The Disk Drive Story
Chapter 1: IBM's RAMAC

Transcript #1

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	John M. Harker (Jack) Joined RAMAC Project - May 19, 1952
	Thomas G. Leary (Tom) Joined RAMAC Project - April 13, 1953
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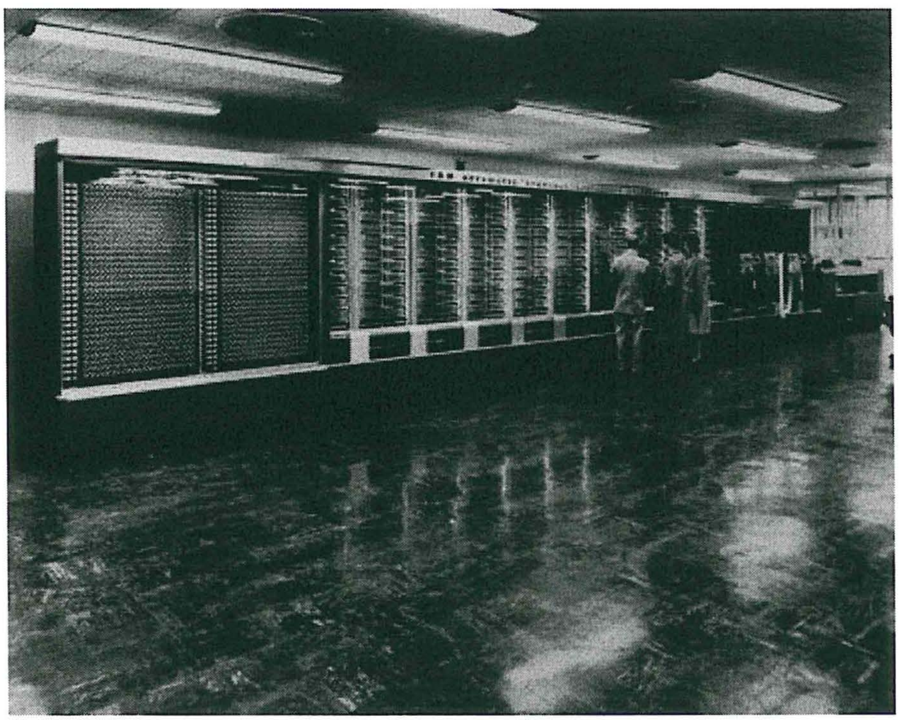
Transcript:

Jim: Our meeting today has been arranged so that we can discuss how the original disk drive was developed and produced. But to start, let's try to understand why it was necessary to set up a San Jose Laboratory and what IBM's objectives were in doing all of this. Let's start with Lou Stevens and get a little background on what the thinking was in the industry about storage and the requirements that led to that.

Lou: I want to talk about two subjects. First is the environment that existed in the world (the computer world) and second, the world of IBM in the late '40's and early '50's. When IBM decided to build a laboratory in San Jose, it's hard to believe, with the predominance of the computer industry today, that **there was no industry**. The very first operational stored program computer started/ran its program in May of 1949. What do I mean by 'stored program computer'? A computer that contained a memory of some kind and in that memory had not only instructions, but data. John von Neumann, at Princeton University *(Institute for Advanced Study)*, wrote a seminal paper talking about the logical conclusion of having machines that have the capability of doing arithmetic on their own instructions – God forbid – a machine could do that – early machines – all machines could do that. *(NOTE: In 2005 the U.S. Postal Service recognized the computer revolution with a U.S. stamp honoring computing pioneer John Von Neumann.)* Today we all have Windows computers and they hang up from time to time. You might not know it, but you probably are trying to execute some data where something went wrong and they are going to some other place in the memory and trying to execute data and it doesn't work well – it hangs up and you end up with [ctrl + alt + delete]. There were computers, big ones, but they were all computers that used control, which was separate from that of main memory.

