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Chapter 10

Intersection of the Careers of Rudolf Hermann and Qian Xuesen*

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Abstract

Dr. Rudolf Hermann was born on 15 December 1904, in Leipzig, Germany. Dr. Qian Xuesen (Hsue-Shen Tsien in common Western Romanization using the Wade-Giles system, and the spelling that he used while in the United States) was born 11 December 1911, in Hangzhou, the capital of Zhejiang Providence, China (180 km southwest of Shanghai). They were contemporary pioneers in space system engineering and particularly in supersonic rocket aerodynamics. Rudolf Hermann was educated in Germany and subsequently led supersonic wind tunnel development and applications in Germany during World War II. Qian Xuesen received his undergraduate education in China and his graduate degrees in the United States, where he wrote early analytical papers on supersonic rocket aerodynamics. Specifically, in 1938, Qian (Tsien) published a theoretical paper on "Supersonic Flow over an Inclined Body of Revolution." An example in the paper was a body whose shape resembled the geometry of the German A4/V2

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rocket. While supporting the successful development of the A4/V2, Hermann conducted supersonic wind tunnel measurements that agreed with the theoretical predictions by Qian. As the war in Europe approached an end, the United States Army Air Force asked Dr. Theodore von Kármán to assemble a team of scientists to go to Germany to interview German scientists and engineers as the advancing U.S. armies overran their locations and facilities. Dr. Qian, a close associate of von Kármán, was one of the team members who interviewed Dr. Hermann and his colleagues in Kochel, Germany at their wind tunnel facility. Hermann and Qian discussed the agreement between Qian's theories and Hermann's measurements. Thus the careers of Qian and Hermann intersected in an historic comparison of pioneering supersonic theory and experiment by leaders in these disciplines. Following the war, Hermann came to the United States, first to the Air Force Wright Field, then to the University of Minnesota and finally to the University of Alabama in Huntsville. Qian left the United States and returned to China in 1955. He had an excellent career in China, establishing himself as the father of the Chinese missile and space programs.

Rudolf Hermann, Early Years

Rudolf Hermann was born on 15 December 1904, in Leipzig, Germany. Rudolf's father, Curt Hermann, was a gymnasium music teacher and also a music critic for a newspaper. The maiden name of Rudolf's mother was Martha Anna Thieme. She was an accomplished pianist [1].

When he reached school age, Rudolf attended Nikolai Gymnasium, where his father taught. In 1924, Rudolf enrolled in the University of Leipzig. He studied physics, astronomy, physical chemistry and mathematics. At the University's Institute of Physics, he was accepted as a doctoral candidate in 1927. Professor Ludwig Schiller became Rudolf's doctoral advisor. Working with Schiller, Rudolf Hermann studied the resistance of water flowing at very high speed and temperature through pipes. In July 1929 he completed his Ph.D. in physics and astronomy. In September 1929, Dr. Hermann was given a position in the Institute of Physics as a teaching assistant to Dr, Schiller.

In 1933, the German Research Society granted Hermann a fellowship at the Aachen Institute of Technology. There he worked the flow of fluid through pipes in the production of fine chinaware. While at the Aachen Institute, in 1935 Rudolf Hermann received his Doctor Phil. Habil., based largely on research accomplished during his last two years at Leipzig. When Hermann first reached the Aachen Institute of Technology, it already had famous subsonic wind tunnels under the direction of Professor Wieselsberger. He told Hermann that the Luftwaffe was funding the development of supersonic wind tunnels at Aachen. In April 1934, Hermann was engaged by Wieselsberger to do the development and was given a staff of about five engineers. The first supersonic wind tunnel built was a blow-down type with a 10 cm by 10 cm cross section where the measurements were conducted. Thus began Hermann's career with supersonic aerodynamics [2].

On 6 January 1936, Wernher von Braun visited Dr. Hermann at Aachen to arrange for badly needed wind tunnel measurements to support rocket development by the German Army at Peenemünde. Von Braun and his team were designing an experimental rocket, designated A-3, that was to be flown to gain data needed to design the A-4 missile that would eventually be an operational weapon. By July 1936 Hermann's measurements on models in the Aachen wind tunnel revealed that the then-current design of the A-3 rocket was unstable aerodynamically. However, by the end of September, Dr. Hermann suggested a redesigned configuration of the A-3 that was stable.

