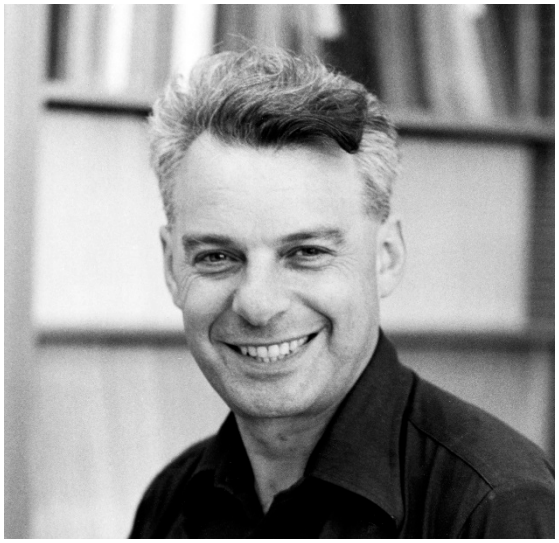

Philip G. Saffman, 1979

PHILIP G. SAFFMAN
(1931 – 2008)

INTERVIEWED BY
SHIRLEY K. COHEN AND
PETER NEUSHUL

December 5 and 12, 1997
April 22, 1999

ARCHIVES
CALIFORNIA INSTITUTE OF TECHNOLOGY
Pasadena, California

Subject area

Engineering and applied science; applied mathematics

Abstract

An interview in three sessions, December 1997 and April 1999, with Philip Geoffrey Saffman, Theodore von Kármán Professor of Applied Mathematics and Aeronautics, in the Division of Engineering and Applied Science. Dr. Saffman received his undergraduate and graduate degrees at Cambridge University and moved to Caltech in 1964 as a professor of fluid mechanics, becoming a professor of applied mathematics in 1970 and Von Kármán Professor in 1995. He died on August 17, 2008.

He discusses his Jewish family's background in the United Kingdom; growing up in Leeds; the family's experiences in World War II. At Cambridge: studies fluid mechanics with George Batchelor (PhD 1956); postdoctoral work with G. I. Taylor; joins faculty as assistant lecturer, 1958. Moves to King's College, London, 1960, to work with Hermann Bondi.

Recalls first visit to Caltech, at JPL with Janos Laufer, 1963; impressions after joining faculty in 1964; genesis of applied mathematics at Caltech; collaboration with neighbor Max Delbrück; sabbaticals at MIT (1970-71 and 1982); operations of Caltech's applied math dept. Comments on two of his children as Caltech

undergraduates. Recalls some of his 37 graduate students, particularly Henry Yuen; Yuen's career and invention of VCR Plus. Discusses his reasons for rejecting Cambridge's offer of the Taylor chair; his fears that Caltech is losing out on best graduate students and faculty, in part because of tight money.

In a supplemental interview in 1999, he reminisces about his Cambridge supervisors Batchelor and Taylor; describes his research on water waves and vortices; and further remarks on offer of Taylor chair at Cambridge.

Administrative information

Access

The interview is unrestricted.

Preferred citation

Saffman, Philip. Interview by Shirley K. Cohen and Peter Neushul. Pasadena, California, December 5 and 12, 1997, and April 22, 1999. Oral History Project, California Institute of Technology Archives. Retrieved [supply date of retrieval] from the World Wide Web:
http://resolver.caltech.edu/CaltechOH:OH_Saffman_P

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CALIFORNIA INSTITUTE OF TECHNOLOGY ARCHIVES

ORAL HISTORY PROJECT

INTERVIEW WITH PHILIP G. SAFFMAN

BY SHIRLEY K. COHEN

SUPPLEMENTAL INTERVIEW BY PETER NEUSHUL

PASADENA, CALIFORNIA

http://resolver.caltech.edu/CaltechOH:OH_Saffman_P

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CALIFORNIA INSTITUTE OF TECHNOLOGY ARCHIVES

ORAL HISTORY PROJECT

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Pasadena, California **Supplemental interview by Peter Neushul**

Session 1	**December 5, 1997**
Session 2	**December 12, 1997**
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COHEN: Why don't you start by telling us a bit about your family and your early education?

SAFFMAN: I was born in England in 1931. My father was a solicitor; my mother was a housewife. I have two brothers: One is two years older than me; the other one is about fourteen years younger. They were both lawyers and are now retired.

COHEN: So they followed in the family business, in some sense.

SAFFMAN: My father created the business. My father's father was a tailor. He worked, I think, mainly in a factory, although he did do some work on his own.

COHEN: So your father was born in England?

SAFFMAN: My father was born in England, yes. My grandfather was born somewhere in Lithuania. My mother came from a somewhat dubious family, I should say. [Laughter] My mother's father never had any settled job or occupation. He was what we used to call in England a "wide boy" or "spiv."

COHEN: I've never heard [those terms] used.

SAFFMAN: These were terms common after World War II for someone who made a living in ways that were not quite legal. So he did various things, my mother's father. He ran a shop; he ran a gambling club; he was a bookmaker. But he seems to have had, somewhere in his genes, an aptitude for mathematics, because my mother's brothers—my mother had four brothers—were all very good at calculations and puzzle-solving and chess and bridge. They were very fond of bridge. That type of intellectual activity they excelled in. None of them, as far as I know, ever went to college—those on my mother's side. My father had four sisters, but they were undistinguished.

COHEN: I see. So you come from a big family.

SAFFMAN: I come from a big family, yes.

COHEN: And they were all living together?

SAFFMAN: All these people were living together. Why they came to Leeds, I don't quite know. Originally, they were just going to stay in Leeds. At least, my father's mother intended to go to America, to Baltimore, where a sister of hers had already gone and set herself up and was doing rather nicely. My grandfather was sent ahead to get everything ready so that my grandmother could follow him, but he didn't like America. My grandfather was a very quiet, very shy, very retiring person. He was a tailor, but for intellectual activity, he looked to the synagogue—the *shul*, as we always called it. He was a quiet man, and he didn't like America. He found it too hectic. He realized he could make a lot more money there, but that didn't compensate for the stress of the mind.

COHEN: He went to Baltimore, then?

SAFFMAN: He went to Baltimore, and then my grandmother had everything packed and was ready to go—

COHEN: And he came back?

SAFFMAN: And he came walking through the front door. [Laughter] In those days, of course, there was no e-mail. There was no rapid communication. You had to wait for the post.

COHEN: So he came as fast as the post on the boat.

SAFFMAN: So I could very easily, I suppose, have been an American rather than an Englishman.

COHEN: That's how things go.

SAFFMAN: That's how things go. What else can I say about them? I think they were happy, as far as I could tell.

COHEN: So they were part of a very large family.

SAFFMAN: Yes. There was a large Jewish community. It was the third largest Jewish community in England, the largest of which was [in] London. And then there was Manchester. And then there's Leeds. So it was a large community. Leeds is a city of about a half-million people, and I think about ten percent were Jewish. I think 50,000 was the size of the Jewish community.

COHEN: And that community stayed to itself?

SAFFMAN: Yes.

COHEN: But of course, you went to school. Were there Jewish schools in Leeds at that time?

SAFFMAN: No.

COHEN: Or you went to the regular government schools?

SAFFMAN: We went to the regular school, which was wise anyway. If you live in a country, you have to learn the language and customs of the country. Children, of course, learn these things much faster.

COHEN: And English was spoken in your home?

SAFFMAN: English was spoken. My parents spoke Yiddish, but they made no attempt to teach it to my brothers or me. They liked having it as a secret language, I think. But I couldn't talk to my grandparents—at least, to my father's parents. They only spoke Yiddish. They also spoke Russian, I think, but they didn't speak English. Communication with them was very difficult. My mother's family was more accessible; my mother's father, being a wide boy or such, [laughter] had to learn English. My maternal grandmother was actually born in England; she was fluent in English. I had no trouble speaking with my mother's parents or any of her brothers and sisters, of course. They all spoke English. It was just my father's parents that I—

COHEN: Yet they encouraged your father to go to school. I mean, if he was a lawyer, he was educated.

SAFFMAN: Oh, yes. It was all through scholarships. He won scholarships in school. I don't know to what extent they encouraged him. I think they would have been happier if he had been a rabbi, perhaps. They were very Orthodox—extremely Orthodox. I wasn't. My parents stopped being Orthodox as soon as they—

COHEN: Had the chance?

SAFFMAN: Had the chance. [Laughter] They knew all the Yiddish characters.

COHEN: The rituals?

SAFFMAN: The rituals. And they lived quite happily in these two worlds of a Jewish home and gentile surroundings. They sent us to school. My mother had a fetish—for fresh air. She loved to be outside. I think she got very claustrophobic when she was inside. She loved to sit in the garden and be in the fresh air as much as possible. So she selected our school on the basis of which institution had the freshest air. [Laughter] It's a criterion I've never come across anywhere else. The school with the freshest air turned out to be in a working-class part of Leeds where there were no Jews, so I was the only Jewish boy in my class.

COHEN: Now, could you do that? Could she go around and decide which school to send you to? There were no districts?

SAFFMAN: In those days, you could do that. They weren't organized. When you were old enough to go to school, you would turn up and they would admit you. They didn't ask you where you lived.

COHEN: Simpler days.

SAFFMAN: Simpler days, yes. They weren't worried about racial inequalities.

COHEN: I bet you had a good-size walk to get to school.

SAFFMAN: No, I took a bus every day. I had to take a bus. In those times—1939—not many people had cars. Those were the days when it was called "public transport." So I'd get on the bus in the morning. I rode that bus four times a day, because I'd go to school in the morning and then I would go home for dinner and then go back to school in the afternoon and come back in the evening and have high tea. The North of England had dinner at twelve o'clock. That was the main meal.

COHEN: So everybody came home for that meal?

SAFFMAN: No. Father didn't. He worked down at the office and usually had lunch with a client or went out for a sandwich or snack. But my brothers and I—my brother and I, because my younger brother came along later—we went back and forth four times a day.

COHEN: You must have done very well in school.

SAFFMAN: I did very well. What was the name of the school? Potternewton Lane Elementary School. I think this is the first time [laughter] that I've realized the significance of that—of the coincidence. Take away the "Potter" and you have "Newton."

COHEN: You never know when you're going to learn something.

SAFFMAN: I was almost the only Jewish boy in the school—my brother was there in another class, of course.

COHEN: Did that matter?

SAFFMAN: No.

COHEN: But you were aware of it.

SAFFMAN: Oh, I was very much aware of it. The others didn't know what Jews were. I mean, it's strange to say that in a city where ten percent of the population was Jewish, they didn't know. I stayed at that school until about 1940. I left after the war started and my parents decided to evacuate us.

COHEN: I was just going to say that the war was going on by then.

SAFFMAN: While I was at school I did very well, except I was second. I was always second. And the top student was always a girl.

COHEN: Uh-huh. [Laughter] Do you know what's happened to her?

SAFFMAN: No idea. No idea at all. I was always number two, with a girl being at the top. And the way that problem was eventually solved was to go away to an all-boys school. [Laughter]

COHEN: So you went to a different school for what we would call high school?

SAFFMAN: Yes. This was in elementary school. This would be what would be called first through sixth.

COHEN: Primary school.

SAFFMAN: Primary school, yes. In 1940, we evacuated ourselves. There was an official evacuation of the city, but my mother didn't want to leave without my father. She was nervous, also, that we might not get enough fresh air.

COHEN: Where did they evacuate to?

SAFFMAN: Blackpool, a holiday town on the west coast.

COHEN: So that was considered safe?

SAFFMAN: Blackpool was considered safe because there was no industry.

COHEN: So women and children were evacuated?

SAFFMAN: No, the government evacuated children only. My parents had more money at this point, due to my father's success as a lawyer, and could afford to evacuate themselves to Blackpool. There was a lot of concern that the Germans might invade, so my parents also attempted to send my brother and me to America. Everybody knew what the Germans were doing to Jews in Europe.

COHEN: Did they know in 1940? They knew that the Germans were sending Jews to concentration camps?

SAFFMAN: Yes, they knew what the Germans were doing, and they tried to send us to America. But the demand for spaces on the boats was very large. So they couldn't—even with what strings a successful lawyer could pull—they couldn't get boat reservations, so we stayed. So I might have been an American. [Laughter]

COHEN: Twice now.

SAFFMAN: Twice now.

COHEN: Your father didn't continue his law business?

SAFFMAN: Yes, he did.

COHEN: From Blackpool?

SAFFMAN: No, he stayed in Leeds; every weekend he'd come. My father had a car. Petrol was rationed of course, but there was enough, so he would come over on Friday night and go back Monday morning. And we were then changed to another school that didn't have quite as much fresh air as the one in Leeds. [Laughter] We didn't actually stay too long in Blackpool. I think it was only about two or three years, until the war was turning.

COHEN: So the war didn't really affect you that much?

SAFFMAN: The war had no effect on me at all. We came home. We had a few air raids—not too many—about a dozen all together. The first time this happened, we went to the air-raid shelter. We had a little air-raid shelter built into the bottom of the garden. And my mother stuck it out for the first night but said that she'd rather be killed by a German bomb than spend another night in that shelter. [Laughter]

COHEN: Without fresh air.

SAFFMAN: So, when the bombers came over, we just went down and got under the biggest table—the dining room table. And we would hear the empty echo of guns and occasionally we'd hear the bombs. My father had a job as an air-raid warden. He had to go around and make sure all the people had switched off their lights.

