Hibbard: This is Jane Hibbard interviewing Professor John Chowning on June 9th, 2010 for the Stanford Oral History Project. We are conducting this interview on the Stanford University campus in The Knoll where the Center for Computer Research in Music and Acoustics, known as CCRMA, is located. Good morning, Professor Chowning. Thank you very much for agreeing to this interview.

Chowning: [00:00:37] Good morning, Jane. It’s a pleasure.

Hibbard: As a founding director of CCRMA, can you tell us how CCRMA started?

Chowning: [00:00:47] Okay, the idea for CCRMA as a kind of administrative research entity came up about the time that Pierre Boulez was forming the large music research institute in Paris, the IRCAM, Institut de Recherche et Coordination Acoustique/Musique. What we realized - all of us who were working in this area [computer music project at the AI Lab] - we realized that having an independent administrative research entity gave us certain freedom in funding and a minimum of administrative dependency upon the Music Department - we wouldn’t have to go through the Music Department to do everything. So we formed CCRMA because we saw that, especially with Boulez’ effort in Paris, that this field was going to grow and become the dominant field in electroacoustic music in the world. And now, the important link here is that Boulez, a very wise man, surveyed all the work that was going on in the field of electroacoustic music when he first proposed the idea for IRCAM to the French government. That was George Pompidou, I believe. He did a survey and saw that there were some groups in the world that were ahead of others. Others had more recent contact
or might have made use of more recent technology than other groups. And, of course, the traditional ones in Europe were those in Cologne and Paris, the *Groupe de Recherches Musicales*, and in Rome, Luciano Berio, Bruno Maderna at the RAI in Milano, all of whom used what we called analog technology. But there were a few, and one primary one, that was involved in digital technology and that was CCRMA. The work we were doing at Stanford, then known as the computer music project, had been launched 10 years before in 1964 with the help of Max Mathews, who at the time was with Bell Telephone Laboratories. So the Americans had this foot in the door already in digital representation, digital technology, what we call now digital domain, that the Europeans were not aware of. And Boulez made contact with us based upon the recommendation of Gyorgy Ligeti, one of the major composers of the late twentieth century, who had visited Stanford as a visiting professor in the spring of 1972.

**Hibbard:** Is he Russian?

**Chowning:** [00:04:19] He’s Hungarian.

**Hibbard:** Oh, Hungarian.

**Chowning:** [00:04:21] Yes. And he is noted for his excellent compositions, but mostly in the public mind, a lot of his music was kind of taken and used in the film, *A Space Odyssey 2001*. So a lot of people first heard of him through that music. But anyway, he had visited here and saw the work that we were doing in 1972 and he told Boulez, whom he knew very well, about this work and that he who’d been planning IRCAM should take a look at what’s going on in America. There were other places - Princeton was active, Bell Labs. Max continued his [computer music] work at Bell Labs since the beginning, in 1957, but it was peripheral to his main job, which was running a big research lab at Bell Labs. So his labor was a labor of love that was mainly in the off hours et cetera, whereas we had a really good research group here that was multidisciplinary, very active in publishing. So we founded CCRMA then in 1975, at the same time that IRCAM was founded in Paris. And IRCAM used all of our software, got
the same computer that we had. So they began at a point that was a very high level, since we had the most advanced system at the time.

**Hibbard:** Now when you started 10 years prior, was that in the Donald C. Power Lab? Was that where that started?

**Chowning:** [00:06:10] No, I began actually in a small computer, the AI Lab at the time, that shared a PDP-1 computer, DEC’s first computer, with Patrick Suppes. His work, I think, was in machine learning - machine teaching, actually. I think the big project was teaching philosophy using the Computer. So he and John McCarthy shared this PDP-1 computer, which was a timeshare computer and that was at Pine Hall on campus. Now does Pine Hall still exist, I don’t know.

**Hibbard:** I wouldn’t—

**Chowning:** [00:06:50] Yes. It’s a historical building that was home to the main computer center where they had a big IBM 7090 machine, which I was able to get a little bit of time on, enough to get this program going that Max had given me when I visited him in Bell Labs at the summer of 1964. And now, the interesting story is how I came to be interested in computer music.

[00:07:30] My years before coming to Stanford as a graduate student - I arrived in 1962 - were spent in Paris where I was studying with a teacher who was not herself interested in electroacoustic music, but she lived in Paris where there was a lot of new music that was going on. The teacher was Nadia Boulanger. A lot of the music that was presented then was beyond her interest and understanding and I listened to a lot of that music and a lot of it was dependent upon the use of loudspeakers - electroacoustic music. So when I came to Stanford, I was interested in the use of loudspeakers, not as a medium for reproducing music that was intended for quite a different venue, but using them as a source for creating sounds, which was the idea behind electroacoustic music as practiced in Europe using analog technology.

When I came [to Stanford as a graduate student], there was no electronic music studio here at all. So I was somewhat disappointed and resigned, but in my second
year of graduate work, a percussionist in the Stanford Symphony—I was the timpanist—Joan Mansour, a biologist by training — gave me an article that she had found in Science that Max Mathews had written and this article described his work at Bell Labs in using computers as a musical instrument, as a source of musical sound. So I read that and there were some startling statements, one of which was any sound that a loudspeaker can produce can be synthesized using a computer. And this was based upon sampling theory, which I didn’t understand at that moment.

And I read this with considerable interest, not realizing the full import at the moment, but I then visited Max in—as I said earlier, in the summer of 1964—and he explained in detail what he was doing [and gave me the music synthesis program in the form of a box of punched cards]. Back at Stanford I found the tuba player in the Stanford Symphony Orchestra hanging around the computation center when I arrived with this big box of cards—David Poole, an undergraduate math major. The timpanist and the tuba player sit next to each another in orchestras typically. And he, not knowing that I had any interest in computers, and I, having no idea that he had interest in computers, confronted each another.

And he said, “What are you doing here?” And I said, “Well, I have this box of cards, which is a program that Max Mathews of Bell Labs had written and I need to see if I can get this work on these computers.” David Poole, being a bright, young, scientifically, technologically gifted student, took me in hand and [over some months] taught me everything I needed to know, from what a function was to how to program. And we got this program going in short order on the 7090 and the PDP-1 computers.

**Hibbard:** And was this what was known as FM synthesis?

**Chowning:** [00:11:32] Not yet. FM synthesis was several years later.

**Hibbard:** But I actually have some questions more about CCRMA and then we can move into that, okay? Back to CCRMA, when it was formed 10 years, well, in ’60—
Chowning: [00:11:50] Eleven years later.

