ANDREW S. GROVE ORAL HISTORY

COMPUTERWORLD HONORS PROGRAM INTERNATIONAL ARCHIVES

Transcript of a Video History Interview with
Andrew S. Grove
Chairman of the Board, Intel Corporation

Recipient of the 1997 Price Waterhouse Leadership Award for Lifetime Achievement

Date: April 23, 1997
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A Journalist Turned Chemist

DKA: I would like to start by asking you what led you to your interest in chemistry and chemical engineering in the first place?

ASG: I was looking for something to be interested in when I was a teenager. My original notion was that I wanted to be a journalist. Some members of my family got into some political trouble with the regime, and when that happened the children's newspaper that I used to write for stopped publishing. I finally figured it out, added two and two together and figured out why. I was very, very hurt and it just destroyed the whole interest I had in any non-objective line of work.

I started looking at what I might do and I didn't want to become an engineer. I didn't want to become a physicist because I didn't think I was good enough in math, which is funny because I turned out to be fairly mathematically oriented in later years. Out of this process of elimination came chemistry, which happened to fit in with my interest in pyrotechnics and fireworks and stuff like that which I liked to mix for myself. That's how I started.

DKA: So your interest was in the subject even before you came to the United States?

ASG: Oh yes. I was thirteen years old. I was in the 7th or 8th grade when this happened.

DKA: Was it an interest you developed on you own or were there important mentors?

ASG: No, I developed it on my own. I don't think I really had any significant mentors until probably college in the United States. There was no single individual that I modeled myself after until much later.

DKA: When you came to the United States, how did you end up going to City College?

ASG: I had an uncle (an aunt's husband, actually), who took me in. He worked for Brooklyn College, so he wanted to arrange for me to continue to study at Brooklyn College in Chemistry. I realized that a liberal arts education is not the same as the chemistry education that I would have had at the University at Budapest--very much lower level and very much more superficial accounting of people going to graduate school and stuff like that. I didn't want to commit myself to that. Somebody suggested that if I wanted more technical courses, go to an engineering school. The only engineering school I could afford to go to was CCNY—City College. All of this played out in the same day. I ended up registering, changing fields and registering at City College in chemical engineering.

DKA: And did you think you would go on to graduate work?

ASG: I didn't think of graduate work until a few months before I graduated. I was very, very goal oriented and the goal was to become an engineer, earn a living, and bring my parents to this country. I needed some financial where-with-all for that. In the last month of my senior year, I felt maybe I should explore to see if I could get financial assistance. As it turned out I got some very acceptable scholarships from a number of schools and I decided to go into graduate school.

DKA: You say you had teachers at CCNY that encouraged you to go into chemistry?

ASG: Yes I did. I had a several teachers who really epitomized what engineering meant to me. They were pragmatic, down to earth, and yet well grounded in technology. Most important among them was the chairman of the department who has since died, Professor Schmitt—Al Schmitt—who kind of took me under his wing. He was a crusty old school engineering professor who hired me as an assistant for the department. So I actually ended up working 20 hours a week through the school year in the department helping out with some kind of low level technical tasks and office tasks. All along I had an opportunity to watch this man and also took a number of courses from him. He made a big impression on me. Then when I went to graduate school, I had an excellent PhD advisor who likewise, made a great impression on me.

DKA: Who was that?

ASG: Andy Acrivos, who ironically now, is an Albert Einstein Professor of Chemical Engineering at CCNY. He and I worked together at Berkeley back in the 1960s. After that it was Gordon Moore. Then I graduated. I've been associated with Gordon for the last 34 years.

"Love at First Sight"

DKA: What kind of connection developed between you and Gordon? What led you from Berkeley to go to Fairchild?

ASG: It was love at first sight, if I could put it that way. I interviewed at Fairchild and at the end of the day they ushered me into the office of the Director of R&D, which was Gordon. Gordon was in his early thirties at the time and a very, very personable, down-to-earth, very quick-minded person. He asked me about my thesis, and all I had been doing is telling people about my thesis, which was pretty arcane—fluid dynamics thesis. Most people didn't relate to it at all. In ten minutes Gordon grasped what my thesis was about and asked some very intelligent questions, and we had a very good discussion about it. I really liked him, his thinking, his lack of pretense. All of these things, that essentially for the next thirty odd years, I've learned to admire in him on the basis of much more exposure, right there in the first half hour exposure. So it was this combination of things; I wanted to stay in California, Fairchild had altogether a rather healthy atmosphere, and Gordon's persona made my choice to go to Fairchild pretty easy.

