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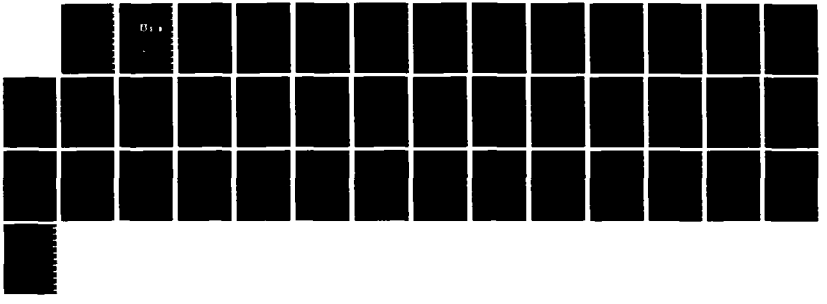

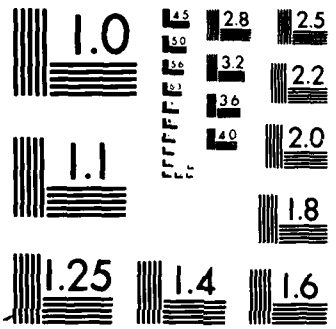
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FOREIGN TECHNOLOGY DIVISION

FUTURE AND DEVELOPMENT

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THE STRATEGY OF DEVELOPMENT OF HIGH TECHNOLOGY IN CHINA

Lu Xuming

Zhongqing Division of Chinese Institute

of Scientific and Technical Information

It is known that from the end of World War II to the 1970s, the Western countries carried out the "Keynes Policy" to promote economic growth by increasing the demand. This was called the strategy of "high speed economy increase." Now the situation is quite different. "High speed economy increase" is impossible and therefore the strategy is switched to emphasize "economy modernization." In order to promote this new strategy, each country uses different slogans. In the United States, it is called "reindustrialization." In Japan, it is called "developing the nation by use of technology." In Britain, Mrs. Thatcher put forward the slogan of "reorganization of industry," etc. Although the slogans are different, their main purposes are the same; that is to make economy more advanced and more efficient by means of high technology.

1. THE RISE OF HIGH TECHNOLOGY

In the past few years, high technology developed rapidly even while the Western economy was undergoing a recession. It showed that high technology was very strong. According to a report of the Commercial Department of the United States, during the period from the 70s to the 80s, the annual average increase of the whole industry of the United States was 3%, but the average increase for high technology industry was 7%. Of the ten fastest developed fields of industry, nine

were involved with high technology.

Therefore high technology is admired greatly by the press abroad. In many countries, such as the United States, Japan, France, Federal Germany, Britain, etc., many people began to invest in high technology. In both the U.S.A. and Japan, the high technology industry gained most in the stock market. With great progress in science and technology, building a high technology industry became popular. This has created many new industry centers. These industry centers have a very important strategic significance. They will be developed and become strong in the formation of the information society and the information economy; at the same time they will influence the quality, cost, and productivity of other fields of industry. Therefore high technology can push the nations' whole economy forward and make these nations more powerful.

2. HIGH TECHNOLOGY AND ITS CHARACTERISTICS

(1) What is high technology

Until now there is no clear definition for high technology. But according to the magazine of "Commercial Weekly," high technology is considered to be the techniques of information processing, communication, semiconductor, robot, biological engineering, etc. A Japanese magazine, "Overseas Information of Mechanical Industry," said that high technology is the combination of all kinds of technology which are standing in the forefront of science and technology, and new industries are being formed with it as the core.

But high technology is different from "guiding technology" and "great science", These are often referred to as types of research and exploitation of sophisticated weapons, space aviation, atomic energy, etc. These types of technology need much more talent resource, equipment, investment, and research institutions, and also require very long periods of development, while the probability of success still might be small and the risk high. Therefore these

types of technology should be supporetd by the government or government-operated enterprises, for most of the projects are national level projects, such as the U.S. Apollo moon-mount program in July of 1969.

On the contrary, high technology attracts many middle or small companies. Nasbeite, the author of the book of "the great trend", has pointed out that the number of small companies are increasing rapidly. In 1982, 25,346 companies were closed, but 566,942 new companies were opened. This shows that high technology does not belong to only one country or to a few large companies, but is a new group of technology fields which are closely related to the whole society. Thousands of middle and small companies also have opportunities in these fields.

Generally, high technology can be divided into three groups such as the following:

A. microelectronics:

a. information industry; b, electronic-mechanical industry; c, electronic-medical industry

B. biological technology:

a. medical pharmacy; b, pesticides and fertilizer, c. grain industry; d, biomass industry.

C. new material industry:

a. amorphous-crystal materials; b. ceramics; c. plastics; d. single crystals; e. chemical fabric material.

(2) Characteristics of high technology

High technology is opening a new period for the whole world, based on two very important features:

A. High technology changes the traditional common concept of technology.

As an example, in the field of microelectronics, there is no dividing line between components and systems, because some electronic components themselves can also be a computer system. For example, the single board micro-processor has all

the features of a computer, such as input, output, memory, calculation, control, etc.

B. High technology enlarges the impact of the technology revolution.

This new revolution of technology has much more impact than ever before. It changes the old structure of industry, employment, nature of work, style of life and working, value viewpoint, and social systems. The speed of such change is so fast and so wide that it is beyond anticipation. Without the development of the high technology industry, especially in microelectronics, countries will only be able to export their raw materials. It will enlarge the gap between the rich and the poor countries.

