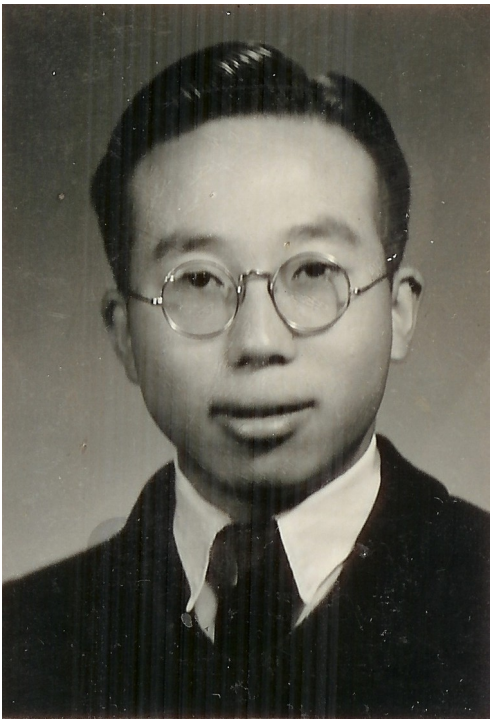
Pao Hsien Fang

方宝贤



born: 1922 6th month 25th day of farmers calendar
died: October 21, 2011

by James L. Crawford

last updated March 15, 2015

FOREWORD

I met Pao Hsien Fang rather late in his life, when he was 70 years old. He was a small, quiet person who did not make much effort to socialize. And I was more interested in his daughter, Anna, who I married. Over the next 19 years I saw him at plenty of Fang family dinners, but had remarkably few conversations with him. The first impediment was his quiet manner, which coupled with my quiet manner meant neither of us were likely to start a conversation. Second, Pao talked with an accent that I found hard to understand. Third, both he and I had hearing problems that meant if there was any background noise or other conversations going on (which of course was practically a certainty with the many people and children at the family gatherings), neither of us could hear the other speaking. Often I remember Anna had to repeat what her Dad had said. Between the accent and the hearing problem, I often knew less than half of what he actually said.

However there was a more fundamental problem: even when I understood every word, I still sometimes had no idea what he was talking about because of his grammar, syntax, and way of expressing himself. I discovered this applied to his written word also. Often, Anna proofread his papers and I would read them to see if the science made sense. Some of his sentences were so convoluted that I could interpret them in multiple ways, but I didn't know the workings of his brain well enough to know which way he in fact meant. Here is an example of the problem: in his last year, he wanted Anna and me to print out a particular photo of his uncle and frame it with the same frame as was used for a drawing of his mother. Since the photos were different shapes, we used a matte of a different width. When Anna showed him the result, he said no, he didn't care about the frames being the same size, he wanted the photos to be the same size. After a second iteration (cropping the photo to be the same size), we learned that he meant the size of the heads should be the same.

I did manage to have a few productive conversations about Pao's early life, which forms the basis of the early sections of this document. I have also looked extensively through his personal papers, letters, diaries, and old photographs. Unfortunately I do not

know chinese, so have been able to add only a little useful information from his siblings and the hundreds of chinese letters in his papers. I have also not written much about his home life once he married; his wife and ten children all know far more than I do. I have concentrated instead on his youth, his employment record, his travels, his published papers, and his patents.

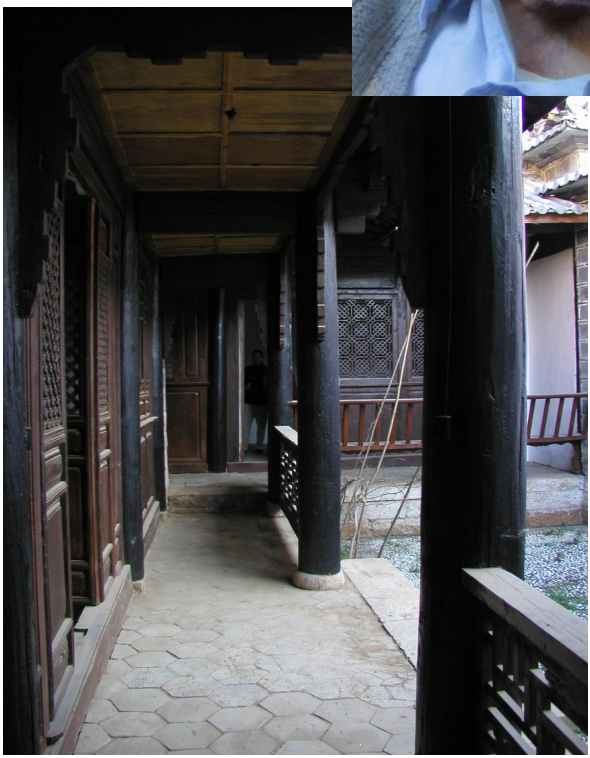
Before we go any further in Pao Hsien Fang's life story, we must come to terms with what to call him. His “milk name” or birth nickname was 阿仲祥 (“Ah Zhonxia” or “Ā Zhòng Xiáng”), given to him by his great uncle Fang Kun. Later, his name used in schools and adulthood was 方宝贤, which in modern pinyin is "Fang Bao Xian", but in the pinyin used in the 1940s was "Fang Pao Hsien". Right before he married in the U.S., he was given the Christian name "Paul Thomas Fang". He also went by the designation "brother 2", and of course was called "Dad" by his children and "Opa" (German for grandfather) by his grandchildren. So we have a lot of choices for what to call him throughout this document. I have chosen "Pao" (or "Pao Hsien Fang") first, because it was his official name as given on all his passports (Chinese and English); and second, because it is short while still uniquely identifying him, since all of his brothers are named "Bao" with a 'B'.

