Founding of the Chinese Academy of Sciences' Institute of Computing Technology

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Computer science originated in the People's Republic of China in 1956 with the founding of the Chinese Academy of Sciences' Institute of Computing Technology. The Soviet Union, which played a pivotal role, gave the Chinese the opportunity to learn computer science by supplying components and describing the manufacturing process. The Soviets also helped solve key difficulties and trained workers.

In 1956, the Chinese Science Planning Commission of the State Council organized scientists around the country to prepare a report for developing science and technology over the next 12 years. This report led to the founding of the Chinese Academy of Sciences' Institute of Computing Technology.

In this article, we describe the events and ideas that led up to the institute's founding, including the role played by the Soviet Union and Soviet experts. The Soviet Union not only helped the Chinese become acquainted with computing technology but also made suggestions for managing Chinese development efforts.

Overview: A technology policy

On 1 July 1949, the Chinese Communist Party formally adopted a policy—called *leaning to one side*—of looking to the Soviet Union for technological and economic advice. Chinese leaders had little choice but to accept such a policy, because the US and other Western countries were refusing to export technology to China. Responding to the actions of the Western countries, the Soviet Union hoped to bring China within the block of socialist countries.

Public evidence of the Soviet strategy was seen in 1954, when a delegation of Soviet officials, led by the new premier, Nikita Khrushchev, visited China and promised greater scientific, technological, and economic aid.

In 1956, with the assistance of the Soviet experts, the Chinese government developed a protocol, outlined in the report *Long-term Protocol for Developing National Sciences and Technology between 1956 and 1967*. This protocol proposed to increase investment in 12 important fields of science and technology. Chinese officials identified four fields as critical for national security: one was computing technology. They stated that developing these fields would require an emergency effort because of pressure from the West. On the basis of this report, the Chinese government decided to develop electronic digital computers, establish the Institute of Computing Technology of the Chinese Academy of Sciences (CAS), and—most significantly—to borrow the basic computing technology from the Soviet Union.

For the Chinese to produce results, they needed the Soviet Union's help. The Soviet Union began in the early stage of the 1950s to supply informal aid, consisting of informal exchanges of information and suggestions on developing computing. In 1956, the Soviet Union helped China create the plan for developing computing technology over the next 12 years. In 1958, the Soviet Union formalized an agreement with China, called the 122-Project Convention (*The Convention on Soviet Union and China Cooperating and Soviet Union Helping China with Significant Scientific and Technical Research*). Consequently, Chinese scientists were able to create the model 104 computer by 1959.

Soon, however, tensions began to build between the Chinese and Soviet governments. The leaders of the Soviet Union and China never fully trusted each other. While China was determined to master modern technology, especially national defense technology, the Soviet leaders was always of two minds. On one hand, Soviet leaders remained unsure of Mao Zedong's desire to stay independent of Soviet technology, nuclear protection, and general strategy, and expressed reluctance to provide China with advanced weapons. On the other hand, Mao Zedong was needed to support the Soviet Union's leadership inside the socialist bloc during Nikita Khrushchev's campaign to remove Stalinism in 1956. Khrushchev agreed in 1957 to give China advanced military technology. Thereafter, he and Mao Zedong slowly moved toward different interpretations of socialism and communism, and their divergence escalated.

In July 1960, the Soviet Union withdrew its experts from China, an event that marked the breakdown of Sino-Russian relationships. In subsequent years, the two countries became increasingly antagonistic. The Soviet Union began reducing its aid to China in science, technology, and the economy and stopped all aid in the late 1960s. Despite this turnabout, China continued to develop computing technology and successfully created a set of fast, transistor computers in 1965 for national defense and all-purpose use.

Because Chinese computing technology related specifically to military needs, the history of that technology has seldom been disclosed. In recent years, however, some publications have described parts of this history.[1] Also, some of the computer researchers of the 1960s have discussed how they duplicated Soviet computers. In these accounts, Chinese researchers usually emphasized the Chinese effort and rarely discussed Soviet aid.

Before we began our research, the most important international research paper was "Computer Technology in Communist China (1956–1965)," written by Donald G. Audette in 1966, which described the development of Chinese computing technology.[2] However, because Audette could not obtain sufficient, reliable sources for crucial context, his description and conclusion were incomplete. For example, Audette stated that China hadn't mastered computing technology before Soviet experts left China and that the first Chinese computers were used mainly in mathematical calculation.

As we will explain, Chinese scientists mastered computing technology before the Soviets left, and their work was used for many applications. Using archival records as well as the testimony of early Chinese computing experts, we describe the foundation of the Institute of Computing Technology within CAS and show how computing technology was transferred from the Soviet Union to China.

Early research and decision making

As we've said, CAS was founded in 1949. Three years later, CAS scientists created a tentative plan to develop computing technology and organized a computer research group led by Hua Luogeng.[1] In July 1953, a delegation of CAS researchers, who had visited the Soviet Union earlier that year, held a special symposium on science and technology. During the symposium's mathematics section, Hua proposed that China develop skills in differential equations, mechanics, elliptical functions, mathematical statistics, and computational mathematics. Hua also advised China to ensure that these skills were disseminated at Chinese universities to train engineers and scientists.[3] This proposal caught the attention of CAS's leaders. On 15 October 1953, CAS held a meeting to discuss the scientific research plan for an Institute of Mathematics. The research plan included implementing Hua's proposal.

At this meeting, Hua recommended that China put into practice, and learn by experience, what it had acquired from the Soviet Union and establish eight mathematical research divisions, or groups, one of which would study computational mathematics.

Hua believed that computational mathematics was urgently needed and was the weakest link in Chinese research. However, Qian Sanqiang, director of the CAS Institute for Modern Physics, thought the CAS plan for developing electronic computers was too ambitious because it required a significant investment of equipment and people. He suggested that computers be developed through a plan that would begin with the simplest objectives and develop more gradually, working with the CAS mathematical divisions. Wu Youxun, vice president of CAS, agreed and decided that the academy should develop computational mathematics and train professional specialists in this field by building an electronic computer. He also concluded that research for electronic computers should be done in the Institute of Physics' electronics group and ordered that Hua's computer research group be transferred to that institute.[4]

By early 1954, China was already studying Soviet computing technology. The CAS computer research scientists had translated the

Soviet book *The Approaches to Study Radiant Electronics* (edited by A.A. Sanin, published in 1958) to study radio tube pulse circuits.

Furthermore, in October 1954, three kinds of computers were shown at the Exhibition of the Achievements of the Soviet Economy and Culture Construction in the Soviet Exhibition Hall (today's Beijing Exhibition Center). The exhibition had an analog computer, an electronic integrator to work out linear differential equations, and a computer to calculate a deflection differential equation. At director Qian's request, the CAS computer group spent a lot of time learning, studying, and analyzing these three computers.