Hermann in Peenemünde and Kochel

The criticality of aerodynamic topics had convinced von Braun that Peenemünde needed its own wind tunnel. The essential work done previously for the Army by Dr. Hermann motivated an offer to him to head the wind tunnel development and operations at Peenemünde. On 1 April 1937, Dr. Hermann came to work at Peenemunde as Director of the Supersonic Wind Tunnel. He reported to Walter Dornberger, as did von Braun. In Dr. Hermann's own words: "The goal in 1937 was to build an aerodynamic-ballistic research institute, capable of furnishing—in a reasonable time frame—all aerodynamic, stability, aerodynamic control, and heat transfer data needed for the development of numerous projects" [1]. This required the design and construction of supersonic wind tunnels of the highest obtainable Mach number (at least 5 and above), which should also operate in the subsonic range, since all rocket-powered vehicles start with zero velocity. The designed size of the test section was 40 cm x 40 cm. A wind tunnel with these characteristics was first operational in the summer of 1939 with a staff of 60 people.

Until summer 1943, Peenemünde had been spared, as Allied bombing raids devastated German cities. On 17 August, however, the bombers hit Peenemünde in a massive attack. The existing supersonic wind tunnel in Peenemünde was undamaged, and a decision was made to move it to Kochel in the Bavarian mountains. Also plans to build a Mach 10 "hypersonic" wind tunnel facility at Kochel were accelerated after the Allied air raid. Dr. Hermann was named director of the new facility and had the task of building it.

In fall, 1943, Dr. Hermann divided his time between Peenemünde and Kochel, with increasingly more time at the latter. By spring 1944, the wind tunnel moved from Peenemünde was in operation at Kochel. It had one blow-down 40 cm by 40 cm test section and one continuous 18 cm by 18 cm section. This wind tunnel remained in operation through the end of the war in Europe. Figure 10–1 is a photo of the wind tunnel facility.

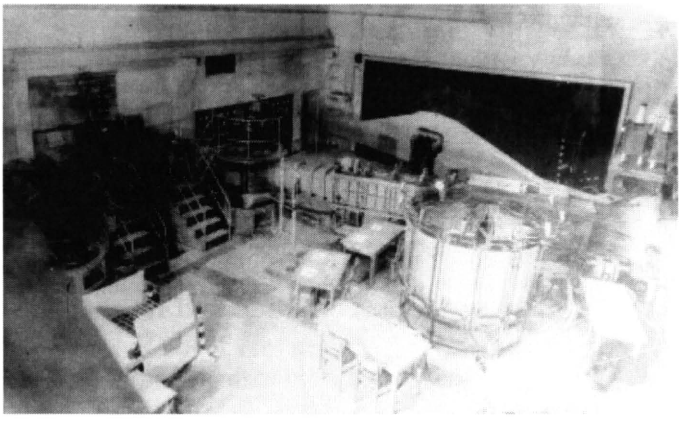

Figure 10–1: Wind tunnel facility in Kochel. Credit: UAH Archives.

Qian Xuesen, Early Life

Qian was born 11 December 1911, and died in October 2009, aged 98. Qian was born in an intellectual family in Hangzhou. He left Hangzhou at the age of three with his family when his father obtained a post in the Ministry of Education in Beijing. Qian graduated from Shanghai Jiaotong University in 1934 with a degree in mechanical engineering, he then spent an internship at Nanchang Air Force Base in Jiangxi Providence southwest of Shanghai. In August 1934, Qian received a Boxer Rebellion Scholarship to study mechanical engineering at the Massachusetts Institute of Technology, where he received a Master of Science degree in 1936 [3].

After he completed his M.S. program at MIT, Qian sought a school where his mathematical skills would be more appreciated than the hands-on engineering culture then prevalent in Cambridge, Massachusetts, and went to the California Institute of Technology to pursue his studies under Theodore von Kármán. Qian earned his doctorate from Caltech in 1939 with a thesis on slender body theory at high speeds. He remained on the Caltech faculty until his departure for China in 1955. He was appointed as the Robert H. Goddard Professor of Jet Propulsion in 1949 and established a reputation as one of the leading rocket scientists in the United States. His thesis advisor, Theodore von Kármán, pronounced him an "undisputed genius." At age 36, Qian's work was providing an enormous impetus to advances in high-speed aerodynamics and jet propulsion.