Jim Crawford
son-in-law of Pao Hsien Fang
October 31, 2011

In the past month I have been sorting through many folders of Pao's patent applications, business correspondence, and personnel records, and have learned enough new material to update this booklet.

Jim Crawford
March 18, 2015

Pao Hsien Fang in June, 2011



The Fang house where Pao was born. Pao's family lived in the part through the doors on the left.

PREFACE

The following is a computer file Pao printed in 2010:

Autobiography

Amid the dusk of my journey, I am writing papers of some claims, yet I am conscious to fill the other part of the journey, my credo: mother, uncle and mystic. In the vastness of cloud, the Southern Cloud to it Lijiang belong.

I was born in 1923, a leap year according to the Farmers Calender. The leap month is June. The Fire Torch Festival is on June 24, 25 and 26. My birth day is on the middle day of the Festival. Throughout my life, Fire Torch is too strong. I wish to recognize it as light from firefly.

My family just completed a somewhat larger house a short distance from the old house where my first cousin Baoshan was the first child born in this new house. The senior grandfather named the child Dao Xiang, meaning great luck. A few months later, I was born and was named Zhong Xiang, meaning lesser luck.

Nightly recitation under great uncle

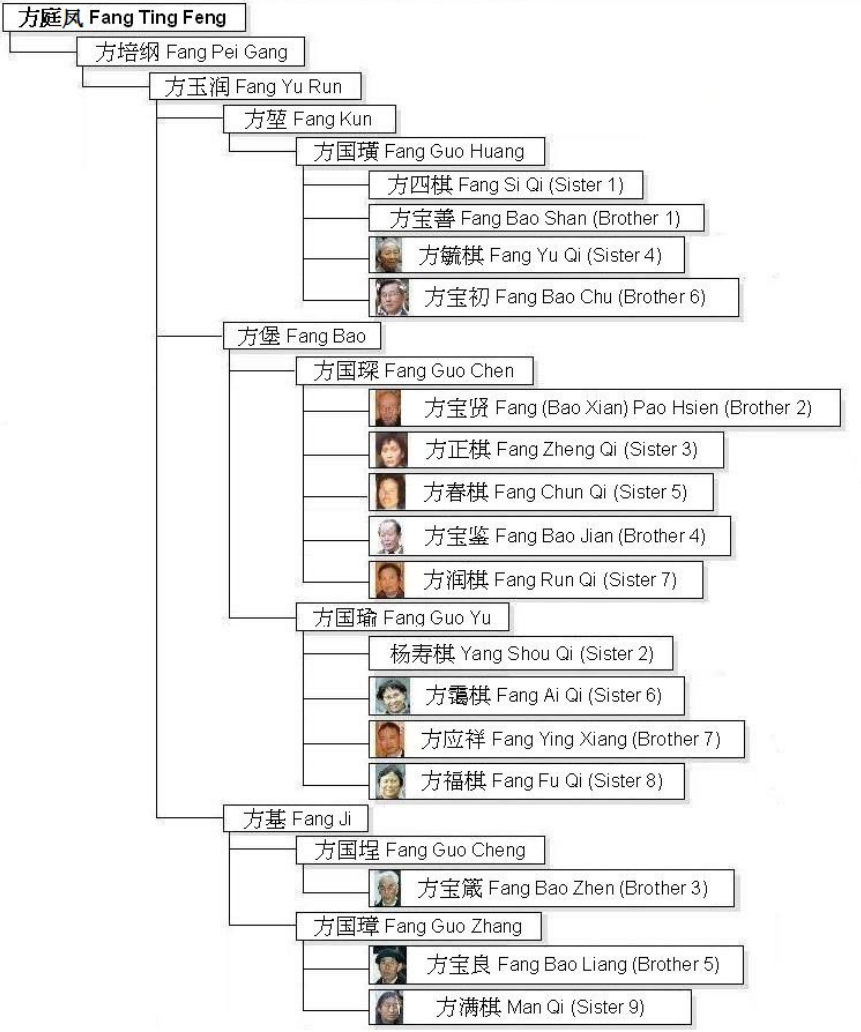
great uncle's last address

great uncle's funeral

uncle's second time to return lijiang

went to public school from previous home school

Descendants of 方庭凤 Fang Ting Feng



In the first 5 generations, sons who died young and daughters are not listed, including 3 sons in generation 5: numbers 2, 4, and 5.

CHAPTER 1 The Fang Family in Lijiang

Several papers and one book have been written about the Fang genealogy in China. Since they are all written in Chinese, I will summarize their contents to set the stage for Pao's life.