CAS's 1954 research plan included the study of computational mathematics. The Institute of Mathematics would conduct the research; in conjunction, the Institute of Physics would study computing machines. This plan called for scientists from both institutes to prepare a working laboratory in 1955 and, if possible, begin the mathematical design of an electronic computer.[5] An interim report that CAS issued, the *Developing Plan of Science Undertakings of CAS between 1953 and 1957*, didn't outline a further plan on computing technology.[6]

On 4 October 1955, the Division of Physics, Mathematics, and Chemistry held the fourth meeting of the CAS standing committee, at which nuclear physicist Deng Jiaxian gave a preliminary report on the division's research development. He said that mathematics would first deal with three subjects—differential equations, probability and mathematical statistics, and computational mathematics. Only after a mathematics department had been established in these areas would the mathematicians begin to further develop computational mathematics. He also suggested that a department of computing technology be established instead of a department of computational mathematics.[7]

Within CAS, growing interest in computing machines was matched by a similar interest within the Chinese government.[8] In January 1956, the Central Committee of the Chinese Communist Party held a conference of intellectuals, where Premier Zhou Enlai emphasized that the computer was an important technical revolution.[9] According to the recollections of computer scientists Xia Peisu and Zhang Xiaoxiang, the Central Government began, by March 1956, to acknowledge the importance of developing electronic computers. About this time, they decided to give electronic computers a place within the long-term protocol for developing science and technology. The Central Government also invited Sergei A. Lebedev, superintendent of the Soviet Academy of Sciences' Institute of Precision Machinery and Computing Technology Research, to China to help plan the research for computing technology.[10]

At the same time, the Chinese scientists had made some independent progress in developing computing circuits. For example, in April 1956, Wu Jikang of the CAS computer research group succeeded in demonstrating oscilloscope tube memory.[1]

Suggestions from Soviet experts

In conjunction with their research on computing technology, Chinese scientists were receiving advice from the Soviets. In August 1955, a delegation from the Soviet Academy of Sciences visited China. A member of this delegation, a Mr. Kostenko, suggested that China should investigate electronic analog computers.[11] Another Soviet scientist, a Mr. Cherkashin, suggested that China send researchers to study analog computers at the Soviet Academy of Sciences and then bring the computers back to China.[12]

On 5 January 1956, the CAS standing committee met to discuss plans for establishing the Institute of Mechanics. At the meeting, Boris R. Lazarenko recommended that CAS should use computers for cybernetic work and research.[12] The meeting participants quickly approved this suggestion. Accordingly, the committee asked Hua, the deputy director, and Qin Lisheng, the deputy secretary-general, to prepare a research plan that would create an electronic computer.[13]

This program did little to advance computing research, however. A more important event in the development of Chinese electronic computers was a March 1956 conference in Moscow, on utilizing mathematical machines and instruments for Soviet manufacturing and development. The secretary-general of the presidium of the Soviet Academy of Sciences, A.V. Topchaev, invited a CAS delegation to this meeting. The meeting participants discussed problems of designing and programming high-speed electronic computers, as well as the problems of special computers and analog devices.[14] The delegation CAS sent included Min Naida, Hu Shihua, Wu Jikang, Zhang Xiaoxiang, Xu Xianyu, and Lin Jianxiang.[14]

These delegates were responsible for preparing a computing technology research plan. While visiting Moscow, they paid close attention to the Soviet experience. They visited the Soviet Academy of Sciences, including the Institute of Precision Machinery and Computing Technology, the Computing Center, the Institute of Dynamics, the Institute of Autocontrol and Distant Control, and the Computing Center at Moscow University's mathematics department. They saw the newest Soviet computer, the BESM—*Bystrodeistvuyushchaya Elektronnaya Schetnaya Mashina* (high-speed electronic calculating machine)—and they investigated the curriculum of Moscow University's computer machine department.

Meeting with Lebedev

The delegates also attended symposia with key Soviet scientists: S.A. Lebedev, who had designed the first Soviet computer, A.A. Dorodnitsin, the director of the Computing Center of the Soviet Academy of Sciences, and S.L. Sobolev, the director of the mathematics education and research group at Moscow University.

During his symposium, Lebedev made a number of important recommendations:[14]

1. *China should set up a research organization of computing technology*. This organization should have a research institute of precision machinery and computing technology, a computing center, and a rudimentary factory like those in the Soviet Union. This organization should have approximately 100 researchers in the institute and 50 workers or so in the factory. At the beginning, the computing center could be combined with the research organization. The computer center could be removed after three years and operated as an independent organization.
2. *China should actively train workers for this new field*:
   - Postgraduates from China would attend classes in the mathematics and mechanics departments at Moscow University, and should start studying computing technology immediately, so that they would master the technology.
   - China should create two computer research groups of mathematicians and electrical engineers. In each group, at least one or two persons should be mechanics specialists. The group size could range from 10 to 25 people. Each worker should hold a graduate degree.
   - China should send two groups of Russian-speaking high school graduates to study in the Soviet Union. Each group should consist of 25 to 30 students. One group would study computational mathematics in Moscow University; the other would learn how to build a computer at Moscow Dynamics College. Chinese students would follow an accelerated plan so that they would finish their study within three or four years.
   - In China, there should be 40 to 100 people who could change their professions and become computer researchers. Invite Soviet experts to China to give lectures on a short-term basis, say, for one month so that the Chinese could study theories of computing. One goal was for Chinese students to teach computing in the future, even before computing machines were available.
   - Chinese universities and colleges should start courses in computational mathematics and computer manufacture. Soviet experts could visit these schools to teach the courses that the Chinese were unable to teach.
   - The Chinese should use Soviet reference books and textbooks, and whatever books it can acquire from the UK and the US. The Soviet Union could provide any information that China needed on the subject of computation.
   - After 5 or 10 years, China should be graduating 200 to 300 graduates in computational mathematics, and 500 to 600 graduates in computer manufacture each year. Those numbers could change depending on the pace of development in China.
3. *China should pay attention to the development of the radio industry and the hardware of high-speed electronic digital computers*. Specifically, it should develop radio components, radio tubes, ferromagnetic materials, semiconductors, photoelectric materials and photographic materials, printed circuits, magnetic tape readers, industrial assemblies, and cables.

Lebedev further recommended that this work should be done with creativity and self-reliance. He gave a three-step plan:

1. First, the Soviet Union would transfer the Soviet machines to China (under the condition of owning the Soviet machines)

and China would train its operators to use and manufacture computers.
2. Next, China would build its own machines from Soviet material and parts.
3. Finally, China would build its own machines using Chinese materials and parts.

