PROFILES OF SWE PIONEERS

ORAL HISTORY PROJECT

Yvonne Brill Interview

November 3, 2005

Anaheim, California

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Yvonne Brill

Yvonne Brill received a B.S. in mathematics from the University of Manitoba in 1945 and an M.S. in Physical Chemistry from the University of Southern California in 1951. She began her career as a mathematician at Douglas Aircraft Company but switched careers in 1946 when she became a research analyst on rocket propellant systems for RAND Corporation. Brill held numerous positions as an engineer or manager at a variety of organizations, worked as an aerospace consultant, and served on the NASA Aerospace Safety Advisory Panel and numerous U.S. National Research Study Council Committees. She joined the Society of Women Engineers in 1975, was a past president of the SWE New Jersey Section, chaired numerous national committees, served as the counselor for two collegiate sections, and served on the national executive committee as treasurer and director of student affairs. Brill was a Fellow of SWE and the American Institute of Aeronautics and Astronautics (AIAA). Among other honors, Brill received the SWE Achievement Award, the SWE Resnik Challenger Medal, the NASA Public Service Medal, and the IEEE Judith A. Resnik Award. She received the National Medal of Technology and Innovation from President Barak Obama in 2011, "For innovation in rocket propulsion systems for geosynchronous and low earth orbit communication satellites, which greatly improved the effectiveness of space propulsion systems." Brill passed away in 2013.

In her 2005 Profiles of SWE Pioneers Oral History Project interview, Yvonne Brill discussed her education and career; her work on rocket propellant systems; her

experiences at Douglas Aircraft Company, RAND Corporation, United Technologies, RCA, and NASA; her involvement in SWE and other professional organizations; and awards that she has received throughout her career. She was also joined by her daughter, Naomi Brill, and together they discussed family history, Naomi's experience in engineering, and their personal and professional relationship as a mother and daughter in engineering.

- July 2016

YVONNE BRILL

DR: This is an interview with Yvonne Brill on November 3rd, 2005, in Anaheim, California, for the Society of Women Engineers. And the interviewer is Deborah Rice.

Well, thanks, again, Yvonne, for agreeing to speak with us today.

YB: It's my pleasure, of course.

DR: And can we start off by talking about your family background, and what your childhood was like growing up in the '20s and '30s in Canada.

YB: Well, neither of my — I'm pretty sure that neither of my parents have graduated from high school. They were literate, they could read and write. My father had immigrated with a slightly older brother from Flanders, Belgium in about 1909, I think, and settled in Chicago. And the whole Claeys family, which is my maiden name, were in the carpentry construction business.

I remember one picture that I've not been able to find where all the ten brothers or something were lined up in front of the workbench in the carpentry shed in the family home in Dupint, Gent (phonetic). And my dad's brother went back to Belgium, but my dad stayed and migrated up to Canada to a city of St. Bonafice, which had a lot of other Flemish speaking people, immigrants.

And my mother came over from Flanders. I guess her stepfather sent for her and the rest of the family, younger brothers and sisters, siblings. And they settled in the city of

Winnipeg. And my parents met there. But we lived in a suburb of Winnipeg, where most of the immigrants — most people were first-generation — like myself, were first-generation Canadians, and had immigrant parents, either from Britain or one of the British possessions.

Education wasn't high on the agenda. I was the youngest of three children. I have an — had an older brother, an older sister, and myself. But we were all pretty good students, so our parents never really paid very much attention to what we did in school.

But I can remember, from a very early age, for whatever reason, the motivation that I wanted to go to university. Most of the transportation in the city of Winnipeg was by streetcar in those days. And the streetcar passed — when you went to the Winnipeg Auditorium for various things, it passed the junior buildings of the University of Manitoba. And I just decided, when I was about ten years old, that I wanted to go there. (laughs)

DR: Did your older brother and sister go to college?

YB: No. I was the first one to go to college. And my brother joined the Canadian Army, and was in the Army for six years until after VE Day and VJ Day.

And I went.I was good at high school — at math and physics and chemistry in high school. But none of the teachers particularly encouraged me. We had a male teacher for physics who just felt that women would never get anywhere.

DR: Did he actually say that?

YB: Yes, yes, really. (laughs) The school principal was a little more forward looking. He thought that I should go to Normal School, which was a preparatory teaching school. After one year at Normal School you'd get a teaching certificate and you could teach. And that was kind of the focus for women in those days. And that just didn't sit well with me. I just felt I had more enterprise than that. (laughs)

We had excellent English teachers. Most teachers in those days had advanced degrees, because it was the Depression, and very, very difficult to get a job. And so they were very good teachers, relative to what I saw when my kids went to school. And I had, I think, a pretty good high school background.

And when I graduated – I just sort of didn't really realize that I was relatively intelligent until (laughs) I got to high school and started to get top marks. And I won a scholarship for the first year at university. It was very inexpensive in those days, because you just had your tuition. The university residences had been given over to the Army. So I enrolled, and I enrolled in science. And for the last two years I took only physics, chemistry and math.

DR: Last two years in high school?

YB: This was university. I did take some liberal arts. I was pretty good at English and writing essays, and things like that. And when I was thirteen, I won a national story contest. (laughs)

DR: Oh, wow.

YB: Which I wish I still had the story. (laughs)

DR: Right. Do you remember what it was?

YB: Oh, yeah. Well, this was a Christmas story contest. And they had two different classifications. One was for people under thirteen, and the other was for adults, real adults. (laughs) And my story was about Christmas on an Arizona ranch. I didn't have a clue what an Arizona ranch was like. (laughter) But it was pretty imaginative. And my prize was *The Wind in the Willows*, which I always remember, as a text. And so I did relatively well, I guess.

In the University of Manitoba, we didn't have grades A, B and C. It was pass or fail.

DR: In all your classes?

YB: In all the classes. The fifty percentile was the pass. And that created some problems when I got down to the States, because it was hard to know exactly where to place you in graduate school. (laughs)

But anyway, when I graduated, because of the fact that men had been conscripted, young men even out of the university had been conscripted into the Canadian Army during the war years, there was a shortage of — I'm sorry, it was in the United States where the men had been conscripted since 1941 on. There was a shortage of technical people, of technical graduates. And so the job offers that I got — I don't know how I ever applied for a job at Douglas in Santa Monica, California. But two of them came through from the United States. One was California, and the other was New York.

And I had gotten the notion in my head by the time I graduated I'd love to go to South America. So California was on the way. And I didn't really discuss it with my parents, I just went ahead and got all the paperwork together and left. (laughs) And I didn't know a soul. I had a one-way ticket— and arrived there. Fortunately, the assistant to the head of Personnel in the Research Department at Douglas, which had hired me, lived with her mother. And they just took me in immediately. And that was really very nice. It was difficult finding housing because of the war and all the extra — it was after VE Day, but before the war with the Japanese had ended. And so there were a lot of people working in Douglas that had come in from Oklahoma and various other places in the United States.

And I was assigned to the Research Department initially, but then after VJ Day, I guess Douglas sent — I had a one-year contract that I had to stay with them for a year. And by the same token, they had to keep me for a year before they could let me go. And I think they sensed that the Research Department work — that they'd have to have big layoffs. And so they transferred me down to Aerodynamics, because the Aerodynamics Department was opening up. You know, it was the end of the war, they were going to have new passenger planes, get away from the DC-3 and the DC-4.

And so I was in the Aerodynamics Department, which was staffed by really brilliant engineers. It was kind of intimidating in some ways. (laughs) But there were just a very

few, maybe three or four professionally graded executive – the differentiation was whether you punched a time clock or not – very few, maybe just three or four women in the executive category. The Aerodynamics and Advanced Design Departments were together in the same physical area. And there was one woman with a green badge there. And she and I became pretty good friends. She had a math degree from UCLA, but her boss had total reliance on her. He really respected her opinion and her work, and that was nice to see.

I started work in July of '45, at Douglas. In the spring of '46, the government issued a request for proposal for Project RAND, which was, at that point in time, to put up an unmanned earth orbiting satellite, which was highly secret then. (laughs) And I was part of the proposal team, and Douglas won the contract.

DR: This is Douglas Aircraft.

YB: Douglas Aircraft, right. And so Project RAND was set up. And I had been doing both slide rule and Marchant – these are old-fashioned calculating – very clunky calculating machines (laughs) – computations on both, for Bob – Dr. Robert Kruger, to whom my friend Eva, who was the professional engineer, reported. I'd been doing these trajectories for the sizing of the different stages on the rocket to get us to 100 nautical mile orbit. And my calculations came within two-hundredths of his guess.

So I was the most capable person (laughs) there. And in the meantime, I just could see that there was absolutely no future

to punching these keys and being classified as a mathematician. It was just a dead end. So I decided, well, now, I need an advanced degree. So what shall it be? And I wasn't good enough at math. And I didn't know what a math Ph.D. would do, anyway, for a job. And I didn't feel I was good enough at math to do a physics degree. So I decided on chemistry.

So I started to work — I had started already before the RAND Proposal, to work on a masters in late-day classes in chemistry. And because of that interest, Dr. Kruger told me when they got the money for the RAND Project to set it up within Douglas, if I would join the project, that he would see that when they set up a propulsion or chemical group, that he would transfer me over. And he was as good as his promise. So in the chemical group I got to review a lot of captured literature to see what the Germans had used in their rockets, so it was very fascinating.

And then because no performance calculations really existed for rocket combinations, fuel combinations, in the United States, that was one of our charters, to calculate. And we needed thermodynamic data up to 5,000 degrees Kelvin. And the National Bureau of Standards tables in those days only went to 3,000, I think — 2,000 or 3,000. So we had to extend those tables beyond, which we did, in order to be able to calculate the performance of these fuel — whatever fuel combinations we decided.

This was very — you had to set up chemical balance equations and all kind of equilibrium equations. But we did it,

and we got the tables extended. And eventually the National Bureau of Standards came up with the extension as well – which wasn't really that far from what we had done – calculated that they should be. But we went ahead and did all these performance calculations.

And meantime, I progressed on my masters degree. A young woman had come from Berkeley who had a Ph.D. who was really a brilliant chemist. And she had worked for – I don't think he had a Nobel Laureate at that time, but she had done her Ph.D. under someone who was quite famous. And Estella (phonetic) was at the very lowest assistant professor level at USC, but there weren't any other women in the faculty, and there weren't that many women graduate students, either. So we got to know each other quite well. And I could see right away that she was just too brilliant to (laughs) be able to progress very far. And they didn't give her tenure.

And so meantime I got tired – RAND was purely theoretical, and there was a Ph.D. every square foot (laughs) in physics or some other discipline.

DR: What about engineering?

YB: There were some engineers, but the engineers also had Ph.D.s. But yeah, there were aerodynamicists. But when the Cold War – when the Berlin Wall was put up in about 1948, then the charter for RAND switched from the unmanned earth-orbiting satellite to war games and missiles. So we started to work on things like Nike and Atlas, and so on, so that the original focus changed. And everything was theoretical.

I was put to work on a special project for propellants for ramjets, and it got to be very interesting. And I applied for a job — I wanted to change, because I wanted to get into a place where I could do something instead of just, you know, do paper. (laughs)

So I went to work at a little company called Marquardt, where I was the only woman engineer. And they sort of reluctantly hired me, but they knew they needed somebody to work on propellant work for ramjets. So just about the time I joined Marquardt, RAND put out a report indicating that ramjets would just never do anything. (laughter)

DR: Really?

YB: But we still were working — we had Navy contracts. And Marquardt was a really interesting entrepreneurial company. The owner and founder worked there, and his wife worked in the library. It was a very family type organization.

DR: So you considered yourself, by this time, an engineer.

YB: Right. And what really motivated this — first, I enjoyed the work even after I started, because in the test cell, you know, doing measurements, performance measurements, and figuring out how you might change a design to do better — and it was very clear that as a woman chemist, even with a Ph.D., that was such an old, established industry, that I would be discriminated against. There was just no question. Whereas engineering, as an individual of one, they weren't about to make rules to block your progress, because that was too much trouble. And that really worked out very well.

DR: So you never felt that there were obstacles, then, for you as a woman engineer, being the only woman engineer at a company?

YB: That's right, right. Yeah. And I was very pleased, because I really only stayed there for about three years, I guess, but in the years that I was there, they specifically — they had never hired chemical engineers before. And they specifically looked for men who had chemical engineering degrees. So I felt this was pretty nice. And I worked for a person who was well-established, very advanced looking, and a tremendous rocket designer who had left North American Rocketdyne to come to Marquardt. I don't know whether he — what had — they wouldn't follow some of his ideas, so he just decided to pack up and leave and come to this small company. And he really sponsored a lot of my activities. So I got more heavily involved in propellants, but also really understood ramjet design.

There were two major divisions within the company. One was the Aero Division, that worried about what happens to the flow of the air as you go through — you know, as you compress in the compressor. And I was working on the stabilization of the flame front in the ramjet, to make it go forward. (laughs)

And one of the individuals who was in the fuser portion, we wrote a report together that illustrated how much more range you could get out of using some very special high-energy fuels, which eventually triggered off a program within in the Navy called Project Zip. And of course, years later, it turned out

these were highly carcinogenic. But still, by good fortune, I guess, how we designed our ramjet, we designed it in a range where some of the properties that were later found to be detrimental would not have affected – in other words, the results still stand. And we did it on like a $2,500 budget, which would be unheard of now. (laughs)

In doing my masters at night, it was very slow going. I was at University of Southern California. But I lived in Westwood, which was close to UCLA. So some of the term papers I had to write I researched in the library at UCLA because SC was in a very rough district in downtown LA, and I had to use public transportation to get there. So it was not a place I wanted to be late at night.

So I went over to UCLA, and several graduate students spotted me there. And in, you know, just casual conversations, who I was, what was I doing, because I obviously wasn't one of the graduate students there. So Linus Pauling, who was a very famous chemist, was giving a talk at the local American Chemical Society section. And I decided I would go, because he just was a really inspirational interesting speaker.

