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COMPUTER–INTEGRATED MANUFACTURING IN CHINA: A TRIP REPORT AND OBSERVATIONS

In April 1990, the People's Republic of China hosted the plenary session of the International Standards Organization subcommittee dealing with integration and communication for industrial automated systems. This session, held in Beijing, demonstrated China's interest in the subject amid its renewed desire to narrow the gap between China and advanced countries in automation technology. Representatives of fourteen nations attended the session. The author of this article, one of three U.S. delegates, had an opportunity to discuss with Chinese engineers and educators the status of their industry, and to visit universities and development laboratories. Those visits are discussed, and observations concerning China's present and future prospects relative to its goals of industrial modernization and self-reliance are reported.

INTRODUCTION

In April 1990, I visited the People's Republic of China to attend a meeting of the International Standards Organization's Technical Committee 184/Subcommittee 5, which develops standards for computer architecture and communication interfaces for industrial automation systems. I was a member of the U.S. delegation, which consisted of one representative each from AT&T, Allen Bradley, Inc., and The Johns Hopkins University Applied Physics Laboratory. The meeting was hosted by the Beijing Research Institute of Automation for the Machine Building Industry (BRIAM). The nations sending representatives were France, Hungary, Italy, the Federal Republic of Germany, Japan, England, the United States, Denmark, Norway, Sweden, Czechoslovakia, South Korea, the People's Republic of China, and Bulgaria. In addition, members of several Chinese universities, the Beijing Institute of Technology, and the China State Bureau of Technical Supervision were observers during the five-day meeting. I visited the Beijing University Engineering School for Aeronautics and BRIAM and held discussions with Chinese engineers and scientists concerning the present status of manufacturing technology. (In Refs. 1 and 2, I discuss manufacturing technology in Japan and modernization and integration programs under way in the western European community.) It was evident in Beijing that the Chinese are seriously interested in industrial automation and know that they must increase their skills and fiscal support to match Japanese, European, and American competence in this technology.

GENERAL OBSERVATIONS

I will briefly mention the cultural history and technical skills demonstrated by the Chinese as long as 4000 years ago. They were the first to develop iron, paper, gunpowder, and pottery (porcelain) industries. They also maintained a written record of their cultural and technical history by means of stone tablets and written documents that date back to the Xia dynasty (2100 to 1600 B.C.) and the Shang dynasty (1600 to 1100 B.C.). These examples of Chinese skills preceded European culture by many centuries. I will limit this article, however, to the technical developments relative to manufacturing automation since 1949, when the People's Republic of China was founded.

The first significant cycle was the first five-year plan (1953 to 1957), which emphasized collectivization of agriculture. This focus was understandable, because with a population of approximately one billion, the requirements for feeding, housing, and clothing that population were then, and remain, major priorities. With the help of the Soviet Union, this five-year plan also included the development of heavy industry, such as steel, oil, and coal production. The next period of interest (1958 to 1965), known as the "Three Red Banners," was catastrophic because industrialization was emphasized and agriculture was neglected, resulting in famine and a generally discontented population. The next phase, a traumatic experience, was known as the "Cultural Revolution" (1966 to 1976). Because of the disenchantment with technology and the neglect of the traditional basic agricultural culture, Mao, with the assistance of his wife, initiated actions against the intellectual elite in an attempt to "get back to the soil." Thus, technology, science, engineering, and education all had a ten-year hiatus, setting China back in these areas, while the U.S. and Europe improved their economies through technological developments. The new policy, which began in 1976 after the collapse of the "Gang of Four" and the cultural revolution, is in place today. Known as the "Four Modernizations," the current policy includes priorities in agriculture, industry, defense, science, and technology. Although much progress has been made in these areas, industrial manufacturing has lacked major advances, especially in the area of automation.

The present Chinese educational system is worth noting because it affects the modernization of technology. Some children attend preschool from the age of three to six years. A general enrollment in elementary schools begins at the age of six, and about 95% of all children attend. Elementary school lasts for five or six years, during which students are taught Chinese, foreign languages, and mathematics, plus basic physics, chemistry, and biology in the higher grades. Children then attend a two-level middle school for a maximum of about five years. Each level lasts two or three years and includes such subjects as physics, mathematics, chemistry, biology, history, music, and art. Middle schools prepare students to attend higher levels or take up a vocation. Only about 40% of middle-school students make the transition from the first to the second level and only about 5% of those who make the transition attend a university. About 85% begin working after they complete middle school, and the others go into military service.