On their return to China, the delegation reported Lebedev's recommendations and added comments of their own.[14] The group reported that:

1. We have studied the development of the electronic computer in the Soviet Union. We discovered that the plan the Soviet Union used to develop the computer is similar to the plan established by CAS in 1953 to enter the field of computing machines and to establish Chinese independence.
2. We learned the details of the Soviet organizations in this field and how mathematicians and engineers cooperate to establish a new independent computing department. We learned how Chinese organizations in this field should be established to be most effective.
3. Through this visit, we increased our specific knowledge of the electronic computer and its importance and developing perspective.
4. By talking with Soviet scientists, we gained further ideas about the relationship between the theoretical problems in researching electronic computers and practical problems. We also learned the subjects that we should emphasize to develop our own computer industry.
5. We appreciated the spirit of the Soviet scientists working in research and development within a socialist state. We saw how this spirit supports a socialist society by initiating advanced work, by carrying out and completing such work. This was a good example for us to learn from.

By attending this computing technology congress, the delegation gained significant ideas for developing Chinese computing technology.[14]

Long-term plan for technology

The CAS delegation's visit to Moscow coincided with an effort to develop a 12-year long-term protocol for developing a national science and technology program in China. This plan had been initiated by the Chinese State Department in January 1956 and was conducted by the Science Planning Commission of the State Council. Premier Zhou Enlai himself guided this task.[15] The Science Planning Commission began its work in Beijing in March 1956. According to CAS vice-secretary-general Du Runsheng's recollection, the Science Planning Commission prepared the report *Long-term Protocol for Developing National Sciences and Technology between 1956 and 1967* with help from Soviet consultant Lazarenko.[16]

The Science Planning Commission assigned a group of experts—mathematicians, computer experts, and other specialists from the Chinese Department of Electronic Industry—to write the computing plan. The group included some of those who had participated in the March 1956 Moscow meeting. It also included people who had studied in the US and knew something about computer development there.[17]

The 12-year plan encouraged education and research.[18] While developing its plan, the computing technology planning commission offered a series of public lectures by members of the Chinese delegation who had attended the March 1956 meeting in Moscow. These lectures presented worldwide developments in computing technology, explained the work of CAS's computer research group, and at one lecture, scientists demonstrated a drum memory that CAS had recently developed. Qian Xuesen, superintendent of CAS's Institute of Mechanics, discussed the necessity of developing an electronic computer to assist his work in designing jet and rocket technology.[19]

Shortly after the 12-year plan was initiated, D.U. Panov, director of the Soviet Institute of Information and deputy director of the Soviet Academy of Sciences' Institute of Computing, replaced Lebedev in China as the consultant to the Science Planning Commission. After Panov arrived in Beijing, he gave lectures about computer development to Chinese experts and to the Military Commission of the Chinese Communist Party's Central Committee.[20] He introduced the topic of computer research, explained the Soviet experience with these machines, and discussed how the Soviet Union had developed computers. He brought documentation for the Chinese: six copies of a report related to the BESM and one copy of a paper on program design,[21] and indicated that the Soviet Union would help China manufacture computers.[22] Panov gave many helpful suggestions about the Chinese computing plan: identified projects that should be promoted, explained how Soviet electronic computers could be purchased, detailed which people could be sent to the Soviet Union to study, and so on. Furthermore, he suggested to Hua Luogeng that a delegation be sent to the Soviet Union to visit and study for a short time as soon as the computing plan was complete. The delegation's members could then teach others about computing technology when they returned to China.[1]

'First assembling, then separating'

Members of the Chinese Planning Commission had differing opinions about starting computer research. Some insisted that a large delegation of Chinese scientists be sent to the Soviet Union for training and then come back with Soviet-made computers. The Soviet Institute's Panov agreed with this idea as did Cherkashin. But because the commission could reach no agreement, the planning group could take no action.

Within the Planning Commission, some scientists said that China should establish many institutes (generally within universities) and that these institutes should conduct research independently. After discussion, the group concluded that China should first establish a central institute but eventually create a number of independent institutes. This idea, first articulated by Hua Luogeng, was called *first assembling to surmount difficulties and then separating to develop*. The idea was that, first, China would collect researchers from many disciplines into a new Institute of Computing Technology. Then, as the group matured and trained more researchers and workers, it would gradually be dispersed into smaller, independent institutes.[1]

In June 1956, the Planning Commission completed the *Long-term Protocol for Developing National Sciences and Technology between 1956 and 1967* report. The protocol consisted of 57 significant science and technology tasks. Task number 41 related to the foundation of computer technology and became the guiding document for developing China's computing technology enterprise.[23] The long-term protocol report defined the purpose of China's computer research: to improve the national economy, national defense, and academic research. It outlined the status and comparison of Soviet and Western computer research, and it described the relevant specialties in Soviet universities. The report also acknowledged that China had no electronic digital computers and that China was very weak in other relevant aspects. Finally, it stated that China lacked a comprehensive, long-term, and integrated plan for creating computers.

Accordingly, the plan emphasized that China should begin as soon as possible to design and manufacture a high-speed, all-purpose digital computer and to master the basic technology to develop different types of computers. The report recommended that China study Soviet achievements in this field while it resolved problems such as computer program design, automatic translation, and so on.

Steps for researchers to take

The long-term 1956–1967 plan, following the *first assembling and then separating* principle, outlined the steps that Chinese researchers should take. It proposed creating a special office to create an Institute of Computing Technology in CAS with the Soviet Union's help. This temporary office would prepare for the institute's official creation in 1957. Other institutes would collaborate with CAS's Institute of Computing Technology until they could gradually release their own personnel to other institutes. The 1956–1967 plan also stated that the new Institute of Computing would have manufacturing facilities associated with it and that CAS would establish a computing center in 1959, with the expectation that this single center would quickly expand into two or three centers.

With regard to acquiring international equipment, the 1956–1967 plan called for China to purchase electronic computers manufactured by the Soviet Academy of Sciences' Institute of Computing Technology. Further, the plan specified that Chinese experts would design electronic computers with help from Soviet experts—moreover, that China would work to produce hardware based on Soviet hardware by 1957. The plan went on to stipulate that China would purchase any equipment that it couldn't make for the computer manufacturing facilities, from either the Soviet Union or Western socialist countries.

As part of its work, the temporary office would establish a one-year computer training class to teach the basic concepts of computer manufacture and operations. According to the 1956–1967 plan, this office would continue to teach this course for three or four years. By then, graduates could create their own classes at Chinese universities. The temporary office would create a library of the relevant books and periodicals relevant on computing technology.

