**Interviewees:** Bernard Howard and Harold Skramstad

**Interviewer:** Henry S. Tropp

**Date of Interview:** February 28, 973

**Tropp:**

During this whole period in Chicago (we're talking about computer development in Illinois and other places) there was another development going on in the West Coast that you had to have some contact with, in the aerospace industry. In particular I'm thinking about Northrop and there was the Snark missile project there and as a result they had some developments like MEDITA. The CPC came out of that. Computer Research Corporation eventually evolved from that group of people. What contact did you have with the West Coast computer industry in that era?

**Bernard Howard:**

You've mentioned them all. There was a man named J.B. Rea who was from Northrop and formed his own company just at the start of this thing and was intimately connected with the MEDITA and so on. We of course had to know the characteristics in terms of our simulation evaluation and so on, the characteristics of the guidance and control systems. One of the volumes in our series, of which I just gave you a copy, is on guidance and control.

**Tropp:**

So there was work on that at Northrop; there was work going on at Hughes, Consolidated...

**Harold Skramstad:**

Hughes, Reynolds...?

**Tropp:**

That's Reynold-Wooldridge.

**Bernard Howard:**

I'm trying to think of the guy at Hughes that...

**Tropp:**

Ramos?

**Bernard Howard:**

No.

**Tropp:**

Well, Eldred Nelson I know was there and wrote a number of papers or reports on the value systems. Does that ring a bell?

**Bernard Howard:**

No. I know the fellow I'm thinking of. I mean, I can see him quite clearly.

**Tropp:**

Did you have contact with Eldred Nelson?

**Bernard Howard:**

No.

**Tropp:**

How about Floyd Steel.

**Bernard Howard:**

Yes, yes, Floyd Steel indeed.

**Tropp:**

He was one of the engineering geniuses I guess, in that development. Who are some of the other people there that you remember?

**Bernard Howard:**

One with the Snark I was trying to remember--Matador. That was another one of the early ones.

**Tropp:**

I mentioned BINAC to you. BINAC was commissioned by Northrop essentially because they wanted a guidance computer aboard the Snark missile project. You know it never flew. That was the reason for them asking Eckert-Mauchly to build a computer for the.

**Bernard Howard:**

The we approached it, of course, we were concerned not so much with the hardware in the field as we were hardware in the laboratory to evaluate hardware in the field--future hardware. We were using the present as a guideline.

**Tropp:**

So, you would just determine the kind of equipment you would need in order to simulate?

**Bernard Howard:**

Exactly, and one of the most significant parameters was that ot the dynamic response--in order to simulate the whole weapons system of course you have very high frequencies, particularly in the air frames and so on--right? And on the other hand, you have very long flight times, half hour or so, which is pretty long in terms of the...so, the dynamic range was--which was it?--was it the highest frequency that went above the flight time--time the flight time, or the other way around. Yeah, that's right. Flight time times the highest frequency--that's right. Dynamic range, before even the missiles, even those relatively primitive missiles was well beyond the range of any existing computer. In other words, if you tried to do the whole calculation on a digital computer, then your round-off errors would accumulate to the point where the solution would cease to have any meaning, have any significant figures on before

the flight was over--right? On the other hand, if you tried to go to an analog computer, you see, which has the high frequency response, well again you can't have precision. One part in a thousand or something, ten thousand at the most. So we came to the conclusion--and this I believe is that--why we were so much interested in what Skramstad was doing at NBS, was the hybrid facility, with the analog computer handling the high frequency, high frequencies, and the digital computer handling the low.

**Tropp:**

Is this what you ended up with...

**Bernard Howard:**

This is what we ended up recommending and so on.

**Tropp:**

And was it realized?