Hibbard: Right. Eleven years later. That would be—

Chowning: [00:11:56] 1975.

Hibbard: 1975. Let’s see. Were there other people, faculty and students involved in the formation of that that you might want to mention?

Chowning: [00:12:08] Absolutely. First of all, Leland Smith, who was my composition professor until I finished my degree in ’66. As soon as I began work with computer, a year or so later, he joined me and became very, very interested himself. And though his work took a somewhat different path than using computers for music composition, his work was very much parallel to my work. His interest was in producing scores, musical scores—music publication, basically. The same sort of data was needed for both music composition and music scores. So that was the common thread. Leland certainly was very supportive of my interest and work in computer music.

Then there were several graduate students who were attracted to this area. One, a composer whom I had first met on a boat trip from Europe, Loren Rush, who was an active composer from Cal Berkeley. He came to Stanford because he wanted to be involved in computer music and very quickly did, you know, very impressive original work. He knew a lot about acoustics and he was a composer who specialized in writing for orchestras, large media. He was commissioned by Ozawa, for example, [to compose a piece] for the San Francisco Symphony. He became one of our group when we formed CCRMA.

Another is John Grey, who came [into computer music via psychology, working with Roger Shepard, a cognitive psychologist at Stanford, now retired. And John Grey was interested in the questions of timbre, what defines tone color in a musical instrument, in a very general way. And it’s a very difficult problem. We still don’t understand it altogether, and Roger Shepard was very happy to work with him on this project.
And then a very important person was Andy Moorer, who came from MIT as a systems programmer for the AI project. But he was [also] a musician, you know, played a lot of blues and played guitar and he saw what we were doing and defined for himself a PhD in computer science and began working in the area of computer music. So these are the four of us, with Leland, you know, peripherally interested—we’re the ones who formed CCRMA. I was a junior professor, an assistant professor on the faculty and so I was the titular head.

Hibbard: [Laughs] The lead.

Chowning: [00:15:39] The lead, but we all contributed. There was one other person I don’t want to forget who was important to me in my initial investigations and continued to be important in the work with graduate students through the next 15 years, Earl Schubert, who was a professor in Speech and Hearing Sciences in the medical school. He retired and became an incredibly rich resource for all the graduate students up through the eighties.

Hibbard: I’m sure.

Chowning: [00:16:22] He was a psychoacoustician and had knowledge that few other people had in the domain of acoustic research, perceptual research.

Hibbard: Did that lead anyone to pursue research that would help him help people in the medical field?

Chowning: [00:16:43] Well, ultimately, yes, there were people who did work with him who also did their work with computers in the domain of speech and hearing sciences, yes.
Hibbard: That’s interesting. What was the Music Department’s view of the formation of CCRMA?

Chowning: [00:17:02] Well—

Hibbard: Did they support it at that time?

Chowning: [00:17:05] They did. Let’s say the Music Department’s view of computer music initially, I think, was—let’s say, I’ll be kind—it was tentative. That is, what we were doing was very primitive at the beginning because we knew so little about what to do to make sounds that were lively and interesting. No one in the Music Department understood sampling theory. Max’s article was based upon an assertion that was, of course, true, that any sound that can be produced by a loudspeaker can be synthesized, represented digitally. So I knew that the future was vast, but it was a question of living with a knowledge deficit and also funding and the availability [of computers]. So it was pretty hard to convince the Music Department that this was anything but an exploration of modest interest. I was convinced it was the future and we were proven—and my colleagues who became involved also believed the same—and we were proven right. Now the whole world, every music department has some digital activity. So the Music Department, I say, was tolerant of this idea, tolerant enough to hire me to teach the course and it was a kind of a commitment to give—well, giving me a chance to show.

Well, after seven years of teaching, you know, universities have to decide whether they keep their young faculty, or let them go. And I had produced only two pieces, two compositions, but a research paper that turned out to have—well, a couple of research papers, both of which turned out to have produced a lot of interest in both the scientific and the music industry worlds. One of them was the FM paper. But when it was read by whomever reads these things, it was not seen as being significant apparently and the work which I—the composition which I’d produced, a piece—well, one, the second one, which was the more mature of the two, let’s say, Turenas—was seen as being this odd piece that was not like music that the people who evaluate music
compositions are used to hearing. So in both—at both points, I lost, so I was denied
tenure and went through some difficult years.

Ligeti, this composer who had been here, 1971-72, arranged for me to get
a grant—from the City of Berlin, which kind of kept me going, although I was not able to
work very effectively because I was away from my computer system at the AI Lab. But
then Boulez saw the value of what I had done, what we had done. Yamaha became
interested in one of these ideas, which was the FM synthesis.

Hibbard: Did this happen when you were on sabbatical?

Chowning: [00:21:05] The discovery of FM synthesis was in 1967. Yes, I was on
sabbatical when—

Hibbard: When the interest started percolating?

Chowning: [00:21:12] Exactly.

Hibbard: Well, we’re going to get to that. But so do you feel that your discovery of
FM synthesis contributed to the development of CCRMA?

Chowning: [00:21:24] Oh, yes. There’s no doubt about that. The prospect of having
the largest music instrument manufacturer purchase from Stanford—I signed over rights
to Stanford—the exclusive rights to this technology. YAMAHA even began paying, not
huge sums, but small sums of money to have access to this option to the patent.

Hibbard: And I think my next question there was—it was granted as a patent.

Chowning: [00:22:05] Yes.

Hibbard: And that was in 19—
Hibbard: Yes.

Chowning:  [00:22:12] I think so. The patent was finally—it was applied for years earlier.

Hibbard: Quite a process, we’ll talk about that. Did the revenue from the patent affect the status of CCRMA and the Music Department?

Chowning:  [00:22:29] Oh, yes. It certainly did. We used the royalty income to build an endowment. Okay, I must say that trying to run a project as an assistant professor who had not been promoted is not easy to do. So, of course, I had to find a way back and after a year in Berlin and with the interest of CCRMA and what not, I came back as a research associate, which is a non-faculty position, although I taught the course in computer music. And we were able to acquire an NSF grant—that's National Science Foundation—and also a grant from National Endowment of the Arts to purchase some very well-designed equipment by friends and colleagues and—

Hibbard: Now was this prior to the patent or after?

