

HANS G. HORNUNG (b. 1934)

INTERVIEWED BY SARA LIPPINCOTT

June 23 and July 3, 2014

Photo taken in 1997

ARCHIVES CALIFORNIA INSTITUTE OF TECHNOLOGY Pasadena, California



Subject area

Engineering and applied science, aeronautics

Abstract

An interview in two sessions, June and July 2014, with Hans Georg Hornung, Clarence L. Johnson Professor of Aeronautics, emeritus, in the Division of Engineering and Applied Science.

Dr. Hornung describes the origins of the German Templer Colony in Palestine and his upbringing there before and during World War II. Family moves to Templer settlement, Melbourne, Australia, 1948. He attends technical college; University of Melbourne; master's in engineering, 1962. Researcher, Aeronautical Research Laboratories, Melbourne; PhD, Imperial College, London, 1965.

He recalls his academic career at the Australian National University, Canberra (1967-1980); his interest in hypersonics; building free-piston shock tunnel with

Raymond Stalker. Sabbatical in Darmstadt with Ernst Becker. Seven years as director of fluid-mechanics institute of the DLR [Deutsches Zentrum für Luftund Raumfahrt], in Göttingen. Comes to Caltech in 1987 to succeed Hans W. Liepmann as director of GALCIT [Graduate Aerospace Laboratories, California Institute of Technology]. Recalls his various aero colleagues, his work with Rocketdyne on Caltech's T5 (successor to Canberra's T3 shock tunnel) and Ludwieg tube, collaboration with JPL on space program, and work with graduate students Simon Sanderson and Eric Cummings. Discusses his involvement in various scientific societies and his current activities and continuing research as an emeritus professor.

Administrative information

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CALIFORNIA INSTITUTE OF TECHNOLOGY ARCHIVES

ORAL HISTORY PROJECT

INTERVIEW WITH HANS G. HORNUNG

BY SARA LIPPINCOTT

PASADENA, CALIFORNIA

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Hans Hornung, 1987

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CALIFORNIA INSTITUTE OF TECHNOLOGY ARCHIVES Oral History Project

Interview with Hans G. Hornung Pasadena, California

by Sara Lippincott

Session 1	June 23, 2014
Session 2	July 3, 2014

Begin Session 1

LIPPINCOTT: We're here in the Archives with Hans Hornung, who is the Clarence L. Johnson Professor of Aeronautics, emeritus. We usually start these interviews with the subject talking about his early life—where you were brought up. And you had an interesting early life, because you were born in Palestine, is that not correct?

HORNUNG: Yes

LIPPINCOTT: 1934?

HORNUNG: Yes.

LIPPINCOTT: Do you mind telling us a little bit about the German colony in Palestine? I think it started up in the 19th century.

HORNUNG: Yes. Well, it came about because of a small religious group in southwestern Germany, who had the idea that they wanted to live according to the Sermon on the Mount. They didn't have any dogmas, and they didn't have baptism, but they were Christians, and they had a lot of trouble because of not being baptized. They couldn't get any teaching jobs and stuff like that. They were also motivated, by their belief in the second coming of Christ, to emigrate to Palestine. This was about 1865 or so. The first group who emigrated had a hard time, because they were not immune to a lot of the diseases there, and half of them died. Then later more came, and they became sufficiently strong to make the first settlement, which was in Haifa, in 1869. It's now in the middle of the city of Haifa, and its German stone buildings are still more-or-less intact.

LIPPINCOTT: It's called Wilhelma?

HORNUNG: No, no, no—this was Haifa. Later, other settlements were founded near the city of Jaffa and also in Jerusalem. There were, in total, five such settlements, and they were very successful. They are today credited with having brought modern techniques of agriculture and engineering and business to the area—it was the Ottoman Empire in those days. And the place called Wilhelma was founded in 1901. My grandparents had already emigrated.

LIPPINCOTT: Your paternal grandparents?

HORNUNG: And my maternal grandparents. Both my father and my mother were born in Palestine. My father was one of six siblings, the only boy, and my grandfather on my father's side bought a lot in Wilhelma, and that's where the family grew up. My maternal grandfather was an engineer, and he had a machine shop and foundry in Jaffa, which was the only such establishment between Syria and Egypt at that time. My mother was one of six siblings also, the only girl.

And then came the First World War. It's very interesting how war was waged in those days. One day in 1915 a French officer came from a ship called *Jeanne d'Arc*, a warship, and he came to my grandfather's door in Jaffa, knocked on the door and said, "Monsieur Wagner, this afternoon at three o'clock we will shell your factory." And the reason was that they believed that my grandfather's factory was manufacturing weapons for the Turks—at that time, the Turks and the Germans were allies. And sure enough, they did, but the factory was on the ground floor and the house was two floors above it. They destroyed the house, but the factory was not damaged at all! [Laughter.] The war brought a lot of grief to that family. Three of the boys were killed on the Western front, in France.

LIPPINCOTT: These would be your-?

HORNUNG: Uncles.

LIPPINCOTT: Your mother's brothers.

HORNUNG: Yes. And one remaining uncle was a prisoner of war in Turkey and came back after the war.

LIPPINCOTT: What happened to the rest of family during that time? Were they interned?

HORNUNG: Yes. When the campaign of Allenby came from the south and took over Palestine from the Turks and the Germans, they were interned and taken to a hotel in Egypt, and this hotel was declared a prisoner-of-war camp. They were released after the war and repatriated to Germany, where they'd never been before. [Laughter]

LIPPINCOTT: They had never visited it?

HORNUNG: Well, only visited.

LIPPINCOTT: Where was your family from originally-Bavaria?

HORNUNG: No, from Baden-Württemberg, which is the area around Stuttgart.

LIPPINCOTT: So your family was sent back there?

HORNUNG: Yes. During the war, my father had been a soldier also, and he, too, was repatriated to Germany, and the Palestine settlements were all looted and destroyed. But these Germans were allowed to go back to Palestine about two years after the war, partly through the intervention of American Mennonites—isn't that interesting? So they started up again and built everything back up. My father and mother met because my mother was friends with his sister.

LIPPINCOTT: And this was back in Palestine, when they met?

HORNUNG: They had met, actually, in Germany, but they both went back to Palestine, and there they kept their friendship up. They got married in 1930, and they had three boys and two girls in quick succession, because my mother was already thirty-two when she got married.

LIPPINCOTT: Where do you come in that lineup?

HORNUNG: I'm in the middle. Two older boys, two younger sisters.

LIPPINCOTT: And you lived in Wilhelma?

HORNUNG: Wilhelma, a small village, small school. The whole school was only some thirty children, and they took a new class every two years only. There were always two grades together, because it was so small.

LIPPINCOTT: My school was like that, too.

HORNUNG: Was it? That's nice. My brother brought stuff home, and I could do the homework much better than he could, so my mother persuaded the teachers to take me into the same class.

LIPPINCOTT: It says in your CV that you began your schooling in 1940, when you would have been six?

HORNUNG: Five, because I was born at the end of the year.

LIPPINCOTT: And you were in that primary school in Wilhelma from 1940 to 1948?

HORNUNG: Yes.

LIPPINCOTT: Nineteen-forty-eight being the year the State of Israel was formed.

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HORNUNG: Yes.

LIPPINCOTT: Now, tell me a little bit about your primary education. Was it a good education?

HORNUNG: Yes, it was very good. There was a lot of mathematics and some science. It was great. I was very good at school. It was easy, so I enjoyed very much more getting into mild forms of trouble outside the school. [Laughter] Our school was from seven-thirty in the morning to midday, and in the afternoon we were free to do other things, like sports, or music lessons.

LIPPINCOTT: Were you maybe the smartest of all your siblings?

HORNUNG: They're gifted in different ways. My immediate older brother, Richard, has become a very successful musician. He was the director of the music school in Adelaide.

LIPPINCOTT: In Australia?

HORNUNG: Yes. Anyway, what was interesting at the beginning of the Second World War—the third of September, 1939—was that on the second day of the war the British came in with big trucks full of barbed wire and fenced the village in and declared it Prisoner of War Camp 5. So for the duration of the war we were interned.

LIPPINCOTT: You were interned in Wilhelma?

HORNUNG: Yes, in our own house. [Laughter]

LIPPINCOTT: Did that mean you couldn't leave the town at all?

HORNUNG: Yes.

LIPPINCOTT: That must have been difficult. How did they get supplies?

HORNUNG: That was interesting, because [the economy] was agricultural, mainly, and all the farmland was outside the village. It was worked by Arab labor, and now there was this fence. This was very difficult, and later the police who were guarding us took some of the farmers and escorted them out [of the village] and back in, so they were able to get out there.

LIPPINCOTT: Did this situation go on like that until 1945, the end of the war?

HORNUNG: Yes, but what was interesting was that in 1941 the British decided to take all the young men and their families and move them to Australia. My father didn't get selected, because we had the chicken pox, and the Australian doctor said, "No skin diseases." By the time they went, we were healthy again, but we stayed behind.

LIPPINCOTT: About how many of the settlers stayed behind?

HORNUNG: About half, because all the old people stayed behind.

LIPPINCOTT: So that's why you were able to continue in the Wilhelma school until '48?

HORNUNG: Yes, in that school. But the people who went to Australia were also in camps, and they had their own schools, too. They started their own schools there.

LIPPINCOTT: Was there much communication between the people back in Wilhelma and the people in Australia?

HORNUNG: It was very difficult, because everything was censored. All the letters were censored, and it took a long time back then.

LIPPINCOTT: Was this in Victoria, in Australia?

HORNUNG: Yes, Victoria.

LIPPINCOTT: OK. Well, eventually your family did go. And in '48 was the-?

HORNUNG: OK. That happened because after the war two Israeli groups, the Haganah and the Irgun Tzvai Leumi, made a lot of trouble for the British military, because they wanted the British out and wanted to found their own state.

LIPPINCOTT: I think Amnon Yariv [Summerfield Professor of Applied Physics and professor of electrical engineering] was part of that struggle.