And I ran into these two students from UCLA that had seen me, and they introduced me to this person who had a post-doctoral fellowship at UCLA. And so out of courtesy, I asked him what he was doing. And he said he was calibrating pistachio nut machines. (laughter) And I thought, "How on earth could this person ever have gotten a Ph.D.?" And so the calibration

of pistachio nuts was putting your money in and seeing how many nuts you could get out. (laughter)

But out of courtesy I asked him what his Ph.D. — what his post-doc work involved. And he was working on something called electron deficient chemicals, which were the acetylenic compounds where you've got unpaired electrons that can rearrange in various ways. And he was saying he had difficulty getting his starting material, and it was something called propargyl alcohol.

And I said, "Well, that's silly. I got a letter in the mail from some company" — that I really couldn't remember the name of — I'd filed the letter, because I worked it out that it was not a viable ramjet fuel. I said, "I've got this letter, and they were offering me a gallon quantity to test." So he had to call me up to find out the name of the company. And at the same time he asked me out folk dancing. (laughs) Well, I thought, well, I've been in a stick-in-the-mud too long, I'm going to go. (laughter) So when he arrived we decided that neither of us cared for folk dancing, and we went to the movies. But within the year, we were married. (laughs)

And then all of my husband's opportunities were in the East because he was a research chemist. And all of my opportunities were mainly on the West Coast, because the aerospace industry was there. But as I was telling the young lady who was sitting next to me at breakfast this morning, who has a similar situation coming up, I told her to remember that good jobs are

easier to find than good husbands. (laughter) And so I married him, and we moved east.

DR: Okay. And your husband's name?

YB: It's William – it's Bill. And he's a very understated person. The pistachio nut machine calibration is sort of typical, but he's certainly – his attitude is different than mine, as far as publication, and things like that. And through the years, he changed, but he's always – he's just his own person.

And anyway, we got married, moved east. And then we went to Europe. We pooled all – the little money we had, and we spent about six months in Europe, just as third-class tourists, went from here to there. And we came back to the United States broke, (laughs) but went to an American Chemical Society meeting in Atlantic City, the national meeting, and both applied for jobs.

DR: Sorry to interrupt, but before we move to the East Coast, I wanted to ask you some questions first about your college experience at the University of Southern California, and what it was like being a woman in what was then technically a male-dominated field, and if you had any insight—

YB: Well, as far as chemistry was concerned – remember, now, my masters is in chemistry. And there were women working on their Ph.D. And there was a woman there who had a post-doctoral, who came from the University of Cambridge in England, who – they wouldn't award her a Ph.D. at Cambridge, but it was some other certificate. But she was very, very capable. So

there were five or six women in the graduate school, and no differentiation. One of the professors was married to a woman chemist who also taught at a different university. It was a good environment there.

DR: Did you ever feel like you had – was the woman from Cambridge, for example, a mentor? Or did you have any mentors at that time?

YB: Not really. I would consider Joe Freedman (phonetic), who was the head of the Ramjet Division at Marquardt as a mentor, in the sense that I had no idea when I started there how much below the men my salary was. But I got a raise every three months for the first two years. (laughs) So I sort of caught on that there was something here. And he was the one who pushed that through, you know, because I did good work, I worked hard.

And I was very careful when I was in the test area. They were very concerned about how the technicians there – who ran the facilities and things, how they would react to a woman. And you know, that all worked out. I think once you show that you're not going to rely on being feminine to get by, that you're going to do your share of the work, and maybe more, that you get along. Actually, I had more discrimination, in a sense, at the University of Manitoba, because after I started there and was working in science, I got the idea that maybe I would like to do an engineering degree.

DR: So you were aware that engineering was a career option.

YB: I was aware of the classical types. But there were no women in the Engineering Department. And they claimed that they couldn't enroll women in the Engineering Department. In those days it was all classical, like mechanical, civil – and mostly civil – and chemical, in the sense of the chemical industry. And part of their curriculum was a summer camp. And they said they just couldn't do special arrangements for women.

And so I guess going back a step, which I skipped, is when I graduated from high school and was ready for college, I would loved to have gone to MIT and studied aeronautics. Sort of like Barbara Johnson in the caption yesterday, Amelia Earhart was one of my heroines. It just seemed like to do things like that with freedom to fly was great. But my parents wouldn't let me go that far from home, and it would have been much too costly, anyway. It was easy to go to the local university, University of Manitoba. And I'd graduated from a high school that had the credentials that you could get in without any problems. So that's really what I did.

DR: So when you were in high school, then, that was when you found out about what engineering was?

YB: I didn't find anything about engineering, but what science was about – and mostly chemistry, because you studied some chemical processes in those days – which I think is probably totally gone from high school curriculum now. (laughs) But anyway, they did teach you how salt was made, or you know, the reactions that took place, and everything.

And I took chemistry and physics, as well as languages. So I really had a pretty well-rounded education to enter the university. And so I gave up thoughts of engineering, actually, at that. I just graduated with a science major.

And we didn't have majors in the same sense that they do in American universities. But I had just taken only physics and chemistry in my last two years, so that they considered that either one of those was a major when I enrolled in graduate school. But I was just a part-time student initially, anyway. And they were eager for students after the war. This was before the big influx of GI people came, so that it was easy to get started that way. And I just continued — it took me at least three years.

And I did a very credible laboratory research project on the conversion of para to ortho hydrogen, which had some value. (laughs) And for my last year, when I had to do a lot of lab work, I had a Douglas Aircraft Scholarship that allowed me to work half-time, so that I could spend half-time in my lab. And then I had the pain of writing up the thesis (laughs) afterwards, which I eventually finished. But by that time I was very well into engineering.

DR: So why a chemistry Masters, then, and not chemical engineering, for instance?

YB: I didn't really think about the chemical engineering aspects. You know, I probably was thinking more of the work I was doing at RAND, which was in extending the thermodynamic tables, that was all really physics, you know, the binding — the

bonding between atoms and molecules. And also the propellant calculations were almost totally involved with chemical equilibria and thermodynamic balance, so that, you know, it didn't seem that far out.

And the one thing that was really great when I did go into engineering, is because most of the engineering graduates had steam boiler experience. (laughs) You know, that's what they were teaching in school. None of them had compressible flow, or the things that were just up and coming. And so the companies taught those within their own confines. So I was really on the same footing at Marquardt with the other engineers who had just graduated. And we took these internal courses on compressible flow. So I never really felt at that much of a disadvantage. Of course, my whole thought process was different than theirs, my orientation, and how I looked at things.

And when we moved east, of course, I couldn't find – well, I guess United – my husband went to work for a company called Ola-Matheson (phonetic), in the Research Department, which they had just set up. And he was very enthusiastic about his job. And I went for an interview at United Aircraft – Pratt & Whitney, actually, which was, of course, a big engine company, even more so then than now. And I felt right away when they sent me over to the Research Department after about an hour interview (laughs) that there was something wrong here.

DR: Oh, really?

YB: So the Research Department – I was interviewed by somebody who was quite impressed with my background and wanted

to hire me. And so I hired in there. And we found a place to live that was sort of equally distant between the two jobs. (laughs) And I had to do turbojet engine cycles, which weren't all that exciting. But I got some special projects started within United Technologies with a lot of initiative and push, and just getting the job done (laughs) with a little help here and there. But we only stayed there three years.

My husband decided to leave where he was and move on. And that's how we wound up, basically, in the Princeton area. And he worked for a company called Petrotex, which was half owned by Tennessee Gas at the time, and FMC, the Food Machinery Company. And they were setting up this nice research lab in the Princeton area. And I found a job that I had to commute to on the train and by car at Wright Aeronautical, which was an engine company.

The person who hired me in at United Technologies in the Research Department, after eighteen years just packed up everything and left. (laughs)

DR: Oh, right after he hired you?

YB: Well, no. It was three years after. And he showed up at Wright Aeronautical, which was the Division of the Curtiss-Wright, the Engine Division. And he had a charter to set up an Advanced Engines Department there. And so he picked off people that he thought would fit into his new organization. And I had decided I'd leave United Technologies — it was really ends-ville. The fellow who eventually became director of research there had told me flat out to my face that I have to work twice

as hard as a man for the same promotion. And I thought, well, I've got to do something else.

So at this point I checked in with Yale University to see how much I would have to make up to do a masters in chemical engineering. And it wasn't all that much. And they thought they would accept me. But in the summer that I was taking some courses to re-orient to chemical engineering, my ex-boss from United Technologies found out I had left, and he made me this great offer at Wright Aero. And we were living in the Princeton area then, I guess. So that was just a natural.

DR: And it was Columbia University that—

YB: It was at Columbia that I was doing the Masters.

DR: So when you went to work for him at Wright, did you continue there?

YB: No, I didn't. It just didn't seem worthwhile. It didn't really make any difference at this stage, I didn't think. I took courses in flow processes, but for what I was doing, I had a combination of ramjet work on the Navajo missile and advanced turbojet turbofan engines.

And when Sputnik went up, Wright Aero decided that they would bid on the lower stage of the Apollo launch vehicle. And of course we had a group of about – less than a dozen people in Rocketry at Wright Aero. So we bravely wrote this proposal. And of course, it wasn't really seriously considered by NASA. (laughter) And Rocketdyne won it. But we made a brave try.

And then I got pregnant with Naomi, and I took a leave of absence. But while I was gone, they lost the Navajo – the

Navajo Project was cancelled. And it wasn't really that practical.

So after Sputnik, then, FMC [FMC Corporation] was doing a lot of work for the advanced — it was ARPA then, not DARPA, Advanced [Research] Projects Agency. And they found out that — I knew from going to technical meetings at the American Rocket Society that there was a division in Buffalo of FMC that did peroxide work. And I connected with those people, I did consulting for them. I did performance calculations.

And luckily, over maybe a six-year span, I was hired two or three different times, each of which they reactivated my security clearance. Everything was classified, and if you didn't know what was going on at other organizations, you really didn't have a clue as to direction. So luckily, each of the times they hired me, they just reactivated my clearance. I was able to do a lot of performance calculations to guide their chemical manufacturing, or to eliminate compounds that wouldn't be fruitful for performance. And then, eventually, my job at RCA showed up.

DR: Well, before we move on there, going back a little bit to when you worked at Wright, were you aware of the Curtiss-Wright Cadet Program for women that they had in the U.S. during the war?

YB: I only learned about that later, through SWE. I met somebody who had been part of it.

DR: So when you were there at Wright, then, you didn't encounter any other women.

YB: No. There were only two other women engineers that I remember. One was in research. They both had graduated from the Newark College of Engineering. One was a Russian immigrant, and the other was married to an engineer, who eventually came to work at the RCA Astro-Electronics. But those were the only other women engineers that I was aware of. And I think both of them were in research, and maybe I was the only one in the Engine Division.

But because of the respect that the upper management had for the person who headed up this Advanced Engines Department and the rest of the people in the group, you know, it just wasn't a problem. We had lots of arguments, (laughs) technical arguments with the other groups. But usually we were able to prove our point, in terms of design, or in what direction things should go. And so, again, it was a positive experience, and not at all negative.

United Technologies was not that negative, either, because I already had professional status. Even though I didn't have an engineering degree, they hired me at a professional level. There were a number of really capable young women working there who'd graduated from Smith and Wellesley, and universities like that, with math majors, who were just hourly employees. They wouldn't give them professional status no matter how good they were. A lot of them did very responsible work. But that was the kind of corporation it was.

And because I had done a lot of rocket work and a lot of ramjet work, two fields they were interested in, in addition to

the turbojets for commercial aircraft and military aircraft, I was assigned a couple of special projects. I was one of four people who was tapped to write a white paper for the Director of Research at United Technologies as to why they should get into the rocket business, which they eventually did. (laughs)

And it was there that I really got to thinking in perspective that finally led me to discover — to propose this new rocket engine that I got a patent on. And just simply in looking at the performance and trying to decide what areas of the periodic table one could put emphasis on to get higher performance fuels.

Just looking at the equations that you use to calculate performance, it occurred to me that if you stripped out all the gamma —1/ gammas — which were the heat capacity functions — that it boiled down to the two important factors were the square root of the chamber temperature divided by the molecular weight of the products.

And so I, just for the heck of it, did a graph of ISP, which is the performance parameter versus tc/m, and I could see quickly if the molecular weight of your exhaust gases didn't change very much and you could increase the chamber temperature of the exhaust gases coming out, you could get higher ISPs. So that just always stuck in my mind.

And eventually, after two or three consulting stints with FMC, which at least kept my clearance up, several of the people from the Engine Division — not the division I'd been in at Wright Aero — but the Engine Division had gravitated down to the

Space Center at RCA when it got started up after Sputnik. And I contacted one of them, and they didn't really need a propulsion engineer. But the one propulsion engineer they had quit, eventually, and they interviewed me and decided to hire me.

DR: So this was after you had been consulting for a number of years.

YB: At this point I had three children, Naomi, Matthew and Joe. And I always remember there was a very old-line person, typical stodgy old-line person in charge of personnel. And his argument was, "How could a woman with three children ever get to work on time?" (laughter) And years later — I mean, I stayed there for almost twenty years. Years later when I got him off the hook many times by my SWE activities, which they gleefully put in as part of their staving off the Equal Opportunities people, (laughs) he apologized to me and said I really had worked out very well.

DR: Well, that was nice of him.

YB: But one of the nicest things that I remember of the first interview at RCA was I was interviewed by this individual whose name was Dr. Jack Keigler (phonetic). And I didn't realize his position within the company at the time. But what he said to me was, well, he thought that I would be an ideal employee, because obviously, being a woman, I was mature (laughs) and had my family bearing years behind me, and it should work out very well. So they did make me an offer, and I started there.

And the first thing that the group I worked with wanted to do with me is they wanted to make me a systems engineer, someone who knew something about propulsion and attitude control, and power systems, because most of the men were all-round, I mean, diversified in what they could do. And my opinion was that their need was for a true propulsion engineer.

