

Return to China One Day

The Learning Life of Qian Xuesen

Chengdong Lv

钱学森的求知岁月

他日归来

若负时代
何来韶华
初心不改

Translated by
Yingchun Zhang



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ZHEJIANG SCIENCE AND TECHNOLOGY PUBLISHING HOUSE

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Prelude: A Special Visit to the Soviet Union

On June 25, 1956, the opening ceremony of the Third Soviet Congress of Mathematics was held in Moscow. The conference was attended by more than 2,000 Soviet scientists and young scholars, and also by more than 60 leading scholars from the USA, UK, China, France, Italy, Sweden, India, Hungary, Poland, Czechoslovakia and other countries. The opening session was followed by a breakout session in which a Chinese scientist gave a presentation on The Poincaré-Lighthill-Kuo Method in the session “Mathematical Problems in Mechanics” from 10:00 to 11:00 a.m. on June 27. This Chinese scientist was Qian Xuesen (also known as Tsien Hsue-Shen), who had just returned to China from the United States and was by now the Director of the Institute of Mechanics of the Chinese Academy of Sciences. Invited by the Soviet Academy of Sciences, Qian Xuesen, together with his wife Jiang Ying, had this visit from June 20 to July 21. Qian was accompanied by his own Russian translator, Wu Hongqing, Assistant Professor of the Department of Mathematics and Mechanics at Peking University.

On June 20, Qian Xuesen and his party arrived in Moscow by plane. They were met by Yuri Ivanovich Shaslov, a staff member of the Foreign Liaison Bureau of the USSR Academy of Sciences, and the staff of the Chinese Embassy in the USSR. It was a high-profile reception, and the USSR Academy of Sciences earmarked 53,066 rubles for the reception, covering air tickets, transportation, accommodation, banquet meals, translation fee and admission tickets on the tour. This staff member of the Foreign Liaison Bureau, who participated in the Patriotic War, accompanied him throughout the trip and was responsible for the security of the entire trip.

After returning to China from the visit, Wu Hongqing drafted a report entitled “Observations on the visit to the Soviet Academy of Sciences”, which was revised and reviewed by Qian Xuesen himself and submitted to the Chinese Academy of Sciences. Through this valuable report, people learned the whole process of Qian Xuesen’s visit and the reason for his high standard reception by the Soviet Academy of Sciences. From the report, it can be seen that Qian’s visit included three kinds of activities: reports, symposiums and visits.

1. Reports. In addition to the presentation at the mathematical congress, Qian Xuesen made three presentations, respectively, at the Presidium of the USSR Academy of Sciences, including “Perspectives on Aviation Technology”, “New Directions in Technical Science” and “Some Problems in Engineering Cybernetics”. He also presented “A Result in the Study of Physical Mechanics—The Nature of Pure Liquids” at the Institute of Mechanics of the USSR Academy of Sciences.
2. Symposiums. The symposiums, attended mainly by scientists and engineers from the Soviet Academy of Sciences, focused on three issues: aerodynamics, missile and automatic control. The Soviet Union intended to refer to Qian Xuesen’s opinions to confirm their judgment on the development of the U.S. aviation industry and aeronautical science. On this occasion, Qian Xuesen raised two issues for discussion, namely “the organization of scientific research forces” and “the combustion problem” in an attempt to understand the Soviet side of the situation. In the symposiums, Soviet scientists and engineers had a frank exchange with Qian Xuesen on these two issues.
3. Visits. According to the visit schedule made by the USSR Academy of Sciences, Qian Xuesen would visit 16 scientific institutions. In fact, he visited a total of 17 research institutions, one of which was the Central Institute of Fluid Aerodynamics. This Institute was not on the list of scheduled visits, but the Soviets agreed to Qian’s request to visit it after careful consideration. The visit was limited to the transonic wind tunnel and the giant low-speed wind tunnel, making Qian the first foreign scientist to be allowed to visit there, despite the fact that the military aircraft originally used for experiments in the wind tunnel had been replaced by civil aircraft during his visit. This was the reason why the Soviet Union took a few days to respond to Qian Xuesen’s request.

On July 21, Qian Xuesen finished his visit. At 4 p.m., the Soviet Academy of Sciences held a grand farewell party for him at the Prague Hotel in Moscow. Afterward, Qian returned to China on a Chinese civil aircraft via Ulaanbaatar Airport, Mongolia. Before his return to China, the Soviet Academy of Sciences paid him a total of 4,500 rubles as expert fees for reports, lectures and talks. Qian returned to China and handed over all the money. This visit was not publicly reported in either China or the USSR, and only became known decades later when the Chinese and Russian Academies of Sciences made their records public.

In recent years, declassified U.S. archives show that the FBI, upon learning of Qian’s visit to the Soviet Union, ordered spies to follow him throughout the trip. Because the FBI and Qian Xuesen had been “in contact” for five years, they knew too well the true purpose of the scientist who had been a Goddard Professor at Caltech, one of the top U.S. institutions, and was invited to visit the Soviet Union at the time of the U.S.-Soviet space race. Qian Xuesen said:

Based on conversations with Soviet scientists in the last days, it is estimated that my visit helped the Soviet Union in the following two ways: first, there were some issues they had noticed before, and their opinions were confirmed and conclusions were consolidated because I pointed out their importance; second, there were some problems they had not anticipated,



Fig. 1 Qian Xuesen in Moscow (Photo by Jiang Ying)

but they reconsidered them and thought they were justified, and decided to start looking into it after I pointed them out. According to them there was one issue about jet flaps, which they started to carry out further research after I pointed its importance to them.

Qian Xuesen's visit had a tight schedule and he attended a variety of social events. However, as one of the world's leading scientists, Qian Xuesen was able to make an accurate judgment on the science level of the Soviet Union even by a glance at their research and facilities. Qian Xuesen concluded: "The Soviet Union had generally reached or exceeded the U.S. level in aeronautical technology and mechanics, and was especially unique in combining theory with practice". It was for this reason that Qian Xuesen had the foresight to suggest that Soviet assistance must be sought in his *Opinions on the Establishment of China's Defense Aviation Industry* submitted to the central government before his visit.

Qian Xuesen's visit to THE Soviet Union was by no means a purely academic activity, and its special significance was self-evident during the Cold War period when the United States and the Soviet Union were fighting for hegemony, and in the era when the newly founded People's Republic of China was determined to develop missiles. However, by lengthening the historical lens, similar historical scenes would always occur. In the meantime, Qian Xuesen's mentor, von Kármán was cooperating with a team of NATO scientists to neutralize the Soviet military threat to NATO and the United States. This historical drama "staged" again, as similar scenes appeared in Germany as early as 11 years ago.

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Chapter 1

Family and Education



1 His Father Qian Junfu

“My father was my first teacher,” Qian Xuesen said seventy years later for the *People’s Daily*, a major Beijing newspaper. “He opened a new world for me in art, music and literature.” Qian Junfu is gradually known to the public as Qian Xuesen’s father only after Qian Xuesen passed away. In fact, Qian Junfu had led a colorful and legendary life, and had contributed much to the country’s education.

The descendant of Qian Lineage in Wuyue

On December 26, 1882 (the seventeenth of November on the Lunar Calendar, the 8th year of Guangxu Emperor), Qian Junfu was born in the Qian lineage’s old residence in Eastern Street, Renhe County, Hangzhou City, Zhejiang Province. Qian’s lineage can be traced back to King Qian Liu of the Kingdom of Wuyue (852–932), of whom Qian Junfu was the 32nd descendant. The Wuyue Qian lineage had been prosperous since Qian Liu established the Kingdom of Wuyue. Qian Jizu, Qian Junfu’s grandfather, run silk business in Eastern Street of Renhe County and was quite wealthy. Qian Jizu had four sons, with Qian Chengrong the eldest son, Qian Chengzi the second and Qian Chengduo the third, while the youngest son was adopted by the Lu lineage, the lineage on the part of Qian Jizu’s wife and thus changed his surname to Lu.

Qian Chengzi had two sons, the elder son Qian Jiarun (courtesy name, Zefu) and the younger son Qian Jiazhi (courtesy name, Junfu). Qian Jiarun’s son, Qian Xuequ, was admitted to the Department of Aeronautical Engineering of Massachusetts Institute of Technology as a Boxer Rebellion Scholarship recipient administered through Tsinghua University after he graduated from the School of Mechanical Engineering at Jiaotong University. He was a well-known expert in the aviation field in the United States. Qian Xuequ and his wife, Li Yiyang had three sons. The eldest son Qian Yongyou is a member of the U.S. National Academy of Sciences; the second son Qian Yongle is a computer scientist and the youngest son Qian Yongjian was a 2008 Nobel Prize winner in chemistry. Qian Junfu and Zhang Lanjuan had a son,

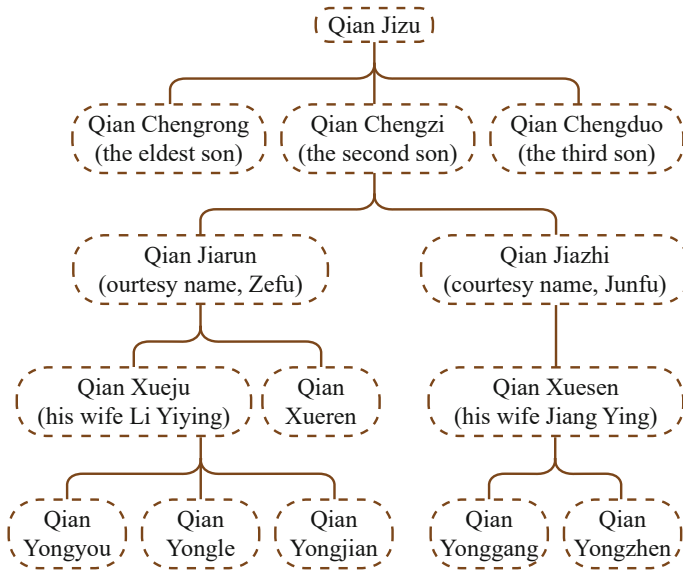


Fig. 1 Qian Junfu's family pedigree

who unfortunately died young. Later on, the couple had another son, Qian Xuesen (Fig. 1).

Receiving both traditional and modern education

Qian Junfu was born in the transitional stage of Chinese society, from traditional to modern, so his life was deeply marked by the times. He had the opportunity to receive both traditional and modern education. In the traditional Chinese class stratification of “scholar, farmer, industrialist and businessmen”, scholar had the highest social status. This traditional concept was deeply rooted in Qian Junfu's grandfather Qian Jizu, who expected that his children would become scholars and officials.

Although the family's economic situation was declining when Qian Junfu was born, his father Qian Chengzi spared no effort in supporting his education. In 1888, Qian Junfu, at six, was sent to *si shu*, an old-style private school, and started to learn Chinese primers such as *Thousand Character Text*, *Three Character Classic*, *A Hundred Family Names*, and *Poetry of a Prodigy*. Unable to pay the tuition fees for a private school later on, Qian Junfu was sent to a free school in 1895. In 1898, he left for Shanghai and entered the Wang Yucai School, the predecessor of Shanghai Nanyang Middle School, with financial support from his relatives and friends.

In 1899, Qian Junfu was admitted to Qiushi shuyuan—then a middle school in Hangzhou and later the predecessor of Zhejiang University. During this period, he often discussed with his classmates on how to save the country and participated in the establishment of *Hangzhou Vernacular Newspaper* to promote vernacular Chinese. He gradually realized the importance of education in national rejuvenation and survival, and was determined to save the country through education [1].

In September 1902, Qian Junfu joined a group of government-funded students, Zhou Chengpeng, Shi Yuruo, Han Qiangshi, Zhang Futing, Han Shutao, Shen Qifang, Xu Shoushang and Shou Changtian, travelling to Japan to study [2]. Upon their arrival in Japan, they were enrolled in Zhejiang class in the general department of Tokyo Hongwen College. Zhou Shuren from Shaoxing, Zhejiang Province, who was to become China's most famous short story writer under the pseudonym Lu Xun, had arrived in Japan earlier. Although he was from Zhejiang Province, he was arranged in Jiangnan class because he was sent to study on Jiangnan official expenses. During this time, Qian Junfu and Zhou Shuren met and befriended each other and later became close friends. Tokyo Hongwen College was a language school with three academic years. From September 1902 to March 1904, Qian Junfu finished the required courses and graduated earlier in July of 1904. He was then admitted to Tokyo Higher Normal School, the predecessor of Tsukuba University. Tokyo Higher Normal School was a modern college specialized in training teacher trainees. The school was divided into four departments, and Qian Junfu was enrolled in the second department (geography and history department) with duration of four years [3]. In the first year, the students attended the preparatory course, followed by three years for the undergraduate course. In the fourth year, students would participate in field teaching at the school affiliated with the college.

Qian Junfu was hard-working and persevering student and he read widely. He often participated in various social activities organized by foreign students, through which he was acquainted with Li Shutong, a famous modern poet, calligrapher, seal cutter, educator in music and art and dramatist. In 1907, Qian Junfu, together with other Chinese students such as Xu Shouchang, Zhou Shuren, Zhou Zuoren, Gong Baoquan, Zhu Xizu and so on, organized the "Students' Revival Society" in Tokyo [4, 5] (Fig. 2).

In the spring of 1908, Qian Junfu graduated from Tokyo Higher Normal School. After his graduation, he decided to spend half a year in investigating the situation of Japanese education as he thought that one could hardly gain rich experiences simply through learning book knowledge. Xu Shoushang, who graduated at the same time and needed to study German in preparation for his stay in Germany, rented No. 7 Lǔzhi in Nishikata-cho, Hongo, Tokyo for 35 *yen* each month and invited Qian Junfu, Zhu Mouxuan, Zhou Shuren and Zhou Zuoren to live with him and share the rental. Xu Shoushang wrote a sign of "Wushe", meaning five people living there together, on the electric pole near the door. During the period of living at "Wushe", they became disciples of Zhang Taiyan, who had exerted great influence on them.

In 1906, Zhang Taiyan was invited by Sun Yat-sen to Japan and joined Tong Meng Hui, the Chinese Revolutionary League, serving as the editor-in-chief and publisher of *Min Bao Newspaper*, the official journal of the Tong Meng Hui. In 1908, Zhang Taiyan lectured on *Shuowen*, *Zhuangzi*, and *Chu Ci* and other Chinese classics in one classroom of Tokyo Dacheng Middle School, which made him very influential among overseas students. The four residents in "Wushe", namely, Qian Junfu, Xu Shouchang, Zhou Shuren and Zhou Zuoren attended Zhang's lectures. As their school schedule was in conflict with the lecture arrangement, they expressed their wish that additional lectures could be delivered on Sunday mornings to Gong Weisheng, Zhang



Fig. 2 A photo of Qian Junfu when he studied in Japan

Taiyan's son-in-law. Zhang Taiyan agreed to their request and lectures were arranged at the office of *Min Bao Newspaper*, also Zhang Taiyan's apartment.

At the office of *Min Bao Newspaper*, there were eight seats around a low table in the center of the room. Zhang Taiyan sat on one side, with his legs crossed, while eight students on the other three sides of the table. Zhou Zuoren commented: "Taiyan usually had no patience with the rich, but he was very kind to the young students. He talked and laughed casually, treating us as family and friends. In summer days, he sat crossed-legged, bare-chested and wore only a long undershirt. With a little loach beard, he looked like a Buddhist Bodhisattva in a temple" [6].

While Qian Junfu was investigating the situation of education in Japan and attending Zhang Taiyan's lectures, Wang Tingyang was sent to Japan by Zhejiang

Provincial government to Japan to investigate the school affairs. He discussed with Qian Junfu, Jing Hengyi, Xu Shoushang, Zhang Bonghua and other students about running a two-level teacher training school in Zhejiang, and invited them to teach at the school after they return to Zhejiang Province. Qian Junfu thus ended his seven-year study in Japan in the winter of 1908 and returned to his hometown to teach, practicing his early idea of education for national salvation.

A practitioner of saving the nation through education

At the beginning of 1909, Qian Junfu went to teach at the Two-level Teacher Training school in Zhejiang. He taught two courses: foreign geography and foreign history for students in the superior level, and he also taught logic. Soon after, as Jing Hengyi resigned from his position as the provost, Qian Junfu took the provost position temporarily, and he taught two additional course: educational theory and history of education.

Qian Junfu was quite busy when he started teaching. Moreover, since there was no uniform textbook in teacher training schools at that time, teaching materials were generally prepared by teachers according to the content of the curriculum. Qian Junfu collected materials extensively and compiled four textbooks: *Nomenclature*, *General Theory of Geography*, *Foreign Geography* and *Western History*.

In 1905 (the thirty-first year of Guangxu), when the Qing government abolished the imperial examination system, studying abroad became the choice of many intellectuals and the number of overseas students kept expanding. After returning from Japan in the winter of 1908, Qian Junfu took the examination organized by the Ministry of Education of the Qing Dynasty in 1909. In fact, after his return to China, Qian Junfu had no intention to achieve fame and fortune, or to be engaged in politics. When he was teaching at the Two-level Teacher Training School in Zhejiang, he participated in the famous “Papaya Battle” with Lu Xun and 25 others, opposing the dawdling of the old guard supervisor Xia Zhenwu.

In 1909 (the first year of Xuantong), the Qing government introduced the examination method for international students, stipulating that all international students must come to Beijing to take the examination. A total of 383 overseas students, including Qian Junfu, had to register for the examination. Qian Junfu’s examination results were classified as “excellent” and rewarded to “Juren of the liberal arts” (the liberal arts scholar). Subsequently, Qian Junfu went to Beijing in April 1910 to take the court examination and scored seventy points, which was classified as the second grade. After the court examination, Qian Junfu was appointed to the Cabinet of the Chinese Secretary, responsible for writing, recording, translating works in the imperial court, and was entitled to be promoted to the governor of Zhili Prefecture, or be sent to the military bureau after a certain years. However, he did not stay in the capital to seek a job, but returned to Zhejiang as deputy head of the general section of the Public School of Learning. In June 1911, he was appointed as the principal of the First Secondary School in Zhejiang Province.

On January 4, 1914, Wang Daxie, the chief education officer of the Beijing government, petitioned Yuan Shikai, the President, to appoint a group of officials in the

Ministry of Education. Xu Shixiong was the secretary, Qian Jiazhi, Zhang Zongxiang, Wang Xiaojie, Wang Senbao, Wang Jiaju, Bai Zhenmin, and Qi Zongyi were the inspectors, and Fan Hongtai was the commander [7]. Qian Jiazhi was Qian Junfu. He accepted the appointment and went to the Ministry of Education in Beijing to serve as an inspector. After his appointment, Qian Junfu was awarded the title of “Senior Scholar” by the President on July 23, 1915 [8], and was honored by the Premier of the State Council and the Chief Education Officer on March 12, 1917, for his dedication to his duties and conduct. On October 3, 1917, General Education Minister Fan Yuanlian signed a decree appointing the inspector Qian Jiazhi as the head of the third section of the General Education Department of the Ministry [9].

After Qian Junfu became the section chief, he still served as an inspector, but only participated in temporary inspections. During his tenure as section chief, Qian Junfu actively participated in and promoted the Mandarin Movement. The Mandarin Movement aimed to promote the unification of the national language and advocated the “unification of the spoken and written language” and the “unification of the national language”, that was, the establishment of a unified official language.

In April 1927, after the establishment of the Nanjing National Government, the central government organs, including the Ministry of Education, were moved to Nanjing. In the following year, Qian Junfu was appointed by Ma Yinchu, the Undersecretary of the Ministry of Education, as a first class officer in the Department of General Education. From 1928 to 1929, Qian Xuesen was in his third year of high school affiliated to Beijing Normal University, and he was preparing for the university entrance examination. Considering the impact of moving and transferring to another school, Qian Junfu went to Nanjing to take up his post, leaving Qian Xuesen in Beijing under the care of his mother Zhang Lanjuan. In 1929, Qian Junfu was recalled back to Zhejiang Province to serve as the supervisor of the Department of Education after serving in Nanjing for less than a year. Qian Xuesen was admitted to Jiaotong University in the same year, and in the autumn of that year, the family returned to Hangzhou.

On March 6, 1931, the President of the Zhejiang Provincial Government, Zhang Nanxian, requested the National Government to issue an order appointing Qian Junfu as the secretary of the Department of Education of Zhejiang Province. The secretary of the Department of Education was not only responsible for “reviewing communications”, “preparing and keeping important documents” and “reviewing documents of various departments”, but also presiding over “departmental meetings.” This was because the then director of the Department of Education of Zhejiang Province, Chen Bulei, was stationed in Nanjing to perform his duties as the Undersecretary of the Ministry of Education. Therefore, the affairs of the Department of Education were represented by Qian Junfu.

Retired life

The year 1934 was particularly memorable for Qian Junfu with the occurrence of two events. The joyful one was that Qian Xuesen was admitted to Tsinghua University as Boxer Rebellion Scholarship recipient to study in the United States. The other was heartbroken. Qian Xuesen’s mother, Zhang Lanjuan passed away because of

severe typhoid fever. This was undoubtedly a heavy blow to both father and son. Too hard to accept his wife's death, Qian Junfu had been depressed for a long time, which caused him serious stomach disease. When message of his mother's illness came, Qian Xuesen was participating professional internships arranged by Tsinghua University at Jianqiao Aircraft Manufacturing Plant in Hangzhou. After learning the news of his mother's critical illness, he wept and immediately took leave from Tsinghua University to go home so that he could see his mother one last time.

At the time of Zhang Lanjuan's death, Qian Junfu was fifty-two years old and in the right age for his career. However, his stomach illness failed him to work further in his post at Department of Education. He resigned on December 22, 1934, and had rested at his residence located at No. 2, Fangguyuan, Hangzhou. On August 20, 1935, Qian Xuesen boarded on steamship *President Jackson* embarking at Shanghai port to the United States. Qian Junfu sent his son off and lived alone since then. Many relatives and friends persuaded him to remarry, but he declined. After a period of adjustment, Qian Junfu gradually came out of the sadness of losing his wife. Since then, although he had resigned from his official position in the Department of Education, he still enthusiastically participated in the local culture and education, making contributions in his capacity.

Qian Junfu could have spent the rest of his life in Hangzhou, but the July 7 Incident that happened soon after changed the course of his life. After a long period of planning, Japan entered Wanping City in 1937 on the pretext of searching for missing Japanese soldiers, and waited for the opportunity to launch the Lugou Bridge Incident, which shocked China and abroad and opened the prelude to a full-scale invasion of China. Soon after, the Japanese began to bomb Hangzhou, and landed in Hangzhou Bay on November 5, occupying Hangzhou.

At that time, there were many intellectuals in Hangzhou who had studied in Japan. After the Japanese occupied Hangzhou, they decided to organize these people to manage the municipal order, and drew up a list, in which Qian Junfu was in. When Qian Junfu heard that his name was on the list on November 11, he went to the town of Heshangdian in the outskirts of Hangzhou to escape the chaos. Since he could not return to Hangzhou in the short term, and his house at Fangguyuan No. 2 was hit by an incendiary bomb dropped by the Japanese during an air raid, in February 1938, Qian Junfu decided to leave Hangzhou and go to Shanghai for refuge.

After Qian Junfu arrived in Shanghai, he stayed at his wife's brother Zhang Leshan's house at No. 111, Qishan Village, Lane 1032, Yuyuan Road, located in public concession. This was a single bay, 3-storied conjoined villa, the property rights of which originally owned by Zhang Leshan, who still lived on the second floor in the form of rent return after selling it for some reason. When Qian Junfu first arrived in Shanghai, he lived on the second floor in Zhang's house, paying regular rent, meals and utilities until November 1943, when he rented the first floor. The first floor had an area of about 40 square meters and was divided into a living room and two bedrooms, as well as a kitchen and a bathroom. At that time, Qian Xuesen was studying in the United States, and Qian Junfu's daily life was taken care of by his goddaughter Qian Yuehua. Qian Xuesen had lived here for about two months when he returned to visit his family in 1947.

In May 1956, Qian Junfu went to live with Qian Xuesen in Beijing. Qian Junfu's later years in Beijing were undoubtedly happy and gratifying. He was often visited by his son and daughter-in-law with two grandchildren, Qian Yonggang and Qian Yongzhen. As Qian Junfu had worked in Beijing for nearly fifteen years, he had many old friends and they often walked around and chatted to catch up with each other.

On August 23, 1969, Qian Junfu died at the age of 87 due to a stomach hemorrhage, and on September 2, the Central Research Institute of Culture and History held a farewell party for Qian Junfu at Babaoshan Revolutionary Cemetery. In his later years, Qian Xuesen placed two framed items in his bedroom, one of which was a portrait of Qian Junfu, which showed Qian Xuesen's endless memory of his father.

2 His Mother Zhang Lanjuan

“My mother Zhang Lanjuan was the eldest daughter of a rich merchant in Hangzhou, and it was said that my maternal grandfather chose my father as his son-in-law because of his talent,” recalled Qian Xuesen.

Daughter of an affluent family

Zhang Lanjuan was born into an affluent family in 1887 and died of typhoid fever at 47 in 1934. Her father, Zhang Zhenzi, served as a salt official in Guangdong and Guangxi provinces for several years. After leaving his post, Zhang Zhenzi started his businesses in salt, silk and soy sauce in Hangzhou and accumulated solid assets which enabled him to purchase properties in Hangzhou, Shanghai and other places. The two former residences of Qian Xuesen, located at No.2 Fangguyuan, Hangzhou and at Lane No.1032, Yuyuan Road, Shanghai, were originally owned by Zhang's family. However, due to the disastrous failure of stock investment in the 1920s and 1930s, the Zhang family's economy went into decline and they had to sell their properties to pay their debts, and finally they could barely make ends meet.

Zhang Zhenzi had one son and three daughters: the son Zhang Leshan, the eldest daughter Zhang Lanjuan, and two younger sisters. Zhang Leshan was enthusiastic about local public welfare, actively participating in public welfare activities in Shanghai and Hangzhou. He was public personage with popularity, and was also the first member of the Zhejiang branch of the China National Road Construction Association.

Zhang Lanjuan was born at a time when her family was at its peak. Having received good family education and Chinese classical education, she was a cultured and courteous young lady. In her photos, Zhang Lanjuan was beautiful and dignified, with delicate facial features, showing a gentle and virtuous temperament. Although the marriage between Qian Junfu and Zhang Lanjuan was arranged by their parents and matchmaker, the couple was affectionate and got along very well, which was clear from the fact that Qian Junfu had no intention to remarry after his wife's death (Fig. 3).

Fig. 3 A photo of Zhang Lanjuan in her teenage years



After Qian Junfu and Zhang Lanjuan got married, the Zhang family gave them the house at No. 2 Fangguyuan as a dowry. Upon the bursting of Xinhai Revolution in 1911, Qian Junfu and his pregnant wife went to Shanghai to avoid chaos. Qian Xuesen was born in Shanghai on December 11 (October 21 in the lunar calendar) in the same year (Fig. 4). Qian Junfu and Zhang Lanjuan nicknamed Qian Xuesen as *Shen'er*, because the word “Shen” harmonized with “Sen”, and Shanghai was called “Shen cheng”. The word “Shen” was a double entendre. Qian Junfu also gave Qian Xuesen an alias, *Bai qing*, which were often called by Qian Xuesen’s classmates and friends.

In 1913, when the revolutionary tide subsided, Qian Junfu returned to Hangzhou with his wife and son, remained as the principal of the First Secondary School in Zhejiang Province. In 1914, Qian Junfu received the order to serve in the Ministry of Education and went to Beijing for his mission. He packed his belongings and went to Beijing alone to get prepared for the whole family. Before his departure, they took a family photo at the Dafangbo Photo Studio in Hangzhou to commemorate the occasion (Fig. 5). After Qian Junfu arrived in Beijing and settled in, he wrote to Zhang Lanjuan that she could bring their son to Beijing for reunion.



Fig. 4 A photo of Qian Junfu and Qian Xuesen in Shanghai (Qian Xuesen's first birthday)

In the early summer of 1914, Zhang Lanjuan and her son took a train from Hangzhou to Shanghai, waiting for the ship to travel north. During their stay in Shanghai, the mother and son took a photo at a photo studio. They arrived in Beijing by train after a stop in Tianjin, and the family was reunited after a short separation.

Mother's love is like water

Qian Junfu's student Huang Pingsun once described a scene: "The revered Mrs. Zhang said that Xuesen had such intentness in reading books that he only attended to the dishes close to his chopsticks while having meals. His mother would move the plates now and then so that he would eat more kinds of food" [10]. What Huang

had said vividly illustrated how Qian Xuesen was fond of reading on the one hand, and on the other hand it reflected the delicate feelings of his mother Zhang Lanjuan towards her son. Mother's love is like water! (Figs. 6 and 7)

Qian Xuesen once recalled that his mother had cultivated him the interest in "loving flowers and plants." Flowers and plants were representative of ecology and nature, the vitality of life. "Loving flowers and plants" was thus to cultivate her son's personality and enrich his emotions in the process of interacting with nature. The wisdom of Zhang Lanjuan was illustrated through another example. When Qian Xuesen was in elementary school in Beijing, his mother would ask him to trace nine characters with an ink brush in his winter vacations. These nine characters were "*Ting, Qian, Chui, Liu, Zheng, Zhong, Dai, Chun, Feng*", which composed a verse, literally meaning "the willow in front of the court was precious and waiting for the spring breeze." This was the famous "Nine-Nine Winter Diagram", which was said to be created by the mother of Emperor Xianfeng. Since the nine characters were all in nine strokes, Zhang Lanjuan gave Qian Xuesen a task, sitting at the table every day to trace a stroke. After 81 days, the coldest time of the winter holidays would be over. Through this method, not only did Qian Xuesen practice his brush writing, but he also exercised his patience and perseverance. This training and cultivation of willpower played an important "genetic role" in Qian Xuesen's scientific research.

When the Qian family lived in Beijing, Jiang Baili also worked in Beijing. During this period, Zhang Lanjuan hoped that they would adopt Jiang Ying, Jiang Baili's third daughter. This was the beginning of the love story between Qian Xuesen and Jiang Ying. As a matter of fact, both parents did not have the thought that Qian Xuesen and Jiang Ying would get married in one day. Zhang Lanjuan's original intention was to find a playmate for Qian Xuesen, so that her son, being the only child in the family, would not become unsociable and eccentric. Qian Xuesen had spent in Beijing for fifteen years, which was the bloom of his youth, and meant so much for him.

In 1929, after Qian Xuesen was admitted to Jiaotong University, his family moved back to Hangzhou. At the end of 1934, the warm-hearted Zhang Lanjuan introduced a girlfriend for the son of a friend living in Shanghai, and took a train from Hangzhou to Shanghai. Unfortunately, she was infected with typhoid fever on the train back to Hangzhou and died soon despite the treatment. At that time, Qian Xuesen was participating in the professional internship arranged by Tsinghua University. After receiving a telegram from his father that his mother was seriously ill, he immediately wrote to Tsinghua University and asked for leave to go home to visit his mother. The loss of his mother as a young man was undoubtedly a heavy blow to him.

In 1935, Qian Xuesen had a tombstone for his mother erected before he went to the United States. Whenever he thought of his mother, he would take out a group photograph with his mother and recall every bit of memory of her. In the summer vacation of 1947, Qian Xuesen returned to China for a short visit. The first thing he did was to sweep his mother's tomb in Hangzhou, accompanied by his father. He took some photographs of his mother's tombstone and surrounding scenery as a memento.



Fig. 5 A family photo taken in Hangzhou in 1914 before Qian Junfu went to Beijing to take up his post in Ministry of Education

3 Primary and Secondary Education

Qian Junfu's appointment to the Ministry of Education in 1914 was a personal promotion in his career. This promotion changed his life trajectory and also provided Qian Xuesen with the opportunity to receive a good primary and secondary education in Beijing. During the period when Qian studied in Beijing, the country was relatively stable politically and the economy was generally on an upward trend, providing a material basis and a favorable social environment for education.

Qian Xuesen's son, Qian Yonggang once summarized his father's experiences of receiving school education: "My grandfather was a section chief of the third

Fig. 6 A photo of Zhang Lanjuan and Qian Xuesen in Shanghai in the early summer of 1914



Department of the Ministry of Education. He was in charge of primary and secondary education. He sent his son to the best kindergarten, the best primary and secondary school at that time. Later, my father went to the best university in China and to the University of California, one of the best universities in the United States.”

The famous “Qian Xuesen’s question” put forward by Qian Xuesen in his later years was grounded in his own experience, especially his educational experiences in Beijing. Therefore, in his list of 17 teachers who influenced his life, eight were from his primary and secondary schools. The primary and secondary education set a cornerstone in Qian Xuesen’s education. What unforgettable experiences had his primary and secondary education brought to him? There are generally four important aspects, which Qian Xuesen himself often mentioned in various occasions.

Emphasizing on balanced academic development

The educational goal in Republic of China emphasized on integrity of students development, and a balanced school curriculum was designed to achieve that goal. Every course, major or minor, had its own value. Taking the primary school affiliated to



Fig. 7 A photo of Qian Xuesen and his mother Zhang Lanjuan

Beijing Women's Normal University where Qian Xuesen had attended as an example, the whole curriculum included five systems:

Semiotics: Chinese, Mandarin, composition, English, mathematics and so forth.

Science: history, geography, observation, natural science, family affairs and so forth.

Arts: arts and crafts, fine arts, practicing writing, sewing, cooking, music, sports and so forth.

General Knowledge: citizenship, health, gardening and so forth.

Specialized courses: calligraphy, lectures, performances, gatherings and so forth (Fig. 8).

Qian Xuesen still cherished a deep memory of his primary school experiences in his later years. On one occasion, Qian Xuesen attended a new year's party organized by the Commission of Science, Technology and Industry in Ministry of National Defense. He could not help bursting into tears while watching the film "Old Stories in the South of the City." The film was set in the primary school Qian Xuesen once attended. He commented: "Mr. Yu Shijian, the grade director, was my teacher and Comrade Deng Yingchao, who was there but had not taught our class. I missed them

Fig. 8 A photo of Qian Xuesen at the age of 10 when he was studying at the Primary School affiliated to the Beijing Normal University



so much.” He was deeply moved by the film’s theme song, *Farewell Song*, written by Li Shutong, a good friend of his father. Qian Xuesen often chanted the lyrics in his later years:

Outside the pavilion, by the side of the ancient road, the grass is green;

The evening wind blows the willows, the sound of the flute is broken, and the setting sun is beyond the mountain.

To the end of the world, to the corner of the earth, dear friends scattered;

A scoop of wine makes me happy; the dream of departing is cold tonight.

When the curriculum was designed in Beijing Normal University Affiliated High School (BNUHS) where Qian Xuesen studied, the emphasis was placed on a holistic and balanced development on the part of the students. The school had a “three-three system”, that was, three years of junior high school and three years of high school, where compulsory and elective courses were set to meet the individual needs of students.

Table 1 shows Qian Xuesen's study profile during the six years in HSBNU. It should be noted that Qian Xuesen took a German course as his second foreign language.

Emphasizing on the accumulation of extracurricular readings

The school curriculum was to some extent limited; therefore, extracurricular reading was considered as an effective way to expand students' scope of knowledge as well as a good way of self-study. There was a reading room in Qian Xuesen's primary school, which was not so spacious and opened twice a day. Students could read books and newspapers after lunch and after school. When Qian Xuesen entered HSBNU, he frequented to the school library. The library was small in size, but the collection of books was quite large. The collection was divided into two categories: classical novels of "liberal arts", such as *Romance of the Three Kingdoms*, *Journey to the West*, *The Scholars* and so on; and books on natural sciences, as well as books on science and technology. Borrowing classical novels required the approval of the Chinese language teacher, while books on science were freely available to all students.

When Qian Xuesen was a freshman in high school, once he browsed books in the reading room, Qian Xuesen spotted a book introducing theory of relativity and he went through the whole book out of curiosity. He recalled: "Although I did not understand it very well, I learned that Einstein's concept of relativity and the theory of relativity were confirmed by astronomical observations" [11]. There was no doubt that it was difficult for high school students to understand such a profound theory, but it stimulated Qian Xuesen's keen interest in natural science (Fig. 9).

Emphasizing on the consolidation of basic knowledge

If the foundation is not firm, the building will not be built high. One of the qualities that made Qian Xuesen so appreciated by his mentor Theodore von Kármán as a technical scientist was his mathematical endowment. The stimulation of this endowment owes to his high school mathematics teacher, Fu Zhongsun.

Fu Zhongsun's way to teach mathematics was "giving lectures and doing exercises." It proved that "exercise method" in mathematics learning was very effective in training logical thinking. Fu stressed that students should learn to discover regularity in the process of repeated exercises. This method could simplify complex problems and effectively improve the ability of logical thinking after long-term training. In this way, students could quickly find solutions when confronting complex problems. Obviously, Qian Xuesen had been effectively trained so that he outstripped others in the ability of logical and abstract thinking. Appropriate "exercise method" had positive effect on the understanding of book knowledge as Fu mentioned:

Learning should depend on practices, not just on listening to lectures. Students are required to listen to the lectures first and then do exercises by themselves. Even literature and art education need memorization! There are figurative thinking and logic thinking, while logical thinking is trained by doing exercises [12].

Therefore, when Qian Xuesen taught at China University of Science and Technology, he also stressed that the best way to learn basic subjects such as mathematics

Table 1 Qian Xuesen's school schedule at Beijing Normal University Affiliated High School

		Term	Compulsory courses (weekly class hours)				Optional courses (weekly class hours)		
Junior middle school	Grade 1	The 1st semester	Civics (1)	Chinese (7)	English (5)				
			Arithmetic (5)	Geography (3)	Physiology and Hygiene (1)		N/A		
			Botanics (2)	Painting and Crafts (2)					
			Physical education (2)	Scout Training (1)					
			Music and song (1)						
	Grade 2	The 2nd semester	Civics (1)	Chinese (7)	English (5)				
			Arithmetic (5)	Geography (3)	Physiology and Hygiene (1)		N/A		
			Botanics (2)	Painting and crafts (2)					
			Physical education (2)	Scout training (1)					
			Music and Song (1)						
Grade 2	The 1st semester	Civics (1)	Chinese (6)	English (6)					
		Arithmetic (5)	History (3)	Zoology (2)	Chinese (2)	Abacus calculation (2)			

(continued)

Table 1 (continued)

	Term	Compulsory courses (weekly class hours)			Optional courses (weekly class hours)		
Grade 3	The 2nd semester	Physics and chemistry (2)	Painting and crafts (2)		Business (2)		Crafts (2)
		Physical education (2)	Scout Training (1)		Painting (2)		Music and song (1)
	The 1st semester	Civics (1)	Chinese (6)	English (6)	Chinese (2)		Abacus calculation (2)
		Arithmetic (5)	History (3)	Zoology (2)	Crafts (2)		Painting (2)
		Physics and chemistry (2)	Painting and crafts (2)		Music and song (1)		
		Physical education (2)	Scout training (1)				
	The 1st semester				Chinese (2)		English (2)
		Civics (1)	Chinese (5)	English (7)	Arithmetics (2)		Minerals and geology (2)
		Arithmetic (5)	Geography (4)	Physics and chemistry (2)	Industry (2)		Chemistry craft (2)
		Physical education (2)	Home economics (2)		Accounting (2)		Music and song (1)
				Painting (2)			

(continued)

Table 1 (continued)

		Term	Compulsory courses (weekly class hours)				Optional courses (weekly class hours)					
Senior middle school	The 2nd semester		Civics (1)	Chinese (5)	English (7)	Chinese (2)	English (2)					
			Arithmetic (5)	Geography (4)	Physics and chemistry (2)	Arithmetics (2)	Minerals and geology (2)					
			Physical education (2)	Home economics (2)		Industry (2)	Chemistry craft (2)					
						Crafts (2)	Painting (2)					
						Music and song (1)						
	The 1st semester	Grade 1		Chinese (3)	English (5)	Chemistry (4)	Algebra (1)	Botanics (4)				
				Arithmetics (5)	Physical education (2)		Mineralogy (3)	Instrumental drawing (2)				
							Crafts (2)	Dialogue (1)				
							Short stories (2)	World geography (2)				
							General science (2)	Ethics (2)				
The 2nd semester						Psychology (2)	Drawing (2)					
						Music (1)	Embroidery (2)					
			Chinese (3)	English (5)	Chemistry (4)	Algebra (1)	Botanics (4)					
			Arithmetics (5)	Physical education (2)		Mineralogy (3)	Instrumental drawing (2)					

(continued)

Table 1 (continued)

	Term	Compulsory courses (weekly class hours)		Optional courses (weekly class hours)	
Grade 2	The 1st semester				Dialogue (1)
				Crafts (2)	World geography (2)
				Short stories (2)	Psychology (2)
				General science (2)	Music (1)
				Drawing (2)	
				Embroidery (2)	
				Physics (4)	Advanced trigonometry (1)
			Chinese (3)	English (4)	Geology (3)
			Arithmetics (5)	Physical education (2)	Inorganic chemistry (4)
					Dialogue (1)
			World history (2)		
			Painting (2)		
			Sociology (1)		

(continued)

Table 1 (continued)

Grade	Term	Compulsory courses (weekly class hours)				Optional courses (weekly class hours)			
Grade 3	The 2nd semester	Chinese (3)	English (4)	Physics (4)	Politics (2)	Second foreign language (3)			
		Arithmetics (5)	Physical education (2)	Zoology (4)	Modern geometry (2)	Advanced Trigonometry (1)			
				Astronomy (2)	Inorganic chemistry (4)	Geology (3)			
				Qualitative analysis (2)	Dialogue (1)				
				Novels (2)	World history (2)				
			Economics (2)	General theory of law (2)					
			Painting (2)	Music (1)					
			Sociology (2)	Second foreign language (3)					
	The 1st semester	Ethics (1)	Chinese (3)	English (4)	Introduction to calculus (3)	General biology (3)			
		Arithmetics (4)	Physical education (2)	Organic chemistry (3)	Applied chemistry (2)				

(continued)

Table 1 (continued)

	Term	Compulsory courses (weekly class hours)			Optional courses (weekly class hours)		
					Mechanics (3)		Magnetolectricity (3)
					Dialogue (1)		Rhetoric (2)
					Introduction to philosophy (1)		Second foreign language (3)
	The 2nd semester	Ethics (1)	Chinese (3)	English (4)	Calculus (3)		General biology (3)
		Arithmetics (4)	Physical education (2)		Surveying (3)		Organic chemistry (3)
					Applied chemistry (2)		Mechanics (3)
					Magnetolectricity (3)		Dialogue (1)
					Rhetoric (2)		Second foreign language (3)

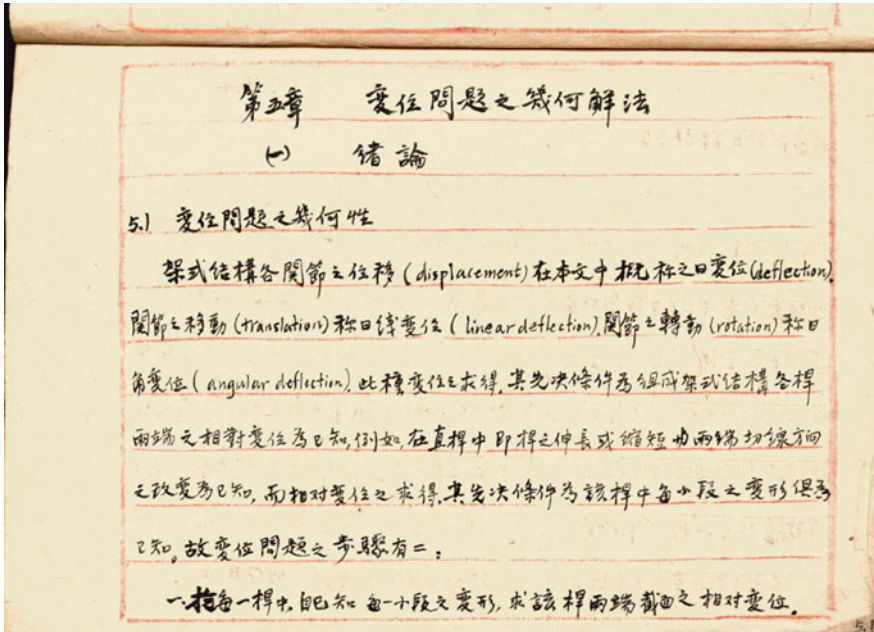


Fig. 9 Qian Xuesen's high school math workbook

and physics was to practice a lot, because “one would fail to recognize its true face if one was not proficient at it.” Memorizing formulas and methods were also necessary in order to apply them flexibly. “Exercise method” was not only an effective way to consolidate a learner’s foundation, but also an essential way to acquire proficient skills. “Without proficient skills, one may even make mistakes in simple copying work” [13], Qian Xuesen once said jokingly.

The teaching method of “giving lectures and doing exercises” requires patience, enthusiasm and carefulness on the part of teachers. Through teachers’ repeated explanations, students were able to grasp the knowledge system of the discipline, understand its composition and correlation, and finally construct a macro and micro knowledge system by themselves. Qian Xuesen mentioned that the teachers in HSBNU were very patient, and would give students assignments in natural science class, in Chinese and foreign language classes as well, which benefited him a lot [14]. For example, Fu Zhongsun often gave students in his science class some extra tutoring, and taught them advanced college-level courses, like calculus. “The courses in the first year of Shanghai Jiaotong University were too easy to me, as I had already learned these courses in high school and I had learned them well” [15], Qian Xuesen said later on.

Emphasizing on the cultivation of practical ability

In Republic of China, from elementary school to high school, practical courses were compulsory, which aimed to cultivate students’ observation and hands-on skills,

effectively combine textbook knowledge with practical knowledge, and deepen their understanding of textbook knowledge in application. The curriculum in Qian Xuesen's elementary school covered many practical courses, such as household chores, crafts and sewing. Through learning these courses, the students would not fall into the inertia of "having rice put to their mouths and clothing to their hands". When Qian Xuesen entered the HSBNU, the proportion of practical courses in the curriculum increased, and teaching methods used in these practical courses were varied, which could be illustrated through two teachers.

One was Qian Xuesen's biology teacher Yu Junshi, who attached special importance to the cultivation of students' ability to observe nature and use their heads and hands by collecting and making specimens. In his letter to Yu Junshi on February 5, 1982, Qian Xuesen pictured scenes over 60 years ago: "I went to the Temple of Heaven in Beijing with my teacher to collect insect specimens and you provided us with glass alcohol bottle in collecting snake. Afterwards we had egg and bean curd soup in *Huai lu*, your residence. I was very grateful for your instruction. What I might have done for my country and people owed to your enlightenment and instruction" [16].

The other was Wang Heqing, Qian Xuesen's chemistry teacher, who attached special importance to the combination of chemical principles and chemical experiments. He encouraged students to learn theoretical knowledge while observing phenomena by participating in experiments. Wang Heqing suggested that students could go to the laboratory whenever they were interested to do experiments under his personal guidance. Qian Xuesen developed a strong interest in chemistry in HSBNU. He studied organic chemistry, inorganic chemistry, applied chemistry, which were supposed to be offered in university. This teaching method of combining theory and practice could enable students to learn not only knowledge but also to understand the learning process. Qian Xuesen commented: "The main thing was not in memorization, but in understanding."