Chowning:  [00:23:33] This is after the patent had been applied for. Okay, the discovery of FM was in 1967, only a few years after I began work and, at the time, I was working on the second major area about which I had published in those earlier years, which was in creating illusory sound sources, using a few speakers to create the illusion of sounds and in a two-dimensional space, or even three-dimensional space. I mean, they could move and they’d appear to be places [between loud-speakers] and, in fact, there were no sound sources at the apparent locations. So I was working on that project when I discovered FM. So I worked on FM a bit but I wanted to finish up this quadraphonic system, and it was in 1971 that I had an effective kind of breakthrough in realizing the potential of FM synthesis, the full potential. It was then that I contacted the Office of
Technology Licensing.

Hibbard: So, the process was that you contacted them.

Chowning: [00:24:52] Yes. Well, I had been in contact with them because they—Stanford got a patent on the omniphonic sound space or quadraphonic on the spatial—illusory space [that I mentioned before]. So we already had a patent and it had gotten a little bit of industrial interest so I knew where to go. I knew Niels Reimers by then and he—

Hibbard: Who is the director there?

Chowning: [00:25:15] Yes, the director of OTL. And so I went to him and explained to him what I thought about the FM synthesis and that it should have broad applications in the music industry.

Hibbard: And we’re going to talk a little further about the process of the patent, but just to finish on CCRMA and the Music Department. Did the revenue from the patent, did it increase faculty positions for either?

Chowning: [00:25:49] Well, it finally did. Yes, we were able to hire a staff of—

Hibbard: In which departments?

Chowning: [00:25:58] In CCRMA.

Hibbard: In CCRMA. For CCRMA.

Chowning: [00:26:01] Right. Yes, with, first of all, our grants, then we got a big grant from the System Development Foundation that John Pierce had arranged, who was kind of the big scientific daddy behind all—that allowed Max to do his work at Bell Labs and
Hibbard: Where was he?

Chowning: [00:26:23] He was at Bell Labs for most of his career and then retired, went to JPL [Jet Propulsion Laboratory] and at Cal Tech for a short time.

Hibbard: That is Mr. Pierce?

Chowning: [00:26:32] Yes. And then came to Stanford. We gave him a place and then appointment without salary, but he didn’t need a salary. And he then was followed by Max who came on our faculty. And so we had these two major figures that—

Hibbard: How exciting.

Chowning: [00:26:51] Yes.

Hibbard: Just to finish up on CCRMA. Do you think that there’s been an increase in undergraduate and graduate student enrollment in computer music?

Chowning: [00:27:03] Oh, yes. I mean, from the very beginning when we began teaching this course, there was an ever-growing interest in the population of applicants to the program.

Hibbard: Do you know how many people today are involved in it?

Chowning: [00:27:22] Oh my gosh. I don’t know.

Hibbard: Or approximately?
Chowning: [00:27:25] Well, there are hundreds. I mean, if you Google, you know, my name, there are tens of thousands of hits. Most of them because of students or students of students and so, I mean, CCRMA, if you Google CCRMA, there’s a huge, huge—

Hibbard: And the last question on CCRMA before we go back to FM synthesis is, what is the role of CCRMA and Stanford in the education and creation of computer music today?

Chowning: [00:27:57] So CCRMA, as a unique interdisciplinary, say, multidisciplinary facility in our original conception—and this has been maintained by Chris Chafe, who took over directorship when I retired in ’96—was to create an environment that had the best technology that we could afford to have and with the idea of having rather a small amount of good stuff and lots of medium good stuff, not so good stuff. So the idea was on giving enormous power to the users and to have a population of people that was a mix of engineering—engineering sciences and music—and especially composition, and so to do that, you have to have faculty or staff who have these qualities.

So one of the major accomplishments was our being able to get appointments for faculty who were not PhDs from a music department, which was the case with all the other music faculty. Everyone had—including me—had degrees, advanced degrees in music. And I guess the way this was achieved was in convincing the university that an interdisciplinary laboratory of this sort could survive in a music department even though the disciplines of higher learning were different in the same way that a philosophy department is able to function and exist. In philosophy, there’s the humanistic philosophers at one pole. The other pole, they’re the logicians. The logicians are basically mathematicians and these people have learned to speak to one another and so I asserted that with the help of our dean at the time, John Etchemendy, who’s now the provost, a philosopher, that we could do the same.
Hibbard: Was this around the time that other departments in the university were becoming more multidisciplinary as well?

Chowning: [00:30:39] Well, there were certain programs that were—symbolic systems. But these were programs that involved faculty in departments getting together and overseeing, you know, a program. But what we were talking about was having an electrical engineer as a professor in the music department, which is a bit different.

Hibbard: And do you feel like you were a groundbreaker as far as organizations like CCRMA for other places in this country?

Chowning: [00:31:15] Yes, I think so.

Hibbard: And have they followed in that direction?

Chowning: [00:31:19] I think so. Perry Cook, who got his degree here in EE and music, in engineering, for example, now has a joint appointment at Princeton in music and computer science. And his field is computer music. One of his students, Ge Wang, CCRMA hired three years ago from computer science at Princeton, now [in] a tenure track position at CCRMA, and his field is computer science. He’s the one who’s gotten so much press recently because of the mobile phone orchestra, the Stanford Laptop Orchestra. He’s gotten lots of press. So yes, the effect of getting these secure appointments for people having disciplines not in music, not in traditional music department areas, was a major breakthrough.

Now it’s not unlike what the German university considered a music department maybe, you know, a hundred and fifty years ago when they had acousticians. That was part of musicology as well as historical musicology and the study of music itself. So it’s kind of come back full circle, but now in the domain of the digital music and acoustics and signal processing.
Hibbard: It’s very gratifying, isn’t it?

Chowning: [00:33:00] Yes, it is. And we have wonderful help from a lot of friends.

Hibbard: And you’ve mentioned a lot of them. Now we’ll talk about FM synthesis—and we may be repeating—but I think it would be good if you would go back and describe what led to the discovery of this.

Chowning: [00:33:22] Sure. So in 1964, when I began—given everything that anyone knew about computer music because that was all part of the, basically, the box of cards and the knowledge that goes with it that was given to me by Max Mathews in 1964. So there was this theoretical assertion that we could do anything with computers and loudspeakers, but no one knew how to do it. And, in particular, the idea of sounds that have some internal dynamism, like all the sounds we hear in nature have this property, vowels and diphthongs or where that [dynamism is] particularly emphasized, like “ooh,” “ah,” we have this change in spectrum. Even in sounds that we hear as a single kind of timbre, in the microstructure of these sounds, there’s a lot going on that is not apparent to the analytical ear, but when dynamism is not present, sounds are dead and not lively. So my ear was tuned, let’s say, my ear was hungry to hear from a computer sounds that had some liveliness to them. And I knew that it was possible by very expensive means, too expensive to do practical experiments with or even to conceive of making a composition with, which is called additive synthesis.