Qian married Jiang Ying, a famed opera singer and the daughter of Jiang Baili and his wife, Japanese nurse Satô Yato. The elder Jiang was a military strategist and advisor to Kuomingtang leader Chiang Kai-shek. The Qians were married on 14 September 1947, in Shanghai and would have two children; their son Qiang Yonggang was born in Boston on 13 October 1948, while their daughter Qiang Yungjen was born in 1950 when the family was residing in Pasadena. His son is now a Professor at the Academy of Opto-Electronics, Chinese Academy of Sciences (CAS), Beijing.

Qian's Career in the United States through 1945

In 1943, Qian and his rocketing group at Caltech drafted the first document using the name Jet Propulsion Laboratory for a proposal to the U.S. Army for developing missiles in response to Germany's V-2 rocket. This led to the Private A, which flew in 1944 and later the Corporal, the WAC Corporal and other designs. In 1945, near the end of World War II, he served under von Kármán as a consultant to the U.S. Army Air Forces and commissioned with the assimilated rank of colonel, as depicted in Figure 10–2.

Figure 10–2: Qian and von Kármán in Army uniforms.
Credit: UAH Archives.

Von Kármán and Qian both were sent by the Army to Germany to investigate the progress of wartime aerodynamics research. Qian investigated research facilities and interviewed German scientists including Wernher von Braun. Of particular significance was his visit to Kochel where Rudolf Hermann was the director of the premier German wind tunnel establishment.

American journal *Aviation Week & Space Technology* named Qian its person of the Year in 2007 and commented on his interview of von Braun, "No one then knew that the father of the future U.S. space program was being quizzed by the father of the future Chinese Space Program." During this time, Qian worked on designing an intercontinental space plane. His work would inspire the X-20, *Dyna-Soar*, which itself would later influence the development of the American Space Shuttle.

Career Intersection

The careers of Hermann and Qian intersected in person in Kochel, Germany, in June 1945. Both left accounts of their meeting. Rudolf Herman in his autobiography mentions these discussions with Qian (Hsue-Shen Tsien) [1]. "Memoirs of Rudolf Hermann" in the form of an extended interview with questions by interviewer Sandy Sherman and answers by Hermann. Hermann edited and approved the manuscript and he distributed autographed copies to many of his colleagues and friends. The following is a copy of the key paragraph from the Memoirs:

> I remember one of them, [the American officer interviewers] Dr. Tsien, von Kármán's closest associates, because he had written the paper about the "Pressure Distribution on a Cone in Supersonic Flow." He was the only scientist who had ever written a complete theory. We knew about his theory, because it was published about two years prior to the end of the war. We had used his theory and tested it in our tunnel exactly. I found out that nobody so far had tested Dr. Tsien's theory in his country. We did it, because we had the equipment, we had the supersonic wind tunnel, the scientists and engineers.

Back in the United States, Qian coauthored a "Technical Intelligence Supplement" that recorded his interview with Hermann and other members of the Hermann organization [4]. The paragraph below is a copy of the introductory paragraph of the section, "Kochel Supersonic Wind Tunnels" from this report prepared by the Army Air Force Scientific Advisory Group assembled by von Kármán:

> The Aerodynamics Institute formerly at Peenemünde was moved in the latter part of 1943 to Kochel in Southern Germany and started operation in 1944 as an independent organization under the name of Wasserbauversuchsanstalt Kochelsee. The establishment at Kochel was visited on 15 June by Drs. H. L. Dryden, F. L. Wattendorf and H. S. Tsien, of the Kármán Mission, AAF Scientific Advisory Group, and the present notes are based on interviews by this group with Dr. Hermann and other key personnel of the establishment.

The theoretical paper by Qian referred to by Herman in [1] was actually titled "Supersonic Flow over an Inclined Body of Revolution" and published in 1938 in *Journal of Aeronautical Sciences* [5]. Although Hermann does not cite this specific reference, it is clear from the paper's summary (abstract) copied below that this is the intended paper:

> A first approximation is obtained for the side force or the lift of a body of revolution inclined in a supersonic flow from the linearized equation of motion of compressible fluids. It is shown that the lift at any fixed Mach's number is directly proportional to the angle of attack of the body. The case of the cone is calculated in detail and a general method using step-wise doublet distribution is developed for a pointed projectile.

This published paper by Qian is the theoretical treatment that Hermann says the German supersonic wind tunnels confirmed and that the rocket designers used. Such a confirmation contributes to the judged reliability of both the theoretical and experimental results. A valid understanding of the aerodynamics of the A4/V2 rocket was undoubtedly a valuable element in the successful design and development of the rocket.

