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SIMON OSTRACH
INTERVIEWED BY SANDRA JOHNSON
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JOHNSON: Today is June 4, 2014. This oral history session is being conducted with Simon Ostrach at NASA's Glenn Research Center in Cleveland, Ohio, as part of the NACA [National Advisory Committee for Aeronautics] Oral History Project, sponsored by the NASA Headquarters History Office. Interviewer is Sandra Johnson, assisted by Rebecca Wright. Thank you again for taking time to meet with us today. To start out, I want to talk about how you first came to work at NACA, and when that was, and how that came about.

OSTRACH: Let me back up a little bit—I came from Eastern European people, and the anticipation was that you're going to be a physician or a teacher or maybe an attorney. I'd never spoken to an engineer, I had no idea what engineers did. I don't know how much of my back history you want to know, but my father came over here in about 1910 to make some money, and he left a wife and three siblings over there. They got separated by 10 years because of the war [World War I], so when they came over here, I had three siblings—two sisters and a brother—who were already teenagers.

My sisters went to work in a sweatshop, really. They made jewelry boxes and they got paid by the piece. We used to after dinner have a glue pot put on the table, and we would all make [jewelry boxes]. The first son was going to be a physician, obviously. Well, things didn't work out for him. So then when my parents came over here, they had a son born nine months

and one day after my mother arrived. I found that out from Ellis Island [immigration point, New York City].

I was born a year and 11 months later. The anticipation was I was going to be a physician. My sisters came to me my junior year in high school, and said, "We're working in sweatshops, we want to have a doctor in the family, and he's older, so we're going to give him our resources." It was a blow, but I don't think I fully appreciated it. My guidance counselor in high school was a magnificent person who knew my family and me, and I'd been a pretty good athlete and an outstanding student, so when I was checking out of graduation, he asked me, would I like a summer job?

"Would I like a summer job?" Yes. He was director of a camp, and he asked me to come to be an athletic counselor. All throughout the camp, he said to me, "How can you think of becoming a physician? You have no support, it's a long haul. Why don't you become an engineer?" I didn't know about engineering. He kept hammering away, and about three weeks before we broke camp, he wrote a letter to the University [of Rhode Island, Kingston], changing me from pre-medicine to engineering.

I went into engineering—and the war [World War II] broke out [in my freshman year], incidentally. My university was 32 miles from the city [Providence, Rhode Island], and I used to go into the city to work. On a Sunday afternoon, I'd go to my girlfriend's house, have dinner, and then hitchhike for 32 miles back. I got stranded at a rotary. It was the main road at the time to New York [City], and there was a rotary that was four miles down from the university. I got stranded there at about two o'clock in the morning.

I used to have to run to that rotary and back for cross-country, and I was thinking, "Should I do that?" I saw a set of headlights coming, and it was the football coach and his son.

He was coming back from New Hampshire. He was prepping his son to become an Olympic skier, and the kid did become one, and got killed in a ski crash. Anyhow, we're driving back to the university—this is December 7, 1941—and they interrupted the program and said [Naval Station] Pearl Harbor [Hawaii] had been bombed.

That didn't mean a thing until we got to the university. We had infantry ROTC [Reserve Officers' Training Corps], and the place was in turmoil. [Many of] the university's [facilities were] turned over [to training soldiers]. We went to school through the summer, and I graduated in two-and-three-quarters years. It was a tremendous stress because people were being drafted. I think out my original class of something like 85 engineers, only 8 of us graduated.

I started out the first two years [doing] math, science, physics, and chemistry, and I did very well. Then, in those days—it was almost the last vestige—they taught us engineering practice. We had to mix mud to make molds for casting. We worked at an anvil. My grandfather was a blacksmith, and we had to draw parts of a sewing machine 12 hours a week. I figured, I'm going to work in a damn factory. Then I started getting interviews, and I went to AT&T [American Telephone and Telegraph Company] labs [laboratories], they sent me to a piezoelectric [electricity resulting from pressure] factory, and I was frankly thinking of enlisting in the [U.S. Army] Air Corps.

A man came through, looked like Columbo [television detective], with a trench coat, and he said, "I'm from a government agency, and we do research on airplanes." By this time, I was very fortunate that one of the adjunct professors was Igor [I.] Sikorsky, and his colleague was the full-time professor, Nikolas Aleksander, who was a commander in the tsarist navy in Russia. They were buddies.

I got interested in airplanes, and had a lot of airplane projects there. Here comes this man, he says, "A government research laboratory, we're going to do research on airplanes, you'll be commissioned a second lieutenant," which was just what I was thinking about. Great, so the three of us got on a train, in those days, from Providence, Rhode Island, to come to Cleveland [Ohio].

This is a true story—we didn't know whether to take dungarees or suits and jackets. We didn't know if we were going to have a secretary. A little girl sitting next to us said, "Mommy, what's an engineer?" She said, "It's a man who drives a train." We started going up forward.

We came here and landed in downtown Cleveland, terminal tower, and there were troops and everything, they had USO [United Service Organizations, Inc.]. There are a lot of funny stories about it, but anyhow, I showed up for work on June 4, 1944.

WRIGHT: Came on a good day today, didn't we?

OSTRACH: That's right, today is the 4th. I'll be damned. I was assigned to John [H.] Collins [Jr.]. It was called the Engine Research Division. We were housed in the Engine Research Building that had been completed. This was completed, the Administration Building, the hangar. Just to show you how little we knew, we were told, "Next week, bring some dungarees. We need to weld some cables underneath the test cells." We went and did it, not knowing that it's really not an engineer's job.

I was assigned to a senior engineer, an interesting guy by the name of Wilson [B.] Schramm. They called him "Cap," and he was a laid-back, sort of guy, you'd think, from Nebraska or something. Our first project was they were having trouble with Pratt & Whitney R-

2800 engines. I understand that they were the engines that were on patrol planes, going from San Diego [California] to Pearl Harbor. They were running low on fuel, so some smart guy said, "Lean out the mixture," and they start dropping in the drink.

When they recovered the engines, they found they all were damaged in one way. The non-thrust piston sides were melted. Schramm said he's got an idea, that we'll first take one cylinder [off the engine] and we'll run 50-hour endurance tests, then we'll put it on a full [engine], and then we'll put it on an airplane. To run the 50-hour endurance test, we had to build a test cell that would keep things constant for 50 hours, and we had all kinds of measurement devices. In those days, there was a lot of equipment just lying out in the field.

We're putting this together, and we had a crew chief assigned to us. The crew chief was old enough to be my father. Remember in '44, June, I was only 20 years old. One day, we were looking over things, and Schramm says to me, "Something's wrong, we need to change that pressure valve. Go down and tell Stan," who was the crew chief.

He was up on a ladder, and I burst in and I said, "Hey, that's all wrong, change this." He later on told me that he nearly split my head with a Stillson [pipe] wrench.

He ran to his supervisor, he says, "I'm not going to take anything from this little kid." That's when I grew my first mustache.

We put this together and we ran these 50-hour endurance tests. Interesting sidebar to that is every 15 minutes, we would hit a recorder that would record thermocouples that were in there. We had young women—who we called "computers" in those days—we had many manometers taking pressure readings throughout, and a lot of these computers ended up being wives of guys. We ran these tests and we got an idea of what was causing the problem, and then we put it on a full-scale engine.

We ran it, and it sort of seemed right, and then our next step was to put it on a [Consolidated] B-24 [Liberator aircraft]. We had to go through parachute training, and then my job was to look at the engine. There was a little indicator in there, and we had determined that the problem was that it would begin to knock and then detonate. That would pit the piston, and then the piston would catch fire and melt, and the engine would fail. In that old B-24 model, we were told that if the engine catches fire, you have 24 seconds to get out of it. And the only way to get out of it was through the bomb bay doors. It was just a narrow catwalk between the cockpit and the gunner's place. It was an old plane, it had twin tails, there was exhaust fumes from the engines, and people were getting sick. I'm thinking, "What am I doing?"