HSBNU occupied an important place in the history of secondary education in the Republic of China and many teachers in HSBNU had innovative educational ideas including combining theory with practice. Yu Junshi and Wang Heqing were just two representatives of these teachers (Figs. 10 and 11).

Lin Liru, the then principal of HSBNU was another scholar worth mentioning. Lin was the director of the Education Department of Beijing Normal University, and the principal of HSBNU was his "part-time job". It was he who implemented the "three-three system" and advocated the teaching philosophy of "whole-person cultivation", which led to a rapid improvement in the teaching quality of the affiliated high school. Qian Xuesen wrote to Lin Andi, Lin Liru's daughter, on September 21, 1989, "Mr. Lin was my revered teacher and I was very grateful for the kind of education in HSBNU under his leadership." That was the reason why Qian Xuesen especially emphasized the role of principals, "It was very important for a school to have a good principal and appropriate educational policies," when he talked about education in his later years.

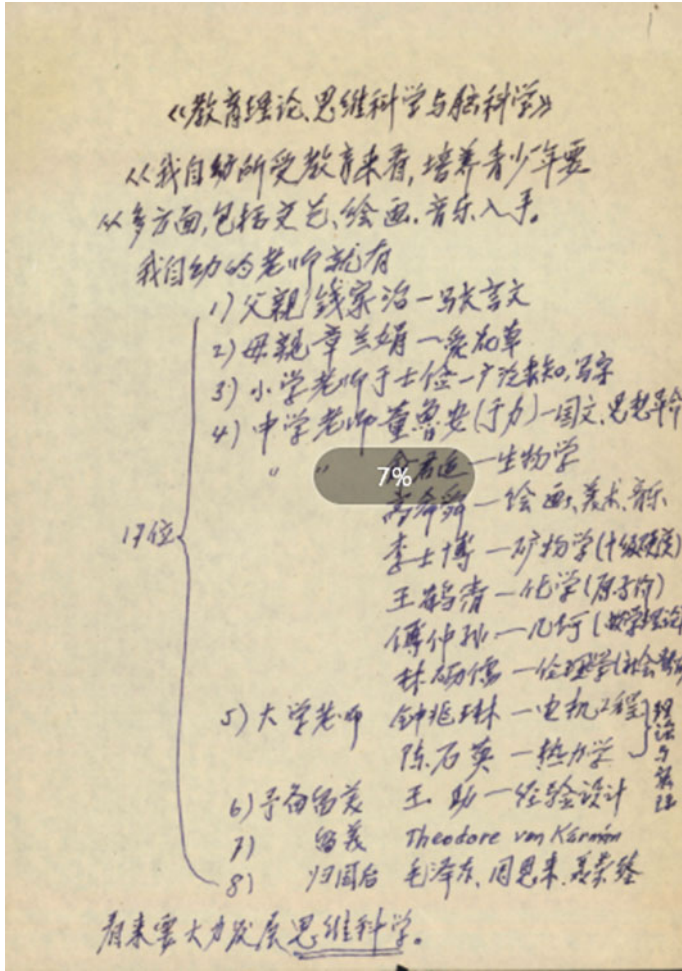


Fig. 10 Seventeen teachers who exerted important influence on Qian Xuesen

4 Family Education

“To write *wen yan wen*, or the classical Chinese was my father’s biggest influence on me”, Qian Xuesen said. Writing *wen yan wen* actually stands for Qian Junfun’s valuing on Chinese culture and humanism. Qian Junfu attached great importance to family education and teaching by precept and example in daily life. This concept of family education endowed Qian Xuesen with artistic and humanistic qualities, laying down the basis for him to be a scientist. To borrow a word from Tu Yuanji, the secretary of Qian Xuesen: “Qian Junfu was a talented person, but his talent was not on full display. His greatest contribution was the cultivation of Qian Xuesen for the country.”

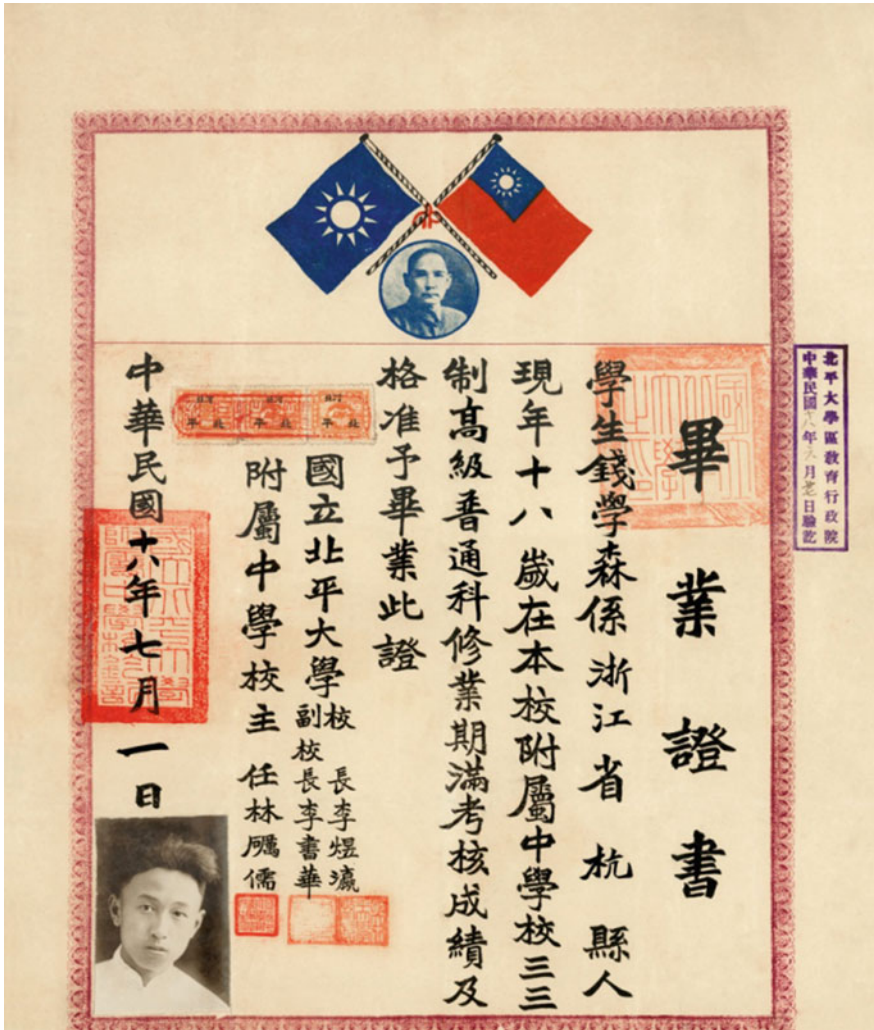


Fig. 11 In July 1929, Qian Xuesen received his diploma from the Secondary School affiliated with National Beiping University (National Beijing Normal University was changed to “National Beiping University” due to the implementation of the graduate school system.)

The concept of family education

Qian Xuesen’s great achievement attributes to his father, the educationalist Qian Junfu. Qian Junfu was majored in educational theory and had more than twenty years of experiences in practices of saving the nation through education. He taught in colleges and high schools, and also took offices in the educational administrations. He was deeply aware that family education was an indispensable part in the cultivation

of “a whole person” and it was an important part of the whole educational system. He said:

I am doubtful about the way some Chinese families educate their children. School and families are equal partners in children’s education. Only when the two kinds of education complement each other can they be effective in cultivating a child. Some families thought they had fulfilled their duties by sending their children to school. This is completely wrong! Some people blamed school education but never reflected on their family education. What a pity to be tolerant of yourself while to blame on others! I hope that the parents will realize the importance of cooperating with the school. In this way, our education would make great progress and our children would have an optimistic future [17].

Qian Junfu regarded it urgent to change some parents’ view that children education should totally depend on school. He compared a life journey with a ship sailing in the sea. He said, “A ship could not escape the fate of capsizing without a solid hull, a strong sail and an accurate rudder.” The implication is that one’s overall development attributes to a healthy body, sufficient knowledge and high morality, that is, all-round development of morality, intelligence, physique and aesthetics. Because of this, Qian Junfu particularly focused on family education. It was blessing for Qian Xuesen to have a father who understood education so profoundly.

The content of family education

Qian Junfu’s concept of family education could be understood in broad and narrow sense. The broad sense of family education focused on cultivating Qian Xuesen’s humanistic temperament and artistic interests, and training his ability to think figuratively. This ability helped Qian Xuesen to think in a “big way” and played a significant role in his scientific career. In his later years, Qian Xuesen recalled with gratitude:

My father, Qian Junfu, knew a lot about modern education. On the one hand, he asked me to study science and technology; on the other hand, he sent me to take art lessons like music and painting. I am not only interested in science, but also in art, and I have read many books on art theory when I was a student at Shanghai Jiaotong University, like George Plekhanov’s *Theory of Art*. These artistic interests not only deepen my understanding of poetic feelings and philosophies of life in art works, but also enable me a macroscopic thinking characterized in arts” [18].

Qian Junfu often asked his friends, some of who were famous cultural scholars, to tutor his son. With his father’s arrangement, Qian Xuesen had received fine artistic and humanistic edification.

In 1917, when Qian Xuesen was six years old and about to enter elementary school, his father took him to the home of Sun Jincai to learn the art of calligraphy. Sun Jincai was a late Qing dynasty scholar who not only had a reputation for calligraphy in the Republic of China, but also well versed in Chinese traditional learning. Qian Xuesen later recalled the first day of his calligraphy class, “My teacher wrote a short sentence for me to imitate, and that was the beginning of my calligraphy learning.” Sun Jincai not only taught calligraphy, but also explained the schools of calligraphy and the Chinese culture. Qian Xuesen had always regarded Sun Jincai as his enlightenment teacher, who later wrote the “mandarin duck album” for him and Jiang Ying.

As calligraphy and painting was from the same origin, Qian Junfu found that his son developed an interest in painting while practicing calligraphy. He asked his best friend Gao Xishun to teach Xuesen painting. Qian Xuesen learned the painting skills quickly. He said happily to his parents: “While observing and drawing, the scenes melt into my mind. I forgot everything at that moment. My heart was so pure.” After the Qian’s family moved to Hangzhou, Qian Junfu had some of Qian Xuesen’s paintings framed and hung in their home. Unfortunately, when Japanese bombed Hangzhou in 1937, those paintings were destroyed.

When Qian Xuesen was thinking about education in his later years, he said bluntly, “It was a fine tradition of Chinese intellectuals that professors were not only scientists and engineers, but also literary scholars and poets. It was a pity that this tradition had nearly died out among today’s young and middle-aged people!” [19] When he recalled the humanistic and artistic training he received in middle school, he said with pride, “I myself painted watercolors and Chinese paintings, played the violin, and wrote short essays in middle school. In college, I played the horn and participated in the school’s wind band. It should be noted that figurative thinking, as inexpressible as it was, was different from abstract thinking” [20].

Qian Junfu’s family education in a narrow sense means extracurricular tutoring. Qian Junfu had invited tutors for Qian Xuesen during elementary and middle school years. Before the college entrance examination, Qian Xuesen was tutored by Zhao Naituan, a student at Peking University, majored in Chinese and English and Luo Wen, a student at Beijing Women’s Higher Normal University, majored in mathematics, physics and chemistry. Interestingly, the two tutors were dating with each other. Zhao Naituan was a student of Qian Junfu when he was the principal of the First Secondary School in Zhejiang Province and he was facing financial problem and nearly dropped out of school at that time. Qian Junfu asked both of them to come to his home to tutor Qian Xuesen, which helped solve their financial problems.

Discussions on learning between father and son

Qian Junfu had developed his own reading method as a student, an efficient “three-step reading method”, which he passed on to his son. Every summer vacation, Qian Junfu gave his son a reading list and he himself also read the books in the list. The first step of reading was skimming and scanning, aiming at understanding the gist of content. The second step was intensive reading. The third step was to focus on the key parts by taking notes. Qian Junfu would review all the notes that his son had put down.

This method of reading was a good way for father and son to share their knowledge with each other. By reviewing his notes, Qian Junfu could know how much his son had learned from these books and what he was thinking. This method of reading was also very useful in expanding his knowledge scope, providing him an access to wider areas of knowledge than he could learn in school, and also stimulating his desire to learn. What is less well known is that this method of learning has also played an important role in inspiring Qian Xuesen to embark on aviation and aerospace.

Qian Junfu had the habit of reading newspapers and periodicals, and he was especially concerned with the development of science and technology in the world.

He had accumulated a wealth of aerospace knowledge through years of reading. On March 7, 1932, during his tenure at the Education Department of Zhejiang Province, he delivered a keynote speech entitled “*Having the Knowledge of Aviation in Fighting with the Invaders.*” He analyzed the international and domestic situations from four aspects, namely, aviation industry, air force organization, aviation force and aviation management. At that time, Japanese invaders were swollen with arrogance, invading Shanghai and bombing Hangzhou with the advantage of aircraft. Qian Junfu’s speech inspired the audiences greatly. At the end of the speech, Qian Junfu called for the cultivation of aviation talents in China as “Germany and Japan had developed the students’ interest in aviation from their primary school years”, but “China lagged behind.” Therefore, he called for vigorous cultivation of aviation talents.

In fact, Qian Junfu had an in-depth conversation with Qian Xuesen before preparing the lecture, discussing the current state of aviation in the world and the prospects of developing aviation in China. After that, Qian published six articles on aerospace from 1933 to 1935, and the examples, data and some ideas used in Qian’s articles were the same or similar to those given by Qian in his lectures. This historical detail revealed that the mutual learning between father and son was most likely the source of the ideas that led Qian to aerospace research. Eventually, Qian Xuesen was admitted to Tsinghua University in 1934 as a Boxer Rebellion Scholarship recipient in the “aviation engineering (rack group)”, fulfilling his father’s dream.

In their family education, Qian Xuesen’s parents had fully respected his interests and guided him to develop positive outlook on life. Therefore, the comment Qian Xuesen had made that “was nurtured and educated by my father and mother” was thought-provoking for parents nowadays.

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Chapter 2

Serve the Country Through Engineering



1 At Shanghai Jiaotong University

Founded in 1896 as Imperial Nanyang University, Jiaotong University owned its origin to Sheng Xuanhai, then famous industrialist and educator, who set the school's goal of fostering economic, political and legal talents. Qian Xuesen witnessed the University's golden period in the developmental history, then well-acclaimed as 'MIT in the East' and later developed into a comprehensive university of science and engineering. Having received sufficient funding and well-equipped for research and teaching, Jiaotong University was renowned as having both "masterminds" and "high buildings."

Unlike the current national college entrance examination system, the universities in Republic of China stipulated their own enrollment regulations, organized entrance exams and recruited students on their own. The universities usually staggered the examination time so that students could apply for several universities. Many students thus were able to apply for several universities at the same time; however, Qian Xuesen was quite determinate to have Jiaotong University his sole choice (Fig. 1).

Jiaotong University had its recruiting regulations published in *Shen Bao*, *Ta Kung Pao*, and *Morning News*, then influential newspaper in the country. The scheduled examinations were on July 23, 24 and 25th, 1929 and the venue was at Jiaotong University. Two subjects were tested each day, with a total of six subjects: Chinese, English, physics, chemistry, advanced algebra and analytical geometry.

On August 4, 1929, the Shanghai newspaper *Shen Bao* published a list of students who had passed the entrance exam of Jiaotong University on the front page. Qian Xuesen's score placed him the third in the nation in mechanical engineering with a total score of 396 points: 51 in Chinese, 80 in English, 50 in physics, 85 in chemistry, 60 in advanced algebra and 70 in analytic geometry respectively.

Being admitted to Jiaotong University was not easy, considering that the admission ratio was about one out of five. The admission was fair as it solely based on the scores gained through written examination.

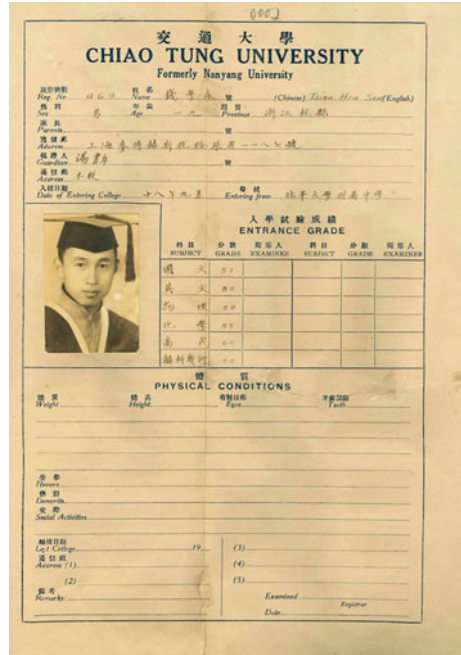


Fig. 1 Group photo at Qian Xuesen's home in Fangguyuan, Hangzhou after he was admitted to Jiaotong University in 1929 (from right: maid, grandmother, his mother Zhang Lanjuan, his father Qian Junfu and Qian Xuesen)

Why wouldn't Qian Xuesen choose Tsinghua University located in Beijing as he went to middle school in Beijing? A reasonable inference could be that the graduates from Jiaotong University were able to find a descent and well-paid job. The railway passenger and freight transportation and other related industries under the jurisdiction of the Ministry of Transportation could provide a so-called "iron rice bowl". It was true with some other industries such as postal service and telecommunications, shipping, infrastructure, banking and management, all of which were high-paid industries. It was not uncommon for freshmen and sophomores in other universities opting for dropping out and applying for Jiaotong University (Fig. 2).

As for Qian Xuesen, two private reasons could well explain his decision. One was his strong determination to serve the country with his expertise in mechanical engineering. The other could be quite personal. His father Qian Junfu had worked in the national government's Ministry of Education and was transferred to Nanjing in 1927, and later to Hangzhou. Qian Junfu decided to leave his wife, Zhang Lanjuan to stay in Beijing for another two years to take good care of their son. The whole family finally moved back to Hangzhou upon Qian Xuesen's admission to Jiaotong University in 1929.

Fig. 2 Qian Xuesen’s registration form at Jiaotong University



Engineering students struggling for high scores

September 9, 1929 was the day when the new students of Jiaotong University registered for admission and 145 freshmen were enrolled in the College of Engineering, including Qian Xueshan. Among them, 55 were directly enrolled through preparatory program and 90 were admitted through entrance examinations. The new students in the three engineering colleges, Mechanical Engineering, Electrical Engineering and Civil Engineering, were organized into three types of classes, and Qian Xuesen was allocated in class A.

Jiaotong University was known for training engineering students, and it required that students’ basic knowledge must be consolidated. Therefore, all engineering students in the first and second year must take basic courses in mathematics, science and chemistry and so forth. It was not until the third year that professional courses were taught separately for the mechanical, electrical and civil engineering majors. Jiaotong University was also featured with the large load of courses, homework assignments, exams and term papers, as shown in Qian Xuesen’s school schedule (Table 1). In order to distinguish the ranking of student performance, the test scores were calculated to two decimal places, as shown in the saying “one point on the hero.” There were two groups of students, graduates from High School Affiliated to Beijing Normal University and from Yangzhou Middle School, who often competed secretly in exam results for the reputation of their alma mater.

At the start, Qian Xuesen felt not adapted to the college as students at Jiaotong University were all top students and they specially valued scores. As a freshman,

Table 1 Qian Xuesen's school schedule at Jiaotong University

Academic year	Courses in the 1st semester (weekly class hours)		Courses in the 2nd semester (weekly class hours)	
The first academic year	Chinese (2)	English (3)	Chinese (2)	English (3)
	GMT party ideology (2)	College physics (4)	College physics (4)	Physical experiment (3)
	Physical experiment (3)	College chemistry (3)	College chemistry (3)	Chemical experiment (3)
	Chemical experiment (3)	Mechanical drawing (6)	Descriptive geometry (6)	Foundry internship (3)
	Foundry internship (3)	Calculus (4)	Calculus (4)	Military science (4)
	Military science (2)	French (3)		
	Mechanics (4)	College physics (4)	Woodworking workshop (3)	College physics (4)
The second academic year	Physical experiment (3)	Engineering chemistry (2)	Engineering chemistry (2)	Chemical analysis (1)
	Chemical analysis (3)	Mechanics (3)	Kinematic diagrams (3)	Machinery workshop (4)
	Experiment design (6)	Woodworking workshop (3)	Strength of materials (3)	Military science (2)
	Military science (2)	Differential equations (2)	Differential equations (2)	Applied mechanics (3)
			Thermal engineering (3)	
The third academic year	Thermal engineering (3)	Chemical experiment (3)	Thermal engineering (3)	Chemical experiment (3)
	Electrical engineering (3)	Electrical experiment (3)	Electrical engineering (5)	Electrical experiment (3)
	Engineering materials (3)	Mechanical design (6)	Mechanical design (6)	Mechanical design theory (3)
	Mechanical design theory (3)	Mechanical workshop (6)	Hydraulics (3)	Engineering contract (2)
	Engineering economics (3)		Investigation report & field trip (4)	
The fourth academic year	Power station (3)	Mechanical experiments (3)	power plants (3)	Mechanical experiments (3)
	Internal combustion engine (2)	Railway engineering (3)	Internal combustion engines (2)	Railway engineering (3)

(continued)

Table 1 (continued)

Academic year	Courses in the 1st semester (weekly class hours)		Courses in the 2nd semester (weekly class hours)	
	Locomotive vehicle design (7)	Industrial management (3)	Locomotive design (7)	Railway management (2)
	Turbine (3)	Power plant (3)	Vehicle design (2)	Automotive engineering (3)
	Mechanical engineering seminar (3)	Aeronautical engineering (3)	Mechanical engineering seminar (3)	Cost accounting (3)
			Official documents (2)	Aeronautical engineering (3)

Qian Xuesen adopted the study method in high school, and had 83.34 and 83.30 overall average scores in two semesters. He ranked first in Class A, but not the best in the entire grade. Qian Xuesen soon realized the differences between college and high school and he had to change his study method. He then set a secret goal: to achieve 90 points in the exams. He recalled:

In my first year at Jiaotong University, I felt that I didn't learn much new, because I had learned all courses at high school. As test scores were emphasized at Jiaotong University, a student with a score of 80 points was considered ordinary. One had to have a score of 90 points to be a good student and one had to memorize the textbooks to get 90 points! I remembered very clearly that we had an analytical chemistry lesson, which was actually a qualitative analysis class. To memorize was the only way out. In a few days before the exam, I memorized everything from the first page to the last page, including the footnotes in order to get a good score (Figs. 3 and 4).

This rote memorization method soon paid off, and Qian Xuesen gradually adapted to the study in college. His grades “rocketed”, and achieved the goal of over 90 points in every semester from his junior year. According to the school's regulations, the students with semester grades of 90 could enjoy an award in the form of tuition waiver, so he enjoyed the tuition waiver for four semesters in his junior and senior years, which was equivalent to a full scholarship.

In July 1934, Qian Xuesen graduated with a high grade point average of 89.10, ranking first in the College of Mechanical Engineering. President Li Zhaohuan presented him with a certificate of appreciation for his “dedication to research and expertise.” Upon graduation, he also received an honor that many students could only dream of: membership in the Phi Tau Phi Scholastic Honor Society. The Phi Tau Phi Honor Society was founded in 1921 as a national inspirational organization by J.H. Ehlers, an American professor at Beiyang University. Phi Tau Phi is the transliteration of the Greek letters Philosophia (philosophy), technologia (technology) and physiologia (natural philosophy). Ehlers was the director general of the Society, and the founding members were Fan Lianyuan, Guo Bingwen, Hu Shi, Zhang Boling, Stuart Leiden, Bao Wen and Bu Fangji. The purpose of the Society was “to select the



Fig. 3 A 1930's group photo of the graduates from Middle School affiliated to Beijing Normal University (Qian Xuesen was the third from the left in the back row)



Fig. 4 A group photo: Qian Xuesen and his classmates upon graduation from Jiaotong University

best and the brightest, to reward scholarship, to honor virtue and respect, to encourage each other, and to contribute to the progress of society.”

After its establishment, the Phi Tau Phi Scholastic Honor Society established branches in major universities in China to select members according to strict standards. Generally, well-known and outstanding professors in colleges and universities served as members, and excellent graduates could also be selected upon the agreement of all Society members. Besides Qian Xuesen, other graduates of Jiaotong University in 1934 such as Zhang Guangdou, An Dingyi, Ni Wenjie, Zhuang Huai, Xu Shengsheng, Bao chengzuo, Yuan Xiang and so forth, were elected as members of the Phi Tau Phi Scholastic Honor Society by unanimous vote of all members.

At 3 p.m., on June 30, 1934, the 34th graduation ceremony of Jiaotong University was held in Wenzhi Hall. Prior to the ceremony, President Li Zhaohuan hosted a banquet at home for the eight newly elected members of the Phi Tau Phi Scholastic Honor Society and they went to the graduation ceremony together after the banquet. Qian Xuesen always kept his membership certificate of the Phi Tau Phi Scholastic Honor Society no matter he was at home or abroad (Figs. 5, 6 and 7).

Two most memorable teachers

When Qian Xuesen recalled his university life in his later years, he often mentioned two teachers, Chen Shiying, a professor of engineering thermodynamics and Zhong Zhaolin, a professor of electrical engineering. Why were these two teachers so memorable to him among more than 30 teachers in the University? The answers might be found in their academic experiences and teaching methods.

Chen Shiying was born in 1890, and was a famous educator in thermal engineering in China. He graduated from Yantai Naval School in 1906 and went to MIT in



Fig. 5 Qian Xuesen’s Diploma of Jiaotong University

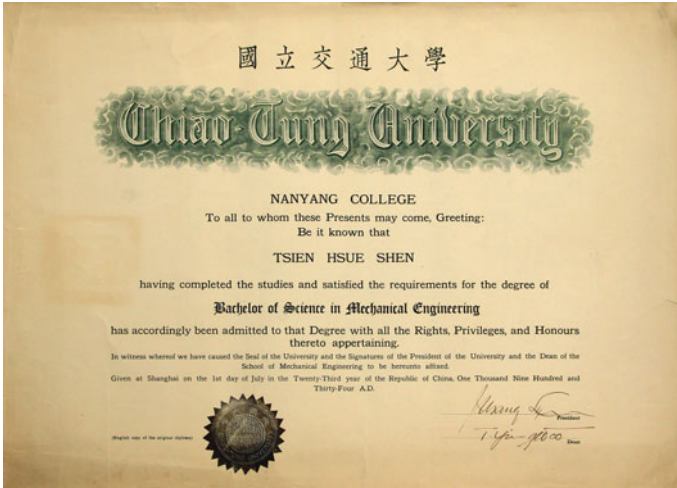


Fig. 6 Qian Xuesen's Bachelor's Degree Certificate

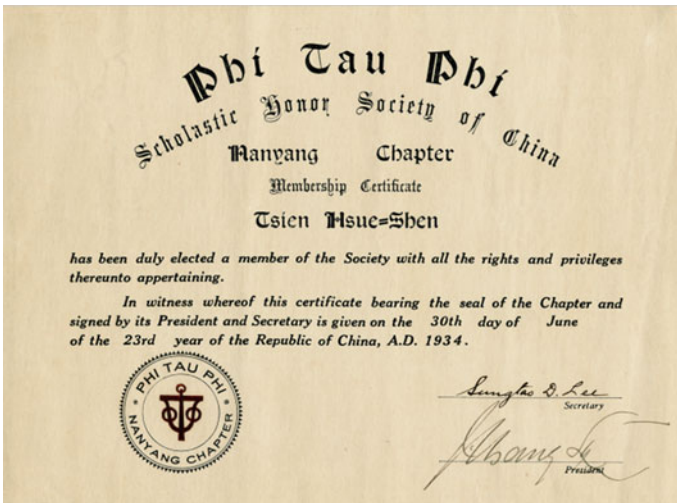


Fig. 7 Qian Xuesen's Membership Certificate of the Phi Tau Phi Scholastic Honor Society

1913. After returning to China in 1916, he had served as professor, department director and acting dean of Jiaotong University. He had served as vice chairman of the council of Jiaotong University, vice president and president of Shanghai branch of Chinese Society of Mechanical Engineering since 1949. Having worked for 67 years at Jiaotong University and died in 1983, Chen Shiying was affectionately known as "Chen laofuzi" (a highly revered teacher).

The main courses taught by Chen Shiyong were mechanics, hydraulics and thermal engineering. Chen was a serious, rigorous and meticulous teacher. Qian Xuesen recalled professor Chen in his later years with gratitude,

Among the basic professional courses, engineering thermodynamics taught by Mr. Chen impressed me most. His way of teaching was serious and combined with practice. It was an insightful course for us future engineers. I did have great respect for Mr. Chen.

In October 1955, Qian Xuesen was invited to his alma mater to give lectures and hold symposium while traveling his way back to China from the United States via Shanghai. Chen Shiyong presided over the symposium. After the event, Qian Xuesen visited the campus and the classrooms where he had studied and the dormitories where he had lived. In 1980, Qian Xuesen made a special visit to Chen Shiyong's home in Shanghai. A few years later, in his manuscript on the seventeen teachers who had influenced his life, Qian Xuesen included Chen Shiyong and Zhong Zhaolin in the list, for the specified reason of combining "theory and practice."

Born in 1901 in Deqing, Zhejiang Province, Zhong Zhaolin was a famous expert in electrical engineering. He graduated from Nanyang University in 1923 (the predecessor of Jiaotong University) and then went to Cornell University to pursue a master's degree. In 1927, he returned to China and taught in his Alma Mater. He had served as the director of the electrical engineering department and director of the electrical equipment manufacturing department at Jiaotong University, and professor of Xi'an Jiaotong University, the first president of Shanxi Electrical Engineering Society as well. In the 1930s, Zhong Zhaolin had successively developed China's first alternator and motor.

Jiaotong University always attached great importance to experimental and hands-on training, and was known for carrying out electrical experiments. There was an electrical laboratory in the engineering hall at Jiaotong University which was well-equipped with all kinds of electrical experiments. The laboratory provided a platform for the students to cultivate hands-on ability. Mr. Zhong Zhaolin always guided students to do experiments by himself.

Zhong Zhaolin not only imparted knowledge to students, but also taught them how to behave as a man and deal with the dialectical relationship between doing and being. In April 1990, Zhong Zhaolin died in Shanghai Huadong Hospital. When the sad news came, Qian Xuesen was disheartened. He laid a wreath at the memorial service to express his grief. On the centenary of Zhong Zhaolin's birth, the 90-year-old Qian Xuesen, wrote a letter to his alma mater: "I was a student of Jiaotong University. I graduated in 1934 and left school that summer. Zhong Zhaolin was my dear teacher and I was a student of Professor Zhong."

The systematic engineering education at Jiaotong University laid the professional foundation for Qian Xuesen to become an engineer. But Qian Xuesen didn't seem to be satisfied with this. The combination of "theory and practice" adopted by the two university teachers enlightened him a lot. For this reason, Qian mentioned in many occasions,

I was very grateful to two teachers at Jiaotong University, who combined rigorous scientific theories with engineering practice. One was Chen Shiyong, professor of engineering thermodynamics, and the other was Zhong Zhaolin, professor of electrical engineering.

In his letter to Qian Xuemin on February 7, 1994, Qian Xuesen explained his gratefulness, “When I entered Jiaotong University to study mechanical engineering (railway engineering) in the early 1930s, most courses were on engineering. However, Professor Zhong Zhaolin, who taught electrical engineering, and Professor Chen Shiyong, who taught thermodynamics, attached great importance to theoretical foundation.” In the development of Qian Xuesen’s scientific thoughts, the idea of technical science is a major theoretical achievement, laying down the basis of his later creation of engineering cybernetics, system engineering, modern science and technology system.

The core of technical science thought was the combination of scientific theory and engineering practice, and could be understood as the unity of “a scientist” and “an engineer.” When Qian Xuesen was invited to give lectures at Jiaotong University in 1947, he systematically expounded the theoretical connotation, research methods and research objects of technical science for the first time. From this point of view, the two teachers played the enlightenment role for Qian’s transition from an engineer to a scientist, and Jiaotong University was the starting point of his science career.

2 Artistic Cultivation of an Engineer Student

During the Republic of China, art courses were emphasized in primary and secondary schools. Qian Xuesen benefited a lot from this kind of aesthetic education. At Jiaotong University, more than a diligent student, he also revealed his outstanding talent in arts such as music, design and photography, changing the stereotypical unsmiling image of an engineering student.

A professional euphonium player

Qian Xuesen’s interest in music started from his musical experiences in contact with his cousin Li Yuanqing. Li had studied in Hangzhou National Academy of Arts and he often took Qian Xuesen to Hangzhou Youth Association. When Qian Xuesen recovered from typhus and returned to campus, he was completely fascinated by music. He began to read Feng Zikai’s book entitled *Listening to Music* and Zhang Ruogu’s *Going to the Concert*, and he also went to the library to read books such as *The One Hundred and One Best Songs*, *Literary Digest* and so on (Fig. 8).

Qian Xuesen frequented to the orchestra to improve his musical skills. Luo Peilin, a mechanical engineering major whom Qian befriended during his last two years at Jiaotong University, recalled:

At that time, both of us were music lovers. He took part in the brass band and practiced euphonium in his room every afternoon for half an hour. He bought an album of Aleksandr Glazunov’s concert waltzes from a music shop on Nanjing Road with his prize money from

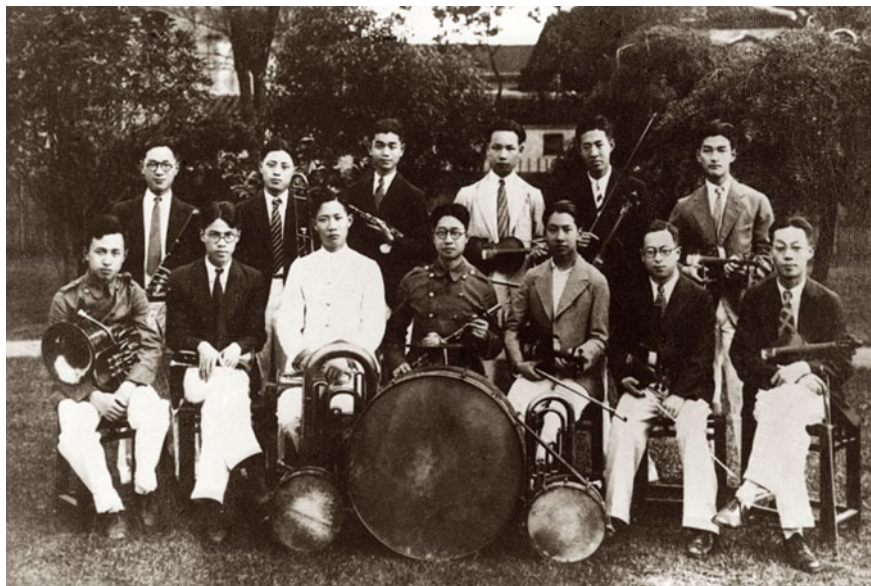


Fig. 8 Group photo of the orchestra of Jiaotong University (Qian Xuesen was the first one on the left in the front row)

the Phi Tau Phi Honor Society. I frequented to the junk shops in Beijing Road to buy old recordings of Enrico Caruso, Ernestine Schumann-Heink, violinist Fritz Kreisler, pianist Ignace Paderewski and conductor Leopold Stokowski, and others. Xuesen often dropped by to enjoy the recordings with me and sometimes he brought with records of his own.

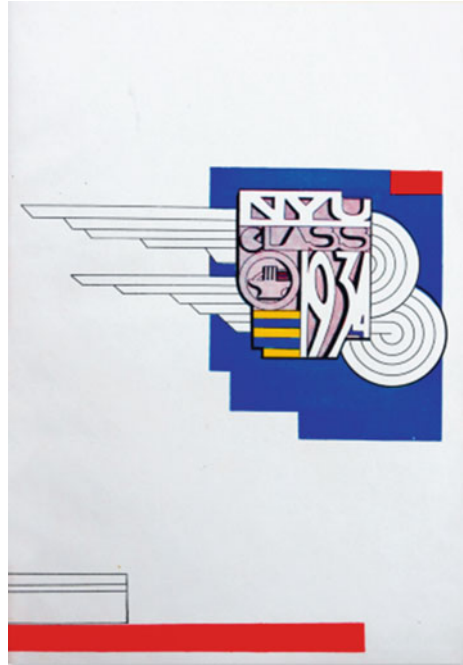
Qian Xuesen actively participated in other musical groups in the University. His name appeared in the list of members of the marching band, the list of members of the orchestra of the student union, the list of members of the Choir Club and Members of Harmonica Club at Jiaotong University in 1933.

A designer with the idea of “technical aesthetics”

Qian Xuesen was a serious and modest scholar. His test paper on the course of hydraulics with a score of 96 points at Jiaotong University could well illustrate this. The paper was neatly composed, showing his proficiency in answering the questions and the six pages of answer sheets were like a piece of art works, giving full expression to the characteristics of “technical aesthetics”, which was put forward by Qian Xuesen in his later years.

Qian Xuesen was the secretary of the fine art department of 1934’s grade journal committee. He was responsible for designing the grade emblem of the second and third grade commemorative journals of Jiaotong University and the cover page of the alumni address book (Fig. 9). A review of Qian Xuesen’s early scientific manuscripts displayed his thought of “technical aesthetics” running through his entire science career. In an interview with *Wen Hui Bao* Newspaper on March 20, 1980, Qian

Fig. 9 The cover of the 1934 Jiaotong University Students' graduation album designed by Qian Xuesen



Xuesen encouraged people engaged in science and technology to develop an interest in literature and art. He said earnestly: “Young people should not be restrained and you should firmly believe that the world could be known and be remolded.” Then, what could they do in order to be free from restraint and be ambitious? He further pointed out: “Technical aesthetics could have an inestimable influence on the training of broad thinking.” As such, in his later years, he proposed and advocated “technical aesthetics” after analyzing the development history of technology and art from the perspective of historical materialism.

A professional and avid photography enthusiast

Qian Xuesen’s interest in photography was influenced by his cousin Zhang Jingqiu, a famous photographer in 1920s and 1930s in Shanghai. Zhang had published many fine photographic works in magazines such as *Red rose*, *Game world* and so on.

When Qian Xuesen was studying at Jiaotong University, he often hung out with Zhang Jingqiu and began to learn photography under his guidance. Qian learned photographic knowledge and skills by reading professional books and through discussions with Zhang Jingqiu. Qian Junfu bought a Rolleiflex binocular camera for his son in support of his interest. As the saying goes, “A workman must sharpen his tools if he is to do his work well”, Qian Xuesen had gradually improved his photography skills after he owned this camera.

A couple of photos taken by Qian Xuesen were precious and had considerable historical and cultural value. The photos were the scenes with broken walls and tiles

splashing all over the spots downtown Hangzhou, taken right after the bombardment by the Japanese invaders. People in these photos showed a mixed expression of confusion and worry towards the incoming war (Fig. 10).

In 1935, when the steamship *President Jackson* was sailing in the Pacific Ocean, Qian Xuesen was a “follow-up reporter” of these Boxer Rebellion Scholarship recipients selected through Tsinghua University, and took a lot of pictures of the people and scenery along the way. Qian’s interest in photography had always been keen when he was in the United States. He was a well-known photography enthusiast in the international student circle. He bought a Weltini camera with his scholarship, and had a photo studio set up in the rented apartment when he was a doctoral student. Fan Xuji, his roommate, said that he had “artistic and technical pursuits in photography” and he was not only skillful in “time, distance, angle and framing”, but also in “soft lens, magnification, splicing and synthesis techniques in the development and printing technology”. Qian Xuesen became a “professional photographer” in the gatherings of Chinese and he was even asked to be the photographer in Yuan Jialiu and Wu Jianxiong’s wedding.

Qian Xuesen was good at selfie, and skillful in handling light and angle. After his marriage in 1947, Qian became a full-time family photographer and took a lot of family photos. He would often select some fine photos to make a slide show to enjoy with the family. Under his guidance, his wife Jiang Ying made progress in photography and often took photos for Qian Xuesen. These photos not only provided images of Qian Xuesen’s daily life, but also offered a glimpse of Chinese students studying in the United States by showing their ways of dressing, living, dieting, and their hobbies and social activities.

3 Developing Interests in Aeronautic Engineering

It was a long-held view that Qian Xuesen started his journey to aerospace research when he passed the competitive examination for Boxer Rebellion scholarship administered by Tsinghua University in 1934. Recent studies indicate that Qian Xuesen had already explored aviation at Jiaotong University. However, at the time when aircraft major was set up in the College of Mechanical Engineering in Jiaotong University in the autumn semester in 1934, Qian Xuesen had graduated. Not until 1942, aeronautical engineering was established at Jiaotong University. A question may be asked: in what way was Qian Xuesen able to explore aeronautical knowledge at his college days? The answer could help us understand his turn of interest in his academic pursuit.

Publishing articles on aviation

Exact numbers of Qian Xuesen’s articles on aviation which were published before he studied in the United States are unknown. Six articles have been found so far, as listed in the follows:



Fig. 10 The aftermath of bombardment by the Japanese invaders in Hangzhou, Photo by Qian Xuesen



Fig. 10 (continued)

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2. "Steam Engine Used in Aviation", *Air Force*, 1933, No. 34
3. "Recent Development of Aircraft Guns", *Air Force*, 1934, No. 67
4. "The Printing House of Flight", *World Knowledge*, No. 7, 1934
5. "Comparison between Airship and Airplane and the Future Development of Airship", *Aviation Journal*, No.1, 1935
6. "Rocket", *Zhejiang Youth*, No. 9, 1935

The first three articles were published when Qian was studying at Jiaotong University and the other three were published during his internship in Nanchang, Hangzhou and Nanjing after being admitted to Tsinghua University as a Boxer Scholarship recipient.

The first article was a detailed analysis of the construction and crash of the American Akron airship (a helium-filled hard-hulled airship owned by the U.S. Navy, which crashed off the coast of New Jersey on April 4, 1933, killing 73 of the 76 people on board and leaving only three alive), but the article landed on why the British and American countries were interested in such a costly aviation project. After analyzing the causes of the airship's crash, Qian Xuesen then asked: "Why did both Britain and the United States spend tens of millions of dollars to construct such large airships? What exactly was the airship used for, for military?" He continued, "We knew that the period of using airships to bombard enemy countries had passed, because it was vulnerable to aircraft attacks. Nowadays, airships were mainly used for reconnaissance missions. However, the navy could use cruisers or airplanes to carry out such mission. Then why did they use airships?" In the article, Qian made comprehensive comparisons between airship and cruiser, and between airship and airplane in terms of observation ability, cost, defense ability and carrying capacity, and concluded that airship had certain advantages. Finally, he pointed out that for China, there was no need to build airships at all and he listed three reasons:

Firstly, China had no colonies and was not a country with aggressive nature; therefore, there was no need for long-distance flights. Moreover, the entire land of Japan, China's current enemy, was within the capability of long-range bombers, so there was no need to have airships that could fly 10,000 *Li* at one time. Secondly, the manufacturing cost of an airplane was only few hundred thousand *yuan*, while it would cost tens of millions of *yuan* for an airship. Moreover, compared with airship which required specialized technology, aircraft was easy to manufacture and the materials used for manufacturing aircraft were also easy to purchase. Even the United States had to consult German engineers in manufacturing an airship. China had no manufacturing capability under current situation. Thirdly, considering that China's navy force was rather weak, there was certainly no need to manufacture special weapons such as airships. It was more necessary to develop a balanced and sound military navy force.

Three months later, Qian Xuesen published another article entitled "Steam Engine in Aviation" in *Air Force*. This article first reviewed the historical cases of steam engine used in aircraft, and then evaluated the feasibility of steam engine used in aircraft in three aspects: characteristics of steam engine used in aviation, current

situation and successful experimental cases. Finally, Qian put: “The steam engine was theoretically superior over the gasoline engine, and the results of experiments had confirmed its strengths, and therefore, in the near future, we would foresee that the gasoline engine dominating the aviation industry today would be replaced by the steam engine in the near future.” He also put that it was precisely because of the advantages of the steam engine that many difficulties in manufacturing large aircraft could be overcome, resulting in the emergence of unprecedented large military aircraft. Qian Xuesen put forward rather an environmentalist point of view: “We must know that the steam engine did not use gasoline, and other kinds of fuels such as coal, charcoal and so on could be used. Therefore, it was of great value to countries that did not produce gasoline such as China. This was especially important when we called for “Saving the nation through aviation.”

The article entitled “Recent Development of Aircraft Gun” was published in *Air Force* three months before his graduation. It summarized the history, specialty, development and use of heavy artillery installed on aircraft. The experimental case cited in this article was that the British air force had installed a 37 mm caliber heavy gun on an aircraft. It was believed that this kind of aircraft gun had great power in the air, sea and land. Qian put: “This new type of aircraft gun was a result of the constant efforts of the British air force.”

All three articles were published in *Air Force*, a journal hosted by Air Force Weekly Publishing House of Central Aviation School. *Air Force* was first issued on November 12, 1932 and ceased publication in August 1937, and it had published 241 issues successively. *Air Force* was not academic journal and the readership was mainly college students. Its main purpose was to introduce aviation knowledge and propagandize “Saving the nation through aviation.” It was certain that the library of Jiaotong University subscribed to this journal and all the issues had been originally kept at the library of Jiaotong University as “Jiaotong University Library Collection” was shown on the cover. After the founding of People’s Republic of China, all the issues were transferred to Shanghai Library.

In 1934, Qian Xuesen was admitted to Tsinghua University to study in the United States as a Boxer Scholarship recipient, and was then arranged by Tsinghua University for a one-year professional internship. During this period, he published three more articles, entitled “The Printing House of Flight”, “Comparison between Airship and Aircraft and the Future Development of Airship”, and “Rocket”. “The Flying Printing House” was published in *World Knowledge* (Vol. 1, No. 7) on December 16, 1934, and was mainly devoted to the introduction of the largest Soviet airplane at that time, the Maxim Gorky. The main function of this plane was to carry a printing press, which was used as a propaganda tool in the Soviet Union. It could print more than 8,000 leaflets per hour and had a photo printing room, as well as 16 telephones, a broadcasting system, a room that could be used as a bathroom or kitchen, and a book display room. Obviously, such an article was of an introductory nature, so it was in the column of “Little Wisdom.”