So they were very disappointed — the men that I worked with were kind of disappointed in me in the first year. But by the end of that time, I think I'd convinced them that I was on the right track. But I really felt pressured. I kept thinking, "Am I a failure?" Because this was a totally different kind of job than anything I had done ever before. Spacecraft is quite different. And you've got a square box to work with, not an aerodynamic— (laughter) surface. And I thought, well, now, of the people I worked with at Wright Aero, for example, most of whom are pretty capable, would any of them be able to do what this group is expecting of me? I thought of a couple that would. And finally I said to the fellows, "If I were as smart as you think I should be, I'd be too smart to work here." (laughs) And that killed their criticism.

And one of the first projects that I got to work on was something called a Voice Broadcast Study, which was out of NASA Lewis, and it was to study spacecraft that would be used for communications. I was the only propulsion engineer there. I had the total responsibility for looking at what kind of propulsion systems to propose.

There was a lot of work being done on electric propulsion at that time, at the research level, at various locations. And they were coming up with these enormous ISPs like 1,000, 2,000 seconds, which was a hundred times more than you could get out of chemical propulsion, so that was the cat's meow.

But when I looked at it from the satellite standpoint, we were using solid apogee motors, so when you inject, you have to have good pointing accuracy, which wasn't really the case in those days. (laughs) And often, for example, the whole — after the apogee motor had burned out, you might find your spacecraft drifting in the wrong direction to the station you wanted it to be at. And you'd have to fire a chemical propulsion system pretty quickly to stop it while you still had it in your ground vision, and send it the other way.

So that convinced me you definitely needed chemical propulsion. And the electric propulsion engines that were being worked on had such high power requirements they couldn't really be used. The thrust levels you needed were not compatible with the power levels that the poor spacecraft could provide.

And so it just occurred to me — I started think well, there's got to be an easier way — something called hydrazine with a Shell 405 catalyst, where hydrazine decomposes exothermically, it gives off heat when it decomposes, when you put it over this catalyst bed. It does it instantaneously, and you can start and stop the engine as many times, and get small impulse bits, that you need for attitude control. It was just becoming the vogue.

And I had remembered reading that – well, your exhaust products from hydrazine are either ammonia – they're ammonia and hydrogen and nitrogen. And the ammonia is a fairly small, lightweight molecule, hydrogen is very lightweight. The nitrogen, I thought, well, might be a drag in this equation of the square root of the temperature over the molecular weight. But if you could put a heater on the hydrazine, when the hydrazine decomposes it automatically takes you to a temperature of about 2,000 Fahrenheit. And if you just used a simple heater, it seemed to me how, up to the limit of materials, that you could get a lot more ISP.

So I did the calculations. And I had somebody that I knew who was capable of checking them check to make sure that my numbers were right before I proposed it. And then I did a whole analysis on my own time, really. I came in nights and weekends and sized the systems and proved that, for this Voice Broadcast Study, if you wanted to put electric propulsion, which had these great ISPs – I proved that you definitely needed chemical propulsion to start and stop the satellite if it was drifting in the wrong direction; or to get a change in orbit or location as well, you need to do it quickly, so you had to have the two systems on board.

And I did it in a parametric study for certain class weights of spacecraft, that you might be going four or five years before you reach the crossover point where just a pure chemical system, like a hydrazine resistojet would be out-stripped, performance-wise. And at that point in time,

communications didn't last that long; the transponders gave out. (laughs)

So RCA – especially Jack Keigler, thought this was a great idea. And we also had a consultant who had always tried to get RCA Astro involved much, much more in propulsion than they were, and they always resisted. But anyway, he tried his best. And he thought it was a good idea, too. And when we talked about it, RCA didn't want to go into the development of the engine itself. But they did go ahead and secure a patent.

And we made many proposals for the first – let's see, I wrote the patent disclosure in 1967, I think it was. They actually secured the patent in 1972, because a patent attorney got interested enough to pursue it. He said, "We either should drop this or pursue it."

DR: The patent was under your name, right?

YB: Yeah, but consigned to RCA. And we proposed it on a number of satellites and didn't get a customer quite ready for it. But many of the satellites we made were for RCA Americom, which was the communications arm of RCA.

And eventually – well, first of all, a decision was made that they would give the idea to industry, like to TRW. And our consultant, Preston Layton, had a graduate student who worked at AVCO. And he got permission from the company to let TRW and AVCO both know about the idea. And AVCO actually started to work on a hydrazine resistojet. And we got hold of one of their engines, and did an IR&D study, which really demonstrated the principle. So that worked out. And TRW also pursued it. But

meantime, AVCO went out of business, especially that kind of business. (laughs)

And we were working with a company called Rocket Research. So between Rocket Research and RCA, they jointly financed the qualification — flight qualification of a hydrazine resistojet, and flew it as a single-engine experiment in 1983. And that worked so well that eventually RCA switched over to — because your performance increase was from like 225 seconds ISP to 300, with not very much power required to do the heating of the exhaust gases, because you already had this nice big push from the hydrazine decomposition. It's about the only propellant that decomposes — that's stable at room temperature that decomposes exothermically.

So after — they put a whole quadrant, four engines for north - south station keeping(?) which uses the major portion of your propellant on a satellite. They introduced that. And then once they had done that, NASA Lewis was working on a research project for a hydrazine arcjet, which increased the performance to 500 to 600 seconds. It required a little more power, but satellites were growing in power, anyway, just as a natural consequence of lighter weight solar cells and more durable cells, and longer life TWTs and so on. So the people from Lewis contacted me and we got an arcjet put on. And when GE took over, they just continued with the hydrazine resistojets, which became known as "electrothermal hydrazine thrusters," which is really a more correct nomenclature, rather than "resistojet." But those became fairly standard on RCA spacecraft.

And at this point in time, I went overseas. I had stopped work at RCA in 1981 to '83, and had taken a job at NASA Headquarters, which had its own interesting aspects. It was work on Shuttle, I was manager of the solid rocket motor on the Shuttle. And when you saw the many problems that they were facing it was a good place to leave. (laughs)

So I got persuaded to go back to RCA, which was really a mistake. You always have to remember you must have good reasons to leave a place initially, and you shouldn't go back. (laughs) Because the management had totally changed from the people who were in power — not in power, but running the place after I returned. And I felt that I was just delegated to doing proposals, which I found very deadening, not very inspiring. Whereas before, I had actually been out on a line, monitoring the build of the propulsion systems, and doing a lot of the design, and the on-orbit or prior-to-orbit analysis.

So one day I was crossing from our editorial building to the parking lot at RCA, and I met an old colleague from TRW who asked me how I liked being back at RCA. I said, "Well, I was thinking of putting a resume together," because I wasn't too happy. And all of a sudden his face lit up and he said, "Would you go to London?" I said, "Well, I don't know, I might." He said, "Well, I know of a group that's just dying to have a good propulsion engineer." (laughs)

So this was in April, I guess — or February, and by April I went for an interview. And I decided to go to — that I would accept a job there, which they offered. And I thought my

husband would come with me, but meanwhile, his company had been sold and resold, and everybody was terminated. He was sort of pushed into early retirement. But he was offered a position of visiting fellow at Princeton University in the Chemistry Department, which was just too much prestige for him to leave behind. So I went off to London. And he stayed – he kept the house foundations.

DR: Did the kids stay with him?

YB: Oh, they were all – Naomi was gone from home. Matthew had graduated from college by that time. Joe was still at the University of Arizona. But that was far enough away – you know, a long way away. And they really didn't need – they didn't need me. (laughs)

DR: Let's stop there just for a moment so we can switch tapes.

(INTERRUPTION IN RECORDING)

DR: Okay. This is tape two, with Yvonne Brill. And we're going to go back and talk a little a bit about when you first started a family, and what it was like trying to maintain a career at the same time you were raising young children.

YB: Right. Well, Naomi was born in 1957. I went to work full time at RCA in June of 1966. And so she was in school a full day. And Matthew was born in 1960, and Joe was born in 1964. So Joe was really only two when I went back to work full time. And I worried a bit about that. How I managed, as far as child care was concerned, through the barber at the local little town, that was local, he knew a widow who needed a job. And she

was a very, very good housekeeper – a terrible cook, but a very good housekeeper.

So we would pick Derling (phonetic) up at 8:00 in the morning, or close to 8:00, either my husband or I, and then we'd take her back to her place, which was just a mile away. And she was there Monday through Friday. And I could leave the dryer running so that she would fold the clothes. And she picked up every toy in the house. (laughs) It was really the neatest looking house that I've ever had. I never achieved the same thing again. But she was just one of those elderly women who did the housewife job very well. (laughs)

And so Derling – we had her during the school term. First of all, she would have exceeded the amount that she could earn and still maintain her Social Security, which she needed desperately because she was a widow, so she had summers off. And I was afraid I wouldn't find anybody for the summer.

But as a last chance, at Rider University, which is a local university, the woman in charge of employment there knew of one young lady who would rather do babysitting type jobs than take a waitress job. So we had Wanda. She was just a marvelous young lady. And she changed her major a couple of times so that she came back at least for four summers.

And the kids loved her. And she took them swimming and did all sorts of things with them, and kept them pretty happy. And if they had to go to two-week camp or something, she drove and got them there. So that worked out very well. I think one of the things, if everything was transposed to this era, I would

really be concerned, because you have a totally different type of person for babysitting. You almost are constrained to finding a really good day care center rather than trusting individuals these days, because I just don't know how you would ever let go... (laughs)

DR: So what prompted your decision, then, to go back to work full time?

YB: Well, I really wanted to go back to work. I really did.

DR: Did you feel you had to, to—

YB: Well, not for economic reasons, but yeah, for my own satisfaction. I just had the drive to do it. And this is something that my husband had agreed to before we got married, that if I wanted to continue working — and I did for at least, I guess, three or four years — oh, I'm trying to think — oh, at least five years after we were married before we had children. And we each had our separate careers.

He's a very self-confident and capable individual. And one nice thing — because I've seen it sometimes in younger engineers who are married who have dual careers — sometimes the husband gets very jealous, depending — you know, I got a lot of very good press just simply because I was in the right place at the right time. It wasn't I was so great, I was just in the right place at the right time, which was really my good fortune. And so he just never really cared.

Somebody asked him once — well, a couple of things. One was because I had to work long hours, being the only propulsion

engineer on these proposals. The first ones were really very difficult to do, to get them right so we'd win the proposal and win the job. And so at some company party somebody asked my husband — there were not very many wives out working then, either, in the late '60s and early '70s — they asked Bill how did he feel about the long hours I put in. He said, well, he'd be happy to outlive me and spend all the money that I made. (laughter) So that was sort of his attitude. He didn't care.

But I felt very put upon. I just made sure that whatever the kids needed for their school projects, that they had it. Bill didn't help at all in those years with any of the housework or anything like that. He'd just been raised in a home where his mother did everything. You know, it was just not anything that his father would have thought of doing. (laughs) And I don't know that that made it any harder, it just meant I had about zero time to myself. But I accepted that, because I was happy in my job, I liked what I was doing. And I felt that I was making real progress, you know, introducing all these new ideas.

And the one wonderful thing about RCA is — when I got together with my other propulsion colleagues at big technical meetings, they were all constrained from doing many things by bureaucratic red tape — the Astro Division of RCA was quite apart from the mainstream. Cherry Hill was the mainstream. And none of the people in management at RCA Astro had aspirations to be president of the corporation, or CEO, or anything like that. There were some internal politics, but not the devastating kind

that you get in a big corporation where somebody really wants to be a VP, or something like that. And so it was a nice environment, in spite of the fact that you had a lot of other bright people that you were working with. (laughs)

DR: So what did your parents think about your career, or your life up to this point, the fact that you had gone to the United States, you'd gotten an advanced degree, you were working full time?

YB: I don't think that they really ever had any idea of what I did, in any of the places where I worked. And I remember once my mother visiting and acting very disgusted because I had to do laundry on Sunday. (laughter) What are you going to do? Kids have dirty clothes and—

DR: Did she expect that you should have been a full-time mom?

YB: My father's idea when I was ready to graduate from high school or college was that I should open up a small dress shop, or some kind of a commercial enterprise like that. Well, I just wasn't cut out for that. (laughs) And I was the youngest. I'm sure it was very difficult – more difficult for my mother. There was a big age difference between the two of them, and my brother was away in the Army, and my sister had gotten married, and was living in Ottawa. And I kept closer contact with her through the years, until she died of cancer in the mid '70s.

But in recent years, when I got closer to my brother – who lived in Vancouver and died about three years ago, he understood

what I did, and was very proud of me. But I just don't think my parents ever had any idea. They couldn't understand why I would want to go so far away from home, because the norm was to stay close to home in those days.

And the minute Naomi was born I just faced the fact that I doubted that any of the kids would be in Princeton, that they — even though there are lots of opportunities there, that they would just go where they wanted to go, which turned out to be exactly the case. (laughter) So I took care of — made sure that they got to things.

And the high school they went to, the junior school — especially the high school, was a new one. When we had moved to the location we're in, the township was a sending district to Princeton High school, which had all kinds of drugs and alcohol as the years progressed, in the school. At Montgomery Township, Princeton threw them out as a sending district because their own school population was too big, they couldn't accommodate the Montgomery Township high school kids, so we had to build our own high school. And the kids who did alcohol and things like that were the "out" group instead of the "in" group.

And our boys were into sports, all kinds of sports. And Naomi was time keeper for the cross-country relay team, and things like that. And so we really didn't ever have any problems like that. And I'm not sure what they did when they went to college, but they seemed to be okay. (laughs)

We're great zoo attendees. We took them to the Philadelphia Zoo. And one of the favorite projects — for some

reason, RCA, which was basically formed by a Jewish person, Sarnoff, we had Good Friday as a holiday, which was always amazing to me. (laughs) But anyway, we used to go to the Philadelphia Mint and watch the copper pennies pour out of the mint, and all sorts of scientific things. My husband had built a telescope with a ten-inch or twelve-inch diameter lens. It was mounted on the garage. But unfortunately as the years passed by, the only clear nights it was like about zero degrees outside. (laughter) The kids used to climb up, and we could see the rings on Saturn.