So in 1967, I was experimenting with vibrato because I needed sounds with some dynamic quality in order to reveal some of the attributes of localization and spatialization in illusory sounds that I was working on. So I was experimenting with vibrato, vibrato being that technique that is applied by violinists and many instrument players, which is where one changes the pitch of a sound through time. A violinist rotates the finger by a small amount above and below the pitch as desired or the singer changes the pitch by a small amount, sometimes a lot. And so this technique for kind of warming up a sound or exposing certain attributes of musical sounds called vibrato is usually limited to a few cycles per second, and up and down a half step or less in pitch.
But computers, of course, are not limited, so I was experimenting producing vibrato where one simple waveform, a pure wave, a sinusoid, is used to change the pitch of another. And in doing this, I had the opportunity with a computer to increase the rate and depth of vibrato to virtually unlimited values and did.

And in the process of doing that, at some point, I heard—my ear told me that I was hearing something that had not to do with change in pitch through time, but I was hearing change in tone quality. And change in tone quality of the sort that I was hearing with only two simple oscillators was a stunning sort of ear event. So this was an ear discovery. And then I did a series of experiments where I kind of created a logical progression of values for these—this kind of swing of pitch above and below some average — now we know as carrier frequency, modulating frequency and frequency deviation, but anyway, three simple numbers that I could change. And within this set of experiments, I produced an enormous variety of sounds and they were not chaotic necessarily. I could transpose them. And I thought this is something important and then went to an engineer, David Poole, my angel.

Hibbard: He’s the tuba player.

Chowning: [00:38:20] He was the tuba player, who was by then the systems programmer for John McCarthy’s AI project, having finished his degree. And he said, I don’t know, let’s go look at an engineering text. And we knew it was in the domain of frequency modulation, so we used a famous textbook written by a famous Stanford personality, engineering professor and then provost, Frederick Terman. Terman’s engineering text had a nice two-page explanation of FM in regard to radio broadcasting.

I had Dave explain to me the mathematics of this and we determined that what I was doing fit exactly the explanation in the text except that my carrier frequency was not in the megahertz. My work was in the audio band. And I was creating sounds using an un-demodulated carrier. And the spectral components that were predicted in that case and the simple explanation explained exactly what I would hear if we applied certain conditions. So I knew that there was a richness, inherent richness. It had an
explanation that was completely non-intuitive and that any engineer would understand when I explained it, which turned out to be true.

I took it to Max Mathews and Jean-Claude Risset, a very important researcher at Bell Labs in 1967, December 18th. And then Jean-Claude Risset wrote down the parameters that I had written in my notebook just a few weeks before. Another engineer had copied the block diagram of the circuit that I used and I explained it to Max Mathews and it was confirmed by their engineers, “yes, what you’re doing is what you think you’re doing,” which was good news because I had no engineering or mathematical background.

Hibbard: So this was in 19—

Chowning: [00:40:57] Sixty-seven.

Hibbard: And then when did you start the process of getting the patent?

Chowning: [00:41:05] So in 1967 as I said earlier, I was working on this illusory sound source and I worked a bit on the FM, developing different kinds of tones. And then in 1971, while working on a write-up of this with Martin Bresnick, who was my graduate student at the time, I realized some important relationships having to do with perception in this FM technology, which I implemented. I produced some, let’s say, stunningly real, lifelike sounds that suggested that we get a patent—that this [FM synthesis] is more than just for electronic uses, this has a wide application in the music industry. So 1971 is when I approached OTL. OTL looked for instrument companies in the United States, for example, Hammond and Lowry and Rogers, organ companies, none of whom understood digital domain. And finally they contacted Yamaha, who sent an engineer who understood in ten minutes when I explained what I was doing, because they were already doing research in computer simulation of sounds using digital means.
Hibbard: So your role was really initiating the process and the discovery and the OTL went out and researched who might be interested in it.

Chowning: [00:42:52] That’s right. Which was a wonderful relationship because it absolved me of all requirements regarding patent searches as I had no interest in that or the business aspect. I mean, I was heavily involved in the technology—as Yamaha developed this technology. I made maybe 15 or 20 trips to Japan.

Hibbard: Right, and we’re going to talk more about that, too. So your experience working with OTL was a good one, I take it.

Chowning: [00:43:21] Excellent, Yes.

Hibbard: And who were the people from that office that you worked directly with?

Chowning: [00:43:27] Okay. In the early years, it was Niels Reimers and Sally [Hines], his assistant, my gosh. I can’t remember the last name for the moment, but it’ll come to me. Anyway, the office was just the two of them, she was the administrator and he was the head of the office and they were alone—they were wonderful. Then they took on, you know, more help. Joe Kepnick, I guess, at some point. And then eventually Niels retired and turned over the directorship to the current director—oh, my gosh.

Hibbard: Well, it can always be filled in.

Chowning: [00:44:15] Yes.

Hibbard: [Laughter]

Chowning: [00:44:17] Who was wonderful.
[Speaking at the same time]
Chowning:  [00:44:20] And she has maintained the same spirit of the place.

Hibbard:  Yes. I think I ran across her name someplace, too.

Chowning:  [00:44:29] Yes. She had a Chinese background, I just can’t remember. [Katharine Ku]

Hibbard:  And were the deans in the humanities and sciences involved with this process at all?

Chowning:  [00:44:38] Well, they were supportive, I must say. At some point before we began receiving royalty income in any substantial amount from the licensing, we sort of ran out of money after an NSF grant had terminated and before the System Development Grant, the grant that John Pierce had arranged. Dean Halsey Royden arranged for some bridge money that supported us. So they were very supportive. Then later, Dean Norman Wessels was very supportive of the project. So I think the administration was—Yes.

Hibbard:  They came a long way from suspecting that this was not music.

Chowning:  [00:45:40] Yes. Well, by this time it was pretty evident. Yamaha started producing musical instruments and the DX7, in 1983, was the biggest selling synthesizer that has ever been produced. And the DX7 is only a small part of what Yamaha produced using this technology. They used it in lots of applications.

Hibbard:  As far as the revenue from the patent, how did the university and you decide to use that revenue?