COHEN: Was this volunteer, or did everybody have to do something?

SAFFMAN: This was kind of volunteer, but you were under pressure. There was peer pressure to do something of this nature. It wasn't compulsory.

COHEN: So you can't say that you did any suffering during this war?

SAFFMAN: We didn't suffer.

COHEN: And you continued your school?

SAFFMAN: And I continued school. I went on till 1944. That's when I took what was called the Higher School Certificate. I must have been about thirteen years old. Oh, one thing happened. When we came back from Blackpool, they gave us tests. The headmistress, or whoever was organizing the school, gave us tests to see where we should go—which level. And I tested extremely well, which meant I was bumped up two years. So when I came back to Leeds, I was a boy of thirteen. Everybody else in the class was fifteen. That was in high school. I continued after the Higher School Certificate, which was a graduating degree. And I found that very difficult socially—it was impossible—because I had the mind of a fifteen-year-old but the body of a thirteen-year-old.

COHEN: Marshall [Marshall H. Cohen, professor of astronomy, emeritus, and Shirley's husband] had the same experience. He would never allow our children to be put ahead.

SAFFMAN: No. I held Louise [Dr. Saffman's elder daughter] back. They wanted to push Louise forward. But I remember the miserable time I had being pushed forward in this way. It was a mistake. My parents were very pleased. They could boast, of course—"My brilliant son," and so on and so on. These two years I had, they weren't thinking, of course, that I was in a class where I was bullied mercilessly. I was still coming in at the top. They could have bumped me up another year. [Laughter]

So Marshall had that problem? I guess a lot of people who are now scientists would have had this problem—they would have been a little precocious. The classic case is poor Mozart.

COHEN: So you then took these exams.

SAFFMAN: So I then took these exams, and I took— Let me see. It must have been at fifteen I took the— I'm finding it hard to keep track of all the dates; I'll have to try and write them out sometime. Because I took the Higher School Certificate, which then meant that I should go to university. That was at fifteen. You're supposed to go to university at seventeen, not fifteen.

COHEN: So they didn't want to take you?

SAFFMAN: Well, I applied for Cambridge and got an entrance scholarship, but they wouldn't take me because I hadn't done my military service—not because I was fifteen, but because I hadn't been in the army. And I went into the army for two years.

COHEN: At fifteen?

SAFFMAN: That was at seventeen. More or less, I spent a year doing nothing. I can't remember. I went to school, but I didn't do anything. There's a gap in the timing that I can't quite puzzle out at the moment. I think I took what was called the entrance scholarship examination to Cambridge when I was fifteen, which would have been 1946. That sounds about right. I actually went to Cambridge in 1950. I'm trying to think: I spent two years in the army; the other two years, I'm not sure. Oh, I remember now. I went to Leeds University and just sat in on the classes there. They gave me permission to go to class. I studied at Leeds University for two years.

COHEN: Did you know you wanted to do mathematics already?

SAFFMAN: I wanted to do science. I knew that I wanted to do science, which was mathematics, physics, and chemistry. But the reason I became a mathematician is because when I went to Cambridge, you had to take chemistry. Chemistry was compulsory, and I did not like chemistry. You're a chemist. [Laughter]

COHEN: Yes. That's all right. [Laughter]

SAFFMAN: Nothing personal.

COHEN: Nothing personal, right.

SAFFMAN: And the only way to avoid taking chemistry was to major in mathematics. Because if you majored in mathematics at Cambridge, you had some physics in the mathematics, but there

was no chemistry. It was basically all mathematics. So, if I had had better feelings toward chemistry, I suppose I would have become a chemist or a physicist. It's coming back to me—this is now forty years ago.

COHEN: Yes, I know, but one remembers.

SAFFMAN: One slowly, slowly remembers. I wanted to be a physicist. That was my desire. But to be a physicist, you had to take chemistry. The alternative way of being a physicist was really to major in mathematics. Then you'd come in from the mathematical side. You wouldn't actually take any formal courses as a physicist; you'd take the mathematical physics. So that is why I became a mathematician. And then when I got into mathematics, I found I started liking mathematics more than physics. So I became a mathematician.

COHEN: It sounds like you had these roots in your family already.

SAFFMAN: Yes.

COHEN: And this was all on scholarship at this time?

SAFFMAN: Not for me. My father was now quite wealthy.

COHEN: But there wasn't high tuition at these schools? Just living expenses?

SAFFMAN: Cambridge was very cheap. I think it was something like £100 a year, tuition and living expenses, which were also not very high, considering the food and accommodations. [Laughter]

COHEN: That was all it was worth?

SAFFMAN: That was all it was worth.

COHEN: So you spent quite a few years at Cambridge. You have all your degrees from Cambridge.

SAFFMAN: Yes. I went to Cambridge in 1950. And I came out of the—I was actually in the air force, not the army. And the only useful thing I learned in those two years—besides a lot of bad habits which I picked up and was unaware of—I learned to type. I was a teleprint operator. That proved to be very useful—to be able to type. It meant that I could, when it got to the stage of writing letters and a secretary was not available—in those days they had secretaries, not word processors—I found I could do my typing. That, I've found, has always been a big help.

COHEN: Now, with the age of computers, it's really—

SAFFMAN: It's even more useful now. So in 1950 I went to Cambridge, and there I took my bachelor's in 1953 and my doctor's in 1956.

COHEN: OK. And I have you getting married in '54.

SAFFMAN: 1954. That sounds right. I was there as a graduate student.

COHEN: And Ruth [Saffman] is also from Leeds, isn't she?

SAFFMAN: Yes. I was very friendly with her brothers.

COHEN: So you knew Ruthie before you went off?

SAFFMAN: Yes. Plus, one of her brothers was in the same class as me. They also moved—Ruth's family—from where they lived, in central Leeds, out to the outskirts, where I lived. Her brother and I would basically take the same tram every day to school—and, actually, back again [laughter] coming home for dinner. So I knew her brothers. It was through them that I met Ruth.

COHEN: So then you came back and you married.

SAFFMAN: As a graduate student, I was married. That's right.

COHEN: Was that very common in Cambridge at that time? It was certainly common here.

SAFFMAN: I would say yes.

COHEN: So many people were delayed in their education because of the war.

SAFFMAN: Because of the war, most of the graduate students were married.

COHEN: That was certainly the case here, also—and very serious about school.

SAFFMAN: Very serious, yes. So I left the air force in 1950 and started Cambridge in 1950. I had a year as a graduate student before I was married. Let me see if that's right: Yes, because I started in '53 and I was married in '54. And then I stayed in Cambridge. I had a postdoc in Cambridge until 1958, and then I took a tenure-track position as an assistant professor in mathematics.

COHEN: Let's go back to your graduate studies, because you actually had a very famous professor.

SAFFMAN: Yes and no. Let me just get the dates, so I know where I am. There was a complication. My postdoc actually started in 1955. At Cambridge I got what is called the Prize Fellowship.

COHEN: Prize?

SAFFMAN: Prize Fellowship. These were by examination—well, by competition. You would send in your PhD to the college to compete.

COHEN: Your thesis, you're talking about?

SAFFMAN: Your thesis, yes. And if your thesis was good enough, then you would be awarded a Prize Fellowship. There was only a certain number. Trinity, which was my college there, gave four every year.

COHEN: Oh, so it was very competitive.

SAFFMAN: It was very competitive. And I actually got mine after two years. I sent in my thesis after two years. This was commonly done as a kind of practice. And actually, after two years of graduate school, I wrote a thesis and submitted it for this prize, and was awarded a Prize Fellowship. This was 1955.

COHEN: What did that mean?

SAFFMAN: It meant I was a fellow in the college. I became a fellow and dined at high table.

COHEN: Ah, so you no longer had student status, but rather you had—

SAFFMAN: Except I didn't yet have my PhD, because it wasn't as creative as— [Laughter] It's a complicated system, which I don't think I have described too well.

COHEN: Was it very common, doing what you did?

SAFFMAN: No, it was unusual to do this in two years. Usually, most people used their thesis for the PhD and the fellowship competition at the same time. It was a little unusual to go in for the fellowship after two years. I'm not quite sure why I did it.

COHEN: Well, someone must have encouraged you.

SAFFMAN: I think my advisor encouraged me to do it.

COHEN: And it wasn't Taylor [Geoffrey Ingram Taylor] at this point?

SAFFMAN: It was Batchelor. My thesis advisor—or my supervisor; we called them supervisors—was actually George Batchelor. It was a common misconception that I was a student of G. I. Taylor's, but I was a student of Batchelor's, except for one term when Batchelor was away on sabbatical. He took a sabbatical, and for that term he left me in the care of G. I. Taylor. So I was a student of G. I. Taylor's for one term. In that term, I think G. I. Taylor spoke to me once. [Laughter] He believed in benign neglect.

COHEN: What did you do with that last year? If you already had handed in your thesis and you had won this prize and you were eating at high table, what did you do the last year, your third year?

SAFFMAN: I did research and I wrote my thesis for publication.

COHEN: So you continued with the same work you had been doing.

SAFFMAN: I continued with the same work I had been doing. So where are we now?

COHEN: Actually, you never go to classes there anyway, so that's not part of it.

SAFFMAN: That's right, there were no classes.

COHEN: The system is different.

SAFFMAN: It's become more American now. The American influence has changed things. But in my day there were no classes for graduate students. If you wanted to learn something, you went to the library, you took out the book, and you sat at home and you read it and you worked your way through it.

COHEN: And you met with your advisor occasionally?

SAFFMAN: You'd meet with your advisor. When G. I. Taylor was the advisor, you'd meet him once a term if you were lucky. With Batchelor you'd meet about once every two or three weeks.

COHEN: It was a self-taught system.

SAFFMAN: Very much a self-taught system.

COHEN: So it was survival of the fittest.

SAFFMAN: In those days, the English system was very much like being thrown into the pool. If you could swim, or if you learned how to swim, or survived, you would then do very well. If you drowned, there was no reason why people should waste time or effort or money supporting your studies when you hadn't demonstrated that you were exceptional.

COHEN: Do you think you have any of those attitudes yourself? Maybe I should ask you this later in the interview.

SAFFMAN: I think I am more tolerant because I have been in America for many years. I think I was less tolerant in England. Their system is harsh.

COHEN: Well, again, it's a survival system.

SAFFMAN: But there were very few jobs.

COHEN: Yes.

SAFFMAN: I know when I was still at high school and I went to go talk with the headmaster to get his advice—already by this time I had feelings that I was going to be a mathematician, or that that was a possibility—and he said to me that the last thing I should do was to stay on as a mathematician, because unless I was a genius there would be no jobs and I would end up as a schoolteacher. My headmaster studied mathematics at Oxford. The only job he could get was as a high school teacher. In the pre-war years, a high school teacher was a more respected position. It was a good job; it had security; it had good holidays. The pay left something to be desired, but it was adequate.

COHEN: Well, it had prestige, too, which counts for more than salary. It's still the case in France and Germany.

SAFFMAN: Yes, but less so there.

COHEN: It's only here where high school teachers have no prestige. [Laughter]

SAFFMAN: That's because we are able to import our scientists. So, where was I?

COHEN: You were talking about your graduate student days. You had a Prize Fellowship, which then led you to really research completely for that third year.

SAFFMAN: That's right, yes.

COHEN: And then you got your degree.

SAFFMAN: I took my degree because I was told I should take the degree. At one time, the Cambridge PhD was a consolation prize for those who failed the fellowship examination—they took a PhD instead. They sent in the same thesis, but they'd ask for a PhD to be awarded.

COHEN: So when people like Fred Hoyle boast that they don't have a PhD, that's kind of a phony boast.

SAFFMAN: It's a phony boast. G. I. Taylor didn't have a PhD. Nor James Lighthill. I don't know any of the famous named people, like Lord Kelvin or Lord Rayleigh, who had PhDs.

COHEN: And that meant that already after their second year everybody recognized that they were scholars and they could move on into the profession?

SAFFMAN: Yes.

COHEN: Oh, that's very interesting!

SAFFMAN: So it was a consolation prize. If you didn't get a college fellowship, you'd have to have something. The main reason why people took the PhD was that by this time, after the war, English scientists were starting to come to America. Without the PhD, they found themselves being treated as graduate students. They realized what was happening—that in America people thought that you had to have this paper saying so-and-so was a PhD, and with that you could go

to the Athenaeum. Without that, you couldn't go to the Athenaeum and you were treated as a student. Well, here you can go, but you know what I mean.

COHEN: Yes, of course.

SAFFMAN: You were treated as a student. So people would find that even if they had a college fellowship, they had better take a PhD, because Americans did not know what a Prize Fellowship was. They knew what a PhD was.

COHEN: So, even at this time, England, or academia, was very much influenced by what was going on in America, because people were setting themselves up according to what was needed here?

SAFFMAN: Yes, because America had the money. That's another reason why so many English people wanted to come to America. It offered them a chance to make a little money. It was quite common for people to come over here for a year or two and then go back to England and buy a house—not a very big or good house, but still buy a house that otherwise they would never have been able to afford.

COHEN: Of course, the years after the war were really booming years here.

SAFFMAN: Yes. Then the American influence: We used to have lots and lots of visitors from America who loved to go to places like Cambridge and look at the ivy-covered, 500-year-old walls.

COHEN: A good relationship: Money there, prestige here.

SAFFMAN: [Laughter] That's right. Of course, the English aristocracy pursued this a hundred years before the academics caught on to it. It was quite common then for an English lord to marry a rich American. Just look at Winston Churchill. He was one of many.