The Fang family book records 20 generations of Fangs starting in 1361. But for the first 14 generations, there is nothing more than names and children. The 15th generation included 4 brothers (the record often lists only the sons with no mention of the daughters). One of them was Fang Ting Feng, born on 1791/7/22 (this means the 22 day of the 7th month of 1791 based on the Chinese solar-lunar calendar). He was the first Fang to live in Lijiang. Prior to him, all the Fangs were Han from northeast of Lijiang. Once they arrived in Lijiang, they started marrying the local Naxi women and soon had predominately Naxi blood. Ting Feng's grandson Fang Yu Run, in the 3rd generation of Lijiang Fangs, was the common ancestor of all the Fangs mentioned in this document. He had 3 sons and 2 daughters. The 3 sons were Fang Kun, born 1872/5/11; Fang Bao born 1880; and Fang Ji born 1884. The 16 grandchildren of these 3 brothers are considered in the current extended Fang family, and are called brothers and sisters with their appropriate chronological number up to brother #7 and sister #9. Pao was brother #2. Several of the Fangs married members of the Naxi Niu family, including Fang Yu Run in generation 3, Fang Ji in generation 4, Fang Guo Chen in generation 5, and Fang Bao Zhen and Fang Bao Chu in generation 6, who married sisters.

As the oldest son in generation 4, Fang Kun was in charge of the family. He made his money from trade with Shanghai and elsewhere, and owned the house that all the Fangs lived in, including Pao's grandfather Fang Bao and wife Li ("grandmother Li"). The first member of generation 6, "sister 1", was born in 1913. This was also the year Fang Bao died. He was killed by bandits while on a boat in Vietnam. With their father dead, Fang Guo Chen and Fang Guo Yu were treated like orphans. They still lived in the house with everybody (including their mother), but were treated poorly. When Fang Kun built a new house (the house

that is now the Fang Guo Yu museum), most of the Fangs, including Fang Guo Chen, moved there. However grandmother Li remained in the old house. Shortly after the Fangs moved, the first baby was born in the new house: Bao Shan, brother 1, who the senior grandfather (Fang Kun) named Dao Xiang meaning great luck. A few months later, Pao was born in the house and named Zhong Xiang, meaning lesser luck, or second great luck.

Grandmother Li (top row on left) in the old Fang house in 1946

The room where Pao was born

Pao's mother

CHAPTER 2 Pao Hsien Fang's life in China

Pao's early life is shrouded in mystery and confusion, both accidental and deliberate. The confusion starts with his birthday. On all of his U.S. passports and official documents, it is listed as August 18, 1923 in the Gregorian calendar. In the Fang Family book, it is listed as 1923/6/25 in the Farmer's calendar. However one day in 2003 I happened to be looking at a web site that converts dates from the Chinese calendar to the Gregorian calendar, and discovered that 1923/6/25 converted to August 8, 1923. I asked Pao about his birth date, and he told me he was born in the Year of the Dog, during a leap year, on the middle day of the 3-day Fire Torch Festival. This festival is celebrated by various ethnic groups of Yunnan, including the Naxi, starting on 6/24 of the lunar calendar (or some years on 6/25). The Year of the Dog was 1922, not 1923; and in 1922, a 2nd month 5 was added, making it a leap year, while 1923 was not a leap year. 1922/6/25 converts to August 17, 1922, giving added confirmation that his birth was really in 1922, not 1923. The one-day discrepancy between his celebrated date of August 18 could be due to incorrect conversion tables, or to the Torch Festival starting on 6/25 in 1922. His Chinese passport also confirms 1922, by stating that Pao was 22 years old when the passport was issued in Nov. of 1944. Likewise, his Ohio State University transcript lists his birthday as August 18, 1922.

When Pao was born, his father Guo Chen was living in Kunming running a tea business. The first time Guo Chen came home was when Pao was 8 (his sister Zheng Qi was conceived during that trip). Pao had to go to meet his father at the station to give him some money to pay off one of the transporters and Pao was very embarrassed. His father had closed the store in Kunming due to the Depression, but he stayed in Lijiang only briefly before going to Shigu (Stone Drum) 50 miles away to work in the family store. Pao has no other memory of his father, but he must have come back to Lijiang in 1933 when Fang Kun died (Chun Qi would have been conceived then).

Zheng Qi

Chun Qi

Bao Jian

Besides bringing his father back to Lijiang, Fang Kun's death had a substanial affect on Pao's life. Up until that time, Pao was tutored at home. But without his great uncle's financial support, he had to go to the public middle school. Sometime while at middle school Pao's grandmother Li and Fang Guo Yu's first wife were kidnapped and ransom money had to be paid to free them. Pao's mother had "money" in her jewelry that was used in part. (Pao recalled this as happening during the march by the British from Burma to LiJiang, but that would be at the end of WW2 long after Pao finished middle school.