IBM had built several computers – there was one at Harvard called Mark IV, or some Mark number, and one was installed at IBM World Headquarters. All were computers that were controlled by some other means, not by memory. The ENIAC *(Electronic Numerical Integrator and Computer)* was the first really large computer that was built by The Moore School of Electrical Engineering at the University of Pennsylvania. John von Neumann at Princeton had a conversation with the people at the ENIAC activity and talked about the importance of the next generation being stored program – a general-purpose computer. The Eckert-Mauchly Computer Corporation proposed a machine called EDVAC **E**lectronic **D**iscrete **V**ariable **A**utomatic **C**omputer. All computers, it seemed like, had to have some sort of 'AC' associated with their name. The EDVAC proposal was made and they had done most of the work to design the thing, but they hadn't actually built anything. They decided to have a summer symposium and invite people from the academic community and from all over the world. One of the attendees at that meeting was a gentleman from Cambridge, England – Maurice Wilkes. Maurice came and listened to the discussion about the EDVAC and all the magic stuff that would be done, but again, nobody was doing anything. So he went back to Cambridge and decided he was going to do something. And he did. He built the first operational stored program computer in Cambridge. It ran its first program in May of 1949. Another computer at Manchester University was built by a gentleman by the name of Frederic C. Williams, which had run a small program a year earlier, but the first full-scale computer was the EDSAC **E**lectronic **D**elay **S**torage **A**utomatic **C**alculator.