HORNUNG: Yes. I'll tell you about Amnon. We have an interesting parallel story. His father and my grandfather had establishments very close to each other. My grandfather's factory in Jaffa and Amnon's father's body shop for repairing cars were almost neighbors, and now we have parking spots next to each other. [Laughter]

LIPPINCOTT: Did Amnon's father and your grandfather know each other?

HORNUNG: Yes, they knew each other.

LIPPINCOTT: Amnon was in the Haganah in that period, around '48.

HORNUNG: Yes, yes. So, what happened then was that the British were kind of protecting us, because they felt responsible for us after having interned us, and they said that if we wanted to—this was two weeks before they left Palestine—we could get transport on a ship to Cyprus, if we could be ready in three days. So we packed up everything and left for Cyprus, where we lived in tents for a year, on the beach. Beautiful! No school! Fantastic! [Laughter] Our parents didn't think so, but we did.

LIPPINCOTT: How did you get from Cyprus to Australia?

HORNUNG: OK. So, going to Germany at that time would have been silly, because people were starving in Germany and it was very bad. So we decided we would go to Australia, where, meanwhile, the people who had been interned there originally had been encouraged by the Australian government to stay there—to become immigrants, which most of them did. And they were quite successful, so everybody thought, "Let's do that, too! Let's go to Australia."

LIPPINCOTT: We should mention that the people of the colony—the Palestine colony of Germans—were called Templers.

HORNUNG: Yes.

LIPPINCOTT: Not "Templars," that's a different thing. And when they went to Australia, they established themselves there, and I think it was called the Temple Society. When you and your family got there, were you members of that society?

HORNUNG: Yes, the group who originally emigrated to Palestine already called themselves the Templers. This word originated because they likened themselves to— Each person was a column in the temple of God, supportive of each other. And this was called, in German, *Tempelgesellschaft*, which means "Temple Society." This name was then anglicized in Australia, and so the Temple Society of Australia was founded. It existed also in Germany—continued to exist, from way back when.

LIPPINCOTT: Even after the war?

HORNUNG: It's still there now.

LIPPINCOTT: Still there now? Oh!

HORNUNG: Yes, and we were members.

LIPPINCOTT: So, you're in Cyprus, on the beach. How did you get on a ship that would take you to Australia?

HORNUNG: First, there was a lot of negotiation with the Australian government. They sent an official to interview us, because we were, at that time, enemy aliens still.

Eventually the negotiations were successful and the Australian government said, "Yes, come," and we then had to find transport. When we left Palestine, we did get some small amount of money from the sale of cattle. Three men stayed behind and sold all the cattle, and that money was used by my father in part to pay for our trip to Australia, because, as enemy aliens, we were, unlike other Europeans, not funded by the Australian government for fares.

LIPPINCOTT: Or not funded by anyone, really.

HORNUNG: Right. So my father went into debt to pay for the rest of the fares, and then in Australia we all went to work, except the two girls, who went to school.

LIPPINCOTT: Now, where in Australia did you end up?

HORNUNG: This was east of Melbourne, in a suburb of Melbourne.

LIPPINCOTT: Called what?

HORNUNG: Called Ferntree Gully.

LIPPINCOTT: It says here [consulting CV] that you went to Box Hill High School in 1949.

HORNUNG: Yes, at first I also went to school. I went to high school.

LIPPINCOTT: Just one year?

HORNUNG: Half a year.

LIPPINCOTT: Half a year!

HORNUNG: Yes. That was interesting. Two weeks after I arrived at the high school, they had a midyear exam, and in arithmetic, algebra, geometry, Latin, I was the top student in that midterm exam.

LIPPINCOTT: Oh my!

HORNUNG: But in English and history and other subjects like that, I had no idea, because I hadn't read the books they had read. [Laughter] But at the end of the year, I was close to the top student in all subjects, so I got a prize for the most improved. [Laughter]

LIPPINCOTT: That's amazing! What grade would this have been? Was this the first year of high school?

HORNUNG: This was the third year of high school. In the Australian system at that time, they had six years of primary school and six years of high school, so in the American system it would have been the first year of high school.

LIPPINCOTT: I see, yes. OK, why did you then stop your high school education?

HORNUNG: Because I felt guilty about not helping finance the family.

LIPPINCOTT: You were fifteen or so?

HORNUNG: Fifteen. And I went to work on a farm.

LIPPINCOTT: What did you do on the farm?

HORNUNG: I plowed and planted.

LIPPINCOTT: [Laughter] What?

HORNUNG: Brussels sprouts. I harvested.

LIPPINCOTT: This was for six years you did this?

HORNUNG: No. At first, I worked on the market garden, on that farm, for two years, and then I changed to a dairy farm. And a dairy farm is a hard life.

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LIPPINCOTT: You have to get up early.

HORNUNG: Yes, and it's twelve hours a day, seven days a week, all year. Because the cows need to be milked, you can't get away. I did that for a number of years. Then we had a lot of machinery, and when the machinery needed repair I had to take the machinery to the blacksmith's shop and he would fix it up and we'd bring it back. So I suggested to my boss, "Why don't we get a welding set? You send me to night school and I'll learn how to do it, then we can do it all ourselves." He thought that was a good idea, so I went to Melbourne to technical college night school [Royal Melbourne Technical College].

LIPPINCOTT: This was in 1954?

HORNUNG: Yes, '54. And there I had to learn to weld, and blacksmithing, and then we had to take a course called Trade Mathematics and Science.

LIPPINCOTT: Trade?

HORNUNG: Like artisan's mathematics and science, very simple stuff. And my teacher said to me, "You're wasting your time in this course. Take a night-school diploma course." And this went to my head, and I started to go to night school full-time.

LIPPINCOTT: Well, that's good, isn't it?

HORNUNG: Yes. So in 1955 I did five nights a week, of four hours each, to cover the same thing as high school would.

LIPPINCOTT: And were you also working on the dairy farm at the same time?

HORNUNG: Yes. It was pretty hard then.

LIPPINCOTT: It must have been.

HORNUNG: And in the second year of doing this, I did the same thing for the university entrance exam.

LIPPINCOTT: This would have been-?

HORNUNG: '56.

LIPPINCOTT: For the University of Melbourne?

HORNUNG: Yes. In Australia at that time, each state had a universal exam for university entrance. Everybody took the same exam at the same time. I did that, and I got pretty good grades in the entrance exam.

LIPPINCOTT: What kind of math did you have to know to pass that exam? Calculus?

HORNUNG: Oh yes, calculus and beginning of differential equations—simple differential equations.

LIPPINCOTT: Had you had any physics at that point?

HORNUNG: Yes, physics and chemistry. I had to do the physics and chemistry lab at Melbourne Tech. I actually didn't want to go to the university; I wanted to stay at Melbourne Tech. But one of our friends at the University of Sydney persuaded me to apply for a Commonwealth Scholarship. He was also a Templer, and he told me, "You should not go to Melbourne Tech; you should go to university." So I applied for a scholarship [to the University of Melbourne] and got it. And because I had been working for five years, this scholarship gave me, in addition, a small living allowance: £5 a week, which was a lot of money in those days.

LIPPINCOTT: So you could live away from home?

HORNUNG: No, I didn't actually live away from home, and I still worked on the weekends on the farm. It was really great.

LIPPINCOTT: How did your family feel about your going to university?

HORNUNG: They left things to me at that point. Decisions about myself were my business. They were reasonably pleased, I think.

LIPPINCOTT: You were in your twenties by now.

HORNUNG: I was twenty-two when I started at the university, in 1957. My first year of university was '57.

LIPPINCOTT: And you got your bachelor's in mechanical engineering with honors?

HORNUNG: Yes.

LIPPINCOTT: Do you remember any of your professors, particularly?

HORNUNG: Oh yes. Lots of them. [Laughter]

LIPPINCOTT: Do you want to talk a little bit about your engineering education at the University of Melbourne?

HORNUNG: Yes, sure. Well, in the first year, we had a very good mathematics teacher. He was Jack Ryan. He was revered by everybody in the class. In those days, the firstyear class was 120 students—all boys; no girls at that time.

LIPPINCOTT: No women at all in the university?

HORNUNG: Well, in the university, yes, but not in engineering. And we turned up with coat and tie in those days [laughter], not like now. The mathematics teachers all wore gowns, and Jack Ryan's was always torn and covered with chalk, but he was so respected

because he was such a fantastic teacher. There was one incident which was really funny. At the end of the year, we were doing stuff on celestial mechanics—orbits and stuff like that, and the rocket equation.

LIPPINCOTT: What kind of equation?

HORNUNG: The rocket equation. And he proved to us, on a Friday in October, that it was not possible to send a satellite into orbit with conventional fuels. And it so happened that the next day, *Sputnik* was launched—the very next day.

LIPPINCOTT: How could he have been so ignorant of what was going on in Russia?

HORNUNG: Nobody knew before the launch—well, maybe they did here. But anyway, he came in on Monday: "Yes, yes, I know. Two-stage." Because staging of rockets was well known, and I think if he had done the calculation with staging, [he would have seen that] it was possible.

LIPPINCOTT: Yes, *Sputnik* gave a great boost to science in the United States, and probably in Australia also.

HORNUNG: Yes.

LIPPINCOTT: Did your interest in aeronautics begin there?

HORNUNG: Yes, it began in the third year, when we had a teacher called Peter Joubert. Peter was a very good teacher, and he taught us fluid mechanics. I *loved* fluid mechanics.

LIPPINCOTT: Why were you attracted to fluid mechanics?

HORNUNG: Well, in the other materials-type of courses we had—elasticity, for instance everything was linear. Linear differential equations. Of course, if you do the interesting stuff nowadays it's all nonlinear. And in fluid mechanics, everything was nonlinear, and so it was much more difficult, I thought. And so I was fascinated by this challenge. And then Peter Joubert was an excellent teacher. He became my advisor in my master's year.

LIPPINCOTT: You got the master's degree in '62. Did you have to do a thesis for that?

HORNUNG: Yes.

LIPPINCOTT: What was your thesis on, do you remember?

HORNUNG: It was on three-dimensional turbulent boundary layers.

LIPPINCOTT: And it was with Professor Joubert?

HORNUNG: Yes.