COHEN: So that was everybody taking what the other had to give.

SAFFMAN: It's a very fair distribution of the world's goods.

COHEN: That's very interesting—that already the standards in the university were being shaped.

SAFFMAN: So I was on the standard track in Cambridge under a college fellowship. I took a PhD because by this time I realized I would probably like to go to America at some time for a year or two years. And then the fellowship expired, and I took the tenure-track position at Cambridge in 1958.

COHEN: Was it uncommon for Cambridge to keep one of its own graduates?

SAFFMAN: No. Very common, in fact. I'd say Cambridge was even more inbred than Caltech.

COHEN: So if you were there, you were there.

SAFFMAN: Yes.

COHEN: And you would wind up staying there.

SAFFMAN: If you wanted to stay, yes. And I stayed. Anti-Semitism was strong in Cambridge, but it did not affect me personally. I must say one thing for the English academics: They did not discriminate against you when it was a matter of profession or a matter of science. They would not, however, invite you to their homes—this was where the discrimination occurred. In a competitive fellowship examination where they had two candidates—me a Jewish boy, and another a gentile—I believe sincerely that they ignored the question of religion in assessing the merits of the theses.

COHEN: A meritocracy. Were there enough Jewish people there to make their own group?

SAFFMAN: There was a temple, or synagogue, and there were enough people. Younger scholars were more tolerant. The anti-Semitism seemed to be more with the older dons—with the older

professors or lecturers, who saw their way of life disappearing. And, of course, we had a lot of foreign students coming to graduate school as well—lots of Indians, Pakistanis, Egyptians.

COHEN: So they probably weren't invited, either.

SAFFMAN: They weren't invited either. I mean, some Jewish people made it—you know, if you behaved properly. It helped if you had been to the right school, but mine was not the right kind of school. In England, a public school is not a public school—it's a private school. If you had gone to a public school, that would have helped. Of course, it would have been hell to get into a public school if you were Jewish, but they had their quotas. So you could probably have gotten into a public school. Maybe not Eton or Harrow or Winchester, but one that was somewhat respectable. And then you'd probably have been invited to have dinner with the don.

COHEN: That's interesting. We spent a summer there—I forgot what year. I was amazed at the newspaper—the blatant racism.

SAFFMAN: Yes.

COHEN: Not that Americans are any better, but they don't print it in the newspaper.

SAFFMAN: Anyway, we decided we would go somewhere else. And London looked exciting, and in 1960 we moved.

COHEN: So you gave up—

SAFFMAN: I was right on the track, and nobody could understand why I left Cambridge.

COHEN: Now, your position was called "lecturer"?

SAFFMAN: Assistant lecturer.

COHEN: What does that mean?

SAFFMAN: It was equivalent to an assistant professor. You taught, you conducted research, and you supervised graduate students. The next grade was lecturer, which would correspond to a professor here, and it was the career grade.

COHEN: So that was the grade you made, and then you knew you had tenure.

SAFFMAN: Tenure was never a problem in England. Once you got your foot in and you got your first job, as long as you behaved yourself and did your work, taught well, and did some research, you never worried about tenure. It wasn't a worry.

COHEN: I see. So you didn't have a six-year assessment.

SAFFMAN: None of the cruel tenure that they have here. Basically, the decision was made at the beginning.

COHEN: When they hired you?

SAFFMAN: They hired you, and then you were there for life. So basically, I was there at Cambridge for life. I was offered a permanent fellowship at Churchill College. The Prize Fellowship was only for, I think, four years—maybe three. 1955 to 1959—it was probably four years.

COHEN: And that paid your salary?

SAFFMAN: That paid my living expenses. We didn't live very well on that, but we had enough to have a car and a baby. Our parents were helping us.

COHEN: Well, that's similar to young people everywhere.

SAFFMAN: Yes. What was my first job—a fellowship of twenty-five hours—paid £8 a week.

COHEN: Fifteen, twenty dollars a week?

SAFFMAN: Say $15 a week.

COHEN: So you decided to take this position in London.

SAFFMAN: In those days it was a very different world than it is now. If I wanted to go to London, all I did was— I did not call them, because we used this other approach. I'd meet Hermann Bondi. Do you know Hermann Bondi?

COHEN: Sure. I just saw him last month.

SAFFMAN: And I'd say to him, "Are there any jobs going in London?" And he'd say, "Yes. They have a readership. Would you like to come?" No letters. So I went to London and to Bondi's department at King's College in 1960. Actually this was a bit unusual: I hadn't yet been to America. I don't know why I was slow. When I had the opportunity, I was slow to take it.

COHEN: Well, you had a baby, obviously.

SAFFMAN: Yes. Traveling with a baby is not much fun. So we moved to London, and we lived at Twickenham to the west, near Richmond.

COHEN: I've seen the sign.

SAFFMAN: It's out towards the airport. We lived in a nice, little modern house for four years. What had happened was that in 1963, at last, I came to America. I met Janos Laufer at a meeting in Marseilles, and he said, "Would you like to come?" Janos Laufer was a student of Hans Liepmann [Von Kármán Professor of Aeronautics, d. 2009] and was running a fluid dynamics group up at JPL [Jet Propulsion Laboratory].

COHEN: You met him at this meeting at Marseilles?

SAFFMAN: I met him [Laufer] at the meeting in Marseilles, and he was the one who invited me to come to JPL for six months. So I came to JPL for six months in 1963. I liked it and had a wonderful time here.

COHEN: You had a taste of Pasadena and Southern California.

SAFFMAN: Yes. And then Gerry [Gerald] Whitham [Powell Professor of Applied Mathematics, emeritus] and Hans Liepmann asked me if I wanted to stay. They had just gotten lots of money from the Ford Foundation. So I went back to England for the remainder of the year but planned on returning to Caltech after six months.

COHEN: There was never a question in your mind that that was what you wanted to do?

SAFFMAN: No question. I was trying to think when the children came. Louise was born in 1956. And Mark was born in 1958. So they were both born in Cambridge while I was still either a Prize Fellow or an assistant professor. And then Emma came later in 1964, after we got back from our first visit to America.

COHEN: So the children were all born in England?

SAFFMAN: The children were all born in England. Mark was six and Louise eight when we moved over. Emma was two weeks old when she came to America. I went first with the two older children, and Ruth followed when Emma was old enough to travel.

COHEN: There was never a question in your mind?

SAFFMAN: No question in my mind. Ruth didn't like it. She wanted to go back to England.

COHEN: Did she like London?

SAFFMAN: Yes, she quite liked London. The problem with London was that we really didn't have enough money to enjoy it. What we should have done—but we couldn't, because we didn't

have enough money—was buy a house fairly close in on the Underground, so we could travel back and forth. Going to the theater was, for us, quite an expedition.

COHEN: How was your work life—your professional life—at the University of London?

SAFFMAN: Very good. Bondi is a—

COHEN: Oh, he's wonderful. I know him very, very well.

SAFFMAN: Oh, good. I have a tremendous respect and admiration for Bondi. It was clear that he had this passionate interest in research. And I liked him, and I think he liked me. I was very happy there. I found the students were quite good. They were not as good as at Cambridge; there was a definite difference.

COHEN: The cream really went to Cambridge.

SAFFMAN: The cream really went to Cambridge. When I found this out, in fact, I almost decided to go back to Cambridge.

COHEN: You enjoyed working so much more with the students there?

SAFFMAN: Yes. But then I came to America and found the atmosphere here was even more stimulating than at Cambridge.

COHEN: Now, your experience with your own professors was such that you didn't see them very much.

SAFFMAN: I'd see Batchelor about once every two weeks or so.

COHEN: How was your relationship with your students in London? Did you see them more?

SAFFMAN: I saw graduate students much less, because of the journeys—the travel times in London. The students lived miles from my home. There would be an attempt, once a year—

perhaps a little bit more than once a term—to have the students over for dinner and make some kind of social contact. But it was difficult because of the distance. I tended just to see the students in King's College.

COHEN: What kind of work were you doing there in London?

SAFFMAN: This was basically the continuation. What had happened in Cambridge, starting in about 1956, was I started to work with G. I. Taylor. But by this time I was a postdoc, or a Prize fellow, I wasn't a student. The first problem he was working on was something called the Reiner disc.

COHEN: Reiner disc?

SAFFMAN: There's a phenomenon that happens when you have two discs rotating in fluid—two discs opposite each other. And they rotate very rapidly and a very small distance apart. When this happens, a very large pressure builds up in the center of the discs, and you have what can be called a centripetal—I forget if it's low or high. The normal thing that happens is that you get a high pressure in the middle—I think it's high—which forces a centrifugal motion forcing the fluid out. But when you rotate these discs very rapidly and put them close together, the direction of the flow is reversed. And instead of having a centrifugal pump, you have a centripetal pump. And we couldn't understand what was causing this. This was observed experimentally. Taylor came up with what he thought was a possible explanation for this. By this time, Taylor was—I suppose he was as old as I am now. He lost his taste for doing mathematics. He went to the engineering laboratory and rebuilt a Reiner apparatus there and repeated the experiment. We had a lot of fun doing that. Of course, his reputation and prestige was such that all you had to mention to one of the engineering faculty was that he'd like to rebuild this, and of course the red carpet was laid out. But he left me to do the theory. He wasn't so interested in the theory.

COHEN: The mathematics?

SAFFMAN: The mathematics. Were you going to say something?

COHEN: In the book—the biography that Batchelor wrote about Taylor[1]—it said that he published some phenomenal number of papers after he was sixty-eight.

SAFFMAN: Yes.

COHEN: I forget the number, but it was big.

Begin Tape 1, Side 2

COHEN: Taylor left the mathematics to you?

SAFFMAN: Yes, that's right. And then that worked out well. He was obviously satisfied with what I had done. Then he started working on another problem that goes into various names of Hele-Shaw fingering. I think Batchelor talks a little bit about this in his book on G. I. Taylor. And, again, that was where Taylor did the experiment—

COHEN: And you did the mathematics. But now that bears both your names, doesn't it? Saffman−Taylor?

SAFFMAN: Yes. Now, it shouldn't be Saffman−Taylor, it should be Taylor–Saffman. That happened because at that time the Royal Society would only publish names alphabetically.

COHEN: Oh, really? So it didn't matter who was the first author?

SAFFMAN: I think they were trying to get away from the first author being identified as the major contributor. But, of course, it failed. It didn't work. But Taylor was the major contributor. I did the mathematics, but he thought of the problem and he did the experiment. The main thing was to think of the problem—that's where the real genius lies. I remember once having a graduate student who didn't think so much of G. I. Taylor, so I sent him to look at some of G. I. Taylor's papers. And he came back and he said, "Well, I still don't think very much of G. I. Taylor. All his work is very simple. I could have done everything he did, if I had thought of it."

[1] George Batchelor, *The Life and Legacy of G. I. Taylor* (Cambridge, U.K.: Cambridge University Press, 1996).

COHEN: [Laughter] Did he realize what he was saying? OK.

SAFFMAN: So, again, I was there because Taylor didn't want to do the mathematics. He wanted somebody else to do it. I think he could have done it.

COHEN: He must have had a lot of confidence in you. I mean, he must have had standards for what his name would appear on.

SAFFMAN: Yes. And that has become, over the years, an industry.

COHEN: That particular problem?

SAFFMAN: Yes. And that we did together in 1958. But when I went to London, he started to find other people to do the mathematics for him.

COHEN: So, after that you no longer worked with him?

SAFFMAN: Very little. In 1970, something else came up in connection with flow through porous media, which I don't think Batchelor mentions or talks about, because—

COHEN: What is this again?

SAFFMAN: Flow through porous media. The flow of liquids through things like sand or clay or soils. We collaborated again, on a very low level. I wrote a paper on it[2] and asked him if he wanted his name on the paper, and he said no. He didn't think he had done enough to be worthy to have his name on the paper.

COHEN: So did you start working on other problems then?

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[2] P. G. Saffman, "A theory of dispersion in a porous medium," *Jour. Fluid Mech.*, 6:321-49 (1959).

SAFFMAN: I think by this time, in London, I was starting to work on lots of other problems. What was I working on? I was working on magnetohydrodynamics. That's right. Inclusion through shock waves. Magnetohydrodynamics of plasma physics was having a great— People were paying lots and lots of attention to it in the 1960s, in connection with thermonuclear power—controlled nuclear fusion.

COHEN: Ah, so this would have been very "in" in those days.

SAFFMAN: Very "in" in those days. So I started working on that. And there were the astrophysical applications as well, in association with the motion of charged fluids.

COHEN: Now, this was quite basic. Were there any problems with security and clearances and things like that that were so prevalent in this country?

SAFFMAN: No. None whatsoever, as far as I know. The only contact I ever came across in relation to security was during a visit— I acted as a consultant for one of the English government review panels. In connection, there was the question of clear-air turbulence, which was beginning to appear at that time. There was a body called the Aeronautical Research Council in London that had a committee to look into questions of clear-air turbulence. I was an appointed member of that committee. There tended to be people who lived in or close to London on the committee—again, because of the travel. The meetings would take place in the afternoon and then you'd go home. I had to have a security clearance for this work. A man came out from the Ministry of Defense and read me the Official Secrets Act. He told me what I should look out for—various things. That was the last I heard of it. I assume I was cleared the amount that was necessary. But the security was very lax. Of course, that was one of the things that the Americans objected to with the British—that they wouldn't take security seriously. And, of course, when you look at the people who left from England—there was [Klaus] Fuchs, [Bruno] Pontecorvo, and probably others. Perhaps the Americans had a good reason to be suspicious. Of course, the English had this academic attitude that security was basically a waste of time. I once sat next to P. M. S. Blackett, the Nobel prize-winning physicist, at the high table in Cambridge. Very famous. That was a nice thing about the high table—you got to sit next to everybody, because you sat in your seat depending on when you came into the room. You'd come into the

room and take the nearest seat, and that's the way you filled them. So if you wanted to avoid some people, you waited. You either waited or you got there early. [Laughter] That was the only control. Anyway, Blackett was there dining once. He said—which of course is obvious—that there was only one secret worth keeping about the atomic bomb, and that was that it could be made. Once you knew the thing could be done—

COHEN: It was just simple physics.

