling, and minimize machine setups and transport parts and products automatically. Although FMS (Flexible Manufacturing System) was in fashion, we wanted to go a step further. We wanted a FA factory of the 21st century.

Problems Which Became Apparent
—Winter Period—

Contrary to the positive public evaluation, various problems surfaced soon after the start of the firm's operation. Mr. Kato of the Manufacturing Department stated the following:

> Excluding some management members who were dispatched form our parent company, most of the people recruited by Suzuka Fuji Xerox were residents of nearby areas. Since Suzuka was not primarily an industrial city, manufacturing was quite new to the employees. For instance, they didn't know what complex lathes or turret punch presses were. However, they heard that the computer would give all the instructions. In addition, they knew that they would be in a cheerful and quiet workplace. Consequently, everyone was enthusiastic about starting up the new factory smoothly.
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> However, when the factory started operations, problems emerged. Setting up NC lathes took several times longer than expected; it sometimes exceeded three hours per setup. During that time, other machines needed to be retooled. Lamps turning on here and there notifying us of the need for retooling made us feel as if were in a cabaret. Since there were only three operators, they had no time to rest from morning till night. Machines that were left untouched after having trouble caused frequent delivery delays. Working overtime on weekends was common. People often worked until midnight and showed up at around five in the morning the next day. One year we didn't have any summer vacation. Yet, we didn't mind this life partly because were so pressed by delivery due dates. We couldn't spare time for worrying. We were also filled with the excitement of realizing a dream factory. We were extremely encouraged by having group after group of visitors.

Similar problems emerged in other sections as well.

A life control logic was incorporated into the computer system. This calculated the life of cutting tools. However, it was often found that such tools wore more quickly than had been calculated. What resulted was that all the products machined automatically were out-of-specification. They had to be treated as defective products. Because of this, at least one out of twenty pieces had to be measured. When a defective product was turned up and placed aside, it was difficult to identify later because of the lack of slips. Everywhere in the factory, unidentifiable items were found.

Setting up machines is not as simple as one may think. Each and every machine has its peculiarities. For example, one unit tends to cut a part too deeply. Others lead to large or small variations for other operations. Like human beings, machines have personalities. Our computer system, however, deals with all the machines as if they were uniform. Even when the machines were setup, the number of pieces that were tested to check whether dimensional differences fell within specific tolerances differed from unit to unit. Extra materials were needed for cutting. They had to be replenished manually by going to the automated warehouse. Although the system contained logic for calculating the learning effect of operations, setups were unlikely to be finished within the time schedule by the computer.

Of all the troubles occurring during machining, the most difficult one was power failure. If the machine stops suddenly in the middle of cutting, all the necessary information had to be investigated and entered into the host computer for the operation to resume. Resuming operations took hours. We even stopped machines when thunder storms were coming.

We had been told that even people with no experience could operate the machines. The computer was supposed to give all the necessary instructions. However, we had to do many things, sometimes very difficult ones. Machining required precision of micron order. Adjusting machining conditions and taking into account individual peculiarities of machines was not work for laymen. Training was always one step behind. To make things worse, there was no air conditioning system because the plant was an unmanned operation. A cooling system was soon introduced to prevent the machines from malfunction due to temperature variations. The air was directed toward the machines instead of people, however.

What proved to be useful about the computer system was the manual operation mode for debugging. Using the mode enabled the use of machines independent from the host computer. I was serving as a subsection chief of the press section. After several months, I became familiar with the operation. Hence, we started operating press machines in a manual mode every day. Being disconnected form the host computer, though, meant that actual output and machine utilization ratios were different from those calculated by the host computer.

The computer prepared schedules every day. However, since it had been designed for small-lot multi-item operations, the program did not include the logic for predicting one product for continuous days. In practice, however, when the operation had to stop, such information had to be entered into the host computer from the terminal beside the NC lathe. Similar data entry was necessary when a work piece required reworking. IT was a tiresome job for those who had never touched the computer before. Worrying about making a mistake in data entry naturally made workers' fingers tremble.

Automatic guided vehicles were products of new technology at the time. The system we adopted allowed routes of vehicles to change freely by arranging electric signals emitted from the floor. A little oil on the floor, however, would block the signals, causing vehicles to run out of control. In such instances, someone had to rush to stop the vehicles. Once a vehicle collided against a valuable lathe. Because the vehicles continued to be unreliable, the sections gave up using them. Materials for shafts were steel bars, four meters long. They were too heavy for people to carry. Consequently, the vehicles were used as "manned vehicles," which were driven by operators to guide them in the right direction. This was extremely inefficient because the vehicles moved at a speed less than half of that of a walking man.

Because the concept of the Suzuka plant was automatic production of multi-item products in small lots, most of the installed equipments were quite heavy. For example, general-purpose machines such as turret punches and compound lathes were adopted for press and shaft machining operations. When we visited a small-scale manufacturer, we found small machines aligned according to operations. For example, there was a D cutting and milling, whose speed was very high. Another problem dealt with space. A large area had been secured for the passage of automatic guided vehicles, allowing for only 13 lathes to be placed where otherwise 100 of such machines could have been installed (see Exhibit 5(3) and (4)).

There was something strange about cost management. Because the idea of the plant was automatically turning materials into finished products, an item for work-in-process did not exist in the computer program for cost accounting. In fact, work-in-process inventories were created when machines stopped. Hence, the machine utilization ratio calculated did not reflect reality.

The electronic parts warehouse was a rotary rack of 320 square meters. An investigation made in 1985 revealed that such parts covered 900 square meters of the facfory floor. It was then natural that computer instructions on parts discharge would never discharge parts from the rotary rack. Searching for parts took time every day. Identical parts were found to have different parts numbers. We found that preparation for the computer system design on parts code and parts structure checking was inadequate.

Some fluctuation was assumed for designing complicated logic. This was for such functions as learning curves, material yield calculations, and set up time minimization. However, changes in production volume, design and equipment required logic adjustment. The IS department was constantly under pressure to make these adjustments. Often, they could not adjust the system in time for production.

Manufacturing sections informed the IS department of problems, including those on the use of the computer system. The IS department was very busy troubleshooting upon the start of the company. Moreover, since the host computer controlled the whole system, even a minor change in one part had to be checked to ensure that other parts were not affected. Sometimes manufacturing sections waited three months for replies to their requests.

Mr. Matsumoto, the auditor who was involved with the project before the establishment of Suzuka Fuji Xerox explained the situation:

> It was our first experience of producing parts in those days. Fuji Xerox used to procure all its parts from the outside. Trying to produce parts in an almost unmanned operation was too big a step for a first manufacturing experience. There were also unexpected changes in the environment. Parts suppliers began to reduce their costs. Competition also became increasingly severe. Manufacturers promoted replacing conventional parts with electronic units and parts of lower cost. They also used plastic materials and simpler shaped shafts, which lead to decreased orders for products requiring lathe operations. We experienced what it was like to have our parts subject to the harsh conditions of the environment.

Reflecting the situation in those days, Mr. Kobayashi, the president of Suzuka Fuji Xerox commented:

> I was the manager of the Design Department of Fuji Xerox when I was invited to the foundation ceremony of Suzuka Fuji Xerox. As I observed the plant at the time, I wondered if there would be enough production volume to justify the huge amount of investment. I also worried whether so many parts could be produced efficiently. I remember being impressed by the beautiful show room like office. After the operation started, cost and quality issues surfaced. I wondered why Suzuka sales people did not visit their parent company so frequently.

Mr. Tsuyuki, a managing director of the company stateed:

> I came to Suzuka in 1989. I was still in the parent company when Suzuka was established. I was in the purchasing department in charge of issuing orders to Suzuka. I had a hard time because of their failure in satisfying delivery requirements. When I met people at Suzuka, however, they complained about the meager profit of their business. They attributed it to a low facility utilization rate. They said that their profit would rise if we gave them more orders. However, they were often late with their deliveries. I felt their complaint was not appropriate.

Relationships between the line and staff became more strained. The following are representative comments from the two parties.

Comments from the line workers:

- Since it was FA I thought that the computer would do everything. However, there are so many things that people have to do.
- The computer keeps producing defects. It does not know anything about the habits of machines or tolerance.
- We are told to do this and that even though we are not used to computers. We are at a complete loss.
- We can produce manually without a computer. Why do we even have to use a computer? Isn't there an easier way?

Comments from the staff people:

- After we have taken care of troubles to modify the system, they ask us to change it again the following day. We don't even know what we are doing.
- If we are asked to make improvements immediately, we have to make sure that it does not affect other parts of FA. This is impossible to accomplish now! I'll fix it when I have time.
- Being pressed by changes in the system, we can't do anything new. The line people should do something for themselves!
- However hard we may teach the line, they don't do as they are told. It would be fine if they only did as they were told!

Naturally, quality problems and delivery delays were frequent. Business performance was poor and ordinary profit showed a deficit every year (see Exhibit 2).

Turning Point

In December 1986, there was a turning point—a change of the president. Mr. Kurihara, the first president, was a friendly and reliable person. The employees called him, "Old Man." He respected consensus and harmony. With his experience in the parent company, he deployed a company-wide movement. He put up slogans when Suzuka Fuji Xerox was established, trying to encourage his new employees. He did not, however, support manufacturing in workshops. By contrast, Mr. Tsuchiya, the new president, served long as the manager of the Ebina Plant (one of Fuji Xerox's three plants in Japan). Mr. Tsuchiya took the lead in improving plant operations. He believed in strengthening the line through continuous improvement activities.

In January 1987, President Tsuchiya gathered 16 department management members for a two-day, one-night camp to discuss business operations. The President proposed the plan, "doubling sales and halving costs." He requested a listing of problems in individual sections as well as issues to be challenged. On the basis of the list, he started project activities. For example, he organized a sales target study team, a production efficiency study team, and a technical trend analysis team. He also enthusiastically met with individual department and section managers. Mr. Tsuchiya recollected on those days soon after he took the new responsibility:

> I believe that the basis of managing a manufacturing company is developing superior engineers and making their expertise a competitive edge. I had a notion about the Suzuka concept at the establishment. It chose the easy way of depending on the outside for the basic production technology. Coming to Suzuka, I found that the deficit situation was a result of structural problems. Some products showed a production cost exceeding their selling prices. Despite the situation, every campaign that was staged focused on the mental framework and a revolution of thinking. These left the root cause of the problem almost untouched. There was also a dependence on the parent company, and the expectation that orders would be given automatically. The manufacturing people did not have the basic technique. They were unable to utilize fully advanced automated machines. These problems were grasped during the camp. In order to change the situation, it was important for the employees to share my awareness of the problems and share my values. Also, they had to have the will to change the organization. Discussing counter measures alone was not useful. Investigating thoroughly the problems and their causes was necessary. This was to that the problems could be presented in a simple, understandable manner. I used the expression "underlying cause" repeatedly. I began activities to analyze and investigate the sales and cost problems of each product group to identify the real causes.