LIPPINCOTT: After you got your master's, your CV says you went to work at the Aeronautical Research Laboratories [ARL] in Melbourne.

HORNUNG: Yes.

LIPPINCOTT: That wasn't an academic job.

HORNUNG: It was a research job. We had a lab with a hypersonic wind tunnel, and we did experiments there and some theoretical stuff and some computational stuff in high-speed flows.

LIPPINCOTT: And then you went to London?

HORNUNG: Yes. The Department of Supply, as it was called, is effectively the Department of Defense, and the ARL was one of their labs. They often sent promising young scientists to England to do a PhD and come back. These young scientists were bonded, so they had to come back and work for ARL for five years. They offered me this, and so we went to England, to London. LIPPINCOTT: When you say "we"—?

HORNUNG: Our family. Meantime I had got married, and we had two children.

LIPPINCOTT: Oh, we shouldn't leave that out. You married an Australian girl?

HORNUNG: No, I married one of the German Templer girls.

LIPPINCOTT: What was her name?

HORNUNG: Her name was Gretl Frank. And by that time, when we went to England, we had two children.

LIPPINCOTT: Oh, my gosh, very young children!

HORNUNG: Yes. One was a baby.

LIPPINCOTT: You went to Imperial College, is that right? How did she like moving to England?

HORNUNG: She found it quite exciting. Of course, we went by ship in those days. It was the cheapest way to go, far cheaper than flying. I think the fare per person was £250, one way. And it was thirty-five days on the ship.

LIPPINCOTT: Can you remember the name of the ship?

HORNUNG: Yes, it was called the *Aurelia*. It was an Italian ship. And it was a *terrible* trip.

LIPPINCOTT: Why?

HORNUNG: Melbourne harbor is a very protected bay. But when you come out of Melbourne harbor, there's a very narrow gap which is called the Rip. And when you come out of that, you go into the Bass Strait, where it's usually very stormy. And it was then, too. I was in the top bunk, Gretl was in the lower bunk, and then we had a little cage for the smaller child and another bed for the older child. And everything broke. We had a vase with flowers that people had given us, and the sugar she had for her solution for the baby fell down and the vase fell onto it and broke—so, water and sugar and glass, all this mess. And I was in the top bunk and I was barefoot, of course. [Laughter] Everybody was seasick except me.

LIPPINCOTT: Oh, that's interesting! You remember how horrible it was, even though it was so long ago.

HORNUNG: Oh yes. And they had these stupid rules on the ship. Children didn't eat together with adults. There were two sessions for adults and one for children. So when we had to go one session for the adults, I went. Then Gretl went to the other session for adults.

LIPPINCOTT: Because one of you had to be with the kids?

HORNUNG: Yes. And then we went with the children. And this three times a day. In the Indian Ocean, it was so stormy that almost nobody went to dinner.

LIPPINCOTT: Everybody was sick?

HORNUNG: Everybody was sick.

LIPPINCOTT: Oh boy! So, thirty-five days later, you come to Southampton?

HORNUNG: Yes.

LIPPINCOTT: Your appointment was at Imperial College. How about your living quarters in London?

HORNUNG: Oh, the Department of Supply was very generous with its trainees, so we had a flat in Kew Gardens. This is in the west of London.

LIPPINCOTT: Oh yes, that's a very nice area.

HORNUNG: Yes. And they paid for the rent, and we could afford a little car.

LIPPINCOTT: That's nice. You were there for one year?

HORNUNG: Two years.

LIPPINCOTT: And you did your PhD with John Stollery?

HORNUNG: Yes, John Stollery and Neil Freeman. I had two advisors. One, Neil Freeman, was a theoretician, and Stollery was an experimenter.

LIPPINCOTT: Was this in physics?

HORNUNG: This was in aeronautics.

LIPPINCOTT: And what was your thesis on?

HORNUNG: "Inviscid hypersonic flow over plane power-law bodies." It's a particular shape.

LIPPINCOTT: And then back to ARL?

HORNUNG: Yes.

LIPPINCOTT: But then you were taken into the Physics Department at the Australian National University, in Canberra?

HORNUNG: Yes. There was a problem, because when I came back from England, a new chief superintendent had started at ARL, and he didn't think this subject I was working in was something he wanted to continue. That upset me a bit, because I thought, "They've sent me to England to study this particular subject, and now I come back and they don't want it anymore!" And I wanted to continue to finish some stuff in it—some ideas I had—so I got into a bit of an argument with the chief superintendent, and I decided I would pay off my bond if I could get a job. And at that time, they were looking for somebody in this field in Canberra.

LIPPINCOTT: And the field would be hypersonics?

HORNUNG: Hypersonics. Hypersonic flow. So I decided to pay off the bond and go there. And they let me pay off the bond; they treated me quite generously. I didn't have to pay back as much as they gave to send me to England, but it was a bit of a hardship at first.

LIPPINCOTT: So you and your family moved to Canberra?

HORNUNG: Yes.

LIPPINCOTT: How was that?

HORNUNG: That was good.

LIPPINCOTT: And you worked on shock tubes.

HORNUNG: We built a big free-piston shock tunnel, which was an invention of Raymond Stalker, one of my colleagues in Canberra. It's a wind tunnel that allows you to test flows up to very high speeds, six kilometers per second.

LIPPINCOTT: T5, the tunnel here at Caltech, was kind of a descendant of that original shock tube, wasn't it?

HORNUNG: Yes. The one we built in Canberra was called T3. The precursors were T1 and T2, but they were very small. T3 was the first big one.

LIPPINCOTT: How big was it?

HORNUNG: It was a fairly long device, because in order to generate this high speed, you have to have all sorts of things in sequence. But the test flow was only about ten inches in diameter.

LIPPINCOTT: Well, you'll forgive my ignorance, but what was it for?

HORNUNG: The main practical application of the problems we were investigating was reentry for space transport. From space into the atmosphere of a planet like the Earth.

LIPPINCOTT: I'm trying to think where the space race was at that point. There were moon shots and so forth in the sixties.

HORNUNG: Oh yes. While I was in Canberra, we watched Apollo.

LIPPINCOTT: So this was in aid of designing reentry capsules for—?

HORNUNG: Understanding the flows that occur there, and from that, learning how to design it.

LIPPINCOTT: For manned spacecraft?

HORNUNG: Or other things, like meteorites.

LIPPINCOTT: Are there any particular professors you remember in Canberra, beside Dr. Stalker?

HORNUNG: Yes, one very close and particularly good friend and colleague was John Sandeman, with whom I did a lot of work; we published stuff together. He was a very gifted optical-equipment man. He understood all about interferometry. [Also, the head of the department of physics was Noel Dunbar, a New Zealander who had been a postdoc at Caltech. There he did an experiment together with Ward Whaling which verified that a particular nuclear state of carbon that had been predicted by Fred Hoyle did indeed exist. This was important, because the formation of all elements heavier than carbon depends on the existence of this state. — H. Hornung]

LIPPINCOTT: I have a list of your publications here.

HORNUNG: So you'll see a couple with Sandeman.

LIPPINCOTT: Yes. In the late sixties, early seventies, you were doing that. And did you teach at the university also?

HORNUNG: Yes, I taught first-year mechanics, second-year electronics, third-year fluid mechanics. And varied around a bit.

LIPPINCOTT: You liked teaching?

HORNUNG: Yes, I loved it.

LIPPINCOTT: In 1974, you received the Alexander von Humboldt fellowship in Darmstadt, in Germany.

HORNUNG: Yes. We had the system in Australia that every six years you could take one year off. Like sabbatical leave. So that came up in '74, and I decided I would like to go someplace where they do theoretical work on the sort of flows I was interested in. And there was one particular guy, called [Ernst] Becker, in Darmstadt who had a very good school of people working on these kinds of problems.

LIPPINCOTT: Had you been in communication with him before you went?

HORNUNG: Yes, I used to send him my publications. We exchanged publications. And then I was very lucky to get this German Alexander von Humboldt fellowship, and so we all went—now we had four children—to Darmstadt.

LIPPINCOTT: You took all four children?

HORNUNG: Yes. We sent them to German schools.

LIPPINCOTT: How was your German by this time?

HORNUNG: My German was always very good. I stayed interested in the language.

LIPPINCOTT: By the way, did the Templers speak German among themselves?

HORNUNG: They spoke a German dialect—Swabian. But the schools were, of course, in *Hoch Deutsch*—High German. And I read a lot of books and wrote stuff in German.

LIPPINCOTT: So you didn't have any problems with the language?

HORNUNG: No.

LIPPINCOTT: How was your time in Darmstadt? Useful?

HORNUNG: Very good. It was academically very interesting and also interesting from the point of view of making new friends and getting to know Germany.

LIPPINCOTT: Had you any connection at all with people at Caltech at this point?

HORNUNG: Actually, yes. When I was doing my master's degree in Melbourne-

LIPPINCOTT: That was back in '62.

HORNUNG: —one of the guys who had a very good hypothesis for the work I was doing was Don [Donald E.] Coles [d. 2013], from Caltech, in aeronautics. And I, a little graduate student in Melbourne, got my courage together and wrote a letter to Don Coles about an idea that I thought needed correcting slightly. And he wrote me back a very nice letter and said yes, this was correct, and he had a way of doing that, but he didn't consider it to be all that important. I didn't, either—I just wanted to make contact with the big man, you know. [Laughter] So that was my first contact with Caltech. Actually no—in my third year I bought a book by [Hans W.] Liepmann and [Anatol] Roshko, *Gasdynamics*.¹

LIPPINCOTT: Oh yes, that was a big text.

HORNUNG: Which was new at that time obviously—it was published in 1957. Then after that, I also had some contact with Hans Liepmann, because I sent him also my publications.

LIPPINCOTT: Was he the head of GALCIT [then the Guggenheim Aeronautical Laboratory, California Institute of Technology; now the Graduate Aerospace Laboratories, California Institute of Technology—ed.] at that point?

HORNUNG: Yes, he was.

LIPPINCOTT: So, back to Darmstadt. You're working with Becker. What did you work on? More of this hypersonics?

