An Interview with

CARL MACHOVER

OH 362

Conducted by Philip Frana

on

20 June 2002

White Plains, N.Y.

Charles Babbage Institute
Center for the History of Information Processing
University of Minnesota, Minneapolis

Carl Machover Interview

20 June 2002

Oral History 362

Abstract:

Carl Machover is computer graphics pioneer and president of Machover Associates Corporation (MAC), a computer graphics consultancy founded in1976. MAC provides a broad range of management, engineering, marketing, and financial services to computer graphics users, suppliers, and investors worldwide.

In this oral history Machover describes his upbringing in Iowa and training in the Eddy radar and radio program and other Navy service schools in Mississippi and Texas. He also provides details of his education under the G.I. Bill at Rensselaer Polytechnic Institute. Machover notes his employment at Norden Laboratories Corporation in White Plains, NY, and his publication of the primer Basics of Gyroscopes (1960), intended initially for the Norden sales force. He then describes his move to Skiatron Electronics & Television Corporation where he helped form a subcontractor RMS Associates to build and market CRT character generators. RMS later changed its name to Information Displays, Inc. (IDI) and created the stand-alone computer-aided design (CAD) platform the IDIIOM (IDI Input-Output Machine). IDIIOM had its own operating system based on the Varian 620-I computer, a DEC PDP competitor.

Machover also comments on TV scan versus vector scan, the relative merits of color and 3D information displays, potential health problems related to flickering display and jitter, interaction with the R.E.S.I.S.T.O.R.S. (Radically Emphatic Students Interested in Science, Technology, and Other Research Subjects), and the adoption of CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) and a SIGGRAPH 'CORE' graphics standard in the 1970s.

This is an oral history taken with Carl Machover on Thursday, June 20, 2002, in White Plains, New York, for the Charles Babbage Institute Software History Project.

Frana: Carl, tell me a little about your upbringing.

Machover: Sure. I was born in Brooklyn. At the age of three my family left New York and came out to the Midwest. My mother had been from the Midwest. She met my father while in New York on a vacation. And so they moved to Davenport, Iowa, together. I stayed there, graduated from Davenport High School, and then entered the Navy during World War II. None of my family really had much of a technical bent at all. I had one cousin who was a chemical engineer, and at one time I wanted to be a chemical engineer. I had no idea why, but most of my relatives came in from the business side. I had one uncle who was a marvelous artist, but most of them founded and operated a big scrap yard in Davenport, Iowa. This was a fairly substantial business. They moved from scrap to doing grain transfer, so they eventually had barges and that type of thing.

Frana: Were you artistic?

Machover: Back in Iowa I was a ‘non-singer.’ They wouldn’t even let me sing in music class. I got everybody off-key. So it may come as somewhat of a shock that my family is so artistic. My wife is a pianist. My son is a composer trained at MIT. My oldest daughter is also an accomplished pianist. My youngest daughter actually took fine arts at Boston University and then worked in the computer graphics field for about ten years. She’s also

a musician. I've learned that we non-musicians serve a valuable function as an audience. We're the listeners and I've now come to view it as an honorable profession.

Frana: So what did you do in the Navy?

Machover: I went in under something called the Eddy program, named after the Navy commander. And during this period what they were trying to do was train radar and radio technicians. At that time radar was extraordinarily secret, and there really was no body of trained people to service that kind of equipment in 1945.

As a matter of fact, the two key elements of radar—the klystron and the magnetron—were so classified that I don't remember seeing the inside of one until way into the advanced school. I'd gone for basic training at Great Lakes, and then went on to Horace Mann, which was an elementary radio school in Gulfport, Mississippi, and then on to another radio school in Corpus Christi, Texas. I had an aviation rating. I spent roughly a year in these service schools, and it changed my mind about chemical engineering. I mean, I had all this electronic training. So I finally went on to school in an electrical engineering program.

Frana: How do you get into the Eddy program?

Well, you have to take a special standardized exam. You know, one of the elements of the program was a special slide rule, which Eddy invented and used to do calculations. I

tracked this down [picks up slide rule]—there is a society which collects slide rules. Through this group I discovered someone who had an Eddy slide rule. And this one is my slide rule from college, from RPI days.

Frana: It looks well worn. How long did you serve in the Navy?

Well, I guess it was about sixteen months. While I was in the Navy the Germans and then the Japanese surrendered. I got out in July of 1946. As you know, at that time the G.I. Bill was just coming through, and I was in long enough to have about two and a half years of college paid for. It is not clear to me that I would have gone on to school without it. Well, I probably could have gotten one kind of scholarship or another—I was solid academically—but the G.I. Bill was a marvelous program.

Frana: Why did you choose RPI?

When I got out in July, I had originally intended to go to school at Iowa State University in Ames. But what happened was that while I was in the service my parents moved out of Iowa, and I was not sophisticated enough to keep my Iowa residence while I was in the Navy. I should have; I could easily have done it. So I couldn't get into Iowa State. The state schools after World War II were very, very crowded. So the state schools tended to accept only state residents.

At that time my parents were living in Jamestown, New York. My dad worked for a clothing store. His boss came by one day and said to me, “Why don’t you go to RPI?” And I said, “What’s an RPI?” I grew up in the Middlewest and it wasn’t a well-known school to me at that time. I had never heard of it. So I took a bus from Jamestown, New York, to Troy and looked around and made my application.