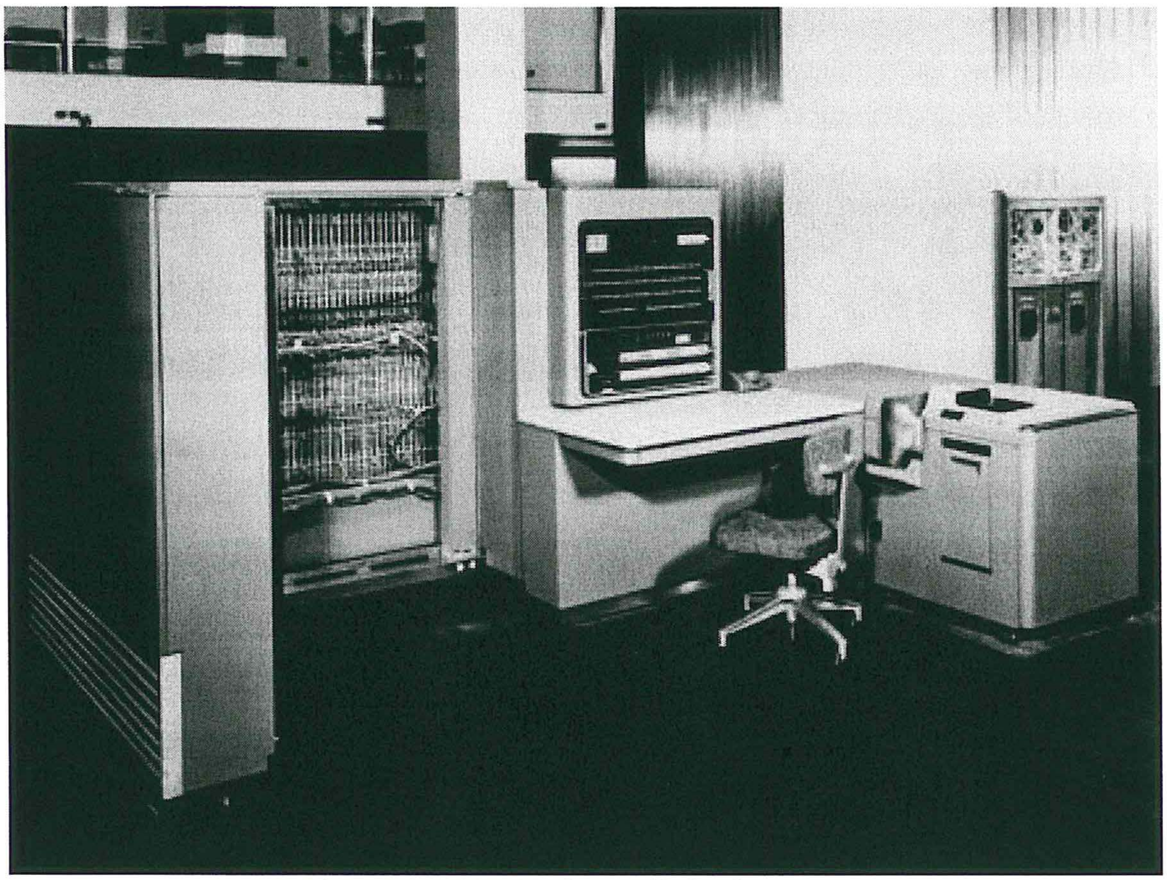
The Mark IV

That brings up the question, if you are going to put both instructions and data in the same memory, what are you going to use for memory? Well, they didn't think they had any choices – they had two choices: 1) Invented by F.C. Williams called the Williams' tube which stored data on the face of a CRT and 2) electronic delay lines or mercury delay lines, which were developed during World War II as a radar moving-target indicator. The EDSAC was based around a delay line and the EDVAC proposal was around mercury delay lines. The EDSAC, which Wilkes built in England, was built around delay lines. They had the problem of being cyclic in nature, but nonetheless, they would provide a uniform memory.

Now, Eckert and Mauchly decided to go into business. They had left the University of Pennsylvania and decided to go into the computer business, except they didn't have any customers because the proposed computers were very hard to use. They wouldn't work with the facilities to use them like normal people today. You had to program with binary language. Eckert and Mauchly were finally successful in getting a contract for the 1950 Census. They built a machine called the UNIVAC – or they proposed a machine called the UNIVAC the **UNIV**ersal **A**utomatic **C**omputer. The UNIVAC became kind of a synonym for computers.

Well this began to get IBM concerned. IBM did not believe – the boss of IBM, Tom Watson, Sr., did not really believe – that there was money to be made in a substantive way with electronic computers. He felt computers were good for some things, but they weren't really good for normal business. But, with a purchase by Remington Rand, which was IBM's main competitor in the punch card business, of the Eckert-Mauchly Computer Corporation, and the forthcoming delivery of a machine to The Bureau of Census, there was some uncertainty as to whether or not we shouldn't be doing something. So it was decided to build up a talent within IBM to build a so-called tape-processing machine, which the UNIVAC was. They started to hire a few guys like me, and others, from universities throughout the country, to begin to work on the tape-processing machine in Poughkeepsie.

In 1951, the United States became involved in the Korean War. So, Tom Watson, Sr. didn't believe that we could have big business for the computer. However, he was a very avid supporter of industry in the world and the war effort, so he and his son, who was the heir apparent to leadership in IBM, decided to offer their services to build a computer for use in support of the war effort. They decided to call it **The Defense Calculator**. All of the people who had been hired on the TPM -- Tape Processing Machine (or the UNIVAC competitor) were then reassigned to work on The Defense Calculator. The Defense Calculator was limited production, so limited exposure. The decision finally was made to build nineteen of these machines, which ended up to be named the IBM 701. In fact, studies at the time indicated that nineteen machines would probably saturate the global need for computing power for the foreseeable future. Though the machine itself only had 4k of memory (all on Williams' Tube Memory that wasn't very reliable), it was fast in the timescale of the day. Access to memory was 12 microseconds, 36-bit words. It was a computer that was a binary general-purpose computer and did not have definitions for ASCI characters or bytes – that came to be later.



The IBM 701 Defense Calculator

These were the environments that IBM faced – how do we get people to work from the West Coast? It was decided to establish a small laboratory in San Jose. Rey Johnson was picked to come to San Jose and start the IBM San Jose Laboratory. In January of 1952, Rey arrived on the scene in San Jose with the edict to hire some people and figure out what to do. I think Rey was limited to hiring something like fifty people for the first year. About half of those people were spending their energy looking at analog-to-digital conversion, and other things, to enhance the punch card accounting machine line. The punch card accounting machine line was the prime business of the company. And, in fact, it was primarily a mechanical company. You could not visit an IBM plant without coming out with metal chips on the bottom of your shoes, because there were a lot of metal chips being cut, both in Endicott and Poughkeepsie. So, the idea was to make an investment in a small laboratory with no real direction of what to do, other than the fact that half of the effort would expand the punch card capability to analog inputs like wind tunnels and so forth, and the other half would be Rey's choice. He spent a lot of time thinking about it.