Although Hermann does not mention the fact in his memoirs, the Qian paper contains a first approximation of the supersonic aerodynamic pressure on the surface of rockets with shapes mathematically more complicated than a cone. Figure 10–3 is a copy of figure 1 from Reference [5]. The shape of this body considered by Qian is quite similar to the final nose configuration of the A4/V2 rocket.

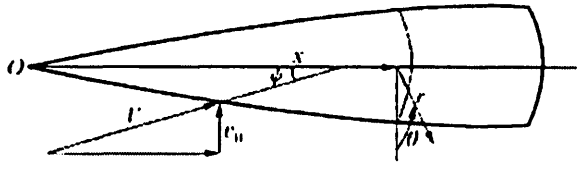

Figure 10–3: Shape of rocket nose considered by Qian in [5]. V is the velocity vector and ψ is the angle of attack. Credit: Figure 1 from Reference [5].

For a rocket with a nose like that in Figure 10–3 and a cylindrical body behind the nose, figure 4 in Qian's paper shows the lift coefficient as a function of angle of attack and the drag coefficient, calculated from the surface forces derived by the theoretical treatment in the paper, see Figure 10–4. The rocket in Figure 10–4 has no fins, so the similarity to the A4/V2 is incomplete in that important respect. Nevertheless, the 1938 paper by Qian gave Hermann and his aerodynamics team a valuable starting point for their understanding of the aerodynamics of the A4/V2.

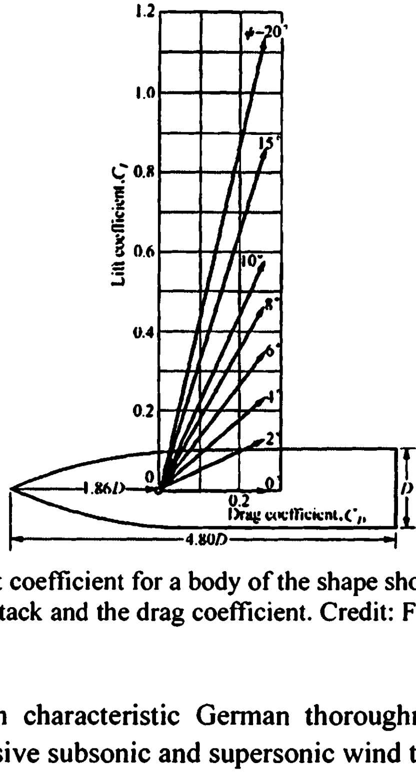

Figure 10–4: Lift coefficient for a body of the shape shown as a function of angle of attack and the drag coefficient. Credit: Figure 4 from Reference [5].

Of course, with characteristic German thoroughness, Hermann and his team performed intensive subsonic and supersonic wind tunnel evaluations of the aerodynamics of various rocket models and eventually of the A4/V2. These investigations are documented in a long series of reports from Peenemünde and Kochel. For example, a report dated 1939, June 1 [6], describes the supersonic wind tunnel used to produce the data in a 1939, June 14, report (English title translations) "Pressure relations at the nose of A-4" [7]. This was followed in 1940, October 10, by the "Report on 3 component measurements of a model of A-4 in the supersonic wind tunnel of the Army research station at Peenemünde" [8]. By early 1941, Hermann's team had refined the technique for pressure measurements on wind tunnel models [9]. In 1942, January 23, they produced a "Preliminary report on pressure distribution measurements on A4/V1P at supersonic velocities [10] and in 1942, November 27, they published "Pressure distribution measurements on A-4 V 1P in the sub and supersonic regimes" [11]. Figure 10–5 shows an A4/V2 model mounted for tests in the Kochel wind tunnel [11].

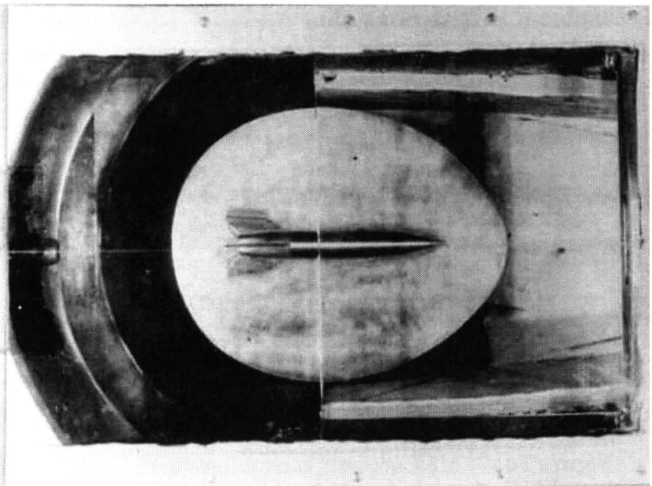

Figure 10–5: A4/V2 model in the wind tunnel. Credit: Reference [11].