And it came time in the fall for acceptances, and I hadn’t heard from them. About that time New York State set up the Associated Colleges of New York State. They set up four or five campuses—Sampson was one of them. So I applied and got into Sampson. I had gone up there to register in September or October, and then I got this telegram from RPI saying that I was selected for the January class. So I said to them, “Fine, I’m at the Associated Colleges—Sampson—I’ll be right over.” And they said, “No, stay there and do your two years and then come over to RPI.” And I didn’t like that at all. I finally convinced them that if I kept my grades up I could drop out of Sampson and transfer over to RPI.

I met my wife in Troy. I still have a number of very dear friends from Sampson. I don’t remember much about those days, but the one thing I remember is that’s when the ballpoint pen came out. They ruined all the textbooks. You’d write in them and the ink would soak through the pages.

Frana: So you were in the RPI Class of 1951? That’s about fifty years ago. Did you get together for a reunion recently?

Machover: Yes, we just did. We just had a class reunion. In fact, I'm on a committee planning class reunions. We meet every month or every other month. As a matter of fact the president of our class died about two weeks ago, so we're going to have to figure out what we're going to do now.

Frana: Are any of them computer graphics pioneers?

Machover: No. A surprising number of them were civil engineers. One of the guys is an electrical engineer.

Frana: So upon graduation in 1951 did you immediately go on for graduate studies?

Machover: No. I worked at my graduate studies part time in the evening. I was working at that time at Norden Laboratories Corporation. I had a good academic record when I graduated, so I was fairly desirable as an employee. I had received an offer from Sperry Gyroscope. At that time their electrical engineers made $3,300. Then I got a counter-offer for $3,600 a year from Norden. So obviously, I took that. My first work after school was here in White Plains.

I don't know what you know about Norden, but the company invented the Norden bombsight during World War II. It was the brainchild of a non-citizen by the name of Carl L. Norden, a Scandinavian. He was an interesting man. There are a lot of stories

about him. I have not met him, but I knew people who worked for him directly. The classic story about Norden is that somebody once looked over his shoulder while he was making a drawing, and asked, "Why did you do that (meaning implementing some new feature)?" He stared him in the eye and said, "You know, at the time that I did it, I had a thousand good reasons for doing it, none of which is any of your god-damned business?" He was kind of a cormungean. The reason that I mention it is that there are two new books that have come out about the Norden bombsight.

Frana: Do you remember Norden-Ketay's electrical engineer Curtiss Shafer and were you exposed to his ideas about the radio or bioelectric control of the brain?

Machover: The guy that I remember from Norden was Carl Shafer. He was one of my first bosses. That might be the same guy.

Frana: Apparently the CIA was interested in Shafer's 'mind control' experiments in the 1950s. Did you know about them?

Machover: The Shafer I remember—I just can't imagine him doing that. He was a fairly mild-mannered fellow. I was supposed to pick up Shafer somewhere in Westchester County once and take him to the airport and fly up to Boston to meet with Dr. Draper, the HIG gyro "guy." And I got lost. Shafer was very generous with me for that.

Frana: You had no experience with gyroscopes in school or the Navy?

Machover: No.

Frana: Where does your idea for writing a textbook on gyroscopes come from?

Machover: Well that was born out of my marketing experience with Norden. I had application engineering responsibility for gyroscopes. And we competed for the sales. What happens in a large corporation is that they may organize in several ways, one of which is to organize a corporate sales force, which represents all the corporate products. Or perhaps instead they have a special sales force for various corporate products. Norden had made a decision to have a generalized sales force. And there wasn't a lot of knowledge about gyroscopes in that field, and the salesmen didn't care. They earned their keep by how much they sold, and the easier it was to sell the better they liked it. I had to view them as my customers. If I was going to get them enthused I had to get them some sort of a document to make it easier for them to sell. So what I did was write this, a gyro primer [holds out bound volume].

Frana: Oh, so this is not the published version published in 1960, but an unpublished version. Are these your hand-drawn illustrations?

Machover: Yes. We would pass this out to the sales force. I tried to make it light enough that they were interested in reading it.

Frana: This was originally given to every salesperson who was supposed to sell gyroscopes?

Machover: Yes. If you look in the back you'll find some data sheets. These were distributed as product literature to the sales force. I guess they distributed ten or twenty thousand copies to the sales force. Eventually we used it as a sales tool. Later I got a contract from Rider to put it out in book form.[1]

Frana: Someone must have gotten the idea that you had a special gift for sales, or for managing sales.

Machover: Oh, yes. I had done that all along. When I was in high school I sold shoes.

Frana: So how long were you at Norden?

Machover: The sequence was that when I first got there Norden was an independent company. They then merged with Ketay, an instrument company that made servo mechanisms. Then they went on a buying spree and picked up about a half-dozen other companies. United Technologies, the aircraft company, acquired Norden in roughly 1957 or 1958. At that point the fellow that I had worked with for a long time, Ken King, didn't particularly like to be a part of very large companies. Norden was four hundred employees, but by the time we were a part of United Technologies the company numbered in the tens of thousands. So he had an opportunity to go to a company called

Skiatron Electronics and TV, which was one of the companies in the late 1950s working on pay TV. He asked me if I'd come along. They had some inventions that they had licensed from England that were relatives of displays. They had a dark-trace tube that was used in very early radar. Do you remember the Berlin blockade after World War II?