As part of this activity, Mr. Tsuchiya visited every workshop himself to guide the improvement. A "QC class" was the name given to such a study meeting. It consisted of thorough observation of the production line, followed by an analysis of the problems with the operators. Mr. Tsuchiya fervently preached improvement activities and their importance. He explained the concept and technigues of quality control. He also pinpointed the areas for improvement on the line. This included setup time reduction, improving the utilization ratio of equipment, and reviewing the equipment maintenance system. Similar review meetings were also held for the staff sections as well. The meetings were for identifying problems clearly. As a result, the people in production came to understand many of their problems, being awakened from the dream of a "FA plant."

One problem was the under use of developed software programs. Of the total

1,100 programs developed by Suzuka, as many as one-third were unused. About 150 million yen was spent on developing these programs and another several million yen was spent every year for maintaining them. Another problem was changes in part names or numbers. When design changes were made, information had to be entered into the computer system. Pressing the return key effected such changes, erasing all the previous information. Therefore, the system put a strain on computer operators. Moreover, departments that were in charge of controlling information varied depending on the type of information. The Materials Department was responsible for suppliers and unit prices of purchased materials. The Accounting Department was in charge of cost information. The Production Department focused on processing time. The Production Control Department governed selling prices and customers. Because of the varied responsibility, no one was able to grasp the entire view of the system. Furthermore, no one knew to what extent the existing database was correct at a time.

On June 1987, the fifth anniversary of the firm's foundation, Mr. Tsuchiya announced "SFX Business Vision." This document made clear sluggish growth in sales and growing debt. It also gave accounts of production, sales and technical challenges. Further, it provided counter measures for each product category based on predictions of market trends. For example, Suzuka's entire business was divided into four major categories based on sales turnover and gross profit. It gave importance to high sales, high profit products such as plastic parts and PWBA. On the other hand, sucn parts as shafts, metal dies, and power sources, which were in the red and lacked technical originality were subject to major restructuring, including subletting. He also proposed a "selective order receipt system." Products would be divided into four groups ranked according to their importance. Type I products were high value added products that helped the firm develop its technical capability. Type II products were those that had good profitability. Type III products were to be accepted only when there were surplus capacity. Type IV products were those that should not be produced in-house. Mr. Tsuchiya also presented a product cost analysis and plans to reduce materials and processing costs. In addition, he proposed rationalization targets for indirect sections as well as targets for skill in business areas. He created a policy that stressed corporate growth through increased sales, while he also wanted to control the increase in the number of employees in indirect sections. He wanted to see increased efficiency of clerical work by using personal computers. Mr. Tsuchiya commented his business vision:

> Suzuka Fuji Xerox was managed with a "waiting posture." It received orders as they came on a first-come first-served basis. Consequently, profitability was not a focus. Sales and machine utilization ratios were emphasized, but cost reduction activity was slow. This is why I proposed the

selective order receipt system. Business conditions at the time were not favorable. It was right before the economic bubble burst. The yen continued to appreciate. The exchange rate against the dollar broke the 160-yen mark for the first time in history. Some people objected about the selective order plan. Our sales kept dropping for some time. Yet, few orders and less work created time for people to think about Suzuka's problems and develop cost consciousness, which was generally lacking.

Mr. Tsuchiya went out and met customers himself to encourage sales. In late 1987, 1-megabyte DRAMs were in shortage around the world. Mr. Tsuchiya purchased their elements in large quantities and eventually succeeded in acquiring orders for PWBA for leading computer manufacturers. Such sales activities by the top management, along with the economic recovery in 1987, led to increase order receipts. Profits increased. In addition, the production department had plenty of work. Each manufacturing section became aware of the necessity to enhance productivity through improvement activities. President Tsuchiya discarded under utilized machines to reduce the burden of depreciation (see Exhibit 2). The automated warehouse was gradually dismantled and reduced. It was transformed into a storage area that required manual work (see Exhibit 5(7) and (8)). Business performance figures were presented to employees, urging everyone to be more conscious of cost. There was a new atmosphere in the company. It was an atmosphere for steady product manufacturing, completely different from the dream like FA plant. Empowering the manufacturing department further was essential for accelerating the improvement activity. Mr. Tsuchiya turned to Professor Takeshi Kawase of Keio University, with whom he was acqainted from his days as the plant manager of Ebina Plant, for consulting services at Suzuka.

A Shift in Emphasis to Improvement
—Line Centered System—

Professor Kawase visited Suzuka Fuji Xerox for the first time in autumn, 1987, about a year after Mr. Tsuchiya became president. It was the first time Suzuka sought consultation from the outside. After observing the plant and listening to explanations by Mr. Tsuchiya, Professor Kawase found that Suzuka's problems were mainly attributed to two points. The first was that the development of the FA system had been the staff department's initiatives. The staff was responsible for the creation and development of the system. For example, the engineering staff had been assigned to design the production lines. In addition, the IS department was to create the computerized production control system. Hence, any changes could not be made without consulting the staff. The second cause was that the production system was built centering around the huge host computer. Since a single host computer governed the control of production facilities and planning, changes took time and caused trouble. This limited production capabilities. Professor Kawase suggested two policies: 1) to shift from the staff-centered FA system to a line-centered improvement activities, and 2) to replace the centralized production control system with a distributed system. The centralized production system depended too much on the host computer. With a distributed system, personal computers would be fully utilized. He named these two policies "the line-centered system." He believed that the manufacturing workshop (the line) created added value in the production process. Therefore, the line should solve workshop problems by itself. The staff's role should support the line in such efforts. What Professor Kawase related in his first visits to Suzuka has been maintained over the years in the organization.

*Don't try to put every piece of data into the database. Don't expect to do everything using the host computer. Enter only key data into the database!

*The IS department should not produce programs. It should keep its work to a minimum!

*Production control should be done by those affected by parts' shortage. The production control department should not handle the problem just because they are staff.

*Human labor is costly. PCs are cheap. PCs should be used by those who want them. They can be kept turned on at all times.

*If something is not identifiable, do not try to "computerize," it. Computers can't do what human beings cannot.

Mr. Tsutsumi, the IS department manager reflects:

> Frankly, I felt that Professor Kawase was a strange person. He told my department not to work hard. He said this when we worked many hours and overtime trying to finish the work. We were skeptical and perplexed by Professor Kawase's suggestions. After his consultation meeting dinner, he said that the staff are "geisha" and the line people are their customers. Therefore, the geisha shouldn't meddle in the line's affairs. I doubted if he was truly a university professor.
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> A little later, he told us that he would change the system so that the production control related work would be done in the workshops. He instructed us to hold a PC class. It was as if the staff of the most sophisticated plant was becoming teachers of a "culture" school! Frankly, we felt we were being degraded.

> The PC class was not popular in the beginning. Yet, a year or so later, enrollment suddenly increased. Small PC systems for parts ordering and expediting control became operational. This excited the line people. Although we helped them with developing software, the line people created the basic systems flow. We felt their enthusiasm. We also saw chronic problems of delivery delays and quality defects decreasing. Materials started flowing smoothly along the line, reducing in-process inventory. We came to understand then, what Professor Kawase meant by the line-centered system.

Exhibit 6 shows the transition of PC installations and the number of people attending PC classes since 1987. Most of the employees took the class; the total number being a little over 1,000. The host computer was used for applications, including technical information control. However, the number of development programs decreased sharply after 1987. This is shown in Exhibit 7. In addition, the number of programs developed by the IS department also decreased. In 1987, there were 100,000 program steps. This dropped to a quarter of that in 1992. Mr. Ochiai, a sub-section chief of the IS Section commented:

> When we first heard about using PCs, we doubted what we could achieve. We knew that using the host computer was not effective. Further, the end of lease contract on the host computer was approaching. We wondered if we would be able to pay the high lease rate under our severe financial conditions. The line people's enthusiasm was reassuring.

Along with the increase in the number of PCs, improvement activities in workshops progressed, bringing a major transformation to the line. In the press section, for example, the area was laid out according to independent operations. Carts handled materials because the pitch times of the operations depended on the products. The layout was rearranged into a line formation. Products were passed one piece at a time, one step to the next by a conveyor belt. The amount of investment was minimal. The cost was only for relocating the equipment, amounting to less than one million yen. The "one piece flow" has been applied to about half the products now, reducing the once large in process inventory to almost zero. In addition, two of the four NC bending robots were removed. Manual work was quicker and more flexible in small-lot productions (see Exhibit 5(6)). All the loading robots that were allocated to magroll process were also eliminated. In the printed circuit board section, there were models produced daily in large volumes and models produced weekly in limited volumes. Both models used to be produced in the same line. This was changed so that small-volume boards were produced along manual assembly lines and large-volume boards along automated lines. All of the large AGVs were removed, and wide passages allotted for AGVs were narrowed. This enabled the machines to be closer to each other. Consequently, an operator in a workshop could be in charge of several machines at a time. This was impossible with the former layout. Other improvements followed such as improvements in the assembly shop layout, and reducing space requirements. The 5S in production workshops and the "Polish Your Machine" campaign were also implemented. Parts order issuance and production planning were also delegated to the line. No longer did people have to work late at night or on weekends and holidays. Delivery delays and quality troubles decreased significantly. As improvement progressed, sales turnover and profit figures increased (see Exhibit 2). The increase in the number of staff people was also controlled (see Exhibit 8). Improvement suggestions increased as well (See Exhibit 9). The production department head explained:

> The use of PCs in the production workshops was significant. The operators could decide on parts ordering and production planning, and monitor their status at anytime on the screen. The values they entered were used as official order forms and based on which the payments were to be made. Therefore, everyone decided these values seriously. Changes in details and improvements were also easier. Coordination with the IS department became much smoother.
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> When we aimed for FA, we tried to improve the entire system all at once. Because we could not tell what the real causes of the problems were, we could not make meaningful suggestions. Professor Kawase put things in perspective. With his assistance, improvement requirements became clear. We implemented the improvement activities, and they worked.
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> Nobody gives us solutions when we work on improvements. We are only given some tips. Unless we understand the problems, these tips won't help us achieve anything. We try to develop our own skills while carrying out improvement activities. Although it is hard, it is worthwhile doing so.