We solved that problem, and then one day we were all told to assemble at the hangar, and a [North American] B-25 [Mitchell Bomber] flew in. It was piloted by Hap [Henry H.] Arnold, who was Commander of the Air Corps, and his passenger was Dwight [D.] Eisenhower [Supreme Allied Commander in Europe]. They said to us that they had engines in production for an airplane that was going to win the war, but it was having a major problem. The exhaust valve ports were melting. They wanted us to find a fix for it without changing [the engine production line]. As we were talking, the biggest airplane I ever saw—there was a [Boeing] B-29 [Superfortress] coming in. (There was a bigger one here, just experimental.) Two of the engines were already feathered because the engines had failed. That was awesome, and we undertook to do that.

Then the war finished, and Abe [Abraham] Silverstein was the dynamic other division chief. He kept pushing jet propulsion, jet propulsion, so I was asked to do thermodynamic analyses of various ways of doing the jet propulsion, or the turbo prop [propulsion]. I started getting interested in turbines, gas turbines. I had a wonderful branch chief, his name was John

[C.] Sanders. There were twin brothers here, Newell [D. Sanders] and John, and they were wonderful, smart, and kind people.

I had graduated with a traditional engineering education, but never had even a course in differential equations. So when I started trying to look at some of the problems with gas turbines, I was using big rolls of papers [to make calculations]. I was doing it in very cumbersome ways. One day, John Sanders came in and said, "We sponsored you for a National Pre-Doctoral Fellowship, and you won it."

I said, "What does that mean?"

He said, "You can go get a doctorate." It never entered my mind because in those days, engineers didn't get doctorates. The people you saw with doctorates were physicists, mathematicians, and chemists.

When the war finished, I bought my first new car. It was a Chevrolet, a 1946 Chevrolet. It had a "V for Victory" sign on the front, and I had a baby, a son, born on April 18, 1947. I had no cash. My initial salary here was $2,433. I read that the famous laboratory in America was at MIT [Massachusetts Institute of Technology, Cambridge], a professor by the name of Edward [S.] Taylor was the director. I wrote to him, and of course with a National Pre-Doctoral Fellowship, they immediately accepted me. I had no idea what graduate school was like.

When the fellowship came through, it was a paltry sum of money. At the time then, I think I was a P4 [pay level]. I was making something like $4,200, and the fellowship was like $500. I wrote to them and I said I couldn't do this, so the dean wrote back from MIT and said, "Of course we'll make a settlement." So arrangements were made for me to go to visit Ed Taylor.

I've got to back up a little bit—the wonderful part about this place was it was a real research laboratory. So I had time, and I came across a paper—I think it was written about a supersonic wind tunnel design—so I read it and I went to my technician and I designed the nozzle. We carved it out of wooden blocks, and I put a wing in there, and I got a shockwave [and took a picture of it]. This is 1946. Most likely it was one of the first supersonic wind tunnels in this country. It was so spectacular.

In those days, supersonic people were [just] talking about it, and I kept [the picture of the shock wave] in my back pocket. This plays a very important role, incidentally—to bring the airflow in smoothly, I [made fairing strips out of sheet metal]. Abe showed this off one time to a congressional delegation, and one of the congresspeople leaned forward, and his necktie came out and just got shredded because it was an induction tunnel. But they were really impressed.

At that point supersonics were not a big deal, but it played a big deal in my life, as you'll see. I went to my mother's home in Providence, which is 50 miles from Boston, and went to see my mother. The next day I take the train to Boston, and I had an 11:00 appointment. I got there at 9:00, and they had a young man meet me to show me MIT. His first question to me was, "Why do you want a Ph.D.?"

I said, "I don't know."

He said, "Well, I don't have one and I'm famous." Time dragged on and I was a skinny kid, and [if I] didn't eat on time, I started getting a little shaky and crabby. About 4:00 in the afternoon, they finally take me in to Professor Edward Taylor. He's sitting with his feet up on the desk and he says, "What can I do for you, sonny?" Here, I've done a few things here, and I'm a married man [and have had some engineering accomplishments]. When I tell him my name, he says, "Oh, you're the fellow who wants all this money. Why do you want the money?"

I said, “Sir, I don’t know anything about graduate school, but I imagine it’s difficult. I have no savings, I’ve just bought a new car, I have a son.”

He said, “Well, you have to expect to make sacrifices. You’ll be getting a doctorate from the Institute.”

I said, “I’m not prepared to do that.” I got on the train and I was angry and I was upset.

I go to my mother’s home. On Sunday morning, I pick up the *Providence Journal* [newspaper], and there was a very famous applied math department getting started. A very famous German had met the president of Brown University [Providence, Rhode Island] and had told him he would bring this whole movement to America, which he did. That was one area where I felt an enormous deficiency.

I read, in the Sunday morning paper, that they want to build a supersonic wind tunnel. I go over there and I show them that I’d built one, so they offered me a research associateship, which paid almost as much as I was making here. It was great because we could stay with my in-laws. What could be better? I show up in September, not knowing what was ahead of me, but I’m going to design this wind tunnel.

Do you want me to go back this far? This is all a prelude to how I came here.

JOHNSON: Yes, that’s great.

OSTRACH: Unbeknownst to the applied math department, the dean of engineering of Brown had been a commander in the Navy at the end of the war, and had spent his time interrogating foreign scientists, and I guess fell in love with German accents. He’d hired a Swiss young man to come over to design the wind tunnel. We meet, and the Swiss fellow says, his opening shot to me was,

"I'm from ETH [Eidgenössische Technische Hochschule Zürich]," which is a famous Swiss university, "and my diploma engineer is better than any American doctorate." Okay.

Then I said, "Oh, you're from ETH, do you know Professor [Jakob] Ackeret," who was a very famous guy.

He says, "Of course."

I say, "Do you know Professor Nicholas Rott?"

He goes, "Oh, he's a Jew."

I said, "Well, I'm a Jew." So that was the start.

The first thing you have to do in designing wind tunnels is determine the losses in all the piping and everything. I'm following this British paper. He comes in one day, he said, "What are you doing?" Now, he's not my boss, you see?

I said, "I'm computing losses."

He said, "How are you doing that?"

I said, "Numerically."

He said, "The Swiss only do it graphically."

I said, "Paul, you can do it any way you want to."

I went to my advisor and I said, "Two people can't design a wind tunnel."

He said, "We just got this brilliant professor in, would you care to work for him?"

I said, "I will clean toilets." It was the greatest break of my life. That professor was George Francis Carrier. I was his number three student, I think. He was an informal guy, brilliant, but Brown was a nightmare for me.

First of all, I found people there who were inherently smarter than I and had gone to great universities. There was also a big conflict—this applied math division was formed at Brown and

a lot of the faculty that were brought in were young people. Carrier was, in fact, only about six years older than I. Here were these [pure math] professors at Brown, Phi Beta Kappa [honor society for the liberal arts and sciences] Keys who'd been there 35 years and were associate professors, and here were these young guys who were full professors [of applied mathematics].

To qualify for a Ph.D. in applied mathematics, you had to qualify in two fields of pure mathematics and three in applied. Those pure [fields] were examined by pure mathematicians. My first [pure] course was differential [and] integral equations in mathematical physics. The textbooks were German. My second course was complex function theory. In addition to that, every three months, the faculty would meet and decide whether they thought you had the ability to do original research. My first officemate was a straight-A student, he was a year ahead of me, and received a note one day that, "We don't think you've got the ability to do research." I had morning sickness, nerves—I mean, failure [would have been] so tremendous.