The other two articles entitled, “Comparison between Airship and Aircraft” and “the Future Development of Airship”, were published in the *Aviation Journal*, No.1, 1935. *Aviation Journal* was a monthly, compiled by editorial board of Aviation

Department. Qian Xuesen made a contrastive analysis of the performance of airship and aircraft, and suggested ways of improvement for airship. At that time, airship was a symbol of scientific and technological progress as well as national strength. However, with the increasing improvement of aircraft performance in the 1920s and 1930s, the military value of airship was gradually replaced by aircraft. In discussing airship's prospect, Qian Xuesen suggested that more researches should be done in its improvement. Through comparison on the advantages and disadvantages of aircraft and airship in terms of flight efficiency, tonnage and passenger comfort, he commented on three aspects: firstly, there was still much room for improvement of airship and large airship was more promising while the tonnage of aircraft seemed to have reached a certain limit; secondly, for long-distance flight, the safety of airship was as good as that of aircraft; thirdly, there would be many large airships in air lines around the world in the near future. Though his last point was proved wrong as seen from the aviation history and his own science career, it showed Qian's innovative thinking on aviation.

The article entitled "Rocket" was published in *Zhejiang Youth* in July, 1935, a monthly magazine compiled by Zhejiang Provincial Department of Education. Firstly, Qian Xuesen talked about the tool for human conquest of space, i.e., rocket, by introducing a news article in the *Southeast Daily*. Secondly, Qian Xuesen used a case in daily life to illustrate the principle of rocket ascent, i.e. Newton's third law. When talking about gunpowder, Qian Xuesen used a diagram to list the discharge velocity and momentum of various explosive mixtures. After analyzing the boiling point and storage conditions of the mixture, he considered liquid oxygen and gasoline as the ideal fuel for rocket. Then, Qian Xuesen analyzed the construction of the rocket to the planet. In order to increase the thrust of the rocket, three stages of rockets were needed. One more stage should be added to travel to the moon, and two more stages should be added to travel to the Mars. Rocket plane was neither a dream, nor a myth, but could be realized. Finally, Qian Xuesen called for: "The whole world started to be enthusiastic about rockets; engineers and scientists were to be mobilized. They worked hard, patiently and step by step on the road to the universe. My friend, every step was solid!" This article was quite a sci-fi, reflecting Qian Xuesen's firm will to explore unknown fields.

Qian Xuesen's articles touched upon the fields of aircraft, spacecraft, rockets, engines for aviation, and aircraft guns (weapons). These fields were supported by the disciplinary knowledge of aerodynamics, steam engines, aerodynamics in wing design, rocket fuel and the concept of multi-stage rockets and interplanetary travel, which indicated that he had already formed a preliminary aviation knowledge system at university.

Aeronautical engineering at Jiaotong University

The Department of Aeronautics was formally established at Jiaotong University in 1942. As a matter of fact, as early as 1929, preparations had been made in setting up the aircraft major, and the major was formally set up in the fall semester of 1934. However, due to various reasons, the plan to establish the Department of Aeronautics in 1934 could not be implemented. Jiaotong University offered the elective courses

in aeronautical engineering in the School of Mechanical Engineering for the fourth year students. Qian Xuesen had published articles on aeronautics in his junior year, and certainly he would not miss the fourth-year aeronautical engineering courses. Moreover, he ranked first among the 14 elective students in that year. A close look at the faculty, courses and textbooks in the school years of 1920 to 1923 enables us to know more about the teachers who taught the elective courses and the textbooks they used during this period in the following table (Table 2).

The aeronautical engineering course which Qian Xuesen attended was taught by Zeng Tong. The basic courses in the curriculum of School of Mechanical Engineering benefited Qian Xuesen a lot in his accumulation of rich knowledge in aeronautics. As such, students were selected from the School of Mechanical Engineering when aeronautics engineering major was set up in Tsinghua University, Zhejiang University and Central University.

Knowledge accumulation through extracurricular activities

Qian Xuesen's knowledge on aeronautics displayed in these six articles was out of the scope of the curriculum. The collection of books in the library provided him with opportunities to learn more as he said many years later:

I majored in mechanical engineering and I often searched for books about internal combustion engine, diesel engine in particular. Although I was a major in railway mechanical engineering and my graduation project was steam locomotive, the books I borrowed from the library were not limited to this area. I read all the books about airship, airplane and aviation theory, as well as the books about U.S. rocket founder Robert Goddard. I remembered reading a book on aerodynamic theory on aircraft wings written by British scientist Hermann Glauert. Although I could not fully understand it at that time, it helped me enter the field of aerodynamics, the major area I was engaged in later.

It was through wide reading that Qian Xuesen came to know about the frontiers in science development and the latest achievements, and he was inspired to find new research topics. His interest in aeronautics engineering had been cultivated when he was a senior in university. Therefore, he decided to give up the internship arranged by the Ministry of Communications after graduation and wait for the examination for the scholarship. After being admitted to Tsinghua University, it took him only two weeks to understand general situation of aircraft design and manufacturing. It was impossible without previous accumulation of aviation knowledge.

Aviation science was an emerging and popular subject at that time. *Air Force*, *Aviation*, *Zhejiang Youth*, and other magazines where Qian Xuesen published his articles were not professional academic journal, but popular publications with the purpose of spreading scientific knowledge. For example, *Small World: Picture Bimonthly*, a magazine targeted at primary and secondary school students had excerpted his article "The American Large Airship Wreck and the Causes of the Construction of American Airship" in the 28th issue of 1933 with the title of "The Wreck of American Large Spaceship." However, it cannot be ignored that it was Qian Xuesen's initial exploration of aviation knowledge when he was studying at Jiaotong University that opened the door to his future aerospace science research.

Table 2 List of Aeronautical Engineering Elective Courses at Jiaotong University

Time	Instructor	Educational background	Weekly hours	Textbook
1st semester of 1920 academic year	Zheng Rifu	B.S. in Civil Engineering from the University of Ohio, M.S. from the Iowa State University (1928), Ph.D. from the Iowa State University (1930)	4 h	Self-compiled handouts
2nd semester of 1920 academic year				Self-compiled handouts
1st semester of 1921 academic year	Zeng Tong	B.S. in mechanical engineering from Nanyang University (1925), M.S. in aeronautical engineering from the University of Michigan, worked as a designer at the U.S. Navy's Martin Machine Works, and as an engineer at China Airlines	3 h	Simple Aerodynamics and the Airplane by Motieth
2nd semester of 1921 academic year				Simple Aerodynamics and the Airplane by Motieth
1st semester of 1922 academic year				Simple Aerodynamics and the Airplane by Motieth
2nd semester of 1922 academic year				Simple Aerodynamics and the Airplane by Motieth
1st semester of 1923 academic year	Wang Chengzhi	Specialized in Television Engineering, Shanghai Technical College (1916), B.S. in Mechanical Engineering, Harvard University (1917), B.S. in Engineering, Massachusetts Institute of Technology (1917), M.S. in Aeronautical Engineering (1918)		Warner: Airplane Design-Aerodynamics
2nd semester of 1923 academic year			3 h	Airplane Design and Construction by Pomilio

4 Boxer Rebellion Scholar

In 1933, Tsinghua University began to openly select students to study in the United States (Boxer Rebellion Indemnity Scholarship program), and by 1944 it had enrolled six classes, totaling 132 students, known as the “National Tsinghua University State-funded Students.” These students have made great achievements and contributed greatly to the development of China’s politics, economy, science and culture in the twentieth century. Qian Xuesen was one of them.

Examination in Nanjing

Upon graduation from Jiaotong University in 1934, Qian Xuesen already made clear of his academic interest. He had two options in the pursuit of further study. One was to study in Italy on the conditions that he would pass the examination organized by the Ministry of Education. The other was to take the competitive examination for the Boxer scholarship administered by Tsinghua University and to study in the United States. Since serving in the Kuomintang Air Force was the prerequisite for the first option, Qian decided to opt for the second choice. Therefore, he did not participate in the internship of Beijing-Shanghai and Shanghai-Hangzhou-Ningbo Railways arranged by the Ministry of Communications upon graduation. Instead, he returned to Hangzhou to prepare for the examination administered by Tsinghua University.

Selection of students qualified for the Boxer Scholarship was an annual event of Tsinghua University. On May 12, 1934, a meeting was held to discuss methods and regulations of the examination and a Committee was organized to implement it. Mei Yiqi, the president of Tsinghua University, was the chairman of the Committee, and Zhang Zigao, Ye Qisun, Gu Yuxiu, Zhou Gensheng, Zhou Binglin, Bingzhi, Zhang Kezhi and other professors were the Committee members. The Ministry of Education sent an official to serve as a committee member to show its importance.

The selection of students studying in the United States was to “meet the urgent needs of China.” The selected students would specialize in the fields “which could not be researched domestically”, or “which lacked of specialists.” It can be seen that Tsinghua University had the ambitious and clear goal of selecting talents for the country. Corresponding regulations on the qualifications of participating in the examination were detailed as follows:

1. Candidates should be graduates from public colleges or universities, or private colleges or universities registered with the Ministry of Education, and had continued their researches in their fields for at least two years, or had written academic works or made other achievements.
2. Candidates should be graduates from public colleges or universities, or private colleges or universities registered with the Ministry of Education, and had held a technical position related to their scientific fields for at least two years.
3. Candidates should be graduates from public universities, or private or independent colleges registered with the Ministry of Education and had excellent academic results [1].

Registration for examination was held in Tsinghua University for candidates from Northern provinces or in Central University in Nanjing for candidates from southern provinces. The registration dates lasted from August 11 to 17, 1934. Only those who passed the physical examination were allowed to take the examination. On August 13, As soon as Qian Xuesen read the examination advertisement in *Shen Bao* Newspaper, he prepared the required registration materials and journeyed to Nanjing to get registered. He stayed in the home of his father's student Li Linwu (then Commissioner of the Ministry of Education) at No. 20 Yihe Road in Nanjing, waiting for the exam. In October, twenty winners were announced. Qian Xuesen was so excited and relieved to be one of them. In the next spring, Qian carried out internship as required in *Regulations for Boxer Rebellion Scholars Selected by National Tsinghua University*. When he was in Nanjing for internship, he stayed with Li's home again for a few days. In his later years, Tang Liling, Li Linwu's wife, told his son Li Shengjiao: "Qian Xuesen wore a long robe, and black gauze around his left arm in memory of his mother who passed away not long ago."

Along with his diploma, Qian Xuesen submitted his senior thesis, physical exam records, photographs, a vitae and published articles in the registration for the exam. In all, 176 students from 21 universities, including Tsinghua University, Jiaotong University and Peking University, signed up for the exam (118 students actually took the exam), of which eight students (six students actually took the exam) applied for aeronautical engineering. No one in Tsinghua University applied for aeronautical engineering.

The examinations were held in Beijing and Nanjing at the same time from August 21 to 28. Three subjects were tested with a total of 100 points: 10% for GMT party ideology, 20% for general subjects (8% for Chinese, 8% for English, 4% for either German or French), and 70% for professional subjects. The time limit of each subject was three hours. The candidates were required to answer in English if the questions were in English. It was unknown which language Qian had chosen as he studied German in high school and French in college. Qian Xuesen attended the exam in the aeronautical engineering (aircraft rack group), which had five subjects. Each subject and its test paper designer were listed as follows:

1. Calculus and Differential Equation, by Jiang Lifu, Nankai University
2. Applied Mechanics and Material Mechanics, by Luo Zhongchen, Tangshan Institute of Technology
3. Thermodynamics, by Zhang Jiarang, Nanjing Construction Committee
4. Architecture, by Cai Fangyin, Tsinghua University
5. Mechanical Design and Principle, by Du Guangzu, Jiaotong University
6. Aeronautical Engineering, by Wang Shizhuo, Tsinghua University [2]

Two subjects, Structural Science or Mechanical Design Principle, were elective. It was assumed that Qian had taken the latter one as he took this course at university. After the examination, Qian returned to Hangzhou, waiting for the results. On September 28, the examination committee finished the scoring and reviewed the test results, and finally determined the qualified ones in each area.

The announcement day

In October 2, twenty winners were announced after the competitive examinations, five less than the set admission number, as the examination committee made a consensus that all the winners should reach average score of 50 points. As it turned out, Qian was the only one who would be studying aeronautics.

The total average score of the six candidates who applied for the aeronautical engineering was below 60 points. Qian Xuesen ranked the first. The articles submitted by Qian impressed the examination committee a lot with its academic quality. The winners were considered as lucky as they were able to pursue their dreams. For Qian Xuesen, it was golden opportunity as he could learn aeronautics systematically. He recalled later: “I won the scholarship to study in the United States in summer of 1934. Since then, I turned to aeronautical engineering. I had one month’s internship in aircraft factories in Jianqiao, Hangzhou, and Nanchang.”

Professional internship

According to *Regulations for Boxer Rebellion Scholars Selected by National Tsinghua University*, the scholarship recipients were required to carry out field investigation or internship for six months to one year in China before going to the United State so as to get full preparation and to learn more about the practical national needs. Each recipient was allotted some advisors to provide advice on and approve their internship. Qian Xuesen was assigned with four advisors, Wang Zhu, Wang Shiluo, Qian Shenjue and Wang Shoujing. He had interned at air factories in Hangzhou, Nanchang, Nanjing and Shanghai for about half a year.

During his internship, Qian Xuesen wrote seven letters to the Office of the President of Tsinghua University. The contents of the letters were mainly concerned with professional internship, living allowance and procedures for going abroad. In the first letter written at the airplane manufacturing factory in Jianqiao, Hangzhou on September 15, 1934, he wrote:

Under the guidance of Mr. Wang Zhu (his advisor and the inspector at Jiangqiao airplane factor), I had read various magazines and research reports and practiced drawing diagrams. I learned knowledge concerning aircraft manufacturing. A few months later, I was scheduled to go for an internship at Mr. Qian Zijue’s office and to the aircraft factories under Aviation Commission. However, I wished my internship would start four weeks later due to my family reason. Mr. Wang suggested I could arrive at the factory as soon as possible. I would also like to ask your Office to send the living allowance directly to me according to the *Regulations*.

The family reason mentioned in the letter was that Qian Xuesen had to return home as his mother was critically ill. Unfortunately, his mother passed away shortly afterwards. After the funeral, Qian Xuesen returned to the airplane factory to continue his internship on December 9. The professional internship focused on practical courses, supplemented by theoretical study and was provided with living allowance of 50 *yuan* per month.

Qian’s internship started in the woodworking section, and then in mechanical engineering and metalworking sections in Hangzhou Jianqiao Airplane Factory which lasted up until the end of April, 1935. After that, he spent two months on the internship

in Nanchang No.2 Airplane Repair Factory, Nanjing No.1 Aircraft Repair Factory and Shanghai Navy Aircraft Office. During his internship, besides a monthly allowance of 50 *yuan*, Qian was reimbursed for the travel expenses, 62.25 *yuan* and 83.40 *yuan* respectively, as shown in the archival records in Tsinghua University.

Reimbursement list submitted by Qian Xuesen on May 7, 1935:

Third class train from Hangzhou to Shanghai: two *yuan* and ninety cents

Third class train from Shanghai to Nanjing: three *yuan* and seventy-five cents;

Official cabin from Nanjing to Jiujiang: eleven *yuan*;

Third class train from Jiujiang to Nanchang: three *yuan* and ten cents

One way trip total: twenty *yuan* and seventy-five cents

Round trip total: forty-one *yuan* and fifty cents

50% of the cost of accommodation: twenty *yuan* and seventy-five cents

Total: sixty-two *yuan* and twenty-five cents

Reimbursement list submitted on June 25, 1935

Third class train ticket from Hangzhou to Beijing: twenty-seven *yuan* and eighty cents

Round trip total: fifty-five *yuan* and sixty cents

50% of the cost of accommodation: twenty-seven *yuan* and eighty cents

Total: eighty-three *yuan* and forty cents

During his internship in Hangzhou, Qian Xuesen learned that Tsinghua University was building a wind tunnel. In his letter to the president's office on June 25, he asked to visit the laboratory when he went to Tsinghua in handling formalities of going abroad. He wrote:

Mr. Wang Shizhuo, Professor of Aeronautics, met with Mr. Qiang Yupeng in Hangzhou and they talked about the installation of wind tunnel. I thought knowing something about wind tunnel shall be helpful to my future research. Professor Wang would stay at the University during summer holidays, and it would be a good opportunity for me to learn from him.

After receiving the letter, Mei Yiqi sought opinion from Wang Shizhuo on July 2, whether the wind tunnel project would be in progress in July and whether Qian could benefit from visiting it. Wang replied that students going to study in the United States should be encouraged to visit their alma mater. But he also mentioned that for the wind tunnel project, there would not be much to see at that time. Despite this, Mei Yiqi replied to Qian on July 4 to express his wish to meet him. They had met and talked but there was no record of the interview.

References

Boxer Rebellion Scholar

1. “Notice for National Tsinghua University’s Selection of Boxer Rebellion Scholarship Recipient to Study in the U.S.” *Shen Bao* Newspaper, August 13, 1934, p. 14.
2. “List of Markers for the Examination for State-funded Students Studying in the U.S. in the National Tsinghua University in 1934”, Second Historical Archives of China, Full File Number: V; Case File Number: 15292

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Chapter 3

Life and Study in the United States



1 Application for MIT

The applications of passport and student visa in Republic of China were handled in Shanghai Public Security Bureau and the U.S. Consulate in Shanghai for students from southern universities, and Tianjin Public Security Bureau and the U.S. Consulate in Tianjin for students from the northern universities. In July of 1935, on his way to Tsinghua University, Qian Xuesen went to Tianjin to apply for an overseas passport and student visa. Afterwards, he went back to Hangzhou to pack up and wait for the journey.

Admission to MIT

The decision to go to MIT was proposed by Qian Changzuo and Wang Yupeng, both of whom were graduates of MIT, and finally approved by Mei Yiqi, then president of Tsinghua University. On November 2, 1934, Qian Changzuo wrote a letter to Mei Yiqi, suggesting that Qian should go to MIT as “there were a number of professors in aeronautics program in MIT, and the facilities and courses were also perfect.” Wang Yupeng wrote a letter to Professor Jerome Hunsaker, then director of the Department of Aeronautics at MIT, inquiring whether Qian would be accepted. Hunsaker replied to Wang Zhu, saying that he agreed and hoped Qian would come to the United States in June. Qian Xuesen then wrote to the president’s office of Tsinghua University on April 21, 1935, proposing that he would go to the United States in May:

Mr. Wang Zhu inquired about my application for MIT with Professor Jerome Hunsaker, director of the Department of Aeronautics at MIT. Professor Hunsaker proposed that I would arrive in June so that I could catch up the summer courses, such as *An Introduction to Aeromechanics*, *An Introduction to Airport Design* and so on. Then, I would take the fourth year undergraduate course at the beginning of the autumn. In the following year, I could be enrolled in graduate school. Gu Guangfu, a former Boxer Scholar, suggested that we could visit the factories and institutes in the next summer. Therefore, I would like to propose to go to MIT as soon as possible.

Mei Yiqi approved Qian Xuesen's proposal to go to the United States in mid-May. Meanwhile, Tsinghua University sent an official letter to MIT to confirm on his admission. On April 30, James L. Tryon, secretary of the Graduate School of MIT, wrote a letter to Mei Yiqi about Qian Xuesen's admission to the graduate program:

I had submitted Qian Xuesen's application documents to the Department of Mechanical Engineering. I was glad to inform you that Qian Xuesen was accepted as a graduate student to our university. Professor C. E. Fuller would be his advisor and Qian could consult him about course arrangement.

As it turned out, Qian Xuesen stuck to the original plan of internship and went to MIT in July as it took several months to go through the passport and visa application procedures (Fig. 1).

Applying for passport

According to the *Procedural Instructions of Studying Abroad* sent by Tsinghua University, Qian Xuesen were to prepare a bunch of documents: two score sheets of English course, four four-inch ID photos, an agreement letter with his personal signature and letter of guarantee signed by the guarantor. In February of 1935, Qian submitted the above documents to Tsinghua University for application of the Stated-funded Student Certificate issued by the Ministry of Education. Qian received his certificate No. 537 in April, signed by Wang Shijie, Minister of Education. After he received a blank medical examination form issued by the U.S. consulate, he went to the hospital for physical examination to prove that he had no infectious disease.

In July of 1935, Qian Xuesen went to Beijing and met with Mei Yiqi. Meanwhile, he received a punch list for passport application and a letter of introduction from Tsinghua University. He also took an ID photo at Dalu Photo Studio located in Xuanwumen Gate. On July 15, Qian went to Tianjin Public Security Bureau to apply for a passport and paid one *yuan* stamp duty. The cover of the passport was made of black Kraft paper, printed with the national emblem of the Republic of China and "Passport of the Republic of China." The passport had sixteen pages in total, and on each page there was a watermark of "passport of the Republic of China" with the size of 16 × 11 cm.

Interestingly, Qian made a mistake in transferring his birth date in the lunar calendar to Gregorian calendar and his birth date written on passport was September 2, 1909, which was two years older than his age. After he returned to China in 1955, he resumed his real birth date.

Applying for a "separate visa"

According to the "An Act to Execute Certain Treaty Stipulations Relating to Chinese" passed in 1882 (also known as the Chinese Exclusion Act of 1882), Chinese workers were prohibited from traveling to the United States. However, Article 4, Sect. 5 of the Johnson-Reid Act passed in 1924 provided that those who were fifteen years of age or older and "qualified for insertion into a school of repute in the United States of North America and licensed by the Ministry of Industry to admit Asian students" could obtain a student visa to study in the United States. Therefore, when the Tianjin

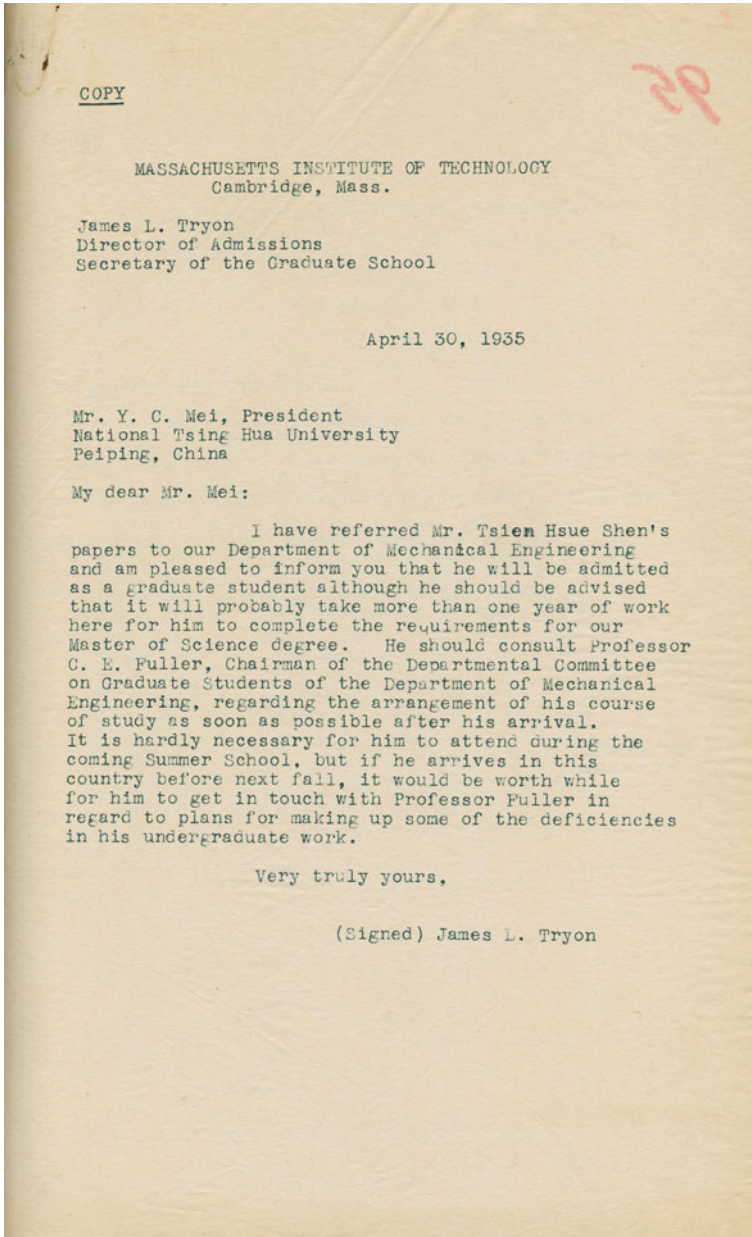


Fig. 1 MIT Graduate School Secretary James Tyrone replied to Mei Yiqi, agreeing to accept Qian Xuesen into the school in April 30, 1935 (the original letter is kept in the Tsinghua University Archives)



Fig. 2 Qian Xuesen's passport of the Republic of China

Public Security Bureau issued the passport, it also issued a document in English and Chinese as usual to prove that Qian Xuesen went to the U.S. on a student visa and not as a Chinese worker (Figs. 2, 3 and 4).

On July 30, Qian went to the U.S. Consulate in Tianjin with his passport, supporting documents and medical examination form to apply for a student visa. The consulate issued a so-called “separate visa” valid for 34 months. The term “separate visa” refers to a separate piece of paper that is not placed inside the passport. The original is sent to the Immigration and Naturalization Service of the U.S. Department of Justice for record, and the copy is returned to the passport holder. At this point, Qian had gone through all the formalities before leaving the country. Subsequently, he returned to his hometown, said goodbye to friends and relatives, and was ready to depart for the United States.

2 From MIT to Caltech

The Massachusetts Institute of Technology (MIT) and the California Institute of Technology (Caltech) are two top institutions of learning in the United States, enjoying high academic standing in the world of science, engineering and education research. Qian Xuesen studied at MIT for his master's degree, then at Caltech for his doctoral degree, and had since taught at both institutions. Qian Xuesen's experience in these two institutions was a valuable asset in his life. When he boarded the steamship

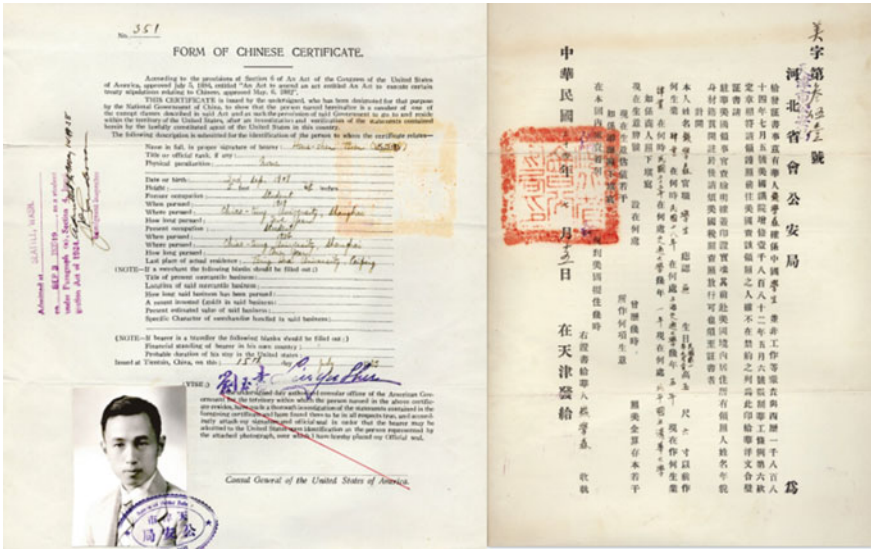


Fig. 3 Chinese and English documents issued by the Tianjin Public Security Bureau

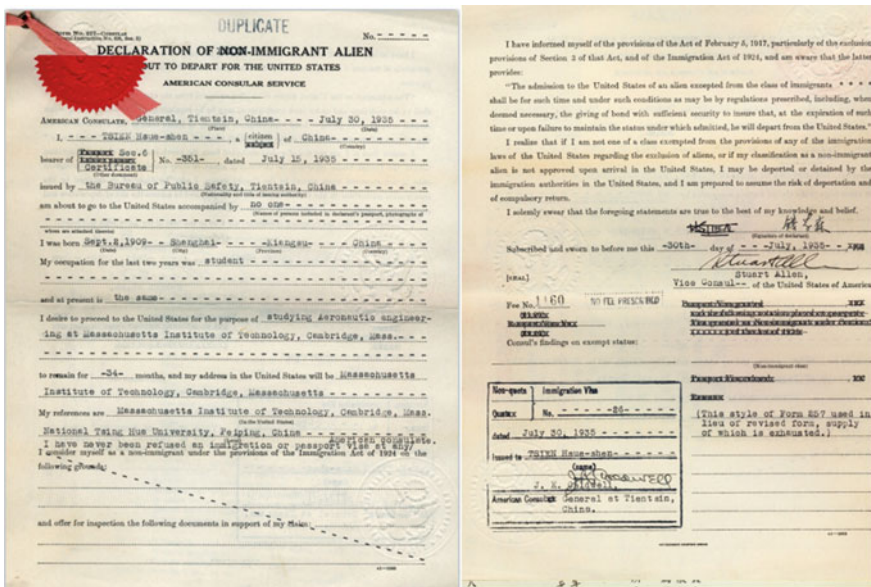


Fig. 4 "Separate visa" issued by the U.S. Consulate in Tianjin

President Jackson at Wusongkou Port, Huangpu River in Shanghai, he would never imagine that he was about to embark on a twenty-year-long period of overseas study.

Departure from Shanghai Bund Pier to the United States

Qian Xuesen returned to Hangzhou and prepared his luggage for his trip abroad, meanwhile saying goodbye to his family and friends in Hangzhou. Soon after, he took a train to Shanghai with his father to wait for his steamship. He also visited several college friends in Shanghai. Xu Zhangben, a student junior to Qian at Jiaotong University, sent parting words to him on August 12:

Xuesen, you have great strength in taking in new things that I have not encountered in other people. This strength is one of the two major elements of successful learning. However, most of what we have seen and heard over the years has been “Americanized”, and I personally feel that one of the problems with “Americanization” is that it leaves out the “philosophical origin of science.” I am sure you will not be misguided. This is what I want to say before your trip to America.

On August 20, Qian Xuesen boarded the steamship *President Jackson* at Wusongkou Port to depart for the United States. His father, Qian Junfun watched his son departing from the pier. Qian was accompanied by twenty students and teaching assistants at Tsinghua University, including eight Boxer Scholarship recipients at that year, namely, Zeng Bingjun, Yang Shaozhen, Shi Jun, Zhao Pu, Dai Shiguang, Huang Kailu, Song Zuonan and Sun Lingxian. Tsinghua University commissioned China Travel Service to book first class cabin for them.

On August 24, the steamship passed through Japan, and they disembarked together to visit Nagoya and Tokyo for two days. Japan was already an industrialized and modernized country at that time, and the neat and clean streets left a deep impression on them. When *President Jackson* was sailing in the Pacific Ocean, they took a group photo standing by the railing on the deck of the steamship and on the escalator, on which a triangular flag written with TSING HUA was hung.

In fact, not all the overseas students in this group photo were students from Qinghua University. According to Chen Hanli, son of Chen Yexun, a friend of Qian Xuesen at university, the person standing on the right side of Qian Xuesen in a light-colored suit in the group photo was I.M. Pei (Yuming Pei), who later became a world-famous architect. I.M. Pei went to the U.S. to study at his own expense. As he was a self-financed student, he said goodbye to the group of students from Tsinghua University after disembarkation.

Qian Xuesen went to the United States and studied at the Department of Aeronautics at MIT for one year and received a master’s degree in aeronautical engineering. I.M. Pei went to the United States and studied architecture at the University of Pennsylvania before transferring to MIT. Both Qian Xuesen and I.M. Pei had studied at MIT. More than thirty Chinese students in the school organized a “MIT branch of the All-American Chinese Association”. Whether Qian Xuesen and I.M. Pei joined the association and whether they had any contact or interaction remained unknown. However, there was also another theory that I.M. Pei went to the United States on steamship *President Coolidge* which set sail on August 13.

On the steamship *President Jackson*, in addition to the students from Tsinghua University, there was a group of graduates from Jiaotong University. Since Qian had the dual alumni status of Tsinghua University and Jiaotong University, he had to “rush” to take a group photo on both sides (Figs. 5 and 6).

On September 3, the steamship *President Jackson* arrived in Seattle, a city on the west coast of the United States, and Qian Xuesen disembarked with his passport, “separate visa” and a medical examination form for entry procedures. In those days, the U.S. immigration officials would inspect travellers with Chinese passports in particular, but the students from Tsinghua University were given special care and quickly released.

The first-class ticket of the *President Jackson* cost \$331, and the train fare was about \$200 after arriving in the United States [1]. The cost was basically provided by Tsinghua University. The students received \$520 before they leave the country, which covered the ferry ticket, cost of dressing, train fare and pocket money for the trip. However, they had to pay a \$150 deposit upon entry “to ensure that they maintain their student status in the U.S. and leaving the U.S. upon graduation”, a cost that would be borne by the students.

Qian Xuesen spent a few days in Seattle, sightseeing the city. He then took a train via Chicago to the MIT in Boston, where he began his 20 year-long study in the United States. Decades later, Qian Xuesen’s mother-in-law Jiang Zuomei said to her grandson Qian Yonggang, “I went to see your father off when he went abroad.



Fig. 5 Group photo of students from Tsinghua University studying in the U.S. on the steamship (from top to bottom, second row from left is Qian Xuesen)

Your father was not tall and not conspicuous at all. I could not imagine that he would become a great scientist in a few decades.”

At MIT

In September 1935, Qian Xuesen became a graduate of Aeronautical Engineering at MIT (Fig. 7). MIT was located in Cambridge, Boston, Massachusetts and had a comparatively small campus. When people in China talked about MIT, they would say: “MIT’s school buildings were not as large as those in Tsinghua. The school had one main building, an Aeronautical Building, an Alker Memorial Hall, two undergraduate dormitories, a graduate dormitory, and two Gyms.” During his one-year study at MIT, Qian Xuesen lived in a single room in graduate dormitory, much more spacious than his two-room dormitory in Jiaotong University.

A saying went in America educational circle at that time: “MIT was hell” and the students were “as busy as a sea otter.” However, for Qian Xuesen, after experiencing a college life of fighting for good grades in China, the MIT curriculum did not seem too stressful for him. He quickly adapted to the MIT learning atmosphere, and the major courses were not a burden at all. In his later years, Qian Xuesen said:



Fig. 6 Self-portrait of Qian Xuesen in the first class cabin of the *President Jackson*



Fig. 8 Self-portrait of Qian Xuesen at MIT

his master's thesis on the turbulent boundary layer. Strictly speaking, this master's thesis was not a theoretical study, but rather "an experimental study of the turbulent boundary layer (Figs. 9 and 10)."

Since Qian Xuesen's research interest had turned to theoretical research before he arrived in the United States, he found his studies in the Department of Aeronautical Engineering at MIT not so satisfying. The light academic load left him much spare time to spend on his hobby in music. He would spend dozens of cents to go to the

Table 1 Qian Xuesen's Graduate Course Schedule at MIT

Course	The first semester	The second semester
Graduate Courses	Aerodynamics of Airplane Design	App. Photoelas
	Airplane Design &. Practice	Aircraft Structure
	Theory of Structure	Aero. Lab.& Res. Methods
	Aeronautical Lab	Construction Details of Aircraft
	Hydrodynamics & its Application to Aerospace	Vector Analysis
	Theory & Application hydrodynamics	Hydrodyn. & its App. to Aero
		Advanced Topics in Aeromechanics
		Advanced Aircraft Structure
		Aircraft Propeller Design
		Function of Complex Variable Thesis



Fig. 9 Qian Xuesen's MIT master's degree certificate in aeronautical engineering

Boston Symphony Orchestra every weekend. Also, he often listened to music on the radio.

MIT was known for its engineering research, and there were many Chinese students in various departments. In fact, Qian Xuesen did not interact much with them while he was much close to a Soviet student and consulted him on how to work in the Soviet Union. The Soviet student replied that he could get in touch with a Soviet trading company in New York. Knowing this, Qian Xuesen wrote to his friend Luo Peilin in China to make an appointment to go to Moscow. Before he went to the U.S., Qian Xuesen had a tendency to believe in communism. He remained contact with some peripheral organizations of Communist Party and participated in their activities many times. After receiving his master's degree in aeronautical engineering in September 1936, Qian chose to pursue his doctoral studies under Theodore von Kármán at Caltech.

At Caltech

It was said that Qian Xuesen took a train from Boston to Los Angeles and planned to return to China by steamship after graduating from MIT in September 1936. But when he arrived in Los Angeles, he changed his plan to return home and decided to continue his studies at the Caltech under the tutelage of Theodore von Kármán.

STUDY OF THE TURBULENT BOUNDARY LAYER.

By

H. S. Tsien

S.B., Chiao-tung University, China

1934



Submitted in Partial Fulfillment of the Requirement for the Degree of Master of Science From the Massachusetts Institute of Technology 1936

Signature of Author - - - - -
Department of Aeronautical Engineering, Sept. 3, 1936
Signature of Professor In charge of Research - - - - -
Signature of Chairman of Department Committee on Graduate Students - - - - -

Fig. 10 Qian Xuesen's master's thesis title page

Such a story may add to the drama of Qian's life in the United States, but it was not supported by historical evidence. In fact, the real reason why Qian chose to go to Caltech was his ambition to improve his theoretical research level in aeronautics. When he arrived at MIT, he gradually realized that the school, which was famous for training engineers, lacked innovation and was somewhat stereotypical. Qian wrote in February of 1989:

The engineering education at MIT in the 1930s was the model of the beginning of the century, which was effective for training engineers in mature engineering technology, but was not suitable for rapidly developing and advancing engineering technologies, like aeronautical engineering. Nevetheles, Caltech took the lead in reform by greatly increasing the weight of professional basic courses so that students could catch up with new developments in technology after graduation. This kind of eform was commonly adopted by American engineering colleges and universities in the 1950s. This was a major change in engineering education in the first half of 20th century [2].

Qian Xuesen decided to go to Caltech to pursue his studies in aeronautical theory, but his idea initially failed to gain the approval of his father Qian Junfu. Qian Junfu believed that one of the reasons for the country's poverty and weakness was China's underdevelopment in engineering, so he wanted his son to take the path of engineering to save the country, while the study of scientific theories was just like the traditional scriptures learning, which could not change China's backward situation. He once said to Qian Xuesen in a letter:

The reason for China's weakness was that it had paid more attention to theory than to practice, and to more talks than actions. Our country was at critical moment of survival. If you discontinued your research in aeronautical engineering, and attempted to take a theoretical path, you were too young to be insightful.

At that time, Jiang Baili visited Europe and America and stopped by to see Qian Xuesen. Qian Xuesen talked about his idea to Jiang Baili and gained his support. When he met Qian Junfu after returning to China, Jiang Baili explained: "Your son was right and your opinion was old-fashioned. The new trend in American and German aviation was the monolithic nature of engineering theory. Engineering follows theory." Then he went on to explain, "The United States was rich country while China was a poor one. The United States could build an aircraft and immediately modify it if there was a new theoretical discovery, but this would not apply to China. That was why those Chinese students who studied aviation should work more on the theory." Qian Junfu was convinced by Jiang Baili and changed his attitude. Interestingly, when Jiang Baili visited Qian Xuesen, he gave him a picture of his daughter, Jiang Ying, setting the stage for their future marriage.

In October 1936, after bidding farewell to several friends in Boston, Qian Xuesen went to Caltech to study for his doctoral degree under Theodore von Kármán. After he checked in, he stayed at the school's Faculty Activity Center, and soon afterwards he approached Fan Xuji to share a room because the rent at the Center was too high. Fan Xuji had already rented an apartment at 290 South Michigan Street in Pasadena, with three bedrooms and a living room, a dining room, a breakfast room. He was joined by Yuan Shaowen and Wang Xiheng. When Qian Xuesen joined them, the four of them had shared the apartment and the rent until 1940. During this period, Chinese students often organized parties, and the apartment at 290 South Michigan Street was a venue due to its convenient location and spaciousness, and it was a place to receive domestic guests, such as Cai Tingkai and Yang Hucheng, famous anti-Japanese generals, who had visited the apartment.

Immediately upon his arrival at Caltech, Qian Xuesen felt its different learning atmosphere from that of MIT. The whole campus was filled with innovation and creative spirit. Unlike MIT, Qian Xuesen threw himself in tense study enthusiastically. In addition to the professional courses designated by his mentor, von Kármán, such as advanced aeronautical theory, aeronautical engineering seminar, aeronautical engineering research, statistics, tensor theory, and aeronautical applications of elastic mechanics, he also took advantage of Caltech's academic resources to expand his knowledge by taking other courses in differential geometry, complex function theory,

quantum mechanics, general relativity, statistical mechanics and structural chemistry to build a broad body of knowledge. For example, Qian Xuesen often attended the physics classes by the famous physicist Paul Sophus Epstein and discussed in depth with him on the frontiers of atomic nucleus theory and nuclear technology. Qian Xuesen later published an academic paper entitled “Atomic Energy” in 1945, discussing the use of atomic energy as an aerospace power plant. As we could see, elective courses were of equal value to the major courses, and the knowledge in the elective courses could be a positive inspiration to the major courses.

At the same time, Qian Xuesen also paid special attention to the training of scientific research norms and the cultivation of academic integrity. He actively integrated into the academic community of *Journal of Aeronautical Sciences*, thus maintaining equal dialogue with the community scientists. At the time of his doctoral studies, Qian Xuesen’s most prized mathematical talent was put to use, and von Kármán developed a rigorous scientific training and doctoral thesis program for him. “Qian Xuesen was a very diligent person who spent almost all his time in learning.” commented by his roommate Fan Xuji. From this perspective, Qian Xuesen’s growth from an ordinary foreign student to a world-class scientist was the result of his hard work.

3 Extended Scholarship from Tsinghua University

Before going to the United States, state-funded students must sign a pledge to abide by the “Regulations for State-funded Students of National Tsinghua University”, which stipulated their rights and obligations and specified the students’ performance evaluation and the number of years of financial support. The archival records at Tsinghua University showed that Qian Xuesen was granted two extensions of his scholarship. It was these two extensions that enabled Qian Xuesen to complete his doctoral studies and to work and live in the United States on legal status.

The first extension of scholarship

In 1932, Tsinghua University decided to abolish the U.S.-based office and entrusted the financial and academic affairs on the part of the students to the China Institute in America. Before Qian Xuesen went to MIT for registration, China Institute in America had already sent him tuition in advancement. After enrollment, Qian Xuesen received a monthly scholarship of \$100 from the China Institute in America to cover his daily living expenses.

According to the “Regulations for State-funded Students of National Tsinghua University” (“Regulations”), the financial support for state-funded students lasted two years, but if it was necessary, the students could apply for an extension for half a year or one year after the approval of the council prior to the expiration of the period. This flexible financial aid policy helped nurture a large number of outstanding talents and Qian Xuesen was one of them.

The year of 1937 was the third year of Qian Xuesen’s third year in the United States. As early as October of 1936, when he arrived at Caltech for his doctoral

studies, Qian Xuesen wrote to the president's office of Tsinghua University to apply for an extension of scholarship. According to the archival records, on March 15, 1937, the 124th Council of Tsinghua University approved the extension of Qian Xuesen's scholarship for one year and recommended that he continue to "focus on research related to aircraft frames". In fact, more than half of the students who had earned their master's degrees and wished to continue their doctoral studies had applied for extensions, including Gu Gongshu, Xiao Zhizhi, Wang Zhuxi, Zhao Jiuzhang, and Xia Nai. According to the "Regulations", students were required to mail their academic research or internship achievements signed and certified by the head of the school or factory and sent to Tsinghua University for assessment, and "if the results were not good, their scholarship would be cancelled (Fig. 11)."

The second extension of scholarship

In 1938, Qian Xuesen was in his second year of doctoral studies at Caltech and had exceeded the maximum limit of three years of funding set by Tsinghua University. Since he was still working on his doctoral dissertation, he decided to write a letter to the president's office of Tsinghua University on June 7, applying for another extension of scholarship. He wrote in the letter:

In the 24th year of the Republic of China (1935), I went to the United States to study aeronautical engineering, at MIT for the first year and at Caltech at for the second and third year. I had worked hard and now I felt quite sure about independent research. In February of this year, I presented a paper entitled "Boundary Layer in Compressible Fluids" (published in the *Journal of the American Institute of Aeronautics and Astronautics*), jointly with Professor von Kármán at the annual conference of the American Aeronautical Society. Another paper entitled "Supersonic Flow over an Inclined Body of Revolution" was forthcoming. I believed that my academic ability could be further cultivated if I could learn under the guidance of Professor von Kármán for one more year and could serve my country better in the future. Professor von Kármán also suggested that this would be the best choice under the present circumstances. As such, I would kindly request another year's extension of the scholarship, which would last until July of the 38th year of the Republic of China (1939).

Von Kármán also wrote to Mei Yiqi on June 8, speaking highly of Qian Xuesen's research ability, and he especially stressed that Qian's research results had been used in the military field, hoping that Mei Yiqi would agree to Qian Xuesen's application for extending his scholarship. Since there was no precedent for two extensions of scholarships at Tsinghua University, Mei Yiqi immediately asked Provost Pan Guangdan for his opinion. Pan Guangdan then consulted Feng Guilian, head of the Department of Aviation. Feng believed that the extension of scholarship for one more year would not only benefit Qian individually, but also the country in the future. Finally, with the consent of Mei Yiqi, the funding period of scholarship for Qian Xuesen was extended again. The decision was proved right that in 1939, Qian Xuesen completed his paper "Two-dimensional subsonic flow of compressible fluids" under the guidance of von Kármán. This paper, known worldwide as "the Kármán-Tsien formula", was almost universally applied in the field of aerospace science until the modern computers made inroads. Therefore, it was worth considering whether Qian Xuesen would have made this outstanding achievement if Tsinghua University had not agreed to his application and he had returned to China before completing

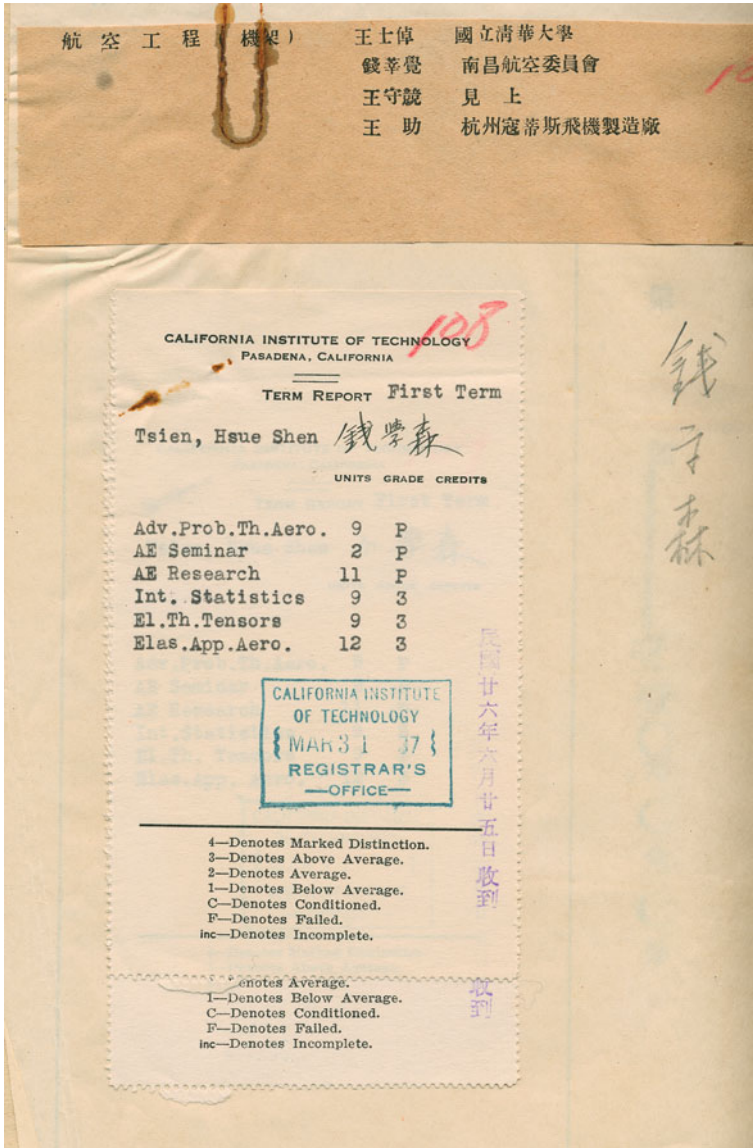


Fig. 11 Qian Xuesen’s report card in the Tsinghua University Archives

his Ph.D. Thus, one had to admire the foresight of Tsinghua University, especially of the president Mei Yiqi.