Training the researchers

The 1956–1967 plan gave specific details about training Chinese researchers:[23]

- To train computer engineers, the new Institute should send a group of 10 to 25 radio or electrical engineers to the Soviet Academy of Sciences' Institute of Computing Technology for one year;
- To train professional people in programming and computing technology, China should send 10 to 25 students to the Soviet Academy of Sciences' computing center for a year;
- To improve the professional level of the teachers in electronic computers, China should send a group of teachers to the Soviet Union to study for one or two months in summer 1956;
- To study the manufacture of electronic computers, China should send about 25 to 30 high school graduates to the Institute of Motion Dynamics. It should also send another 25 to 30 high school graduates to Moscow University to study computational mathematics. The Soviet Higher Education Commission would be asked to make a special, accelerated learning plan for these students so that they could be qualified as experts within four years instead of the normal five and a half years.
- China would request that the Soviet government send teachers who will give courses in computers and computing technology. Meanwhile, these Soviet teachers could also teach the training courses given to Chinese engineers in mathematics and take on some work in the Institute of Computing Technology.
- Programming and computational mathematics courses would be added to the curriculum of Chinese college and graduate students studying mathematics and mechanics in the Soviet Union. In addition, Chinese students in the Soviet Union who were studying electrical engineering would also take courses in designing and manufacturing electronic computers.

Comparing the suggestions that Lebedev had made during the March 1956 Moscow conference attended by the Chinese[14] and the plans in the *Long-term Protocol for Developing National Sciences and Technology between 1956 and 1967*[23] for the foundation of computing technology, we see that the plan's basic contents were essentially those originating with Lebedev, having been brought back to China by the Chinese delegation. These ideas had also been articulated by the Science Planning Commission of the State Council and by Panov after he arrived in China.[24]

Emergency development measures

The State Council's Science Planning Commission then presented the 1956–1967 plan to Zhou Enlai. Zhou, however, responded that the printed book was too detailed—he wanted a report that analyzed only the most urgent issues.[25] In response, the State Council organized a team to prepare emergency measures to speed up development of computers, semiconductors, automatic control, electronics, atomic energy, and missiles. The Science Planning Commission's secretary general, Zhang Jinfu, asked Qian Sanqiang, Hua Luogeng, Qian Weichang, Wang Shouwu, and Luo Peilin to draft the emergency measures report. Lougeng wrote the section on computers, and Peilin wrote about electronics. Secretary General Jinfu outlined five emergency measures, plus a sixth on missile development for vice prime minister Nie Rongzhen to implement.[26] Because China, at that time, kept secret its activities in atomic energy and missile development, the committee separated these two issues from the rest. The other four emergency measures were assembled into a report titled *The Emergency Measures and Projects about the Development of Computing Technology, Semiconductor Technology, Radio Electronics, Automatics and Long-Distance Controlling Technology* (the report is known in shortened form as *Four Emergency Measures*).[25] Computing technology was included in the final draft because of Qian Xuesen's influence. The superintendent of CAS's Institute of Mechanics cited many examples to illustrate the importance of high-speed electronic computers. These examples sufficiently persuaded the committee to identify computing technology as one of the emergency measures.[27]

On 20 May 1956, the *Four Emergency Measures* report was officially presented to the State Department, championed by Zhou Enlai, and was approved.[28] The Science Planning Commission of the State Council officially printed the report later, on 5 July.[24] The section on computing technology looked much like the earlier (1956–1967) government report on establishing computing.[29] The main difference between the two reports was the tone. In contrast to the original report, *Four Emergency Measures* stated that China should take steps as quickly as possible to develop its computing technology and to cooperate with the Soviet Union.[29]

Meanwhile, following Zhou Enlai's instructions, the CAS commissioned Hua Luogeng to take charge of preparing the office of the Institute of Computing Technology. On 19 June 1956, Hua chaired the preliminary meeting of the Preparation Commission for the Institute of Computing Technology—Preparation Commission, for short.[30] It was called the Preparation Commission because officially, the CAS Institute of Computing Technology was not founded until May 1959. Attending the meeting were the vice secretary-general of CAS, Du Runsheng, and the vice director of the Division of Mathematics, Physics, and Chemistry, Yun Ziqiang. The commission—consisting of computing experts from CAS, various government agencies, and colleges and universities—was formally accepted by the government on 25 August 1956.

The Preparation Commission oversaw three research departments, one administration office, and one experimental factory. The first research department, which dealt with computer software and operations, was directed by Min Naida. The second research department, the hardware department, was directed by Wang Zheng. The third research department dealt with computational mathematics and was directed by Xu Xianyu.

The administration office had five personnel divisions: secretary, general affairs, equipment, accounting, and a translation group. There was also a temporary training class controlled by the Preparation Commission. Two years later, in November 1958, the commission would establish an information division. These organizations employed Soviet experts to give lectures and guidance. They translated and published several dozen books and pamphlets on special computing subjects and compiled a Chinese-Russian dictionary of computing technology.[31] In December 1958, the preparation office would create the first Chinese computer journal, *The Trend of Electronic Computers*.

Second CAS study delegation

After creating the Preparation Commission, CAS organized a second study delegation to visit the Soviet Union. CAS decided to send a group of researchers with practical experience, a strong theoretical background, and who were roughly 35 years old.[10,32] In August 1956, the Science Planning Commission of the State Council invited Zhou Shouxian of Qinghua University, Xu Xianyu of Beijing University, and Jiang Shifei of the Beijing Institute of Aeronautics to join the group. This invitation was followed, three weeks later, by a letter from the third department of the Headquarters of General Staff of the military, which asked CAS to choose a cadre of 10 others to study electronic computer technology at the Soviet Academy of Sciences.[33] The CAS delegation consisted of 15 people. Most were scientists; several were translaters and one was a secretary.

The investigation group met during late August and early September to prepare for their trip. Three basic documents guided their preparations: "The Working Planning of the Computing Technology Investigation Group of CAS in the Soviet Union," "The Designing Assignments of the Institute of Computing Technology of CAS," and "The Tentative Working Contents of the Computing Technology Investigation Group of CAS in the Soviet Union." The first of these documents dealt with the scope of the trip; this paper instructed CAS to send 10 researchers to the Soviet Union so they could learn about the state of Soviet work on computing.[24]

"The Working Planning of the Computing Technology Investigation Group of CAS in the Soviet Union" paper dealt with many problems in computer research, including the direct transfer of technology from the Soviet Union to China, the training of senior Chinese researchers, the organization and management of computer research, the education of new computer scientists, and the collection of books and other instructional material on computers. Moreover, the delegation was instructed to visit Soviet labs, to discuss matters of technical cooperation, to see the work relevant to mechanical manufacturing and mathematics, to learn how to conduct a computer training course and how to set up a computing specialty in universities, and to learn how to administer computing research.