HORNUNG: Yes. I was working on a particular problem—trying to solve a particular problem theoretically, which was the flow behind a curved shock wave with dissociation. This was very challenging, and I got a good solution in the end.

LIPPINCOTT: Is Becker still with us?

¹ H. W. Liepmann & A. Roshko, *Elements of Gasdynamics* (New York: Wiley & Sons, 1957).

HORNUNG: No, unfortunately not. He died at age fifty-five.

LIPPINCOTT: That's young! What a shame.

HORNUNG: He was five years older than I.

LIPPINCOTT: So, you go back to the Australian National University. You remained there until 1980.

HORNUNG: Right.

LIPPINCOTT: And then you became director of an institute of the DLR—the German Aerospace Center, I think, is the name in English.

HORNUNG: Yes. It's an interesting story, because the director of that institute retired, and they were looking for a successor.

LIPPINCOTT: This was in Göttingen?

HORNUNG: In Göttingen. And in 1977 Liepmann had visited us in Australia, and he spent a few days in Canberra looking at my lab and discussing stuff with me. And at the time, the Germans asked both Becker and Liepmann for suggestions for the successor in Göttingen, and both of them suggested me. So I was invited to come to Göttingen to give a talk. I was in the middle of teaching, and they called me up and said, "Can you come in two weeks?"—they didn't give you much time. So I said, "I can't do that. I'm in the middle of teaching." And the guy at the other end, who was the head of the DLR, said, "I'm sure you can find somebody." [Laughter] So I did, and I went, and I gave a talk, and it was extremely well attended. And at the time the big man, [Hermann] Schlichting, was still alive and was there. He's a famous guy in our field. And after the talk I had to meet all these different committees. In Germany, they have all kinds of committees for the institute—internal, government, and external relations.

LIPPINCOTT: I wasn't aware that Germany had a space program. Did they?

HORNUNG: This particular institute was not a space program. This institute was an institute for fluid mechanics—very broadly, fluid mechanics, wind tunnels and—

LIPPINCOTT: But DLR itself—?

HORNUNG: It's basically like NASA.

LIPPINCOTT: So there was an interest in space travel there.

HORNUNG: Yes.

LIPPINCOTT: But Germany never had a space program.

HORNUNG: Yes, they did, together with NASA. They had astronauts and experiments.

LIPPINCOTT: But you weren't particularly concerned with that aspect of it, were you?

HORNUNG: Half of my institute was, yes. Satellite aerodynamics and plume impingement, the attitude-control jets of satellites.

LIPPINCOTT: Because when you hear "fluid dynamics," you don't right away think about aero—

HORNUNG: Well, gasdynamics is fluid. Gas is a fluid.

LIPPINCOTT: Gas is a fluid?

HORNUNG: Yes.

LIPPINCOTT: I didn't know that. So a fluid and a liquid are two different things?

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HORNUNG: A fluid is more general. Liquid is only one phase of a fluid.

LIPPINCOTT: Well, I've learned something now—that's incredible. You were director there for seven years?

HORNUNG: Yes. This was a very interesting time, because I had not had a bigger group to take charge of than my small group of graduate students in Australia, and now suddenly I was the boss of eighty professionals not including a lot of infrastructure: library, machine shop, computer center. These eighty professionals were in five sections, each with a section leader, and when I got to Germany every piece of expendable equipment and every travel request had to go across my desk and I had to sign it. I didn't know whether this guy should travel or not, I didn't know if they had to buy this piece of equipment. So I decided to delegate this stuff to the section leaders and distribute the money according to head count and keep a small reserve to be able to jump in where necessary. This was the smartest move I ever made, because now these guys treated this money as their own money and they were much more careful with it than when I had to spend it. Not only that, they saw that I trusted them. So they said, "This guy trusts us we're going to trust him, too." And it immediately set up a situation of exceptional teamwork.

LIPPINCOTT: That's pretty good management.

HORNUNG: Yes. I thought this was an obvious thing, actually. [Laughter] But apparently not always used.

LIPPINCOTT: Did you have time to do your own research?

HORNUNG: Yes I did. And I also taught a course at the University of Göttingen for graduate students—different courses each year. Yes, I did quite a bit of research myself.

LIPPINCOTT: How was Göttingen? It was such a star place in physics, earlier.

HORNUNG: Before the Nazis came, yes.

LIPPINCOTT: Had it recovered somewhat from that?

HORNUNG: Well, it never really recovered, not to that degree. German science was dealt a very bad blow by the Nazis.

LIPPINCOTT: Yes, I know, except for [Werner] Heisenberg, who tried to keep relativity alive.

HORNUNG: Yes, well, Heisenberg was an exception who stayed.

LIPPINCOTT: I think he stayed just to protect German physics from-

HORNUNG: I don't know. I think he was just such an ingrained German.

LIPPINCOTT: You think?

HORNUNG: Yes.

LIPPINCOTT: Well, we won't get into that, because we could talk about that for hours. So you became something called *Honorarprofessor*. What is that?

HORNUNG: That's a professor who doesn't get paid. [Laughter]

LIPPINCOTT: This was in the Physics Department at Göttingen.

HORNUNG: Yes. You had to be appointed in order to be allowed to teach. So I was appointed *Honorarprofessor*. *Honorarprofessor* is someone who doesn't get paid but it allows you to be an advisor of graduate students.

LIPPINCOTT: Did you have many graduate students?

HORNUNG: Not many, but I had a few.

LIPPINCOTT: All in aeronautics, obviously.

HORNUNG: Yes.

LIPPINCOTT: How was the Aeronautics Department there—if the physics wasn't quite what it was before the war?

HORNUNG: There was no Aeronautics Department at Göttingen.

LIPPINCOTT: Oh, it was the Physics Department.

HORNUNG: It was the Physics Department. They had some good people, but they didn't have— Before the war, before the Nazis came, it was a star-studded place.

LIPPINCOTT: I know. It was a mecca for people.

HORNUNG: Yes. People went there from here.

LIPPINCOTT: I think Oppenheimer did.

HORNUNG: Oppenheimer spent time there. I think a lot of mathematicians went there, too.

LIPPINCOTT: You were also on the executive council for the DGLR [German Society for Aeronautics & Astronautics]?

HORNUNG: Yes. I had quite a few such jobs.

LIPPINCOTT: This was just an advisory job?

HORNUNG: This was a society for aerospace research.

LIPPINCOTT: Kind of like the American—?

HORNUNG: Yes, AIAA [American Institute of Aeronautics & Astronautics].

LIPPINCOTT: We want to get to Caltech, and maybe we can do that next time, but how did they recruit you? You came here in 1987. What were the circumstances behind your leaving Göttingen and going to Caltech?

HORNUNG: Oh yes, that was quite interesting. But let me go back to talking about going to Germany. When I decided to go to Germany, this caused very big trouble with my wife, because we had two older children, one of whom was already in university in Australia, and two younger ones, and we decided to leave the older ones there—well, they decided to stay there. The two younger ones we took with us, so that was a disruption of the family, which my wife hated. But she went along with it, and in the end it turned out to be not so bad.

Anyway, you asked about going to Caltech. They were looking for a successor for Hans Liepmann—

LIPPINCOTT: When did he step down?

HORNUNG: Nineteen-eighty-five. Brad Sturtevant [Liepmann Professor of Aeronautics; d. 2000] was on the search committee; I think he was the chair of the search committee. Brad and I knew each other very well, because of the shock-wave symposia, which happened every two years, and we became good friends and had similar interests.

LIPPINCOTT: Where were these symposia held? Just all over?

HORNUNG: Internationally—a different place every two years. So Brad wrote me a letter and said he would like to have some advice about a successor for Hans Liepmann. So I wrote a letter in which I said I thought there were two people at Caltech who could do it: Anatol Roshko [von Kármán Professor of Aeronautics, emeritus] or Brad Sturtevant, and the only thing I could think of against them was that Brad Sturtevant was a bit too abrasive for some tastes and Anatol Roshko was too kind for his own good in that job.

LIPPINCOTT: You need administrative talents.

HORNUNG: Well, you need to make tough decisions, and Anatol is just such a kind guy. [Laughter]

LIPPINCOTT: A pussycat.

HORNUNG: No, not a pussycat, but he would find it very hard to make a decision that would hurt somebody.

LIPPINCOTT: I see.

HORNUNG: So then they said OK, I should come and spend a bit of time discussing a successor to Hans Liepmann. So I came and I was actually quite critical of the aero department, because I thought they were a little bit full of themselves.

LIPPINCOTT: Who did you express this criticism to?

HORNUNG: The committee.

LIPPINCOTT: And the committee were all aeronautics people?

HORNUNG: No. Phil [Philip] Saffman [von Kármán Professor of Applied Mathematics and Aeronautics, d. 2008] was one of them, from applied math.

LIPPINCOTT: Ah, this was a search committee?

HORNUNG: Yes. And then I went home thinking, "These guys will never talk to me again."

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LIPPINCOTT: What criticisms did you make?

HORNUNG: Just that they were out of touch with the industry and the not-invented-here sort of attitude, which was actually not so bad. I overstepped the mark a bit. Anyway, I went back to Göttingen, and it was a nice summer Sunday, and Ray Stalker from Australia was visiting with his wife. We were sitting outside in the garden, and a phone call comes from Paul Jennings [professor of civil engineering & applied mechanics, emeritus], who was chair of the Engineering Division, and he said, "You've got the job." I had to sit down. [Laughter] Anyway, they wanted us to come in two weeks, both of us.

LIPPINCOTT: And two children were in Germany and two in Australia.

HORNUNG: Yes.

LIPPINCOTT: How did your wife feel about moving to California?

HORNUNG: Well, she felt better about that than she had about moving to Germany. It was kind of tough going to Germany, because the children couldn't speak German very well, and she didn't speak it perfectly either.

LIPPINCOTT: They were good English speakers, though?

HORNUNG: Yes. Anyway, in the meantime, the children were very good friends with everybody in Germany and doing very well. When we got to Caltech, we entered them in Occidental College.

LIPPINCOTT: The two younger ones?

HORNUNG: The two younger ones. They had driven the car down to Heidelberg to do an SAT test, and they got into Occidental. That was quite good.