There were three kinds of passports in the Republic of China: diplomatic, official and ordinary. Qian Xuesen’s passport was an ordinary passport, valid for three years (from July 15, 1935 to July 14, 1938). If the period was exceeded, he must apply to

the consular office of the Republic of China in the United States for an extension, and each time it was valid for one year. Qian Xuesen's passport had 11 applications for extension at the Consulate General of the Republic of China in Los Angeles and the Consulate in Boston, and he had to pay a registration fee ranging from one to five dollars each time. Undoubtedly, Qian Xuesen's status during his stay in the United States was a citizen of the Republic of China.

On the one hand, Qian's choice at a crucial moment enabled him to maintain legal status in the United States to pursue his studies. On the other hand, his mentor, von Kármán's assistance showed the value of Qian Xuesen as his research partner. That was why von Kármán devoted a chapter in his autobiography to the memory of "Dr. Qian of Red China".

4 Life-Long Beneficial Academic Training

Under the strict training of his mentor Theodore Von Kármán, Qian Xuesen mastered a set of effective scientific research methods in the process of research, which he summarized as "To be erudite, then to be concise; from specialized to professional, from professional to mastery."

To be erudite, then to be concise: strengthening the ability to carry out literature review

In the process of rapid development of modern science, there has been a trend of "overlapping" in the development of science and technology. Therefore, it is not only necessary but essential to review previous researches before starting a new research topic. It is not only a prerequisite for research, but also a "tribute" to our predecessors in the academic field.

During his doctoral study, Qian Xuesen emphasized on training his ability to carry out literature review. After he joined the rocket research group organized by Frank Malina in 1937, in order to improve the small liquid propellant test rocket, he comprehensively and systematically reviewed the existing researches and wrote a 114-page literature review. His references include: 12 earlier papers from 1827 to 1931, 37 professional books from 1913 to 1933, and 19 professional research papers from 1927 to 1935. In addition, he consulted articles published in four professional journals in recent ten years on combustion chamber temperature, ideal rocket efficiency, gas expansion generated by combustion, combustion nozzle design, engine thrust calculation and so on.

Literature review should enumerate, describe, summarize, evaluate and clarify the previous research objectively. It provides a theoretical base for the research and help one determine the nature of his or her research. Qian Xuesen put:

Doing research was to expand the existing areas of knowledge and know the academic frontier. Therefore, we must know the latest development of science as well as the latest academic achievements. When I had spare time, I would go to read the latest papers on the open display rack of periodicals in the college library and got some inspiration [3].

Comprehensive and systematic literature review could help avoid repetitive research and find new research directions. In his long research process, Qian Xuesen valued two important methods, reading and analyzing. By reading the introduction and conclusion of a research paper, one can judge the paper's academic level as the author would usually raise a research question and put forward the solution at the introductory part and summarize the results in conclusion [4]. Later, when Qian Xuesen was a doctoral supervisor, he also taught this method to his postgraduates.

From specialized to professional: writing high-quality academic papers

Academic papers are important manifestations of one's scientific research ability. During his doctoral studies, Qian Xuesen published a number of high-quality academic papers in international professional journals. At the aerodynamics session of the sixth annual conference of the American Academy of Aeronautical Sciences on January 26, 1938, Qian delivered a report titled "Boundary Layer in Compressible Fluids", which was completed by himself under the guidance of von Kármán. This academic report was part of Qian Xuesen's doctoral thesis, and his "debut" in the field of Aeronautics in the United States. After the conference, Qian revised and submitted the report to *Journal of Aeronautical Sciences*, which was published in volume 5 in 1938. This was Qian's first officially published academic paper. Although Qian Xuesen was the second author, the publication stimulated his strong desire to write high-quality academic papers. Since then, Qian had successively completed many academic papers by himself or jointly with other scholars and most of which had been published in international academic journals.

Qian Xuesen was a diligent writer and a good thinker, and achieved the goal of specialization through writing and publishing high-quality academic papers. Under the guidance of his supervisor von Kármán, he divided his doctoral dissertation entitled "Flow of Compressible Fluids and Reaction Propulsion" into four parts. The first part was "Boundary Layers of Compressible Fluids", which was based on the academic report he completed in collaboration with his supervisor. The second part was "Supersonic Winding Flow of Rotating Bodies with Angle of Attack", which he completed independently under the guidance of his supervisor. The third part, "Application of Tschapligin Transformation to Two-Dimensional Subsonic Flow", was later published as "Two-Dimensional Subsonic Flow of Compressible Fluids" (the Kármán-Tsien formula). The fourth part, "Analysis of the flight of sounding rockets propelled by continuous pulses", was a collaborative effort with Frank Malina. The first three parts were theoretical research, while the fourth part was applied research, that was, to solve practical problems. Qian Xuesen vividly compared the writing of his graduation thesis to "military training", the step prior to scientific research. When he returned to teach at the University of Science and Technology of China, he said:

What meant by writing a thesis? It was the first practice for students to do research work. Students attended classes for the first few years, and the way of learning was mainly listening to lectures, reviewing, doing exercises and taking exams. There was no experience in how to do research work. Doing thesis was like military training, a transition from the knowledge learning to doing research and preparing for the future job. Only by training the army well could we make better contributions to the country in the future [5].

Qian Xuesen also put that since doing thesis was like “military training” for the future scientific research, we should be strict with it and regard it as a real battle. Because of this, he always thought holistically during the process of designing his doctoral thesis. He always emphasized later:

There was an old Chinese saying, “Learning makes one wise.” It meant to understand the laws of nature. Mastering the laws of nature was the foundation of our future work. How could this knowledge be truly mastered? It was to master the contents in an outline, and use several lines to string them together. We needed to understand what could work and what would not work in nature.

Therefore, in the process of writing his doctoral dissertation, Qian Xuesen worked “one part by one part”, but he always had a general outline and “was able to string them together with several lines”, and finally completed his thesis as scheduled. One of the research papers that made him famous in the community of *Journal of Aeronautical Sciences* was “Two-dimensional subsonic flow of compressible fluids” (the “Kármán–Tsien formula”). As a witness to the creation of this paper, William Rees Sears, Qian’s colleague, later recalled it in a fascinating way. Sears once went to von Kármán’s house and heard the discussion between von Kármán and Qian about their mathematical manuscripts. It turned out that von Kármán and Qian Xuesen had performed their calculations on the same problem in different ways and obtained the same results [6]. In other words, Qian Xuesen found a new method of calculation, so when this paper was published later, von Kármán insisted that Qian Xuesen would be the sole author. When Qian Xuesen published this paper, he specifically stated in acknowledgement: “The author expresses his gratitude to Dr. Th. von Kármán for suggesting the subject and for his kindly criticism during the course of the work (Fig. 12).”

Qian Xuesen defended his doctoral dissertation in May 1939 and received his doctorate from Caltech. It can be said that the efforts behind this certificate laid the foundation for Qian Xuesen’s subsequent development in the field of aerospace

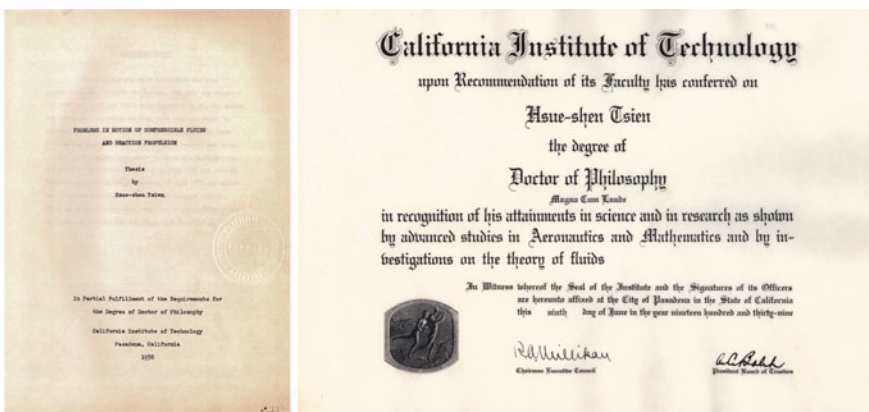


Fig. 12 Qian Xuesen’s doctoral dissertation title page and certificate of Doctor of Philosophy from Caltech

science research, and gradually made him emerge as a young Chinese scholar in the world scientific community. When Qian Xuesen received his doctorate, he put on his doctoral uniform, posed well, and asked his friend Fan Xuji to take a full-body photo on this day of great commemorative significance (Fig. 13).

From professional to mastery: building a broad system of scientific knowledge

In Song Dynasty, a scholar named Lu Dian once said, “There must be a teacher for learning and there must be a friend for teaching”. That is, one must discuss with teachers and friends for learning. Because individual insight is always limited, it is impossible to for individuals to learn everything. Qian Xuesen paid special attention



Fig. 13 A photo of Qian Xuesen in Caltech doctoral uniform (Photo by Fan Xuji)

to academic communication during his study, and was deeply influenced by his mentor, von Kármán. In the mid to late 1930s, there were many Chinese students studying at Caltech, such as Yuan Jialiu, Tan Jiazhen, Gu Gongxu, Yin Hongzhang, Zhu Zhengyuan, Huang Xiaqian, Guo Yicheng, Yuan Shaowen and so on. Qian Xuesen later recalled:

I was transferred from MIT to Caltech in the fall of 1936 to pursue my Ph.D. When I arrived at Caltech, I met Guo Yicheng, who was in the Department of Physics and we met every day and got along very well. At that time, there were Tan Jiazhen and Yin Hongzhang in the Department of Biology, as well as some Chinese students from other departments. The Chinese students advocated mutual learning to expand our knowledge, so we gathered in a classroom for academic discussions at about 10:00 a.m every Sunday morning [7].

Such salon-style academic discussions helped them understand the frontiers of their disciplines and develop a broad academic perspective in the process of communicating with each other. On January 23, 1993, when Qian Xuesen wrote to Zeng Chengkui, an academician of the Academy of Sciences, he recalled, “I had listened to your lecture on the importance of reproducing kelp at the Sunday morning academic discussions at Caltech in the 1930s, and that was 60 years ago!” Evidently, Qian Xuesen was very impressed by this kind of academic activity. Later, when he was the director of the Guggenheim Jet Propulsion Center at Caltech, discussion classes were integrated into the curriculum, and his class became “one of the most active discussion classes on the Caltech campus, with almost all professors talking regardless of who was presenting, and the atmosphere was so lively.” Zheng Zhemin, one of Qian’s doctoral students, had attended the class and recalled:

In a jet propulsion discussion class, Mr. Qian gave a wonderful speech on how to conduct theoretical research and the relationship between practice or experiment and theory, which left a deep impression on me. He drew a diagram on the blackboard with a curve to represent the progress of theoretical research and two straight lines forming a trumpet-like line on both sides of the curve to represent practice or experiment. He said that when the curve collided with the straight line, a change in the direction or path of theoretical research should be considered, and that only under the condition that theory and practice constantly interacted with each other could theoretical research make substantial progress. Now although decades had passed, Mr. Qian’s diagram was still clearly imprinted in my mind [8].

These kind of academic discussions are effective in expanding one’s academic vision and building a broad knowledge system by “crossing over” from specialized courses to other research fields. Qian Xuesen later concluded: “The more extensive one’s knowledge scope was, the deeper one could master; the more experiences one had, the more one could take “shortcuts” in the process of figuring out the mechanism and building models. This could reflect a scholar’s research level.” This is because for a scientist with a strategic vision, he or she not only had a professional foundation, but also a broad academic vision.

Because of the high student to faculty ratio at Caltech, discussion classes were common, where students and faculty were free to discuss and even “go head-to-head” with each other’s ideas. However, these academic “rivals” often became friends. For example, Qian Xuesen often went to the chemistry department to listen to the head of the chemistry department, L. Pauling’ lectures on structural chemistry. Although

they were more than ten years apart, they became good friends in the process of discussion and exchange. Later, Pauling's idea of taking large doses of vitamins was generally opposed by the biomedical community, but Qian Xuesen supported Pauling by taking vitamins himself. In this democratic academic culture at Caltech, there was no distinction between faculty and students, and full discussion was possible no matter how young or how old one was (Figs. 14, 15 and 16).

This democratic academic culture at Caltech deeply influenced Qian Xuesen and became the gene of his academic life. In his scientific career, Qian Xuesen's new ideas were rooted in his courage to express his opinions in front of academic authorities. Qian Xuesen's doctoral research turned to aerodynamic theory, which was considered as "abandoning engineering for science." However, he knew that "solving engineering problems with mathematical theory" must not ignore engineering, so he often sought out engineers to exchange ideas while studying for his doctorate, and he often went to engineering sites, as he believed that "seeing was believing." Through three years of academic training, he formed the scientific research method of "To be erudite, then to be concise; from specialized to professional, from professional to mastery." Qian Xuesen had a deeper understanding of the value of "combining theory



Fig. 14 Weekend academic discussion for Chinese Students at Caltech (Photo by Qian Xuesen)



Fig. 15 Group photo of Chinese students at Caltech after the weekend academic discussion (third from right is Qian Xuesen)



Fig. 16 Qian Xuesen and other Chinese students at a dam project site

and practice.” The connotation of technical scientific thought and its methodology gradually became clear.

5 Professional Music Critic

Being a member of the school orchestra at Jiaotong University, Qian Xuesen played euphonium quite well and he also read music theory books intensively. Little known was that he had three music reviews published in his early years. Two reviews were published on the eve of traveling to the United States, and the third one was published when he studied in the United States. It was justifiable to say that Qian Xuesen was a professional music critic as well as a musician “obscured” by his scientific research.

The first review: “Music and the Content of Music”

The first review entitled “Music and the Content of Music” was published in *Zhejiang Youth* (Vol. 1, Issue. 4, 1935), a magazine edited and printed by the Department of Education of Zhejiang Province. When he read a news report on some concerts held in a primary and secondary school in Hangzhou at the end of December 1934, he noticed that “harmonica solo”, “*jing hu* solo” and “*er’hu* solo” were in the concert’s program list. He then realized that the students seemed to “fail to understand music in a correct way”, and decided to write a review to “explain to the youth of Zhejiang Province so that they could know how to appreciate music.” In this review, starting from his own musical experiences, Qian Xuesen focused on three aspects from the perspective of his peers.

Firstly, how could one understand music properties? Qian Xuesen found that most young people’s understanding of music was still at the superficial level and neglected its content. Although many young people considered music as art, they did not see it as the same as literature, painting and other forms of arts. For them, music was a means of communication and was given a utilitarian purpose. For example, at a school concert, a girlfriend of his classmate played the piano, his classmate asked others to applaud and shout “Encore”! It was very wrong to go to a concert with such a mood. Then, how should young people understand music? Qian Xuesen explained by analogy.

After reading a novel, one would feel a kind of pleasure and comfort, not because of the whiteness of the paper or the exquisite printing, but because of the moving content. When one looked at a landscape painting, one would feel a kind of pleasure and comfort, not because of the vividness of the colors or the majestic tone of the brush, but because it led him or her into the world in the painting and merge with the content of the painting. When one looked at a plaster statue, one would feel a kind of pleasure and comfort, because he or she was moved by the change and harmony of all the curves of the statue. After reading a poem, one would feel a sense of comfort and a sense of consolation, not because of the arrangement of the syllables or words of the poem, but because of the beauty of the content it contained. This was true of novels, landscapes, statues and poems, and it was also true of music. The appreciation of music must focus on the content and on the flow of the emotions. Thus the best music must contain the most moving content, and the best music performance must be

the most understandable and moving. In other words, the quality of music was completely based on its content.

It is clear that Qian Xuesen believed that good music was an interaction between the performer and the listener in terms of “content.” “In the case of the listener, of course, the ability to listen and appreciate was essential, but in the case of the performer, he must also be able to express the content of the piece completely”, he added. How to fully express the content of a musical piece? Qian put, “Firstly, the musical instrument used must suffice to express itself, and secondly, the performer must have the adequate technique to express the content. The perfect music must have all three aspects.” Qian then gave an example: “Three years ago, when I was listening to music at the Hangzhou Youth Association, a lady played Beethoven’s dance music, and many people applauded afterwards. But I didn’t want to applaud. I thought that she played just like an automatic steel piano. Technique was only the means of music performance, not the life of music performance; the life of music performance was the expression of content!”.

Secondly, how could one improve the ability to appreciate music? There is a dialectical relationship between music theory and appreciation practice. Knowing theory helps guide practice, and through practice one can understand the mystery of theory more deeply. Qian Xuesen believed that the only way to improve music appreciation ability was to listen to famous music, by “starting from simple ballads, gradually to short fiddle pieces, piano pieces, then trios, quartets, and finally to the largest, most informative symphony”. He then pointed out that for beginners, it would be best that some professionals could provide with them some guidance, to “explain the content of each piece”. He further explained:

It was true that the interpretation of the content of a piece of music did not have to be the same for everyone, and each person could have his or her own interpretations according to his or her own free imagination. But for the beginners, it would be better to tell them how to understand the content of the piece.

Qian Xuesen explained his idea through a song, the “Old Black Joe” written by the American folk songwriter Stephen C. Foster’s (see *The One Hundred and One Best Songs XLVI*). The first half of the lyrical lines expressed the desolation of loneliness, and the middle two lines, “I’m coming”, were either heavy or light, like echoes of an empty valley, which made Old Black Joe’s loneliness more outstanding. The last two lines led to the apex of the whole song and made one so moved.

Thirdly, how could one appreciate world-class masterpieces? One needs to improve his or her appreciation of music by listening to the works of famous artists. How exactly could one achieve this? When Qian Xuesen studied at Jiao-tong Univeristy, there was a large orchestra in Shanghai that gave orchestral music recitals every Sunday from October to May. In addition, many of the world’s most famous performers would come to Shanghai to give concerts, such as violinist Efrem Zimbalist and pianist Leonid Kreutzer and so on. However, these elegant concerts were expensive and thus unrealistic for most young people. Even if the next best thing was to listen to famous songs over and over again on the phonograph, the prices of

musical records were far beyond the average student's ability to pay, at about 6.60 *yuan* each. Qian Xuesen proposed a "crowd funding" approach as he explained:

Students could organize a group with members of 40 people. If each member would pay 40 cents a month, there would be 16 *yuan* in all. They could negotiate with the record company for a discount. Three gramophone records could be purchased in a month. One could listen to the record twice, three times, four times... This was most suitable for beginners. As for the record player, one could buy a second-hand one at 20 or 30 *yuan*. The school could also sponsor the students to buy a recorder player. For such an organization, it was important to have a professional instructor who would help select and purchase the musical records and provide guidance in music appreciation.

Second review: "Mechanical Music"

The second review entitled "Mechanical Music" was published in *Music Education* (Vol. 3, Issue. 8, 1935), edited and distributed by Jiangxi Provincial Committee for the Promotion of Music Education. This review well disclosed Qian Xuesen's identity as an engineering student, as he focused on the combination of "machinery" and "music" from the perspective of science and technology. Three aspects were discussed in this review.

Firstly, what was "mechanical music"? The concept of "mechanical music" was in comparison to "living music". With the emergence of machinery, various human activities were "replaced" by machinery, and there was mechanization in the form of artistic expression. For example, the phonograph has become an indispensable medium for the preservation of modern music. However, Qian Xuesen argued that "mechanical music" was not simply a substitute for "living music", but "could become an independent category in modern art", based on the differences between "mechanical music" and "living music."

According to Qian Xuesen, the elements of a good performance were threefold: the score, the technique, and the instrument. The differences between "mechanical music" and "living music" lies in technique and instrument, because the technique of "a living performer" (e.g., pianist, violinist) was limited by his physiological maximums, such as arm strength, lung capacity, physique, articulation strength and so on. In addition, each instrument had its own timbre at the time of production, i.e., the timbre of each instrument was also "limited" and could not be changed at will. However, "mechanical music" was able to break through the limitations of "physiology" and "technology" and could accomplish what "living music" could not do. He concluded:

What "mechanical music" could do was what "living music" could not do. "Mechanical music" was to open and remove these two limitations: the physical limitations of the performer and the limitations of the musical instruments. This liberation was what the mechanical industry was to the handicraft industry - the mechanical industry rescued industry from the limitations of manpower and tools. The "mechanical music" liberated music from the limitations of performance technology as Paul Stefan called it, "machinery was the way to greater freedom, the way to greater possibilities."

Secondly, what was the unique value of "mechanical music" as an independent art discipline? Qian Xuesen believed that the value of "mechanical music" should be

considered from two aspects: whether “mechanical music” could evoke listeners’ thoughts and emotion; and whether the image (in this case sound) could conform unhindered and correctly to such evoked feelings and thoughts. To the first question, his answer was affirmative:

No matter how ordinary music was, the composer recorded his thoughts and feelings in the music score. In the performance, the performer reinterpreted the score and his or her performance displayed his own thoughts and feelings. This process was no different in “mechanical music.” Although in some “mechanical music”, the thoughts and feelings of the composer were recorded directly and later transformed into sound without fail, this was still entirely under the control of the composer.

In fact, in the whole process of music creation, the only difference between “mechanical music” and “living music” was the distance from the player’s emotional thought to the expression of the sound, and “living music” was more direct than “mechanical music.” When a flute was played, once the air came out of the mouth and the finger pressed a button, the sound came out. But what about music played through the radio? The sound must pass through the many direct air tubes of the radio station, complex circuitry, and then run thousands of miles through the radio wave, and then by the radio antenna to another set of direct air tubes and circuitry. Finally it had to pass through the amplification tube to reach the ears of the audience. Because of this long distance, people felt that the role of the composer and performer was small and invisible. It seemed that it was machinery that controlled everything. But if you gave a thought about it, you would know that it was wrong.

His answer to the second question was that “mechanical music” was better than “living music.” He said:

“Mechanical music” would outperform live music. Why? “Mechanical music” had a broader and freer expressivity than that of musical instruments; therefore it was inevitable that “mechanical music” was more capable of expressing the thoughts and feelings of the composer and performer correctly and without hindrance.

Qian Xuesen also thought that the artistic value of a new thing like “mechanical music” was no less than “living music”. Therefore, “mechanical music” could become an independent artistic discipline. However, he also raised the question of whether it was possible to produce music specifically for “mechanical music”, so that the technical strengths of machinery could be fully exploited.

Thirdly, what was the sounding principle of “mechanical music”? After discussing the concept and value of “mechanical music”, Qian Xuesen introduced the sounding principle of “mechanical music.” He summarized four kinds of “mechanical music”: Mechanical Tone-Production, Mechanical–Electrical Tone-Production, Electrical Tone-Production, and Photo–Electrical Tone-Production. Qian Xuesen’s explanation of the four “mechanical music” sounding principles revealed his expertise in understanding music. He also summarized the relationship between “mechanical music” and “living music” in a dialectical perspective. He said:

In terms of articulatory structure, we shall include the phonograph, radio and sound film in the category of “mechanical music.” However, since these devices were not to create new technical possibilities and they were not independent of general music, they were different from the mechanical instruments mentioned above. In this sense, they were not kinds of musical instruments, but communication tools. The merits of the phonograph, the radio and the sound film were to increase and intensify the inherent role of music in society.

However, it was also not quite true to say that they were completely unable to create new technical possibilities at all. In the process of filming audio movies, the elements such as dialogue, music and singing were processed separately. The final film with soundtrack was produced by synchronizing those elements. Recently, it was reported that some American had acquired method of filling phonograph records separately. For example, we could fill the violin part, and then fill the piano accompaniment part in the same piece to make a violin solo. Leaving aside whether this method had artistic value or not, it was beyond doubt that it had opened up a new path.

This review was ostensibly a discussion of music, but behind it was a discussion of the social impact of scientific and technological developments. Qian Xuesen was keenly aware of how new technology could give rise to such new things as “mechanical music”. Through this review, it was clear that the young Qian Xuesen was curious and longing for the world of the future as he enjoyed beautiful music. As he said, the development of science and technology would bring all kinds of new possibilities, and although many of these developments were only first steps, “inevitably, we had already begun a new era.”

The third review: “An American Correspondence”

On September 3, 1935, Qian Xuesen arrived in Seattle on the west coast of the United States after a ten-day voyage on steamship *President Jackson*. He stayed in Seattle for a few days and did not forget to ask the local youth association if there was a concert hall in Seattle and when there was a concert. Afterwards, Qian Xuesen took a train to the MIT in Boston on the East Coast to go through the admission procedures and start his study life.

In early 1936, Qian Xuesen’s cousin Li Yuanqing, who was the editor of *Music Education* magazine in the Committee for the Promotion of Music Education in Jiangxi Province, sent him a letter, hoping that he would write an introduction on the music scene in the United States for the magazine. Qian Xuesen then wrote a reply letter with more than 2,500 words, which was published in *Music Education* (Vol. 4, No. 4, 1936), entitled “An American Correspondence”, dated March 31, 1936. Qian wrote at the beginning of the letter:

The situation in North China had grown tense since last year and I had thought magazines such as *Music Education* might cease publishing. During the winter holidays, I could have written something for you but I thought maybe you did not need it. Since I was quite busy, what I wrote might not be fit for your magazine.

Qian Xuesen’s letter touched upon three aspects: his views on *Music Education*; the situation of the American music scene; and the situation of opera in the United States.

Qian Xuesen was a devoted reader of *Music Education* before he left for the United States. His second music review was published in *Music Education*. He not only enjoyed listening to music, but also had high musical accomplishment as he read widely and intensively on music. He wrote in his letter:

I was afraid that the style of *Music Education* was a bit dull as it focused more on music theories. I certainly liked the theoretical work that you and Mr. Miao have done, but I was

afraid that it might not be suitable for the general readership. And misconceptions about music were still not corrected. I would propose to include in the magazine, as far as possible, accounts and reviews of current music events in China. And in this way could we naturally correct current misconceptions. The magazine might also include small addenda, in order to point out the misconceptions of the newspapers and magazines about music in a sarcastic tone. For example, I once saw a novel written by KuroSakura in *Modern Times* the year before last, which wrote that Beethoven's Symphony No. 18 was played in a dance hall! That was the right material. I thought there must be inexhaustible examples of such nasty instances in China.

“Were Americans really interested in music?” Qian asked before introducing the American music scene. He then answered this question based on his own experiences. When he arrived in the United States and lived in the MIT dormitory, he went to Boston Symphony Hall to enjoy a concert every week by bus. In his letter, Qian described what he saw and heard during his trips to the concerts as follows:

There were about 400 students boarding on campus. However, only two or three, sometimes none, would go to Boston Symphony Hall together with me every week. Although this might not be a reliable way to calculate the number of students attending the concert, it was certain that this was similar to the situation in Chinese universities. In terms of audiences' age range, seven out of ten were in their forties and fifties, with the least number of middle-aged people, and most of the teenagers were girls from secondary schools. Moreover, most of the senior audiences were wealthy people. Listening to concerts was a necessity of the upper class for socializing. Therefore, I would reasonably doubt that those teenage girls were recommended by their music teacher to the concert. From this point of view, Americans were not necessarily much more interested in music than the Chinese were. As for those who went to concerts, whether they had the ability of music appreciation was also doubtful. I once heard my seatmate say to his companion in Stravinsky's *Le Sacre Du Printemps*: “Oh, it was funny!” But such a person was very energetic when he was applauding. In the case of Boston Symphony Orchestra, which I often went to, it was common that the conductor, Serge Koussavisky, had to get up three times for each piece. Among over a dozen audiences next to me, I only saw one person, also a frequenter, did not do this. He shook his head and did not applaud when the conductor did not well.

Probably, this was just one side of music scene in the States as what I talked about was symphony concert. Many people could not afford the concert as it usually would cost \$0.85 for back seat ticket in concert hall while it cost only around \$0.3 for a matinee and \$0.5 for night movie. Symphonies were also played on the radio four or five times a week during the music season, though “hot music” were played for the most of time.

Qian Xuesen introduced the situation of radio music, in terms of time, repertoire and conductor and so on. He specifically mentioned the use of radio music for advertising by Ford Motor Company and General Motors as they were competitors. He approved of this method, as he sometimes heard good music and music critics through this channel.

Qian Xuesen then introduced the situation of opera in the United States. At that time, the best opera house in the United States was the Metropolitan Opera in New York. At the time of Qian Xuesen's letter, this opera house had just performed in Boston for a week. But from the letter, we could see that Qian did not like opera, and even found it “hateful.” Why was that? From the letter, we can see the reason as he said:

I regarded music as the most abstract and sublimated art, while drama was real and material. Because of this fundamental differences, it was impossible to fuse them into a new art, i.e. Wagner's Music drama. Only dancing, or the art of dancing, was worthy to be integrated with music, because dancing was a sublimation of human expression, abstracted. The great dancer Duncan was right when she said: "Wagner had great achievements, but the master also made a big mistake" (see Isadora Duncan's autobiography *My Life*), and Wagner's beautiful music in Goetter Daemmerung and Parsifald could be said to have been spoiled. As for the applause of the opera audience at the end of each section, it was particularly annoying that the final musical flavor was ruined.

This comment shows how Qian Xuesen lived in his early days in the United States, especially when he first arrived and needed to adapt to new life. He might feel longly as a foreign student, but he could go to a concert in Boston every week to satisfy his hobby. What would Qian think about when he sat in the bus on the way back to school after the concert? Maybe he was missing his father in Shanghai, or his late mother, or his future life. When he wrote this letter, he was twenty-five years old, in the prime of his youth.

Qian Xuesen maintained a keen interest in music while attending Caltech for his doctorate. Every summer he went to open-air concerts in Hollywood, and in winter he attended chamber concerts near the school. In addition, he mobilized his fellow students William Rees Sears and Frank Marble to form a "Harp Trio." Sears played the soprano harp, Qian played the alto harp, and Marble played the tenor harp. The three of them often played together, and the pleasant sound of the flute echoed in the quiet campus. The "Harp Trio" did not disband until 1941, when Sears left Caltech.

Interestingly, Qian Xuesen also made the comment in this review that "I personally had no interest in opera," but he later disproved his judgment by proposing to Jiang Ying. Today, the love story of scientist Qian Xuesen and soprano Jiang Ying was widely known.

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From MIT to Caltech

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Chapter 4

From Young Scholar to World-Class Scientist



1 Young Scholar at Caltech

In 1939, after receiving his doctorate, Qian Xuesen had intended to return to China to participate in the Anti-Japanese War. To serve his own country with his talent would be his earnest wish. However, addressing cutting-edge problem and breaking new scientific ground in a supportive environment would be a good opportunity for him. Theodore von Kármán, his mentor, earnestly invited him to be a member of the aeronautics staff at Caltech. After much consideration, Qian Xuesen decided to stay at Caltech as a research fellow. His research interest gradually extended from aerodynamics and thin shell theory to rocket technology, engineering cybernetics and physical mechanics. A young scientific star, known as a “first-class star”, emerged many years later.

The decision to stay at Caltech

Since the emergence of modern science and education systems, the cultivation of scientific and technological talents has abandoned the traditional “teacher-apprentice” and “mentorship” has become an important part of the modern education system. Undoubtedly, mentor plays a very important role in the growth of young scholars.

Theodore von Kármán was a giant in aeronautical circles, regarded as the scientific genius of the aerospace era in the twentieth century. Qian Xuesen first met Kármán when he sought Kármán to inquire about graduate studies at Caltech. Kármán was undoubtedly a key figure in his journey to the world’s top scientist (Fig. 1).

From October 1936 to May 1939, Qian Xuesen completed his doctoral thesis under the guidance of von Kármán. During the three years of his doctoral studies, they had maintained important intellectual and personal relationships. In a casual conversation, Qian jokingly described himself as Giulio Douhet, the “Father of the Air Force”, (the originator of the theory of air power), predicting that their research work would make them the “father of missiles.” During his doctoral studies, the most important academic idea that Qian Xuesen learned from von Kármán was that



Fig. 1 Self-portrait of Qian Xuesen in his office at Caltech

“theory must be used to solve the key problems in practice”, i.e., the integration of theory and practice.

In the fall of 1938, Qian Xuesen’s doctoral dissertation was almost finished, and he began to prepare for PhD defense. Meanwhile, he began to plan for his return to China to join the Anti-Japanese war after graduation. When he told his mentor about his plan, Kármán suggested Qian Xuesen to stay at Caltech for the reason that “doing scientific research in the United States can also strengthen the anti-fascist force.” At that time, Kármán had many scientific research projects commissioned by the U.S. military and needed young talents like Qian Xuesen to help him complete the projects.

The second World War has just begun and the war between China and Japan was in full swing. Qian Xuesen followed his mentor’s advice and decided to stay after careful consideration. Thus, Qian Xuesen became a young research fellow in the Department of Aeronautics at Caltech. It should be noted that the student visa Qian Xuesen applied for when he went abroad was valid for 34 months (from July 1935 to April 1938). After receiving a reply letter from Tsinghua University agreeing to his second extension of scholarship in 1938, he applied to the Los Angeles Immigration Bureau for an extension of his visa. His visa was extended from April 4, 1938 to November 13, 1940. Since Qian stayed had a contract of employment at Caltech, his visa was extended for one more year until November 13, 1941. Thereafter, due to the recommendation and guarantee provided by his mentor von Kármán to the U.S. Department of War, Qian’s student visa was extended every year. During this period, Caltech also decided to grant Qian Xuesen a visiting scientist visa valid for 18 months on August 25, 1941, which was later extended several times.

The extension of passport and visa validity ensured Qian Xuesen’s legal residence in the United States, while the visiting scientist treatment served to reduce the review process for participation in classified research projects. Another important external

factor that enabled Qian to participate in U.S. defense research projects was the Sino-American alliance during World War II, which provided a rare historical opportunity for Qian. Many Chinese scientists had participated in U.S. defense research projects, which helped improve the defense research level on the part of the United States.

Qian Xuesen's graduation from Caltech and becoming its staff member was the starting point of his "institutionalized" path of scientific research and a key turning point in his life. Without von Kármán's acceptance of Qian as a doctoral student and his recommendation to stay at Caltech after graduation, Qian's life would have been on a different trajectory. Von Kármán and Qian Xuesen were intellectual partners as well as close friends. In 1988, when Science Press asked Qian Xuesen to evaluate the scientific contributions of Von Kármán, the always rational Qian Xuesen showed his rare emotion and politely declined. He said: "Von Kármán was my respected teacher. I had strong personal feelings for him, and I was afraid I could not evaluate him fairly [1]."

"Double-shouldered" in research and teaching

It was Qian Xuesen's tenacity and his gift in applied mathematics that won Kármán's recognition. Kármán was indeed an insightful supervisor who had not only used students' works but also created opportunities in fostering them. In 1940, when Guggenheim Aeronautical Laboratory of the California Institute of Technology's (GAL-CIT) decided to build a supersonic wind tunnel for ballistic test, Kármán entrusted the task to Qian, which enabled him rich accumulation of practical engineering experience, during the process of independent investigation, calculation and design.

At Caltech, Qian attended the annual conference of the American Institute of Aeronautical Science (IAS), and presented his paper. Attended by hundreds of people every year, this conference was a great event for scientists in the field of aeronautical science to exchange and discuss their ideas. For Qian Xuesen, the eighth annual conference of IAS in 1940 was an unforgettable event. This was his debut at an international academic conference as a young scholar after graduation. He had prepared for long time in the writing of the academic report entitled "The Influence of Curvature on the Flexural Properties of Structures". This report was entirely his research result out of academic interests. Years later, Qian Xuesen especially emphasized that, "It was an independent research work."

During World War II, the United States had a strong need to improve the combat performance of its aircraft in order to suppress the German and Japanese air forces, thus creating a strong demand for aviation science research. Against this background, Qian Xuesen joined the American Air Jet Corporation as a consultant (Theodore von Kármán' as general manager and Frank J. Malina as treasurer) in March 1941 and began to participate in Air Force research projects.

In 1942, the U.S. War Department began to entrust von Kármán with a classified military project. Von Kármán then enrolled Qian Xuesen into the research team. However, since Qian Xuesen was not allowed to participate in military-related classified projects as he was not a U.S. citizen, von Kármán vouched for his personal reputation. He wrote:

Qian had lived in the United States for seven years and was now a researcher and lecturer at Caltech. He was one of the leading experts in the field of supersonic flight research in the United States. He had published a number of academic papers, including those on ballistics, which had made him famous throughout the United States. Hiring Qian would help us complete the research work in the contract, and I had not the slightest doubt as to Qian's loyalty to the United States.

On December 1, Qian Xuesen received a letter of permission to participate in classified military projects, and was allowed to participate in classified projects of the Navy, Army and Army Air Corps, War Department and Office of the Scientific Research and Development. Since then, Qian Xuesen had been working on projects almost every day for a long time, and had played an important role in promoting the scientific research capability of the United States in aviation. However, even with the von Kármán's guarantee, Qian Xuesen was still under scrutiny of U.S. government. For example, on December 16, 1944, the U.S. War Department wrote separately to W. R. Sears and Louis J. Dunn to confirm Qian's loyalty (Figs. 2 and 3).

Moreover, Qian Xuesen combined teaching and research quite well at Caltech. In addition to completing his annual research and thesis tasks, he also undertook teaching duties (Fig. 4). On the one hand, as an academic assistant to Von Kármán, Qian became a "part-time tutor" and was a teaching assistant for graduate students. On the other hand, in 1942, the U.S. military commissioned Caltech to hold a training program on jet technology, and Qian was one of the instructors. Year later, he recalled, "I was one of the instructors and had contact with the technical staff of the Army, Navy and Army Air Corps, and later many of the officers in the U.S. Army in missiles and rockets were students in this program." Qian Xuesen learned to move smoothly among the spheres of academia, industry and government. In his early thirties and at the very height of his creative powers, Qian Xuesen had every confidence in scientific research especially after he was promoted to an associate professor in 1945 at Caltech.

2 An American "Army Colonel" on Europe Trip

The Second World War highlighted the importance of science and technology in warfare, especially aircraft carriers, missiles, aircraft and radar. In 1944, when the outcome of World War II had been decided, the United States began to set up the Army Air Forces Scientific Advisory Group (SAG) to plan the development of postwar military science in order to maintain absolute military superiority, especially against the increasingly powerful Soviet Union. Qian Xuesen was recommended by his mentor to be a member of SAG and had the opportunity to participate in the code name Operation Lusty, to travel to Europe to inspect the situation of military science research in Germany and other countries. On the eve of his preparations for the mission, Qian Xuesen encountered the so-called "re-entry" problem.

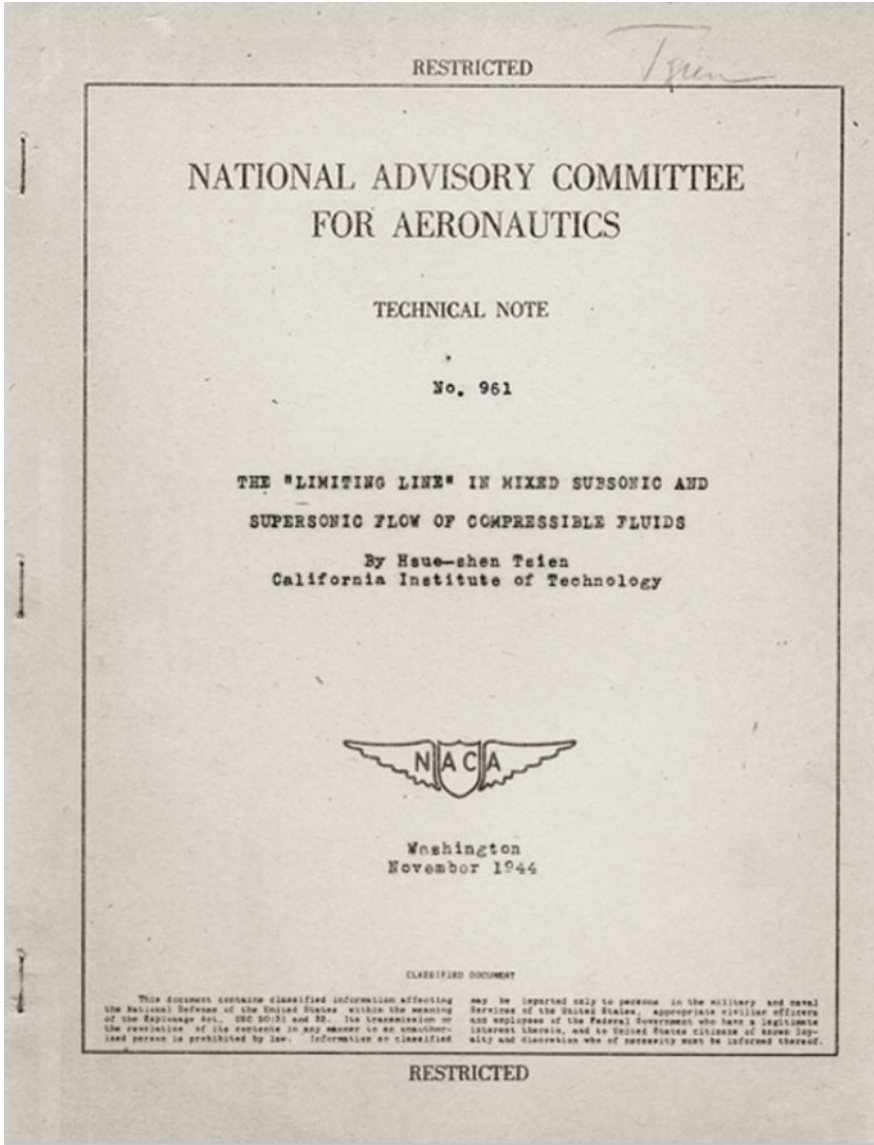


Fig. 2 Qian Xuesen’s 1944 technical report for the National Advisory Committee for Aeronautics, entitled “The ‘Limiting Line’ in Mixed Subsonic and Supersonic Flow of Compressible Fluids”

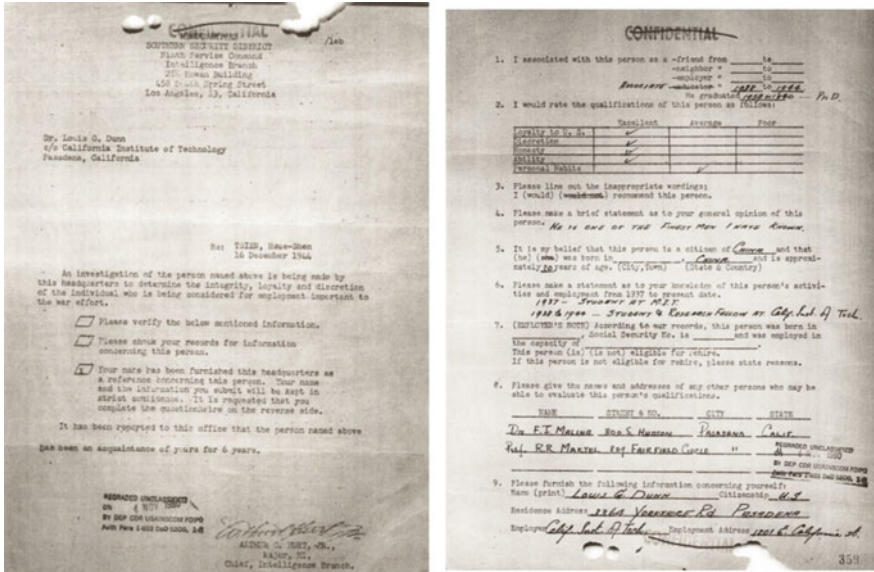


Fig. 3 This declassified file, dated November 4, 1980, shows that on December 16, 1944, the U.S. Department of War investigated Qian Xuesen’s loyalty through his colleague Louis J. Dunn (the original version was kept in the U.S. National Archives)

“Re-entry” problem

After the outbreak of World War II, the United States began to invest heavily in military science and technology in order to upgrade its aviation science and technology to counter and surpass Germany and to maintain a strategic advantage over the Soviet Union after the war. To this end, the United States also accepted scientists persecuted by the Nazis on a large scale, a movement historically known as the “intercontinental transfer” of science and technology.

By 1944, when the United States took the initiative of the War and was about to win, it began to think about how to take control of the airpower after the war. In September of that year, after a secret meeting between five-star general Henry Harley Arnold and Von Kármán in an Air Force sedan at New York’s LaGuardia Airport, they decided to establish Army Air Forces Scientific Advisory Group (SAG) to plan the development of cutting-edge military science for the United States in the next twenty to fifty years after the war (Fig. 5).