Delegation's responsibilities

The delegation, led by Min Naida, left China in small groups after 11 September 1956.[24] They traveled to the Soviet Academy of Sciences' Institute of Computing Technology, where they were hosted by Sergei Lebedev.[34] The delegation led this group to investigate the research, production, and education of computing technology in Moscow and Leningrad. Each member of the delegation was responsible to investigate a different aspect of computer technology or a different computer institution.

All told, the delegation visited 21 Soviet organizations. Of those, 10 belonged to the Soviet Academy of Sciences, 8 belonged to the Ministry of Radio Industry, of which 1 was attached to the Ministry of Instrument and Automation industry, and 3 were educational organizations.[24] The delegation spent most of their time at the Institute of Precision Machinery and Computing Technology, the Computing Center of the Soviet Academy of Sciences, and the Moscow CAM Computer Factory. They became very familiar with the M-20 computer but they also saw the BESM, Strela, M-2, M-3, Ural, and the IPT analog computers as well as punch card computers. They visited the CAM Factory many times to learn how to manufacture the M-20.

During the visit, experts from the Institute of Precision Machinery and Computing Technology, the Computing Center of the Soviet Academy of Sciences, and Moscow University gave 22 academic lectures to the Chinese delegation. The lectures involved mathematics, computers, arithmetic units, memories, elements, and the control and application of semiconductors. Following these lectures, the delegation focused on the study of large-sized all-purpose computers: the BESM and the M-20. They divided into small groups and visited different Soviet research institutes for study purposes and to participate in experimental work.

Informal discussions with Soviets

While visiting Moscow, Min, accompanied by other CAS members, had many informal discussions with Lebedev and Panov; also with S. Mukhin, a computing technology scientist in the Institute of Precision Machinery and Computing Technology, and the principals of each research department of that institute. The delegation asked questions about research management, key research tasks, building a research department, and organizing and administering an institute. They also asked about building the first Institute of Computing Technology in China; computer development; equipment needed in research departments; factory requirements; and issues concerning to personnel training. The delegation negotiated matters relating to the invitation of the Soviet experts to China, the number of Chinese scientists who could receive advanced training, and the purchase of Soviet-made machines. Additionally, the delegation inquired about conducting computing technology training courses and establishing a computing course of study in universities.

Lebedev invited the principals of each Soviet research department to introduce their work and give specific suggestions on constructing a Chinese research institute. The Soviet scientists gave the visiting delegation 90 pages of suggestions and technical reports. This suggestion notebook related the projects, concepts, and procedures of the research departments' organizational systems; the research direction and tasks; numbers and proportion of every kind of personnel; the size of laboratories; types and numbers of equipment; and so on.

Delegation reports to CAS

The Chinese delegation, which left the Soviet Union in late fall 1956, reported on 18 December to the 37th meeting of the CAS standing committee.[35] The *Working Summary of this Investigation Group* report, coupled with members' personal recollections, conveyed to CAS what the committee had learned.[22,24,34] In essence, the visit was highly positive: the delegation learned much about the Soviet scientists' computing skills, which they admired, and had come away with enough knowledge so that they themselves could quickly organize research labs, start educational programs, and begin constructing computing equipment. The report also indicated a future of promising technical cooperation between China and the Soviet Union.

The returning Chinese delegation made the following suggestions:[24]

- Create an Institute of Computing Technology in the CAS by fall 1957,
- Begin cooperating with Soviet computer researchers,
- Create Chinese versions of the BESM and M-20 computers,
- Use replicates of the Soviet computers to train Chinese workers to build and operate computers,
- Send a delegation to buy Soviet computers and components (the delegates noted that this should be done secretly),
- Begin plans to make computer components in China,
- Ask Soviets to transfer information about computers, and
- Ask Soviets to send five experts to China for six months.

Beyond recommendations for creating a Chinese computing infrastructure, the delegation identified problems that would soon need to be addressed. Problems needing resolution included these: the fundamental question of building a few large computers or many small computers; the need to cooperate with the Ministry of Mechanical Industry, the General Staff of the Military, and the Ministry of Higher Education; a concern for placing researchers with the Ministry of Education; the need to obtain equipment for experimental factories; and the need to build its infrastructure quickly.

China–Soviet aid conventions

In fall 1957, the Chinese government sent a third delegation, headed by Guo Moruo, to the Soviet Union to negotiate a comprehensive science and technology agreement between the two governments, which would cover China's second five-year plan.[36] Delegation members in the computing field included Min Naida, Qian Wenji, and Luo Peilin. The group talked with Soviet representatives Lebedev, A. Dorodnitsin, and a Mr. Boryuk. Zhang Xiaoxiang, who at that time was studying in the Soviet Union, was also involved in the meetings.

After much discussion between the Soviet Union and China, the two countries signed, on 11 December 1957, a five-year agreement titled "The Convention on the Scientific and Technical Cooperation between the Academy of Sciences of the Union of the Soviet Socialist Republics and Chinese Academy of Sciences (1958–1962)." At this meeting, Guo Moruo represented CAS. In accordance with this convention, the two countries' academies of sciences signed a second scientific protocol the following year. This protocol outlined the cooperation between the Soviet Academy of Sciences' Institute of Computing, the Soviet Academy of Sciences' Computing Center, and the CAS's Institute of Computing Technology.[37] With this protocol, the Soviet Union agreed to accept four to six researchers from the CAS's Institute of Computing Technology and involve them in computer research and manufacture. The Soviets also agreed to send four experts to China to initiate Chinese computer research and to accept four postgraduate students for advanced study. Finally, the Soviet Union agreed to send experts to China for a short-term visit whenever there was a specific technical problem to solve.[38]

Besides the conventions signed between the two countries' academies of sciences, the Soviet Union and China also endorsed "The Convention on the Cooperative Scientific and Technical Research." A key item in this document was the establishment of scientific research and the industrial basis of computing technology. The electrical engineering group took charge of the specific negotiation of computing technology and reached an agreement to start computer research in China.[39]

The agreement considered opening a Chinese computing laboratory in the Soviet Union with roughly 30 researchers but concluded that such a decision should be made in the future. It stated that the first goal of the CAS Institute of Computing Technology was to build a copy of the BESM and the M-3 Soviet computers. It also stated the conditions under which the Soviet Union would transfer the technology necessary to build these machines. In addition, the agreement also included a provision for building an analog computer in China after 1958.