Chowning:  [00:46:18] The revenue, in those days, the inventor had an option to develop an idea privately or to sign over the rights to the patent to the university, in which case, they divided any royalty income, four ways - 15 percent, I guess, to OTL,
then the remainder, 85 percent divided three ways, the inventor, the inventor’s department and general funds. So in the course of this little history, as I’ve told you, I lost my job. I came back [from sabbatical leave] and I didn’t have a position. [We at CCRMA] were supporting ourselves with grants from NSF and from the National Endowment for the Arts, and then had gotten this big grant, you know, $2.5 million from SDF—System Development Foundation.

Hibbard: Was that—was that after you came back that you got those grants?

Chowning: [00:47:51] Yes. I came back in ’75.

Hibbard: Yes.

Chowning: [00:47:54] Yes,—I think Leland Smith and then Al Cohen was the principal investigator because I was not able to be, as a research associate. Then I was made a research professor and I was able to be the PI, principal investigator. So the university saw that we were able to support ourselves, even before the royalty income, and that this work was promising. So they agreed to put their two shares into an endowment to kind of build up a fund that would allow CCRMA to support itself.

Hibbard: So is that endowment—is that the same as or different than an endowed chair?

Chowning: [00:48:57] An endowed chair is different. An endowment is just a pot of money that goes into the investment—

Hibbard: Oh, [investment] pool and then—

Chowning: [00:49:05] [Investment] pool and then the income from that is used to support an activity.
Hibbard: And that supports CCRMA.

Chowning: [00:49:12] Yes. So I gave—at some point, I gave a portion of mine, they gave all of theirs and that continues.

Hibbard: So you said that—there were—it was divided three ways and two of those—

Chowning: [00:49:28] Went to the endowment for CCRMA. And that, I think, has grown and is what supports CCRMA to this day.

Hibbard: Because eventually the revenue from the patent stopped, but—

Chowning: [00:49:44] Yes. But the endowment continues and the university is very good at handling its endowment funds.

Hibbard: Yes, they are, I think. Did you work with Yamaha when applying for the patent?

Chowning: [00:50:04] Well, of course, Yamaha was very interested in the patent and they made suggestions, as I remember, that Stanford then agreed to. But Yamaha also got lots and lots of patents on the FM technology because it had to do with their particular implementation of the technology.

Hibbard: So they got their own patents as well.

Chowning: [00:50:29] Yes.

Hibbard: So they weren’t necessarily involved with you and the university and—
Chowning: [00:50:33] No. No.

Hibbard: I understand you consulted with Yamaha for some time.

Chowning: [00:50:41] For periods from a few days to a week.

Hibbard: Was this regarding FM synthesis or other things?

Chowning: [00:50:49] No, FM synthesis. It was in the lead-up to their production because Yamaha committed to this idea long before there was the technological possibility of making, you know, reasonably priced musical instruments. So they saw a future that, when they began, was 10 years off. So during those 10 years, I went many, many times to consult and work with them on voicing, how the technology could be optimized for getting better sounds, et cetera. And then finally, their big winning instrument was in 1983. It was when this technology was—

Hibbard: Was that the DX7?

Chowning: [00:51:34] Yes. So the overall semiconductor industry advanced so that it was more and more power in less and less—in smaller and smaller devices. So everyone, the whole industry benefited from that and, of course, Yamaha, too. They built their own LSI’s for music, these music chips.

Hibbard: LSI's?

Chowning: [00:51:59] Large scale integrated circuits. Now in 1969, Stanford gave me a full professorship, we mustn’t leave that out.

Hibbard: ’69? Is that right?
Chowning:  [00:52:14] Oh. '79.

Hibbard:  I think so.

Chowning:  [00:52:16] Yes, '79. Sorry. Yes, the University of California system offered me one, so they—

Hibbard:  I read that.

Chowning:  [00:52:27] I don’t want to leave that out. And that really settled CCRMA as an entity because, not having tenured faculty, makes it hard to get graduate students, the very best. We wanted and we were getting the very best and wanted to keep them. So because—

Hibbard:  Has Yamaha been involved with the Music Department or Stanford in other ways?

Chowning:  [00:52:57] Well, there were other—other technologies that Yamaha worked on and based upon the work of Julius Smith—who’s the professor in computer music who has an engineering degree—in physical modeling, different technologies than FM, but with the same goal, producing lively, affordable interesting sounds. And today, I’m not sure whether or not Yamaha has any agreements with CCRMA. They have over the years, off and on. One of our graduate students, Xavier Serra, who did his work with us, is now in Barcelona and he had a contract with Yamaha based upon the work that he had done as a graduate student.

Hibbard:  Wasn’t there a discussion at one time about Yamaha endowing a chair in the Music Department?

Chowning:  [00:54:05] I think they were asked. I don’t know about this.
Hibbard: You don’t know.

Chowning: [00:54:10] But I think they were asked.

Hibbard: I saw some communication about this but no official—

Chowning: [00:54:16] Yes. And I don’t think they understood or it was something that they [did not want to do.] They were willing to support us and did—to keep this work going because it had a direct relationship to their interests.

Hibbard: Well, support through—

Chowning: [00:54:33] At one point, they just gave us a couple hundred thousand dollars with which to match money that we gave from our royalty to get a system, a computer system. After we split from the AI lab, we had no computer.

Hibbard: I think I read, too, did they also furnish the department with some of their instruments?

Chowning: [00:54:55] Yes, well, they gave us some very high quality audio equipment. But they—Yamaha—local Yamaha has an agreement with the Music Department for Disklavier pianos that get exchanged every year or two or something.

Hibbard: Oh, that’s great.

Chowning: [00:55:16] But I think that’s not the same thing. I think they do that with other universities, so it’s not unique to Stanford.

Hibbard: But it’s more of the matching funds for the computer.
Chowning:  [00:55:26] They helped us get a computer because we had none and that was in ’79, ’80, I think.

Hibbard:  So around the time of the patent.

Chowning:  [00:55:36] That’s right. When the—just after the patent was granted and when we needed money and didn’t have royalty income. They saw that they would be producing royalty income, but they weren’t going to give it to us in advance. Well, they did give us some in advance. They had to give a minimum amount every year, which is a typical licensing agreement to show what they call, I forgot, good intentions or due diligence, I think it was.

Hibbard:  Would you agree that CCRMA and FM synthesis are milestones in your career history?

Chowning:  [00:56:14] Oh, absolutely. Yes.

Hibbard:  How did that impact you? How did both of these impact you?