Rey was a guy who had grown up in Endicott. I want to make a point that is so important. By way of explanation, Endicott was a place and IBM in general (Engineering) was a place of small fiefdoms, where Tom Watson, Sr. controlled the budget strings on all development activities. All investments for new products were controlled really by Tom Watson. The fiefdom of senior engineers maintained a cloistered environment.

Rey wanted to establish a new different environment in San Jose. He had three principles/tenets which he reiterated often: 1) It is essential that each engineer be familiar with the purpose and function and the environment of the machine or machine components of which he is working. You had to know what it was trying to solve. What kind of problems were you trying to solve? Why were you doing it? Why were you doing it? 2) Second major tenet: It is the responsibility of each engineer to be conversant with all the other projects going on in the laboratory – ALL the other projects. That was so diametrically opposed to the modus operandi of the existing laboratories in the East, who felt that if they did it they wanted to keep it close to the belt so nobody else new what was going on until it was ready for announcement; 3) Third and most important tenet was: The third most important assignment is that every engineer give assistance in the form of consultation, experimentation, or suggestion when asked by another engineer. The second most important assignment – the **SECOND** most important assignment – is that of carrying forward the project to which you are assigned. That seemed so absurd at the time. You're supposed to help other guys before you help yourself?

There was a method in his madness. It created an environment that is hard to describe. It's hard to describe because it was such an open environment. People spent so much time talking to others trying to understand what was going on and why they were doing what they were doing – there were no walls built, no mine/yours sort of thing.

One of the guys that was very important in Rey's mind and a big influence, was a fellow named Ed Perkins. Ed was a senior salesman in the IBM San Francisco office. Ed used to come to the lab and give lectures and arrange for lectures to help us find out what problem we were going to try to solve? What is a problem worth solving? That's what we spent most of the first year looking for was **a problem worth solving**!

Jim: While you're at that point let's take a brief break and hear from the rest of the panel. First of all, how about yourself, I understand that you were one of the first fellows that Rey Johnson really brought out to the West Coast with that operation.

Lou: I was in Poughkeepsie at the time on the 701 and the Defense Calculator project. And, I had done a lot of interviewing – college interviewing – and Rey asked that Poughkeepsie send somebody to help him do some interviewing for the new hires. I was fortunate enough to be the guy who came out to help him.

Jim: That was in 1952?

Lou: That was in very early '52. I was fortunate enough to convince Rey that I really should work here. So I moved to San Jose in May of 1952.

Jim: Okay. The others on our panel today are Jack Harker. Jack, when did you start with IBM?

Jack: I started in May of '52. I had just received a Masters Degree at Berkeley in Mechanical Engineering. Actually, I'd been studying fluid mechanics thinking about going into the petroleum industry. But I interviewed there and found out where the jobs were. I was married by then, Betsy and I both loved the Bay Area, so I turned down a couple of offers, which really peeved my advisor *(laughter)*. Then came an ad in the Daily Cal. IBM was opening up a small advanced development laboratory in San Jose. I called about the ad, sent in an application, came down, and was interviewed by the Assistant Lab Manager, Jim Hood. We talked for about an hour or so and he walked me around the place – it was a small building then. At that point, he offered me a job. I subsequently accepted and he accepted and I came down from Berkeley and got started with IBM.

Jim: What were you working on originally?

Jack: The first real project I had was working with a fellow named John Lynott – you'll hear more about John. We worked on the development of a plotter printer that would enable users to create essentially graphs, label them and do all that. We came up with a machine and it sort of worked. That was really what I worked on until the idea of a disk file got going. We all got pretty well moved into that business.

Jim: Our third member of the panel is Tom Leary. Tom, when did you start with IBM?