The timeline of Figure 10–6 illustrates the dates of the most significant reports and events in the development of the A4/V2 missile.

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 Qian                                              First A4          First A4/V2
 Paper                                             Success         Operational Use
May 27                                              Oct 3               Sep 8
  *                                                   *                   *

^----------^----------^----------^----------^----------^----------^----------^----------^
   1938       1939       1940       1941       1942       1943       1944       1945
                *                            *              *                    *
              Jun 1                        Jan 23         Aug 17              June 15
          Hermann Rpt.               Prelininary Rpt.   Peenemunde          Qian visits
         on Peenemunde          Pressure Measurements    Bombed              Hermann
           Supersonic              on A4/V2 Model                           in Kochel
          Wind Tunnel          at Supersonic Velocities
                                                                 *
< 1937 Apr 1                                                Spring 1944
 Hermann at                                         Supersonic Wind Tunnel
 Peenemunde                                          Operational in Kochel
```

Figure 10–6: Timeline of events.

The aerodynamic pressures on the models were measured by the methods described in reference [8]. The measurement instrumentation shown in Figure 10–7, for its time, was a sophisticated feature of the wind tunnel. Figure 10–8 from Reference [11] shows pressure as a function of angle of attack and Mach number for the v2. Note the similarity of the body geometry in Figures 10–4 and 10–8.

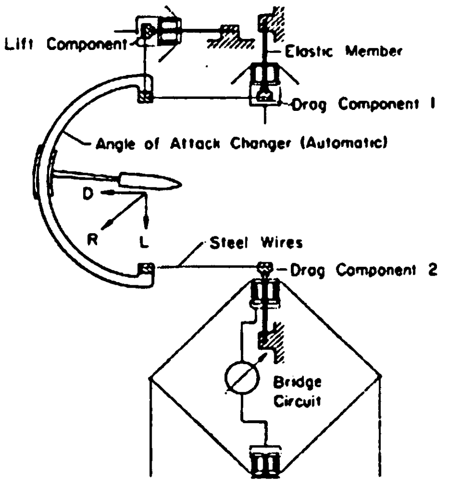

Figure 10–7: Measurement technology in the wind tunnel.

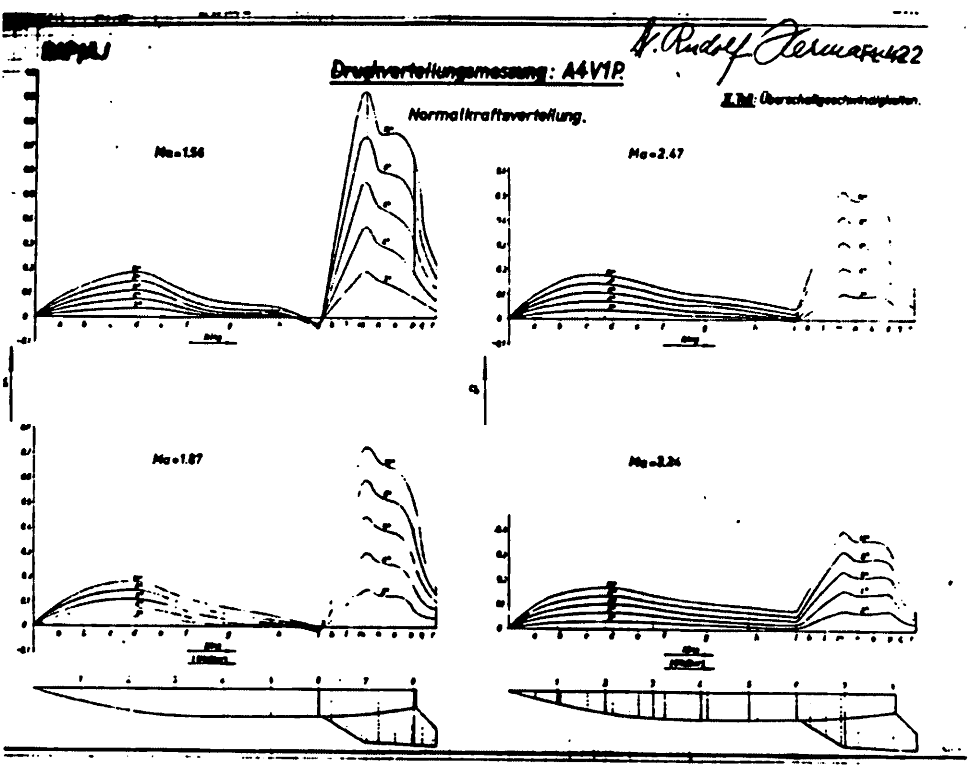

Figure 10–8: Pressure distribution on the V2 rocket as a function of angle of attack and Mach number. Credit: Reference [11].

Hence, in June 1945, two pioneering space figures who had been isolated by World War II met and discussed supersonic aerodynamics. Qian was the brilliant author of important theoretical analyses while Hermann had developed the best wind tunnels in the world for experimental investigations. Herman testifies that the theoretical and experimental results agreed. This incident is a fascinating historical example of how theoretical and experimental sciences interact and advance together.

Hermann Career in the United States

In fall 1945, Dr. Hermann and many of his key associates in Germany were offered initial, one-year contracts to consult with the military in the U.S. Dr. Hermann had no reservations in accepting such a contract. Thus on 17 November 1945, Rudolf Hermann arrived in the U.S. His consulting contract was with the Army Air Force at Wright Field in Dayton, Ohio. His family remained in Landshut, Germany, in the housing complex for families of German scientists working in the U.S. Rudolf's family came to Dayton in February 1947.

The parts from the disassembled wind tunnel at Kochel were taken to the Naval Ordnance Laboratory. There the tunnel was reassembled with the help of about 35 of Hermann's colleagues from Kochel. Dr. Hermann Kurzweg, Rudolf's deputy in Peenemünde and Kochel, became the director of the NOL wind tunnel laboratories.