Mr. Sawaki of No. 5 Production Department stated:

> Given the "line-centered system," duties and responsibilities of individual sections became clear. Previously, we used to call the Engineering Department staff when we had problems in setup operation. For computer related problems, we depended entirely on the IS section. Once the system was changed to what we call line-centered improvement, all the problems of the line must be solved by the line itself. Power and responsibility were given to the line. The Production Control Department could no longer

> make changes without the line's consideration. Under this situation, everybody started taking care of his or her work seriously. The meaning of "automation" changed. Automation could be achieved without a large investment and using people's judgment. The workshops also had to develop their own skills for executing their duties. They could not make excuses or blame things on the staff. I think building the line's capabilities and enriching the support system are keys to a successful line-centered system.

Future Dreams and Challenges

Suzuka Fuji Xerox had the initial dream of becoming the most up-to-date, unmanned FA plant. In the past ten years, it has gone through three stages. The first stage was the effort to try to realize the dream. The second stage saw the changes following the change in president. The third stage was the transition moving to the line-centered system. Mr. Tsuyuki, a managing director remembers the business policy of those days.

> Looking at the performance of those ten years, the latter five years shows a significant improvement over the first five years. In fact, from 1988, figures went into the black. Furthermore, accumulated loss was eliminated in 1991. Quality and delivery showed improvement in the latter five years and working overtime and on weekends lessened. Our situation has attracted the attention of many people. Recently, we have been receiving visits from other companies as well as journalists and even reporters from CNN. Some doubted if it was right to dream about FA at the outset. It is true that profit was not generated at the beginning. However, it is not right to jump to come to the simplistic conclusion that dreaming of FA was a mistake.

He continued, referring to a recent newspaper article (See Exhibit 10):

> There were two possible directions Suzuka could have followed at the time of establishment. One was to realize the dream of a state of the art FA factory by focusing all an entirely new technological capabilities. The other was to automate steadily, taking a step by step approach to improvements. Perhaps the latter was adopted for the second five years. I am not sure if the second approach would have developed a sufficient sense of unity and orientation when an entirely new plant was set up. In particular, almost

everyone had little experience in manufacturing. Ambition as the dream may have been, it was because of this dream that people were enthusiastic. They were able to accept willingly working overtime hours. At the same time, people realized the difficulty and problems of attaining that particular goal. The experience of the first five years helped to achieve improvements in the following years. Unless the vision was set at the beginning, improvements for as long as ten years might not have led people to build the "ideal plant," or realize the "dream." To convert an existing plant to a highly automated one would be extremely difficult, since production has to go on every day.

Another important point about establishing a new factory is that we should determine what is to be produced at what cost. Although we had press machines and lathes, we had no pointing facility. Therefore, we subcontracted paintwork of semi-finished parts after cutting. This meant that the profit margin of the painting subcontractor was an additional cost for us. Moreover, covers and frames, which Suzuka had produced initially, had multiple varieties and limited value added. Establishing a new factory requires serious consideration and planning. One needs to take into account such factors as production volume, unit price, cost and technological trends.

Mr. Tsusumi, a department manager also responded:

I worked as a staff member at the IS Department from the start of Suzuka. Pressed with request for changes and modifications of the systems, we worked hard during the first few years. The IS department felt that the staff should be responsible to design and realize the FA plant. The line people should just work according to our instructions. When the improvement period came, this policy was changed. Now the line was to be involved in the systems design. In addition, the staff was expected to concentrate on educating and supporting functions. Some staff resisted this idea thinking their role had been diminished. However, the transition was rather smooth. Perhaps it was because our company was young. Furthermore, turning point was after five years since establishment, when many people were involved into operational problems. If it were earlier, the parent company might have been reluctunt against the change. There was also strong leadership from Professor Kawase and top management. Sometimes workshop area is called end users. However, since it were mostly the people at the workshops that created value, I think they should be called first users.

FA itself does not produce quality. It is the people who produce products. Examining the conditions of tools and making minor adjustments to machines is necessary. Moreover, being able to sense trouble of a machine just by listening to its sound—this kind of craftsmanship is vital in manufacturing. Investment in people, therefore, should never be spared.

The past ten years was a period of learning for us. We do not think it was too long. Manufacturing cannot be done readily by people without the knowledge of equipment or systems.

Mr. Sugino, a member of the No. 2 Sales Department added:

I worked in a shaft production shop for the first seven years. I then moved to the Sales Department in charge of sales outside the Xerox group. I am doubtful about a CIM concept. A CIM factory is where market information automatically controls computer-operated manufacturing. Stable volume production may be left to a computer. However, our company needs to manufacture multiple varieties of products and has to address frequent rush orders and design changes. People can better cope with the situation. The initial plan was not suitable for small lot multi-item production.

Mr. Kato of the No. 3 Production Department agreed:

There is a notion that precision machining on the micron order should be left to automatic machines. Is this really the case? Let's say that a cutting tool is changed to cut twenty workpieces, when the workpiece is found to be two microns larger in diameter due to the wear of the tool. We are not sure that after cutting another twenty, the diameter will become larger by two microns again. Is it adequate to leave the subtle adjustment to a computer?

Mr. Tsutsumi responded:

Now I know now how difficult it is to manufacture products. Good manufacturing does not come just by thinking. A staff group working in the office all the time cannot achieve it. I think a desirable relationship between the staff and line is important. It should not be a division of roles. Rather, it should be one where the line produces what the staff wants and staff help build skills for that purpose. This idea is taking root in Suzuka now. Leaving technical problems to the Production Engineering Section

> and computer matters to the IS Section does not work. I feel that more power should be delegated to the workshops in the futures. For instance, if the manufacturing section has a design function, they would be able to design production based on the specs to facilitate manufacturing.

Regarding the shift from the dream-like FA plant to improvement orientation, Mr. Tsuyuki continued:

> Although we changed our direction after five years of operation, the company did not become overwhelmingly frustrated nor did many people leave. Of the 700 current employees, 400 still work at Suzuka. I think the shift went relatively smoothly. However, we should remember the factors that facilitated the process. First, most of the employees had no experience in manufacturing. Nevertheless, they were very open minded. If we had employed people with a lot of manufacturing experience, they might have given up more easily. Strong leadership from top management was another important factor. They had confidence and sound reasoning behind the shift. In addition, they had a positive attitude, visiting sections to listen to those at the workshops. Good timing was also important. A state of the art FA factory was the dream of the parent company. At the outset, we received positive press and received the FA prize of the Nikkei Shimbun. If we had started slowly and then tried to force the shift from FA after a year or two, we might have met strong resistance. The policy shift occurred after people started to feel doubtful about the direction. This was the case when the company failed to show an upward financial trend after five years.

Mr. Kobayashi, the president, presented his view about when he took office:

> I received the baton from Mr. Tsuchiya, my predecessor, in April. 1990. The first impression I had about the company was that everybody was quiet. Although that made the shift from FA easier, I was not sure if this was conducive to taking new steps for growth. To boost morale, I encouraged employees to become "passionate." I raised the moral with "management with a focus on people and workshops." In my greeting when I assumed my position, I asked people to talk to me without reserve. I told them I was eager to learn all the names and faces of the employees. I then announced the programs to be implemented. This included a quality improvement program complying with the BSI quality standard. Also, I proposed the

> "My Challenge" program, in which everyone was to obtain one or more qualifications or skills every year. Third, I introduced work improvement programs, where section and sub-section mangers were to submit reports on work improvement every term. The company is determined by its people. The fact that one can enjoy work and feel that it is worthwhile draws out latent abilities in individuals. It generates energy for improvement. I am convinced that the most important mission of for management promoting the line-centered system is to develop problem finding and solving skills. If people can identify problems without delay, they can quickly take appropriate preventative measures. Skill development in workshops through steady effort underlies the past several years of business upturn.

Mr. Kobayashi talked about the future of Suzuka Fuji Xerox:

> After ten years, we are ready to sketch a vision for the future. "Vision 2000," our plan to become a world class general manufacturer, is our objective for the year 2000. This plan consists of three key concepts. One is "a resilient company," that keeps growing with stable sales and profit. The second is to be a "friendly company," that contributes to the wellbeing and assumes responsibility for society. The third is to be an "interesting company," where people can enjoy working and feel that it is worthwhile. To achieve these goals, it is vital for the company to maintain independence. For this purpose, we strongly want to develop our own products with our own technology. Last year, a product-engineering department was established as a technological development center. It targets several years ahead. Although the R&D Department needs further growth, there is a dilemma because of rising indirect costs. In our business plan, we will need to address issues such as the yen's appreciation (100 yen to the dollar) and making division and plants independent.

Mr. Tsuyuki added:

> Since Mr. Tsuchiya, the former president, initiated the shift in policy, the role of top management changed. Strong leadership for turning red figures to black ones and leadership for increasing profit should differ in content. Currently, the management of Suzuka is made up of those who previously worked at Fuji Xerox. Those recruited locally occupy department management and lower ranks. The top management is required to address mounting challenges in the future. It will have to increase the scale of the

company under severe conditions. In addition, they must help employees develop skills, and improve workshops. It must also review the relationship with the parent company, subsidiaries and suppliers. Management must also develop new technology and products.

Automation is actively promoted as the trend of the times. It has become a habit to follow steps of improvement before automation. The other day, unmanned operation of turret punch presses during night house was started after there was improvement in the setup and maintenance operations. In the plant's eleventh year of operation, some machines have become obsolete. In addition, because of rising labor cost, further rationalization is needed. The IS Section still implements personal computer training. It has reached a certain stage in terms of the number of people who have participated in the program. To increase efficiency, I think we need to devise a way to link networking and managing databases. Staff assistance might be necessary in these areas. One challenge we face is to create a new relationship between the line and the staff. We need to bring out the capabilities with the staff without affecting the line-centered system which is the base of accelerating improvement activities.

Mr. Suzuki, the chief in charge of Production Engineering expressed his opinion:

If I am told to describe my own dream about the future of Suzuka, my answer would be to tackle the dream of an FA plant again. I see a totally automated plant. Production planning, parts ordering, production and shipment should be controlled by pressing a button. I have a better understanding about manufacturing know-how and information systems now than we did ten years about. This would mean another major shift from the line-centered system and improvement approaches. Yet, I still want to pursue such a dream. I think it may be the fate of engineers.