DKA: So they offered you a job soon after the interview?

ASG: Yes.

DKA: And what was Fairchild's reputation to a graduate student?

ASG: Controversial. Keep in mind that I was not a graduate student in electrical engineering or solid-state physics. I was a graduate student in chemical engineering with a specialization in fluid dynamics. So the people I dealt with were not in the field. It was very random input that I had.

My alternative to make this work was Bell Labs, which back in 1960 was the mecca of semiconductor science. I had probably the prevalence of the faculty that I talked to about this, who said "If you don't take that offer at Bell Labs, you're crazy." "Fairchild, yeah, they're good to make money at, but they are a flakable company." You have the phrase Silicon Valley, which didn't exist at the time. They probably would have said it with derision. Not everybody, but that was the general tenor. So I kind of went against the grain in accepting the job at Fairchild, particularly because Bell Labs exerted a perceptional pool in academia and generally all the papers came out of Bell Labs, all the significant papers in the 1950s. So it seemed that was the place to go to.

DKA: Do you think it was your discussion with Moore that was the deciding factor?

ASG: It was a combination of things. Location as I mentioned, was an important factor. Bell Labs was a very formal organization. Fairchild was a very informal organization. I felt more comfortable with the atmosphere at Fairchild. Bell Labs was an East Coast company. The people that I talked with referred to the Bell organization as the company—with a capital "C"—and they were saying it was very paternalistic. All the rules were well set up.

Fairchild was much more free flowing. I liked that. And yes, Gordon was another factor, an important factor. Actually it turned out to be more important as the years went on, because what I ended up doing at Fairchild was pretty well architected. The whole project of studying MOS technology, which is what all chip technology today is based on, pretty much Gordon directed. Although different people managed different programs, Gordon was the initiator and the overseer of that project there. So that was very good also. I got to get into the field on the ground floor, and go with it.

DKA: People remember Fairchild as being a company that did a lot of innovation, but then failed somehow to capitalize on it ultimately. Looking back, how does it look to you?

ASG: Very interesting question. Fairchild was a very important lesson for me personally in management. It was an outstanding place technically, much better than its reputation was. And yet as you say, it failed to capitalize on a lot it. For a while it capitalized very well. But by the time I got in there it had outgrown the ability of the organization to manage the flow of technology into product and product into the marketplace. It was a very chaotic place. It was disorderly. That's probably the best way to put it.

When the general manager of the central electric division left—his name was Charlie Spork—to go to National, one of the strongest managers in the place left. He was about the last thing to pull the whole thing together and the place broke in two. Warring fiefdoms and things got worse. It disintegrated because of the lack of strong management.

You have to keep in mind that this is the mid 1960s and there is Ken Kesey, and the pranksters and free speech movement and stuff like that. So strong management is not exactly what people of my age crave or readily accepted. It was really very unpopular to manage anybody. The whole idea was very unpopular, far more so than today.

In spite of that when Intel got started I came with the determination this is not going to be another Fairchild. We're going to manage this place, whether it's popular or not popular. In a sense what I learned at Fairchild, both the positive and the negative values, had an impact on how we developed Intel.

The Birth of Intel

DKA: How do you remember the discussions that led to that decision? I know that Bob Noyce and Gordon Moore were involved. It's unclear to me exactly what your involvement was in those early discussions.

ASG: It's very simple. Gordon and I went to some technical meeting someplace in Colorado. I think it was a device research conference or something like that. And I was there a day earlier and he arrived, we said "Hello," and we went for a walk. In the course of the walk we talked about one thing or another about what was going on at the conference, and Gordon has something on my mind. He told me that he decided to leave Fairchild. And I asked, "What are you going to do?" He says, "Well, start a new company, building semi-connected memories." So before he finished his sentence, I said "I'll go with you." So I was never invited. I volunteered. I never gave him a chance to invite me. I served notice a few days later and after some very chaotic weeks joined him and Bob Noyce and a couple other people that they recruited, one for marketing and one for finance. Then I set out to recruit people in what I would call today the operations end of things. So that's how it happened.

DKA: Do you remember that as a time of excitement, anxiety, worry? You've often been thought of as someone who worries a lot. I wonder how you felt about that transition?