I'm in my hometown, I'd given up my job here. I was the first person to go get a degree [in the lab here] without any government subsidies, so I really had quit my job in a sense. Abe had told me—Abe was [Center] Director by this time—if I [obtain a doctorate], he would give me a double jump in pay. It turns out that my wife's sister's husband was a SAC [Strategic Air Command pilot], and he got sent overseas, so she moved in. I come home one night and [my wife and her sister] had a big conflict. We had to move out. We had to rent an apartment, and that ate up money. Brown put up Quonset huts [prefabricated steel structures] in their athletic field, it was called Brown Town, and we [moved there into] Quonset huts.

It was very strenuous. I was in awe of these people, and if you survived to a certain point, then they let you take what they called prelims [preliminary examinations], which were really qualifying. Those were awesome because [the exam] was an amphitheater with five

examiners, and then anybody in that audience could [ask questions]. There are a lot of interesting things I could tell you, which I won't bore you with, but anyhow I passed. In those days professors did not have grants, and had students come and give them problems.

At Brown at that time, Sydney Goldstein was a professor in England, in [the University of] Manchester [and was a visiting professor]. He actually was the mentor of Sir [M.] James Lighthill, and had written the two classic books in fluid dynamics. The people were just awesome. Now the question was, I had to come up with a Ph.D. thesis topic. Every time I would suggest one to Carrier, he'd say, "Why don't you try it out with Goldstein?"

The applied math division was in an old mansion at Brown, and Goldstein sat in the parlor. There was a fireplace, and he suffered from the gout, so he would [often be in] a silk undershirt. In his classes, he was just brutal—everything American, he had utter disdain for. I would come in [to his office] and say, "I've suggested this topic to Professor Carrier."

He said, "Oh, I gave that as a homework problem in 1928," and on and on. Later on he and I became great friends, and when I related some of these things to him, he just kept saying, "I'm sorry, I'm sorry." And then he looked up and he said, "I'm damn glad I did, it made a man out of you."

I finally [found a thesis research problem in a roundabout way]. When our fleet was sunk at Pearl Harbor, I didn't realize that the Navy used a lot of linoleum. Somehow or other, Professor [William] Prager, who was this famous person who brought the applied math division to Brown, got a call from Armstrong Cork & Linoleum, that they had to increase their production of linoleum [for rebuilding naval vessels]. Professor Prager got this grant, and that turned out to be a Ph.D. problem for a fellow by the name of Mort [Morton] Finston, who actually became a professor of aeronautics at MIT, and we were given that problem for homework one time.

The other thing that happened with Armstrong Cork & Linoleum is they were just coming out with Styrofoam cups. Somebody there had suggested that, and when he was presenting it to his superiors [one of them] looked at it with a magnifying glass and he said, "That's just air bubbles, and that isn't going to be a good insulator because if you put a temperature difference on it, the hot air will rise and circulate, [and pass the heat out]." That problem was given to George's student right ahead of me, and because the cells were very, very small, it turns out that that motion was unimportant.

I was desperate, and I finally said, "Well, what happens if the cells are not small?" Boundary layer theory was just being developed at the time, and here was a case of [an enclosed] boundary layer [that surrounded the interior fluid]. So that was my thesis topic, and my thesis was 18 pages long with two figures. It was, I think, the second-shortest Ivy League thesis, except for a mathematician at Harvard [University, Cambridge, Massachusetts]. There was no history on the problem that we knew of, and Carrier was a terse guy, and also it was costing $0.40 [per page] for a certain vellum that we had to use [for our thesis write up], so Carrier said, "[Make it short]." It was a terrible solution. I had to use a Friden [mechanical] calculator to try and calculate the fifth order coupled non-linear differential equations [that described the problem], and I spent the whole summer punching buttons. It was not a very good solution.

Before I got my Ph.D., I started getting offers from great universities, and Brown was anxious [for me to take an academic position], but Abe had promised me this double pay jump. That was good money—it would have brought me, like, to $6,400, which was a lot of money in those days. I came here, and this is an encounter that most likely nobody heard about. Abe said to me, "I want you to go talk to Ben [Benjamin] Pinkel and go talk to John [C.] Evvard, and see

where you'd be comfortable." I go to Ben Pinkel, and Ben Pinkel was just this wonderful, fatherly kind of figure. He would be delighted to have me.

John Evvard was an interesting man. I think he came from some Midwest town and had gone to Caltech [California Institute of Technology, Pasadena, California], and he was brilliant. He developed the supersonic flow over finite wings, a very famous paper. I go in there and John says, right off the bat, "I expect 2.34 reports from every young Ph.D.," and then he looks and he says, "Oh, I couldn't have you in my organization. This double jump in pay would upset my organization."

Fine. I go back to Abe's office, and before I say a word, Abe says, "I want you to go to work for Evvard."

I said, "But I don't want to."

He said, "Why?" and I told him. He said, "I wouldn't worry about that."

Whatever possessed me, I don't know, but I grabbed him by the shoulder and I said, "You don't have to worry about it, but I do." Many years later, Abe tells me, nobody ever did that.

I come here, and I couldn't have had a finer postdoc [postdoctoral research studies]. There were brilliant people up and down the corridor. I was assigned to a section with Frank Moore. Frank Moore looked like a mean, nasty guy. I knew he was a student of Bill [William R.] Sears at Cornell [University, Ithaca, New York], and Bill Sears had been the first student of Theodore von Kármán at Caltech, so a pretty good lineage.

What was I going to do, 2.34 reports? I thought rather than doing this very complicated problem [like my thesis], I'll do a simpler problem [of buoyancy flow] over a flat plate. I find out that they had just installed a card programmed electronic calculator. It was the first of the so-

called high-speed computing machines. The head of that was a wonderful guy by the name of Lynn [U.] Albers. Lynn was intrigued with the problem, and he basically had people working day and night to solve it.

I was in fluid dynamics, but basically, in those days, we all thought about air and water. Lynn said to me, "There's a parameter in here, why don't I calculate it for a whole series of parameters?" I had no idea what that parameter was. That came out as [NACA] TR [Technical Report]-1111, which is a classic, and there's hardly a textbook on heat transfer that doesn't refer to it.

I've got to back up again—we had captured a number of German researchers, and they were at Wright Field [Wright-Patterson Air Force Base, Ohio]. To rehab [rehabilitate] them, certain ones were sent to different places. We had a guy by the name of Ernst [R. G.] Eckert, who was a very famous heat transfer guy. I may have to remind you, this problem of mine was really sort of a heat transfer problem. I had never had a course in heat transfer in my life, ever, so we hear that this famous Ernst Eckert—now, he was also the developer of the buzz bombs [V-1 flying bomb] at Peenemünde [Army Research Center, Germany]—but he was a wonderful guy.

He came through one day and I showed him that I did [my buoyancy paper]. And he said to me, "That was done in 1934 by Ernst [H. W.] Schmidt in Germany." What! He said, "Yes, you most likely didn't hear about it because the journal in which it was published, somehow [Adolf] Hitler's people didn't like it, so it wasn't well known." He not only did the calculations, but he did experiments. I'd already had the paper accepted for presentation at a meeting in Chicago [Illinois].

About three weeks before the meeting, I get a call from Eckert. He said, "Ernst Schmidt is in this country, and I can't get down to Chicago—would you take him?" So I get on a train

with him here, gulp, and I hand him the paper and I tell him I've done this work. I get up to present the paper, and I am shaking. It's my first presentation ever, and I present my stuff.

I see that he's got my paper and he's written all over the back of it. He gets up and he says, "As the pioneer work in this field, I want to say that the way Ostrach did it is brilliant research," and on and on and on. Ernst Schmidt and I became great, great friends after that.