Chowning:  [00:56:20] Well, you know my training as a composer, my interest in using loudspeakers in a creative way was directly related to this work. So initially, I didn’t understand the impact it would have in the larger world. You know, I never anticipated that it would become so successful in the music industry. But it certainly was provocative in my own work and I saw—

(interruption by a grad student from outside interview space)

Chowning:  [00:57:09] So FM synthesis and the spatialization were kind of all one thing for me. These were ideas that were directly related to my interest in composition and revealed aspects of music perception that I would otherwise never have encountered, that turned out to be extremely important in my own work. So it was very exciting for me, personally. If I had been able to keep my job without Yamaha’s involvement, I
would be equally happy. That we have CCRMA because Yamaha was able, with that license, to produce income that allowed us to keep CCRMA, well, that makes me happier. But I would’ve been perfectly happy just with FM synthesis, doing my music and—

Hibbard: The creative—

Chowning: [00:58:17] Yes.

Hibbard: The excitement of—

Chowning: [00:58:18] That’s really what drives me. I mean, I’m a fair computer programmer but I would never program a computer or not extensively without the ultimate purpose of producing music, music composition.

Hibbard: Are there any other milestones that you can think of in your career that were important?

Chowning: [00:58:43] Well, the spatialization certainly was important. I think that was. It was an important moment because it was early in my contact with computers. And I knew from having read about all other means of electronic music production that one had to have an engineer or be an engineer in order to accomplish anything of significance in producing electroacoustic music. So I learned to program and in learning to program, I became my own engineer. I could do all these things that—

Hibbard: It initiated the process, didn’t it?

Chowning: [00:59:32] That would’ve required enormous amounts of equipment and people time at any other analog institution in Europe or Columbia, Princeton at the time. They were doing synthesizer stuff, but by, you know, tape music and analog means. They had to have equipment. So all I needed was access to a computer, a fairly simple
device called a digital analog converter and a program. And these computers, Max told us, would become cheaper and cheaper and he was right. And even the big expensive computers, because they were time shared at the AI lab, I could get weekends and late night access to the machine’s cycles that I needed and accomplish my ends. And the others who joined me were able to do the same.

So that was a big moment because I realized that the digital domain provided a conceptual access that bypassed a lot of the detailed engineering that had been required learning how to solder the circuitry, et cetera. It was all at the level of, you know, symbols and not unlike what we’re used to dealing with in music. And so it was an extremely important realization that the future was not only this means of producing it - sound - by means of computers and loudspeakers, but the whole world of programming and what that offered in terms of just thought development, manipulating information, musical information. The idea of recursion in music, does that have an application, and I found one.

**Hibbard:** What is recursion?

**Chowning:** [01:01:27] Recursion is just a self-referential algorithm. One can think of Mandelbrot patterns where you have little patterns within big patterns and they’re similar. That’s also all based upon recursive functions. And so these were ideas that were computer science ideas that provoked musical thoughts that I would never have had without this contact with computers.

**Hibbard:** There’s a real relationship there.

**Chowning:** [01:02:06] Much bigger than just producing electroacoustic sounds.

**Hibbard:** What accomplishments are you most proud of in your career?

**Chowning:** [01:02:16] Well, certainly in the life of a computer is one’s pieces, I mean, the life of a composer, sorry. It’s what one--it’s the compositions one produces and I
haven’t produced many. I mean, it takes me a long time to produce a composition because I become engaged in perceptual, technical issues that enrich and enliven the whole compositional idea and I explore those to the fullest extent that I can. And so to do a piece may take me years, but it’s a process that I love. And the ultimate result of a piece of music that I understand in detail usually has resulted in some understanding about music or acoustics or perception that’s beyond the piece that has some general interest. For example, out of FM grew lots of ideas that I used in pieces but were also interesting to people in the perceptual sciences.

**Hibbard:** I understand you—one of your pieces was performed at the opening of the Pompidou Center in Paris.

**Chowning:** [01:03:45] Yes. One piece was, in 1977. [The name of the piece is *Stria.*]

**Hibbard:** Were you there for that?

**Chowning:** [01:03:51] I was there, yes. That was a commission for the opening and it was very exciting.

**Hibbard:** How would you like to be remembered? As a musician, a composer, a teacher, an inventor, or in other ways?

**Chowning:** [01:04:10] Well, teaching is the other thing that you—I didn’t get to in regard to your previous question. One’s always happy to be able to see students make use of one’s work and I’ve always felt my students, my graduate students—not just graduate students, but they’re more like colleagues because we’re in a field that was and remains open with so many unknowns that it always has felt like we’re exploring together. And I benefit as much from ideas from students as they do from mine. And so this, you know, the work of the students—and seeing their success, of course, is very gratifying, because it’s bigger than me, Chowning. It’s an institution of what they learn from one another, what they learn from other faculty, what they’ve learned in addition to
what they’ve learned from my own experiences. And to see this aspect of education, which is organic and kind of self-generating, has been a wonderful thing to be part of. So I’m certainly happy about the students with whom I’ve worked and who have now become, you know, important people in their own right.

So how do I want to be remembered? Would I like to—well, first of all, alive. I want to keep that going for as long as I can. But I don’t know. I mean, a composer is an inventor, that’s what composers do. And that—the composers having made contact in technology are inventing in ways that is not unlike what we do with just orchestras and chamber music and traditional resources, but now certain things can be quantified and can be made objective, like FM synthesis, looked at and exploited in ways that are not unlike what I would’ve been doing had I been working with traditional instruments. I mean, I wrote a paper before I had ever seen a computer on using traditional percussion instruments in unusual ways, with different kinds of attacks and sticks and places and what not. So a lot of composers think this way, but the domain of computing gives a kind of place and palette for exploration, or palette of materials for exploration that is open, general and unique. So it doesn’t really matter. I’m a composer—that drives everything.

Hibbard: You are first of all a composer.

Chowning: [01:07:43] First of all a composer.

Hibbard: And still composing.

Chowning: [01:07:45] And that FM turned out to be an invention—it really wasn’t. It was a discovery of something that existed. It was an application that was unforeseen, counter-intuitive. It had been around for years before in the purview of engineers who might’ve seen this. But I have the feeling they were over-educated.

Hibbard: [Laughter] Maybe they weren’t musicians.
Chowning: [01:08:12] And they didn’t discover with their ears in the same way that I did.

Hibbard: Exciting. Can you tell us about your background before you came to Stanford as a graduate student?