ASG: It was all of those things. It was excitement and it was a lot of anxiety. Chaotic especially. It was a company. Predictable processes and not very predictable, but still it was a place to go to work. Showing up in Bob Noyce's study for work and literally my first task at Intel was rent a PO Box so when we sent away for information on products and manufacturing equipment and things like that we had a place to receive it other than Bob's mailbox. I had no experience like this and it scared the hell out of me. And then the other thing is I was not so sure as to what my role or contribution potential was going to be. My background was sort of a theoretical devices physicist, and I was pretty satisfied. I played a pretty important role in the ecology of the Fairchild R& D labs and I was pretty good at working with the manufacturing force. I thought I was pretty good at it, and all of a sudden being put into an organization that started to buy equipment, design processes and products all from the ground. I didn't know how I was going to pull my weight.

So I had most organizational anxieties and personal anxieties, and they got worse, the organizational anxieties got worse. Startups are not a romantic place. They are a very tough existence, particularly when money is running out and there is no corporate umbrella to keep you dry. The anxiety that builds in everyone else turns into pretty ugly emotions. When things don't go well, you start to blame each other. You don't trust each other. It's not a team that has been honed over any period of time. You got thrown together. It was rough. The first two or three years it was very rough, and I'm not anxious to go through that again. I never was. Typically when you read about startups you get a much more Pollyannish view of it. I don't know if ours was tougher or if I just internalized all of these effects. Perhaps my memory is not being very kind to it, but I do remember those as very hard years.

DKA: Was it hard to decide what products you were going to work on, or did you have an idea?

ASG: No, the products were pretty easy. We had some customers coming around who were interested in some connected memories. There was request for a proposal "on the streets." We kind of knew what we wanted, what we could do, and what this customer wanted. Then we knew what package we could buy, a ready-made package, and that kind of decided the organization of the memory. It had to be a fully decoded memory, because we had just so many pins on the package. We didn't have that many choices. We knew what we wanted to do with semi-connected memories. We kind of knew the complexity levels we could build, and then the rest of it, the externalities decided for us. We were building them from nothing, with a fabrication capability that a few months ago didn't exist, with a process that had never been tried, with a design that was thrown together in a pretty big hurry by hand. All of this all of a sudden grew out of the ground. That was hard.

Shockley, Silicon & D-RAM Revolutions

DKA: What would you say were the key points of the strategy that Intel was going to adopt compared to the other people who were in that market?

ASG: This is back when we started? We hedged. We went in three different technological directions. We built a MOS memory, a bipolar memory and a hybrid memory—a multi-chip memory. That hedging was because we weren't sure technologically what was going to happen. Very rapidly we jettisoned the hybrid memory because the multi-chip technology was not very good, and to this day that has not been a mainstream production technology.

Then we went bipolar and MOS together, and both of them we bet on unproven and very significant technologies. In the bipolar area we the bet on the use of Shockley dials, a particular component technology that had never been used, at least to our knowledge had never been used. We didn't know what was going to work. Actually it turned out to be very good. The company ended up making the cover story in the then prominent trade magazine, *Electronics* magazine, because of the use of the technology.

In the MOS area, we were probably the first to use Silicon-gate technologies instead of the metal oxide silicon sandwich. The metal was poly-crystal and silicon and although the stuff had been presented in paper, no one had made a complex circuit out of it, let alone a commercial product. So we brought a lot of stuff together technologically that we struck out in a novel and potentially lucrative directions. And both of us turned out to be right. The Shockley technology became mainstream, and silicon technology of course, is a hundred billion dollar industry today.

DKA: So was being forward technologically and taking a sort of border technical risks, is that what you say characterized the approach?

ASG: Clearly the market idea wasn't that novel. Memories have been served by different technologies. The fact that we were going after it with then complex silicon chips was new. But it was a very obvious new. What was really new was actually doing it, and delivering it in a reliable fashion, and building these products so they would be reliable. The use of these technologies was significant in that. So, it was all technological risks.

Shortly after that, a year-and-a-half to two years later, we struck out in a different direction using dynamic circuitry, dynamic as the "D" in D-RAM in today's terminology. First of all we were using dynamic memory technology, which was new. Many people talked about it, but again it was new, the combination of using that and silicone-gate together were new things in combination. Yet the combination ultimately gave us a very, very producible product. A thousand-bit memory chip was actually our first truly successful product. The name was the 1103. And after we overcame the difficulty that was inherent in these new approaches it turned out to be a very producible, high volume product. At some point I counted 11 major computer companies that based their memory implementations on the 1103, and alternate devices of the same design were generated by other semi-conductor companies. It became an industry in and of itself. So it was a big success. It was very, very hard to reach that point, but once you reached that point it was excellent.