SAFFMAN: And the Russians have their share of great physicists.

COHEN: That's true.

SAFFMAN: So when they knew it was doable—that there was an answer—they built the bomb. And all that Pontecorvo and Fuchs did, perhaps, was delay the Russians. Because they probably had their own ideas and their own program, and then this extra information would come in and they'd have to read it to find out whether it was— There was always a possibility, of course—they would have to keep it in mind—that this could be false information as well. So it probably slowed them down. I shouldn't say things like this on tape.

COHEN: No, no, no. It's probably true. [Laughter]

SAFFMAN: So the English had this academic attitude. Of course, that's counterintuitive. The Americans wouldn't believe it anyway.

COHEN: Well, the Americans were going through a bad period then, as far as these things went—as far as the security was concerned. McCarthyism and the aftermath of that, so the climate was different. And then, of course, the Americans felt very vindicated with all this.

SAFFMAN: When all the spies appeared.

COHEN: When all the spies appeared. So you worked on these other problems then, on this one committee.

SAFFMAN: Yes, and when I came to Caltech I worked on other problems. I've made some notes here: "magnetohydrodynamics," "turbulence," "rotating fluids," "vortex dynamics," "liquid helium," "viscous flow dynamics," "porous media," "water waves," "shear waves." Those are the topics. Shall I say them again? [Laughter]

COHEN: That's OK. Now, when you came to Caltech, you came originally, you say, to visit at JPL?

SAFFMAN: Yes.

COHEN: And that's when you met all these people?

SAFFMAN: No, that's when I met Whitham and Liepmann. They were at Caltech. In those days there was a very close connection between Caltech and JPL in the areas of applied mathematics and fluid mechanics. That is now dead. But it was 1963 when I came, and it was very strong.

COHEN: Who at JPL was working on these things?

SAFFMAN: Janos Laufer.

COHEN: And he had a group there?

SAFFMAN: Yes.

COHEN: And then this group was at Caltech?

SAFFMAN: They collaborated. They'd always come down to our seminars, and it would be quite common for people here to go there for JPL seminars.

COHEN: And students would go back and forth also?

SAFFMAN: Oh, they didn't have students. The students would be down here on campus. But occasionally a student would, although I don't think any of our students were actually supervised by people from JPL. But they'd certainly go up there, perhaps to consult with them.

COHEN: How long did this relationship last?

SAFFMAN: It died in about 1970, I would say.

COHEN: Why did that happen?

SAFFMAN: I think money started to become important. During the 1960s, money was no problem.

COHEN: Who would raise the money? The JPL people or the Caltech people?

SAFFMAN: JPL was being directed—the JPL administration didn't see the purpose of supporting work in fluid mechanics. I think that's what happened.

COHEN: That seems shortsighted, considering—

SAFFMAN: They started to have to—what's that awful word—to prioritize. We were approaching an era when money was starting to become finite. We were becoming aware that the money was finite.

COHEN: [William H.] Pickering [JPL director 1954-1976] was still in charge?

SAFFMAN: Pickering was still in charge but I think slowing down. He was succeeded by Bruce Murray, as far as I can remember.

COHEN: And Bruce Murray didn't stay very long.

SAFFMAN: A couple of years. [Murray was director of JPL for six years, 1976-1982—ed.]

COHEN: But I thought Bruce Murray really tried to push collaboration between the campus and JPL.

SAFFMAN: He perhaps did, but not in fluid mechanics. They were closing down. When Laufer left JPL [1964], they made it impossible for him to come to here. He went to USC. He founded a group in fluid mechanics at USC. He did very well; he had a good nose for people. So it was JPL which cut the connection.

COHEN: That's too bad.

SAFFMAN: When I came to Caltech, I got to know the Whithams quite well. We became quite friendly, because they were from the same part of England as we were and in many ways had the same kinds of experiences—leaving home when you have young children, and so on. One day I think I mentioned to Gerry that I liked it here and wondered if there was any possibility of staying. He said he'd talk to Hans Liepmann. A day later, he said, "Yes, when do you want to start?"

COHEN: It was as easy as that? This is during your six-month visit?

SAFFMAN: Yes. I said, "Well, I can't start straight away, because I promised London that I'd go back, and I can't go back on my word." I mean, it wasn't a legal promise of any kind, but I'd given my word, and so I went back and started [here] in 1964. Money was not a problem, not like it is now.

COHEN: Well, the sixties were a very expansive time.

SAFFMAN: What we were starting to run into in 1970 with JPL—they were beginning to see that their money was finite.

COHEN: So you made decisions about what to keep and what not to keep.

SAFFMAN: And they did not regard fluid mechanics as a— And that was a very shortsighted and very foolish decision.

COHEN: Considering what they mostly do, it seems silly.

SAFFMAN: Yes.

COHEN: Turbulence is a big problem, isn't it?

SAFFMAN: Yes.

COHEN: Now, when you did come here then as a permanent faculty member, you came as a professor?

SAFFMAN: I came as a full professor.

COHEN: What department were you in? It's hard for me to understand the different departments.

SAFFMAN: I was a professor of fluid mechanics in the Engineering and Applied Science Division.

COHEN: I'm trying to understand a little bit about how these different things worked.

SAFFMAN: I was the only member of this department.

COHEN: [Laughter] Oh, I see, a department of one. Now, why is that? They created this name for you? Was there nobody else doing this?

SAFFMAN: Yes. Well, there were a lot of people doing fluid mechanics, but they were doing it as mathematicians or engineers or environmental engineers or physicists. But there was nobody doing fluid mechanics as fluid mechanics. At that time, they asked me if I would accept this title. I could have been a professor of applied mathematics if I had wanted to. But I said, "Yes, I'd be glad to take it on." At the time, I didn't want to be a professor of mathematics, because

American mathematics at that time was still very pure. I didn't have too much interest in pure mathematics.

COHEN: They can be very snobby, too.

SAFFMAN: Yes. Physics at that time really didn't do very much in the way of fluid mechanics. It was mostly done in engineering departments. So I said that I'd be happy to be in the engineering division with the title of professor of fluid mechanics. And my main contacts were with aeronautics—basically with Liepmann and [Anatol] Roshko [Von Kármán Professor of Aeronautics, emeritus].

COHEN: Now, they were in a separate department, too, before they amalgamated that into the engineering division.

SAFFMAN: No, they were always a part of the engineering division. I think they were always a part of the engineering division.

COHEN: I interviewed Frank Marble [Hayman Professor of Mechanical Engineering and Professor of Jet Propulsion, emeritus] about how some of the departments were set up.

SAFFMAN: There were difficulties. There were personal conflicts.

COHEN: And then, of course, electrical engineering was in physics, it wasn't in engineering at all.

SAFFMAN: That's right. Then applied physics came along, too.

COHEN: Now, all these things moved over into the engineering division. It left mathematics isolated.

SAFFMAN: Yes, that's right.

COHEN: And they are isolated. I mean, they're in the PMA [Physics, Mathematics, and Astronomy] division, but they're not really very much part of physics or astronomy.

SAFFMAN: That's right.

COHEN: And how much do the two departments mix?

SAFFMAN: Zero. Well, at one time some members of the applied math department—that would be Whitham, [Herbert B.] Keller, and [Donald S.] Cohen—were members of mathematics. But then they resigned or left [the PMA division], because, again, they had nothing scientific in common. The official department of applied mathematics appeared about 1968. Then I decided that it would make more sense, since I was working with those people—there are other people who had tended to become more experimental. It made more sense for me to be a professor of applied mathematics, which I became [1970].

COHEN: Do you still have an appointment in aeronautics also?

SAFFMAN: I don't know. Practically, no. Theoretically I should have, because I have this titled chair [Theodore von Kármán Professor of Applied Mathematics and Aeronautics], the title of which is actually Applied Mathematics and Aeronautics. So I should be in both. But my contact with aeronautics is professionally almost zero.

COHEN: You're in another building.

SAFFMAN: No, we're not. We're in the same building, because the buildings are continuous. Kármán, Guggenheim, and Firestone are basically one building. Of course, we're all on the same floor.

COHEN: So you came here, and it must have been very different from Cambridge or London.

SAFFMAN: Very different. We rented a house for the first year, up in Altadena. Then we bought a house on Ninita Parkway that turned out to have a very good neighbor—Max Delbrück. In

fact, I did some work with Max. We published a couple of papers on various aspects of dynamics of protein molecules moving through cells.[3]

COHEN: I see. Of course, he was trained as a physicist, so he must have had plenty of mathematics.

SAFFMAN: Yes. And that was very exciting work.

COHEN: What year was that?

SAFFMAN: We came here in ’64 and rented a house for one year on Sonoma Drive, next to the Altadena golf course, and then we moved down here in 1965. We’ve been here a long time.

COHEN: The Delbrücks were already living there?

SAFFMAN: The Delbrücks were already there, yes. I don’t know when they moved in, but they were already there. They thought we were very strange.

COHEN: [Laughter] But Max was from Europe.

SAFFMAN: They thought—and I think they were right—that we were very stiff and formal. We weren’t. We were very shy and nervous.

COHEN: So, tell me some more about your impressions of Caltech when you first came here.

SAFFMAN: Well, the thing that I liked was that it was so lively. There wasn’t the dead wood at Caltech that one found at Cambridge and London. And I had the impression here that it was a meritocracy—that you were judged by the quality of your work and not by your age or your seniority, as you were in England. In England, the person called the professor was automatically the head of the department, and he could have been the biggest fool in the world, but he was the professor and what he said went. There was no arguing with him. I got the feeling that that

[3] P. G. Saffman & M. Delbrück, “Brownian motion in biological membranes,” *Proc. Nat. Acad. Sci. USA*, 72:8, 3111-13 (1975).

wasn't the case in America. Maybe I was wrong in thinking that, but that was the impression I got. The people were respected here as long as they were producing, but when they stopped producing, the respect— I mean, they may still be liked—especially if they were honest about what they did—but you would not respect their work if it was of low quality, independent of what position they may have held.

COHEN: That may have been a Caltech thing, also.

SAFFMAN: That could have been very much a Caltech thing, but I was coming to Caltech.

COHEN: No, but I'm just saying that that could have been, because Caltech in some ways is a unique institution. So who was the president [then]? [Lee A.] DuBridge?

SAFFMAN: DuBridge was president.

COHEN: Was [Robert F.] Bacher provost then?

SAFFMAN: Bacher was provost, yes.

COHEN: Did you speak with Bacher before you came?

SAFFMAN: No. Mainly Hans Liepmann and Gerry Whitham. I spoke with them. And I grew to like Southern California.

COHEN: It was very nice here.

SAFFMAN: The warm weather. The lovely summer evenings. And also, I remember now, we had a problem with Mark's health. He had a problem in England. He had a history of medical problems. Some of them were potentially very serious. And we came to spend six months at JPL with sunshine—

COHEN: And fresh air. [Laughter]

SAFFMAN: No, the air wasn't fresh—that was one of the problems. But certainly sunshine. And—touch wood—Mark's problems healed. And then we went back to England. We were there one week and he went and broke his leg. [Laughter]

COHEN: So that was a sign.

SAFFMAN: I remember writing to Gerry Whitham about something or other and saying, "Could you bottle a bit of sunshine and send it over? Because I think it's been four weeks since we last saw the sun."

COHEN: So you were happy to come back.

SAFFMAN: So for that reason we were happy—certainly from the point [of view] of Mark's health; it made a very big difference.

COHEN: Now he's moved out of the sunshine.

SAFFMAN: He's trying to move back, actually. But things are not so easy nowadays.

COHEN: What else can you say about Caltech? Did you travel back and forth? You went to meetings?

SAFFMAN: I went to meetings. Then, as a family, we went back every year. We would go back for about three or four weeks every year to see all of our relations. That continued, more or less, until my parents died. Ruth's parents died first; they were somewhat older. My parents died—I'm trying to think of when it was that they died. My father died around 1980, perhaps; I'm not quite sure of the actual year. One loses track. When my parents died, I had my brothers, but we had no interests in common. I'd go to their house, and it would be, "Philip, how are you?" "Leonard, how are you?" "How are things going?" "Well." Et cetera. And after ten minutes that was the end of it. We had no common interests. We had nothing to talk about.

COHEN: Are you a citizen, Philip?

SAFFMAN: Yes. I became a citizen.

COHEN: When did you do that?

SAFFMAN: 1990.

COHEN: Oh, so it was relatively recent.

SAFFMAN: Relatively recent. It's because of the change in the tax law. Your income tax, or your inheritance, or whatever it is, or your Social Security depends on if you're a citizen or not. And you'll notice they can discriminate. A green card does not entitle you to all the benefits that a naturalized citizen has. So there was a strong economic reason to become a citizen. There's also another reason. And that was I was consulting at TRW. In my consulting work, I said I wasn't going to do anything classified, and that was all right with them. I only worked on matters that were not classified or secret. But then their administration was under pressure, and they said, "We can't have you working as a consultant if you're not a citizen." And I had to make a choice. And I chose to become a citizen.