Exhibit 1 Plant Layout

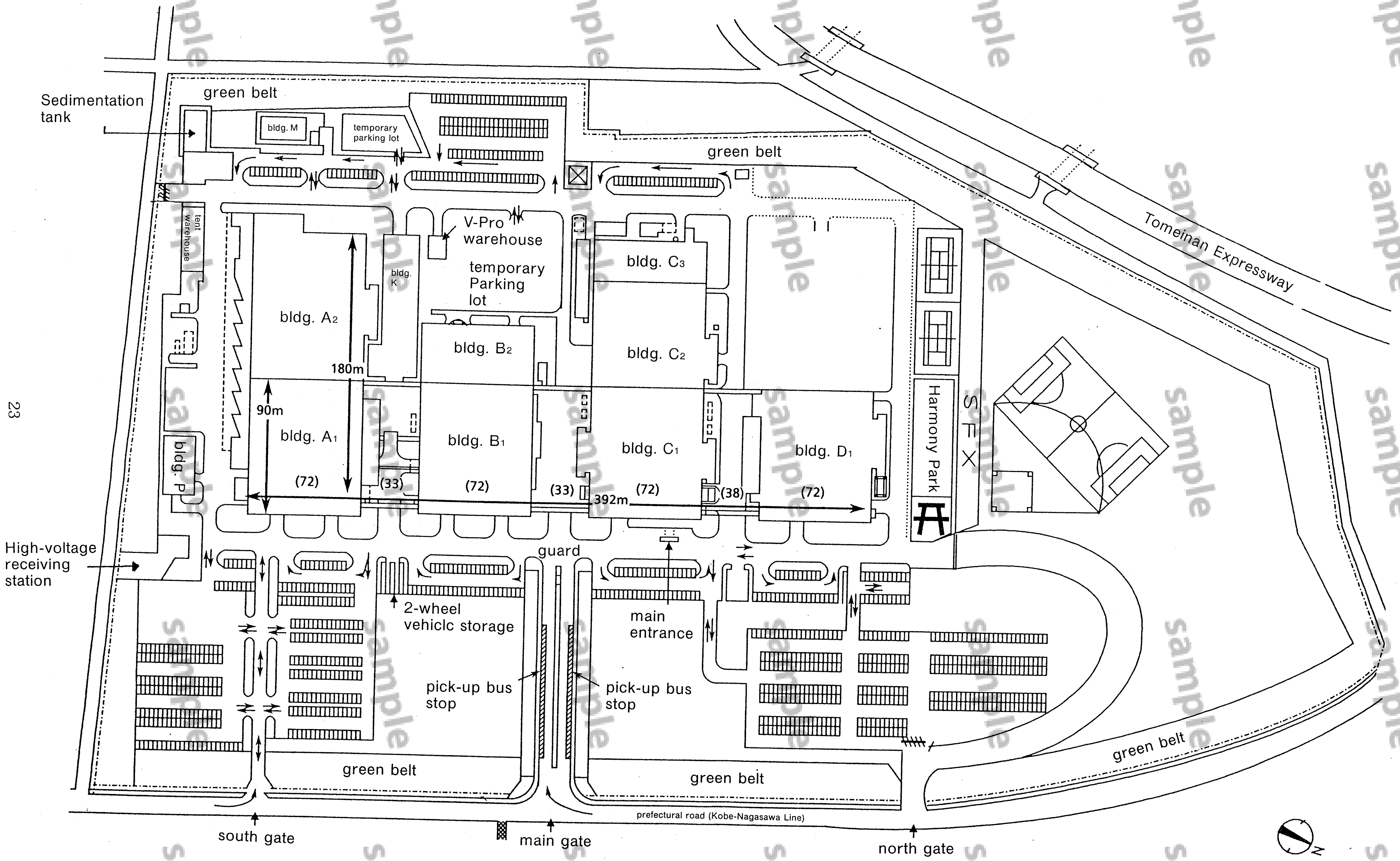
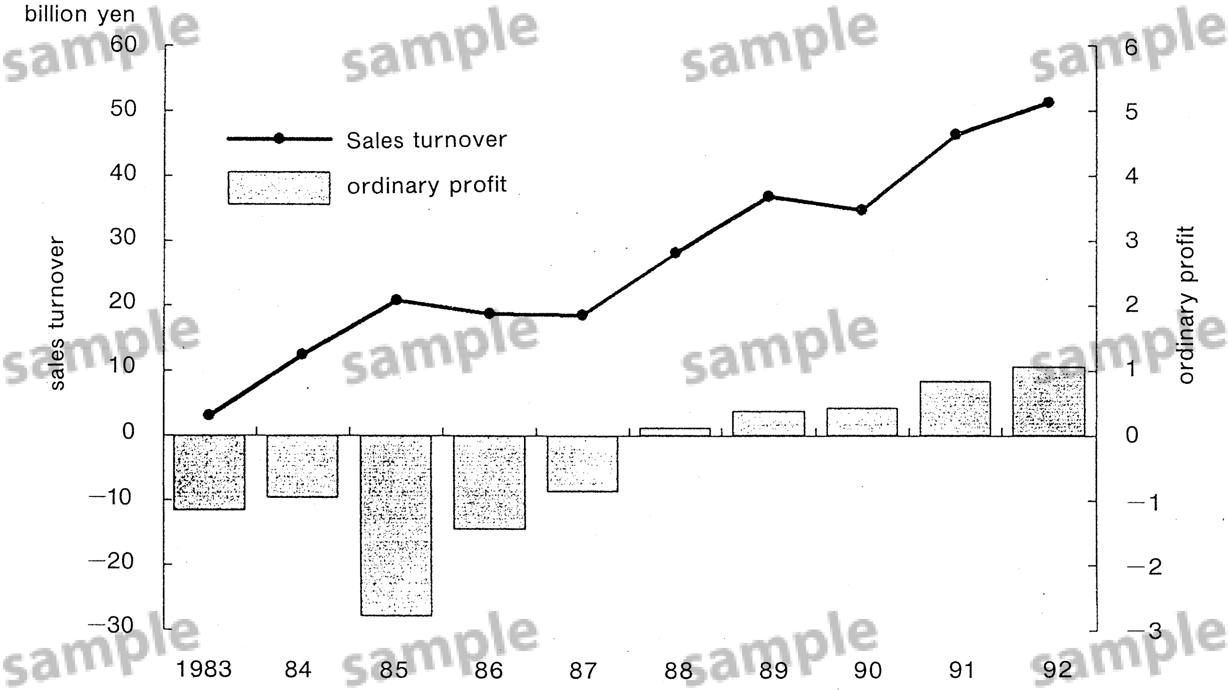
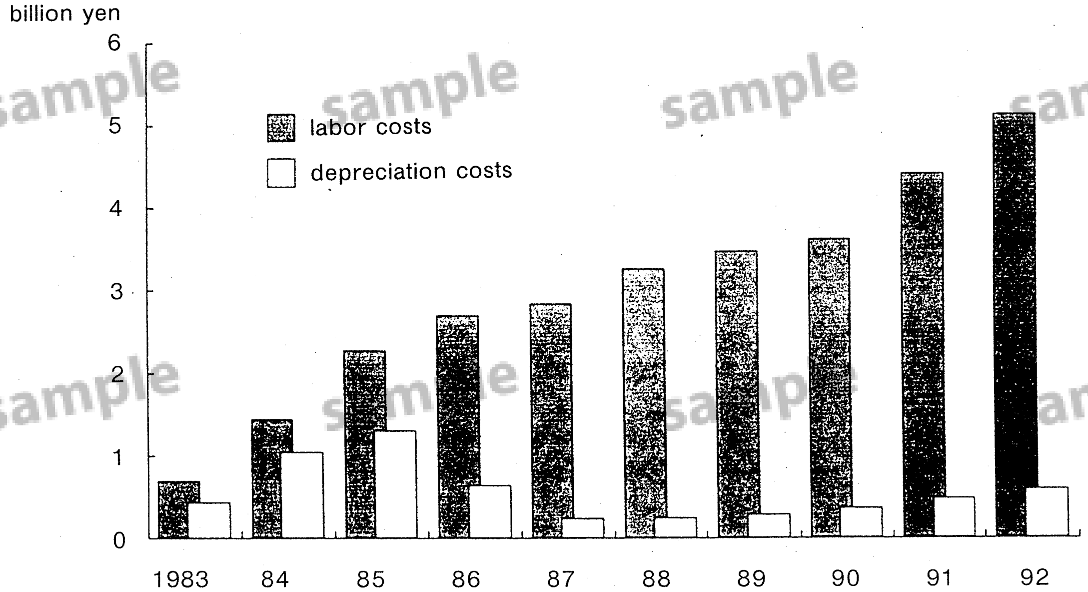