Tom: It's kind of interesting, I was the supervisor of an installation of IBM machines with the Calavo Growers, the avocado growers co-op. One day I was sitting at my desk, which had a vice on it and everything else. We had finished setting up the installation and I was automating the packinghouse. Ed Perkins and my salesman came in, and I thought 'oh shute' *(laughter)* because I was busy. They said they wanted to talk to me. So I talked with them and they wanted to see my control panels and other equipment. I showed them – took them through the packinghouse and brought them back in. Ed Perkins turned to the salesman and said, 'you go on, I'm going to spend the day with Tom'. I thought 'oh no' *(laughter)*. So he spent the day and he started talking eventually about a lab that IBM was going to have up in San Jose. He kept mentioning it and mentioning it. I thought, is he dangling bait in front of me? So I said, 'are you trying to finagle me into going up there and asking for a job?' He said, 'would you be interested?' I said, 'well sure I'd be interested'. He said, 'We'll have to talk to your management because IBM doesn't hire from customers'. I said, 'you can only do me a good favor by doing that – I'll either get a raise here or I'll go up there'. So he talked to my management and then my wife and I drove up to San Jose for a visit. We had a nice time with Rey Johnson, however, he didn't offer me a job. He just seemed to want to talk about things. I thought – gee that's funny.

I'll never forget the point where I was walking from Rey Johnson's office to the street and as I passed his secretary's *(Gloria Doolittle)* office, she called me in and asked 'how much did it cost you to come up here?' I thought, for heaven's sake, that's different. So I told her what it cost me and she gave me $100, which was a lot of money in those days. After we went home, we didn't hear anything for quite a long time.

Then I got an invitation from the Lab to bring my wife and come up again to spend the weekend. They didn't say that they wanted to offer anything. They just said that transportation had been booked for us on the railroad train. So we went up on the train and went to the lab. One of the wives took my wife out while I talked to Rey Johnson. Rey talked and talked and he had a big stack of books on the corner of his desk. He was over there and I was over here *(one on each side of the desk)* and I guess I kept looking at those books. He said 'you're interested in what that is'. I said, 'I guess so'. He said, "that's the research we did on you. We've talked to your neighbors and we've talked to everybody we could think of and we collected all this information on you. If we offer you a job and you accept, you've got a job for life". It isn't like that now.

Jim: Did you take the job?

Tom: Yes I did.

Jim: What did you work on originally, Tom?

Tom: That was interesting. When I came back in to go to work, Rey Johnson said, 'take your time because we need you to get set up'. I said to Rey, 'what do you want me to do?' He said, 'Well that's up to you'. I said 'WHAT?' *(laughter)* I usually had an assignment to do specific things. I drove myself crazy. I went through all the books in the library *(established by Marjorie Griffin)*. I visited all the guys in the Lab to see what they were doing. I felt lost. I was trying to figure out what I was supposed to be doing there. Eventually the RAMAC came along, then I knew.

Jim: Let's discuss the start of that project. Lou, you were in a responsible position at that time weren't you? It was within about a year after the Lab got started wasn't it?

Lou: When the Lab started, I reported to Rey. Basically everybody reported to Rey. I was his Technical Assistant, and kind of the honcho who went around and handled the mundane day-to-day stuff. But basically everybody reported to Rey. Rey was the first to tell you, 'I'm looking for the right thing to do – I'm looking for the right problem to solve. The more the merrier in helping me look – that's great.'

Jim: When did it start to gel – the project to do something with the disk?

Lou: Rey assigned Art Critchlow to do a study. Rey had always been interested in source recording per se; source recording being key punching. Rey had built the 026 key punch in Endicott and he had done a lot of other source recording-like things – that's conversion of something to punch card format. So he assigned Art Critchlow to look at the source recording problem – how could we get information into the punch card at the earliest possible time? Art looked at lots and lots of different alternatives. It was obvious there should be some sort of a storage medium – unchanging data. He ran across a thing called a tub file. A tub file was a place where you stored pre-punched cards. To do an invoice, you'd pick a card of the customer and his address and a card for each of the items on the invoice and then process them in typically EAM machines – EAM means **E**lectrical **A**ccounting **M**achines – punched card machines – until they produced a printed invoice. So this was random access to the individual punched card records.