**Bernard Howard:**

No, it wasn't--political reasons, I think. Down at Wright Field they had a digital group and an analog group, but I guess they did everywhere, and the two of them just weren't getting together. They were trying to see who could have control of the whole spot and, oh, there were some very interesting things that happened. For example, in the early stages, of course, one of the big problems with the analog computer was the multiplier, you know. It still is today, but RCA developed this electronic multiplier and so, they built a model which they called--instead of calling it an analog computer something, it was, the Air Force had to have a fancy name and they called it a "dynamic system synthesizer". [LAUGHTER] Well, anyway, it was a very interesting gadget. It has a novel feature of connecting--you know the long time it takes to wire up a patch board for an analog computer. Now of course, you can have [prepatch?] panels and so on and plug them in but then they're hard to store. So, what RCA came

up with was a panel--let me see now, how many pins were there in each direction--something like 64 by 64 connections in the panel, something like that. There was this stiff piece of paper, it was maybe, oh, 2 feet by 2 feet, something like that. There were these stiff semi-cardboard sort of things and you could put this semi-cardboard--would locate it very carefully with pins. It had to be rather precisely located on a panel and then you would wire up your problem by going around it punching holes in the paper where you wanted connections to be made. All right, then you'd take this problem and you'd open the door in this sort of--almost like a telephone switchboard, you see--you'd open the door and you'd put your paper into the thing and you'd close the door and put the hinge down and, lo and behold, all these little springs were springing and moving and they'd go through the paper and make contact down at the bottom.

**Tropp:**

When you'd push the pins through?

**Bernard Howard:**

Right, the pins were automatically punched through. Of course, the mechanical problems in designing that were nontrivial because in the first place you had to have the paper stiff enough to resist the pin pushing through when you closed the door. Or on the other hand you had to have a spring strong enough so that it would push through and so the total force in all the springs couldn't be too much and the individual ones [Not clear]...

Well, anyway, it was a very interesting design and they finished the thing, the model, and the Air Force said, "Fine. Now we want to have the University of Chicago go out and test this." Well of course the guys at RCA, the Defense Lab at Princeton--crazy nuts, you know, are we going to have some mathematicians come out and test this computer developed by the world's greatest electricians. They sort of took a dim view of the whole thing but they still--their sponsors said we're going to test it and so

they were polite and so on. We said, "Well of course we're not going to test the electronics, but this is to solve some mathematical problems so we want to see what king of problems it can solve. Try it out, that's all."

Well, so we went out there and we spent four weeks testing this thing and in the beginning they just said, well here it is and this how you work it. They gave us an hour lecture on how it worked and, go to it--if you need any help, holler. Wo we went to work, and we started solving problems and so on. This Art Vance was one of the members of the Board, Advisory Board. He was a big tough character and he'd come around every so often, you know, "Hm, what're you doing?" He came in once and here we were--(Face space?) incidentally was a problem, a test problem, that--it was a new kind of a test problem--but it was drawing pretty pictures, you see. He said, "Huh, what are you doing now?" So, we explained to him the theory and so forth and so on of what the machine was doing. He said, "Hm." So he went away.

A couple of days later he had a group come in from the Naval Postgraduate School at Monterey, a whole bunch of Navy guys came in and wanted to see it, so he wanted to demonstrate. They were on a tour, you know, and he wanted to demonstrate his machine. So, he came in--"Hey," he said, "Could you get out that problem you had on before?" Pretty curves--sure, happy to. We had a different problem on then but this will give us an opportunity to demonstrate how quickly we can change problems. And so we did and everybody was happy with the demonstration.

Well, anyway, it was a pretty good machine and we did recommend on the basis of some elaborate tests that it satisfied the special requirements that the Air Force wanted. Well, of course, they had to send out bids--I mean, invite bids from all interested parties, half a dozen or so. It was a big deal, half a dozen companies responded and who should come in with the low bid but Reves Instrument Company, not

RCA, not EAI or whatever --ACE or EASE--I've' forgotten the names of the analog computers.

**Tropp:**

The Reeves one was the REAC.

**Bernard Howard:**

The Reeves was the REAC but then there was a SEES and there was a Beckley--Berkeley Instruments...?

**Tropp:**

I guess I don't know that one. The REAC is the only one I've run into that I've still seen in existence.

**Bernard Howard:**

Well, anyway, Reeves started to work and after they'd spend their million and a half, you know, they didn't have a machine. What are they going to do? They ended up with a hundred and fifty percent overrun, you know. That million and a half bid ran into three million dollars.

**Tropp:**

RCA must have been fuming. That was an interesting peiod. Well, you originally (looking at your vitae here) cut your teeth on the analog computers at MIT, differential analyzer.