The admission of students for higher education is highly selective. Fewer than 3% of China's people graduate from colleges or universities. In addition, before entering a university, each student is assigned to a particular profession on the basis of test results. This process seems to indicate that only the best are selected for higher education, although evidence suggests that children of well-placed individuals manage to gain entrance regardless of merit.

CHINA'S PRESENT AUTOMATION TECHNOLOGY PROGRAM

In 1987, the Chinese government initiated the National High Technology Development Program (NHTDP), which selected the following seven areas for development: biotechnology, space, information transmission, laser technology, manufacturing automation, energy, and advanced materials.[3] Two areas of manufacturing automation are being emphasized: computer-integrated manufacturing (CIM), and intelligent robots. The Chinese hope that successful implementation of the program will contribute significantly to the social and economic development of China by the year 2000. At the meeting I attended, members of the Chinese delegation were frank in stating the following:

1. Less than 5% of China's industry uses computer-aided design (CAD), computer-aided manufacturing (CAM), and computer-aided engineering (CAE).
2. The technological level in China must be improved if the country is to be globally competitive in industry. The cost of products manufactured in China must be reduced, quality must be improved, and lead time for development must be shortened.
3. The machine tool industry needs help and is lagging far behind Japan, North America, and Europe.
4. China is making an unabashed plea for assistance in her modernization program.

VISITS TO NHTDP RESEARCH AND DEVELOPMENT CENTERS

The International Standards Organization delegates visited BRIAM, which is devoted to research and development of automation for the machine tool industry. This institute has a staff of 1300, including 650 engineers and hundreds of technicians who concentrate on computer software, industrial robots, artificial intelligence, integrated circuit design and masking, hydraulics, automatic controls, and instrumentation. The institute (Fig. 1) has accumulated many Japanese and Western computer systems and workstations for the development of CAM items. Figure 2 shows one of the workstation areas.

A project discussed in detail was an automated sheet metal facility they developed for the Chinese automotive industry and which is now operational in one Chinese truck plant. Figure 3 is a schematic of the concept, which appears to be fairly sophisticated. It is evident that the Chinese can design a sheet-metal CAD/CAM system; however, the equipment used to implement this system includes hardware and software developed outside China,

Figure 1. Main building of the Beijing Research Institute of Automation for the Machine Building Industry.

such as the Compaq 386, Intel system, and optical communications links. Figure 4 is a robot for spray painting, and Figure 5 shows some of the integrated circuits designed and fabricated at BRIAM.

Our BRIAM hosts were proud of a nitride plating process that they developed for machine tools and hand-exercise balls. Figure 6 shows the ion plating machine that they are offering for international sale. The BRIAM scientists and engineers believe that the nitride plating machine is a unique product; however, nitride plating for machine tools is an existing technology in the United States and Europe (the APL machine shop has been using titanium nitride cutting tools for at least ten years). Obviously a closed society, the People's Republic of China suffers by being unaware of technical developments outside her borders.

Figure 2. Computer workstations at the Beijing Research Institute of Automation for the Machine Building Industry.

Other developments at BRIAM were related to the Chinese automotive industry, which is not well developed. Figure 7 is a vibration test bed for truck development at one of the automotive plants. Figure 8 is an automated warehousing arrangement used in the steel, machine tool, and automotive industries in China. All of the items shown in Figures 7 and 8 were developed at BRIAM and are now operational.

It is evident that the BRIAM scientists are aware of technologies related to robot engineering, pattern recognition, artificial intelligence, optical communication linking, electronic database development for CIM, and networking requirements. They are also working with CAE and flexible manufacturing automation systems.

A VISIT TO BEIJING UNIVERSITY ENGINEERING SCHOOL FOR AERONAUTICS

I was invited to visit Beijing University without the other members of the International Standards Organization. I found myself with three Soviet engineers who