LIPPINCOTT: We'll stop here and pick up next time with your Caltech career.

HANS G. HORNUNG SESSION 2 July 3, 2014

LIPPINCOTT: We're in the Archives with the Clarence L. Johnson Professor of Aeronautics, emeritus, Hans Hornung. I thought in this session we'd talk about your arrival at Caltech in 1987. This was occasioned by Hans Liepmann leaving as head of GALCIT.

HORNUNG: Yes.

LIPPINCOTT: I guess he went emeritus. He was still here at Caltech, but he wasn't going to be the director of GALCIT.

HORNUNG: Yes.

LIPPINCOTT: We talked a bit last time about the circumstances of how you were chosen, and now I want to talk about your arrival. You and Gretl had four children by this time, but they didn't all come with you?

HORNUNG: No, two of them, when we went to Germany in 1980, had stayed in Australia. Our oldest daughter was at university, and our son was, at the time, seventeen.

LIPPINCOTT: You mean in 1980?

HORNUNG: Yes. He had dropped out of high school and was bumming around working for a Toyota representative as a hand, helping with the mechanics. And the two girls came with us to Germany and went to school in Germany, and just before we came here they finished their high school in Germany and took the SAT test in Heidelberg.

LIPPINCOTT: For an American university?

HORNUNG: Yes, and that got them into Occidental College. Which was good, because we wanted them to continue.

LIPPINCOTT: Were they in the same class at Occidental?

HORNUNG: No. Initially they were, but then Lisa, the older one of the two, skipped a year, so she was a class ahead of Jenny.

LIPPINCOTT: Did you have any kind of housing set up when you got here?

HORNUNG: Yes. Caltech had a nice large house for us on Catalina Street, which was very convenient and comfortable for us. We didn't need such a large house, but it was convenient when all the children came at Christmastime that year. We arrived in September '87, and I went to a conference in Naples, Italy, about a week afterward. [This was an AGARD meeting—a NATO-organized Advisory Group for Aeronautical Research and Development initiated by Theodore von Kármán. —H. Hornung] Anatol Roshko was also at this conference. And during our stay in Naples, the Whittier Narrows earthquake struck. [Laughter] And my wife was very scared, but Robbie [Rochus E.] Vogt [Avery Distinguished Service Professor and professor of physics, emeritus], who was the provost, came over immediately. He was living not far away on Catalina, and he came over immediately in order to pacify her and say, "It's all right, but expect aftershocks." [Laughter] Meantime, Anatol and I, who could both read Italian, read the newspapers in Italy, and they were so ridiculously exaggerating. They said, "Thousands dead," and we were scared. I called up, and eventually I got through to our son in Canberra, and he had spoken to Gretl.

LIPPINCOTT: Because the phone lines were down.

HORNUNG: Yes, it was really hard to get through. That was exciting.

LIPPINCOTT: That happened to me about nine months after I moved here—Northridge [January 1994]. Now it's been years since there was a really big one. Just refresh my memory: Was it Roshko who brought you here?

HORNUNG: No, it was actually the search committee headed by Brad Sturtevant. I don't know who was on it, but I know that Philip Saffman was on it.

LIPPINCOTT: So they shepherded you through the first weeks, or were you pretty much OK on your own, finding out the ins and outs of GALCIT?

HORNUNG: Well, we had regular faculty meetings once a week, on Fridays. And that very quickly got me up to speed.

LIPPINCOTT: You had PhD students from the get-go, didn't you?

HORNUNG: Yes.

LIPPINCOTT: There was David Bridges, and can you remember the others?

HORNUNG: One joined me—that was Jacques Bélanger, a French Canadian—and fairly quickly I had five graduate students. When I came, there was a big push by the government to build what was called the National Aero-Space Plane. This was announced by Reagan, and it was going to go into space in a single stage.

LIPPINCOTT: And land like a plane?

HORNUNG: Yes—the National Aero-Space Plane project. It was a \$2-billion project. And for that, Rocketdyne was very keen to build a facility of the type I had operated in Canberra.

LIPPINCOTT: The shock tube?

HORNUNG: A free-piston-driven shock tunnel. In Germany, just before I left, we got money to build something like that. I made the preliminary design for it, and they went ahead in Germany to build it. Rocketdyne wanted to build a very large machine of this type, and in order to get some ideas, they wanted a pilot facility built here at Caltech. This was the facility now called T5.

LIPPINCOTT: It was to be on the roof of the Guggenheim lab?

HORNUNG: Yes. The only place where we could find a straight line long enough was on the roof, so we built a fourth floor onto Guggenheim and in it we built this machine, which actually took quite a while, because I made the preliminary design in '88 and then we chose a company, which was WBM—Winders, Barlow, & Morrison—in Australia, together with Ray Stalker. They teamed up with Bechtel to construct it here. WBM and Stalker made the detailed design, and Bechtel had it built and put it in. This took until December 1990, when it was finished.

LIPPINCOTT: So it took two or three years to build?

HORNUNG: Yes. Meantime, the National Aero-Space Plane program was about to fold.

LIPPINCOTT: Why did it fold?

HORNUNG: It was too big a thing. It was too ambitious. To get an airplane up into space by scramjet combustion engine is something that was just technologically too advanced. They weren't ready; they couldn't do it yet. There were many ifs that made it impossible.

LIPPINCOTT: I wonder why they wanted to do it? They could shoot the shuttle up on rockets.

HORNUNG: That's a different thing. This was supposed to take off from a runway, like a plane, under its own engine thrust.

LIPPINCOTT: So if they were able to do it, it would be cheaper than a rocket launch?

HORNUNG: Well, partly because it would be reusable—it would come back and land. The difficulties were that there are a number of things that are not understood well enough to make the design feasible. They're still working on stuff like that.

LIPPINCOTT: Do you think eventually they'll make—

HORNUNG: Yes, eventually it will be possible, although only with a second rocket stage.

LIPPINCOTT: That's great! And this would get into low Earth orbit?

HORNUNG: Yes.

LIPPINCOTT: Like the shuttle?

HORNUNG: Yes.

LIPPINCOTT: Presumably if they perfect it, it will be able to get out of orbit and go right to the moon?

HORNUNG: No, because it's an air-breathing engine.

LIPPINCOTT: So it couldn't leave the moon, because there's no air.

HORNUNG: Right. Even to leave the atmosphere, it would have to have enough speed so that its momentum would carry it into orbit or use a second stage rocket. Anyway, because they never built anything, and because they only produced presentations— viewgraphs and computations, the only remaining tangible evidence of the National Aero-Space Plane program is T5. That's the only thing left of it.

LIPPINCOTT: Could you conceive of other uses for T5?

HORNUNG: Oh, of course.

LIPPINCOTT: What did you think it would be used for?

HORNUNG: For one thing, to clear up the unknowns—questions we needed to answer before we could build an air-breathing engine-driven plane that goes into orbit. One of the very important things in that field is the transition from laminar to turbulent flow in a boundary layer on the surface of a vehicle, and this is something on which we made enormous progress with T5.

LIPPINCOTT: Were you working closely with NASA then?

HORNUNG: Not at that stage. At that stage, we worked mainly with Rocketdyne, who tested its engine in T5.

LIPPINCOTT: Rocketdyne was going to build the Aero-Space Plane if it got-

HORNUNG: Together with Pratt & Whitney and other companies.

LIPPINCOTT: So once you got it built, did your association with Rocketdyne end because there was no plane?

HORNUNG: No. During the time when we built it, Rocketdyne actually got me to give them some lectures on hypersonic flow.

LIPPINCOTT: Where is Rocketdyne?

HORNUNG: This was in Thousand Oaks.

LIPPINCOTT: You went over there to lecture?

HORNUNG: Yes.

LIPPINCOTT: Whom did you talk to, their engineers?

HORNUNG: Yes, their engineers. And also they then brought their own engine and tested it in T5. They did a lot of tests there. Later we used T5 for NASA, for reentry capsules testing the heating on those.

LIPPINCOTT: For Apollo?

HORNUNG: No, much later.

LIPPINCOTT: Oh yes, Apollo was much earlier.

HORNUNG: Yes. But the capsules were a similar shape. One of them was a little different—that one was for entry into Titan's atmosphere. And also for Mars entry.

LIPPINCOTT: So, in other words, unmanned capsules.

HORNUNG: Yes.

LIPPINCOTT: Did your graduate students work with Rocketdyne?

HORNUNG: No, they worked on different projects that were funded by the air force. And by ONR [Office of Naval Research]. We do fundamental stuff with the graduate students; they don't work directly for the companies.

LIPPINCOTT: In the meantime, you did some teaching?

HORNUNG: Yes, I taught a lot. At that time, everybody taught at least three quarter courses a year, and I taught at least four courses each year.

LIPPINCOTT: Did you teach undergraduates?

HORNUNG: No, at that time I didn't. Aero is only a graduate school; we don't have undergraduates in aero. But we do help out with applied physics and mechanical engineering undergraduate teaching, and later I did statistical mechanics and thermodynamics teaching for a couple of years—undergrads—and also fluid mechanics for undergrads.

LIPPINCOTT: How did you find Caltech undergrads?

HORNUNG: Great.

LIPPINCOTT: You were impressed?

HORNUNG: Yes. Also graduate students—very good! It's kind of different from the style we had in Australia or in Germany, because here you give them a lot of homework, which is not the case in Germany, where they're supposed to do their own— Well, the undergrads do homework, but the graduate students here also do homework.

LIPPINCOTT: So they stay up until four in the morning, too?

HORNUNG: I don't know, but they do the problems. [Laughter]

LIPPINCOTT: That's what the undergraduates seem to do.

HORNUNG: Yes.

LIPPINCOTT: OK. Well, are there any graduate students in particular that you want to remember?