And of course, when Sputnik went up — we followed space very carefully. And one of the anecdotes that I remember is my son, Matthew, who's the middle kid, and I, were driving somewhere when astronauts were going to the moon. And I said to him would he like to be an astronaut; he said yes. I said, "You know, I might like to be, too." And he said, "Well, you can't, Mom, too much payload." (laughter)

DR: Cute.

YB: So that put me in my place.

DR: Well, while you were at RCA, you know, getting back to the patent and the work that you did there, you also won an award from RCA, the Astro-Electronics Engineering Excellence Award in 1970.

YB: That was a very coveted award. It was very interesting. And many of the fellows thought that I wasn't — they couldn't relate me to them. (laughs)

DR: Because you were a woman?

YB: I don't know whether that was it. We had a few women engineers at RCA. When I first joined the company, there were five there. And one moved when her husband moved, he went up to Rummond (phonetic), and she moved. Another one was married to a theology major, or seminary person, and when we was assigned to a church, she left. And I guess for a while, I was the last one left. And I never really felt discriminated against.

One of the women felt that she was discriminated against, that the fellows always gave her a hard time. But after she complained to me, when I got into meetings, I looked, I listened. And they challenged each other just the same way they challenged her and me. And you know, it's just part of life. RCA tended to hire 4.0 people, you know, very smart, very high scholastic achievers. And they put them through a training program, and they stayed there for life. This was one of the problems that I got into, I was very well accepted at the time that I left RCA to go to NASA Headquarters. And coming back, you know, I sort of felt like a traitor, having left. (laughs) Because most of the people just worked there their entire working career.

DR: So what did that mean to you win that prestigious award?

YB: I was very flattered, because I had no knowledge of it. But it was just awarded once a year, I guess. And the two or three people who received it before I did were all people I thought very highly of, you know, technically. But then I was nominated for the Central Jersey Engineering Award by both SWE –

the SWE section and the American Institute of Aeronautics and Astronautics, where I was very, very active in the local section.

Going back to the AIAA, when I had been in Connecticut at United Technologies, I founded the Connecticut Valley section of the American Rocket Society, which then grew into a very big section. And I just continued my membership when I got to New Jersey, and participated. And we had a very lively section in New Jersey for a long time.

DR: So is the Rocket Society the same as AIAA, or was it a different organization?

YB: It was a merger of the International Astronautical Society and the American Rocket Society, into the American Institute of Aeronautics and Astronautics. And so I was very active in both. But how I got involved in SWE reminded me of when I told the story about the effigy — what did I call—

DR: Oh, the Voodoo doll.

YB: Voodoo doll, with Dorothy Hoffman. Dorothy worked at RCA Sarnoff, which was a really high powered research organization. And she persuaded RCA to join SWE as a corporate member, which allowed RCA to designate five women.

DR: Was she already a member, or—

YB: Well, yes, she was a member of SWE. And she persuaded the corporate group to get a corporate membership. And she had her membership paid for, then, under that corporate umbrella. Well, she decided it was time for her to be a life member. And she had the money. And when she withdrew, then that left an

opening, and somehow I got recommended to fill that. And I thought, well, if the company is going to pay my dues to this organization — I didn't really know anything about SWE — I really owe it to them to find out what they do. And of course a year later I found myself president of the New Jersey section, and very, very much involved.

DR: Yeah, you did become, very early on, pretty involved in leadership roles in SWE.

YB: Right. And I enjoyed that. I was the CSR rep initially, I guess, so I got to the Denver Conference. But the one I remember, which was the second one I went to, was in Cincinnati, that Jean Hoppert and Judy Simmons were the co-chairs of. And this was really, for me, an eye opener, because they offered seminars there that just weren't available to women anywhere else — you know, management type things. And they had a whole series of those.

I remember going to a talk that Eleanor [Elaine] Pitts gave for the Catalysts. You know, she was at Sperry Hutchinson then, and Catalyst was one of their divisions. And it was on resume writing. And I just clearly remember her.

And another thing is Shirley McCarty, who is a member of the LA section, gave an assertiveness seminar. And it was attended — there were only two people — or one other person in my age group in that seminar. They were all fairly new graduates, maybe in their mid-twenties. And as a last jab before we dispersed after Shirley gave us lots of good advice on how to be assertive without being too aggressive, she went

around the audience and asked what their salaries were. Well, the other woman in my age group was Rose Shapiro, who had a pretty high position at Hamilton Standard. I'd heard about her, but never met her before I attended this seminar. And her salary was higher than mine.

So I marched back to RCA, and I said, "United Technologies is just competing in salaries with button factories." (laughter) And they gave me a raise.

I think all of the time that I worked for RCA my salary was below that of men. It's just nothing I ever thought about.

DR: So that didn't really bother you?

YB: It didn't bother me at all, because the freedoms that I had, first of all, after I became active in SWE, they were very happy to sponsor my activities. And I could go to — there weren't regional meetings. The student sections usually gave their own career days and colloquia and things, their own meetings.

And they were happy to have me go and recruit. For $100 we could set up an exhibit booth. And I got to talk to all these young engineers who were doing interesting things. And so I always figured even though I worked hard, I had to do all my SWE work at night, on my own, it was a good trade-off for me. It was time well spent. I just found that it energized me a great deal. And I really believe in what the organization was trying to do, and was just really happy that I finally heard of it, because it worked on two levels; not only making young women aware of engineering, but it gave a network.

You know, after my experience at Cincinnati, I saw that many other women were in the same kind of boat I was in. And you know, you just realize that maybe you're better off than you think. (laughs) And as I say, I felt it was a very good trade-off. And I also was very active in Local AIAA. The two years that I was in the Washington area, when I worked at NASA, I really wasn't carried away by the bureaucracy at NASA.

How that started is I was sitting at my desk one day eating lunch at RCA and the phone rang. And it was a headhunter who was describing all these great jobs that were available at NASA, and would I like an interview. So I decided I'd take an interview. And it sounded pretty exciting.

And my thoughts about NASA related back to the Apollo days when Headquarters had the technical responsibility as well as the fiscal responsibility for the Apollo and the man on the moon; and not realizing that some changes had taken place in the interim after the Space Shuttle — or after Apollo ran down, and the Space Shuttle started up. So I was looking to get back into liquid rocket engine work, more than little just teensy engines.

So I left RCA, and I was offered a job in the Liquid Engine Division first, but then my job got caught in Reagan's freeze. So I just was too proud to go back to RCA (laughs) and said, "Well, I might have made a mistake." I just stuck it out and did some consulting work. I got a job in Italy for a couple of weeks that was fun, and just waited.

And eventually, I did wind up at NASA, and it was as Manager of the Solid Rocket Motor on Shuttle. (laughs) And I

knew a lot about solid rockets, because having been in missiles, again, early on at RAND, I knew just about much about liquids and solids. And I followed both technologies through the years.

DR: So this was the early '90s then when you came back to work for NASA?

YB: No. I worked from '81 to '83 at Headquarters. And I left the day before Sally Ride went up. I remember watching on the NASA Net – I was still able to get into the building, watching the launch on the NASA Net.

But the things that I learned, I guess, were about big program management. We never looked at any digits to the right of the decimal, (laughs) so I was dealing in multimillion dollars. And I learned how to answer 200 congressional questions without saying anything.

DR: (laughs) What do you mean by that?

YB: Well, congressmen would get – and senators, too, would get these inquiries or questions from constituents. And if anything was space related, it got turned over to NASA, and then within NASA, got distributed to whoever seemed the most appropriate group to answer them. And some of them were really inane questions. (laughs) But you learned how to skirt, things like that.

It was an interesting experience, although it derailed my career, to an extent, as far as RCA was concerned, and progress, because I'd been a manager when I left there, and they wouldn't give me that status when I moved back. But the things that I learned in general about big program management were very

worthwhile. And the whole business of how the agency operates, how government agencies operate. And NASA was supposedly the poster child at that time.

And I was interested in the work. I had a feeling that because of the way things were being shuffled around, I really thought their first Shuttle failure would be in the liquid engine, the Rocketdyne engine, because they were playing such big games with the turbo pumps, and never seemed to have adequate turbo pumps or enough of them. And so it was kind of horrifying when I watched the launch of the Challenger on live television at RCA, and when I saw the whiff of smoke and where it was coming from, I knew exactly what was going to happen. It was just really devastating. There wouldn't have been anything I could have done to avert it, either. It was really some pig-headed people at Marshall Spaceflight Center, who eventually got their comeuppance as a result — who were basically responsible.

There were changes made in the materials of the O-rings in the joints. They had asbestos in them, which the EPA — OSHA was pressuring to remove, and so(Inaudible) had to remove it. They had a zinc putty that sealed better, and they had to take that out for some reason. And a couple of those changes had been made, and so that nobody in their right mind would have launched a solid rocket at the temperatures that they had reached. And that was a real fallacy — except for the pressure. But I personally believe had they still had the asbestos and the zinc oxide putty, that they would have survived. But there's no way to prove that.

And with such a complex – I mean, the Shuttle is so beautiful, really, in spite of all the criticisms, et cetera, it's such a fantastic engineering achievement that it was a shame to have that happen. But you have to expect that, because there's so many things that can go wrong that it just can happen.

So anyway, I got very involved in SWE. Somehow I was tapped to be on the executive committee. And the job I was offered was being the Student – in the early days before all the changes were made into regions and so on, the Student Activities Chair was an Executive Committee post. And that was my first introduction to SWE on the national level. And that was, oh, such a fun, fun job.

DR: So how did that compare to working on the section level? Would you (Inaudible)–

YB: Oh, it was much bigger. But I generated a little newspaper that I mailed out to – we had 180 sections at that time. It's now over 300, and one individual couldn't handle the job anymore. But the most typical things, (laughs) strangely enough, were keeping current with student addresses, where to send things so they'd get them, because it was before e-mail or anything like that.

But it was really wonderful to read the reports. And we decided – there were just five or six of us in New Jersey Section decided that we should – we should host a conference, which we did in 1980. We had the Student Conference and the Professional Engineering Conference. And we just really worked

hard, and did that. And with the overage from that convention, we eventually put it into the New Jersey SWE Scholarship, which now, you know, the Board of Trustees handles, and we've made a scholarship available.

We never were very energetic about doing scholarship fundraising within the section. New Jersey, being a long, skinny state, it's hard to figure out where you can meet and get people who are in the north and the south together, and it's always been very difficult to really keep a section vital. So that was fun.

And then I stepped up into being treasurer. And that was — having to account for every nitty-gritty little piece of petty cash (laughs) was too much. It was a bookkeeping job. And what really upset me, it was the years when corporations were willing to give money to SWE. They were all eager.

And I thought the treasurer's job, which I think for most technical organizations, was to raise funds, to get funding, you know, coming in. And I had to spend so much of my time bookkeeping. And Helen Grenga, who was president, wouldn't hear of hiring a bookkeeper. So we clashed on that. After I finished my year as treasurer, I was still at NASA, and really hadn't planned to leave at that point in time. And NASA had no mechanism — I don't know how Kathleen Harer managed to be president and work for NASA, except they may have changed their whole outlook by the time she was SWE president. But even if I was willing to pay my own way to a meeting, they didn't have a mechanism that could give me the time off with pay. (laughs)

So I decided I just should opt out and not continue to be first VP or something. And so I really didn't work any longer at the national level. I still continued to be very active in the local level.

DR: Do you feel that the career guidance aspect of SWE, like keeping in contact with students is something that most interests you about SWE? It seems like you've been pretty active in that, in the Princeton-

YB: Well, I think just even – although I feel that the age difference between myself and a young group of, say, third-graders is too great for me to be very inspirational to them, or to motivate them in any way. Just in younger years, twenty years ago, it was fun to go out and give a talk at a seventh grade level, and make kids aware that there were women engineers.

And one of the things that I did at RCA that was very successful is because we were so close to the manufacturer of the satellites, I put a series of viewgraphs together for talks I'd give at many universities, many university student groups, relating what they were learning at school to what you could do with it in a sophisticated piece of apparatus like a spacecraft, which kind of amazed them. Because a lot of kids probably still do wonder, "What am I going to do – what am I going to be able to do that's useful once I get a job?" You know, "Will I really be able to handle it? And what is the relevance to this awful stuff that I have to learn sometimes?" (laughter)

And so that was always a fun thing. As I say, I figured just the trade-off — it was a lot of my time that went into that, but it was well worth it. And it came as a complete surprise to me when Karen [Geraldine] Cox? — I may have her first name wrong — who was the Achievement Award recipient the year before me — when she called me up on the phone and said that I was the awardee for 1986. I just couldn't really believe it. I just couldn't relate (laughs) to it.

DR: Why do you say that?

YB: It just seemed so — beyond any expectations. I really had never thought about it, and it just didn't occur to me that what I was doing or had contributed was just all that valuable.

DR: So after you got over the initial, you know, awe that you — or whatever, that you'd be selected for the award, looking back on it, how do you think—

YB: Well, it's a very prestigious award. And I know the competition is always very keen. And just prior to that award — although the nomination was already in for the award — my friend, Pres Layton, who had persuaded the company to give the electrothermal hydrazine engine out to industry so that somebody would build it and use it, he had motivated the company to nominate me as AIAA fellow. And I was elected as an AIAA fellow that year, too, earlier in the spring. And so the two awards were just heaven. (laughs)

DR: So what did it — comparing the two, one is from a technical society, as opposed to SWE, which is a cross — covers

engineers in many different fields. What did it mean to you to be recognized by SWE?

YB: Well, to me, the Achievement Award has always been more for technical achievements.

DR: Sure.

YB: I don't really know, in the evaluation – because after I received the award in 1986, I went overseas that same year, and therefore wasn't available to be a peer reviewer to know what the criteria that they judge by – I don't know how much emphasis was put on your SWE work. I'd say very little, because, for example, last year's awardee, Kristen Johnson (phonetic) had just virtually no SWE, and no mentor – well, she had some mentoring, but not a lot of what you might normally expect. And most of the awardees are in that category, it's really for their technical work that they've been selected. So it was a great honor, and one that I cherish.