So I became the buoyancy guy. Abe was the Director of this place, but anytime anything new was going to be done, Abe requested—I forget how often, maybe once a month or once every other month—that all people with new ideas, who want to start new things, would make presentations in front of him. The guy in front of me was a very brilliant chemist doing fuel chemistry, and he had a doctorate. The guy got a third of the way through and Abe says, "I don't believe it," and the guy just melted. Now I come up and I start talking about flow over a heated plate, and he exploded. He said, "Hell, man, we're not interested in heating homes." Everybody thought they knew [about] buoyancy. Hot air rises, so what's the problem? Everybody knows that—well, everybody didn't know it.

Abe exploded, but he never stopped me. I started increasing the complexity, and I kept going back to my thesis problem. It took me about seven students [later when I was at Case Western Reserve University, Cleveland], and Carrier went to Harvard after he left Brown. He most likely had five students, all who did the problem wrong, until I did some experiments and got the right solution. It was a really tough problem, and it had characteristics that led to some of the stuff I did in space later on. It started out in this way of just saying, "Well, let me look at a big cell instead of a small cell," opened up a whole new field. I got [accepted by] the heat transfer community, and it was great.

In the meantime, Abe then thought he wanted a brain trust, so he took four of us. He took Frank Moore, who I told you about; and me; and a guy from New York—a big, tall, handsome guy who got his Ph.D. at Cornell—Hal Mirels, and Steve Maslen, perhaps the most brilliant guy that I ever met in my life, who got his Ph.D. at Brown. So two had gotten degrees at Brown, and two had gotten them at Cornell. You never met four people who did different kinds of research, although Frank and I collaborated a little bit, and who were different people, and we became like brothers. To this very day, Frank Moore is my closest friend.

I later became Home Secretary of the National Academy of Engineering [NAE], and eventually all four of us [were members of the NAE—this group got to be very famous. This guy, Bill Sears that I told you about, who founded the School of Aeronautical Engineering at Cornell and was a student of von Kármán, he named us the Four M's: there's Moore, Mirels, Maslen, and "*M*Ostrach." This got to be known. Abe threw tough problems at us, like how do we quiet the sonic boom; how do we quiet jet engines, but other than that he left us alone [to do our own research].

Now, the space agency came. Abe is quoted in the newspaper, the Cleveland paper, that he's never less sure of the direction the lab is going. The four of us march over there and said, "Abe, you've given us all these years of freedom—we've got ideas."

He said, "What's the matter, aren't I taking care of you? You need more money? What are you, crazy, you want to get involved?"

I said, "Yes, I want to be in line," so he made me a branch chief in Wolf [Wolfgang] Moeckel's division. That was a good experience except from day one, I had problems with secretaries, and problems with people, and problems with space.

When a technical question would come up, I would be so relieved that I would solve it. I finally said, "What am I doing? I enjoy solving problems." In the meantime, people were being hustled off. Frank was offered the directorship of Cornell Aero [Aeronautical] Lab, so he left, and Harold got a chief scientist job, some good position, at [The] Aerospace Corporation. People were peeling off because what is happening here was instead of it being a research laboratory anymore, it was program managing, and it was obvious research was not a big deal.

I kept hanging on because we liked Cleveland, and I was getting offers from all kinds of universities. I had lots of kids—I had five kids [ultimately]—so every time we'd think of moving and the kids will settle in, and the school—it's a wonderful place to raise kids. Yale [University, New Haven, Connecticut], a lot of good schools—Brown, in fact, brought me back about eight years later and said, "You were one of the outstanding graduates," and I thought, "What happened to all these other smart people?" I found out then, I almost fainted, to have a professorship at Brown. It turns out it was all on soft money, and I didn't know at the time that I could raise money. So even though that was my dream, I didn't do it.

I had been taking night courses at Case for my master's degree as an undergraduate, and Case offered me a position. We figured, hey, if I'm going into academia, at least I don't have to move. When I was just an engineer here in the early days, I started teaching at Fenn College [now the Washkewicz College of Engineering at Cleveland State University]. A lot of them were GIs [General Issue (American soldiers)] coming back. Teach algebra. I loved it—they were more mature students. I liked teaching, so I figured, well, I could try teaching at Case.

When they offered me a professorship, I said yes, and I took it. It was wonderful. Evvard, by this time, gave me a $100,000 blanket grant, which in those days was a lot of money, and as I was hiring in young people, I would tell them, "You don't have to worry for a couple of

years." All I had to do for Evvard was write a one-page task [description], and I could go ahead and help these young people get started. So I went to Case, going to be a professor. "No more of this administrative thing."

A short time afterwards, the president of the university was T. Keith Glennan [who became the first Administrator of NASA], called five of us together. It was me; it was a guy in macromolecular [science]; there was a guy in systems by the name of Don Eckman—I don't remember the fifth one at the moment. He said, "Case is a good regional school, but if you make it nationally renowned, I'll make it worth your while." I'd never talked to a college president before, and with that, I thought I would get a sweater letter.

I had three kids about this time. My next paycheck, I notice there's a reduction in money. I check it, they said, "The president has established a fund for you, an annuity for you, and they're going to take 7 percent of your salary and the university's going to add 14 percent." Thirty years later, it was worth a $1.25 million. Then they're reorganizing completely in a different way, not with departments, but by disciplines, and they wanted me to be head of the division of fluid, thermal, and aerospace sciences. It was like a kick in the pants because here, I loved people, but I don't want to spend all my time dealing with people problems.

I'll never forget, as long as I live, I was at an ASME [American Society of Mechanical Engineers] meeting in New York, and C.C. [Chia-Chiao] Lin, a very famous guy who left Brown and who ultimately went to MIT, was giving a big talk on the spiral galaxy. I was approaching the grand ballroom, and sitting on the couch was Professor Carrier, my mentor, and C.C. Lin, the speaker, the brilliant applied mathematician. I go up there, whining to them. I said, "Gee, I just left NASA because I didn't want any more administrative work, and now I get to the university, and the first thing they want"—and Lin says to me, "Can something good be done there?"

I said, “I think so.”

He said, “Is there someone else who could do it?”

I said, “I don’t know.”

He said, “Well, stop whining and do it. I gave up a year and a half of my life to establish applied mathematics at MIT, so you do it.”

And Carrier said to me, “I know you can do it, so do it.” So I came back and I founded this great department. In that day, my vision—everybody talks about interdisciplinary [now]—was, yes, we’re going to do fluid and thermal sciences for engineering, for aeronautics and mechanical [engineering], but we’re going to do biological fluid mechanics and geophysical fluid mechanics [as well]. That was a very unique concept, if you look back at the days—this is 1960, and I hired in people to do that. It didn’t all work out.

I then started getting the same whining. I hired in a guy, was an All-American lacrosse player with a broken nose, he tells me he can’t get in to see me because of my secretary. I said to him, “My secretary is 4’5”, you’re an All-American lacrosse player.” This kind of whining. I went to the dean and I said, “I’ve established a good department. It’s time for me to step aside.”

He said, “I can’t picture you out of the power structure. Tuesday, we got a surprise for you.” Tuesday, they announced that I was the recipient of the first $1 million [endowed] professorship. It’s called a distinguished professorship. I became a distinguished professor, and I did my research.

I look back at it, and I can’t believe all that I did. The environment here couldn’t have been better for me to have had the freedom—I published in a lot of things, I’m just amazed. Then I went to the university and I maintained contact. Ultimately, I became the Home Secretary of the National Academy of Engineering. Through Aaron Cohen, I got to meet Dan

[Daniel S.] Goldin, and Dan and I hit it off. We're great friends because I don't get intimidated by New York intimidators. Dan was raised on the streets of New York, but he was a brilliant and a kind person. When he did upset people, he usually apologized. One time, he went crazy. I was in his office and I grabbed him by the wrist, and you could just hear an audible [gasp].