Frana: Not personally, but yes I know about it.

Machover: Well, the radars that were used to bring the planes into Berlin during the blockade used the storage tube. It's a potassium chloride tube that once you drew an electron beam across it, it turned purple. And it would stay that way until you heated it. There was some interest in possibly exploiting it for commercial applications. They also developed an ultrasonic light modulator that was used to show large screen projection in England prior to World War II. And they developed some character generation equipment. They also tried to exploit pay TV using scrambled TV technology.

Frana: Were you working on pay TV?

Machover: That work was kept separate. We worked on the display components to build a business out of it, because the pay TV stuff was horribly caught up in politics. There was a representative from Florida by the name of Owen Harris, who was representing the movie interests. And they were dead set against pay TV. They saw it as a terrible proposition. So the idea of trying to get sufficient funding to set up a large enough network to begin to really profit from pay TV looked like a formidable proposition. The

[1] Carl Machover, *Basics of Gyroscopes,* 2 vols. (New York: J.F. Rider, 1960).

company wanted to see if it could exploit these other products to generate revenue and give them a base for moving on to pay TV.

Frana: They actually tried to implement it on WOR-TV in New York.

Machover: Well, that may have been. I don't remember anything about WOR. Their thought was that they would use pay TV to send secure images in certain fields. So for example, as part of a doctor's education he or she needed to take advanced courses. And the thought was that some of the drug companies would sponsor scrambled broadcasts that showed them new techniques, and we hoped to be able to exploit that. Well, it turned out that they sent them out over UHF, and UHF was so narrowly used that it provided the security without the necessity of scrambling. In any case, we stayed with it for about a year, but it just didn't move. We built some test equipment and that type thing.

Frana: These tubes you were working with were composed of potassium chloride and white in color, but gave a persistent magenta trace?

Machover: Yes, the material was called skodaphor.

Frana: So this experience led you in the direction of computer graphics display?

Machover: Yes.

Frana: Does knowledge about gyroscopes also have something to do with the direction of your career in computer graphics?

Machover: In a sense, yes. The place that it helps—and I didn't realize it until later—is that you look at computer graphics, especially when you are trying to get rotations and movements: The equations which define the way in which these images moved are exactly the same equations which define how gyroscopes work. So this whole idea of coordinate transformation which a gyro is doing transfers, almost transfers directly into the computer graphics field. But that's all after the fact. That's something I learned later.

Frana: So this company you were growing, this is RMS Associates?

Machover: It started out as RMS Associates.

Frana: And then what happened to that company?

Machover: What happened is it changed its name…to Information Displays.

Frana: It was a spin-off?

Machover: No, what happened is that Ken King and I who were involved with Norden moved over to Skiatron with a couple of other Norden people. We decided that Skiatron wasn't going to go anywhere, we contacted a man by the name of Al Vollendweider who

had a company called RMS Associates and they had been the subcontractor to Norden. They built equipment on subcontract and also had some instructional simulators and things of that type, and Vollendweider was looking for a way of expanding their business, and we were looking for a way of exploiting what we then called 'information display technology.' Vollendweider and Ken King were the two principal investors and owners of RMS Associates. I was a minor owner. You know, their logo was a slide rule. It's interesting because it reflected the technical orientation of the two principals.

Frana: So you coined that word, 'information display'?

Machover: No, I think we stole it. We called our original project 'Computer Control Displays,' which is what they were. That was the idea. The 'information display' concept grew out of a couple of things. There was a book published in the late 1950s, early 1960s, talking about some of the early information display technology, basically from the military use for command and control. 'Information display' was adopted by the Society for Information Displays, but I don't remember whether SID existed before RMS borrowed the name or not. SID is about to celebrate its 40th anniversary.

Frana: There were other companies that were commercializing this new technology coming from SAGE?

Machover: Yes, coming out of that. There were really a couple of sources. One was the Whirlwind/SAGE stuff, and then there was a company in Minnesota that was building

technical data displays at about the same time. There was another company using displays to design transformers. All of them are beginning to use a technology to design what we now describe as computer-aided design.

Frana: You got started about the same time DAC-1 started?

Machover: Yes. It was about the same time that DAC-1. We were getting Sutherland's Sketchpad worked on at MIT, which went public in about 1962 or 1963, right about the same time that DAC went public.

Frana: And you knew at that time about the computer-aided design work of the aerospace companies?

Machover: One of the things that we have on the film[2] is an interview with Sylvan Chasen who was with Lockheed. He talks about seeing the DAC stuff and the MIT stuff. He used that exposure to get Lockheed involved in computer graphics.

Frana: Was it IDI's idea all along to build a stand-alone CAD platform?