At some point Pao became engaged to somebody from Lijiang, a 1st (or perhaps 2nd) cousin on his mother's side. His mother made two or three trips after her marriage back to her mother (grandmother Su), who lived over the mountains 40 miles away. On one of these trips, Pao remembered riding in a basket with his future fiancee in a basket on the other side. When Pao was older, he had a friend in school from Tibet who had a sister. Boys were not supposed to speak to girls, especially Tibetians who were considered inferior to the Naxi for marriage, but Pao talked to the sister, which was the equivalent of becoming "engaged". This infuriated his uncle (his cousin's father) since it meant Pao was rejecting his daughter for an inferior, and the uncle came looking for Pao with a knife. Pao immediately headed for Kunming, where his uncle Fang Guo Yu lived. He was around age 14, and had just

graduated from lower/middle school in LiJiang. Simultaneously, Pao's Father moved to LiJiang (Pao's brother was born shortly thereafter in 1937). Pao never went back to LiJiang to visit because it took 18 days to walk between the cities.

Pao's uncle Fang Guo Yu graduated from high school the year Pao was born. He matriculated at the University in 1925, but was hospitalized and had to return home to recuperate. During this time home in Lijiang, he married a Naxi and had a child in 1928 (Yang Shou Qi, sister 2). In the autumn of 1929 he returned to Beijing U. where he graduated in 1933. He returned to Lijiang when Fang Kun died, and spent a year doing field work on the Dongba culture. He returned to Beijing U., and later moved to Kunming where he lived the rest of his life. In Beijing he met his second wife, Cai Jin Ruo, and their first child was born in 1938 (Ai Qi, sister 6). Cai Jin Ruo never went to Lijiang, and Fang Guo Yu never returned. Pao thought this was tragic since Guo Yu was fluent in Naxi and knew so much about the cultures in Lijiang and became a national figure due to this work. Pao became a part of the family, and in essence Fang Guo Yu became Pao's father, and was listed as such as late as 1964 on a U.S. security investigation of Pao.

Pao, Cai Jin Ruo, and Fang Guo Yu, with Guo Yu's 3 children in 1945

Pao Hsien Fang – photos taken from 1937 through 1941

Pao graduated from Middle School of Yunnan University in Kunming. While he was there he received a scholarship to attend college in the United States. The benefactor of the scholarship was Lung Yun, the rich warload of Yunnan. According to a biography of General Stillwell, Lung was rich from the opium trade. But according to Greg Weisz, Lung made his money by "owning" the silk road that went though Kunming. He required all cars over the road to have tires, and he owned the only tire factory. Plus he charged a car tax. In either case, he was rich enough to sponsor 40 students who were selected mainly by tests. Pao said the only time he saw Lung was when the prospective students were "interviewed". The students remained in one room, and one by one went into the room where Lung and his associates were. Lung didn't say anything, he just held a pen that he would use to indicate whether the student was in or out.

The 40 selected students, including 3 from Li Jiang who were Naxi, continued their studies at a newly created Yunnan Prepatory School. Pao took math, chemistry, physics, geology, and U.S.

History. It took 2 or 3 years before all the red tape was processed for passports, visas, acceptances at U.S. colleges, etc. Pao received an acknowlegement on Sept. 16, 1944 from the Ministry of Education for the National Government of the Republic of China that he had passed the final examination for the fellowship students. Two months later Pao received his Chinese passport, but passage by ship to the United States was impossible during the War, and the students had to keep waiting.


教育部發給公費留學生證書 教第29號

方寶賢年二十二歲係雲南省麗江縣人國立西南聯合大學

畢業經本部核定給予雲南省政府官費派往美

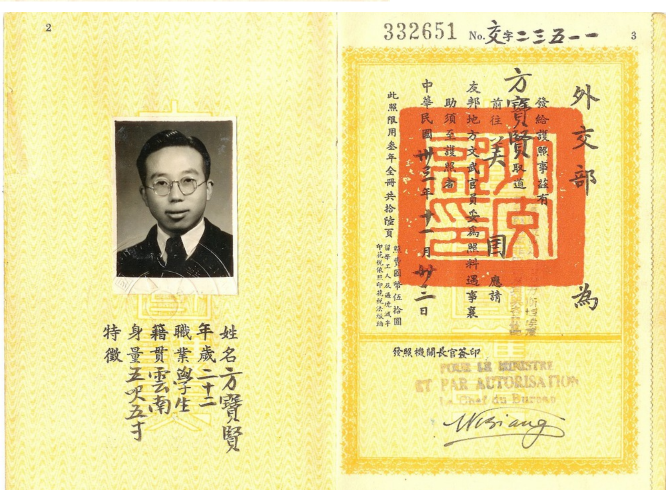
國留學合給證書

教育部部長 陳立夫

中華民國三十三年九月十六日

Translation:
The Ministry of Education, National Government of the Republic of China

This is to certify that Mr. Fang Pao-Hsien of 22 years of age, born at Li-Jiang, Yunnan Province, has passed the final examination conducted by the Ministry of Education of the National Government of the Republic of China for the fellowship students selected by the Yunnan Provinial Government for the technological studies in the U.S. This 16th day of September, 1944. Li-Fu Cheng, Minister of Education