3. THE STRATEGY OF U.S.A. AND JAPAN AND ITS INFLUENCE

After World War II, the strategy of technology in the U.S.A. has been changed as described below. During the 60s military technology was totally separated from commercial technology; but since the 70s, advanced military technology began to be transferred to the fields of commercial application (such as the technology of space aviation of Apollo. In the 80s, high technology and military technology supported each other (such as microelectronic industry, new materials industry, and biological technology industry. In the 90s, the whole country's strategy of technology will be mainly to push the development of high technology (the technology policy for strengthening the nation's security). The reason for this is:

(1) High technology has more and more great influence on the nation's military power. Now microelectronic technology and information communication are key technology fields which influence military power. For example, the cost of microelectronic devices is 70% in a guided-missile, 50% in an airplane, 30% in a tank. Therefore the United States is trying to hold the dominant position in the field of microelectronics technology in order to maintain its military superiority.

(2) High technology is viewed as a key to raising productivity. The improvement of quality and decrease of the cost of high technology products are playing a

very important role in the American economy. During the last ten years, the productivity of the high technology industry has increased 5.6%, while industry as a whole has only increased 0.9%. For example, a U.S.A. company, "Apple Computer Company", which was founded by two people, now has become one of the five hundred biggest companies. Recently it set up a highly automatized factory with an investment of $20 million. Although only 200 employees are directly engaged in production in this company, it can produce one computer, which has 450 parts, in 27 seconds, or 5 million computers in one year. The cost of labor is only 1% of the whole cost of a computer.

(3) The trade of high technology products is under good development. In 1982, the American trade deficit was $43 billion. In 1983, the deficit was estimated from $60 billion to $70 billion, but the trade in high technology products was flourishing. From the year 1975, the favorable balance of trade added up to $128 billion.

According to the formal analysis of Japanese economist Shitanisei, after World War II, the technology progress played a 60~70% role in the economic development, while the capital and labor force only played about 25~30% and 10% roles, respectively. As for Japanese science and technology after the War, 90% is imported from foreign countries. We can say that the high speed development of economy in Japan after the War depended on, in a large extent, absorbing and reforming the technology from the Western countries (30% from Europe and 70% from U.S.A.) It should be noticed that the new technology revolution in Japan has shown its special sensitivity to the mowt newly developed fields of science and technology.

(1) Making the "microelectronics revolution". Now a "microelectronics revolution," mainly in production automatization, is rising in Japanese industry; one of the main features is the wide application of robots. According to an estimation by the Japanese Association of Electronics and Mechanical Industry, the total output of the electronic industry of Japan can reach 30 million Japanese Yuans in ten years, and at that time its output will exceed steel and automobiles and will

be the biggest industry.

(2) Promoting large companies to make reforms to meet the needs of the new technology revolution. The principles are: dispersive management, independent accounting. simplification of the organizations, strengthening of production lines, organizing flexible technological teams, occupying the markets; build-up of productive systems of small batch but multi-type products, wide use of automatic equipment such as digital computer-controlled machines, and robots, which have high ability to switch product types.

(3) Encouraging people to build up "high risk investment companies" which is aimed at exploiting high technology. By using other's experience, they hope to win the battle of technology. In the last year, about twenty companies of the Mitsubishi group founded a "Technological Association" to cope with their international competitors of high technology. They exchange or offer their latest new information of technology within the Association so that they can avoid repeated investment, and the unnecessary competition in research and development within the company. Between different professions they have made some adjustment and coordination in the fields of high technology applications.

(4) Developing high technology to flourish in local industry. From the year of 1984, 43 local government organizations adopted some measures for the development of new technology and new products. For instance, biological engineering, which is under the most heavy research, has been carried out by 21 local governments through one or several research programs.

(5) Building up loan and subsidy systems for encouraging some small local companies to develop new products of high technology. For example, Tochinoki county has already set up a loan system of "promoting new technology and new products"; Tokyo city has also founded a similar subsidy system. Now altogether 14 local governments have established such systems.

THE INFLUENCE BY THE UNITED STATES AND JAPAN ON THE STRATEGY OF HIGH TECHNOLOGY

According to the analysis of an American economist, Leoncve, along with the revolution of new high technology, electronic computers will gradually replace employees who are engaging in daily routine work and so the trend of the flow of the labor force from the manufacturing industry into the service industry will gradually stop. The more advnaced the technology of the society is, the less important labor in production will be. The low cost of labor will no longer be an advantage. Therefore the labor-condensed industries in the developing countries will lose their advantage in the competition.

In order to cope with this situation, South Korea decided to give a special deduction and profit compensation for those foreign companies who have invested in steel and ship-building industries in South Korea. The "South Korea Exploiting Institute" has suggested building several centers of science and technology near main cities. According to each city's features and advantages for the technology, industries, such as semiconductor, computer, genetic engineering, photo communication, precise ceramics, advanced aeronautical materials, etc., were selected as the direction for development. Singapore has already made its full effort to develop computer and electronic industries. In order to attract foreign investors, it has built the most comprehensive system of the world to encourage foreign investment. It carries out a tax-free policy up to ten years for foreign investors, and also allows them to extract their profits out of this country.

4. SEVERAL SUGGESTIONS ABOUT CHINA'S STRATEGY OF DEVELOPMENT OF HIGH TECHNOLOGY INDUSTRIES

According to the trend of development in the Western countries, investment in concentrated large scale enterprises and in diverse small businesses will continue

to coexist for a long period. Therefore according to the situation in China, if we neglect integrating technology, economy, and society and neglect the strategic priority of the economic development, and pay attention only to some of the new fields of technology, then we will make mistakes. Historical experience has shown that the result of unbalanced development in some fields will end with a total failure.