Machover: Well, the first thing we started with was a character generator. When we started, the character generator—a character generator being something that would draw numbers and symbols and things on a CRT—was put in a rack-mounted box that was 5 inches high and about 12 inches deep. That would draw about ten thousand characters per

second and sold for about ten thousand dollars. The technology has moved to the point now that a chip that's about a quarter of the size of your fingernail runs 10-100 times faster and costs a fraction of a penny. So the original idea of trying to make a product out of something like that was naïve to say the least. What would happen was that the people we dealt with would buy one, build it into their systems and then when it came time to buy quantities, they built it themselves. So we had to expand this character generation into full systems, and that's when we began building out our own display systems. That ultimately became the 'IDIIOM,' the IDI Input-Output Machine, which included intelligence furnished by a Varian 620-I computer. That happened contemporaneously with the introduction of the DEC PDP-11 and some of the DEC graphic systems. One of the articles I wrote on the history of computer graphics shows about half a dozen of the contemporary display systems.[3]

Frana: Those were your competitors. The IBM 2250 was your chief competitor?

Machover: The 2250, yes. Even at that time IBM was a major player in this field. We were trying to sell the display concept and the general response was, "If they're so good, why doesn't IBM make them?" From our point of view, when IBM finally came to market with the 2250 series it was great because it gave a legitimacy to the market that a small company of 20-30 people simply couldn't.

Frana: The IBM computer graphics terminal is based on DAC-1 technology, then?

---

[2] *The Story of Computer Graphics*, which premiered August 8, 1999, at SIGGRAPH 99 in Los Angeles.

Machover: Yes, the display that GM used was called a Z-something-or-other. But it evolved into the 2250.

Frana: Did unbundling have any effect on the computer graphics community generally?

Machover: I think it was very hardware-oriented. That was one of the problems that IBM had. They built their reputation not only on providing hardware, but very sound software support. When they finally got into the graphics business, there wasn't any software. Their clients didn't have the levels of support for the graphics stuff that they were used to having in computing. That was a hindrance for quite a while.

Frana: Was IDIIOM a complete 'turnkey' system?

Machover: Yes.

Frana: Did it include programming and software support?

Machover: It did. It had its own operating system based on a Varian 620-I, and we modified that. At the time that we were making our decision we had a choice between using Varian or the DEC PDP-8. At that time, we perceived DEC as direct competition—which in fact it was—and we weren't going to use their system. Instead, we used

[3] See Carl Machover, "A Brief, Personal History of Computer Graphics," *IEEE Computer* 11 (November 1978): 38-45.

Varian's system. In retrospect, I'm not sure that was such a good idea. The PDP proved much more popular than the Varian.

Frana: So you actually supplied application programs?

Machover: Yes, we began to do that. We had our own CAD system called ICAD.

Frana: I know much of this is in the article Bissell wrote.[4]

Machover: No, that's okay. Generally speaking, what we supplied were operating systems. Most people built their own applications. We'd kind of latch onto them after the fact. RCA, one of our customers, built a chess playing program that won second place in the first international computer chess contest.

Frana: What did most of your customers use it for, circuit design?

Machover: IC was not that commonly used. One of the big users and developers of IC programs—Norden as a matter of fact—used it for specialized design programs. We had delivered some systems to England and they were used in designing turbine blades, submarine blades. We built a system that was used in England by the Treasury Department to do financial 'gaming.' They were also used in a number of simulators.

[4] Don Bissell, "Was the IDIIOM the First Stand-Alone CAD Platform?" *IEEE Annals of the History of Computing* 20 (April-June 1998): 14-19.

Frana: An ACM reporter once asked Andy van Dam in an interview, 'Why didn't the idea of connecting a CRT to a computer surface sooner?'[5] Why is that not an obvious thing to do?

Machover: Well, for one thing, processors are fairly expensive. Either you need the computer itself as a refresh mechanism for the display, which was a fairly expensive use of really large resources, or you built your own memory, which you loaded from the computer. At one point the cost of memory was so high, it was about a buck a bit. So if you are going to store a megabyte of data, you're going to be spending a million dollars to get the memory, which is one of the reasons why the vector writing displays were more popular in the beginning.

Do you know the difference between TV scan and vector scan? The point is that you're already building millions of television sets. So it's attractive to use that technology and gain the cost advantages of quantity. But the problem was that you needed to generate the TV image on the fly, which turns out to be a very formidable task. That's a lot of information to generate continuously. Or perhaps you stored it in a buffer memory and then played it from the buffer memory. But early on these memories were buck a bit and that was a pretty costly way of storing information. It wasn't until the cost of memory went way down that things like raster refresh display became practical. The exception was the military. Because of the advantages it has, it will always spend a million bucks for a buffer memory.

[5] See "Computer Graphics Comes of Age: An Interview with Andries van Dam," *Communications of the ACM* 27 (July 1984): 638-48.

Incidentally, the other major advantage of television technology is power. In most of the vector writing systems, power is very costly. It's just a very expensive technology. You could do stroke writing on a color tube, but it's a real technical problem to get all the colors registered and what have you.

Frana: Were there people who actually said it was unnecessary to have color?

Machover: Always [laughs]. I've long been a proponent of color. I remember giving a lecture once in Japan and talking about how it was inevitable that we would have color printers. This was at a time when black and white was perfectly adequate. Someone remarked to me afterward that as a result of my talk the Japanese were going to have color printers in five years. I've long been a proponent of color.

Frana: Do people say the same thing about 3D? You once wrote that 2D information display is easier for people to comprehend.