DR: So you mentioned, again I know we talked it about a little – briefly already, that you took a job in London, then, after you'd gone back to RCA, and then decided to move on. Who did you work for (Inaudible)–

YB: I worked for the International Maritime Satellite Organization, which had the charter from the United Nations to do communications from space to ships. And then they got the charter changed slightly to all mobile equipment, so it was not just ships. Whereas INTELSAT – which is the International Telecommunications Organization chartered by the United Nations had the charter for all fixpoints on earth.

And so INMARSAT, up to the time I worked for them, had purchased time channels on satellites. And the INMARSAT -2 was their first satellite that they were going to build just for their own use. And it was a satellite that had been dreamed up by British Aerospace and the European Consortium. And we quickly found out that it was — we were building a Chinese copy of a spacecraft that didn't exist. (laughs)

So we went through a lot of haggling on it. We finally got the spacecraft off the ground, and it's been very successful. There are still — we had troubles along the way. The little German engine that they were using had its own problems that we ironed out in the way we utilized the engine, which the Germans at first didn't agree with. They were totally against it, but finally agreed. And so the way we used the engine, there was just no problem with whether or not it would continue to work.

There are still Inmarsat-2 Satellites up in space that are spares, just have been moved over. And the first one was launched in 1990, and then there was a progression of three more, I guess. And since then they've done, Inmarsat-3 and Inmarsat-4. And Inmarsat-4 has returned to this British Aerospace Matra (phonetic) concept of the spacecraft that we first built, but a bigger version. So as a prototype it really worked out well.

DR: What was it like working on such a significant international effort?

YB: Well, the attractive things about working there were — first of all, you had a tax-free salary. (laughter) It was

tax-free, both by treaty, both in the UK and the United States, so that as long as it didn't exceed a certain amount — which was a pretty high amount, like $70,000 a year, which was a pretty high salary in those days — you had a tax-free salary. The only thing is, you could not spend more than thirty or thirty-one days in the United States in any one year, or you'd lose your tax-free status. But that wasn't a problem, because my family came over to visit me, and we went to different places in Europe on holiday instead of going back to the United States.

DR: Oh, nice.

YB: And I had known a few people from international conferences who worked at ESA, which is the European Space Agency, and they knew my work. And I also then interfaced with the French for the Attitude Control System. And all the different parts of the satellite were made in different places. British Aerospace had the bus, the main structure, and the thermal. But the Attitude Control was done by the French, and the engines were done by the Germans, and the Italians had the reaction wheel, and the Dutch did the solar panels. (laughs)

And all of that worked, actually, fairly — much better than you'd think, because in the U.S. the tendency was to do everything in-house rather than have it spread out like that, because having some subcontractors really increases the cost. But somehow they managed, for organizations that would just buy European, to win contracts.

So that was fun, because I got to do a lot of traveling. We had a diplomatic passport, which also was a great thing,

because you never had to stand in line (laughs) to get back into the country. My first European passport folded out like an accordion with all the different stamps I had from vacations, as well as numerous trips back and forth.

(INTERRUPTION IN RECORDING)

DR: Okay. We were talking about your work that you did in London. And it was roughly around this time, in 1993, that you got your second SWE award, which was the Resnik Challenger Award. And can you talk a little bit about that, how that made you feel?

YB: Well, I think it was mainly based on – well, more than two things, but two major things. Before I left RCA in 1981, I was Manager of Propulsion on the NOVA Spacecraft. The NOVA Spacecraft was a satellite in a constellation for the Navy that gave ephemerous data to the Navy for submarines and various things. The NOVA Satellite had a propulsion system onboard that was a pulse plasma system, which was very unusual. And I didn't invent the pulse plasma engine, but I made it work (laughs) on the satellite.

And there was also a device on the satellite called the discus that gave the satellite the – it was always in the same location. The propulsion system was designed to overcome drag and solar pressure in – I think it was a 630 nautical mile orbit. And NOVA would give ephemerous data in real-time to especially submarines, and other ships. So it was a very valuable component of the whole constellation.

And this was prior to GPS. The GPS was being built. And it was a program that RCA bid on and lost, and Rockwell got it. But the first GPS satellites were already up when NOVA was up. NOVA could give the ephemerous data in real-time, whereas it took the computers on GPS a whole day to give the same accuracy of position as this little satellite, which was ingeniously designed by the Applied Physics Lab in Laurel, Maryland. And we worked with them, we built it. They really didn't – well, they had built some satellites that were very successful, but it was just cheaper for the Navy to outsource to a commercial company. (laughs) So it was for the NOVA.

And incidentally, the NOVA was the first operational use of electric propulsion. There were three spacecraft, and I think two of them were still working at the time that the whole system was retired, because GPS was far enough along. This happened in the'90s sometime, when it was retired. But at least two of those satellites were still working. And it is really an electric propulsion device, again, relatively simple. And I just was the person, like I say, lucky enough to be standing in the right place at the right time to implement this.

But in addition to that, there was the electrothermal hydrazine thruster, which by the time the Resnik Award was made, we were well aware of how many of those had been built and were being used.

And incidentally, the electrothermal hydrazine thruster got onto iridium, which really greatly increased the number that were in space, because people from RCA had gone to work for

Motorola just outside of Phoenix, and carried that idea with them, that this was the propulsion system to use on such a small satellite – which is a very good application for it. So the Resnik is based on that, plus the fact that I never was afraid to risk my job to further ideas that I thought should be adopted, that were good technical ideas, that maybe somebody considered were a little bit far out. But as long as I knew technically I was on the right – or had the confidence that I was technically on the right path, I'd push it.

And we were the first group to fly a carbon/carbon nozzle on a solid rocket motor and do a capillary(?) propellant management feed system on a commercial communication satellite in geosynchronous orbit, and a couple of other things like that. But I think had I not worked for a company that was willing to really look at new ideas, if I'd worked for Lockheed or – Hughes was a little bit better than Lockheed... But some of the bureaucratic companies just – it was so much trouble that people just gave up.

And I just kept pushing. I didn't care whose shins I kicked (laughs) as long as... And the ideas got adopted. We were able to eventually sell them because Dr. Keigler was so highly respected by Americom, our customer – our internal customer, really, that he convinced them that they ought to do those things. And of course, once you get it in space and it works, then it's fine. (laughs)

And we were so hard pressed for payload weight on the original Americom Satellites, RCA put up twenty-four

communication channels on a slightly bigger launch vehicle. And Hughes could only put up twelve. (laughs) So we had to save every ounce we could, and that allowed us to really push some of these ideas. And they all, fortunately, worked out without any disasters. (laughter) So then that became set, and other groups, then, were able to say, "Well, look, RCA does this and it works. Why can't we do it?" And so, you know, quickly a lot of them adopted it too.

So after I left INMARSAT, one of the people who was hired as a consultant, who set up the ground station, had his own little company in — let me just—

DR: Do you want to stop again?

YB: Yeah, I think, for a minute.

(INTERRUPTION IN RECORDING)

YB: — (Inaudible) the ground station. And he had his own little company called Telespace, which operated out of Toronto. And he asked me before he knew I was leaving INMARSAT to come back home, he said if he ever needed a propulsion engineer for any of the work he was doing, would I be willing to consider working for his company. So I said, "Sure." So I came back to the U.S.

(INTERRUPTION IN RECORDING)

DR: Okay, we're back again, and we were just getting started talking about some of the consulting work that you did through the '90s, that you still continue to do today. Is there any one project or—

YB: Well, as soon as I got back, I was tapped to work on a National Research Council study that was handed to the National Research Council. It was a mandate from Congress to NASA to look into the advanced solid rocket motor that was being proposed for Shuttle. So I got to work on that, and two or three other different National Research Council studies, which were a great deal of fun, you know, because, again, you weren't paid, but they paid your expenses and your travel and hotel. And so that was really something worthwhile to do, it was a contribution.

I had been elected to the National Academy of Engineering in 1987 when, I guess, less than one tenth of one percent of the membership were women. So Sheila Widnall and I were the only two women in the Aerospace section at that time. And so Sheila was higher up in the — well, she was at MIT, and she had a professor's job there. I was delegated as a committeeperson to a number of committees that were very interesting to work on. (laughs)

DR: So at this time you were basically retired from full-time work and just doing consulting.

YB: Right. But the first — one of the important things that I've been trying do is to try to nominate women for fellows of AIAA and SWE, and other awards that they really should have been nominated for years before, you know, that have been overlooked. And there's so much of that, you'd be surprised.

DR: Have you been successful at all in that?

YB: Yes, I think I have. The first AIAA Fellows meeting I went to after I got back – I think it was 1991 – and there was just one woman elected that year. Many years since then there had been none. And I just made up my mind then that I was going to spend time doing this. And I think that there's probably four or five women that I've managed – either I've manipulated (laughs) the paperwork by people who should have done it years before – shamed them into it, or helped write the paper – do the paperwork – because there are certain ways to do this.

And I think that I did this not only for women, but for men, also, you know, because organizations like that, the CEOs of this world tend to nominate themselves or get themselves nominated, and nominate the vice president, and these people are not usually the workers in an organization. (laughs) And so I hate to see that, because a lot of really good technical people are passed by. So not only that, I've managed to get two women who certainly were very deserving elected to the – I've been their nominator for the National Academy. And I'm very proud of that.

And I'm working on some more. I'll just keep doing it. It's just a nice – it's a fun thing to do. It takes an awful lot of work. But when you're successful – I've had a few failures, too, which always make me feel very discouraged – well, disappointed, because I keep wondering, "What could I have done better?" And sometimes I just try again another time, and it goes through. (laughs)

So anyway, in along with that, then, I got invited to be the first woman who was on the NASA Aerospace Safety Advisory Panel, which was a panel set up to monitor safety within NASA in aeronautics and in space. And I think that – I'm not quite sure how – what triggered the invitation, I mean, whether – I'm sure there was some pressure on NASA to have a woman on the panel, or more than one. But I think it was probably the work I did. I interfaced with some people on that panel when I did these National Research Council studies.

And so I was on that panel for six years, until Dan Golden (phonetic) fired me and seven other people, (laughs) mostly because – it was not official, but he just thought that older people – that he wanted young people on the panel. And they completely eviscerated it, unfortunately. But again, I was glad I wasn't on the panel when the last failure occurred.

So I did six years of that, along with other consulting. The first job that I did for little Telespace was to monitor the build of two spacecraft at Hughes for Thailand. And he got us a week's work in Thailand instructing the ground crew who were going to operate the satellite on the various aspects of the satellite. So that was fun.

DR: That must have been interesting.

YB: Yes, it was. And then later, Telespace got a contract from the Norwegians, and we went over to Norway. That was a handover in orbit. And what was really fun for me is because Hughes had always been our arch competitor to RCA, and just to see how they did things on their spacecraft relative to how we

used to do them was very interesting. So I guess the last spacecraft we worked on for Telenor — which was the space arm of the Norwegian telecommunications — was in 2000, I think. And I haven't really done any satellite consulting since.

But the current job I'm working on is a National Research Council job that is for the Air Force and DOD [Department of Defense] to assess the status of air breathing and rocket propulsion in the United States. And there are thirty people on this panel. Nearly all of them are extremely well-known in their field, they're very capable. And it was an eighteen-month study. We were going to have to issue an report in six months, which we dutifully cobbled up. But it was so huge (laughs) that they've decided that they would only have one report. So we're now massaging that.

But two-thirds of the people are in the air-breathing part, the turbojet turbofan part and ramjet part, and one-third are in rockets. But the people I'm working with in rockets, I have a lot of respect for, and I've known them many years. And I think the reason I was probably invited is because I'm known to them.

And so whether they — sometimes the really disappointing thing on these National Research Council studies is they don't take your advice, which we always think is the very best. (laughs)

But for one reason or another, they don't follow through. But we'll see what happens here when we finally get our report out. But it keeps me active in seeing whether there are changes

in the state of the art, and what's new, and where things are going.

And the satellite industry itself has been fairly flat for a number of years. There just haven't been the number of spacecraft put up, and Telespace just hasn't been very active in that period of time. And I'm not sure that we ever will be called upon again. But the owner and principal in Telespace — we have this small group, all of whom are retired, who he could collect together. And we work very well as a team, really complementary technical expertise. So that was just very nice.

So I've enjoyed doing things like that. I don't think I could ever sustain getting up at 8:00 o'clock in the morning and working a full day. (laughs) I could do it for a short period of time, but I don't think I'd really enjoy it anymore, because your energy levels, unfortunately, change with age.

So I guess that's about where we are.

DR: Okay. All right. That sounds good. I guess my last question for you, then, would be a simple one — or maybe not. We've talked about your lengthy career and everything. What would you consider your most important contributions that you've made to science and engineering?

YB: I think the advances in propulsion and propulsion systems. One thing that I didn't mention, which is really the top of the world to me, is in 2002 I was given the James Wilde (phonetic) Medal of the AIAA, which is their very highest award in propulsion. And I'm the only woman in the fifty-two years of the existence of the award that's ever received it. And this,

again, is really the same contributions being considered over and over again. But that gives you a feeling of the relative importance of what it has contributed, and what your peer group thinks of your contributions, because nobody would – I didn't write these things up myself. (laughs) I just wouldn't do that. So that was really a very wonderful award, in the same category as being a SWE Achievement Award Recipient.

DR: Right. Well, thank you.

YB: Okay, all right.

END

NAOMI & YVONNE BRILL

DR: Okay. This is tape three of the interview with Yvonne Brill. And we're now joined by her daughter, Naomi. Thank you for being here today.

NB: Thanks for inviting me.

DR: And Naomi, when did you first understand what it was that your mother did for a living?

NB: Well, that's an interesting question. (laughs) Mom did a lot of government defense contract work, and she did a lot of things she never really could talk about. I knew she did something that had to do with astronauts. And we weren't allowed to watch much TV as children, but we were not only allowed to watch TV, but we were allowed to stay up very, very late when man first walked on the moon.