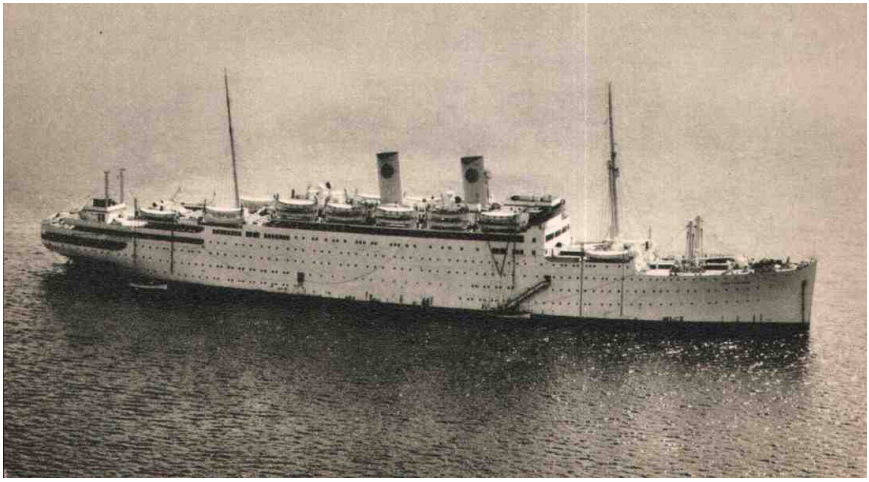
Pao's Chinese passport issued November 11, 1944

The Yunnan scholarship students; Pao is the 6th from the left in the top row

Pao middle row on right; photo taken June 12, 1945 in Calcutta

CHAPTER 3 Trip to the United States

Pao received visas from both the British and United States governments in May, 1945, and flew from Kunming to Calcutta on June 2. There the students were in limbo, waiting for a ship that could take them further west. Pao wrote each day in a diary, in English because of his fear of Chinese censorship. He wrote that he spent his last night in China at Shau-lung's home, and then went to the air field with Shau-lung. His uncle also came to the field to see him off. The students traveled in a very uncomfortable Flying Tiger plane, 20 people on 2 benches, and very messy because a quarter of the people threw up. The flight took 2-3 hours over mountains to a small town on the border of India. After refueling they flew on to Calcutta. Pao was in Calcutta for one month, passing the time reading (Newtonian Attraction), walking, watching movies, listening to classical music (Beethovan or Wagner), visiting zoos and colleges, or writing letters to "Chi-shu" (perhaps "Qi-zhu"). Pao complained of a skin disease, of the humidity, and of spending his money too quickly.



MS Gripsholm sailing under the Swedish American Line

On July 2nd, they finally recived word that a boat was available, and Pao took a 3-day train to Bombay. Pao had to hurridly board the train without having lunch, and had very little food on the train.

Rumours of good Chinese food in Bombay led him to further food disappointment when the train pulled right up to the docks and he had to immediately embark on the Swedish ship Gripsholm. He spent the first week on the Indian Ocean in the deepest birth of the hull where the noise and his sea-sickness made him miserable. After a week he was able to swim, eat, read physics, listen to the piano, and try to compose music. The boat arrived at Suez on July 15, Greece on July 19, and Gibraltar on July 24. The rough seas of the open Atlantic Ocean saw a return of his sea-sickness, which lasted for most of the crossing.

On August 2 the ship docked in New York City, the first commercial ship to cross the Atlantic after the war. Pao wrote: "2 is a great day to us. The second day of June we left Kunming, & then the second of July left Calcutta, so the second of August we'll leave Gripsholm & so will arrive the land of free. How beautiful this first impression of which comes to my sight, the Statue of Goddess of Liberty --- & wonderful symbolisim." Pao was extremely tired, and more interested in heading on to Ohio than to experience the big city. He did attend a couple parties at the China Institute, and saw his first broadway operetta, "Song of Norway". Throughout his trip over and his first months in America, music was his constant companion. He rarely mentioned interactions with other people, but often wrote about music, whether it be critiques of Indian or Greek music, or times when he listened to the classics.

The 40 students dispersed to different colleges throughout the United States, but Pao kept in close touch with at least two of them through dozens of letters: Shao Lung and Chen Ping. The others he saw at reunions; the last reunion he attended was in New York in 2005.

CHAPTER 4 Life in the United States

Pao was the last of the fellowship students to leave NYC on August 8. He was on an overnight train that arrived at Ohio State University in Columbus, Ohio, early morning on the 9th. A Chinese student met him at the station, and his introduction to the university, which had 5 other Chinese students, was smooth. He lived in International House, which he thought was loud but interesting to meet students from so many countries. He was very appreciative of his new American life, whether it be the quality and abundance of radios in restaurents, or the graciousness of a Sunday afternoon dinner hostess who made everyone feel at ease, or the home of the church's minister who actually cultivated the land himself. In his first shopping trip he bought 4 classical records.