Dan and I became great friends, and Dan got the idea that he wanted to have a great university affiliated with each of the [NASA] Centers. I said, "Great, we'll do it between Case and here, formed the National Center for Microgravity Research." The president of the university calls me over one day and he says Dan Goldin called him and wants me to be the director of it. I said, "No way." I'm already, at that time, I think, 74. This is '97. The president said Dan said he'd put an extra $500,000 a year in if you would do it. I became the director of this Center, and it was a great experience also. I assembled some great people. We had 15 faculty [also involved], we had I forget how many scientists, but it was an $8 million budget. It was a powerful group; students and faculty from other universities came. It met every one of the standards, and Dan was really pleased with it. After five years, the contract was renewed.

Now we have to come back to the 70's—maybe even before that, in the mid-60's. One day, I got a letter from a renowned guy from Bell Labs [Laboratories, Inc.], who said that he was growing crystals for semiconductors, and that almost always, when he grew the crystals there were oscillations [that caused problems in the crystal's structure]. He got the idea that it was due to buoyancy, and he realized that I was the world's authority, so he liked to talk to me about growing crystals. He thought growing them in space would make a lot of sense. I got involved with the crystal growers and pointed out that the oscillations were coming from a certain form of buoyancy. I actually wrote three seminal papers on the role of fluid in the heat transfer, which materials people hadn't understood.

About in the 70's—one of my dreams, really, was to fly in space. In the early 70's, [NASA launched] Skylab. Incidentally, I had been involved with the people at Huntsville [Marshall Space Flight Center, Huntsville, Alabama]. When the [Skylab crew] got bored, they called down for some experiments, we made up simple little things they could do.

In the 70's, it must have been about '72, [NASA] assembled a group of people. Materials people who wanted to do things in space, and fluids people, like myself, and chemical engineers. They said, "What would be worthwhile doing in space?" I don't recall exactly why, but I said, "Surface tension is dominated by gravity." In other words, if you have a glass half-full of water, you see the line between the water and the air is flat, and that's because gravity's pressing on it. If you took a glass of water into space, it forms a glob and wants to float. That's because surface tension now becomes important. I thought if you put a temperature gradient, it will cause a flow.

The chemical engineers knew about that, but really didn't seem interested. So I proposed an experiment of surface-tension-driven convection. At that time, they said the idea was that if you got the experiment accepted and prepared, then the PI [Principal Investigator] would fly with it. They asked, "How many of you would want to fly?" I was the only guy who had his hand up. Great! There were science reviews, then starting to design the equipment. The people here at Glenn were fabulous, that engineering team was fabulous, but there were engineering reviews, and then, as you came closer and closer, there were out-gassing reviews and vibration reviews.

In the meantime, we had this real problem, that we were going to do this in the biggest free surface ever done. It was a 10-centimeter dish, and the question was, how do we keep the oil in there? We worked with chemists for maybe a year and a half, tried everything, and one day, one of the technicians sprayed Scotchgard™ [stain and water repellent] on there, and that did it.

That's when I started flying in the KC-135 [reduced gravity aircraft]. We had to do the tests to see how to keep [the oil in the test chamber]. Also, we were going to view the motion by means of little particles in there that we would illuminate with a laser, so you could see the motion. The question was, how many particles? I was just euphoric in the airplane. The crews were sick and the astronauts don't like it. I, literally from day one, was euphoric in that airplane. I just loved it. I just felt so great.

Taylor [G.] Wang was a guy at Vanderbilt [University, Nashville, Tennessee]. He, in fact, was a PI who went up with his experiment. It broke, so he was back on the panel a good deal of the time, and mine was being developed. Of course, mine was much more complicated than what he did.

Then, the [Space Shuttle] *Challenger* accident [STS 51-L] happened. It was then they decided that everybody aboard [a Shuttle] had to be a full astronaut. It was a two-year training. I've got a family, young family, I've got a great career. You have to be true to yourself. As much as I wanted to do it—and it was kind of a militaristic thing. You had to wear a shirt, tie, and jacket, you had to ask permission from your payload commander whether you could go home. So I nominated one of my colleagues, who was a young guy. We sailed together—he's a great sailor. This was going to be one of the few fully interactive experiments. He was a Ph.D. in fluid and thermal sciences, and we would be in direct communication.

We opened up a whole new field of science, developed a great rapport with the crew, and then what we learned from the first set, we [wanted to do more]. The next opportunity was on USML [United States Microgravity Laboratory]-2, which was three years later [STS-73], and they said, "There's no way you can redesign it and get it all done." This team did it, and it was

great. It was just an exponential increase in the research in this field, and it actually has practical applications. We opened up a whole new field of science, and I had a lot of fun.

I named it the "Fly Before I Die" experiment because, remember now, it was somewhere in the 70's that it was approved, and every time I would do a review, I would conclude it with a portrait of myself and say, "Fly before I die." It flew in 1992 [STS-50], so it was 17 years [in development]. Even then, I almost had a heart attack. I was in China on some business, and I knew that they were putting the [experiment] racks into the Shuttle. I got, I think, a telegram saying, "Your package was dropped." We had lasers and all kinds of optics, and I was sick. Then a couple of days later it said, "We checked out, all the optics are fine, good to go." As I'm flying back from China, I said, "Whoops."

The pump that puts the fluid in [the test chamber] is ceramic, and ceramic doesn't take impact [very well], so the question was, what would be a backup? So I became a free-floating satellite in the KC-135. I had a model of my experiment with a camera, and I had various syringes that I tried to get [the oil] in, and in zero gravity, try to pull the syringe out. [The oil] came out with it. I had six people around me, and when we got airborne, I would try various techniques. Then when they were coming out [of low-G], the people would grab me. The package weighed 75 pounds.

I [finally] developed [a technique], and then a few weeks before the flight, the crew came in and we went up and I showed them how to do it. When Bonnie [J. Dunbar] went through [the tunnel in *Columbia*] and opened up the Spacelab, I said, "Turn on the pump," and the pump worked. So all that work for nothing. That's a long answer to how did I get here, but it sort of covers a lot of what I did.

JOHNSON: It does, that's great. Those relationships with the crews that actually flew those experiments—

OSTRACH: We became great friends. Bonnie came to my home for dinner, and [Kenneth D.] Bowersox was the pilot on the first flight and the commander of the second. Carl [J.] Meade, who was one of the crew and an astronaut, when we were taking off on our first flight in the KC-135, he says, as we're revving up, "One day, the wings are going to come off this thing."

He got to be a great friend. I drove Corvettes all the time, and he said if I let him drive my Corvette, he'd give me a ride in the [Northrop] T-38 [Talon training aircraft]. It never happened because he left [NASA] before I got my ride, which ticked me off. We got to be great friends, and to this day we've kept in touch. They have thousands of feet [of film] of me because people were sick so I would get in, and they were always saying, "Look at Ostrach, he's getting his hands dirty. Take pictures of that." We had fun. After we would finish our [test] parabolas, we'd take a few parabolas—it was actually on their webpage, I have it for my page on my computer—I was doing flips and they caught me just with my hands out like this [demonstrates]. It's a great shot. We had a lot of fun.

I've got to come back a little bit, too. This friend of mine, who was in training to be my payload commander, he got into some problems at a very bad time, and so they said [he could not fly]. I spent hours with Dan trying to get that reversed. Dan said to me, "Okay, here is your chance to fly, why don't you do it?"

I said, "Dan, give me three months to learn the safety, and I'm your man."

He said, "I can't do it."