Meanwhile, plans were being made for the transition of the Army Air Force into an independent branch of the Department of Defense, the U.S. Air Force. Von Kármán headed an Army Air Force Scientific Advisory Group (SAG) who advised General Henry "Hap" Arnold on what the future Air Force should anticipate. One recommendation was an "engineering development center" including state-of-the-art wind tunnels. Nine of the German scientists at Wright Field, including Dr. Hermann, were assigned to prepare preliminary plans for such a center. A report by Rudolf Hermann, "A Supersonic Wind Tunnel for High Mach Number and Large Test Section Diameters," supported the plans. Such a wind tunnel, similar to that planned for Kochel, was eventually built and operated at the Arnold Engineering Development Center established by the Air Force in Tullahoma, Tennessee.

After five years at Wright Field, Rudolf Hermann accepted an appointment offer from the University of Minnesota. In January 1951 he became a professor in the Department of Aeronautical Engineering. This satisfied his long-held wish for such an academic position. Since January 1947, the University had been developing what was envisioned to be a "gigantic research center" at a site adjacent to Rosemont, a small town some 15 miles south of Minneapolis and St. Paul. A centerpiece of the new Rosemont Research Center was a wind tunnel facility for the Aeronautical Engineering Department.

By the mid-1950s, a wind tunnel with a 40 cm by 40 cm test section was in operation with the ability for continuous flow up to Mach 1.4. Higher Mach numbers and blow-down equipment followed later. This was exactly the research environment in which Rudolf was comfortable. From 1959 through 1962, he was Technical Director and later Director of Hypersonic Laboratories at the Rosemount Aeronautical Laboratories.

In 1962, Dr. Hermann accepted a new challenge in Huntsville, Alabama, where in 1950, the U.S. Army rocket team, with Wernher von Braun and his colleagues had moved from Fort Bliss, Texas. By 1960 this German and American team had logged many accomplishments, including the launch of the first U.S. satellite in 1958. During the period from 1950 to 1960, a component of the University of Alabama had developed in Huntsville. Major General Bruce Medaris and Dr. von Braun were instrumental in convincing the legislature and people of Alabama that a new research arm of the University was needed in Huntsville to support the efforts of the Army and NASA organizations. Subsequently in 1962, Dr. Hermann became the first permanent director of the University of Alabama Research Institute.

One immediate task was to facilitate the building authorized by the bond issue. Dr. Hermann gave this task policy guidance from Minnesota. He also assigned his assistant, Kenneth O. Thompson, to follow the details of the building process. K. O. Thompson came to Huntsville before Dr. Hermann, who arrived in summer 1962. Another early task addressed by Dr. Hermann was staffing the Institute with senior research engineers and scientists, even before the building was complete.

On 25 May 1961, President John F. Kennedy had committed the nation to land a man on the moon and return him to earth before the end of the decade. This gave the NASA Marshall Center and the Huntsville technological community daunting responsibilities. Increased staffing for the push to the Moon and for missile commitments was a serious problem faced by the government agencies and industries in Huntsville. Finding and keeping junior employees was part of that problem. Typically, a B.S. level "new-hire" wanted to continue his education by entering a graduate program while working. An immediate benefit from senior faculty in the Research Institute was their availability to teach graduate courses and direct thesis projects.

The extent to which Dr. Hermann aided his former Peenemünde colleagues by advice and judgments is not easy to ascertain. Clearly, in the 1960s he participated in the technological life of Huntsville. He was present in 1969 when Huntsville celebrated the first lunar landing.

In 1970, Dr. Hermann reached age 65, the nominal retirement age for administrators in the University. He consequently retired from his post as Director of the Research Institute. He had been a significant factor in the growth and maturation of the Huntsville campus of the University.