During discussions with their Soviet counterparts, the Chinese found that they would need to adjust their original plans. They had intended to first build an M-20 computer but, after learning that the Soviets were having trouble with their version of that computer, the Chinese decided instead to build a copy of the older BESM. The Soviets delivered the BESM technical specifications in the first quarter of 1958.[40]

As the Chinese prepared to build the BESM, the Soviets had two suggestions:[41] First, they suggested that China proceed with creating a computer research department in the Soviet Union for the purpose of designing, with guidance from Soviet experts, a midsized digital computer. The department would be staffed by 15 to 20 specialists. The Soviets also suggested that China begin designing its own computer immediately. The Soviets would send some experts to help with this project and promised to supply computer components. In the process, they gave no specific suggestions about the nature of the computers that the Chinese would create, although they indicated that this project would take considerably longer than establishing the computer laboratory in Russia.

The Chinese researchers were more attracted to the idea of building their own computer, however, than to working in the Soviet Union. They felt that building their own computer would be more beneficial to the growth of China's computing industry and to the acquisition of a midsized digital computer in the shortest time possible. The Chinese acknowledged that this project might require more foreign exchange than establishing a laboratory in Russia, but that it should be adopted anyway.[41]

In mid-December 1957, Min Naida returned to China to seek guidance about the choice between the two competing projects. Because Chinese officials wanted to expand every aspect of the electronic computer industry and to train a large number of technical specialists at home, they decided that they couldn't send their experts to live in Russia. Therefore, they decided to forgo establishing a Chinese laboratory in the Soviet Union and instead learn how to manufacture the BESM computer in China.

At December's end, Min returned to the Soviet Union to continue negotiations. His work concluded with an agreement to purchase a BESM-II computer from the Soviet Union and duplicate that computer in China.[42] The BESM-II computer was an improved version of the original BESM. Its technical specifications and architecture were the same as for the original BESM except for improvements in the assembling structure, some internal components, and replacing the CRT memory with magnetic core and in some peripheral equipment. At the time, the BESM had a 10-millisecond clock. The agreement also included how the two countries should cooperate on the development of the digital computer and of analog computers.

This agreement embodied every idea that had been put forward in the plan to establish computing technology and in "The Emergency Measures of Computing Technology." Before the relationship between the Soviet Union and China broke down in 1960, the two countries successfully implemented each item in the agreement.

Training the researchers

In February 1957, the Chinese Academy of Sciences selected 20 professionals for advanced studies in the Soviet Union. The group, headed by Zhang Xiaoxiang, consisted of individuals largely between 25 and 30 years in age. In all, they came from five cooperative units.[43] Most of their classes concerned the design and operation of the Soviet M-20 computer. Their teachers were the principal officers in research departments or key engineers. In early 1958, some of the Chinese students were transferred to study the BESM-II computer, which was the basis for the 104 computer and the BESM-II computer. After 18 months of study, most students had mastered the basic Soviet technology and went on to work on the 104 computer—essentially a BESM copy—and developed an application for the computer.[18] The team returned to China in 1958, except for one student who remained in the Soviet Union until 1959.[44]

Originally, the Chinese State Council's Science Planning Commission had planned to send 60 to 100 high school graduates to study computers in the Soviet Union, but the Soviets had agreed to accept only 30 students.[45] Thus, in the latter half of 1956, China had chosen 30 high school graduates with one year of study in the Soviet Union. Half of these students had been sent out to the Institute of Motion Dynamics; the other half to the Institute of Leningrad Engineering. Most of these students had returned to China after graduating in 1962.[1]

Between 1956 and 1959, the Preparation Commission selected 10 individuals to study in the Soviet Union for an academic degree:[44] five studied at the Soviet Academy of Sciences' Institute of Computing; the other five were at the Soviet Academy of Sciences' Computing Center. Most of these postgraduates returned to China between 1960 and 1962—for various reasons, only four received a degree equivalent to the doctor of philosophy.

In early 1956, CAS had found that it needed more trained people than it could find. That March, in an effort to quickly bring workers up to speed with the requisite skills, the Institute of Modern Physics' computer research group had conducted a computer study group at the Institute of Mathematics. This group had more than 20 participants, including people from Beijing University and Tsinghua University. Xia Peisu lectured to the group, explaining the basic principles and operational methods of electronic computers.[1] The group met once a week for more than three months.

Later in 1956, the CAS investigation learned the methods to conduct a computing technology training course from the Soviet Academy of Sciences and other relevant units.[46] According to the plan, from the latter half of 1956 to 1962, the Preparation Commission held four training classes, lasting one or two years each, and cultivated 684 computer technology professionals who reached the graduate level.[44]

In the late 1950s, the Preparation Commission had held three training classes, which received Soviet help directly or indirectly. Some of the classes' teachers had been members of the delegation that had earlier visited the Soviet Union, and some were those postgraduates who had returned after studying in the Soviet Union. The lecture topics were based on Soviet computing technology. One of the teachers was an expert from the Soviet Academy of Sciences' Computing Center, U.D. Shmiglebsky. The course text was a Chinese translation of a 1,000-page manual that D.U. Panov had brought to China.[47]

Between fall 1960 and summer 1962, the CAS Institute of Computing Technology and the Chinese University of Science and Technology ran the fourth training class, which had about 150 students. In all, CAS trained more than 800 people in computing technology between 1956 and 1962.[44] This training prepared urgently needed people for work in computer research and manufacturing. Ultimately, those attending the courses mastered the required technology and knowledge, and were instrumental in developing the 104, 109, and 119 computers.[44]

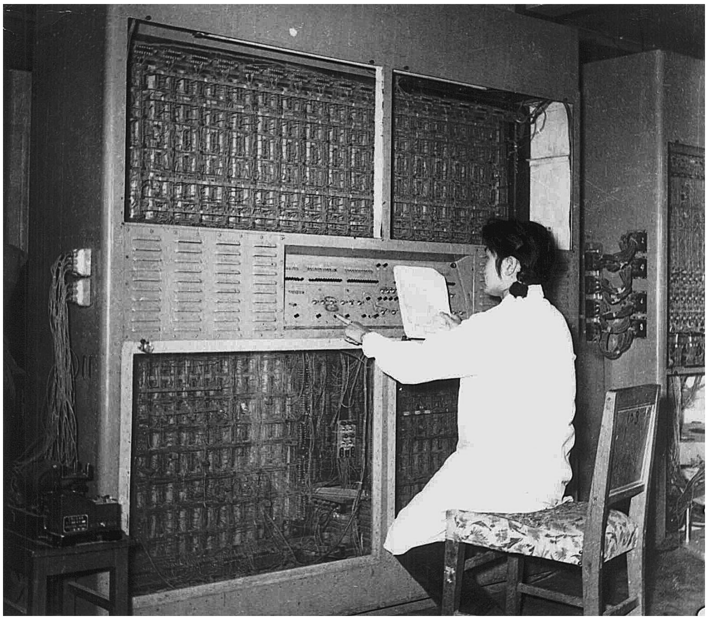

Figure 1. The 103 computer. (Courtesy of CAS.)