Premier Zhao Ziyang said, "It is possible for us to jump over some stages in the development of some traditional industries." Therefore we should not limit ourselves to the balance of the national economy of China. We should start from the viewpoint of the whole world, and closely watch the new world trends of the development of science, technology, and economy. We must try to retain the balance of economic development with the whole world, otherwise our country will be left far behind.

Therefore, I make some suggestions, which might not be perfect, as the following:

(1) China has already organized the "Leading Office of New Technological Revolution and Policy" which reports to the National Council. With reference to other countries' experience, we should also set up a committee of promoting high technology industry. This organization will be responsible for making new policies which can support new high technology industries and promote the application of new technology. These policies should include depreciation, tax deduction, and exemption. Under the arrangement of the government, we should consider selecting a regional district to build a Chinese "silicon valley", to choose one or several cities to build new high technology industries, and to define computer technology and industry as new professions; allowing them not to be controlled by the present system of administration. Therefore they can fully exploit and develop new high technology.

(2) Building new banks to support the exploitation of high technology. This business usually is supported by "risk capital" in foreign countries, but in China

there is no such kind of capital yet. However if we have these kinds of banks, we will have enough capital to support the exploitation of high technology. Any enterprise which has the ability to exploit high technology and be able to apply high technology to production can apply for loans from these banks. Therefore a new effort vigorously exploiting high technology will be launched. Furthermore they can also use these banks' functions of consulting and risk-sharing therefore decreasing the possibility of failure. Such exploiting banks are social organizations of multi-areas and multi-professions. When combined with scientific societies and future new enterprises, they can act in funding, technology, and production. Thus the isolated administration method, which had impeded the progress of China's science and technology for a long time, can be changed and the advantages of high level socialization can be fully exploited.

(3) Build up the silicon industry base along with the steel and petroleum industry bases. Silicon Valley grew due to interest overlap of universities and enterprises, and in the personnel communication. Japan had decided to build seventeen technology condensed cities (Technopolis), and this was influenced by the development of the Silicon Valley of the United States. Such cities are centered at universities and are centers for research and development of high technology. In these centers, universities and enterprises are closely combined together. The Yangtze River Delta is the best place to build China's "Silicon Valley", because there are about 100 universities in this area, therefore the knowledge density of this area is high. Furthermore there are several hundred electronic plants in this area.

(4) Encouraging overseas Chinese to build high technology companies and permitting and encouraging Chinese students, who are studying abroad and have reached high standards, to open high technology companies using foreign funds as soon as they finish their studies. This way the newest development of high technology can be followed, minimizing the time required for the transfer of

technology, and avoiding the loss of information.

(5) Preparing to enter the world software market as early as possible. We should not only develop high technology, but also accurately estimate the future of the international market and enter this market, combining the development of high technology. In the next few years, because of the fast popularization of micro-computers, there will soon be a huge computer software market in the world. China lacks funds, but it holds a great quantity of good minds. Software development mainly needs people's minds and we should use software, which is a knowledge condensed product, to exchange for the funds. The software export business is a promising prospect. The key for this field is high level software personnel as well as fast and accurate commercial information service. We can send experts to foreign countries to organize Chinese students who study abroad to open software companies.

(6) The feature of high technology is that, in non-research and development departments, such as manufacturing and sale departments, technical personnel is five times that of traditional industries. There are 70% more skilled technicians than in the manufacturing industries. Besides that, because high technology products are the result of new knowledge and high level techniques and skills, technical talent is the source of strength for the development of high technology industries. Higher education and high technology have been combined for the first time in history. Therefore paying attention to the function of education and the quality of the labor force in high technology industries should be treated as part of the whole strategy.

THE LEAPING MODE AND THE STRATEGY OF TECHNOLOGY DEVELOPMENT

HUANG JUEZHOU

Quangxi Institute of Technology

TWO DEVELOPING MODES OF TECHNOLOGY

1. The gradient transfer and the abrupt leap are two basic developing modes of technology. The history of technology has shown that it was not uncommon that backward nations took over the leadership in technology. By investigating technology in modern history, we find that when some nations or regions held leading positions of technology during some period, the technology would flew from the technologically advanced nations to the technologically backward nations. Therefore the difference in technology between these nations became gradually smaller. Then because of some breakthrough, the technology of former technologically backward nations would develop very rapidly, and they eventually became the new leaders of technology. The new technology would flow out again from these new technologically advanced nations, and so on and so forth. In this manner, the technology of the whole world was pushed forward continuously.

But the gradient transfer of technology can not explain this whole process of technology transfer. Therefore we should admit that there is another mode which is more important. It is the leap mode. Under this so-called leap mode of technology, when some aspect of technology achieved some new breakthrough in some nation or some technology field, the technology level of the whole nation or the whole technology field is pushed to a new level within a short period.

In this process, the former technologically backward nation only took a very

short time period to fulfill the technology development which usually required a very long period for the former technologically advanced nations, or even some stages of development could be jumped over and the former technologically backward nation could directly enter the new high level.

2. The gradient transfer and leap modes are decided by the features of knowledge developing.

The concept of technology is usually defined as the tools which can be used to control the objective world and the ability of people to use these tools. Therefore technology is a manifestation of knowledge. As we have known, knowledge can be transferred from people to people. People who did not command knowledge of some field can learn from those who have commanded it. Therefore knowledge flows according to the gradient which is formed by the difference of knowledge levels of people. During this process, the knowledge level of those who have less knowledge will be raised. This is a gradual and continuous process. But there is another situation: when the current technology can not solve problems which people are facing, a new method will be invented and therefore the knowledge level in this field will leap to a new height.