Obviously, you could replace that tub file with some sort of a magnetic storage that would be automatic. Let's try it. What kind of a magnetic storage could we find? So Critchlow looked at many alternatives. There had been an article published in *Electrical Engineering* *(in 1950)* by Jacob Rabinow. It described a funny disk drive with a number of stationary disks in the shape of an 'O' with a 'V' cut into them so a head could move around and select a disk. After selection, the disk was then rotated – a really amazing mechanical monster. From that starting point, they said – why not rotate the disk constantly and cause the head to move back and forth between the disks? Critchlow proposed a project, which was ultimately labeled the file-to-card machine, which was really just a storage device to replace the tub file. Tom was a vital ingredient for making those pieces fit.

Jack: Along about that time came the proposal from the Air Force.

Lou: Good point.

Jack: They put out an RFP for automation of the Air Force Base Supply System. What they were looking for turned out to be what we built.

Lou: That's right. That RFP was an important document. In fact, weren't you *(turning to Tom)* part of the team? Didn't you and Haanstra go study that thing?

Tom: Yes, for a while.

Lou: Bill Goddard did the actual response to the RFP. We responded to it and amazingly enough, lost the business. It did change our whole perspective. This was to be a perpetual supply system for the U.S. Air Force, called the Material Information Flow Device, MIFD. From there on in it changed the whole perspective of what the problem was we were working on. It changed from a little problem to a much much more grandiose problem – a much larger problem of how you might have on-line processing to do useful processing work. Think a little bit about how on-line processing today is kind of taken for granted. The fact that I can go to an ATM or to a bank and get the balance of my bank account as of maybe 30 or 40 microseconds ago is a modern-day phenomenon. In those days (circa 1955) you couldn't obtain your precise bank balance unless it was the next day after the batch run, which would post the data to a big ledger.

Jim: So the disk was coming along at a point in time when the only other alternatives for a large-scale computer were a tape drive, which took too long to get to the data; or a magnetic drum, which was very fast but couldn't handle large capacity.

Lou: That's correct.

Jim: So it was possible to provide the large capacity and true random access, but the only practical way to do that, I presume, was the objective that you were then working on.

Lou: That's correct and the only way we saw at that particular point in time, was to have the volumetric efficiency that was the disk. Drums – they were fast, but they didn't have volume enough. With the magnetic recording technology of the time, you needed a lot of surface area.

Jack: Basically, we took the specs from the Air Force proposal – 50,000 records with 100 characters – and that became the target against which we were designing.

Lou: That's correct. We found that wasn't bad – 50,000 records fit most wholesale businesses -- 50,000/100 character records fit most businesses.

Jack: One of the things Rey did early on that was so wonderful – he believed his people should go out and understand the customer. So almost every week, a group of us would visit a customer along with one of the sales reps who really new the business. We would understand how that business ran – how they processed information, what they were happy and unhappy about. As Lou said, we were trying to understand what the problem was that was worth solving.

Jim: It was around this time, that the problem was becoming clear. The solution was apparently going to be something to be done on a flat surface with a magnetic disk. How did that hypothesis get defined into the project that eventually emerged as the RAMAC?

Lou: Let me make one other point. The disk idea was an interesting idea. However it wasn't practical because it didn't have a way to get a magnetic head close enough to the disk surface. So the invention of the hydrostatic air bearing support for the magnetic head was a key ingredient.

Jack: That was John Lynott and Bill Goddard.

Lou: Yes, when that was first done and first illustrated, when John Haanstra had written by hand on a disk the word THINK in 6-bit ASCII code. The whole environment changed, because a lot of people weren't really too happy with disks as a mechanical structure – one of them being Jack.