COHEN: Was that difficult for you?

SAFFMAN: Yes. It was difficult, and it still is difficult. Because I'm really not English—I'm Lithuanian, or Russian, really. I was born in England, but my grandparents, my roots, are not English.

COHEN: Let's talk a little bit more about the forming of the engineering division. Were you very involved in all that?

SAFFMAN: No. At that time, one of the things that attracted me to Caltech was that you were left alone to get on with your work and get on with your research. In fact, one of the very nice things that I found at Caltech when I first came here was that people had contracts. I wasn't really aware of this when I was in England.

COHEN: You mean to do consulting?

SAFFMAN: No. Contracts for research with the government. With ONR [Office of Naval Research] or the National Science Foundation.

COHEN: OK. Grants.

SAFFMAN: Grants. And I remember saying to Gerry, "Should I apply for a grant?" And he thought a minute and said, "No, it's not necessary at the moment. We have enough money to do whatever we want to do. There's no point."

COHEN: You weren't setting up labs.

SAFFMAN: No, that's right. It was just—

COHEN: Pencil money.

SAFFMAN: Well, it's more than that now, of course, because they want salary money. And so I didn't have a grant for many years. As I said, I was free to get on then with my own work and research.

COHEN: So you didn't have to write grant proposals that take six months.

SAFFMAN: I didn't have to write grant proposals. Well, no. At that time, the grants were different. We're zigzagging here. When computers appeared, we suddenly found that we needed money, because we had to buy equipment; pencils were no longer sufficient. And I remember that I was doing some work at that time on water waves. I thought perhaps that I should try to get some grants. I called up a person I knew at ONR and said, "I think I need to buy some computers. I need some money. Can I write a proposal to ONR?" And they said, "Oh, don't bother writing a proposal. How much money do you want?"

COHEN: What year was this?

SAFFMAN: 1970 or 1972.

COHEN: ONR was very generous.

SAFFMAN: These were the golden days. So, that was another thing. I don't think I would come now, with the pressure. Except grant writing has spread to England. I talk to my friends in England now and they're writing grant proposals.

COHEN: All the time?

SAFFMAN: All the time. It's as bad as here.

So, where were we then? You had asked me about the engineering division. I was free to do my own research and talk to my own students, and I kept myself out of any administrative work, so I can't tell you anything about the creation of the division or how the engineering division came to take the form it has, because I deliberately stayed away from this kind of politics.

COHEN: You weren't curious what was going on?

SAFFMAN: No. As long as I was free to do my work, I wasn't curious. I thought to myself that it really didn't matter what they did, anyway. All that really mattered was that I could get on with my work. And that's one of the reasons I liked Caltech so much. In England, I was moving up the ladder and becoming more senior. The ambition that most people had there eventually was to become a professor or head of the department. And that was given to the most senior scientist or mathematician, independent of whether they could administrate or not. And I saw this as happening to me—that I was moving up as I was staying there, becoming more senior, writing papers, which was increasing my reputation. Soon I realized that the next time there was a vacancy for head of the department, it was going to be me, because I was most senior.

COHEN: Not that your work was best, or anything like that.

SAFFMAN: Not that my work was best, but that I was most senior.

COHEN: And that would be the end of your solitude.

SAFFMAN: And that would be the end of my science. And I didn't want that to happen. Then I was a keen, enthusiastic, energetic young man.

COHEN: So, you did your work happily. Did you do anything for the institute? I mean, were you on any committees that interested you?

SAFFMAN: No.

COHEN: How did you manage that?

SAFFMAN: Caltech allowed you that. Louise was on infinitely more committees than I was.

COHEN: You mean when she was a student here?

SAFFMAN: When she was a student here as an undergraduate. We were moving into the age—when was it? 1972.

COHEN: When they had student representation.

SAFFMAN: Student representation. Being politically correct came about.

[Tape Ends]

PHILIP G. SAFFMAN

SESSION 2

December 12, 1997

Begin Tape 2, Side 1

COHEN: Perhaps you'd like to tell us a bit about your sabbatical at MIT [1970-71].

SAFFMAN: I went there as a visiting professor. I did a little teaching; I did more research. And I interacted with some of the people there, with whom I'm quite friendly—the main people being David Benney and Harvey Greenspan. I found the atmosphere there very exciting—more so than Caltech, actually, because it was larger. Caltech has always gone on about being unique because it's so small, with the implication that it's better to be small than big. But I don't think that's necessarily the case. MIT is what—about eight or ten times the size of Caltech?

COHEN: Five. I think five.

SAFFMAN: Just five? But even so, it meant that they could do a lot more. There were many more—

COHEN: More resources?

SAFFMAN: There were more resources. And the student life, I think, was richer than it is here. They have the Coop there, and they have the student houses. There are more activities and entertainment put on for the students. Research-wise—five times the fields that Caltech [has].

COHEN: I think that's it. They cover more things than Caltech does.

SAFFMAN: So they demonstrate that being big is not automatically bad. I think that what one wants is actually variety. With a Caltech and an MIT, you can have the big and also the small. Because one thing I did miss at MIT, which is associated with its large size—I had very few contacts outside the math department. I was visiting in mathematics, and there were eighty

professors of mathematics. Hence there was quite an active intellectual and social life just within mathematics. So there was no opportunity or incentive to meet physicists, engineers, aerodynamicists, or biologists, because your own department was large enough to occupy all your time. And that's one thing that Caltech does allow you to do. Many of my friends here are not in the math department, they are in physics or engineering.

COHEN: But how about the fact that it's in a big city? I mean, I've heard that people go home at night and that's it—you don't even know who their families are. That was not so?

SAFFMAN: That was so in London. When I was in London, its being a big city was difficult, because the traveling was so long. If you went anywhere in London, it was an hour each way, with the result that you didn't tend to go out in the evening or even on the weekends. But Boston was smaller, more compact. I don't think most of the people actually lived in Cambridge; they tended to live around Cambridge. Lexington was popular, Belmont, and so on. And the distances were not large. We went out quite a lot in the evening in Boston; we had quite an active social life. And I think being a big city helped. We'd go to the theater much more than we do here. We would go out to the theater and for dinner, usually with the Benneys, Greenspans, or other friends.

COHEN: So you really enjoyed that year.

SAFFMAN: Yes.

COHEN: Of course, you had the winter weather that you don't like.

SAFFMAN: That was nice winter weather. I remember that Christmas, being on the East Coast, we decided to visit England, because it wasn't so far. So we all went to England, and we had a miserable time there with the weather. We enjoyed the visit—being with our family for a few weeks—but the weather was terrible. It made it difficult to enjoy yourself. It hovered around 35° Fahrenheit, so it was slush. And it was just damp from the cold. The damp would get into your bones.

COHEN: One gets unused to that in a hurry.

SAFFMAN: Yes. And we came back to Boston and it was much colder, but the sun was shining, the air was crisp, the snow was firm, and the houses were warmer as well. I suppose now the English houses are getting warmer in the winter, but at that time they were only just beginning to install central heating in English houses.

COHEN: So that was a good year at MIT.

SAFFMAN: That was a good year. And academically also it was a very good year. I managed to solve a problem that I had worried about for several years and that proved rather difficult. I eventually got it while I was at MIT. I found the way to do it.

COHEN: Did that have a name?

SAFFMAN: Yes, "finite amplitude instability of Von Kármán vortex street." It's the wake behind a cylinder or a blunt body. I don't know if you've ever seen pictures. You'll see them sometimes in the newspapers or in *Time* magazine. A vortex is a swirl. Actually these were, as far as I could tell, probably first described by Leonardo Da Vinci; there are some beautiful pictures of these in [his] sketches. There's a book on vorticity by Hans Lugt which is at the popular level, not the technical level—or halfway between the two.[4] He claims, actually, that the Assyrians noticed this phenomenon. You see it on some of their walls. What was the name? That's one thing I find as I reach the age of mid-sixties—my vocabulary is starting to decrease.

COHEN: The words don't come as easily.

SAFFMAN: I know what I want to say, but I can't think now of the word. It's a stone wall.

COHEN: A frieze, you mean?

[4] Hans J. Lugt, *Vortex Flow in Nature and Technology* (Malabar, FL: Krieger, 1995).

SAFFMAN: It's like a frieze, yes, but it has a special name. It will come to me later; it doesn't matter.

COHEN: I find I can't think of a word, but I can see the letters. [Laughter] They don't come together.

SAFFMAN: We enjoyed it so much that we actually went back for a second sabbatical, but only a half. We just went for a few months. I went to Madison, Wisconsin. I took another sabbatical in Madison. I thought I should see what living in the Midwest was like.

COHEN: Now, this sabbatical at MIT was what year?

SAFFMAN: I went twice—1970 and 1980. So this would have been the 1970 sabbatical. I went again in 1980.

COHEN: So you must have had your whole family in 1970.

SAFFMAN: In 1970, I had the whole family. We went as a family. The children went to school there, and they loved that. The schools were so good. I don't know if they still are.

COHEN: Well, I remember when you came back the second time and you weren't willing to put Emma back in the public school.

SAFFMAN: That's right, yes.

COHEN: I do remember that.

SAFFMAN: She didn't go to school the first time we went there. She was too small.

COHEN: She would have been in kindergarten.

SAFFMAN: She would have been in kindergarten, yes.

COHEN: Did you live in the Newtons?

SAFFMAN: No. We lived in Belmont.

COHEN: So you were right close.

SAFFMAN: Very close. I used to take the bus. Transportation wasn't a problem. The car was useless, actually. There was nowhere to park it, and the traffic was unbearable. I used to take the bus and the train, but mainly the bus—although I would walk a bit. I would walk from MIT up to Cambridge, up to Harvard Square.

COHEN: That's a good walk.

SAFFMAN: That was a nice walk. And I used to have a competition to see how many buses would pass me. Half the time I got there before the bus. And then two or three buses would come together, of course—bunched together. And then I would have to get a bus from Harvard Square to Belmont. The house we had was actually next to a bus stop.

COHEN: Why did I think that you were in the Newtons? Were you in the Newtons the next time you came?

SAFFMAN: No, in 1980 we stayed at MIT. Our children were away at this point. Emma had started at Yale. I'm trying to think: If she was at kindergarten, that's ten years more. Somehow the timing doesn't seem right. Maybe it was a little later—maybe '81 or '82. Because Emma was at Yale and Louise was in Stockholm and Mark was in Los Angeles.

COHEN: Holding down the fort.

SAFFMAN: Mark graduated from Caltech and didn't, at that time, want to go to graduate school. So he got a job at TRW and lived in Venice, where he burned up my Volkswagen van but escaped with his life. Volkswagens are very badly designed with regards to the pipe that takes

fuel from the fuel tank to the engine. Those pipes wear out. And, of course, then instead of gasoline going into the cylinders, it goes onto the hot engine, and the thing catches fire.

COHEN: So you had another year at MIT.

SAFFMAN: No, three months.

COHEN: Were you ever tempted to just go there?

SAFFMAN: Yes. They asked me, in fact. But I think the logistics of packing up, selling the house, and moving 3,000 miles—I just didn't feel that it was worth it. And, as I said, the winters were cold, and we felt the cold the second time we visited more than on the first. And we were also ten or twelve years older, and my friends were also older, and there was less interest in the science and research. It was no longer the exciting challenge it would be for a young man. And we had slowed down a bit. But we did think about it.

COHEN: So this was home, and you came back.

SAFFMAN: This was home. And we came back. I don't know if it was the right decision.

COHEN: Do you think about it?

SAFFMAN: I think about it. I sometimes have regrets. It would have been different, but it's hard to say.

COHEN: Well, hindsight is always very good.

SAFFMAN: I sometimes wonder if I did the right thing in coming to the United States and leaving England. I had several opportunities to go back. But, again, we talked it over and thought it over and decided that, weighing everything out, this was home now.

COHEN: Well, one doesn't know about these things. But you've done very well here.

SAFFMAN: Yes. Basically I've been happy here.

COHEN: That's what most people say when they come in. If not, I guess they really wouldn't stay. I mean, almost everybody here must have opportunities.

SAFFMAN: You don't come to Caltech if you're not the kind of person who is going to receive offers from other places.

COHEN: Then you came back here in '82.

SAFFMAN: I spent three months in Madison and three months at MIT. I went to Madison—first of all, I was asked to go. But that wasn't, of course, the main reason. I thought I'd like to see what the Midwest was like. I had passed through Chicago and Madison—this is the University of Wisconsin in Madison. I had never been there for any extended time—never for more than one or two days, and I thought it would be an interesting experience. It was easier then to move, because it was just Ruth and I. And, of course, we would then be a little bit nearer to Emma who, I think, was just in her first year at Yale. We enjoyed it very much. It's very different in the Midwest.

COHEN: You lived in Madison itself, which is sort of a small town.

SAFFMAN: It's a small Midwest town. People didn't lock their doors. It was the same situation when I came to California—people didn't lock their doors. But that didn't last too long, of course. Madison was a nice town. It was a big university, so there was a lot going on all the time. There was theater and cinema—you name it and it was there. There were 20,000 students.

COHEN: It was, what, 100 miles north of Chicago?

SAFFMAN: One hundred miles, yes. Well, two hours on the bus or by car.