A few weeks after his arrival in Ohio, Professor Alice Robinson of the Fine Arts Department called the Director of International House to find a student to help her with small tasks such as cleaning her studio and mowing her lawn. The Director chose Pao, and as he wrote years later in a letter:

> *"It was such a curiosity for me to work, to earn some money for the first time in my life. I remember I indeed took upon myself the task of work, and physically, as I was even less strong then than now.[1] I was so tired, that I had to get a taxi-cab to come back home, which, I remember distinctly, cost me more than the 'wage' I earned."*

Professor Robinson took a motherly interest in Pao, and when he complained to her about the noisy atmosphere in International House, she introduced him to Professor Henderson. Again, from the same letter, Pao wrote:

> *"When I went to see Professor Henderson with Professor Robinson, he told me about his memories of an oriental journey with Mrs. Henderson, who had just passed away. So two days after Christmas 1945, I moved to a small room in the third floor of the house of Professor Henderson. His sister and brother-in-law, Professor McPherson, gave me a wel-*

[1]Pao was 5' 7" and weighed 135 lb at this time. By 1961 he weighed 148 lb.

come picnic in their backyard, which was just two houses away. Now I found myself in personal relationship with both authors of "College Chemistry", a textbook I had in China. Professor Henderson wanted to know all the new subjects I had learned in the school. He showed concern in me, and he was angry when I tried to buy an expensive camera. When spring came, he took me with his special automobile to visit the grave of his wife several times. He explained to me German music as he listened to Wagner on the radio.... He was furious once, when I came back home rather late. But he was so kind, and I cannot forget in all my life, when I had once, during the summer of 1946, a medical operation at the University Hospital. In spite of his lameness and difficulty to walk, he paid me daily visits with my mail and a small flower from the garden....

After I came out from the hospital, I did not go back to the house of Professor Henderson. My post-operative condition rendered me to walk with difficulty, and my room was on the third floor. Also, it was a very hot summer, and I remember the maid refused to come upstairs to give me bed linen.... I was afraid of the maid: a colored lady of rather small physical stature, but she used to scold Professor Henderson with all her fierceness.... I tried to call by telephone to make an appointment [to see Henderson on one of my return trips to Ohio] but the same maid I described above, answered the phone; she was not kind to me and would not let me see the Professor....

At OSU, Pao started studying ceramic engineering, as that was the field specified by his fellowship. He did terrible in it, and his teacher thought he was terrible. His first three quarters were filled with C's, D's, and E's. In fact, he was automatically suspended from the college after he got three E's in the spring of 1946. He was again suspended after the fall quarter, but each time was successfully able to petition for reinstatement. Pao sent a letter to China to request a change to physics, but after 2 months the reply was "no". He transferred from the Engineering Dept to the Arts department in October 1946, and for the following year took mainly physics and music courses. Because he earned advanced credit from his Yunnan Preparatory Academy, and he took courses during the summer, Pao was able to graduate with a Bachelor of

Science in just over 2 years, on December 19, 1947. He then transferred to the Graduate School, and on September 3rd, 1948 he received a Master of Science degree. His dissertation dealt with the experiment of the high frequency gas and metal vapour discharge.

His scholarship ended when China was taken over by the Communists around 1947 or 1948. He was able to stay in the U.S. after receiving his master's by getting jobs. First he moved to Syracuse U. in N.Y. where he worked for a professor he had corresponded with. From there he went to the U. of Minnesota (agriculture school) doing math calculations on a "calculator" that would take hours for each calculation. He had gone to Minnesota to meet Tang (a friend who lived in Hong Kong), to go back to China together. After 8 months in Minnesota, he returned for half a year to Syracuse U. Finally he moved in September 1950, to Catholic U. in Washington D.C. to work/study for Prof. Karl Herzfeld, a physics professor from Austria.

Pao arrived there within weeks of when his future wife, Josephine Riss, arrived. They met by chance when he happened to stop in her building to ask directions. When she responded in her accented voice, he asked where she was from. Once he learned she was from Vienna, he started talking about Beethoven, and the following day he found her and presented her with a copy of Time Magazine, which showed on the cover the newly restored Vienna Opera House. They connected through music, and within half a year they were married March 31, 1951. He worked in a basement lab, while his professor worked on the second floor. He would get calls from Josephine, and since there were no phones in the basement, somebody would yell down "Dr. Riss (pronouncing it Reese) on the phone".

Around this time Pao was told he had to go back to China if he got a job, but then the next year (which he thought was the start of the Korean War) he was told that he could not return to China under any circumstances. His Chinese passport was renewed in 1947 for 2 years, in 1949 for 2 years, but in 1951 for only 1 year. By 1952 Pao was granted permanent residency in the U.S. as a refugee from the Communist takeover of China. Two years later,

on March 9, 1954, he became a naturalized citizen. From 1952 until 1968 he had no communication with China, and did not learn of his parents deaths until he returned to China in 1971.

Always the perfectionist, Pao wanted to keep working on his dissertation and only finished it after much prodding from his adviser and wife. He received his PhD on June 9, 1953. He continued his work in the lab for another year as a Research Assistant. He worked for $2 an hour for Dr. Pulvari, who had a contract with the Air Force for a research project. During that time he wrote letters to many colleges and businesses inquiring about job possibilities. He accepted a position as a Project Engineer with Philco Corporation in Pennsylvania starting June 1, 1954, at a salary of $533.33 per month. He was now 32 years old, a U.S. citizen with a PhD, married with two children. He applied for his first patent while at Philco, although it wasn't actually granted until 1958.