Exhibit 2 Main Financial Data

(1) Transition of Sales Turnover and Profit

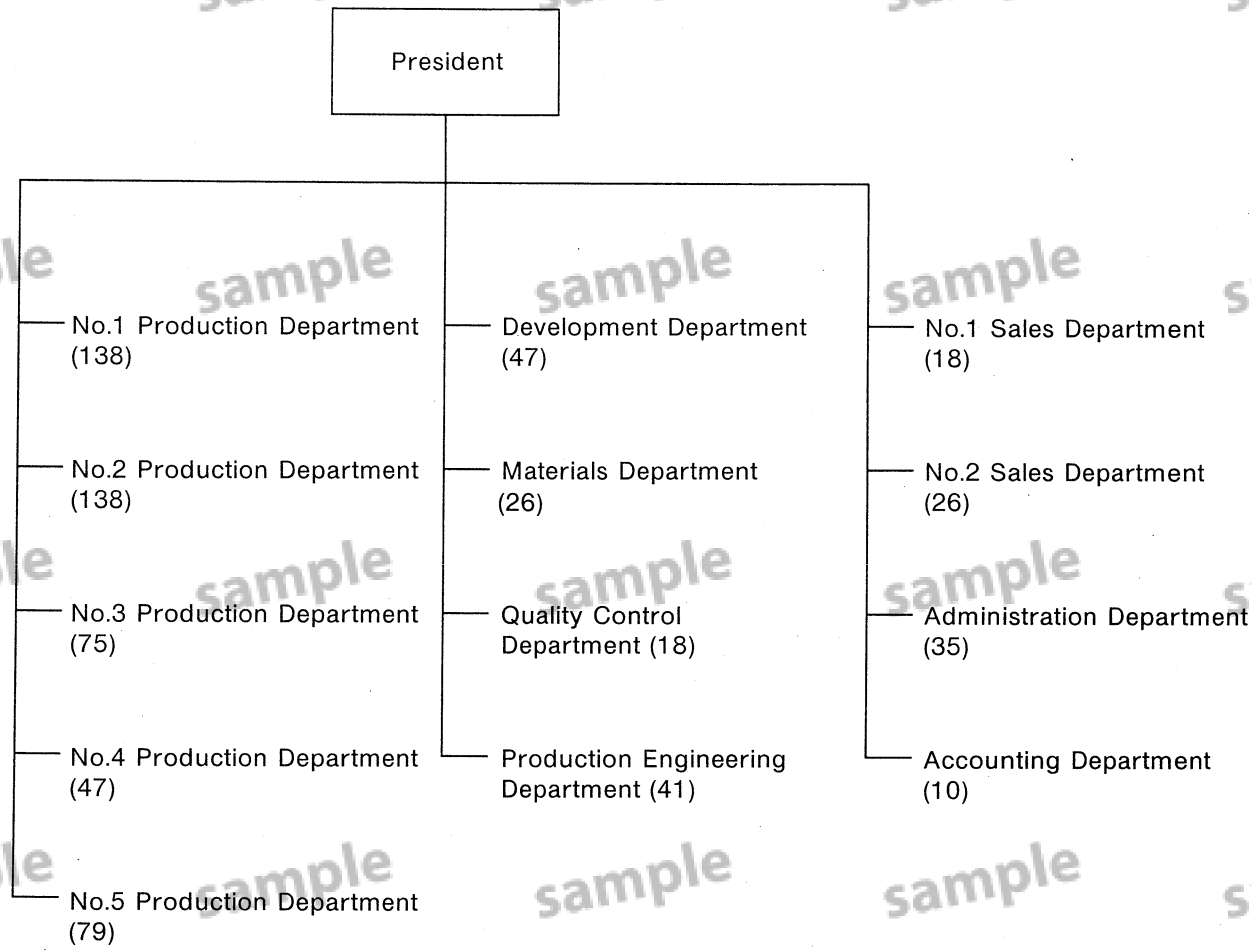


(2) Transition of Labor



(The day of financial settlement is Sep. 20, and so a fiscal year covers from Sep. 21 of the previous year to Sep. 20 of the next year.)

Exhibit 3 Organization Chart

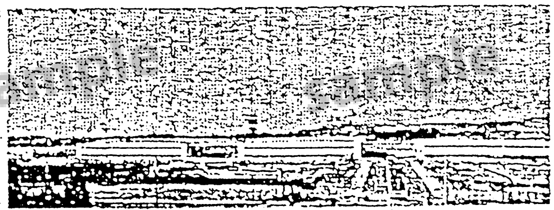


(Numbers in parentheses indicate the number of employees as of the end of 1993 Jan.)

Exhibit 4

Newspaper Articles Carried Soon After the Company's Establishment

Suzuka Fuji Xerox
Phase I Construction Completed Lined with New and Powerful Equipment



Suzuka Fuji Xerox
To Be a Global Parts Production Base,
Assuring Good Quality and Low Cost