COHEN: It's beautiful country. I've been there.

SAFFMAN: Yes. We went to Chicago a few times and thought that Chicago was a marvelous city.

COHEN: It's getting to be more and more marvelous, I understand.

SAFFMAN: Really? Well, it's full of ethnic restaurants, opera—not that I, at that time, was fond of opera. Ruth was, so Ruth used to go to the opera. She went a few times. They'd run tours from Madison. Again, with a big university, you have enough people to fill a bus to go to the opera. You can't do that at Caltech; it's not large enough to fill a bus. But then again, I was invited to the math department. I got to know the mathematicians, but I didn't know any of the engineers or physicists.

COHEN: That's interesting, because here you're really with the engineers.

SAFFMAN: Yes. But I'm here also with physicists. We talk to the physicists. We're beginning to talk to biologists, though that's in the future. There are methods of applied mathematics that are being used in biology.

COHEN: Wouldn't you say that was a real strength of being here? The fact that you're not just with mathematicians?

SAFFMAN: Oh yes, very much so. That's one of the things that makes Caltech so attractive.

COHEN: I know that mathematicians at Cornell were a world apart.

SAFFMAN: But I think Oxford and Cambridge actually handle this in a nicer way, with the institution of the college. Because everybody is split up in the college. You are a member of the university for the teaching. And there would be a math department, say, and you would be a member of that math department and you would meet other mathematicians. But you would also be a fellow of a college, and you would have a social and academic life also through the college, where you would meet other people, because the college has about fifty to one hundred fellows and they are spread out amongst all the disciplines.

COHEN: OK. So you had good sabbatical leaves at MIT.

SAFFMAN: Very good sabbatical leaves at MIT. I enjoyed it very much.

COHEN: But there must be a real advantage, given the—well, I don't want to insult you by calling your work practical—but given the kind of work you do, to be able to talk to physicists and engineers. Or doesn't that matter?

SAFFMAN: No, it does matter, because they are the source of the problems. Applied mathematics is the application of mathematics to, shall we say, the real world. Therefore, we want to talk. We get ideas, or we become aware of problems, by talking to physicists. Historically at Caltech, applied mathematics is not as close to engineering as it is to aeronautical engineering. Von Kármán was really an applied mathematician as well as being an aeronautical engineer. And that tradition persisted at Caltech. Gerry Whitham was a professor of aeronautics before he helped start the applied math department. And Julian Cole—I don't know if you remember Julian Cole—and Paco Lagerstrom. They were all in the aeronautics department. And then when Caltech started the applied math department, they came over and changed their titles. But of course the connection was still there—they were in the same building. Well, not the same building, but it's horizontally stratified. I find that if you want to talk to people, you must be on the same floor as them, if you want to interact closely. If you are on the floor above or below, you have much less interaction.

COHEN: I see. Well, sometimes there is a coffee room, and that helps.

SAFFMAN: Sometimes there's a coffee room, yes, and that helps. But there was a coffee room, and there was a horrid little corridor which went from applied mathematics on the east end of Firestone to continue on to where the Kármán building is, by Sloan. And we had very close contact. In fact, when I came—I think I told you in a previous interview—I was originally a professor of fluid mechanics, not a professor of applied mathematics.

COHEN: Right. And that was just a unique title for you for a brief time.

SAFFMAN: For a brief time, yes.

COHEN: So then you came back from MIT and passed up the offers to go to these other places, and continued on here. Now I'd like to ask you something else. I asked you at one point if you had done committee work or anything like that, and you said that you had not.

SAFFMAN: Well, I was on the graduate student housing committee once for one year.

COHEN: Is this because you really didn't enjoy this sort of thing?

SAFFMAN: Yes. In fact, Louise was on far more committees than I was. She was on the student admissions committee and another committee that I can't remember.

COHEN: Did you ever feel any sense of people thinking that you should be on the committee?

SAFFMAN: No.

COHEN: So there was no pressure there?

SAFFMAN: I found there was no pressure to sit on committees.

COHEN: I see. OK. So you didn't mind if they made rules that you didn't care for?

SAFFMAN: Only if they really impacted me seriously.

COHEN: But how about your department itself?

SAFFMAN: Well, we were small enough that basically the whole department was the committee. So if something came up, then the department as a whole would meet and decide what to do. There wouldn't be a committee composed just of members—

COHEN: Did you have a presiding officer or an executive officer?

SAFFMAN: We had an executive officer who did the dog work—whatever it was—who called the meeting for deciding about what we were going to teach next year and who was going to teach what. And when we had questions of that kind or questions about admitting students, those were done by the applied math department as a whole. I shouldn't really call it a department, but it was a department. We did it all as a whole. We didn't have any special committee for those purposes. We could say that the department itself was a committee.

COHEN: So all of you just felt secure enough in your own work that you went on?

SAFFMAN: Yes.

COHEN: You weren't worried about getting your share, or whatever.

SAFFMAN: That was one thing that was attractive. I don't know whether it was a Caltech thing, but it was certainly so in applied math that we cooperated. If we had a student to support—say, one of my students needed support and I didn't have money—I would just go and ask the others. I'd say, "Has anybody here got enough money to support a student?" And we had the tradition that those who had money would help the others who didn't have money. The understanding was that at any one time somebody would have some money. Then next time, say, Whitham would come to me and say, "Do you have any money, Philip?" And I'd say, "Yes, I've got some money. Here you are." We were very cooperative in that way.

COHEN: Has that continued with these more austere days?

SAFFMAN: I think it has still continued. We still have this. But what has happened is that money has tended to come now to only one or two people. Now more of us do not have any money. So now it's tending to go one way. But if we have the money, we will give it to our colleagues.

COHEN: So are you taking fewer students then?

SAFFMAN: We're beginning to take fewer students, yes. Though applied math is fortunate in its teaching that we have the course AMA95.

COHEN: Which course?

SAFFMAN: Applied Mathematics 95, which all the undergraduates have to take. It is the fundamentals of applied mathematics. It's where the students learn useful mathematics. What they learn in Math 1 and Math 2 is rarely useful. All the useful stuff comes in the third year. It's a junior course, and it's 200 students. The institute gives us about eight or nine graduate students—GTAs [graduate teaching assistants].

COHEN: To do the sections?

SAFFMAN: To do the sections. And basically we use that to support half our graduate students. Half are supported through contract money. As contract money has decreased, we've tended to use these GTAs.

COHEN: To give them support?

SAFFMAN: Yes. So we're managing. We still have the attitude that those who have will give to those who don't have.

COHEN: That's very good.

SAFFMAN: It's very rare actually. We are quite unique in this attitude.

COHEN: Well, people who get more money just have more students of their own.

SAFFMAN: Well, one thing is that applied mathematicians don't really like to have lots of students. Remember Hermann Bondi? What was it that he said? "A PhD is a piece of research done by a professor under circumstances of great difficulty."

COHEN: [Laughter] That sounds a bit like Hermann.

SAFFMAN: And theoreticians are different anyway. We don't have labs. We don't need bodies to run experiments or mass data. We're basically pencil and paper. Though the computer is used more now.

COHEN: And a wastebasket.

SAFFMAN: And a wastebasket. So all we need to support students is salary support—very little money. We don't need equipment or lab assistance or technical help.

COHEN: So when the institute gives you money to support these students, you don't have to pay overhead either, do you?

SAFFMAN: Not on the GTAs. Of course, we have to pay overhead on the GRAs—the research assistants.

COHEN: OK. Because I hear complaints about that. Well, that gets us into the students.

SAFFMAN: Well, I've had about thirty-seven students, actually, which is very unusual in applied mathematics.

COHEN: That's a lot.

SAFFMAN: I was going to say that applied mathematicians basically don't want students. But that's changed a little bit, because as we use computers more, the students help. I've had roughly thirty-seven—when I last counted them. In applied mathematics that's quite a lot. I've lost touch with most of them. They've tended to go into industry, government research labs, and academia. I suppose my most successful student on the industry side is Henry Yuen, who came to us from the University of Wisconsin at Madison. He came to Caltech to do graduate work. I don't quite know how our process of matching professors and students takes place. It's a kind of osmosis or merging that takes place. He ended up with me.

COHEN: Well, do they go around and sort of talk to everybody?

SAFFMAN: They go around and talk to people. Some professors won't take them if they don't like them. I suppose I found it hard to say no. I was always the professor of last resort. That is, if they couldn't get anybody else in the department to take them on, I would take them on. This is one reason why I had so many of them. Another reason is that many of them, or most of them, were somewhat undistinguished.

COHEN: Well, OK. That's interesting. So tell me more about—

SAFFMAN: Henry Yuen. Well, he worked with me on some problems of vortex dynamics. His PhD thesis was not particularly noteworthy, actually.[5] It was good, but not exceptional or outstanding. And then he took a postdoc at the Courant Institute in New York.

COHEN: Well, he must have been a good student to do that—to get into the Courant.

SAFFMAN: Yes. Well, this was through Joe [Joseph B.] Keller. This was the way it happened: Do you know Herb Keller?

COHEN: Yes, and his brother Joe.

SAFFMAN: You know his brother Joe. His brother Joe is extremely successful. Joe always has lots of money. He's on great terms with the contract managers. So Joe finds money without a problem. In fact, most of the contract managers are now ex-students of Joe's. Joe Keller has had an enormous number of students. He must have had more PhD students than all the other applied mathematicians in America put together, because he was very good with them. He could handle them. He could think of problems that they could do.

COHEN: So now these ex-students are in charge of the funding agencies?

SAFFMAN: Yes. So he has no problem with money. They're ex-students.

[5] Henry Che-Chuen Yuen, "Waves on Vortex Filaments," Dissertation (Ph.D.), California Institute of Technology (1973).

COHEN: [Laughter] Well, they must have left him on good terms.

SAFFMAN: He never fell out with them—not like some people, whom I won't mention. He was always, as far as I could see, on the best of terms with all his students. He has this wonderful power of concentration. A student could come in and he would immediately remember what the student was doing.

COHEN: Ah, so they always felt that he was really involved with them.

SAFFMAN: And then the student would walk out the door and he'd forget the student entirely and go back to what he was doing before the student came in. Wonderful powers of concentration. I don't know who else had that. In England, there was a man called [James] Lighthill who also had those powers. But basically applied mathematicians don't have many students.

COHEN: So then Henry, of course, went on after that.

SAFFMAN: He was a postdoc at Courant. And then TRW was starting to build up a department in ocean engineering, and they wanted people who knew applied mathematics and would be willing to learn the fluid mechanics of ocean waves. Our students at Caltech would have been well trained for that, because Whitham used to teach a course on water waves. So any student who would have been through our courses would have been just what TRW wanted. The postdoc that he had at New York was only a year or two-year postdoc. I think I told him that I didn't think his chances of getting a job in a university were all that good and that he ought to consider going into industry, where his talents would be more valuable and useful. I think he followed this. He went to work at TRW and did extremely well, actually. He could give TRW what they wanted. And he did very good work. He started to blossom as an ocean engineer and TRW, in fact, had such a high opinion of him that they made him what is called a TRW fellow. IBM has such a position. They would be supported by TRW to do work on whatever they wanted—a very, very good position to have.

COHEN: So it's a research position within the industrial organization.

SAFFMAN: Basically, it's supposed to have tenure. But industry is not legally obligated to do so. So it's not one-hundred-percent secure—not as secure as a professorship. But it was still very good. So that's what he did. During this time, we decided that he didn't sleep. That was how Henry managed to do that amount of work—because he was doing good work in ocean engineering and at the same time attending law school at night.

COHEN: Did he have any family?

SAFFMAN: He had a wife and two sons. And, in fact, he started to practice as a lawyer.

COHEN: Here in Los Angeles?

SAFFMAN: In Los Angeles, or down in Temple City, or Monterey Park—dealing with matters of import/export. I think he was doing quite well as a lawyer. Again, I don't know how he managed with the time, because he was at TRW at the same time as he was practicing as a lawyer. And then he invented VCR Plus.

COHEN: So that was his invention?

SAFFMAN: Well, [his] and a student of Dave [David L.] Goodstein's called Daniel Kwoh and somebody in Hong Kong whose name I don't know—a man called Wilson, I think. The three of them thought of the idea of VCR Plus. I think they found some electronic engineers and computer scientists who lived in Hong Kong who could actually build the hardware. So Henry invented a third of it. It was the three of them together, but I think Henry was the main driving force behind VCR Plus.

COHEN: Well, that's very impressive.

SAFFMAN: And that's been quite successful. Louise's part in VCR Plus was with the marketing, not with the invention of the device or the manufacturing. She did marketing and had contact with the newspapers, because you know how VCR Plus worked—the codes had to be published.

COHEN: We have one, but we haven't figured out how to do it.

SAFFMAN: Switching it on is the hard part. Once it's on, it works. I believe you don't have to do anything.

COHEN: Well, it worked for a while—until daylight saving time. But now I understand they had that built in. [Laughter] But that's OK. Given how well they've done, have they given anything back to Caltech?

SAFFMAN: Not yet.

COHEN: Do you think that will come?

SAFFMAN: Well, I think that Development is trying to get them to give something back—some support, a fellowship, or even the support of a main professor. I think they could endow a chair without noticing it. Henry talks about giving things to Caltech, but he hasn't actually done so as yet.

COHEN: Do you think that's sort of outside the tradition there?

SAFFMAN: I don't know. I don't understand it. I would have thought that they would have already given something. I know they hire students in the summer, but that's peanuts.