Chowning: [01:08:27] Well, I grew up in a non-musical family and discovered music through the school system and my love for it.

Hibbard: Where was that?

Chowning: [01:08:38] In Wilmington, Delaware is where I spent my school years. And I was born in New Jersey, but in Wilmington, Delaware is where I graduated high school and my interests were absolutely music once I discovered it—and did music, music and that’s what I excelled at—didn’t do very well in the rest of my courses in high school. During the Korean War, I was either to be drafted or go to college, which I probably could not have done because I didn’t have high enough grades, or go into the military. So I enlisted in the music program in the Navy and spent three years in the—mostly in the Mediterranean and the Atlantic.

Hibbard: I read that you were on a ship.

Chowning: [01:09:33] I was on a carrier with some very, very fine musicians. So I learned a lot about jazz, playing jazz, and became a pretty good jazz drummer. And after the Navy in 1955, I had the GI Bill available so I wanted to go to college and found a—my father found a college that would accept me kind of provisionally because my grades were so poor—high school grades. But I had the GI Bill so I could pay. So Wittenberg University in Ohio, Wittenberg College then, in Springfield, Ohio had a nice music department and they accepted me if I could show that I could do the work the first quarter. Well, I had grown up when I was in the Navy, so I was already 21 and a freshman and I was anxious about being able to do it, but I knew how to work and I
worked really, really hard and cleared the hurdle of that [first quarter]. My academic career from that point on was secure. After my degree from Wittenberg, then I went to Paris for three years and studied with Nadia Boulanger.

Hibbard: What drew you to go there?

Chowning: [01:11:03] Why did I go there? Well, Paris was a very lively place, culturally, and, of course, still is, but at that moment in music, it was very lively.

Hibbard: What year was that?

Chowning: [01:11:16] In 1959. So my wife, Elisabeth, and I went to Paris and I studied with Nadia Boulanger, who was a very famous teacher. She taught people like Gershwin and Aaron Copeland—I know, lots of American composers. She was known, so I went and studied with her. And it was while I was there, during those three years before applying to graduate school in 1962 and coming to Stanford, that I heard electroacoustic music for the first time.

Hibbard: Do you know when it started historically?

Chowning: [01:12:05] Electroacoustic music?

Hibbard: Historically?

Chowning: [01:12:07] Oh, it started probably—the idea is quite old, back in the early part of the twentieth century with a great, huge machine built by Cahill. But the practical beginning of electroacoustic music was Theremin, who developed this musical instrument, electronic instrument, the first performable instrument back in 1919, I think, in Russia. And then there was the Ondes Martenot in France some decades later. Then the first group was in Paris just after—in 1948, the Groupe de Recherche Musicale in Paris, headed by Pierre Schaeffer, a technical person who had this idea of recording and
manipulating sounds. And then in the early fifties in Cologne, radio studios made available some of their equipment to composers.

**Hibbard:** Looking back, what led you to come to Stanford as a graduate student?

**Chowning:** [01:13:23] Well, I applied to three schools—University of Michigan, UC Berkeley and Stanford. And having gone to—grown up in the East and gone to undergraduate in the Midwest, I decided that we would come to California and Stanford gave me a better grant.

**Hibbard:** Often the case for people choosing a school.

**Chowning:** [01:13:48] But I was lucky, in fact, as things developed because Stanford—of what I was able to do at Stanford—kind of walk between these school walls and department walls, get people to help me, which I think would’ve been much more difficult at Berkeley just because of the size of the university and attitudes were more fixed—as was later shown by someone who tried to start computer music at Berkeley— it was not so easy.

**Hibbard:** Now when you came to Stanford as a graduate student, was that in the back of your mind, or—?

**Chowning:** [01:14:25] It was. I had the—I was interested in electroacoustic music and we didn’t have a studio, an analog studio, to do what they were doing in Europe or in Columbia or Princeton. I was disappointed. But it—and that’s why reading this article, having this article kind of given to me by Joanie Mansour, who’s part of the Historical Society [Stanford Historical Society], actually, I think—it’s a famous story how it happened because had she not given me this article….

**Hibbard:** Was that the article in *Science*?
Chowning: [01:15:01] Yes—I might not be sitting here talking to you today. So I was able to begin because Stanford was small and dynamic and had just started the computer science department.

Hibbard: And that—was that key in you coming here as well?


Hibbard: No.

Chowning: [01:15:21] No. It was music.

Hibbard: It was music.

Chowning: [01:15:22] Yes. This was all serendipitous. This, you know, that this all happened quite aside from any intentions I might’ve had.

Hibbard: And then you later in—you land in a place that is later Silicon Valley.

Chowning: [01:15:40] Right. Yes, exactly.

Hibbard: Yes. Very serendipitous.

Chowning: [01:15:43] Yes. I think it was Louis Pasteur who said that chance favors the prepared mind. So my mind was prepared, I was looking for—and then chance, being at Stanford and having this new computer science department where George Forsythe invited non music—the non mathematician, non scientist to learn to program computers. I took my first program course because of that. So that was—

Hibbard: Was that in graduate school?
Chowning: [01:16:18] When I—yes, after I read Max’s article, I immediately took a programming course.

Hibbard: Now you came here in 19—

Chowning: [01:16:26] In ’62.

Hibbard: In ’62. And you read the article in—?

Chowning: [01:16:30] It was given to me in, I think, it was January ’64. The article was written in November ’63, only two months earlier. So I read this article, was really excited and went and took a computer science course, which Forsythe had made available to non-mathematicians. That was really exciting. And so the computer science department saw that computers were not just for engineering, mathematics, and well, not mathematics, but engineering and physics and, you know, the—

Hibbard: Your mind was prepared.

Chowning: [01:17:09] My mind was prepared and chance was my having come to this university.

Hibbard: Can you elaborate on any other graduate studies or was that the spark?

Chowning: [01:17:22] Well, I took a math course that was outside the Music Department and this was Algebra A. I thought, well, I’ve got to learn my math because I was already 30 years old. My last math course had been in high school, like Algebra I, I think. So I took—they called it “bonehead algebra” because it was for people to make up credits, and it was me and a bunch of football players as I remember.

Hibbard: [Laughter] What was your most memorable experience at Stanford, whether as a graduate student or faculty member? Or maybe you have more than one
memorable experience here.

**Chowning:** [01:18:12] You mean positive, don’t you? I mean, the not getting tenure was a difficult moment.

**Hibbard:** I can imagine.

**Chowning:** [01:18:31] Not because of tenure per se—I don’t really believe that much in tenure—but that I was not able to come back and work.