Duplicating the Soviet computer

At the end of 1957, CAS received the technical drawings and specifications from the Soviet Union for the M-3 computer. At that time, CAS formed a committee to study the drawings and prepare to duplicate its design. This committee was headed by Mo Gensheng, who had translated a book on the M-3 computer, and Zhang Zichang.[48] At the same time, the Preparation Commission signed a contract with the 738th Factory of Beijing to manufacture M-3 and BESM-II computers. In December 1957, when CAS received the remaining engineering drawings for the M-3, the Preparation Commission formed an M-3 engineering group. Beginning in March 1958, the 738th Factory of Beijing started the trial manufacture of M-3 computers. By September, it had produced the first working small digital computer.[48] This computer was named *by Youle*, which means *we have a computer for the first time*. The name was later changed to *August 1st*, which had significance because it was the day the Chinese People's Liberation Army was formed. In 1959, when it was manufactured in small batches, the computer's name was changed again to the 103 computer (see Figure 1).

The 103 electronic computer was almost entirely made on the basis of Soviet M-3 computer specifications. The M-3, a first-generation computer, contained 800 vacuum tubes, 2,000 copper oxide diodes, 10,000 capacitor elements, 400 plugs in three cabinets, and a 1,024-word-capacity magnetic drum. The M-3 was a binary fixed-point, 32-bit word computer. The Chinese engineers slightly modified the Soviet design:[48] Although the original computer's Enhanced Messaging Service used a vertical memory drum, the Chinese engineers added a magnetic core memory. The original input device was a teletype keyboard, but the Chinese added a photoelectric tape reader. The original output device was a teleprinter that the Chinese replaced with a high-speed printer. These changes increased the calculation speed from 30 to 1,800 operations per second. The input speed was increased from 52 to 1,250 digits per minute. The output speed improved from 24 to 650 digits per minute.[49]

Early achievements

By 1958, China directed some of the 20 students in the Soviet Union to change their studies and learn about the BESM-II computer. To do so, these students remained in the Soviet Union for an extra six months, then returned to China by May 1958 and began work to create a BESM-II. With the Soviets' help, they were able to create an operating BESM by September 1959. This machine was China's first large-sized, all-purpose digital electronic computer. Named the 104, it was only slightly different from the BESM (see Figure 1).[50]

The 104 computer featured

- a binary system,
- 39-word length,

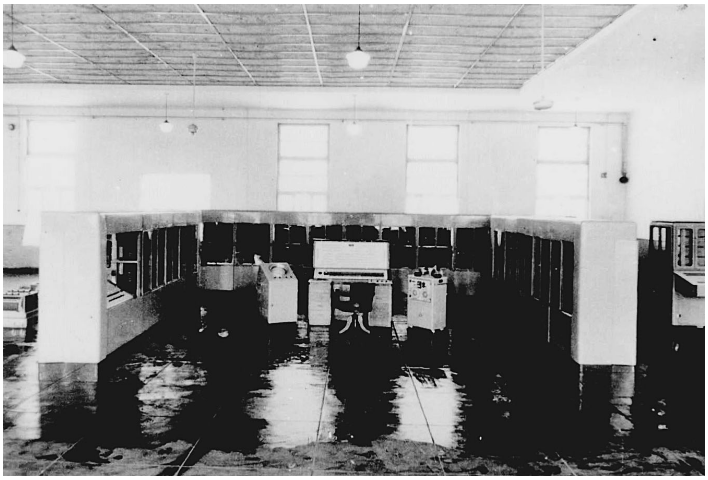

Figure 2. The 104 computer. (Courtesy of CAS.)

- a three-address instruction,
- a 2,048-word magnetic core memory,
- two 6,000-word magnetic drum memories,
- 10-microsecond access time,
- 10,000-operations-per-second performance,
- floating-point arithmetic operation,
- 120,000-word magnetic tape storage,
- 10,000-operations-per-second average calculating speed,
- a photoelectric paper tape reader for input with a speed of 15 numbers per second, and
- a printer capable of 15 lines per second.

The 104 was comparable to an IBM 704 computer in 1956.[51] The 104 was inferior to the newer machines being produced in the US and the Soviet Union, but it was better than those coming out of England, Japan, and West Germany.[52]

By duplicating the M-3 and the BESM-II, Chinese engineers mastered computer design and manufacturing techniques. They trained a complete technical contingent in computer research, design, manufacture, and operations. These two computers—the 103 and 104—completed the initial state of China's computer development and were the major accomplishments of the initial 12-year plan.

Between December 1961 and January 1962, the 103 and 104 computers were certified as formal industrial products of the People's Republic of China.[53] Both machines were given to military departments and made an important contribution in a variety of ways. For example, the 103 computer was used for short-term weather forecasting, for calculating the platform's mechanical structure in the Great Hall of the People, and for analyzing aerial surveys. The 104 computer was used in national defense, for advanced scientific research, meteorology, survey, dam hydrology, architecture, design of power equipment, and so on. Most visibly, the 104 computer aided engineers in the theoretical design and detonation of the first Chinese atomic bomb.[54]

During the process of duplicating the M-3 and BESM computers, Soviet experts played an important role. Between the end of 1957 and the end of 1959, seven Soviet experts came to China and helped CAS.[55] In particular, they helped resolve crucial problems such as magnetic core memory manufacture, core storage installation and testing, operation control adjustment, peripheral equipment design and testing, as well as testing the entire system. Several Soviet experts extended their stay in China because of the need to solve difficult problems.[56] The Soviets' role began to decline only after the cohort of students returned from the Soviet Union, a time that corresponded to China's work on the 104 computer.[57] After these researchers returned, the Soviets' role diminished noticeably.