DKA: So you had a lot of successes in pushing the limits in memory, and I wondered when I read your book whether you thought that decision was an early strategic inflection point in Intel.

ASG: I think the strategic inflection point, if I look back at it, was not for us, but for the builders of memory product. We used a completely different technology, a very, very labor-intensive technology. It was magnetic technology, little magnetic doughnuts were threaded on wires. It was very labor intensive, very, very reliable with lots of experience in the technology. So the companies that built it by our size were huge. Many of those companies were divisions of computer companies that supplied internal needs in that way. So from their vantage point, here comes this little start-up in California. Actually there were several of us, several start ups like that, but even in combination we barely amounted to much. We were proposing a completely different approach to it. Building a semiconductor, my God, memories were even called core memories then, because there were no magnetic cores in how they were built. So even the name was routed in the technology. The technology and the name were one in the same. It meant a completely different built-up transistor, integrated transistors replacing core memories. And the first approach we took, the first devices we built, were very much more expensive than core memories. So from that standpoint we must have looked laughable.

And yet technology was on our side because technology has always allowed us to put more and more transistors together for more of the same cost, so therefore the cost per transistor, the cost per memory cell would inexorably calm down. Sooner or later we were going to topple the core. And they didn't act. Not one of the coreman reproducers got into the semiconductor memory business. So this has all of the strategic inflection points from the standpoint of coreman reproducers. Gone, they were all gone, maybe within 5 years time. We were the perpetrators of the new technology, so we caused the strategic inflection point. We didn't have one. We were it!

DKA: Because you brought the new regime.

ASG: That's right.

The "Traffic Light" Stage of Invention

DKA: Intel had a tremendous amount of successes in its early years, but there were also some failures. I know Gordon Moore often talks about the digital watch business. So I wonder how you look back at those early years in terms of what worked and what didn't.

ASG: I don't take a look at the digital watch as such a terrible failure. As a project, as an undertaking, it was naive and it failed, but it was a very good learning lesson for the company. We did a respectable job. We didn't fail because we didn't build a good watch. We failed in spite of having built a good watch and a good display. We pioneered liquid crystal display that at the time all the watches were done with light emitting dials. You had to use your hand to light up. So we went again our own way on that one. I look back at that with some measure of satisfaction about what we did there.

What we were naive about was history repeating itself because of the marketing. And we approached this with a great deal of casualness regarding what it would take to market a wearable consumer product. That was our failure, in that learning didn't really get put to use because we shunned away from consumer products. Probably that was a good choice for many, many years to come. We could have failed microprocessors. We didn't. But we were pretty close to failing. We did the development of the first microprocessor as a custom development and we didn't really realize the importance of it until sometime after. Now fortunately, once we realized it, we reacted on it and exploited it. But that was in retrospect, an uncomfortable near- miss on something that was probably the most important discovery, the most important development in the life of Intel.

DKA: You said that Intel was in danger of missing what was an important invention in the microprocessor. I'm wondering, looking back, if you can explain that and talk about why.

ASG: What I intended to say is not that we missed the invention, we missed the significance of that even after we said, "Hey, this is a big deal. This is a programmable computer and a chip, etc." Most of the industry was incredulous. This was not very obvious. The fact that you put a computer in a chip and program memory in another chip and customize, organize, different implementations of computers out of that, was not a common concept. And what you can do with 4-bit computers, re-programmable computers, was also not very obvious.

Now people use low actuators and mechanical devices for all of the applications that we went after subsequently. Electronic terminals were years in the future, let alone personal computers. There was no viable application obvious for this capability. The capability we didn't miss. What to do with it was a struggle for many years actually. It remained a struggle until intelligent terminals came in. That was the first large volume application and that was several years later, so I'm not surprised we missed the significance of it.

If anything, I think it is a credit probably to Bob Noyce, more than anybody else to realize that, "Hey, this thing is bigger than we think, especially with the low cost of chips. This is more than a calculator. This can be used for all sorts of stuff." And we said, "Bob, what? What kinds of stuff." So that kind of gives you a flavor "What all kinds of stuff" was a marketing plan for this type of thing. And for many years after that, after this thing was in the market, when people asked what do you use this for, you say, "Well this is good for traffic light controlling." What else? "Well its good for traffic light controllers." After a while it was postage meters. Took awhile for the large number of applications to develop.