COHEN: Because obviously they have all done very well.

SAFFMAN: I think [Thomas E.] Everhart [Caltech president 1987-1997] and Henry did talk at one time about various possibilities in which VCR Plus might help Caltech, but I don't think anything came of it. Why, I really don't know.

COHEN: Maybe something offended them. You never know.

SAFFMAN: You never know. And you can't find out from the Chinese. [Laughter]

COHEN: That's true. OK. Is there anybody else who has done noteworthy things?

SAFFMAN: In the industrial world, I would say no. Henry stands out of the thirty-seven by a large amount. In terms of people working in the government laboratories, I don't think I have many of my students there. I have some at [Lawrence] Livermore [National Laboratory] and some at Sandia [National Laboratories], but they're not outstanding. They are not outstanding the way Henry was outstanding. And then in academia. Some of them have done rather well. There was Steve [Steven C.] Crow and Saleh Tanveer.

COHEN: Is he a Middle Easterner?

SAFFMAN: He's from Bangladesh. What was the first one I said? Oh, Steve Crow. He's an American. And then there's Greg [Gregory R.] Baker.

COHEN: Now they've gone on to academic positions?

SAFFMAN: They are in academic positions. Doyle Knight. These are people who are very distinguished. These are people who are full professors now. Doyle Knight is a full professor—a named professor—at Rutgers. So is Greg Baker. He has an endowed chair.

COHEN: Also at Rutgers?

SAFFMAN: No. He is at Ohio State. Saleh Tanveer is at Ohio State. He hasn't got a named chair yet, but he ought to. Steve Crow, I think, did have a named chair, but he's changed departments so I'm not sure whether he kept it. He's at [the University of] Arizona. And I have some others: Sy [Seymour E.] Goodman, who is a named chair in economics at Arizona. He left applied mathematics and went more into economics, and what he actually specialized in was computers behind the iron curtain. He was the American expert on Russian computing facilities.

COHEN: Well, that's quite a few. When you say you didn't have many, I think that's quite a few to be distinguished.

SAFFMAN: Yes. And then there were a number who were not particularly distinguished. But they all tend to be at good universities.

COHEN: So many of them went into academia.

SAFFMAN: I would say that about half went into academia. About one quarter went into industry, and one quarter into military labs. I've got two students at the University of Wyoming. That would be Benito Chen and Jim [James C.] Schatzman, but they're not particularly distinguished there.

COHEN: Chen, did you say?

SAFFMAN: Benito Chen. A strange combination. I think his mother is Mexican and his father is Chinese.

COHEN: I see. OK. Well, I think that's quite a few.

SAFFMAN: Well, I've also had postdocs to work with, but not too many—relatively few. There I haven't got on well. I think that's probably my personality. I find postdocs—where they've hired people with PhDs—that their mental processes and my mental processes do not mesh too well. Their training and my training did not seem to fit.

COHEN: How do you account for that?

SAFFMAN: Well, they were trained in other places. I suppose the fault is mine for not being sufficiently flexible. It's up to me to adjust to them, not them to adjust to me. Looking back at it, one is working, and you know the way to do the problem, and you want it done your way. Well, some of the postdocs I got on very well with; we had very good, close relations. And others, when they left there were sighs of relief on all sides.

COHEN: I see. Now these people who went on to do distinguished work at universities—the people you mentioned—did they go somewhere else and do postdocs, or did they go immediately into the university?

SAFFMAN: They went somewhere else as postdocs. A lot of them used to go to MIT. MIT had one-year instructorships, so a lot of them took MIT instructorships. Again, this worked out because MIT had these instructorships which were part of the university funding and because of my contacts with MIT. I mean, Dave Benney would call me up and say, "Philip, do you have any students suitable for instructorships?"

COHEN: I see. Because they had a lot of teaching to do, because it is a big place, and they were a service organization.

SAFFMAN: They were a service organization, yes, in a way. Well, we were a service organization—

COHEN: That's one of the minuses, by the way.

SAFFMAN: That's a very big minus, yes indeed. So these students would tend to take these instructorships, or postdocs, or even go on fellowships to government labs—Los Alamos—for a year or so.

COHEN: So it was the custom to do something like that?

SAFFMAN: Yes, and then get a tenure-track position.

COHEN: Not straight to an assistant professorship?

SAFFMAN: No. There would be another year or two as a postdoc.

COHEN: That's a good record. So let's come down to your honors and awards. You have a named professorship, of course. And when did that come about?

SAFFMAN: That must have been about 1994, I guess—or ’95 [1995—ed.].

COHEN: In the old days that would have been good, because they would have helped to pay the tuition of your kids to school. But, of course, I don’t think they do that anymore.

SAFFMAN: I don’t know. I think they do.

COHEN: Oh, do they?

SAFFMAN: I think they still do. But I’m not sure how much they pay. It came to me too late to use that.

COHEN: Two of your children went to Caltech. How did you find having your own children here at school?

SAFFMAN: Well, I didn’t want them to come to Caltech, and I tried to persuade them not to come. My argument was that they had been exposed to Caltech for fifteen years or so and that they should see a different part of the world. They should go to another university, where they would be in another town and where there would be a different atmosphere. So they wouldn’t know the professors—of course they knew half the professors here. Before they went where they were just faculty children, they should go somewhere else. And that was advice that was, at the time, ignored. Louise said, “No,” that she wanted to go to Caltech. Mark did go to [UC] San Diego for one year, but after a year at San Diego he decided he wanted to come back to Caltech. So they did not take my advice. But I said, “If you’re going to come to Caltech—I mean, I can’t stop you from coming if you’re admitted—but you’re not going to live at home. You’re going to live in a dormitory, and you’re going to be a student.” I think we occasionally had a compromise; we let them come home to do the laundry. And I suppose that sometimes we perhaps felt that they might be going a little hungry—so occasionally they would have to come home for a meal.

COHEN: But it was a good experience for them? They did enjoy it?

SAFFMAN: They enjoyed it and they did very well. Again, I would have preferred them to have gone elsewhere, but they didn't want to. Emma was the one who wasn't going to stay. She left.

COHEN: And she's done very well, of course. Well, they've all done well.

SAFFMAN: They both took AMA95 when I was teaching it. That was no problem whatsoever. Again, it was a large class, so they were just part of the class.

COHEN: I see FRS [Fellow of the Royal Society] here, but that was early on wasn't it?

SAFFMAN: No, it was actually quite late. All my friends said that was long overdue. That was 1988.

COHEN: But do the English have a problem giving an FRS to somebody who has left them?

SAFFMAN: There is a little problem that way. It does make it more difficult. That partly would have explained the long-overdue nature. But that was a nice honor. It gives you a hotel room in London if you want, or the Royal Society has bedrooms. So if you're just passing through London—

COHEN: I see. If you'll just go, you always have a place to stay?

SAFFMAN: Provided it's not on the weekend. Which is not too convenient, because most of the time I'm in London it's on a weekend—or in August, because they close down for a month in August. And they close down for two weeks at Christmas, so you can't use it at Christmas.

COHEN: I see. Well, they're more hospitable than the National Academy, I must say.

SAFFMAN: The National Academy doesn't have that?

COHEN: It doesn't have rooms, no.

SAFFMAN: And nothing at all.

COHEN: Oh, well, when they have the meeting, they can say, "You can go to this hotel at a reduced price," or something.

SAFFMAN: But they don't actually have bedrooms?

COHEN: If they do, I don't know about it.

SAFFMAN: Do they have a restaurant? Can you have lunch there? The Royal Society has a nice little restaurant.

COHEN: Yes, but I have a feeling that if the meeting itself isn't going on—which is the only time I've been there—you pay for everything.

SAFFMAN: Oh, at the Royal Society you have to pay. It's not free. But it's more the availability. And of course, compared with the price of a hotel in London— I think they charge £30 a night. That's $45 a night. Where can you stay in London for $45? You can sleep in the park for $45. [Laughter]

COHEN: I know a few years ago you were offered a very, very nice position in Cambridge, the Taylor [chair].

SAFFMAN: The Taylor one; that would be in Cambridge.

COHEN: So you were tempted?

SAFFMAN: I was. I was very much tempted. But it was the same. The logistics of the thing were, again, too much. It would have meant selling the house, then moving across an ocean. Also, by this time Louise was settled in Pasadena. As far as Mark and Emma were concerned, we would have been closer to them if we had moved to London. But we would then have been much farther from Louise, who had a family and a house and a business. So the children were pulling us in both directions. But I think it was actually the logistics of selling the house,

moving, and starting over again. I'm not as young now—starting over again at fifty. When we came here I was thirty-four.

COHEN: Then it's easy.

SAFFMAN: It was easy at thirty-four. You're not the same at fifty as you are at thirty-four in your ability to change. And it would also have been a financial hardship, because the English salaries are just ridiculously low.

COHEN: Even now?

SAFFMAN: Even now. So that was also a factor to be taken into consideration.

COHEN: But it was very nice to have been offered.

SAFFMAN: It was nice to have been offered. And there was also the question of the teaching. By the time I was fifty, I found that my ability to absorb new ideas had deteriorated so that I could notice it. Going there would have meant starting to teach again. I would have had to develop one or two new courses. I wanted to husband, as much as possible, my energies and my abilities for research purposes. I didn't want to have to start over. Now, when I was thirty-four and came here, I found no difficulty whatsoever in writing two new courses and carrying on research and supervising a half-dozen students.

COHEN: And there's something else: You *had* to do it. I mean, that's what it was. Now you don't have to do it, so you can think about it differently.

SAFFMAN: Yes.

COHEN: So it hasn't been bad staying on. I mean, you really are living quite a comfortable life here.

SAFFMAN: Yes, we live a comfortable life. I think it was probably wise not to go back. Or go now that I am retired. We sometimes think we'll perhaps go back. But we really don't have much family left now in the U.K.

COHEN: Your family is here, in some sense.

SAFFMAN: Yes. We have brothers and sisters, but we have nothing in common.

COHEN: You've grown apart. Yes, I know—you mentioned that last week. So here you are and here you'll stay.

SAFFMAN: Here I hope to stay.

COHEN: Do you think sometimes about the future of Caltech, with the new president [David Baltimore] and things like that?

SAFFMAN: I worry about Caltech.

COHEN: You do?

SAFFMAN: I do worry about it. But not too much, because there's not very much I can do about it.

COHEN: What are your worries?

SAFFMAN: I'm worried that there's a deterioration of quality in the faculty.

COHEN: You mean, incoming faculty is not of the caliber that the other is?

SAFFMAN: Yes.

COHEN: Is that partly, maybe, because people are much narrower, because of the nature of things now?

SAFFMAN: It may be that the very clever people, or the best people, are not in the fields that I know or understand. It may be that they're in fields where I cannot assess the quality. It may be that biology is very good in attracting bright people, so maybe the biology faculty is as good as it ever was. They have several Nobel Prize candidates in biology, I think. That was something I heard that Baltimore was supposed to have observed—that if you are a leading, international, world-famous, outstanding university, then in any department a quarter or so of that department should be on that list which the Swedish Academy is perusing.

COHEN: I see. That's pretty high standards.

SAFFMAN: Well, but we're supposed to be a leading university. That's the requirement.

COHEN: Yes, but where are the people who are recommending the people for that list? I mean, it's a little bit ingrown.

SAFFMAN: [Laughter] It is a little bit ingrown, yes. Another problem is that we get people now—we offer positions—let's take the faculty level. We offer a position to a young man and Stanford offers a position to that young man. They always go to Stanford.

Begin Tape 2, Side 2

SAFFMAN: We cannot compete with a faculty appointment from Stanford. And I think the same is true with graduate students now. We accept a graduate student. Stanford accepts that graduate student. He goes to Stanford. I don't know whether it's true of the undergraduate level or not.

COHEN: I think in astronomy they compete with Berkeley.

SAFFMAN: Is that because of the facilities there? Astronomers need telescopes, and there's a telescope at Berkeley?

COHEN: No. I think, from what I've heard, that students come down here and [find] that graduate students are not happy in astronomy. They go to Berkeley and the graduate students are

happy. This is what I've heard from people. It's not a matter of better or worse. They come down and talk to the students.

SAFFMAN: Yes, well, that's sensible.

COHEN: They see where they are happy. But astronomy is special.

SAFFMAN: Astronomy is special. Well, Stanford has no astronomy.

COHEN: Traditionally, I think, they've always competed with Princeton. But, from what I hear, it seems to me that they're always going to Berkeley.

SAFFMAN: Well, when Emma was thinking about going to graduate school in biology, she went on a tour around the country and starting visiting all the graduate schools: MIT, Harvard, Stanford, and then they all came to Caltech. There was a group of about ten of them traveling together, I think, from Yale, looking at the various graduate schools. And I asked Emma how Caltech stacked up in this. And she said, "Well, all the students came and they thought Caltech was all right, but they didn't think that would be their first choice." I don't think any of this group had Caltech as their first choice.

COHEN: For biology?

SAFFMAN: For biology, yes. I suppose there was something unattractive or less attractive. Maybe the size.

COHEN: Or maybe they just talked with the graduate students who said that life was not pleasant here. Because I think there is a problem with the happiness of the students. And that worries you.

SAFFMAN: The inability to compete with our supposed peers is worrying. Some of it is financial.

COHEN: You mean that they offer more there?