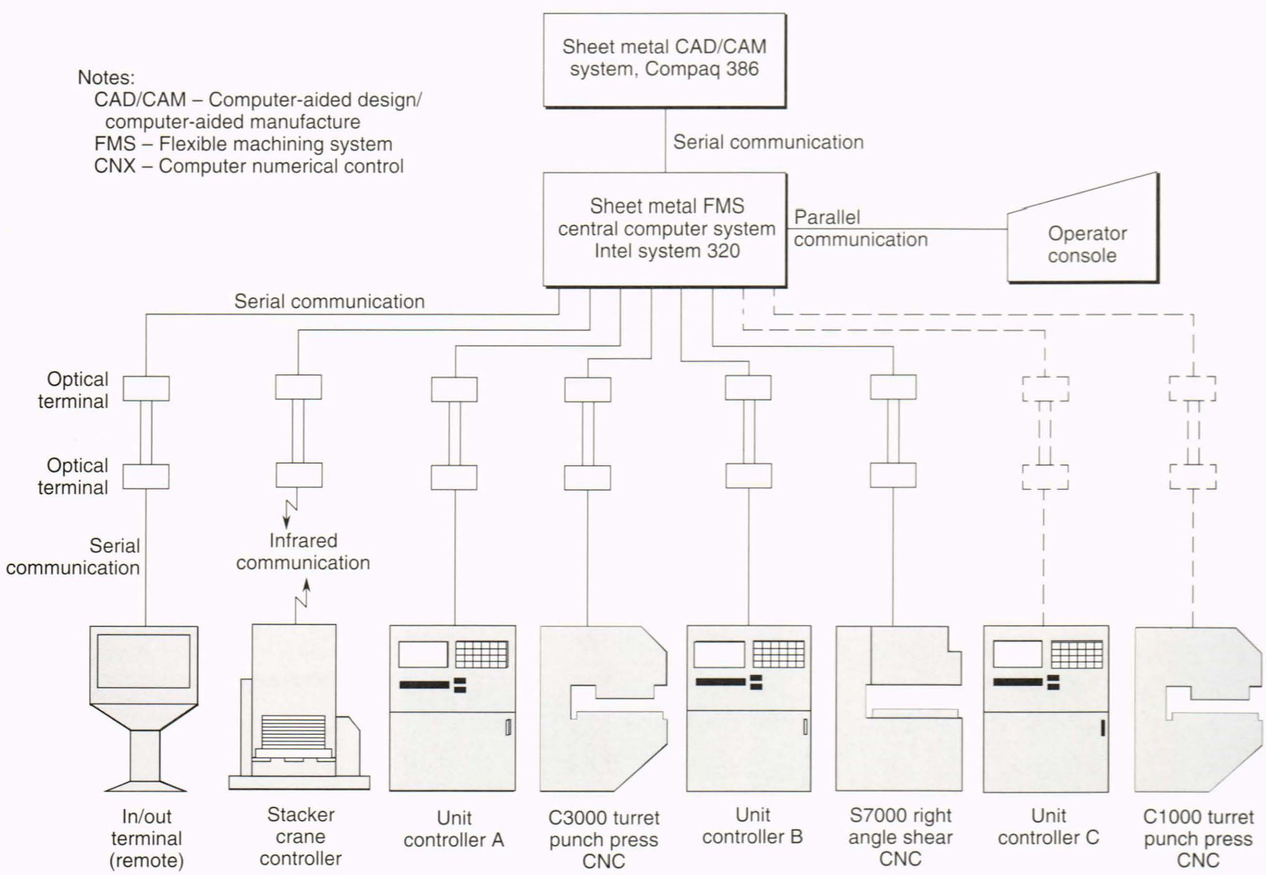

Figure 3. Schematic of an automated sheet metal facility that is operational in automotive and appliance manufacturing factories in China.

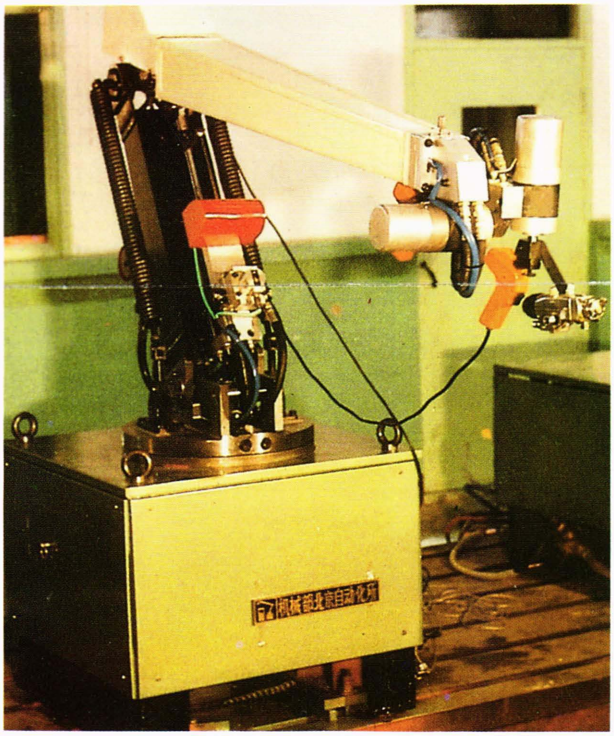

Figure 4. Painting robot for general use in major Chinese industries.