Then, of course, they did it with John [H.] Glenn [Jr.]. John had been a previous astronaut, but I gave Dan a lot of static about that. I would have done it in a heartbeat, but you can't chase dreams and not be true to yourself. It would not have been a smart move on my part. I came the closest thing to it, and I had more low-gravity time—I forget what the numbers were now—than the early astronauts. I was just euphoric. When I was 82 or something like that, Johnson [Space Center, Houston, Texas] people called and said, "The *Guinness Book of World Records* wanted to know who was the oldest person to fly [in the KC-135]," and they thought it was John Glenn or me. I think it was me, or it might have been John, and they said there was a Russian lady who was somewhat older. They said, "Would I care to fly again?"

I had to go through the physiologic training and everything. Even when they took us up [in a hypobaric chamber] and people were fainting, my fingernails would get purple, but I was okay. I showed up now and I'm 82, and here are these kids with ponytails and earrings, and the [Navy] SEAL is saying, "Older people who are a little overweight, they've got a bigger chance of getting a bubble in their brain."

I'm thinking, "What am I doing?"

JOHNSON: Just for a record.

OSTRACH: These kids, we'd get halfway up and you'd get, "Oh, my ears!" You had to bring them down [to a lower altitude], and then some of them didn't want to be in the explosive decompression part of it. The second part, you go in and they take you up to 30,000 [feet] and they explosively decompress you, which is pretty awesome. When I was turning in my equipment, the guy said, "Hey, for an old guy, you did really great." I went up [in the KC-135]

and people from my Center had the number of experiments [aboard and] kids were getting sick. I got involved, and I always want more, so I got picture after picture of me in the cockpit. They put me up in the cockpit to shut me up. I always wanted more. It was good.

That was a long answer. You can ask some questions.

JOHNSON: No, that's all good. We'll go back to the NACA time for a few minutes. When you first started and then when you came back as a Ph.D.—you mentioned that it changed somewhat later—but the atmosphere seemed to be very supportive of research for pure research, not with a goal in mind.

OSTRACH: Yes, there was lots of research with a goal in mind because there was a lot of people pushing, in those days, to develop rockets, which was a big mistake that they didn't do. There was research on fuels for planes, and the immediate needs of the war. My first two main projects were related to aircraft during the war. So there was a lot of applied research, a lot of very directed research.

There was a wealth of smart people and a certain amount of time that you had to pursue new things. Abe wanted everything to be directed and he exploded, but he didn't stop me. I actually found out that in Germany, a guy had used this buoyancy to cool turbine blades, and that's what I used as my crutch [to justify my basic research]. Nobody pressed me, and I did lots of stuff on buoyancy, and became the world's expert in buoyancy flows. There was a lot of that stuff. We developed [new] aspects of boundary layer theory. It was just a great, great period.

After it became the space agency, then it started to be program managers. There were little pockets of research, but they aren't research labs anymore, unfortunately. I think Goddard [Space Flight Center, Greenbelt, Maryland] is maybe one of the few that is still left that way.

JOHNSON: Once it became NASA, then there was that whole push—some people went from Glenn to Langley [Research Center, Hampton, Virginia], and then went to Houston with the Space Task Group. Did you ever even consider that?

OSTRACH: No.

JOHNSON: Even though you wanted to fly at some point, that wasn't something you wanted to do?

OSTRACH: No, I spent a fair amount of time at Houston because I was going to Ellington [Field, Houston, Texas], plus I was on the Space Studies Board. I got to know Aaron Cohen. Funny story, just [when I was] beginning to stop smoking—I was a cigar and pipe smoker, and I had a long meeting at Houston. It dealt with the astronauts because I think Bonnie was sort of chauffeuring me around. Somebody said to me, "Would you like to meet the Director?" Yes, so I went up there, and of course it's like [Benito] Mussolini's [Italian dictator] office, a great, big office.

I don't know how it came up, but Aaron said to me, "Would you like a cigar?"

I said, "What?" We were up there smoking cigars together. He was a wonderful guy. I got to know him quite well, and then through him I met Dan Goldin. I still hear from Dan. His

$2 million president for two days, you know that story. Dan was a remarkable guy. As I say, he has a lot of pluses, a few negatives, but a visionary. I enjoy him very much.

JOHNSON: In 1957, again, when everything was changing, they had an open house here. Then Sputnik [Russian satellite] of course happened. You mentioned that Hap Arnold and Dwight Eisenhower flew in on the plane. Do you recall any other visitors, or anybody during some of the open houses, that you, personally, were involved with?

OSTRACH: I'll tell you another thing that helped my career, since you mention it. I was coming back from a dental appointment one day, and I was out in Rocky River Drive, and I see somebody frantically waving me down. It was Ben Pinkel, and he had a flat tire. He said to me, "Can you take me? Admiral [Hyman G.] Rickover is here and I'm late." As we're driving, he says, "You do something in heat transfer—do you want to come and listen?"

I said, "Sure." So I'm hearing Rickover describe the first nuclear power plant for the submarines. When they turned it on, they got 40 times, or some enormous amount, extra heat transfer going up and it basically melted it. I raised my hand and I said, "I bet you that was due to natural convection," because I was trying to justify [my research].

He leaned over and he said, "Sonny, everybody knows that natural convection is an innocuous process."

Later on I got a call from Knolls Atomic [Power] Laboratory, and they said, "We understand you made some comments, and I looked at the fuel rods, and sure enough, we put piston rings in and that stopped the heat transfer from going up."

There were people like that. Eckert came in, as I told you, a very famous guy. He later on founded a big department at the University of Minnesota [Minneapolis and St. Paul], which turned out a lot of people. There was constantly people like that coming through, and that was stimulating. One day, we heard that Henry [Heinrich] Görtler is coming through. There are Görtler vortices that go off wingtips, a very famous applied mathematician. Evvard came down and said, "Görtler's coming here." Everybody's just—we've all read Görtler and he's done a lot of great work.

Görtler came, and he looked like Dick Tracy [cartoon police detective], and he was on a mission. They were going to have an international union of theoretical and applied mechanics at his university in Freiberg, Germany [Albert Ludwig University of Freiburg]. He was picking out general lecturers from each country. I had just discovered these kinds of thermal instabilities everybody knew happened in horizontal layers, as I had just discovered that they occur in vertical layers.

A number of us were asked to give presentations to Görtler. We didn't really know why—we thought it was discussing current work. And I am informed that I have been chosen to be the U.S. general lecturer. I'm a young kid. This most likely is maybe '55 or something. I came back here in '50 with my Ph.D. So I go to Freiberg, Germany, in the *Schwarzwald* [Black Forest], and I walked on the street with Görtler. People get off the sidewalk. Professors are very highly regarded there, not like here.

Just to show you what these interactions mean, I give my talk, and in the audience is von Kármán. There's Görtler. There is [Hermann] Schlichting. There is Sir Geoffrey [I.] Taylor. Every great person in my field. It was awesome. I had caught a little cold on the airplane, and I gave my talk, I went up to my room, and was just all shaken. I come down to go to lunch, and

you give your key to the concierge, and there's a note there. It says, "Would you have lunch with me? G.I. Taylor." Taylor and von Kármán are, I think, considered two of the eight geniuses of that [field].

G.I. Taylor, we go to lunch and he chortles with delight over my research. He had observed this in saline solutions and I had explained it all. I know German, I was a good German speaker, and that evening they said there was going to be an *Imbiss*—*Imbiss* meant snacks—up in the *Schwarzwald*, up in the Black Forest. We go up there, and Taylor comes and sits next to me on the bus, and it was the most enormous buffet.

As we're coming back, Sir Geoffrey has a bottle of rosé wine, which is indigenous, in each hand. This is very important—as I told you, I was asked by the president at Case to make Case famous, so one of the first things I did was there was a little conference that floated around called Midwest Mechanics Conference. I brought it to Case and I had each session headlined by a very famous person. Sydney Goldstein was one of them, and it was his last work, ever. I asked him to give his reflections on it. He gave me a 50-page paper, and he told me, "Edit it any way you want." After I read it, I didn't change it.