Jack: If you'd seen that first array of disks you wouldn't have been very happy either. They were taken out of sheets of aluminum; stacked fifty on a shaft; some of them were touching; some of them had a big space in between; and they wobbled *(hearty laughter by all)* as they ran! All of us looked at it and said 'oh my'. But Rey had faith. Rey knew all the doubters.

Lou: A lot of us were doubters as to whether that would work or not.

Jack: I guess the next major step was taken when we started making disks out of Almag engravers sheets. They were about a tenth of an inch thick and dead flat. They were cut out with a router on an arm. A hole was drilled in the middle of the sheet and a peg inserted. Then a wooden arm with router attached made a circle. That created the disk.

Lou: Bill Goddard brought his router in from home.

Jack: Yes, in fact, Bill Goddard brought his router from home. It was a very hands-on environment. In fact, one of the things Rey did was give us a machine shop. He paid to have the machinists stay late a couple of nights a week and encouraged all of us to sign up and learn how to run the tools.

Lou: He bought special tools for the engineers to run.

Jack: That was the environment. The thing about it, and probably one of the things that made the RAMAC happen, was that you really got into a mode where no solution was unthinkable.

Lou: That's right.

Jack: That gets us to the disk pour – how they formed the disk. How do you get a level coat of paint on a disk? In the first place, what do you use for paint? I think that's when Marcel Vogel or Jake Hagopian first used a fortified paint that was essentially the paint used on the Golden Gate Bridge. There was iron oxide base in the paint. Then the question was – how do you paint a disk?

Jack: Bill Crooks came up with the idea – spin the disk and pour it out of a Dixie Cup.

Jack: The paint was also filtered through a woman's stocking to get the lumps out. Filling up a bunch of paper cups with the same amount of paint, and spinning the disks at the same speed would give a consistent coating thickness from disk to disk.

Jim: And of course machines were later built for this process.

Lou: Not until considerably later.

Jack: But with those two things, you had the parts.

Lou: The Almag was too hard to cut – too thick – and very expensive. We tried to talk to Alcoa about aluminum disks. Alcoa wasn't really interested because the volume was not enough. Alcoa made LP masters for transcription records and the substrate of that was a 51 thousandth thick piece of aluminum. We bought several 24-inch square sheets and from there on in made our disks by cutting those up and then fabricating a 100 thousandth thick by laminating two 51 thousandth single sheets into a disk. They were coated before they were laminated. This process made a disk that was dead flat and very good from a ringing point of view. These three or four key ingredients were the items that made the first model work.

Jim: And when did it all come together to demonstrate that it really worked?

Jack: The first horizontal shaft file card machine demonstrated it.

Lou: That first model still exists, I believe, over in Building 10 (at Cottle Road).

Jack: That machine demonstrated that you could use punch card as I/O: read it; record it; and then read it back.

Lou: This was the electronic equivalent of a tub file.

Jim: We talked about the mechanical developments, what about the electronics that made it all work? Was that under development too?

Lou: Yes, Dave Kean and a team of the guys did the electronics to make the file-to-card machine. Al Hoagland was also involved with helping to do the magnetics because we didn't have a lot of magnetics experience at that time. Al was brought in as a consultant at the time to help put the right magnetics in the head design.

Tom: And I did the programming.

Lou and Jack: And Tom did the programming.

Lou: That's right. He was the world's first RAMAC computer programmer.

Jack: At the same time that this was going on, there was a separate group – Haanstra, Murray Lesser, Tom – looking at what the machine's system should do to solve the problem that we'd addressed with the Air Force. That was the start of the RAMAC.

Lou: Separating the RAMAC from the RAMAC File. The RAMAC wasn't much of a computer. There was a debate in the lab as to whether it should be a stored program computer or a plug program computer. It ended up to be a little of each. We did not at that time know how to do adequate formatting on printers, so you could have eight columns here appear over on the left-hand side. Those were done primarily with plug boards. Decisions were made on the plug board – many decisions were made on the plug board – but most of the stuff was stored program. The distinction between the two was a magnetic drum. At that time – early 1953 or '54 – you could only afford core memory in small pieces. We had a small 100-character core memory buffer for moving data back and forth on the drum.