**Bernard Howard:**

Oh yes, we used the Bush for ray tracing and so on, right.

**Tropp:**

So, you used that along with your Monroes and Marchants. The one thing we didn't talk about was any of your memories of the Whirlwind project that was going on when you were AT MIT, because it was analog at that period of time.

**Bernard Howard:**

Yes, it was the servomechanisms laboratory. During World War II there was a radiation laboratory, there was a servomechanisms laboratory--I'm not sure--were there anymore?

**Tropp:**

Those were the main ones.

**Bernard Howard:**

Instrumentation laboratory. Well, we had ordinary contact buy you know all of these were classified projects and they were all pigeon-holed and unless you had a need to know they kept knowledge fairly well separated.

**Tropp:**

I see. Did Von Neumann cross your path during that period or did you run into him later?

**Bernard Howard:**

No, not personally, it was later. Of course, every mathematician knew Von Neumann from, you know, about him and so on--well, I guess it was just a question of where you were and so on. People know about Von Neumann the way they knew about Norbert Wiener, and I happened to be at the place where Wiener was and so consequently the sort of job I was doing was such that I had a lot of personal contact with him. But after all, I was just a little old undergraduate, you know.

**Tropp:**

In terms of your period here, I gather then you were around when the computational lab was not a design, but build--or the computational center?

**Bernard Howard:**

I started from scratch.

**Tropp:**

Are you still connected with the computation center?

**Bernard Howard:**

No.

**Tropp:**

The timing is interesting because that's just about the time the first computer science programs began to evolve. I gather--and this is not an area I know much about--but I gather Forsythe at Stanford and Purdue were just about parallel in their early development of the computer science programs and this couldn't have been too far behind it though.

**Bernard Howard:**

No, that's right, it was just at the stage where computer centers were becoming service facilities and computer science departments were beginning to be conceived as a different entity. As a matter of fact, this was what Aiken said when he came down here. He said, "Look, when I built my computing center, well, fine. That was important." A computing center was an important thing, but now the computer is something that's like a physical plant, a mowing machine. You want to keep the lawns mowed and so on. You want to have good service provided but you know in order to move on with it we want to go with the higher order, the next level up idea; and his concept was that the computer is an information processing device. Consequently, we should turn our attention to the--that with which the computer deals, see, turn our attention to the--I can't think of the word.

**Tropp:**

Hate to put words into Aiken's mouth?

**Bernard Howard:**

Well no, the reason I'm hesitating about it is because it was neatly phrased, you see, and the principal commodity of the computer is information and so we should concern ourselves with the nature of information, its structure, its measurement, its coding, its processing, its origin, its retrieval, its utilization, transmission, and so on; and the computer is then just an information processing device. In fact this is the basis, I think, that should be used. It's not as yet but I think it will be. It clears the comparing of computers. When, for example, you're deciding which computer you're going to get--oh boy, the salesmen can come in and you have a steady stream of them. One of them shows you what a nice, pretty, red and blue finish his machine has, and it's got this gadget and that gadget. The the next salesman comes in and he explains to you what kinds of gadgets he has and they all sound great. If eventually you sit down and write a contract to buy a machine it's usually in the vendor's terms, you see. Not in terms of the buyer and so it seems to me the thing to do is to analyze the task--what you want to get a computer for is to process information, so you have to look at the kind of information you want processed. How much information you want processed. How much information, of what form and how much speed and what volume and so on, you see. These can be quantized and then you proceed and buy a computer to do your job.

**Tropp:**

And if there isn’t one, then what do you do?

**Bernard Howard:**

Ah, well, if somebody wants to sell you--then you redo; you have to, I suppose, you have to modify your job, don't you? So nevertheless, buy the thing in terms, the purchase agreement in terms of the job that you want done, rather than the pieces of equipment that the manufacturer is making.

**Tropp:**

Before I--I know you want to get home, so I want to ask you one very unfair question. What do you see as some of the major impacts of something like the MARK I? How do you see its impact in the last 25 years or so? What do you think its major role has been? From where you sit.