DKA: So there really wasn't an understanding that something built for a calculator could grow through a calculator to a much bigger and more powerful processor?

ASG: No.

DKA: Or probably the speed in which that could happen.

ASG: We had a feeling that that would happen, an understanding, no. We're going through this as we speak. Interactive entertainment. We want something more than digital games, but what is it? Or we want something more than video-on-demand. Well, what is it? Well, it's something big. If it's happening right now in a completely different field and there are people with lots of convictions, and there's going to be a major source of activities and a major creative outlet for artistic creators and some new form of entertainment and the like, but nobody can really point to a killer example. They're still at the traffic light stage of it. And it helps to have gone through that sometimes in the past to have a confidence in one's notion that even though we cannot point to a specific example, it can be big.

DKA: But even knowing when to invest is often more difficult than knowing what to invest in.

ASG: Right, and how much and which customer to really pay a lot of attention to because they are formative, as compared to someone who's not. There is a lot of judgment, a lot of luck involved.

Engineering Intel

DKA: You mentioned that when you and Gordon and Bob came to form Intel, you wanted a different management style and structure than what you experienced at Fairchild. We've talked about some of the early successes. What was different about the management style at Intel in those early years?

ASG: We tried to be a disciplined, organized organization as compared to the Fairchild that was an undisciplined, disorganized organization. I could say we wanted to be an informal organization, but Fairchild was for its size and its time period, pretty informal. It was getting worse but its origin, its center of gravity, its natural state of affairs, was a pretty informal place. So that wasn't such a big break but it was never a well-run organization, in my opinion anyway, at least during the period of time that I was there. And we tried to over-react to that. That's one major element.

We said earlier that Fairchild created a lot of technology but not a lot of it was put into use. There was always a huge gap between the R&D organization and the manufacturing organization, and that was aided by the physically separate R&D labs. The R&D labs were in Palo Alto, and the manufacturing was in Monte View. So we were going to go the other direction. We were not going to have a separate R&D organization. We were going to have manufacturing and R&D operate out of the same lines, with engineers and production people brushing against each other, which had its own problems. But things have changed a lot obviously. To this day that is closer to the way we do things than the opposite. It really had been a very important technological manufacturing, management dictum, compressing the development and the manufacturing people. These two things, I would say, were the key elements.

DKA: It seems like you've always had technical expertise near the top of the organization rather than manufacturing.

ASG: So did Fairchild. That is not a change. Gordon Moore and Bob Noyce were senior management at Fairchild as well. Fairchild was a technically adept company, certainly as compared to the companies in the industry. I interviewed at about a dozen of them, Bell Lab being the major exception, but all the rest of them were not that technically run. Fairchild was. It was an engineer's company and Intel continued with that tradition. We didn't break with that.

DKA: As you looked to develop different products, different lines, how did you make decisions as to what lines you would pursue, and what you wouldn't?

ASG: In the conference room we argued about it. Maybe the way I could describe it was three forces. In engineering they said, "We can do this or we could learn how to do this." And the marketing people were saying, "We got to have this. If you know how to do this, fine. If you don't know how to do it, figure it out." And then there were the external realities of what it was being a very small company. We had to rely on things we could buy. We had to rely on equipment we could buy, which today in a age of outsourced world, is not so surprising. But then all the larger companies were vertically integrated. Many semi-conductor companies made their own silicon crystals, their own packages, their own equipment, and we had to buy everything on the outside. Right from the beginning we said, "We are only going to do those things that we have to do." That was a new thing. It allowed us to move pretty rapidly, but since we had to use commercially available tools and building blocks, it put a constraint on what we could do. So it was a combination of those three factors.

DKA: Did the tradition have a lot to do with how you eventually grew the company, both here and abroad? Or did you come to that strategy from a different angle?

ASG: I think the concepts I described are with us today. We're not trying to be vertically integrated, backwards integrated. We are still striving to be an organizer of all of companies of big value, and optimally orientated, disciplined and getting results. All of that stuff is still on every poster in the company. They are key corporate values and we practice those. We are still a technologically run company and we are still a very informal and open company. At that level, Intel hasn't changed as we went from five people to 50,000. I hope it won't.

DKA: Certainly, a part of the management philosophy had to do with the fact that the three of you at the top knew each other and got along well.