HORNUNG: We had some really good students. We had an Australian guy whose name was Simon Sanderson. He was so inventive! He needed to make a visualization system, and he was very ambitious. He said, "I can make an interferometer work, a holographic interferometer." He knew nothing about optics, but he studied it all up, and he made this

beautiful instrument and made some exquisite pictures of flows—interferograms of flows in T5, as one example. He made lots of different things. He invented a new heat flux gauge, to measure the heating at the surface of a vehicle. And then I had a student whose name was Eric Cummings, who came from Penn State. He was excellent. He did some stuff which he called LITA, Laser-Induced Thermal Acoustics, with which he was able to measure, using lasers, the speed of sound and the diffusivity of a gas at a point at temperatures up to 4,000 degrees and high densities. A really beautiful instrument.

LIPPINCOTT: How would that be practical?

HORNUNG: Well, it's very important for us to know these quantities, because the speed of sound gives you the temperature, and the diffusivity gives you the viscosity, which we need to know.

LIPPINCOTT: For instance, you mean for the reentry of a space-?

HORNUNG: Yes. If you want to study what happens in the layer of gas immediately adjacent to the surface, then if you can measure the viscosity there, it's very valuable, because that causes the friction. Eric was very good. He not only got the [William F.] Ballhaus Prize shared with Simon for the best aeronautics thesis in Caltech for that year, 1995; but he also got the Clauser Prize for best thesis of all of Caltech for that year. While we were building T5, they all helped in various ways.

LIPPINCOTT: Did you have a kind of hands-on thing with T5, or did you just do the designing?

HORNUNG: I was up there every day. [Laughter] I have this style of graduate teaching where I interact with each of my graduate students, one-on-one, each day, so we do things in front of the blackboard, stuff like that. And this was for me wonderful, this interaction with the graduate students. I still do it. [Laughter].

LIPPINCOTT: You still do it, even though you're emeritus?

HORNUNG: Yes.

LIPPINCOTT: Do you still have graduate students?

HORNUNG: Not officially, because the advisor needs to be an active professor. But they often come to my room and discuss stuff with me.

LIPPINCOTT: Oh, that's terrific! And is this free-piston shock tunnel still operating?

HORNUNG: Yes.

LIPPINCOTT: Do you still go up there and tinker with it?

HORNUNG: No. Well, I discuss stuff the graduate students do, and the technician.

LIPPINCOTT: Before I forget this, when you came here, you had a chair right away—the Clarence L. Johnson chair.

HORNUNG: Yes.

LIPPINCOTT: Who was Clarence L. Johnson?

HORNUNG: Kelly Johnson was his nickname. He was the most important aircraft designer in this country, ever. He designed the [Lockheed] U-2 and the SR-71 and several other planes. He was just one of the best.

LIPPINCOTT: But he's no longer with us?

HORNUNG: No, he actually— I saw him, and he was already sick with Alzheimer's disease, in a hospital in Burbank. I visited him there, with his wife, and he gave me a picture, which he signed, of himself, which I gave to Joe [Joseph E.] Shepherd, who is the Kelly Johnson Professor now. He's got it in his office.

LIPPINCOTT: Was Professor Johnson at Caltech?

HORNUNG: He was not a professor. He was a designer, at the Lockheed Skunk Works.

LIPPINCOTT: Yes, of course. I think he had something to do with CAD [Computer Aided Design] design, right?

HORNUNG: Probably not; that came after his time. He had the ideas, and he had a clever way to do things. He had this principle called KISS—"Keep It Simple, Stupid." [Laughter]

LIPPINCOTT: Let's move for a minute to Caltech as an institution. When you came, Thomas Everhart [Caltech president 1987-1997] had just begun his presidency.

HORNUNG: Yes, we both came at the same time.

LIPPINCOTT: Did you have much interaction with him?

HORNUNG: Not a lot, but some.

LIPPINCOTT: And who was the head of the Engineering Division?

HORNUNG: That was Paul Jennings. He was great. It was interesting. Before I came, I had an interview with the president then, who was Murph [Marvin L.] Goldberger [Caltech president 1978-1987], and also with Robbie Vogt. And these interviews were interesting for the following reason: Neither of them required me to say a thing; they just talked. They talked and talked and talked. And I just nodded. [Laughter] It was very funny.

LIPPINCOTT: Were these interviews at Caltech?

HORNUNG: Yes, in their offices.

LIPPINCOTT: So you visited here, before you actually came for good in September?

HORNUNG: Right.

LIPPINCOTT: Well, Robbie is very vocal—and very interesting.

HORNUNG: Yes.

LIPPINCOTT: That's probably why he came to see Gretl, because he knew a fellow German was—

HORNUNG: Oh, no. He was very protective of the newly hired faculty. He knew that we had just started, and he knew we didn't know anything about earthquakes. [Laughter]

LIPPINCOTT: So, Paul Jennings was the head of the division, and you were, in essence, the head of the aeronautics department, as the director of GALCIT.

HORNUNG: Yes.

LIPPINCOTT: I want to talk later about the Mars *Pathfinder*, because I see you had something to do with that. But there was something called the Ludwieg tube?

HORNUNG: Yes, that was a very interesting story. I always wanted to build a Ludwieg tube, because a Ludwieg tube is the cheapest way to have a decent-sized supersonic wind tunnel, at low speed and high Mach number—but not such high speed as T5.

LIPPINCOTT: And smaller than a T5?

HORNUNG: Actually, it's almost the same exit diameter, a little bit smaller. And I went to Lockheed to see if they would be interested in funding such a facility. I estimated it would cost something like \$700,000.

LIPPINCOTT: This was about when?

Hornung-44

HORNUNG: This was after T5 was already built—maybe in the mid-nineties. But I had this idea right from the beginning, so when we made sort of a strategic plan for GALCIT together—the faculty of GALCIT—the Ludwieg tube featured in that also. And then Bill [William R.] Sears—he was a graduate of Caltech, a student of von Kármán's. He also taught here early on and then went to Cornell and then to the University of Arizona. Bill Sears kept up a very keen interest in GALCIT, and he liked this idea for a Ludwieg tube. And when John Wild—one of his colleagues, who had been involved in the design of the flying-wing airplane; this was, I think, in the fifties—when John Wild died, he left some money, and his widow wanted to give this money to a church. But Bill Sears, who was very close to John Wild, persuaded her to give it to us, for a Ludwieg tube. It was \$350,000, but I didn't think this was quite enough. Caltech invested this money, and it grew and grew, and when it had reached \$500,000, about the year 2000, I decided to go ahead and build the Ludwieg tube with this money—because Lockheed never came through. And this was very smart, because it was just before the crash. Lucky, not smart.

LIPPINCOTT: Why is it called the Ludwieg tube? Was Mr. Ludwieg the inventor?

HORNUNG: Yes. Hubert Ludwieg, who was in Göttingen. He was my predecessor in Göttingen.

LIPPINCOTT: Did you meet him?

HORNUNG: Yes. We had some publications together.

LIPPINCOTT: Did you participate in this invention?

HORNUNG: No, that was much earlier, in the fifties. So we built this Ludwieg tube, and it's a gem. It's a beautiful facility, extremely cheap to operate.

LIPPINCOTT: Where is it physically?

HORNUNG: Next to T5. We built another part of the fourth floor. [Laughter]

LIPPINCOTT: Up on the roof?

HORNUNG: Yes.

LIPPINCOTT: Is this enclosed?

HORNUNG: Yes. Nice lab.

LIPPINCOTT: So if it were open to the air, it would make a tremendous noise?

HORNUNG: No, it doesn't make much noise.

LIPPINCOTT: You just turn it on and then it—?

HORNUNG: We have a flow that lasts 100 milliseconds

LIPPINCOTT: That's not very long.

HORNUNG: No, but it's ages; with modern instrumentation, it's a very long time. It only takes about 10 milliseconds to set up the flow, and then it's steady for 90 milliseconds. And during that time we can make movies that are boring to watch because they're so long. [Laughter]

LIPPINCOTT: Really?

HORNUNG: High-speed movies.

LIPPINCOTT: Did you work with any companies using the Ludwieg tube, or is this just for pure research?

HORNUNG: So far, we haven't done any work in the Ludwieg tube for any companies. We've done work in T5 for various companies and also for NASA. LIPPINCOTT: For the space program. Are you still working with NASA?

HORNUNG: On and off. Not regularly. NASA and the air force together funded several hypersonic science centers. One of them is the National Center for Hypersonic Laminar-Turbulent Transition, which was several universities together, and T5 was one of the elements.

LIPPINCOTT: Do you work with people at JPL [Jet Propulsion Laboratory] on these things?

HORNUNG: We have done both with T5; and I've also done some computations for the Mars landing of *Curiosity*.

LIPPINCOTT: Didn't you work on *Pathfinder*? I saw that somewhere—maybe you did a paper on it? That was the early lander that was low-budget, if you can call anything at NASA low-budget.

HORNUNG: No, the preparation for *Pathfinder* happened before my time here. In our style of work with JPL they bring some design in and want to test it, and we do the tests. We did one together with JPL for Mars—a generic capsule, to see what heat loads are when you have a carbon dioxide atmosphere with dissociation.

LIPPINCOTT: A much lighter atmosphere on Mars.

HORNUNG: Yes, the density is different.

LIPPINCOTT: So, over the years to other [Caltech] presidents: David Baltimore [1998-2006] and Jean-Lou Chameau [2006-2013]. Any changes in your fortunes or the fortunes of the aeronautics department under those people?

HORNUNG: Not so much the presidents. But after Paul Jennings' division chairmanship, I was the chair of the search committee that found John Seinfeld [Nohl Professor and

professor of chemical engineering; division chair 1990-2000] as his successor. And he was very good for us, as was Jennings. He was very sympathetic toward the quality work we were doing and stuff like that, and we hired some people under him. We hired first Mory [Morteza] Gharib [Liepmann Professor of Aeronautics and professor of bioinspired engineering] and Joe Shepherd.

LIPPINCOTT: Where did they come from?

HORNUNG: Mory was a professor at UC San Diego, and Shepherd was a professor at RPI [Rensselaer Polyechnic Institute]. Both were graduates from GALCIT. Then we hired Dale Pullin [von Kármán Professor of Aeronautics], who came from Australia, and then we hired Michael Ortiz [Marble Professor of Aeronautics and Mechanical Engineering]. Dale Pullin had been a postdoc with Philip Saffman. Michael Ortiz came from Brown.