As technology belongs to the scope of knowledge, of course it can be learned and also can be innovated. The mode of technology transfer corresponding to the process of learning is the gradient mode; the mode corresponding to the process of innovation is the leap mode.

3. The two stages of the leap mode.

For some fields or some regions, the process of learning from outside is a process of gradient transfer. But if this transfer of technology can quickly improve technology in other fields, it can therefore raise the whole level of the technology. Then from the regional viewpoint, this is already a technology leap. Of course the technology level is still lower than that of the most advanced nations. This is only a regional leap. Therefore it is a primitive

form of technology leap. But the impact is obvious and has already been proved by many facts.

When the technology gradient between some nations or regions tended to be zero, there would be no gradient transfer of technology. But when there were still problems required to be solved when the technology was already explored in the extreme limit, eventually some new breakthrough would appear. As soon as such new technology appeared, it would penetrate and improve all the technology fields. In a short time the whole technology level would leap to a new height. Either from the viewpoint of the region or the world, this was a new leap, therefore it was a high level leap. As soon as such high level leap happened, a new gradient between nations or regions would be formed and a new turn of gradient transfer of technology would take place. It was such interaction of the two modes of technology transfer that had pushed the technology forward continuously.

4. The spontaneous and activized development of technology.

Usually the gradient transfer of technology between some technology field of some region is always taking place. The driving force of pushing technology is the economic benefits. When either side of export or import can benefit from this transfer, the transfer will take place. If both sides can benefit then the process of transfer will be accelerated. But if one side has some economic loss, the transfer will stop. Most of such transfer is limited in a small scale and the impact to the whole technology level is quite limited. Also such transfer usually has no outside driving force or enforced policies; it is a spontaneous process. Therefore the speed of development of the general technology level of the backward regions is very slow.

The leap of technology is a totally different process. Even the primitive leap is not spontaneous. During the first industrial revolution, for example, England at first sent many people to the European continent to learn the technology. The purpose was to catch up with the advanced level of technology.

Around 1650, the technology of England reached the level of the European continent and the primitive technology leap was achieved. Thereafter, in 1665 Newton discovered the three basic laws of mechanics. In 1764 the new textile machine was invented. At last in 1784 Watt improved the steam engine and applied it to the major departments of industry. Thus the high level technology leap was achieved. Afterwards Germany exceeded England, and the United States exceeded Europe. Their technology leaps, even in the primitive stages were not spontaneous but were driven by goal making, policy making, and great endeavor. This is even true for the stages of high level technology leaps and the goals were achieved by use of a great quantity of funds and manpower. Entering the twentieth century, technology is developing in depth and the difficulty in development is larger. Therefore the efforts of individuals or a few people can not help solve the problems. If no organizational work is done to gather funds and manpower for carrying out the difficult exploitation, no breakthrough can be made. Even after the breakthrough is made, if no effort is made to organize manpower to popularize the new technology, this technology will not be able to improve all the major departments of industry, therefore there will be no technology leap. From the above discussion, we can know that the technology leap in modern history requires activation from outside the technology. But as soon as the technology leap is achieved, the economic leap will follow and therefore the economic benefits are huge.

THE LEAPING STRATEGY OF TECHNOLOGY DEVELOPMEMT

1. The leaping strategy is the main strategy of technology development.

There are several strategies for developing a nation's or a region's technology. For the technologically backward nations, the tracing strategy of gradient transfer mode can be used. For technologically advanced nations the strategy of actively exploiting the most advanced technology can be used to keep their leadership in technology. But considering that the leap mode exists, people will naturally use this mode of technological transfer and this is the

leaping strategy.

The technology development of different fields in different nations is always unbalanced due to different factors. Nations which are backward in technology will try to catch up and the competition is very high. Therefore the leaping strategy was often used and was successful in most cases.

Japan is a typical example of success in using the leaping strategy. It imported advanced technology from other nations and commercialized it quickly. In a short period Japan improved its major fields of technology and the primitive technological leap was achieved based on this gradient transfer. In the beginning of the 50s, immediately after the transistor was invented in the United States, Japan bought the expensive patent rights of this invention. Then Japan organized funds and teams to commercialize this technology and applied it to consumer products such as radio, television, and cassette recorders, which were not very advanced products but had a huge market. In this way Japan raised its economic power. Also some other technological fields were improved by this policy. In the beginning of the 60s, Nimanta Robot was invented in the United States. Japan immediately bought the permission of this technology and used it to improve the automization of its machine building and automobile manufacturing industries. Eventually Japan exceeded the United States in the automobile industry. In the 70s, Japan accumulated enough economic and technological force and thus switched to the high level technology leaping. For example, in 1976 it decided to invest 7.2 billion Japanese yuans to exploit the 256k very large scale integrated circuit. In 1980 the goal was achieved and it obtained a favorable balance of trade with the United States in this field. Recently Japan is aiming for new goals, such as the fifth generation of computers, preparing a new technology leaping. "Information technology strategy" represents this endeavor.

2. Technology import is the major method for technologically backward nations to achieve the primitive technology leaping.

A great quantity of facts has shown that it is essential to make a right choice of the import items of technology for achieving primitive technology leaping. It is also important to organize manpower to absorb and digest the imported technology and use it to improve the other technological fields and to increase the nation's economic power. It is even more important to study the high level technology leaping in the future. Technology importing does not always mean technology leaping. Some developing countries have already imported technology, but the goal of technology leaping was not achieved. The reason is that the import was treated as the ultimate goal rather than a means to achieve technology leaping.