So all I knew was that for some reason that was special, and it had something to do with whatever it was that Mom did for a living. Probably not until I was college age, late high school, college age, did I really understand, you know, that there were weather satellites. I was more a science person than an engineering person as a child.

DR: Well, your father was—

NB: My father is a chemist. So he used to pull family pranks, like getting bottles of Gatorade and mixing up the ingredients from the chemistry lab and giving it to my kid brother saying, "You want Gatorade? I'm not paying for the advertising for the label, but here, it's the exact same thing." So I was very conscious of science and mixing experiments,

things like that. Yeah, Dad's homemade Gatorade from the lab is a story you need to get from my brothers. (laughter) And Mom is laughing, because she remembers the whole thing.

DR: So luckily you were never at the other end of the prank, right?

NB: (laughter) I was smarter than my younger brothers. I'm the oldest child. I knew better. I knew Dad was up to something, and I didn't want to find out what.

DR: But you didn't necessarily understand what an engineer did?

NB: Well, it was a little less tangible. If your dad is a chemist and he brings home a bottle of Gatorade because he's read the exact ingredients off the label and he's dumping them together in front of you and shaking it up and throwing green food coloring in, it's like, okay, that's what you do at work, you throw stuff together until you get what you want. So it's kind of like baking chocolate chip cookies or something.

I think maybe if my mother had been in a different discipline or type of engineer, I might have understood sooner. But I mean, we hadn't had TV for all that long when I was a kid, and there was this thing called the Space Race. But when you're five or six years old, that's some grownup political thing, and what does that mean and what is really involved with that? So it took until I was much older — even with that constant publicity. I mean, the publicity that I would see in the newspapers and the radios and the TVs and stuff matched, you know, Gemini stickers on the sliding glass door.

Again, as a child, you grow up in a family, you don't realize that your experience is different than everybody else's until you're into high school or college, and you leave. And very few people had mothers who worked when I was a child.

And I do remember that difference in school. You know, the first day of school you had to take home the contact emergency information form and fill it out with your parents' phone number at work, and what did your parents do for a living. And I was always the only kid in the class who had a mother that worked, and that she was something called an aerospace engineer. (laughter) Most of my elementary schoolteachers didn't know what that was, so I knew there was something different about me. And I knew it had something do with it when I turned that piece of paper in, you know, in first grade and second grade, that said my mother worked. (laughs) So it didn't really dawn on me that that was not what everybody else's mothers did – not at that age, at least.

DR: And Yvonne, you had mentioned briefly that when they were young children, Naomi and your two sons, that you did a lot of science oriented outings. Like you mentioned the zoo, and that type of thing. Can you both talk about that a little bit more?

YB: Well, one of Matthew's projects was building a solar oven. And we cooked a chicken in it. (laughs) This is about the time that Marie Telkes was doing solar work. we went to the library and got a book. And Matthew built the oven.

DR: Do you remember that, Naomi?

NB: Can you tell I don't remember that from the look on my face? (laughter)

DR: Yes.

NB: I remember building the paper mache volcanoes, and having access to the chemicals that make them look like they're exploding long before you could get them in the stores like you can now. But yeah, I mean, there were science things like that. Well, we had the model rockets. I don't know if Mom talked about that.

DR: No.

YB: I forgot about that.

NB: The Estes Model Rockets, now, that was something I knew it had something to do with what Mom did at work, because she had access to those engines, the little tiny pellet engines with the fuses. So us kids used to fight over who got the expensive rocket out of the catalog. (laughter) And I figured since I was oldest, I was entitled to the bigger and more expensive rocket, and my kid brother should get the little one that would crash and burn right away. But I mean, I do remember knowing that that was a very science related thing, like somehow you're going to use this little firecracker thing that kind of looked like flypaper, or whatever, that was going to send your rocket...

And we had a farm across the street, so we had someplace to go launch them, and it was kind of a rural area. So I remember that that was something that not everybody had access to, you

know, because Mom had some way to get those engines. I still don't know—

YB: You needed a license.

NB: Well, you needed a license, but she had a way of getting a license that nobody else knew how to do. And now I understand they sell them if you go into the Imagination and Explore stores and science museums, that you can get them.

DR: Oh, really?

NB: In some states you can, not where I live now. I remember those kinds of experiments, you know, volcanoes, and firing off rockets — so more the physics and the chemistry experiments.

DR: And Yvonne, you had mentioned something about how your husband had set up a telescope.

YB: A telescope that was on the roof.

NB: The telescope, yep. That, you understand, it's kind of liking a magnifying glass looking at the moon, and your friends can get in on that, too. So that was something unique. But that was shared in the neighborhood, you know, if there's a really good full moon or some planet that was close.

DR: So do you think this early exposure to science and technology in your family life kind of influenced your interests in school? Were you really interested in math and science throughout—

NB: Oh, sure. And I was always very good at them from a young age. I was very good in everything at school. And my grade-school teachers never discouraged me in any way. I was

one of the smarter – there were two of us. There was a boy and I, and we were always the smartest two in the class. It was a fairly small school system, you know, you'd see the same kids for eight years running. So my teachers encouraged me, and that exposure was at home.

And in all honesty, one of the family jokes is that if you were me or Matthew or Joe, you grew up thinking there were only two careers in the world. You had to either be a scientist or you had to be an engineer. So you could pick one of those two. And I happened to have picked scientist first, that was actually biology. And one brother picked science, and then kind of went into environmental engineering. And the other brother picked engineering, and then became a financial business type person. So I tried science, and then switched over to engineering as a second – I have two bachelor's degrees.

DR: Right. Well, in your early school days, then through high school, do you think, then, because of what you said about thinking that there's only two careers for you out there, do you think that made you naturally gravitate towards science?

NB: Yeah, it was going to be one or the other. And I happened to like science a little better because it was a little more tangible. And I do a very different kind of engineering than what my mother does. I'm a manufacturing engineer and an operations engineer, and more on the management side of things, managing manufacturing operations. And I'm much more hands-on and people oriented.

And the other famous family story about why Naomi wasn't an engineer at first was because science just looked like a whole lot more fun. But I remember being maybe about eight years old — and I've only ever had one earache in my life, and it was when I was eight years old.

And I woke up in the middle of the night, as a child, and I did not know what was going on. I had an earache. I had no experience with them. And I went looking for my mother. And I tell this story a lot. (laughs) I wandered out of my bedroom. You know, it's like 2:00 in the morning, maybe 2:30. I kind of remember the clock in the kitchen saying 2:00. And I looked in my parents' bedroom. And Dad was snoring away in the bed, and there was no mother there. (laughter)

And so I thought, well, I don't know, maybe my brother was sick, so I went to baby brother's room. He's snoring away, no Mom. And at that point, I was — I was very sick. I panicked. I mean, "I don't know where my mother is!" And you know, a little bit of sexism, you just don't think to wake your father up when you don't feel well in the middle of the night and you're eight years old.

So it finally dawned on me somehow that the kitchen light way down the hall was on. So I wandered down the hallway, and I look in the kitchen. And there's my mother at the kitchen table, yellow pads of paper spread out, pencils all over, and she's sliding away on her slide rule. And so I associated engineering with this horrible physical pain of an earache. (laughter) It must have been what happened subconsciously.

But I grew up thinking that if Dad came home at 5:30 every night, and Dad did the gardening and played with us or whatever, and he went to bed and he slept all night. And the story goes that I figured if engineers had to stay up all night with slide rules by themselves at the kitchen table, that was not the career for me.

DR: That wasn't fun.

NB: I was going to be the scientist, because they went to work, they came home. (laughs) And I always thought the gardening and yard work was fun. So you know, Dad was doing the outside work. You know, they'd come home and they have some fun, and then they get to sleep at night. So I was going to be a scientist. So that really truly was, however strange it sounds, an impetus for why I chose science first.

And it wasn't until I'd gone through college – I went to a very liberal arts school in the Midwest for a bachelor's in biology – that I realized in my senior year I had two choices: Grad school, which was more laboratory time and small group settings, and I wasn't really keen on what that actually entailed when I found out what it was, or just being a worker in a laboratory by myself. And I'm much more sociable than a research scientist. I don't have the right personality for that.

And so then I started to look around. Well, if you really love science – I mean, I've always hated math and physics. That's something I use in outreach, I tell girls, "You don't have to like math and physics to be an outstanding engineer."

It's a little bit of an odd way – but if you're not into it, you know, look, it's something you have to do. You have to know how to do it, but you don't have to love it. It's a tool that you use to get somewhere else.

So I finished my bachelor of science, and thought about the fact that if I went and got an engineering degree, I would be working with this science. But that's when I finally understood – probably at the age of twenty-one or twenty-two, that engineering is the application of science. So bingo! It's like, okay, if I go back and I do engineering, I've got the science, but I get to work with the people, and I'm not going to be stuck in a lab by myself. I'm not going to be at my kitchen table at midnight with a slide rule by myself – with all due respect. (laughter)

So I went back to school to get – my degree was in biology – to get a biomedical engineering degree. And I am just old enough that I wasn't allowed to take industrial arts in any of those, you know, quote, unquote, boy classes in high school. My first exposure to manufacturing processes in metal machine came in a required lab course in my mechanical engineering degree.

And so I always tell people I went back to school, already having a bachelor's to get a biomedical – or a bioengineering degree. And I hit the entry level, got to take it, manufacturing class, and it was love at first sight, and that's all she wrote. And the rest of my career has been manufacturing.

My degree is actually in mechanical engineering, because that was primarily what was available at the time. And so I took that mechanical engineering degree and went off in the manufacturing world working with people all day long, and had a good time for twenty years. (laughs)

DR: Right. Okay. Well, Yvonne, what were your expectations, you know, being an engineer yourself, and your husband was a scientist… what were your expectations for your children? Did you expect them to grow up to be engineers and scientists? Did you hope that they would choose that?

YB: Right, yeah. They all appeared to be self-motivated, really.

NB: (laughs) It wasn't a choice.

YB: You know, that they had ambition, or however you want to describe that. But they were doers, not sitters, and interested. And for the time frame that my husband and I worked, careers in science and engineering were more than adequate for earning your livelihood. I'm not sure I'd say the same thing today. But it just seemed like there would always be employment in those fields. And chemistry, of course, is not so good anymore, even for a Ph.D. level.

But we definitely expected them to go to college, there's no question about that. And we didn't really try to direct what they took, I don't think — except Naomi went away to this liberal arts college. And when she went away to school as a freshman, it was the era when there was a lot of emphasis being

put on women engineers, you know, getting women to take engineering.

And I felt that her progress, as far as positions were concerned, would be greater. But I couldn't convince her. I had friends like Lisa Kline (phonetic), is a professor at Rutgers — I just couldn't convince Naomi that engineering was a good career.

But I didn't worry too much when she went off to Carlton, because they had a program that would allow you to transfer to MIT. Therefore, we figured their academics were pretty good. The only thing I found out from visiting Carlton for Parents Day occasionally was that nobody ever did that. (laughter) They were all happy—

NB: It's true.

DR: — happy at Carlton. (laughter)

NB: I know two people in twenty-five years worth of alum who've done that. I volunteer as a career mentor, should Carlton have a student that might want to be an engineer. And they know they've got one out there in their alumni ranks. I've talked to two students in that twenty-five years who have taken advantage of what's known as a three-two program — three years liberal arts, and finish up with two years of — so it's like a five-year engineering degree. You end up with a degree from both schools.

YB: We were very happy when Naomi decided that she would go back to school and get her engineering degree, because the employment opportunities for biologists looked pretty slim.

NB: Which is what I found. I could work in a lab for $7.00 an hour or I could go be a typist, an administrative office person for $7.50 an hour. And neither one of those appealed to me. (laughs) So that was where the thought was, well, take the biology and apply it as biomedical engineering. And then I just found something I truly liked.

And SWE enters into the picture – there's famous SWE stories about my introduction to SWE. When I was probably fourteen or fifteen years old, Mom used to pay me three cents a copy to collate, fold, label and stamp the New Jersey SWE Section Newsletter. (laughter) So we weren't given allowances, per se. There were projects where you could earn your allowance. And boy, I used to get three dollars, because there were a hundred people in the New Jersey Section. But that was a lot of money back – you know, I was a little kid. So there's a lot of people who laugh at that, because here I sit on the Society's Board of Directors, so it's sort of like the guy from the mailroom who becomes a CEO. Well, my mom used to pay me three cents a copy, so count those three pennies.

DR: So literally, that happened.

NB: And here I sit on the board, you know, influencing the policy for the Society. So I had that exposure. But that was also negated by another – numbers and paperwork all over the kitchen table all night. Mom was the national treasurer for a year, back before there were PCs, laptop PCs, or any kind of PC. So she's doing the books, which looks to me like piles of

numbers, and not something I want to do. So it's sort of like, I don't know about this SWE.

DR: Not something that you really wanted to do, either, right? (laughter)

NB: No, no. And she may have talked about that. I think we had a very similar opinion about that, although at the time, you know, I didn't really appreciate how inefficient that way of doing it was.

So I knew what SWE was. And when I decided that I didn't want to work in a lab by myself for $7.00 an hour, and that maybe pure science wasn't really in line with my personality, Mom, of course, conveniently says, "Ah, she's out in Minneapolis. I have SWE friends there." (laughter) And Mom called a friend of hers named Maggie Hickel, who has worked through the ranks, and she's a SWE Society past president, very well-respected fellow in the organization.

And she had Maggie call me up. And I was like, "Yeah, you're one of my mother's friends. Why do I want to talk to you?" (laughs) But Maggie got smarter – I mean, that didn't work. Maggie got really smart, and she called the Student Section at the University of Minnesota, which is about two miles from where I was living, and said, "There's a gal here who doesn't know that engineering is the right career for her." (laughter) And gave a woman - I wish I knew where Marla Schneider (phonetic) was so that she could hear this story.

But there was a gal who was a junior there, named Marla Schneider, who called me up and said, "We got your name from

Maggie Hickel, and I understand she got it from your mom, and I understand you don't want to do this. But we have a SWE meeting tomorrow night, and I'm waiting for you. And here's how you get here." And I don't know why, I think I just gave in and I went just to say, "Look, I did what you asked, I went."