**Hibbard:** Well, it’s sort of a validation, isn’t it?

**Chowning:** [01:18:44] Well, that—it is, but that—that was—you know, I’m an artist by nature and we know the hazards—there’s no tenure in art. And—

**Hibbard:** So that was pretty memorable.

**Chowning:** [01:18:59] Yes, but not being able to come back and continue this work, which had just—you know, FM had exploded, become something clearly useful and the system which we had worked so hard to develop on the computer now was ripe for use and so that was a tough moment. And curiously, getting tenure in 1979 was not that big for me. That was not so important. So tenure wasn’t the issue, the issue was the continuity of one’s work and that was dependent upon tenure. But we managed anyway. I came back as a research associate and we got some grants.

**Hibbard:** And you were continuing with your work in your absence?

**Chowning:** [01:19:49] In my absence, not really. Kind of, at some level, but I didn’t have access to computers and—
Hibbard: The equipment was key.

Chowning: [01:19:58] In Berlin, there was a computer but it didn’t have the central piece of equipment that I needed to do work with sound. But I thought a lot, did a lot of paper headwork.

And so memorable moments, well, having Boulez and the whole IRCAM team come to study computer music at Stanford in 1975, that was a memorable time, certainly. He was conductor of the New York Philharmonic, the BBC Orchestra, now director of this incipient center in Paris which was being built. And they all came and took a course that we gave in the latest developments in sound synthesis and processing and analysis with, you know… Andy Moorer and Leland Smith, John Grey and Loren Rush and I giving these courses to these major figures. Luciano Berio, Vinko Globokar, Pierre Boulez, Gerald Bennett—it was Jean-Claude Risset, who was already in the field and he was—

Hibbard: Especially after they really were a catalyst for, you know, really this becoming an entity at Stanford as well?

Chowning: [01:21:27] The idea of having a separate [entity]—

Hibbard: Very exciting.

Chowning: [01:21:32] So that was certainly a big moment and they went back and got the same computer and used the same software. So that was a very important kind of validation of our work—and Stanford caught it. They knew what was going on.

Hibbard: That’s great. Music aside, I hear that your family enjoys sailing and one time you sailed all the way to Hawaii. Can you tell me about that?

Chowning: [01:22:02] Well, I’ve sailed all my life, well, since I was a child. Never club sailing, it was always just fooling around with boats and I’ve always loved being on
the water. When I was younger, it was the Chesapeake Bay. And we got a boat when I was first hired at Stanford in 1966—or I guess we got it in 1967 because we were faculty parents, dorm parents, so we had no [living] expenses. And so I was able to buy a small boat with the Stanford loans, of course, and when I went on sabbatical in ’72, we sold that boat and borrowed some more money and bought a boat in Europe and we lived on this boat for a year in the Mediterranean. That’s where I wrote the FM paper, in fact.

**Hibbard:** Oh, is that right? Very historic.

**Chowning:** [01:23:08] Yes. And it was during that year that I first met Boulez and then it was also during that year that I didn’t—was told I didn’t get tenure. So the boat had to go. I mean, all sorts of things happened in my life. But anyway, finally, in 1986, I was able to get a boat again. And that one, we sailed to Hawaii in ’89, my father was 86 at the time and my young son was three years old. Max Mathews and Marge Mathews went with us and then they came back directly after the trip, Max did the navigation going over. That was before GPS, so we used a sextant and twenty dollar watches.

**Hibbard:** So how many people on the boat?

**Chowning:** [01:24:10] Seven including myself.

**Hibbard:** And how long did it take?

**Chowning:** [01:24:10] It took 17 days. Then Max and Marge Mathews came back after we got there and we sailed with my father and his second wife and my family, the three of us, through all the islands except Ni’ihau. And then came back in September, so we were gone about three months.

**Hibbard:** Do you still sail today?
Chowning: [01:24:39] Yes, I still sail. And in ’96, we sold that boat and got a slightly larger one, we did the trip again to Hawaii. And then this time, rather than directly back, we sailed to Victoria and so that was a long leg. That was a faster boat, but it took 17 days to go from Maui to Victoria, which is on Vancouver Island, of course. Yes, I love to sail and do it to the extent that I can.

Hibbard: Is there anything else you would like to talk about today, John? I’ve pretty much covered my questions.

Chowning: [01:25:29] Well, I certainly would emphasize the values of a place like Stanford, having strong but small departments. I mean, it’s a community where I feel I can go talk to people and feel not intimidated by these huge barriers that sometimes exist between schools and departments. And that certainly is—was—especially in the early years, was very important. But I think still continuing—the ease with which students pass from CCRMA to engineering or CCRMA to psychology or other departments is a wonderful thing—or art or dance department, this is so enriching and it’s now facilitated by Stanford. I mean, it was sort of possible, there was a passive potential, but now with this commitment to the arts, like SiCa [Stanford Institute for Creativity & the Arts] and the new music building [Bing Concert Hall], it’s really become a very active kind of encouragement of the arts and to engage in whatever seemingly peripheral activity.

We have a wonderful project that is with archaeology, John Rick in archaeology, that just happened because I happened to read this article about him while I was writing a piece about—it had to do with the Pythia and cavernous spaces. And I read this article and John Rick was doing this research in Chavín de Huántar in Peru, involving these underground galleries, and his theory that their acoustic properties had some bearing upon the building of these things and I thought this is a connection that we just can’t miss. So now we have a graduate student who’s working with John Rick and she’s a music student at CCRMA working with John Rick in archaeology. So I mean, these things that happen, I think, happen at Stanford with greater ease and because the departments are strong and rich, a lot of really great people who communicate easily with
one another—so a good sized community.

**Hibbard:** And it’s, you know, being—like you when you were young, seeing the possibility of something new and a new way of looking at things.

**Chowning:** [01:28:32] And we never can see very far. You know, we can’t see 10 steps ahead, I don’t think. But we see potential, we sense implicit richness and we are attracted to that.

**Hibbard:** So anything else you’d like to mention today?

**Chowning:** [01:28:52] Well, I can’t think of anything else.

**Hibbard:** Well, thank you so much. It’s really been enjoyable interviewing you.

**Chowning:** [01:29:00] And thank you for the interview, and your enthusiasm and your research….

**Hibbard:** Thank you.

**Chowning:** [01:29:06] …that matters a lot.

[End of the interview – John Chowning – 06/09/10]