The Scientific Advisory Group was headed by Theodore von Kármán, and its members were mainly scientists and engineers from universities and research institutions, as well as high government officials. On December 1, 1944, the first plenary meeting of the advisory group was held. In early 1945, when the United States began to take full control of the European battlefield, the military decided to send an advisory group to Germany to inspect their research and development facilities and gather information on the Germans by interviewing aerodynamicists in neighboring neutral

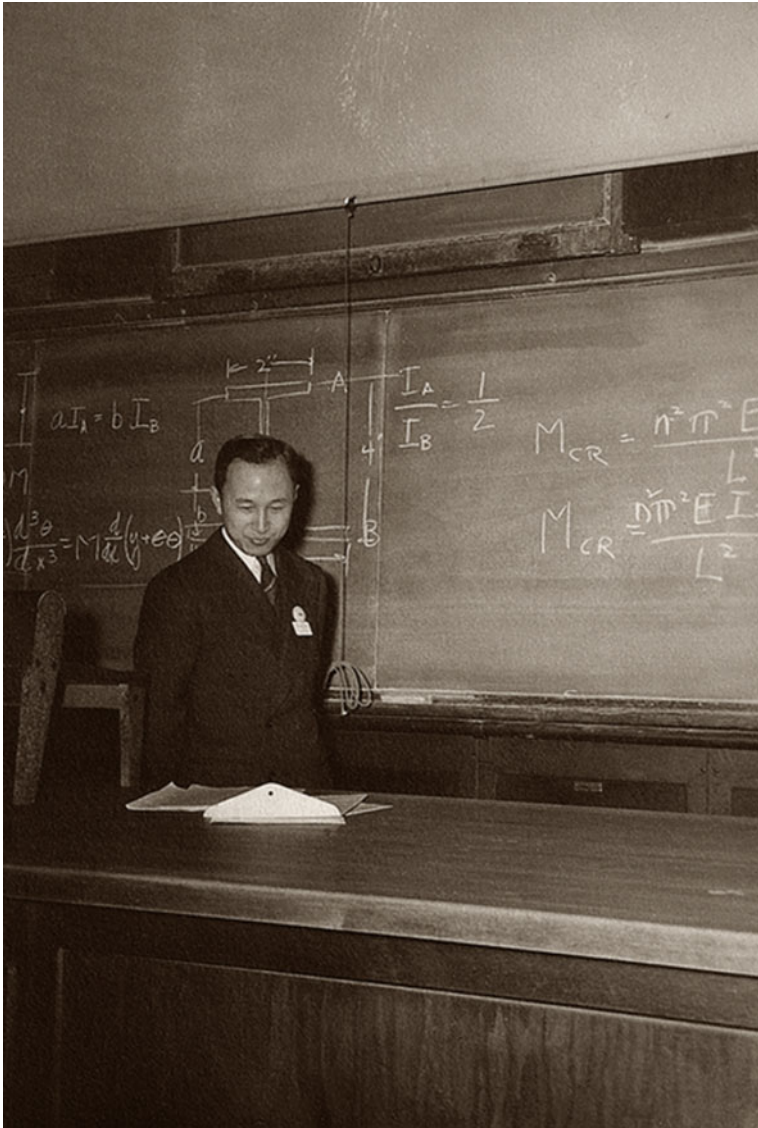


Fig. 4 Qian Xuesen in the classroom at Caltech

countries such as Switzerland and Sweden. After receiving the mission, the advisory group began to prepare for the visit and select the personnel to form the mission group on April 19. On March 25, Qian Xuesen was appointed as a research advisor to the U.S. Defense Research Board.

As Frederic E. Glantzberg, director of the Advising Panel, was compiling the list of visitors, it was discovered that Qian Xuesen had a “re-entry” problem. As the only



Fig. 5 U.S. Department of Defense Army Air Forces Scientific Advisory Group (SAG) established on December 1, 1944 (Qian Xuesen was standing in the second from left in the back row)

Chinese scientist in the group, Qian Xuesen still possessed a student 4E visa from 1936 and a passport from China. Getting out of the United States was not a problem but Qian was worried that he might encounter difficulties with the Immigration and Naturalization Service when the European service was over and not be able to get back in. Kármán wanted Qian to come along, so he asked U.S. Department of War to explain the reason to INS to ensure Qian's exit and reentry so that he could resume his student status upon returning to the United States. On April 23, the INS granted Qian a special waiver so that he could return with the same status he possessed before departure. On April 24, the Air Force promoted Qian to be the assimilated rank of colonel and gave him the title of expert consultant. The Air Force issued two identification cards for Qian Xuesen. One was general identification card to prove that he was a field grade colonel and was mainly used for identification inside the U.S. Army. The back of the document had Qian's fingerprints. The other was special identification card because the war was not really over and the U.S. Army prepared for the possibility of the SAG members being captured by enemy forces. This special identification card was a non-combatant identification issued by the U.S. Department of War, showing that Qian Xuesen was employed as a consultant. This identification card also had Qian's fingerprints on the back, but was specifically marked "VALID ONLY IF CAPTURED BY THE ENEMY". It was specifically stated that if captured by the enemy, he was to be treated as a prisoner of war in accordance with the provisions of Article 81 of the Geneva Convention of July 27, 1929, at the rank of colonel (Figs. 6, 7, 8, 9 and 10).



Fig. 6 Qian Xuesen’s U.S. Department of Defense Army Air Corps Scientific Advisory Corps Member ID

A participant of code name Operation Lusty

Interestingly, the U.S. military also humorously gave the expedition a special code name, Operation Lusty, which was derived from the word Lust, meaning strong desire. Everything was ready, and on April 29 Qian Xuesen, as a participant in Operation Lusty, left for Europe on a C-54 military aircraft from Virginia’s Crushed Rock Island military airport at Gravelly Point. During the expedition, Qian Xuesen was dressed in a U.S. Army uniform, wearing a military cap, looking handsome and dashing.

The team’s destination was mainly Germany, including Britain, France and Switzerland. The expedition was of great significance both to U.S. military science and to Qian Xuesen, especially in that it made a comprehensive study of the state of German military science and technology research on rockets, aerodynamics, engines

<i>EMPLOYED BY W.D. as an Eng. Cons. at \$5.00 a Day.</i>	Dr. Theodore von Karman, Aerodynamicist, Calif. Inst. of Tech., Director, AAF Scientific Advisory Group
<i>on loan to W.D. without compensation</i>	Dr. Hugh L. Dryden, Bureau of Standards, Consultant for Guided Missiles
<i>EMP. BY W.D. as an Eng. Cons. without compensation same as above</i>	Dr. Vladimir K. Zworykin, RCA Research Lab., Television Consultant Mr. George S. Schairer, Boeing Aero. Eng., Consultant for Aircraft Design
<i>EMP. BY W.D. as an Eng. Cons. at \$5.00 a Day.</i>	Dr. Hsue-shen Tsien, Prof. at Calif. Inst. Tech., Consultant for Rocket Motors (no passport required in this case, see par. 2 below)
<i>EMP. as W.D. field employes at Wright Field as a P.T.</i>	Dr. Frank L. Wattendorf, Eng. Wright Field Wind Tunnel, Consultant for Jet Propulsion Col. Frederic E. Glantzberg, Member Scientific Advisory Group Lt. Col. Godfrey T. McHugh, Member Scientific Advisory Group

Fig. 7 List of visitors compiled by Air Force Colonel Frederic E. Glantzberg, head of the Advisory Corps Office

and so on, and obtained first-hand reliable information. For example, in a dry well near an aerodynamical laboratory in a village outside the city of Braunschweig, the group retrieved thousands of top secret documents weighing 1,500 tons. In response, the U.S. Navy and Army set up a special Military Technical Intelligence Agency to sort through the documents. Since then, the agency has grown into the U.S. Defense Technical Information Center, which is today a worldwide center for the aggregation and analysis of defense science and technology intelligence.

During May and June, Qian Xuesen inspected wind tunnel facilities in Germany and throughout Europe and wrote several reports such as “Arrow Wing”, “Rocket”, “Supersonic Aerodynamics”, “Ramjet Engine”, “Pulsating Air Jet Engine”, and “Installation of Turbojet Engine on Aircraft” and so on. These reports recorded a full and accurate development of aircraft, rockets and bombs in Germany. For example, Qian Xuesen found that the arrow-shaped wing research in Germany was much more in-depth than that in the United States during his inspection.

The group also found a large number of research reports and experimental equipment that the German army tried to destroy during withdrawal. It was found that, as early as 1936, Germany had concentrated on the development of rockets, trying to use them as power propulsion devices for fighter acceleration, torpedo launch and so on. Later, in his report “Rocket”, Qian analyzed the structure and performance of rockets developed by Germany, and pointed out that Germany had conducted research on rockets in three categories: solid propellant rockets, solid-liquid propellant rockets, and liquid propellant rockets.

On May 5, Qian Xuesen interviewed Wernher von Braun in the German village of Kochel and asked him to prepare a report detailing the rocketry research he had engaged in and his predictions for the future. He also interviewed mechanics master

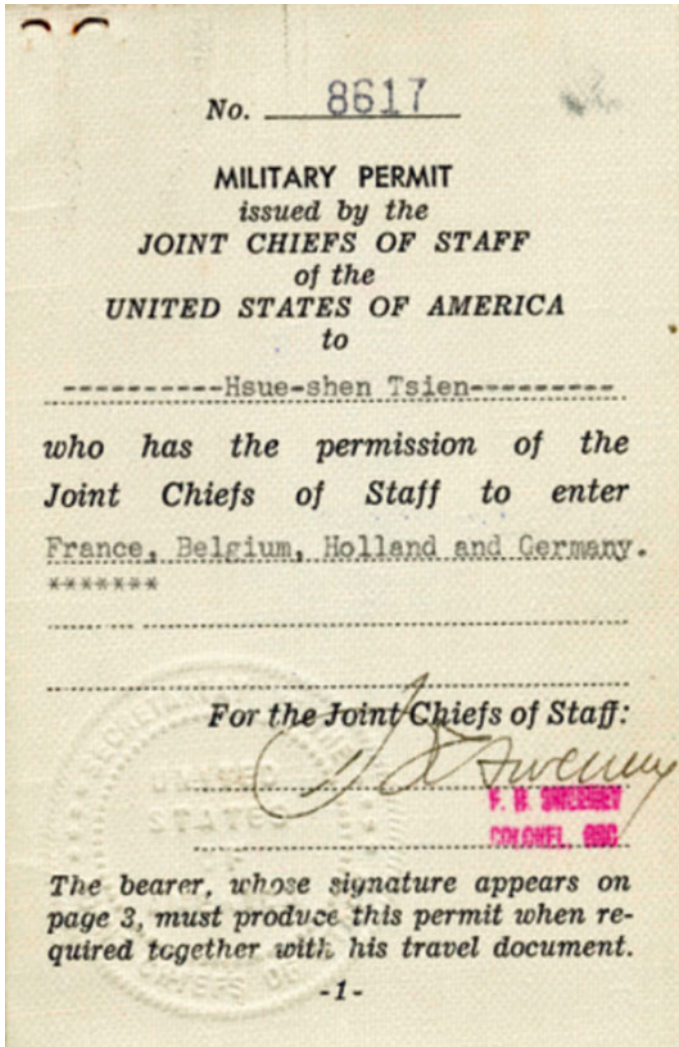


Fig. 8 Special permit issued by the U.S. War Department for Qian Xuesen's visit to Europe (April 24, 1945)

Ludwig Prandtl, Kármán's teacher. Ironically, the war turned the academic community of the Göttingen School into the victor and the defeated. Von Kármán said jokingly later on (Figs. 11, 12 and 13):

I suddenly realized how peculiar this meeting was. One was my most brilliant student, who finally returned to China, and the other was my great mentor, who had worked for Nazi Germany. How incredible were the circumstances that divided three generations of aerodynamicists. They were meant to work together in harmony.

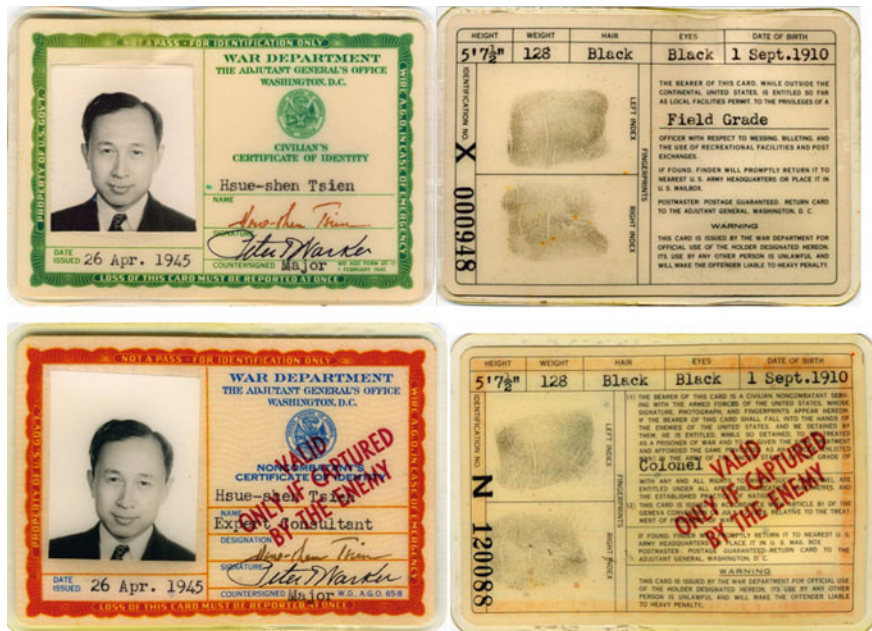


Fig. 9 Qian Xuesen’s “general identification document” and the bottom is Qian Xuesen’s “special identification document”

However, this historical scene occurred again eleven years later, that was, Qian Xuesen’s special visit to the Soviet Union as mentioned in the Preface. Although it was not in the sense of the victor and the defeated, it turned the relationship of harmonious supervisor and student into opponents.

After finishing his visit to Germany, Qian Xuesen went with the group to England, France, Switzerland and other countries. A group of SAG members prepared to go on to Japan to inspect the aerodynamic facilities there. Qian Xuesen was to be one of them, but for reasons unknown, he did not go to Asia. The Asian group included Fritz Zwicky, Frank L. Walden and William H. Pickering. When they were in China, they suggested Gu Yuxiu to travel to Japan together and asked General Douglas MacArthur’s allied headquarters to select a batch of research equipment to be transported to China. On June 20, Qian Xuesen returned to Washington and prepared for the writing of *Toward New Horizons*. This series of reports later pointed the way for the development of cutting-edge military science in the United States after the war, and was of great significance in the history of American military and science and technology.

Towards New Horizons

Towards New Horizons was a series of technical reports in thirteen books, expanding on Kármán’s theories in detail. It included topics in aerodynamics, aircraft power



Fig. 10 Badge used by Qian Xuesen during his stay in the United States

plants, aircraft fuels, rocket propellants, guided missiles, pilotless aircraft, explosives, terminal ballistics, radar communication, aviation medicine and psychology. The reports provided a blueprint for the development of a modern air force. Qian Xuesen provided his own insight and ideas for *Towards New Horizons*. As part of his contribution for the series, Qian Xuesen wrote seven reports and he summarized his findings in Germany and Switzerland, devoting considerable space to describing different wind tunnel facilities, the swept-back wing concept, and propellant fuels. He also elaborated on the theoretical analyses conducted at Caltech or JPL during the war years. The following is a list of the seven reports written by Qian Xuesen.

1. Recent Developments of Several Selected Fields of Aeronautics in Germany and Switzerland
2. High Speed Aerodynamics
3. Experimental and Theoretical Performance of Aeropulse Engines



Fig. 11 Qian Xuesen's Europe inspection



Fig. 12 Three generations of masters of mechanics, from the left: Ludwig Prandtl, Qian Xuesen, and von Kármán

4. Performance of Ramjets and Their Design Problems
5. Future Trends in the Design and Development of Solid and Liquid Fuel Rockets
6. Possibilities of Atomic Fuels for Aircraft Propulsion Power Plants
7. The Launching of a Winged Missile for Supersonic Flight.



Fig. 13 From the second left: Ludwig Prandtl, von Kármán and Qian Xuesen, taken at the Hohenheim Institute, Germany

The series *Towards New Horizons* was the result of collective wisdom, and 31 scientists, including Qian Xuesen, participated in the writing. On December 21, General Henry Arnold, chief of the Army Air Corps, signed a citation recognizing each member who had participated in the expedition, and on February 13, 1946, Arnold gave Qian an official commendation for his “excellent and complete” survey of ramjet and rocket performance and “invaluable” contribution to the field of propulsion and nuclear energy (Fig. 14).

This European trip was of great significance for Qian Xuesen. He not only gained practical experience in the formation of his own technological and scientific thought, but also confirmed his thought of combining scientific theory with engineering practice. He gained a deeper understanding of the relationship between nation and science so that he was able to “think big and far” in his own words.

3 First Chinese Professor at MIT

The so-called “Von Kármán School Exodus” is a notable incident in the history of Caltech. As the successor of Von Kármán School, Qian Xuesen chose to leave Caltech and joined the department of aeronautics of MIT in the fall semester of 1946. In May 1947, MIT started the staff promotion process and Qian Xuesen was promoted to tenured full professor. It was a year that Qian Xuesen became the first Chinese professor in MIT’s history at the age of thirty-six. Subsequently, Qian Xuesen applied for a permanent residency status in the United States in order to have higher

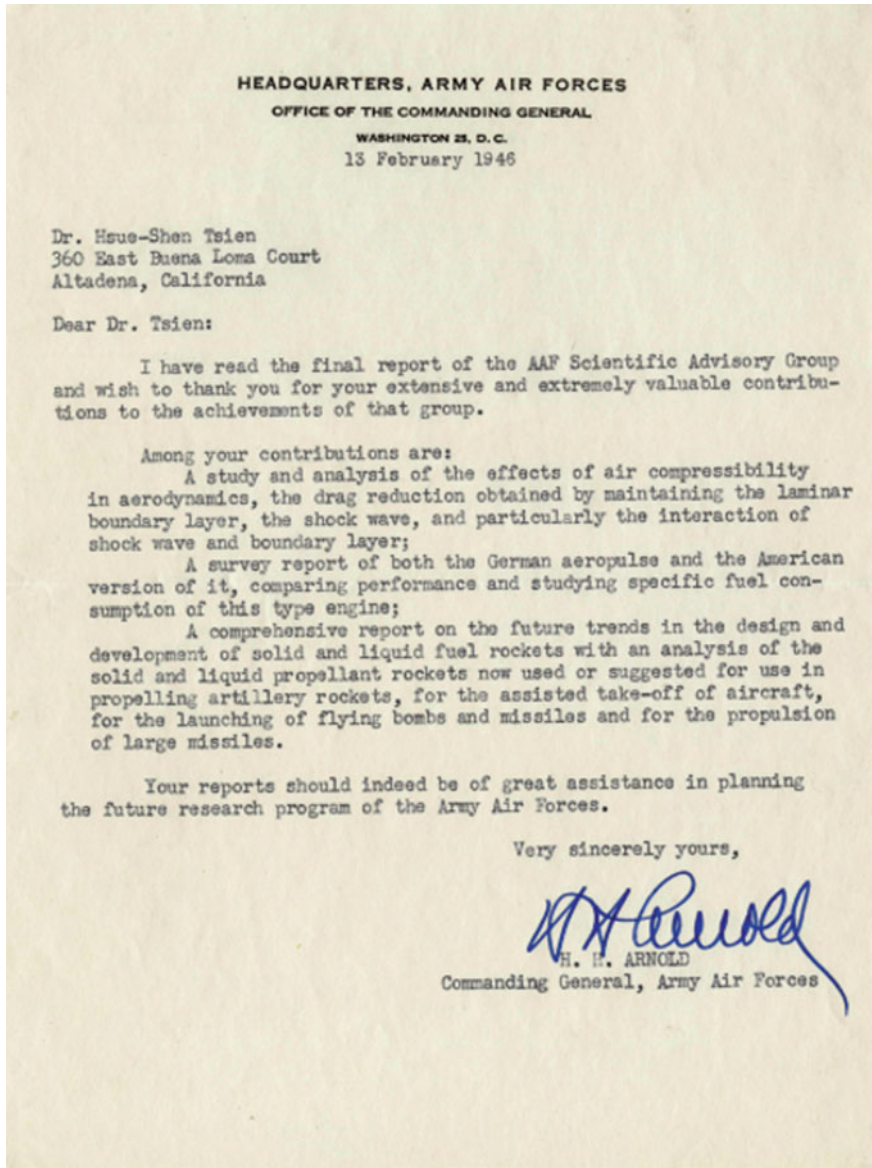


Fig. 14 Letter from General Henry Arnold, Commander of the Army Air Corps, U.S. Department of Defense, honoring Qian Xuesen

level of treatment. Since then, he had taught at MIT's Department of Aeronautical Engineering until the summer of 1949.

Joining Department of Aeronautics at MIT

In August 1946, Qian Xuesen officially resigned his position at Caltech and left the Pasadena campus, where he had been studying and working for ten years. In the fall of that year, he joined MIT as an associate professor in the Department of Aeronautics. Qian Xuesen had transitioned from a student to a young scholar, and became a rising star in the field of aeronautical science research. A direct reason for Qian's departure from Caltech could be his mentor von Kármán, who left Caltech in 1944 for his disagreement over research and teaching philosophies with the university.

Qian Xuesen later recalled, "I quitted my job because of Professor Von Kármán's disagreement with the Caltech authorities, and as a student of Von Kármán, I also wanted to express my disagreement." On November 7, Qian Xuesen, Lin Jiaqiao, Qian Weizhang, and Guo Yonghuai sent a joint letter to von Kármán, expressing their desire to leave the university. They wrote in the letter:

We are writing to confirm that you may not return to the university within the next six to eight months. We understand very well the reasons for your choice, and we will also reconsider our positions.

Firstly, we are only "guests" in the United States, and we do not intend to stay here permanently. Secondly, we are just scientists. We like to work in an atmosphere of inspiration and interpersonal enthusiasm, and it is you who create such an atmosphere. Without your presence, we feel tremendously uncomfortable. Thirdly, we love theoretical research work, and we feel that it will be difficult to do so without your guidance.

For these reasons, we are considering other choices and we need your advice on whether we should stay at Caltech or not. We fully respect your opinion. We have preliminary plans, but we will make a final decision based on your advice.

Qian Xuesen considers for a two- or three-year faculty position, or research position similar to the work he participated in during the war, probably at the University of California; Guo Yonghuai considers a research position with preference, possibly at Princeton University; Qian Weizhang considers a faculty position or a research position similar to the U.S. military research program in which Qian Xuesen had participated in; Lin Jiaqiao considers a research or teaching position in applied mathematics at one of the top universities in the east.

We are very sorry that our decisions may upset you. But you are our mentor, and we would not have done anything without your advice.

Qian Xuesen's original plan was to go to the University of California. But it was MIT, the school where he had studied for his master's degree that finally offered him an invitation, recommended by Jerome C. Hunsaker, the head of MIT's department of aeronautics. Hunsaker, who had been the departmental chair when Qian was studying at MIT, was impressed with the student from China. It was not known how Hunsaker convinced Qian to come to MIT, but on June 14, 1946, Hunsaker wrote to the dean of MIT to inform him explicitly that Qian would teach at MIT in the fall semester, and that Caltech might "pressure" him to prevent a brain drain.

At this time, Qian Xuesen was invited by von Kármán and was attending the first meeting of the U.S. National Advisory Committee on Aeronautics at the Pentagon in Washington, D.C., on June 17. After the meeting, Qian flew back to California, going through resigning procedures. He and Guo Yonghuai then drove from the west coast to the eastern part of the U.S. and Qian drove alone to Boston after sending Guo to Cornell University for his posting. In a commemorative essay for *Guo Yonghuai's Collected Works*, Qian Xuesen still recalled with fondness:

In the fall of 1946, Guo Yonghuai took a teaching position at School of Aeronautics, Cornell University, chaired by W. R. Sears, and I went to MIT. Both universities were in the eastern part of the United States nearly 3,000 km away from Caltech, so he and I drove to our destinations. It was a rare chance to have such a confidant traveling with me, so when he arrived at Cornell and I had to drive on eastward to MIT alone, I felt a little lonely [2].

On August 31, Qian Xuesen officially joined the MIT Department of Aeronautics as an associate professor but MIT offered him a professor's annual salary. Perhaps, Hunsaker had promised to give him full professorship when he recommended Qian Xuesen to MIT.

Becoming a full professor at MIT

Within months of his arrival at MIT, the faculty considered promoting Qian Xuesen to full professorship immediately. In MIT's "President's Files", a memo from T. K. Shewood, dean of the School of Engineering, to the president was kept. The memo, dated January 29, 1947, was about Hunsaker's visit to T. K. Shewood on January 15 to discuss the promotion of Qian Xuesen. The memo recorded:

Hunsaker thought it was appropriate to promote Qian Xuesen to be a full professor because Qian Xuesen had a clear research direction and was doing excellent work. Recently, Qian's research contributions in the field of supersonic aerodynamics and his proposed research program for supersonic vehicles with Mach 1.0 or higher had led Hunsaker to believe that we had a "first-class star."

Jerome Hunsaker also asked von Kármán in February 1947 to provide a recommendation for Qian's promotion to tenured full professor. Kármán wrote:

Dr. Qian is certainly one of the leading men in the field of application of mathematics and mathematical physics to problems in aerodynamic and structural elasticity. He has a very broad knowledge in applied mathematics, as well as in the sub-disciplines of physics and mathematics. He has the ability to combine mathematical skills with natural phenomena and engineering vision. I was very impressed with him when he was a young student working with me, and he used his talent to help me solve and clarify several scientific problems.

I believe that, in his new position, Dr. Qian will lead young scholars and engineering students to build a solid foundation for their future research. In fact, Dr. Qian has inspired many aviation researchers in the field of aerodynamics and elasticity during his three or four years at Caltech.

I believe he has the maturity required for a full professorship. I believe he is a good teacher and that he also has a talent for organization. His intellectual honesty and sincere devotion to both science and the institution which gives him the opportunity for working scientific research represent great assets, which I am sure you will appreciate.

Hunsaker's efforts and von Kármán's letter of recommendation helped. On March 7, the *MIT Technology Review* officially announced the results of the promotion, in which twelve people were promoted to be full professor, and Qian Xuesen was among them. Qian Xuesen was then thirty-six years old.

In his recommendation letter, von Kármán emphasized that "He also has a talent for organization", which played an extremely important role when Qian returned to China to lead the missile development project. It was this organizational ability that made Qian Xuesen a strategic scientist and was the basis for his research on organizational management, system engineering, and systems science in his later years.

In twelve years, since Qian Xuesen set his foot in U.S. soil, he was transformed from a student to a professor. This was an "upgrading" in his life through his own efforts. In his words, "I had climbed to the top in the American academic world."

Applying for a U.S. permanent residency status

When Qian Xuesen joined MIT, he was still a member of the U.S. Aeronautics Advisory Board (the predecessor of NASA), which meant that he had to travel to Washington frequently to attend meetings. At MIT, he taught aerodynamics, a course for graduate students. In the first half of 1948, Qian Xuesen offered a course "Rocket Engineering" and co-chaired a seminar on aeronautics with Lin Jiaqiao.

Claude Brenner, a former graduate student at MIT, recalled that Qian Xuesen was already famous, "a great guy" before he came to MIT. But Qian's classes were not popular, and Claude Brenner even used the word "terrible" to describe them. It was not that Qian's classes were terrible, but the way they were taught made many students "unable to keep up", said Claude Brenner.

His course was terrible because he didn't allow any questions! We had learned that early. We sat in the classroom while he stood and wrote on the blackboard. Five minutes into the lecture, someone interrupted him and said, "Excuse me, sir. I didn't understand the equation." He turned around and said, "Have you studied it in advance?" "Yes." "Well, then you didn't need my explanation." He continued his lecture and we sat there, dumbfounded. In the next class, someone asked another question and he turned around and said, "Did you pay attention?" "Yes." "Then, you didn't need an answer." We studied in his classroom for a whole year and never asked another question! We just copied his equations and listened to his lectures. At the end he gave us a test and the question had nothing to do with aviation! To a large extent, it was a math test on hypothetical situations, testing our mathematical understanding of what he taught us, and the concepts of what he taught us. He was a very tough teacher.

In fact, Qian Xuesen's lecture on compressible fluid aerodynamics was a cutting-edge subject, and the lecture was based on his latest research. Many students in his class were not up to date with their knowledge, and therefore found it quite difficult. But Claude Brenner recalled the Chinese teacher's class, "It was a very interesting moment." In Claude Brenner's view, Qian Xuesen was a very good friend and "a very charming person socially." Maybe it was because Qian Xuesen would meet with his students for dinner almost once a month to talk with them about life and ideals.

The year 1947 was a turning point in Qian Xuesen's life when, at the age of thirty six, he became the first Chinese professor in the history of the MIT. In addition,



Fig. 15 Qian Xuesen's U.S. Permanent Residence Permit

after receiving full professorship, Qian Xuesen applied for a permanent residence permit (No. 4656868), or “U.S. Green card”, from the U.S. Department of Justice Immigration Service on April 21 in order to facilitate his participation in classified programs (Fig. 15). This meant that he could stay in the United States permanently without a visa and enjoy all the civil rights of the United States except the right to vote and to be elected, and more importantly, to participate in classified projects. There were six levels of confidentiality for U.S. researchers, namely, the “unclassified, declassified, classified, confident secret, top secret and topmost secret.” According to Zhu Kezhen's diary, Qian Xuesen was able to read the “confident secret” grade file. There was no doubt that Qian Xuesen's access to the files at confidential level played an important role in the enhancement of his scientific vision. This was also the reason why the U.S. military immediately revoked Qian's secret status license after the so-called “Qian Xuesen case.”

A green card holder is not only able to enter and leave the United States without a visa, but his/her spouse is also able to enter the United States legally. Thus, when Qian returned to China in the summer to visit his family and married Jiang Ying, he applied for a visa for Jiang Ying from the U.S. Consulate in Shanghai.

In the history of MIT, Qian Xuesen was a “special” person. In a way, MIT was the “lucky place” where Qian became a world-renowned scientist. MIT continued to keep an eye on Qian Xuesen after his return to China, and when China achieved the “two-bomb combination” in 1966, the *MIT Technology Review* reported on November 4, 1966, with the headline “Chinese bomb expert MIT grad”, recalling the alumnus who had studied and taught at MIT and claimed, “What he learned at MIT and Caltech undoubtedly helped to make Red China a nuclear power.”

4 Summon from China

The year of 1947 coincided with Qian Xuesen's big year (one's year of birth considered in relation to the Twelve Terrestrial Branches), and his promotion to full professorship was an important turning point in his scientific career. From July to

September, Qian Xuesen delivered speeches on the topic of engineering and engineering science in Zhejiang University, Jiaotong University and Tsinghua University on the occasion of his return to China, systematically expounding his thoughts on the ideological system of technical science, including scientific connotation, research objects and research methods. It symbolized the formation and perfection of Qian Xuesen's technical scientific thought. During this period, he plainly realized that "the first-class technical scientists were all spontaneous dialectical materialists", but it was not until he returned to China that he realized that the methodology of technical scientific thought had already been expounded in the classical works of Mao Zedong's philosophical thoughts *On Practice* and *On Contradiction*. This realization remained ideological basis for him to become a firm Marxist.

An invitation from Alma Mater Jiaotong University

On April 21, 1947, Zhang Sihou wrote to Wu Baofeng, President of Jiaotong University, and Li Zhenwu, Provost of Jiaotong University, informing them that Qian Xuesen would return to China soon, and he proposed:

Qian Xuesen planned to return to China this June and would stay for one or two months. I had asked him whether he could make speeches at Jiaotong University one hour every day for two weeks. Qian was very influential in the American aviation industry. He was one member of the Scientific Advisory Group of the United States to travel to Germany to inspect the situation of military science research. If the alma mater could deliver lectures in the summer and students and researchers specialized in aviation from Beijing, Shanghai and Hangzhou could be invited to gather together, it would be beneficial to promoting the research atmosphere. If Mr. Hesun (Cao Hesun, Director of Department of Aeronautics of Jiaotong University) and Mr. Junliao agreed to this proposal, please send messages to Prof. H. S. Tsien, Department of Aeronautics, MIT. For any assistance, please send message to S. H. Chang, 48 Conant Hall Cambridge 38 Mass.

Zhang Sihou, Cao Hesun and Qian Xuesen were graduates of Jiaotong University. Zhang and Cao was majored in electrical engineering while Qian Xuesen in mechanical engineering. Cao obtained a doctorate from the University of Turin and Zhang was then studying for his doctorate at Harvard University.

On May 27, Wu Baofen sent Zhang Sihou a signed formal invitation which was then sent to Qian Xuesen. When Qian Xuesen received the invitation letter, he made a decision to give a lecture to spread the frontiers of the scientific theories to the domestic scientific, engineering and educational communities at his alma mater during his summer return to China.

On the evening of March 31, 1947, Professor Zhao Yuanren of Harvard University hosted a banquet at his home in Boston for Zhu Kezhen, President of Zhejiang University, who was then visiting the United States. On November 3, 1946, Zhu Kezhen went to Paris as a member of the National Government delegation to attend the founding conference of UNESCO. On February 13, Zhu left New York for Cambridge, where he was greeted at the train station by the couple of Zhao Yuanren. Qian Xuesen was invited to the reception dinner, and during the meeting Qian Xuesen and Zhu Kezhen had a pleasant talk. When Zhu Kezhen learned that Qian Xuesen was the son of his friend Qian Junfu and that Qian would return to China during the summer vacation,

he immediately invited him to come to Zhejiang University to deliver a speech. After Zhu learned that Qian Xuesen had returned to Hangzhou on July 14, he invited him to have dinner at school the next day, accompanied by Tan Jiazhen, Zhu Zhengyuan, Fan Xuji, Su Buqing, Li Qiaonian, Wa Renxuan, Wang Jinfu and others from the College of Engineering of Zhejiang University.

At 7:00 a.m., on July 28th, 1947, Qian Xuesen came to Classroom 61 in the College of Engineering, Zhejiang University and delivered a lecture on “Engineering Science and Engineering”, which lasted for two hours. More than 40 teachers and students, including Zhu Kezhen, Zheng Xiaocang, Yue Yijie, Fan Xuji, Pan Yuan and Ding Xubao, attended the lecture. Zhu Kezhen put down the main content of the lecture in his diary:

Firstly, the development of engineering science must depend on basic science. In ancient times, applied science and pure science were unified but tended to diverge in the 19th century. The recent developments of both had made them interconnected with each other. Secondly, pure science could solve some problems without proof of experiments. Some people might say that theory and experiment were two different things and it was not justifiable as sometimes theory was not correct. Thirdly, the impact of the theory on the future development of engineering science, such as jet propeller, fuel problem and so on, was elaborated. Finally, Qian talked about the kind of education required for engineers.

In August, Qian Xuesen went to his alma mater Jiaotong University to deliver a lecture. The *Frontline Daily*, a Shanghai newspaper, reported in its education column on August 2, 1947, that Qian Xuesen, a renowned professor at MIT, would come to Shanghai in mid-August at the invitation of Jiaotong University to give a lecture on the topic of “The Development of Aeronautical Engineering in the Last Ten Years.” The lecture was hosted by the Department of Aeronautics of Jiaotong University, and students and teachers from other departments crowded in to attend the lecture. Chen Guoxiang, a teacher of the Department of Mechanical Engineering was responsible for recording the content of the lecture, which was later published in *Engineering World* (Vol. 2, No. 12, December 1947), edited by the Chinese Association of Science and Technology, under the title of “How to study engineering science and what to study”, providing valuable materials for studying Qian Xuesen’s thoughts on science and technology.

In this speech, Qian Xuesen elaborated on the outstanding achievements of aircraft and atomic energy in recent ten years. He said:

In the past, progress in engineering often depended on more experience or experimentation, and less on theoretical analysis. Engineering progress was much slower as the accumulation of experiences was a long-term process. Currently engineering was in rapid development with the support of analyses and theory. In the past, we thought that what engineers needed was to have experiences while theoretical science was useless. This was a misconception. For example, Isaac Newton was a great scientist and people always thought that he did not know about engineering, but he designed a bridge in Oxford, England.

Leonhard Euler was also a scientist, but his cylinder calculation formula solved the most important cylinder problem in civil engineering. The list of examples could go on and on. Science and engineering were connected in the past, but with the rapid development, the knowledge scopes of both had extended. Since an individual’s ability was limited and it was

impossible to learn everything, practical engineering and theoretical science were separated. Some people focused on engineering or manufacturing rather than general theories; others paid attention to science or basic principles but ignore practical problems. For example, in fluid mechanics, there were two basic assumptions: one was that water cannot be compressed; the other was that water was not adhesive. With these two assumptions, the properties of the fluid can be studied. However, the engineers did not think it was practical, because water can actually have a little compressibility and adhesion. Therefore, based on the results of experiments, engineers had a practical science of hydraulics, and hydraulics, strictly speaking, was just a collection of empirical formulas and coefficients, many of which were worthless in the view of theorists. The situation of lack of cooperation between engineering and theoretical science did not change until the beginning of the 20th century, when scientific theories were gradually applied to engineering.

Subsequently, Qian Xuesen advocated an independent scientific system between natural science and engineering technology, namely, engineering science. He further pointed out that engineering science had two research directions: "There were two major types of research problems. One was the pure problem of science or engineering and the other was the general research of a certain phenomenon. Examples of the former were the design of rockets, and the latter, the turbulence. If the problem of turbulence could be solved, it was not only meaningful for hydraulics, but also directly helpful to aerodynamics, meteorology and the design of engine combustion chamber."

As for the research methods of engineering science, Qian Xuesen proposed to "simplify the problem" and that "experimenters should cooperate closely with theorists." What was included in the knowledge scope of engineering science? He put:

There were two basic research tools: practical experience and basic science. The former was the foundation of manufacturing technology and mathematics, while the latter the foundation of modern physics, chemistry and mathematics. For example, in the past, the theory of molecular nucleus and molecular motion was discovered because of the explanations of the properties of matter, and the success of the atomic bomb was just to further prove the accuracy of this theory. The previous conclusions were the basis of the current research. Mathematics, being a reasonable inference, was also one of the research tools. In addition to several basic mathematics courses learned in engineering schools, there were some more to be learned, namely, Analysis, Partial Differentiation and Integral Equation, and Computing Machine. While Analysis and Partial Differentiation were frequently used in engineering, the modern computing machine could be used to solve complex differential equations and calculate the trajectory and range.

Qian Xuesen urged young engineering students to think of themselves as scientists rather than high-paid technicians. He advised them to take courses not only in engineering but also in mathematics, chemistry and physics. The training of a competent engineering scientist, Qian Xuesen put, was a long process, but as long as one became an experienced master, every problem could be solved easily. He outlined the merits of a university doctoral program: "The free academic atmosphere in an educational institution was certainly conducive to thinking, which was, after all, the only way to gain wisdom." The recent development of engineering science and the invention of atomic bomb, radar, rocket and plastic body were all due to this group of well-trained scientists.

Finally, Qian Xuesen pointed out the directions of engineering science and foresaw engineering applications in the fields of hydrodynamics, elasticity, plastics, thermodynamics, combustion problems, electronics, materials and nuclear research. Qian stressed that any researcher aspiring in engineering science must also have the spirit of the times, because “the responsibility of engineering science was to solve any problem related to scientific progress.” He ended his speech by inspiring the students and teachers in the audience with the words of Harold Urey, the well-known American atomist, “It is our duty to remove discomfort, dissatisfaction and poverty, and we are to contribute to the comfort, leisure and grace of mankind.”

On August 26, 1961, when Qian Xuesen was visiting his friends in Beijing, he was invited to Tsinghua University to give another lecture on engineering science, which was presided over by Tao Baokai, dean of the School of Engineering of Tsinghua University. The lecture was attended by Mei Yiqi, Ye Qisun and others. On July 17, 1961, Peng Bingpu, a 1950 graduate of Tsinghua University who was present at the speech, wrote to Qian, saying: “I was deeply impressed by your lecture on engineering sciences.” Two days later, on August 28, Qian delivered a second speech on his most recent research in mechanics of rarefied gas at the science museum in Tsinghua University.

Technical scientific thought and Marxist philosophy

In these lectures, Qian Xuesen systematically elaborated the concept of engineering science, (the concept of technical science was used after his return to China in 1955) for the first time, and he finished the first draft soon after his return to the United States. In 1948, Qian published the paper entitled “Engineering and Engineering Sciences” in the *Journal of Chinese Institute of Engineers* (1948, Vol. 6), which attracted great attention from the American scientific community.

The core of technical science is to combine science and engineering, which is a concept commonly advocated today, but it was still a frontier theory back then. More importantly, the value of technical scientific thought is that it has laid the ideological foundation for Qian Xuesen as a staunch Marxist. Combination of “practice and theory” in the thought of technical science comes down in one continuous line with the viewpoint of practice and contradiction in Marxist philosophy. In 1956, Qian Xuesen was invited to participate in a written discussion organized by the *Bulletin of Research in Natural Dialectics*, and he wrote an article entitled “Methodological Problems in Technical Science”, in which he wrote:

In the study of technical science, we should combine theory and practice flexibly and not act in a rigid way. I thought this flexible combination of theory and practice was also the true essence of dialectical materialism. Therefore, I thought that the world’s first-class technical scientists were also dialectical materialists, and their research methods were worth summarizing. And we could also apply dialectical materialism to the study of technical science to improve the efficiency of research.

Qian Xuesen's understanding of Marxist philosophy had a solid practical foundation. Therefore he could not wait to start studying Marxist philosophy after his return to China in 1955, as his secretary Zhang Kewen recalled, "When I was in the Institute of Mechanics, I often saw Mr. Qian Xuesen and Mr. Guo Yonghuai studying and discussing Chairman Mao's *Theory of Contradiction* and *Theory of Practice* in those evenings." Because of this, Qian Xuesen always adhered to Marxist philosophy as a guideline in guiding his scientific research practice and academic research, and he learned to analyze and deal with problems with dialectical materialism and historical materialism.

As late as the 1980s, Qian Xuesen still firmly pointed out: "Basic research, whether purely basic or basic applied research, was highly exploratory work. Human initiative was very important. Mechanical materialism sometimes will lead us to failure; therefore we should ground our research on the sharp ideological weapon of dialectical materialism." Qian Xuesen summarized up his academic research experiences in his later years: "I started on the road from engineering technology to technical science, then to social science, and I ultimately knocked on the door of Marxist philosophy."

5 A Presentation at the American Rocket Society Conference

It is generally accepted that Qian Xuesen's 1954 publication of *Engineering Cybernetics* established his worldwide academic status, especially with Theodore von Kármán's widely circulated comment, "You have now surpassed me in scholarship!" Qian Xuesen's academic status as a world-class scientist could be traced back to his presentation at American Rocket Society conference in 1949, taking the triple role as a member of the American Rocket Society, Goddard Chair Professor at Caltech and Director of the Guggenheim Jet Propulsion Center. Qian Xuesen's presentation was not really an academic report, but a working report with a summary and an outlook. It was through this presentation that Qian Xuesen had established himself as "an academic leader" in the field of aeronautical science.

Return to Caltech

In 1948, the Guggenheim Foundation decided to establish jet propulsion centers at both Caltech and Princeton University. The foundation promised to provide \$500,000 to each center over the next seven years to cover the salaries of the center's researchers, graduate student scholarships and other related expenses. The centers' offices and laboratories, and equipments were provided by the host universities. On the establishment of the two centers, von Kármán commented: "A new era had opened up in both engineering and human thought that would affect the future more profoundly than was now anticipated."

In fact, before the establishment of the Guggenheim Jet Propulsion Center, Caltech already had two institutions that focused on aeronautical science research: the Jet Propulsion Laboratory (JPL) and the Guggenheim Aeronautics Laboratory (GAL). Although the research fields of these three institutions were all aeronautical sciences, their specific research directions and focus were different. Guggenheim Jet Propulsion Center was responsible for the triple goals of teaching, research and industry. To be specific, firstly, it was to train young engineers and scientists in the field of rocket and jet propulsion technology, to push the aviation frontier to a higher level. Secondly, it was to promote advanced research in the fields of rocket and jet propulsion. Thirdly, it was to promote the commercial and scientific application of rockets and jet propulsion in peacetime. Actually, in the process of teaching, the three institutions shared each other's faculty and the Guggenheim Jet Propulsion Center had unconditional access to JPL and GAL's expensive laboratory equipment.

When both Caltech and Princeton University identified candidates for the directorship of the Center, the first choice was Qian Xuesen. The first person to extend an invitation to Qian was Caltech President Lee Alvin DuBridge, who wrote to Qian Xuesen on September 29, 1948, expressing his desire for the appointment, "Both Princeton University and Caltech were planning to build the Guggenheim Jet Propulsion Center, and it immediately occurred to me that you were the right person to lead this laboratory, and I hoped you would accept Caltech's invitation."

On October 7, after careful consideration, Qian Xuesen wrote to DuBridge accepting the offer and agreeing to serve as Goddard Professor and Director of the Guggenheim Jet Propulsion Center. Harry F. Guggenheim, chairman of the Guggenheim Foundation, officially announced the establishment of the Guggenheim Jet Propulsion Center at Caltech. At the inauguration ceremony, DuBridge announced to the news media that:

Dr. Xuesen Qian, a 38 year-old Chinese student at Caltech and a member of Caltech's Academic Council, will lead the Center. Dr. Qian is now a professor in the Department of Aeronautics at MIT.

On December 27, Qian Xuesen wrote to his friend Frank J. Malina, informing him that he had decided to leave MIT to take his post at Caltech. In the letter, he wrote:

The atmosphere here is very rigid and stagnant. It doesn't fit well with me as a "Caltechite" or "Von Kármánite." To be honest, I'm not happy here. I don't think Hunsaker would be upset about me leaving! Anyway, I don't fit in at all in this old aeronautical engineering department!

In the first half of 1949, Qian Xuesen had already begun preparations for his next semester at Caltech, and during the summer of 1949, Qian Xuesen and Ying Jiang packed their household goods and gave them to a transportation company to be shipped to Pasadena, Los Angeles, while they took their infant son, Qian Yonggang and drove themselves to Pasadena. They also made a special stop at Cornell University to meet with the couple of Guo Yonghuai and Li Pei, and W. R. Sears.

During their stay at Cornell University, they not only exchanged pleasantries, family stories and went sightseeing, but also discussed in depth the problem of singular regimes in transonic aerodynamics. Guo Yonghuai had already conducted in-depth research, and in 1953, when Guo Yonghuai went to Caltech for a visit, Qian Xuesen again discussed further with him. The Poincaré–Lighthill–Kuo Method was completed before Qian’s return to China in 1955, after many years of research and synthesis of Kuo’s method with that of Poincaré and Lighthill [3]. When Qian returned to Caltech, he was no longer the associate professor when left Caltech a few years earlier. Of course, his return was not because of his status as a student of von Kármán, but rather as a rising “first-class star” in the field of aerospace science (Fig. 16).

A Presentation at the American Rocket Society Conference

Shortly after his return to Caltech, Qian Xuesen established his worldwide academic status in the field of aeronautical science by making a presentation at the annual meeting of the American Rocket Society held at the Statler Hilton Hotel in New York City on December 1, 1949, as a member of the Society, Goddard Professor and director of the Guggenheim Jet Propulsion Center at Caltech. The annual meeting of the American Rocket Society was an international academic conference in the field of rocket, aerospace and aerodynamics research in the United States. Qian Xuesen’s presentation at the conference was “Instruction and Research at the Daniel and Florence Guggenheim Jet Propulsion Center”.

Strictly speaking, Qian Xuesen’s presentation was not really an academic report, but a working report with a summary and an outlook. The report was divided into three parts: the introduction of the Jet Propulsion Center, the teaching and research plans of the Jet Propulsion Center, and the recent research projects of the Jet Propulsion Center, which included characteristics of rocket and jet propulsion engineering, material problems, heat exchange, combustion, and performance of rocket and jet propulsion vehicles. The mainstream American news media reported that it was not a conventional academic conference, but was of great significance. In addition, the Guggenheim Foundation held a press conference in New York to announce that Qian Xuesen would attend the conference.