Problems on the horizon

During the period when China was duplicating Soviet electronic computers, China embraced Mao Zedong's idea of the Great Leap Forward. This idea, promoted in 1958, was intended to spur China's economic growth, caused the Chinese leadership to set some impractical goals that slowed research on computers.[58] In building the 103 computer, for example, Chinese industry did not implement sufficient inspection procedures to ensure a quality project. Pressured to build an unrealistic number of computers, workers were reluctant to stop production lines and hence accepted inferior or flawed components. The visiting Soviet experts noticed this problem and suggested that the Chinese should change their production methods. However, because China was committed to break from convention and move its economy forward, Chinese manufacturers did not follow the Soviet advice but instead tried to fix the problem with superficial solutions. As a result, the workers produced few operational computers. When China started building the 104 computer, officials recognized the problems of poor quality and adjusted their methods, but these steps failed to fix the problems.[58] According to Zhang Xiaoxiang's recollection, China had no significant failures with the 104 computer's components, and it reliably operated for many years.[59]

The Chinese modified the 103's design shortly after the computer went into production. In deciding to modify the computer, the Chinese experts fell into two camps. One group argued that the 103 design should be improved before the machine was ready for full production and operation; the other urged that the machine be produced and operated as soon as the design was ready. The Soviet expert G.P. Lopato helped resolve this issue. He argued that the 103 design needed to be improved and helped the Chinese experts who favored that decision to convince the others of the plan's benefits. Lopato argued that the resulting machine would be more reliable and stable.[22]

Founding of computing institute

After years of operating through the Preparation Committee, CAS officially founded its Institute of Computing Technology on 17 May 1959. Over the following years, CAS set up in succession nearly 20 institutes of computing technology, computing centers, and computer research departments in Shanghai, Shenyang, Wuhan, Xian, Chengdu, Hefei, Nanjing, Tianjin, and Taiyuan.[53] Following the principle of first assembling and then separating, as outlined in the 1956–1967 plan, the individuals who had transferred to work at the Institute of Computing Technology from the third department of the Headquarters of the General Staff, the Ministry of the Second Mechanical Industry, the Fifth Institute of National Defense, and from colleges and universities, all returned to their original departments. By the early 1960s, these research organizations started their own work in duplicating Soviet computers.

Beginning with the duplicates of the Soviet M-3 and BESM-II computers, China later developed vacuum tube and transistor computers on its own. Within six or seven years after duplicating the BESM-II, China successfully developed

- the 107 computer—with vacuum tubes (April 1960),
- the 119 computer—with vacuum tubes; a large-sized, all-purpose computer (April 1964),
- the 109 computer Model II—with transistors; a large-sized, all-purpose digital computer (1965), and
- the 109 computer Model III—with transistors; a large-sized all-purpose digital computer (1967).

Other Chinese institutions had also made strides in the 1960s. The Huabei Institute of Computing Technology, the Huadong Institute of Computing Technology, Tsinghua University, and the Haerbin Institute of Electronic Engineering had achieved significant progress in developing transistor computers as well. These computers played a significant part in China's development of the atomic and hydrogen bombs and China's management of its economy. These computers symbolized China's mastering of Soviet technology.

Conclusions

The earliest interest in computing in China dates to 1951, when Hua Luogeng, a CAS mathematician, suggested developing a group devoted to computational mathematics and computing technology. The Institute of Mathematics organized a few people to start work in this field; however, no one knew much about computing's mathematical or technical aspects. The group did not accomplish much until the academy drafted the *Long-Term Protocol for Developing National Sciences and Technology between 1956 and 1967* and the subsequent *Four Emergency Measures*. Once those two documents were complete, the Chinese successfully duplicated the Soviet computing effort in roughly two years' time. Clearly, the development of computing technology needed the support of the state before it could proceed.

Besides state support, computer science needed a well-conceived plan to advance. The Chinese plan followed the suggestions of Soviet expert Lebedev and drew on the idea of first assembling to surmount difficulties and then separating to develop computers that Hua Luogeng had recommended. The point on which it differed from Lebedev's suggestion was in the decision to forego the creation of a Chinese computing laboratory in Russia. The success of the Chinese effort shows that such a laboratory was not necessary. The advantage of such a laboratory was that it might have lessened the ill-effects of the Great Leap Forward, but as we have seen, that period of political turmoil did not significantly affect computer development. In the process of making and carrying out its plan for creating computers, the Chinese government relied on both Chinese and Soviet experts. Without the

Soviet experts and information, it would be unimaginable for the Chinese to have mastered computing technology within several years.

In all, the Soviets helped their Chinese counterparts in eight key areas. First, a Soviet conference in 1956 informed the Chinese about the accomplishments of Soviet computer experts and started the planning for Chinese computer research. Second, Soviet experts, most notably Lebedev, helped the Chinese prepare a 12-year plan for computing.

Third, in September 1956, the Soviet Academy of Sciences hosted a delegation from CAS. This delegation visited the organizations of computer research, design, trial-manufacture, production, and higher education in the Soviet Union, and learned theories and techniques for every aspect of computer development. Fourth, shortly after this visit, the Soviets agreed to provide the Chinese with computers, computer plans, and computer components.

Fifth, the Soviets trained Chinese students at the Institute of the Computing Technology, the Computing Center of the Soviet Academy of Sciences, Institute of Molotov Dynamics, and Institute of Leningrad Engineering. In turn, these people trained others in China. Sixth, the Soviet Academy of Sciences helped Chinese engineers duplicate the M-3 and the BESM-II. In this effort, Chinese scientists actually improved the Soviet designs.

Seventh, Soviet technology was spread through the Institute of Computing Technology of CAS. This institute played the role of an incubator and a disseminator. Finally, Soviet technology provided examples to Chinese researchers as they created the 107, 119, 109 Model II, and 109 Model III between 1960 and 1965.[60] In this last effort, China moved into the transistor stage and demonstrated its ability to design and manufacture computers.

All in all, the Soviet Union aided China to create its first computers by successfully transferring its technology. This transfer occurred under specific historical conditions and in a manner very different from the usual way of technology transfer between countries. For example, it was carried out during a time of cooperation between the two governments. The technology transfer occurred when the two governments were interested in forging a larger, more productive relationship as a bulwark against the West. Therefore, when the general conventions on computer technology were signed, the two countries did not worry about agreements on technical patents and the distribution of economic benefits among the various institutions. The agreements were surprisingly flexible, for activities involving the Soviets, and had no limitation of scope. The friendship between the Soviet Union and China fostered a comfortable atmosphere for the Soviet Union to help with founding the Institute of Computing Technology and transferring computing technology.

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57. In the telephone interview on 11 June 2003, Zhang Xiaoxiang mentioned it.
58. ''The Situation of Professional Work in Computing Institute in 1958,'' manuscript, 58-1-1, Archives of the Inst. of Computing Technology.
59. Zhang Xiaoxiang made such a comment in the author's telephone interview on 11 June 2003.
60. The 109 Model III and 119 computers played a more important role in China's industrial and national defense programs than the 107 computer.

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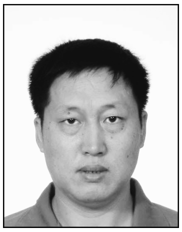

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