Next thing that happened was during this transition period, Sir Geoffrey Taylor had a milestone birthday, and one of his former postdocs, a guy by the name of Chia-Shun Yih, said there would be a big celebration of this at University of Michigan [Ann Arbor]. He was going to give a series of lectures. Clearly, I was invited. A light bulb lit up, and I wrote to him and I said, "Sir Geoffrey, would you come and spend a week at Case?"

He wrote me back—and incidentally, in England, you may be this Sir Isaac Newton professor, but when you retire you don't have a secretary—so in his squiggly handwriting, he

writes back and he says, “I’ll have to ask the people at Michigan because they’ve arranged everything.” Then he writes back, “Because of you, they said it would be okay.”

Now I go to this thing, and Yih, he and I had had a little tussle. He had started to write papers on buoyancy. We had these Applied Mechanics Reviews, where the papers would be reviewed, and I reviewed [one of his] and found a mistake in it. He was very nervous, he was just a meticulous guy. We became great friends, obviously, but he had a greenhouse attached to his home because he raises hybrid orchids, that was his hobby, and it was a beautiful party.

I was sitting at the table with Sir Geoffrey, and there was no wine. I noticed there was good French wine. As I’m leaving, I said to Chia-Shun, “Wonderful party, but someone blew it. There was no wine on Sir Geoffrey’s table.”

He says, “He doesn’t drink.”

I thought, “Hey, I saw him with these two bottles.” Now, [Taylor] comes to my home and we have a reception at my home and faculty, and I went around and asked the ladies what they wanted to drink, and I had a tray. As I go by, he reached up and he grabbed the first thing there.

The other thing is he’s an inveterate sailor. I became one, but at the time I was not a sailor, I didn’t have a sailboat. I decided to take him—there was a restaurant called the Top of the Town that overlooks the lake. I took my colleague, Eli Reshotko, who had been here too, and that I had brought over to Case. Eli was a Caltech Ph.D. Sir Geoffrey just chortled. He just loved the lake and everything.

Now we sit down and have lunch. The waiter comes and says, “Here’s the wine menu.” My colleague, Eli Reshotko, is from Caltech and he grabs it. I’m still buzzing, so I said, “Sir Geoffrey, would you care to pick the wine?”

He says, “Don’t mind if I do.” He takes it and he looks and he says, “I’d like a bottle of Châteauneuf-du-Pape. I prefer—some year—but I suppose we can only get that in Cambridge.” I had never in my life paid what that bottle of Châteauneuf-du-Pape [cost]. Incidentally, my students and others kept giving me Châteauneuf-du-Pape, and I love it. It’s the nectar of the gods.

Let me tell you another thing. At this Görtler banquet, I got seated at the table with von Kármán’s sister and girlfriend. Von Kármán evidently had a love affair when he was a young man and it didn’t work out. She went on and had a family and [when she became a widow decided to help von Kármán], and so whenever von Kármán traveled, his sister [and he] would travel, and [they] would make sure his scarf was on and that his beret was on. I’m sitting at the table with his sister and I’m hearing some of these stories about the lady in his life, and he comes over. He sees a cigar in my pocket. I see his eyes light up, so we lit up cigars, we went for a walk, and during the course of the meeting we got friendlier.

He became my Uncle Todor, and he asked me to sit next to him at all of his milestone birthdays, which was great, but he’d turn off his hearing aids and doodle and say, “Tell me when something important.” We were at a meeting one time and I poked him. A very famous professor—I’m not going to mention his name—giving a talk, and I poked him. He looked up and he said, “He talks a lot and doesn’t say very much.” Kármán just had the way of cutting people to ribbons.

I got to know these great people through Brown and through my work. Again, I digressed in many different directions. These aren’t just people—when I first went with my first wife to England, the first time I took her there, Sir Geoffrey wanted me to drive from London to his home, and he, in his scraggly handwriting, gave me directions. On every corner, he

described the garden and the pub. I have the letter. I had the opportunity to meet and be with these great people, and very personal relationships.

With regard to Kármán, one of his big milestone birthdays was a very fancy hotel in Washington [DC]. We were standing around, and there was military brass, because Kármán was the father of the American Air Force, really, in a sense. We'd had a couple of Manhattans [cocktails], and I noticed that his glass was empty, so he says to me, "Would you get me another glass?" I had had—Manhattans are pretty tough. I walk up and I see the brass buttons and everything, so I say, "Two more Manhattans." Nothing happened. I look up at General Curtis [E.] LeMay. The Air Force dress uniforms were very much like the bellboys. That was another mistake.

Just a lot of wonderful experiences, with a fantastic life. Been all over the world, except for the Balkan countries. China many times, Japan, Korea, Australia, New Zealand, Egypt, Jordan, Israel, England, Italy, France—I lived in many of these places for some time—months, weeks. My eight years in the Academy were just wonderful, when I got to know presidents of most of the great universities, the CEOs [Chief Executive Officer] of many corporations, heads of government agencies. I was sort of the chief operating officer of the Academy, so my signature's on a lot of stuff. The president at Case would come and he'd say, "Everywhere I go in Washington, people know you."

I said, "Yes, they should know you, but my signature is there."

And that happened inadvertently. Fridays, I'd have meetings with my graduate students, and I get a call that said, "I'm head of the nominating committee of the National Academy, and they've nominated you to be the Home Secretary." I'm busy but I said, "Okay." I had no idea what the Home Secretary did. I have a very funny colleague who wrote me a letter, said,

"Congratulations on your being named the Home Secretary. Of course, I don't know what the Home Secretary does—I suppose he stays home."

The Home Secretary of the Academy is the chief operating officer, and the whole membership operation—I had a staff of about 12 people. It was just great. Black-tie dinners and all the elegance. I used to kid and say working stiffs are a neglected national resource because everything there is prestigious—college presidents and CEOs. It was great fun.

JOHNSON: Yes, and it all came about because you had an advisor that told you, you didn't need to be a doctor, you should look at engineering.

OSTRACH: A high school guidance counselor opened up this whole world.

JOHNSON: Then John Sanders, also.

OSTRACH: John Sanders, yes, and then George Carrier. George Carrier showed me what world-class is. A completely different style from me—he was brilliant and quick, and I developed a scaling technique, a formal, mathematical way of deciding what's important in a problem. George was incredulous when he saw it and I told him, "George, I did it in defense of you. You look at a problem and say, 'Oh, this is important.'" I found out that he is wrong 30 percent of the time, but he's so brilliant and a Harvard professor with two chairs, who's going to challenge him? I developed my own style. I'm much more cautious. Two people in your life just opened up a world to you, and in every way. I mean, intellectually, socially, and monetarily.

JOHNSON: In your research, what I find interesting is some of the research that you and other people were doing here—then you find out how important it is, when these people that you respect come back and tell you how much they admire what you've done. That's amazing.

OSTRACH: Yes, it's mind-boggling. So many things that I had an opportunity to investigate here, and you had support. If you needed computational [support], I had great computational [support]. If you needed diagrams made—when I was at the university, I'd make up my own PowerPoint [presentation slides]. Over here, they [did it for me]. After you did a report, they had English people review it.

You just had to be smart. You just had to do your work at your level. That's what I loved. When I set up my center, I didn't want anybody doing work that could be done easily by someone else. That would free you up. That's why so many creative things came out of this place.

JOHNSON: You mentioned the support, and you mentioned your technicians, when you were doing the supersonic tunnel, and creating it in wood. I would imagine in some of the experiments, that you worked with photographers that were documenting everything.