ASG: Well actually we didn't know each other that well. Gordon and I knew each other. Gordon and Bob knew each other. Gordon, Bob and I did not know each other at Fairchild particularly well. That level of acquaintance was already developed at Intel just with other people. But yes, I think the fact that each of us in these pairs with each other had a major factor and continued as long as Bob lived. And it continues to date with Gordon and me in whatever capacities we work here. Other relations then got developed and added to those two relationships.

DKA: It has been a stable management for a long time.

ASG: Very stable. Craig Barrett has been with the company twenty-something years and it's hard for me to remember that he wasn't here at the very beginning. But he came soon after that. When you look around, and I go to a different site and have dinner with the senior management team of that size, just about everyone that has been in any senior/middle management and above capacity, have been with the company for 15 to 20 years.

DKA: And is part of your corporate strategy to grow your own people?

ASG: Absolutely. Not that it's not without danger mind you. There were other companies that have reduced their ability to change, to go with internal change, because they were so inbred. On the other hand, I'd rather work on making us more change-receptive than go through some of the problems that we went through in the early years when we just threw people together who didn't know and didn't trust each other. It's a pretty open and trusting environment and it makes me very, very effective. That comes from the fact that we know each other pretty well.

Only the Paranoid Survive

DKA: In your book, *Only the Paranoid Survive*, you gave what I thought was a brilliant analysis of the decision to move from the focus on memory onto the focus on microprocessors. One of the things I wasn't as clear about reading the book was how difficult it was to carry that out through the company.

ASG: It was very difficult. The company's perception of itself was that we were a memory company even though we weren't. When you look at what our factories built, what our different market segment was. We were trivial in what was the D-RAM business at the time. We didn't think of ourselves in that way. So it's kind of like taking your identity away from you. We ran into a lot of resistance. We had to rely on that organizational culture to its utmost, and even with that, it was a two-year process.

It's much easier to reflect on it ,a nd it's an obvious thing in retrospect to have done given that we made the transition and we were successful with the new path. Well, kind of obvious. It wasn't that obvious to most people of what we were doing. The questions were, "If we get beaten out of one field, why won't we get beaten out of another? Why, why, why, why...why not, why not, why not, why not." There was a resistance all through that.

DKA: What was the technique that you used to help the company through that? Were there a lot of open discussions?

ASG: Open discussion and pretty forceful driving of the stake a flag in the ground. This is what we're going to do. I didn't have answers to a lot of the questions people asked, so it was pretty forceful change.

DKA: Maybe we should talk about Pentium and about the future. The thing I want to ask you about the Pentium: What was the experience Intel had with the Pentium? We talked a little bit about this before the interview and that was whether the experience that Intel had with the Pentium was in some ways, like the new coke experience that Coca Cola had when they thought they had the market right and then reread it. I thought your response to that was interesting. How would you compare those two?

ASG: I think of all the examples that people dealt with their companies, where they've made a mistake in the marketplace and they've had to recall products or change strategies. The most analogous, big-time example was what Coke went through with the introduction of "New Coke" and the positioning and withdrawal and the reintroduction of "Classic Coke;" at least from looking from the outside.

Obviously I will say that I have a very different perspective. I see Coke from the outside and Intel from the inside, but that's what it looked like. In both instances there were rational basis for making a major product decision. And in both instances there was customer reaction to that very rational, data-driven position by the company. And in both instances company experts at first ignored the irrational, emotional consumer reaction. And the public won in both instances. Intel retreated and Coca Cola retreated. After the retreat, both of us succeeded better than we had succeeded before.

Very interesting. I talked with a gentleman called Don Keough, who was Coca Cola's CEO at the time, a little bit about it, but not enough to really understand the details of it. But it would be a very interesting for us to compare notes, because I bet we were both equally bewildered by the public reaction. We thought, "The public just doesn't get it!" And of course, it was us who doesn't get it.

Building a New Universe

DKA: You've said that the network computer that many have talked about as being a fundamental change in computing, you don't see as a major threat to Intel or forming a new direction. What do you think will be the next strategic change that will most likely affect where Intel will go?

ASG: Actually, I think natural computing is that strategic change. I think computing is being reshaped before our eyes. I don't see that as a threat because I think we are in a very good position to shape efforts and take advantage of all the goodness that the upside of this growth curve. But it is a major change.