Figure 6. Sales brochure for nitride plating machine produced by the Beijing Research Institute of Automation for the Machine Building Industry.

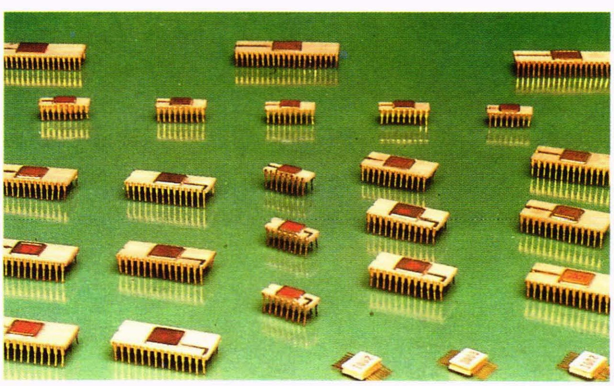

Figure 5. Some integrated circuits produced in China.

were visiting Beijing as part of the rapprochement between China and the Soviet Union, which heralds a renewal of the Russian technical aid to China that was discontinued in the 1970s. The facilities, although crude, appeared to be used by many students in the area we visited, the CIM Training Center for Manufacturing Engineering. We were hosted by Yu Meishen. He was particularly proud of the networking aspects of their training program. They use a large amount of American computer equipment.

Figure 9 is a schematic of the teaching tool used to acquaint engineering students with the complexities of networking equipment that communicates in an automated enterprise. The schematic shows the Ethernet network,

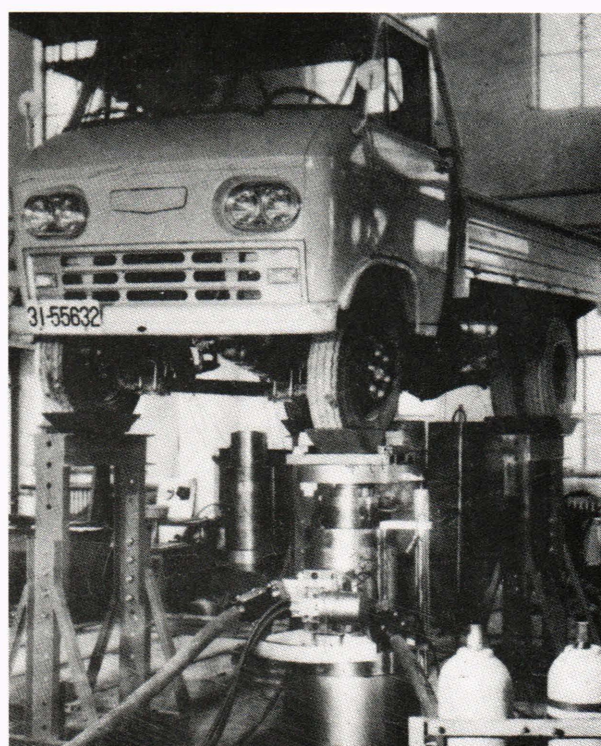

Figure 7. Vibration test fixture for the automotive industry.

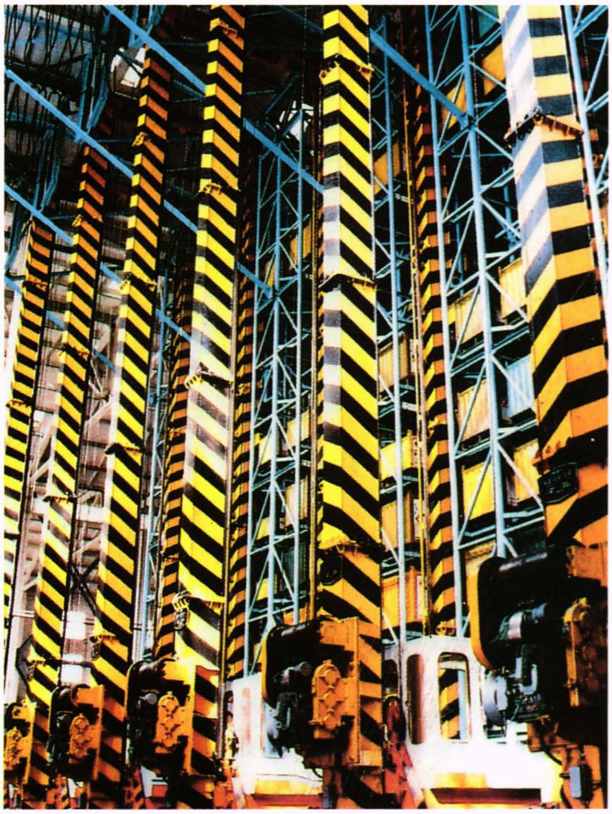

Figure 8. Computer-controlled warehouse automated to access high-bay areas.