I mean, the University of Minnesota, where I got my engineering degree is a school — I think it's the second largest student base in the country, 50,000 students. I went to a liberal arts college. I knew everybody in my class of 400 people. And were only 1,400, 1,500 of us on campus. And registration was — I was not a number, I was a person. And the University of Minnesota is, you're a number.

And what the SWE section there did — I mean, and not just for me, it was really part of what they did for the Engineering Department to get women into the Engineering School — they got me the registration catalogs, they got me the admission forms. They told me the tricks to fill them out. And so they literally coached me through this horrific process so that I wasn't a number. I might have been a number in the end. I got some student ID. I think I'm number 50,000-something. No, I'm 100,000-something, is my student ID number there.

But they got me through that process by being a human face. It's like, you know, you look, okay, this has got to go to Williamson Hall. Well, you look at the map. Well, I can't figure out where that is. And you walk up to Williamson Hall, and it looks like a fortress. So they literally provided the

friendly face. And I watched them do that for lots and lots of other women after I started school.

I mean, it isn't necessary anymore because admission departments reach out to the high school students to get them to enroll. But back in those days, it was a state school, it was huge, they had more students than they could handle. They didn't care if you fell out of the system along the way, there was another number waiting to take your place.

So this SWE section reached out and got me into school. And then once I was there, it was the wonderful support mechanism that we all know SWE is, especially at the student level. And you're in Intro to Physics with 2,000 other students, and you have a question about something you don't understand, there isn't anybody to ask. But you can go back to the SWE lounge in between classes and hang out until somebody who just took the class shows up and say, "Explain this. I didn't get it."

So it was a wonderful academic support network that way, a wonderful source of encouragement. I don't think I would have — even being motivated to be an engineer where I could go out and use science and work with people, I would not have gotten through school without the support of a good strong local SWE section.

DR: So do you think that's one of the key strengths of SWE, then, is student support?

NB: I think it's one of the biggest benefits that we offer to our students is that face-to-face contact at your school. My

SWE section had a big sister/little sister mentoring program. We had one within the section, the seniors and the freshmen, which I didn't take advantage of, because I wasn't an eighteen-year-old freshman at that point. (laughs) I was a little bit older. But we had a big sister/little sister program with our local professional section, the section I'm actually now part of. And my big sister turned out to be Maggie Hickel, same person — it was just a coincidence!

DR: It all comes around, right?

NB: It was just a coincidence that that was the person Mom sent to go grab me. So Maggie became my big sister, and this support network goes way — with my relationship with Maggie, we go around to Minnesota Section Professional Development Conferences talking about the importance of mentoring and networks. And we joke that... She was one of my early mentors. I know that you're asking some folks about that.

Well, Maggie was a mentor early in my career, just the transition to work. And twenty-five years later, if I — she's always been at a level just a tad above me. So you know, twenty-five years later, if I'm in an executive management situation and I don't quite understand what the old boys are asking me to do, Maggie's phone number is (stricken from the record.)

DR: Scratch that from the record. (laughter)

NB: No, I didn't give you the area code. It's not going to do you a lot of good. And that's been lucky for me, that's been her phone number at 3M where she works for many, many,

years. But it's like, you know, "What are they – I don't get it, what am I supposed to do here?" She's like, "Oh, I went through that three years ago." So there's still – I mean, there's a large network out there, but in that instance, there's a big sister/little sister mentoring relationship that was set up that, you know, will last forever. And maybe within the last five years Maggie has been calling me, going, "You ever run into this?" So you kind of feel... (laughs)

DR: So it's reciprocal, then, yeah?

NB: Yeah. And then I watched Maggie raise three girls, two of whom are engineers now. And I always used to joke around with Katie (phonetic), Maggie's oldest daughter at the SWE Conferences, "Is your mom here, Katie?" Because everybody used to ask both of us that – "Is your mom here?" "But I have a name, too." (laughs) So it's kind of my Katie Hickel joke. Every time I see Katie she goes, "Don't ask. She's not here." I go, "I wasn't going to ask you this time." I mean, I guess maybe that's something that's unique to the mother/daughter situations in SWE, because Maggie and Katie and Maggie – and I believe it's Stephanie is the other daughter who's the engineer – there aren't that many of us. And so if you're the daughter generation, you know who the other ones are. You know, the biggest welcome, get used to it is: "Is your mom here?"

Katie, you know, she's good-natured about it, too. And she goes, "I know. Your mother called my mother." She knew that story when she was a five. I think she could recite it. (laughter)

DR: Do you think that that gave you pause at the beginning to join an organization that your mother had been so involved with, both on the local level and nationally? Because I've heard from some other daughters, and the mother/daughter SWE thing — that they didn't join SWE because they considered that Mom's organization, not theirs.

NB: No.

DR: You never felt that?

NB: No, because my father is a chemist, and he was active in the American Chemical Society. And my mother was an engineer, and she was active in AIAA, whatever that stands for Mom — the aerospace engineering association. (American Institute for Aeronautics and Astronautics)

DR: Yeah, we've covered that. (laughter)

NB: I think they've changed the initials since I was a kid.

DR: Yeah, they did.

NB: But Mom and Dad belonged to their respective technical societies. And the value that rubbed off subconsciously — because it really wasn't conscious with me for a long time — was that that's something you do. If you're in that type of profession, to say current, to make the contacts you need for your career, you join. I mean, it's not something you stop and take — you join. I did belong to American Society of Mechanical Engineers, but because I really became a manufacturing engineer, I've been an SME member for a very long time, almost as long as

a SWE member. And I've been very active through their regional structure, too.

DR: And that's the Society of—

NB: Society of Manufacturing Engineers. I've been active in the Upper Midwest Region. And there I've made a lot of job change, job stay current contacts. I joined SWE because they got me to take a second look at engineering. And I figured if they had the power to do something a parent couldn't, I was really interested in knowing what the secret was. (laughter)

And then once a group of complete strangers — they may have been initially prompted by your mother — but once a group of complete strangers has extended their hand and helped you through school, there's that concept of turning around pulling from under you. So there's a debt in some sense. But we were raised — we've got some morals here, there's a moral obligation to turn around and help from behind.

And the older I get, the more distance there gets to be between me and the students, the more I really get a kick out of what they're learning in school, what they're experiencing. And a lot of them now have a parent who was an engineer. And once in a while I find one who's got a mom who's an engineer, besides Maggie's daughters. So, no, it never bother me at all. The only problem — there's two problems Mom and I have had with that.

And that's when we come to conference, her initials are Y.C. Brill, and my initials are N.C. Brill. And before there were computer labels, they weren't sure if there was one of us

or two of us, or who was who. So we'd end up here, both of us, coming from different parts of the country, and there'd be one registration packet. That happened more than once. (laughter) It took SWE in general a while to figure out there were two Brills running around.

And then the other is that in the Midwest there's such a strong family value system, and people don't move far from home. And so I go to SWE, and I talk about my mother being in SWE. And all of a sudden there's a bunch of people in Minnesota who are livid because my mother is a member and she never shows up at meetings. (laughter) And it was very hard to explain, "I live 1,800 miles from my mother. My mother is a member of the New Jersey Section. Look at a map. I don't think she needs to"...

And there was a little bit of that with the New Jersey folks — "Why don't you ever come to meetings with your mother?" "Because I live in Minneapolis." So I mean, those are the only — you know, people know now, because they know both of us. It was really funny watching the cultural values from the upper Midwest just kind of collide with reality. It's like well, just because your mother is an engineer and also a SWE member, she doesn't necessarily live two blocks from her mother and call her five times a day.

DR: Right. (laughter) And we had talked about that a little bit earlier, how all of your children, Yvonne, moved away from home. And it was just kind of something that was assumed, you know, you go to college, away from home.

NB: Well, she pokes fun at me and says, "The apple didn't fall from the original tree" because she grew up in Winnipeg. And she went to USC in Southern California. So why would I think I had to stay anywhere close to home? But I didn't ever really think about how close Minneapolis is to Winnipeg until a couple of years ago. I was like, "Oh, my, it is only a few hundred miles." It's straight north. There's an interstate. It's straight north. It probably 500 miles, but still... So I now I get why she said the apple didn't fall far from the tree. (laughter)

DR: Well, Yvonne, how did that make you feel, then, when your daughter finally did get her engineering degree and become an engineer?

YB: Well, we're just very proud of her, because she did very well in all of the jobs that she took, wherever she worked, and was very satisfied. She's really very happy with engineering as a career. And I think, just as I said, I realized very early on that as an engineer — there was so few of us at the time I entered engineering that they wouldn't make — they wouldn't pass laws that would discriminate against me, or wouldn't work to discriminate against me. I had the world open to a greater degree. And so I think engineering is a great career for women — much, much better than chemistry just simply because it's such an old-line profession.

And then I'd watch many women in physics, for example, really struggle, who are very, very capable. And that's just so

male dominated, and just has not changed. They're still in the dinosaur age.

DR: Well, let's talk about that is little bit, then.

NB: Well, I know I was going to say, Deb, one of the things you're asking about is what do I see intergenerationally.

DR: Yeah.

NB: And yeah, I was always very conscious that Mom was the only woman working in her profession, because she used to get these interviews from the local newspapers and stuff. And there was one article at one point – was it in 1975 – you were the only woman propulsion engineer in the country. And of course, Mom's comment was, "Well, I don't know where my company is, but it better be coming soon." (laughter) And I know within four years she told me she was no longer the only one, and she was very glad she was no longer the only one.

But I knew that she was out there in an area that just by being competent, both in terms of the way – professional and technically competent, that Mom had never really had any issues. Some of the best stories she tells are about her boss bidding his one-woman engineer against nine male engineers at another company. And I don't know if she gave you—

YB: Oh, that's a wonderful story I didn't tell you. (laughter) One of the times at RCA we had a visitor from an outside company, who had worked at Hughes previously. And we were sitting around in a conference room listening to his presentation. And he asked how many propulsion engineers they had at RCA. So it very quickly came out that I was the only

one. And this fellow looked horrified. He said, "Hughes has seventy-five." And one of the program managers spoke up and said, "But we believe in quality, not quantity." (laughter) I could have kissed him. That was really so super.

NB: And so I grew up listening to stories like that, knowing that what counted was your competency and how well you did your job and how you conducted yourself. And so Mom was an only. So I went out and I ended up in manufacturing in a metal cutting machine shop, not a place where a lot of women end up. But that just happened to be what fascinated me for that five-year part of my career. And so there weren't a lot of women around. And I thought, well, I don't know — it didn't dawn on me, yeah, this shouldn't be a problem, it was never a problem for Mom.

And I actually found the reverse, that in the particular era when I started to work, it was an advantage, because there was a woman manufacturing engineer in Rosemount Incorporated's heavy metal alloys. We machined some very high, peculiarly structured metal alloys. And it required highly specialized tools. Every machine tool vendor in the Twin Cities area knew there was a gal at Rosemount. And that was somebody new, and maybe they'd get a new foot in the door.

And so in terms of starting my career, being a woman and an only got me that vendor network that you need, you know, for whatever your technical discipline is, very, very quickly. And I had a good sense of humor. And you know, some of the guys would go, "Well, do you bake brownies, too?" And I'd say,

"Yeah, but there might be arsenic in them, so be careful." (laughter) Some of them weren't sure how to deal with a woman in a machine shop, because there really weren't a whole lot of us at that point. Yeah, and I thought, well, that's okay, you know, it's no big deal.

But SWE was the company outside of work that — I mean, you do that day after day after day, you do your job, and you get recognition for being technically competent, and you get opportunities and stuff. But you still wonder what's going on in the rest of the world. And there's more women in machining now — a couple good friends from the good old days.

DR: So in a way you kind of both did experience the same thing, you know, a generation of her as being the only and your jobs in the beginning.

NB: Yeah. I mean, the particular thing that I started out in there just didn't happen to be a lot of women. And so I was an only. And SWE was company and a safe place to unload and learn things and try out leadership skills. And because I'd seen a role model that just went and did and as long as you were competent and the quality of your work was there you were fine, that was what I did.

And I'd watched in cycles — I really think that — Mom was an only, and she was pitted against seventy-five engineers at whatever company that is — I was one of the few. But then it seems like there was a time period when American culture changed, there were a lot more women in the workplace. And the guys figured out that we were pretty bright, and we usually had

a little bit better people skills than them. So yeah, I'm a little biased there. (laughter) And the multitasking thing, you know, yeah.

So we were a threat in terms of competition for advancement. And I actually watched discrimination in the local area where I worked kind of start up. And then diversity efforts came in and started to undo it. And now we've been through this huge circle, and it's sort of like it doesn't matter who you are, it matters how well you do your job.

So we're back there at twenty-five years later. And I don't know if you saw any cycles between you and my career. I mean, you're such a technical expert that you're just recognized as knowing what you're doing. I went more the route of management. I used engineering as a stepping stone to open the door to management.

DR: Right, because you did go back and get a business degree.

NB: Yes, I did go back and get an MBA at night. And I took on more operations management, technical management, project management. My specialty is working between design and introduction of a product. So how do you actually take the design concepts that people like my mom create at 2:00 in the morning at the kitchen table and make them something real that another person is going to use someday for something? So I'm more on the people — develop people side and the management skills.

That may be because there's a little more competition there, in terms of more people want to do it. Maybe that's why I have, at various points, sensed some issues that a woman's cultural values – you know, I don't happen to be very good at golf, so I spare people having to play golf with me. (laughter) But I won't go, because I'm just terrible at it. So when you get into the management club – "She doesn't play golf. What are we going do with her?" You do miss out on some of the business information and the networking that you need.