Machover: Yes, in some cases. For example, a 2D air traffic control system is easier to work with than a 3D system. On the other hand, if you're trying to get a realistic representation of an object for design purposes, 3D is the obvious thing to do. The problem we face is that most engineers were not trained in 3D. They have to go through a relearning process. Once you try to build 3D software for design purposes, you run into equipment limitations: software is pretty expensive, it's quite hard to learn, and requires

significant resources from a computing standpoint. You had a hard time justifying them when these systems were quite expensive, when you're talking about spending one million dollars. A lot of time is spent on doing an ROI (return on investment) analysis so that you can justify what you did. Until we knew more about it, and were willing to look at secondary benefits, it was impossible to do a compelling ROI of 3D. We finally learned to focus on things like reducing error, which was more important than focusing on the quickest way to make a drawing. Once you recognize that, 3D begins to have quantitative value.

Frana: Why haven't VRML and other 3D modeling languages been more popular on the Web?

Machover: I would say that reason is that the technology wasn't very good. It was not terribly responsive. It required a lot of encumbrances to get the full advantages of 3D. This idea of being tethered to equipment through a helmet or something is intellectually acceptable, but practically, it's not very acceptable. That's one of the reasons why you get into some of the virtual reality rooms that surround you, so you can go in them with the minimum of encumbrances. Even there you put on special glasses and things of that type. Obviously if you had some dire need for it, if you were an experimenter, you'd put up with those inadequacies, but a casual observer is not going to put up with a bunch of stuff. You have to make it very easy for them to use.

Frana: So there's a place for each of these technologies? They're each appropriate in difference circumstances?

Machover: Well, I think there are two responses here. First of all, there is a significant cost difference between the two: Color is much more expensive than black and white. 3D is much more expensive than 2D. You have to have some driving force that says, 'I need it for this application. I need to be able to justify why I'm using it. I'm using it because I get a job done faster, or I'm using it to clarify my understanding, or I'm using it to reduce cost.' You need to have some rationale other than the fact that it's pretty. Once the cost difference is mitigated, in my view, people are going to pick the one they like. They pick it because the pictures are better. We've reached that point with color, we're getting to that point with 3D. The increment that people have to pay for the use of those has gone way down. Once I don't have to spend my life learning how to use the technology, then it becomes a no-brainer. We go through these phases.

So the first answer to your question is 'yes,' we spend a lot of time looking for specific applications that are demonstratively enhanced by this additional capability. We spend a lot of time doing it. Once the incremental cost to the user—in terms of learning time and equipment cost—begins to disappear, then you do what you like. You know, I like color, and at some point, that can be an adequate justification.

Frana: So a technical achievement is made and then there's this emotional appeal that follows on its heels.

Machover: If they don't feel the need for it at first and there's a significant cost in terms of economics and training then it doesn't grow. Once that cost difference goes away, then you have a reasonable chance of growing in those areas.

Frana: Tell me about the R.E.S.I.S.T.O.R.S. [Radically Emphatic Students Interested in Science, Technology, and Other Research Subjects].[6] We traded an email about that subject. They came up to IDI?

Machover: Yes, some of them did. What happened is that a couple of artists asked to use our equipment to do their work. We said, 'Sure, but we don't have the time to give you programming support.' They said, 'Never mind. We don't need you. We have some kids from Jersey who will come up and do the programming for you.' That was quite an experience. These kids were in late junior high school and high school. Bright as whips, and not intimidated by anything, they wandered around IDI programming, asking our people questions they couldn't answer. All in all it was an experience. At that time we were in Mount Kisco, New York. Now do you know some of the background on this, the resistor group?

Frana: Yes, I know what we have in our CBI archival collection.

[6] The R.E.S.I.S.T.O.R.S. was one of the first computer clubs in the United States, meeting in the sixties and seventies in central New Jersey.

Machover: Claude Kagan ran the R.E.S.I.S.T.O.R.S. He was from Bell Labs, and he had these kids on his hands. He got together with DEC and DEC began to give him some surplus equipment. So these kids formed a club called the R.E.S.I.S.T.O.R.S. Club.

Frana: Did you meet Ted Nelson of R.E.S.I.S.T.O.R.S. at that time as well?

Machover: Oh, I know Ted quite well. I know him quite well. I didn't know him from his R.E.S.I.S.T.O.R.S. advising. I didn't know him regarding the R.E.S.I.S.T.O.R.S. I knew him when he first self-published those two books on the computing environment.[7] I got to know him through that.

Frana: I didn't know you were a connoisseur of computer art.

Machover: Yes. It was fun. I did a special issue of *CG&A* on computer art.[8] I've been a collector of computer art. If you nose around my office, you'll see some interesting stuff.

Frana: Yes, it's almost overwhelming.

Frana: So you were with IDI then until 1976?

Machover: 1976. That's correct.

[7] See Theodor H. Nelson, *Computer Lib/Dream Machines* (Chicago: Nelson, 1974).
[8] See the May 1995 issue of *Computer Graphics & Applications* (Vol. 15, No. 3).

Frana: That's when you started Machover Associates.

Machover: That's correct. I'm presently employed here.

Frana: What was your role at IDI?

Machover: I was fundamentally the marketing guy.