**Bernard Howard:**

Well, before I answer seriously let me tell you a little story. It was a few years ago,

you know, the Internal Revenue Service decided to recognize, and they set up a large installation at Chamblee, Georgia, to process all the returns from the Southeastern United States, and of course, they had certain criteria for flagging out returns for personal identification, you see. Well, when they cranked up their system and ran through the first batch, who was on the first list that came out to be looked at personally--nobody else but Howard Aiken. [Laughter] Whe he heard about this he was fit to be tied. He was storming around.

Well, I think that essentially it opened a can of worms. There is no doubt about it; it changed the world. Oh, one of the analogies that I use in my classes is between information processing and speed of transportation. Now, 100 years ago we went from the 6-mile-an-hour buggy to the 60-mile-an-hour train, or 150, whatever you want--one order of magnitude and it changed the world and it took us a generation to do it. See, and then we went from the 60-mile-an-hour train to the 600-mile-an-hour jet and again it changed the world. It took a whole generation to do it. Well now, what have they done in the space of a mere 20 years? In our information processing capabilities, we have increased them one million times, and this is not one order of magnitude, not ten times, but ten to the sixth. Right? This is such a fantastic increase and in such a short space of time that we haven't begun--we can't even conceive--the human mind isn't that imaginative because the potential of the computer and what it will

do. MARK I just opened up the whole era.

**Tropp:**

There was another thing that I guess I was kind of groping for. It's still fuzzy in my own mind and that's why I keep tossing out the question, and that was, in order to make these quantum jumps you have to introduce people to this new environment; and it struck me as I look back through the publications of Harvard in that era, that that was a very important function that they were performing, of introducing people to this world of information processing. Then I look at the names of people who got thier first exposure there and you are now one of them and see where they are today. It looks like it performed a second function; namely, as an initial training ground for the people who were going to participate in this $10^6$ leap. The more I look at that the more I find more and more evidence for this incredible impact of the early machines and I look back and people ask me, you know, about kinds of milestones and I have the feeling that the 1946 Moore Summer School, the Harvard Symposia, were incredible milestones for the dissemination of information. That's something different than what a computer does, but it created the environment in which this new concept could flourish.

**Bernard Howard:**

I don't think there's that much difference in what the computer does. It is dissemination. It's still processing information which is something that is on an entirely different energy level than kilowatt hours or something. It's of such a low energy level and yet it's--isn’t it our brain that's what is making us to rule the world, or we think we do anyway.

**Tropp:**

We could be kidding ourselves.

**Bernard Howard:**

In any event it may be what will cause us to extinguish the world.

**Tropp:**

Or it may be the means whereby we save the world.

**Bernard Howard:**

But, you're right. We haven't begun to realize the potential of the symbiosis between man and machine, because man can still do things better than a computer--pattern recognition, for example, and we know how we do it, so we come again and instruct the computer.

**Tropp:**

Even some simple decision making it can still do it.

**Bernard Howard:**

Right, the computer has ____ it processes very quickly. So, you put the man and the machine in the same loop, you see. Now, these seminars of 25 years ago. All right, these were disseminating information. What do we do? That's exactly the same way the Greeks were doing it two thousand years ago--getting a bunch of people together and talk. We're only beginning to realize, in terms of higher education for instance, we are faced with economic crises and the reason that workers in Detroit can get raises is because they're increasing their productivity. You know, they used to be able to build--one man could build one car in a week and now he can build two cars in a week or something so he's working twice as much. In terms of teaching information, that's our job--information. A comparable increase in our productivity would be an increase in the rate of information transmittal and it's hard to see how we could do it by voice contact or channels, you know the voice channels, limited phonemes can come out at a certain, you know, carrying capacity is rather low. So we have to speed up the process in other

ways. In particular, when one man has knowledge how can he spread it out to more people and faster? I think the computer is an important link in this system.

**Tropp:**

The whole system of information, moving information around. Well, then you very, very much.