CHINA SHOULD MAKE LEAPING STRATEGY FOR ITS TECHNOLOGY DEVELOPMENT

1. The historical background for making the leaping strategy.

Socialist modernization is our ultimate goal. Modernization is a dynamic concept which is time and space dependent. Therefore we should not only focus our concentration on China and a small period of history. We have already carried out an open door policy and the general economic tendency is from regional economy to world economy, therefore modernization has world meaning, that is, the modernization of China should be compared with the world's advanced level rather than be compared only with its own technological history. Therefore we should pay attention to the changes of the international environment due to new technological history. Therefore we should pay attention to the changes of the international environment due to new technological revolution, especially deep changes of economy and society. We should use the results of this study as the main basis for strategy making.

Since the 70s, the Western economy has entered a slow- or even zero-increase period. There are no important breakthroughs in science and technology.

Technology is developing according to the mode of gradient transfer and reorganization. When the speed of economy and technological development of the major Western industrialized countries is slowing down, it gives a chance for the technologically backward countries to catch up. Therefore the current world situation of science and technology is very favorable for the technologically backward countries to practice the leaping strategy. Meanwhile the policies made after the Third Plenary Meeting of the Thirteenth Central Committee of the Chinese Communist Party already released the production force greatly and a suitable social environment has been created. Therefore the conditions for making the leaping strategy has matured. If we can use these conditions timely and correctly, it is very possible that China can leap into the technologically advanced nations and keep continuously developing, before the coming of a new technological revolution.

2. Making an unhesitating decision and acting immediately by choosing breakthrough points.

We should choose suitable breakthrough points by careful comparisons. By means of technological imports we should achieve the primitive technological leaping in microelectronics, computers, information technology, and bioengineering. Such primitive technological leaping still belongs to the gradient transfer. We should use the results of such technological transfer to improve other major technology departments and push the whole technological level of China close to the world level. Then the primitive technology leaping of whole nation's technology can be achieved. During this period, attention should be paid to transfering the new technology to economic benefits and increasing the economic power. Attention should also be paid to organizing manpower to carry out fundamental research, to accumulate power, and to prepare the necessary conditions for the future high level technology leaping. When the technological level of China is equal to the world level, the high level technology leaping can

certainly be achieved if we still have back up power. At that time China will be a great nation of science, technology, and economy in the world.

THE MULTI-LEVEL STRATEGY OF TECHNOLOGY DEVELOPMENT

LIU YINGBAI

Jiujiang Metullugy and Coal Industry Corporation

The Marxists always pay attention to the important role of science and technology for the progress of the society. Marx thought that science is a driving force of history and therefore is a revolutionary force in the ultimate meaning. This is because the change of a society and the production relations are caused by the change of the production force and production tools; and science and technology are the major decisive factors in changes of production tools and production force. Therefore it is necessary to make a technology development strategy which can fast promote the progress of the science and technology of China.

THE DETERMINATION OF THE STRATEGY OF TECHNOLOGY DEVELOPMENT

Engels said, "as soon as the society needs it, more progress will be promoted than by ten universities." This vividly and accurately described the relation between science, technology, and economy. That is: science and technology are serving the economic needs of the society. In other words, it is only a means used to achieve the economic goals and to satisfy the social needs. The development of science and technology is decided by the needs of the economic development and the ability of the economy. But science and technology themselves decide the level and speed of economic development. Therefore the policy made by the Central Committee of the Chinese Communist Party is: the economic development will depend on the progress of science and technology, and science and technology should serve the

economic development. This policy reflects the objective rule of the development of science and technology and it is the starting point for the strategy of technology development of China.

The current situation of production technology and economic development can be summarized as multi-layer co-existing. There are very advanced and also very backward technology levels, also there are medium levels between them, in China. For example, the artificial synthesis technology of protein, the hybridization technology of rice, etc., are in the advanced level in the world, but there are also backward techniques such as the use of physical power by humans for transportation. The development of different regions and nationalities are very unbalanced. Logically we can not require a single mode and single level for technological development. From the viewpoint of improving the economic effects of all the fields and the whole nation, by considering the actual situation of unbalance, we should make a strategy of multi-level development of technology. By carrying out this strategy, science and technology will be promoted by the improvement of the economic effects and the increase of the economic power. Of course this multi-level development does not mean that all levels should be developed with an equal speed. We should try to use the most advanced technology if the current conditions permit us to do so. Such "most advanced" and "current conditions" could not be considered separately. Such technology should be practical and useful but not necessarily be the most advanced technology of the world, because some of the world level advanced technology might be impractical for China and could not be achieved soon by China. It is the most advanced among those which are practical for the current local conditions. Obviously such achievable technological level is not equal to the medium level and there is a distinct line between these two concepts. We can summarize the technology development strategy of China as: a multi-level technology development strategy which will use the advanced technology as much as possible. This strategy is based on the great goal of effectively improving the economic effects and is suitable for real situations.

It is a natural conclusion obtained from the scientific analysis of the dialectical relations between science, technology, and economy.