Frana: Who ran the technical side of the business?

Machover: Certainly the driving technologist at IDI was Al Pestonewho came with us from Skiatron and he was at Norden before. He's an interesting guy in that he did not have an engineering degree. I had all the good experiences with folks who were playing the role of technical guru without having the degree. He could also drink with the best of them. In fact, one of our early customers was SLAC [the Stanford Linear Accelerator Center]. We sold them a graphics display system that was used to do earthquake studies. There was a woman who worked there who was a true geek and I think she and Pestone spent a lot of time trying to out-drink each other.

Frana: What was IDI doing in the 1970s?

Machover: Well, I thought I could make a business out of selling character generators, but that was not true. We did some projection display systems. We'd get involved with

some specialized applications. We did some work for A.B. Dick on printing techniques that they used to make mailing labels. We liked to believe we had a product, but there was an awful lot of customer service associated with it. We had a catalog and published prices and that sort of thing.

Frana: How did you come to make the decision to leave in 1976?

Machover: We ran into a couple of tough years. We began to have some economic problems. Several of us were co-signing notes to keep the company going. We had our house mortgaged; it got nerve wracking.

Frana: The early 1970s were difficult for everybody in this business.

Machover: Yes, they were. So we began looking around for a buyer for IDI and after a couple of false starts, we found a couple of people who were willing to make the investment, and willing to take over the debt that we had. They got our names off of the notes. I stayed there for about a year and then decided to go off and find other things.

Frana: You have said repeatedly that ‘computer graphics are the cure for no known disease.’ Why did you say that in the 1970s?

Machover: Well, because the market was pretty small. You still have an awful lot of education to do to really convince people of this kind of technology. You needed to show

people that there was an economic return on using these things. It was not that easy. The equipment was very expensive, and the measurable results given some of the information out there was misleading. I have to say that there was a great deal of misinformation out there on things like computer-aided design: 'Produce drawings ten times faster.' That's pretty good, but it's true only under special circumstances—with the wind blowing in the right direction and light coming over your shoulder you might be able to do that. But in general, the returns were not that great in terms of faster work. We were only beginning to look at what we now describe as downstream benefits. The fact that I can make drawing changes faster became very worthwhile. Drawings were better and easier to use.

You even had to watch that. I was at IDI and I was invited to talk to a summer course at MIT on architecture. I was talking to the class, giving my usual pitch on the advantages of CAD and computer graphics. One of the things I said was that you can make drawings better. I almost got run out of town by this architecture class because they viewed the architectural drawings as art, and what they saw computer graphics doing was making it much more sterile. The lines are straight and have no character or anything else. Shortly after, you began to see CAD programs that could draw curves and vary line thickness and change the quality of the lettering.

Frana: One of the other things that happened in the 1970s that caught my attention was the CORE graphics standard. Were they trying to create a standard high-level graphics language?

Machover: There was an idea floating around out there called ‘transportability,’ and the idea in the early days of graphics was that each system had a proprietary design—the words, structure, languages, and pictures were unique to each manufacturer. IDIIOM used 16-bit words. Other companies used 24-bit words. That kind of thing. The result is that if you wrote an application program for one system and you wanted to transfer it to another one, the costs were really prohibitive. We had a rule-of-thumb: ‘If I can move from one system to another, and the cost of modifying the software is not more than about 10 percent of the cost of writing fresh software, I have a transportable system.’ Because of the wide variation in the hardware configurations, of course, some of those guys started from scratch and the only thing that you had going for you was that you knew the form of what you were trying to do. Several efforts were going on around the world to create transportability. One effort was launched through SIGGRAPH and the other through a European organization.

Frana: EUROGRAPHICS?

Machover: No. At that time EUROGRAPHICS didn’t exist. The point is that there were several efforts trying to create a standard so that I could write my graphics application independent of the hardware. I’d have a translator between the application and the particular piece of hardware. There were several efforts, one of which was the SIGGRAPH CORE program. There was a German program that attempted to do the same thing. The idea was to solve this transportability problem so that we could readily reuse

software from one system to another. The original CORE, I think, was 2D. I think the German effort had more of a 3D aspect to it.

Frana: There was an NBS meeting in 1974 where they focused on device independence through a 'Graphical Kernal System.' How important was that?

Machover: Well—and this is just a personal observation—I think the Germans were better politicians than we were. They did a better job of promoting their standard as being the one that ought to be pervasive. My recollection is that their position prevailed. The whole idea was to give 'universality' to the software. You raised the question about the National Computer Graphics Association—at about that time they were focused on two issues. One issue was how you standardize the software application, and the second was how you standardize on the software. Could I create what effectively were transportable applications?

The core effort of SIGGRAPH was an effort to look at the software side. They set up a committee to look at the application side. Well, it turns out that the people who got involved on the application side were not quite content to stay within the guidelines that SIGGRAPH had formed. They decided there was a need for an organization which was more hardware and industrial-oriented than SIGGRAPH.

Frana: Now does this go hand-in-hand with the idea of creating a standard high-level language?