The reason why this conference attracted the attention of the *New York Times*, the *Washington Post*, the *Los Angeles Times* and other mainstream media was because Qian Xuesen proposed in his outlook that “a 9,140 mph spacecraft was technically feasible.” To put in other words, “an intercontinental rocket could cross the entire country in one hour.” Although this was only a conjecture, it attracted a lot of attention from the society because it was very likely to be the dawn of a new era. *The Washington Post* reported on December 2, 1949:

This is an artist’s concept of a rocket ship which, according to scientists, will fly from New York to Los Angeles in less than an hour. The blueprint was described by Dr. Qian Xuesen at Caltech to the American Society of Mechanical Engineers in New York yesterday. Dr. Qian Xuesen said it would fly almost 10,000 miles in one hour, but land at the speed of only 150 miles.

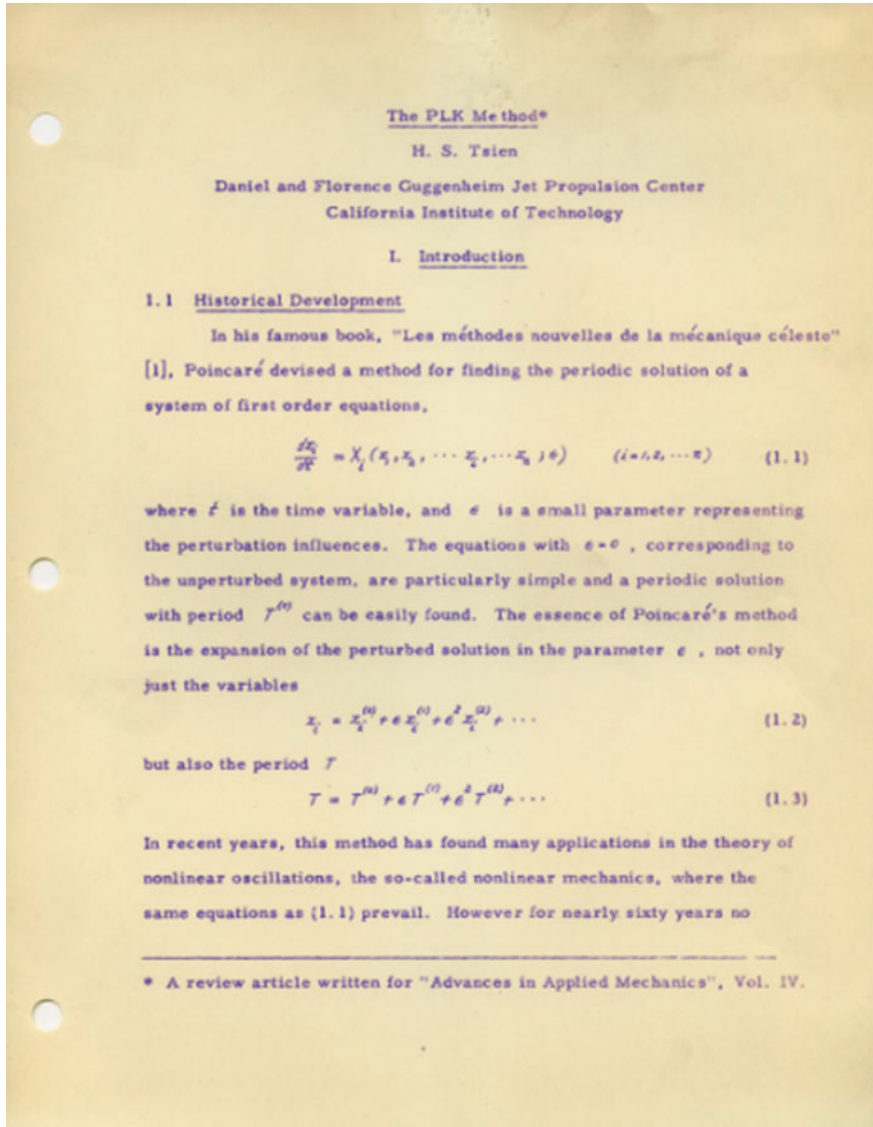


Fig. 16 The first page of the printed version of The Poincaré–Lighthill–Kuo Method completed by Qian Xuesen (96 pages in total). The paper was later included in the book *Advances in Applied Mechanics*, published by Academic Press, New York

The concept of rocket spaceship was very imaginative and almost science fiction at that time, but it was the basis for “Qian Xuesen trajectory” proposed in 1952 and now becomes a necessary trajectory for the development of manned spacecraft. In addition, Qian Xuesen stressed that fuel of rocket spaceship was not a hard issue as several raw materials could be mixed with liquid oxygen to make liquid fuel as power. But there was no doubt that a high-speed rocket was a better choice than an aircraft, because the materials of aircraft must be able to withstand long-term wear while the rocket only took a few minutes or even seconds. He concluded: “The designing of rocket ship aimed at several minutes rather than thousands of hours in flying and we were able to use pressure-resistant materials that withstand tremendous stress instead of wear resistant materials.”

The annual conference of the American Rocket Society was followed by the second conference of the Guggenheim Foundation. The conference had two agendas: one was to pass the Guggenheim Jet Propulsion Center Fellow selection process and membership development plans for the coming year, and the other was to focus on current programs and future perspectives at the Centers. Qian Xuesen attended the meeting as the director of the Jet Propulsion Center at Caltech, where he emphasized the importance of the educational work of the Jet Propulsion Center as an important location for the nation’s graduate education and training in rocket and jet propulsion, with the hope of producing outstanding engineers for industry and government departments. He then introduced the curriculum of the Guggenheim Jet Propulsion Center at Caltech, as well as the research work of fifteen researchers. Finally, Qian suggested that since there was no journal dedicated to publishing rocket research results, each Goddard professor could become an editor of the *Journal of the American Rocket Society* to add up to the publications of rocket research (Fig. 17).

In a sense, it was a conference symbolizing the transition from the old generation to the new generation. In fact, before the official meeting of the second Guggenheim Foundation conference, Qian Xuesen was the representative who thanked von Kármán for his outstanding and groundbreaking contributions to the world of aerodynamics research. At this time, Von Kármán had already returned to Europe to organize a team of scientists for NATO to carry out aeronautical research, and was gradually taking a back seat. It can be said that Qian Xuesen’s work report at this conference means that he had become the academic leader, planning the direction and future of aerodynamics. In this conference, Von Kármán and Qian Xuesen completed the academic “honorary” handover.

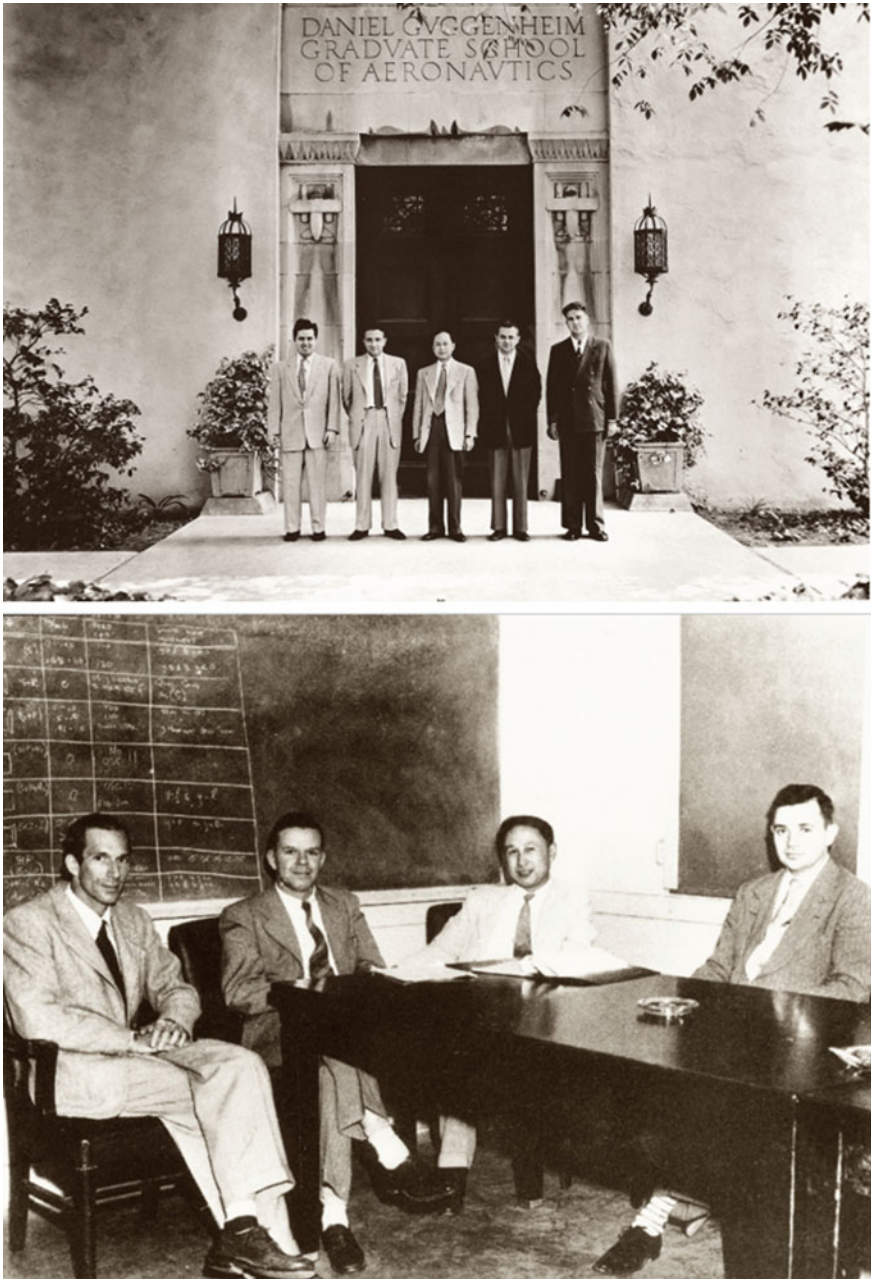


Fig. 17 Qian Xuesen's central position in the photo indicates his important role

References

Young Scholar at Caltech

1. Tu Yuanji, Li Ming, and Gu Jihuan, eds. *Qian Xuesen's Letters (4)*, National Defense Industry Press, 2007, p. 274.

First Chinese Professor at MIT

2. Qian Xuesen, Afterword of *The Collected Works of Guo Yonghuai*, The Collected Works of Guo Yonghuai, Science Press, 1982, p. 331.

A Presentation at the American Rocket Society Conference

3. Henri Poincaré (1854–1912), the French mathematician, physicist and celestial mechanic, founded algebraic topology and wrote *A New Approach to Celestial Mechanics* and *Science and Hypothesis*. Lighthill (1924–1998), founded flight acoustics, nonlinear acoustics and biofluid mechanics. He proposed “Lighthill’s theory” and wrote *Mathematical Biofluid Dynamics*, etc. Kuo is Guo Yonghuai.

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Chapter 5

Marriage and Family Life



1 Jiang Ying's Recital

Jiang Ying, born in an elite family in China, was elegant and intellectual. She had received a good family education since childhood. Influenced by her father, Jiang Baili, a military strategist for the Nationalist government of China, and her Japanese mother, Jiang Zuomei, Jiang Ying developed a personality that was both independent and gentle. She received modern education in Shanghai during her teenage years and developed a strong interest in music. Later on, she studied in Europe, specializing in singing, and became famous for her recitals in Shanghai and Hangzhou upon her return at the end of 1946. With a single performance, Jiang Ying had burst upon the Chinese music scene as a rising star. If she had not met Qian Xuesen, she would not have chosen to give up her booming music career when she was so successful.

Daughter of an elite family

Jiang Ying was born in Beijing on October 1, 1919 (the eighth day of the eighth lunar month) and her ancestral home was in Haining, Zhejiang Province. His father, Jiang Baili (1882–1938), was a famous military theorist and military educator during the period of the Republic of China and served as the president of Baoding Army Academy and the acting president of the Army University. Her mother Jiang Zuomei (1890–1978), was originally from Hokkaido, Japan. She graduated from Tokyo School of Nursing and Obstetrics, and then interned in the Affiliated Hospital of Imperial University of Tokyo for five years. After she married Jiang Baili in 1914, she changed her surname to his husband's, and was renamed Zuomei by her husband.

Jiang Baili and Jiang Zuomei had five daughters in total. Jiang Ying was the third oldest in the family, and her parents nicknamed her *san'er*, meaning the third child, at home. The eldest daughter, Jiang Zhao, died prematurely due to illness. The second daughter, Jiang Yong, studied at the Chinese University of Hong Kong, joined the ambulance corps during the Anti-Japanese War, and later settled in the United States. The fourth daughter, Jiang Hua, graduated from Cornell University with a degree in nutrition and settled in Belgium, where she founded the European

Zhongshan School and made important contributions to overseas Chinese education. The youngest daughter Jiang He had been on trip together with Jiang Ying and their father to Europe and America and she later settled in Beijing after the founding of People's Republic of China.

Qian Junfu and Jiang Baili, fathers of the couple were close friends and the Qian family always wanted to find a playmate for their only son Qian Xuesen, so they begged Jiang Baili for permission to adopt Jiang Ying and to this Jiang Baili gave his blessings. At around three years old, Jiang Ying moved to the Qian family and took on a new name Qian Xueying. Later, missing her daughter so much, Jiang Zuomei took Jiang Ying back.

Jiang Baili was in deep love of his “five golden flowers.” He would never disappoint them with some fruits, Guangdong litchi, Xinhui orange, foreign melon, grapes, and snacks upon returning home from trips. But the eldest daughter Jiang Zhao unfortunately died early in life due to illness, and it was so sad for the Jiang family.

Jiang Ying spent her early childhood in Beijing and later went to live in Shanghai with her parents. When she was in Zhongxi Girls' School, the predecessor of Shanghai No. 3 Women's Middle School, she learned to sing and play the piano. In 1929, when Qian Xuesen was admitted to the Jiaotong University, he often visited Jiang Ying. Jiang Ying later said, “When I was in middle school, Qian Xuesen came to visit me and I introduced him to my classmates as my godbrother. I felt quite embarrassed as I was a big girl by then, and I remembered playing the piano for him. Later he went to the United States, I went to Germany, and we lost contact (Figs. 1, 2 and 3).”



Fig. 1 The “Five Golden Flowers” of Jiang Baili and Jiang Zuomei (right)



Fig. 2 Jiang Ying as a teenager



Fig. 3 In September 1936, Jiang Baili wrote a poem to Jiang Ying as encouragement

Study in Europe

At the end of 1935, Jiang Baili was dispatched to Europe and the United States to investigate military and defense. His two daughters, Jiang Ying and Jiang He, joined the family's three-month grand tour of Europe. Jiang Ying then decided to remain in Germany to attend college and major in vocal music. In 1936, she enrolled in the prestigious von Stonefeld School in Berlin to study German, as well as English, French, Italian and Russian, in order to build up her language skills for her future studies in opera. The day before she enrolled in the school, Jiang Baili took Jiang Ying and Jiang He to the Berlin Zoo and took a picture of them, each holding a lion cub. Jiang Baili inscribed on the photo: "The ambition of the old man was not yet rested; the future would be on the four lions." Likening his daughters to lion cubs showed Jiang Baili's earnest wish for their daughters' promising future. When Jiang Baili went to the United States, he went to California to visit Qian Xuesen and story went that he talked about his daughter with him and also gave Qian a picture of Jiang Ying.

After a year of language study, Jiang Ying entered the German Academy of Music in Berlin in 1937 and formally studied vocal music under the guidance of the distinguished baritone Hermann Weissenborn. Through continuous practice and with her musical talent, Jiang Ying gradually mastered the pronunciation skills such as "cadences", "interruptions" and "through-tones" in opera, as well as how to apply the "soft connection between sound and sound" and "emotional evolution."

It was not easy for a Chinese to sing the opera, known as "the highest skill of world vocal music", which required a deep understanding of European literature and art as well as Greek mythology. The years in Berlin witnessed Jiang Ying's hard work, practicing foreign languages, singing and playing the piano. She also read a large number of European classic literary works. She mingled with the life of local people and cultivated an optimistic attitude towards life through her hobbies such as photography, skiing, mountaineering and swimming.

With her diligence and hard work, Jiang Ying received the school's comment that she was "gifted with exceptional talent, and her voice and expression were both of the highest quality." Just as she threw herself in musical studies, news came that her father died of heart attack while traveling in Yishan, Guangxi Province on November 4, 1938. Though she longed to see his remains, the raging war kept her in Germany. In memory of his smiling voice and happy countenance, she wrote the article "Crying to Death of My Father Jiang Baili" with an extremely sad mood, expressing her endless memory for her father.

During her study at the Berlin Conservatory, Jiang Ying also participated in many singing activities in the German Grand Theater. With her rich vocal skills, she became a contracted singer of the Deloitte Wind recording company. In 1941, Jiang Ying interrupted her studies due to lung disease and spent two years in Germany and Switzerland for recuperation. After recovering in 1943, she resumed her studies under a Hungarian vocalist named Ilona Durigo in a small conservatory in the town of Lausanne, Switzerland. She started to learn German art songs and oratorios under the guidance of Ilona Durigo. In the same year, Jiang Ying was invited to participate

Fig. 4 Jiang Ying in youth

in the European and American Soprano Competition at the Lucerne International Music annual conference in Switzerland, and won the first place in the competition. Jiang Ying was the first Asian female to win the first place since the competition was held (Figs. 4 and 5).

During her study abroad, Jiang Ying often went to sing in church in her spare time to gain stage performance and singing experience. Carl Flesch (1873–1944), a famous modern Hungarian violin pedagogue, happened to hear Jiang Ying singing when he visited the church. After listening to Jiang Ying's singing, he lauded Jiang Ying with amazement as “the queen of singing with great promise.” This was because Jiang Ying's singing combined the essence of both religious culture and philosophical thought, and it was difficult for ordinary singers to grasp the true essence.

In 1946, through ten years of hard work, Jiang Ying mastered the theoretical knowledge and practical skills of opera systematically, and was successful in her studies. In the same year, her sister Jiang Hua, who had studied at Cornell University in the United States and obtained a master's degree in nutrition, also decided to return to China, so they agreed to meet in Paris, France, and return to China on the French steamship *General Joffre*. The steamship arrived in Shanghai. Her mother, Jiang Zuomei, waited for a long time at the pier and was so excited to see her daughters who had studied abroad for many years.



Fig. 5 Jiang Ying makes records for Deloitte Wind recording company

A rising star in the Chinese music scene

Jiang Ying quickly attracted the attention of local press, which reported “the lyric soprano returning home.” A report in Shanghai Newspaper *Shen Bao* wrote on January 29, 1947:

Ms. Jiang Ying, daughter of Jiang Baili, has been studying music in Germany and Switzerland for ten years. Recently returned to China, she is employed as a professor by the National Conservatory of Music. Ms. Jiang plans to give concerts in Beijing and Shanghai in the near future.

It was not sure whether National Conservatory of Music offered her employment or not, but Jiang Ying received invitation as a vocal music instructor by the Shanghai Zhengsheng Choir. Jiang’s return also attracted the attention of Shanghai’s cultural and educational circles. On May 16, 1947, Gu Yuxiu, director of Shanghai Municipal Bureau of Education, organized and hosted a banquet specifically to welcome Jiang Ying’s return to China. At the welcome party, Jiang Ying sang solo arias from the opera *Carmen* and Schubert’s *Song of Eternal Life*, with a clear tone and rich expression, showing superb cultivation and attainment.

Jiang decided to start her musical career afresh in Shanghai, and debuted with a recital in the Lanxin Theatre in May. The recited was reported in *Shen Bao* Newspaper:

Ms. Jiang Ying’s recital is scheduled to be held in Lanxin Theatre on the 31st of this month. It is her first concert upon her return to China. The concert program includes songs and

opera by famous artists from Germany, Italy and France, with professor Maglins at National Shanghai Music Academy as accompaniment. We expect that this recital will introduce an outstanding soprano to the Shanghai music scene, and her voice will certainly attract a wide audience.

As the final days of the recital approached, Jiang Ying was slightly nervous. She kept practicing works by Wolfgang Amadeus Mozart, Georges Bizet, Giacomo Puccini and others over and over again, and carefully designed a whole set of coherent stage performance movements, including singing postures and emotional expressions. On May 30, *Shen Bao* Newspaper announced that, "Soprano Jiang Ying was scheduled to give a recital at 5:30 p.m. tomorrow at the Lanxin Grand Theatre (Figs. 6, 7 and 8)."

On May 31 at 5:30 p.m., Jiang Ying's recital was held at the Shanghai Lanxin Grand Theatre. The concert lasted for more than three hours and Jiang Ying sang sixteen songs, including European arias and modern love songs, as well as two popular Chinese ballads. At the end of the concert, the Chinese and foreign audience stood up and gave Jiang Ying a standing ovation. The concert also featured two special guests: her mother Jiang Zuomei and her sister Jiang Hua. The concert was a great success and critics lauded her as one of the best sopranos in the country.

On June 15, the 24th graduation ceremony of the Jianqiao Air Force School in Hangzhou was presided over by General Zhou Zhirou, the Commander-in-Chief of the Air Force, and Hu Weike, the Director of Education of the Air Force School, sent a plane to Shanghai to meet Jiang Ying for the occasion. At 8:00 p.m., after

Fig. 6 A photo of Jiang Ying with her mother and sisters after she returned to China





Fig. 7 Poster for Jiang Ying's Recital

the graduation ceremony, a solo concert was held in which Jiang Ying sang seven songs and Zhou Guangren was invited to accompany her on the piano. Jiang Ying's singing received a lot of applause. Her singing was characterized with a melodious voice, which embodied the upward attitude of life and the spirit of struggle, and was therefore described as "an ode to the addition of a new force to the air force of the motherland." Later, on June 30, Jiang Ying sang again at the graduation ceremony of Daxia University (the predecessor of East China Normal University).

With a single performance, Jiang Ying had burst upon the Chinese music scene as a rising star. Nevertheless, her performance also triggered a debate on the necessities of introducing foreign music. This was because European opera, like Chinese Peking opera, was a reflection of the history and culture of the country in which it was performed, and was a reflection of a certain social economy. Jiang Ying sang arias from operas such as "The Marriage of Figaro", "Carmen", and "The Troubadour", which required of the audiences a certain level of literary knowledge to understand the meaning and feelings, and was "not as easy as listening to anti-war songs or dance music." However, opera, as an art form, transcended national boundaries. During her stay in Europe, Jiang Ying also paid special attention in introducing opera singing skills into Chinese folk songs, and promoted the integration and development of Chinese and western music. From this perspective, the importance of Jiang Ying's recital in 1947 in modern Chinese music history was comparable to Qian Xuesen's lectures on the dissemination of technical and scientific ideas in 1947 in the history of modern Chinese science and technology.



Fig. 8 Jiang Ying sings at the graduation ceremony of Jianqiao Air Force School in Hangzhou on June 15, 1947

2 Wedding Bill

The wedding ceremony of Qian Xuesen and Jiang Ying was held on September 17, 1947, in Shanghai. The wedding was a simple one, judging from the expenses on the wedding bill. They did not have a real romantic relationship and went straight into married life at thirty-six and twenty-eight years old respectively, but this did not affect their happy life after marriage. The Chinese traditional concept of “getting married first and then falling in love”, to some extent, made them cherish each other even more in a foreign country.

Return to China

On July 1, 1947, Qian Xuesen returned to China by flight and was greeted by Fan Xuji at Shanghai Longhua Airport. Fan was in preparation of establishing the Department of Aeronautics at Zhejiang University. When he learned that Qian Xuesen’s return, he borrowed a car from the school and drove to the airport to pick him up him. After receiving Qian Xuesen, Fan drove around the Bund and then sent him to rejoin his father, who lived in Qishan Village, Yuyuan Road. On July 13, the father and son journeyed to Hangzhou by train. The first thing the father and the son did was to sweep the tomb of the beloved wife and mother Zhang Lanjuan. Qian Xuesen also

went to visit his childhood calligraphy teacher Sun Jincai, who was so happy to meet his student. The father and son lived in Hangzhou for more than half a month. During this period, Qian was invited by Zhu Kezhen to give a lecture at Zhejiang University.

After returning to Shanghai from Hangzhou, Qian Xuesen received a telegram from Hu Shih, president of Peking University, on August 19, inviting him to come north so that he could “seek his advice on the development of Institute of Technology.” Qian Xuesen had a deep affection for Beiping (Beiping was changed to Beijing in 1949), where he lived for fifteen years from 1914 to 1929 with his father, who then worked for the Ministry of Education. After arriving in Beiping, Qian Xuesen made a special trip to visit Qian Weichang, who was teaching at Tsinghua University. He also visited his teachers and friends Ye Qisun, Rao Yutai, Luo Peilin, Jiang Ancai, Zhao Guangzeng, Hu Maoyuan and others. They visited the Temple of Heaven, the Summer Palace and other famous historic sites.

On September 1, Qian Xuesen flew back to Shanghai, and on September 27, he returned to the United States by plane. It was during this time that Qian Xuesen proposed to Jiang Ying and then they held a simple wedding ceremony in Shanghai.

A precious wedding bill

On September 30, 1947, in the bedroom on the first floor of the villa at No. 111, Qishan Village, Lane 1032, Yuyuan Road, Shanghai, Qian Junfu took out his account book, brush and ink as usual to record his income and expense for the month. In addition to daily expenses such as rent, rice, salt, soy sauce, sugar and so on, there was an additional expense for the wedding of Qian Xuesen and Jiang Ying. He wrote in his account book:

Wedding envelopes and car expenses at 831,000 *yuan*; gifts for the couple, a pair of seals at 390,000 *yuan*; marriage certificate at 338,000 *yuan*; wedding banquets of four tables at 3,658,000 *yuan*; Shanghai and Hangzhou round-trip bus fare at 619,000 *yuan*; incense, candles and wine at 47,000 *yuan*; candy, towel, cigarette and milk powder at 315,000 *yuan*; bridal gift box and wedding gifts for guests at 310,000 *yuan*.

The “marriage certificate” mentioned in the account book was also called “mandarin duck album” of Qian Xuesen and Jiang Ying. It consisted of the cover, the body and the back cover. The cover and the back cover were made of silk and satin, while the inside page was made of rice paper. In the inside pages, there were a paragraph of text written by Qian Xuesen’s calligraphy teacher, Sun Jincai and two illustrations, drawn by Chen Handi and Wu Shanyin respectively. One illustration was entitled *Xia Qing Tu*, or “Picture of Summer Clear”, symbolizing Qian Xuesen’s gentleman demeanor with bamboo; the other was a picture of colorful Phoenix and Xia crown, symbolizing Jiang Ying’s nobility and elegance with peony.

Chen Handi and Wu Shanyin were a couple and famous painters in the Republic of China. Chen Handi was the teacher of Qian Junfu and Jiang Baili at Qiushi Academy, so Qian Junfu specially sought the highly respected elder to match the lovebirds of Qian Xuesen and Jiang Ying (Figs. 9 and 10).

After Qian Junfu finished his accounts, he put aside his pen and could not help but think of the situation two months ago when his son returned to China. For Qian

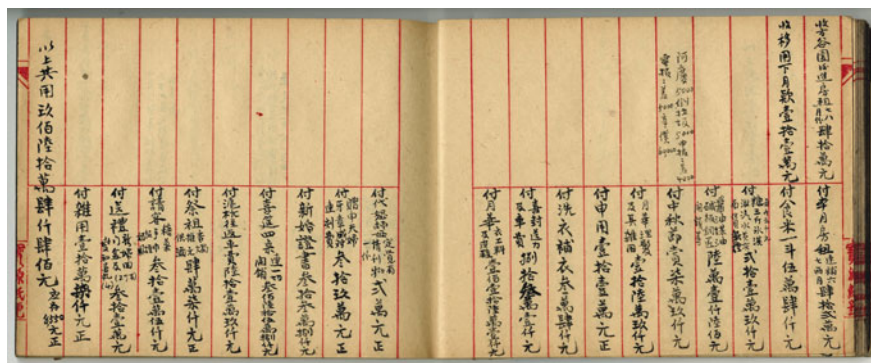


Fig. 9 The wedding bill of Qian Xuesen and Jiang Ying's marriage

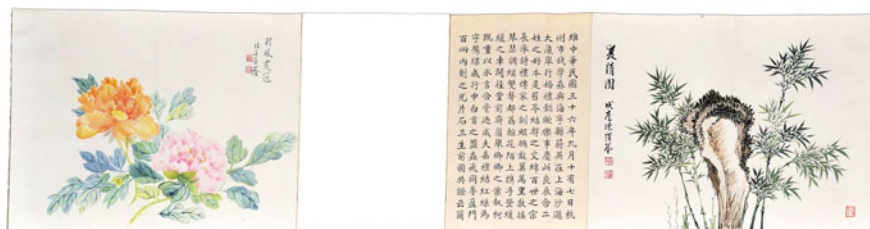


Fig. 10 The mandarin duck album of Qian Xuesen and Jiang Ying, originally consisted of six folded pages

Junfu, the marriage was his biggest wish, and the scene of the wedding at Sassoon Mansion in Shanghai on September 17 was still vivid in his mind. At this time, Qian Xuesen had returned to the United States, and his daughter-in-law Jiang Ying was applying for a visa, and expecting to reunite with Qian Xuesen at the end of the year.

A simple wedding

For Qian Xuesen, marrying Jiang Ying was undoubtedly the happiest thing and the marriage was the earnest wish of his father. Interestingly, Qian Junfu once asked Jiang Ying to help introduce a girlfriend to his son. Jiang Ying held a welcome party for Qian Xuesen and invited several female friends. Qian looked absent-minded at the party as “he was completely attracted by Jiang Ying at the party and didn’t pay attention to others at all”, mentioned Jiang Hua. In the next few days, Qian went to Jiang’s house and asked Jiang Ying to marry him. Jiang Ying declined him at first as she worried about the differences in professions between the two and also was reluctant to be separated from her family.

Seeing that his sister Jiang Ying was still worried, Jiang Hua invited Qian Xuesen to their home for several days so that the two could know more about each other. One day, Qian Xuesen suddenly asked Jiang Ying, “Come to America with me!” Qian made a second attempt several days later. Jiang Ying recognized his earnestness in

this matter and finally accepted his proposal. She said humorously years later: “I surrendered without saying much.”

The two families started to get busy for the wedding. Qian Xuesen, accompanied by his father, made a special trip back to Hangzhou to sweep the tomb of his mother, Zhang Lanjuan, and to console his mother’s spirit in heaven with the wedding news. Afterwards, the couple went to take wedding photos in Shanghai Guangyi photo studio on Nanjing Road. The owner of the studio, Zhang Danzi, received them warmly and took pictures of the couple personally and he also acted as the photographer at the wedding. Qian Junfu booked the Beijing restaurant in Chinachem hotel in Sassoon building, which was called “the first grand building in the Far East”, as the venue for the wedding.

On September 17, 1947, the wedding was held. The wedding ceremony adopted a combination of Chinese and Western etiquette, simple but grand. The wedding was attended mainly by relatives and friends from the two families, with more than 100 people sitting at four tables. The witness of the wedding was Yu Bin [1], Archbishop of the Catholic Archdiocese of Nanjing, as the bride’s mother Jiang Zuomei was a Catholic. At the wedding, Yu Bin blessed the couple with the four words of “truth, goodness, beauty and purity”. According to the convention, every relative and friend should sign on the blank page in the mandarin duck album when they arrived at the wedding site. The signed page was torn off by Jiang Ying reluctantly during “Cultural Revolution”. Qian Yonggang once said (Figs. 11, 12 and 13):

The mandarin duck album was the witness of my parents’ marriage. The original one had six pages, but now it had only five. My mother tore one page off during the “Cultural Revolution.” Although Premier Zhou (Zhou Enlai) had my family protected, my mother was still very cautious and tore the page off, on which many celebrities in the Republic of China left their signatures. My mother must be very reluctant in doing this, but it was precisely such a move that the mandarin duck album could be preserved.

After Qian Xuesen returned to the United States, he bought a Steinway grand piano as a wedding gift for Jiang Ying, who gave up her music career and became a full-time wife to support her husband’s research and teaching work. The birth of their son Qian Yonggang in 1948 and Qian Yongzhen in 1950 brought infinite joy to the family.

3 Wedded Life

Qian Xuesen and Jiang Ying had lived in the United States for eight years, in Boston for the first two years and in Los Angeles for the next six years, from their marriage in 1947–1955, when they returned to China. During this period, they had a son and a daughter. Qian Xuesen not only wore the different hats of scientist, teacher, and administrator, but also was the pillar of the family while Jiang Ying chose to give up her music career on her own initiative in order to better perform her domestic duties. Their family life was the marriage style of “breadwinning men and homemaking women”.



Fig. 11 Qian Xuesen and Jiang Ying's wedding photo taken in Shanghai Guang Yi Photo Studio

The newly-wedded couple in Boston

In November 1947, Jiang Ying applied for a visa to the United States at the U.S. Consulate General in Shanghai and joined her husband at the end of the year. Going to America must have been a bittersweet choice for her. She gave up her favorite music career and became a full-time housewife so that Qian Xuesen could devote himself to research and teaching. Their marriage life was serene and happy. They respected and cared for each other. Qian fully supported Jiang Ying's interests and hobbies. Every week, they frequented to Boston Symphony Orchestra to enjoy the symphonies, concerts and operas. The two of them were in the honeymoon and closely bound together (Figs. 14 and 15).

On October 13, 1948, their son was born. Qian Xuesen named the baby boy Yonggang, with “yong” the Chinese character in the family line and “gang” meaning strong and firm. Qian immediately informed his father of the birth. Qian Junfu was very happy and had “good luck red eggs” distributed to his relatives and friends in China. He wrote in his account book: “Yonggang, my eldest grandson was born



Fig. 12 Qian Xuesen and Jiang Ying receiving blessings from friends and relatives

on October 13 at nine o'clock in the city of Boston, United States." At this stage, Qian Xuesen had a successful career, was a new father and had a happy family. It was not until the summer of 1949 that Qian Xuesen accepted the Robert Goddard position at Caltech, and served as the director of the newly established Guggenheim Jet Propulsion Center and returned to live in Los Angeles again.

In the first half of 1949, Qian Xuesen had already started preparing for his next semester at Caltech. Since his marriage, Qian had not taken Jiang Ying out on a proper trip, so he took her on a 10 day trip to Canada from June 6 to 16 to make up for their honeymoon. In July 1949, Qian and Jiang drove from Boston to Los Angeles with their infant son, Qian Yonggang. On the way, they also made a special trip to Cornell University, where they met briefly with Guo Yonghuai and W. R. Sears. Just before Qian Xuesen left for Los Angeles, he was elected as a member of the American Academy of Arts and Sciences in Boston on May 12, 1949, because of his outstanding scientific achievements (Fig. 16).

Life at Los Angeles

Pasadena in Los Angeles was a familiar city to Qian Xuesen, where he had studied and lived for ten years and had a lot of fond memories. Now he took Jiang Ying and his son Yonggang to live in Los Angeles, a revisit to the old place. As a scholar



Fig. 13 The bride and groom toasting to friends and relatives

with high reputation, Caltech offered him an annual salary of \$10,000, a teaching assistant and three scholarships per year, as well as a seven-year research fund totaling \$500,000. Upon his return to Pasadena, Qian Xuesen rented a cottage with a garden in the Oaknoll community. Qian later recalled: “The three of us, Ying Jiang, I and our child, arrived at Caltech in the fall of 1949, and I lived the life of a typical professor, teaching and researching in addition to being a consultant for General Jet.” Shortly after arriving at Caltech, Qian and Jiang attended the 1949 Mid-Autumn Festival celebration of the founding of the People’s Republic of China held by the Caltech Reunion at Tournament Park (Fig. 17).

It was widely known that Qian Xuesen had been confined in the United States from 1950 to 1955, during which he had been denied of security clearance to classified documents and military projects. Despite anger, confuse and fear, Qian Xuesen remained optimistic. His daily life was regular and he spent more time with his family. After breakfast, he drove the two children to the kindergarten, and then went to school to work. After work, he picked up the children home. Jiang Ying was busy with housework and would practice music in her spare time and read British and American literary works. Dinner was usually cooked by Jiang Ying, and Qian occasionally cooked. Family became the focus of Qian Xuesen’s life. They bought a lot of children’s music records, story books and all kinds of toys for their two children, and often took them to the park. Qian narrated later on: “During the five years from

Fig. 14 Qian Xuesen and his son Qian Yonggang



1950 to 1955, when I was suspected and investigated by the U.S. government, Jiang Ying had made great sacrifices for the family which I must not forget.” After they returned to China, Jiang Ying took care of the family, Qian Xuesen’s father and her mother. Jiang Ying was a much praised daughter-in-law as Qian Junfun mentioned in his later years. Zheng Zhemin, a doctorate supervised by Qian Xuesen, mentioned that he always went to his house and was invited having meals with them, and he often took the two kids to climb hills nearby.

Qian Xuesen’s personal freedom was largely limited during the five years due to U.S. government’s surveillance. He was unable to communicate directly with his father. Jiang Ying would write, receive and send the letters. Qian reduced interpersonal and social activities in order to avoid implicating others. He stopped attending the activities of the North American branch of the Chinese Association of Scientists, considering that “his actions were monitored by American spies and it was inconvenient for these kinds of activities.” When he was able to leave America for China, he received a farewell call from Yuan Jialiu and Wu Jianxiong and he just said to them “you are American citizens, I won’t talk to you.”

Fig. 15 Jiang Ying and his son Qian Yonggang



Music was dear companion to Qian Xuesen in cheering him up. In her later years, Jiang Ying said: “When I sung, he was alongside me. Music freed us from loneliness.” Qian would regularly listen to the symphonies of Béla Bartók and Ludwig van Beethoven. “It was the persistent strength in Bartok’s music that Qian Xuesen liked”, Luo Peilin explained, “This may be his emotional connection with Bartok as a lonely scientist from China (Figs. 18, 19 and 20).”

4 Income and Expenditure

Qian Xuesen was born into a privileged family and lived in Beijing as a teenager, receiving the best education. Although he was in financial distress due to family reasons, he was fortunate to be admitted to Tsinghua University as a Boxer Scholarship student so that he was able to complete his master’s and doctoral studies in



Fig. 16 This back photo is a snapshot of Qian Xuesen and Guo Yonghuai's thirty-year friendship (taken by Jiang Ying, from left, Qian Xuesen, Li Pei, Guo Yonghuai)

the United States. After Qian Xuesen was employed at MIT and Caltech, his financial situation was improved. However, what he pursued was not a wealthy life but scholarly contribution and spiritual freedom.

Scholarship

Qian Xuesen's father, Qian Junfu, served as a minor official in the Ministry of Education and the acting director of the Department of Education of Zhejiang Province. His mother was from a family of silk merchants whose members had obtained powerful political posts in Shanghai and Hangzhou. When Qian Junfu first came to Beijing in 1914, he had a monthly salary of 280 *yuan*. In 1920 and 1921, due to awards for his excellent work, his monthly salary was increased to 300 *yuan* and had "annual merit reward" of 500 *yuan* per year. Moreover, he would also receive a travel subsidy of 200 *yuan* per month for his inspection trips outside Beijing [2]. Qian Xuesen had lived a happy life in Beijing, taken good care of by a maid and went to school and back home by a chartered rickshaw. The family's economy went down partly because Qian Xuesen's mother was ill at the end of 1934. Medical expenses and funeral expenses were expensive, resulting in family distress. This could be also seen from Qian Xuesen's letter to the president's office of Tsinghua University on June 3, 1935 in which he wrote: "The accounting office of the University had not issued the travel expenses. Xuesen was really unable to make long-term advances. I sincerely request the accounting office to send me the travel allowance and the living expenses in June [3]."



Fig. 17 Qian Xuesen “walking his son” (Photo by Jiang Ying)

At the time when Qian Xuesen went to the United States, his family was in financial difficulties. His father’s good friend, Zhu Mouxian once provided them with financial assistance, which Qian Xuesen cherished a deep gratefulness. During the World War II, He remitted a sum of money to Zhu Weiheng, son of Zhou Mouxian, who then studied in the United States [4]. Qian Xuesen quickly adapted himself to live an independent life while studying in the United States. He washed clothes, cleaned the rented apartment and so on, by himself.

Tsinghua University had a strict management system for the scholarship provided for students studying in the U.S. Before 1933, the Office of the Supervisor of Students in the U.S., located in Washington, D.C., was responsible for the distribution of scholarship. In 1933, Tsinghua University entrusted the affairs to the China Institute in America. Qian Xuesen received a monthly allowance of \$100 for his living expenses [5], slightly higher than the government’s subsidy of \$1,080 per year for



Fig. 18 Qian Xuesen and his daughter Qian Yongzhen (Photo by Jiang Ying)

students studying in the United States in the same period [6]. Ma Zusheng, a graduate majored in chemistry in Tsinghua University in 1934 and studying for a doctorate at the University of Chicago said:

Most of the state-funded students administered through Tsinghua University entered famous universities in the United States. In addition to good learning conditions, such as experimental equipment, library learning resources and so on, these universities were open-minded, well managed and had strong teaching staff. Students have opportunities to be taught by Nobel laureates. Of course, the tuitions were also high, but for these students with scholarship from Tsinghua University there was no problem at all. Before going abroad, they received traveling and dress subsidies and monthly allowance, and while in U.S., there were no restrictions on tuition and medical expenses. In addition, their dissertation printing fees, diploma fees and travel expenses were also covered [7].

As mentioned earlier, Qian Xuesen had extended his study time for twice, and he received a scholarship totaling \$4,800. It was this large sum of money that supported his life and study in the United States, enabling him to complete his doctoral studies.

Financial independence

In September 1939, Qian Xuesen served as an assistant researcher in the Department of Aeronautics at Caltech, with an annual salary of \$2,000 [8], or \$200 for each month as salary was distributed for ten month in American universities at that time,

Fig. 19 Jiang Ying and her daughter Qian Yongzhen (photo by Qian Xuesen)



which was the average salary level of new employees at Caltech. In 1950, when Luo Peilin was an assistant professor upon graduation from the Department of Electrical Engineering at Caltech, his annual salary and bonus were a bit over \$2,000 [9]. Two hundred dollars was equal to about 760 *yuan* according to the exchange rate at that time. Compared with universities in China at the same period, Qian's salary was much higher than that of professors in Chinese universities such as Tsinghua University and Peking University in the same period, which was 300 *yuan* per month [10].

In September 1943, Qian Xuesen was appointed as an assistant professor in the Department of Aeronautics, and in November 1945, he was promoted to be an associate professor. In August 1946, he went to the Department of Aeronautics of the MIT as an associate professor, and was promoted to full professorship in March of the following year. The diary of Zhu Kezhen, president of Zhejiang University provides valuable historical information about Qian Xuesen's salary. On February 27, 1947, during his visit to the United States, Zhu Kezhen talked with Dai Zhenduo, a doctoral student of Harvard University on the five Chinese outstanding scholars majored in engineering in MIT. Zhu wrote in his diary:



Fig. 20 A photo of Qian Yonggang and Qian Yongzhen (photo by Qian Xuesen)

Qian Xuesen, graduate of Jiaotong University, majored in hydrodynamics fluid mechanics; Gu Peimu, graduate of Jiaotong University, majored in Airplane engine; Lin Jiaqiao, graduate of Tsinghua University, majored in aerodynamics; Liu Yijin, majored in mechanical engineering; Zhu Lancheng, majored in radar. Qian, Lin and Zhu are associate professors with an annual income of \$7,000, and Gu and Liu are assistant professors with an annual income of \$5,000 [11].

In the letter from the president's office of MIT, kept in the Qian Xuesen Library at Jiaotong University, Qian Xuesen was informed that his annual professorial salary was increased to \$9,000 as of July 1948 [12]. In 1949, Qian Xuesen returned to Caltech as director of Guggenheim Jet Propulsion Center, with an annual salary of \$10,000. Based on the above archival records, it was estimated that Qian Xuesen's annual salary at each title stage was \$2,000 as assistant researcher, \$5,000 as assistant professor, \$7,000 as associate professor, \$9,000 as professor at MIT, and \$10,000 as professor at Caltech. According to the above data, Qian Xuesen's total salary during his teaching period in the United States from 1939 to 1955 exceeded \$100,000.

Salary was not the only source of income. Qian Xuesen published more than fifty academic papers while he was in the United States, and his manuscript fees were also a significant source of income. For example, the manuscript fee for The Poincaré–Lighthill–Kuo Method, published in *Advances in Applied Mechanics*, was \$112 [13]. If this was the standard calculation, Qian Xuesen's income from manuscript fees alone during his stay in the United States would be US \$5,000–6,000. In addition, the English edition of his academic book, *Engineering Cybernetics*, was printed twice in 1954 and 1955, and sold 3,080 copies worldwide, earning \$2,333.65 in royalties. Furthermore, he held a number of positions, such as a member of the Scientific Advisory Group of the Army Air Corps of the U.S. Department of Defense, an expert advisor to the Bureau of Military Affairs of the U.S. Department of War, and a member of the U.S. National Advisory Committee on Aeronautics and so on. It was unknown whether these positions were paid and the amount of remuneration. Nevertheless, the stable source of income was mainly his salary.

In short, Qian Xuesen was financially independent since his teaching career started, and his salary was higher than that of his contemporaries in American and Chinese universities. A side-by-side comparison can be made with Hu Shih, whose monthly salary as ambassador to the United States at that time was US \$540 (US \$6,480 per year), nearly one-third less than that of Qian Xuesen. Qian Xuesen was not in pursuit of an affluent life after he was financial better off; instead, he was trying to find the direction of spiritual freedom.

Categories of expenditure

On September 16, 1955, Qian Xuesen went to the First National Bank of Los Angeles and withdrew his entire demand deposit of \$1,007.64 [14]. In the following day, he and his family returned home on the steamship *President Cleveland*. It was puzzling why Qian returned home with a deposit of a bit over \$1,000, considering that his total income in U.S. was over \$100,000.

A glance at the expenditures at different stages during his 20-years stay in the United States could shed us some light. The living expenses altered in different periods and covered different areas, which can be summarized into the following three categories.

1. Daily living expenses as a student

As mentioned earlier, as a student with scholarship from Tsinghua University, Qian Xuesen received \$520 for traveling abroad and \$100 for living expenses from the

Chinese American Association for the advancement of life per month. Pu Xuefeng, also a student with scholarship from Tsinghua University, recalled: “When I first arrived in the United States, I had all the coats, suits, shirts, shoes and so on. Although the monthly fee was only eighty dollars, it was enough to cover the living expenses. Later, the monthly fee was increased from eighty to one hundred dollars so that we could pay coats, raincoats, suits, leather gloves, leather shoes and books and other items [15].”