鈴鹿富士ゼロックス

Suzuka Fuji Xerox Completion Ceremony with 400 People Present

きょうから一部で操業

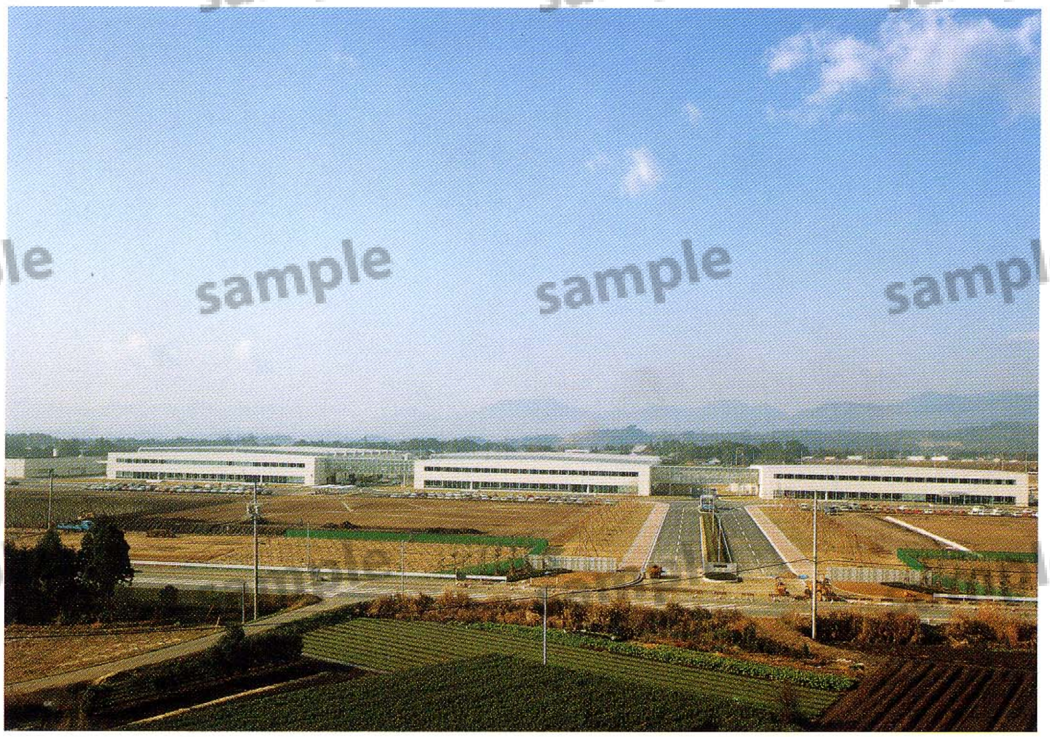
鈴鹿富士ゼロックス

地元密着を期待 田川知事

Expectations High for the Advanced Industry Plant of Suzuka Fuji Xerox Completed

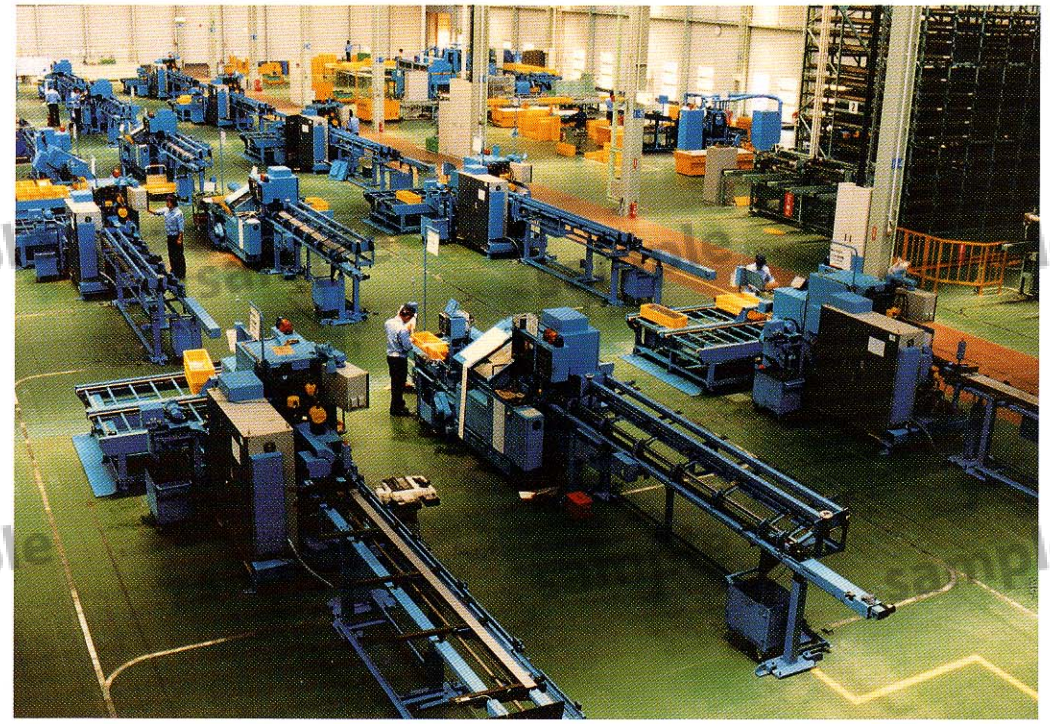
鈴鹿富士ゼロックス工場が完成

Exhibit 5　Pictures at the Time of Estabilshment

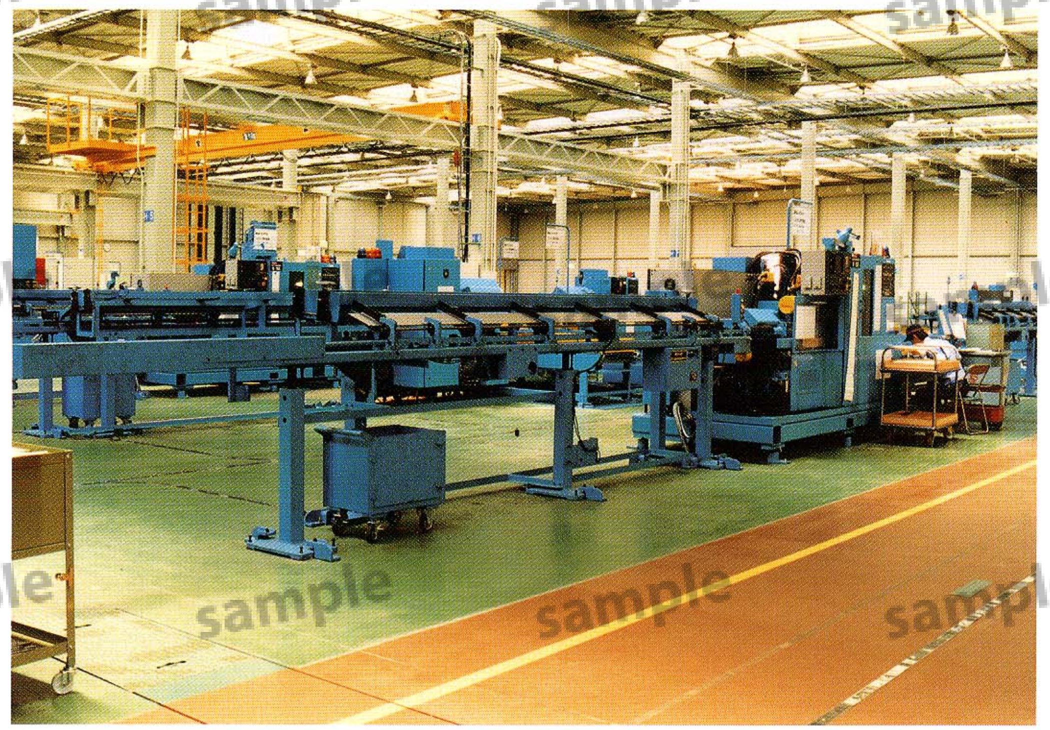


(1) Plant overview

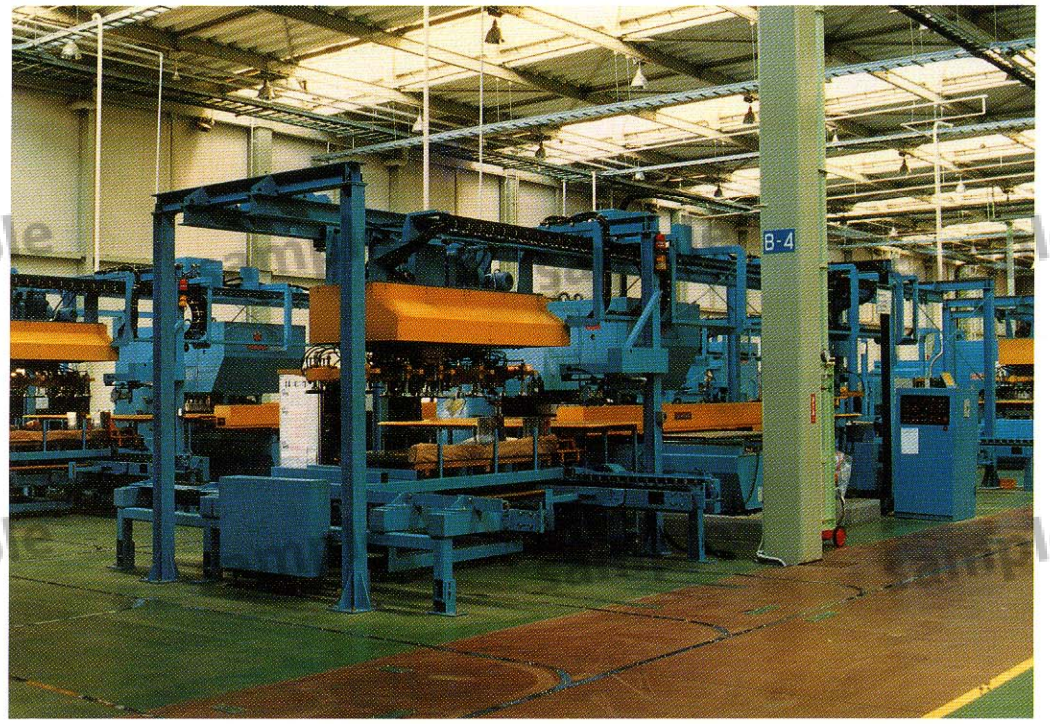
(2) Office Layout



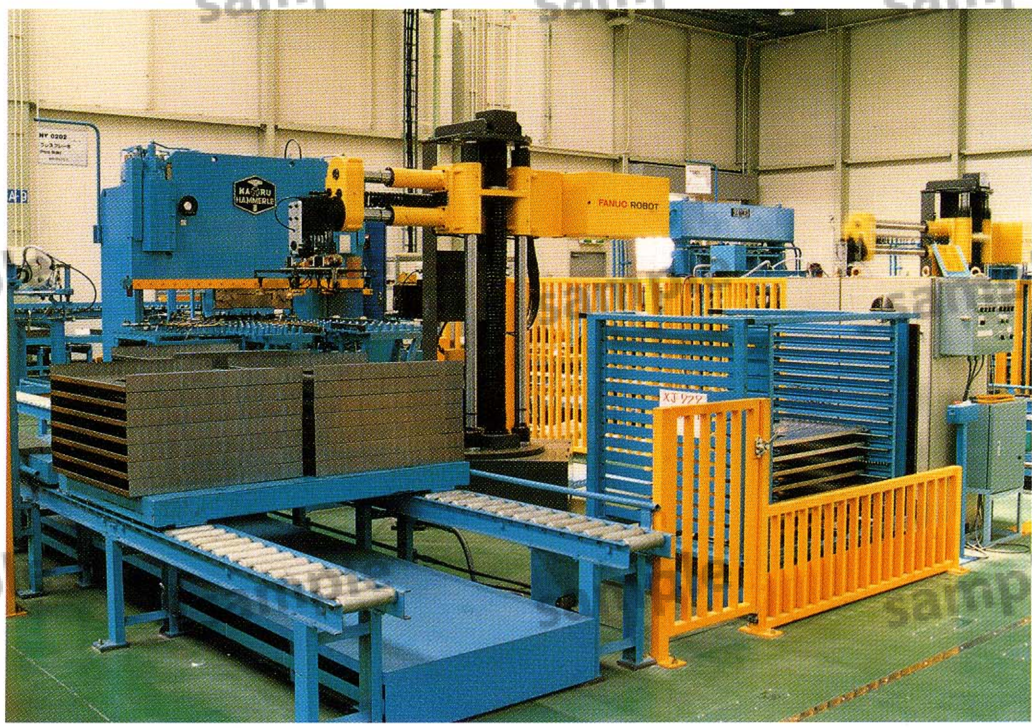
(3) Shaft production line



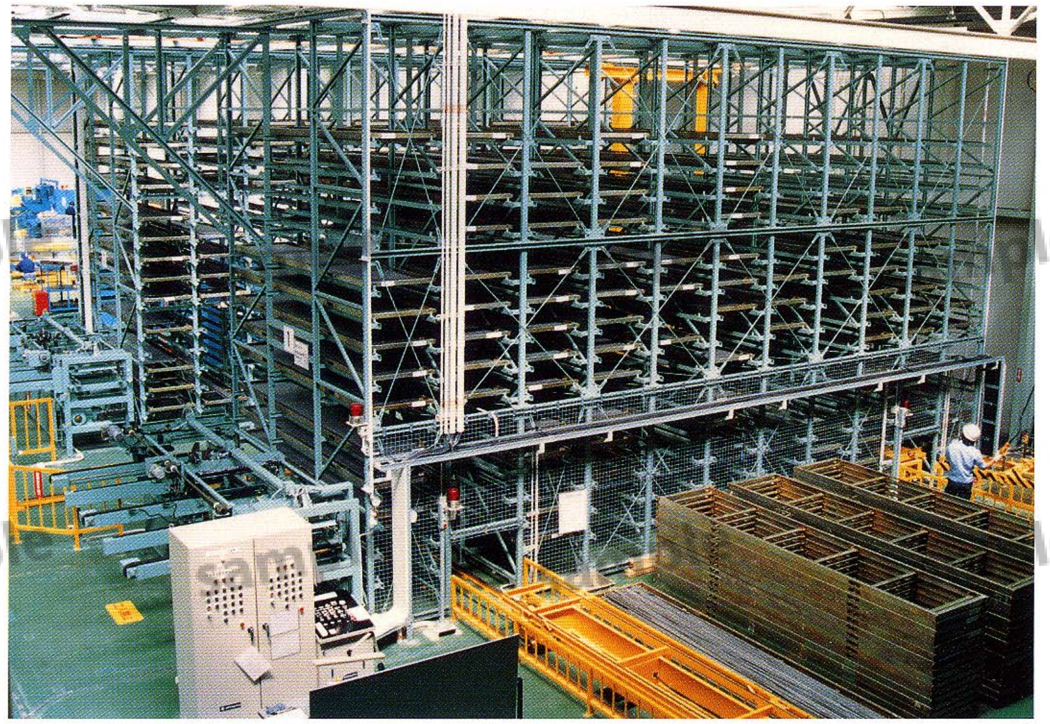