Qian in the United States after 1945

In 1949, when Qian was applying for naturalization, allegations were made that he was a communist and his security clearance was revoked in June 1950. Qian found himself unable to pursue his career and announced plans to return to Mainland China then under communist rule. After Qian's plans became known, the U.S. government detained him at Terminal Island, an isolated U.S. Navy facility and federal prison near the Port of Los Angeles. The Under-Secretary of the Navy at the time, Dan A. Kimball, tried to keep Qian in the U.S., commenting, "It was the stupidest thing this country ever did. He was no more a communist than I was and we forced him to go." Then, Qian became the subject of five years of secret Sino-American diplomacy and negotiations. During this time, he lived under constant surveillance with permission to teach without classified research. Qian received support from his colleagues from Caltech, including the institution president Lee DuBridge, who flew to Washington to argue Qian's case. Caltech appointed attorney Grant Cooper to defend Qian. Later, Cooper would say, "that the government permitted this genius, this scientific genius, to be sent to communist China to pick his brain is one of the tragedies of this country."

Qian's Career in China

Qian had a stellar career in China after he returned in September 1955. He established himself as the Father of the Chinese Missile Program with the construction of China's Dongfeng ballistic missiles and the Long March space launch vehicles. A book about this scientist's life was written by Iris Chang, titled *The Thread of the Silkworm* [3]. Qian was awarded Caltech's Distinguished Alumni Award in 1979. In the early 1990s, Caltech offered Qian the filing cabinets containing his earlier research work there. Most of these works become the foundation for the Qian Library at Xian Jiaotong University; and the CAS Institute of Mechanics, which he founded. Qian eventually received his award from Caltech, when his friend Frank Marble brought it to his home in a widelycovered ceremony. After the normalization of Sino-American relations, the AIAA invited Qian to visit the United States but he declined. In a 2002 published reminiscence, Marble stated that he believed that Qian had "lost faith in the American government" but he had "always had very warm feelings for the American people."

From the early 1980s, Qian investigated a number of areas and created "Systematics." He contributed on science and technology systems, somatic science, philosophy, natural sciences, engineering disciplines, literature, art, military science, geography, social science, and education. In particular he advanced the concept, theory and method of system science, from a qualitative to a quantitative discipline. He thus established a Chinese school of the science of complexity.

Qian retired in 1991. In his later years, he advocated scientific investigation of traditional Chinese medicine, Qigong (i.e., a kind of flow within the body) and "special human body function." In fact, Qian actually did not spend his effort on Qiqong, but he just expressed that people should consider the widely practiced Qiqong in a scientific manner.

In a fitting capstone to Qian's lifetime aerospace efforts, the PRC government launched its manned space program in 1992. Qian's research was used as the basis for the Long March rocket, which successfully launched the *Shenzhou V* mission in October 2003. The elderly Qian was able to watch China's first manned space mission on television from his hospital bed.

Acknowledgments

The authors wish to thank the Archives and Special Collections Division of the Library at the University of Alabama in Huntsville for access to the Archives collections and for additional assistance.

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