Machover: They tried to create a series of standardized functions. Functions that were standardized from one system to another and could be translated easily for various hardware applications. Now at the same time, there were other companies trying to set their own standards. Tektronix had it's own language that kind of prevailed. CalComp is a plotter company. They had a language that became standard for plotters. There were a couple of British efforts to create standard languages that were kicked around. I don't know if you remember a guy named Tom Lazear who started one of the first companies that made a PC software package, VersaCAD. Tom sold the company and then he got it back again.[9] Tom's astute observation is that the nice thing about standards is that there are so many to chose from.

Frana: Isn't that the truth.

Machover: Sure. There are several kinds of standards. There are government-imposed standards, and ANSI standards and things like that. There are organizationally-imposed standards, the things that come out of the standards groups. Then there are commercial standards in the sense that a product is so pervasive that if people want to get into the

[9] VersaCAD is an IBM PC-based 2D computer-aided design and drafting product developed and marketed by the VersaCAD Corporation (originally T&W Systems) beginning in the early 1980s. The principle developers of VersaCAD are Tom and Mike Lazear. VersaCAD was often used in the training of new students in the principles of computer-aided design. The product ran on the UCSD-P operating system, which in turn was implemented on the IBM PC. VersaCAD is today available for the MS-DOS, Windows, and Macintosh operating systems. VersaCAD's chief competitor is Autodesk's AutoCAD *(qv),* first released in December 1982.VersaCAD Corp. and the VersaCAD software were sold to Prime Computer in 1987. In April 1999 the software was reaquired by the company's founders from Parametric Technologies, and has since revised and re-released by Archway Systems of Huntington Beach, Calif. Other CAD products developed by the VersaCAD Corporation included T-Square (written for the Terak personal

marketplace, they have to be compatible with those standards. Certainly Microsoft fits into that kind of a situation.

Frana: The other big thing in the 1970s that I wanted to ask you about was the 'anti-jaggie' movement. I know that in 1980 everybody showed up at SIGGRAPH wearing t-shirts with a jaggie crossed out by a red circle and a slash through it.

Machover: The reason for that is because at about that time, you started getting faster systems. You are talking about a period in which we were moving away from vector graphics and were beginning to use raster systems of relatively low resolution because of the cost of the memory. A good vector display, for example, might have an addressability of 1024 x 1024. It meant that I could start and end effectively at one of these points, but the lines in between were smooth. They were generated in essentially analog fashion. Well, the early raster systems—again because of the cost of memory—were roughly 300 lines, and the only place I could put a pixel was on one of the lines. Therefore, if I had slopes that were away from 45 degrees, I had to approximate what that line looked like by deciding where to put the pixels.

Frana: When do people begin noticing that there's a physiological problem with staring at these displays?

---

computer), CADapple (for the Apple II), OmniDraft (marketed by AT&T), and MarsCAD (marketed by Staedtler Mars).

Machover: There's a phenomenon in some of the early writers where the frame rates became a function of data content. If you didn't do something to change it, you could get displays flickering at you at about 12 to 14 frames a second. It turns out that those rates trigger certain effects that can put people into a catatonic state. There are certain health problems that are associated with a flickering display.

Frana: Can you get an epileptic seizure from them?

Machover: Yes that's what some people were arguing.

Frana: Can you still trigger catatonia or a seizure today?

Machover: No, because they are operating at 30 or 60 frames a second. There's a range at about 10-15 frames a second that creates catatonia.

Frana: It's all about frame rates.

Machover: It's all about frame rates. The ones I'm familiar with are all about frame rates.

Frana: So people weren't complaining about eyestrain?

Machover: Not in my experience. That may have been, but that's not something I remember.

Frana: And then there's a problem with jitter. Is jitter the…?

Machover: Jitter is the fact that the beam comes back to a different location every time you refresh it. That's terribly annoying. What happens sometimes is that you get a beat frequency between the line frequency and the frame rates. They cause the picture to jitter back and forth. That generally was more a problem of the era of vector writers than they have been in raster systems.

Frana: Now, you said something about this when you started the NCGA. You'd look at the social and health impacts of displays.

Machover: Yes, I've had an interest in that for a long time.

Frana: I remember when Lotus 1-2-3 made its debut. There were concerns about what are these people doing to themselves staring at these CRT displays all day long. Are they harming their eyesight?

Machover: There were an awful lot of studies that were done. I ran a panel once at SIGGRAPH, in fact, bringing together people who were looking at the health and safety issues of TV. And my conclusion was—and I'm not sure that everybody agreed—that the problem was overrated. I remember once getting a telephone call, 'My name is so-and-so.

I'm pregnant. Are displays going to be any problem for me?' My conclusions had been that it wasn't, but you want to take a second look when you get that type of phone call.

Frana: Now, my mother used to worry—she was a nurse—that it was okay to walk in front of the display, but not behind it.

Machover: Well, it was believed that you had good shielding in front. You didn't have good shielding behind. Still, I think it borders on being an 'old wives' tale.'

Frana: So, the screens that we look into today have no long-term effects?

Machover: No as far as we know. The idea was that the potentials on the screens were so high that they were subject to giving off x-rays and this type of thing. Generally there's enough shielding on these devices where that's not true. The possibility of this kind of radiation today is much less. I used to subscribe to a newsletter called *Health and Safety VET* and I've given a number of lectures on these issues. I used to turn out data sheets quoting various articles, and either I'm losing track of it, or it's not as ubiquitous an issue any longer. You just don't see it much anymore.