SEVERAL PROBLEMS WHICH REQUIRE APPROPRIATE DISPOSAL DURING CARRYING OUT THE STRATEGY OF MULTI-LEVEL TECHNOLOGY DEVELOPMENT

1. The relation between different fields, especially between the front fields and traditional fields.

With the fast development of science and technology, many new fields of science and technology and new industries are developed and are continuously booming. Among the most important ones are information science, system science, material science, genetic science, and electronic and computer technology, optical fiber glass, laser communication technology, robot technology, artificial intelligence technology, genetic engineering, bio-engineering, space technology, and ocean engineering, etc., which are based on the above sciences. Only the development of these front fields of science and technology and the new industries can promote the progress of the traditional science, technology, and industry. On the contrary, only the progress and improvement of the traditional science, technology, and industry can offer a profound basis and suitable environment for the development of the front of science, technology, and new industry. Therefore the correct policy should be: give priority to the development of new fields of science and technology, combining the development of the traditional fields of science, technology, and industry. Because the direction of the new science, technology, and industrial revolution is information and systematization, the most important front science and industry will be information science and computer industry. We must develop them with great effort and use them to promote the progress of the traditional fields of science, technology, and industry.

2. The relation between different sub-fields under the same field of

science and technology, especially between the leading sub-fields and the other sub-fields.

Each field of science and technology is divided into many sub-fields, and the development speed of different sub-fields can not be the same. Therefore some are leading sub-fields and some are not. Using biology as an example: today it has been developed into the stage of molecular biology. Based on the analysis of DNA, people can design new molecules by using genetic factors, therefore people can change and create new species of animals and plants with excellent properties. Obviously genetic factors and genetic engineering are the leading sub-fields of modern biology and we should develop them with great efforts. But the traditional species selection and development methods, which include distant hybridization, are still not out of date. Therefore we shoule still develop them. Compared to bio-engineering which is far from immediate practical applications, such traditional sub-fields still have important significance which we should not neglect. Therefore the correct policy should be: give priority to the leading sub-fields and at the same time actively develop the other general sub-fields to promote the fast development of all the fields.

3. The relation between the different regions, especially between the coast region and the far border regions.

The southeast coast region has better economic development and higher science and technology level, and also has a traditional and favorable situation for building connection with foreign countries. But it holds less energy resources and other resources, whereas the situation in the southwest and northwest regions is the opposite. The situation in middle China is between the two mentioned above. Thus for a field or an industry, there are different bases, different current situations, and different developmental promises. Obviously the coast region has the conditions for developing the leading fields of science and technology and new industries. This region will obtain more new information of science, technology, and industrial

revolution of the world. By digesting, absorbing, improving, and innovating this information, the development will be faster than the other regions. The development of the interior regions will also be accelerated by the new information obtained from domestic technical communication. Therefore this will form a promising picture of technical and economic development, which is step-like from the west to the east, from the interior region to the coast region. The whole technology and economy level of the nation will be pushed forward faster. Of course some fields, by their special features, will be developed faster in the west region than in the east region, such as the cultivation of glaciers and deserts, the exploitation of the salt lakes, the mining and refining of non-ferrous metals, etc. But these special aspects can not cover the general features. Therefore the correct policy should be: give priority to the leading fields and new industries in the coast region, at the same time actively develop the leading fields and new industries of the interior regions. That is: import technology in the east region and transfer the results to the west region, and develop both regions together.

4. The relation between the different departments of economy, especially between the military industry and civil economy.

Because of historical reasons, the development of the military industry was faster than the civil economy. But it is the development of the civil economy which offers the economic and material basis for the military industry; and it is the development of the military industry and the technical transfer from military industry to the civil economy which will promote the faster development of the civil economy. Therefore the military industry and the civil economy should be combined together closely. The correct policy is: give priority to the military technology, at the same time promote the development of the civil technology by the active technology transfer.

5. The relation between different enterprises especially between the large enterprises and the middle and small enterprises.

Large enterprises have more manpower, funds, and properties, therefore they

can absorb and develop new technology faster. But small enterprises have the flexibility to switch from one technology to another, and the flexibility to meet the requirement of current local situations and local resources. Under the current situation of improving the organization of specialities and economic planning, and improving economic effects, many small enterprises still have the driving force from the inside for continuous development which is the result of flexibly coping with current local situations. Therefore the correct policy should be: give priority to the use of the advanced technology in the large enterprises, at the same time help middle and small enterprises to improve their technology by strengthening the cooperation between the large enterprises and the middle and small enterprises.

6. The relation between technology, production, and construction.

Today, science research and technology development are already being separated from production and construction, and they have formed an independent system. This is a tendency of separation. But finally science research and technology development should serve the economic effects of the enterprises. Therefore there is a tendency of recombination between the research and development of science and technology and the production and construction of enterprises. This opposite tendency is so strong that all production and construction enterprises are strengthening their science research and technology development. They build their own research teams and build the research-production unity with other independent research institutions. Thus the production type enterprises are transferred into production-administration-research type enterprises. In this way the results of research can be transferred into the productive force and improve the economic effects. Therefore both sides will benefit from the recombination. This is an important point for the strategy of technology development. Therefore the correct policy should be: develop the science research and technology development with great effort, especially the research and development of production and construction enterprises, promote the research cooperation between research

institutes and production and construction enterprises to form many research-production unities and to effectively transfer the research results into productive forces and improve economic effects.