**[THERE IS A SILENT SPACE IN TAPE HERE.]**

**Bernard Howard:**

Of course, he had a knack of remembering, you see, what the equation should be, so he would start with a certain hypothesis and then he'd say, "Well, now, we just do this and obviously we get this," you know, and he would write down the next step, but of course there were several pages of calculations in between and he would write, you know, do all this mentally. It wasn't clear how much of it was showmanship and how much of it was _____ calculation. So, this particular proposition he came up with, and I've forgotten by now what it was, but it was one of the important principles in the prediction theory and so on--and he worked around, and he knew what the answer was and finally he got around on the board way over there, and he had the answer. And in the answer appeared a lambda that he hadn't started with, you see. So, somebody said, "Professor Wiener, where did the lambda come from?" And he said, "The lambda? Let me see, now." and so on. He had to run over to it and so here he was running--starting back along the boards to try to find where that lambda was, to rationalize it. The bell rang and everybody left while he was still trying to figure out.

So, the next class meeting there was a chart, maps, you know, there was this roll on the blackboard where you could pull down a map or a screen. It pulled down, you see, and covering up part of the board. So, when Professor Wiener came in and of course he needed a board, so he just left the screen up and underneath the screen was the little poem.

"Professor Wiener had a lambda
Where it came from he did not know
But not everywhere that Wiener went
Was lambda sure to go.

**Tropp:**

Oh, that's beautiful. I haven't heard that story.

**Bernard Howard:**

He laughed but it wasn't too sure what he was laughing about, whether people were laughing with him or at him, or course he never could stand the latter.

All right, another occasion I can remember, I believe it was Professor N.H. Frank had come up with a new gadget, something to do with some radar development. I've forgotten what it was at the time. It was a great idea, you see, and he set the shop to building a model and everything, you know, and he came in and he took his shop men to tea and he was telling us all about it and he was feeling so great and everything. "Of course," he said, "a mathematician would worry about the convergence in the series but we haven't got time for that. I mean, there is a war on. We have to come out with it; we can’t worry about silly trivia like that." Needling the mathematicians--two of us, two mathematicians and two astronomers. So, several days wend by and they completed the gadget and it didn't work. He tried to find out why. It was about a week later and I went by his office and here he was sitting at his long table and taking notes like a little schoolboy and here was Wiener at the board lecturing him on series of convergence and so on. We knew about it because Wiener came shortly after and said, "Well, Professor Franks thing didn’t work. He built the steering on the first term of a rapidly diverging series."

[Laughter]

**Tropp:**

Kind of a deadhead decimal point. Well, that's a marvelous...Did you have any experiences with Norbert Wiener, actually being involved in concepts of rapid calculation, thinking about, talking about it, in this very early period? I just can't seem to find any direct evidence although he has comments on it in his own works.

**Bernard Howard:**

I don't seem to recall him talking--if he did the ideas didn't register with me.

**Tropp:**

What was your reaction to MARK I when it first...

**Bernard Howard:**

I thought it was the most fabulous breakthrough. I mean it just...this is as important as the atomic bomb.

**Tropp:**

Of course, without computational ability like that there wouldn't have been a bomb, at least at the point in time there was. I gather one of the very first people to work on MARK I was Von Neumann, although he later worked on the same problem with ENIAC when it was operative, AEC problem.

**Bernard Howard:**

I don't recall him, meaning connection with the MARK I, but boy, I remember at Illinois his lectures were marvelous. He gave a very famous series and he was there for a week and the ideas that he came up with were just unbelievable. I mean, for example, the synthesis of reliable mechanisms from unreliable components and his famous paper on the inversion of matrices of high order and so on.

**Tropp:**

That's really kind of a landmark paper in numerical analysis.

**Bernard Howard:**

Yes, but I heard him lecture on this before he wrote the paper. It was--God, I mean, you know, it was just so exciting!

**Tropp:**

That was before the paper. The paper was--what, 1948?

**Bernard Howard:**

'47, November of 1947. It took up the entire November issue of the Bulletin of the Mathematics Society.

**Tropp:**

He was really an incredible person, just incredible.

**Bernard Howard:**

Wiener was extremely far-seeing. What I remember Wiener lecturing about more to the point was feedback, sensory prostheses, information theory, and things like that. I mean, I can see to this day his method use it--I reproduce often. How do I pick up a pencil, you know, the feedback. The eye to brain to hand. As a matter fact it was Wiener's concepts that were used all during the fifties at the University of Chicago in their system research... The idea of the sensors and the processor and the effectors. The eye, the brain, and the hand... radar for a sensor, our computer to the brain, and our servomechanisms for the effectors.