LIPPINCOTT: The only aeronautics professor I know is Fred [E. C.] Culick [Hayman Professor of Mechanical Engineering and professor of jet propulsion, emeritus], because his wife and I were classmates at college. And I love Fred, because he's so funny. I think he's emeritus too, now.

HORNUNG: Yes, he's eighty.

LIPPINCOTT: Did you do any work with him?

HORNUNG: Not directly, no. His field was slightly different; he was working in combustion instability and things like that. He was also a pilot. I learned to fly in Germany.

LIPPINCOTT: You did? What do you fly?

HORNUNG: Small planes, like Cessnas.

LIPPINCOTT: I think Fred is working on a Wright brothers' plane.

HORNUNG: Yes—a big project, for a long time.

LIPPINCOTT: He's not going to fly it, is he?

HORNUNG: No, not anymore he's not. [Laughter]

LIPPINCOTT: I went to his last big birthday party. Were you there?

HORNUNG: Yes! His 80th.

LIPPINCOTT: The 80th at their house.

HORNUNG: Yes, Gretl and I were there.

LIPPINCOTT: Let's talk about your memberships in the various societies. There's the American Institute of Aeronautics and Astronautics. Did you do any work with them?

HORNUNG: Not really. I was just a session chair a few times and on one or two committees, but nothing much. I go to the conferences. They have several conferences each year. Two main ones, one in June and one in January.

LIPPINCOTT: And you became a member of the National Academy of Engineering in '97.

HORNUNG: Yes.

LIPPINCOTT: That's like the NAS [National Academy of Sciences], isn't it?

HORNUNG: Yes, the NAE and NAS are in the same category, part of the National Research Council.

LIPPINCOTT: Did you ever do any government work then, as government work?

HORNUNG: I was on a number of NRC committees. The way it works is that the government wants a certain question to be discussed and resolved. So the NRC, which is the three academies together—

LIPPINCOTT: What's the third academy?

HORNUNG: The Institutes of Medicine. Then they choose members for a committee to look into such-and-such a question and they finish up with a report. And I was on a number of those.

LIPPINCOTT: Can you think of anything particularly interesting about them?

HORNUNG: They are actually very tedious and a lot of work. I remember some of those committees very well, because on a couple of them Neil Armstrong was also a member, and Neil Armstrong is a very impressive man. He doesn't say much. He hardly ever says anything, but when he does, everybody shuts up and listens, because it's always very much to the point.

LIPPINCOTT: When he does speak. Didn't he die?

HORNUNG: He died about a year ago.

LIPPINCOTT: Did you become friendly with him?

HORNUNG: Yes, fairly. It was not difficult.

LIPPINCOTT: Even though he doesn't say anything?

HORNUNG: I remember him telling me a joke, which was about [Eduard] Shevardnadze. Shevardnadze, after the Soviet Union broke up, became the president of Georgia. And he made his inaugural speech. According to Neil Armstrong, it went like this: "Yesterday we stood at the brink of an abyss. Today, we took a giant step forward." [Laughter] LIPPINCOTT: That's really good! I like that. So, what did the NRC want you people to study for them? Do you remember any of the topics?

HORNUNG: They were all to do with aeronautics and space, and—I have to think.

LIPPINCOTT: Maybe you'll remember some specifics. Because NASA was having trouble at that time; their budgets were being squeezed, and there was always a conflict between the manned space program and the science program. Did you get involved in any of those debates?

HORNUNG: [Laughter] I remember one occasion. Do you remember Dan [Daniel] Goldin?

LIPPINCOTT: Oh, yes.

HORNUNG: He was on this committee with me and others. Robert Crandall was also on this one; he was the head of one of the airlines, a dry old guy. On this occasion, Dan Goldin was spouting forth about NASA.

LIPPINCOTT: He was head of NASA at this point?

HORNUNG: Yes, and what wonderful things it was doing and stuff. And I interrupted him and said, "NASA only has two diseases, the space shuttle and the space station." And he got wild. He was red in the face and said, "Don't you dare say that!" And he went on and on and on, attacking me.

LIPPINCOTT: Why?

HORNUNG: Because I challenged the value of these two things.

LIPPINCOTT: "Diseases," you called them? I see, because you were on the side of the science projects as opposed to the manned space program.

HORNUNG: Yes. Anyway, so he went on and on, and Crandall said, "Dan, get off your soapbox." [Laughter] There were some scenes that were memorable.

LIPPINCOTT: Why were you opposed to the manned space program?

HORNUNG: It's so expensive. I'm not opposed to it in principle, but the space station is something that is of very questionable value, for the cost. The cost/benefit ratio is very bad.

LIPPINCOTT: Unless you view it as practice—as the first step into space, into getting off the planet.

HORNUNG: Well, that's what's being argued.

LIPPINCOTT: To me, that's a valid argument.

HORNUNG: But it's very expensive. I believe the only reason it's still there is political, because it's international.

LIPPINCOTT: So you think it has no value?

HORNUNG: It has some value, but it's not worth it.

LIPPINCOTT: Because eventually we'll have to get off this planet, so it's valuable from that point of view. We can't stay here.

HORNUNG: We can't?

LIPPINCOTT: No. In a billion years this planet isn't going to be habitable.

HORNUNG: In a billion years, there won't be any humans.

LIPPINCOTT: Well, perhaps there will and perhaps there won't. We might be partly bionic. I hope by then we'll be somewhere else. What do you think? That the species will blow itself up? Or die out?

HORNUNG: No. Every million years or so, there's a big event that is civilizationdestroying.

LIPPINCOTT: Oh, a big extinction event. Yes. Well, maybe we'll be elsewhere by that time. Are there any other honors or memberships you'd like to talk about?

HORNUNG: I was elected to the Royal Swedish Academy of Engineering Sciences, and I was pretty proud of that.

LIPPINCOTT: When was that?

HORNUNG: '91.

LIPPINCOTT: Did you have to go over to Sweden?

HORNUNG: Yes, and shake the hand of the King, and all of that. [Laughter]

LIPPINCOTT: Oh! That's almost like getting a Nobel, isn't it?

HORNUNG: Not quite.

LIPPINCOTT: Did Gretl go with you?

HORNUNG: Yes. That was also an interesting occasion, because when the new foreign members had to meet the King, I was the first in the alphabet. We were all standing around drinking champagne when he came in.

LIPPINCOTT: Where was this?

HORNUNG: In Stockholm, in a special building—I don't remember what it was called.

LIPPINCOTT: Probably where they have the Nobel ceremony.

HORNUNG: Maybe, I don't know. Anyway, the King came in and then they called me over, so I gave my glass of champagne to Gretl. And then they said, "No, no, she comes too." I was already walking over to the King, so she followed me.

LIPPINCOTT: With the glass in her hand?

HORNUNG: No, she got rid of it. And then I went up to the King and held out my hand, and he said, "No, no, no! First you take this, you know." [Laughter]. We did everything wrong.

LIPPINCOTT: They didn't go over the protocol with you?

HORNUNG: No, they didn't. And then the next one was a British guy, and his wife was *beautifully* dressed, and she made a *huge* curtsey. Gretl said, "Why didn't you tell me I'd got to do that?" [Laughter]

LIPPINCOTT: Do you remember who the British guy was?

HORNUNG: Not offhand.

LIPPINCOTT: Have you had much contact with the Royal Swedish Academy since then?

HORNUNG: Not really. They send me their stuff, and we communicate by email and so on.

LIPPINCOTT: But you don't go to annual meetings?

HORNUNG: No. I did go to Sweden to review their aeronautical research laboratories, together with some other people.

LIPPINCOTT: Do they have a big aeronautics program there?

HORNUNG: They used to. In fact, they build their own fighter planes. It's an amazing country. Eight million people, and they have an aircraft industry, and they have an automobile industry, and they have a high-tech industry. It's a very smart country.

LIPPINCOTT: And those detective novels.

HORNUNG: Yes. [Laughter].

LIPPINCOTT: How about the Royal Aeronautical Society? Is that British?

HORNUNG: Yes, that's British. They also got me to give the Lanchester Memorial Lecture, which was nice.

LIPPINCOTT: Where was that given?

HORNUNG: The Royal Aero Society has a house in Hamilton Place in London, which is right at the southeast corner of Hyde Park. That was very nice. Also I gave the Prandtl Memorial Lecture, which was in Vienna.

LIPPINCOTT: Who is Prandtl?

HORNUNG: Ludwig Prandtl was the father of many ideas in modern aerodynamics.

LIPPINCOTT: Was he 19th century?

HORNUNG: No, he was appointed to the technical university in Hannover in 1901. Just a few years later, he made one of the huge contributions to solving the problem of flow near a surface.

LIPPINCOTT: This is before the Wright brothers?

HORNUNG: Yes. About the same time.

LIPPINCOTT: We always think of the Wright brothers as having invented flight.

HORNUNG: Well, they were not the first to think of it. Nor to practice it. There was a guy in Berlin called Otto Lilienthal, who actually killed himself in one of these experiments at flying. But the Wright Brothers were the first to succeed.

LIPPINCOTT: You mean he crashed?

HORNUNG: He crashed. But the Wright brothers were fully aware of all the stuff he'd done. They may actually have communicated with him—I'm not sure. They were really up on all the stuff going on in Europe. But Prandtl was the scientific father of aerodynamics. And then he did a lot of other things. He was a giant contributor to our field.

LIPPINCOTT: This lecture was sponsored by the Deutsche Gesellschaft für Luft- und Raumfahrt?

HORNUNG: It's the German aerospace society.

LIPPINCOTT: So they had you give a lecture in Berlin?

HORNUNG: No, in Vienna.

LIPPINCOTT: And how did that go?

HORNUNG: It was the biggest audience I've ever had, about 700 people, and of course it was a somewhat heterogeneous audience, so you had to aim it at a level that could be understood by all. They were all scientists, but in different fields.

LIPPINCOTT: Not all in aeronautical science?

HORNUNG: Right.

LIPPINCOTT: What did you talk about then, with those people?

HORNUNG: I talked about the reflection of shock waves.

LIPPINCOTT: And do you think they got it, most of them?