7. The relation between the research institute and the research personnel.

The research and development of China is composed of three parts: (1) fundamental science research which is mainly carried out by the Chinese Academy of Science and universities; (2) applied science research which is mainly carried out by specialized institutes, universities, and industrial departments; (3) technology development which is mainly carried out by industrial departments and enterprises. The structure of these three level research activities should be pyramid-like. The structure of the research personnel should also be pyramid-like. The task of the research teams is to solve the key problems of science and technology. First of all, we should choose the research topics by considering the needs of the economy, then organize suitable teams according to the degree of difficulty of the topics. Attention should be paid to: (1) a reasonable staff ratio of major staff to the staff of auxiliary specialities; (2) a reasonable staff ratio of the research personnel to the auxiliary technical personnel. It is most important to choose a good principal investigator. He should be the highest level scientist and well trained research scientist with the major speciality of the project. Therefore the correct policy should be: pay attention to the fundamental research, at the same time give priority to the applied science and technology development, especially strengthen the research and development of enterprises and form a pyramid-like structure; organize optimized cooperation between the major speciality and auxiliary specialities, and between the major research scientists and the auxiliary technical personnel; therefore make the transfer of research results to the productive forces as effective as possible.

8. The relation between learning from foreign countries and importing technology, and depending on China's own efforts and innovatively digesting the

foreign technology.

The starting point should still be on self efforts. This is not only because China is a large country with one billion people, it is also because the imported technology must be digested by our own technical personnel; only in this way can foreign technology produce real effects and we can talk about innovation. Therefore the correct policy should be: actively introduce and learn from foreign countries with advanced science and technology, at the same time pay attention to improve the ability of absorbing, digesting, and innovating foreign technology.

9. The relation between science, technology, and education, that is: the relation between technological revolution and the exploitation.

The development of science and technology in the recent thirty years is very fast. Some people call this "information expansion", "knowledge explosion". Such abundant knowledge of science and technology is truly the most valuable information resource of mankind. This type of knowledge is still increasing. In other words, the future society should be called "information society" or "knowledge society", because the value produced will be mainly created by mental labor rather than physical labor. Therefore society will put higher requirements on each member. The society requires people to exploit their intelligence and become mental workers with high level educational and cultural cultivation. Therefore the popularization of education and the exploitation of intelligence are the prerequisites of the development of science and technology. The multi-level strategy of developing science and technology does not require the immediate achievement of single high level of education for all the people. On the contrary intelligence exploitation is in the form of multi-level; that is pyramid-like and the progress is wave-like. We should organize the education of young students and adults according to this multi-level structure and therefore make a good match between the intelligence exploitation, science, technology, and economy. Therefore the correct policy should be: give priority to the education and intelligence

exploitation, thus preparing a good basis for the new revolution of science, technology, and industry.

SCIENCE PREDICTION IS THE BASIS FOR MAKING THE STRATEGY OF TECHNOLOGY DEVELOPMENT

Wang Yicheng

Wuhan Institute of Construction Materials

PART ONE

Science prediction has two aspects of meaning: 1. science requires prediction; 2. prediction must be scientific.

Science requires prediction (here science includes technology). Science prediction is defined as that making correct estimation of the direction of development of science and the impact produced by such development. The significance of science prediction is: first, it can point out the direction for science research and help scientists to avoid aimlessness of the research. This is reflected in the determination of goals and topics of research. For technology research, the research topics should be those which have good promise but are not solved yet in practice. For example, Bell Laboratory chose semiconductors as its research goal after World War II and succeeded. Second, it should be able to point out the direction for the application of the research results and for improving the economic effect. For example, the "dry printing" technology invented by Carlson underwent many years of development until it was applied in practice. But the early apparatus was designed by pure experience, the cost was high and the volume of sales was small. Science prediction had shown that along with the progress of people's understanding of the properties of electric charges in materials and the research of new materials which were more suitable for image formation and image developing, the experiential method would eventually be replaced by scientific

process design, and the quality of the dry print technology would improve greatly. This encouraged many enterprisers to invest a large amount in this technology. As a result, science prediction became reality. In the end of the 70s, the total sale of copy equipment of the world exceeded 4 billion U.S. dollars. Third, it should be able to point out the major aspects of the deep impact on society by the technology development. Therefore it will offer a basis for making a suitable policy for the economic and social development. The deep impact of the development of science and technology is well known. One of the most important functions of science prediction is that it can point out the impact to the whole society by science and technology, point out the degree of such impact by each individual technology and therefore encourage people to take suitable actions to cope with such impact, then promote the progress of human history.

Prediction must be scientific. When we say prediction must be scientific, usually we mean that the results of prediction are correct. But in order to obtain correct results, we must observe scientific rules and use scientific methods. These two aspects are correlated to each other: only by making prediction scientifically we can obtain scientific prediction. The prerequisite of making prediction scientifically is that we should consciously use the objective laws of the material world as the basis. Science prediction itself is to reveal the objective laws of the material world. Development of modern technology depends on the progress of the understanding of the fundamental laws of the objective world. The deeper we understand these rules, the more precise our prediction will be. Furthermore, the use of scientific methods of prediction is also very important. Some people divided the methods of prediction into exploration and normalization. The so-called exploration method is to make prediction according to the current technology and point out the possibilities of development; the so-called nomalization method it to consider problems according to the standard of the future technology. The extension method, the curve method, the analogy method, free discussion, and voting method

belong to the first; the free representation, the network method, and the anticipation method belong to the second.

PART TWO

The strategy of technology development must be built on the basis of science prediction; this is decided by the three pairs of conflicted aspects which we have to solve.

First, the requirement of the relative stability of the strategy of technological development and the acceleration of the progress of science and technology.

An obvious feature of the modern technology is that the period between the invention and the practical application is shortened. The usual period from invention to application of the modern technology is not longer than five years.