controlled by IBM PC-AT's through a CDC Ciber computer, which, in turn, interfaces with Intergraph, Tektronix, Sun, ComputerVision, IBM, and Hewlett–Packard equipment. The Ethernet network interfaces with two Token Ring networks using Apollo nodes running PATRAN and MENTOR software. These are all of U.S. manufacture. The electronic digital information developed in the networks is then transmitted to a Japanese Fanuc controller operating a Japanese horizontal Mitsuiseiki mill. The only component of Chinese manufacture is the power supply for the CDC computer. It is not simple to make such a system work, so the system is therefore an excellent teaching tool. Dr. Meishen indicated that the reason they have so much American and Japanese equipment (see the lower left-hand corner of Fig. 9) is because the United Nations supports the development of technology in so-called Third World nations, and China is considered eligible for funding in this category. Beijing University uses the funds to buy state-of-the-art foreign computer equipment so that it can train students to become competent manufacturing engineers.

CONCLUSION

The Chinese admit that their machine tool industry is ten to fifteen years behind the rest of the industrialized world. They face a large catch-up program but appear to know what is required. The Chinese have technical skills, although only a relatively small percentage of them are educated above the middle-school level. They also appear to have the drive and energy to improve. An example is the annual machine tool sales convention that the Chinese government sponsors to entice foreigners to buy Chinese machine tools. Figure 10 shows the floor of a machine tool convention in Canton, China, that attracted several foreign buyers, some from nearby capitalistic Hong Kong.

I came away from this visit with the feeling that China is aware of the need to modernize her machine tool industry and is initiating priority programs to accelerate technology in this area. It will take years of consistent government emphasis and funding to bring Chinese technology up to date. China has a huge population and

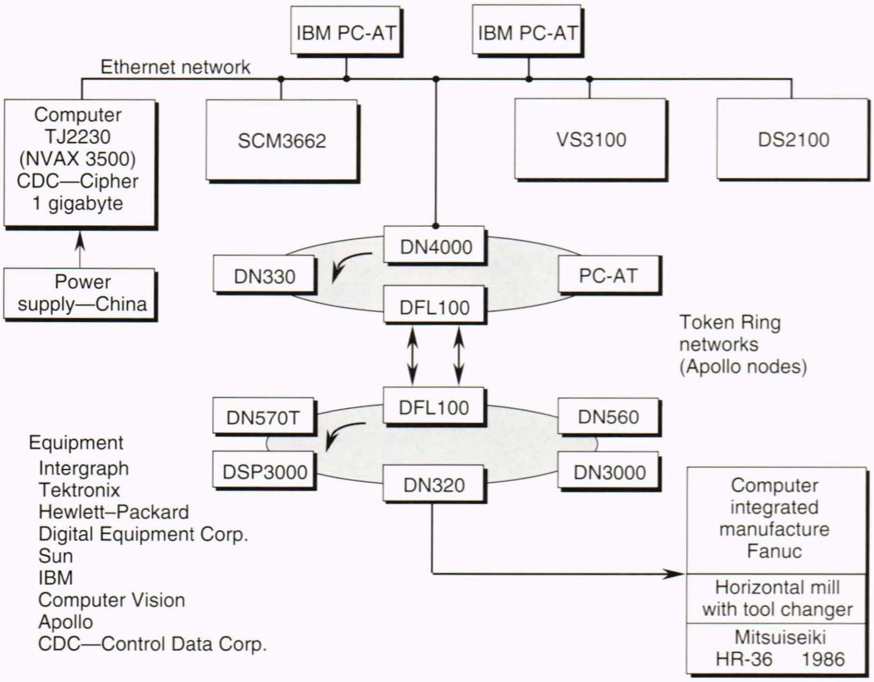

Figure 9. Beijing University's computer-aided design and manufacturing computer-networking training system.

Figure 10. Canton (Guangzhou) machine tool trade fair, with small manually operated machines on display.

traditionally has used manpower in major programs. The Chinese will continue to use manpower in their manufacturing industries to a greater extent than Japanese and Western nations do. They will also incorporate automation, however, to improve the quality of their products and to manufacture items best produced by machinery. They must also maintain a stable political, economic, and social environment with ready access to the technically advanced nations of the world.

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