After two years with Philco, the growing family (now 4 children) moved back to Washington where Pao again worked at Catholic University as a Researcher. He listed his reason for leaving Philco as "desire for basic research". He was not long at Catholic U. before starting on a 14-year stretch of working for the federal government. In October 1956 he joined the National Bureau of Standards (NBS) to conduct research in ferroelectricity. Within the year he presented his first talk at a scientific conference (a meeting of the American Physical Society in Philadelphia), and published his first scientific paper in the Physical Review. In his seven years of employment with the NBS, he published 21 papers in physics journals such as Physical Review (7), Journal of Applied Physics (3), and Physica (2). One paper was published in the Journal of the American Ceramic Society, probably as close as he ever got to the ceramic engineering studies mandated by his original Chinese fellowship. He served his last year with NBS as a Federal Government Fellow at the Institut Fourier, in Grenoble, France. Since he was traveling on official U.S. business, he was issued a "Special Passport". The passport was renewed twice through 1965, and was used by Pao for two additional trips to

Europe in 1962 and 1964.

Pao started his next federal job on November 13, 1962 working at NASA's Goddard Space Flight Center in Greenbelt, Maryland, as a Section Chief and Division Consultant. Here his research switched to materials science, with a heavy emphasis on solar cells. In eight years working for NASA Pao published 45 papers and received his second patent. In 1968 he had the option of moving to NASA's Electronics Research Center in Cambridge, Massachusetts, or to NASA's Jet Propulsion Laboratory in Pasadena, California. He made the fateful decision to move the family, now with 10 children, to Massachusetts; due to politics, the center shut down in 1970 and Pao's days of working for the federal government were over.

Pao returned to academia where he became a Research Professor in the Department of Physics at Boston College. The college provided him with lab space, but his salary was paid for out of his grants with the National Science Foundation, the Air Force, and the Dept. of Energy. These grants started drying up in 1975, and by 1978 his lab at Boston College was moved to a much smaller space. The college also decided that since he was only a Research Professor with no possibility of tenure, that his children could no longer attend Boston College at reduced tuition. During his time at Boston College, he published 62 papers, the majority pertaining to solar cells.

Finally, in 1992, Pao left the college and created his own company, F. S. Labs, in his basement. He had an impressive amount of equipment in his basement and garage and was still able to carry on research, although he excelled more at theoretical calculations. He was able to obtain a few small government grants, and he travelled often to China, where he obtained support from Yunnan University. Pao wrote another 17 papers while working at home, and was still writing clear up until his death in 2011.

In all, Pao had 149 papers published in scientific journals, and dozens more reports and abstracts in university, government, and conference publications. He also wrote over 25 patent applications

and was granted nine U.S. Patents and at least one French Patent and one West German Patent, and perhaps others in China and Japan. The diversity of subjects covered by his patent applications is astonishing. Although a large number are for solar cells, other topics include ceramics, seat belts, semi-conductors, super-conductivity, cold fusion, growing diamonds, tobacco, fullerene, and Ginkgo leaf tea. Pao was the sole inventor for most of his patent work, although he collaborated with others at NASA for his first solar cell work; with Robert S. Roth and William S. Brower of NBS for his ceramic work; with Thomas K. Tsao for his seat belt work; with Xin Luo and Nianling Zhu for his tobacco work; with Welville B. Nowak for his first diamond work; and with Allen R. Kirkpatrick for his last diamond work. Starting in 1972, all of his patent work was handled by one attorney, Richard J. Birch. To fund the legal costs associated with so many applications, Pao and Birch entered into a relationship where Pao assigned 35% of any royalties earned from his patents to Birch, in addition to mailing him checks to cover some of the costs. I am not aware of any royalties that were ever made, but there were negotiations with companies (such as Sharp Corp. in Japan) to sell one or more of the patents.

One of the most interesting (and non-scientific) stories of Pao's work involved his efforts to obtain a seat belt safety switch patent. Seat belts became a standard feature in American cars around 1958. However seat belts are only effective if they are used, and even with large public service campaigns in the 1960s to educate drivers to wear seat belts, there were still far too many injuries and deaths of people not wearing their belts. By 1970 there was talk of developing ways to force people to wear seat belts, or to provide air bags to make belts obsolete. Over a half dozen patents were granted to people in the late 1960s for electrical connections that would prevent a driver from starting the car without the seat belt attached. In spite of the competition, Pao thought he had a better method and submitted his first seat belt application in 1970 with Thomas K. Tsao, who must have been a former colleague of Pao's at NBS or NASA. At this time Pao lived in Belmont, and Tom lived in Maryland, so most of their collaboration was by mail.

Their lawyer was Walter S. Pawl, who was in the D.C. Area. The first application was rejected more for the style of the application than for the content (e.g., too many indefinite “it”s). They abandoned that application and submitted another (called a continuation) which also covered seat belts with shoulder straps. Basically the invention showed the wiring (and switches, solenoids, etc) needed to prevent the driver from starting a car if his or any passenger's seat belt was not connected. Once the car was started, the circuits would stay closed even if one of the seat belts was opened, although a buzzer would alert the driver of an open seat belt. Paul converted his 1965 Ford Farlane car to use the invention during a Fang vacation in Canada.