But there is an important feature for the strategy of technological development, that is, it requires relative stability. This requirement is decided by the following characteristics: 1. the long period nature of strategy; 2. the seriousness of strategy; 3. the complicated correlation with other social systems. As we know, as same as the other strategies, the strategy of technological development deals with long term, general and directional problems of technological development such as the technological structure, driving forces, goals, etc. It does not deal with the specific projects, plans, and temporary policies, but is a general policy body which should play guiding functions for a long period. Thus as soon as we have made a strategy of the technological development, we should guarantee long term stability of this strategy. Of course, when the situation changes, the strategy should not be absolutely unchangeable but needs continuous improvement. But the change of the direction of the strategy should be treated very carefully. It is not permitted to make frequent changes, otherwise many problems and even crisis will arise. Therefore we should pay attention to the

seriousness of the direction change of the strategy. The partial adjustment of the strategy is always needed, but the strategy of technological development is a large system and it has very complicated relations with other systems and with its own sub-systems. Therefore any adjustment of the strategy of technological development will require all the other related systems to make corresponding r actions. This is the correlation for the adjustment of strategy. The above characteristics decide that the strategy of technology development must be relatively stable.

Therefore the conflict between the acceleration tendency of the technological progress and the relative stability of the strategy of technological development is formed. But such conflict is not unresolvable. An important method to solve this problem is to strengthen the science prediction. If the prediction of the technology development is correct, then the instability of the technology progress can be transferred to stability. Such stability can be reflected in the strategy of technological development and the stability of the strategy can be achieved. This is one of the reasons that the strategy of technological development must be built on science prediction.

The second conflict is the conflict between the stability requirement for the large production and the shortened period of technology development.

We have mentioned that the frequency of the period from new invention to application is accelerated. This means that the renewing of technology is accelerated, or the time for a new technology to be out of date is shortened. According to statistics, the aging period of technology was 40 years in the first ten years of this century, 25 years in the 30s, 15 years in the 50s, 8-9 years in the 70s, and 3-5 years in the 80s. The shortened period of aging of technology will certainly lead to the shorter lifetime of the new processes, new equipment, and new products. Or we can say that the aging rate is increasing. According to statistics, in economic developed countries, the lifetime of new materials is about 10 years, the lifetime of new processing methods is about 7 years, and the

lifetime of new products is about 6-8 years. The lifetime of some new products is only 2-3 years. Within the recent 10 years, about 30% of the methods of technology were already out of date, and more than 50% for electronic industry. During the same period, many new products and processing methods were invented. Since the 60s, only in the field of space industry, about 12,000 new products and new processing methods were developed.

The shortened period of the lifetime of technology and products will bring many difficulties to the investment and production. The reason is very obvious: a certain amount of time is required for a new plant from design, construction, to production. Although the advanced technology level makes the construction period shorter, but relative to the shortened period of new products, the construction still requires some degree of stability. The time period required for medium or larger plants from planning, funcing, land purchasing, design, construction, installation of equipment, to production is at least 3-5 years, some even require more than 10 years. Thus a serious problem appears, that is, before a new plant being put into production, the technology or products might be already out of date.

The third conflict is the principle of economic effect of the strategy of the technology development and the higher risk of technology development caused by the larger scale of technology.

The final goal of strategy of technology development is to improve the economic effect of the industry and to strengthen the economic power of the nation. If the new technology can not bring economic benefit to the enterprises and to the nation, then such technology will have no promising future and will not be applied to production. Similarly, if the strategy of technology development does not set economic effect as its final goal, then this strategy can not be approved. Therefore economic effect is the core of strategy of technological development.

But the progress of technology makes the technology itself become more and more complicated. For example: the technology elements are increased, the correlated factors of the technology process are also increased, the types of

products are increased, and the number of components are increased. In order to achieve technological progress, the scale of enterprise and investment required by the new technology are increased. According to an estimation, the old radio equipment only had 10-15 devices, but not the number of devices are increased by 1,000 times. A plant with 5,000 employees was already a large plant before, but now it is common that a plant has 30,000-40,000 employees. Now each research and development project requires funds a hundred times more than before. As for some important leading technology, such as nuclear energy, space shuttle, etc., the cost from the research to the application was as high as several billion U.S. dollars or even more. This continuously enlarged scale of the technology brings huge risks to economy.

Here the goal of economic effect of the strategy of technological development meets the high economic risk of the new technology. Success of the new technology will bring huge economic benefit to the users, but failure of the application of new technology will bringe huge economic loss to the users. We can not refuse the new technology even if we have to face the risk. The right attitude is that we should make the right choice of a new technology by scientific prediction.

According to the above analysis, the three pair of conflicting aspects have founded the basis of science prediction. In a short summary, science prediction is an important prerequisite for making a scientific, stable, and economic strategy. This is the problem we can not neglect when we make the strategy of technological development.

PART THREE

The relation between science prediction and the strategy of technological development is much more complicated than what we analyzed above. Following is a general summary which does not consider the specific content, methods, and goals of science prediction, but only considers the pure process of science prediction.

The prediction of science and technology is no longer primitive information. It has abstract nature and scientific value obtained by a series of analysis, summarization, judgement, and proof. Such prediction will be sent to all the related departments, such as the National Science and Technology Committee, Chinese Academy of Science, government ministries, science and technology institutes, and consulting institutions, etc. All these institutions will submit suggestions for the technology development based on their own specialities. Then some coordinating institutions will fully consider these suggestions based on the general prediction of technological development, and make a final strategy of technological development. With this strategy as a guide, the related departments will make a series of policies and plans for technological development, and also make detailed projects for achieving the goals. The results of the projects carried out will be fed back to the predictors. In this manner science prediction and the strategy of technological development will form two basic factors in the hugh technology development system. Therefore science prediction will not be a negative factor.

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