Another key ingredient electronics-wise, was developed by a gentleman named Len Seader. Len invented a scheme for recovering the clock. That sounds like a simple thing, but in the environment that we were in, recovering the clock off of the rotating disk without a stable clock track was a very big deal!

Jack: All the drums we built would have a clock that was permanently recorded. The drum would speed up and as it slowed down by having an oscillator, when it hit the right speed to have a totally closed track, you would record. You would get a clock track or you'd have a clock head on the track, but that didn't sit very well.

Lou: It just didn't work. Len invented an electronic scheme to recalibrate the clock for every character it read. Len's circuit was really **the** key ingredient to making the machine read and write reliably.

Jim: Well it was quite an adventure to pull all that together but at one point didn't the thing fall apart and seriously injure someone?

Jack: That's a story I know very well. This was not the first tub file, but the first vertical shaft machine. You had spacers, and spacers have steps on them, and the disk fit over the step on the spacer. You could grind the spacers very accurately so you wouldn't get a large tolerance build-up, having fifty of these things. It was very hard to take those spacers on and off the shaft because there had to be a very close fit. Unfortunately, you had to change disks very quickly and we had some failures along the way. So, somebody came up with the idea to put a slot in the spacer and that made it easy. When the disk is on it, there's no problem because it contains it. Unfortunately, one of the files was loaded without a full complement of disks and a bunch of the spacers slipped. As long as they were tightly clamped, it started up and ran, but at one point one of the spacers just worked its way loose. They were cast iron. All the spacers that had no disks on them just flew to pieces. I still have one of the pieces. I felt responsible – I think we all felt responsible.

Lou: Oh my yes. We were really fortunate nobody was really seriously injured.

Jack: Len Seader had a tendon cut in his hand. That was repaired. Wes Dickinson had a nose injury.

Tom: We were lucky.

Jack: Really lucky. Those were deadly projectiles.

Lou: Deadly shrapnel – sharp points. It made a lot of noise – scared us. We were fortunate in another sense. There was an emergency clinic within a half-block of 99 Notre Dame.

Jack: For a young engineer, it sure was an education!

Jim: You got past the battle phase of putting it together, and you had a model that would demonstrate the principles – what happened from there? Did final definition get established at that point of what the RAMAC should be?

Lou: Pretty much so, I think at that time we started debating what we were going to do next. Rey kind of pulled a one-upmanship. We got an operational model of the vertical file. He invited some people in to publicize that. He put some pressure on the people in the East, but they weren't ready to decide what we were going to do. So the PG&E *Progress* newspaper, of which I've got a copy, comes out and it had a picture of Wes Dickinson and the original file. It was announced. Well here it is, what are we going to do with it now? From there on in, the debate of whether or not we were going to have a product, and what the product was going to be a part of, became the major topic of discussion – and where it would be manufactured.

Jack: You're skipping over something. To me it's significant that this is the group that defined the RAMAC; came up with the idea that we should have a transaction-processing machine. I don't think that had really been thought through before.

Lou: No it hadn't.

Jack: Instead of running things in batches, you would update all the records affected by a single transaction. The 305 was designed as a Transaction Processor. That was quite a step and a very different idea. It was different because the tape machines were all batch processors -- a master tape and a data tape.

Tom: And a card tape too.

Jack: And a card tape too. That's the emulation of the card.

Lou: We were fortunate. There was a gentleman who worked for Louis H. LaMotte, who was a key decision maker in those days, named F. J. Wesley. Wesley was a great advocate of transaction processing.

Jack: There was also Bill Woodbury, who had been an IBM Field Engineer. He had helped install an early CPC at Northrop. He, John Haanstra, Tom Leary and Murray Lesser were part of the team that defined the RAMAC.

Tom: I was starting the specifications, remember? When you'd tell me something and I didn't like it, I'd change it in the specs. *(Hearty laugher by all)*

Jack: And nobody knew the difference.

Jim: We've taken the discussion to the point where feasibility has been defined. We plan to go on in our next session to discuss how the RAMAC actually got built.