(4) Complex lathe for shaft machining



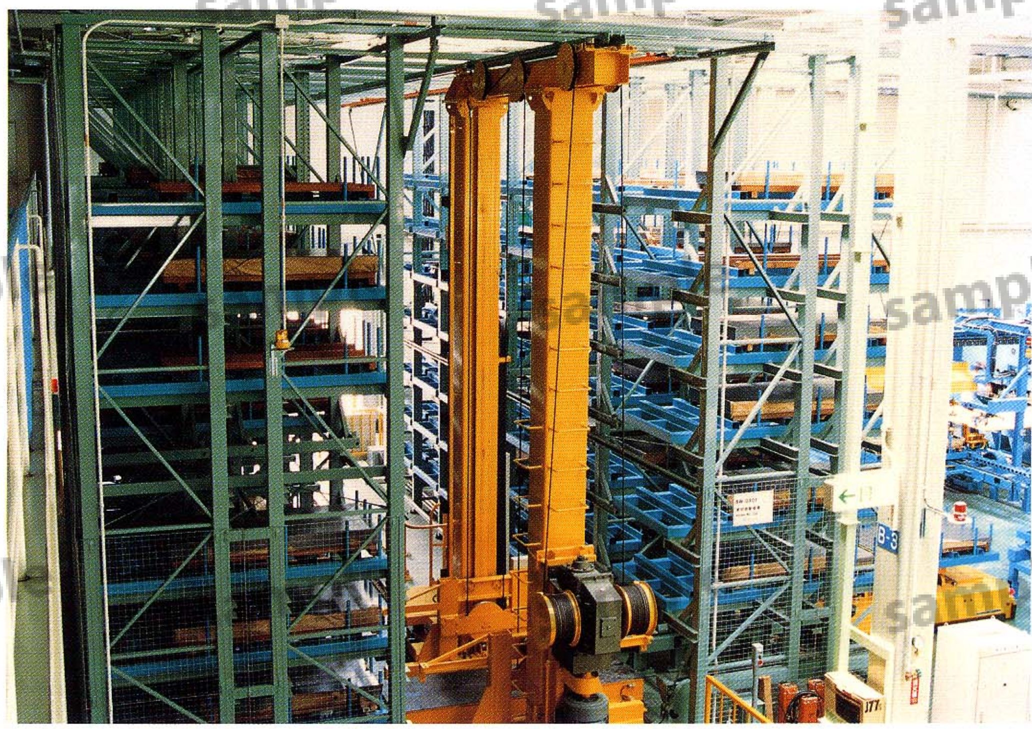
(5) Turret punch press



(6) Bending robots for press machining



(7) Automatic warehouse for shafts



(8) Automatic warehouse for press machining

Exhibit 6

Number of PC Installations and the Number of People Enrolled on PC Classes

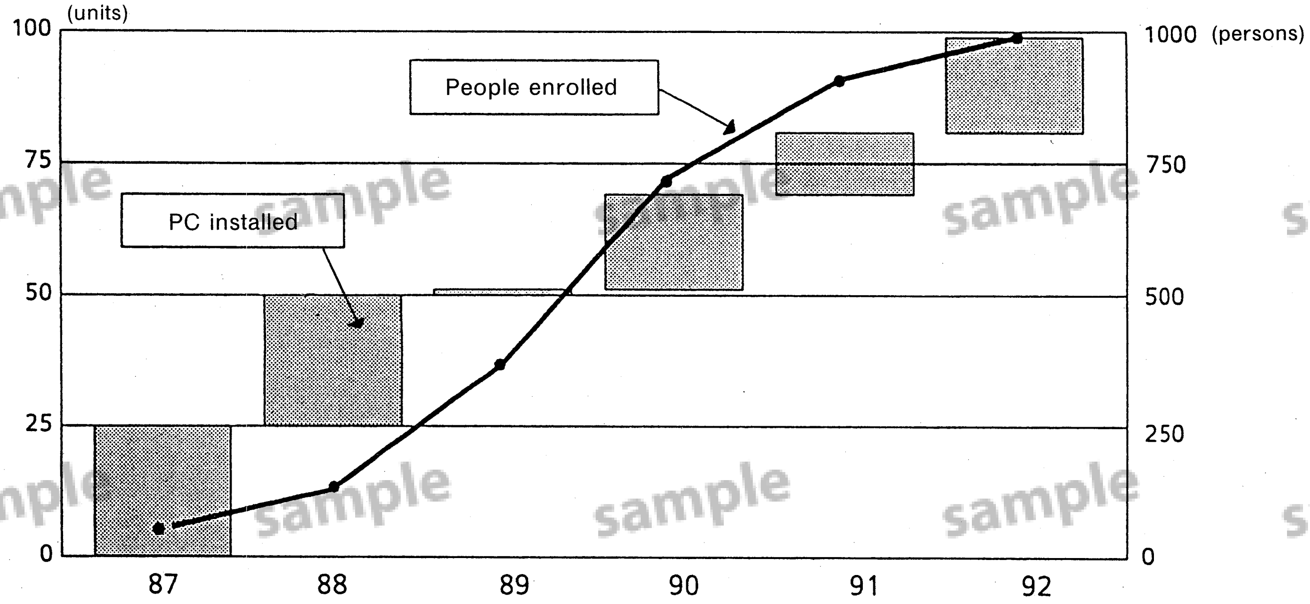


Exhibit 7

Number of Program Development Steps of Host System

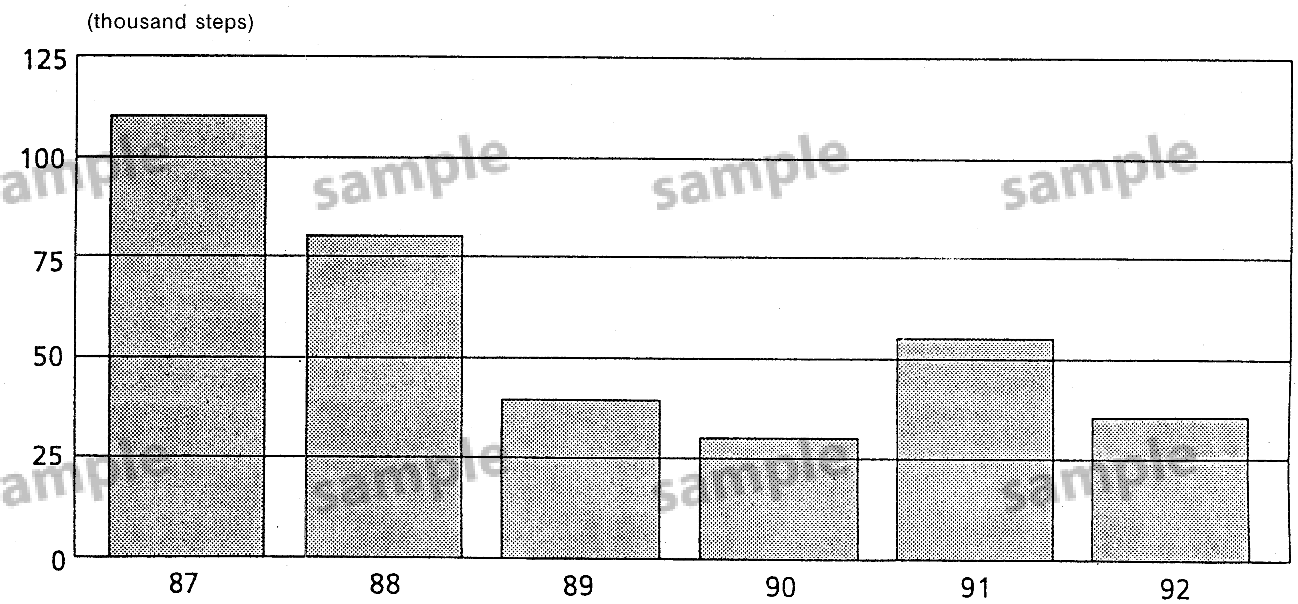


Exhibit 8

Growth Rate of Sales Turnover and Indirect Workers

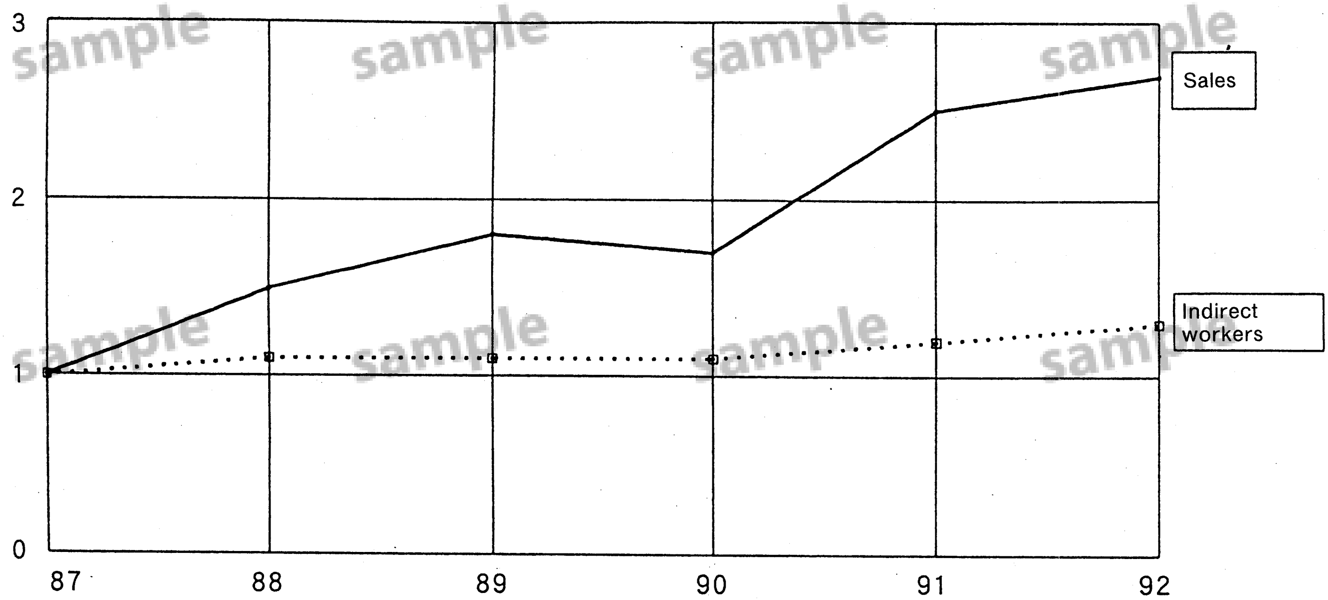
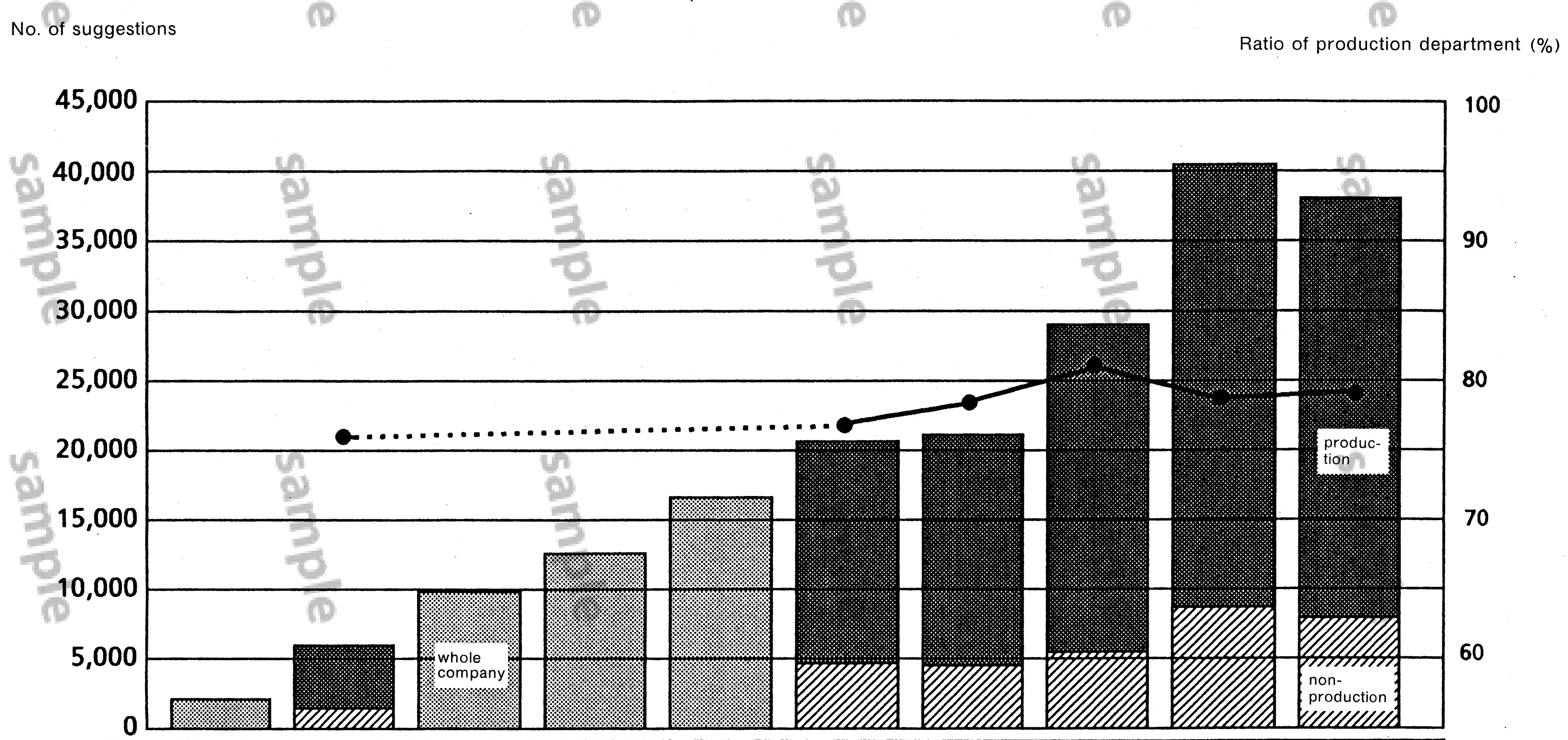