Frana: It was a hot issue, particularly in the 1980s.

Machover: Absolutely. I remember clearly during this panel I told you that I ran, all the speakers were well qualified, had pretty good data, and told a story that I thought was

very persuasive. Then we got questions from the audience that said, 'Yeah, but what haven't they measured?' There was a real feeling that you weren't being told the whole story or you didn't know quantitatively this had that effect. There was a real fear factor involved early on. People told stories about how it affected egg embryos. There were studies done in Scandinavia that had results that worried people. You may remember that there was a period of time when the yellow-brown phosphors were very popular because they were perceived to have less adverse effects on the eye. There was a study of pupil dilation in people looking at displays. How quickly the pupil came back depended on the color of the display.

Machover: Have you done any research in the area of industrially-oriented standards?

Frana: Do you mean computer-integrated manufacturing?

Machover: Yes. CAD/CAM. I worked on the Initial Graphics Exchange Specification that was moved more into the manufacturing side.

Frana: I don't know much about IGES.

Machover: You might want to add that to your list of looking into.

Machover: [Speaking to office assistant in next room] Mary Lou, can you make a copy of the bibliography that includes CAD? That's 506 B.

Frana: You have a very interesting filing system for your papers and email. I notice on the subject line there's a little code.

Machover: What I do is I give all of my projects a project number. So, for example, you're '20' or '30' and that gives me a way of keeping similar stuff together.

Frana: Oh, I see. You've got a 'J' file.

Machover: Yeah, I started with J 1000 and I'm up now to 3252. So I've worked on like 2200 projects. It's just a convenient way to keep track of what I'm doing. One part of the whole task is creating a system. For example, I give all my data sheets a number so I can find those, and then I have technical files that are usually by the manufacturer, and I have topic files, those are what goes into here, and the job files. There's some redundancy. The problem is, after 27 years of putting this stuff together, you lose some of the detail.

[pause]

Frana: Who's your oldest SIGGRAPH Computer Graphics Pioneer?

Machover: Well, Burt Herzog got the 'Mickey Mouse' award for that.

Frana: He works in Providence?

Machover: Yes, but he's in Germany right now. He's had some heart trouble and we wanted to make sure that we racked up the pioneers while there were still some around. In fact, that was an issue with the movie, making sure we got everybody interviewed. Since the movie was made we've lost about five or six people. You don't want to make a group like that with pioneers an obituary column.

Frana: You want it to be a living organization.

Machover: Yes.

Machover: How much controversy do you run into in establishing historic fact? The reason I ask is that when we were doing things like writing the script for this movie, one of the pieces of advice that I got from Gwen Bell—do you know Gwen Bell?

Frana: Yes. I know Gordon and Gwen Bell.

Machover: Yes, lovely people. Her advice was never to say 'the first.'

Frana: Yes, that's a good rule-of-thumb.

Machover: If you want to say, 'this was one of the first,' that's fair enough.

Frana: Or use the word ‘pioneering’ or something. Yes, the Bells are pouring a lot of effort into the Computer History Museum. I don’t know if you’ve visited that facility. They’ve got some displays and ‘Visible Storage,’ which is what they call a little peek into their warehouse of artifacts.

Machover: We borrowed some of their stuff when we did the movie for SIGGRAPH.

[pause]

Frana: You don’t have an office down at 100 Main anymore?

Machover: Well, I was at 199 Main Street, and then we built this facility. In fact, let’s go stretch and I’ll take you downstairs and show you the conference room.

Frana: Thanks Carl.

END OF INTERVIEW.

APPENDIX

Machover Chronology

1951 — Bachelor's degree in Electrical Engineering, Rensselaer Polytechnic Institute; Graduate study at New York University

1952 - 1969 — interested in design and marketing of display devices, servo components, gyroscopes, bombing and navigation systems, and precision test equipment

early 1950s — United Technology Corporation

1958 — Manager of application engineering, Ketay Department, Norden Division, United Aircraft Corporation

1958 — Sales Manager at Skiatron Electronics & Television Corporation, RMS Associates a subcontractor which led to founding of Information Displays, Inc.

1960 — publication of *Basics of Gyroscopes*

1960 - 1976 — co-founder and Executive VP of Marketing for Information Displays, Incorporated (IDI), Mt. Kisco, NY, a computer graphics manufacturing company

1966 — ACM SIC SIGGRAPH founded

1969 — President of the Society for Information Display (SID), later a Fellow

1973 — ACM special interest group SIGGRAPH founded

April 1976 - present — President of Machover Associates Corporation, White Plains, NY, a management consulting company to provide management, engineering, marketing, and financial services to computer graphics users, vendors, and investors

1980 — publication of the *CAD/CAM Handbook*

1983 — formation of Computer Graphics Pioneers group

1983 to present, Adjunct Professor of Interactive Computer Graphics at RPI

1985 — Advisory Board member of the Pratt Center for Computer Graphics in Design

1988 — received NC State University Orthogonal Award; president of Art + Science Collaborations, Inc. (ASCI) founded in 1988

1990 — President of the National Computer Graphics Association (NCGA)

1998 — History Chair for SIGGRAPH 98, co-executive producer of *The Story of Computer Graphics*