SAFFMAN: Stanford, for instance, saw the problem of graduate student support coming up. It's a problem that is being discussed now here. And I've told you what we did in applied mathematics, where we would help one another. But that's not going to be possible. Not because we don't want to do it but because we're not going to have the funds. Stanford has gone out and raised something like $100,000,000 to endow graduate student fellowships for four years. Now, we do have some endowed. I don't know how endowed they are. We get money from the institute to give graduate student fellowships, which we're supposed to use to invite the best students. But in our case, these are only for one year, and at the end of that year the student either has to take a teaching assistantship or a research assistantship. In the past, we had research assistantships. Now, we don't have those, because of money problems and the changes in the way they calculate the staff benefits or the overhead. As you know, this is something that is under discussion at the moment. But Stanford has approached this problem by raising $100,000,000 and endowing four-year student fellowships. Now, if you come to Caltech and are offered a fellowship for one year, and you go to Stanford and are offered a four-year fellowship, Caltech has got to be an order of magnitude better to compensate for that, and we're not.

COHEN: That's right. So you lose your best students to Stanford.

SAFFMAN: We are losing our best students to Stanford. And I don't know whether any of the eastern schools or the Ivy League is doing this at all or something similar. I don't know.

COHEN: So now you are losing your first choice on faculty. You are also losing your first choice [on graduate students].

SAFFMAN: And that worries me.

COHEN: Well, that is a worry.

SAFFMAN: Yes. I'm not sure I know what's causing it. Maybe it's Los Angeles. They don't want to live in Los Angeles. We were talking about this at lunch a day or two ago, and someone said that one of the reasons is the wives—that the wives don't know anything about Los Angeles except what they read in the paper. And they read about smog, and they read about crime, and

they read about riots, and they read about congestion, and they read about people being shot on the freeway, and they don't want to go live in the jungle.

COHEN: Or they hear about earthquakes.

SAFFMAN: And I'm not saying that these things are things they should worry about, but what matters is not what is but what your perception of it is. We were saying that the husband wants to come to Caltech. In some of the cases where I've said that we have lost faculty appointments to Stanford, it has definitely been [due to] the wife, who said that she wanted to live in Palo Alto, which is a very nice little place when you visit it. Actually, I think it's very dull. I spent a summer there and I wouldn't go back.

COHEN: Well, my daughter has lived there also.

SAFFMAN: I was surprised how dull it was. Pasadena is livelier, especially with Old Town.

COHEN: Well, so that's a real worry. Is that the main one?

SAFFMAN: Well, that's one of them.

COHEN: And the others?

SAFFMAN: The money. That's another worry.

COHEN: You mean, other places are offering higher salaries?

SAFFMAN: No. That doesn't worry me, because I think the salaries more or less stay the same. I don't think an academic—certainly not a senior academic—is going to worry about salary. I think that we're very lucky to be paid what we are paid.

COHEN: OK. So that's OK?

SAFFMAN: It's more in the way of support for students, visitors, and postdocs. It's the kind of thing that we had. Our contracts would support us to hire visitors, postdocs, and students. And now, of course, we need a little money—not enormous sums—but we need something like $50,000 to bring our computing facilities up to date.

COHEN: So you think the institute is not getting the money?

SAFFMAN: The Institute's not getting the money. I assume that if the institute had the money, they would give it to us. I assume that the fact that we are not getting any money from the institute is because the institute has no money.

COHEN: Well, you hear about all these vast sums being raised all the time. And do you worry that our new president doesn't know how to do this?

SAFFMAN: I don't know.

COHEN: I mean, he talks about opening his own lab and doing his research, but that's not why he was hired. [Laughter]

SAFFMAN: [Laughter] I don't know.

COHEN: I see. So you think there's a real money worry here?

SAFFMAN: I think there's a real money worry. Now, I don't want money to hire more faculty. I don't think we should grow. If Caltech has decided to stay small, it should stay small. We should not try to be another MIT or another Stanford or another Princeton. We're different from those and we should try and maintain it. But we have to keep the faculty and the students of high quality. And I'm worried that we're not succeeding.

[Tape Ends]

PHILIP G. SAFFMAN

SUPPLEMENTAL INTERVIEW

April 22, 1999

BeginTape 3, Side 1

NEUSHUL: Could you elaborate on your relationship with your advisor at Cambridge?

SAFFMAN: My advisor at Cambridge was George Batchelor, an Australian. He was a very nice person but a little stiff and cold. It was hard to imagine being a close friend of his. He was very helpful and sympathetic. When you were not making progress with your research, he tried to encourage you. I think I could have done a lot worse with an advisor.

NEUSHUL: Did you use any of his methods in training your own graduate students?

SAFFMAN: Everybody tends to have their own style. I was closer to student research than Batchelor. Part of the difference is that at Cambridge they were getting very good students, basically getting the best mathematics students in England. At Caltech, we get very good students but not necessarily the best in the country. At Cambridge, you knew they were. Hence advising at Cambridge was somewhat easier. The advisor would suggest a topic and the student would be expected to go out by himself and make a problem based on the advisor's suggestion. Here I found it was necessary to keep a very tight, close watch on the students. At one stage, I even got to the point of meeting with a student once a week to review his research. On average, students at Cambridge were better than those at Caltech.

NEUSHUL: Did Batchelor direct you toward your thesis topic?

SAFFMAN: Yes. One day, Batchelor was in laboratory, or perhaps in the café, and was looking at a glass of champagne or fizzy water. He noticed that the bubbles did not rise straight up. Instead they went round, and he wanted to know why. I did some analysis on the problem but wasn't too successful.

NEUSHUL: That was the basis for your thesis?

SAFFMAN: Part of it, yes. Other problems arose as well. Batchelor, or maybe [G. I.] Taylor, pointed out that if you put a disk in a very viscous fluid that is being sheared, the axis of the disk tends to orient itself in a particular orientation in relation to the shear. The question is, Why does this happen? Originally we thought it was due to nonlinear effects. I did some calculations and found the result was much too small to account for the observed rates at which the disk was aligned with the lines of vorticity in the fluid. Then we thought it must be due to non–Newtonian effects. I ended up leaving this problem to work with Taylor on Hele-Shaw fingering.

NEUSHUL: You went from meeting with Taylor as a substitute advisor once or twice to working closely with him?

SAFFMAN: That was when I was a graduate student.

NEUSHUL: This changed entirely?

SAFFMAN: Yes.

NEUSHUL: What sort of a person was Taylor? Was he more open than Batchelor?

SAFFMAN: Yes. He was a gentle man, very nice. He was rather selfish when it came to his work. I don't mean that as a criticism; I think he was right. He had talent and genius and was focused.

NEUSHUL: He was advanced in his career when you worked together?

SAFFMAN: He had retired but just kept on going straight. He didn't slow down, didn't go faster, but just kept on going at the same pace as he did in 1910. I got to know him in 1956, when he started working on the Reiner disc. Later we worked on Hele-Shaw fingering.

NEUSHUL: Did Batchelor ever work as closely with Taylor as you did? Did anyone?

SAFFMAN: No, I don't think so.

NEUSHUL: This was a unique working relationship?

SAFFMAN: I wouldn't say unique but perhaps at a unique level. He did have other people. I have the feeling that he really didn't like to work with students. Maybe he didn't like the responsibility. If you have a student, they have three years to write a thesis. Perhaps this was a pressure that Taylor didn't like.

NEUSHUL: He didn't train many students?

SAFFMAN: Very few. In fact, Batchelor made himself a Taylor student by telling him that he expected him to be his advisor. Batchelor was so good that there wasn't a thesis problem. There was no doubt Batchelor was going to write an excellent thesis.

NEUSHUL: Your work with Taylor was very productive, and yet you decided to move to London in the midst of it. Was this a difficult decision to make? Had you reached a point where you'd had enough of the relationship?

SAFFMAN: I think that our particular problem was winding down. We had at that time gone as far as we could. We knew the problem was unsolved. We had a problem that we called lambda equals a half, and it was clear that at this time we wouldn't be able to solve it. Taylor was interested in going to something else. I suppose I felt that after four to five years it was time to move on. I also was losing interest.

NEUSHUL: How did Taylor react to your decision to leave Cambridge?

SAFFMAN: Taylor said he thought that was a good idea. I had a feeling that he wasn't altogether happy at the way fluid mechanics was developing. It was no longer a one-person field. I think Taylor thought it would be a good thing if people left Cambridge and spread throughout the

country carrying the message. I think he spoke to Batchelor about this a few days later, and the next time I saw him he said that it really wasn't such a good idea for me to go. He now thought I should stay. The only reason I can think of for the change is that Batchelor had said I shouldn't go. If it was entirely a scientific decision, I probably wouldn't have gone, but I had other reasons. I look back and can't say whether I made the right decision.

NEUSHUL: When you arrived at Caltech, there wasn't much of an infrastructure for you to move into.

SAFFMAN: Applied mathematics was just being made by Gerry Whitham and Julian Cole. Together with Paco Lagerstrom, they created applied mathematics at Caltech. They built it up somewhat in the European tradition, with more engineering and less theory.

NEUSHUL: Did you have any contact with Von Kármán?

SAFFMAN: I met him once at a meeting in Marseilles in 1960. I don't think Kármán created applied mathematics as such, although he was, of course, an applied mathematician second to none. He laid the groundwork at Caltech but didn't actually do it himself. I suppose Cole would have been the person to ask about this. Otherwise, Gerry Whitham might know.

NEUSHUL: What exactly did you do for TRW?

SAFFMAN: I studied water waves. The problem I addressed had to do with surface waves produced by disturbances below the ocean's surface. They wanted to try and find submarines by locating the disturbances they made on the surface. One idea was that as the submarine goes along, it produces a current that changes motion on the surface. This might be detectable by looking at wave change. I studied the effect of shear current flow on water waves, with the goal of calculating whether this might be related to the size and speed of a body beneath the water. The effect of the wind was also a factor: For example, are wind waves different if there is a current produced by an underwater body? At the start, I informed TRW that I didn't want any part of the classified aspects of the project.

NEUSHUL: Can you give examples of the impact your work had on other fields?

SAFFMAN: Not really. That's a hard question. I didn't get too much cooperation from the experimental people. Not as much as I would have liked. My work tended to be almost entirely theoretical, and I don't think the experimentalists would have noticed if I had left.

NEUSHUL: So working in the same building as experimentalists wasn't a factor in your career at Caltech? Did this proximity stimulate your research?

SAFFMAN: I'll put it this way: I was aware of what they were doing. Some of my work in turbulence was to derive an understanding of the experimental work that was in progress. One example is the flow between rotating cylinders. It was found that this flow was not unique and that it depended on the history—how the flow originated. That had a big effect on my research because it pushed me into the area of what we call bifurcation analysis. It was really a one-way street. I was picking the brains of the experimentalists, and they weren't really picking mine. I suppose I felt that they should have been more willing to do experiments that tested my theories. Once again, however, in order to be a successful scientist you have to focus and concentrate on a topic rather than thinking about what other people are doing.

NEUSHUL: Being in this atmosphere was useful?

SAFFMAN: Being at Caltech, where experimentalists were working on turbulence and other aerodynamics—vortex dynamics—was a benefit to me.

NEUSHUL: Could you elaborate on your decision to write a book on vortex dynamics?

SAFFMAN: I taught a course on vortex dynamics, and there was no suitable book that I could use as a text.

NEUSHUL: When did you first teach the course?

SAFFMAN: It must have been in the 1980s—late 1980s, I think. Then Hans Hornung followed Liepmann as director of GALCIT [Graduate Aeronautical Laboratories of the California Institute of Technology], and he exerted pressure on me to write the book. He did his best to accentuate my guilt complex. I needed a push, and Hornung gave it to me.

NEUSHUL: This was a first for you?

SAFFMAN: Yes. A book is very different—really much harder than papers.

NEUSHUL: Was the decision to teach the course a culmination of many years of research?

SAFFMAN: Yes. I taught the course because I was studying vortex dynamics. My interest in the vortex field, or wake, behind an aircraft started in 1970. This gave rise to what is called the wake-turbulence problem. There was a whole body of research building up, and it appeared that there was a need for a book. I took a six-month sabbatical and stayed home to work on the book. Fortunately, scientific word-processing software was available. It took a week or so to master the program.

NEUSHUL: So the book is a capstone to your teaching career?

SAFFMAN: Yes.

NEUSHUL: It must have been well received, as I see it came out in a second edition.

SAFFMAN: The second edition was paperback. The book was reasonably well received, although I haven't made a fortune out of it.

NEUSHUL: Did any of your children study mathematics?

SAFFMAN: My elder daughter studied astronomy before going into business. My son took a PhD in applied physics and is quite mathematical. In some respects, he is more mathematical than I am. Mathematics is something you can lose—actually lose the ability to do. I have lost it now.

My son has it and does work on nonlinear optics. He is also half experimental. My younger daughter is a biochemist at McGill University and is not that mathematical.

NEUSHUL: Later in your career, you were invited back to take up the Taylor chair at Cambridge. Was this because of lasting connections with that university?

SAFFMAN: I suppose I was known in the community. Part of the reason they asked me was sentimental. They wanted somebody who had worked with Taylor, and I was the natural candidate, because I had worked with Taylor, for one reason or another, far longer than anybody else. It really should have gone to George Batchelor, but he was close to retirement and ineligible for the position. There was nobody around who worked as long and as hard as I did with Taylor. I wrote Batchelor a letter explaining my decision not to go. He wrote back a very nice letter saying that he understood and that it obviously must have been a very, very difficult decision. It was. Batchelor had hoped that I would occupy the chair when it was created.