If one studied in a big city in the United States, such as New York, Philadelphia, Chicago, Boston, San Francisco, or Oakland, the minimum amount for food, lodging, and incidental expenses was \$65 a month, to be specific, \$40 a month for food, \$20 for lodging, and \$5 for pocket money. Sixty-five dollars was quite a miserable living while eighty to one hundred dollars was the cost of living for the average Chinese student [16]. It can be seen that the financial support from Tsinghua University could guarantee basic living needs, but it was not generous. Qian Xuesen’s tuition fee was sent directly to the school by the Chinese American Association, so his daily living expenses were mainly rent and food expenses [17]. Qian had lived in dormitory at MIT and then shared with the apartment with Fan Xuji and Yuan Jialiu. As Yin Hongzhang, who studied at the Caltech for a doctorate in biology recalled: “As Caltech was a private school, tuition fee was especially high. There were few students, only two or three hundred at that time, and most of them were the children from wealthy families. For us students with scholarship, we could make the ends meet while other graduate students had to take part-time job. Dormitories were also very expensive, so most students chose to live outside campus [18].”

Three meals a day was a considerable expense. As students with scholarship were not permitted to work part-time, they must make full use of \$100 per month. Therefore, Qian Xuesen often cooked or packed meals with his classmates to reduce expenses. It was about \$1.3–1.5 per day with three meals at school, and \$28–\$30 per month. Therefore, accommodation remained the largest part of expenditure, accounting for two-thirds of the daily expenses.

2. Remittance to his father

Qian Xuesen was very frugal as a single person, and even though he had a generous annual salary since he worked, his daily expenses were still kept to a minimum. His income he saved was used for other purposes, the most important of which was to remit to his father Qian Junfu in China. When Zhang Lanjuan passed away in 1934, Qian Junfu became depressed and suffered from severe stomach problems, so he resigned from his post at the Department of Education of Zhejiang Province and recuperated at home in Hangzhou. After the Lugouqiao Incident in 1937, the Japanese bombed Hangzhou in 1937. Qian Junfu went to Shanghai to escape the chaos and lived in No. 111, Qishan Village, Lane 1032, Yuyuan Road. Qian Junfu had lived there for nearly twenty years until 1955, when Qian Xuesen returned to China and moved to Beijing.

Little known was that Qian Junfu recorded in his account book in detail the amount of 111 remittances made by Qian Xuesen from 1938 to 1951. According to the chronological order, the remittances include: (1) 8,743.00 in paper currency

from 1938 to 1942 (paper currency issued by the KMT government from 1935 to 1948); (2) 6,310,000.00 in reserve certificates from 1943 to 1946; (3) 230,000.00 in paper currency in 1946; and (4) 5,327.00 in US dollars from 1945 to 1951. From the account book, it can be seen that Qian Junfu received the first remittance of paper currency 101.00 in December 1938 when Qian Xuesen was still studying for a doctoral degree; therefore, it can be inferred that he must have saved it from the Tsinghua University scholarship.

Qian Xuesen's remittances supported his father's living in Shanghai. Even when Shanghai was occupied by the Japanese, he did not stop the remittance, as Li Linxiang, a student of Qian Junfu, recalled: "At that time, Since Shanghai was occupied by Japan, and Mr. Qian refused to work under the government of Japanese occupation, his living was mainly maintained by Qian Xuesen remitting money from the United States." When Qian Xuesen was in U.S. government surveillance in 1950, his personal freedom was restricted and he could not send money to his father, but whenever he heard that someone would return to China, he would entrust him to bring some dollars to his father. For example, when Luo Shijun, a doctoral student supervised by Qian Xuesen, returned to China in 1951, Qian Xuesen entrusted him to bring 300 dollars in cash to his father.

The remittance recorded in Qian Junfu's account book [19] was a true record of Qian Xuesen's filial piety as a son to his father. It was not only about the living expenses, but also showed Qian Xuesen's deep love for his father. Whenever Qian Junfu received the money, he must feel his son's filial piety. During his stay in the United States, it was through this form of communication that the father and the son showed their concerns for each other. It was a true revelation of the mutual care and love between the father and the son.

3. Living expenses after establishing a family

After Qian Xuesen and Jiang Ying got married in 1947, their living expenses increased significantly. These family living expenses mainly included rent, daily meals, clothes, baby items, toys, and a large number of records and books on fetal education and early education. In addition, there was also a daily expense, the professional journals and books bought at his own expense.

It had to be mentioned that Qian Xuesen paid high attorney fees for hiring lawyers to fight lawsuits in the last five years in the United States. For example, when Qian Xuesen hired a lawyer for the first time, the cost was as high as \$2,500. It should also be noted that the \$15,000 bail money paid by Qian Xuesen after his detention in 1950 was advanced by his friend Pauline Riedberg Milles in the form of a purchase of U.S. bonds. Qian Xuesen later said: "The bail was \$15,000 and I could really be 'proud' of, compared to the usual ransom of one or two thousand demanded by robbers for kidnapping. Naturally I could not get such a large sum of money, and the bail was paid by the American friend on my behalf [20]."

Qian Xuesen's bankbook only had five cash deposits from 1949 to 1950, except for \$660.56 when it was processed: \$2.00 on July 21, 1949, \$118.55 on January 12, 1950, \$76.12 on March 12, 1950, \$51.86 on August 10, 1950 and \$48.92 on December 18, 1950. Strangely enough, Qian Xuesen took out \$900.00 on October



Fig. 21 Qian Xuesen's kitchen at his home in Pasadena, Los Angeles

13, 1950, yet deposited it back on October 24. It was unknown whether it was because he intended to hire a lawyer when he was preparing to return to China. It was worth noting that Qian Xuesen did not deposit any money after 1951, perhaps because of the balanced daily income and expenditure, or because he was preparing for leaving the United States at any time (Figs. 21 and 22).

In fact, when the United States lifted the restrictions on Qian Xuesen's departure, he could have chosen to stay in the United States and live an affluent life with a good annual salary, but he resolutely chose to return to China. From this point of view, Qian Xuesen did not go to the United States to pursue an affluent life. If he had aimed to stay in the United States, he could have made long-term plans for his family. He said in later years:

In all my time in the United States, I have never thought of staying there for the rest of my life, and I say that with good reason. Because in the United States, once a person joins the workforce, he or she always deposits a portion of his or her income into an insurance company for later retirement. During my stay in the U.S., I was asked several times if I had saved any insurance money, and they were surprised when I said I didn't save a single dollar. In fact, it's no surprise, because I'm Chinese and I don't plan to live in the US for the rest of my life [21].

When he was interviewed by the *Los Angeles Times* before leaving the United States on September 17, 1955, he said with confidence and pride:

When I return to China, I will do my best to help the Chinese people build a nation where they will get along with dignity and happiness.



Fig. 22 Qian Xuesen's current account passbook

References

Wedded Life

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Chapter 6

Communism Enlightenment and Dedication to His Country



1 A Chinese Painting “A Corner of the Westlake”

In his later years, Qian Xuesen had two framed items hanging in his bedroom: one was the portrait of his father, Qian Junfu, and the other was a traditional Chinese painting, entitled “A Corner of the West Lake”, depicting his hometown scenery of the West Lake in Hangzhou. The painter was Jiang Danshu, a close friend of Qian Junfu. Jiang Danshu painted it in early spring of 1941 and sent it to Qian Xuesen, then far away in the United States. When Qian Xuesen returned to China in 1955, he brought the painting back. “Returning in another day” was an inscription on the painting, which also revealed the Qian Xuesen’s original ideal in his pursuit of knowledge during his overseas years. This traditional Chinese painting was regarded as his lifelong treasure and was indeed of special significance to him.

The painter

“A Corner of the Westlake” was painted by Jiang Danshu, alias Jing Lu. Born in Liyang, Jiangsu Province in 1885, Jiang graduated from Nanjing Liangjiang Superior Teacher’s Training College in 1907, majored in painting and handicraft. He had traveled to Japan and North Korea. In 1911, he taught at Zhejiang Two Level Normal School as a teacher of drawing and handicraft, and he also taught art courses at Zhejiang Women’s Normal School and Zhejiang No. 1 High School. In 1924, he taught basic art courses at Shanghai Art College and at Hangzhou National Art College. He commuted between the Shanghai and Hangzhou, staying in each city for three or four days respectively in a week.

When Jiang was teaching in Zhejiang Two Level Normal School, he befriended with Qian Junfu, who was teaching at the same school. The Qian family had lived at No. 28, Fengqiqiao River Road in Hangzhou, next to Jiang’s family. Jiang Shukai, the son of Jiang Danshu, once recalled:

Aunt Qian (Qian Xuesen’s mother) was kind and well educated, and a lady of the house. There were various trees and flowers in my garden and a lush bamboo forest. We invited aunt Qian to dig some bamboo shoots every spring. My youngest sister, Qiao Chun, was

only six or seven years old, the most adorable one of my five sisters. Aunt Qian liked her very much and recognized her as her goddaughter. Unfortunately, aunt Qian died of typhoid fever in 1934.

After Qian Junfu took the position of inspector in the Ministry of Education in Beijing, he still kept correspondence with Jiang Danshu. In 1917, Qian Junfu assisted in the publication of Jiang Danshu's book *History of Art* to be approved by the Ministry of Education, which was designated as textbook for five-year teacher training schools. This textbook *History of Art* was the pioneering work in the study of modern art history in China, which included a wide range of topics such as architecture, sculpture, printing, calligraphy and arts and crafts, and history of Western art and the art of India and the East. Jiang Danshu had successively compiled *Reference Book on Art History*, *Collection of Art Papers*, *Perspective*, *Thirty eight Lectures on Art Anatomy* and other books.

After Qian Xuesen was admitted to Jiaotong University in 1929, he returned to Hangzhou every summer vacation and spent a year in Hangzhou to recuperate from typhoid fever. Meanwhile, Qian Xuesen often went to Jiang Danshu's house. Once, he told Jiang that he was studying radio technology and needed to pull an antenna between the two houses on the third floors. Jiang Danshu readily agreed. In 1931, Jiang Danshu gifted Qian Junfu a painting entitled "Xixi Wetland", and inscribed on the painting a poem:

西溪打桨觅诗材，诗未成吟画已催。芦花万亩柿千树，疑是雪中送炭来。

Paddling in Xixi for poetic muse, before which comes the art source;

Persimmon trees and reed blossoms in wetland, truly are gifted beauty to my hand.

On Qian Junfu's 60th birthday, Jiang Danshu also created a painting to celebrate his birthday. It could be seen that the relationship between the two families of Qian and the Jiang was very harmonious.

In 1937, when Qian Junfu lived in Shanghai after the Japanese occupation of Hangzhou, Jiang Danshu also moved to Shanghai and they often met with each other. Jiang was very concerned about Qian Xuesen, and would ask him about his studies and life in the U.S. After the founding of People's Republic of China in 1949, Jiang Danshu was transferred to Wuxi East China Art College. Shortly after Qian Xuesen returned home in 1955, Qian Junfu wrote to Jiang to tell him the news and asked him not to worry about Qian Xuesen. After that, Qian Junfu moved to Beijing from Shanghai, but there had been constant correspondence between the Qian and Jiang families. On June 8, 1962, Jiang Danshu died of illness in Hangzhou. Qian Junfu sent ten *yuan* for memorial ceremony.

Returning in another day: "native land emotion" in a traditional Chinese painting

In the history of modern art, Jiang Danshu occupied a very important position as he pioneered art courses in anatomy, perspective and photography. However, he rarely created artworks for quite a long time afterwards; instead, he devoted most of his

time to teaching, and trained many great artists, such as Feng Zikai, Pan Tianshou, Lai Chusheng, Zheng Wucheng and so on.

“A Corner of the Westlake” was created by Jiang Danshu in early 1941 at a time when he became more adept with his painting skills. Upon the request of Qian Junfu, Jiang created this painting and sent it to Qian Xuesen. Jiang Danshu did not immediately put pen to paper, but took some time in the conception of this painting and decided to paint in the form of “memory writing” with the content of West Lake scenery in Qian Xuesen’s hometown. When the painting was finished, Jiang Danshu wrote an inscription with more than 100 Chinese characters as follows:

I learned the way of Yu Gong Yishan (i.e., a Chinese parable about “the old man Yu Gong moving the mountain”) and moved West Lake to the canvas by trickery. This painting will travel with the ship only that I am still on the east side of the earth. West Lake is still the same as it was back then, where will it be covered with dirt? The landscape of our hometown is contained in this painting, and I will trust it with my thoughts for thousands of miles to appease.

You have been studying in America for many years, so you must yearn for your homeland. I am sending this painting to you as a way to enjoy the West Lake. I have left West Lake for four or five years, but when we return to West Lake, the landscape will still be the same. Let us commit to revisit West Lake together. This painting should be our dwelling place.

Inscription by Jiang Danshu on the Spring of the Year of Xinyi (Fig. 1)

This inscription was short, but contained extremely rich emotions. It was not only the emotional expression of the painter through the artwork, but also his ardent expectation for Qian Xuesen (Fig. 2). At a time when the anti-Japanese war was stalemated, Jiang Danshu could only imagine the creation of the West Lake in the “isolated island where the birds live in a cage”, which was quite a sense of helplessness. During Qian Xuesen’s summer visit to his family in 1947, he and Jiang Danshu fulfilled the agreement of “revisiting West Lake together.” When Qian Xuesen and Jiang Ying got married, they invited Jiang Danshu to attend the wedding.

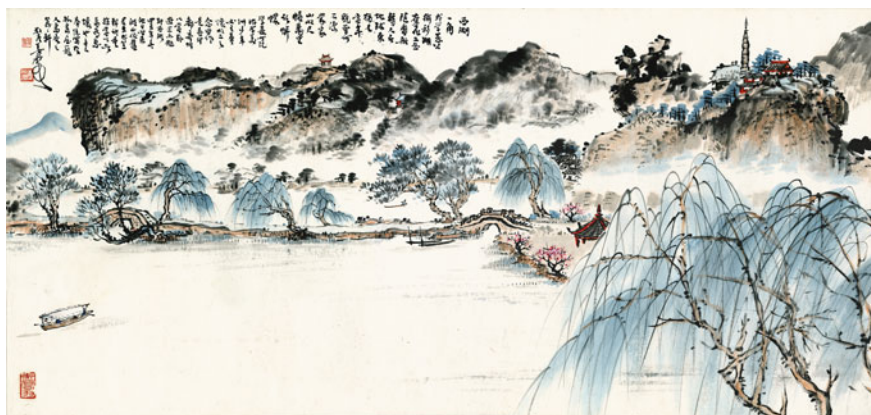


Fig. 1 Chinese painting: A Corner of West Lake



Fig. 2 Qian Xuesen rafting on West Lake during his return to China in 1947

It was conceivable that Qian Xuesen, who was far away from home in the United States, and Jiang Danshu, who was “living in an isolated island”, had the same emotion that their hometown was being occupied and ravaged by Japanese invaders, and their hearts were full of grief and longing. Therefore, for Qian Xuesen, who had been studying in the United States for six years, “A Corner of West Lake” could undoubtedly help relieve the “nostalgic thoughts of the homeland.” But more importantly, this painting carried Jiang Danshu’s earnest expectation for Qian Xuesen: “When you returned in another day, the lakes and mountains would remain unchanged.” “Return in another day” was the initial thought of Qian Xuesen during his overseas study. Whether he was at home or abroad, he would never forget his original ideal of serving the country with science and technology, just like “the lake and the mountain remain unchanged.” It was not until 1955 that Qian Xuesen finally returned to his homeland after all the hardships, finally realizing his original ideal of serving his country.

Qian Yonggang once mentioned: “In my father’s later years, he asked me to take out “A Corner of the Westlake” and hang it in his bedroom. This painting was very important to my father as he usually did not like keeping stuff in his bedroom.” Though this traditional Chinese painting only depicted a corner of the West Lake, it Qian Xuesen’s deep emotion for his motherland. This “native land emotion” was deeply burned in Qian’s heart and had become the centralized embodiment of his patriotic spirit.

2 Secret Letter from the “North Bureau”

Recent archival disclosures and historical research show that the Central Committee of the Communist Party of China (CPC) started to mobilize foreign students to return to China to participate in socialist construction as early as the eve of the founding of People’s Republic of China. Qian Xuesen was one of the scientists who were invited to return to China, but when he received a letter from the “Northern Bureau” and booked a plane ticket to return to China, he was detained in the United States for five years on the grounds of supporting communism and carrying classified documents.

Receiving the letter from the “North Bureau”

In early summer of 1949, Zhou Enlai instructed that “the central task was to mobilize Chinese intellectuals in the United States, especially high-tech experts, to return home to construct a new China.” After that, the CPC Central Committee made a series of decisions to encourage overseas students to return to China, and established the Committee for Handling the Return of International Students to China as a special responsible organization. Against this background, Qian Xuesen received a secret letter from the “Northern Bureau” written by Cao Richang.

On May 14, 1949, Cao Richang [1], a professor of psychology at the University of Hong Kong and head of the Hong Kong branch of the Chinese Association of Science and Technology, wrote a letter to Qian Xuesen, as instructed by his superiors. Since Cao Richang did not know much about Qian Xuesen, he wrote another letter to Ge Tingsui at the University of Chicago, hoping to encourage more people who “were politically pure and had expertise” to return to China. Cao wished that Ge would hand over his letter to Qian Xuesen as he wrote:

You surely know Mr. Qian Xuesen. The “North Bureau” wishes that he could return home and ask me to contact him. I don’t know his correspondence, so I’m enclosing a letter to ask you to pass it on and to give him more encouragement, it would be the best if he could return home! Please assist in this matter [2].

On May 20, Ge Tingsui forwarded this confidential letter to Qian Xuesen with the following message.

You have such great academic achievement and international reputation. If you are willing to return home, all Chinese people studying or working in the United States will be encouraged to come home for the construction of new China, which will benefit all Chinese people. I deeply feel that personal attainments and academic status are infinitely insignificant compared to the struggle for survival of the nation. Considering that we have been abroad for a long time, I feel sad and ashamed of not being able to participating in the great struggle of survival at home [3].

Ge Tingsui copied the secret letter before sending it out, so this copy of this precious secret letter from Cao Richang was kept, which wrote:

Mr. Xuesen,

I have heard about you from several students studying in the United States. It is a pity that we haven’t the opportunity to meet with each other.

I think you know well about recent domestic situation. The national liberation is imminent. The Northeast and the North China have already settled and various industries are being actively restored, and the aviation industry is also underway. The director responsible for northern industries has heard of your name long time ago. He specially asked me to give his regards to you. If you may quit your job in the U.S., it is our earnest wish that you can return to China and lead the establishment of aviation industry in Northeast or North China. I will do my best to assist you in transportations. Finally, I would like to introduce myself. I am a psychologist and teaching at the University of Hong Kong. Because of the location of Hong Kong, most friends in foreign countries would transit via Hong Kong when they return to the mainland. Looking forward to your reply.

Best wishes

Cao Richang

May 14, 1949

Cao Richang's letter (Fig. 3) played an important role in prompting Qian Xuesen to make the decision to return to China. In 1993, Qian wrote in his congratulatory letter on Ge Tingsui's 80th birthday: "I will never forget it is you who guided me back to the embrace of my country." On the eve of receiving the secret letter, Qian had learned that western suburbs of Beijing were liberated and the defeat of the Kuomintang army was a foregone conclusion. However, Qian Xuesen had already accepted the offer from Caltech and signed the employment contract. After discussing with Jiang Ying, he decided to work at Caltech and then took the opportunity to find the right reason for returning home. In preparation of returning to China at any time, Qian began to resign from part-time positions in the Army Air Forces Scientific Advisory Group, the Naval Artillery Research Institute, the Naval Ordnance Laboratory and other institutions.

After resuming his post at Caltech, Qian Xuesen went to the Oaknoll branch of the First National Bank of Los Angeles Security in the Oaknoll neighborhood of Pasadena on July 18, 1949, to get a demand passbook. He would be able to withdraw money any time he wanted, which was an indication that Qian was ready to return to China whenever possible.

Joint investigation by FBI and CIA

After the end of World War II in 1945, the U.S.-Soviet alliance quickly disintegrated. The fear of communism in the United States and the successful development of nuclear weapons in the Soviet Union eventually plunged international relations into a Cold War in which the two camps of capitalism and socialism confronted each other. The U.S. launched an "anti-Communist campaign" at the beginning of the Cold War, and President Harry S. Truman issued a "loyalty investigation" on March 21, 1947, to investigate Communist sympathies, but in fact to liquidate domestic Communist and related organizations. This was followed by the FBI, CIA, and the House Committee to Investigate Un-American Activities (HCUA), which created numerous cases of contempt of Congress, refusal to express political beliefs, communist sympathies, and membership in communist organizations, resulting in either prison or bail. Examples include the Joint Committee Against Fascist Exiles, the Hollywood Ten, the Eisler Case, the Joseph Case, and the Machaney Case, the Morford Case and so on.

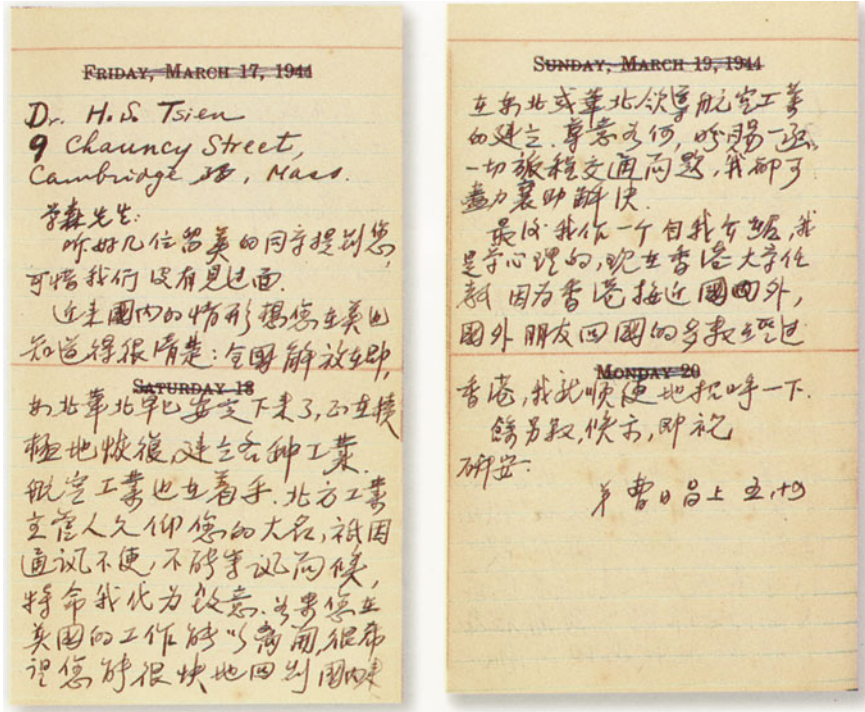


Fig. 3 Letter from Cao Rizhao to Qian Xuesen on May 14, 1949 (copy by Ge Tingsui)

The culmination of this “war against the Communist movement” in the United States was the sentencing of Eugene Dennis, General Secretary of the Communist Party of America, to one year in prison and a \$1,000 fine for “contempt of Congress” in 1947. Meanwhile, in 1948, the U.S. launched a frontal “war of annihilation” by arresting twelve members of the National Political Bureau Committee of the Communist Party of America for violating the Alien Registration Act of 1940 (the Smith Act). It was against this backdrop, and as the outcome of the war for power between the Chinese Communist Party and the Kuomintang became clearer, that the alliance formed between the United States and China during World War II tended to disintegrate. As the alliance gradually turned hostile, Qian Xuesen’s identity as a Chinese scientist naturally attracted attention, especially whether he had communist tendencies.

The FBI made special visits to the MIT and the CIT, where Qian Xuesen worked, as well as to the American Association for the Advancement of Science and the Sigma Xi Society, where Qian worked. The results of the investigation showed that Qian Xuesen had subscribed to pro-communist newspapers, but he was not found to have communist tendencies. However, when the “McCarthyism” in the name of protecting the national security interests of the United States became widespread,

anti-communist and xenophobic movements became rampant, and the “loyalty investigation campaign” resumed. All those who served in the military, government, universities and scientific institutions were subject to such investigations; even Albert Einstein was not spared.

The so-called “Qian Xuesen Case” occurred against such a complex historical background, and it began when the FBI discovered a “valuable” lead. Sidney Weinbaum’s membership in the Communist Party coincided with his recommendation for a position at JPL by Qian Xuesen. The FBI took this as a clue and conducted an intensive investigation from May to August 1949, which revealed that Qian Xuesen and Weinbaum were friends and that Qian Xuesen’s political leanings were not apparent.

As the FBI investigated, the CIA, specialized in gathering foreign intelligence, stepped in. On August 8, 1949, the CIA’s Los Angeles Bureau wrote to the Pasadena Police Department in California and the Cambridge Police Department in Massachusetts to find out what was going on. The results were disappointing, as the two police departments replied on August 12 and 15, respectively, that no records had been found. But when the CIA went to the FBI’s Los Angeles Bureau on August 18 to review the documents again, it was convinced that the “John M. Decker” on a list of Communist Party members was none other than Qian Xuesen. This discovery convinced the FBI and the CIA that Qian Xuesen was a member of the American Communist Party and was sympathetic to and supportive of communism.

Subsequently, the FBI and CIA gradually expanded the scope of the investigation, and Qian Xuesen’s entire circle of friends became the target of the investigation. They hoped to find more conclusive evidence through “peripheral” channels. For example, on September 27, CIA officers went to Cornell University’s Department of Aerospace Engineering to question Qian’s former colleague at Caltech, Professor William Rees Sears; and on October 3, the FBI went to MIT to question two of Qian’s colleagues, Professor Sartre Stuart Ober and Professor John Makam [4].

In fact, the “peripheral” evidence gathered by the FBI and CIA was not sufficient, as Sears, Ober and Markham testified in favor of Qian Xuesen. What really changed the dynamics of the case was not the joint investigation by the FBI and CIA, but the involvement of the U.S. military. Even during the FBI and CIA investigation, Qian Xuesen still had a license to lead and participate in classified research projects, but the U.S. military’s involvement changed the situation completely.

After the “Weinbaum case”, Qian Xuesen realized that he had to leave the United States as soon as possible, “so he decided to go back to China under the pretext of visiting his family, and never returned.” But he did not know that the FBI and CIA were already investigating him, especially after the spread of McCarthyism and the outbreak of Korean War, the U.S. military became involved, and they thought it was not in the U.S. interest to keep Qian Xuesen’s classified license.

On May 18, 1950, the U.S. Army, Navy, and Air Force Military Security Agency held a joint meeting specifically to discuss the matter of Qian Xuesen’s classified license. The meeting reached a consensus that there was no good reason to ask Qian to resign from the Guggenheim Jet Propulsion Center at Caltech at this time, but it was clear that retaining his classified status permit would do the United States more harm than good. Even though not enough evidence was presented at the meeting,

two points were recognized. First, Qian Xuesen had been a member of a communist organization that the Justice Department had determined to be subversive in nature. Second, Qian Xuesen had a relatively close relationship with and was sympathetic to members of the Communist Party.

This meeting finally reached a consensus and decided that the U.S. Army, Navy, and Air Force Military Security Agency would send a letter to Qian Xuesen requesting that he would be banned from participating in any level of classified scientific research projects. Why would the U.S. military convene a special meeting to discuss whether to cancel Qian’s license for classified status? The reason was very simple. Qian Xuesen was the director of the Guggenheim Jet Propulsion Center at Caltech, and his research projects mainly came from the U.S. military. If the classified license was cancelled, it meant that Qian Xuesen would not be able to participate in classified projects.

The U.S. Army’s Sixth Army Headquarters sent a letter to Caltech on June 6, as requested by the joint meeting, informing that Qian Xuesen’s classified status would be revoked, and that Qian could appeal under the Industrial Employment Review Board’s regulations. Upon receipt of the letter on June 16, Qian Xuesen showed his intention of resignation to Professor Fred Lindvall, chair of Caltech’s mechanical engineering discipline, on the same day, saying emphatically: “I felt that I was no longer welcome in the United States, and the only thing I could do now was to resign and return to China.” The FBI then called Qian to verify the details. Qian said: “I resigned from Caltech unofficially. I had expressed my readiness to resign to Dr. Fred Lindvall, chairman of the mechanical engineering discipline, because that was the only thing I could do. No information had been received from him so far, and it was not yet known whether the resignation has been accepted. However, if the resignation was approved, I would return to China immediately.”

The FBI wanted to interview Qian Xuesen on the phone, to which Qian agreed. The interview was scheduled on June 19. During the interview, Qian told the FBI that he had made contributions to the development of science and technology in the United States in the past ten years, but now he was not welcome. The only thing he could do was to return to China once his resignation was approved. In the following day, Qian Xuesen formally submitted his resignation request to Professor Ernest C. Watson, chairman of the Committee of teaching staff at Caltech.

Soon after, Qian Xuesen wrote to the U.S. Department of State on July 29 to express his willingness to return to China, while inquiring about the U.S. International Trade Service Association and booked a flight to Hong Kong on August 28 with Canadian Pacific Airlines. In order to prepare for his return to China, Qian Xuesen called the staff of Bekins Van and Storage Company to his home and office to pack his luggage for two consecutive days on August 18 and 19.

However, things were not as simple as Qian Xuesen had planned. The whole situation took a sharp turn for the worse when the manager of the Bekins Van and Storage Company snatched on him. This snatching incident seemed to be a coincidence, but it was inevitable against the background of the “anti-communist war” and the McCarthyism in the United States. At the same time, the United States began to take the initiative, and Qian gradually fell into a passive situation.

Qian Xuesen Case

Qian Xuesen and his family would have boarded the flight to Hong Kong on August 28 as scheduled without the snitch from the manager of Bekins Van and Storage Company. However, when an employee of the Bekins found that certain papers in Qian Xuesen's luggage were marked with "secret", "confidential" and "internal" on August 19 and he immediately informed his boss, Harold Sexsmith. Sexsmith immediately contacted Los Angeles customs official, who told him to proceed no further with the packing and reported the situation to the Navy, Air Force, State Council and Atomic Energy Commission, requiring them to send representatives to inspect Qian's luggage on August 21.

On the morning of August 21, representatives from Los Angeles Customs, the Navy, the Air Force and the State Department were appointed to form a delegation to the warehouse. The FBI learned of this and volunteered to send a representative to join in order to keep abreast of the information. Because of Qian Xuesen's status as a Chinese scientist, the entire investigation operation was then led by the Immigration and Naturalization Service of the U.S. Department of Justice, which coordinated the investigation. The delegation drew boxes and examined them and found that some of the papers, notes, and letters were marked with classified levels, mainly related to atomic energy, rockets, missiles, and jet propulsion. However, the delegation was cautious to hold the baggage first so that the information could be fully reviewed by professional technical experts, and classified documents should be judged by the issuing agency.

Between the afternoon of August 21 and 22, Los Angeles Customs notified the Atomic Energy Commission, the Department of Ordnance of the State Department, the Customs Service of the Department of the Treasury, and the Office of Business and Industry Enforcement of the Department of Commerce of the preliminary results of the review. The State Department officials recommended seizure of the documents and Qian's detention while the U.S. attorney's office in Los Angeles wanted Qian put under surveillance. Los Angeles Customs applied for a civil warrant of detention for his cases of documents on the grounds that Qian might have violated the Export Control Act, the Neutrality Act, and the Espionage Act.

From August 21 to 23, Qian Xuesen was in Washington, where he met with Admiral Dan Kimball, telling him everything and he was ready to return home. On August 23, when Qian arrived at Los Angeles airport that night, the chief inspector of the INS was waiting for him and handed him a paper from Department of Justice forbidding him to leave the country. Without any option of returning home, Qian reluctantly canceled his reservation on Canada Pacific Airlines to travel from Vancouver to Hong Kong scheduled on August 28.

On August 24, the Los Angeles District Court signed an official order to detain Qian Xuesen's luggage. This was apparently done without his knowledge as he only knew the detention from the news report carrying headline "Secret Data Seized in China Shipment" in the *Los Angeles Times* the next day on August 25, which wrote:

The ship was loaded with eight boxes of secret and confidential documents that Caltech Professor Qian Xuesen was attempting to transport to China. Yesterday, government agents

filed charges against him. The U.S. government announced that they had seized books, photographs, sketches, photocopied negatives, records, and a large amount of technical information on rocket research in coded form.

In fact, the *Los Angeles Times* did not really have the inside story of the case, and relied only on “gossip” to report on the case under the title “Secret data seized.” It was this news report that turned “Qian Xuesen case” into a public event. On August 26, Jiang Ying called the manager of Bekins to see if he could get Qian’s luggage back on the grounds that his daughter had just been born and needed a washing machine, but all her efforts were in vain. In response to the sudden seizure of his luggage, Qian Xuesen decided it was necessary to make a public statement. On August 26, he issued a statement that was reprinted in the *Examiner*:

I planned to return to China as a family and would come back later. My father was in China and there were family issues that required my return. I had arranged for a transportation company to take care of the packing of my luggage. On Wednesday night, I received an order from the INS that I could not leave the United States. Before that, my luggage was all packed and ready to be shipped. Before I packed my personal documents, I went through them, took out all the classified information and stored it in a cabinet in my office, with the key given to Mr. Milliken. To the best of my knowledge, there were no internal, top secret or secret documents among those I carried (Fig. 4).



Fig. 4 Qian Xuesen’s seized luggage

In fact, Qian Xuesen's luggage did contain classified technical documents, but subsequent investigations disclosed that these documents had already been declassified. The day of September 6, 1950 was the darkest moment in Qian Xuesen's life. At 4 p.m., officials from the INS of the U.S. Department of Justice, armed with an arrest warrant, quickly knocked on Qian's door. The moment Qian Xuesen opened the door, the INS officer took him away for violating immigration law. Qian was then detained in a prison on Terminal Island, south of Los Angeles. At this time, only Jiang Ying and her two young children were left at home, and her daughter Qian Yongzhen was still a three-month-old baby.

This was the sensational "Qian Xuesen Case" that took place in the United States in 1950. In the end, Qian Xuesen was released on bail on September 23, which was set at \$15,000, paid by a wealthy American friend through purchasing U.S. bonds. For comparison, Eugene Dennis, the general secretary of the Communist Party of the United States, was sentenced for a year and paid a fine of \$1,000; the figure of bail for Qian was unusually high. Qian lost thirty pounds of weight and even had auditory hallucinations. When Jiang Ying visited him, he could barely speak but nod to her.

The detention of Qian Xuesen quickly became hot news with continued coverage in the *Los Angeles Times*, the *Washington Post* and other mainstream newspapers, making it so much publicity. He Guozhu, who returned home with Qian Xuesen on the same ship in 1955, recalled:

After Qian Xuesen was detained, the U.S. State Department convened a meeting with presidents of ten universities, inquiring about the policies on the detained Chinese scientists. Under normal circumstances, Chinese students would have to return home after graduation, and not been allowed to work in the United States. These presidents reached an agreement that students, especially those majored in science and technology, should not be allowed to return to China [5].

In 1950, the U.S. Congress passed the China Area Aid Act of 1950, which allowed the government to allocate \$6 million for relief work for international students and scholars. Due to this Act, a total of about \$8 million was spent to support 4,000 international students, which achieved the purpose of retaining Chinese students in their home countries. However, it was only temporary, and the tide of returning home never stopped after the founding of People's Republic of China.

3 Suspicion and Detention

Ever since the "Qian Xuesen Case" occurred, the truth had been shrouded in layers of fog. Seemingly, the Case was the confrontation between Qian Xuesen and the United States. But its occurrence and development was rather a tense game between Qian Xuesen and the U.S. military, the U.S. Department of Justice Immigration and Naturalization Service, and the U.S. Department of State. Qian Xuesen was finally in the state of "to be expelled but not deported", and this was the response taken by all parties after comprehensive consideration in accordance with their own interests.

But what Qian Xuesen did not expect was that there was another force behind the game, the close attention from his motherland and that the Chinese government was ready to rescue him at any time.

Consideration of U.S. interests by various parties

The FBI and CIA, the two major American intelligence systems, aiming at safeguarding the national security interests of the United States, were important participants. To some extent, they were the co-makers of the Qian Xuesen case. From “Weinbaum case” to “Qian Xuesen case”, the FBI and CIA relied on their own intelligence sources to investigate Qian Xuesen, expecting to find any valuable clues. The FBI was responsible for the surveillance of Qian for five years, “the secret service agent watched me, checked our letters, listened to our phone calls, and questioned our friends who came to see us,” as Qian Xuesen said.

The CIA was also actively involved in the “Qian Xuesen Case” because of Qian’s status as a Chinese scientist and his involvement in external affairs. Moreover, the new director of the CIA at that time was Walter Bedell Smith, the former U.S. ambassador to the Soviet Union, who had already learned about the Soviet Union’s development of sophisticated weapons such as missiles and atomic bombs through his intelligence network he had established during his tenure as ambassador to the Soviet Union, and was therefore particularly interested in Qian Xuesen as a rocket technology expert in China who had once hoped to return to the Soviet Union.

The U.S. military (Air Force, Navy and Army) focused on two core issues during the course of the case: whether Qian Xuesen’s possession of a classified license would have a negative effect on U.S. interests; and whether Qian carried classified documents in his luggage. On the first issue, the joint meeting of the Army, Navy, and Air Force Military Security Agency held on May 18, 1950 reached a consensus that Qian’s classified license must be revoked immediately. For the second issue, the U.S. Customs Service and the INS proposed to conduct technical identification of the documents in Qian’s luggage.

Technical appraisal of Qian’s seized documents

The technical appraisal of the classified documents carried in Qian Xuesen’s luggage to China was led by the U.S. Customs Service, which organized technical experts from the Navy, Air Force, and Army research institutions. The entire identification process had three steps. In the first step, the U.S. Customs Service commissioned the U.S. Wright-Patterson Air Force Base to microfilm the documents, which were done from September 5 to 8. In the second step, the documents were catalogued according to whether they were classified or not. In the third step, the Customs Service invited technical experts from Air Force, Army, and Navy research institutions to identify the contents of the classified documents based on the Presidential Decree No. 2776 list of prohibited equipment and its design drawings, and the FBI assisted in investigating the source of the classified documents.

Since the majority of the classified documents were in aerospace science, the identification process was primarily undertaken by the U.S. Air Force. The Wright-Patterson Air Force Base Intelligence Department reclassified the documents and

appraised them in three batches. The results of the three batches were returned on September 27, October 17 and October 30, respectively. The results of the report showed that the appraisal materials were all internal, and the documents concerning the Air Force were unclassified in nature and also showed that these papers were not included in the prohibition list of Presidential Decree No. 2776. Therefore, Qian Xuesen did not violate the law [6].

The technical appraisal results for the U.S. Army and Navy were released simultaneously on November 20. The results from the U.S. Army's Los Angeles Ordnance Department showed that documents marked as classified were issued by other agencies and were not under the Army's jurisdiction, while unclassified documents and publications could be obtained through purchase. The U.S. Navy Bureau of Aeronautics gave similar results to those of the Army's Los Angeles Ordnance Department. The technical appraisal results from the U.S. Army and Navy therefore revealed the ambiguous attitude towards Qian Xuesen [7].

While the U.S. military was conducting a technical examination of the contents of the classified documents, the U.S. Customs Service and the FBI were also investigating the "source" of Qian Xuesen's access to the classified documents. The agencies that issued the classified documents included the U.S. Atomic Energy Commission, the U.S. Air Force Intelligence Agency, the U.S. Aviation Advisory Board, the U.S. Navy Ordnance Agency Technical Liaison Office (Southern California District), the U.S. Army Ordnance Department in Los Angeles, the U.S. Air Force Acquisition Office in Los Angeles, and the Jet Propulsion Laboratory at the California Institute of Technology, all of which participated in the identification process. The results of these appraisals indicated that the classified documents had been declassified and did not pose a threat to the United States. These declassified documents might be used by other countries, but including those listed in the Presidential Decree No. 2776.

Not giving up any chance, the FBI went to Caltech on September 22 to search Qian Xuesen's office for clues. When the FBI entered the office and found two locked safes, they immediately ordered Clark Milliken to open the safes and found that many classified documents were stored. The FBI then asked Customs to compare the documents in the luggage with those in the safes, and they found that a note on jet propulsion in the unclassified documents was highly similar to the printed document in the safe. However, Milliken clearly explained: "Qian Xuesen did a great deal of work editing this document and contributed a great deal to its final completion. He further put: "I believe that as one of the authors, he has the right to retain the materials formed by their scientific research activities as collaborator, just as most professors have believed so [8]."

The FBI then asked Milliken to provide a list of all the projects in which Qian Xuesen participated, as well as the names of the institutions and professors in charge of the projects, in order to fully verify the possibility of issuing classified documents to Qian Xuesen. But the results of the investigation turned out to be disappointing. Moreover, the FBI failed to find any record of Qian ever copying any classified materials in the records of similar classified project management offices at Caltech.

In fact, before Qian Xuesen packed his luggage, he had sorted out the documents and classified them into different types. In particular, when Caltech executed the

order to revoke Qian's classified license, Qian Xuesen took the initiative to return the classified documents, and those that could not be returned temporarily were stored in the office safe, the key to which was handed over to Clark Milliken. This was why the U.S. military found nothing after repeated technical appraisals. Also, it showed that Qian Xuesen had made a lot of preparations for his return to China, and he had anticipated the possible "obstacles" and made arrangements in advance.

Hearings

The focus of the "Qian Xuesen Case" was first on whether he was a communist or supporter of communism, and later on whether he violated the President's Decree 2776 on carrying classified documents. However, all the efforts of the FBI, CIA and the U.S. Customs Service were in vain and failed to collect any evidence of violations of the law on the part of Qian Xuesen. When the Customs Service reported to the U.S. Department of Justice on November 24 on its final findings, it remained inconclusive as to whether Qian had violated the law, noting only at the end, "If criminal prosecution was contemplated, we would submit the case report usually required." At this point, the U.S. Department of Justice, which had legal discretion, became involved in the Qian Xuesen Case. How exactly would the U.S. Department of Justice rule as it was so tricky a case?

When Attorney General Dowling of the U.S. Department of Justice, Los Angeles office wrote to Customs representative Glazer on January 4, 1951, he was careful to point out that there was not sufficient justification for charging Qian Xuesen with violating the Espionage Act, either for involvement in subversive communist activities, or for violating the Export Control Act for allegedly carrying classified documents. Accordingly, Qian Xuesen should be granted personal freedom under U.S. law. However, Dowling added in his letter that Customs should retain the luggage until INS decided whether to initiate deportation proceedings. Customs then held the "classified documents" at a Los Angeles Customs warehouse, pending for further review.

The Department of Justice held four hearings in the six months from November 1950 to April 1951. The two sides went head-to-head in the hearings, which centered on Qian's participation in Communist Party organizations and on attending their meetings and activities from 1938 to 1939. Qian's attorney Grant B. Cooper was involved throughout the case and provided quite professional legal advice and defense strategies. Undoubtedly, Qian Xuesen suffered physically and psychologically on the six-month hearing. Nevertheless, the moral support from von Kármán, Caltech President DuBridge and Harry Guggenheim, President of the Guggenheim Foundation of the United States, provided much help and comfort to him. DuBridge wrote a private letter to Norman Chandler, publisher of the *Los Angeles Times* on October 18, hoping that the *Los Angeles Times* could publish positive reports on Qian's case.

U.S. Department of Justice organized four hearings in accordance with legal procedures. However, whether there was a chain of evidences to prove that Qian Xuesen was an American Communist was no longer important just as Qian Xuesen exclaimed: "How would the enemy let me go easily!" On April 26, 1951, the U.S.



Fig. 5 Qian Xuesen in the hearing

Department of Justice finally ruled that Qian had joined the Communist Party of the United States in 1938 and issued a legal decision to deport him (Fig. 5).

On May 3, 1951, Qian Xuesen received the verdict as calmly as ever, because deportation meant he could leave the United States. It can be imagined that Qian Xuesen was under great pressure from May 18, 1950, when his classified permit was revoked, to April 26, 1951, when the verdict was handed down. During the politicization and complication of the case, the birth of his daughter on June 26, 1950, brought him comfort and infinite hope.

Qian Xuesen's defense attorney Cooper filed a complaint with the U.S. Department of Justice on May 23, 1951, and it was not until February 8, 1952 that the U.S. Department of Justice responded by upholding the verdict, but at the same time stressing that the execution of the deportation order was still subject to clear instructions. Subsequently, Cooper filed several appeals without success. In the end, "to be expelled but not deported" became the result of the game between the various parties engaged in Qian Xuesen Case. As late as December 2, 1952, a reporter from the *New York Times* asked the Los Angeles Immigration Department whether it had received an order to deport Qian Xuesen. This again threw the case into a fog. However, on March 6, 1953, a report in the *New York Times* wrote, "The departure of Qian Xuesen, a rocket expert at the Caltech, would harm the core interests of the United States."

The Chinese government's action

According to the declassified archives in recent years, the Chinese government had been closely monitoring the development of the Qian Xuesen case since its occurrence and was ready to rescue Qian Xuesen at any time.

When the China's Ministry of Foreign Affairs learned that Qian Xuesen was detained by the United States in 1950, it immediately took corresponding measures. It collected news reports from the *New York Times* and *Agence France-Presse*, and closely followed the progress of the case. The Ministry of Foreign Affairs also asked Jin Yinchang on October 5, 1950, who had just returned from the United States and was working at the Chinese Academy of Sciences about the exact situations. Jin Yinchang mentioned:

When Qian Xuesen decided to return to China in mid-August, his luggage, including books, notes, etc. weighing over 2,000 pounds, was inspected on the Los Angeles Wharf. It was found that some of Qian's papers were printed with "Top Secret", and Qian Xuesen was not allowed to leave the country. However, according to the dean of the California Institute of Technology, Qian was not carrying any top secret government documents, but only records of his own research and books that had been sold publicly [9].

Ling Qing, head of the first section of the U.S.-Australia Department of the Ministry of Foreign Affairs, reported to his superiors that it was not suitable for the Ministry of Foreign Affairs to issue a statement to denounce the irrationality of the U.S. government as Qian Xuesen was detained because he carried secret documents. He suggested that nongovernmental groups and organizations could issue a public declaration. Thus, after Qian Xuesen was banned from returning to China in 1950, organizations such as the Wuhan Branch of the Chinese Association of Scientists, the All-China Natural Science Specialists Society, and the Jiu San Society issued a joint statement protesting the U.S. actions and demanding the release of Qian Xuesen to China. Tao Menghe, vice president of the Chinese Academy of Sciences, also suggested to the Ministry of Foreign Affairs that "our government could ask the Indian Embassy in the United States to request from Washington for the speedy release of the arrested persons." On the other hand, when the Chinese Academy of Sciences discussed the establishment of research institutions in 1950, it planned to set up a Preparatory Office for Engineering Science Research to "recruit Qian Xuesen and Lin Jiaqiao, who were still abroad, to return to China to prepare for the establishment of such institutions [10]."