DR: Well, it's interesting that – beginning in the '80s, when you were just beginning your career, the whole concept of the glass ceiling came – you know, that term came to be coined. And you, as having gone into more of a management type role, you know, were you aware that that was–

NB: I was aware that there was a social construct called the glass ceiling. But my role model, in that sense, said if you were good at your job – I mean, as long as you weren't a jerk in terms of your personality – I don't know how else to say it, as long as you were a team player and you were good at your job... Maybe there's a company that's managed in a very conservative way where there are issues with upper management being all male. But there's a company right next door that doesn't care. And so I'm not beyond saying I'd change companies to keep my career moving; but who hasn't done that?

I think that's a perfectly normal thing nowadays. I mean, it's not like you work twenty or thirty years for the same company like my mother did. Now they tell us we'll switch

careers, what, five to seven times, and have I don't know how many employers. So when you feel you've gotten as far as they're going to let women go in a company, you find another one that will let you go to the next level, and then you find another one. I mean, I've been all —

DR: It's sort of like United technologies, was it, that you worked for?

YB: Right, right.

NB: Yeah, I've been all the way to the corporate board room in a private company defending what I was doing with a million and a half dollars of private investors' money. So I don't know if it's more or less threatening than being in the board room for a major company. But I know when you're looking at the three men who put up the million and a half dollars, and they've got you cornered in a room at 8:00 in the morning, you better have a good explanation. So it was like, to me, there's not a glass ceiling; you just keep going. I may have been a little intimidated by that, but I got over it.

DR: Well, the whole concept of getting a masters in business administration, was that something that was even considered back when you were advancing in your career, Yvonne?

YB: I forget now where I was employed when I became aware that the Harvard Business School allowed five women — I think it was five women, to enroll. But that just was not available. And as I told you, the Cincinnati convention was an eye opener for me because of the management type seminars that they

offered. There were a whole group of them for professional development, which really wasn't available.

Although RCA eventually did send me for a short course to the Wharton School when we got a really livewire in the personnel department who instituted a six-week course or something, for men and women. I think I was the only woman in it. But typically I wasn't aware — I might have been able to go back to school to get a Harvard business degree, but I wasn't sure whether that was the sort of thing I wanted to do.

DR: Well, I ask because it does seem like a rather recent phenomenon, that a lot of people in technical careers, whether it be engineering or some other field, do tend to go for masters in business administration. And I'm just wondering—

NB: Well, and what I see is by the late 1980s — I'd worked in Minneapolis, St. Paul. Honeywell and Rosemount were the major employers of engineers at that point in time for very high-tech instrumentation applications, high-tech defense applications, aircraft, sensors — those kinds of things.

And the local job market was such that as an entry-level engineer, I better have had a few MBA classes under my belt to get to second-level engineer. And if you're going to go to third-level engineering, where you started to be a team leader, you had to have an MBA, or be pretty close to being there. And at first I thought, well, maybe that's just a peculiarity. Minnesotans don't like to leave Minnesota. And the university was cranking out a thousand engineers a year, so there were a lot of us in that area.

And I thought, well, maybe that's just a local thing with them. No, it's across the country, you're now expected, if you're going to take a management route or even get into a technical team leader spot on a dual ladder, you're expected to do that, because they pay for it. It's at night, so that's your time. And I was in an environment in the late '80s, early '90s where it was an expectation. I had to have that MBA, or I wasn't going to be anything more than a shop floor supervisor.

DR: Right, right. That's interesting how that's changed. Well, I want to go back to an earlier thread of discussion and talk about SWE's involvement in the whole career guidance and reaching out to students, primarily, I think on the college level. I know that Yvonne, you're still involved with Princeton's student SWE Section.

YB: Yes. I think Naomi expressed that very well, this big sister/little sister concept, because when I was the executive committee member in charge of student affairs, the annual reports from the student sections made it very clear this was one of their big strong points. And I think that is a wonderful thing about SWE, the support groups, because just as I was given the impression when I was taking physics in high school that women just didn't do that, and you didn't have the ability, the mental capacity, many entry engineering students have the feeling they can't hack the physics, either. And just having this support group helps them get over that. And I think SWE is wonderful in that way.

DR: And so you're now both active with local student sections at local colleges and universities

NB: That happens to be my favorite level to reach out and work with. I mean, I've worked with all levels, that just happens— And I helped — a dear friend of mine that I've known for years through the Society of Manufacturing Engineers, became a dean of engineering at a very small private school. And they had diversity issues. And he was smart enough to know there was an organization called SWE out there. And he called me into his office one day to talk about it.

And I'm not an alum of the school, and I had no association other than I knew him through another professional society. He worked on parts of his strategic plan to increase his enrollment of women and to improve the quality of the experience they had at the Engineering College as women, and literally put it into the university's business plan that they were going to charter a student SWE section.

And so I was the person who, you know, got that action item from his strategic plan. And we chartered the University of St. Thomas Section in St. Paul, Minnesota — no, it's not in the Hawaiian Islands or the Virgin Islands. (laughter) People always ask me that because of their name. That's just their name. That was about five years ago. And they got a good start out of the gates. And their first year in existence, they won our coveted Outstanding New Student Section Award.

So the director of engineering was just absolutely thrilled. He had a woman's support group on campus, and not

only that, that were a darn good one, being recognized by the group that had chartered them. And he's a Rodney Chipp type person, really truly does support women in engineering. He's a lot of fun to work with.

And my students at University of St. Thomas are a lot of fun to work with. And I've always done — you know, turned around and reached behind and been a big sister for the University of Minnesota's alumni programs, and mentoring, too.

People at that age are — they're sure they want to be engineers, so I don't have to pretend that I like math and physics with them. (laughter) What they're looking for is what are the options. And that was something we'll get on tape here is part of my outreach deal to students is that, you know, I had this mother who was an engineer. I had this earache, I never wanted to be one because she spent all night at the kitchen table. But we're both engineers.

And then there's another story. My first job, my folks came out for Thanksgiving or something. But you know, that was in the days when there was no flex time. And I explained to my boss they were coming from very far away, and they've never seen where I worked, and would it be okay if I took two hours. And I gave them a tour of this machine shop I worked in. And I distinctly remember my mother saying, "That's engineering that you do?" (laughs) It wasn't her idea of engineering, nor what she does was my idea.

DR: It's so different, yeah.

NB: And so I use that to say, "Look, engineering accommodates all kinds of personality types and all kinds of different activities. And if engineering is big enough for my mother and I, then it's big enough for anybody to find some part of it that they like."

So I like the outreach. And by college they know they want to be an engineer. And so the question is: What kind and how do I get hooked up with folks in that industry so – you know, you have to have work experience to get a job. You have to start making those contacts by your junior year in college, or you're not going to get a summer internship. I mean, all those things – it's just a lot harder now than when I was a student. When I was a student, it helped to have an internship. But now it's a necessity. It kind of shows that you know how to function in the workplace and work on teams.

So I enjoy more introducing engineering students to the different kinds of things they could do when they get out, because often that's what they don't know. And at a small school like my section is, they don't have any kind of technical placement office, so they don't have the school bringing in companies. So the SWE section brings in speakers for everybody. We've had people from the medical device industry, we've had folks from IBM and the Rochester facility come in.

And again, the Dean of Engineering is still madly in love with SWE, because their meetings are open to everyone. So SWE is performing a placement service function for him and his engineering department.

It's getting the kids used to what's going to be out there when they get in the workplace, and that's a lot of fun – getting them set on their feet. And I think it's the management side of my personality, you're supposed to develop your subordinates and set them free, and they'll accomplish more than you ever could alone. So you mentor these SWE students, and turn them loose, and one of them is going to find cure for cancer, or whatever it is, that I – you know, that's not my thing, but I'm going to fire them up to go do it.

DR: Right. Well, we've talked about how you both became SWE members, and what it meant to you back then, and your roles throughout the years as mentors to other younger SWE members, student members. And I just want to ask you both for your impressions of how SWE has grown since – or if they have grown or changed since the time when you first entered SWE. Yvonne, it was in the '70s, the height of the women's movement.
(INTERRUPTION IN RECORDING)

DR: We were talking – I was asking you both for your impressions of how SWE has grown or how it may have changed from when you first became a SWE member to today. And do you feel like SWE is still relevant? And maybe do you think the focus of SWE might be different today than it was when you were first a member?

YB: Well, I still see our major strength in the student sections, because of the networking and support at that level to keep women in engineering until they graduate. And then the organization gives them the opportunities to network. Through

my contacts at SWE in years gone by, I've been able to help students find summer jobs, and things like that, you know. It's just a good resource.

I think the student sections function about the same, but what I think has changed is society itself. We need a culture change with less emphasis on razzmatazz and (laughter) big money from baseball. I think that we're going downhill in the sense that we're training fewer technical people. And I know it's discouraging sometimes to people who are in technical fields to see outsourcing and other things. And hopefully that may come to an equilibrium.

DR: So you think SWE needs to change to address these new issues?

YB: I think SWE is still relevant, and is necessary as an organization. There are still companies all over the place where they have just one woman engineer. And that individual needs to have someone — others to relate to, to maintain their equilibrium sometimes in that job that they hold, you know, to help them realize that they're on the right path, (laughs) that it's not all hopeless — (laughter) or to help them get out, if it is a dead end.

But I just see a lack of interest in younger people, in high school kids, in technical things. They just don't seem to relate to that. I'm not sure what's in their minds.

DR: Right. And there's been studies, too, that the United States is falling behind other countries in that sense.

YB: Yeah. There's just no question of that. No question at all.

DR: Right. Naomi, do you want to chime in with your thoughts?

NB: Well, my answer would be, yes, indeed, SWE is still relevant. If you look at our mission and our objectives and our strategies, you know, we're heavy on the encouragements. You know, we are an educational non-profit. We're educating the general public to engineering opportunities.

And if you go back to the tag line we have now — that's the aspire part, right — we're going to reach out and have people of any age — women of any age to aspire to be engineers, which is important. And I see the trends that my mother does, but I guess I don't know where exactly I as one person am going to exert any influence. SWE as a whole does have some voice. So we help with the aspirations.

The advancement, the professional development opportunities — if you look at our strategies, one of them is to provide professional development, to provide that networking, the benchmarking, you know, is this a normal career progression, the mentoring — all of those things are a tremendous service at both the collegiate level and the professional level for the organization. And I just blanked out on the third one. (laughs) It's like professional development, career guidance and—

YB: Aspire, achieve, advance?

NB: Well, advancement – there are two other things – recognizing the accomplishments of women engineers. And that's something that I've learned from my mother after she won the Achievement Award. She's spent the last twenty years working to recognize other women. And that's what she stays up at the kitchen table doing until 2:00 in the morning now. Dad tells me she's still doing that, when I call home. (laughter)

DR: Yeah, we talked a little bit about that.

NB: But the motivation that's there – and she's shared some of it – is that really, for the achievement part, it isn't just aspire, advance and achieve, it's also believing. And we have the power to validate the accomplishments of our own members, therein validating women in the profession. And that gets to the fourth objective is, you know, valuing diversity in the sense that we are a role model for diversity, yet we're women, and that's different than men. But take it beyond that, we have all kinds of different personalities and all kinds of different engineers in this organization, so we're role modeling the good of engineering as a whole to society. So we're still very, very relevant.

In terms of the organization changing internally, in the last three years we've had tremendous membership growth. I believe the number is thirty-three or thirty-four percent growth in membership in the last three years. And the interesting thing about that is that is if that happened in a company, you would have growing pains all over and mass confusion. But there's such a strong value in SWE, and the folks have been

members for a long time – like Mom and her friends – SWE doesn't feel any different to me than it did back in 1981 when I joined.

DR: As far as the culture.

NB: In terms of the culture. Those are the beliefs: "We are going to network, we are going to help ourselves develop, and we are going to role model what this is really all about." And now, in the last, maybe, ten years, we're getting much, much better at recognizing those achievements and doing that part of it. But everybody who is here who sticks it out for any length of time believes in those things.

And so SWE doesn't feel any different. It's just there's more of us, and so there's more friends to make, and more networking to do. And you lose a lot more sleep now than you used to because there's so many people to meet and talk to. (laughter) But that's the only thing that's really changed, is the amount of sleep people get at national conference.

So I think we're very, very relevant, well into the future. And sitting on the Board of Directors, I can say that the board is looking at how there's more of us. What do we do with that voice that we now have that people are now recognizing? How do we help change some of those cultural issues?

DR: Okay. Great. Well, I guess I want to end asking Naomi a question. What does it mean to you to have a mother who's considered a pioneer woman engineer, both through her acknowledgements at SWE, and her other professional recognition?

NB: This is sort of a – in the Brill family and in the SWE family that knows us both joke, I would say she's just my

mother. (laughter) I mean, and "just" is a little disrespectful, so I should take it out of there. But she's my mother. I do understand that she has these accomplishments, and she is a tremendous role model, and yes, I'm very proud of her. But she's my mother!

DR: Right. (laughs) Okay, well, is there anything else that you both would like to address today?

YB: I don't think so. I guess I've talked a lot. (laughs)

DR: Yeah, it's been a long time.

NB: But I love her stories. I love her friends' stories. I'm glad that they're being recorded. You know, maybe in twenty years I'm going to call you up and ask you to look at the tape. "Oh, no, SWE hasn't changed at all." (laughter) Hopefully by then there will be, you know, 80,000 of us.

DR: Right. Well, that might be a good time to come back and interview you, then, again.

YB: Right.

NB: It could be.

DR: All right. Well, I want to thank you both very much for your participation.

YB: Well, thank you, Deborah for interviewing us and interviewing us together. Naomi is much more articulate, I think, about some of these things with SWE than I am. I have the same feelings, and it has meant a great deal to me to be a member of the organization. And I certainly have enjoyed everything I've done.

And I think my biggest contribution now can be to ensure that women who deserve to be nominated for awards get nominated and get the award – you know, do the paperwork the way one has to to ensure that we increase the number. The number of women in the National Academy of Engineering since I was elected has progressed from a great tenth of one percent to three percent (laughs) over twenty years, almost twenty years. So it's a very inch-y slow movement.

DR: Right. Well, I think we might run out of tape here, so we should probably end it before that happens. But thank you again.

YB: Okay. Well, thank you, Deborah.

NB: You're welcome.

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