Exhibit 9 Transition of the Number of Improvement Suggestions



fiscal year	83	84	85	86	87	88	89	90	91	92
company total (number) (average/person/month)	2,061 (0.8)	5,965 (1.7)	9,805 (1.8)	12,639 (2.2)	16,568 (2.8)	20,686 (3.5)	21,155 (3.3)	29,111 (4.4)	40,515 (5.5)	38,048 (4.6)
production department total (number) (average/person/month)	N. A. -	4,585 (1.7)	N. A. -	N. A. -	N. A. -	15,972 (3.7)	16,637 (3.6)	23,670 (5.2)	31,804 (6.0)	30,096 (5.0)
production department ratio (%)	-	76.8	-	-	-	77.2	78.6	81.3	78.4	79.1

Exhibit 10 A Recent Newspaper Article

日本の製造技術 21世紀への遺産

第7部 新しい工場 ▼㊤

"解体"されるFMS

分散管理で柔軟に対応

「いいものを安く」作る技術を武器に、戦後何度も不況をくぐり抜けてきた日本の工場が今、変わろうとしている。時短の推進、若年労働者の減少や製造業離れといった長期的課題に直面し、いままで目標だった自動化、ロボット化、コンピューター化を単に進めても解決できないことに気づき始めた。一九一〇年代に米フォード社で大量生産方式が確立し、それに取ってかわった多品種少量生産方式は五〇年代、日本のトヨタ自動車で生まれた。再び四十年。九〇年代は「新しい工場」が生まれる十年になる。

時間かかる工程変更

自動倉庫、搬送装置、NC（数値制御）付き工作機械——。つい最近まで、この"三種の神器"をコンピューターで統合管理するFMS（フレキシブル生産システム）は、工場の目標だった。だが今や急速に色あせ、"解体"を急ぐ工場が増えている。

「特定の条件のもとでは自動生産は非常に効率がよかったのだが」。富士ゼロックスの部品生産会社、鈴鹿富士ゼロックス（三重県鈴鹿市）の浜口部・生産技術部長は振り返る。

トナーに電荷を与えるマグネットロール、文字・画像を紙に定着させるゴムロールなどの機能部品や、プレス成型部品などを製造する同工場は、八二年の完成当時、"次世代工場""FMSのモデル"などと評価され、多くの見学者が訪れた。

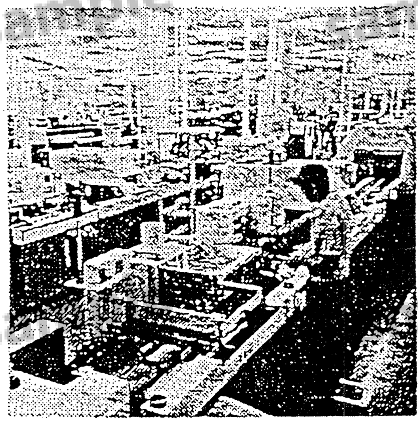
自動倉庫から無人搬送車（AGV）を通して運び出された金属材料を合計十七台のNC旋盤、NCタレットパンチプレスが自動加工する。コンピューターで一括管理され、もちろん二十四時間の連続加工が可能。およそ七十種類の「多品種少量生産」が可能なシステムだった。

ところが、意外にフレキシブルではないことが数年たって露呈する。「最大の欠陥は、工程の変更に時間がかかること」（浜口部長）だった。

多品種を自動生産するには、本社がどの品をどれくらい必要としているのか、どの加工素材をどのパレットに何個積むか、加工にはどの工具を使うか——などをキメ細かく計画し、システムを構築しなければならない。

"頭"のある現場を

だが、親会社からの注文が少ロット・短納期化するに従い、一度構築したシステムを次々と変更せざるをえなくなった。



一極管理をやめ、現場ごとに分散管理を目指す（三重県鈴鹿市の鈴鹿富士ゼロックス）

FMSは理論的には人手がかからず、年数を経るに従って償却コストが減っていくはずだったが、実際は工程変更のために多くの人が必要となり、製造原価が当初に比べて二〇%も上昇。製造現場からの工程変更要求に対して実際の変更も追い付かず、「今日受け取った変更依頼の実現が三年先という事態になり、ついに工場解体を決意した」（浜口部長）。

新体制への移行は今、最終段階にさしかかっている。一つのコンピューターで管理するのではなく、シャフト加工、プレス、樹脂成型品など製品ごとに別々に自動化を進める。一極集中管理から分散管理へのシフトだ。

加えてシステムを作る主体も現場の工場従業員に移行させる。いままでは工場内の生産管理スタッフが担当していた。その一人、総務部の落合敏彦氏は「仕事が変わった。以前はシステムを作ることが仕事だったが、今は現場自身がシステムをつくれるよう、彼らを教育するのが仕事」と語る。生産管理スタッフが"頭"で、現場従業員は"手足"という位置付けを捨て、"頭"のある柔軟な現場をつくろうというわけだ。

長野県伊那谷。ここでもひとつの工場解体が進んでいる。抵抗器が主力の電子部品メーカー、KOAは一昨年から主力の二工場で様々な自動工作機やベルトコンベヤーを撤去した。今年三月までには「蔵の助」というあだ名の大型自動倉庫も"お蔵入り"する。「流行に踊らされて半導体工場並みのハイテク工場にあこがれた面が確かにあった」と向山孝一社長は反省する。

KOAでは八〇年代半ばまで工作機械メーカーから一台一億円前後する設備を次々に購入、完全自動化ラインを追求した。汎用抵抗器の需要は長期的に拡大、価格が一個〇・四円程度にまで下がる。だから人手に頼った生産では採算が合わない——との判断もあった。

出典：日経産業新聞　1993年2月22日

Title:

Production Engineering in Japan -- Legacy for the 21st Century

New Factory Series No. 7, 1)

Dismantled FMS -- Flexibly Coping with Decentralized Control

Photograph: Aiming for decentralized control per workshop, discarding centralized control (Suzuka Fuji Xerox, Suzuka City, Mie Prefecture.)

Japanese factories, which have survived successive recessions after the war armed with techniques to produce products of high quality at low cost, are now under transformation. Faced with long-term trends toward shorter working hours, fewer young workers, and more people moving away from manufacturing, they have begun to realize that pursuit of robotization and computerization, which has been their primary goal until recently, cannot solve their problems. Forty years after the mass-production system was established by Ford Motor in the U.S. in the 1910s, multi-kind, small-lot production was born in Toyota Motor in the 1950s. After another forty years, the 1990s may be the decade that witnesses the birth of "new-style factories."

Time-Consuming Process Change

The search for FMS, Flexible Manufacturing System, which performs computer integrated control of "Three Sacred Treasures," i.e. an automated warehouse, an automatic materials handling system, and numerically controlled (NC) machine tools, has been an overriding goal of any factory. Such a dream, however, has faded rapidly, and an increasing number of factories are giving up on such a system.

"Automated production was highly efficient under certain conditions" says Ken Hamaguchi, Manager of the Production Engineering Department of Suzuka Fuji Xerox (based in Suzuka-shi, Mie), which is a subsidiary of Fuji Xerox producing parts.

The factory, which produces such functional parts as magnet rolls, which electrically charge toner, and rubber rolls, which thermally fix characters and images on paper, as well as press-formed parts, was praised at the time of its establishment in 1982 as a "next-generation factory," and "a model FMS factory," and attracted many visitors.

Metal materials, which were transported from an automated warehouse by AGV, automated guided vehicles, were automatically processed by a total of 17 NC lathes and turret punch presses. Centralized computer control allowed around-the-clock operation. It was a system which enabled multi-kind, small-lot production, producing up to around 70 kinds of parts.

A few years later, however, a lack of flexibility unexpectedly appeared. "The biggest shortcoming was that it took a long time to change processes" (Hamaguchi's comment.)

Automatic production of many kinds of parts requires a system to be built from elaborate planning and clear ideas about the requirements of the customer, in terms of which parts in what quantities, about how much of which materials are to be palletized on which pallets, about which tools are to be used for machining, etc.

Aiming for Workshops with "Heads"

Despite this, the system, once it had been established and put into operation, needed successive changes as orders from the parent company came to require production in smaller lots and shorter lead time.

Although FMS, theoretically, was supposed to require less labor and to reduce depreciation costs over the years, in reality a great deal of human labor was involved in process setups, leading to swollen production costs by as much as 20% over the initial period of its operation. Actual process changes were far behind requests for such changes. "Finding that such requests had to wait for three months before they were fulfilled, (they) finally decided to dismantle the system" (Hamaguchi's comment.)

A shift to a new system is now approaching the final stage. In the new system, automation is pursued separately for different types of products, such as parts requiring shaft machining, press machining, and plastic molded parts, rather than controlling the whole production by computer. It represents a shift from centralized control to decentralized control.

In addition, factory workers are to be the system's builders, the function of which has been undertaken by the production control staff, under the new system. Toshihiko Ochiai, a member of the Administration Department who used to be on the staff, says: "Our work is over. Although our work used to be building the system itself, it now is to help operators build their own system through training programs." In other words, they have shed the general picture of the production control staff being the "head" and first-line operators being "hands and feet." Rather they have chosen to build flexible workshops which have their own heads.

(Source: Nikkei Sangyo Shinbun Feb. 22, 1993)

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