HORNUNG: Yes. You have to understand what happens in order to design an engine at supersonic flow. It's a field in which I'm considered a guru. And they also gave me the Ludwig Prandtl ring, which is the DGLR's highest distinction.

LIPPINCOTT: It's an actual ring that you wear?

HORNUNG: It's an actual ring.

LIPPINCOTT: Do you have it on now?

HORNUNG: No, it's too big. [Laughter]

LIPPINCOTT: When do you wear it?

HORNUNG: If I go to the Ludwig Prandtl Memorial Lecture, I wear it. [Laughter]

LIPPINCOTT: You're also a fellow of the Australasian Fluid Mechanics Society?

HORNUNG: That's a recent one. That society has only existed since three years ago.

LIPPINCOTT: So you were a pioneer member of it?

HORNUNG: No, but they remembered me. [Laughter]

LIPPINCOTT: Is it based in Australia?

HORNUNG: Yes.

LIPPINCOTT: Do you go back there much?

HORNUNG: Yes. We still have two children and four grandchildren there.

LIPPINCOTT: They stayed there, the two older children?

HORNUNG: Yes. Our son, who had been a dropout, came back the hard way and became an engineer, and he's now the regional manager of a company, based in Canberra.

LIPPINCOTT: That's impressive. So he had his Bohemian period and then he straightened up. What's the name of the company?

HORNUNG: It's Hirotec. What they do is building maintenance. In buildings there are things like automatic doors, elevators, air conditioning, refrigeration, heating. All that infrastructure is the stuff that he does.

LIPPINCOTT: And you have a daughter there?

HORNUNG: A daughter in Melbourne. She's an architect.

LIPPINCOTT: Is she married?

HORNUNG: Yes. Her two children are visiting right now with us—nineteen and seventeen.

LIPPINCOTT: Are they having a good time in Pasadena? Are they going to go to school here, do you think?

HORNUNG: No, they're just here for three weeks.

LIPPINCOTT: What's the George Julius Medal? That's an old one—1981. You were in Australia at that point?

HORNUNG: Yes, it was just before we went to Göttingen. And that was for the best paper at a conference. It's not so important.

LIPPINCOTT: One important thing to talk about is, you were at GALCIT until 2003. Then you decided to step down as GALCIT director. Why was that?

HORNUNG: I decided to take what they call scholarly leave. When you're sixty-eight and you promise that you'll retire at seventy, then in the last two years you can do what you like. And I decided to take that option. So in 2003 I was sixty-eight, and I stepped down as director and took the scholarly leave.

LIPPINCOTT: In scholarly leave, you stay at Caltech but you just devote yourself to-?

HORNUNG: You don't have to. You can go to the beach, if you want.

LIPPINCOTT: What did you do?

HORNUNG: Stayed here. [Laughter]

LIPPINCOTT: And continued with your research but just didn't bother with the administration of GALCIT.

HORNUNG: Yes.

LIPPINCOTT: Ares Rosakis replaced you.

HORNUNG: Yes, he was my successor.

LIPPINCOTT: Had he been your deputy?

HORNUNG: No. He was a professor in experimental solid mechanics, and very successful, and he took over.

LIPPINCOTT: Was he a lot younger than you were?

HORNUNG: He is quite a lot younger than I am. I'm going to be eighty this year, and he's still in his fifties.

LIPPINCOTT: Does he like being director of GALCIT?

HORNUNG: He's no longer the director. He is now the [engineering] division chair.

HORNUNG: Who's directing GALCIT now?

HORNUNG: [Guruswami] Ravichandran—who is also a solid mechanics professor.

LIPPINCOTT: So then two years after that, in 2005, you became emeritus?

HORNUNG: Yes.

LIPPINCOTT: Now, Caltech is pretty good to their emeritus professors. You still have an office, and quite a lot of connection with the aeronautics grad students?

HORNUNG: Yes, and with some of the faculty—Joe Shepherd, in particular.

LIPPINCOTT: What do you do with Joe Shepherd?

HORNUNG: Joe has taken over my labs.

LIPPINCOTT: And the T5?

HORNUNG: And the Ludwieg tube. Joe and I have always had common interests. He does other things also, like detonations, explosions.

LIPPINCOTT: He does explosions?

HORNUNG: Yes, he's an expert on stuff like that.

LIPPINCOTT: Well, that must be noisy. Where does he do that?

HORNUNG: Well, it's all contained, so it's not noisy.

LIPPINCOTT: I wouldn't think so. Is it in Guggenheim?

HORNUNG: It's in the basement of Guggenheim.

LIPPINCOTT: Great. And we have to talk about your seventy-fifth-birthday symposium, in June 2009, in San Antonio, Texas. You went down there, obviously.

HORNUNG: Yes. Several of my students and colleagues gave talks at this session.

LIPPINCOTT: It was very well attended, I understand.

HORNUNG: Yes, it was very good.

LIPPINCOTT: Did you give any of the talks?

HORNUNG: No, but two of the people presenting papers added me as coauthor. [Laughter] I had contributed to the work, but not very significantly.

LIPPINCOTT: Still, it gives the paper a kind of sheen it wouldn't have otherwise.

HORNUNG: I don't know.

LIPPINCOTT: Any old friends you saw there that you'd like to mention?

HORNUNG: Oh, lots of them. My former graduate student Simon Sanderson was not there, but he was one of the coauthors. Joanna Austin, who was a student of Joe Shepherd's, gave one of the talks; and Chiyung Wen, one of my graduate students from Taiwan, was there.

LIPPINCOTT: Had he gone back to Taiwan?

HORNUNG: Yes. He was for many years a professor at Taiwan and now he's in Hong Kong.

LIPPINCOTT: So that's a pretty long way to come. Simon Sanderson—you've mentioned him. Where did he go after—?

HORNUNG: He went to GE Global Research—General Electric—and he's still there.... No, he just left them and went to Boeing.

LIPPINCOTT: And he's what you call a heavy hitter in the aeronautics industry?

HORNUNG: Yes.

LIPPINCOTT: We're coming up to the present, but one thing I want to mention is that a couple of years ago you got an honorary doctorate from the ETH [Eidgenössische Technische Hochschule] in Zurich, where Einstein studied. Did you go over there?

HORNUNG: Yes. Big celebration.

LIPPINCOTT: And Gretl went with you?

HORNUNG: Yes, she went with me.

LIPPINCOTT: That's an impressive place, I guess.

HORNUNG: It's a great place. I've been there every year since four years ago.

LIPPINCOTT: Do you teach or lecture there when you go?

HORNUNG: No, I just kick things around with the graduate students and maybe give a seminar.

LIPPINCOTT: And I would think they're pretty high-caliber graduate students.

HORNUNG: They're very good.

LIPPINCOTT: Before we wrap this up, are there things you'd like to say about Caltech and your career here? This is something you can add later, if you have some thoughts about it. I also want to ask you about your current work, and what you see yourself doing in the next few years. After all, you're not going to go on cruises. You're going to hang around here and do aeronautics, right? You are not really retired in the classic sense.

HORNUNG: No, I still do stuff and I publish papers. We find new things out.

LIPPINCOTT: What are you most interested in right now, in the aeronautics field?

HORNUNG: Well, two things. One is that recently I predicted that there would be a particular frequency that is amplified when you measure the pressure with an impact probe. And they've just measured it and found out that my little theory was right, which is nice.

LIPPINCOTT: Is there a paper about that that we might cite?

HORNUNG: Not yet. And another thing I'm working on is computations of reflections of a shock wave from an axis of symmetry, which is very different from what happens in two-dimensional flow, and there are some new effects there that I've discovered. These are not huge steps forward, but they're interesting. And I studied what happens when a shock wave interacts with a vortex. That's been done before, but usually they compute one case and are done with that, and I like to explore the parameter space, so that I learn some more about what governs changes when you change the parameters.

LIPPINCOTT: This is probably a dumb question, but you don't do this with paper and pencil?

HORNUNG: No, with a computer.

LIPPINCOTT: You don't have to actually go up to the Ludwieg tube?

HORNUNG: Well, this experiment, the interaction of a shock wave with a vortex, is very difficult to set up. It can be done, but it's not easy, and you have to build a special device, and I don't have any money to do stuff like that now.

LIPPINCOTT: You don't apply for research grants anymore?

HORNUNG: No. Joe Shepherd lets me help him a bit.

LIPPINCOTT: Do you still go to the Athenaeum [Caltech faculty club]?

HORNUNG: Yes.

LIPPINCOTT: Are you one of the Round Table people?

HORNUNG: Yes.

LIPPINCOTT: Tell me who sits there. I know Marshall Cohen [professor of astronomy, emeritus] goes there.

HORNUNG: Yes, well, he goes to the other one. The people who go to the table I sit at are Clarence Allen [professor of geology and geophysics, emeritus], Brian Wernicke [Chandler Professor of Geology], David Stevenson [Goldberger Professor of Planetary Science], Steve [Steven] Frautschi [professor of theoretical physics, emeritus]. One of the regulars used to be Ed [Edward B.] Lewis [Morgan Professor of Biology; d. 2004], and one of the regulars also used to be Wal [Wallace L. W.] Sargent [Bowen Professor of Astronomy. d. 2012].

LIPPINCOTT: And Bob [Robert F.] Christy [Institute Professor of Theoretical Physics; d. 2012]?

HORNUNG: Bob Christy was at the other table.

LIPPINCOTT: How often do you congregate at the Athenaeum with these people?

HORNUNG: Every day.

LIPPINCOTT: That's nice!

HORNUNG: We have a lot of fun.

LIPPINCOTT: Do you talk shop, or just gossip?

HORNUNG: Well, it's interesting. Sometimes you find out about what's going on in geology, and what's going on in astrophysics, and what's going on in physics, and so on; but everything goes, so long as it's informative or told with humor or wit; we have a great deal of fun.

LIPPINCOTT: Any other comments you'd like to make about your current situation at Caltech?

HORNUNG: No, I'm pretty happy.

LIPPINCOTT: It sounds like you've had a marvelous career—and it's still ongoing.

HORNUNG: I've had a lot of fun.