I think in time that all computing is going to be defined by the network and all the data is going to come from the network, and an increasing amount of the programming is going to come from the network and that a hundred million, two hundred million, five hundred million, a billion computers will all be interconnected with data networks that are increasingly capable of doing all those things. It's going to be a very different world. It's going to be unlike anything else. It's going to be not quite like broadcasting, and not quite like computing, but somehow an amalgamation of those. I'd Intel to be the leading supplier of all the building blocks needed. Not all, but as many as we can possibly do, at least to build that universe. We have to be very network savvy. We have to let that network define what we do, all the way down into the chips. I think we have the capabilities because we've kind of pushing into that direction without fully understanding, pushing towards communications for five, six, seven years. So we've built up the internal capabilities. We are looking at this thing completely as outsiders, but we still have to make a lot of changes. We are in the middle of making a lot of those changes, and relatively productively. I think we're going win that change, but not without changing ourselves.

DKA: One, sort of broad, social question. Obviously, the work Intel has done with microprocessors has fundamentally changed the world in which we live. What changes stand out most for you as you look back from your position as being the most striking for society at large?

ASG: There are two things that I think are phenomenal. One is personal computing and the pervasiveness of personal computing to people who had nothing to do with computers before. The second thing is repeated again, with Internet, the prevalence and the penetration of the Internet into people's lives.

I kind of woke up to the first one during some weekend at Sacramento Delta in somebody else's house and I was reading some newspaper. This is in the early 1980s and I listened to a couple people in the house, both of whom were schoolteachers. I was reading and they were talking. And all of a sudden, I'm hearing about floppy drives and megs of this and that. To listen to hear those words coming out of these individuals' mouths! And I sat there and put my newspaper down and listened to the conversation. These people were comparing computers! Classroom computers! I never knew that they knew anything about it or that they cared. It had penetrated their life and their work life. The fact that I remember this is 15 years later, like this is an indication of, "My God! This is something very big."

The same thing is happening with the Internet today. The corresponding example is that I teach a class at Stanford every year. And every year I teach them cases in there that have to do with networking, and the Internet, and online services. Afterward I always ask a poll about the individual familiarity from the 66 students I have in class. That began a couple of years ago, and I continued one year to the next asking. The number of people who per their own polls, who have had personal experience in actually using the Internet, not as a voyeur, but who actually use it for something, went from three or four or five out of 66, to 50 in one year. It's like a wave coming in, sweeping. Those twenty-somethings are going into the workplace, and that workplace doesn't provide them with the capability they have learned to rely on in their school, and in the process of going through business school, they're going to make it happen. So those two things were kind of revelations for me.

DKA: Anything worries you about what you see? Or concerns you?

ASG: I worry a lot. There's not one thing that worries me, it's a lot of things that worry me. I make it sound very simple what changes a company from supplying personal computing, the building blocks, to networked computing building blocks. It's a big deal. A lot of people need to change their perceptions and their expertise. That worries me. Making the right technical choices, of course, worries me. I don't make them, but I've watched them and helped fret. I worry about the growth of the industry. If we talk ourselves into this phenomenal growth and make 10 billion dollar capacity investments in supply and growth, and that growth doesn't happen, we got a bit loaded with a gigantic depreciation load, with no financial model that can or will make sense. It's not one thing. It's running a business in a very turbulent environment and not very tolerant of mistakes because things shake up pretty quickly and if you're not in the right place at the right time, people don't wait for you.

DKA: Any final thoughts of things that we should mention?

ASG: I'm shocked at all the things that have happened in my professional lifetime. I can't believe it. It must be what the aviators of the early part of the century must have gone through watching airports grow up and air traffic control coming in, when they still remember when they delivered the mail by the seat of their pants. It's like that.

In the last thirty years this industry has grown from a little known laboratory, nation industry, to a global, major industry. A couple of weeks ago when we put out our earnings report, I picked up the *Wall Street Journal* and I look in the "What's New" column and I see General Motors is one of the icons of earnings announcement. And I can't find Intel. We didn't make it on page One in the *Wall Street Journal*. It was the top item! I didn't even bother to look at the top item. Normally it's Alan Greenspan or General Motors generally dominate it. It was our earnings announcement, which was not particularly dramatic one way or the other. I scratched my head. This industry is really awesome. It all happened in a relatively short period of time and I then I kind of wonder what the next ten years is going to bring about. Can we do justice to this last ten years? So, it's been a very exciting ride.

DKA: Thank you so much for your time and insights.

ASG: My pleasure.