OSTRACH: Sure. There was almost nothing that you had to do yourself. They had technicians. There were crew chiefs assigned to every test cell in the early days, when we were doing experiments in the engineering research. Every organization had a certain number of technicians of different types, and it was just wonderful. If you needed something typed, we used to Xerox [copy] them, you didn't go and do it. In the university, you would do it. The university didn't

give you that kind of support. That was what just enhanced the whole thing. It was a fabulous experience. The 10 years that I was here with my Ph.D., and the other years that I was here—I actually had, I guess, 17 years altogether—and I don't regret one moment of it.

JOHNSON: That's great. I was going to ask Rebecca, if you don't mind, if she has any questions before we end.

WRIGHT: This really doesn't have anything to do with NACA, but all the students that you touched through all these years, what is the reason or what is the encouragement that you give them to continue working in the field of research, although it's time-consuming and sometimes very difficult finding funding?

OSTRACH: I look back and I think of how hard it was, but yet, how satisfying it is. How do I motivate them? They read my stuff and they know what I've done and they want to emulate it. They haven't any idea what's ahead of them—nor did I—but yes, I've turned out some pretty damn good students.

I'll tell you another great story. My first Ph.D. was an Israeli who was a very formal person. Even though when I went to Israel, after he got his Ph.D. with me, we'd go swimming together, he always called me Professor Ostrach. He went there and he became dean of the faculty, and he produced some graduate students. When I went over on sabbatical, they put my name on the mailbox, and about 20 minutes later there was a knock on the door, and the guy standing there, "I can't believe the famous Professor Ostrach blah, blah, blah," just like when I met Kármán for the first time, or Sir Geoffrey.

It turns out that he was a student of my student, and we got talking, and it turned out his apartment house was across the street. We got friendly; he had two young kids. They were much younger than I, of course. He worked for the Israeli research, sort of military research organization. Whenever we'd go to Israel, we'd always spend some time. They were delightful people. We were over there a number of years ago, and I was named one of the [lectureships], had to give private and public lectures, and had a week of all of this being treated like a VIP [Very Important Person], giving lectures, and staying in fancy hotels.

Another thing—shortly after the establishment of the State of Israel [in 1948], my mentor and myself and another one of the students from Brown, who did his postdoc in Israel, were invited over to see how the universities could help stimulate indirect with industry. We were met by two young men, who not only knew contemporary history, but the biblical history. It turned both of them had gotten Ph.D.s at Brown. We became very close.

I arranged to have one of the guys come to my place in sabbatical, and I received a letter on Thursday saying the whole arrangement. He was killed in a tank battle. He was commander of a tank, and took out five Syrian tanks and got killed. The other guy carries his endowed professor. The other guy became the academic vice president, which is like the provost, and he came and spent two sabbaticals with me and turned out two brilliant papers.

We became real good friends, so after the ceremonial week, he said, "You're spending a week at Chez Sulan." His name is Sulan, and he has this gorgeous apartment overlooking the Mediterranean. The second day we're there, it's raining like holy hell, which rarely happens, and he had to go teach, and his wife was a lawyer. They were apologetic. We said, "Look, we'd love to have a day." My wife gets on the phone and calls this younger man, and his wife says,

"Oh, he's going to be so upset. He's down in Elat and I'm going to join him, we're having a little vacation."

He calls me the next day and he said sorry, and I said, "Are you still working at Rafael [Advanced Defense Systems, Lmtd.]?" which is the Israeli research thing.

He says, "No. I just formed a new company that became an IPO," Initial [Public] Offering on the New York [Stock] Exchange. He said, "I developed these tiny, tiny sensors, and I got to the age where I had to have endoscopy done. I realized that I could put this into a pill and you could swallow it, and it would go through. I had trouble getting financing and I had to give a good piece of it away, so I am listed as a chief technical officer, but I'm very well taken care of." He actually gave me one of them later on.

It didn't mean anything to me, but we came back and about a week later we're watching world news, and here's the chief of gastroenterology, I think, at the Mayo Clinic, saying this wonderful thing has occurred. So I bought the stock. It opened at 10, I bought it at 12. It just recently sold at 32—they were bought out. That's one of my technical grandchildren. So the genealogy goes on.

Some of the things happen—I had this big football player at Case, big, gentle giant, who was very smart, he got his degrees with me but was very nervous. He had married during this period, and I told him it was a tough time. His wife left him right before he took his exams and he didn't do well on exams, and then he couldn't defend his thesis. He is now perhaps the most distinguished professor at Purdue [University, West Lafayette, Indiana].

It's like I get together with Carrier quite frequently, I see him and we get talking, and I tell him about how nervous and upset I was. He looks incredulously, he said, "We all knew you were going to be great."

I said, “George, why didn’t you ever give me a clue?” So I made it a business that my students knew where they stood. George was just the kind of guy, the minute he accepted you, he wasn’t a professor and you weren’t a student—you were an equal. If I were to ask him a question, he would go, “You know that, you know that, you know that, you know that,” and I’d have to spend three weeks figuring out what I knew. I didn’t appreciate the fact that once he knew I was going to be good enough, he was not particularly saying, “Oh, nice work,” or anything like that.

JOHNSON: Not encouraging, yes.

OSTRACH: What a life changer.

JOHNSON: It sounds like it.

OSTRACH: Who could have ever dreamed, this little guy from Providence, Rhode Island, out on his own? No entitlement programs.

JOHNSON: Just small decisions and chance meetings.

OSTRACH: Yes, the crossroads. You work your butt off, and it’s an incredible story. I’m writing vignettes of my life for my children. I got bogged down somewhere in the 60’s.

I got another giant that I met, Hans [W.] Liepmann. I studied from his books, and he was a great admirer of George Carrier, and so he accepted me from day one. When I became Home

Secretary of the Academy, he used to call me all the time because he was always complaining. We got to be great friends. Last time I was at Caltech we had lunch, and he sat here [demonstrates]. One of his students, who was a professor at Caltech, just retired, sat here. On his left was a student of him, Mory [Morteza] Gharib, who is now the provost at Caltech. To his left was one of his graduate students, who was Liepmann's son.

Liepmann told me that he was doing vignettes of his life, and what a life he led. When we get off the mic [microphone], I can tell you some stories about him. Here was this fearsome, brilliant guy known all over the world, and he couldn't do mathematics. He kept flunking mathematics. Very interesting stories would come out. Here is a guy whose books I studied from, who became a close personal friend.

JOHNSON: What an opportunity.

OSTRACH: I've been grieving [over my wife's death]. People tell me that I should think back on the life I led, and man, it was great. When I was the center director [of the National Center for Microgravity Research] here, I would come and spend time here, and I got called one day by one of Abe's close friends, saying, "Abe is pretty lonely." Abe is lonely? He had 15,000 people. They thought for a while that Abe had Alzheimer's [disease], but evidently he was overmedicated. I went over to see Abe, and he was in a wheelchair and it was troublesome to get to lunch.

Now I find myself in the same situation. I have this life of being known all over the world, roaming all over the world, and now there are weeks that I don't talk to anybody but my

little kitty. I have a different one of my children call me every night, but that's the extent of it. You run around, you don't think about that.

WRIGHT: Somehow I think that in about 5 or 10 years, we'll be reading more of the stuff that you've done in the next 10 years, so I don't think you're through yet.

OSTRACH: I'm 90 years old. People tell me I look good, and I say, "Smoking, drinking, and being overweight's the answer."

JOHNSON: That's the answer, right? That's how to keep healthy.

OSTRACH: How can germs get in with alcohol and tobacco?

JOHNSON: Maybe that's the secret.

OSTRACH: I'm sorry that I may have rambled.

JOHNSON: No, you've done great. We really appreciate you coming in today and sharing.

[End of interview]