On October 5, 1951, when the Ministry of Foreign Affairs learned from Cao Richang, Director of the General Office of the Chinese Academy of Sciences, that the U.S. might send Qian Xuesen to Taiwan, it immediately took corresponding countermeasures and proposed two sets of plans. If Qian Xuesen was expelled by the U.S. Empire and might go to the vicinity of Hong Kong, it should telegraph Wu Dizhou, who was doing United Front work in Hong Kong, to take care of him and try to get him back. If Qian Xuesen could not move freely and was sent to Taiwan under U.S. surveillance, it should telegraph J. G. Crowther, a famous British progressive scientist, to mobilize forces in the U.S. to rescue him from being sent to Taiwan under the surveillance of the United States [11]. The Ministry of Foreign Affairs then adopted the first plan, and wrote to Wu Dizhou, a Xinhua News Agency

correspondent in Hong Kong, “to keep an eye on Qian’s whereabouts”, hoping that Wu Dizhou would “try to escort him to Guangzhou” if Qian passed through Hong Kong. However, the United States did not take any action to deport Qian Xuesen or send him to Taiwan. For security reasons, the Ministry of Foreign Affairs decided to adopt the second plan and sent a telegram to Ambassador Tan Xilin in the Czech Republic on January 7, 1953, briefly explaining the circumstances of the “Qian Xuesen Case” as follows:

On December 26, 1952, the AFP news agency in Taipei said that the U.S. had decided to expel Qian Xuesen from the country, but no action had been taken yet, and his recent status was unknown. Please contact Xinhua News Agency to ask Crowther, a famous British progressive scientist, to help Qian return to China safely through the British Communist Party [12].

On January 18, Tan Xilin sent a telegram back to the Ministry of Foreign Affairs, saying: “Chen Tiansheng and the British Communist Party wish to know further information about Qian’s situation so that they could find some way in assisting him in returning to China [13].” Chinese Ministry of Foreign Affairs kept a close eye on the case after Qian Xuesen was trapped in the United States, and collected all kinds of reliable information in order to find opportunities to rescue Qian Xuesen. Such an opportunity did not come until 1955, when ambassadorial-level talks were held between the United States and China.

4 Return to China

“For every single moment, my wish of returning home and participating in the great construction of China never ceases.” This was Qian Xuesen’s true thought in the last five years in the United States. He continued to work while waiting for the opportunity to return to China. In 1954, Qian Xuesen published *Engineering Cybernetics*, a book on systems of communication and control and he also developed physical mechanics, which was beyond the research scope of classical mechanics. All his intellectual efforts were “to get prepared to help Chinese people when I return to my country one day,” as Qian Xuesen put. When the opportunity of Sino-U.S. ambassadorial talks came, Qian Xuesen wrote a letter to Chinese government, expressing his earnest wish to return to his homeland, who finally sent personnel to greet and escort him back to China.

Moments of bitterness and sweetness

From March 1953 to September 1955, Qian Xuesen had been forbidden to travel outside the boundaries of Los Angeles. During this period, he was required to report his whereabouts to the Los Angeles Immigration Bureau on a monthly basis. For a scientist who once had classified license and access to the Pentagon, one could imagine how frustrated and depressed he was! On his way home from the monthly report, there was a café and Qian would usually stop and console himself by having a cup of his favorite coffee.

Qian Xuesen was only 39 years old and at the peak age of scientific research when his classified license was revoked in 1950. During his last five years in the U.S. from 1950 to 1955, Qian was still a professor and doctoral supervisor at Caltech and he continued to work, teach and do researches. He turned to other fields of research, such as the study of games and economic behavior. In 1954, he published a book entitled *Engineering Cybernetics*. Following the new trend of scientific and technological development, he developed physical mechanics by drawing on microscopic theories such as atoms, molecules and condensed matter and his *Lecture Notes on Physical Mechanics* became the pioneer of this new discipline. It was these two academic works that made Qian Xuesen surpass his mentor von Kármán academically. In his later years, Qian Xuesen recalled the experience in this period:

I studied under Von Kármán, a world-renowned authority on engineering mechanics and aeronautics, a mentor whom I can never forget, and who taught me the perspectives and methods of modern science and technology. In the summer of 1955, I was allowed to return to China. When I went to say goodbye to my teacher with my kindergarten-aged son and daughter, I gave him my newly published book *Engineering Cybernetics* and a copy of *Lecture Notes on Physical Mechanics*. “You have now surpassed me academically,” said Kármán. He was 74 years old at this time. When I heard his words, I was very excited and thought, “My goal of 20 years of endeavor has finally come true. This is the first time in my life that I am so excited! [14]” (Figs. 6 and 7)

It was for his outstanding scientific achievements that Qian Xuesen received the Pendray Aerospace Literature Award in 1953, representing the world’s top achievements in aerospace science, but he did not accept the award, and the trophy was still kept at Caltech to this day. As a matter of fact, the two disciplines pioneered by Qian

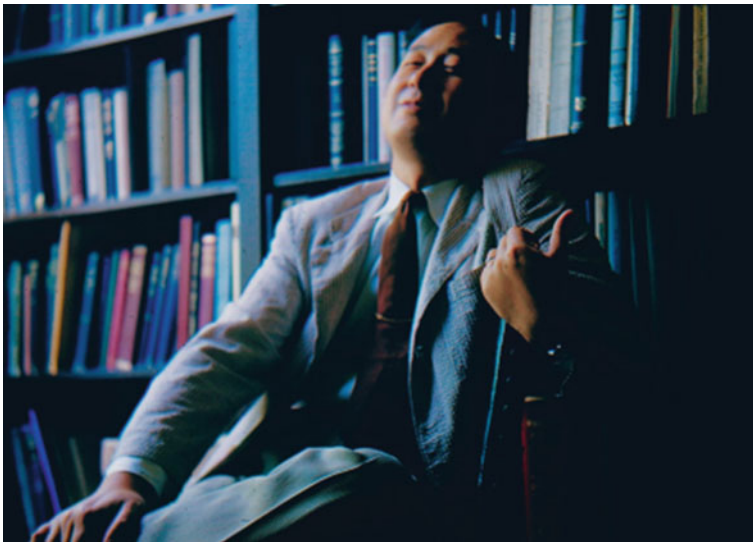


Fig. 6 Qian Xuesen maintains an optimistic attitude towards life while trapped in the United States for five years



Fig. 7 Handbook for Returning to China, in Qian Xuesen's collection, was compiled and printed by the General Union of Chinese Students in Britain in April 1954

Xuesen are closely related to rocket and space research. Engineering cybernetics, in particular, became the guiding technical thought for the development of China's aerospace industry after Qian returned to China. On October 27, 1966, the *New York Times* reported under the headline "The Valuable Chinese Scientist Qian Xuesen":

It is an irony of Cold War history that a man who was trained, educated, encouraged, respected, paid and trusted by the United States for fifteen years helped the Chinese Communist Party put the first atomic bomb into the sky with a missile.

This report summarized the complex relationship between Qian Xuesen and his era. Would he think of the small cafe he consoled himself during the five years of being trapped in the United States at the time when China independently completed the development of missiles and the combination of the two bombs? Perhaps that cup of good-tasting coffee was a metaphor for Qian's five year life in the United States, a taste of sweetness and bitterness. It should also be objectively pointed out that the reason why Qian Xuesen was able to return to China in 1955 was related to President Eisenhower's decision, or perhaps miscalculation to release Qian in 1955.

A Miscalculation by the U.S. President

During the 1954 Geneva Conference, China and the United States began discussing the repatriation of American prisoners of war (POW) and returning of Chinese students. Although no consensus was reached during the talks, the United States began to review the issue of Chinese students residing in the United States. John Foster Dulles, Secretary of State, asked the Department of Justice to speed up the

trial of the exit of 123 Chinese students who were previously not allowed to leave the country in exchange for the early release of POWs by the Communist Party of China. The Department of Defense had doubts about the merits of letting Qian go as “he would, if released, take back with him high competence in his professional field, much background information on jet propulsion as applied to weapons, and unusual ability to interpret technological progress in the U.S.,” and claimed, “Qian himself seems to have no intention of leaving the United States [15].”

On September 3, 1954, the first Taiwan Strait Crisis broke out, once again putting in jeopardy the relations between China and the United States, which had just resumed exchanges. But at the end of the year China sent word through India suggesting that the POW issue was comparable to the issue of returning Chinese students to China. So when, during the Bandung Conference in April 1955, Premier Zhou Enlai issued a statement that the Chinese government was willing to negotiate with the United States. In response, the U.S. began to seek a resumption of Sino-American talks and re-intensified its review of Chinese students’ exit permits, and in late April 1955, the U.S., through UN Secretary General Hammarskjöld, informed China that all Chinese scholars could leave the U.S. at any time except for two who had learned high technology in national defense and one of them was Qian Xuesen [16].

At the end of May 1955, China released four American POWs and asked the United States to respond accordingly. Under external pressure, President Eisenhower made the final decision about Qian Xuesen and the other Chinese scientist that it was “quite probable that any classified information which Qian possessed at that time is by now outdated by later research and is common knowledge in the Soviet Bloc.” President Eisenhower’s decision was to express his sincerity to China in exchange for American POWs held in China. However, the U.S. Department of Defense “reluctantly agreed to let the last scientist who learned missile technology return to the mainland China [17]” not until the end of July, the eve of the ambassadorial level talks. Qian Xuesen was informed of the news on July 27, He sent a letter to his father on July 29, written by Jiang Ying, that “July 27 was a day that we should commemorate and we shared the same feeling even across the sea, so please be patient for the time being [18].”

On the course of Sino-U.S. talks, Qian wrote the famous “letter for help” to Chen Shutong “for fear of missing the opportunity” when China and the United States were trying to talk. What is less known is that before writing that letter, Qian Xuesen repeatedly told Xu Zhangben, who was about to return to China, to convey a message to the Chinese government that “he was willing to return to China in the middle of this summer [19].” The archives of the Ministry of Foreign Affairs show that on July 29, 1955, after his return to China, Xu Jangben wrote to the All-China Federation of Specialized Societies of Natural Sciences, saying:

Mr. Qian is eager to return home and serve our country. I hope that the Federation could consult with the Ministry of Foreign Affairs. During the Sino-U.S. ambassadorial talks in Geneva, our government will try our best to enable Mr. Qian Xuesen be free of the unreasonable obstruction of the U.S. government and help him to return to our country.

On August 4, the Federation forwarded Xu Zhangben’s letter to the Ministry of Foreign Affairs. After receiving the letter, the Ministry of Foreign Affairs replied to

Xu on August 10 through Xu Yonghuan, director of the U.S.-Australia Department, stating, “Regarding the return of Professor Qian Xuesen, who was unreasonably detained by the United States, we were trying to assist him to return to China at an early date to participate in the country’s construction work.” And on August 4, the INS of the U.S. Department of Justice officially notified Qian Xuesen of the announcement to lift the ban of August 23, 1950, which he received the following day. This meant that the legal obstacles to Qian’s return to China had been cleared, and he booked a steamship ticket to Hong Kong immediately.

Arguably, Eisenhower’s judgment was a miscalculation. In fact, it was not the technical documents that posed a threat to the United States, but the scientific ideas that were in his head. Professors Seifert and Alperin of Caltech’s Jet Propulsion Laboratory commented, when asked about the value of the documents in Qian’s luggage: “The contents were already in his head.” As an immigrant country, the United States needs a large number of excellent intellectuals, who might be a potential threat to the United States under certain historical conditions. This ambivalence continues unchanged to this day. As an American scholar concluded in his analysis of the “Qian Xuesen Case”, “JPL was not only training scientists for the United States, but also training scientists for America’s enemies [20].”

Qian Xuesen’s letter for help

The belief of “returning home in another day” became stronger and stronger during Qian Xuesen’s last five years in the United States. When he learned that ambassadorial talks between China and the United States were being held in June 1955, and especially when he saw a newspaper report about Chen Shutong, his father’s teacher, on his “spirit of service and effort for the people”, he wasted no time in making the central government recognize his strong desire to return to China through a letter for help. Qian Xuesen wrote a letter to Chen Shutong (Fig. 8), expressing his earnest wish of returning home. The content of the letter was as follows:

Dear respectable Mr. Shutong,

We have not corresponded for a long time since September of 1947. Upon reading the news report about your spirit of serving for the people, I am deeply touched. I have been detained by the U.S. government for five years. But I have never failed to think of returning to my country to participate in the great construction. Compared with the more important and urgent issues, the situations of an individual like me were nothing and I could not complain much about it. During these years, I have only tried to study and carry out researches as much as possible to prepare for my return.

I have read from the newspapers that China and the United States may exchange detainees. The United States is lying about that all the Chinese students who are willing to return to China have been released. I am really anxious about it. Apart from me, there are other compatriots who are not allowed to return home. To my knowledge, Prof. Yung-Hui Kuo at Cornell University is the one.

Of course, I understand that our government is clear about the tricks of the U.S. However, we are very anxious about missing the opportunity. Attached is the news clipping from *New York Times*, describing my situation in the United States in the past five years.

I wish you very well!

Qian Xuesen [21]

June 15, 1955

The news clipping mentioned in Qian's letter was the report in the *New York Times* on March 6, 1953. This report confirmed that there were no classified documents in Qian's luggage and that he was deported but not allowed to leave the United States because his departure would harm the core interests of the United States. Regarding how the letter was forwarded, many biographies suggest that Mr. Chen Shutong sent it to Premier Zhou Enlai the same day he received it, but this is not what is recorded in the archives of the Ministry of Foreign Affairs.

As Qian Xuesen was under surveillance, he sent this letter to Jiang Ying's sister Jiang Hua in Belgium, who forwarded the letter to Qian Junfun in Shanghai immediately. Jiang Ying recalled later:

It was impossible to send the letter directly to China, so we had to send it to my sister Jiang Hua in Belgium. We drove to a convenience store where many black people frequented and quickly dropped the letter into the mailbox. My sister was also very smart and forwarded this letter to Qian Xuesen's father in Shanghai. Chen Shutong then forwarded this letter to Premier Zhou after receiving it from Qian Junfu [22].

This letter was actually not directly transferred to Premier Zhou Enlai. On July 7, Qian Junfu forwarded this letter to Chen Shutong, then vice chairman of the Standing Committee of the National People's Congress and vice chairman of the National Committee of the Chinese people's Political Consultative Conference, in the hope that Chen would pass his request along to the responsible Chinese authorities (Fig. 8).

Chen Shutong did not forward this letter directly to Premier Zhou Enlai, but to his friend Zhu Kezhen, vice president of the Chinese Academy of Sciences. On July 12, Zhu Kezhen forwarded the letter to Zhang Jiafu, Secretary of the Party and vice president of the Chinese Academy of Sciences, asking him to help. Zhu said:

It is clear from Qian Xuesen's personal letter that he was eager to return to China and was extremely reluctant to stay in the U.S. But from the enclosed news clipping from the American newspapers, we can see that the Americans regarded him as an authority on aeronautical engineering and used him as an expert on developing missiles. Therefore, the true reason of detaining was not the 1,800 books he carried, but that they were afraid that he would return to serve his country. Please try to help Mr. Qian Xuesen leave the U.S [23].

On July 17, Zhang Jiafu wrote to Chen Yi, Vice Premier of the State Council and Minister of Foreign Affairs, to "try to secure his return", and on July 21, Chen Yi instructed Zhang Hanfu, Vice Minister of Foreign Affairs, "to find a way". After a detailed investigation of Qian Xuesen Case, Xu Yonghuan, Director of the U.S.-Australia Department, Ministry of Foreign Affairs concluded that the U.S. would not easily release a rocket expert like Qian Xuesen, but the U.S. had accepted the proposal of direct negotiations announced by Premier Zhou at the Bandung Conference, so there was a possibility of releasing him back. At the same time, Xu Yonghuan also proposed to Vice Foreign Minister Zhang Hanfu to deal with the situation.

Zhang Hanfu agreed with Xu Yonghuan's opinion and sent a telegram to Wang Bingnan On August 2, who was conducting ambassadorial-level talks between China

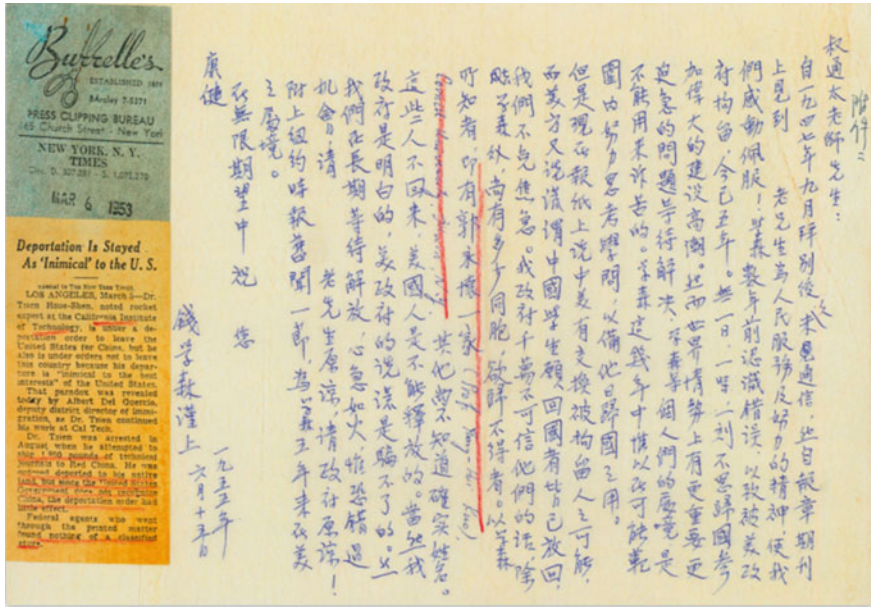


Fig. 8 Letter for help written by Qian Xuesen to Chen Shutong on June 15, 1955 (the original is in the archives of the Ministry of Foreign Affairs)

and the United States in Geneva. Wang Bingnan was required to be flexible with the situation at the ambassadorial talks, to argue on the basis of reasoning, and to insist on the release of Qian Xuesen to China with a reasonable attitude. Qian Xuesen’s letter eventually became the direct cause in winning his return at the Geneva Talk.

Welcome from the Chinese government

On September 17, Qian Xuesen and his family boarded the steamship *President Cleveland* bound for Hong Kong and embarked on a journey home. The moment Qian boarded the steamship, his U.S. permanent residence permit lost its legal effect, and he automatically obtained the nationality of the People’s Republic of China upon his return to China. What is less known is that the Chinese government made elaborate arrangements to ensure his smooth arrival in Beijing when he departed for China.

On the one hand, the Ministry of Foreign Affairs sent a telegram on September 21 in the name of his father, Qian Junfu, asking Qian Xuesen to pay attention to his personal safety, saying, “I am very relieved to know that you will soon return to China. I hope you will take care of yourself and do not disembark along the way. The government will send someone to pick you up at the border station.” On the other hand, careful arrangements had been made in Hong Kong and mainland China as the situation in Hong Kong was complicated. In order to avoid unnecessary troubles, Premier Zhou Enlai instructed the Ministry of Foreign Trade to entrust the China Resources Corporation, which had a Communist background, with the

responsibility of receiving Qian Xuesen in Hong Kong. According to the recollection of Cui Zhe [24], on September 20, 1955, the General Office of the Ministry of Foreign Trade received a confidential document from Premier Zhou Enlai’s office, in which Premier Zhou instructed the Ministry of Foreign Trade to telegraph China Resources Corporation to “designate reliable comrades, together with Cai Fu and Fang Yuanhong, to transport Qian Xuesen and others. The expenses will be allocated by Zhang Ping.” (Figs. 9 and 10).

Cui Zhe immediately handed the confidential letter over to Li Qiang, Vice Minister of Foreign Trade. Under Li Qiang’s instruction, Cui sent a telegram to Zhang Ping, general manager of China Resources Company, who quickly contacted Cai Fu [25] and Fang Yuanhong of Hong Kong China Travel Service (HCT) to handle this matter. HCT was specifically responsible for this matter because HCT staff was more complex, with Chinese Communist Party members, members of Kuomintang and some old gang members, making it suitable for this task in the direct intervention and communication with the British Hong Kong authorities and various forces in Hong Kong. HCT had no experience of transporting such an important and sensitive patriot as Qian Xuesen. As Cai Fu recalled later, both China Resources Company and

Fig. 9 Telegram sent to Qian Xuesen in the name of Qian Junfu by the Ministry of Foreign Affairs (the original is in the archives of the Ministry of Foreign Affairs)

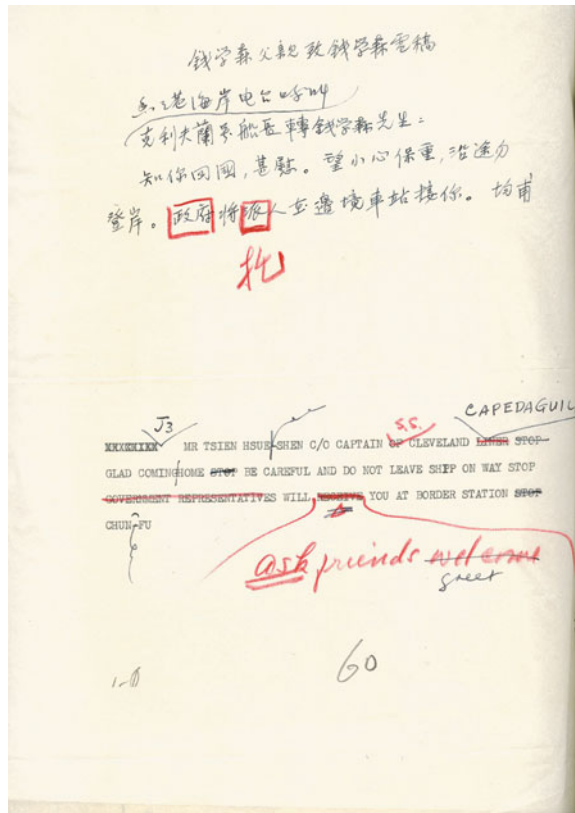




Fig. 10 Family photo of Qian Xuesen on the steamship *President Cleveland*

HCT took the same responsibility in the coordination to ensure Qian's safe arrival in Shenzhen, Guangzhou Province.

Subsequently, China Resources Company and HCT worked out a set of safe and reliable pick-up and drop off plan. China Resources Company would send its own personnel to get in touch with Qian Xuesen before docking of *President Cleveland*. This would require coordination with Hong Kong shipping industry, customs and immigration departments of Hong Kong British authorities. Due to the complicated situation in Hongkong, Qian Xuesen was suggested not stop in Hong Kong. Zhang Ping, general manager of China Resources Company, would book the train tickets for Qian's family from Kowloon to Shenzhen on October 8.

On September 27, the State Council sent Zhu Zhaoxiang of the Chinese Academy of Sciences to Shenzhen to greet them and asked the Guangdong Provincial People's Committee to help with accommodation and food arrangements. On the early morning of October 8, when the *President Cleveland* approached Hong Kong, the family was met by HCT. They boarded a yacht sailing directly to Kowloon. Then they took train from Kowloon to Shenzhen through Luohu Port. In the letter to Bao Shixing and Gu Mengchao on November 10, 1998, Qian Xuesen recalled vividly, "I crossed the Pacific Ocean by passenger ship in 1955 and landed in Kowloon. Shenzhen was the first city in the motherland after being stranded in the United States for 20 years. I remember the excitement of seeing the five-Star Chinese red flag and the statue of Chairman Mao right at the border!"

On October 9, Qian Xuesen boarded a train for Guangzhou, a southern metropolis on the banks of the Pearl River. He visited the Peasant Movement Training Institute and the Soviet Union Economic and Cultural Achievements Exhibition. In Shenzhen, Qian had gained some perceptual knowledge and direct experience about socialist China. He also purchased *Constitution of the People's Republic of China* and *The First Five-Year Plan of the People's Republic of China for Developing the National Economy (1953–1957)*. On October 10, accompanied by Zhu Zhaoxiang, Qian Xuesen and his family boarded the train to Shanghai and arrived in Shanghai. His father, now 74, met him at the train station on October 12. Afterwards, all the family members went to his childhood home of Hangzhou to pay respect to his deceased mother and to sweep her grave, while meeting with relatives and friends (Fig. 11).

During Qian Xuesen's stay in Shanghai, he returned to his alma mater, Jiaotong University, on October 22 and 25 for visits and talks. The symposium held on October 25 were attended by more than 30 people, including the provost, department chairs, and faculty deans, and was chaired by the Mr. Chen Shiyong, who was then the vice president of Jiaotong University. In the symposium, Qian Xuesen explained the difficulties encountered in the scientific researches by citing his personal experience in the United States, and he pointed out that China's science and technology would surely have a bright future and will surpass the United States one day.

On October 28, Qian Xuesen and his family finally returned to Beijing, the capital of People's Republic of China. A delegation of twenty distinguished scientists greeted him at the station. The group included Wu Youxun, Hua Luogeng, Zhou Peiyuan, Qian Weichang and Zhao Zhongyao and others in the Chinese Academy of Sciences. Two days after their arrival in Beijing, Qian Xuesen and his family visited Tiananmen Square, feeling so excited in front of the flying five star flag. On November 1, Guo Moruo, president of the Chinese Academy of Sciences, presided a welcome dinner for Qian at the Beijing Hotel. Zhu Kezhen, who had met Qian Xuesen eight years ago and was now vice president of the Chinese Academy of Sciences, also attended the dinner. Zhu Kezhen wrote in his diary: "I haven't seen Qian Xuesen for seven or eight years. He looks a litter older than his age at 43. He must have suffered a lot from the detaining and surveillance in the United States." Qian also met Mr. Chen Shutong, his father's teacher. Thirty years later, he recalled with passion:



Fig. 11 A group photo of Qian Xuesen with his family in Shanghai after his return to China (the first one on the right is Qian Yuehua, Qian Junfu's goddaughter)

In 1955, our family was able to return to the motherland which we dreamed day and night. I am much grateful to my Mr. Shutong, who helped us at the critical moment. The Communist Party of China led all Chinese people to establish the great People's Republic of China and China was no longer a target of bullying [26].

Qian Xuesen was exceptionally moved to see the full enthusiasm of domestic scientists during his short time back in China, which made him feel the care and attention of the Chinese Communist Party for the cause of science and scientists. In an interview with *People's Daily* reporter Bai Sheng, he said:

I have just returned to my motherland and still have a lot to learn. I am willing to fully contribute to our country with my research achievements over the past 20 years and to train young research scholars for my country [27].

Soon after his return to China, Qian Xuesen was appointed as the director of the Institute of Mechanics of the Chinese Academy of Sciences, presiding over and leading the research of mechanics in China. Qian Xuesen knew that his work would not be limited to the Institute of Mechanics, but that a major national project was waiting for him.

5 A Declassified Confidential File

On December 11, 2011, a library dedicated to the memory of Qian Xuesen was opened at the Xuhui Campus of Shanghai Jiaotong University, where he once studied. This is the largest memorial hall for scientists in China, and it is a national patriotic education base and a national science education base. On the opening day, a top-secret file was published in full for the first time. This top secret file was entitled the *Opinions on the Establishment of China's National Defense Aerospace Industry* (hereinafter the *Opinions*), drafted by Qian Xuesen, which laid the foundation for the brilliant course of China's aerospace industry.

Trips to Northeast China

From October 30 to November 11, 1955, Qian Xuesen visited research institutions and universities such as the Chinese Academy of Sciences, Peking University and Tsinghua University to learn about the scientific achievements since the founding of People's Republic of China. Arranged by the State Council, Qian Xuesen made a special trip to the three northeastern provinces to comprehensively evaluate the feasibility of developing aerospace industry. The telegram sent by the State Council on November 20 to the three northeastern provinces and relevant institutions stated: "Qian Xuesen's expertise lies in mechanics, automatic control, aeronautical engineering and so on. It will be helpful to his future research in knowing about our country's current construction and technical level."

From November 22 to December 21, Qian Xuesen visited cities, institutions and factories in Northeast China proposed by the State Council as follows:

Harbin: Harbin Institute of Technology, Institute of Civil Architecture, Academy of Sciences, Automatic Electric Heating Factory, Linen Factory, Measuring and Cutting Tools Factory, Mechanized Farm;

Changchun: Institute of Mechatronics, Institute of Applied Chemistry, Instrument Museum, No. 1 Automobile Factory, Northeast People's University, Chinese Academy of Sciences;

Jilin: Xiaofengman Hydropower Station, Northeast Institute of Technology, Institute of Metals of Academy of Sciences, Machine tool factory, Pneumatic tool factory, heavy machinery factory, smelter and agricultural cooperative;

Fushun: open pit coal mine and oil plant;

Anshan: Angang Steelmaking Plant;

Lüshun and Dalian: Dalian Institute of Technology, shipyard, Institute of Petroleum, Chinese Academy of Sciences;

In addition to the above-mentioned institutions and factories, Qian Xuesen also took the initiative to visit the Harbin Military Engineering Institute. Through the visit and discussion, Qian Xuesen gained a general picture of the country's industries and the foundation of China's aerospace industry. Later, he wrote in the *Opinions*:

Our aerospace industry is currently rather weak. We have only recently moved from the stage of aircraft repair to the aircraft production, and have an aircraft factory and one jet propulsion plant built. But these two factories are now completely dependent on the drawings supplied by the Soviet Union, and are not yet able to design new aircraft by ourselves, much less to conduct engineering and scientific research for design purposes. As for missiles and rockets, we do not have them at all.

We are also short of materials used in aerospace industry. There is only one aluminum plant with an annual capacity of 20,000 tons. We still have to import the specialized metals from foreign countries. The electronic equipment factory has just been established and is not yet ready to produce all types of spare parts.

As for aeronautical research, we only have some wind tunnels and experimental equipment mainly for teaching purposes. We don't have any equipment used for research, let alone large equipment for design research. So we have absolutely no aerospace research. We are short of researchers and scientists. In terms of mechanics, it is estimated that there are 180 teaching staff in mechanics in the country. Among the senior researchers of mechanics, only about 30 are the most capable and can do leadership work. The number of aerospace researchers, only a part of the mechanics researchers, is even smaller.

Overall, Qian Xuesen concluded from his trip to the northeast provinces that the foundation of China's aerospace industry was very weak. Was it possible for China to develop missiles totally on itself? A conversation between Qian and Chen Gang, director of the Harbin Military Engineering Institute, on Nov. 25 answered this question. Chen Gang asked: "Could China develop missiles?" Qian Xuesen replied, "Why not? If foreigners could do it, why couldn't we Chinese do it? Are the Chinese weaker than the foreigners?" Chen Gung said, "Good, this is the answer I am expecting." Qian Xuesen's confidence came from the fact that during his visit, he found that although China's scientific and industrial foundation was extremely weak, it already had the "sparks" for missile development. The conversation between Chen Gung and Qian Xuesen was widely circulated and set the stage for Qian Xuesen to write and submit the *Opinions* to the central government.

The drafting of the *Opinions*

After Qian Xuesen returned to Beijing, he visited Minister of National Defense Peng Dehuai, who was hospitalized due to illness, accompanied by Chen Gung and Zhu Zhaoxiang on December 26. During the conversation, Peng Dehuai revealed that what China urgently needed at present was anti-aircraft rockets, followed by rockets for maritime targets, which were required to be able to hit objects as far as 300–500 km. During the conversation, Peng Dehuai directly asked Qian Xuesen: "Could we build a missile with a range of 500 km by ourselves? What human and material resources would the development of such a missile require? How long was it estimated to take

to build it?" Why did Peng Dehuai ask whether a missile with a range of 300–500 km could be developed? This was mainly in response to the military threat of Taiwan, because this distance is comparable to the width of the Taiwan Strait, which is about 200-km wide in the north and 410-km wide in the south. If a missile with a range of 500 km could be developed, the entire Taiwan would be within the range, thus effectively suppressing the military threat from Taiwan.

No information was available on how Qian Xuesen answered Peng Dehuai's question, but a conversation between Qian and Wan Yi (then head of the Equipment Planning Department of the General Staff of the People's Liberation Army) on December 27 provided an answer. Qian Xuesen said that the development of missiles with a range of 300–500 km "was within two years from the development of trial production to industrial production, but this only solved 20% of the problem; the automatic flight controller was more difficult, accounting for 80% of the whole task and it might take ten years to develop automatic flight controller without outside help." Qian Xuesen followed up with a detailed discussion of technical personnel, institutional set-up and capital investment, and suggested that the Military Commission should discuss and resolve to start the research work on this weapon." Subsequently, Wan Yi immediately reported to Peng Dehuai the contents of this conversation.

In February 1956, Qian Xuesen and Jiang Ying, accompanied by Chen Gang, were invited to the home of Marshal Ye Jianying, Vice Chairman of the National Defense Commission. During the meeting, the topic of their conversation was still how to develop missiles. Ye Jianying's goddaughter Dai Qing later recalled in *My Godfather—Ye Jianying*, "When I was a student in junior high school and one day, my father invited Qian Xuesen and his wife to dinner, who had just returned from the United States. Before the guests arrived, he was extremely happy to tell the children that the incoming guest was a remarkable scientist who was researching a kind of bomb that could chase the flying airplane."

Qian Xuesen then received a special assignment from Premier Zhou Enlai, and was received by Zhou Enlai and Chen Yi on February 16, 1956. Also present were Fan Changjiang, deputy director of the State Science and Technology Commission, Zhang Jiafu, vice president of the Chinese Academy of Sciences, and Liu Jie, Vice Minister of Geology. On February 17, Qian Xuesen began to write the *Opinions on the Establishment of China's National Defense Aerospace Industry* in accordance with Premier Zhou Enlai's commission. Qian Xuesen later recalled:

Marshal Ye invited me and my wife to dinner at his home, probably on Saturday night, and Chen Geng was also there. After dinner, they said we would meet the Premier who was dancing at the Three Seats Gate. We went there, and Marshal Ye and Chen Gung talked with the Premier. Then it was probably settled, and the Premier gave me a task, asking me to write the *Opinions* on how to organize this research institution. Then I wrote the *Opinions* which was discussed in a meeting held in the West Flower Hall, and decision to engage in missiles was thus made.

The nine pages and 2,700 words of this *Opinions* are divided into four sections: several parts in aerospace industry, the organization of the aerospace industry, the current situation in the country, and the development plan. At the start, it emphasized that the development of missiles was not simple production of military weapons, but

the need for “a sound aerospace industry.” So, what exactly does this sound aerospace industry entail? The *Opinions* proposed four conditions from the perspective of system engineering and functional division of labor: a leading agency, scientific research, design research and production plants. Subsequently, Qian further analyzed the respective responsibilities.

1. Leading agency

The leading agency that Qian Xuesen referred to was not purely administrative, but “an agency for comprehensive planning and arrangement, which should include scientific, engineering, military, and political personnel” and was proposed to be located in the Ministry of Defense. This recommendation was related to the national situation, as the development of missiles required a coordinating body to ensure the cooperation of different institutions. This suggestion was quickly implemented, and on May 26, 1956, when Zhou Enlai announced the development of missiles on behalf of the CPC Central Committee: “More people should be mobilized to help and support the development of missiles. The technical experts and administrative cadres needed for this work will be drawn from the parts of industrial construction, higher education, scientific research, and the military, and the military should play an exemplary role.” Accordingly, in July 1956 the Central Military Commission approved the establishment of the Missile Administration Bureau (the Fifth Bureau of the Ministry of National Defense) as the leading agency for the work of developing missiles.

2. Scientific research

Missile development is not only an engineering project, but also involves applied mechanics, explosive mechanics, materials science, chemistry, electronics, cybernetics and other theories. The *Opinions* suggested that these theoretical studies could rely on the Chinese Academy of Sciences as it put:

The research work of the Institute of Mechanics in the Academy of Sciences is more or less related to the aerospace industry, and other institutes in high-temperature materials research, electronics research, computer research and so on, are also closely related to aerospace industry. In the future, new institutes will be established to promote researches in certain areas, such as the Institute of Aerodynamics and the Institute of Automatic Control. It is estimated that there will be 600 researchers working in this area when the whole system is completed, of whom 120–150 will be at the level of candidate doctor or above.

Qian Xuesen’s first position after his return to China was the director of the Institute of Mechanics of the Chinese Academy of Sciences. During his tenure as director, the Institute of Mechanics undertook a considerable number of missile development tasks and made great contributions to the development of Chinese aerospace. Later, Qian Xuesen also served as the director of the Fifth Research Institute of the Ministry of National Defense, effectively coordinating the division of labor and collaboration between the Fifth Bureau of the Ministry of National Defense and the Chinese Academy of Sciences.

3. Design research

The main task of the design study proposed by Qian Xuesen was “to produce new products in the trial production and conduct test flights. In this section, Qian Xuesen answered Peng Dehuai’s question about the human and material resources needed in developing the missile. Qian Xuesen estimated that the entire system would require about 6,000 technicians, including 500–600 candidate doctors or more, and a site of 200 km². The *Opinions* proposed that the institution could be called Aviation Design Institute and be divided into the following institutes according to its mission: Aerodynamics Institute, Materials Research Institute, Fuel Research Institute, Structural Research Institute, Rocket Propulsion Research Institute, Ramming Propulsion Research Institute, Turbine Propulsion Research Institute, Control System Research Institute, Application Research Institute, Design Bureau, Pilot Plant, and Test Flight Station. This recommendation was implemented and executed. The Fifth Bureau of the Ministry of National Defense was established on October 8, 1956, and its subordinate institutions were set up in general accordance with the *Opinions*.

4. Production plants

The *Opinions* noted that the eventual production of finished missile weapons would also require “a series of plants in the aerospace production, which could manufacture the new designs massively.” Specifically, these production plants would include metal plants, non-metal material plants, electrical manufacturing plants, fuel plants, and various parts plants. Most of these factories were under the leadership of the Second Ministry of Machinery Industry, and would be coordinated through a lead agency located in the Ministry of Defense. This was one of the reasons why Qian Xuesen proposed to locate the leading agency in the Ministry of National Defense, which facilitated the coordination of related institutions.

Obviously, these four conditions are the four “small systems” that together make up the “big system” of missile development which explain to the central government the conditions needed to carry out missile project. For these four conditions, the first one is relatively easy to achieve. For the other three conditions, i.e., research, design, and production, it was more difficult due to the unevenness of their respective bases and development. Qian Xuesen proposed a basic principle: “Research, design, and production went hand in hand. But at the beginning, the focus was on production, then on design and research.” This idea later proved to be correct. Only by improving the factories’ production capacity could we provide materials and spare parts for design work. The Chinese Academy of Sciences had already gathered a group of accomplished scientists and accumulated some theoretical research results.

Relying on foreign aid or independent development

Qian Xuesen had studied in the United States for twenty years and made extraordinary research achievements in the field of aeronautical engineering, aviation science and other areas. Based on his experience, Qian Xuesen believed that the development of missiles would take twenty to thirty years without outside help as he pointed out that “China must win over the help of the Soviet Union and other countries.” At the

time Qian Xuesen drafted the *Opinions*, China and the Soviet Union were negotiating assistance for Chinese weapons development projects, including missiles. Therefore, it was specifically pointed out in the *Opinions* that in order to develop a successful missile in a short period of time, “we must enlist the help of the Soviet Union and other sister countries.” It was for this reason that Qian Xuesen visited the Soviet Union in 1956 to see what specific assistance the Soviet Union could provide. Therefore, the *Opinions* suggested that domestic aerospace researchers and corresponding military and political personnel should be selected as soon as possible to organize visiting delegations to the Soviet Union and other countries in the near future and to discuss cooperation proposals.

Also, the *Opinions* expressed an extremely important point, “Relying on foreign aid was not a long-term solution, and China must have the full capability to develop missiles.” Objectively speaking, Soviet scientists and technicians played a role in China’s missile development, but the fundamental reason for China’s success in developing missiles after the withdrawal of Soviet aid in 1960 was that China chose the path of independent development from the very beginning of its missile project, and the key was to gather a group of “senior talents” into this project. In the *Opinions*, a list of senior scientists was selected as follows:

Aerodynamics: Shen Yuan, Lu Shijia, Zhuang Fenggan, Luo Shijun, Lin Tongji, Pan Liangrun;

Aerostructure: Wang Junkui, Qian Weichang, Wang Ren, Du Qinghua, Hu Haichang, Qian Lingxi, Zheng Zhemin, Li Minhua and Fan Xuji;

Propeller: Wu Zhonghua, Chen Shihu, Liang Shoupan;

Control system: Luo Peilin, Lin Jin;

Rocket: Ren Xinmin

These scientists were the pioneers and laid the foundation for China’s space industry. A detailed personnel training objectives were laid down in the *Opinions*. Year by year, the research work of the Chinese Academy of Sciences related to aerospace would be expanded, reaching the number of 600 people in 1967. According to the above development plan, the number of graduates from aerospace related departments of higher education institutions was needed every year as follows:

In 1956: 400 (100 in craft, 300 in design);

In 1957: 400 (complete craft);

In 1958: 400 (complete craft, starting missile manufacturing)

In 1959: 600 (complete design, starting work in aviation design institute);

In 1960: 700 (100 in craft, 600 in design);

In 1961: 700 (100 in craft, 600 in design);

In 1962: 800 (200 in craft, 600 in design);

In 1963: 800 (200 in craft, 600 in design);

In 1964: 800 (200 in craft, 600 in design);

In 1965: 800 (in craft, 600 in design);

In 1966: 900 people (300 in craft, 600 in design);

In 1967: 900 (300 in craft, 600 in design);

By 1967, there will be 2,400 technicians in factories and 5,700 technicians in design institutes.

Since then, the Chinese Academy of Sciences, colleges and universities, and other research institutions have set up majors to train personnel in aerospace science research and design. Moreover, Qian Xuesen himself taught the course of *Introduction to Missile* and weekly workshops were held at the Institute of Mechanics. At the time he drafted the *Opinions*, the State Council was formulating a twelve-year scientific plan from 1956 to 1967, and included jet and rocket technology as one of the key development projects. By placing the timing in 1967, Qian Xuesen was able to incorporate the missile development program into the national scientific development plan, thus gaining the greatest support and input from the state. At the very start, the missile development work was a top-down national project which has received full support and active cooperation from the central government as well as from the military industry, universities, research institutions, factories, and other systems since it was launched.

On February 22, Premier Zhou Enlai sent the *Opinions on the Establishment of the National Defense Aerospace Industry* written by Qian Xuesen to Mao Zedong for his review, with a letter stating in particular, "This was the *Opinions* I asked Qian Xuesen to write, and I was going to talk about atomic energy." On February 28, Zhou Enlai sent the *Opinions* to the Central Military Commission and the Ministry of National Defense, as well as to other Party and State leaders. The *Opinions* soon entered the implementation stage and became the guiding document for China's missile development project.

There were two major reasons that Qian Xuesen's *Opinions* in 1956 was quickly approved by the central government and used as a guiding document for missile development. For the first, as the first scientist who provided advice to Mao Zedong and Zhou Enlai who seriously listened and took concrete actions, Qian Xuesen provided the government the most important thing, the confidence; for the second, Qian Xuesen formulated a set of feasible schemes from top-level design to specific development plans, and integrated them with China's national development plan.

Qian Xuesen said very modestly: "I was ashamed to think of it now, for I did not know anything about the situation in China at that time and there must have been many shortcomings in the *Opinions*." On October 8, the central government announced the establishment of the Fifth Bureau of the Ministry of National Defense and appointed Qian Xuesen as the director, with full responsibility for missile development.

To date, China's aerospace industry has developed for more than 60 years, starting from nothing, and growing larger and stronger. It is the endeavor, dedication and efforts of tens of thousands of spacefarers, including Qian Xuesen, and even their precious lives.

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Epilogue

An era has its own theme, and a generation has its own mission. Qian Xuesen was born and grew up in the era of China's awakening and rejuvenation, and his life was deeply marked by the times.

The twentieth century was an era of "Big Science" and scientific research achievements could be shared by scientists worldwide in a short time. Because of this, coupled with the catalytic effect of the two world wars, the world aviation industry entered the "jet propulsion era" in the first half of the twentieth century after rapid development from the "propeller era", then set one foot into the "aerospace era".

In response to the trend of the times, Qian Xuesen gradually shifted his academic interests to the field of aeronautical engineering research, and then specialized in aerodynamics, solving many challenging academic problems in the field of aviation science, and gradually grew from a young scholar to a world-class scientist. At the same time, with his global vision and broad-mindedness, he gradually expanded the scope of his research to include jet propulsion, rocket boosters, atomic energy utilization, engineering science, engineering cybernetics, physical mechanics and other fields, and made academic achievements one after another, making outstanding contributions to the development of world science and technology, climbing the peak of world science.

However, what is more important than his scientific achievements is that Qian Xuesen experienced the awakening process of "scientific self-confidence: during the years of seeking knowledge. This awakening was a practical rebuttal to the modern notion that Chinese science and technology were inferior to those of others. As a student in the United States in 1937, when he heard that the Qiantang River Bridge, built by Mao Yisheng, had been opened to traffic, "I was so happy", he said. This made him realize that "In the field of engineering technology, foreigners cannot dominate the world. The Chinese can also do whatever the foreigners can do!" In 1955, Qian Xuesen visited his mentor Theodore von Kármán before he returned to China. When von Kármán said, "You had surpassed me academically now", Qian Xuesen was very excited because his twenty years of endeavor had finally been paid off and his "scientific confidence" was awakened. In a sense, Qian Xuesen's scientific achievements were a demonstration of his "scientific confidence" as a

Chinese scientist on the world stage. Therefore, Qian often said to Jiang Ying: “We should aim at the world’s advanced level of learning. Why wouldn’t Chinese people surpass foreigners?”.

For Qian Xuesen, “science has no borders but scientists have a motherland”. Born in a family of patriotic intellectuals, Qian Xuesen received modern education and good family education since his childhood, and he had some excellent teachers and friends from elementary school to university. He established a positive world view, values and outlook on life. During his early years, he set up the goal of “saving the country through science” and he was enlightened by the Communist ideology, “We could only rely on the Communist Party to save China and to unite the world.” It was for this reason that he remained steadfast in his initial thoughts during his twenty years of study in the United States and made every effort “to return to serve the country when a Communist regime was established in the motherland.”

The idea of “returning home in another day” was the initial thought of Qian’s early years of learning. In fact, in 1955, Qian Xuesen could choose to stay in the United States as the U.S. Government lifted the ban on his departure from the United States. If he had chosen to stay in the United States and teach at Caltech, he would have been able to achieve remarkable success in his academic research. But he decisively gave up the opportunity to stay in the United States, the high salary at Caltech, the good material life in the United States, and high social status and honors, and resolutely chose to return to his homeland. When Qian Xuesen was interviewed by the *Los Angeles Times* before he returned to China, he said, not without determination, “It is my earnest wish that I may help Chinese people live a life of dignity and happiness.” This was the strongest and heartfelt wish of a Chinese scientist who had studied abroad for twenty years.

Looking back at the historical era in which Qian Xuesen had lived, groups of students went abroad, and what they were pursuing was nothing but the rejuvenation of the nation and the strengthening of the country. Qian Xuesen caught up with the trend of the times, found the direction of his life, and finally became a Chinese scientist with a high reputation in the world history of science and technology. His name is recorded in the history of the Communist Party of China. As the saying goes, “If one fails to live up to the times, one will never know what a true and brilliant youth is.”