The patent examiner complained that the invention was already covered by other patents, although Pao and Tom thought the examiner did not fully understand the point of some of their switches. They claimed that their invention was different from others in that it handled all of the seat belts and allowed for the continued operation of the car once it was started, even if a seat belt was opened with the car running. At one point the lawyer made some changes in response to the examiner that were incorrect, and when Tom discovered it the lawyer did not charge them for some of the work. They ended up making a third application in 1973, but the examiner never sided with them and the patent was not granted. During this time Pao sent numerous letters to companies to try to find somebody interested in using their invention. One round of letters went to members of the National Safety Belt Council, while another went to the heads of the big three auto manufactures (Lee Iacocca of Ford and John Delorean of G.M.) and to Sec. Volpe of the U.S. Department of Transportation. He received several letters showing interest and willing to talk with them if they first signed the appropriate disclosure agreements. However the industry as a whole was going in a different direction. Consumer advocates like Ralph Nader wanted air bags and were not concerned with seat belts. Car manufacturers had enough clout to postpone air bag requirements, while keeping out of regulations any notion of requiring users to actually put on seat belts. So in the end, no car ever used Pao's

concept of forcing all people in a car to put on a seat belt before the car would start, and thus even if his patent had been awarded, there would have been no royalties to be gained.

Date	Patent Application Title	Patent #
1956-58	Thermionically emitting device	2,866,915
1960	Ceramic composition	
1966-71	Recovery of radiation damaged solar cells through thermal annealing	3,597,281
1970-73	Seat belt safety switch controlled ignition and warning device	
1972-75	Economical solar cell for producing electricity	3,914,856
1972-85	Metal oxide semiconductor device with built-in annealing against radiation	
1975-79	An economical solar cell and method of making same	
	Solarzelle (German)	3049226
	Economical solar cell (French)	2,343,332
1979-82	A solar cell plant in space environment	
1980-89	Method for producing an economical solar cell	
1983-87	Low vacuum silicon thin film solar cell and method of production	4,702,965
1983-85	A microcrystalline windowed solar cell and method of making same	
1984-85	Article and method for the formation of microcrystals on silicon solar cells by a post-laser processing	
1985	Metallic glass substrate for thin film electronic devices	
1985-87	Semiconductor devices having a metallic glass substrate	4,639,543

Date	Patent Application Title	Patent #
1988-90	Superconductive materials	
1989	Method and apparatus for increasing fusion efficiency in deuterium-palladium fusion	
1989	Method for replacement of heavy water as deuterium source in cold fusion	
1989	A method for augmentation of fusion yield in palladium-deuterium system	
1989	Method for improving cluster impact fusion efficiency	
1991-95	Method for growing diamond crystals utilizing a diffusion fed epitaxy	5,429,069
1993-95	Method and apparatus for production of a carbon nitride	5,405,515
1993	Human radiative treatment of tobacco for its improvement	
1995-98	several applications pertaining to fullerene	
1998-99	Method for growing a diamond crystal on a rheotaxy template	6,001,174
1998	A composite for diamond growth through thermal diffusion	
2002	A method for the preparation of superconductor film on flexible substrates by excimer laser irradiation	
2002-04	Apparatus for the Production of Ginkgo Leaf Tea	6,787,743

Start	End	Position	Salary
9/45	12/47	Ohio State University B.Sc.	fellowship
1/48	9/48	Ohio State University M.Sc.	fellowship
9/48	6/50	Syracuse (graduate classes)	
7/49	2/50	U. of Minnesota-Statistician	$50/week
9/50	6/53	Catholic U. Ph.D.	
9/50	5/51	Catholic U.-Research Assistant	$1.50/hour
6/1/53	5/31/54	Catholic U.-Research Associate	start: $2/hour end: $6000/yr
6/1/54	1/56	Philco Corp-Project Engineer	start: $6400 end: $7000
2/7/56	9/30/56	Catholic U.-Research Assoc.	$4666.67 total
10/1/56	10/62	NBS[2]-Pysicist GS-12; promoted to GS-13 on 12/28/58	start: $7570 3/57: $8645 end: $10130
11/62	5/68	NASA Goddard Flight Center-Section Chief GS-14 and Division Consultant GS-14.5	start: $15150 end: $17953
5/68	6/30/70	NASA Electronic Research Center-Physicist GS-15.4	$25174
9/70	1990	Boston College-Research Professor Dept. of Physics	start: $28000 10/76: $35170
1991	1991	NASA/JSC Summer Fellow	
1991		F. S. Lab	

[2] 8/60-8/61 Fed. Gov. Fellow studying at Institute Fourier, Grenoble, France and Kamerlingh Omnes Laboratorium, Leiden, Netherlands. The government paid $4820 expenses in addition to his regular salary.

Dates	Countries	Purpose
8/1960 – 9/1961	France, Netherlands, Europe	Gov. Training Program
7/1962 – 8/1962	Holland, Italy	
8/1963 – 10/1963	Belgium	
7/1964	France	
7/1966	Japan, Hong Kong	
9/24/1984	China	TOKTEN
8/1985 – 10/1985	China	TOKTEN
7/1987 – 10/1987	China	TOKTEN

[more to come...]